The first directly dated evidence for Palaeolithic occupation on the Indian coast at Sandhav, Kachchh

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Abstract:

South Asia has a rich Palaeolithic heritage, and chronological resolution for this record has substantially improved over the past decade as a result of focused, interdisciplinary research at a number of key sites. Expanding the spatial diversity of dated Palaeolithic sites in South Asia grows increasingly important to examine how patterns of change through time vary within and between the region's diverse habitats. Critically, alternate models of modern human dispersals into South Asia highlight the significance of either coastal or continental routes of dispersal, but currently no coastal Palaeolithic sites directly dating to the timeframe of human expansions are known. Our previous research in Kachchh was the first study to clearly identify the presence of Palaeolithic sites in Late Pleistocene landscapes in close proximity to the Indian Ocean coastline. Here, we present the first results of surface survey and test excavation at the site of Sandhav (Kachchh, India), approximately 25km from the modern shoreline. We characterise the geomorphology of the landscape, highlighting multiple phases of alluvial aggradation and post-depositional carbonate formation, associated with Palaeolithic artefacts. To date, excavations have tested the uppermost Pleistocene deposit, yielding a small collection of fresh Middle Palaeolithic artefacts associated with a luminescence age dating to the first half of MIS 5 (~114 ka), which provides a minimum age for Late Acheulean artefacts in underlying units. We discuss our findings in the context of debates surrounding the timing, lithic technologies, and ecologies associated with the expansions of modern humans into South Asia.

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Introduction:

South Asia plays a unique role in debates surrounding the dispersal of modern humans from Africa due its central location on hypothesised eastward routes of expansion across Asia. The scarcity of human fossils in South Asia prohibits detailed examination of biological evolution in the region (Athreya, 2015), further complicated by the recent discoveries of demographic diversity in Southeast (Demeter et al., 2012; Détroit et al., 2019; Shackelford et al., 2018), East (Michel et al., 2016; Zhou et al., 2017) and Central Asia (Jacobs et al., 2019; Zhang et al., 2018). As a result, examination of the nature and timing of human dispersals in South Asia have relied upon archaeological and environmental records (Blinkhorn and Petraglia, 2017). Initially, models for human dispersal focused heavily upon coastal corridors of expansion out of Africa and into South Asia, arguing that a single ecological adaptation could enable a recent (~60 thousand years ago [ka]) and rapid expansion from Africa to Australia, reconciling evidence from archaeological and mitochondrial DNA studies (Mellars, 2006; Mellars et al., 2013). Over the past decade, a number of interdisciplinary research projects have been conducted that have substantially advanced our understanding of the chronology, biogeography and variability of human behaviour in Late Pleistocene South Asia (Blinkhorn & Petraglia 2017; Roberts et al., 2018). Alongside a range of inter-regional evidence, more recent models argue this evidence supports earlier (Marine Isotope Stage [MIS] 5: 128-71ka), continental routes of expansion from Africa to South Asia (Blinkhorn and Petraglia, 2014; Boivin et al., 2013; Groucutt et al., 2015a, 2015b). Moreover, Late Pleistocene occupations in South Asia are now known to span a broad range of ecologies, from desert (Blinkhorn et al., 2013) to tropical rainforest (Deraniyagala, 1992; Perera, 2011; Roberts et al., 2017; Wedage et al., 2019), and from broad low-lying river valleys (Petraglia et al., 2012) to high altitude settings (Corvinus et al., 2007).

This fits with growing evidence that Late Pleistocene *Homo sapiens* occupied, and specialized in, a diversity of more 'extreme' settings around the world by the end of the Pleistocene (Roberts and Stewart, 2018). Indeed, if coastal settings were important to the movement of human populations into and beyond South Asia, then they were one of a number of diverse settings relevant to human adaptations at this time. GIS-based models of human expansion into South Asia have supported the feasibility of coastal dispersals in the region, but also highlight the large number of river corridors as likely routes of expansion inland (Field et al., 2007). Prominent models of coastal expansion around the Indian Ocean Rim argue that a single economic adaptation to coastal contexts would enable human dispersals (Mellars, 2006; Stringer, 2000). However, this may overlook the variability in coastal resources that are accessible to human populations as well as the dramatic changes in ecology in the coastal hinterlands in South Asia. A more nuanced assessment is presented by Erlandson and Braje (2015), who have highlighted the importance of mangrove habitats as likely centres of Late Pleistocene human occupation and engagement with marine resources in South Asia. Beyond opportunities to access distinct suites of floral and faunal resources, proximity to the shoreline may have other benefits for human habitation, such as increases in precipitation that would be particularly marked on the edge of arid zones. Studies from both the Eastern African and Arabian coastlines have failed to support predictions from coastal dispersal models (Shipton et al. 2018; Groucutt et al. 2015b), yet very limited work has been conducted on the South Asia coastline. Here, we present dated evidence for a Middle Palaeolithic occupation close to the coast at the site of Sandhav (Kachchh, Gujarat, India) (Figure 1).

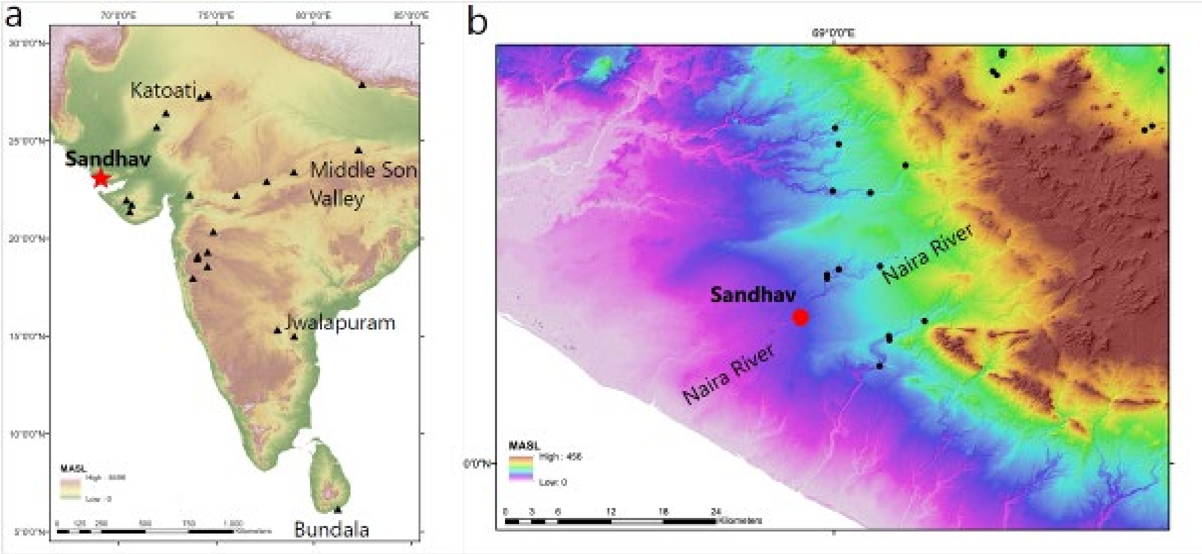

Figure 1: Location maps showing (left) the position of Sandhav (red star) in South Asia with respect to other dated Late Pleistocene Middle Palaeolithic sites (black triangles), including those mentioned in the text on an SRTM digital elevation model showing meters above sea level (MASL) (Jarvis et al. 2008) and (right) the location of Sandhav (red circle) and the Naira River in southern Kachchh with respect to other Palaeolithic sites reported from Kachchh (black dots; Blinkhorn et al. 2017) on an ALOS digital elevation model (Tadono et al. 2014).

Sandhav, Kachchh: Environments and Archaeology

Kachchh is a district of Gujarat, India, lying immediately east of the Indus delta, and currently experiences a semi-arid climate with average annual rainfall of ~350mm, and mean daily temperatures ranging from 17.9 to 32°C. The central uplands of Kachchh are formed of east-west oriented hill ranges, resulting from active fold-thrust tectonism, draining into the Arabian Sea to the southwest and the Gulf of Kachchh to the southeast, whereas northward channels drain into the Raans of Kachchh, low-lying seasonal wetlands. Recent studies present evidence for the uplift of the central hill ranges during the Late Pleistocene through to the present (Das et al., 2016; Prizomwala et al., 2016). Remote sensing (Ghose et al., 1979; Gupta et al., 2011) and sediment core studies (Clift et al., 2012; Khonde et al., 2017) suggest that the Raans formed part of the Late Pleistocene Ghaggar-Hakra drainage, which was active until the Holocene. Studies of the Indus delta fan indicate complex patterns of sediment deposition and recycling alongside mobility of the sub-marine Indus Canyon, with significant volumes of post-glacial sedimentation (Clift et al., 2014). The relationship between the modern and Pleistocene coastline in the region is not straightforward, suggesting that the modern bathymetry of the South Asian coastline need not directly reflect the past coastline. Meanwhile, greater fluvial contribution to the Raans alongside raised sea-levels may have further isolated Kachchh from mainland Gujarat, with the region forming either a distinct peninsula or a chain of islands.

Following earlier research, our survey of Kachchh revisited known sites in the northern catchments and identified the first Palaeolithic sites in the southern catchments, including the site of Sandhav (E68° 58', N23° 09'; 35m above sea level) (Blinkhorn et al., 2017). This study repeatedly identified Middle Palaeolithic assemblages associated with Late Pleistocene landforms, whereas microlithic assemblages, predicted by coastal dispersal models to indicate the arrival of modern humans, were only identified on top of the recent land surfaces. Maurya and colleagues (2008, 2003) have undertaken geomorphological mapping of the Naira River, identifying ravines and gullies cutting through an alluvial plain down to the modern river channel, alongside a spatially discontinuous

Holocene terrace. Upriver of Sandhav, a sediment section recorded by Maurya and colleagues (2003; 2008) illustrates a sequence with (from top down) single silt, brown soil and red soil horizons split by 1m thick gravel levels. A single radiocarbon age from pedogenic carbonate in the upper portion of the brown soil dates to 18,320±250 C14 yr (22,210-21,320 cal yr BP), providing a minimum age for sediment deposition. Amongst the sites identified in the southern draining river valleys, Sandhav, on the Naira River, was noted as yielding lithic artefacts from a number of sediment units, underlying the brown soil horizon previously dated to MIS 2 (Blinkhorn et al. 2017). We targeted alluvial deposits at Sandhav for more detailed examination of the relationship between lithic artefacts and sediment units, and to explore their age and environment.

Methods:

Pedestrian survey was conducted along the riverbanks and associated stream cuttings (*nallahs*) Sandhav to characterise the nature of archaeological deposits present, with artefact collection aiming to collect the breadth of technological types (flakes, cores, heavy tools, retouched tools) from distinct sediment contexts. Six discrete sampling locations were identified and labelled Sandhav 1-5 (in the order of discovery) and Siruvandh. Schematic sedimentary logging for the section of river system with abundant stone tools was conducted on the eastern banks of the Naira river and associated *nallahs*. Test excavation (Test Pit 1) focused upon the uppermost artefact bearing alluvial deposits in a $1m^2$ trench to a total depth of 2.9m, differentiating single sediment contexts into 10cm spits where necessary to constrain artefact provenance. This trench was expanded laterally to sample up to $5m^2$ in a key artefact bearing horizon to increase sample sizes. Sediment samples were recovered at 10cm intervals in the upper 1.9m of deposit, and subject to laser particle size analysis, loss on ignition, magnetic susceptibility and ICP-OES studies. Pedogenic carbonates, where present, were subsampled from these sediments and subject to stable isotope analyses, while a sample for potassium feldspar infrared stimulated luminescence (IRSL) dating was recovered at a depth of 1.7m associated with a key artefact horizon (see SI1 & 2 for details). Primary assessment of lithic artefacts involved identifying raw material use and counting and classifying artefacts employing commonly used typological terminology.

Results:

Sediment Contexts and Palaeoenvironments

Below agriculturally modified sediments, four broad major landforms were identified, labelled Naira Unit (NU) 1 to 4 across the six sampling locations. The uppermost deposits (NU1) comprise a range of fluvial silts, sands and gravels (predominately composed of larger silicified sandstone clasts, with finer quartz and chert clasts), with some spatial variability in the appearance of weak powdery calcrete, observed either *in situ* or eroding at all sites except for Sandhav 5. A sharp increase in the presence of carbonates is identified at the contact with NU2, comprised of cycles of silty sands and gravels, and was exposed in varying thickness in all Sandhav sites. NU3 comprises cemented carbonate rich alluvial sediments primarily exposed at Sandhav 4 and 5, which overly the fourth major unit, NU4, a reddish-brown clay that is prominent at Sandhav 5. Lithic artefacts were predominately found eroding from NU1 and NU2 deposits, whereas isolated artefacts were found cemented into NU3 deposits, and none were observed *in situ* in NU4 clays.

Excavations targeted NU1 deposits at Sandhav 2 in Test Pit 1, that also includes NU2-4 sediments, described in Table 1. Beyond differences in sediment composition, laboratory analyses identified limited variability in the NU1 sediments (Figure 2). Level 7 shows a higher level of magnetic susceptibility, despite the higher presence of carbonate, which may signal some variability in sediment source. The scale of weathering processes affecting Level 3, evident from Chemical Index of Alteration and the Weathering Index of Parker, appears different to the variability observed in other horizons. Isotopic analysis of pedogenic carbonates suggest two distinct environmental phases. A strong presence of C_3 vegetation and less evaporative contexts is evident between 0.74-1.4m suggests a suppressed summer monsoon, with a greater proportion of C_4 vegetation and more evaporative contexts between 1.51-1.95m indicative of an enhanced summer monsoon. A single IRSL sample was processed from Level 6, yielding a mean age of 113.80 ± 12.81ka (see SI2).

Table 1: Sandhav 2: TP1 sediment descriptions including identification of Naira Unit (NU), Level number, depth from surface, and description combining field observation with results of LPSA analysis.

NU	Level	Depth (m)	Description
1	1	0-0.05	Friable mid brown, bimodal, very poorly sorted, very coarse silty very fine sand, with rare grits. Lithic artefacts n=5
1	2	0.05-0.55	Compact, dark brownish grey, trimodal, very poorly sorted, very coarse silty very fine sand, with common grits.
1	3	0.55-0.8	Moderately compact, mid brownish yellow, trimodal, very poorly sorted, very coarse silty fine sand with common grit. Lithic artefacts n=2
1	4	0.8-1	Compact mid yellowish brown, polymodal, very poorly sorted, very coarse silty fine sand
1	5	1-1.6	Compact, mid brownish grey, trimodal, very poorly sorted, cross bedded sandy gravel, fining upwards from very coarse silty very coarse sands to very coarse silty very fine sand. Lithic artefacts n=31
1	6	1.6-1.75 IRSL: 113.8 ± 12.81ka	Friable, yellow, trimodal, very poorly sorted, very coarse silty coarse sand. Lithic artefacts n=17
1	7	1.75-1.95	Compact, mid brownish grey, unimodal, very poorly sorted, cross bedded gravelly very coarse silty very fine sand. Lithic artefacts n=10
2	8	1.95-2.25	Compact pale reddish grey, trimodal, very poorly sorted very coarse silty very fine sand and powdery calcrete
3	9	2.25-2.65	Mixed $CaCO_3$ gravelley sand with occasional cobbles. Lithic artefacts n=1
3	10	2.65-2.9	Cemented $CaCO_3$ and fine sediments, with occasional gravels
4	11	2.9+	Mottled reddish silty clays

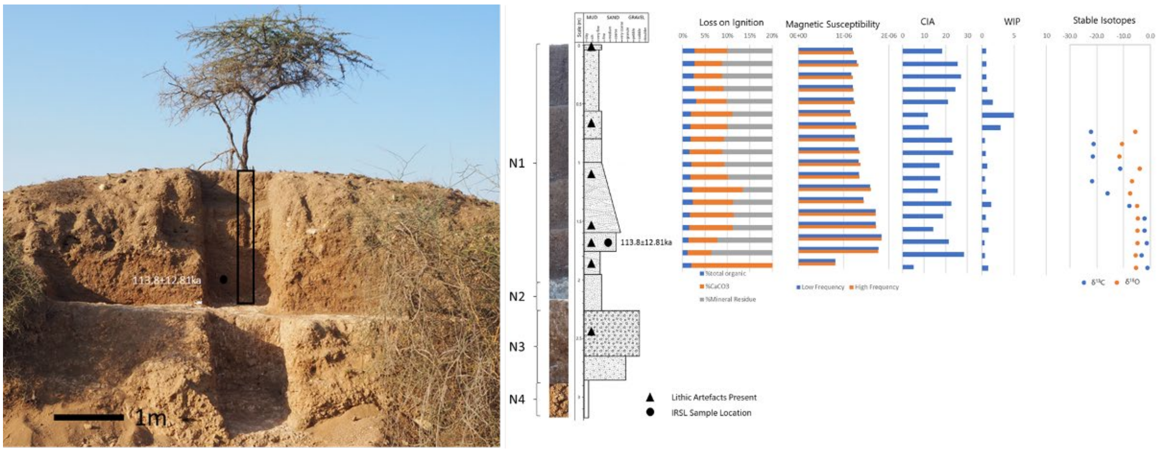

Figure 2: (left) Excavations at TP1, Sandhav2 illustrating the sampling profile for detailed sediment studies (black box) and IRSL sample location (black dot); (right) Section diagram from excavation at Sandhav showing (from left to right): photographic record, stratigraphic log indicating the presence of artefacts by sediment horizon and the location of IRSL sample, results of Loss on Ignition, Magnetic Susceptibility (Blue: LF, Orange: HF); Chemical Index of Alteration (molar %), Weathering Index of Parker, and stable isotope analyses (carbon and oxygen) of pedogenic carbonates.

Lithic Assemblages

Surface assemblages have been collected from Sandhav over the course of three seasons (2015; 2016; 2019) and are reported in Table SI3.1. Artefacts are most numerous at Sandhav 2 (n=128), predominately deriving from NU1 deposits, with sizeable collections at Sandhav 1 (n=90) and Sandhav 4 (n=64) indicating rich artefact collections in NU2 deposits as well. The bifacial handaxe at Sandhav 4 (Figure 3), associated with NU2 or NU3 deposits, may suggest a Late Acheulean presence. The presence of Levallois technologies alongside a diverse retouched toolkit, including retouched points and tanged pieces, largely associated with NU1 deposits indicates Middle Palaeolithic occupations. Raw material use predominately focuses upon siliceous sandstones, which are locally available in the form of cobbles within gravel horizons. Smaller and more finely crafted artefacts, including Middle Palaeolithic types, focus on the use of cherts, as well as a distinctive non-local green siliceous stone, and are typically associated with NU1 deposits.

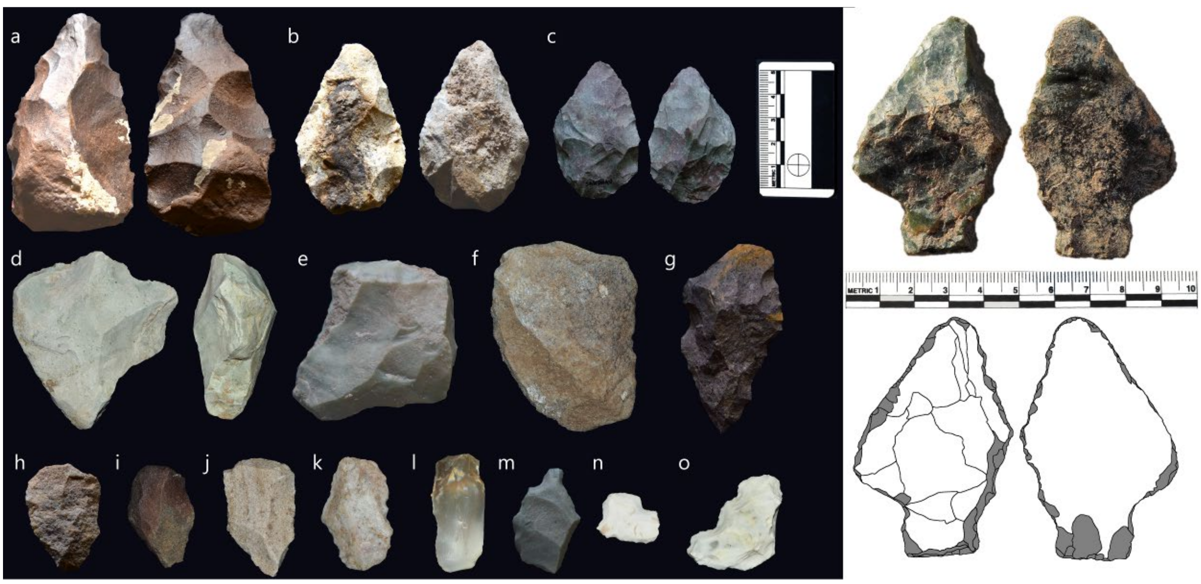

Figure 3: (left) Lithic artefacts from surface contexts at Sandhav including (a) an Acheulean handaxe [Sandhav 4]; (b & c) small bifaces/cores [Sandhav 4; Sandhav 1], (d) prepared core [Sandhav 2], (e) prepared core [Sandhav 2; eroding from section adjacent to TP1 Level 6]; (f) large flake [Sandhav 2]; (g) retouched flake [Sandhav 1]; (h, i, j & k) retouched flakes [Sandhav 2]; (l) blade [Sandhav 2]; (m) tanged tool [Sandhav 3]; (n) broken tanged tool [Sandhav 2]; (o) notched tool [Sandhav 2]; (right; top) tanged point recovered from TP1 Level 6, with (right; bottom) schematic depiction of retouch in grey.

A more limited range of artefact types were recovered from excavation (Table SI3.2). Two discrete concentrations of artefacts were identified in Level 5, which are differentiated by depth between upper (1.1-1.4m) and lower (1.5-1.6m) assemblages. Core technology predominately comprises single and multi-platform types, with a single discoidal core recovered from Level 6. A large multi-platform core is the only artefact recovered from NU2 deposits. Debitage that is diagnostic of specific reduction practices are absent although the fresh appearance of both complete and broken elements, including small pieces <20mm, does suggest reduction was undertaken at the site. Retouched artefacts include a finely crafted example of a tanged point produced on green siliceous material. A break is evident on one side of the piece, which may explain why the tool was discarded.

Discussion:

We describe an alluvial sediment sequence from Sandhav, the upper component of which (NU1) dates to the early Late Pleistocene and preserves evidence for Middle Palaeolithic occupation within close proximity to the coastline during MIS 5 and humid environmental conditions. Lateral variability was observed in the expression of NU1 deposits, becoming substantially thicker upstream, with evidence for supressed summer monsoon intensity in the upper levels of NU1 deposits at Sandhav consistent with a minimum age from MIS 2 reported by previous research (Maurya et al. 2008). The basal date from NU1 presents a minimum age for the underlying formations (NU2-4) that are therefore likely to represent Middle Pleistocene sequences, which would be consistent with the presence of Late Acheulean populations. The chronology of Middle Palaeolithic assemblages from test excavation, dating to ~114ka, falls precisely between the oldest Middle Palaeolithic assemblage known from elsewhere in western South Asia, dating to ~96ka at Katoati (Blinkhorn et al. 2013), and the youngest Late Acheulean assemblages across the subcontinent, dating to ~130ka in the Middle Son Valley (Haslam et al., 2011). This fills a notable gap in the Palaeolithic chronologies of South Asia (see Blinkhorn & Petraglia 2017), whilst broadening the geographic and ecological range of Late Pleistocene occupations sites.

With a basal date of ~114ka, NU1 deposits are the oldest chronometrically dated sediment formation across Kachchh as elsewhere research has focused on the terminal Pleistocene and Holocene sediment archives (Chowksey et al., 2012; Das et al., 2016; Maurya et al., 2008; Prizomwala et al., 2016; Roy et al., 2013), enabling broader regional comparisons. Quaternary archives in Kachchh are notably different from adjacent Saurashtra given the absence of miliolites (Bhatt, 2003), which were deposited over a comparable timeframe to Late Pleistocene NU1 deposits, suggesting distinct sedimentary processes despite the proximity of the regions. The MIS 5 stable isotope record from Sandhav matches records from MIS 5 horizons at Katoati (Blinkhorn et al., 2017), suggesting strong C_4 communities flourished in the context of increased monsoonal intensity. Close comparisons between isotopic records in both the north-east Thar Desert and coastal Kachchh during MIS 5 may indicate broadly similar environments during the timeframe of modern human dispersals across Asia.

This focused study corroborates the results of earlier archaeological surveys in Kachchh, which indicate widespread presence of Middle Palaeolithic assemblages within suites of Late Pleistocene sediments, alongside more limited occurrence of Late Acheulean technologies (Ansari and Pappu, 1973; Blinkhorn et al., 2017). Late Palaeolithic industries, characterised in the region by the use of microblade technologies and the prominence of backed retouched pieces, appear absent from Late Pleistocene sediments. This is particularly notable as the upper deposits of NU1 overlap in age with Late Palaeolithic occupations in western South Asia at Buddha Pushkar (Blinkhorn, 2018). In contrast, although Late Acheulean technologies have been identified elsewhere across Kachchh, they frequently occur in heavily reworked contexts. The presence of stratified artefacts in sediment deposits pre-dating MIS 5 may offer the potential to explore longer term patterns of behavioural change in the region.

The presence of multiple tanged artefacts, both in excavation and from surface surveys, alongside the use of Levallois technologies fit neatly with expressions of Middle Palaeolithic assemblages from western South Asia (Blinkhorn et al., 2015), as well as elsewhere in the Indian subcontinent, such as Jwalapuram 22 (Clarkson et al., 2012), that have been directly linked with expanding populations of modern humans. Critically, functional studies in other regions have illustrated how the production of tangs on lithic artefacts relates to hafting practices (Tomasso and Rots, 2018). While to date no comparable studies have been conducted for Palaeolithic artefacts in South Asia, the presence of multiple tanged artefacts at Sandhav may offer some of the earliest indices for hafting practices in the region, and is comparable to tanged artefacts reported from Late Pleistocene Middle Palaeolithic sites including Patne, Katoati, Jwalapuram, the Sagileru Valley, and Chamu (Blinkhorn 2019). Current models support a modern human expansion into South Asia during MIS 5 associated with Middle Palaeolithic technologies (Blinkhorn & Petraglia 2017). The absence of tanged artefacts from Middle Palaeolithic assemblages associated with modern humans in South-West Asia is notable. Comparative studies are required to resolve whether the appearance of tanged points in South Asia marks an independent innovation of a functionally significant feature of hafting technologies or reflects cultural inheritance from populations further to the west, such as those producing Aterian industries. Significant changes in environment and ecology, as well as the nature and distribution of lithic raw materials and other resources that may be important for hafting practice (such as mastic ingredients) occur at the western margin of South Asia, relating to the transition to the monsoonal zone and distinct geological history of the Indian tectonic plate. Examining human expansions through the lens of hafting practices may offer new avenues to explore patterns of adaptation and innovation in the face of radically new habitats (Blinkhorn 2019).

The proximity of Sandhav to the modern coastline is particularly notable amongst broadly contemporaneous sites (Figure 1). The Middle Palaeolithic occupation at Bundala, Sri Lanka, in the latter stages of MIS 5 (Deraniyagala 1993) offers the only parallel, although renewed dating and more detailed descriptions of lithic technology are required for effective comparisons. The relationship between the modern and ancient coastline of Kachchh is not straightforward. Yet the combination of active tectonism and considerable fluvial dynamism modulating offshore deposition as well as sedimentation of the Raans of Kachchh may support the proximity of Sandhav to ancient shorelines and raise the prospect that Kachchh was disconnected from the mainland during the last interglacial, either seasonally or throughout the year. In spite of this unique landscape, the Middle Palaeolithic occupations at Sandhav suggest a shared technological repertoire to contemporaneous inland sites, both at the western edge of the monsoonal zone and across South Asia. Despite the prominence of coastal models for modern human dispersals from Africa around 60ka, this evidence from Sandhav better supports models for earlier expansions in MIS 5 associated with Middle Palaeolithic technologies that are shared in both continental and coastal contexts. This research helps to illuminate the high environmental variability associated with early expansions of modern human populations into South Asia, rather than narrow ecological specialisations, and such plasticity may have been critical to successful expansion into the regions mosaic habitats and beyond.

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The authors declare no competing interests.

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