

MINERALISATION, GREISENISATION AND KAOLINISATION  
AT GOONBARROW CHINA CLAY PIT, CORNWALL, U.K.

Colin James Bray, B.Sc..

Pembroke College

Thesis presented to the University of Oxford  
for the degree of Doctor of Philosophy

Trinity 1980

Volume II : FIGURES AND PLATES

### List of Figures

1. The St. Austell granite showing mineral lodes (after Exley, 1955).
2. The St. Austell granite showing mineral lodes (after Dines, 1956).
3. The St. Austell granite showing granite types and china clay producing pits.
4. Position of old mines and china clay pits in relation to the present Goonbarrow pit.
5. Cross-section showing veins in the Old Beam area.
6. Cross-section showing veins on the island opposite Old Beam.
7. Cross-section showing veins in Imperial Goonbarrow (western end of north face).
8. Cross-section showing veins in Imperial Goonbarrow (central area of north face).
9. Cross-section showing veins in Imperial Goonbarrow (eastern end of north face).
10. Cross-section showing veins in Imperial Goonbarrow (south face).
11. Cross-section showing veins on the island opposite Old Beam (south face).
12. Cross-section showing veins in the area near Martins Goonbarrow.
13. Equal area projection of the poles to the veins at Goonbarrow.
14. Equal area projection of the poles to the veins at Goonbarrow.
15. Sketch map showing localities of specimens used for K/Ar dating.
16. The China Clay refining process.
17. The overall sequence of geological events at Goonbarrow.
18. Necking down of an inclusion with time from its original state.
19. An example of a CO<sub>2</sub> inclusion.
20. A "Boiling" assemblage.

21. The vertical relationships of the ore-mineral zones in south-west England.
22. Histogram of fluid inclusion filling temperatures from Goonbarrow.
23. Histogram of salinities of fluid inclusions from Goonbarrow.
24. Graphical plot of filling temperature against salinity for inclusions in Goonbarrow vein samples.
25. Boiling point curves for 10, 25 and 40 wt % NaCl.
26. Filling temperature vs. hydrostatic pressure for 10, 25 and 40 wt % NaCl brines.
27. Loge (specific volume) against temperature for pure water at various pressures.
28. Block diagram of the JEOL X-ray energy dispersive analysing system.
29. An X-ray spectrum obtained from a cubic daughter mineral.
30. X-ray spectrum from vein quartz attached to a brass holder.
31. X-ray spectra obtained from two daughter minerals within a fluid inclusion from a quartz-tourmaline vein.
32. X-ray spectra obtained from two daughter minerals within a fluid inclusion from a quartz-tourmaline vein.
33. Plot of  $\delta D$  vs  $\delta^{18}O$  values of minerals and waters from Cornish granites, alteration haloes, china clay deposits, sedimentary clay deposits of Bovey Tracey and modern meteoric waters.
34. Plot of  $\delta D$  vs  $\delta^{18}O$  for calculated isotopic composition of the waters that would be in equilibrium with the unaltered granites at magmatic temperatures, and the alteration minerals at the stated temperatures.
35. Plot of  $\delta D$  vs.  $\delta^{18}O$  of vein quartz, greisen muscovites and their calculated waters from Goonbarrow.

36. Calculated  $\delta^{18}\text{O}$  compositions of waters in equilibrium with Goonbarrow vein quartz and greisen muscovite at various temperatures.
37. Mixing relationships between magmatic and other waters.
38. Oxygen fractionation curve between water(l) and water(v).
39. Hydrogen fractionation curve between water(l) and water(v).
40. The dependence of boiling induced liquid and vapour compositions on the sign of the hydrogen fractionation factor.
41. Overall model to explain the observed isotopic compositions of vein quartz, greisen muscovites and kaolinites from Goonbarrow.
- A1. The Institute of Geological Sciences' high vacuum extraction line for the determination of the argon isotopic compositions of rocks and minerals.
- A2. The Chaixmeca heating/freezing stage.
- A3. Schematic diagram showing the adaption of the Chaixmeca stage to eliminate "frost buildup" on the bottom condenser.
- A4. Plot of melting point vs. heating rate for signotherm SK70 calibration standard.
- A5. Plot of melting point vs. heating rate for signotherm SK100 calibration standard.
- A6. Plot of melting point vs. heating rate for signotherm SK135 calibration standard.
- A7. Plot of melting point vs. heating rate for signotherm SK180 calibration standard.
- A8. Plot of melting point vs. heating rate for signotherm SK200 calibration standard.
- A9. Plot of melting point vs. heating rate for signotherm SK247 calibration standard.



- A10. Plot of melting point vs. heating rate for sodium nitrate calibration standard.
- A11. Plot of melting point vs. heating rate for potassium dichromate calibration standard.
- A12. Final calibration graph for the Chaixmeca stage.

Figure 1. The St. Austell granite showing mineral lodes (after Exley, 1955)

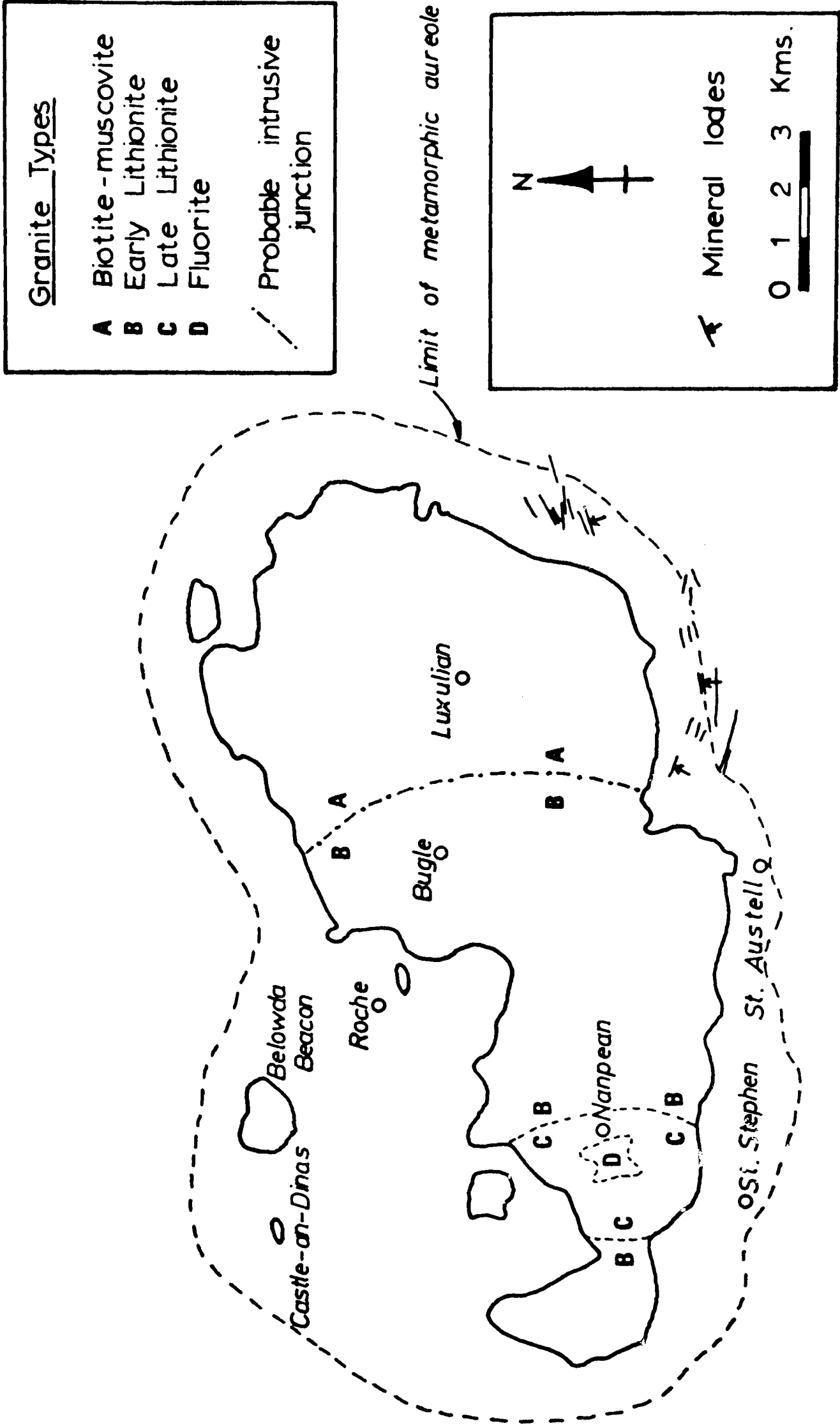


Figure 2. The St. Austell granite showing mineral bodes (after Dines, 1956)

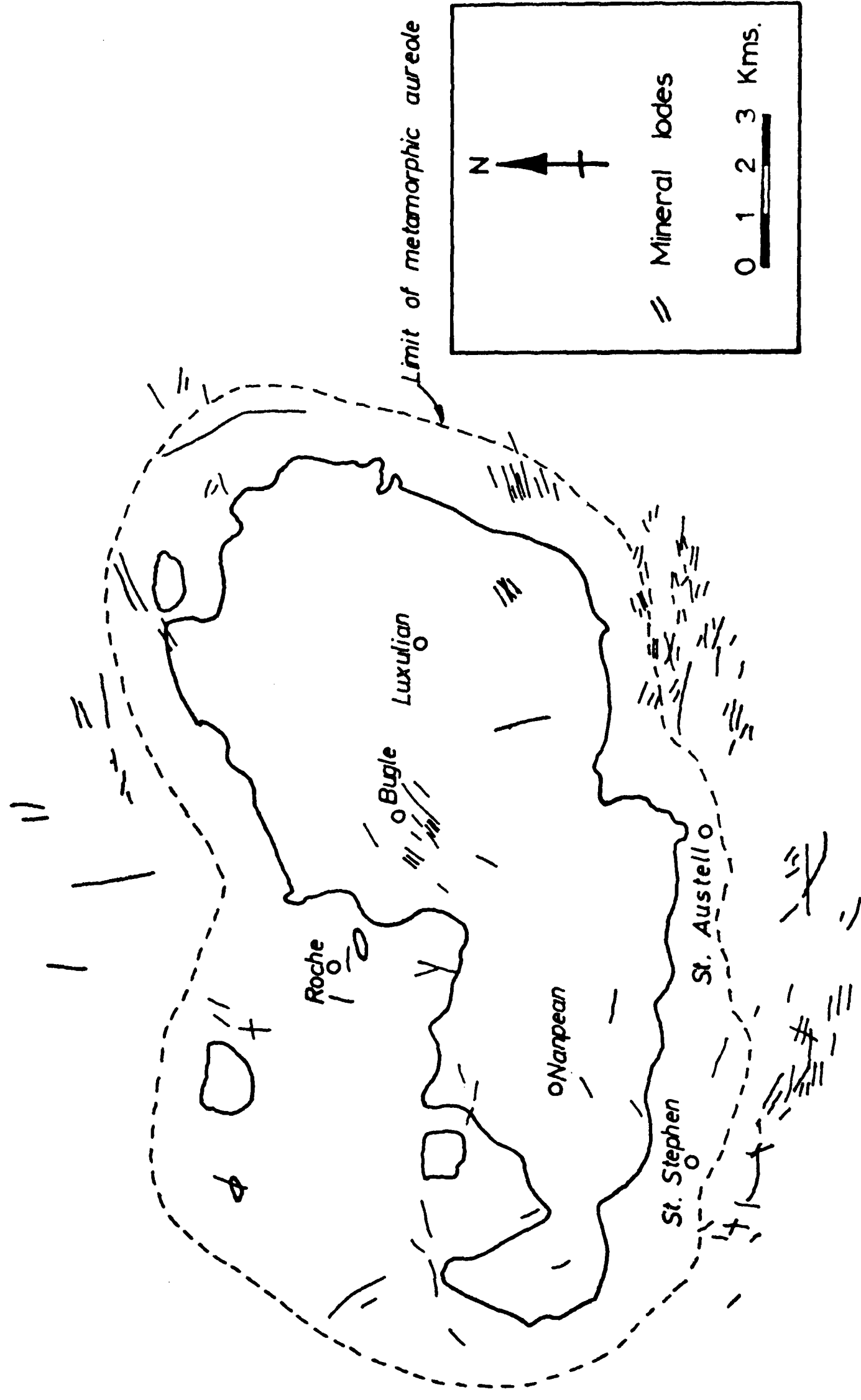


Figure 3. The St. Austell granite showing granite types and china clay producing pits.

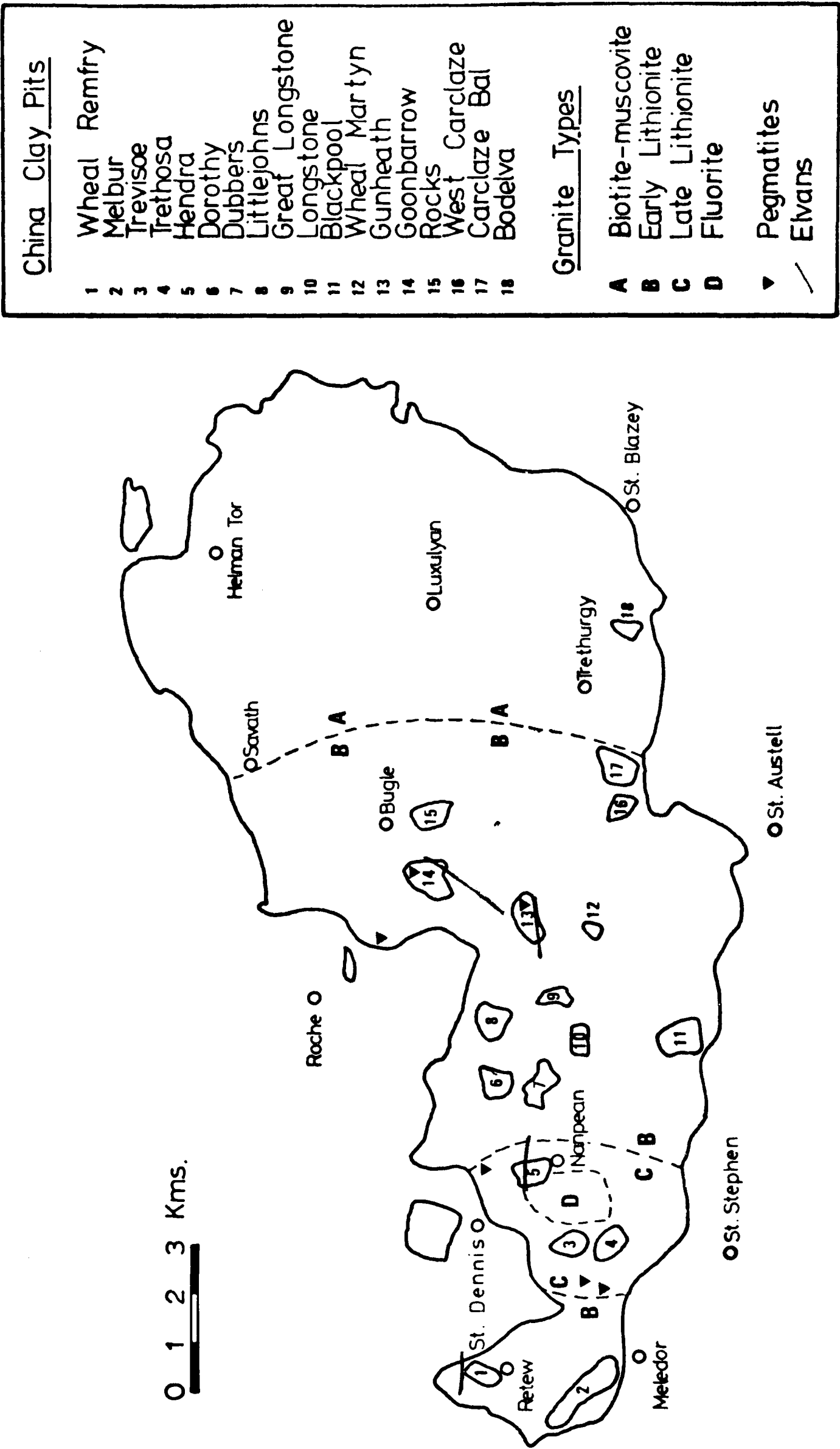


Figure 4. Position of old mines and china clay pits in relation to the present Goonbarrow pit.

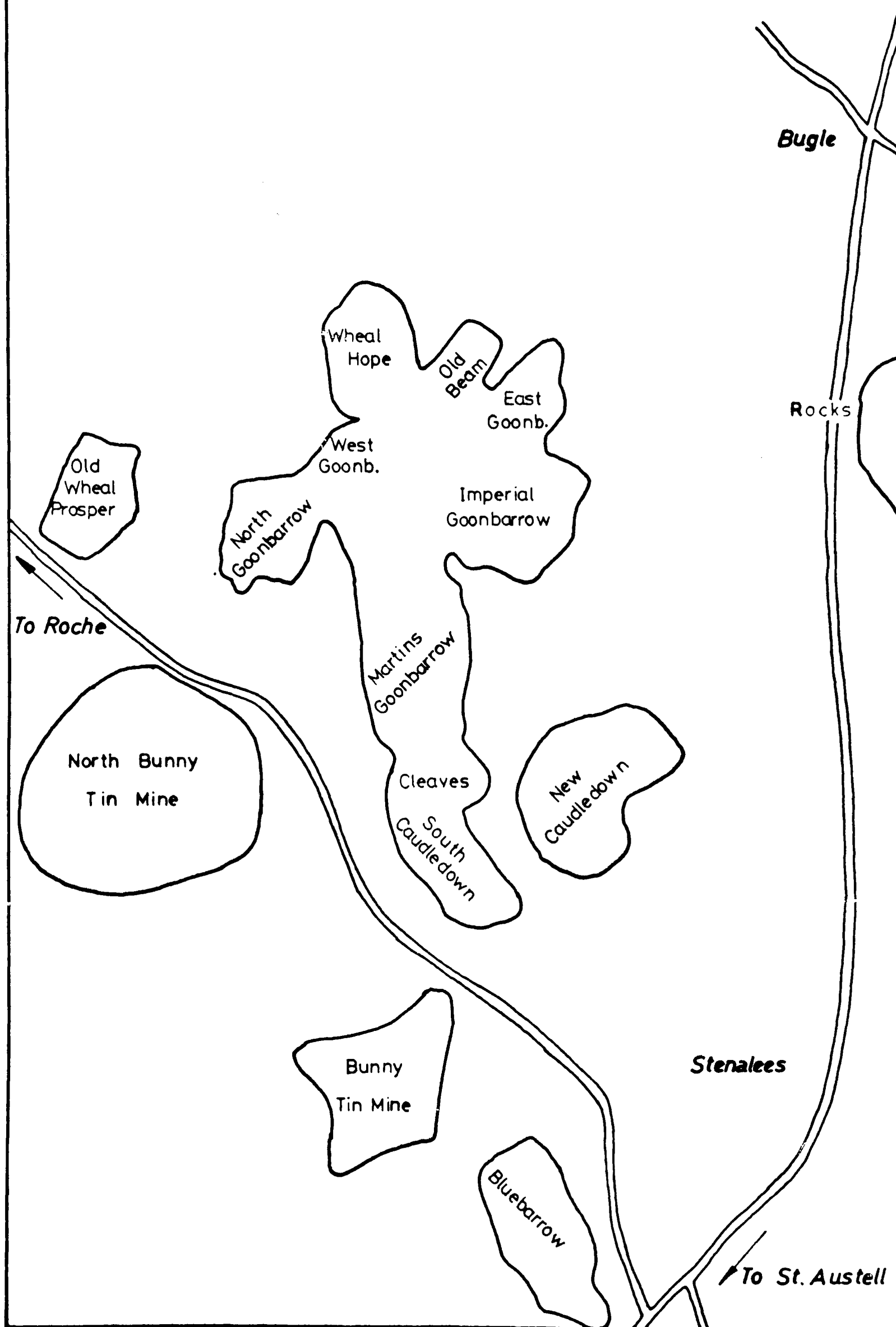
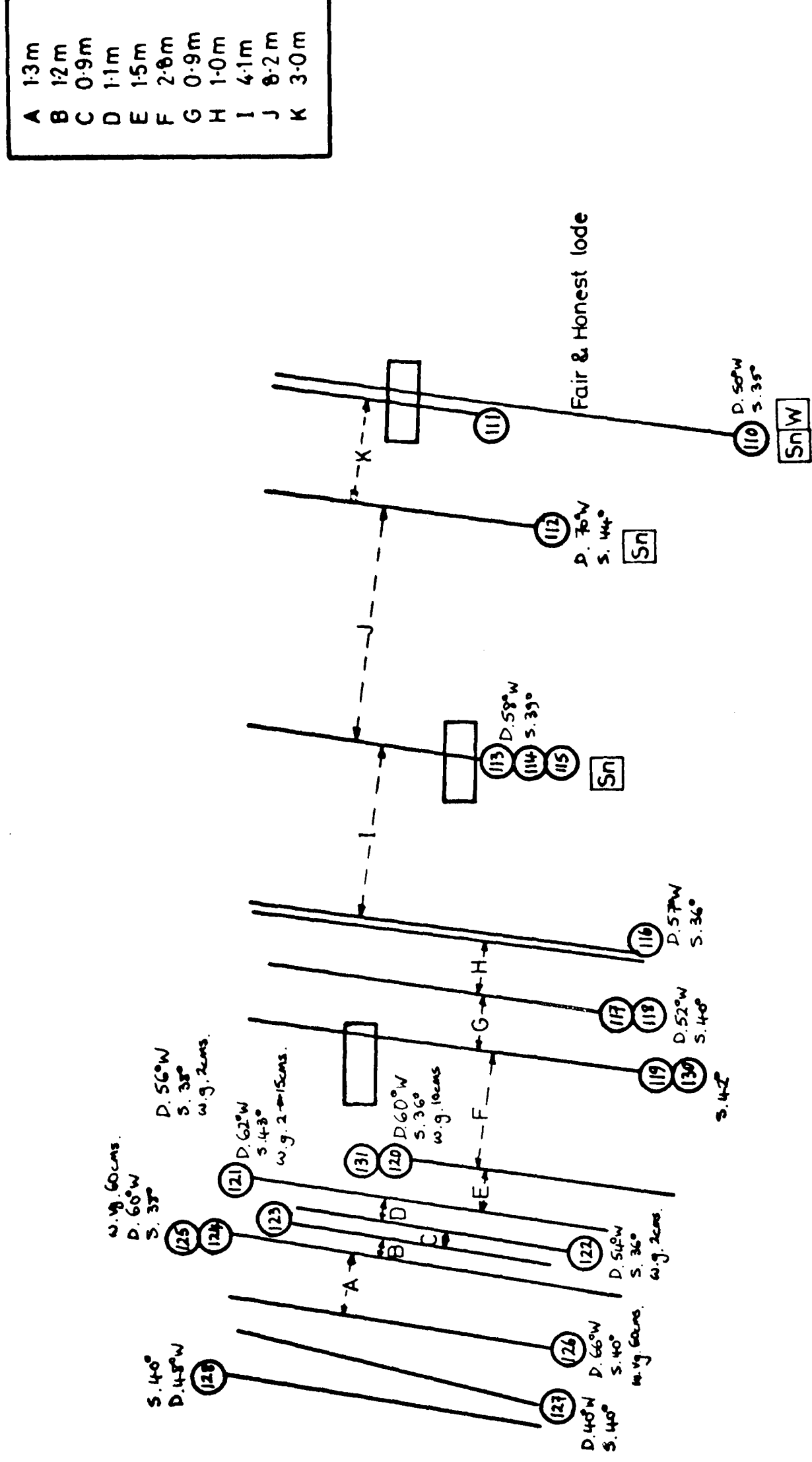


Figure 5. Cross-section showing veins in the Old Beam area



All this area intensely kaolinised

Figure 6. Cross-section showing veins on the island opposite Old Beam (now removed)

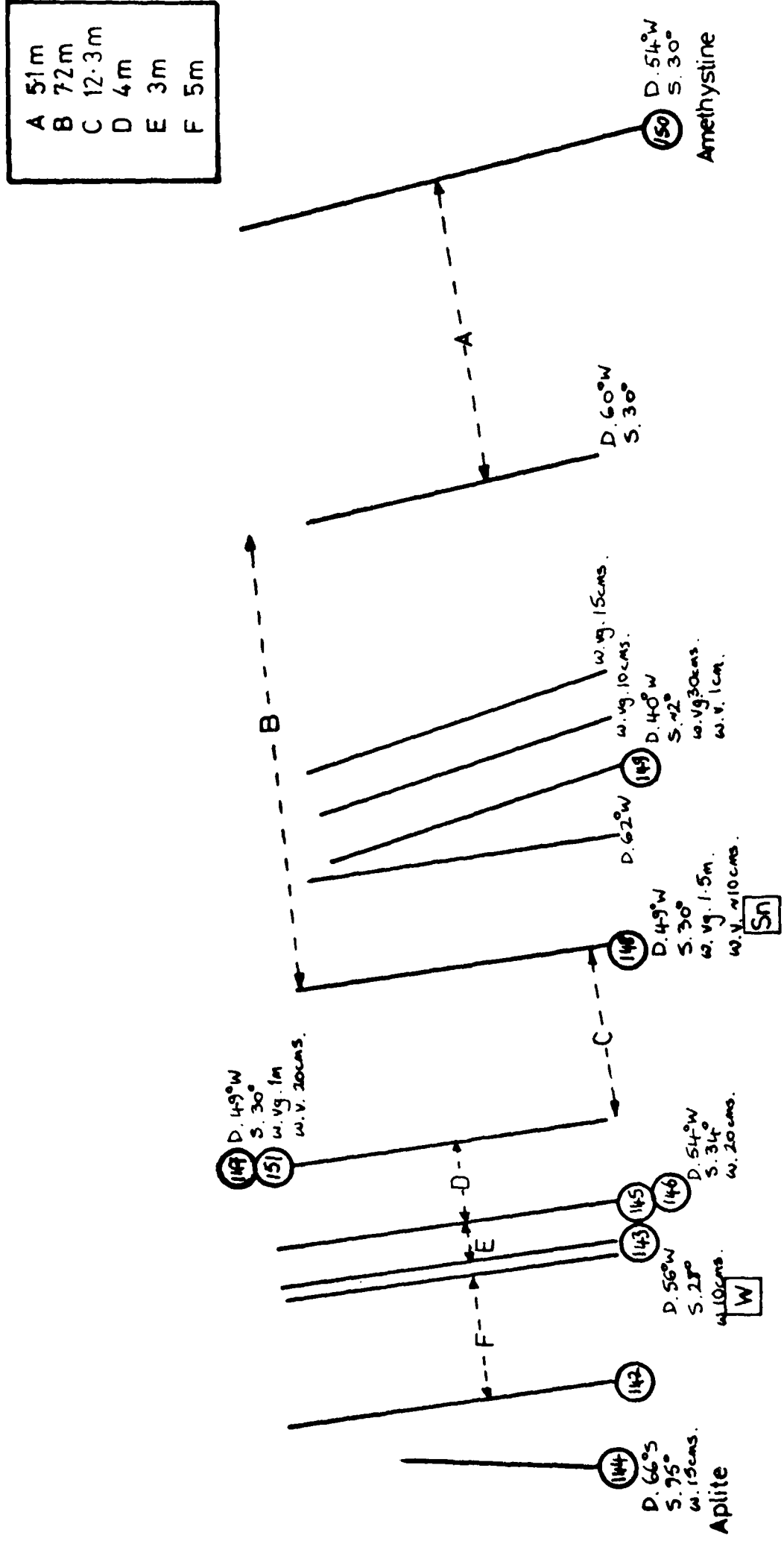




Figure 7. Cross-section showing veins in Imperial Goonbarrow (western end of north face)

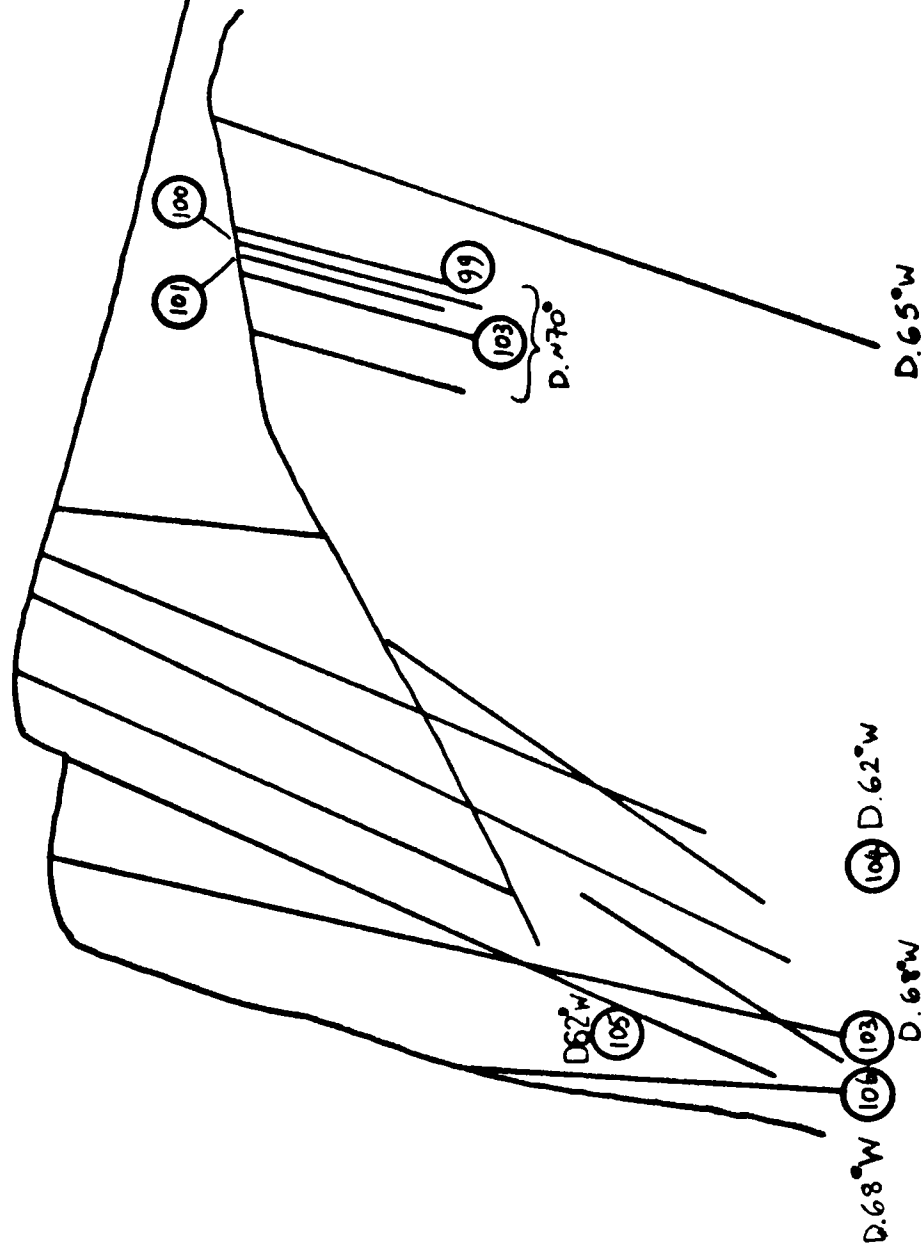




Figure 8. Cross-section showing veins in Imperial Goonbarrow (central area of north face)

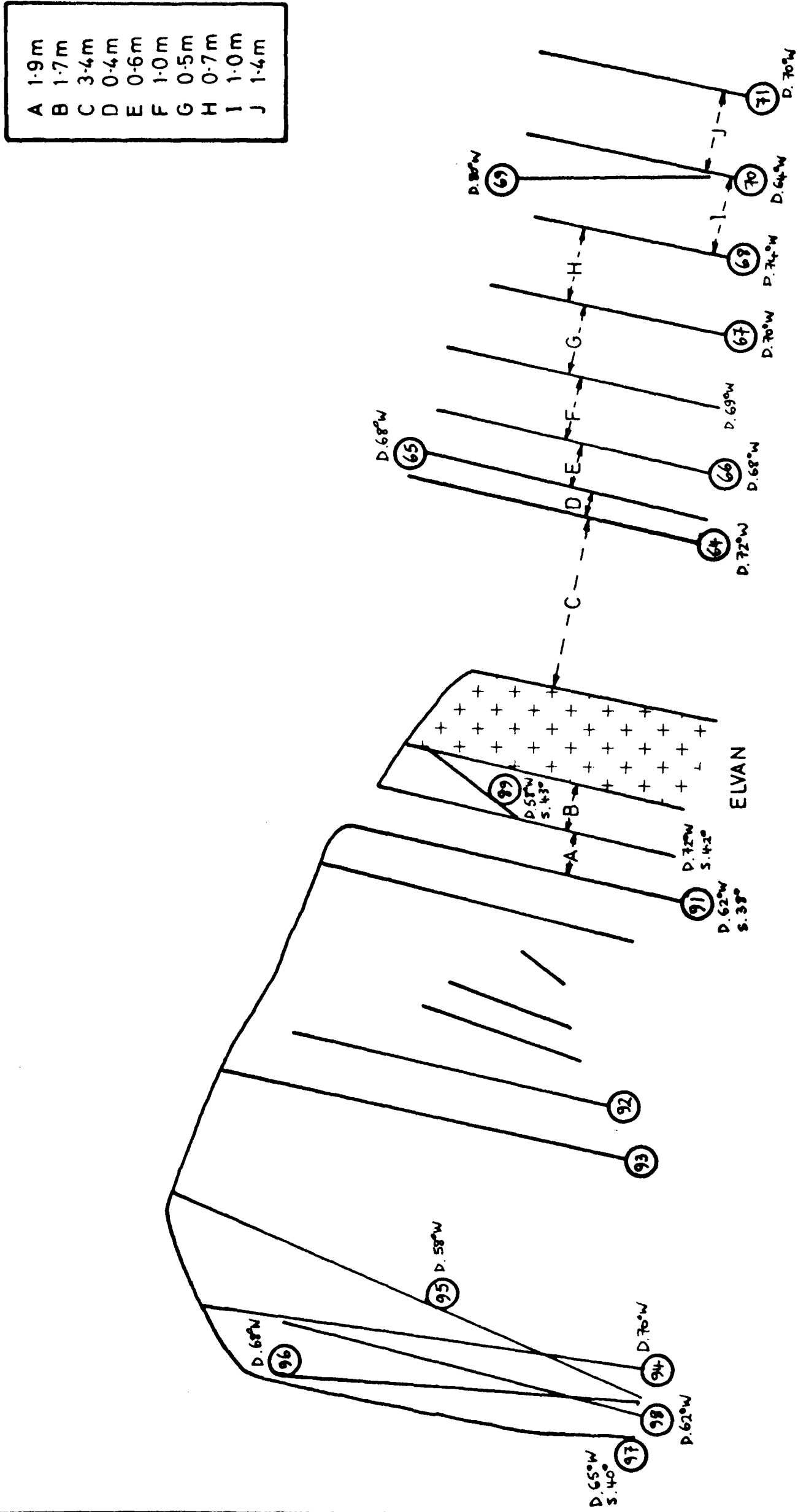


Figure 9. Cross-section showing veins in Imperial Goonbarrow (eastern end of north face)

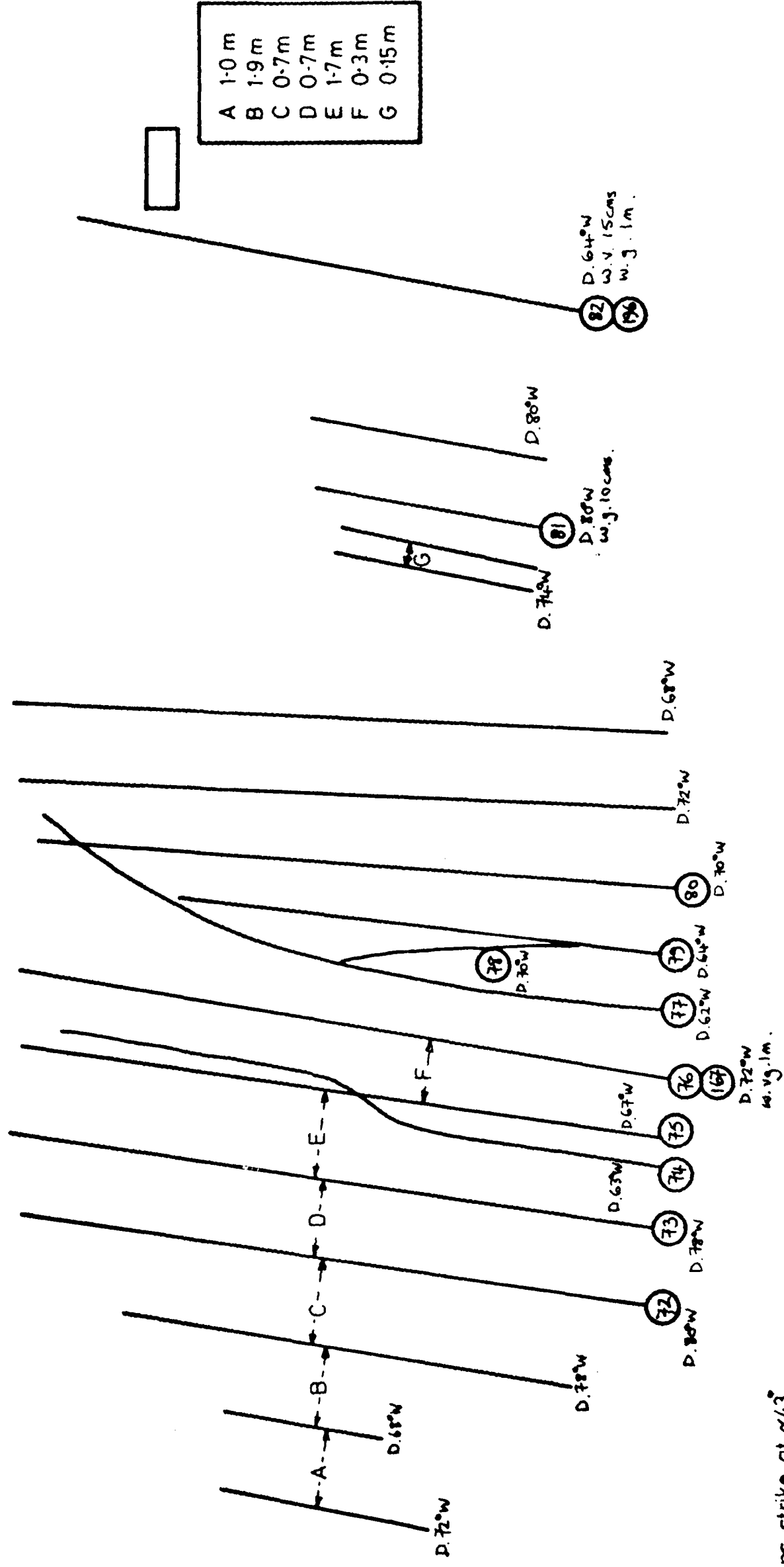




Figure 11. Cross-section showing veins on the island opposite Old Beam (south face, now removed)

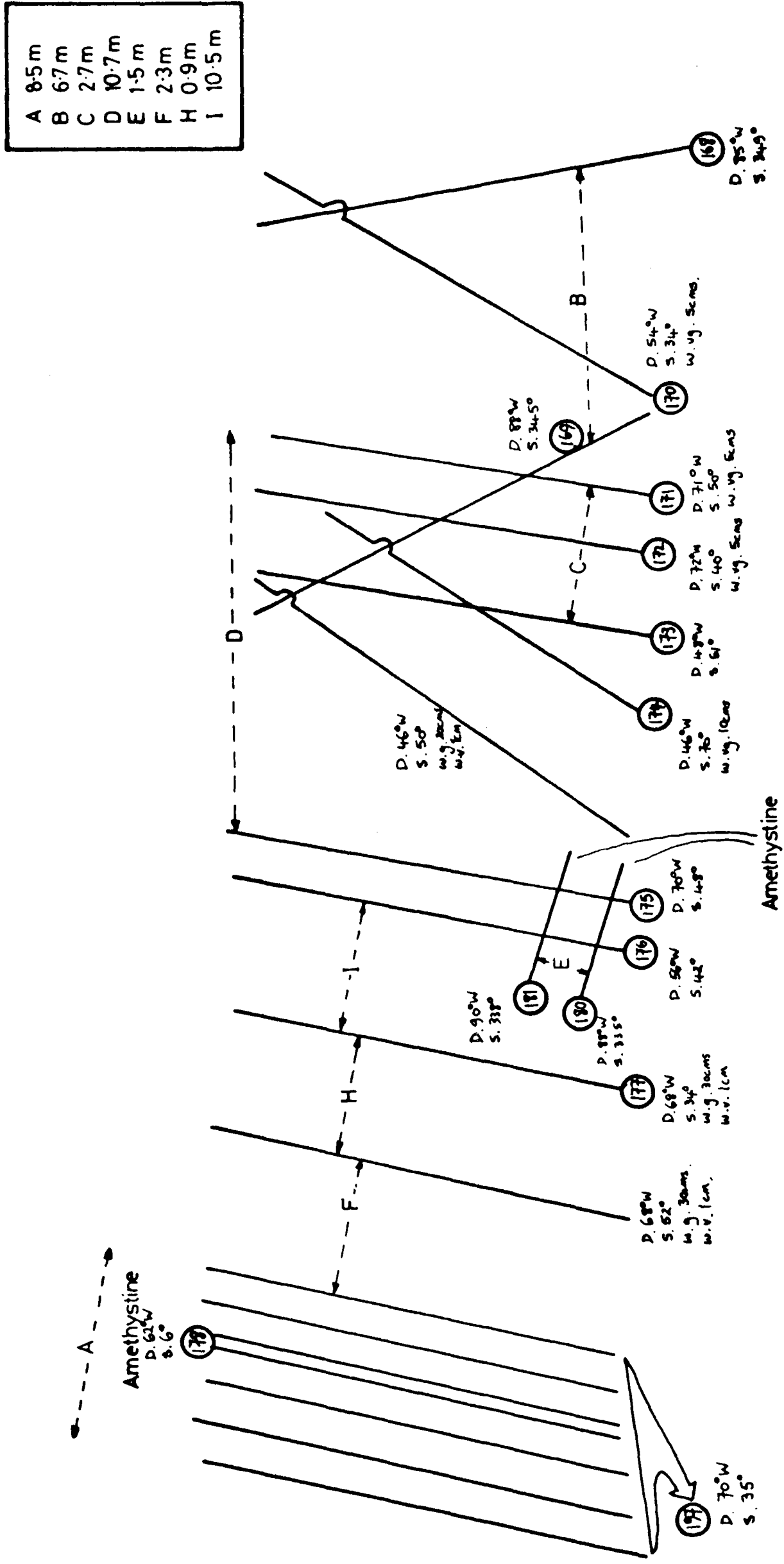
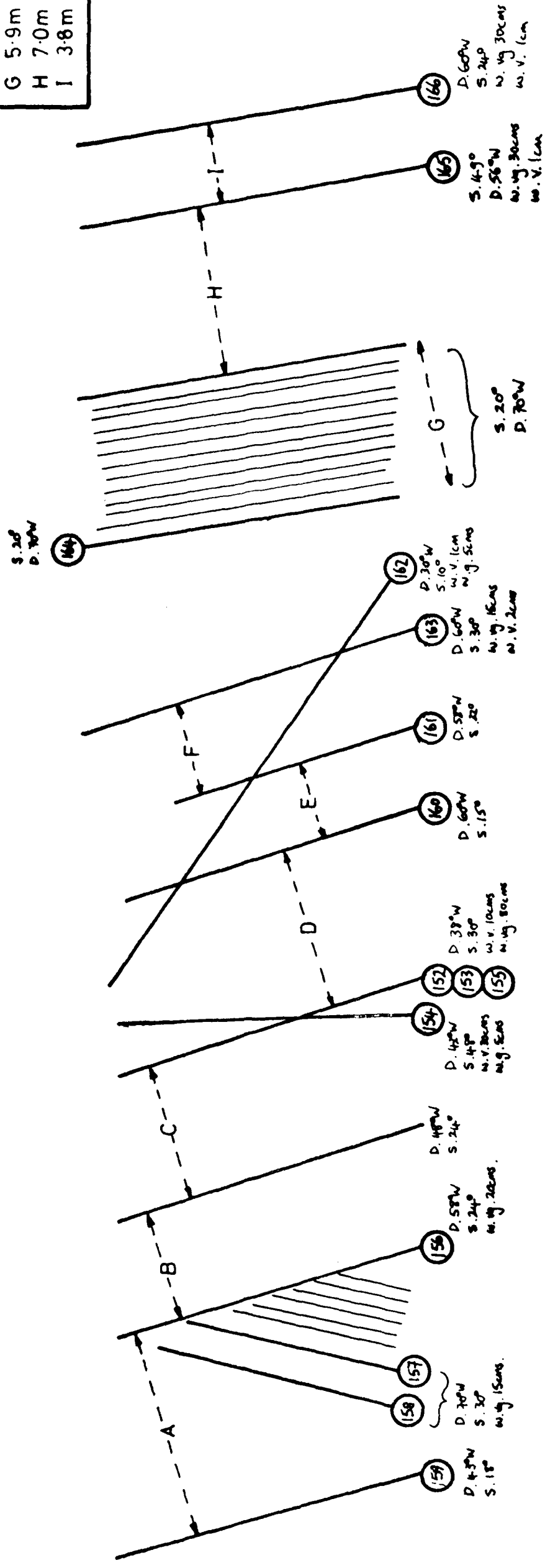


Figure 12. Cross-section showing veins in the area near Martins Goonbarrow

|   |      |
|---|------|
| A | 17m  |
| B | 11m  |
| C | 3.9m |
| D | 8.3m |
| E | 1.3m |
| F | 1.9m |
| G | 5.9m |
| H | 7.0m |
| I | 3.8m |

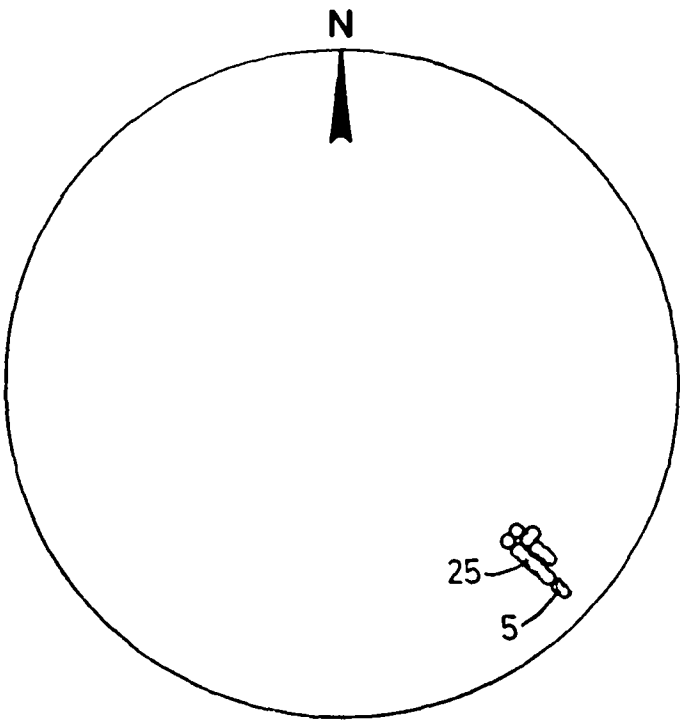


Intensely Kaolinitised area

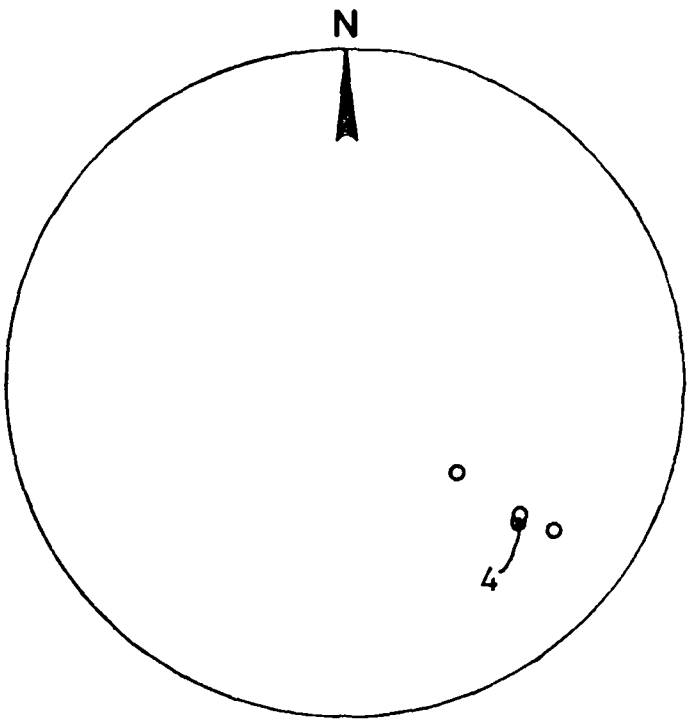
Figure 13. Equal area projection of the poles to the veins at Goonbarrow.

All quartz/tourmaline veins.

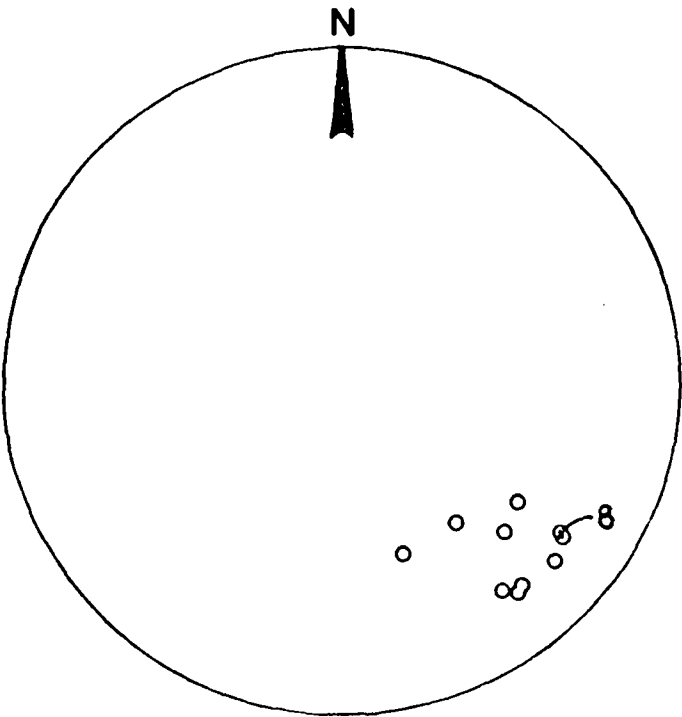
Imperial-North face



Imperial-South face



Island facing south



Near Martins Goonbarrow

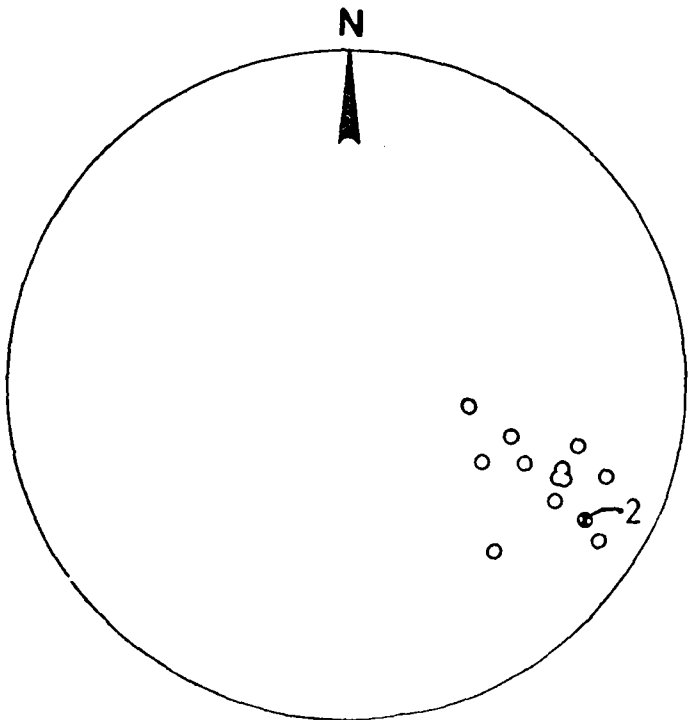
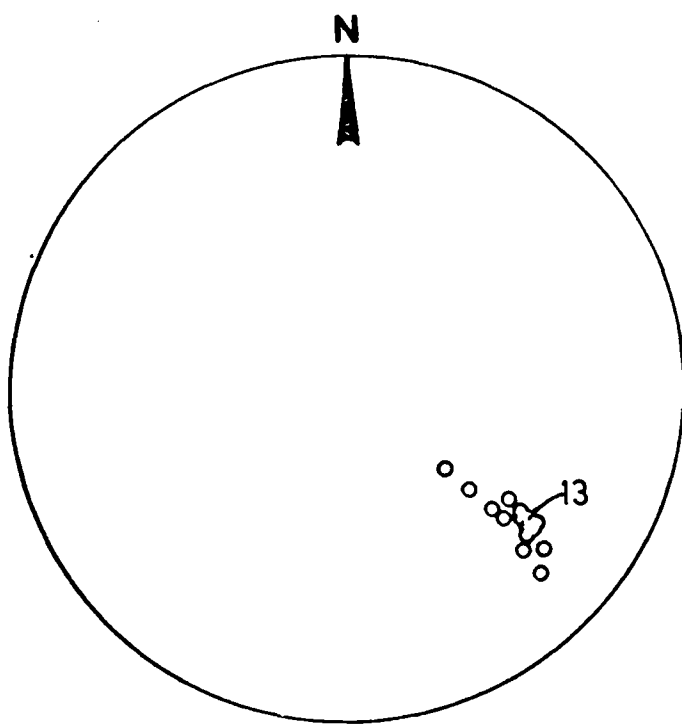


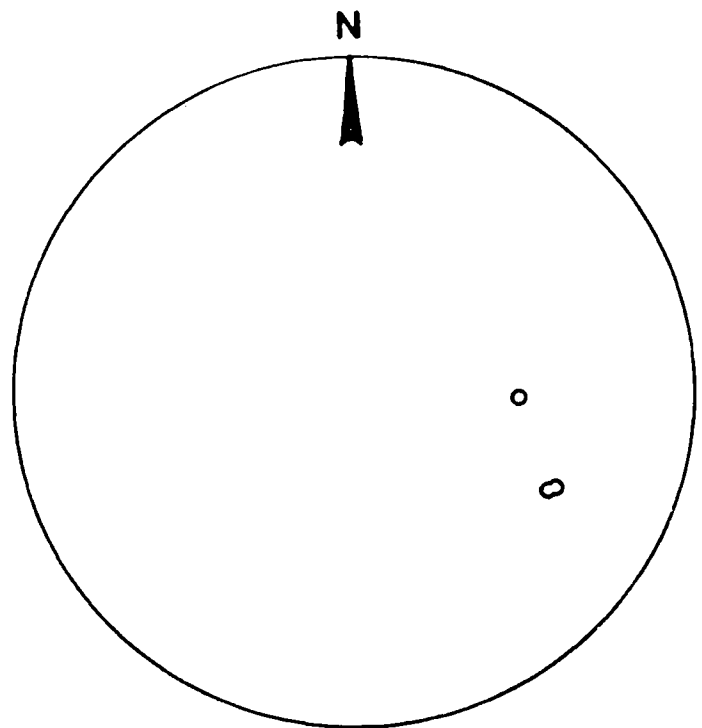
Figure 14. Equal area projection of the poles to the veins at Goonbarrow.

All quartz/tourmaline veins unless otherwise stated.

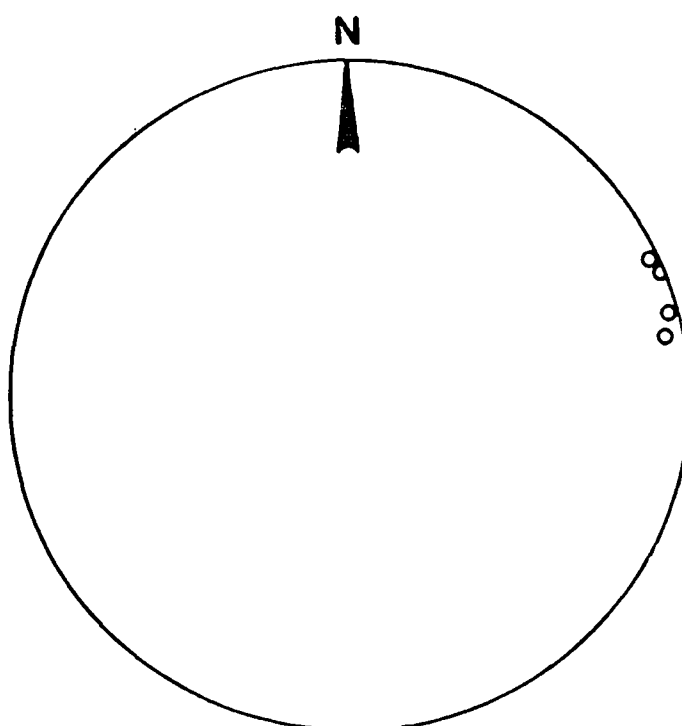
Old Beam



Opposite Old Beam



Island facing south  
(amethyst veins)



Multimineral veins

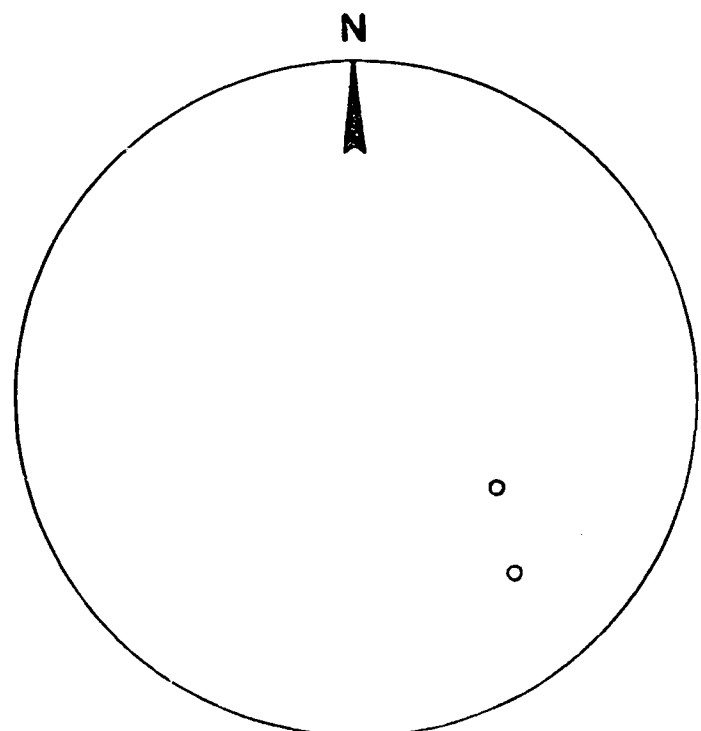




Figure 15. Sketch map showing localities of specimens used for K/Ar dating.

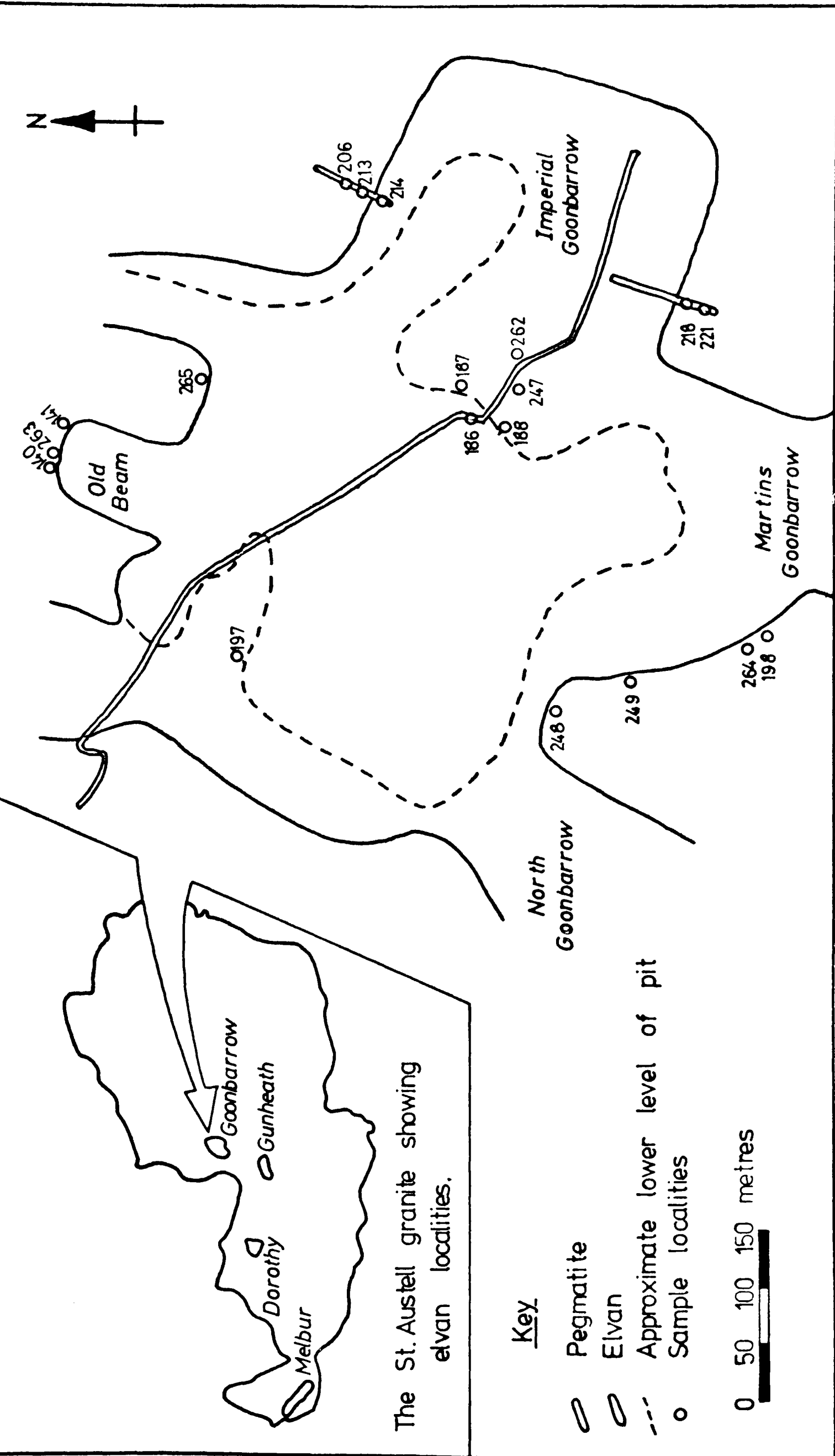


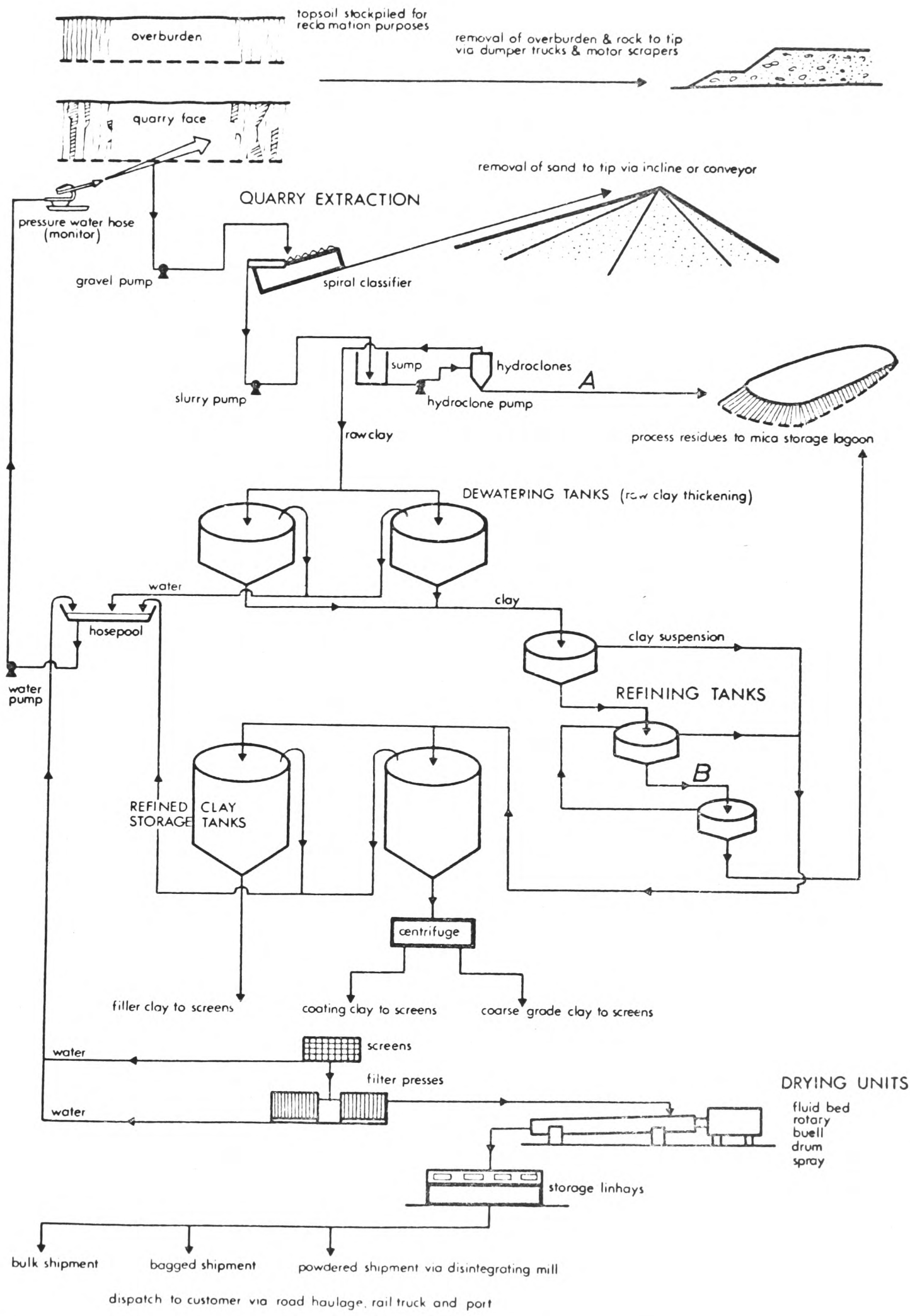


Figure 16. The China Clay refining process.

Samples from points A and B were used in the K/Ar age study

A = Hydroclone residue

B = No.2 underflow



(Reproduced by kind permission of ECLP)

Figure 17. The overall sequence of geological events at Goonbarrow.

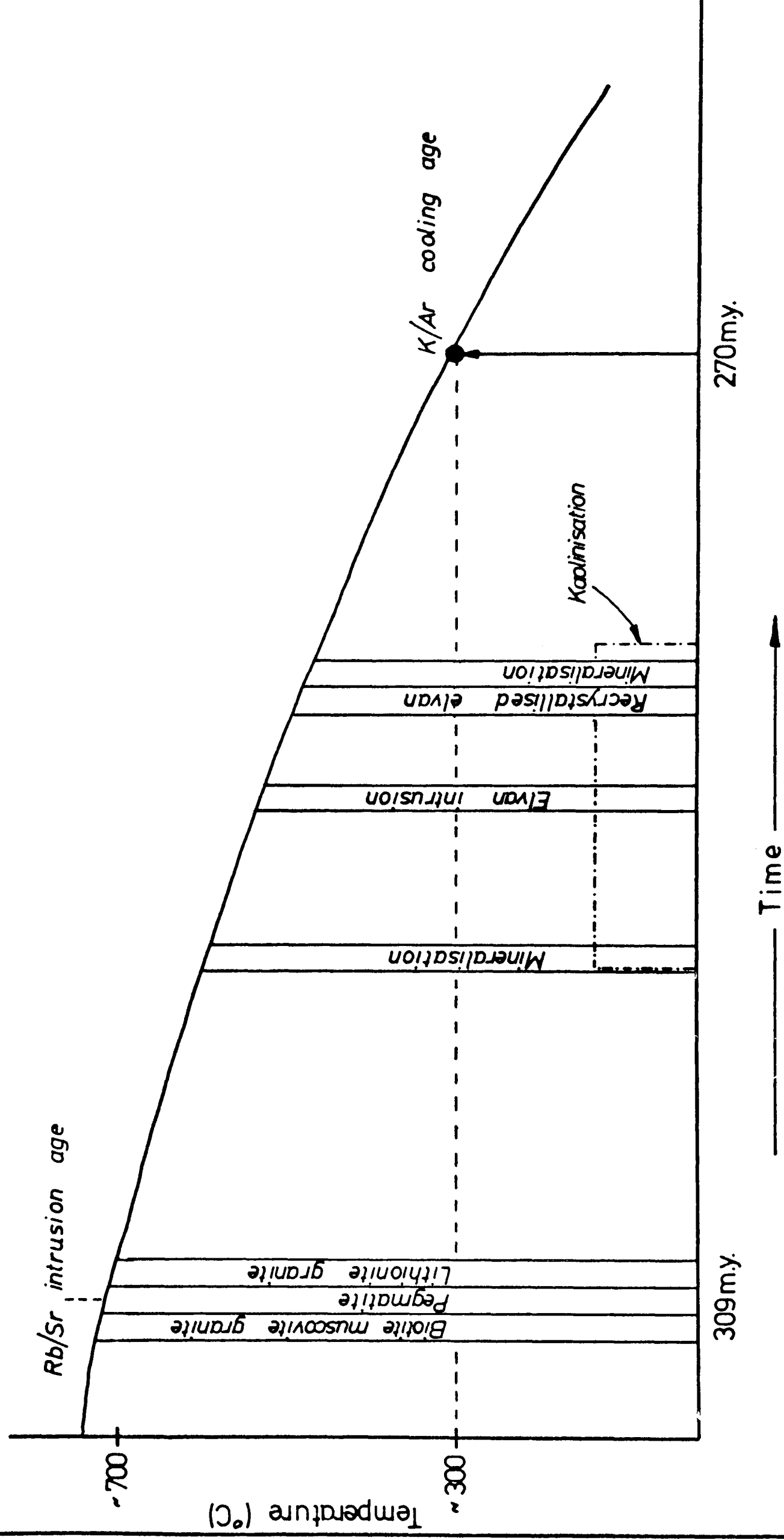
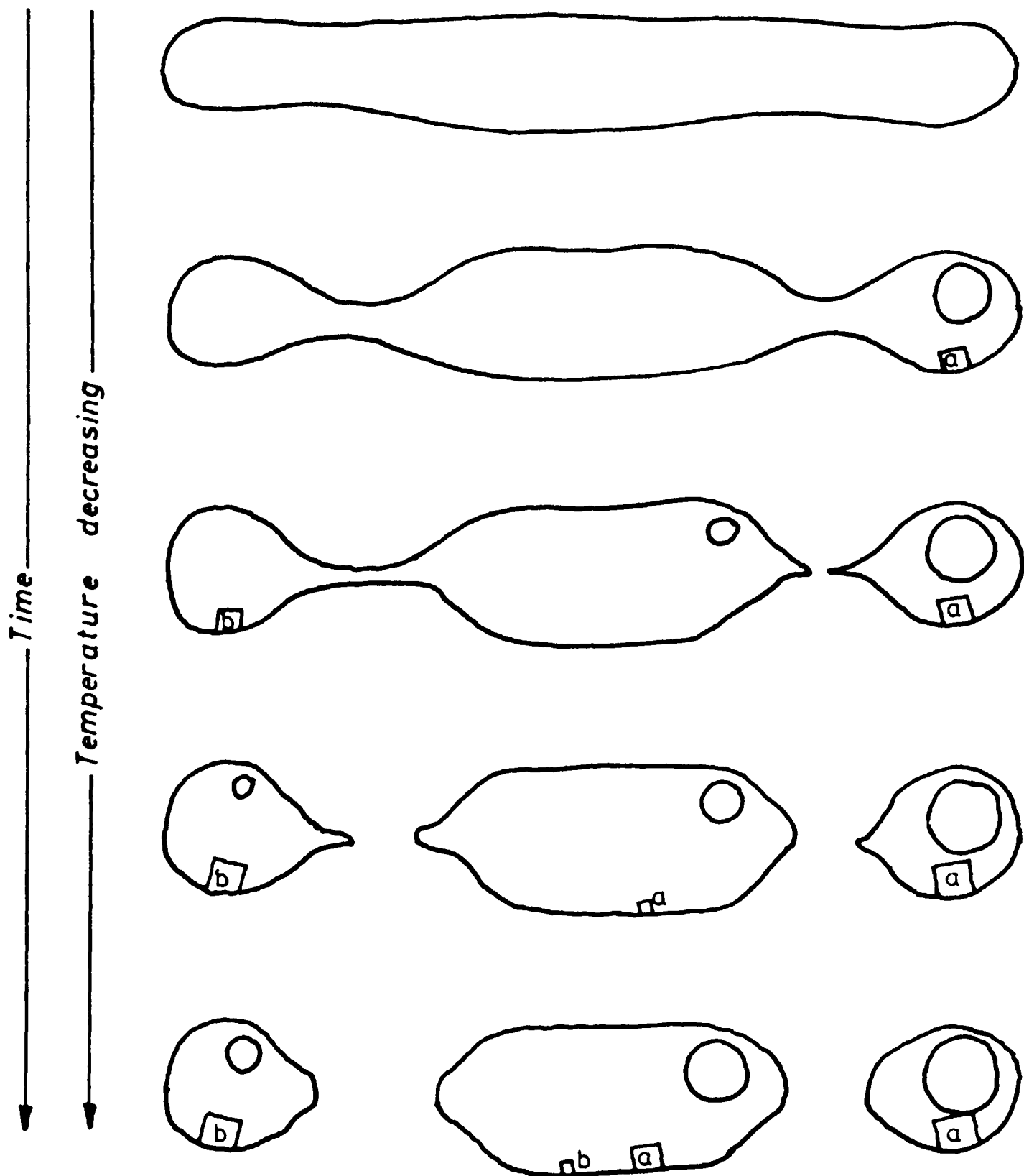


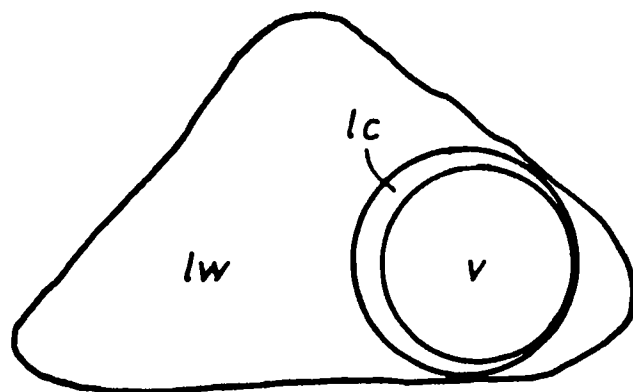
Figure 18. Necking down of an inclusion with time from its original state

*The resultant necked inclusions have varying vapour/liquid ratios which would produce erroneous filling temperatures. Only some of the necked inclusions may contain daughters. (adapted from Roedder, 1967)*



a = NaCl , b = KCl.

Figure 19. An example of a  $\text{CO}_2$  inclusion.



*v = vapour (a mixture of water and  $\text{CO}_2$ )*  
*lw = liquid water solution*  
*lc = liquid  $\text{CO}_2$*

Figure 20. A "Boiling" assemblage

*Vapour rich and liquid rich phases have been trapped simultaneously. Inclusions A will homogenise into the liquid phase and inclusions B into the vapour phase.*

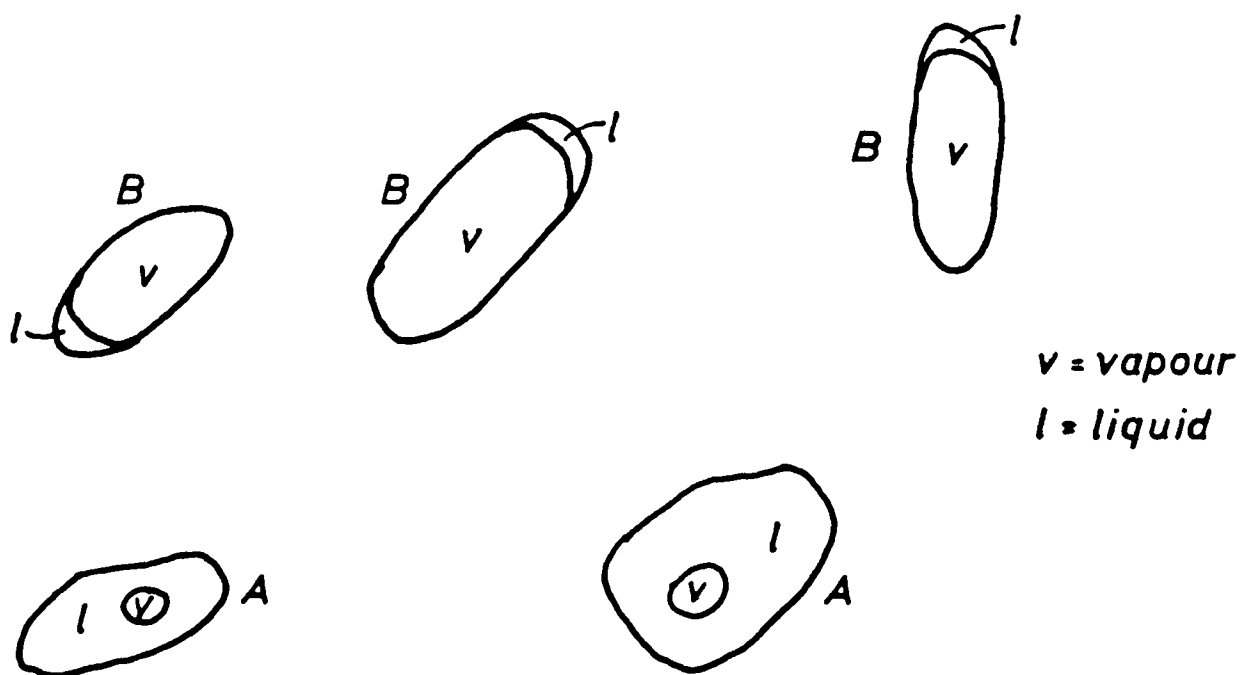


Figure 21. The vertical relationships of the ore-mineral zones in south-west England (after Edmonds et al., 1975)

| Zone<br>(Hosking) | Approx.<br>temp. of<br>formation<br>(°C) | Range and<br>distribution<br>of elements<br>of economic<br>importance | Major ore minerals                                                           | Approx.<br>thickness<br>in feet |
|-------------------|------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------------|---------------------------------|
| 6 & 7             | 50-200                                   | Fe, Sb                                                                | Hematite, Siderite, Jamesonite,<br>Stibnite, Bournonite, Tetrahedrite.       | 400                             |
| 5b                | 200-300                                  | Ag, Pb, Zn                                                            | Argentite,<br>Galena,<br>Sphalerite                                          | 200                             |
| 5a                |                                          | U, Ni, Co                                                             | Pitchblende, Niccolite,<br>Smaltite, Cobaltite                               | 1800                            |
| 4                 | 300-500                                  |                                                                       | Chalcopyrite, Arsenopyrite,<br>Sphalerite, Pyrite,<br>Wolframite, Scheelite. | 2500                            |
| 3                 |                                          |                                                                       | Chalcopyrite, Arsenopyrite,<br>Wolframite, Scheelite,<br>Cassiterite.        |                                 |
| 2                 |                                          |                                                                       | Cassiterite, Wolframite,<br>Scheelite, Arsenopyrite.                         | 2500                            |
| 1                 |                                          |                                                                       | Cassiterite, Specularite,<br>Molybdenite.                                    |                                 |

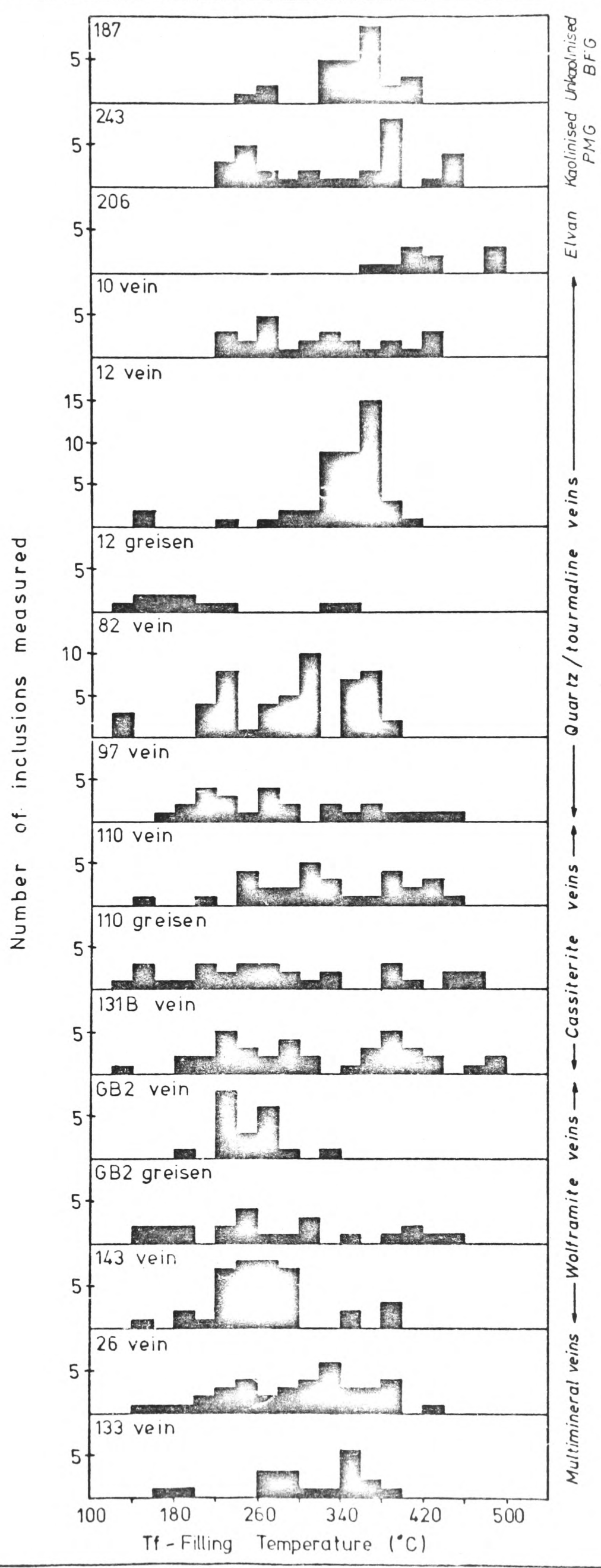


Figure 22.

Histogram of fluid inclusion filling temperatures from Goonbarrow.

Figure 23. Histogram of salinities of fluid inclusions from Goonbarrow.

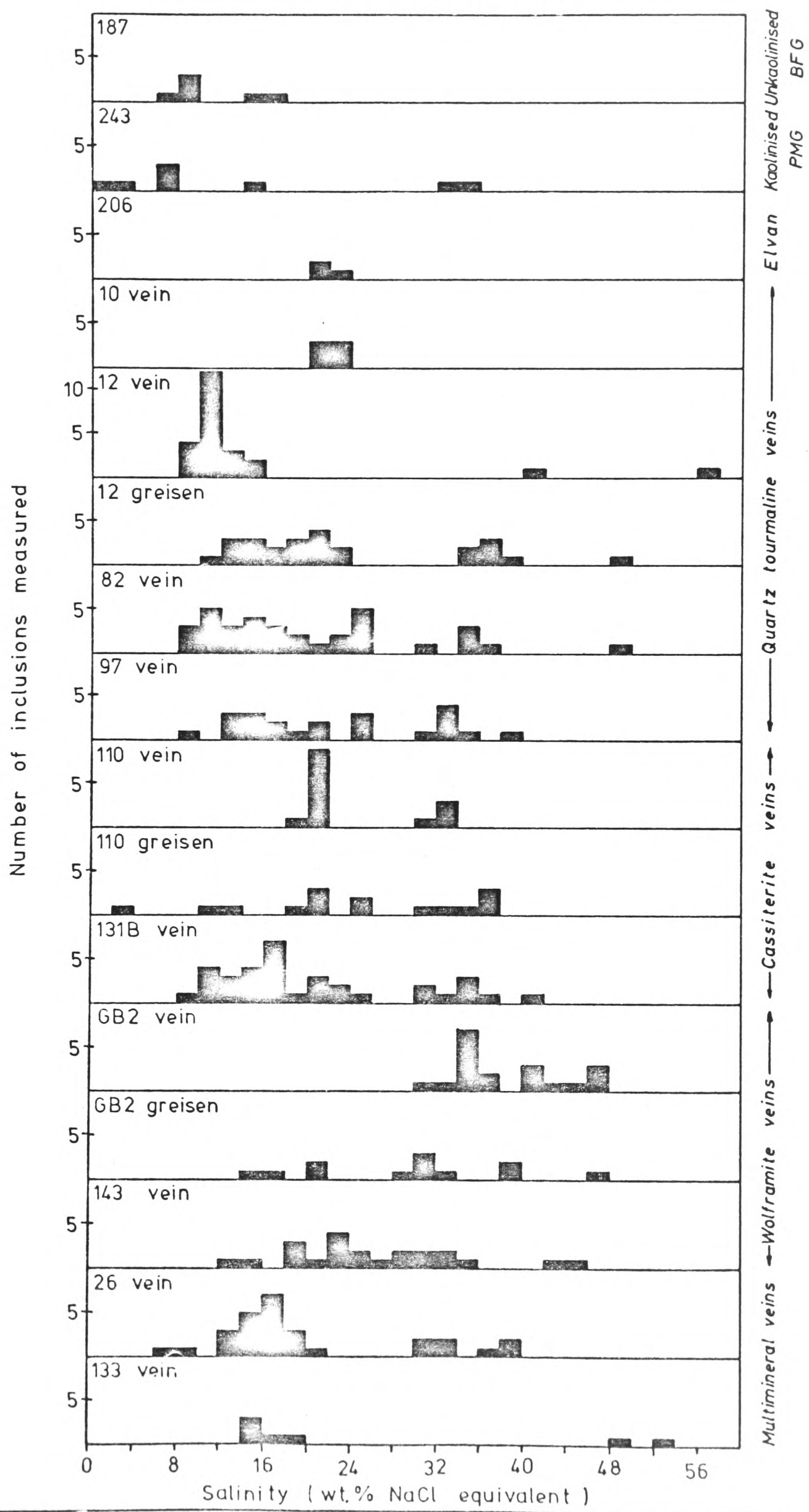




Figure 24. Graphical plot of filling temperature against salinity for inclusions in Goonbarrow vein samples.

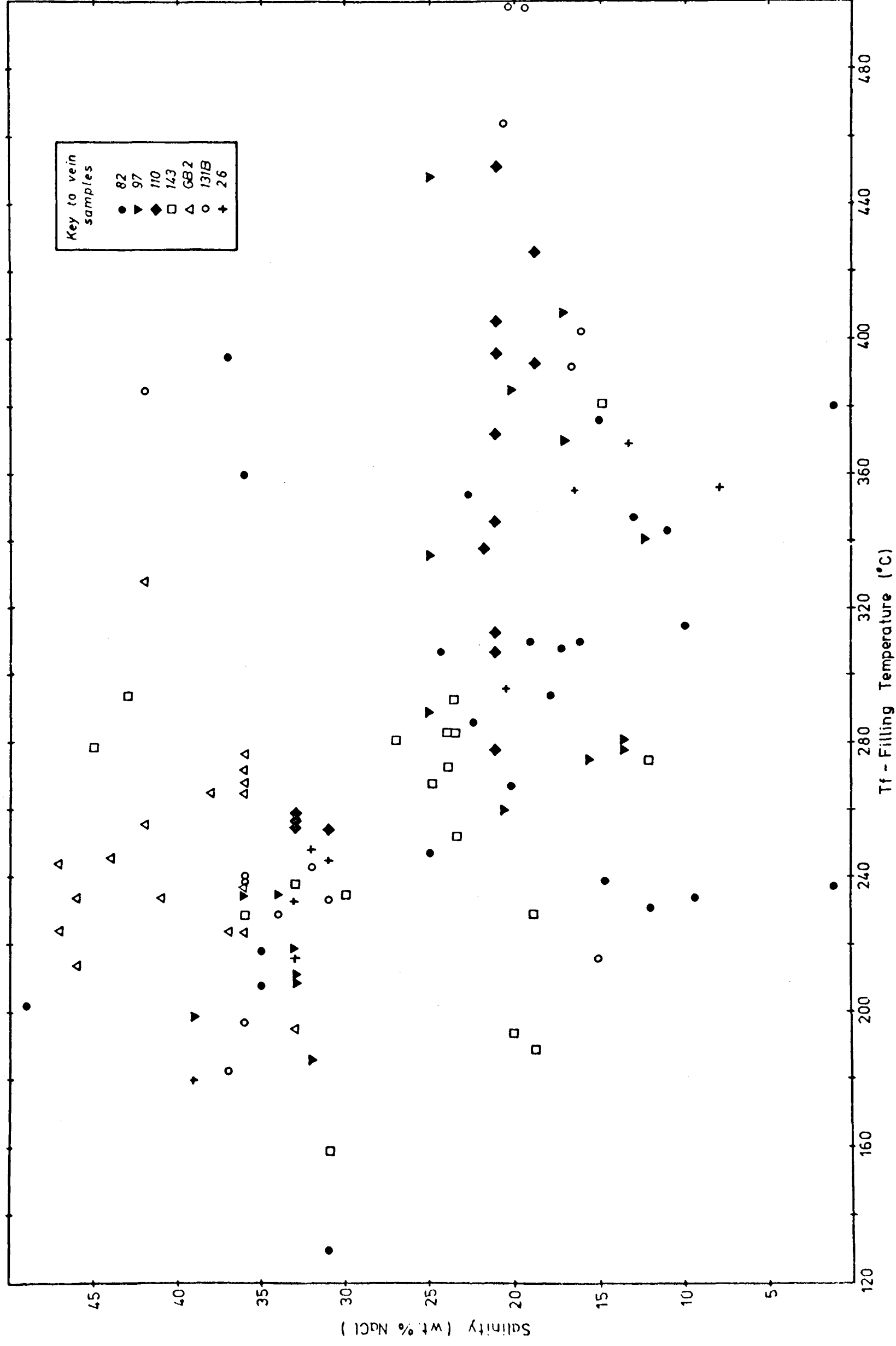




Figure 25. Boiling point curves for 10,25,40 wt% NaCl.  
(Based on and extrapolated from Haas,1971)

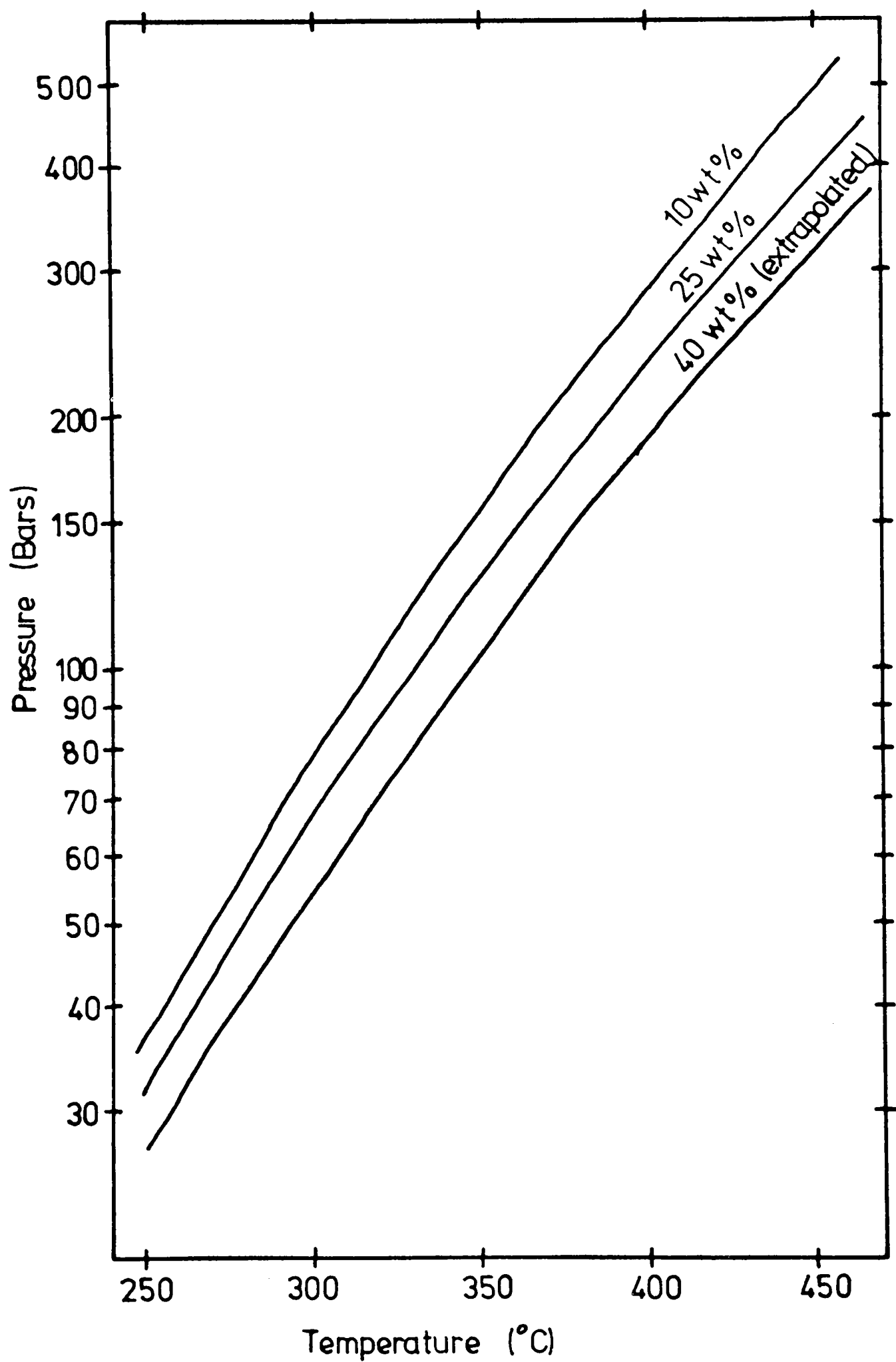


Figure 26. Filling temperature vs. hydrostatic pressure for 10,25,40 wt% NaCl brines. (from Haas,1971)

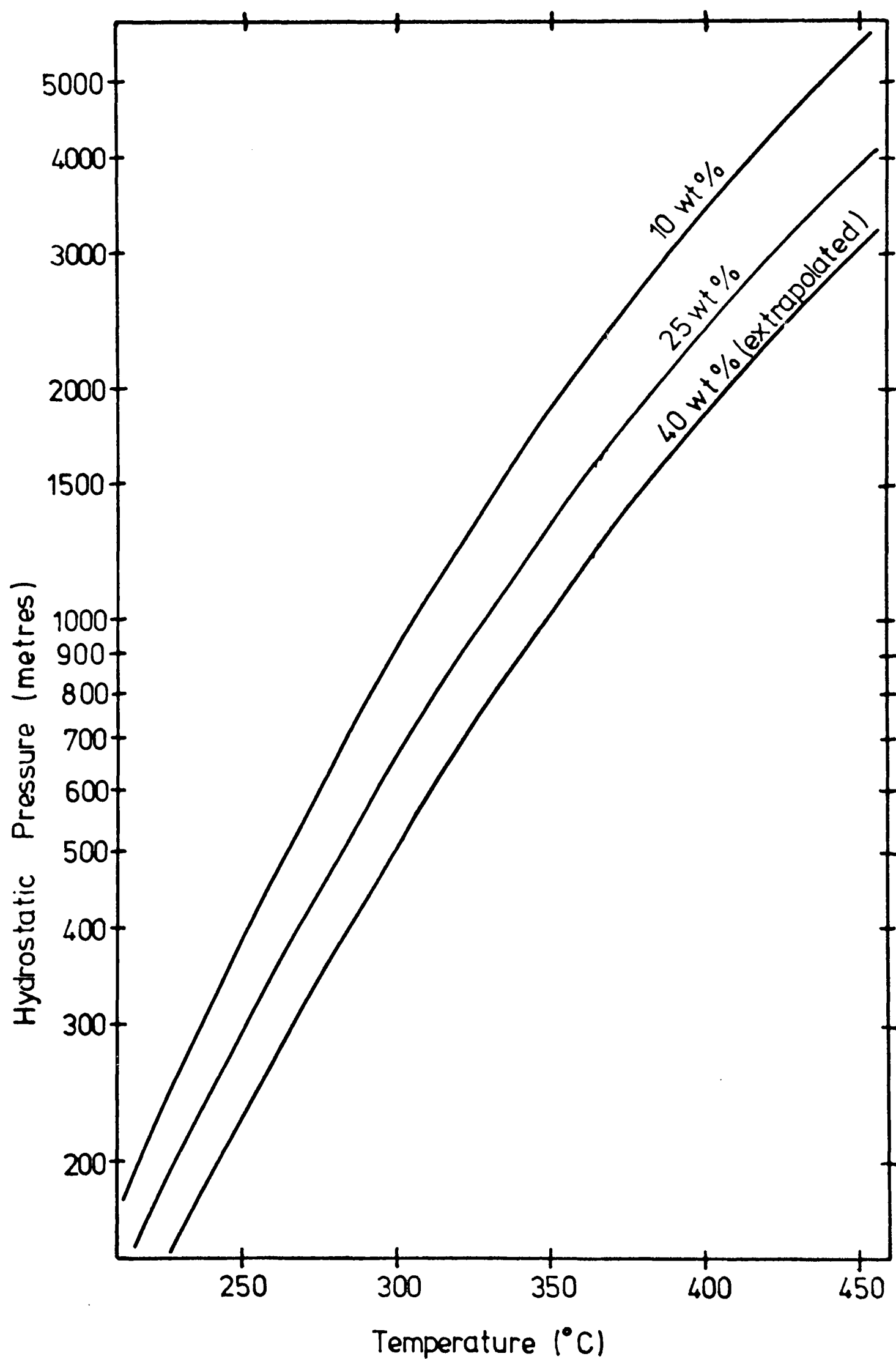


Figure 27.  $\text{Log}_e$ (specific volume) against temperature for pure water at various pressures (data from Burnham et al. 1969).

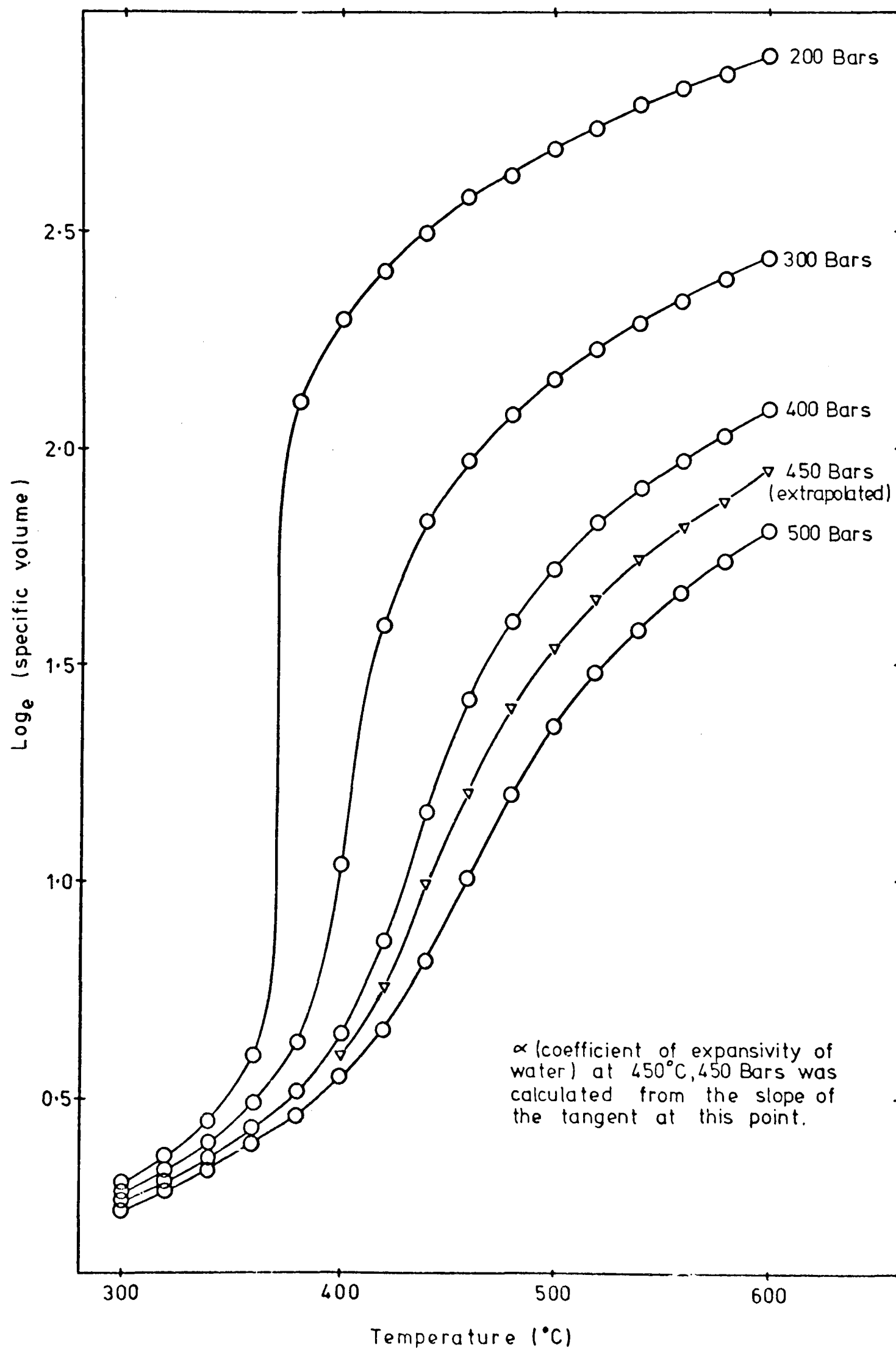


Figure 28. Block diagram of the JEOL x-ray energy dispersive analysing system.

(From JEOL News, 1977)

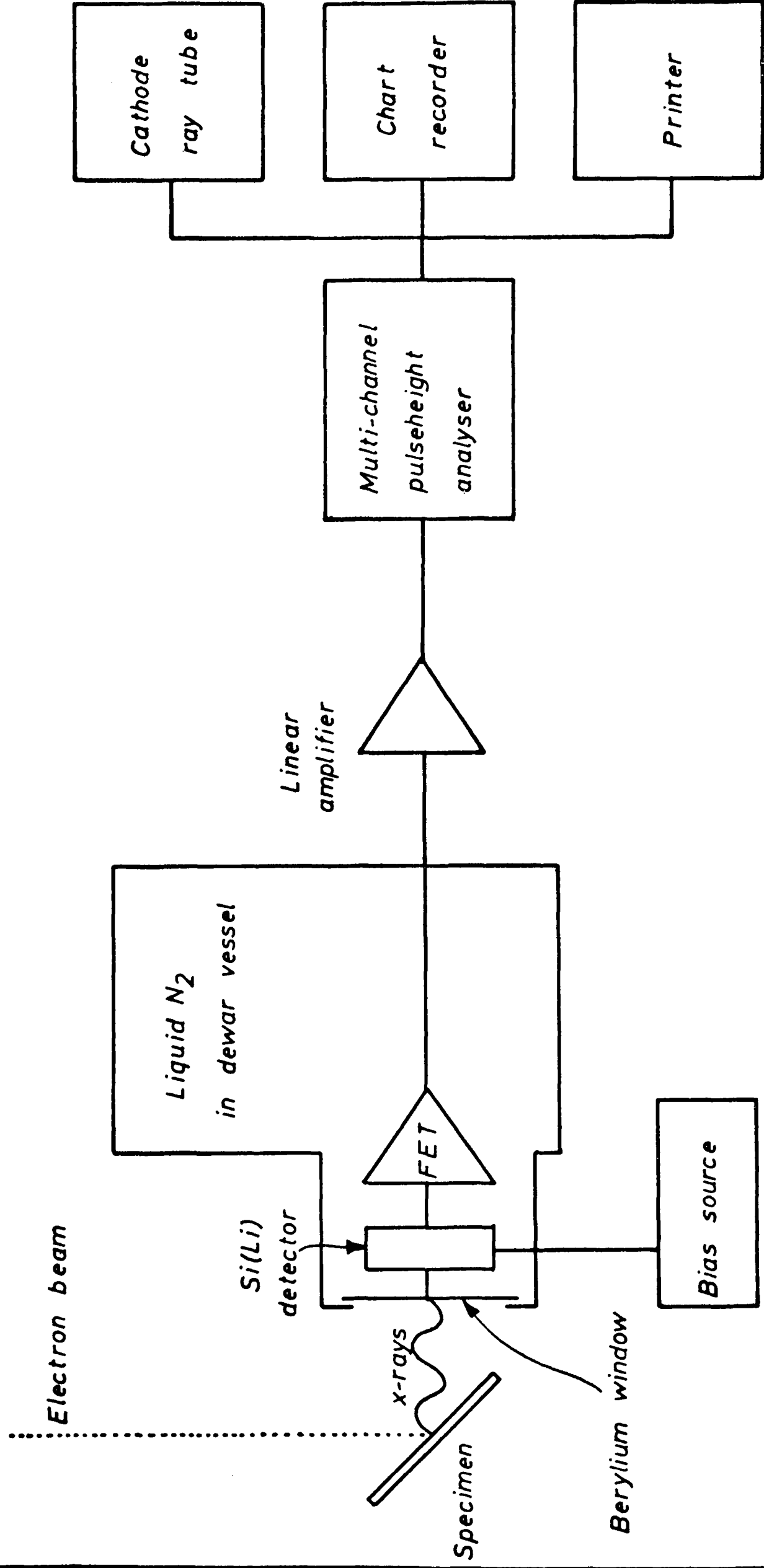


Figure 29. An x-ray spectrum obtained from a cubic daughter mineral (from sample no.148A). The silicon peak, produced from the host mineral (quartz), was significantly reduced on lowering the accelerating voltage of the electron beam.

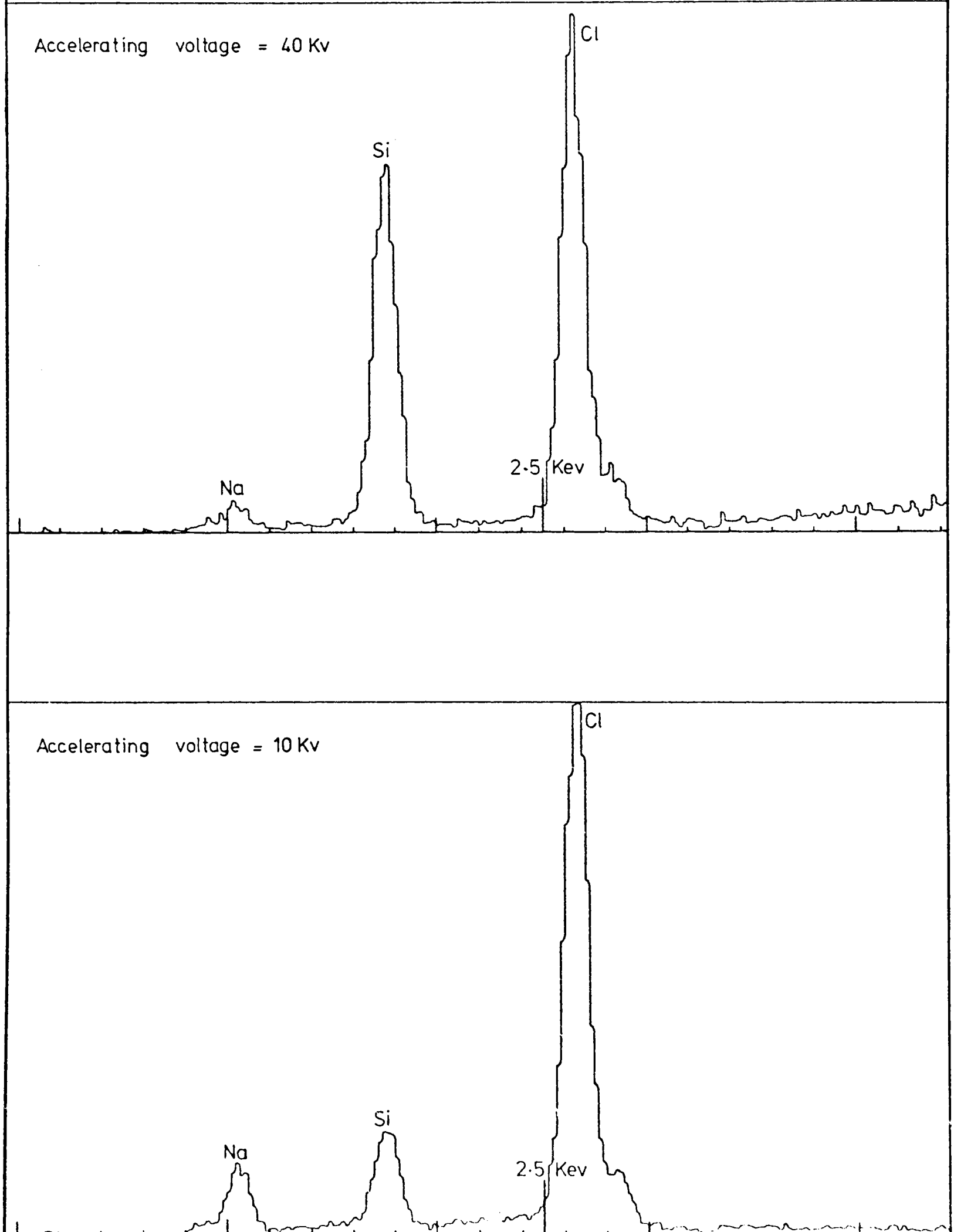


Figure 30. Xray spectrum from vein quartz attached to a brass holder.  
*The Cu and Zn peaks were virtually eliminated after coating with "aquadag".*

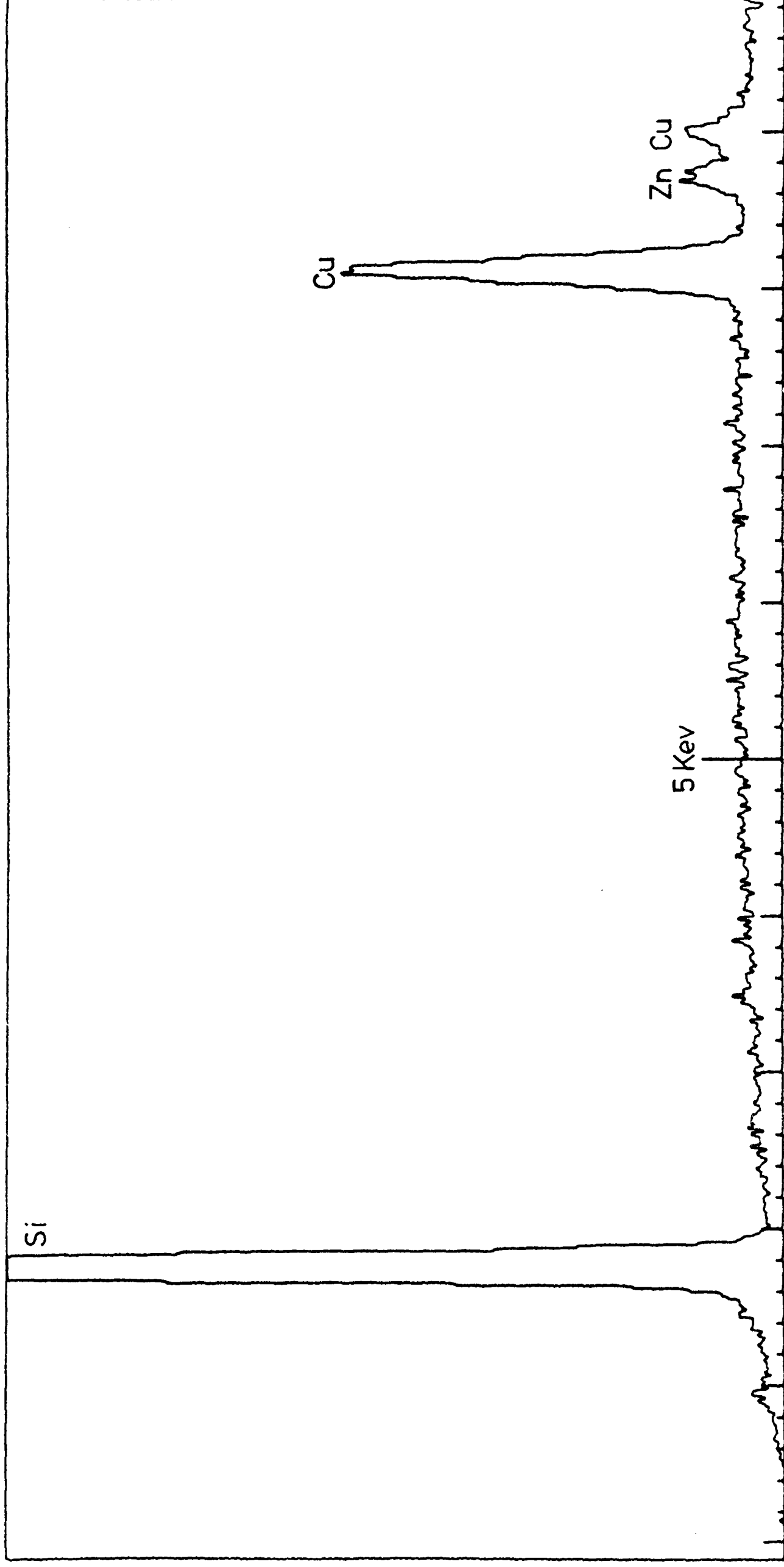


Figure 31. X-ray spectra obtained from two daughter minerals within a fluid inclusion from a quartz-tourmaline vein (sample no. 152v)

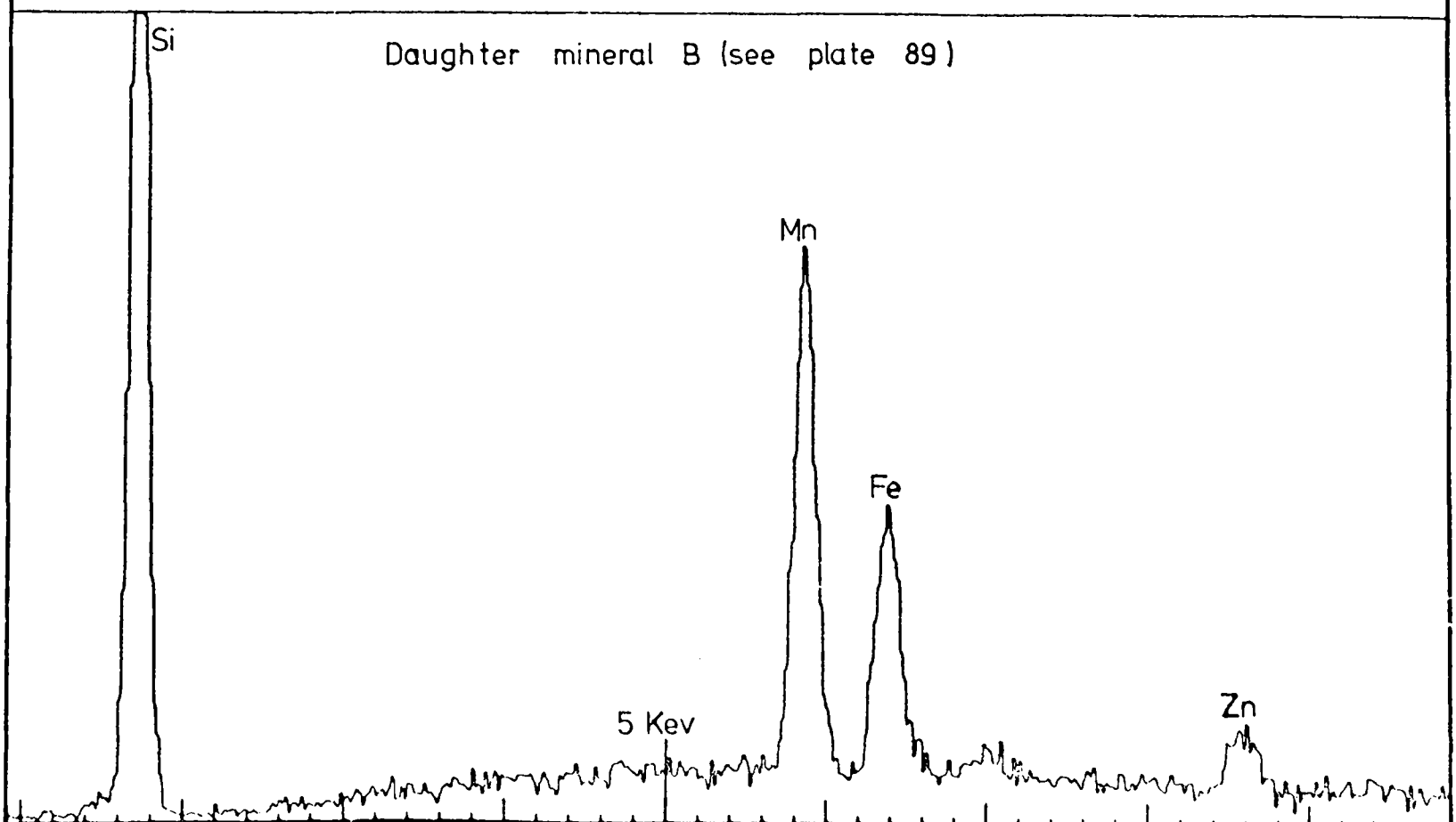
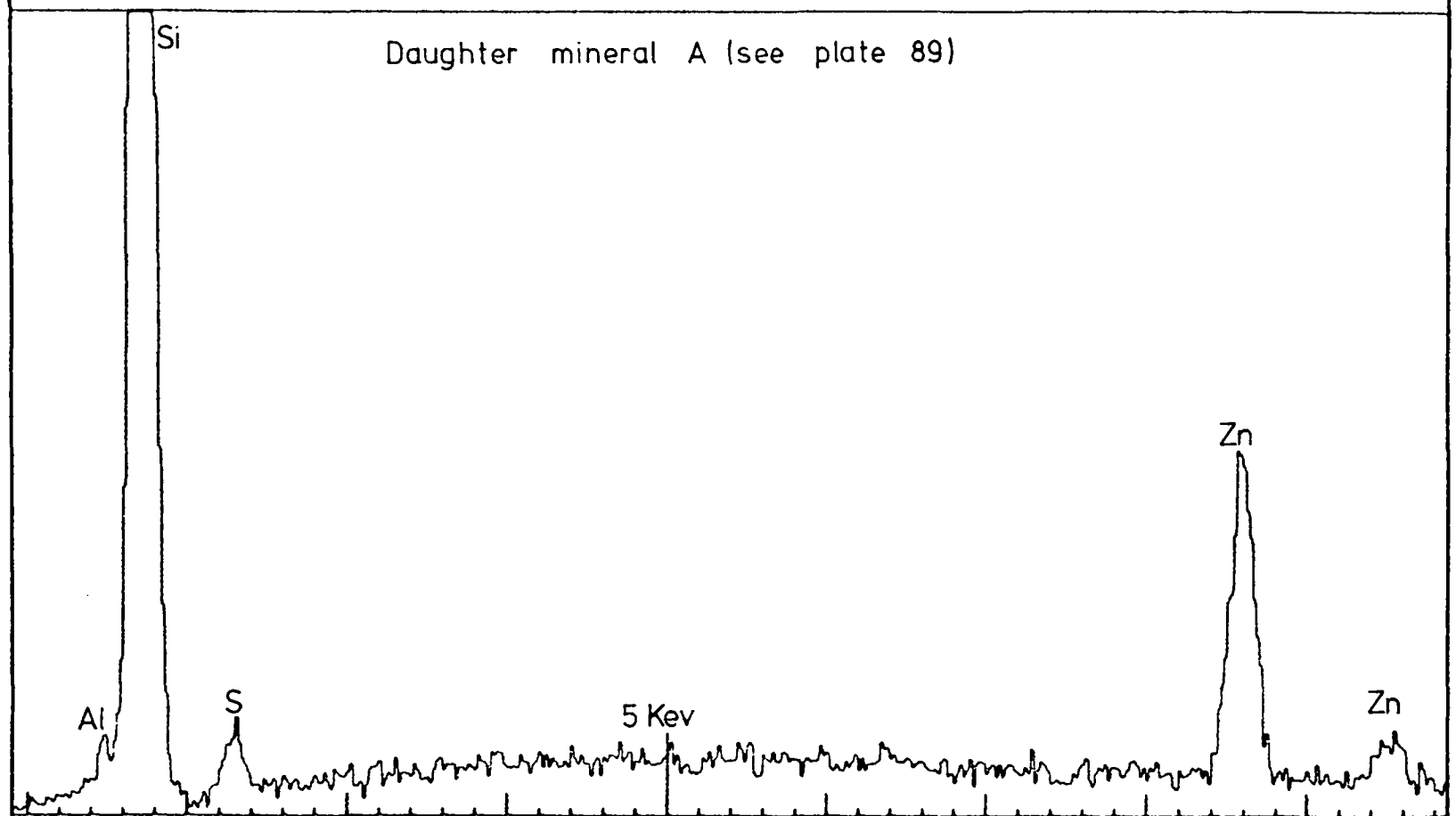




Figure 32. X-ray spectra obtained from two daughter minerals within a fluid inclusion from a quartz-tourmaline vein (sample no. 152v)

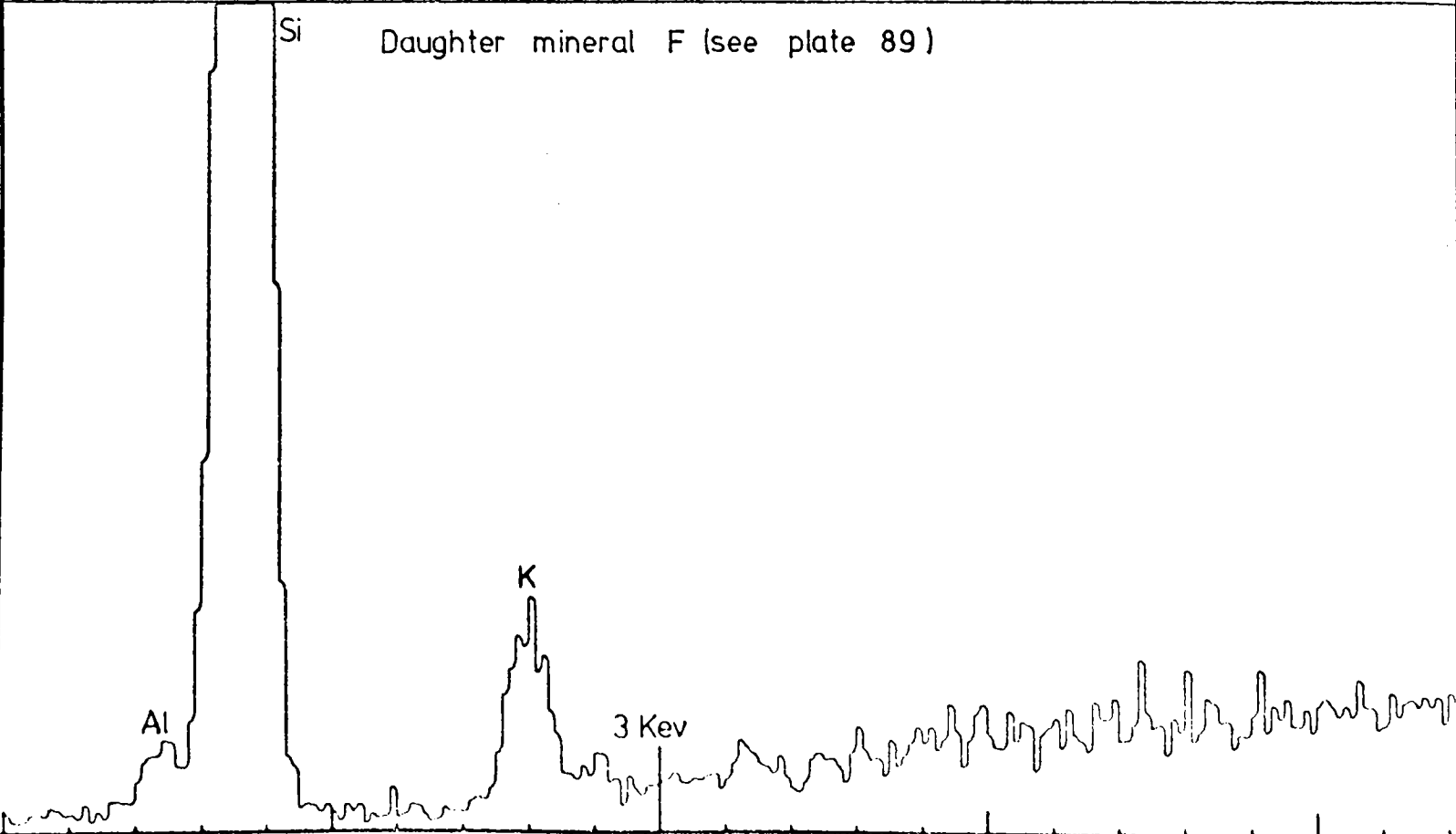
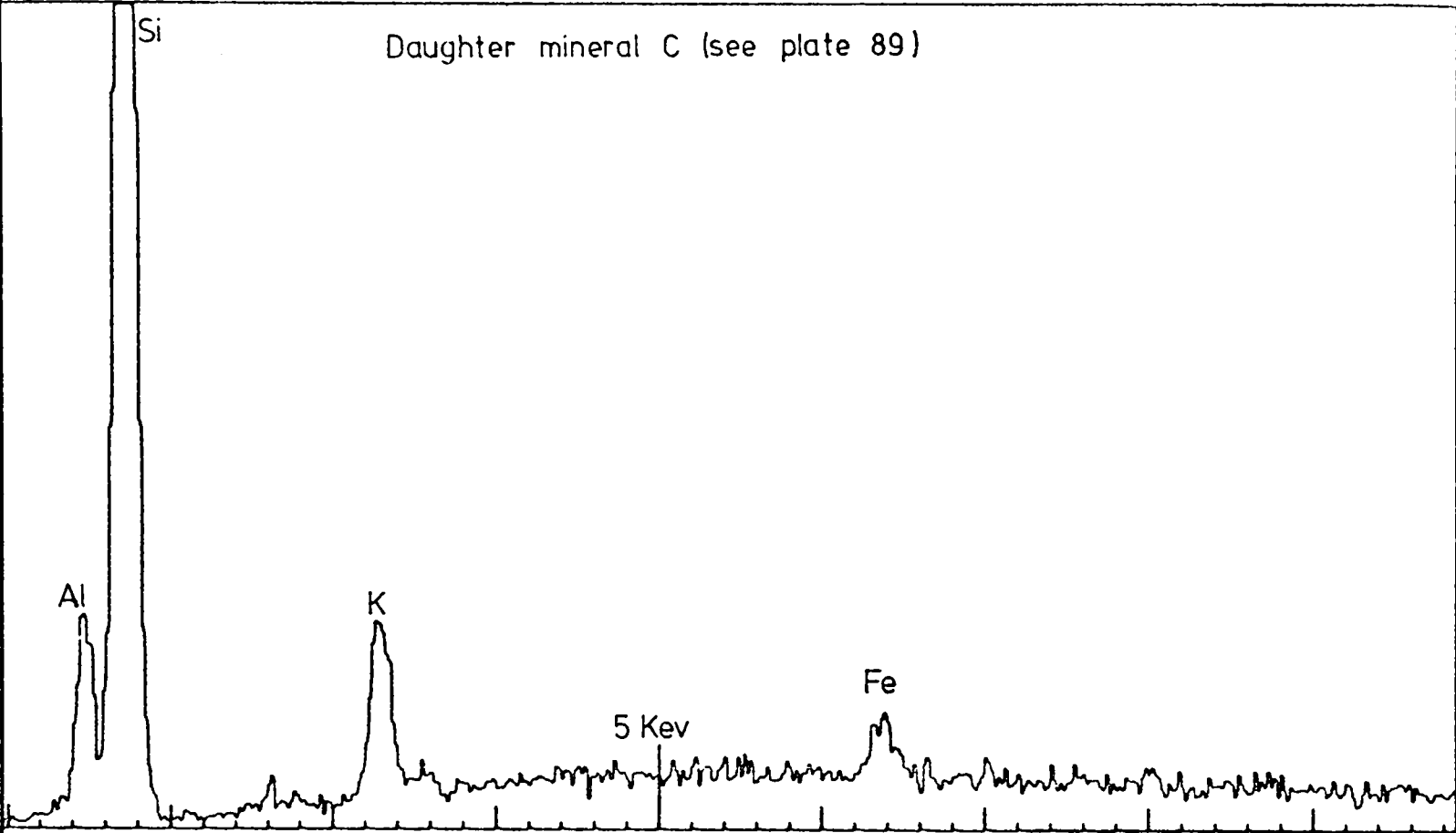




Figure 33. Plot of  $\delta D$  vs.  $\delta^{18}O$  values of minerals and waters from Cornish granites, alteration haloes, china clay deposits, sedimentary clay deposits of Bovey Tracey and modern meteoric waters. (after Sheppard, 1977).

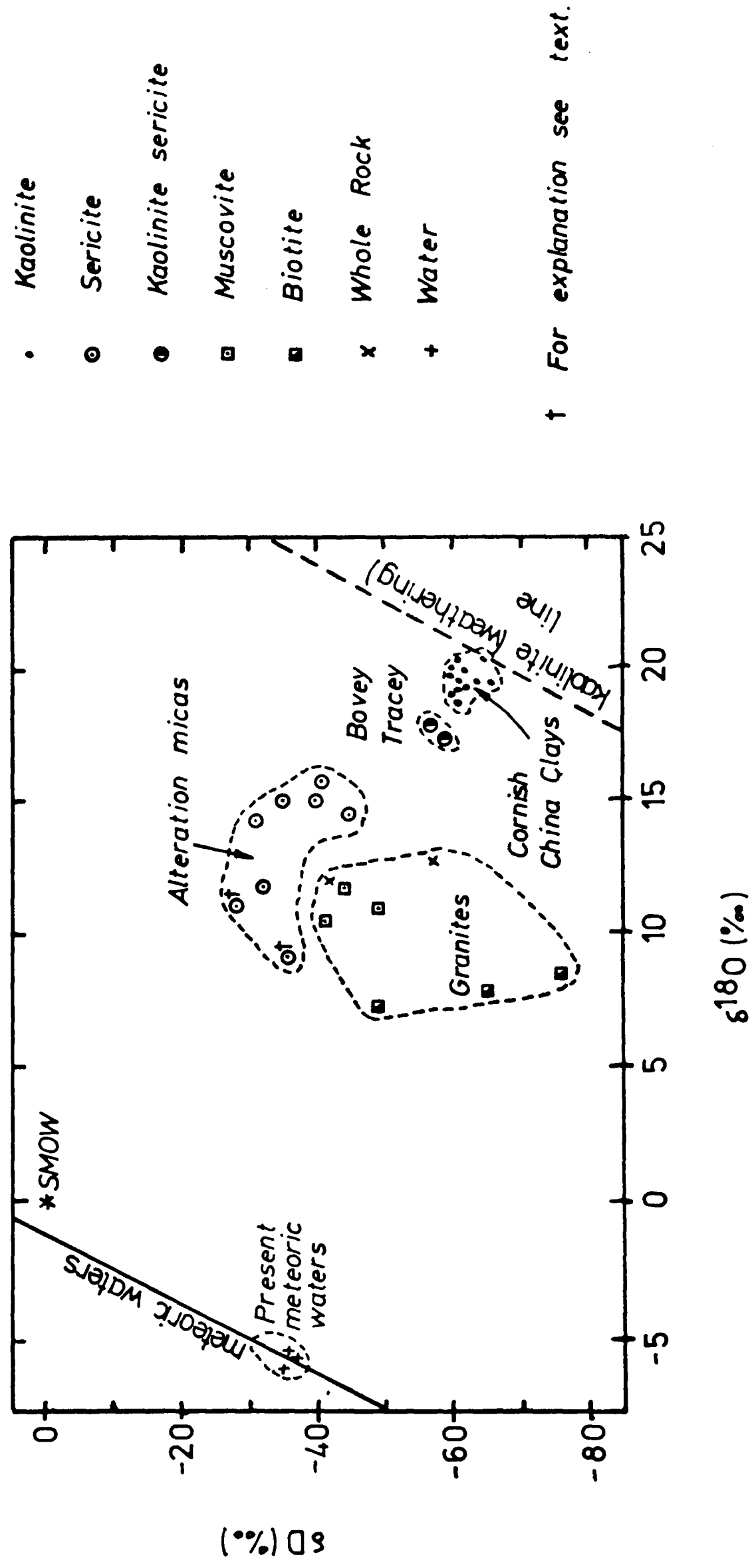
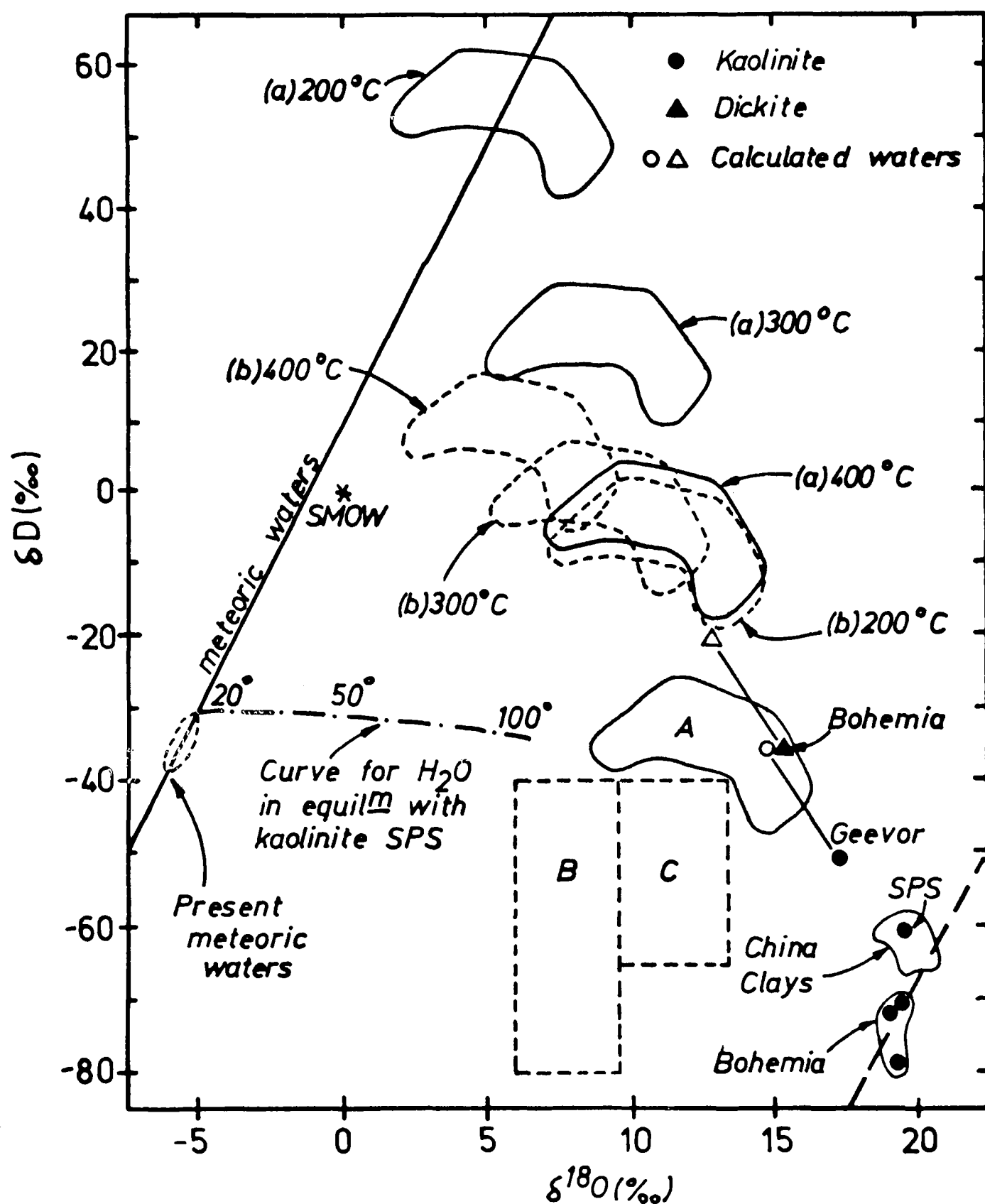


Figure 34. Plot of  $\delta D$  vs  $\delta^{18}O$  for calculated isotopic composition of the waters that would be in equilibrium with the unaltered granites at magmatic temperatures, and the alteration minerals at the stated temperatures. (adapted from Sheppard, 1977).

Note: waters in equilibrium with alteration micas calculated using fractionation curve for hydrogen of (a) Friedman and O'Neil, 1977 (b) Taylor, 1974.



A = Alteration micas. B = Primary magmatic water.  
C = Cornubian magmatic waters.

Figure 35. Plot of  $\delta D$  versus  $\delta^{18}O$  of vein quartz, greisen muscovites and their calculated waters from Goonbarrow.

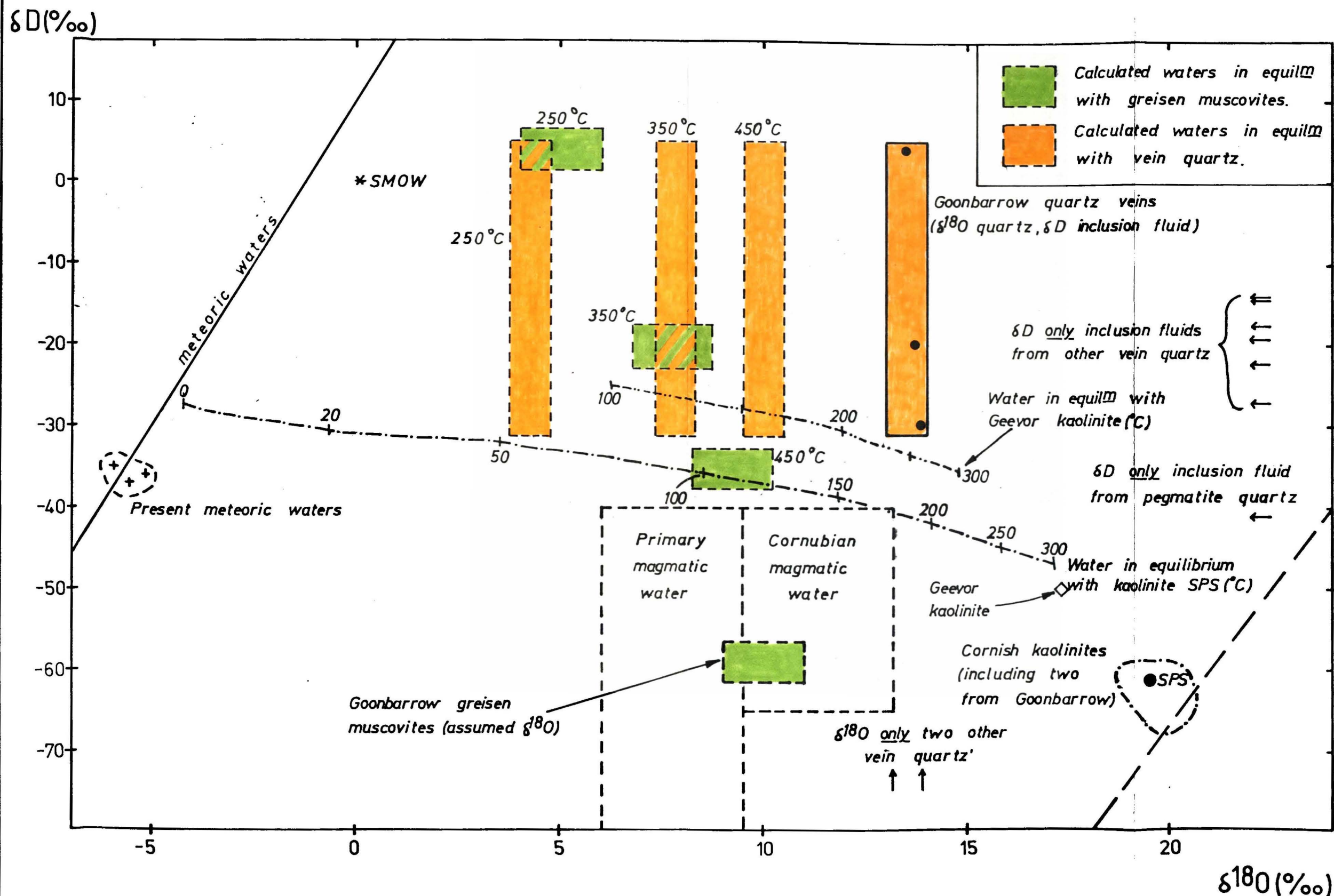


Figure 36. Calculated  $\delta^{18}\text{O}$  compositions of waters in equilibrium with Goonbarrow vein quartz and greisen muscovite at various temperatures.

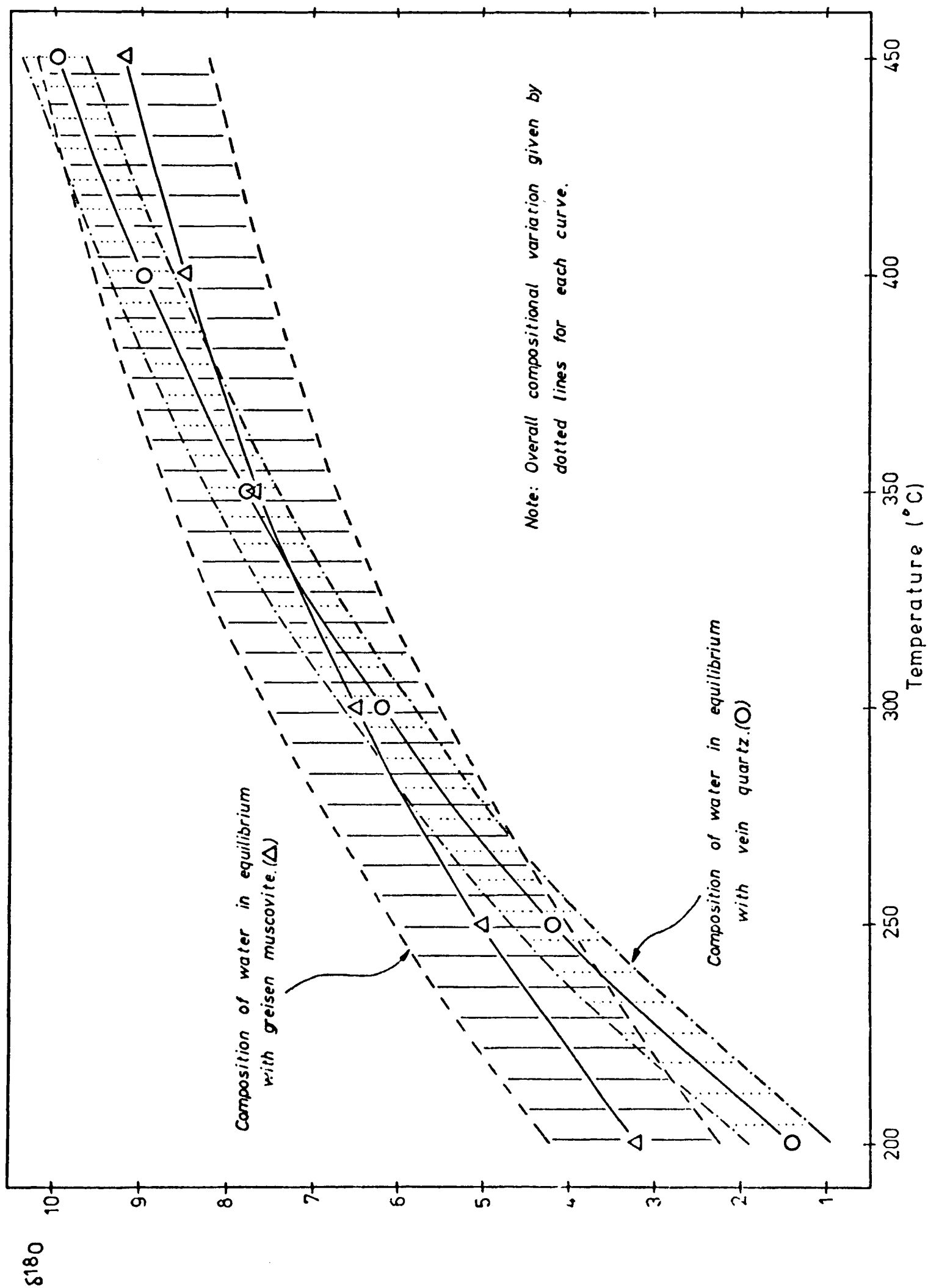
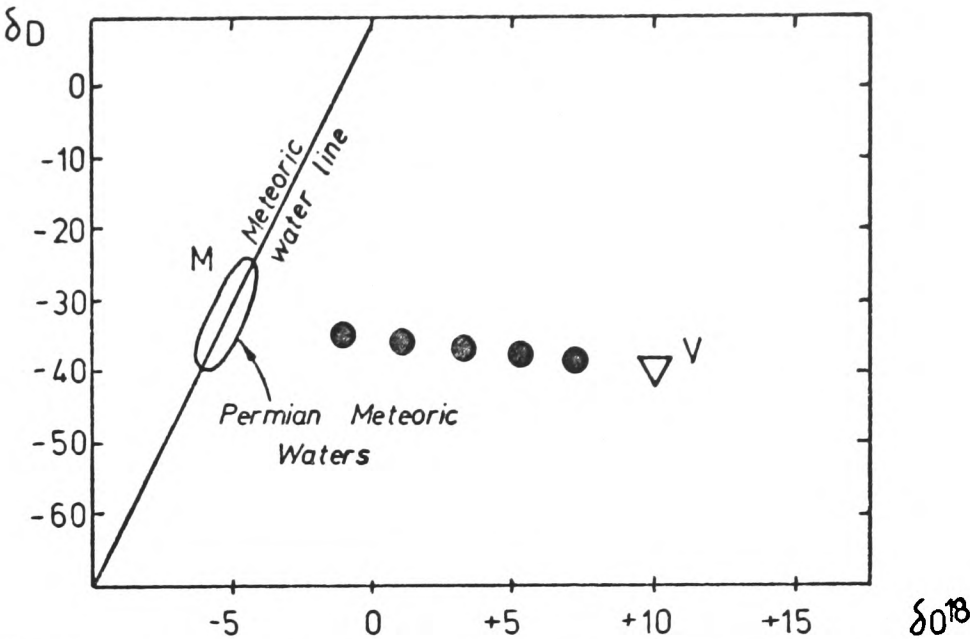


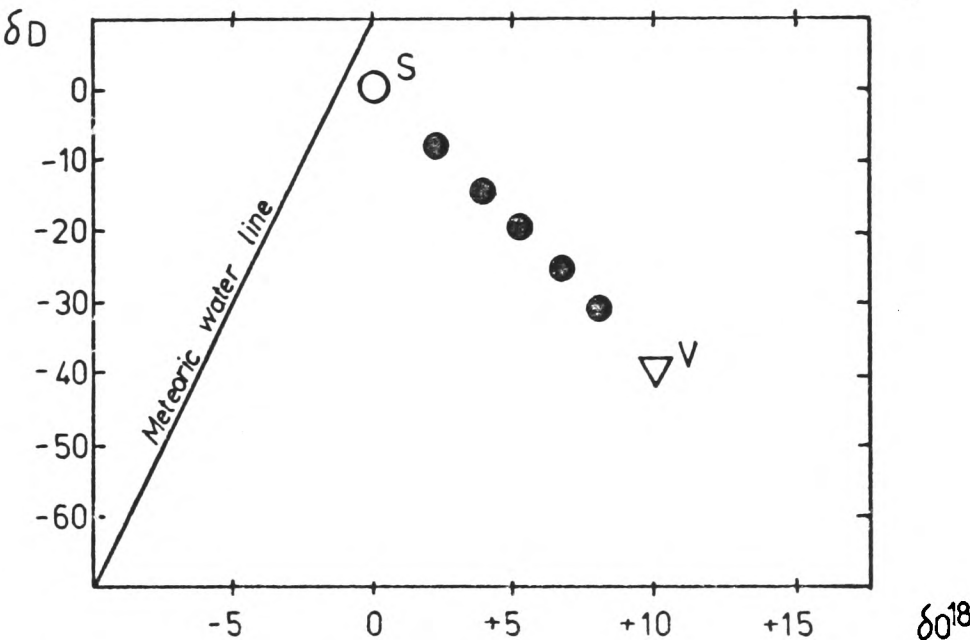
Figure 37. Mixing relationships between magmatic and other waters.

● Expected isotopic compositions of mineral vein quartz and inclusion waters within vein quartz.

(a) Magmatic water (V) mixing with meteoric water (M).



(b) Magmatic water (V) mixing with sea water (S).



(c) Magmatic water (V) mixing with derived sea water (DS).

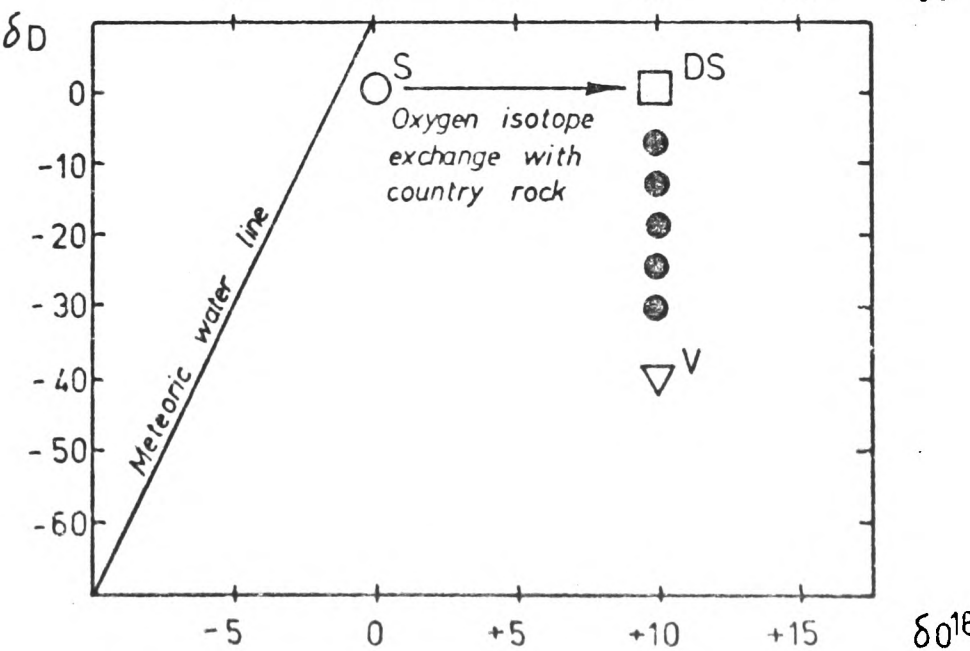


Figure 38. Oxygen fractionation curve between water(l) and water(v). (Friedman and O'Neil, 1977)

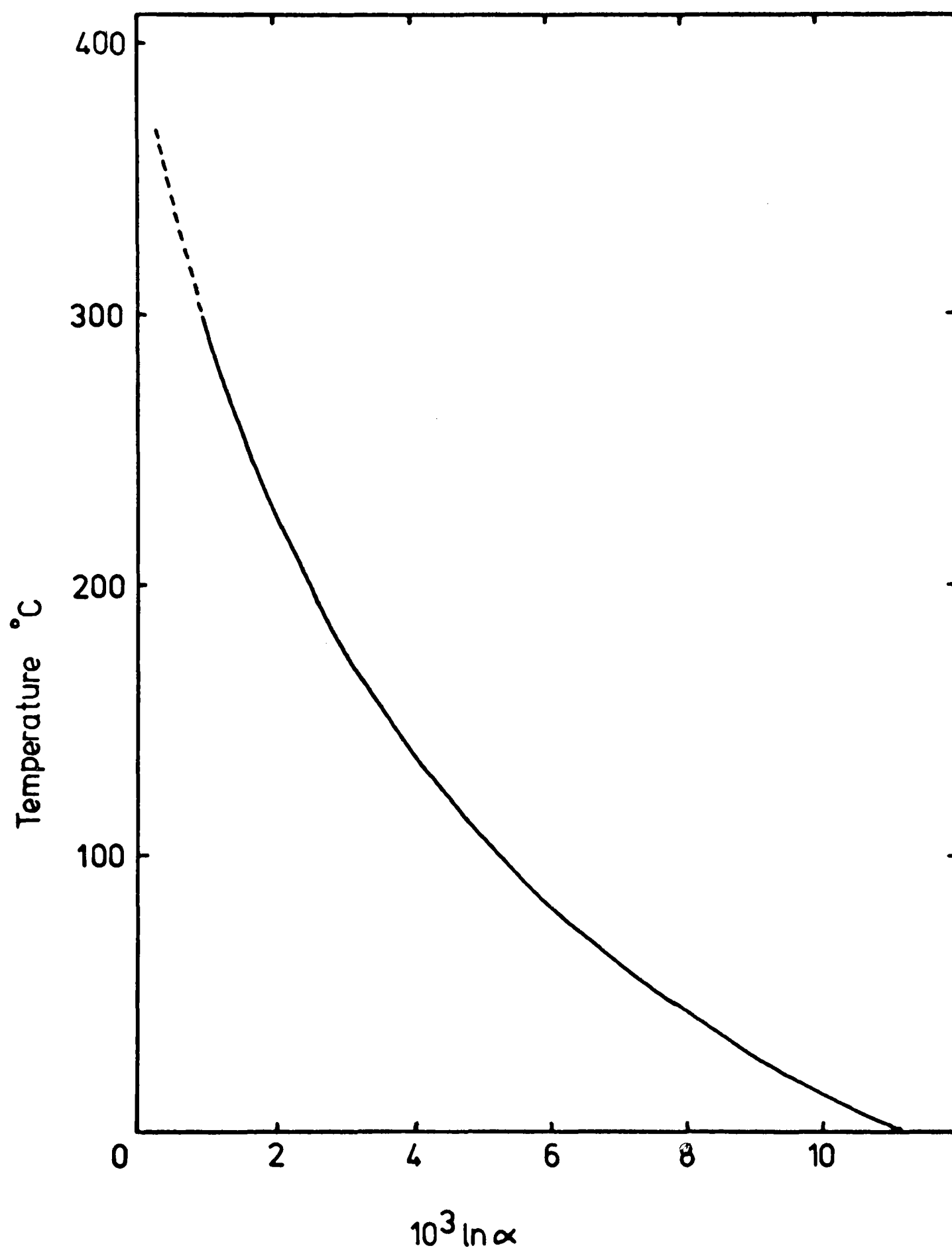


Figure 39. Hydrogen fractionation curve between water(l) and water(v). (Friedman and O'Neil, 1977)

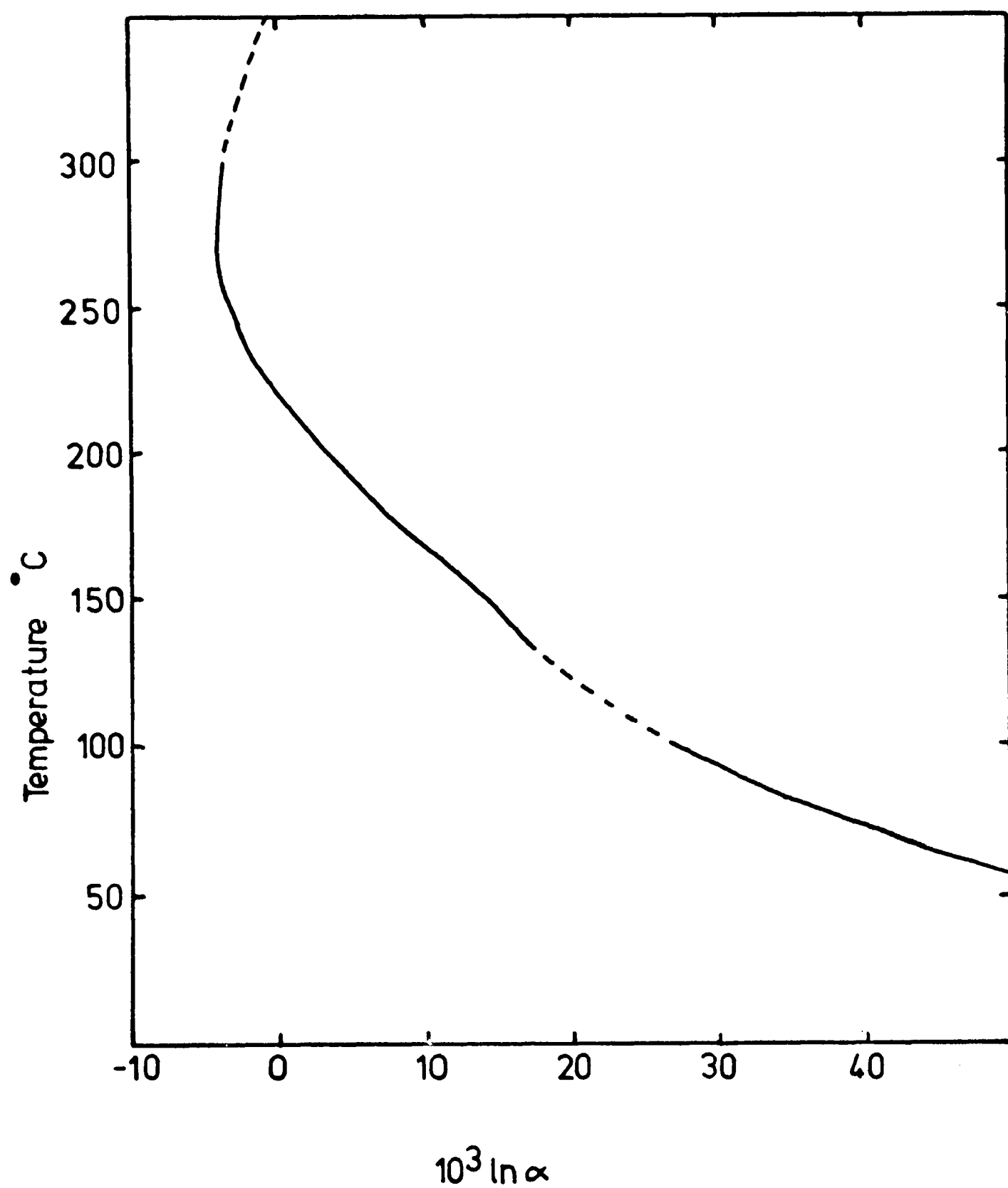
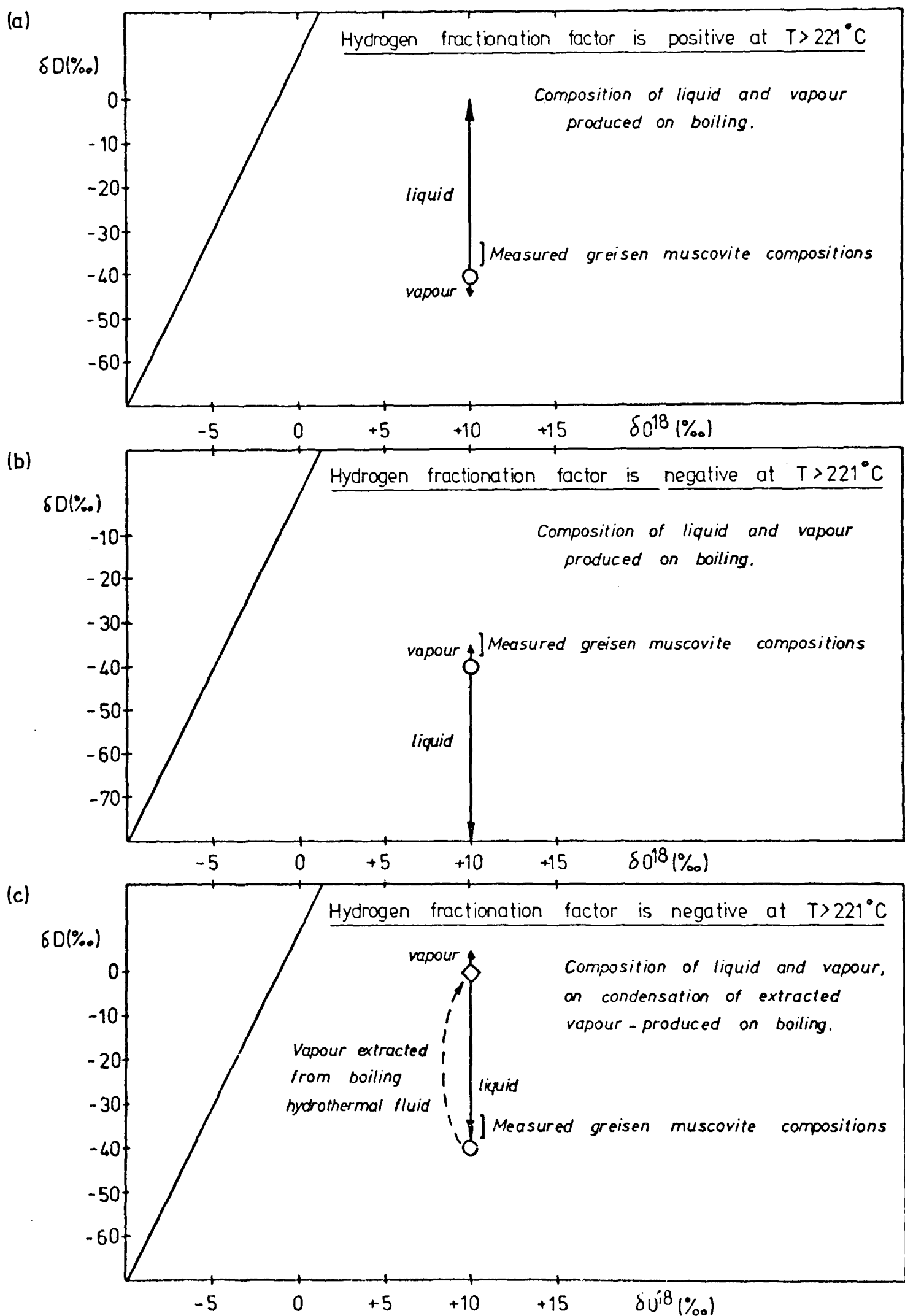




Figure 40. The dependence of boiling induced liquid and vapour compositions on the sign of the hydrogen fractionation factor.



○ Initial starting composition.



Figure 41. Overall model to explain the observed isotopic compositions of vein quartz, greisen muscovites and kaolinites from Goonbarrow.

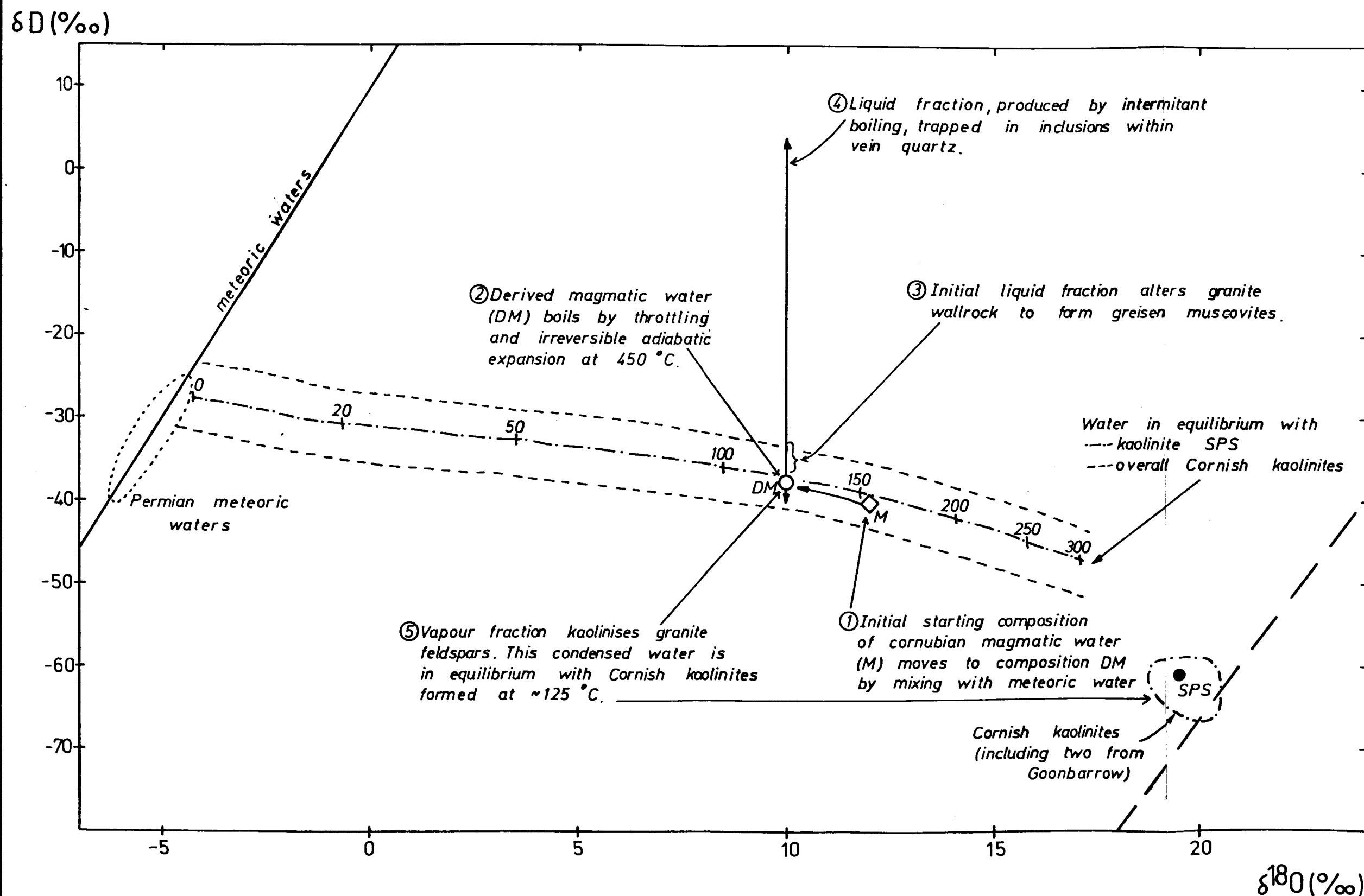


Figure A1. The Institute of Geological Sciences' high vacuum extraction line for the determination of the argon isotopic compositions of rocks and minerals.

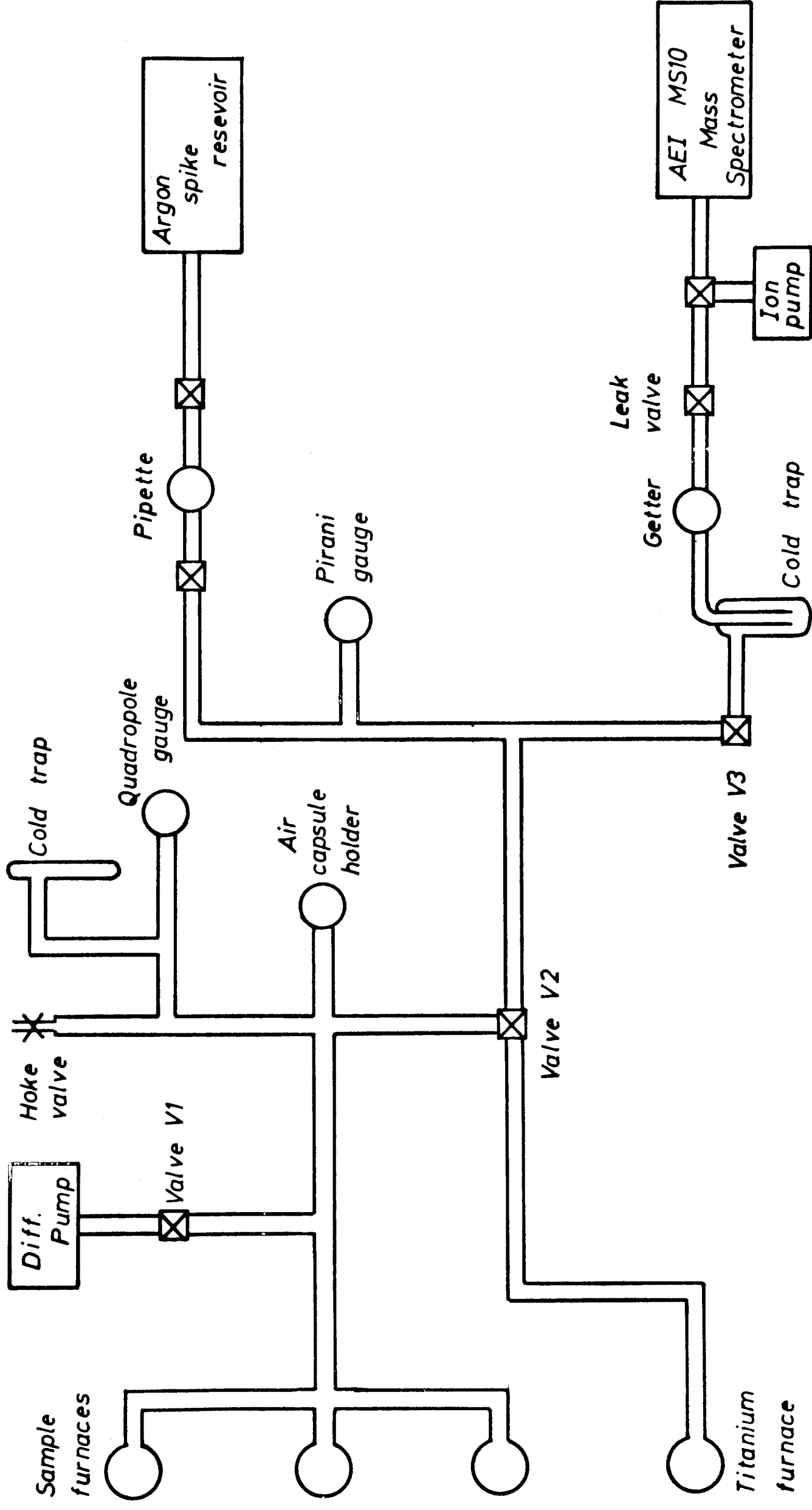
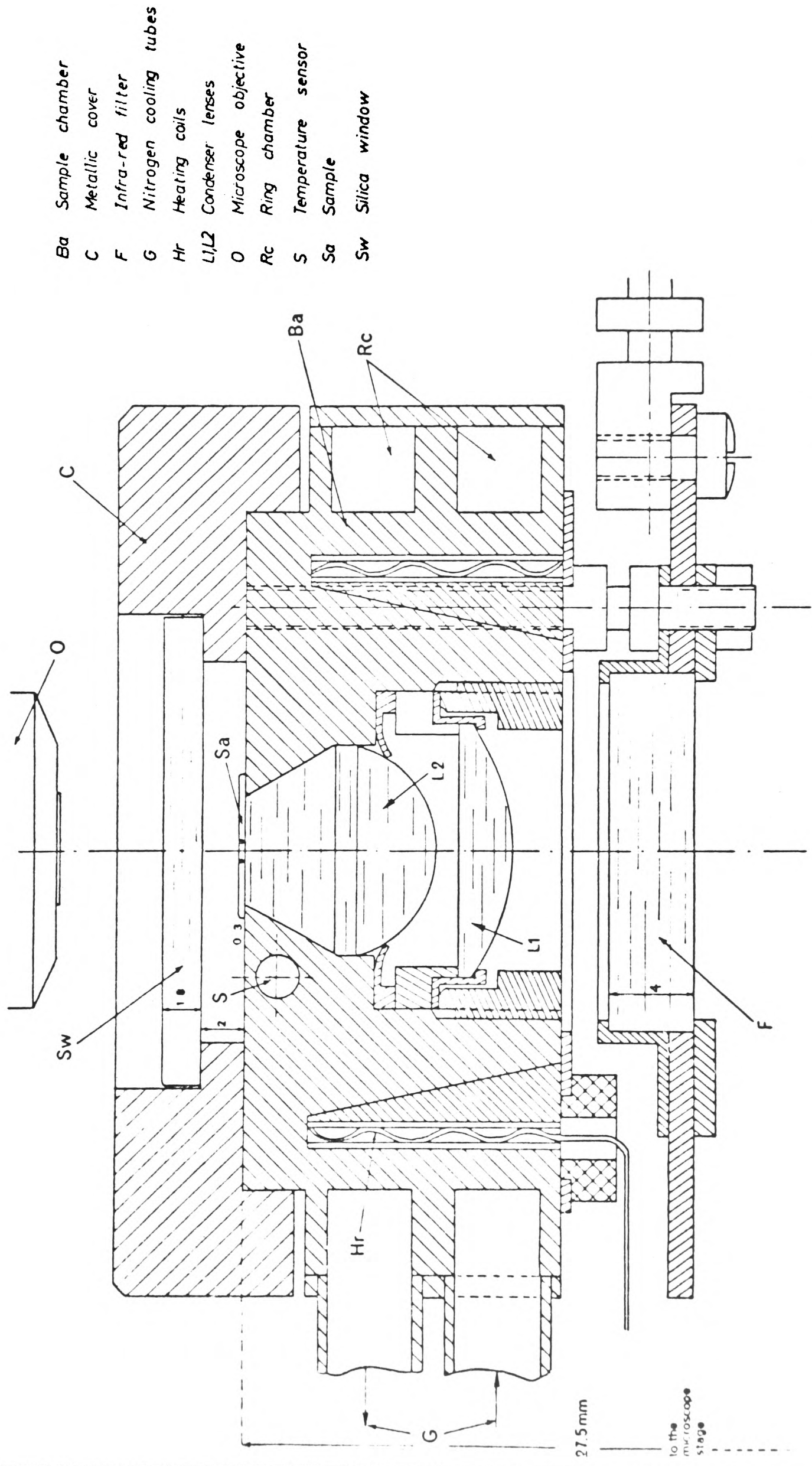


Figure A2. The Chaixmeca heating/freezing stage (schematic cross section 5X)



- Ba Sample chamber
- C Metallic cover
- F Infra-red filter
- G Nitrogen cooling tubes
- Hr Heating coils
- L1, L2 Condenser lenses
- O Microscope objective
- Rc Ring chamber
- S Temperature sensor
- Sa Sample
- Sw Silica window

Figure A3. Schematic diagram showing the adaptation of the Chaixmeca stage to eliminate frost buildup on the bottom condenser lens L2.

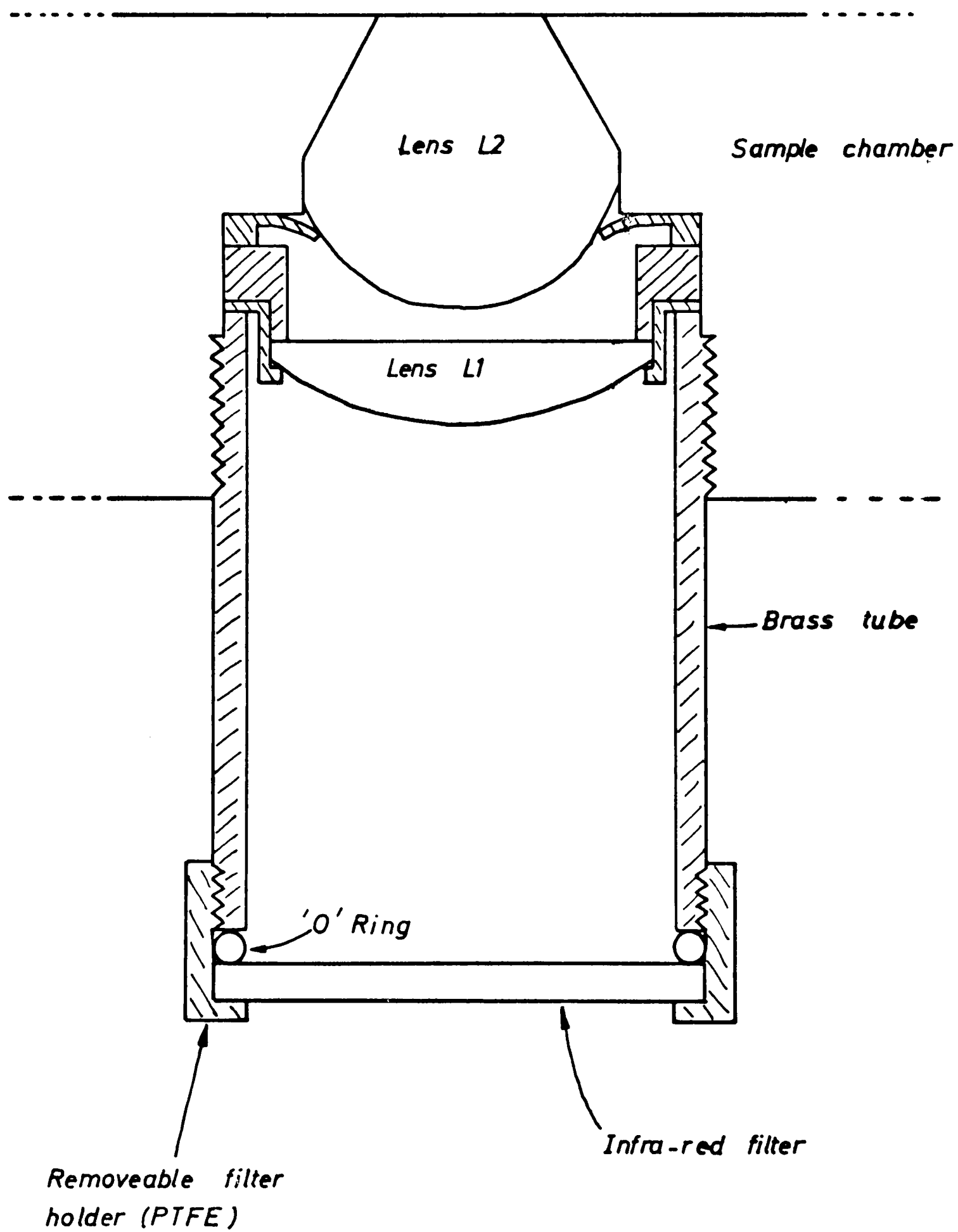


Figure A4. Plot of melting point vs. heating rate for  
signotherm SK70 calibration standard.

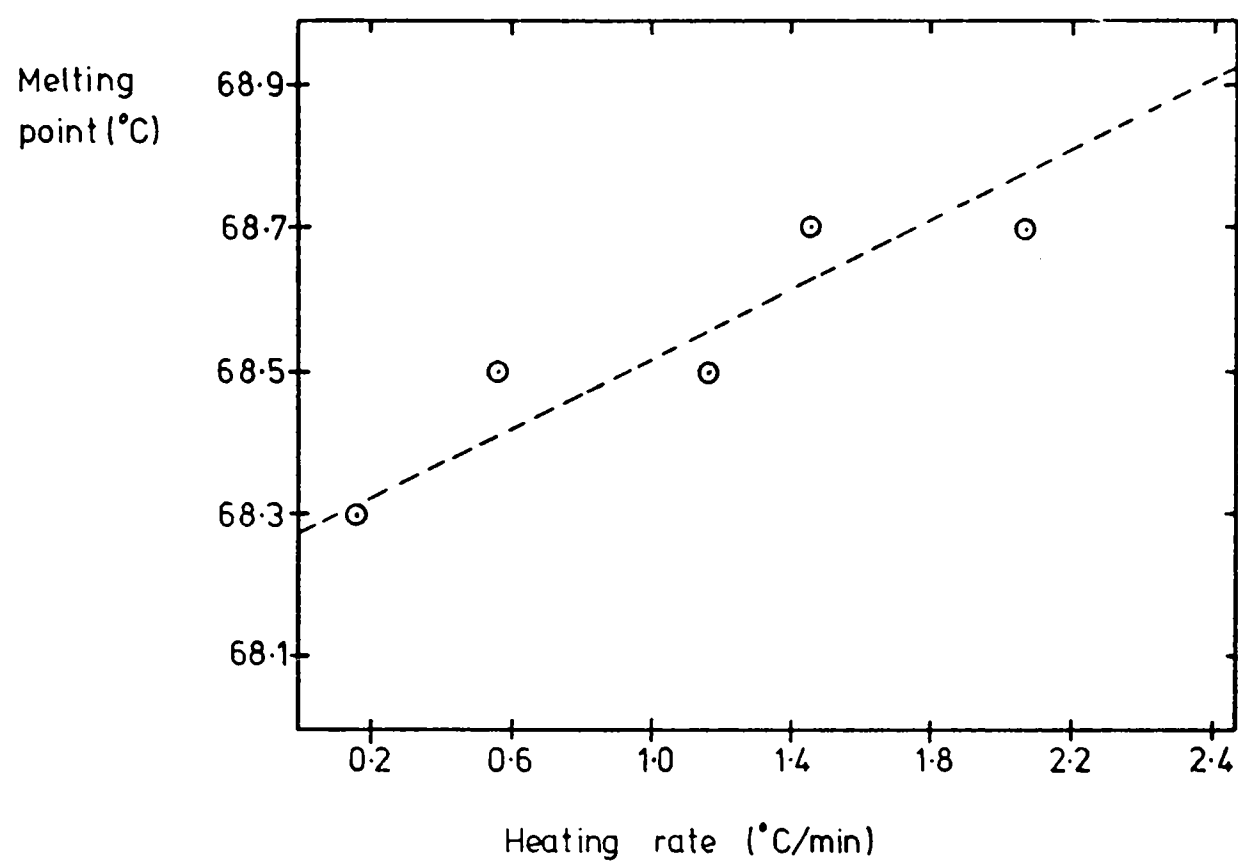


Figure A5. Plot of melting point vs. heating rate for  
signotherm SK100 calibration standard.

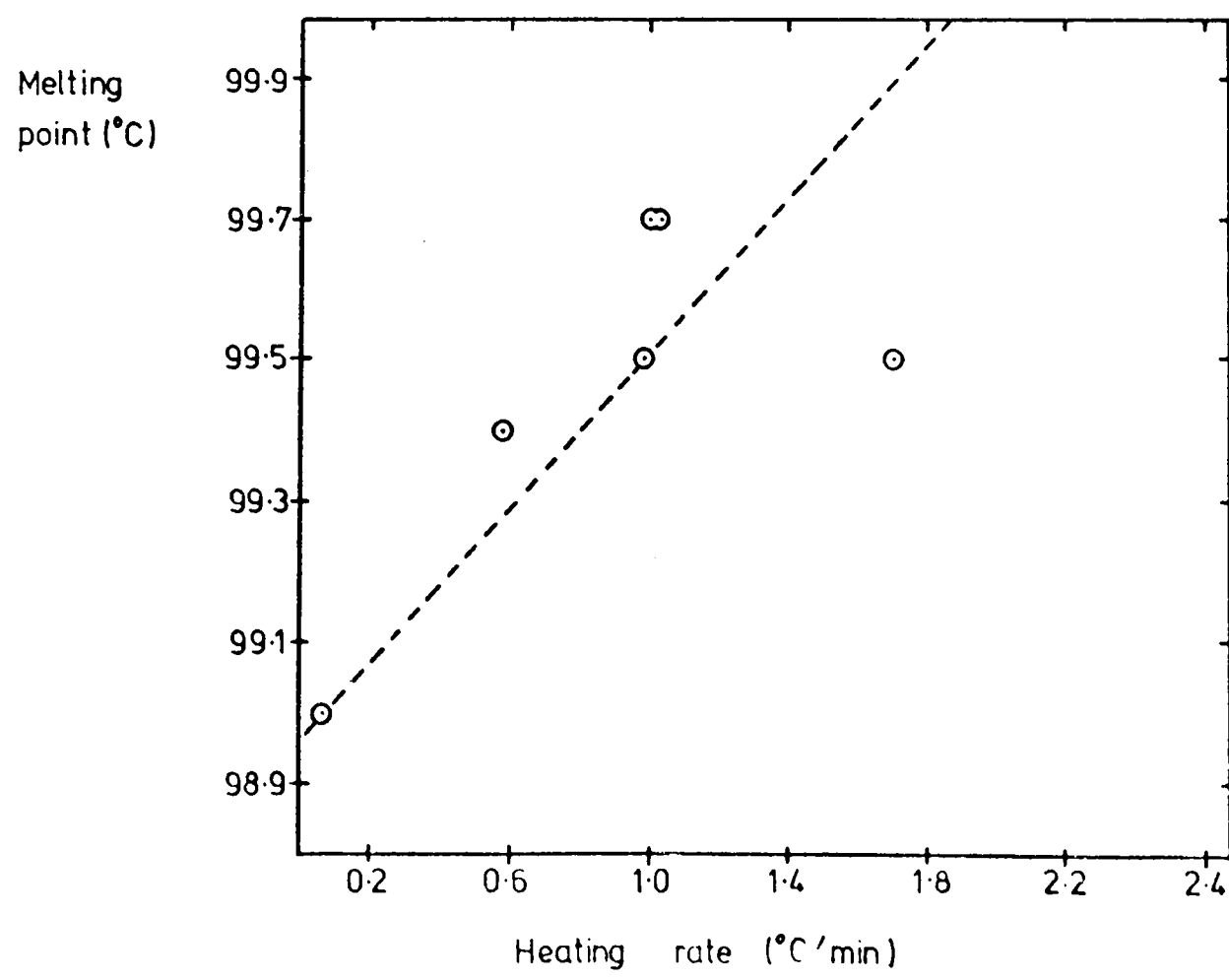


Figure A6. Plot of melting point vs. heating rate for signotherm SK135 calibration standard.

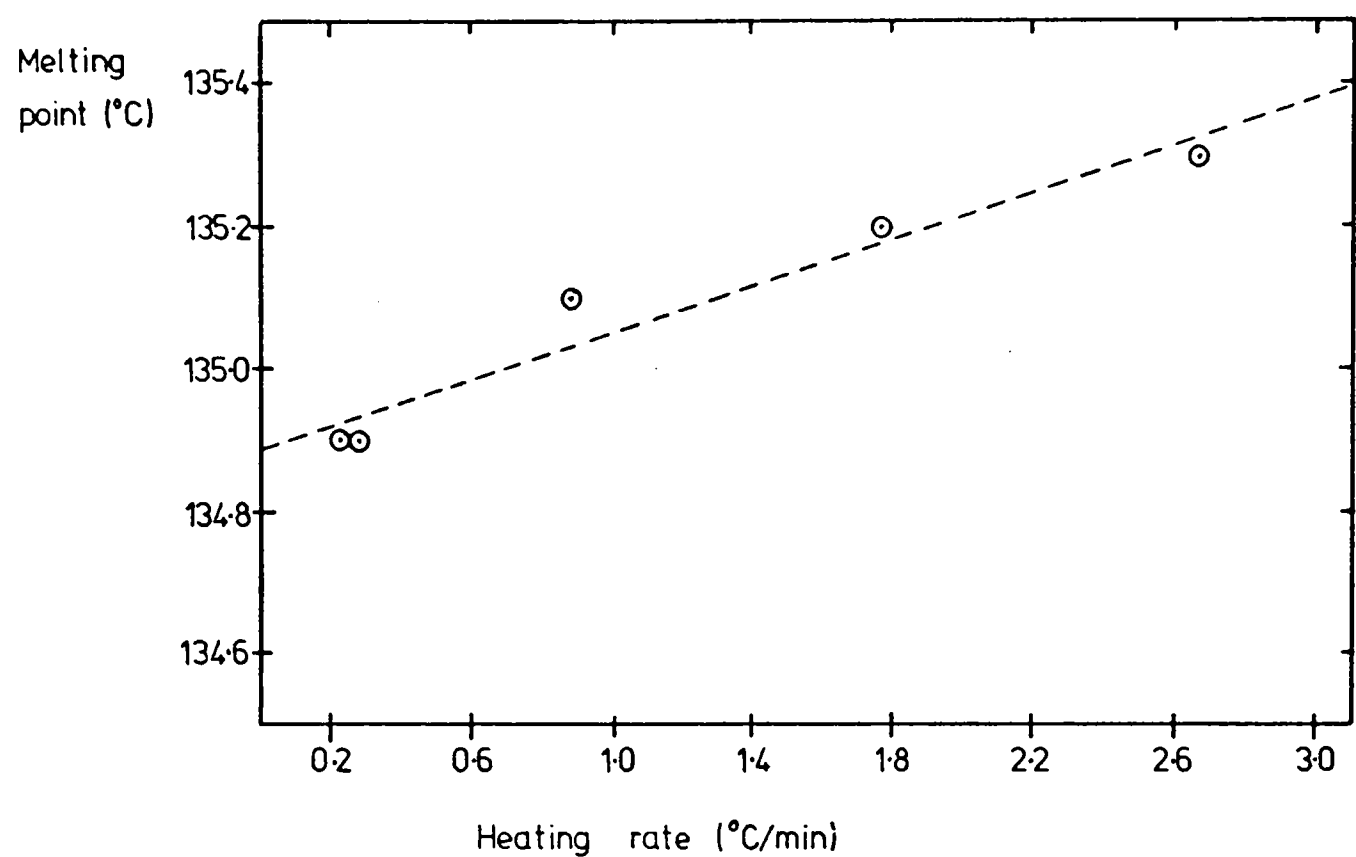


Figure A7. Plot of melting point vs. heating rate for signotherm SK180 calibration standard.

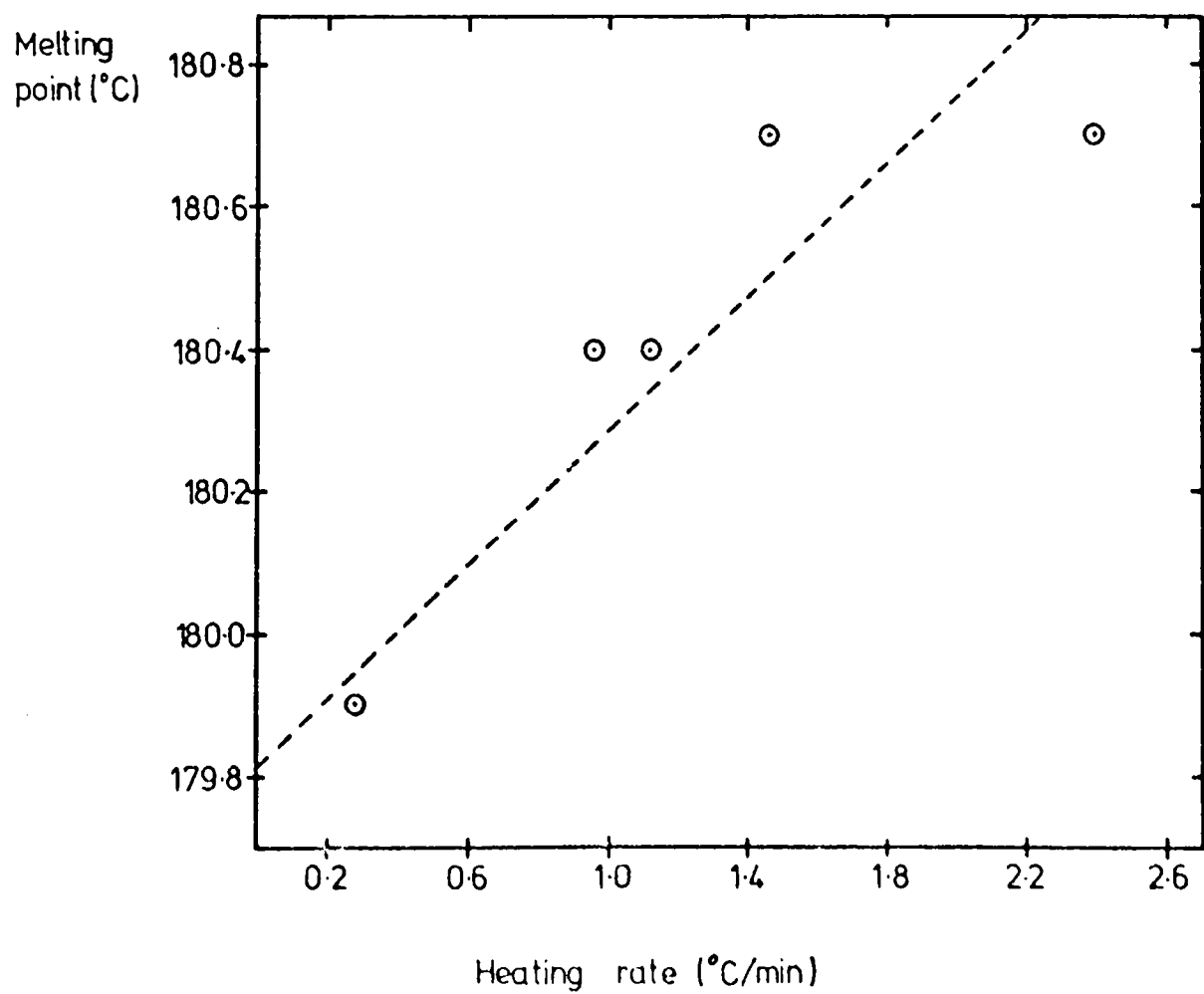


Figure A8. Plot of melting point vs. heating rate for signotherm SK200 calibration standard.

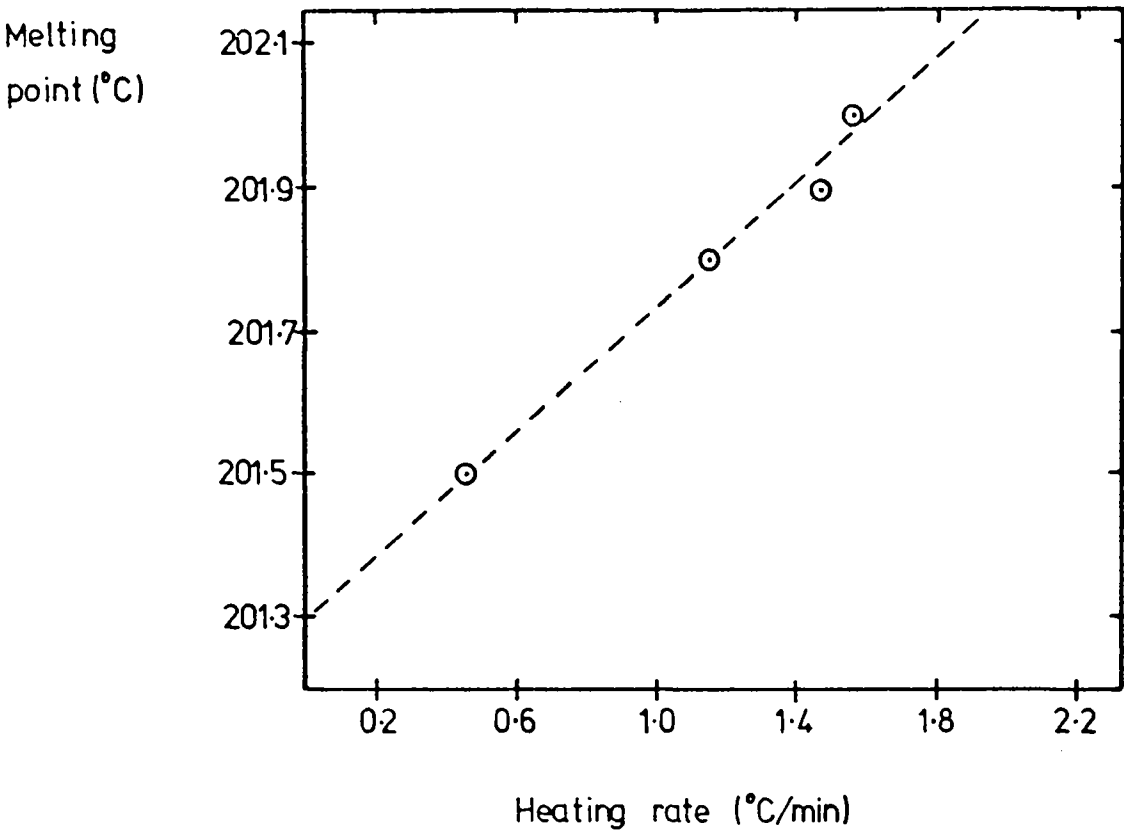


Figure A9. Plot of melting point vs. heating rate for signotherm SK247 calibration standard.

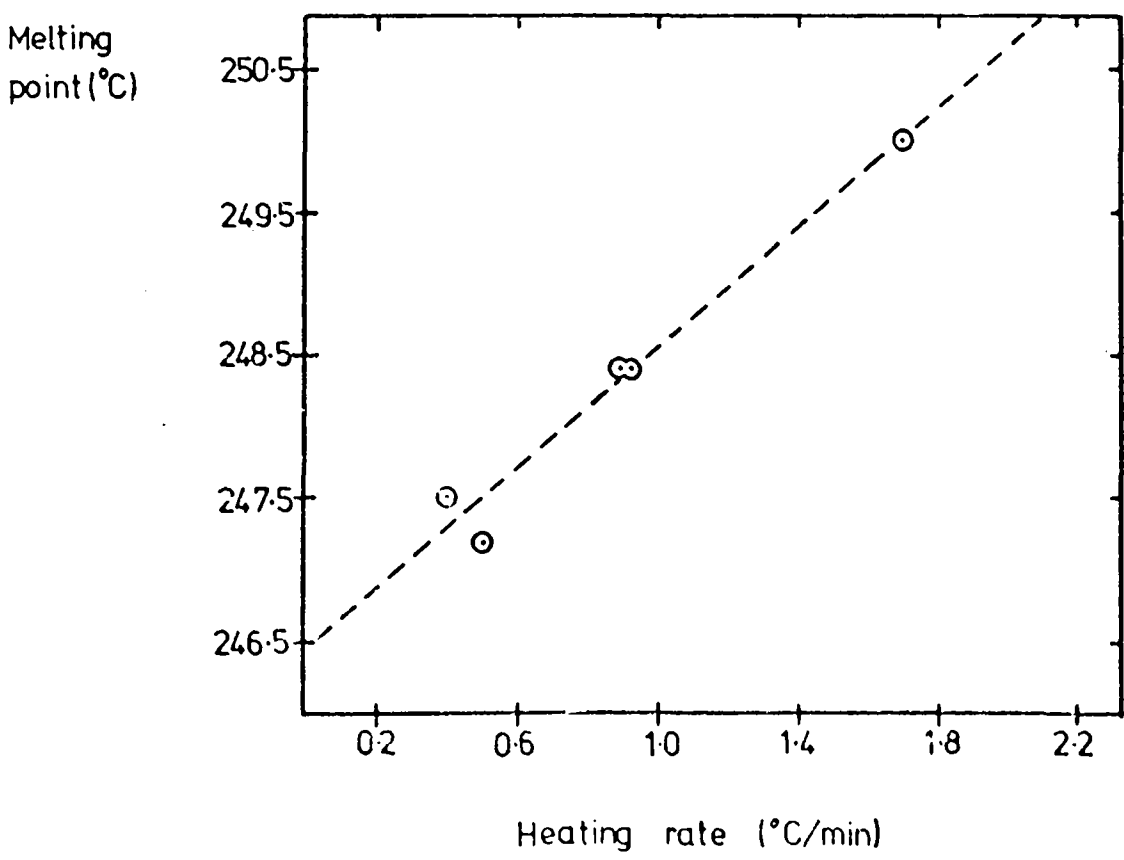




Figure A10. Plot of melting point vs. heating rate for sodium nitrate calibration standard.

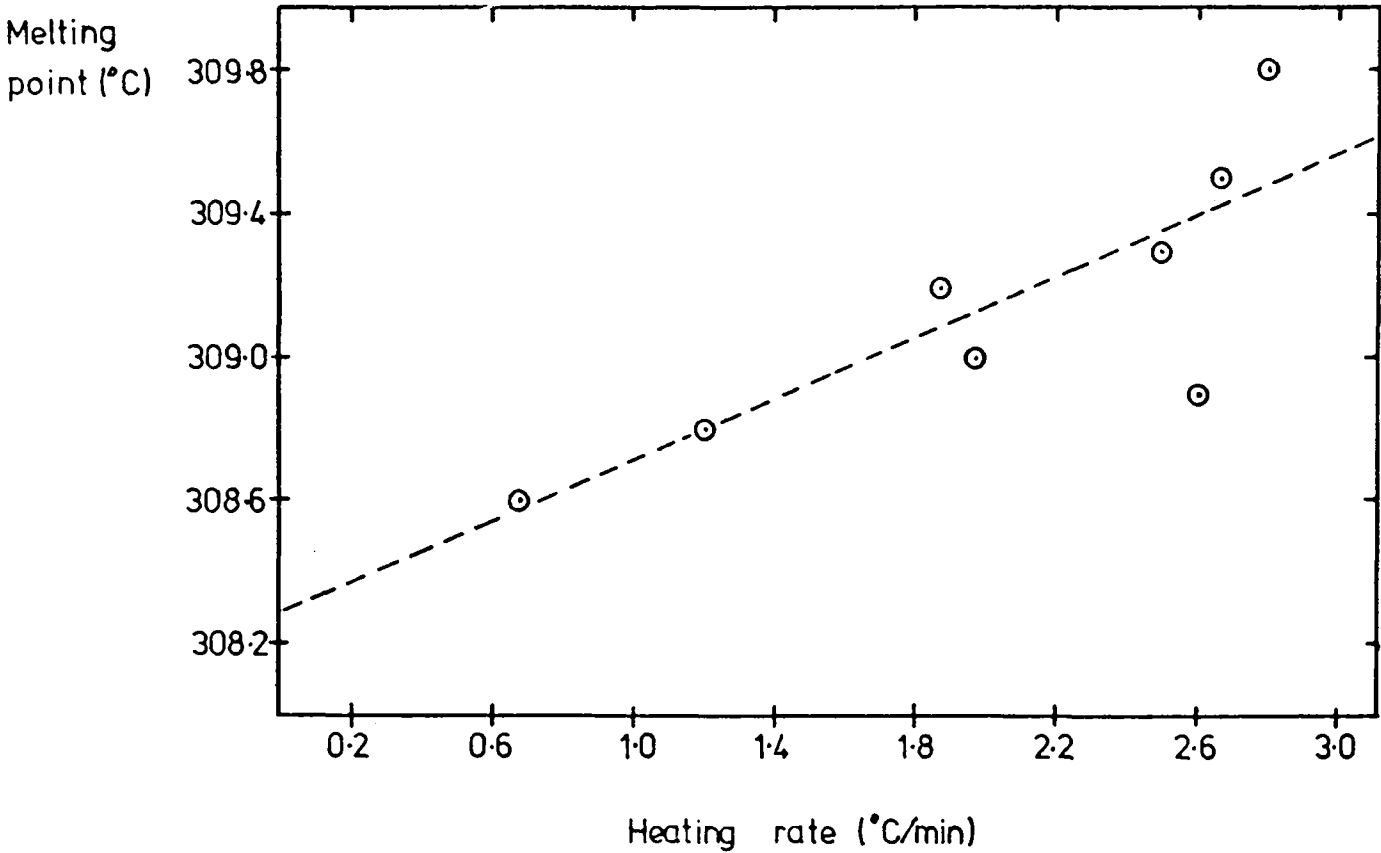


Figure A11. Plot of melting point vs. heating rate for potassium dichromate calibration standard.

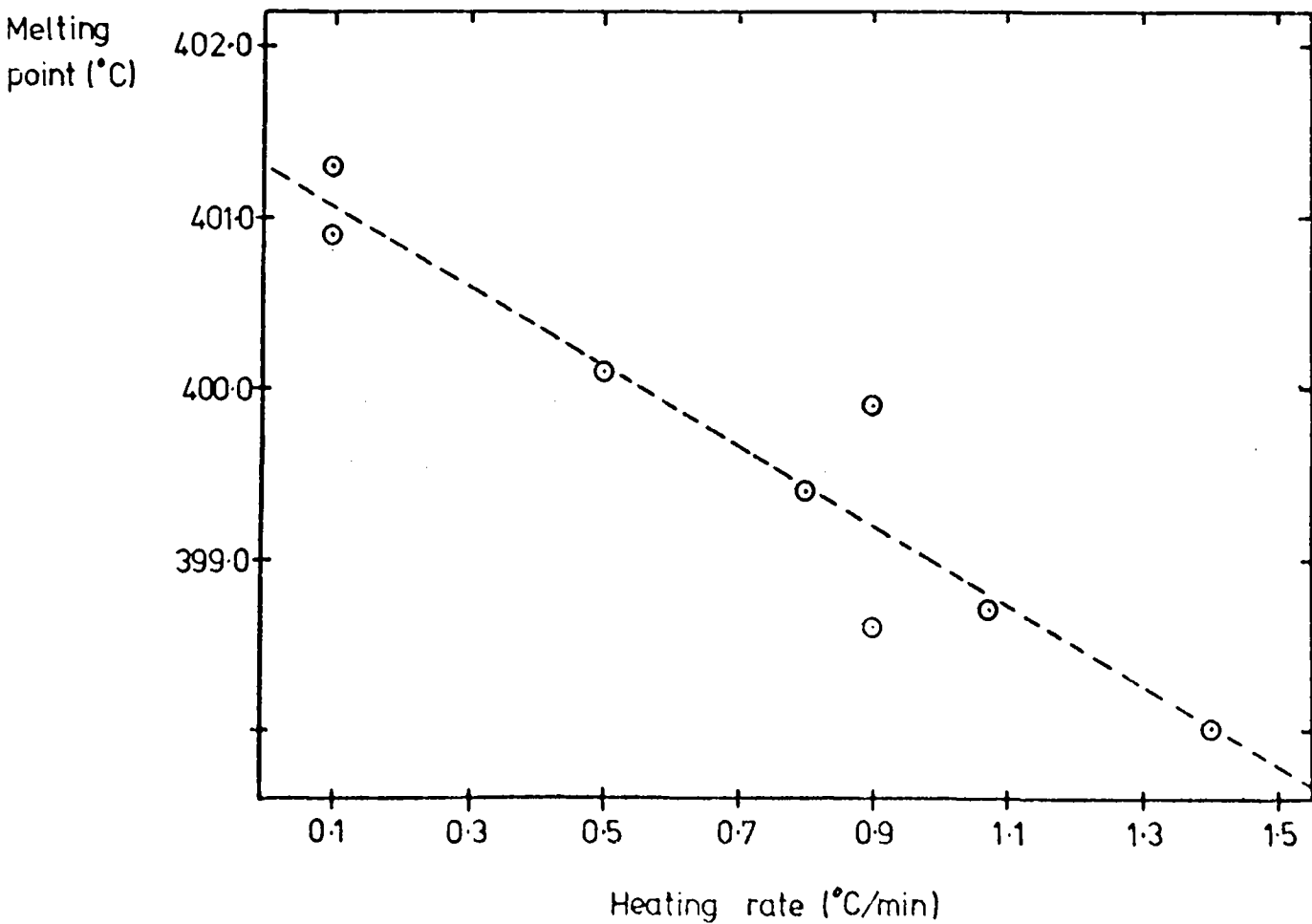
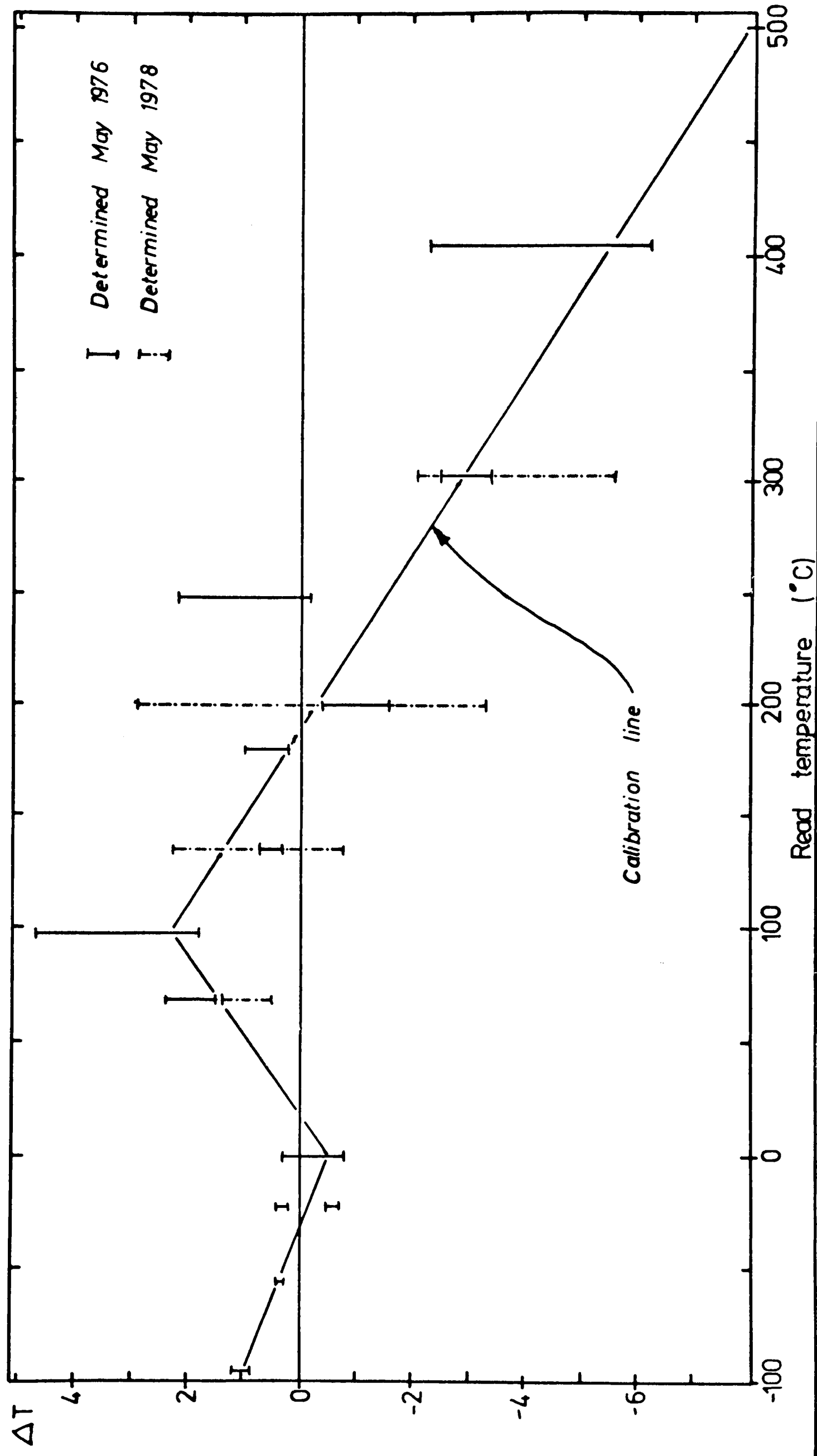




Figure A12. Final calibration graph for the Chaixmeca stage.



### List of Plates

1. The three types of granite at Goonbarrow.
2. "Big feldspar" granite (BFG).
3. Thin section of "big feldspar" granite.
4. Thin section of "big feldspar" granite.
5. Thin section of "big feldspar" granite.
6. Thin section of "small feldspar" granite.
7. Thin section of "pale mica" granite.
8. As Plate 7., crossed nicols.
9. Sheet of "small feldspar" granite intruding "big feldspar" granite in the new sump area exposed in the summer of 1978.
10. Biflicated sheet of "small feldspar" granite intruding "big feldspar" granite in the new sump area exposed in the summer of 1978.
11. Xenolith of "big feldspar" granite set in "small feldspar" granite in the Martins Goonbarrow area.
12. The Goonbarrow pegmatite exposed in the Imperial Goonbarrow area.
13. The Goonbarrow pegmatite exposed in the West Goonbarrow area.
14. The Goonbarrow pegmatite/"small feldspar" granite junction exposed at Imperial Goonbarrow.
15. A sample from the main core of pegmatite showing long black tourmaline needles in contrast to the pinkish orthoclase feldspars.
16. A sample of the Goonbarrow pegmatite from Imperial Goonbarrow showing dark blades of biotite in contrast to the orthoclase feldspars.
17. Kaolinised pegmatite from the West Goonbarrow area.
18. The pegmatite lying between "big feldspar" granite and "small feldspar" granite.

19. Section through the pegmatite in Imperial Goonbarrow.
20. An example of the "dog leg" effect seen in Imperial Goonbarrow.
21. The pegmatite in Imperial Goonbarrow.
22. The pegmatite in Imperial Goonbarrow.
23. The pegmatite in Imperial Goonbarrow.
24. Imperial Goonbarrow, south face. The greenish yellow elvan crosscutting a quartz/tourmaline vein swarm.
25. The pegmatite showing curved orthoclase crystals.
26. The pegmatite showing curved and branching orthoclase crystals.
27. Section through the pegmatite at Imperial Goonbarrow.
28. Section through "pinched" pegmatite exposed at the far eastern end of Imperial Goonbarrow.
29. Close up of the "pinched" pegmatite shown in plate 28.
30. The "Big feldspar" granite - pegmatite junction.
31. The "small feldspar" granite - pegmatite junction.
32. A sample of the "small feldspar" granite - pegmatite junction.
33. Thin section of the Goonbarrow elvan.
34. Thin section of the Goonbarrow elvan.
35. Thin section of the Goonbarrow elvan.
36. The Goonbarrow elvan exposed at the south face of Imperial Goonbarrow.
37. Apophysis of the Goonbarrow elvan showing laminated flow banding.
38. The western end of Old Beam looking towards North Goonbarrow.
39. The western end of Old Beam, the steep walls of the old North Goonbarrow pit in the background.
40. A vein swarm exposed in the area near Martins Goonbarrow.
41. A sample of a cassiterite bearing vein from Old Beam.
42. Thin section of a cassiterite bearing vein.

- 43. A typical cassiterite bearing lode in the Old Beam area, with the old mine workings in the background.
- 44. Close up of the topaz rich greisen shown in plate 43.
- 45. Close up of the "normal" greisen shown in plate 43.
- 46. Old Beam.
- 47. Thin section of "pale mica" granite.
- 48. Thin section of kaolinised "pale mica" granite.
- 49. Thin section of kaolinised "pale mica" granite.
- 50-55. Photomicrographs of fluid inclusions in quartz from Goonbarrow.
- 86-97. Scanning electron micrographs of daughter crystals in fluid inclusion cavities.
- 98. A large xenolith of kaolinised country rock (killas) seen lying in intensely kaolinised granite in Melbur china clay pit.
- 11. A portion of the high vacuum extraction line used for the determination of the argon isotopic compositions of rocks and minerals at the Institute of Geological Sciences, London.
- 12. The high vacuum argon extraction line.

Plate 1. The three types of granite at Goonbarrow. From left to right, "Pale mica" granite (PMG), "Small feldspar" granite (SFG) and "Big feldspar" granite (BFG).

Plate 2. "Big feldspar" granite (BFG). Note the large potash feldspar megacryst. Coin is 25 mm across.

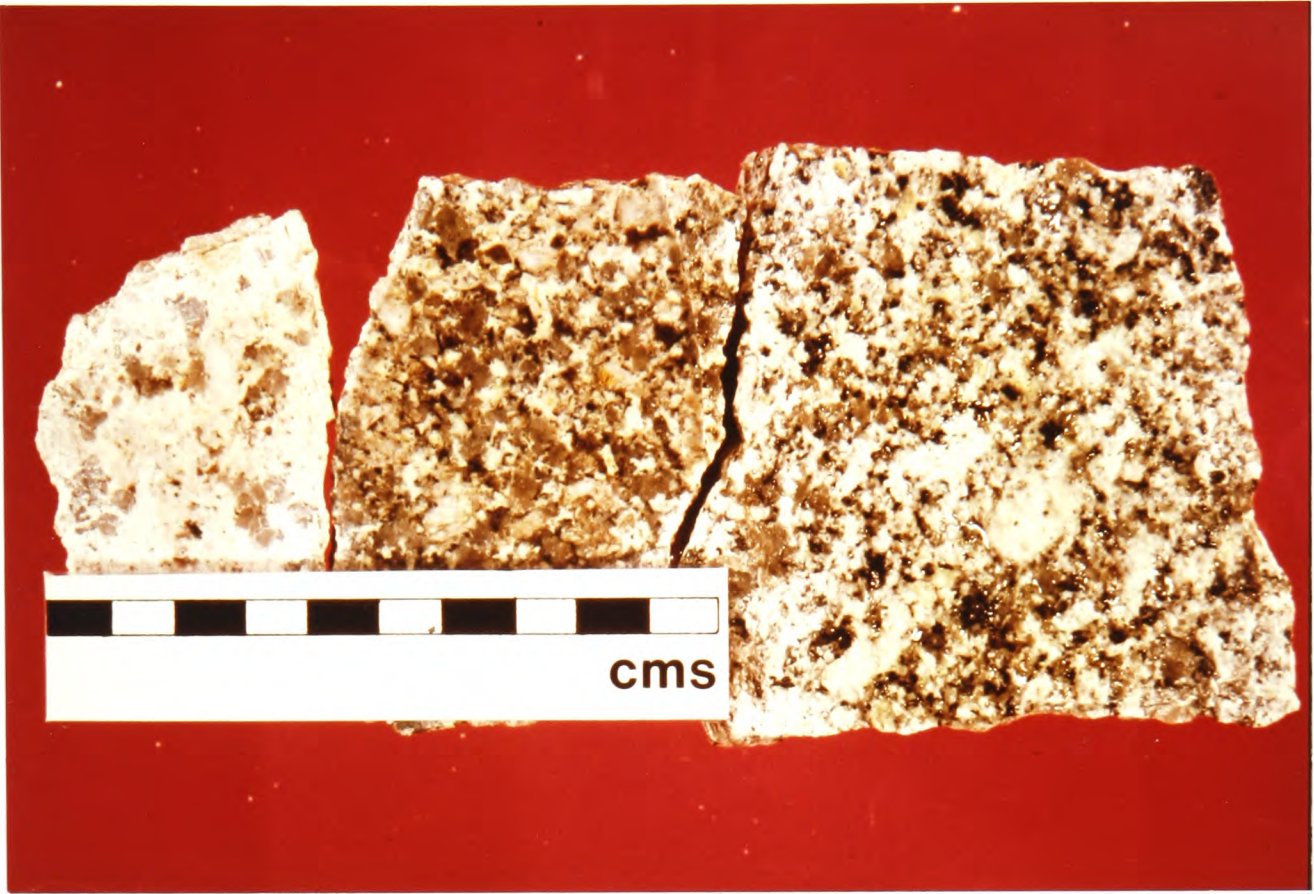


Plate 3. Thin section of "big feldspar" granite, X200, crossed nicols. Plagioclase in centre of field is altered to secondary muscovite. Biotite in bottom left hand corner contains dark pleochroic haloes.

Plate 4. Thin section of "big feldspar" granite, X200, crossed nicols. Euhedral potash feldspar megacryst in centre of field, slightly altered to secondary muscovite. The plagioclase to the top and bottom of the potash feldspar megacryst is more altered to secondary muscovite.



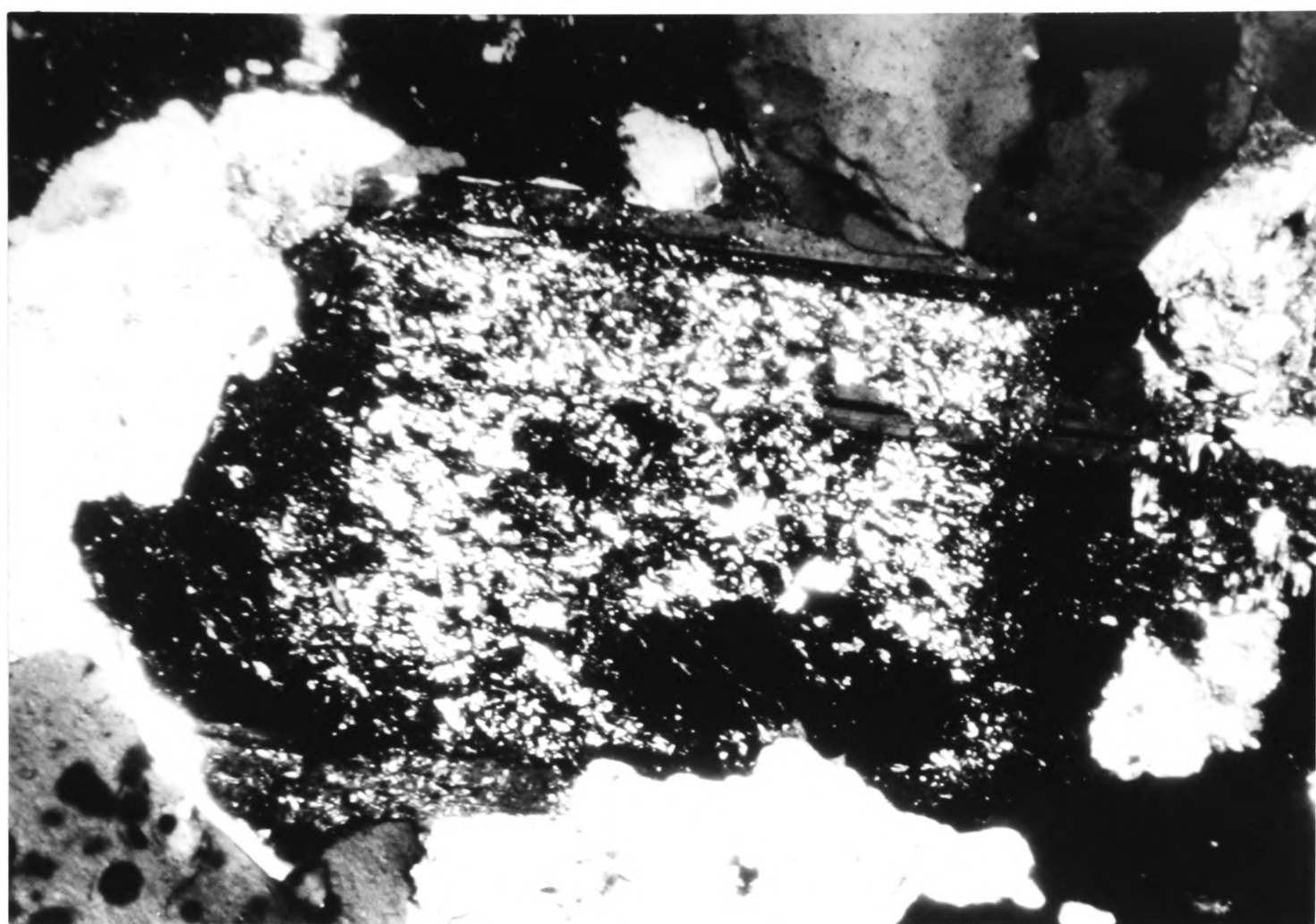
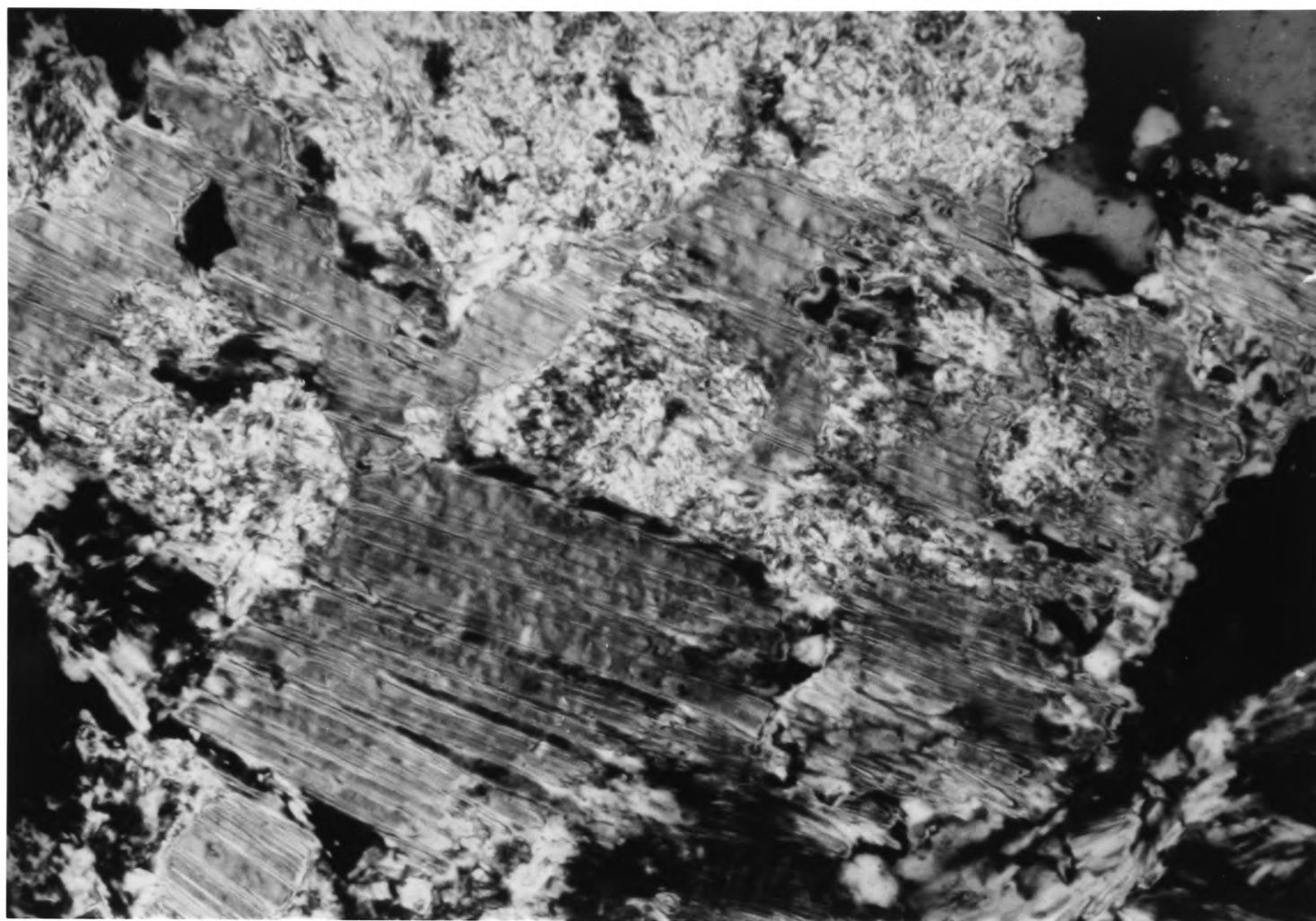




Plate 5. Thin section of "big feldspar" granite, X800,  
crossed nicols. Primary muscovite altering  
to secondary muscovite.

Plate 6. Thin section of "small feldspar" granite, X80,  
crossed nicols. Plagioclase in centre of field  
altering to secondary muscovite. Potash feldspar  
(F) altering to secondary muscovite.



F

Plate 7. Thin section of "pale mica" granite, X16, plain polarised light. Lithionite (L) containing some pleochroic haloes. Note absence of dark minerals such as tourmaline and biotite.

Plate 8. As Plate 7, crossed nicols. Plagioclase megocryst, lying approximately vertical contains secondary muscovite. Potash feldspar altered to secondary muscovite along the cleavage.

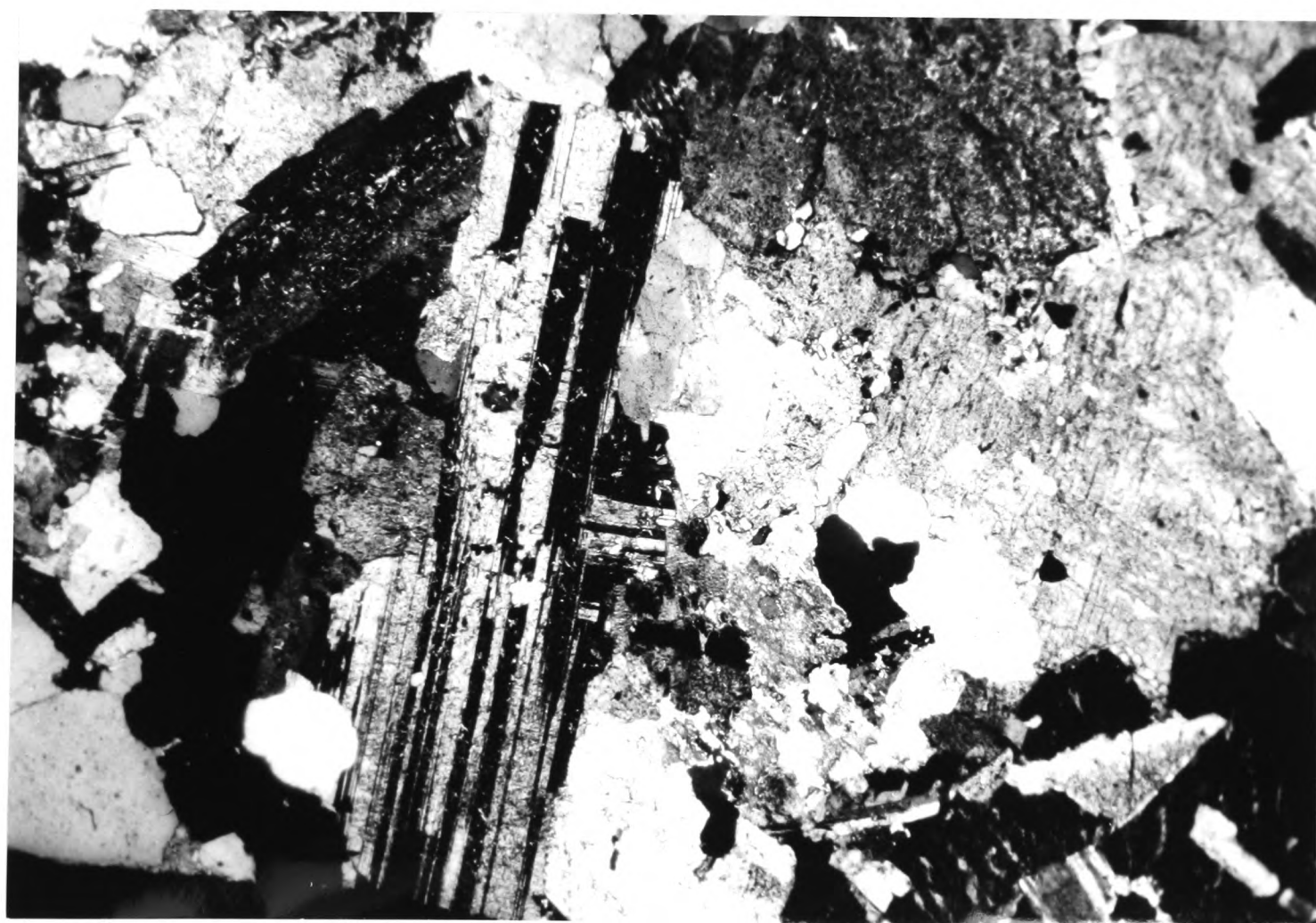
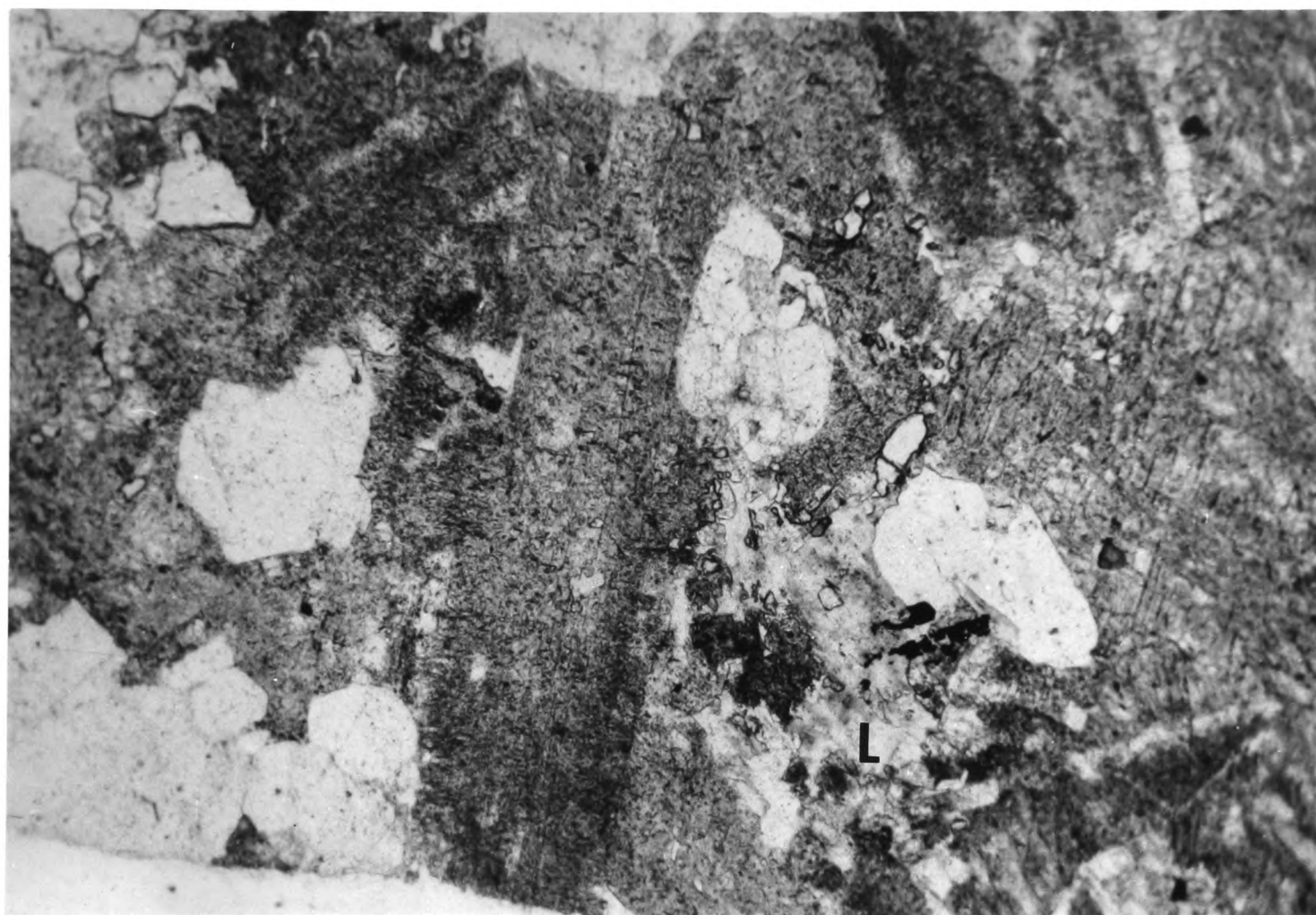


Plate 9. Sheet of "small feldspar" granite intruding "big feldspar" granite in the new sump area exposed in the summer of 1978 (location 4).

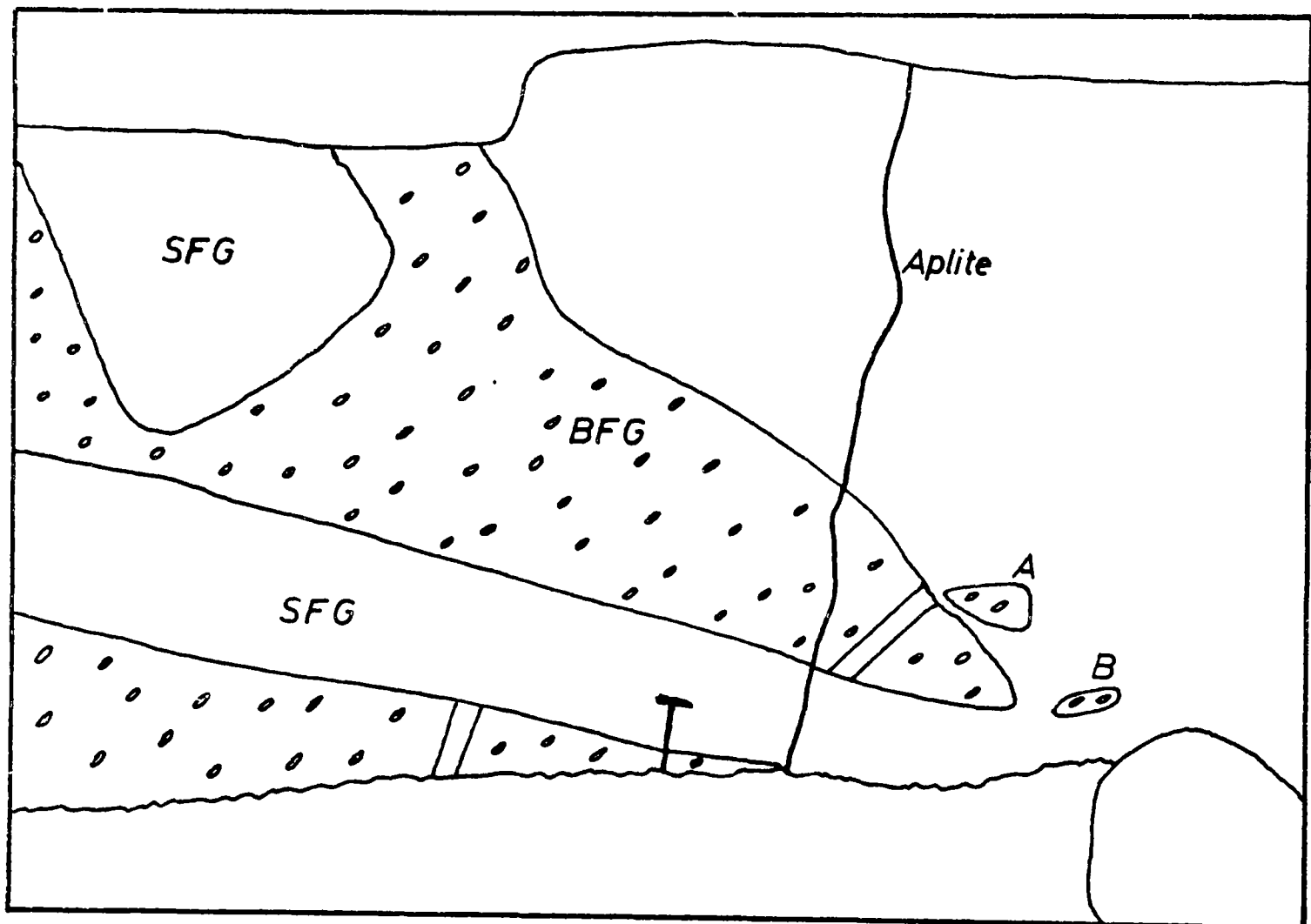


Plate 10. Bifurcated sheet of "small feldspar" granite intruding "big feldspar" granite in the new sump area exposed in the summer of 1978 (location C). Two xenoliths of BFG (marked A and B) have been broken off; their angular nature suggests that the BFG was fairly solid at the time of emplacement of the SFG.







Plate 11. Xenolith of "big feldspar" granite set in "small feldspar" granite in the Martins Goonbarrow area. Note the pegmatitic growth of feldspar and tourmaline around the xenolith.

Plate 12. The Goonbarrow pegmatite exposed in the Imperial Goonbarrow area. The curved nature of the white orthoclase crystals can be clearly seen. Note the dark bands of tourmaline rich matrix which lie parallel to the granite/pegmatite contact.



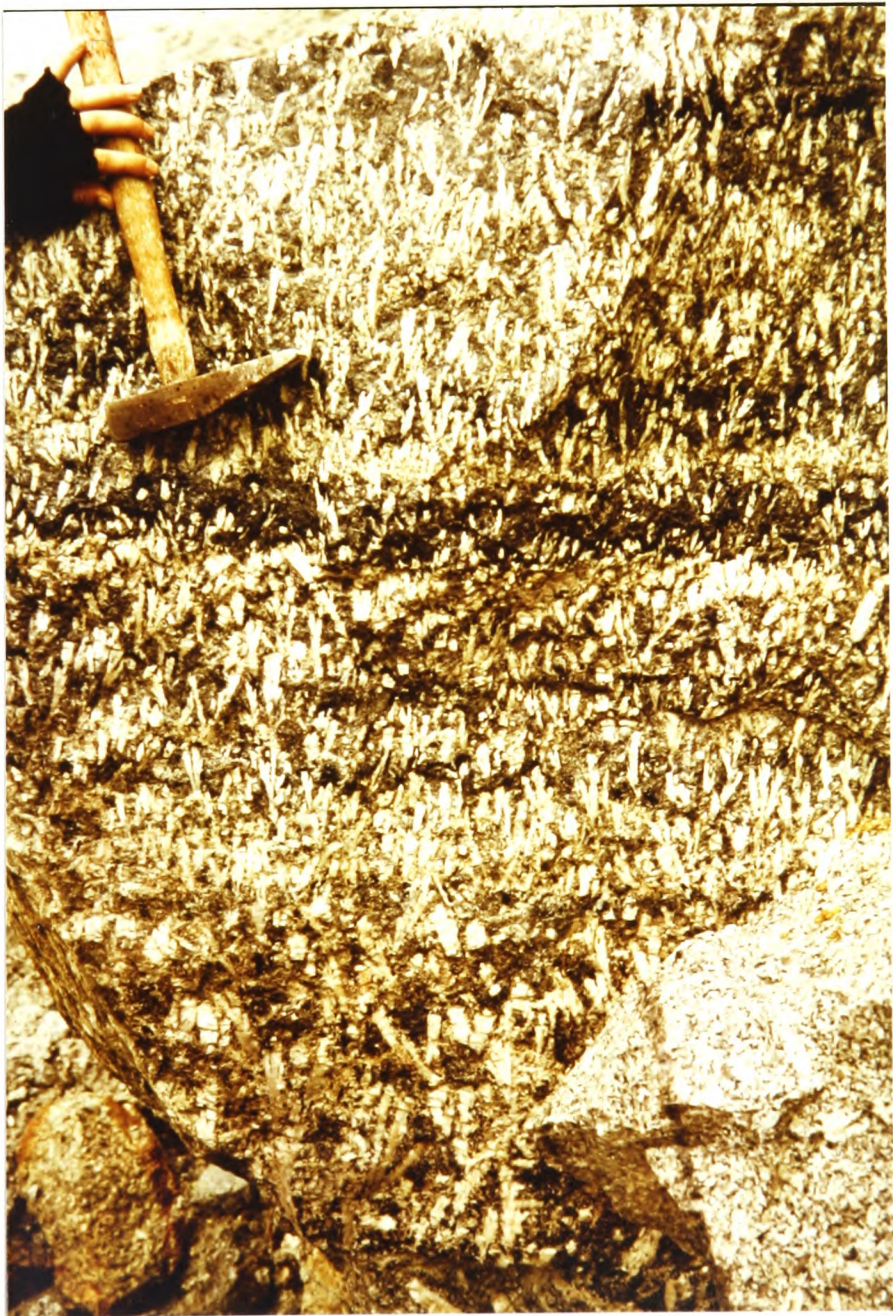
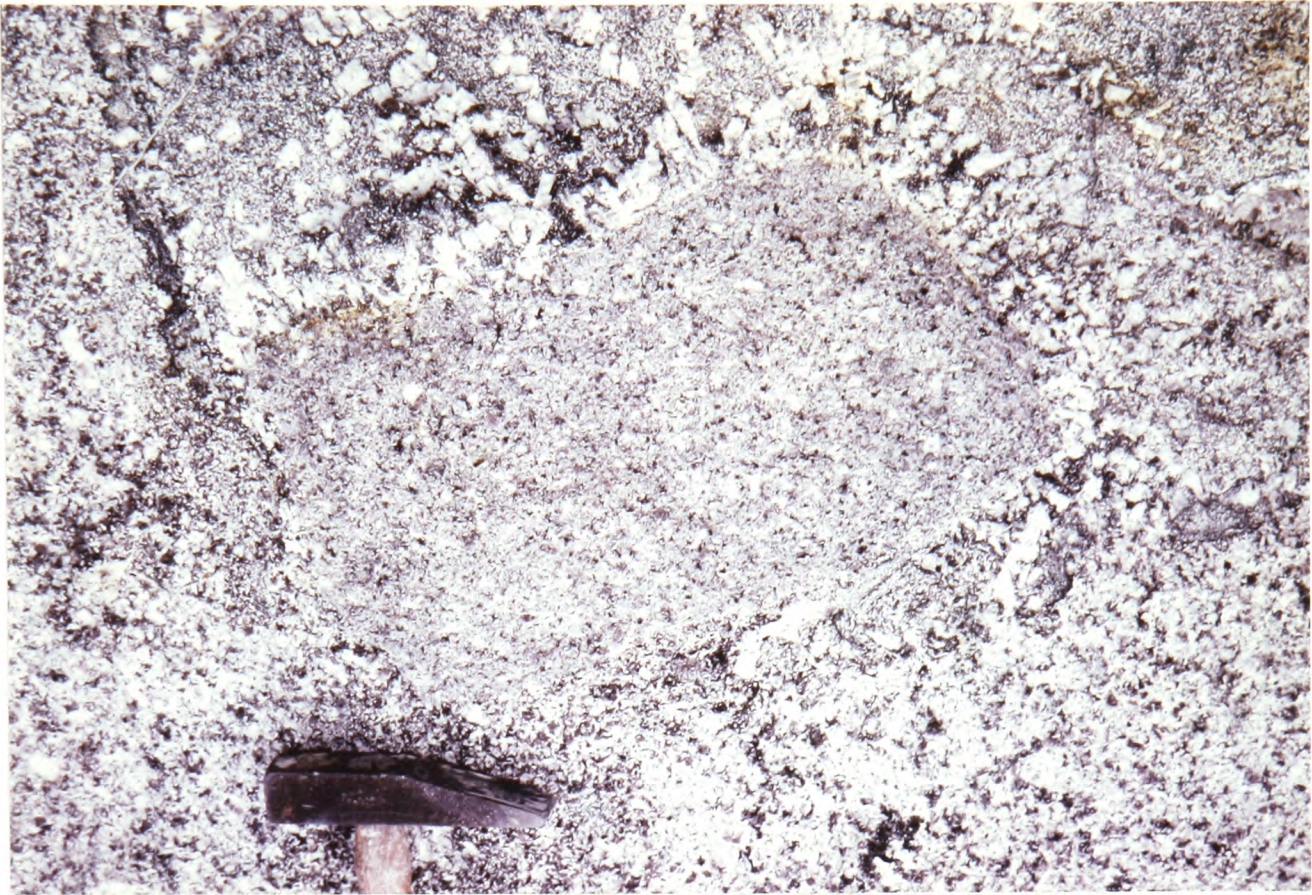




Plate 13. The Goonbarrow pegmatite exposed in the West Goonbarrow area (location A). The potash feldspars are not curved at this location, however the layered nature of the interstitial matrix can be clearly seen. The dark bands are tourmaline rich layers lying parallel to the granite (pegmatite contact).

Plate 14. The Goonbarrow pegmatite/"small feldspar" granite junction exposed at Imperial Goonbarrow. Long tourmaline needles have formed at the contact.



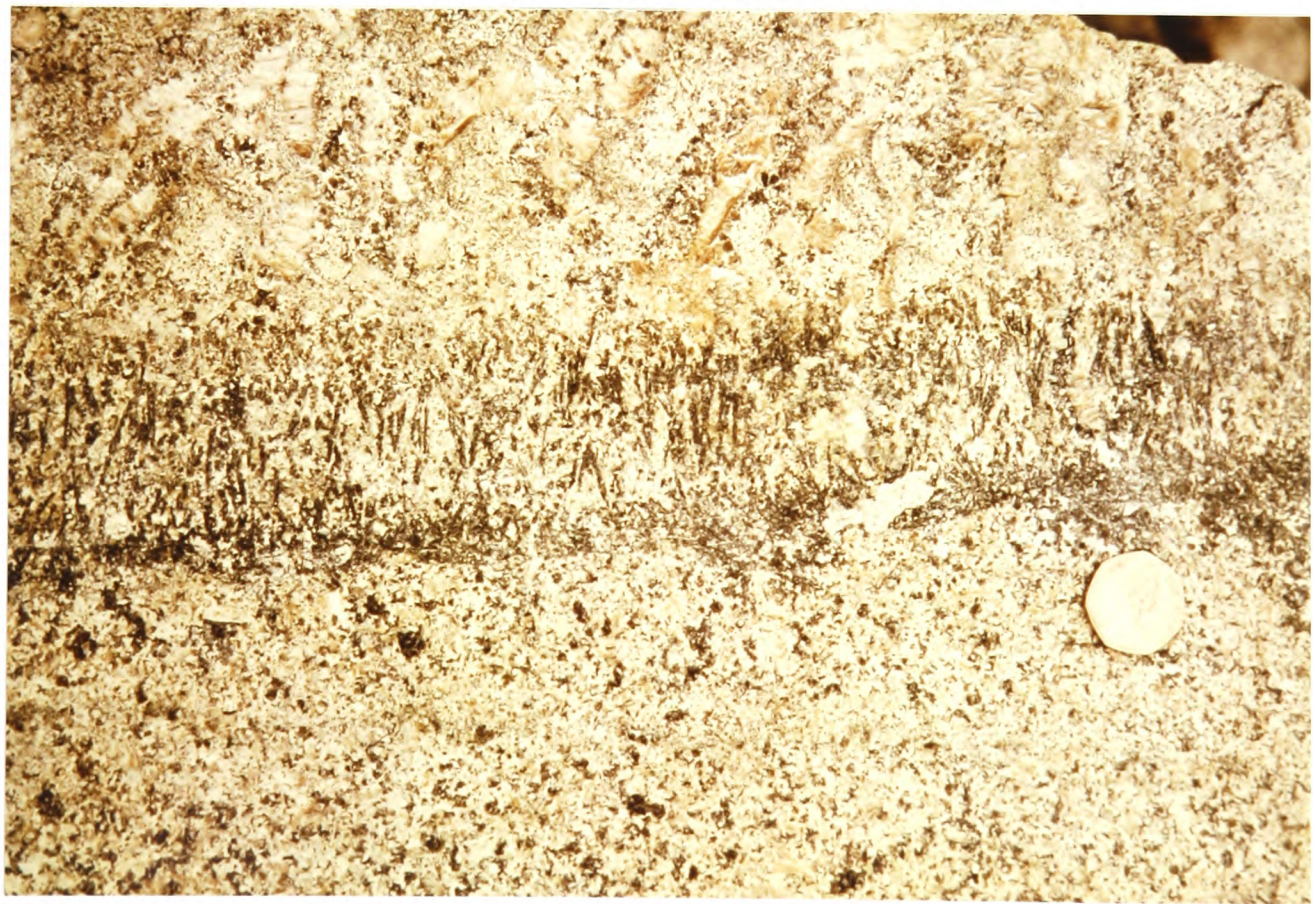




Plate 15. A sample from the main core of pegmatite supplied by Mr. C. Hancock (pit captain at Goonbarrow) showing long black tourmaline needles in contrast to the pinkish orthoclase feldspars.

Plate 16. A sample of the Goonbarrow pegmatite from Imperial Goonbarrow showing dark blades of biotite in contrast to the orthoclase feldspars.

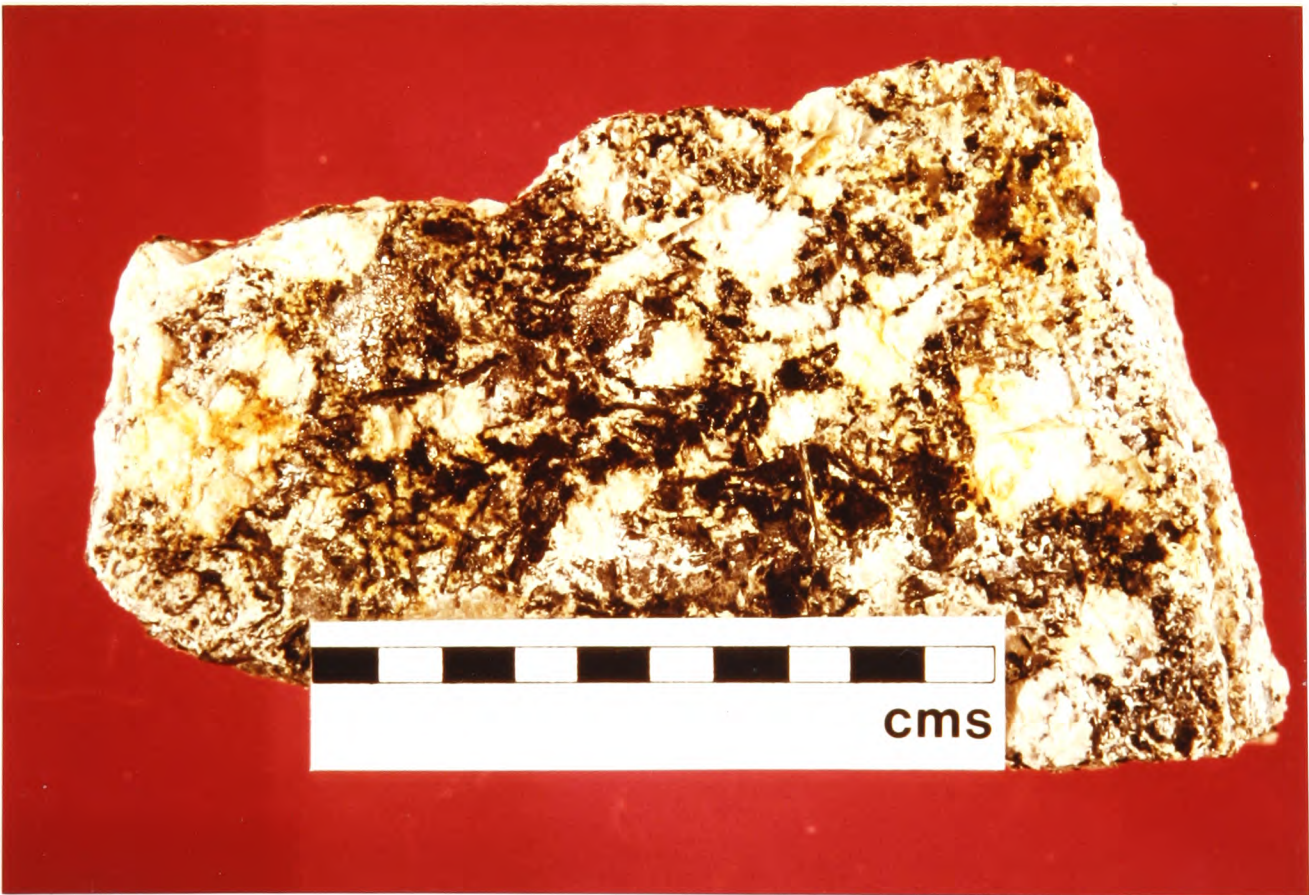


Plate 17. Kaolinised pegmatite from the West Goonbarrow area (location A). Lensoid pod of coarse grained quartz and kaolinised orthoclase feldspar.

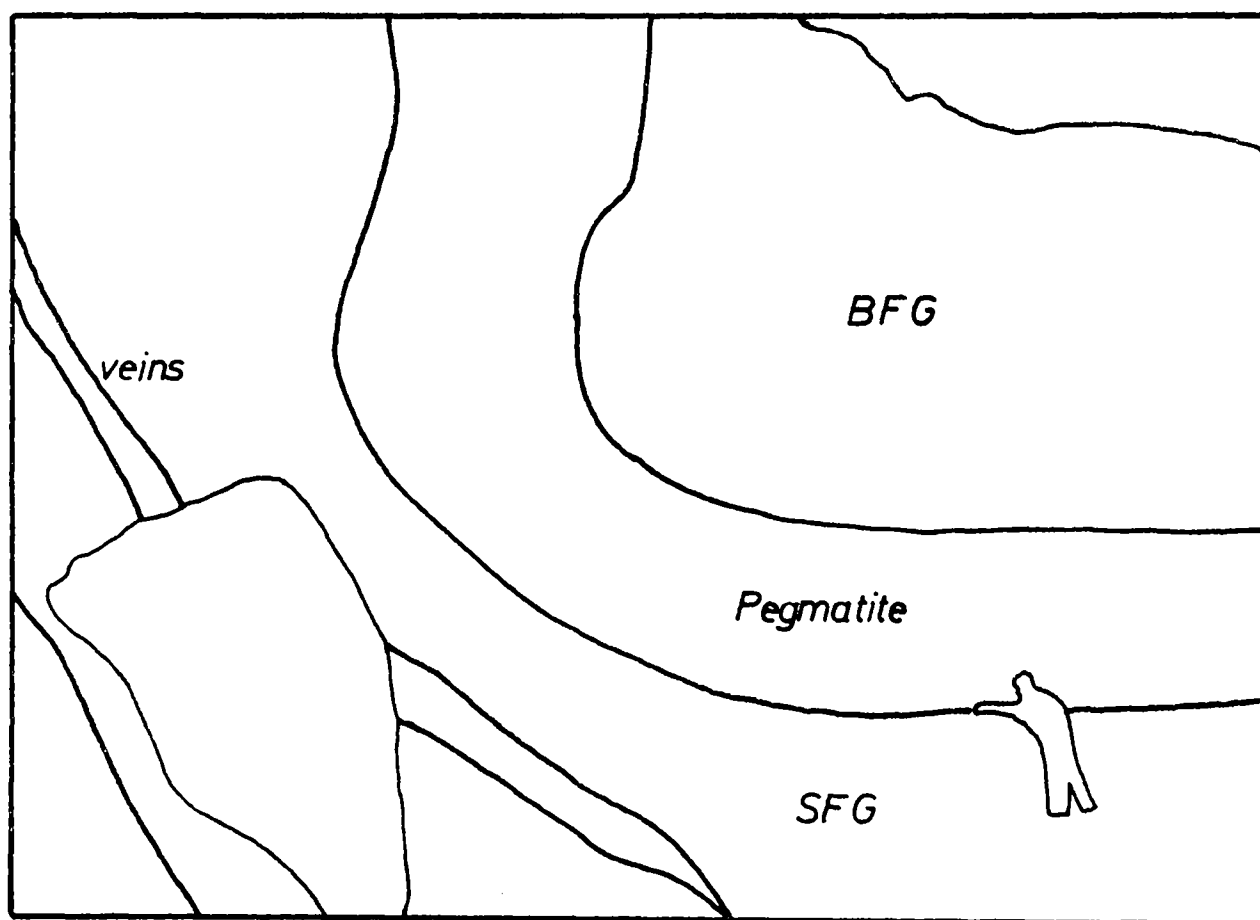


Plate 18. The pegmatite lying between "big feldspar" granite (to the top) and "small feldspar" granite. This shows a good example of the "dog leg" effect of the pegmatite. Note the quartz/tourmaline veins cutting the granite and pegmatite (Location C).







Plate 19. Section through the pegmatite in Imperial Goonbarrow (Location C). The "big feldspar" granite lying above the pegmatite can be easily recognised.

Plate 20. An example of the "dog leg" effect seen in Imperial Goonbarrow. The pegmatite outcrops in the bottom left hand corner and suddenly swings vertically just by the observer. The "big feldspar" granite lies to the left. The orthoclase crystals within the pegmatite display their maximum amount of curvature as the pegmatite swings to a vertical position (Location D).









Plate 21. The pegmatite in Imperial Goonbarrow (Location E).

The attitude changes abruptly at points A and B.

The pegmatite can be recognised by the bands of tourmaline.

Plate 22. The pegmatite in Imperial Goonbarrow. The "big feldspar" granite can just be recognised to the left of the pegmatite. An example of the sudden change in attitude of the pegmatite producing this "indian headress" effect.



Plate 23. The pegmatite in Imperial Goonbarrow (Location D).  
The pegmatite outcropping at the bottom left hand  
corner changes attitude abruptly by the observer.



Plate 24. Imperial Gooberrow, South face. The greenish yellow elvan crosscutting a quartz/tourmaline vein swarm. The granite is intensely kaolinised in this area. The temporal sequence of - veins followed by elvan - was first suspected when the small elvan apophysis on the extreme left was seen lying in a matrix of tourmaline in early 1977. The pegmatite can be seen on the extreme right suddenly changing in attitude about 7 cms from the right. The "big feldspar" granite lies at the top right.







Plate 25. The pegmatite showing curved orthoclase crystals.

Plate 26. The pegmatite showing curved and branching  
orthoclase crystals.

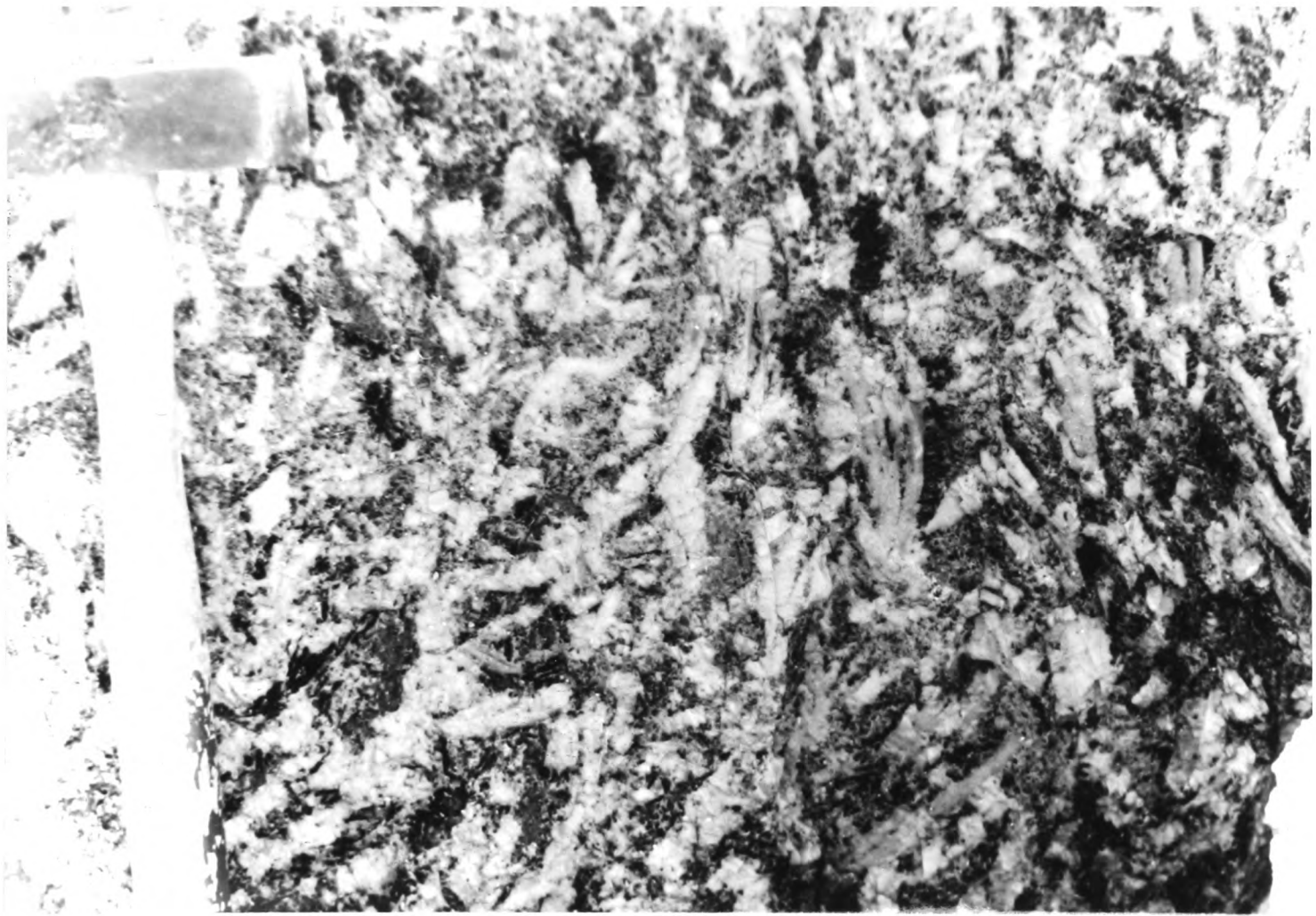


Plate 27. Section through the pegmatite with the "big feldspar" granite on the left and "small feldspar" granite to the right. Some parts of the "small feldspar" granite have been intensely tourmalinised. Tourmaline rich bands lying parallel to the pegmatite-granite contact can be clearly seen throughout the pegmatite. The curved pegmatite feldspars display their maximum curvature when the pegmatite is vertical. (Location D).

Plate 28. Section through "pinched" pegmatite exposed at the far eastern end of Imperial Goonbarrow (Location E). The two granite types can be clearly discerned.







Plate 29. Close up of the "pinched" pegmatite shown in plate 28. The pegmatite at this point consists mainly of orthoclase with interstitial biotite and tourmaline.

Plate 30. The BFG-pegmatite junction. The sharpness of this junction suggests that the BFG was essentially solid at the time of pegmatite formation. Orthoclase crystals within the pegmatite can be seen increasing in cross-sectional area away from the BFG and also branch in this direction.



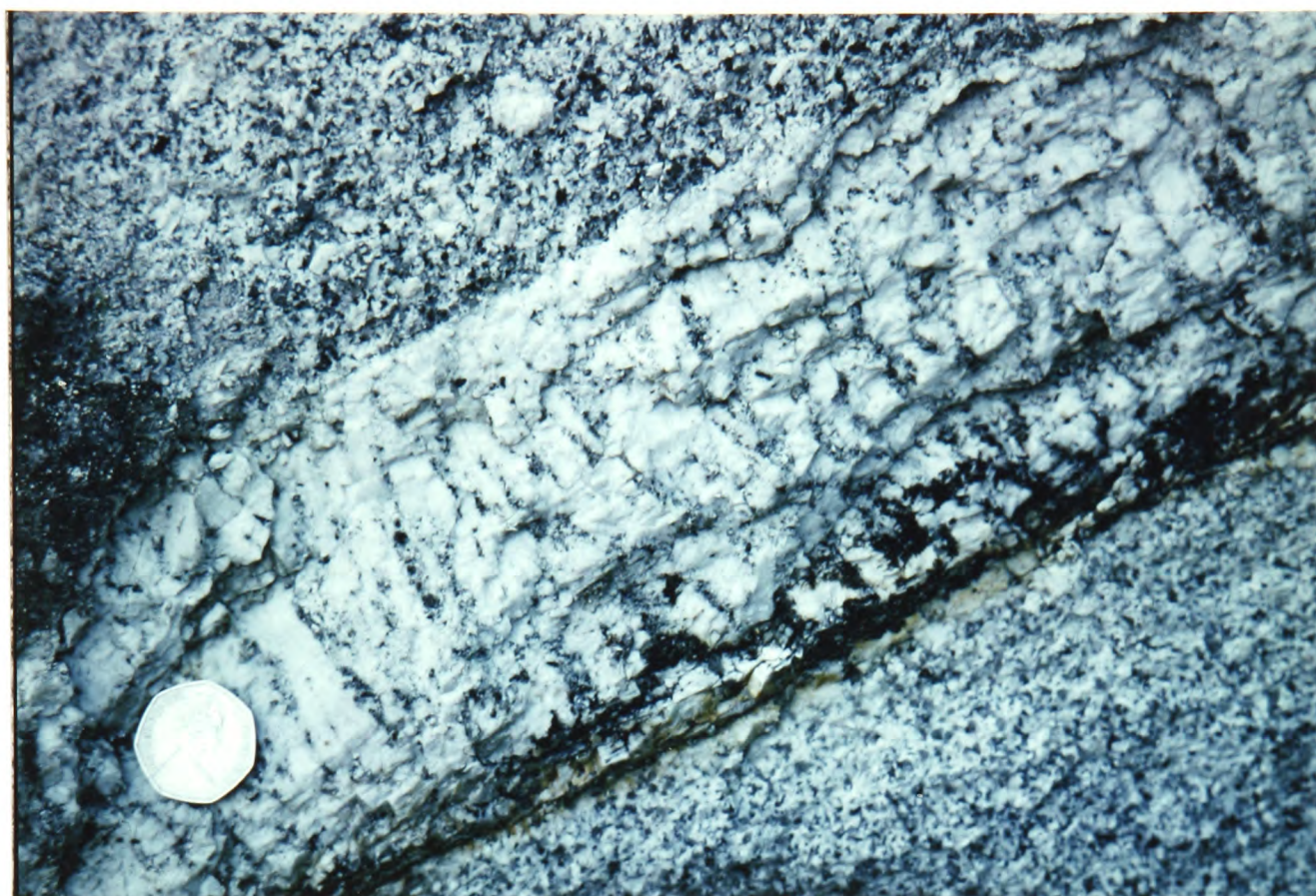




Plate 31. The SFG-pegmatite junction. Orthoclase crystals can be seen growing in cross-sectional area and branching in the direction of the SFG. Protruding feldspars are surrounded and overgrown by a fine grained aplitic matrix which blends gradationally into the SFG.

Plate 32. A sample of the SFG-pegmatite contact. Feldspars can be seen growing in cross-sectional area and branching towards the SFG. The protruding feldspars are surrounded and overgrown by a fine grained aplitic matrix which blends gradationally into the SFG. Two thin tourmaline rich bands can be seen within the aplite, one of which grows around the protruding feldspars.







Plate 33. Thin section of the Goonbarrow elvan, X200, crossed nicols. A large quartz megacryst is surrounded by a fine grained matrix of sericite-quartz. A small flake of relic primary muscovite is seen to the right hand corner of the quartz megacryst.

Plate 34. Thin section of the Goonbarrow elvan, X80, crossed nicols. Quartz megacrysts are surrounded by a fine grained matrix of sericite-quartz. A tourmaline "star" is seen at the upper left of the photograph.

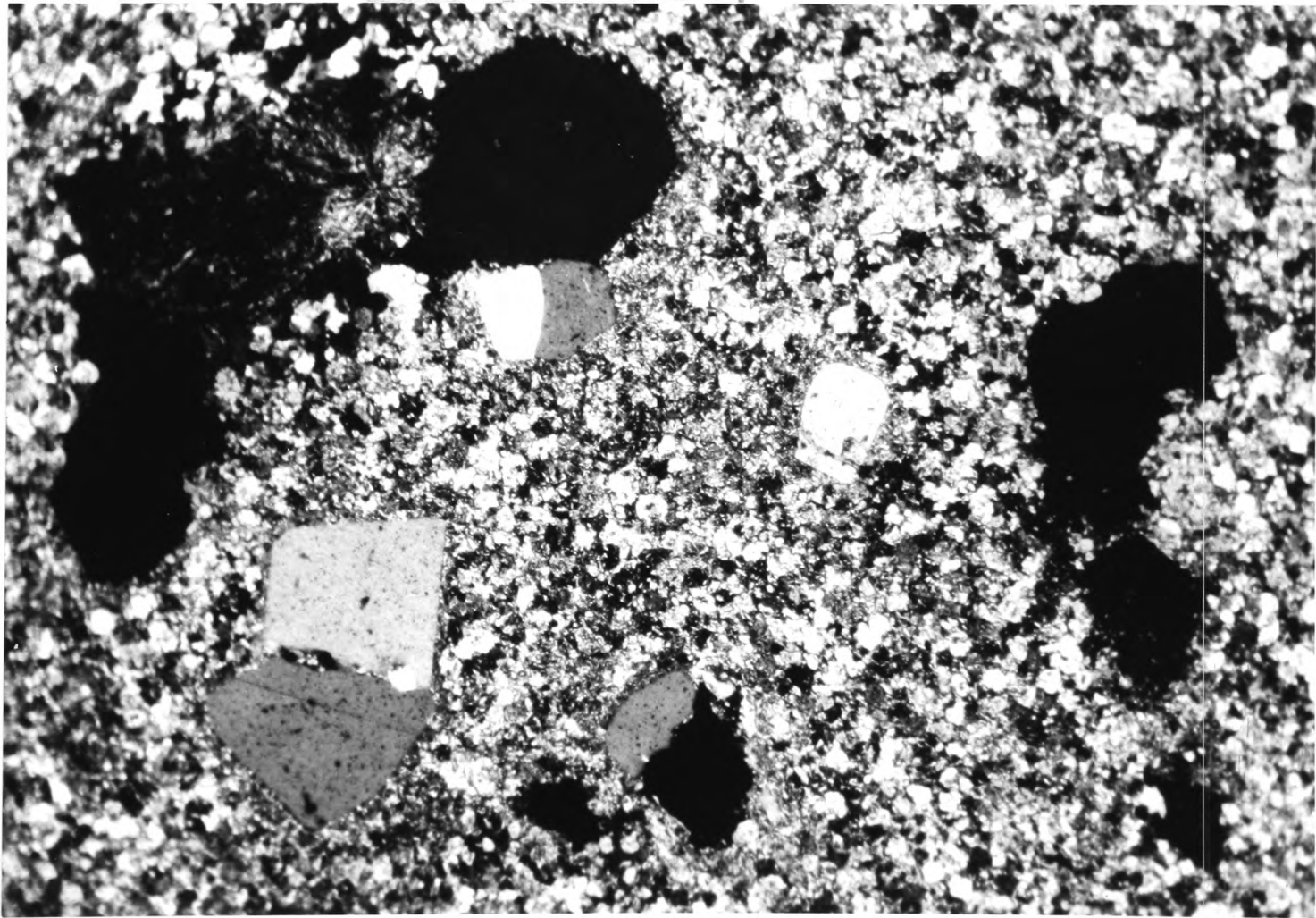
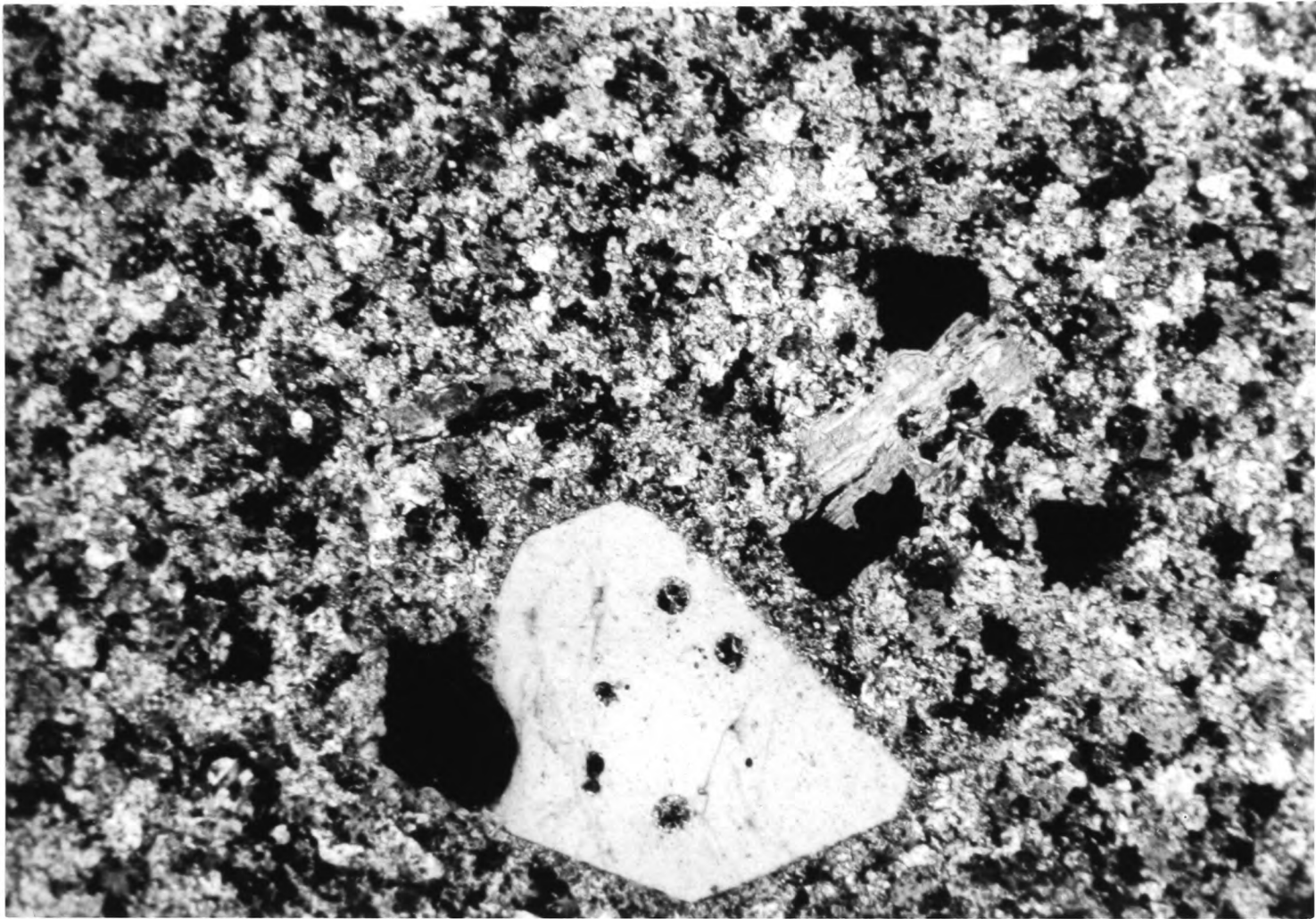


Plate 35. Thin section of the Goonbarrow elvan, X800, crossed  
nicols. Fine grained kaolinite/sericite intergrowth  
pseudomorphing feldspar in a quartz/muscovite matrix.



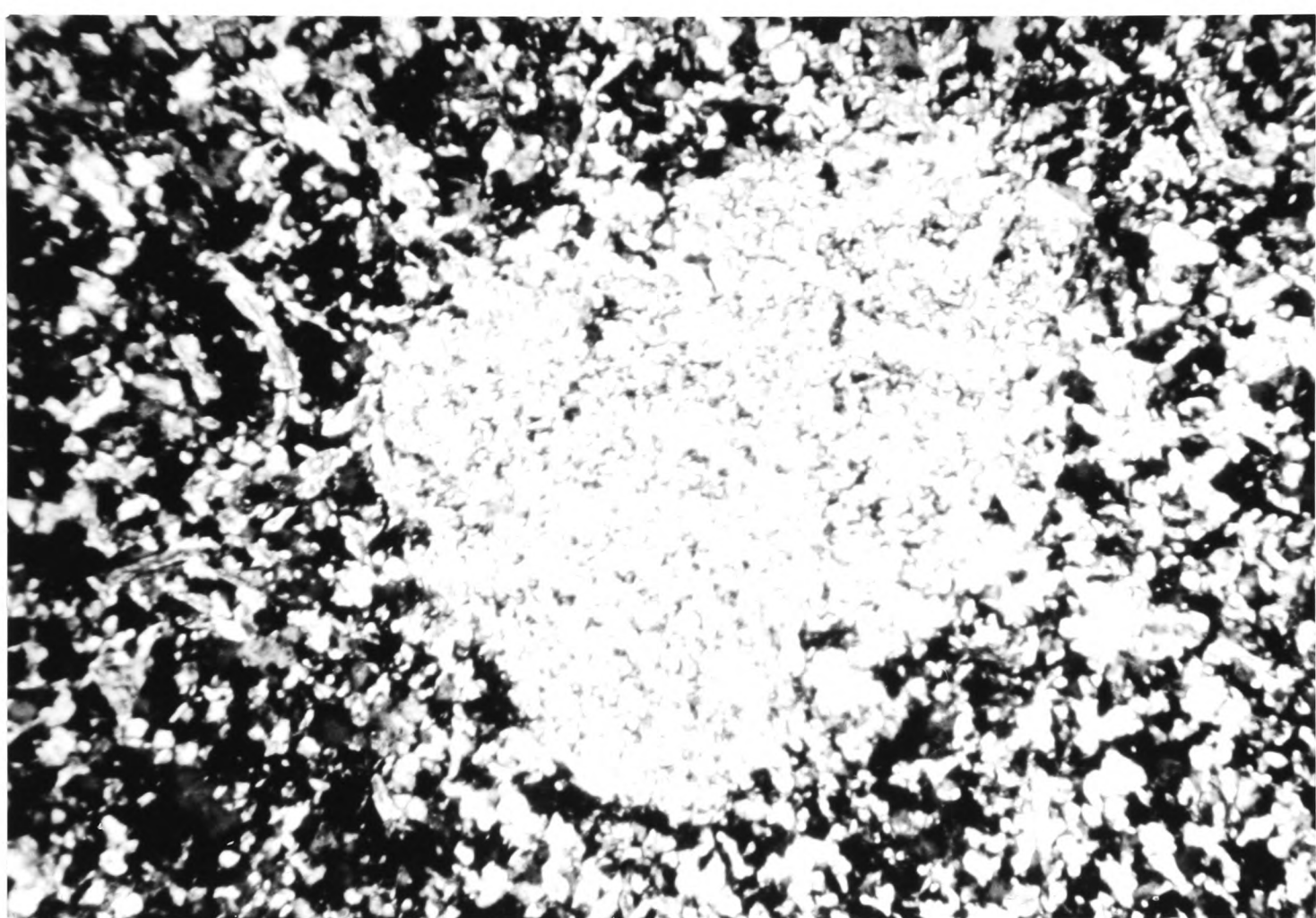


Plate 36. The Goonbarrow elvan exposed at the south face of Imperial Goonbarrow. The quartz/tourmaline vein swarm surrounded by kaolinised granite is crosscut by the elvan.



Plate 37. Apophysis of the Goonbarrow elvan showing laminated flow banding (Location F).

Plate 38. The western end of Old Beam looking towards North Goonbarrow. Unkaolinised granite is exposed on the extreme left cut by a few small veins. As the vein swarm on the right is approached the granite becomes progressively more kaolinised.







Plate 39. The western end of Old Beam, the steep walls of the old North Goonbarrow pit in the background. Grey unkaolinised granite is clearly seen at the extreme right and left of the photograph crosscut by a few quartz/tourmaline veins. The large vein swarms in the centre are surrounded by kaolinised granite clearly discerned by its whiteness.

Plate 40. A vein swarm exposed in the area near Martins Goonbarrow. The granite is extremely kaolinised (see cross-section in Figure 12).



Plate 41. A sample of a cassiterite bearing vein from Old Beam. Tourmaline is found in the centre of the vein surrounded on either side by zoned cassiterite. A band of fine grained white topaz is found at the interface between the cassiterite and greisen. The scale is in one centimetre blocks.

Plate 42. Thin section of a cassiterite bearing vein (G00 76/55 from Old Beam, 100X, crossed nicols. The cassiterite on the left is zoned. A matrix of intergrown quartz and tourmaline is shown on the right.



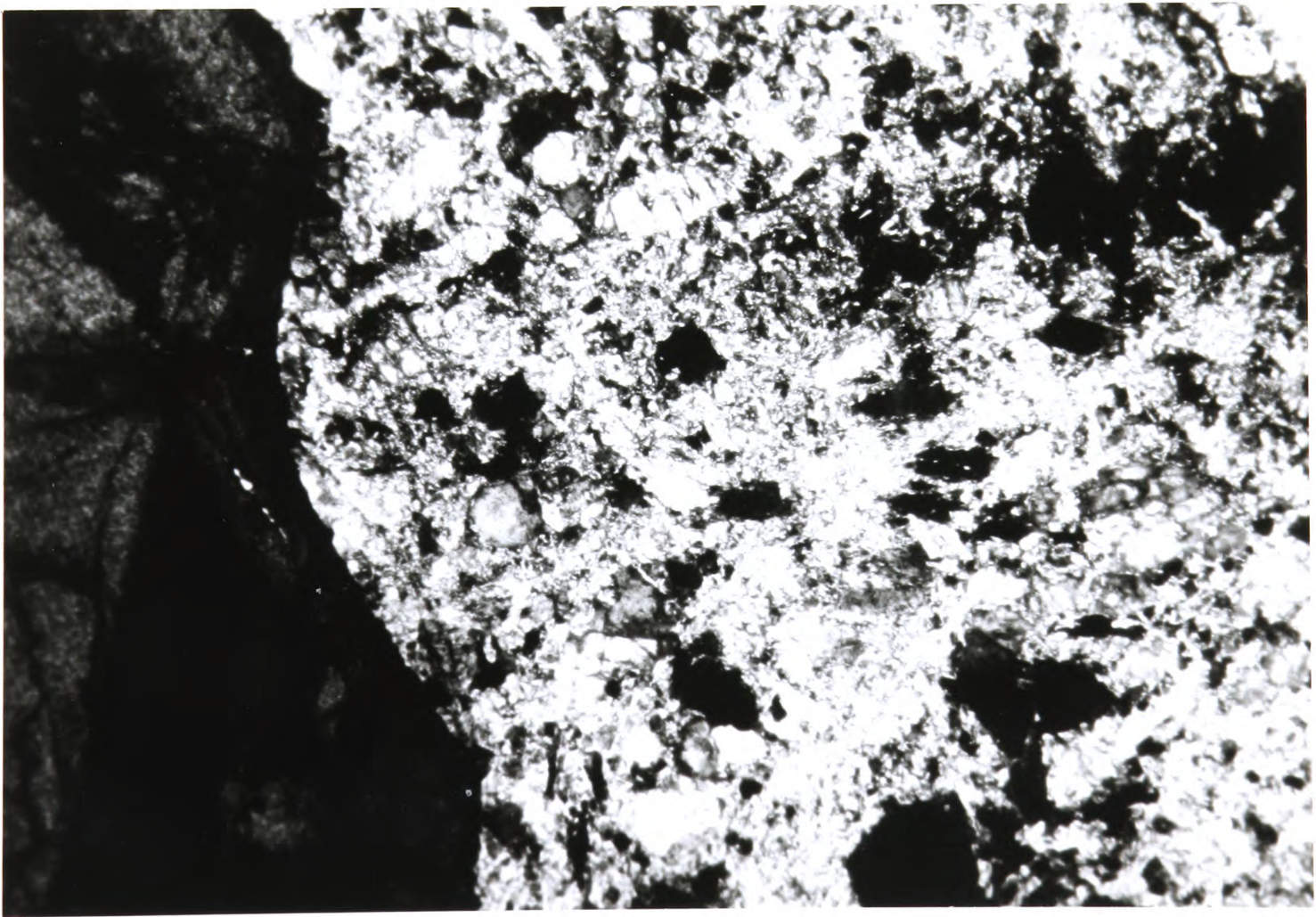


Plate 43. A typical cassiterite bearing lode in the Old Beam area, with the old mine workings in the background. A white topaz rich greisen in the foreground alters gradationally to a "normal" greisen in the background. Cassiterite was found associated with the topaz greisen.

Plate 44. Close up of the topaz rich greisen shown in plate 43. Cassiterite is found throughout the greisen.





Plate 45. Close up of the "normal" greisen shown in plate 43.  
Cassiterite was not found associated with this greisen.

Plate 46. Old Beam. The stockwork of veins, many tin and tungsten bearing, is surrounded by intensely kaolinised granite. The remains of the old nineteenth century mine workings can be clearly seen. At the top of the photograph is the conveyor used to transport coarse grained quartz and unkaolinised granite, previously separated by a rotary classifier, to the top of the waste heap. A water monitor can be seen in the foreground, used to wash out the china clay.





Plate 47. Thin section of "pale mica" granite, X200, crossed nicols. The plagioclase in the centre of the field has been preferentially altered in the core. This is the first stage of kaolinisation.

Plate 48. Thin section of kaolinised "pale mica" granite, X200, crossed nicols. Highly corroded quartz megacrysts and relic muscovite are surrounded by a fine grained kaolinite/sericite matrix.



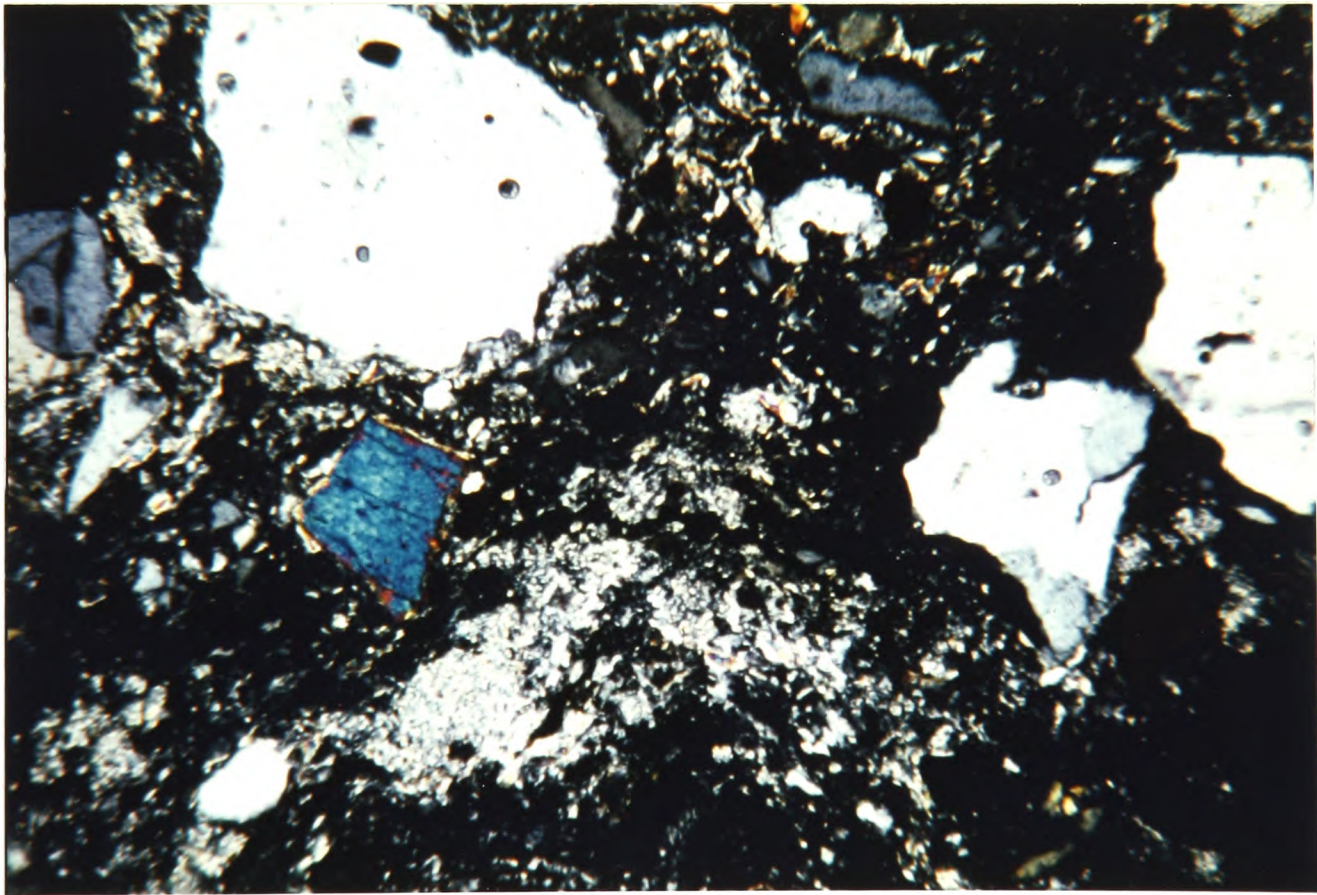
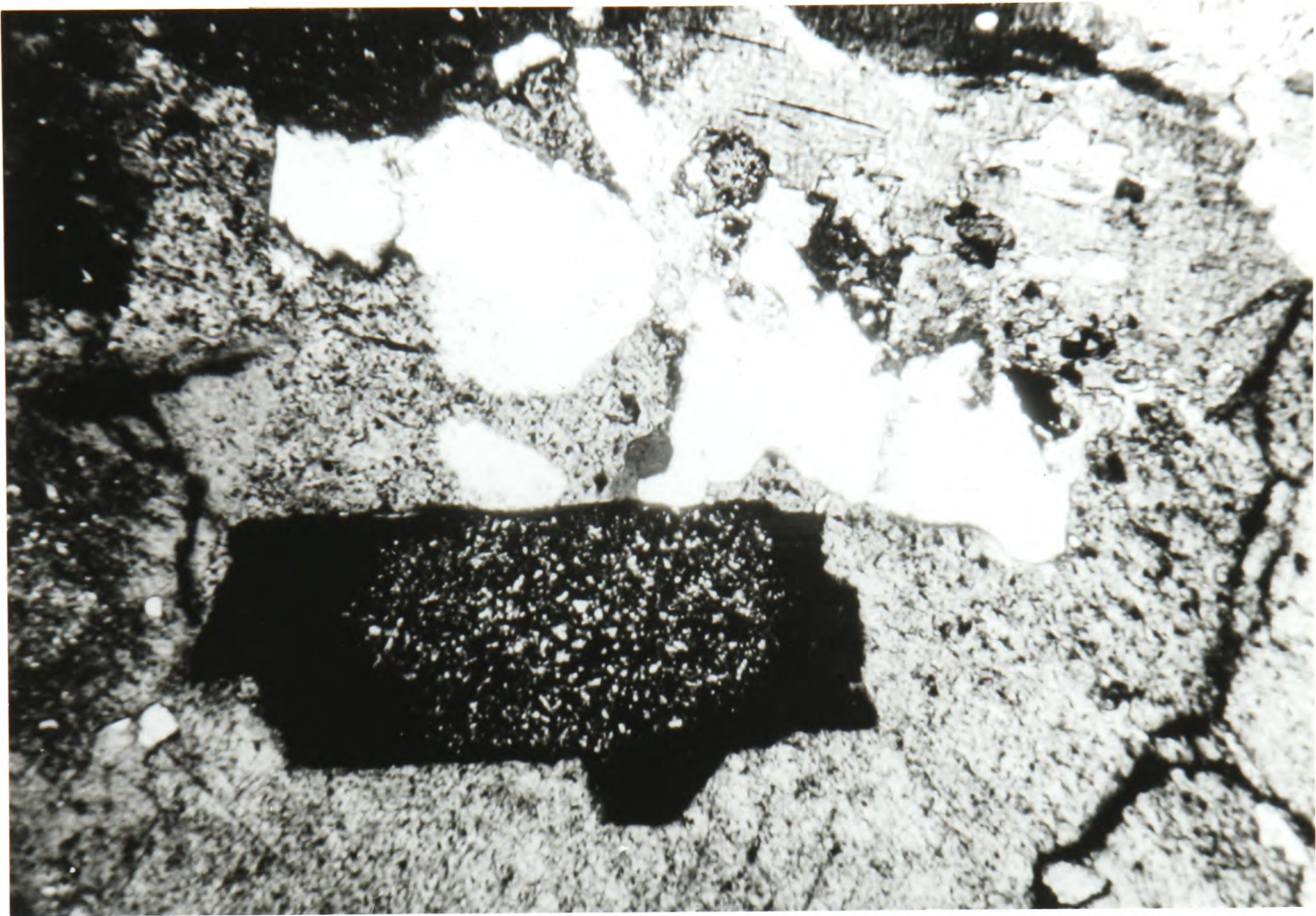
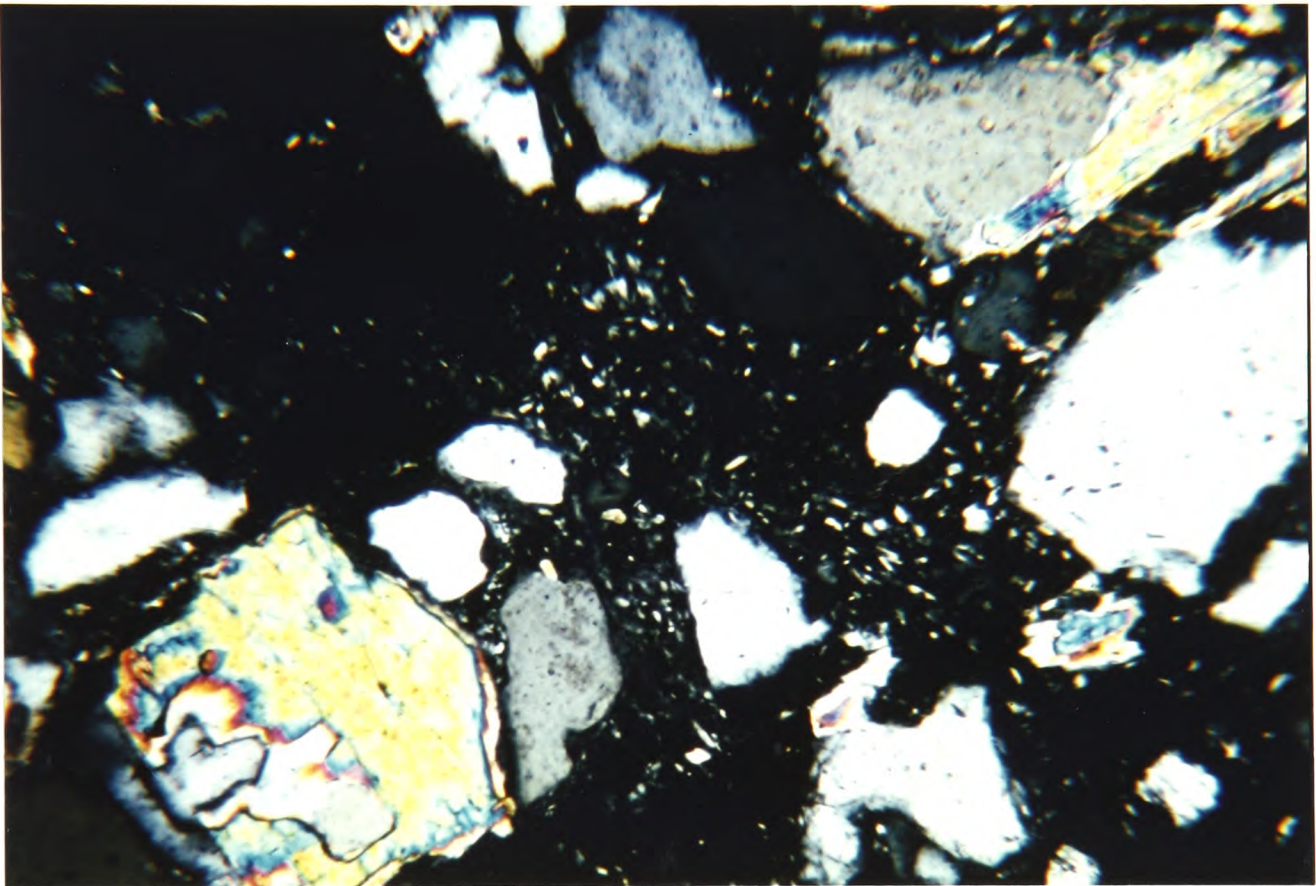




Plate 49. Thin section of kaolinised "pale mica" granite, X800, crossed nicols. Highly corroded quartz megacrysts and relic muscovite are surrounded by a fine grained kaolinised/sericite matrix.



Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Plate 50 A typical two phase fluid inclusion. A trail of secondary inclusions lies above it. (Sample No. 145V).

Plate 51 A plane of secondary two phase inclusions. (Sample No. 10V).

Plate 52 A "necked" inclusion probably produced by tectonic movement or reheating. On heating an erroneous filling temperature would almost certainly be obtained. (Sample No. 187).

Plate 53 An inclusion formed before the process of "necking" has been completed. Had the process gone to completion it is probably that the majority of the water vapour would have been trapped in the upper right hand part of the inclusion and the daughter crystals on the lower left. Subsequent heating/freezing studies would have produced very anomalous results. (Sample No. 82V).

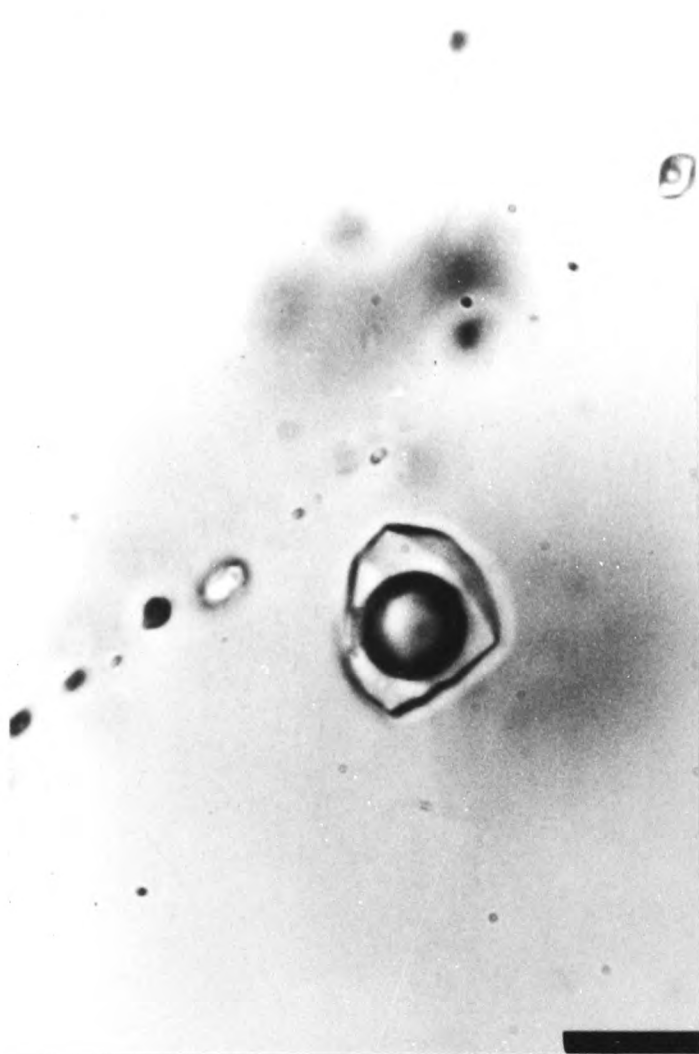


Plate 50.

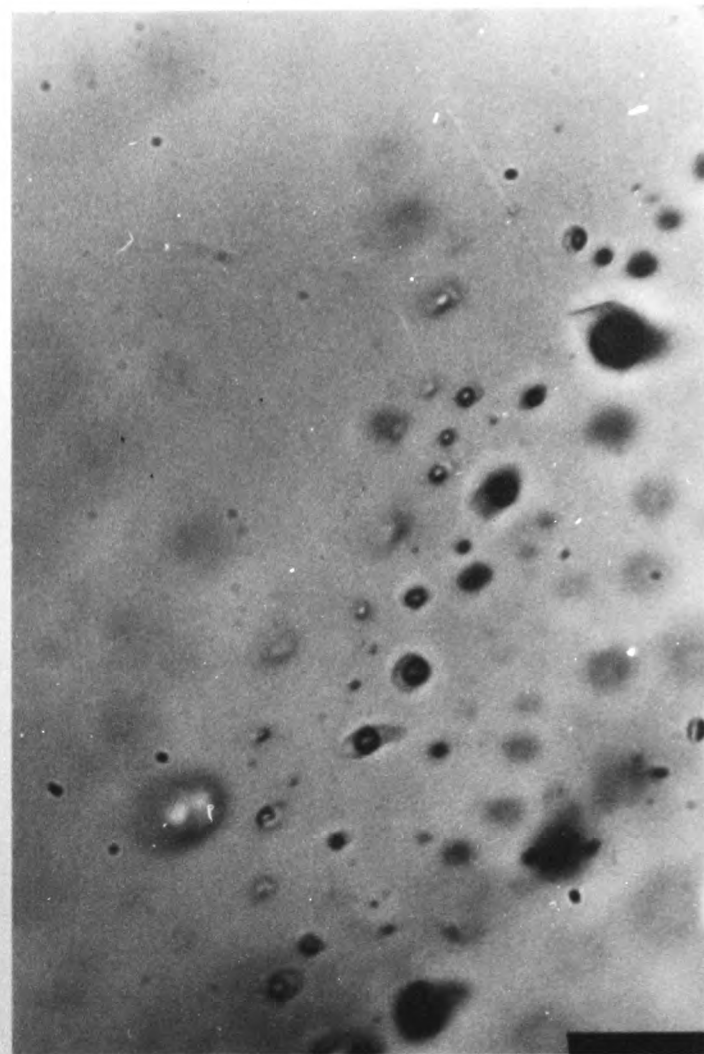


Plate 51.



Plate 52.



Plate 53.



Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Examples of vapour or "boiling" inclusions. Unlike normal fluid inclusions these will homogenise into the vapour phase. When occurring in close proximity to normal fluid inclusions (Plate 55) this suggests that both vapour rich and fluid rich phases were trapped simultaneously from a boiling solution and that the aqueous fluid lies on the critical curve for that particular solution. If the salinity and temperature of the fluid is known from other inclusion evidence then the pressure may be easily obtained from the appropriate critical curve.

Plate 54 Sample No. 187

Plate 55 Sample No. 73V

Plate 56 Sample No. 73V

Plate 57 Sample No. 187

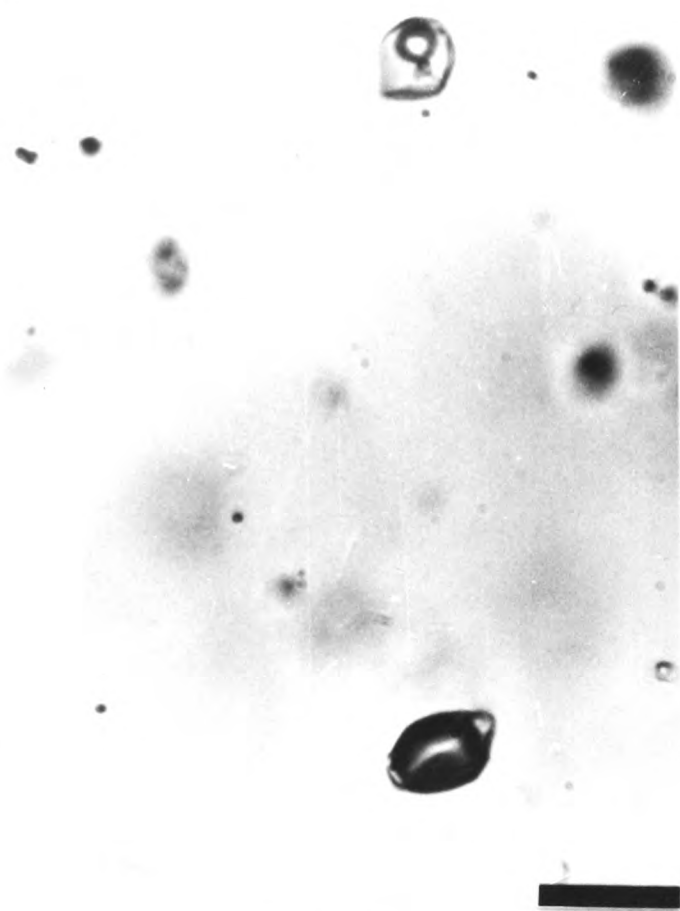


Plate 54.

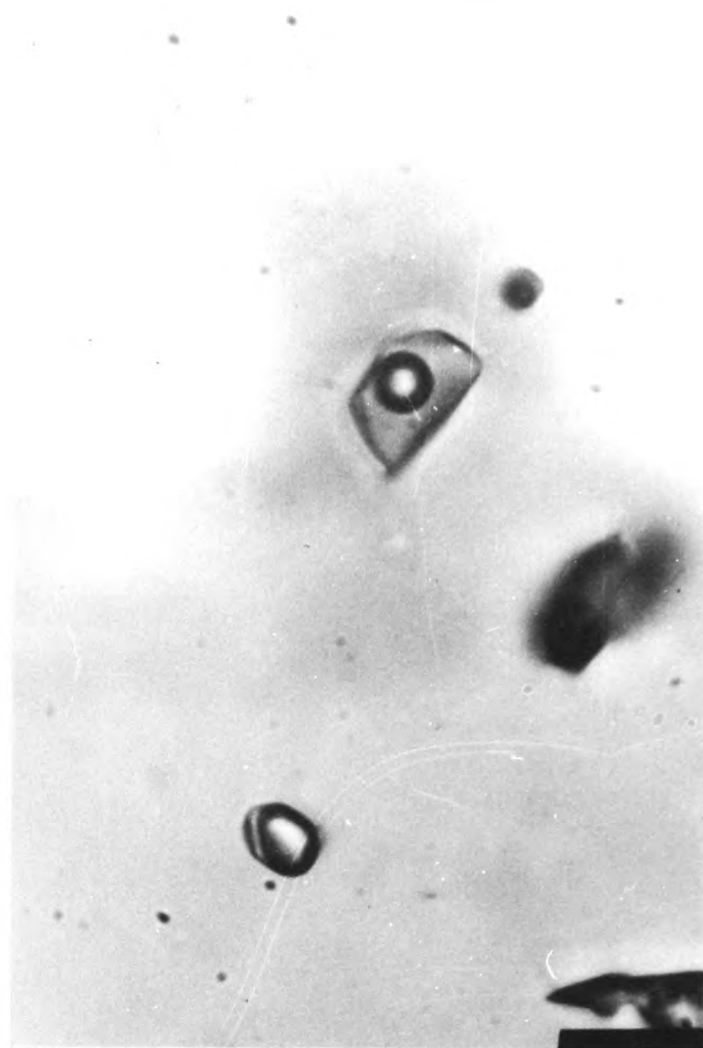


Plate 55.

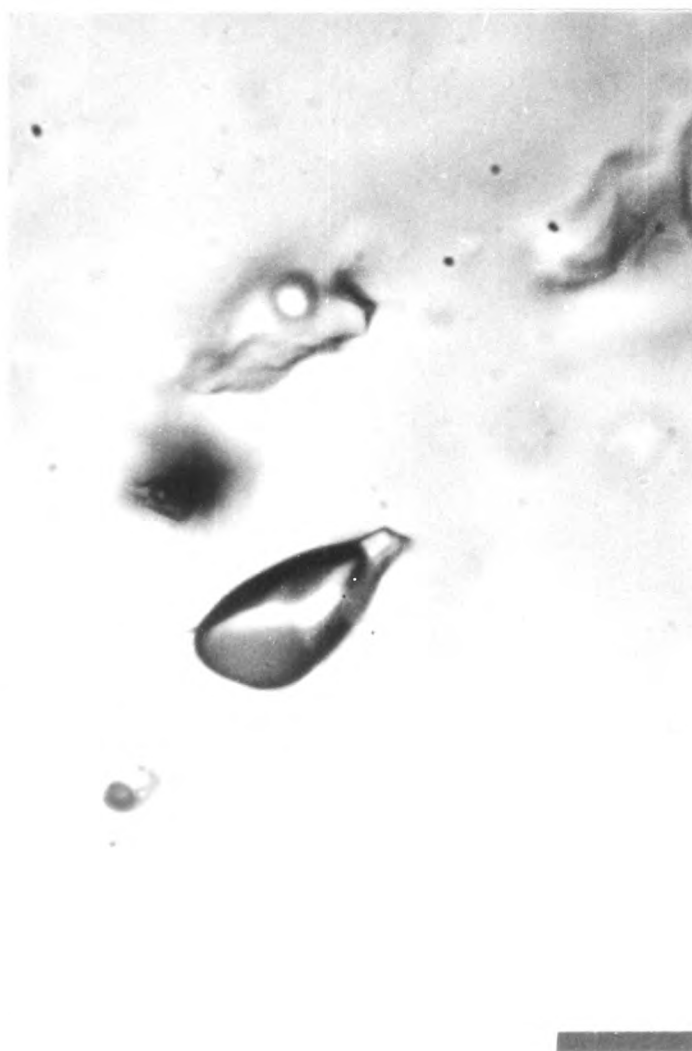


Plate 56.

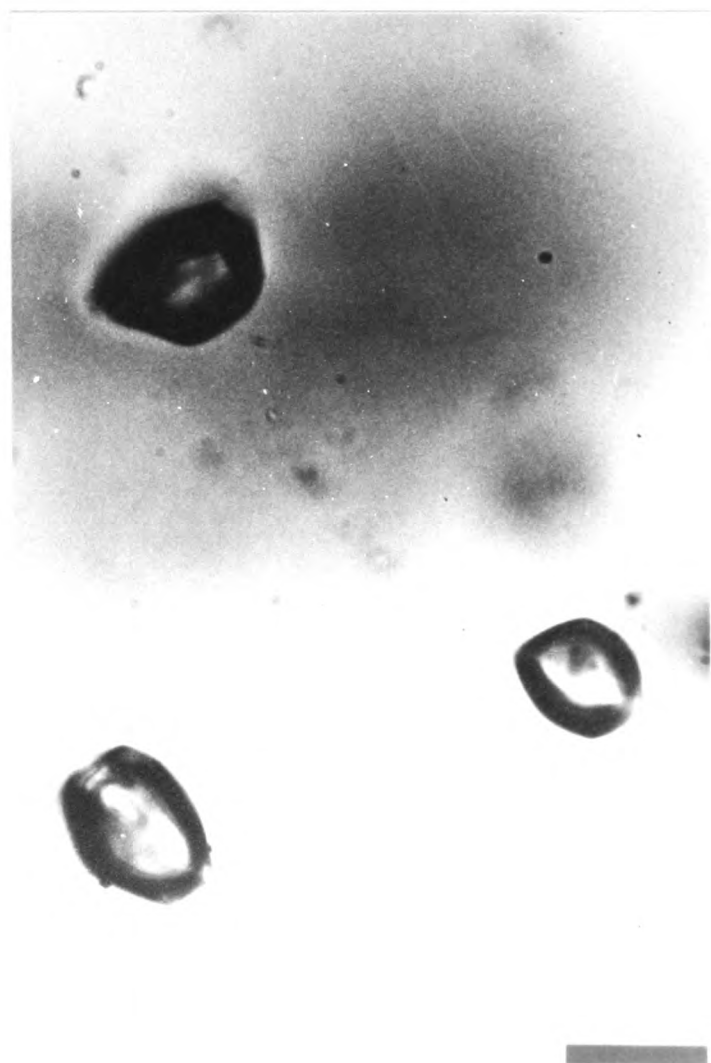


Plate 57.

Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Plate 58 An example of a fluid inclusion containing several rod like daughter minerals. The vapour bubble is deformed as it has insufficient room to assume its normal spherical shape. The outline of this inclusion suggests it has been distorted since formation. (Sample No. 82V).

Plate 59 Another example of a fluid inclusion containing a deformed vapour bubble and several daughter minerals including a cubic mineral - probably halite or sylvite. (Sample No. 243).

Plate 60 (plain light) and Plate 61 (crossed nicols). An irregular, deformed inclusion containing several daughters. The cubic mineral is halite or sylvite and the rod like birefringent mineral (in plate 60b) is probably a mica viewed perpendicular to its c - axis.

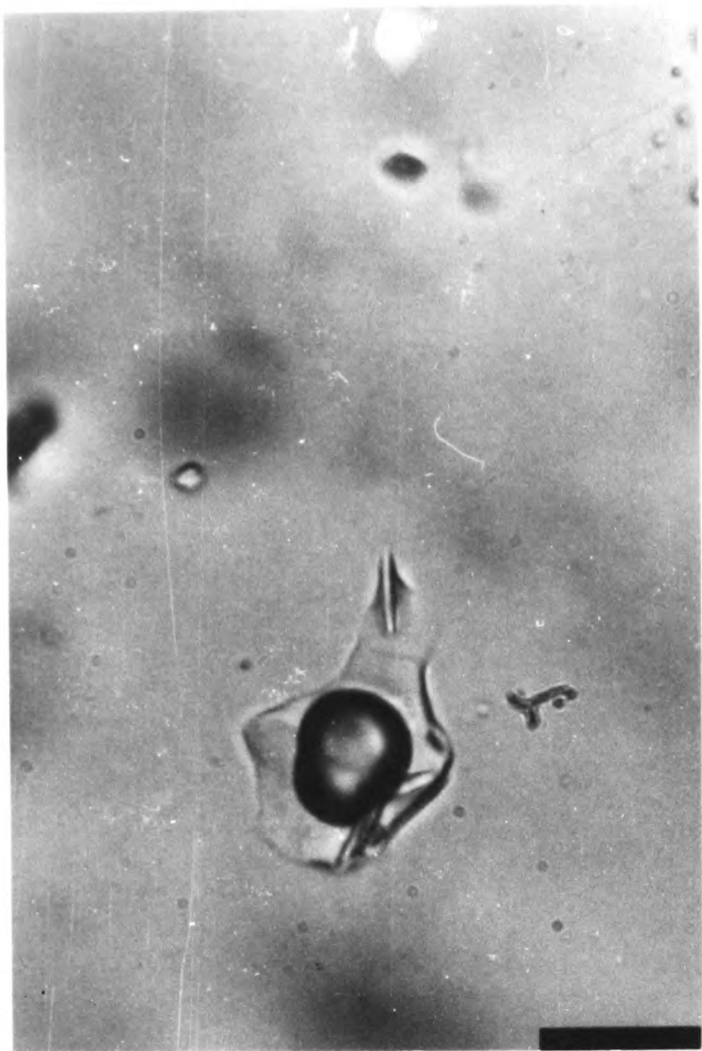


Plate 58.

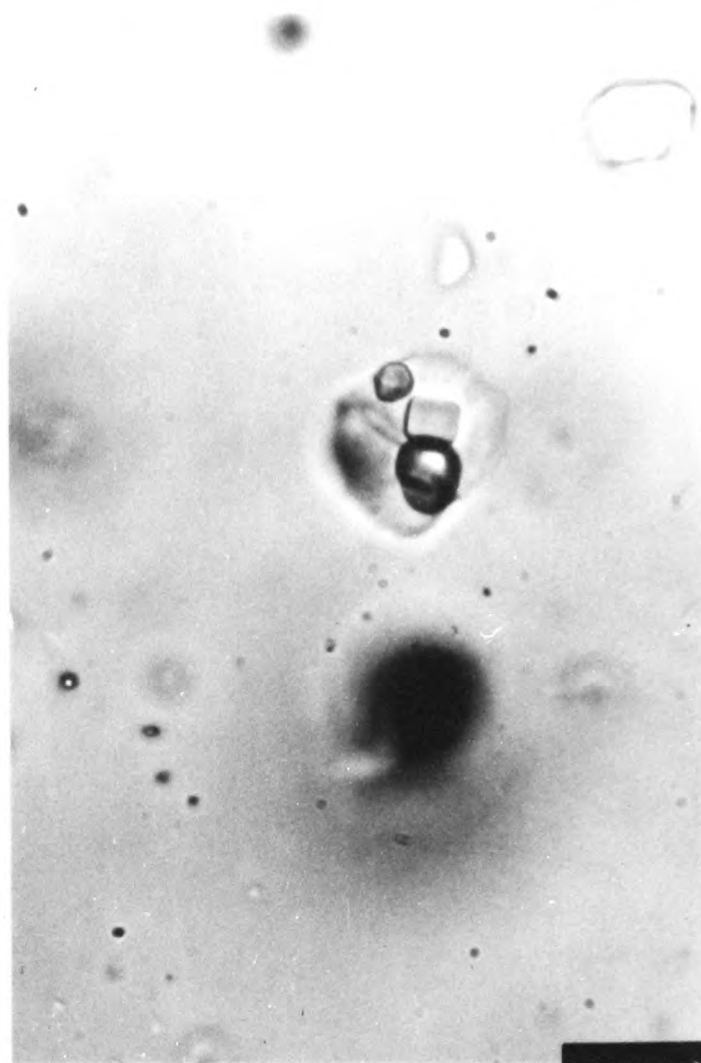


Plate 59.

Plate 60a.

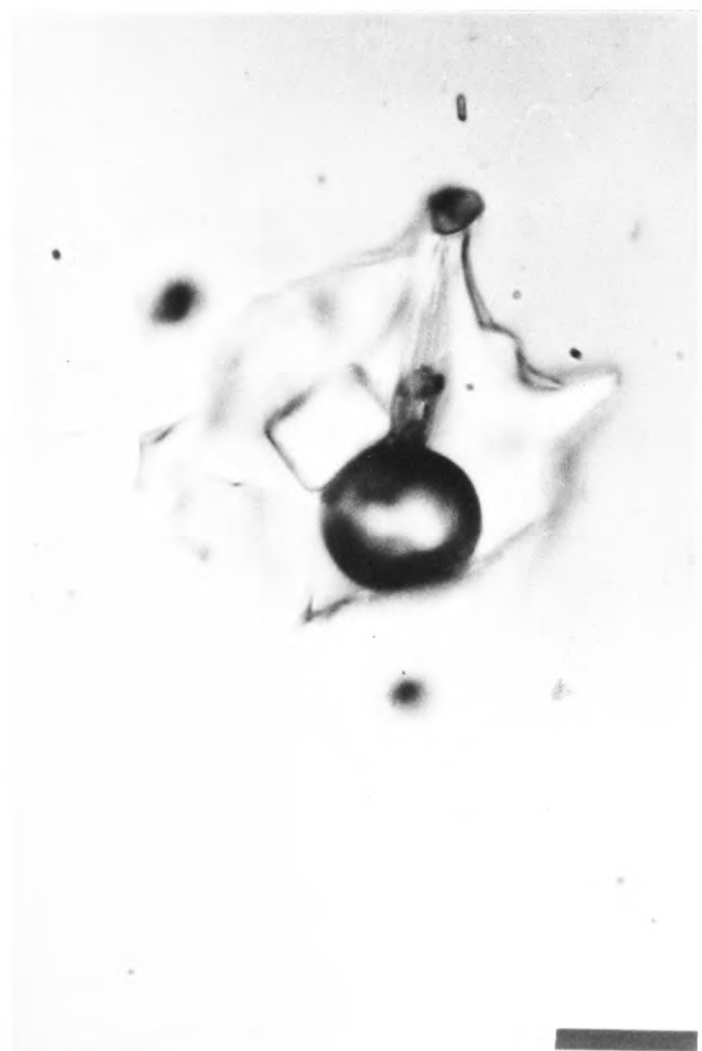
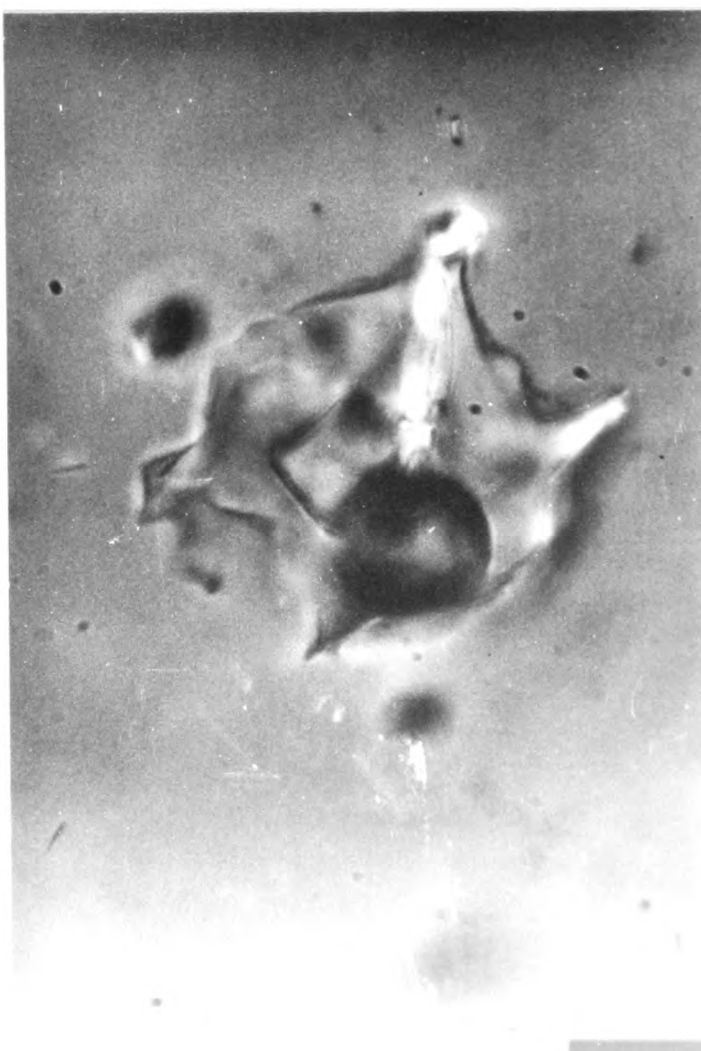


Plate 60b.





Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Examples of cubic daughter minerals in fluid inclusions.

Plate 61 Sample No. 243

Plate 62 Sample No. 82V

Plate 63 Sample No. 243

Plate 64 Sample No. GB2V



Plate 61.

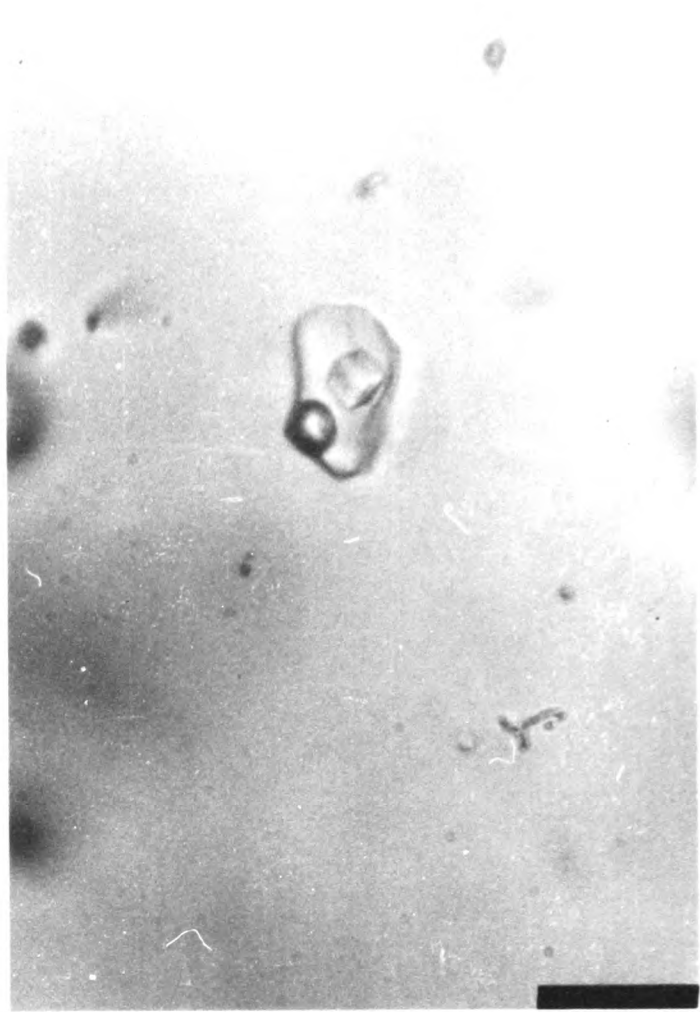


Plate 62.



Plate 63.



Plate 64.

Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Plate 65 An inclusion containing a cubic mineral - halite or  
sylvite. (Sample No. GB2V).

Plate 66 An inclusion containing a cubic mineral and an hexagonal  
plate - almost certainly a mica. (Sample No. 243).

Plate 67 An inclusion containing several daughters including a  
cubic mineral. (Sample No. 243).

Plate 68 An inclusion containing several daughters including a  
cubic mineral and a rod - possibly a mica viewed  
perpendicular to its c - axis. (Sample No. 243).

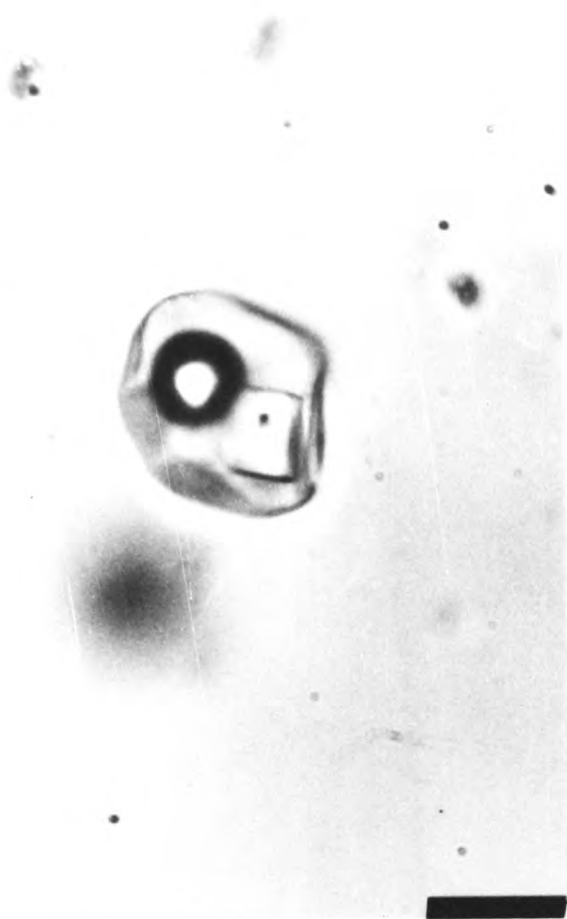


Plate 65.

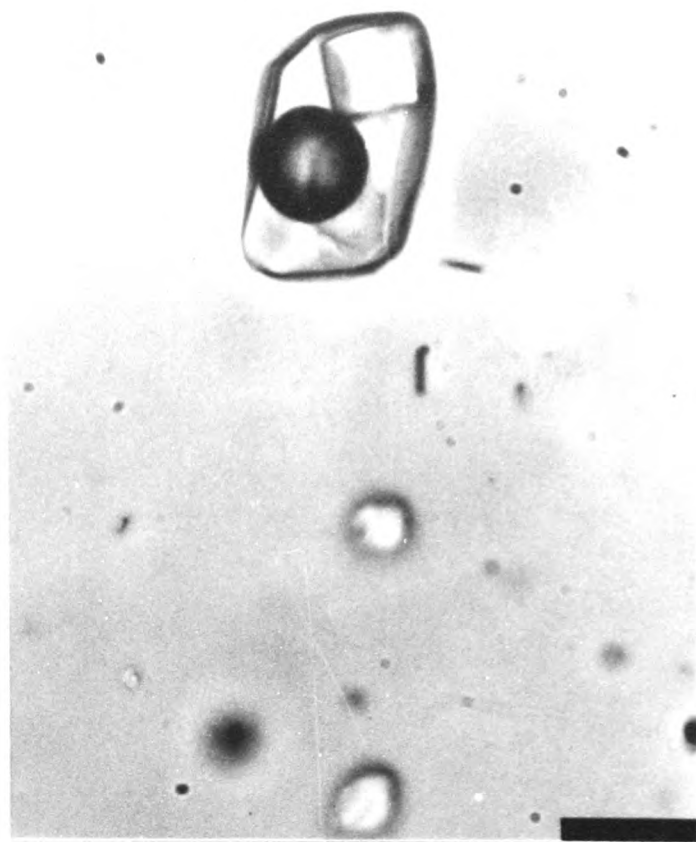


Plate 66.

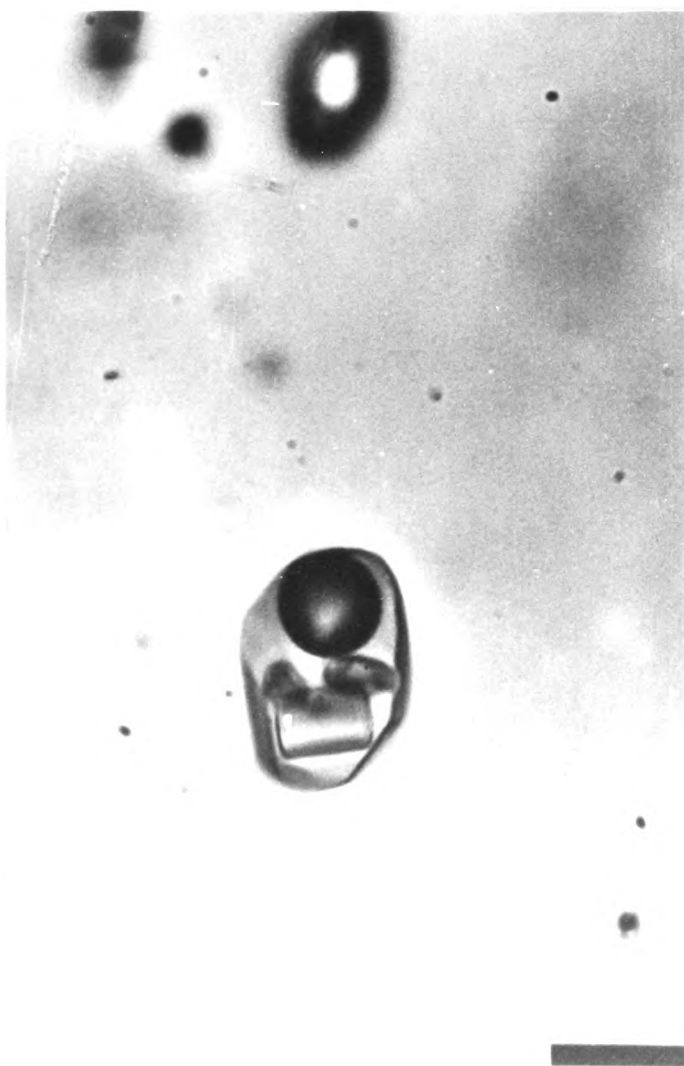


Plate 67.



Plate 68.

Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Plate 69 Two inclusions containing several daughters, some cubic. The inclusion on the right also contains a fibrous mineral (Sample No. 243).

Plate 70a (plain light) and Plate 70b (crossed nicols). A fluid inclusion containing a birefringent rod. (Sample No. 82V).



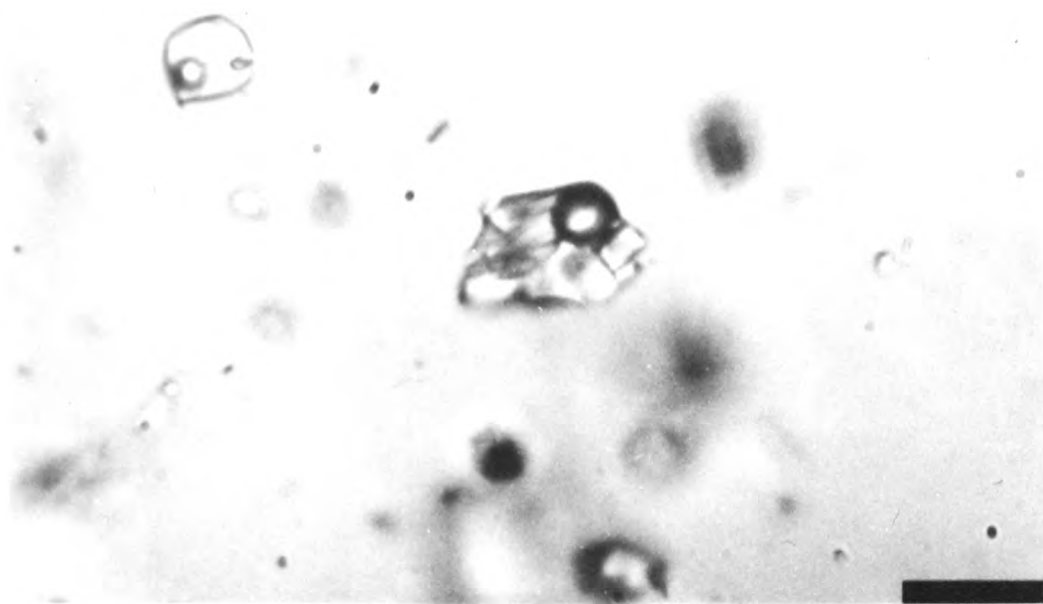


Plate 69.

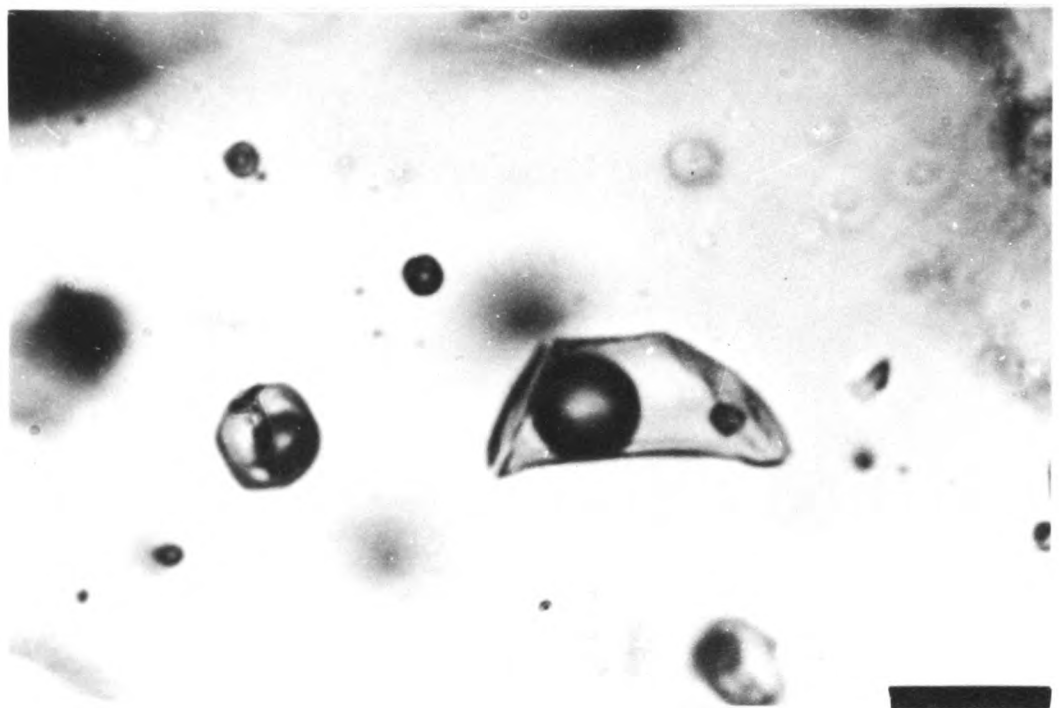


Plate 70a.

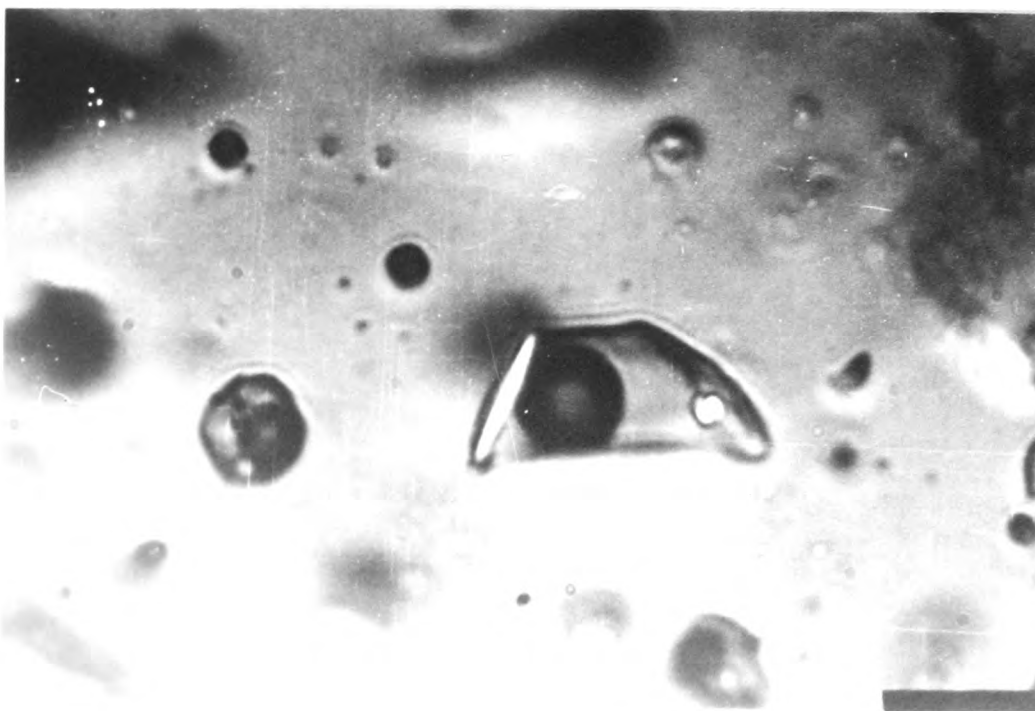


Plate 70b.

Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Plates 71a and 72a (plain light) and 71b and 72b (crossed  
nicols). Inclusions containing birefringent  
rods possibly a mica plate viewed perpendicular  
to the c - axis.

Plate 71                      Sample No. 243

Plate 72                      Sample No. 82V

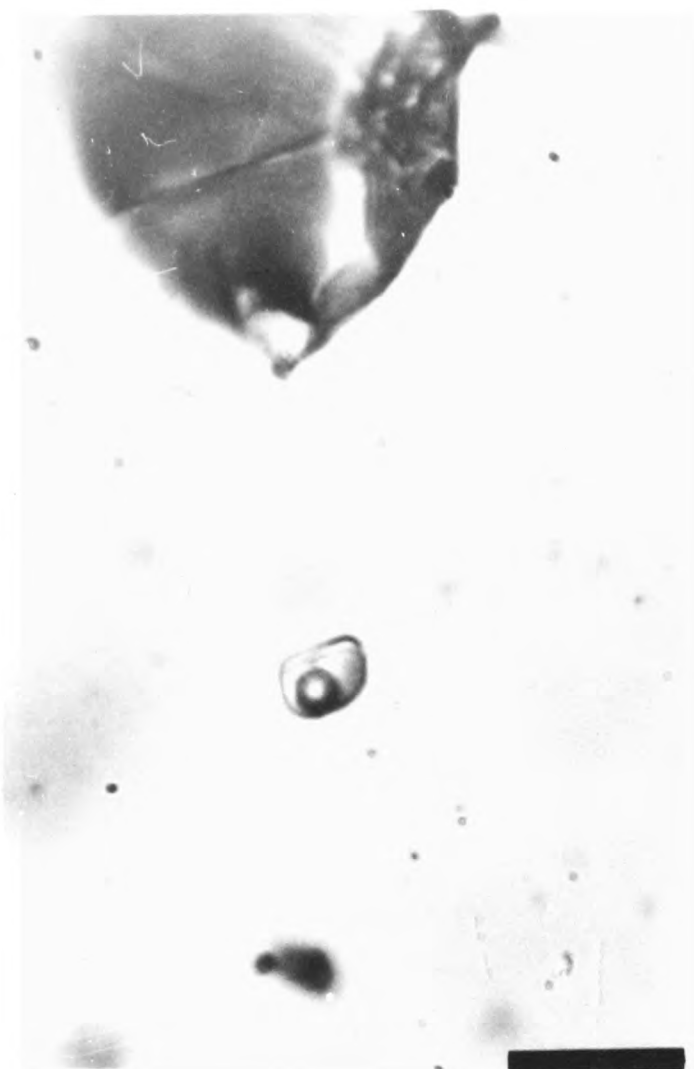


Plate 71a.

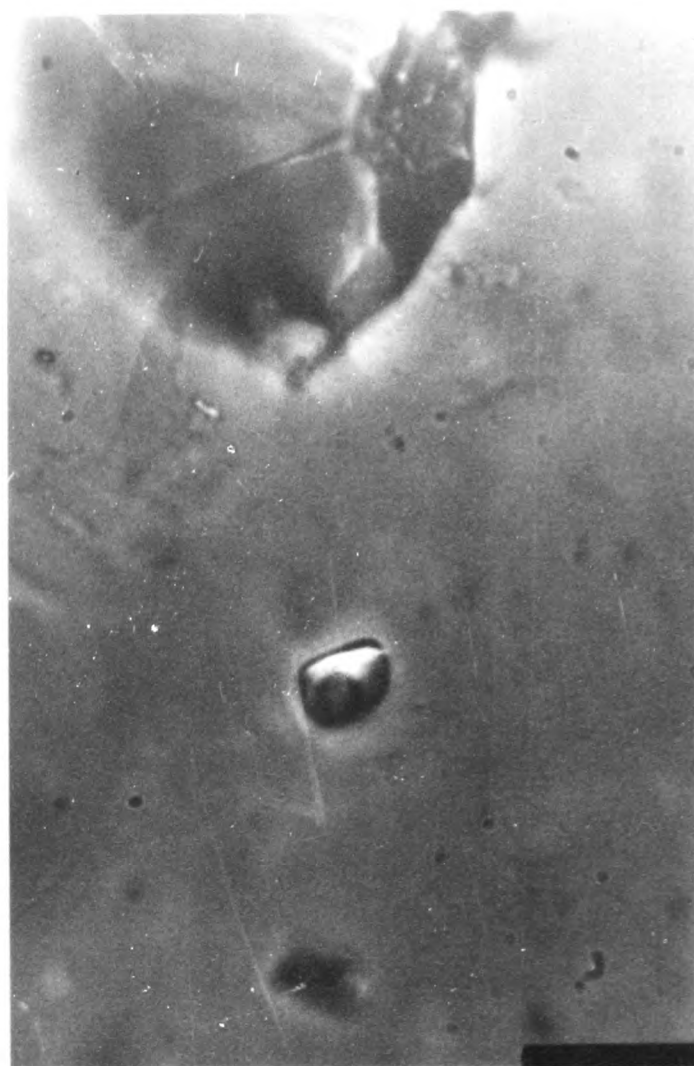


Plate 71b.

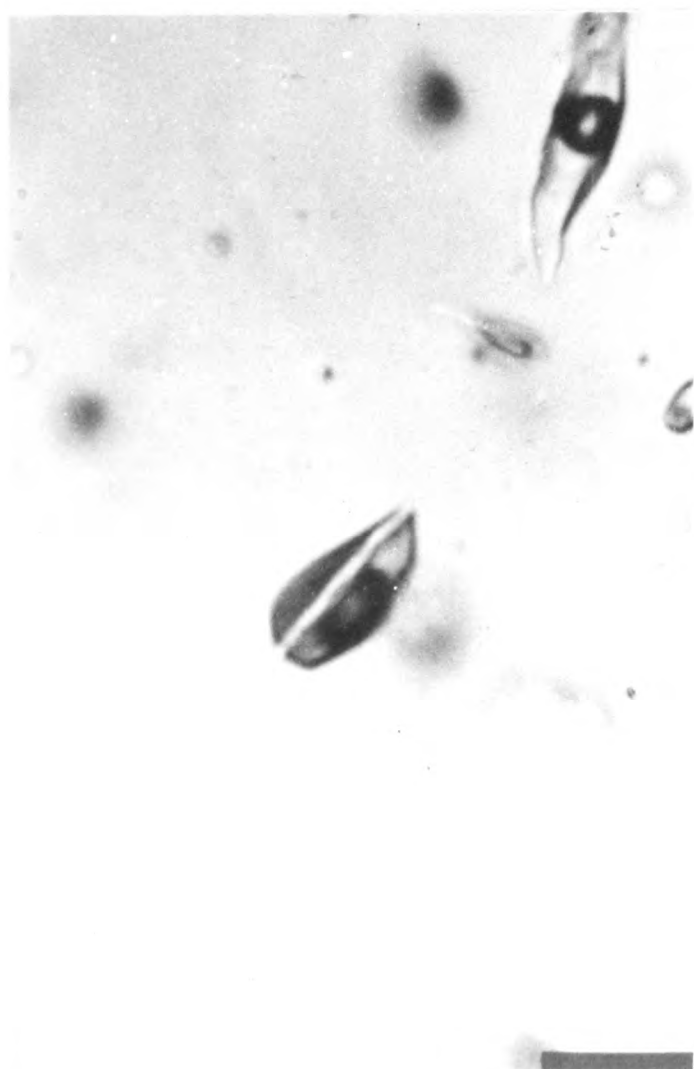


Plate 72a.



Plate 72b.

Fluid inclusions in quartz from Goonbarrow. Scale bars = 10µm.

Examples of inclusions containing hexagonal platelike daughters - almost certainly micas.

Plate 73 Sample No. 82V

Plate 74 Sample No. 187

Plate 75 Sample No. 82V

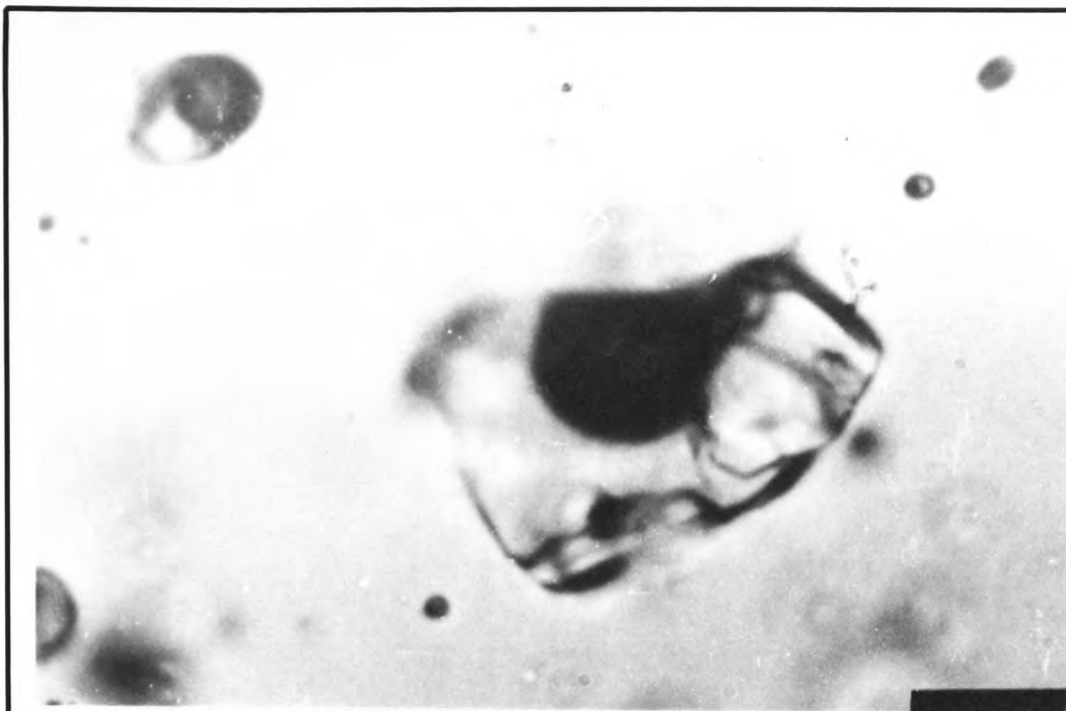


Plate 73.

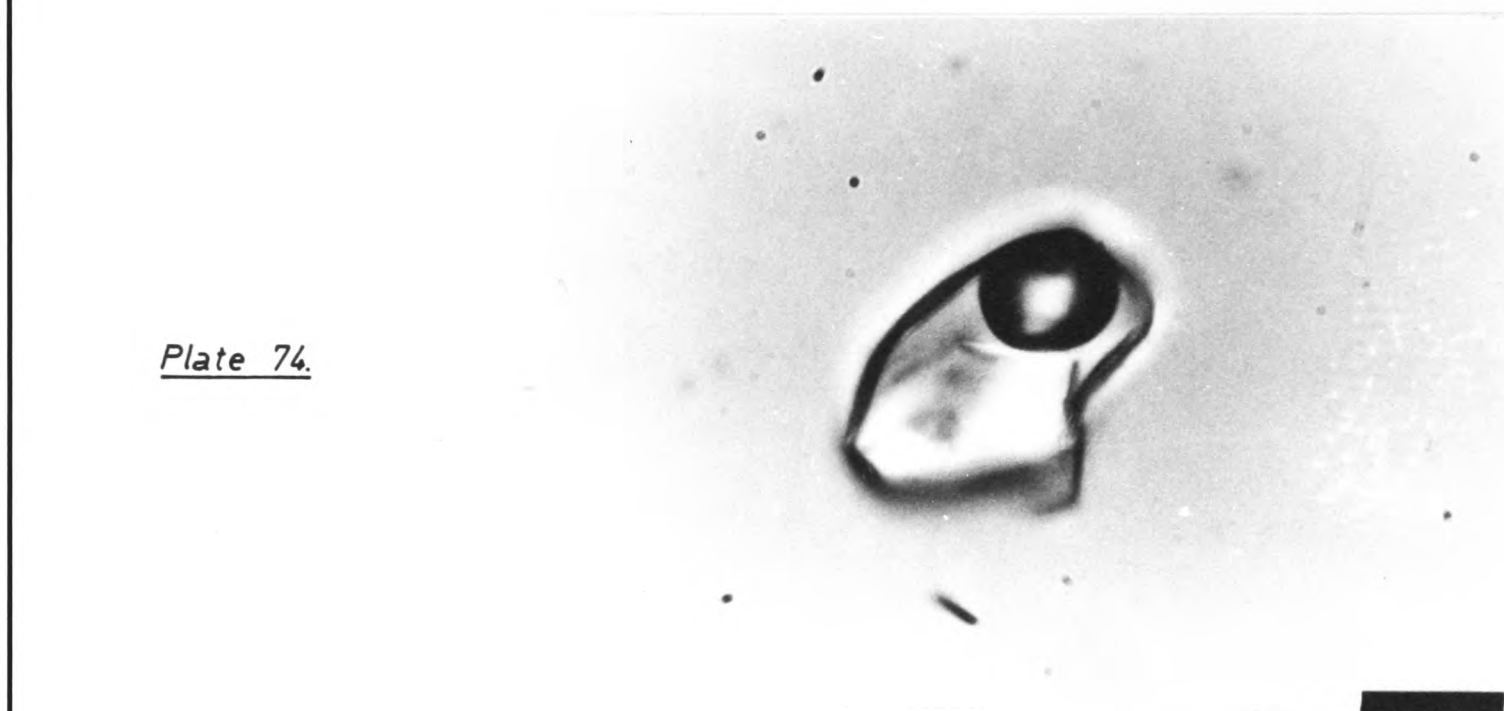


Plate 74.

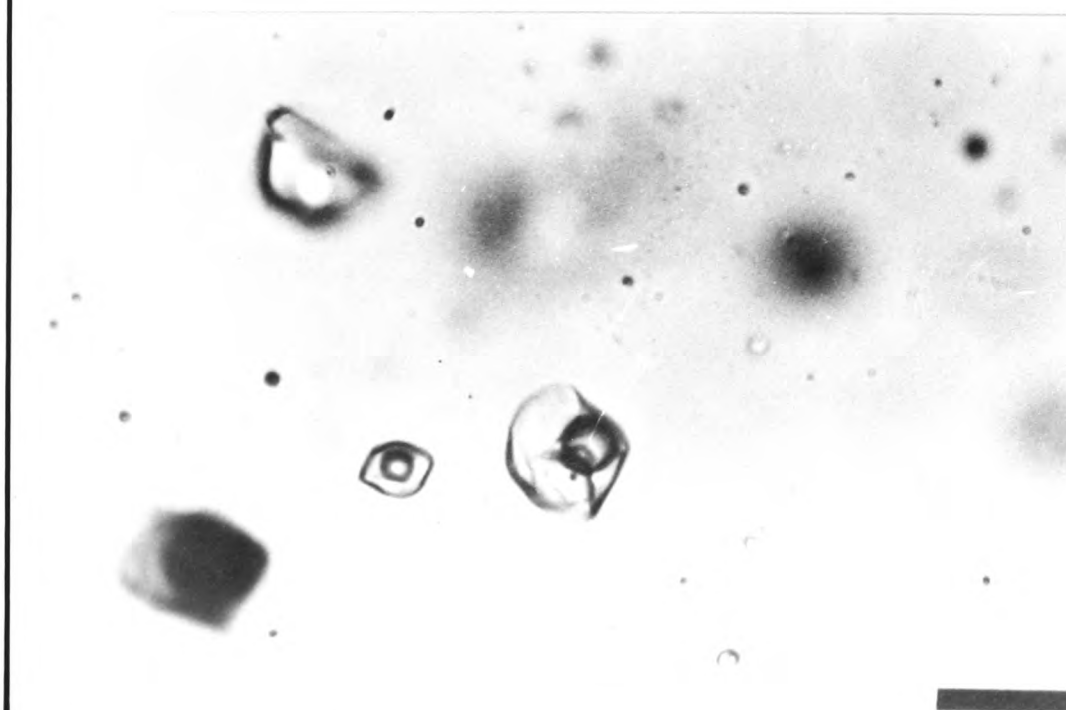


Plate 75.



Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Examples of fluid inclusions containing birefringent sub-spherical daughters.

Plates 76a and 77a - plain light and Plates 76b and 77b (crossed nicols).

Plate 76                      Sample No. 82V.

Plate 77                      Sample No. 187.

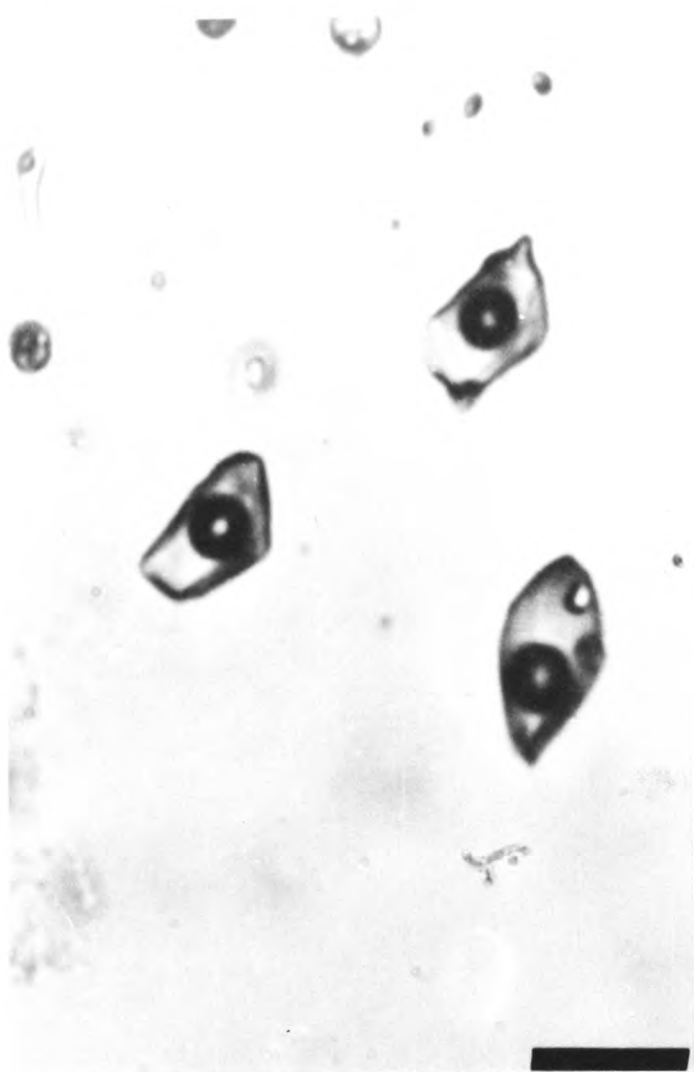


Plate 76a.

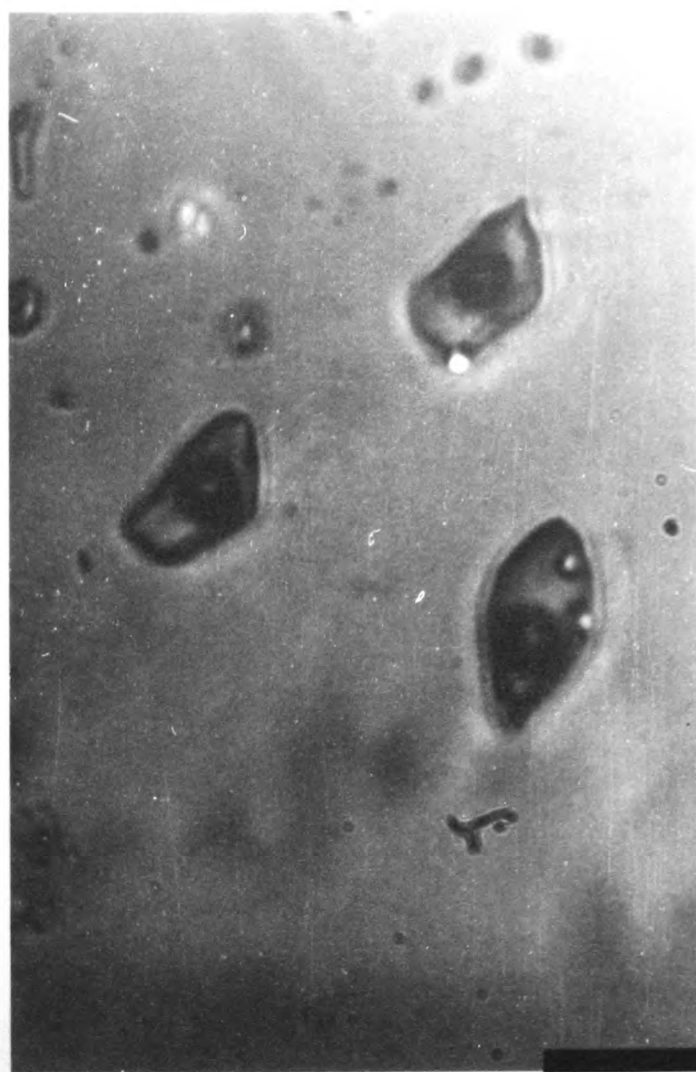


Plate 76b.

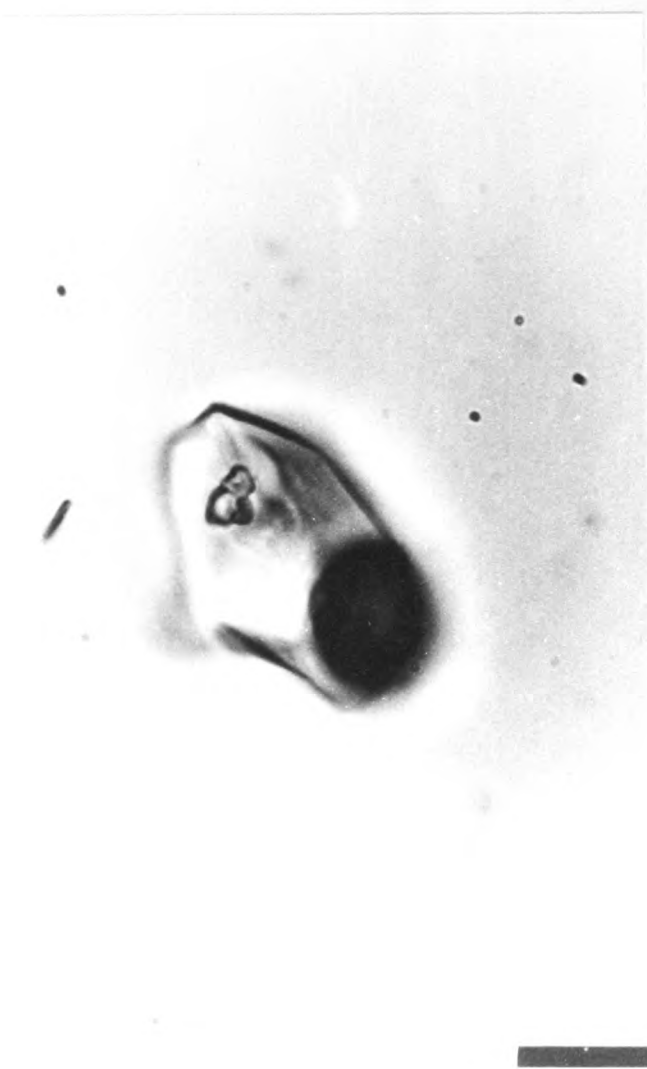


Plate 77a.

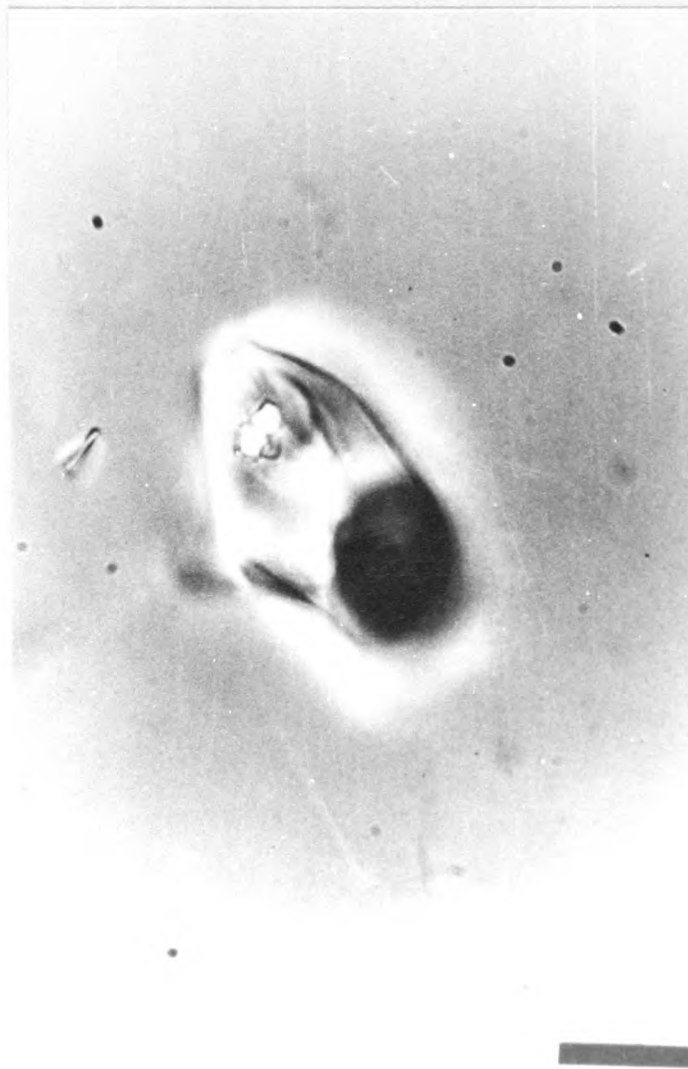


Plate 77b.

Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Plate 78. An inclusion containing several sub-spherical daughters and a small vapour bubble. (Sample No. 243).

Plate 79. An inclusion containing a sub-spherical daughter. (Sample No. 143V).

Plate 80. An inclusion containing several sub-spherical daughters and another containing a deformed vapour bubble. (Sample No. 110V).

Plate 81. An inclusion containing a large blocky birefringent daughter. (Sample No. 243).

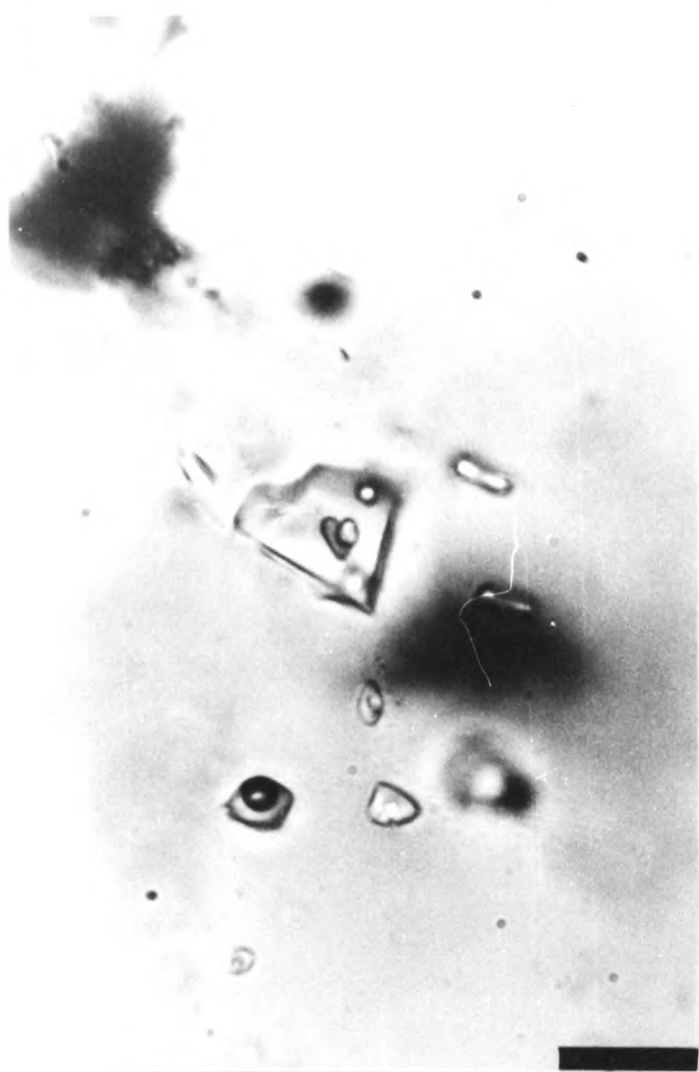


Plate 78.

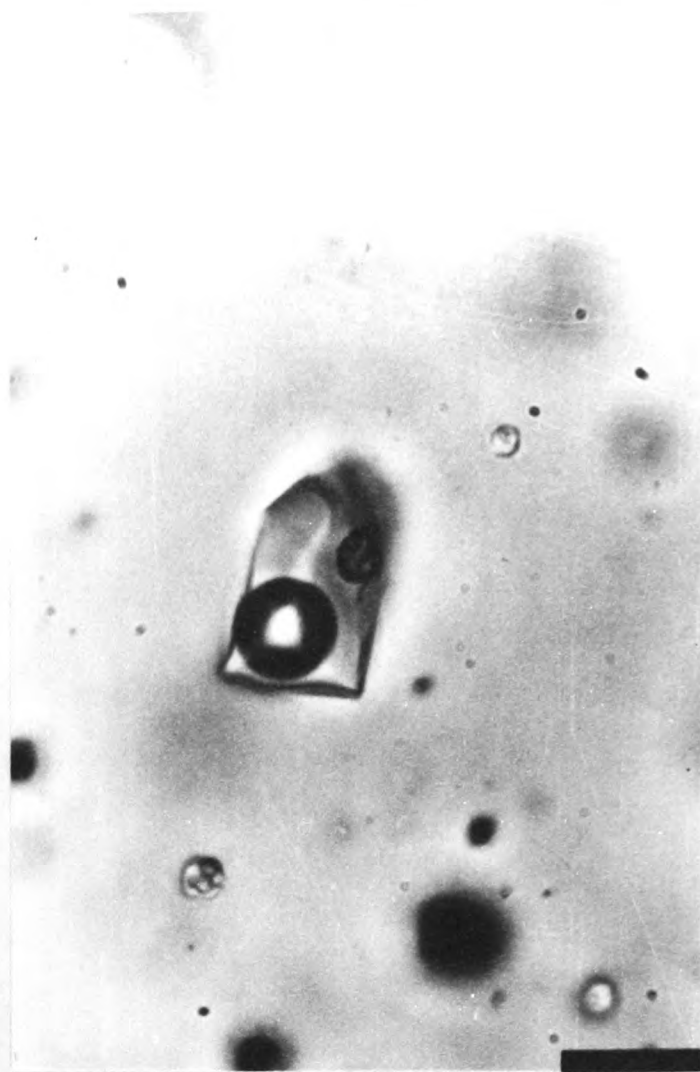


Plate 79.

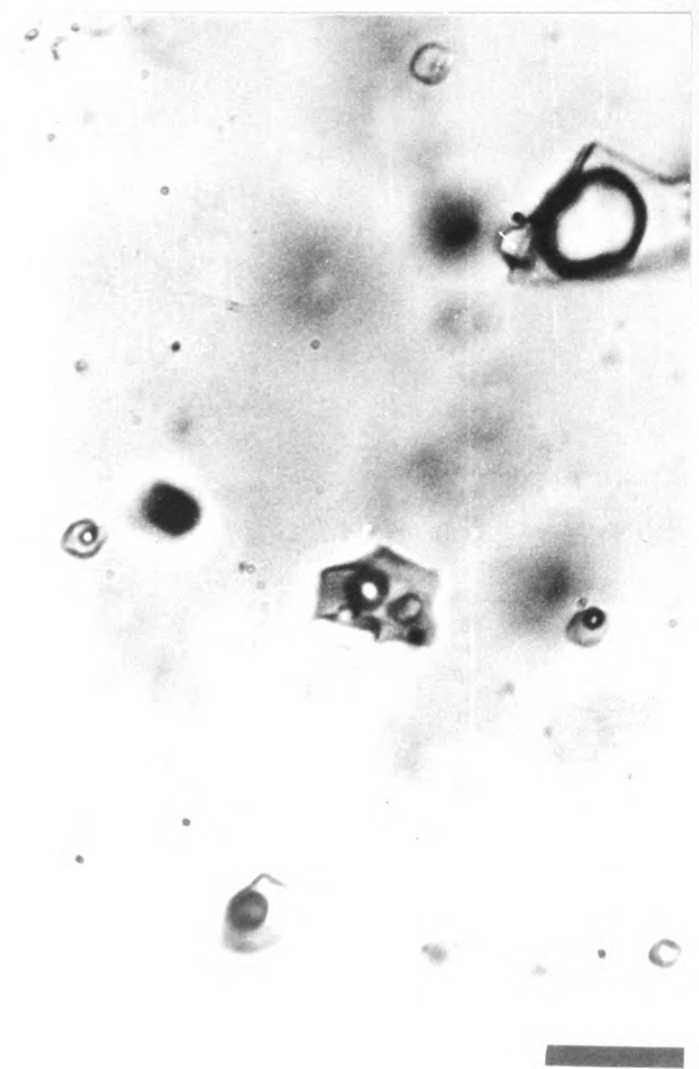


Plate 80.

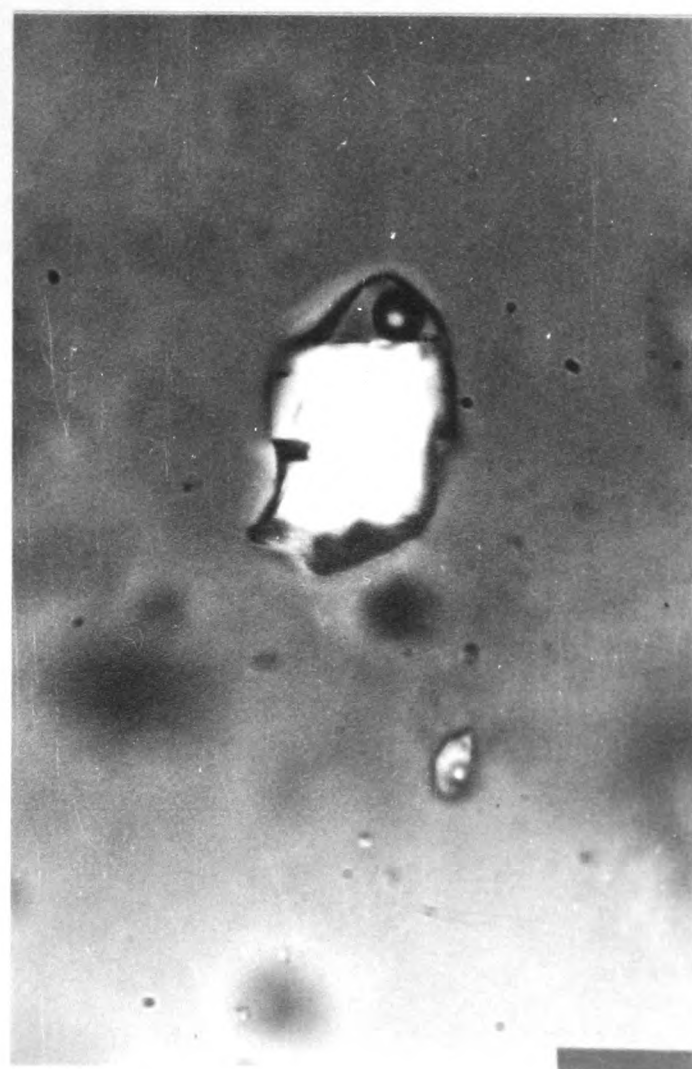


Plate 81.

Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Plates 82a (plain light) and 82b (crossed nicols). An inclusion containing a large blocky birefringent daughter.  
(Sample No. 143V).

Plates 83a (plain light) and 83b (crossed nicols). An inclusion containing a birefringent fibrous mineral - rarely observed. (Sample No. 143V).



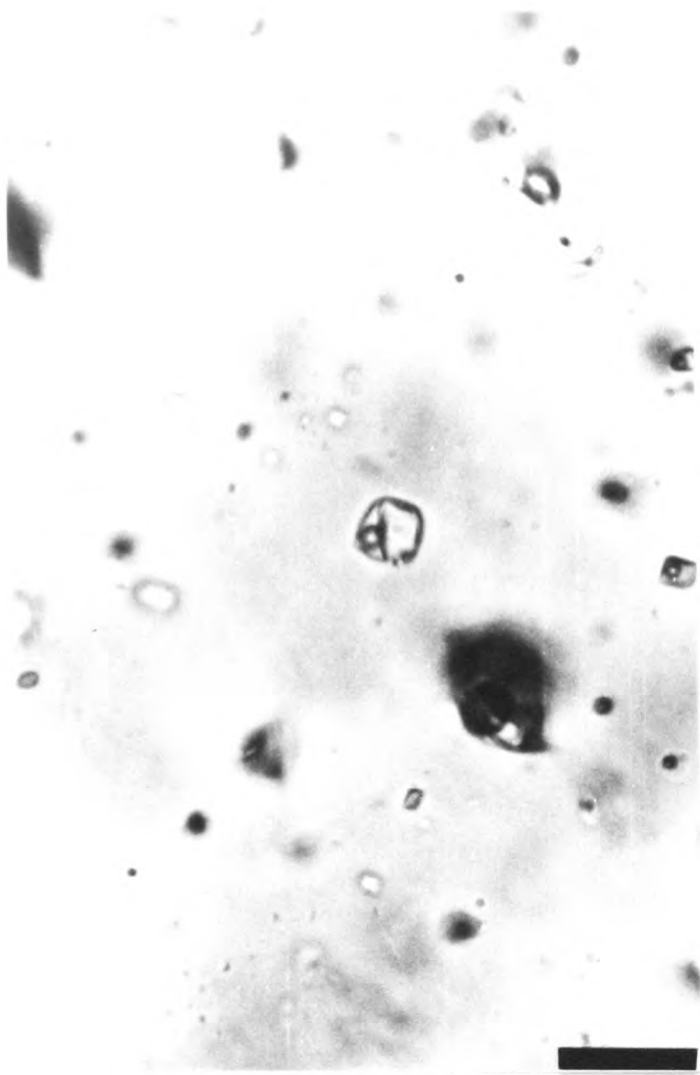


Plate 82a.

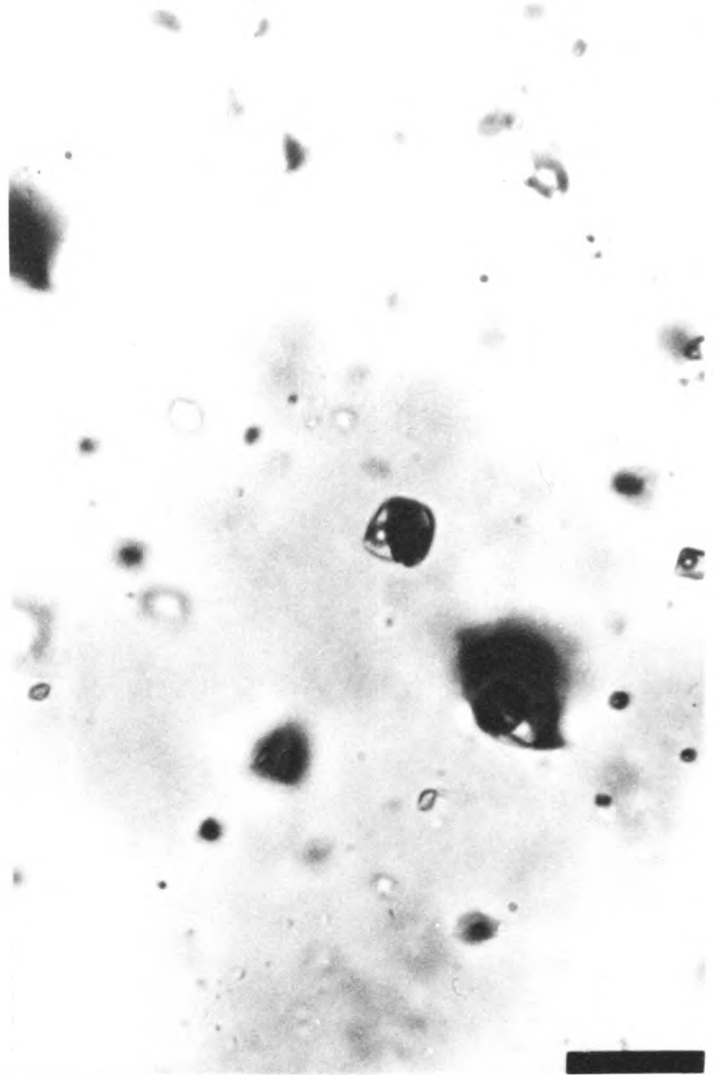


Plate 82b.

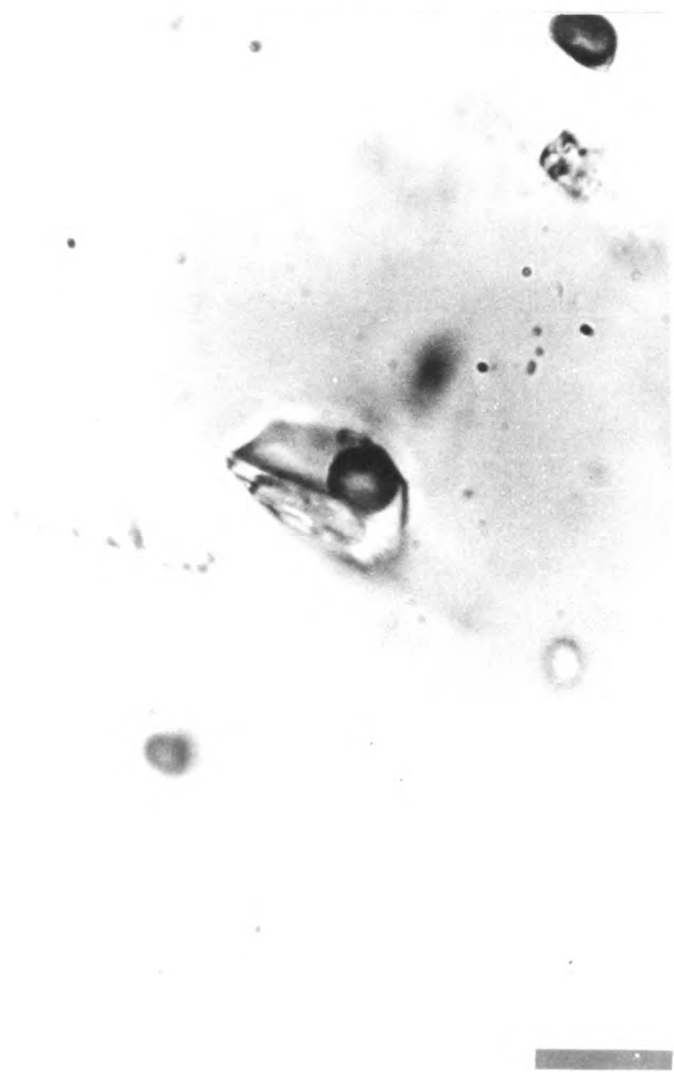


Plate 83a.



Plate 83b.

Fluid inclusions in quartz from Goonbarrow. Scale bars = 10 $\mu$ m.

Plates 84a (plain light) and 84b (crossed nicols). An inclusion containing a birefringent fibrous mineral. (Sample No. 143V).

Plate 85 An inclusion containing black opaque crystals. (Sample No. 10V).

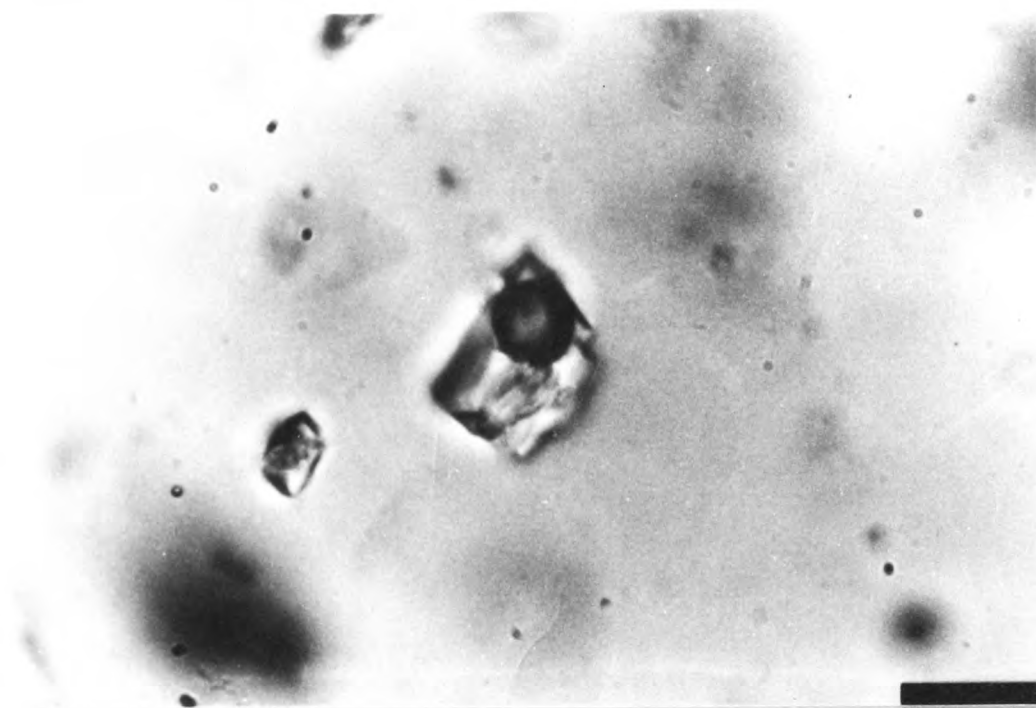


Plate 84a.



Plate 84b.

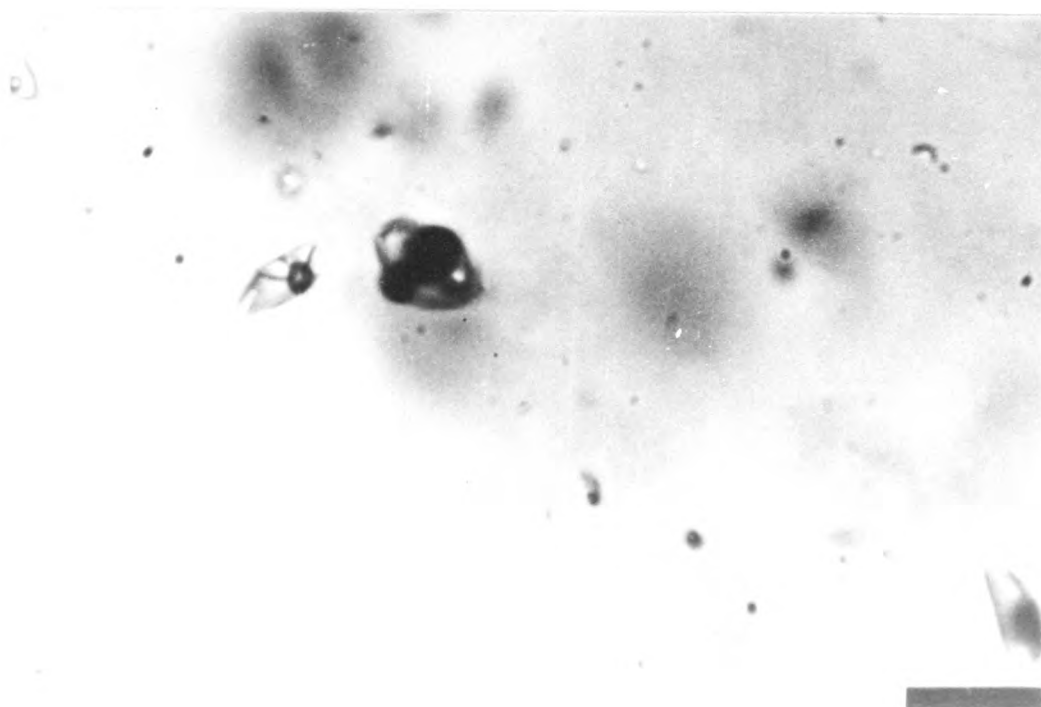


Plate 85.

Plate 86

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars =  $1\mu\text{m}$ . All spectra contained a Si peak which may have come from the daughter or host mineral (quartz).

- a. Inclusion cavities containing cubes of halite (Sample No. 152V).
- b. Close up of central inclusion in a.
- c. Close up of inclusion in extreme left of a. Note small spots on halite cube which have been produced during analysis by the electron beam. Area analysed is therefore around  $0.1\mu\text{m}$ .
- d. Needle-like daughter containing Al, Fe, Mn and Zn. (Sample No. 152V).
- e. Platey mineral containing Si(?), Al and K. (Sample No. 152V). Identified as muscovite.
- f. Amorphous daughter probably deposited from inclusion fluid during opening of inclusion (Sample No. 152V). Contains, Al, Cl, K and Na.
- g. Cubic mineral containing Na and Cl (Sample No. 152V). Identified as halite.
- h. Amorphous mineral containing Fe and Mn. (Sample from lensoid pegmatite).

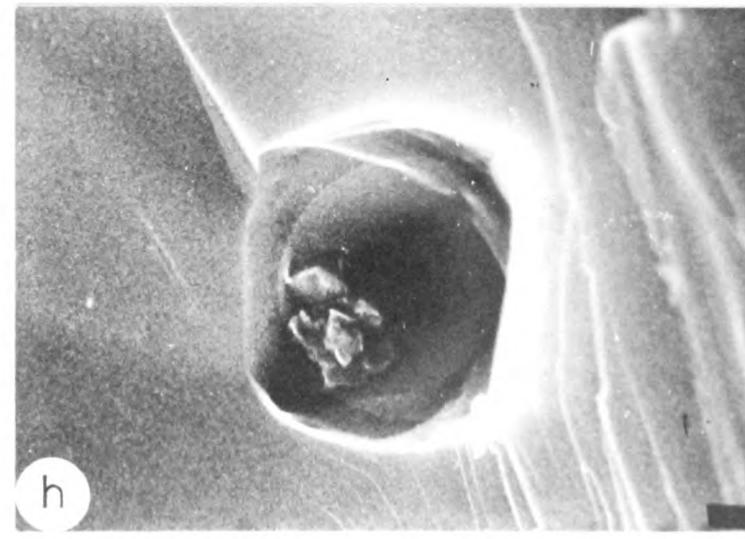
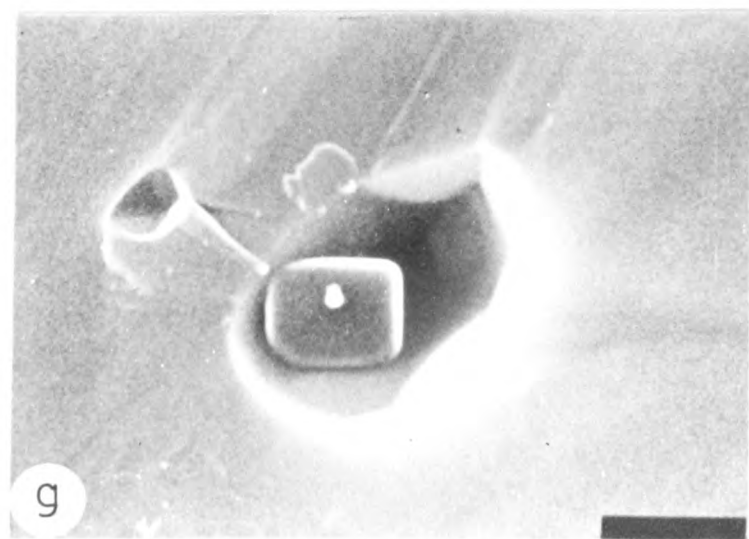
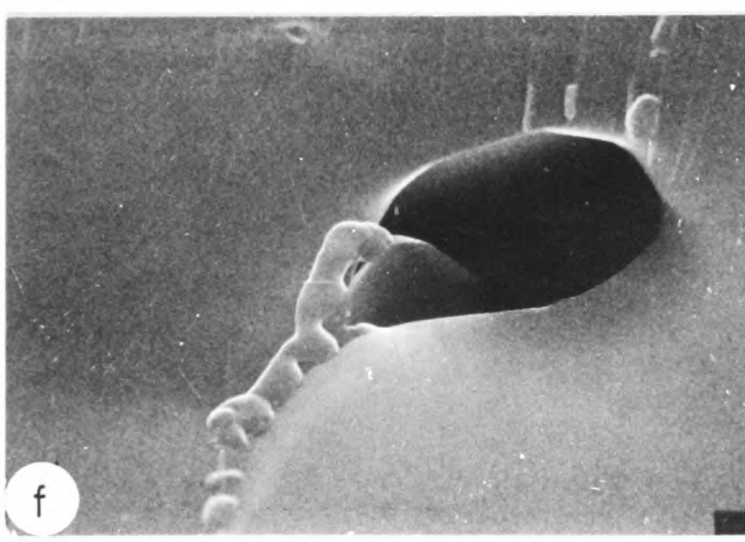
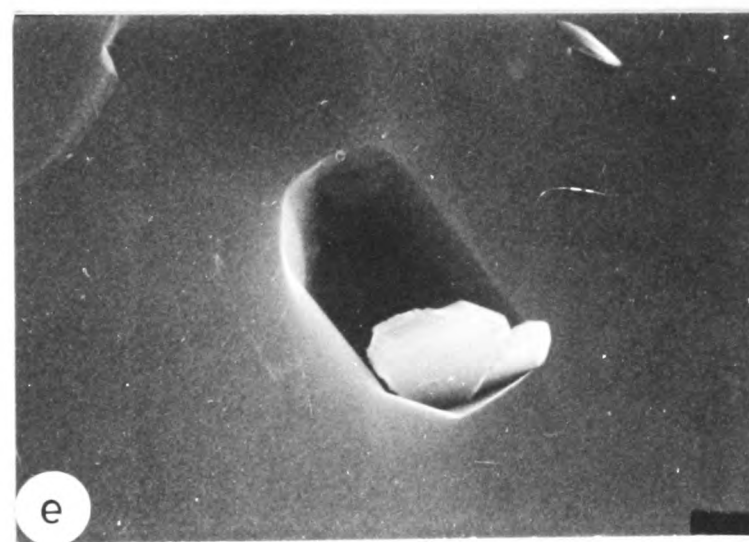
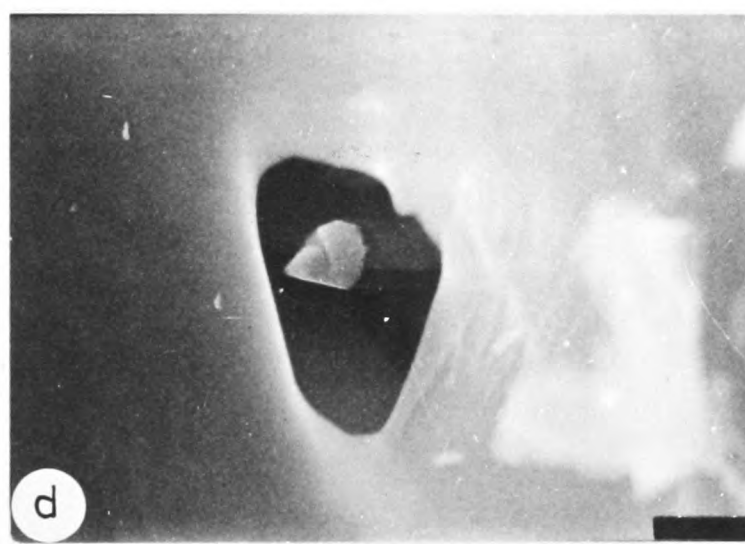
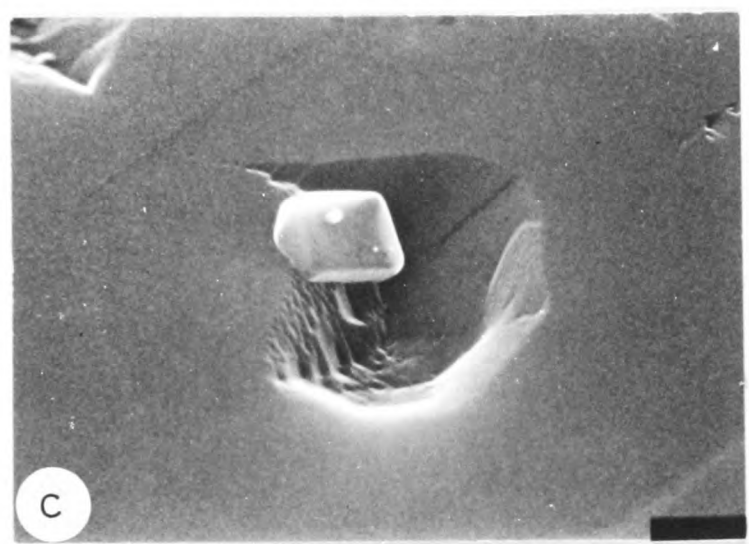
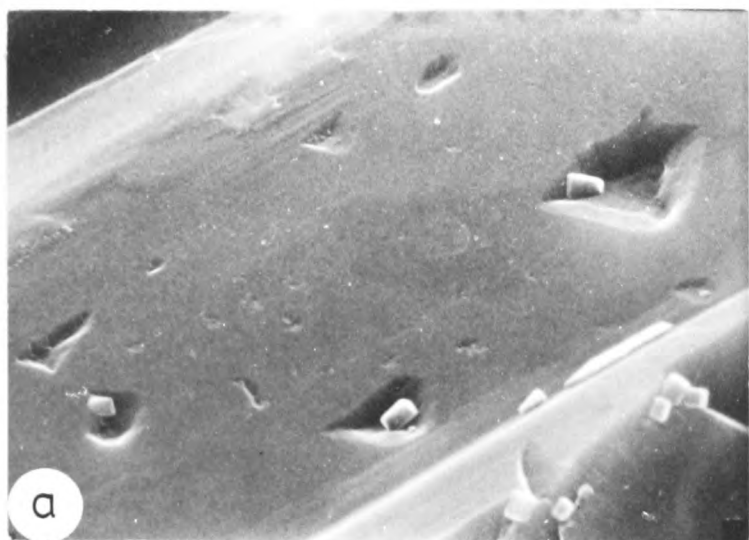




Plate 37

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars = 1 $\mu$ m. All spectra contained a Si peak which may have come from the daughter or host mineral (quartz).

- a. All crystals gave the same spectra containing Cl, Fe, Mn and S. (Sample No. 143G).
- b. All crystals gave the same spectra containing Al and Na. (Sample No. 143G). Their platy habit suggests they are micaceous.
- c. Platy mineral containing Al, Cl, K and Na. (Sample No. 53V).
- d. Platy mineral containing Al, Cl, Fe and K. (Sample No. 53V).
- e. Platy mineral containing Al, Cl, K and Na. (Sample No. 73V).
- f. Crystal contains Na and Cl. Probably halite but does not have cubic morphology. (Sample No. 73V).
- g. Platy hexagonal mineral containing Al, Cl and K. (Sample No. 165V).
- h. Mineral probably of cubic morphology containing Cl, probably halite. (Sample No. 152V).

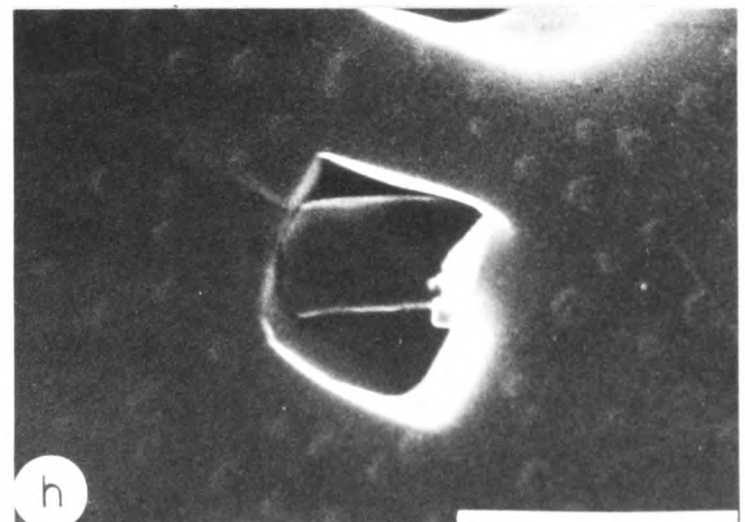
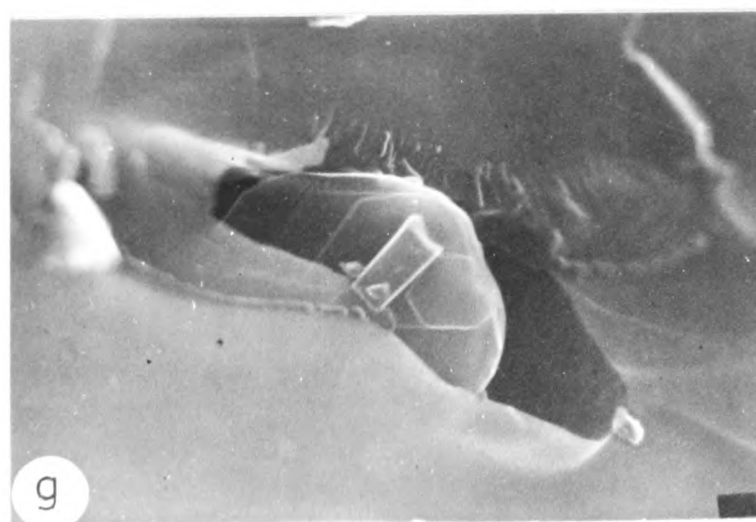
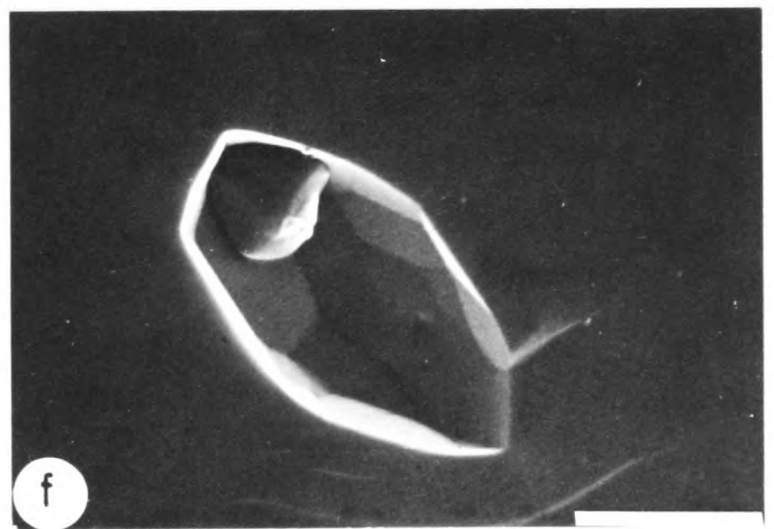
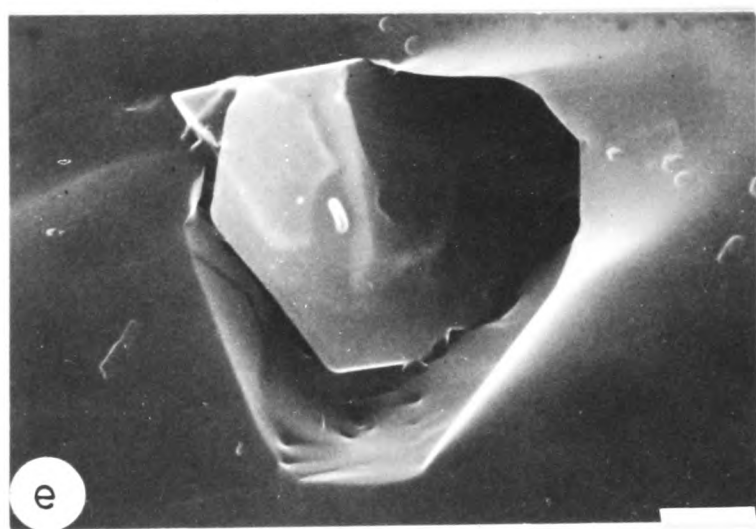
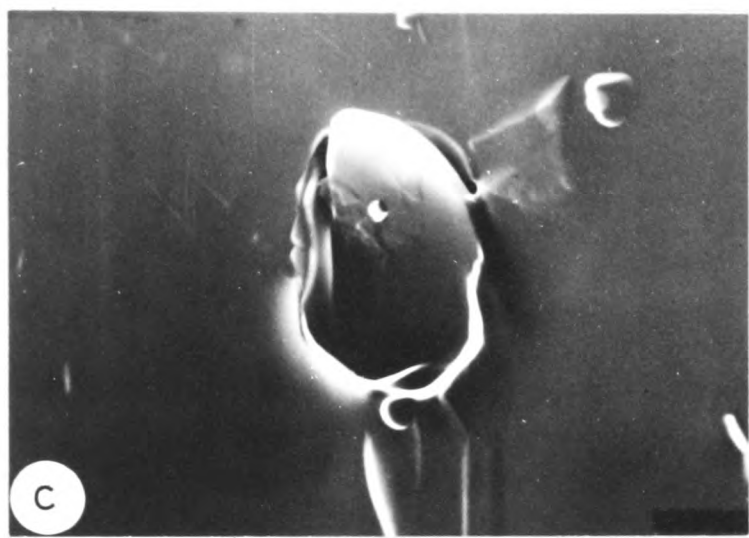
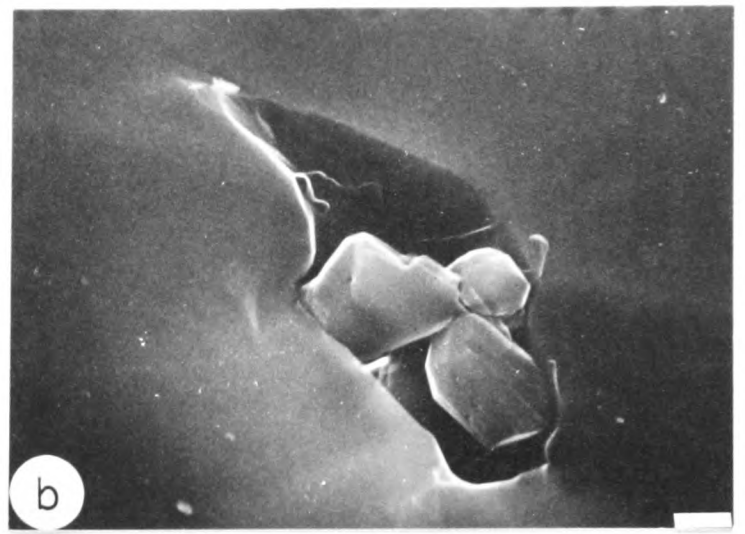
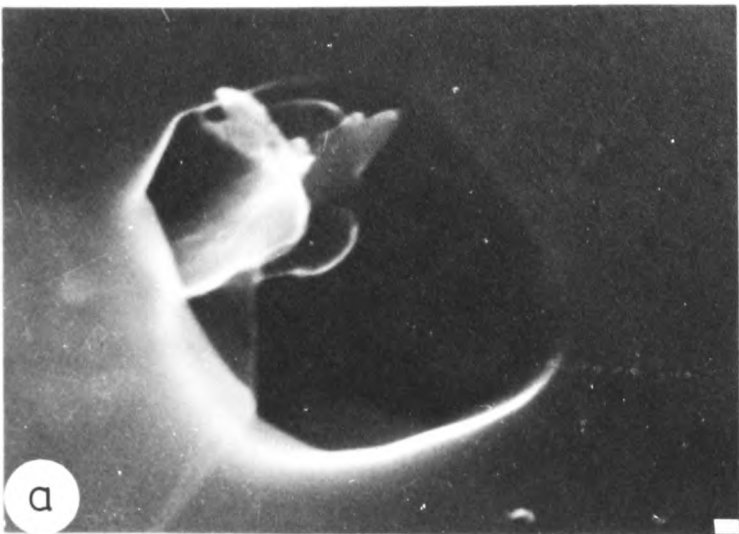


Plate 88

Scanning electron micrographs of daughter crystals in fluid inclusions cavities. Scale bars =  $1\mu\text{m}$ . All spectra contained a Si peak which may have come from the daughter or host mineral (quartz).

- a. and b. Mineral contains Al and K. (Sample No. 111).
- c. and d. Mineral contains Fe and Mn. (Sample No. 111).
- e. and f. Mineral contains Fe and Mn. (Sample No. 149A).
- g. Platey mineral containing Al and K. (Sample No. 149A).
- h. Both crystals have identical spectra containing Cl, K and Na. (Sample No. 171V).

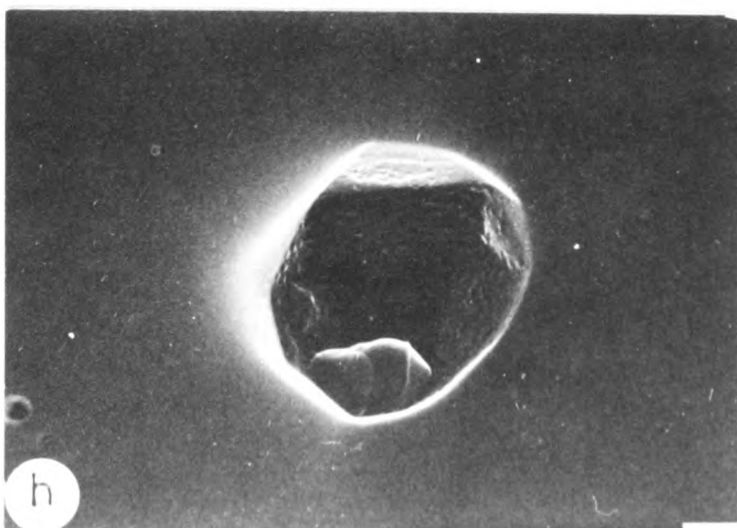
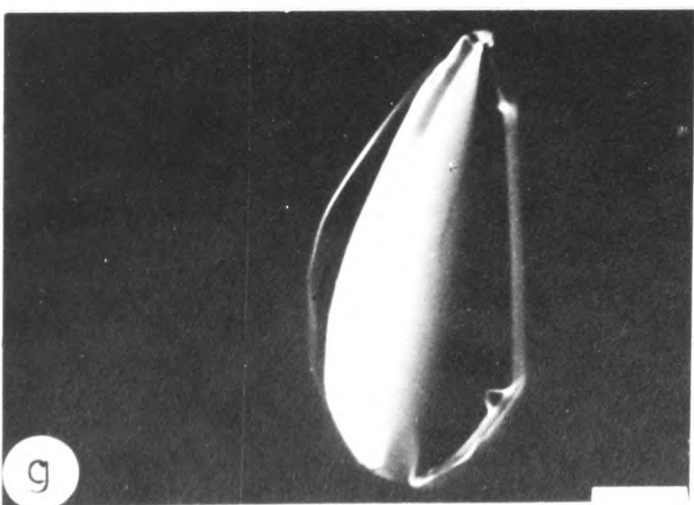
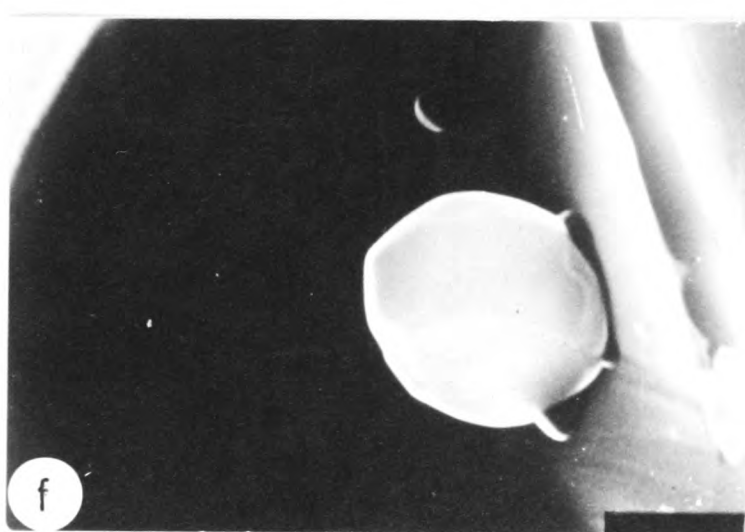
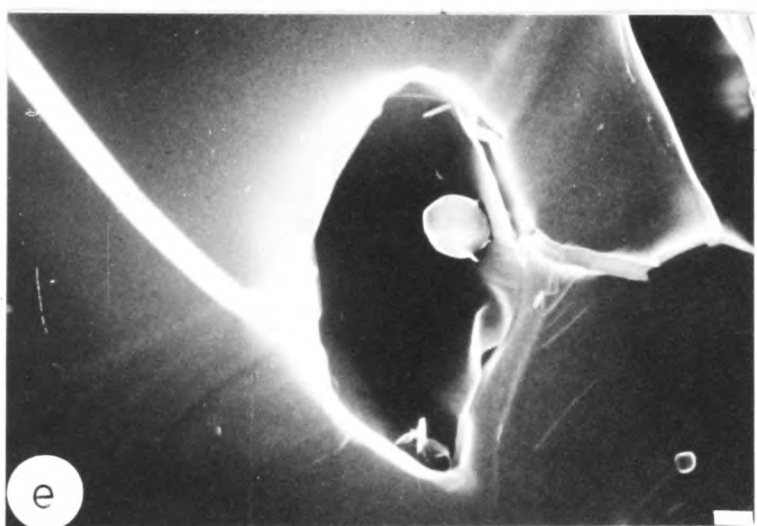
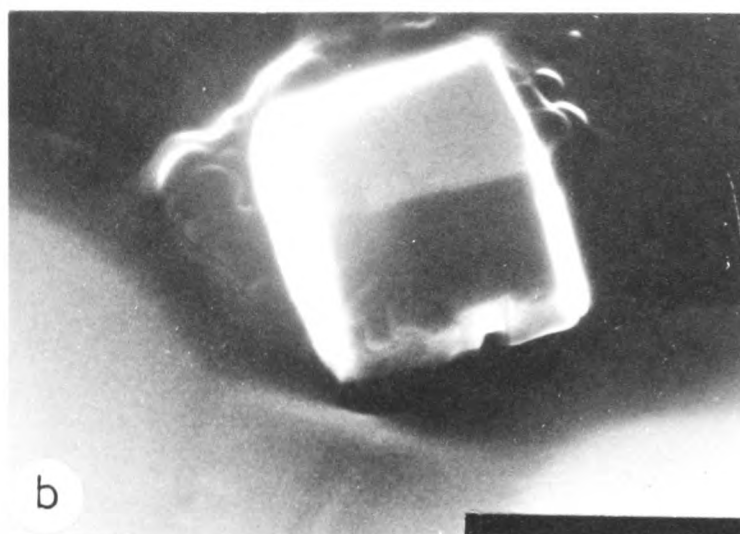
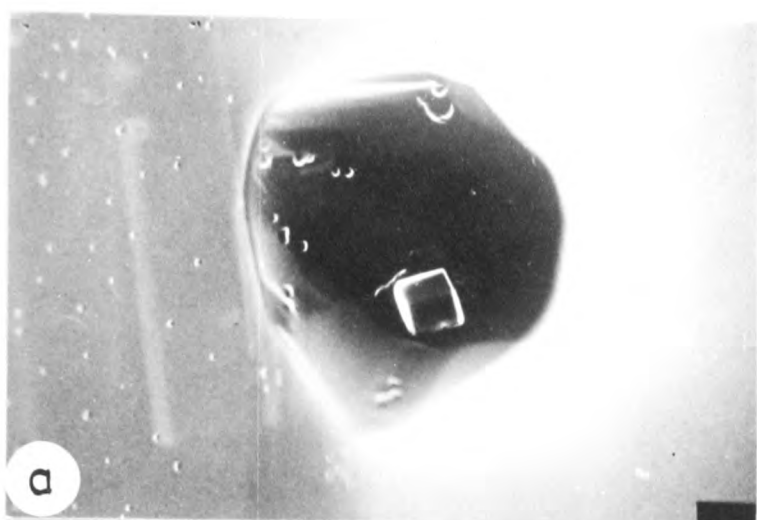


Plate 89

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars = 1 $\mu$ m. All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagram for easy reference.

- a. Inclusion cavity containing several daughter crystals (Sample No. 152V).
- b. View of crystals B, C, D and E. X-ray analysis revealed the following analyses:
  - B. Fe, Mn and Zn
  - C. Al, Fe and K
  - D. No spectra peaks
  - E. K
- c. Close up of crystals B and C.
- d. Crystal A. containing Al, S and Zn.
- e. Crystal F. containing Al and K.
- f. Crystal G. containing Cl.
- g. Crystals H and I neither producing any spectral peaks.



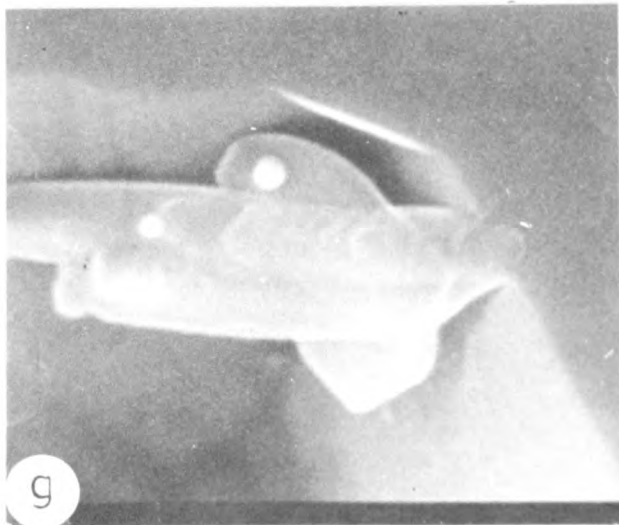
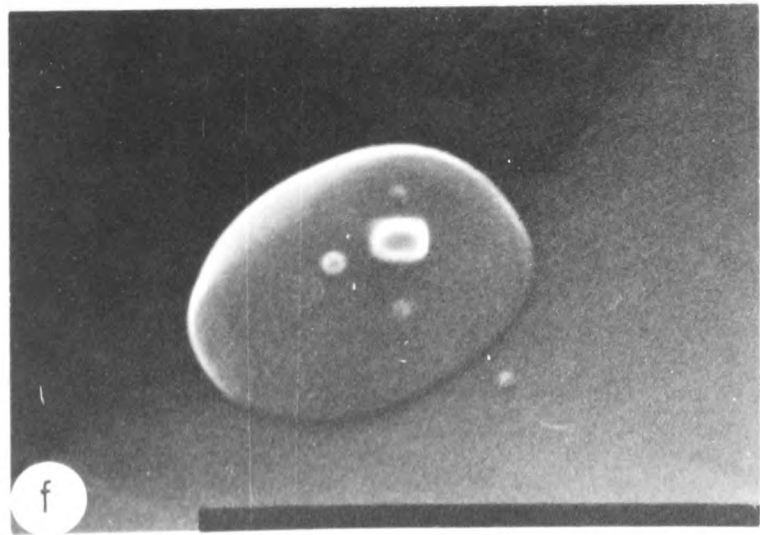
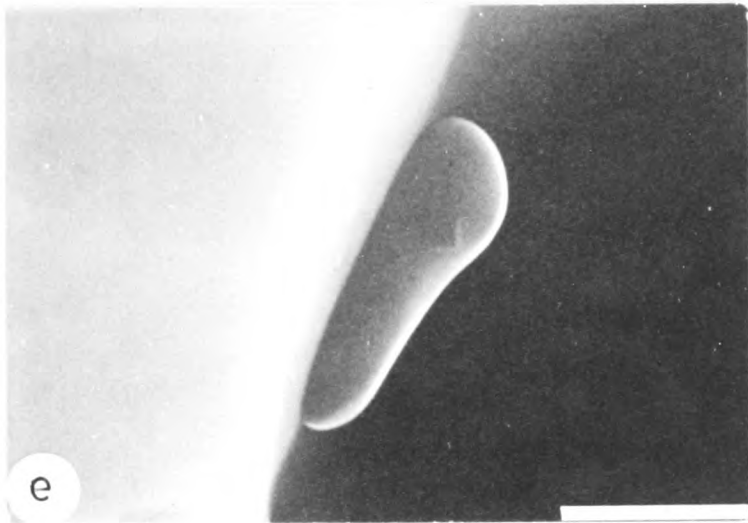
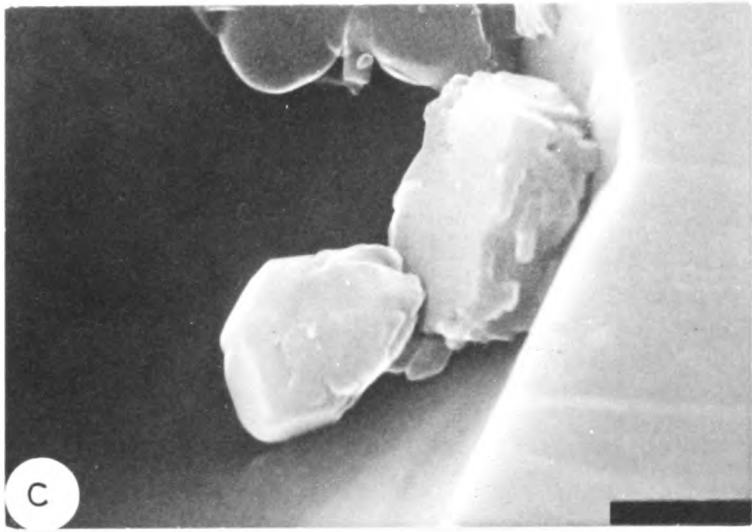
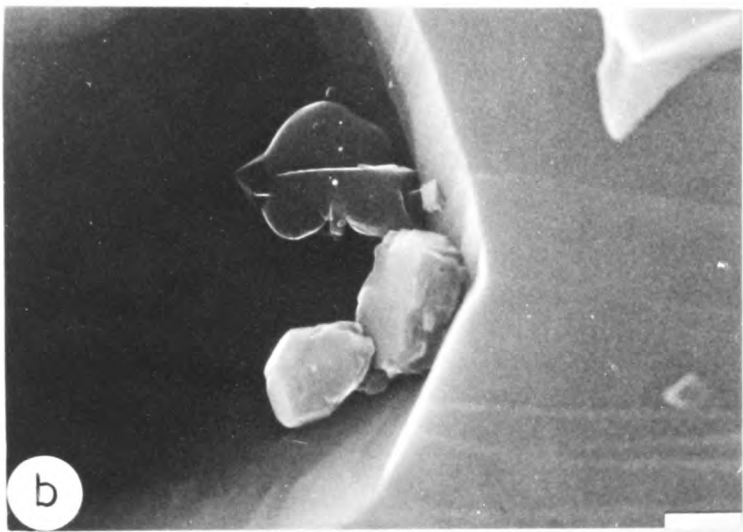
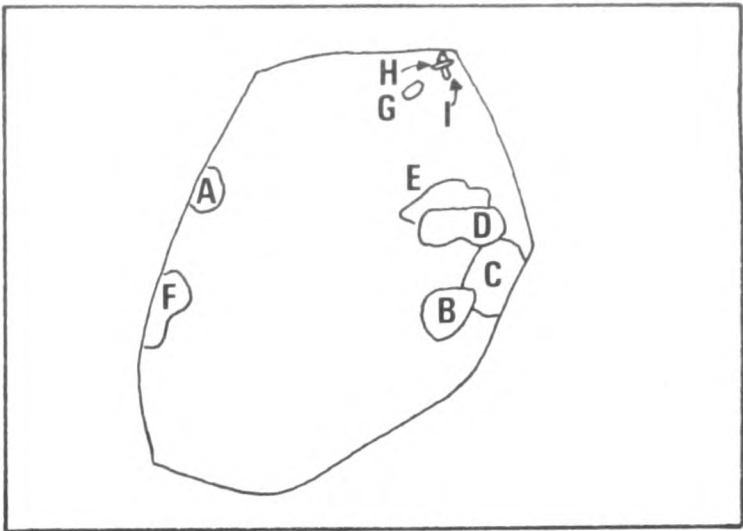
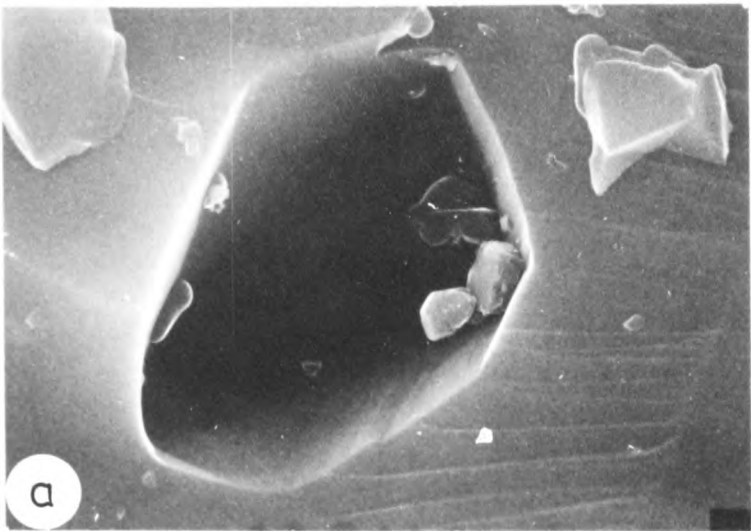


Plate 90

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars =  $1\mu\text{m}$ . All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagrams for easy reference.

- a. Inclusion cavity containing two daughters (Sample No. 152V).
- b. Close up of daughters A and B from a.
  - A. contained Fe and K
  - B. contained Fe and Mn
- c. Inclusion containing a rhombohedral daughter (Sample No. 171V).
- d. Close up of daughter A from c. Note ropey sides possibly produced by cleavage of crystal. Analysis indicated the presence of Fe and Mn.

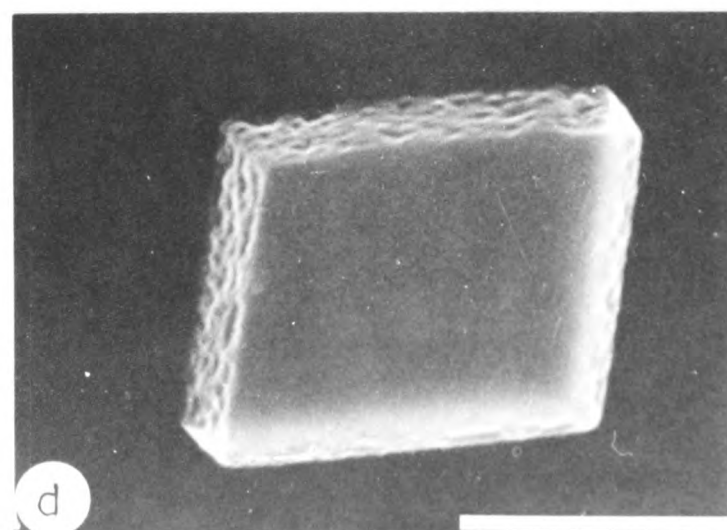
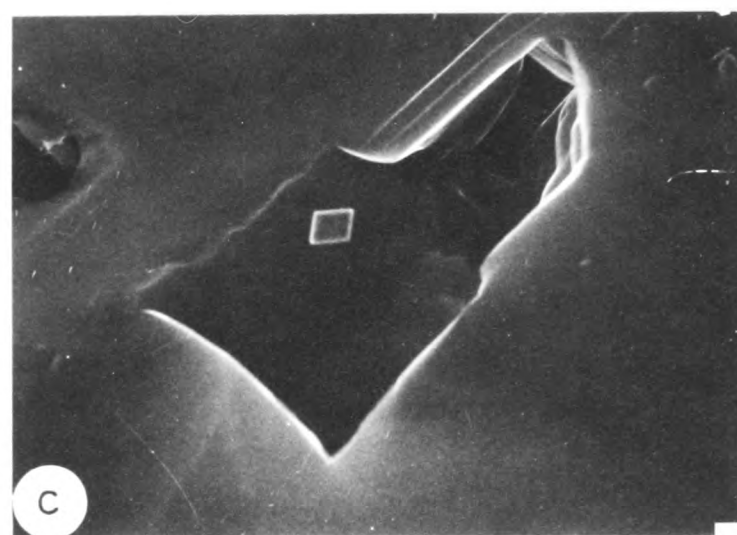
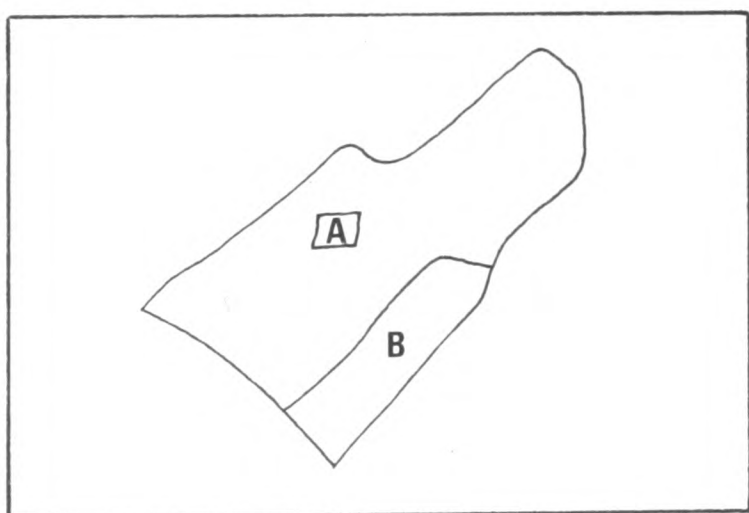
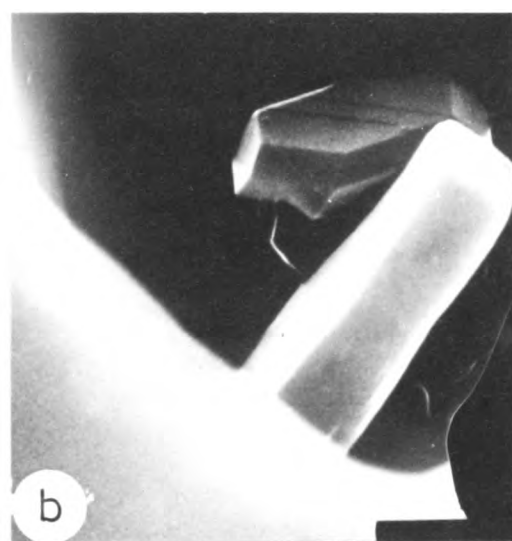
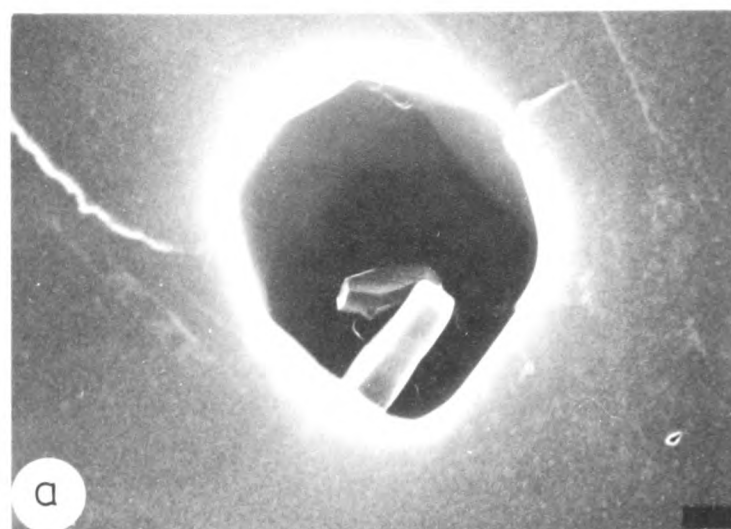
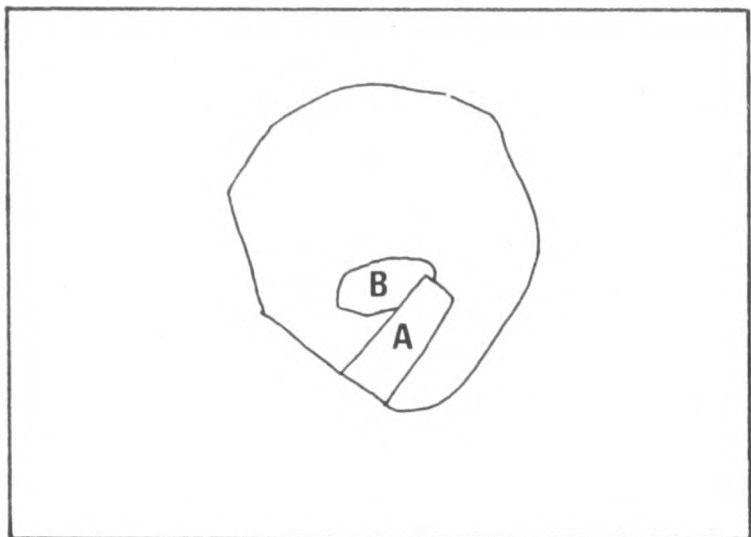


Plate 91

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars =  $1\mu\text{m}$ . All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagrams for easy reference.

- a. Inclusion cavity containing several daughters (Sample No. 73V).
  - A. contained Al and Fe
  - B. contained Al, Cl and Fe. rod like.
  - C. contained Cl, Fe and K. rod like.
- b. Inclusion cavity containing several daughters (Sample No. 73V).
  - A. contained Cl and K
  - B. contained Al and Cl
  - C. no spectral peaks obtained
  - D. contained Cl, K and Na
- c. Inclusion cavity containing two daughters (Sample No. 137V).
  - A. Cubic(?) mineral containing Ca, Cl, Fe and Mn
  - B. No spectral peaks obtained
- d. Inclusion cavity containing three daughters (Sample No. 147V).
  - A. Amorphous mineral containing Fe
  - B. Platey mineral containing Al, Ca, Cl, K and S
  - C. No spectral peaks obtained

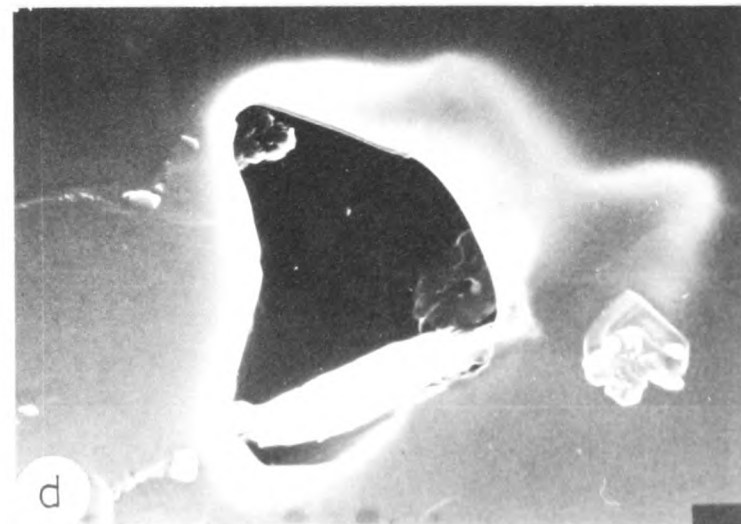
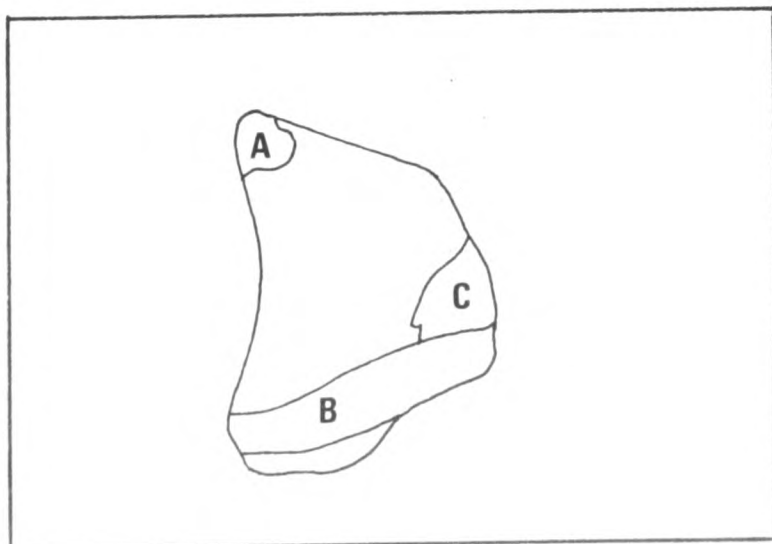
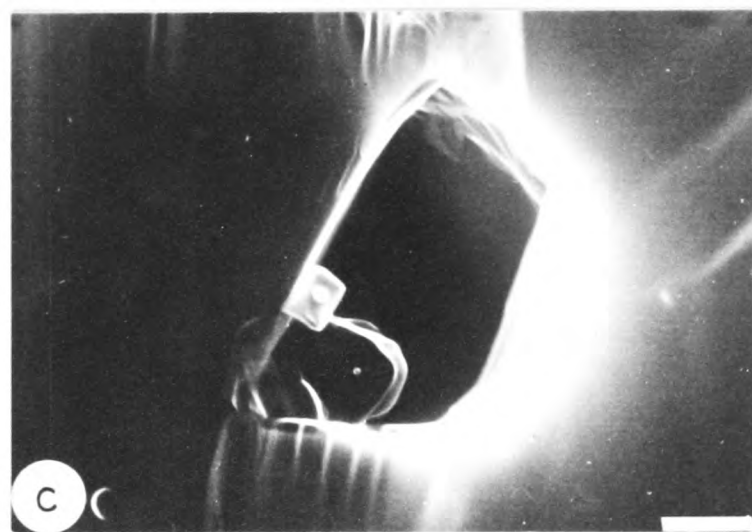
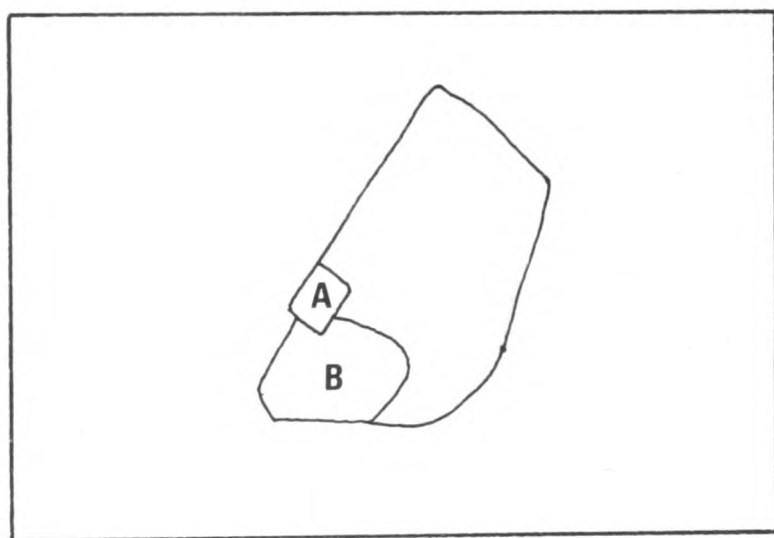
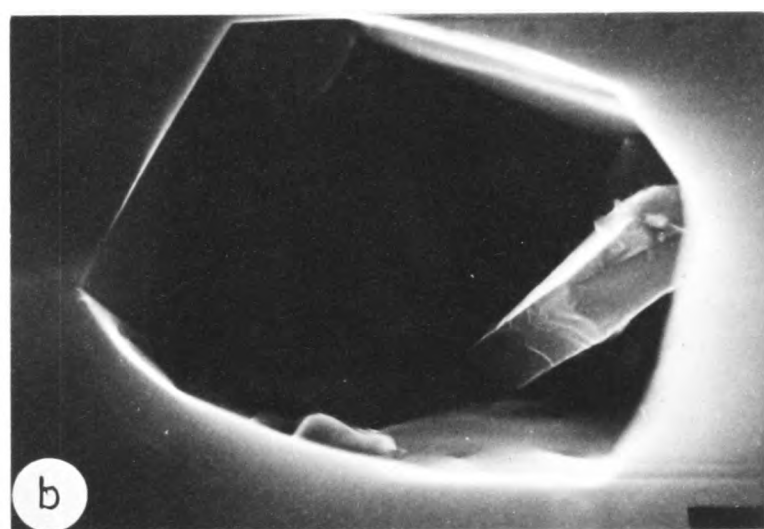
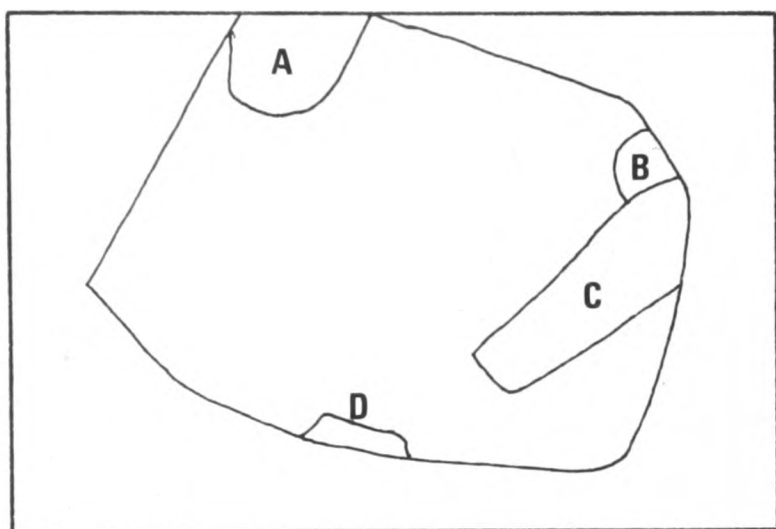
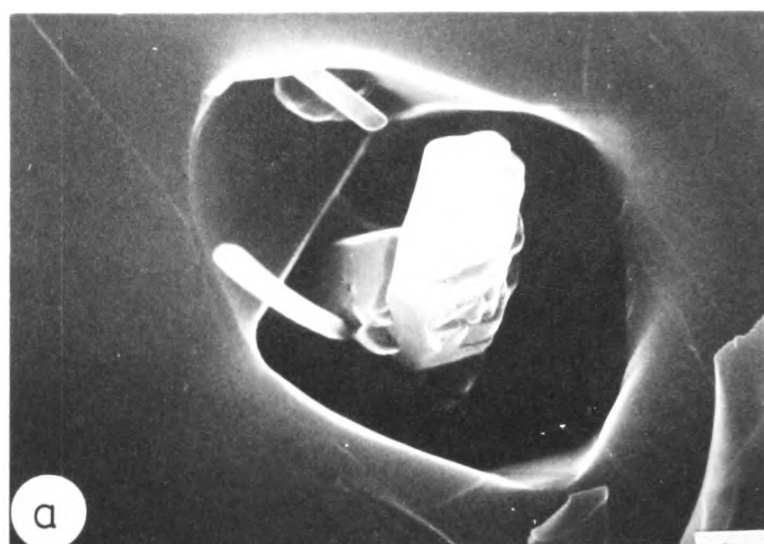
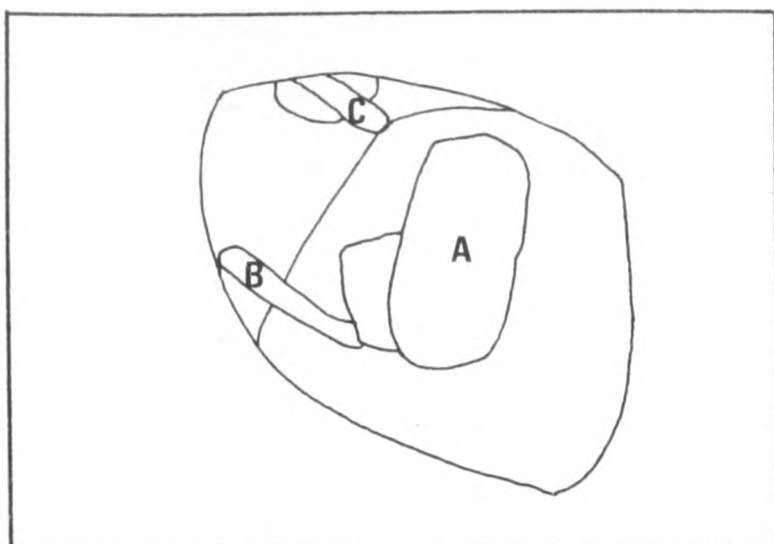




Plate 92

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars =  $1\mu\text{m}$ . All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagrams for easy reference.

a. Inclusion cavity containing two daughters (Sample No. 165V).

A. Platey mineral containing Al and K

E. Amorphous crystals containing Cl and K - probably deposited from fluid on opening the inclusion. Identified as sylvite.

b. Inclusion cavity containing several daughters (Sample No. 97V).

Individual crystals were difficult to define hence several spot and raster analyses were made.

Raster A. revealed Cl, Fe, S and Zn

Spot E. which was in the centre of raster A. revealed Fe, S and Zn.

Spot C. contained Cl, Fe, S and Zn

Spot D. contained Fe, S and Zn

Spot E. gave no spectral peaks

At least two daughters were identified, one containing Fe, S and Zn. The other Cl, Fe, S and Zn.

c. Inclusion containing three platey minerals (Sample No. 152V).

A. contained Al and K

F. contained Al, Cl and K

C. contained Al and K

d. Inclusion containing two daughters (Sample No. 124V).

A. contained Ca, Cl, Fe and Mn

B. contained Ca(?) and Sn

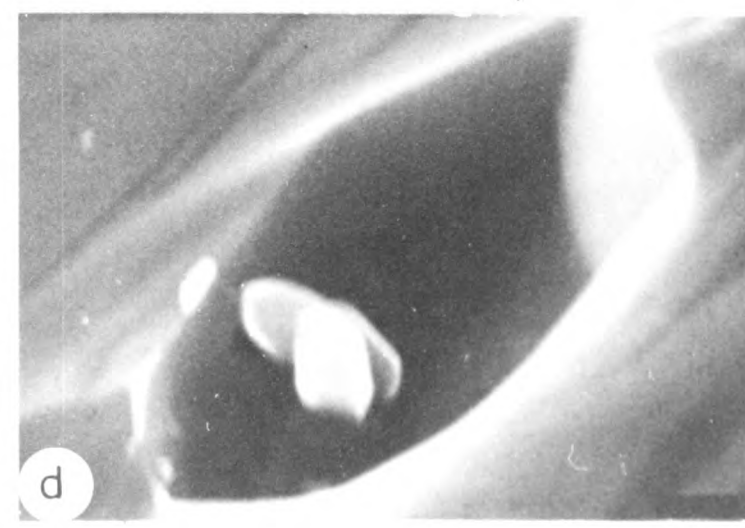
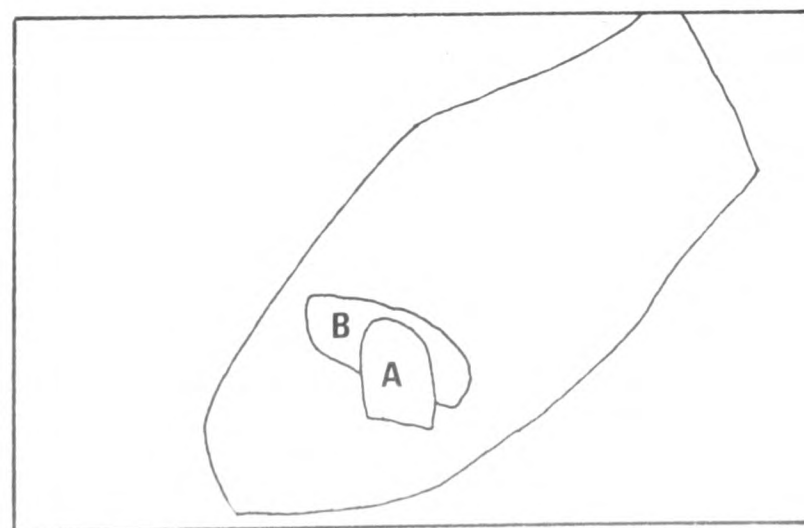
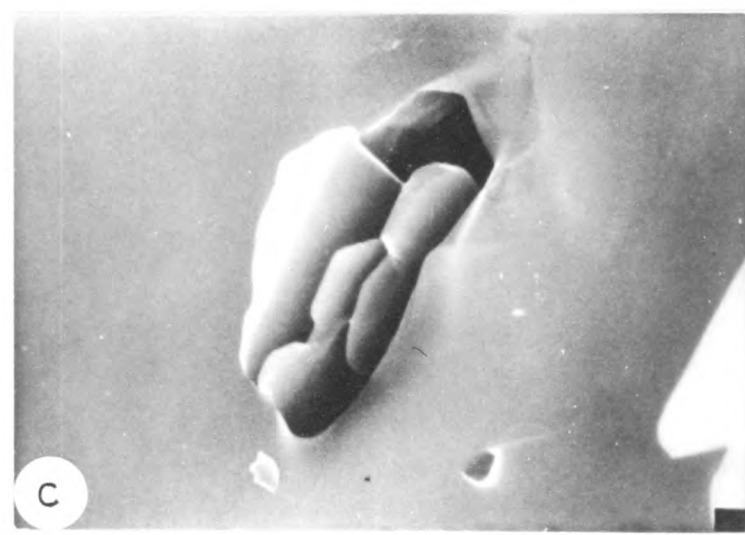
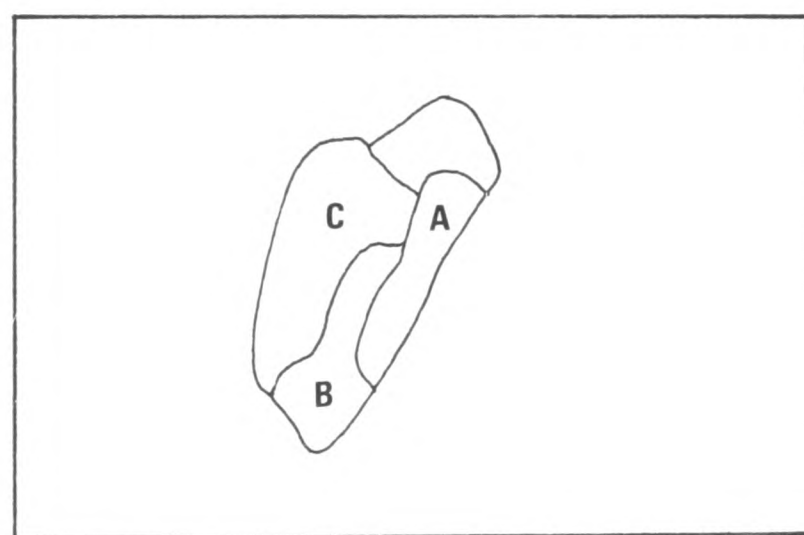
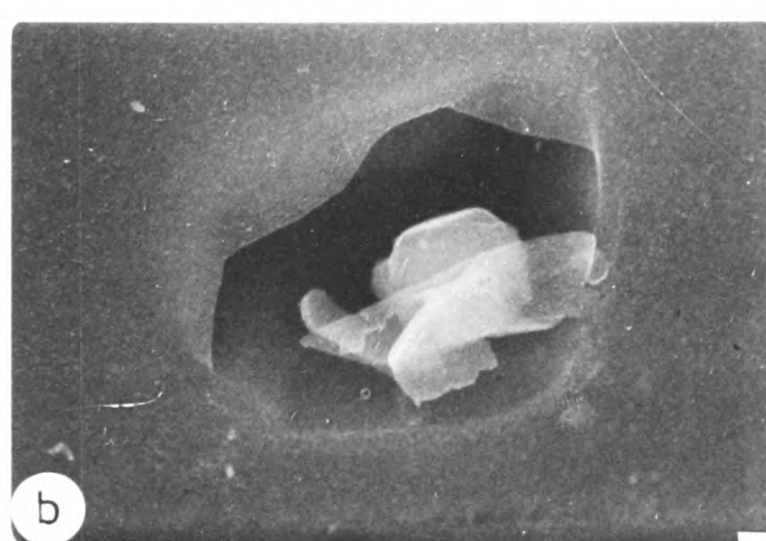
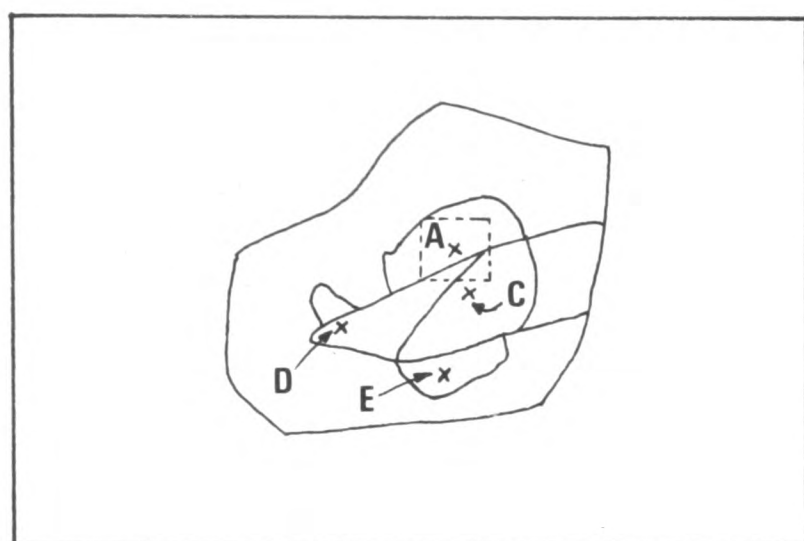
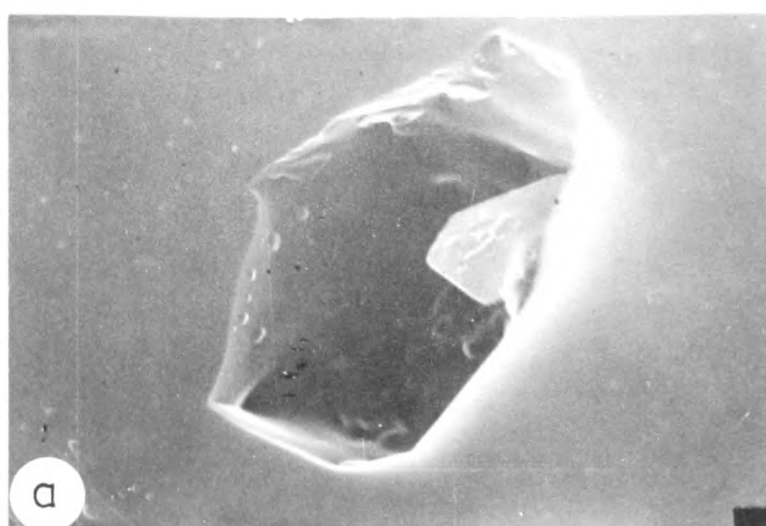
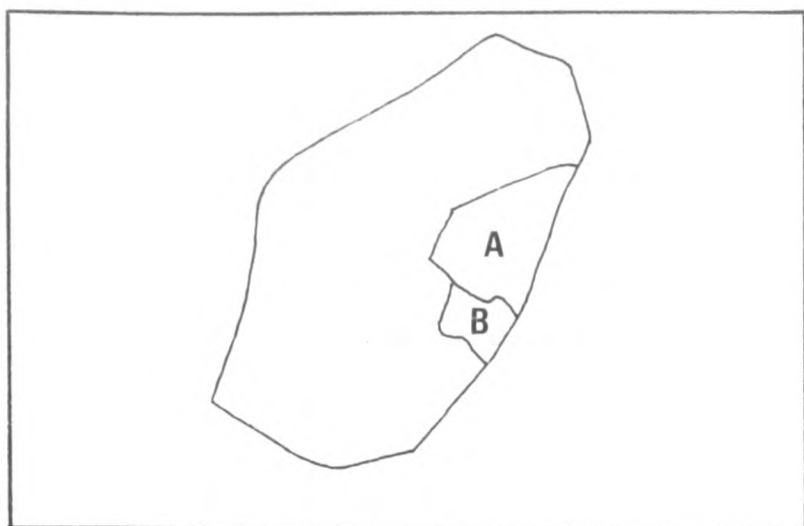


Plate 93

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars = 1 $\mu$ m. All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagrams for easy reference.

a. Inclusion cavity containing several daughters (Sample No. 82G).

- A. contained As and Fe
- B. contained Fe
- C. contained Fe, Mn and Zn
- D. no spectral peaks obtained
- E. no spectral peaks obtained
- F. contained Fe
- G. contained Fe

b. Inclusion cavity containing two daughters (Sample No. 152V).

The daughter to the left of the platy mineral is very difficult to see in the photograph.

- A. contained Al, Fe and K
- B. contained Al and Cl

c. Inclusion cavity containing several daughters (Sample No. 82G).

- A. contained Fe, Mn and Zn
- B. contained Al and K. platy mineral
- C. no spectral peaks obtained
- D. contained Al and K
- E. no spectral peaks obtained
- F. crystals that were probably deposited from the fluid when the inclusion was opened. Contained Al, Cl, Fe, K, Mn and Zn.

d. Inclusion cavity containing two daughters (Sample No. 262).

- A. contained Al, Fe and K
- B. Rat like daughter crystal, no spectral peaks obtained.

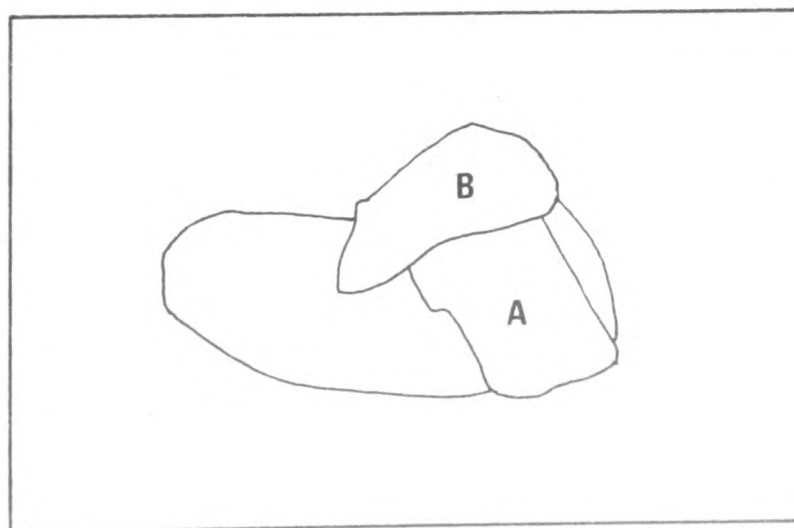
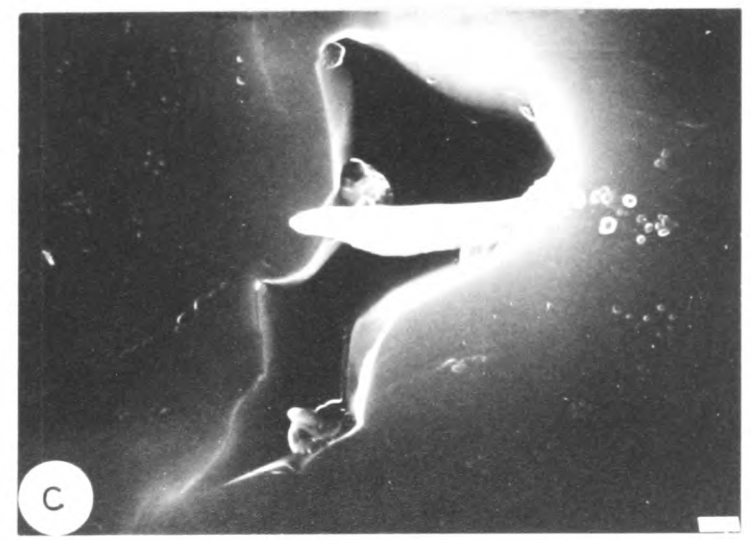
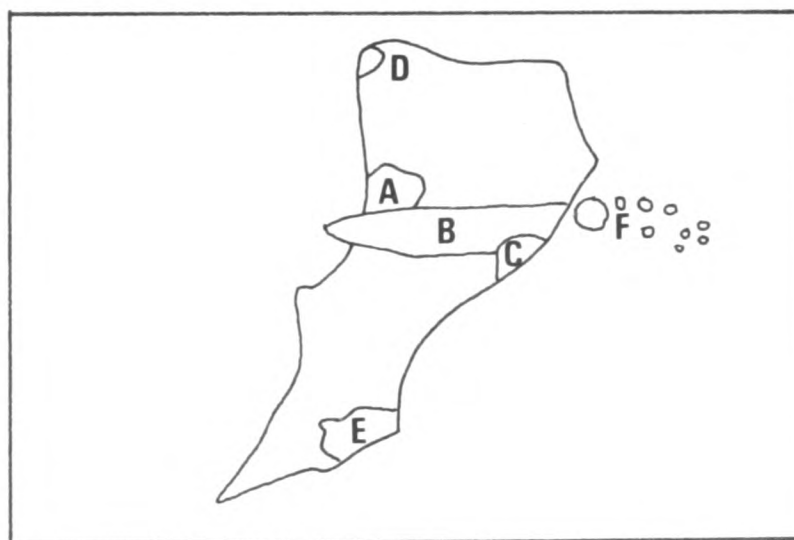
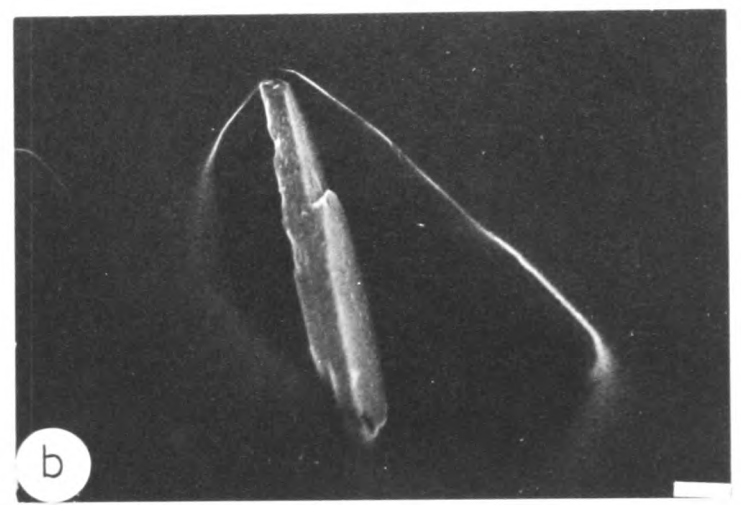
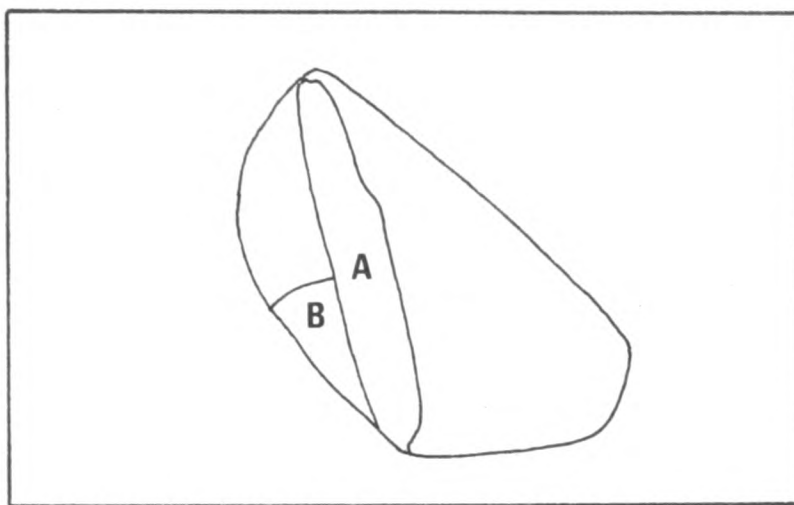
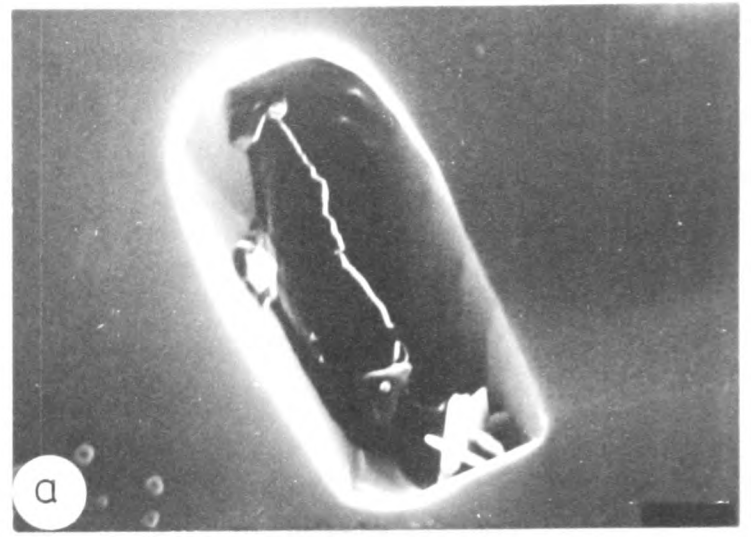
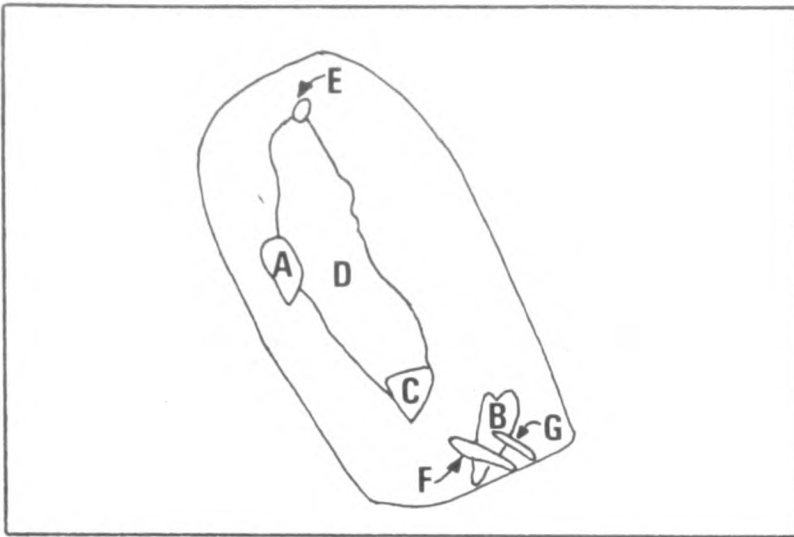


Plate 9A

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars = 1 $\mu$ m. All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagrams for easy reference.

- a. Inclusion cavity containing several daughters (Sample No. 152V).
  - A. contained Cl, Fe and Mn
  - F. contained Al and Fe
  - C. contained Al, Cl and Fe
  - D. contained Cl, Fe and Mn
  - E. contained Cl
  - F. contained Cl, Fe and K
- b. Inclusion cavity containing three daughters (Sample No. 137V).
  - A. contained Cl, Cu, Fe and Mn
  - B. no spectral peaks obtained
  - C. no spectral peaks obtained
- c. Inclusion cavity containing several daughters (Sample No. 73V).
  - A. Platey mineral containing Fe and K
  - B. contained Fe and Mn
- d. Inclusion cavity containing several daughters (Sample No. 53V).
  - A. Cubic mineral containing Fe and Mn
  - B. no spectral peaks obtained
  - C. no spectral peaks obtained



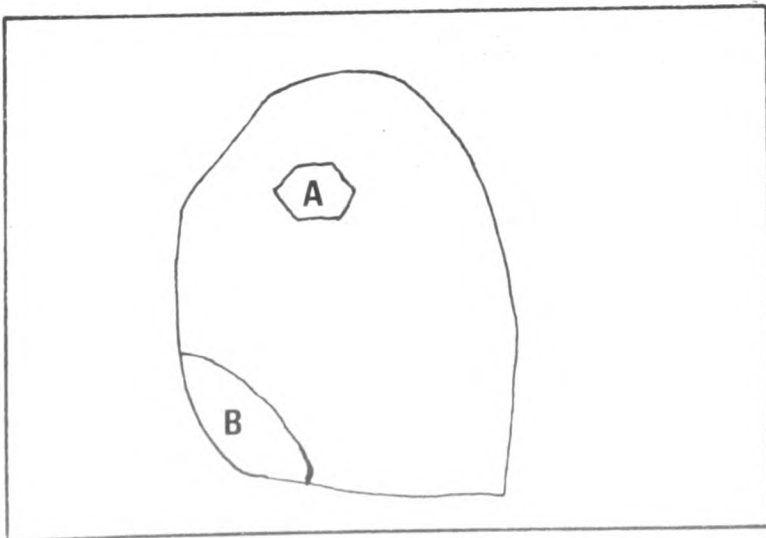
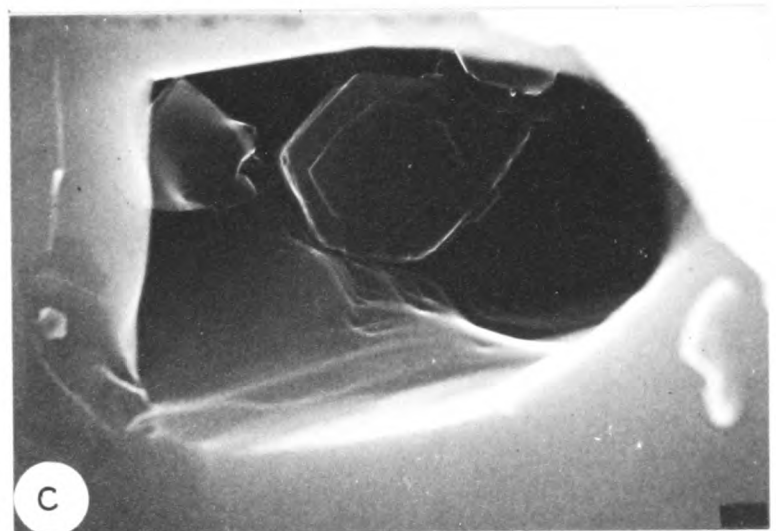
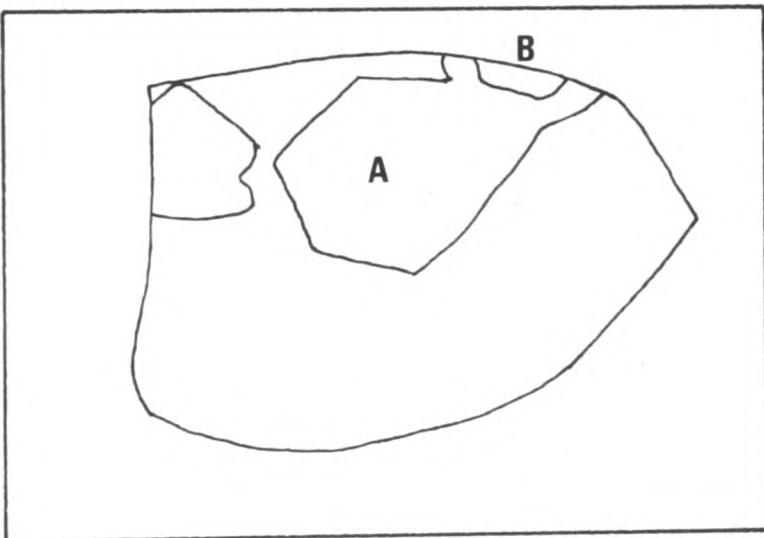
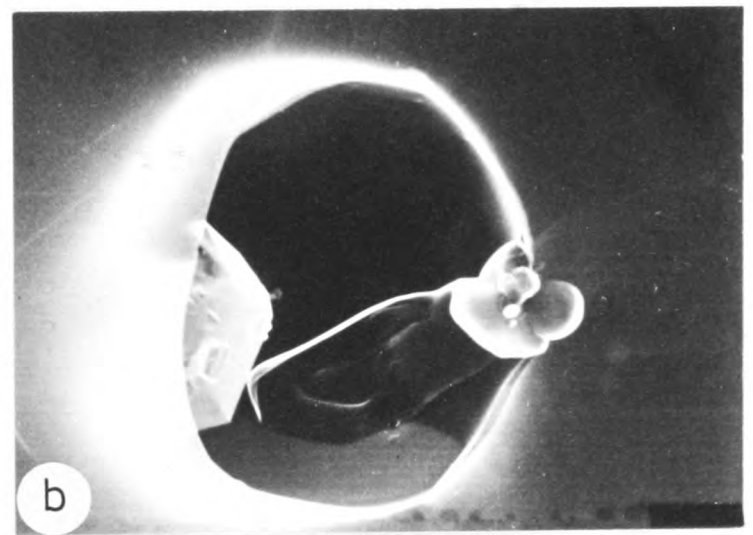
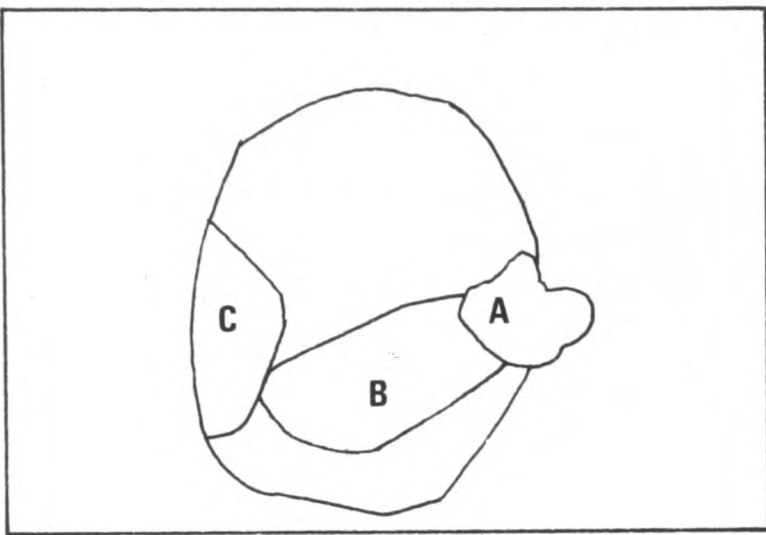
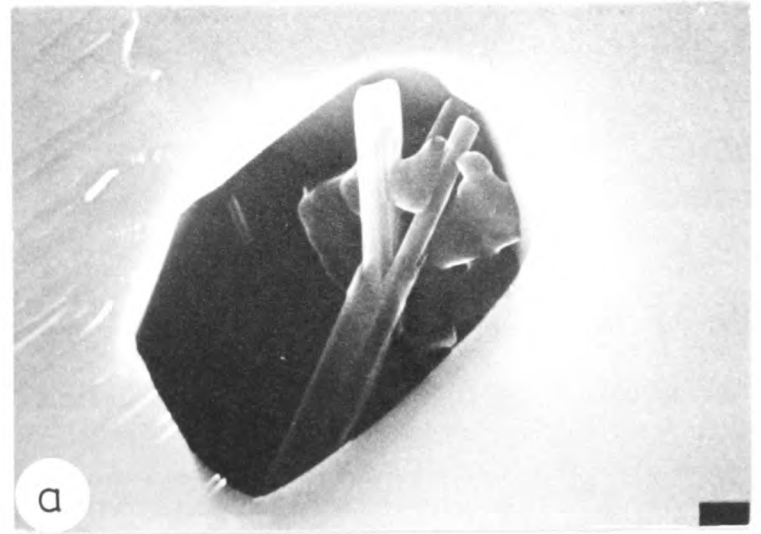
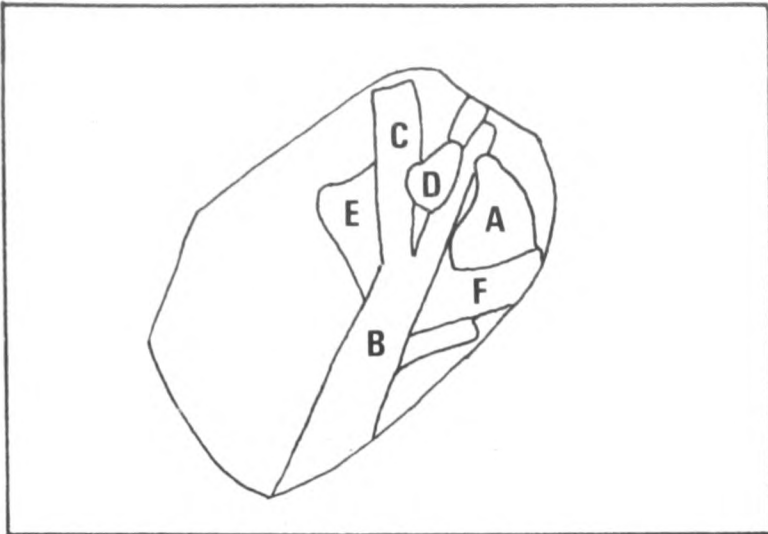


Plate 95

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars = 1 $\mu$ m. All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagrams for easy reference.

- a. Inclusion cavity containing two daughters (Sample No. 152V).
- b. Close up of crystal A from a. X-ray analysis identified the presence of Al and K. Its platey habit suggests that the mineral is muscovite.
- c. Close up of crystal B from a. X-ray analysis identified the presence of Al and K. Its platey habit suggests the mineral is muscovite.
- d. Inclusion cavity containing two daughters (Sample No. 152V).
- e. Close up of crystals from d. X-ray analysis gave the following result:
  - A. As, Cu, Fe and S. Identified as arsenopyrite.
  - B. Cu, Fe and S. Identified as chalcopyrite.

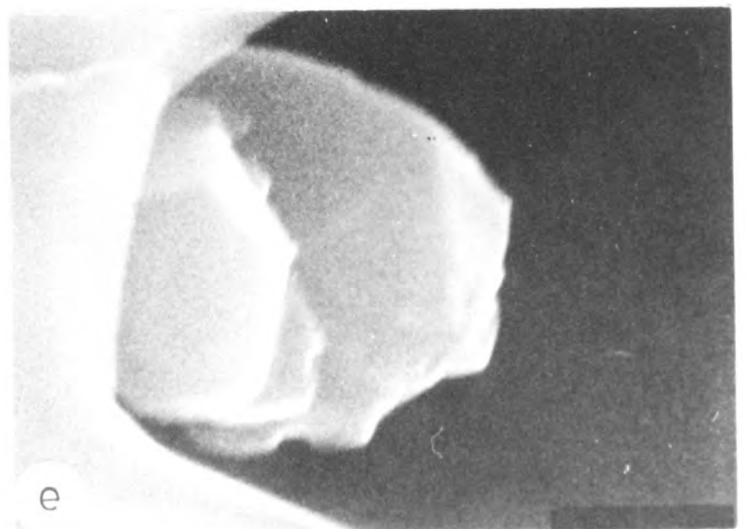
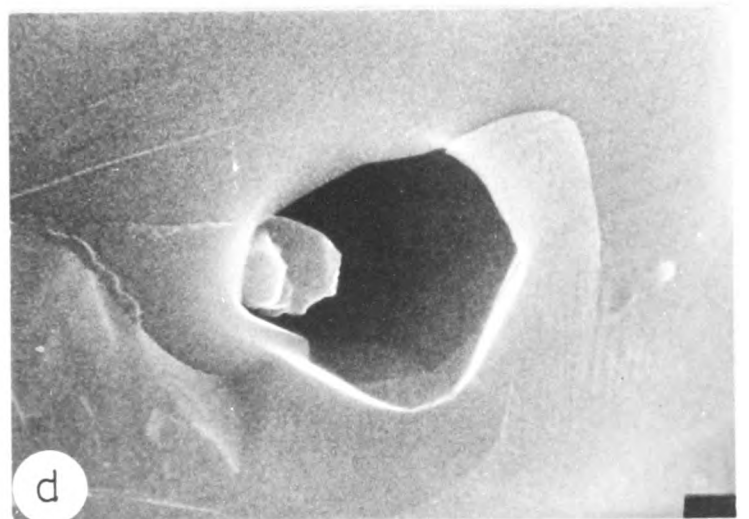
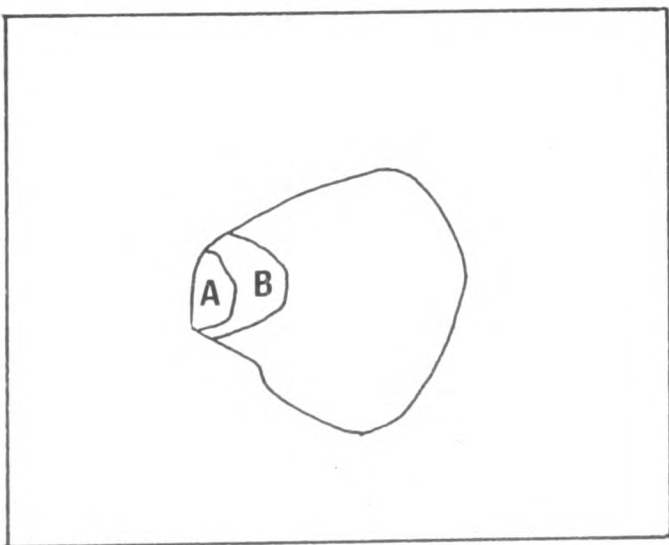
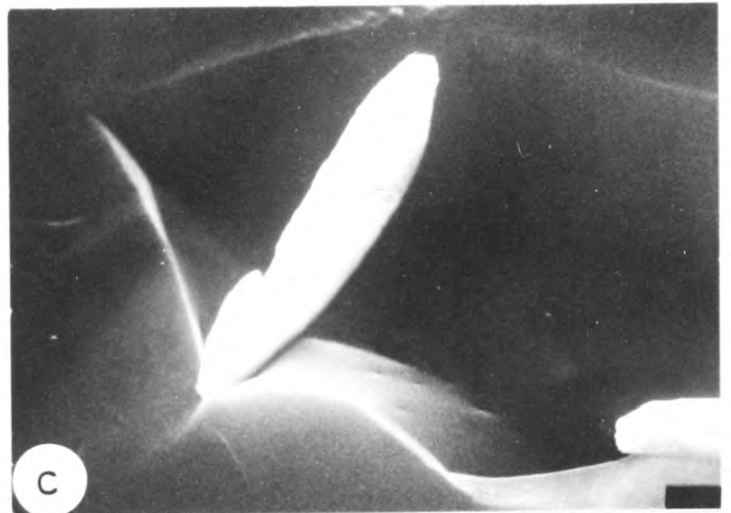
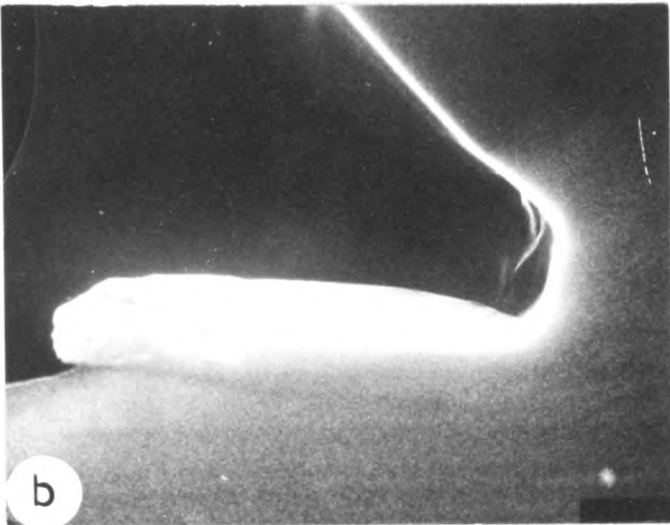
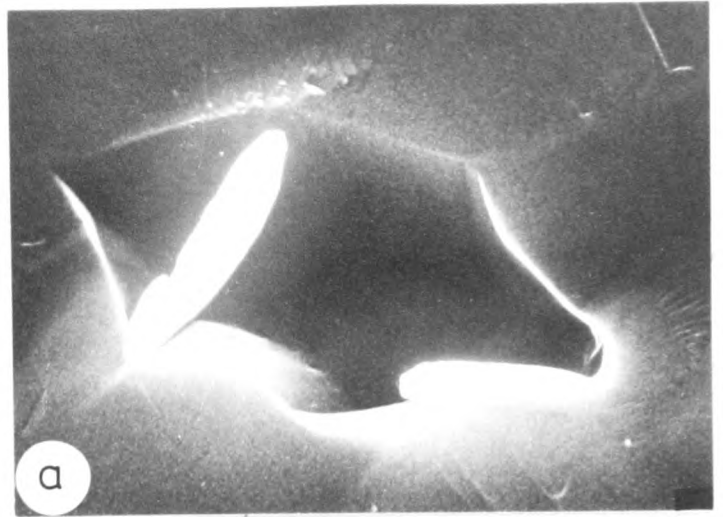
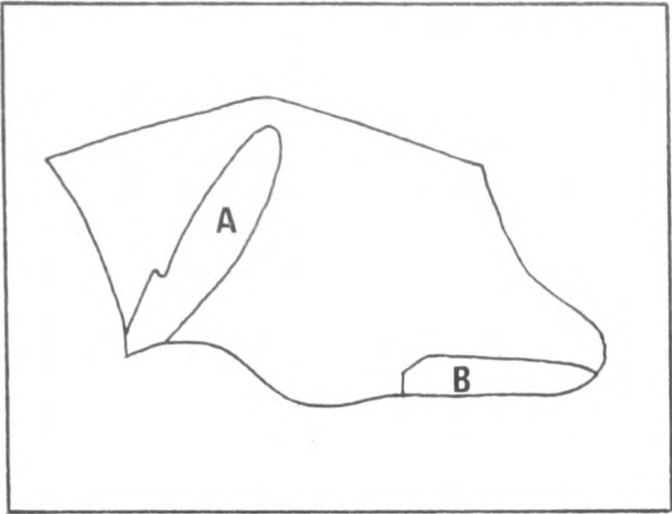


Plate 96

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars = 1 $\mu$ m. All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagrams for easy reference.

- a. Inclusion cavity containing two daughter crystals. (Sample No. 152V).
- b. Close up of crystal B. from a. X-ray analysis indicated the presence of Al and K. Its platy habit suggests the mineral is muscovite.
- c. Close up of crystal A. from a. X-ray analysis indicated the presence of Fe and Mn. Its rhombohedral habit suggests the mineral is ferroan-rhodochrosite.
- d. Inclusion cavity containing three daughter crystals. (Sample No. 152V).
- e. Close up of crystal A. from d.
- f. Close up of crystal B. from d.

X-ray analysis of crystals A, B and C gave the following results:

- A. contained Al and K. Identified as muscovite.
- B. contained Cl and Na. Its cubic form identifies it as halite.
- C. contained Cl and Na. This budgie like substance may have been deposited from the fluid on opening the inclusion.

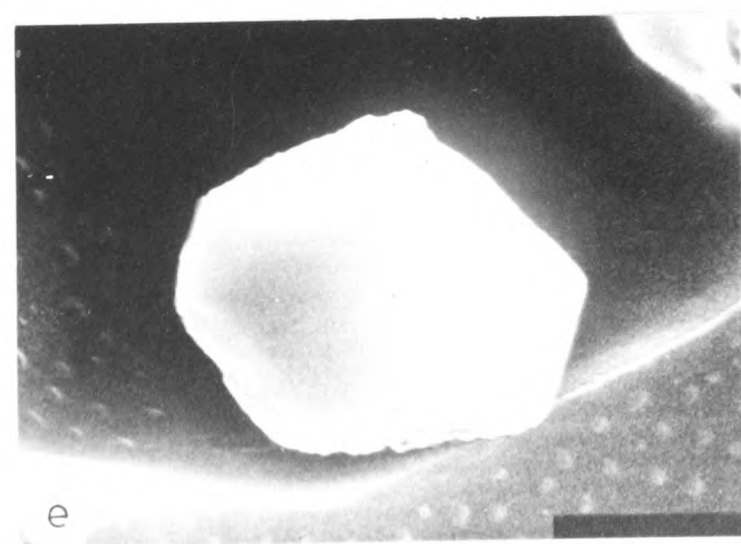
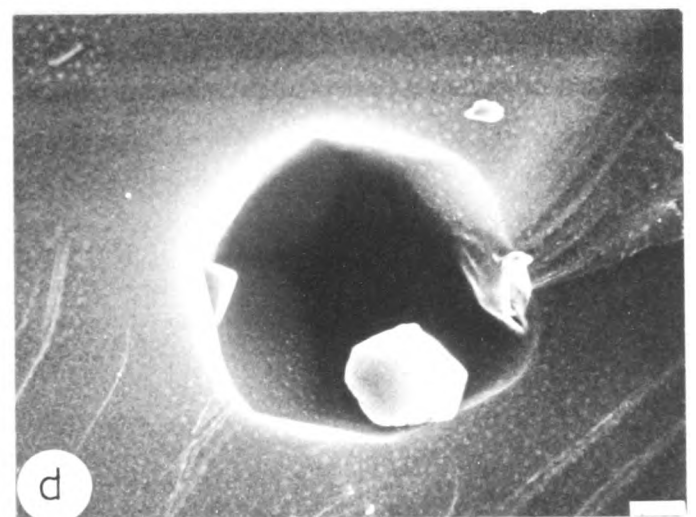
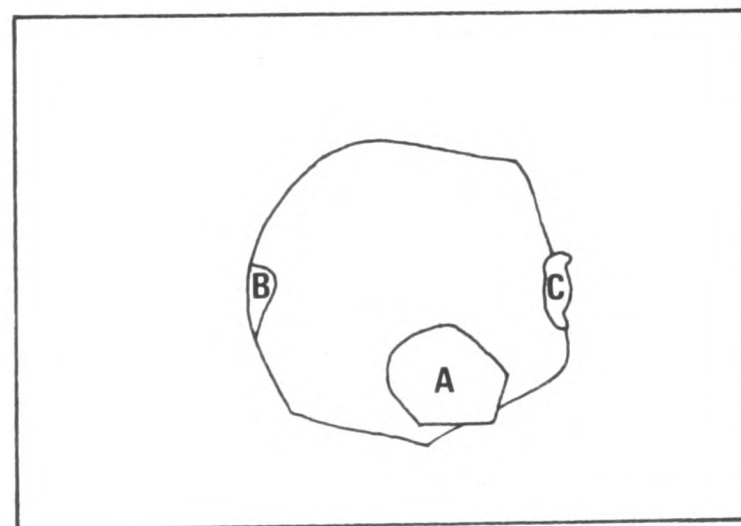
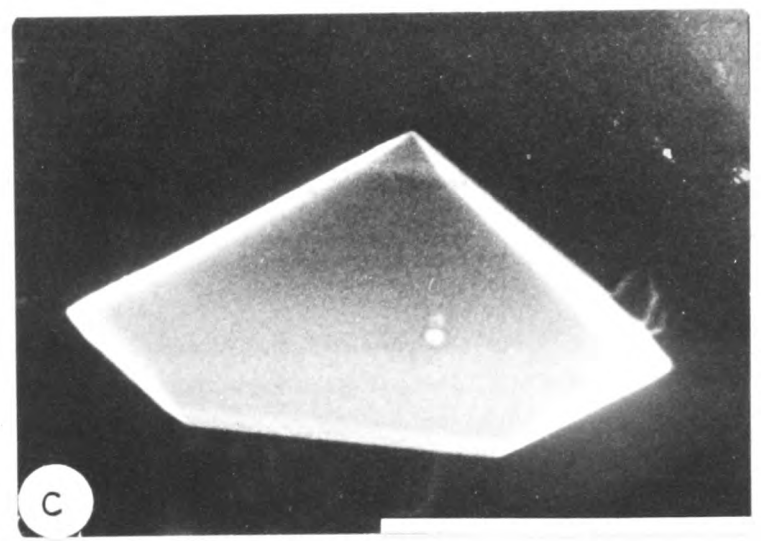
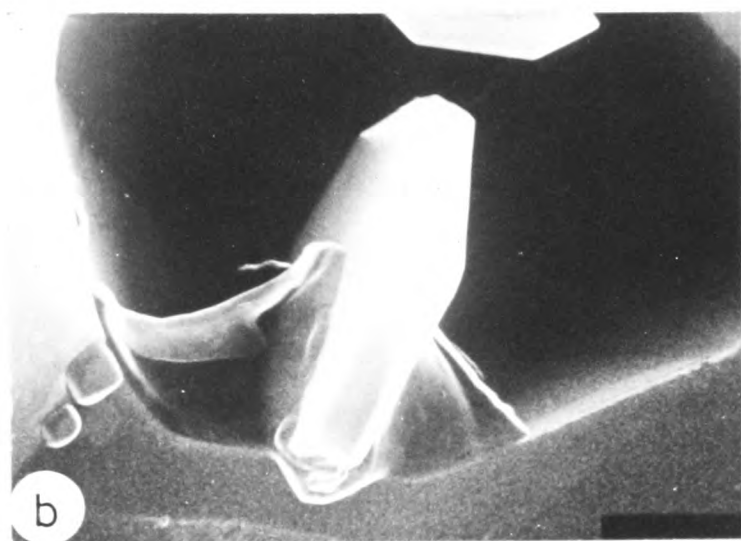
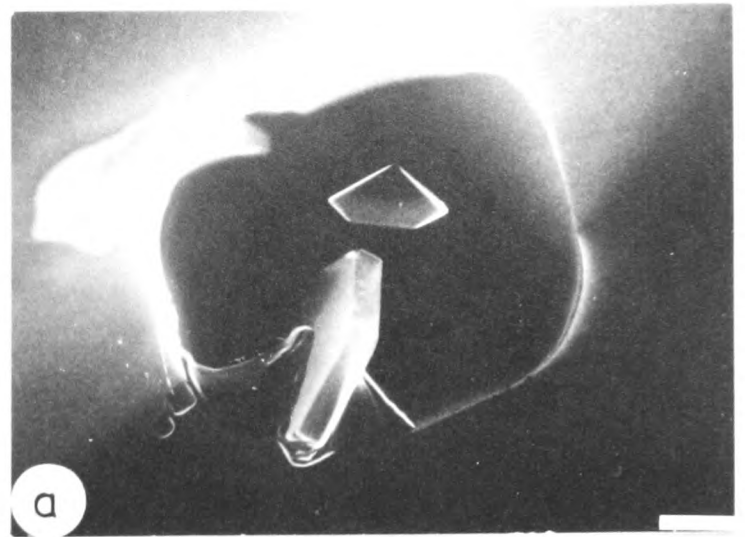
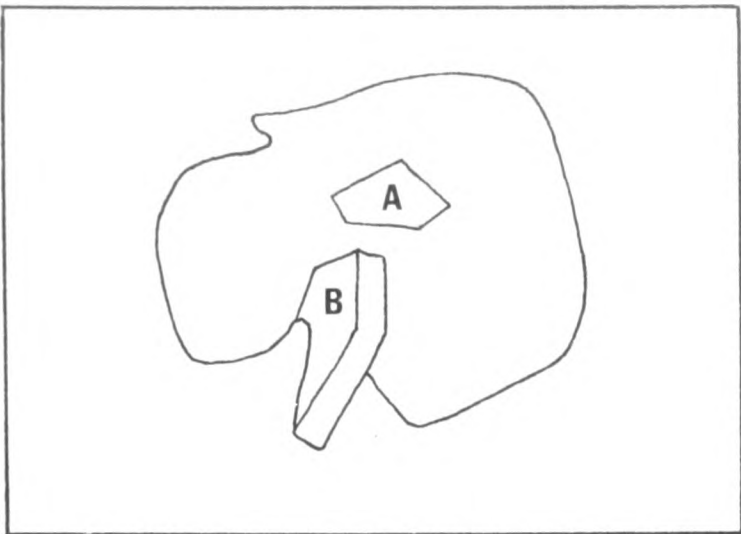




Plate 97

Scanning electron micrographs of daughter crystals in fluid inclusion cavities. Scale bars = 1 $\mu$ m. All spectra contained a Si peak which may have come from the daughter or host mineral (quartz). The crystals are labelled in the diagrams for easy reference.

- a. Inclusion cavity containing two daughters (Sample No. 152V).
- b. Close up of crystal B. from a. X-ray analysis of crystals A and B gave the following results:
  - A. Al and K. Its platy habit identified the crystal as muscovite.
  - B. Fe and Mn. Identified as probably ferroan-rhodochrosite.
- c. Inclusion cavity containing several daughters (Sample No. 73V).
- d. Close up of crystals A and B from c. X-ray analysis gave the following results:
  - A. Al, Cl, Fe, K, Mn and Na.
  - B. No spectral peaks obtained.

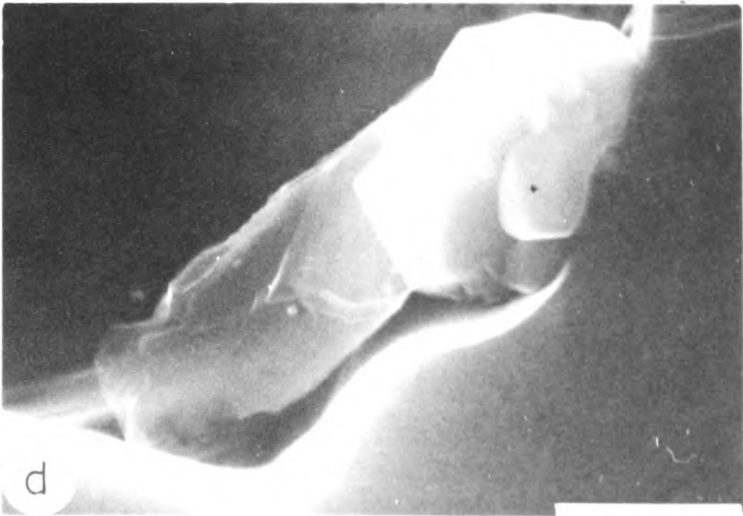
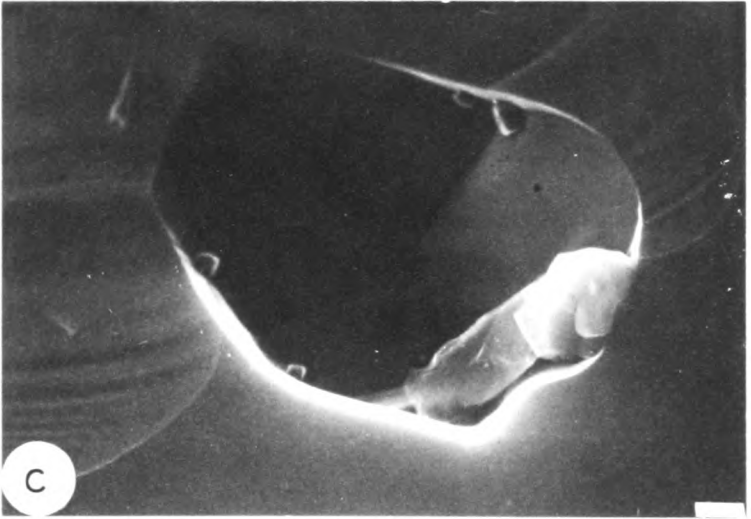
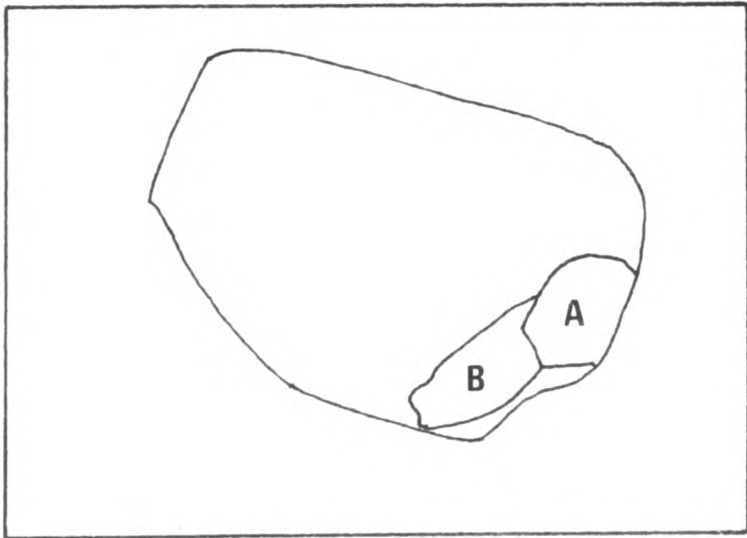
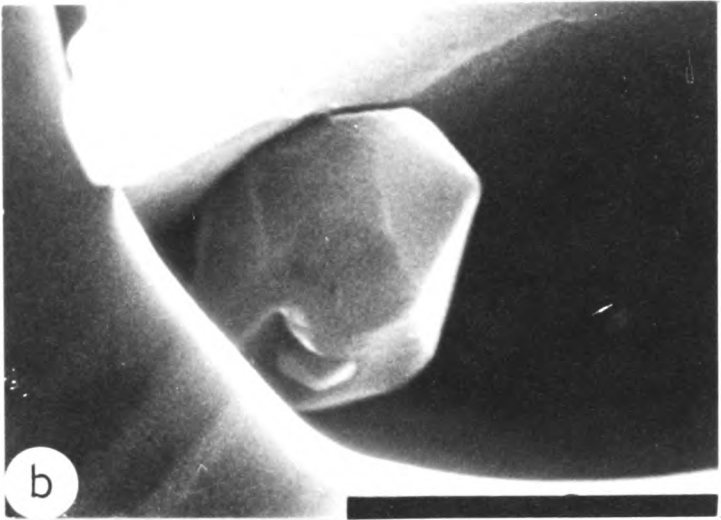
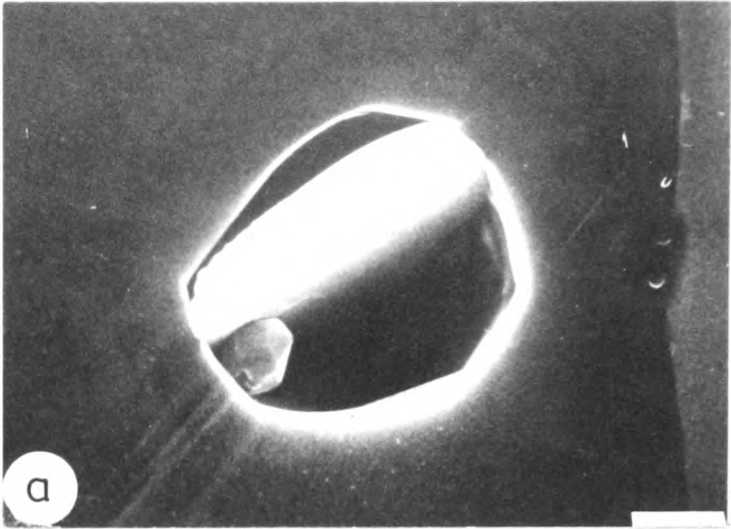
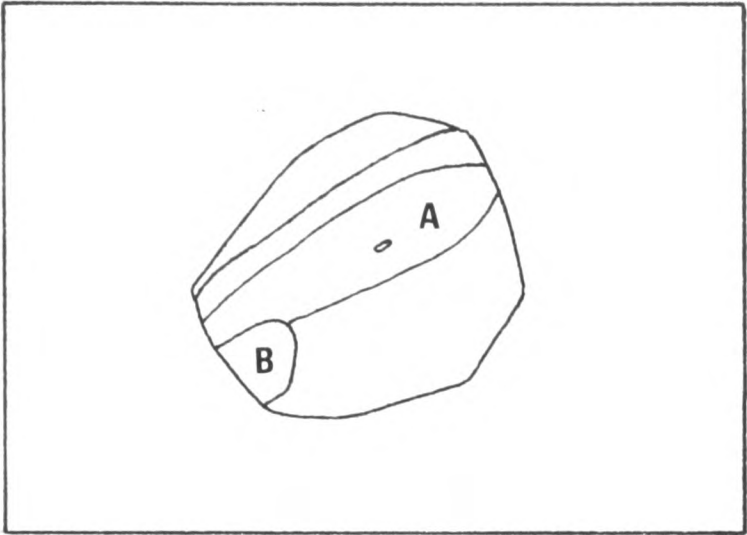


Plate 98. A large xenolith of kaolinised country rock (killas) seen lying in intensely kaolinised granite in Melbur china clay pit.



Plate A1. A portion of the high vacuum extraction line used for the determination of the argon isotopic compositions of rocks and minerals at the Institute of Geological Sciences, London. The RF heating coil can be seen operating on the middle sample furnace. The titanium furnace is on the extreme left. The air capsule holder and quadrupole gauge lies just to the right of the operator.





Plate A2. The high vacuum argon extraction line. The roughing, diffusion and ion pumps lie underneath the bench. The mass spectrometer electronics are on the right.

