

Age, Depositional History and Tectonics of the Indo-Burman Ranges

by

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DECLARATION

The contents of this thesis are all my own work, except where otherwise stated.
The views and opinions expressed herein are mine and not necessarily those of
any other person or body unless so attributed.

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Abstract

This thesis examines the provenance and depositional processes of the sedimentary rocks of the Indo-Burman Ranges (IBR), the geology of the Kalemio ophiolites, and discusses the tectonic evolution of the IBR, and presents a synthesis of the geological evolution of Myanmar. The IBR form an enigmatic mountain belt, comprising a western belt of folded and thrustured mainly Cenozoic sedimentary rocks, a central zone of highly deformed Triassic turbidites (Panaung Formation) and low-grade metamorphic rocks (Kanpetlet Schist), and an eastern zone comprising a major Neotethyan suture zone. The newly discovered early Jurassic-early Cretaceous radiolarian assemblages from ophiolitic mélanges in the Kalemio area and late Paleocene-early Eocene radiolarian ages from the Ngazun mélanges, with ages similar to those of the Indus – Yarlung Tsangpo suture zone of south Tibet and Nagaland, reinforces the hypothesis that the Kalemio - Nagaland suture and Indus – Yarlung Tsangpo suture represent a single suture zone that separates the Indian plate to the west (IBR) and Asian plate to the east (Central Basin and Wuntho-Popa Arc). The data presented suggest that Triassic turbidites were originally deposited on the northeastern India (Gondwana) margin, not the Asian (Sibumasu) plate, and that a wide Neotethyan ocean separated the IBR from the Wuntho-Popa Arc (WPA) and the Shan Plateau. The geochemistry of detrital zircons from Upper Cretaceous sedimentary rocks of the IBR to be derived predominantly from the core of the IBR where marks a broad suture zone. Similar data from the Paleocene-Eocene flysch sediments suggest derivation from the Wuntho-Popa Arc and the core of the IBR.

Extended Abstract

Age, Depositional History and Tectonics of the Indo-Burman Ranges

The Indo-Burman Ranges (IBR) run north-south through Myanmar from the Gulf of Martaban in the south to connect with the Himalaya to the north. The IBR are flanked to the east by the Central Basin and to the west by the Bengal Basin. The IBR are important for understanding processes related to early ophiolite obduction, and later continental (India-Asia) collision as well as processes related to the post-collisional northward indentation of India along its highly oblique eastern margin. This thesis reviews the stratigraphic and structural evidence for the timing of key events in the IBR, deduced from observations and fieldwork over three field seasons in the Rakhine area, Kanpetlet-Mindat area, and the Kalemio area. The samples were examined by using detrital zircon geochronology, biostratigraphy and petrology to constrain the stratigraphy, provenance and tectonic history of the IBR.

The IBR comprise a western belt of folded and thrustured mainly Cenozoic sedimentary rocks, a central zone of highly deformed Triassic deep-sea sediments and low-grade metamorphic rocks (Kanpetlet Schist), and an eastern zone comprising a major Neotethyan suture zone. Fragments of ophiolites were formed in the Cretaceous and obducted and incorporated into the accretionary prism during the Late Cretaceous-Paleogene. The Neotethyan suture zone includes a series of mainly Cretaceous ophiolites including the Manipur-Nagaland ophiolites in India, and the Kalemio ophiolite massifs in Myanmar. The suture zone also contains radiolarian cherts of Jurassic and Early Cretaceous age, oceanic volcanic rocks, mélanges and sedimentary rocks that were deposited in the Neotethyan Ocean. The radiolarian assemblages provide new age constraints on deep-marine sedimentation that are consistent with those reported from ophiolites

in Tibet and the Nagaland, and reinforces the hypothesis that the Kalemmyo, Nagaland and Indus – Yarlung Tsangpo suture zone (IYTSZ) ophiolites were once part of the same Neotethyan ocean floor. The newly discovered late Paleocene-early Eocene (59-54 Ma) radiolarians in the *mélange* of the southern IBR provide a maximum age constrain on the timing of formation of the *mélange*. The radiolarian fauna, the tectonic attribution of the radiolarian cherts and basalt blocks indicate that oceanic crust persisted in the southern IBR until the early Eocene. The Kalemmyo – Nagaland suture has many similarities to the Indus – Yarlung Tsangpo Suture in Tibet. This single suture zone separates Indian plate rocks to the west (IBR) from Asian margin rocks to the east (Central Basin forearc sediments and Wuntho-Popa Arc).

The early stages of accretionary prism development are marked by pre-Aptian complex deformation and metamorphism of the Kanpetlet Schist, Naga Metamorphics, and Jade Belt (including HP-LT metamorphism). Metamorphic units include a low-grade greenschist to amphibolite grade metamorphic sole beneath the Kalemmyo ophiolite.

The Upper Triassic Pane Chaung Formation in outcrop shows evidence for an early phase of extensional faults, some of which were later inverted, multiple phases of folding and thrusting, followed by superimposition of dextral strike-slip faulting. Thick Triassic flysch sedimentary rocks in the IBR were originally deposited on the northern Gondwana margin, in the vicinity of regions that would later become NE India. The provenance of the Triassic detrital zircons was likely from the Indian plate, not the Asian (Sibumasu) plate as at this time a wide Neotethyan ocean separated the IBR from the Wuntho-Popa Arc and the Shan Plateau. Common volcanic fragments and plagioclase grains together with a cluster of 300-200-Ma-aged magmatic zircons in Pane Chaung Formation indicate sediments source from a long-lived magmatic-arc terrane, possibly Gondwanide Orogeny formed above the Pan-Pacific subduction zone along the

southeastern Gondwana, with a subordinate input from India. Deposition of the Pane Chaung Formation was most likely controlled by regional tectonism, possibly a rifting event along the northern margin of Gondwana. This resolves the long-standing debate regarding where the Pane Chaung Formation was deposited. The Pane Chaung and Falam Formations both show bedding that strikes predominantly NNW-SSE with high-angle dips, although the outcrops display numerous examples of short-wavelength folding. In contrast, the Paleogene section (Chunsung Formation and Kennedy Sandstone) shows gentler dips, and NNE-SSW strike directions on west-dipping bedding and little short-wavelength folding.

The Upper Cretaceous sandstones (Falam Formation) in the IBR show a coherent single zircon population (unimodal distribution), with a mixture of positive and negative ϵ_{Hf} values. This is interpreted as the Falam Formation derived predominantly from the core of the IBR rather than a mixture from a long-lived feature such as the Wuntho-Popa arc or Gangdese Batholith. The core of the IBR marks a broad suture zone of Neotethys Ocean and related back-arc basin derived rock units comprising oceanic-related units and thick sequence of turbidite units.

The Late Paleocene-Middle Eocene sedimentary rocks of the IBR were derived from the Wuntho-Popa arc and the core of the IBR, as evidenced by petrography, ϵ_{Nd} values and proportions of arc-derived Mesozoic-Paleogene zircons.

The Central Basin has many similarities to the Xigaze Basin in Tibet. Both basins contain Cretaceous-Cenozoic sedimentary rocks, both have compatible detrital zircon U-Pb age and Hf isotope data (Wu et al., 2010; Wang et al., 2014; Wang et al., 2017; Zhang et al., 2019), both are located along the margin of the main India-Asia suture zone, and both are located in the forearc position to the Gangdese batholith (Tibet) and the Wuntho-Popa Arc (Myanmar).

The Wuntho-Popa Arc has many similarities to the Gangdese batholith in Tibet. Both hold a similar ϵ_{Hf} fingerprint (Zhang et al., 2017), both are composed of I-type biotite and hornblende granites and diorites of Cretaceous to Eocene age, both have an andesite volcanic component (Linzizong volcanics in Tibet, andesitic lavas in the Wuntho-Popa Arc), both contain large subduction-related porphyry copper (and gold) deposits, and both were formed above a north-dipping (Tibet) east-dipping (in present-day coordinates, Myanmar) subduction zone of Tethyan oceanic lithosphere.

The Sagaing Fault was initiated at 27 Ma and has approximately 400-480 km of dextral displacement (Morley & Arboit, 2019). The Kalembo – Nagaland suture was likely continuous with the Tagaung – Myitkyina ophiolite belt and offset dextrally along strands of the Sagaing Fault. Overall, the Indo-Burman Ranges are part of the Indian plate. The ‘West Burma micro-plate’ or ‘Burma platelet’ does not exist. There is no known suture zone west of the IBR and the eastern boundary, the Sagaing dextral strike-slip fault, was only initiated after 27 Ma according to Morley & Arboit (2019) based on U-Pb ages of detrital zircon and titanite in the Minwun basin sediments, or after 21 Ma according to Searle et al. (2020) based on U-Pb ages of granulite facies gneisses and leucogranites in the Mogok Metamorphic Belt. In either case, it is clear that the Sagaing Fault cannot have been a plate boundary prior to Oligocene at the earliest. Major strike-slip faults such as the Sagaing and Kabaw faults were initiated during the northward indentation of the Indian plate.

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Contents

Abstract	i
Extended Abstract	ii
Acknowledgements	vi
1 Introduction	1
1.1 Introduction	2
1.2 Geological Framework of Myanmar	9
1.3 Geological Provinces of Myanmar	14
1.4 Geological Setting of Indo-Burman Ranges (IBR)	19
1.5 Thesis Outline	24
2 Materials, Sample Preparations and Analytical Methods	26
2.1 Introduction	27
2.2 Sampling Strategy	27
2.3 Methods for Biostratigraphy	31
2.3.1 Sample Preparation for Foraminifera	31
using the Freeze-Thaw Technique	
2.3.2 Extracting Radiolaria from Chert Samples	32
2.3.3 Sample Imaging (SEM)	32
2.3.4 Thin Section Imaging (Petrography)	33
2.3.5 Biostratigraphic Schemes	33
2.4 Methods for Lithological Characterization	33
2.4.1 Petrographic Techniques & Sandstone Classification	34
2.4.2 X-ray Diffraction Analysis	35

2.5 Stable-Isotope Method	35
2.5.1 Sample Preparation	35
2.5.2 Sample Analysis	35
2.6 Detrital zircon U-Pb dating	36
2.6.1 Sample Preparation	36
2.6.2 U-Pb Analysis	38
2.7 Hf-isotopic Analyses	41
3 Geology of the Rakhine Area	44
3.1 Introduction	45
3.2 Previous work	48
3.3 Lithostratigraphy and Field Observations from the Rakhine Area	49
3.3.1 Rakhine Yoma	50
3.3.2 Rakhine Coastal Area	58
3.3.3 Ramree Island	60
3.4 Structure of the Rakhine Area	63
3.5 Biostratigraphy	66
3.5.1 Limestone	66
3.5.2 Shale	74
3.5.3 Chert	78
3.6 Petrography	80
3.6.1 Sandstone	80
3.6.2 Limestone	84

3.6.3 Basalt	88
3.6.4 Serpentine	89
3.7 Stable Isotope Geochemistry	91
3.8 Detrital Zircon U-Pb Ages	94
3.9 Detrital Zircon Hf Isotope	101
3.10 Discussion	103
3.10.1 Age of the Flysch in the Rakhine Area	103
3.10.2 Depositional Environments of the Rakhine Area	105
3.10.3 Provenance Interpretation	111
3.10.3.1 Upper Triassic Sandstones	111
3.10.3.2 Paleocene-Eocene Sandstones	114
3.11 Conclusions	117
 4 Geology of the Mt. Victoria Area	 119
4.1 Introduction	120
4.2 Lithology and Field Observations of the Mt. Victoria Area	123
4.2.1 Kanpetlet Schist	123
4.2.2 Pane Chaung Formation	126
4.2.3 Paung Chaung Formation/Limestone	129
4.2.4 Kabaw Formation and Paunggyi Formation/Conglomerate	130
4.3 Structure of the Mt. Victoria Area	131
4.3.1 Kanpetlet Schist	131

4.3.2 Pane Chaung Formation	134
4.3.3 Kabaw Fault	139
4.4 Biostratigraphy	140
4.4.1 Limestone	140
4.4.2 Shale	141
4.5 Petrography	143
4.5.1 Sandstone	143
4.5.2 Limestone	146
4.5.3 Kanpetlet Schist	147
4.5.4 Ultramafic rock	150
4.5.5 Mafic rock	152
4.6 Detrital Zircon U-Pb Ages	153
4.7 Discussion	158
4.7.1 Depositional Age and Environments of Sedimentary Rocks	158
in the Mt. Victoria Area	
4.7.2 Provenance Interpretation	161
4.7.2.1 Upper Triassic Sandstones	161
4.7.2.2 Upper Cretaceous-Paleogene Sandstones	163
4.7.3 Metamorphism of Kanpetlet Schist	164
4.8 Conclusions	165

5	Geology of the Kalemmyo Area	167
5.1	Introduction	168
5.2	Lithology and Field Observations of the Kalemmyo Area	172
5.2.1	Stratigraphy of the Indo-Burman Ranges west of Kalemmyo	172
5.2.1.1	Yazagyo and Khweka metamorphics	174
5.2.1.2	Kalemmyo Ophiolite	175
5.2.1.3	Pane Chaung Formation	177
5.2.1.4	Falam Formation	178
5.2.1.5	Chunsung Formation	181
5.2.1.6	Kennedy Sandstone Formation	181
5.2.2	The Kabaw Formation, Chindwin Basin east of Kalemmyo	182
5.3	Structure of the Kalemmyo Area	184
5.4	Biostratigraphy	187
5.4.1	Limestone	187
5.4.2	Chert	190
5.5	Petrography	195
5.5.1	Sandstone	195
5.5.2	Limestone	201
5.5.3	Conglomerate	203
5.5.4	Ultramafic Rock	204
5.5.5	Mafic rock	206
5.5.6	Amphibolite Schist	206
5.6	Detrital Zircon U-Pb Ages	208

5.7 Detrital Zircon Hf Isotope	213
5.8 Discussion	215
5.8.1 Depositional age and environments of sedimentary rocks	215
in the Kalembo Area	
5.8.2 A Suture Zone in the Kalembo area?	218
5.8.2.1 Ophiolite Formation	219
5.8.2.2 Relationship to the Indus-Yarlung Tsangpo	221
Suture Zone	
5.8.3 Provenance Interpretation	223
5.8.3.1 Upper Triassic Sandstones	223
5.8.3.2 Kabaw Formation in the Chindwin Basin	225
5.8.3.3 Upper Cretaceous-Eocene sandstones in the	226
Indo-Burman Ranges	
5.9 Conclusions	231
6 Discussion	233
6.1 Introduction	234
6.2 Refinements of the Regional Stratigraphy	234
6.3 What were the Source Terranes for the Flysch in the	241
Indo-Burman Ranges	
6.3.1 Upper Triassic Sediments	241
6.3.2 Upper Cretaceous-Middle Eocene Sediments	246
6.4 Tectonic Evolution of the Indo-Burman Ranges	254
6.4.1 The West Burma micro-plate	263

6.4.2 The Sagaing Fault	265
6.4.3 The Myitkyina Ophiolite Belt	265
6.5 A Simplified Tectonic Model for the	266
Indo-Burman Ranges	
7 Conclusions and Further Work	271
7.1 Conclusions	272
7.2 Further Work	275
Bibliography	277
Appendix	303
Appendix 1	
Appendix 2	
Appendix 3	
Appendix 4	
Appendix 5	
Appendix 6	

List of Figures

1.1	Geology map of Myanmar	3
1.2	EW synthetic lithospheric cross section of Myanmar	4
1.3	Schematic composite cross section across Indo-Burman Ranges	5
	and Central Basin	
1.4	Map of the major terranes in SE Asia	9
1.5	General structural map of the Myanmar	13
1.6	General stratigraphic units of the Indo-Burman Ranges and	17
	Central Myanmar Basin	
1.7	Early Permian-Early Jurassic palaeographic reconstruction	23
2.1	Sample locations map	28
2.2	QFL plots	34
2.3	Presentation of U-Pb zircon age data	41
3.1	General structural map of Myanmar and geology map of Rakhine area	46
3.2	Geological map of the Rakhine area with sample locations	51
3.3	Geological map and cross-section of the Padaung-Taungup	53
	road section	
3.4	Field photographs of the Rakhine area	56
3.5	The Ramree Island LANDSAT map	61
3.6	Field photographs of the Rakhine area	65
3.7	Stratigraphic ranges of the Upper Cretaceous planktonic	70
	foraminifera	
3.8	Photomicrographs of limestones from the Ramree Island	71
3.9	Stratigraphic ranges of the Paleocene-Eocene larger benthic	74
	foraminifera	
3.10	Stratigraphic ranges of the radiolarian fossils in the Ngapali	80
	Formation	

3.11	QFL plots for the Rakhine area sandstones	81
3.12	Photomicrographs of the sandstones in the Rakhine area	83
3.13	Field photos and photomicrographs of limestone	85
3.14	Photomicrographs of limestones from the Rakhine area	87
3.15	Field photos and photomicrographs of pillow basalt	89
3.16	Field photos and photomicrographs of serpentinite	90
3.17	Photomicrographs of limestones from the Rakhine area	92
3.18	$\delta^{13}\text{C}$ - $\delta^{18}\text{O}$ bivariate plot of the limestones from the Rakhine area	93
3.19	CL images of detrital zircons from the sample KM76a	96
3.20	CL images of detrital zircons from the Paleocene-Eocene sandstones	97
3.21	U-Pb age spectra for detrital zircons from the sample KM76a	98
3.22	U-Pb age spectra for detrital zircons from the Cretaceous unit	99
3.23	U-Pb age spectra for detrital zircons from the Paleocene-Eocene unit	100
3.24	U-Pb vs ϵHf data for Middle Eocene detrital zircons	102
3.25	Comparison of detrital zircon ages from the Cretaceous and Paleocene-Eocene units	105
3.26	$\delta^{18}\text{O}$ vs $\delta^{13}\text{C}$ stable isotope cross-plot illustrating the $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values of the limestones	110
3.27	Comparison of Upper Triassic detrital zircon ages from the Rakhine area, Mt. Victoria and Kalembo areas	113
3.28	Comparison of detrital zircon ages from the Paleocene-Eocene unit	115
3.29	Comparison of Paleocene-Eocene Hf isotopic data from the Rakhine area, Rakhine coastal area and Central Basin	116
4.1	General structural map of Myanmar and geology map of the Mt. Victoria area	121
4.2	Geological cross-sectional across the Indo-Burman Ranges	122
4.3	Field photographs of the Mt. Victoria area	125
4.4	Location map of the <i>Halobia fossils</i>	128

4.5	Stereonet showing structural orientation data from	132
	the Mt. Victoria area	
4.6	Detail of Mindat road section (attached at the back cover)	
4.7	Sketches of new road section through the Pane Chaung Formation	136
4.8	Examples of structural styles in the Pane Chaung Formation	137
4.9	Examples of normal faults in the Pane Chaung Formation	138
4.10	Photomicrographs of the limestones and SEM photo of	142
	microfossil from shale	
4.11	QFL plots for the Mt. Victoira area sandstones	144
4.12	Photomicrographs and XRD result of the sandstones	145
4.13	Photomicrographs of the Kanpetlet Schist	148
4.14	Photomicrographs of the mantle peridotite	151
4.15	Photomicrographs of the gabbro	153
4.16	CL images of detrital zircons from the Mt. Victoria area	154
4.17	U-Pb age spectra for detrital zircons from the	155
	Pane Chaung Formation	
4.18	U-Pb age spectra for detrital zircons from the Central Basin	157
4.19	Comparison of Upper Triassic detrital zircon ages from	162
	the Mt. Victoria and Rakhine areas	
4.20	Comparison of detrital zircon ages from the Minbu Basin	164
	and Chindwin Basin	
5.1	General structural map of Myanmar and geological map	169
	of the Kalemmyo area1	
5.2	Field photographs of ophiolitic mélange in the Kalemmyo area	176
5.3	Field photographs of the Kalemmyo area	179
5.4	Field photo, photomicrograph and detrital zircon U-Pb ages of	183
	the Kabaw Formation	
5.5	Cross-section along the Kalemmyo - Falam road section	185
5.6	Calculation of the dip of the base of massive peridotite bodies	186

5.7	Stratigraphic ranges of the radiolarian fossils from	195
	the ophiolitic mélange	
5.8	QFL plots of the Kalemmyo area sandstones	196
5.9	Photomicrographs of the sandstones from the Kalemmyo area	198
5.10	XRD analyses of the Kalemmyo area sandstones	199
5.11	Photomicrographs of the limestones from the Falam	202
	Formation and Kabaw Formation	
5.12	Field photo and photomicrographs of conglomerate block	203
	in the Falam Formation	
5.13	Photomicrographs of the mantle peridotite and gabbro	205
5.14	Field photo and photomicrographs of the amphibolite schist	207
5.15	CL images of detrital zircons from the Kalemmyo area	209
5.16	U-Pb age spectra for detrital zircons from the Pane Chaung	210
	Formation	
5.17	U-Pb age spectra for detrital zircons from the Cretaceous-	212
	Paleogene Sandstones	
5.18	U-Pb vs ϵHf data for Cretaceous-Paleogene detrital zircons	214
5.19	Comparison of Upper Triassic detrital zircon ages from the	224
	Pane Chaung Formation	
5.20	Comparison of detrital zircon ages from the Cretaceous-Paleogene	228
	flysch in the Kalemmyo area	
5.21	Comparison of Cretaceous-Paleogene Hf isotopic data from	229
	the Kalemmyo area	
6.1	Modified geological map of the Rakhine area	237
6.2	Modified geological map of the Kalemmyo area	238
6.3	Location of radiolaria fossils map and chronostratigraphic chart	240
6.4	Comparison of Upper Triassic detrital zircon ages from the IBR,	242
	Langjiexue Group, Lhasa, Sibumasu and Carnarvon Basin	
6.5	Comparison of QFL data from the Upper Triassic sandstones	244

from the IBR and Langjiexue Group	
6.6 Comparison of Upper Triassic detrital zircon Hf isotopic data	245
from the IBR and Langjiexue Group	
6.7 Comparison of detrital zircon U-Pb ages for the Cretaceous-Paleogene	248
sandstones from the IBR, CB, Xigaze Forearc Basin and Nepal	
6.8 Comparison of detrital zircon Hf isotopic data from the	249
Cretaceous-Paleogene sandstones from the IBR, CB and WPA	
6.9 Comparison of QFL data from the Cretaceous-Paleogene sandstones	251
from the IBR, Rakhine coastal area and CB	
6.10 Comparison of detrital zircon U-Pb ages from the Upper Cretaceous	253
Falam Formation, IBR and Kabaw Formation, CB	
6.11 Late Triassic-Early Jurassic palaeographic reconstruction	257
of Model A	
6.12 Late Triassic palaeographic reconstruction of Model B	259
6.13 Late Triassic palaeographic reconstruction of Model C	261
6.14 The Burma Platelet and reconstruction of the Burma Terrane	262
and Asia in Model D	
6.15 Schematic diagrams showing the evolution of the IBR through time	268

List of Plates

3.1 Planktonic foraminifera from the Upper Cretaceous limestone	68
in the Rakhine area and Ramree Island	
3.2 Planktonic foraminifera from the Upper Cretaceous limestone	69
in the Rakhine area and Ramree Island	
3.3 Larger benthic foraminifera from the Ramree Island	72
3.4 Larger benthic foraminifera from the Ramree Island	73
3.5 SEM images of microfossils and nannofossils from the Padaung-	76

Taungup road section	
3.6 SEM images of microfossils from the Padaung-Taungup road section	77
3.7 SEM images of radiolarians from the Ngapali Formation	79
5.1 Planktonic foraminifera from the Upper Cretaceous limestone, Falam Formation	188
5.2 Larger benthic foraminifera from the east of Kalemmyo	189
5.3 SEM images of radiolarian assemblages in sample KM37b	191
5.4 SEM images of radiolarian assemblages in sample KM37	192
5.5 SEM images of radiolarian assemblages in sample KM39a	193
5.6 SEM images of radiolarian assemblages in sample KM39b	194

List of Tables

2.1 Summary of the methods and number of analyses and samples	30
3.1 Stratigraphy of the Rakhine area	50
3.2 Summary detrital zircon U-Pb data from the Padaung-Taungup and Gwa road section of Rakhine area	95
3.3 Summary biostratigraphy and zircon U-Pb data from the Paleogene and Cretaceous units of the Rakhine area	106
5.1 Characteristics of ophiolite occurrences in Myanmar and Andaman Islands	171
5.2 Stratigraphy of the Kalemmyo area	173
6.1 Comparison of the timing of events in the Indus-Yarlung Suture Zone and IBR Ophiolites	267

CHAPTER

ONE

INTRODUCTION

1.1 Introduction

Myanmar (Burma) occupies a critical geological position along the obliquely colliding eastern margin of the Indian Plate. It connects the ongoing tectonic processes controlled by the India-Asia collision zone along the Himalayan Range in the north to the newly formed oceanic crust in the Andaman Sea in the south, via the active plate margin along the dextral strike-slip Sagaing Fault and subduction along the Burma Seismic Zone (Fig. 1.1). The geology of Myanmar has been affected by two major plate collisions that resulted in (1) the closing of the Palaeotethys Ocean during the Triassic, and (2) the closing of Neotethys and the collision of India with Sibumasu (Asia) during the Eocene, with subsequent crustal thickening and regional metamorphism (Mitchell, 1993; Sone and Metcalfe, 2008; Searle & Morley, 2011; Morley, 2012; Gardiner et al., 2015; Searle et al., 2017). Due to a complex tectonic history and limited geological studies the tectonic framework of Myanmar is poorly understood and this has led to controversy and different interpretations regarding the number and location of potential suture zones (e.g. Acharyya, 2007, 2010; Mitchell et al., 2012; Metcalfe, 2013), and the origin of basement blocks. Consequently, Myanmar remains geologically enigmatic. The varying regional tectonic settings of Myanmar not only give rise to disparate regional features, but they also foster the formation of petroleum basins and a diverse mix of mineral resources.

The Indo-Burman Ranges (IBR), in western Myanmar, have been interpreted as having developed as a result of N- to NE directed subduction during the Mesozoic - Cenozoic (Mitchell, 1993). The tectonic and uplift history of the core of the IBR (comprising ophiolites, metamorphic rocks and deep-water turbidites) has implications for

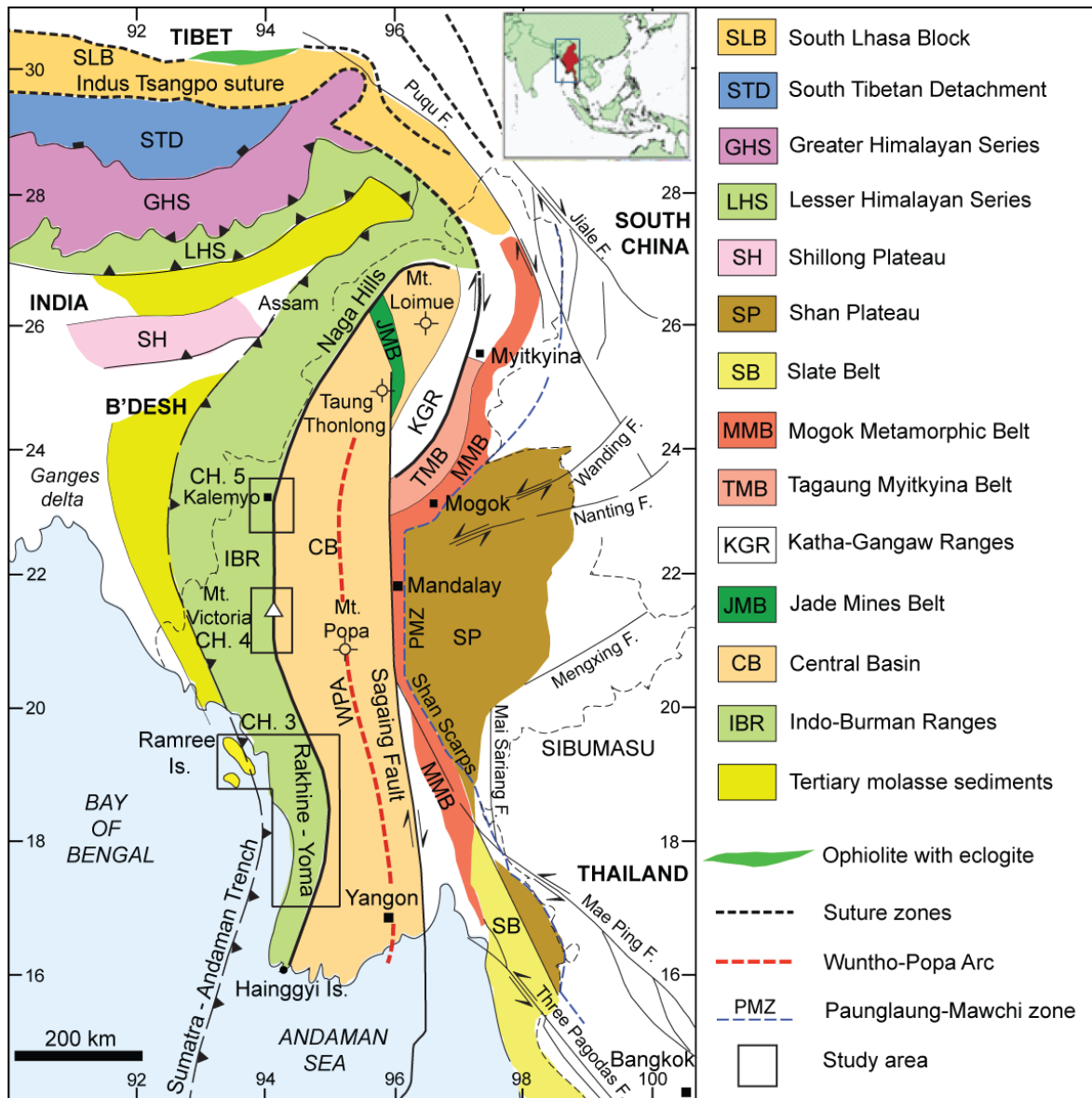


Fig. 1.1: Geological map of Myanmar (Burma) from the Eastern Himalayan Syntaxis area south to Mergui, modified after Searle et al., (2007).

paleogeographic reconstructions and the significant onshore and offshore oil and gas reserves that are present both to the E and W of the range. However, geological interpretations of the IBR vary significantly. One interpretation requires the existence of a so called ‘West Burma plate’ or ‘Burma micro-plate’ (Rangin et al., 2013) that includes

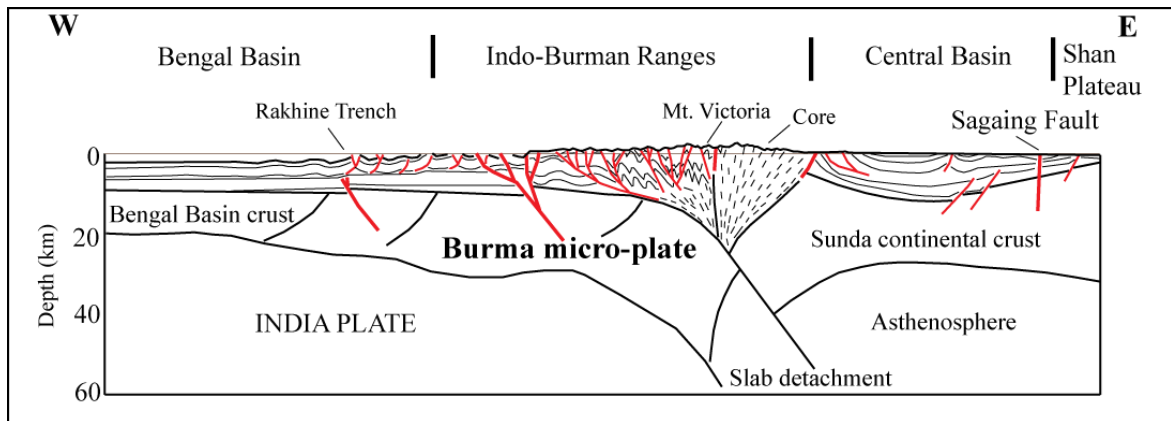


Fig. 1.2: EW synthetic lithospheric cross section of Myanmar, in part based on Rangin et al. (2013).

the IBR, the Kalembo - Nagaland suture zone and the Central Basin (Fig. 1.2). Rangin et al. (2013) interpreted the IBR as a pop up structure, comprising a pre-Cenozoic subduction/collision complex that protrudes through the overlying Palaeogene basin and extends from the Bay of Bengal to central Myanmar. In addition, the Mesozoic ophiolites of the IBR (including Nagaland) obducted on the Mt. Victoria-Burma micro-continent during the Cretaceous provide evidence for the suture of a Mesozoic ocean, probably Neo-Tethys. They considered only one ophiolite obduction event. An alternative interpretation is that because of the different age of ophiolites (e.g. Mt. Victoria and Naga Hills) with different accretion timing and modalities, the IBR are a series of accreted microcontinents and ophiolite complexes (Acharyya, 2015), (Fig. 1.3). The core of the IBR has also been suggested as the suture between the Indian plate and Asia and thus equivalent to the Indus – Yarlung Tsangpo Suture Zone in the Himalaya (Morley & Searle, 2017; Searle et al., 2017). However, the timing of closure and the sequence of events in the IBR is very poorly known and it is unclear whether the IBR records a similar Eocene closure history as the

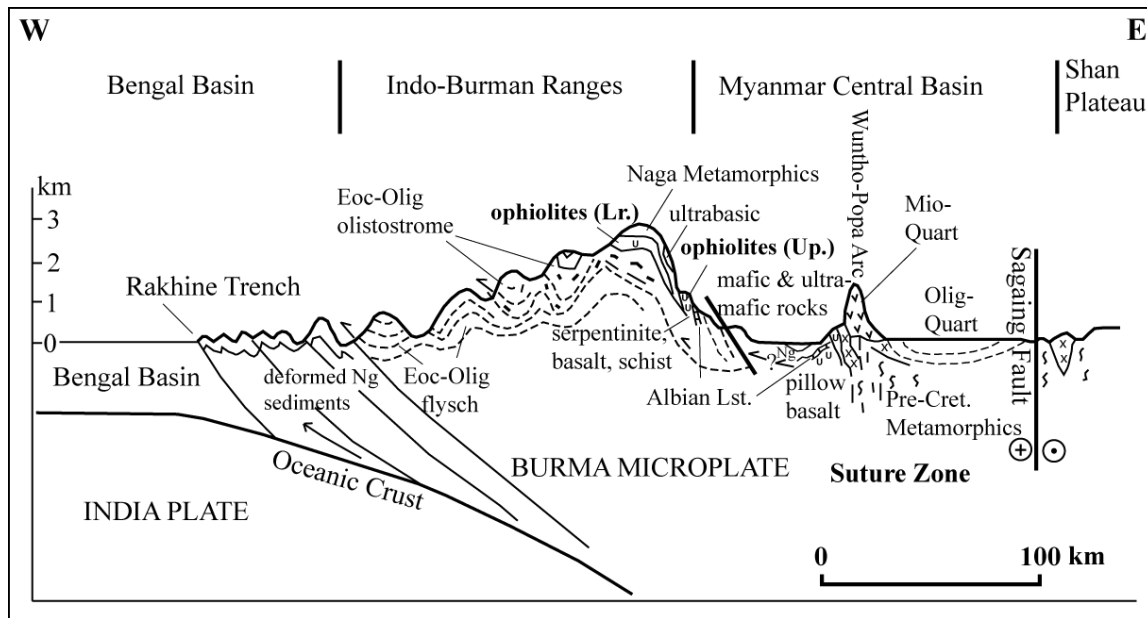


Fig. 1.3: Schematic composite cross section across Indo-Burman Ranges and Central Basin, showing major morphological and structural units, in part based on Acharyya (2015).

Himalaya in India and south Tibet. At the centre of these debates are the ages and obduction histories of a number of discrete ophiolites and the associated sediments of the IBR. Better knowledge of the age of ophiolites and their timing of obduction together with age and structural relationships of the Mt. Victoria belt and the Cenozoic rocks of the IBR is needed in order to allow a clearer reconstruction of the tectonic history of this part of the Neotethys and to develop a unique tectonic model for the region.

The term West Burma Block is widely used in the literature, but definition of the extent of the block remains confused. Mitchell (1993) suggested the West Burma Block represents the western part of Slate Belt-West Myanmar/Sibumasu Terrane that was recently divided in the Cenozoic by the Sagaing Fault. Sevastjanova et al. (2015) interpreted the West Burma Block including IBR and CB. The ophiolites and deep-sea sediments along the Kalemio zone represents a suture zone between the IBR to the west and the Central Basin to the east

(Liu et al., 2016). Thus, the IBR west of the suture zone does not belong to the West Burma Block (Li et al., 2017; Yao et al., 2017). Moreover, the origin of West Burma Block is very poorly constrained and published models suggest very different timing for its tectonic evolution. Metcalfe (1996) suggested that West Burma rifted from the NW Australia margin, along with the Lhasa Terrane in the Late Triassic – Early Jurassic. Metcalfe (2011) suggested that West Burma is the continuation of the West Sumatra Terrane and was displaced by several thousand kilometers of margin parallel strike-slip in the Triassic. The tectonic affiliation of the West Burma Block hinges on whether it is correlated to the Lhasa Terrane (Mitchell, 1993; Searle et al., 2007) or to the West Sumatra Block (Barber and Crow, 2009). Hall (2012) assumed that West Burma had accreted to the Eurasia margin by Late Jurassic. Sevastjanova et al. (2015) argued that the West Burma Block was part of Eurasia from the Late Triassic. The complex tectonic history of West Burma has led to controversy over when and where the crustal fragment separated from Gondwana, and when and where it docked with SE Asia. In SE Asia the principal Gondwana fragment is known as Sibumasu (Shan-Thai terrane) that formed part of SE Asia by the closing of the Paleotethys ocean during the Triassic and the concomitant collision with Indochina (Sone and Metcalfe, 2008; Barber and Crow, 2009; Sevastjanova et al., 2011; Metcalfe, 2013). The variety of models concerning the origin of West Burma and its evolution arise from the lack of information on the age and composition of the underlying basement.

The geological context of tectonic events in the IBR remain open to multiple interpretations. Early writers on the plate tectonics of Myanmar considered the complexly folded and thrust IBR to be related to subduction processes that formed the trench and popularly interpreted as an accretionary prism or accretionary complex. Mitchell (1974) and

Mitchell and McKerrow (1975) interpreted the IBR as an east-dipping imbricate wedge of oceanic-trench turbidites within which thrust packages increase in age from Neogene in the west to Cretaceous in the east. However, with the discovery of Triassic turbidites, older metamorphic rocks and ophiolite complexes in the eastern belt of the IBR, an alternative explanation was sought (Socquet et al., 2002; Acharyya, 2007, 2010; Rangin et al., 2013; Ghose et al., 2014). Therefore, the tectonic complexity of the region makes it an important area for understanding the history of the Indian-Asian collision, the genesis of extensive mineral deposits and the existence and style of onshore and offshore petroleum systems. At present the position and nature of the suture between the Indian and Asian plate in Myanmar is highly debated.

Important questions impacting the geological history of Myanmar are: (1) where exactly is the Indian-Asian suture within Myanmar?, (2) what is the origin of ‘West Burma’ and the timing for its accretion to Asia?, and (3) does Sibumasu extend as far west as the Mt. Victoria Belt or does the Indus-Yarlung Tsangpo Suture Zone reappear along the Mt. Victoria Belt?

Knowledge of the suturing of Myanmar is critical to develop a tectonic model. Hutchison (1975) considered three belts of ophiolites within Myanmar, the Western, Central and Eastern belts, while others recognise two belts (Mitchell, 1993; Mitchell et al., 2010; Acharyya, 2007; Liu et al., 2016), i.e., the Western and Eastern belts. Of particular interest here are the Western Belt ophiolites (the Kalemio ophiolites) that crop out at the eastern margin of the IBR. These ophiolites formed during the Early Cretaceous according to U-Pb zircon dating of two rodingites (Liu et al., 2016a), a hornblende gabbro and a granite sample (Zhang et al., 2018). The radiolarian assemblage in the associated deep-sea sediments may

be assigned to the Middle Jurassic (Zhang et al., 2018). The evolution and tectonic significance of the various ophiolite bodies remains an ongoing source of investigation and debate.

The aim of this thesis is to build on field-based studies and to constrain the stratigraphic ages, palaeoenvironmental significance, and structural and tectonic history of the deformed rocks from western Myanmar, now exposed along the IBR, through biostratigraphic, petrographic and geochemical studies. Key questions to answer include: (1) what are the ages of ophiolites, radiolarian chert, and *mélange*?, (2) when did suturing take place?, and (3) what are the deposition ages of post-collisional sedimentation?

The overall objective of this thesis is to provide improved biostratigraphic and radiometric age constraints with which to better understand the tectonic evolution of areas presently located along the eastern margin of the Indian subcontinent. Microfossils (foraminifera and radiolarian) and detrital zircon U-Pb ages are used to determine the depositional ages of sediments. Petrographic and detrital zircon U-Pb and Hf isotope data provide insights into the provenance of sedimentary rocks of western Myanmar and thereby are used to test different paleogeographic reconstructions and tectonic models.

After a brief outline of the geology of Myanmar, this chapter presents a review of the current understanding of the stratigraphic and tectonic frameworks of the IBR, as published in the geological literature. A chapter by chapter synopsis of the thesis concludes this introduction.

1.2 Geological framework of Myanmar

SE Asia comprises an amalgamation of terranes or blocks (e.g. Indochina, Sibumasu and West Myanmar terranes), see Fig. 1.4, derived ultimately from the Gondwana super-continent by rifting events during the Late Palaeozoic and Mesozoic (e.g. Metcalfe, 1988; Hutchison, 1989; Metcalfe, 1996, 2011, 2013a). Separation and northwards migration of the

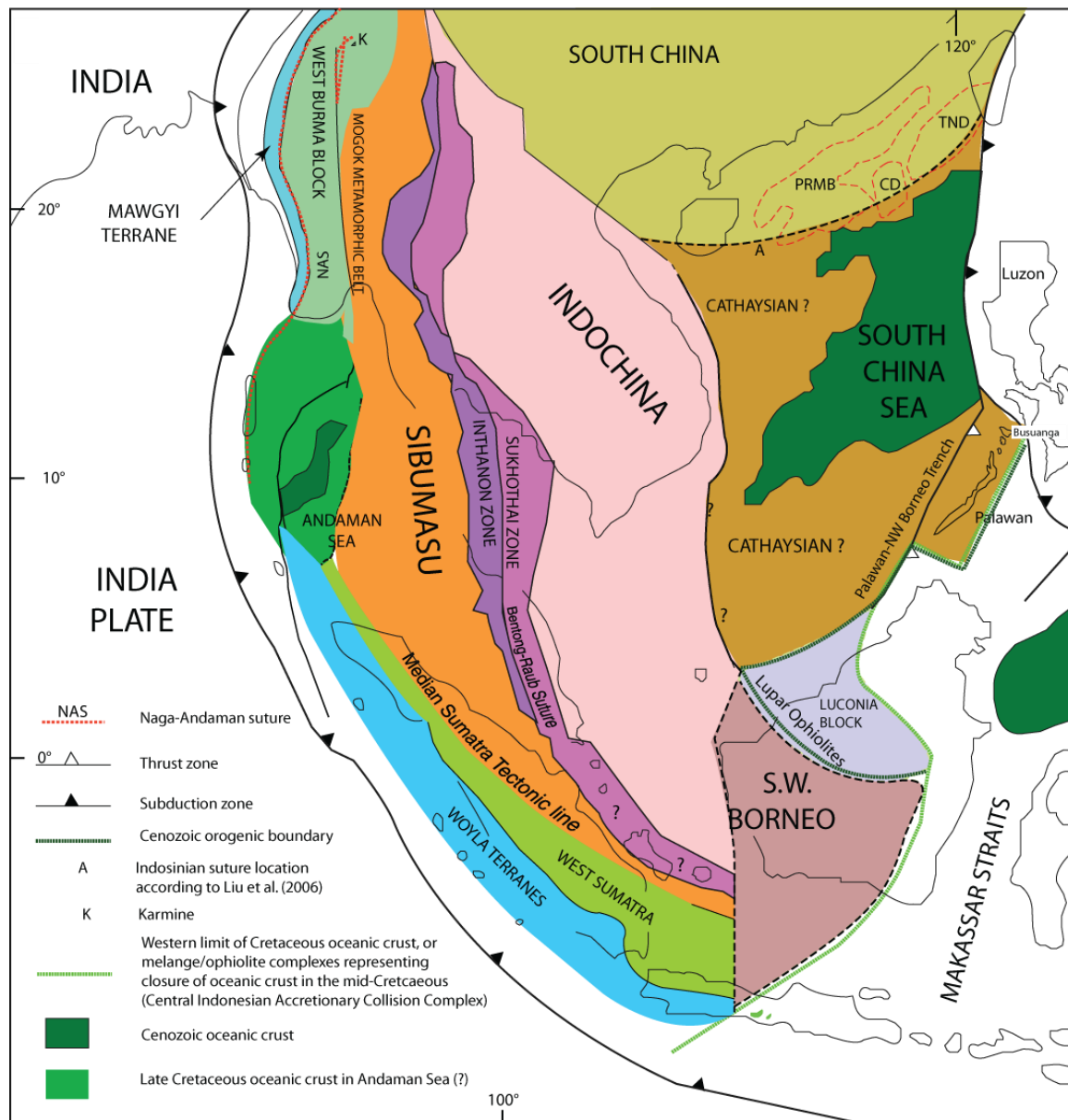


Fig. 1.4: Map of the major terranes in SE Asia (Morley, 2012).

continental fragments from Gondwana led to the opening of three intervening Tethyan oceans, the Palaeo-Tethys (Devonian-Triassic), Meso-Tethys (late Early Permian-Late Cretaceous) and Neo-Tethys (Late Triassic-Late Cretaceous), (Metcalf, 1996, 2013). Remnants of these ancient oceans are preserved in the various narrow suture zones and fold-thrust belts bounding the continental blocks (Metcalf, 2013). Suturing events occurred during closing of the multiple Tethyan Oceans with progressively younger continental collisions and associated suture zones from east to west in Sundaland (the continental core of SE Asia) (reviews in Hall, 2012; Metcalf, 2013). Geographically, Sundaland comprises the Malay Peninsula, Sumatra, Java, Borneo and Palawan and is located at the zone of convergence between the Indian-Australian, Philippine and Eurasian Plates (Metcalf, 2011). These Tethyan-related sutures extend further north along the main India-Asian collision zone where the stratigraphy, structure and metamorphic-magmatic evolution of the Himalaya is reasonably well constrained (reviews by Hodges, 2000; Yin and Harrison, 2000; Searle et al., 2010b). The Tethyan suture zones of the Himalaya and Tibet are thought to continue around the East Himalayan syntaxis into Myanmar.

The major tectonic units of SE Asia are the Indochina block and Sibumasu block. Sibumasu is a continental sliver that underlies much of eastern and central Myanmar. It occupies the eastern half and was derived from Australia in the late Early Permian. It is now accepted that Sibumasu formed part of SE Asia by the Triassic after collision with the Sukhothai Arc and the Cathaysian Indochina-East Malaya Block (Sone and Metcalf, 2008; Barber and Crow, 2009; Sevastjanova et al., 2011; Metcalf, 2013). The Indochina block was accreted onto the South China Terrane during the Triassic Indosinian Orogeny (Searle and Morley, 2011). The recent geological history of SE Asia is dominated by Mesozoic-

Cenozoic subduction and accretion of several continental micro-plates and island arc terranes that rifted off from Gondwana in the south, migrated north and eventually sutured onto the South China Craton. Most plate reconstruction models of Asia (e.g. Hall, 2012; Morley, 2012; Zahirovic et al., 2014) are focused on the India-Eurasia collision, and, to a lesser extent, on SE Asia. There are strength and weakness to all the models regarding the magnitude of the effect of escape tectonics on SE Asia.

Myanmar, the second largest country (676,577 km²) in Southeast Asia, is located between India, China, Thailand and Bangladesh. It has one of the most diverse collections of natural resources in Southeast Asia ranging from metallic mineral deposits, to gemstones and hydrocarbons. Many of these deposits are inferred to be directly tied to plate-margin processes, and largely reflect a geological history stretching from the Precambrian to the Miocene. The geology of Myanmar has been affected by two major Tethyan plate collisions, related to the closure of the Palaeo-Tethys and the Neo-Tethys Oceans. The closure of the Palaeo-Tethys Ocean during the Triassic and the concomitant collision of Sibumasu (Shan-Thai terrane) with Indochina terrane resulted in active magmatism (Metcalf, 2000). Some workers have postulated the existence of a suture zone sited between the Slate Belt and the Shan Plateau sequences called the Paunglaung –Mawchi Zone that is part of a Medial Suture Zone within Sibumasu (e.g. Mitchell et al., 2012, 2015; Ridd, 2015, 2017), see Fig. 1.1. The suture is proposed by Mitchell et al. (2012) to have developed as a consequence of closure of the Meso-Tethys in the Late Jurassic. However, the suture zone does not include ophiolites or deep-sea sediments, such as radiolarian cherts. The closure of the Neo-Tethys Ocean and the collision of India with Sibumasu during the Eocene along the main convergent margin, resulted in subsequent crustal thickening and regional metamorphism

(Mitchell, 1993; Sone & Metcalfe, 2008; Metcalfe, 2011; Searle & Morley, 2011; Morley, 2012; Gardiner et al., 2016; Searle et al., 2017).

Myanmar, lying east of the Indian plate has rotated clockwise by about 90° during the northward indentation (~15cm/yr) of India into Asia since collision at 50 Ma (Sloan et al., 2017). At present, Myanmar lies in a transitional location between the India-Asia Plate collision zone along the Himalaya in the north and the Sunda Arc (Sumatra-Java subduction zone) in the south, where the Indian Oceanic Plate is at present subducting northward beneath the Sunda Arc (e.g. Curray et al., 1979; Mitchell 1993; Acharyya, 1998). During the collision of India with Sibumasu (Asia) in the Eocene, the eastern margin of India was brushing the western margin of Sundaland (Bertrand and Rangin 2003). Geodetic measurements show that the northwards motion of the Indian Plate relative to the Sundaland is 3-4 cm/year at the latitude of Myanmar (Socquet et al., 2006; Wang et al., 2014; Sloan et al., 2017). The oblique nature of the collision is reflected in a number of significant regional strike-slip faults that developed in Myanmar (Fig. 1.5) and the Andaman Sea during the Palaeogene and Neogene (Morley & Searle 2017).

In Myanmar, active tectonics is dominated by major strike-slip faulting along the right-lateral Sagaing Fault and other strike-slip faults to the west (Maurin & Rangin, 2009; Sloan et al., 2017). The related structural complexity is supposedly widespread as a result of the India-Asia collision. From GPS data the Sagaing Fault accommodates more than half of the right-lateral motion between Sundaland and the eastern margin of India (e.g. Vigny et al., 2003; Nielsen et al., 2004; Socquet et al., 2006). The Sagaing Fault links major thrust systems in the north near the Eastern Himalayan Syntaxis, and extends to the NE Andaman

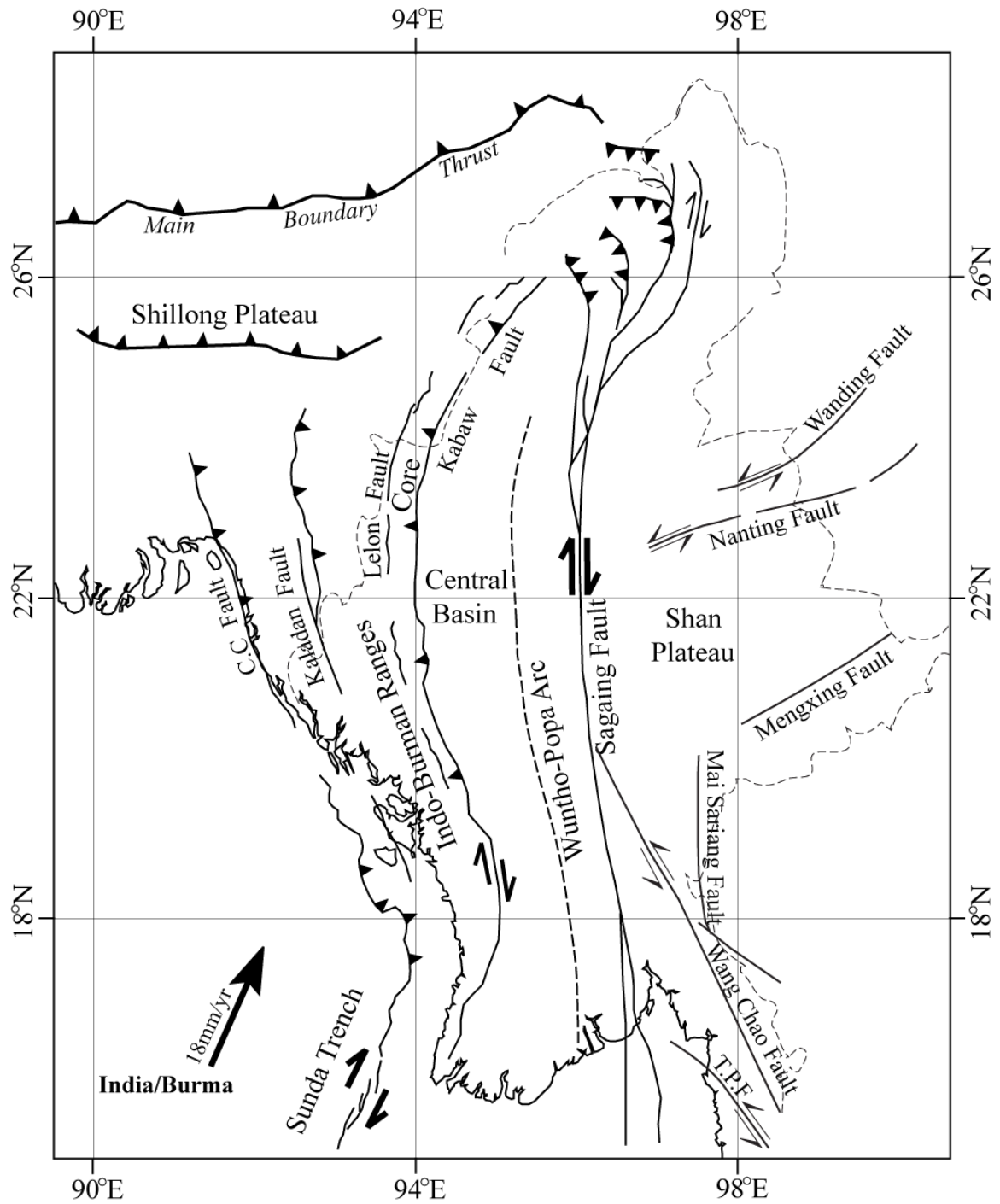


Fig. 1.5: General structural map of the Myanmar, modified after Searle et al. (2007) and Maurin and Rangin (2009). T.P.F, Three Pagodas Fault.

Sea in the south, where it eventually connects to the present-day back-arc spreading centre (e.g. Win Swe, 1972; Curray, 2005; Morley, 2012). The relative movement on the Sagaing Fault has been measured by using GPS to indicate a rather constant 1.8 cm/year of strike-slip component (Maurin et al., 2010; Socquet et al., 2006). The present-day plate boundary is the Sumatra-Andaman Trench west of the Andaman Islands and the plate appears to pass into more dextral strike-slip dominated deformation, passing northwards into the western part of the Indo-Burman Ranges (Rangin et al., 2013). This was probably the result of oblique subduction of the Indo-Australian Plate beneath Sundaland. The terrane bounded by this plate margin to the west and the active Sagaing Fault to the east has been termed the ‘Burma Platelet’ (Rangin, 2017). The Burma Platelet acts as a buffer zone, between the two major plates: the Sundaland in the east and the Indian Plate in the west. The southern boundary of the Burma Platelet is in the Andaman Sea where a rifting and seafloor-spreading zone exposes oceanic crust of Pliocene-Recent (Curray, 2005), or Miocene age (Morley and Alvey, 2015). In contrast, Rangin (2017) suggested there may be no oceanic crust in the Andaman Sea. The deformation of the Burma Platelet is rather complex and there is considerable uncertainty about the extent of oceanic crust in the Andaman Sea.

1.3 Geological provinces of Myanmar

Myanmar can be divided into three broadly north-south trending major geological provinces (Fig.1.1). From east to west these are: (1) Shan Plateau and the Shan Scarps Area, (2) Western Myanmar (including Central Basin and Wuntho-Popa Arc) and (3) the Kalembo suture zone and Indo-Burman Ranges. These lie on two basement blocks; Sibumasu and West Burma plate (United Nations, 1979; Mitchell, 1993; Pivnik et al., 1998; Mitchell et al., 2012; Metcalfe, 2013), and as proposed in this thesis, the IBR west of the Kalembo

suture may be part of the Indian plate. These provinces are reflections of the underlying stratigraphy and structures in that each contains lithologically and structurally related rock units.

The Shan Plateau (SP) is part of the Sibumasu block, and lies in eastern Myanmar. It consists of a distinct Palaeozoic stratigraphic succession, unconformably overlain by the Carboniferous - Lower Permian Mergui Group comprising glacial diamictites ('pebbly mudstones' of Mitchell 1989). Both these units are unconformably overlain by thick Middle-Upper Permian limestones, variously termed the Plateau Limestone (Thura Oo et al., 2002; Mitchell et al., 2004) or Moulmein Limestone (Brunnschweiler, 1974). The Permian in turn is overlain by deformed Upper Triassic to Lower Jurassic turbidites and mudstones, Middle Jurassic limestones and shales, and younger Mesozoic continental strata (Mitchell et al., 2012). Middle-Upper Permian limestones may represent the protolith for the high-grade Mogok Metamorphic Belt (MMB) marbles (Searle et al., 2017). The Shan Scarps area forms a narrow zone, east of the Sagaing Fault. This area is interpreted as a fold-and-thrust belt (Barley et al., 2003; Bertrand & Rangin, 2003) and it can be further subdivided into the Paunglaung-Mawchi Zone (PMZ), the Slate Belt and the Mogok Metamorphic Belt (MMB). The PMZ is composed of folded Upper Jurassic to Early Cretaceous turbidites associated with Permian-Triassic limestones and igneous rocks. The Slate Belt has a distinct Late Palaeozoic succession of low-grade metasedimentary units; glacial marine pebbly mudstones and wackes with occasional limestones. The Lower Permian diamictite-bearing units have been described as mass-flow deposits, similar to those in Thailand, Malaysia and NE Sumatra (Metcalf, 1996; Barber and Crow, 2009; Ridd and Watkinson, 2013, Ridd, 2016; Ridd, 2017), collectively defined as the Mergui Group

(Mitchell, 1992). The MMB is composed of mainly high-grade metamorphic rocks (that host some of the world's finest rubies and sapphires) and granites. It is a north-south aligned belt that extends the whole length of Myanmar along the western margin of the Sibumasu block from the Andaman Sea to the EHS (Searle et al., 2017). The MMB and the Mergui Slate Belt together lie to the west of the Shan Scarps and the PMZ, interpreted by Mitchell et al., (2012) as a possible suture zone. Gardiner et al., (2016) and Searle et al., (2017), refer to this entire zone of metamorphic rocks comprising MMB, plus the Slate Belt and pre-collisional granites east of the Sagaing Fault and west of the PMZ, as the Mogok-Mandalay-Mergui Belt (MMMB).

Western Myanmar includes the Central Myanmar Basin (CMB)/Central Basin (CB) and Wuntho-Popa Arc (Mitchell et al., 2010, 2012). The general stratigraphic units of the IBR, CB and SP shown in Fig. 1.6. The CB lies between the Sagaing Fault and the IBR and extends southward in the Andaman Sea. The CB is classically considered as a series of fore-arc/back-arc basins related to Cretaceous subduction in the Bay of Bengal (Pivnik et al., 1998; Rangin et al., 1999), that are filled with Late Cretaceous to Recent sediments reaching a thickness of at least 15 km (Pivnik et al., 1998; Ridd & Racey, 2015). Deposition was in both marine and non-marine environments. The basin has simple broad synformal geometries, affected by an active tectonic inversion (Pivnik et al., 1998) that started during the Miocene (Bertrand & Rangin, 2003). This basin is bounded by two major right-lateral strike-slip faults, the Kabaw Fault along the west and the Sagaing Fault along the eastern margin. A series of calc-alkaline andesite-dacite strato-volcanoes (e.g Mt Popa, Taung Thonlon, Mt Loimue) define the Wuntho-Popa Arc (WPA), that runs north-south through central Myanmar. The WPA is a continental magmatic arc (Mitchell and McKerrow, 1975;

System	Epoch		Indo-Burman Ranges				Central Myanmar Basin		Shan Plateau	
			Rakhine Coast	Rakhine Yoma	Western Belt	Eastern Belt	Minbu Basin	Chindwin Basin		
NEOGENE	Pliocene		Leikkamaw Fm.	Molasse	molasse in the northern Chin Hills	metamorphic event (Socquet et al. 2002)	Irrawaddy Fm.	Irrawaddy Fm.	Aungban Sediments	
	Miocene	L	Yenandaung Fm.				Obogon Fm. Kyaukok Fm. Pyabwe Fm.	Shwetamin Fm. Natma Fm.		
		M	Sane Fm.							
		E	Nga Ok Congl.							
	Oligocene	L	Kalangan Fm.				Okhmintaung Fm. Padaung Fm. Shwezeta Fm.	Letkat Fm.		
		M	Yechangi Fm.							
		E								
PALEOGENE	Eocene	L	Kalaba Fm. (Konbwe Shale)	Modi Taung Unit	Kennedy Peak Fm.		Yaw Fm.	Yaw Fm.	Kalaw Red Beds	
		M	Ngapali Fm.	Central Range Unit (United Nations 1979)			Pondaung Fm. Tabyin Fm. Tilin Fm.	Pondaung Fm. Tabyin Fm. Tilin Fm.		
		E	Kyaukkale Fm.				Laungshe Fm.	Laungshe Fm.		
	Paleocene				Chunsung Fm.		Paunggyi Fm.	Paunggyi Fm.		
					Falam Fm.		Kabaw Fm.	Kabaw Fm.		
CRETACEOUS	Maastrichtian	L	Kyauknimaw Fm.	Olistostromes		(Liu et al., 2016; Zhang et al., 2017)	hiatus ?		Legya Limestone	
	Campanian		?				hiatus ?			
	Santonian									
	Coniacian									
	Turonian									
	Cenomanian	E	?		Paung Chaung limestone (Gramann, 1974; UN, 1979a; Sevastjanova et al., 2015)	hiatus ?				
	Albian									
	Aptian									
	Barremian									
	Hauterivian									
	Valanginian									
Berriasian										
JURASSIC	L	ophiolitic seafloor			Pane Chaung Group	(Gondwana metamorphic?) ophiolitic seafloor	Loi-an Group Shweminbon Fm.			
	M									
	E									
TRIASSIC	L								Plateau Limestone Group	
	M									
	E									
PERMIAN										
CARBONIFEROUS										Taungnyo Group
DEVONIAN	L									Maymyo Fm. Zebingyi Fm.
	M									
	E									
SILURIAN	L						Namhsim Fm. Linwe Fm.			
	M									
	E									
ORDOVICIAN	L						Nan On Fm. Wunbye Fm. Lokepyin Fm.			
	M									
	E									
CAMBRIAN	L						Molohein Group			
	E									
PRE-CAMBRIAN							Chaungmagyi Group Mogok Metamorphics			

Fig. 1.6: General stratigraphic units of the Indo-Burman Ranges, Central Myanmar Basin and Shan Plateau in Myanmar (after Bannert et al., 2011; Mitchell, 2017).

United Nations, 1978b; Advokaat et al., 2018) and exhibits important Mesozoic plutonism and two much more recent phases of volcanic activity (Eocene and Neogene-Present). It comprises major Cretaceous - Eocene granodiorite intrusions with associated volcanic rocks, and middle Miocene rhyolites and dacites (Mitchell and McKerrow, 1975; Barley et al., 2003; Mitchell et al., 2012), overlain by Quaternary basaltic andesites and pyroclastic flows (Maury et al., 2004; Lee et al., 2010), principally outcropping in Mt. Popa and outliers to the south. This subduction-related volcanism is interpreted to have formed in an Andean-type tectonic setting during the Late Cretaceous-Eocene (Gardiner et al., 2015), as a consequence of slab detachment (Maury et al., 2004). Pliocene to active calc-alkaline volcanoes above the Burma Seismic Zone suggests that they were derived from melting above a subduction slab of oceanic lithosphere (Stephenson & Marshall, 1984; Maury et al., 2004). There are three metamorphic complexes splayed off the northern end of the Sagaing Fault in Myanmar, some considered to be ophiolitic in origin: the Jade Mines Belt (JMB), the Katha Gangaw Belt (KGB), and the Tagaung-Myitkyina Belt (TMB), (Mitchell et al., 2004; Searle et al., 2007, 2017). The JMB has experienced high-pressure subduction-related metamorphism and includes mantle-derived harzburgites and lherzolites associated with jadeitite assemblages, and with rare blueschists and eclogites (Searle et al., 2017). Originally thought to be Late Cretaceous-Eocene in age, the JMB is now thought to be Middle Jurassic age from recent U-Pb zircon dating (Qui et al., 2009), although the validity of a U-Pb zircon age from a peridotite has been questioned. The KGB is mainly composed of metamorphic rocks, such as quartzites, kyanite schists, and quartz mica-garnet schists (Mitchell et al., 2007), and the links north towards the Eastern Himalayan Syntaxis (EHS) although the connection remains tenuous. The TMB comprises low-grade metamorphosed basic and

ultrabasic rocks, such as chlorite and talc schists, locally associated with Upper Triassic turbidites, serpentinized harzburgites, basalts and cherts (Searle et al., 2007). The ophiolites are Jurassic-Cretaceous in age (e.g. Maung Maung et al., 2008), and commonly occur as inliers within late Cenozoic sediments and alluvium.

To the west of the Central Basin, the Kalemio suture zone and the IBR composed of schists, pillow lavas, ultramafic rocks and Triassic to Eocene sedimentary rocks. As the main focus of this thesis, the IBR is described in more detail in Section 1.4.

1.4 Geological setting of Indo-Burman Ranges (IBR)

The Indo-Burma Range (IBR) is a N-S trending, approximately 1250 km long arc-shaped structure. It merges with the Eastern Himalayan Syntaxis further north, and connects southward with the Andaman Sea, resurfacing in the Andaman Islands. The IBR sits at the convergent boundary of the India and Burma Platelet in Myanmar. It lies on the east of the subduction zone that extends from the collisional Himalaya in the north to the subduction-related Andaman-Indonesian island arc in the south (Acharyya et al., 1990, Ghose et al., 2010). The IBR is flanked to the east by the CMB and to the west by the Bengal Basin. Early work interpreted the west-verging IBR sediments as an accretionary prism of oceanic material that were accreted during the subduction of the Indian Plate beneath the Eurasian Plate and postulated to be sourced by the emerging Himalaya to the north (Curry et al., 1979; Bender 1983; Hutchison, 1989; Curry, 2005). Recent provenance studies contend this view and infer a much more complex tectonic setting for IBR. An alternative view of the IBR is that the main India-Asia suture zone runs along a discontinuous belt of ophiolites including the Naga Hills in India (e.g. Acharyya, 2007; Singh, 2013; Ghose et al., 2014);

and the Kalemio ophiolites in the IBR (Liu et al., 2016). The geology of western Myanmar is the consequence of a complex oblique collision of India with Sibumasu (Asia) during the Eocene and the closure of Neotethys (Mitchell, 1993; Metcalfe, 2011; Searle & Morley, 2011; Morley, 2012; Gardiner et al., 2015; Gardiner et al., 2016, Searle et al., 2017). Prior to the closing of Neo-Tethys and the India-Asia collision, early ophiolite obduction was followed by collision-related thrusting, folding and metamorphism along both the Asian plate and Indian plate. The IBR represents the folded and thrust margin of the Indian plate interpreted as the southward extension of the Himalaya, rotated clockwise as a result of the northward indentation of the Indian plate and shortened by transpression during the Neogene (Rangin, 2017; Sloan et al., 2017). Zhang et al., (2018) interpreted western Myanmar as an accretionary margin that progressively grew westwards from the Jurassic to the Present, there is still much debate about the tectonic boundaries, the age of plate convergence and associated subducting polarities of the IBR. A prominent narrow zone of deep earthquakes (Burma seismic zone) beneath the central IBR is interpreted as an active subduction zone beneath the Pliocene - recent calc-alkali volcanoes such as Mount Popa. To the south of the region, the IBR passes into the Sumatra-Andaman Trench, indicating relatively more orthogonal plate motions to the south.

The IBR is divided geographically into three main areas: northern Naga Hills, Central Chin Hills, and southern Rakhine Yoma. It is divisible into the eastern and western belts, based on rock assemblages (Brunnschweiler, 1966; United Nations, 1979a). The eastern belt, mainly consisting of shallow-marine to terrestrial sandstones and shales of Cretaceous - Palaeogene age, is exposed in the Rakhine Yoma, Naga and Chin Hills (Bannert et al., 2011). Graphite-biotite schists (Kanpetlet Schist), folded into a dome, are overthrust by

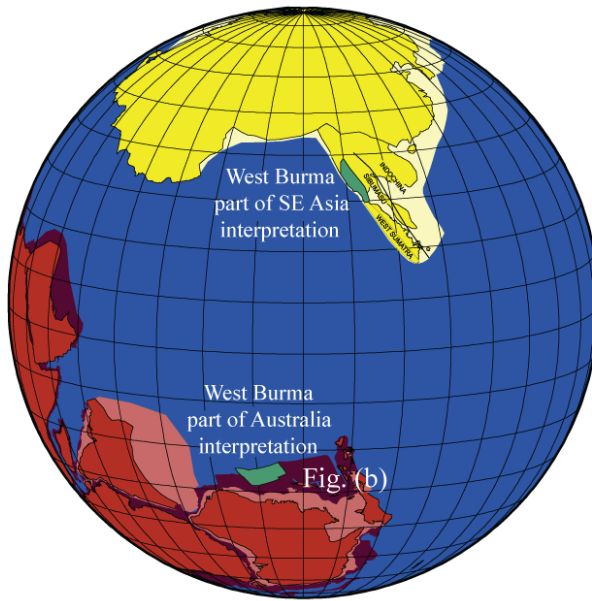
highly deformed Triassic flysch and discontinuous outcrops of ophiolite (Mitchell, 1993; Acharyya, 2007) exposed along the eastern belt. Schist and gneisses referred to as the Naga Metamorphic Complex are present in the Naga Hills, which are overthrust from the east and form the highest structural unit (Acharyya, 2007). The western belt, locally up to 200 km wide (Acharyya, 2007), is composed of Eocene to Recent deepwater to shelfal-marine shales, sandstones and conglomerates (Chhibber, 1934; Mitchell, 1993). Cretaceous limestone blocks, volcanics and other lithologies occur occasionally in mélanges throughout the IBR (Brunnschweiler, 1966; Bender, 1983). In the southern Rakhine Yoma and coastal area, the Eocene turbidites are overlain unconformably by Miocene sediments, and ophiolites occur together with exotic blocks of chert and limestone. Small basaltic plugs and numerous mud volcanoes formed by natural gas seeps occur along the Rakhine coastal areas and offshore islands. Many of these mélange deposits in the IBR are the product of mud diapirism which is still active today (Mitchell, 1993; Barber, 2013).

The geological, structural and deformation features of the region are strongly influenced by proximity to plate margins and the pre-existing tectonic history. The detail geology of the IBR is poorly known, and the only existing data include rough maps, scarce structural and lithologic descriptions and rare isotopic age data. Interpretation of the geology of the IBR is hindered by isotopic age constraints (e.g. Allen et al., 2008; Naing et al., 2014; Sevastjanova et al., 2015), limited biostratigraphy (e.g. Nagappa, 1959; Gramann, 1974) and poor outcrop exposure. The evolutionary history of the West Burma Block and the nature of the basement in western Myanmar are both topics that are actively debated (e.g. Mitchell, 1992; Barber and Crow, 2005; Hall, 2012; Morley, 2012; Metcalfe 1996, 2011; 2013). Several palaeogeographic reconstruction models have been proposed for the West

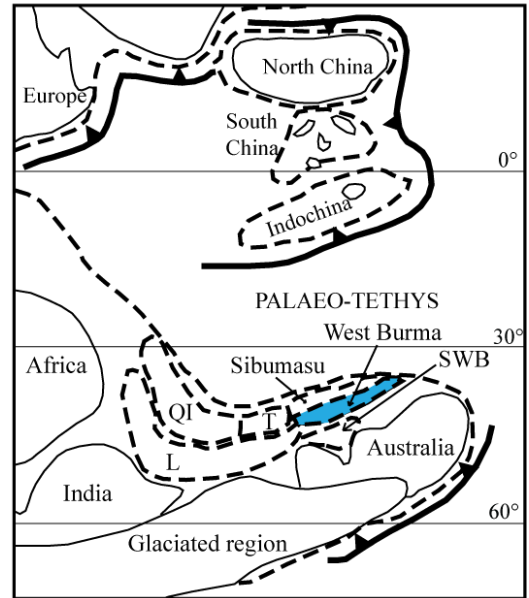
Burma Block, which can be summarized in two groups. One view is that the West Burma Block was part of SE Asia by the Early Mesozoic (e.g. Hutchison, 1989; Mitchell, 1992; Barber and Crow, 2005, 2009; Metcalfe, 2011; Hall, 2012; Morley, 2012). This implies that the West Burma Block was part of the Gondwanan Sibumasu or the Cathaysian West Sumatra Block (Barber and Crow, 2005). An alternative view is that the West Burma Block is a product of Jurassic rifting from Western Australia and that it collided with SE Asia in the Cretaceous (Veevers, 1988; Metcalfe, 1990). Rangin et al., (2013) interpreted the Mt. Victoria Belt as evidence for a continental fragment underlying the IBR (Mt. Victoria-Burma microcontinent), in which case the IBR is underlain by a fragment of continental crust of India Plate affinity. More constraints have recently been added to the origin of this western terrane by detrital zircon U-Pb analysis of rocks from the Mt. Victoria area. Sevastjanova et al. (2015) suggested West Burma was part of the Sibumasu (Fig. 1.7a) and the Mt. Victoria area lay between Sibumasu and Western Australia. Morley & Searle, (2017) interpreted an arrangement of continental blocks that is consistent with the results obtained by Sevastjanova et al. (2015), (Fig. 1.7b). This implies that West Burma was part of SE Asia before the Mesozoic and suggests it was not of Cathaysian or Indian Plate origin, and hence argues against the models (Fig. 1.7c,d) of various authors (e.g. Barber & Crow, 2009; Metcalfe, 2013; Rangin et al., 2013). Nonetheless, the evidence for the crust type under the IBR remains uncertain and the original position of West Burma in Gondwana and the time of its accretion to SE Asia are still matters of controversy (Wang et al., 2016; Yao et al., 2017).

During the present study, detailed geological mapping concentrating on the Rakhine, Mt. Victoria and Kalembo areas of the IBR has been carried out in order to unravel some

(a) Early Jurassic (190 Ma)



(b) Early Permian (~295 Ma)



(c) Late Triassic (202 Ma)



(d) Early Permian (290 Ma)

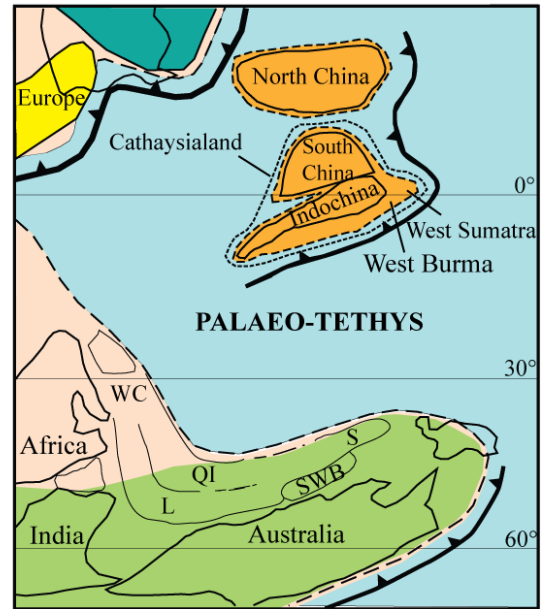


Fig. 1.7: Early Permian-Early Jurassic palaeogeographic reconstruction showing locations of key blocks. (a) Sevastjanova et al. (2015), (b) Morley & Searle (2017), (c,d) Metcalfe (2013), and. L, Lhasa Block; S, Sibumasu terrane; QI, Qiangtang Block; WC, Western Cimmerian Continent; T, Tenchong; SWB, SW Borneo Block; WS, West Sumatra Block; SG, Songpan Ganiz; NC, North China; SC, South China; I, Indochina; EJ-WS, East Java-West Sulawesi; EM, East Malaya Block.

of the structural complexity of the IBR and hence provide a greater insight into the processes involved with subduction and exhumation. The thesis also discusses the deformation and depositional history through the Mesozoic to Cenozoic, focusing on the flysch and deep-sea pelagic sediments associated with the ophiolites with the aim to better elucidate the tectonic history of the IBR and its relation to the closure of Neo-Tethys Ocean.

1.5 Thesis Outline

Chapter 2 (page 26) outlines the sample preparation and analytical methods used in this thesis.

Chapter 3 (page 44) presents the results of fieldwork, along east-west transects of the Rakhine Yoma to coastal area, focusing on the depositional, deformational, detrital zircon U-Pb geochronology and Hf isotope analysis, and stable isotope signatures of this region. This chapter presents $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ results of exotic limestones and new U-Pb zircon ages of sandstones, petrographic description of sandstones and limestones, integrated biostratigraphy and an updated geological map of the region, and discusses the new ages with respect to previously published data.

Chapter 4 (page 119) is based on fieldwork in the Mt. Victoria area and focuses on the depositional and complex tectonic history, to demonstrate the processes of accretion, wedge extrusion and obduction of ophiolites. This chapter presents petrographic descriptions of sandstones, low-grade metamorphic schists and ophiolites, detrital zircon U-Pb ages of sandstones and an integrated structural interpretation of the region, and discusses these new ages in relation to previously published U-Pb data.

Chapter 5 (page 167) is based on field investigation in the Kalembo area and focuses on a new interpretation on the structural evolution, and a reconstruction of the complete

sequence of subduction-accretion events in western Myanmar. This chapter presents petrological and geochemical compositions of the mantle peridotites, observations on the nature of contacts and deformation of ophiolites, petrographic description of sandstone and limestones, biostratigraphy, detrital zircon U-Pb ages and Hf isotopic data of sandstones, and discusses the tectonic settings of the region and these new ages in relation to previously published U-Pb data.

Chapter 6 (page 233) ties together the main findings of Chapters 3 through 5 and presents a detailed discussion constraining the provenance and depositional processes of the IBR, the tectonic implications for the evolution of the IBR, and a synthesis of the geological evolution of Myanmar.

Chapter 7 (page 271) attempts to summarise the conclusions made in previous chapters that outline the main results, interpretations, and implications for timing of the tectonic evolution of the IBR. A brief outline of further work leading on from this project follows.

CHAPTER

TWO

**MATERIALS, SAMPLE PREPARATIONS AND
ANALYTICAL METHODS**

2.1 Introduction

Independent fieldwork was conducted to sample many of the Triassic-Eocene exposure sites in both the Indo-Burman Ranges and Central Basin, Myanmar. Representative samples of the various lithologies encountered during fieldwork (e.g. sandstones, limestones, shales, cherts, ultramafic and metamorphic rocks) were collected from the three different locations (Rakhine, Mt. Victoria and Kalemmyo areas) of the Indo-Burman Ranges and two sub-basins (Minbu and Chindwin) of the Central Basin (Fig. 2.1). In the Rakhine area, samples were collected along the Padaung-Taungup and Gwa road sections and Rakhine coastal area (see Fig. 3.2, 3.3, 3.5). In the Mt. Victoria area, sample collection was carried out along the Saw to Mt. Victoria road, the main Mindat-Kyaukhtu road, the Mindat-Kanpetlet road, and the Saw River (see Fig. 4.1). In the Kalemmyo area, sample collection was carried out along the Kalemmyo-Falam-Kennedy Peak road, Wabula-Taung-Falam road, and Kalemmyo-Kalewa road (see Fig. 5.1). The Rakhine area is introduced in detail in Chapter 3, Mt. Victoria area in Chapter 4, and Kalemmyo area in Chapter 5.

Fundamental challenges to understanding the IBR include: historically highly limited access by roads and trails, limited exposures in high relief terrain covered by jungle, highly complex structure, highly monotonous flysch units with a wide age-range (Triassic-Paleogene) and limited biostratigraphic control.

2.2 Sampling strategy

Rock samples used in this study were collected during 2016, 2017 and 2018. In the field it can be difficult to find clear outcrop contacts between the Triassic Pane Chaung Formation and lithologically similar Upper Mesozoic and Cenozoic strata. Source

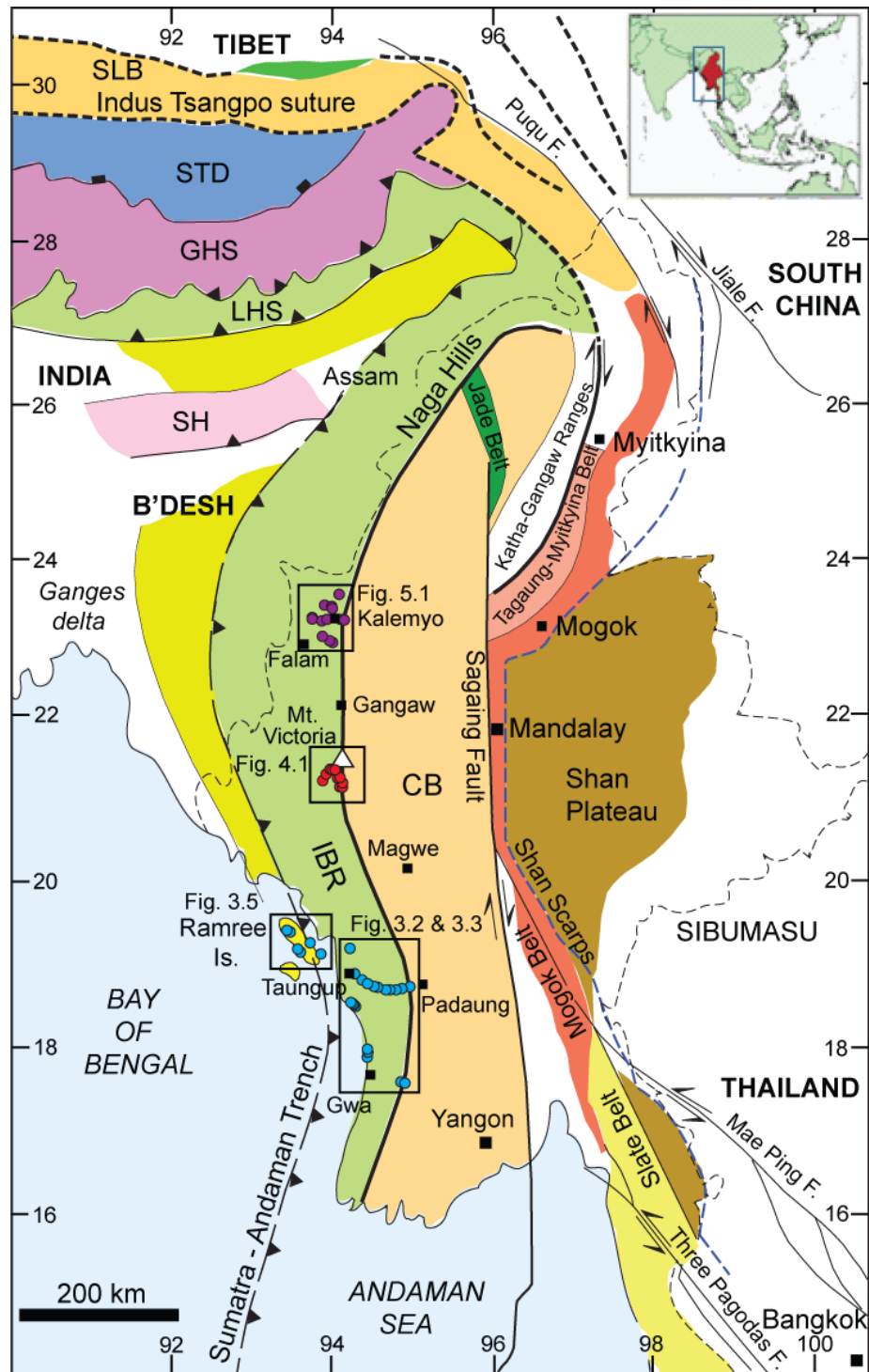


Fig. 2.1: The main structural belts of Myanmar, dots show sample locations and squares show study areas. For simplicity, the sample numbers are omitted from all samples on the map. IBR, Indo-Burman Ranges, CB, Central Basin.

lithologies were characterised based on the published literature, and using the geological map contacts (United Nations, 1979a; Mitchell, 1993; Mitchell et al., 2010; Bannert et al., 2011). Road building has created new outcrop sections, and some excellent river sections exist. New structural observations were made during fieldwork over three field seasons in the Kanpetlet-Mindat area, Kalemmyo area and Rakhine area.

Among the collected samples, I have analysed a total of 108 samples (Table. 2.1). Of these, 100 samples were collected from the Indo-Burman Ranges, and 8 from the Central Basin. To constrain the age of the succession, fourteen shale samples, four chert samples and twenty-eight limestone samples were used for biostratigraphic studies. Limestone thin sections were prepared to evaluate the distribution of the microfacies, textural features and fossil assemblages. The diagenetic environmental signatures of fourteen limestones have been studied through microfacies analysis and carbon and oxygen isotope values. Twenty sandstone samples were examined and point counted in thin sections; five of these samples were selected for XRD powder diffraction. Seventeen thin sections of mafic and ultramafic rocks were analysed for petrographic studies. Nine metamorphic samples were selected for petrographic analysis. Zircons from twenty four sandstone samples were dated using U-Pb techniques and six representative samples were selected for Hf-isotope analyses with the aim of covering all potential source areas. Source lithologies were characterised based on the published literature, and geological maps (United Nations, 1979). Sample location details are presented in Appendix 1. Details on sample preparation techniques and explanations about each analytical method are presented in the section below.

Methods	No. of analyses	Lithology	Locations	Purpose
Biostratigraphy	14	Shale (11)	Rakhine area	to determine the depositional ages of sediments
		Shale (3)	Mt. Victoria area	
	4	Chert (1)	Rakhine area	to determine the depositional ages of deep marine sediments
		Chert (3)	Kalemyo area	
Petrography	20	Sandstone (5)	Rakhine area	to produce regional-scale provenance-discriminating QFL plots
		Sandstone (5)	Mt. Victoria area	
		Sandstone (10)	Kalemyo area	
	28	Limestone (21)	Rakhine area	to identify microfacies and to evaluate the texture and depositional environment
		Limestone (2)	Mt. Victoria area	
		Limestone (5)	Kalemyo area	
	9	Schist (7)	Mt. Victoria area	to interpret type of paragenesis
		Schist (2)	Kalemyo area	
	8	Peridotite (2)	Mt. Victoria area	to discuss on the origin and tectonic settings
		Peridotite (6)	Kalemyo area	
	2	Gabbro (1)	Mt. Victoria area	
		Gabbro (1)	Kalemyo area	
	5	Basalt	Rakhine area	
	1	Serpentine	Rakhine area	
	1	Conglomerate	Kalemyo area	
Detrital zircon U-Pb analysis	24	Sandstone (9)	Rakhine area	to constrain maximum ages for sedimentary units, as well as to characterize the ages of rocks in source areas
		Sandstone (5)	Mt. Victoria area	
		Sandstone (10)	Kalemyo area	
Hf isotope analysis	6	Sandstone (2)	Rakhine area	to refine paleogeographic reconstructions
		Sandstone (4)	Kalemyo area	
Stable isotope analysis	14	Limestone	Rakhine area	to provide an isotopic record, diagenetic condition and environments
XRD	5	Sandstone (1)	Rakhine area	to determine the character of the sandstone matrix
		Sandstone (4)	Kalemyo area	

Table. 2.1: *Summary of the methods and number of analyses and samples utilized for the study.*

2.3 Methods for biostratigraphy

Given the dominantly deep-water nature of most of the Late Mesozoic and Paleogene sedimentary formations in the IBR, biostratigraphy is based primarily on pelagic organisms, in particular planktonic foraminifera, radiolaria, and calcareous nannofossils. The main objectives of the biostratigraphic studies were (1) to compare Cretaceous and Paleogene reference sections in the Rakhine area, and (2) to ascertain the biostratigraphic ages of the Mesozoic and Cenozoic formations in the IBR.

2.3.1 Sample preparation for foraminifera using freeze-thaw techniques

Green (2001) noted that repeated freeze-thaw technique will disaggregate most shales and that this method has been successful for disaggregating clay-rich sedimentary deposits for the extraction of microfossils. It has been used to disaggregate shales once crushed to 5 to 10 mm sized pieces. Each sample was saturated in cold water for 24h. After decanting off the water and placing the sample in a sealed plastic container, deionized water was added to cover the sample. The sample was then frozen in fridge for approximately 3 hours. The sample was then removed from the freezer and rapidly heated by covering it in boiling water for several minutes. After decanting off the warm water the sample was sieved through 63 μm and 500 μm sieves stacked together under a gentle water jet to extract the fraction between 63 μm and 500 μm . The freeze-thaw steps were repeated 15-20 times on each fraction until almost all the original sample was disaggregated to less than 500 μm . The fraction was dried, and foraminiferal specimens were individually handpicked and transferred to a cardboard microscope slide using a water-dampened hairline paintbrush under the light microscope.

2.3.2 Extracting radiolaria from chert samples

Chert samples were selected by examination of thin sections for the best preserved radiolarians. In thin section, the best preserved radiolarian tests should be sharply defined with respect to the matrix. Samples were prepared using standard radiolarian extraction techniques (Pessagno and Newport, 1972). Radiolarite samples were crushed to fragments <1 cm in size and suspended in a plastic mesh bags and immersed in a diluted (5%) hydrofluoric acid bath for a period of 24 hours to extract radiolaria. This was repeated, up to 5 times, to capture as many radiolarian tests as possible. The samples were then wet-sieved through 125 μm and 35 μm sieves and the residue was collected and dried. Radiolarians were individually handpicked with a fine brush under a Wild Heerbrugg M8 binocular microscope at 20x and then mounted onto a microfossil slide.

2.3.3 Sample imaging (SEM)

The scanning electron microscope (SEM) is a microscope that uses electrons instead of light to form an image, allowing a much higher resolution and depth of field. This is advantageous when identifying morphological features of microfossils and radiolaria. First, an aluminium SEM stub was covered with double-sided sticky carbon tape and then the fossils were transferred to the stub using the hairline paintbrush dampened with a mixture of water and clear glue. The stub was then covered to ensure that the fossils were not disturbed and to reduce accumulation of dust particles. The stub was coated by using a gold-palladium (AuPb) sputter coater and then it was placed in a storage box within a dehydrating chamber with desiccant material to absorb air moisture to preserve the sample before being photographed with SEM. A FEI Quanta 650 Scanning Electron Microscope (SEM) with a LINK INCA Energy 300 (EDS) system in the Department of Earth Sciences, University of

Oxford was utilized using BSE (backscattered electrons) to acquired – SEM images. More than 200 SEM images were taken.

2.3.4 Thin section imaging (Petrography)

Planktonic foraminifera were identified from limestone thin sections using Nikon Optiphot-pol polarizing microscope with Q IMAGING camera attachment. More than 400 photomicrographs were taken at the Department of Earth Sciences, University of Oxford.

2.3.5 Biostratigraphic schemes

The biostratigraphic zonation used for Cretaceous planktonic foraminifera examined in thin section was based mainly on Sliter (1989, 1992), and Silva and Sliter (1995), with some guidance from Professor Maria-Rose Petrizzo (University of Milan). The identification of nanno fossils and age assignment was provided by Professor Paul Brown (University College London). The identification of radiolarian taxa and age assignment was provided by Professor Taniel Danelian from the Université de Lille, France. In addition, radiolarian studies were also based on Baumgartner et al. (1995), and SEM images were compared with type specimens in the literature and an age range was compiled.

2.4 Methods for lithological characterization

The petrographic textures and mineral assemblages of sandstones, ultramafic and metamorphic rocks have been analysed from thin sections using Nikon Optiphot-pol polarizing microscope with Q IMAGING camera attachment, at the Department of Earth Sciences, University of Oxford.

2.4.1 Petrographic techniques & sandstone classification

Thin-section petrographic analyses were performed on sandstone following the Folk classification (Fig. 2.2a) and the Gazzi-Dickinson methods (Fig. 2.2b). These methods are widely used in sandstone petrography, because they are required for producing regional-scale provenance-discriminating QFL plots (Quartz, Feldspar, and Lithic fragments). A minimum of 500 grains (including matrix and cement) were counted per thin section and the mineralogical composition was recalculated on a matrix free basis prior to plotting the necessary components. Sandstone petrographic data are presented in Appendix 2. Mineralogical classification, framework composition, tectonic setting and provenance were plotted on standard ternary diagrams. Classification in this study places total quartz grains (including polycrystalline grains such as chert and quartzite) at the Q pole. Plagioclase and potassium feldspars are grouped together at the F pole. Rock fragments (also called lithic fragments) including sedimentary, metamorphic and igneous clasts plot at the L pole.

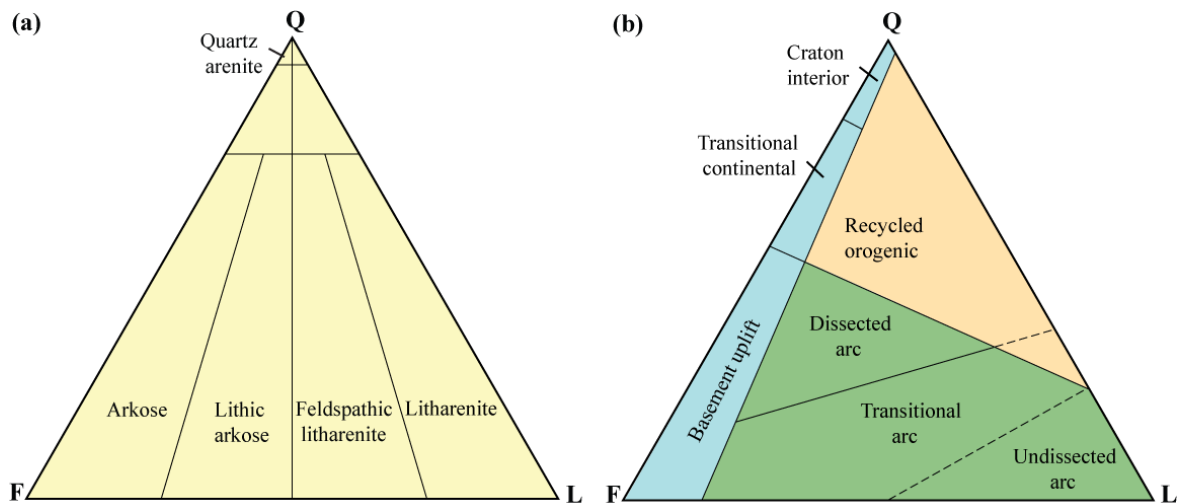


Fig. 2.2: QFL plots showing (a) sandstone classification (Folk, 1980), and (b) the relationship between detrital terrigenous sandstone compositional modes and inferred provenance types (Dickinson et al., 1983).

2.4.2 X-ray diffraction analysis

The sandstones were mainly lithofeldspathic varieties, with an argillaceous matrix and some carbonate cement. In order to determine the character of the sandstone matrix, the fine-grained component of the samples was analysed with XRD powder diffraction at the Department of Earth Sciences, University of Oxford. Samples were prepared by crushing using a Swing Mill (TEMA). Then, the XRD analyses were carried out on whole powdered samples by using PANalytical Empyrean Series 2 powder diffractometer. The samples thus obtained were top loaded into 2.5 cm diameter circular cavity holders and run on Empyrean with a θ/θ goniometer. The divergence slit was a fixed 1° , receiving slit 0.5° , and Co- $K\alpha$ radiation was selected by a diffracted beam monochromator. XRD patterns of sandstone were collected from $5-79^\circ 2\theta$, with a step size of 0.02° and counting for 2s per step, with the sample spun continuously throughout. XRD data files are presented in Appendix 3.

2.5 Stable-isotope methods

2.5.1 Sample preparation

First, a dental drill was used to gain powder for stable isotope analysis from matrix and calcite veins of limestones. Carbonate samples were weighed using a Sartorius microbalance and 150-220 μg of carbonate was loaded into 15 mL Na-glass vials and sealed with butyl rubber septa.

2.5.2 Sample analysis

The two most naturally abundant isotopes of oxygen, ^{18}O and ^{16}O , and of carbon, ^{13}C and ^{12}C , are normally used, with variations in $^{13}\text{C}/^{12}\text{C}$ and $^{18}\text{O}/^{16}\text{O}$ ratios between samples being measured by high-precision mass spectrometry. Carbon and oxygen isotopic

compositions are conventionally given in parts per thousand in δ -notation: $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$. The measurement of the $^{13}\text{C}/^{12}\text{C}$ and $^{18}\text{O}/^{16}\text{O}$ isotope ratios in carbonates is based on the CO_2 extraction techniques. CO_2 gas was extracted from powdered carbonate after reaction with orthophosphoric acid (H_3PO_4) at 90 °C, which is then sampled with a sampling loop of 100 μL and transported in a helium stream of 2 mL/min to the mass spectrometer. Carbonate samples were analysed routinely on a GasBench II continuous flow IRMS setup, with standard deviations smaller than 0.07‰ for both, $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$. A microliter pump (standard pump supplied by ThermoFinnigan) is used for acid introduction into each analytical vial. Each sample has a reaction time of ca. 1 hour, which is sufficient for biogenic and inorganically precipitated calcite, aragonite, and dolomite. Normal corrections were applied and the results are reported in the conventional delta notation as the per mil (‰) deviation relative to the Vienna Pee Dee Belemnite (VPDB) standard. The precision of the analyses was better than $\pm 0.1\text{‰}$ for $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$, based on multiple analyses of an internal laboratory standard and long-term monitoring of this standard. Carbon and oxygen isotope analyses were carried out at the Stable Isotope Laboratory of the Department of Earth Sciences, University of Oxford. Stable isotope data are presented in Appendix 4.

2.6 Detrital zircon U-Pb dating

2.6.1 Sample preparation

Rock samples were individually crushed and disaggregated using a jaw crusher at the University of Oxford and Disc Mill DM 400 at NIGL and then sieved to 355 μm . Zircon samples were prepared and analysed at the NERC Isotope Geosciences Laboratory (NIGL) in Keyworth, Nottinghamshire, UK. Disaggregated samples were individually processed on

a Rogers table and Superpanner to removed muds and to separate heavy from light sand fractions. Heavy sand fractions were oven-dried and run through a Frantz magnetic separator to remove magnetic minerals. Settings for the slope Frantz were 100 volts at 0.2 angstroms (Å), 0.5 Å and 1.7 Å (10° forward slope and 15° side slope). Final density separation of the non-magnetic heavy fraction was achieved by using methylene iodide, which separated minerals with a specific gravity greater than 3.3 g/cm³ from less dense minerals. Following heavy mineral separation zircons were picked using the denset fraction. Zircons were randomly selected and hand-picked by using a tweezer under a binocular microscope, regardless of shape, size, or color to prevent any possible biasing. There is potential for bias to be introduced during the hand-picking of zircon grains, as euhedral grains are more easily identified than rounded grains. This is mitigated by attempting to pick all the zircon grains within the field of view of the microscope. All zircon grains were picked from the sample except for those: 1) too small for the ion probe to accurately target, 2) with extensive cracks and/or inclusions, and 3) regarded as too metamict to yield meaningful results. The zircons were covered with epoxy resin and left to harden into mounts overnight. The mounts are 2.5-cm-diameter. The epoxy mount was polished with 1200 grit sandpaper and later, 2500 sandpaper to expose the interior of the zircon grains. The last and most delicate polishing process was achieved using diamond paste with grain sizes of one and six micron. Next, the mounts were photographed in reflected light. Imaging was carried out using the cathodoluminescence (CL) detector on a FEI Quanta 600 Environmental SEM equipped with a Centaurus detector. Detailed examination using CL imaging revealed strong contrasts between the core and rim of zircons from some samples (Fig.2.3d). These images were carefully examined when picking spots on each zircon grain for analysis, in

order to illuminate the internal structure of the grain prior to LA-MC-ICPMS analysis. The spots were targeted to the rims and cores of the grains with simple zonation patterns on the CL images (Fig.2.3d). It is commonly observed that regular growth zoning is interrupted by textural discontinuities along which the original zoning is resorbed and succeeded by the deposition of new-growth-zoned zircon. U-Pb ages from the rims and cores of these zircons reflect the magmatic growth and inheritance of zircon.

2.6.2 U-Pb analysis

All U-Pb dating analyses were conducted by laser ablation-multicollector-inductively coupled plasma mass spectrometry (LA-MC-ICPMS) at the NERC Isotope Geosciences Laboratory (NIGL) in Keyworth, Nottinghamshire, UK. The analyses were carried out using a solid state 193nm wavelength laser ablation system (UP193SS, New Wave Research). The laser was run at a frequency of 10 Hz with intensity of 2.01 J/cm². Grains typically were ablated with 25 µm laser spot and a 20 µm laser spot was used for finer-grained samples. Each spot analysis consisted of approximately 15s background acquisition and 30s sample data acquisition. The ablated material is carried in helium into the plasma source of a Nu HR ICPMS, which is equipped with a flight tube of sufficient width that U, Th and Pb isotopes are measured simultaneously. All masses in the range 202-207, 235 and 238 are simultaneously detected. Ion beams for ²⁰⁴(Pb & Hg), ²⁰⁶Pb and ²⁰⁷Pb were collected on ion counting detectors; all other ions were collected on analogue (Faraday) detectors. Analytical sessions were designed around the standard-sample bracketing method where primary (91500, 1062.4 ± 0.4 Ma, Wiedenbeck et al., 1995) and secondary (GJ-1, 600.4 ± 0.6 Ma, Jackson et al., 2004; Mud Tank, 732 ± 5 Ma, Black and Gulson, 1978; Plesovice, 337.13 ± 0.37 Ma, Sláma et al., 2008) zircon calibration standards were analyzed following every 20

sample zircons. The primary standard is used for correcting mass fractionation and model machine drift throughout the session, and the secondary standards are used to check the accuracy and precision of the data reduction method. It is widely known that the $^{206}\text{Pb}/^{238}\text{U}$ measurement is more precise for younger detrital zircons whereas $^{206}\text{Pb}/^{207}\text{Pb}$ provides greater precision for older zircons (Fedo et al., 2003). ^{204}Pb could not be measured for common lead correction because of interference from ^{204}Hg in the carrier gas. Raw zircon U-Pb age data were processed using Iolite software that provides the stable parts of the laser ablation signal, and makes corrections for instrumental drift, and fractionation as the laser drills deeper into the grains. The number of zircon grains that should be analysed to obtain reliable data of each sample is a topic of debate. Dodson et al., (1988) showed that 59 detrital zircons should be analysed while others prefer ~100 analyses per sample, which is statistically adequate for determining the presence of at least the main age groups (Vermeesch 2004). Individual assessments were made of each data point in relation to the grain microtexture and to other analysed spots from same grain.

U-Pb detrital zircon data are typically displayed using concordia diagrams (Fig.2.3a) to convey information about the analytical process such as accuracy and precision. The ratios of $^{206}\text{Pb}/^{238}\text{U}$ and $^{207}\text{Pb}/^{235}\text{U}$ are plotted in a concordia diagram and the intersection of each measurement with the concordia is representative of an age for the zircon. If the measurements all fall along the concordia curve then the sample is said to be concordant. A zircon plotting below the Concordia curve in a $^{206}\text{Pb}/^{238}\text{U}$ vs. $^{207}\text{Pb}/^{235}\text{U}$ diagram by more than the analytical uncertainty is said to be normally discordant. Discordant data are often the result of inheritance or Pb loss (Gehrels, 2012). Three major processes can induce normal discordance in zircon: 1) loss of radiogenic lead; 2) gain of excess uranium after

primary crystallization; or 3) incorporation of common lead (Andersen et al., 2019). My data are not common-Pb corrected because common Pb is not a big problem in zircons unless there has been weathering or hydrothermal alteration of crystals already damaged by radiation. A 10% cutoff was adopted to reject discordant data. By default, a $\pm 5\%$ discordance cut-off was used for analyses younger than 1200 Ma, and a $\pm 10\%$ discordance cut-off for analyses >1200 Ma. Populations of zircon ages are typically presented on relative age probability density plots that include information about the uncertainty envelope of each data point is summed to produce a probability curve (Fig.2.3b). These have a major problem, in the young grains, with much smaller absolute uncertainties, produce extremely pronounced peaks (e.g. if the typical uncertainty on an analysis is 2%, grains at 500 Ma will be ± 10 Ma, grains at 5 Ma will be ± 0.1 Ma). All relative age probability density plots, and weighted averages (Fig.2.3c) presented in this study were constructed by using IsoplotR (Vermeesch, 2018). Detrital zircon analyses are presented in Appendix 5.

The data point uncertainties define the MSWD (Mean Square of the Weighted Deviates) of the data relative to the weighted mean (better known as the ‘reduced chi-squared statistic’). The key target for analytical precision is to obtain an MSWD value around 1 or less for a weighted mean of a data population, indicating that the data population reflects a single discrete value (Horstwood et al., 2016). The data with low U or Pb concentration, or unstable signals resulting in high uncertainties were filtered out during processing in Iolite. The data point uncertainty therefore represents a limiting factor in the interpretation of geological age (Ludwig, 2012).

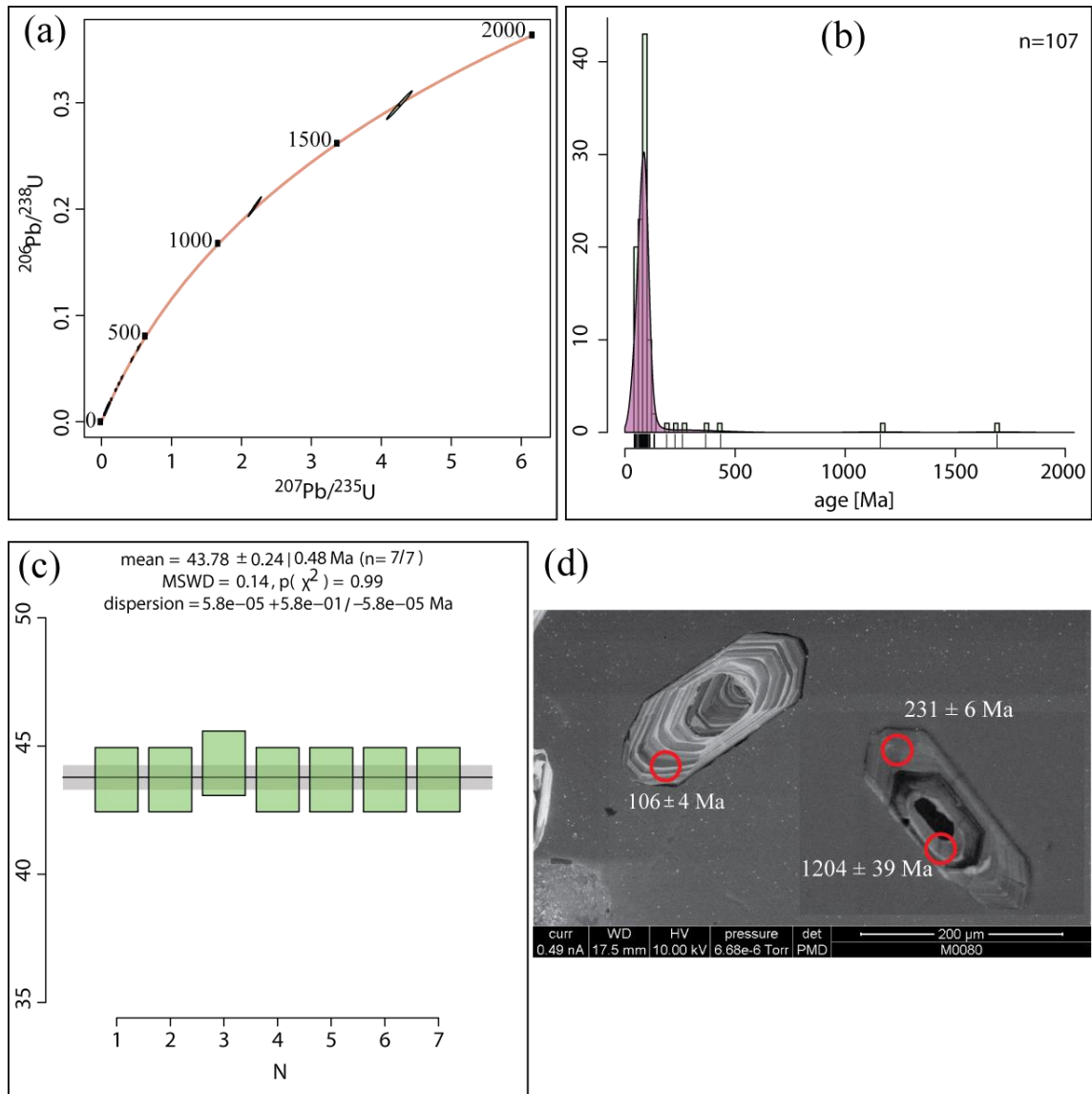


Fig. 2.3: Presentation of U-Pb zircon age data in this thesis is by: (a) U-Pb concordia diagrams, (b) probability density plot and age histograms (c) weighted mean of synthetic U-Pb data, and (d) CL images of detrital zircons.

2.7 Hf-isotopic analyses

Zircon Hf- isotopic analyses were performed at the NERC Isotope Geosciences Laboratory (NIGL) of the British Geological Survey (BGS) in Nottingham, UK. Hf isotope

analyses were carried out using a Thermo Scientific Neptune Plus MC-ICP-MS coupled to a New Wave Research UP193UC Excimer laser ablation system. Helium was used as the carrier gas through the ablation cell with Ar make-up gas being connected via a T-piece and sourced from a Cetac Aridus II desolvating nebulizer. 0.0006 l/min of nitrogen were introduced via the nebulizer in addition to Ar in order to minimize oxide formation. Lutetium (^{175}Lu), Ytterbium (^{172}Yb , ^{173}Yb), and Hafnium (^{176}Hf , ^{178}Hf , ^{179}Hf and ^{180}Hf) isotopes were measured simultaneously during static 30 second ablation analyses. The spot size used was 35 μm or 50 μm ; fluence = 7-10J/cm².

The mass spectrometer was tuned using Yb and Lu-doped JMC475 Hf reference solutions during the analytical session. Repeated analysis of the JMC475 Hf standard solution gives a mean value for $^{176}\text{Hf}/^{177}\text{Hf} = 0.282160$ (Nowell & Parrish, 2001). For all analyses, correction for ^{176}Yb on the ^{176}Hf peak was made using reverse-mass-bias correction of the $^{176}\text{Yb}/^{173}\text{Yb}$ ratio empirically derived using Hf mass bias corrected Yb-doped JMC475 solutions (Nowell & Parrish, 2001). ^{176}Lu interference on the ^{176}Hf peak was corrected by using the measured ^{175}Lu and assuming $^{176}\text{Lu}/^{175}\text{Lu} = 0.02653$.

Hf-isotope data was processed using the Iolite data reduction package (Paton et al. 2011), with background measurements of varying lengths throughout each day. Three zircon reference materials (91500, Mud Tank, Plesovice) were analysed throughout the analytical session. The 91500 zircon reference material was used as the primary standard in Iolite, and was used to normalize the $^{176}\text{Lu}/^{177}\text{Hf}$ ratio assuming a value of 0.000311 and $^{176}\text{Hf}/^{177}\text{Hf}$ value of 0.282306 ± 8 (Woodhead and Hergt, 2005). It was also used for experiments to provide a dataset for the assessment of the stability and accuracy of the $^{176}\text{Lu}/^{177}\text{Hf}$ determination. Mud Tank zircon served as a secondary reference material and has fairly

homogeneous $^{176}\text{Hf}/^{177}\text{Hf}$ ratio value of 0.282507 ± 6 (Woodhead and Hergt, 2005). It was also used to test the effect of matrix load on the robustness of the Yb correction. Repeated analyses of 91500 and Mud Tank zircon standards were used to monitor data quality.

Analytical uncertainties for unknowns were propagated by quadratic addition to include the standard error of the mean of the analysis and the reproducibility of the 91500 reference material. ϵHf values were calculated using a ^{176}Lu decay constant of $1.867 \times 10^{-11} \text{y}^{-1}$ (Söderlund et al., 2004), the present-day chondritic $^{176}\text{Lu}/^{177}\text{Hf}$ value of 0.0336 and $^{176}\text{Hf}/^{177}\text{Hf}$ ratio of 0.282785 (Bouvier et al., 2008). Detrital zircon Hf isotopic data are presented in Appendix 6.

CHAPTER

THREE

GEOLOGY OF THE RAKHINE AREA

3.1 Introduction

This chapter presents results of field work in the Rakhine Yoma and coastal area. The Indo-Burman Ranges (IBR) comprise a thick sequence of Mesozoic and Cenozoic flysch deposits associated with several large and numerous ophiolite fragments. The underlying structure is thought to continue south to the Andaman Islands subduction zone (Ridd & Racey, 2015). The tectono-stratigraphic evolution of the Indo-Burman orogeny, with the Naga Hills, Chin Hills and Rakhine Yoma positioned between the Sunda arc and the Himalayas, is vital in the framework of convergence of the Indian plate with Asia (Nandy, 1986). The Rakhine region is located in the southern part of the IBR and extends along almost the whole length of the Bay of Bengal coast to the southern Bangladesh border. The Rakhine Yoma falls in elevation gradually to the south and reaches the sea at Cape Negrais, but this general line of uplift continues through the Andaman and Nicobar Islands to Sumatra. The northern Rakhine Yoma is separated by the Kaladan Fault (Sikder and Alam 2003) from the Rakhine Coastal area which is part of the Chittagong-Tripura Fold Belt (CTFB). Alam et al. (2003) and Maurin & Rangin (2009) identified the Chittagong Coastal, Kaladan, Lelon and Kabaw faults as the main structures that could be accommodating the oblique dextral motion (Fig. 3.1a). Some workers view the CTFB as the expression of an active accretionary prism associated with ongoing subduction beneath the IBR (e.g. Steckler et al., 2008; Wang et al., 2014). The Rakhine Yoma passes westward into the narrow Rakhine Coastal area. The best exposures of sedimentary units can be found along the tidal areas of the Rakhine coast and the nearby islands (e.g. Ramree and Cheduba). Along the Rakhine coast, there is a thick of sequence turbiditic sandstones exposed that are interbedded

with grey shales and mudstones which contain blocks of pillow basalt, *Globotruncana* limestone, chert and serpentinite, and *Nummulitic* limestone (Bannert et al., 2011).

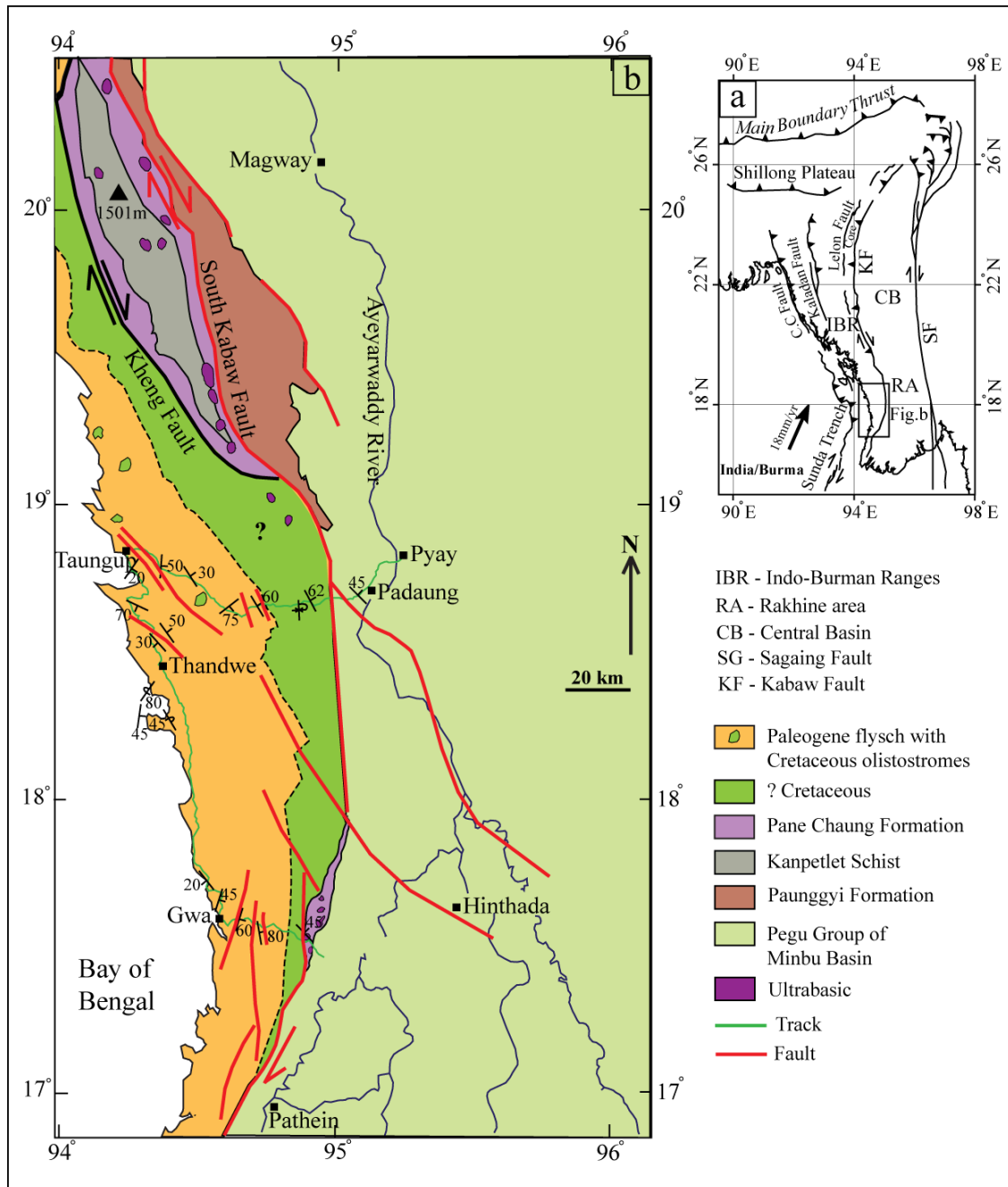


Fig. 3.1: (a) General structural map of Myanmar (Maurin and Rangin, 2009) shows the location of the Rakhine area, and (b) the Rakhine area geological map (modified from United Nations, 1979).

Blocks of Cretaceous limestone, volcanics and other lithologies occur sporadically in mélanges throughout the IBR (Brunnschweiler, 1966; Bender, 1983). These mélanges are interpreted as olistostromes or debris flow that are imaged on the floor of the Bay of Bengal as well as being identified clearly in the geological record on Ramree Island (Nielsen et al., 2004; Rangin, 2017). In the central Rakhine Yoma, the boundary between the eastern and western belts is poorly defined, and no stratigraphic divisions are discernible either in the field or on aerial photographs. Brunnschweiler (1966) considered the turbidites and mudstones in the Rakhine Yoma and coastal area to be largely Cenozoic and Upper Cretaceous in age, but there is no direct palaeontological evidence; the conclusion is based on regional considerations. Bender (1983) stated that mafic volcanic rocks occur sporadically in the central part of the Rakhine Yoma. In the southern Rakhine Yoma, outcrops of ophiolite composed of serpentinized peridotites are in tectonic contact with a low-grade metamorphic schist, together with ‘floaters’ of chert and limestones (Chhibber, 1927; United Nations, 1979; Bannert et al., 2011). Triassic fossil (*Halobia* sp. and *Ammonite* sp.) occur in thinly laminated shales and are well exposed in the southern Rakhine Yoma (Than Htut et al., 2012). Gramann (1974) suggested the unit may be equivalent to those along the eastern margin of the Chin Hills. However, how the Triassic flysch of the southernmost Rakhine Yoma relate to the Chin Hills is still not resolved.

The IBR of the Rakhine region has been intermittently studied over many years, particularly in relation to petroleum exploration, but debate exists as to whether the deep-water sediments of the coastal belt represent an accretionary complex related to subduction of oceanic crust of the Indian plate (Curry et al., 1979; Bender, 1983; Curry, 2005) or a fold and thrust belt (Searle et al., 2017). These debates exist because the stratigraphy,

structure and metamorphic-magmatic evolution of the IBR is poorly constrained, particularly in the Rakhine region. After recent large gas discoveries in the northern Rakhine coastal area, the depositional history and tectonic evolution of the Rakhine Yoma and coastal area have received much attention from earth scientists. The sedimentary rocks of this area are therefore potentially important in understanding the tectonics, and to interpret the history of sediments with respect to the main interval of interest for hydrocarbon exploration. As such the present study aims at a reappraisal of the regional geology and tectonic evolution of the IBR in the Rakhine region in the context of new U-Pb and stable isotope data, combined with petrographic and biostratigraphic data.

3.2 Previous work

Geological traverses of the Rakhine area were carried out by Theobald (1871, 1873), Lehner (1941), Clegg (1941, 1954), and Brunnschweiler (1966, 1974). They recognized that Cretaceous and late Triassic rocks along with Paleogene rocks have been folded into the IBR. The occasional occurrence of Upper Cretaceous limestones led Lehner (1941) to postulate major thrust tectonics in the Rakhine Yoma. The geological features along the Rakhine coast indicate a complicated interplay in Cenozoic times, evident as W-directed thrusts in early deformed turbidites in the Rakhine Yoma (United Nations, 1979).

The geological maps and cross-sections from air photographs of the Rakhine area were published by Brunnschweiler (1966). A geological map of the Hainggyi Island in the southernmost part of the Rakhine Yoma was made by Tin Aung Han et al. (1972) who also reported Triassic fossils found in shales. Bannert (1977) carried out field work in the Ramree and Chedua Islands, Rakhine coastal area, and reported the systematic stratigraphic

succession and large scale slumping-structures in the flysch sediments. The entire IBR was mapped at a scale of 1:100,000 in 1979 by the United Nations-Directorate of Geological Survey and Mineral Exploration (UNDGSE), and established the stratigraphic and structural framework for the IBR as well as conducting widespread stream sampling for mineral exploration. From 1980 to 1986, a German-Burmese project undertook fieldwork and satellite-image studies from the Naga Hills, the Chin Hills and the Rakhine Yoma, the results of which were recently summarized by Bannert et al. (2011).

More recent studies of the IBR used 2D seismic reflection data to investigate the nature of the plate boundary and the southern extent of the ranges offshore (Nielsen et al., 2004), and to produce a structural model for the development of the IBR (Maurin and Rangin, 2009). This work suggested that subduction ceased early in the Cenozoic, and dangling Indian plate slab is present that is currently undergoing lateral dextral translation (e.g. Rangin et al., 2013; Rangin, 2017).

Many workers (e.g. Allen et al., 2008; Naing et al., 2014; Kyi Khin et al., 2017) carried out fieldwork and undertook sedimentary provenance studies of the Palaeogene and Neogene sedimentary rocks in the Rakhine coastal area. They have interpreted the Palaeogene section of the IBR as predominantly locally sourced from the Wuntho-Popa Arc, whereas Himalayan sources become more important during the Neogene.

3.3 Lithostratigraphy and field observations from the Rakhine area

The geological succession of the Rakhine area is shown in Table 3.1 and discussed in more detail in the following sections.

Location	Age	Group/Formation	Lithology
Rakhine Yoma (Padaung-Taungup road section & Gwa road section) (United Nations 1979)	Late Eocene	Modi Taung unit	Turbidite sandstones and shales
	Middel Eocene - Cretaceous	Central Range Unit	Mudstones with exotics and micritic limestone blocks, grits, turbidite sandstone, mudstones, broken beds
	Late Cretaceous	Peinnegon Unit	
	Late Cretaceous- Late Triassic	Serpentinite	Sills and irregular bodies of serpentinite
	Late Triassic	Pane Chaung Group	Turbidite sandstones and shales with minor limestones and schist
Rakhine coastal area (Than Htut et al., 2012)	Middel Eocene	Ngapali Formation	Turbidite sandstones and shales, mélange, olistostromes
Ramree Island (Bannert et al., 2011)	Late Miocene	Leikhamaw Formation	Sandstones and shales
	Middle Miocene	Sane Formation	Shales
	Early Miocene	Nga Ok Conglomerate	Conglomerate
	Oligocene	Yechangyi Formation	Turbidites, Cretaceous limestone floaters
	Late Eocene	Kalaba Formation	Turbidites, chert
	Middle Eocene	Madekyun Formation	<i>Nummulitic</i> sandstone and chert
	Cretaceous	Kyauknimaw Formation	Red chert, micritic limestones, basalts

Table. 3.1: *Stratigraphy of the Rakhine area (based on United Nations, 1979; Bannert et al., 2011; Than Htut et al., 2012).*

3.3.1 Rakhine Yoma

The current stratigraphy of the Rakhine area is based on lithological mapping and can be traced back to the pioneering work of Brunnschweiler (1966). Thick turbidite sequences are exposed along the Padaung to Taungup road in the central Rakhine Yoma and coastal area (Fig. 3.2).

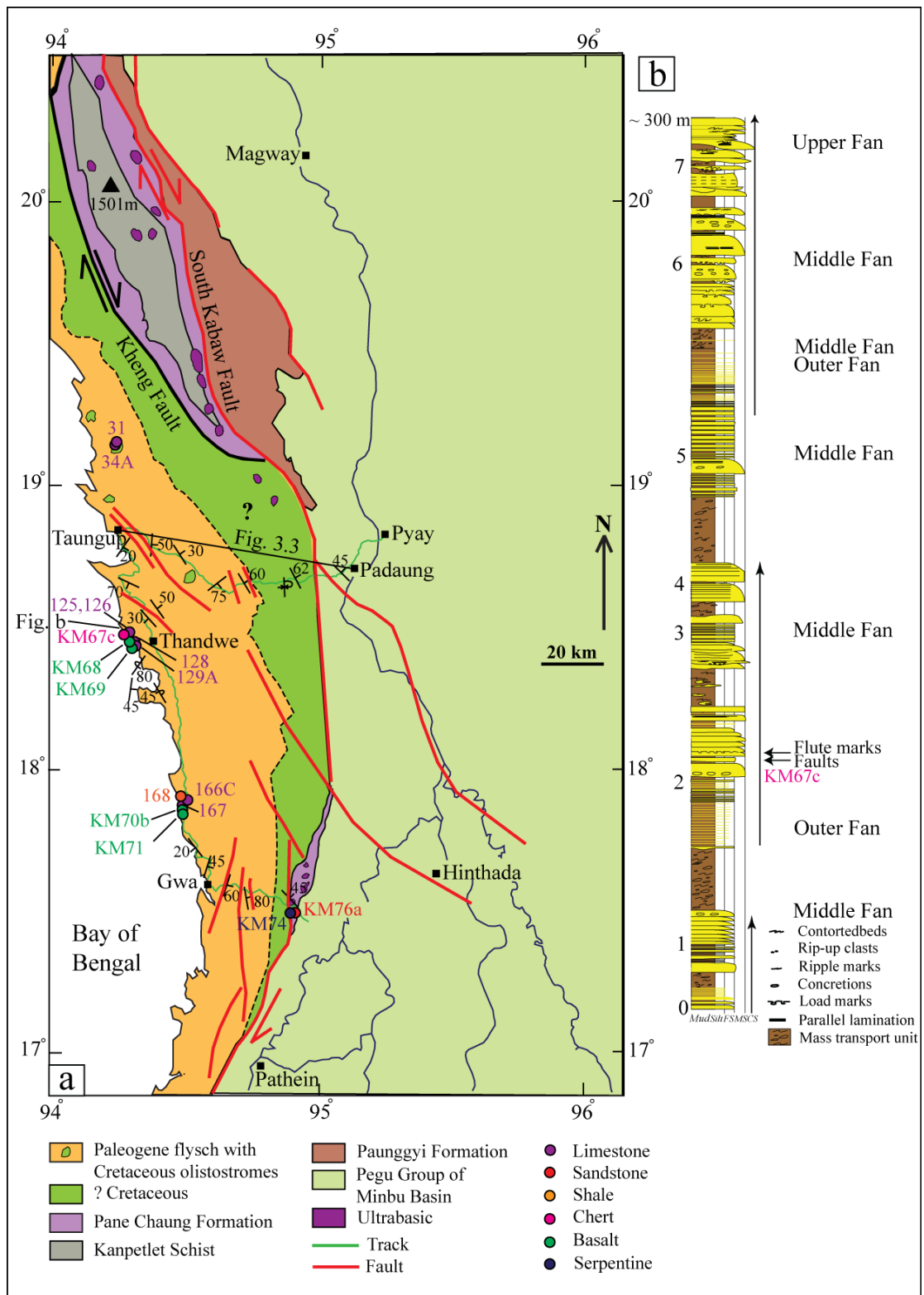
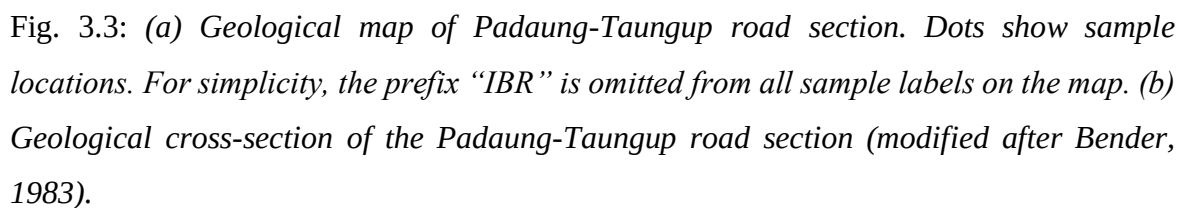


Fig. 3.2: (a) Geological map of the Rakhine area. Dots show sample locations, and (b) Sedimentary log of the Ngapali Formation, Ngapali Beach (Morley, 2014).

The United Nations (1979a) divide the Rakhine Yoma into a Modi Taung unit, a Central Range unit, and Peinnegon unit. They have reported the existence of Cretaceous-Paleogene flysch along the Padaung-Taungup road. However, it is difficult to differentiate the Cretaceous from the Paleogene flysch due to the monotonous and strongly weathered nature of the exposed sediments. The problem is aggravated by the fact that neither the original base nor the top of the Cretaceous flysch sequence has ever been recognized or defined in the literature. Consequently, knowledge of the Cretaceous rocks in the Rakhine Yoma is meagre. The Upper Cretaceous rocks (as mapped by the United Nations) have limited outcrops along the Padaung-Taungup road, while Eocene sediments are more widespread in the Rakhine Yoma. Detailed geological and structural maps of the Padaung-Taungup road section are shown in Fig. 3.3. The area southwest of Padaung to Nyaung-chi-dauk, a sequence of greenish-grey, fine-to-medium-grained sandstones with fragments of dark shales and carbonaceous material is exposed. The area west of Nyaung-chi-dauk is dominated by dark shales which are hard and slightly indurated. Many of the sandstones in this sequence are fairly rich in feldspars, chert grains, and volcanic (basic) fragments. The greenish colour is due to glauconite. This sequence appears to be continuous from the eastern foothills of the Rakhine Yoma through to the east of Nyaunggyo. The whole sandstone-shale sequence up to Nyaunggyo is characterized by graded bedding (Fig. 3.4a) and incompetent folding of shales between more resistant sandstone bodies. The sandstones are massive to thickly-bedded yellowish brown, fairly soft to hard, and fine-to-medium-grained with bluish grey, hard thinly-bedded fine-grained glauconitic layers. The sandstone beds on weathered surfaces exhibit a reddish brown colour due to oxidation. West of Nyaunggyo, the sequence consists predominantly of an often thoroughly contorted mass of argillites with some layers



of calcareous, fine-grained sandstones. Thick beds of yellowish brown soft sandstone interbedded with yellowish shales were observed. This unit extend westwards along the road until Taungup Pass, and consists predominately of deeply weathered greenish-grey shales, that are poorly stratified, fairly soft and micaceous. Further west of the Taungup Pass, incompetent shale facies containing abundant floaters of quartzite and agglomeratic (andesite fragments) predominate, while the yellowish brown soft sandstone is less abundant. The shales vary from olive green to dark grey, usually soft, friable, conchoidal and occasional exhibit slippage small scale distortion, slumping, folding and characteristic pencil structure. The prominent outcrops of tuff and argillite and also beds of red clays offered the main lithological characteristic of this area. The thin volcanic tuffaceous beds are white to pale yellow, with a comparatively low specific gravity. The sporadic interbedded red shale strata are generally poorly exposed. A big block of limestone at Nabutaung quarry (see location on Fig. 3.3), locally named Nabutaung Limestone was recorded. The quarry is located some little distance off the road and the limestone block has a thickness of about 600 m and is some 3-5 km in length. The limestone does not show any bedding traces and the contact is not very clear with the associated shales. In places, the limestones show irregular micro and macro stylolite structures. The limestone is whitish, pink, pale-green or grey in colour, fine-grained, hard and compact. It is significant that the shales surrounding the limestone floaters are entirely devoid of fossils. The shales must be post-Cretaceous because the Rakhine Yoma sequence plunges eastwards beneath the Pegu Group of the Central Basin (Brunnschweiler, 1966). There can be no doubt that the limestones with *Globotruncana* must be a large exotic block similar to others occurring at various levels in the flysch of the Rakhine Yoma. Brunnschweiler (1966) reported

Globotruncana limestone floaters of Late Cretaceous age within flysch between Mileposts 25 and 26 (east of Nyaunggyo). At the end of Taungup road (4 km, east of Taungup), the flysch type rocks disappear beneath a sequence of strongly folded, thin-bedded, light-coloured claystones and siltstones with sandstone as thin interbeds. The whole series contains many tuffaceous horizons, termed the 'Taungup series' by Brunnschweiler (1966). These are characteristic bluish grey and very soft clays, containing secondary crystals of gypsum which on weathering exhibit white spots of anhydrite. Brunnschweiler (1966) suggested this tuffaceous Taungup series represents Miocene, but there is no direct palaeontological evidence.

In the Gwa road section (see location on Fig. 3.2), indurated shale with thin sandstone beds and occasionally sandstone-shale alternation sequences are present. The shales are bluish grey to grey, hard, indurated with laminations of sands. Fine-to-medium grained fining upward graded sandstones interbedded with hard and grey to dark grey shales (Fig. 3.4b). Sedimentary features like flue casts, groove casts and load casts are common along bedding planes. Plant debris and leaves are present (Fig. 3.4c). The secondary quartz and calcite veins are common along joint planes. Serpentinite bodies (a few meters size) have also been found in the area north of Ngathaingyaung (at 17°30'N / 94° 55'E) that are in tectonic contact with sandstones, as evidenced by slickensides on the serpentinite (Fig. 3.6f).

In the southernmost region of the Rakhine Yoma, the Eocene is represented by massive sandstones, varying in colour from green to yellow, grey and blue, with occasional conglomerates (Than Htut et al., 2012). These sediments are almost entirely devoid of shales. The Negrais Group in the southernmost part of the Rakhine Yoma consists of indurated, contorted sandstones and shales, with rare conglomerates. They are in tectonic

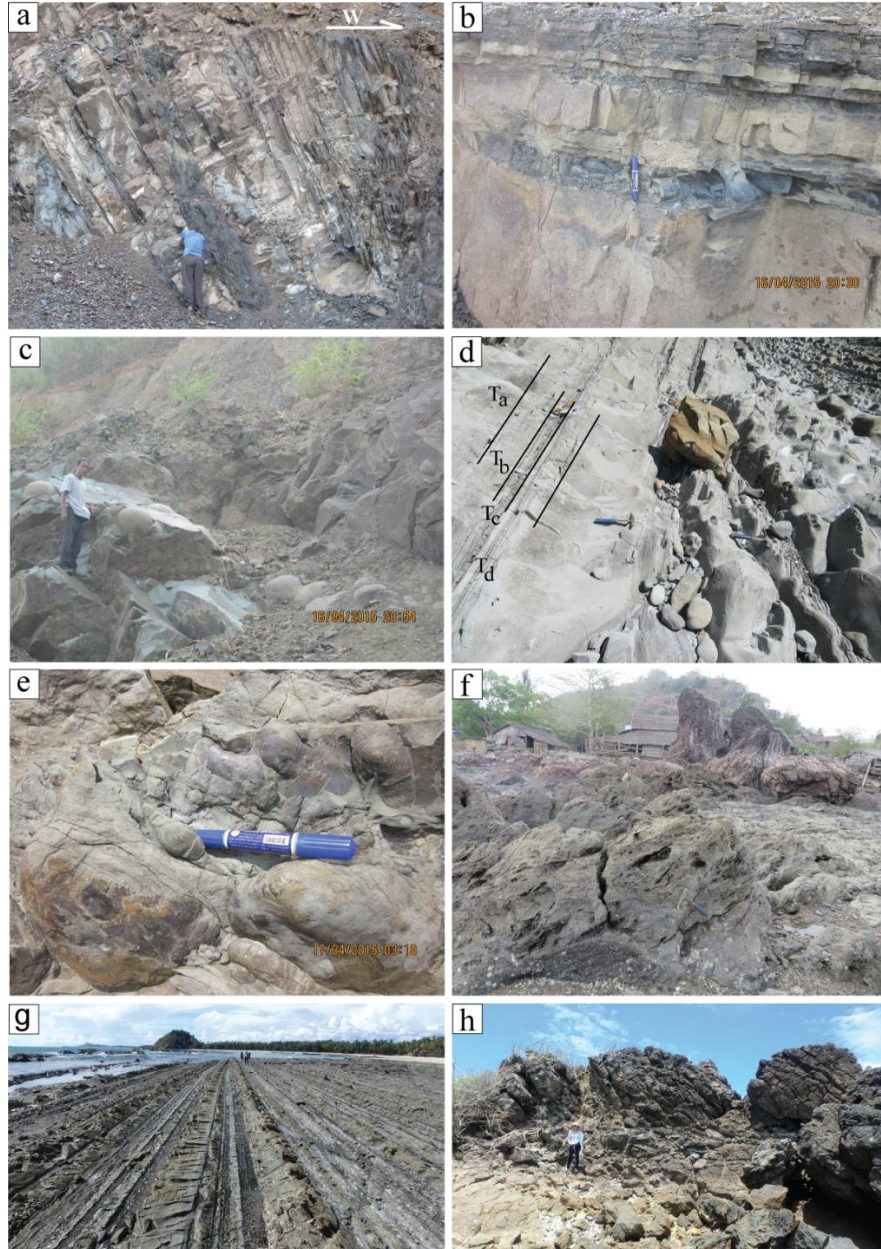


Fig. 3.4: Field photographs of the study area. (a) thinning upward interbedded sandstones and shales (Padaung-Taungup road section), (b) graded sandstone bed (Gwa road section), (c) massive nodular sandstone bed (Gwa road section), (d) graded sandstone bed showing part of Bouma sequence (Ngapali Formation), (e) Flute casts on the base of sandstone beds (Ngapali Formation), (f) Shear zone in serpentinite overlain by red chert (Ramree Island), (g) outcrop of the Rakhine flysch (Ngapali Formation), and (h) exposure of serpentinite (Ngapali Formation).

contact with metamorphic schists, ophiolites occur together with ‘floaters’ of chert and limestone (Than Htut et al., 2012). The Triassic fossil *Halobia* sp. and ammonites bearing silty shales are well exposed in the Hainggyi Island (Tin Aung Han et al., 1972; Than Htut et al., 2012), (see location on Fig. 1.1). The shales are ash grey to black, hard to very hard, thinly laminated, micaceous and highly carbonaceous, which are about 49 m thick (Than Htut et al., 2012). In the eastern coast of the Hainggyi Island, the IGCP (International Geological Correlation Programme) field team (1979) reported a fault contact between the Triassic unit and some exotic limestones contain larger benthic foraminifera such as *Nummulites*, *Operculina*, *Assalina*, *Discocyclina*, and *Ranikothalia* sp., indicate an Early Eocene age (Kyi Khin et al., 2017). The Negrais Group is dominated by undifferentiated Eocene and older Paleocene sediments (Kyi Khin et al., 2017). The Triassic unit was therefore exhumed by the fault zone, which is probably an extension of the Kabaw Fault.

Bender (1983) stated that basic volcanic rocks occur sporadically in the central part of the Rakhine Yoma, but gave no details of location and lithology. In the eastern foothills of the Rakhine Yoma (west of Laemyethna), basalt lavas are described by Chhibber (1972) and United Nations (1979), and metamorphic rocks have also been found in a more or less continuous belt extending southwards into the area north of Pathein at 17°28’N / 94°55’E (Bannert, 2011).

From the spatial association between the ultramafic rocks and Triassic flysch in the southern IBR, it is concluded that the ultramafics were emplaced over, and deformed with, the flysch (United Nations, 1979a). It should be noted, however, that this conclusion is not easily reconciled with the view of Bannert et al. (2011) that the ophiolitic rocks were ocean

floor on which the flysch was deposited. The basalt lavas may be equivalent to those along the eastern margin of the northern Chin Hills.

3.3.2 Rakhine Coastal Area

Regionally the Rakhine Coastal area can be divided into two parts namely: the Northern Rakhine area (Lat. 19° 30''N and 21° 30''N) and the Southern Rakhine area (Lat. 16° 00''N and 19° 30''N). The division is based on the differential environmental conditions of sedimentation and tectonism. The northern territory is adjoined with India and Bangladesh. Geologically this area is the southern continuation of the Assam Basin. It is entirely made up of Miocene and Pliocene sediments that have been folded with a general strike of NNW-SSE direction. The southern Rakhine area, in contrast, is predominantly made up of Eocene and Upper Cretaceous rocks with scattered outliers of Miocene sediments in Ramree and other offshore islands, and coastal strips with local serpentine intrusions.

Along the Rakhine coast at Ngapali near Thandwe (Sandoway), the Eocene (locally named the Ngapali Formation) is over 300 m thick and is completely exposed along an extensive wave cut platform (Morley, 2014) (Fig. 3.2b). The Ngapali Formation is composed predominantly of turbidite sandstones and shaley mass transport deposits: background deepwater pelagic sediments are a minor component. Thin to moderately thick (10-150 cm) beds of silty to medium-grained turbidite sandstones, deposited in predominantly tabular beds dominate the succession (Fig. 3.4g). Thin shales either separate these beds, or the sandstones are amalgamated to form sandstone bodies up to 2-3 m thick. Thin-bedded and graded sandstone-shale sequences are frequently and abruptly interspersed with cut-and-fill type lenses that indicate intense deformation with squeezing of shales between more competent sandstone lenses and layers, faulting and puckering in the

sandstones themselves, and intraformational slipping and thrusting. Current directional structures such as flute casts, groove casts, and current bedding, have been observed at the base of sandstone beds (Fig. 3.4e). The sedimentary structures are consistent with sediment deposition on turbidite lobes in a middle to outer fan setting (Morley, 2014). Channelized turbidites suggest an inner fan setting and are only seen at the top of the section. Near-complete Bouma sequences are common in the Ngapali Formation, with flute casts at the base and thin pelagic sediments at the top (Fig. 3.4d). The best exposures of the Ngapali Formation are found at the Mazin Point, near Thandwe airfield, where outcrops of steeply dipping, olistoliths of volcanic agglomerate and volcanic pillow lava, have broken loose from a nearby submarine extrusion within the succession. The exposure of base of serpentinite block (Fig. 3.4h) at Mazin Point shows the serpentinite fragments are sheared into the underlying mudstone. This indicates that the large block of serpentinite was emplaced into the mudstones along a shear zone. The shales mixed together with exotic blocks such as ‘floaters’ of chert and limestone, conglomerate, volcanics, and other lithologies occur in mélanges. Mélanges have been observed frequently within the flysch sequence along the Rakhine coastal and island areas and are commonly interpreted as olistostromes, deposited by debris flows. Small lenses of grey and reddish radiolarian cherts and of silicified radiolarian limestones with rare foraminifera occur at intervals throughout the sequence. The most conspicuous olistolith is the very prominent pillow basalt outcrop observed in the formation at the Ngapali Beach. Ultramafic intrusions are found locally (Fig. 3.4h), but did not observe any depositional contacts between the flysch and the ophiolite blocks.

Brunnschweiler (1966) reported the presence of an Upper Cretaceous sequence in the Rakhine coastal area, based on the *Globotruncana* limestone. However, Gramann (1974) did not find a Cretaceous sequence exists in the region other than floaters in the Rakhine coastal area. Bannert et al. (2011) mentioned a limestone floater at the Mazin Point, near Thandwe airfield, yielded *Globigerinidae* and *Globorotalia aequa* of Late Paleocene to Early Eocene age.

3.3.3 Ramree Island

On Ramree Island, northwest of Thandwe, Bannert et al., (2011) describe early Eocene sandstones overlain by mid-Eocene to early Miocene deformed turbidites with exotic blocks of white porcelain-like *Globotruncana* limestones, red and green radiolarites and unfossiliferous cherts, pillow lava and serpentinite, and *Nummulitic* limestone.

Numerous occurrences of Cretaceous limestone floaters and Cretaceous foraminifera in mud pebbles have been found embedded as exotics in the flysch sediments, in exactly the same way as in the flysch of the Rakhine Yoma. The source area of the Upper Cretaceous limestone remains obscure. Similarly, the source of the *Nummulitic* limestones is poorly constrained. In the central part of Ramree Island, the rocks are composed mainly of Oligocene flysch sequences which have been deformed into conspicuous circular synclines (Fig. 3.5). Large, circular synclines of sandstone with diameters up to 10 km (Tin Myint et al., 2003) are underlain by rapidly sedimentated overpressurised shale and olistostromes. These sandstone sequences have been reported by the German Geological Advisory Group and dated by Maurin and Rangin (2009), as Oligocene age based on the palaeontological evidence from sediment ejected by mud volcanoes north of Kyauknimaw. Mud volcanoes

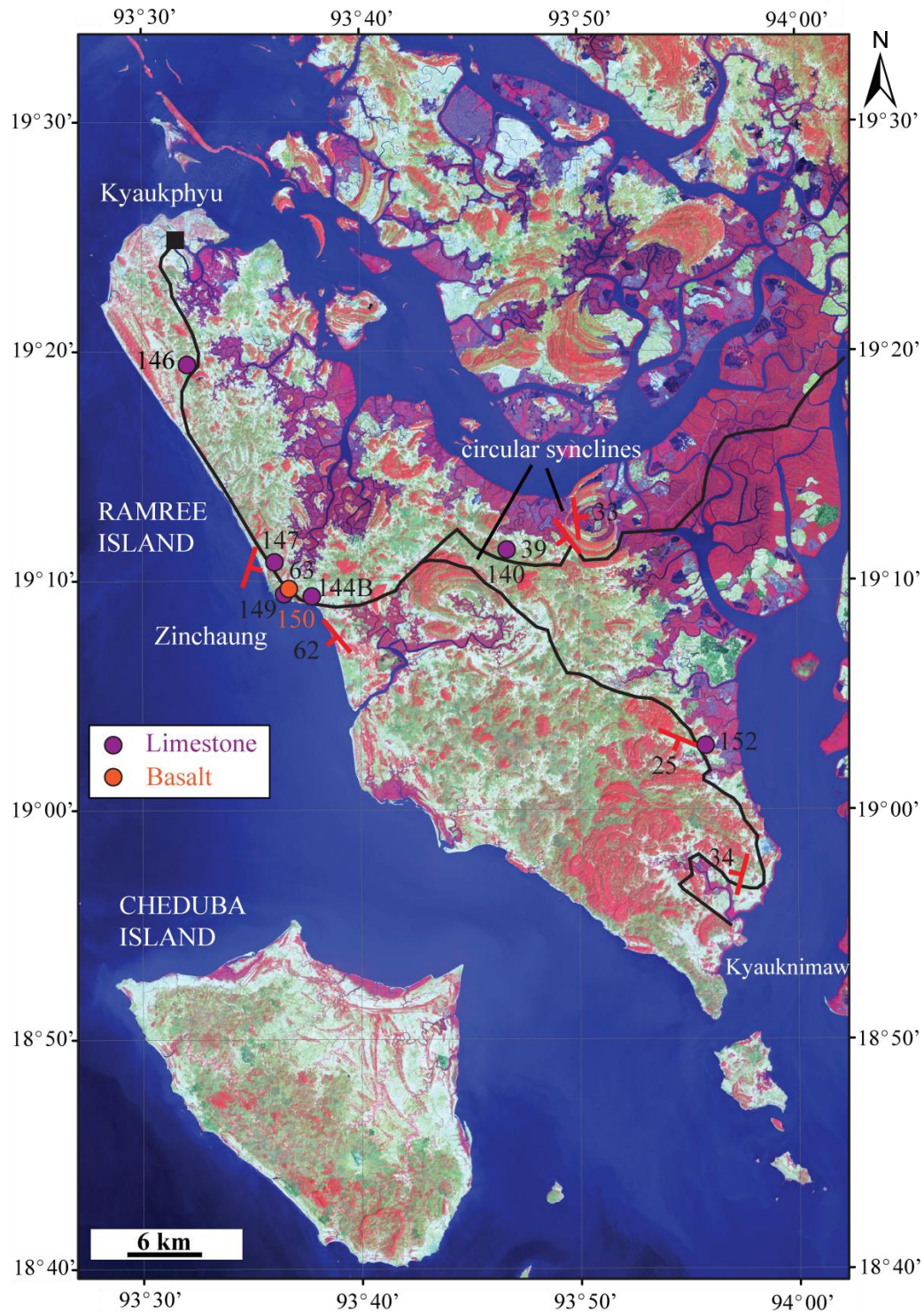


Fig. 3.5: The Ramree Island with circular synclines (detail of LANDSAT-TM image 134-047). Dots show sample locations. For simplicity, the prefix “IBR” is omitted from all sample labels on the map.

occur in a large number and develop considerable sizes, such as the Zinchaung on Ramree Island (erupted on 5 January 2008) and their origin might be in the underlying overpressured shale. The succession differs the style of deformation from that the Thandwe in forming spectacular circular synclines, interpreted as either slump or tectonic folds. At Kyauknimaw on the southeast coast of Ramree Island (Fig. 3.5), several hundred meters of strongly folded and distorted ophiolitic suite occur. The assemblage consists of serpentinite, pillow lava and green and red chert. The ophiolitic rocks are in tectonic contact with the surrounding Oligocene flysch. A steeply dipping sequence of radiolarite followed by tough and greenish grey sandstone which Brunnschweiler (1966) suggested was most likely of Upper Cretaceous age. However Cretaceous rocks occur as olistoliths within younger sequences, so this seems unlikely. A >10 m thick strongly folded and sheared red radiolarian cherts is underlain by a 2 – 4 m thick, strongly sheared section of metamorphic rocks (Fig. 3.4f). This association of metamorphosed basic igneous rocks and radiolarites suggests that the radiolarites were originally deposited on basaltic rocks and that the two were metamorphosed and sheared together during emplacement. These rocks are always closely associated on Ramree with strongly sheared grey mudstones and interbedded turbidite sandstones and siltstones. A remarkable sequence of mud-matrix olistostromes with similar blocks (cherts and basalts) are interbedded with Oligocene deformed turbidites. On the Ramree Islands, excellent exposures of flysch occur along the shores, showing features typical of turbidites are observed in the Oligocene sediments such as graded bedding, parallel lamination, climbing ripple lamination, convolute bedding with flame structures, load casts and flute casts. The deposition of flysch ended during the latest Middle Miocene

(Tin Myint et al., 2003) with well exposed molasses facies along the western and northern margin of Ramree Island.

3.4 Structure of the Rakhine Area

The traverse along the Padaung -Taungup road, illustrates that the structure of the IBR in the Rakhine region is very complicated, and it was not possible to recognize the full succession represented in the area. This factor makes it difficult to work out the correct stratigraphic sequence. The Rakhine Yoma forms the southern part of the IBR and in the south the NNE striking west vergent folds parallel the west coast. The northern Rakhine Yoma is separated by the Kaladan Fault (Sikder and Alam, 2003) from the Rakhine coastal area (Fig. 3.1), but it is relatively seismically inactive. In the region of 19°N, the tectonic regime is marked by west vergent folds and imbricate structures in flysch-like sediments of Upper Cretaceous age. The strike of the region has changed from NNE to NNW due apparently, to extension of a NW-SE lineament approaching from the southeast (Maurin and Rangin, 2009). The dip of the sequence remains around 40° to the NE along the Taungup road (Fig.3.2, 3.3a, 3.6a,b). The central and western parts of Rakhine Yoma sequence along the Taungup road, have undergone Alpine-type orogenic deformation. Lehner (1941) and Clegg (1954) suggested the occasional occurrence of Upper Cretaceous limestones led to a major thrust in the Rakhine Yoma. Flysch and molasses sediments of the eastern and western Rakhine Yoma are folded into a sequence of narrow north-south anticlines, sometimes disrupted by thrusts.

On the Rakhine coast, the turbidite beds on the extensive wave cut platform show classic sedimentary load structures. Consequently, NNW-SSE to NNE-SSW trending folds and

WNW-ESE orientation of the faults have been observed. The coastal strips of southern Rakhine area is rugged with small islands that show complicated imbricate thrusts associated with movement of the main Rakhine Yoma type structures. Most of the rocks exposed on Ramree Island and Ngapali are steeply-dipping. The Eocene section along Ngapali Beach is over 300 m thick and is completely exposed along an extensive wave cut platform (Fig. 3.2b). Bedding strike and bedding dip at the faulted locality is about 025° 80-85° ENE (Fig. 3.6c), younging direction is to the ENE. Structurally, local shallow folds are present and shear zones (tectonic *mélange*) with only a few patches of coherently folded turbidite beds are exposed (Fig. 3.6d). Small scale intraformational folds such as drag folds and slump structures are present (Fig. 3.6e). Most of the slumps are strongly folded and sheared shale in the units found between undeformed sand-rich sections. In the Ramree Island area, at 20° N, both the trench and the IBR bend from a NNE to NNW direction. In Ramree Island, crescent shape synclinal structures bounded by faults are particularly well developed, and the area is almost devoid of anticlinal structure (Fig. 3.5). Maurin and Rangin (2009) suggested that the circular synclines were formed by an Oligocene-Miocene gravity tectonic episode. West of the Island, the structure of the thrust sheet is complex due to early gravity tectonics. The structural style differs from the one observed in the north.

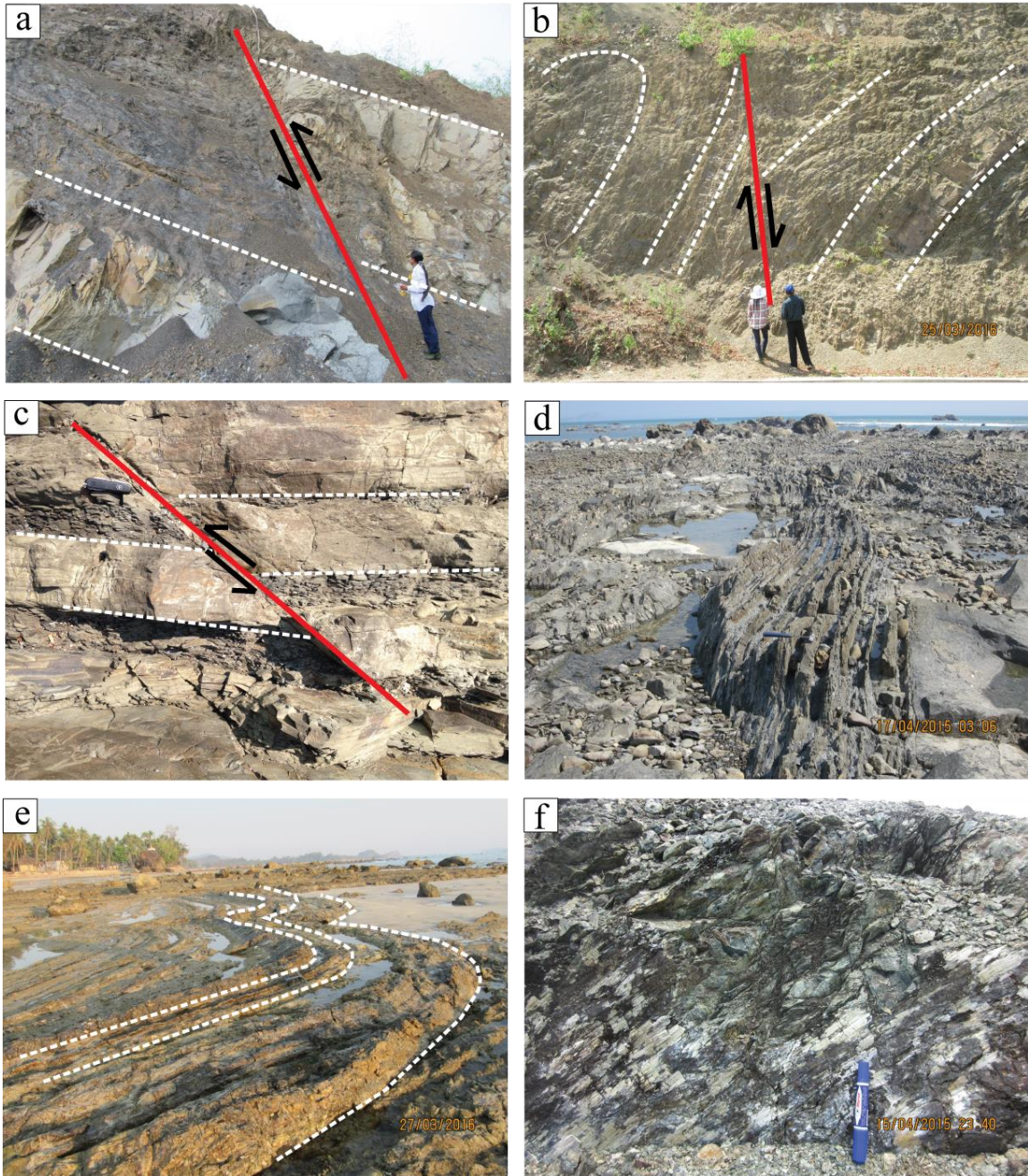


Fig. 3.6: Field photographs of the study area. (a)(b) structural styles in the Padaung-Taungup road section, (c) normal fault (Ngapali Formation), (d) shear zone of mélangé (Ngapali Formation), (e) small scale intraformational folds (Ngapali Formation), and (f) slickenside on a serpentinite, Gwa road section.

3.5 Biostratigraphy

3.5.1 Limestone

From the Rakhine area it is well known exotic pelagic limestone blocks exist that are embedded within the Paleogene flysch and found within a highly sheared matrix. The relationship between the flysch and the olistolith limestone blocks is unclear. The aims of the present work are to study the distribution of planktonic and benthic foraminifera and coccoliths to construct an integrated biostratigraphy, and determine the depositional environments.

The biostratigraphy of ten exotic limestone blocks from Rakhine Yoma and the coastal area was studied (Fig. 3.2, 3.3, 3.5). Of these, four (IBR09, 22, 23, and 25) were collected from the Nebutaung (Padaung – Taungup Road), two (IBR31 and 34A) from the Gutaung (Taungup – Ma-ei Road), two (IBR 166C and 167) from the Gwa road section, and two (IBR 149 and 152) were collected in the Ramree Island. *Globotruncana*-bearing limestone was first described from the Padaung – Taungup Road by Nagappa (1959) and Brunnschweiler (1966), whereas Gramann (1974) found limestones yielding the large foraminifera *Assilina sp.*, *Discocyclina sp.* and small Nummulites (confirming an Eocene age) on the same road section at Milepost 47. Thura Oo (2000) reported the occurrence of *Globotruncana* limestone from the Nebutaung. The diversity of ages reported and the varying palaeoenvironmental significance of the different foraminifera indicates that the limestone blocks warrant further detailed study.

Characteristic planktonic and benthonic foraminiferal assemblages were studied in thin sections. Most of the limestones studied contain planktonic foraminifera in great abundance,

and nearly all of them contain oblique sections of double-keeled specimens of *Globotruncana* forms, single-keeled *Globotruncanita* forms and non-keeled forms of the genera such as *Heterohelix*, *Hedbergella*, and *Globigerinelloides* (Plate. 3.1 and 3.2). Planktonic foraminiferal assemblages in the Nebutaung, Gutaung, Gwa road section and Ramree Island area are dominated by the genera *Globotruncana*, *Globotruncanita*, *Contusotruncana*, *Heterohelix* associated with some *Globigerinelloides*, *Pseudotextularia*, and rare *Marginotruncana*, *Hedbergella*, and *Sigalia*. The dominant species in all these samples are *Globotruncana arca*, *G. neotricarinata*, *G. hilli*, *Contusotruncana fornicata*, *C. patelliformis*, *C. contusa*, *Globotruncanita elevata*, *G. stuartiformis*, *G. stuarti*, *Marginotruncana tarfayaensis*, *M. schneegansi*, *Heterohelix globulosa*, *H. reussi*, *Hedbergella planispira*, *H. delrioensis*, *Globigerinelloides alvarezi*, and *G. messinae*. Using the planktonic foraminiferal zonal scheme of Sliter (1989), three biozones are proposed based on faunal assemblages, *Gansserina gasseri* Zone (Maastrichtian), *Globotruncana ventricosa* Zone (Campanian) and *Globotruncanita elevata* Zone (Campanian). The smallest of the foraminifera are difficult to determine in thin sections of the rock, but they include *Globigerina* sp. The whole assemblage represents a period in time ranging from early late Albian to late Maastrichtian. Overlapping age ranges of abundant, well-preserved taxa of the pelagic limestones indicate Campanian to Maastrichtian ages (Fig. 3.7).

On Ramree Island, the olistolith limestones contain either abundant Cretaceous planktonic foraminifera (Fig. 3.8a), radiolarians, such as in sample IBR147 (Fig. 3.8b), and larger benthic foraminifera (Fig. 3.8c), or Dasycladacean algae (Fig. 3.8d), associated with gastropods, pelecypods, echinoderms and byrozoans as observed in sample IBR146. More than one species of calcareous algae are present, but poorly preserved. Various forms of

Plate 3.1

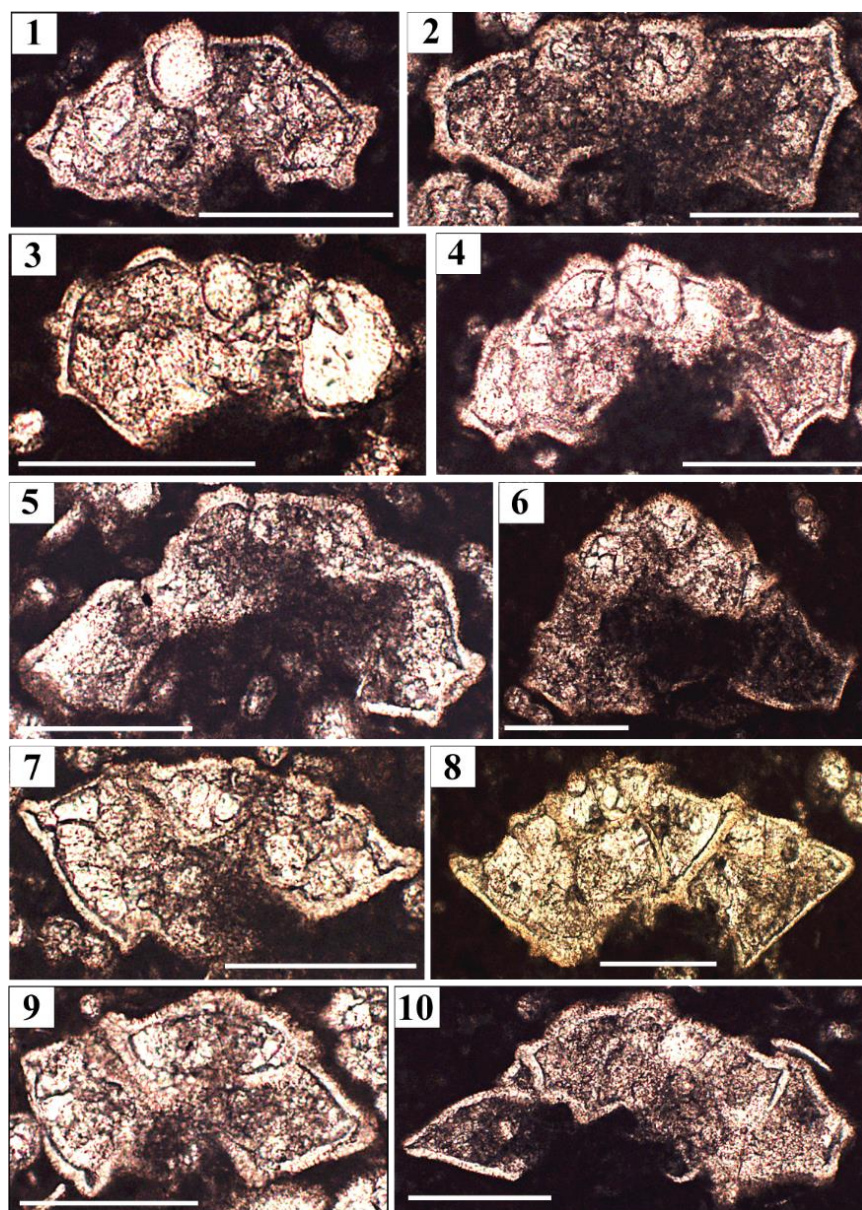


Plate. 3.1: Photomicrographs of the planktonic foraminifera from the studied limestone: the scale bars correspond to 200 μm . 1. *Globotruncana arca* (Cushman), 2. *Globotruncana neotricarinata* (Petrizzo), 3. *Globotruncana hilli* (Pessagno), 4. *Contusotruncana fornicata* (Plummer), 5. *Contusotruncana patelliformis* (Gandolfi), 6. *Contusotruncana contusa* (Cushman), 7. *Globotruncanita elevata* (Brotzen), 8. *Globotruncanita stuarti* (de Lapparent), 9. *Globotruncanita stuartiformis* (Dalbiez), 10. *Marginotruncana tarfayaensis* (Lehmann).

Plate 3.2

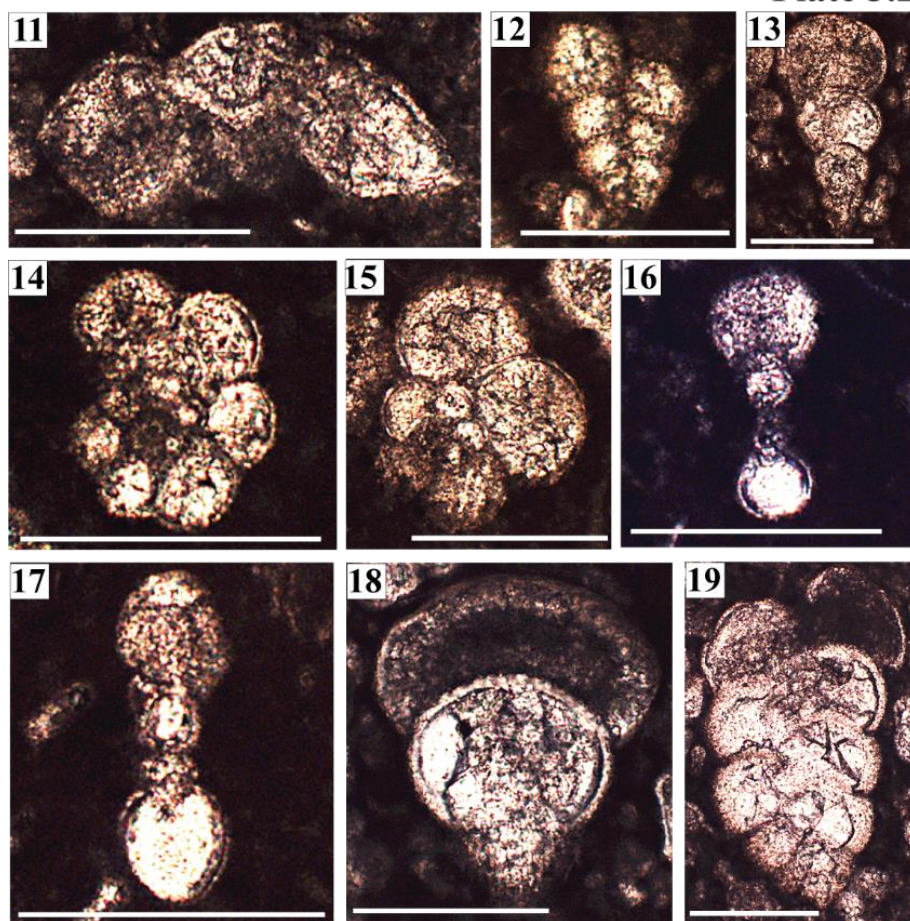


Plate. 3.2: Photomicrographs of the planktonic foraminifera from the studied limestone: the scale bars correspond to 200 μm . 11. *Marginotruncana schneegansi* (Sigal), 12. *Heterohelix globulosa* (Ehrenberg), 13. *Heterohelix reussi* (Cushman), 14. *Hedbergella planispira* (Tappan), 15. *Hedbergella delrioensis* (Carsey), 16. *Globigerinelloides alvarezi* (Eternod Olvera), 17. *Globigerinelloides messinae* (Brönnimann), 18. *Pseudotextularia nuttalli* (Voorwijk), 19. *Sigalia deflaensis* (Sigal).

Nummulites (Plate. 3.3, IBR146), such as *Nummulites globulus* (Leymerie) and *Nummulites atacicus* (Leymerie), are present. The discocyclines are also large and more robustly built, the common ones being *Discocyclina dispansa* (Sowerby) and *Discocyclina sowerbyi* (Nuttall). These assemblages correspond to shallow benthic zone SBZ 9 of the Early Eocene

CENO.		TUR.	SAN.	CAMPA.	MAASTR.				STAGE	SELECTED PLANKTONIC SPECIES						
17	18a	19	20	21	22	23	24	25	26		27	28	29	30	31	KS
																<i>Globotruncan arca</i>
																<i>Globotruncanita elevata</i>
																<i>Globotruncanita stuartiformis</i>
																<i>Globotruncanita stuarti</i>
																<i>Heterohelix globulosa</i>
																<i>Heterohelix reussi</i>
																<i>Marginotruncana schneegansi</i>
																<i>Contusotruncana fornicata</i>
																<i>Contusotruncana patelliformis</i>
																<i>Contusotruncana contusa</i>
																<i>Globigerinelloides messinae</i>

Fig. 3.7: Stratigraphic ranges of selected stratigraphically useful Cenomanian to Maastrichtian planktonic foraminifera recognizable in thin section.

(Serra Kiel et al., 1998) (Fig. 3.8). The Paleocene larger benthic foraminifera (Plate. 3.4, IBR144B) are characterized by the presence of *Ranikothalia sidensis* (Davies), *Miscellanea miscella* (d'Archiac and Haime), *Lockhartia conditi* (Nuttall), *Aberisphaera gambanica*

(Wan) with *Archaeolithothamnium nummuliticum* (Gümbel). *Ranikothalis*, *Miscellanea*, *Lockhartia*, and *Aberisphaera* can be taken as index fossils for SBZ3-5 (Fig. 3.8). A few species of Upper Cretaceous *Orbitoides* such as *Orbitoides apiculate* (Schlumberger) and *Orbitoides media* (d'Archiac) are also recognized. *Orbitoides* are characteristic of coastal and reef facies, and commonly found in the Upper Cretaceous sediments of the Tethys. *Archaeolithothamnium* algae has considerable geologic range, extending from the Late Cretaceous (Santonian-Campanian) to the Eocene.

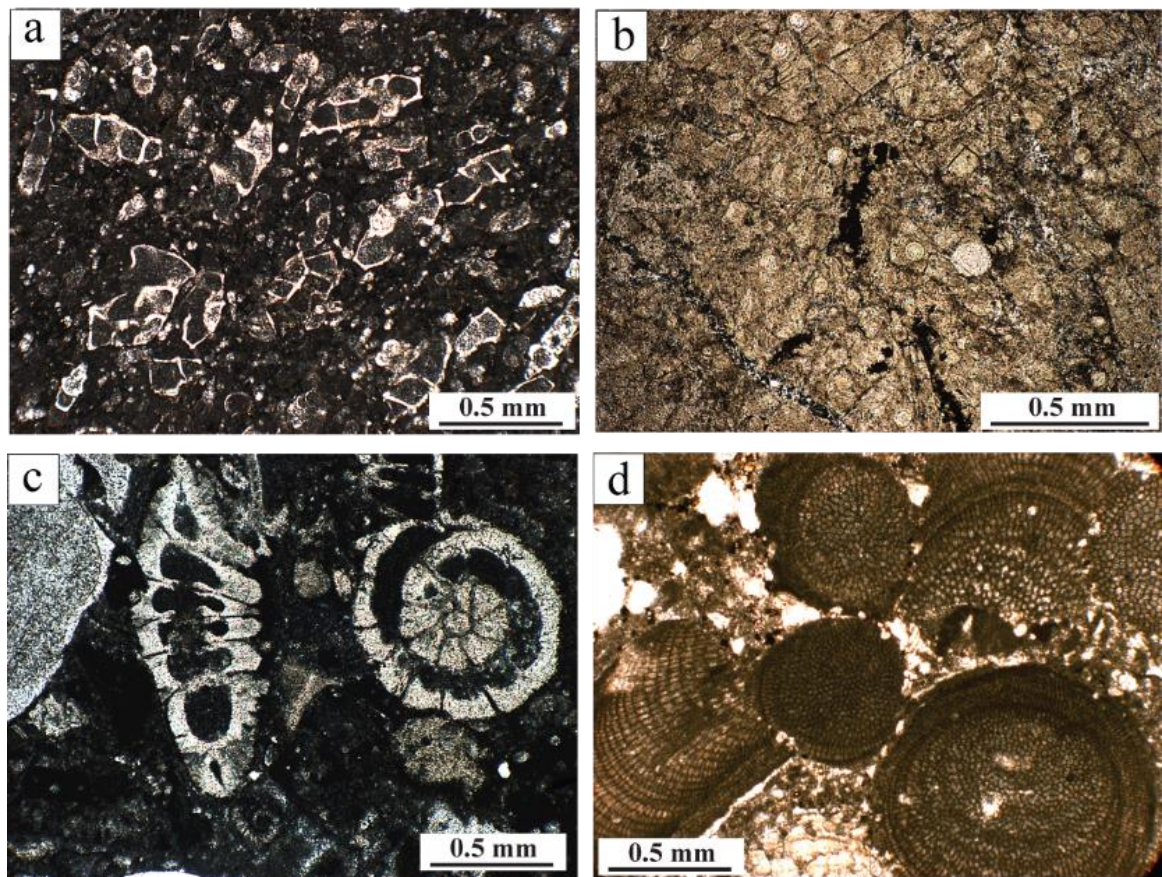


Fig. 3.8: Photomicrographs of limestones exposed at Ramree Island. (a) planktonic foraminifera, (b) radiolarian fossils, (c) larger benthic foraminifera, and (d) Dasycladacean algae.

Plate 3.3

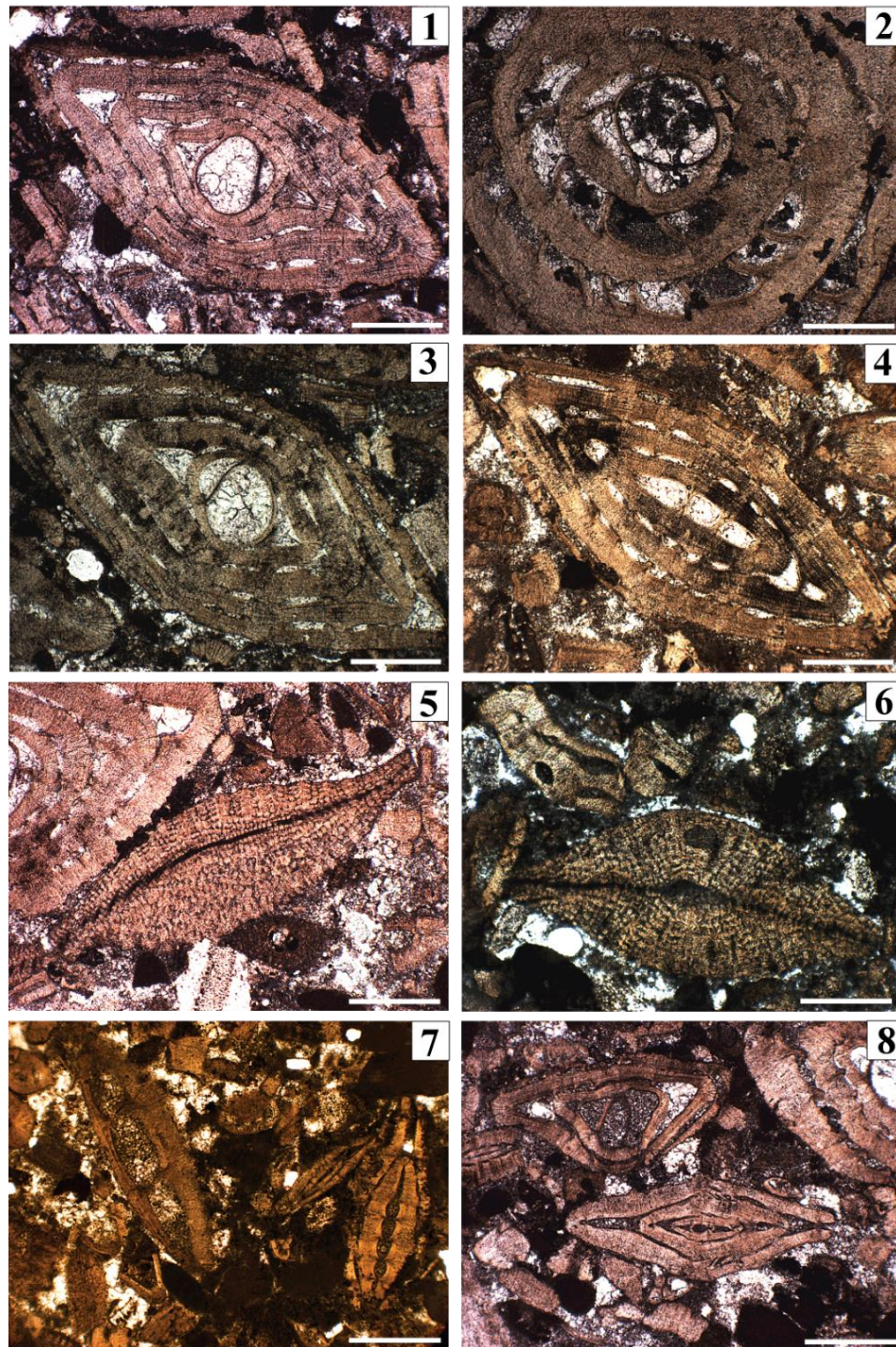


Plate. 3.3: Photomicrographs of the larger benthic foraminifera from the Ramree Island (IBR146): the scale bars correspond to 0.5 mm. 1, 2. *Nummulites globulus* (Leymerie), 3, 4. *Nummulites ataticus* (Leymerie), 5. *Discocyclina dispana* (Sowerby), 6. *Discocyclina sowerbyi* (Nuttall), 7 and 8. *Nummulite* sp. and *Assilina* sp.

Plate 3.4

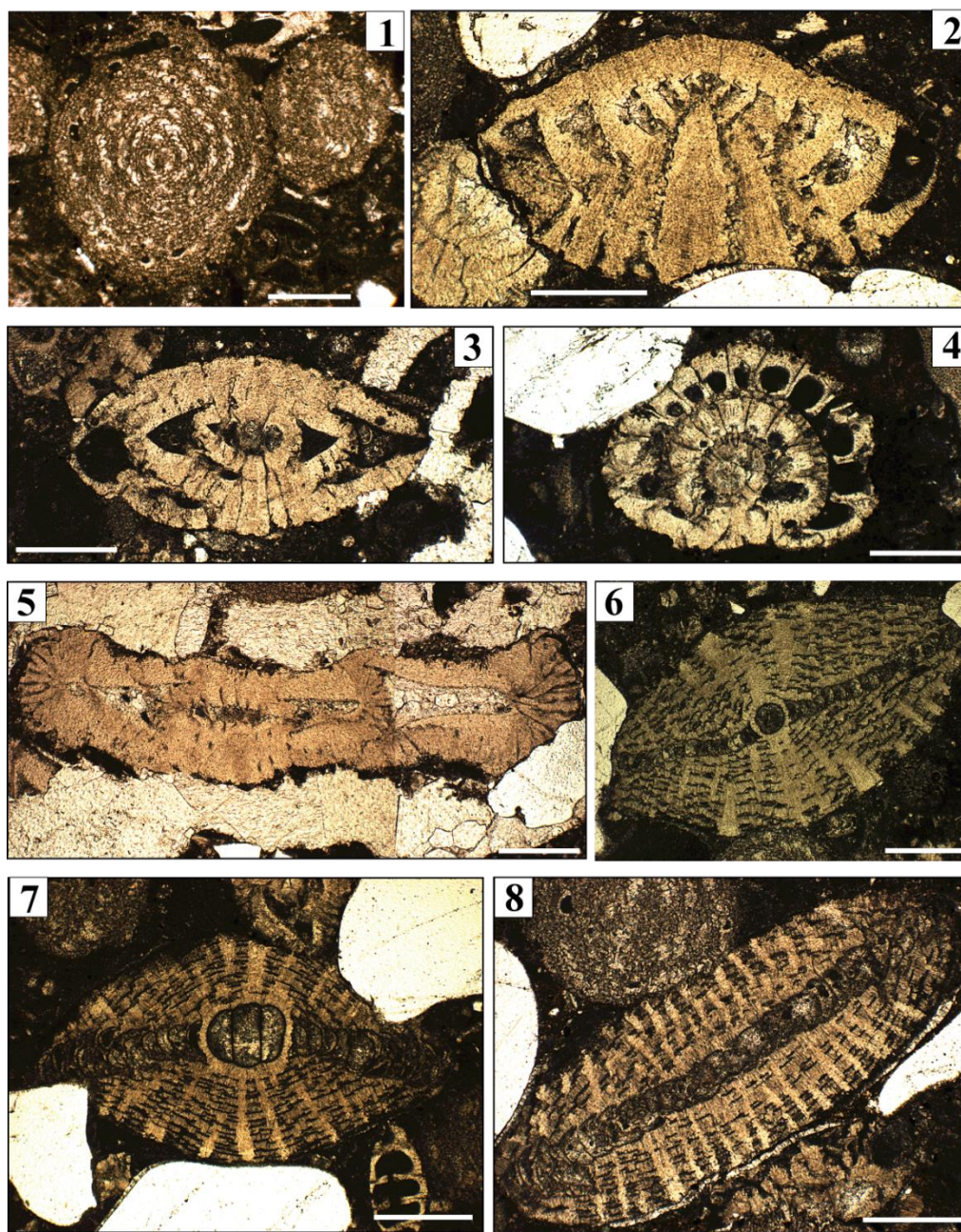


Plate. 3.4: Photomicrographs of the larger benthic foraminifera from the Ramree Island (IBR144B): the scale bars correspond to 0.5 mm. 1. *Aberisphaera gambaica* (Wan), 2. *Lockhartia conditi* (Nuttall), 3, 4. *Miscellanea miscella* (d'Archiac & Haime), 5. *Ranikothalia sindensis* (Davies), 6. *Orbitoides media* (d'Archiac), 7. *Orbitoides apiculata* (Schlumberger), and 8. *Orbitoides cf. tissoti* (Schlumberger).

Shallow Benthic Zone (SBZ)	Paleocene				Early Eocene				
	2	3	4	5	6	7	8	9	10
IBR146									
<i>Nummulites globulus</i>							■	■	
<i>Nummulites ataticus</i>							■	■	
<i>Discocyclina dispansa</i>								■	■
<i>Discocyclina sowerbyi</i>								■	■
IBR144B									
<i>Aberisphaera gambanica</i>			■						
<i>Ranikothalia sindensis</i>			■	■					
<i>Miscellanea miscella</i>			■	■					
<i>Lockhartia conditi</i>				■					

Fig. 3.9: Stratigraphic distributions of the Paleocene-Eocene larger benthic foraminifera in limestones from Ramree Island.

3.5.2 Shale

Eleven shale samples from the transect through the Rakhine Yoma were analysed for biostratigraphy. Samples range from Cenozoic continental/paralic sediments of the Central Basin in the east, a deep-water Cretaceous unit, and in the west deep-water Cenozoic deposits. The purportedly Cretaceous-Cenozoic deep-water sediments are typically unfossiliferous and difficult to differentiate by lithology alone. This study attempted to identify new, more robust biostratigraphic ages for this region, based on planktonic foraminifera, radiolaria and nannofossils extracted from the dominant shale lithology.

Gramann (1974) recorded agglutinated foraminiferal fauna from the red shales at Milepost 89 on the Padaung-Taungup road, yielding *Ammodiscus siliceus* (Terquem),

Glomospira irregularis (Grzybowski), *Glomospira charoides* (Jones & Parker), *Glomospirella gaultina* (Berthelin) and *Haplophragmoides nonionoides* (Reuss). However, he could not give a precise date and assigned an Upper Cretaceous - Paleogene age. In general, agglutinated foraminiferal faunas have long age ranges and have limited biostratigraphic utility (e.g. *Ammodiscus siliceus* (Terquem) is known from much of the Late Mesozoic to Cenozoic (e.g. Morgiel & Olszewska, 1981; Neagu, 2004). At Taungup Pass (Milepost 47 and 48), Cretaceous-age planktonic foraminiferal faunas (*Globotruncana* 2 and *Gumbelina* 7) were recorded by Fay Lain and Win Maw (1970). Lithologically, this area is a monotoneous series of shales and very hard to differentiate from the Eocene flysch. Given the paucity of accessible, well-documented biostratigraphic data an attempt has been made to constrain the age of mapped Cretaceous and Eocene successions (United Nations, 1979). Unfortunately, most of the samples processed were devoid of datable microfossils, but some of them (IBR93, 98, 99A, 103, 107, 108 and 111) from the Padaung-Taungup road and IBR168 from the Gwa road section yielded rare diagnostic fossils. Samples from the Padaung-Taungup road were taken from the Cretaceous unit (between milepost 33 - 47) and have yielded *Heterohelix globulosa* (Ehrenberg) in all samples *Hedbergella planispira* (Tappan) in IBR108 and *Hedbergella delrioensis* (Carsey) in IR103 (Plate. 3.5a,b,c,d). Nannofossils adhered to the planktonic foraminifera in IBR98 were identified (by Paul Brown, University College London) in SEM images as *Prediscosphaera columnata* (Stover) and *Watznaueria* sp. (Plate. 3.5e,f). The age of planktonic foraminifera assemblage indicates the age range from Aptian to Maastrichtian and the nannofossils indicate Albion – Turonian. The microfossils associated with this unit indicate the sediments were deposited during the Cretaceous if they are not reworked. Samples, IBR06 and IBR12 from the Paleogene Era

Plate 3.5

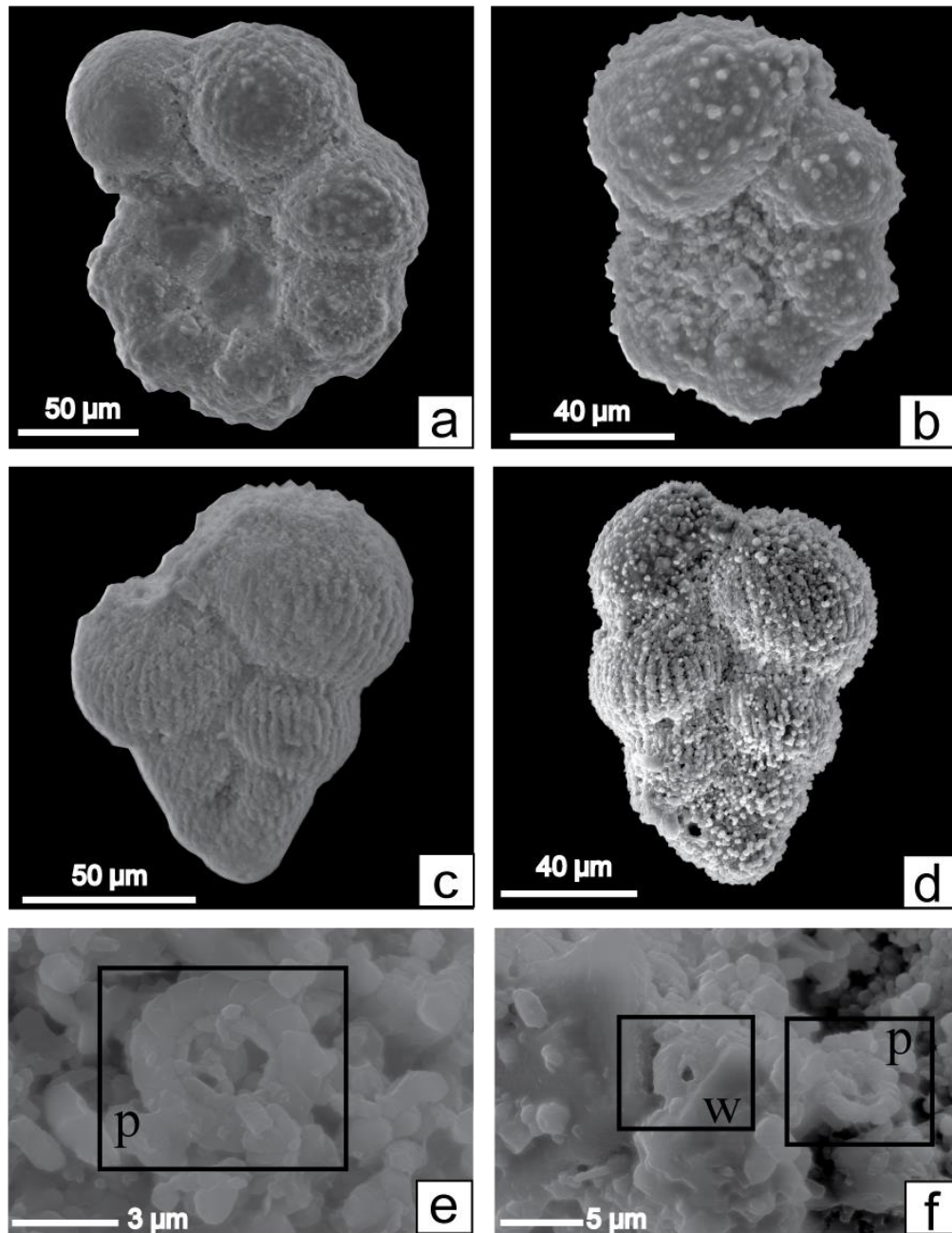


Plate. 3.5: SEM images of microfossils and nannofossils from the Padaung-Taungup road section. (a) *Hedbergella planispira* (Tappan), (b) *Hedbergella delrioensis* (Carsey), (c) and (d) *Heterohelix globulosa* (Ehrenberg), (e) *Prediscosphaera columnata* (Stover) (p), and (f) *Prediscosphaera columnata* (Stover) (p) and *Watznaueria* sp. (w).

Plate 3.6

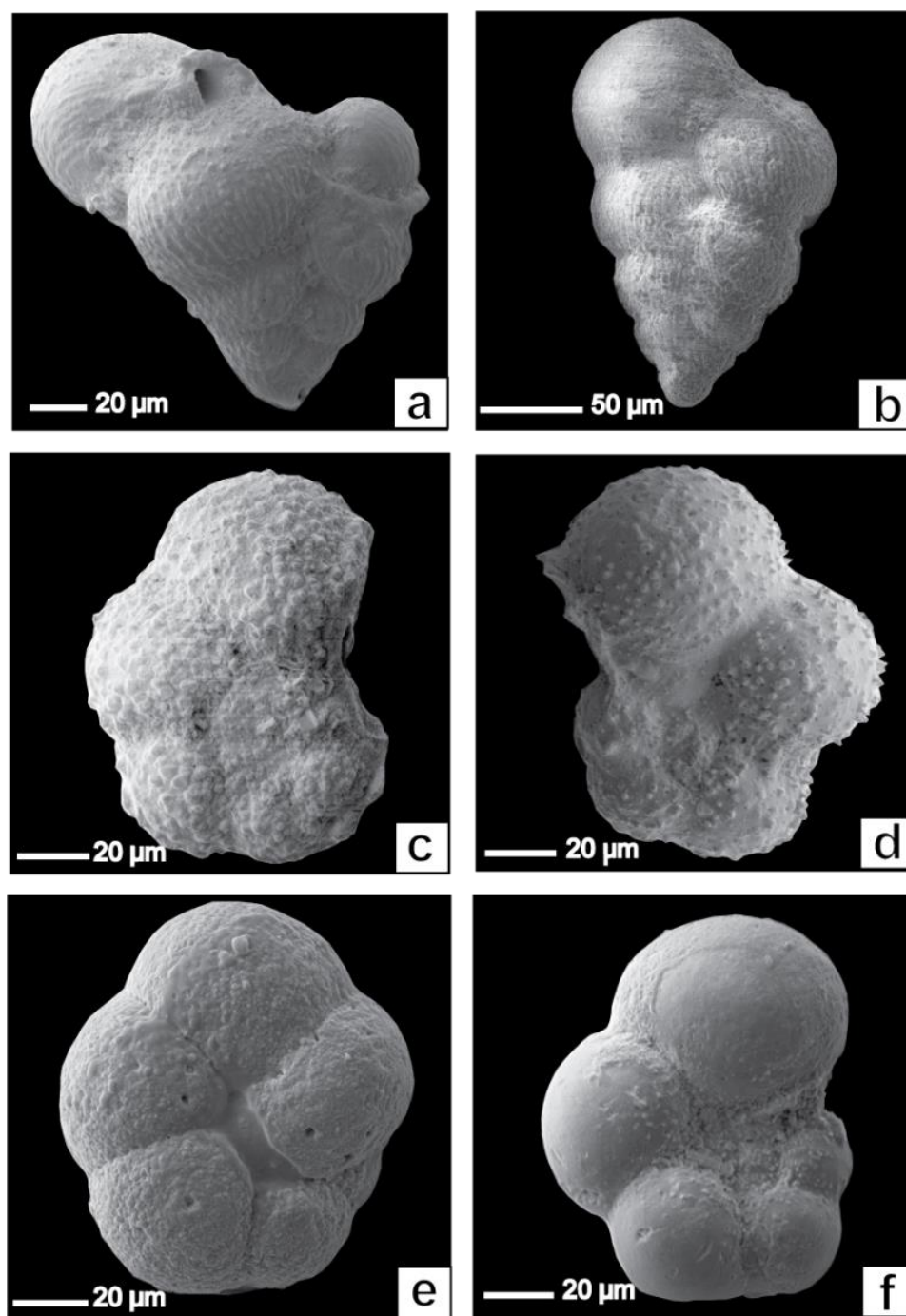


Plate. 3.6: SEM images of microfossils from Padaung-Taungup road section. (a) *Chiloguembelina wilcoxensis* (Cushman & Ponton), (b) *Chiloguembelina ototara* (Finlay), (c,d) *Globorotaloides carcoselleensis* (Toumarkine & Bolli), (e) *Planorotalites chapmani* (Parr), and (f) *Morozovella pseudobulloides* (Plummer).

have yielded only a few microfossils including both Eocene and Paleocene species. *Chiloguembelina wilcoxensis* (Cushman & Ponton), *Chiloguembelina ototara* (Finlay) (Plate. 3.6a,b), and *Globorotaloides carcoselleensis* (Toumarkine & Bolli) (Plate. 3.6c,d), were observed and a Paleocene age determined by the presence of *Planorotalites chapmani* (Parr) and *Morozovella pseudobulloides* (Plummer) (Plate. 3.6e,f). Despite these rare identifications, there are simply too few occurrences of fossils from the shales in the area to be sure of the age of sediments.

3.5.3 Chert

One sample (KM67c) of the chert in the Ngapali Formation was treated for radiolarian extraction. Presented here are the first assemblages of well-preserved radiolarians from the mélange. The radiolarian fauna is dominated by *Amphisphaera macrosphaera* (Nishimura), *A. coronata* (Ehrenberg), *Actinommidae gen. et sp. indet.*, *Phormocyrtis turgida* (Krasheninnikov), *Podocyrtis papalis* (Ehrenberg), *Lamptonium fabaeforme fabaeforme* (Krasheninnikov), *Lychnocanoma carinatum* (Ehrenberg), *L. babylonis* (Clark and Campbell), *Cryptamphorella macropora* (Dumitrica), *Clathrocycloma parcum* (Foreman), *Haliomma teuria* (Hollis), and *Spongodiscus sp.* (Plate. 3.7). The radiolarian assemblage is assigned to a late Paleocene to early Eocene age (Fig. 3.10).

Plate 3.7

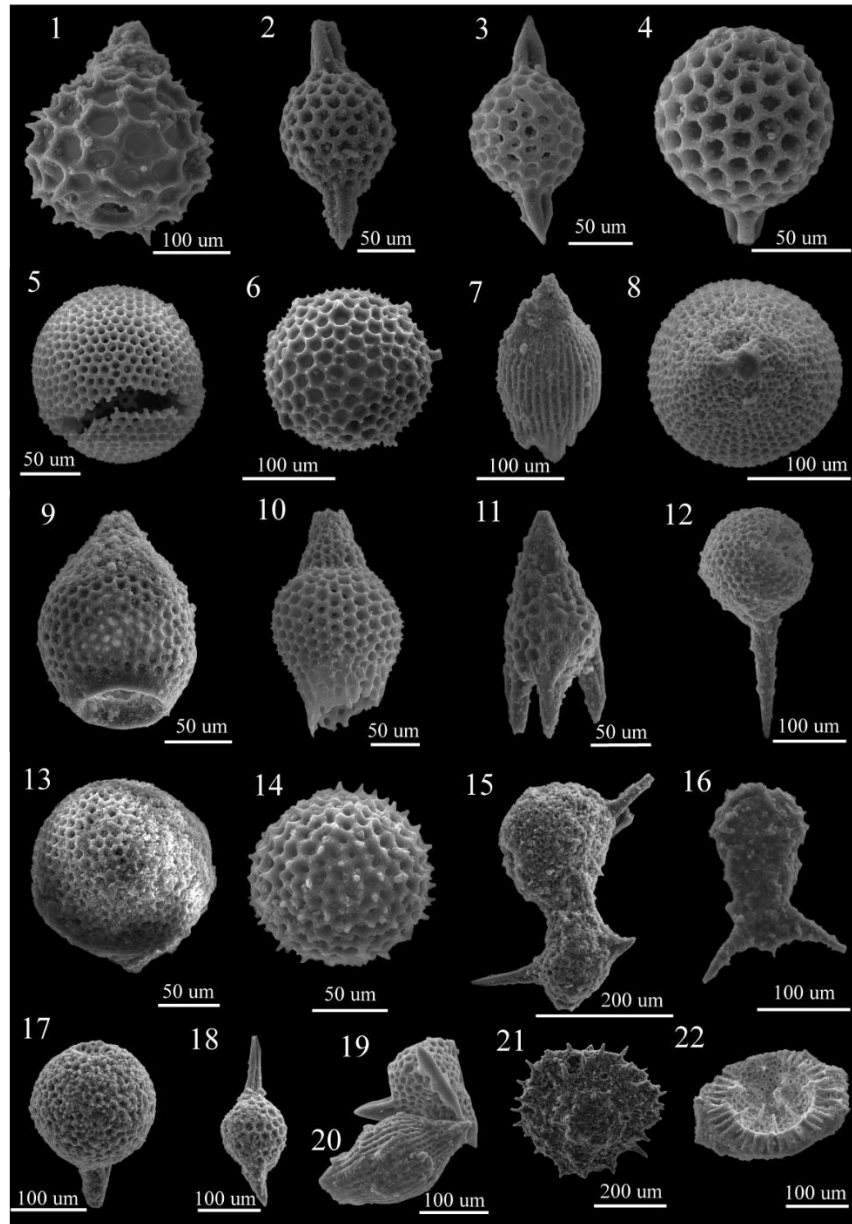


Plate. 3.7: SEM images of radiolarians from the Ngapali Formation. 1. *Clathrocycloma parcum* (Foreman), 2,3,4. *Amphisphaera macrosphaera* (Nishimura), 5,6,8,14. *Actinommidae* sp., 7,20. *Phormocyrtis turgida* (Krasheninnikov), 9. *Podocyrtis papalis* (Ehrenberg), 10. *Lamptonium fabaeforme fabaeforme* (Krasheninnikov), 11. *Lychnocanoma carinatum* (Ehrenberg), 12,17,18. *Amphisphaera coronata* (Ehrenberg), 13. *Haliomma teuria* (Hollis), 15,16. *Amphisphaera* (?) sp., 19. *Lychnocanoma babylonis* (Clark and Campbell), 21. *Orbula* (?) sp., and 22. *Spongodiscus* sp.

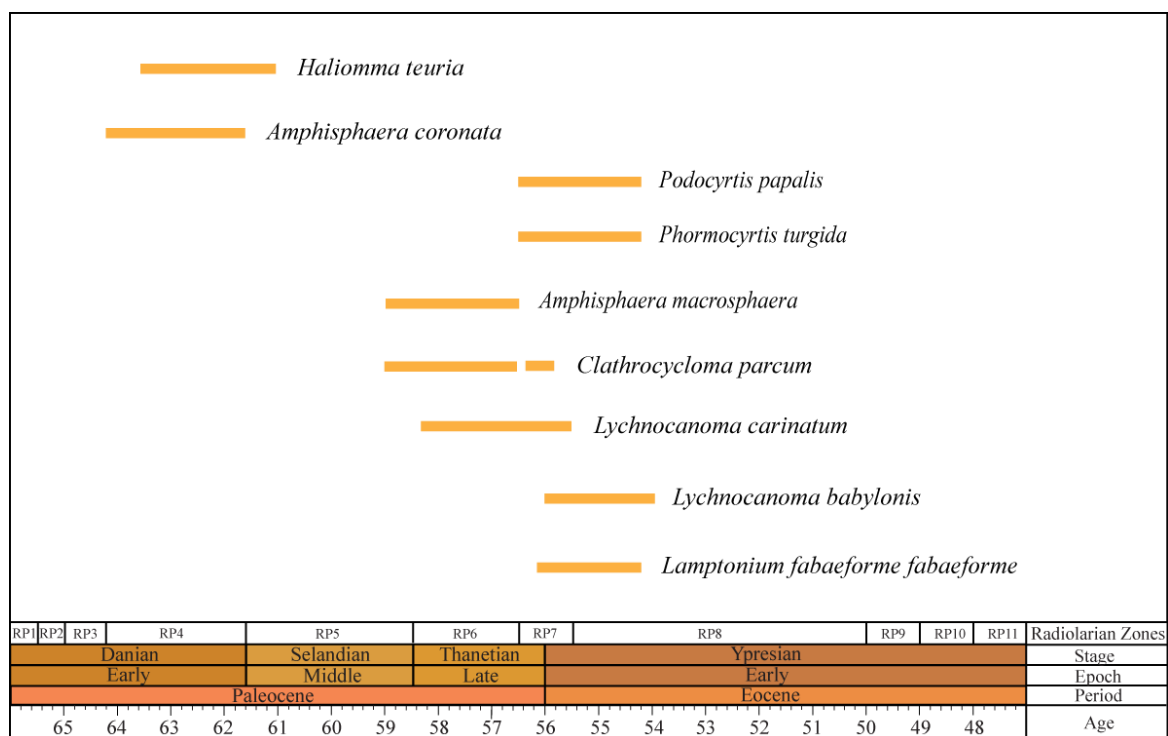


Fig. 3.10: Stratigraphic ranges of the radiolarian fossils in the Ngapali Formation, Rakine coastal area (sample KM67c).

3.6 Petrography

3.6.1 Sandstone

Five sandstone samples (IBR10, 45A, 101, KM60 and KM76a) were collected along the Padaung-Taungup road and Gwa road sections. Petrographic point-count data from the fine to medium grained sandstones are presented in Appendix 2 and plotted on ternary diagrams (Fig. 3.11).

One sample (KM76a) was collected from the Gwa road section where serpentinites are in tectonic contact with strata of either Eocene or Triassic age. The analysed sample is a litharenite (Fold, 1980) that is composed predominantly monocrystalline quartz with

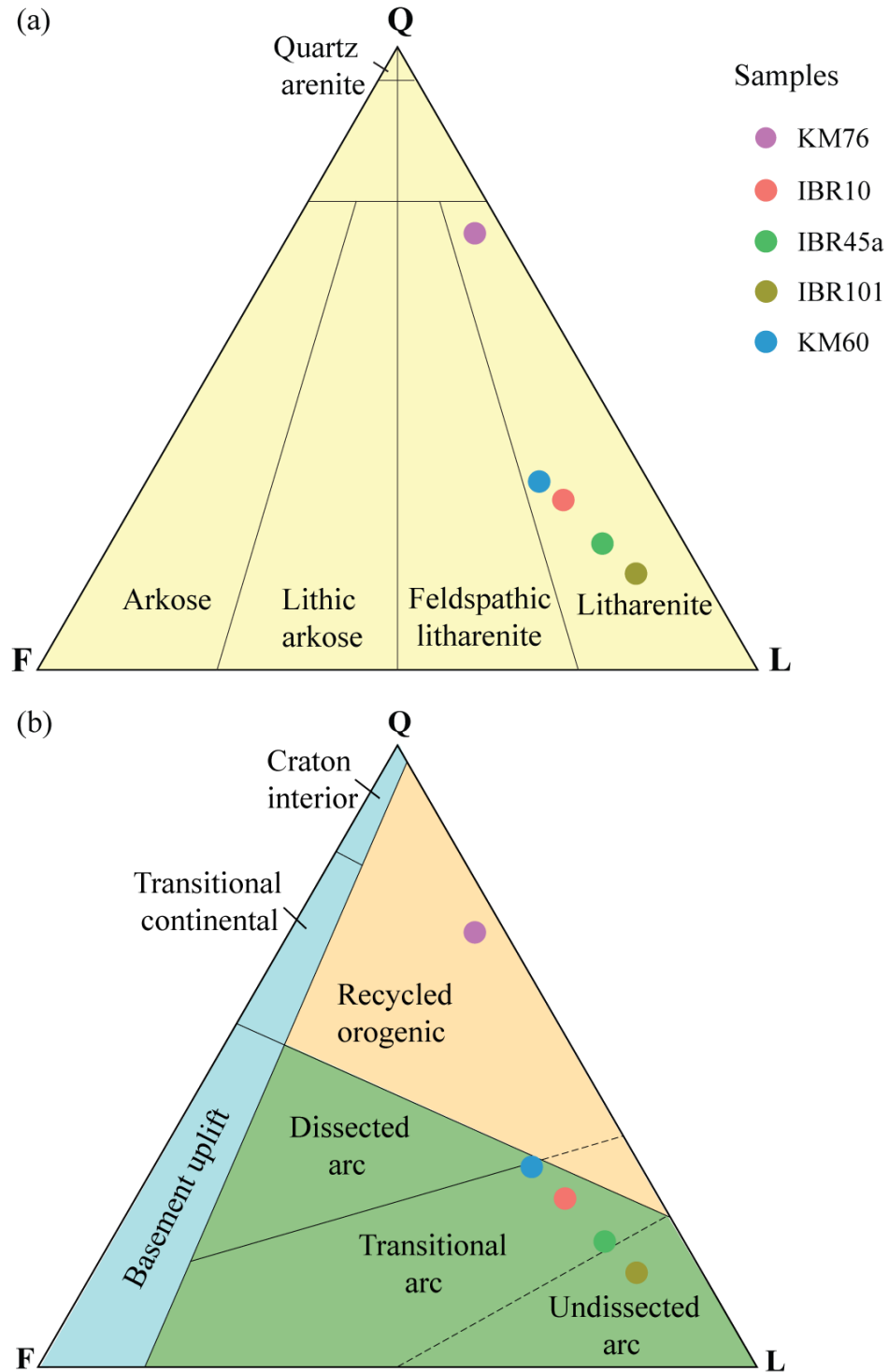


Fig. 3.11: QFL plots showing (a) sandstone classification (Folk, 1980) and (b) provenance fields (Dickinson et al., 1983) for the study area. Q-total quartz, F-total feldspar and L-total lithics.

subordinate polycrystalline quartz, plagioclase feldspar and lithic fragments, which include phyllite, mudstone, chert, and intermediate to basic volcanic rocks. Muscovite, chlorite, zircon and rutile are common accessory minerals. Subangular to subrounded and mostly monocrystalline quartz grains constitute 56% of total framework grains. The semicomposite quartz grains exhibit slightly undulatory extinction. The polycrystalline quartz grain with strong elongation or stretching of the quartz crystals that indicate the origin of these grains are from a metamorphic source terrane. Lithic fragments constitute 23% of framework grains and are mainly represented by metamorphic lithics (phyllite) and minor sedimentary lithics (mudstone, chert). Plagioclase feldspar (3%) is a minor phase and shows twinning. Some plagioclase feldspar grains have been partly replaced by clay minerals as well as calcite (Fig. 3.12a). In places matrix has replaced the grain boundaries (Fig. 3.12a,b). On QFL (quartz, feldspar, lithics) plots (Dickinson et al., 1983) the sandstone lies within the recycled orogenic provenance field (Fig. 3.11).

Petrographic examination of the sandstone samples (IBR10, 45A, 101 and KM60) from the Padaung – Taungup road section indicates that they are primarily litharenites. Petrographic point-count data from the fine to medium grained sandstones are presented in Appendix 2. The petrographic data show a significant proportion of volcanic lithic detritus with subordinate sedimentary (argillaceous fragments) and metamorphic fragments (phyllites) (Fig. 3.12c,d,f,g) and on the standard QFL plot of Dickinson et al. (1983) plot within the magmatic arc provenance field (Fig. 3.11). Lithic fragments provide the most significant evidence of source rock compositions. Among the framework grains, fine-medium size monocrystalline quartz is the most abundant constituent showing the presence of sub-angular to sub-rounded, non-undulatory and undulatory as well as polycrystalline

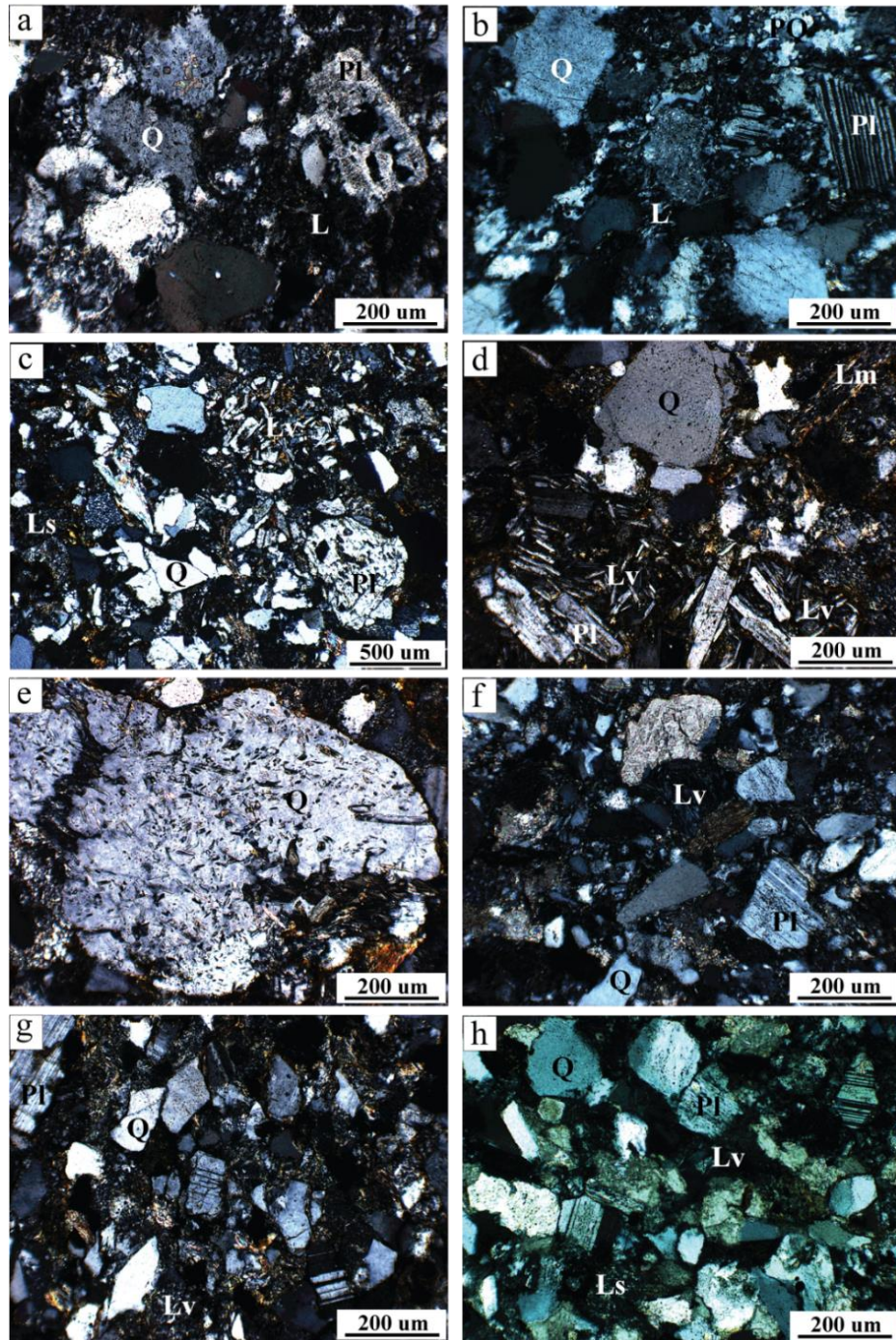


Fig. 3.12: Photomicrographs of the sandstones in the study area. (a), (b) Late Triassic Pane Chaung Formation, (c),(d) litharenite volcanoclastic sandstones, (e) quartz grain include mineral inclusions, (f),(g) litharenite volcanoclastic sandstones, and (h) litharenite sandstone. Q-quartz, Pl-plagioclase, L-lithic, Lv-volcanic lithic, Ls-sedimentary lithic, Lm-metamorphic lithic.

quartz. A few quartz grains show both fluid and mineral inclusions. The smaller needle-fibre inclusions are probably tourmaline on the basis of their greenish crystal colour, shape and birefringence (Fig. 3.12e). Feldspar is dominated by plagioclase. Plagioclase grains exhibit euhedral crystal outlines and well developed twinning (Fig. 3.12b,f,g,h). The thin, more brightly birefringent minerals surrounding some of the grains are carbonate cements. The matrix content is high in these mineralogically and texturally immature, and poor to moderately sorted sandstones.

3.6.2 Limestone

Petrographic description of the limestones of Rakhine area has been carried out primarily to understand their depositional and diagenetic origin, and to resolve their field relations with the predominant siliciclastic lithologies of the area. The planktonic foraminifera-bearing limestones are fine-grained, compact, and usually massive (Fig. 3.13a,c,d,e). The larger benthic-bearing limestones are coarse-grained and usually massive. In most of the cases the underlying beds are mostly shales and the contact is not very clear because they do not show any bedding traces. In some planktonic foraminifera-bearing limestones, there are irregular micro and macro stylolite structure and cross-cutting calcite veins (Fig. 3.13b). The pelagic limestones are composed of calcite spar, carbonate grains or aggregates including fossils and reworked limestone fragments, and terrigenous and authigenic constituents. Calcite spar occurs as cement, vein fillings, and recrystallized or replaced fossil fragment. Fossils are by far the most abundant and varied of the carbonate grains. Fossils identified in thin-section study include planktonic and benthonic foraminifera, and red algae. They hold great promise as indicators of environment. The percentage of fossils were determined by visual estimation in thin section. The terrigenous

constituents, clay minerals cannot be adequately studied in thin section. The matrix of the limestone consists of microcrystalline calcite that appears dusty or imperfectly translucent in thin section (IBR09, 48B and 53A). Very finely crystalline fragments which probably are fragments of reworked limestone and poorly preserved fossils.

A petrographic description of limestone types has been completed based on a Dunham (1962) classification for the purpose of environmental interpretation. Four petrographic types have been identified i.e., mudstone, wackestone, packstone, and grainstone (Fig. 3.14).

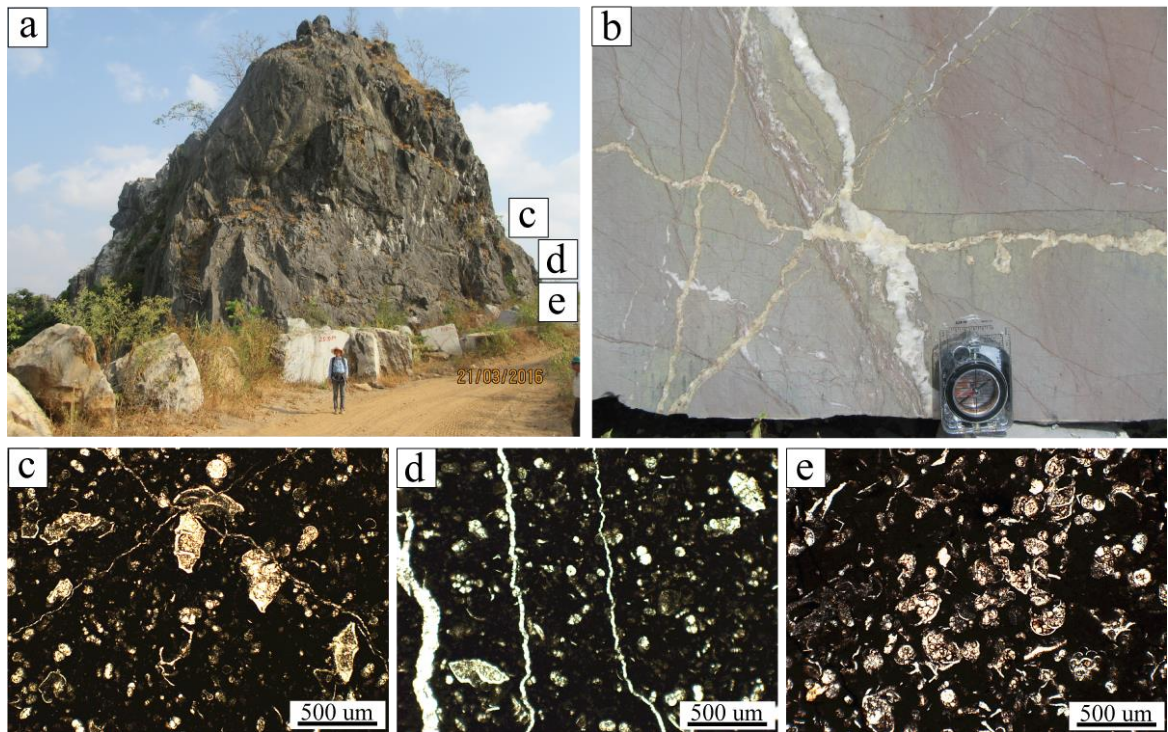


Fig. 3.13: (a) massive limestone block from Nabutaung, (b) parallel and cross-cutting calcite veins and irregular micro and macro stylolite structures, (c),(d) and (e) photomicrographs of planktonic foraminifera from Nabutaung, show sample locations on fig. 3.3(a), c- IBR22, d-IBR23, e-IBR25.

Mudstone microfacies has been observed in sample IBR48B, 53A, 166C and 167, and shows a high proportion of micrite with few grains (Fig. 3.14a). The matrix is likely dominated by carbonate mud. Foraminifera occur within the vein and dissolution surfaces that are almost certainly diagenetic. According to Dunham (1962), mudstone is deposited in low energy environment either in protected seas or below the fair weather base (calm water). In addition, this muddy carbonate rock is also indicative of low maturity of the limestones that are characterized by a high proportion of micrite and low proportion of allochems.

Wackestone microfacies is one of the most common microfacies occurring in the planktonic-bearing limestones (IBR09, 22, 25, 34A, and 152). This microfacies is a mud-supported carbonate rock containing more than 10% allochems which are floating in a carbonate mud matrix (Fig. 3.13c,d,e, 3.14b). The limestones exhibit numerous interparticle pore spaces that are filled with micorsparite and sparry calcite cement. Thin films of isopacheous microcrystalline calcite cement are formed around the bioclasts. The limestones show minor veins, which are filled with micorsparite calcite cement.

Packstone or fossiliferous limestones are grain supported muddy carbonate rocks where micrite is precipitated within the intergranular pores (IBR23, 31 and 149). Fossils are filled interstitially and dominantly with sparry calcite cement and some carbonate mud (Fig. 3.14c). In samples IBR23, 31 and 149, the grains are mainly planktonic foraminifera, and other unidentified skeletal fragments. The internal structures of most of the fossils are obliterated due to micritization and recrystallization during diagenesis. Fossils are found embedded in the microcrystalline calcite matrix. These limestones are planktonic foraminiferal biomicrites whose paleodepths of deposition are problematic, but probably ranged from outer shelf to deep ocean basin (Nelson et al., 1996). The mass occurrences of

poor- to moderate-preserved planktonic foraminifera were observed in pelagic packstones. The test chambers of the foraminifera are frequently filled with calcite cement, pyrite

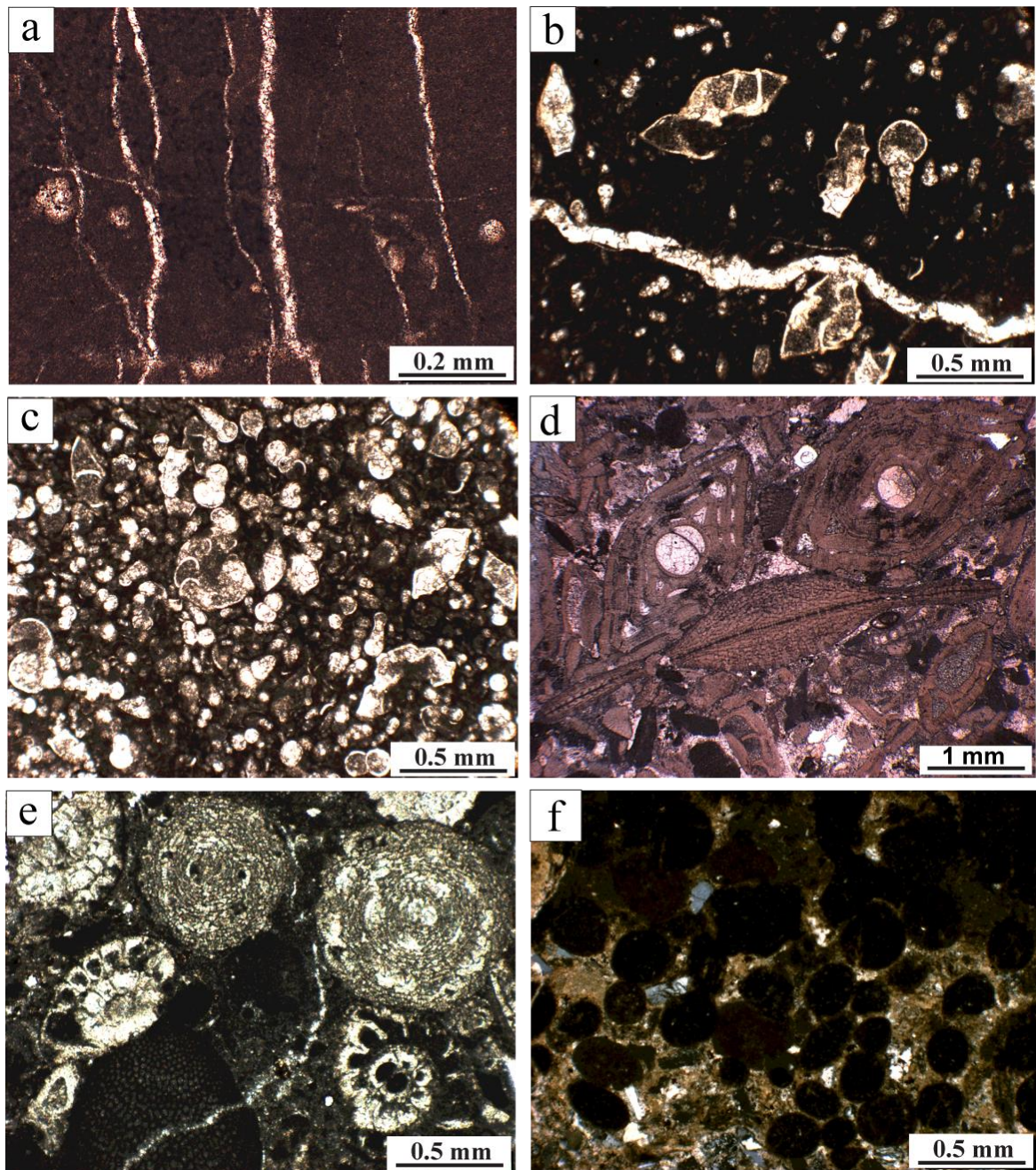


Fig. 3.14: Photomicrographs of the limestones from the study area. (a) parallel and mudstone with little allochem, (b) wackestone, (c) planktonic foraminifera packstone, (d) larger benthic foraminifera packstone, (e) larger benthic foraminifera grainstone, and (f) sand-sized peloids.

framboids, authigenic clays and organic matter and also exhibit calcispheres scattered through the matrix. In the larger benthic foraminiferal-bearing limestone samples, the *Nummulites* packstone is dominated by *Nummulites* sp. (up to 40%) and subordinate *Discocyclus* sp., *Assilina* sp. are also present (IBR146). Both the wall structure and test morphology of *Nummulites* (predominantly A-form) and minor *Discocyclus* which showing largely intact in this sample (Fig. 3.14d). The inter-particle as well as intra-particle pore spaces are generally filled with drusy spar.

Grainstone (IBR144B) is characterized by abundant large benthic foraminifera and calcareous algae in sparry calcite cement (Fig. 3.14e). Algal micrites are associated with algal components having specific algal features. IBR128 (Fig. 3.14f) is made up largely of sand-sized, peloids.

3.6.3 Basalt

Pillow basalts are well exposed in the Rakhine coastal area. The pillow lavas are brownish, massive, showing pillow structures at many places, and are highly variable both in size and shape (Fig. 3.15a). Pillows mostly tend to be spheroidal in shape (Fig. 3.15b). In some of the pillows, xenoliths of lava fragments are also noticed. Petrographic observation of the pillow lavas (IBR150, KM68, 69, 70b and 71) shows that the mineralogy mainly comprises plagioclase and clinopyroxene microphenocrysts in a fine-grained ferruginous groundmass, along with glass and shows well preserved basaltic textures. Plagioclase occasionally occurs as a network of randomly oriented plagioclase laths enclosing other minerals of the rock, being microlites. Plagioclase microlites exhibit quenched morphologies. Some are skeletal and acicular (Fig. 3.15c,d), while a few are characterized by the swallow-tailed morphology, and hopper or H-shaped morphology. The

clinopyroxenes also occur as quenched forms in association with plagioclase microlites. Quenched clinopyroxenes are spherulitic, intergrown with closely spaced plagioclase fibers.

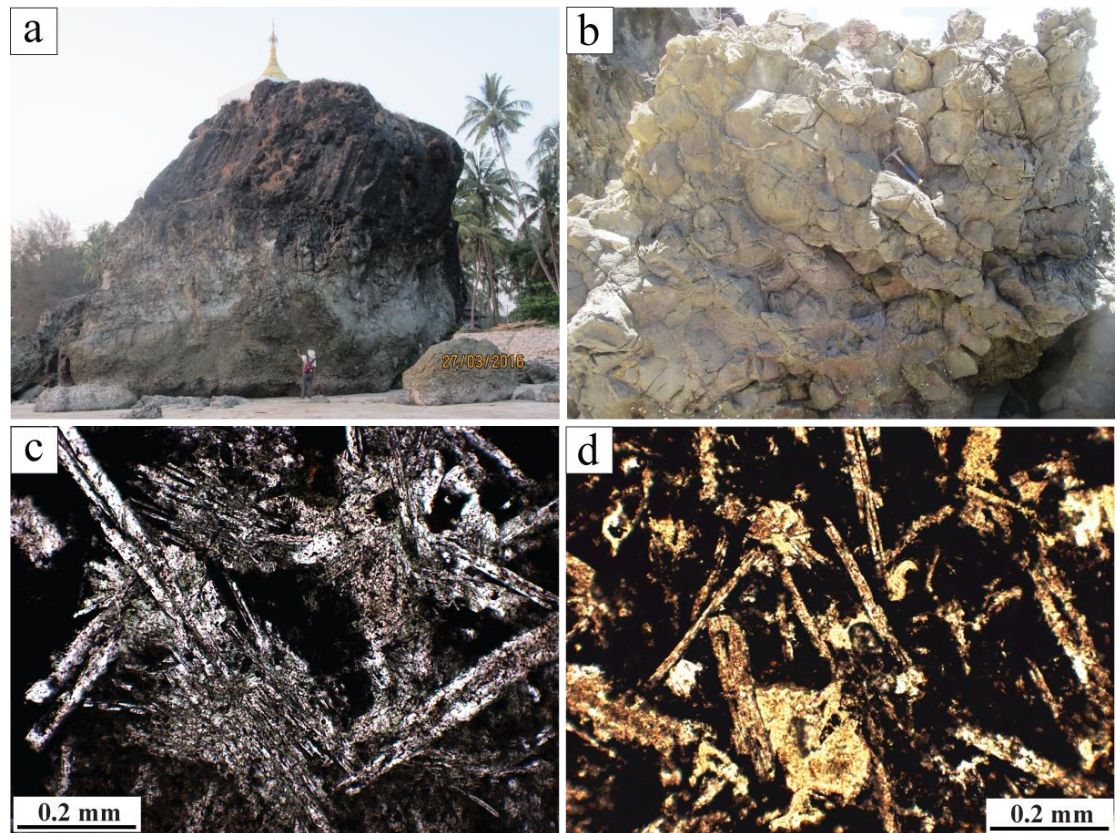


Fig. 3.15: (a), (b) Field photos of pillow basalt from the Ngapali Formation, Rakhine coastal area. (c) and (d) photomicrographs of pillow basalt show spherulitic nature of clinopyroxene, and skeletal and acicular nature of plagioclase.

3.6.4 Serpentinite

Serpentinite is a green or dark green colored and massive rock, exhibiting a mesh texture even in hand specimen with a fine network of dark veins composed of serpentine (Fig. 3.16a). In the serpentinite samples (KM74, 74a), serpentines occur as fine sheaf and plates often in a criss-cross meshwork texture (Fig. 3.16b). Mesh texture is common, consisting of

primary and secondary veins of serpentine enclosing isolated grains of olivine and pyroxene in serpentinites. Almost all of the primary silicates have been altered in all samples, but chrome spinel has survived alteration and preserved as primary fine spinel granules at the core (Fig. 3.16c,d). Besides serpentine, other minor phases such as opaque/chrome spinel, talc, and mica are present.

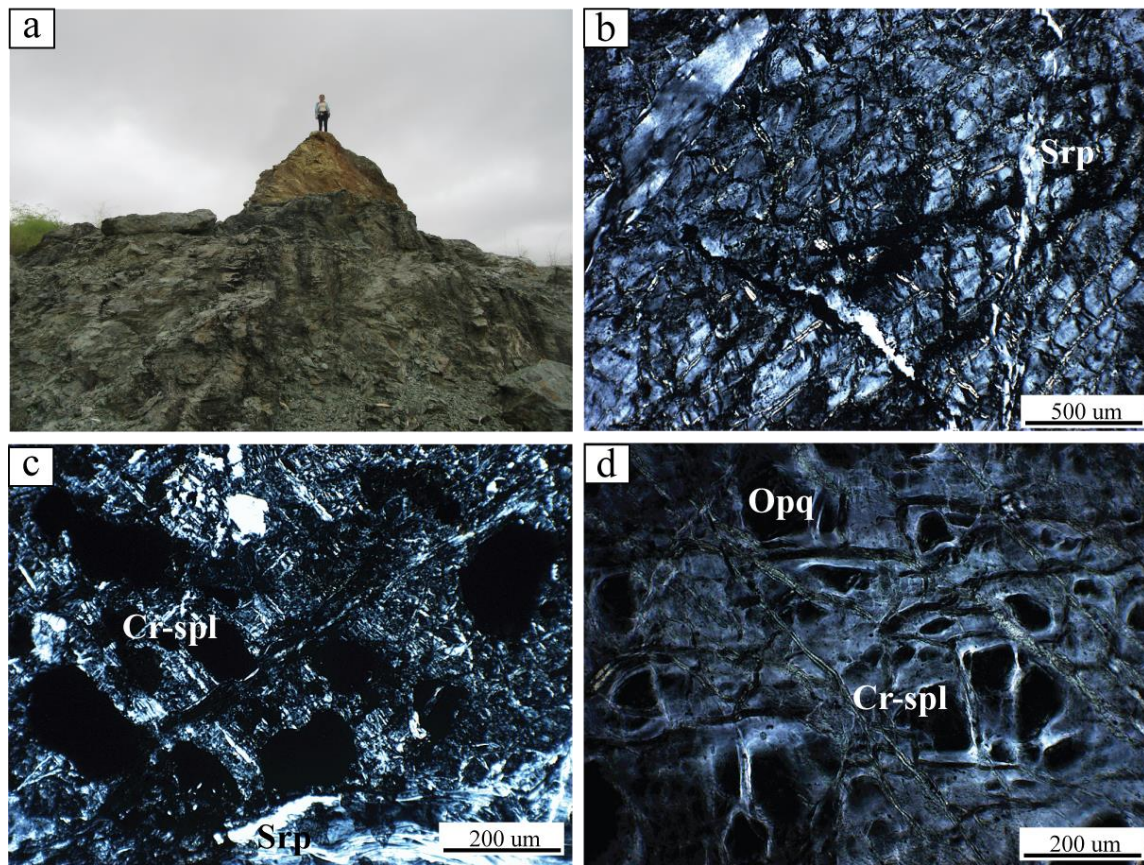


Fig. 3.16: (a) Field photos of serpentinite from the Gwa road section. Photomicrographs of serpentinite: (b) criss-cross meshwork texture, (c) and (d) spinel granules at the core. Srp= serpentine, Cr-spl=spinel, Opq=opaque.

3.7 Stable Isotope Geochemistry

The carbon and oxygen isotopic composition of ancient limestone may change during epigenesis or may continue to reflect the sedimentary environment in which it formed (Magaritz, 1975). $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ of carbonates are commonly used to distinguish the depositional and/or diagenetic (paleo)environments responsible for carbonate formation (Nelson & Smith, 1996). In the present study, the analysis of the stable isotopes of oxygen and carbon in carbonate samples aimed to assist with the interpretation of sedimentary and diagenetic conditions and environments.

The petrographic study of fourteen limestone samples reveals a range of lithofacies from mudstone, bioclastic wackestone to packstone, that consist chiefly of planktonic foraminifera. Foraminifera display a wide range in quality of preservation in which the chamber walls have been partially or wholly obliterated by diagenetic processes (Fig. 3.17a,b). Many tests are broken, some by compaction and others by preburial processes as evident from isolated test fragments (i.e. water column fragmentation). Some tests are truncated by solution contact with the adjacent matrix. The pore spaces are filled with microsparite and sparry calcite cement. In the case of pelagic limestones the micrite comes mainly from coccoliths and so the mineralogy should be calcite. Samples (IBR129A and 140) show visible evidence of recrystallization in thin section.

The isotopic composition of limestones is illustrated by the relationship between their $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values on a cross-plot (Fig. 3.18) and the stable isotope data are presented in Appendix 4. Samples were extracted from both micritic matrix and from diagenetically-recrystallised carbonate (including veins). The $\delta^{13}\text{C}$ values of micrite varies from -11.2‰

to 2.6‰ (VPDB) and $\delta^{18}\text{O}$ values from -12‰ to -3.8‰ (VPDB). The $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values of calcite veins range from -11‰ to 2.4‰ (VPDB) and -11‰ to -3.9‰ (VPDB), respectively. In Figure. 3.18, it is shown that the $\delta^{13}\text{C}$ values from the planktonic foraminifera-bearing micrite and the vein calcite are similar, whereas the $\delta^{18}\text{O}$ values differ significantly. The carbon and oxygen isotope composition of micrites and veins from the fine-grained carbonate (IBR48B, 53A, 166C, Fig. 3.17c,d) and recrystallized limestones (IBR129A, 140) have very light $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values, -8.0‰ to -11.0‰ (VPDB) and -10.0‰ to -12.0‰ (VPDB), respectively. These observations are consistent with burial

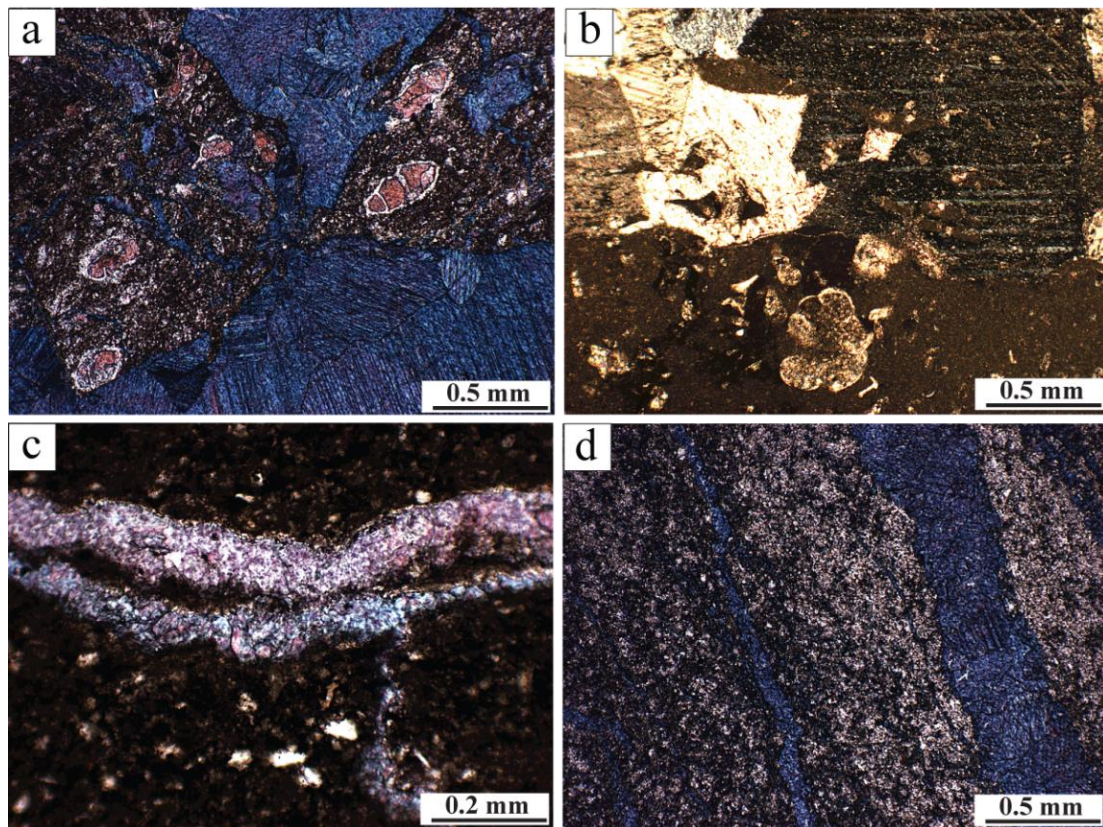


Fig. 3.17: Photomicrographs of limestones from the study area. (a), (b) planktonic foraminifera-bearing micrite with sparry calcite cement, (c) and (d) fine-grained micrite with calcite veins and microstylolites.

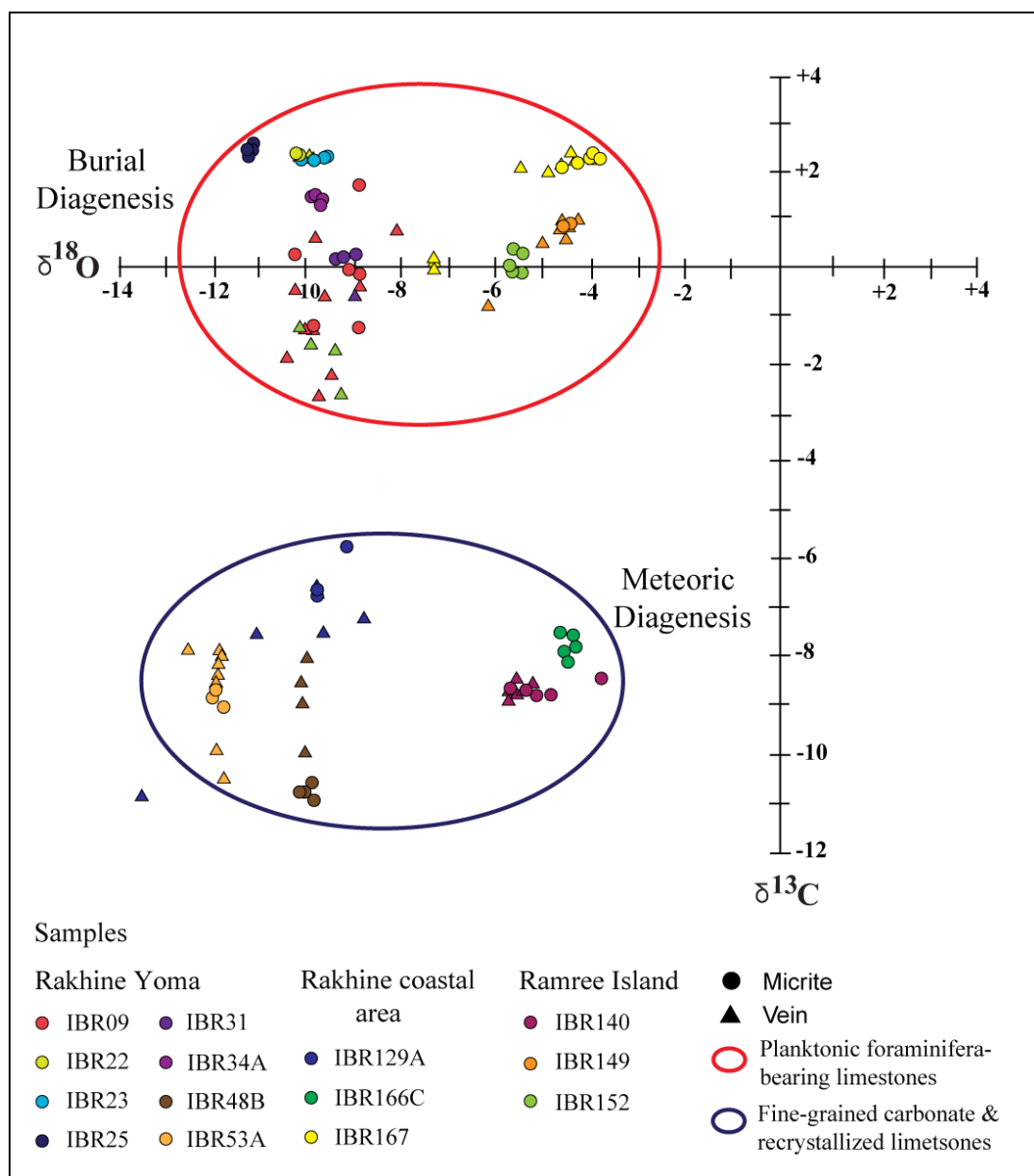


Fig. 3.18: $\delta^{13}\text{C}$ - $\delta^{18}\text{O}$ bivariate plot of the limestones from the study area.

diagenesis of the planktonic foraminifera-bearing limestones and meteoric diagenesis of the fine-grained carbonate and recrystallized limestones (Fig. 3.18). This fine-grained carbonate and recrystallized limestones group is also consistent with carbonate formation in the presence of organic-carbon respiration.

3.8 Detrital zircon U-Pb ages

Detrital zircon U-Pb ages provide useful information for strata that are devoid of fossils or where biostratigraphic control has not yet been established. Due to the lack of conclusive biostratigraphic studies of the Rakhine area, detrital zircons provide a method of constraining maximum depositional ages for these sediments.

Nine samples of fine-to-medium grained sandstones exposed along the road of Padaung – Taungup (IBR01, 11, 48A, 55, 71B, 102, 110A and KM60) and Gwa road (KM76a) sections were chosen for detrital zircon dating (Table. 3.2). Following Gehrels (2012), about 100 zircons were randomly selected for analysis from each sample. However, the limited number of zircons in samples IBR11, 48A and 55 meant that only 85, 69 and 25 zircons could be mounted, respectively. Most zircons are transparent, colourless to pale brown, and typically a mixture of euhedral, subhedral, and rounded to subrounded grains. They show well-developed oscillatory zoning in CL images (Fig. 3.19, 20). Some zircon grains in KM76a show metamorphic overprints and inherited cores (Fig. 3.19). A total of 718 zircons were analysed from the Padaung – Taungup road section, yielding 606 concordant zircon ages and similar U-Pb age clusters, and a total of 147 zircons were analysed from the Gwa road section, yielding 127 concordant zircon ages. Detrital zircon U-Pb age data are presented in Appendix 5.

Location	Mapped Ages	Sample no.	No. of grains	Zircon U-Pb ages	Youngest zircon ages
Padaung - Taungup road section	Paleogene Unit	IBR01	116	dominated by Late Cretaceous (ca. 80-110 Ma) zircons, with a secondary population of Paleogene (40-60 Ma)	44 ± 1 Ma
		IBR11	85		48 ± 1 Ma
		IBR48A	69		58 ± 1 Ma
		IBR55	25		
		IBR71B	119		51 ± 1 Ma
		KM60	92		48 ± 1 Ma
Padaung - Taungup road section	Cretaceous Unit	IBR102	118	dominated by Late Cretaceous (ca. 80-110 Ma) zircons, with a secondary population of Paleogene (40-60 Ma)	49 ± 1 Ma
		IBR110A	119		50 ± 1 Ma
Gwa road section	Triassic Unit	KM76a	147	dominated by Permian - Triassic (ca. 230-300 Ma), Neoproterozoic - Cambrian (ca. 500-700 Ma), and Mesoproterozoic (ca. 1000-1250 Ma) zircons	221 ± 2 Ma

Table. 3.2: *Summary of mapped stratigraphic ages and detrital zircon U-Pb ages from the Padaung-Taungup road section and Gwa road section of Rakhine area.*

Detrital zircon U-Pb age data from Triassic unit KM76a are displayed by using density histograms and concordia plots and weighted mean of the same dataset (Fig. 3.21). This sample yielded over 100 concordant ages. Detrital zircon U-Pb ages in the sample range in age from 2749 ± 14 Ma to 214 ± 10 Ma. The zircon-age spectra display three main clusters in the Mesoproterozoic (18% of total analyzed grains), Neoproterozoic-Cambrian (28%), and Late Paleozoic-Early Mesozoic (28%). Minor clusters occur in the Paleoproterozoic (1.9-1.6 Ga, 14%), Archean (2.7-2.6 Ga, 5%) and a scatter of Silurian-Carboniferous ages.

Two samples (IBR102 and IBR110A) were collected from the mapped Cretaceous unit. Detrital zircons from these samples range in age from 1734 ± 17 Ma to 43 ± 1 Ma. They contain abundant Eocene (13 – 14%), Paleocene (4 - 5%), Cretaceous (70 – 72%), Triassic (2 – 5%), and Precambrian (4 – 5%) populations. Detrital zircons from these samples yielded similar age spectra, with a prominent Cretaceous cluster (110 – 80 Ma) displaying a major

peak at ~ 100 Ma (Fig. 3.22). Small numbers of Jurassic and Permian – Cambrian zircons are present.

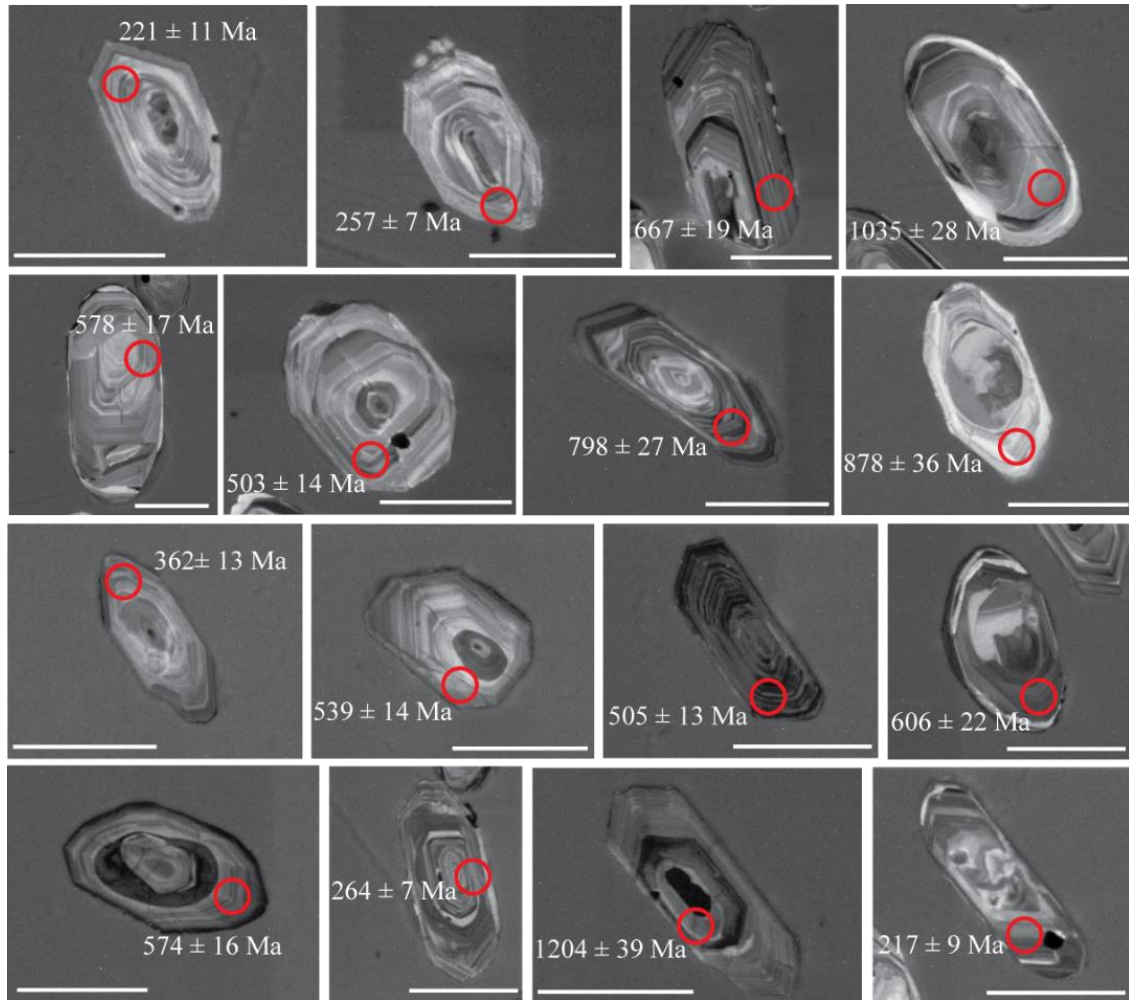


Fig. 3.19: CL images of zircons from the sample KM76a, Gwa road section (scale bar = 100 μ m). Red circles indicate the positions of U-Pb age analyses.

Five sandstone samples (IBR01, IBR11, IBR48A, IBR71B, KM60) were collected from the Paleogene flysch sediments. U-Pb zircon ages from all these samples range in age from 2759 $\pm$ 20 Ma to 43 $\pm$ 2 Ma each. Each sample yielded a similar age spectra. The samples

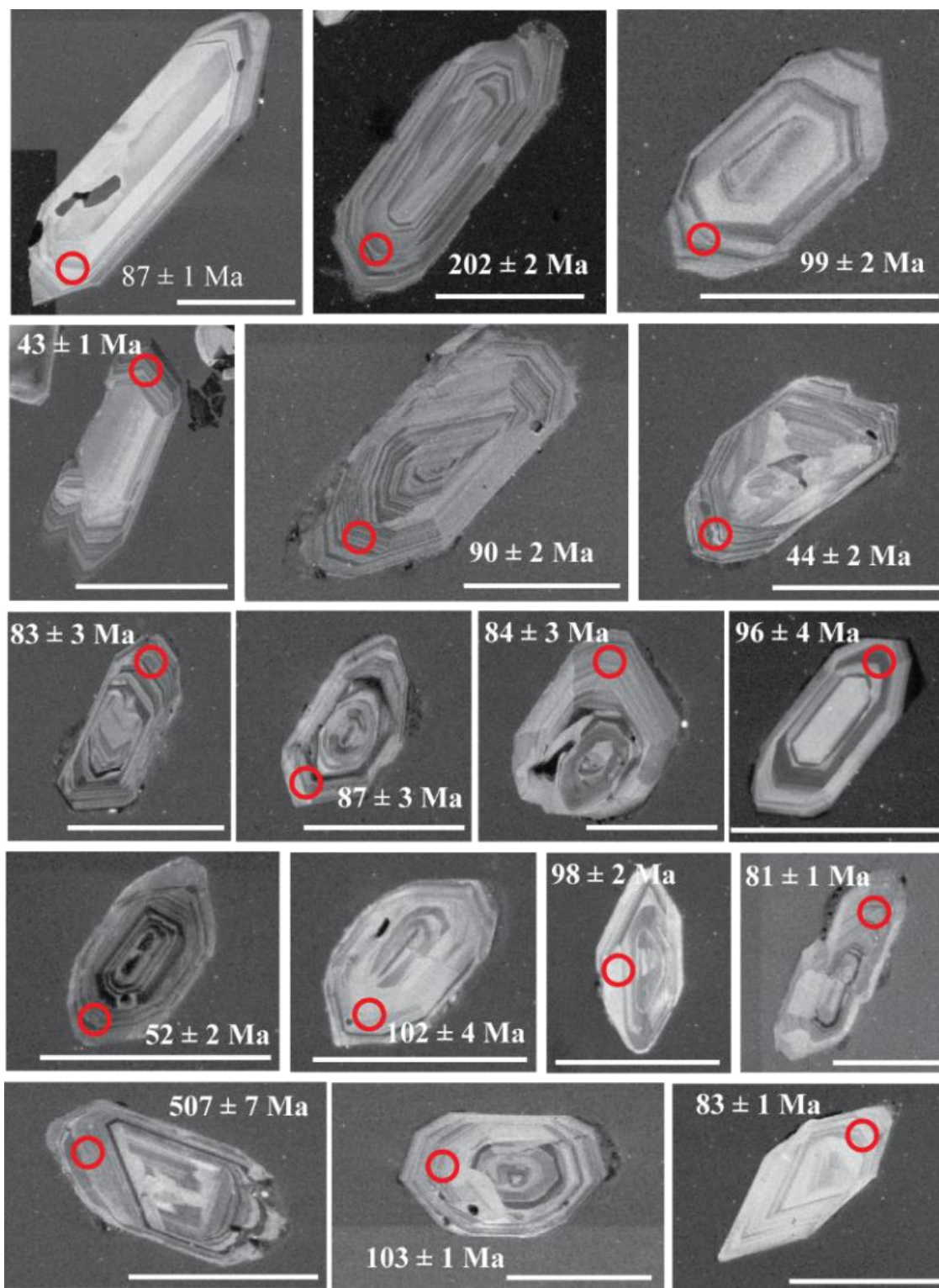


Fig. 3.20: CL images of zircons from the Paleocene-Eocene sandstones, Padaung-Taungup road section (scale bar = 100 μ m). Red circles indicate the positions of U-Pb age analyses.

contain abundant Eocene (5 – 18%), Paleocene (4 – 6%), Cretaceous (52 – 65%), Triassic (1 – 10%), and Precambrian (5 – 20%) populations. The prominent Cretaceous cluster (110 – 80 Ma) displays a notable peak at ~95 Ma. Jurassic and Permian – Cambrian zircons are present, but do not form clear-cut populations. IBR48A contains an abundant Paleocene (21%) population but does not appear to contain Eocene grains.

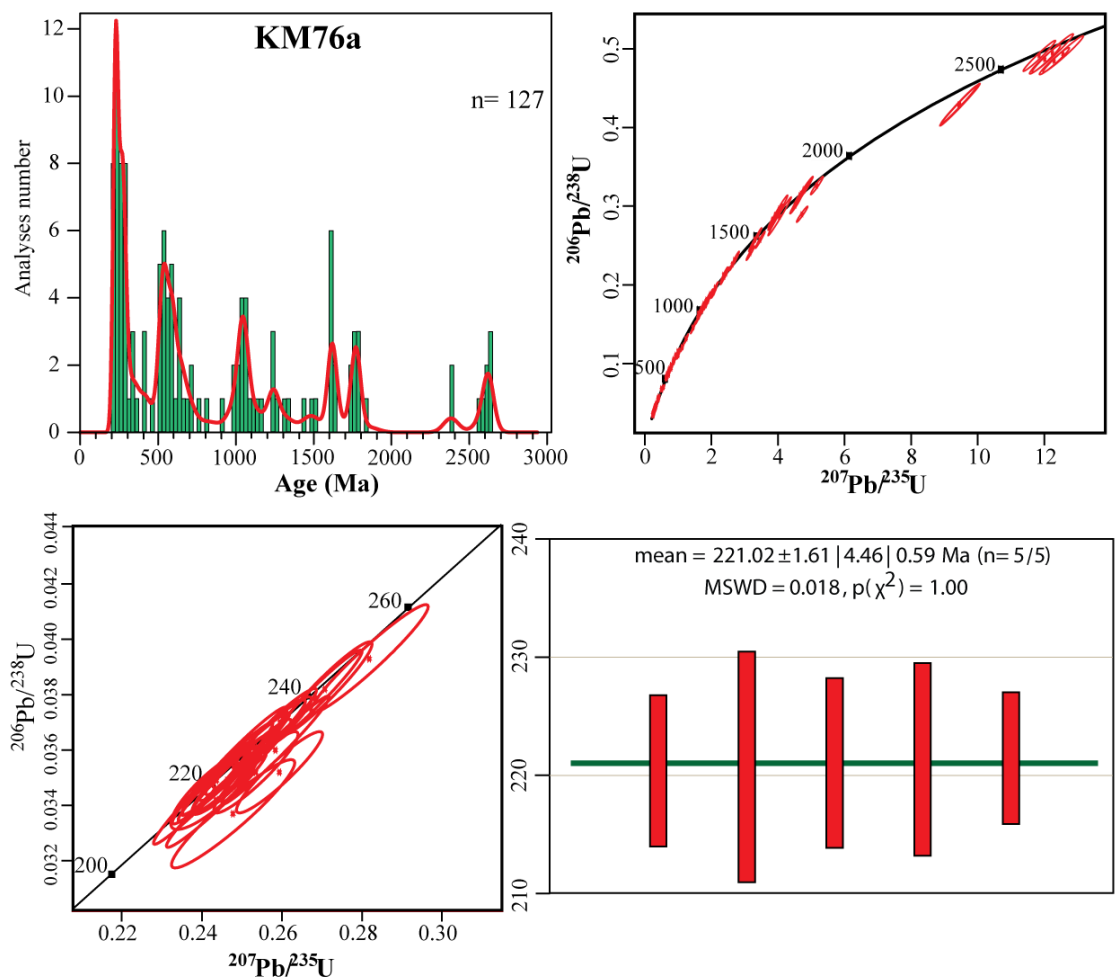


Fig. 3.21: Histogram and probability density plot, concordia diagrams and weighted mean diagram showing detrital zircon U-Pb ages from the sample KM76a.

By definition, the youngest detrital zircon grains are always older than the sedimentary unit in which they are found (Gehrels, 2014). However, the measured age of the youngest zircon can be slightly younger than the true age of deposition, because of Pb loss, analytical uncertainties of each analysis or unavoidable systematic uncertainties that are introduced during the reduction of the raw data (Gehrels, 2014). A weighted average age of the three youngest zircons that overlap in age at 1σ gives a more accurate estimate of the maximum

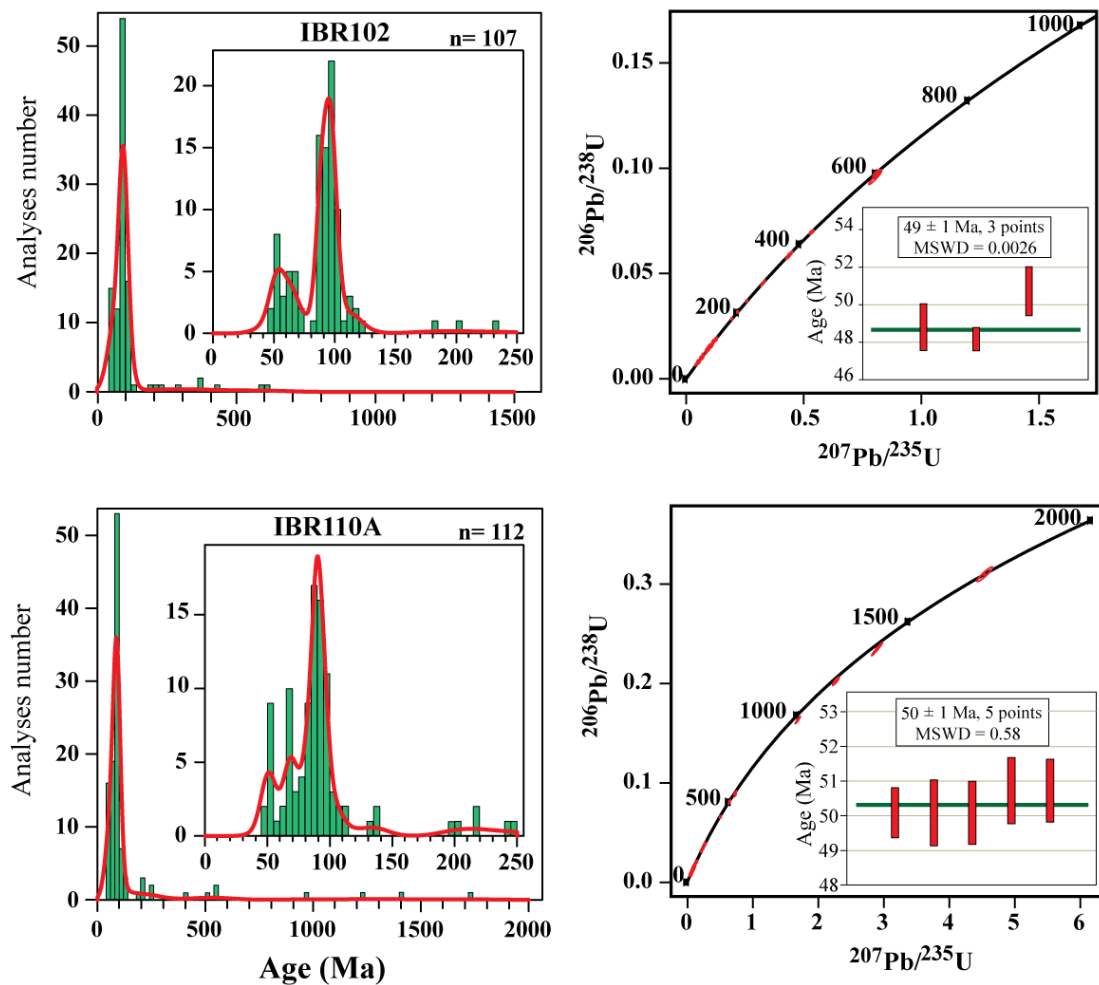


Fig. 3.22: U-Pb age spectra for detrital zircons from the Cretaceous unit, Padaung-Taungup road section, shown as histograms, probability density plots, concordia diagrams and weighted mean diagrams.

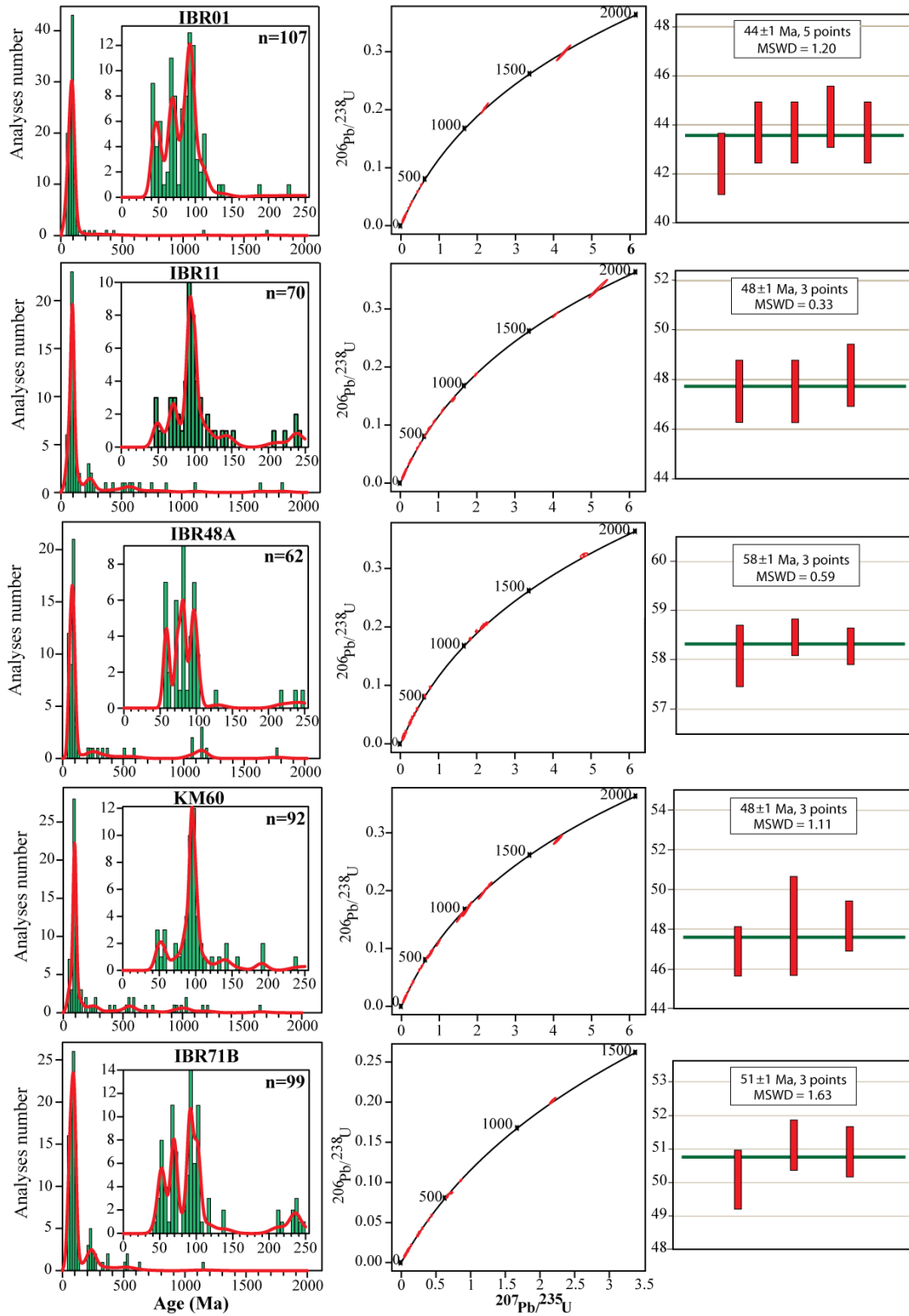


Fig. 3.23: U-Pb age spectra for detrital zircons from the Paleocene-Eocene unit, Padaung-Taungup road section show as histograms, probability density plots, concordia diagrams and weighted mean diagrams.

depositional age of the host sediment (e.g. Dickinson and Gehrels, 2009; Gehrels, 2014). The youngest zircon from the sample KM76a is 214 ± 10 Ma and the five youngest zircons give a weighted average age of 221 ± 2 Ma, indicate the maximum depositional age of the host rock which has to be younger than the Late Triassic. The youngest zircon in the purportedly Cretaceous unit is 43 ± 1 Ma and the weighted average age is 48 ± 1 Ma, indicating a maximum depositional age of Middle Eocene (Fig. 3.22), in contrast to age assigned by the UN map. The weighted average ages of the youngest zircons in the Paleogene unit are 44 ± 1 Ma, 48 ± 1 Ma and 51 ± 1 Ma, except for IBR48a, in which the weighted average age of 58 ± 1 Ma (Fig. 3.23). Maximum depositional ages are therefore of Late Paleocene-Middle Eocene in range. Youngest ages will be used for only those samples that give a weighted average ages with a MSWD around 1 or less.

3.9 Detrital zircon Hf isotope data

Two samples (IBR71B and 102) were analysed from the Padaung-Taungup road section. 248 detrital zircons from these samples were analyzed for Hf isotopic compositions. The majority of the $\epsilon_{\text{Hf}}(t)$ values are located between the Depleted Mantle and Chondritic lines, with a few grains below the Chondritic line. The zircons yield high $^{176}\text{Hf}/^{177}\text{Hf}$ isotopic ratios of 0.281696-0.283151 that yielded $\epsilon_{\text{Hf}}(t)$ values ranging from -19 to +17 (Fig. 3.24). Cretaceous zircons (68% of the total grains) yielded $\epsilon_{\text{Hf}}(t)$ values ranging from -8 to +15, that show the dominant positive $\epsilon_{\text{Hf}}(t)$ values ranging from +5 to +15, with five grains dropping down to negative values range from -8 to -1. Paleogene zircon grains (17% of the total grains), mostly between 63 and 42 Ma in age, yielded $\epsilon_{\text{Hf}}(t)$ values ranging from -14 to +12, that show the dominant positive $\epsilon_{\text{Hf}}(t)$ values ranging from +1 to +12, with nine

grains dropping down to negative values range from -14 to -4. Jurassic-Mesoproterozoic zircons form a broad cluster, yielded $\epsilon_{\text{Hf}}(t)$ values between -19 and +17.

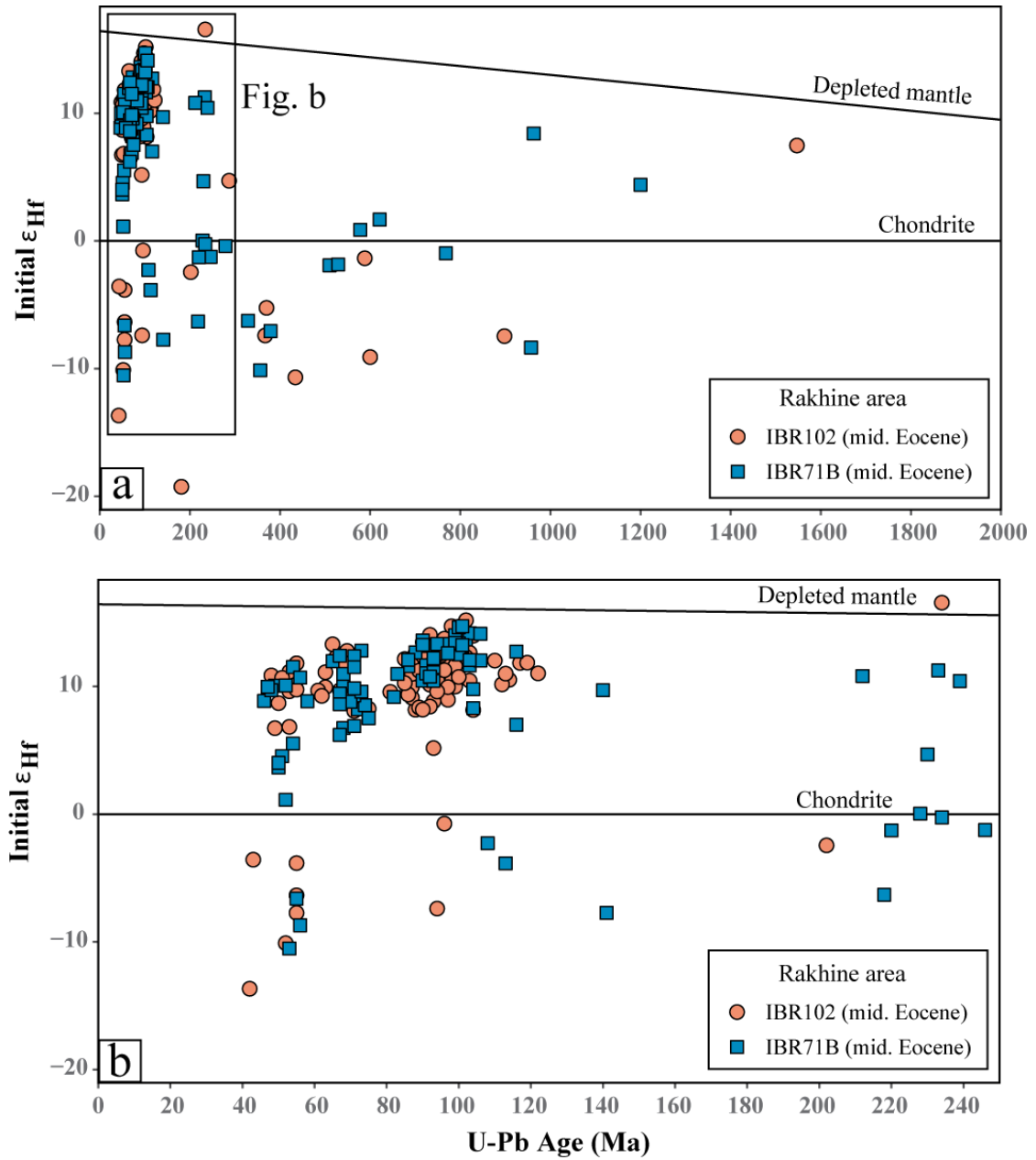


Fig. 3.24: U-Pb vs ϵ_{Hf} data for Middle Eocene detrital zircons from the Padaung-Taungup road section. (a) shows 0-2000 Ma and (b) shows 0-240 Ma ages, see location on (a).

3.10 Discussion

3.10.1 Age of the flysch in the Rakhine area

The detrital zircon ages of the sample KM76a reveal new details about the age of sandstone deposition in the Gwa road section. The youngest zircon in KM76a sandstone is 217 ± 9 Ma and the five youngest zircons give a weighted average age of 221 ± 2 Ma, indicating a Late Triassic or younger age. Two major bodies of serpentinite ($17^{\circ}30'51''\text{N}$, $94^{\circ}54'18''\text{E}$ and $17^{\circ}30'11''\text{N}$, $94^{\circ}55'02''\text{E}$) were observed in the Gwa road section and KM76a was collected near the one at $17^{\circ}30'11''\text{N}$, $94^{\circ}55'02''\text{E}$. Zhang et al. (2018) suggested that serpentinite and Eocene strata occur in tectonic contact in the Gwa road section, and provided U-Pb zircon age for the sandstone of 49-42 Ma (at $17^{\circ}36'6''\text{N}$, $94^{\circ}35'12''\text{E}$). However, their sample was approximately 4 km west of the serpentinite bodies (see Figure 11c in Zhang et al., 2018). Sample KM76a was taken from a sandstone directly adjacent to the serpentinite body, suggesting that the serpentinite is in tectonic contact with Triassic sediments, at least on the eastern side. It is interesting to note that the United Nations (1979) map indicates the occurrence of Triassic sandstones in the Gwa road section, although what evidence this was based on is unknown. Based on the field observations in the Mt. Victoira and Kalemmyo areas (United Nations, 1979; Zhang et al., 2018; Chapters 4 and 5), the bodies of ultramafic rock occur overlying and within the Triassic Pane Chaung Formation. My result, supports a Triassic age of Pane Chaung Formation which therefore continues to the southern part of IBR and suggests a similar relationship between ophiolites and Triassic sediments.

The Rakhine area comprises a thick sequence of flysch sediments, purportedly deposited in Cretaceous to Paleogene times. Being monotonous and rather poorly exposed they have

been given very little attention. They lack reliable criteria for stratigraphic correlation, such as age diagnostic fauna or easily recognisable marker horizons. Brunnschweiler (1966) concluded that the bulk of the flysch is not older than the youngest (Eocene) fossils known at that point. In contrast, Fay Lain and Win Maw (1970) and Gramann (1974) recorded Cretaceous and Paleogene foraminiferal assemblages in the flysch, although with limited descriptions photographs or figures it is not possible to assign a more precise age based on their data. In the present study, planktonic foraminifera of Cretaceous age have been observed from the Cretaceous unit between milepost 33-47, indicating an age range from Aptian to Maastrichtian, whilst the nannofossils indicate Albian-Turonian. These dates are in agreement with previous results from nearly the same location (Fay Lain and Win Maw, 1970). However, the biostratigraphically determined age of the Cretaceous unit is inconsistent with the youngest detrital zircon U-Pb age of 48 ± 1 Ma (Fig. 3.25a). It is suggested that the Cretaceous microfossils are widely scattered over the region and are likely reworked in the younger flysch sediments. The youngest zircon U-Pb age is similar to that described for the Paleogene sediments further west, 44 ± 1 Ma (Fig. 3.25b), which also yield an Eocene-Paleocene biostratigraphic age. Gramann (1974) noted that some of the shales of the Cenozoic of Rakhine region contain derived microfossils from the Upper Cretaceous and it is suggested that this is likely true for all the recorded Cretaceous fossils, given the juxtaposition of Cretaceous biostratigraphic ages with Eocene-age detrital zircons. Thus, the interpretation that the bulk of the flysch is Paleogene in age is correct as was suggested by Brunnschweiler (1966) and supported by the U-Pb detrital zircon ages.

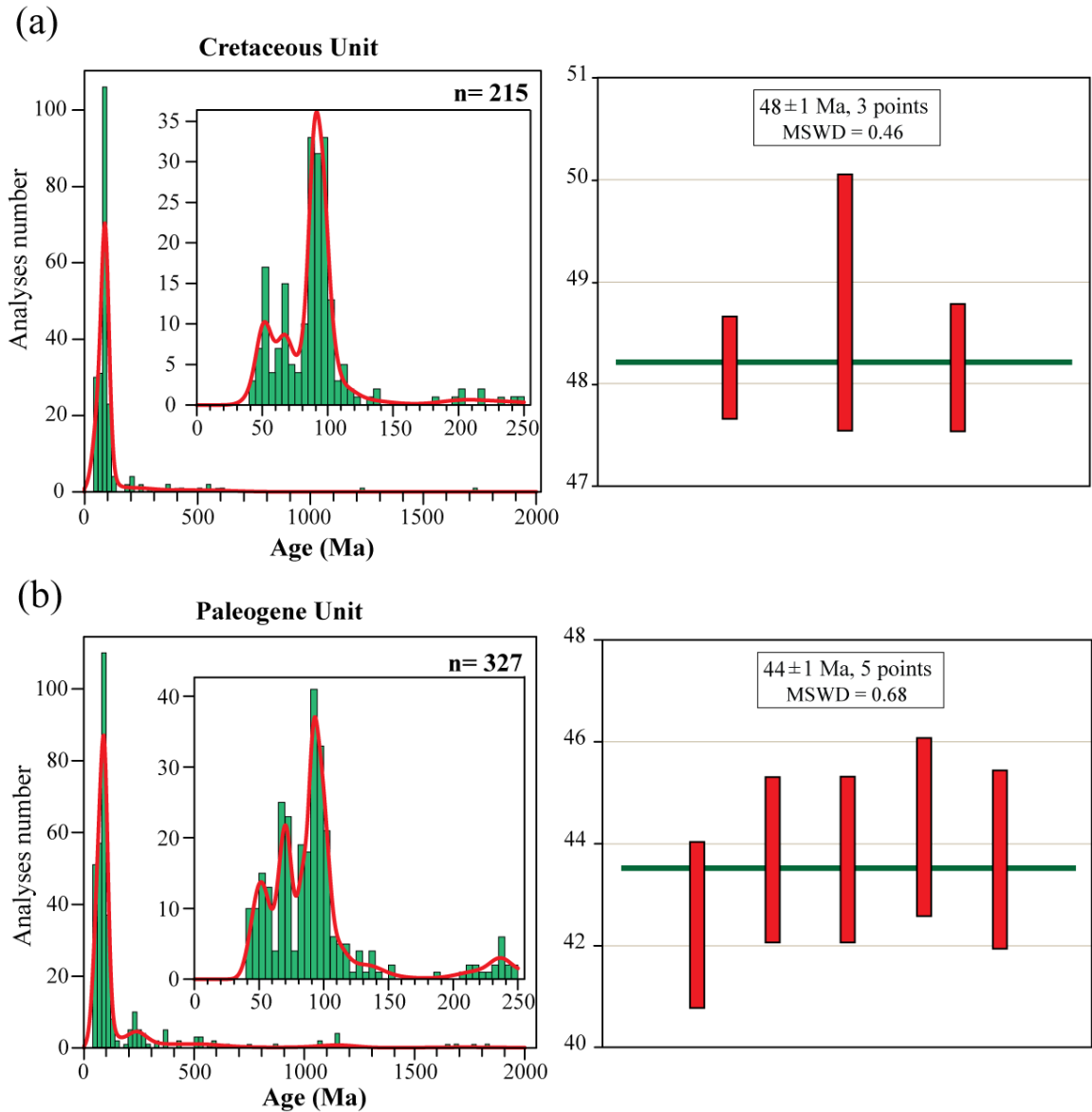


Fig. 3.25: Comparison of detrital zircon ages from the (a) Cretaceous and (b) Paleocene-Eocene units on the Padaung-Taungup road section.

3.10.2 Depositional environments of the Rakhine area

Attempts to identify new, more robust biostratigraphic control for flysch, based on microfossils and nannofossils, failed owing to the barren nature of the shales. The sampled rocks yield very few foraminifers and nannofossils, some of which, as discussed above, may

have been reworked. Nannofossils either were never greatly present in the depositional environment, were diluted by the high clastic sedimentation rates, were dissolved below the carbonate compensation depth (CCD) or have since been dissolved during diagenesis and/or weathering. Mudstone samples collected from units mapped as Cretaceous in age contain planktonic foraminifera of Cretaceous age (see Plate. 3.5), however sandstone samples in the same unit (see Fig. 3.22, 3.25), contain Paleogene detrital zircons, with the youngest population indicating reassignment to Lutetian, (or younger), depositional age. Bender (1983) noted the allochthonous nature of some of the Cretaceous outcrops and reworking of some Cretaceous fossils in Cenozoic units. This, or unmapped structural interleaving of Eocene and Cretaceous rocks, may be the cause of the mismatched age assignments. U-Pb detrital zircon ages of Paleogene sandstones are consistent with the depositional age of the samples indicated by fossils (Table. 3.3). They were probably not reworked. The Paleogene planktonic foraminiferal faunas indicate the whole sandstone-shale sequence was deposited in a deep marine environment.

Location	Mapped Ages	Biostratigraphic ages	Zircon U-Pb ages
Padaung - Taungup road section	Paleogene Unit	Paleocene - Eocene <i>Chiloguembelina wilcoxensis</i> <i>Chiloguembelina ototara</i> <i>Globorotaloides carcoselleensis</i> <i>Planorotalites chapmani</i> <i>Morozovella pseudobulloides</i>	Predominant age peaks at 80-110 Ma Maximum depositional age 44 ± 1 Ma
Padaung - Taungup road section	Cretaceous Unit	Albian - Maastrichtian <i>Hedbergella planispira</i> <i>Hedbergella delrioensis</i> <i>Heterohelix globulosa</i> <i>Prediscosphaera columnata</i>	Predominant age peaks at 80-110 Ma Maximum depositional age 48 ± 1 Ma

Table. 3.3: Summary mapped ages, biostratigraphy and zircon U-Pb ages from the Paleogene and Cretaceous units of the Rakhine area.

The limestones found as isolated blocks in the southern IBR have late Cretaceous to middle Eocene depositional ages based on the characteristic planktonic and larger benthic foraminifera recorded from the studied samples. The Upper Cretaceous rocks of the Rakhine region have been typically known as ‘the *Globotruncana* bearing limestones’ (Campanian-Maastrichtian) and occur as floaters or olistoliths. The planktonic foraminifera occur together with filaments forming graded wackestones and packstones which are indicative of a higher energy environment during deposition. The occurrence of planktonic foraminifera associated with abundant ‘calcspheres’ indicates an open-marine deep shelf depositional environment. The Cretaceous pelagic limestones in the Rakhine Yoma contain low-latitude planktonic foraminifers and were likely deposited in an open marine deep shelf or open ocean depositional environment, suggesting deposition took place at bathyal water depths above the carbonate compensation depth (CCD). They were probably deposited at depths of 1000 to 1500 m as suggested by rare benthic foraminifers (Sliter, 1984). On Ramree Island, the foraminiferal assemblages of the olistolith limestones yield different ages, including Late Cretaceous, Paleocene and Eocene. The occurrence of large *Nummulites* with lenticular test shapes indicates primary deposition in an inner to proximal middle shelf environment. The high density of larger benthic foraminifers and presence of frame-builders (e.g. red algae) indicate well-oxygenated clear warm water. The sediments of this facies were deposited on an outer-shelf marine environment. The limestones with *Ranikothalia* and *Dasycladacean* algae were formed under conditions of extremely shallow water. *Orbitoides* live in shallow marine environments (like reefs and barrier reefs) and are very widely distributed in the early Cenozoic sediments of India (Abyat and Lari, 2015). *Archaeolithothamnium* algae appears to have always lived in warm shallow marine waters.

The occurrence of *Nummulites*, *Ranikothalia* and *Orbitoides* associated with fossil calcareous algae, indicate that a reef environment prevailed during the deposition of these limestones. Paleocene fauna is present in Ramree Island, however *in situ* Paleocene sediments are not developed in this area. Nagappa (1959) considered that there is an unconformity between the Cretaceous and the Eocene in the Ramree Island. *Ranikothalia* and *Miscellanea* are typically Paleocene in India and Pakistan (Nagappa, 1959). *Ranikothalia* is well known from Pakistan (Ranikothalia beds), Oman, Tibet, India (Assam and Meghalaya) and Andaman Island (Nagappa, 1959; Zhang et al., 2013; Koley and Wanjarwadkar, 2013). *Miscellanea* is recorded from India, Pakistan, or the Middle East, is only represented by one equatorial and one meridional section (Nagappa, 1959). Larger benthic foraminifera assemblages in the Ramree Island were taxonomically close to the Paleocene-Early Eocene carbonate successions of the Indus Basin, Pakistan (Afzal et al., 2010) and Sylhet Limestone Group in NE India (Sarkar, 2016). The Ramree-locality in Myanmar is the easternmost record of these fossils and provides a link between the Tethys and Myanmar during the beginning of the Cenozoic period.

In the present study, well-preserved radiolarian fossils are found for the first time from the Ngapali Formation. The radiolarian assemblage is assigned to the late Paleocene to early Eocene, based on the occurrence of *Amphisphaera macrosphaera*, *Clathrocycloma parcum*, *Phormocyrtis turgida*, *Lychnocanoma carinatum*, *Lychnocanoma babylonis*, and *Lamptonium fabaeforme fabaeforme*. The lithologic and paleontologic features of the Ngapali Formation indicate that it was deposited in a deep marine environment. The detrital zircons from the litharenite within the Ngapali Formation indicate a Middle Eocene age (Naing et al., 2014). The Late Paleocene-Early Eocene (59-54 Ma) radiolarian fauna, the

tectonic attribution of the radiolarian cherts and the basaltic block indicate that oceanic crust persisted in the southern IBR until the early Eocene. The radiolarian assemblages are compared well with the Late Paleocene-Early Eocene radiolarians in other areas, especially in the Yarlung Zangbo suture zone, e.g. Sangdanlin, Zhongba and Yamdrok mélange, Southern Tibet (Liu and Aitchison, 2002; Liang et al., 2012; Wang et al., 2017).

The limestones from the Rakhine area are dominated by bioclastic wackestone and packstone lithofacies. The petrographic study reveals the presence of fibrous calcite cement, drusy calcite, equant calcite cement, sparry calcite cement and small scale stylolites which indicate that the limestones of the Rakhine area were subjected to burial diagenesis. Diagenesis often results more negative $\delta^{18}\text{O}$ values in marine carbonates (Allan and Matthews, 1977) and the low $\delta^{18}\text{O}$ data was interpreted as influence of burial diagenesis that is a common phenomenon of Mesozoic and Palaeozoic rocks (Veizer et al., 1999). The $\delta^{18}\text{O}$ values decrease sharply compared with the carbonates precipitated in equilibrium with contemporaneous seawater, which indicates that the studied limestones were subjected to burial diagenesis (Fig. 3.26). Burial cements are almost universally isotopically low in $\delta^{18}\text{O}$ values compared to earlier marine and meteoric cements (James and Jones, 2015). The oxygen isotopic compositions of the Rakhine area limestones suggest that they may also relate to the associated temperature-dependent fractionations accompanying increased burial pressures and tectonic stresses, and varying amounts of calcite recrystallization and also imparted correspondingly to the primary planktonic microfossil elements comprising the micrites. The $\delta^{18}\text{O}$ values between -4 and -6‰, indicate the oxygen isotopic compositions of the precipitates are inherited largely from the meteoric water and most new

precipitates will have the values of fresh water (James and Jones, 2015). Oxygen isotopes are more susceptible to diagenesis than carbon isotopes (Morse and Mackenzie, 1990)

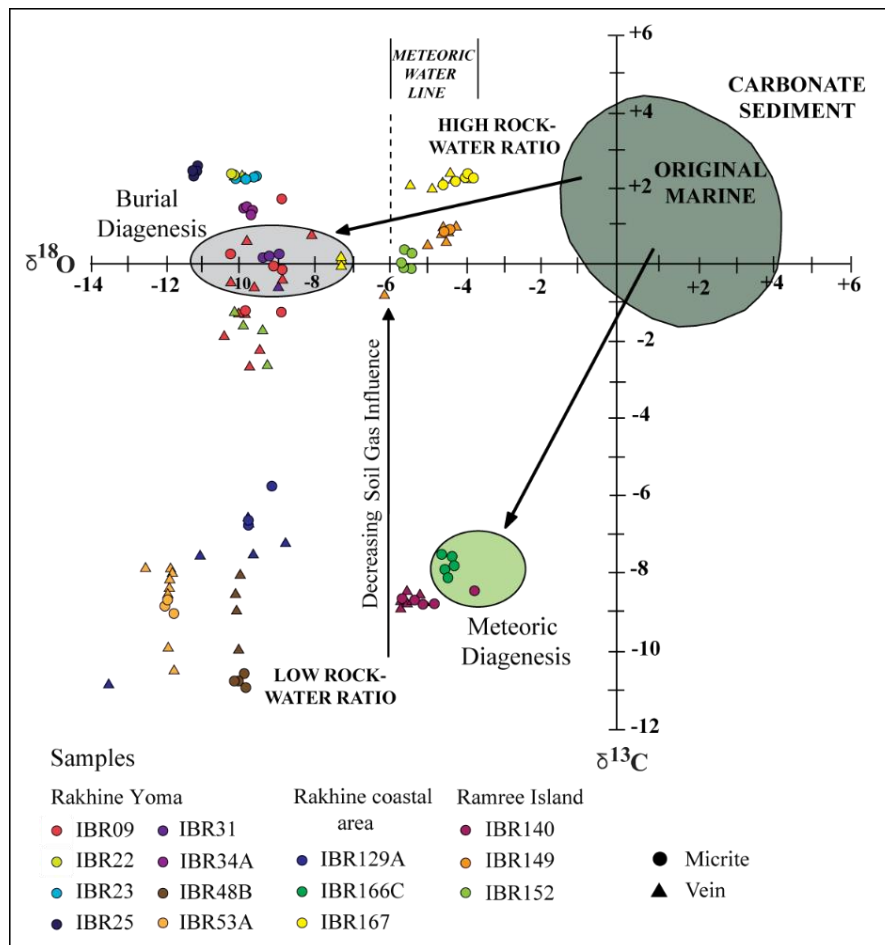


Fig. 3.26: $\delta^{18}\text{O}$ vs $\delta^{13}\text{C}$ stable isotope cross-plot (James and Jones, 2015) illustrating the values of the limestones from the study area.

and consequently, the $\delta^{13}\text{C}$ values of planktonic foraminiferal-bearing limestones do not change much with burial diagenesis. The data presented here from these pelagic limestones shows positive $\delta^{13}\text{C}$ values, and slightly negative $\delta^{18}\text{O}$ values, consistent with burial diagenesis under conditions with a high rock-water ratio (Fig. 3.26). Mudstone and recrystallized limestones show more negative $\delta^{13}\text{C}$ values suggesting meteoric diagenesis

of the underlying carbonates and limestones immediately adjacent to an exposure surface with a soil cover (Fig. 3.26). The carbon isotopic variations in carbonate rocks from the Rakhine area are mainly the consequence of the amount of CO₂ derived from the oxidation of organic carbon included in pore waters during limestone cementation and recrystallization (Marshall, 1992; Maliva et al., 1995; Maliva and Dickson, 1997).

Cotter (1938) recorded *Orbitoides apiculate* from the Gangaw and Kyauktu-Saw area in the Chin Hills. He discovered typical Ranikot molluscan fossils in beds near the base of the Cenozoic succession in the Pakokku District. Brunnschweiler (1966) described autochthonous *Globotruncana* limestone in the area of Gangaw. This region, together with its extensions has been regarded as the area from which the allochthonous *Globotruncana* limestone originated. The Paleocene limestones in the southern Tethyan Himalaya are rich in larger benthic foraminifera that have been interpreted to represent a carbonate ramp on the Indian passive continental margin (Willems et al., 1996). The close affinity of the presently described *Nummulites*, *Ranikothalia*, *Miscellanea*, *Lockhartia*, and *Aberisphaera* with the Tethyan Himalayas of Tibet and NE India species present evidence of foraminiferal migration to western Myanmar.

3.10.3 Provenance interpretation

3.10.3.1 Upper Triassic sandstones

The Triassic sandstone (KM76a) is made up of various constituents including monocrystalline and polycrystalline quartz, plagioclase, rock fragments, mica, matrix and cement. Each of these minerals and their nature give some useful insights into the provenance of the Rakhine area. The relationship amongst quartz, feldspar and lithic

fragments, in the diagram of Dickinson et al., (1983), point to a recycled orogeny provenance field (Fig. 3.11). The petrographical and detrital zircon U-Pb age data suggest that the sandstone contains contributions from several sources, including reworked and volcanic materials and first-cycle metamorphic detritus. A wide spread of zircon U-Pb ages in KM76a and the presence of sedimentary lithics in thin section, indicates contributions from multiple sources, is also diagnostic of mixed provenance and reworking. A significant proportion of euhedral and subhedral zircons that commonly show well developed oscillatory zoning suggests a first-cycle magmatic origin and a direct contribution from igneous sources. Some rounded and zoned zircon grains pointed to a polycyclic origin or continuous reworking through prolonged transport from distant sources. The presence of foliated and platy metamorphic lithics and mica that are common in thin section, as well as chlorite, suggest a contribution from a local metamorphic basement. Potential metamorphic source rocks for the Rakhine area are the Kanpetlet Schists in the Mt. Victoria.

Detrital zircon U-Pb age distribution of Triassic sandstones from the Rakhine area shows similar zircon age distributions to the Mt. Victoria and Kalemmyo areas (Sevastjanova et al., 2015; Yao et al., 2017) (Fig. 3.27). Similar age populations would suggest that the Upper Triassic sandstone from the Rakhine, Mt. Victoria and Kalemmyo areas were formed from the erosion of the same source rocks, and hence would suggest deposition at similar times. It can be further interpret the Pane Chaung Formation extends southward from the Kalemmyo area to the southern IBR. A detailed discussion of the provenance and palaeogeographic significance of the Pane Chaung Formation will be presented in Chapter 6.

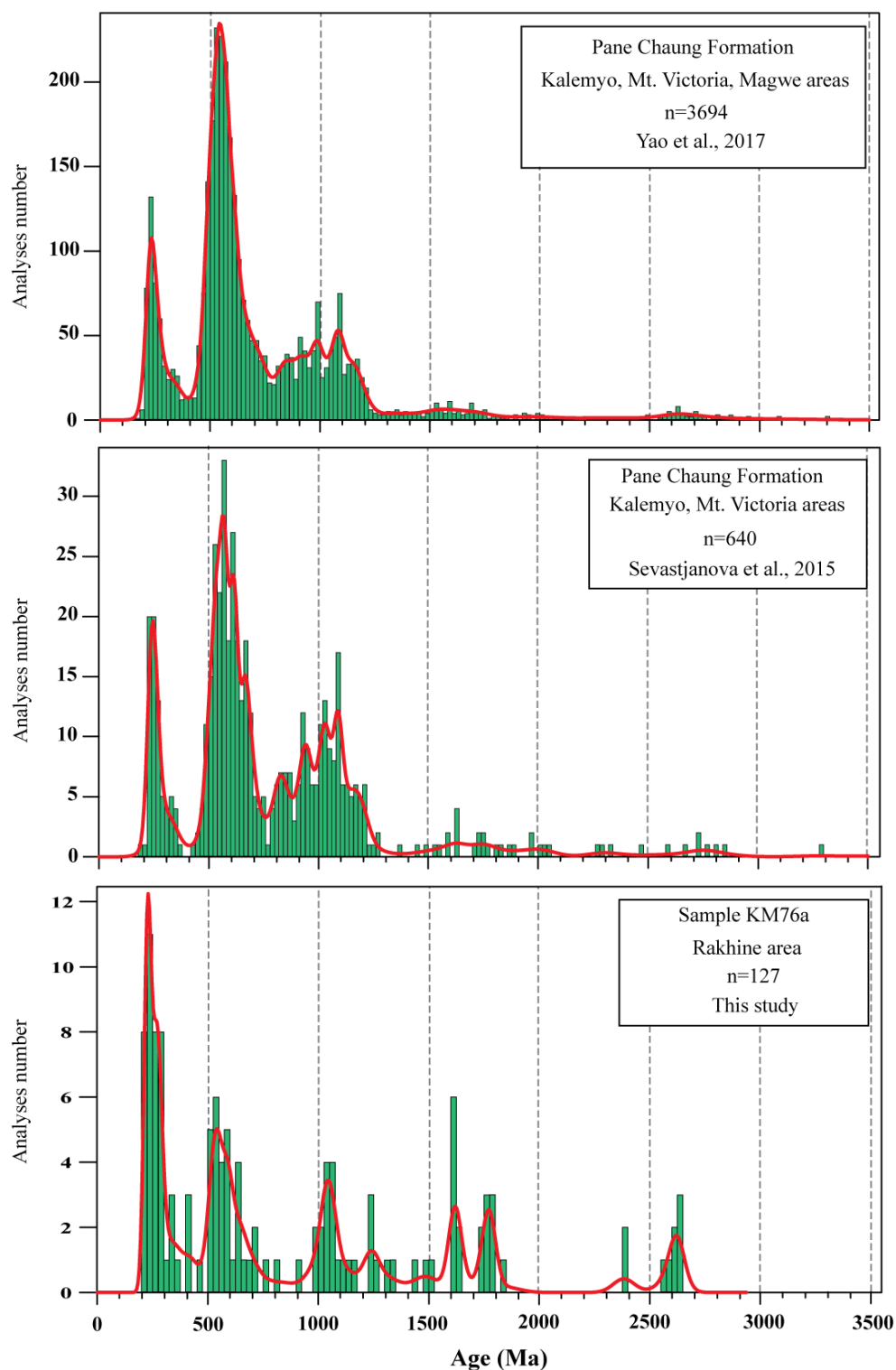


Fig. 3.27: Comparison of detrital zircon ages from the sample KM76a in Rakhine area (this study), with those from published results of the Mt. Victoria and Kalemmyo area (Sevastjanova et al., 2015; Yao et al., 2017).

3.10.3.2 Paleocene-Eocene sandstones

The U-Pb ages distributions and grain-counts from Paleocene to middle Eocene sandstones from the Padaung-Taungup road section show a prominent Cretaceous cluster with a notable peak at ~95 Ma and subordinate peaks at ~70 Ma and ~50 Ma. Samples lie within the magmatic arc provenance on QFL plot (Fig. 3.11). Samples from the Rakhine area contain slightly more volcanic lithic grains compared to coeval samples from the CB. Detrital zircon age distributions of the Rakhine Yoma are broadly similar to the Rakhine coastal area and the CB (Fig. 3.28). However, a careful comparison indicates several differences in zircon-age spectra. Detrital zircons from Paleogene modern river sandstones from the Rakhine coastal area show slightly difference, with a subordinate crustal component from the Himalaya (Allen et al., 2008). Zircons in the Paleogene flysch of Rakhine Yoma and Rakhine coastal areas display age clusters at ~50 Ma, whereas zircons with this ages are notably rare in the CB (Wang et al. 2014; Licht et al. 2018; this study). This study and published data (Naing et al. 2014) from the Rakhine Yoma and Rakhine coastal area show that for Cretaceous-Eocene zircons, ϵ_{Hf} values are predominantly positive for Eocene samples, with a few grains with negative ϵ_{Hf} values. In the CB, Paleocene to Eocene samples have Cretaceous-Eocene zircons with overwhelmingly positive ϵ_{Hf} values. The southern IBR signature contrasts with data from the CB (Wang et al., 2014; Zhang et al., 2019). Thus, the Paleocene to Eocene sedimentary rocks of the southern IBR derived predominantly from the Wuntho-Popa arc and the core of the IBR sediments to the east. Additional contribution from crustal material, potentially from the Indian ‘basement’ or from trench sediment input from the west, is indicated by, for example, the presence of Palaeozoic zircons.

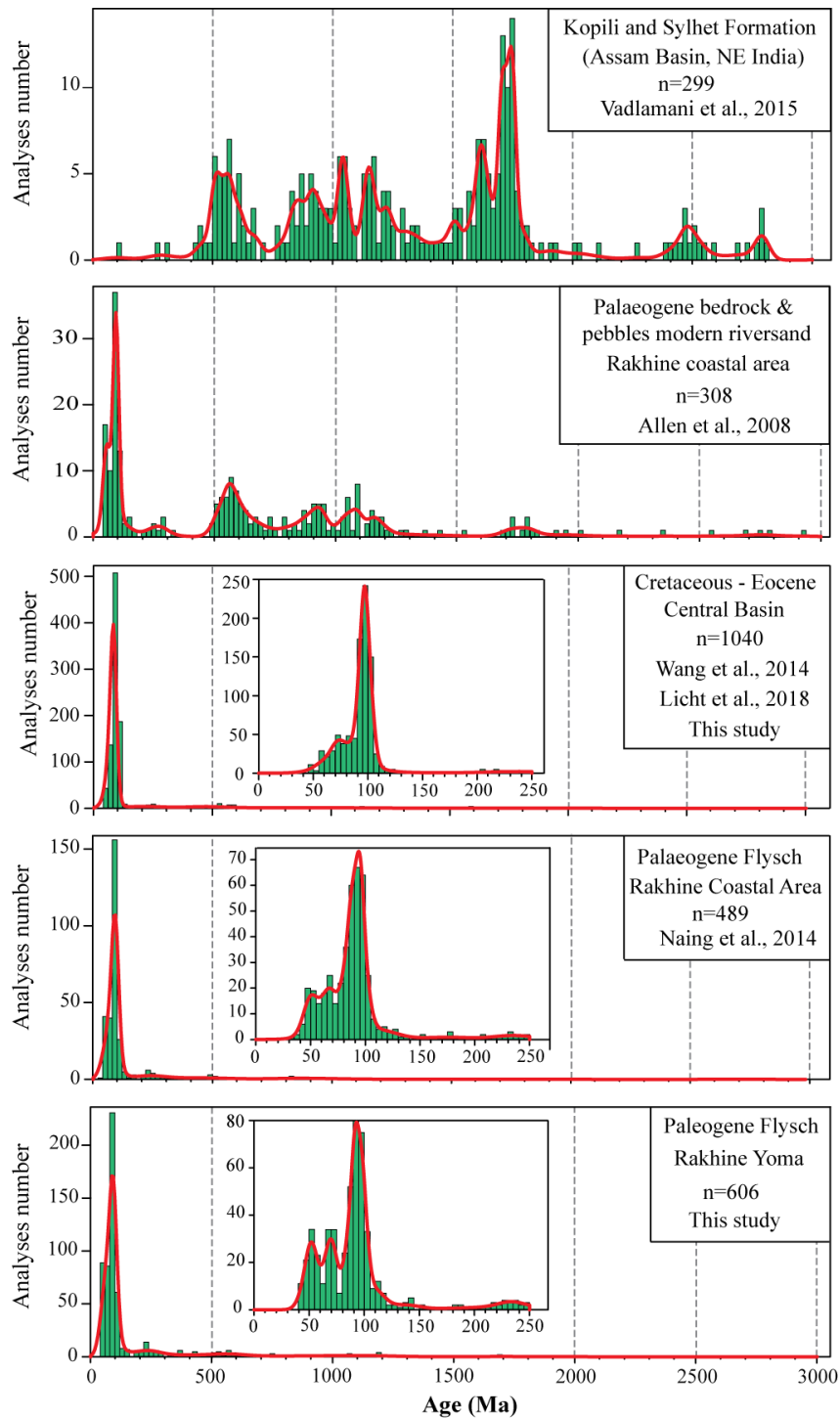


Fig. 3.28: Comparison of detrital zircon ages from the Paleocene-Eocene flysch on the Padaung-Taungup road section (this study), with those from Rakhine area (this study), with those from published results from the Mt. Victoria and Kalemmyo area (Sevastjanova et al., 2015; Yao et al., 2017).

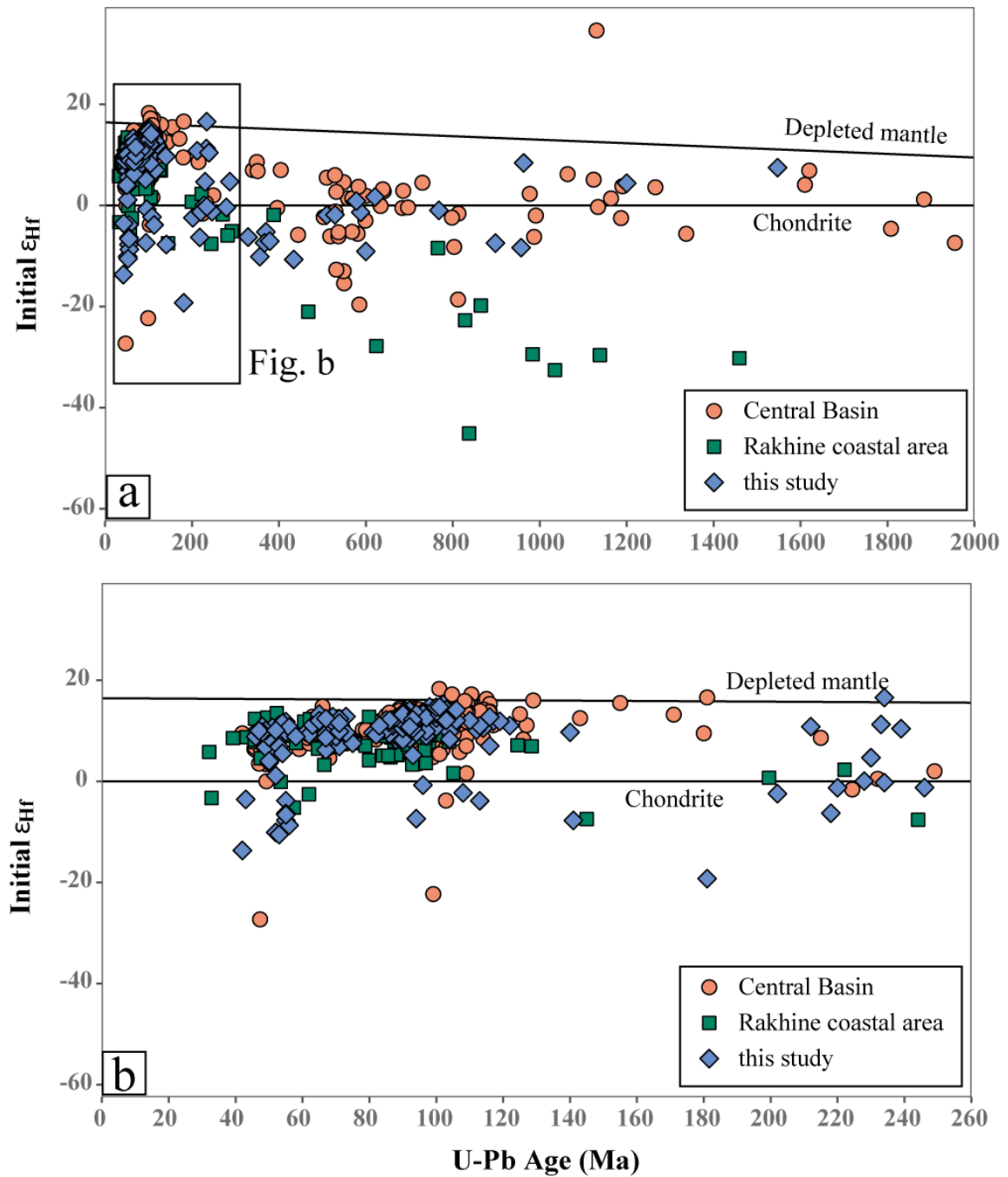


Fig. 3.29: Comparison of detrital zircon Hf isotopic data from the Paleocene-Eocene flysch, Padaung-Taungup road section (this study), with those from Rakhine coastal area (Naing et al., 2014) and Central Basin (Wang et al., 2014; Zhang et al., 2019). (a) shows 0-2000 Ma and (b) shows 0-260 Ma ages, see location on (a).

Published data from the Indian source is predominantly arkosic, with zircon populations of Precambrian–Early Palaeozoic age (Najman et al., 2008) (Fig. 3.28), and have negative $\epsilon_{\text{Hf}}(t)$ values (Vadlamani et al., 2015). These differences indicate that India craton and Tethyan Himalaya are unlikely sources for the southern IBR.

3.11 Conclusions

Field observations, biostratigraphic and petrographic data, and U-Pb detrital zircon and Hf isotopic data from Mesozoic to Cenozoic strata in the Rakhine area, lead to the following major conclusions:

1. The record of Cretaceous planktonic foraminifera indicate the pelagic limestones were deposited in an open marine deep shelf depositional environment above the CCD. The majority of Rakhine area pelagic limestones were deposited at depths of 1000 to 1500 m as suggested by rare benthic foraminifera. The larger benthic foraminifera attributed to genera *Nummulite* and *Discocyclina*, and *Ranikothalia*, *Miscellanea*, *Lockhartia* and *Aberisphaera*, indicate shallow marine environment.
2. The newly discovered late Paleocene-early Eocene (59-54 Ma) radiolarians found in the mélange of the Ngapali Formation in the southern IBR indicate that it was deposited in a deep marine environment. It provides a maximum age constraint on the timing of formation of the mélange. The late Paleocene-early Eocene radiolarian fauna, the tectonic attribution of the radiolarian cherts and basalt blocks indicate that oceanic crust persisted in the southern IBR until the early Eocene.
3. The limestones collected from the Rakhine area, in the southern part of IBR comprise mudstone, wackestone, packstone and grainstone lithofacies. The

petrographic and isotopic analysis reveal the limestones were subjected to burial and meteoric diageneses.

4. The southern IBR sandstones have both recycled orogenic and magmatic arc provenance fields. New provenance data on the Upper Triassic sandstone from the Gwa road section, indicate that it was formed from the erosion of the same source rocks of the Mt. Victoria and Kalemyo area, and deposition took place at similar time. Sedimentary provenance studies of Paleogene flysch along the Padaung-Taungup road section show clear evidence of significant arc-derived input from the Wuntho-Popa arc and the core of the IBR sediments to the east. New U-Pb zircon dating results indicate that the Padaung - Taungup road section was deposited in Paleocene to middle Eocene times.

CHAPTER

FOUR

GEOLOGY OF THE MT. VICTORIA AREA

4.1 Introduction

It is widely accepted that the Indo-Burman Ranges (IBR) can be split into an Eastern and Western Belt as identified by Bender (1983) and Bannert et al. (2011). The Eastern Belt is best defined in the southern Chin Hills, represented in the Mt. Victoria area (Fig. 4.1a,b). At the eastern margin of Mt. Victoria, basalts and flysch of the Eastern Belt are overlain unconformably by the basal beds of the mid Cretaceous-Cenozoic forearc basin, part of the Central Burma Depression according to Mitchell (2017). The Mt. Victoria belt is over 30 km wide, rising to over 3000 m elevation and bounded in the west by the Kheng fault (Mitchell, 2017). The Mt. Victoria belt is composed mainly of low-grade metamorphic rocks, dominantly graphite-biotite schists (Kanpetlet Schist) folded into a dome, overthrust by Triassic flysch (named Pane Chaung Formation) and late Mesozoic age ophiolites (Mitchell, 1993; Acharyya, 2007). Mitchell (1986) proposed that the Mt. Victoria area represents the continental basement of a microcontinent, which collided with and underthrust western Burma before the Albian (Fig. 4.2a). Searle & Morley (2011) and Searle et al. (2017) considered that the overthrust ophiolites may represent an obduction event during the Early Cretaceous, because they are capped by shallow marine Albian Limestone (Mitchell, 1993), and, therefore, were not part of the Paleogene emplacement event (Fig. 4.2b). Bannert et al. (2011) considered the ophiolites associated with the Triassic Pane Chaung Formation to represent pre-Upper Triassic ocean floor. Rangin et al. (2013) proposed the existence of a Mt. Victoria-Burma Microcontinent representing a sliver of continental crust belonging to the Indian Plate interpreted to be present under the IBR and lying between the subducted Tethys oceanic crust slab to the east and Bengal Basin (oceanic?) crust to the west (Fig. 4.2c). Ridd & Racey (2015) proposed a block called the

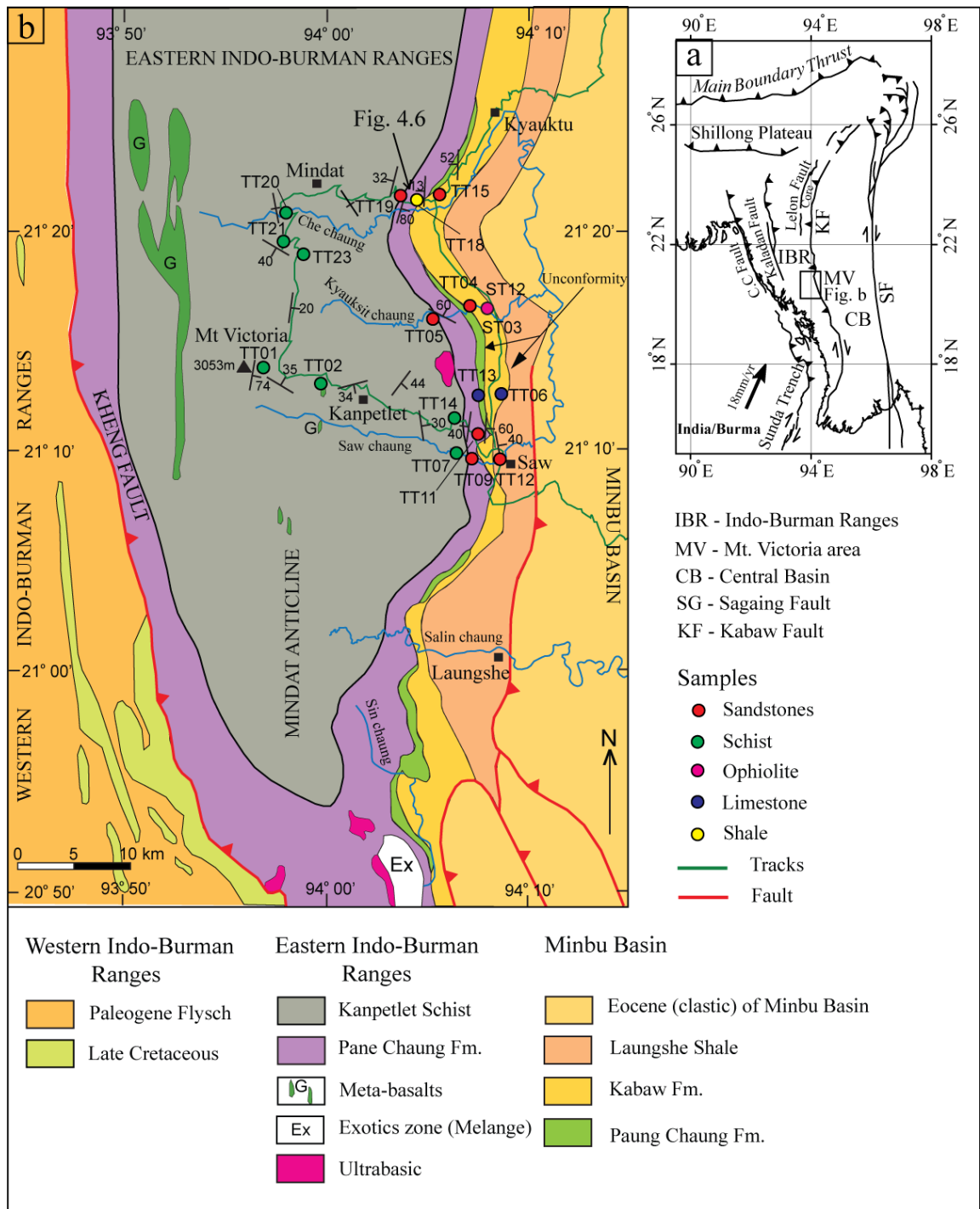


Fig. 4.1: (a) General structural map of Myanmar (Maurin and Rangin, 2009) shows location of Mt. Victoria area and (b) geological map of the Mt. Victoria area, Southern Chin Hills (modified from United Nations (1979a) and Mitchell et al. (2010) with sample locations.

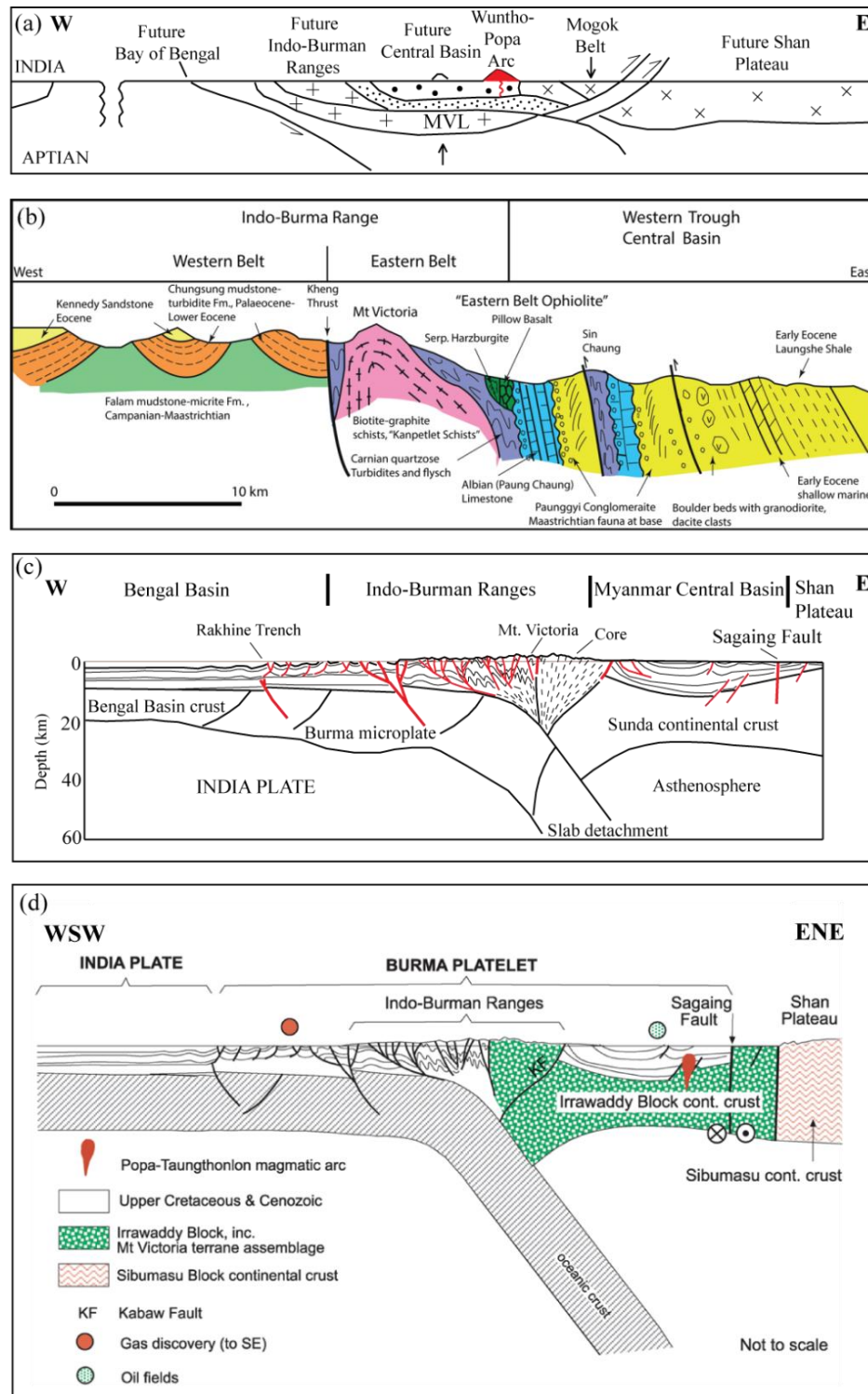


Fig. 4.2: Geological cross-sectional across the Indo-Burman Ranges: Mt. Victoria belt, (a) Mitchell (1986), MVL=Mount Victoria Land; (b) Searle et al. (2017); (c) Rangin et al. (2013); and (d) Ridd & Racey (2015).

Indo-Burman or Irrawaddy Block was separated from Sibumasu by a Late Paleozoic-Jurassic oceanic rift (Fig. 4.2d). Furthermore, they suggested that the schists and meta-sediments of the Mt. Victoria area represent the westernmost occurrences in outcrop of this Australia-derived terrane in western Myanmar.

This Chapter presents field observations, petrographic, XRD and detrital zircon U-Pb age data from the Mt. Victoria area. In an attempt to resolve existing arguments about the origin of the Mt. Victoria-Burma Microcontinent/Irrawaddy Block, this chapter compares the new data to those published from the Mt. Victoria and Rakhine areas.

4.2 Lithology and field observations of the Mt. Victoria Area

4.2.1 Kanpetlet Schist

Metamorphic rocks have been observed in various localities along the eastern margin of the Rakhine Yoma – Chin Hills. The largest body of metamorphic rock in the areas consists of schists and schistose sedimentary rocks which extend north-south through the Mt. Victoria area (Fig. 4.1a), and its northern equivalents, termed the Naga Metamorphic Complex. The Kanpetlet Schist was named by Cotter (1938) from the Kanpetlet Town in the southern Chin Hills southeast of Mt. Victoria. He reported talc schist, mica schist, chlorite schist, quartzite schist and blue shaley schists, and considered the boundary with adjacent sedimentary rocks to be transitional. He interpreted a gradual increase in metamorphic grade from east to west through the area. Clegg (1941) recognized the Kanpetlet Schist as metasedimentary, but suggested that metamorphism was caused by intrusion of serpentinites. United Nations (1979a) recorded muscovite and rare biotite schists. Socquet et al. (2002) describe three lithologies, namely metapelites, metabasites and

metagreywackes. Bannert et al. (2011) reported the presence of greenschist, black schist and quartzite phyllite within the Kanpetlet Schists.

A thick sequence of folded metasediments dominantly composed of low-grade regionally metamorphosed rocks is exposed in numerous river sections, and some road cuts. The Kanpetlet Schists were observed in this study along the Saw Chaung/River, the Che Chaung/River, the Saw to Mt. Victoria Road, the main Mindat Road, and the Mindat-Kanpetlet Road (Fig. 4.1). The predominant lithology of the Kanpetlet Schist is fine- to medium-grained mica-schist, that in places is black and graphitic, and that exhibits intercalated metabasites (greenstones) scattered through the unit. Crenulation- and foliation- like features are commonly observed (Fig. 4.3a). The gentle pinch and swell structures of lenses of locally abundant quartz veins are typical of the schists. The veins occur mostly as thin irregular stringers parallel with the schistosity (Fig. 4.3b). Locally the Kanpetlet Schists include quartz grains and chlorite-epidote greenstones. Relict pillow structures can be observed at some localities (United Nations, 1979). A large variety of other minerals such as augite and hornblende phenocrysts, epidote layers and lenses, and pyrite are present as disseminated crystals or thin layers, in the schists (Bannert et al., 2011). In water-polished exposures in the Saw Chaung River the schist is characteristically dark grey to black in colour. In several localities, greenschists up to a few meters thick are interbedded with black schists. The black schists consist of quartz, carbonaceous matter and sericite.

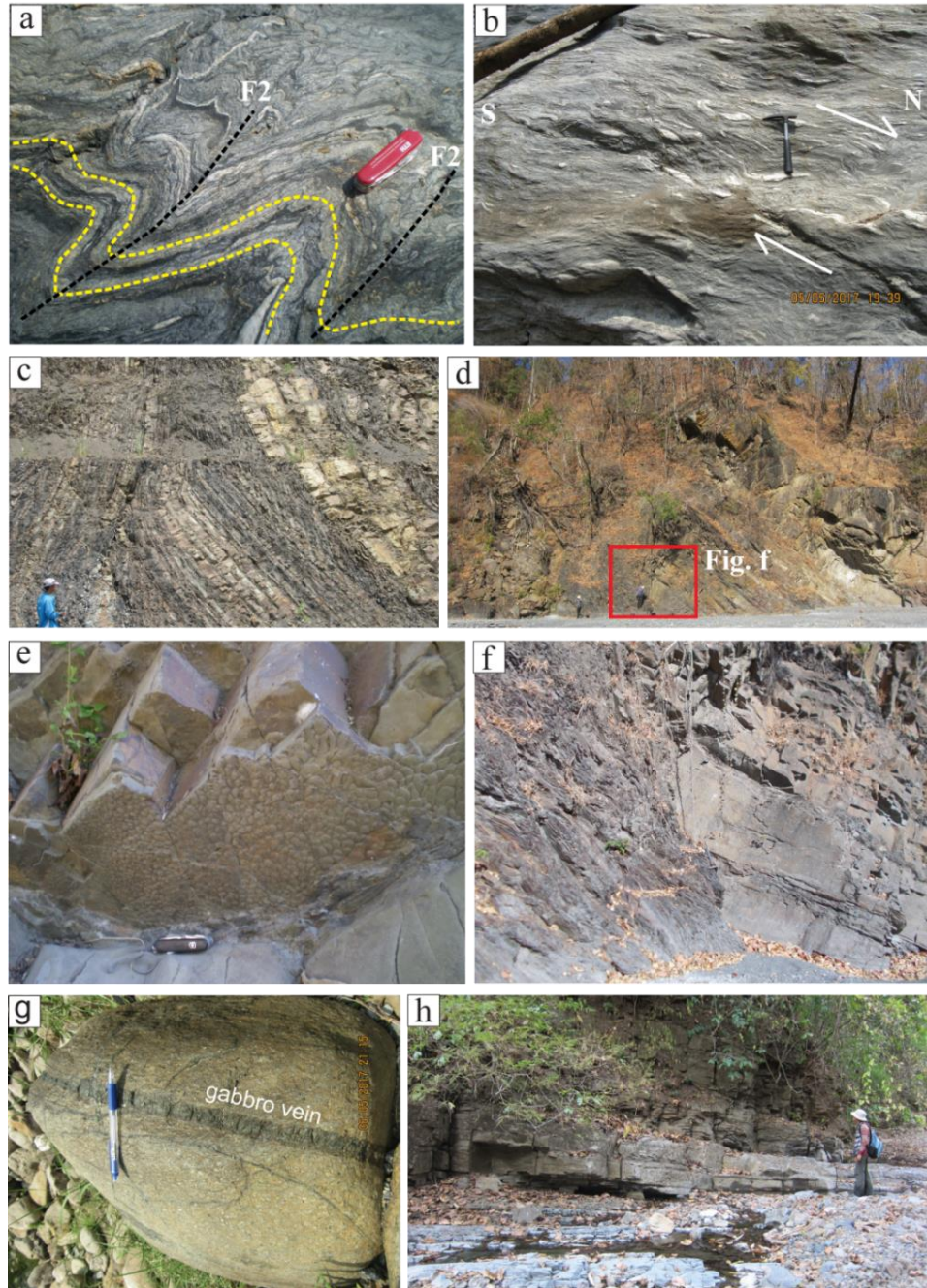


Fig. 4.3: Field photographs of outcrops sampled in the present study. Kanpetlet Schist, (a) quartz veins lie parallel to schistosity, and (b) quartz exsolution indicates top-to-the-north motion. Pane Chaung Formation, (c) thin-to medium-bedded sandstone interbedded with shale, (d) thick-bedded sandstone, (e) sole marks at the base of beds, and (f) close-up view of (d). (g) a gabbroic veinlet within the harzburgite. (h) Paung Chaung Limestone tectonically mixed in with the Pane Chaung Formation.

The low-grade metamorphic rocks were originally considered to be part of the pre-Mesozoic basement complex (e.g. Brunnschweiler, 1966; Gramann, 1974). Socquet et al. (2002) suggested that the schists were the metamorphosed equivalent of adjacent Triassic flysch and that metamorphism took place in the Upper Cretaceous and Eocene. Bender et al. (1983) and Mitchell et al. (2010) interpreted a stratigraphic connection with the overlying Triassic flysch sediments (Pane Chaung Formation), suggesting a Triassic age for the Kanpetlet Schists. Recently, Zhang et al. (2017) reported detrital zircon U-Pb ages of 228-239 Ma from the sericite schists. The Late Triassic detrital zircon ages unequivocally point to a post-late Triassic depositional age, so there is consequently no possibility that the Kanpetlet can be an older basement. Many authors (e.g. United Nations, 1979; Socquet et al., 2002; Mitchell et al., 2010, Bannert et al., 2011; Zhang et al., 2017) have noted the transitional nature of metamorphism increasing from the Triassic rocks into the Kanpetlet Schists. This relationship implies that the schists are simply a higher-grade equivalent of the Pane Chaung Formation. These observations support that there is a transitional contact between Triassic rocks and the metamorphic units, but it is not possible to state with certainty that the Triassic rocks are entirely equivalent to the Kanpetlet Schists.

4.2.2 Pane Chaung Formation

The sedimentary rocks of the Pane Chaung Formation are widely exposed along the eastern flank of the southern Chin Hills and Rakhine Yoma. The Triassic age of the Pane Chaung Formation was first recognized by Theobald (1871), who reported a *Halobia* fossil from the northern Rakhine Yoma. The age of the Pane Chaung Formation has been assigned as Triassic based on the rare occurrence of *Halobia* fossils (United Nations, 1979; Bannert et al., 2011; Yao et al., 2017; Zhang et al., 2017). The dark shales containing *Halobia* and

thin sections of dark limestone containing ostracods and foraminifera of the *Nodosariid* group (Gramann, 1974; Bannert et al. 2011), indicate a Late Triassic age for the Pane Chaung Formation (Fig. 4.4). However, across large tracts of the IBR the Pane Chaung Formation has been identified based on lithological criteria, without any supporting fossil evidence. The discontinuous nature of outcrops in hilly, jungle-dominated terrain, the structural complexity of the area, and similar lithologies in the overlying Cretaceous-Paleogene units, have given rise to considerable uncertainty as to how far north from the Chin Hills the Pane Chaung Formation can be mapped (Bannert et al. 2011). For example, Brunnschweiler (1966) just mapped a single flysch unit, that incorporated Paleogene, Cretaceous and Triassic unit. Recently published detrital zircon analysis of the Pane Chaung Formation, indicate maximum depositional ages of Late Triassic and Early Jurassic age (Sevastjanova et al., 2015; Yao et al., 2017). Hence, it is considered here that the upper part of the Pane Chaung Formation is Early Jurassic in age. A key problem is that the maximum depositional age information does not necessarily constrain the full age range of the Pane Chaung Formation.

Three types of flysch sediments were observed in the Mt. Victoria region assigned to the Pane Chaung Formation: the first one is thin bedded siltstones and shales intercalated with grey chert that only crop out in the Mindat-Kyauktu road section (Fig. 4.3c). The second type is interbedded sandstone, shale and a few thin limestones that crop out in the Saw-Kyauktu area. The third one is interbedded sandstones and shales that form continuous, thick and monotonous exposures along parts of some rivers and streams. These sandstones are commonly massive or weakly graded beds up to 2 m thick (Fig. 4.3f) with well-

developed (and locally abundant) sole marks, load casts (Fig. 4.3e) and concentrations of intraformational dark gray mud-clasts at the base (Fig. 4.3d). Scattered small sized blocks

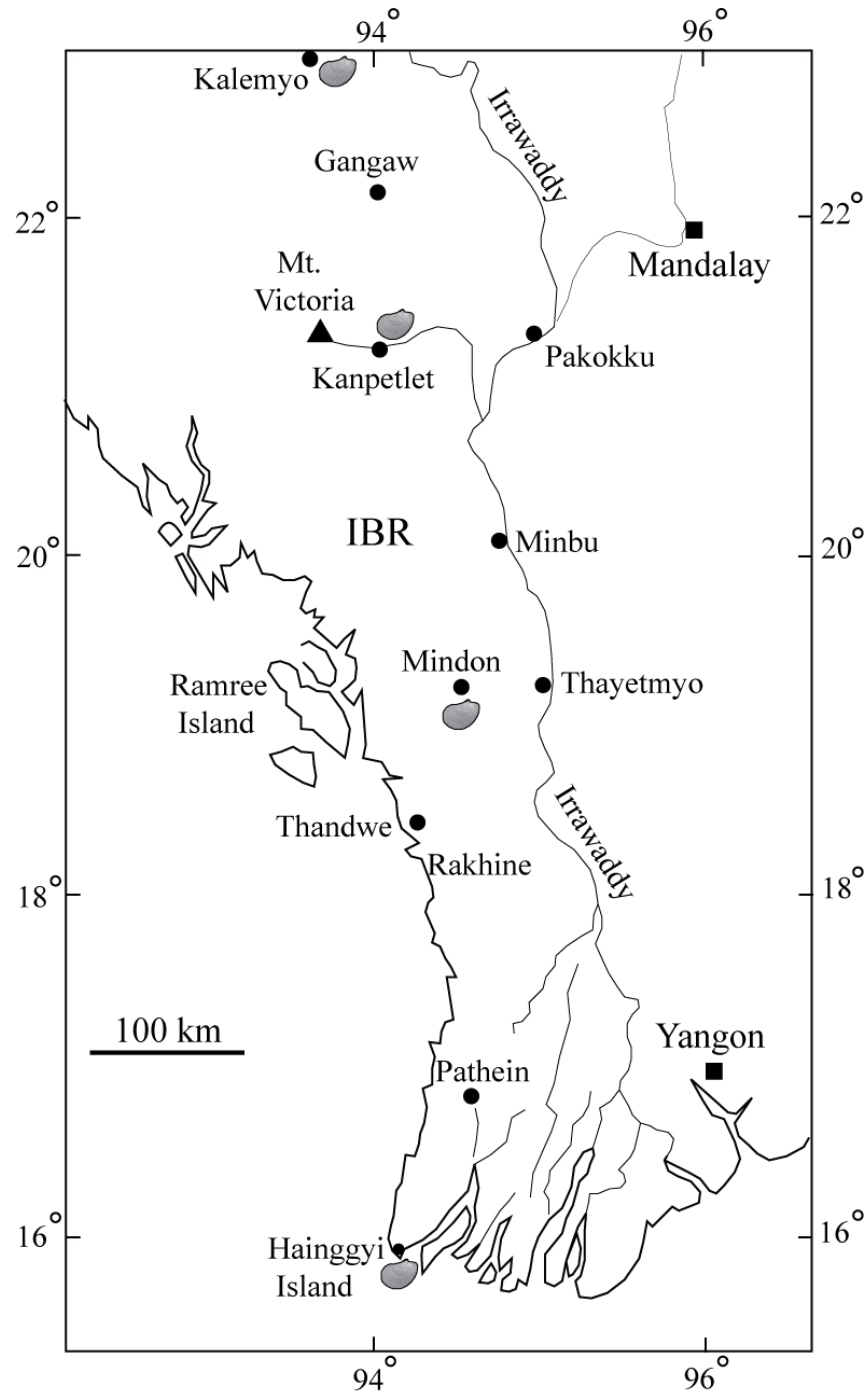


Fig. 4.4: Location of *Halobia* fossils found in the Indo-Burman Ranges (IBR), modified from Gramann (1974).

(<10 m²-size) of peridotites and gabbros have been observed in the Kyauksit Chaung River (Fig. 4.3h). Pillow basalts occur at several localities south and north of the Mindat-Saw area, mostly at or near the eastern margin of the Pane Chaung Formation. They are commonly associated with gabbroic rocks. In the Mindat section, pillow basalts are associated with thin-bedded red cherts. The best exposures of green amygdaloidal pillow lava occur in the Che Chaung, northeast of the Mindat-Saw area (Fig. 4.3g). West of the Kanpetlet Schist and the Pane Chaung Formation there are outcrops of interbedded shales, sandy turbidites, and micritic limestones. Exotic boulders of ophicalcites, gabbros, basalts, cherts and quartzose sandstones are also present (Mitchell et al., 2010). Along the eastern margin of the Chin Hills, the Pane Chaung Formation outcrops are overlain unconformably by the Cretaceous Paung Chaung Formation/Limestone.

4.2.3 Paung Chaung Formation/Limestone

The Paung Chaung Formation was first described in the Chin Hills area by Gramann (1974), who identified the formation over a distance of 50 km as a series of limestones of Aptian through Cenomanian age. The name of the formation is derived from the Paung Chaung stream that lies 7 km NW of Saw - the unit is also referred to as the Paung Chaung Limestone by United Nations (1979). This formation is narrowly exposed, typically it has a maximum stratigraphic thickness of 200 m, is variably affected by weak to strong folding, and lies in a tectonically repeated belt, up to 800 m wide (United Nations, 1979a). In the Saw-Kyauktu area, the limestones are grey to black, well bedded and contain planktonic foraminifera, ammonites, corals and other fossils (Gramann, 1974; Thura Oo, 2000). Gramann (1974) noted the limestones are commonly carbonaceous and were deposited in the open marine environment (Thura Oo, 2000). The limestone unit continues southwards

as a discontinuous unit along the eastern foothills of the Chin Hills, and appears sporadically below another unconformity at the base of the younger Kabaw Formation (Fig. 4.1). The Albian-Cenomanian Limestone is unconformably overlain by the Maastrichtian Kabaw Formation and locally by clastics and minor limestones of the Paleocene Paunggyi Formation (United Nations, 1979).

4.2.4 Kabaw Formation and Paunggyi Formation/Conglomerate

The forearc basin of Central Myanmar comprises two major sub-basins, the Minbu Basin to the south and the Chindwin Basin to the north. The Cretaceous-early Cenozoic depositional history is largely similar in both sub-basins. The sequence starts with the Kabaw Formation which is well exposed along the eastern flank of the Kabaw Valley through Kalemyo, Gangaw, Saw and finally into Mindon area. The Kabaw Formation has been assigned ages ranging from Maastrichtian to Paleocene (Clegg, 1938; Cotter, 1938; Gramann, 1974). There is some uncertainty regarding the stratigraphy of the Kabaw and Paunggyi Formation. The United Nations report (1979) suggested that the Kabaw Formation could not be distinguished as a mappable unit of formation-rank, and so included it into with the Paunggyi Formation that was assigned a Late Cretaceous-Eocene age. It was suggested that there was an internal unconformity to the formation, with the Paleocene thought by the UN report (1979) to be largely absent. This view has been modified by more recent work. Thura Oo (2000) reported that faunas of Campanian to Danian age have been observed in the Kabaw Formation. Theingi Kyaw (2005) established the Paleocene part of the sequence as the Paunggyi Formation, on the basis of benthic and planktonic foraminifera. Further constraints by fossils and maximum depositional ages from detrital zircons indicate that the age of the Kabaw Formation is Maastrichtian, while the overlying Paunggyi Formation is

Danian (Wang et al., 2014). Licht et al. (2018) reported the age of the Paunggyi Formation is upper Maastrichtian to Paleocene, while the overlying Laungshe Formation is uppermost Paleocene to Lower Eocene in age (Wang et al., 2014; Licht et al. 2018).

The Kabaw Formation mainly comprises dark grey to bluish grey shales, with a few argillaceous fine-grained sandstones, together with marine limestones. The lower part of the formation is best exposed in the Saw-Mindat area, and is composed of interbedded sequence of greenish grey shales and coarse-grained micaceous sandstones. A few conglomeratic layers are composed of volcanic rock fragments, predominantly felsitic, andesitic and basaltic types. *Orbitoides sp.* and *Siderolite sp.* have been observed in limestone lenses (Thura Oo, 2000) within the shales. In places, the rest of the formation is dominated by the nodular shale with few sandstone intercalations. The Kabaw Formation or the Paunggyi Formation is overlain by the partly marine, transitional Laungshe Formation.

4.3 Structure of the Mt. Victoria Area

4.3.1 Kanpetlet Schist

In the Mt. Victoria area, there have been no detailed investigations of the structure of the Kanpetlet Schist. At the largest scale, the Kanpetlet Schist is up to 30 km wide in an E-W direction in the southern Chin Hills and forms a domal feature called the Mindat Anticline or Dome. The regional metamorphic foliation is generally parallel to the minor shear planes (Fig. 4.3b). Foliation in the schist is generally high angle, with small-scale folds that have gently plunging hinges and sub-horizontal surfaces, or low-angle foliations where crenulations and small-scale folds have gently plunging hinges, and steep axial surfaces (Fig. 4.5). The fold hinges on the low-angle foliations commonly trend between 110°-140°

and the angle of inclination from 0° to 45° . The transition between the two orientations is observed in some outcrops and the shear sense in quartz exolutions show a top to the north deformation in the area. Shear sense inversions could be produced during sheath fold formation related to NW-SE dextral shearing, as suggested by Maurin and Rangin (2009). The measurements the fold hinge orientations trend NW to SE, show diverse orientations from E-W and N-S to NE-SW. The Mt. Victoria area shows that the foliation strike is highly varied and includes E-W, NNW-SSE, NNE-SSE and N-S trends (Fig. 4.5). In some outcrops, often in strongly weathered schist, late NNW-SSE to NNE-SSW trending sub-

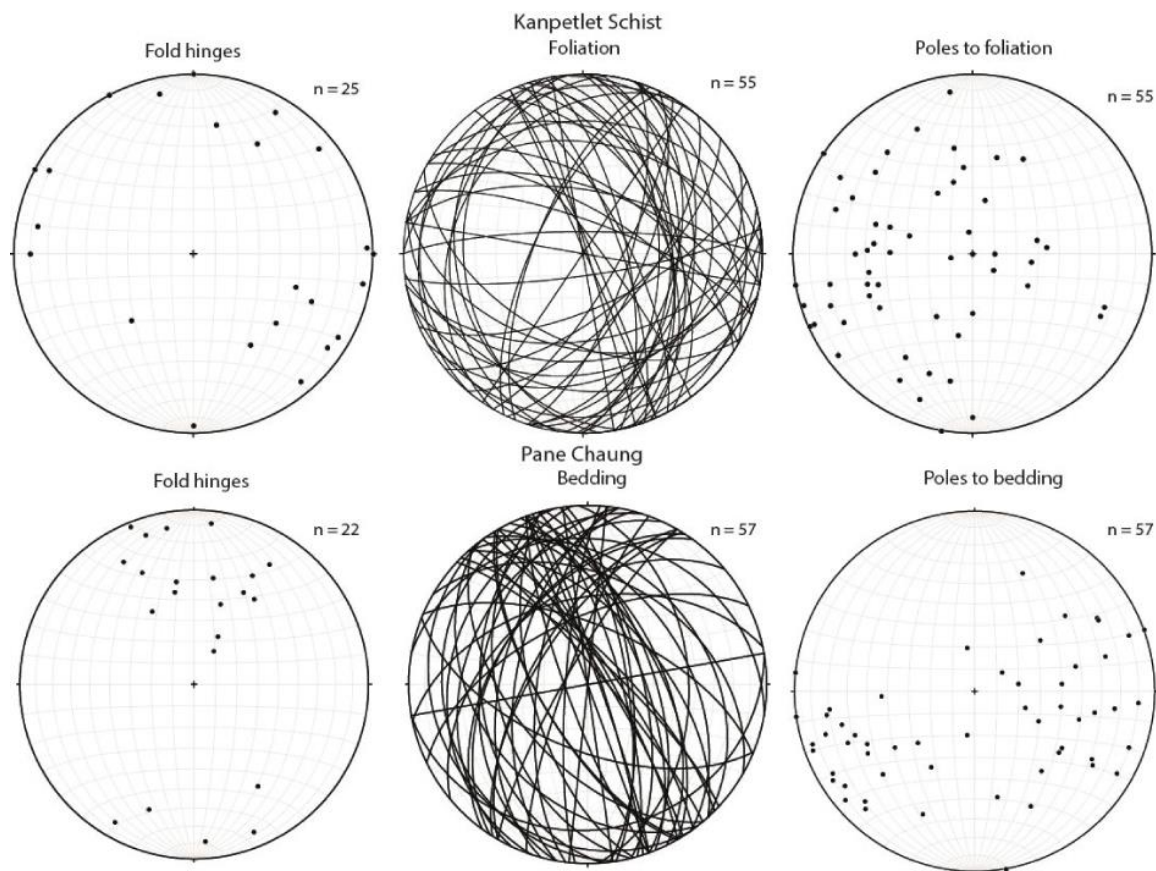


Fig. 4.5: Stereonets showing structural orientation data for the Kanpetlet Schists, and Pane Chaung Formation from the Mt. Victoria area.

vertical, brittle fault zones. These outcrops are related to the latest phase of deformation, after exhumation of the Kanpetlet Schist in the Mindat Dome.

Zhang et al. (2017) studied the nature of metamorphic rocks along the main road across the Mindat Dome and found a reversal in metamorphic grade. However, they interpret the structural-metamorphic relationship by wedge extrusion associated with exhumation of high-pressure-low-temperature metamorphic rocks. They also noted three phases of deformation, and suggest an early N-S striking foliation, with cleavages of second generation folds striking NE-SW, and third generation folds striking NW-SE. This interpretation requires the overlying Pane Chaung to exhibit an extensional detachment with the Kanpetlet Schist, that is yet to be convincingly demonstrated in outcrop. In addition, the anticline appears to be a late structure related to the Kheng Fault, which emplaces the Eastern Belt against Paleogene section (Fig. 4.1), and is not related to an earlier (Mesozoic) wedge extrusion. Consequently, the wedge extrusion model remains a conjectural model, with little supporting evidence in the Mt. Victoria area, other than the presence of a large anticline. Debate concerning the structural and metamorphic features within the Kanpetlet Schist have been identified in previous studies (e.g. Cotter, 1938; Brunnschweiler, 1966; Mitchell, 1993; Socquet et al., 2002; Acharyya, 2007; Bannert et al., 2011), however the level of detail provided is low. For example, there are indications that thinning of the schists has occurred, but the timing, kinematics, and tectonic significance of the thinning has yet to be determined. How local observations of a particular shear direction or fold can be traced more regionally is unknown. It is apparent that the Kanpetlet Schist has been affected by numerous deformation phases related to deformation within an accretionary prism, and in the later orogenic wedge that underwent further deformation and metamorphism. To

properly unravel these events needs a much more integrated and detailed study of the metamorphism, structural development and geochronology than is available from present studies.

4.3.2 Pane Chaung Formation

The Pane Chaung Formation contains abundant sole marks and load casts on the base of the turbidite sequences that provide excellent evidence for the primary way-up structures. These way-up structures indicate the beds are commonly folded and overturned (United Nations, 1979). In the southern Chin Hills, the presence of minor folds with antiformal syncline and synformal anticline geometries and younging directions consistent with a structural position on the inverted limb of a major nappe structure have been described (United Nations, 1979). The United Nations (1979) report provides information on the large-scale structure and regional mapping of the Chin Hills, however details about the structure of the Pane Chaung Formation are lacking. Mitchell et al. (2010) described the Pane Chaung Formation as having a complex structure with widespread broken beds.

Fortunately, recent road improvement schemes have enabled a few continuous sections to be observed through the Pane Chaung Formation on the roads to Kanpetlet and Mindat. Some of these sections have recently been discussed in Zhang et al. (2017) and Yao et al. (2017). On the road section to Mindat, which offers the best exposed continuous section through the Pane Chaung Formation. The E-W Kyauktu-Mindat road section traverses about 2 km width of the Pane Chaung Formation on the east side of the Mindat Dome (Fig. 4.6). In the new road sections, impressive arrays of folds and faults with fold wavelengths of metres to tens of metres are present, in a section in excess of 100 m long and 10-15 m high (Fig. 4.6, attached at the back cover). The exposures tend to exhibit steep to vertical beds,

affected by isoclinal folds with sub-vertical axial surfaces and flat lying dips associated with isoclinal recumbent folds. These isoclinal and recumbent fold styles are commonly juxtaposed or superimposed. The bedding strike directions and the strike of fold axial surfaces ranges from NW-SE to NE-SW, with NNE-SSW and NNW-SSE directions (Fig. 4.7). The dip of fold hinges varies considerably from about 60° to horizontal in the one 100 m long road section. Thrust faults strike predominantly NNE-SSW, and dextral strike-slip faults are common features that strike between NNW-SSE and NNE-SSW directions, with N-S being the most frequent. In some parts of the sections bedding can be traced consistently across the outcrop as well. However, bedding is often highly discontinuous or competent units simply occur as blocks-in-matrix. In the Saw River section some examples of normal faults that strike between 100° and 145° are exposed (Fig. 4.8a). Competent and incompetent beds have been dragged into some fault zones with a deformation style typical of poorly lithified beds (Fig. 4.8b). Figure 4.9, shows a normal fault geometry where bedding lies sub-parallel to the fault plane. This geometry suggests inversion of the normal fault, which is supported by the presence of a small thrust fault in the hangingwall (Fig. 4.9b). The deformation style of the fault zones, and inversion structures indicate the normal faults formed early, prior to compressional deformation (Fig. 4.9a). Furthermore, the relatively small-scale recumbent, isoclinal folds from the Mindat Road section, that are probably related to early-stage deformation in an accretionary prism. These structures formed relatively early (F1) since they are deformed and folded by later structures. For example, in Fig. 4.5, up to four (including F1 and F2) folding events occurred prior to the deformation. The first generation folds (F1) have been folded by later upright folds (F2) that are cut by

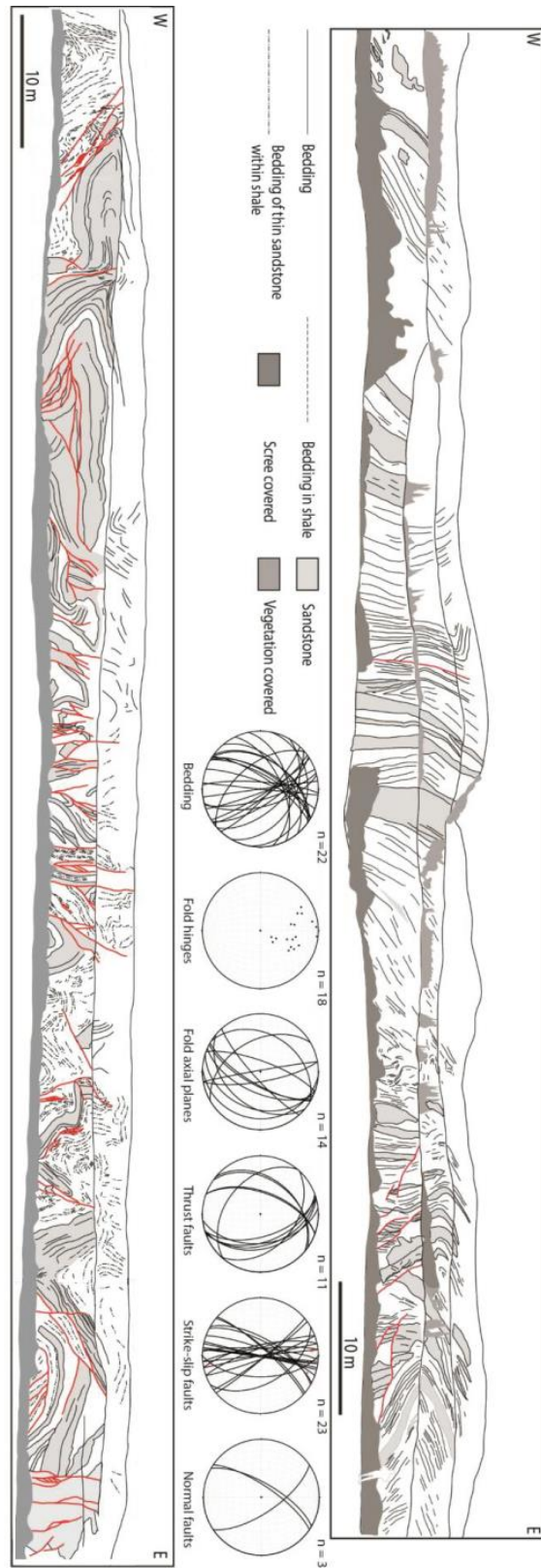


Fig. 4.7: Sketches of new road sections through the Pane Chaung Fm. on the road to Mindat.

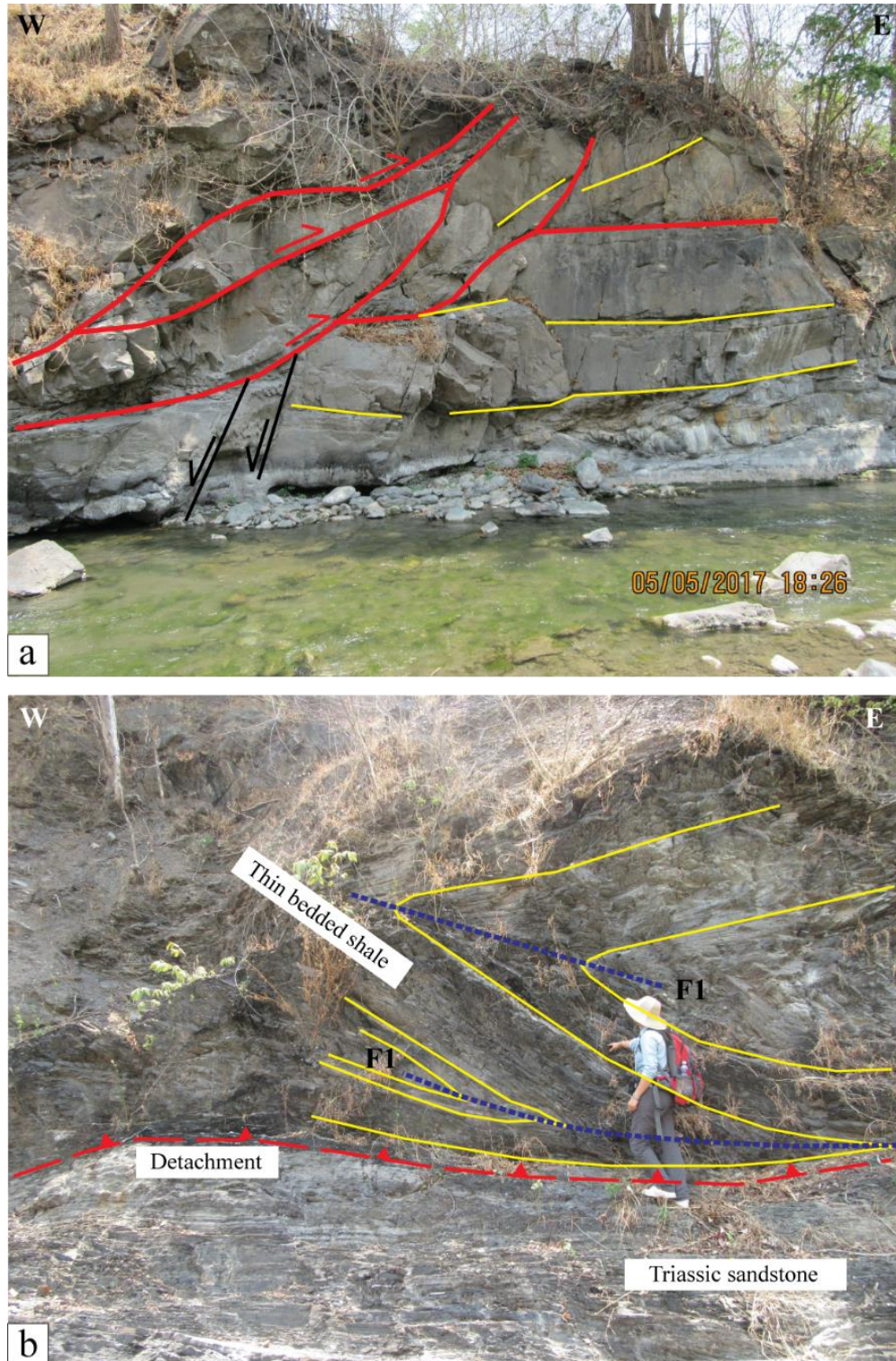


Fig. 4.8: Examples of structure styles in the Pane Chaung Formation, Saw River. (a) two small, relatively old normal faults are truncated by the small eastward-vergent ramping thrust, and (b) a low-angle detachment fault.

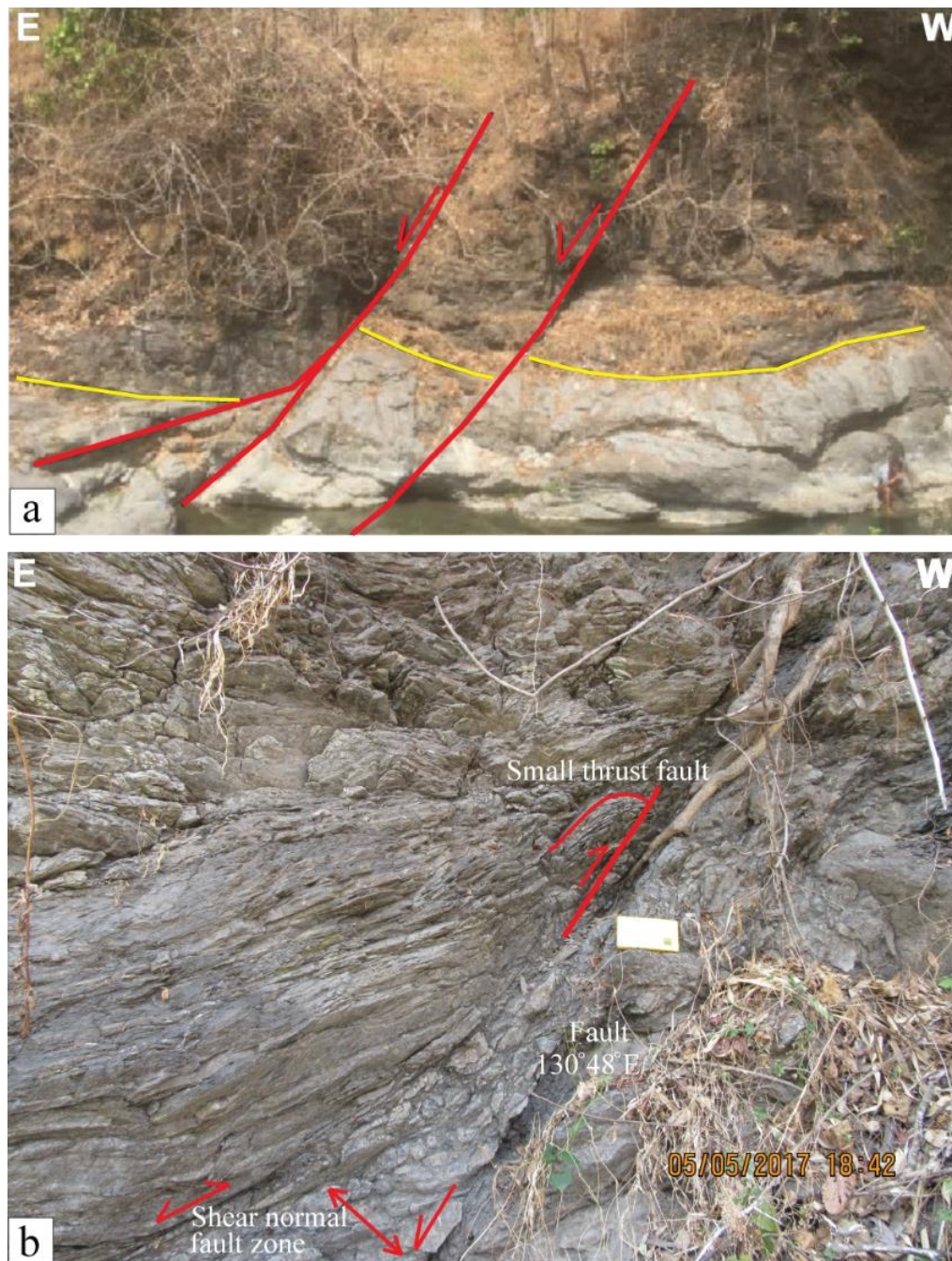


Fig. 4.9: Examples of normal faults in the Pane Chaung Formation, Saw River. (a) small normal faults with 1-2m offset, and (b) detail of normal fault zone, showing broad, sheared zone, typical of weakly lithified rock, and small thrust faults suggesting the fault is inverted.

later NNW-SSE striking, WSW-directed thrusts (T). These (T) thrusts truncate earlier small-scale folds. A fold (F1) with a steeply-dipping axial surface that is associated with an oblique-reverse dextral strike-slip fault set (SS) folds the sub-horizontal F1 axial surface. At the eastern end of the outcrop, an early set of thrusts (T) is observed, and some small, fault-related folds (F2) are related to the (T) thrusts. The road sections indicate early recumbent folding that is affected by a later phase of dominantly WSW-verging, to upright folding, accompanied by predominantly ENE-dipping, WSW-directed thrust faults. Later oblique-reverse dextral strike-slip motion on NNE-SSW faults (but ranging between NW-SE and NE-SW orientations) extensively affected the sequence, and produced dominantly upright to ESE-verging folds, together with some thrusts and late normal faults.

4.3.3 Kabaw Fault

The Kabaw Fault is present along almost the full length of the eastern margin of the IBR and has long been inferred to approximately mark the boundary between the Central Basin (CB) to the east, and the IBR to the west (Win Swe et al., 1972). There are diverse views regarding the structural significance, geometry, and extent of the Kabaw Fault. It was originally interpreted as an east-dipping fault (Chibber, 1934; Mitchell, 1984; Wang et al., 2014; Stecker et al., 2016a), whilst others, including Hla Maung (1987), Curray (2005). Maurin and Rangin (2009) and Rangin et al. (2013) interpreted it as a west-dipping fault. Maurin and Rangin (2009) show the core region of the IBR as thrust eastwards over the CB along the reverse-dextral slip, west-dipping Kabaw Fault. Bannert et al. (2011) described the Kabaw Fault as lying at the boundary between the IBR and the CB and showed a cross-section through several steeply-dipping to vertical strands of the Kabaw Fault zone that juxtaposes Kanpetlet Schist with serpentinite, and Paunggyi Formation and Laungshe

Formation with serpentinite. Morley et al. (2020) interpreted the Kabaw Fault as a dextral strike-slip fault bounding the western margin of the Central Basin, parallel to the Sagaing Fault in the east.

The west-dipping thrust fault interpretation would place, older, more highly deformed, high metamorphic grade rocks in the hangingwall over, younger, sedimentary rocks of the Central Basin in the footwall. The east-dipping thrust fault would be the inverse case (younger rocks over older), which does not make sense for a thrust, except for an out-of-sequence thrust interpretation. Based on the fieldwork in Saw area, the boundary between the IBR and the CB is marked by a series of unconformities (Fig. 4.1). Bedding dips recorded in the field (Fig. 4.7), and the sinuous relationships between geological boundaries and topographic contours (United Nations, 1979) indicate that, in the Mindat-Kanpetlet sector, the boundary between the Paung Chaung Formation or the Kabaw Formation and the Pane Chaung Formation is low-angled and east-dipping. This would fit either an east-dipping unconformity, or an east-dipping thrust interpretation for the Kabaw Fault (e.g. Brunnschweiler, 1966; Stecker et al., 2016a), not a steeply west-dipping fault (Curry, 2005; Maurin and Rangin, 2009; Rangin et al., 2013). Irrespective of the earlier unconformities, the Kabaw Fault is dominantly a later dextral strike-slip fault, probably related to the later Cenozoic northward indentation of India (with the IBR).

4.4 Biostratigraphy

4.4.1 Limestone

Two limestone samples (TT06 and TT13) were collected from the Mt. Victoria (Saw-Kyauktu) area (Fig. 4.1). TT06 is grey in colour and occurs as an exotic block within the

Kabaw Formation. TT13 is a thin-bedded, fissile, asphaltic limestone, and grey to dark grey colour on fresh surface, that was collected from the Paung Chaung Limestone/Formation.

Sample TT06 is characterized by a high diversity of red algae (*Lithothamnion*), and accompanied by spiculae, filaments, planktonic and benthic foraminifera (Fig. 4.10a). In addition, fragments of echinoderms, millolid, and gastropods, accompanied by corals and bryozoans are also present (Fig. 4.10b). The larger benthic foraminifera *Nummulites atacicus* (Leymerie) (Fig. 4.10c) was also found. The common, small foraminifera present are *Globorotalia* and *Quinqueloculina*. The occurrence of *Nummulites atacicus* indicates an Early Eocene age.

Sample TT13 consists of dominant planktonic foraminifera such as *Hedbergella planispira* (Tappan), and *Multispirina sp.* with minor benthic foraminifera and radiolarians (Fig. 4.10d,e,f,g). Based on the occurrence of *Hedbergella planispira*, the age range is from the Albian-Cenomanian (Sliter, 1989, 1992).

4.4.2 Shale

An attempt was made to identify new, more robust biostratigraphic controls for the transition of Pane Chaung Formation and Kabaw Formation. Samples of shale (TT16, 17 and 18) were taken from the Mindat road section. Poorly-preserved *Hedbergella sp.* were found from TT16 and TT17, whereas well-preserved planktonic foraminifera are present in sample TT18 (Kabaw Formation). The foraminifera in TT18 included *Hedbergella holmdelensis* (Olsson) of Campanian – early Maastrichtian age (Fig. 4.10h).

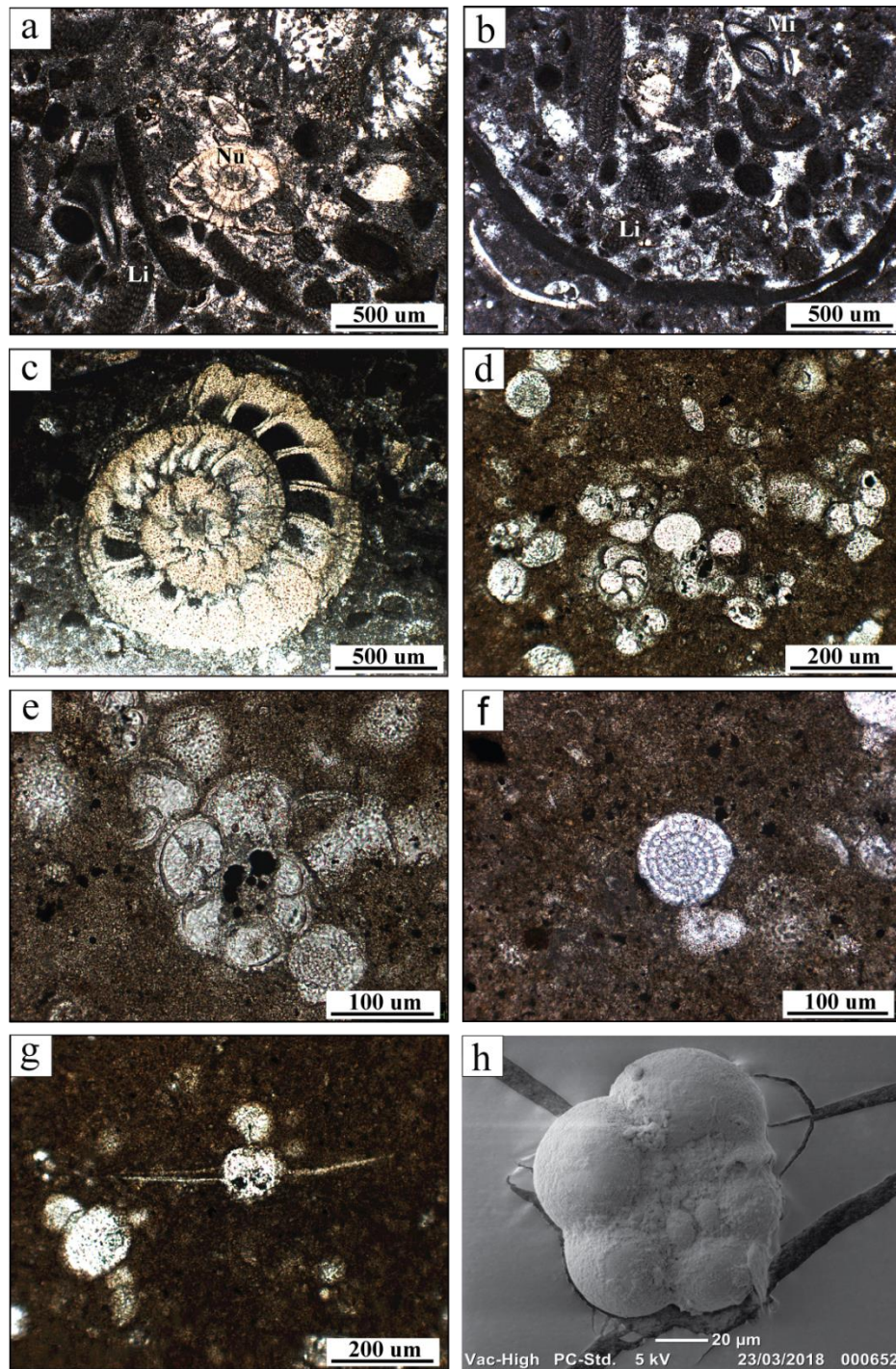


Fig. 4.10: Photomicrographs of limestones and shale of the study area. (a) and (b) red algae assemblage with *Nummulites* sp., millolid and gastropods, (c) *Nummulites ataticus*, (d) planktonic foraminifera assemblage, (e) *Hedbergella planispira*, (f) *Multispirina* sp., (g) radiolarian sp., and (h) *Hedbergella holmdelensis* (SEM).

4.5 Petrography

4.5.1 Sandstone

Five sandstone samples (TT04, 09, 11, 15 and 19) were analyzed to better understand the general petrography and provenance of the Pane Chaung, Kabaw and Paunggyi Formations. Petrographic point-count data from the fine to medium grained sandstones are presented in Appendix 2 and plotted on ternary diagrams (Fig. 4.11).

Sandstones (TT09, 11 and 19) from the Pane Chaung Formation are composed predominantly of angular to subrounded monocrystalline quartz grains with subordinate polycrystalline quartz, plagioclase feldspar and lithic fragments. Monocrystalline quartz is easily identifiable due to its lack of cleavage or alteration (Fig. 4.12a). Many quartz grains exhibit undulose extinction and the rest of them show uniform (unitary) extinction. Lithic fragments are mainly represented by phyllite, shale, siltstone, chert, and intermediate to basic volcanic rocks. Sedimentary lithic fragments (e.g. shales) are difficult to distinguish from low-rank metamorphic fragments. Feldspars are dominated by plagioclase grains and some have been partly altered to clays, and clay cement formed around the detrital grains (Fig. 4.12b). Muscovite, biotite, chlorite and heavy minerals are common accessory minerals (Fig. 4.12c). The matrix in all sandstone samples is dominated by clay minerals and organic matter. Both chlorite and mixed-layer clay cements are present in all samples. Texturally, the sandstones are immature and poorly to moderately sorted. The Pane Chaung Formation plots in the recycled orogenic provenance of the standard QFL plot (Dickinson et al., 1983) and the sandstones are feldspathic litharenites (Folk, 1980). XRD analysis of a sample (TT05) from the Pane Chaung Formation, shows quartz, plagioclase, illite/

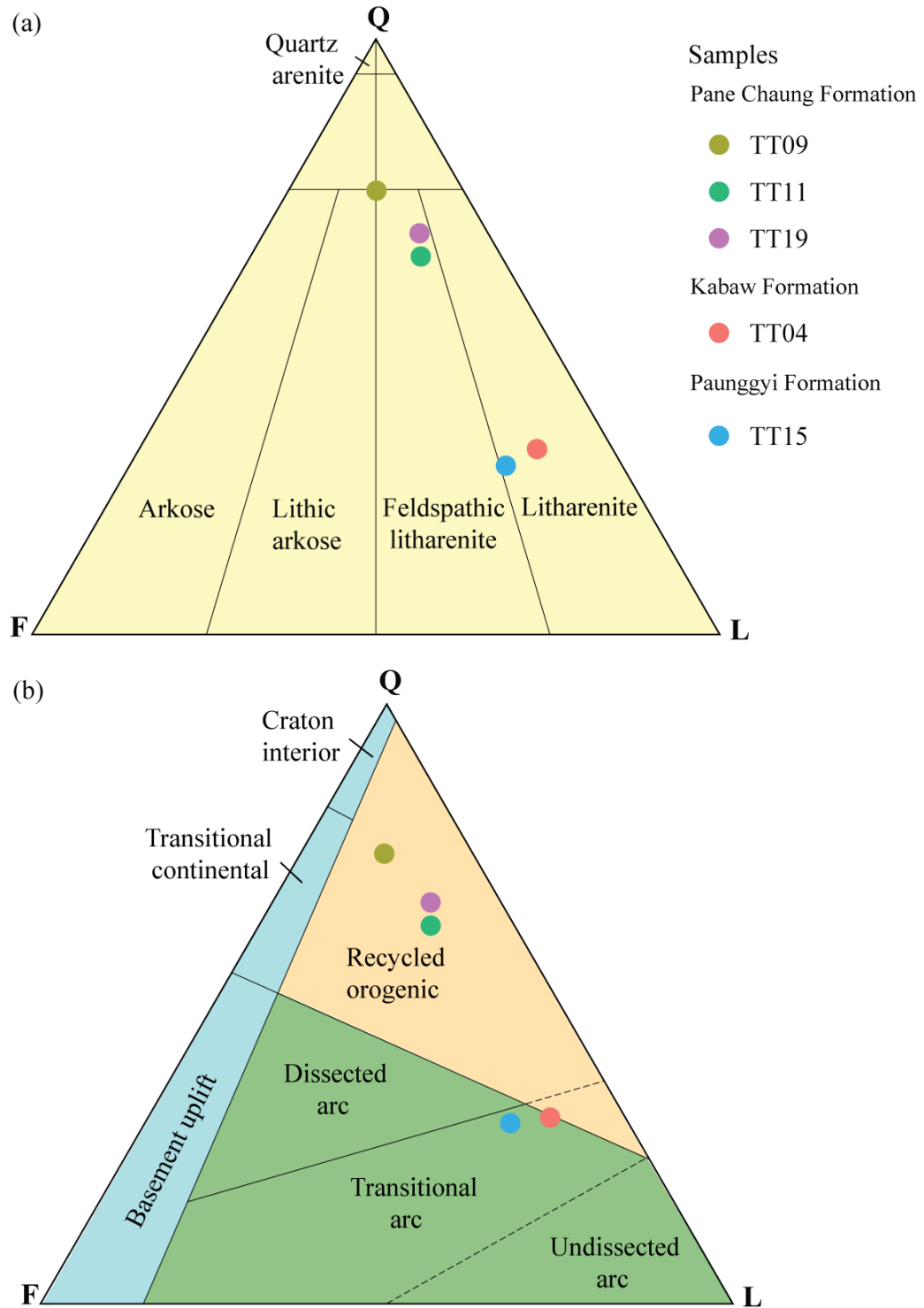


Fig. 4.11: QFL plots showing (a) sandstone classification (Folk, 1980) and (b) provenance fields (Dickinson et al., 1983) for the study area. Q-total quartz, F-total feldspar and L-total lithics.

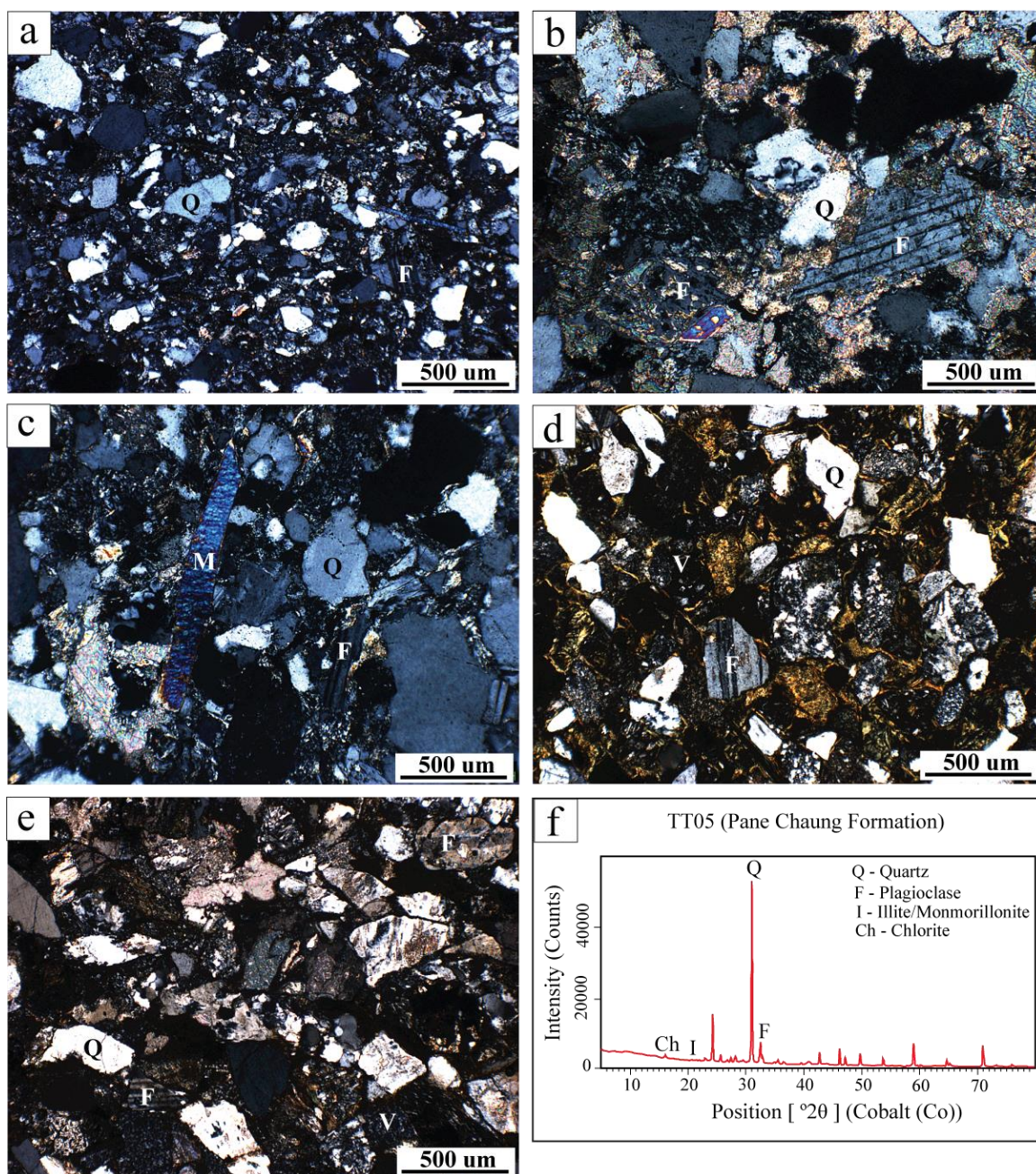


Fig. 4.12: Photomicrographs of the sandstones in the study area. (a), (b) and (c) Pane Chaung Formation, (d) Kabaw Formation, and (e) Paunggyi Formation. (f) XRD analysis of the Pane Chaung Formation. Q-quartz, F-feldspar, M-muscovite, V-volcanic lithic.

montmorillonite, and chlorite are all present (Fig. 4.12f). Within the clay minerals ~64% is illite with the rest being Fe-chlorite (36%).

Sandstones, TT04 from the Kabaw Formation and TT15 from the Paunggyi Formation are composed of a significant proportion of lithic fragments (Fig. 4.12d,e). Volcanic grains are mainly represented by felsite, with subordinate microlitic (andesitic) and lathwork (basaltic) types. Sedimentary lithics include shale, siltstone and chert. Quartz grains commonly show uniform extinction; some display embayments indicative of volcanic origin. Plagioclase grains exhibit euhedral crystal outlines and are twinned. Lithic fragments include plagioclase present in the form of phenocrysts, lath-like crystals and elongated microlites in groundmass. Clay cement formed fairly complete coatings with irregular thickness around detrital grains (Fig. 4.12d). Framework grains are characterized by angular to subangular morphologies. Texturally, the sandstones are moderately sorted and compositionally immature. The Kabaw and Paunggyi Formations sandstones are volcanic-rich and lie in magmatic arc provenance and are classified as litharenites.

4.5.2 Limestone

A petrographic description of the limestone types has been documented based on the Dunham (1962) classification.

The packstone of TT06 is composed mainly of angular to subangular fragments of macroforaminifera accompanied by some microfossils and varying amounts of comminuted fossil debris. A striking feature of this packstone is the high diversity of shapes (rounded and elongated) calcareous red algae (*Lithothamnion*). *Lithothamnion* has skeletons composed of cryptocrystalline calcite, which is precipitated within and between cell walls

(Fig. 4.10a,b). They occur as ovoid and elongate shapes and the grains are cemented by high-Mg calcite marine cement.

Sample TT13 shows wackestone microfacies containing fine bioclastic grains, particularly foraminifera represented by both planktonic and rare benthic forms with mud support and some sparry calcite cement (Fig. 4.10d). The foraminifera present are dispersed in a fine-grained and clay-rich micritic matrix. The internal chambers and tests of the planktonic organisms are frequently filled with pyrite and organic matter. The dark color of the grains is due to a high abundance of organic matter.

4.5.3 Kanpetlet Schist

Petrographic analysis of seven thin sections (TT01, 02, 07, 14, 20, 21 and 23) was conducted to determine the mineralogy of the metamorphic rocks collected in the field. The Kanpetlet Schist is a monotonous, thick sequence of highly deformed quartz-mica schists, which result from an assemblage of metamorphosed mudstone, graywacke and basic rocks. The most common and wide-spread greenschist can be divided into two groups: actinolite-chlorite bearing schist (TT01, 02 and 14) and quartz-mica bearing schist (TT07, 20, 21 and 23). The first group dominantly consists of actinolite-chlorite associations, together with quartz, albite, epidote and subordinate amounts of rutile, sphene and opaque (Fig. 4.13a,b,c,d), while the second group consists of quartz-muscovite-chlorite-albite and accessory opaques (Fig. 4.13e,f,g,h). Under the microscope, the darker layers consist mainly of ragged, fibrous actinolite and chlorite, and the lighter-coloured layers of quartz, albite and epidote which occur as granoblastic grains (Fig. 4.13a,b). Actinolite is a common alteration product of pyroxene. Recrystallised prisms of actinolite are transformed into fibrous actinolite and brown secondary actinolite is recrystallized at grain boundaries of

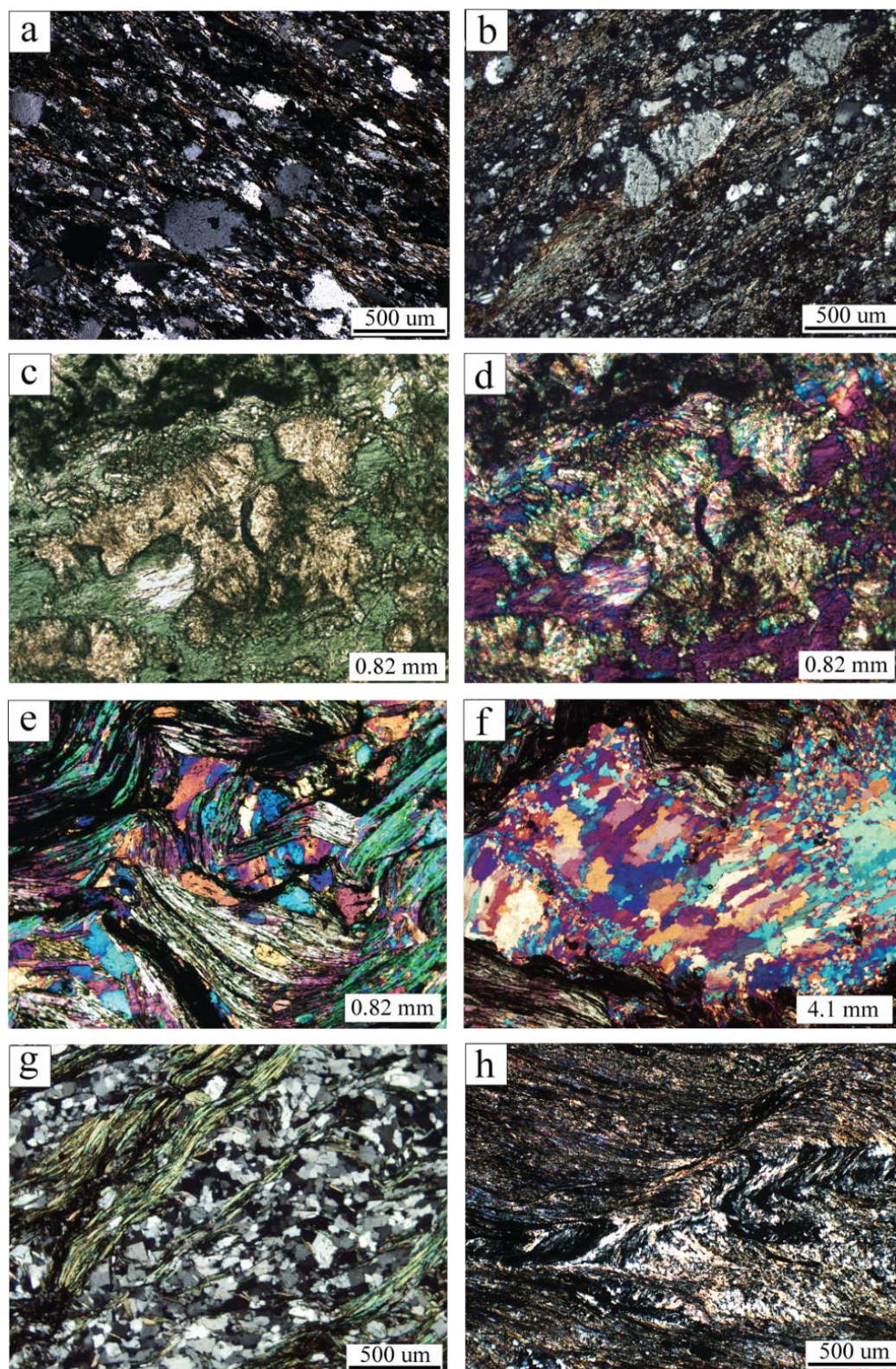


Fig. 4.13: Photomicrographs of the Kanpetlet Schist in the study area. (a), (b), (c) and (d) actinolite-chlorite bearing schist. (e), (f), (g) and (h) quartz-mica bearing schist.

primary iron-rich actinolite. Actinolite is most commonly found in contact- and regionally-metamorphosed calcareous sediments and is also found in metamorphosed mafic and ultramafic rocks (Deer et al., 1997). Chlorite shows its characteristic greenish pleochroism with low to moderate relief. It forms by the recrystallization of clay minerals or alteration of mafic minerals. It is an important constituent of many contact and regional low to medium grade metamorphic rocks (Deer et al., 1997). Deformation of quartz grains allows the rotation of planar or prismatic minerals, which enhances foliation development. Quartz grains possess undulose extinction and occur in coarser and finer form with irregular grain boundaries and showing granoblastic texture. A few quartz grains possess inclusions of minute actinolite, chlorite and secondary quartz. Relict pre-tectonic igneous crystals or structures may be deformed and wrapped around by a foliation due to parallel crystals and layers of elongate actinolite and chlorite.

Quartz-mica bearing schists are dominated by medium- to coarse-grained quartz and muscovite (Fig. 4.13e,h). The schist consists of interlocking, elongate quartz crystals as layers or lenses alternating with layers of interleaved, parallel muscovite flakes forming the foliation. Quartz grains arrange themselves parallel to the foliation plane and are sandwiched between mica minerals. Quartz grains show undulose extinction. Sheet-silicates exhibit some degree of bending and shearing, especially in connection with second-generation microfolds or intersecting foliations (Fig. 4.13e). They are often characterized by elongate grains and serrated grain boundaries (Fig. 4.13f) suggesting dynamic recrystallization (Shelley, 1993). Muscovites show well developed schistose texture. Muscovite occurs as lepidoblasts with basal cleavage (Fig. 4.13e). Quartz is associated with

S-type foliation while the muscovite represents C-type foliation (Fig. 4.13f). Quartz and muscovite may have all crystallized syntectonically and simultaneously.

4.5.4 Ultramafic rock

Two small bodies of ultramafic rock occur in the Mt. Victoria area. Two peridotites samples (ST03 and ST12b) were collected from the Kyauksit Chaung (Fig. 4.1), where they occur as small exotic blocks. Texture, mineral association and relative abundance of minerals were taken into account in the identification of these rocks. These rocks are classified on the basis of abundance of olivine, ortho- and clinopyroxenes. Olivine represents the dominant mineral composition and most of the olivine grains are serpentized. Olivine is fine to coarse grained and shows different degrees of orientation, and together with serpentine, develops a strong foliation. Most of the olivines display a porphyroblastic texture and usually have two distinct modes of olivine: large porphyroblasts and protogranular (>2 mm) olivine, and small neoblasts (sheared type) and fine-grained (<1 mm) olivine (Fig. 4.14a,b,c,d). The porphyroblasts are elongated, flattened or curved, and are surrounded by small olivine neoblasts and chrome spinel. The neoblasts show uniform extinction. They are mostly anhedral with embayed margins surrounded by aggregates of olivines protruding in their rims. Serpentine is present mostly as the alteration product of primary olivine. The original mantle textures indicate growth of olivine and orthopyroxene in a typical mantle peridotite; there has been no subsequent metamorphism but the peridotites show extensive low-temperature alteration during serpentinisation where the olivine forms serpentine minerals and the orthopyroxene forms bastite. The porphyroblasts are commonly strained and show features of high-temperature plastic deformation such as

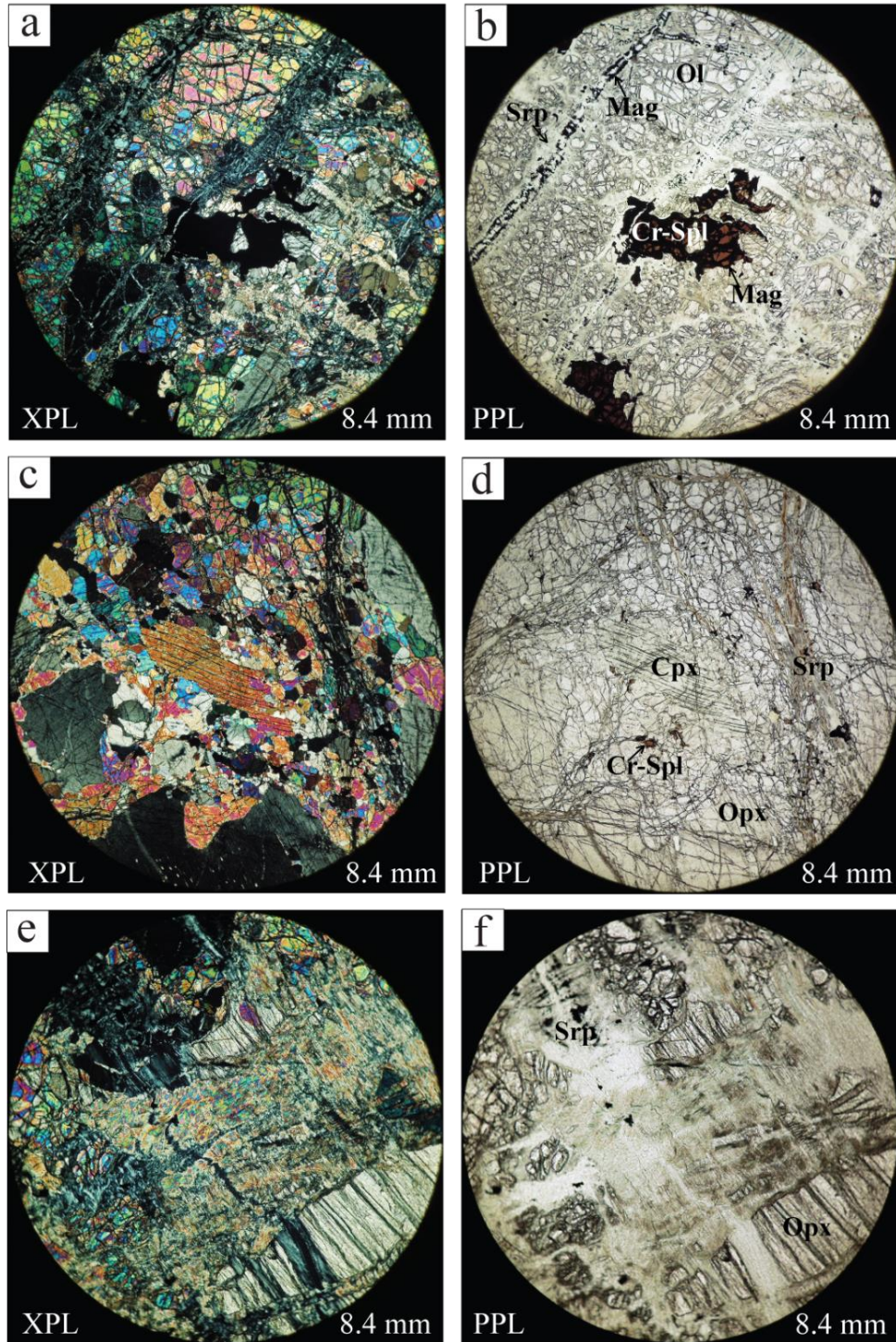


Fig. 4.14: Photomicrographs of the mantle peridotite under PPL and XPL. (a) and (b), spinels in a holly-leaf shape. (c) and (d) porphyroblastic texture. (e) and (f), shear deformation. Ol-olivine, Cpx-clinopyroxene, Opx-orthopyroxene, Srp-serpentine, Cr-Spl-spinel, Mag-magnetite.

undulose extinction and kink-bands. Accessory chrome spinel grains in peridotites display holly-leaf or lobate structures (Fig. 4.14a,b) and are interstitial between silicate minerals. Spinel occurs as reddish-brown hypidiomorphic and xenomorphic textured grains with veinlets of magnetite. Tiny stringers of spinel also occur within clinopyroxene exsolved lamellae in orthopyroxene (Fig. 4.14e,f). The peridotites are devoid of plagioclase and interpreted as original mantle harzburgite or lherzolite affected by extensive serpentinization and hydrothermal alteration. The core of the serpentine veins often entrap trails of fine magnetite granules (Fig. 4.14a,b).

4.5.5 Mafic rock

One gabbro sample (ST12a) from a small size block (<10m²-size) has been collected from the Kyauksit Chaung (Fig. 4.1). The gabbro is an essential part of the lower oceanic crust, and is a component of most ophiolites. It is mainly composed of medium to coarse-grained plagioclase feldspar and pyroxene (both clino and orthopyroxene) porphyroblasts, and a groundmass of amphibole, plagioclase, pyroxene with minor olivine, hornblende, interstitial magnetite and spinel (Fig. 4.15a,b). The gabbro displays granular texture. The original igneous gabbro is not recrystallized, which has presumably seen a similar history as the peridotites. The plagioclase grains in places show partial alteration to sericite, epidote and clay minerals. They are mostly untwinned and contain olivine inclusions. Pale brown clinopyroxene phenocrysts are surrounded by hastingsite and plagioclase. The pyroxene content is mostly clinopyroxene, but small amounts of orthopyroxene may also be present. The poikilitic clinopyroxene contains inclusions of serpentinised olivine and exsolution lamellae of orthopyroxene diagonally across the cleavage. The pyroxenes are partially

altered to chlorite near their rims. Biotites are observed as reaction products around opaque iron oxides.

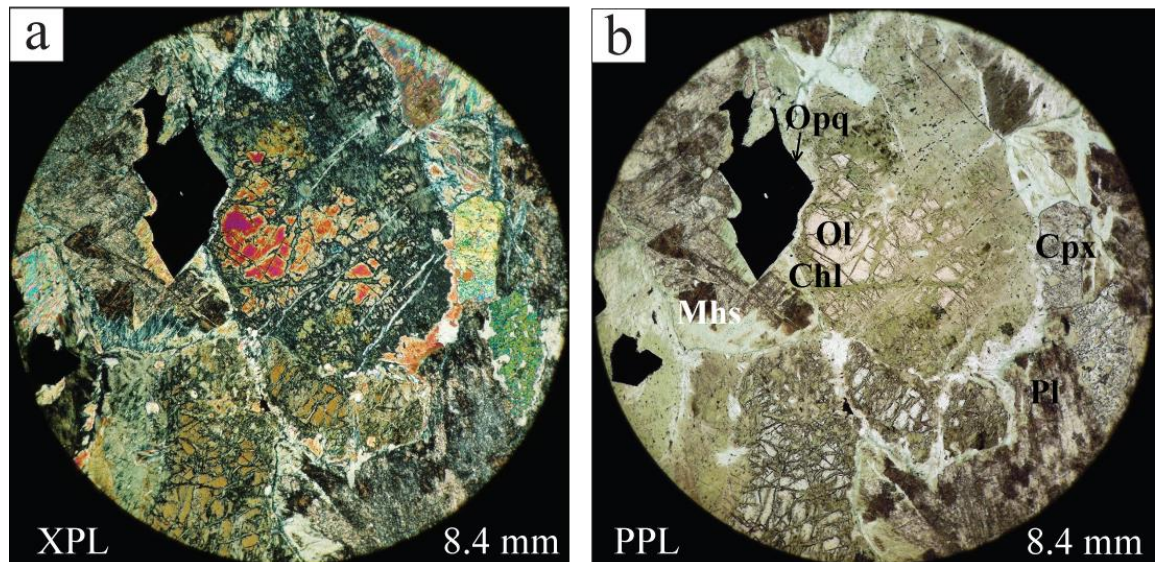


Fig. 4.15: Photomicrographs of the gabbro under PPL and XPL. (a) and (b), porphyritic olivine gabbro. Ol-olivine, Cpx-clinopyroxene, Pl-plagioclase, Chl-chlorite, Mhs-magnesio-hastingsite, Opq-opaque.

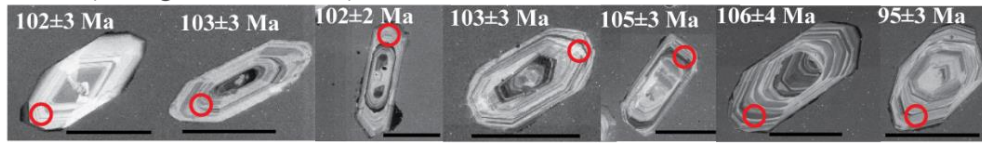
4.6 Detrital zircon U-Pb ages

Five sandstone samples (TT04, 05, 12, 15 and 19) were analysed for detrital zircon U-Pb dating from the Mt. Victoria area (Fig. 4.1). Of these, two (TT05 and 19) were collected from the Pane Chaung Formation, two (TT04 and TT15) were collected from the Kabaw Formation and one (TT12) was collected from the Laungshe Formation.

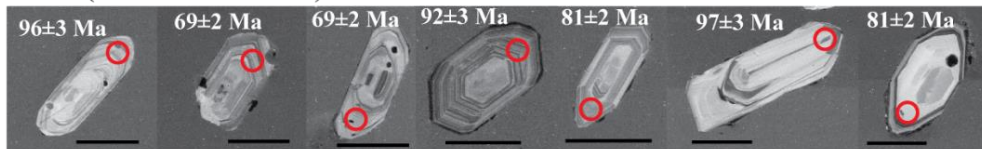
Detrital zircons from all five samples are predominantly subrounded to euhedral and have elongated to stout prismatic habits. Most zircons are transparent, colorless to pale brown, and show a simple oscillatory growth pattern on CL images (Fig. 4.16), suggesting a

contemporaneous igneous provenance. A few grains in TT05 and TT09 contain an oscillatory-zoned core enveloped by a thin structureless rim. The zoning within the core is truncated at the rim and the orientation of the core does not conform to the external shape of the crystal probably suggesting that these grains grew during a phase of high-grade metamorphism (Williams, 1995). All samples yielded over 100 concordant zircon U-Pb ages.

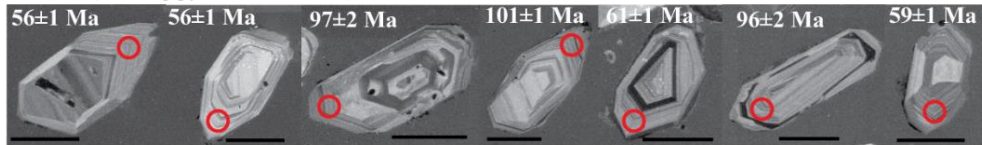
TT12 (Laungshe Formation)



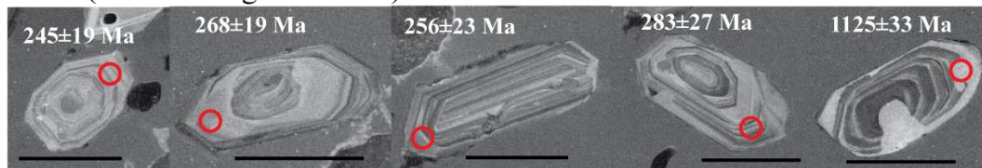
TT04 (Kabaw Formation)



TT15 (Paunggyi Formation)



TT05 (Pane Chaung Formation)



TT19 (Pane Chaung Formation)

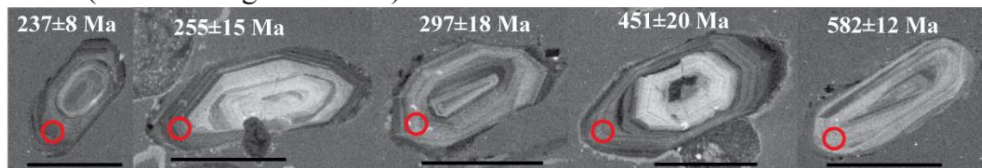


Fig. 4.16: Representative CL images of detrital zircons from the study area (scale bar = 100 μm). Red circles indicate the positions of U-Pb age analyses and ages of analyses zircons.

Detrital zircon U-Pb ages in samples TT05 and TT19 (Pane Chaung Formation) range in age from 2966 ± 19 Ma to 232 ± 9 Ma and 2049 ± 15 Ma to 228 ± 9 Ma, respectively. The zircon-age spectra display three main clusters in the Mesoproterozoic (1.3-1.0 Ga, 15 - 26% of total analyzed grains), Neoproterozoic-Cambrian (800-490 Ma, 31 - 37%), and Late Paleozoic-Early Mesozoic (350-230 Ma, 22 - 36%), as well as scattered Paleoproterozoic – Archean (3.0-1.6 Ga) and Ordovician - Devonian (484-360 Ma) ages (Fig. 4.17). The

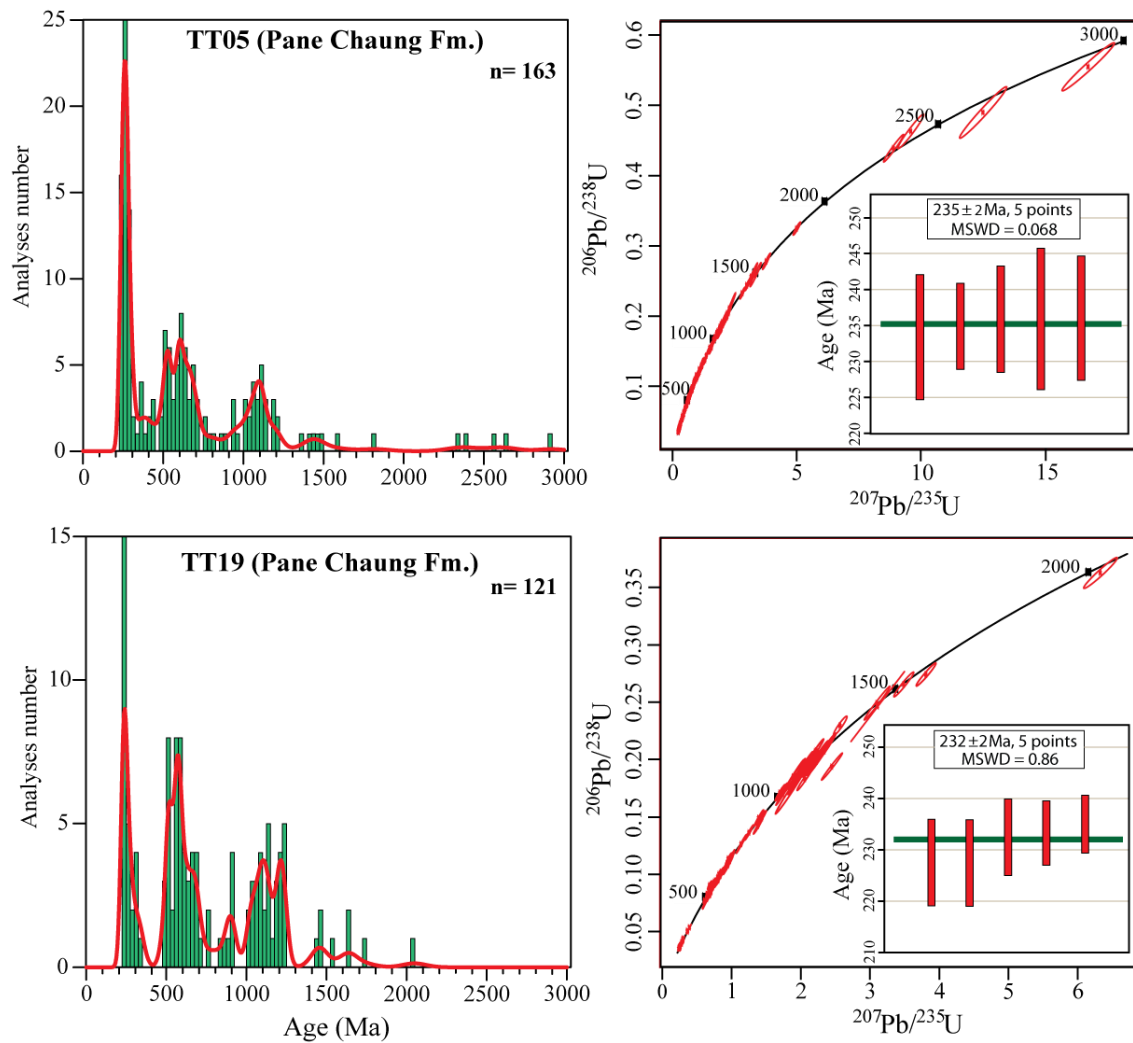


Fig. 4.17: Histograms and probability density plots, concordia diagrams and weighted average age diagrams showing detrital zircon U-Pb ages of the Pane Chaung Formation.

youngest zircons in Pane Chaung Formation sandstones are 228 ± 9 Ma and 232 ± 9 Ma, and the five youngest zircons give a weighted average age of 232 ± 2 Ma and 235 ± 2 Ma respectively (Fig. 4.17).

Detrital zircon U-Pb ages in sample TT04 (Kabaw Formation) range in age from 1904 ± 18 Ma to 69 ± 2 Ma. Grains from TT04 displays a prominent age cluster in the Cretaceous (120-69 Ma, 89% of total analyzed grains) with a notable peak at ~ 75 Ma, and scattered Precambrian (1.9-0.6 Ga, 5%) and Carboniferous-Triassic (310-220 Ma, 6%) ages (Fig. 4.18). The youngest zircons ages and the weighted average ages of the youngest zircons in Kabaw Formation sandstone sample is 69 ± 2 Ma.

Detrital zircon U-Pb ages in sample TT15 (Paunggyi Formation) range in age from 1474 ± 6 Ma to 56 ± 1 Ma. In sample TT15, the zircon-age spectra shows two main clusters in the Cretaceous (105-70 Ma, 46%) and Paleocene (65-56 Ma, 42%) with a peak at ~ 60 Ma. Precambrian (1.5-0.6 Ma, 7%) and Devonian-Triassic (370-210 Ma, 5%) zircons are present, but do not form clear-cut population (Fig. 4.18). The youngest zircons ages and the weighted average ages of the youngest zircons in Paunggyi Formation sandstone sample is 56 ± 1 Ma.

Detrital zircon U-Pb ages in sample TT12 (Laungshe Formation) range in age from 1872 ± 12 Ma to 47 ± 1 Ma. The data are dominated by a Cretaceous population (112-85 Ma, 73% of total analyzed grains) with a notable peak at ~ 100 Ma (Fig. 4.18). There is also small Eocene (50-47 Ma, 8%) population present in the sample. Precambrian-Cambrian (1.8-0.5 Ma, 10%) and Carboniferous-Jurassic (355-191 Ma, 7%) zircons also occur in the sample. The youngest zircon in Laungshe Formation sandstone is 47 ± 1 Ma, and the seven youngest zircons give a weighted average age of 50 ± 1 Ma.

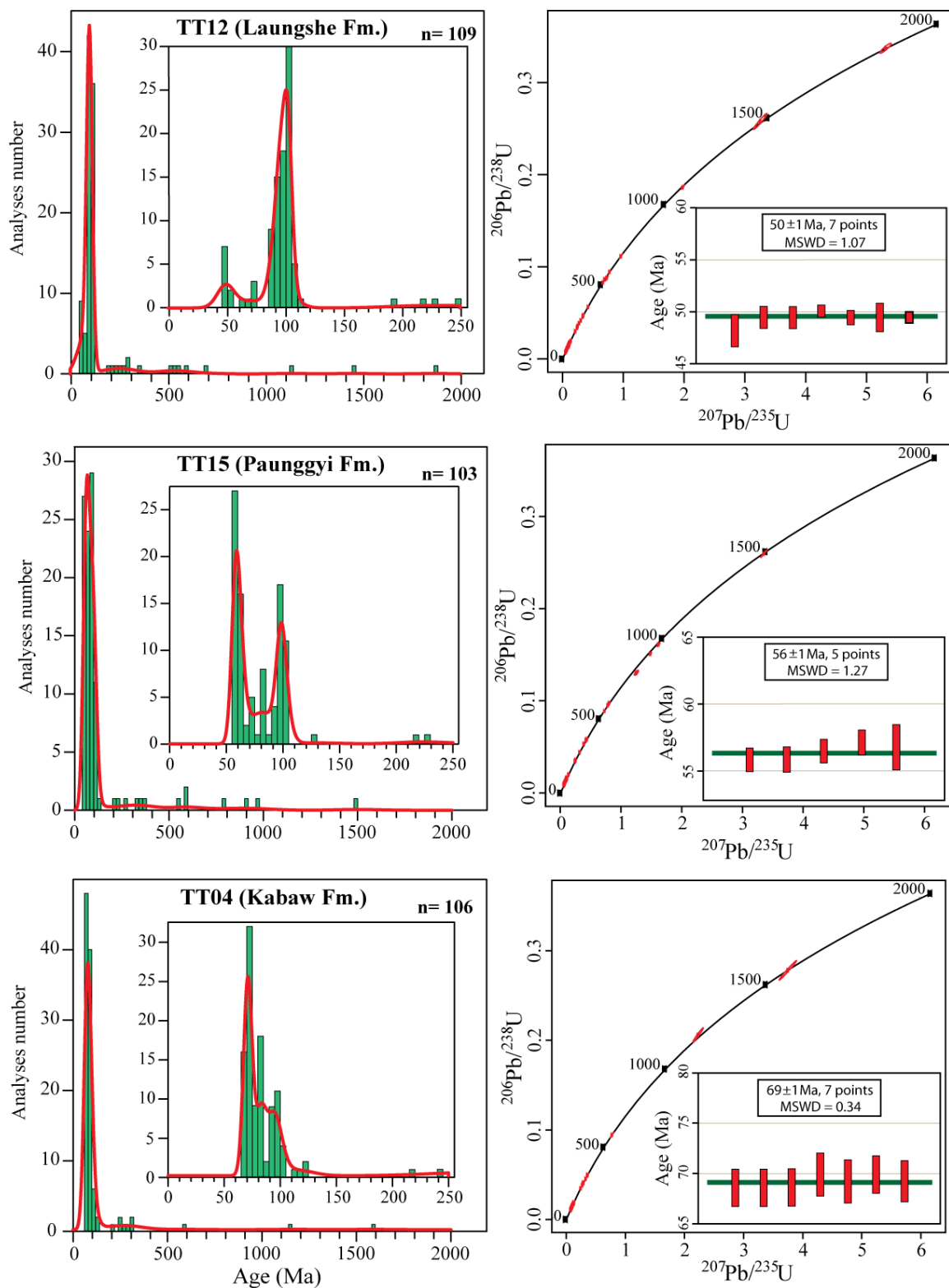


Fig. 4.18: Histograms and probability density plots, concordia diagrams and weighted average age diagrams of the Central Basin.

4.7 Discussion

4.7.1 Depositional environments and ages of sedimentary rocks in the Mt. Victoria area

The depositional age of the Pane Chaung Formation has previously been reported as Triassic based on the rare occurrence of *Halobia* fossils (Theobald, 1871; Myint Lwin Thein, 1970; Gramann, 1974; United Nations, 1979; Bannert et al., 2011; Yao et al., 2017; Zhang et al., 2017) and detrital zircon U-Pb dating ages (Sevastjanova et al., 2015; Yao et al., 2017). The new detrital zircon U-Pb data obtained in the present study confirm that the age of youngest zircon (228 Ma) and the age of the youngest zircon population as Triassic. However, some previously published samples yielded Early Jurassic maximum depositional ages with secondary peaks between 200 Ma and 170 Ma (Sevastjanova et al., 2015; Yao et al., 2017). Detrital zircon analysis of the Pane Chaung Formation indicates the maximum depositional ages are predominantly of Late Triassic age, with a few samples exhibiting possible Early Jurassic ages. Fossils of age-diagnostic bivalves (*Halobia aff.*, *Dilatata*, *Halobia cf. convexa*), indicate a Carnian-Norian depositional age for the Pane Chaung Formation (Yao et al., 2017). However, the stratigraphic relationships between the *Halobia* samples and the samples containing Jurassic zircons are not known (nor can be sufficiently well-established from the literature) and, therefore, it is impossible to determine whether or not the Jurassic zircon-bearing samples occur stratigraphically above *Halobia*-bearing samples. The lithology, biostratigraphy and sedimentary structures of the Pane Chaung Formation indicate deposition as submarine fan turbidites.

Sevastjanova et al. (2015) reported that the detrital zircon ages of marlstone collected from the Paung Chuang Formation are dominated by a Late Cretaceous (Cenomanian-

Turonian) zircon population. The age of the Paung Chaung Limestone has previously been reported at Upper Albian-Cenomanian, based on the occurrence of Cenomanian fossil *Orbitolina birmanica* (Gramann, 1974), and Upper Albian ammonite (United Nations, 1979a). The new biostratigraphic data presented in this study indicates an Albian-Cenomanian age, based on the occurrence of *Hedbergella planispira*. The overlapping age ranges of Cretaceous fossils are consistent with the detrital zircon ages. The depositional environment of the Paung Chaung Limestone has previously been interpreted as reflecting a calm-water marine environment (Sevastjanova et al., 2015). These observation suggests otherwise: (1) the high content of planktic foraminifera suggests an outer neritic to upper bathyal environment below normal-wave base, (2) the rarity of benthic foraminifera indicate that the sediment was deposited in an oxygen deficient environment, and (3) the sub-seafloor anoxic conditions were interpreted due to the presence of foraminifera tests infilled by pyrite. Taken together, these observations suggest deposition in a proximal ramp facies of the type generally found in the lower slope environment (Baudin et al., 1997).

The exotic limestone block (TT06) is richly fossiliferous and contains abundant *Lithothamnium* together with *Nummulites ataticus*, which constrain the age from late Ypresian to early Lutetian and deposition in a shallow marine environment. Red algae are common contributors to reefs and lagoons in modern carbonate environments (Tucker, 2001). The Laungshe Formation in the Minbu Basin very occasionally contains macroforaminifera-*Lithothamnium* limestone, and foraminifera include *Nummulites ataticus* (Bender, 1983). It has been regarded as an allochthonous limestone that either originated from the Langshe Formation or post Paleogene reworking in the Kabaw Formation.

The area around, and to the south of, Mt. Victoria is structurally a part of the Minbu Basin despite its topographic similarity to the Indo-Burman Ranges. In the Minbu Basin, the boundaries of the Kabaw Formation and Paunggyi Formation units are vaguely defined. The Kabaw Formation was deposited in a fairly deep shallow marine depositional environment (Thura Oo, 2000), and the Paunggyi Formation was deposited in shallow marine environment (Bender, 1983). Fossils and detrital zircon ages of the Paunggyi Formation have previously been interpreted as Maastrichtian to Paleocene and have yielded young zircon ages of 64 Ma and 69 Ma (Wang et al., 2014; Licht et al., 2018). The youngest zircon age of the Kabaw Formation is around 70 Ma (Wang et al., 2014). Rangin et al. (2013) also reported Maastrichtian-aged *Globotruncana* in the conglomerate of the Kabaw Formation which consists of ophiolite-derived clasts. They infer that this marks the time of obduction of Mesozoic ophiolites onto the Mt. Victoria terrain. Detrital zircon U-Pb results show that the maximum depositional age of the Paunggyi Formation is 56 ± 1 Ma, and the Kabaw Formation 69 ± 1 Ma. These data suggest that only the Paleocene part of the sequence should be called the Paunggyi Formation and that the age of Kabaw Formation is Maastrichtian. Fossils and maximum depositional ages from the detrital zircons indicate the age of the Laungshe Formation is Early-Middle Eocene (Bender, 1983; Wang et al., 2014), but Licht et al. (2018) have interpreted the unit as uppermost Paleocene to Lower Eocene using lithostratigraphy. In contrast to Licht et al. (2018), the new data presented here indicate that the youngest zircon age is 47 ± 1 Ma and the maximum depositional age is 50 ± 1 Ma. The new results thus support the early-middle Eocene age of the Laungshe Formation, determined by Bender (1983) based on fossils.

4.7.2 Provenance interpretation

4.7.2.1 Upper Triassic Sandstones

The Upper Triassic Pane Chaung Formation in the IBR, has long been an enigmatic geological unit and its paleogeographic position at the time of deposition has remained a controversial topic for a long time. On QFL plots, grain-counting results lie within the recycled orogenic provenance field that have been compiled with the data from Upper Triassic unit in the Rakhine area (Fig. 3.9, 4.11) and published results by Sevastjanova et al. (2015) and Yao et al. (2017). The U-Pb zircon ages presented here from the Mt. Victoria are strikingly similar to the age distributions of the same unit in the Rakhine area and that studied previously by Sevastjanova et al. (2015) and Yao et al. (2017) in the Mt. Victoria area (Fig. 4.19). Similar age populations would suggest that the Upper Triassic sandstones from the Mt. Victoria and Rakhine area were formed from the erosion of the same source rocks, and hence would suggest deposition at similar times. A detail discussion of the tectonic evolution and the paleogeographic position of the Pane Chaung Formation will be presented in Chapter 6.

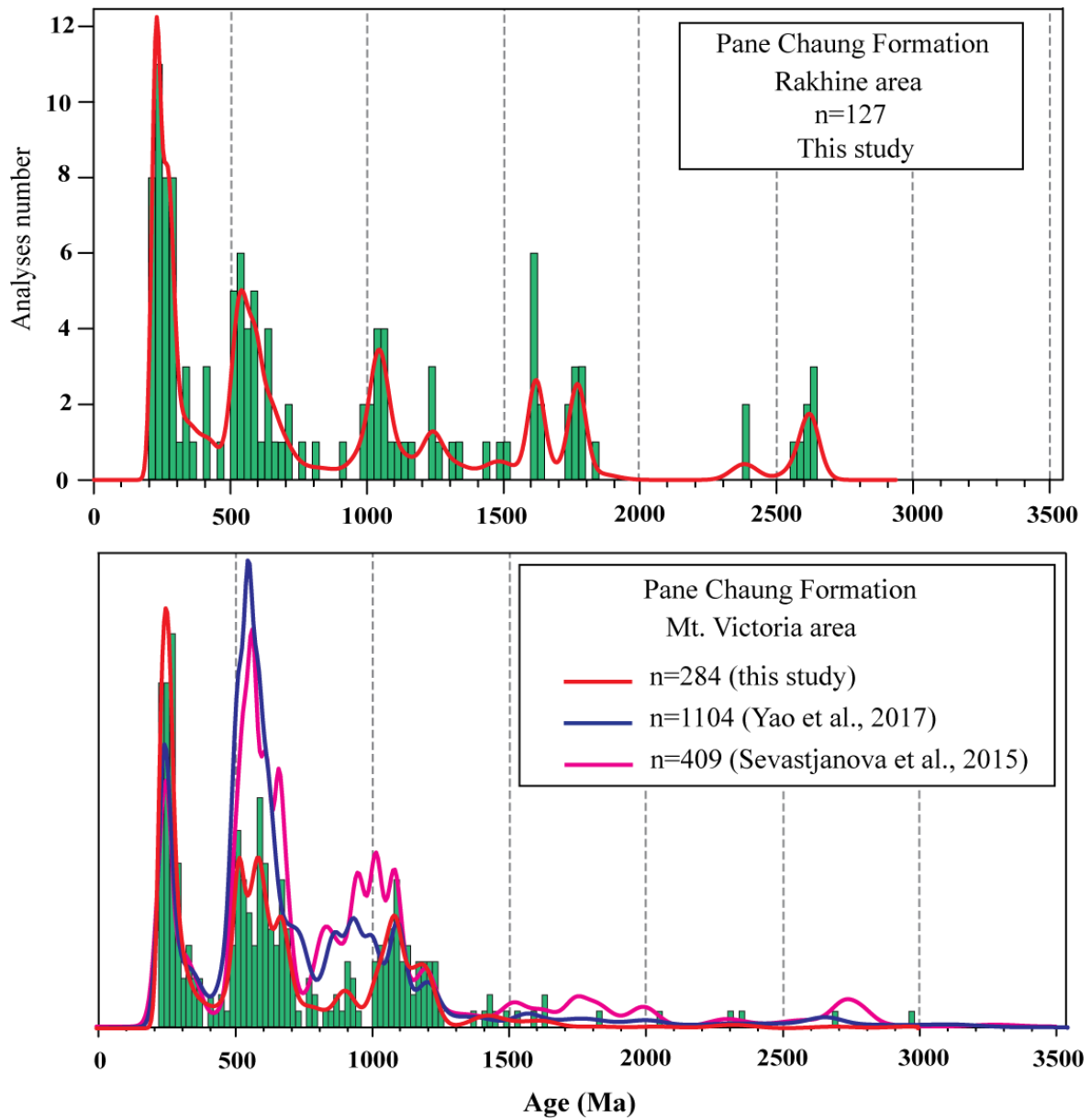


Fig. 4.19: Comparison of detrital zircon ages from the Pane Chaung Formation in Mt. Victoria (present study), with those from the published results (Sevastjanova et al., 2015; Yao et al., 2017) and Rakhine area (present study).

4.7.2.2 Upper Cretaceous-Paleogene Sandstones

The QFL plots give some useful insights into the provenance of the Kabaw and Paunggyi Formations in the Minbu Basin. The grain-counts and U-Pb ages distributions from the Kabaw and Paunggyi sandstones indicate a provenance from Late Cretaceous-Paleogene rocks, likely the Wuntho-Popa magmatic arc located to the east, which was active during the same period and displays the same age peaks (Mitchell et al., 2012; Wang et al., 2014; Gardiner et al., 2015, 2016; Zhang et al., 2018). Dating of detrital zircon populations extracted from the Kabaw and Paunggyi Formation in the Minbu Basin and the laterally equivalent unit in the Chindwin Basin (Wang et al., 2014) yield similar age populations (Fig. 4.20), that would suggest that the rocks were formed from the erosion of the same source rocks. Zhang et al. (2017) has shown that zircons from the Wuntho-Popa Arc have similar ϵ_{Hf} fingerprint to the Gangdese batholiths. These proximal sources (Wuntho-Popa Arc and Gangdese batholiths) are corroborated in the Minbu Basin by ϵ_{Nd} and Sr isotopic values, grain counts and paleocurrents that all indicate a proximal volcanic source located east in the east of the forearc basin (Licht et al., 2013). A minor contribution of zircon grains have ages between 550 and 1900 Ma which may have been sourced from the Burmese margin or the Himalayan orogeny.

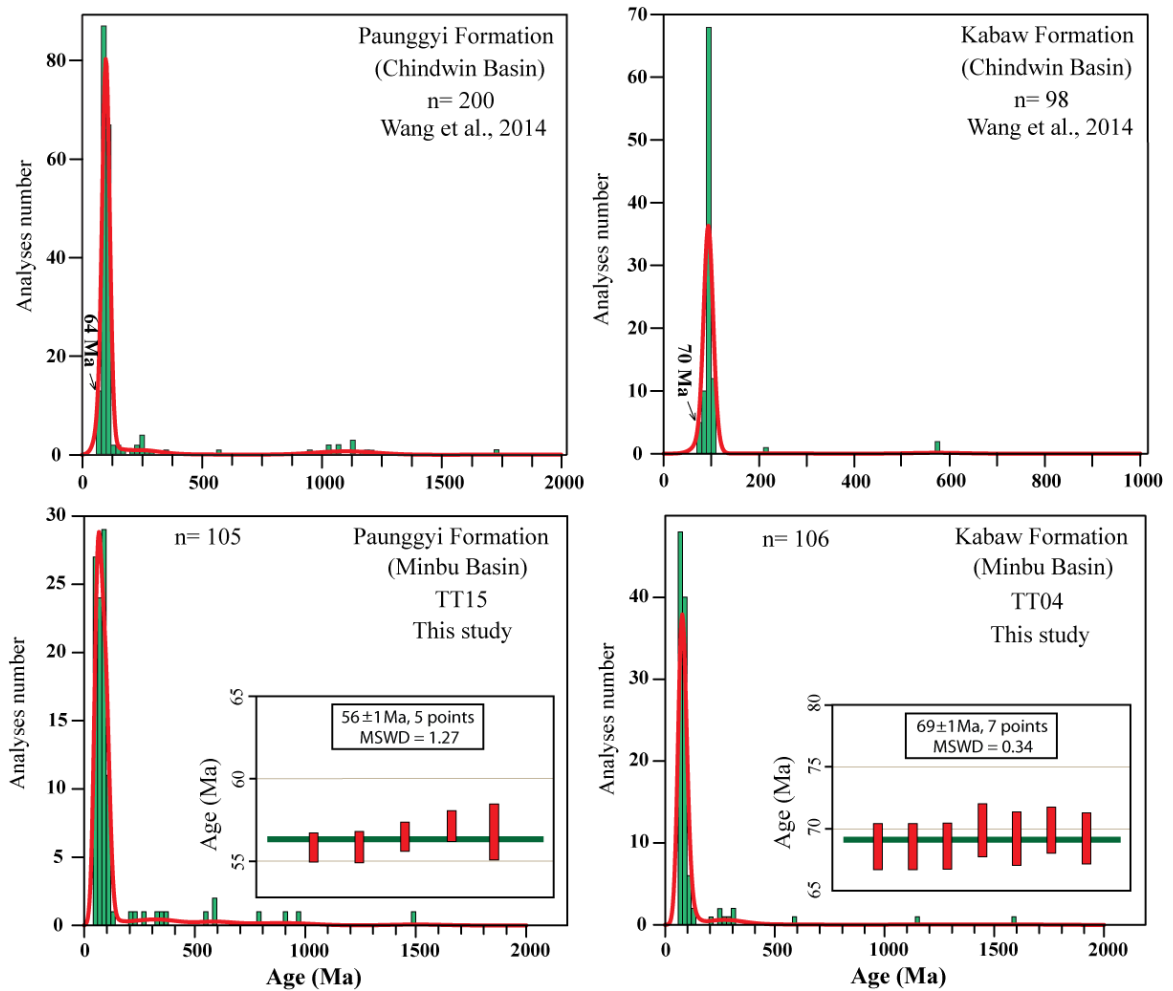


Fig. 4.20: Comparison of detrital zircon ages from the Minbu Basin (present study), with those from the Chindwin Basin (Wang et al., 2014).

4.7.3 Metamorphism of Kanpetlet Schist

The Kanpetlet Schist has been previously interpreted as three types of paragenesis: (1) actinolite-chlorite associations (greenschist facies) in the metabasites, (2) chlorite-phengite associations in the metapelites, characteristic of greenschist, and (3) chlorite-crossite-epidote-albite associations in some metagreywackes reflecting borderline greenschist and blueschist metamorphism (Socquet et al., 2002). The characteristic conditions for

greenschists range from around $4\text{--}5 \pm 1$ kb, $300\text{--}400 \pm 100$ °C to 8 ± 1 kb, 450 ± 100 °C (Socquet et al., 2002). Petrographic studies of Kanpetlet Schist from the Mt. Victoria-Saw and Mindat-Mt. Victoria road sections identified metapelites within the schist with chlorite-phengite associations, and metabasites with actinolite-chlorite associations. The greenschist assemblages are interpreted to be formed in metapelitic and metabasic rocks. The mineral assemblages observed in all samples are typical greenschist facies. Zhang et al. (2017) have noted a decrease in metamorphic grade, as would be expected when passing from the core to the margins of a typical anticline. The greenschist facies rocks of the Kanpetlet schists are related to low-grade regional burial metamorphism, probably associated with crustal thickening processes. There are no blueschist or eclogite facies rocks reported in this area so a subduction related origin is unlikely.

4.8 Conclusions

Petrographic data and detrital zircon U-Pb dating analysis from the Mt. Victoria area and Minbu Basin have led to the following major conclusions:

1. The Upper Triassic Pane Chaung Formation sandstones have a recycled orogen affinity and U-Pb zircon age distributions are strikingly similar to those from the Rakhine area.
2. The Kabaw and Paunggyi Formations contain a significant component of arc-derived material, interpreted as derived from the Wuntho-Popa magmatic arc to the east with minor contributions from the Burmese margin and Himalayan orogeny.

3. The Kanpetlet Schist is composed of greenschist facies, metapelitic and metabasic rocks related to crustal thickening and burial metamorphism during formation of the IBR.
4. The tectonic evolution of the Mt. Victoria belt is related to westward emplacement of ophiolites and oceanic sedimentary rocks onto the IBR followed by crustal thickening and regional low-grade metamorphism, followed by dextral strike-slip shearing along the bounding north-south faults like the Kabaw Fault.

CHAPTER

FIVE

GEOLOGY OF THE KALEMYO AREA

5.1 Introduction

Kalemyo is situated in the northern Chin Hills. The Kalemyo area straddles the boundary between the Indoburman flysch in the west and the molasses deposits of the Chindwin Basin in the Central Basin to the east (Fig. 5. 1). The western part of the Falam-Kalemyo area includes the highest ridges in the range south of the Naga Hills. The highest peak in the region is Mt. Kennedy, which attains an elevation of 2704 m. This area is underlain almost entirely by variably deformed and locally metamorphosed flysch strata of Mesozoic to early Cenozoic age referred to as the Indoburman flysch. Around Kalemyo, along the western side of the Kabaw Valley, there are isolated mountains such as Webula Taung, Mwe Taung and Bophi Vum, which are made up of serpentinites and related ophiolite rocks. The ophiolites and the sediments are in tectonic contact along the Kabaw Fault. The Kabaw Fault forms a major fault zone between the Indo-Burman Ranges (IBR) and the Central Basin (Bannert et al., 2011) but the amount of offset and slip rates on it are so far unknown. Some authors have interpreted the Kabaw Fault as an east-dipping fault (Win Swe et al., 1972; Wang et al., 2014; Stecker et al., 2016a), while others have interpreted it as a west-dipping fault (Curry, 2005; Maurin and Rangin, 2009), and others as dominantly a dextral strike-slip fault (Morley et al., 2020).

Ophiolites within Myanmar have been traditionally classified into the Western Ophiolite Belt and the Eastern Ophiolite Belt (Liu et al., 2016). The Kalemyo Ophiolite is part of the Western Ophiolite Belt (WOB) and crops out along the eastern margin of the IBR as a series of dismembered bodies. The WOB stretches from the Naga and Manipur Hills (in northeastern India) in the north, via Kalemyo and the Mt. Victoria belt adjacent to the IBR and then continues south to crop out along the Andaman Islands (Mitchell, 1993; Curry,

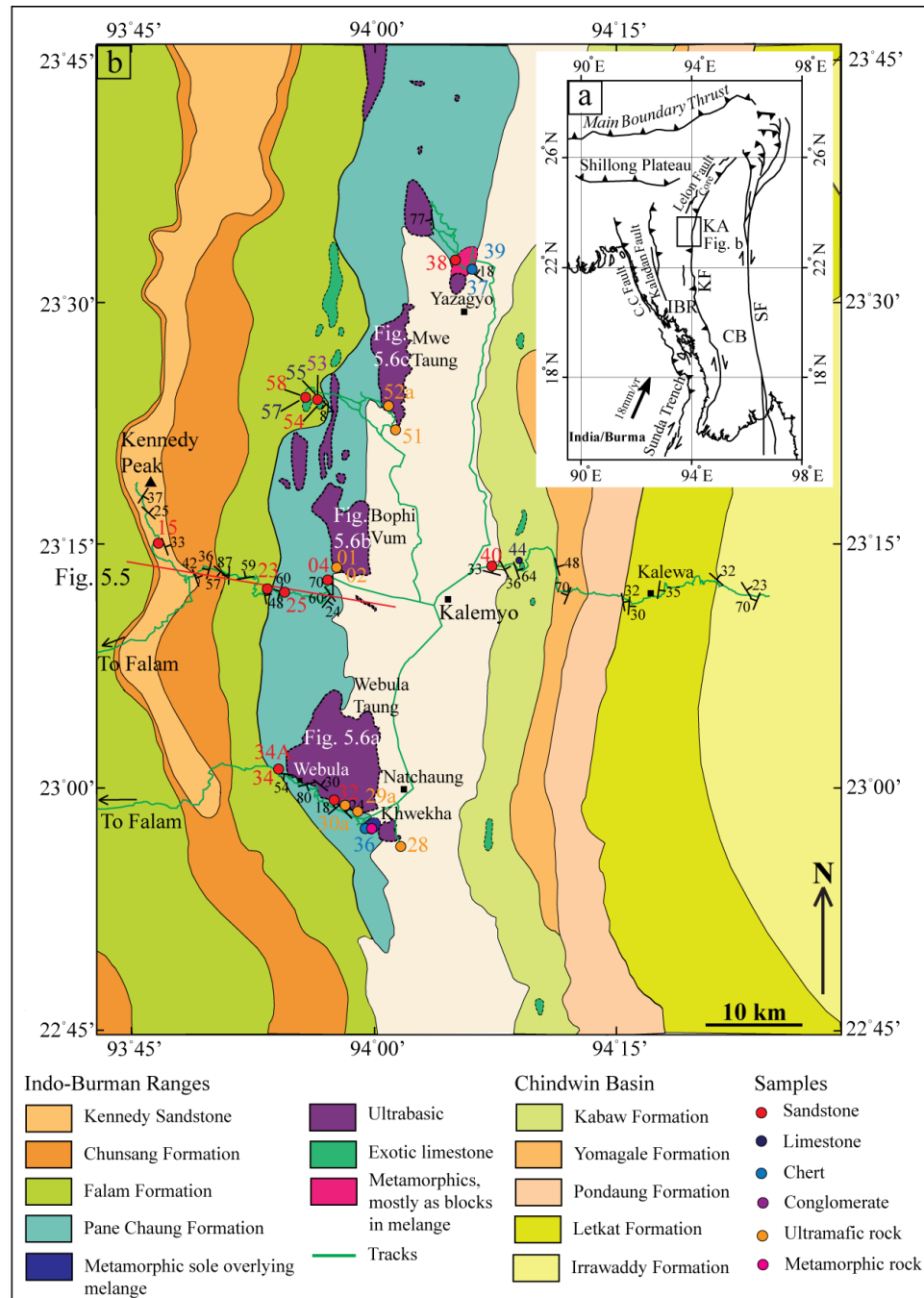


Fig. 5.1: (a) General structural map of Myanmar (Maurin and Rangin, 2009) show location of Kalemmyo area, and (b) geological map of the Kalemmyo area, Northern Chin Hills (modified from United Nations (1979a) and Mitchell et al. (2010)). Dots show sample locations. For simplicity, the prefix “KM” is omitted from all sample labels on the map. IBR, Indo-Burma Ranges, KA, Kalemmyo area, CB, Central Basin, SG, Sagaing Fault, KF, Kabaw Fault.

2005; Acharyya 2007). The age of the ophiolites and the timing of obduction in the ophiolite belts are shown in Table 5.1. The Kalembo ophiolite has yielded Cretaceous U-Pb ages (127 Ma; Liu et al., 2016), similar to the Naga ophiolite (Singh et al., 2016) and ophiolites (e.g. Dangxiong, Zhongba, Sangsang, Jiding massifs) within the central part of the Indus – Yarlung Tsangpo Suture in Tibet (Wang et al., 2006; Chan et al., 2007; Xia et al., 2008; Dai et al., 2012; Chan et al., 2015). The Neo-Tethys suture is represented in Tibet by the Indus – Yarlung Tsangpo belt, which probably connects with the ophiolite belt along the eastern IBR. However, the existence of a Neo-Tethys suture within the IBR is highly debated. One view is that the ophiolitic mélange of the IBR occupies the suture zone of the Neo-Tethys Ocean (Metcalf, 1996, 2011; Ghose et al., 2014; Liu et al., 2016). An alternative view is that the ophiolitic mélange is a klippen of a cryptic Eastern Ophiolite Belt along the central magmatic arc axis within the Central Basin (Acharyya et al., 1989; Acharyya, 2007, 2015; Zhang et al., 2018). The timing of ophiolite emplacement is also controversial. Some studies regard ophiolite emplacement as having occurred prior to the deposition of Aptian-Cenomanian limestones (e.g. United Nations, 1979; Mitchell et al., 1993, 2010), while others argue for later emplacement, around Maastrichtian times (e.g. Socquet et al., 2002; Rangin et al., 2013). Furthermore, it is noted that, in most previous models, some of the proposed suture zones have been reported as containing only low-to high-temperature metamorphic rocks, with no ophiolites present (Mitchell et al., 2015). Two main bodies of metamorphic rocks crop out in the Kalembo area, both of which appear to be associated with ophiolites: the Yezagyo and Khwekha metamorphics.

Locality	Age of crust (Ma)	Environment of formation	Presence and age of HP-LT metamorphism	Age of emplacement	References
Chin Hills	?	?	No	Pre-Middle Cretaceous	Mitchell (1993), Liu et al. (2016)
Kalemyo	127	MOR			Liu et al. (2016), Zhang et al. (2017, 2018)
Jade Belt	163.2 ± 3.3	MOR?	Yes 77 ± 3 Ma	Pre-Middle Cretaceous? Late Cretaceous?	Shi et al. (2008), Yui et al. (2013)
Tagaung-Myitkyina	176-166	SSZ	?	Pre-Middle Cretaceous	Yang et al. (2012), Liu et al. (2016)
Naga Hills	118-116	MOR & SSZ	Yes Age?	Late Eocene-Early Oligocene	Baxter et al. (2011), Ningthoujam et al. (2012), Ghose et al. (2014)
Andaman Islands	95 ± 2	SSZ	No	Palaeogene	Pedersen et al. (2010), Ghost et al. (2009), Pal (2011)

Table. 5.1: *Characteristics of ophiolite occurrences in Myanmar and Andaman Islands.*

Geological investigations in the Kalemmyo area are constrained by the mountainous terrain, lack of infrastructure, monsoonal rains, thick soil/vegetation cover and discontinuous, and poorly exposed lithologies. In this study, field structural relations are combined with U-Pb dating of detrital zircons, zircon Hf isotopic compositions, petrology, XRD and biostratigraphy to provide critical new constraints on the formation of the Kalemmyo ophiolites and on Tethyan suturing in SE Asia. This latter point is essential to our understanding of the closing of the Tethys Ocean that played a key role in global plate tectonics during the Mesozoic.

5.2 Lithology and field observations of the Kalemmyo area

5.2.1 Stratigraphy of the Indo-Burman Ranges west of Kalemmyo

The geological succession of Kalemmyo area can be classified as shown in Table 5.1 and is discussed in more detail in the following sections.

Age	Group/Formation	Lithology
Middle to Upper Eocene	Kennedy Sandstone	Presence of cross-bedded sandstones, alternating with shales and contains shell fragments, mud-pebble conglomerates
Paleocene to Middle Eocene	Chunsung Formation	Dominantly shales and minor sandstones (turbidite), broken beds in the lower part, rare limestones
Upper Cretaceous	Falam Formation	Exotic blocks of ophicalcite, gabbro, basalt, and chert with rare silicic volcanic <i>Globotruncana</i> -bearing limestones
Middle Cretaceous U-Pb zircon ages of amphibolites: 119 ± 3 Ma and 115 Ma (Liu et al., 2016; Zhang et al. 2017)	Yazagyo and Khweka metamorphics	Greenschist to amphibolite grade metamorphic sole
Jurassic to Early Cretaceous K-Ar age of hornblende pegmatite: 158 ± 10 Ma (Mitchell, 1981) U-Pb zircon ages of rodingites: 126 ± 2 Ma and 127 ± 1 Ma (Liu et al. 2016a,b) U-Pb zircon ages of hornblende gabbros: 131 ± 2 Ma and 133 ± 2 Ma U-Pb zircon ages of granite: 128 ± 2 Ma Zhang et al. (2018)	Kalemyo Ophiolite	----- Tectonic contact ----- Pelagic oceanic sediments: Triassic unmetamorphosed sediments, pelitic-psammitic-calcareous-carbonaceous sediments and chert containing radiolaria Mafic/intermediate volcanics: basalts Metabasics: greenschist facies and amphibolite facies Mafic-ultramafic rocks: peridotite, gabbroids, plagiogranite, serpentinite
Upper Triassic Biostratigraphic age: <i>Halobia</i> fossils (United Nations, 1979; Bannert et al., 2011; Yao et al., 2017; Zhang et al., 2017) U-Pb zircon age of sandstones: Maximum depositional ages range between 233 ± 2 Ma and 199 ± 13 Ma (Sevastjanova et al., 2015; Yao et al., 2017)	Pane Chaung Formation	----- Tectonic contact ----- Indurated sandstones and shales with rare thin limestones and ribbon cherts Presence of sole marks, load casts and intrabasinal mud clasts

Table. 5.2: *Stratigraphy of the Kalemyo area, Northern Chin Hills (modified from United Nations, 1979 and Mitchell et al., 2010).*

5.2.1.1 Yazagyo and Khwekha metamorphics

In the Kalemio area, two main bodies of high-grade metamorphic rocks occur either within or at the eastern margin of the Triassic Pane Chaung Formation. They crop out near Yazagyo (NNE of Kalemio) and Khwekha (south of Kalemio), see Figure 5.1.

The Yazagyo metamorphics are exposed in the south-flowing Yagazyo stream, associated with ultramafic rocks. The metamorphics occur as a 3-km-long north-trending body of chlorite schist and chert, garnet schist, and amphibolite with blocks of marble (Mitchell, 2017). They are faulted against serpentinite in the south and unmetamorphosed Triassic sedimentary rocks to the north. The amphibolite and chlorite schist are succeeded to the northwest by a zone of amphibolite and marble blocks enclosed in serpentinite.

The Khwekha metamorphic sole has been mapped in the east of Webula (United Nations, 1979). The presence of a low-grade metamorphic *mélange* unit overlain by a greenschist to amphibolite-grade metamorphic sole below the southern outcrops of the Webula ultrabasic massif, supports a low-angle thrust interpretation for the emplacement of the ophiolite (Zhang et al., 2017, 2018). The steeply-dipping succession of garnet bearing amphibolite schist, piemontite (Mn-epidote) schist, and quartz-mica schist is up to 2km wide (Brunnschweiler, 1966; United Nations, 1979). The amphibolite is foliated and most exposures show small-scale folds (Fig. 5.2a). U-Pb zircon dating of amphibolites yielded ages of 119 ± 3 Ma and 115 Ma (Liu et al., 2016; Zhang et al., 2017).

These rocks are interpreted as the metamorphic sole of the Kalemio ophiolite, that formed during obduction or emplacement of the ophiolite onto the continental margin. They were subsequently disrupted during formation of a typical ophiolitic *mélange*.

5.2.1.2 Kalemyo Ophiolite

The Kalemyo ophiolite is an incomplete, dismembered ophiolite, that mainly consists of large peridotite massifs, such as Bophi Vum, Mwe Taung and Webula Taung. While some gabbros and pillow lavas are present, sheeted dyke complexes appear to be missing. The Webula peridotite massif has an area of 120 km², while the Bophi Vum and Mwe Taung peridotite massifs are each about 50 km² in area. Scattered outcrops of *mélange*, containing deep-water radiolarian cherts and exotic limestones are associated with the ophiolite suite (United Nations, 1979; Mitchell, 2010; Zhang et al., 2017). The best exposed ophiolitic *mélange* is found in the spillway area of the Yazagyo Dam (Fig. 5.2), comprising major blocks up to hundred meters across of serpentinite, harzburgite, dunite, gabbro and metabasalt, chert and some metamorphic rocks within a matrix of serpentinite (Bannert et al., 2011; Liu et al., 2016; Zhang et al., 2017). In general, the mantle peridotite massifs are relatively fresh, although the margins of some peridotites are affected by serpentinitization. The peridotites are predominantly composed of harzburgite that is commonly extensively fractured, and serpentinitised, while lherzolites, dunites and gabbros are also present. All peridotites are affected varying amounts of serpentinitisation (Fig. 5.2). There are some associated massive chromite-bearing bodies, particularly around Mwe Taung (Fig. 5.2c). The massive chromite is most abundant whereas a nodular type is rare (Hla Htay et al., 2017). Gabbros are occasionally found as small size blocks (< 10 m²) in a serpentinite matrix. In the *mélange* around Yazagyo Dam, tightly folded metasediments, and massive, highly jointed, fractured and sheared cherts (some with microscopic folds and faults) (Fig. 5.2d,e,f) extend for a few hundred meters, bounded to the north and south by serpentinite shear zones. The serpentinite probably forms part of a larger body to the west of the

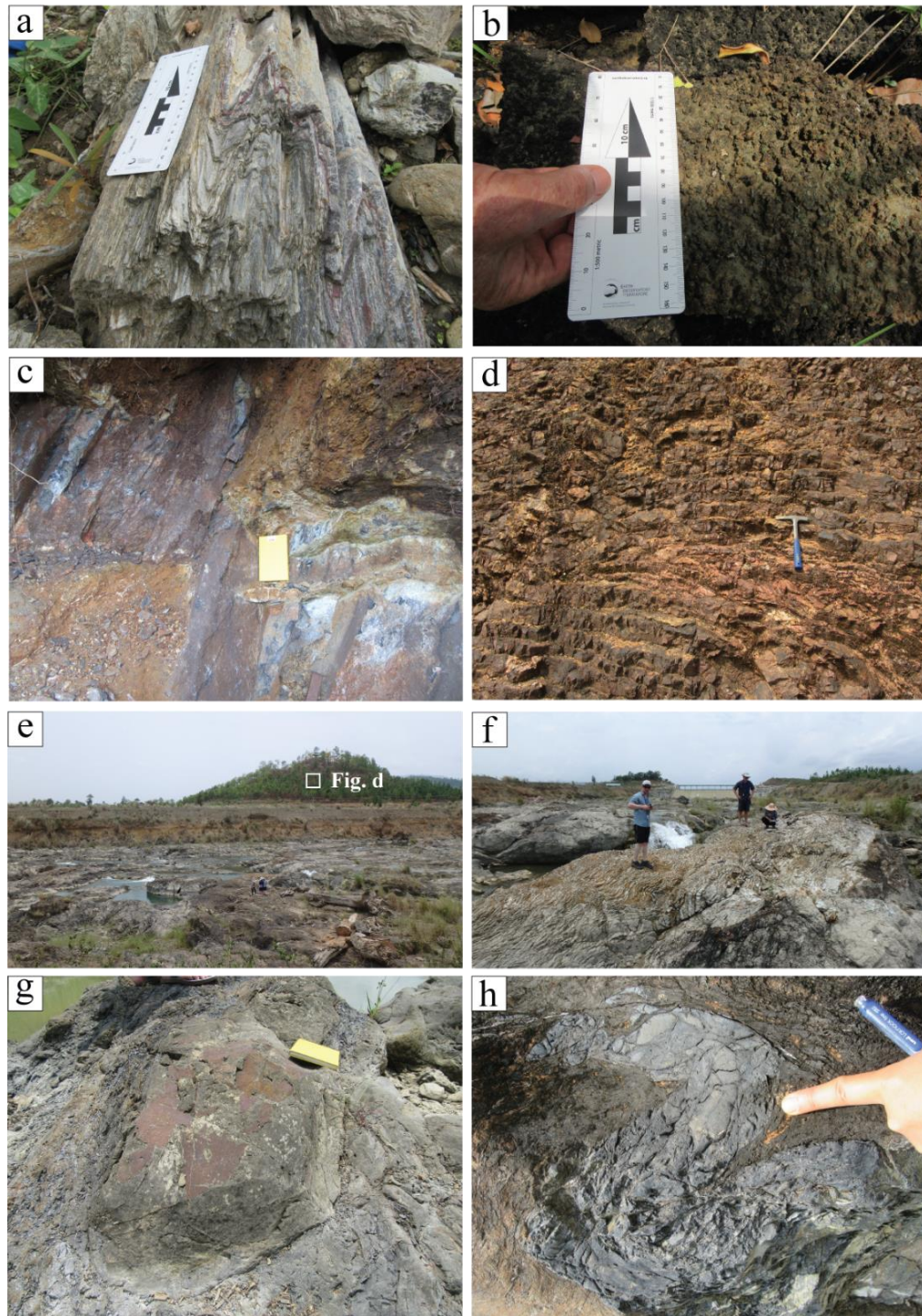


Fig. 5.2: Field photographs of outcrops sampled in the present study. (a) amphibolite schist from Khwekha metamorphic sole, (b) Iherzolite, (c) massive chromite, (d) red chert, (e), (f) ophiolite mélangé in the Yazagyo Dam, (g) pillow basalt in the ophiolite mélangé, and (h) pillow basalt intruded by basalt dyke.

spillway, and to the east is overlain by red banded chert that forms an isolated hill. Also, in the Yazagyo Dam area are some pillow basalts that are associated with thinly-bedded red cherts, themselves thrust over poorly-exposed, unmetamorphosed Triassic sedimentary rocks (Fig. 5.2g,h).

U-Pb ages of zircons from gabbros and rodingites in the *mélange* are Early Cretaceous, ranging between 126 ± 2 Ma - 133 ± 2 Ma (Liu et al., 2016; Zhang et al., 2018), suggesting that the Kalemio Ophiolite was formed during the Early Cretaceous (Liu et al., 2016). Based on the geochemical data the ophiolite formed in a MOR (mid-ocean-ridge) setting (Liu et al., 2016), but almost certainly was related to a supra-subduction zone setting to account for its emplacement onto continental crust. Radiolaria ages reported for cherts associated with the Kalemio ophiolite have been assigned to the Middle Jurassic (Zhang et al., 2018).

The Kalemio ophiolite is not preserved in a sequential order typical of other ophiolite sections in the Tethyan domain (e.g. Semail ophiolite, Oman Mountains), prior to their emplacement. The contacts of the larger ultrabasic bodies with the adjacent Triassic Pane Chaung Formation are irregular on the scale of the geological maps, suggesting that they were probably emplaced as thrust slices over the Triassic flysch (Mitchell, 2017).

5.2.1.3 Pane Chaung Formation

The Upper Triassic Pane Chaung Formation in the Kalemio area, has been studied in particular along the Kalemio-Falam road, where there are extensive good exposures (Fig. 5.3). Although gradual changes in sedimentary characteristics through the section are evident, the boundaries of the Pane Chaung with other units are often vague. I relied on the

mapped boundaries (United Nations, 1978; Mitchell et al., 2010) to indicate approximately where changes in formation were to be expected.

The Pane Chaung Formation consists mostly of turbiditic sandstones and mudstones, with minor amounts of thin-bedded limestone. Sandstone beds are commonly discontinuous and exhibits numerous quartz veins. Sandstone-mudstone alternations up to 10 m in thickness show highly disturbed or folded bedding but which is apparently not sheared (Fig. 5.3a). In many places abundant sole marks on the base of turbidite beds provide excellent evidence for the way-up (Fig. 5.3b), indicating that the sedimentary rocks of the Pane Chaung Formation are tightly folded and often overturned. Along the Kalemyo-Falam and the Webula-Falam road sections the Pane Chaung Formation is apparently unconformably overlain by the Upper Cretaceous Falam Formation (Mitchell et al., 2010). The clearest example of the boundary between the Pane Chaung Formation and the Falam Formation was found on the Webula-Falam road (Fig. 5.3c), where about 30 m of land slide-affected hillside separates the Pane Chaung from the Falam Formation.

5.2.1.4 Falam Formation

The Falam Formation was first described as the Falam Mudstone-Micrite Formation by United Nations (1979), and is here-after abbreviated to the Falam Formation. Brunnschweiler (1966) and others have interpreted the occurrences of *Globotruncana*-bearing limestones as indicating a Late Cretaceous (Campanian-Maastrichtian) age for the Falam Formation. During fieldwork, the Falam Formation was observed in a narrow north-south trending linear belt west of the Triassic flysch along the eastern foothills of Chin Hills. The Falam Formation extends to the north along the eastern foothills of Naga Hills. On the road west of Webula Taung and along the Kalemyo-Falam road, there is no clear indication

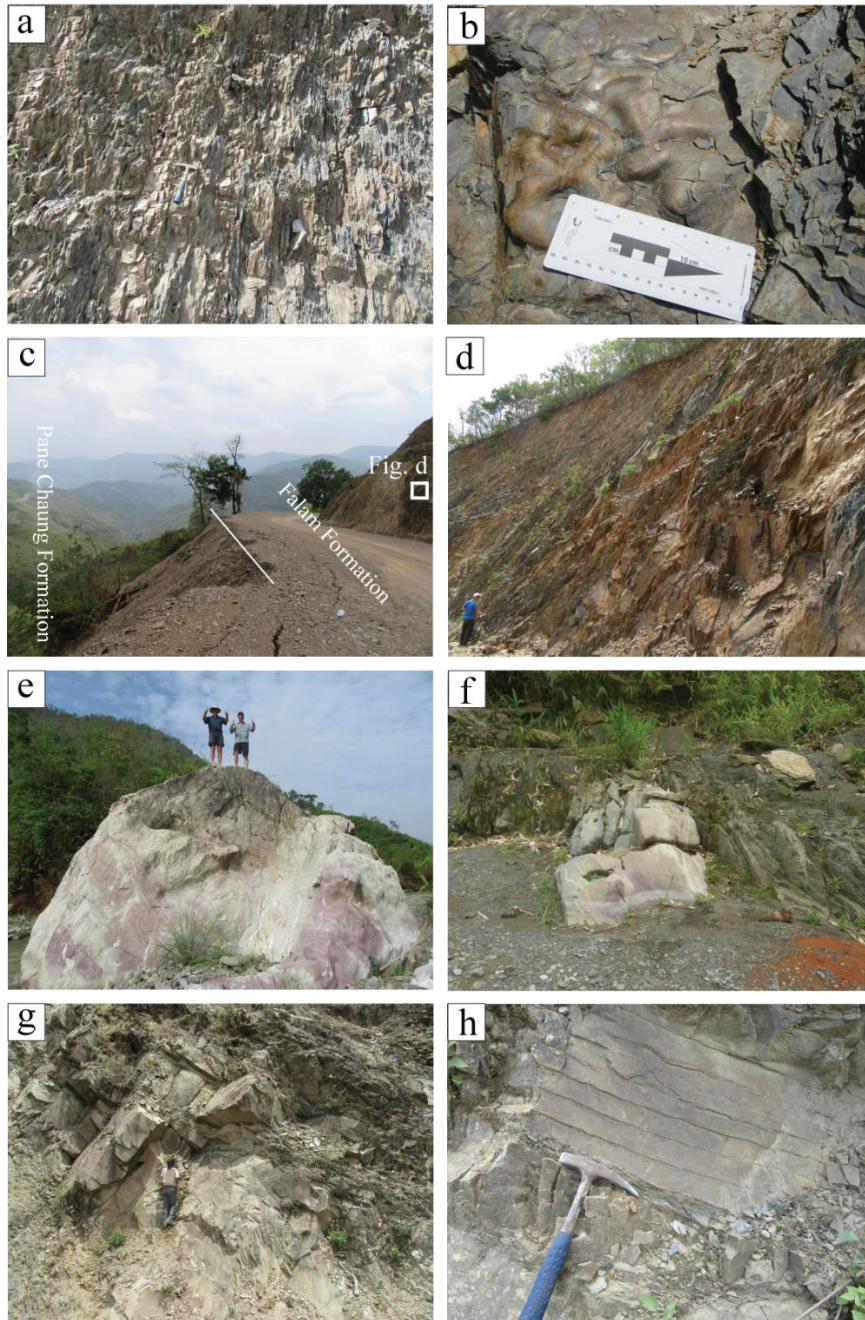


Fig. 5.3: Field photographs of outcrops sampled in the present study. Pane Chaung Formation: (a) sandstone-shale alterations, (b) flute casts on the sandstone beds. (c) the boundary between the Pane Chaung and Falam Formations. Falam Formation: (d) interbedded sandstones and mudstones, (e), (f) reddish, pelagic limestone block, (f) limestones within shales. (g) graded sandstone bed in the Chunsung Formation, and (h) cross-bedding in the Kennedy Sandstone.

from the outcrop relationships that a thrust separates the Falam and Pane Chaung and Falam Formations leaving the possibility of an unconformable contact between them. The Falam Formation is remarkably monotonous, and exhibits continuous sandstone layers and a few small limestone clasts or floaters. Quartz veins are largely absent, and the bedding is steep (Fig. 5.2d). The sandstones are mostly fine-grained and some are calcareous and carbonaceous. The presence of blocks of fine-grained micritic or porcellanous limestone is typical of the Falam Formation. The limestones are cream, white or pink in color, mostly show faint lamination, commonly include small planktonic foraminifera visible in hand specimen and are associated with secondary calcite and quartz veins. The limestone blocks vary in dimensions from a few meters to >0.5 km thick. These limestone deposits are also found in a north-south trending narrow and linear belt. Some of the limestone blocks occurring within the Falam Formation may well be exotic deposits (Fig. 5.2e). They are laterally discontinuous with generally conformable contacts with the overlying and underlying shale and sandstone. In some places the limestones commonly protrude from the shales and can be shown to pinch out along bedding (Fig. 5.3f). The limestones are crystalline and associated with secondary calcite and quartz veins. Often, however, the outcrops are not always sufficiently conclusive regarding the autochthonous nature of the intercalated limestone in the flysch. The limestones are well-exposed in river gorges: at the Nattaga Chaung/River, and Lungrang Klang, Gangaw (Brunnschweiler, 1966). Broken beds (block-in-matrix) are common, and consist of angular sandstone bodies ranging in size from pebbles to large blocks, and boulders of micritic limestone, in a tightly folded laminated to structureless mudstone matrix.

In a few localities conglomerates and grits are interbedded with the mudstones of the Falam Formation, and these contain clasts of ophiolite, quartz and rarely volcanic pebbles (Fig. 5.12) in the Nattaga Chaung/River. The Falam Formation is overlain stratigraphically by the Chunsung Formation.

5.2.1.5 Chunsung Formation

The Chunsung Formation is about 2 km thick and is dominated by mudstones and siltstones with minor amounts of interbedded fine-grained sandstones throughout. It is similar in the lower part to much of the Falam Formation, but lacks micritic limestones. However, it does include rare limestone beds with Paleocene to Eocene fossils, and is probably equivalent to part of the Disang Series of Assam (Mitchell et al., 2010). Thin sandstone beds mostly show sharp bases and tops and lack both sole marks and distinct internal sedimentary structures. Thicker sandstones beds, some of which are up to 2 m thick, are mostly medium to coarse-grained with abundant dark gray mud-clasts. Some exhibit deep to shallow water depositional features like ripple marks, sole marks, graded bedding and cross bedding (Fig. 5.3g). The Chunsung Formation passes stratigraphically up into the Kennedy Sandstone Formation.

5.2.1.6 Kennedy Sandstone Formation

The Kennedy Sandstone forms a distinct lithological unit characterised by cross-bedded sandstones, mud-pebble conglomerates, and mudstones and contains small molluscs fragments of probable Late Eocene age (Mitchell, 2017). The sandstone forms Mt. Kennedy, the highest peak in the Kalemmyo-Falam area, and is largely confined to synclines at high elevation around 2000 m. The sandstones are fine to medium-grained and micaceous with

erosive bases resulting in lateral variations in thickness. Some of the thicker beds contain mud-pebbles near the base, are cross-bedded in the lower part (Fig. 5.3h), and pass upwards into parallel-laminated sandstone, but many either lack lamination or are parallel-laminated throughout (United Nations, 1979). Road-cut sections in the scarp of Kennedy Peak show a number of sandstone beds interbedded with mudstone. The Kennedy Sandstone is mapped as overlying the Chunsung Formation.

5.2.2 The Kabaw Formation, Chindwin Basin east of Kalemmyo

The sediments of the Chindwin Basin range from Upper Cretaceous to Neogene and generally strike N-S. Here, only the Kabaw Formation (Upper Cretaceous) is described but for a full description of the stratigraphy of the Chindwin Basin see Wang et al. (2014) and Licht et al. (2018).

The Kabaw Formation is present in the Chindwin Basin and occupies a generally north-trending belt of ridges and valleys, and is the lowermost unit exposed in the Central Basin. In the Kalemmyo area, the Formation is bordered in the west by alluvium of the Myittha Valley but is exposed along the Kalemmyo-Kalewa road section. At the base of Kabaw Formation, east of Kalemmyo, along the Kalemmyo-Kalewa road section, ophiolite and volcanic clasts were observed in litharenite sandstone (Fig. 5.4a). In the middle part of the Kabaw Formation the road section exposes sandstones and shales, locally carbonaceous, with local quartzose grits and a distinctive boulder bed with rounded clasts up to 4 cm diameter of vein quartz, mudflakes, dacitic lava and red and grey chert. The Kabaw Formation comprises a very wide range of lithologies, of which the most characteristic are conglomerates and grits, cross-bedded sandstone and shales, and limestones.

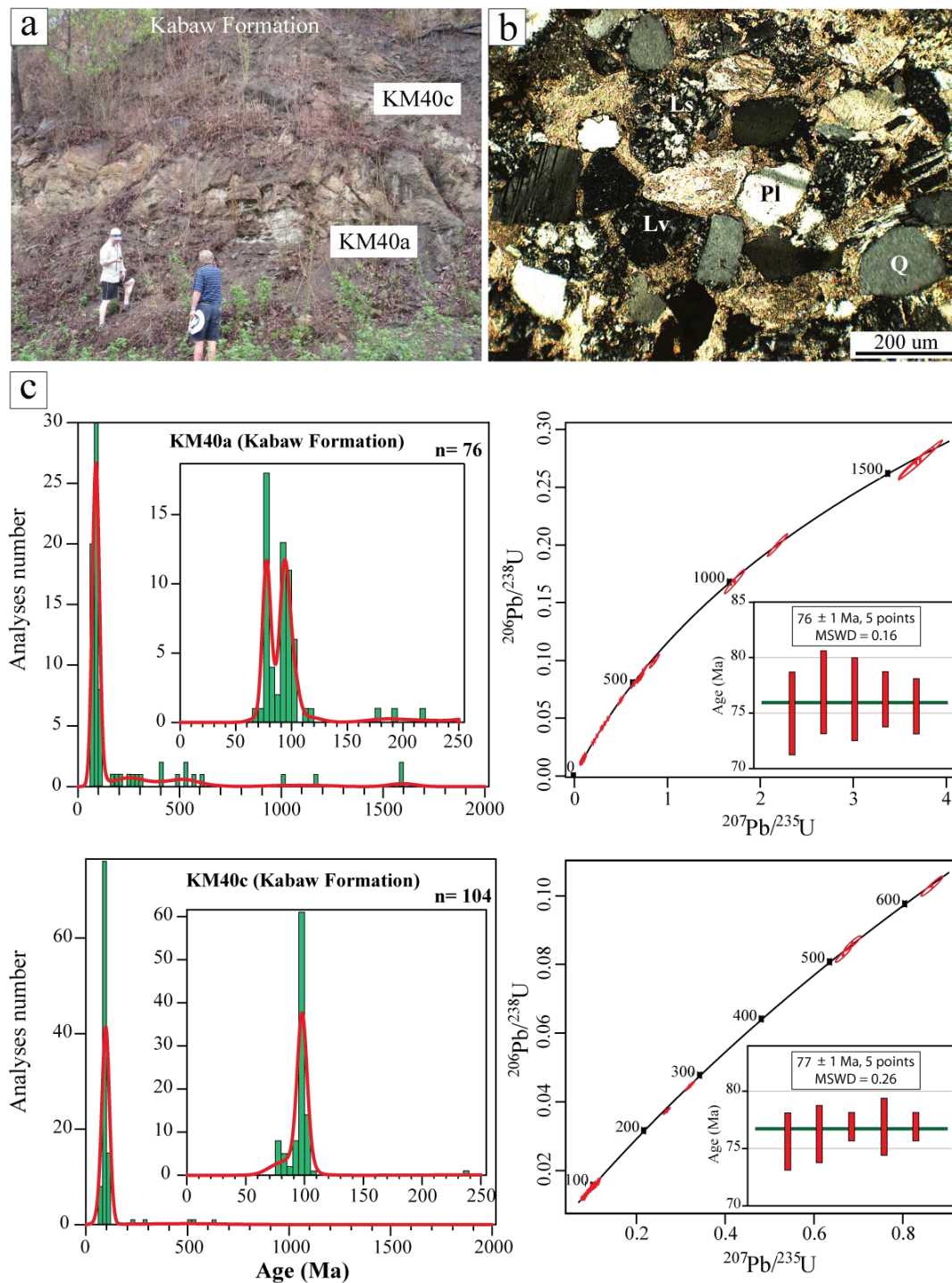


Fig. 5.4: Kabaw Formation:(a) field photograph, (b) photomicrograph (Q=quartz, Pl=plagioclase, Lv=volcanic lithic, Ls=sedimentary lithic) , and (c) histograms and probability density plots, concordia diagrams and weighted average age diagrams showing detrital zircon U-Pb ages.

5.3 Structure of the Kalemmyo area

In the Kalemmyo area, structural observations of the Triassic Pane Chaung Formation, and Late Cretaceous to Paleogene flysch (including the Falam Formation, Chunsung Formation and Kennedy Sandstone) have been made. Along the Kalemmyo-Falam road section, gradual changes in sedimentary characteristics through the section are evident, but no clear, sharp exposed contacts between units were observed. The clearest example was found at the boundary between the Pane Chaung and the Falam Formation on the Webula-Falam road. Sections through the Pane Chaung Formation in the Kalemmyo area show generally steeply dipping, commonly tightly to isoclinally folded beds that are cut by steep, sub-vertical strike-slip faults with strike between 340° and 015° (Fig. 5.5). In low lying outcrops the Pane Chaung is affected by short wavelength folds, with fold axes oriented NNW-SSE strike and axial planes east-dipping. The Falam Formation exhibits more continuous sandstone layers, and the bedding is steep, but continuous, with short wavelength folds. Bedding strike in the Falam Formation ranges between 320° and 340° with dips consistently around 65° . Hence, in general, the deformation in the Falam Formation is less intense than in the Pane Chaung Formation. The geological map shows the contact between the two formations as a thrust, called the Kheng thrust (United Nations, 1979a), which is now interpreted as an extensional fault (Mitchell, 2017). However, the outcrop geometry, suggests that it is more plausible that the Pane Chaung Formation simply dips below the Falam Formation, and that the contact is an east-dipping unconformity. Similar relationships were observed in the vicinity of the mapped contact on the Kalemmyo-Falam road, and in other stream cuts, suggesting an unconformable contact rather than a structural contact.

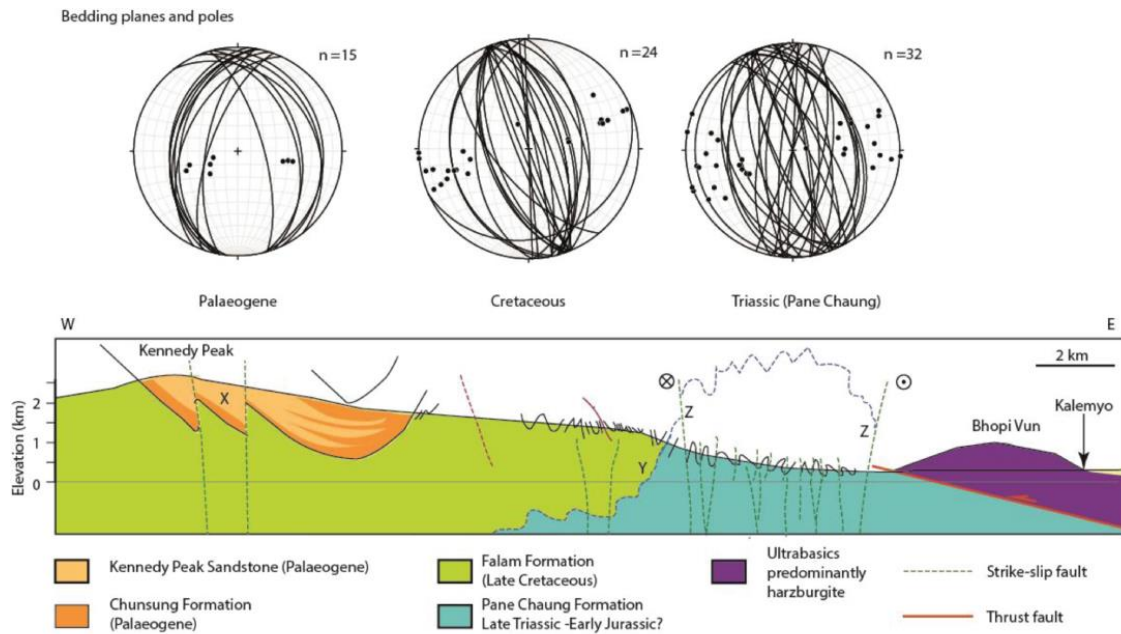


Fig. 5.5: Cross-section along the Kalembo-Falam road based on field observations. Z=hypothetical strike-slip faults driving uplift of Pane Chaung Formation. Stereonets of bedding orientations for the different formations, showing that the Cretaceous (Falam Fm.) and Triassic (Pane Chaung Fm.) are more tightly folded than the Paleogene (Chunsung Fm.), see fig. 5.1 for location. Strike-slip faults were observed affecting the Kennedy Sandstone, shown schematically in the figure around location X.

A cross-section from the Kalembo to the Kennedy Peak region was constructed from measurements taken along the Kalembo-Falam road, and the Falam-Kennedy Peak road (shown in Figure 5.5). In the east, the Bhopi Vun ultrabasic body is shown as thrust over the Triassic flysch (Fig. 5.6). As mentioned above, the boundary between the Pane Chaung and the Falam Formation is interpreted as an unconformity. The decrease in intensity of deformation between the Pane Chaung and Falam Formation may reflect the presence of deformation older than the Late Cretaceous in the Pane Chaung Formation. As

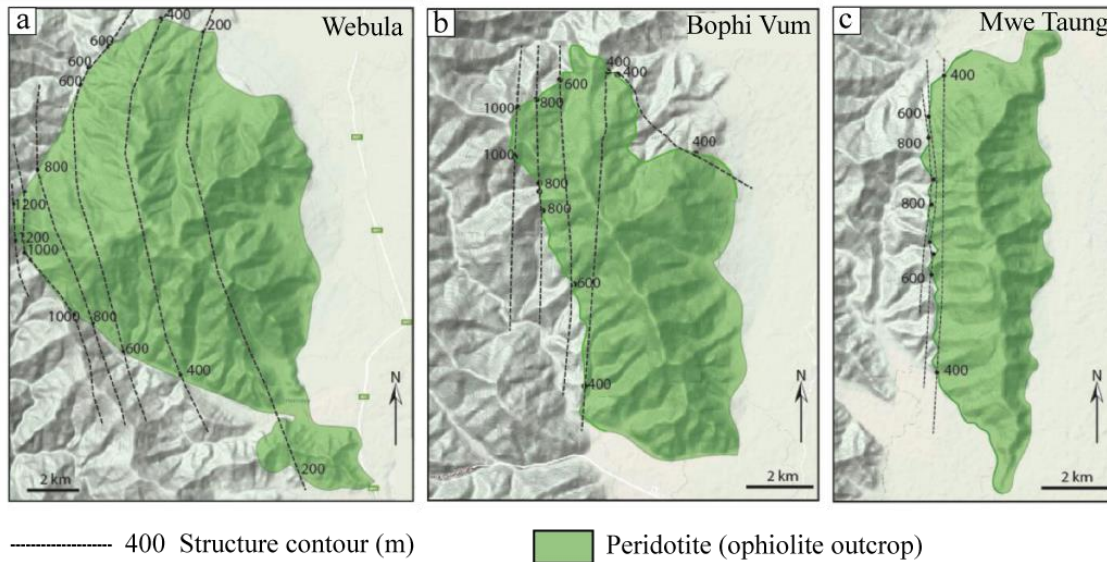


Fig. 5.6: Calculation of the dip of the base of massive peridotite bodies from its intersection with stratigraphic contours, Kalemyo area. (a) Webula, dip 10.5° , (b) Bhopi Vun, dip 13.5° , and (c) Mwe Taung, dip 34° . See Fig. 5.1 for locations.

schematically shown in Figure 5.5, the exposure of the Pane Chaung Formation was interpreted as possibly due to uplift in a transpressional zone, with major faults marked Z in the figure. Passing up-section to the west, tectonic deformation becomes less intense and passes into the Paleogene Chunsung Formation. The Chunsung Formation shows gentler dips, NNE-SSW strike directions on west-dipping bedding and relatively little short-wavelength, outcrop-scale folding. The main syncline is a broad simple fold. Although the Kennedy Sandstone is mapped as overlying the Chunsung Formation (United Nations, 1979), both are similar lithologically, and suggest that the Kennedy Sandstone is a more sand-rich lateral equivalent unit to the Chunsung Formation. There appears to be some stratigraphic thickening passing across the syncline from east to west.

The Pane Chaung and Falam Formations both show bedding that strikes predominantly NNW-SSE with high-angle dips (between 340° and 015°), (Fig. 5.5), although the outcrops display numerous examples of short-wavelength folding. In contrast, the Paleogene section (Chunsung Formation and Kennedy Sandstone) shows gentler dips, and NNE-SSW strike directions on west-dipping bedding and little short-wavelength folding.

5.4 Biostratigraphy

5.4.1 Limestone

Five limestone samples were analysed. Of these, four (KM53a, 55, 57 and 58a) were collected from the Falam Formation in the Nattaga Chaung/River. An *ex situ* limestone block (KM44) was collected from the Kabaw Formation in the Chindwin Basin.

The planktonic foraminifera from the Falam Formation include *Globotruncana arca* (Cushman), *Globotruncana venticosa* (White), *Globotruncana hilli* (Pessagno), *Globotruncanita elevata* (Brotzen), *Globotruncanita stuartiformis* (Dalbiez), *Radotruncana subspinoso* (Pessagno), *Heterohelix reussi* (Cushman), *Racemiguembelina* (?) sp., *Globigerinelloides bollii* (Pessagno) and *Globigerinelloides* sp., as shown in Plate 5.1, as well as unidentified benthic foraminifera. The planktonic foraminiferal taxa identified in the Falam Formation in the Nattaga Chaung/River are very common and similar with those identified by earlier workers from other localities (Kyaw Win and Thit Wai, 1972; United Nations, 1979; Zin Mar Aung, 1997; Thura Oo, 2000). The abundance of *Globotruncana* indicates a Santonian-Maastrichtian age for limestones in the Falam Formation. The exotic block (Sample KM44) consists of common algal fragments, including *Distichoplax biserialis* (Dietrich), and relatively common larger benthic foraminifera, including

Plate 5.1

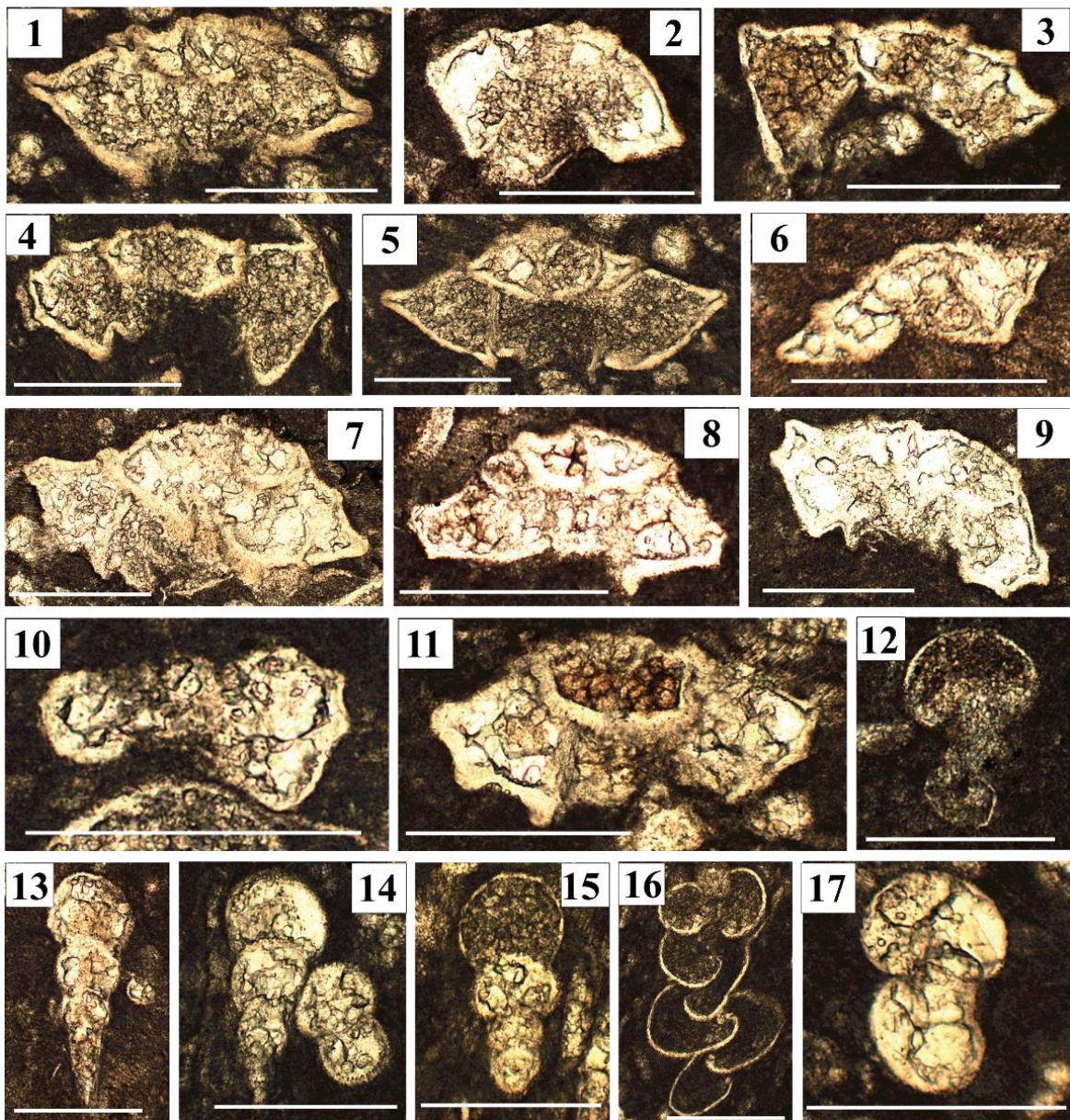


Plate. 5.1: Photomicrographs of the planktonic foraminifera from the Falam Formation: the scale bars correspond to 200 μm . 1,2,5,7. *Globotruncanita stuartiformis* (Dalbiez), 3,4 *Globotruncanita elevata* (Brotzen), 6. *Radotruncana subspinoso* (Pessagno), 8,11. *Globotruncana venticosa* (White), 9. *Globotruncana arca* (Cushman), 10. *Globotruncana hilli* (Pessagno), 12. *Globigerinelloides bollii* (Pessagno), 13,14,15 *Heterohelix reussi* (Cushman), 16. *Racemiguembelina* (?) sp., and 17. *Globigerinelloides* sp.

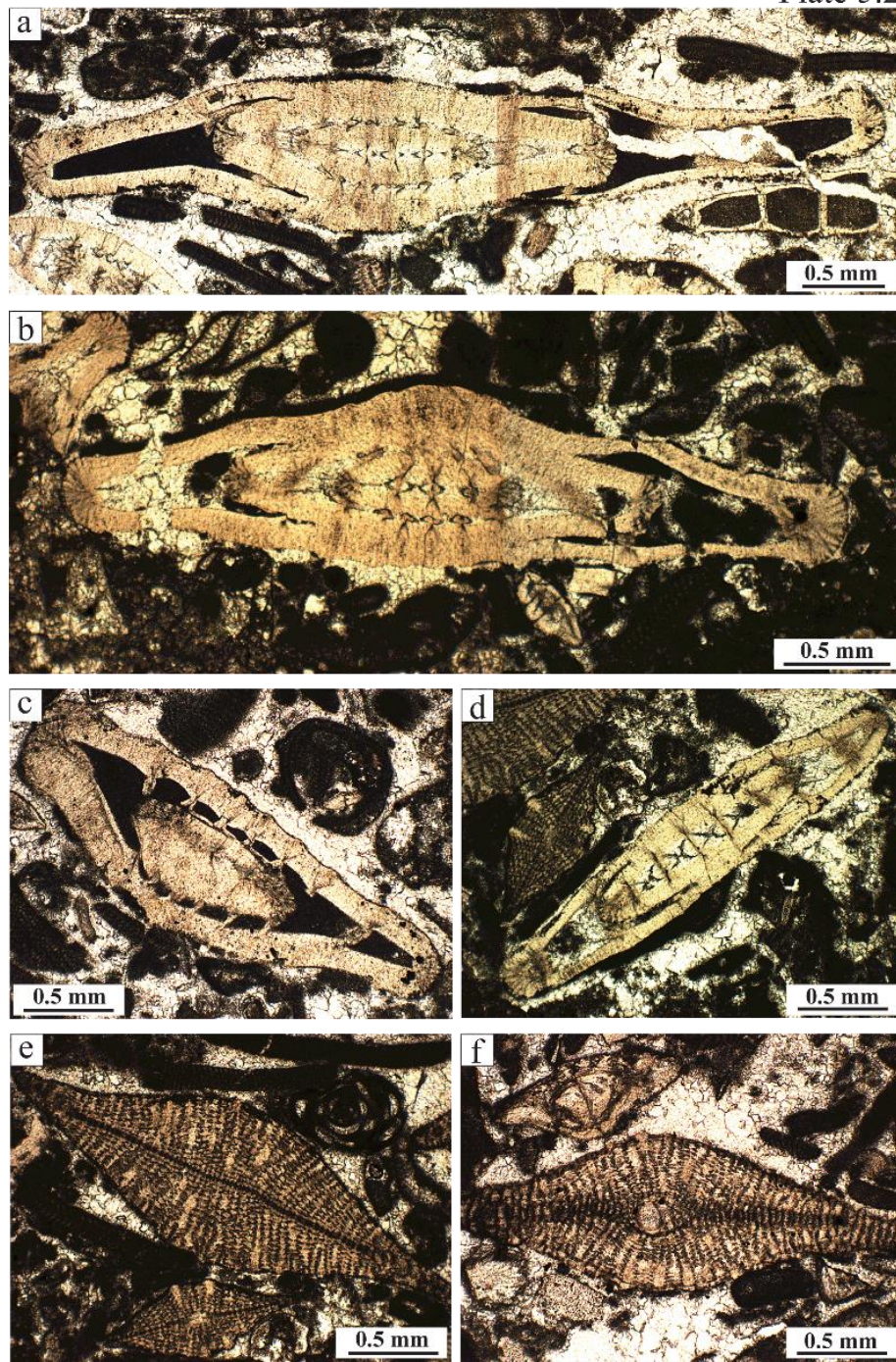


Plate. 5.2: Photomicrographs of the larger benthic foraminifera from the east of Kalemno: the scale bars correspond to 200 μ m. (a) *Ranikothalia sindensis* (Davies), (b) *Ranikothalia nuttalli* (Davies), (c), (d) *Ranikothalia* sp., (e) *Discocyclina dispansa* (Sowerby), and (f) *Discocyclina sowerbyi* (Nuttall).

Ranikothalia sindensis (Davies), *Ranikothalia nuttalli* (Davies), *Discocyclusa dispansa* (Sowerby) and *Discocyclusa sowerbyi* (Nuttall), Plate 5.2. The occurrence of *Discocyclusa dispansa* and *Discocyclusa sowerbyi* indicates a Late Paleocene age.

5.4.2 Chert

Four samples of red bedded cherts (KM37, 37b, 39a, and 39b) were collected from the ophiolite mélange in the Yazagyo Dam. Chert samples were able to extract a diverse assemblage of moderately to well-preserved radiolarian fossils from the ophiolite mélange (Plate 5.3, 5.4, 5.5, 5.6). The identification and age determination of radiolarian fossils was assisted by Prof. Taniel Danelian (Université de Lille, France). Radiolarian fossils from these sediments include the following taxa: *Stichocapsa robusta* (Matsuoka), *Zhamoidellum ovum* (Dumitrica), *Holocryptocanium* sp., *Hiscocapsa* sp. cf. *H. dorysphaeroides* (Neviani), *H. kitoi* (Jud), *Spinocapsa* sp. cf. *S. quadriaculeata* (Steiger), *Cryptamphorella conara* (Foreman), *Gongylothorax favosus* (Dumitrica), *Yamatoum spinosum* (Takemura), *Tethysetta dhimenaensis* (Baumgartner), *Cinguloturris carpathica* (Dumitrica), *Paronaella skowkonaensis* (Carter), *P. kotura* (Baumgartner), *Eucyrtidiellum* sp., *Bagotum modestum* (Pessagno), *Pantanellium riedeli* (Pessagno), *Hemicryptocapsa* sp., *Williriedellum* sp., and *Parahsuum* sp. The preservation varies among samples. The radiolarian assemblage in sample KM37b (Plate 5.3) indicates a late Bathonian-early Oxfordian age, based on the occurrence of *Tethysetta dhimenaensis* and *Cinguloturris carpathica*. A Bathonian-early Callovian age for KM37 (Plate 5.4) is inferred from the occurrence of *Stichocapsa robusta*. A Pliensbachien-early Toarcian age was determined for sample KM39a (Plate 5.5), based on the occurrence of *Bagotum modestum*. Overlapping age ranges of abundant, well-preserved taxa of chert samples indicate Early Jurassic to Early Cretaceous (Fig 5.7).

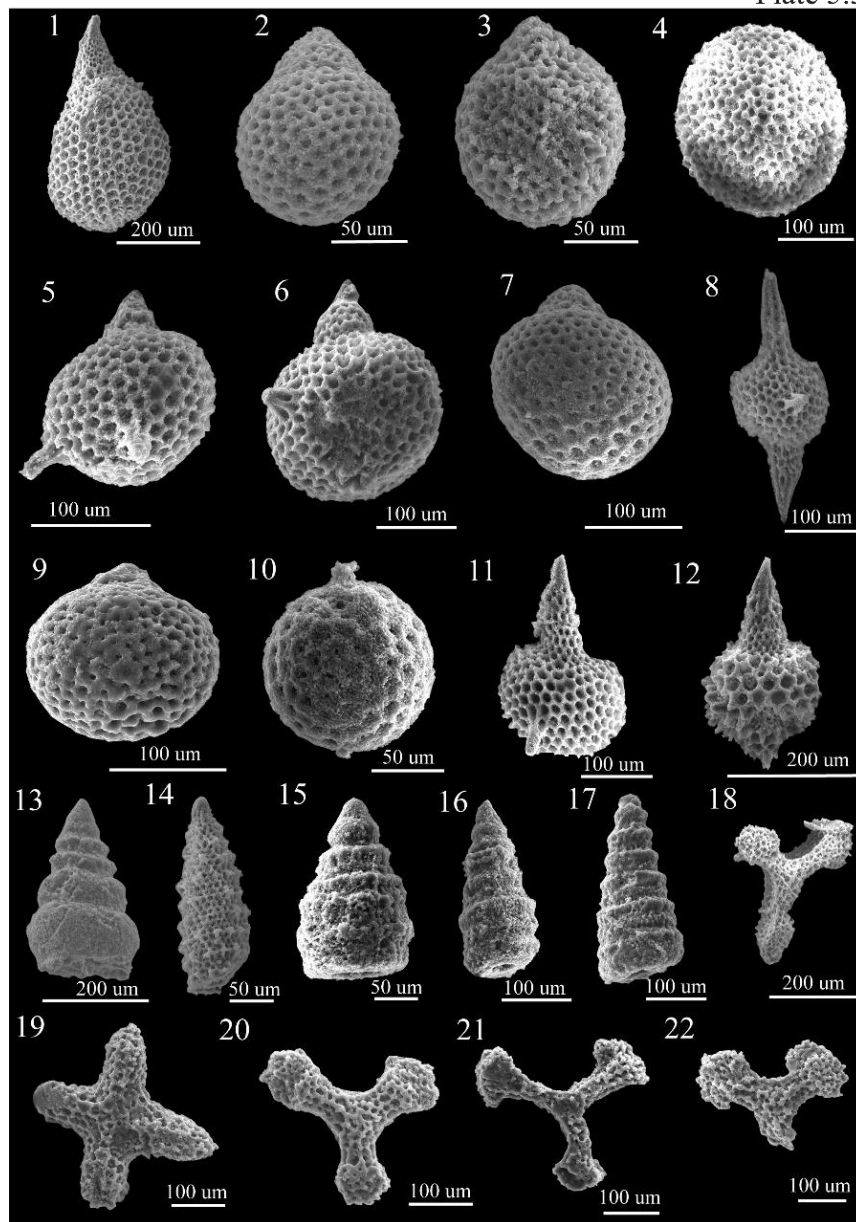


Plate. 5.3: SEM images of radiolarian assemblage in sample KM37b. 1. *Crococapsa* sp., 2. *Zhamoidellum ovum*, 3. *Stichocapsa robusta* (Matsuoka), 4. *Holocryptocanium* sp., 5,6. *Hiscocapsa* sp. cf. *H. dorysphaeroides* (Neviani), 7. *Hiscocapsa kitoi* (Jud), 8. *Spinocapsa* sp. cf. *S. quadriaculeata* (Steiger), 9. *Cryptamphorella* sp., 10. *Gongylothorax favosus*, 11,12. *Yamatoum spinosum* (Takemura), 13,15,16,17. *Cinguloturris carpathica* (Dumitrica), 14. *Tethysetta dhimenaensis* (Baumgartner), 18, 20. *Paronaella* sp., 19. *Crucella* sp., 21. *Paronaella skowkonaensis* (Carter), 22. *Paronaella kotura* (Baumgartner).

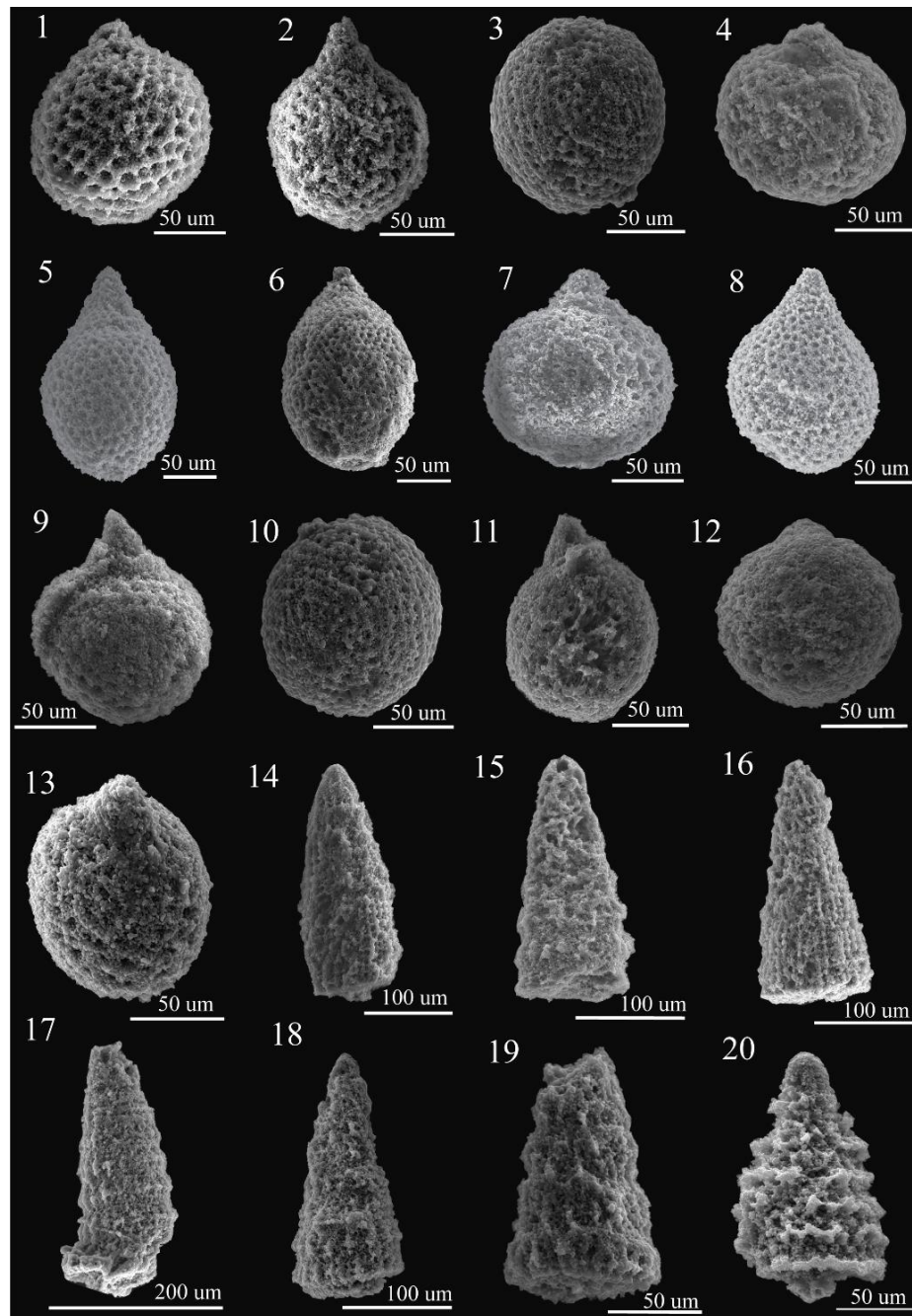


Plate. 5.4: SEM images of radiolarian assemblage in sample KM37. 1,2,11,13. *Williriedellum* sp., 3,10. *Holocryptocanium* sp., 4,12. *Cryptamphorella* sp., 5,8. *Stichocapsa robusta* (Matsuoka), 6. *Striatojaponocapsa* (?) sp., 7. *Zhamoidellum* sp., 9. *Obesacapsula* sp., 14,16. *Parahsuum* sp., 15,17,18. *Hsuum* sp., 19. *Pseudodictyomitra* sp., and 20. *Xitus* sp.

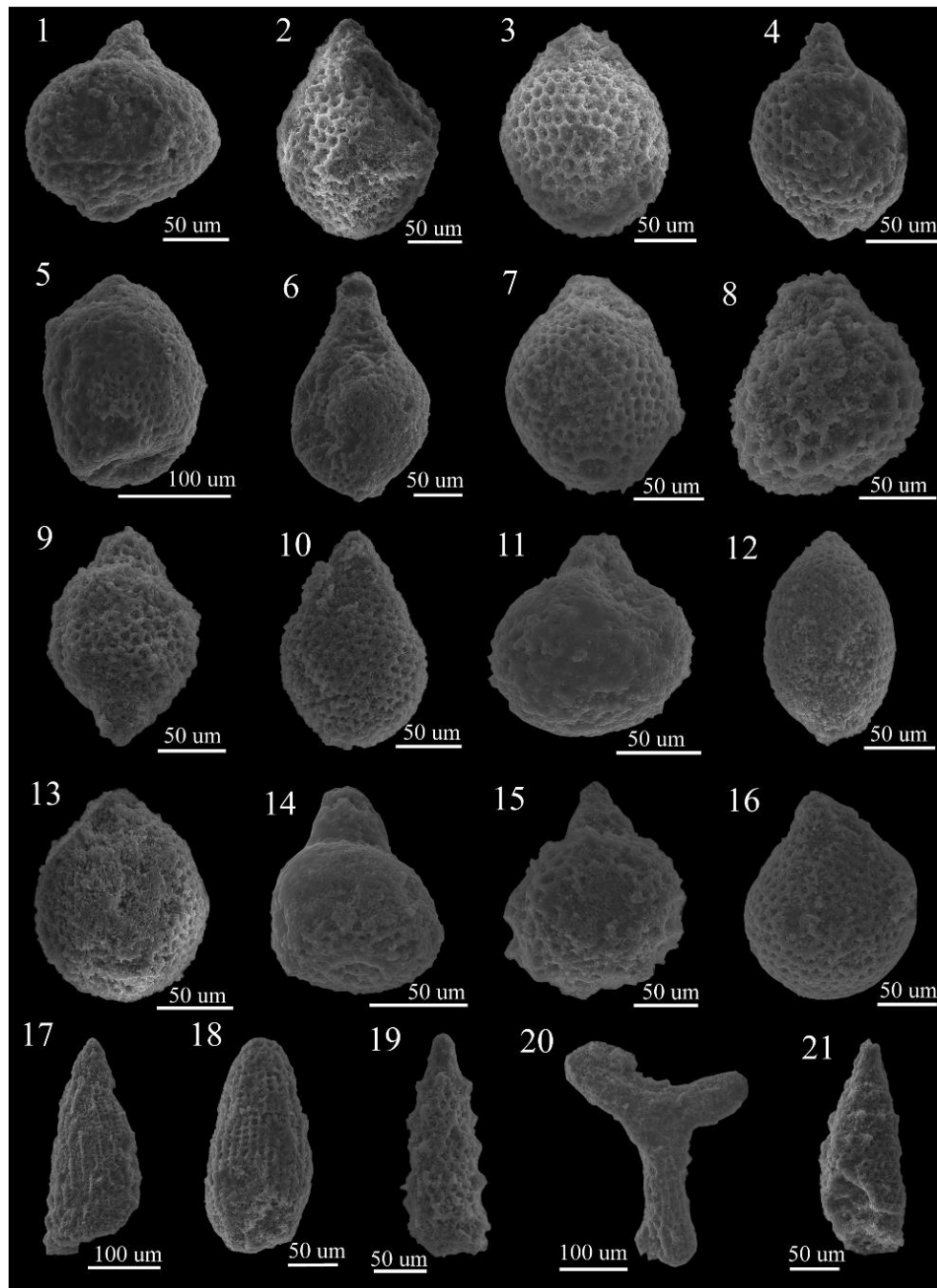


Plate. 5.5: SEM images of radiolarian assemblage in sample KM39a. 1. *Obesacapsula* sp., 2,10,13. *Williriedellum* sp., 3,5,7. *Striatojaponocapsa* (?) sp., 4,6. *Williriedellum* sp., 8. *Eucyrtidiellum* sp., 9. *Hemicryptocapsa* (?) sp., 11. *Zhamoidellum* sp., 12. *Aitaum* (?) sp., 14. *Eucyrtidiellum* sp., 15. *Hiscocapsa* sp., 16. *Hiscocapsa* sp., 17,19,21. *Parahsuum* sp., 18. *Bagotum modestum* (Pessagno), 20. *Tritrabs* sp.

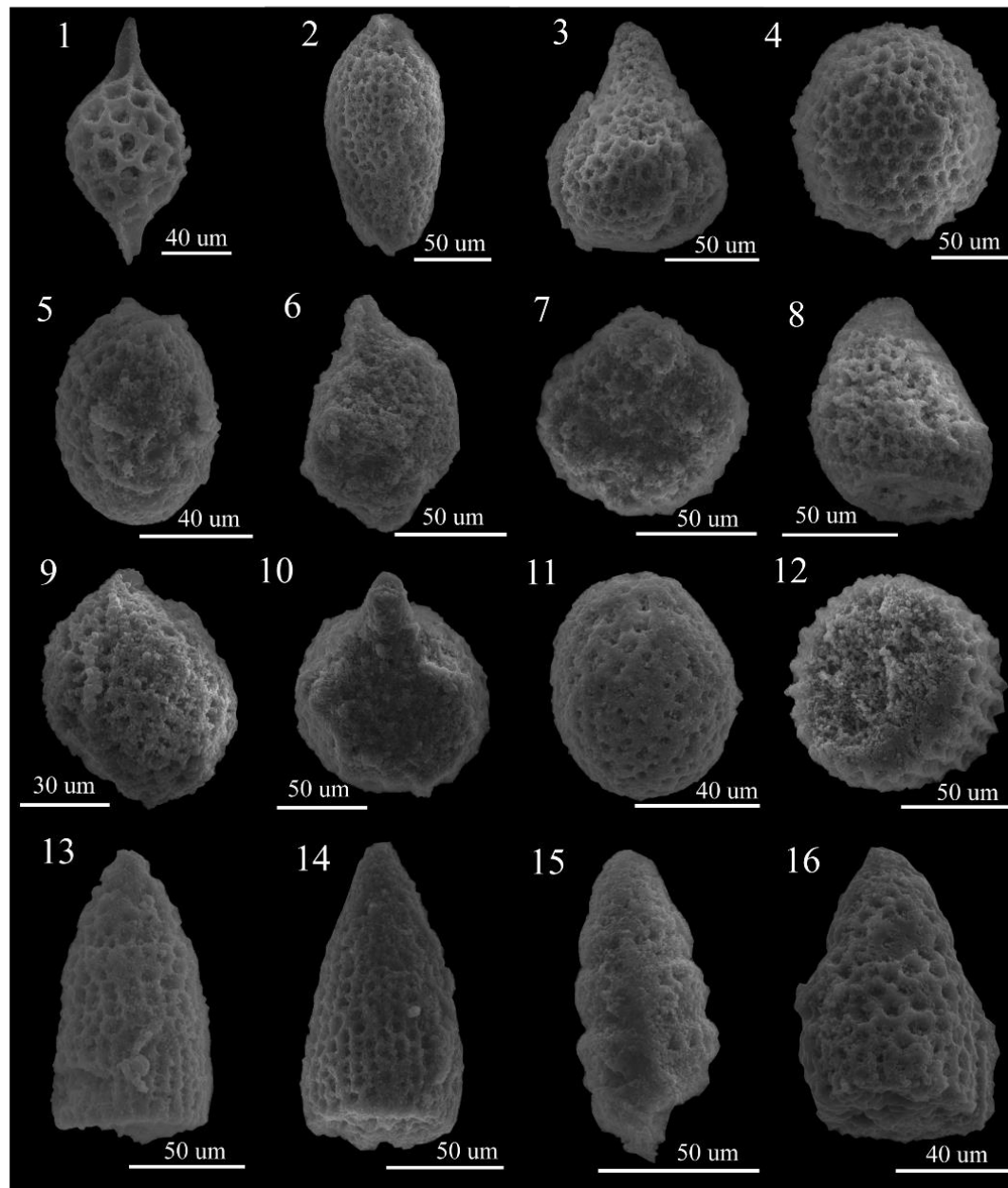


Plate. 5.5: SEM images of radiolarian assemblage in sample KM39b. 1. *Pantanellium riedeli* (Pessagno), 2. *Aitaum* (?) sp., 3. *Hiscocapsa* sp., 4. *Holocryptocanium barbui* (Dumitrica), 5, 11. *Holocryptocanium* (?) sp., 6. *Hemicryptocapsa* (?) sp., 7. *Cryptamphorella* (?) sp., 8. *Striatojaponocapsa* (?) sp., 9. *Hemicryptocapsa* sp., 10. *Willriedellum* sp., 12-16. *Parahsuum* sp.

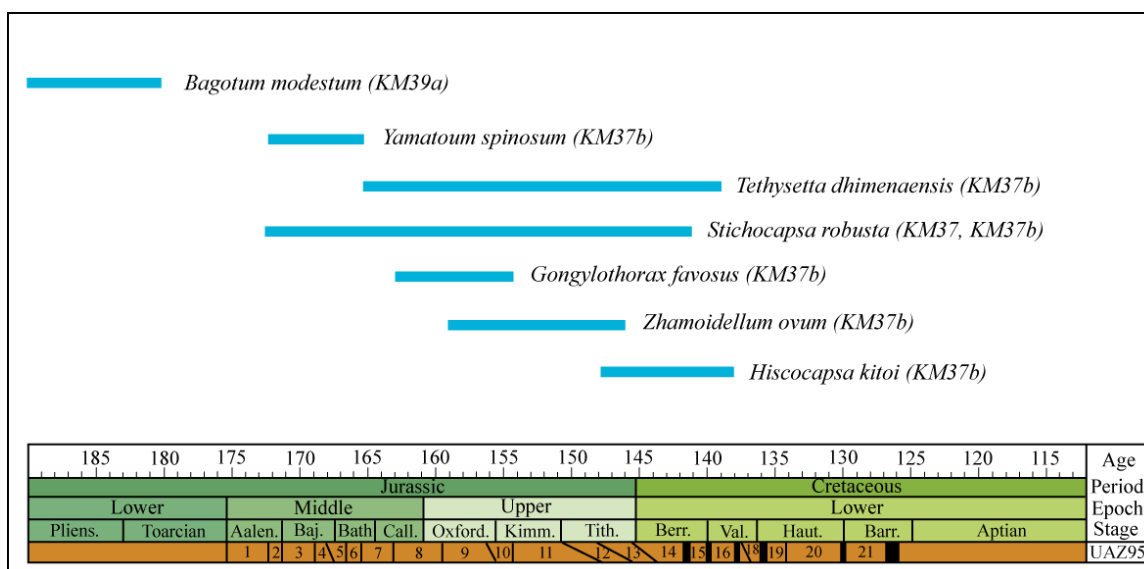


Fig. 5.7: Stratigraphic ranges of radiolarian fossils from the ophiolitic mélange, Yazagyo Dam, Kalemmyo area.

5.5 Petrography

5.5.1 Sandstone

Eight sandstone samples (KM04, 15, 23, 25, 34, 34a, 38 and 54b) were collected along the Kalemmyo-Falam-Mt. Kennedy road section and two samples (KM40a and 40b) were collected from the Kabaw Formation. Petrographic point-count data from the fine to medium grained sandstones are presented in Appendix 2 and plotted on QFL (quartz-feldspar-lithic) ternary diagrams (Fig. 5.8).

Four sandstone samples were analysed from the Pane Chaung Formation (KM04, 23, 25 and 38). All of the analysed samples are litharenites (Folk, 1980) composed predominantly of monocrystalline quartz with subordinate polycrystalline quartz, plagioclase feldspar and

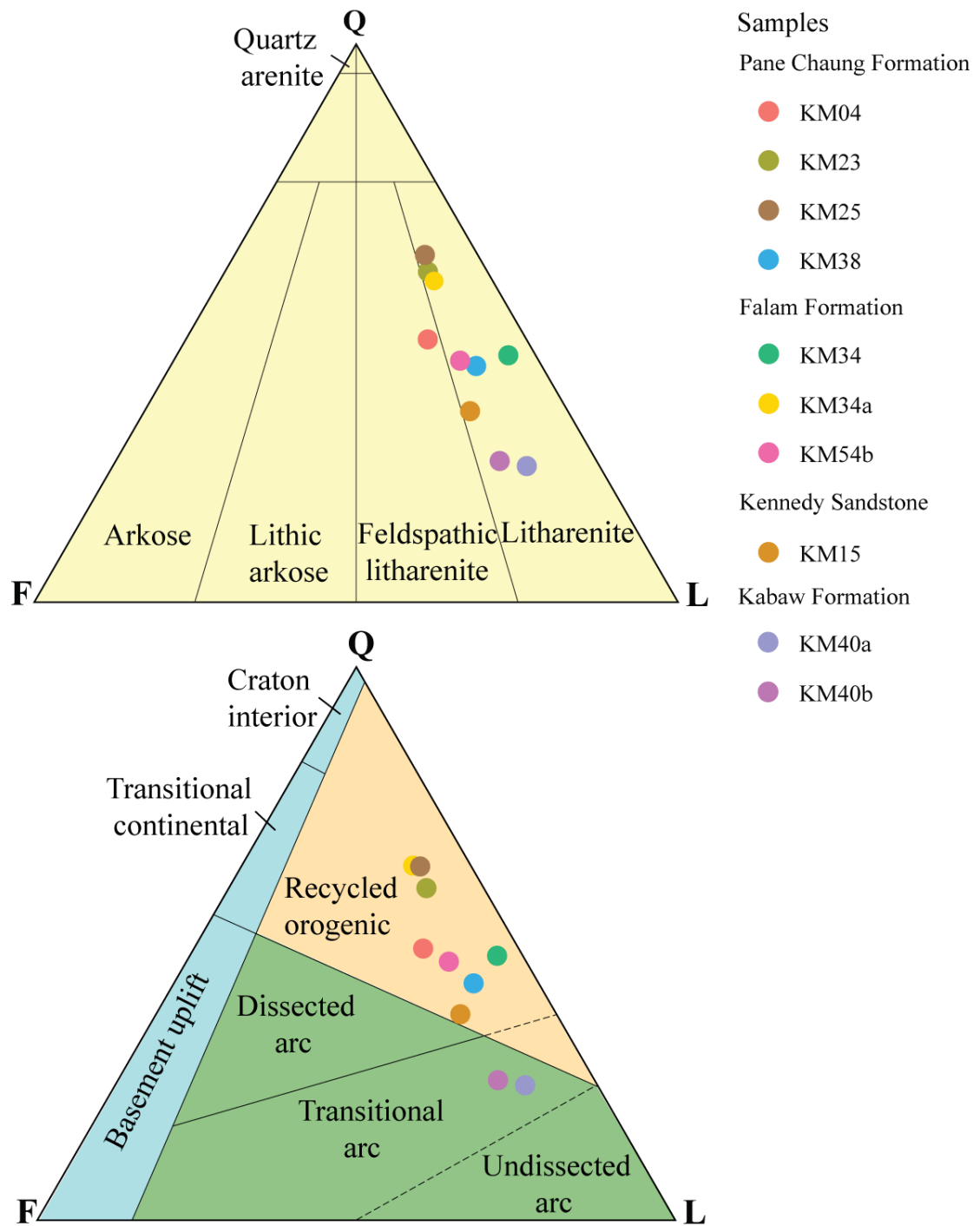


Fig. 5.8: QFL plots showing (a) sandstone classification (Folk, 1980) and (b) provenance fields (Dickinson et al., 1983) for the study area. Q-total quartz, F-total feldspar and L-total lithics.

lithic fragments. The monocrystalline quartz grains (40%-50% of framework grains) are angular to subrounded and display undulose extinction. The polycrystalline quartz is composed primarily of metamorphic quartz with curved grain boundaries. Lithic fragments constitute 25% to 35% of framework grains and are mainly represented by phyllite, mudstone, chert, and intermediate to basic volcanic rocks (Fig. 5.9a,b,c,d). Feldspars (5-10%) are mainly twinned plagioclase and some of them have been partly replaced by clay minerals as well as calcite. Muscovite, biotite, chlorite, zircon, epidote, tourmaline and rutile are common accessory minerals. The matrix in all samples is dominated by clay minerals and organic matter. Texturally, the sandstones are poorly sorted and immature. On QFL plots (Dickinson et al., 1983) the sandstones lie within the recycled orogenic provenance field (Fig. 5.8).

Sandstones (KM34, 34a and KM54b) in the Falam Formation are dominated by quartz grains and lithic fragments, often poorly sorted with angular to subrounded shapes (Fig. 5.9e,f,g). Quartz is mainly monocrystalline and has uniform extinction. Feldspar is a minor constituent and shows twinning. Lithic fragments are abundant, and are mainly composed of intermediate volcanic fragments together with some metamorphic and sedimentary contributions (Fig. 5.9g). The amount of clay minerals and/or other matrix-sized materials is high with an average of 30%. XRD results show that the fine-grained fraction (2- μ m size) of these sandstones is composed of quartz, plagioclase, chlorite, illite, dolomite, calcite and pyrite (Fig. 5.10). Authigenic cements are dominated by calcite. Accessory minerals include zircon, pyrite and rutile. The compositional data of all samples fall in the litharenite, and recycled orogenic provenance (Fig. 5.8). The presence of sedimentary lithics in the Falam Formation confirms recycling from older sedimentary rocks.

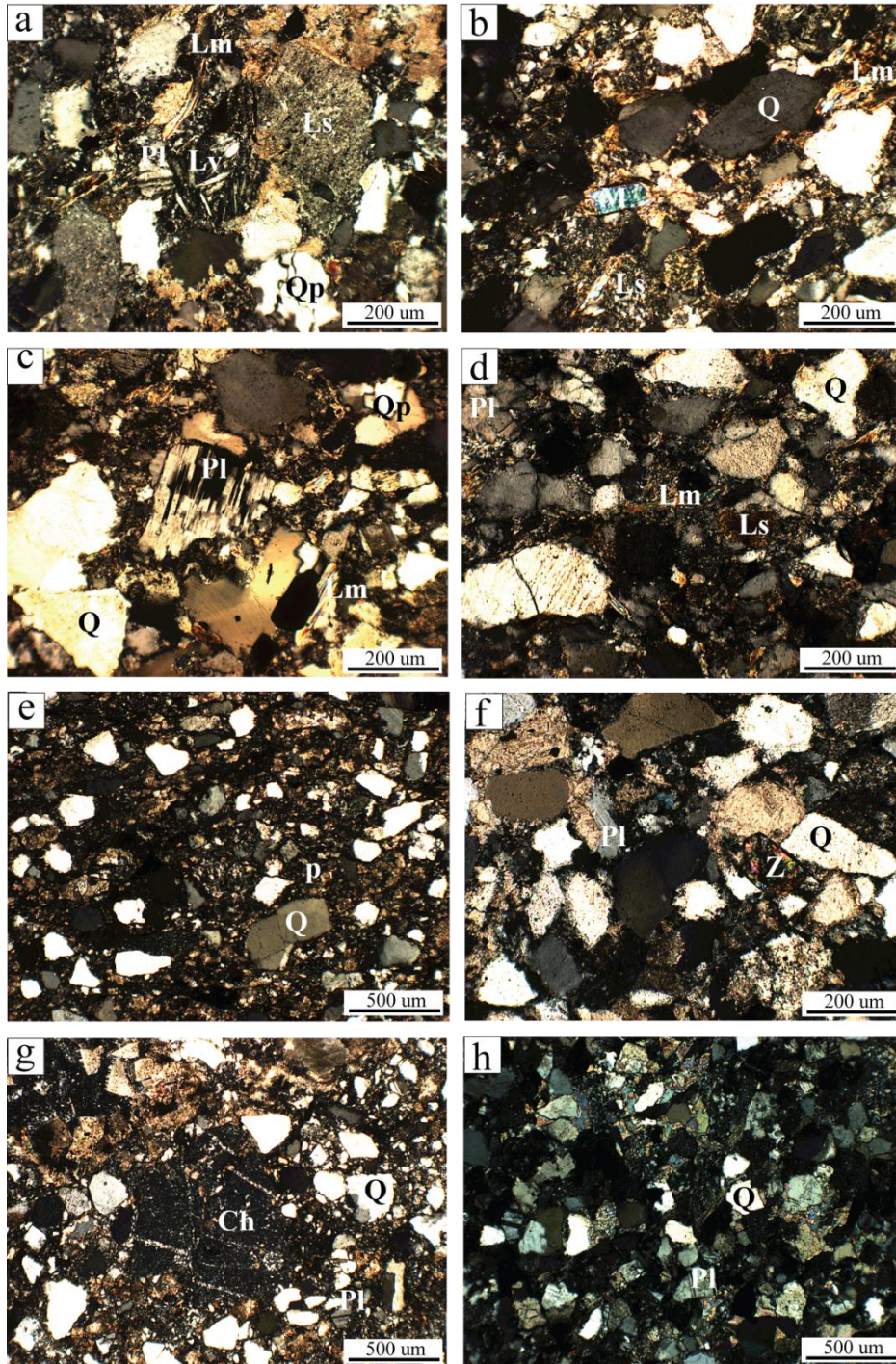


Fig. 5.9: Photomicrographs of the sandstones in the study area. (a),(b),(c) and (d) Pane Chaung Formation, (e),(f), (g) Falam Formation. (h) Kennedy Sandstone. Q-quartz, Qp-polycrystalline quartz, Pl-Plagioclase, Lv-volcanic lithic, Ls-sedimentary lithic, Lm-metamorphic lithic, M-muscovite, Ch-chert, Z-zircon.

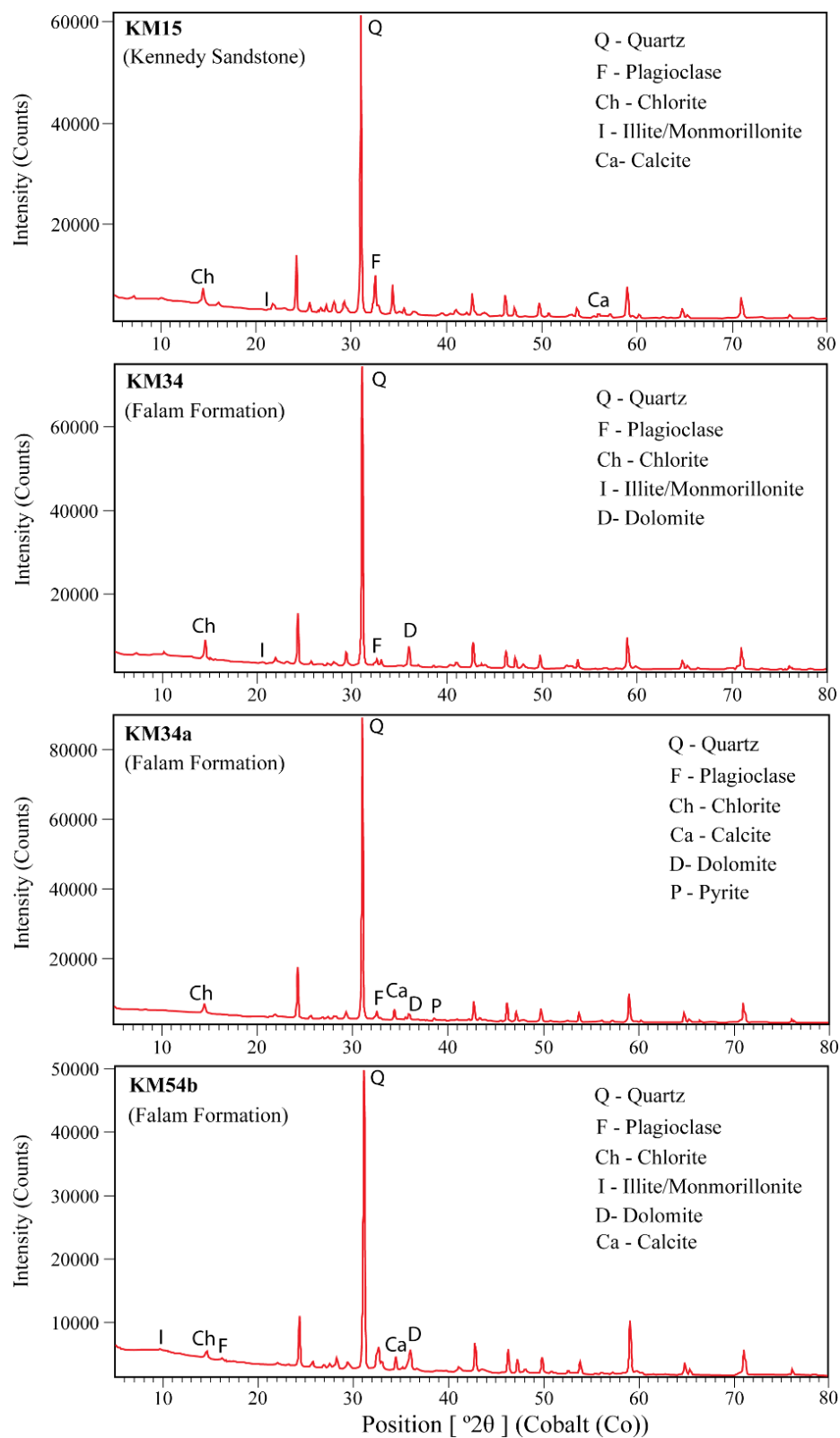


Fig. 5.10: XRD analyses of the Falam Formation and Kennedy Sandstone.

Sample KM15 (Fig. 5.9h) from the Kennedy Sandstone is composed of fine- to medium-grained, subangular to subrounded grains, that are mostly monocrystalline quartz, with some foliated and equant polycrystalline quartz, plagioclase, sedimentary and metamorphic lithic fragments of phyllite grade and fine-grained quartz-mica-chlorite schist. Sedimentary and low-grade metasedimentary lithic fragments suggests derivation of sediments from proximal orogenic sources. The large angular monocrystalline quartz and plagioclase content probably reflect the presence of a calc-alkaline magmatic source. The sandstone is texturally immature and generally poorly sorted, with a high matrix content. Calcite is a common pore-filling cement in this sandstone. XRD analysis show that the fine-grained fraction (2- μm size) of the sandstone is composed of quartz, plagioclase, chlorite, illite and calcite (Fig. 5.10). The petrographic data from the Kennedy Sandstone falls in the litharenite and recycled orogenic provenance fields on the QFL plot (Fig. 5.8).

KM40a and KM40b were collected from the Kabaw Formation in the Chindwin Basin. Grain-counting results are plotted on a QFL diagram (Fig. 5.8) and compared with previous data collected from the same unit (Wang et al., 2014). The sandstones of the Kabaw Formation are moderately sorted, angular to subangular, volcanic-rich, litharenites (Fig. 5.4b) and the new grain-counting results compare well with those of Wang et al. (2014). Quartz grains commonly show uniform extinction; some display embayments indicative of volcanic origin. However, polycrystalline quartz grains with a tectonic fabric also occur. Volcanic rock fragments are predominantly felsic (rhyodacitic), with subordinate microlitic (andesitic) and lathwork (basaltic) types. Textures indicate that volcanic fragments are commonly basic to intermediate in composition. Sedimentary lithics consist of shale and siltstone. Metamorphic lithics are phyllite and slate. Plagioclase feldspars are present and

some are altered on the boundary and inner part of the grain to clay minerals. Accessory minerals include zircon, tourmaline, epidote and Cr-spinel. Calcite cement is present in the form of micrite and filling pore spaces and replacing framework grains. The relatively quartz- poor and lithic-rich sandstones plot in the magmatic arc provenance field (Fig. 5.8).

5.5.2 Limestone

A petrographic description of the limestone types has been completed based on the Dunham classification (1962). The samples examined from the limestone blocks of the Falam Formation (KM53a, 55, 57 and 58a) are wackestones to packstones (Fig. 5.11a,b,c,d). The grain content is more than 10% in a carbonate mud matrix. The matrix consists of sparry calcite and skeletal remains of foraminifera represented by both planktic and benthic forms.

Sample KM44, from an *ex situ* limestone block in the Kabaw Formation, is light grey, and fossil fragments can be observed in hand specimens. The limestone was identified as a packstone on the basis of the dominant biogenic components (Fig. 5.11e,f). The allochems are filled interstitially with sparry calcite cement and some carbonate mud. This microfacies consist of larger benthic foraminifera, algal fragments, and other unidentified skeletal fragments which are grain-supported.

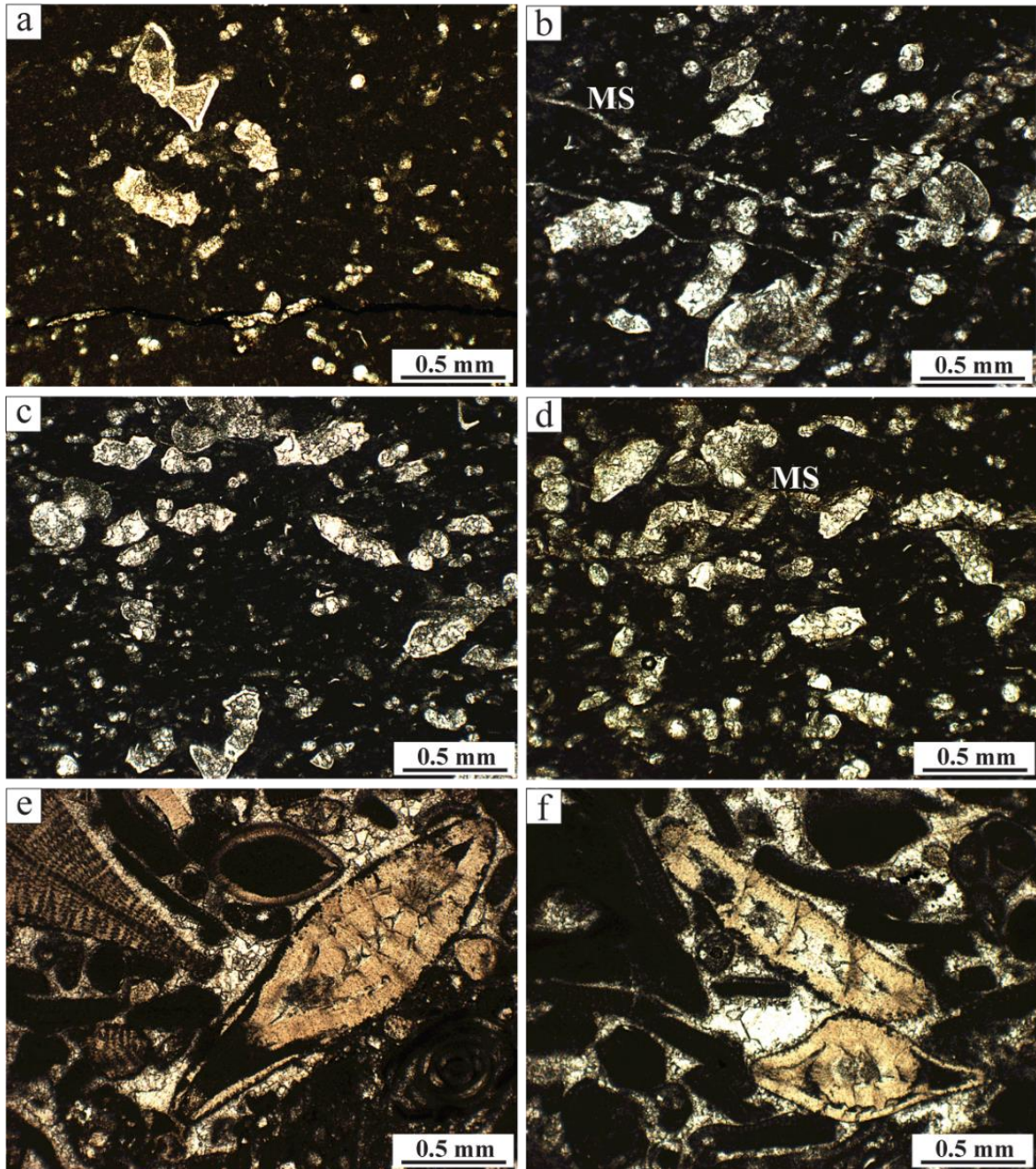


Fig. 5.11: Photomicrographs of limestones from the study area. (a),(b),(c) and (d) wackestones to packstones microfacies in the Falam Formation, and (e), (f) larger benthic foraminifera packstone from an ex situ limestone block in the Kabaw Formation. MS - microstylolite structures.

5.5.3 Conglomerate

The conglomerate (sample KM53) in the Falam Formation seen in the Nattaga Chaung/River is a block hosted within mudstone (Fig. 5.12a), and contain clasts of ophiolites, quartz and rarely volcanic pebbles. In thin section, the conglomerate contains clasts of chert (with and without radiolaria), serpentinite, gabbro, basalt, quartz, and phyllite embedded in a reworked tuffaceous to siliceous cement. Clasts are angular to well rounded, poorly sorted, and matrix- or clast-supported. Chert grains are the majority of grains in sample (Fig. 5.12b,c). Quartz is identifiable due to its lack of cleavage and unaltered appearance. A few opaque minerals are also present.

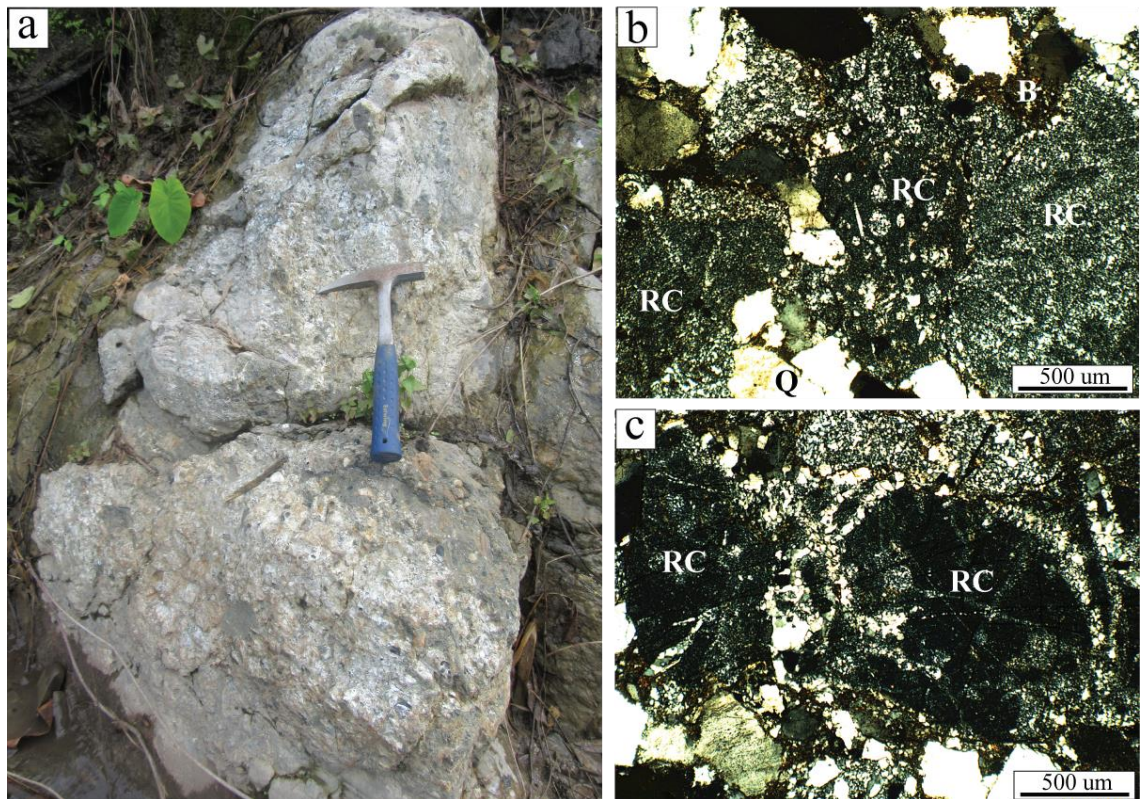


Fig. 5.12: (a) Field photo, (b) and (c) photomicrographs of conglomerate block in the Falam Formation. Q, quartz, RC, chert, B, basalt.

5.5.4 Ultramafic Rock

The Kalembo peridotites were sampled from three peridotite massifs, Bophi Vum (KM01 and KM02), Webula Taung (KM28, KM29a and K30a) and Mwe Taung (KM51 and KM52a). Petrographically, the samples investigated here consist of harzburgites and lherzolite. They are classified on the basis of the abundance of olivine, orthopyroxene -and clinopyroxene, which are variably altered to serpentine along fractures.

The peridotites in the Kalembo massif are typical ophiolitic mantle rocks, dominantly harzburgites and lherzolite. The peridotites display a massive, fine-grained texture with relict orthopyroxene and disseminated spinel grains. They exhibit a porphyroblastic texture with kink bands and highly stretched olivine and orthopyroxene porphyroblasts showing undulose extinction (Fig. 5.13a,b,c,d). The olivines are anhedral, fine grained and most of them have been serpentinized. Orthopyroxenes show corrosion or absorption gulfs on their rims (Fig. 5.13e), and often contain exsolution lamellae of clinopyroxene and are partly altered to bastite. These gulfs have been filled with fine grained replacive olivines (Fig. 5.13e). Orthopyroxenes are surrounded by fine-grained, undeformed olivine neoblasts (Fig. 5.13b), that show uniform extinction. The original mantle textures observed indicate growth of olivine and orthopyroxene in a typical mantle peridotite; there has been no subsequent metamorphism but the peridotites have undergone low-temperature alteration during serpentinisation, and are not recrystallized. Two types of spinels are observed in these samples and even in the same thin section: Cr-spinel crystals, which are holly-leaf shape with lobate boundaries and small vermicular intergrowths (Fig. 5.13a,b), and chromite crystals, which are euhedral and, rarely, subhedral (Fig. 5.13c). Local, fine-grained, euhedral spinel and skeletal spinel grains are present within the olivine porphyroblasts, and

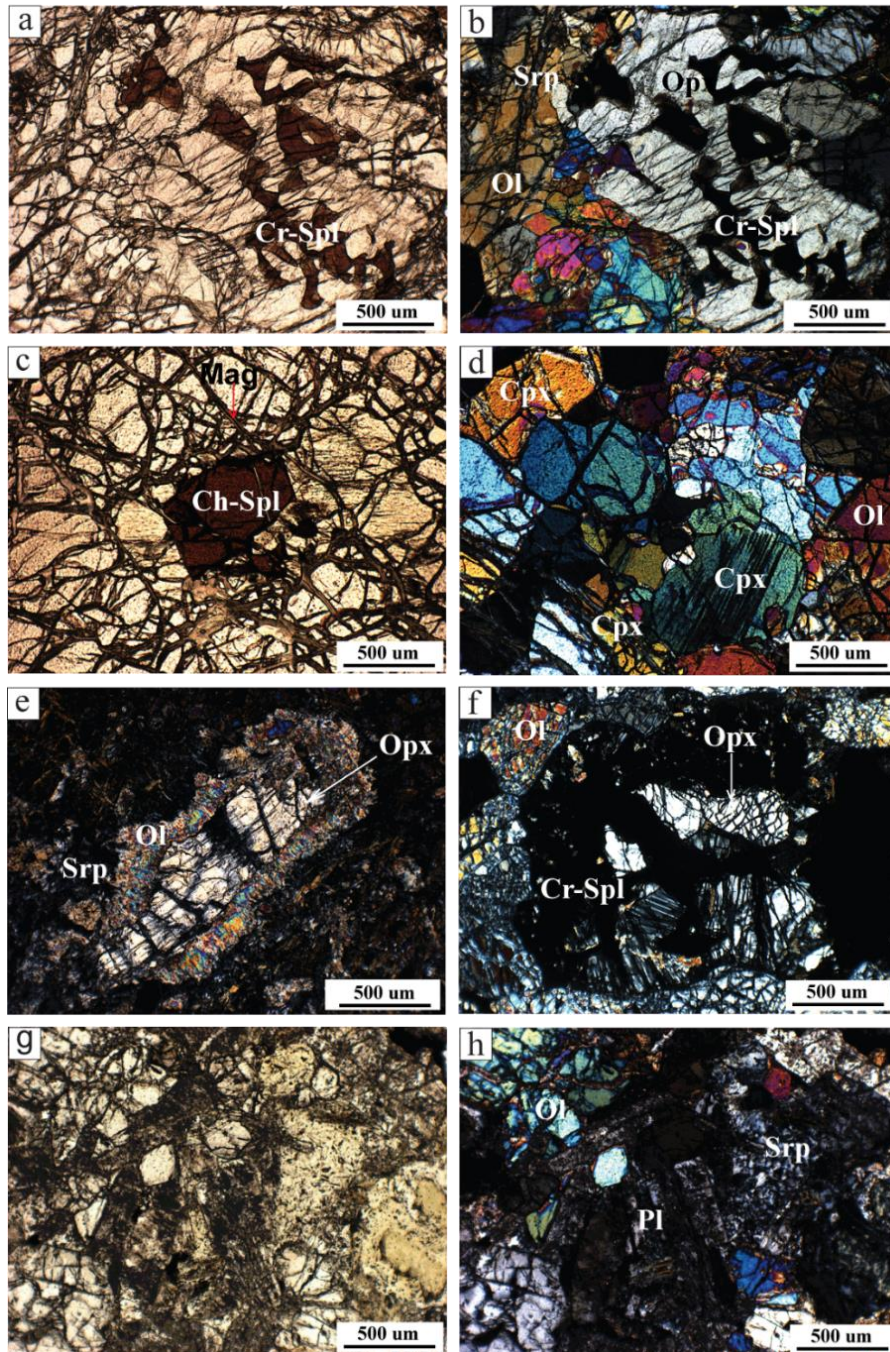


Fig. 5.13: Photomicrographs of the mantle peridotite under PPL and XPL. (a), (b) holly-leaf shape spinel in the harzburgite, (c),(d), euhedral chromite crystal in the lherzolite, (e) irregular shape orthopyroxene porphyroblast with embayment of olivine at its rim, (f) large grain Cr-spinel with cracked texture in the harzburgite, and (g),(h) olivine gabbro. Ol-olivine, Op-orthopyroxene, Cpx-clinopyroxene, Cr-Spl-Cr spinel, Srp-serpentinite, Pl-plagioclase, Mag-magnetite.

amoeboid spinel grains are associated with the olivine neoblasts. The large grains (>2 mm) of Cr-spinel have cracked textures and are altered to Fe-rich spinel along margins and fractures (Fig. 5.13f). The spinels often display thin and thick rims of Cr-bearing magnetite. Secondary phases include serpentine, chlorite and magnetite.

5.5.5 Mafic rock

One gabbro sample (KM51a) was analysed from the Mwe Taung peridotite massif. The gabbro is medium- to coarse-grained, displays a dominantly hypidiomorphic granular texture, but is in places porphyritic and poikilitic. It is mainly composed of plagioclase, clinopyroxene and amphibole with relict olivine, rare hornblende, magnetite and opaque oxides. Some of the large plagioclase is euhedral and it is usually poikilolitically enclosed by clinopyroxene (Fig. 5.13g,h). Plagioclase occurs as megacrysts and commonly exhibits twinning. Clinopyroxene occurs as oikocrysts with olivine and plagioclase inclusions, and smaller interstitial grains. Olivine is commonly serpentinized. A few relict olivine grains occur as inclusion within plagioclase and clinopyroxene. Amphibole also occurs as rims around clinopyroxene or in late-stage veins. The original igneous lower crust gabbro that has undergone low-temperature alteration during serpentinisation and not igneous recrystallization.

5.5.6 Amphibolite Schist

Three amphibolite schist samples (KM36a, 36b, and 36c) were analysed from the metamorphic sole (Fig. 5.14a,b) in the Webula ultramafic massif. Petrographically, the piemontite-bearing schist contains quartz, muscovite, albite, chlorite and piemontite, with apatite and epidote occurring as minor minerals. It commonly shows compositional banding,

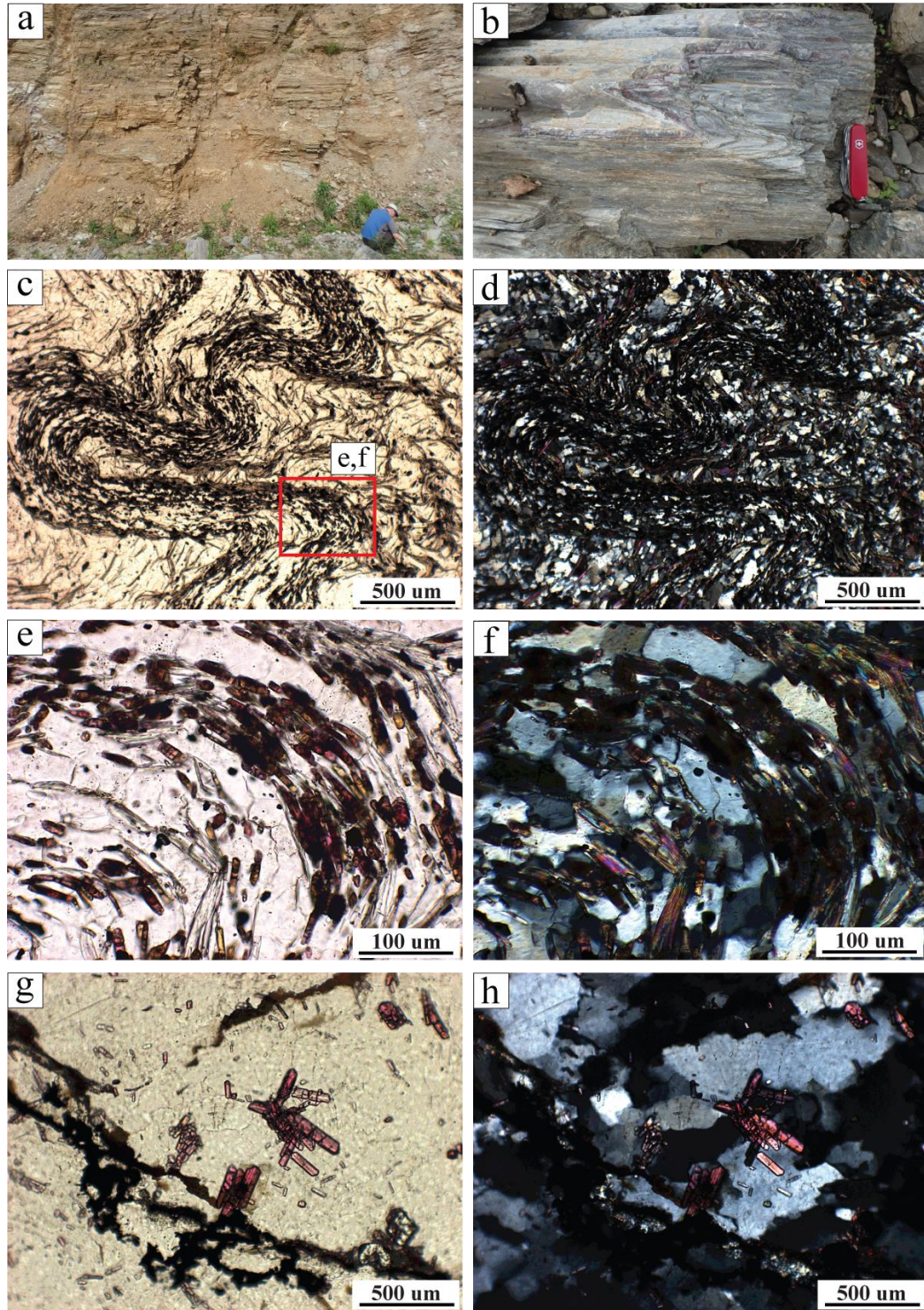


Fig. 5.14: (a),(b) Field photographs of outcrop sampled in the metamorphic sole. (c),(d),(e),(f),(g) and (h) Photomicrographs of the amphibolite schist with piemontite-rich bands. Red box in (c) is shown at a larger scale under PPL (e) and XPL (f).

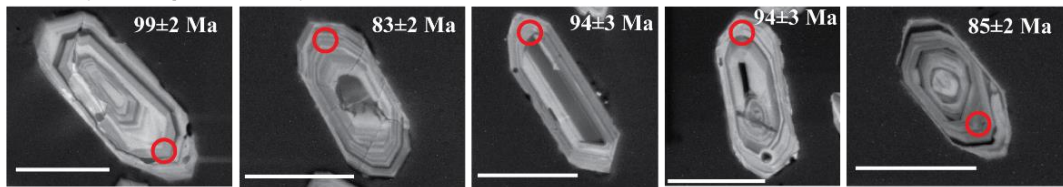
with alternating quartz-rich and piemontite-rich bands (Fig. 5.14c,d,e,f). Muscovite flakes with a twisted and warped appearance show parallel alignment and are elongated to form a seam. The width of the piemontite-rich bands ranges from 0.5 to 1.5 mm. They are mainly composed of piemontite (a Mn-rich epidote), hematite, rutile, tourmaline and epidote, with subordinate amounts of quartz, muscovite and chlorite. Piemontite is pink-red in color and displays a nematoblastic texture (Fig. 5.14g,h). It is occasionally included as minute crystals within xenomorphic quartz grains and a preferred orientation is clearly developed. Hematite, rutile and tourmaline are associated with piemontite and show a cataclastic feature. The most common occurrence of piemontite is in schist and indicates low- to -medium-grade regional metamorphism.

5.6 Detrital zircon U-Pb ages

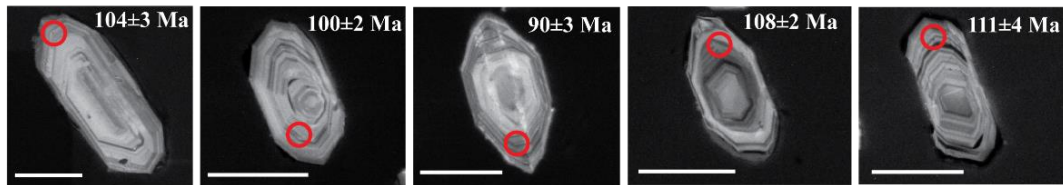
Detrital zircons have been extracted from ten sandstone samples from the Kalembo area (locations are shown in Fig. 5.1). Of these, three (KM23, 25 and 32) were collected from the Pane Chaung Formation, four (KM34, 34a, 54b and KM58) from the Falam Formation, one (KM15) from the Kennedy Sandstone, and two (KM40a and 40c) from the Kabaw Formation in the Chindwin Basin.

Detrital zircons in the Kalembo area are predominantly colourless euhedral and subhedral, whereas rounded zircon grains with small remnants of a core are rare (Fig. 5.15). A striking feature of the detrital zircon assemblages from the Kalembo area is the abundance of transparent, colorless to pale brown zircons, with well-developed oscillatory compositional zoning, sector zoning or homogeneous texture in CL images (Fig. 5.15).

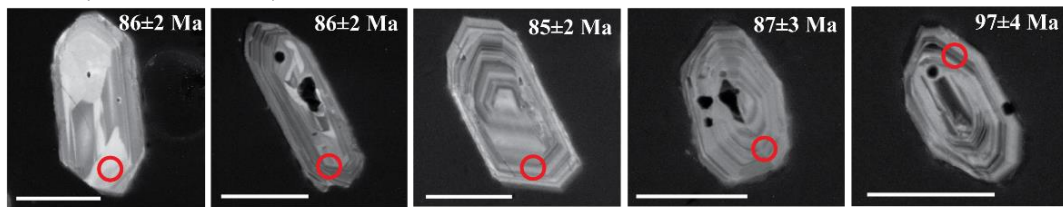
KM15 (Kennedy Sandstone)



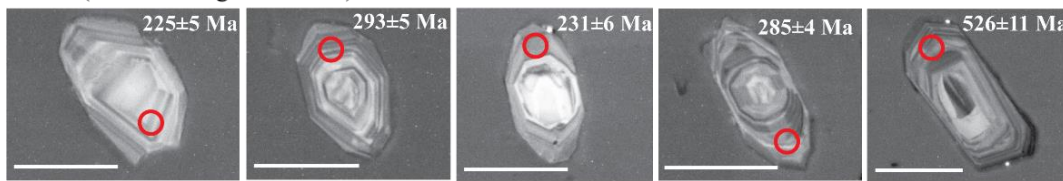
KM34a (Falam Formation)



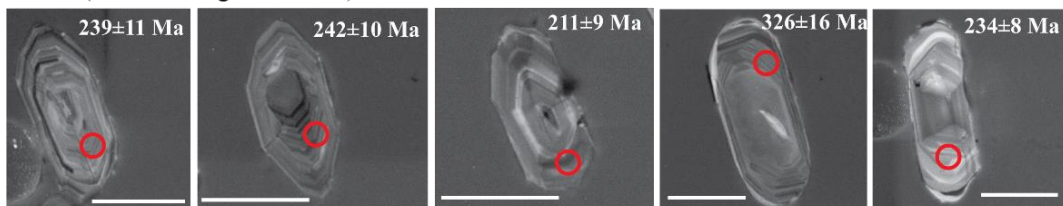
KM34 (Falam Formation)



KM23 (Pane Chaung Formation)



KM25 (Pane Chaung Formation)



KM40a (Kabaw Formation)

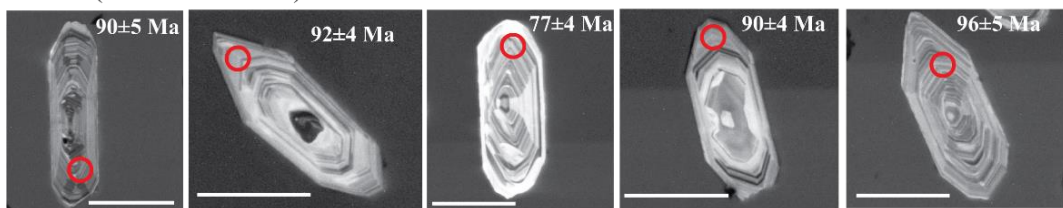


Fig. 5.15: Representative CL images of detrital zircons from the study area (scale bar = 100 μm). Red circles indicate the positions of U-Pb age analyses and ages of analyses zircons.

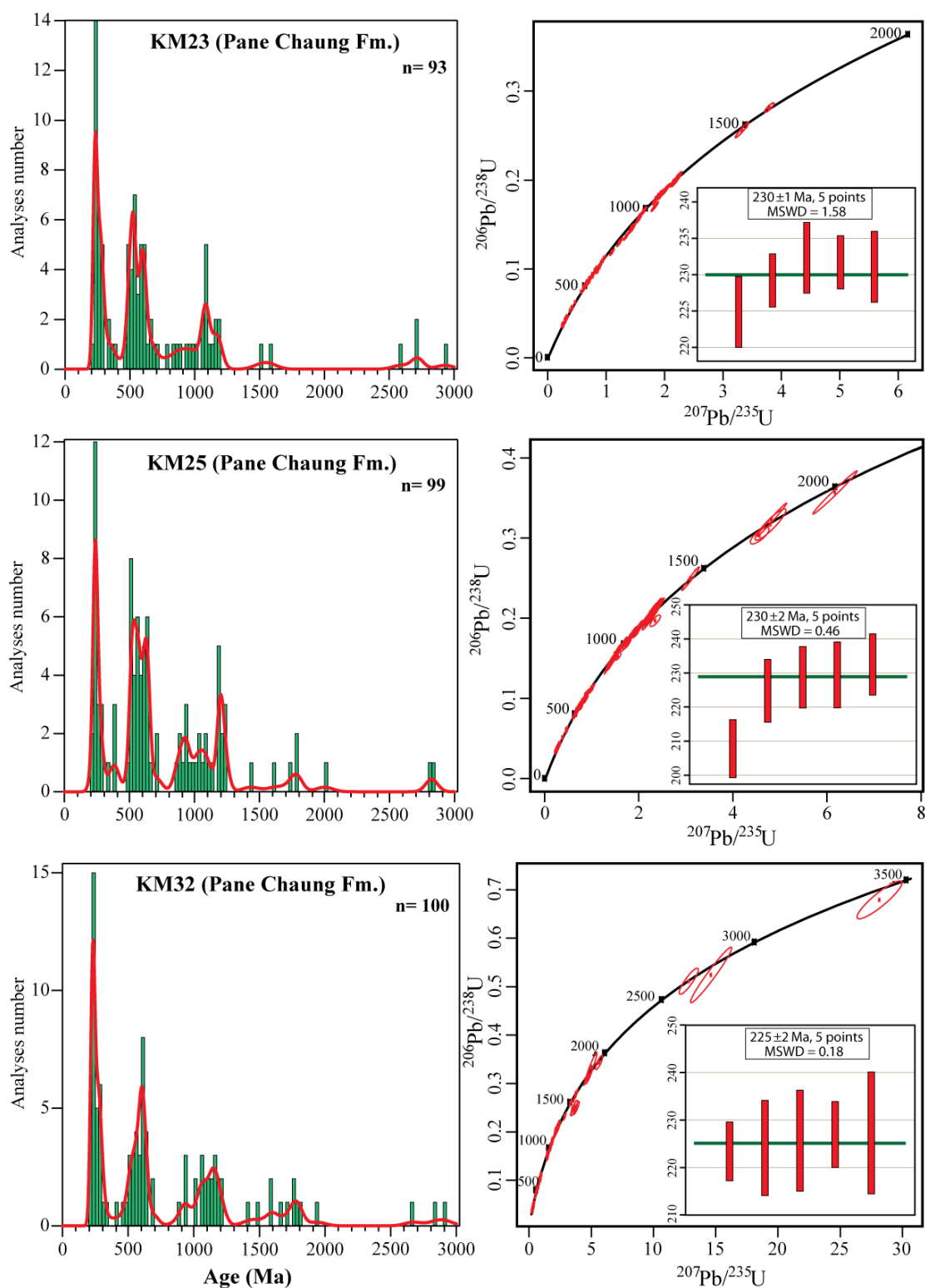


Fig. 5.16: Histograms and probability density plots, concordia diagrams and weighted average age diagrams showing detrital zircon U-Pb ages of the Pane Chaung Formation.

Probability density plots and concordia diagrams of U-Pb age distribution of individual zircons are shown in Fig. 5.16 and 5.17.

A total of 356 detrital zircon grains were analysed from the Pane Chaung Formation (KM23, 25 and 32), yielding 292 concordant zircon ages. Detrital U-Pb ages range in age from 3474 ± 37 Ma to 211 ± 9 Ma. The samples show consistent detrital zircon age patterns with three main clusters in the Mesoproterozoic (1.3-1.0 Ga, 16% of total analyzed grains), Neoproterozoic-Cambrian (800-460 Ma, 35%), and Late Paleozoic-Early Mesozoic (350-220 Ma, 28%), and scattered Paleoproterozoic – Archean (3.5-1.6 Ga) and Ordovician - Devonian (480-370 Ma) ages (Fig. 5.16). The youngest zircon ages in the Pane Chaung Formation sandstones are 211 ± 9 Ma, 222 ± 7 Ma, and 225 ± 5 Ma and the five youngest zircons in each of the 3 samples analyzed yield weighted average ages of 225 ± 2 Ma, 230 ± 1 Ma and 230 ± 2 Ma respectively (Fig. 5.16).

In total, 445 zircon grains were analysed from the Falam Formation (KM34, 34a, 54b and 58) in the Kalemmyo area, and 355 interpretable ages were obtained (Fig. 5.17). The zircon-age spectra from all samples display a prominent peak at 90-100 Ma, with a subordinate cluster at 110 Ma observed in KM34a and KM58, and scattered Proterozoic, Paleozoic and Mesozoic ages also evident. The youngest zircon ages in Falam Formation sandstones are 82 ± 2 Ma, 74 ± 2 Ma, 78 ± 2 Ma and 67 ± 3 Ma and the five youngest zircons give a weighted average age of 84 ± 1 Ma, 86 ± 1 Ma, 81 ± 1 Ma and 87 ± 1 Ma respectively (Fig. 5.17).

One sample (KM15) from the Kennedy Sandstone yielded detrital zircon U-Pb ages ranging from 1272 ± 30 to 46 ± 1 Ma, with a dominant peak at ~ 90 Ma and a subordinate

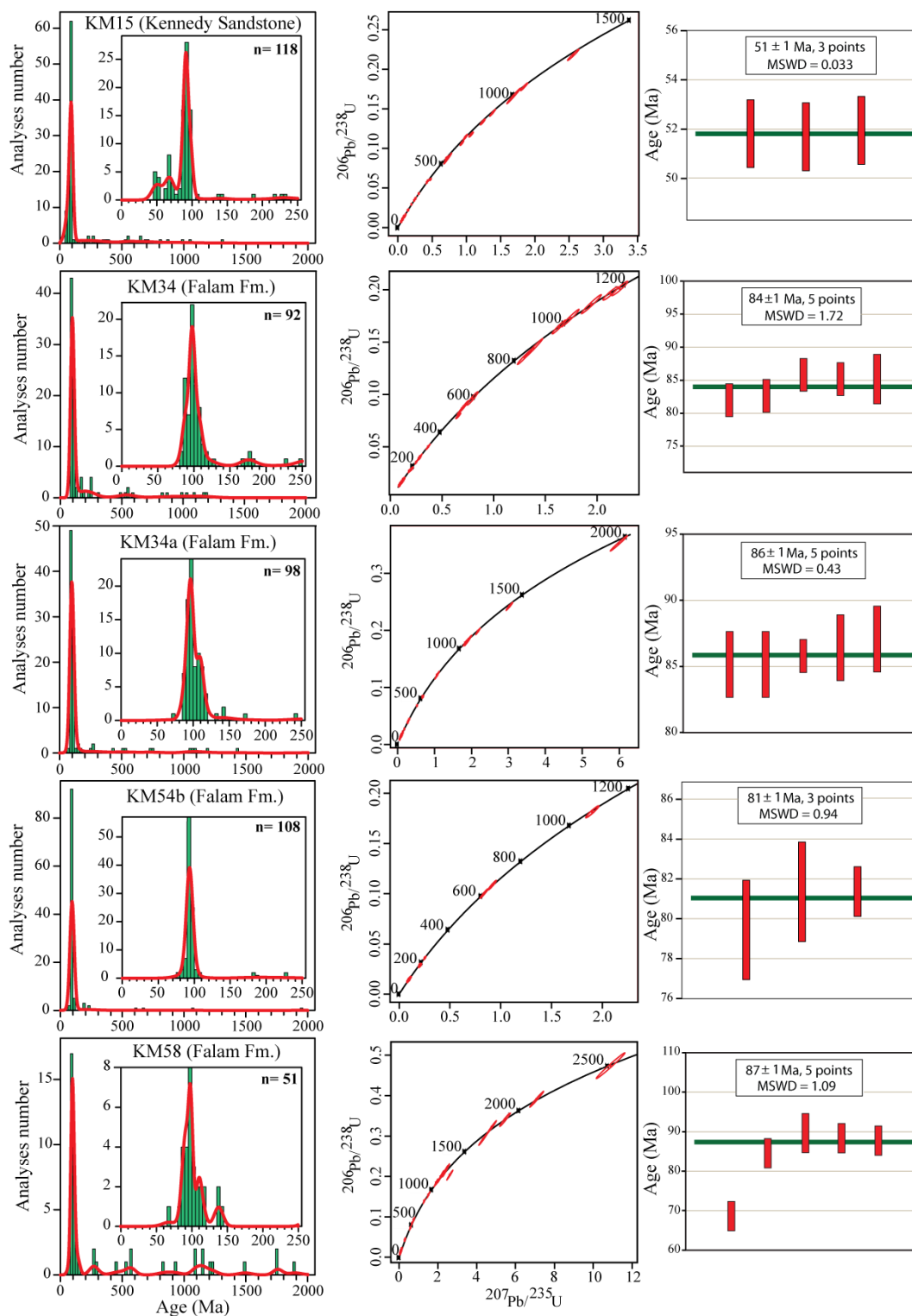


Fig. 5.17: Histograms and probability density plots, concordia diagrams and weighted average age diagrams showing detrital zircon U-Pb ages of the Kennedy Sandstone and Falam Formation.

peak of ~70 Ma (Fig. 5.17). The youngest zircon age is 46 ± 1 Ma and the three youngest zircons yielded a weighted average age of 51 ± 1 Ma (Fig. 5.17).

A total of 225 detrital zircon grains were analysed from the Kabaw Formation (KM40a and 40c), yielding 180 concordant zircon ages (Fig. 5.4c). Grains from the Kabaw Formation are dominated by Late Cretaceous (ca 80-110 Ma) zircons with a notable peak at ~100 Ma, and some scattered ages of Meso-Neoproterozoic age (1.6-5.6 Ga). The youngest zircons in the Kabaw Formation sandstones are 69 ± 3 Ma, and 76 ± 2 Ma and the five youngest zircons from each sample gave a weighted average age of 76 ± 1 Ma, and 77 ± 1 Ma respectively (Fig. 5.4c).

5.7 Detrital zircon Hf isotope

Four sandstone samples were analysed from the Kalembo area. Of these, three (KM34, 34a, 54b) were collected from the Falam Formation and one (KM15) from the Kennedy Sandstone. A total of 385 detrital zircons from these samples were analyzed for Hf isotopic compositions (Fig. 5.18). A majority of the $\epsilon_{\text{Hf}}(t)$ values are located between the Depleted Mantle and Chondritic lines, while a few grains fall below the Chondritic line (Fig. 5.18). The $\epsilon_{\text{Hf}}(t)$ values of these zircons show a wide range from -45 to +17. Two groups are defined by Hf isotopic data: one is characterized by positive $\epsilon_{\text{Hf}}(t)$ values ranging from +6 to +17, and the other by negative to slight positive $\epsilon_{\text{Hf}}(t)$ values from -15 to +5 (Fig. 5.18). Proterozoic zircons form a broad cluster between 2.0 Ga and 544 Ma without pronounced age peaks and have $\epsilon_{\text{Hf}}(t)$ values mostly between -7 and +9. Mesozoic zircons display high $^{176}\text{Hf}/^{177}\text{Hf}$ isotopic ratios of 0.281854-0.283167 that yielded positive $\epsilon_{\text{Hf}}(t)$ values ranging from +0.5 to +17 (87% of total grains) with nine grains dropping down to negative values

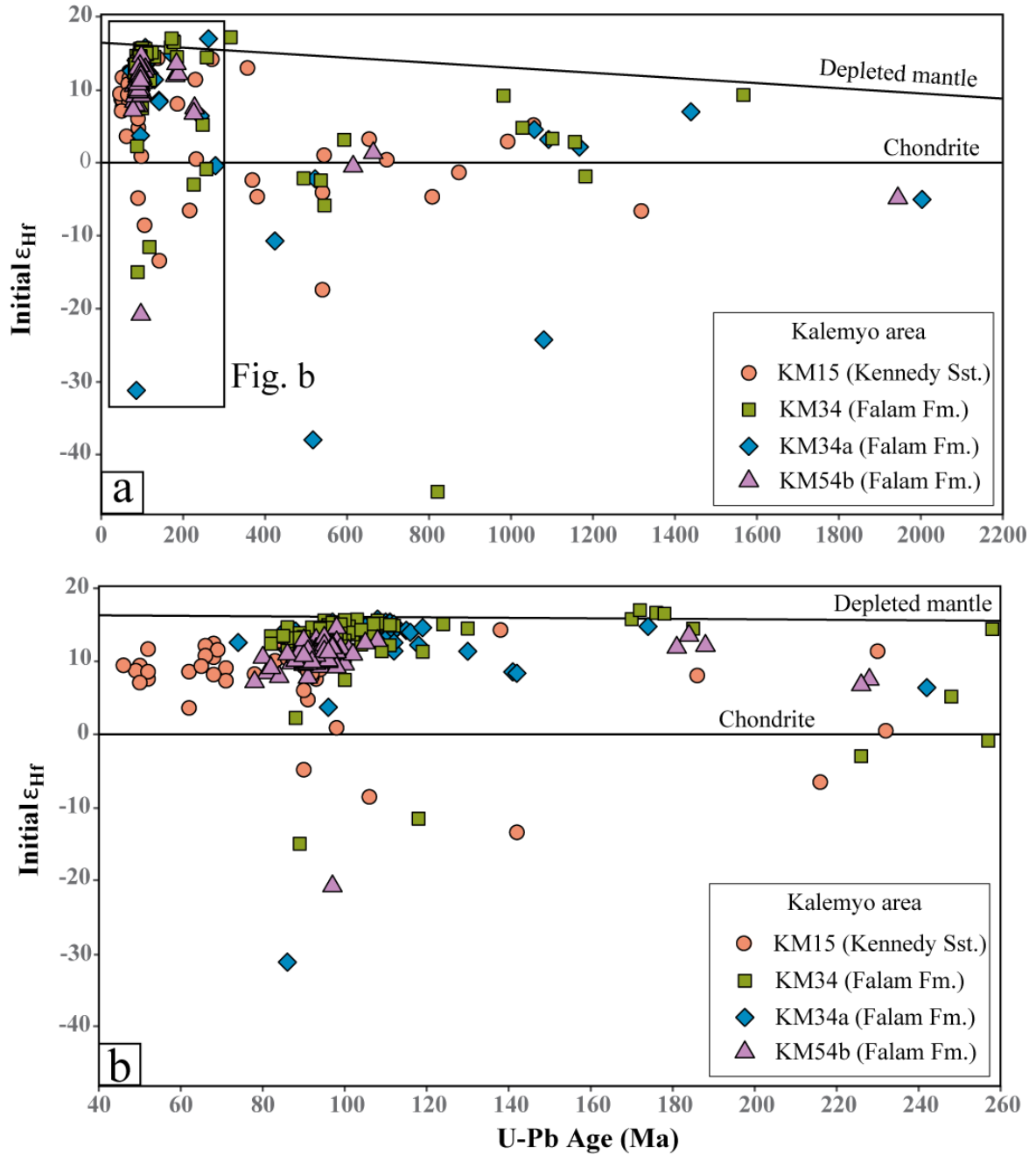


Fig. 5.18: U-Pb vs ϵ_{Hf} data for Upper Cretaceous (Falam Formation) and Middle Eocene (Kennedy Sandstone) detrital zircons from the study area. (a) is shown at 0–2200 Ma and (b) is shown at 0–260 Ma ages, see location on (a).

from -31 to -3. Jurassic zircons mostly between 190 and 170 Ma, have $\epsilon_{\text{Hf}}(t)$ values ranging from +8 to +17. The $\epsilon_{\text{Hf}}(t)$ values of mid Cretaceous (120-80 Ma) detrital zircons range from +1 to +16 with a few grains dropping down to negative values from -31 to -5. Paleogene zircon grains (62 and 46 Ma), exhibit positive $\epsilon_{\text{Hf}}(t)$ values ranging from +4 to +12.

5.8 Discussion

5.8.1 Depositional environment and age of sedimentary rocks in the Kalemmyo area

In the Kalemmyo area, the conformable sequence of the Falam Formation, Chunsung Formation and Kennedy Sandstone rests disconformably upon the Pane Chaung Formation. The Kalemmyo sediments west of the ophiolites are dominated by deep-sea flysch facies that consist of sandy turbidites, conglomerates with a few small pelagic limestone clasts or floaters and calcareous shale. The sediments show steeply dipping, tight to isoclinal folds, and sub-vertical strike-slip faults close to the ophiolite contact.

In the present study, abundant and moderately-to well-preserved radiolarian fossils are found from the ophiolite *mélange* in the Yazagyo Dam. The radiolarian assemblage is Pliensbachian to Valanginian in age (Fig. 5.7). Recent work on the radiolarian microfossils from this locality has reported a Middle Jurassic age (Zhang et al., 2018). Suzuki et al. (2004) reported Middle to Late Jurassic radiolarians from chert pebbles in the Cenozoic Pondaung Formation in the Central Basin and they considered these to have been reworked from the IBR. Similar rocks to those seen in the Yazagyo Dam area lie in the same structural position elsewhere along the Indus - Yarlung Tsangpo suture zone in southern Tibet (e.g. Xialu chert, Gyangze, Matsuoka et al., 2002) and the Naga Hills ophiolite in NE India. The

biostratigraphic ages reported here correlate well with those studies (Matsuoka et al., 2002; Baxter et al., 2011; Xu and Luo, 2017; Zhang et al., 2018). Therefore, the fragment preserved in the Kalemmy ophiolites appears to be of Jurassic-Cretaceous age and likely formed in a mid-ocean ridge setting upon which deep-sea sediments (radiolarites) were deposited. The radiolarian assemblage from the Kalemmy ophiolite provides the first robust age constraints on deep-marine sedimentation that are consistent with ages reported from ophiolites in Tibet and the Naga Hills (e.g. Matsuoka et al., 2002; Baxter et al., 2011; Zhong et al., 2017), and reinforces the hypothesis that the Kalemmy, Naga and YZSZ ophiolites were once part of the same Neotethyan ocean floor.

The presence of limestones is typical of the Falam Formation, which also contains olistoliths of pelagic limestones. The biostratigraphic data indicates a Santonian-Maastrichtian age for the limestones in the Falam Formation (Plate. 5.1) and, based on detrital zircon U-Pb, maximum depositional ages of the host siliciclastic sediments between 81 Ma and 87 Ma (Fig. 5.17). The Upper Cretaceous limestones contain entirely planktonic foraminifers and, hence, they were deposited in deep-water open marine conditions above the carbonate compensation depth (CCD). The presence of microstylolite structures in thin sections suggest that the pressure solution was caused during the late stages of burial diagenesis of the limestone as these structures do not cut across the fossil allochem grains (Fig. 5.11b,d). Conglomerate includes clasts sourced from the ophiolite in the Falam Formation giving it a similar provenance to the Phokphur Formation in the Naga Hills (Roeder, 2015). The large size of clasts, combined with the textural immaturity of the conglomerate, indicates that the area of deposition was located near the source region.

The Kennedy Sandstone has been mapped as Late Eocene in age based on the occurrence of a barnacle from a rippled ferruginous sandstone (United Nations, 1979a). However, barnacles do not become common as skeletal remains in the fossil record until the Neogene (Taylor et al. 2019). A number of outliers of folded and faulted molasses deposits of probable late Palaeogene age are preserved around Kennedy peak within the northern IBR (Bannert et al., 2011). During the field investigation, the Chunsung Formation and Kennedy Sandstone were observed to be lithologically similar and, thus, the simplest interpretation of structural data is to consider the Kennedy Sandstone as a lateral equivalent of less-sand-rich facies in the Chunsung Formation. The detrital zircon U-Pb data from the Kennedy Sandstones yields a weighted average age of the three youngest zircons of 51 ± 1 Ma (KM15). This is consistent with a middle Eocene age for the Kennedy Sandstone consistent with its interpretation as a lateral equivalent unit to the Paleocene-Middle Eocene Chunsung Formation (United Nations, 1979a). This enables a simple synclinal geometry to be drawn that matches the data gathered on the traverse.

The exotic limestone sample (KM44) in the Kabaw Formation to the east of Kalemyo, is of Upper Paleocene age due to the occurrence of *Discocyclusa dispansa* and *Discocyclusa sowerbyi* (Plate. 5.2). Nagappa (1959) considered that *Ranikothalia* is restricted to the Paleocene in India, Pakistan and Myanmar. *Distichoplax biserialis* (Dietrich) indicates a Late Paleocene - Early Eocene age. Nagappa (1959) reported that *Discocyclusa* and *Ranikothalia* affinities occur in the Paunggyi Conglomerate (Paunggyi Formation), so the latter has been regarded as the area from which the exotic limestone originated. The occurrence of *Discocyclusa* and *Ranikothalia* in association with calcareous algal assemblage observed in

KM44 suggests that a shallow-water carbonate platform environment prevailed during the deposition of this limestone (Fig. 5.11e,f).

5.8.2 A suture zone in the Kalembo area?

In the Kalembo area, there are many conflicting models for the type of ophiolite, emplacement direction of the ophiolite, and location of the ophiolite suture zone in the Indo-Burman Ranges (see review in Searle et al., 2017). Most of these models suggest that the Kalembo bodies are classified either as a Penrose-type obducted ophiolite, that was subsequently eroded and dismembered (e.g. UNGESE, 1979; Mitchell, 1993; Socquet et al., 2002; Acharyya, 2007), or alternatively the ophiolites in the IBR have also been interpreted as accretionary-type (Franciscan-type), where most of the fragments of ophiolite-related units (i.e. slices of pillow lavas, gabbros, serpentinite, deep-sea sedimentary rocks) are derived from the downgoing plate (Harlow et al., 2014; Fareeduddin and Dilek, 2015). Fragments of oceanic lithosphere, including high pressure/low temperature metamorphic rocks (i.e. blueschists, jadeitite, eclogites), are interpreted as products of exhumed blocks into the subduction channel along the plate interface, together with some coherent blocks (peridotite, serpentinite, metamorphic sole) from the overlying forearc or supra-subduction zone oceanic lithosphere (e.g. Harris, 1992, 2003; Harlow et al., 2014; Fareeduddin and Dilek, 2015). Although no eclogites or blueschists are present around the Kalembo ophiolite, blueschists, glaucophane schists, and eclogites have been reported from the Naga ophiolite mélangé along strike to the north in India (Ghose et al. 2010; Bannert et al. 2011; Acharyya, 2015), and glaucophane schists crop out in the jade belt area of northern Myanmar (Thet Tin Nyunt et al. 2017). Ophiolite fragments (serpentinites, basaltic volcanic rocks) can also be generated by tectonic slicing of the downgoing slab (Vogt and Gerya,

2014; Ruh et al. 2025). Slicing commonly occurs within the subduction channel, but can also occur by thrusting of oceanic crust beneath the distal part of the wedge, or slices can be inserted in the very proximal part of the accretionary wedge (Vogt and Gerya, 2014; Ruh et al. 2025). Early subduction of the Jurassic part of the slab below the IBR accretionary prism could have inserted thrust slices of Jurassic age oceanic crust into the prism bisecting the Pane Chaung Formation and Kanpetlet Schists, while later subduction inserted slices of Cretaceous age ophiolite oceanward, landward or adjacent to the Jurassic-age slices.

5.8.2.1 Ophiolite Formation

The Kalemio ophiolite was formed during the Early Cretaceous (ca. 127 Ma) based on U-Pb zircon ages of rodingites (Liu et al., 2016). This age is inferred to represent the age of oceanic crust (Searle et al., 2017). Strongly foliated amphibolites embedded in a sheared serpentinite matrix at the base of the Kalemio ophiolites are commonly interpreted as the remnants of dismembered metamorphic soles, which can potentially indicate the time of emplacement of the ophiolites. Hence the age of 119-115 Ma, based on U-Pb zircon ages of amphibolites from the metamorphic sole, indicates the time of subduction initiation and the beginning of ophiolite emplacement (Liu et al., 2016; Zhang et al., 2017). Since the peridotite bodies overlie the Pane Chaung Formation, and if the tectonic position of the ophiolites is not severely affected by deformation post-emplacement, then the ophiolites were obducted onto the Pane Chaung Formation around 119-115 Ma. The choice of the model for the depositional location of the Pane Chaung Formation (i.e. as either part of India, Sibumasu, Western Burma, or an Indian-affinity microcontinent, see review in Searle et al., 2017 and Chapter 6) determines whether ophiolite emplacement was either within an accretionary wedge (Western Burma, or Sibumasu model), or emplaced onto a colliding

continental margin (e.g. India, Indian-affinity microcontinent). The timing of ophiolite emplacement around 119-115 Ma fits with the observation of the United Nations (1979) and Mitchell et al. (1993, 2010) that Aptian-Cenomanian limestone unconformably overlies the Kanpetlet Schists, the Pane Chaung Formation and ophiolite fragments around Mt. Victoria (as discussed in Chapter 4). Erosion of ophiolites (i.e. probable subaerial emergence of parts of the accretionary prism) occurred episodically during Maastrichtian times (e.g. Socquet et al., 2002; Rangin et al., 2013), to the Late Eocene-Early Oligocene for the Nagaland region of India (Ghose et al., 2014).

The ultramafic massif of the Kalemio ophiolite is tectonically underlain by amphibolites, and greenschists representing the subophiolitic metamorphic sole. The metamorphic sole could have been formed at the inception of intra-oceanic subduction (Wakabayashi and Dilek, 2000), or may represent the emplacement of mantle rocks associated with a subduction channel (Fareeduddin and Dilek, 2015). The diachronous timing of ophiolite formation, and its highly dismembered nature best fits with an accretionary-type model, where the oldest ophiolites (Myitkyina ophiolite), related to Jurassic subduction, lie to the east, and the youngest ones (Late Cretaceous-Eocene) lie to the west (Fareeduddin and Dilek, 2015; Hla Htay et al., 2017; Barber et al., 2017; Zhang et al., 2018).

The peridotites in the Kalemio ophiolite show variable degrees of serpentinization of the sub-crustal mantle that can occur in the downgoing oceanic plate. The well-developed porphyroblastic textures, with large prophyroblasts of orthopyroxene and small granoblastic grains of olivine, in the Kalemio peridotites show extensive low-temperature alternation during serpentinisation where the olivine forms serpentine minerals and the orthopyroxene

forms bastite. They are neither metamorphic porphyroblasts nor recrystallization products. Fine-grained clinopyroxene and olivine occurring as interstitial crystals are thought to have been crystallised from the mantle melts. Olivine and orthopyroxene commonly show lobate boundaries and chromite inclusions surrounded by olivine neoblasts, an indication of mantle melting reaction (Ghose et al., 2014). Kink bands and highly stretched olivine and orthopyroxene porphyroblasts with undulatory extinction are interpreted as further evidence of mantle deformation. The geochemical characteristics of the Kalemio ophiolite reported suggest that the peridotites yielded fractional melting degrees of 3-15%, whereas the Kalemio spinel harzburgites yielded higher (i.e., 12-21%) degrees of fractional melting (Liu et al., 2016). Therefore, they infer that the Kalemio peridotites represent the residues of upper mantle rocks after variable degrees of basaltic magma extraction at a mid-oceanic ridge environment. The mineral assemblages, bulk rock element compositions and REE patterns support the co-existence of fertile peridotites in the Kalemio ophiolite with a composition similar to abyssal peridotites formed in a mid-ocean-ridge environment close to a continental margin (Liu et al., 2016, Niu et al. 2017). Therefore, the upper mantle Cretaceous ophiolites in the IBR appear to be mid-ocean-ridge related without any detectable subduction influence in their melt evolution. The MOR type peridotites and their crustal counterparts might therefore represent accretion to the IBR from the downgoing Tethyan plate as part of subduction-accretion processes (Fareeduddin and Dilek, 2015).

5.8.2.2 Relationship to the Indus-Yarlung Tsangpo Suture Zone

Remnants of the Tethyan lithosphere are now exposed as ophiolites along the suture zone where India and Eurasia collided in the Early Eocene to form the Himalayan Mountain Range along its northern margin and the IBR along its eastern margin (Ghose et al., 2014).

The peridotites in the dismembered Manipur ophiolite in the northern part of the IBR in northeast India show abyssal peridotite mineralogies and geochemical affinities; they represent residual mantle rocks after low degrees of partial melting (2-12%) in a mid-ocean-ridge setting (Singh, 2013; Ghose et al., 2014), and in this sense are very similar to the Kalemio peridotites (Liu et al., 2016; Niu et al., 2017). The Manipur ophiolite represents the eastern extension of the ophiolite belt running along the India-Asia suture (Ghose et al., 2010). Previous studies have shown that ophiolites found at the western, central and eastern segments of the Indus – Yarlung Tsangpo Suture Zone (IYTSZ) were formed during the Early Cretaceous, coeval with the Kalemio ophiolite in the IBR (Liu et al. 2016), and thus may have formed in the same tectonic setting. The IYTSZ contains fragments of Cretaceous oceanic lithosphere, Mesozoic radiolarian cherts, alkali volcanic rocks, *mélange* and *flysch* very similar to the Naga Hills and Kalemio ophiolites in the IBR. The ophiolite complexes preserved along the IYTSZ and obducted onto the northern continental margin of India in southern Tibet represent the remnants of the once extensive Permian-Mesozoic Neotethyan ocean that separated India from Asia (Chan et al., 2015). The Kalemio ophiolites are tectonically interleaved with, and overlie, metamorphosed accretionary prism rock assemblages, which show west-vergent imbricate thrust tectonics, sympathetic with the modern subduction zone dipping eastward beneath the IBR (Niu et al., 2017). The Tethyan ophiolites and the IBR largely represent a westward-migrating subduction-accretionary system, rather than a collisional suture zone along the eastern margin of India. Therefore, the IYTSZ is correlated with the Kalemio ophiolite in Myanmar, and both represent fragments of the Neotethyan ocean lithosphere (Mitchell, 1993; Liu et al., 2016; Searle et al., 2017; Singh et al., 2016; Niu et al., 2017). Based on field evidence coupled with

geochronological data, the Kalemio - Nagaland zone of accretionary-type ophiolites represents a broad suture zone that marks the closing of a succession of back-arc and ocean basins in the Tethyan realm, and marks the India-Asia suture zone in Myanmar. During suturing, the rocks were subjected to low grade metamorphism from greenschist to blueschist facies (Chatterjee and Ghose, 2010). All these tectono-magmatic units were juxtaposed together during suturing and were thrust into and onto the shallow to deep marine pelagic sediments.

5.8.3 Provenance interpretation

5.8.3.1 Upper Triassic sandstones

In order to discriminate the provenance of the Upper Triassic Pane Chaung Formation in the Kalemio area, a comparison is made between the new petrographical and U-Pb analyses of detrital zircons data from the Rakhine and Mt. Victoria areas, together with published results from the Kalemio area by Sevastjanova et al. (2015) and Yao et al. (2017) (Fig. 5.19).

Multidisciplinary petrographical and detrital zircon U-Pb age data utilized in the present study all suggest that the Pane Chaung Formation contains contributions from several sources, including reworked material, contemporaneous volcanic material and first-cycle metamorphic detritus. In the present study they give some useful insights into the provenance of the Pane Chaung Formation. The reworked provenance is further support supported by the presence of sedimentary lithics in thin section. Moreover, a wide spread of zircon U-Pb ages in each sample, indicating contributions from multiple sources, is also

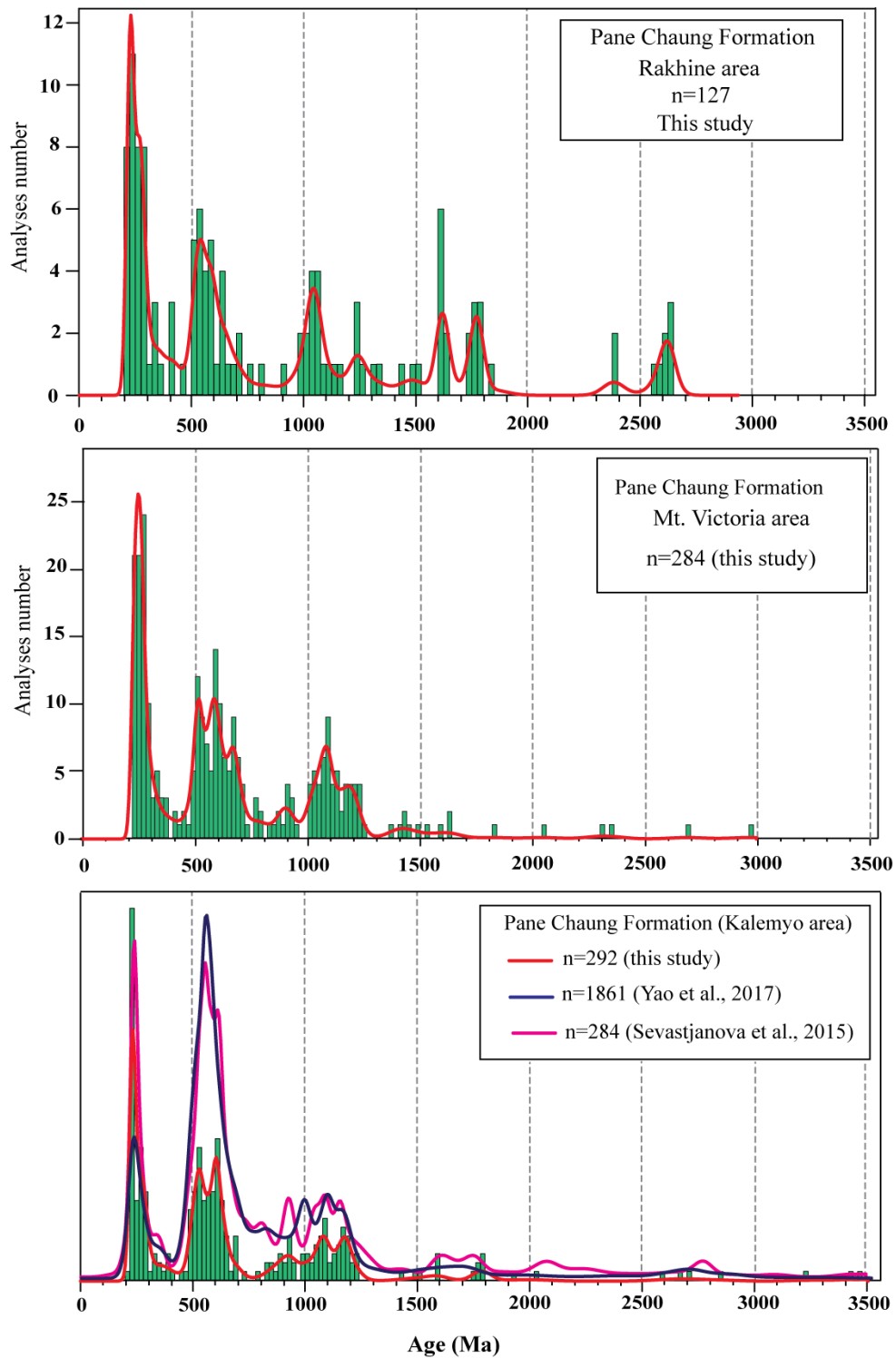


Fig. 5.19: Comparison of detrital zircon ages from the Pane Chaung Formation in the Kalembo area (this study), with those from published results (Sevastjanova et al., 2015; Yao et al., 2017), the Rakhine area (this study) and Mt. Victoria area (this study).

diagnostic of mixed provenance and reworking. The presence of basic to intermediate volcanic lithics, and a significant proportion of euhedral and subhedral zircons in the Pane Chaung Formation samples, suggest a direct contribution from igneous sources. Foliated and platy metamorphic lithics are most probably derived from chlorite schists or phyllites, such as those of the Kanpetlet Schist, and Yazagyo and Khwekha Metamorphics.

For the Pane Chaung Formation, the age of the youngest detrital zircon and the age of the youngest zircon population is Triassic, and close to the depositional age of the samples indicated by fossils. The new data obtained in the present study indicate that all of the samples analysed from the Kalemmyo area contain a contribution from contemporaneous volcanism. It is therefore reasonable to expect that the maximum depositional age determined from zircon geochronology is close to actual depositional age of the sediments. Permian-Triassic zircons have a wide range of ages and this suggests they were probably produced by a long-lived volcanic episode. Dating of detrital zircon populations extracted from the Kalemmyo sandstones, Mt. Victoria sandstones and the equivalent rocks in the Rakhine area may shed some insight into the correlatability between these similar-looking rocks. Similar age populations would suggest that the rocks were formed from the erosion of the same source rocks, and hence suggest deposition took place at the same time. A detailed discussion of the sedimentary provenance, tectonic evolution and the paleogeographic position of the Pane Chaung Formation is presented in Chapter 6.

5.8.3.2 Kabaw Formation in the Chindwin Basin

Grain-counts and zircon U-Pb ages distributions from Upper Cretaceous sandstones of the Kabaw Formation indicate a provenance from Late Cretaceous-Paleogene rocks, likely the Wuntho-Popa Arc located ~100 km to the east, which was active during the same period

and displays the same age peak (Mitchell et al., 2012; Wang et al., 2014; Gardiner et al., 2015; Zhang et al., 2017). Additionally, a proximal source is corroborated in the Minbu Basin near Mt. Victoria area by grain-counts, similar detrital zircon age populations (Chapter 4), and paleocurrents that all indicate a nearby volcanic source located east of the forearc (Licht et al., 2013).

5.8.3.3 Upper Cretaceous-Eocene sandstones in the Indo-Burman Ranges

In agreement with previous work (Allen et al., 2008; Naing et al., 2014), sedimentary provenance studies of the Paleogene unit of the IBR suggest that sediments were predominantly derived from the Wuntho-Popa Arc, whereas Himalayan sources became more important during the Neogene. It is not known how the Cretaceous-Eocene sandstones in the Kalemio area compare with the Rakhine region. Comparison of new U-Pb and Hf-isotope data with those published from the Central Basin was used to determine the provenance of the Mesozoic-Cenozoic sediment in the Kalemio region of the IBR.

Cretaceous to Eocene samples from the Kalemio area are lithic rich and relatively quartz-poor and show signatures of a recycled orogenic provenance (Fig. 5.8). They contain fewer volcanic lithic grains compared to coeval samples from the Rakhine area and Central Basin (CB). The presence of sedimentary lithics in thin sections could reflect the recycling of older sedimentary rocks in the Kalemio area.

The U-Pb analyses of zircons show a dominant Mesozoic population, with a major peak between 90-110 Ma, that is similar detrital populations of age-equivalent rocks in the Rakhine area (Chapter 3), and the Central Basin (Chapter 4, Wang et al., 2014; Licht et al., 2018). However, a careful comparison indicates differences in zircon-age spectra. Detrital

zircons from Upper Cretaceous – Middle Eocene units in the Kalemmyo area form a relatively coherent single population at 90-110 Ma. Zircons from the Paleocene – Middle Eocene units in the Rakhine area display notable age clusters at 90-110 Ma, ~70 Ma and ~50 Ma. Zircons from Upper Cretaceous to Eocene units in the CB display notable age clusters at at 90-110 Ma, ~70 Ma (Fig. 5.20).

The Hf isotope data allow further discrimination between potential sources for the Kalemmyo region. The Hf isotopic results from Cretaceous-Eocene zircons in the Kalemmyo area show high $^{176}\text{Hf}/^{177}\text{Hf}$ ratios, and both positive and negative $\epsilon_{\text{Hf}}(t)$ values, reflecting their derivation from mantle and crust-derived sources. The Hf isotopic compositions of Mesozoic-Paleogene detrital zircons from the CB and Rakhine area appear to be broadly similar to those of the Kalemmyo area (Fig. 5.21), although a careful comparison indicates several key differences. The Hf isotopic compositions of the detrital zircons from the Upper Cretaceous Falam Formation of the IBR have both positive and negative $\epsilon_{\text{Hf}}(t)$ values ranging from -49 to +17. The positive $\epsilon_{\text{Hf}}(t)$ values from +1 to +17 (93% of total grains) whereas the negative values vary from -45 to -0.5 (7% of total grains). Cretaceous- aged zircons (78% of total grains) yielded dominantly positive $\epsilon_{\text{Hf}}(t)$ values from +2 to +16, with only four grains dropping down to negative values range from -31 to -12 (Fig. 5.21a.b). In contrast, the Upper Cretaceous Kabaw Formation of the CB yielded positive $\epsilon_{\text{Hf}}(t)$ values from +3 to +12, with one grain with a value of -33 (Wang et al., 2014). Cretaceous-aged zircons in the CB have entirely positive $\epsilon_{\text{Hf}}(t)$ values from +3 to +12 (Fig. 5.21e.f). Thus, the Cretaceous rocks of the CB are clearly distinguished from the Cretaceous sediments of the Kalemmyo area.

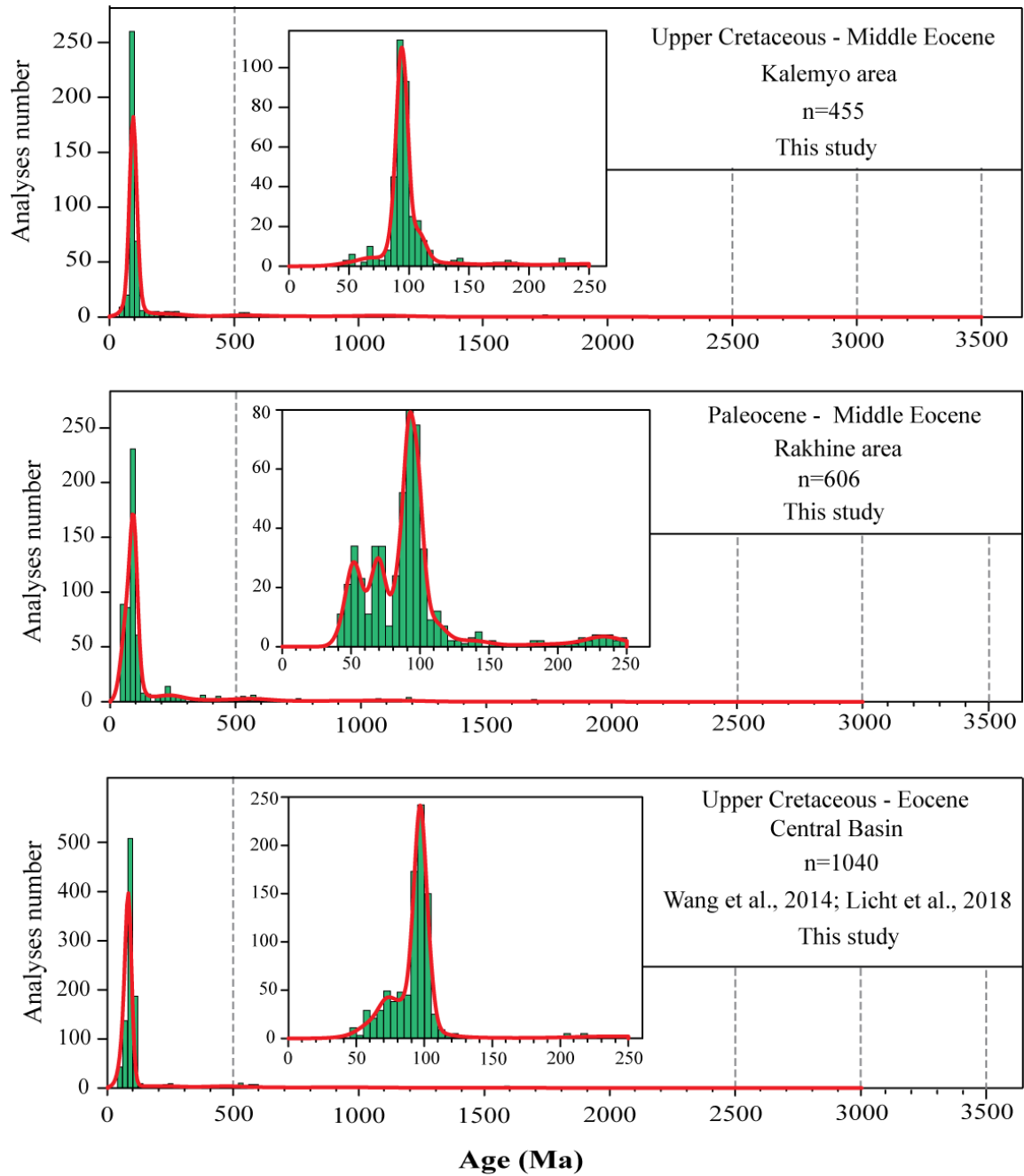


Fig. 5.20: Comparison of detrital zircon ages from the Upper Cretaceous-Middle Eocene flysch in the Kalemlyo area (this study), with those from published results in the CB (Wang et al., 2014; Licht et al., 2018; this study), and the Rakhine area (this study).

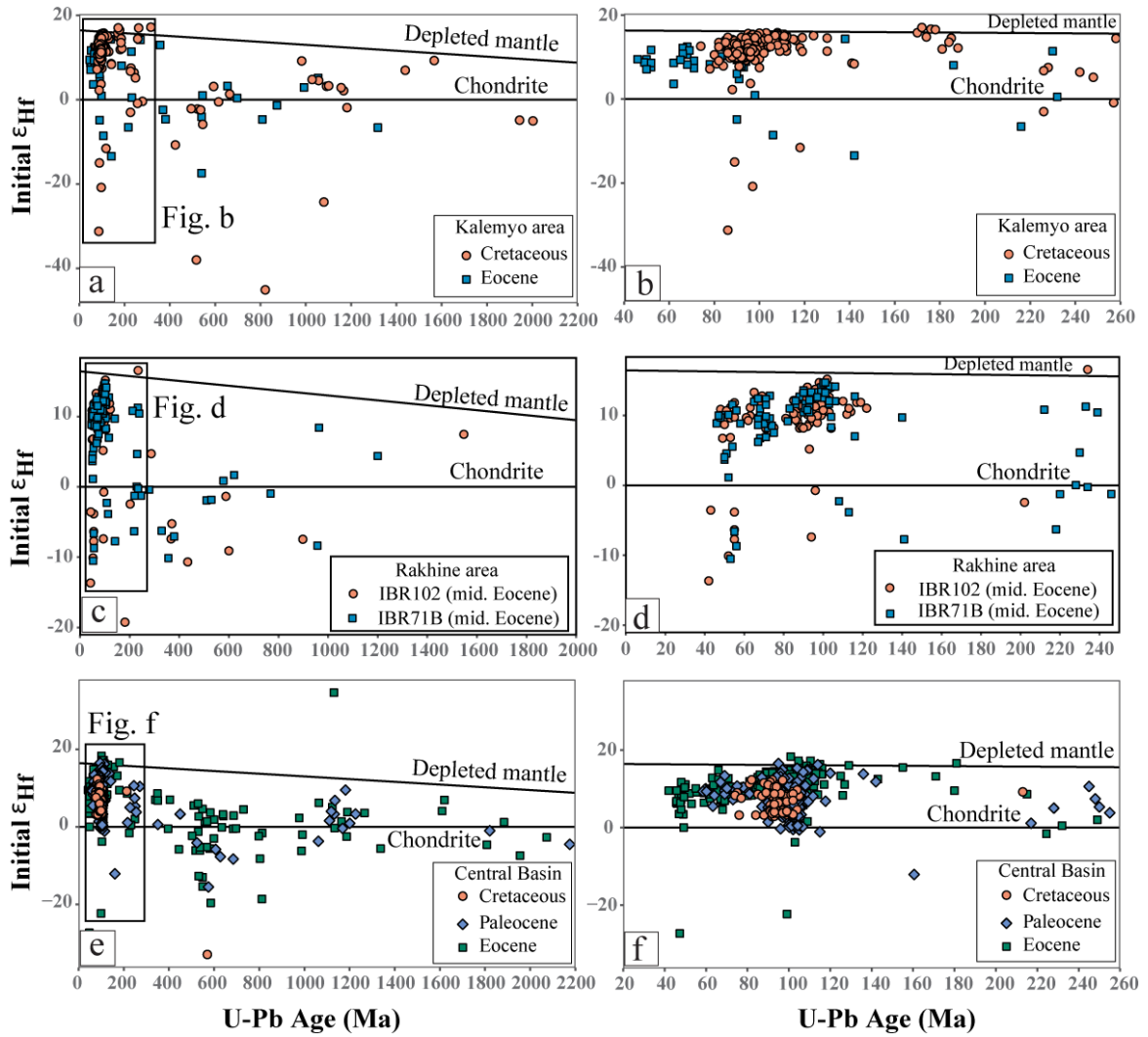


Fig. 5.21: Comparison of Hf isotopic data from the IBR with those from Central Basin: (a) detrital zircon Hf isotope data from the Kalemly area (this study), (b) see location on (a), (c) detrital zircon Hf isotope data from the Rakhine area (this study), (d) see location on (c), (e) detrital zircon Hf isotope data from the CB (Wang et al., 2014; Zhang et al., 2019), and (f) see location on (e).

In comparison, Hf isotopic data from the Eocene Kennedy Sandstone (KM15) have both positive and negative ϵ_{Hf} (t) values ranging from -17 to +15. The Cretaceous-Eocene-aged zircons from the Kennedy Sandstone yielded positive ϵ_{Hf} (t) values +1 to +15 with a few

grains yielding negative values of -13 to -5, similar to the Eocene sandstones from the Rakhine area and CB. The Hf isotopic compositions of the Rakhine area have positive ϵ_{Hf} (t) values +1 to +15 and a few grains yielding negative values of -14 to -0.5 (Fig. 5.21c,d), and the CB which have positive ϵ_{Hf} (t) values 0 to +15 and a small number of grains with negative values between -27 to -4. Thus, the Eocene sediments of the Kalemmyo region contain zircons of a similar age, and with a similar Hf isotope signature, as those in the Rakhine area and Central Basin, indicating a shared provenance.

New Hf isotopic data show that Cretaceous-Eocene sediments in the Kalemmyo area have positive ϵ_{Hf} (t) values ranging from +0.5 to +17 (92% of total grains), suggesting a primary contribution from a juvenile mantle source, likely from Wuntho-Popa arc. However, such large variations of zircon ϵ_{Hf} (t) values likely reflect different proportions of mantle and crustal contribution in their source regions. Moreover, Liu et al. (2016) reported zircons from the Kalemmyo rodingites have highly depleted Hf isotopes, with positive ϵ_{Hf} (t) values of +18.4 to +18.9, and zircons from the Kalemmyo amphibolite have slightly lower ϵ_{Hf} (t) values (+14.2 $\pm$ 2.4). Thirty zircon grains (8% of total grains) have negative ϵ_{Hf} (t) values of -45 to -0.5, suggesting additional contributions from crustal material, potentially from the core of the IBR or from Indian “basement”. The core marks a broad suture zone of Tethys ocean and related back-arc basin derived rock units comprising oceanic crust-related units (including peridotite and serpentinite, pillow lavas, radiolarian chert, *mélange*) and sedimentary and meta-sedimentary units.

Considered together, the Falam Formation which was deposited during the Santonian-Maastrichtian is documented to contain a number of Cretaceous zircon grains with large variations of positive and negative zircon ϵ_{Hf} (t) values. This indicates that the Falam

Formation was sourced from mantle and crustal material, likely sourced from the core of the IBR. In addition, the detrital U-Pb zircon ages in the Falam Formation form a relatively coherent single population (Fig. 5.17) that suggests a simple source rather than a mixture from a long-lived features such as the Wuntho-Popa arc. Zircon U-Pb ages and Hf isotopes data of the Eocene strata (Kennedy Sandstone) in the Kalemmyo area are similar to those of the Rakhine area and Central Basin. Therefore, the Eocene sedimentary rocks of the IBR are considered to have been derived from the Wuntho-Popa arc and the core of the IBR to the east, from which material was eroded and transported as the India-Asia collision commenced.

5.10 Conclusions

Field observations, biostratigraphic and petrographic data, and U-Pb detrital zircon and Hf isotopic data from Mesozoic to Cenozoic strata in the Kalemmyo area, lead to the following major conclusions:

1. Abundant and moderately- to well-preserved radiolarian fossils from the red bed cherts in the Yazagyo Dam, indicate an Early Jurassic-Early Cretaceous age and imply deposition in a deep-marine, pelagic setting. The biostratigraphic age correlates well with radiolarian ages from Tibet, especially in the Yarlung Zangbo suture zone (e.g. Xialu chert, Gyangze) and Naga Hills ophiolite and reinforces the hypothesis that the Kalemmyo ophiolite was once part of the same Neotethyan ocean floor.
2. The Upper Cretaceous limestones from the Falam Formation are represented by a wackestone microfacies and dominantly planktonic foraminifera indicative of

deposition in deep-water open marine conditions above the carbonate compensation depth (CCD).

3. Accretionary-type Kalemio ophiolites represent a broad suture zone that marks the closing of a succession of back-arc and ocean basins in the Tethyan realm, and marks the India-Asia suture zone in Myanmar. They represent mid-oceanic ridge-type Tethyan oceanic lithosphere derived from a downgoing plate and accreted onto a westward-migrating subduction-accretion system along the eastern margin of India.
4. The provenance features of the Upper Triassic Pane Chaung Formation compare well with those of the Rakhine and Mt. Victoria areas.
5. U-Pb ages distributions of sandstones from the Upper Cretaceous Kabaw Formation in the Chindwin Basin are considered to have been derived predominantly from the Wuntho-Popa Arc.
6. New provenance data indicate that Upper Cretaceous-Eocene sandstones contain common intermediate volcanic fragments, minor plagioclase, and euhedral to subhedral zircon grains yielding positive $\varepsilon_{\text{Hf}}(t)$ values. The Upper Cretaceous Falam Formation is likely sourced from the core of the IBR, and the Eocene Kennedy Sandstone was derived from both the WPA and the core of the IBR sediments, from which material was eroded and transported as the India-Asia collision commenced.

CHAPTER

SIX

DISCUSSION

6.1 Introduction

This chapter ties together the main findings of Chapters 3 through 5 and presents a detailed discussion constraining the provenance and depositional processes of the Indo-Burman Ranges (IBR), the tectonic evolution of the IBR, and a synthesis of the geological evolution of Myanmar.

6.2 Refinements of the regional stratigraphy

Fundamental challenges to understanding the IBR include: highly monotonous flysch units with a wide age-range (Triassic-Paleogene), limited biostratigraphic control, and limited exposures in high relief terrain covered by jungle. U-Pb dating of detrital zircons has helped advance our understanding of the stratigraphy.

Mapping by the United Nations (1979) project showed that there are Triassic to Paleogene flysch sediments exposed in the IBR. The Triassic age of the Pane Chaung Formation is based on the rare occurrence of *Halobia* fossils (Gramann, 1974; United Nations, 1979; Bannert et al., 2011; Yao et al., 2017; Zhang et al., 2017), and detrital U-Pb zircon ages (Sevastjanova et al., 2015; Yao et al., 2017; this study). The Pane Chaung Formation occurs discontinuously along the eastern flank of the IBR. Zircon analysis of samples from the Magwe, Mindat, Saw River, Kanpetlet and Kalembo areas, helps address the problem of Pane Chaung Formation correlation in the northern and central areas of the IBR. In the southern IBR, in the Gwa road section, serpentinites are in tectonic contact with flysch of uncertain age. Zhang et al. (2018) suggested that Eocene sediments are in contact with the serpentinite on both eastern and western boundaries, with a normal fault to the east and a thrust contact to the west. This configuration led them to suggest that the serpentinite

exhumed via wedge extrusion. However, the newly found zircons from the flysch sample KM76a on Gwa road section have been dated at 214 ± 10 Ma indicating that Upper Triassic, not Eocene, sediments are in contact with the serpentinite at the western boundary (Fig. 3.2). It is nevertheless probable that the Eocene sediments are present at the eastern boundary. The Triassic flysch sediments in the southern IBR have similar detrital zircon age distribution patterns as those in the central part of IBR and therefore, may be equivalent to (and represent the southward extension of) the Pane Chaung Formation. The western margin of the serpentinite body in the Gwa road section was noted that is thrust over the Pane Chaung Formation. The discontinuous nature of Triassic rocks in the IBR, and lithological similarities with overlying Cretaceous units, cause considerable uncertainty in mapping the Pane Chaung Formation (Brunnschweiler, 1966; Bannert et al., 2011) but the approach used here of detailed detrital zircon U-Pb dating provides a clear way forward to reconstructing the occurrence and extent of the Triassic flysch in the IBR.

Intriguingly, there appears to be an almost total absence of Jurassic - early Cretaceous rocks in western Myanmar (Bannert et al., 2011). Some Albian limestones (named Paung Chaung Formation) have been mapped in the area east of the Kabaw Fault (Fig. 4.1), but this is the only known occurrence of Lower Cretaceous sediments. Recently published detrital zircon ages confirm that the Pane Chaung is entirely of Late Triassic age, however, a few samples have yielded Early Jurassic maximum depositional age with secondary peaks between 200 Ma and 170 Ma (Sevastjanova et al., 2015; Yao et al., 2017). Hence, the upper part of the Pane Chaung Formation is likely of Early Jurassic age. Although, early Cretaceous zircon grains are present in the Upper Cretaceous Falam Formation, it has not been possible to identify any Early Cretaceous sections in western Myanmar.

In the southern IBR, mapping by the United Nations (1979) project showed the presence of an Upper Cretaceous-Paleogene unit along the Padaung-Taunggup road section (Fig. 6.1 a). These sediments lack reliable evidence for stratigraphic correlation, such as age diagnostic faunas or easily recognizable marker horizons (Fay Lain and Win Maw, 1970; Brunnschweiler, 1966; Gramann, 1974). To constrain the age of the succession, biostratigraphy and detrital zircon analysis was used. In the Cretaceous unit, a very small number of planktonic foraminifera were found, defining an age range from Aptian-Maastrichtian, and a few nannofossils indicating an Albian-Turonian age, whilst the weighted average age of the youngest zircons is 48 ± 1 Ma. The biostratigraphically determined age of the Cretaceous unit is therefore inconsistent with the maximum age of deposition, which has to be an Eocene (Lutetian), or younger, depositional age. In the Paleogene sediments further west, the weighted average ages of the youngest zircons are 44 ± 1 Ma and 58 ± 1 Ma, and close to the depositional ages of the samples indicated by fossils. Gramann (1974) noted that upper Cretaceous microfossils were found reworked in some Cenozoic sediments that he studied and suggest that this is likely true for all recorded Cretaceous microfossils, given the juxtaposition of Cretaceous biostratigraphic ages with Eocene-age detrital zircons. Bender (1983) noted the allochthonous nature of some of the Cretaceous outcrops and reworking of some Cretaceous fossils in Cenozoic units. The evidence for reworked Cretaceous lithologies and fossils in close physical proximity to samples yielding early Paleogene maximum depositional ages suggests that the unit previously mapped as Late Cretaceous in age is most likely Paleogene (Fig. 6.1a,b). Although unmapped structural interleaving of Paleogene and Cretaceous rocks may be an alternative explanation, no evidence for this was observed. The Falam Formation and/or the

Kabaw Formation could provide a source for reworked Cretaceous microfossils and blocks in the Rakhine region.

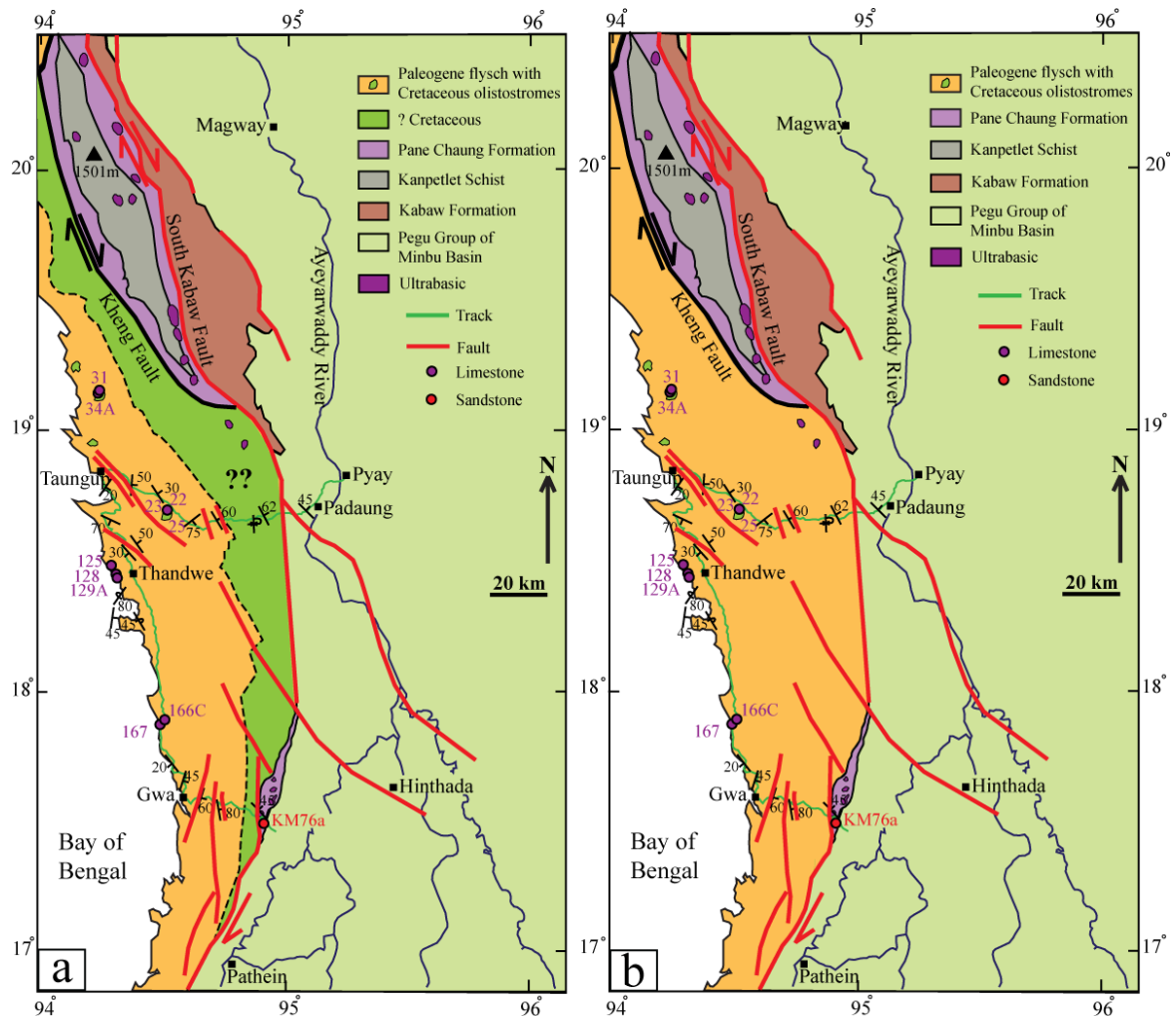


Fig. 6.1: Geological map of Rakhine area, (a) with Cretaceous unit, and (b) without Cretaceous unit.

In the Kalemmyo area, the Kennedy Sandstone is mapped as overlying the Chunsung Formation (United Nations, 1979), and both are deep-water turbidite units (Fig. 6.2a). The Chunsung Formation is biostratigraphically dated as Paleocene to middle Eocene (United

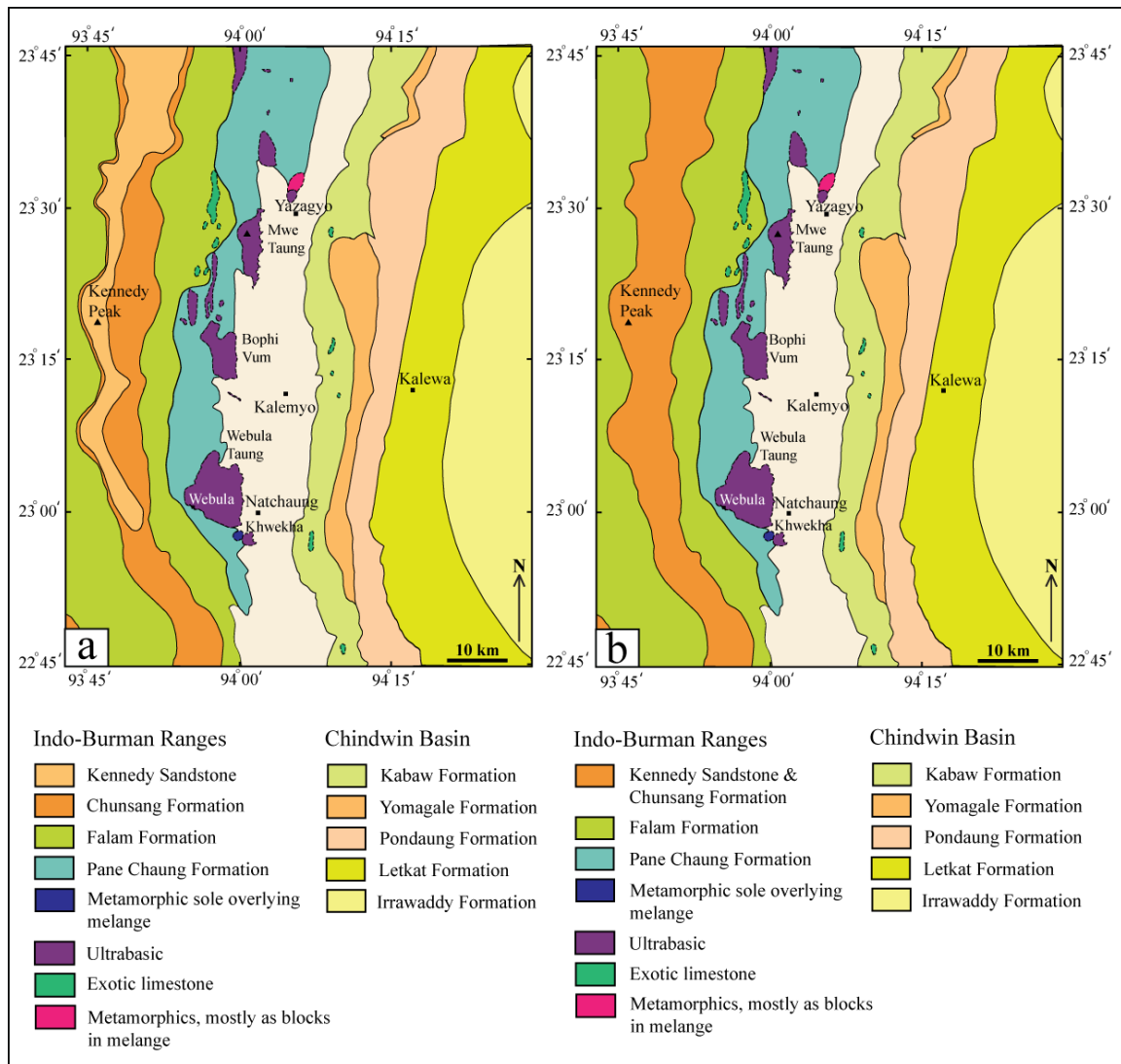


Fig. 6.2: Geological map of Kalembo area, (a) with Kennedy Sandstone, and (b) Kennedy Sandstone as a member of the Chunsung Formation.

Nations, 1979), and is probably equivalent to part of the Disang Formation of Naga Hills in the northern IBR (Mitchell et al., 2010; Lukram and Kachhara, 2010). The Kennedy Sandstone is largely confined to synclines at high elevations around 2000 m (United Nations, 1979) (Fig. 6.2a). However, the Chunsung Formation and Kennedy Sandstone are broadly similar lithologies as observed during field investigation. Sandstones were observed with

erosive bases resulting in rapid lateral variation in thickness in both formations. Moreover, the youngest detrital zircon U-Pb age from the Kennedy Sandstone is 46 ± 1 Ma and the three youngest zircons give a weighted average age of 48 ± 1 Ma. Therefore, the Kennedy Sandstone was potentially deposited in the middle Eocene, indicating it could be a lateral equivalent unit to the Chunsung Formation (Fig. 6.2b), and should probably be redesignated as the Kennedy Sandstone Member. Inclusion of the Kennedy Sandstone Member within the Chunsung Formation enables a simple synclinal geometry, conforming with structural data, and appears to show some stratigraphic thickening passing across the syncline from east to west. Moreover, the Chunsung Formation in the northern Chin Hills extends southward to the Paleocene-Eocene unit in the southern IBR.

The late Paleocene-early Eocene (59-54 Ma) radiolarian extracted from the *mélange* in the Ngapali Formation of southern IBR, provides a maximum age constraint on the timing of formation of the *mélange*. The radiolarian fauna and the tectonic attribution of the radiolarian cherts and basalt blocks indicate that oceanic crust persisted in the southern IBR until the early Eocene. The youngest radiolarian age (~ 54 Ma) provide a valuable new age constraint on the timing of its development and associated tectonic events in the area. The radiolarian assemblages are similar to those seen in the Indus - Yarlung Tsangpo Suture Zone (IYTSZ), e.g. Sangdanlin, Zhongba and Yamdrok *mélange*, southern Tibet (Liang et al., 2012; Wang et al., 2017), (Fig. 6.3a,b).

The discovery of early Jurassic-early Cretaceous radiolarian faunal assemblages from thin-bedded cherts collected from an ophiolitic *mélange* in the Yazagyo Dam, northern Chin Hills (Zhang et al., 2018; this study) provides a robust biostratigraphic age constraint

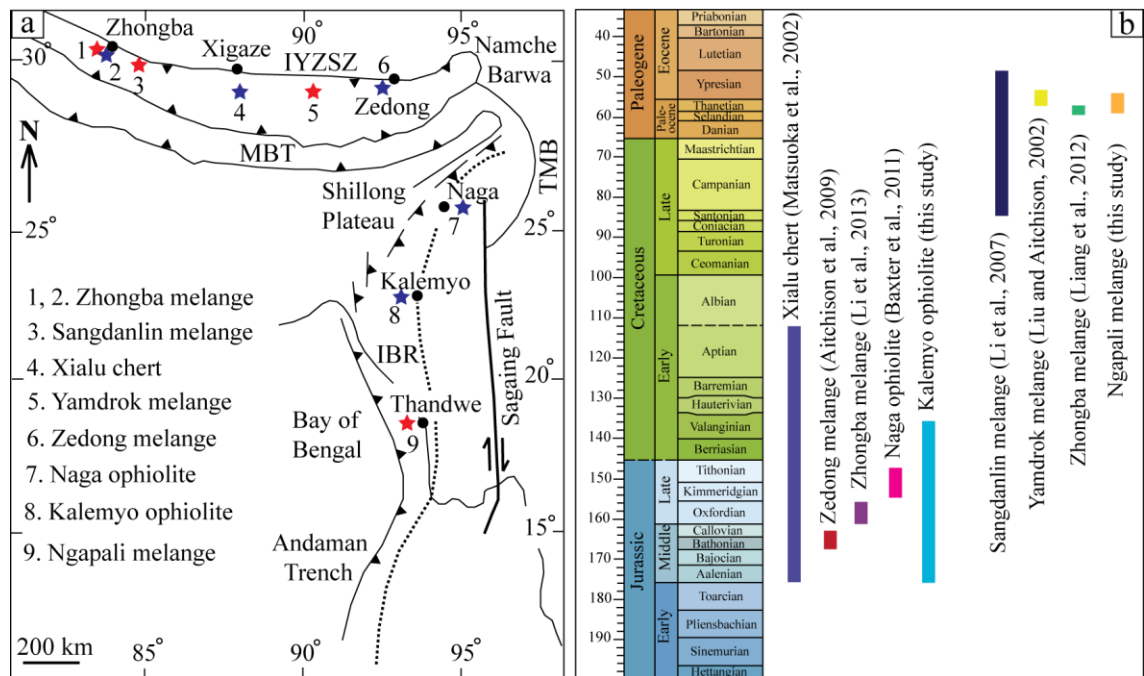


Fig. 6.3: (a) Map of the Himalayan and Myanmar regions showing the location of Indus – Yarlung Zangpo (IYZSZ) and Kalemmyo – Nagaland suture zone (modified after Baxter et al., 2011), MBT, Main Boundary Thrust, IBR, Indo-Burman Ranges, TMB, Tagaung-Myitkyina Belt, blue star (Jurassic-Cretaceous age), red star (Paleocene-Eocene age). The highlighted numbers are nine regions where radiolarians have been reported. (b) Chronostratigraphic chart summarizing the age constraints of deep-water sedimentation in the Neo-Tethys Ocean.

associated with the Kalemmyo ophiolite. The radiolarian assemblages, the age assignment of which lies between published radiometric ages (K-Ar ages and U-Pb ages) of the ophiolite (e.g. Mitchell, 1981; Sarkar et al., 1996; Liu et al., 2016; Zhang et al., 2018), provide new age constraints on deep-marine sedimentation that are consistent with those reported from ophiolites in Tibet and Naga Hills (e.g. Matsuoka et al., 2002; Baxter et al., 2011), (Fig. 6.3a,b). This reinforces the hypothesis that the Kalemmyo, Naga and IYTSZ ophiolites were once part of the same Neotethyan ocean floor.

6.3 What were the source terranes for the flysch in the Indo-Burman Ranges?

6.3.1 Upper Triassic sediments

Many provenance studies have been carried out on the Pane Chaung Formation, and several different paleogeographic scenarios have been hypothesized (as discussed in Sevastjanova et al., 2015; Yao et al., 2017). Sevastjanova et al. (2015) interpreted the Upper Triassic Pane Chaung Formation as part of SE Asia, with perhaps a close affinity to Sibumasu sandstones; consequently in this view, the sequence cannot be associated with the Indian Plate (Fig. 6.4). However, comparison of detrital zircon age distributions from the Loi-an Group within the Sibumasu terrane (Cai et al., 2017) and the Pane Chaung Formation reveals significant differences (Fig. 6.4; and Yao et al., 2017). Both units contain detrital zircons from 200-250 Ma, but key peaks in the Pane Chaung Formation occur at around 500-700 Ma, and 1000-1200 Ma which are troughs in the Loi-an Group data. Similarly, while peaks for the Loi-an Group occur at around 400-500 Ma, 700-900 Ma, and 1800-1900 Ma, these time intervals are represented by troughs in the Pane Chaung Formation data. Hence these Late Triassic turbidite units were not derived from the same source area. Yao et al. (2017) suggested, therefore, that the Pane Chaung Formation was deposited in a Late Triassic submarine fan along the northwestern margin of Australia rather than being derived from Sibumasu. However, Sevastjanova et al. (2015), Wang et al. (2016) and the present study noted that the Pane Chaung Formation contains (1) a large Permian-Triassic zircon population that is not present in northwestern Australia, (2) a lack of zircons dated to 1000-1250 Ma and 1500-1850 Ma, in contrast to notable age peaks in zircons from northwestern Australia (Fig. 6.4), and (3) the presence of Cr spinel clasts, likely derived from ophiolitic belts, which are rare in Western Australia. Moreover, the depositional environment of the

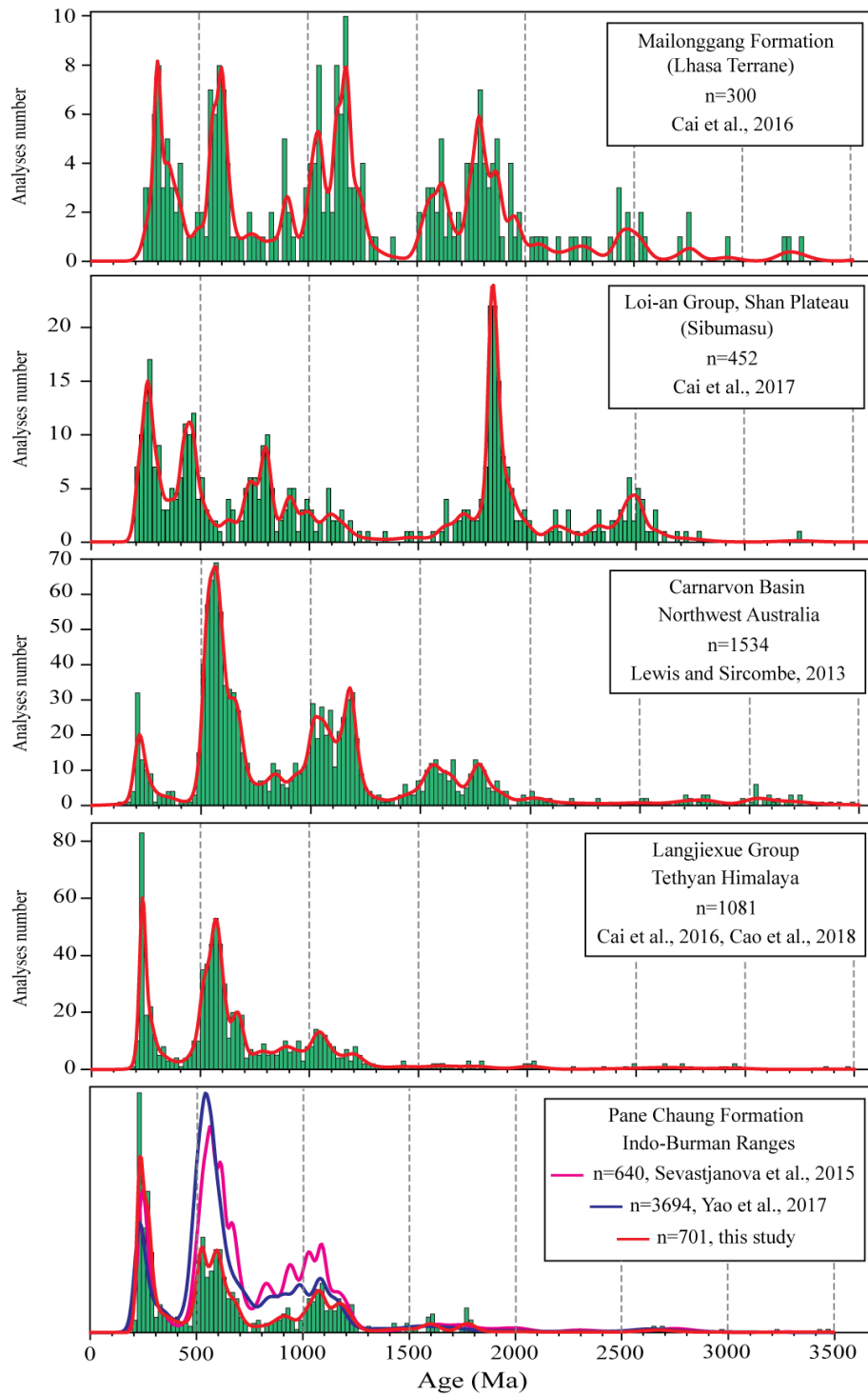


Fig. 6.4: Comparison of detrital zircon ages from the Pane Chaung Formation in the IBR (present study), with those from Langjiexue Group (Cai et al., 2016; Cao et al., 2018) Lhasa terrane (Cai et al., 2016), Sibumasu (Cai et al., 2017), and Carnarvon Basin (Lewis and Sircombe, 2013).

Late Triassic turbidite sandstones of the IBR are quite different from Late Triassic sedimentation in Western Australia and the NW Australian Shelf which was dominated by fluvio-deltaic and carbonate shelf environments (e.g. Bradshaw et al., 1998; Longley et al., 2002). Therefore, the Pane Chaung Formation was not sourced from northwestern Australia.

The Mailonggang Formation in the Lhasa terrane and the Pane Chaung Formation have similar depositional ages based on the presence of bivalve fossils, and the framework petrography of both units lies within the recycled orogenic provenance (Cai et al., 2016). However, comparison of the detrital zircon age distribution from the Mailonggang Formation from the Lhasa Block (Cai et al., 2016) and the Pane Chaung Formation displays significant differences. Both contain detrital zircons of Pre-Cambrian age, but key peaks in the Lhasa Block data are clearly different from the Pane Chaung Formation data (Fig. 6.4). Common volcanic rock fragments, plagioclase and Late Paleozoic-Early Mesozoic magmatic zircons in the Pane Chaung sandstones indicate detrital input from a magmatic-arc source, however the Lhasa Block lacks evidence for Paleozoic to Early Mesozoic magmatism (Wang et al., 2016). Moreover, $\epsilon_{\text{Hf}}(t)$ values of Late Paleozoic to Early Mesozoic zircons tend to be lower in sandstones from the Lhasa Block than in the Pane Chaung Formation. Hence the Pane Chaung turbidites cannot share a source with those present in the Lhasa Block.

Key age peaks of detrital zircons for the Pane Chaung Formation most closely match those from Langjiexue Group turbidites exposed south of the Indus – Yarlung Tsangpo suture in south Tibet (Cai et al., 2016; Wang et al., 2016; this study). Framework petrography and $\epsilon_{\text{Hf}}(t)$ values in both units also consistently indicate an orogenic provenance, suggesting some commonality in origin (Fig. 6.4, 6.5, 6.6). By investigating

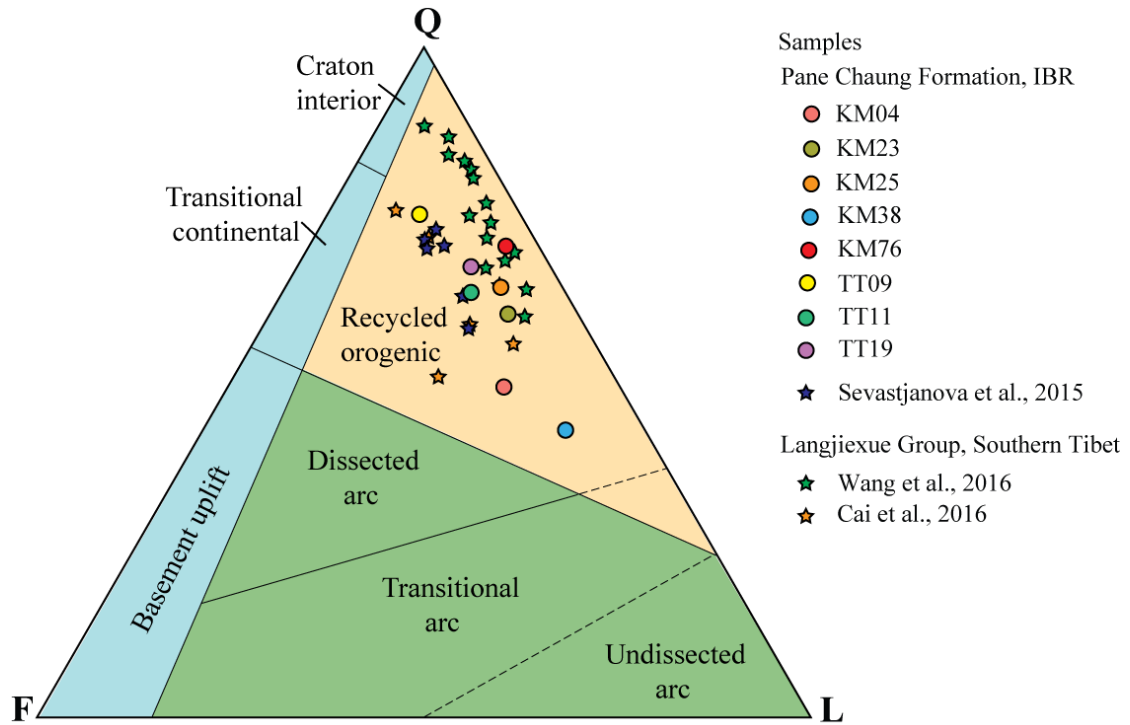


Fig. 6.5: Comparison of QFL data from the IBR (present study), with those from the previous study (Sevestjanova et al., 2015) and Langjiexue Group (Wang et al., 2016; Cai et al., 2016).

stratigraphic, sedimentological, and provenance features of the Upper Triassic sedimentary system in IBR, it is therefore concluded that sandstones within the Pane Chaung Formation display a similar provenance to the Langjiexue Group turbidites. Paleocurrent directions of Langjiexue Group indicate WNW-directed sediment transport (Wang et al., 2016); unfortunately no reliable paleocurrent data exist, or could be found in the field from the Pane Chaung Formation for comparison. The Langjiexue Group was originally deposited on the northern Gondwana margin and was derived from a distant Gondwanide orogeny generated by Pan-Pacific subduction beneath the southeastern margin of Gondwana (Wang et al., 2016; Meng et al., 2019). Thus both the Langjiexue Group and the Pane Chaung

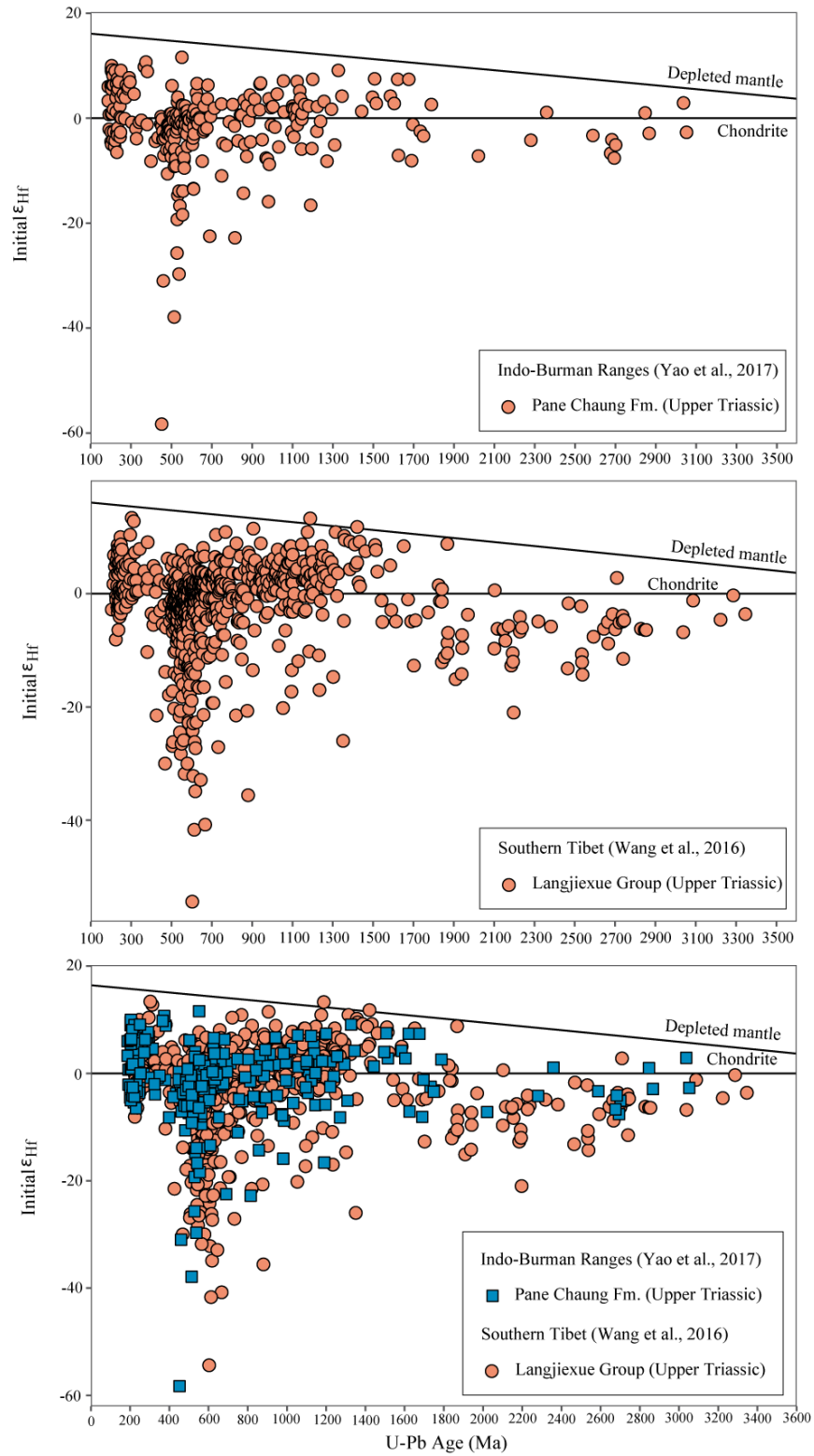


Fig. 6.6: Comparison of detrital zircon Hf isotopic data from the Pane Chaung Formation in the IBR (Yao et al., 2017), with those from Langjiexue Group (Wang et al., 2016).

Formation belong to the same sedimentary system deposited on the northern Gondwana margin during the Late Triassic. In addition, deposition of both units was most likely controlled by regional tectonism, including a possible a rifting event along the northern margin of Gondwana. Mir et al. (2016) suggested that rifting and eruption of middle Permian basalts along the northern margin of Gondwana was followed by separation of blocks, the birth of the Neotethys Ocean, and rapid thermal subsidence of the northern Gondwana margin during Upper Permian and Triassic times, in the vicinity of regions that would later become NE India. According to stratigraphic and magmatic studies (Spring et al., 1993; Veevers and Tewari, 1995; Rehman et al., 2016; Cao et al. 2018), numerous Permian to Triassic magmatic rocks are present in India, Oman and Tethyan Himalaya. Moreover, the Permian -Triassic stratigraphic sequence, which constitutes the main part of the Gondwana is developed in the Eastern and Central Indian rifted basins (Biswas, 1999). Therefore, the large Permian-Triassic zircon population of the IBR possibly derived from India.

6.3.2 Upper Cretaceous-Middle Eocene sediments

The broad similarity in the U-Pb zircon ages distributions and Hf isotope compositions of the IBR samples and the Central Basin (CB) appears, at first, to suggest that the IBR flysch had derived most of its sediment from the same sources as those in the Central Basin, i.e., from the Wuntho-Popa Arc (Allen et al., 2008; Wang et al., 2014; Naing et al., 2014; Licht et al., 2018, Zhang et al., 2019), (Fig 6.7, 6.8). However, a careful comparison indicates several subtle differences in petrography, zircon-age spectra and Hf isotopic data. The U-Pb analyses of zircons show a dominant Mesozoic population that is also similar to detrital populations of age-equivalent rocks in the Xigaze forearc basin (Fig 6.7). In contrast, Indian craton detrital zircons have characteristic of ages between the Archean and

Proterozoic, with small Mesozoic populations ranging from 140-110 Ma (DeCelles et al., 2004). Thus, an Indian craton source is unlikely for the Cretaceous-Paleogene sediments of the IBR (Fig 6.7).

The Xigaze forearc basin (XFB) lies between the subduction-related magmatic arc on the Lhasa Terrane to the north and the IYTSZ to the south (Wang et al., 2017). The XFB contain Cretaceous-Cenozoic sedimentary rocks and is dominated by zircon age populations of 80-130 Ma and 150-190 Ma (Fig 6.7). The Mesozoic zircon grains yielded positive ϵ_{Hf} (t) values ranging from +10 to +17 (Cai et al., 2011). The source of these grains has been suggested to be the Gangdese batholith (Wu et al., 2010; Wang et al., 2017). Although the XFB compares well with the Cretaceous-aged zircon populations in the IBR flysch, there are rare 150-190 Ma zircon grains and the Hf isotope signatures are different from those of the IBR. Thus, the source is unlikely to be the XFB.

Mitchell (2017) interpreted the Upper Cretaceous Falam Formation in the IBR as age-equivalent to the Kabaw Formation in the CB, based on the *Globotruncana* limestones. The suggestion that sediments of the Kabaw Formation are derived from a magmatic arc is based on the standard QFL plot (Wang et al., 2014; this study), while the data from the Falam Formation indicates a recycled orogenic provenance (Fig. 6.9a). Comparison of detrital zircon age distributions and Hf-isotope data also show important differences. When looking at the details of the zircon age distribution, the Kabaw Formation is dominated by Late Cretaceous (c. 90-105 Ma) zircons, with a secondary population at ~70 Ma (a bimodal distribution) (Fig. 6.10b), whilst the dominant population in the Falam Formation lies between c. 90-120 Ma, with an unimodal distribution (Fig. 6.10a). In addition, Mesozoic grains aged between 70-110 Ma from the CB have predominantly positive ϵ_{Hf} (t) values,

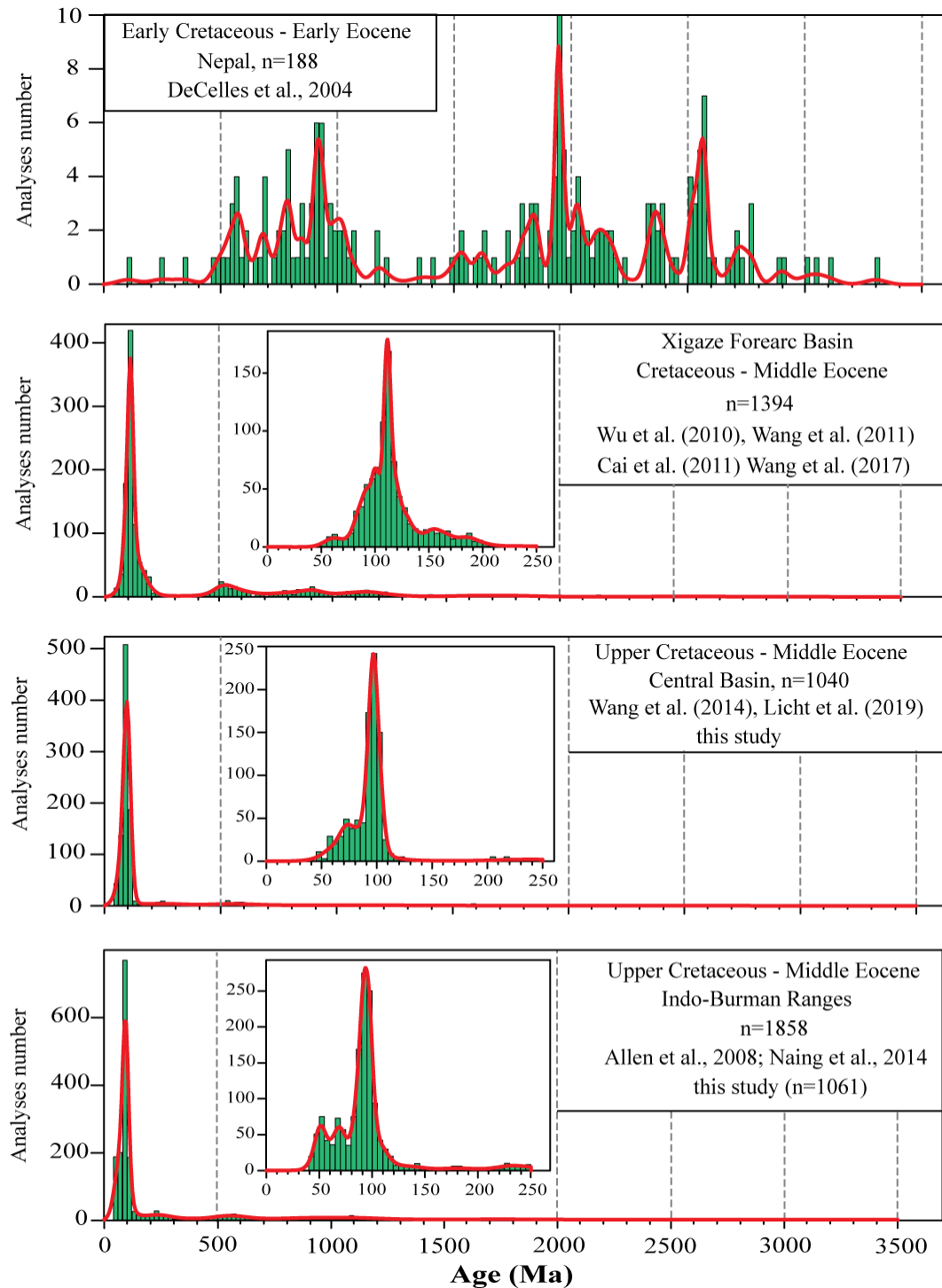


Fig. 6.7: Comparison of detrital zircon U-Pb ages for the Upper Cretaceous-Middle Eocene sandstones, IBR (Allen et al., 2008; Naing et al., 2014; this study), with those from Central Basin (Wang et al., 2014; Licht et al., 2018), Xigaze Forearc Basin (Wu et al., 2010; Wang et al., 2011; Cai et al., 2011; Wang et al., 2017), and Nepal (DeCelles et al., 2004).

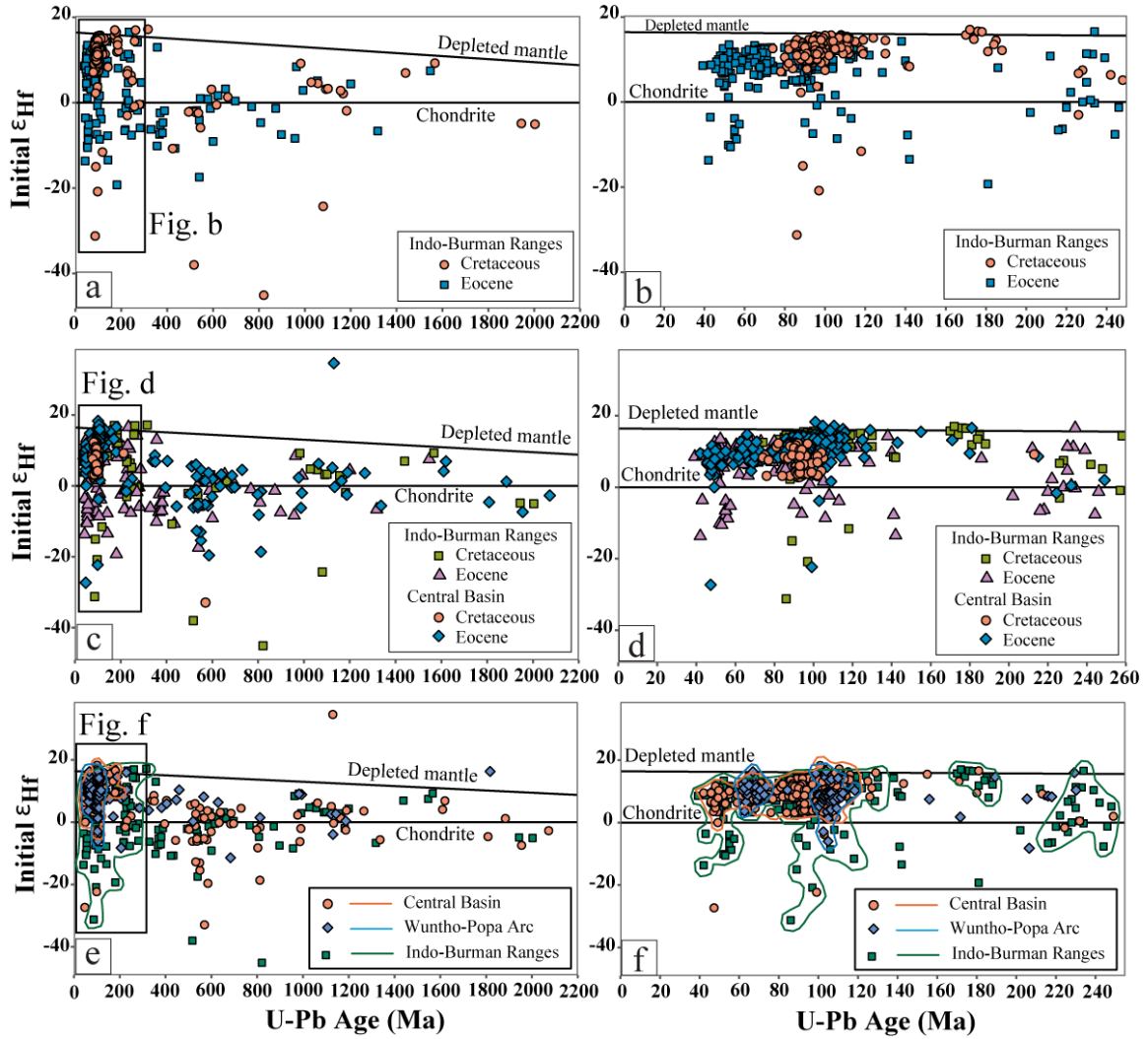


Fig. 6.8: (a) Detrital zircon Hf isotopic data from the Upper Cretaceous-Eocene flysch in the IBR (Naing et al. 2014; this study) and (b) see location on (a). (c) Comparison of Hf isotopic data from the IBR with those from Central Basin (Wang et al., 2014; Zhang et al., 2019) and (d) see location on (c). (e) Comparison of detrital zircon Hf isotopic data from the IBR with those from Central Basin and Wuntho-Popa Arc (Zhang et al., 2017) and (f) see location on (e).

whilst IBR zircons of the same age in the Falam Formation have a mixture of positive and negative ϵ_{Hf} (t) values (Fig. 6.8). This is interpreted as indicating that the Falam Formation

was sourced from depleted mantle and crustal material. The ages in the Falam Formation form a relatively coherent single population that suggests a simple source, potentially from the core of the IBR rather than a mixture from a long-lived feature such as the Wuntho-Popa Arc or Gangdese Batholith. The core marks a broad suture zone of Tethys ocean and related back-arc basin derived rock units comprising oceanic crust-related units and thick sequence of turbidite units. These oceanic crust-related ophiolites are the along-strike equivalent to the Naga Hills ophiolite and Indus – Yarlung Tsangpo suture zone (IYTSZ). Moreover, the presence of chert, reworked bioclasts and the abundance of basaltic opaques in the Falam Formation sandstones support a contribution from the ophiolite and associated pelagic sediments. In addition, a conglomerate in the Falam Formation includes sediments sourced from the ophiolite, and is similar to observations characteristics of the Phokphur conglomerate of Naga Hills (Roeder, 2015). If the mid-late Cretaceous zircons are not from the oceanic crust-related units and sedimentary and meta-sedimentary units of the suture zone, then the material could conceivably have been derived from the Wuntho-Popa Arc (WPA). However, this is not consistent with the WPA as a source because this would require closure of the Neotethys Ocean prior to ~65 Ma, when most other indicators would argue for an open Tethys ocean at this time.

Chhibber (1934) and Mitchell (1993) considered the Paleogene sediments of the IBR to be a lateral equivalent or extension to the forearc sediments of the CB. Paleocene and Eocene rocks in the CB have a petrographic signature of arc-affinity (Licht et al., 2013, 2014, 2018; Wang et al., 2014; Zhang et al., 2019; this study), and some of them display recycled orogenic provenance indicators (Fig.6.9b). Mesozoic and Paleogene zircons from

the CB have entirely positive $\varepsilon_{\text{Hf}}(t)$ values (Robinson et al., 2014; Wang et al., 2014; Zhang et al., 2019), juvenile Sr-Nd bulk signatures (Licht et al., 2013, 2014; Zhang et al., 2019),

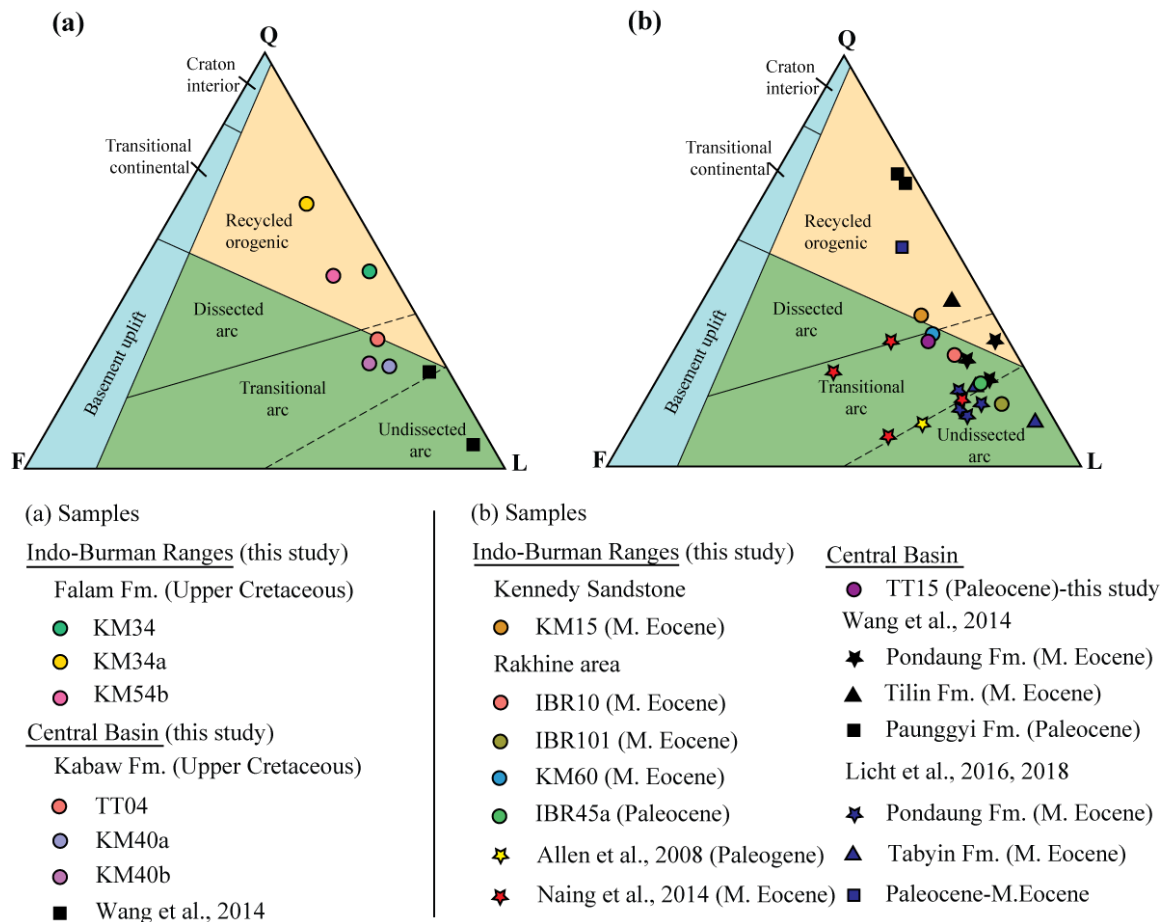


Fig. 6.9: (a) Comparison of QFL data from the Upper Cretaceous sandstones from the IBR (this study) and CB (Wang et al., 2014; this study). (b) Comparison of QFL data from the Paleocene-Eocene sandstones from the IBR (Allen et al., 2008; Naing et al., 2014; this study) and Central Basin (Wang et al., 2014; Licht et al., 2016, 2018; this study).

and zircon fission track ages show dominant Cretaceous populations (Brezina, 2014). The U-Pb analyses of zircons from the CB show a dominant late Cretaceous (c. 90-110 Ma) population, with a secondary population of 60-70 Ma zircons (Fig. 6.10d). Provenance of

the Paleocene to middle Eocene sandstones further indicate derivation of detritus from the Wuntho-Popa Arc (Wang et al., 2014; Licht et al., 2018; Zhang et al., 2019).

Whilst the late Paleocene to middle Eocene samples from the IBR contain slightly more volcanic lithic grains than coeval samples from the CB, the overall similarity in grain-counts with the Paleocene-Eocene samples from the CB (Wang et al., 2014; Licht et al., 2016, 2018), suggests an arc-affinity for the IBR flysch (Allen et al., 2008; Naing et al., 2014; this study), (Fig. 6.9b). Mesozoic and Paleogene zircons have predominantly positive $\epsilon_{\text{Hf}}(t)$ values, suggesting a significant juvenile mantle source, with a few grains with negative $\epsilon_{\text{Hf}}(t)$ values (Naing et al., 2014; this study). A crustal source with a subordinate arc-derived component is indicated by the weakly negative ϵ_{Hf} values for the Paleogene IBR (Fig. 6.8). The $\epsilon_{\text{Nd}}(0)$ values (between -4 and -7.4) of bulk sediments from the Paleogene flysch are consistent with derivation from arc sources and that detrital zircon fission track data show a dominant population of grains at c. 56-120 Ma (Allen et al., 2008). The U-Pb zircon data from the late Paleocene-middle Eocene sandstones show a significant component of typical ages from 90-110 Ma, ~70 Ma and ~50 Ma, consistent with the WPA (Fig. 6.10c). The WPA experienced at least four episodes of arc magmatism from 110-90 Ma, 69-64 Ma 53-38 Ma, and Neogene-Present (e.g. Mitchell et al., 2012; Gardiner et al., 2016; Zhang et al., 2017; Zhang et al., 2018). An additional continental source is identified by low-grade metamorphic and siltstone lithic fragments, by more negative ϵ_{Nd} values than expected for arc-derived rocks (see review in Licht et al., 2013, 2014; Zhang et al., 2019), by fission track ages (Allen et al., 2008), and by negative ϵ_{Hf} signatures. All these data suggest crustal materials were being sourced during the onset of the India-Asia collision. The rare Precambrian grains in the IBR could be of Indian or Asian origin because grains with such

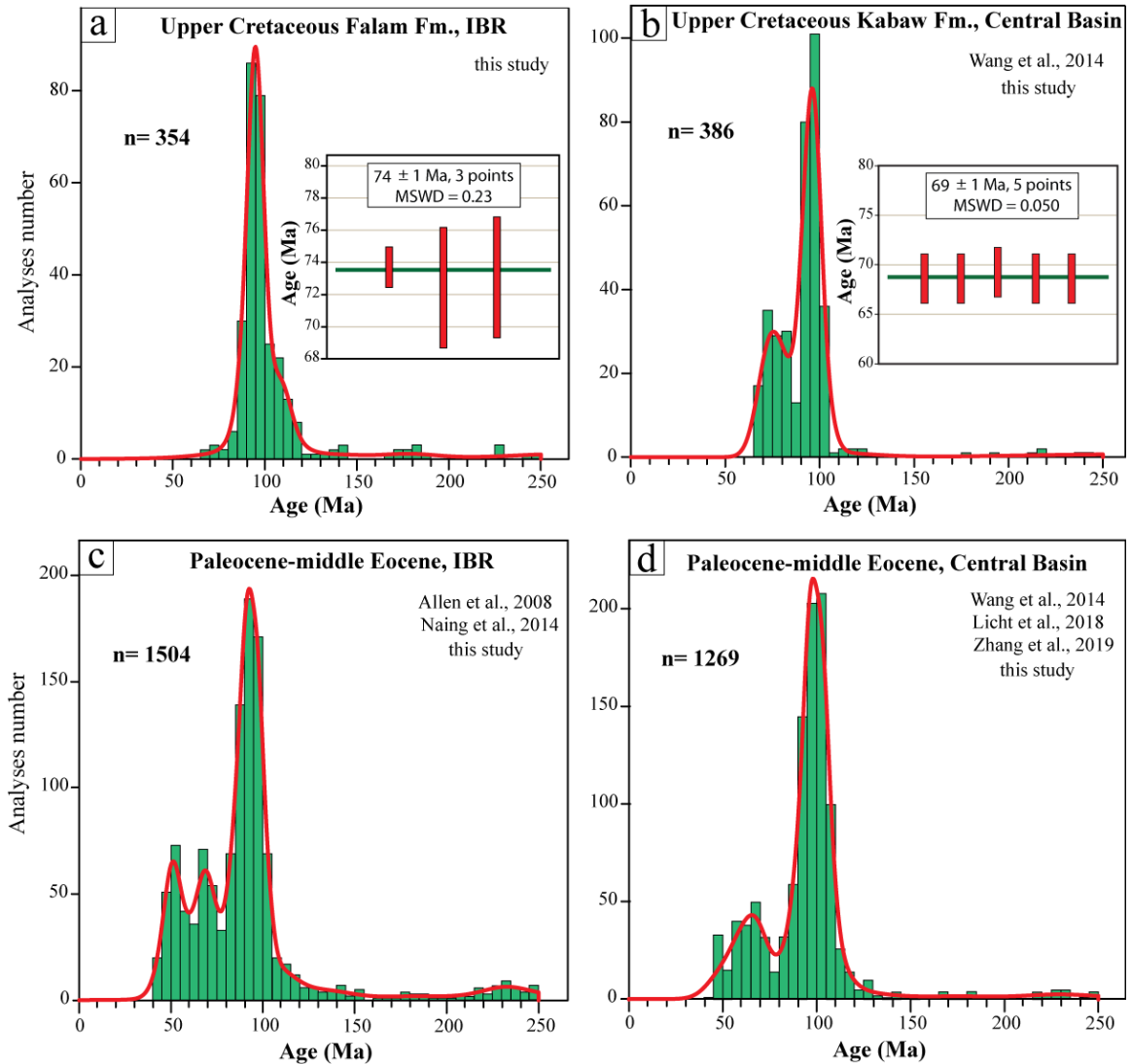


Fig. 6.10: Comparison of detrital zircon U-Pb ages from the IBR and CB. (a) Kabaw Formation, CB, (b) Falam Formation, IBR, (c) Paleocene-middle Eocene, CB and (d) Paleocene-middle Eocene, IBR.

ages exist on both plates. All provenance data are consistent with the interpretation of both arc- and crustal-derived detritus and is in partial agreement with previous models of Chhibber (1934) and Mitchell (1993).

Finally, it is noted that during the Late Paleocene and Middle Eocene a significant number of grains with ~90-110 Ma, ~70 Ma and ~50 Ma ages were deposited onto the colliding Indian margin and preserved in the IBR. Comparison with possible source regions shows a good match with the CB, as well as the Xigaze forearc basin, which are themselves inferred to have been eroded from the Wuntho-Popa Arc and Gangdese batholith, respectively (e.g. Wu et al., 2010; Wang et al. 2014). These data suggest that the magmatic arc, which formed along the pre-collisional active margin of Asia, was uplifted and eroded along the entire suture shortly after collision started in the Early Eocene. This also implies the closure of the Neotethys Ocean by the time of middle Eocene sedimentation if material is to be derived from these arcs onto the Indian margin.

6.4 Tectonic evolution of the Indo-Burman Ranges

The Indo-Burman Ranges (IBR) run north-south through Myanmar from the Gulf of Martaban in the south to connect with the Himalaya to the north. The thesis has shown that the ranges comprise a western belt of folded and thrustsed mainly Cenozoic sedimentary rocks, a central zone of highly deformed Triassic deep-sea sediments and low-grade metamorphic rocks (Kanpetlet Schist), and an eastern zone comprising a major Neotethyan suture zone. The suture zone includes a series of mainly Cretaceous ophiolites including the Manipur-Naga ophiolites in India and the Kalembo ophiolite massifs in Myanmar. The zone of ophiolites continues south as far as the Bay of Bengal. The suture zone also contains radiolarian cherts of Jurassic and Cretaceous age (Fig. 6.3a,b), oceanic volcanic rocks, mélanges and sedimentary rocks that were deposited in the Neotethyan ocean, and is clearly a major oceanic suture separating rocks that belong to the Indian plate in the west from rocks in the east that were part of Sibumasu (Asian plate). A single suture zone is preserved in the

bedrock record between India and Asia, which implies that the Neotethys Ocean was subducted down a single subduction zone (Hu et al., 2016a). Within a plate kinematic framework, the single subduction configuration places a fundamental constraint on the paleogeographic restoration of Greater India, because at the onset of collision, northern India was located at the equator, whilst the southern Asian margin may have been located as much as >3000 km to the north according to some paleomagnetic data (e.g. van Hinsbergen et al., 2012, 2019). The Tethyan Himalaya formed the northern passive margin of the Indian continent with the Greater Himalayan metamorphic rocks part of the internal Indian plate to the south. There is no evidence along the Main Central Thrust of any suture zone separating the Greater Himalaya from the Lesser Himalaya (Searle et al., 2019), so the concept of a ‘Greater Indian basin’, as proposed by van Hinsbergen et al. (2012, 2019) cannot be correct. The timing of ‘India-Asia collision’ is also disputed, but it depends entirely on which definition is used. Some authors favour an onset of collision at 59 ± 1 Ma (Parsons et al., 2020). Others define the age of collision at 50.5 Ma, based on the well-constrained paleontological evidence of the youngest marine sedimentary rocks along the suture zone and along the north Indian continental margin (Rowley, 1996, 1998; Searle et al., 1997; Zhu et al., 2005; Green et al., 2008). Some favor a double subduction zone configuration of the Indian and Asian continents (Replumaz et al., 2010, 2014).

The Nagaland-Kalemyo suture zone has all the components of a Neotethyan suture zone and is closely comparable to the Indus-Yarlung Tsangpo Suture Zone (IYTSZ) in Tibet, the main India-Asia suture north of the Himalaya. In Tibet, final marine sedimentary rocks along the IYTSZ have been accurately dated using foraminifera at ~ 50 Ma (Rowley, 1996; Searle et al., 1997; Green et al., 2008; Searle, 2018). Initial meeting of Indian and Asian

crust may have preceded this but the age of collision cannot be younger than 50 Ma. An early phase of folding and thrusting associated with ophiolite emplacement preceded collision, but post-collision crustal shortening, involving folding and thrusting of the Tethyan shelf carbonates and Greater Himalayan rocks propagated southwards across the Himalaya from 50 Ma onwards (Searle, 2015). As the Indian plate continued to move northwards following collision, the Burma section was rotated clockwise around the East Himalayan syntaxis (Sloan et al., 2017).

Four different models have been proposed to explain the evolution of western Myanmar during the Mesozoic. These can be summarized as Model A: West Burma originating as part of Sibumasu (Hall et al., 2009; Morley, 2012; Sevastjanova et al., 2015; Zhang et al., 2018), Model B: West Burma originating as part of Australia (Yao et al., 2017), Model C: West Burma as part of the northern margin of India (Wang et al., 2016; this study) and finally Model D: West Burma as a distinct and separate micro-plate that rifted away from Gondwana and was accreted to Sibumasu and India by suture zones (Rangin, 2017; Licht et al., 2018; Westerweel et al., 2019). Published accounts show that there are many uncertainties in the evolution of the Indo-Burman Ranges. The paleogeographic location of the IBR (West Burma) has been a long standing question in plate reconstructions of western Myanmar. One major question to be resolved is: Was the late Triassic flysch deposited on the continental margin of Sibumasu (Asia), of Australia, of the northern margin of India, or as a distinct and separate micro-plate? These four models will now be discussed individually.

Model A: West Burma as part of Sibumasu

This model is supported by the interpretation of the detrital zircon provenance of the Upper Triassic Pane Chaung Formation by Sevastjanova et al., (2015) and Metcalfe (2013) based on the studies of low-grade metamorphic rocks and geochronological and structural data (Fig. 6.11). Zhang et al. (2018) also agreed with the interpretation of West Burma as

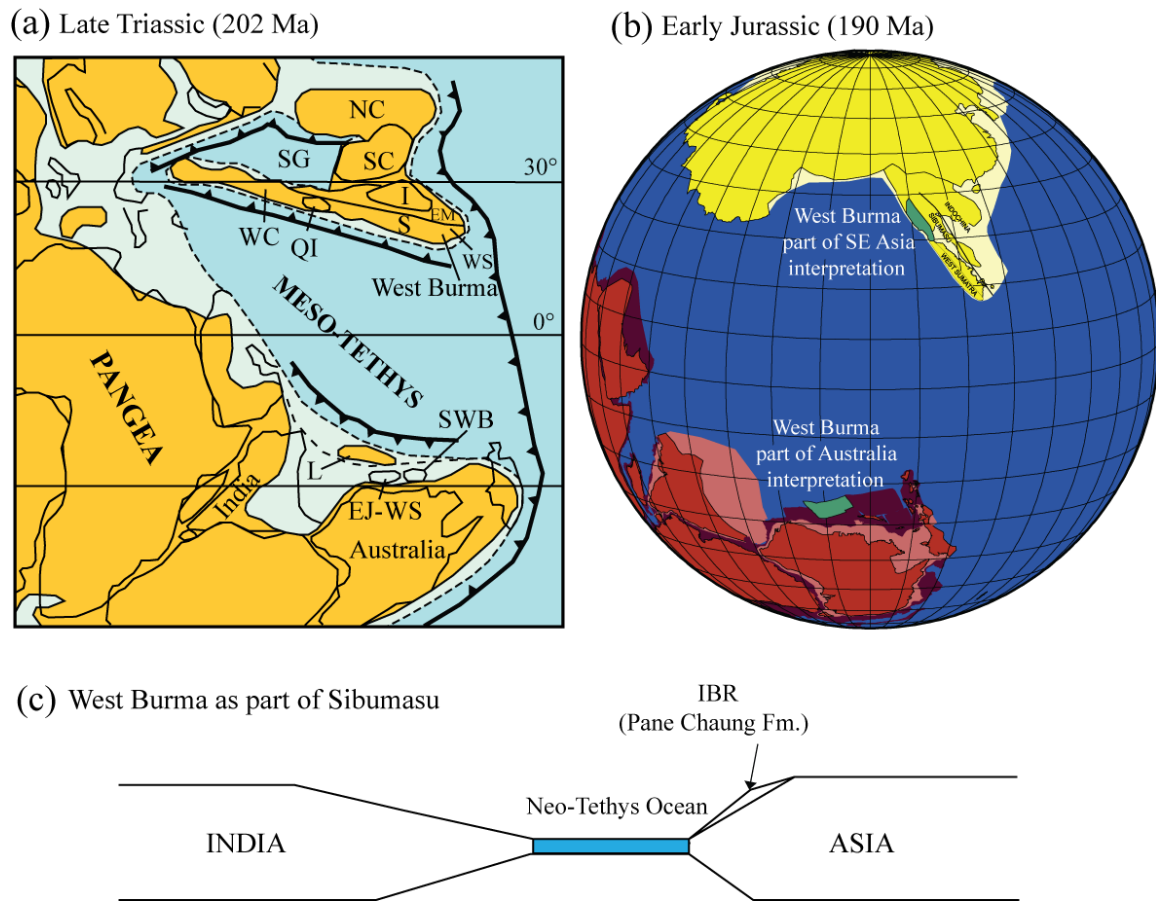


Fig. 6.11: Late Triassic-Early Jurassic palaeogeographic reconstruction showing locations of key blocks. (a) Metcalfe (2013), (b) Sevastjanova et al. (2015) and (c) West Burma as part of Sibumasu. L, Lhasa Block; S, Sibumasu terrane; QI, Qiangtang Block; WC, Western Cimmerian Continent; T, Tenchong; SWB, SW Borneo Block; WS, West Sumatra Block; SG, Songpan Ganiz; NC, North China; SC, South China; I, Indochina; EJ-WS, East Java-West Sulawesi; EM, East Malaya Block.

part of the margin of Sibumasu. However, more recent detrital zircon studies of the Pane Chaung Formation argue against this model. The differences in zircon populations of the Pane Chaung Formation and the Loi-an Group (or Shweminbon Group) suggest that West Burma was not close to Sibumasu (Fig. 6.4). A detailed comparison of the detrital zircon age distribution has been discussed in section 6.3.1 above, and shows significant differences between the units suggesting derivation from different source areas (Fig. 6.4). The Zhang et al. (2018) model interpreted western Myanmar as an accretionary margin that progressively grew westwards from the Jurassic to the present day. In this model, they incorporated dextral offset of some 400 km on the Sagaing Fault to reconstruct Jurassic and Cretaceous trends in Myanmar. In their model, the subduction of the Neotethyan Ocean beneath the Sibumasu continental block during Early to Middle Jurassic time resulted in an accretionary complex of high pressure metamorphic rocks (Jade Mine Belt), and broadly coeval continental margin Jurassic magmatism in the Tagaung-Myitkyina Belt and Mogok Metamorphic Belt. Along the western margin of the Shan Plateau, a belt of Upper Triassic-Lower Jurassic flysch deposits runs from the Tagaung-Myitkyina Belt in the north to the Loi-an Group. Zhang et al. (2018) ignored the presence of these Triassic turbidites of the Loi-an Group on the margin of the Shan Plateau and did not recognize that they have a significantly different provenance from the Pane Chaung Formation. This observation negates the interpretation of the West Burma as part of Sibumasu.

Model B: West Burma as part of Australia

Yao et al. (2017) interpreted the Pane Chaung Formation as being deposited in a Late Triassic submarine fan along the northern margin of Australia (Fig. 6.12). In the discussion of section 6.3.1 above, the Pane Chaung Formation has some significant differences from

Late Triassic

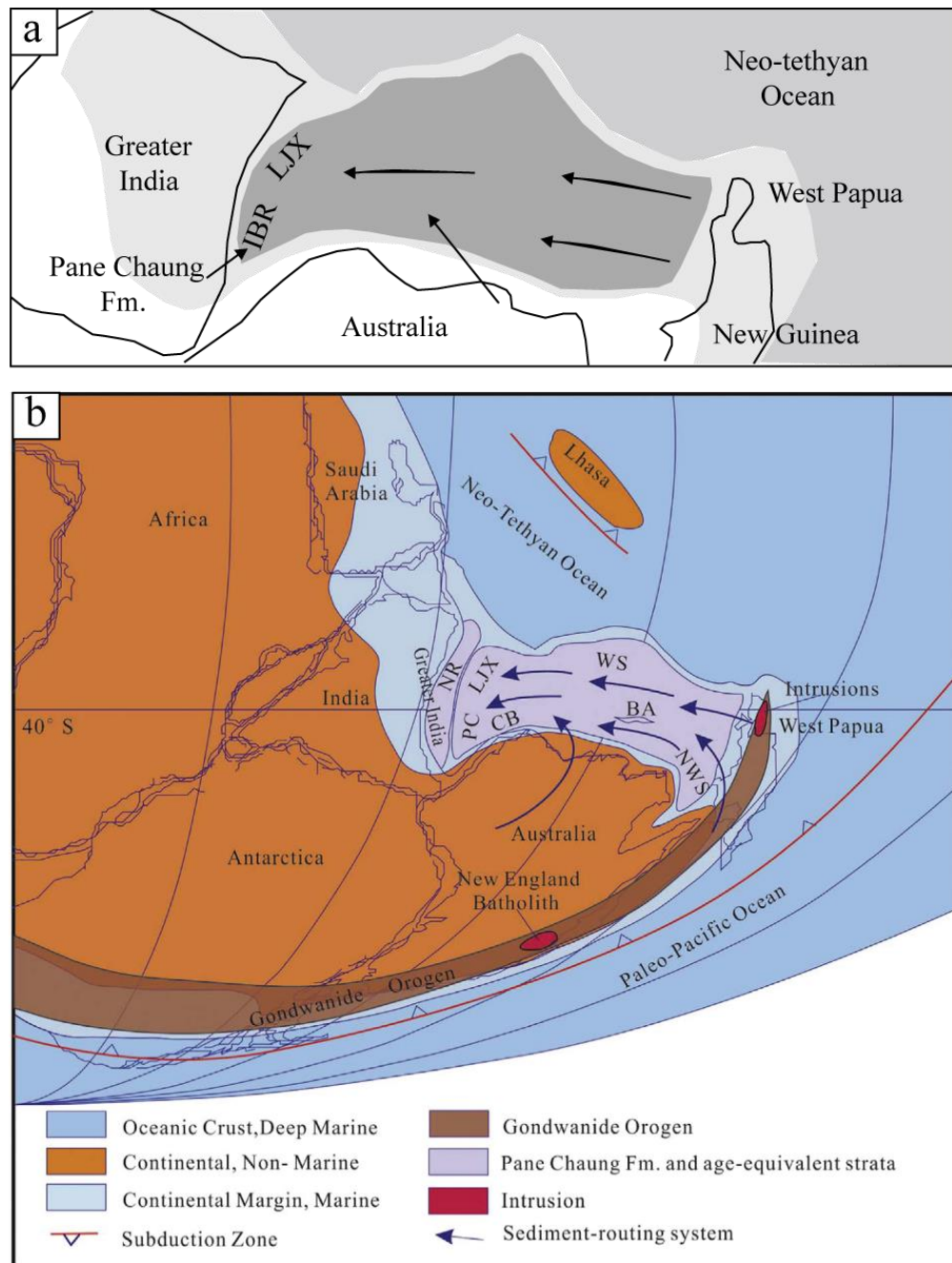


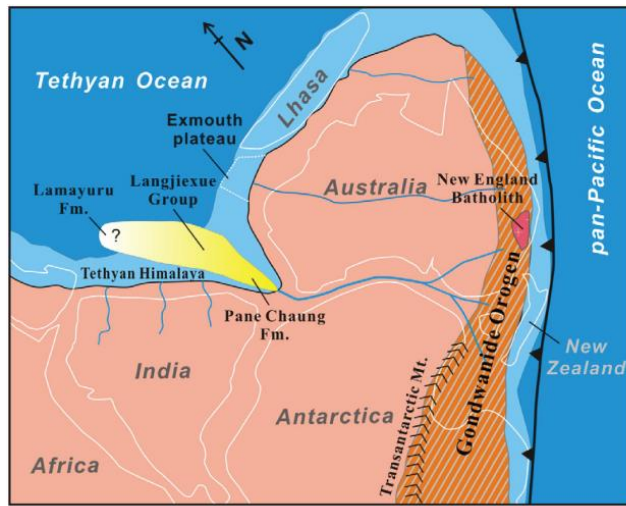
Fig. 6.12: Late Triassic palaeogeographic reconstruction of the Pane Chaung Formation, IBR. (a) modified after Cai et al. (2016), and (b) Yao et al. (2017), showing locations of key blocks (Yao et al., 2017). BA, Banda Arc; CB, Carnarvon Basin; LIX, Langjiexue Formation; NR, Nieru Formation; NWS, Northwest Sulawesi; PC, Pane Chaung Formation; WS, West Sulawesi.

the sediments of the Carnarvon Basin on the Australia NW Shelf. For examples, Carnarvon Basin contains a very small proportion of Permian-Triassic zircons, rare Triassic Cr spinel and quite different depositional environment. It is concluded, therefore, that West Burma was not part of Australia.

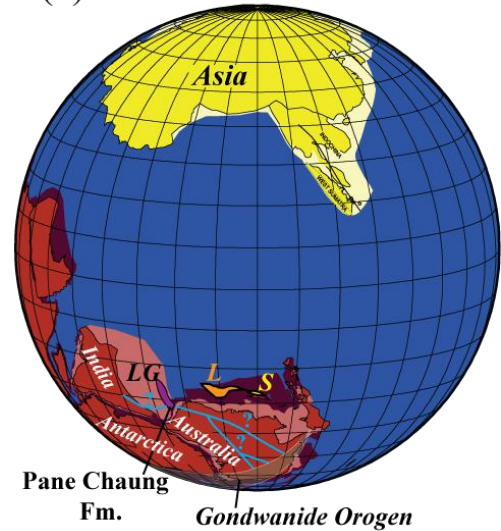
Model C: West Burma as part of northern India

The Pane Chaung Formation shows similar fossil, sedimentary, provenance (recycled orogeny), and detrital zircon provenance characteristics (zircon ages, ε_{Hf} (t) values) to the Langjiexue Group (Wang et al., 2016; Yao et al., 2017; this study) (Fig. 6.13). A detailed comparison of the detrital zircon age distribution and sedimentary provenance of the two sequences has been discussed in section 6.3.1 above. The correlation of the Pane Chaung Formation with the Langjiexue Group suggests the IBR was part of Indian continental margin derived from an adjacent area of Gondwana rather than from Sibumasu and Australia. This in turn implies that the Pane Chaung Formation was originally deposited along or adjacent to the northern passive continental margin of India during the Late Triassic. The simplest solution and one that agrees with all geological data is that the IBR was part of the northern passive continental margin of the Indian plate during Neotethys closure and the India-Asia collision.

(a) Late Triassic



(b) Late Triassic



(c) West Burma as part of northern India

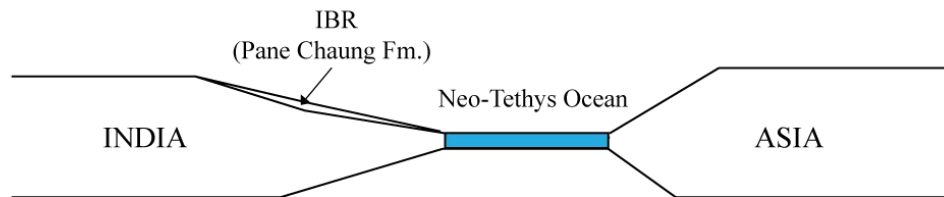


Fig. 6.13: Late Triassic palaeogeographic reconstruction showing locations of key blocks. (a) Wang et al. (2016), (b) this study (modified after Sevastjanova et al., 2015), and (c) West Burma as part of northern India. LG, Langjiexue Group, L, Lhasa, S, Sibumasu.

Model D: West Burma as a separated ribbon continent

Central to the discussion of the evolution of the Myanmar area is the existence of a so-called ‘West Burma plate’ or ‘Burma micro-plate’ as defined by Rangin et al. (2013), or a ‘Burma Terrane’ as suggested by (Westerweel et al., 2019), (Fig. 6.14a,b,c). The Burma micro-plate includes the Indo-Burman Ranges, the central Kalemmyo-Nagaland suture and the Central Basin and therefore is an amalgamation of three distinct terranes. A recent palaeomagnetic study of the Late Cretaceous igneous and Eocene sedimentary sequences

of the Wuntho-Popa Arc indicates that Burma Terrane lay at around 5°S in the Late Cretaceous (97-87 Ma), and 4°N in the Late Eocene (Westerweel et al., 2019). The paleomagnetic data indicates Burma Terrane underwent significant clockwise rotation

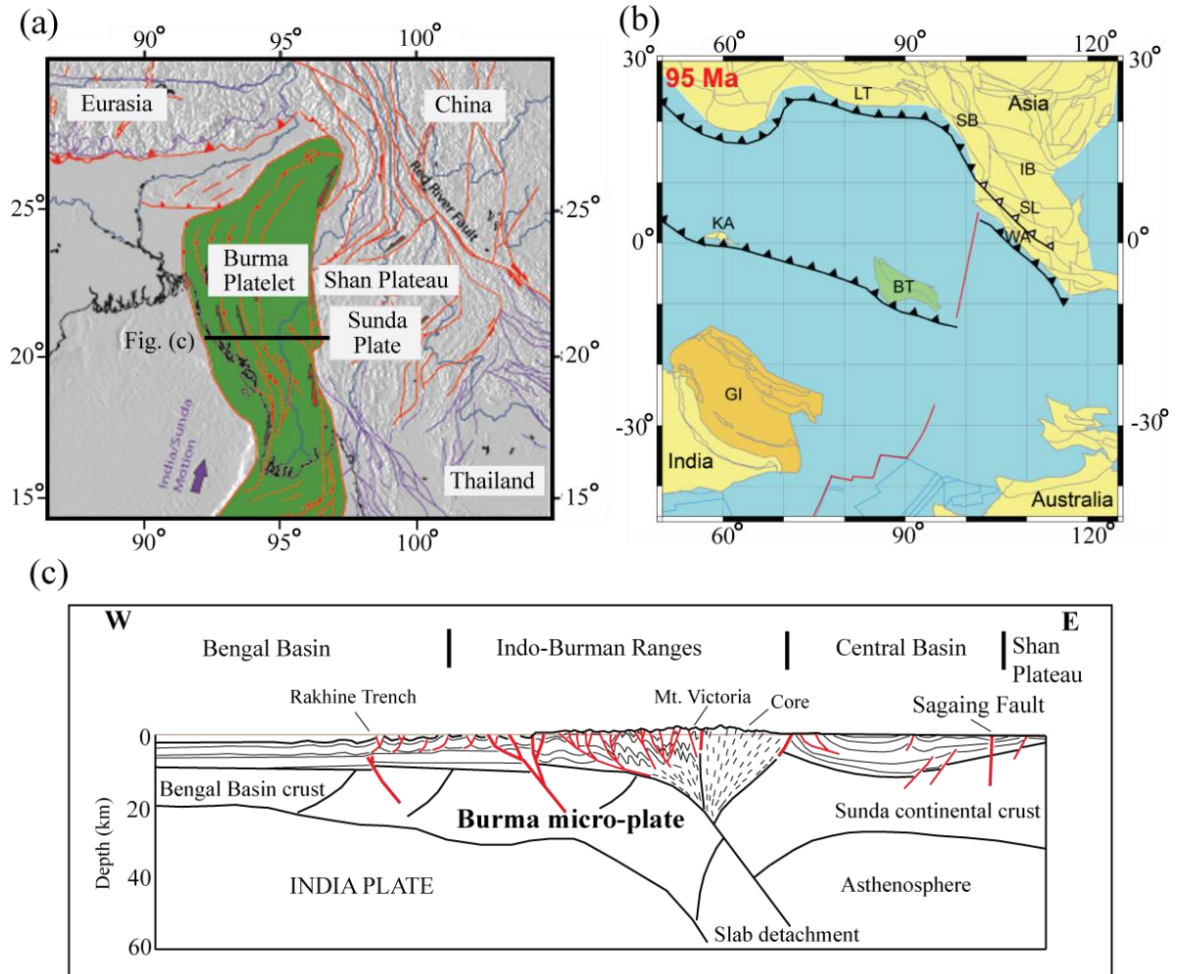


Fig. 6.14: (a) The Burma Platelet shows in green, active faults show in red and inactive faults in purple (Rangin, 2017). (b) Reconstruction of the Burma Terrane and Asia at 95 Ma with GPlates (Westerweel et al., 2019). (c) EW synthetic lithospheric cross section of Myanmar, see location in (a), in part based on Rangin et al. (2013). BT, Burma Terrane, KA, Kohistan Arc, GI, Greater India, LT, Lhasa Terrane, SB, Sibumasu Block, IB, Indochina Block, SL, Sundaland, WA, Woyla Arc.

between ~80-50 Ma and it was pushed northward on the Indian plate by an exceptional distance of at least 2000 km along a dextral strike-slip fault system at its eastern side (Westerweel et al., 2019). The eastern margin of the Burma micro-plate/Burma Terrane is the continental Sagaing Fault, a major dextral strike-slip fault that was initiated about 28 - 27 My ago (Morley & Arboit, 2019) and therefore does not represent a suture zone. The western margin of the Burma micro-plate is also not a suture zone, and is poorly defined as it lies buried beneath the young sediments of the Ganges-Bhramaputra delta region.

6.4.1 The West Burma micro-plate

The so-called ‘West Burma micro-plate’ or ‘Burma micro-platelet’ (Rangin et al., 2013; Rangin, 2017) comprises three distinct zones, namely the Indo-Burman Ranges accretionary prism, the central Kalemio-Nagaland suture zone (KNSZ), and the Central Basin. The Kalemio-Nagaland suture is a major geological feature that contains Cretaceous ophiolites, Mesozoic deep-sea sedimentary rocks (that were deposited a long way from any continental margin), oceanic volcanic rocks and mélanges. These rocks are very similar to rocks within the Indus-Yarlung Tsangpo suture zone (IYTSZ) and compare well with the timing of events in the IYTSZ (Hébert et al., 2012) in Tibet. It is suggested that the IYTSZ and the KNSZ were continuous, separating Indian plate rocks to the south (Tibet) and west (Myanmar) from Asian plate rocks to the north (Tibet) and east (Myanmar).

In Tibet the IYTSZ also contains various island arcs and ophiolite complexes with a deep Cretaceous-Cenozoic forearc basin (Xigaze Basin) developed above the suture zone (Einsele et al., 1994; Wang et al., 2017). North of the Xigaze forearc basin, a 2000 km east-west striking granite batholith (the Gangdese batholith of Late Jurassic to Eocene age; Hébert et al., 2012) marks the southern margin of the Lhasa Block (Asian plate). In

Myanmar the Central Basin also consists of Cretaceous-Cenozoic sedimentary rocks (Pivnik et al., 1998), and occupies a similar relative tectonic position to the Xigaze Basin, namely east of the Kalemio ophiolites and suture zone and west of the Wuntho-Popa Arc (WPA). The WPA comprises granites of similar I-type composition and age ranges as the Gangdese batholith. Thus the simplest explanation is that one major suture zone (Indus – Yarlung Tsangpo suture in Tibet; Kalemio-Nagaland suture in Myanmar) separates Indian plate rocks to the south (Himalaya) and west (Indo-Burman Ranges) from Asian plate rocks to the east (Central Basin, Wuntho-Popa Arc, etc.).

The correlation of the Gangdese Arc with the WPA, and the Kalemio-Nagaland ophiolites with the Tibetan Indus – Yarlung Tsangpo suture, has been challenged by recent paleomagnetic data from Myanmar published by Westerweel et al. (2019). They proposed that the Burma Terrane could be part of the Incertus Arc (incorporating the Woyla Arc and the Kohistan Arc) when Neo-Tethyan subduction began in the Late Cretaceous (Fig. 6.14b). Their plate reconstruction model shows a small separate west Burma plate during the Cretaceous with accretion to Asia first, followed by dextral strike-slip accretion since 38 Ma (Figure 4 in Westerweel et al., 2019). This model implies that during the Late Cretaceous to Eocene west Burma was at an equatorial paleo-latitude, and therefore could not have been a part of the Gangdese Belt of south Tibet, and might not even have been coupled with India. The problems with this model are: (a) The IBR west of the Kalemio-Nagaland suture zone, is a contiguous part of the Indian plate with no suture between them; (b) The Kalemio-Nagaland suture contains all the same lithologies as the Indus – Yarlung Tsangpo suture, and is most likely to be the same plate collision zone rotated around the Eastern Himalayan Syntaxis; (c) There is no evidence for pre-Miocene motion along the Sagaing Fault, which

cuts Early Miocene granites and metamorphic rocks in the Mogok Belt and must have been active only after ~21 Ma (Searle et al., 2007, 2017, 2020); and (d) Clockwise rotation of Burma east of the Sagaing Fault and SE Asia occurred during the late Neogene (Sloan et al., 2017), and not before 50 Ma as required in the Westerweel et al. (2019) reconstructions.

6.4.2 The Sagaing Fault

The Sagaing Fault is a major dextral intra-continental strike slip fault that initiated at around ~27 Ma (Morley and Arboit, 2019) and accommodated the northward motion of the indenting Indian plate to the west. It links southwards into a young active back-arc spreading center in the Andaman Sea (Morley & Searle, 2017). In the north the fault splays into at least three strands and probably connects to the Eastern Himalayan Syntaxis (Sloan et al., 2017). Offsets along the Sagaing Fault are disputed but the general consensus appears to be around 400-480 km of dextral motion since ~27 Ma (Mitchell, 1993; Mitchell et al., 2012; Morley & Arboit, 2019). As the Sagaing fault marks the eastern boundary of the so-called ‘West Burma plate’, this plate can only have existed since 27 Ma.

6.4.3 The Myitkyina Ophiolite Belt

The Myitkyina ophiolite belt contains ophiolites of Jurassic-Cretaceous age, deep-sea sedimentary rocks and mélanges and is similar to the Kalemio-Nagaland ophiolite belt in the IBR. It is likely that the Tagaung – Myitkyina ophiolite belt may have been continuous with the Kalemio – Nagaland suture before being cut and offset by the dextral motion along the Sagaing Fault. This solution would then require only one Neotethyan suture zone, offset by Late Cenozoic dextral shearing along the Sagaing Fault. It remains unclear how the Jade

Belt ophiolites fit with any model, but one solution is that this belt is also an offset splay of the Kalembo – Nagaland suture zone.

6.5 A simplified tectonic model for the Indo-Burman Ranges

A simplified tectonic model is presented to account for the structural, geochronological and geochemical data presented in this thesis. This model attempts to elucidate the evolution of the Neotethys Ocean from Permian to present day (Fig. 6.15).

In this model the IBR and Lhasa block do not rift away from Australia in the Triassic as proposed by Metcalfe (2013) and Sevastjanova et al. (2015). Instead the IBR was located along the northern Indian plate in the Late Triassic. The IBR, then rifted away from SW Australia and then, together with India, moved northward in Cretaceous times (Fig. 6.15a). Commencing with the break-up of the Gondwana supercontinent during the Permian - Early Mesozoic, India rifted away from southern Africa-Madagascar and Australia/Antarctica around 120 Ma (Ali and Aitchison, 2008; Gibbons et al., 2012). The Early Cretaceous was associated with the final break-up of the Gondwana supercontinent, and the Indian plate moved rapidly north toward Asia at this time (van Hinsbergen et al., 2011a,b, 2012). The rapid movement of the Indian plate was possibly accommodated by the formation of several subduction zones within the western part of the Neotethys Ocean, as both the Spong island arc in Ladakh (Corfield et al., 2001) and the Dras-Kohistan island arc in Pakistan require north-dipping subduction zones during the Cretaceous.

Comparison of the timing of events in the IYTSZ with those in the IBR is instructive (Table. 6.1). Hébert et al. (2012) summarized the key events in IYTSZ as follows: 1) a subduction-related Jurassic intra-oceanic arc formed around 177-150 Ma, 2) around 130- 88

Locality of suture zone	Ophiolite formed in a nascent arc (Ma)	Ophiolite generation in the subduction zone (Ma)	Environment of formation	Presence of HP-LT metamorphism	Dating of ophiolite emplacement	References
Indus-Yarlung Tsangpo suture zone	177 - 150	130 - 88	MOR & SSZ	Yes	Late Cretaceous	Hébert et al. (2012)
Indo-Burman Ranges Tagaung-Myitkyina Belt Jade Belt	176 - 166 163.2 ± 3.3		SSZ MOR?	? Yes 77 ± 3 Ma No	Pre-Middle Cretaceous Pre-Middle Cretaceous? Late Cretaceous?	Yang et al. (2012), Liu et al. (2016) Shi et al. (2008), Yui et al. (2013)
Kalenyio Naga-Manipur Andaman Islands		127 118 - 116 95 ± 2	MOR MOR & SSZ SSZ	Yes Age? No	Pre-Middle Cretaceous Late Eocene-Early Oligocene Palaeogene	Liu et al. (2016), Zhang et al. (2017, 2018) Baxter et al. (2011), Ningthoujam et al. (2012), Ghose et al. (2014) Pedersen et al. (2010), Ghost et al. (2009), Pal (2011)

Table. 6.1: Comparison of the timing of events in the Indus-Yarlung suture zone and IBR ophiolites.

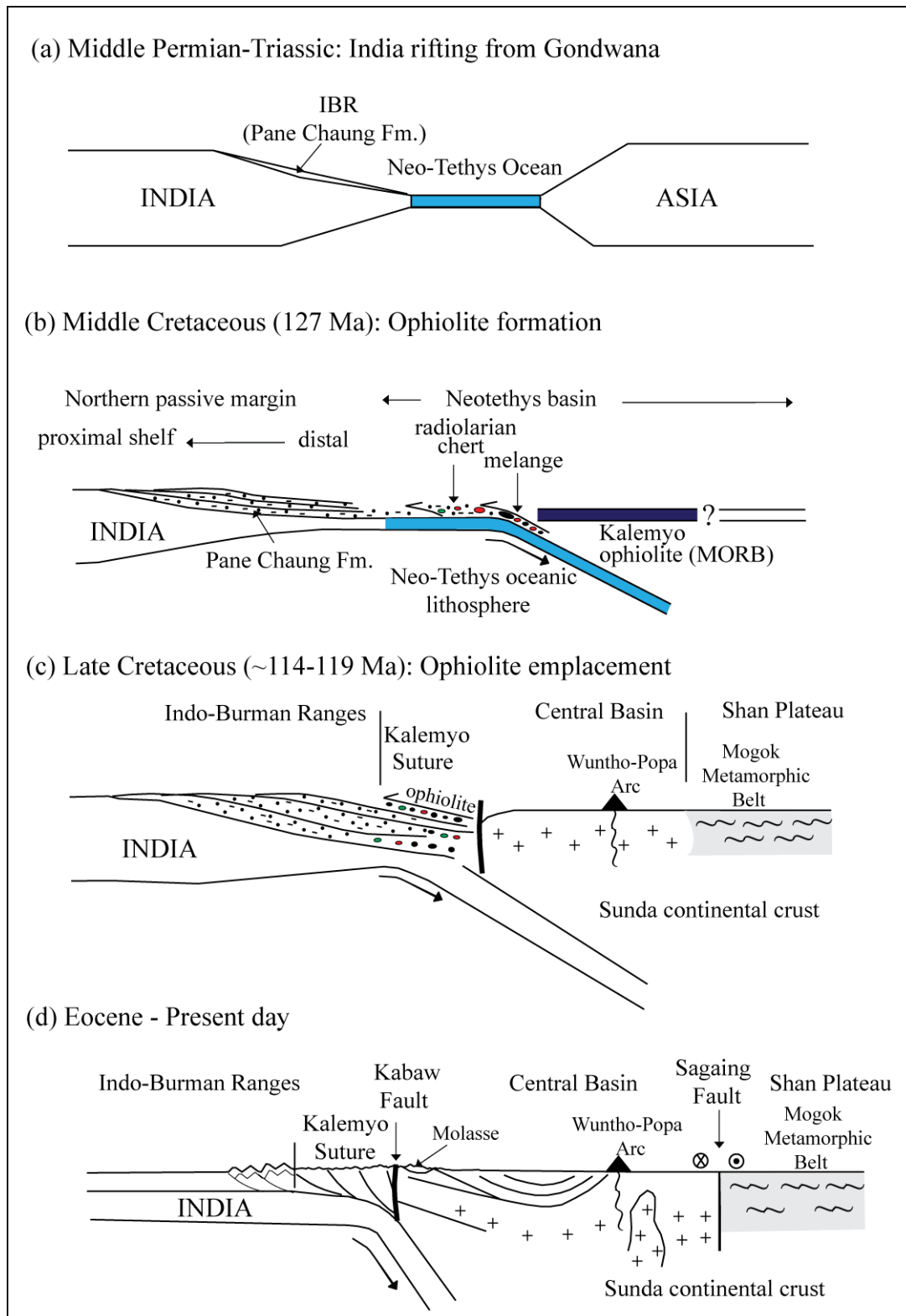


Fig. 6.15: Schematic diagrams showing the evolution of the Indo-Burman Ranges through time.

Ma a fast-spreading intra-arc ridge developed related to slab rollback, low- to high-grade high pressure metamorphic rocks were exhumed, and the intra-arc basin provided most of the IYTSZ relicts, and 3) Late Cretaceous obduction of the intra-arc basin and remnant arc on top of the active arc. The timing of these stages is very much in line with equivalent events in the IBR, with the Jurassic events in the Myitkyina ophiolite belt (ca. 173 Ma) followed by the overthrusting of the 130-115 Ma Kalemio and Naga ophiolites onto the Triassic Pane Chaung Formation (Fig. 6.15b), which is itself unconformably overlain by Campanian-Maastrichtian marine mudstones and limestones (Falam Formation), (Fig. 6.15c). In detail the history of the island arcs and back-arc basins in the IYTSZ and IBR are slightly different in that specific obduction events associated with arcs in the IYTSZ have yet to be identified in the IBR, although they form part of a similar overall tectonic pattern and history.

Following obduction of the Kalemio ophiolite and underlying thrust sheet (Pane Chaung Formation and Kanpetlet Schist), a period of deep marine sedimentation occurred during the Late Cretaceous-Middle Eocene from ca. 80-40 Ma. This suggest that India, the Central Basin and Shan Plateau were connected in Late Cretaceous times. During the Paleocene-Early Eocene, the Indian plate, with its Permian-Mesozoic passive margin sediments approached the trench area (Hébert et al., 2012) prior to closure of the Neotethys suture zone at ~50 Ma. Trench sedimentation includes the *mélange* zones and the flysch sequences now located west of the ophiolitic massifs. Deposition of the Chunsung and Kennedy Sandstone Formations probably occurred at this time. At the same time, the Burmese subduction zone displayed an Andean-type margin, with a forearc basin (Central Basin) developed on a nascent accretionary prism open to the trench occupied by a

westward-prograding deltaic system fed by rivers eroding the Wuntho-Popa Arc (Licht et al., 2018). Similar zircon U-Pb ages and Hf isotopes as well as bulk rock Nd data of the Eocene strata in the IBR and CB suggest that detrital material was probably transported from the east to as far west as the Sunda Trench (Zhang et al., 2019). The Late Paleocene-Early Eocene (59-54 Ma) radiolarians found in the southern IBR provide a maximum age constraint on the timing of formation of the *mélange*. The radiolarian fauna, the tectonic attribution of the radiolarian cherts and basalt blocks indicate that oceanic crust persisted in the southern IBR until the early Eocene. The youngest radiolarian fossils (~54 Ma) provide a valuable new age constraint on the timing of its development and associated tectonic events in the area. The final Neotethys Ocean closure is precisely dated along the IYTSZ and the northern margin of India at 50.5 Ma (Rowley, 1998; Zhu et al., 2005; Green et al., 2008).

Following the closure of the Neotethys, the final marine sedimentation in the IBR is difficult to establish, but probably occurred during the middle Eocene, as evidenced by continental molasse deposits formed during the late Eocene-Miocene and now exposed on Ramree Island and south of Falam (Bannert et al., 2011) (Fig. 6.15d). These molasses sequences overlie the Kennedy Sandstone of middle Eocene age (Bannert et al., 2011). Similar molasse facies sedimentary rocks are found along the Kabaw Fault in the CB. From the late Miocene to the present day, strike-slip deformation became increasingly important within the CB, and probably also affected the IBR (Fig. 4.5, 4.6, 5.5; Kheng and Kabaw Faults). The effects of the collision continue to the present day as dextral strike-slip shearing along the Sagaing Fault as evidenced by abundant seismic activity along the fault (Sloan et al., 2017).

CHAPTER

SEVEN

CONCLUSIONS AND FURTHER WORK

7.1 Conclusions

The IBR contains an important record of Tethyan tectonic evolution that can be used to test and refine Mesozoic-Cenozoic plate reconstructions. The field observations, structural-stratigraphic studies, biostratigraphy, petrographic data, and geochemical data from the IBR reveal a protracted history of subduction and accretion of Neotethyan oceanic rocks along the eastern margin of the Indian continent during the Mesozoic-Cenozoic. These data support the following conclusions:

- The newly discovered late Paleocene-early Eocene (59-54 Ma) radiolarians found in the *mélange* of the Ngapali Formation in the southern IBR provide a maximum age constraint on the timing of formation of the *mélange*. The radiolarian fauna, the tectonic attribution of the radiolarian cherts and basalt blocks indicate that oceanic crust persisted in the southern IBR until the early Eocene.
- Early Jurassic-early Cretaceous radiolarian faunal assemblages from thin-bedded cherts collected from an ophiolitic *mélange* in the Yazagyo Dam, northern Chin Hills, provides the first robust biostratigraphic age constraints from rocks associated with the Kalemmyo ophiolite. The radiolarian assemblages provide new age constraints on deep-marine sedimentation that are consistent with those reported from ophiolites in Tibet and the Naga Hills, and reinforces the hypothesis that the Kalemmyo, Nagaland and Indus – Yarlung Tsangpo suture zone (IYTSZ) ophiolites were once part of the same Neotethyan ocean floor (Fig. 6.3). This single suture zone separates Indian plate rocks to the west (the IBR) from Asian margin rocks to the east (Central Basin forearc sediments and WPA).

- The combined biostratigraphic and detrital zircon U-Pb data indicate that the bulk of the flysch in the southern IBR is Paleogene in age. The U-Pb detrital zircon maximum depositional ages are 44 ± 1 Ma and 48 ± 1 Ma, in both of the mapped Paleogene and Cretaceous units. The occurrence of reworked Upper Cretaceous and Paleocene-Eocene fossils is widely scattered over the region. Moreover, the Kennedy Sandstone in the northern Chin Hills is laterally equivalent to the Chunsung Formation confirmed by the middle Eocene U-Pb zircon ages. The new data presented in this study show that the Paleogene unit in the IBR may be equivalent to part of the Disang Formation of Naga Hill, along the western margin of the IBR.
- Sedimentary provenance and geochemical studies indicate that the Upper Triassic Pane Chaung Formation was originally deposited on the northern Gondwana margin, derived from the Gondwanide orogeny and Indian plate, not the Asian (Sibumasu) plate. At this time a wide Neotethyan ocean separated the IBR from the Wuntho-Popa Arc (WPA) and the Shan Plateau. This resolves the long-standing debate regarding where the Pane Chaung Formation was deposited.
- The new provenance data on the Upper Cretaceous Falam Formation shows that it contains abundant Cretaceous zircon grains (c. 90-120 Ma) with mixed positive and negative ϵ_{Hf} values. This is interpreted as the Falam Formation derived predominantly from the core of the IBR where marks a broad suture zone of Neotethys Ocean.
- A provenance study of the late Paleocene-middle Eocene sandstones from the IBR shows a significant component of typical arc ages from 90-110 Ma, ~70 Ma and ~50 Ma, and of positive and negative ϵ_{Hf} values that are mainly derived from both such as the Wuntho-Popa Arc and the core of the IBR sediments.

- The IBR comprises Late Cretaceous-Cenozoic sedimentary rocks overlying Indian lower crust that is presently subducting eastwards along the Burma Seismic zone beneath the active WPA. Thick Triassic turbidites sedimentary rocks in the IBR were deposited along the northeastern margin of the Indian plate.
- The Central Basin has many similarities to the Xigaze Basin in Tibet. Both basins contain Cretaceous – Cenozoic sedimentary rocks, both are located along the margin of the main India – Asia suture zone, and both are located in the forearc position to the Gangdese batholith (Tibet) and the WPA (Myanmar).
- The WPA has many similarities to the Gangdese batholith in Tibet. Both are composed of I-type biotite and hornblende granites and diorites of Cretaceous to Eocene age, both have an andesite volcanic component (Linzizong volcanics in Tibet, andesitic lavas in the WPA), both contain large subduction-related porphyry and epithermal copper (and gold) deposits, and both were formed above a north-dipping (Tibet) east-dipping (in present-day coordinates, Myanmar) subduction zone of Tethyan oceanic lithosphere.
- The Sagaing Fault was initiated at ca. 27 Ma and has approximately 400-480 km of dextral displacement (Morley & Arboit, 2019). The Kalembo – Nagaland suture was likely originally continuous with the Tagaung – Myitkyina ophiolite belt and has been offset dextrally along strands of the Sagaing Fault.
- Overall, the IBR is part of the Indian plate. The ‘West Burma microplate’ or ‘Burma platelet’ does not exist and is now referred to as the Sunda continental crust in Figure 6.15. There is no known suture zone west of the IBR and the eastern boundary, the Sagaing dextral strike-slip fault, was only initiated after 27 Ma according to Morley & Arboit (2019) based on U-Pb ages of detrital zircon and titanite in the Minwun basin

sediments, or after 21 Ma according to Searle et al. (2020) based on U-Pb ages of granulite facies gneisses and leucogranites in the Mogok Metamorphic Belt. In either case, it is clear that the Sagaing Fault, cannot have been a plate boundary prior to the Oligocene at the earliest.

7.2 Further Work

Although a revised tectonic model has been presented here, additional work in the future is required to refine the findings of this thesis further. In particular, three areas warrant further investigation, namely (1) the biostratigraphy of the IBR and suture zone, (2) an explanation for the near-total absence of Jurassic-early Cretaceous sedimentation on the Indian margin and (3) the uplift history of the IBR.

Although this thesis has shown that there is a paucity of microfossils in the IBR, it has also shown that a combination of biostratigraphy and detrital zircon U-Pb dates can be informative in unravelling the timing of deposition and tectonic events. More work needs to be carried out, in particular, to characterize the radiolarians. With more detailed examination of radiolarian types, it may be possible to assign more precise species names and provide better age constraints to the timing of the *mélange* formation.

The absence of Jurassic sediments on the Indian margin is puzzling. Detrital zircon analysis of the Pane Chaung Formation yielded an early Jurassic maximum depositional age from some samples (Sevastjanova et al., 2015; Yao et al., 2017), but did not find any zircons of early Jurassic age. Additional U-Pb zircon geochronology is needed in order to assess whether the Pane Chaung Formation is entirely of Late Triassic age or whether the upper part of the Pane Chaung Formation might be of early Jurassic age.

All tectonic models proposed for the IBR have weaknesses or ambiguities, and the uplift history of the IBR is still poorly constrained. Zircon-fission track analysis could be used to better understand the thermal history of continental crust, the timing of volcanic events, and the exhumation history of orogenic belts.

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APPENDIX

Appendix 1: Geographical location and characteristics of the analysed samples in the

Indo-Burman Ranges

Sample no.	Latitude	Longitude	Lithology	Location	Analysis
IBR01	18°41'19.4"	94°58'57"	Sandstone	Rakhine area (Padaung-Taungup road)	DZA
IBR06	18°51'16"	94°15'55.6"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR09	18°51'14.4"	94°17'29.5"	Marlstone	Rakhine area (Padaung-Taungup road)	BIO, PG, SI
IBR10	18°51'15.6"	94°17'30.7"	Sandstone	Rakhine area (Padaung-Taungup road)	PG
IBR11	18°51'08.2"	94°17'53.4"	Sandstone	Rakhine area (Padaung-Taungup road)	DZA
IBR12	18°51'10.3"	94°17'47.5"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR13	18°50'37.8"	94°20'39.9"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR22	18°41'47.6"	94°32'01.8"	Limestone	Rakhine area (Padaung-Taungup road)	BIO, PG, SI
IBR23	18°41'51"	94°32'03"	Limestone	Rakhine area (Padaung-Taungup road)	BIO, PG, SI
IBR25	18°41'52.3"	94°31'59"	Limestone	Rakhine area (Padaung-Taungup road)	BIO, PG, SI
IBR31	19°09'30.4"	94°14'34.7"	Limestone	Rakhine area (Taungup-Ma-I road)	BIO, PG, SI
IBR34A	19°09'30.3"	94°14'17.5"	Limestone	Rakhine area (Taungup-Ma-I road)	BIO, PG, SI
IBR45A	18°46'18.8"	94°23'41.9"	Sandstone	Rakhine area (Padaung-Taungup road)	PG
IBR48A	18°46'23.9"	94°23'23.3"	Sandstone	Rakhine area (Padaung-Taungup road)	DZA
IBR48B	18°46'23.9"	94°23'23.3"	Marlstone	Rakhine area (Taungup-Ma-I road)	PG, SI
IBR53A	18°45'37.2"	94°27'56.9"	Marlstone	Rakhine area (Taungup-Ma-I road)	PG, SI
IBR55	18°45'33.7"	94°28'35.8"	Sandstone	Rakhine area (Taungup-Ma-I road)	DZA
IBR71B	18°40'47"	94°34'50.9"	Sandstone	Rakhine area (Taungup-Ma-I road)	DZA, HI
IBR93	18°39'52.2"	94°44'35.4"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR98	18°39'26.3"	94°47'46.1"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR99A	18°39'29.2"	94°47'54.5"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR101	18°39'21.8"	94°48'30.3"	Sandstone	Rakhine area (Padaung-Taungup road)	PG
IBR102	18°39'08.5"	94°48'35.6"	Sandstone	Rakhine area (Padaung-Taungup road)	DZA, HI
IBR103	18°39'26"	94°48'59.3"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR107	18°39'51.8"	94°51'52.1"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR108	18°39'50.1"	94°51'59.1"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR110A	18°39'56.1"	94°52'58.8"	Sandstone	Rakhine area (Padaung-Taungup road)	DZA
IBR111	18°40'25.1"	94°53'21.1"	Shale	Rakhine area (Padaung-Taungup road)	BIO, SEM
IBR125	18°27'57"	94°17'29"	Marlstone	Rakhine coastal (Ngapali Formation)	BIO
IBR126	18°27'08.5"	94°17'41.7"	Limestone	Rakhine coastal (Ngapali Formation)	PG
IBR128	18°26'57.9"	94°18'31.1"	Limestone	Rakhine coastal (Ngapali Formation)	PG
IBR129A	18°26'56.9"	94°18'32.8"	Limestone	Rakhine coastal (Ngapali Formation)	PG, SI
IBR140	19°11'42.9"	93°46'46"	Limestone	Rakhine coastal (Ramree Island)	PG, SI
IBR144	19°08'59.1"	93°37'45.7"	Marlstone	Rakhine coastal (Ramree Island)	PG
IBR144B	19°08'59.1"	93°37'45.7"	Marlstone	Rakhine coastal (Ramree Island)	BIO, PG
IBR146	19°20'11.9"	93°32'01.6"	Limestone	Rakhine coastal (Ramree Island)	BIO, PG
IBR147	19°10'36.4"	93°35'26.7"	Limestone	Rakhine coastal (Ramree Island)	BIO, PG
IBR149	19°09'21.9"	93°36'01.8"	Limestone	Rakhine coastal (Ramree Island)	BIO, PG, SI
IBR150	19°09'21.9"	93°36'01.8"	Basalt	Rakhine coastal (Ramree Island)	PG
IBR152	19°03'42.3"	93°54'50"	Limestone	Rakhine coastal (Ramree Island)	BIO, PG, SI
IBR166C	17°53'57.2"	94°30'38.3"	Limestone	Rakhine area (Thandwe-Gwa road)	BIO, PG, SI
IBR167	17°52'50.8"	94°29'36.2"	Limestone	Rakhine area (Thandwe-Gwa road)	BIO, PG, SI
IBR168	17°43'16.9"	94°32'06"	Shale	Rakhine area (Thandwe-Gwa road)	BIO, SEM
KM60	18°40'30.78"	94°57'48.66"	Sandstone	Rakhine area (Padaung-Taungup road)	PG, DZA
KM67c	18°27'56.79"	94°17'28.75"	Chert	Rakhine coastal (Ngapali Formation)	BIO, SEM
KM68	18°27'10.96"	94°17'45.84"	Basalt	Rakhine coastal (Ngapali Formation)	PG
KM68a	18°27'10.96"	94°17'45.84"	Basalt	Rakhine coastal (Ngapali Formation)	PG
KM69	18°27'00.96"	94°18'32.64"	Basalt	Rakhine coastal (Ngapali Formation)	PG
KM70b	17°52'08.34"	94°29'02.75"	Basalt	Rakhine area (Thandwe-Gwa road)	PG
KM71	17°48'58.69"	94°29'20.91"	Basalt	Rakhine area (Thandwe-Gwa road)	PG
KM74	17°30'51.38"	94°54'18.42"	Serpentine	Rakhine area (Gwa-Ngathainggyaung road)	PG
KM76a	17°30'11.26"	94°55'02.4"	Sandstone	Rakhine area (Gwa-Ngathainggyaung road)	PG, DZA
TT01	21°14'00"	93°54'11.3"	Schist	Mt. Victoria	PG
TT02	21°12'53.3"	94°00'30.5"	Schist	Mt. Victoria-Kanpetlet road	PG
TT04	21°16'30.3"	94°06'55.6"	Sandstone	Saw-Kanpetlet road (Kabaw Formation)	PG, DZA
TT05	21°15'54.7"	94°05'05.4"	Sandstone	Saw-Kanpetlet road (Pane Chaung Formation)	DZA, XRD
TT06	21°12'38.9"	94°08'48.2"	Limestone	Saw-Kyaukhtu road	BIO, PG

Sample no.	Latitude	Longitude	Lithology	Location	Analysis
TT07	21°09'40.4"	94°06'35.9"	Schist	Saw Chaung/River	PG
TT09	21°09'24.8"	94°07'21"	Sandstone	Saw Chaung/River	PG
TT11	21°10'49.7"	94°07'38.6"	Sandstone	Kanpetlet-Saw road	PG
TT12	21°09'23"	94°08'45.5"	Sandstone	Kanpetlet-Saw road	DZA
TT13	21°12'35"	94°07'35"	Limestone	Anyarkadin Chaung/River	BIO, PG
TT14	21°10'56.4"	94°06'56.1"	Schist	Kanpetlet-Saw road	PG
TT15	21°22'18.3"	94°03'18.9"	Sandstone	Mindat-Kyaukhtu road	PG, DZA
TT16	21°22'34.7"	94°03'10.9"	Shale	Mindat-Kyaukhtu road	BIO
TT17	21°22'36"	94°03'06.2"	Shale	Mindat-Kyaukhtu road	BIO
TT18	21°22'04.56"	94°02'11.1"	Shale	Mindat-Kyaukhtu road	BIO, SEM
TT19	21°22'15.8"	94°01'23.7"	Sandstone	Mindat-Kyaukhtu road	PG, DZA
TT20	21°21'16.6"	93°56'11.8"	Schist	Che Chaung/River	PG
TT21	21°18'59.6"	93°56'56.2"	Schist	Mindat-Kanpetlet road	PG
TT23	21°22'40.4"	93°59'38.7"	Schist	Mindat-Kanpetlet road	PG
ST03	21°16'28.1"	94°07'43.7"	Peridotite	Kyauksit Chaung/River	PG
ST12a	21°16'28.1"	94°07'43.7"	Gabbro	Kyauksit Chaung/River	PG
ST12b	21°16'28.1"	94°07'43.7"	Peridotite	Kyauksit Chaung/River	PG
KM01	23°13'40.15"	93°57'38.56"	Peridotite	Bophi Vum	PG
KM02	23°13'39.65"	93°57'38.44"	Peridotite	Bophi Vum	PG
KM04	23°12'52.91"	93°57'08.34"	Sandstone	Kalemyo-Mt. Kennedy road	PG
KM15	23°15'09.06"	93°46'35.93"	Sandstone	Kalemyo-Mt. Kennedy road	PG, DZA, HI,XRD
KM23	23°12'19.16"	93°53'42.65"	Sandstone	Kalemyo-Mt. Kennedy road	PG, DZA
KM25	23°12'04.67"	93°54'28.56"	Sandstone	Kalemyo-Mt. Kennedy road	PG, DZA
KM28	22°56'37.62"	94°01'41.87"	Peridotite	Kalemyo-Webula road	PG
KM29a	22°58'45.81"	93°58'25.24"	Peridotite	Kalemyo-Webula road	PG
KM30a	22°58'51.63"	93°58'13.59"	Peridotite	Kalemyo-Webula road	PG
KM32	22°59'08.78"	93°57'32.86"	Sandstone	Kalemyo-Webula road	DZA
KM34	23°01'04.49"	93°54'11.43"	Sandstone	Kalemyo-Webula road	PG, DZA, HI,XRD
KM34a	23°01'04.83"	93°54'08.99"	Sandstone	Kalemyo-Webula road	PG, DZA, HI,XRD
KM36	22°58'14.26"	93°59'19.01"	Amphibolite Schist	Kalemyo-Webula road	PG
KM36a	22°58'14.26"	93°59'19.01"	Chert	Kalemyo-Webula road	BIO
KM36c	22°58'14.26"	93°59'19.01"	Amphibolite Schist	Kalemyo-Webula road	PG
KM37	23°32'07.16"	94°06'00.76"	Chert	Kalemyo-Yazagyo	BIO
KM37	23°32'07.16"	94°06'00.76"	Chert	Kalemyo-Yazagyo	BIO
KM38	23°32'47.61"	94°05'05.34"	Sandstone	Kalemyo-Yazagyo	PG
KM39a	23°32'19.16"	94°06'12.36"	Chert	Kalemyo-Yazagyo	BIO
KM39a	23°32'19.16"	94°06'12.36"	Chert	Kalemyo-Yazagyo	BIO
KM40a	23°13'43.58"	94°07'21.29"	Sandstone	Kalemyo-Kalewa	PG, DZA
KM40b	23°13'43.58"	94°07'21.29"	Sandstone	Kalemyo-Kalewa	PG
KM40c	23°13'43.58"	94°07'21.29"	Sandstone	Kalemyo-Kalewa	DZA
KM44	23°13'34.87"	94°09'16.42"	Limestone	Kalemyo-Kalewa	BIO, PG
KM51	23°22'03.24"	94°01'07.72"	Peridotite	Mwe Taung	PG
KM51a	23°22'03.24"	94°01'07.72"	Gabbro	Mwe Taung	PG
KM52a	23°23'20.85"	94°01'07.29"	Peridotite	Mwe Taung	PG
KM53a	23°24'06.20"	93°56'38.63"	Conglomerate	Nattaga Chaung/River	PG
KM53a	23°24'06.20"	93°56'38.63"	Limestone	Nattaga Chaung/River	BIO, PG
KM54b	23°24'06.52"	93°56'35.98"	Sandstone	Nattaga Chaung/River	PG, DZA, HI,XRD
KM55	23°24'11.22"	93°56'30.96"	Limestone	Nattaga Chaung/River	BIO, PG
KM57	23°24'14"	93°55'40"	Limestone	Nattaga Chaung/River	PG
KM58	23°24'14.01"	93°55'44.28"	Sandstone	Nattaga Chaung/River	DZA
KM58a	23°24'14.01"	93°55'44.28"	Limestone	Nattaga Chaung/River	BIO, PG

Analysis key: DZA-detrital zircon age, BIO-biostratigraphy, SEM-scanning electron microscope, PG-petrography
SI-stable isotope, HI-Hf isotope, XRD-X-rays diffraction

Appendix 2: Detrital modes of samples analysed from the Indo-Burman Ranges

(a) Detrital modes of samples analysed from Rakhtine

Sample	Quartz		Feldspars		Lithics/Rock fragments					Authigenics & Matrix		Heavy mineral & Opaque		
	Monocrystalline quartz	Polycrystalline Total quartz	Plagioclase Feldspars	K-feldspar Total feldspar	Sedimentary lithic	Metamorphic lithic	Volcanic lithic	Chert	Muscovite	Biotite	Chloritic Total lithics/Rock fragments		Quartz + Plagioclase + Calcite cement	
IBR10	14.5	8.0	22.5	10.5	0.0	10.5	4.2	31.0	0.0	1.4	0.0	50.8	13.8	2.4
IBR45a	12.0	5.4	17.4	9.8	0.0	9.8	5.8	35.8	0.0	0.0	0.6	59.2	13.2	0.4
IBR101	9.8	3.2	13.0	8.0	0.0	8.0	10.8	49.0	0.0	0.4	0.2	67.4	10.8	0.8
KM60	20.4	5.6	26.0	13.0	0.0	13.0	12.5	23.4	2.0	1.6	0.2	46.7	14.1	0.2
KM76	29.8	26.2	56.0	3.2	0.0	3.2	7.6	11.0	0.4	0.2	0.0	23.0	17.4	0.4

(b) Detrital modes of samples analysed from Mt. Victoria

Sample	Quartz		Feldspars		Lithics/Rock fragments							Authigenics & Matrix		Heavy mineral & Opaque
	Monocrystalline quartz	Polycrystalline Total quartz	Plagioclase Feldspars	K-feldspar Total feldspar	Sedimentary lithic	Metamorphic lithic	Volcanic lithic	Chert	Muscovite	Biotite	Chloritic Total lites/Rock fragments	Quartz + Plagioclase + Calcite cement		
TT04	25.8	4.0	29.8	10.0	0.0	10.0	16.0	4.8	35.0	0.0	0.0	55.8	4.0	0.4
TT09	42.0	10.0	52.0	9.0	0.0	9.0	0.6	2.5	5.0	0.3	0.2	8.9	30.0	0.1
TT11	33.7	9.0	42.7	8.0	0.0	8.0	3.0	1.0	9.0	0.0	1.0	16.5	32.5	0.3
TT15	20.0	5.0	25.0	15.0	0.0	15.0	25.0	5.0	15.0	1.0	0.0	1.0	48.0	0.0
TT19	41.5	8.0	49.5	7.0	0.0	7.0	2.0	3.0	11.0	0.0	0.2	0.3	27.0	0.0

(c) Detrital modes of samples analysed from Kalaynyo

Sample	Quartz		Feldspars		Lithics/Rock fragments					Authigenics & Matrix			Heavy mineral & Opaque	
	Monocrystalline quartz	Polycrystalline Total quartz	Plagioclase Feldspars	K-feldspar Total feldspar	Sedimentary lithic	Metamorphic lithic	Volcanic lithic	Chert	Muscovite	Biotite	Chloritic Total lites/Rock fragments	Quartz + Plagioclase + Calcite cement		
KM04	25.8	14.0	39.8	12.6	12.6	3.8	5.0	20.0	2.2	1.2	0.2	32.4	15.0	0.2
KM15	17.0	11.0	28.0	12.0	12.0	8.4	4.0	24.0	3.0	1.2	1.0	42.2	15.8	2.0
KM23	41.0	9.0	50.0	7.4	7.4	2.8	5.6	10.0	1.2	4.2	2.6	27.0	13.6	2.0
KM25	40.5	10.2	50.7	6.8	6.8	2.2	6.0	9.3	1.2	3.2	1.2	23.9	17.1	1.5
KM34	15.0	8.0	23.0	2.0	2.0	4.2	2.4	18.0	2.0	0.2	0.2	27.0	46.6	1.4
KM34a	34.0	12.4	46.4	6.6	0.2	6.8	9.8	3.8	6.0	5.2	2.0	26.8	19.6	0.4
KM38	27.6	9.2	36.8	8.4	8.4	5.6	7.2	19.0	0.8	1.0	7.2	41.4	12.6	0.8
KM40a	13.5	7.0	20.5	9.5	0.2	9.7	15.0	5.0	32.0	2.4	0.8	55.2	13.2	1.4
KM40b	14.5	7.0	21.5	12.6	0.4	13.0	16.0	5.0	25.5	4.8	0.8	51.3	13.4	0.8
KM54b	25.8	4.8	30.6	8.5	8.5	10.4	1.0	17.5	3.0	3.0	0.0	31.9	27.8	1.2

Appendix 3: XRD bulk mineralogy and Clay mineralogy results of the analysed samples from the Indo-Burman Ranges

Sandstones XRD Bulk mineralogy results

Sample	Quartz	K-feldspar	Plagioclase	Calcite	Dolomite	Pyrite	Illite/Montmorillonite	Chlorite	Clay subtotal	Total
KM 15	66		11	6			8	9	17	100
KM 34	74		9		6		6	6	12	101
KM 34A	85		3	3	2	1		6	6	100
KM 546	64		23	3	4		1	5	6	100
TT 05	81		7				7	5	12	100

Clay Mineralogy Results

Sample	Peak (d-spacing)	Clay Species	Species amount (%)
KM 15	1.572	Fe-chlorite	28
	1.542	Quartz	0
	1.523	Nontronite	8
	1.513	Glauconite ?	15
	1.505	Illite/montmorillonite	49
KM 34	1.568	Fe-chlorite	17
	1.549	Chlorite	35
	1.542	Quartz	0
	1.513	Glauconite ?	14
	1.501	Illite/montmorillonite	34
KM 34A	1.565	Fe-chlorite	0
	1.548	Chlorite	34
	1.542	Quartz	0
	1.512	Glauconite ?	25
	1.503	Illite/montmorillonite	41
KM 546	1.576	Fe-chlorite	20
	1.549	Chlorite	32
	1.542	Quartz	0
	1.543	Chlorite	10
	1.502	Illite/montmorillonite	38
TT 05	1.574	Fe-chlorite	36
	1.542	Quartz	0
	1.501	Illite/montmorillonite	64

Appendix 4: $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values of the analysed samples from the Indo-Burman Ranges

Row	Identifier 1	Identifier 2	Peak Count	Ampl.44	Mean d13C/12C	s.d.	Mean d18O/16O	BGD_44	Corrected d13C/12C	Corrected d18O/16O
1	42874	NOCZ	7	8843	2.105	0.018	-1.928	8.8	2.204534278	-1.779699665
2	42874	NOCZ	7	6724	2.125	0.039	-1.969	8.371	2.224589507	-1.821206643
3	42874	NBS-18-granular	7	6908	-5.077	0.053	-23.198	8.4	-4.997298355	-23.31271001
4	42874	NBS-18-granular	7	8932	-5.037	0.027	-23.246	8.943	-4.957187898	-23.36130354
5	42874	NBS-19-grain	7	6627	1.882	0.052	-2.355	8.371	1.980918478	-2.211979656
6	42874	NBS-19-grain	7	5572	1.901	0.053	-2.34	8.057	1.999970945	-2.196794176
7	IBR09	IBR09_V1	7	4052	-1.386	0.064	-10.108	7.657	-1.296105895	-10.06084798
8	IBR09	IBR09_V2	7	6930	-1.981	0.039	-10.49	8.486	-1.892748949	-10.44757153
9	IBR09	IBR09_V3	7	5123	-0.499	0.054	-8.961	7.986	-0.406656501	-8.899664955
10	IBR09	IBR09_B1	7	6644	-1.381	0.034	-9.932	8.343	-1.291092088	-9.88267168
11	IBR09	IBR09_V4	7	7498	0.516	0.046	-9.899	8.614	0.611146356	-9.849263625
12	IBR09	IBR09_B2	7	5495	-0.219	0.048	-8.976	8.114	-0.125883299	-8.914850435
13	IBR09	IBR09_B3	7	5687	-0.121	0.042	-9.189	8.143	-0.027612679	-9.130484248
14	IBR09	IBR09_B4	7	7420	1.647	0.029	-8.98	8.586	1.74526954	-8.918899896
15	IBR09	IBR09_V5	7	4634	-1.392	0.046	-9.933	8	-1.302122464	-9.883684046
16	IBR09	IBR09_V6	7	4309	-0.699	0.076	-9.701	7.843	-0.607208789	-9.648815292
17	42874	NOCZ	7	7374	2.129	0.045	-2.06	8.643	2.228600552	-1.913331887
18	IBR09	IBR09_V7	7	3737	-2.345	0.056	-9.561	7.843	-2.257754112	-9.507084147
19	IBR09	IBR09_B5	7	4844	-1.333	0.051	-8.99	8.143	-1.242959539	-8.92902355
20	IBR09	IBR09_V8	7	3468	0.676	0.042	-8.199	7.814	0.771588186	-8.128242582
21	IBR09	IBR09_V9	7	3863	-2.786	0.074	-9.828	7.871	-2.699971905	-9.777385687
22	IBR09	IBR09_V10	7	6096	-0.559	0.042	-10.313	8.457	-0.466822188	-10.26838287
23	IBR09	IBR09_B6	7	6491	0.203	0.028	-10.325	8.671	0.297282027	-10.28053125
24	IBR22	IBR22_B1	7	8106	2.155	0.035	-10.184	9.086	2.25467235	-10.13778774
25	IBR22	IBR22_B2	7	7687	2.234	0.025	-10.263	9.114	2.333890503	-10.2177646
26	IBR22	IBR22_B3	7	9410	2.289	0.03	-10.3	9.543	2.389042382	-10.25522212
27	IBR22	IBR22_B4	7	8956	2.311	0.034	-10.307	9.529	2.411103134	-10.26230868
28	42874	NBS-18-granular	7	7505	-5.074	0.044	-23.109	9.171	-4.994290071	-23.22260949
29	42874	NBS-19-grain	7	9785	1.923	0.027	-2.231	9.8	2.022031696	-2.086446357
30	IBR22	IBR22_B5	7	8979	2.282	0.043	-10.207	9.743	2.382023052	-10.16107214
31	IBR22	IBR22_V1	7	5973	2.168	0.038	-9.926	9.143	2.267708248	-9.876597488
32	IBR22	IBR22_V2	7	6412	2.216	0.05	-10.234	9.271	2.315840797	-10.18840601
33	IBR22	IBR22_V3	7	8005	2.235	0.042	-10.015	9.686	2.334893264	-9.966698002
34	IBR22	IBR22_V4	7	5913	2.219	0.054	-10.187	9.129	2.318849082	-10.14082484
35	IBR23	IBR23_B1	7	8022	2.22	0.031	-9.707	9.586	2.319851843	-9.654889483
36	IBR23	IBR23_B2	7	6628	2.24	0.036	-9.636	9.229	2.339907072	-9.583011546
37	IBR23	IBR23_B3	7	5806	2.204	0.038	-10.184	8.986	2.30380766	-10.13778774
38	IBR23	IBR23_B4	7	7685	2.146	0.022	-9.921	9.4	2.245647497	-9.871535662
39	IBR23	IBR23_B5	7	7015	2.182	0.045	-9.922	9.257	2.281746908	-9.872548027
40	42874	NOCZ	7	9792	2.14	0.033	-1.885	10	2.239630928	-1.736167956
41	IBR25	IBR25_B1	7	7097	2.38	0.045	-11.199	9.371	2.480293673	-11.16533854
42	IBR25	IBR25_V1	7	6261	2.288	0.035	-11.255	9.157	2.388039621	-11.222031
43	IBR25	IBR25_B2	7	7154	2.261	0.05	-11.27	9.343	2.360965062	-11.23721648
44	IBR25	IBR25_B3	7	8673	2.346	0.033	-11.179	9.786	2.446199784	-11.14509123
45	IBR25	IBR25_B4	7	7306	2.307	0.03	-11.203	9.443	2.407092088	-11.169388
46	IBR25	IBR25_V2	7	6236	2.363	0.039	-11.236	9.129	2.463246728	-11.20279606
47	IBR25	IBR25_B5	7	6483	2.5	0.064	-11.179	9.157	2.600625045	-11.14509123
48	IBR31	IBR31_B1	7	5539	-1.276	0.04	-8.684	8.929	-1.185802137	-8.619239762
49	IBR31	IBR31_V1	7	5259	-0.687	0.058	-9.078	8.871	-0.595175651	-9.018111698
50	IBR31	IBR31_B2	7	6561	0.121	0.059	-9.475	9.157	0.215055589	-9.420020729
51	42874	NBS-18-granular	7	8783	-5.072	0.026	-23.11	9.686	-4.992284548	-23.23262186

Row	Identifier 1	Identifier 2	Peak Count	Ampl.44	Mean d13C/12C	s.d.	Mean d18O/16O	BGD_44	Corrected δ13C/12C	Corrected δ18O/16O
52	42874	NBS-19-grain	7	6887	1.86	0.046	-2.368	9.243	1.958857726	-2.225140405
53	IBR31	IBR31_B3	7	6296	0.146	0.038	-9.315	9.086	0.240124625	-9.258042278
54	IBR31	IBR31_B4	7	5512	0.088	0.063	-9.449	8.871	0.181964462	-9.393699231
55	IBR34A	IBR34A_B1	7	8797	1.287	0.016	-9.758	9.757	1.384275423	-9.706520115
56	IBR34A	IBR34A_B2	7	9559	1.336	0.026	-9.737	10	1.433410734	-9.685260443
57	IBR34A	IBR34A_B3	7	9047	1.254	0.041	-9.777	9.971	1.351184296	-9.725755056
58	IBR34A	IBR34A_B4	7	7170	1.405	0.053	-9.979	9.514	1.502601273	-9.93025285
59	IBR34A	IBR34A_B5	7	8166	1.424	0.03	-9.873	9.7	1.52165374	-9.822942126
60	IBR48B	IBR48B_V1	7	6465	-8.25	0.04	-10.061	9.214	-8.179060391	-10.01326681
61	IBR48B	IBR48B_V2	7	6260	-8.769	0.039	-10.188	9.1	-8.699493577	-10.1418372
62	IBR48B	IBR48B_V3	7	4412	-10.235	0.059	-10.1	8.571	-10.16954184	-10.05274905
63	42874	NBS-19-granular	7	6084	1.817	0.05	-2.433	8.986	1.915738984	-2.290944151
64	42874	NOCZ	7	6802	2.073	0.032	-2.043	9.229	2.172445912	-1.896121677
65	IBR48B	IBR48B_V4	7	3814	-9.2	0.083	-10.16	8.457	-9.131683756	-10.11349097
66	IBR48B	IBR48B_B1	7	4198	-10.838	0.056	-9.958	8.529	-10.77420699	-9.908993179
67	IBR48B	IBR48B_B2	7	3701	-11.214	0.047	-9.924	8.4	-11.15124529	-9.874572758
68	IBR48B	IBR48B_B3	7	3414	-11.059	0.082	-10.099	8.257	-10.99581726	-10.05173669
69	IBR48B	IBR48B_B4	7	3495	-11.046	0.057	-10.17	8.3	-10.98278137	-10.12361463
70	IBR53A	IBR53A_V1	7	7354	-8.211	0.02	-11.865	9.243	-8.139952695	-11.83957384
71	IBR53A	IBR53A_V2	7	9107	-8.765	0.023	-11.95	9.8	-8.695482531	-11.92562489
72	IBR53A	IBR53A_V3	7	9917	-8.105	0.016	-11.899	10.071	-8.033659983	-11.87399426
73	IBR53A	IBR53A_V4	7	8528	-8.381	0.034	-11.91	9.843	-8.31042214	-11.88513028
74	IBR53A	IBR53A_V5	7	7757	-8.617	0.028	-11.917	9.671	-8.547073838	-11.89221684
75	42874	NBS-18-granular	7	7786	-5.12	0.025	-22.791	9.671	-5.040417097	-22.90067732
76	IBR53A	IBR53A_B1	7	2032	-9.065	0.082	-12.035	8.171	-8.996310962	-12.01167595
77	IBR53A	IBR53A_V6	7	6703	-10.776	0.026	-11.8	9.257	-10.71203578	-11.7737701
78	IBR53A	IBR53A_V7	7	5593	-10.188	0.037	-11.952	9.043	-10.12241205	-11.92764963
79	IBR53A	IBR53A_B2	7	2884	-9.263	0.08	-11.804	8.371	-9.194857726	-11.77781956
80	IBR53A	IBR53A_B3	7	1839	-8.9	0.074	-11.963	7.971	-8.830855325	-11.93878564
81	IBR53A	IBR53A_V8	7	4089	-8.084	0.058	-12.545	8.514	-8.012601993	-12.52798226
82	IBR129A	IBR129A_V1	7	7541	-7.43	0.037	-8.889	9.5	-7.356796014	-8.826774652
83	IBR129A	IBR129A_V2	7	3844	-7.729	0.073	-9.721	8.557	-7.656621683	-9.669062598
84	IBR129A	IBR129A_V3	7	7078	-6.783	0.03	-9.867	9.286	-6.708009365	-9.816867935
85	IBR129A	IBR129A_V4	7	667	-7.753	0.137	-11.115	7.586	-7.680687958	-11.08029985
86	42874	NBS-19-grain	7	5657	1.724	0.047	-2.332	8.871	1.822482171	-2.188695254
87	42874	NBS-18-granular	7	6299	-5.158	0.032	-23.066	9.186	-5.078522031	-23.17907778
88	IBR129A	IBR129A_B1	7	9765	-6.93	0.028	-9.844	10.086	-6.855415296	-9.793583532
89	IBR129A	IBR129A_V5	7	112	-11.139	0.411	-13.513	7.657	-11.07603818	-13.50795189
90	IBR129A	IBR129A_V6	7	9383	-6.9	0.024	-9.869	9.971	-6.825332453	-9.818892665
91	IBR129A	IBR129A_B2	7	9840	-6.803	0.024	-9.838	10.257	-6.728064594	-9.78750934
92	IBR129A	IBR129A_B3	6	3053	-5.905	0.066	-9.245	8.367	-5.827584824	-9.187176706
93	IBR140	IBR140_V1	6	3129	-8.965	0.071	-5.87	8.367	-8.896034818	-5.770443753
94	IBR140	IBR140_V2	6	3170	-9.158	0.058	-5.864	8.25	-9.089567775	-5.764369562
1	42919	NOCZ	6	4567	1.955	0.027	-1.844	0.035	2.177654928	-1.986464692
2	42919	NOCZ	6	5060	1.951	0.031	-1.838	0.033	2.173628607	-1.980392598
3	42919	NBS-18-granular	6	5014	-5.173	0.019	-22.952	0.037	-4.997249982	-23.34809163
4	42919	NBS-18-granular	6	5724	-5.191	0.028	-22.9	0.043	-5.015368429	-23.29546681
5	42919	NBS-19-grain	6	4984	1.734	0.041	-2.057	0.042	1.955200665	-2.202024031
6	42919	NBS-19-grain	6	4424	1.742	0.019	-2.091	0.049	1.963253308	-2.236432564
7	IBR140	IBR140-v3	6	5754	-9.114	0.027	-5.41	0.039	-8.964183238	-5.5953126
8	IBR140	IBR140-v4	6	5690	-9.041	0.021	-5.279	0.02	-8.890702871	-5.462738547

Row	Identifier 1	Identifier 2	Peak Count	Ampl.44	Mean d13C/12C	s.d.	Mean d18O/16O	BGD_44	Corrected δ13C/12C	Corrected δ18O/16O
9	IBR140	IBR140-v5	6	6500	-8.867	0.01	-5.081	0.035	-8.715557886	-5.262359442
10	IBR140	IBR140-v6	6	5774	-8.778	0.035	-5.423	0.03	-8.625972232	-5.608468804
11	IBR140	IBR140-b1	6	4931	-8.996	0.06	-5.207	0.034	-8.845406754	-5.389873418
12	IBR140	IBR140-b2	6	3218	-8.744	0.044	-3.649	0.052	-8.5917485	-3.813152991
13	IBR140	IBR140-b3	6	5875	-9.107	0.029	-4.989	0.022	-8.957137176	-5.169254
14	IBR140	IBR140-b4	6	4253	-8.955	0.049	-5.538	0.046	-8.804136959	-5.724850607
15	IBR140	IBR140-b5	6	5710	-9.084	0.028	-4.702	0.033	-8.933985827	-4.8788055
16	IBR149	IBR149-v1	6	4957	0.733	0.032	-4.224	0.047	0.94761371	-4.395062006
17	42919	NOCZ	6	5093	1.999	0.031	-1.852	0.049	2.221944465	-1.994560817
18	IBR149	IBR149-v2	6	4395	0.701	0.052	-4.479	0.034	0.915403138	-4.653126004
19	IBR149	IBR149-v3	6	4711	0.294	0.05	-4.877	0.035	0.505724926	-5.055908244
20	IBR149	IBR149-v4	6	4276	0.591	0.017	-4.505	0.028	0.804679297	-4.679438412
21	IBR149	IBR149-v5	6	5702	0.626	0.038	-4.387	0.035	0.83990961	-4.560020562
22	IBR149	IBR149-v6	6	4919	-1.016	0.049	-6.003	0.039	-0.812895365	-6.195437898
23	IBR149	IBR149-v7	6	7473	0.377	0.02	-4.398	0.023	0.589271097	-4.571152734
24	IBR149	IBR149-b1	6	5767	0.716	0.033	-4.298	0.065	0.930501844	-4.469951166
25	IBR149	IBR149-b2	6	5795	0.672	0.049	-4.364	0.042	0.886212307	-4.536744201
26	IBR152	IBR152-v1	6	7823	-1.459	0.014	-9.936	0.032	-1.258810471	-10.17569556
27	IBR152	IBR152-v2	6	8070	-1.82	0.021	-9.705	0.022	-1.622185986	-9.941919938
28	42919	NBS-18-granular	6	6969	-5.151	0.013	-22.848	0.021	-4.975105214	-23.242842
29	42919	NBS-19-grain	6	7236	1.778	0.025	-1.929	0.039	1.999490202	-2.072486025
30	IBR152	IBR152-v3	6	6482	-1.941	0.029	-9.188	0.036	-1.743982211	-9.418707833
31	IBR152	IBR152-v4	6	5944	-2.855	0.038	-9.074	0.053	-2.663996674	-9.303338045
32	IBR152	IBR152-b1	6	3721	-0.219	0.049	-5.55	0.022	-0.010650806	-5.736994795
33	IBR152	IBR152-b2	6	3486	-0.291	0.062	-5.515	0.042	-0.083124593	-5.701574247
34	IBR152	IBR152-b3	6	3143	0.193	0.057	-5.485	0.052	0.404060308	-5.671213776
35	IBR152	IBR152-b4	6	3330	-0.303	0.053	-5.417	0.029	-0.095203558	-5.60239671
36	IBR152	IBR152-b5	6	3301	0.106	0.067	-5.274	0.042	0.316487815	-5.457678468
37	IBR166C	IBR166C-b1	6	3133	-7.795	0.065	-4.508	0.05	-7.636503724	-4.682474459
38	IBR166C	IBR166C-b2	6	3731	-8.413	0.036	-4.337	0.034	-8.258570396	-4.509419778
39	IBR166C	IBR166C-b3	6	3833	-8.191	0.059	-4.43	0.065	-8.035109552	-4.603537236
40	42919	NOCZ	6	7315	1.985	0.04	-1.623	0.023	2.207852339	-1.762809227
41	IBR166C	IBR166C-b4	6	4646	-8.099	0.04	-4.175	0.032	-7.942504158	-4.345473238
42	IBR166C	IBR166C-b5	6	4192	-7.861	0.057	-4.232	0.051	-7.702938029	-4.403158131
43	IBR167	IBR167-c1	6	6622	-0.112	0.042	-7.132	0.034	0.097053294	-7.338003598
44	IBR167	IBR167-c2	6	7429	-0.259	0.024	-7.133	0.024	-0.050914021	-7.339015614
45	IBR167	IBR167-c3	6	7712	-0.02	0.029	-7.137	0.02	0.189658688	-7.343063677
46	IBR167	IBR167-v1	6	6544	1.93	0.013	-4.49	0.037	2.152490419	-4.664258176
47	IBR167	IBR167-v2	6	5750	2.025	0.032	-3.813	0.036	2.248115554	-3.979123562
48	IBR167	IBR167-v3	6	4705	1.865	0.04	-5.337	0.031	2.087062694	-5.521435456
49	IBR167	IBR167-v4	6	6153	2.179	0.028	-4.287	0.03	2.403128932	-4.458818994
50	IBR167	IBR167-v5	6	5417	2.025	0.035	-4.218	0.05	2.248115554	-4.388989912
51	42919	NBS-18-granular	6	4980	-5.181	0.036	-22.77	0.054	-5.005302625	-23.16390477
52	42919	NBS-19-grain	6	5592	1.72	0.014	-2.058	0.021	1.94110854	-2.203036047
53	IBR167	IBR167-v6	6	5563	1.769	0.039	-4.761	0.022	1.990430978	-4.938514425
54	IBR167	IBR167-b1	6	4725	1.98	0.043	-4.138	0.054	2.202819437	-4.308028658
55	IBR167	IBR167-b2	6	6235	2.061	0.022	-3.674	0.016	2.284352448	-3.838453383
56	IBR167	IBR167-b3	6	6304	2.204	0.023	-3.824	0.029	2.428293441	-3.990255735
57	IBR167	IBR167-b4	6	7772	2.094	0.012	-3.912	0.03	2.3175696	-4.079313114
58	IBR167	IBR167-b5	6	7290	1.898	0.022	-4.47	0.049	2.120279847	-4.644017863

Appendix 5: Detrital zircon U-Pb ages of the analysed samples from the Indo-Burman Ranges

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	±1s	Pb206/U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
IBR01	1	0.00001	0.00031	0.00001	0.02064	128.00	0.0984	0.0021	0.0150	0.0003	0.88	-14.17	0.48	84	49	95	4	96	4	96	4	0.63	96	4
IBR01	2	0.00001	0.00075	0.00003	0.06640	411.90	0.0739	0.0015	0.0114	0.0002	0.93	-35.77	0.78	54	35	72	3	73	3	73	3	0.27	73	3
IBR01	3	0.00001	0.00031	0.00001	0.03076	190.80	0.0663	0.0014	0.0102	0.0002	0.86	-2.93	0.08	63	51	65	3	65	2	65	2	0.94	65	2
IBR01	4	0.00000	0.00073	0.00003	0.04170	258.50	0.1162	0.0023	0.0175	0.0003	0.93	0.76	-0.03	112	35	112	4	112	4	112	4	0.96	112	4
IBR01	5	0.00000	0.00747	0.00123	0.01621	100.60	12.1436	0.2354	0.4589	0.0085	0.96	11.75	-7.43	2759	20	2616	37	2435	75	2740	18	0.00	2759	20
IBR01	6	-0.00001	0.00069	0.00003	0.05320	330.30	0.0839	0.0018	0.0130	0.0003	0.94	-72.39	1.40	48	36	82	3	83	3	83	3	0.05	83	3
IBR01	7	-0.00001	0.00090	0.00004	0.07920	492.00	0.0743	0.0015	0.0113	0.0002	0.94	11.43	-0.38	82	35	73	3	72	3	73	3	0.59	72	3
IBR01	8	0.00000	0.00029	0.00001	0.02045	126.90	0.0936	0.0020	0.0146	0.0003	0.88	-188.09	2.41	32	47	91	4	93	3	93	3	0.01	93	3
IBR01	9	0.00001	0.00048	0.00002	0.07090	439.80	0.0447	0.0009	0.0068	0.0001	0.90	32.67	-0.88	65	41	44	2	44	2	44	2	0.31	44	2
IBR01	10	0.00002	0.00063	0.00003	0.02112	131.10	0.2049	0.0041	0.0299	0.0006	0.93	-4.70	0.33	181	35	189	7	190	7	190	7	0.63	190	7
IBR01	11	0.00002	0.00049	0.00002	0.03530	225.00	0.0934	0.0020	0.0142	0.0003	0.91	-2.78	0.10	88	42	91	4	91	3	91	3	0.91	91	3
IBR01	12	0.00001	0.00056	0.00002	0.03800	242.00	0.1027	0.0022	0.0149	0.0003	0.89	51.22	-4.15	195	47	99	4	95	4	95	4	0.00	95	4
IBR01	13	0.00002	0.00027	0.00001	0.01876	119.80	0.0955	0.0022	0.0148	0.0003	0.86	-104.67	1.92	46	56	93	4	94	4	94	4	0.08	94	4
IBR01	14	0.00002	0.00058	0.00002	0.04200	268.80	0.0945	0.0020	0.0141	0.0003	0.92	26.56	-1.33	123	40	92	4	90	3	91	3	0.10	90	3
IBR01	16	0.00003	0.00266	0.00011	0.25020	1604.00	0.0711	0.0014	0.0108	0.0002	0.95	16.84	-0.57	83	30	70	3	69	3	69	3	0.35	69	3
IBR01	17	0.00003	0.00031	0.00001	0.02359	151.50	0.0892	0.0020	0.0136	0.0003	0.90	-1.74	0.06	85	46	87	4	87	3	87	3	0.95	87	3
IBR01	18	0.00002	0.00029	0.00001	0.01904	122.50	0.1040	0.0022	0.0156	0.0003	0.90	9.05	-0.40	110	45	100	4	100	4	100	4	0.66	100	4
IBR01	19	0.00001	0.00012	0.00000	0.00984	63.40	0.0824	0.0021	0.0126	0.0003	0.79	-2.67	0.08	78	75	80	4	80	3	80	3	0.96	80	3
IBR01	20	0.00001	0.00015	0.00001	0.01186	76.50	0.0866	0.0021	0.0133	0.0003	0.82	-34.29	0.87	63	66	84	4	85	3	85	3	0.51	85	3
IBR01	21	0.00001	0.00140	0.00006	0.10970	709.00	0.0856	0.0017	0.0130	0.0002	0.94	6.32	-0.23	89	32	83	3	83	3	83	3	0.73	83	3
IBR01	22	0.00002	0.00017	0.00001	0.02080	134.70	0.0559	0.0013	0.0084	0.0002	0.82	49.97	-2.24	108	64	55	3	54	2	54	2	0.10	54	2
IBR01	23	0.00002	0.00034	0.00001	0.01663	107.80	0.1415	0.0031	0.0208	0.0004	0.90	21.20	-1.44	168	45	134	5	133	5	133	5	0.12	133	5
IBR01	24	0.00003	0.00172	0.00008	0.03970	258.00	0.3347	0.0070	0.0443	0.0009	0.92	30.73	-4.89	403	37	293	11	279	10	285	11	0.00	279	10
IBR01	25	0.00002	0.01220	0.00164	0.03170	206.10	8.5990	0.1808	0.3952	0.0080	0.96	11.73	-6.97	2432	20	2296	38	2147	74	2415	18	0.00	2432	20
IBR01	26	0.00001	0.00024	0.00001	0.02091	136.20	0.0766	0.0021	0.0116	0.0003	0.88	20.29	-0.77	93	59	75	4	74	4	74	4	0.53	74	4
IBR01	27	0.00001	0.00286	0.00014	0.04203	274.20	0.5358	0.0109	0.0699	0.0014	0.95	0.38	-0.06	437	28	436	14	435	16	436	14	0.92	435	16
IBR01	28	0.00001	0.00035	0.00001	0.02548	166.50	0.0920	0.0020	0.0141	0.0003	0.89	-32.83	0.89	68	48	89	4	90	3	90	3	0.35	90	3
IBR01	30	0.00001	0.00012	0.00000	0.01041	68.20	0.0756	0.0020	0.0113	0.0002	0.75	38.30	-1.86	118	83	74	4	73	3	73	3	0.28	73	3
IBR01	31	0.00002	0.00050	0.00002	0.04780	314.00	0.0692	0.0015	0.0105	0.0002	0.92	20.95	-0.73	85	40	68	3	67	3	68	3	0.38	67	3
IBR01	32	0.00002	0.00174	0.00007	0.12000	804.00	0.1000	0.0019	0.0150	0.0003	0.94	20.95	-1.03	121	31	97	4	96	3	96	3	0.10	96	3
IBR01	33	0.00001	0.00043	0.00002	0.05450	366.00	0.0540	0.0011	0.0082	0.0002	0.90	45.47	-1.81	96	41	53	2	52	2	52	2	0.04	52	2
IBR01	34	0.00001	0.00824	0.00056	0.04213	283.20	2.2260	0.0433	0.2023	0.0038	0.95	0.38	-0.13	1192	24	1189	27	1188	40	1191	20	0.85	1188	40
IBR01	35	0.00001	0.00302	0.00013	0.22160	1492.00	0.0953	0.0019	0.0140	0.0003	0.93	47.41	-3.33	170	35	92	4	89	3	90	3	0.00	89	3
IBR01	37	0.00001	0.00107	0.00004	0.10720	723.00	0.0681	0.0013	0.0103	0.0002	0.94	26.67	-0.99	90	33	67	3	66	2	66	2	0.15	66	2
IBR01	38	0.00002	0.00094	0.00004	0.06752	456.70	0.0971	0.0019	0.0143	0.0003	0.93	41.76	-2.70	157	34	94	4	92	3	92	3	0.00	92	3
IBR01	40	0.00001	0.00023	0.00001	0.01573	106.50	0.0979	0.0022	0.0148	0.0003	0.85	1.01	-0.04	96	54	95	4	95	4	95	4	0.97	95	4
IBR01	41	0.00001	0.00049	0.00002	0.03554	240.70	0.0960	0.0020	0.0143	0.0003	0.92	27.80	-1.44	127	39	93	4	92	3	92	3	0.07	92	3
IBR01	42	0.00001	0.00045	0.00002	0.01944	131.80	0.1661	0.0037	0.0238	0.0005	0.93	32.61	-2.97	225	38	156	6	152	6	152	6	0.00	152	6
IBR01	43	0.00001	0.00057	0.00002	0.07450	505.00	0.0520	0.0011	0.0078	0.0001	0.91	57.88	-2.87	119	40	51	2	50	2	50	2	0.00	50	2
IBR01	44	0.00001	0.00094	0.00004	0.14210	965.00	0.0445	0.0009	0.0068	0.0001	0.94	30.22	-0.78	63	34	44	2	44	2	44	2	0.27	44	2
IBR01	46	0.00002	0.00056	0.00002	0.04000	272.00	0.0967	0.0020	0.0145	0.0003	0.91	23.60	-1.16	121	39	94	4	93	3	93	3	0.15	93	3

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages										Preferred	
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s	
IBR01	47	0.00002	0.00074	0.00003	0.06980	474.30	0.0728	0.0014	0.0111	0.0002	0.93	11.52	-0.38	80	35	71	3	71	3	71	3	0.59	71	3	
IBR01	48	0.00002	0.00013	0.00001	0.00994	67.70	0.0890	0.0021	0.0136	0.0003	0.79	-10.88	0.34	78	70	87	4	87	3	87	3	0.81	87	3	
IBR01	50	0.00001	0.00105	0.00004	0.12960	883.00	0.0556	0.0011	0.0083	0.0002	0.94	55.52	-2.78	120	33	55	2	53	2	53	2	0.00	53	2	
IBR01	51	0.00001	0.00069	0.00003	0.04810	328.00	0.1003	0.0020	0.0150	0.0003	0.93	25.73	-1.35	129	35	97	4	96	4	96	4	0.06	96	4	
IBR01	52	0.00002	0.00053	0.00002	0.03397	223.50	0.1093	0.0022	0.0165	0.0003	0.91	-1.69	0.07	104	39	105	4	105	4	105	4	0.93	105	4	
IBR01	54	0.00002	0.00303	0.00023	0.01572	103.20	2.5098	0.0553	0.2037	0.0038	0.85	15.35	-6.67	1412	45	1275	32	1195	41	1287	34	0.00	1412	45	
IBR01	55	0.00002	0.00152	0.00006	0.07680	504.00	0.1436	0.0029	0.0212	0.0004	0.94	14.94	-0.95	159	32	136	5	135	5	135	5	0.15	135	5	
IBR01	56	0.00002	0.00058	0.00002	0.05920	388.40	0.0675	0.0014	0.0102	0.0002	0.92	37.64	-1.62	105	37	66	3	65	2	65	2	0.03	65	2	
IBR01	57	0.00003	0.00090	0.00004	0.13950	914.00	0.0450	0.0009	0.0068	0.0001	0.93	58.37	-2.55	105	34	45	2	44	2	43	2	0.00	44	2	
IBR01	58	0.00002	0.00098	0.00009	0.00344	22.54	4.2442	0.0828	0.2978	0.0055	0.95	0.30	-0.13	1685	24	1683	32	1680	55	1685	22	0.87	1685	24	
IBR01	59	0.00002	0.00016	0.00001	0.01967	128.60	0.0545	0.0012	0.0083	0.0002	0.83	21.63	-0.61	68	60	54	2	54	2	54	2	0.63	54	2	
IBR01	60	0.00002	0.00025	0.00001	0.01966	128.50	0.0924	0.0020	0.0138	0.0003	0.88	26.61	-1.31	121	49	90	4	89	3	89	3	0.19	89	3	
IBR01	62	0.00001	0.00088	0.00004	0.07430	485.00	0.0825	0.0017	0.0126	0.0002	0.93	-15.72	0.44	70	36	80	3	81	3	81	3	0.54	81	3	
IBR01	63	0.00002	0.00035	0.00001	0.03667	239.20	0.0663	0.0014	0.0101	0.0002	0.89	17.82	-0.57	79	46	65	3	65	2	65	2	0.54	65	2	
IBR01	64	0.00002	0.00034	0.00001	0.04520	294.60	0.0523	0.0011	0.0079	0.0002	0.89	49.87	-2.09	101	45	52	2	51	2	51	2	0.03	51	2	
IBR01	66	0.00003	0.00067	0.00003	0.05390	351.00	0.0889	0.0018	0.0133	0.0003	0.93	29.68	-1.47	121	36	86	3	85	3	85	3	0.05	85	3	
IBR01	67	0.00002	0.00425	0.00020	0.07660	499.00	0.4349	0.0086	0.0586	0.0011	0.95	-0.78	0.11	364	28	367	12	367	13	367	12	0.85	367	13	
IBR01	68	0.00002	0.00164	0.00007	0.04850	315.30	0.2522	0.0052	0.0360	0.0007	0.95	3.41	-0.31	236	31	228	8	228	9	228	8	0.61	228	9	
IBR01	69	0.00001	0.00055	0.00002	0.03240	211.00	0.1181	0.0024	0.0179	0.0003	0.91	-28.99	1.02	89	40	113	4	115	4	114	4	0.20	115	4	
IBR01	70	0.00001	0.00012	0.00000	0.01837	119.30	0.0430	0.0012	0.0066	0.0001	0.70	11.34	-0.22	48	92	43	2	43	2	43	2	0.91	43	2	
IBR01	71	0.00002	0.00239	0.00010	0.16500	1071.00	0.1005	0.0020	0.0153	0.0003	0.95	-16.59	0.56	84	30	97	4	98	4	98	4	0.36	98	4	
IBR01	72	0.00002	0.00030	0.00001	0.02005	128.10	0.1086	0.0023	0.0162	0.0003	0.90	17.41	-0.88	126	45	105	4	104	4	104	4	0.33	104	4	
IBR01	73	0.00002	0.00054	0.00002	0.05280	337.30	0.0707	0.0015	0.0109	0.0002	0.92	-8.98	0.23	64	39	69	3	70	3	70	3	0.77	70	3	
IBR01	74	0.00001	0.00016	0.00001	0.01060	67.70	0.1064	0.0025	0.0158	0.0003	0.82	26.24	-1.46	137	63	103	5	101	4	101	4	0.26	101	4	
IBR01	75	0.00001	0.00015	0.00001	0.02078	132.60	0.0487	0.0012	0.0077	0.0002	0.81	-61947358.58	2.76	0	93	48	2	50	2	50	2	0.04	50	2	
IBR01	76	0.00002	0.00117	0.00005	0.08950	571.00	0.0933	0.0019	0.0141	0.0003	0.94	4.04	-0.15	94	33	91	4	90	3	90	3	0.82	90	3	
IBR01	77	0.00002	0.00025	0.00001	0.03440	219.80	0.0498	0.0011	0.0077	0.0002	0.89	-4.77	0.09	47	48	49	2	49	2	49	2	0.93	49	2	
IBR01	78	0.00003	0.00217	0.00009	0.33920	2164.00	0.0443	0.0009	0.0068	0.0001	0.95	11.67	-0.24	50	31	44	2	44	2	44	2	0.71	44	2	
IBR01	79	0.00003	0.00027	0.00001	0.02222	141.70	0.0872	0.0019	0.0130	0.0003	0.90	39.23	-2.20	137	46	85	4	83	3	83	3	0.02	83	3	
IBR01	80	0.00003	0.00044	0.00002	0.04160	265.30	0.0739	0.0016	0.0112	0.0002	0.91	18.56	-0.67	88	41	72	3	72	3	72	3	0.43	72	3	
IBR01	81	0.00002	0.00078	0.00003	0.06270	399.50	0.0892	0.0019	0.0136	0.0003	0.93	-21.43	0.62	72	36	87	3	87	3	87	3	0.39	87	3	
IBR01	82	0.00002	0.00016	0.00001	0.01340	85.10	0.0841	0.0020	0.0130	0.0003	0.82	-120.03	1.82	38	67	82	4	84	3	83	3	0.17	84	3	
IBR01	83	0.00002	0.00041	0.00002	0.04096	261.00	0.0695	0.0015	0.0106	0.0002	0.90	4.49	-0.13	71	46	68	3	68	3	68	3	0.89	68	3	
IBR01	84	0.00002	0.00031	0.00001	0.02221	141.50	0.1009	0.0022	0.0152	0.0003	0.91	14.90	-0.69	114	44	98	4	97	4	97	4	0.44	97	4	
IBR01	85	0.00003	0.00013	0.00001	0.02134	136.00	0.0462	0.0012	0.0069	0.0001	0.77	68.96	-4.13	142	77	46	2	44	2	44	2	0.01	44	2	
IBR01	86	0.00002	0.00048	0.00002	0.03030	193.00	0.1171	0.0025	0.0172	0.0003	0.92	36.21	-2.54	172	39	112	4	110	4	110	4	0.00	110	4	
IBR01	87	0.00002	0.00021	0.00001	0.03057	194.60	0.0477	0.0011	0.0075	0.0002	0.88	-193.24	1.28	16	52	47	2	48	2	48	2	0.22	48	2	
IBR01	88	0.00002	0.00060	0.00002	0.06430	409.00	0.0655	0.0014	0.0100	0.0002	0.93	2.29	-0.06	66	37	64	3	64	2	64	2	0.94	64	2	
IBR01	89	0.00002	0.00029	0.00001	0.01774	112.90	0.1163	0.0026	0.0175	0.0004	0.89	-3.11	0.14	109	48	112	5	112	4	112	4	0.89	112	4	
IBR01	90	0.00002	0.00038	0.00002	0.04000	254.90	0.0673	0.0015	0.0102	0.0002	0.92	36.20	-1.52	102	42	66	3	65	3	65	3	0.08	65	3	
IBR01	91	0.00002	0.00044	0.00002	0.03736	237.80	0.0843	0.0018	0.0128	0.0003	0.92	9.34	-0.34	90	38	82	3	82	3	82	3	0.66	82	3	

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR01	94	0.00002	0.00092	0.00004	0.08800	565.00	0.0746	0.0017	0.0114	0.0002	0.94	-16.72	0.42	63	36	73	3	73	3	73	3	0.55	73	3
IBR01	95	0.00001	0.00044	0.00002	0.03014	193.50	0.1083	0.0024	0.0163	0.0003	0.93	6.13	-0.27	111	40	104	4	104	4	104	4	0.73	104	4
IBR01	96	0.00001	0.00073	0.00003	0.05180	333.00	0.1031	0.0022	0.0155	0.0003	0.93	8.93	-0.39	109	37	100	4	99	4	99	4	0.60	99	4
IBR01	97	0.00000	0.00025	0.00001	0.01943	125.00	0.0888	0.0021	0.0139	0.0003	0.89	-344.84	2.73	20	52	86	4	89	4	88	4	0.01	89	4
IBR01	98	0.00000	0.00039	0.00002	0.04600	296.00	0.0614	0.0013	0.0093	0.0002	0.91	40.62	-1.68	100	43	60	3	59	2	60	2	0.06	59	2
IBR01	99	0.00000	0.00031	0.00001	0.02809	180.90	0.0772	0.0018	0.0120	0.0002	0.90	-123.52	1.70	34	49	76	3	77	3	77	3	0.08	77	3
IBR01	100	0.00001	0.00105	0.00004	0.10420	672.00	0.0707	0.0015	0.0109	0.0002	0.94	-28.73	0.63	54	35	69	3	70	3	70	3	0.38	70	3
IBR01	101	0.00001	0.00049	0.00002	0.01322	85.30	0.2926	0.0065	0.0415	0.0009	0.92	-4.85	0.46	250	40	261	10	262	11	261	10	0.56	262	11
IBR01	102	0.00002	0.00045	0.00002	0.02821	182.20	0.1171	0.0025	0.0174	0.0004	0.93	22.34	-1.29	143	39	112	5	111	4	111	4	0.10	111	4
IBR01	103	0.00002	0.00070	0.00003	0.11310	731.00	0.0449	0.0009	0.0068	0.0001	0.94	46.07	-1.55	81	36	45	2	44	2	44	2	0.04	44	2
IBR01	104	0.00001	0.00061	0.00002	0.06560	424.30	0.0665	0.0014	0.0103	0.0002	0.92	-33.83	0.67	49	40	65	3	66	3	66	3	0.40	66	3
IBR01	105	0.00001	0.00029	0.00001	0.04710	304.70	0.0432	0.0009	0.0068	0.0001	0.87	-896.27	1.59	4	51	43	2	44	2	44	2	0.12	44	2
IBR01	106	0.00000	0.00046	0.00002	0.03520	228.20	0.0928	0.0020	0.0143	0.0003	0.92	-86.41	1.69	49	39	90	4	92	4	91	4	0.03	92	4
IBR01	107	0.00000	0.00047	0.00002	0.03374	218.90	0.1002	0.0022	0.0153	0.0003	0.90	-39.38	1.11	70	44	97	4	98	4	98	4	0.21	98	4
IBR01	108	0.00001	0.00017	0.00001	0.01671	108.50	0.0720	0.0017	0.0111	0.0002	0.82	-21.76	0.51	58	66	71	3	71	3	71	3	0.70	71	3
IBR01	109	0.00001	0.00036	0.00001	0.02570	167.20	0.1007	0.0022	0.0155	0.0003	0.91	-58.59	1.46	62	45	97	4	99	4	98	4	0.10	99	4
IBR01	110	0.00002	0.00022	0.00001	0.03502	228.10	0.0444	0.0011	0.0069	0.0001	0.84	-60.27	0.68	28	62	44	2	44	2	44	2	0.59	44	2
IBR01	111	0.00001	0.00010	0.00000	0.00666	44.40	0.1177	0.0033	0.0174	0.0004	0.75	26.67	-1.64	152	86	113	6	111	5	111	5	0.35	111	5
IBR01	112	0.00001	0.00060	0.00002	0.09160	611.00	0.0481	0.0011	0.0073	0.0002	0.94	42.21	-1.42	81	37	48	2	47	2	47	2	0.06	47	2
IBR01	113	0.00000	0.00057	0.00002	0.04280	286.00	0.0982	0.0022	0.0150	0.0003	0.93	-40.78	1.11	68	38	95	4	96	4	96	4	0.15	96	4
IBR01	114	0.00000	0.00031	0.00001	0.02383	159.50	0.0963	0.0023	0.0145	0.0003	0.90	13.71	-0.60	108	49	93	4	93	4	93	4	0.55	93	4
IBR01	115	0.00001	0.00022	0.00001	0.02382	159.60	0.0650	0.0015	0.0102	0.0002	0.84	-275.06	1.92	17	62	64	3	65	3	65	3	0.12	65	3
IBR01	116	0.00002	0.00120	0.00005	0.08950	601.00	0.1016	0.0024	0.0150	0.0003	0.96	36.59	-2.27	152	33	98	4	96	4	96	4	0.00	96	4
IBR11	1	0.00002	0.01454	0.00141	0.04840	334.00	5.2094	0.1055	0.3348	0.0065	0.96	-0.86	0.40	1846	22	1854	35	1862	63	1847	21	0.64	1846	22
IBR11	2	0.00002	0.00519	0.00033	0.03710	256.00	1.5589	0.0354	0.1552	0.0034	0.96	7.89	-2.58	1010	25	954	28	930	38	987	21	0.00	930	38
IBR11	3	0.00003	0.00077	0.00003	0.07820	541.00	0.0723	0.0016	0.0110	0.0002	0.94	20.36	-0.73	88	37	71	3	70	3	70	3	0.33	70	3
IBR11	4	0.00003	0.00045	0.00002	0.03000	208.00	0.1174	0.0028	0.0169	0.0004	0.91	48.90	-4.28	212	46	113	5	108	5	108	5	0.00	108	5
IBR11	5	0.00002	0.00089	0.00004	0.01466	101.70	0.5220	0.0125	0.0678	0.0016	0.95	5.14	-0.84	446	32	426	17	423	19	429	17	0.22	423	19
IBR11	6	0.00001	0.00010	0.00000	0.00741	51.40	0.1018	0.0031	0.0155	0.0004	0.75	-11.91	0.42	88	94	98	6	99	4	99	4	0.82	99	4
IBR11	7	0.00001	0.00104	0.00004	0.05370	374.00	0.1492	0.0034	0.0219	0.0005	0.95	19.41	-1.35	173	33	141	6	139	6	140	6	0.04	139	6
IBR11	8	0.00001	0.00095	0.00004	0.11940	831.00	0.0588	0.0013	0.0087	0.0002	0.91	63.92	-4.15	154	42	58	2	56	2	56	2	0.00	56	2
IBR11	9	0.00000	0.00063	0.00003	0.03160	219.80	0.1515	0.0035	0.0226	0.0005	0.95	-14.92	0.74	126	36	143	6	144	6	144	6	0.30	144	6
IBR11	10	0.00001	0.00182	0.00008	0.05380	375.00	0.2668	0.0060	0.0374	0.0008	0.95	13.85	-1.49	275	32	240	10	237	10	239	10	0.02	237	10
IBR11	11	0.00001	0.00036	0.00002	0.02754	192.20	0.0990	0.0023	0.0147	0.0003	0.91	30.84	-1.71	136	46	96	4	94	4	94	4	0.07	94	4
IBR11	12	0.00002	0.00122	0.00006	0.01297	90.70	0.8854	0.0195	0.1053	0.0022	0.95	-1.06	0.23	639	30	644	21	645	26	642	19	0.73	645	26
IBR11	13	0.00001	0.00363	0.00020	0.03297	232.90	1.1131	0.0229	0.1245	0.0025	0.96	1.66	-0.43	769	26	760	22	756	28	763	19	0.50	756	28
IBR11	14	0.00001	0.00053	0.00002	0.03780	267.10	0.1079	0.0024	0.0160	0.0003	0.94	25.79	-1.45	138	37	104	4	103	4	103	4	0.06	103	4
IBR11	15	0.00001	0.00202	0.00009	0.09550	674.00	0.1627	0.0036	0.0237	0.0005	0.96	16.81	-1.22	182	30	153	6	151	6	152	6	0.05	151	6
IBR11	16	0.00001	0.00091	0.00004	0.13050	921.00	0.0531	0.0013	0.0081	0.0002	0.95	38.93	-1.36	85	35	53	2	52	2	52	2	0.06	52	2
IBR11	17	0.00001	0.00091	0.00004	0.13050	921.00	0.0531	0.0013	0.0081	0.0002	0.95	38.93	-1.36	85	35	53	2	52	2	52	2	0.06	52	2
IBR11	18	0.00002	0.00034	0.00001	0.02442	172.30	0.1072	0.0024	0.0160	0.0003	0.92	20.06	-1.04	128	43	103	4	102	4	103	4	0.24	102	4

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	disc1W	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR11	19	0.00002	0.00029	0.00001	0.02220	156.60	0.0963	0.0022	0.0146	0.0003	0.90	-1.73	0.06	92	49	93	4	93	4	93	4	0.95	93	4
IBR11	20	0.00002	0.00097	0.00004	0.01811	127.60	0.4442	0.0102	0.0597	0.0013	0.95	-1.13	0.16	370	32	373	14	374	16	373	14	0.82	374	16
IBR11	21	0.00001	0.00199	0.00009	0.06040	377.10	0.2669	0.0055	0.0385	0.0008	0.95	-16.05	1.29	210	29	240	9	243	9	240	9	0.03	243	9
IBR11	22	0.00001	0.00193	0.00010	0.02403	149.70	0.7384	0.0151	0.0930	0.0018	0.95	-11.53	2.06	514	29	561	18	573	21	552	16	0.00	573	21
IBR11	23	0.00001	0.01308	0.00070	0.18540	1152.00	0.6870	0.0149	0.0817	0.0017	0.96	20.73	-4.88	639	26	531	18	506	20	555	18	0.00	506	20
IBR11	24	0.00001	0.00074	0.00003	0.05580	345.70	0.1011	0.0022	0.0155	0.0003	0.94	-51.74	1.35	65	36	98	4	99	4	99	4	0.06	99	4
IBR11	25	0.00002	0.00042	0.00002	0.03996	247.10	0.0818	0.0019	0.0123	0.0003	0.91	27.97	-1.25	110	45	80	3	79	3	79	3	0.18	79	3
IBR11	1	0.00003	0.00107	0.00005	0.08550	412.00	0.0988	0.0011	0.0148	0.0001	0.89	25.08	-1.29	126	24	96	2	94	2	95	2	0.01	94	2
IBR11	2	0.00002	0.00156	0.00007	0.04903	236.60	0.2608	0.0023	0.0375	0.0003	0.90	-10.78	0.89	214	18	235	4	237	4	236	4	0.01	237	4
IBR11	3	0.00002	0.00034	0.00001	0.03654	176.50	0.0698	0.0008	0.0108	0.0001	0.76	-34.75	0.72	51	37	68	2	69	1	69	1	0.33	69	1
IBR11	4	0.00002	0.00070	0.00003	0.05240	253.50	0.1001	0.0010	0.0152	0.0001	0.82	-15.45	0.52	84	27	97	2	97	2	97	2	0.33	97	2
IBR11	5	0.00002	0.00261	0.00013	0.06530	316.10	0.3477	0.0034	0.0460	0.0004	0.92	28.01	-4.42	403	18	303	5	290	5	296	5	0.00	290	5
IBR11	7	0.00003	0.00070	0.00004	0.00576	27.90	1.3919	0.0190	0.1443	0.0018	0.91	6.28	-1.91	927	23	886	16	869	20	894	16	0.00	869	20
IBR11	8	0.00003	0.00029	0.00001	0.02074	100.70	0.1114	0.0014	0.0166	0.0001	0.69	21.62	-1.19	135	42	107	3	106	2	106	2	0.17	106	2
IBR11	10	0.00003	0.00065	0.00003	0.04500	218.90	0.1171	0.0014	0.0170	0.0002	0.86	44.86	-3.63	197	29	112	3	108	2	109	2	0.00	108	2
IBR11	11	0.00002	0.00016	0.00001	0.01424	69.30	0.0861	0.0014	0.0134	0.0001	0.62	-125.23	1.90	38	62	84	3	85	2	85	2	0.12	85	2
IBR11	12	0.00002	0.00044	0.00002	0.04350	211.80	0.0788	0.0009	0.0119	0.0001	0.78	26.53	-1.12	104	36	77	2	76	1	76	1	0.13	76	1
IBR11	14	0.00002	0.00073	0.00003	0.05720	279.00	0.0973	0.0011	0.0148	0.0002	0.87	-3.96	0.14	91	28	94	2	94	2	94	2	0.79	94	2
IBR11	15	0.00002	0.00116	0.00005	0.08590	440.70	0.1045	0.0010	0.0158	0.0001	0.86	-2.39	0.09	99	23	101	2	101	2	101	2	0.84	101	2
IBR11	16	0.00002	0.01168	0.00108	0.04690	240.90	4.0569	0.0314	0.2901	0.0021	0.94	0.50	-0.22	1650	12	1646	13	1642	21	1648	10	0.49	1650	12
IBR11	17	0.00002	0.00038	0.00002	0.02840	146.20	0.1041	0.0011	0.0158	0.0001	0.64	-6.95	0.26	94	40	101	2	101	1	101	1	0.74	101	1
IBR11	18	0.00003	0.00075	0.00003	0.12020	620.00	0.0482	0.0005	0.0074	0.0001	0.83	26.22	-0.69	64	26	48	1	47	1	47	1	0.20	47	1
IBR11	19	0.00003	0.00168	0.00007	0.13030	673.00	0.1016	0.0009	0.0154	0.0001	0.91	-2.77	0.11	96	18	98	2	98	2	98	2	0.77	98	2
IBR11	20	0.00004	0.00047	0.00002	0.03830	198.30	0.0942	0.0010	0.0143	0.0001	0.81	5.22	-0.20	96	31	91	2	91	2	91	2	0.75	91	2
IBR11	21	0.00003	0.00721	0.00050	0.04520	234.40	1.9663	0.0158	0.1867	0.0014	0.93	0.16	-0.05	1105	13	1104	11	1103	15	1104	10	0.86	1103	15
IBR11	22	0.00002	0.00020	0.00001	0.01827	94.90	0.0868	0.0013	0.0132	0.0001	0.63	-8.12	0.26	78	55	85	2	85	2	85	2	0.82	85	2
IBR11	23	0.00001	0.00097	0.00004	0.06040	314.00	0.1266	0.0013	0.0190	0.0002	0.88	-1.57	0.08	119	23	121	2	121	2	121	2	0.87	121	2
IBR11	25	0.00001	0.00571	0.00047	0.03061	159.90	2.7383	0.0264	0.2222	0.0021	0.96	8.41	-3.51	1412	12	1339	14	1293	22	1385	10	0.00	1412	12
IBR11	26	0.00001	0.00029	0.00001	0.02253	118.00	0.0985	0.0012	0.0149	0.0001	0.66	10.00	-0.43	106	43	95	2	95	2	95	2	0.63	95	2
IBR11	27	0.00002	0.00063	0.00003	0.05370	281.90	0.0921	0.0010	0.0138	0.0001	0.85	26.27	-1.28	120	28	89	2	88	2	88	2	0.03	88	2
IBR11	28	0.00002	0.00507	0.00027	0.06790	357.40	0.7026	0.0049	0.0872	0.0006	0.93	1.30	-0.25	546	14	540	6	539	7	540	6	0.35	539	7
IBR11	29	0.00002	0.00073	0.00003	0.04850	256.00	0.1191	0.0018	0.0182	0.0003	0.93	-58.39	1.70	73	26	114	3	116	3	115	3	0.00	116	3
IBR11	30	0.00002	0.00039	0.00002	0.02276	120.30	0.1347	0.0015	0.0203	0.0002	0.72	-24.50	1.01	104	36	128	3	130	2	130	2	0.16	130	2
IBR11	31	0.00001	0.01708	0.00112	0.14010	743.00	1.3871	0.0140	0.1412	0.0014	0.95	11.72	-3.76	965	14	883	12	851	15	915	11	0.00	851	15
IBR11	32	0.00001	0.00061	0.00003	0.07990	424.00	0.0586	0.0006	0.0090	0.0001	0.79	15.16	-0.42	68	31	58	1	58	1	58	1	0.51	58	1
IBR11	33	0.00001	0.00876	0.00056	0.07270	387.00	1.3682	0.0174	0.1414	0.0018	0.97	8.68	-2.68	934	13	875	15	853	20	911	11	0.00	853	20
IBR11	34	0.00001	0.00101	0.00005	0.03686	196.90	0.2229	0.0025	0.0324	0.0003	0.93	-8.36	0.62	190	21	204	4	206	4	205	4	0.13	206	4
IBR11	35	0.00002	0.00040	0.00002	0.03180	170.40	0.1004	0.0012	0.0149	0.0002	0.84	34.27	-2.03	145	31	97	2	95	2	95	2	0.00	95	2
IBR11	37	0.00001	0.00220	0.00012	0.03155	196.50	0.6480	0.0052	0.0819	0.0006	0.91	-0.22	0.04	506	16	507	6	507	7	507	6	0.90	507	7
IBR11	38	0.00001	0.00215	0.00012	0.02754	172.60	0.7521	0.0059	0.0927	0.0007	0.89	-1.81	0.36	561	17	569	7	571	8	570	7	0.27	571	8
IBR11	40	0.00001	0.00140	0.00006	0.11710	744.00	0.0927	0.0007	0.0140	0.0001	0.85	12.74	-0.53	103	19	90	1	90	1	90	1	0.17	90	1

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR11	41	0.00002	0.00077	0.00003	0.06400	409.00	0.0943	0.0009	0.0142	0.0001	0.78	13.04	-0.55	105	27	91	2	91	1	91	1	0.32	91	1
IBR11	42	0.00002	0.00021	0.00001	0.03280	210.80	0.0488	0.0007	0.0074	0.0001	0.57	42.82	-1.48	83	55	48	1	48	1	48	1	0.20	48	1
IBR11	43	0.00002	0.00117	0.00005	0.09520	616.00	0.0960	0.0009	0.0145	0.0001	0.87	4.41	-0.17	97	22	93	2	93	1	93	1	0.70	93	1
IBR11	44	0.00002	0.00030	0.00001	0.03490	227.20	0.0662	0.0009	0.0102	0.0001	0.66	-14.00	0.33	57	50	65	2	65	1	65	1	0.75	65	1
IBR11	45	0.00001	0.00062	0.00003	0.05320	348.00	0.0919	0.0008	0.0141	0.0001	0.68	-34.83	0.93	67	29	89	1	90	1	90	1	0.11	90	1
IBR11	46	0.00001	0.00076	0.00003	0.08140	535.00	0.0735	0.0006	0.0112	0.0001	0.81	18.07	-0.64	87	25	72	1	72	1	72	1	0.20	72	1
IBR11	47	0.00001	0.00131	0.00006	0.03794	250.60	0.2900	0.0023	0.0407	0.0003	0.86	5.15	-0.54	271	19	259	4	257	3	258	3	0.15	257	3
IBR11	48	0.00001	0.00080	0.00004	0.06610	438.00	0.0975	0.0010	0.0143	0.0001	0.69	45.54	-3.16	168	34	94	2	92	1	92	1	0.00	92	1
IBR11	50	0.00003	0.00238	0.00011	0.15540	1040.00	0.1223	0.0009	0.0181	0.0001	0.89	20.91	-1.24	146	17	117	2	116	2	116	2	0.00	116	2
IBR11	51	0.00002	0.00112	0.00006	0.01395	93.60	0.7821	0.0072	0.0948	0.0008	0.86	2.29	-0.48	598	20	587	8	584	9	586	8	0.22	584	9
IBR11	52	0.00002	0.00029	0.00001	0.02214	149.00	0.1080	0.0014	0.0155	0.0001	0.70	53.84	-4.82	215	42	104	3	99	2	99	2	0.00	99	2
IBR11	53	0.00002	0.00077	0.00000	0.01031	69.60	0.0509	0.0014	0.0075	0.0001	0.27	67.01	-4.14	147	120	50	3	48	1	48	1	0.11	48	1
IBR11	54	0.00001	0.00455	0.00020	0.51430	3477.00	0.0693	0.0005	0.0105	0.0001	0.91	24.53	-0.90	89	16	68	1	67	1	67	1	0.01	67	1
IBR11	55	0.00001	0.00046	0.00002	0.03914	265.00	0.0931	0.0010	0.0138	0.0001	0.76	38.81	-2.30	144	34	90	2	88	1	88	1	0.00	88	1
IBR11	56	0.00001	0.00056	0.00003	0.01575	106.70	0.3057	0.0032	0.0423	0.0004	0.80	12.60	-1.49	305	29	271	5	267	4	268	4	0.01	267	4
IBR11	57	0.00001	0.00055	0.00002	0.04220	286.00	0.1034	0.0009	0.0155	0.0001	0.76	18.63	-0.92	122	28	100	2	99	1	99	1	0.11	99	1
IBR11	58	0.00002	0.00050	0.00002	0.04077	276.10	0.0988	0.0008	0.0146	0.0001	0.63	38.78	-2.43	153	30	96	1	93	1	93	1	0.00	93	1
IBR11	59	0.00002	0.00057	0.00089	0.02950	199.50	5.4101	0.0454	0.3462	0.0028	0.95	-3.39	1.56	1854	11	1886	15	1916	26	1864	11	0.00	1854	11
IBR11	60	0.00002	0.00149	0.00007	0.05020	339.20	0.2423	0.0020	0.0349	0.0002	0.86	-3.06	0.25	214	20	220	3	221	3	221	3	0.51	221	3
IBR48A	3	0.00002	0.00041	0.00002	0.05730	313.00	0.0590	0.0005	0.0090	0.0000	0.57	9.74	-0.26	64	35	58	1	58	1	58	1	0.72	58	1
IBR48A	4	0.00002	0.00047	0.00002	0.04987	272.20	0.0787	0.0008	0.0119	0.0001	0.57	22.73	-0.92	99	40	77	2	76	1	76	1	0.27	76	1
IBR48A	5	0.00003	0.00122	0.00009	0.00750	40.90	2.2513	0.0180	0.2054	0.0013	0.76	-1.67	0.59	1184	21	1197	11	1204	13	1198	11	0.11	1204	21
IBR48A	6	0.00002	0.00024	0.00001	0.02468	134.80	0.0827	0.0010	0.0126	0.0001	0.44	6.72	-0.24	86	50	81	2	81	1	81	1	0.82	81	1
IBR48A	7	0.00002	0.00048	0.00002	0.04890	267.10	0.0851	0.0008	0.0125	0.0001	0.58	53.70	-3.85	172	34	83	1	80	1	80	1	0.00	80	1
IBR48A	8	0.00001	0.00024	0.00001	0.02325	127.10	0.0874	0.0010	0.0133	0.0001	0.42	-8.85	0.28	78	50	85	2	85	1	85	1	0.78	85	1
IBR48A	9	0.00001	0.01128	0.00183	0.02877	157.30	12.0979	0.0829	0.4936	0.0026	0.75	1.74	-1.00	2632	16	2612	13	2586	22	2616	13	0.00	2632	16
IBR48A	10	0.00001	0.00356	0.00016	0.27620	1510.00	0.1065	0.0007	0.0161	0.0001	0.72	-11.85	0.44	92	23	103	1	103	1	103	1	0.34	103	1
IBR48A	11	0.00001	0.00051	0.00002	0.04080	233.00	0.1052	0.0013	0.0161	0.0002	0.77	-52.96	1.42	67	36	102	2	103	2	103	2	0.05	103	2
IBR48A	12	0.00002	0.00016	0.00001	0.01759	100.70	0.0750	0.0011	0.0114	0.0001	0.41	6.43	-0.20	78	65	73	2	73	1	73	1	0.88	73	1
IBR48A	13	0.00002	0.00006	0.00000	0.00166	9.48	0.3085	0.0081	0.0450	0.0004	0.30	-53.53	3.68	185	117	273	13	283	4	283	4	0.08	283	4
IBR48A	14	0.00002	0.00303	0.00021	0.01951	111.80	2.1414	0.0159	0.1989	0.0012	0.78	-1.77	0.61	1149	19	1162	10	1169	12	1163	10	0.08	1169	12
IBR48A	15	0.00002	0.00035	0.00002	0.02920	167.40	0.1015	0.0010	0.0155	0.0001	0.50	-44.27	1.22	69	42	98	2	99	1	99	1	0.15	99	1
IBR48A	17	0.00001	0.00989	0.00097	0.03920	225.00	4.8238	0.0328	0.3225	0.0017	0.75	-1.57	0.71	1774	17	1789	12	1802	16	1789	12	0.02	1774	17
IBR48A	18	0.00001	0.00108	0.00005	0.04030	231.70	0.2379	0.0018	0.0343	0.0002	0.66	-4.17	0.34	209	28	217	3	217	2	217	2	0.53	217	2
IBR48A	19	0.00001	0.00020	0.00001	0.01750	100.60	0.0938	0.0013	0.0145	0.0001	0.37	-115.65	1.98	43	61	91	2	93	1	93	1	0.10	93	1
IBR48A	20	0.00001	0.00009	0.00000	0.00875	50.30	0.0825	0.0017	0.0126	0.0001	0.27	-2.76	0.09	78	95	80	3	81	1	81	1	0.96	81	1
IBR48A	21	0.00002	0.00207	0.00011	0.03256	187.40	0.6399	0.0042	0.0821	0.0004	0.65	-7.11	1.20	475	22	502	5	508	4	507	4	0.00	508	4
IBR48A	22	0.00002	0.00065	0.00003	0.05180	298.30	0.1067	0.0009	0.0161	0.0001	0.56	1.16	-0.05	104	33	103	2	103	1	103	1	0.94	103	1
IBR48A	23	0.00002	0.00070	0.00003	0.01496	86.20	0.4372	0.0037	0.0597	0.0003	0.65	-11.68	1.44	335	29	368	5	374	4	373	4	0.01	374	4
IBR48A	24	0.00001	0.00012	0.00001	0.00792	45.66	0.1395	0.0021	0.0203	0.0001	0.40	33.37	-2.63	194	65	133	4	129	2	129	2	0.05	129	2

Sample	Spot	Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)				Discordance		Ages				Preferred							
							Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR48A	25	0.00001	0.00022	0.00001	0.01823	105.20	0.1008	0.0013	0.0153	0.0001	0.43	-17.74	0.59	83	55	98	2	98	1	98	1	0.59	98	1
IBR48A	26	0.00001	0.00030	0.00001	0.03341	192.90	0.0765	0.0008	0.0115	0.0001	0.53	30.39	-1.32	106	43	75	2	74	1	74	1	0.14	74	1
IBR48A	28	0.00001	0.00043	0.00002	0.04260	246.00	0.0863	0.0008	0.0131	0.0001	0.56	2.11	-0.07	86	35	84	1	84	1	84	1	0.92	84	1
IBR48A	29	0.00002	0.00033	0.00001	0.02870	166.00	0.1007	0.0010	0.0149	0.0001	0.60	37.57	-2.35	153	38	97	2	95	1	95	1	0.00	95	1
IBR48A	30	0.00002	0.00038	0.00002	0.03830	221.50	0.0845	0.0009	0.0127	0.0001	0.50	23.89	-1.04	107	42	82	2	81	1	81	1	0.23	81	1
IBR48A	31	0.00001	0.00047	0.00002	0.06630	402.00	0.0595	0.0005	0.0091	0.0000	0.37	25.67	-0.82	78	38	59	1	58	0	58	0	0.29	58	0
IBR48A	32	0.00002	0.00022	0.00001	0.01856	112.50	0.1020	0.0011	0.0154	0.0000	0.30	2.61	-0.11	101	48	99	2	99	1	99	1	0.91	99	1
IBR48A	33	0.00002	0.00047	0.00002	0.04100	248.00	0.0978	0.0008	0.0149	0.0000	0.31	-28.45	0.85	74	37	95	1	96	0	96	0	0.25	96	0
IBR48A	34	0.00001	0.00023	0.00001	0.02585	156.80	0.0760	0.0008	0.0116	0.0000	0.33	13.72	-0.48	86	45	74	1	74	1	74	1	0.61	74	1
IBR48A	35	0.00001	0.00508	0.00034	0.03693	224.10	1.8288	0.0096	0.1795	0.0005	0.48	-2.50	0.80	1038	19	1056	7	1064	5	1062	5	0.01	1064	5
IBR48A	36	0.00001	0.00015	0.00001	0.01365	82.90	0.0957	0.0013	0.0146	0.0000	0.22	-11.72	0.39	83	65	93	2	93	1	93	1	0.76	93	1
IBR48A	37	0.00001	0.00033	0.00001	0.04634	281.50	0.0610	0.0006	0.0092	0.0000	0.29	41.91	-1.76	102	43	60	1	59	0	59	0	0.05	59	0
IBR48A	38	0.00001	0.00391	0.00028	0.02511	152.60	2.1981	0.0118	0.2032	0.0006	0.50	-2.94	1.01	1158	19	1180	8	1192	6	1189	6	0.00	1192	6
IBR48A	39	0.00001	0.00026	0.00001	0.02619	159.20	0.0853	0.0009	0.0128	0.0000	0.28	34.42	-1.76	125	49	83	2	82	1	82	1	0.08	82	1
IBR48A	40	0.00002	0.00601	0.00041	0.04070	247.30	2.0036	0.0108	0.1924	0.0006	0.53	-4.79	1.56	1083	19	1117	7	1134	6	1129	6	0.00	1134	6
IBR48A	41	0.00002	0.00298	0.00016	0.03995	243.10	0.7809	0.0043	0.0964	0.0003	0.51	-6.14	1.19	559	21	586	5	593	3	592	3	0.00	593	3
IBR48A	42	0.00002	0.00029	0.00001	0.02853	173.60	0.0862	0.0009	0.0131	0.0000	0.28	11.31	-0.43	94	47	84	2	84	0	84	0	0.65	84	0
IBR48A	43	0.00001	0.00045	0.00002	0.06010	366.00	0.0639	0.0006	0.0096	0.0000	0.33	41.16	-1.78	105	41	63	1	62	0	62	0	0.04	62	0
IBR48A	44	0.00001	0.00048	0.00002	0.06840	416.60	0.0592	0.0005	0.0091	0.0000	0.41	-1.14	0.03	58	36	58	1	58	0	58	0	0.97	58	0
IBR48A	45	0.00001	0.00042	0.00002	0.06440	392.00	0.0581	0.0015	0.0090	0.0001	0.44	-76.29	1.01	33	108	57	3	58	1	58	1	0.64	58	1
IBR48A	46	0.00001	0.00048	0.00002	0.05320	324.00	0.0756	0.0006	0.0115	0.0000	0.36	3.79	-0.12	77	37	74	1	74	0	74	0	0.87	74	0
IBR48A	47	0.00001	0.00054	0.00002	0.04490	273.90	0.1050	0.0008	0.0155	0.0001	0.44	33.61	-2.05	150	34	101	2	99	1	99	1	0.00	99	1
IBR48A	50	0.00002	0.00021	0.00001	0.02301	140.50	0.0789	0.0009	0.0116	0.0000	0.30	55.76	-3.90	168	52	77	2	74	1	74	1	0.00	74	1
IBR48A	52	0.00002	0.00032	0.00001	0.02770	172.30	0.1025	0.0011	0.0152	0.0001	0.36	34.93	-2.13	149	48	99	2	97	1	97	1	0.03	97	1
IBR48A	53	0.00001	0.00126	0.00006	0.04404	273.60	0.2636	0.0018	0.0374	0.0002	0.63	2.83	-0.27	244	25	238	3	237	2	237	2	0.58	237	2
IBR48A	54	0.00002	0.00081	0.00004	0.02680	166.90	0.2750	0.0020	0.0395	0.0001	0.47	-15.64	1.29	216	30	247	3	250	2	250	2	0.02	250	2
IBR48A	55	0.00002	0.00224	0.00011	0.05780	360.00	0.3688	0.0021	0.0511	0.0001	0.48	-6.89	0.78	301	23	319	3	321	2	321	2	0.07	321	2
IBR48A	57	0.00003	0.00013	0.00001	0.01294	80.50	0.0890	0.0014	0.0129	0.0001	0.27	58.43	-4.86	199	70	87	3	83	1	83	1	0.00	83	1
IBR48A	58	0.00002	0.00007	0.00000	0.00648	40.36	0.0982	0.0023	0.0143	0.0001	0.21	52.97	-4.27	194	107	95	4	91	1	91	1	0.06	91	1
IBR48A	59	0.00002	0.00027	0.00001	0.03755	233.80	0.0613	0.0006	0.0093	0.0000	0.35	31.98	-1.15	88	45	60	1	60	0	60	0	0.22	60	0
IBR48A	60	0.00001	0.00258	0.00019	0.01687	105.10	2.1869	0.0136	0.2015	0.0008	0.64	-1.58	0.55	1165	20	1177	9	1183	9	1180	8	0.09	1183	9
IBR48A	62	0.00001	0.00047	0.00002	0.06760	420.90	0.0588	0.0005	0.0090	0.0000	0.47	18.00	-0.52	70	34	58	1	58	0	58	0	0.46	58	0
IBR48A	63	0.00002	0.00034	0.00001	0.04940	307.70	0.0600	0.0006	0.0090	0.0000	0.47	50.80	-2.47	117	40	59	1	58	1	58	1	0.00	58	1
IBR48A	64	0.00002	0.00019	0.00001	0.02715	169.20	0.0624	0.0007	0.0093	0.0000	0.40	56.94	-3.28	138	48	61	1	59	1	59	1	0.00	59	1
IBR48A	65	0.00002	0.00045	0.00002	0.03970	248.00	0.0973	0.0008	0.0147	0.0001	0.47	-0.53	0.02	94	36	94	2	94	1	94	1	0.98	94	1
IBR48A	66	0.00002	0.00017	0.00001	0.02438	152.10	0.0639	0.0009	0.0094	0.0000	0.28	62.55	-4.23	161	67	63	2	60	1	60	1	0.00	60	1
IBR48A	67	0.00002	0.00026	0.00001	0.02606	162.60	0.0839	0.0010	0.0129	0.0001	0.40	-54.01	1.16	54	51	82	2	83	1	83	1	0.25	83	1
IBR48A	68	0.00001	0.00044	0.00002	0.05020	313.50	0.0741	0.0006	0.0115	0.0000	0.40	-74.79	1.26	42	38	73	1	73	1	73	1	0.10	73	1
IBR48A	69	0.00001	0.00017	0.00001	0.02436	152.10	0.0607	0.0008	0.0093	0.0000	0.37	24.25	-0.78	78	55	60	1	59	1	59	1	0.49	59	1
IBR71B	2	0.00005	0.00194	0.00009	0.21590	261.20	0.0572	0.0009	0.0087	0.0001	0.94	21.94	-0.65	72	26	56	2	56	2	56	2	0.23	56	2

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR71B	3	0.00005	0.00300	0.00014	0.18700	224.00	0.1075	0.0017	0.0159	0.0002	0.94	35.15	-2.25	156	25	104	3	101	3	102	3	0.00	101	3
IBR71B	4	0.00004	0.01208	0.00061	0.32500	385.00	0.2614	0.0044	0.0368	0.0006	0.96	11.91	-1.23	264	21	236	7	233	7	236	7	0.00	233	7
IBR71B	5	0.00005	0.00157	0.00007	0.13270	156.00	0.0745	0.0012	0.0115	0.0002	0.94	-30.56	0.69	56	26	73	2	73	2	73	2	0.18	73	2
IBR71B	6	0.00004	0.00229	0.00011	0.19470	227.00	0.0752	0.0012	0.0113	0.0002	0.94	39.67	-1.96	120	26	74	2	72	2	72	2	0.00	72	2
IBR71B	7	0.00006	0.00351	0.00017	0.45400	526.00	0.0510	0.0008	0.0076	0.0001	0.94	64.39	-3.69	137	27	50	2	49	1	48	1	0.00	49	1
IBR71B	8	0.00004	0.00255	0.00012	0.23420	269.10	0.0707	0.0011	0.0107	0.0002	0.94	36.79	-1.63	108	26	69	2	68	2	68	2	0.00	68	2
IBR71B	9	0.00004	0.00203	0.00009	0.18640	212.80	0.0706	0.0011	0.0106	0.0002	0.95	34.77	-1.49	105	25	69	2	68	2	68	2	0.00	68	2
IBR71B	10	0.00005	0.00140	0.00007	0.09670	109.80	0.0964	0.0015	0.0143	0.0002	0.94	39.82	-2.48	152	25	93	3	91	3	91	3	0.00	91	3
IBR71B	11	0.00004	0.01039	0.00052	0.26290	378.20	0.2776	0.0044	0.0389	0.0006	0.96	10.12	-1.08	274	20	249	7	246	7	249	7	0.01	246	7
IBR71B	12	0.00005	0.00943	0.00044	0.87100	1254.00	0.0708	0.0013	0.0107	0.0002	0.97	34.53	-1.48	105	21	69	2	68	2	69	2	0.00	68	2
IBR71B	13	0.00004	0.00836	0.00042	0.22610	325.80	0.2562	0.0044	0.0363	0.0006	0.97	9.05	-0.89	252	21	232	7	230	7	232	7	0.04	230	7
IBR71B	14	0.00003	0.00189	0.00009	0.13120	189.00	0.0949	0.0017	0.0143	0.0002	0.96	18.82	-0.86	112	24	92	3	91	3	92	3	0.09	91	3
IBR71B	15	0.00004	0.00697	0.00050	0.04260	61.20	1.6478	0.0291	0.1612	0.0028	0.97	7.82	-2.62	1045	19	989	22	963	31	1024	16	0.00	963	31
IBR71B	17	0.00003	0.00282	0.00013	0.23850	342.20	0.0762	0.0013	0.0115	0.0002	0.96	26.35	-1.08	100	23	75	3	74	2	74	2	0.02	74	2
IBR71B	18	0.00003	0.00177	0.00008	0.13030	186.50	0.0908	0.0017	0.0134	0.0002	0.96	42.53	-2.62	150	25	88	3	86	3	86	3	0.00	86	3
IBR71B	22	0.00006	0.01473	0.00073	0.43000	608.00	0.2381	0.0051	0.0334	0.0007	0.98	22.14	-2.38	272	20	217	8	212	9	219	9	0.00	212	9
IBR71B	25	0.00003	0.02130	0.00112	0.39800	557.00	0.3955	0.0085	0.0523	0.0011	0.98	19.04	-2.97	406	20	338	12	329	13	352	12	0.00	329	13
IBR71B	26	0.00003	0.00107	0.00005	0.14660	204.50	0.0476	0.0009	0.0072	0.0001	0.96	47.19	-1.72	88	27	47	2	46	2	46	2	0.00	46	2
IBR71B	27	0.00003	0.00091	0.00004	0.06370	88.40	0.0948	0.0019	0.0142	0.0003	0.95	25.71	-1.28	122	29	92	3	91	3	91	3	0.03	91	3
IBR71B	28	0.00003	0.00992	0.00076	0.04730	65.40	2.2876	0.0436	0.2071	0.0039	0.97	-1.13	0.40	1200	18	1208	27	1213	41	1202	16	0.55	1200	41
IBR71B	30	0.00004	0.00105	0.00005	0.06570	90.30	0.1061	0.0020	0.0159	0.0003	0.94	15.14	-0.73	120	30	102	4	102	4	102	4	0.22	102	4
IBR71B	31	0.00005	0.00306	0.00014	0.35300	525.00	0.0573	0.0012	0.0086	0.0002	0.96	46.73	-2.01	104	28	57	2	55	2	56	2	0.00	55	2
IBR71B	32	0.00004	0.00165	0.00007	0.10610	159.00	0.1034	0.0018	0.0156	0.0003	0.95	-2.84	0.11	97	25	100	3	100	3	100	3	0.83	100	3
IBR71B	34	0.00004	0.01716	0.00096	0.18260	277.70	0.7727	0.0180	0.0938	0.0022	0.98	2.74	-0.57	594	19	581	21	578	25	588	15	0.30	578	25
IBR71B	35	0.00004	0.00145	0.00007	0.08810	134.80	0.1064	0.0019	0.0161	0.0003	0.95	-4.19	0.17	99	26	103	4	103	4	103	4	0.75	103	4
IBR71B	36	0.00005	0.00319	0.00014	0.39200	603.00	0.0523	0.0009	0.0080	0.0001	0.95	18.69	-0.49	63	24	52	2	51	2	52	2	0.33	51	2
IBR71B	37	0.00004	0.00087	0.00004	0.08170	126.50	0.0685	0.0014	0.0105	0.0002	0.95	-13.77	0.33	59	29	67	3	67	3	67	3	0.57	67	3
IBR71B	39	0.00004	0.00054	0.00002	0.06260	97.90	0.0558	0.0012	0.0085	0.0002	0.93	32.60	-1.08	81	38	55	2	54	2	55	2	0.17	54	2
IBR71B	40	0.00004	0.00826	0.00037	0.50200	788.00	0.1066	0.0024	0.0160	0.0004	0.98	5.05	-0.22	108	21	103	4	103	4	103	4	0.61	103	4
IBR71B	41	0.00005	0.00438	0.00020	0.26620	420.00	0.1079	0.0023	0.0163	0.0003	0.98	2.49	-0.11	107	22	104	4	104	4	104	4	0.81	104	4
IBR71B	45	0.00004	0.00111	0.00005	0.07840	125.20	0.0951	0.0022	0.0140	0.0003	0.96	42.54	-2.74	156	29	92	4	90	4	90	4	0.00	90	4
IBR71B	46	0.00004	0.00297	0.00013	0.35340	566.00	0.0555	0.0012	0.0084	0.0002	0.97	46.56	-1.94	101	26	55	2	54	2	54	2	0.00	54	2
IBR71B	47	0.00004	0.00213	0.00010	0.19100	307.00	0.0734	0.0017	0.0111	0.0002	0.97	25.60	-1.00	96	25	72	3	71	3	71	3	0.05	71	3
IBR71B	51	0.00008	0.01954	0.00145	0.12890	180.20	1.6734	0.0352	0.1601	0.0033	0.96	12.17	-4.30	1090	23	998	27	957	36	1055	19	0.00	957	36
IBR71B	52	0.00004	0.00383	0.00018	0.24730	344.30	0.1036	0.0021	0.0156	0.0003	0.97	6.30	-0.27	107	23	100	4	100	4	100	4	0.56	100	4
IBR71B	53	0.00004	0.00196	0.00009	0.13010	180.30	0.1018	0.0020	0.0154	0.0003	0.97	-1.85	0.07	97	24	98	4	99	4	98	4	0.88	99	4
IBR71B	54	0.00004	0.00492	0.00023	0.36400	502.00	0.0912	0.0018	0.0138	0.0003	0.97	10.61	-0.42	99	22	89	3	88	3	88	3	0.34	88	3
IBR71B	55	0.00004	0.00069	0.00003	0.06520	86.80	0.0737	0.0014	0.0111	0.0002	0.92	29.53	-1.22	101	36	72	3	71	2	71	2	0.10	71	2
IBR71B	56	0.00004	0.00535	0.00026	0.38800	530.00	0.0987	0.0019	0.0143	0.0003	0.96	55.52	-4.75	205	25	96	4	91	3	91	3	0.00	91	3
IBR71B	57	0.00004	0.00181	0.00008	0.12680	172.40	0.0958	0.0020	0.0145	0.0003	0.97	-2.98	0.11	90	24	93	4	93	4	93	4	0.83	93	4
IBR71B	58	0.00004	0.00081	0.00004	0.04494	60.70	0.1218	0.0025	0.0182	0.0004	0.96	9.66	-0.50	128	28	117	5	116	5	116	5	0.39	116	5

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR71B	60	0.00003	0.00051	0.00002	0.05940	79.40	0.0573	0.0011	0.0087	0.0002	0.93	30.78	-1.02	81	35	57	2	56	2	56	2	0.15	56	2
IBR71B	62	0.00003	0.00361	0.00017	0.25200	333.00	0.0963	0.0018	0.0145	0.0003	0.97	11.16	-0.47	105	23	93	3	93	3	93	3	0.32	93	3
IBR71B	64	0.00003	0.00733	0.00034	0.94200	1230.00	0.0517	0.0010	0.0078	0.0001	0.97	43.32	-1.59	89	21	51	2	50	2	50	2	0.00	50	2
IBR71B	65	0.00003	0.00143	0.00007	0.10470	135.90	0.0919	0.0018	0.0140	0.0003	0.96	-24.20	0.70	72	25	89	3	90	3	89	3	0.17	90	3
IBR71B	67	0.00005	0.01387	0.00071	0.38800	498.00	0.2602	0.0059	0.0360	0.0008	0.98	25.02	-3.01	304	23	235	10	228	10	237	10	0.00	228	10
IBR71B	68	0.00004	0.00690	0.00037	0.12120	154.60	0.4287	0.0096	0.0567	0.0013	0.98	12.33	-1.89	406	20	362	14	356	15	374	13	0.00	356	15
IBR71B	69	0.00004	0.00155	0.00007	0.10480	132.80	0.1001	0.0023	0.0150	0.0003	0.97	20.23	-0.99	120	26	97	4	96	4	96	4	0.06	96	4
IBR71B	70	0.00004	0.00127	0.00006	0.09300	117.10	0.0944	0.0022	0.0140	0.0003	0.97	36.83	-2.14	142	27	92	4	90	4	90	4	0.00	90	4
IBR71B	71	0.00005	0.00458	0.00021	0.29120	434.00	0.1092	0.0027	0.0165	0.0004	0.98	-9.20	0.36	97	22	105	5	106	5	105	5	0.43	106	5
IBR71B	72	0.00007	0.00424	0.00021	0.20140	300.60	0.1522	0.0036	0.0220	0.0005	0.97	29.56	-2.39	200	27	144	6	141	6	142	6	0.00	141	6
IBR71B	74	0.00004	0.01144	0.00054	0.83200	1221.00	0.0959	0.0022	0.0144	0.0003	0.98	19.08	-0.88	114	21	93	4	92	4	93	4	0.04	92	4
IBR71B	75	0.00004	0.00591	0.00028	0.55200	792.00	0.0730	0.0014	0.0110	0.0002	0.97	31.23	-1.31	103	22	72	3	71	3	71	3	0.00	71	3
IBR71B	76	0.00004	0.00213	0.00010	0.12220	170.50	0.1225	0.0033	0.0182	0.0005	0.98	14.25	-0.78	136	24	117	6	116	6	117	6	0.11	116	6
IBR71B	78	0.00004	0.00095	0.00004	0.09210	118.30	0.0720	0.0017	0.0109	0.0002	0.96	28.90	-1.16	98	32	71	3	70	3	70	3	0.08	70	3
IBR71B	80	0.00004	0.00090	0.00004	0.06160	70.20	0.1056	0.0028	0.0154	0.0004	0.94	45.64	-3.41	181	40	102	5	99	5	99	5	0.00	99	5
IBR71B	81	0.00004	0.00418	0.00019	0.37660	399.10	0.0765	0.0017	0.0117	0.0003	0.98	0.76	-0.02	75	22	75	3	75	3	75	3	0.96	75	3
IBR71B	82	0.00004	0.00405	0.00019	0.26340	259.90	0.1070	0.0024	0.0162	0.0004	0.98	-12.33	0.46	92	22	103	4	104	4	103	4	0.32	104	4
IBR71B	83	0.00004	0.00135	0.00006	0.09670	87.70	0.0976	0.0022	0.0147	0.0003	0.97	9.09	-0.38	104	25	95	4	94	4	94	4	0.46	94	4
IBR71B	84	0.00003	0.01060	0.00056	0.18480	154.20	0.4504	0.0106	0.0605	0.0014	0.98	-2.10	0.29	371	20	378	15	379	17	375	13	0.56	379	17
IBR71B	85	0.00004	0.01825	0.00120	0.15200	115.30	1.1765	0.0284	0.1266	0.0030	0.98	9.61	-2.76	850	20	790	27	768	34	830	17	0.00	768	34
IBR71B	86	0.00004	0.00165	0.00008	0.11980	83.10	0.1012	0.0023	0.0152	0.0003	0.97	15.76	-0.74	115	24	98	4	97	4	98	4	0.14	97	4
IBR71B	87	0.00003	0.00187	0.00009	0.12360	78.10	0.1052	0.0023	0.0159	0.0003	0.97	4.43	-0.19	106	24	102	4	101	4	102	4	0.70	101	4
IBR71B	88	0.00003	0.00228	0.00010	0.32270	184.80	0.0484	0.0008	0.0075	0.0001	0.96	10.83	-0.24	54	25	48	2	48	2	48	2	0.64	48	2
IBR71B	89	0.00003	0.00236	0.00011	0.17020	89.50	0.0957	0.0022	0.0146	0.0003	0.98	-16.03	0.52	80	24	93	4	93	4	93	4	0.29	93	4
IBR71B	90	0.00004	0.01325	0.00068	0.40300	192.30	0.2524	0.0063	0.0347	0.0009	0.98	30.92	-3.93	318	21	229	10	220	11	235	11	0.00	220	11
IBR71B	1	0.00008	0.00288	0.00014	0.15210	198.60	0.1475	0.0025	0.0220	0.0004	0.97	-7.12	0.37	131	21	140	4	140	5	140	5	0.38	140	5
IBR71B	2	0.00007	0.00340	0.00016	0.23780	310.90	0.1123	0.0019	0.0168	0.0003	0.97	7.86	-0.37	117	21	108	3	108	3	108	3	0.39	108	3
IBR71B	3	0.00007	0.00147	0.00007	0.21000	275.00	0.0538	0.0010	0.0081	0.0001	0.86	55.47	-2.69	116	45	53	2	52	2	52	2	0.00	52	2
IBR71B	4	0.00006	0.00347	0.00017	0.25400	332.00	0.1056	0.0018	0.0161	0.0003	0.97	-20.98	0.71	85	20	102	3	103	3	102	3	0.08	103	3
IBR71B	6	0.00005	0.00229	0.00011	0.36000	472.00	0.0483	0.0009	0.0074	0.0001	0.95	41.90	-1.41	81	29	48	2	47	2	47	2	0.02	47	2
IBR71B	7	0.00006	0.00903	0.00046	0.28130	369.60	0.2656	0.0043	0.0377	0.0006	0.97	1.73	-0.16	243	19	239	7	239	7	239	7	0.67	239	7
IBR71B	8	0.00005	0.01093	0.00054	0.37410	492.00	0.2390	0.0036	0.0343	0.0005	0.96	-0.08	0.01	217	19	218	6	218	6	218	6	0.99	218	6
IBR71B	9	0.00005	0.00113	0.00005	0.09880	130.10	0.0880	0.0015	0.0134	0.0002	0.95	0.83	-0.03	86	27	86	3	86	3	86	3	0.96	86	3
IBR71B	10	0.00005	0.00439	0.00020	0.65400	861.00	0.0504	0.0008	0.0078	0.0001	0.97	5.48	-0.12	53	20	50	2	50	2	50	2	0.78	50	2
IBR71B	12	0.00006	0.00151	0.00007	0.12400	153.50	0.0967	0.0015	0.0145	0.0002	0.94	20.90	-1.00	117	25	94	3	93	3	93	3	0.05	93	3
IBR71B	13	0.00005	0.02150	0.00126	0.31280	386.30	0.6665	0.0101	0.0823	0.0012	0.96	8.51	-1.71	557	18	519	12	510	14	528	12	0.00	510	14
IBR71B	14	0.00005	0.00187	0.00009	0.17430	214.80	0.0856	0.0013	0.0128	0.0002	0.95	31.98	-1.58	121	24	83	3	82	2	82	2	0.00	82	2
IBR71B	15	0.00005	0.00072	0.00004	0.10610	130.50	0.0546	0.0009	0.0081	0.0001	0.90	62.44	-3.63	139	33	54	2	52	2	52	2	0.00	52	2
IBR71B	16	0.00005	0.00173	0.00009	0.18200	223.40	0.0774	0.0012	0.0114	0.0002	0.93	55.66	-3.81	164	28	76	2	73	2	73	2	0.00	73	2
IBR71B	17	0.00005	0.01945	0.00118	0.22760	278.90	0.8539	0.0139	0.1011	0.0016	0.97	4.22	-0.95	648	17	627	15	621	19	636	13	0.03	621	19
IBR71B	18	0.00005	0.00249	0.00012	0.20270	247.90	0.1002	0.0018	0.0146	0.0002	0.96	50.89	-4.01	190	23	97	3	93	3	93	3	0.00	93	3

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR71B	19	0.00005	0.00082	0.00004	0.06810	83.10	0.0947	0.0015	0.0143	0.0002	0.92	2.11	-0.08	94	30	92	3	92	3	92	3	0.90	92	3
IBR71B	20	0.00005	0.00371	0.00018	0.34200	417.00	0.0853	0.0013	0.0130	0.0002	0.96	0.92	-0.03	84	21	83	2	83	2	83	2	0.94	83	2
IBR71B	21	0.00006	0.02401	0.00115	2.73300	3328.00	0.0698	0.0010	0.0104	0.0002	0.97	46.88	-2.44	126	18	69	2	67	2	67	2	0.00	67	2
IBR71B	22	0.00004	0.00085	0.00004	0.09650	117.40	0.0687	0.0011	0.0105	0.0002	0.93	14.32	-0.46	78	28	67	2	67	2	67	2	0.43	67	2
IBR71B	23	0.00004	0.00479	0.00023	0.63500	770.00	0.0595	0.0010	0.0091	0.0001	0.96	25.25	-0.81	78	20	59	2	58	2	58	2	0.06	58	2
IBR71B	24	0.00004	0.00579	0.00028	0.39170	475.00	0.1187	0.0019	0.0178	0.0003	0.97	8.98	-0.45	125	20	114	4	113	4	114	4	0.27	113	4
IBR71B	25	0.00004	0.00105	0.00005	0.08080	97.90	0.1036	0.0017	0.0157	0.0002	0.95	-10.01	0.37	91	24	100	3	100	3	100	3	0.44	100	3
IBR71B	26	0.00004	0.00197	0.00010	0.15060	182.20	0.1042	0.0017	0.0157	0.0002	0.96	1.02	-0.04	102	23	101	3	101	3	101	3	0.93	101	3
IBR71B	27	0.00004	0.01075	0.00054	0.34480	417.00	0.2593	0.0040	0.0370	0.0006	0.97	0.67	-0.06	236	18	234	6	234	7	234	6	0.87	234	7
IBR71B	28	0.00004	0.00092	0.00005	0.10500	126.80	0.0706	0.0011	0.0104	0.0001	0.87	56.28	-3.59	153	37	69	2	67	2	67	2	0.00	67	2
IBR71B	29	0.00004	0.00253	0.00012	0.36290	437.80	0.0540	0.0008	0.0083	0.0001	0.95	7.67	-0.18	58	22	53	2	53	2	53	2	0.69	53	2
IBR71B	32	0.00005	0.02303	0.00133	0.32970	404.80	0.6907	0.0108	0.0856	0.0013	0.97	3.63	-0.71	549	17	533	13	529	15	538	12	0.08	529	15
IBR71B	33	0.00006	0.00220	0.00011	0.26680	327.80	0.0687	0.0011	0.0101	0.0002	0.96	57.49	-3.67	153	23	67	2	65	2	65	2	0.00	65	2
IBR71B	34	0.00005	0.00384	0.00020	0.10640	130.90	0.3165	0.0052	0.0442	0.0007	0.97	0.48	-0.05	280	20	279	8	279	9	279	8	0.90	279	9
IBR71B	35	0.00005	0.00167	0.00008	0.18630	229.40	0.0719	0.0012	0.0111	0.0002	0.96	-20.50	0.49	59	23	70	2	71	2	71	2	0.30	71	2
IBR71B	38	0.00005	0.00093	0.00005	0.10750	132.70	0.0679	0.0012	0.0104	0.0002	0.94	-2.07	0.06	65	27	67	2	67	2	67	2	0.92	67	2
IBR71B	39	0.00005	0.00439	0.00021	0.33900	418.00	0.1101	0.0018	0.0166	0.0003	0.96	3.74	-0.17	110	21	106	3	106	3	106	3	0.69	106	3
IBR71B	40	0.00004	0.00123	0.00006	0.13800	170.50	0.0728	0.0013	0.0111	0.0002	0.94	16.35	-0.57	85	27	71	2	71	2	71	2	0.31	71	2
IBR102	1	0.00001	0.00040	0.00002	0.03095	91.40	0.1005	0.0009	0.0155	0.0001	0.50	-103.89	2.01	49	37	97	2	99	1	99	1	0.01	99	1
IBR102	2	0.00001	0.00061	0.00003	0.04910	145.10	0.0988	0.0007	0.0151	0.0001	0.61	-29.74	0.89	74	29	96	1	96	1	96	1	0.12	96	1
IBR102	3	0.00001	0.00057	0.00003	0.05070	149.90	0.0916	0.0007	0.0137	0.0001	0.54	27.29	-1.34	121	29	89	1	88	1	88	1	0.03	88	1
IBR102	4	0.00001	0.00016	0.00001	0.02348	69.46	0.0518	0.0008	0.0082	0.0000	0.35	-72748350.47	2.25	0	88	51	2	53	1	52	1	0.10	53	1
IBR102	5	0.00001	0.00200	0.00009	0.07610	225.20	0.2189	0.0014	0.0318	0.0002	0.81	-3.43	0.26	195	18	201	2	202	2	201	2	0.47	202	2
IBR102	6	0.00000	0.00132	0.00006	0.10340	306.00	0.1000	0.0006	0.0152	0.0001	0.68	-18.24	0.60	82	21	97	1	97	1	97	1	0.15	97	1
IBR102	7	-3.7e-7	0.00104	0.00005	0.08040	238.00	0.1023	0.0007	0.0156	0.0001	0.71	-29.90	0.92	77	24	99	1	100	1	100	1	0.06	100	1
IBR102	8	-8.6e-7	0.00172	0.00007	0.13590	402.50	0.0999	0.0006	0.0152	0.0001	0.76	-23.47	0.74	79	19	97	1	97	1	97	1	0.06	97	1
IBR102	9	0.00000	0.00033	0.00001	0.02884	85.50	0.0871	0.0008	0.0135	0.0001	0.54	-159.79	2.12	33	39	85	2	87	1	87	1	0.01	87	1
IBR102	10	0.00001	0.00295	0.00013	0.26170	775.00	0.0910	0.0005	0.0137	0.0001	0.76	13.88	-0.57	102	17	88	1	88	1	88	1	0.09	88	1
IBR102	11	0.00001	0.00017	0.00001	0.01783	52.85	0.0735	0.0010	0.0117	0.0001	0.36	-9339546.36	3.71	0	86	72	2	75	1	75	1	0.00	75	1
IBR102	12	0.00001	0.00083	0.00004	0.06208	184.00	0.1042	0.0008	0.0161	0.0001	0.65	-89.24	1.92	54	27	101	1	103	1	103	1	0.00	103	1
IBR102	13	0.00001	0.00084	0.00004	0.05530	164.00	0.1201	0.0008	0.0183	0.0001	0.73	-48.31	1.51	79	22	115	1	117	1	117	1	0.00	117	1
IBR102	14	0.00001	0.00136	0.00006	0.09140	270.90	0.1187	0.0007	0.0179	0.0001	0.73	-3.69	0.16	110	21	114	1	114	1	114	1	0.69	114	1
IBR102	15	0.00000	0.00343	0.00016	0.11150	330.60	0.2578	0.0015	0.0370	0.0002	0.84	-7.52	0.63	218	15	233	2	234	2	234	2	0.03	234	2
IBR102	16	0.00000	0.00039	0.00002	0.03170	94.00	0.0968	0.0009	0.0150	0.0001	0.51	-136.76	2.20	41	38	94	2	96	1	96	1	0.00	96	1
IBR102	17	0.00000	0.00095	0.00004	0.11600	344.10	0.0635	0.0004	0.0099	0.0000	0.67	-76.10	1.10	36	24	63	1	63	1	63	1	0.02	63	1
IBR102	18	0.00001	0.00090	0.00004	0.07440	220.60	0.0946	0.0006	0.0145	0.0001	0.61	-34.59	0.95	69	26	92	1	93	1	93	1	0.06	93	1
IBR102	19	0.00001	0.00098	0.00004	0.08100	240.40	0.0965	0.0007	0.0147	0.0001	0.78	-19.36	0.61	79	21	94	1	94	1	94	1	0.15	94	1
IBR102	20	0.00002	0.00070	0.00003	0.09820	291.60	0.0555	0.0004	0.0086	0.0000	0.68	-47.59	0.72	37	26	55	1	55	1	55	1	0.18	55	1
IBR102	21	0.00002	0.00033	0.00001	0.03835	113.80	0.0659	0.0007	0.0102	0.0001	0.44	-93.77	1.28	34	48	65	1	66	1	66	1	0.18	66	1
IBR102	22	0.00002	0.00455	0.00023	0.09240	279.70	0.4405	0.0031	0.0591	0.0004	0.89	0.48	-0.07	372	15	371	4	370	5	370	4	0.82	370	5

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR102	23	0.00002	0.00065	0.00003	0.07600	230.40	0.0673	0.0006	0.0103	0.0001	0.72	-8.15	0.20	61	30	66	1	66	1	66	1	0.73	66	1
IBR102	24	0.00001	0.00086	0.00004	0.06820	207.10	0.1010	0.0009	0.0153	0.0001	0.82	-1.00	0.04	97	25	98	2	98	1	98	1	0.94	98	1
IBR102	25	0.00001	0.00023	0.00001	0.02465	75.00	0.0732	0.0009	0.0111	0.0001	0.46	27.80	-1.12	98	54	72	2	71	1	71	1	0.32	71	1
IBR102	26	0.00001	0.00151	0.00007	0.10440	318.00	0.1161	0.0009	0.0176	0.0001	0.79	-16.61	0.64	96	22	112	2	112	1	112	1	0.15	112	1
IBR102	27	0.00002	0.00229	0.00013	0.02797	85.40	0.8092	0.0062	0.0976	0.0007	0.87	1.32	-0.28	608	17	602	7	600	8	602	7	0.39	600	8
IBR102	28	0.00002	0.00039	0.00002	0.03090	94.60	0.1043	0.0009	0.0155	0.0001	0.64	31.73	-1.88	145	33	101	2	99	1	99	1	0.01	99	1
IBR102	29	0.00003	0.00019	0.00001	0.02195	67.30	0.0724	0.0010	0.0107	0.0001	0.47	51.50	-3.04	142	58	71	2	69	1	69	1	0.01	69	1
IBR102	30	0.00002	0.00056	0.00003	0.04180	128.30	0.1089	0.0010	0.0162	0.0001	0.66	24.26	-1.35	137	32	105	2	104	1	104	1	0.04	104	1
IBR102	31	0.00002	0.00049	0.00002	0.04251	130.70	0.0914	0.0008	0.0140	0.0001	0.60	-45.29	1.12	62	35	89	2	90	1	90	1	0.10	90	1
IBR102	32	0.00002	0.00342	0.00015	0.32700	1009.00	0.0845	0.0006	0.0127	0.0001	0.84	30.82	-1.48	117	17	82	1	81	1	81	1	0.00	81	1
IBR102	33	0.00001	0.00798	0.00070	0.04100	126.40	3.0976	0.0310	0.2341	0.0023	0.96	12.36	-5.62	1547	12	1432	15	1356	24	1512	10	0.00	1547	12
IBR102	34	0.00001	0.00045	0.00002	0.03678	113.70	0.0980	0.0009	0.0149	0.0001	0.69	-18.80	0.61	80	31	95	2	95	1	95	1	0.32	95	1
IBR102	35	0.00001	0.00065	0.00003	0.04430	137.40	0.1165	0.0010	0.0177	0.0001	0.73	-38.41	1.25	82	28	112	2	113	1	113	1	0.02	113	1
IBR102	36	0.00002	0.00211	0.00009	0.18290	568.00	0.0919	0.0006	0.0139	0.0001	0.83	8.93	-0.35	98	18	89	1	89	1	89	1	0.33	89	1
IBR102	37	0.00002	0.00063	0.00003	0.05490	170.60	0.0921	0.0008	0.0140	0.0001	0.74	-0.14	0.01	89	28	89	1	89	1	89	1	0.99	89	1
IBR102	38	0.00003	0.00063	0.00003	0.04440	138.50	0.1135	0.0010	0.0172	0.0001	0.73	-11.13	0.44	99	30	109	2	110	1	110	1	0.46	110	1
IBR102	39	0.00002	0.00029	0.00001	0.02549	79.60	0.0902	0.0011	0.0137	0.0001	0.59	-9.47	0.31	80	46	88	2	88	1	88	1	0.74	88	1
IBR102	40	0.00002	0.00049	0.00002	0.06148	192.20	0.0625	0.0006	0.0095	0.0001	0.64	17.14	-0.52	74	33	62	1	61	1	61	1	0.44	61	1
IBR102	41	0.00002	0.00136	0.00006	0.16750	525.00	0.0638	0.0005	0.0097	0.0001	0.78	23.35	-0.78	81	22	63	1	62	1	62	1	0.08	62	1
IBR102	43	0.00001	0.00062	0.00003	0.11550	370.20	0.0431	0.0003	0.0066	0.0000	0.57	38.02	-1.07	68	27	43	1	42	0	42	0	0.06	42	0
IBR102	44	0.00001	0.00138	0.00006	0.11360	364.00	0.0973	0.0006	0.0147	0.0001	0.76	2.61	-0.10	97	20	94	1	94	1	94	1	0.80	94	1
IBR102	45	0.00002	0.00048	0.00002	0.03987	127.60	0.0976	0.0009	0.0146	0.0001	0.61	21.50	-1.04	119	34	95	2	94	1	94	1	0.13	94	1
IBR102	46	0.00002	0.00047	0.00002	0.04137	132.30	0.0922	0.0008	0.0139	0.0001	0.52	16.55	-0.72	107	34	90	1	89	1	89	1	0.30	89	1
IBR102	47	0.00002	0.00057	0.00002	0.04806	153.60	0.0940	0.0007	0.0144	0.0001	0.54	-32.79	0.91	69	31	91	1	92	1	92	1	0.14	92	1
IBR102	48	0.00002	0.00017	0.00001	0.01289	41.10	0.1057	0.0016	0.0160	0.0001	0.38	-4.07	0.16	98	64	102	3	102	1	102	1	0.90	102	1
IBR102	49	0.00002	0.00090	0.00004	0.07200	229.60	0.1015	0.0007	0.0153	0.0001	0.75	2.64	-0.11	101	21	98	1	98	1	98	1	0.80	98	1
IBR102	50	0.00002	0.00130	0.00006	0.09780	312.00	0.1055	0.0008	0.0158	0.0001	0.79	11.06	-0.51	114	22	102	1	101	1	101	1	0.26	101	1
IBR102	51	0.00001	0.00052	0.00002	0.04090	130.10	0.1016	0.0008	0.0154	0.0001	0.63	-15.07	0.52	86	29	98	1	99	1	99	1	0.36	99	1
IBR102	52	0.00001	0.00027	0.00001	0.02137	67.90	0.1008	0.0011	0.0154	0.0001	0.44	-27.92	0.86	77	47	97	2	98	1	98	1	0.36	98	1
IBR102	53	0.00002	0.00160	0.00007	0.06760	214.60	0.1948	0.0012	0.0285	0.0001	0.75	-3.97	0.27	174	20	181	2	181	2	181	2	0.49	181	2
IBR102	54	0.00002	0.00070	0.00003	0.05460	172.80	0.1032	0.0008	0.0157	0.0001	0.66	-12.79	0.46	89	28	100	1	100	1	100	1	0.42	100	1
IBR102	55	0.00003	0.00058	0.00003	0.04870	154.10	0.0997	0.0010	0.0145	0.0001	0.59	50.97	-4.00	189	38	97	2	93	1	93	1	0.00	93	1
IBR102	56	0.00002	0.00045	0.00002	0.03680	116.30	0.0994	0.0009	0.0149	0.0001	0.56	15.04	-0.68	112	35	96	2	96	1	96	1	0.34	96	1
IBR102	57	0.00002	0.00110	0.00005	0.08270	261.00	0.1067	0.0007	0.0162	0.0001	0.70	-13.96	0.51	91	23	103	1	103	1	103	1	0.26	103	1
IBR102	58	0.00002	0.00074	0.00004	0.01330	41.70	0.5348	0.0039	0.0697	0.0004	0.74	0.99	-0.16	439	22	435	5	434	5	434	4	0.71	434	5
IBR102	59	0.00001	0.00038	0.00002	0.04846	152.40	0.0652	0.0006	0.0098	0.0000	0.54	48.80	-2.47	122	37	64	1	63	1	63	1	0.00	63	1
IBR102	60	0.00001	0.00052	0.00002	0.03990	125.40	0.1061	0.0010	0.0160	0.0001	0.63	1.71	-0.07	104	35	102	2	102	1	102	1	0.92	102	1
IBR102	61	0.00001	0.00044	0.00002	0.03750	117.70	0.0917	0.0008	0.0140	0.0001	0.54	-31.48	0.86	68	35	89	1	90	1	90	1	0.21	90	1
IBR102	62	0.00001	0.00041	0.00002	0.03272	99.90	0.1041	0.0011	0.0155	0.0001	0.77	27.56	-1.53	137	33	101	2	99	2	99	2	0.02	99	2
IBR102	64	0.00002	0.00021	0.00001	0.01644	50.08	0.1044	0.0016	0.0156	0.0001	0.56	24.80	-1.33	132	58	101	3	100	2	100	2	0.26	100	2
IBR102	65	0.00003	0.00095	0.00004	0.07550	229.90	0.1055	0.0010	0.0157	0.0001	0.85	29.73	-1.73	142	24	102	2	100	2	100	2	0.00	100	2

Sample	Spot	Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)				Discordance		Ages					Preferred						
							Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
IBR102	66	0.00003	0.00064	0.00003	0.05090	154.80	0.1058	0.0011	0.0153	0.0001	0.57	52.54	-4.50	206	41	102	2	98	1	98	1	0.00	98	1
IBR102	67	0.00002	0.00020	0.00001	0.02367	71.90	0.0683	0.0009	0.0101	0.0001	0.55	58.68	-3.83	156	53	67	2	65	1	65	1	0.00	65	1
IBR102	68	0.00002	0.00173	0.00008	0.26270	797.00	0.0528	0.0005	0.0081	0.0001	0.91	32.24	-1.01	76	19	52	1	52	1	52	1	0.01	52	1
IBR102	69	0.00001	0.00117	0.00005	0.09940	301.60	0.0947	0.0008	0.0143	0.0001	0.84	5.72	-0.22	97	22	92	1	92	1	92	1	0.62	92	1
IBR102	70	0.00001	0.00451	0.00020	0.38300	1160.00	0.0971	0.0009	0.0144	0.0001	0.93	34.33	-1.97	141	16	94	2	92	2	93	2	0.00	92	2
IBR102	71	0.00001	0.00285	0.00012	0.40970	1241.00	0.0555	0.0005	0.0085	0.0001	0.91	12.24	-0.31	62	17	55	1	55	1	55	1	0.38	55	1
IBR102	72	0.00001	0.00063	0.00003	0.10310	312.00	0.0493	0.0004	0.0075	0.0001	0.74	43.56	-1.54	85	29	49	1	48	1	48	1	0.01	48	1
IBR102	73	0.00002	0.00190	0.00008	0.17210	521.00	0.0892	0.0009	0.0136	0.0001	0.90	-4.25	0.14	83	21	87	2	87	2	87	2	0.73	87	2
IBR102	74	0.00002	0.00143	0.00006	0.20250	612.00	0.0568	0.0005	0.0086	0.0001	0.89	35.01	-1.23	85	18	56	1	55	1	55	1	0.00	55	1
IBR102	75	0.00002	0.00179	0.00008	0.14260	431.00	0.1000	0.0007	0.0151	0.0001	0.81	0.49	-0.02	97	21	97	1	97	1	97	1	0.96	97	1
IBR102	76	0.00002	0.00077	0.00003	0.06100	184.30	0.1047	0.0009	0.0155	0.0001	0.81	31.96	-1.90	146	23	101	2	99	1	99	1	0.00	99	1
IBR102	1	0.00002	0.01445	0.00075	0.28230	861.00	0.4395	0.0060	0.0587	0.0008	0.93	4.55	-0.65	385	22	370	8	367	9	370	9	0.15	367	9
IBR102	3	0.00003	0.00054	0.00002	0.04280	131.70	0.0965	0.0015	0.0145	0.0002	0.87	24.01	-1.19	122	35	94	3	92	2	93	2	0.10	92	2
IBR102	4	0.00004	0.00295	0.00014	0.24440	754.00	0.0921	0.0013	0.0138	0.0002	0.93	21.88	-1.01	113	25	90	2	89	2	89	2	0.05	89	2
IBR102	5	0.00003	0.00075	0.00003	0.04468	138.20	0.1277	0.0019	0.0191	0.0003	0.90	-1.59	0.08	120	31	122	3	122	3	122	3	0.90	122	3
IBR102	6	0.00002	0.02527	0.00147	0.30260	938.00	0.8043	0.0112	0.0955	0.0013	0.94	8.63	-1.97	643	21	599	13	588	15	605	13	0.00	588	15
IBR102	7	0.00002	0.00401	0.00027	0.03034	94.20	1.4596	0.0029	0.1494	0.0020	0.94	5.85	-1.81	953	21	914	17	898	22	927	16	0.00	898	22
IBR102	8	0.00001	0.00644	0.00029	0.51900	1610.00	0.0949	0.0013	0.0143	0.0002	0.93	15.39	-0.67	108	25	92	2	91	2	92	2	0.18	91	2
IBR102	9	0.00001	0.00050	0.00002	0.07540	234.60	0.0488	0.0007	0.0076	0.0001	0.87	-26.26	0.41	38	36	48	1	49	1	49	1	0.57	49	1
IBR102	12	0.00003	0.00011	0.00001	0.01512	47.13	0.0572	0.0012	0.0086	0.0001	0.63	55.19	-2.82	123	78	57	2	55	1	55	1	0.09	55	1
IBR102	13	0.00003	0.00057	0.00003	0.06150	191.70	0.0691	0.0010	0.0105	0.0001	0.88	10.85	-0.34	76	35	68	2	68	2	68	2	0.64	68	2
IBR102	14	0.00002	0.00344	0.00016	0.29300	915.00	0.0884	0.0013	0.0134	0.0002	0.93	0.38	-0.01	86	26	86	2	86	2	86	2	0.98	86	2
IBR102	16	0.00001	0.00222	0.00010	0.18130	565.00	0.0929	0.0013	0.0141	0.0002	0.92	1.84	-0.07	92	27	90	2	90	2	90	2	0.90	90	2
IBR102	17	0.00001	0.00208	0.00009	0.29860	930.00	0.0511	0.0007	0.0079	0.0001	0.93	13.39	-0.32	58	26	51	1	50	1	51	1	0.55	50	1
IBR102	18	0.00001	0.00221	0.00010	0.17760	553.00	0.0930	0.0013	0.0141	0.0002	0.93	-1.72	0.06	89	25	90	2	90	2	90	2	0.90	90	2
IBR102	19	0.00002	0.00164	0.00007	0.12950	403.10	0.0961	0.0014	0.0146	0.0002	0.92	-6.32	0.22	88	27	93	3	93	2	93	2	0.68	93	2
IBR102	20	0.00001	0.00101	0.00005	0.17380	605.00	0.0436	0.0006	0.0067	0.0001	0.89	26.10	-0.63	58	31	43	1	43	1	43	1	0.33	43	1
IBR102	21	0.00002	0.00030	0.00001	0.02410	84.40	0.0940	0.0016	0.0144	0.0002	0.79	-51.87	1.26	61	48	91	3	92	2	92	2	0.19	92	2
IBR102	22	0.00003	0.00292	0.00013	0.31770	1119.00	0.0686	0.0010	0.0105	0.0001	0.93	13.82	-0.44	78	25	67	2	67	2	67	2	0.40	67	2
IBR102	23	0.00002	0.00124	0.00006	0.09450	334.10	0.0999	0.0014	0.0151	0.0002	0.91	3.62	-0.15	100	29	97	3	97	2	97	2	0.80	97	2
IBR102	24	0.00002	0.00050	0.00002	0.03859	137.10	0.0975	0.0014	0.0149	0.0002	0.87	-38.61	1.06	69	35	94	3	95	2	95	2	0.13	95	2
IBR102	25	0.00001	0.00020	0.00001	0.02760	98.30	0.0523	0.0010	0.0083	0.0001	0.71	-70279733.40	2.69	0	61	52	2	53	1	53	1	0.03	53	1
IBR102	26	0.00001	0.00754	0.00037	0.19110	683.00	0.3270	0.0046	0.0455	0.0006	0.94	0.76	-0.08	289	23	287	7	287	7	287	7	0.85	287	7
IBR102	27	0.00001	0.00089	0.00004	0.11590	430.00	0.0550	0.0008	0.0085	0.0001	0.89	-26.76	0.47	43	31	54	2	55	1	55	1	0.46	55	1
IBR102	28	0.00001	0.00054	0.00002	0.04729	170.00	0.0867	0.0013	0.0133	0.0002	0.86	-20.68	0.59	70	37	84	2	85	2	85	2	0.43	85	2
IBR102	29	0.00002	0.00048	0.00002	0.03421	123.20	0.1083	0.0016	0.0163	0.0002	0.88	3.03	-0.13	108	34	104	3	104	3	104	3	0.85	104	3
IBR102	30	0.00002	0.00083	0.00004	0.07040	253.90	0.0899	0.0013	0.0136	0.0002	0.90	2.80	-0.10	90	30	87	2	87	2	87	2	0.87	87	2
IBR102	31	0.00003	0.00023	0.00001	0.01426	51.47	0.1272	0.0023	0.0186	0.0003	0.79	30.19	-2.09	171	52	122	4	119	3	119	3	0.05	119	3
IBR102	32	0.00003	0.00063	0.00003	0.05213	188.30	0.0925	0.0015	0.0139	0.0002	0.90	24.31	-1.16	117	33	90	3	89	3	89	3	0.09	89	3
IBR102	33	0.00002	0.00042	0.00002	0.06072	219.50	0.0539	0.0010	0.0079	0.0001	0.79	67.97	-4.56	159	52	53	2	51	1	51	1	0.00	51	1
IBR102	34	0.00002	0.00171	0.00008	0.14750	533.10	0.0879	0.0013	0.0133	0.0002	0.92	18.43	-0.78	104	27	86	2	85	2	85	2	0.16	85	2

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages										Preferred	
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235 ± 1s	Pb206U238 ± 1s	Pb206U238 ± 1s	Rho1	discTW	disc58	207Pb/206Pb ± 2s	207Pb/235U ± 2s	206Pb/238U ± 2s	Concordia ± 2s	probability	Age	± 2s						
IBR1102	36	0.00001	0.00098	0.00004	0.07400	267.00	0.1005	0.0016	0.0151	0.0002	0.92	12.50	-0.56	110	30	97	3	97	3	97	3	0.36	97	3	3
IBR1102	37	0.00001	0.00139	0.00006	0.10610	382.50	0.0995	0.0015	0.0150	0.0002	0.93	2.98	-0.12	99	27	96	3	96	3	96	3	0.83	96	3	3
IBR1102	38	0.00002	0.00091	0.00004	0.07070	255.00	0.0970	0.0016	0.0146	0.0002	0.89	8.71	-0.36	103	35	94	3	94	3	94	3	0.61	94	3	3
IBR1102	40	0.00003	0.00025	0.00001	0.01833	65.78	0.1109	0.0019	0.0160	0.0002	0.83	50.18	-4.27	206	45	107	4	102	3	102	3	0.00	102	3	3
IBR1102	41	0.00002	0.00063	0.00003	0.08830	316.10	0.0950	0.0009	0.0082	0.0001	0.89	56.58	-2.87	122	36	54	2	53	2	53	2	0.00	53	2	2
IBR1102	42	0.00002	0.00144	0.00007	0.11770	420.40	0.0933	0.0014	0.0141	0.0002	0.92	4.11	-0.16	94	28	91	3	90	3	90	3	0.78	90	3	3
IBR1110A	1	0.00002	0.00143	0.00007	0.15440	414.00	0.0719	0.0009	0.0108	0.0001	0.88	40.04	-1.90	115	29	70	2	69	2	69	2	0.00	69	2	2
IBR1110A	3	0.00002	0.00023	0.00001	0.03440	92.10	0.0525	0.0010	0.0080	0.0001	0.72	42.06	-1.53	88	60	52	2	51	1	51	1	0.22	51	1	1
IBR1110A	4	0.00002	0.00580	0.00028	0.55500	1484.00	0.0812	0.0011	0.0123	0.0002	0.95	21.52	-0.88	100	21	79	2	79	2	79	2	0.04	79	2	2
IBR1110A	6	0.00001	0.000216	0.00010	0.11790	315.00	0.1459	0.0020	0.0216	0.0003	0.93	7.73	-0.46	149	23	138	3	138	3	138	3	0.32	138	3	3
IBR1110A	7	0.00002	0.00057	0.00003	0.04750	126.80	0.0954	0.0014	0.0141	0.0002	0.86	41.41	-2.62	154	36	93	3	90	2	90	2	0.00	90	2	2
IBR1110A	8	0.00001	0.00230	0.00012	0.07580	202.20	0.2502	0.0034	0.0359	0.0005	0.94	-1.62	0.14	223	22	227	6	227	6	227	6	0.75	227	6	6
IBR1110A	9	0.00001	0.00807	0.00048	0.10290	274.40	0.7639	0.0097	0.0920	0.0011	0.94	7.23	-1.57	612	19	576	11	567	13	581	11	0.00	567	13	13
IBR1110A	10	0.00001	0.00049	0.00002	0.04791	127.70	0.0794	0.0012	0.0121	0.0002	0.85	12.50	-0.45	88	36	78	2	77	2	77	2	0.55	77	2	2
IBR1110A	11	0.00002	0.00449	0.00033	0.02985	80.30	1.8599	0.0025	0.1803	0.0021	0.94	-0.47	0.16	1064	18	1067	16	1069	22	1065	14	0.72	1069	22	22
IBR1110A	12	0.00002	0.00450	0.00033	0.02992	80.60	1.8603	0.0025	0.1807	0.0021	0.94	-1.06	0.35	1060	18	1067	16	1071	22	1064	14	0.43	1071	22	22
IBR1110A	13	0.00002	0.00742	0.00044	0.08980	242.40	0.8179	0.0097	0.0985	0.0011	0.94	1.06	-0.23	612	19	607	11	605	13	608	11	0.57	605	13	13
IBR1110A	14	0.00003	0.00742	0.00044	0.08930	241.40	0.8271	0.0101	0.0997	0.0012	0.94	-0.31	0.07	611	19	612	11	612	13	612	11	0.87	612	13	13
IBR1110A	15	0.00003	0.00140	0.00009	0.01376	37.23	1.0843	0.0134	0.1238	0.0014	0.92	-3.61	0.87	726	21	746	13	752	16	743	13	0.05	752	16	16
IBR1110A	16	0.00003	0.00140	0.00009	0.01358	36.80	1.0838	0.0137	0.1233	0.0015	0.93	-2.20	0.54	733	20	745	13	750	17	743	13	0.22	750	17	17
IBR1110A	17	0.00002	0.01661	0.00123	0.11800	343.00	1.7748	0.0219	0.1717	0.0020	0.94	4.32	-1.45	1068	17	1036	16	1021	22	1050	14	0.00	1021	22	22
IBR1110A	18	0.00002	0.00165	0.00008	0.04810	431.10	0.0887	0.0011	0.0134	0.0002	0.91	6.23	-0.23	92	25	86	2	86	2	86	2	0.65	86	2	2
IBR1110A	19	0.00002	0.00525	0.00030	0.07400	215.70	0.6829	0.0085	0.0855	0.0010	0.94	-0.47	0.09	527	20	529	10	529	12	528	10	0.83	529	12	12
IBR1110A	22	0.00002	0.00035	0.00002	0.03085	90.30	0.0946	0.0014	0.0138	0.0002	0.83	50.86	-3.80	180	40	92	3	88	2	88	2	0.00	88	2	2
IBR1110A	23	0.00002	0.00122	0.00006	0.10220	299.40	0.0958	0.0013	0.0143	0.0002	0.92	25.87	-1.30	124	25	93	2	92	2	92	2	0.01	92	2	2
IBR1110A	24	0.00002	0.00079	0.00004	0.09000	263.80	0.0703	0.0011	0.0106	0.0001	0.88	38.10	-1.72	110	34	69	2	68	2	68	2	0.02	68	2	2
IBR1110A	25	0.00002	0.00059	0.00003	0.07210	211.30	0.0680	0.0010	0.0100	0.0001	0.86	61.13	-4.22	165	36	67	2	64	2	64	2	0.00	64	2	2
IBR1110A	26	0.00001	0.00305	0.00015	0.20820	611.00	0.1210	0.0016	0.0178	0.0002	0.93	28.21	-1.82	159	23	116	3	114	3	114	3	0.00	114	3	3
IBR1110A	27	0.00002	0.00391	0.00019	0.31090	869.00	0.1028	0.0013	0.0155	0.0002	0.94	2.33	-0.10	102	21	99	2	99	2	99	2	0.82	99	2	2
IBR1110A	28	0.00002	0.00070	0.00003	0.10600	296.00	0.0559	0.0008	0.0083	0.0001	0.87	64.52	-4.06	150	33	55	2	53	1	53	1	0.00	53	1	1
IBR1110A	29	0.00002	0.00266	0.00016	0.03490	97.10	0.7751	0.0104	0.0946	0.0012	0.94	-0.01	0.00	583	20	583	12	583	14	583	11	1.00	583	14	14
IBR1110A	31	0.00002	0.00260	0.00013	0.21780	602.60	0.0988	0.0014	0.0147	0.0002	0.93	30.45	-1.68	135	24	96	3	94	2	94	2	0.00	94	2	2
IBR1110A	32	0.00002	0.00086	0.00004	0.08050	222.10	0.0865	0.0012	0.0131	0.0002	0.91	5.91	-0.21	89	28	84	2	84	2	84	2	0.71	84	2	2
IBR1110A	33	0.00002	0.00216	0.00010	0.25120	691.00	0.0706	0.0009	0.0107	0.0001	0.92	25.65	-0.97	92	24	69	2	69	2	69	2	0.05	69	2	2
IBR1110A	36	0.00001	0.00090	0.00004	0.08300	226.70	0.0902	0.0012	0.0136	0.0002	0.91	22.78	-1.04	112	27	88	2	87	2	87	2	0.06	87	2	2
IBR1110A	37	0.00002	0.00397	0.00019	0.46200	1269.00	0.0703	0.0009	0.0107	0.0001	0.94	11.72	-0.37	78	21	69	2	69	2	69	2	0.40	69	2	2
IBR1110A	38	0.00002	0.00116	0.00005	0.10920	302.00	0.0851	0.0011	0.0130	0.0002	0.92	-8.15	0.25	77	25	83	2	83	2	83	2	0.62	83	2	2
IBR1110A	39	0.00002	0.00128	0.00006	0.14510	402.90	0.0721	0.0009	0.0110	0.0001	0.91	6.43	-0.20	75	26	71	2	71	2	71	2	0.71	71	2	2
IBR1110A	40	0.00002	0.00201	0.00010	0.22310	620.00	0.0773	0.0010	0.0113	0.0001	0.87	61.33	-4.80	186	31	76	2	72	2	72	2	0.00	72	2	2
IBR1110A	41	0.00002	0.00023	0.00001	0.01837	51.25	0.1055	0.0019	0.0154	0.0002	0.67	43.64	-3.15	175	61	102	3	99	2	99	2	0.01	99	2	2

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235 ± 1s	Pb206/U238 ± 1s	Rho1	discTW	disc58	207Pb/206Pb ± 2s	207Pb/235U ± 2s	206Pb/238U ± 2s	Concordia ± 2s	probability	Age ± 2s							
IBR110A	42	0.00001	0.00030	0.00001	0.02576	72.10	0.0975	0.0015	0.0148	0.0002	0.79	-8.53	0.30	87	46	94	3	95	2	95	2	0.75	95	2
IBR110A	43	0.00002	0.00090	0.00004	0.11920	334.60	0.0631	0.0009	0.0093	0.0001	0.86	61.40	-3.98	155	34	62	2	60	1	60	1	0.00	60	1
IBR110A	44	0.00002	0.00325	0.00015	0.56100	1579.00	0.0463	0.0006	0.0071	0.0001	0.93	30.18	-0.81	65	23	46	1	46	1	46	1	0.08	46	1
IBR110A	45	0.00002	0.00106	0.00005	0.08810	248.30	0.1016	0.0014	0.0150	0.0002	0.89	38.45	-2.46	156	29	98	3	96	2	96	2	0.00	96	2
IBR110A	46	0.00002	0.00043	0.00002	0.04751	134.30	0.0759	0.0011	0.0111	0.0001	0.83	58.04	-4.13	170	38	74	2	71	2	71	2	0.00	71	2
IBR110A	47	0.00001	0.00057	0.00003	0.04674	132.30	0.0994	0.0014	0.0150	0.0002	0.84	11.40	-0.50	108	37	96	3	96	2	96	2	0.50	96	2
IBR110A	48	0.00001	0.00297	0.00014	0.47100	1335.00	0.0520	0.0007	0.0080	0.0001	0.93	26.91	-0.77	70	23	51	1	51	1	51	1	0.10	51	1
IBR110A	50	0.00001	0.00119	0.00006	0.06737	191.50	0.1504	0.0019	0.0220	0.0003	0.90	18.53	-1.28	172	27	142	3	140	3	141	3	0.02	140	3
IBR110A	51	0.00001	0.00036	0.00002	0.05350	152.10	0.0564	0.0008	0.0086	0.0001	0.82	39.51	-1.48	91	38	56	2	55	1	55	1	0.06	55	1
IBR110A	52	0.00001	0.00035	0.00002	0.03290	93.60	0.0902	0.0013	0.0134	0.0002	0.79	42.32	-2.58	148	43	88	2	85	2	86	2	0.00	85	2
IBR110A	53	0.00001	0.00789	0.00040	0.27920	795.00	0.2469	0.0031	0.0354	0.0004	0.94	0.12	-0.01	224	20	224	5	224	5	224	5	0.98	224	5
IBR110A	54	0.00001	0.01910	0.00169	0.10000	284.80	2.9284	0.0372	0.2372	0.0029	0.95	3.08	-1.25	1416	16	1389	19	1372	30	1406	14	0.01	1416	16
IBR110A	55	0.00001	0.00042	0.00002	0.06960	198.20	0.0494	0.0008	0.0075	0.0001	0.79	47.65	-1.81	92	44	49	1	48	1	48	1	0.05	48	1
IBR110A	56	0.00001	0.00282	0.00014	0.08990	256.10	0.2801	0.0036	0.0393	0.0005	0.93	8.50	-0.89	272	22	251	6	248	6	250	6	0.04	248	6
IBR110A	57	0.00002	0.00462	0.00023	0.18560	540.00	0.2127	0.0027	0.0309	0.0004	0.94	-2.91	0.22	191	21	196	4	196	5	196	4	0.60	196	5
IBR110A	58	0.00002	0.00122	0.00006	0.10910	317.70	0.0906	0.0012	0.0137	0.0002	0.93	8.85	-0.34	96	24	88	2	88	2	88	2	0.48	88	2
IBR110A	59	0.00001	0.00159	0.00008	0.12190	354.00	0.1088	0.0015	0.0162	0.0002	0.91	23.99	-1.33	136	26	105	3	104	3	104	3	0.01	104	3
IBR110A	60	0.00002	0.00041	0.00002	0.03501	101.10	0.0962	0.0014	0.0147	0.0002	0.85	-20.57	0.64	78	36	93	3	94	2	94	2	0.37	94	2
IBR110A	61	0.00002	0.00129	0.00006	0.11430	327.70	0.0953	0.0013	0.0141	0.0002	0.90	41.85	-2.67	155	27	92	2	90	2	90	2	0.00	90	2
IBR110A	62	0.00002	0.00256	0.00012	0.21890	621.00	0.0973	0.0013	0.0146	0.0002	0.94	22.08	-1.07	120	22	94	2	93	2	94	2	0.02	93	2
IBR110A	63	0.00002	0.00078	0.00004	0.06868	192.30	0.0927	0.0013	0.0139	0.0002	0.88	29.39	-1.51	126	31	90	2	89	2	89	2	0.02	89	2
IBR110A	66	0.00002	0.00045	0.00002	0.03728	98.00	0.0996	0.0014	0.0149	0.0002	0.84	22.58	-1.13	123	37	96	3	95	2	95	2	0.14	95	2
IBR110A	69	0.00001	0.00133	0.00006	0.09510	228.20	0.1148	0.0015	0.0173	0.0002	0.91	-5.21	0.22	105	26	110	3	111	3	111	3	0.68	111	3
IBR110A	70	0.00001	0.00110	0.00005	0.09470	217.80	0.0959	0.0012	0.0145	0.0002	0.91	10.68	-0.45	104	26	93	2	93	2	93	2	0.40	93	2
IBR110A	71	0.00001	0.00063	0.00003	0.05500	121.40	0.0910	0.0013	0.0140	0.0002	0.88	-43.40	1.08	62	32	88	2	89	2	89	2	0.09	89	2
IBR110A	72	0.00001	0.00271	0.00013	0.21470	451.30	0.1028	0.0013	0.0155	0.0002	0.93	-0.65	0.03	99	22	99	2	99	2	99	2	0.95	99	2
IBR110A	73	0.00001	0.00205	0.00010	0.18930	382.00	0.0896	0.0012	0.0135	0.0002	0.93	19.68	-0.86	108	23	87	2	86	2	87	2	0.07	86	2
IBR110A	74	0.00001	0.00031	0.00001	0.03038	58.20	0.0851	0.0013	0.0127	0.0002	0.78	35.12	-1.81	126	46	83	2	81	2	82	2	0.06	81	2
IBR110A	75	0.00001	0.00137	0.00006	0.12710	231.20	0.0878	0.0012	0.0133	0.0002	0.91	7.63	-0.29	92	26	85	2	85	2	85	2	0.59	85	2
IBR110A	76	0.00001	0.00078	0.00004	0.07020	121.00	0.0919	0.0012	0.0138	0.0002	0.88	25.16	-1.21	118	31	89	2	88	2	88	2	0.05	88	2
IBR110A	2	0.00002	0.00084	0.00004	0.05182	200.20	0.0990	0.0016	0.0151	0.0002	0.92	-13.50	0.46	85	31	96	3	96	3	96	3	0.46	96	3
IBR110A	3	0.00002	0.00079	0.00004	0.04940	192.90	0.0979	0.0016	0.0147	0.0002	0.92	21.60	-1.05	120	31	95	3	94	3	94	3	0.10	94	3
IBR110A	7	0.00002	0.00154	0.00007	0.17720	703.00	0.0526	0.0008	0.0080	0.0001	0.94	45.71	-1.78	94	26	52	2	51	1	51	1	0.00	51	1
IBR110A	8	0.00002	0.00617	0.00034	0.08330	330.00	0.5248	0.0084	0.0681	0.0011	0.96	4.85	-0.80	447	21	428	11	425	13	431	11	0.07	425	13
IBR110A	9	0.00002	0.00037	0.00002	0.02236	88.10	0.0993	0.0017	0.0153	0.0002	0.87	-60.45	1.47	61	40	96	3	98	3	97	3	0.06	98	3
IBR110A	10	0.00002	0.00120	0.00006	0.08050	314.80	0.0898	0.0014	0.0136	0.0002	0.93	10.56	-0.42	97	28	87	3	87	2	87	2	0.47	87	2
IBR110A	11	0.00002	0.00170	0.00008	0.10250	398.00	0.1022	0.0016	0.0153	0.0002	0.95	17.54	-0.84	119	24	99	3	98	3	98	3	0.08	98	3
IBR110A	12	0.00002	0.01235	0.00128	0.03676	141.20	4.5266	0.0686	0.3093	0.0045	0.96	-0.18	0.08	1734	17	1736	25	1737	44	1735	15	0.90	1734	17
IBR110A	13	0.00002	0.00436	0.00022	0.10630	404.00	0.2672	0.0040	0.0381	0.0006	0.95	-2.88	0.26	234	22	240	6	241	7	240	6	0.55	241	7
IBR110A	14	0.00002	0.00125	0.00006	0.14490	543.00	0.0541	0.0008	0.0080	0.0001	0.92	68.85	-4.77	164	28	53	2	51	1	51	1	0.00	51	1
IBR110A	15	0.00002	0.00088	0.00004	0.05840	216.00	0.0938	0.0015	0.0140	0.0002	0.92	33.69	-1.86	135	30	91	3	89	3	90	3	0.00	89	3

Sample	Spot	Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)				Discordance		Ages					Preferred				
							Pb207/U235 ± 1s	Pb206/U238 ± 1s	Rho1	discTW	disc58	207Pb/206Pb ± 2s	207Pb/235U ± 2s	206Pb/238U ± 2s	Concordia ± 2s	probability	Age ± 2s					
IBR110A	16	0.00002	0.00027	0.00001	0.01689	61.60	0.1001	0.0018	0.0151	0.0002	0.84	3.43	-0.14	100	46	97	3	97	3	0.88	97	3
IBR110A	17	0.00001	0.00045	0.00002	0.02660	95.70	0.1096	0.0019	0.0160	0.0002	0.83	45.44	-3.50	187	45	106	3	102	3	0.00	102	3
IBR110A	18	0.00001	0.00071	0.00003	0.04289	152.10	0.1052	0.0017	0.0154	0.0002	0.90	42.47	-3.00	171	32	102	3	99	3	0.00	99	3
IBR110A	20	0.00001	0.00045	0.00002	0.03412	117.40	0.0827	0.0015	0.0122	0.0002	0.90	50.49	-3.30	158	36	81	3	78	2	0.00	78	2
IBR110A	21	0.00002	0.00386	0.00018	0.31920	1152.00	0.0743	0.0011	0.0114	0.0002	0.95	-6.62	0.18	68	22	73	2	73	2	0.68	73	2
IBR110A	22	0.00002	0.00182	0.00008	0.15720	568.00	0.0706	0.0011	0.0109	0.0002	0.94	-42.09	0.84	49	25	69	2	70	2	0.10	70	2
IBR110A	23	0.00002	0.02618	0.00206	0.12080	436.10	2.2789	0.0349	0.2040	0.0030	0.96	2.06	-0.75	1222	17	1206	22	1197	32	0.17	1222	17
IBR110A	24	0.00001	0.00192	0.00009	0.12890	463.00	0.0959	0.0015	0.0142	0.0002	0.93	41.88	-2.68	156	28	93	3	91	3	0.00	91	3
IBR110A	25	0.00001	0.00226	0.00011	0.14550	518.00	0.0962	0.0016	0.0145	0.0002	0.95	5.24	-0.21	98	24	93	3	93	3	0.66	93	3
IBR110A	26	0.00001	0.00012	0.00001	0.01387	48.88	0.0540	0.0013	0.0082	0.0001	0.61	36.74	-1.26	83	90	53	2	53	2	0.50	53	2
IBR110A	27	0.00001	0.00085	0.00004	0.05250	182.60	0.1020	0.0016	0.0153	0.0002	0.94	15.46	-0.73	116	27	99	3	98	3	0.19	98	3
IBR110A	28	0.00002	0.00063	0.00003	0.04200	143.70	0.0959	0.0016	0.0143	0.0002	0.91	32.94	-1.83	136	32	93	3	91	3	0.01	91	3
IBR110A	29	0.00001	0.00209	0.00010	0.18050	607.00	0.0713	0.0012	0.0110	0.0002	0.95	-17.40	0.42	60	24	70	2	70	2	0.39	70	2
IBR110A	30	0.00001	0.00080	0.00004	0.05301	174.20	0.0964	0.0015	0.0142	0.0002	0.91	41.42	-2.65	155	31	93	3	91	3	0.00	91	3
IBR110A	31	0.00001	0.00117	0.00005	0.13810	443.70	0.0520	0.0008	0.0081	0.0001	0.94	-44.34	0.65	36	25	51	2	52	1	0.21	52	1
IBR110A	32	0.00001	0.00054	0.00003	0.04970	155.70	0.0683	0.0011	0.0104	0.0002	0.92	15.96	-0.52	79	32	67	2	67	2	0.43	67	2
IBR110A	34	0.00001	0.00103	0.00005	0.12160	361.40	0.0522	0.0008	0.0081	0.0001	0.93	-5.12	0.10	49	29	52	2	52	2	0.86	52	2
IBR110A	36	0.00001	0.00082	0.00004	0.05090	143.00	0.1074	0.0020	0.0154	0.0002	0.86	54.74	-4.97	218	44	104	4	99	3	0.00	99	3
IBR110A	37	0.00001	0.00096	0.00004	0.06460	175.90	0.0938	0.0016	0.0142	0.0002	0.94	8.49	-0.34	99	28	91	3	91	3	0.55	91	3
IBR110A	38	0.00001	0.00526	0.00025	0.37400	991.00	0.0906	0.0014	0.0138	0.0002	0.96	-0.24	0.01	88	22	88	3	88	3	0.98	88	3
IBR110A	39	0.00001	0.00023	0.00001	0.02702	69.29	0.0517	0.0010	0.0080	0.0001	0.80	-35.49	0.55	38	56	51	2	51	2	0.63	51	2
IBR110A	40	0.00001	0.00143	0.00007	0.09000	224.00	0.1023	0.0016	0.0153	0.0002	0.94	17.43	-0.84	119	25	99	3	98	3	0.10	98	3
IBR110A	41	0.00002	0.00295	0.00014	0.39400	850.00	0.0481	0.0007	0.0073	0.0001	0.94	53.42	-2.22	100	25	48	1	47	1	0.00	47	1
IBR110A	42	0.00001	0.00384	0.00018	0.50200	1054.00	0.0481	0.0007	0.0073	0.0001	0.95	41.06	-1.35	80	23	48	1	47	1	0.00	47	1
IBR110A	43	0.00001	0.00332	0.00015	0.45000	916.00	0.0464	0.0007	0.0071	0.0001	0.95	27.75	-0.72	63	23	46	1	46	1	0.12	46	1
KM60	3	0.00001	0.00085	0.00004	0.08180	366.1	0.0970	0.0017	0.0145	0.0003	0.96	25.53	-1.30	125	24	94	3	93	3	0.01	93	3
KM60	4	0.00001	0.00102	0.00005	0.09270	415.0	0.1005	0.0017	0.0149	0.0002	0.96	32.30	-1.86	141	24	97	3	95	3	0.00	95	3
KM60	5	0.00001	0.00111	0.00005	0.19670	883.0	0.0519	0.0010	0.0078	0.0001	0.97	53.31	-2.38	108	23	51	2	50	2	0.00	50	2
KM60	8	0.00001	0.00040	0.00002	0.03831	173.5	0.0984	0.0019	0.0142	0.0003	0.93	55.54	-4.74	205	32	95	3	91	3	0.00	91	3
KM60	9	0.00001	0.00061	0.00003	0.02922	132.0	0.2063	0.0046	0.0290	0.0006	0.93	31.01	-3.33	267	38	190	8	184	8	0.00	184	8
KM60	11	0.00001	0.00085	0.00004	0.10760	488.0	0.0728	0.0015	0.0110	0.0002	0.98	33.70	-1.47	106	22	71	3	70	3	0.00	70	3
KM60	13	0.00001	0.00059	0.00003	0.05670	258.1	0.0999	0.0019	0.0147	0.0003	0.93	44.56	-3.11	169	32	97	3	94	3	0.00	94	3
KM60	14	0.00000	0.00164	0.00008	0.15110	690.0	0.1016	0.0016	0.0152	0.0002	0.96	23.31	-1.20	127	21	98	3	97	3	0.01	97	3
KM60	15	0.00001	0.01052	0.00073	0.09310	425.0	1.5574	0.0310	0.1571	0.0031	0.99	4.31	-1.36	983	12	953	25	941	35	0.02	941	35
KM60	16	0.00001	0.00015	0.00001	0.02784	127.4	0.0479	0.0010	0.0073	0.0001	0.87	46.83	-1.70	88	49	47	2	47	2	0.10	47	2
KM60	19	0.00001	0.00228	0.00013	0.03743	172.1	0.6826	0.0122	0.0851	0.0015	0.98	1.83	-0.35	536	15	528	15	526	18	0.40	526	18
KM60	20	0.00001	0.01014	0.00072	0.08170	376.0	1.7732	0.0305	0.1738	0.0030	0.99	0.80	-0.26	1041	12	1036	22	1033	32	0.63	1033	32
KM60	21	0.00001	0.00085	0.00004	0.02867	135.5	0.3087	0.0069	0.0417	0.0009	0.97	26.41	-3.72	358	24	273	11	263	11	0.00	263	11
KM60	22	0.00001	0.00076	0.00004	0.07420	351.0	0.0954	0.0015	0.0144	0.0002	0.96	14.14	-0.61	107	22	92	3	92	3	0.16	92	3
KM60	23	0.00001	0.00047	0.00002	0.04600	218.2	0.0977	0.0018	0.0142	0.0002	0.94	53.68	-4.37	196	30	95	3	91	3	0.00	91	3

Sample	Spot	Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)			Discordance		Ages					Preferred							
							Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM60	24	0.00000	0.00388	0.00021	0.07800	370.0	0.5396	0.0114	0.0693	0.0015	0.99	8.31	-1.44	471	15	438	15	432	17	455	11	0.00	432	17
KM60	25	0.00001	0.00030	0.00001	0.02673	127.1	0.1027	0.0023	0.0156	0.0003	0.94	-4.44	0.17	95	35	99	4	99	4	99	4	0.81	99	4
KM60	26	0.00001	0.00110	0.00005	0.10990	523.0	0.0987	0.0019	0.0142	0.0003	0.95	56.56	-4.95	210	27	96	3	91	3	91	3	0.00	91	3
KM60	28	0.00001	0.00215	0.00011	0.08210	392.0	0.2651	0.0044	0.0368	0.0006	0.97	21.35	-2.49	296	18	239	7	233	7	241	7	0.00	233	7
KM60	29	0.00001	0.00019	0.00001	0.02288	109.4	0.0781	0.0018	0.0116	0.0002	0.92	44.29	-2.45	134	42	76	3	75	3	75	3	0.01	75	3
KM60	30	0.00001	0.00104	0.00005	0.10770	515.0	0.0893	0.0019	0.0132	0.0003	0.98	41.32	-2.45	144	23	87	4	85	4	85	4	0.00	85	4
KM60	32	0.00001	0.01677	0.00098	0.25260	1212.0	0.7901	0.0217	0.0934	0.0026	0.99	11.66	-2.71	652	13	591	25	576	30	641	11	0.00	576	30
KM60	51	0.00001	0.00274	0.00021	0.01812	88.5	2.3189	0.0220	0.2103	0.0019	0.95	-2.85	1.00	1196	13	1218	14	1230	20	1206	11	0.00	1196	20
KM60	53	0.00001	0.00015	0.00001	0.01371	66.8	0.1054	0.0017	0.0155	0.0002	0.72	38.36	-2.53	161	52	102	3	99	2	99	2	0.02	99	2
KM60	54	0.00001	0.00053	0.00002	0.05080	247.5	0.0972	0.0014	0.0144	0.0002	0.83	38.50	-2.36	150	37	94	3	92	2	92	2	0.00	92	2
KM60	57	0.00000	0.00025	0.00001	0.04030	195.7	0.0568	0.0008	0.0085	0.0001	0.71	56.45	-2.94	125	44	56	1	54	1	54	1	0.00	54	1
KM60	58	6.5e-7	0.00130	0.00006	0.10430	505.0	0.1174	0.0016	0.0174	0.0002	0.93	21.06	-1.20	141	23	113	3	111	3	112	3	0.01	111	3
KM60	59	9.2e-7	0.00368	0.00017	0.35450	1717.0	0.0982	0.0016	0.0145	0.0002	0.98	41.29	-2.68	158	17	95	3	93	3	93	3	0.00	93	3
KM60	60	5.3e-7	0.00082	0.00004	0.08470	409.8	0.0889	0.0016	0.0133	0.0002	0.95	25.32	-1.18	114	26	86	3	85	3	86	3	0.03	85	3
KM60	61	3.3e-7	0.00052	0.00002	0.04880	235.6	0.0985	0.0020	0.0149	0.0003	0.95	9.15	-0.39	105	29	95	4	95	4	95	4	0.52	95	4
KM60	62	0.00000	0.00075	0.00054	0.07100	343.0	1.5126	0.0253	0.1518	0.0025	0.99	8.30	-2.68	993	13	935	20	911	28	981	11	0.00	911	28
KM60	64	0.00000	0.00870	0.00063	0.07180	345.1	1.7451	0.0282	0.1696	0.0027	0.99	4.59	-1.53	1058	12	1025	21	1010	30	1052	11	0.00	1010	30
KM60	66	0.00000	0.00064	0.00003	0.05700	273.2	0.1030	0.0020	0.0155	0.0003	0.96	8.22	-0.36	108	28	100	4	99	4	99	4	0.53	99	4
KM60	67	0.00000	0.00044	0.00002	0.07120	340.8	0.0567	0.0009	0.0087	0.0001	0.91	20.91	-0.60	70	33	56	2	56	2	56	2	0.37	56	2
KM60	68	0.00000	0.00289	0.00021	0.02461	117.5	1.6702	0.0262	0.1620	0.0025	0.96	8.90	-3.04	1062	17	997	20	968	27	1036	15	0.00	968	27
KM60	69	-7.4e-7	0.00152	0.00009	0.02238	106.7	0.7723	0.0123	0.0941	0.0015	0.97	1.12	-0.23	586	18	581	14	580	17	583	12	0.60	580	17
KM60	71	0.00001	0.00877	0.00054	0.11140	496.0	0.9701	0.0215	0.1099	0.0024	0.99	9.45	-2.43	742	17	689	22	672	28	725	14	0.00	672	28
KM60	72	0.00001	0.00060	0.00003	0.05260	233.6	0.1058	0.0014	0.0158	0.0002	0.89	20.15	-1.03	127	30	102	3	101	2	101	2	0.09	101	2
KM60	74	0.00001	0.00137	0.00006	0.08640	381.0	0.1485	0.0024	0.0220	0.0004	0.97	3.12	-0.18	145	19	141	4	140	4	141	4	0.65	140	4
KM60	76	0.00001	0.00038	0.00002	0.03760	165.1	0.0951	0.0016	0.0141	0.0002	0.87	36.60	-2.14	142	38	92	3	90	3	90	3	0.01	90	3
KM60	77	0.00001	0.00004	0.00000	0.00451	19.8	0.0879	0.0025	0.0133	0.0003	0.75	17.66	-0.74	103	89	86	5	85	4	85	4	0.68	85	4
KM60	79	0.00001	0.00302	0.00016	0.06650	289.0	0.4715	0.0080	0.0628	0.0011	0.98	-0.69	0.10	390	16	392	11	393	13	392	10	0.79	393	13
KM60	82	0.00001	0.00328	0.00019	0.05150	222.3	0.7236	0.0102	0.0874	0.0012	0.97	10.74	-2.34	605	14	553	12	540	14	573	10	0.00	540	14
KM60	86	0.00000	0.00101	0.00005	0.09700	415.0	0.1022	0.0021	0.0148	0.0003	0.93	54.28	-4.67	206	35	99	4	94	3	94	4	0.00	94	3
KM60	88	0.00000	0.00300	0.00015	0.09690	410.6	0.3047	0.0044	0.0428	0.0006	0.97	-0.11	0.01	270	16	270	7	270	7	270	7	0.97	270	7
KM60	90	0.00000	0.00323	0.00016	0.24400	1028.0	0.1281	0.0022	0.0187	0.0003	0.98	32.68	-2.36	178	16	122	4	120	4	122	4	0.00	120	4
KM60	91	5.4e-7	0.00052	0.00002	0.04930	207.2	0.0957	0.0020	0.0146	0.0003	0.95	-11.14	0.38	84	31	93	4	93	4	93	4	0.54	93	4
KM60	93	0.00001	0.00034	0.00002	0.06370	228.0	0.0487	0.0012	0.0075	0.0002	0.95	8.64	-0.19	53	34	48	2	48	2	48	2	0.79	48	2
KM60	94	0.00001	0.00048	0.00007	0.05370	192.4	2.1358	0.0446	0.1955	0.0041	0.99	2.28	-0.81	1178	12	1160	29	1151	44	1176	11	0.23	1151	44
KM60	102	0.00001	0.00029	0.00001	0.02920	104.5	0.0960	0.0018	0.0143	0.0002	0.89	35.05	-2.02	141	40	93	3	91	3	91	3	0.02	91	3
KM60	105	0.00000	0.00028	0.00001	0.02776	99.2	0.0914	0.0014	0.0138	0.0002	0.86	5.50	-0.21	94	36	89	3	89	2	89	2	0.78	89	2
KM60	106	0.00000	0.00189	0.00011	0.03082	110.1	0.7075	0.0083	0.0856	0.0009	0.90	11.98	-2.60	602	23	543	10	529	11	542	10	0.00	529	11
KM60	110	0.00001	0.00168	0.00008	0.31300	1120.0	0.0494	0.0006	0.0075	0.0001	0.95	36.18	-1.13	76	18	49	1	48	1	48	1	0.00	48	1
KM60	111	0.00001	0.00022	0.00042	0.02055	73.4	4.1126	0.0464	0.2884	0.0032	0.97	3.14	-1.43	1686	12	1657	19	1634	32	1680	11	0.00	1686	12
KM60	112	0.00000	0.00027	0.00001	0.02687	96.0	0.0934	0.0014	0.0140	0.0002	0.85	26.80	-1.34	122	37	91	3	89	2	90	2	0.08	89	2
KM60	113	0.00001	0.00155	0.00008	0.07220	257.9	0.2068	0.0032	0.0295	0.0004	0.96	20.57	-1.93	236	20	191	5	187	5	190	5	0.00	187	5

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/235	± 1s	Pb206/238	± 1s	Rho1	disc1W	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM76	2	0.00001	0.00157	0.00008	0.03090	166.40	0.5125	0.0101	0.0684	0.0013	0.97	9.63	-1.51	385	23	420	14	426	16	413	12	0.00	426	16
KM76	5	0.00001	0.00106	0.00005	0.03132	167.40	0.3228	0.0067	0.0455	0.0009	0.96	9.24	-1.01	260	28	284	10	287	11	283	10	0.08	287	11
KM76	6	0.00001	0.00148	0.00007	0.04400	235.00	0.3282	0.0068	0.0454	0.0009	0.96	-6.56	0.71	305	26	288	10	286	11	289	10	0.18	286	11
KM76	7	0.00001	0.00809	0.00048	0.09800	522.00	0.9474	0.0192	0.1110	0.0022	0.98	1.15	-0.27	671	20	677	20	679	26	674	15	0.63	679	26
KM76	8	0.00001	0.00233	0.00011	0.08780	466.50	0.2534	0.0051	0.0361	0.0007	0.97	-3.05	0.27	236	23	229	8	229	9	230	8	0.56	229	9
KM76	9	0.00001	0.00984	0.00175	0.02695	143.00	12.5619	0.2480	0.4932	0.0095	0.98	-4.31	2.37	2696	16	2647	37	2585	82	2692	15	0.01	2696	16
KM76	10	0.00001	0.00449	0.00025	0.06520	345.20	0.7493	0.0145	0.0931	0.0018	0.97	5.06	-1.02	545	20	568	17	574	21	559	14	0.05	574	21
KM76	11	0.00001	0.00255	0.00024	0.01181	62.40	3.9372	0.0771	0.2888	0.0055	0.97	1.99	-0.87	1603	18	1621	32	1636	55	1606	17	0.26	1603	18
KM76	12	0.00001	0.00386	0.00037	0.01813	95.70	3.9496	0.0774	0.2884	0.0055	0.97	1.35	-0.59	1611	18	1624	32	1634	55	1614	17	0.45	1611	18
KM76	13	0.00001	0.00271	0.00013	0.08550	451.00	0.3015	0.0059	0.0424	0.0008	0.97	0.92	-0.09	265	22	268	9	268	10	267	9	0.84	268	10
KM76	14	0.00001	0.00131	0.00007	0.03270	171.80	0.4035	0.0080	0.0548	0.0011	0.96	-1.05	0.14	347	25	344	12	344	13	344	11	0.80	344	13
KM76	15	0.00001	0.00866	0.00051	0.11190	588.00	0.8880	0.0173	0.1053	0.0020	0.97	0.07	-0.02	645	20	645	19	645	23	645	15	0.98	645	23
KM76	16	0.00001	0.00438	0.00032	0.03269	171.50	1.8913	0.0383	0.1796	0.0036	0.97	-3.77	1.23	1105	19	1078	27	1065	39	1098	17	0.06	1065	39
KM76	17	0.00001	0.01288	0.00135	0.05453	285.60	4.8065	0.0993	0.3217	0.0065	0.98	1.44	-0.67	1772	17	1786	35	1798	63	1774	16	0.43	1772	17
KM76	18	0.00001	0.00639	0.00046	0.04800	251.20	1.8659	0.0380	0.1810	0.0036	0.98	0.95	-0.31	1062	18	1069	27	1072	39	1064	17	0.64	1072	39
KM76	19	0.00001	0.00290	0.00039	0.07110	371.00	9.4640	0.2462	0.4290	0.0110	0.99	-6.71	3.48	2456	16	2384	48	2301	99	2452	15	0.00	2456	16
KM76	20	0.00001	0.00543	0.00052	0.02480	129.20	4.0486	0.0973	0.2967	0.0070	0.98	4.19	-1.88	1605	18	1644	39	1675	70	1609	18	0.05	1605	18
KM76	21	0.00001	0.00535	0.00030	0.08370	436.20	0.6855	0.0138	0.0864	0.0017	0.98	4.07	-0.78	512	20	530	17	534	20	523	14	0.13	534	20
KM76	22	0.00001	0.00044	0.00002	0.01739	90.50	0.2478	0.0063	0.0337	0.0008	0.94	-60.39	4.94	343	41	225	10	214	10	216	10	0.00	214	10
KM76	23	0.00001	0.00978	0.00069	0.07510	390.10	1.7880	0.0351	0.1748	0.0034	0.97	-0.77	0.25	1047	18	1041	26	1039	37	1045	16	0.70	1039	37
KM76	24	0.00001	0.01075	0.00186	0.02934	152.30	12.2495	0.2529	0.4945	0.0100	0.98	-2.30	1.28	2650	15	2624	39	2590	86	2648	15	0.17	2650	15
KM76	25	0.00001	0.00169	0.00008	0.06470	335.00	0.2481	0.0054	0.0356	0.0008	0.97	1.87	-0.16	221	25	225	9	225	9	225	9	0.75	225	9
KM76	26	0.00001	0.00316	0.00018	0.04456	230.60	0.7996	0.0167	0.0962	0.0020	0.97	-3.66	0.75	614	22	597	19	592	23	603	16	0.17	592	23
KM76	28	0.00001	0.00646	0.00052	0.03776	195.00	2.7031	0.0527	0.2317	0.0044	0.97	2.74	-1.06	1307	18	1329	29	1343	46	1312	17	0.14	1307	18
KM76	29	0.00001	0.00926	0.00097	0.03925	202.50	4.7798	0.0991	0.3203	0.0065	0.98	1.19	-0.55	1770	17	1781	35	1791	64	1771	16	0.52	1770	17
KM76	2	0.00001	0.00164	0.00009	0.03270	169.90	0.5015	0.0071	0.0667	0.0009	0.95	5.98	-0.92	392	20	413	10	416	11	411	9	0.03	416	11
KM76	5	0.00001	0.00107	0.00005	0.03191	165.80	0.3143	0.0049	0.0444	0.0007	0.94	8.61	-0.92	256	25	278	8	280	8	278	8	0.07	280	8
KM76	6	0.00001	0.00149	0.00008	0.04410	229.00	0.3176	0.0049	0.0440	0.0007	0.95	-8.26	0.87	301	23	280	8	278	8	280	8	0.06	278	8
KM76	7	0.00001	0.00821	0.00049	0.09960	517.00	0.9294	0.0141	0.1090	0.0016	0.97	-0.26	0.06	669	17	667	15	667	19	668	12	0.89	667	19
KM76	8	0.00001	0.00234	0.00011	0.08770	455.60	0.2485	0.0037	0.0354	0.0005	0.96	-5.05	0.44	236	20	225	6	224	6	225	6	0.29	224	6
KM76	9	0.00001	0.00989	0.00175	0.02711	140.80	12.3005	0.1838	0.4843	0.0070	0.97	-5.70	3.11	2691	14	2628	28	2546	61	2684	13	0.00	2691	14
KM76	10	0.00001	0.00450	0.00025	0.06540	339.90	0.7340	0.0105	0.0914	0.0013	0.96	4.25	-0.85	540	18	559	12	564	15	554	11	0.04	564	15
KM76	11	0.00001	0.00255	0.00024	0.01185	61.50	3.8433	0.0572	0.2824	0.0041	0.96	0.23	-0.10	1600	16	1602	24	1603	41	1600	15	0.87	1600	16
KM76	12	0.00001	0.00384	0.00037	0.01815	94.30	3.8612	0.0561	0.2826	0.0040	0.96	-0.17	0.07	1607	16	1606	24	1604	40	1607	15	0.90	1607	16
KM76	13	0.00001	0.00273	0.00014	0.08640	449.00	0.2961	0.0044	0.0418	0.0006	0.96	1.58	-0.16	260	20	263	7	264	7	263	7	0.69	264	7
KM76	14	0.00001	0.00126	0.00006	0.03120	162.20	0.3935	0.0058	0.0537	0.0008	0.94	0.06	-0.01	337	23	337	9	337	9	337	9	0.99	337	9
KM76	15	0.00001	0.00875	0.00052	0.11290	587.00	0.8700	0.0122	0.1033	0.0014	0.96	-1.25	0.27	642	17	636	13	634	16	638	12	0.50	634	16
KM76	16	0.00001	0.00442	0.00032	0.03335	173.30	1.8267	0.0277	0.1741	0.0026	0.97	-6.08	1.94	1098	17	1055	20	1035	28	1082	14	0.00	1035	28
KM76	17	0.00001	0.01282	0.00134	0.05450	283.30	4.7059	0.0715	0.3157	0.0047	0.97	0.05	-0.02	1768	15	1768	26	1769	46	1768	14	0.97	1768	15
KM76	18	0.00001	0.00642	0.00046	0.04790	249.10	1.8285	0.0281	0.1778	0.0027	0.97	-0.23	0.08	1057	16	1056	20	1055	29	1057	14	0.88	1055	29

Sample	Spot	Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)					Discordance		Ages					Preferred					
							Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM76	19	0.00001	0.002230	0.00343	0.06960	362.00	9.4362	0.2228	0.4290	0.0100	0.99	-6.49	3.37	2451	14	2381	43	2301	90	2447	13	0.00	2451	14
KM76	20	0.00001	0.00550	0.00052	0.02470	128.50	3.9237	0.0834	0.2879	0.0060	0.98	1.75	-0.77	1602	16	1619	34	1631	60	1604	16	0.36	1602	16
KM76	21	0.00001	0.00534	0.00029	0.08420	438.60	0.6708	0.0102	0.0848	0.0013	0.97	3.58	-0.67	506	18	521	12	525	15	517	11	0.11	525	15
KM76	23	0.00001	0.00980	0.00070	0.07540	393.20	1.7488	0.0254	0.1715	0.0024	0.97	-1.95	0.62	1040	16	1027	19	1020	26	1035	14	0.20	1020	26
KM76	24	0.00001	0.01071	0.00185	0.02934	153.10	12.0207	0.1904	0.4864	0.0075	0.97	-3.55	1.95	2646	14	2606	30	2555	65	2642	13	0.01	2646	14
KM76	25	0.00001	0.00167	0.00008	0.06410	335.00	0.2424	0.0040	0.0348	0.0006	0.96	1.90	-0.16	217	22	220	7	221	7	220	7	0.71	221	7
KM76	26	0.00001	0.00318	0.00018	0.04475	234.10	0.7860	0.0130	0.0945	0.0015	0.96	-5.68	1.15	615	20	589	15	582	18	597	13	0.01	582	18
KM76	28	0.00001	0.00646	0.00053	0.03785	198.40	2.6319	0.0380	0.2260	0.0032	0.97	0.78	-0.30	1303	16	1310	21	1314	33	1305	14	0.58	1303	16
KM76	29	0.00001	0.00924	0.00096	0.03928	206.10	4.6677	0.0714	0.3136	0.0047	0.97	-0.38	0.17	1765	15	1761	26	1758	46	1764	14	0.78	1765	15
KM76	30	0.00001	0.00613	0.00036	0.08710	521.00	0.7928	0.0123	0.0938	0.0014	0.96	-12.44	2.50	650	19	593	14	578	17	609	13	0.00	578	17
KM76	31	0.00001	0.00218	0.00011	0.07810	467.90	0.2596	0.0037	0.0370	0.0005	0.95	-0.42	0.04	235	20	234	6	234	6	234	6	0.93	234	6
KM76	33	0.00001	0.00658	0.00121	0.02030	121.90	11.4814	0.1761	0.4364	0.0065	0.97	-17.76	8.92	2749	14	2563	29	2335	58	2730	12	0.00	2749	14
KM76	34	0.00001	0.00444	0.00022	0.17060	1027.00	0.2437	0.0035	0.0349	0.0005	0.96	-3.24	0.28	228	19	221	6	221	6	221	6	0.48	221	6
KM76	35	0.00001	0.00266	0.00013	0.08718	525.60	0.2915	0.0041	0.0409	0.0006	0.95	-5.10	0.51	272	20	260	6	258	7	260	7	0.22	258	7
KM76	36	0.00001	0.00013	0.00001	0.00183	11.07	0.7604	0.0138	0.0932	0.0014	0.80	0.17	-0.03	573	48	574	16	574	16	574	15	0.97	574	16
KM76	37	0.00001	0.00988	0.00068	0.08200	496.00	1.6209	0.0231	0.1639	0.0023	0.96	0.02	-0.01	978	16	978	18	978	25	978	13	0.99	978	25
KM76	38	0.00001	0.00722	0.00076	0.03236	196.20	4.5193	0.0668	0.3009	0.0043	0.97	-5.06	2.23	1782	15	1735	25	1696	43	1772	14	0.00	1782	15
KM76	39	0.00001	0.00287	0.00017	0.03350	203.50	1.0031	0.0149	0.1156	0.0017	0.96	-0.10	0.02	706	18	705	15	705	15	706	13	0.95	705	19
KM76	40	0.00001	0.00129	0.00009	0.00917	55.80	1.9780	0.0293	0.1882	0.0027	0.95	0.95	-0.32	1101	19	1108	20	1112	29	1104	16	0.54	1112	29
KM76	41	0.00001	0.00979	0.00111	0.04525	275.80	4.7224	0.0684	0.2897	0.0041	0.97	-17.66	7.41	1930	15	1771	24	1640	41	1900	13	0.00	1930	15
KM76	42	0.00001	0.00301	0.00017	0.04730	289.00	0.6839	0.0100	0.0856	0.0012	0.96	0.17	-0.03	528	18	529	12	529	14	529	11	0.94	529	14
KM76	43	0.00001	0.00201	0.00012	0.02770	169.40	0.7984	0.0116	0.0973	0.0014	0.95	2.11	-0.44	586	20	596	13	599	16	594	12	0.32	599	16
KM76	44	0.00001	0.00086	0.00004	0.03138	192.30	0.2581	0.0038	0.0367	0.0005	0.93	-3.79	0.34	241	25	233	6	232	6	233	6	0.50	232	6
KM76	45	0.00000	0.00170	0.00008	0.05381	330.40	0.3008	0.0045	0.0422	0.0006	0.95	-2.28	0.23	272	22	267	7	266	7	267	7	0.60	266	7
KM76	46	0.00000	0.00164	0.00009	0.02608	160.40	0.6744	0.0096	0.0843	0.0012	0.95	-1.54	0.29	530	19	523	12	522	14	525	11	0.50	522	14
KM76	47	0.00000	0.00250	0.00014	0.04114	253.60	0.6424	0.0095	0.0811	0.0012	0.96	-1.45	0.26	510	19	504	12	503	14	505	11	0.53	503	14
KM76	49	0.00001	0.00423	0.00033	0.02677	165.60	2.3741	0.0344	0.2115	0.0030	0.96	0.43	-0.16	1231	16	1235	21	1237	31	1233	14	0.76	1231	16
KM76	50	0.00001	0.00242	0.00014	0.03755	232.70	0.7063	0.0102	0.0872	0.0012	0.95	-3.29	0.63	557	20	543	12	539	14	545	12	0.15	539	14
KM76	51	0.00001	0.00100	0.00005	0.03083	191.50	0.3111	0.0045	0.0434	0.0006	0.95	-5.24	0.55	288	22	275	7	274	7	275	7	0.22	274	7
KM76	52	0.00001	0.00103	0.00005	0.03898	242.60	0.2594	0.0044	0.0352	0.0006	0.93	-57.49	4.89	351	28	234	7	223	7	226	7	0.00	223	7
KM76	53	0.00001	0.00248	0.00014	0.03790	236.40	0.7186	0.0102	0.0884	0.0012	0.96	-3.45	0.66	565	19	550	12	546	14	553	11	0.11	546	14
KM76	54	0.00000	0.00430	0.00032	0.02988	186.60	2.1221	0.0319	0.1966	0.0029	0.97	0.25	-0.09	1154	16	1156	21	1157	31	1155	14	0.87	1157	31
KM76	55	0.00000	0.00036	0.00002	0.01205	75.40	0.2847	0.0042	0.0402	0.0006	0.92	-2.26	0.22	260	28	254	7	254	7	254	7	0.69	254	7
KM76	57	0.00000	0.00344	0.00025	0.02688	168.80	1.7662	0.0282	0.1723	0.0027	0.96	-2.55	0.81	1051	18	1033	21	1025	29	1044	15	0.12	1025	29
KM76	58	0.00001	0.01454	0.00153	0.06410	403.70	4.5885	0.0689	0.3066	0.0045	0.97	-2.97	1.33	1775	15	1747	25	1724	44	1770	14	0.03	1775	15
KM76	59	0.00001	0.00772	0.00081	0.03270	206.50	4.7969	0.0726	0.3205	0.0047	0.97	0.94	-0.44	1775	15	1784	26	1792	46	1777	14	0.48	1775	15
KM76	60	0.00001	0.00019	0.00001	0.00765	49.48	0.2432	0.0045	0.0346	0.0006	0.85	-10.72	0.91	243	45	221	7	219	7	219	7	0.31	219	7
KM76	61	0.00001	0.00131	0.00007	0.01983	128.50	0.7266	0.0100	0.0891	0.0012	0.94	-4.20	0.81	573	21	555	12	550	14	557	12	0.07	550	14
KM76	62	0.00001	0.00061	0.00003	0.00976	63.32	0.6848	0.0096	0.0850	0.0011	0.92	-3.75	0.70	546	24	530	12	526	13	530	12	0.15	526	13
KM76	63	0.00001	0.00119	0.00006	0.03407	221.50	0.3422	0.0047	0.0472	0.0006	0.93	-4.27	0.48	310	23	299	7	297	7	299	7	0.29	297	7
KM76	64	0.00001	0.00139	0.00007	0.02848	185.50	0.5110	0.0073	0.0669	0.0009	0.94	-2.46	0.38	428	23	419	10	418	11	419	10	0.41	418	11

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/235	± 1s	Pb206/238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM76	65	0.00001	0.00088	0.00004	0.03448	225.00	0.2463	0.0036	0.0349	0.0005	0.91	-11.16	0.96	246	29	224	6	221	6	222	6	0.09	221	6
KM76	66	0.00001	0.00633	0.00032	0.20360	1331.00	0.3024	0.0041	0.0423	0.0006	0.96	-3.58	0.37	277	18	268	6	267	7	268	6	0.32	267	7
KM76	67	0.00001	0.00141	0.00008	0.02347	153.80	0.6465	0.0089	0.0815	0.0011	0.94	-1.39	0.25	512	21	506	11	505	13	507	11	0.57	505	13
KM76	68	0.00001	0.00854	0.00078	0.04900	321.70	3.1664	0.0503	0.2403	0.0037	0.97	-10.88	4.19	1539	16	1449	25	1388	38	1520	14	0.00	1539	16
KM76	69	0.00001	0.00143	0.00010	0.01136	74.70	1.7081	0.0277	0.1695	0.0027	0.96	-0.69	0.22	1016	18	1012	21	1009	29	1014	15	0.68	1009	29
KM76	70	0.00001	0.00276	0.00020	0.02144	141.30	1.7820	0.0333	0.1757	0.0032	0.98	1.35	-0.44	1029	17	1039	24	1043	35	1032	15	0.47	1043	35
KM76	71	0.00001	0.00195	0.00010	0.04661	307.70	0.4273	0.0080	0.0577	0.0011	0.97	0.80	-0.11	359	20	361	11	362	13	361	11	0.81	362	13
KM76	72	0.00001	0.00119	0.00006	0.04600	304.50	0.2535	0.0043	0.0352	0.0006	0.93	-33.33	2.86	297	30	229	7	223	7	225	7	0.00	223	7
KM76	73	0.00001	0.00062	0.00005	0.00448	29.70	2.0667	0.0345	0.1904	0.0030	0.94	-3.71	1.26	1165	22	1138	23	1124	33	1152	18	0.03	1124	33
KM76	74	0.00001	0.00678	0.00054	0.04260	283.00	2.4389	0.0386	0.2144	0.0033	0.97	-0.42	0.15	1257	16	1254	23	1252	35	1257	14	0.78	1257	16
KM76	75	0.00001	0.00163	0.00008	0.05830	388.00	0.2683	0.0048	0.0379	0.0007	0.97	-8.38	0.77	260	21	241	8	239	8	242	8	0.07	239	8
KM76	76	0.00001	0.00435	0.00034	0.02825	188.20	2.3759	0.0451	0.2127	0.0040	0.98	1.72	-0.63	1222	16	1235	27	1243	42	1225	15	0.34	1222	16
KM76	77	0.00001	0.01783	0.00301	0.04940	330.00	11.8488	0.1980	0.4910	0.0080	0.98	-1.21	0.68	2606	14	2593	31	2575	69	2605	14	0.38	2606	14
KM76	78	0.00001	0.00356	0.00020	0.05900	394.80	0.6500	0.0106	0.0823	0.0013	0.97	1.44	-0.26	502	19	508	13	510	15	507	12	0.55	510	15
KM76	80	0.00001	0.00709	0.00079	0.02990	204.60	5.1668	0.0770	0.3262	0.0047	0.97	-3.19	1.47	1878	15	1847	25	1820	46	1873	14	0.02	1878	15
KM76	81	0.00001	0.00103	0.00005	0.03950	271.00	0.2498	0.0051	0.0354	0.0007	0.97	-10.95	0.95	249	25	226	8	224	9	227	8	0.06	224	9
KM76	83	0.00000	0.00479	0.00035	0.03650	251.10	1.8783	0.0382	0.1803	0.0036	0.98	-1.38	0.45	1083	16	1073	27	1069	39	1081	15	0.49	1069	39
KM76	84	0.00000	0.00232	0.00013	0.03265	225.00	0.8070	0.0168	0.0978	0.0020	0.98	0.60	-0.13	598	19	601	19	602	23	599	15	0.81	602	23
KM76	85	0.00001	0.00381	0.00037	0.01834	126.70	3.9019	0.0838	0.2840	0.0060	0.98	-0.37	0.16	1617	15	1614	35	1611	60	1617	15	0.85	1617	15
KM76	86	0.00001	0.00359	0.00018	0.09940	687.00	0.3587	0.0074	0.0493	0.0010	0.98	-2.89	0.34	319	19	311	11	310	12	313	10	0.43	310	12
KM76	87	0.00001	0.00213	0.00014	0.02256	156.30	1.2446	0.0235	0.1317	0.0024	0.97	-10.95	2.85	885	21	821	21	798	27	854	17	0.00	798	27
KM76	88	0.00001	0.00720	0.00068	0.03790	263.20	3.4603	0.0600	0.2572	0.0044	0.98	-6.97	2.81	1578	15	1518	27	1476	45	1568	14	0.00	1578	15
KM76	89	0.00001	0.00199	0.00010	0.04930	343.20	0.4109	0.0079	0.0558	0.0011	0.97	1.13	-0.15	346	20	350	11	350	13	349	11	0.74	350	13
KM76	90	0.00001	0.00529	0.00034	0.06610	460.60	1.0022	0.0169	0.1103	0.0018	0.97	-19.08	4.32	803	18	705	17	674	21	749	15	0.00	674	21
KM76	92	0.00000	0.00063	0.00004	0.00850	59.50	0.8592	0.0184	0.1016	0.0021	0.97	-4.35	0.94	651	24	630	20	624	25	638	17	0.11	624	25
KM76	94	0.00001	0.00223	0.00013	0.02911	204.40	0.8723	0.0159	0.1041	0.0019	0.97	1.13	-0.25	631	18	637	17	638	22	634	14	0.61	638	22
KM76	96	0.00001	0.00172	0.00009	0.06570	463.00	0.2584	0.0055	0.0360	0.0008	0.98	-26.28	2.30	288	22	233	9	228	9	236	9	0.00	228	9
KM76	97	0.00001	0.00492	0.00048	0.02302	162.50	4.0464	0.1420	0.2870	0.0100	0.99	-2.39	1.04	1665	17	1644	57	1627	100	1664	16	0.44	1665	17
KM76	98	0.00001	0.00118	0.00006	0.04070	287.50	0.2819	0.0060	0.0393	0.0008	0.96	-15.33	1.46	287	28	252	10	248	10	252	10	0.01	248	10
KM76	100	0.00001	0.00277	0.00019	0.02660	191.70	1.4524	0.0324	0.1459	0.0032	0.98	-12.94	3.61	992	17	911	27	878	36	972	15	0.00	878	36
KM76	101	0.00000	0.00175	0.00009	0.07040	508.00	0.2436	0.0051	0.0342	0.0007	0.97	-24.66	2.07	270	22	221	8	217	9	223	9	0.00	217	9
KM76	102	0.00000	0.00103	0.00007	0.09001	65.00	1.6140	0.0393	0.1594	0.0038	0.98	-7.61	2.28	1026	21	976	31	953	42	1013	18	0.00	953	42
KM76	103	0.00001	0.00183	0.00011	0.02926	211.50	0.7134	0.0125	0.0857	0.0015	0.97	-16.40	3.05	617	20	547	15	530	17	568	14	0.00	530	17
KM76	105	0.00001	0.00184	0.00016	0.00967	70.00	3.3134	0.0783	0.2576	0.0060	0.99	-1.10	0.45	1494	16	1484	37	1478	62	1493	16	0.61	1494	16
KM76	106	0.00001	0.00074	0.00004	0.02371	171.90	0.3098	0.0070	0.0433	0.0010	0.97	-2.78	0.29	281	27	274	11	273	12	274	11	0.60	273	12
KM76	107	0.00001	0.00079	0.00004	0.02481	180.00	0.3188	0.0084	0.0446	0.0012	0.98	0.93	-0.10	279	26	281	13	281	14	281	12	0.86	281	14
KM76	108	0.00001	0.00236	0.00015	0.02663	193.40	1.1264	0.0216	0.1208	0.0023	0.97	-16.60	4.03	857	19	766	21	735	26	817	16	0.00	735	26
KM76	109	0.00001	0.00457	0.00033	0.03770	274.00	1.7128	0.0355	0.1672	0.0034	0.98	-5.30	1.64	1050	17	1013	27	997	38	1041	15	0.01	997	38
KM76	110	0.00000	0.00142	0.00007	0.05500	400.20	0.2480	0.0057	0.0354	0.0008	0.98	0.32	0.32	233	22	225	9	224	10	226	9	0.49	224	10
KM76	111	0.00001	0.00112	0.00005	0.04390	320.00	0.2428	0.0061	0.0348	0.0009	0.98	-1.12	0.10	223	25	221	10	221	11	221	10	0.85	221	11
KM76	113	0.00001	0.00655	0.00052	0.04236	308.50	2.3830	0.0473	0.2104	0.0041	0.98	-1.46	0.53	1249	16	1238	28	1231	44	1247	15	0.44	1249	16

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235 ± 1s	Pb206U238 ± 1s	Rho1	discTW	disc58	207Pb/206Pb ± 2s	207Pb/235U ± 2s	206Pb/238U ± 2s	Concordia ± 2s	probability	Age ± 2s							
KM76	114	0.00001	0.01710	0.00314	0.05080	369.90	12.3100	0.3052	0.4690	0.0115	0.99	-10.73	5.68	2745	14	2628	47	2479	101	2741	13	0.00	2745	14
KM76	115	0.00001	0.00131	0.00006	0.04668	340.30	0.2708	0.0048	0.0382	0.0007	0.95	-7.41	0.69	260	26	243	8	242	8	243	8	0.19	242	8
KM76	116	0.00001	0.00324	0.00019	0.04779	348.50	0.7859	0.0139	0.0937	0.0016	0.97	-9.69	1.95	633	20	589	16	577	19	604	14	0.00	577	19
KM76	118	0.00001	0.00106	0.00005	0.03296	240.50	0.3304	0.0058	0.0449	0.0008	0.94	-22.67	2.43	347	27	290	9	283	9	288	9	0.00	283	9
KM76	119	0.00001	0.00071	0.00004	0.01404	102.40	0.5647	0.0101	0.0698	0.0012	0.92	-27.60	4.32	555	32	455	13	435	14	450	14	0.00	435	14

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	probability	Age	± 2s		
TT04	1	0.00002	0.00114	0.00005	0.11810	402.00	0.0748	0.0011	0.0114	0.0002	0.91	15.16	-0.53	86	29	73	2	73	2	0.37	73	2		
TT04	2	0.00001	0.00035	0.00002	0.03695	126.10	0.0718	0.0011	0.0110	0.0002	0.86	-10.57	0.27	64	39	70	2	71	2	0.73	71	2		
TT04	4	0.00003	0.00061	0.00003	0.04585	156.90	0.1065	0.0018	0.0157	0.0002	0.91	36.53	-2.37	158	33	103	3	101	3	0.00	100	3		
TT04	6	0.00003	0.00028	0.00001	0.02957	101.20	0.0711	0.0013	0.0109	0.0002	0.86	-8.63	0.23	64	44	70	2	70	2	0.80	70	2		
TT04	7	0.00002	0.00046	0.00002	0.04134	141.40	0.0852	0.0014	0.0129	0.0002	0.88	5.70	-0.20	88	38	83	3	83	2	0.79	83	2		
TT04	9	0.00002	0.00336	0.00025	0.01908	65.10	2.2205	0.0368	0.2058	0.0033	0.95	-4.60	1.56	1153	21	1188	23	1206	35	1168	18	0.01	1206	21
TT04	10	0.00001	0.00128	0.00006	0.03695	125.90	0.2890	0.0052	0.0412	0.0007	0.94	-10.87	0.97	235	28	258	8	260	9	0.08	260	9		
TT04	11	0.00002	0.00031	0.00001	0.02274	77.30	0.1045	0.0020	0.0158	0.0003	0.88	-10.38	0.38	92	42	101	4	101	3	0.65	101	3		
TT04	12	0.00002	0.00938	0.00088	0.03910	132.70	3.7463	0.0627	0.2780	0.0045	0.96	0.01	0.00	1581	19	1581	27	1581	45	1581	17	1.00	1581	19
TT04	13	0.00003	0.00062	0.00003	0.05610	189.90	0.0849	0.0015	0.0129	0.0002	0.92	0.12	0.00	83	33	83	3	83	3	1.00	83	3		
TT04	14	0.00003	0.00040	0.00002	0.03549	119.90	0.0861	0.0015	0.0133	0.0002	0.88	-73.09	1.44	49	40	84	3	85	3	0.07	85	3		
TT04	15	0.00003	0.00063	0.00003	0.05060	170.50	0.0940	0.0016	0.0143	0.0002	0.88	-7.81	0.27	85	38	91	3	91	3	0.72	91	3		
TT04	16	0.00002	0.00022	0.00001	0.01741	58.60	0.0963	0.0019	0.0147	0.0002	0.80	-28.30	0.83	73	55	93	3	94	3	0.45	94	3		
TT04	17	0.00002	0.00783	0.00036	0.62800	2109.00	0.0966	0.0015	0.0145	0.0002	0.95	15.83	-0.71	110	24	94	3	93	3	0.15	93	3		
TT04	18	0.00001	0.00083	0.00004	0.07680	257.10	0.0832	0.0013	0.0127	0.0002	0.92	-15.89	0.45	70	30	81	2	82	2	0.46	82	2		
TT04	19	0.00002	0.00008	0.00000	0.00855	28.54	0.0715	0.0019	0.0109	0.0002	0.61	10.82	-0.35	78	100	70	4	70	2	0.87	70	2		
TT04	21	0.00002	0.00083	0.00004	0.06500	230.90	0.0990	0.0015	0.0150	0.0002	0.90	0.97	-0.04	97	31	96	3	96	3	0.95	96	3		
TT04	22	0.00002	0.00051	0.00002	0.05200	184.70	0.0748	0.0012	0.0114	0.0002	0.87	15.09	-0.53	86	37	73	2	73	2	0.48	73	2		
TT04	23	0.00002	0.00034	0.00002	0.03481	123.70	0.0747	0.0012	0.0114	0.0002	0.84	6.92	-0.22	78	42	73	2	73	2	0.80	73	2		
TT04	24	0.00002	0.00027	0.00001	0.02440	86.70	0.0840	0.0016	0.0128	0.0002	0.78	1.78	-0.06	83	55	82	3	82	2	0.96	82	2		
TT04	25	0.00003	0.02021	0.00223	0.07550	268.10	5.0346	0.0715	0.3133	0.0042	0.94	7.72	-3.88	1904	18	1825	24	1757	41	1882	16	0.00	1904	18
TT04	26	0.00003	0.00169	0.00008	0.15200	540.00	0.0863	0.0013	0.0131	0.0002	0.92	8.16	-0.30	91	27	84	2	84	2	0.58	84	2		
TT04	27	0.00003	0.00035	0.00002	0.03691	130.80	0.0735	0.0012	0.0111	0.0002	0.85	25.15	-0.98	95	41	72	2	71	2	0.25	71	2		
TT04	28	0.00003	0.00048	0.00002	0.05290	187.00	0.0696	0.0011	0.0107	0.0002	0.86	-30.50	0.65	53	39	68	2	69	2	0.41	69	2		
TT04	29	0.00002	0.00015	0.00001	0.01498	52.83	0.0759	0.0015	0.0114	0.0002	0.69	40.64	-2.05	123	68	74	3	73	2	0.15	73	2		
TT04	31	0.00001	0.00543	0.00031	0.06810	238.70	0.7735	0.0110	0.0943	0.0013	0.93	0.58	-0.12	584	22	582	13	581	15	0.80	581	15		
TT04	32	0.00002	0.00028	0.00001	0.02287	79.90	0.0943	0.0016	0.0144	0.0002	0.81	-15.09	0.48	80	46	91	3	92	2	0.60	92	2		
TT04	33	0.00002	0.00030	0.00001	0.03160	110.10	0.0741	0.0013	0.0111	0.0002	0.81	43.92	-2.29	127	48	73	2	71	2	0.02	71	2		
TT04	34	0.00003	0.00114	0.00005	0.09000	312.00	0.0990	0.0015	0.0149	0.0002	0.92	8.24	-0.35	104	29	96	3	96	3	0.55	96	3		
TT04	35	0.00003	0.00063	0.00003	0.04120	142.20	0.1188	0.0019	0.0178	0.0003	0.90	10.03	-0.51	126	32	114	3	113	3	0.44	113	3		
TT04	36	0.00003	0.00071	0.00004	0.01679	57.71	0.3560	0.0053	0.0491	0.0007	0.89	1.11	-0.13	312	31	309	8	309	8	0.83	309	8		
TT04	37	0.00003	0.00018	0.00001	0.01952	66.70	0.0703	0.0013	0.0107	0.0002	0.74	17.68	-0.60	83	60	69	3	69	2	0.62	69	2		
TT04	38	0.00002	0.00042	0.00002	0.03790	129.20	0.0846	0.0014	0.0129	0.0002	0.83	-12.88	0.38	73	45	83	3	83	2	0.67	83	2		
TT04	39	0.00002	0.00088	0.00004	0.09510	322.80	0.0710	0.0011	0.0107	0.0002	0.90	34.71	-1.50	105	33	70	2	69	2	0.03	69	2		
TT04	40	0.00002	0.00049	0.00002	0.03061	103.40	0.1277	0.0027	0.0188	0.0004	0.92	24.26	-1.56	159	40	122	5	120	5	0.06	120	5		
TT04	41	0.00003	0.00047	0.00002	0.04810	176.00	0.0763	0.0012	0.0116	0.0002	0.86	7.33	-0.24	80	37	75	2	74	2	0.75	74	2		
TT04	42	0.00002	0.00083	0.00004	0.09020	331.00	0.0709	0.0011	0.0108	0.0001	0.89	10.96	-0.35	78	33	70	2	69	2	0.60	69	2		
TT04	43	0.00002	0.00037	0.00002	0.03149	116.00	0.0911	0.0014	0.0138	0.0002	0.85	6.82	-0.26	95	40	89	3	88	2	0.75	88	2		
TT04	44	0.00001	0.00071	0.00003	0.06460	239.00	0.0876	0.0013	0.0132	0.0002	0.91	14.58	-0.59	99	30	85	2	85	2	0.34	85	2		
TT04	45	0.00001	0.00074	0.00003	0.07670	284.40	0.0758	0.0011	0.0114	0.0002	0.88	39.96	-1.99	121	33	74	2	73	2	0.00	73	2		
TT04	46	0.00001	0.00063	0.00003	0.05910	219.00	0.0831	0.0013	0.0126	0.0002	0.87	14.43	-0.55	94	37	81	2	81	2	0.46	81	2		
TT04	47	0.00002	0.00114	0.00005	0.12390	461.00	0.0711	0.0010	0.0109	0.0001	0.92	3.02	-0.09	72	27	70	2	70	2	0.87	70	2		

Sample	Spot	Normal (Wetherill concordia plot)											Discordance			Ages					Preferred																	
		Pb204_V					Pb206_V					Pb207_V					disc58			207Pb/206Pb					207Pb/235U		206Pb/238U		Concordia		± 2s		probability		Age		± 2s	
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	± 2s	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s	probability	Age	± 2s								
TT04	48	0.00002	0.00023	0.00001	0.02501	93.10	0.0717	0.0013	0.0110	0.0002	0.82	3.57	-0.11	73	49	70	2	70	2	70	2	70	2	0.92	70	2	0.92	70	2									
TT04	50	0.00003	0.00025	0.00001	0.02657	98.80	0.0751	0.0013	0.0111	0.0002	0.77	49.70	-2.92	142	53	74	2	71	2	71	2	71	2	0.01	71	2	0.01	71	2									
TT04	51	0.00002	0.00043	0.00002	0.04650	172.80	0.0734	0.0011	0.0111	0.0002	0.87	26.05	-1.03	96	37	72	2	71	2	71	2	71	2	0.18	71	2	0.18	71	2									
TT04	52	0.00002	0.00135	0.00006	0.13940	517.30	0.0755	0.0011	0.0114	0.0002	0.93	24.70	-0.98	97	27	74	2	73	2	73	2	73	2	0.08	73	2	0.08	73	2									
TT04	53	0.00002	0.00044	0.00002	0.04650	172.20	0.0728	0.0012	0.0111	0.0002	0.85	4.78	-0.15	75	39	71	2	71	2	71	2	71	2	0.86	71	2	0.86	71	2									
TT04	54	0.00001	0.00099	0.00004	0.10400	384.30	0.0742	0.0011	0.0113	0.0002	0.90	6.28	-0.20	77	31	73	2	73	2	73	2	73	2	0.75	73	2	0.75	73	2									
TT04	55	0.00002	0.00080	0.00004	0.08600	316.80	0.0710	0.0011	0.0109	0.0002	0.90	-33.04	0.70	53	33	70	2	70	2	70	2	70	2	0.29	70	2	0.29	70	2									
TT04	56	0.00002	0.00893	0.00068	0.05540	203.70	2.0848	0.0298	0.1898	0.0026	0.94	5.75	-2.10	1189	20	1144	20	1120	28	1166	16	0.00	1120	28	0.00	1120	28											
TT04	57	0.00002	0.00015	0.00001	0.01357	49.69	0.0874	0.0017	0.0130	0.0002	0.69	36.99	-2.01	132	68	85	3	83	2	83	2	0.15	83	2	0.15	83	2											
TT04	58	0.00003	0.00384	0.00019	0.09940	362.80	0.3274	0.0046	0.0455	0.0006	0.93	1.63	-0.18	292	24	288	7	287	7	288	7	0.70	287	7	0.70	287	7											
TT04	59	0.00003	0.00059	0.00003	0.04646	169.00	0.1027	0.0016	0.0151	0.0002	0.89	42.66	-2.95	168	34	99	3	96	3	97	3	0.00	96	3	0.00	96	3											
TT04	60	0.00002	0.00050	0.00002	0.04621	167.50	0.0840	0.0013	0.0128	0.0002	0.88	1.78	-0.06	83	36	82	2	82	2	82	2	0.93	82	2	0.93	82	2											
TT04	61	0.00003	0.00047	0.00002	0.04840	172.80	0.0787	0.0013	0.0115	0.0002	0.87	57.52	-4.18	174	37	77	2	74	2	74	2	0.00	74	2	0.00	74	2											
TT04	62	0.00002	0.00071	0.00003	0.07820	279.40	0.0715	0.0012	0.0108	0.0002	0.92	35.49	-1.56	107	30	70	2	69	2	69	2	0.01	69	2	0.01	69	2											
TT04	63	0.00002	0.00056	0.00003	0.05220	186.50	0.0851	0.0015	0.0129	0.0002	0.91	15.21	-0.60	97	35	83	3	82	3	83	3	0.40	82	3	0.40	82	3											
TT04	64	0.00001	0.00045	0.00002	0.04730	169.00	0.0737	0.0014	0.0113	0.0002	0.91	0.17	-0.01	72	37	72	3	72	2	72	2	0.99	72	2	0.99	72	2											
TT04	65	0.00001	0.00038	0.00002	0.04220	150.70	0.0705	0.0013	0.0108	0.0002	0.87	7.76	-0.24	75	42	69	2	69	2	69	2	0.78	69	2	0.78	69	2											
TT04	66	0.00001	0.00109	0.00005	0.11800	420.60	0.0725	0.0011	0.0110	0.0002	0.92	24.05	-0.91	93	29	71	2	70	2	71	2	0.13	70	2	0.13	70	2											
TT04	68	0.00002	0.00042	0.00002	0.03188	113.40	0.1059	0.0018	0.0157	0.0002	0.88	33.74	-2.08	151	37	102	3	100	3	100	3	0.01	100	3	0.01	100	3											
TT04	69	0.00002	0.00132	0.00006	0.14660	520.00	0.0710	0.0011	0.0109	0.0002	0.93	0.33	-0.01	70	28	70	2	70	2	70	2	0.99	70	2	0.99	70	2											
TT04	70	0.00003	0.00123	0.00006	0.13360	474.00	0.0717	0.0011	0.0108	0.0002	0.92	32.08	-1.34	102	28	70	2	69	2	69	2	0.02	69	2	0.02	69	2											
TT04	71	0.00003	0.00011	0.00001	0.01231	43.57	0.0732	0.0017	0.0110	0.0002	0.63	37.55	-1.74	113	83	72	3	71	2	71	2	0.31	71	2	0.31	71	2											
TT04	72	0.00002	0.00071	0.00003	0.07980	281.90	0.0705	0.0011	0.0107	0.0002	0.90	23.67	-0.87	90	32	69	2	69	2	69	2	0.19	69	2	0.19	69	2											
TT04	73	0.00002	0.00030	0.00001	0.03108	109.60	0.0764	0.0013	0.0114	0.0002	0.81	40.80	-2.08	124	48	75	2	73	2	73	2	0.04	73	2	0.04	73	2											
TT04	75	0.00001	0.00015	0.00001	0.01239	43.55	0.0928	0.0018	0.0141	0.0002	0.75	-2.13	0.08	88	60	90	3	90	3	90	3	0.95	90	3	0.95	90	3											
TT04	76	0.00001	0.00027	0.00001	0.03030	106.40	0.0712	0.0012	0.0109	0.0002	0.83	11.15	-0.36	78	44	70	2	70	2	70	2	0.69	70	2	0.69	70	2											
TT04	77	0.00002	0.00020	0.00001	0.02210	77.50	0.0733	0.0014	0.0110	0.0002	0.79	37.49	-1.74	113	54	72	3	71	2	71	2	0.12	71	2	0.12	71	2											
TT04	78	0.00003	0.00140	0.00007	0.04350	152.30	0.0705	0.0042	0.0382	0.0006	0.93	5.38	-0.53	256	26	243	7	242	7	243	7	0.31	242	7	0.31	242	7											
TT04	81	0.00002	0.00070	0.00003	0.07590	296.60	0.0713	0.0013	0.0109	0.0002	0.92	15.01	-0.50	82	34	70	2	70	2	70	2	0.47	70	2	0.47	70	2											
TT04	82	0.00002	0.00162	0.00008	0.03888	152.50	0.3610	0.0058	0.0499	0.0008	0.94	-1.69	0.20	308	26	313	9	314	9	313	9	0.71	314	9	0.71	314	9											
TT04	83	0.00002	0.00173	0.00008	0.05130	201.60	0.2856	0.0045	0.0405	0.0006	0.94	-2.39	0.23	255	25	255	7	256	7	255	7	0.65	256	7	0.65	256	7											
TT04	84	0.00002	0.00075	0.00003	0.07230	284.00	0.0815	0.0014	0.0125	0.0002	0.91	-22.46	0.59	65	33	80	3	80	2	80	2	0.38	80	2	0.38	80	2											
TT04	85	0.00001	0.00101	0.00005	0.08060	317.50	0.0989	0.0015	0.0150	0.0002	0.91	-9.36	0.33	88	31	96	3	96	3	96	3	0.59	96	3	0.59	96	3											
TT04	86	0.00001	0.00092	0.00004	0.08530	335.90	0.0849	0.0013	0.0130	0.0002	0.93	-10.87	0.33	75	29	83	3	83	2	83	2	0.57	83	2	0.57	83	2											
TT04	87	0.00001	0.00029	0.00001	0.02463	96.90	0.0908	0.0016	0.0141	0.0002	0.84	-166.56	2.24	34	45	88	3	90	3	90	3	0.01	90	3	0.01	90	3											
TT04	88	0.00001	0.00039	0.00002	0.03279	128.80	0.0953	0.0016	0.0143	0.0002	0.85	16.98	-0.76	110	42	92	3	92	3	92	3	0.38	92	3	0.38	92	3											
TT04	89	0.00001	0.00136	0.00006	0.11180	438.10	0.0963	0.0014	0.0146	0.0002	0.92	-7.22	0.25	87	27	93	3	94	3	94	3	0.64	94	3	0.64	94	3											
TT04	90	0.00002	0.00068	0.00003	0.07480	292.00	0.0725	0.0011	0.0110	0.0002	0.90	16.23	-0.56	84	32	71	2	71	2	71	2	0.40	71	2	0.40	71	2											
TT04	91	0.00002	0.00151	0.00007	0.11970	466.90	0.1011	0.0015	0.0152	0.0002	0.92	8.56	-0.37	107	28	98	3	97	3	98	3	0.52	97	3	0.52	97	3											
TT04	93	0.00001	0.00137	0.00006	0.11400	441.00	0.0943	0.0015	0.0144	0.0002	0.94	-16.62	0.53	79	27	91	3	92	3	92	3	0.34	92	3	0.34	92	3											
TT04	94	0.00001	0.00032	0.00001	0.03504	134.90	0.0720	0.0012	0.0110	0.0002	0.85	-7.40	0.20	66	42	71	2	71	2	71	2	0.82	71	2	0.82	71	2											
TT04	95	0.00001	0.00019	0.00001	0.02088	80.00	0.0700	0.0013	0.0108	0.0002	0.80	-19.52	0.46	58	56	69	3	69	2	69	2	0.69	69	2	0.69	69	2											

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages										Preferred	
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s	
TT04	96	0.00000	0.00038	0.00002	0.03040	115.80	0.1007	0.0018	0.0152	0.0002	0.88	0.34	-0.01	98	39	97	3	97	3	97	3	0.99	97	3	
TT04	97	0.00001	0.00099	0.00005	0.06560	249.00	0.1219	0.0021	0.0183	0.0003	0.94	1.34	-0.06	118	29	117	4	117	4	117	4	0.91	117	4	
TT04	98	0.00002	0.00032	0.00001	0.02968	112.10	0.0856	0.0015	0.0130	0.0002	0.84	-3.85	0.13	80	46	83	3	83	2	83	2	0.89	83	2	
TT04	99	0.00002	0.00026	0.00001	0.02359	88.60	0.0879	0.0016	0.0132	0.0002	0.82	25.09	-1.16	113	49	86	3	85	2	85	2	0.25	85	2	
TT04	100	0.00002	0.00079	0.00004	0.08410	314.50	0.0739	0.0013	0.0113	0.0002	0.93	9.05	-0.29	79	31	72	2	72	2	72	2	0.65	72	2	
TT04	101	0.00002	0.00053	0.00002	0.05910	234.60	0.0715	0.0011	0.0110	0.0002	0.88	-14.81	0.37	61	36	70	2	70	2	70	2	0.61	70	2	
TT04	102	0.00002	0.00029	0.00001	0.03212	128.20	0.0717	0.0012	0.0110	0.0002	0.83	-5.40	0.15	67	44	70	2	70	2	70	2	0.87	70	2	
TT04	103	0.00002	0.00026	0.00001	0.02793	112.00	0.0757	0.0013	0.0115	0.0002	0.79	19.89	-0.74	92	49	74	2	74	2	74	2	0.46	74	2	
TT04	104	0.00002	0.00059	0.00003	0.04644	186.80	0.1006	0.0016	0.0153	0.0002	0.89	-23.57	0.75	79	34	97	3	98	3	98	3	0.27	98	3	
TT04	107	0.00001	0.00026	0.00001	0.02115	85.60	0.1021	0.0020	0.0152	0.0002	0.74	26.48	-1.43	132	63	99	4	97	3	97	3	0.27	97	3	
TT04	108	0.00001	0.00059	0.00003	0.05620	227.80	0.0838	0.0013	0.0127	0.0002	0.90	19.89	-0.82	101	32	82	2	81	2	81	2	0.21	81	2	
TT04	109	0.00002	0.00020	0.00001	0.02183	88.40	0.0734	0.0013	0.0110	0.0002	0.77	42.33	-2.13	122	54	72	2	70	2	70	2	0.06	70	2	
TT04	110	0.00002	0.00140	0.00006	0.10900	441.00	0.1030	0.0015	0.0155	0.0002	0.92	9.86	-0.44	110	27	100	3	99	3	99	3	0.43	99	3	
TT04	111	0.00003	0.00176	0.00008	0.06130	247.80	0.2420	0.0036	0.0347	0.0005	0.93	1.87	-0.16	224	25	220	6	220	6	220	6	0.75	220	6	
TT04	112	0.00003	0.00065	0.00003	0.06790	274.20	0.0758	0.0012	0.0116	0.0002	0.89	-0.39	0.01	74	34	74	2	74	2	74	2	0.99	74	2	
TT04	113	0.00002	0.00049	0.00002	0.03834	154.40	0.1012	0.0016	0.0154	0.0002	0.87	-8.75	0.32	90	37	98	3	98	3	98	3	0.67	98	3	
TT04	114	0.00002	0.00033	0.00002	0.03058	122.90	0.0865	0.0015	0.0131	0.0002	0.84	17.71	-0.73	102	44	84	3	84	2	84	2	0.42	84	2	
TT04	115	0.00002	0.00020	0.00001	0.02183	87.40	0.0715	0.0013	0.0111	0.0002	0.75	-143.86	1.69	29	57	70	2	71	2	71	2	0.13	71	2	
TT04	116	0.00001	0.00065	0.00003	0.06840	273.00	0.0745	0.0012	0.0114	0.0002	0.89	4.57	-0.14	76	35	73	2	73	2	73	2	0.84	73	2	
TT04	117	0.00001	0.00031	0.00001	0.02468	98.10	0.0981	0.0017	0.0149	0.0002	0.81	-7.89	0.28	88	49	95	3	95	3	95	3	0.78	95	3	
TT04	119	0.00002	0.00082	0.00004	0.06070	239.20	0.1086	0.0017	0.0164	0.0002	0.89	-7.99	0.31	97	33	105	3	105	3	105	3	0.64	105	3	
TT04	120	0.00003	0.00011	0.00001	0.01022	40.07	0.0866	0.0019	0.0127	0.0002	0.68	52.33	-3.71	171	76	84	4	81	2	81	2	0.02	81	2	
TT04	121	0.00003	0.00139	0.00006	0.08850	345.00	0.1262	0.0019	0.0188	0.0003	0.92	6.36	-0.33	128	29	121	3	120	3	120	3	0.57	120	3	
TT04	122	0.00002	0.00024	0.00001	0.02545	98.80	0.0750	0.0013	0.0115	0.0002	0.80	-0.12	0.00	73	49	73	2	73	2	73	2	1.00	73	2	
TT05	1	0.00003	0.00309	0.00015	0.09370	666.00	0.2653	0.0045	0.0374	0.0006	0.94	8.76	-0.88	260	26	239	7	237	7	238	7	0.10	237	7	
TT05	2	0.00004	0.00123	0.00008	0.01033	73.60	1.3320	0.0266	0.1394	0.0027	0.95	7.31	-2.19	908	26	860	23	841	30	880	20	0.00	841	30	
TT05	3	0.00004	0.00110	0.00008	0.00667	47.60	1.9830	0.0421	0.1893	0.0039	0.96	-2.12	0.70	1094	25	1110	29	1118	42	1101	21	0.34	1118	42	
TT05	4	0.00004	0.00340	0.00018	0.05430	389.00	0.5526	0.0109	0.0716	0.0014	0.96	1.24	-0.20	451	25	447	14	446	16	447	14	0.71	446	16	
TT05	5	0.00003	0.00972	0.00069	0.05800	416.00	1.9400	0.0390	0.1860	0.0036	0.96	-1.29	0.43	1086	22	1095	27	1100	39	1089	19	0.54	1100	39	
TT05	7	0.00002	0.00568	0.00033	0.06160	444.00	0.8839	0.0179	0.1050	0.0021	0.96	-0.40	0.09	641	24	643	19	644	24	642	17	0.88	644	24	
TT05	9	0.00002	0.00304	0.00021	0.01941	140.90	1.8253	0.0394	0.1773	0.0037	0.97	0.69	-0.23	1060	23	1055	28	1052	41	1058	20	0.75	1052	41	
TT05	10	0.00002	0.00153	0.00007	0.04580	334.00	0.2641	0.0049	0.0374	0.0007	0.94	6.84	-0.67	254	28	238	8	236	8	238	8	0.24	236	8	
TT05	11	0.00001	0.00220	0.00012	0.03090	235.40	0.6654	0.0174	0.0845	0.0022	0.98	-5.44	0.96	496	26	518	21	523	26	510	18	0.14	523	26	
TT05	12	0.00000	0.00052	0.00003	0.01238	94.10	0.3420	0.0090	0.0476	0.0012	0.96	-3.34	0.37	290	33	299	14	300	15	298	13	0.59	300	15	
TT05	14	0.00001	0.00405	0.00029	0.02444	185.40	2.0361	0.0538	0.1933	0.0050	0.98	-3.05	1.02	1105	23	1128	36	1139	54	1111	21	0.25	1139	54	
TT05	15	0.00002	0.00223	0.00013	0.02480	188.00	0.8942	0.0256	0.1070	0.0030	0.98	-4.76	1.02	626	25	649	27	655	35	636	20	0.17	655	35	
TT05	16	0.00002	0.00394	0.00023	0.03970	301.00	1.0020	0.0246	0.1173	0.0028	0.97	-6.33	1.43	672	25	705	25	715	32	688	19	0.04	715	32	
TT05	17	0.00002	0.00185	0.00009	0.04710	356.00	0.3259	0.0092	0.0454	0.0013	0.98	-0.06	0.45	288	27	286	14	286	15	287	13	0.91	286	15	
TT05	18	0.00001	0.01138	0.00080	0.07330	554.00	1.8510	0.0518	0.1803	0.0050	0.98	-1.40	0.45	1054	22	1064	37	1069	54	1056	20	0.61	1069	54	
TT05	19	0.00001	0.01009	0.00055	0.13890	1048.00	0.6642	0.0170	0.0837	0.0021	0.98	-1.04	0.19	513	24	517	21	518	25	515	17	0.76	518	25	
TT05	20	0.00000	0.00777	0.00043	0.09150	690.00	0.8035	0.0206	0.0978	0.0025	0.98	-2.21	0.45	588	24	599	23	602	29	594	18	0.49	602	29	

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	±1s	Pb206U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
TT05	21	0.00001	0.00215	0.00010	0.05690	428.00	0.3067	0.0084	0.0431	0.0012	0.98	-1.32	0.14	268	27	272	13	272	14	271	13	0.82	272	14
TT05	22	0.00001	0.00089	0.00005	0.01324	99.60	0.6777	0.0268	0.0822	0.0032	0.98	14.57	-3.17	596	32	525	33	509	38	562	26	0.00	509	38
TT05	23	0.00002	0.00116	0.00006	0.03350	252.30	0.2844	0.0087	0.0402	0.0012	0.98	0.22	-0.02	255	29	254	14	254	15	254	13	0.97	254	15
TT05	24	0.00002	0.00200	0.00011	0.02930	220.00	0.6429	0.0219	0.0819	0.0028	0.99	-3.78	0.66	489	26	504	27	507	33	496	20	0.38	507	33
TT05	25	0.00002	0.00243	0.00012	0.06750	507.00	0.3107	0.0087	0.0422	0.0012	0.98	23.01	-3.12	346	27	275	13	266	14	281	14	0.00	266	14
TT05	26	0.00002	0.00326	0.00019	0.03220	241.80	0.9921	0.0274	0.1163	0.0032	0.98	-5.90	1.33	670	24	700	28	709	36	682	20	0.07	709	36
TT05	27	0.00001	0.00309	0.00018	0.03400	254.60	0.8961	0.0268	0.1074	0.0032	0.98	-5.74	1.22	622	25	650	29	658	37	634	21	0.11	658	37
TT05	28	0.00001	0.00379	0.00021	0.05110	383.00	0.7108	0.0220	0.0874	0.0027	0.98	4.65	-0.94	566	28	545	26	540	31	555	21	0.21	540	31
TT05	29	0.00001	0.00222	0.00010	0.06690	501.00	0.2789	0.0092	0.0401	0.0013	0.98	-17.53	1.44	216	28	250	15	253	16	244	13	0.02	253	16
TT05	30	0.00001	0.00083	0.00005	0.00943	70.60	0.8167	0.0272	0.0995	0.0033	0.98	-4.23	0.86	587	28	606	30	611	38	596	23	0.30	611	38
TT05	31	0.00002	0.00028	0.00001	0.00795	59.40	0.3104	0.0127	0.0428	0.0017	0.97	13.37	-1.61	312	43	275	20	270	21	277	20	0.08	270	21
TT05	32	0.00002	0.00304	0.00022	0.01722	128.60	2.2332	0.0609	0.2059	0.0055	0.98	-3.71	1.28	1164	23	1192	38	1207	59	1169	21	0.17	1207	23
TT05	33	0.00002	0.00034	0.00002	0.01035	77.30	0.2719	0.0108	0.0387	0.0015	0.97	-2.66	0.24	238	42	244	17	245	19	244	17	0.78	245	19
TT05	35	0.00001	0.00040	0.00002	0.01166	86.90	0.2844	0.0129	0.0405	0.0018	0.98	-7.75	0.70	238	42	254	20	256	22	252	19	0.45	256	22
TT05	36	5.1e-7	0.00119	0.00009	0.00642	47.80	2.3167	0.0989	0.2130	0.0090	0.99	-6.46	2.20	1169	24	1217	61	1245	96	1174	25	0.13	1169	96
TT05	38	0.00001	0.00041	0.00002	0.01129	84.00	0.3187	0.0155	0.0449	0.0022	0.98	-7.97	0.79	262	42	281	24	283	27	277	22	0.41	283	27
TT05	39	0.00001	0.00017	0.00001	0.00519	38.70	0.2852	0.0138	0.0405	0.0019	0.95	-4.76	0.45	244	72	255	22	256	23	255	22	0.76	256	23
TT05	40	0.00002	0.00342	0.00021	0.03370	251.00	1.1136	0.0578	0.1260	0.0065	0.99	-2.69	0.67	745	25	760	56	765	74	747	24	0.61	765	74
TT05	41	0.00002	0.00108	0.00007	0.01110	86.10	1.0994	0.0384	0.1210	0.0042	0.98	8.33	-2.28	803	28	753	37	736	48	787	24	0.01	736	48
TT05	42	0.00001	0.00177	0.00009	0.05550	430.00	0.2721	0.0080	0.0383	0.0011	0.98	8.23	-0.84	264	28	244	13	242	14	246	13	0.15	242	14
TT05	43	0.00001	0.01083	0.00076	0.07080	548.00	1.8341	0.0577	0.1773	0.0055	0.99	1.59	-0.53	1069	22	1058	41	1052	60	1067	21	0.60	1052	60
TT05	44	0.00000	0.00310	0.00054	0.00759	58.80	12.5130	0.3875	0.4920	0.0150	0.98	4.23	-2.50	2693	19	2644	58	2579	130	2691	18	0.08	2693	19
TT05	45	-9e-7	0.00057	0.00003	0.01600	123.70	0.2971	0.0107	0.0424	0.0015	0.98	-15.11	1.33	233	34	264	17	268	19	259	16	0.07	268	19
TT05	46	0.00000	0.00304	0.00019	0.02770	214.00	1.2117	0.0391	0.1308	0.0042	0.98	6.07	-1.71	844	25	806	36	792	47	833	21	0.05	792	47
TT05	47	0.00001	0.00059	0.00003	0.00724	55.90	0.8137	0.0289	0.0979	0.0034	0.98	1.90	-0.41	614	33	605	32	602	40	609	25	0.65	602	40
TT05	48	0.00002	0.00115	0.00006	0.01390	107.20	0.8197	0.0270	0.1003	0.0033	0.98	-6.76	1.34	577	27	608	30	616	38	590	22	0.10	616	38
TT05	49	0.00002	0.00113	0.00008	0.00741	57.00	1.9591	0.0542	0.1822	0.0049	0.97	5.89	-2.09	1146	26	1102	37	1079	53	1134	23	0.02	1079	53
TT05	50	0.00001	0.00180	0.00010	0.01965	151.20	0.9482	0.0272	0.1105	0.0031	0.98	0.94	-0.22	682	26	677	28	676	36	680	21	0.77	676	36
TT05	51	0.00001	0.00542	0.00047	0.02457	188.70	3.3632	0.0920	0.2610	0.0070	0.98	0.15	-0.06	1497	21	1496	43	1495	72	1497	20	0.95	1497	21
TT05	52	0.00001	0.00867	0.00122	0.02219	170.20	9.6051	0.2128	0.4650	0.0100	0.97	-5.03	2.60	2344	19	2398	41	2462	88	2350	20	0.01	2344	19
TT05	53	0.00000	0.00144	0.00007	0.03990	305.60	0.3058	0.0073	0.0433	0.0010	0.97	-9.04	0.86	251	29	271	11	273	12	270	11	0.15	273	12
TT05	54	0.00001	0.00844	0.00061	0.05440	416.00	1.9338	0.0446	0.1807	0.0041	0.97	5.83	-2.06	1137	22	1093	31	1071	44	1124	19	0.01	1071	44
TT05	55	0.00001	0.00180	0.00009	0.05400	412.00	0.2828	0.0089	0.0404	0.0013	0.98	-10.87	0.96	230	28	253	14	255	15	249	13	0.12	255	15
TT05	56	0.00002	0.01150	0.00097	0.05460	416.00	3.1927	0.1004	0.2580	0.0080	0.99	-4.18	1.64	1420	21	1455	49	1480	82	1424	21	0.16	1420	21
TT05	57	0.00002	0.00075	0.00004	0.00759	57.70	1.0051	0.0250	0.1177	0.0028	0.96	-6.78	1.52	672	31	706	25	717	32	694	22	0.04	717	32
TT05	58	0.00002	0.00240	0.00012	0.03900	296.10	0.5542	0.0130	0.0725	0.0017	0.97	-4.88	0.76	430	26	448	17	451	20	443	15	0.20	451	20
TT05	59	0.00002	0.00514	0.00033	0.04380	332.00	1.3875	0.0446	0.1457	0.0046	0.98	2.66	-0.78	901	25	884	38	877	52	896	23	0.40	877	52
TT05	60	0.00001	0.00178	0.00009	0.03630	274.70	0.4258	0.0118	0.0573	0.0016	0.98	2.05	-0.28	367	28	360	17	359	19	362	16	0.66	359	19
TT05	61	0.00001	0.00269	0.00015	0.03180	241.00	0.7942	0.0211	0.0964	0.0025	0.98	0.23	-0.05	595	25	594	24	593	29	594	19	0.94	593	29
TT05	62	0.00000	0.00171	0.00008	0.04880	367.00	0.3005	0.0115	0.0425	0.0016	0.99	-5.93	0.57	253	28	267	18	268	20	263	16	0.38	268	20
TT05	63	0.00001	0.00388	0.00021	0.05410	406.00	0.6765	0.0231	0.0861	0.0029	0.99	-8.45	1.46	491	25	525	28	532	34	506	20	0.06	532	34
TT05	64	0.00002	0.00194	0.00009	0.04740	355.00	0.3582	0.0121	0.0497	0.0017	0.98	-5.09	0.57	298	27	311	18	313	20	307	16	0.37	313	20

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	±1s	Pb206/U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
TT05	65	0.00002	0.00276	0.00015	0.03930	293.00	0.6927	0.0223	0.0851	0.0027	0.98	7.36	-1.50	568	25	534	27	526	32	553	20	0.04	526	32
TT05	66	0.00003	0.00091	0.00008	0.00476	35.50	3.1171	0.1344	0.2280	0.0095	0.97	17.68	-8.53	1608	42	1437	66	1324	100	1575	35	0.00	1608	42
TT05	67	0.00002	0.00114	0.00005	0.03380	251.00	0.2807	0.0086	0.0398	0.0012	0.98	-1.67	0.16	247	29	251	14	252	15	251	13	0.80	252	15
TT05	68	0.00002	0.00095	0.00005	0.02457	181.80	0.3363	0.0109	0.0471	0.0015	0.98	-7.50	0.78	276	31	294	17	297	18	291	16	0.26	297	18
TT05	70	0.00000	0.00080	0.00004	0.02219	163.20	0.3078	0.0112	0.0432	0.0016	0.98	-0.55	0.06	271	32	272	17	273	19	272	16	0.94	273	19
TT05	71	0.00002	0.00033	0.00002	0.00459	26.40	0.7201	0.0180	0.0883	0.0021	0.93	4.70	-0.96	572	41	551	21	545	24	552	21	0.25	545	24
TT05	73	0.00003	0.00091	0.00007	0.00583	33.60	2.0437	0.0429	0.1896	0.0038	0.96	2.79	-0.98	1151	25	1130	29	1119	41	1143	21	0.18	1119	41
TT05	74	0.00004	0.00525	0.00036	0.03980	229.70	1.5916	0.0390	0.1574	0.0038	0.97	7.91	-2.61	1023	24	967	31	942	42	1004	21	0.00	942	42
TT05	75	0.00004	0.00087	0.00005	0.01750	101.10	0.4738	0.0121	0.0607	0.0015	0.97	20.29	-3.67	477	30	394	17	380	18	403	17	0.00	380	18
TT05	76	0.00003	0.00271	0.00014	0.05830	337.00	0.4212	0.0113	0.0555	0.0015	0.98	15.91	-2.51	414	27	357	16	348	18	367	16	0.00	348	18
TT05	77	0.00003	0.00169	0.00008	0.05470	318.00	0.2617	0.0055	0.0369	0.0008	0.96	10.47	-1.06	261	28	236	9	234	9	236	9	0.06	234	9
TT05	78	0.00002	0.00266	0.00018	0.01933	112.30	1.6815	0.0348	0.1682	0.0034	0.96	-0.20	0.06	1000	24	1002	26	1002	37	1001	20	0.93	1002	37
TT05	79	0.00002	0.00408	0.00022	0.05330	310.00	0.7569	0.0161	0.0923	0.0019	0.97	2.62	-0.54	584	24	572	19	569	22	576	17	0.35	569	22
TT05	80	0.00001	0.00150	0.00008	0.02820	164.30	0.4850	0.0109	0.0646	0.0014	0.96	-3.49	0.50	390	28	402	15	404	17	400	14	0.40	404	17
TT05	81	0.00002	0.00723	0.00041	0.08620	504.00	0.8374	0.0186	0.0999	0.0022	0.97	2.86	-0.63	632	24	618	21	614	25	623	17	0.29	614	25
TT05	82	0.00002	0.00093	0.00005	0.02550	149.00	0.3150	0.0071	0.0439	0.0010	0.95	3.65	-0.40	287	31	277	11	277	12	278	11	0.53	277	12
TT05	83	0.00003	0.00242	0.00012	0.07200	422.00	0.2919	0.0066	0.0409	0.0009	0.97	5.92	-0.63	275	27	260	10	258	11	261	10	0.26	258	11
TT05	85	0.00002	0.00219	0.00011	0.06480	382.00	0.3025	0.0078	0.0417	0.0011	0.97	15.67	-1.90	312	28	268	12	263	13	271	12	0.00	263	13
TT05	86	0.00001	0.00146	0.00007	0.04630	273.00	0.2713	0.0086	0.0386	0.0012	0.98	-2.01	0.19	239	30	244	14	244	15	243	13	0.78	244	15
TT05	87	0.00001	0.00220	0.00011	0.07210	426.00	0.2584	0.0055	0.0366	0.0008	0.96	7.37	-0.72	250	27	233	9	232	9	234	9	0.20	232	9
TT05	88	0.00001	0.00023	0.00002	0.00144	8.51	2.0929	0.0521	0.1937	0.0045	0.92	1.28	-0.45	1156	38	1146	34	1141	48	1150	30	0.63	1141	48
TT05	89	0.00001	0.00314	0.00020	0.03000	177.90	1.1945	0.0259	0.1312	0.0028	0.97	1.56	-0.42	807	24	798	24	795	31	803	19	0.52	795	31
TT05	90	0.00002	0.00043	0.00002	0.01258	74.80	0.3075	0.0092	0.0418	0.0012	0.96	23.25	-3.13	344	39	272	14	264	15	272	15	0.00	264	15
TT05	91	0.00003	0.00314	0.00015	0.08200	488.00	0.3377	0.0078	0.0467	0.0011	0.97	3.51	-0.41	305	26	295	12	294	13	296	12	0.46	294	13
TT05	93	0.00003	0.00318	0.00018	0.04010	240.00	0.8060	0.0192	0.0970	0.0023	0.97	2.65	-0.57	613	24	600	22	597	26	606	18	0.37	597	26
TT05	94	0.00002	0.00679	0.00119	0.01850	110.90	11.6072	0.2642	0.4520	0.0100	0.97	11.26	-7.03	2709	19	2573	43	2404	89	2698	17	0.00	2709	19
TT05	95	0.00001	0.00221	0.00011	0.07250	435.00	0.2630	0.0055	0.0373	0.0008	0.96	4.60	-0.44	247	27	237	9	236	9	237	9	0.42	236	9
TT05	96	0.00001	0.00190	0.00039	0.00423	25.50	16.7378	0.4307	0.5570	0.0140	0.98	3.75	-2.30	2966	19	2920	49	2854	116	2963	18	0.06	2966	19
TT05	97	0.00001	0.00126	0.00006	0.04130	249.00	0.2616	0.0062	0.0371	0.0009	0.96	5.10	-0.49	247	30	236	10	235	11	236	10	0.43	235	11
TT05	99	0.00002	0.00367	0.00024	0.02850	172.90	1.5290	0.0342	0.1569	0.0034	0.97	0.91	-0.27	948	23	942	27	940	38	946	20	0.70	940	38
TT05	100	0.00003	0.00140	0.00010	0.00884	53.70	1.9593	0.0452	0.1855	0.0042	0.97	1.26	-0.43	1111	23	1102	31	1097	45	1108	21	0.58	1097	45
TT05	101	0.00003	0.00372	0.00026	0.02550	155.40	1.8527	0.0375	0.1797	0.0035	0.96	-0.27	0.09	1062	23	1064	27	1065	38	1063	19	0.90	1065	38
TT05	1	0.00004	0.00325	0.00020	0.03460	187.00	1.0000	0.0225	0.1127	0.0024	0.95	8.60	-2.23	753	31	704	23	688	28	717	22	0.00	688	28
TT05	2	0.00004	0.00052	0.00003	0.01328	71.70	0.3507	0.0063	0.0481	0.0008	0.93	6.38	-0.79	323	30	305	9	303	10	305	9	0.20	303	10
TT05	4	0.00003	0.00571	0.00041	0.03750	203.00	2.0119	0.0332	0.1907	0.0031	0.97	-1.50	0.50	1109	17	1120	22	1125	33	1112	15	0.38	1125	33
TT05	5	0.00003	0.00257	0.00015	0.03134	169.70	0.8648	0.0121	0.1023	0.0014	0.95	3.44	-0.78	650	20	633	13	628	16	637	13	0.08	628	16
TT05	6	0.00003	0.00234	0.00013	0.03070	166.30	0.7750	0.0093	0.0945	0.0011	0.93	0.47	-0.10	585	20	583	11	582	12	583	10	0.82	582	12
TT05	7	0.00002	0.00128	0.00006	0.03513	190.60	0.3154	0.0032	0.0442	0.0004	0.87	-2.04	0.21	273	23	278	5	279	5	279	5	0.64	279	5
TT05	8	0.00002	0.00863	0.00060	0.06250	340.00	1.7526	0.0168	0.1718	0.0015	0.91	1.83	-0.60	1041	17	1028	12	1022	17	1032	12	0.10	1022	17
TT05	9	0.00003	0.00987	0.00054	0.14710	799.00	0.6717	0.0099	0.0842	0.0012	0.96	0.59	-0.11	524	18	522	12	521	14	522	11	0.79	521	14
TT05	10	0.00003	0.00379	0.00021	0.04787	260.50	0.8161	0.0133	0.0986	0.0016	0.97	-0.24	0.05	605	19	606	15	606	18	605	13	0.91	606	18
TT05	11	0.00003	0.00222	0.00011	0.06550	402.00	0.3005	0.0051	0.0423	0.0007	0.97	-1.16	0.12	264	21	267	8	267	9	267	8	0.78	267	9

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	±1s	Pb206/U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
TT05	12	0.00003	0.00109	0.00006	0.01813	111.20	0.6108	0.0095	0.0749	0.0011	0.95	18.65	-3.96	572	23	484	12	466	13	490	13	0.00	466	13
TT05	13	0.00002	0.00100	0.00005	0.03298	202.30	0.2641	0.0048	0.0375	0.0007	0.96	3.04	-0.29	245	24	238	8	237	8	238	8	0.56	237	8
TT05	14	0.00002	0.00159	0.00008	0.02595	159.20	0.6094	0.0076	0.0779	0.0009	0.92	-0.49	0.08	481	22	483	10	484	11	483	10	0.85	484	11
TT05	15	0.00002	0.00086	0.00004	0.02640	162.00	0.3093	0.0048	0.0418	0.0006	0.92	26.07	-3.66	357	27	274	7	264	7	268	8	0.00	264	7
TT05	16	0.00002	0.00550	0.00033	0.06050	371.00	0.9902	0.0035	0.1147	0.0015	0.96	-0.71	0.17	695	18	699	14	700	17	698	12	0.69	700	17
TT05	17	0.00002	0.00044	0.00003	0.00516	31.70	0.9086	0.0171	0.1082	0.0019	0.93	-4.17	0.90	636	29	656	18	662	22	653	17	0.15	662	22
TT05	18	0.00002	0.00352	0.00019	0.05130	315.60	0.6907	0.0100	0.0865	0.0012	0.96	-1.58	0.29	527	19	533	12	535	14	532	11	0.48	535	14
TT05	19	0.00003	0.00274	0.00014	0.08990	553.00	0.2796	0.0059	0.0392	0.0008	0.97	9.47	-1.01	274	24	250	9	248	10	251	9	0.04	248	10
TT05	20	0.00003	0.00176	0.00010	0.02274	139.80	0.8102	0.0105	0.0984	0.0012	0.94	-1.99	0.41	593	20	603	12	605	14	601	11	0.34	605	14
TT05	21	0.00003	0.00060	0.00003	0.01835	112.90	0.3112	0.0055	0.0423	0.0007	0.93	22.35	-3.01	344	30	275	9	267	9	272	9	0.00	267	9
TT05	22	0.00003	0.00374	0.00028	0.02354	144.90	2.2024	0.0322	0.2028	0.0029	0.96	-2.07	0.72	1166	17	1182	20	1190	31	1172	15	0.17	1190	31
TT05	23	0.00002	0.00036	0.00002	0.01218	75.00	0.2615	0.0047	0.0375	0.0006	0.89	-7.09	0.60	222	37	236	8	237	7	237	7	0.41	237	7
TT05	25	0.00002	0.00091	0.00004	0.03004	185.10	0.2726	0.0045	0.0388	0.0006	0.95	-2.72	0.25	239	25	245	7	245	7	245	7	0.62	245	7
TT05	26	0.00002	0.00291	0.00022	0.01788	110.20	2.2805	0.0395	0.2065	0.0035	0.97	-0.90	0.32	1199	18	1206	24	1210	37	1201	16	0.60	1199	37
TT05	27	0.00002	0.00564	0.00027	0.17840	1100.00	0.2843	0.0044	0.0398	0.0006	0.97	9.14	-0.98	277	19	254	7	252	7	255	7	0.01	252	7
TT05	28	0.00002	0.00074	0.00004	0.02341	144.40	0.2834	0.0043	0.0399	0.0006	0.91	4.31	-0.44	264	29	253	7	252	7	253	7	0.44	252	7
TT05	29	0.00003	0.00109	0.00005	0.03708	228.80	0.2602	0.0038	0.0371	0.0005	0.93	-0.01	0.00	235	24	235	6	235	6	235	6	1.00	235	6
TT05	30	0.00003	0.00102	0.00007	0.06697	43.00	1.9137	0.0306	0.1835	0.0028	0.95	-0.06	0.02	1085	20	1086	21	1086	31	1086	17	0.97	1086	31
TT05	31	0.00002	0.00207	0.00010	0.05870	365.00	0.3330	0.0047	0.0453	0.0006	0.95	16.56	-2.19	342	21	292	7	286	7	291	7	0.00	286	7
TT05	32	0.00002	0.00153	0.00011	0.01101	68.40	1.9861	0.0275	0.1836	0.0024	0.94	6.20	-2.22	1158	19	1111	19	1087	26	1134	15	0.00	1087	26
TT05	35	0.00003	0.00129	0.00006	0.03990	247.70	0.2973	0.0049	0.0419	0.0007	0.95	-1.07	0.11	262	24	264	8	265	8	264	8	0.83	265	8
TT05	36	0.00003	0.00602	0.00042	0.04310	267.70	1.8021	0.0349	0.1768	0.0034	0.98	-0.96	0.31	1039	17	1046	25	1049	37	1041	15	0.62	1049	37
TT05	37	0.00003	0.00166	0.00009	0.02167	134.60	0.7913	0.0141	0.0960	0.0017	0.96	0.81	-0.17	596	22	592	16	591	19	593	14	0.74	591	19
TT05	38	0.00002	0.00140	0.00008	0.01944	120.70	0.7388	0.0118	0.0917	0.0014	0.95	-3.57	0.68	546	21	562	14	566	17	558	13	0.15	566	17
TT05	39	0.00002	0.00578	0.00044	0.03720	231.00	2.2175	0.0381	0.2005	0.0034	0.97	2.02	-0.73	1202	17	1187	24	1178	36	1198	15	0.22	1178	36
TT05	40	0.00002	0.00239	0.00014	0.02921	181.50	0.8695	0.0150	0.1025	0.0017	0.96	4.33	-0.99	658	21	635	16	629	20	643	15	0.05	629	20
TT05	41	0.00002	0.00210	0.00019	0.00965	60.00	3.8006	0.0652	0.2800	0.0047	0.97	0.22	-0.10	1595	17	1593	28	1591	47	1594	16	0.89	1595	17
TT05	42	0.00002	0.00715	0.00099	0.02100	130.30	8.9118	0.1657	0.4410	0.0080	0.98	-2.12	1.11	2306	15	2329	34	2355	72	2308	15	0.18	2306	15
TT05	45	0.00003	0.00094	0.00005	0.03116	193.50	0.2745	0.0042	0.0387	0.0006	0.94	6.18	-0.62	261	24	246	7	245	7	246	7	0.20	245	7
TT05	46	0.00003	0.00444	0.00037	0.02370	147.40	3.0169	0.0417	0.2461	0.0033	0.96	-1.15	0.45	1402	16	1412	21	1418	34	1405	15	0.39	1402	16
TT05	47	0.00003	0.00057	0.00003	0.00650	40.36	0.9607	0.0153	0.1120	0.0017	0.93	-0.43	0.10	681	26	684	16	684	19	683	15	0.85	684	19
TT05	48	0.00002	0.00234	0.00012	0.04249	263.90	0.5330	0.0085	0.0689	0.0011	0.95	5.91	-0.99	457	22	434	11	430	13	436	11	0.03	430	13
TT05	49	0.00002	0.00430	0.00029	0.03492	216.90	1.5487	0.0299	0.1561	0.0029	0.96	5.04	-1.60	985	22	950	24	935	32	969	18	0.01	935	32
TT05	50	0.00001	0.00194	0.00010	0.03840	238.00	0.4918	0.0086	0.0651	0.0011	0.96	-0.66	0.10	404	21	406	12	407	13	406	11	0.83	407	13
TT05	51	0.00001	0.00121	0.00008	0.01652	88.10	0.8254	0.0069	0.0968	0.0007	0.86	10.92	-2.59	669	19	611	8	596	8	606	8	0.00	596	8
TT05	52	0.00003	0.00155	0.00009	0.02067	117.50	0.7836	0.0152	0.0954	0.0018	0.97	0.12	-0.02	588	21	588	17	587	21	588	15	0.96	587	21
TT05	54	0.00002	0.00645	0.00037	0.10200	625.00	0.6686	0.0084	0.0801	0.0010	0.94	20.27	-4.66	623	18	520	10	497	11	528	11	0.00	497	11
TT05	55	0.00001	0.00201	0.00010	0.05450	325.50	0.3419	0.0042	0.0478	0.0006	0.93	-7.51	0.79	280	21	299	6	301	7	299	6	0.06	301	7
TT05	56	0.00001	0.00307	0.00021	0.02584	143.90	1.5350	0.0199	0.1548	0.0019	0.95	5.67	-1.80	984	18	945	16	928	21	961	14	0.00	928	21
TT05	57	0.00001	0.00142	0.00012	0.00776	28.60	2.8319	0.0425	0.2347	0.0034	0.95	0.92	-0.36	1372	19	1364	23	1359	35	1369	16	0.52	1372	19
TT05	58	0.00002	0.00263	0.00013	0.08470	511.00	0.2788	0.0032	0.0395	0.0004	0.93	-0.99	0.09	247	21	250	5	250	5	250	5	0.82	250	5
TT05	59	0.00002	0.00072	0.00004	0.02196	115.00	0.3151	0.0044	0.0433	0.0006	0.90	14.39	-1.78	319	28	278	7	273	7	275	7	0.00	273	7

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
TT05	60	0.00003	0.00168	0.00008	0.04560	262.50	0.3394	0.0040	0.0470	0.0005	0.91	1.78	-0.20	301	23	297	6	296	6	296	6	0.65	296	6
TT05	61	0.00002	0.00151	0.00007	0.04730	271.60	0.2982	0.0038	0.0418	0.0005	0.93	3.56	-0.37	274	22	265	6	264	6	265	6	0.40	264	6
TT05	62	0.00002	0.00105	0.00005	0.03240	176.10	0.3008	0.0037	0.0412	0.0004	0.86	20.26	-2.58	326	29	267	6	260	5	262	5	0.00	260	5
TT05	63	0.00002	0.00063	0.00003	0.01349	55.40	0.4338	0.0064	0.0600	0.0008	0.91	-23.36	2.60	304	28	366	9	376	10	367	9	0.00	376	10
TT05	64	0.00001	0.00258	0.00015	0.03006	158.60	0.9221	0.0129	0.1090	0.0015	0.95	-2.35	0.52	652	19	663	14	667	17	660	13	0.24	667	17
TT05	65	0.00001	0.00080	0.00004	0.02330	115.00	0.3120	0.0040	0.0441	0.0005	0.89	-9.25	0.89	255	28	276	6	278	6	277	6	0.10	278	6
TT05	66	0.00001	0.00017	0.00001	0.00547	0.13	0.2853	0.0058	0.0414	0.0007	0.84	-34.83	2.55	194	51	255	9	262	9	259	8	0.01	262	9
TT05	68	0.00002	0.00099	0.00006	0.01165	42.10	0.9302	0.0140	0.1111	0.0016	0.93	-7.90	1.68	629	24	668	15	679	18	661	14	0.00	679	18
TT05	69	0.00002	0.00136	0.00007	0.03350	182.50	0.3800	0.0051	0.0525	0.0007	0.93	-7.41	0.85	307	23	327	7	330	8	327	7	0.06	330	8
TT05	70	0.00002	0.00439	0.00031	0.03379	186.00	1.7034	0.0253	0.1680	0.0024	0.96	2.69	-0.87	1029	17	1010	19	1001	27	1021	14	0.08	1001	27
TT05	71	0.00003	0.00192	0.00010	0.02980	162.60	0.6518	0.0103	0.0828	0.0013	0.96	-3.56	0.63	495	20	510	13	513	15	507	12	0.16	513	15
TT05	72	0.00002	0.00349	0.00019	0.05190	304.90	0.6937	0.0104	0.0868	0.0013	0.96	-1.55	0.29	528	19	535	13	537	15	534	12	0.51	537	15
TT05	73	0.00002	0.00197	0.00012	0.02311	123.30	0.9550	0.0133	0.1108	0.0015	0.94	2.06	-0.49	692	21	681	14	677	17	683	13	0.28	677	17
TT05	75	0.00001	0.00273	0.00015	0.04050	237.30	0.6920	0.0089	0.0869	0.0011	0.94	-3.22	0.59	520	19	534	11	537	12	532	10	0.15	537	12
TT05	76	0.00001	0.00154	0.00008	0.04147	245.50	0.3425	0.0043	0.0475	0.0006	0.93	-0.25	0.03	298	22	299	6	299	7	299	6	0.95	299	7
TT05	77	0.00001	0.00098	0.00005	0.02086	115.70	0.4377	0.0064	0.0590	0.0008	0.93	-1.82	0.25	363	25	369	9	370	10	369	9	0.62	370	10
TT05	78	0.00002	0.00357	0.00021	0.04430	267.00	0.8905	0.0141	0.1051	0.0016	0.96	1.66	-0.38	655	19	647	15	644	19	650	13	0.41	644	19
TT05	79	0.00002	0.00515	0.00035	0.03844	231.50	1.7350	0.0288	0.1713	0.0028	0.97	0.71	-0.23	1027	18	1022	21	1019	30	1025	15	0.68	1019	30
TT05	80	0.00002	0.00100	0.00005	0.03185	191.10	0.2903	0.0046	0.0409	0.0006	0.93	1.46	-0.15	262	27	259	7	258	7	259	7	0.78	258	7
TT05	81	0.00002	0.01876	0.00197	0.07500	469.00	5.0210	0.0615	0.3266	0.0038	0.95	0.12	-0.05	1824	15	1823	21	1822	37	1824	14	0.92	1824	15
TT12	1	0.00003	0.00024	0.00001	0.01857	73.90	0.1056	0.0018	0.0159	0.0002	0.82	7.66	-0.34	110	46	102	3	102	3	102	3	0.71	102	3
TT12	2	0.00003	0.01547	0.00135	0.07370	295.80	3.2631	0.0475	0.2580	0.0036	0.95	-1.22	0.49	1462	19	1472	23	1480	36	1466	17	0.39	1462	19
TT12	3	0.00003	0.00519	0.00116	0.00987	39.99	20.7812	0.3104	0.6372	0.0090	0.95	-2.62	1.56	3097	17	3128	29	3178	71	3101	17	0.03	3097	17
TT12	4	0.00003	0.00070	0.00003	0.05360	218.90	0.1049	0.0016	0.0158	0.0002	0.89	1.35	-0.06	103	35	101	3	101	3	101	3	0.94	101	3
TT12	5	0.00004	0.00097	0.00004	0.15410	634.00	0.0513	0.0008	0.0077	0.0001	0.90	57.73	-2.81	117	33	51	2	49	1	49	1	0.00	49	1
TT12	6	0.00004	0.00073	0.00003	0.02983	123.70	0.2089	0.0034	0.0301	0.0005	0.92	9.87	-0.82	212	30	193	6	191	6	192	6	0.17	191	6
TT12	7	0.00003	0.00273	0.00012	0.20160	842.00	0.1100	0.0016	0.0165	0.0002	0.93	7.72	-0.36	114	26	106	3	106	3	106	3	0.50	106	3
TT12	8	0.00002	0.00094	0.00004	0.07110	298.90	0.1069	0.0017	0.0162	0.0002	0.91	-13.55	0.50	91	30	103	3	104	3	104	3	0.41	104	3
TT12	10	0.00002	0.00123	0.00006	0.09390	398.80	0.1058	0.0016	0.0160	0.0002	0.93	1.02	-0.04	103	27	102	3	102	3	102	3	0.94	102	3
TT12	11	0.00002	0.00225	0.00010	0.17750	758.00	0.1011	0.0015	0.0153	0.0002	0.93	3.49	-0.14	101	26	98	3	98	3	98	3	0.79	98	3
TT12	12	0.00002	0.00163	0.00007	0.12130	520.00	0.1088	0.0016	0.0164	0.0002	0.93	2.11	-0.09	107	27	105	3	105	3	105	3	0.87	105	3
TT12	13	0.00003	0.00200	0.00009	0.15060	647.00	0.1074	0.0016	0.0162	0.0002	0.93	0.02	0.00	104	27	104	3	104	3	104	3	1.00	104	3
TT12	14	0.00003	0.00054	0.00002	0.04300	185.30	0.1028	0.0018	0.0155	0.0002	0.92	8.34	-0.36	108	33	99	3	99	3	99	3	0.59	99	3
TT12	15	0.00004	0.01309	0.00074	0.18460	797.00	0.7239	0.0105	0.0876	0.0012	0.94	9.81	-2.12	600	22	553	12	542	14	558	12	0.00	542	14
TT12	16	0.00002	0.00221	0.00010	0.16410	710.00	0.1081	0.0017	0.0162	0.0002	0.94	9.27	-0.43	114	26	104	3	104	3	104	3	0.42	104	3
TT12	17	0.00002	0.00065	0.00003	0.04968	215.10	0.1051	0.0017	0.0160	0.0002	0.91	-32.50	1.00	77	33	101	3	103	3	102	3	0.12	103	3
TT12	18	0.00001	0.00077	0.00003	0.08070	349.70	0.0761	0.0012	0.0117	0.0002	0.92	-23.21	0.57	61	30	74	2	75	2	75	2	0.34	75	2
TT12	19	0.00001	0.00058	0.00003	0.04440	192.20	0.1062	0.0018	0.0161	0.0003	0.91	-6.25	0.24	97	34	103	3	103	3	103	3	0.72	103	3
TT12	20	0.00002	0.00089	0.00004	0.06750	292.20	0.1069	0.0018	0.0162	0.0002	0.92	-3.61	0.14	100	31	103	3	103	3	103	3	0.82	103	3
TT12	21	0.00002	0.00539	0.00026	0.41350	1786.00	0.1094	0.0016	0.0159	0.0002	0.94	46.41	-3.63	190	24	105	3	102	3	102	3	0.00	102	3
TT12	22	0.00002	0.00075	0.00003	0.05710	234.00	0.1068	0.0017	0.0161	0.0002	0.90	-1.41	0.06	102	33	103	3	103	3	103	3	0.93	103	3

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	±1s	Pb206U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
TT12	24	0.00002	0.00032	0.00001	0.02506	100.20	0.1043	0.0020	0.0158	0.0003	0.89	-11.37	0.41	91	42	101	4	101	3	101	3	0.63	101	3
TT12	25	0.00002	0.00053	0.00002	0.03771	148.60	0.1153	0.0020	0.0172	0.0003	0.90	14.44	-0.75	128	36	111	4	110	3	110	3	0.30	110	3
TT12	26	0.00001	0.00045	0.00002	0.03735	144.80	0.0962	0.0018	0.0147	0.0003	0.91	-29.99	0.87	72	37	93	3	94	3	94	3	0.24	94	3
TT12	27	0.00001	0.00032	0.00001	0.02686	102.20	0.0968	0.0019	0.0147	0.0003	0.87	-2.84	0.10	91	46	94	4	94	3	94	3	0.91	94	3
TT12	28	0.00001	0.00320	0.00021	0.02897	108.20	1.2951	0.0202	0.1356	0.0020	0.94	9.60	-2.91	907	22	844	18	820	23	866	16	0.00	820	23
TT12	1	0.00004	0.00103	0.00005	0.07810	439.10	0.1035	0.0011	0.0154	0.0001	0.87	24.04	-1.27	130	24	100	2	99	2	99	2	0.01	99	2
TT12	2	0.00004	0.00168	0.00008	0.13480	801.00	0.1005	0.0010	0.0146	0.0001	0.90	53.22	-4.41	199	21	97	2	93	2	93	2	0.00	93	2
TT12	3	0.00002	0.00113	0.00005	0.08260	511.00	0.1059	0.0011	0.0160	0.0001	0.87	-5.32	0.21	97	24	102	2	102	2	102	2	0.67	102	2
TT12	4	0.00003	0.00055	0.00003	0.04320	273.00	0.0990	0.0010	0.0150	0.0001	0.80	-0.64	0.02	95	30	96	2	96	2	96	2	0.97	96	2
TT12	5	0.00003	0.00124	0.00006	0.13690	868.00	0.0686	0.0006	0.0105	0.0001	0.88	2.21	-0.06	69	21	67	1	67	1	67	1	0.88	67	1
TT12	6	0.00004	0.00108	0.00005	0.08650	540.10	0.0962	0.0008	0.0144	0.0001	0.84	21.98	-1.06	118	22	93	1	92	1	92	1	0.02	92	1
TT12	7	0.00004	0.00449	0.00025	0.06070	368.60	0.6938	0.0052	0.0866	0.0006	0.92	-0.32	0.06	534	14	535	6	535	7	535	6	0.83	535	7
TT12	9	0.00004	0.00088	0.00004	0.06400	353.50	0.1086	0.0010	0.0162	0.0001	0.85	18.40	-0.95	127	23	105	2	104	2	104	2	0.04	104	2
TT12	10	0.00003	0.00199	0.00009	0.16960	879.00	0.0903	0.0009	0.0137	0.0001	0.92	7.07	-0.27	94	19	88	2	88	2	88	2	0.48	88	2
TT12	12	0.00003	0.00154	0.00007	0.13280	605.00	0.0901	0.0006	0.0137	0.0001	0.78	6.79	-0.26	94	20	88	1	87	1	87	1	0.53	87	1
TT12	13	0.00003	0.00874	0.00052	0.09100	386.00	0.9609	0.0091	0.1115	0.0010	0.95	1.43	-0.34	691	13	684	9	681	12	686	9	0.26	681	12
TT12	14	0.00003	0.00157	0.00007	0.25450	499.00	0.0486	0.0004	0.0073	0.0000	0.86	55.22	-2.41	105	19	48	1	47	1	47	1	0.00	47	1
TT12	15	0.00003	0.01183	0.00128	0.04130	81.20	5.3295	0.0380	0.3375	0.0022	0.91	-0.11	0.05	1872	12	1874	12	1875	21	1873	10	0.86	1872	12
TT12	16	0.00003	0.00095	0.00004	0.08040	158.20	0.0927	0.0009	0.0140	0.0001	0.89	16.08	-0.70	107	22	90	2	89	2	90	2	0.13	89	2
TT12	17	0.00004	0.00348	0.00017	0.09860	195.00	0.2996	0.0020	0.0418	0.0002	0.86	7.95	-0.88	287	16	266	3	264	3	265	3	0.01	264	3
TT12	18	0.00004	0.01763	0.00129	0.11140	221.90	1.9784	0.0110	0.1865	0.0009	0.87	1.53	-0.52	1120	12	1108	8	1102	10	1109	8	0.03	1102	10
TT12	21	0.00003	0.00063	0.00003	0.05090	105.20	0.0970	0.0008	0.0146	0.0001	0.75	17.07	-0.78	112	26	94	1	93	1	93	1	0.15	93	1
TT12	22	0.00002	0.00043	0.00002	0.03410	71.70	0.1013	0.0009	0.0151	0.0001	0.53	25.32	-1.33	129	37	98	2	97	1	97	1	0.08	97	1
TT12	23	0.00002	0.00039	0.00002	0.05860	125.90	0.0509	0.0005	0.0078	0.0000	0.61	22.05	-0.58	64	38	50	1	50	1	50	1	0.46	50	1
TT12	24	0.00003	0.00102	0.00005	0.07670	168.80	0.1065	0.0008	0.0158	0.0001	0.76	28.05	-1.60	141	23	103	1	101	1	101	1	0.00	101	1
TT12	25	0.00003	0.00090	0.00004	0.07660	173.50	0.0926	0.0008	0.0140	0.0001	0.79	12.86	-0.54	103	25	90	1	89	1	89	1	0.29	89	1
TT12	26	0.00004	0.00040	0.00002	0.02975	69.50	0.1100	0.0012	0.0160	0.0001	0.81	45.51	-3.52	188	30	106	2	102	2	102	2	0.00	102	2
TT12	27	0.00004	0.00071	0.00003	0.05190	125.70	0.1093	0.0009	0.0163	0.0001	0.78	22.24	-1.21	134	25	105	2	104	1	104	1	0.02	104	1
TT12	28	0.00004	0.00057	0.00003	0.04540	114.70	0.1004	0.0009	0.0147	0.0001	0.64	45.74	-3.27	173	31	97	2	94	1	94	1	0.00	94	1
TT12	29	0.00003	0.00033	0.00002	0.05025	133.00	0.0513	0.0005	0.0077	0.0000	0.57	56.58	-2.68	114	39	51	1	49	1	49	1	0.00	49	1
TT12	30	0.00002	0.00020	0.00001	0.03066	85.70	0.0502	0.0008	0.0077	0.0001	0.69	32.87	-0.99	73	55	50	2	49	1	49	1	0.39	49	1
TT12	31	0.00002	0.00049	0.00002	0.03687	109.70	0.1049	0.0013	0.0157	0.0002	0.84	15.00	-0.72	118	32	101	2	101	2	101	2	0.27	101	2
TT12	32	0.00002	0.00014	0.00001	0.01126	36.00	0.1018	0.0019	0.0152	0.0002	0.61	23.74	-1.23	128	68	98	3	97	2	97	2	0.38	97	2
TT12	33	0.00003	0.00080	0.00004	0.05480	190.00	0.1188	0.0017	0.0176	0.0002	0.94	26.46	-1.64	153	24	114	3	112	3	113	3	0.00	112	3
TT12	34	0.00004	0.00051	0.00002	0.03873	354.20	0.1057	0.0008	0.0156	0.0000	0.36	33.84	-2.09	151	33	102	1	100	1	100	1	0.00	100	1
TT12	35	0.00004	0.00063	0.00003	0.06590	561.00	0.0752	0.0005	0.0114	0.0000	0.51	14.18	-0.49	85	29	74	1	73	1	73	1	0.41	73	1
TT12	36	0.00004	0.00039	0.00002	0.02794	222.90	0.1124	0.0011	0.0166	0.0001	0.35	34.31	-2.26	161	42	108	2	106	1	106	1	0.01	106	1
TT12	37	0.00002	0.00036	0.00002	0.02814	210.60	0.1008	0.0009	0.0154	0.0001	0.48	-35.20	1.03	73	39	98	2	99	1	98	1	0.19	99	1
TT12	38	0.00002	0.00071	0.00003	0.05390	379.00	0.1039	0.0008	0.0158	0.0001	0.64	-9.76	0.36	92	28	100	1	101	1	101	1	0.51	101	1
TT12	39	0.00002	0.00034	0.00002	0.02712	179.00	0.1012	0.0012	0.0152	0.0001	0.60	12.31	-0.55	111	44	98	2	97	1	97	1	0.54	97	1
TT12	40	0.00002	0.00073	0.00003	0.06020	375.00	0.0979	0.0008	0.0146	0.0001	0.77	27.77	-1.47	129	26	95	2	94	1	94	1	0.01	94	1
TT12	41	0.00003	0.00020	0.00001	0.01522	90.10	0.1081	0.0017	0.0156	0.0001	0.57	52.02	-4.49	208	60	104	3	100	2	100	2	0.00	100	2

Sample	Spot	Normal (Wetherill concordia plot)										Discordance			Ages				Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	±1s	Pb206U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
TT12	42	0.00003	0.00179	0.00009	0.06000	337.00	0.2502	0.0023	0.0358	0.0003	0.92	0.38	-0.03	228	17	227	4	227	4	227	4	0.92	227	4
TT12	43	0.00002	0.00026	0.00001	0.02150	115.30	0.0972	0.0017	0.0148	0.0002	0.80	-13.48	0.45	83	50	94	3	95	3	95	3	0.65	95	3
TT12	44	0.00002	0.00022	0.00001	0.01847	94.70	0.0960	0.0017	0.0142	0.0002	0.77	37.99	-2.29	147	53	93	3	91	2	91	2	0.04	91	2
TT12	45	0.00002	0.00587	0.00047	0.03560	176.40	2.2613	0.0191	0.1962	0.0016	0.93	9.99	-3.94	1283	13	1200	12	1155	17	1236	10	0.00	1283	13
TT12	46	0.00002	0.00209	0.00010	0.06390	304.00	0.2755	0.0025	0.0388	0.0003	0.91	5.85	-0.59	261	18	247	4	246	4	246	4	0.10	246	4
TT12	47	0.00002	0.00172	0.00008	0.14760	682.00	0.0923	0.0006	0.0140	0.0001	0.83	1.89	-0.07	91	19	90	1	90	1	90	1	0.85	90	1
TT12	48	0.00002	0.00141	0.00007	0.03024	135.90	0.4211	0.0024	0.0566	0.0002	0.74	4.24	-0.59	370	18	357	3	355	3	355	3	0.08	355	3
TT12	49	0.00003	0.00069	0.00003	0.05334	235.00	0.1020	0.0007	0.0154	0.0001	0.64	-0.96	0.04	98	26	99	1	99	1	99	1	0.94	99	1
TT12	50	0.00004	0.00160	0.00008	0.09760	423.00	0.1356	0.0020	0.0196	0.0003	0.96	39.35	-3.31	206	19	129	4	125	4	126	4	0.00	125	4
TT12	51	0.00003	0.00021	0.00001	0.01605	68.70	0.1106	0.0020	0.0161	0.0002	0.74	45.67	-3.56	189	56	106	4	103	3	103	3	0.00	103	3
TT12	52	0.00003	0.00147	0.00007	0.12350	525.00	0.0949	0.0009	0.0144	0.0001	0.91	-8.15	0.28	85	20	92	2	92	2	92	2	0.49	92	2
TT12	53	0.00002	0.00042	0.00002	0.03673	155.80	0.0912	0.0013	0.0137	0.0001	0.77	28.47	-1.42	122	42	89	2	87	2	87	2	0.10	87	2
TT12	55	0.00004	0.00083	0.00004	0.06800	240.00	0.0998	0.0007	0.0148	0.0001	0.75	33.03	-1.91	142	23	97	1	95	1	95	1	0.00	95	1
TT12	56	0.00004	0.00030	0.00001	0.03281	114.70	0.0750	0.0008	0.0111	0.0001	0.57	54.96	-3.60	157	43	73	2	71	1	71	1	0.00	71	1
TT12	57	0.00003	0.00051	0.00002	0.03770	130.80	0.1093	0.0010	0.0163	0.0001	0.69	21.92	-1.18	133	32	105	2	104	1	104	1	0.07	104	1
TT12	58	0.00004	0.00066	0.00003	0.05274	181.50	0.1043	0.0008	0.0151	0.0001	0.71	52.87	-4.50	205	26	101	2	96	1	96	1	0.00	96	1
TT12	59	0.00002	0.00092	0.00004	0.14520	497.20	0.0510	0.0004	0.0077	0.0001	0.83	45.92	-1.74	92	23	51	1	50	1	50	1	0.00	50	1
TT12	60	0.00002	0.00034	0.00002	0.02893	98.30	0.0964	0.0010	0.0146	0.0001	0.63	4.57	-0.18	98	38	93	2	93	1	93	1	0.82	93	1
TT12	61	0.00002	0.00378	0.00021	0.04808	162.60	0.7731	0.0055	0.0946	0.0006	0.90	-0.96	0.19	577	14	582	6	583	7	582	6	0.49	583	7
TT12	63	0.00003	0.00038	0.00002	0.04802	161.30	0.0641	0.0006	0.0096	0.0001	0.69	49.19	-2.47	121	31	63	1	62	1	62	1	0.00	62	1
TT12	64	0.00003	0.00041	0.00002	0.03562	119.50	0.0940	0.0010	0.0140	0.0001	0.62	28.43	-1.46	126	39	91	2	90	1	90	1	0.07	90	1
TT12	65	0.00003	0.00086	0.00004	0.07020	235.50	0.1002	0.0011	0.0150	0.0002	0.90	15.88	-0.74	114	23	97	2	96	2	96	2	0.12	96	2
TT12	66	0.00002	0.00443	0.00024	0.06440	216.10	0.6626	0.0059	0.0832	0.0007	0.94	1.08	-0.20	521	14	516	7	515	8	517	7	0.49	515	8
TT12	67	0.00002	0.00046	0.00002	0.03639	122.40	0.1004	0.0013	0.0153	0.0002	0.83	-24.11	0.76	79	35	97	2	98	2	98	2	0.28	98	2
TT12	68	0.00002	0.00027	0.00001	0.02243	75.80	0.1004	0.0016	0.0148	0.0002	0.77	42.71	-2.90	165	47	97	3	94	2	94	2	0.00	94	2
TT12	69	0.00002	0.00013	0.00001	0.01687	57.30	0.0613	0.0013	0.0091	0.0001	0.53	55.73	-3.07	132	87	60	3	59	1	59	1	0.10	59	1
TT12	71	0.00003	0.00067	0.00003	0.10490	362.00	0.0506	0.0006	0.0077	0.0001	0.88	37.62	-1.23	79	28	50	1	50	1	50	1	0.04	50	1
TT12	72	0.00003	0.00078	0.00004	0.06530	228.00	0.0976	0.0008	0.0145	0.0001	0.78	34.51	-2.00	142	25	95	2	93	1	93	1	0.00	93	1
TT12	73	0.00003	0.00028	0.00001	0.01007	35.63	0.2405	0.0032	0.0340	0.0003	0.69	14.53	-1.44	252	45	219	5	216	4	216	4	0.11	216	4
TT12	74	0.00004	0.00071	0.00003	0.05570	204.50	0.1045	0.0008	0.0157	0.0001	0.53	17.41	-0.85	121	29	101	1	100	1	100	1	0.15	100	1
TT12	75	0.00004	0.00178	0.00008	0.13560	494.00	0.1061	0.0010	0.0160	0.0001	0.90	7.20	-0.32	110	19	102	2	102	2	102	2	0.40	102	2
TT12	76	0.00004	0.00054	0.00002	0.04302	155.20	0.1029	0.0012	0.0153	0.0002	0.82	28.94	-1.62	138	32	99	2	98	2	98	2	0.01	98	2
TT12	77	0.00003	0.00061	0.00003	0.04670	167.50	0.1046	0.0013	0.0160	0.0002	0.85	-37.33	1.11	74	31	101	2	102	2	102	2	0.07	102	2
TT12	78	0.00002	0.00105	0.00005	0.09170	326.40	0.0929	0.0011	0.0140	0.0002	0.92	14.26	-0.60	105	22	90	2	90	2	90	2	0.17	90	2
TT12	79	0.00002	0.00246	0.00012	0.06540	231.30	0.3328	0.0031	0.0461	0.0004	0.93	2.84	-0.32	299	16	292	5	291	5	292	5	0.32	291	5
TT12	80	0.00002	0.00041	0.00002	0.03242	113.90	0.1027	0.0013	0.0153	0.0002	0.79	23.38	-1.22	128	36	99	2	98	2	98	2	0.10	98	2
TT12	81	0.00002	0.00229	0.00010	0.17640	616.00	0.1061	0.0010	0.0160	0.0001	0.92	1.25	-0.05	104	18	102	2	102	2	102	2	0.89	102	2
TT12	82	0.00003	0.00124	0.00006	0.09280	322.40	0.1105	0.0012	0.0165	0.0002	0.92	15.57	-0.79	125	20	106	2	106	2	106	2	0.06	106	2
TT12	84	0.00003	0.00050	0.00002	0.07890	271.50	0.0515	0.0006	0.0078	0.0001	0.86	47.68	-1.89	96	29	51	1	50	1	50	1	0.00	50	1
TT12	86	0.00002	0.00104	0.00005	0.08350	285.50	0.0998	0.0010	0.0151	0.0001	0.88	-5.47	0.20	92	23	97	2	97	2	97	2	0.66	97	2
TT12	87	0.00002	0.00196	0.00010	0.05100	174.10	0.3415	0.0037	0.0476	0.0005	0.94	-3.54	0.39	289	17	298	6	299	6	298	6	0.26	299	6
TT12	88	0.00002	0.00099	0.00005	0.07960	271.10	0.1034	0.0013	0.0153	0.0002	0.92	35.74	-2.22	152	24	100	2	98	2	98	2	0.00	98	2

Sample	Spot	Normal (Wetherill concordia plot)												Discordance				Ages				Preferred	
		Pb204_V						Pb206_V						Rho1		disTW		207Pb/235U		206Pb/238U		probability	Age
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	±1s	Pb206U238	±1s	Rho1	disTW	dis58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s		
TT12	89	0.00002	0.00079	0.00004	0.07270	247.60	0.0881	0.0010	0.0134	0.0001	0.88	7.36	-0.28	92	26	86	2	85	2	86	2	0.60	85
TT12	90	0.00002	0.00081	0.00004	0.06170	210.10	0.1083	0.0012	0.0152	0.0002	0.89	11.11	-0.52	117	25	104	2	104	2	104	2	0.30	104
TT12	91	0.00003	0.00157	0.00007	0.11990	409.30	0.1089	0.0016	0.0164	0.0002	0.96	5.62	-0.25	111	21	105	3	105	3	105	3	0.55	105
TT12	93	0.00003	0.00044	0.00002	0.03326	114.20	0.1071	0.0020	0.0163	0.0003	0.91	-16.95	0.58	89	36	103	4	104	3	104	3	0.42	104
TT12	94	0.00003	0.00063	0.00003	0.04810	166.10	0.1078	0.0014	0.0160	0.0002	0.90	29.45	-1.74	145	27	104	3	102	2	102	2	0.00	102
TT12	95	0.00002	0.00013	0.00001	0.02085	72.40	0.0478	0.0011	0.0075	0.0001	0.69	-2635.48	1.88	2	84	47	2	48	2	48	2	0.26	48
TT12	96	0.00002	0.00102	0.00005	0.07570	264.80	0.1109	0.0022	0.0166	0.0003	0.97	17.33	-0.90	128	23	107	4	106	4	106	4	0.05	106
TT12	97	0.00002	0.00059	0.00003	0.04950	174.60	0.0971	0.0019	0.0148	0.0003	0.95	-12.73	0.43	84	30	94	4	95	3	94	3	0.48	95
TT15	1	0.00002	0.00014	0.00001	0.01698	56.10	0.0591	0.0008	0.0088	0.0000	0.34	61.72	-3.79	147	58	58	1	56	1	56	1	0.00	56
TT15	3	0.00003	0.00134	0.00006	0.16260	538.30	0.0592	0.0004	0.0089	0.0001	0.88	42.73	-1.77	100	17	58	1	57	1	57	1	0.00	57
TT15	4	0.00003	0.00079	0.00004	0.07300	242.10	0.0794	0.0006	0.0118	0.0001	0.79	46.05	-2.67	140	22	78	1	76	1	76	1	0.00	76
TT15	7	0.00003	0.00118	0.00005	0.08240	274.00	0.1045	0.0006	0.0157	0.0001	0.73	13.79	-0.65	116	19	101	1	100	1	100	1	0.09	100
TT15	8	0.00002	0.00073	0.00003	0.06940	231.30	0.0760	0.0006	0.0114	0.0001	0.78	37.19	-1.78	116	25	74	1	73	1	73	1	0.00	73
TT15	9	0.00002	0.00071	0.00003	0.04952	165.20	0.1057	0.0010	0.0158	0.0001	0.83	19.89	-1.02	126	24	102	2	101	2	101	2	0.04	101
TT15	10	0.00002	0.00070	0.00003	0.04965	165.80	0.1066	0.0007	0.0155	0.0001	0.60	45.88	-3.48	184	24	103	1	99	1	99	1	0.00	99
TT15	11	0.00003	0.00092	0.00004	0.11120	392.40	0.0608	0.0003	0.0094	0.0000	0.67	-22.34	0.45	49	17	60	1	60	0	60	0	0.19	60
TT15	12	0.00002	0.00057	0.00003	0.04167	147.20	0.1019	0.0008	0.0154	0.0001	0.51	6.99	-0.30	106	32	98	1	98	1	98	1	0.64	98
TT15	13	0.00001	0.00120	0.00005	0.13390	473.60	0.0647	0.0003	0.0100	0.0000	0.66	-30.22	0.60	49	18	64	1	64	0	64	0	0.09	64
TT15	14	0.00001	0.00076	0.00003	0.05417	191.90	0.1015	0.0007	0.0154	0.0001	0.70	-5.43	0.20	93	24	98	1	98	1	98	1	0.67	98
TT15	15	0.00002	0.00100	0.00004	0.11880	421.30	0.0608	0.0003	0.0094	0.0000	0.61	-68.59	1.00	36	20	60	1	61	0	61	0	0.02	61
TT15	16	0.00002	0.00064	0.00003	0.05559	197.40	0.0835	0.0005	0.0130	0.0000	0.48	-138.01	1.92	35	26	81	1	83	1	83	1	0.00	83
TT15	17	0.00002	0.02401	0.00162	0.16760	596.00	1.5839	0.0086	0.1611	0.0009	0.97	0.35	-0.11	966	7	964	7	963	9	965	6	0.58	963
TT15	18	0.00002	0.00097	0.00004	0.12030	428.10	0.0581	0.0004	0.0090	0.0000	0.71	-73.81	1.00	33	21	57	1	58	1	58	1	0.02	58
TT15	19	0.00002	0.01181	0.00079	0.08800	313.70	1.4555	0.0065	0.1510	0.0007	0.97	2.06	-0.62	926	7	912	6	907	7	917	5	0.00	907
TT15	20	0.00001	0.00071	0.00003	0.06910	246.70	0.0740	0.0005	0.0116	0.0000	0.58	-252.75	2.12	21	26	72	1	74	1	74	1	0.00	74
TT15	21	0.00001	0.00061	0.00003	0.04340	155.10	0.1031	0.0007	0.0158	0.0001	0.59	-48.84	1.32	68	25	100	1	101	1	101	1	0.01	101
TT15	22	0.00001	0.00232	0.00010	0.27100	969.00	0.0626	0.0004	0.0097	0.0000	0.85	-24.74	0.50	50	15	62	1	62	1	62	1	0.11	62
TT15	23	0.00001	0.00224	0.00010	0.17220	616.50	0.0964	0.0004	0.0148	0.0001	0.77	-38.18	1.04	68	14	93	1	94	1	94	1	0.00	94
TT15	24	0.00002	0.00272	0.00014	0.05380	193.00	0.4152	0.0019	0.0571	0.0002	0.80	-12.76	1.50	317	13	353	3	358	3	356	3	0.00	358
TT15	26	0.00002	0.01361	0.00090	0.11730	422.00	1.2352	0.0109	0.1305	0.0011	0.95	10.98	-3.29	888	12	817	10	791	13	842	9	0.00	791
TT15	28	0.00001	0.00040	0.00002	0.04990	180.00	0.0609	0.0006	0.0090	0.0000	0.45	59.74	-3.59	144	44	60	1	58	1	58	1	0.00	58
TT15	29	0.00001	0.00047	0.00002	0.03437	124.00	0.1057	0.0010	0.0155	0.0001	0.52	40.29	-2.75	166	37	102	2	99	1	99	1	0.00	99
TT15	31	0.00002	0.00053	0.00002	0.03896	140.90	0.1015	0.0010	0.0155	0.0001	0.79	-23.84	0.76	80	29	98	2	99	2	99	2	0.19	99
TT15	32	0.00003	0.02178	0.00190	0.09470	342.80	3.3050	0.0212	0.2597	0.0017	0.99	-1.00	0.41	1474	6	1482	10	1488	17	1475	6	0.11	1474
TT15	33	0.00003	0.00077	0.00003	0.09510	344.30	0.0593	0.0006	0.0092	0.0001	0.85	-20.80	0.41	49	25	59	1	59	1	59	1	0.41	59
TT15	34	0.00003	0.00041	0.00002	0.05160	187.20	0.0587	0.0007	0.0090	0.0001	0.80	8.07	-0.21	63	34	58	1	58	1	58	1	0.76	58
TT15	37	0.00001	0.00039	0.00002	0.02224	81.00	0.1340	0.0013	0.0200	0.0001	0.75	-0.54	0.03	127	30	128	2	128	2	128	2	0.96	128
TT15	38	0.00002	0.00360	0.00016	0.36960	1347.00	0.0715	0.0003	0.0110	0.0000	0.88	-12.96	0.33	62	10	70	1	70	1	70	1	0.12	70
TT15	39	0.00002	0.00068	0.00003	0.07540	275.00	0.0675	0.0007	0.0101	0.0001	0.87	45.63	-2.25	119	25	66	1	65	1	65	1	0.00	65
TT15	40	0.00003	0.00037	0.00002	0.02718	103.70	0.1085	0.0009	0.0158	0.0001	0.56	45.40	-3.46	185	31	105	2	101	1	101	1	0.00	101
TT15	41	0.00002	0.00034	0.00002	0.02972	113.40	0.0885	0.0007	0.0131	0.0000	0.46	45.62	-2.90	154	34	86	1	84	1	84	1	0.00	84

Sample	Spot	Normal (Wetherill concordia plot)														Discordance			Ages				Preferred	
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	±1s	Pb206U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
		±0.00002	±0.00077	±0.00043	±0.09960	380.00	0.7341	0.0029	0.0890	0.0003	0.92	7.76	-1.65	596	8	559	4	550	4	558	4	0.00	550	4
TT15	42	0.00002	0.00077	0.00043	0.09960	380.00	0.7341	0.0029	0.0890	0.0003	0.92	7.76	-1.65	596	8	559	4	550	4	558	4	0.00	550	4
TT15	44	0.00003	0.00077	0.00004	0.05640	215.30	0.1060	0.0009	0.0157	0.0001	0.82	31.09	-1.85	146	22	102	2	100	1	101	1	0.00	100	1
TT15	45	0.00002	0.00042	0.00002	0.05450	208.10	0.0582	0.0006	0.0088	0.0001	0.77	35.03	-1.26	87	32	57	1	57	1	57	1	0.05	57	1
TT15	46	0.00001	0.00272	0.00013	0.09100	347.00	0.2419	0.0020	0.0343	0.0003	0.96	12.49	-1.22	248	12	220	3	217	3	220	3	0.00	217	3
TT15	47	0.00001	0.00062	0.00003	0.07660	292.00	0.0611	0.0006	0.0093	0.0001	0.85	26.20	-0.87	81	25	60	1	60	1	60	1	0.10	60	1
TT15	48	0.00001	0.00019	0.00001	0.01469	56.00	0.0979	0.0012	0.0151	0.0001	0.55	-100.90	1.93	48	51	95	2	97	1	97	1	0.05	97	1
TT15	50	0.00002	0.00083	0.00004	0.10130	386.10	0.0622	0.0006	0.0095	0.0001	0.83	24.39	-0.80	80	25	61	1	61	1	61	1	0.12	61	1
TT15	51	0.00002	0.00101	0.00005	0.07570	289.00	0.1029	0.0006	0.0153	0.0001	0.74	29.72	-1.69	139	20	99	1	98	1	98	1	0.00	98	1
TT15	52	0.00002	0.00048	0.00002	0.05520	210.50	0.0685	0.0008	0.0102	0.0001	0.71	52.73	-3.03	138	37	67	1	65	1	65	1	0.00	65	1
TT15	53	0.00002	0.00070	0.00003	0.05246	199.90	0.1005	0.0011	0.0152	0.0001	0.87	8.19	-0.35	106	25	97	2	97	2	97	2	0.50	97	2
TT15	54	0.00001	0.00022	0.00001	0.02677	102.00	0.0625	0.0008	0.0096	0.0001	0.65	12.83	-0.37	70	46	62	2	61	1	61	1	0.70	61	1
TT15	55	0.00001	0.00069	0.00004	0.00829	31.59	0.7858	0.0073	0.0953	0.0008	0.85	1.62	-0.34	596	22	589	8	587	9	588	8	0.41	587	9
TT15	56	0.00001	0.00072	0.00003	0.05304	201.90	0.1034	0.0009	0.0156	0.0001	0.84	10.76	-0.48	111	23	100	2	99	1	100	1	0.30	99	1
TT15	57	0.00001	0.00124	0.00006	0.10820	411.70	0.0873	0.0005	0.0132	0.0001	0.81	12.54	-0.49	97	16	85	1	85	1	85	1	0.14	85	1
TT15	58	0.00002	0.00015	0.00001	0.01825	69.40	0.0635	0.0009	0.0094	0.0000	0.27	60.28	-3.82	152	62	62	2	60	0	60	0	0.00	60	0
TT15	59	0.00002	0.00100	0.00004	0.12560	477.70	0.0599	0.0005	0.0092	0.0001	0.88	12.63	-0.35	67	19	59	1	59	1	59	1	0.36	59	1
TT15	60	0.00002	0.00288	0.00014	0.07460	283.90	0.3177	0.0027	0.0443	0.0004	0.97	3.34	-0.37	289	11	280	4	279	5	281	4	0.11	279	5
TT15	61	0.00001	0.00113	0.00006	0.02430	92.40	0.3892	0.0036	0.0533	0.0005	0.93	-2.57	0.31	326	16	334	5	335	6	334	5	0.33	335	6
TT15	62	0.00001	0.00085	0.00004	0.10900	414.40	0.0590	0.0005	0.0090	0.0001	0.86	25.91	-0.83	78	20	58	1	58	1	58	1	0.05	58	1
TT15	63	0.00001	0.00057	0.00002	0.05690	216.00	0.0744	0.0007	0.0114	0.0001	0.85	-10.14	0.27	66	24	73	1	73	1	73	1	0.57	73	1
TT15	64	0.00001	0.00040	0.00002	0.03022	114.80	0.0980	0.0009	0.0149	0.0001	0.79	-20.37	0.65	79	27	95	2	96	1	95	1	0.23	96	1
TT15	65	0.00002	0.00260	0.00013	0.05130	194.70	0.4372	0.0035	0.0585	0.0005	0.95	3.59	-0.51	380	12	368	5	366	5	369	5	0.03	366	5
TT15	66	0.00002	0.00038	0.00002	0.04880	185.30	0.0596	0.0006	0.0090	0.0001	0.73	35.04	-1.29	89	35	59	1	58	1	58	1	0.08	58	1
TT15	67	0.00003	0.00058	0.00003	0.05957	226.00	0.0736	0.0008	0.0111	0.0001	0.85	25.85	-1.02	96	27	72	1	71	1	71	1	0.06	71	1
TT15	68	0.00003	0.00017	0.00001	0.02021	75.60	0.0665	0.0010	0.0100	0.0001	0.52	47.97	-2.44	123	58	65	2	64	1	64	1	0.05	64	1
TT15	69	0.00003	0.00058	0.00003	0.04384	163.80	0.1042	0.0010	0.0153	0.0001	0.74	42.36	-2.95	170	31	101	2	98	1	98	1	0.00	98	1
TT15	70	0.00003	0.00041	0.00002	0.03013	112.50	0.1076	0.0011	0.0157	0.0001	0.73	43.53	-3.19	178	32	104	2	101	1	101	1	0.00	101	1
TT15	71	0.00004	0.00096	0.00004	0.06760	252.50	0.1097	0.0009	0.0164	0.0001	0.85	20.14	-1.07	131	21	106	2	105	1	105	1	0.01	105	1
TT15	72	0.00003	0.00064	0.00003	0.04830	180.30	0.1012	0.0010	0.0153	0.0001	0.83	7.16	-0.30	105	25	98	2	98	2	98	2	0.55	98	2
TT15	73	0.00003	0.00085	0.00004	0.06260	233.50	0.1050	0.0009	0.0158	0.0001	0.85	13.05	-0.61	116	21	101	2	101	1	101	1	0.15	101	1
TT15	74	0.00002	0.00113	0.00006	0.01337	49.80	0.8010	0.0071	0.0975	0.0008	0.93	-1.92	0.39	588	15	597	8	600	9	597	8	0.21	600	9
TT15	75	0.00002	0.00045	0.00002	0.05808	216.20	0.0589	0.0007	0.0090	0.0001	0.82	15.41	-0.43	68	33	58	1	58	1	58	1	0.52	58	1
TT15	76	0.00002	0.00029	0.00001	0.03840	142.80	0.0588	0.0007	0.0089	0.0001	0.67	45.38	-1.95	104	41	58	1	57	1	57	1	0.02	57	1
TT15	77	0.00003	0.00023	0.00001	0.02976	110.70	0.0585	0.0007	0.0089	0.0001	0.59	39.99	-1.56	95	48	58	1	57	1	57	1	0.12	57	1
TT15	78	0.00003	0.00407	0.00018	0.36100	1340.00	0.0857	0.0007	0.0130	0.0001	0.96	2.28	-0.08	85	12	83	1	83	1	83	1	0.74	83	1
TT15	79	0.00003	0.00158	0.00007	0.11280	419.00	0.1069	0.0008	0.0163	0.0001	0.91	-29.54	0.95	80	16	103	2	104	1	104	1	0.00	104	1
TT15	81	0.00003	0.00057	0.00003	0.04380	162.40	0.0994	0.0010	0.0150	0.0001	0.87	7.44	-0.31	104	25	96	2	96	2	96	2	0.54	96	2
TT15	82	0.00002	0.00065	0.00003	0.08120	301.20	0.0604	0.0006	0.0093	0.0001	0.81	-2.27	0.05	58	26	60	1	60	1	60	1	0.92	60	1
TT15	83	0.00002	0.00058	0.00003	0.04464	165.40	0.0983	0.0011	0.0148	0.0001	0.82	9.34	-0.39	105	31	95	2	95	2	95	2	0.53	95	2
TT15	84	0.00002	0.00038	0.00002	0.03443	127.50	0.0859	0.0010	0.0130	0.0001	0.69	14.42	-0.57	97	38	84	2	83	1	83	1	0.47	83	1
TT15	86	0.00003	0.00019	0.00001	0.01536	56.80	0.0948	0.0015	0.0142	0.0001	0.61	19.29	-0.88	113	59	92	3	91	2	91	2	0.46	91	2
TT15	87	0.00003	0.00039	0.00002	0.05146	190.20	0.0566	0.0006	0.0087	0.0001	0.79	11.92	-0.31	63	31	56	1	56	1	56	1	0.62	56	1

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	±1s	Pb206U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
		88	0.00003	0.00025	0.00001	0.02596	95.90	0.0717	0.0009	0.0109	0.0001	0.69	20.57	-0.74	88	43	70	2	70	1	70	1	0.41	70
TT15	89	0.00002	0.00064	0.00003	0.07830	289.10	0.0615	0.0008	0.0093	0.0001	0.91	41.70	-1.76	102	27	61	2	60	1	60	1	0.00	60	1
TT15	90	0.00002	0.00031	0.00001	0.04111	151.70	0.0571	0.0007	0.0087	0.0001	0.73	36.63	-1.32	88	38	56	1	56	1	56	1	0.10	56	1
TT15	91	0.00002	0.00045	0.00002	0.05133	189.30	0.0648	0.0006	0.0100	0.0001	0.80	-40.92	0.76	46	29	64	1	64	1	64	1	0.19	64	1
TT15	92	0.00002	0.00020	0.00001	0.01605	59.10	0.0930	0.0016	0.0142	0.0002	0.74	-15.74	0.50	78	55	90	3	91	2	91	2	0.65	91	2
TT15	93	0.00002	0.00008	0.00000	0.01014	37.32	0.0584	0.0008	0.0088	0.0001	0.53	52.27	-2.56	118	112	58	3	56	2	56	2	0.28	56	2
TT15	94	0.00003	0.00088	0.00004	0.11380	419.00	0.0587	0.0005	0.0089	0.0001	0.87	28.60	-0.94	80	22	58	1	57	1	57	1	0.04	57	1
TT15	95	0.00003	0.00031	0.00001	0.03626	133.40	0.0650	0.0007	0.0099	0.0001	0.77	28.71	-1.05	89	34	64	1	63	1	63	1	0.14	63	1
TT15	96	0.00003	0.00014	0.00001	0.01710	62.90	0.0619	0.0011	0.0094	0.0001	0.54	22.79	-0.73	78	70	61	2	61	1	61	1	0.61	61	1
TT15	98	0.00003	0.00076	0.00003	0.06730	244.00	0.0883	0.0008	0.0131	0.0001	0.88	41.74	-2.47	144	22	86	2	84	1	84	1	0.00	84	1
TT15	99	0.00002	0.00096	0.00004	0.06890	249.60	0.1113	0.0011	0.0163	0.0002	0.91	42.25	-3.12	180	20	107	2	104	2	104	2	0.00	104	2
TT15	100	0.00002	0.00175	0.00008	0.05670	205.30	0.2565	0.0019	0.0360	0.0002	0.91	16.53	-1.77	273	15	232	3	228	3	229	3	0.00	228	3
TT15	104	0.00003	0.00035	0.00002	0.04421	160.00	0.0625	0.0007	0.0093	0.0001	0.67	59.52	-3.65	147	37	62	1	59	1	59	1	0.00	59	1
TT15	105	0.00002	0.00085	0.00004	0.07720	279.50	0.0869	0.0009	0.0129	0.0001	0.90	40.30	-2.30	139	22	85	2	83	2	83	2	0.00	83	2
TT15	108	0.00002	0.00050	0.00002	0.05870	212.30	0.0666	0.0007	0.0099	0.0001	0.81	50.00	-2.64	128	37	65	2	64	1	64	1	0.00	64	1
TT15	109	0.00002	0.00054	0.00002	0.06970	252.30	0.0609	0.0007	0.0091	0.0001	0.86	54.99	-2.96	129	27	60	1	58	1	58	1	0.00	58	1
TT15	111	0.00003	0.00055	0.00003	0.06493	234.90	0.0675	0.0007	0.0099	0.0001	0.84	64.38	-4.81	178	27	66	1	63	1	63	1	0.00	63	1
TT15	112	0.00003	0.00070	0.00003	0.05430	196.00	0.1040	0.0012	0.0152	0.0001	0.86	43.64	-3.11	173	27	100	2	97	2	98	2	0.00	97	2
TT15	113	0.00002	0.00041	0.00002	0.04803	173.70	0.0656	0.0007	0.0099	0.0001	0.76	35.53	-1.44	99	33	65	1	64	1	64	1	0.03	64	1
TT15	115	0.00002	0.00064	0.00003	0.08330	301.30	0.0601	0.0006	0.0090	0.0001	0.84	56.44	-3.10	132	25	59	1	57	1	57	1	0.00	57	1
TT15	116	0.00002	0.00079	0.00004	0.07200	260.50	0.0870	0.0011	0.0128	0.0001	0.90	52.11	-3.69	171	26	85	2	82	2	82	2	0.00	82	2
TT15	117	0.00003	0.00069	0.00003	0.09040	326.70	0.0610	0.0007	0.0090	0.0001	0.88	65.02	-4.50	164	26	60	1	58	1	57	1	0.00	58	1
TT15	118	0.00003	0.00056	0.00003	0.07010	253.40	0.0621	0.0007	0.0092	0.0001	0.84	58.19	-3.44	142	30	61	1	59	1	59	1	0.00	59	1
TT15	121	0.00002	0.00084	0.00004	0.06520	235.60	0.1037	0.0013	0.0152	0.0002	0.91	45.99	-3.41	179	25	100	2	97	2	97	2	0.00	97	2
TT15	122	0.00004	0.00110	0.00005	0.07810	282.30	0.1103	0.0011	0.0164	0.0002	0.91	21.49	-1.17	134	20	106	2	105	2	105	2	0.00	105	2
TT15	123	0.00004	0.00030	0.00001	0.03939	142.40	0.0613	0.0009	0.0090	0.0001	0.75	66.88	-4.91	174	44	60	2	58	1	57	1	0.00	58	1
TT15	125	0.00003	0.00061	0.00003	0.04680	169.20	0.1011	0.0012	0.0152	0.0002	0.87	15.87	-0.74	115	27	98	2	97	2	97	2	0.18	97	2
TT15	126	0.00002	0.00095	0.00004	0.12370	447.30	0.0586	0.0006	0.0089	0.0001	0.89	37.91	-1.43	92	21	58	1	57	1	57	1	0.00	57	1
TT19	1	0.00005	0.01907	0.00154	0.11840	137.20	2.1897	0.0302	0.1973	0.0026	0.95	4.00	-1.46	1209	17	1178	19	1161	28	1196	14	0.00	1161	28
TT19	2	0.00005	0.01907	0.00154	0.11840	137.20	2.1897	0.0302	0.1973	0.0026	0.95	4.00	-1.46	1209	17	1178	19	1161	28	1196	14	0.00	1161	28
TT19	3	0.00006	0.00665	0.00033	0.22310	258.20	0.2604	0.0036	0.0365	0.0005	0.95	15.27	-1.63	273	20	235	6	231	6	234	6	0.00	231	6
TT19	4	0.00006	0.00665	0.00033	0.22310	258.20	0.2604	0.0036	0.0365	0.0005	0.95	15.27	-1.63	273	20	235	6	231	6	234	6	0.00	231	6
TT19	7	0.00005	0.01753	0.00101	0.27900	322.00	0.6228	0.0084	0.0780	0.0010	0.96	7.80	-1.49	525	18	492	10	484	12	497	10	0.00	484	12
TT19	8	0.00005	0.01753	0.00101	0.27900	322.00	0.6228	0.0084	0.0780	0.0010	0.96	7.80	-1.49	525	18	492	10	484	12	497	10	0.00	484	12
TT19	9	0.00003	0.02004	0.00119	0.25860	298.10	0.7881	0.0108	0.0950	0.0013	0.96	4.00	-0.86	609	17	590	12	585	15	595	11	0.03	585	15
TT19	10	0.00003	0.02004	0.00119	0.25860	298.10	0.7881	0.0108	0.0950	0.0013	0.96	4.00	-0.86	609	17	590	12	585	15	595	11	0.03	585	15
TT19	11	0.00003	0.01007	0.00069	0.08140	93.70	1.4447	0.0199	0.1510	0.0020	0.96	0.41	-0.12	910	17	908	17	907	22	909	13	0.79	907	22
TT19	12	0.00003	0.01007	0.00069	0.08140	93.70	1.4447	0.0199	0.1510	0.0020	0.96	0.41	-0.12	910	17	908	17	907	22	909	13	0.79	907	22
TT19	13	0.00003	0.02049	0.00109	0.49300	567.00	0.3748	0.0050	0.0509	0.0007	0.96	7.76	-1.02	347	18	323	7	320	8	324	7	0.01	320	8
TT19	14	0.00003	0.02049	0.00109	0.49300	567.00	0.3748	0.0050	0.0509	0.0007	0.96	7.76	-1.02	347	18	323	7	320	8	324	7	0.01	320	8
TT19	15	0.00003	0.01051	0.00054	0.29990	344.20	0.3063	0.0041	0.0427	0.0006	0.95	5.13	-0.56	284	19	271	6	270	7	271	6	0.15	270	7

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
TT19	16	0.00003	0.01051	0.00054	0.29990	344.20	0.3063	0.0041	0.0427	0.0006	0.95	5.13	-0.56	284	19	271	6	270	7	271	6	0.15	270	7
TT19	17	0.00003	0.01689	0.00098	0.24760	283.70	0.6690	0.0092	0.0834	0.0011	0.96	3.76	-0.72	537	18	520	11	516	13	524	11	0.06	516	13
TT19	18	0.00003	0.01689	0.00098	0.24760	283.70	0.6690	0.0092	0.0834	0.0011	0.96	3.76	-0.72	537	18	520	11	516	13	524	11	0.06	516	13
TT19	19	0.00003	0.02693	0.00265	0.12360	141.40	3.8184	0.0581	0.2750	0.0041	0.97	4.34	-1.95	1637	15	1597	25	1566	41	1629	14	0.00	1637	15
TT19	20	0.00003	0.02693	0.00265	0.12360	141.40	3.8184	0.0581	0.2750	0.0041	0.97	4.34	-1.95	1637	15	1597	25	1566	41	1629	14	0.00	1637	15
TT19	21	0.00003	0.01487	0.00079	0.35180	402.10	0.3783	0.0078	0.0516	0.0011	0.98	3.44	-0.44	336	18	326	12	324	13	328	11	0.30	324	13
TT19	22	0.00003	0.01487	0.00079	0.35180	402.10	0.3783	0.0078	0.0516	0.0011	0.98	3.44	-0.44	336	18	326	12	324	13	328	11	0.30	324	13
TT19	25	0.00003	0.00979	0.00050	0.30900	352.00	0.2742	0.0061	0.0389	0.0009	0.98	0.04	0.00	246	19	246	10	246	11	246	9	0.99	246	11
TT19	26	0.00003	0.00979	0.00050	0.30900	352.00	0.2742	0.0061	0.0389	0.0009	0.98	0.04	0.00	246	19	246	10	246	11	246	9	0.99	246	11
TT19	27	0.00003	0.00792	0.00047	0.10690	121.70	0.7393	0.0154	0.0904	0.0019	0.98	3.58	-0.73	579	18	562	18	558	22	570	14	0.14	558	22
TT19	28	0.00003	0.00792	0.00047	0.10690	121.70	0.7393	0.0154	0.0904	0.0019	0.98	3.58	-0.73	579	18	562	18	558	22	570	14	0.14	558	22
TT19	29	0.00003	0.01472	0.00117	0.09150	104.10	2.1398	0.0435	0.1953	0.0039	0.98	2.85	-1.02	1184	16	1162	28	1150	42	1179	15	0.13	1150	42
TT19	30	0.00003	0.01472	0.00117	0.09150	104.10	2.1398	0.0435	0.1953	0.0039	0.98	2.85	-1.02	1184	16	1162	28	1150	42	1179	15	0.13	1150	42
TT19	31	0.00003	0.01557	0.00094	0.18600	211.00	0.8645	0.0122	0.1030	0.0014	0.96	0.44	-0.10	635	17	633	13	632	16	633	12	0.82	632	16
TT19	32	0.00003	0.01557	0.00094	0.18600	211.00	0.8645	0.0122	0.1030	0.0014	0.96	0.44	-0.10	635	17	633	13	632	16	633	12	0.82	632	16
TT19	33	0.00003	0.00854	0.00057	0.08090	91.60	1.1507	0.0298	0.1272	0.0033	0.99	2.78	-0.74	794	19	778	28	772	37	789	17	0.29	772	37
TT19	34	0.00003	0.00854	0.00057	0.08090	91.60	1.1507	0.0298	0.1272	0.0033	0.99	2.78	-0.74	794	19	778	28	772	37	789	17	0.29	772	37
TT19	35	0.00003	0.00270	0.00014	0.09000	101.80	0.2511	0.0053	0.0360	0.0008	0.98	-2.67	0.23	222	21	227	9	228	9	227	8	0.60	228	9
TT19	36	0.00003	0.00270	0.00014	0.09000	101.80	0.2511	0.0053	0.0360	0.0008	0.98	-2.67	0.23	222	21	227	9	228	9	227	8	0.60	228	9
TT19	37	0.00003	0.01742	0.00088	0.55300	650.00	0.2619	0.0054	0.0368	0.0008	0.98	13.22	-1.39	268	18	236	9	233	9	240	9	0.00	233	9
TT19	39	0.00003	0.00181	0.00009	0.05690	67.00	0.2704	0.0057	0.0371	0.0008	0.97	27.21	-3.48	323	24	243	9	235	9	243	9	0.00	235	9
TT19	40	0.00003	0.00803	0.00041	0.25170	297.00	0.2679	0.0058	0.0377	0.0008	0.98	9.95	-1.03	265	19	241	9	239	10	244	9	0.01	239	10
TT19	43	0.00003	0.00725	0.00046	0.07500	88.70	0.9871	0.0223	0.1126	0.0025	0.98	5.48	-1.37	728	18	697	23	688	29	717	15	0.02	688	29
TT19	45	0.00003	0.00562	0.00050	0.02669	31.60	3.1109	0.0757	0.2500	0.0060	0.99	-0.54	0.21	1431	16	1435	37	1438	62	1431	15	0.81	1431	16
TT19	46	0.00003	0.00968	0.00076	0.05510	65.30	2.2867	0.0479	0.2066	0.0043	0.98	-0.58	0.21	1204	16	1208	30	1211	45	1204	15	0.77	1204	16
TT19	48	0.00002	0.00831	0.00048	0.10600	125.70	0.7782	0.0209	0.0942	0.0025	0.99	3.35	-0.71	600	19	584	24	580	29	595	16	0.25	580	29
TT19	49	0.00003	0.01993	0.00145	0.13760	163.20	1.7490	0.0400	0.1706	0.0039	0.99	3.40	-1.12	1051	16	1027	30	1015	42	1047	15	0.11	1015	42
TT19	50	0.00003	0.02621	0.00208	0.15380	182.00	2.2413	0.0537	0.1991	0.0047	0.98	5.38	-2.01	1237	17	1194	34	1170	51	1230	16	0.01	1237	17
TT19	51	0.00003	0.02370	0.00187	0.12850	152.00	2.2855	0.0789	0.2040	0.0070	0.99	2.51	-0.92	1228	16	1208	49	1197	75	1226	15	0.42	1228	16
TT19	52	0.00003	0.00332	0.00020	0.04085	48.40	0.7806	0.0157	0.0943	0.0019	0.98	3.94	-0.84	605	19	586	18	581	22	595	14	0.10	581	22
TT19	54	0.00003	0.00774	0.00053	0.06430	76.50	1.3945	0.0283	0.1430	0.0029	0.98	9.26	-2.90	950	17	887	24	862	32	932	15	0.00	862	32
TT19	55	0.00003	0.02630	0.00230	0.13300	158.50	3.1192	0.1584	0.2470	0.0125	1.00	2.46	-1.02	1459	17	1437	78	1423	129	1458	16	0.58	1459	17
TT19	59	0.00003	0.01091	0.00085	0.05970	71.20	2.4164	0.0415	0.2150	0.0036	0.97	-1.75	0.63	1234	16	1247	25	1255	38	1237	15	0.30	1234	16
TT19	60	0.00003	0.00155	0.00009	0.01575	18.81	1.0091	0.0181	0.1163	0.0020	0.96	-0.47	0.11	706	22	708	18	709	23	708	16	0.84	709	23
TT19	62	0.00004	0.02470	0.00141	0.37100	443.00	0.6564	0.0271	0.1793	0.0033	0.99	18.66	-4.16	605	23	512	33	492	39	581	19	0.00	492	39
TT19	63	0.00003	0.03020	0.00169	0.41300	493.00	0.6796	0.0180	0.0840	0.0022	0.99	6.32	-1.26	555	18	527	22	520	26	544	15	0.02	520	26
TT19	64	0.00004	0.01504	0.00088	0.17220	205.60	0.8625	0.0143	0.1027	0.0017	0.97	0.93	-0.21	636	17	632	16	630	19	634	13	0.65	630	19
TT19	65	0.00003	0.02483	0.00141	0.34380	410.50	0.6898	0.0117	0.0851	0.0014	0.97	5.89	-1.18	559	17	533	14	526	17	542	12	0.01	526	17
TT19	66	0.00003	0.00958	0.00053	0.13610	162.50	0.6603	0.0110	0.0836	0.0014	0.97	-3.00	0.54	502	18	515	13	518	16	511	12	0.22	518	16
TT19	67	0.00003	0.00380	0.00022	0.04691	56.00	0.7641	0.0122	0.0942	0.0015	0.97	-3.46	0.68	561	19	576	14	580	17	572	12	0.13	580	17
TT19	68	0.00003	0.00895	0.00050	0.12690	151.50	0.6630	0.0099	0.0833	0.0012	0.96	0.68	-0.13	519	18	516	12	516	14	517	11	0.76	516	14
TT19	69	0.00003	0.02026	0.00248	0.06580	78.50	6.3352	0.0991	0.3635	0.0055	0.97	2.43	-1.23	2049	15	2023	28	1999	52	2045	14	0.07	2049	15

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
TT19	70	0.00003	0.02667	0.00181	0.20980	250.20	1.4505	0.0257	0.1499	0.0026	0.98	3.55	-1.07	934	16	910	21	900	29	926	14	0.05	900	29
TT19	72	0.00004	0.01026	0.00052	0.27900	326.00	0.3105	0.0048	0.0435	0.0007	0.97	0.59	-0.06	276	19	275	7	274	8	275	7	0.87	274	8
TT19	73	0.00003	0.01459	0.00073	0.47250	552.00	0.2582	0.0040	0.0366	0.0006	0.97	6.55	-0.63	248	19	233	6	232	7	234	7	0.10	232	7
TT19	74	0.00003	0.01669	0.00098	0.21850	255.00	0.7430	0.0115	0.0902	0.0014	0.97	6.32	-1.34	594	17	564	13	557	16	574	12	0.00	557	16
TT19	75	0.00005	0.01057	0.00086	0.05430	63.30	2.5792	0.0399	0.2303	0.0034	0.94	-8.90	3.09	1227	21	1295	23	1336	35	1257	18	0.00	1227	21
TT19	76	0.00003	0.00257	0.00013	0.08400	97.80	0.2572	0.0047	0.0366	0.0007	0.97	3.18	-0.30	239	21	232	8	232	8	233	8	0.50	232	8
TT19	79	0.00003	0.01434	0.00149	0.06320	73.50	3.9761	0.0815	0.2730	0.0055	0.98	9.81	-4.71	1725	15	1629	33	1556	56	1715	14	0.00	1725	15
TT19	81	0.00003	0.03330	0.00270	0.20100	233.00	2.3159	0.0624	0.2071	0.0055	0.99	0.87	-0.32	1224	19	1217	38	1213	59	1223	18	0.73	1224	19
TT19	84	0.00003	0.01112	0.00086	0.06600	76.40	2.1476	0.0426	0.1981	0.0039	0.98	-0.21	0.07	1163	16	1164	28	1165	41	1163	15	0.91	1165	41
TT19	85	0.00003	0.01283	0.00076	0.14850	171.80	0.8480	0.0166	0.1015	0.0020	0.98	0.26	-0.06	625	17	624	18	623	23	624	14	0.91	623	23
TT19	87	0.00003	0.00293	0.00017	0.03670	42.40	0.7808	0.0148	0.0952	0.0018	0.97	-0.24	0.05	585	20	586	17	586	21	585	14	0.92	586	21
TT19	88	0.00003	0.01849	0.00138	0.11820	136.30	1.9242	0.0389	0.1841	0.0037	0.98	0.06	-0.02	1090	16	1090	27	1089	40	1090	15	0.98	1089	40
TT19	89	0.00003	0.00252	0.00013	0.07920	91.20	0.2639	0.0061	0.0375	0.0009	0.98	2.32	-0.22	243	21	238	10	237	11	238	9	0.63	237	11
TT19	90	0.00004	0.00161	0.00010	0.02072	24.12	0.7960	0.0141	0.0945	0.0016	0.96	9.40	-2.14	642	22	595	16	582	19	608	15	0.00	582	19
TT19	91	0.00003	0.01284	0.00067	0.42100	491.00	0.2626	0.0045	0.0367	0.0006	0.96	16.53	-1.80	279	22	237	7	233	7	237	7	0.00	233	7
TT19	93	0.00003	0.00828	0.00049	0.10090	117.90	0.8129	0.0148	0.0984	0.0018	0.98	-0.76	0.16	600	18	604	17	605	21	602	13	0.74	605	21
TT19	95	0.00003	0.00608	0.00036	0.07230	84.90	0.8318	0.0136	0.1009	0.0016	0.97	-3.96	0.81	596	18	615	15	620	19	608	13	0.08	620	19
TT19	96	0.00003	0.01003	0.00051	0.32580	384.60	0.2632	0.0057	0.0375	0.0008	0.98	-0.29	0.03	237	19	237	9	237	10	237	9	0.95	237	10
TT19	97	0.00003	0.00857	0.00066	0.05420	64.40	0.2966	0.0378	0.1907	0.0035	0.97	0.69	-0.24	1133	17	1128	25	1125	37	1132	16	0.71	1125	37
TT19	98	0.00003	0.01113	0.00069	0.13920	165.80	0.8174	0.0153	0.0952	0.0017	0.96	14.23	-3.48	683	24	607	17	586	20	626	16	0.00	586	20
TT19	99	0.00003	0.01492	0.00078	0.43700	522.00	0.2913	0.0052	0.0404	0.0007	0.97	14.44	-1.68	298	21	260	8	255	9	261	8	0.00	255	9
TT19	100	0.00003	0.01138	0.00059	0.33330	398.00	0.2933	0.0051	0.0412	0.0007	0.97	3.22	-0.33	269	20	261	8	260	9	262	8	0.42	260	9
TT19	101	0.00003	0.02890	0.00179	0.35600	426.00	0.8497	0.0357	0.0996	0.0042	0.99	8.61	-2.03	670	22	624	39	612	49	661	20	0.03	612	49
TT19	102	0.00002	0.02240	0.00135	0.29900	358.00	0.7166	0.0507	0.0850	0.0060	1.00	18.37	-4.33	644	19	549	60	526	71	639	15	0.00	526	71
TT19	103	0.00002	0.02064	0.00194	0.09360	112.20	3.4961	0.0587	0.2663	0.0044	0.97	0.68	-0.29	1532	16	1526	27	1522	44	1531	15	0.66	1532	16
TT19	105	0.00003	0.02724	0.00161	0.37120	488.00	0.7429	0.0128	0.0896	0.0015	0.97	9.07	-1.97	608	18	564	15	553	18	581	13	0.00	553	18
TT19	106	0.00004	0.02346	0.00213	0.14490	190.20	2.4595	0.0614	0.1947	0.0048	0.99	21.43	-9.89	1459	15	1260	36	1147	52	1147	2	0.00	1459	15
TT19	107	0.00004	0.00853	0.00065	0.05560	72.90	1.9457	0.0436	0.1839	0.0041	0.98	2.34	-0.80	1114	17	1097	30	1088	44	1111	16	0.27	1088	44
TT19	108	0.00003	0.01648	0.00132	0.09430	123.20	2.3506	0.0539	0.2080	0.0047	0.99	2.13	-0.79	1245	16	1228	33	1218	50	1242	15	0.31	1245	16
TT19	109	0.00003	0.00739	0.00037	0.22860	298.00	0.2739	0.0051	0.0387	0.0007	0.98	4.21	-0.42	256	19	246	8	245	9	247	8	0.30	245	9
TT19	110	0.00004	0.02740	0.00173	0.28900	375.00	0.9600	0.0282	0.1085	0.0032	0.99	11.14	-2.90	747	18	683	29	664	37	732	16	0.00	664	37
TT19	111	0.00003	0.01481	0.00079	0.32600	419.00	0.4051	0.0083	0.0545	0.0011	0.98	6.92	-0.96	368	18	345	12	342	13	351	11	0.02	342	13
TT19	113	0.00003	0.00891	0.00052	0.12590	160.50	0.6704	0.0136	0.0830	0.0017	0.98	6.83	-1.36	552	18	521	17	514	20	535	14	0.00	514	20
TT19	114	0.00003	0.01701	0.00133	0.10120	128.40	1.9252	0.0480	0.1984	0.0043	0.98	2.09	-0.75	1192	16	1175	31	1167	46	1189	15	0.31	1167	46
TT19	115	0.00003	0.02165	0.00134	0.23770	298.50	0.9352	0.0207	0.1075	0.0024	0.99	7.47	-1.84	711	17	670	22	658	27	697	14	0.00	658	27
TT19	116	0.00003	0.02365	0.00147	0.25680	320.70	0.9551	0.0196	0.1094	0.0022	0.98	6.91	-1.72	719	17	681	20	669	26	704	14	0.00	669	26
TT19	117	0.00003	0.00736	0.00059	0.04690	58.30	2.0691	0.0466	0.1839	0.0041	0.98	11.96	-4.63	1236	19	1139	31	1088	44	1215	17	0.00	1088	44
TT19	118	0.00003	0.02538	0.00166	0.20760	255.00	1.2640	0.0254	0.1372	0.0027	0.98	0.40	-0.11	832	17	830	23	829	31	831	15	0.85	829	31
TT19	119	0.00005	0.01144	0.00086	0.07580	83.60	1.9264	0.0391	0.1801	0.0036	0.97	6.03	-2.13	1136	20	1090	27	1068	39	1123	17	0.00	1068	39
TT19	120	0.00005	0.03000	0.00183	0.33300	367.00	0.9528	0.0411	0.1106	0.0048	1.00	2.09	-0.49	691	18	680	43	676	55	689	17	0.62	676	55
TT19	121	0.00004	0.03180	0.00191	0.45100	494.00	0.6984	0.0183	0.0829	0.0022	0.99	20.13	-4.76	643	18	538	22	513	26	605	15	0.00	513	26
TT19	122	0.00004	0.02870	0.00220	0.20140	220.50	1.8681	0.0865	0.1740	0.0080	0.99	9.56	-3.46	1143	22	1070	61	1034	88	1138	20	0.01	1034	88

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	±1s	Pb206U238	±1s	Rho1	discTW	disc58	207Pb/206Pb	±2s	207Pb/235U	±2s	206Pb/238U	±2s	Concordia	±2s	probability	Age	±2s
TT19	123	0.00004	0.00467	0.00028	0.04750	51.90	0.9691	0.0171	0.1145	0.0020	0.96	-7.07	1.55	653	20	688	18	699	23	674	15	0.00	699	23
TT19	124	0.00005	0.00771	0.00059	0.04340	47.48	2.2349	0.0431	0.2090	0.0040	0.98	-7.75	2.57	1135	16	1192	27	1223	42	1148	16	0.00	1223	16
TT19	125	0.00004	0.00913	0.00061	0.07080	77.40	1.4049	0.0241	0.1496	0.0025	0.97	-3.08	0.86	872	17	891	20	899	28	879	14	0.10	899	28
TT19	126	0.00004	0.03280	0.00240	0.20830	227.80	1.9241	0.0622	0.1870	0.0060	0.99	-4.41	1.41	1058	17	1090	43	1105	65	1062	17	0.17	1105	65
TT19	127	0.00004	0.00036	0.00002	0.00469	5.13	0.6952	0.0126	0.0913	0.0015	0.90	-33.67	4.85	421	35	536	15	563	18	530	15	0.00	563	18
TT19	128	0.00004	0.00382	0.00019	0.09950	109.00	0.3152	0.0054	0.0448	0.0008	0.97	-16.72	1.53	242	20	278	8	283	9	275	8	0.00	283	9
TT19	129	0.00003	0.02510	0.00190	0.14860	162.70	2.0769	0.0392	0.1947	0.0036	0.98	-1.43	0.49	1131	16	1141	26	1147	39	1133	15	0.44	1147	39
TT19	130	0.00004	0.01510	0.00108	0.10080	110.40	1.7447	0.0295	0.1732	0.0029	0.97	-1.40	0.44	1016	16	1025	22	1030	31	1019	14	0.42	1030	31
TT19	131	0.00003	0.01405	0.00107	0.08170	89.60	2.1317	0.0381	0.2002	0.0035	0.98	-4.38	1.47	1127	16	1159	25	1176	38	1135	15	0.02	1176	38
TT19	132	0.00003	0.01805	0.00103	0.23160	254.30	0.7300	0.0146	0.0915	0.0018	0.98	-7.58	1.39	525	18	557	17	564	21	541	13	0.00	564	21
TT19	133	0.00005	0.01144	0.00086	0.07580	85.30	1.9145	0.0386	0.1789	0.0035	0.97	6.69	-2.37	1137	20	1086	27	1061	38	1122	17	0.00	1061	38
TT19	134	0.00006	0.03000	0.00183	0.33300	375.00	0.9472	0.0390	0.1099	0.0045	0.99	2.82	-0.67	692	18	677	41	672	52	690	17	0.48	672	52
TT19	135	0.00005	0.03180	0.00191	0.45100	507.00	0.6936	0.0183	0.0824	0.0022	0.99	20.38	-4.81	641	18	535	22	510	26	603	15	0.00	510	26
TT19	136	0.00004	0.02870	0.00220	0.20140	226.70	1.8554	0.0864	0.1730	0.0080	0.99	9.88	-3.57	1141	22	1065	61	1029	88	1136	20	0.01	1029	88
TT19	137	0.00005	0.00467	0.00028	0.04750	53.40	0.9646	0.0171	0.1139	0.0020	0.97	-6.31	1.39	654	20	686	18	695	23	673	15	0.01	695	23
TT19	138	0.00005	0.00771	0.00059	0.04342	48.70	2.2203	0.0431	0.2079	0.0040	0.98	-7.48	2.48	1133	16	1187	27	1218	42	1145	16	0.00	1218	16
TT19	139	0.00005	0.00913	0.00061	0.07080	79.00	1.4052	0.0273	0.1499	0.0029	0.98	-3.71	1.03	868	17	891	23	900	32	876	15	0.08	900	32
TT19	140	0.00004	0.03280	0.00240	0.20830	230.30	1.9028	0.0619	0.1860	0.0060	0.99	-5.05	1.60	1047	17	1082	43	1100	65	1050	17	0.12	1100	65
TT19	141	0.00004	0.00036	0.00002	0.00471	5.17	0.7203	0.0131	0.0905	0.0015	0.91	-7.55	1.37	519	33	551	15	558	18	549	15	0.04	558	18
TT19	142	0.00004	0.00382	0.00019	0.09960	108.80	0.3127	0.0054	0.0446	0.0008	0.97	-20.25	1.79	234	20	276	8	281	9	272	8	0.00	281	9
TT19	143	0.00004	0.02510	0.00190	0.14860	161.20	2.0459	0.0388	0.1937	0.0036	0.98	-2.74	0.92	1111	16	1131	26	1141	39	1116	15	0.15	1141	39
TT19	144	0.00004	0.01510	0.00108	0.10080	108.40	1.7114	0.0291	0.1719	0.0029	0.97	-3.10	0.95	992	17	1013	22	1023	31	999	15	0.09	1023	31
TT19	145	0.00004	0.01405	0.00107	0.08170	87.10	2.0936	0.0372	0.1992	0.0035	0.98	-6.36	2.08	1101	16	1147	24	1171	37	1113	15	0.00	1171	37
TT19	146	0.00004	0.01805	0.00103	0.23160	243.70	0.7155	0.0144	0.0910	0.0018	0.98	-14.01	2.40	492	18	548	17	561	21	521	13	0.00	561	21

Sample	Spot	Ph204_V	Ph206_V	Ph207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)					Discordance		Ages					Preferred					
							Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM15	1	0.00001	0.00076	0.00004	0.01751	113.3	0.4753	0.0054	0.0608	0.0006	0.87	20.43	-3.71	479	25	395	7	381	7	386	7	0.00	381	7
KM15	3	0.00001	0.00065	0.00003	0.06340	411.0	0.0947	0.0010	0.0143	0.0001	0.84	10.45	-0.43	102	28	92	2	91	2	92	2	0.45	91	2
KM15	4	0.00001	0.00021	0.00001	0.01916	124.2	0.1032	0.0014	0.0153	0.0002	0.82	30.02	-1.71	140	37	100	3	98	2	98	2	0.03	98	2
KM15	5	0.00001	0.00098	0.00005	0.09000	584.0	0.1017	0.0014	0.0152	0.0002	0.91	17.91	-0.86	119	26	98	2	98	2	98	2	0.11	98	2
KM15	6	0.00001	0.00114	0.00005	0.10200	662.0	0.1028	0.0013	0.0154	0.0002	0.92	12.16	-0.55	112	25	99	2	99	2	99	2	0.27	99	2
KM15	7	0.00001	0.00261	0.00017	0.03090	200.9	1.0686	0.0129	0.1176	0.0013	0.91	10.77	-2.97	803	21	738	13	717	15	745	13	0.00	717	15
KM15	8	0.00001	0.00024	0.00001	0.02436	158.5	0.0926	0.0013	0.0139	0.0001	0.77	28.28	-1.43	124	41	90	2	89	2	89	2	0.10	89	2
KM15	9	0.00001	0.00028	0.00001	0.02805	182.6	0.0942	0.0013	0.0140	0.0002	0.79	34.67	-1.95	137	39	91	2	90	2	90	2	0.02	90	2
KM15	10	0.00001	0.00349	0.00023	0.03625	236.3	1.2371	0.0149	0.1335	0.0015	0.93	4.32	-1.21	844	19	818	14	808	17	824	13	0.00	808	17
KM15	11	0.00001	0.00031	0.00001	0.04142	270.1	0.0688	0.0008	0.0106	0.0001	0.79	-31.46	0.66	52	35	68	2	68	1	68	1	0.35	68	1
KM15	13	0.00001	0.00023	0.00001	0.02182	142.5	0.0951	0.0013	0.0145	0.0001	0.72	-8.45	0.29	85	44	92	2	93	2	93	2	0.75	93	2
KM15	14	0.00001	0.00010	0.00000	0.01700	111.1	0.0500	0.0010	0.0077	0.0001	0.67	-15.27	0.27	43	71	50	2	50	1	50	1	0.85	50	1
KM15	15	0.00001	0.00069	0.00003	0.06620	432.9	0.0974	0.0011	0.0146	0.0001	0.84	17.86	-0.83	114	29	94	2	94	2	94	2	0.16	94	2
KM15	16	0.00001	0.00024	0.00001	0.02194	143.5	0.1010	0.0013	0.0152	0.0001	0.67	7.34	-0.31	105	45	98	2	97	2	97	2	0.73	97	2
KM15	17	0.00001	0.00113	0.00005	0.09310	609.0	0.1148	0.0016	0.0167	0.0002	0.91	45.25	-3.62	194	27	110	3	106	3	107	3	0.00	106	3
KM15	18	0.00001	0.00037	0.00002	0.03738	244.8	0.0896	0.0013	0.0137	0.0002	0.87	-25.56	0.72	70	35	87	3	88	2	88	2	0.30	88	2
KM15	19	0.00001	0.00018	0.00001	0.01759	115.2	0.0929	0.0017	0.0141	0.0002	0.86	-4.03	0.14	87	44	90	3	90	3	90	3	0.87	90	3
KM15	20	0.00001	0.00045	0.00002	0.04439	290.9	0.0952	0.0015	0.0143	0.0002	0.90	24.09	-1.18	120	33	92	3	91	3	91	3	0.08	91	3
KM15	21	0.00001	0.00044	0.00002	0.04020	263.1	0.1025	0.0014	0.0153	0.0002	0.85	21.04	-1.06	124	34	99	3	98	2	98	2	0.13	98	2
KM15	22	0.00001	0.00021	0.00001	0.01936	126.7	0.1031	0.0015	0.0155	0.0002	0.78	7.26	-0.31	107	44	100	3	99	2	99	2	0.73	99	2
KM15	23	0.00001	0.00013	0.00001	0.01186	77.6	0.1043	0.0016	0.0154	0.0002	0.68	34.95	-2.17	152	53	101	3	99	2	99	2	0.05	99	2
KM15	24	0.00001	0.00284	0.00017	0.03689	241.3	0.9338	0.0109	0.1067	0.0012	0.93	9.74	-2.46	724	19	670	11	654	13	676	12	0.00	654	13
KM15	25	0.00001	0.00347	0.00021	0.04240	277.5	0.9848	0.0131	0.1142	0.0015	0.95	-0.64	0.15	693	18	696	13	697	17	695	17	0.72	697	17
KM15	27	0.00001	0.00038	0.00002	0.03704	241.9	0.0979	0.0015	0.0142	0.0002	0.77	55.53	-4.72	204	46	95	3	91	2	91	2	0.00	91	2
KM15	29	0.00001	0.00027	0.00001	0.02472	161.3	0.1028	0.0014	0.0155	0.0002	0.79	7.07	-0.30	107	39	99	3	99	2	99	2	0.70	99	2
KM15	30	0.00001	0.00231	0.00011	0.22640	1476.0	0.0961	0.0012	0.0144	0.0002	0.92	28.25	-1.47	128	23	93	2	92	2	92	2	0.00	92	2
KM15	31	0.00001	0.00067	0.00003	0.06140	399.8	0.1010	0.0012	0.0152	0.0002	0.85	8.68	-0.37	107	29	98	2	97	2	97	2	0.52	97	2
KM15	32	0.00001	0.00072	0.00003	0.07090	462.0	0.0940	0.0011	0.0141	0.0001	0.83	19.61	-0.90	112	30	91	2	90	2	90	2	0.15	90	2
KM15	33	0.00001	0.00093	0.00005	0.01481	96.3	0.7157	0.0084	0.0880	0.0009	0.87	4.02	-0.81	566	25	548	10	544	11	547	10	0.10	544	11
KM15	34	0.00001	0.00134	0.00006	0.16770	1090.0	0.0732	0.0008	0.0111	0.0001	0.89	23.36	-0.89	93	24	72	2	71	1	71	1	0.07	71	1
KM15	36	0.00001	0.00077	0.00004	0.07510	487.6	0.0985	0.0012	0.0144	0.0001	0.79	49.83	-3.78	183	34	95	2	92	2	92	2	0.00	92	2
KM15	37	0.00001	0.00050	0.00002	0.05410	351.1	0.0865	0.0011	0.0130	0.0001	0.85	24.97	-1.13	111	33	84	2	83	2	83	2	0.10	83	2
KM15	38	0.00001	0.00026	0.00001	0.02682	173.9	0.0926	0.0013	0.0134	0.0001	0.77	55.76	-4.52	194	40	90	2	86	2	86	2	0.00	86	2
KM15	39	0.00001	0.00357	0.00018	0.13730	890.0	0.2567	0.0027	0.0363	0.0003	0.91	8.88	-0.87	252	21	232	4	230	4	231	4	0.03	230	4
KM15	1	0.00003	0.00109	0.00073	0.08310	357.0	1.6896	0.0409	0.1663	0.0040	0.99	3.99	-1.30	1033	13	1005	31	992	44	1030	12	0.07	992	44
KM15	3	0.00003	0.00028	0.00001	0.03529	152.3	0.0693	0.0013	0.0106	0.0002	0.90	4.08	-0.12	71	39	68	2	68	2	68	2	0.88	68	2
KM15	4	0.00003	0.00059	0.00003	0.05690	245.7	0.0935	0.0014	0.0141	0.0002	0.94	12.06	-0.50	103	26	91	3	90	3	90	3	0.34	90	3
KM15	5	0.00003	0.00861	0.00050	0.13690	592.0	0.7279	0.0231	0.0873	0.0028	0.99	13.05	-2.92	621	15	555	27	540	33	608	13	0.00	540	33
KM15	6	0.00003	0.00164	0.00008	0.21230	921.0	0.0673	0.0014	0.0102	0.0002	0.97	25.36	-0.91	88	24	66	3	66	3	66	3	0.07	66	3
KM15	7	0.00003	0.00072	0.00003	0.04440	192.9	0.1534	0.0035	0.0222	0.0005	0.95	28.13	-2.24	197	33	145	6	142	6	143	6	0.00	142	6
KM15	8	0.00003	0.00049	0.00002	0.04662	202.9	0.0963	0.0016	0.0145	0.0002	0.94	19.84	-0.93	115	27	93	3	92	3	93	3	0.09	92	3
KM15	9	0.00003	0.00054	0.00003	0.05200	226.6	0.0942	0.0018	0.0142	0.0003	0.96	15.60	-0.68	108	25	91	3	91	3	91	3	0.19	91	3
KM15	10	0.00002	0.00068	0.00003	0.06700	292.5	0.0918	0.0015	0.0138	0.0002	0.95	18.47	-0.81	109	25	89	3	88	3	89	3	0.12	88	3
KM15	11	0.00002	0.00190	0.00009	0.18890	826.0	0.0913	0.0015	0.0138	0.0002	0.97	5.63	-0.21	94	18	89	3	88	3	89	3	0.57	88	3
KM15	12	0.00002	0.00135	0.00006	0.12400	543.0	0.0967	0.0018	0.0147	0.0003	0.97	-1.06	0.04	93	22	94	3	94	3	94	3	0.93	94	3
KM15	13	0.00002	0.00033	0.00001	0.05610	246.1	0.0523	0.0008	0.0081	0.0001	0.89	-3.25	0.07	50	33	52	2	52	1	52	1	0.92	52	1
KM15	14	0.00003	0.00044	0.00002	0.03877	170.5	0.1073	0.0022	0.0154	0.0003	0.94	54.86	-4.99	218	32	104	4	99	4	98	4	0.00	99	4
KM15	15	0.00002	0.00033	0.00002	0.03321	146.3	0.0920	0.0015	0.0136	0.0002	0.90	40.35	-2.43	146	34	89	3	87	3	87	3	0.00	87	3

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Ph204_V	Ph206_V	Ph207_V	U238_V	U_ppm	Ph207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM15	17	0.00003	0.00131	0.00006	0.12210	540.0	0.0961	0.0020	0.0145	0.0003	0.98	8.71	-0.36	102	21	93	4	93	4	93	4	0.40	93	4
KM15	18	0.00002	0.00050	0.00002	0.04690	207.6	0.0960	0.0016	0.0144	0.0002	0.95	16.41	-0.74	110	26	93	3	92	3	93	3	0.16	92	3
KM15	19	0.00002	0.00052	0.00002	0.04850	215.1	0.0955	0.0018	0.0144	0.0003	0.95	4.94	-0.19	97	27	93	3	92	3	92	3	0.73	92	3
KM15	20	0.00002	0.00210	0.00010	0.07790	346.3	0.2572	0.0053	0.0367	0.0008	0.99	0.28	-0.03	233	16	232	9	232	9	232	9	0.94	232	9
KM15	21	0.00002	0.00075	0.00004	0.07520	356.0	0.0909	0.0010	0.0137	0.0001	0.92	13.10	-0.54	101	22	88	2	88	2	88	2	0.23	88	2
KM15	23	0.00002	0.00022	0.00001	0.02202	104.6	0.0896	0.0015	0.0134	0.0002	0.83	30.92	-1.57	124	44	87	3	86	2	86	2	0.08	86	2
KM15	24	0.00002	0.00188	0.00009	0.18300	870.0	0.0933	0.0012	0.0140	0.0002	0.96	23.29	-1.11	117	16	91	2	90	2	90	2	0.00	90	2
KM15	25	0.00002	0.00268	0.00013	0.10630	507.2	0.2385	0.0027	0.0341	0.0004	0.96	6.40	-0.58	231	15	217	4	216	5	217	5	0.06	216	5
KM15	26	0.00002	0.00174	0.00009	0.05610	268.0	0.3058	0.0037	0.0428	0.0005	0.96	2.05	-0.22	276	17	271	6	270	6	271	6	0.52	270	6
KM15	27	0.00002	0.00051	0.00002	0.04869	233.2	0.0957	0.0013	0.0143	0.0002	0.90	32.08	-1.76	134	29	93	2	91	2	91	2	0.00	91	2
KM15	28	0.00002	0.00224	0.00012	0.05210	250.2	0.4374	0.0054	0.0589	0.0007	0.96	-1.07	0.15	365	16	368	8	369	9	368	7	0.67	369	9
KM15	29	0.00002	0.00046	0.00002	0.04482	215.5	0.0937	0.0014	0.0142	0.0002	0.90	9.07	-0.37	100	30	91	3	91	2	91	2	0.55	91	2
KM15	30	0.00001	0.00056	0.00003	0.05040	242.6	0.1019	0.0013	0.0151	0.0002	0.92	31.12	-1.78	141	24	99	2	97	2	97	2	0.00	97	2
KM15	32	0.00001	0.00017	0.00001	0.01704	82.4	0.0917	0.0015	0.0138	0.0002	0.85	21.93	-1.01	113	42	89	3	88	2	88	2	0.24	88	2
KM15	33	0.00001	0.00117	0.00006	0.11240	544.8	0.0961	0.0013	0.0142	0.0002	0.94	37.94	-2.28	147	23	93	2	91	2	91	2	0.00	91	2
KM15	35	0.00001	0.00038	0.00002	0.03740	182.0	0.0966	0.0016	0.0143	0.0002	0.89	38.04	-2.31	148	35	94	3	92	3	92	3	0.00	92	3
KM15	36	0.00002	0.00052	0.00002	0.07460	363.8	0.0636	0.0008	0.0096	0.0001	0.88	36.90	-1.48	98	29	63	2	62	1	62	1	0.02	62	1
KM15	37	0.00001	0.00015	0.00001	0.02595	126.8	0.0518	0.0009	0.0077	0.0001	0.73	67.54	-4.31	152	57	51	2	49	1	49	1	0.00	49	1
KM15	40	0.00001	0.00031	0.00001	0.02962	145.6	0.0927	0.0015	0.0142	0.0002	0.92	-20.18	0.61	75	30	90	3	91	3	90	3	0.31	91	3
KM15	41	0.00002	0.00042	0.00002	0.04272	217.1	0.0910	0.0014	0.0134	0.0002	0.91	49.17	-3.42	168	31	88	3	85	2	86	2	0.00	85	2
KM15	42	0.00001	0.00037	0.00002	0.03623	184.2	0.0928	0.0015	0.0142	0.0002	0.89	-18.69	0.57	76	35	90	3	91	3	91	3	0.41	91	3
KM15	43	0.00001	0.00072	0.00003	0.06845	348.3	0.0960	0.0013	0.0144	0.0002	0.94	19.37	-0.90	114	22	93	2	92	2	92	2	0.04	92	2
KM15	44	0.00001	0.00061	0.00003	0.06000	305.0	0.0942	0.0013	0.0139	0.0002	0.93	44.17	-2.90	159	25	91	2	89	2	89	2	0.00	89	2
KM15	45	0.00001	0.00026	0.00001	0.03240	165.0	0.0726	0.0012	0.0111	0.0002	0.85	7.59	-0.24	77	42	71	2	71	2	71	2	0.78	71	2
KM15	46	0.00001	0.00068	0.00003	0.11450	582.9	0.0524	0.0008	0.0081	0.0001	0.93	10.55	-0.25	58	26	52	1	52	1	52	1	0.64	52	1
KM15	47	0.00001	0.00066	0.00003	0.11170	568.9	0.0529	0.0008	0.0081	0.0001	0.92	27.73	-0.82	72	28	52	2	52	1	52	1	0.16	52	1
KM15	48	0.00001	0.00029	0.00001	0.03232	164.6	0.0795	0.0013	0.0121	0.0002	0.89	4.03	-0.13	81	35	78	2	78	2	78	2	0.85	78	2
KM15	49	0.00002	0.00369	0.00021	0.05793	294.8	0.7090	0.0103	0.0874	0.0013	0.98	3.71	-0.74	561	13	544	12	540	15	552	10	0.04	540	15
KM15	52	0.00001	0.00601	0.00050	0.03800	193.1	2.5600	0.0341	0.2182	0.0029	0.98	3.44	-1.33	1318	11	1289	20	1272	30	1312	10	0.00	1318	11
KM15	53	0.00001	0.00055	0.00003	0.07080	358.9	0.0695	0.0011	0.0107	0.0002	0.95	-29.02	0.62	53	24	68	2	69	2	69	2	0.19	69	2
KM15	55	0.00001	0.00160	0.00007	0.16900	854.0	0.0855	0.0012	0.0131	0.0002	0.96	-15.67	0.46	72	19	83	2	84	2	84	2	0.24	84	2
KM15	56	0.00001	0.00023	0.00001	0.02121	107.0	0.1017	0.0027	0.0151	0.0004	0.93	33.44	-1.98	145	47	98	5	96	5	97	5	0.04	96	5
KM15	57	0.00001	0.00019	0.00001	0.01740	87.3	0.0972	0.0017	0.0147	0.0002	0.87	9.46	-0.40	104	41	94	3	94	3	94	3	0.63	94	3
KM15	58	0.00001	0.00009	0.00000	0.01740	87.3	0.0472	0.0008	0.0072	0.0001	0.75	44.67	-1.54	83	55	47	2	46	1	46	1	0.18	46	1
KM15	59	0.00001	0.00016	0.00001	0.01440	72.1	0.0993	0.0017	0.0150	0.0002	0.84	0.07	0.00	96	44	96	3	96	3	96	3	1.00	96	3
KM15	60	0.00001	0.00097	0.00005	0.09200	459.2	0.0953	0.0014	0.0143	0.0002	0.95	16.55	-0.74	110	21	92	3	92	3	92	3	0.09	92	3
KM15	61	0.00001	0.00046	0.00002	0.04370	204.5	0.0959	0.0012	0.0145	0.0002	0.84	5.57	-0.22	98	32	93	2	93	2	93	2	0.74	93	2
KM15	63	0.00001	0.00268	0.00020	0.02040	94.1	1.8428	0.0214	0.1779	0.0020	0.97	1.53	-0.51	1072	13	1061	15	1055	22	1068	11	0.20	1055	22
KM15	64	0.00001	0.00027	0.00001	0.02651	121.5	0.0908	0.0013	0.0139	0.0002	0.84	-32.12	0.87	67	38	88	2	89	2	89	2	0.25	89	2
KM15	65	0.00001	0.00061	0.00003	0.05742	261.5	0.0962	0.0012	0.0146	0.0002	0.92	2.16	-0.08	95	25	93	2	93	2	93	2	0.87	93	2
KM15	66	0.00001	0.00229	0.00011	0.29860	1351.0	0.0718	0.0009	0.0106	0.0001	0.95	57.12	-3.77	158	17	70	2	68	2	68	2	0.00	68	2
KM15	67	0.00001	0.00301	0.00014	0.28960	1302.0	0.0945	0.0011	0.0144	0.0002	0.96	-9.05	0.31	84	15	92	2	92	2	92	2	0.31	92	2
KM15	68	0.00001	0.00033	0.00001	0.04340	193.9	0.0665	0.0009	0.0103	0.0001	0.89	-95.65	1.30	34	31	65	2	66	2	66	2	0.04	66	2
KM15	69	0.00001	0.01097	0.00074	0.10420	462.0	1.3827	0.0175	0.1450	0.0018	0.98	3.39	-1.00	903	11	882	15	873	20	896	10	0.01	873	20
KM15	70	0.00001	0.00073	0.00003	0.03390	149.4	0.1993	0.0025	0.0293	0.0003	0.92	-14.64	0.93	162	24	185	4	186	4	185	4	0.05	186	4
KM15	71	0.00001	0.00017	0.00001	0.02257	98.8	0.0671	0.0010	0.0102	0.0001	0.76	26.41	-0.96	89	44	66	2	65	1	65	1	0.29	65	1
KM15	72	0.00001	0.00040	0.00002	0.03587	156.0	0.1040	0.0014	0.0152	0.0002	0.87	45.71	-3.37	179	31	100	3	97	2	97	2	0.00	97	2
KM15	73	0.00001	0.00066	0.00003	0.06610	285.9	0.0923	0.0013	0.0137	0.0002	0.93	35.92	-2.02	137	24	90	2	88	2	88	2	0.00	88	2

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred	
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235 ± 1s	Pb206U238 ± 1s	Rho1	discTW	disc58	207Pb/206Pb ± 2s	207Pb/235U ± 2s	206Pb/238U ± 2s	Concordia ± 2s	probability	Age ± 2s			
KM15	74	0.00001	0.00959	0.00050	0.23400	1005.0	0.4237	0.0057	0.0008	0.98	2.66	-0.37	367	13	359	8	357	9	357	9
KM15	75	0.00001	0.00019	0.00001	0.02730	116.6	0.0640	0.0010	0.0097	0.60	39.97	-1.70	103	54	63	2	62	1	62	1
KM15	76	0.00001	0.00115	0.00005	0.20330	862.0	0.0521	0.0006	0.0078	0.99	63.07	-3.56	135	25	52	1	50	1	0.00	50
KM15	77	0.00001	0.00107	0.00005	0.06800	286.4	0.1467	0.0020	0.0003	0.95	13.15	-0.84	159	20	139	3	138	3	0.04	138
KM15	78	0.00001	0.00033	0.00002	0.04320	181.0	0.0751	0.0011	0.0107	0.87	71.65	-7.40	242	32	74	2	68	2	0.00	
KM23	1	0.00002	0.01044	0.00072	0.10320	587.0	1.3448	0.0189	0.1368	0.0019	14.43	-4.69	966	17	865	16	827	21	0.00	827
KM23	3	0.00001	0.00261	0.00015	0.03996	226.2	0.7169	0.0101	0.0895	0.0012	-3.61	0.68	533	19	549	12	553	14	0.11	553
KM23	4	0.00001	0.00202	0.00015	0.01531	86.6	1.8535	0.0266	0.1791	0.0025	0.74	-0.25	1070	18	1065	19	1062	27	0.62	1062
KM23	5	0.00001	0.00991	0.00074	0.07160	404.0	2.0256	0.0283	0.1896	0.0026	1.28	-0.44	1134	16	1124	19	1119	28	0.37	1119
KM23	6	0.00001	0.00408	0.00023	0.06630	373.0	0.6710	0.0095	0.0846	0.0012	-2.31	0.42	512	19	521	12	524	14	0.31	524
KM23	7	0.00001	0.00744	0.00058	0.05051	284.0	2.2001	0.0341	0.1996	0.0030	1.88	-0.67	1196	16	1181	22	1173	32	0.21	1173
KM23	8	0.00001	0.00144	0.00007	0.05340	300.0	0.2553	0.0033	0.0367	0.0004	-5.80	0.49	219	23	231	5	232	6	0.28	232
KM23	9	0.00001	0.00476	0.00027	0.07560	424.0	0.6866	0.0107	0.0860	0.0013	-1.08	0.20	526	18	531	13	532	15	0.64	532
KM23	10	0.00001	0.00346	0.00019	0.06000	336.1	0.6261	0.0117	0.0800	0.0015	-2.85	0.49	482	19	494	15	496	17	0.29	496
KM23	12	0.00001	0.00674	0.00041	0.08600	480.0	0.9158	0.0123	0.1069	0.0014	3.53	-0.83	679	19	660	13	655	16	0.05	655
KM23	13	0.00001	0.01546	0.00089	0.24000	1340.0	0.7119	0.0172	0.0859	0.0021	12.52	-2.75	607	18	546	20	582	15	0.00	531
KM23	16	0.00001	0.00186	0.00011	0.02338	130.4	0.9413	0.0141	0.1093	0.0016	3.08	-0.73	690	21	674	15	669	18	0.13	669
KM23	19	0.00001	0.01333	0.00242	0.03495	194.8	13.4396	0.1629	0.5202	0.0060	0.95	-0.41	2719	14	2711	23	2700	51	0.47	2719
KM23	20	0.00001	0.00563	0.00043	0.03830	213.6	2.1566	0.0234	0.1978	0.0020	0.93	-0.32	1174	17	1167	15	1163	22	0.44	1163
KM23	21	0.00001	0.01041	0.00064	0.14120	810.0	0.8897	0.0089	0.1024	0.0010	11.31	-2.82	709	17	646	10	628	11	0.00	628
KM23	22	0.00001	0.00395	0.00020	0.12810	737.0	0.2966	0.0031	0.1417	0.0004	0.92	-0.20	268	20	264	5	263	5	0.60	263
KM23	23	0.00001	0.00555	0.00031	0.09080	524.0	0.6557	0.0066	0.0834	0.0008	0.91	-0.34	526	18	518	8	516	9	0.36	516
KM23	24	0.00001	0.00455	0.00025	0.08390	485.0	0.5752	0.0052	0.0742	0.0006	0.89	-0.34	460	19	461	7	462	7	0.88	462
KM23	25	0.00002	0.00172	0.00009	0.06500	377.5	0.2580	0.0033	0.0359	0.0004	8.83	-2.62	294	32	233	5	227	5	0.00	227
KM23	26	0.00002	0.00650	0.00183	0.01325	77.2	26.8356	0.4344	0.6670	0.0105	3.88	-2.53	3427	14	3377	32	3294	81	0.00	3427
KM23	27	0.00002	0.00965	0.00003	0.02460	143.8	0.2568	0.0046	0.0357	0.0006	0.94	-2.65	293	28	232	7	226	7	0.00	226
KM23	28	0.00001	0.00214	0.00012	0.02910	170.7	0.8349	0.0119	0.0999	0.0014	1.87	-0.41	626	20	616	13	614	16	0.36	614
KM23	29	0.00001	0.00435	0.00024	0.07400	436.5	0.6320	0.0098	0.0801	0.0012	0.96	-0.12	500	19	497	12	498	11	0.77	497
KM23	30	0.00001	0.00046	0.00002	0.01106	65.3	0.4230	0.0063	0.0568	0.0008	0.89	-0.58	372	32	358	9	356	9	0.34	356
KM23	31	0.00001	0.01154	0.00118	0.05620	333.0	4.0786	0.0608	0.2811	0.0041	7.07	-3.33	1718	15	1650	24	1597	41	0.00	1718
KM23	32	0.00001	0.00654	0.00038	0.09470	563.0	0.7694	0.0103	0.0938	0.0012	1.23	-0.25	585	18	579	12	578	14	0.53	578
KM23	33	0.00001	0.00162	0.00009	0.02572	153.4	0.6861	0.0110	0.0856	0.0013	1.00	-0.19	535	23	530	13	529	15	0.70	529
KM23	34	0.00001	0.00966	0.00059	0.13470	805.0	0.8593	0.0123	0.0987	0.0014	14.90	-3.78	713	18	630	13	607	16	0.00	607
KM23	35	0.00001	0.00100	0.00006	0.01461	87.6	0.7786	0.0096	0.0940	0.0011	4.46	-0.95	606	23	585	11	579	12	0.04	579
KM23	36	0.00001	0.00291	0.00015	0.08620	519.0	0.3381	0.0043	0.0464	0.0006	0.92	-1.05	320	23	296	7	293	7	0.02	293
KM23	38	0.00001	0.00209	0.00011	0.04582	277.4	0.4693	0.0053	0.0623	0.0007	1.95	-0.29	397	21	391	7	390	8	0.49	390
KM23	39	0.00001	0.00137	0.00007	0.04165	252.9	0.3218	0.0043	0.0448	0.0006	0.93	-0.27	290	23	283	7	283	7	0.56	283
KM23	40	0.00001	0.00140	0.00082	0.19730	1201.0	0.8090	0.0109	0.0968	0.0013	4.78	-1.05	626	17	602	12	596	15	0.01	596
KM23	41	0.00001	0.00549	0.00030	0.09390	584.0	0.6347	0.0072	0.0804	0.0009	0.93	-0.10	501	19	499	9	499	10	0.79	499
KM23	42	0.00001	0.01204	0.00112	0.07040	438.0	3.1168	0.0373	0.2338	0.0027	13.24	-6.09	1561	16	1437	19	1354	28	0.00	1561
KM23	43	0.00001	0.00208	0.00016	0.01450	90.1	2.1563	0.0267	0.1982	0.0023	0.94	-0.12	1170	18	1167	17	1166	25	0.79	1166
KM23	44	0.00001	0.00520	0.00029	0.08630	536.4	0.6542	0.0084	0.0822	0.0010	1.95	-0.36	519	18	511	10	509	12	0.36	509
KM23	45	0.00001	0.00212	0.00011	0.06920	430.0	0.3005	0.0027	0.0423	0.0003	0.86	-1.55	263	21	267	4	267	4	0.70	267
KM23	46	0.00001	0.00731	0.00054	0.05470	339.0	1.9051	0.0193	0.1829	0.0017	0.92	-0.01	1083	17	1083	14	1083	19	0.98	1083
KM23	47	0.00001	0.00375	0.00044	0.01715	106.4	5.0209	0.0522	0.1575	0.0029	0.92	-8.61	1992	16	1823	18	1678	28	0.00	1992
KM23	49	0.00001	0.00594	0.00043	0.04590	284.6	1.8474	0.0231	0.1775	0.0021	0.95	-2.60	1081	17	1063	17	1053	23	0.05	1053
KM23	50	0.00001	0.00132	0.00007	0.04320	267.2	0.2974	0.0045	0.0419	0.0006	0.94	-0.90	262	24	264	7	265	7	0.85	265

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages										Preferred	
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	discS8	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s	
KM23	51	0.00001	0.00354	0.00020	0.05250	325.0	0.7618	0.0119	0.0927	0.0014	0.96	3.01	-0.63	589	19	575	14	571	17	579	13	0.15	571	17	
KM23	52	0.00001	0.00419	0.00031	0.03075	190.1	1.9979	0.0314	0.1879	0.0029	0.97	1.26	-0.43	1124	17	1115	21	1110	31	1121	15	0.42	1110	31	
KM23	53	0.00001	0.00029	0.00001	0.01092	67.4	0.2620	0.0041	0.0368	0.0005	0.82	14.45	-1.54	272	42	236	7	233	6	233	6	0.07	233	6	
KM23	54	0.00001	0.00112	0.00006	0.01948	120.2	0.6095	0.0074	0.0776	0.0009	0.91	1.71	-0.30	490	23	483	9	482	10	483	9	0.50	482	10	
KM23	55	0.00001	0.00300	0.00019	0.03482	214.7	1.0998	0.0156	0.1188	0.0016	0.95	14.07	-4.09	842	19	753	15	724	18	782	14	0.00	724	18	
KM23	56	0.00001	0.01012	0.00091	0.05480	338.0	3.3254	0.0466	0.2562	0.0035	0.96	2.68	-1.13	1511	16	1487	22	1470	35	1504	14	0.04	1511	16	
KM23	57	0.00001	0.00460	0.00027	0.06230	383.6	0.8431	0.0090	0.1011	0.0010	0.93	0.01	0.00	621	18	621	10	621	12	621	10	1.00	621	12	
KM23	58	0.00001	0.00050	0.00003	0.00809	49.8	0.6809	0.0069	0.0851	0.0007	0.81	0.95	-0.18	531	27	527	8	526	8	527	8	0.72	526	8	
KM23	59	0.00001	0.00325	0.00031	0.01587	97.5	3.7923	0.0335	0.2815	0.0022	0.88	-1.15	0.49	1581	16	1591	14	1599	22	1587	13	0.19	1581	16	
KM23	60	0.00001	0.00184	0.00009	0.05630	345.8	0.3225	0.0028	0.0452	0.0003	0.85	-3.54	0.37	275	22	284	4	285	4	284	4	0.38	285	4	
KM23	61	0.00001	0.00379	0.00028	0.02810	172.6	1.9417	0.0163	0.1856	0.0014	0.87	-0.52	0.17	1092	17	1096	11	1097	15	1095	11	0.62	1097	15	
KM23	62	0.00001	0.01043	0.00064	0.14470	884.0	0.8475	0.0102	0.0973	0.0011	0.94	16.17	-4.13	714	18	623	11	599	13	637	11	0.00	599	13	
KM23	64	0.00001	0.00371	0.00027	0.02816	171.9	1.9241	0.0196	0.1820	0.0017	0.92	3.13	-1.08	1113	17	1089	14	1078	19	1097	13	0.01	1078	19	
KM23	65	0.00001	0.00191	0.00009	0.07230	441.6	0.2545	0.0026	0.0362	0.0003	0.89	5.57	-0.53	243	22	230	4	229	4	229	4	0.22	229	4	
KM23	66	0.00001	0.00306	0.00015	0.11350	693.0	0.2586	0.0028	0.0369	0.0004	0.92	1.04	-0.09	236	20	233	5	233	5	233	4	0.82	233	5	
KM23	67	0.00001	0.00044	0.00002	0.01655	101.1	0.2554	0.0030	0.0366	0.0003	0.80	-3.68	0.32	223	32	231	5	232	4	232	4	0.61	232	4	
KM23	68	0.00001	0.00594	0.00042	0.05270	321.9	1.5564	0.0201	0.1560	0.0019	0.94	6.17	-1.98	996	18	953	16	935	21	970	14	0.00	935	21	
KM23	69	0.00001	0.00550	0.00038	0.04800	293.1	1.5739	0.0188	0.1595	0.0018	0.94	2.02	-0.63	974	17	960	15	954	20	965	13	0.13	954	20	
KM23	70	0.00001	0.00482	0.00036	0.03599	219.9	1.9384	0.0190	0.1847	0.0017	0.91	0.50	-0.17	1098	17	1094	13	1093	18	1095	12	0.66	1093	18	
KM23	71	0.00001	0.00376	0.00019	0.13710	838.0	0.2730	0.0042	0.0382	0.0006	0.94	13.00	-1.41	278	24	245	7	242	7	244	7	0.00	242	7	
KM23	72	0.00001	0.00228	0.00011	0.07340	449.0	0.3058	0.0042	0.0429	0.0006	0.95	1.69	-0.18	275	21	271	6	270	7	271	6	0.67	270	7	
KM23	73	0.00001	0.00643	0.00036	0.10310	630.0	0.7101	0.0105	0.0878	0.0013	0.96	2.12	-0.42	554	18	545	12	543	15	547	12	0.31	543	15	
KM23	74	0.00001	0.00208	0.00014	0.01736	106.2	1.6438	0.0198	0.1652	0.0019	0.93	0.51	-0.16	991	19	987	15	986	20	988	14	0.72	986	20	
KM23	75	0.00001	0.00302	0.00020	0.03192	195.3	1.2301	0.0095	0.1300	0.0020	0.95	11.24	-3.37	888	21	814	18	788	22	840	16	0.00	788	22	
KM23	76	0.00001	0.00151	0.00008	0.05740	351.4	0.2637	0.0046	0.0362	0.0006	0.95	28.76	-3.67	322	24	238	7	229	7	234	8	0.00	229	7	
KM23	79	0.00001	0.00326	0.00023	0.03052	187.0	1.4440	0.0224	0.1451	0.0022	0.96	11.86	-3.89	991	19	907	19	873	24	948	15	0.00	873	24	
KM23	80	0.00001	0.00960	0.00160	0.02707	165.9	11.4104	0.2436	0.4770	0.0100	0.98	2.99	-1.71	2592	15	2557	40	2514	87	2589	14	0.08	2592	15	
KM23	82	0.00001	0.00442	0.00030	0.04240	264.1	1.4378	0.0176	0.1469	0.0017	0.94	7.68	-2.41	957	17	905	15	884	19	924	13	0.00	884	19	
KM23	83	0.00001	0.00129	0.00006	0.04800	298.9	0.2644	0.0029	0.0373	0.0004	0.89	7.84	-0.78	256	24	238	5	236	4	237	4	0.10	236	4	
KM23	84	0.00001	0.00152	0.00009	0.02161	134.7	0.8474	0.0100	0.0972	0.0010	0.87	16.49	-4.22	716	25	623	11	598	12	616	11	0.00	598	12	
KM23	85	0.00001	0.00117	0.00006	0.02950	183.9	0.4077	0.0046	0.0554	0.0006	0.88	-0.95	0.12	344	24	347	7	348	7	347	6	0.79	348	7	
KM23	86	0.00001	0.01761	0.00318	0.05280	329.2	11.9368	0.1304	0.4627	0.0048	0.94	9.77	-6.04	2717	14	2599	21	2451	42	2692	13	0.00	2717	14	
KM23	89	0.00001	0.00517	0.00029	0.08770	548.0	0.6421	0.0088	0.0809	0.0008	0.93	2.28	-0.42	513	18	504	8	501	10	504	8	0.25	501	10	
KM23	90	0.00001	0.00125	0.00006	0.04790	299.0	0.2556	0.0030	0.0365	0.0004	0.91	0.89	-0.08	233	22	231	5	231	5	231	5	0.85	231	5	
KM23	91	0.00000	0.00142	0.00007	0.05490	343.6	0.2592	0.0041	0.0364	0.0005	0.87	14.27	-1.50	269	37	234	7	231	6	231	6	0.04	231	6	
KM23	92	0.00001	0.00416	0.00024	0.06320	395.2	0.7670	0.0075	0.0915	0.0008	0.89	10.68	-2.41	632	20	578	9	564	9	576	9	0.00	564	9	
KM23	93	0.00001	0.00288	0.00014	0.10590	663.0	0.2656	0.0028	0.0377	0.0004	0.91	1.52	-0.14	243	21	239	4	239	4	239	4	0.73	239	4	
KM23	94	0.00001	0.00125	0.00006	0.04000	250.8	0.3096	0.0032	0.0432	0.0004	0.88	3.45	-0.37	283	23	274	5	273	5	273	5	0.41	273	5	
KM23	95	0.00001	0.00232	0.00017	0.01773	111.2	1.8987	0.0203	0.1825	0.0018	0.92	0.01	0.00	1081	17	1081	14	1081	20	1081	13	0.99	1081	20	
KM23	96	0.00001	0.00148	0.00007	0.04408	276.7	0.3338	0.0035	0.0465	0.0004	0.90	-0.92	0.10	290	21	292	5	293	5	293	5	0.81	293	5	
KM23	97	0.00001	0.00748	0.00043	0.10570	664.0	0.8156	0.0074	0.0983	0.0008	0.90	1.09	-0.23	611	18	606	8	604	9	606	8	0.51	604	9	
KM23	98	0.00001	0.00105	0.00005	0.03462	217.6	0.2981	0.0032	0.0417	0.0004	0.88	5.32	-0.57	278	23	265	5	263	5	264	5	0.22	263	5	
KM23	99	0.00001	0.00156	0.00009	0.02522	158.6	0.6858	0.0074	0.0860	0.0009	0.91	-1.60	0.30	523	20	530	9	532	10	530	9	0.46	532	10	
KM23	100	0.00001	0.01130	0.00085	0.09280	584.0	1.8332	0.0248	0.1701	0.0022	0.96	12.02	-4.42	1151	16	1057	18	1013	24	1110	14	0.00	1013	24	
KM23	102	0.00001	0.01979	0.00406	0.05760	364.4	14.0094	0.1532	0.4769	0.0049	0.94	14.17	-9.41	2929	14	2750	21	2514	43	2892	12	0.00	2929	14	
KM23	103	0.00001	0.00614	0.00034	0.10800	684.0	0.6205	0.0083	0.0786	0.0010	0.95	2.71	-0.49	501	18	490	10	488	12	492	10	0.21	488	12	
KM23	104	0.00001	0.00438	0.00024	0.07190	455.5	0.6770	0.0077	0.0850	0.0009	0.93	-0.97	0.18	521	18	525	9								

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM23	106	0.00001	0.00156	0.00012	0.01080	68.5	2.2288	0.0276	0.2036	0.0024	0.93	-1.07	0.38	1182	19	11590	17	11195	25	1186	15	0.42	1195	25
KM23	107	0.00001	0.00278	0.00014	0.10500	667.0	0.2587	0.0034	0.0365	0.0005	0.94	10.48	-1.06	258	21	234	5	231	6	233	5	0.01	231	6
KM23	109	0.00001	0.00084	0.00004	0.02208	140.5	0.3836	0.0042	0.0528	0.0005	0.87	-5.36	0.63	315	25	330	6	332	6	331	6	0.19	332	6
KM23	110	0.00000	0.00163	0.00009	0.02324	148.0	0.8083	0.0094	0.0978	0.0011	0.92	0.00	0.00	602	20	602	11	602	12	602	11	1.00	602	12
KM23	111	0.00001	0.00170	0.00009	0.05040	321.4	0.3336	0.0032	0.0464	0.0004	0.89	0.66	-0.07	294	21	292	5	292	5	292	5	0.86	292	5
KM23	112	0.00001	0.00513	0.00031	0.06390	408.0	0.9661	0.0123	0.1121	0.0014	0.95	0.92	-0.22	691	18	686	13	685	16	688	12	0.59	685	16
KM25	2	0.00002	0.00520	0.00031	0.07166	204.80	0.8835	0.0148	0.1010	0.0012	0.71	-16.57	3.51	723	50	643	16	620	14	626	14	0.00	620	14
KM25	5	0.00002	0.01050	0.00200	0.02776	67.83	15.0826	0.2655	0.5280	0.0070	0.75	-5.51	3.10	2884	38	2820	34	2733	59	2839	33	0.00	2884	38
KM25	6	0.00001	0.00103	0.00008	0.00731	17.75	2.3484	0.0448	0.1969	0.0029	0.77	-16.46	5.58	1349	47	1227	27	1159	31	1210	29	0.00	1349	47
KM25	7	0.00002	0.00171	0.00009	0.03930	95.30	0.4675	0.0085	0.0596	0.0008	0.74	-30.61	4.18	487	54	389	12	373	10	375	10	0.00	373	10
KM25	13	0.00000	0.00104	0.00006	0.01489	38.50	0.8482	0.0152	0.0973	0.0013	0.75	-19.57	4.02	716	51	624	17	599	15	606	15	0.00	599	15
KM25	14	0.00001	0.00121	0.00007	0.01866	49.40	0.7670	0.0165	0.0895	0.0016	0.83	-22.94	4.40	679	52	578	19	553	19	564	19	0.00	553	19
KM25	16	0.00001	0.00431	0.00025	0.05980	167.20	0.8593	0.0156	0.0991	0.0014	0.75	-15.67	3.28	705	51	630	17	609	16	616	16	0.00	609	16
KM25	17	0.00002	0.00674	0.00068	0.03521	102.10	3.9534	0.0666	0.2664	0.0033	0.72	-15.58	6.29	1760	43	1625	27	1523	33	1602	29	0.00	1760	43
KM25	18	0.00003	0.00242	0.00017	0.01869	55.97	1.9237	0.0348	0.1818	0.0025	0.76	-3.51	1.15	1115	47	1089	24	1077	27	1086	24	0.17	1077	27
KM25	19	0.00002	0.00293	0.00017	0.04576	142.10	0.7317	0.0125	0.0884	0.0011	0.73	-10.75	2.06	605	51	558	15	546	13	546	13	0.03	546	13
KM25	20	0.00002	0.00846	0.00229	0.01851	59.20	25.3716	0.5289	0.6410	0.0110	0.82	-6.54	3.90	3402	38	3323	41	3193	86	3370	34	0.00	3402	38
KM25	21	0.00001	0.00114	0.00006	0.01764	59.40	0.7489	0.0162	0.0903	0.0016	0.82	-9.29	1.81	609	54	568	19	557	19	562	18	0.07	557	19
KM25	22	0.00003	0.00206	0.00012	0.02491	87.80	0.9984	0.0177	0.1130	0.0015	0.75	-7.85	1.83	744	50	703	18	690	17	696	17	0.04	690	17
KM25	23	0.00003	0.00104	0.00006	0.01649	60.84	0.7165	0.0118	0.0875	0.0010	0.70	-7.73	1.47	582	51	549	14	540	12	542	12	0.12	540	12
KM25	24	0.00001	0.00036	0.00002	0.01382	53.30	0.2622	0.0053	0.0358	0.0006	0.76	-46.09	4.00	332	60	236	9	227	7	228	7	0.00	227	7
KM25	25	0.00001	0.01138	0.00080	0.10280	419.00	1.5530	0.0271	0.1525	0.0020	0.75	-13.40	3.86	1038	47	952	22	915	22	935	21	0.00	915	22
KM25	26	0.00001	0.00217	0.00012	0.03387	144.80	0.7426	0.0138	0.0900	0.0013	0.78	-7.63	1.49	598	51	564	16	556	15	559	15	0.11	556	15
KM25	27	0.00001	0.00112	0.00006	0.01779	80.10	0.7138	0.0126	0.0874	0.0012	0.74	-6.58	1.25	576	52	547	15	540	14	542	13	0.19	540	14
KM25	28	0.00001	0.00651	0.00039	0.09310	441.00	0.8431	0.0157	0.0980	0.0014	0.77	-14.09	2.92	688	51	621	17	603	16	609	16	0.00	603	16
KM25	29	0.00002	0.00155	0.00009	0.02200	145.50	0.8293	0.0143	0.0989	0.0012	0.70	-4.06	0.86	633	53	613	16	608	14	609	14	0.37	608	14
KM25	30	0.00002	0.00163	0.00008	0.06125	409.80	0.2600	0.0043	0.0370	0.0004	0.69	-0.92	0.08	237	55	235	7	234	5	234	5	0.94	234	5
KM25	32	0.00002	0.01686	0.00355	0.04570	310.80	15.1880	0.3004	0.5090	0.0080	0.79	-11.38	6.18	2954	39	2827	38	2652	68	2881	35	0.00	2954	39
KM25	33	0.00002	0.00182	0.00011	0.02435	166.60	0.8911	0.0164	0.1044	0.0015	0.75	-4.78	1.05	671	52	647	18	640	17	643	16	0.27	640	17
KM25	34	-0.00001	0.00104	0.00006	0.01519	105.20	0.7935	0.0150	0.0942	0.0014	0.76	-10.71	2.16	642	53	593	17	580	16	585	16	0.03	580	16
KM25	35	0.00003	0.001791	0.00046	0.03711	258.10	23.8648	0.4945	0.6700	0.0115	0.83	2.10	-1.32	3237	37	3263	41	3306	89	3247	35	0.15	3237	37
KM25	36	0.00001	0.00756	0.00044	0.10850	757.00	0.8175	0.0164	0.0978	0.0016	0.82	-4.05	0.85	626	50	607	18	602	19	604	18	0.36	602	19
KM25	37	0.00000	0.00484	0.00028	0.07090	496.00	0.7929	0.0145	0.0953	0.0014	0.77	-4.96	1.01	616	50	593	16	587	16	589	15	0.27	587	16
KM25	39	0.00000	0.00278	0.00014	0.08690	610.00	0.3229	0.0059	0.0443	0.0006	0.74	-16.13	1.71	324	56	284	9	279	7	280	7	0.11	279	7
KM25	40	-0.00001	0.01450	0.00152	0.06720	471.00	4.5678	0.0815	0.3031	0.0042	0.77	-4.75	2.11	1788	42	1743	30	1707	41	1746	30	0.01	1788	42
KM25	41	-0.00001	0.00056	0.00003	0.01787	125.20	0.3179	0.0059	0.0437	0.0006	0.74	-15.09	1.58	317	56	280	9	276	7	276	7	0.15	276	7
KM25	42	-0.00002	0.00580	0.00035	0.08370	586.00	0.8467	0.0161	0.0990	0.0015	0.77	-10.96	2.30	675	52	623	18	609	17	614	17	0.02	609	17
KM25	44	-0.00001	0.01475	0.00156	0.06660	464.00	4.7996	0.1338	0.3170	0.0080	0.91	-1.19	0.55	1796	43	1785	47	1775	78	1791	38	0.64	1796	43
KM25	45	0.00000	0.00731	0.00049	0.06730	467.00	1.4506	0.0332	0.1493	0.0029	0.85	-5.02	1.44	942	50	910	28	897	33	910	28	0.13	897	33
KM25	46	0.00004	0.02045	0.00159	0.14070	972.00	2.2987	0.0670	0.2063	0.0055	0.92	-0.65	0.23	1217	47	1212	41	1209	59	1214	37	0.83	1217	47
KM25	47	0.00002	0.00314	0.00023	0.02380	163.70	1.9126	0.0370	0.1832	0.0028	0.79	-0.29	0.10	1088	48	1085	26	1084	31	1085	26	0.91	1084	31
KM25	48	0.00002	0.00296	0.00021	0.02430	166.00	1.7475	0.0370	0.1690	0.0030	0.82	-6.14	1.92	1068	48	1026	27	1007	33	1025	28	0.03	1007	33
KM25	49	0.00002	0.00284	0.00016	0.04460	304.00	0.7589	0.0165	0.0931	0.0017	0.84	0.38	-0.08	572	52	573	19	574	20	574	19	0.94	574	20
KM25	50	0.00001	0.00661	0.00045	0.06480	438.00	1.3754	0.0331	0.1418	0.0030	0.86	-9.79	2.69	939	50	878	28	855	33	879	29	0.00	855	33
KM25	51	0.00001	0.00107	0.00005	0.03639	244.20	0.2993	0.0063	0.0416	0.0007	0.80	-11.57	1.16	293	57	266	10	263	9	263	9	0.29	263	9
KM25	52	0.00000	0.00233	0.00012	0.08900	593.00	0.2660	0.0056	0.0369	0.0007	0.84	-27.56	2.47	298	53	240	9	234	8	235	8	0.02</		

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages										Preferred	
		Pb204_V	Pb206_V	Pb207_V	U238_V	U235_V	U_ppm	Pb207/235	± 1s	Pb206/238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	208Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM25	55	0.00000	0.00458	0.00023	0.17850	1160.00	0.2535	0.0061	0.0356	0.0008	0.88	-19.45	1.69	269	53	229	10	226	9	227	9	0.11	226	9	
KM25	56	0.00000	0.00510	0.001240	79.80	23.9161	0.5788	0.6130	0.0130	0.0033	0.88	-9.65	5.60	3379	37	3265	47	3082	104	3348	33	0.00	3379	37	
KM25	57	0.00000	0.00052	0.00004	0.00440	28.10	1.7050	0.0397	0.1672	0.0033	0.83	-4.38	1.36	1040	52	1010	30	997	36	1010	30	0.17	997	36	
KM25	1	0.00002	0.00153	0.00008	0.03293	184.10	0.4616	0.0129	0.0617	0.0017	0.98	1.00	-0.14	382	24	385	18	386	21	384	15	0.81	386	21	
KM25	2	0.00002	0.00083	0.00006	0.00538	30.08	2.2942	0.0724	0.2090	0.0065	0.99	2.95	-1.07	1187	21	1211	45	1223	69	1191	21	0.32	1187	21	
KM25	3	0.00002	0.00225	0.00017	0.01477	82.60	2.2335	0.0608	0.2048	0.0055	0.99	2.21	-0.79	1174	19	1192	38	1201	59	1177	18	0.39	1201	59	
KM25	4	0.00002	0.01155	0.00077	0.09900	554.00	1.4966	0.0427	0.1560	0.0044	0.99	1.99	-0.59	916	18	929	35	935	49	918	17	0.48	935	49	
KM25	6	0.00002	0.00485	0.00027	0.07990	447.00	0.6495	0.0174	0.0812	0.0022	0.99	-5.37	0.96	530	20	508	21	503	26	520	16	0.09	503	26	
KM25	7	0.00002	0.00222	0.00012	0.03830	214.40	0.6248	0.0160	0.0777	0.0020	0.98	-12.35	2.13	542	21	493	20	482	23	515	16	0.00	482	23	
KM25	8	0.00001	0.00095	0.00005	0.01482	83.00	0.6987	0.0208	0.0857	0.0025	0.98	-7.92	1.48	572	26	538	25	530	30	554	20	0.03	530	30	
KM25	9	0.00001	0.00335	0.00019	0.04380	245.50	0.8668	0.0232	0.1041	0.0028	0.98	3.24	-0.72	618	21	634	25	638	32	624	17	0.28	638	32	
KM25	10	0.00001	0.00880	0.00060	0.07070	396.50	1.6330	0.0444	0.1656	0.0045	0.99	1.58	-0.49	972	18	983	34	988	49	974	17	0.55	988	49	
KM25	11	0.00001	0.01828	0.00221	0.06690	375.00	6.1698	0.1920	0.3570	0.0110	0.99	-3.34	1.61	2034	17	2000	54	1968	105	2032	16	0.21	2034	17	
KM25	12	0.00001	0.00685	0.00072	0.02820	157.90	4.8263	0.1287	0.3230	0.0085	0.99	1.78	-0.83	1772	17	1789	45	1804	83	1774	17	0.45	1772	17	
KM25	13	0.00001	0.00257	0.00014	0.03730	209.30	0.7291	0.0192	0.0906	0.0024	0.98	2.80	-0.55	543	21	556	23	559	28	549	17	0.37	559	28	
KM25	14	0.00001	0.00514	0.00026	0.13300	745.00	0.3831	0.0098	0.0518	0.0013	0.98	-9.41	1.15	356	21	329	14	326	16	337	13	0.02	326	16	
KM25	15	0.00002	0.00264	0.00015	0.04038	226.70	0.6945	0.0170	0.0872	0.0021	0.98	3.36	-0.64	521	21	536	20	539	25	528	16	0.27	539	25	
KM25	16	0.00001	0.00904	0.00051	0.14360	807.00	0.6741	0.0150	0.0827	0.0018	0.98	-11.53	2.09	571	20	523	18	512	21	544	15	0.00	512	21	
KM25	17	0.00001	0.00858	0.00060	0.07580	426.00	1.4962	0.0422	0.1507	0.0042	0.99	-8.98	2.58	986	18	929	34	905	47	976	16	0.00	905	47	
KM25	18	0.00001	0.00119	0.00006	0.03628	203.90	0.3138	0.0085	0.0436	0.0012	0.98	-6.88	0.72	294	26	277	13	275	14	279	13	0.20	275	14	
KM25	19	0.00001	0.01463	0.00092	0.17090	961.00	1.0126	0.0225	0.1129	0.0025	0.98	-12.53	2.90	776	21	710	23	690	28	747	17	0.00	690	28	
KM25	21	0.00002	0.00097	0.00005	0.03196	184.10	0.2813	0.0066	0.0398	0.0009	0.97	-0.50	0.05	253	28	252	10	252	11	252	10	0.93	252	11	
KM25	22	0.00002	0.01061	0.00062	0.17530	1011.00	0.6733	0.0145	0.0808	0.0017	0.98	-23.60	4.17	619	19	523	18	501	20	566	15	0.00	501	20	
KM25	24	0.00001	0.01732	0.00117	0.16690	965.00	1.3500	0.0345	0.1390	0.0035	0.99	-12.18	3.29	941	18	868	30	839	40	925	16	0.00	839	40	
KM25	25	0.00001	0.00249	0.00014	0.04170	241.00	0.6431	0.0164	0.0801	0.0020	0.98	-8.43	1.49	539	22	504	20	497	24	519	17	0.01	497	24	
KM25	26	0.00001	0.00493	0.00029	0.06250	362.50	0.8974	0.0195	0.1061	0.0023	0.98	-0.19	0.04	651	20	650	21	650	26	651	16	0.94	650	26	
KM25	27	0.00001	0.00251	0.00020	0.01565	90.90	2.3951	0.0487	0.2145	0.0043	0.97	2.53	-0.94	1221	19	1241	29	1253	45	1226	17	0.20	1221	19	
KM25	28	0.00001	0.00296	0.00017	0.04070	236.70	0.7937	0.0169	0.0964	0.0020	0.98	0.01	0.00	593	20	593	19	593	24	593	15	1.00	593	24	
KM25	29	0.00002	0.01345	0.00096	0.10370	604.00	1.7767	0.0401	0.1740	0.0039	0.98	-0.86	0.28	1043	18	1037	29	1034	42	1042	17	0.70	1034	42	
KM25	30	0.00001	0.00083	0.00004	0.02927	170.70	0.2604	0.0062	0.0369	0.0009	0.97	-5.88	0.53	247	26	235	10	234	11	236	10	0.33	234	11	
KM25	31	0.00001	0.00184	0.00014	0.01189	69.50	2.2373	0.0492	0.2050	0.0044	0.98	2.17	-0.78	1176	19	1193	31	1202	47	1180	18	0.31	1202	47	
KM25	32	0.00001	0.00143	0.00011	0.00883	51.65	2.4088	0.0542	0.2138	0.0047	0.98	0.83	-0.31	1239	20	1245	32	1249	50	1240	18	0.70	1239	20	
KM25	33	0.00001	0.00793	0.00062	0.05160	302.20	2.2561	0.0517	0.2000	0.0045	0.98	-5.59	1.95	1241	18	1199	32	1175	48	1234	16	0.01	1241	18	
KM25	34	0.00001	0.00105	0.00008	0.00702	41.20	2.2163	0.0584	0.1978	0.0050	0.96	-5.53	1.91	1228	29	1186	37	1163	54	1214	26	0.03	1163	54	
KM25	35	0.00001	0.00285	0.00020	0.02123	124.80	1.8295	0.0444	0.1784	0.0043	0.98	0.62	-0.20	1052	19	1056	32	1058	47	1053	17	0.80	1058	47	
KM25	36	0.00001	0.01605	0.00110	0.13710	807.00	1.5233	0.0331	0.1550	0.0033	0.98	-3.93	1.16	965	18	940	27	929	37	958	16	0.07	929	37	
KM25	37	0.00001	0.00112	0.00005	0.04035	237.90	0.2580	0.0058	0.0370	0.0008	0.97	4.11	-0.37	224	25	233	9	234	10	233	9	0.48	234	10	
KM25	38	0.00001	0.00202	0.00010	0.07790	430.00	0.2573	0.0057	0.0367	0.0008	0.98	-0.03	0.00	233	23	232	9	232	10	232	9	0.99	232	10	
KM25	39	0.00002	0.00674	0.00046	0.06340	374.90	1.3746	0.0312	0.1418	0.0032	0.98	-9.66	2.65	937	20	878	27	855	36	919	17	0.00	855	36	
KM25	40	0.00001	0.00040	0.00003	0.00258	15.28	2.2578	0.0534	0.2075	0.0048	0.97	3.74	-1.36	1170	24	1199	33	1215	51	1179	22	0.11	1215	51	
KM25	41	0.00002	0.00249	0.00015	0.03189	196.70	0.8899	0.0208	0.1047	0.0024	0.98	-3.09	0.68	662	21	646	22	642	28	655	17	0.25	642	28	
KM25	43	0.00001	0.00158	0.00014	0.00851	52.60	3.0996	0.0760	0.2494	0.0060	0.98	0.48	-0.19	1428	19	1433	38	1435	62	1429	18	0.83	1428	19	
KM25	44	0.00001	0.00224	0.00011	0.08670	537.00	0.2478	0.0058	0.0350	0.0008	0.98	-14.49	1.24	254	24	225	9	222	10	226	10	0.01	222	10	

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM25	50	0.00001	0.00203	0.00010	0.07070	440.50	0.2674	0.0062	0.0378	0.0009	0.98	-6.28	0.58	254	24	241	10	239	11	242	10	0.25	239	11
KM25	51	0.00001	0.00167	0.00008	0.05860	365.00	0.2732	0.0060	0.0382	0.0008	0.95	-15.67	1.46	280	31	245	10	242	10	245	10	0.02	242	10
KM25	52	0.00001	0.00286	0.00022	0.01958	122.30	2.1021	0.0457	0.1951	0.0042	0.98	-0.14	0.05	1151	19	1150	30	1149	45	1150	17	0.95	1149	45
KM25	54	0.00001	0.00559	0.00029	0.12220	767.00	0.4624	0.0111	0.0612	0.0015	0.98	-5.47	0.77	404	21	386	15	383	18	392	14	0.12	383	18
KM25	55	0.00001	0.00145	0.00007	0.05410	339.70	0.2527	0.0057	0.0361	0.0008	0.98	-0.92	0.08	231	24	229	9	229	9	229	9	0.87	229	10
KM25	56	0.00001	0.00171	0.00010	0.02692	169.20	0.6732	0.0160	0.0841	0.0020	0.98	-2.16	0.40	532	22	523	19	521	23	526	16	0.48	521	23
KM25	57	0.00001	0.00144	0.00007	0.05020	316.00	0.2679	0.0062	0.0378	0.0009	0.97	-8.15	0.75	259	25	241	10	239	11	242	10	0.15	239	11
KM25	58	0.00001	0.00590	0.00043	0.04250	267.90	1.9615	0.0429	0.1869	0.0040	0.98	0.58	-0.20	1098	18	1102	29	1105	43	1099	17	0.79	1105	43
KM25	59	0.00001	0.00206	0.00011	0.03242	204.40	0.6726	0.0163	0.0843	0.0020	0.98	-0.55	0.10	525	22	522	20	522	24	523	16	0.86	522	24
KM25	60	0.00002	0.00162	0.00008	0.06600	540.00	0.2271	0.0053	0.0332	0.0008	0.97	16.82	-1.39	175	25	208	9	211	9	206	8	0.01	211	9
KM32	1	0.00006	0.00142	0.00007	0.05200	186.70	0.2788	0.0030	0.0388	0.0004	0.94	14.81	-1.67	288	17	250	5	246	5	248	5	0.00	246	5
KM32	2	0.00005	0.00323	0.00025	0.02117	76.10	2.3566	0.0228	0.2116	0.0020	0.95	-1.76	0.63	1216	13	1230	14	1237	21	1222	11	0.08	1216	13
KM32	4	0.00005	0.00366	0.00018	0.13050	469.00	0.2783	0.0036	0.0390	0.0005	0.97	9.73	-1.03	273	15	249	6	247	6	250	6	0.00	247	6
KM32	5	0.00006	0.01402	0.00081	0.21130	761.00	0.7492	0.0073	0.0912	0.0009	0.96	4.39	-0.92	588	13	568	8	563	10	573	8	0.00	563	10
KM32	7	0.00005	0.00203	0.00010	0.06060	218.20	0.3400	0.0042	0.0469	0.0006	0.95	4.40	-0.52	309	18	297	6	296	7	297	6	0.16	296	7
KM32	8	0.00005	0.01415	0.00136	0.07050	254.00	3.8039	0.0400	0.2803	0.0029	0.97	0.10	-0.04	1595	11	1594	17	1593	29	1594	10	0.92	1595	11
KM32	9	0.00005	0.00477	0.00029	0.05990	215.90	0.9874	0.0158	0.1127	0.0018	0.97	5.23	-1.30	726	17	697	16	688	20	711	13	0.00	688	20
KM32	11	0.00005	0.00308	0.00016	0.10700	386.30	0.2852	0.0045	0.0393	0.0006	0.98	20.54	-2.52	313	16	255	7	248	7	259	7	0.00	248	7
KM32	12	0.00005	0.00533	0.00037	0.04690	169.40	1.5840	0.0235	0.1582	0.0023	0.98	5.63	-1.81	1003	12	964	18	947	26	993	11	0.00	947	26
KM32	13	0.00005	0.01011	0.00088	0.06000	216.80	2.8778	0.0428	0.2324	0.0034	0.98	5.24	-2.16	1421	12	1376	22	1347	36	1415	11	0.00	1421	12
KM32	14	0.00005	0.00116	0.00007	0.01672	60.50	0.8001	0.0112	0.0978	0.0013	0.95	-3.82	0.77	579	20	597	13	602	15	593	12	0.08	602	15
KM32	15	0.00005	0.01021	0.00051	0.40030	1448.00	0.2511	0.0039	0.0356	0.0006	0.98	10.46	-1.03	252	13	228	6	225	7	230	6	0.00	225	7
KM32	16	0.00005	0.00152	0.00008	0.04910	177.60	0.3162	0.0046	0.0429	0.0006	0.96	21.90	-2.97	347	19	279	7	271	7	279	7	0.00	271	7
KM32	18	0.00005	0.00818	0.00045	0.15420	559.00	0.5753	0.0106	0.0738	0.0014	0.99	3.04	-0.52	473	13	461	14	459	16	468	10	0.17	459	16
KM32	19	0.00005	0.00605	0.00035	0.09340	338.70	0.7449	0.0133	0.0909	0.0016	0.99	3.80	-0.78	583	13	565	15	561	19	576	11	0.05	561	19
KM32	20	0.00005	0.00747	0.00044	0.10350	375.70	0.8329	0.0123	0.0997	0.0015	0.98	1.95	-0.42	625	13	615	14	613	17	620	10	0.26	613	17
KM32	21	0.00004	0.00090	0.00005	0.01267	46.30	0.8068	0.0081	0.0980	0.0009	0.91	-1.43	0.30	594	18	601	9	602	11	600	9	0.42	602	11
KM32	22	0.00004	0.00258	0.00013	0.08310	304.20	0.3068	0.0028	0.0430	0.0004	0.93	1.03	-0.11	274	16	272	4	271	5	272	4	0.74	271	5
KM32	23	0.00004	0.00664	0.00051	0.04560	167.20	2.2296	0.0250	0.2026	0.0022	0.97	0.26	-0.09	1192	12	1190	16	1189	24	1192	11	0.81	1189	24
KM32	24	0.00004	0.00376	0.00018	0.14380	527.00	0.2526	0.0043	0.0361	0.0006	0.98	0.52	-0.05	230	15	229	7	229	7	229	7	0.89	229	7
KM32	26	0.00004	0.01534	0.00111	0.11990	440.00	1.8391	0.0274	0.1771	0.0026	0.98	2.40	-0.80	1077	12	1060	20	1051	29	1073	11	0.09	1051	29
KM32	27	0.00004	0.01527	0.00158	0.06830	250.60	4.5530	0.0699	0.3074	0.0047	0.99	1.61	-0.74	1756	11	1741	26	1728	46	1755	11	0.23	1756	11
KM32	28	0.00004	0.00081	0.00006	0.06617	22.65	1.9171	0.0293	0.1849	0.0027	0.96	-1.86	0.61	1074	19	1087	20	1094	29	1080	16	0.25	1094	29
KM32	29	0.00004	0.00076	0.00004	0.01073	39.50	0.8245	0.0159	0.0988	0.0019	0.97	2.40	-0.52	622	20	611	18	607	22	615	15	0.31	607	22
KM32	31	0.00003	0.00458	0.00023	0.18260	672.00	0.2461	0.0039	0.0350	0.0006	0.98	7.69	-0.72	240	15	223	6	222	7	225	6	0.03	222	7
KM32	32	0.00003	0.00674	0.00049	0.05280	194.50	1.8725	0.0326	0.1802	0.0031	0.99	0.95	-0.31	1078	12	1071	23	1068	34	1077	11	0.57	1068	34
KM32	33	0.00003	0.00342	0.00017	0.10650	392.50	0.3236	0.0055	0.0446	0.0008	0.98	10.05	-1.21	313	15	285	9	281	9	290	8	0.00	281	9
KM32	34	0.00003	0.00561	0.00028	0.20640	761.00	0.2705	0.0044	0.0379	0.0006	0.98	12.70	-1.36	275	14	243	7	240	7	247	7	0.00	240	7
KM32	35	0.00004	0.00253	0.00013	0.07480	276.00	0.3413	0.0062	0.0474	0.0009	0.98	-1.23	0.14	295	16	298	9	299	10	297	9	0.70	299	10
KM32	36	0.00004	0.00153	0.00007	0.05970	220.50	0.2536	0.0046	0.0363	0.0007	0.98	-1.83	0.16	226	17	229	8	230	8	229	7	0.67	230	8
KM32	37	0.00004	0.00222	0.00013	0.03352	123.90	0.7485	0.0121	0.0921	0.0015	0.98	-0.52	0.10	565	15	567	14	568	17	566	11	0.80	568	17
KM32	38	0.00004	0.00511	0.00030	0.07390	273.20	0.8058	0.0146	0.0978	0.0018	0.99	-1.15	0.24	595	13	600	16	602	21	597	11	0.58	602	21
KM32	39	0.00004	0.00446	0.00027	0.05490	203.20	0.9712	0.0150	0.1123	0.0017	0.98	1.82	-0.43	699	13	689	15	686	20	695	11	0.28	686	20
KM32	40	0.00004	0.00723	0.00041	0.12420	460.00	0.6305	0.0139	0.0789	0.0017	0.98	7.29	-1.40	528	19	496	17	490	20	510	14	0.01	490	20
KM32	41	0.00004	0.00408	0.00024	0.05910	220.90	0.7995	0.0136	0.0956	0.0016	0.98	6.12	-1.35	627	14	597	15	589	19	614	11	0.00	589	19
KM32	42	0.00004	0.00454	0.00045	0.02580	96.40	3.4884	0.0717	0.2468	0.0050	0.99	14.86	-1.72	1670	14	1525	32	1422	52	1656	12	0.00	1670	14
KM32	44	0.00003	0.00357	0.00018	0.12140	454.00	0.2888	0.0040	0.0407	0.0006	0.97	1.38	-0.14	261	15	258	6	257	7	258	6	0.66	257	7

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM32	45	0.00003	0.00335	0.00019	0.05016	187.70	0.7756	0.0154	0.0945	0.0019	0.99	0.71	-0.15	586	15	583	18	582	22	585	12	0.75	582	22
KM32	47	0.00003	0.00056	0.00003	0.02160	81.00	0.2546	0.0042	0.0361	0.0006	0.93	7.62	-0.73	247	28	230	7	229	7	230	7	0.20	229	7
KM32	48	0.00003	0.00084	0.00005	0.01382	51.80	0.6861	0.0113	0.0839	0.0013	0.94	10.24	-2.14	579	24	530	14	519	15	536	14	0.00	519	15
KM32	49	0.00003	0.00956	0.00069	0.07780	291.80	1.7426	0.0323	0.1689	0.0031	0.99	5.43	-1.83	1064	12	1024	24	1006	34	1058	11	0.00	1006	34
KM32	51	0.00003	0.00485	0.00044	0.02608	97.90	3.3480	0.0415	0.2606	0.0032	0.97	-0.09	0.04	1492	12	1492	20	1493	32	1492	11	0.94	1492	12
KM32	52	0.00003	0.00253	0.00014	0.03854	144.80	0.7401	0.0116	0.0913	0.0014	0.98	-0.67	0.13	559	15	562	14	563	17	561	11	0.74	563	17
KM32	54	0.00003	0.00586	0.00043	0.04627	174.10	1.8554	0.0344	0.1773	0.0033	0.99	3.67	-1.25	1092	12	1065	25	1052	36	1088	11	0.03	1052	36
KM32	56	0.00003	0.01153	0.00067	0.17000	640.00	0.7862	0.0085	0.0952	0.0010	0.97	2.25	-0.47	600	12	589	10	586	12	593	9	0.12	586	12
KM32	57	0.00003	0.00376	0.00028	0.02677	100.90	2.1096	0.0297	0.1963	0.0027	0.98	-0.87	0.30	1145	13	1152	19	1155	29	1147	12	0.54	1155	29
KM32	59	0.00003	0.00456	0.00044	0.02272	85.70	3.7320	0.0756	0.2750	0.0055	0.99	1.78	-0.77	1595	13	1578	33	1566	56	1593	13	0.32	1593	13
KM32	60	0.00003	0.00072	0.00004	0.02826	106.70	0.2505	0.0044	0.0359	0.0006	0.96	-1.76	0.15	223	23	227	7	227	7	227	7	0.75	227	7
KM32	1	0.00001	0.00217	0.00011	0.05600	276.20	0.4027	0.0119	0.0535	0.0015	0.92	-17.65	2.21	395	54	344	17	336	18	341	17	0.04	336	18
KM32	4	0.00001	0.00856	0.00049	0.13770	636.00	0.7289	0.0170	0.0857	0.0018	0.87	-25.10	4.65	663	49	556	20	530	21	546	21	0.00	530	21
KM32	5	0.00001	0.00354	0.00018	0.10610	481.00	0.3539	0.0107	0.0467	0.0013	0.92	-39.62	4.37	411	53	308	16	294	16	300	16	0.00	294	16
KM32	7	0.00000	0.00228	0.00012	0.07020	307.00	0.3412	0.0110	0.0450	0.0014	0.93	-45.07	4.80	412	53	298	17	284	17	290	17	0.00	284	17
KM32	8	0.00000	0.00679	0.00041	0.09150	393.00	0.9050	0.0262	0.1016	0.0027	0.92	-22.06	4.68	761	49	654	28	624	32	659	30	0.00	624	32
KM32	11	0.00001	0.00342	0.00019	0.05370	221.00	0.7367	0.0240	0.0870	0.0027	0.94	-21.56	4.05	654	49	560	28	538	31	568	29	0.00	538	31
KM32	12	0.00003	0.00334	0.00019	0.04510	182.50	0.8966	0.0246	0.1032	0.0026	0.90	-11.92	2.58	709	51	650	26	633	30	651	27	0.01	633	30
KM32	14	-0.00002	0.00259	0.00027	0.01069	37.10	5.6229	0.1185	0.3432	0.0060	0.83	-1.92	0.92	1939	43	1920	36	1902	58	1926	34	0.30	1939	43
KM32	18	-0.00003	0.01706	0.00322	0.04780	164.20	14.7554	0.4722	0.5040	0.0150	0.93	-11.12	6.02	2923	39	2800	61	2631	129	2902	34	0.00	2923	39
KM32	20	-0.00001	0.00412	0.00040	0.02272	77.70	3.7964	0.0949	0.2494	0.0055	0.88	-25.82	9.84	1806	43	1592	40	1435	57	1676	38	0.00	1806	43
KM32	22	-0.00001	0.00039	0.00004	0.00211	7.20	3.6238	0.1121	0.2490	0.0065	0.84	-20.28	7.81	1724	61	1555	49	1433	67	1589	51	0.00	1724	61
KM32	29	0.00000	0.00734	0.00053	0.06890	460.00	1.4789	0.0293	0.1468	0.0024	0.81	-15.04	4.21	1016	47	922	24	883	26	911	25	0.00	883	26
KM32	30	0.00000	0.00073	0.00004	0.00992	70.20	0.8231	0.0167	0.1005	0.0016	0.78	5.74	-1.24	582	55	610	19	613	18	617	19	0.22	617	19
KM32	31	0.00000	0.00134	0.00007	0.04150	313.00	0.3091	0.0064	0.0438	0.0008	0.83	9.80	-1.04	249	54	274	10	276	9	275	9	0.32	276	9
KM32	32	0.00000	0.00126	0.00006	0.04810	389.00	0.2526	0.0054	0.0366	0.0007	0.83	14.90	-1.34	197	56	229	9	232	8	231	8	0.22	232	8
KM32	34	0.00000	0.00144	0.00011	0.00975	92.50	2.1225	0.0442	0.2005	0.0035	0.83	5.32	-1.89	1115	47	1156	29	1178	37	1154	28	0.04	1178	37
KM32	36	0.00000	0.00086	0.00004	0.03200	368.00	0.2470	0.0063	0.0359	0.0008	0.88	16.34	-1.45	190	56	224	10	227	10	226	10	0.19	227	10
KM32	38	-0.00001	0.00058	0.00003	0.00845	119.90	0.7866	0.0208	0.0976	0.0023	0.89	8.92	-1.88	547	53	589	24	600	27	588	23	0.07	600	27
KM32	39	-0.00001	0.00121	0.00009	0.00823	131.60	2.1747	0.0581	0.2039	0.0049	0.90	5.51	-1.98	1130	47	1173	37	1196	52	1159	34	0.06	1196	52
KM32	40	-0.00002	0.00626	0.00188	0.01240	222.40	28.1521	0.7398	0.6790	0.0160	0.90	-3.99	2.45	3474	37	3424	52	3341	123	3463	34	0.04	3474	37
KM32	41	-0.00002	0.01366	0.00249	0.03620	735.00	12.8251	0.3132	0.5110	0.0110	0.88	-0.40	0.22	2671	39	2667	46	2661	94	2670	36	0.84	2671	39
KM32	42	-0.00002	0.00183	0.00011	0.02429	556.00	0.8536	0.0214	0.1039	0.0023	0.88	7.65	-1.69	588	51	627	23	637	27	626	23	0.09	637	27
KM32	43	-0.00002	0.00113	0.00009	0.00783	200.80	2.1308	0.0524	0.2010	0.0044	0.88	5.29	-1.89	1118	47	1159	34	1181	47	1150	32	0.06	1181	47
KM32	44	-0.00003	0.00192	0.00013	0.01726	489.00	1.4730	0.0353	0.1553	0.0033	0.87	4.10	-1.22	892	48	919	29	931	36	917	28	0.21	931	36
KM32	45	-0.00003	0.00212	0.00011	0.04440	1359.00	0.4816	0.0106	0.0654	0.0012	0.83	15.25	-2.31	346	55	399	15	408	15	404	14	0.03	408	15
KM32	46	-0.00003	0.00192	0.00015	0.01318	422.00	2.2046	0.0554	0.2044	0.0045	0.88	3.86	-1.39	1153	48	1182	35	1199	48	1176	34	0.18	1199	48
KM32	47	-0.00003	0.00088	0.00005	0.01483	478.00	0.6398	0.0132	0.0810	0.0014	0.81	-0.08	0.01	502	54	502	16	502	16	502	15	0.99	502	16
KM32	48	-0.00003	0.00179	0.00013	0.01454	451.00	1.7339	0.0433	0.1722	0.0038	0.88	0.93	-0.30	1015	47	1021	32	1024	42	1020	31	0.76	1024	42
KM32	49	-0.00001	0.00548	0.00031	0.09040	2591.00	0.6467	0.0165	0.0833	0.0019	0.89	9.96	-1.85	464	51	506	20	516	23	507	20	0.07	516	23
KM32	50	-0.00001	0.00160	0.00009	0.02584	659.00	0.6934	0.0192	0.0864	0.0022	0.90	-0.60	0.11	537	53	535	23	534	26	535	23	0.91	534	26
KM32	51	-0.00002	0.00374	0.00019	0.13820	3060.00	0.2573	0.0060	0.0372	0.0008	0.86	13.89	-1.27	203	56	233	10	235	9	234	9	0.24	235	9
KM32	52	-0.00002	0.00146	0.00012	0.01014	191.80	2.2646	0.0758	0.2080	0.0065	0.93	3.85	-1.40	1171	48	1201	47	1218	69	1187	39	0.27	1218	69
KM32	53	-0.00001	0.00107	0.00006	0.04000	645.00	0.2665	0.0091	0.0377	0.0012	0.93	-5.99	0.55	253	58	240	15	239	15	239	15	0.64	239	15
KM32	54	0.00002	0.00137	0.00007	0.05330	380.00	0.2581	0.0067	0.0365	0.0009	0.89	-9.80	0.87	254	54	233	11	231	11	232	10	0.41	231	11
KM32	55	0.00001	0.00212	0.00011	0.08170	585.00	0.2537	0.0055	0.0353	0.0007	0.85	-30.11	2.59	291	53	230	9	224	8					

Sample	Spot	Normal (Wetherill concordia plot)										Discordance			Ages					Preferred				
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM32	58	0.00001	0.00106	0.00007	0.00991	69.90	1.5220	0.0507	0.1543	0.0048	0.93	-5.17	1.52	973	49	939	41	925	54	951	37	0.18	925	54
KM32	59	0.00000	0.00357	0.00038	0.01554	108.30	4.8005	0.1270	0.3170	0.0075	0.89	-1.21	0.56	1797	43	1785	45	1775	73	1791	37	0.61	1797	43
KM32	60	0.00002	0.00632	0.00037	0.08560	588.00	0.8721	0.0210	0.1036	0.0022	0.88	-0.88	0.19	641	50	637	23	635	26	637	23	0.84	635	26
KM32	61	0.00001	0.00181	0.00009	0.07260	490.00	0.2489	0.0067	0.0350	0.0009	0.90	-20.26	1.74	267	54	226	11	222	11	223	11	0.10	222	11
KM32	62	0.00000	0.00053	0.00003	0.01690	111.60	0.3219	0.0102	0.0433	0.0013	0.91	-34.50	3.56	368	59	283	16	277	16	277	16	0.00	273	15
KM32	63	0.00000	0.00090	0.00004	0.03560	231.30	0.2509	0.0081	0.0353	0.0011	0.92	-18.66	1.61	265	58	227	13	224	13	225	13	0.16	224	13
KM32	64	0.00003	0.00707	0.00074	0.03060	194.80	4.9944	0.1884	0.3340	0.0120	0.95	4.53	-2.17	1774	42	1818	64	1858	116	1784	41	0.18	1774	42
KM32	65	0.00002	0.00029	0.00001	0.00957	59.80	0.3105	0.0107	0.0426	0.0014	0.92	-20.13	2.06	323	60	275	17	269	17	272	17	0.08	269	17
KM32	66	0.00002	0.01373	0.00107	0.09230	566.00	2.3529	0.0618	0.2108	0.0050	0.89	1.03	-0.38	1220	46	1228	37	1233	53	1226	35	0.72	1220	46
KM32	67	0.00003	0.01738	0.00337	0.04760	287.00	14.6246	0.6775	0.5240	0.0235	0.97	-4.77	2.69	2846	38	2791	88	2716	199	2841	36	0.20	2846	38
KM32	68	0.00003	0.00229	0.00012	0.06910	399.00	0.3644	0.0131	0.0488	0.0017	0.94	-22.91	2.64	378	54	315	19	307	20	314	20	0.01	307	20
KM32	69	0.00004	0.00231	0.00017	0.01529	87.30	2.2210	0.0509	0.2054	0.0040	0.85	3.87	-1.40	1158	48	1188	32	1204	43	1184	31	0.15	1204	43
KM32	70	0.00004	0.00951	0.00073	0.06270	353.00	2.3136	0.0434	0.2109	0.0031	0.77	3.84	-1.41	1186	47	1216	27	1234	33	1218	26	0.10	1186	47
KM32	71	0.00004	0.00161	0.00008	0.05990	333.00	0.2627	0.0058	0.0378	0.0007	0.84	10.80	-1.00	213	55	237	9	239	9	238	9	0.35	239	9
KM32	72	0.00003	0.00102	0.00007	0.00789	43.10	1.8758	0.0444	0.1816	0.0037	0.86	0.88	-0.29	1066	49	1073	31	1076	40	1072	31	0.77	1076	40
KM34	1	0.00001	0.00014	0.00001	0.01320	96.00	0.1000	0.0017	0.0150	0.0002	0.81	-25.95	1.00	121	47	97	3	96	3	96	3	0.29	96	3
KM34	2	0.00001	0.00008	0.00000	0.00861	62.67	0.0905	0.0018	0.0135	0.0002	0.69	-59.27	2.05	137	68	88	3	86	2	86	2	0.14	86	2
KM34	3	0.00001	0.00555	0.00032	0.09770	711.00	0.6577	0.0097	0.0797	0.0011	0.94	-21.13	3.70	599	23	513	12	494	13	517	12	0.00	494	13
KM34	4	0.00000	0.00018	0.00001	0.01576	114.80	0.1014	0.0017	0.0155	0.0002	0.81	34.27	-1.38	65	46	98	3	99	3	99	3	0.14	99	3
KM34	5	0.00000	0.00025	0.00001	0.02740	199.70	0.0852	0.0014	0.0128	0.0002	0.87	-42.12	1.39	116	39	83	3	82	2	82	2	0.08	82	2
KM34	7	0.00000	0.00034	0.00002	0.03530	257.60	0.0883	0.0014	0.0134	0.0002	0.87	3.73	-0.13	83	38	86	3	86	2	86	2	0.86	86	2
KM34	8	0.00000	0.00125	0.00006	0.11780	861.00	0.0974	0.0014	0.0146	0.0002	0.94	-34.84	1.30	126	23	94	3	93	2	93	2	0.01	93	2
KM34	9	0.00000	0.00232	0.00018	0.01609	117.80	2.2180	0.0317	0.2012	0.0028	0.96	-1.19	0.42	1196	17	1187	20	1182	30	1192	15	0.41	1182	30
KM34	10	0.00000	0.00047	0.00002	0.04003	293.50	0.1080	0.0017	0.0162	0.0002	0.89	-18.23	0.76	122	34	104	3	103	3	103	3	0.27	103	3
KM34	12	0.00000	0.00020	0.00001	0.01878	138.10	0.0980	0.0017	0.0148	0.0002	0.81	-9.04	0.34	103	48	95	3	95	3	95	3	0.72	95	3
KM34	13	0.00000	0.00006	0.00000	0.00446	32.87	0.1135	0.0028	0.0174	0.0002	0.58	38.46	-1.72	68	95	109	5	111	3	111	3	0.37	111	3
KM34	14	0.00000	0.00029	0.00001	0.02514	185.80	0.1094	0.0017	0.0162	0.0002	0.88	-37.73	1.57	143	36	105	3	104	3	104	3	0.03	104	3
KM34	15	0.00000	0.00014	0.00001	0.01188	88.10	0.1140	0.0020	0.0170	0.0002	0.77	-17.21	0.75	128	53	110	4	109	3	109	3	0.49	109	3
KM34	16	0.00000	0.00278	0.00021	0.01973	146.60	2.1280	0.0296	0.1964	0.0026	0.95	-0.50	0.17	1162	17	1158	19	1156	28	1160	15	0.73	1156	28
KM34	17	0.00000	0.00055	0.00003	0.04831	360.10	0.1044	0.0015	0.0157	0.0002	0.91	-10.51	0.42	111	29	101	3	100	3	100	3	0.47	100	3
KM34	19	0.00000	0.00012	0.00001	0.01146	86.00	0.0987	0.0018	0.0149	0.0002	0.77	-13.61	0.52	108	54	96	3	95	3	95	3	0.63	95	3
KM34	20	0.00001	0.00007	0.00000	0.00585	44.10	0.1146	0.0026	0.0170	0.0003	0.65	-35.31	1.53	147	81	110	5	108	3	109	3	0.35	108	3
KM34	21	0.00001	0.00030	0.00001	0.03196	255.20	0.0885	0.0014	0.0133	0.0002	0.85	-30.87	1.06	111	40	86	3	85	2	85	2	0.19	85	2
KM34	22	0.00002	0.00009	0.00000	0.00758	60.90	0.1155	0.0021	0.0167	0.0002	0.76	-85.67	3.64	199	56	111	4	107	3	107	3	0.00	107	3
KM34	23	0.00002	0.00056	0.00003	0.02967	240.00	0.1825	0.0026	0.0267	0.0004	0.92	-2.85	0.19	175	26	170	4	170	4	170	4	0.72	170	4
KM34	25	0.00001	0.00010	0.00000	0.00897	73.50	0.1002	0.0019	0.0150	0.0002	0.71	-22.58	0.87	118	63	97	4	96	3	96	3	0.50	96	3
KM34	27	0.00001	0.00004	0.00000	0.00332	27.52	0.1178	0.0031	0.0170	0.0002	0.54	-95.95	4.13	212	101	113	6	108	3	108	3	0.05	108	3
KM34	28	0.00001	0.00013	0.00001	0.01161	97.00	0.1050	0.0017	0.0156	0.0002	0.82	-43.43	1.73	143	45	101	3	100	3	100	3	0.06	100	3
KM34	29	0.00001	0.00027	0.00001	0.02237	188.00	0.1131	0.0018	0.0168	0.0002	0.84	-26.68	1.15	136	40	109	3	108	3	108	3	0.16	108	3
KM34	30	-0.00001	0.00010	0.00000	0.01047	88.50	0.0877	0.0017	0.0129	0.0002	0.72	-107.03	3.53	171	61	85	3	82	2	82	2	0.01	82	2
KM34	32	-0.00001	0.00007	0.00000	0.00643	55.00	0.0962	0.0021	0.0144	0.0002	0.65	-38.74	1.43	128	78	93	4	92	3	92	3	0.36	92	3
KM34	33	-0.00001	0.00010	0.00000	0.00869	74.60	0.1128	0.0022	0.0167	0.0002	0.69	-37.47	1.60	147	67	109	4	107	3	107	3	0.24	107	3
KM34	35	-0.00001	0.00012	0.00001	0.01038	89.90	0.1073	0.0020	0.0160	0.0002	0.74	-29.51	1.21	132	58	103	4	102	3	102	3	0.30	102	3
KM34	37	0.00000	0.00017	0.00001	0.01566	136.50	0.1012	0.0016	0.0152	0.0002	0.83	-22.38	0.87	119	42	98	3	97	3	97	3	0.31	97	3
KM34	38	0.00000	0.00034	0.00002	0.03444	301.20	0.0912	0.0014	0.0138	0.0002	0.86	-8.36	0.30	96	38	89	3	88	2	88	2	0.70	88	2
KM34	41	0.00001	0.00014	0.00001	0.01329	112.20	0.1027	0.0019	0.0151	0.0002	0.76	-66.50	2.57	161	57	99	4	97	3	97	3	0.03	97	3
KM34	42	0.00001	0.00036	0.00002	0.02503	209.70	0.1389	0.0022	0.0203	0.0003	0.87	-34.71	1.79	175	36	132	4	130	3	130	3	0.01	130	3

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM34	43	0.00001	0.00064	0.00003	0.06420	536.00	0.0913	0.0014	0.0138	0.0002	0.92	-4.70	0.17	93	29	89	3	89	2	89	2	0.77	89	2
KM34	44	0.00001	0.00011	0.00000	0.01023	84.90	0.1051	0.0020	0.0157	0.0002	0.75	-22.00	0.89	123	58	101	4	101	3	101	3	0.45	101	3
KM34	45	0.00001	0.00010	0.00000	0.00935	77.10	0.1031	0.0019	0.0152	0.0002	0.75	-71.06	2.75	166	57	100	4	97	3	97	3	0.02	97	3
KM34	46	0.00001	0.00018	0.00001	0.01598	131.00	0.1065	0.0019	0.0157	0.0002	0.77	-60.60	2.43	161	52	103	3	100	3	100	3	0.02	100	3
KM34	49	0.00000	0.00007	0.00000	0.00535	43.07	0.1200	0.0025	0.0175	0.0003	0.69	-65.27	2.90	185	70	115	5	112	3	112	3	0.04	112	3
KM34	52	0.00001	0.00014	0.00001	0.01267	100.20	0.1063	0.0019	0.0157	0.0002	0.78	-55.86	2.24	156	53	103	3	100	3	100	3	0.04	100	3
KM34	53	0.00001	0.00028	0.00001	0.02883	226.70	0.0938	0.0015	0.0139	0.0002	0.85	-55.98	2.00	139	40	91	3	89	2	89	2	0.01	89	2
KM34	55	0.00000	0.00070	0.00003	0.06320	492.00	0.1034	0.0016	0.0155	0.0002	0.92	-14.73	0.59	114	29	100	3	99	3	99	3	0.32	99	3
KM34	56	0.00001	0.00191	0.00013	0.01635	126.60	1.6305	0.0272	0.1645	0.0027	0.97	-10.10	0.03	983	18	982	21	982	29	982	15	0.95	982	29
KM34	57	0.00001	0.00121	0.00006	0.11490	886.00	0.0990	0.0018	0.0149	0.0003	0.97	-10.08	0.39	105	23	96	3	95	3	96	3	0.41	95	3
KM34	58	0.00001	0.00150	0.00008	0.05210	400.00	0.2889	0.0051	0.0408	0.0007	0.96	0.92	-0.09	256	22	258	8	258	9	258	8	0.84	258	9
KM34	60	0.00001	0.00298	0.00021	0.02453	186.90	1.7388	0.0349	0.1729	0.0034	0.98	1.54	-0.49	1012	17	1023	26	1028	37	1015	16	0.44	1028	37
KM34	61	0.00001	0.00051	0.00003	0.01812	137.50	0.2862	0.0057	0.0397	0.0008	0.95	-18.55	1.78	298	27	256	9	251	9	255	9	0.00	251	9
KM34	62	0.00001	0.00046	0.00002	0.04160	316.50	0.1029	0.0019	0.0153	0.0003	0.93	-42.69	1.67	140	32	99	3	98	3	98	3	0.01	98	3
KM34	63	0.00001	0.00028	0.00001	0.02553	194.60	0.0994	0.0020	0.0149	0.0003	0.90	-20.33	0.78	115	42	96	4	95	3	96	3	0.36	95	3
KM34	64	0.00001	0.00101	0.00005	0.03994	305.20	0.2522	0.0055	0.0356	0.0008	0.97	-14.51	1.26	258	25	228	9	226	9	229	9	0.01	226	9
KM34	65	0.00001	0.00011	0.00001	0.00916	70.20	0.1135	0.0024	0.0167	0.0003	0.82	-50.86	2.17	161	57	109	4	107	4	107	4	0.06	107	4
KM34	66	0.00001	0.00021	0.00001	0.02182	167.70	0.0916	0.0023	0.0138	0.0003	0.93	-24.12	0.86	110	43	89	4	88	4	88	4	0.32	88	4
KM34	67	0.00001	0.00008	0.00000	0.06999	53.80	0.1038	0.0025	0.0152	0.0003	0.84	-75.24	2.92	171	61	100	5	97	4	97	4	0.02	97	4
KM34	68	0.00001	0.00041	0.00002	0.03921	303.00	0.0984	0.0020	0.0147	0.0003	0.94	-28.59	1.08	121	32	95	4	94	3	94	3	0.10	94	3
KM34	69	0.00001	0.00025	0.00001	0.01277	99.00	0.1903	0.0038	0.0278	0.0005	0.90	-3.84	0.27	183	40	177	6	176	6	177	6	0.74	176	6
KM34	71	0.00001	0.00043	0.00002	0.02162	168.70	0.1976	0.0041	0.0280	0.0006	0.95	-38.66	2.69	247	31	183	7	178	7	180	7	0.00	178	7
KM34	73	0.00001	0.00087	0.00004	0.07870	618.00	0.1051	0.0024	0.0158	0.0004	0.97	-13.89	0.56	115	26	101	4	101	5	101	4	0.28	101	5
KM34	74	0.00001	0.00028	0.00001	0.02875	226.40	0.0913	0.0020	0.0136	0.0003	0.93	-53.65	1.88	134	38	89	4	87	3	87	4	0.02	87	3
KM34	75	0.00001	0.00019	0.00001	0.01737	137.20	0.1015	0.0025	0.0152	0.0004	0.92	-24.64	0.96	121	45	98	5	97	4	97	4	0.30	97	4
KM34	76	0.00001	0.00019	0.00001	0.01731	137.20	0.0988	0.0025	0.0149	0.0004	0.91	-11.92	0.46	107	49	96	5	95	4	95	4	0.65	95	4
KM34	77	0.00001	0.00017	0.00001	0.01495	118.80	0.1096	0.0023	0.0162	0.0003	0.90	-39.03	1.62	144	42	106	4	104	4	104	4	0.06	104	4
KM34	78	0.00001	0.00039	0.00002	0.03530	280.90	0.1043	0.0021	0.0156	0.0003	0.94	-18.81	0.76	119	32	101	4	100	4	100	4	0.25	100	4
KM34	79	0.00001	0.00153	0.00009	0.02471	197.40	0.7080	0.0149	0.0878	0.0018	0.98	-1.00	0.19	548	20	544	18	543	21	545	15	0.71	543	21
KM34	80	0.00001	0.00047	0.00002	0.01724	138.10	0.2773	0.0063	0.0392	0.0009	0.96	-2.55	0.24	254	31	248	10	248	11	249	10	0.70	248	11
KM34	81	0.00001	0.00014	0.00001	0.01327	107.90	0.1026	0.0029	0.0155	0.0004	0.93	-8.32	0.33	107	49	99	5	99	5	99	5	0.74	99	5
KM34	82	0.00001	0.00017	0.00001	0.01535	124.90	0.1022	0.0029	0.0153	0.0004	0.93	-18.63	0.73	116	48	99	5	98	5	98	5	0.45	98	5
KM34	84	0.00001	0.00206	0.00010	0.07190	585.00	0.2884	0.0079	0.0407	0.0011	0.99	-0.58	0.06	259	21	257	12	257	14	258	11	0.90	257	14
KM34	85	0.00001	0.00018	0.00001	0.01683	137.00	0.1048	0.0029	0.0151	0.0004	0.94	-113.41	4.36	206	44	101	5	97	5	97	5	0.00	97	5
KM34	86	0.00001	0.00025	0.00001	0.00370	30.07	0.7950	0.0218	0.0963	0.0026	0.96	-1.06	0.22	599	32	594	25	593	30	596	22	0.77	593	30
KM34	87	0.00001	0.00005	0.00000	0.00263	21.40	0.2069	0.0066	0.0291	0.0008	0.86	-44.23	3.18	267	76	191	11	185	10	186	10	0.04	185	10
KM34	88	0.00001	0.00212	0.00012	0.03470	281.80	0.6952	0.0195	0.0867	0.0024	0.98	0.08	-0.02	536	19	536	23	536	28	536	16	0.98	536	28
KM34	89	0.00001	0.00216	0.00012	0.03540	287.30	0.7078	0.0195	0.0883	0.0024	0.99	1.96	-0.38	535	20	543	23	545	28	538	16	0.54	545	28
KM34	90	0.00001	0.00020	0.00001	0.01523	123.60	0.1297	0.0035	0.0185	0.0005	0.94	-95.04	4.44	231	43	124	6	118	6	118	6	0.00	118	6
KM34	91	0.00001	0.000375	0.00005	0.03560	289.00	1.3852	0.0365	0.1442	0.0038	0.99	-5.78	1.62	919	19	883	31	868	42	911	17	0.03	868	42
KM34	92	0.00001	0.00197	0.00009	0.16400	1329.00	0.1129	0.0030	0.0170	0.0004	0.99	2.95	-0.13	106	22	109	5	109	6	109	5	0.78	109	6
KM34	94	0.00001	0.00060	0.00003	0.05520	446.00	0.1022	0.0029	0.0155	0.0004	0.98	0.14	-0.01	99	29	99	5	99	5	99	5	0.99	99	5
KM34	95	0.00001	0.00371	0.00018	0.19310	1560.00	0.1846	0.0045	0.0271	0.0007	0.98	2.99	-0.20	167	20	172	8	172	8	172	8	0.64	172	8
KM34	96	0.00001	0.00032	0.00002	0.02921	235.70	0.1093	0.0031	0.0157	0.0004	0.96	-117.03	4.66	218	38	105	6	100	5	100	5	0.00	100	5
KM34	97	0.00001	0.00063	0.00003	0.06090	490.00	0.0953	0.0025	0.0144	0.0004	0.97	-17.62	0.65	108	28	92	5	92	5	92	5	0.26	92	5
KM34	98	0.00000	0.00038	0.00002	0.02920	235.10	0.1242	0.0038	0.0187	0.0006	0.97	6.53	-0.31	111	37	119	7	119	7	119	7	0.68	119	7
KM34	99	0.00001	0.00020	0.00001	0.01881	151.20	0.0970	0.0018	0.0147	0.0002	0.83	1.31	-0.05	93	50	94	3	94	3	94	3	0.96	94	3
KM34	100	0.00001	0.00012	0.00001	0.01146	92.00	0.1016	0.0021	0.0153	0.0002	0.79	-5.22	0.21	103	59	98	4	98	3	98	3	0.86		

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	disc1TW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM34	103	0.00001	0.00475	0.00024	0.13680	1079.00	0.3668	0.0082	0.0502	0.0011	0.98	-4.08	0.49	329	19	317	12	316	14	320	11	0.26	316	14
KM34	104	0.00000	0.00409	0.00027	0.04211	331.80	1.2977	0.0282	0.1358	0.0029	0.98	-10.61	2.82	908	17	845	25	821	33	891	15	0.00	821	33
KM34	107	0.00000	0.00075	0.00003	0.07640	601.00	0.0916	0.0023	0.0139	0.0003	0.97	7.72	-0.28	82	27	89	4	89	4	89	4	0.62	89	4
KM34	108	0.00000	0.00305	0.00029	0.01802	141.50	3.2167	0.0746	0.2405	0.0055	0.99	-12.82	4.92	1567	16	1461	36	1389	57	1557	14	0.00	1567	16
KM34	110	-0.00001	0.00015	0.00001	0.01110	87.00	0.1282	0.0042	0.0195	0.0006	0.94	33.05	-1.65	83	55	122	8	124	8	123	7	0.14	124	8
KM34	111	-0.00001	0.00019	0.00001	0.01596	125.00	0.1088	0.0030	0.0163	0.0004	0.91	-17.91	0.75	123	54	105	5	104	5	104	5	0.49	104	5
KM34	113	-0.00001	0.00021	0.00001	0.01670	130.70	0.1163	0.0029	0.0174	0.0004	0.93	-11.25	0.50	124	42	112	5	111	5	111	5	0.56	111	5
KM34	114	-0.00001	0.00008	0.00000	0.00819	64.00	0.0952	0.0030	0.0140	0.0004	0.89	-79.59	2.86	161	67	92	6	90	5	90	5	0.04	90	5
KM34	115	-0.00001	0.00012	0.00001	0.01124	87.90	0.0973	0.0024	0.0151	0.0003	0.88	60.66	-2.37	38	56	94	5	96	4	96	4	0.04	96	4
KM34	117	0.00000	0.00009	0.00000	0.00805	62.80	0.0991	0.0027	0.0148	0.0004	0.86	-40.13	1.52	132	68	96	5	94	4	95	4	0.27	94	4
KM34	118	0.00000	0.00048	0.00002	0.04900	382.00	0.0946	0.0020	0.0139	0.0003	0.94	-90.45	3.21	169	34	92	4	89	3	89	3	0.00	89	3
KM34	119	0.00000	0.00018	0.00001	0.01891	147.50	0.0893	0.0020	0.0133	0.0003	0.89	-60.17	2.06	136	48	87	4	85	3	85	3	0.04	85	3
KM34	120	0.00001	0.00244	0.00018	0.01796	140.00	1.9428	0.0394	0.1862	0.0037	0.98	1.29	-0.44	1087	17	1096	27	1101	40	1089	16	0.52	1101	40
KM34a	3	0.00003	0.00046	0.00002	0.04554	169.7	0.0924	0.0011	0.0140	0.0002	0.87	7.00	-0.27	96	29	90	2	89	2	90	2	0.64	89	2
KM34a	4	0.00003	0.00017	0.00001	0.01598	59.6	0.1007	0.0014	0.0149	0.0002	0.82	38.23	-2.41	154	37	97	3	95	2	95	2	0.00	95	2
KM34a	6	0.00002	0.00019	0.00001	0.01689	63.0	0.1031	0.0015	0.0155	0.0002	0.75	5.85	-0.25	106	44	100	3	99	2	99	2	0.78	99	2
KM34a	7	0.00002	0.00035	0.00002	0.03190	119.0	0.1004	0.0013	0.0152	0.0002	0.87	-8.50	0.31	90	30	97	2	97	2	97	2	0.61	97	2
KM34a	8	0.00002	0.00092	0.00004	0.07330	274.0	0.1166	0.0014	0.0175	0.0002	0.92	8.00	-0.39	121	23	112	3	112	3	112	3	0.40	112	3
KM34a	9	0.00002	0.00022	0.00001	0.01740	65.1	0.1213	0.0016	0.0176	0.0002	0.84	43.33	-3.53	198	33	112	3	112	2	112	2	0.00	112	2
KM34a	10	0.00002	0.00096	0.00004	0.09920	371.0	0.0884	0.0010	0.0134	0.0001	0.92	7.58	-0.28	93	22	86	2	86	2	86	2	0.53	86	2
KM34a	12	0.00002	0.00132	0.00006	0.11320	424.2	0.1065	0.0012	0.0161	0.0002	0.94	-10.60	0.40	93	18	103	2	103	2	103	2	0.28	103	2
KM34a	14	0.00002	0.00142	0.00010	0.01057	39.7	1.9284	0.0265	0.1846	0.0025	0.97	-0.29	0.10	1089	15	1091	18	1092	27	1090	13	0.84	1092	27
KM34a	15	0.00002	0.00027	0.00001	0.02286	85.9	0.1118	0.0014	0.0164	0.0002	0.82	35.69	-2.38	163	35	108	3	105	2	105	2	0.00	105	2
KM34a	16	0.00002	0.00122	0.00006	0.12200	459.0	0.0894	0.0013	0.0136	0.0002	0.96	4.37	-0.16	91	20	87	2	87	2	87	2	0.70	87	2
KM34a	17	0.00002	0.00075	0.00004	0.06740	253.5	0.1051	0.0016	0.0153	0.0002	0.94	46.91	-3.58	185	24	102	3	98	3	98	3	0.00	98	3
KM34a	18	0.00002	0.00029	0.00001	0.02773	104.5	0.0952	0.0014	0.0146	0.0002	0.85	-36.50	1.00	68	37	92	3	93	2	93	2	0.17	93	2
KM34a	19	0.00002	0.00016	0.00001	0.01459	55.0	0.0996	0.0017	0.0150	0.0002	0.80	11.22	-0.49	108	49	96	3	96	3	96	3	0.62	96	3
KM34a	20	0.00002	0.00311	0.00016	0.11460	443.0	0.2785	0.0034	0.0383	0.0004	0.96	24.50	-3.09	320	16	249	5	248	6	248	6	0.00	242	6
KM34a	22	0.00002	0.00011	0.00001	0.00821	31.9	0.1203	0.0020	0.0182	0.0002	0.68	-12.44	0.51	103	59	115	4	116	3	116	3	0.66	116	3
KM34a	23	0.00002	0.00069	0.00003	0.06160	239.3	0.1046	0.0013	0.0154	0.0002	0.88	40.15	-2.71	164	28	101	2	98	2	99	2	0.00	98	2
KM34a	24	0.00002	0.00020	0.00001	0.01791	69.7	0.1046	0.0016	0.0156	0.0002	0.78	22.29	-1.16	128	44	101	3	100	2	100	2	0.20	100	2
KM34a	26	0.00002	0.00019	0.00001	0.01757	68.6	0.0995	0.0016	0.0148	0.0002	0.76	30.96	-1.73	137	48	96	3	95	2	95	2	0.08	95	2
KM34a	27	0.00002	0.00035	0.00002	0.02763	107.9	0.1178	0.0016	0.0175	0.0002	0.86	21.06	-1.21	142	33	113	3	112	3	112	3	0.07	112	3
KM34a	28	0.00002	0.00037	0.00002	0.03643	142.5	0.0941	0.0013	0.0141	0.0002	0.89	25.59	-1.26	121	31	91	3	90	2	90	2	0.05	90	2
KM34a	30	0.00002	0.00010	0.00001	0.00810	31.8	0.1207	0.0023	0.0180	0.0003	0.72	13.16	-0.70	132	63	116	4	115	3	115	3	0.58	115	3
KM34a	31	0.00002	0.00033	0.00002	0.03230	126.8	0.0942	0.0012	0.0142	0.0002	0.86	15.21	-0.66	107	32	91	2	91	2	91	2	0.31	91	2
KM34a	32	0.00002	0.00018	0.00001	0.01614	63.5	0.1101	0.0016	0.0160	0.0002	0.78	48.24	-3.93	197	43	106	3	102	2	102	2	0.00	102	2
KM34a	33	0.00001	0.00033	0.00002	0.03062	120.5	0.1016	0.0014	0.0151	0.0002	0.86	33.53	-1.98	145	32	98	3	96	2	96	2	0.00	96	2
KM34a	34	0.00001	0.00036	0.00002	0.03829	150.9	0.0880	0.0012	0.0133	0.0002	0.86	17.53	-0.74	103	32	86	2	85	2	85	2	0.26	85	2
KM34a	35	0.00001	0.00019	0.00001	0.01558	61.5	0.1142	0.0019	0.0173	0.0002	0.80	-16.63	0.63	95	47	110	3	111	3	110	3	0.50	111	3
KM34a	36	0.00002	0.00007	0.00000	0.00549	21.7	0.1150	0.0021	0.0169	0.0002	0.64	32.81	-2.15	161	67	111	4	108	3	108	3	0.12	108	3
KM34a	37	0.00002	0.00027	0.00001	0.02439	96.5	0.1056	0.0015	0.0157	0.0002	0.86	26.79	-1.50	137	34	102	3	100	2	101	2	0.03	100	2
KM34a	38	0.00002	0.00015	0.00001	0.01156	45.8	0.1218	0.0019	0.0175	0.0002	0.76	47.27	-4.14	212	46	117	3	112	3	112	3	0.00	112	3
KM34a	39	0.00002	0.00091	0.00004	0.08840	351.2	0.0952	0.0011	0.0142	0.0002	0.93	25.70	-1.28	123	20	92	2	91	2	91	2	0.00	91	2
KM34a	40	0.00002	0.00027	0.00001	0.02240	90.4	0.1170	0.0016	0.0172	0.0002	0.84	34.56	-2.37	168	35	112	3	110	2	110	2	0.00	110	2
KM34a	41	0.00002	0.00250	0.00015	0.04160	168.1	0.6895	0.0090	0.0835	0.0011	0.97	13.80	-3.01	600	15	533	11	517	13	551	10	0.00	517	13
KM34a	42	0.00002	0.00030	0.00001	0.02911	117.7	0.0978	0.0014	0.0146	0.0002	0.85	29.29	-1.58	132	35	95	3	93	2	93	2	0.03	93	2

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho=1	disc1W	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM34a	43	0.00002	0.00008	0.00000	0.00676	27.3	0.1091	0.0022	0.0162	0.0002	0.70	24.39	-1.36	137	68	105	4	104	3	104	3	0.33	104	3
KM34a	44	0.00002	0.00058	0.00003	0.04466	180.9	0.1221	0.0015	0.0184	0.0002	0.91	-10.81	0.46	106	24	117	3	118	3	117	3	0.35	118	3
KM34a	45	0.00001	0.00640	0.00049	0.04500	182.9	2.1771	0.0253	0.1984	0.0023	0.98	1.68	-0.60	1187	11	1174	16	1167	24	1183	10	0.13	1167	24
KM34a	46	0.00001	0.00449	0.00040	0.02640	107.0	3.0275	0.0372	0.2422	0.0029	0.98	2.87	-1.18	1439	12	1415	19	1398	30	1434	11	0.01	1439	12
KM34a	47	0.00001	0.00023	0.00001	0.02423	98.3	0.0892	0.0013	0.0135	0.0002	0.80	8.77	-0.34	95	42	87	2	86	2	86	2	0.69	86	2
KM34a	48	0.00001	0.00019	0.00001	0.01729	70.2	0.1006	0.0014	0.0153	0.0002	0.80	-5.73	0.21	92	39	97	3	98	2	98	2	0.79	98	2
KM34a	50	0.00001	0.00013	0.00001	0.01044	42.5	0.1156	0.0020	0.0171	0.0002	0.71	27.92	-1.72	152	57	111	4	109	3	109	3	0.15	109	3
KM34a	51	0.00001	0.00036	0.00002	0.03359	136.6	0.1002	0.0013	0.0150	0.0002	0.87	22.12	-1.11	123	31	97	2	96	2	96	2	0.09	96	2
KM34a	52	0.00001	0.00580	0.00042	0.04540	184.8	1.8316	0.0226	0.1782	0.0022	0.98	-0.08	0.03	1056	11	1057	16	1057	24	1056	10	0.95	1057	24
KM34a	53	0.00001	0.00058	0.00003	0.05330	217.0	0.0989	0.0013	0.0149	0.0002	0.91	8.30	-0.35	104	26	96	2	95	2	96	2	0.51	95	2
KM34a	54	0.00001	0.00070	0.00003	0.06290	256.0	0.1022	0.0013	0.0155	0.0002	0.91	-4.99	0.19	94	25	99	2	99	2	99	2	0.70	99	2
KM34a	55	0.00001	0.00037	0.00002	0.03950	161.1	0.0883	0.0012	0.0133	0.0002	0.87	24.80	-1.14	113	33	86	2	85	2	85	2	0.09	85	2
KM34a	56	0.00001	0.00047	0.00002	0.04420	180.1	0.1000	0.0013	0.0148	0.0002	0.87	35.22	-2.11	146	30	97	2	95	2	95	2	0.00	95	2
KM34a	57	0.00001	0.00020	0.00001	0.01868	76.2	0.1007	0.0016	0.0151	0.0002	0.81	19.43	-0.94	120	43	97	3	96	2	97	2	0.28	96	2
KM34a	58	0.00001	0.00039	0.00002	0.02646	108.0	0.1407	0.0020	0.0204	0.0002	0.79	34.51	-2.79	199	41	134	4	130	3	130	3	0.00	130	3
KM34a	59	0.00001	0.00018	0.00001	0.00927	37.9	0.1894	0.0033	0.0273	0.0004	0.84	17.19	-1.43	210	44	176	6	174	5	174	5	0.11	174	5
KM34a	60	0.00002	0.00018	0.00001	0.01657	68.0	0.1027	0.0015	0.0152	0.0002	0.74	33.27	-1.98	146	45	99	3	97	2	97	2	0.03	97	2
KM34a	61	0.00001	0.00144	0.00007	0.13920	571.0	0.0954	0.0011	0.0144	0.0002	0.93	5.07	-0.20	97	19	92	2	92	2	92	2	0.61	92	2
KM34a	63	0.00001	0.00021	0.00001	0.01668	68.5	0.1187	0.0016	0.0173	0.0002	0.80	40.11	-3.04	185	39	114	3	111	2	111	2	0.00	111	2
KM34a	64	0.00001	0.00024	0.00001	0.02065	84.8	0.1108	0.0014	0.0165	0.0002	0.80	18.05	-0.94	129	35	107	3	106	2	106	2	0.19	106	2
KM34a	65	0.00001	0.00018	0.00001	0.01482	60.9	0.1167	0.0017	0.0173	0.0002	0.75	23.67	-1.39	145	44	112	3	111	2	111	2	0.12	111	2
KM34a	66	0.00001	0.00031	0.00001	0.02775	114.1	0.1050	0.0013	0.0156	0.0002	0.82	31.29	-1.85	145	34	101	2	100	2	100	2	0.01	100	2
KM34a	67	0.00001	0.00091	0.00004	0.08190	336.7	0.1042	0.0012	0.0157	0.0002	0.89	9.74	-0.44	111	25	101	2	100	2	100	2	0.40	100	2
KM34a	68	0.00001	0.00569	0.00032	0.09370	386.0	0.6764	0.0075	0.0843	0.0009	0.97	2.85	-0.55	537	13	525	9	528	11	528	8	0.07	522	11
KM34a	69	0.00001	0.00092	0.00004	0.05810	238.9	0.1482	0.0017	0.0221	0.0002	0.91	-6.76	0.35	132	22	140	3	141	3	141	3	0.42	141	3
KM34a	70	0.00001	0.00041	0.00002	0.03409	140.3	0.1129	0.0014	0.0169	0.0002	0.81	9.31	-0.45	119	33	109	2	108	2	108	2	0.51	108	2
KM34a	72	0.00002	0.00566	0.00031	0.11530	475.0	0.5292	0.0056	0.0680	0.0007	0.96	9.66	-1.68	470	13	431	8	424	8	437	7	0.00	424	8
KM34a	73	0.00001	0.00032	0.00001	0.03035	125.1	0.0963	0.0013	0.0146	0.0002	0.87	-6.54	0.23	88	33	93	2	94	2	94	2	0.73	94	2
KM34a	74	0.00001	0.00045	0.00002	0.04356	179.6	0.0949	0.0015	0.0144	0.0002	0.92	-11.55	0.39	83	28	92	3	92	3	92	3	0.50	92	3
KM34a	75	0.00001	0.00077	0.00004	0.07120	293.6	0.0999	0.0012	0.0150	0.0002	0.92	15.38	-0.71	113	23	97	2	96	2	96	2	0.13	96	2
KM34a	76	0.00001	0.00018	0.00001	0.01619	66.8	0.1021	0.0017	0.0153	0.0002	0.75	16.91	-0.81	118	54	99	3	98	2	98	2	0.46	98	2
KM34a	80	0.00001	0.00034	0.00002	0.03226	133.9	0.0975	0.0012	0.0147	0.0002	0.82	13.43	-0.59	109	35	95	2	94	2	94	2	0.40	94	2
KM34a	81	0.00001	0.00024	0.00001	0.03714	154.2	0.0609	0.0008	0.0090	0.0001	0.76	64.06	-4.31	160	40	60	2	58	1	57	1	0.00	58	1
KM34a	82	0.00001	0.00036	0.00002	0.03433	142.6	0.1005	0.0012	0.0148	0.0001	0.83	43.20	-2.96	166	31	97	2	94	2	95	2	0.00	94	2
KM34a	83	0.00001	0.00054	0.00003	0.05010	208.2	0.1023	0.0012	0.0152	0.0002	0.86	28.56	-1.58	136	29	99	2	97	2	97	2	0.01	97	2
KM34a	84	0.00001	0.00014	0.00001	0.01271	52.8	0.1082	0.0016	0.0157	0.0002	0.67	48.22	-3.87	194	51	104	3	100	2	100	2	0.00	100	2
KM34a	86	0.00001	0.00059	0.00003	0.04850	201.7	0.1145	0.0014	0.0169	0.0002	0.87	28.37	-1.74	151	28	110	2	108	2	108	2	0.00	108	2
KM34a	87	0.00001	0.00265	0.00013	0.08910	370.7	0.2944	0.0031	0.0414	0.0004	0.95	1.59	-0.16	266	15	262	5	262	5	262	5	0.60	262	5
KM34a	88	0.00001	0.00056	0.00003	0.04569	190.2	0.1146	0.0014	0.0172	0.0002	0.87	10.28	-0.51	122	29	110	3	110	2	110	2	0.39	110	2
KM34a	92	0.00001	0.00089	0.00004	0.09080	378.6	0.0898	0.0013	0.0137	0.0002	0.95	-6.93	0.23	82	22	87	2	88	2	87	2	0.61	88	2
KM34a	94	0.00001	0.00023	0.00001	0.02032	84.8	0.1078	0.0017	0.0163	0.0002	0.89	-2.85	0.12	104	33	104	3	104	3	104	3	0.86	104	3
KM34a	95	0.00001	0.00037	0.00002	0.04550	189.7	0.0744	0.0011	0.0115	0.0001	0.88	-105.97	1.53	36	33	73	2	74	2	74	2	0.02	74	2
KM34a	96	0.00001	0.00021	0.00001	0.01916	80.0	0.1031	0.0016	0.0152	0.0002	0.81	36.74	-2.32	154	44	100	3	97	2	97	2	0.01	97	2
KM34a	98	0.00001	0.00044	0.00002	0.04246	177.3	0.0985	0.0015	0.0145	0.0002	0.90	42.59	-2.83	162	31	95	3	93	3	93	3	0.00	93	3
KM34a	99	0.00001	0.00022	0.00001	0.01980	82.9	0.1049	0.0018	0.0156	0.0002	0.86	27.81	-1.56	138	42	101	3	100	3	100	3	0.07	100	3
KM34a	100	0.00001	0.00032	0.00002	0.02958	123.8	0.1038	0.0018	0.0154	0.0003	0.92	28.84	-1.63	139	33	100	3	99	3	99	3	0.02	99	3
KM34a	101	0.00001	0.00174	0.00013	0.01354	56.7	1.9117	0.0393	0.1823	0.0037	0.99	1.55	-0.52	1097	14	1085	27	1080	40	1095	13	0.43	1080	40
KM34a	102	0.00001	0.00566	0.00068	0.02228	93.2	5.9888	0.0946	0.3526	0.0055	0.99	2.79	-1.40	2003	11	1974	28	1947	52	2001	10	0.04	2003	11

Sample	Spot	Normal (Wetherill concordia plot)										Discordance			Ages					Preferred				
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM34a	103	0.00001	0.00123	0.00006	0.09980	418.0	0.1147	0.0023	0.0172	0.0003	0.97	2.06	-0.09	112	22	110	4	110	4	110	4	0.84	110	4
KM34a	104	0.00001	0.00011	0.00001	0.00889	37.2	0.1196	0.0026	0.0174	0.0003	0.86	39.66	-3.00	185	52	115	5	111	4	112	4	0.01	111	4
KM34a	109	0.00001	0.00021	0.00001	0.01593	66.6	0.1249	0.0022	0.0186	0.0003	0.88	12.21	-0.66	135	39	120	4	119	4	119	4	0.40	119	4
KM34a	110	0.00001	0.00034	0.00002	0.03337	139.5	0.0943	0.0016	0.0142	0.0002	0.89	20.08	-0.93	113	36	91	3	91	3	91	3	0.21	91	3
KM34a	112	0.00001	0.00030	0.00001	0.03041	127.0	0.0942	0.0019	0.0141	0.0003	0.92	26.18	-1.30	122	38	91	4	90	3	90	3	0.10	90	3
KM34a	113	0.00001	0.00422	0.00021	0.13380	559.0	0.3189	0.0055	0.0443	0.0008	0.99	5.25	-0.59	295	13	281	8	279	9	284	8	0.06	279	9
KM34a	114	0.00001	0.00083	0.00004	0.05240	218.9	0.1492	0.0028	0.0222	0.0004	0.97	-5.83	0.31	134	22	141	5	141	5	141	5	0.48	142	5
KM34a	115	0.00001	0.00023	0.00001	0.01956	81.7	0.1127	0.0020	0.0170	0.0003	0.86	0.10	0.00	109	43	108	4	108	3	108	3	1.00	108	3
KM34a	117	0.00001	0.00021	0.00001	0.01969	82.2	0.0994	0.0017	0.0150	0.0002	0.88	2.63	-0.10	99	39	96	3	96	3	96	3	0.89	96	3
KM34a	120	0.00001	0.00012	0.00001	0.00961	40.1	0.1159	0.0017	0.0171	0.0002	0.74	30.12	-1.92	156	48	111	3	109	2	109	2	0.05	109	2
KM34a	121	0.00001	0.00046	0.00002	0.04580	190.9	0.0929	0.0011	0.0141	0.0002	0.90	7.95	-0.31	98	26	90	2	90	2	90	2	0.55	90	2
KM34a	122	0.00001	0.00052	0.00002	0.05090	212.0	0.0971	0.0021	0.0146	0.0003	0.97	10.01	-0.42	104	24	94	4	94	4	94	4	0.40	94	4
KM34a	123	0.00001	0.00061	0.00003	0.05590	233.0	0.1012	0.0016	0.0154	0.0002	0.94	-9.35	0.34	90	26	98	3	98	3	98	3	0.51	98	3
KM34a	125	0.00001	0.00036	0.00002	0.03439	143.2	0.0983	0.0016	0.0146	0.0002	0.88	30.23	-1.66	134	35	95	3	94	3	94	3	0.02	94	3
KM34a	127	0.00001	0.00028	0.00001	0.02670	110.9	0.1033	0.0022	0.0152	0.0003	0.92	38.27	-2.47	158	40	100	4	97	4	98	4	0.00	97	4
KM34a	128	0.00001	0.00166	0.00010	0.01954	80.2	1.0666	0.0232	0.1211	0.0026	0.99	0.11	-0.03	738	15	737	23	737	30	738	14	0.96	737	30
KM34a	129	0.00001	0.00170	0.00011	0.01954	80.1	1.0811	0.0202	0.1227	0.0026	0.98	-1.05	0.26	738	16	744	20	746	26	740	13	0.61	746	26
KM40a	1	0.00002	0.00100	0.00005	0.02679	170.50	0.3627	0.0084	0.0495	0.0011	0.96	-7.44	0.87	335	29	314	12	311	14	315	13	0.14	311	14
KM40a	2	0.00002	0.00325	0.00015	0.36500	2324.00	0.793	0.0018	0.0120	0.0003	0.98	-16.49	0.51	90	23	77	3	77	3	77	3	0.28	77	3
KM40a	3	0.00001	0.00045	0.00002	0.04980	317.40	0.0808	0.0019	0.0121	0.0003	0.96	-68.91	2.14	130	33	79	4	77	4	77	4	0.00	77	4
KM40a	4	0.00001	0.00048	0.00002	0.04470	285.00	0.0990	0.0022	0.0146	0.0003	0.94	-71.60	2.67	160	36	96	4	93	4	94	4	0.00	93	4
KM40a	5	0.00001	0.00029	0.00001	0.02745	174.90	0.0945	0.0022	0.0142	0.0003	0.94	-22.63	0.83	111	37	92	4	91	4	91	4	0.27	91	4
KM40a	6	0.00001	0.00103	0.00005	0.09590	612.00	0.0959	0.0023	0.0144	0.0003	0.97	-18.57	0.69	110	26	93	4	92	4	93	4	0.20	92	4
KM40a	7	0.00002	0.00023	0.00001	0.02026	129.20	0.1007	0.0023	0.0151	0.0003	0.93	-14.06	0.55	110	40	97	4	97	4	97	4	0.50	97	4
KM40a	9	0.00001	0.00088	0.00004	0.02925	186.60	0.2902	0.0077	0.0407	0.0011	0.98	-5.95	0.59	272	27	259	12	257	13	260	12	0.30	257	13
KM40a	11	0.00001	0.00074	0.00004	0.06410	409.00	0.1105	0.0031	0.0160	0.0004	0.98	-101.36	4.11	206	28	106	6	102	5	102	6	0.00	102	5
KM40a	15	0.00001	0.00061	0.00003	0.05120	327.00	0.1079	0.0028	0.0160	0.0004	0.97	-41.10	1.68	144	31	104	5	102	5	103	5	0.01	102	5
KM40a	17	0.00001	0.00024	0.00001	0.02489	159.10	0.0853	0.0022	0.0127	0.0003	0.94	-75.21	2.45	142	41	83	4	81	4	81	4	0.00	81	4
KM40a	20	0.00001	0.00104	0.00005	0.09240	591.00	0.0969	0.0025	0.0146	0.0004	0.97	-6.40	0.24	100	27	94	5	94	5	94	5	0.67	94	5
KM40a	21	0.00001	0.00181	0.00010	0.03590	229.70	0.5103	0.0125	0.0668	0.0016	0.98	-2.82	0.43	429	23	419	17	417	19	422	15	0.43	417	19
KM40a	22	0.00001	0.00011	0.00001	0.01027	65.70	0.1036	0.0031	0.0150	0.0004	0.92	-101.67	3.90	194	56	100	6	96	5	96	5	0.00	96	5
KM40a	24	0.00001	0.00047	0.00002	0.05010	320.70	0.0857	0.0021	0.0127	0.0003	0.96	-90.55	2.95	154	33	83	4	81	4	81	4	0.00	81	4
KM40a	25	0.00001	0.00526	0.00032	0.06940	445.00	0.8609	0.0213	0.0993	0.0024	0.96	-15.39	3.22	704	31	631	23	610	28	651	22	0.00	610	28
KM40a	26	0.00001	0.00076	0.00004	0.08540	547.00	0.0813	0.0021	0.0122	0.0003	0.96	-59.44	1.87	124	33	79	4	78	4	78	4	0.01	78	4
KM40a	27	0.00001	0.00159	0.00007	0.14160	907.00	0.1000	0.0026	0.0149	0.0004	0.98	-40.94	1.57	134	25	97	5	95	5	96	5	0.00	95	5
KM40a	28	0.00001	0.00022	0.00001	0.02431	155.80	0.0830	0.0024	0.0121	0.0003	0.95	-151.18	4.67	194	41	81	4	77	4	77	4	0.00	77	4
KM40a	29	0.00001	0.00044	0.00002	0.03860	247.50	0.1004	0.0030	0.0151	0.0004	0.97	-14.86	0.58	111	36	97	6	97	6	97	6	0.43	97	6
KM40a	30	0.00001	0.00114	0.00005	0.10300	660.00	0.0978	0.0024	0.0145	0.0004	0.97	-54.03	2.01	143	26	95	4	93	4	93	5	0.00	93	4
KM40a	31	0.00001	0.00069	0.00003	0.06140	395.00	0.1033	0.0024	0.0152	0.0003	0.96	-70.83	2.75	166	29	100	4	97	4	97	4	0.00	97	4
KM40a	33	0.00001	0.00021	0.00001	0.02094	134.90	0.0904	0.0020	0.0134	0.0003	0.89	-71.74	2.47	147	48	88	4	86	3	86	3	0.01	86	3
KM40a	34	0.00001	0.00200	0.00010	0.09340	602.00	0.1970	0.0040	0.0281	0.0006	0.97	-31.19	2.18	234	24	183	7	179	7	182	7	0.00	179	7
KM40a	36	0.00002	0.00055	0.00003	0.04550	294.00	0.1085	0.0025	0.0161	0.0004	0.96	-41.42	1.70	145	31	105	5	103	4	103	4	0.01	103	4
KM40a	37	0.00002	0.00116	0.00007	0.01800	116.20	0.7099	0.0156	0.0846	0.0018	0.97	-21.18	3.89	634	25	545	19	524	21	570	18	0.00	524	21
KM40a	38	0.00001	0.00038	0.00002	0.03304	213.40	0.1066	0.0023	0.0155	0.0003	0.93	-97.05	3.82	195	38	103	4	99	4	99	4	0.00	99	4
KM40a	39	0.00001	0.00043	0.00002	0.03692	238.60	0.1022	0.0022	0.0153	0.0003	0.95	-25.98	1.02	123	34	99	4	98	4	98	4	0.14	98	4
KM40a	40	0.00001	0.00050	0.00002	0.05390	348.80	0.0831	0.0019	0.0121	0.0003	0.95	-154.79	4.78	197	32	81	4	77	3	77	3	0.00	77	3
KM40a	42	0.00001	0.00282	0.00017	0.04460	288.60	0.7093	0.0145	0.0851	0.0017	0.97	-17.73	3.28	620	21	544	17	526	20	573	15	0.00	526	20

Sample	Spot	Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)					Discordance		Ages					Preferred					
							Pb207U235	± 1s	Pb206U238	± 1s	Rho1	disc1TW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KN40a	43	0.00001	0.00019	0.00001	0.02035	131.80	0.0821	0.00019	0.0119	0.0003	0.90	-156.15	4.76	195	47	80	4	76	3	76	3	0.00	76	3
KN40a	44	0.00001	0.00019	0.00001	0.02119	137.30	0.0803	0.00020	0.0121	0.0003	0.92	-48.78	1.52	115	46	78	4	77	3	77	3	0.11	77	3
KN40a	45	0.00002	0.00639	0.00049	0.04272	276.90	2.1841	0.0442	0.1999	0.0040	0.98	-0.29	0.10	1178	18	1176	28	1175	42	1178	16	0.88	1175	42
KN40a	46	0.00002	0.00087	0.00004	0.07350	477.00	0.1054	0.0022	0.0155	0.0003	0.95	-61.87	2.45	161	31	102	4	99	4	100	4	0.00	99	4
KN40a	47	0.00001	0.00086	0.00004	0.08210	533.00	0.0936	0.0026	0.0141	0.0004	0.98	-24.84	0.90	112	28	91	5	90	5	91	5	0.12	90	5
KN40a	48	0.00001	0.00080	0.00004	0.07260	472.00	0.0991	0.0027	0.0150	0.0004	0.97	-4.07	0.16	100	29	96	5	96	5	96	5	0.79	96	5
KN40a	50	0.00001	0.00174	0.00009	0.06830	444.00	0.2442	0.0058	0.0346	0.0008	0.98	-13.67	1.16	249	24	222	9	219	10	223	10	0.02	219	10
KN40a	51	0.00001	0.00080	0.00004	0.06730	438.00	0.1062	0.0026	0.0159	0.0004	0.97	-20.23	0.83	122	28	102	5	102	5	102	5	0.15	102	5
KN40a	52	0.00001	0.00034	0.00002	0.02787	181.40	0.1095	0.0025	0.0161	0.0004	0.95	-55.79	2.30	161	34	106	5	103	4	104	4	0.00	103	4
KN40a	57	0.00001	0.00037	0.00002	0.04103	267.90	0.0804	0.0019	0.0122	0.0003	0.94	-28.67	0.90	100	39	79	4	78	3	78	3	0.25	78	3
KN40a	59	0.00001	0.00035	0.00002	0.03220	210.50	0.0952	0.0026	0.0144	0.0004	0.95	1.16	-0.04	91	38	92	5	92	5	92	5	0.96	92	5
KN40a	62	0.00001	0.00044	0.00002	0.04909	323.90	0.0790	0.0016	0.0119	0.0002	0.94	-29.64	0.92	99	33	77	3	77	3	77	3	0.17	77	3
KN40a	63	0.00001	0.00027	0.00001	0.03027	199.90	0.0790	0.0017	0.0118	0.0002	0.92	-62.58	1.91	123	39	77	3	76	3	76	3	0.02	76	3
KN40a	64	0.00002	0.00017	0.00001	0.01614	106.70	0.0940	0.0025	0.0143	0.0003	0.90	14.56	-0.54	78	55	91	5	92	4	92	4	0.63	92	4
KN40a	65	0.00002	0.00014	0.00001	0.01184	78.30	0.1096	0.0028	0.0164	0.0004	0.90	-17.05	0.72	123	54	106	5	105	5	105	5	0.51	105	5
KN40a	66	0.00002	0.00038	0.00002	0.03583	237.20	0.0950	0.0023	0.0144	0.0003	0.94	-5.77	0.21	97	38	92	4	92	4	92	4	0.78	92	4
KN40a	69	0.00001	0.00132	0.00013	0.00657	43.60	3.6774	0.0767	0.2710	0.0055	0.97	-3.13	1.31	1594	19	1566	33	1546	56	1589	18	0.10	1594	19
KN40a	70	0.00001	0.00020	0.00001	0.00636	42.30	0.3033	0.0070	0.0422	0.0009	0.92	-9.74	0.99	292	42	269	11	266	11	268	11	0.24	266	11
KN40a	71	0.00001	0.00042	0.00002	0.04480	298.00	0.0821	0.0018	0.0124	0.0003	0.93	-31.88	1.02	105	39	80	3	79	3	79	3	0.19	79	3
KN40a	72	0.00001	0.00035	0.00002	0.01035	68.90	0.3283	0.0070	0.0454	0.0009	0.93	-7.06	0.77	306	35	288	11	286	11	288	11	0.27	286	11
KN40a	73	0.00001	0.00109	0.00005	0.04810	320.70	0.2150	0.0048	0.0301	0.0007	0.97	-46.92	3.47	280	27	198	8	191	8	195	8	0.00	191	8
KN40a	74	0.00001	0.00054	0.00003	0.05070	338.20	0.0975	0.0022	0.0142	0.0003	0.94	-114.64	4.14	194	34	94	4	91	4	90	4	0.00	91	4
KN40a	75	0.00002	0.00080	0.00004	0.09120	609.00	0.0789	0.0019	0.0119	0.0003	0.97	-42.02	1.29	108	29	77	3	76	3	76	3	0.03	76	3
KN40a	76	0.00001	0.00129	0.00006	0.09660	646.00	0.1197	0.0030	0.0179	0.0004	0.98	-11.20	0.51	127	25	115	5	114	6	115	5	0.31	114	6
KN40a	77	0.00001	0.00031	0.00001	0.03345	223.80	0.0827	0.0022	0.0124	0.0003	0.94	-61.77	1.97	128	44	81	4	79	4	79	4	0.03	79	4
KN40a	78	0.00001	0.00025	0.00001	0.02875	192.50	0.0788	0.0023	0.0120	0.0003	0.95	-19.86	0.62	92	42	77	4	77	4	77	4	0.48	77	4
KN40a	80	0.00001	0.00055	0.00003	0.05140	345.20	0.0966	0.0026	0.0144	0.0004	0.97	-35.36	1.31	125	31	94	5	92	5	93	5	0.04	92	5
KN40a	81	0.00001	0.00070	0.00003	0.06580	446.00	0.0936	0.0023	0.0140	0.0003	0.97	-38.05	1.37	124	30	91	4	90	4	90	4	0.02	90	4
KN40a	84	0.00001	0.00066	0.00003	0.05790	394.00	0.1019	0.0028	0.0151	0.0004	0.98	-56.79	2.19	151	28	99	5	96	5	97	5	0.00	96	5
KN40a	85	0.00001	0.00035	0.00003	0.00278	18.92	1.7234	0.0450	0.1683	0.0043	0.97	-4.59	1.43	1049	28	1017	34	1003	47	1037	24	0.09	1003	47
KN40a	87	0.00001	0.00083	0.00004	0.09300	636.00	0.0822	0.0020	0.0119	0.0003	0.96	-159.59	4.87	198	31	80	4	76	4	75	4	0.00	76	4
KN40a	88	0.00001	0.00535	0.00051	0.02653	181.60	3.7217	0.0966	0.2736	0.0070	0.99	-2.55	1.08	1599	17	1576	42	1559	71	1597	17	0.27	1599	17
KN40a	90	0.00001	0.00051	0.00002	0.05690	391.00	0.0810	0.0019	0.0121	0.0003	0.95	-58.58	1.83	123	33	79	4	78	3	78	3	0.01	78	3
KN40a	92	0.00001	0.00009	0.00000	0.00813	56.00	0.0984	0.0027	0.0145	0.0004	0.88	-68.33	2.54	156	62	95	5	93	5	93	5	0.04	93	5
KN40a	93	0.00001	0.00015	0.00001	0.01687	116.50	0.0825	0.0027	0.0121	0.0004	0.93	-120.13	3.73	171	57	80	5	77	5	77	5	0.00	77	5
KN40a	94	0.00001	0.00098	0.00005	0.01635	113.10	0.6398	0.0141	0.0799	0.0017	0.97	-7.47	1.32	533	25	502	17	496	20	510	16	0.02	496	20
KN40a	96	0.00001	0.00021	0.00001	0.02381	165.40	0.0806	0.0020	0.0120	0.0003	0.92	-69.33	2.15	130	45	79	4	77	3	77	3	0.02	77	3
KN40a	97	0.00001	0.00435	0.00023	0.08980	625.00	0.4964	0.0120	0.0650	0.0016	0.98	-5.38	0.80	428	21	409	16	406	19	416	14	0.11	406	19
KN40a	98	0.00001	0.00018	0.00001	0.01559	108.80	0.1009	0.0023	0.0150	0.0003	0.87	-42.92	1.65	137	53	98	4	96	4	96	4	0.13	96	4
KN40a	100	0.00001	0.00192	0.00011	0.02840	199.00	0.7417	0.0087	0.0908	0.0023	0.98	-2.82	0.56	576	21	563	22	560	27	570	17	0.35	560	27
KN40a	101	0.00001	0.00051	0.00002	0.05900	472.00	0.0767	0.0018	0.0117	0.0003	0.95	5.07	-0.15	71	36	75	3	75	3	75	3	0.83	75	3
KN40a	102	0.00001	0.00047	0.00002	0.03398	272.50	0.1221	0.0026	0.0184	0.0004	0.95	13.65	-0.64	102	32	117	5	118	5	117	5	0.32	118	5
KN40a	103	0.00001	0.00027	0.00001	0.02843	228.50	0.0878	0.0020	0.0129	0.0003	0.88	-100.67	3.33	166	52	85	4	83	3	83	3	0.00	83	3
KN40a	104	0.00001	0.00031	0.00001	0.03258	262.50	0.0853	0.0019	0.0132	0.0003	0.91	58.25	-2.01	35	44	83	4	85	4	84	3	0.02	85	4
KN40a	105	0.00001	0.00052	0.00002	0.06350	512.00	0.0681	0.0016	0.0107	0.0002	0.94	100.00	-2.99	0	31	67	3	69	3	68	3	0.00	69	3
KN40a	111	0.00001	0.00125	0.00006	0.11900	970.00	0.0949	0.0020	0.0144	0.0003	0.96	1.96	-0.07	90	29	92	4	92	4	92	4	0.90	92	4
KN40c	1	0.00001	0.00033	0.00002	0.03156	130.70	0.1006	0.0011	0.0150	0.0001	0.82	28.62	-1.57	134	31	97	2	96	2	96	2	0.01	96	2

Sample	Spot	Normal (Wetherill concordia plot)												Discordance		Ages					Preferred			
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM40c	2	0.00001	0.00044	0.00002	0.03953	163.60	0.1070	0.0012	0.0159	0.0002	0.83	30.25	-1.79	145	30	103	2	101	2	101	2	0.00	101	2
KM40c	3	0.00001	0.00041	0.00002	0.03720	154.00	0.1039	0.0012	0.0155	0.0002	0.81	23.07	-1.21	129	33	100	2	99	2	99	2	0.08	99	2
KM40c	4	0.00001	0.00016	0.00001	0.01601	66.20	0.0950	0.0013	0.0142	0.0001	0.70	24.25	-1.19	120	45	92	2	91	2	91	2	0.20	91	2
KM40c	5	0.00001	0.00044	0.00002	0.04725	195.30	0.0878	0.0011	0.0132	0.0001	0.85	20.12	-0.87	106	33	85	2	85	2	85	2	0.19	85	2
KM40c	6	0.00001	0.00095	0.00005	0.11320	467.70	0.0816	0.0010	0.0118	0.0001	0.89	60.88	-4.96	194	25	80	2	76	2	76	2	0.00	76	2
KM40c	7	0.00001	0.00128	0.00006	0.11880	490.50	0.1015	0.0012	0.0153	0.0002	0.94	12.47	-0.56	111	20	98	2	98	2	98	2	0.17	98	2
KM40c	8	0.00001	0.00060	0.00003	0.05570	230.20	0.1007	0.0013	0.0152	0.0002	0.89	6.21	-0.26	104	28	97	2	97	2	97	2	0.65	97	2
KM40c	9	0.00001	0.00045	0.00002	0.04014	165.60	0.1048	0.0014	0.0157	0.0002	0.91	20.90	-1.07	127	27	101	3	100	2	100	2	0.05	100	2
KM40c	10	0.00001	0.00037	0.00002	0.03370	138.90	0.1016	0.0015	0.0154	0.0002	0.89	-10.46	0.38	89	31	98	3	99	3	99	3	0.55	99	3
KM40c	11	0.00001	0.00038	0.00002	0.03640	150.10	0.1003	0.0014	0.0150	0.0002	0.90	26.65	-1.42	130	28	97	3	96	2	96	2	0.01	96	2
KM40c	12	0.00001	0.00084	0.00004	0.07860	324.00	0.1014	0.0012	0.0153	0.0002	0.93	9.63	-0.42	108	21	98	2	98	2	98	2	0.33	98	2
KM40c	13	0.00001	0.00086	0.00004	0.07710	318.00	0.1035	0.0013	0.0157	0.0002	0.92	-8.69	0.32	92	24	100	2	100	2	100	2	0.50	100	2
KM40c	14	0.00001	0.00056	0.00003	0.05240	216.10	0.1001	0.0013	0.0151	0.0002	0.90	6.76	-0.28	104	27	97	2	97	2	97	2	0.60	97	2
KM40c	15	0.00001	0.00306	0.00016	0.11620	479.00	0.2683	0.0032	0.0373	0.0004	0.97	18.66	-2.13	291	15	241	5	236	5	242	5	0.00	236	5
KM40c	16	0.00001	0.00050	0.00002	0.05168	212.80	0.0909	0.0013	0.0138	0.0002	0.90	1.07	-0.04	89	29	88	2	88	2	88	2	0.95	88	2
KM40c	17	0.00001	0.00040	0.00002	0.03750	154.30	0.0991	0.0014	0.0150	0.0002	0.89	2.40	-0.09	98	30	96	3	96	2	96	2	0.88	96	2
KM40c	18	0.00001	0.00019	0.00001	0.01837	75.60	0.0988	0.0016	0.0148	0.0002	0.82	17.04	-0.79	114	43	96	3	95	2	95	2	0.37	95	2
KM40c	19	0.00001	0.00032	0.00002	0.02970	122.10	0.1017	0.0014	0.0152	0.0002	0.81	23.55	-1.22	127	37	98	3	97	2	97	2	0.11	97	2
KM40c	20	0.00001	0.00049	0.00002	0.04880	200.70	0.0966	0.0013	0.0143	0.0002	0.87	39.69	-2.47	152	30	94	2	91	2	92	2	0.00	91	2
KM40c	21	0.00001	0.00039	0.00002	0.03553	145.50	0.1026	0.0012	0.0154	0.0002	0.83	11.44	-0.52	111	31	99	2	99	2	99	2	0.41	99	2
KM40c	22	0.00001	0.00024	0.00001	0.02179	89.20	0.1066	0.0014	0.0158	0.0002	0.80	27.42	-1.56	140	37	103	3	101	2	101	2	0.04	101	2
KM40c	23	0.00001	0.00031	0.00001	0.02882	118.00	0.1011	0.0013	0.0150	0.0002	0.79	29.35	-1.63	136	38	98	2	96	2	96	2	0.04	96	2
KM40c	24	0.00001	0.00033	0.00002	0.03708	151.80	0.0867	0.0011	0.0128	0.0001	0.76	44.91	-2.76	149	39	84	2	82	2	82	2	0.00	82	2
KM40c	25	0.00001	0.00052	0.00002	0.06130	250.80	0.0789	0.0009	0.0120	0.0001	0.87	16.95	-0.64	92	27	77	2	77	2	77	2	0.25	77	2
KM40c	26	0.00001	0.00053	0.00002	0.04990	204.30	0.1004	0.0011	0.0152	0.0002	0.87	-3.17	0.12	94	27	97	2	97	2	97	2	0.83	97	2
KM40c	27	0.00001	0.00045	0.00002	0.04223	172.80	0.0995	0.0011	0.0151	0.0001	0.84	-16.14	0.54	83	30	96	2	97	2	97	2	0.36	97	2
KM40c	28	0.00001	0.00040	0.00015	0.02738	112.00	1.1326	0.0115	0.1239	0.0012	0.95	7.71	-2.13	816	14	769	11	753	14	785	10	0.00	753	14
KM40c	29	0.00001	0.00141	0.00008	0.02350	96.20	0.6865	0.0077	0.0861	0.0009	0.93	-1.78	0.33	523	18	531	9	532	11	530	9	0.38	532	11
KM40c	30	0.00001	0.00108	0.00005	0.10110	414.00	0.1001	0.0011	0.0151	0.0002	0.91	7.26	-0.31	104	22	97	2	97	2	97	2	0.49	97	2
KM40c	31	0.00001	0.00017	0.00001	0.01575	64.40	0.1030	0.0018	0.0151	0.0002	0.72	43.35	-3.04	171	57	100	3	97	2	97	2	0.01	97	2
KM40c	32	0.00001	0.00154	0.00008	0.04920	201.30	0.3206	0.0045	0.0446	0.0006	0.97	4.13	-0.46	293	17	282	7	283	7	283	7	0.19	281	7
KM40c	33	0.00001	0.00075	0.00004	0.06970	285.30	0.1017	0.0011	0.0154	0.0002	0.92	-6.26	0.23	93	21	98	2	99	2	99	2	0.59	99	2
KM40c	34	0.00001	0.00052	0.00002	0.05250	214.60	0.0927	0.0013	0.0141	0.0002	0.93	-13.18	0.42	80	25	90	2	90	2	90	2	0.41	90	2
KM40c	35	0.00001	0.00028	0.00001	0.02560	104.70	0.1034	0.0016	0.0157	0.0002	0.87	-11.68	0.42	90	36	100	3	100	3	100	3	0.56	100	3
KM40c	36	0.00001	0.00034	0.00002	0.03227	132.00	0.1013	0.0014	0.0151	0.0002	0.88	26.79	-1.44	132	31	98	3	97	2	97	2	0.03	97	2
KM40c	37	0.00001	0.00105	0.00005	0.09080	371.60	0.1138	0.0016	0.0163	0.0002	0.94	53.45	-4.98	224	22	109	3	104	3	104	3	0.00	104	3
KM40c	38	0.00001	0.00056	0.00003	0.05080	208.00	0.1058	0.0015	0.0150	0.0002	0.92	34.69	-2.17	153	26	102	3	100	3	100	3	0.00	100	3
KM40c	40	0.00001	0.00037	0.00002	0.03457	141.50	0.1009	0.0016	0.0151	0.0002	0.91	24.44	-1.27	128	32	98	3	96	3	97	3	0.06	96	3
KM40c	41	0.00001	0.00034	0.00002	0.03130	128.30	0.1007	0.0013	0.0153	0.0002	0.83	-10.69	0.38	88	34	97	2	98	2	98	2	0.58	98	2
KM40c	42	0.00001	0.00081	0.00004	0.07710	316.00	0.1015	0.0011	0.0151	0.0001	0.88	30.11	-1.70	138	24	98	2	97	2	97	2	0.00	97	2
KM40c	43	0.00002	0.00030	0.00001	0.02710	111.10	0.1029	0.0014	0.0156	0.0002	0.78	-15.88	0.55	86	42	99	3	100	2	100	2	0.51	100	2
KM40c	44	0.00001	0.00010	0.00000	0.00987	40.50	0.1004	0.0015	0.0150	0.0002	0.66	24.78	-1.29	128	53	97	3	96	2	96	2	0.24	96	2
KM40c	45	0.00001	0.00094	0.00004	0.08150	334.90	0.1092	0.0012	0.0164	0.0002	0.91	6.27	-0.28	112	21	105	2	105	2	105	2	0.51	105	2
KM40c	46	0.00001	0.00025	0.00001	0.02301	94.60	0.1021	0.0012	0.0152	0.0002	0.78	24.40	-1.28	129	38	99	2	98	2	98	2	0.10	98	2
KM40c	47	0.00001	0.00037	0.00002	0.03470	142.50	0.1000	0.0012	0.0151	0.0002	0.84	12.06	-0.53	110	31	97	2	96	2	96	2	0.40	96	2
KM40c	48	0.00001	0.00047	0.00002	0.04630	190.40	0.0965	0.0011	0.0145	0.0001	0.82	17.05	-0.77	112	33	94	2	93	2	93	2	0.24	93	2
KM40c	49	0.00001	0.00047	0.00002	0.04400	181.00	0.1017	0.0012	0.0152	0.0002	0.85	18.63	-0.90	120	29	98	2	97	2	98	2	0.13	97	2
KM40c	50	0.00001	0.00042	0.00002	0.03908	160.90	0.0998	0.0012	0.0152	0.0002	0.82	-31.10	0.93	74	34	97	2	98	2	97	2	0.18	98	2

Sample	Spot	Normal (Wetherill concordia plot)										Discordance			Ages					Preferred				
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	discS8	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM40c	51	0.00001	0.00028	0.00001	0.02592	106.70	0.1025	0.0013	0.0154	0.0002	0.80	13.93	-0.64	114	36	99	2	98	2	98	2	0.38	98	2
KM40c	52	0.00001	0.00041	0.00002	0.03731	153.70	0.1032	0.0013	0.0156	0.0002	0.84	-6.63	0.25	94	31	100	2	100	2	100	2	0.69	100	2
KM40c	53	0.00001	0.00014	0.00001	0.01659	68.41	0.0780	0.0014	0.0118	0.0002	0.71	18.78	-0.71	93	59	76	3	76	2	76	2	0.56	76	2
KM40c	54	0.00001	0.00017	0.00001	0.01584	65.30	0.1000	0.0015	0.0152	0.0002	0.82	-16.75	0.56	83	41	97	3	97	2	97	2	0.50	97	2
KM40c	55	0.00001	0.00036	0.00002	0.03510	144.90	0.0963	0.0013	0.0145	0.0002	0.90	17.27	-0.78	112	29	93	2	93	2	93	2	0.19	93	2
KM40c	56	0.00001	0.00023	0.00001	0.02101	86.80	0.1014	0.0016	0.0153	0.0002	0.84	-2.51	0.10	96	42	98	3	98	3	98	3	0.91	98	3
KM40c	57	0.00001	0.00034	0.00002	0.03126	129.20	0.1045	0.0016	0.0155	0.0002	0.90	27.83	-1.56	138	32	101	3	99	3	100	3	0.02	99	3
KM40c	58	0.00001	0.00020	0.00001	0.02186	90.40	0.0867	0.0015	0.0132	0.0002	0.83	-0.75	0.03	84	45	84	3	84	2	84	2	0.98	84	2
KM40c	61	0.00001	0.00026	0.00001	0.02380	100.10	0.1009	0.0017	0.0152	0.0002	0.90	6.03	-0.25	104	36	98	3	97	3	97	3	0.73	97	3
KM40c	62	0.00001	0.00110	0.00005	0.10120	425.00	0.1005	0.0015	0.0152	0.0002	0.95	2.57	-0.10	100	21	97	3	97	3	97	3	0.81	97	3
KM40c	63	0.00001	0.00027	0.00001	0.02223	93.40	0.1153	0.0019	0.0172	0.0003	0.89	17.68	-0.95	133	36	111	4	110	3	110	3	0.20	110	3
KM40c	64	0.00001	0.00028	0.00001	0.02633	110.80	0.1001	0.0016	0.0151	0.0002	0.89	1.92	-0.08	99	35	97	3	97	3	97	3	0.91	97	3
KM40c	65	0.00001	0.00027	0.00001	0.02522	106.20	0.1022	0.0016	0.0154	0.0002	0.87	7.12	-0.30	106	37	99	3	99	3	99	3	0.68	99	3
KM40c	66	0.00002	0.00067	0.00003	0.06250	263.40	0.1043	0.0018	0.0157	0.0003	0.95	8.76	-0.39	110	26	101	3	100	3	100	3	0.47	100	3
KM40c	67	0.00002	0.00057	0.00003	0.06790	286.20	0.0789	0.0012	0.0119	0.0002	0.93	21.76	-0.87	98	28	77	2	76	2	77	2	0.14	76	2
KM40c	68	0.00001	0.00048	0.00002	0.05790	244.20	0.0793	0.0013	0.0120	0.0002	0.93	18.35	-0.70	94	29	78	2	77	2	77	2	0.24	77	2
KM40c	69	0.00001	0.00070	0.00003	0.06520	275.50	0.1008	0.0014	0.0153	0.0002	0.91	-18.45	0.61	83	27	98	3	98	2	98	2	0.25	98	2
KM40c	70	0.00001	0.00012	0.00001	0.01126	47.60	0.1003	0.0018	0.0152	0.0002	0.73	1.23	-0.05	98	59	97	3	97	3	97	3	0.97	97	3
KM40c	71	0.00001	0.00028	0.00001	0.02588	109.60	0.1038	0.0016	0.0156	0.0002	0.89	10.02	-0.45	111	35	100	3	100	3	100	3	0.52	100	3
KM40c	72	0.00001	0.00148	0.00007	0.13600	576.00	0.1017	0.0015	0.0154	0.0002	0.97	-0.12	0.00	98	18	98	3	98	3	98	3	0.99	98	3
KM40c	73	0.00001	0.00083	0.00004	0.07730	327.70	0.1071	0.0015	0.0155	0.0002	0.93	52.45	-4.53	208	24	103	3	99	3	99	3	0.00	99	3
KM40c	74	0.00001	0.00096	0.00004	0.10950	465.00	0.0835	0.0009	0.0127	0.0001	0.90	4.74	-0.16	85	23	81	2	81	2	81	2	0.73	81	2
KM40c	75	0.00001	0.00030	0.00001	0.02803	119.10	0.1029	0.0013	0.0155	0.0002	0.82	3.21	-0.13	103	36	99	2	99	2	99	2	0.85	99	2
KM40c	76	0.00001	0.00042	0.00002	0.03949	167.90	0.1028	0.0015	0.0154	0.0002	0.91	20.78	-1.05	124	28	99	3	98	3	98	3	0.06	98	3
KM40c	78	0.00001	0.00053	0.00002	0.04820	205.20	0.1047	0.0016	0.0159	0.0002	0.93	-8.76	0.33	93	27	101	3	101	3	101	3	0.54	101	3
KM40c	79	0.00001	0.00025	0.00001	0.02164	92.30	0.1087	0.0020	0.0162	0.0003	0.87	17.31	-0.88	126	43	105	4	104	3	104	3	0.32	104	3
KM40c	80	0.00001	0.00039	0.00002	0.03689	157.50	0.1019	0.0013	0.0153	0.0002	0.85	15.57	-0.73	116	31	99	2	98	2	98	2	0.24	98	2
KM40c	82	0.00002	0.00138	0.00007	0.15850	670.00	0.0832	0.0014	0.0121	0.0002	0.90	60.53	-4.97	196	34	81	3	77	2	77	2	0.00	77	2
KM40c	83	0.00002	0.00044	0.00002	0.03922	165.80	0.1036	0.0016	0.0154	0.0002	0.94	31.26	-1.82	143	26	100	3	98	3	99	3	0.00	98	3
KM40c	84	0.00002	0.00036	0.00002	0.03240	137.20	0.1083	0.0019	0.0157	0.0003	0.91	47.49	-3.76	192	35	104	3	101	3	101	3	0.00	101	3
KM40c	85	0.00002	0.00026	0.00001	0.02357	99.70	0.1082	0.0023	0.0156	0.0003	0.92	52.65	-4.61	211	39	104	4	100	4	100	4	0.00	100	4
KM40c	86	0.00001	0.00074	0.00003	0.06440	272.60	0.1066	0.0013	0.0159	0.0002	0.91	22.65	-1.21	131	24	103	2	102	2	102	2	0.01	102	2
KM40c	87	0.00001	0.00046	0.00002	0.04747	201.10	0.0915	0.0012	0.0136	0.0002	0.87	36.47	-2.05	137	30	89	2	87	2	87	2	0.00	87	2
KM40c	88	0.00001	0.00028	0.00001	0.02515	106.60	0.1050	0.0020	0.0155	0.0003	0.90	38.46	-2.53	161	39	101	4	99	3	99	3	0.00	99	3
KM40c	89	0.00001	0.00033	0.00002	0.03064	129.90	0.1018	0.0018	0.0151	0.0003	0.93	34.31	-2.06	147	31	98	3	96	3	97	3	0.00	96	3
KM40c	90	0.00002	0.00046	0.00002	0.03877	164.40	0.1125	0.0015	0.0162	0.0002	0.87	49.47	-4.21	206	31	108	3	104	2	104	2	0.00	104	2
KM40c	91	0.00002	0.00265	0.00015	0.03590	152.20	0.0856	0.0101	0.0128	0.0012	0.96	1.71	-0.38	642	15	633	11	631	13	636	10	0.27	631	13
KM40c	92	0.00001	0.00040	0.00002	0.04750	202.00	0.0802	0.0010	0.0121	0.0001	0.87	31.33	-1.44	112	30	78	2	77	2	77	2	0.02	77	2
KM40c	93	0.00001	0.00041	0.00002	0.03717	158.00	0.1032	0.0015	0.0154	0.0002	0.90	21.80	-1.12	126	30	100	3	99	3	99	3	0.07	99	3
KM40c	94	0.00001	0.00036	0.00002	0.03321	141.20	0.1024	0.0014	0.0152	0.0002	0.88	33.66	-2.01	146	31	99	3	97	2	97	2	0.00	97	2
KM40c	95	0.00001	0.00025	0.00001	0.02408	102.50	0.0962	0.0014	0.0143	0.0002	0.81	33.97	-1.93	139	40	93	3	92	2	92	2	0.02	92	2
KM40c	96	0.00001	0.00042	0.00002	0.03897	165.90	0.1006	0.0013	0.0151	0.0002	0.88	19.48	-0.95	120	29	97	2	96	2	97	2	0.10	96	2
KM40c	97	0.00001	0.00040	0.00002	0.03760	160.30	0.1026	0.0016	0.0151	0.0002	0.85	39.26	-2.56	159	37	99	3	97	2	97	2	0.00	97	2
KM40c	98	0.00001	0.00029	0.00001	0.03368	143.60	0.0796	0.0011	0.0120	0.0001	0.84	31.48	-1.44	112	34	78	2	77	2	77	2	0.04	77	2
KM40c	99	0.00001	0.00277	0.00016	0.04676	199.50	0.0657	0.0072	0.0828	0.0009	0.94	5.31	-1.03	542	16	518	9	513	10	521	9	0.00	513	10
KM40c	100	0.00001	0.00046	0.00002	0.04170	178.00	0.1016	0.0014	0.0152	0.0002	0.90	19.34	-0.95	121	29	98	3	97	2	98	2	0.10	97	2
KM40c	101	0.00001	0.00044	0.00002	0.04886	211.10	0.0835	0.0011	0.0125	0.0001	0.88	28.86	-1.33	113	29	81	2	80	2	80	2	0.03	80	2
KM40c	102	0.00001	0.00032	0.00002	0.02890	125.00	0.1035	0.0016	0.0155	0.0002	0.86	20.89	-1.06	125	38	100	3	99	3	99	3	0.17	99	3

Sample	Spot	Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)					Discordance		Ages					Preferred					
							Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM40c	103	0.00001	0.00048	0.00002	0.04390	190.20	0.1038	0.0017	0.0154	0.0002	0.94	29.86	-1.71	141	27	100	3	99	3	99	3	0.00	99	3
KM40c	105	0.00001	0.00109	0.00005	0.09820	426.00	0.1025	0.0013	0.0155	0.0002	0.92	5.51	-0.23	105	21	99	2	99	2	99	2	0.58	99	2
KM40c	106	0.00001	0.00061	0.00003	0.05220	226.50	0.1094	0.0016	0.0163	0.0002	0.94	20.67	-1.10	131	27	105	3	104	3	104	3	0.05	104	3
KM40c	107	0.00001	0.00054	0.00003	0.05100	221.60	0.0996	0.0013	0.0148	0.0002	0.90	30.13	-1.67	136	27	96	2	95	2	95	2	0.00	95	2
KM40c	108	0.00001	0.00038	0.00002	0.03436	149.50	0.1036	0.0014	0.0156	0.0002	0.90	12.67	-0.58	114	28	100	3	99	2	100	2	0.30	99	2
KM40c	109	0.00001	0.00034	0.00002	0.03120	135.90	0.1011	0.0016	0.0151	0.0002	0.87	28.29	-1.55	134	38	98	3	96	3	96	3	0.05	96	3
KM40c	110	0.00001	0.00034	0.00002	0.03090	134.70	0.1035	0.0015	0.0154	0.0002	0.88	27.42	-1.51	136	33	100	3	99	2	99	2	0.03	99	2
KM40c	111	0.00001	0.00054	0.00003	0.04970	216.90	0.1011	0.0016	0.0150	0.0002	0.92	35.87	-2.19	149	30	98	3	96	3	96	3	0.00	96	3
KM54b	1	0.00004	0.00044	0.00002	0.03940	342.0	0.0971	0.0012	0.0144	0.0002	0.85	36.00	-2.12	144	32	94	2	92	2	92	2	0.00	92	2
KM54b	3	0.00004	0.00113	0.00005	0.10570	913.0	0.0950	0.0014	0.0141	0.0002	0.93	35.73	-2.06	141	26	92	3	90	2	91	2	0.00	90	2
KM54b	5	0.00004	0.00036	0.00002	0.03750	323.0	0.0862	0.0011	0.0127	0.0001	0.83	48.93	-3.22	159	35	84	2	81	2	81	2	0.00	81	2
KM54b	6	0.00004	0.00043	0.00002	0.03806	326.6	0.0995	0.0015	0.0148	0.0002	0.90	33.20	-1.92	142	32	96	3	95	3	95	3	0.00	95	3
KM54b	7	0.00003	0.00080	0.00004	0.06910	592.0	0.1023	0.0015	0.0152	0.0002	0.92	34.17	-2.06	147	27	99	3	97	3	97	3	0.00	97	3
KM54b	9	0.00003	0.00043	0.00002	0.03903	331.9	0.0987	0.0014	0.0147	0.0002	0.87	33.74	-1.95	142	32	96	3	94	2	94	2	0.00	94	2
KM54b	10	0.00003	0.00049	0.00031	0.03000	254.0	1.9016	0.0263	0.1815	0.0024	0.96	1.78	-0.60	1095	17	1082	18	1075	26	1089	14	0.21	1075	26
KM54b	11	0.00003	0.00043	0.00002	0.03800	321.0	0.1013	0.0015	0.0151	0.0002	0.90	27.00	-1.46	132	32	98	3	97	3	97	3	0.03	97	3
KM54b	12	0.00003	0.00113	0.00005	0.09620	809.0	0.1056	0.0016	0.0157	0.0002	0.95	23.70	-1.27	132	24	102	3	101	3	101	3	0.01	101	3
KM54b	13	0.00003	0.00038	0.00002	0.03494	292.3	0.0950	0.0014	0.0142	0.0002	0.87	23.94	-1.17	120	34	92	3	91	2	91	2	0.10	91	2
KM54b	15	0.00003	0.00098	0.00005	0.09650	799.0	0.0869	0.0013	0.0131	0.0002	0.93	23.21	-1.03	109	25	85	2	84	2	84	2	0.05	84	2
KM54b	16	0.00003	0.00037	0.00002	0.03230	266.0	0.0995	0.0016	0.0146	0.0002	0.89	46.36	-3.33	174	35	96	3	93	3	93	3	0.00	93	3
KM54b	17	0.00003	0.00026	0.00001	0.02259	185.0	0.1037	0.0014	0.0151	0.0002	0.81	48.90	-3.82	189	37	100	3	96	2	97	2	0.00	96	2
KM54b	18	0.00003	0.00018	0.00001	0.01579	128.8	0.1052	0.0016	0.0153	0.0002	0.80	47.05	-3.60	185	44	102	3	98	2	98	2	0.00	98	2
KM54b	19	0.00003	0.00027	0.00001	0.02430	196.5	0.0992	0.0018	0.0148	0.0002	0.88	22.59	-1.13	123	41	96	3	95	3	95	3	0.18	95	3
KM54b	21	0.00003	0.00025	0.00001	0.02234	129.9	0.0989	0.0014	0.0147	0.0002	0.79	35.28	-2.09	145	40	96	3	94	2	94	2	0.01	94	2
KM54b	22	0.00003	0.00036	0.00002	0.03171	182.6	0.0995	0.0014	0.0147	0.0002	0.86	41.10	-2.69	159	34	96	3	94	2	94	2	0.00	94	2
KM54b	23	0.00003	0.00042	0.00002	0.03837	219.0	0.0985	0.0011	0.0146	0.0001	0.83	34.10	-1.98	142	31	95	2	94	2	94	2	0.00	94	2
KM54b	25	0.00002	0.00019	0.00001	0.01604	89.9	0.1051	0.0017	0.0153	0.0002	0.81	46.06	-3.46	182	44	101	3	98	3	98	3	0.00	98	3
KM54b	26	0.00002	0.00026	0.00001	0.02320	128.9	0.0994	0.0017	0.0146	0.0002	0.89	43.45	-2.96	165	37	96	3	94	3	94	3	0.00	94	3
KM54b	27	0.00002	0.00014	0.00001	0.01304	71.9	0.0970	0.0016	0.0145	0.0002	0.68	24.30	-1.21	123	58	94	3	93	2	93	2	0.31	93	2
KM54b	28	0.00002	0.00028	0.00001	0.02445	133.6	0.1005	0.0012	0.0148	0.0001	0.77	40.68	-2.67	160	35	97	2	95	2	95	2	0.00	95	2
KM54b	29	0.00002	0.00019	0.00001	0.01606	87.1	0.1043	0.0015	0.0154	0.0002	0.72	37.85	-2.45	158	45	101	3	98	2	98	2	0.01	98	2
KM54b	30	0.00002	0.00081	0.00004	0.06890	370.6	0.1064	0.0014	0.0157	0.0002	0.88	36.19	-2.33	157	31	103	3	100	2	101	2	0.00	100	2
KM54b	31	0.00002	0.00014	0.00001	0.01227	65.5	0.1066	0.0016	0.0156	0.0002	0.76	45.29	-3.39	182	46	103	3	99	2	100	2	0.00	99	2
KM54b	32	0.00002	0.00119	0.00005	0.10330	548.0	0.0998	0.0010	0.0150	0.0001	0.87	9.76	-0.42	107	24	97	2	96	2	96	2	0.40	96	2
KM54b	33	0.00002	0.00022	0.00001	0.01709	89.9	0.1153	0.0015	0.0169	0.0002	0.73	35.50	-2.43	168	43	111	3	108	2	108	2	0.01	108	2
KM54b	35	0.00002	0.00060	0.00003	0.05340	277.2	0.0992	0.0011	0.0149	0.0001	0.88	15.57	-0.71	113	25	96	2	95	2	95	2	0.17	95	2
KM54b	36	0.00002	0.00020	0.00001	0.01846	95.2	0.0953	0.0013	0.0141	0.0002	0.80	40.53	-2.52	152	39	92	2	90	2	90	2	0.00	90	2
KM54b	37	0.00002	0.00066	0.00003	0.06210	318.0	0.0944	0.0013	0.0141	0.0002	0.90	28.08	-1.44	126	29	92	2	90	2	90	2	0.02	90	2
KM54b	38	0.00002	0.00036	0.00002	0.03230	164.6	0.0967	0.0014	0.0145	0.0002	0.85	16.15	-0.73	111	36	94	3	93	2	93	2	0.33	93	2
KM54b	39	0.00002	0.00028	0.00001	0.02448	124.2	0.1031	0.0015	0.0153	0.0002	0.85	31.80	-1.86	143	37	100	3	98	2	98	2	0.01	98	2
KM54b	40	0.00002	0.00016	0.00001	0.00725	36.6	0.2047	0.0065	0.0284	0.0008	0.94	39.32	-4.75	298	79	189	11	181	9	181	9	0.00	181	9
KM54b	41	0.00003	0.00081	0.00004	0.07440	363.3	0.0988	0.0018	0.0148	0.0003	0.95	21.60	-1.06	121	27	96	3	95	3	95	3	0.06	95	3
KM54b	42	0.00002	0.00190	0.00009	0.06970	341.0	0.2521	0.0047	0.0360	0.0007	0.97	1.38	-0.12	231	22	228	8	228	8	228	8	0.78	228	8
KM54b	43	0.00002	0.00203	0.00012	0.02499	122.5	0.9172	0.0162	0.1085	0.0019	0.97	-2.13	0.47	650	19	661	17	664	22	656	14	0.34	664	22
KM54b	44	0.00002	0.00018	0.00001	0.01700	83.5	0.0903	0.0018	0.0136	0.0002	0.82	13.24	-0.54	101	54	88	3	87	3	87	3	0.63	87	3
KM54b	45	0.00002	0.00047	0.00002	0.04260	209.8	0.0969	0.0019	0.0148	0.0003	0.94	-16.81	0.55	81	32	94	4	93	4	94	3	0.39	94	3
KM54b	46	0.00002	0.00053	0.00002	0.04920	242.7	0.0970	0.0020	0.0145	0.0003	0.95	28.46	-1.50	129	30	94	4	93	4	93	4	0.02	93	4

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages					Preferred					
		Pb207/U235	± 1s	Pb206/U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s					
KM54b	47	0.00002	0.00044	0.00002	0.03940	194.9	0.1011	0.0020	0.0150	0.0003	0.93	31.66	-1.82	141	34	98	4	96	3	96	4	0.01	96	3
KM54b	48	0.00002	0.00024	0.00001	0.02219	110.0	0.1011	0.0018	0.0146	0.0002	0.88	53.85	-4.55	203	39	98	3	93	3	93	3	0.00	94	3
KM54b	50	0.00002	0.00041	0.00002	0.03702	184.4	0.0985	0.0020	0.0146	0.0003	0.94	34.85	-2.05	143	33	95	4	94	4	94	4	0.00	93	4
KM54b	51	0.00002	0.00044	0.00002	0.03869	193.2	0.1002	0.0018	0.0149	0.0002	0.91	26.97	-1.44	131	34	97	3	96	3	96	3	0.04	96	3
KM54b	52	0.00002	0.00063	0.00003	0.05770	289.0	0.0966	0.0017	0.0146	0.0002	0.95	11.74	-0.50	106	28	94	3	93	3	93	3	0.38	93	3
KM54b	53	0.00002	0.00032	0.00002	0.02948	148.0	0.0957	0.0015	0.0145	0.0002	0.88	1.61	-0.06	94	35	93	3	93	3	93	3	0.93	93	3
KM54b	54	0.00002	0.00021	0.00001	0.01857	93.5	0.1020	0.0018	0.0151	0.0002	0.84	37.60	-2.38	154	45	99	3	96	3	96	3	0.01	96	3
KM54b	56	0.00002	0.01035	0.00119	0.04680	237.1	4.7817	0.0922	0.2910	0.0055	0.98	15.30	-8.21	1944	15	1782	32	1647	55	1927	13	0.00	1944	15
KM54b	57	0.00002	0.00054	0.00003	0.04920	249.4	0.0987	0.0015	0.0148	0.0002	0.92	24.55	-1.25	125	29	96	3	94	3	95	3	0.04	94	3
KM54b	58	0.00002	0.00014	0.00001	0.01328	67.6	0.0995	0.0016	0.0144	0.0002	0.79	55.15	-4.72	205	46	96	3	92	2	92	2	0.00	92	2
KM54b	59	0.00002	0.00138	0.00006	0.11000	561.0	0.1108	0.0016	0.0165	0.0002	0.92	22.64	-1.25	136	26	107	3	105	3	106	3	0.02	105	3
KM54b	60	0.00002	0.00032	0.00002	0.02970	151.9	0.0969	0.0017	0.0144	0.0002	0.89	31.27	-1.71	134	39	94	3	92	3	92	3	0.03	92	3
KM54b	61	0.00002	0.00066	0.00003	0.05980	321.5	0.0972	0.0016	0.0146	0.0002	0.93	15.69	-0.71	111	30	94	3	94	3	94	3	0.24	94	3
KM54b	62	0.00002	0.00053	0.00002	0.04920	264.5	0.0947	0.0015	0.0142	0.0002	0.90	18.28	-0.83	111	32	92	3	91	3	91	3	0.21	91	3
KM54b	63	0.00002	0.00065	0.00003	0.05750	310.0	0.1002	0.0020	0.0151	0.0003	0.95	13.11	-0.59	111	31	97	4	96	4	97	4	0.35	96	4
KM54b	64	0.00002	0.00037	0.00002	0.03354	180.9	0.0960	0.0018	0.0144	0.0002	0.92	16.35	-0.73	110	35	93	3	92	3	93	3	0.30	92	3
KM54b	65	0.00002	0.00047	0.00002	0.04200	226.8	0.0999	0.0017	0.0149	0.0002	0.92	24.22	-1.24	126	31	97	3	96	3	96	3	0.05	96	3
KM54b	66	0.00002	0.00038	0.00002	0.03474	187.8	0.0968	0.0017	0.0144	0.0002	0.91	30.01	-1.62	132	35	94	3	92	3	92	3	0.03	92	3
KM54b	67	0.00002	0.00137	0.00006	0.11510	623.0	0.1064	0.0019	0.0159	0.0003	0.96	19.02	-0.97	126	25	103	3	102	3	102	3	0.06	102	3
KM54b	69	0.00002	0.00439	0.00026	0.05830	315.9	0.8359	0.0158	0.1001	0.0019	0.98	1.40	-0.30	624	19	617	18	615	22	620	14	0.54	615	22
KM54b	70	0.00002	0.00061	0.00003	0.05710	309.9	0.0934	0.0016	0.0141	0.0002	0.94	6.96	-0.27	97	28	91	3	90	3	91	3	0.64	90	3
KM54b	71	0.00002	0.00055	0.00003	0.05060	274.7	0.0947	0.0014	0.0144	0.0002	0.90	-8.56	0.29	85	32	92	3	92	2	92	2	0.65	92	2
KM54b	72	0.00002	0.00049	0.00002	0.05280	287.0	0.0801	0.0013	0.0121	0.0002	0.90	16.60	-0.63	93	34	78	2	78	2	78	2	0.36	78	2
KM54b	74	0.00001	0.00047	0.00002	0.04050	220.9	0.1004	0.0014	0.0153	0.0002	0.86	-28.25	0.86	76	33	97	3	98	2	98	2	0.19	98	2
KM54b	75	0.00001	0.00063	0.00003	0.05820	317.2	0.0948	0.0014	0.0146	0.0002	0.91	-55.93	1.34	60	30	92	3	93	2	93	2	0.02	93	2
KM54b	77	0.00001	0.00040	0.00002	0.03683	201.2	0.0958	0.0014	0.0144	0.0002	0.89	11.23	-0.47	104	31	93	3	92	2	92	2	0.46	92	2
KM54b	78	0.00002	0.00031	0.00001	0.02804	153.3	0.0977	0.0012	0.0148	0.0001	0.77	-2.09	0.08	93	37	95	2	95	2	95	2	0.92	95	2
KM54b	79	0.00002	0.00045	0.00002	0.04795	262.5	0.0821	0.0012	0.0124	0.0002	0.90	14.55	-0.55	93	32	80	2	80	2	80	2	0.40	80	2
KM54b	80	0.00002	0.00037	0.00002	0.03279	179.7	0.0996	0.0015	0.0150	0.0002	0.88	9.46	-0.41	106	33	96	3	96	2	96	2	0.54	96	2
KM54b	81	0.00002	0.00023	0.00001	0.02390	133.5	0.0844	0.0017	0.0127	0.0002	0.90	18.93	-0.78	101	41	82	3	82	3	82	3	0.35	82	3
KM54b	82	0.00002	0.00029	0.00001	0.02720	152.0	0.0974	0.0016	0.0143	0.0002	0.82	47.95	-3.47	175	44	94	3	91	2	91	2	0.00	91	2
KM54b	83	0.00002	0.00064	0.00003	0.05880	328.4	0.0966	0.0017	0.0145	0.0002	0.93	19.56	-0.92	115	30	94	3	93	3	93	3	0.14	93	3
KM54b	84	0.00002	0.00029	0.00001	0.02688	150.2	0.0969	0.0016	0.0145	0.0002	0.90	23.69	-1.17	122	34	94	3	93	3	93	3	0.09	93	3
KM54b	85	0.00002	0.00027	0.00001	0.02415	135.1	0.0973	0.0014	0.0147	0.0002	0.78	8.03	-0.33	102	43	94	3	94	2	94	2	0.71	94	2
KM54b	86	0.00002	0.00109	0.00005	0.09380	525.0	0.1028	0.0016	0.0154	0.0002	0.95	19.42	-0.96	122	23	99	3	98	3	99	3	0.04	98	3
KM54b	87	0.00001	0.00037	0.00002	0.01409	79.0	0.2518	0.0039	0.0357	0.0005	0.90	9.17	-0.89	249	31	228	6	226	6	227	6	0.15	226	6
KM54b	88	0.00001	0.00040	0.00002	0.03680	206.4	0.0939	0.0017	0.0142	0.0002	0.93	6.50	-0.26	97	31	91	3	91	3	91	3	0.69	91	3
KM54b	89	0.00002	0.00053	0.00003	0.04935	277.1	0.0955	0.0016	0.0142	0.0002	0.92	36.80	-2.16	143	31	93	3	91	3	91	3	0.00	91	3
KM54b	90	0.00002	0.00029	0.00001	0.02658	149.4	0.0960	0.0018	0.0143	0.0002	0.88	27.75	-1.44	127	42	93	3	92	3	92	3	0.10	92	3
KM54b	91	0.00002	0.00035	0.00002	0.03271	184.0	0.0959	0.0016	0.0144	0.0002	0.88	24.83	-1.23	122	37	93	3	92	3	92	3	0.10	92	3
KM54b	92	0.00002	0.00034	0.00002	0.03087	173.8	0.0973	0.0017	0.0145	0.0002	0.90	29.93	-1.62	132	36	94	3	93	3	93	3	0.03	93	3
KM54b	93	0.00002	0.00033	0.00002	0.03059	172.3	0.0970	0.0017	0.0145	0.0002	0.91	29.87	-1.61	132	36	94	3	92	3	93	3	0.03	92	3
KM54b	94	0.00002	0.00034	0.00002	0.03047	171.8	0.0988	0.0018	0.0149	0.0002	0.89	14.75	-0.67	111	39	96	3	95	3	95	3	0.41	95	3
KM54b	95	0.00002	0.00062	0.00003	0.05818	328.3	0.0919	0.0014	0.0140	0.0002	0.91	-13.72	0.44	79	30	89	3	90	2	90	2	0.47	90	2
KM54b	96	0.00001	0.00060	0.00003	0.05740	324.0	0.0944	0.0015	0.0142	0.0002	0.92	18.51	-0.84	111	30	92	3	91	3	91	3	0.17	91	3
KM54b	97	0.00001	0.00027	0.00001	0.02389	135.1	0.0999	0.0015	0.0149	0.0002	0.83	28.89	-1.58	134	38	97	3	95	2	95	2	0.05	95	2
KM54b	98	0.00001	0.00075	0.00004	0.03319	187.9	0.2053	0.0032	0.0296	0.0004	0.93	8.83	-0.72	206	28	190	5	188	5	189	5	0.20	188	5
KM54b	99	0.00001	0.00120	0.00006	0.10610	601.0	0.1001	0.0013	0.0152	0.0002	0.93	-4.55	0.17	93	24	97	2	97	2	97	2	0.72	97	2

Sample	Spot	Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Normal (Wetherill concordia plot)					Discordance			Ages					Preferred						
							Pb207U235	± 1s	Pb206U238	± 1s	Rho1	discTW	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s		
KM54b	100	0.00001	0.00067	0.00003	0.03060	173.0	0.2008	0.0030	0.0289	0.0004	0.93	14.71	-1.25	215	27	186	5	184	5	184	5	0.02	184	5		
KM54b	101	0.00002	0.00042	0.00002	0.04109	233.4	0.0906	0.0015	0.0137	0.0002	0.88	3.70	-0.14	91	38	88	3	88	3	88	3	0.86	88	3		
KM54b	102	0.00002	0.00028	0.00001	0.02550	156.7	0.0993	0.0012	0.0147	0.0001	0.64	35.02	-2.08	145	43	96	2	94	1	94	1	0.02	94	1		
KM54b	103	0.00002	0.00084	0.00004	0.07930	488.0	0.0925	0.0009	0.0141	0.0001	0.82	-6.79	0.23	84	27	90	2	90	1	90	1	0.67	90	1		
KM54b	104	0.00002	0.00056	0.00003	0.05530	341.0	0.0943	0.0011	0.0137	0.0001	0.67	54.81	-4.43	194	40	92	2	88	1	88	1	0.00	88	1		
KM54b	105	0.00002	0.00050	0.00002	0.04630	285.6	0.0956	0.0010	0.0144	0.0001	0.76	12.71	-0.54	106	31	93	2	92	1	92	1	0.38	92	1		
KM54b	106	0.00001	0.00094	0.00004	0.08440	521.0	0.1003	0.0010	0.0150	0.0001	0.82	19.04	-0.92	119	26	97	2	96	2	96	2	0.09	96	2		
KM54b	107	0.00001	0.00073	0.00003	0.06930	428.7	0.0919	0.0009	0.0140	0.0001	0.83	-4.80	0.17	85	27	89	2	89	1	89	1	0.76	89	1		
KM54b	108	0.00001	0.00024	0.00001	0.02201	136.2	0.0975	0.0011	0.0148	0.0001	0.73	1.41	-0.05	96	37	94	2	94	2	94	2	0.94	94	2		
KM54b	109	0.00001	0.00016	0.00001	0.01453	90.0	0.1033	0.0013	0.0150	0.0001	0.63	48.69	-3.78	187	44	100	2	96	1	96	1	0.00	96	1		
KM54b	110	0.00001	0.00055	0.00003	0.05120	317.2	0.0954	0.0009	0.0145	0.0001	0.80	-10.03	0.34	84	29	92	2	93	1	93	1	0.55	93	1		
KM54b	111	0.00001	0.00024	0.00001	0.02230	138.4	0.0939	0.0012	0.0141	0.0001	0.76	20.07	-0.92	113	38	91	2	90	2	90	2	0.24	90	2		
KM54b	112	0.00001	0.00058	0.00003	0.05430	337.0	0.0944	0.0011	0.0142	0.0001	0.77	21.71	-1.02	116	36	92	2	91	2	91	2	0.17	91	2		
KM54b	113	0.00002	0.00037	0.00002	0.03688	229.2	0.0903	0.0010	0.0135	0.0001	0.74	30.63	-1.56	125	35	88	2	86	1	86	1	0.03	86	1		
KM54b	114	0.00002	0.00044	0.00002	0.04121	256.3	0.0958	0.0010	0.0144	0.0001	0.80	12.87	-0.55	106	30	93	2	92	2	92	2	0.37	92	2		
KM54b	115	0.00001	0.00041	0.00002	0.03888	242.0	0.0924	0.0010	0.0141	0.0001	0.70	-24.04	0.70	73	37	90	2	90	1	90	1	0.34	90	1		
KM54b	116	0.00001	0.00029	0.00001	0.02677	166.7	0.1004	0.0011	0.0148	0.0001	0.73	39.41	-2.53	156	34	97	2	95	1	95	1	0.00	95	1		
KM54b	117	0.00001	0.00034	0.00002	0.03105	193.5	0.0980	0.0011	0.0148	0.0001	0.70	3.01	-0.12	98	38	95	2	95	1	95	1	0.88	95	1		
KM54b	118	0.00001	0.00054	0.00003	0.04880	304.0	0.1010	0.0010	0.0151	0.0001	0.76	20.82	-1.03	122	31	98	2	97	1	97	1	0.10	97	1		
KM54b	119	0.00001	0.00028	0.00001	0.02522	157.3	0.0994	0.0012	0.0150	0.0001	0.66	8.30	-0.35	105	41	96	2	96	1	96	1	0.68	96	1		
KM58	1	0.00001	0.00024	0.00001	0.02302	178.90	0.1022	0.0022	0.0152	0.0003	0.88	-43.13	1.68	139	47	99	4	97	4	97	4	0.08	97	4		
KM58	2	0.00002	0.01214	0.00136	0.05180	403.00	5.4633	0.1140	0.3410	0.0070	0.98	-0.37	0.18	1899	15	1895	36	1891	67	1898	14	0.84	1899	15		
KM58	3	0.00001	0.00021	0.00001	0.00703	54.70	0.3024	0.0069	0.0421	0.0009	0.93	-8.96	0.91	290	38	268	11	266	11	268	11	0.22	266	11		
KM58	4	0.00001	0.00508	0.00029	0.07910	615.00	0.7555	0.0170	0.0926	0.0021	0.98	-0.45	0.09	573	18	571	20	571	24	573	14	0.86	571	24		
KM58	5	0.00001	0.00011	0.00001	0.00869	67.50	0.1241	0.0033	0.0180	0.0004	0.87	-68.55	3.13	194	61	119	6	115	5	115	5	0.01	115	5		
KM58	6	0.00001	0.00012	0.00001	0.01516	117.90	0.0776	0.0022	0.0113	0.0003	0.82	-154.88	4.49	185	75	76	4	72	3	72	3	0.00	72	3		
KM58	7	0.00001	0.00138	0.00006	0.18150	1412.00	0.0710	0.0019	0.0107	0.0003	0.98	-38.31	1.07	95	25	70	4	69	4	69	4	0.03	69	4		
KM58	9	0.00001	0.00323	0.00024	0.02326	181.10	2.1471	0.0440	0.1993	0.0040	0.98	1.81	-0.64	1150	17	1164	28	1172	43	1153	16	0.36	1172	43		
KM58	10	0.00001	0.00342	0.00016	0.07400	4470.00	0.0568	0.0017	0.0085	0.0003	0.99	-105.35	2.34	112	20	56	3	55	3	55	3	0.00	55	3		
KM58	13	0.00000	0.00920	0.00045	0.60300	4707.00	0.1504	0.0030	0.0217	0.0004	0.97	-53.46	2.91	212	21	142	5	138	5	140	5	0.00	138	5		
KM58	14	0.00001	0.00008	0.00000	0.00684	53.50	0.1189	0.0033	0.0174	0.0004	0.88	-57.59	2.55	175	61	114	6	111	5	111	5	0.04	111	5		
KM58	17	0.00001	0.01504	0.00135	0.10440	818.00	2.6141	0.0631	0.2033	0.0049	0.99	-25.16	8.55	1493	15	1305	36	1193	52	1193	2	0.00	1493	15		
KM58	19	0.00001	0.00010	0.00000	0.00852	66.90	0.1190	0.0034	0.0171	0.0004	0.89	-94.02	4.08	212	60	114	6	109	6	110	6	0.00	109	6		
KM58	21	0.00001	0.00192	0.00015	0.01248	100.10	2.4179	0.0738	0.2150	0.0065	0.99	1.62	-0.60	1235	17	1248	44	1255	69	1236	17	0.57	1235	17		
KM58	22	0.00001	0.00711	0.00055	0.04760	382.00	2.3612	0.0616	0.2132	0.0055	0.99	3.28	-1.21	1205	16	1231	37	1246	58	1208	16	0.18	1205	16		
KM58	23	0.00001	0.00668	0.00038	0.10110	812.00	0.7563	0.0193	0.0930	0.0024	0.99	1.18	-0.24	566	18	572	22	573	28	568	15	0.68	573	28		
KM58	24	0.00001	0.00012	0.00001	0.01660	134.00	0.0716	0.0019	0.0105	0.0002	0.87	-161.00	4.34	175	61	70	4	67	3	67	3	0.00	67	3		
KM58	25	0.00001	0.00762	0.00123	0.02290	184.90	10.8931	0.3013	0.4740	0.0130	0.99	-0.94	0.52	2525	14	2514	52	2501	114	2524	14	0.68	2525	14		
KM58	26	0.00000	0.00211	0.00012	0.04140	336.00	0.5858	0.0079	0.0728	0.0022	0.99	-19.96	3.25	543	21	468	23	453	26	512	17	0.00	453	26		
KM58	27	-0.00001	0.00093	0.00004	0.09010	732.00	0.1005	0.0022	0.0146	0.0003	0.96	-107.85	4.01	194	28	97	4	93	4	93	4	0.00	93	4		
KM58	28	-0.00001	0.00128	0.00006	0.11490	936.00	0.1036	0.0022	0.0155	0.0003	0.97	-30.41	1.21	129	25	100	4	99	4	99	4	0.02	99	4		
KM58	29	-0.00001	0.00009	0.00000	0.00954	78.00	0.0864	0.0021	0.0132	0.0003	0.82	7.09	-0.24	78	65	84	3	84	3	84	3	0.85	84	3		
KM58	30	-0.00001	0.00011	0.00001	0.00902	73.90	0.1175	0.0034	0.0171	0.0004	0.87	-73.38	3.19	189	65	113	6	109	5	109	5	0.02	109	5		
KM58	31	-0.00001	0.00014	0.00001	0.01432	117.60	0.0917	0.0027	0.0140	0.0004	0.93	12.44	-0.45	78	50	89	5	89	5	89	5	0.66	89	5		
KM58	32	-0.00001	0.00099	0.00005	0.16630	1370.00	0.0562	0.0015	0.0084	0.0002	0.97	-124.52	2.72	121	29	55	3	54	3	54	3	0.00	54	3		
KM58	34	0.00000	0.00077	0.00006	0.00568	47.00	2.1398	0.0655	0.1990	0.0060	0.99	-2.00	-0.71	1146	21	1162	42	1170	65	1149	20	0.49	1170	65		
KM58	35	0.00000	0.00017	0.00001	0.001507	125.20	0.1042	0.0025	0.0154	0.0003	0.86	-59.08	2.32	156	57	101	5	98	4	98	4	0.05	98	4		

Sample	Spot	Normal (Wetherill concordia plot)										Discordance		Ages				Preferred						
		Pb204_V	Pb206_V	Pb207_V	U238_V	U_ppm	Pb207U235	± 1s	Pb206U238	± 1s	Rho1	disc1W	disc58	207Pb/206Pb	± 2s	207Pb/235U	± 2s	206Pb/238U	± 2s	Concordia	± 2s	probability	Age	± 2s
KM58	40	0.00005	0.00744	0.00051	0.06110	313.80	1.5158	0.0302	0.1546	0.0031	0.99	-3.65	1.07	961	13	937	24	927	34	956	12	0.06	927	34
KM58	42	0.00004	0.00048	0.00002	0.02820	144.40	0.1463	0.0024	0.0213	0.0003	0.92	-42.05	2.26	193	31	139	4	136	4	136	4	0.00	136	4
KM58	43	0.00004	0.00301	0.00022	0.02114	108.10	1.9057	0.0392	0.1842	0.0038	0.99	1.87	-0.63	1069	13	1083	27	1090	41	1071	12	0.34	1090	41
KM58	44	0.00004	0.00445	0.00056	0.01451	74.00	7.0883	0.1462	0.3910	0.0080	0.99	0.45	-0.23	2118	11	2123	37	2127	74	2118	11	0.80	2118	11
KM58	45	0.00004	0.00050	0.00002	0.03490	178.00	0.1245	0.0029	0.0182	0.0004	0.93	-46.76	2.17	171	39	119	5	117	5	117	5	0.01	117	5
KM58	46	0.00004	0.00376	0.00019	0.10610	540.00	0.3264	0.0062	0.0456	0.0009	0.98	2.14	-0.23	281	16	287	9	287	10	286	9	0.52	287	10
KM58	50	0.00003	0.00272	0.00014	0.08470	429.00	0.2957	0.0051	0.0416	0.0007	0.98	-1.16	0.12	266	16	263	8	263	9	263	8	0.73	263	9
KM58	51	0.00003	0.00266	0.00017	0.02427	122.80	1.2983	0.0024	0.1389	0.0024	0.98	-2.82	0.77	862	15	845	20	838	27	857	13	0.12	838	27
KM58	52	0.00003	0.00034	0.00002	0.02790	141.00	0.1047	0.0021	0.0155	0.0003	0.89	-49.57	1.97	148	43	101	4	99	3	99	3	0.02	99	3
KM58	54	0.00003	0.00081	0.00004	0.06520	329.00	0.1104	0.0017	0.0158	0.0002	0.93	-116.94	4.70	220	26	106	3	101	3	101	3	0.00	101	3
KM58	55	0.00003	0.00092	0.00004	0.08250	416.00	0.0956	0.0015	0.0144	0.0002	0.96	-21.72	0.80	112	21	93	3	92	3	92	3	0.06	92	3
KM58	56	0.00003	0.00026	0.00001	0.02142	107.90	0.1037	0.0020	0.0153	0.0003	0.91	-55.12	2.16	152	38	100	4	98	3	98	3	0.01	98	3
KM58	57	0.00002	0.00023	0.00001	0.02211	111.30	0.0927	0.0019	0.0137	0.0003	0.89	-79.69	2.80	157	43	90	4	88	3	88	3	0.00	88	3
KM58	58	0.00003	0.00123	0.00009	0.00856	43.00	1.9605	0.0290	0.1859	0.0027	0.97	-0.79	0.26	1108	16	1102	20	1099	29	1106	14	0.60	1099	29
KM58	60	0.00002	0.00041	0.00002	0.03370	171.30	0.1063	0.0027	0.0158	0.0004	0.96	-42.76	1.73	144	31	103	5	101	5	101	5	0.01	101	5
KM58	61	0.00002	0.00113	0.00005	0.08580	437.00	0.1181	0.0023	0.0173	0.0003	0.96	-58.67	2.58	175	25	113	4	110	4	111	4	0.00	110	4
KM58	62	0.00002	0.00092	0.00004	0.08650	441.00	0.0919	0.0018	0.0138	0.0003	0.97	-29.47	1.05	114	21	89	3	88	3	89	3	0.01	88	3
KM58	64	0.00001	0.00444	0.00046	0.01776	90.90	4.7763	0.0972	0.3220	0.0065	0.99	2.26	-1.05	1759	11	1781	34	1799	63	1760	11	0.21	1759	11
KM58	65	0.00001	0.00032	0.00002	0.02710	139.20	0.1046	0.0023	0.0153	0.0003	0.93	-73.77	2.89	171	38	101	4	98	4	98	4	0.00	98	4
KM58	66	0.00001	0.00082	0.00004	0.07510	386.00	0.0950	0.0023	0.0144	0.0003	0.98	-2.34	0.09	94	24	92	4	92	4	92	4	0.86	92	4
KM58	67	0.00002	0.00044	0.00002	0.04200	216.50	0.0928	0.0021	0.0137	0.0003	0.96	-67.93	2.40	148	31	90	4	88	4	88	4	0.00	88	4
KM58	68	0.00002	0.00021	0.00001	0.01794	92.70	0.0998	0.0018	0.0151	0.0002	0.89	5.70	-0.22	91	40	97	3	97	3	97	3	0.78	97	3
KM58	70	0.00002	0.00027	0.00001	0.02534	131.60	0.0974	0.0028	0.0144	0.0004	0.96	-55.18	2.05	143	40	94	5	92	5	93	5	0.01	92	5
KM58	71	0.00002	0.00300	0.00017	0.04660	242.00	0.6787	0.0150	0.0845	0.0019	0.99	-3.13	0.58	539	15	526	18	523	22	534	12	0.22	523	22
KM58	72	0.00002	0.00178	0.00009	0.10560	551.00	0.1517	0.0028	0.0220	0.0004	0.97	-39.97	2.21	196	22	143	5	140	5	142	5	0.00	140	5
KM58	74	0.00001	0.01310	0.00135	0.05900	309.40	4.3285	0.0898	0.2920	0.0060	0.99	-6.43	2.78	1758	12	1699	34	1652	60	1754	11	0.00	1758	12
KM58	75	0.00002	0.00138	0.00007	0.12500	656.00	0.1011	0.0024	0.0150	0.0004	0.98	-51.03	1.96	145	22	98	4	96	4	97	5	0.00	96	4
KM58	76	0.00002	0.00089	0.00004	0.10310	545.00	0.0781	0.0018	0.0114	0.0003	0.98	-133.85	3.94	171	22	76	3	73	3	73	3	0.00	73	3
KM58	77	0.00002	0.00109	0.00005	0.09350	495.00	0.1055	0.0021	0.0158	0.0003	0.98	-20.50	0.83	122	21	102	4	101	4	102	4	0.06	101	4

Appendix 6: Detrital zircon Hf isotope data of the analysed samples from the Indo-Burman Ranges

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
IBR71B_1	21.1	0.000947	0.000043	0.283015	0.000046
IBR71B_2	20.7	0.001236	0.000046	0.282505	0.000044
IBR71B_3	25.7	0.001112	0.000050	0.283095	0.000040
IBR71B_4	26.0	0.001019	0.000035	0.282961	0.000043
IBR71B_5	22.5	0.000791	0.000022	0.283102	0.000040
IBR71B_6	23.6	0.000919	0.000028	0.282973	0.000043
IBR71B_7	23.2	0.000899	0.000033	0.283040	0.000054
IBR71B_8	24.6	0.001269	0.000041	0.283034	0.000039
IBR71B_9	25.0	0.000881	0.000026	0.283054	0.000039
IBR71B_10	25.4	0.000330	0.000009	0.283058	0.000042
IBR71B_11	28.2	0.000641	0.000021	0.282598	0.000043
IBR71B_12	22.9	0.003174	0.000096	0.282937	0.000042
IBR71B_13	25.9	0.001203	0.000041	0.282778	0.000039
IBR71B_14	24.8	0.000546	0.000016	0.283103	0.000040
IBR71B_15	23.5	0.001024	0.000036	0.282868	0.000042
IBR71B_16	11.8	0.000838	0.000026	0.282427	0.000055
IBR71B_17	22.3	0.001307	0.000039	0.282982	0.000040
IBR71B_18	26.0	0.000652	0.000019	0.283060	0.000038
IBR71B_19	22.1	0.000560	0.000017	0.283133	0.000041
IBR71B_20	26.1	0.000577	0.000020	0.282975	0.000039
IBR71B_21	27.0	0.000571	0.000016	0.281734	0.000039
IBR71B_22	41.7	0.000863	0.000025	0.282961	0.000051
IBR71B_23	22.3	0.000251	0.000011	0.281951	0.000056
IBR71B_24	27.6	0.000968	0.000036	0.282019	0.000042
IBR71B_25	31.2	0.001731	0.000062	0.282412	0.000037
IBR71B_26	26.0	0.000555	0.000016	0.283007	0.000040
IBR71B_27	23.2	0.000509	0.000014	0.283101	0.000043
IBR71B_28	28.7	0.000406	0.000011	0.282156	0.000039
IBR71B_29	24.4	0.001100	0.000035	0.282906	0.000038
IBR71B_30	24.8	0.000462	0.000015	0.283109	0.000041
IBR71B_31	18.7	0.000815	0.000029	0.282564	0.000045
IBR71B_32	25.0	0.000949	0.000031	0.283078	0.000042
IBR71B_33	23.7	0.001208	0.000048	0.282947	0.000042
IBR71B_34	23.2	0.000980	0.000027	0.282455	0.000040
IBR71B_35	25.9	0.000912	0.000055	0.283123	0.000038
IBR71B_36	24.6	0.001928	0.000092	0.282883	0.000039
IBR71B_37	24.9	0.000758	0.000022	0.283005	0.000041

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
IBR71B_38	31.2	0.000740	0.000110	0.281996	0.000053
IBR71B_39	22.2	0.001838	0.000110	0.282909	0.000041
IBR71B_40	34.4	0.000641	0.000018	0.283051	0.000036
IBR71B_41	22.8	0.003376	0.000095	0.283003	0.000036
IBR71B_42	26.7	0.001268	0.000058	0.282819	0.000039
IBR71B_43	26.2	0.002243	0.000065	0.282360	0.000038
IBR71B_44	23.9	0.001306	0.000089	0.282994	0.000041
IBR71B_45	25.5	0.000467	0.000013	0.283025	0.000038
IBR71B_46	20.3	0.001747	0.000070	0.283079	0.000043
IBR71B_47	23.0	0.001264	0.000072	0.283005	0.000041
IBR71B_48	30.0	0.000334	0.000012	0.281696	0.000043
IBR71B_49	28.3	0.000449	0.000020	0.282219	0.000041
IBR71B_50	25.1	0.000691	0.000023	0.282906	0.000038
IBR71B_51	24.4	0.000579	0.000022	0.281953	0.000043
IBR71B_52	22.4	0.000758	0.000022	0.283102	0.000040
IBR71B_53	24.7	0.000868	0.000034	0.283121	0.000038
IBR71B_54	26.4	0.000757	0.000026	0.283089	0.000042
IBR71B_55	22.4	0.000942	0.000028	0.283091	0.000040
IBR71B_56	26.3	0.000854	0.000031	0.283041	0.000036
IBR71B_57	23.8	0.000520	0.000017	0.283031	0.000039
IBR71B_58	20.6	0.000958	0.000027	0.283074	0.000038
IBR71B_59	28.1	0.001700	0.000054	0.281789	0.000057
IBR71B_60	24.9	0.000517	0.000023	0.283053	0.000037
IBR71B_61	24.1	0.000702	0.000067	0.282513	0.000040
IBR71B_62	21.6	0.000837	0.000039	0.283054	0.000037
IBR71B_63	27.6	0.000721	0.000032	0.282336	0.000038
IBR71B_64	22.2	0.001320	0.000140	0.282858	0.000045
IBR71B_65	24.9	0.000484	0.000016	0.283114	0.000039
IBR71B_66	25.8	0.000469	0.000013	0.282941	0.000043
IBR71B_67	18.5	0.002660	0.000074	0.282654	0.000039
IBR71B_68	25.3	0.000498	0.000014	0.282278	0.000044
IBR71B_69	22.8	0.000843	0.000087	0.283103	0.000039
IBR71B_70	20.8	0.000673	0.000019	0.283105	0.000042
IBR71B_71	23.6	0.001589	0.000063	0.283062	0.000037
IBR71B_72	25.5	0.000721	0.000027	0.282480	0.000040
IBR71B_73	28.9	0.001434	0.000050	0.282170	0.000036
IBR71B_74	27.9	0.000919	0.000027	0.283032	0.000039

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
IBR71B_75	29.2	0.001800	0.000130	0.282938	0.000037
IBR71B_76	25.7	0.001420	0.000110	0.282913	0.000039
IBR71B_77	27.5	0.001753	0.000052	0.283028	0.000041
IBR71B_78	24.7	0.000585	0.000017	0.282991	0.000039
IBR71B_79	25.8	0.000379	0.000014	0.282561	0.000039
IBR71B_80	24.3	0.000535	0.000021	0.283103	0.000040
IBR71B_81	23.5	0.001625	0.000045	0.282953	0.000040
IBR71B_82	24.8	0.000683	0.000029	0.282956	0.000039
IBR71B_83	23.8	0.000702	0.000025	0.283104	0.000041
IBR71B_84	27.0	0.000884	0.000030	0.282353	0.000040
IBR71B_85	26.3	0.000572	0.000016	0.282280	0.000040
IBR71B_86	20.4	0.000947	0.000029	0.283082	0.000042
IBR71B_87	24.3	0.001109	0.000062	0.283098	0.000040
IBR71B_88	18.5	0.001630	0.000068	0.283031	0.000041
IBR71B_89	21.1	0.000682	0.000020	0.283070	0.000043
IBR71B_90	22.9	0.001025	0.000032	0.282615	0.000039
IBR71B_91	25.5	0.000709	0.000034	0.282973	0.000041
IBR71B_92	26.8	0.000943	0.000027	0.282655	0.000040
IBR71B_93	27.0	0.001750	0.000110	0.282786	0.000037
IBR71B_94	22.2	0.001246	0.000100	0.283064	0.000038
IBR71B_95	25.2	0.001540	0.000067	0.283062	0.000039
IBR71B_96	23.9	0.000472	0.000052	0.283038	0.000043
IBR71B_97	26.9	0.001036	0.000030	0.282934	0.000038
IBR71B_98	23.7	0.001549	0.000049	0.282476	0.000038
IBR71B_99	23.6	0.000639	0.000038	0.283074	0.000041
IBR71B_100	26.4	0.000740	0.000022	0.282868	0.000040
IBR71B_101	23.3	0.000873	0.000036	0.283060	0.000043
IBR71B_102	22.4	0.000615	0.000025	0.283023	0.000039
IBR71B_103	20.7	0.001649	0.000074	0.282425	0.000038
IBR71B_104	24.6	0.000638	0.000027	0.282994	0.000042
IBR71B_105	24.4	0.000816	0.000024	0.283038	0.000037
IBR71B_106	23.9	0.001044	0.000034	0.283012	0.000040
IBR71B_107	27.1	0.000507	0.000020	0.282446	0.000038
IBR71B_108	28.3	0.000734	0.000037	0.283073	0.000038
IBR71B_109	24.7	0.000552	0.000017	0.283033	0.000037
IBR71B_110	25.5	0.000918	0.000048	0.283045	0.000037
IBR71B_111	29.7	0.002689	0.000074	0.282922	0.000034

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
IBR71B_112	23.9	0.000813	0.000033	0.283011	0.000040
IBR71B_113	24.0	0.001332	0.000039	0.283000	0.000040
IBR71B_114	26.5	0.001082	0.000031	0.282607	0.000041
IBR71B_115	23.1	0.000750	0.000025	0.283137	0.000041
IBR71B_116	25.3	0.000557	0.000030	0.283139	0.000055
IBR71B_117	21.6	0.000755	0.000049	0.282634	0.000038
IBR71B_118	25.9	0.000518	0.000015	0.282987	0.000043
IBR71B_119	23.4	0.000954	0.000028	0.282455	0.000039
IBR71B_120	22.0	0.000973	0.000094	0.283028	0.000038
IBR71B_121	27.4	0.001136	0.000033	0.282935	0.000040
IBR71B_122	28.2	0.001935	0.000054	0.282418	0.000040
IBR71B_123	26.2	0.000962	0.000035	0.283084	0.000038
IBR71B_124	24.3	0.000576	0.000016	0.282601	0.000039
IBR71B_125	19.8	0.003512	0.000110	0.283024	0.000038
IBR71B_126	22.4	0.000845	0.000035	0.283028	0.000040
IBR71B_127	23.2	0.000845	0.000094	0.283063	0.000055
IBR71B_128	23.4	0.000939	0.000028	0.283095	0.000040
IBR71B_129	24.2	0.000996	0.000033	0.283120	0.000043
IBR71B_130	18.7	0.001374	0.000050	0.283068	0.000062

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM15_1	30.4	0.000521	0.000014	0.282417	0.000039
KM15_2	25.5	0.000558	0.000025	0.283035	0.000038
KM15_3	24.7	0.000631	0.000015	0.282863	0.000037
KM15_4	24.1	0.000804	0.000028	0.282750	0.000040
KM15_5	32.6	0.000693	0.000030	0.283002	0.000041
KM15_6	22.6	0.000654	0.000017	0.283115	0.000041
KM15_7	25.0	0.000825	0.000022	0.283064	0.000043
KM15_8	25.2	0.001224	0.000032	0.283118	0.000039
KM15_9	29.0	0.000417	0.000011	0.283062	0.000040
KM15_10	23.8	0.000676	0.000018	0.282152	0.000039
KM15_11	28.6	0.000942	0.000034	0.283042	0.000039
KM15_12	22.9	0.000606	0.000015	0.283070	0.000038
KM15_13	22.4	0.000454	0.000012	0.282942	0.000039
KM15_14	27.0	0.000820	0.000120	0.283021	0.000039
KM15_15	32.1	0.000647	0.000020	0.282979	0.000036
KM15_16	21.6	0.000513	0.000017	0.283062	0.000040
KM15_17	23.6	0.002560	0.000150	0.282481	0.000036
KM15_18	28.9	0.000548	0.000013	0.283020	0.000038
KM15_19	24.5	0.000505	0.000019	0.282992	0.000043
KM15_20	32.3	0.000600	0.000016	0.282972	0.000040
KM15_21	21.2	0.000659	0.000020	0.283109	0.000041
KM15_22	26.5	0.000847	0.000023	0.283137	0.000039
KM15_23	22.1	0.000939	0.000028	0.283077	0.000040
KM15_24	28.9	0.000657	0.000021	0.282471	0.000041
KM15_25	27.9	0.000660	0.000019	0.282364	0.000038
KM15_26	30.3	0.001060	0.000029	0.283074	0.000041
KM15_27	27.0	0.000629	0.000015	0.283065	0.000041
KM15_28	28.0	0.000940	0.000033	0.282969	0.000041
KM15_29	25.4	0.000610	0.000016	0.283089	0.000044
KM15_30	33.4	0.000674	0.000017	0.283048	0.000040
KM15_31	26.1	0.000966	0.000033	0.283013	0.000041
KM15_32	31.5	0.001407	0.000036	0.282901	0.000038
KM15_33	23.2	0.000425	0.000013	0.282475	0.000042
KM15_34	23.1	0.003609	0.000091	0.283002	0.000038
KM15_35	34.8	0.001211	0.000034	0.283110	0.000038

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM15_36	24.9	0.001081	0.000028	0.282953	0.000044
KM15_37	23.8	0.000818	0.000030	0.283019	0.000040
KM15_38	26.6	0.000851	0.000024	0.283026	0.000041
KM15_39	26.7	0.000892	0.000025	0.282966	0.000039
KM15_40	16.9	0.001801	0.000074	0.283038	0.000040
KM15_41	30.1	0.002554	0.000120	0.282286	0.000037
KM15_42	28.0	0.001006	0.000031	0.283072	0.000038
KM15_43	23.8	0.001642	0.000041	0.283096	0.000040
KM15_44	27.2	0.000550	0.000015	0.283096	0.000040
KM15_45	26.6	0.001141	0.000032	0.281964	0.000041
KM15_46	29.3	0.001339	0.000035	0.283089	0.000043
KM15_47	29.0	0.001483	0.000049	0.282320	0.000041
KM15_48	23.7	0.000762	0.000019	0.283038	0.000040
KM15_49	31.3	0.000488	0.000012	0.283035	0.000040
KM15_50	29.6	0.000848	0.000030	0.283070	0.000036
KM15_51	28.7	0.000822	0.000022	0.283033	0.000039
KM15_52	23.4	0.001071	0.000033	0.283007	0.000038
KM15_53	26.3	0.001020	0.000046	0.282968	0.000044
KM15_54	25.6	0.000508	0.000014	0.283033	0.000041
KM15_55	28.1	0.000528	0.000017	0.283093	0.000041
KM15_56	22.8	0.000458	0.000011	0.283016	0.000044
KM15_57	34.2	0.000811	0.000026	0.282994	0.000037
KM15_58	25.3	0.000813	0.000025	0.282964	0.000037
KM15_59	25.0	0.000411	0.000009	0.283068	0.000040
KM15_60	27.0	0.001006	0.000028	0.282657	0.000039
KM15_61	23.5	0.001252	0.000063	0.283066	0.000039
KM15_62	29.1	0.000371	0.000010	0.282977	0.000039
KM15_63	26.0	0.000392	0.000010	0.283061	0.000035
KM15_64	25.5	0.000813	0.000036	0.282593	0.000036
KM15_65	29.6	0.000740	0.000022	0.282467	0.000036
KM15_66	31.1	0.000570	0.000024	0.283018	0.000040
KM15_67	28.9	0.000372	0.000010	0.283115	0.000040
KM15_68	26.1	0.000421	0.000012	0.282488	0.000039
KM15_69	30.1	0.000305	0.000008	0.283012	0.000039
KM15_70	27.7	0.000840	0.000032	0.283110	0.000038

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM15_71	33.6	0.000408	0.000018	0.283045	0.000046
KM15_72	25.2	0.000453	0.000015	0.283075	0.000041
KM15_73	30.2	0.000498	0.000013	0.283001	0.000036
KM15_74	28.6	0.000495	0.000018	0.283130	0.000038
KM15_75	27.1	0.000322	0.000012	0.283092	0.000037
KM15_76	28.8	0.000749	0.000020	0.282990	0.000037
KM15_77	25.3	0.000488	0.000041	0.283001	0.000048
KM15_78	27.8	0.000400	0.000011	0.283038	0.000037
KM15_79	30.4	0.000603	0.000017	0.283045	0.000038
KM15_80	22.4	0.000855	0.000058	0.283122	0.000037
KM15_81	28.9	0.000520	0.000014	0.283079	0.000037
KM15_82	28.4	0.000413	0.000011	0.283113	0.000039
KM15_83	30.5	0.000370	0.000010	0.283107	0.000036
KM15_84	29.1	0.000398	0.000020	0.283070	0.000038
KM15_85	26.0	0.000546	0.000014	0.282949	0.000037
KM15_86	28.9	0.001162	0.000039	0.283084	0.000037
KM15_87	25.9	0.000681	0.000018	0.282996	0.000040
KM15_88	24.4	0.000911	0.000030	0.282971	0.000041
KM15_89	24.1	0.000391	0.000012	0.282333	0.000039
KM15_90	21.2	0.001638	0.000057	0.282387	0.000038
KM15_91	26.0	0.000424	0.000012	0.283032	0.000041
KM15_92	24.2	0.000998	0.000044	0.281785	0.000043
KM15_93	23.4	0.001320	0.000049	0.283071	0.000041
KM15_94	24.6	0.000587	0.000068	0.283039	0.000037
KM15_95	36.3	0.000526	0.000015	0.283096	0.000037
KM15_96	27.7	0.000457	0.000035	0.283015	0.000039
KM15_97	26.8	0.000176	0.000005	0.283126	0.000038
KM15_98	21.9	0.000554	0.000030	0.283024	0.000038
KM15_99	26.3	0.000265	0.000008	0.283060	0.000038
KM15_100	26.4	0.000717	0.000017	0.283091	0.000039
KM15_101	23.7	0.000646	0.000018	0.283023	0.000039
KM15_102	27.7	0.000639	0.000019	0.283072	0.000044
KM15_103	25.2	0.000472	0.000027	0.282270	0.000043
KM15_104	28.1	0.000459	0.000011	0.283029	0.000041
KM15_105	27.6	0.000769	0.000025	0.283046	0.000040

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM15_106	31.5	0.001556	0.000039	0.282976	0.000037
KM15_107	26.6	0.000635	0.000017	0.283042	0.000039
KM15_108	28.8	0.000640	0.000016	0.283049	0.000037
KM15_109	34.3	0.000820	0.000022	0.282208	0.000038
KM15_110	25.6	0.000732	0.000026	0.282898	0.000038
KM15_111	24.2	0.000814	0.000032	0.283009	0.000041
KM15_112	25.7	0.000900	0.000024	0.283106	0.000042
KM15_113	31.2	0.000430	0.000014	0.283057	0.000043
KM15_114	23.2	0.000965	0.000036	0.282933	0.000042
KM15_115	29.5	0.001275	0.000035	0.282850	0.000038
KM15_116	26.0	0.000952	0.000027	0.282955	0.000039
KM15_117	23.2	0.001693	0.000045	0.283107	0.000039
KM15_118	35.6	0.001906	0.000053	0.282381	0.000042
KM34_1	25.7	0.000437	0.000019	0.283144	0.000043
KM34_2	21.3	0.000464	0.000015	0.283146	0.000046
KM34_3	27.6	0.001990	0.000120	0.282431	0.000041
KM34_4	23.2	0.001025	0.000034	0.283126	0.000041
KM34_5	25.2	0.000770	0.000030	0.283115	0.000072
KM34_6	22.3	0.000741	0.000031	0.283048	0.000040
KM34_7	27.3	0.000631	0.000041	0.283056	0.000040
KM34_8	25.4	0.000919	0.000036	0.283106	0.000041
KM34_9	26.2	0.000353	0.000009	0.281989	0.000039
KM34_10	20.8	0.001074	0.000045	0.283167	0.000040
KM34_11	25.2	0.000778	0.000023	0.283139	0.000041
KM34_12	25.6	0.000356	0.000011	0.283066	0.000042
KM34_13	21.9	0.001336	0.000043	0.283146	0.000042
KM34_14	24.7	0.000651	0.000017	0.283069	0.000042
KM34_15	21.8	0.000501	0.000019	0.283061	0.000045
KM34_16	28.8	0.000316	0.000008	0.282138	0.000048
KM34_17	22.7	0.001747	0.000043	0.282936	0.000038
KM34_18	25.9	0.000739	0.000020	0.282449	0.000041
KM34_19	22.2	0.000638	0.000020	0.283167	0.000039
KM34_20	24.3	0.000760	0.000026	0.283159	0.000042
KM34_21	25.1	0.000782	0.000022	0.283111	0.000041

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM34_22	23.7	0.000650	0.000038	0.283141	0.000042
KM34_23	23.5	0.000868	0.000032	0.283127	0.000041
KM34_24	21.2	0.001255	0.000072	0.283166	0.000038
KM34_25	25.0	0.000520	0.000014	0.283104	0.000042
KM34_26	22.7	0.000560	0.000017	0.283149	0.000038
KM34_27	23.7	0.000527	0.000014	0.283142	0.000042
KM34_28	24.9	0.000604	0.000019	0.283085	0.000039
KM34_29	23.7	0.001006	0.000032	0.283149	0.000040
KM34_30	26.6	0.000604	0.000015	0.283117	0.000038
KM34_31	28.0	0.000516	0.000015	0.283109	0.000040
KM34_32	26.2	0.001980	0.000073	0.283044	0.000039
KM34_33	28.8	0.000379	0.000010	0.283106	0.000042
KM34_34	22.9	0.001392	0.000062	0.283112	0.000040
KM34_35	24.7	0.000437	0.000012	0.283142	0.000041
KM34_36	27.0	0.000694	0.000018	0.282616	0.000041
KM34_37	23.8	0.000583	0.000015	0.283132	0.000040
KM34_38	22.6	0.000828	0.000027	0.283160	0.000044
KM34_39	23.6	0.000422	0.000013	0.283140	0.000042
KM34_40	25.9	0.000993	0.000041	0.283074	0.000041
KM34_41	22.9	0.001146	0.000037	0.283116	0.000038
KM34_42	21.1	0.000700	0.000021	0.283143	0.000041
KM34_43	19.9	0.001120	0.000029	0.283117	0.000038
KM34_44	26.3	0.000541	0.000031	0.283091	0.000040
KM34_45	24.5	0.000360	0.000020	0.280874	0.000041
KM34_46	23.3	0.001181	0.000056	0.283148	0.000038
KM34_47	23.3	0.001146	0.000071	0.283125	0.000040
KM34_48	26.1	0.000450	0.000015	0.283136	0.000038
KM34_49	25.5	0.000528	0.000014	0.283124	0.000043
KM34_50	23.9	0.000467	0.000012	0.283125	0.000041
KM34_51	25.8	0.000550	0.000014	0.283166	0.000046
KM34_52	21.3	0.000913	0.000025	0.283123	0.000044
KM34_53	31.6	0.000502	0.000013	0.283129	0.000040
KM34_54	25.5	0.000351	0.000010	0.283156	0.000040
KM34_55	23.4	0.000350	0.000010	0.282428	0.000041
KM34_56	24.1	0.001409	0.000037	0.283149	0.000040

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM34_57	26.2	0.000855	0.000031	0.283086	0.000039
KM34_58	25.9	0.001812	0.000048	0.283146	0.000039
KM34_59	24.7	0.000307	0.000009	0.283146	0.000042
KM34_60	23.4	0.000961	0.000097	0.283135	0.000041
KM34_61	23.6	0.000579	0.000020	0.283141	0.000038
KM34_62	26.5	0.000633	0.000020	0.282561	0.000036
KM34_63	24.6	0.000496	0.000016	0.283110	0.000039
KM34_64	22.5	0.000975	0.000040	0.283158	0.000037
KM34_65	28.2	0.000621	0.000029	0.283033	0.000037
KM34_66	30.8	0.000828	0.000035	0.283135	0.000042
KM34_67	23.4	0.001246	0.000088	0.283162	0.000042
KM34_68	27.0	0.000570	0.000016	0.282794	0.000043
KM34_69	24.1	0.001041	0.000027	0.282288	0.000042
KM34_70	25.6	0.000558	0.000016	0.282617	0.000039
KM34_71	24.7	0.001396	0.000054	0.283118	0.000039
KM34_72	24.9	0.000655	0.000018	0.283150	0.000041
KM34_73	23.4	0.001193	0.000034	0.281881	0.000038
KM34_74	25.3	0.000774	0.000028	0.282602	0.000038
KM34_75	26.8	0.000573	0.000015	0.283104	0.000042
KM34_76	27.8	0.000823	0.000049	0.283131	0.000040
KM34_77	27.6	0.000601	0.000016	0.283113	0.000040
KM34_78	21.0	0.000372	0.000010	0.282503	0.000040
KM34_79	26.6	0.000972	0.000029	0.282388	0.000040
KM34_80	27.9	0.000585	0.000028	0.283130	0.000038
KM34_81	32.2	0.000400	0.000011	0.283053	0.000039
KM34_82	26.7	0.001364	0.000038	0.283088	0.000040
KM34_83	25.4	0.000651	0.000018	0.282778	0.000039
KM34_84	29.4	0.000845	0.000021	0.283040	0.000041
KM34_85	25.8	0.001095	0.000038	0.283115	0.000036
KM34_86	25.9	0.001055	0.000037	0.283161	0.000041
KM34_87	40.1	0.000685	0.000017	0.283101	0.000038
KM34_88	24.0	0.001010	0.000027	0.282386	0.000037
KM34_89	22.8	0.000908	0.000024	0.283081	0.000039
KM34_90	27.1	0.001151	0.000030	0.282287	0.000047
KM34_91	23.8	0.001763	0.000076	0.282799	0.000038

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM34_92	24.2	0.000847	0.000030	0.282072	0.000042
KM34_93	27.2	0.001850	0.000100	0.282308	0.000040
KM34_94	25.1	0.000532	0.000015	0.283142	0.000038
KM34_95	35.1	0.000564	0.000015	0.283075	0.000038
KM34_96	26.8	0.000293	0.000010	0.283097	0.000038
KM34_97	25.4	0.000455	0.000012	0.283118	0.000040
KM34_98	23.3	0.000411	0.000011	0.283031	0.000045
KM34_99	23.7	0.000787	0.000031	0.283025	0.000037
KM34_100	24.1	0.002547	0.000077	0.283048	0.000035
KM34_101	25.2	0.001149	0.000049	0.282913	0.000039
KM34_102	28.6	0.000594	0.000093	0.281908	0.000041
KM34_103	30.2	0.000541	0.000041	0.281001	0.000044
KM34_104	20.6	0.001512	0.000039	0.283127	0.000039
KM34_105	21.9	0.000545	0.000017	0.283156	0.000042
KM34_106	24.1	0.000712	0.000025	0.283135	0.000039
KM34_107	19.5	0.001506	0.000076	0.283142	0.000040
KM34_108	24.1	0.000357	0.000014	0.283107	0.000043
KM34_109	23.4	0.000889	0.000028	0.282756	0.000039
KM34_110	27.5	0.000365	0.000009	0.282459	0.000041
KM34_111	24.2	0.000519	0.000020	0.283138	0.000044
KM34_112	22.2	0.001619	0.000044	0.283105	0.000039
KM34_113	24.6	0.000587	0.000018	0.283136	0.000039
KM34_114	27.0	0.000432	0.000013	0.282188	0.000039
KM34_115	20.2	0.000634	0.000020	0.283114	0.000041
KM34a_1	23.1	0.001264	0.000034	0.283048	0.000047
KM34a_2	13.6	0.000543	0.000016	0.283027	0.000068
KM34a_3	24.2	0.000402	0.000011	0.283100	0.000043
KM34a_4	21.0	0.000407	0.000010	0.283134	0.000048
KM34a_5	24.5	0.000469	0.000016	0.283086	0.000045
KM34a_6	21.5	0.000590	0.000018	0.283119	0.000051
KM34a_7	26.6	0.000446	0.000016	0.283106	0.000046
KM34a_8	21.9	0.000794	0.000029	0.283039	0.000044
KM34a_9	24.8	0.000575	0.000017	0.283117	0.000047
KM34a_10	22.9	0.003420	0.000130	0.281854	0.000039

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM34a_11	28.6	0.000614	0.000027	0.283093	0.000049
KM34a_12	21.3	0.000978	0.000027	0.283134	0.000042
KM34a_13	23.4	0.001473	0.000094	0.283086	0.000043
KM34a_14	25.4	0.000458	0.000016	0.282191	0.000041
KM34a_15	26.6	0.000667	0.000018	0.283137	0.000048
KM34a_16	26.6	0.000596	0.000015	0.283045	0.000042
KM34a_17	27.8	0.000898	0.000026	0.283105	0.000048
KM34a_18	25.5	0.000339	0.000010	0.283084	0.000041
KM34a_19	24.2	0.000432	0.000014	0.283143	0.000042
KM34a_20	24.9	0.001182	0.000032	0.282819	0.000044
KM34a_21	25.0	0.000521	0.000013	0.283120	0.000045
KM34a_22	24.2	0.000432	0.000011	0.283108	0.000041
KM34a_23	29.1	0.000468	0.000018	0.283104	0.000042
KM34a_24	26.8	0.000569	0.000015	0.283131	0.000046
KM34a_25	18.0	0.000950	0.000023	0.283019	0.000051
KM34a_26	25.0	0.000610	0.000025	0.283148	0.000042
KM34a_27	26.2	0.000862	0.000046	0.283072	0.000048
KM34a_28	27.6	0.000251	0.000009	0.283091	0.000046
KM34a_29	24.9	0.000676	0.000019	0.283152	0.000041
KM34a_30	23.0	0.000752	0.000042	0.283117	0.000047
KM34a_31	25.0	0.000516	0.000018	0.283060	0.000046
KM34a_32	24.5	0.000843	0.000022	0.283148	0.000045
KM34a_33	25.0	0.000490	0.000013	0.283133	0.000046
KM34a_34	25.2	0.000512	0.000015	0.283108	0.000048
KM34a_35	25.2	0.000584	0.000019	0.283152	0.000049
KM34a_36	20.6	0.000750	0.000035	0.283165	0.000048
KM34a_37	24.7	0.000525	0.000017	0.283140	0.000046
KM34a_38	25.4	0.000924	0.000027	0.283143	0.000044
KM34a_39	25.4	0.000722	0.000019	0.283093	0.000045
KM34a_40	21.8	0.001474	0.000040	0.283140	0.000045
KM34a_41	30.0	0.000367	0.000045	0.281389	0.000043
KM34a_42	23.5	0.000454	0.000012	0.283074	0.000061
KM34a_43	24.5	0.000451	0.000012	0.283125	0.000047
KM34a_44	19.7	0.003265	0.000088	0.283064	0.000040
KM34a_45	22.0	0.001304	0.000037	0.282133	0.000041

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM34a_46	22.3	0.000629	0.000025	0.282082	0.000048
KM34a_47	26.8	0.000513	0.000013	0.283059	0.000043
KM34a_48	23.9	0.000410	0.000019	0.283138	0.000045
KM34a_49	25.0	0.001020	0.000028	0.282558	0.000041
KM34a_50	22.7	0.000796	0.000021	0.283125	0.000046
KM34a_51	20.5	0.000581	0.000016	0.283089	0.000052
KM34a_52	24.6	0.000338	0.000009	0.282249	0.000043
KM34a_53	31.3	0.000451	0.000012	0.283125	0.000046
KM34a_54	25.0	0.000774	0.000030	0.283097	0.000043
KM34a_55	20.9	0.000879	0.000025	0.283129	0.000047
KM34a_56	23.1	0.000405	0.000015	0.283052	0.000046
KM34a_57	23.8	0.000343	0.000010	0.283126	0.000046
KM34a_58	17.9	0.001330	0.000077	0.283028	0.000042
KM34a_59	20.7	0.001746	0.000057	0.283099	0.000045
KM34a_60	23.6	0.000582	0.000027	0.283108	0.000046
KM34a_61	22.2	0.000685	0.000021	0.283052	0.000041
KM34a_62	21.5	0.000854	0.000027	0.283039	0.000042
KM34a_63	23.5	0.000676	0.000019	0.283139	0.000043
KM34a_64	21.9	0.000490	0.000014	0.283118	0.000041
KM34a_65	23.9	0.001015	0.000028	0.283150	0.000048
KM34a_66	26.1	0.000866	0.000022	0.283151	0.000044
KM34a_67	21.7	0.001740	0.000110	0.283107	0.000047
KM34a_68	26.4	0.001514	0.000053	0.282408	0.000041
KM34a_69	24.1	0.000673	0.000032	0.282940	0.000041
KM34a_70	23.5	0.000805	0.000028	0.283130	0.000043
KM34a_71	19.4	0.001810	0.000200	0.283065	0.000045
KM34a_72	31.1	0.001107	0.000031	0.282223	0.000042
KM34a_73	22.7	0.000379	0.000012	0.283057	0.000046
KM34a_74	24.4	0.000811	0.000030	0.283098	0.000046
KM34a_75	19.8	0.002158	0.000059	0.282833	0.000045
KM34a_76	23.6	0.000555	0.000037	0.283131	0.000041
KM34a_77	23.4	0.000599	0.000018	0.283045	0.000053
KM34a_78	27.0	0.000684	0.000019	0.283019	0.000044
KM34a_79	22.4	0.000436	0.000014	0.283134	0.000043
KM34a_80	21.4	0.000801	0.000027	0.283094	0.000053

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM34a_81	22.1	0.000493	0.000014	0.283128	0.000048
KM34a_82	26.3	0.000603	0.000018	0.283104	0.000044
KM34a_83	24.1	0.000380	0.000011	0.283135	0.000043
KM34a_84	22.1	0.000224	0.000006	0.283131	0.000047
KM34a_85	23.6	0.000590	0.000018	0.283095	0.000044
KM34a_86	21.5	0.001518	0.000039	0.283108	0.000046
KM34a_87	26.7	0.000535	0.000016	0.283152	0.000044
KM34a_88	21.5	0.001134	0.000070	0.283040	0.000044
KM34a_89	20.7	0.001096	0.000079	0.283166	0.000050
KM34a_90	25.8	0.001777	0.000055	0.283143	0.000039
KM34a_91	24.2	0.000457	0.000017	0.283131	0.000045
KM34a_92	27.8	0.002310	0.000200	0.282011	0.000041
KM34a_93	26.6	0.000788	0.000021	0.283127	0.000040
KM34a_94	23.8	0.000687	0.000023	0.283095	0.000042
KM34a_95	21.1	0.000519	0.000019	0.283160	0.000048
KM34a_96	21.9	0.000646	0.000018	0.283184	0.000048
KM34a_97	22.2	0.000578	0.000015	0.283097	0.000043
KM34a_98	26.2	0.000729	0.000030	0.283115	0.000045
KM34a_99	25.3	0.000771	0.000020	0.283116	0.000045
KM34a_100	20.5	0.000624	0.000016	0.281428	0.000041
KM34a_101	22.9	0.000426	0.000012	0.281377	0.000043
KM34a_102	23.9	0.001012	0.000027	0.283139	0.000044
KM34a_103	22.7	0.000899	0.000027	0.283101	0.000043
KM34a_104	16.0	0.002919	0.000077	0.283114	0.000038
KM34a_105	23.2	0.000855	0.000035	0.283081	0.000047
KM34a_106	21.4	0.000704	0.000023	0.282768	0.000045
KM34a_107	24.3	0.001085	0.000028	0.283136	0.000046
KM34a_108	24.6	0.000364	0.000010	0.283124	0.000043
KM34a_109	24.2	0.000405	0.000011	0.283078	0.000044
KM34a_110	26.8	0.000362	0.000011	0.283010	0.000042
KM34a_111	23.6	0.000425	0.000015	0.283079	0.000049
KM34a_112	22.1	0.001473	0.000037	0.282605	0.000047
KM34a_113	24.7	0.000625	0.000018	0.282934	0.000046
KM34a_114	30.1	0.000404	0.000010	0.283151	0.000048
KM34a_115	25.7	0.000989	0.000039	0.283100	0.000045

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM34a_116	25.0	0.000492	0.000021	0.283141	0.000044
KM34a_117	25.5	0.001165	0.000030	0.283121	0.000051
KM34a_118	26.1	0.000695	0.000019	0.283108	0.000050
KM34a_119	22.1	0.000762	0.000023	0.283141	0.000044
KM34a_120	26.2	0.000511	0.000016	0.283080	0.000049
KM34a_121	25.8	0.000529	0.000018	0.283067	0.000039
KM34a_122	26.0	0.000780	0.000032	0.283098	0.000045
KM34a_123	25.9	0.000745	0.000021	0.283125	0.000050
KM34a_124	24.9	0.000520	0.000022	0.283065	0.000047
KM34a_125	25.4	0.000501	0.000020	0.283065	0.000052
KM34a_126	26.1	0.000556	0.000028	0.283110	0.000043
KM54b_1	25.9	0.000731	0.000028	0.283001	0.000043
KM54b_2	21.2	0.000621	0.000024	0.283021	0.000042
KM54b_3	24.6	0.000738	0.000027	0.283007	0.000045
KM54b_4	21.6	0.000873	0.000049	0.283011	0.000045
KM54b_5	25.7	0.000647	0.000035	0.282972	0.000051
KM54b_6	25.7	0.000710	0.000022	0.283037	0.000048
KM54b_7	26.5	0.000282	0.000012	0.283004	0.000045
KM54b_8	21.8	0.000719	0.000026	0.283000	0.000044
KM54b_9	27.2	0.000637	0.000019	0.282989	0.000045
KM54b_10	24.9	0.000505	0.000015	0.282992	0.000043
KM54b_11	28.1	0.000560	0.000016	0.282137	0.000038
KM54b_12	33.3	0.000662	0.000022	0.283048	0.000038
KM54b_13	27.4	0.000564	0.000025	0.282948	0.000045
KM54b_14	26.2	0.000621	0.000017	0.283008	0.000044
KM54b_15	26.6	0.001110	0.000049	0.282957	0.000040
KM54b_16	25.4	0.000540	0.000023	0.283003	0.000042
KM54b_17	26.0	0.000506	0.000018	0.283035	0.000039
KM54b_18	25.1	0.000629	0.000020	0.283035	0.000042
KM54b_19	26.7	0.000687	0.000022	0.283034	0.000042
KM54b_20	26.4	0.000643	0.000021	0.283089	0.000042
KM54b_21	26.0	0.000823	0.000036	0.283035	0.000039
KM54b_22	25.5	0.000727	0.000023	0.283036	0.000041
KM54b_23	26.6	0.000629	0.000021	0.283034	0.000040

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM54b_24	26.5	0.000376	0.000012	0.283099	0.000048
KM54b_25	27.6	0.000765	0.000023	0.283137	0.000044
KM54b_26	25.9	0.000438	0.000013	0.283046	0.000040
KM54b_27	27.3	0.000479	0.000018	0.283048	0.000043
KM54b_28	29.4	0.000567	0.000016	0.283070	0.000042
KM54b_29	26.9	0.000861	0.000025	0.283082	0.000041
KM54b_30	25.3	0.001105	0.000036	0.282995	0.000039
KM54b_31	26.8	0.000498	0.000014	0.283057	0.000039
KM54b_32	32.4	0.000610	0.000021	0.283061	0.000037
KM54b_33	26.7	0.000578	0.000017	0.283081	0.000040
KM54b_34	24.7	0.000447	0.000022	0.283049	0.000043
KM54b_35	19.0	0.001925	0.000053	0.283038	0.000039
KM54b_36	25.4	0.000662	0.000026	0.282999	0.000038
KM54b_37	26.5	0.000602	0.000025	0.283022	0.000039
KM54b_38	26.2	0.000656	0.000018	0.283094	0.000041
KM54b_39	26.8	0.000609	0.000022	0.283039	0.000038
KM54b_40	23.6	0.002817	0.000120	0.283017	0.000041
KM54b_41	22.9	0.001253	0.000043	0.283079	0.000040
KM54b_42	25.5	0.000344	0.000010	0.282855	0.000041
KM54b_43	26.1	0.000348	0.000012	0.282407	0.000037
KM54b_44	21.1	0.000810	0.000027	0.283007	0.000038
KM54b_45	23.8	0.000398	0.000016	0.283047	0.000040
KM54b_46	27.0	0.000671	0.000030	0.283024	0.000039
KM54b_47	23.5	0.000762	0.000030	0.283008	0.000039
KM54b_48	25.2	0.000398	0.000013	0.283007	0.000039
KM54b_49	21.7	0.000586	0.000017	0.283054	0.000044
KM54b_50	24.4	0.000298	0.000008	0.283033	0.000041
KM54b_51	25.1	0.000514	0.000016	0.283058	0.000043
KM54b_52	25.0	0.000391	0.000019	0.283039	0.000043
KM54b_53	24.1	0.000575	0.000033	0.283026	0.000042
KM54b_54	26.0	0.000380	0.000013	0.283101	0.000039
KM54b_55	23.7	0.000287	0.000009	0.281415	0.000039
KM54b_56	27.2	0.000396	0.000019	0.282890	0.000040
KM54b_57	19.7	0.000757	0.000028	0.283020	0.000041
KM54b_58	19.4	0.000604	0.000019	0.283022	0.000043

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM54b_59	27.8	0.001124	0.000032	0.283074	0.000043
KM54b_60	23.8	0.000389	0.000021	0.283051	0.000039
KM54b_61	24.5	0.000693	0.000023	0.283012	0.000045
KM54b_62	26.5	0.000446	0.000013	0.283048	0.000042
KM54b_63	24.1	0.000608	0.000019	0.283005	0.000044
KM54b_64	21.6	0.000637	0.000021	0.283018	0.000044
KM54b_65	21.1	0.001015	0.000035	0.283071	0.000046
KM54b_66	23.5	0.000361	0.000019	0.283032	0.000043
KM54b_67	25.4	0.000835	0.000023	0.283032	0.000041
KM54b_68	28.0	0.000560	0.000016	0.283009	0.000042
KM54b_69	26.6	0.000453	0.000014	0.282387	0.000042
KM54b_70	27.5	0.000523	0.000014	0.283007	0.000041
KM54b_71	24.4	0.001043	0.000047	0.283003	0.000041
KM54b_72	26.4	0.000842	0.000034	0.282940	0.000041
KM54b_73	25.3	0.000471	0.000021	0.282939	0.000045
KM54b_74	26.4	0.000572	0.000016	0.283042	0.000042
KM54b_75	29.4	0.000436	0.000015	0.283001	0.000043
KM54b_76	24.2	0.000431	0.000013	0.283033	0.000042
KM54b_77	27.8	0.000566	0.000018	0.283027	0.000042
KM54b_78	24.3	0.000478	0.000013	0.283054	0.000038
KM54b_79	25.0	0.000350	0.000012	0.283033	0.000042
KM54b_80	23.9	0.001008	0.000028	0.283048	0.000046
KM54b_81	30.0	0.000645	0.000021	0.282992	0.000043
KM54b_82	24.4	0.000514	0.000015	0.283007	0.000050
KM54b_83	24.1	0.000719	0.000023	0.283013	0.000042
KM54b_84	25.9	0.000733	0.000021	0.283045	0.000047
KM54b_85	22.4	0.000482	0.000023	0.283020	0.000044
KM54b_86	25.5	0.000522	0.000018	0.282984	0.000042
KM54b_87	23.7	0.000906	0.000055	0.282837	0.000039
KM54b_88	24.1	0.000464	0.000014	0.283026	0.000039
KM54b_89	25.1	0.000614	0.000022	0.283002	0.000039
KM54b_90	24.2	0.000537	0.000018	0.283023	0.000041
KM54b_91	25.4	0.000374	0.000010	0.283015	0.000045
KM54b_92	26.3	0.000462	0.000015	0.283008	0.000040
KM54b_93	21.6	0.000873	0.000041	0.283027	0.000039

SelectionLabel	TotalHf	176Lu177Hf	± 2SE	176Hf177Hf	± 2SE
KM54b_94	28.3	0.000449	0.000014	0.283077	0.000040
KM54b_95	24.5	0.000843	0.000032	0.283010	0.000042
KM54b_96	27.2	0.000441	0.000012	0.283050	0.000044
KM54b_97	27.2	0.001105	0.000034	0.283102	0.000042
KM54b_98	27.3	0.000845	0.000023	0.283013	0.000043
KM54b_99	24.8	0.000587	0.000019	0.283067	0.000042
KM54b_100	19.8	0.000585	0.000019	0.283054	0.000041
KM54b_101	24.9	0.000687	0.000022	0.283031	0.000040
KM54b_102	20.6	0.001244	0.000056	0.283039	0.000046
KM54b_103	24.5	0.000406	0.000015	0.283029	0.000042
KM54b_104	24.8	0.000643	0.000028	0.283016	0.000043
KM54b_105	25.2	0.000445	0.000012	0.283039	0.000042
KM54b_106	21.2	0.001030	0.000049	0.283007	0.000040
KM54b_107	24.6	0.000598	0.000025	0.283048	0.000044
KM54b_108	26.1	0.000484	0.000014	0.283045	0.000044
KM54b_109	24.8	0.000427	0.000054	0.283011	0.000051
KM54b_110	25.4	0.000527	0.000019	0.283032	0.000038
KM54b_111	24.3	0.000651	0.000022	0.283094	0.000041
KM54b_112	25.2	0.000502	0.000015	0.283051	0.000040
KM54b_113	22.5	0.000662	0.000024	0.283042	0.000039
KM54b_114	21.1	0.000804	0.000034	0.283009	0.000040
KM54b_115	24.8	0.000442	0.000013	0.283033	0.000040
KM54b_116	21.7	0.001154	0.000044	0.283073	0.000037
KM54b_117	23.7	0.000720	0.000023	0.283048	0.000037
KM54b_118	22.8	0.000750	0.000024	0.283060	0.000041
KM54b_119	26.3	0.000304	0.000019	0.283043	0.000046