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EXPLORATION GEOSCIENCE

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MAGNETIC PROPERTIES OF ARCHAEAN AND PROTEROZOIC ROCKS FROM THE EYRE PENINSULA

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AMIRA P78/P96C: Rock Magnetism and Magnetic Petrology Applied to Geological Interpretation of Magnetic Surveys

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SUMMARY

Three hundred and eighty samples from 36 localities were collected during October 1990 from representative rock types from the Gawler Craton. These were supplemented by a further thirty five samples from eight localities collected during October 1991. The localities are shown on the transparent overlay for Plates 1 and 2, while geographic coordinates and rock types are listed in Table I.

Sampling included 10 traverses across heterogeneous metamorphic terranes of the Sleaford Complex, the Lincoln Complex and the Hutchison Group. Banded mafic/felsic gneiss from the mylonite zone at Port Neill (locality 01) is extremely magnetic, as is the mafic gneiss of the Lincoln Complex at Cape Donington (locality 03). Foliated granite of the Lincoln Complex outcropping within the Hutchison Group at Sleaford Bay (locality 06) is moderately magnetic. Most other Hutchison Group units at locality 06 are too weathered to be representative, although the Cook Gap Schist from locality 13 is very magnetic. A fresh drill core sample thought to be from the Hutchison Group supplied by SADME proved to be moderately magnetic (Table II). Other moderately magnetic rocks include some metadolerite dykes. Generally the amphibolite dykes are low to weakly magnetic.

Three characteristic remanent components have been isolated. The A component directed to the southeast is present in mafic gneiss from the Kalinjala Mylonite Zone and in mafic and felsic granulites from Bratten Cairn, a few km north. The most prevalent component, the B component directed upward to the northeast, is observed in the Lincoln Complex gneiss (at Cape Donington, Port Lincoln and Salt Creek), in amphibolite dykes (near Port Neill and Salt Creek), and in the Gawler Range Volcanics to the north. A third component, the C component, is observed in the Lincoln Complex gabbro-norite and amphibolite dykes (Cape Donington and Cape Colbert), and metadolerite dykes, the latter thought to be late stage intrusions of low metamorphic grade. The C magnetization, downward to the west, is almost though not exactly 180° reversed from the B magnetisation, and is extremely stable in the some metadolerite dykes, e.g. samples from locality 16 are only partially demagnetised by 1000 Oe (Appendix 1). The remanent components may represent a craton-wide tectonic event post-dating the Gawler Range Volcanics (~1600 Ma).

A simple model of retrograde metamorphism accompanied by a geomagnetic field reversal (normal to reversed) can explain the occurrence of different polarity remanence at different localities. The C component is similar to magnetizations seen in dolerite dykes from central Australia and may be of similar age (~1050 Ma). The B component is not seen in the metadolerite dykes which suggests that the retrograde metamorphism is bracketted between 1600 Ma and 1050 Ma. Notwithstanding their different polarities, the magnetic axes of the two components are close, although not exactly the same, which further suggests that the magnetic components are of similar age, that is the B component is not very much older that 1050 Ma.

The results have important implications fro Australia's Precambrian apparent polar wander path. Firstly, the present pole path does not recognise the possibility that the 1050 Ma Stuart Dykes of the Arunta Block may belong to the same swarm as the GB dykes from the Gawler Craton, i.e. the Gairdner Dykes. With similar characteristic directions of reversed polarity this must be considered a possibility, particularly

since the Kulgera Dykes from the intervening Musgrave Block also possess similar directions (Schmidt, 1991). This would require replotting the GB pole near the Stuart Dykes and the Kulgera Dykes poles, not 180° away. The implication of this is that the Gawler, Musgrave and Arunta Blocks have not rotated significantly with respect to each other since 1050 Ma. Secondly, the Gawler Range Volcanics pole (GR) is derived from overprint magnetisations and can no longer be treated as a key pole for 1590 Ma. Thirdly, reversals of the Earth's field at about 1100 Ma have been shown in other studies, e.g. the Keweenawan Volcanics (Pesonon and Nevanlinna, 1981), to be oblique and not 180°. This suggests that the normal polarity and reversed polarity magnetisations found in all kinds of rock types from the Eyre Peninsula may be more closely related temporally than has been thought previously. Many of the poles plotted around the 1.65 Ga to 1.5 Ga segment of the pole path ought to be plotted near the 1.1 Ga segment about 180° away.

If this model of retrograde metamorphism during a time that the geomagnetic field switched polarity is substantially correct, basement rocks may be remanently magnetised in stripes analogous to the sea-floor. This may be discernible as base level jumps in magnetic surveys.

1.0 INTRODUCTION

As part of AMIRA project 78/P96C a total of four hundred and fifteen oriented samples from 44 localities on the Eyre Peninsula have been subjected to detailed palaeomagnetic and rock magnetic experiments. Sampling was assisted by the Geological Society's SGTSG field guide which introduced us to the geology of the peninsula (Parker *et al.*, 1988), a Magellan GPS Navigation instrument, and an Elliot susceptibility meter. Plate 1 shows a geological map for the Eyre Peninsula. Sampling localities are listed in Table 1 and shown on the transparent overlay for Plate 1. Abbreviations for rock types are shown below.

A sequence ranging in age from Archaean to Middle Proterozoic has been recognised with a major metamorphic event, the Kimban Orogeny occurring from ca.1850 Ma to ca.1700 Ma and a final event possibly overlapping the time of widespread basic dyke intrusion. The Late Archaean to Early Proterozoic Sleaford Complex forms the basement of the southern Eyre Peninsula. The Carnot Gneisses were sampled as representatives of this basement. They comprise garnetiferous quartzofeldspathic gneiss interlayered with leucogneiss, biotite-garnet gneiss, hypersthene bearing felsic gneiss and basic granulite.

Early Proterozoic stratigraphy overlying the Sleaford Complex include metasediments and metavolcanics of the Hutchison Group, Myola Volcanics, Broadview Schist, McGregor Volcanics and the Moonabie Formation. These are broadly synchronous with the Lincoln Complex. The Donington Granitoid Suite of the Lincoln Complex were emplaced at about this time during the early Kimban Orogeny. Late Kimban granites that were sampled include the the Carpa and Burkitt Granites.

Middle Proterozic sediments and volcanics on the Eyre Peninsula are represented by the Corunna Conglomerate, Gawler Range Volcanics and the Pandurra Formation. The Hiltaba Suite Granites date from this time. These post-tectonic plutons are typically circular and are represented in this study by the Charleston and Buckleboo Granites, and the Cunyarie Rocks granite.

The remanences and susceptibilities of samples from traverses are presented as profiles. Results from localities within homogeneous rock types are listed in Table II. Details of results are presented as appendices. Appendix 1 consists of representative demagnetisation plots (intensity dacay, stereographic projections and orthogonal projections). The locality number is incorporated into each sample number for ease of identification. Appendix 2 contains representative suceptibility versus temperature diagrams (k-T curves). These curves show that the only significant magnetic mineral present in most rock types is almost pure end-member magnetite.

An image of the aeromagnetics over much of the Eyre Peninsula is shown in Plate 2 at the same scale as the geological map and the sampling locality overlay.

Abbreviations of rock types

ag - augen gneiss, amph - amphibolite, bc - breccia, dk - metadolerite dyke, fe - iron rich sediment, fg - felsic gneiss, gb - gabbro/norite, gg - granite gneiss, gn - gneiss, gt - granite, mf - banded mafic/felsic gneiss, mg - mafic gneiss, mgt - mafic granulite, mx - megacrystic granite, qtz - quartzite

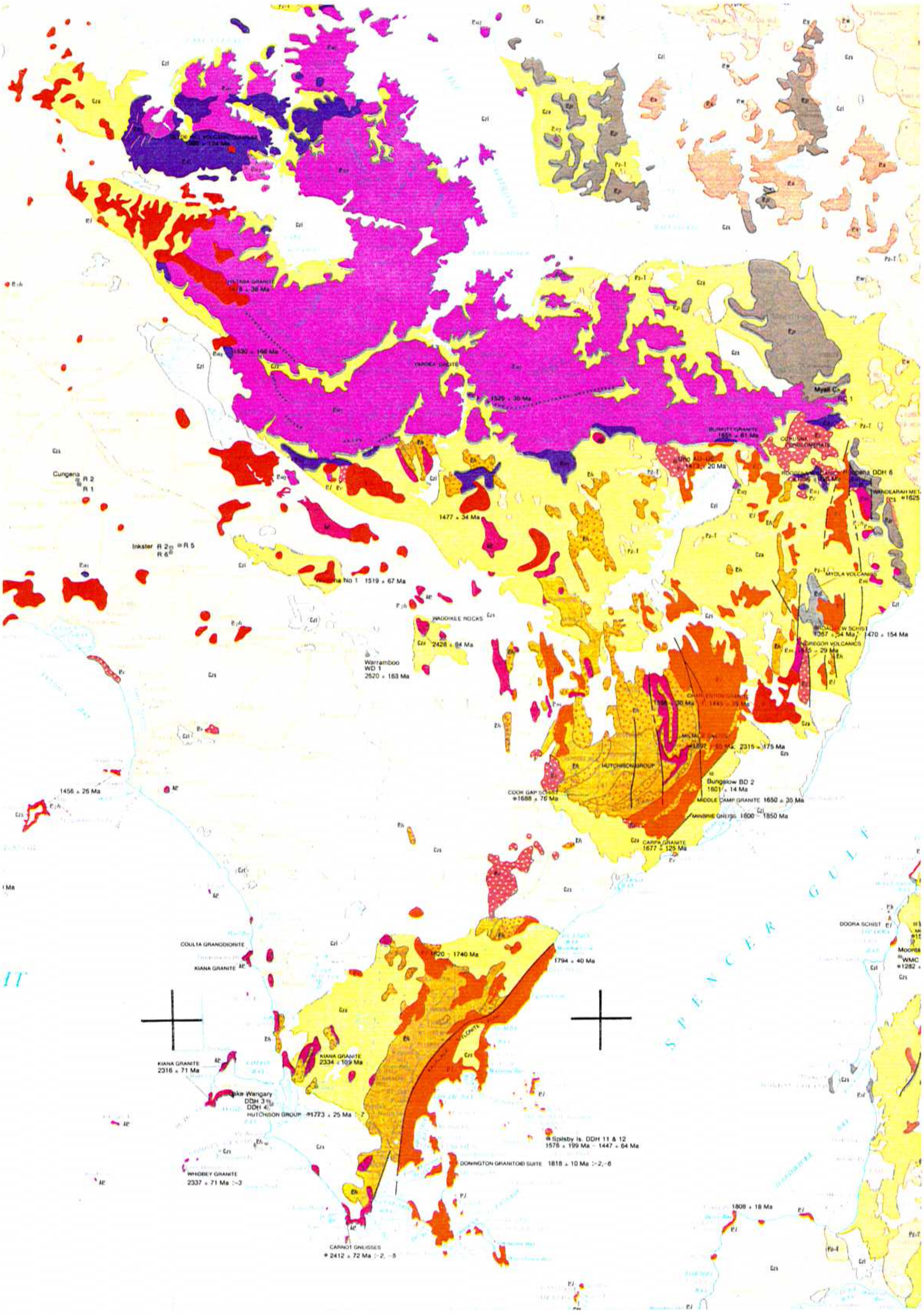

HILTABA GRANITE
1478 ± 38 Ma
1530 ± 166 Ma
YARDEA DACITE
1529 ± 30 Ma
BUNKITT GRANITE
1655 ± 61 Ma
Myall Ck
RC 1
CORUNNA CONGLOMERATE
Uno AU-UC
1473 ± 20 Ma
Moonabie DDH 6
WANDEARAH MET.
+1625
MYOLA VOLCANICS
BROADVIEW SCHIST
1067 ± 54 Ma
1470 ± 154 Ma
McGREGOR VOLCANICS
1615 ± 29 Ma
CHARLESTON GRANITE
1445 ± 39 Ma
MILTALIE GNEISS
2315 ± 175 Ma
HUTCHISON GROUP
COOK GAP SCHIST
+1688 ± 76 Ma
Bungalow BD 2
1601 ± 14 Ma
MIDDLE CAMP GRANITE 1650 ± 35 Ma
MINBRIE GNEISS 1600 – 1850 Ma
CARPA GRANITE
1677 ± 125 Ma
1477 ± 34 Ma
Cungena
R 2
R 1
Inkster R 2 R 5
R 6
No 1 1519 ± 67 Ma
WADDIKEE ROCKS
2428 ± 84 Ma
Warramboo
WD 1
2620 ± 163 Ma
1456 ± 26 Ma
SPENCER GULF
DOORA SCHIST
Moonta
WMC
+1282
1808 ± 18 Ma
1620 – 1740 Ma
1794 ± 40 Ma
COULTA GRANODIORITE
KIANA GRANITE
KIANA GRANITE
2334 ± 109 Ma
KIANA GRANITE
2316 ± 71 Ma
Lake Wangary
DDH 3
DDH 4
HUTCHISON GROUP +1773 ± 25 Ma :-7
Spilsby Is. DDH 11 & 12
1576 ± 199 Ma – 1447 ± 64 Ma
DONINGTON GRANITOID SUITE 1818 ± 10 Ma :-2,-6
WHIDBEY GRANITE
2337 ± 71 Ma :-3
CARNOT GNEISSES
+2412 ± 72 Ma :-2, -5

PLATE 1

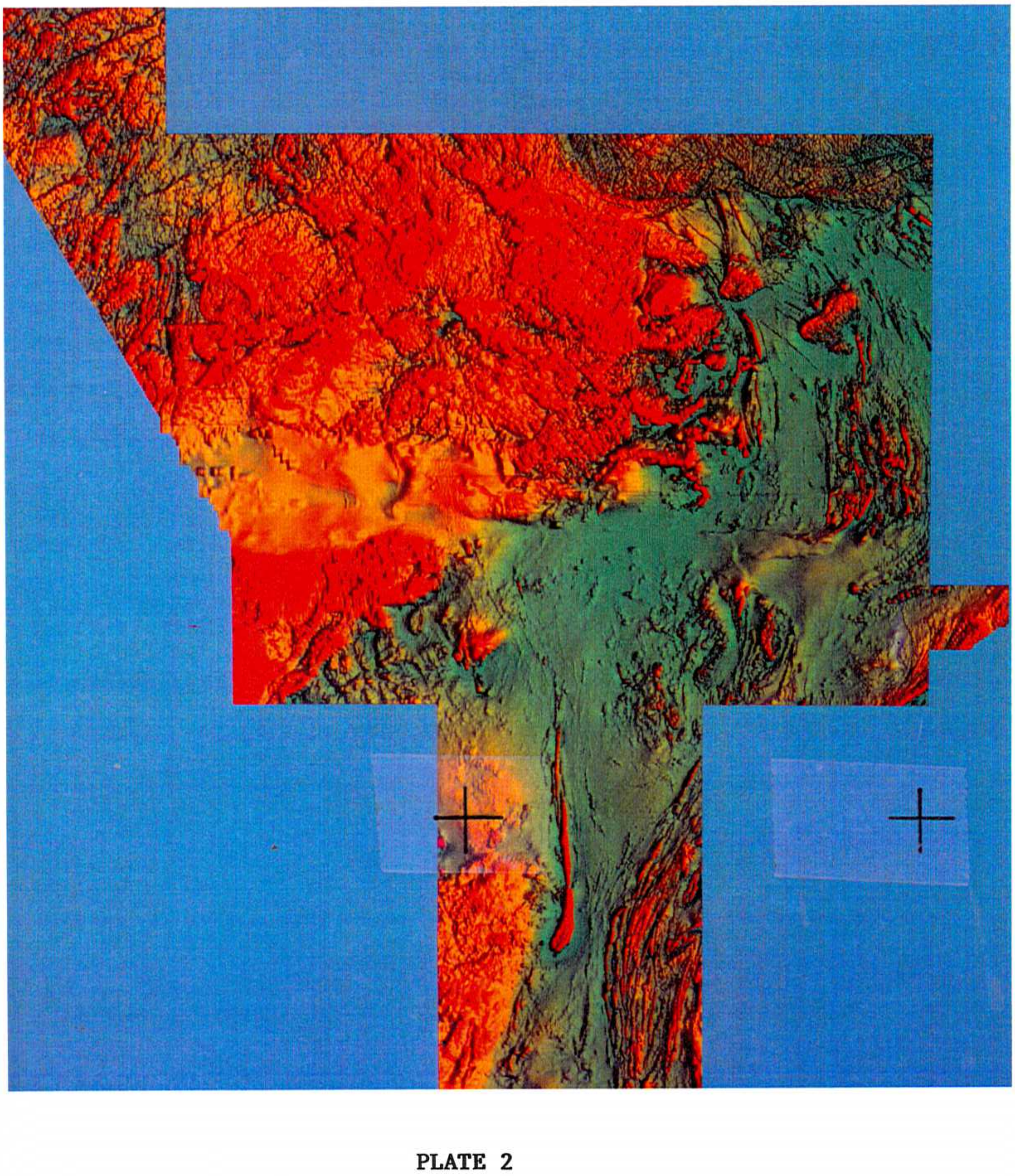
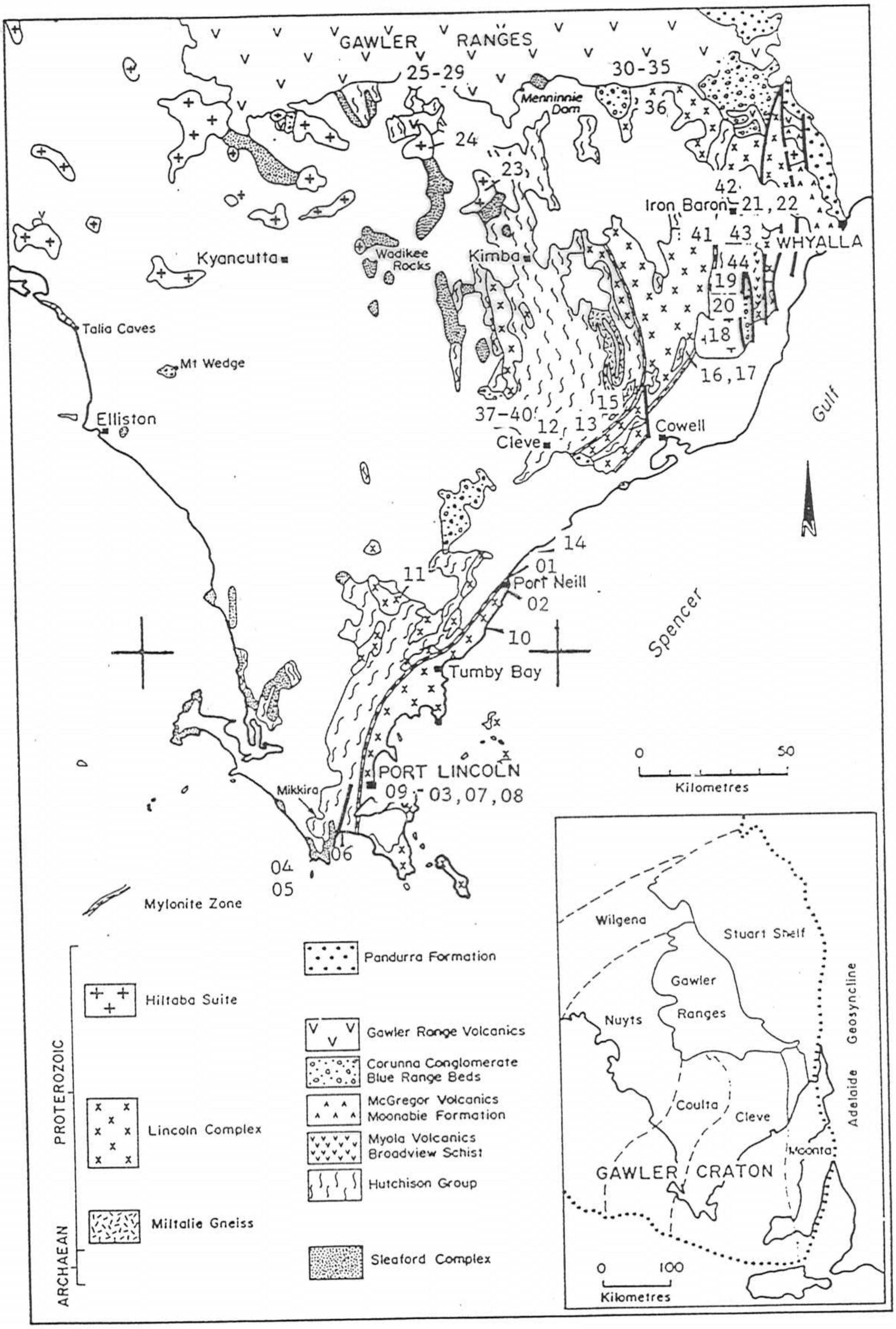


PLATE 2



Regional geological map of Eyre Peninsula with inset showing the tectonic subdivisions of the Gawler Craton.

2.0 DISCUSSION AND INTERPRETATION

This section expands on the above summary with details of results given in Sections 3.0 and 4.0 and the Appendices below. Most of the magnetic property information pertains to the east, and particularly the southeast, Eyre Peninsula because sampling was necessarily confined to well exposed areas described in the SGTSG field guide (see Fig. 1 and overlay for the Plates). Because of the incomplete coverage of the magnetics (Plate 2), which presumably concentrated on areas where exposure is poor, some sites are outside the survey area. Nevertheless several generalisations emerge.

The strong magnetisations of samples from the Kalinjala Mylonite Zone just north of Port Neill (see magnetic property profile in Fig. 2) readily explains the intense magnetic highs striking parallel to the coast on the far eastern edge of the survey. These highs presumably will be found to follow the Kalinjala Mylonite Zone to the southwest when the survey is completed. It is noted that the remanent component of this magnetisation is directed shallowly south-southeastward, and this combined with an intense induced component close to the Earth's field yields an overall magnetisation directed steeply upward.

Units associated with the prominent anomalies due to ferruginous units within the Hutchinson Group are not well preserved in outcrop. However, SADME kindly supplied core samples from Wangary which proved to be moderate to strongly magnetic. Although the declination is ambiguous, since it is not known whether the strata are dipping east or west (Table II), the remanence is directed upward consistent with the form of the Wangary anomaly. This anomaly, in the centre of the soutern portion of the survey area, is adequately explained if these samples are representative.

The measured magnetic properties of the Hiltaba Suite granites explains the highly variable signatures of these granites. Cunyarie Rocks (locality 23) displays a prominent anomaly while magnetics over the Buckleboo Granite (locality 24) are flat. The magnetic properties show that this is basically due to the relative abundance of magnetite (see samples 23H and 24H in Appendix 2). The Hiltaba Suite granites may be analogous to Lachlan Fold Belt granites with a first order classification of I-type and S-type.

Characteristic directions of remanence are plotted in Fig. 3. The A component directed to the southeast was found in the Kalinjala Mylonite Zone and at Bratten Cairn. The most prevalent component, the B component directed upward to the northeast, was found at Port Lincoln, Cape Burr(?), Cape Donington, Salt Creek and in the Gawler Range Volcanics. Only two samples carried the component at Cape Burr, which therefore may be extraneous. The C component, almost but not exactly reversed from the B component, was found at Cape Colbert and Cape Donington. Both polarities were observed at Cape Donington. This dichotomy of directions has been noted in dykes from the Eyre Peninsula and iron ores of the Middleback Ranges in previous studies (Giddings and Embleton, 1976, Chamalaun and Dempsey, 1978). These workers attributed the two directions to separate geological events dated loosely at 1700Ma and 1500 Ma. In fact the latter workers argued that the coincidence of directions from two dyke sets with those from the Iron Prince and Iron Monarch ore bodies was strong evidence for a hypogene origin for the iron ore. However, the present study shows that the B component, at least, is an overprint and in all probability not related to a separate dyke swarm. The Gawler Range Volcanics at Uno are dipping almost vertically to the north but possess remanence directions identical to those found by Chamalaun and Dempsey (1978). Clearly, the Gawler Range Volcanics have been magnetised after tilting.

The similarity of the C component direction with directions from the Kulgera Dykes of the Musgrave Block and the Stuart Dykes of the Arunta Block suggests that these dykes are synchronous. Collectively the dykes may belong to the largest dyke swarm yet identified in Australia, challenging the Canadian Mackenzie and Franklin Swarms in size. The age of the Kulgera Dykes is thought to be 1050 Ma (Comancho *et al.*, 1991).

Detailed studies of dykes and volcanics about 1100 Ma from around the world have established that the Earth's magnetic field did not simply reverse then. That is, sequences or units of different polarities were not magnetised exactly 180° apart (Pesonen and Nevanlinna, 1981). This suggests that the B and C components found in the present study may not be greatly separated in time, only a few Ma and not the ~200 Ma previously thought. A period of remagnetisation spanning a geomagnetic polarity switch and possibly coinciding with the dykes at about 1050 Ma would provide the simplest explanation for the westerly/down and northeasterly/up magnetisations occurring in so many different rock types on the Eyre Peninsula.

The reversed polarity is extremely stable in some dykes, as mentioned in the Introduction, thus if the magnetite is magmatic then it is difficult to explain other than as original thermoremanent magnetisation. The magnetite would require reheating to close to the Curie temperature to be re-set thermally. There is no petrological evidence of high temperature metamorphism in the metadolerites so this is unlikely. Therefore the characteristic components of at least some of the reversely magnetised dykes are most probably primary, dating from their initial cooling. This would require the order of polarity change to be form normal to reversed.

The directions and pole positions are listed in Table III and the poles are plotted in Fig. 5, adapted from Idnurm and Giddings (1988). There are several key points. Firstly, the path as drawn does not recognise the possibility that the 1050 Ma Stuart Dykes (pole SD) of the Arunta Block may belong to the same swarm as the GB dykes from the Gawler Craton, i.e. the Gairdner Dykes. With similar characteristic directions of reversed polarity this must be considered a possibility, particularly since the Kulgera Dykes from the intervening Musgrave Block also possess similar directions (Schmidt, 1991). This would require replotting the GB pole near the Stuart Dykes and the Kulgera Dykes poles, not 180° away. The implication of this is that the Gawler, Musgrave and Arunta Blocks have not rotated significantly with respect to each other since 1050 Ma. Secondly, the Gawler Range Volcanics pole (GR) is derived from overprint magnetisations and can no longer be treated as a key pole for 1590 Ma. Thirdly, reversals of the Earth's field at about 1100 Ma have been shown in other studies, e.g. the Keweenawan Volcanics (Pesonon and Nevanlinna, 1981), to be oblique and not 180°. This suggests that the normal polarity and reversed polarity magnetisations found in all kinds of rock types from the Eyre Peninsula may be more closely related temporally than has been thought previously. Many of the poles plotted around the 1.65 Ga to 1.5 Ga segment of the pole path ought to be plotted near the 1.1 Ga segment about 180° away.

In terms of aeromagnetic signature the predominance of one polarity remanence over another in any particular area suggests that a shift in base level of the magnetics may be discernible. For instance, the characteristic remanence is of normal polarity at Port Lincoln, while 20km east at Cape Donington and Cape Colbert it is predominantly of reversed polarity. This area is not covered by the magnetic survey (Plate 2) yet, but it will prove of interest when it becomes available. There may be a base level change in the northwest of the survey, where the grain appears to be regular but the colour changes from red to greenish.

3.0 RESULTS FROM TRAVERSES

3.1 Port Neill and Cape Burr (localities 1 and 2)

The Kalinjala Mylonite Zone represents an intensely deformed belt between the Lincoln Complex and the Hutchison Group. The type locality of this zone outcrops just north of Port Neill (Fig. 1a). Extremely intense magnetisations were found in a highly sheared heterogeneous mafic/felsic unit. A magnetic property profile of remanent intensities and susceptibilities is shown in Fig. 2a. Susceptibilities of up to 20 mG/Oe (0.25 SI) and remanent intensities of almost 15 mG (15 Am^{-1}) were observed. These yield a Koenigsberger ratio of 1.5, indicating the dominance of remanence. The direction associated with this intense remanence is south-southeasterly (Fig. 3a). Felsic gneiss and amphibolites were found to be moderately to weakly magnetic.

Deformed Lincoln Complex granitoids and amphibolite dykes outcrop south of Cape Burr at Port Neill(Fig. 1a). Layered mafic/felsic gneiss were found to be moderately magnetic although no systematic remanence directions could be identified. A magnetic property profile for this locality is shown in Fig. 2a. Although relatively weak, the remanence of the amphibolite dykes (02b2 and 02e2) is consistently directed upward to the northeast (Appendix I). The northeasterly upward directed remanence direction proved to be relatively common throughout the Lincoln Complex and other rock types, including the Gawler Range Volcanics.

3.2 Capes Donington and Colbert (localities 3, 7 and 8)

Amphibolite and gneiss of the Lincoln Complex and metadolerite dykes outcrop at Cape Donington and Cape Colbert, 20km east of Port Lincoln (Fig. 1b). Magnetic property profiles are shown in Fig. 2b. Mafic gneiss was found to be intensely magnetic with susceptibilities of up to 20 mG/Oe (0.25 SI) and remanent intensities of about 10 mG (10 Am^{-1}). Nevertheless Qs are lower (Q ~ 1.0) than those found within the mylonite zone. Remanence directions of the mafic gneiss are similar to the weakly magnetised amphibolites at Cape Burr (Fig. 2a), upward to the northeast. The remanence of amphibolite dykes at Cape Donington are weak, like their Cape Burr counterparts, but are of reversed polarity, westerly and downward. Metadolerite dykes and gabbro-norite from Cape Donington and Cape Colbert are moderately magnetic and also of reversed polarity. Thus remanence components of both normal polarity (to the northeast) and reversed polarity (to the west) are present at Cape Donington and Cape Colbert (Fig. 2a and b).

3.3 Cape Carnot and Sleaford Bay (localities 4, 5 and 6)

The Archaen Sleaford Complex, the Proterozoic Lincoln Complex and Hutchison Group units were sampled about 40km south of Port Lincoln at Cape Carnot and Sleaford Bay (Fig. 1b). Magnetic property profiles are shown in Fig. 2c. Although only moderately magnetic, the most magnetic rocks types were the amphibolites, mafic/felsic banded gneisses and the foliated granitoids of the Lincoln Complex. Augen and garnet gneisses of the Sleaford Complex and metasediments of the Hutchison Group are weakly magnetic. No consistent remanent components were identified at these sites. It should be noted that the ferruginous sediments of the Hutchison Group, which most probably account for the strong magnetic anomalies associated with this unit, are highly weathered in outcrop and are considered highly unrepresentative.

3.4 Port Lincoln (locality 9)

The Lincoln Complex outcrops around the foreshore at Port Lincoln (Fig. 1b). Metadolerite, some amphibolite and the gneiss are moderately magnetic (Fig. 2d) with susceptibilities of up to 3 mG/Oe (0.038 SI) and remanent intensities of about 6 mG (6 Am^{-1}). Qs for the some metadolerite dykes are over 10. The remanences of all units are directed upward to the northeast similar to the Cape Burr amphibolite and Cape Donington mafic gneiss.

3.5 Lipson Cove and Bratten Cairn (localities 10 and 14)

Mafic granulite within felsic gneiss of the Lincoln Complex occurs at Lipson Cove, 30km south of Port Neill, and near Bratten Cairn, 20km north of Port Neill. The Lipson Cove rocks are only weakly magnetic. A magnetic property profile for Bratten Cairn is shown in Fig. 2d. The mafic rocks are moderately magnetic while the felsic rocks tend to be weakly magnetic, although the latter possess the highest Qs of up to 20. Susceptibilities of up to 5 mG/Oe (0.063 SI) and remanent intensities of about 2 mG (2 Am^{-1}) were recorded. Regardless of rock type, all samples display the same direction of remanence down to the southeast (Fig. 1a). This direction is similar to those of the intensely magnetised mafic/felsic gneiss of the mylonite zone just north of Port Neill.

3.6 Salt Creek Dyke and Host Rock (locality 17)

At this locality a metadolerite dyke and its Lincoln Complex host is exposed in the bed of Salt Creek. A magnetic property profile is shown in Fig. 2d. The very intense remanent magnetisations in two of the dyke samples are most probably due to lightning strikes. For other dyke samples remanent intensities of about 2 mG (2 Am^{-1}) were found. Susceptibilities of about 5 mG/Oe (0.063 SI) were recorded for the dyke samples. Both the intensity of remanence and susceptibility of the host gneiss are very low. The remanence of both dyke and host are directed upward to the northeast, similar to the Lincoln Complex about 200km to the south at Port Lincoln.

4.0 RESULTS FROM INDIVIDUAL UNITS

The results from individual units that were sampled are listed in Table II. Significant points are noted below.

The Moody Adamellite (locality 11) and the Carpa Granite (localities 12, 37 and 38), both Lincoln Complex granitoids, are very weakly magnetic. The Burkitt Granite (locality 36), also part of the Lincoln Complex, has a weak remanence 143 μG (140 mAm^{-1}) although moderate susceptibility of about 2.4 mG/Oe (0.031 SI). The magnetic properties of the Cook Gap Schist (localities 13, 39 and 40) are very variable, while the dolomitic marble from Ferns Quarry is only weakly magnetic, as listed in Table II.

The Myola Volcanics are fairly weak with a remanence of 848 μG (848 mAm^{-1}) and a susceptibilities of about 934 μG/Oe (0.012 SI). The somewhat younger less deformed McGregor Volcanics are more magnetic with a remanence of 2.6 mG (2 Am^{-1}) and a susceptibility of about 1.4 mG/Oe (

0.017 SI).

The Gawler Range Volcanics display a range of properties from moderately to weakly magnetic. The most intensely magnetic unit was the Black Yardea Dacite (locality 29) with a remanence of 3.2 mG (3.2 Am^{-1}) and susceptibility of about 292 μG/Oe (0.0036 SI). The least intensely magnetic unit was the Bitali Rhyolite (locality 25) with a remanence of only 37 μG (37 mAm^{-1}) and a susceptibility of only 12 μG/Oe (0.00015 SI). A consistent remanence directed up to the north/northeast was found at five localities (31 - 35). This direction is reminiscent of the normal polarity directions found in amphibolite/metadolerite dykes and the Lincoln Complex at Cape Donington and Port Lincoln.

A Hiltaba Suite granite, the Charleston Granite (locality 18), possesses a moderate susceptibility but only a weak remanence. Other Hiltaba Suite granites, Cunyarie Rocks (locality 23) and Buckleboo Granite (locality 24), possess very different properties. Cunyarie Rocks has a moderate remanence (2.4 mG or 2.4 Am^{-1}), although no consistent direction was observed, and a low susceptibility of about 600 μG/Oe (0.0075 SI). Buckleboo Granite is weakly magnetic with a remanence of only 357 μG (357 mAm^{-1}) and a susceptibility of about 123 μG/Oe (0.0015 SI).

The dolerite from locality 16 appears to be unmetamorphosed and possesses a very stable remanence of reversed polarity (downward directed to the west). This direction is very similar to the reversed directions observed in samples from Cape Donington and Cape Colbert.

Acknowledgements

We are grateful for discussions with SADME, particularly with John Parker and Terry Crabb. SADME kindly loaned us core samples from Wangary. Figures from the SGTSG field guide (Parker *et al.*, 1988) and other reference sources have been utilised extensively. John Anderson of Aberfoyle is also thanked for supplying a sample of Gawler Range Volcanics. Discussions and magnetic data from David Tucker proved useful. John Sumpton of Stockdale generously supplied the magnetic image.

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TABLE I LIST OF TRAVERSES AND SITES

Site or Traverse #	Locality/rx	Rock Association	Co-ords
01	Port Neill	mylonite	34°06.34'S, 136°20.56'E
02	Cape Burr	Lincoln Complex	34°07.56'S, 136°21.01'E
03	Cape DoningtonI	Lincoln Complex	34°43.64'S, 135°59.63'E
04	Cape Carnot I	Sleaford Complex	34°56.57'S, 135°16.00'E
05	Cape Carnot II	Sleaford Complex	34°56.67'S, 135°37.52'E
06	Sleaford Bay	Hutchison Group	34°50.34'S, 135°50.56'E
07	Cape Colbert	Lincoln Complex	34°43.34'S, 135°59.56'E
08	Cape DoningtonII	Lincoln Complex	34°43.64'S, 135°59.62'E
09	Port Lincoln	Lincoln Complex	34°43.30'S, 135°51.60'E
10	Lipson Cove	Lincoln Complex	34°15.68'S, 136°15.99'E
11	Moody Adamellite	Lincoln Complex	34°10.18'S, 135°59.28'E
12	Carpa Granite	Lincoln Complex	34°41.17'S, 136°29.70'E
13	Cook Gap Schist	Hutchison Group	33°38.00'S, 136°28.00'E
14	Bratten Cairn	Lincoln Complex	34°02.03'S, 136°24.99'E
15	Dolomitic marble	Hutchison Group	33°37.00'S, 136°30.00'E
16	Salt CreekI	Gairdner Dykes	33°25.66'S, 137°00.83'E
17	Salt CreekII	Gairdner Dykes	34°25.01'S, 135°59.26'E
18	Charleston Gran	Hiltaba Suite	33°22.81'S, 137°03.33'E
19	McGregor Vols	Lincoln Complex	33°16.00'S, 137°11.00'E
20	McGregor Vols	Lincoln Complex	33°16.81'S, 137°11.07'E
21	Myola Vols	pre-Lin Complex	33°01.05'S, 137°14.02'E
22	Myola Stn	Gairdner Dykes	33°00.98'S, 137°14.09'E
23	Cunyarie Rocks	Hiltaba Suite	32°55.95'S, 136°17.75'E
24	Buckleboo Gran	Hiltaba Suite	32°49.56'S, 136°04.32'E
25	Bittali Rhyolite	Gawler Rg Vols	32°39.30'S, 135°21.84'E
26	Eucarro Dacite	Gawler Rg Vols	32°39.36'S, 135°40.02'E
27	Yannabie Rhyoda	Gawler Rg Vols	32°37.86'S, 135°37.56'E
28	Paney Rhyolite	Gawler Rg Vols	32°37.14'S, 135°44.76'E
29	Black Yardea Da	Gawler Rg Vols	32°31.38'S, 136°07.50'E
30	Yardea Dacite	Gawler Rg Vols	32°36.10'S, 136°56.35'E
31	Black Yardea Da	Gawler Rg Vols	32°36.32'S, 136°56.28'E
32	Rhyolite	Gawler Rg Vols	32°36.74'S, 136°56.45'E
33	Rhyolite	Gawler Rg Vols	32°36.74'S, 136°56.45'E
34	Porph. rhyolite	Gawler Rg Vols	32°36.94'S, 136°56.51'E
35	Rhyolite	Gawler Rg Vols	32°36.94'S, 136°56.51'E
36	Burkitt Granite	Lincoln Complex	32°39.55'S, 137°00.99'E

TABLE II GAWLER CRATON - MEAN REMANENCE AND SUSCEPTIBILITY
(excl. traverses)

Site	N	Rock Type	Dec	Inc	Int(μG)	Susc(μG/Oe)
10	6	Lipson Cove mf	305.8	-71.7	2.38	101
11	15	Moody Adamellite	344.7	-9.5	0.85	8.82
12	7	Carpa Granite	14.6	-67.4	1.34	4.67
13	11	Cook Gap Schist	27.6	-82.5	30383	60912
15	4	Dolomitic marble	36.4	-6.8	66.3	267
16	16	Gairdner Dykes	104.4	79.4	1193	2531
18	15	Charleston Gran	11.2	-65.7	249	2673
19	11	McGregor Vols	154.0	-1.6	3575	912
20	12	McGregor Vols	117.3	-23.0	1729	1840
21	22	Myola Volcanics	121.0	14.6	848	934
22	21	Gairdner Dykes	121.4	-51.6	32454	2248
23	18	Cunyarie Rocks	306.3	-57.6	2402	589
24	26	Buckleboo Gran	94.9	-11.8	357	123
25	12	Bittali Rhyolite	346.1	35.7	37.2	12.3
26	11	Eucarro Dacite	337.5	-9.3	2841	267
27	14	Yannabie Rhyoda	313.4	-70.6	498	337
28	9	Paney Rhyolite	1 138.8	11.5	737	460
29	11	Black Yardea Da	283.7	-26.9	316	510
30	14	Yardea Dacite	276.1	-56.8	1759	283
31	15	Black Yardea Da	54.0	-43.9	3274	292
32	7	Rhyolite	12.4	-45.6	21.9	87.4
33	8	Rhyolite	20.1	-69.3	40.6	117
34	6	Porph. rhyolite	0.7	-55.5	135	77.1
35	6	Rhyolite	3.7	-67.9	321	437
36	18	Burkitt Granite	144.1	11.9	143	2450
37	8	Carpa Granite	353.4	-58.8	0.34	2.83
38	14	Carpa Granite	10.7	-73.4	0.53	3.88
39	12	Cook Gap Schist	335.5	-74.5	0.46	34.1
40	18	Cook gap Schist	41.6	-12.8	0.26	39.8
41		Iron Monach dyke	295.2	-26.6	23.3	21.3
41		" " ore	255.0	-54.8	2253	10980
42	23	I. Princess ore	185.8	-11.3	3073	8866
43	18	Iron Duke dyke	53.2	-47.2	5.28	77.1
44	27	Iron Duke ore	106.3	2.9	453	1320
SADME		Hutchison Group	301.7	-64.2	7282	8825
	22	DDH core ambig.	121.7	-64.2	7282	8825

N - number of specimens

POLES

TABLE III GAWLER CRATON - CLEANED REMANENCES AND PLOES

Unit	N	Dh(°)	Ih(°)	α_{95}(°)	Lat(°)	Long(°)	A_{95}(°)	R	K
Kalinjala(1)	3	165.7	-4.8	56.3	51.7	113.2	30.4	2.659	5.87
Lincoln(3+8)	8	269.9	73.3	13.0	30.5	280.0	22.3	7.634	19.1
Lincoln(7)	11	288.0	68.9	7.6	18.1	279.0	11.7	10.736	37.9
Lincoln(9)	14	58.9	-58.7	8.9	-43.8	72.6	11.8	13.378	20.9
Bratten(14)	11	140.6	19.9	9.4	47.0	70.1	8.5	10.593	24.6
Lincoln(17)	10	45.0	-51.9	10.9	-53.7	61.1	11.6	9.563	20.6
GRV(31-35)	26	32.3	-43.2	6.5	-61.7	42.5	6.6	[illegible]	[illegible]

combine 3,8+7 (-20.7, 36.0) SBSC

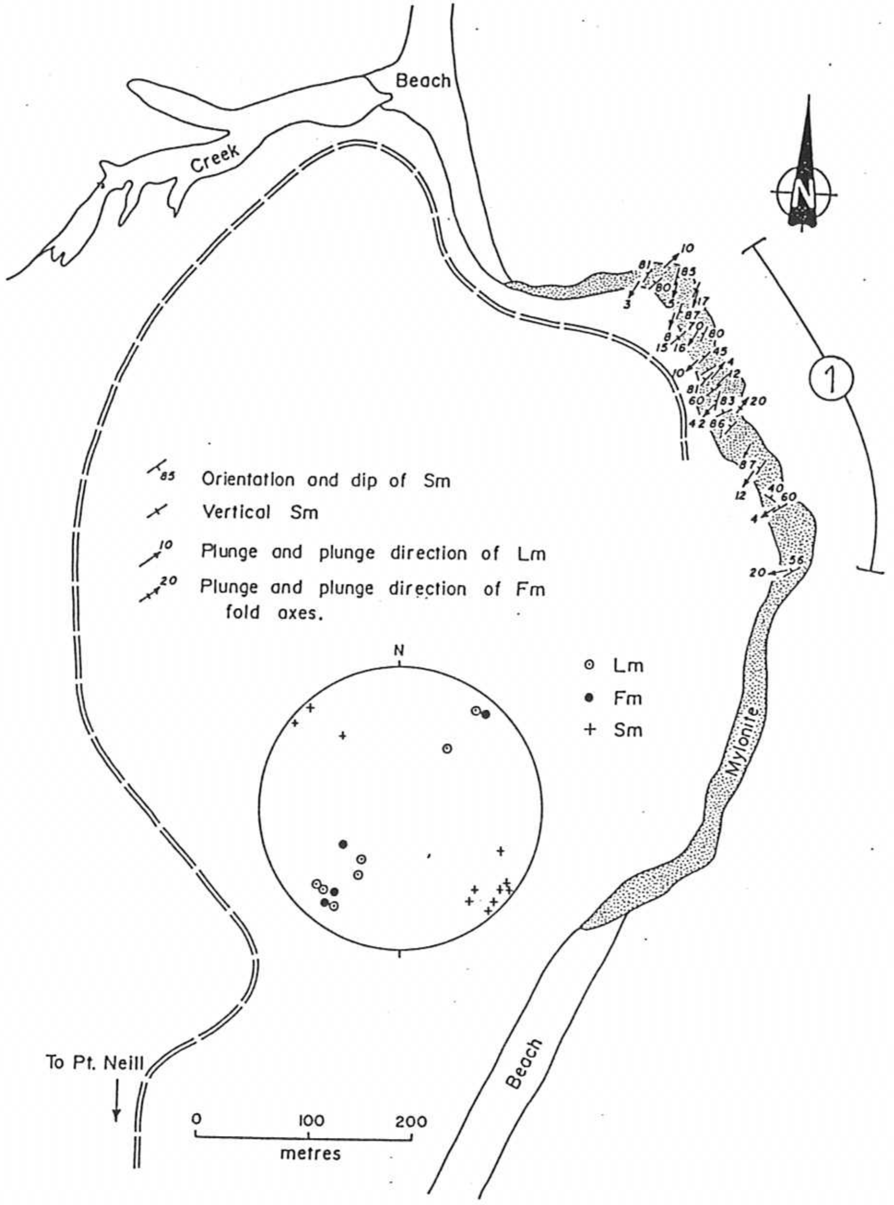
19 279.0 70.9 18.337 28.785 6.636 -22.0 98.9 9.9 11.0

Combine 9 & 17 324.6 (35.9) SBSC

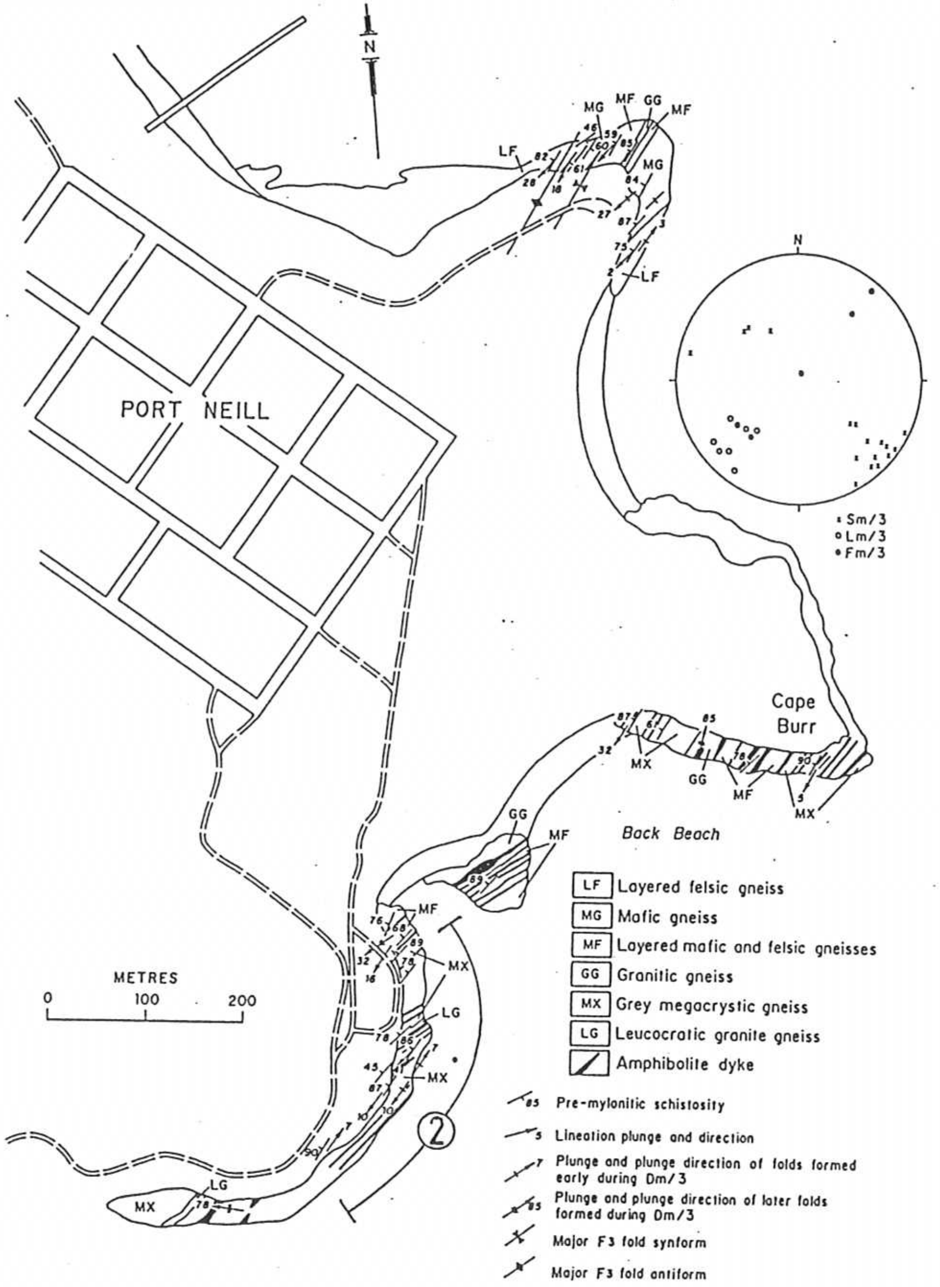
24 [illegible] -55.0 [illegible] 19.6 [illegible] 47.7 263 7.0 [illegible]

FIGURE 1

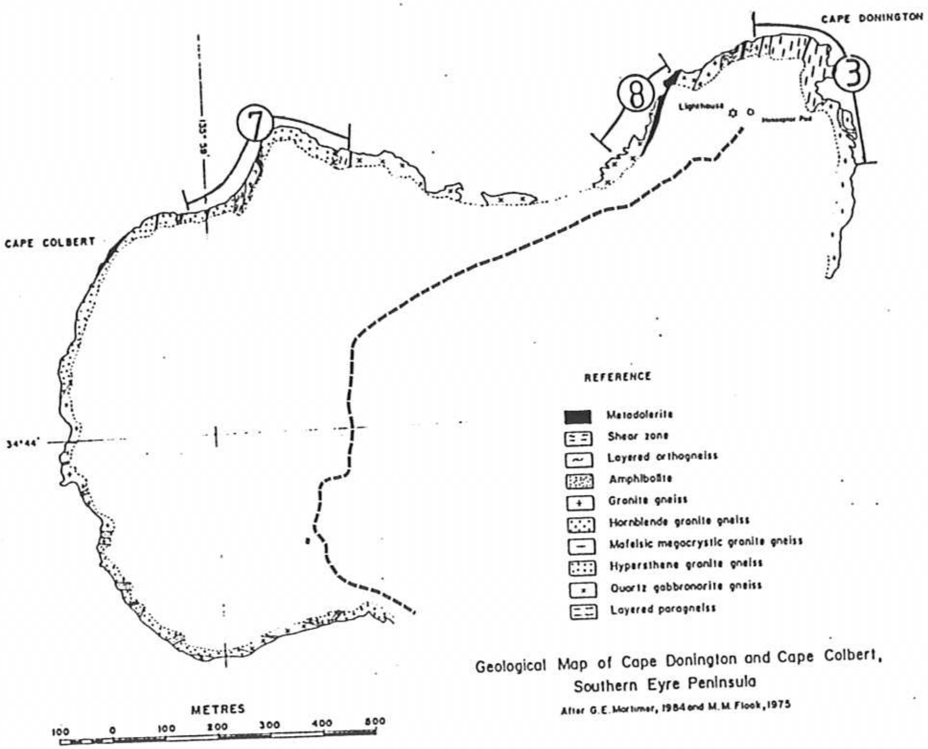
LOCALITIES OF TRAVERSES ACROSS HETEROGENEOUS METAMORPHIC TERRANES



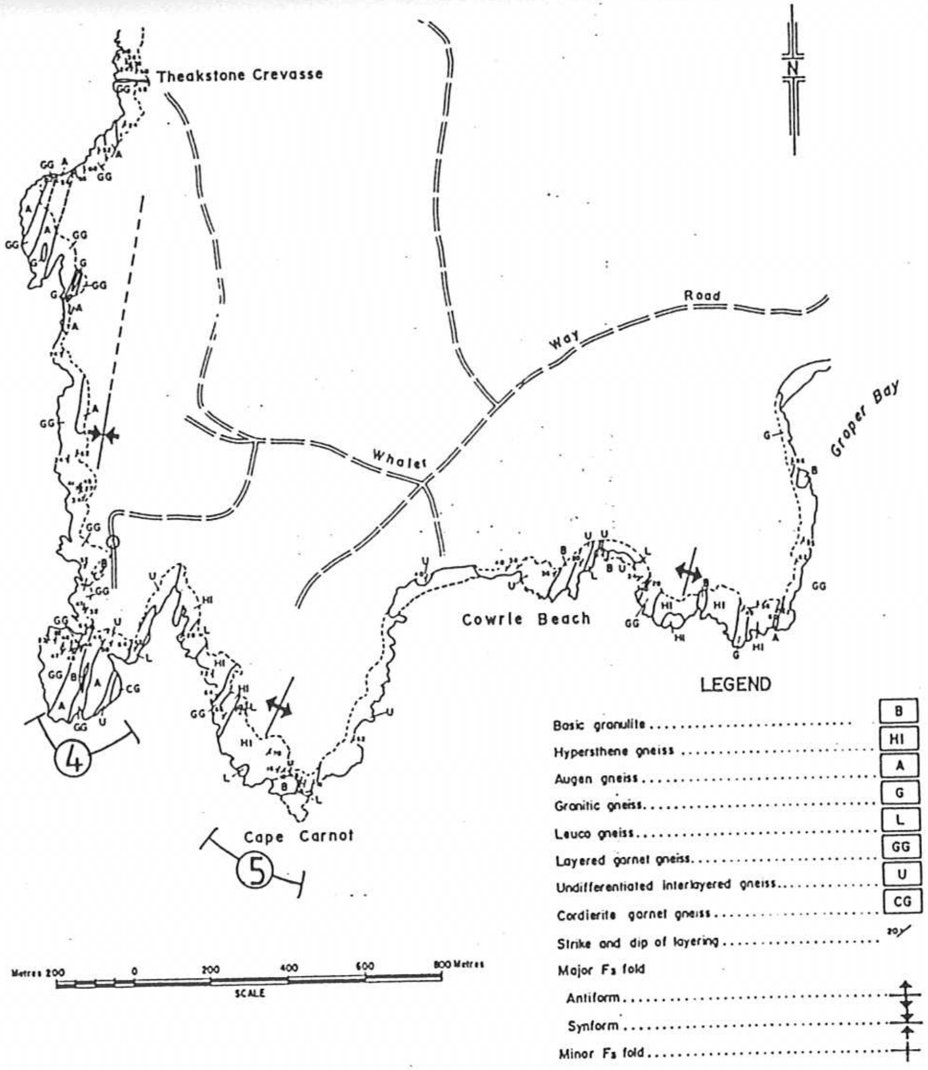
Beach
Creek
N
1
Orientation and dip of Sm
Vertical Sm
Plunge and plunge direction of Lm
Plunge and plunge direction of Fm fold axes.
N
Lm
Fm
Sm
Mylonite
Beach
To Pt. Neill
0
100
200
metres

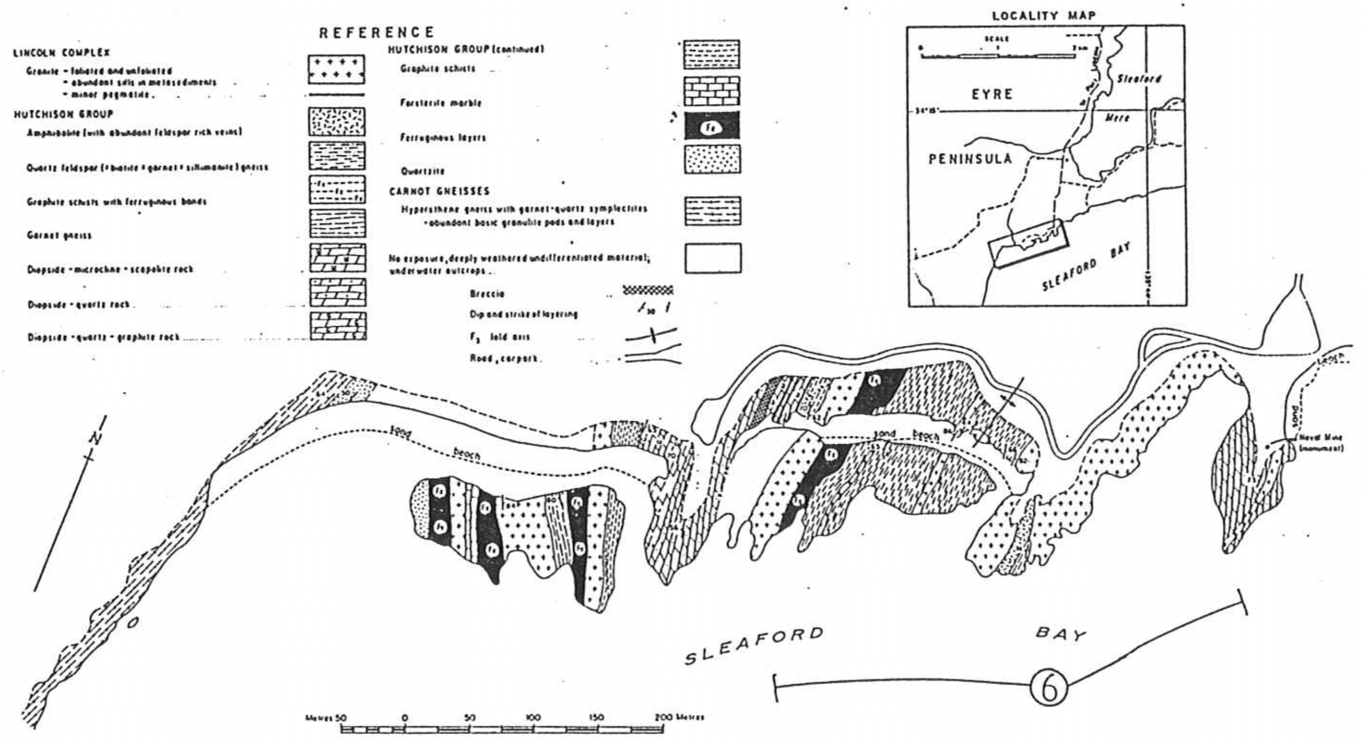


N
PORT NEILL
LF
MG
MF
GG
MF
MG
LF
N
Sm/3
Lm/3
Fm/3
Cape Burr
MX
GG
MF
MX
Back Beach
GG
MF
MF
MX
LG
MX
LG
MX
2
METRES
0
100
200
LF Layered felsic gneiss
MG Mafic gneiss
MF Layered mafic and felsic gneisses
GG Granitic gneiss
MX Grey megacrystic gneiss
LG Leucocratic granite gneiss
Amphibolite dyke
Pre-mylonitic schistosity
Lineation plunge and direction
Plunge and plunge direction of folds formed early during Dm/3
Plunge and plunge direction of later folds formed during Dm/3
Major F3 fold synform
Major F3 fold antiform



Geological Map of Cape Donington and Cape Colbert,
Southern Eyre Peninsula
After G.E. Mortimer, 1984 and M.M. Flook, 1975




REFERENCE
LINCOLN COMPLEX
Granite - foliated and unfoliated
- abundant sills in metasediments
- minor pegmatite.
HUTCHISON GROUP
Amphibolite (with abundant feldspar rich veins)
Quartz feldspar (± biotite ± garnet ± sillimanite) gneiss
Graphite schists with ferruginous bands
Garnet gneiss
Diopside - microcline - scapolite rock
Diopside - quartz rock
Diopside - quartz - graphite rock
HUTCHISON GROUP (continued)
Graphite schists
Forsterite marble
Ferruginous layers
Fe
Quartzite
CARNOT GNEISSES
Hypersthene gneiss with garnet-quartz symplectites
- abundant basic granulite pods and layers
No exposure, deeply weathered undifferentiated material; underwater outcrops.
Breccia
Dip and strike of layering
30
F3 fold axis
Road, carpark.
LOCALITY MAP
SCALE
0
2 km
EYRE
PENINSULA
Sleaford
Mere
34°15'
SLEAFORD BAY
sand
beach
Naval Mine (monument)
Leach
SLEAFORD
BAY
6
Metres 50
0
50
100
150
200 Metres
N

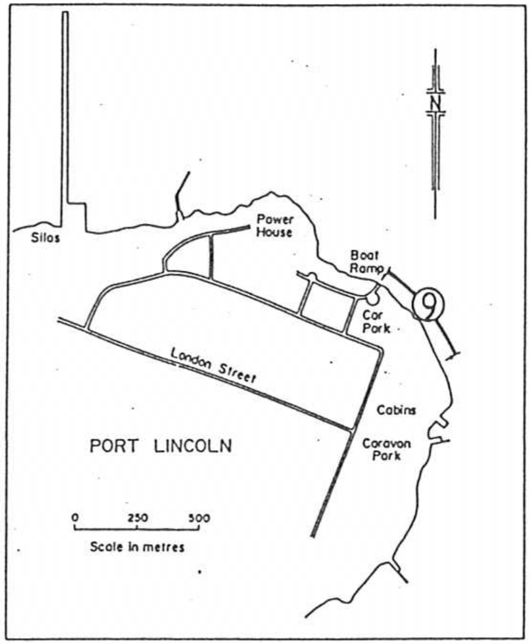
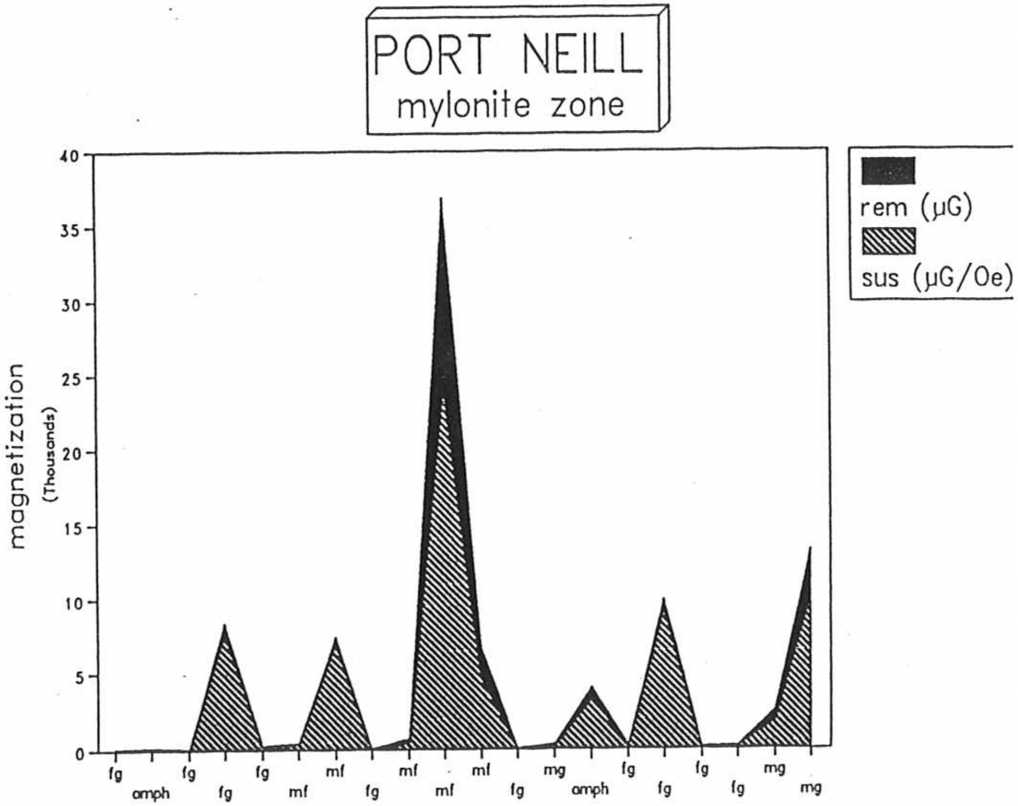

N
Silos
Power House
Boat Ramp
9
Car Park
London Street
Cabins
Caravan Park
PORT LINCOLN
0
250
500
Scale in metres

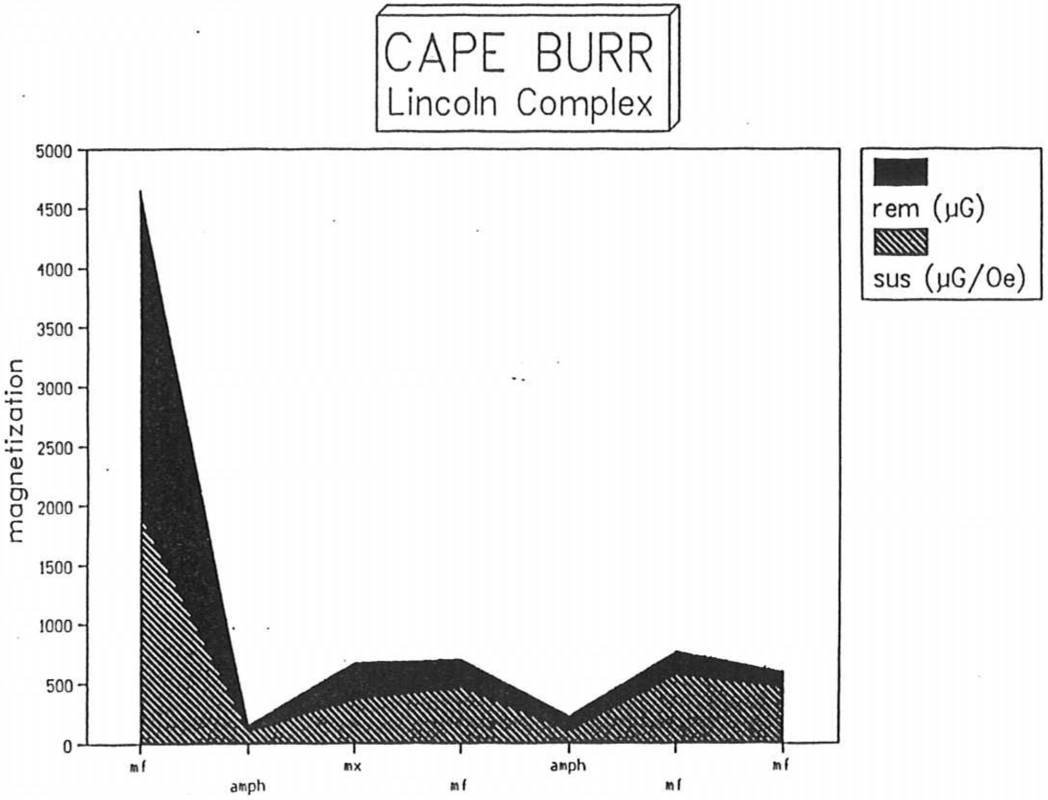
FIGURE 2

MAGNETIC PROPERTY PROFILES FOR TRAVERSES ACROSS HETEROGENEOUS TERRANES

Note that the susceptibility assumes unit field, 1 Oersted. The induced magnetisation, and therefore the Koenigsberger ratio (Q), can be visualised by appropriately scaling the susceptibility, i.e. for the Earth's field of about 0.6 Oe, the induced magnetisation in μG is given by 0.6 x susceptibility. The remanence in μG divided by the induced magnetisation (in μG) yields the dimensionless Q ratio. This is why cgs units are preferred.

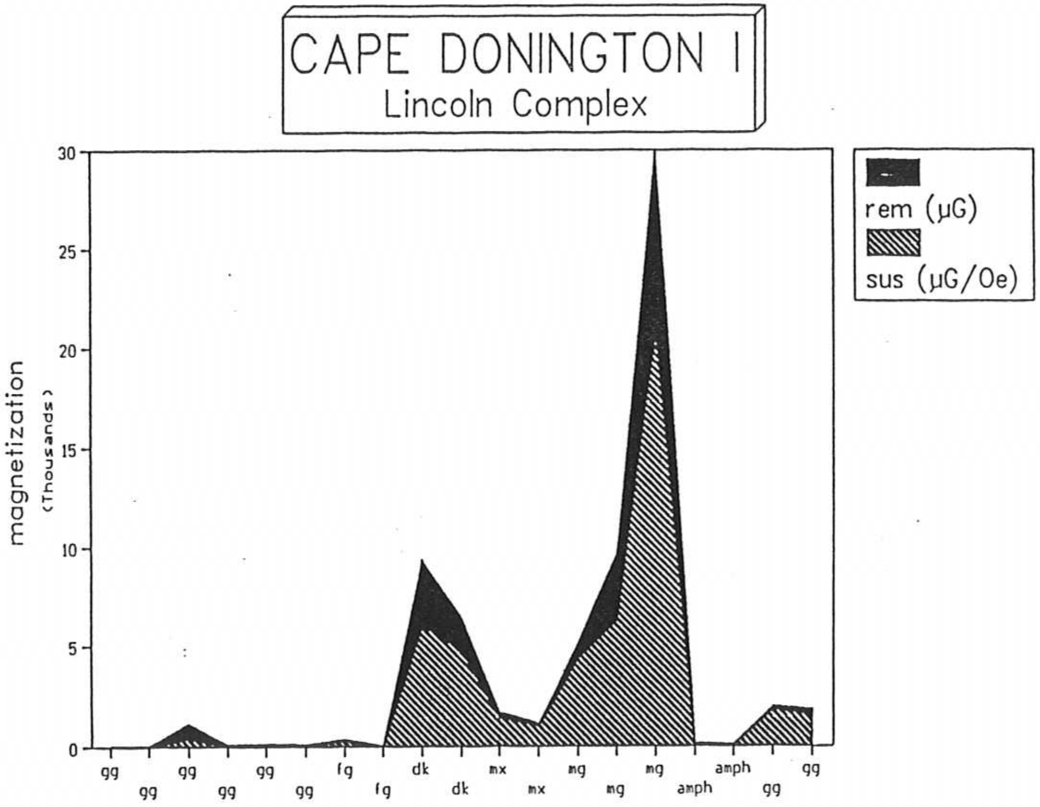


Locality 1

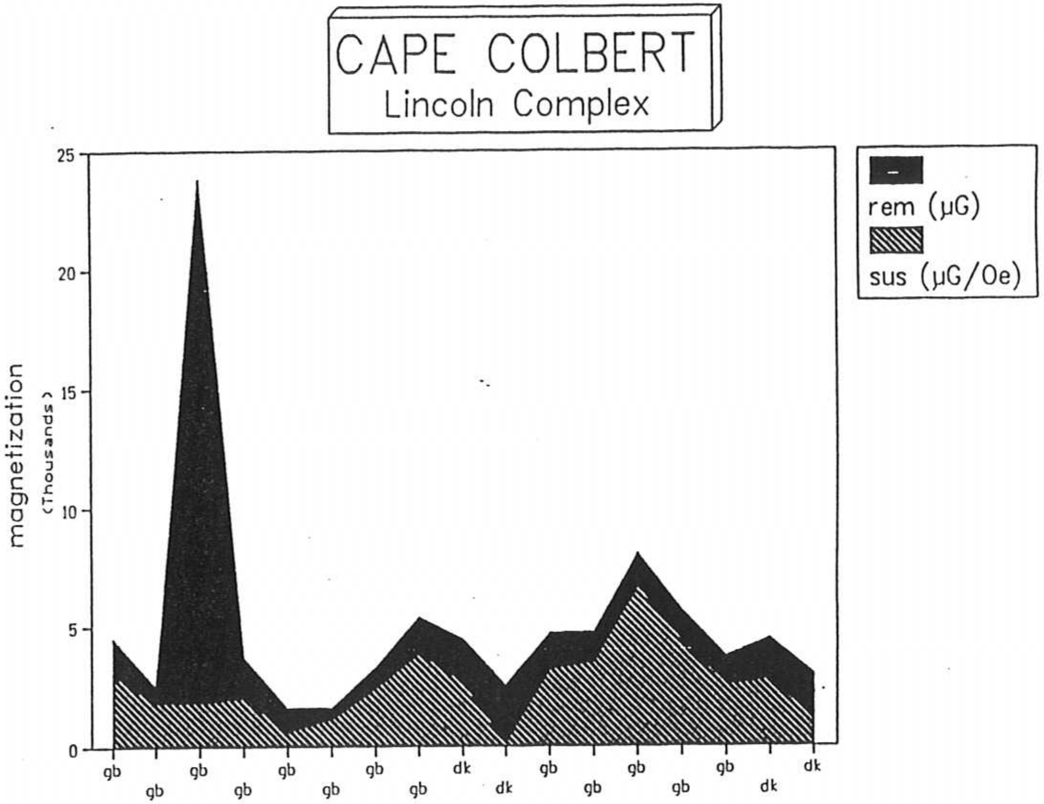


Locality 2

FIGURE 2a



Locality 3



Locality 7

FIGURE 2b

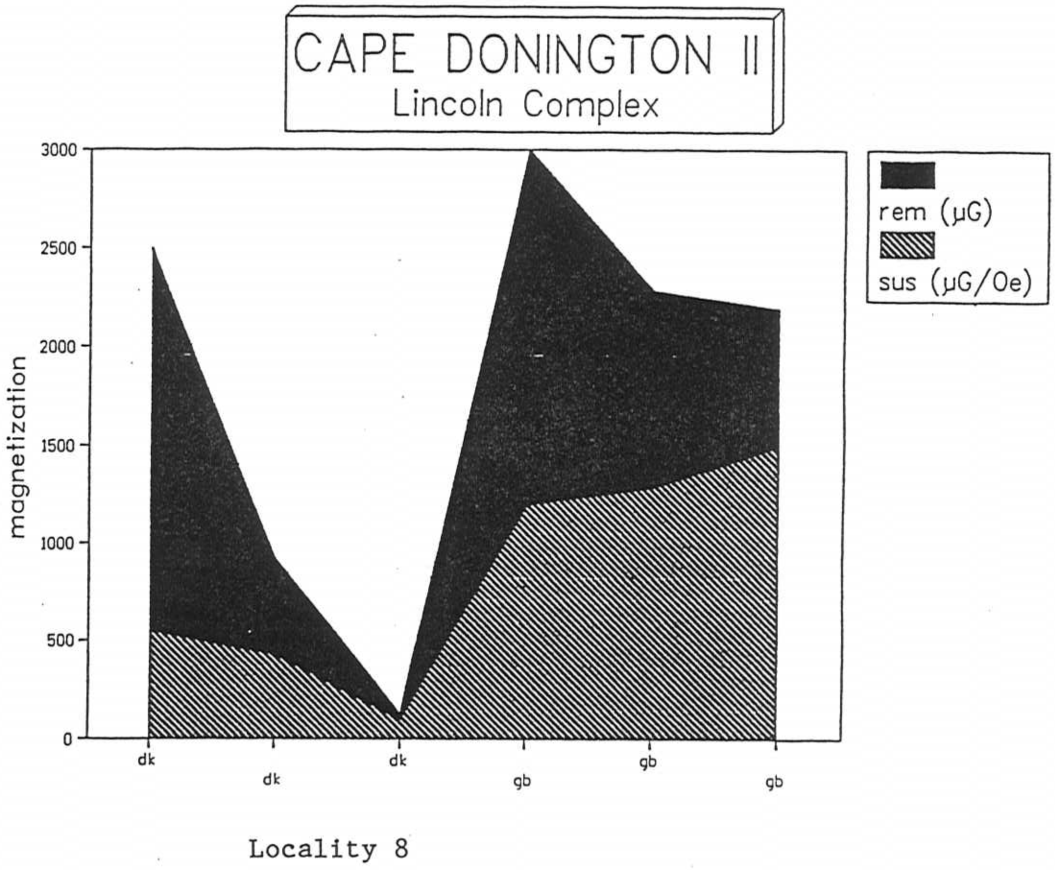


FIGURE 2b cont'd

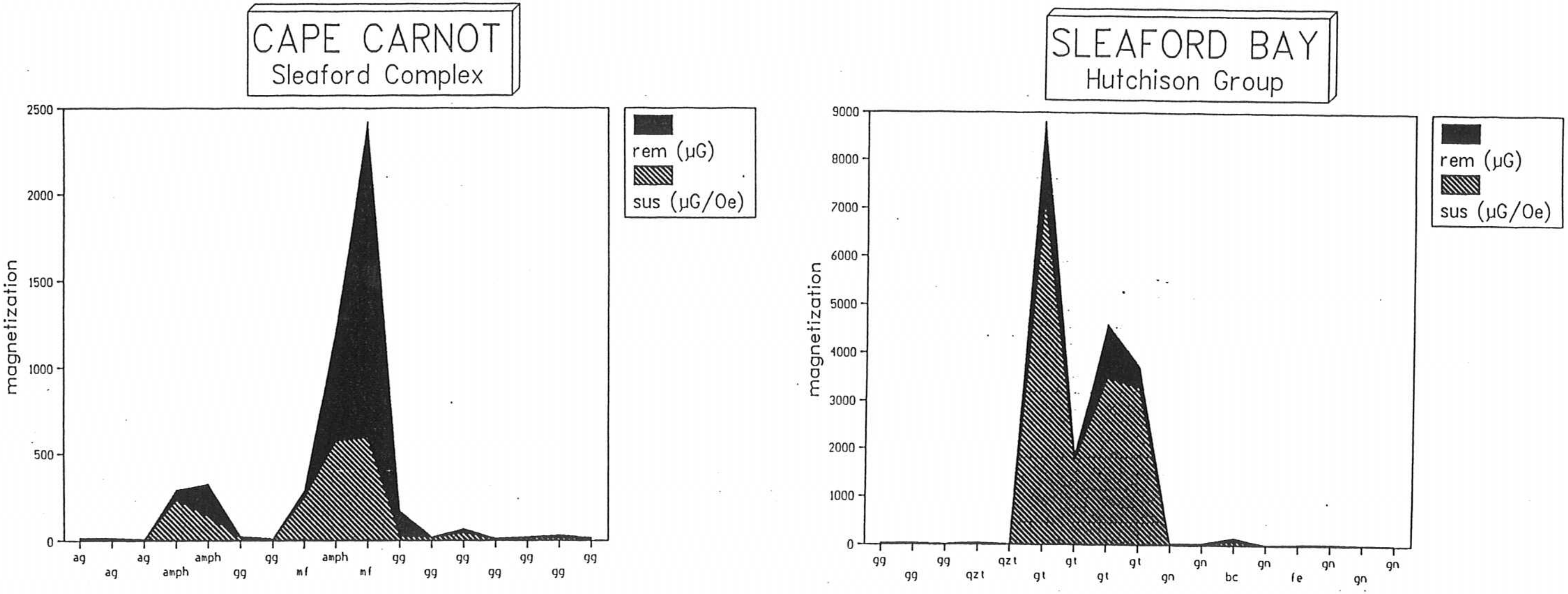
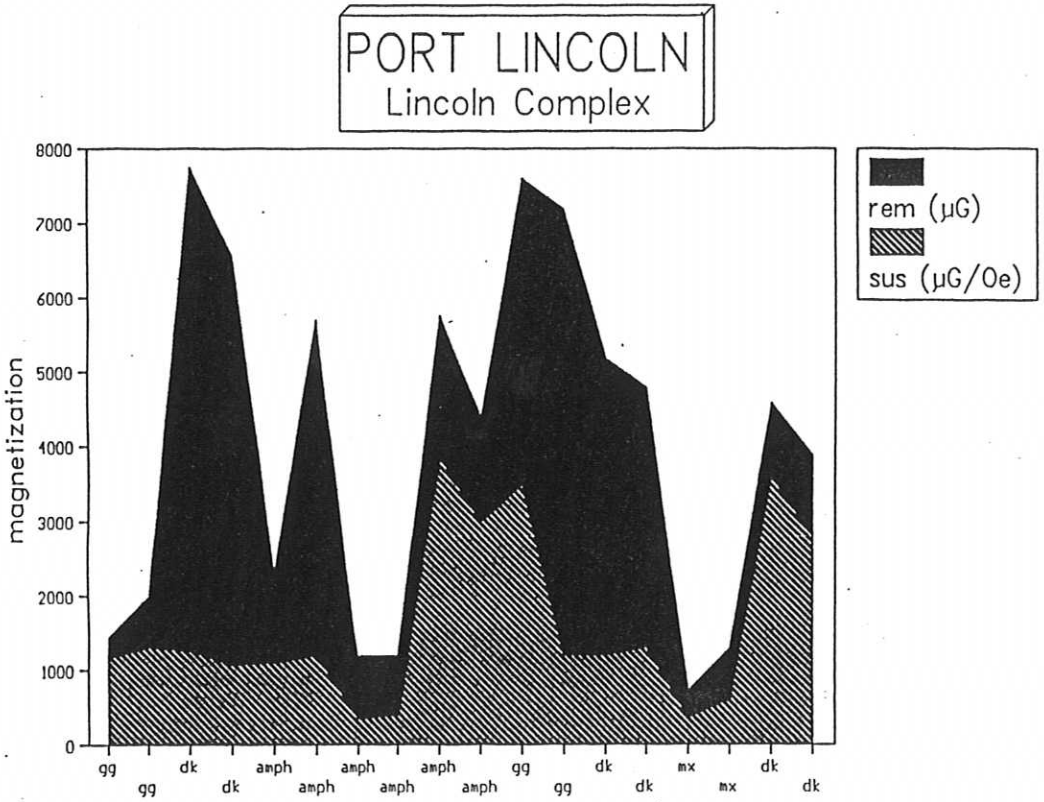


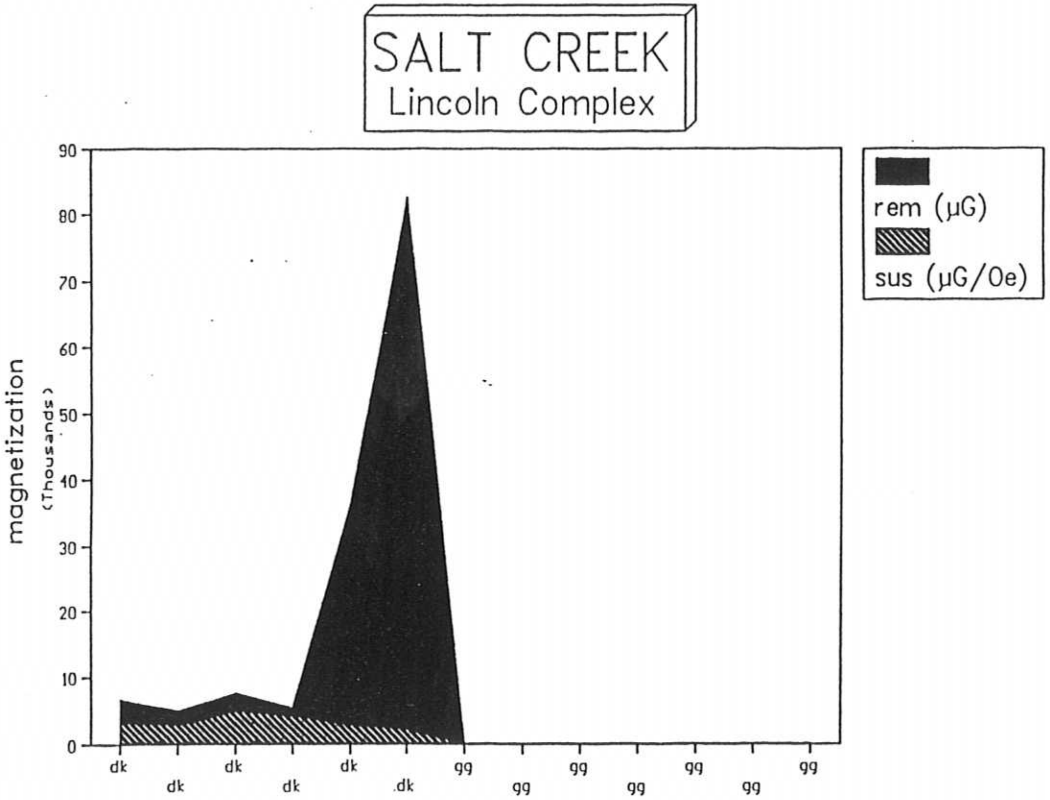
FIGURE 2c

Locality 4

Locality 6



Locality 9



Locality 17

FIGURE 2d

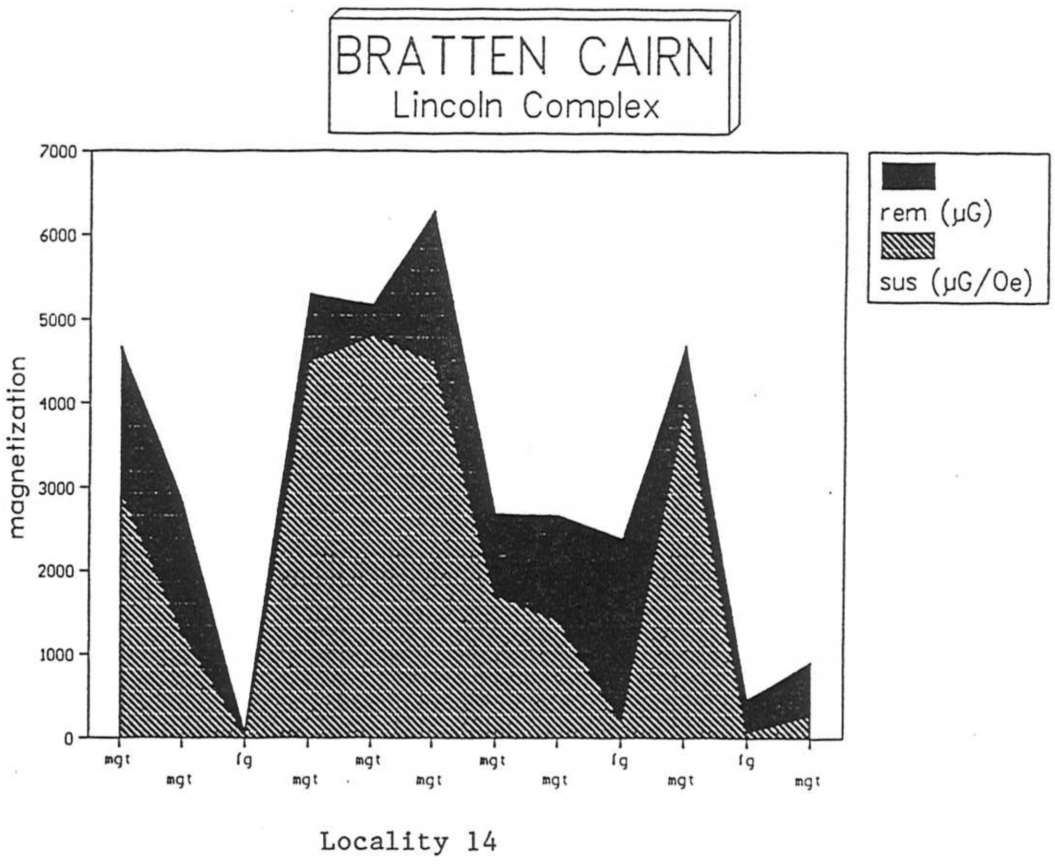
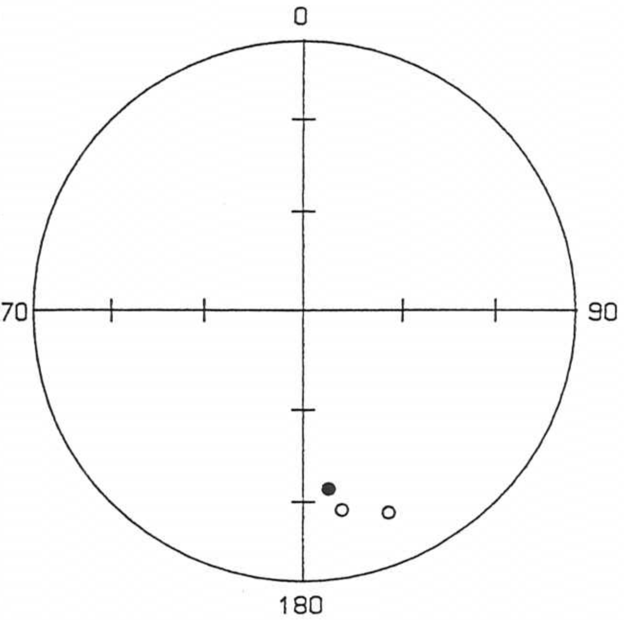


Figure 2d cont'd

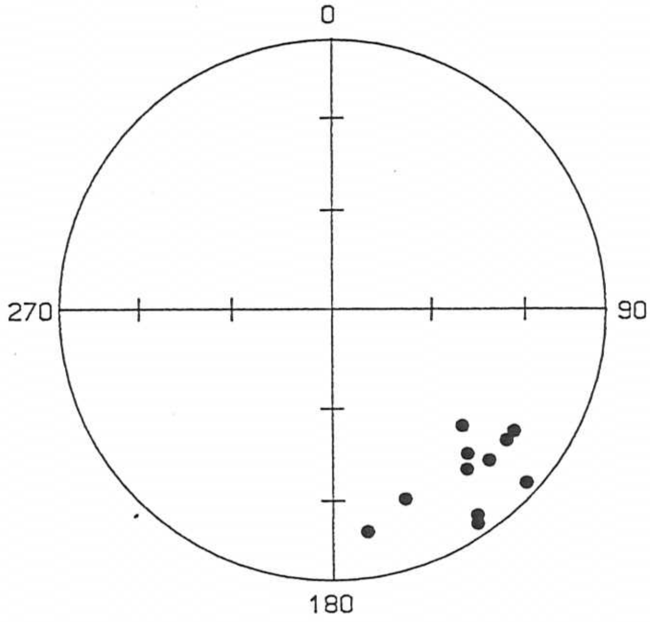
FIGURE 3

STEREOGRAPHIC PROJECTIONS OF CHARACTERISTIC REMANENCE COMPONENTS FROM DIFFERENT LOCALITIES

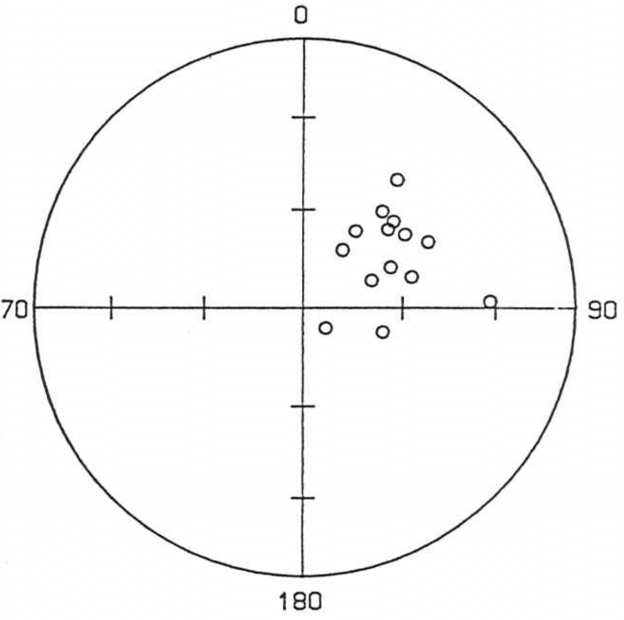
Kalinjala Mylonite Zone
AF cleaned



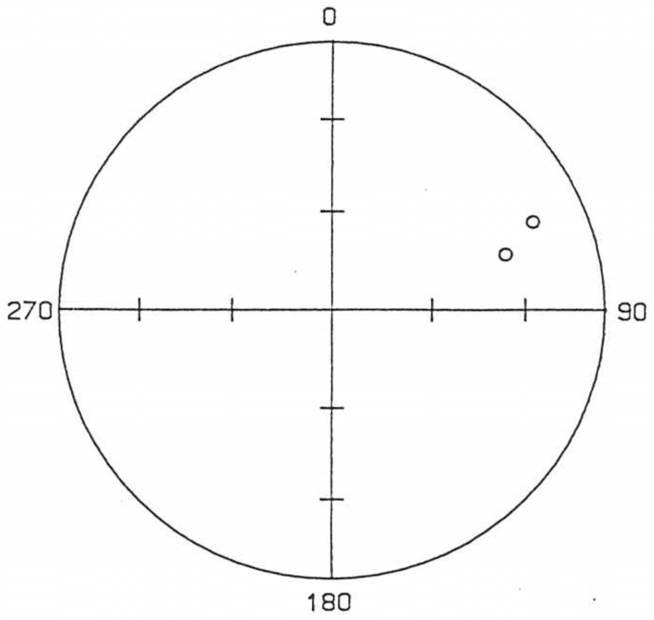
Bratten Cairn
AF cleaned



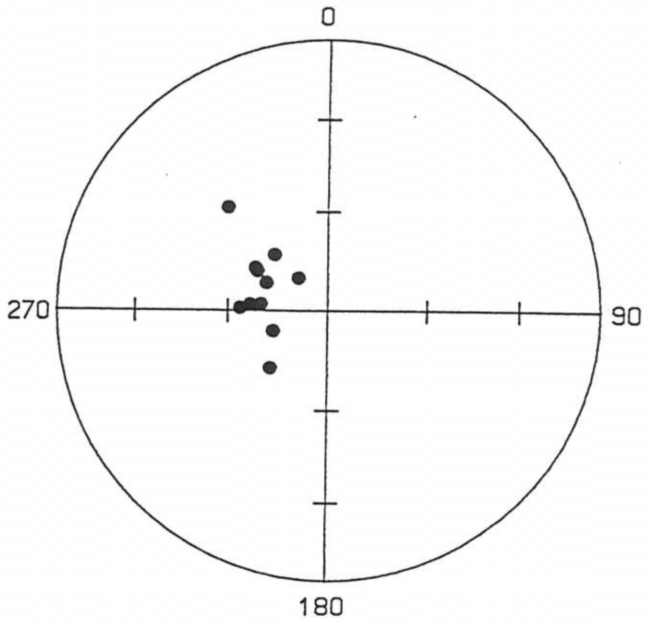
Port Lincoln
AF cleaned



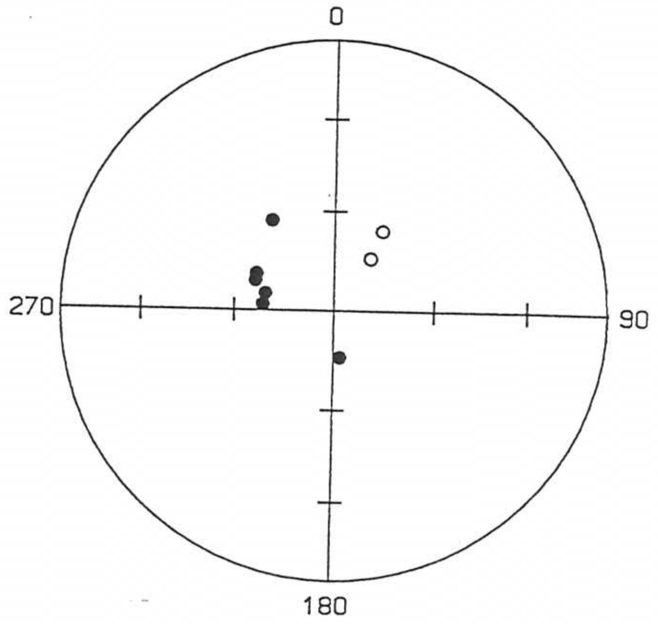
Cape Burr
AF cleaned



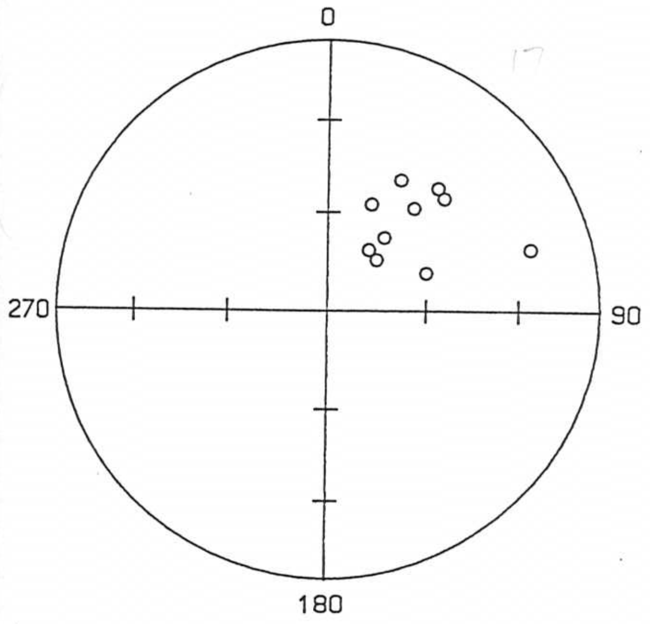
Cape Colbert
AF cleaned



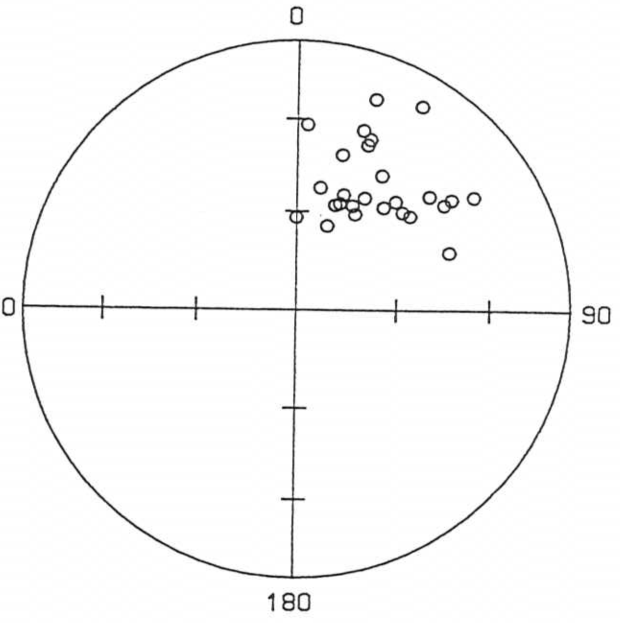
Cape Donington
AF cleaned



Salt Creek
AF cleaned



Gawler Range Volcanics
AF and thermal



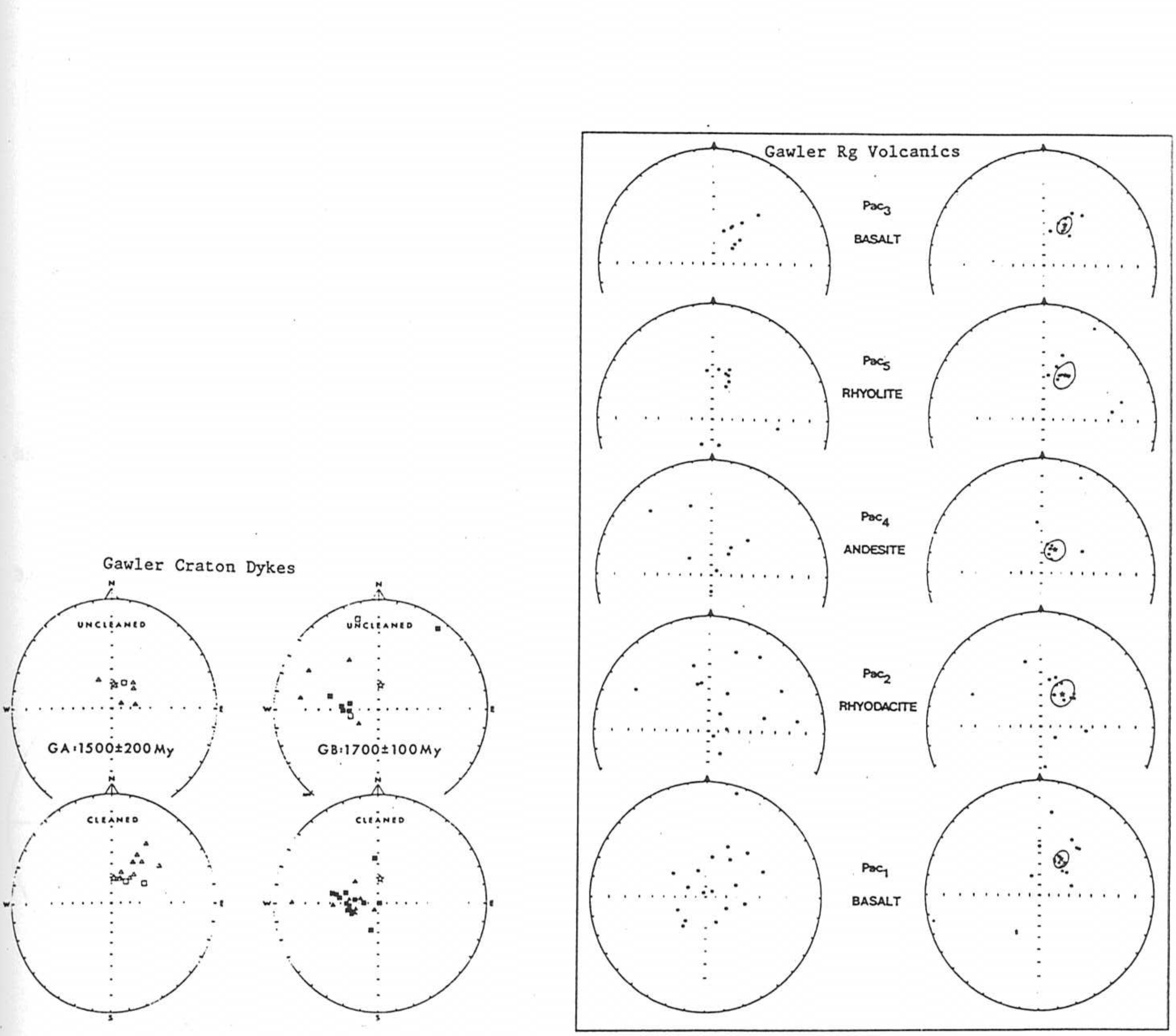
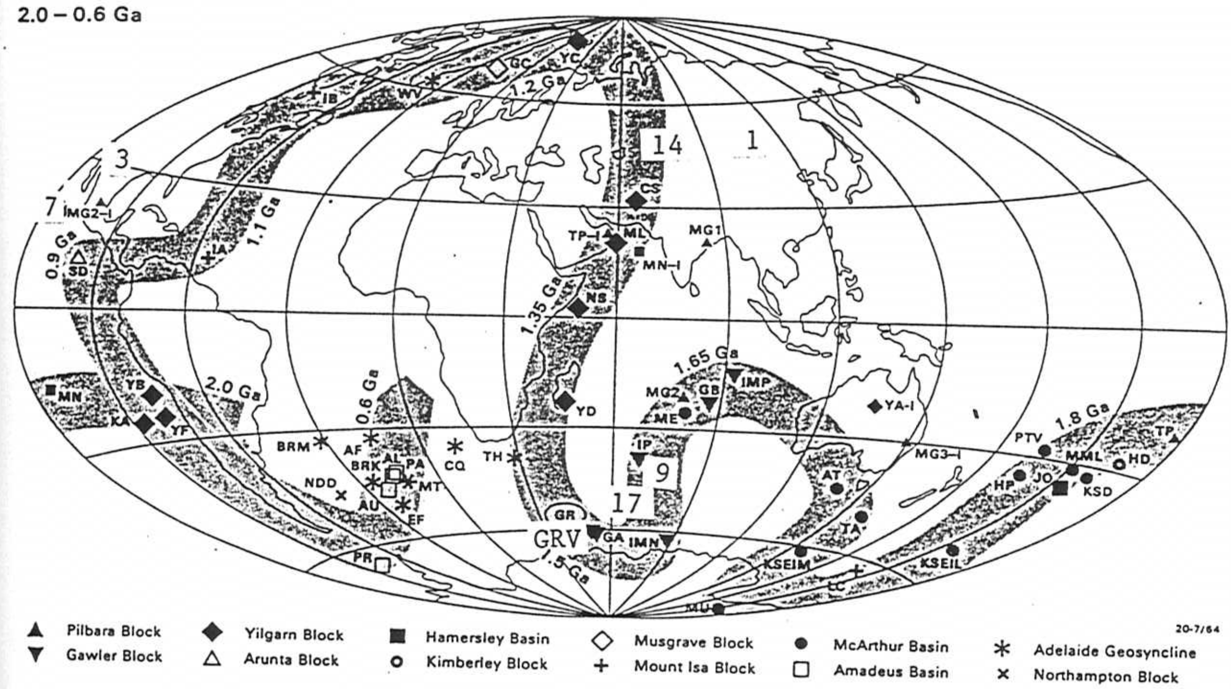
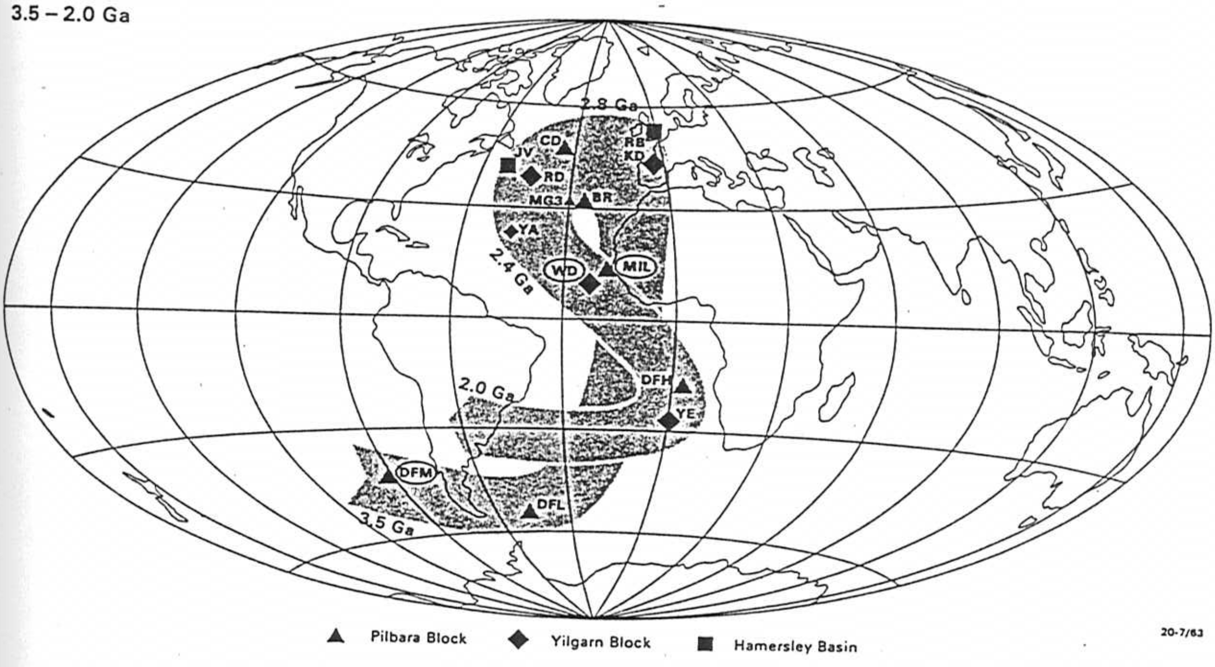


FIGURE 4

Stereographic projections of directions from Gawler Craton dykes from Giddings and Embleton (1976) and the Gawler Range Volcanics from Chamalaun and Dempsey(1978). Note the similarity between the GA dyke and the Gawler Range Volcanics directions. The Gawler Range Volcanics are essentially flat lying at these localities, unlike those whose results are plotted in the previous figure from this study.



. Australian apparent polar wander path for the period 2.0-0.6 Ga. Small symbols denote poles with ambiguous polarities. Key poles defined in the text have mnemonics encircled. Approximate ages are shown alongside the path.

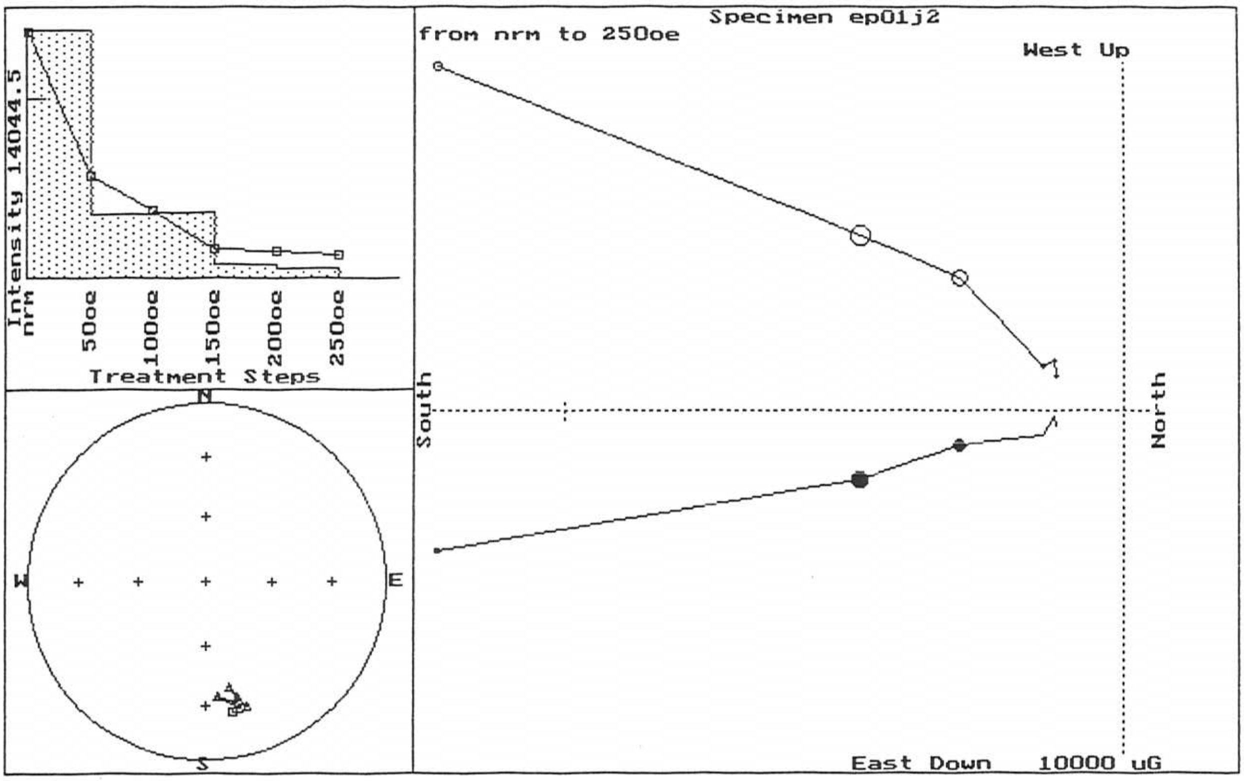


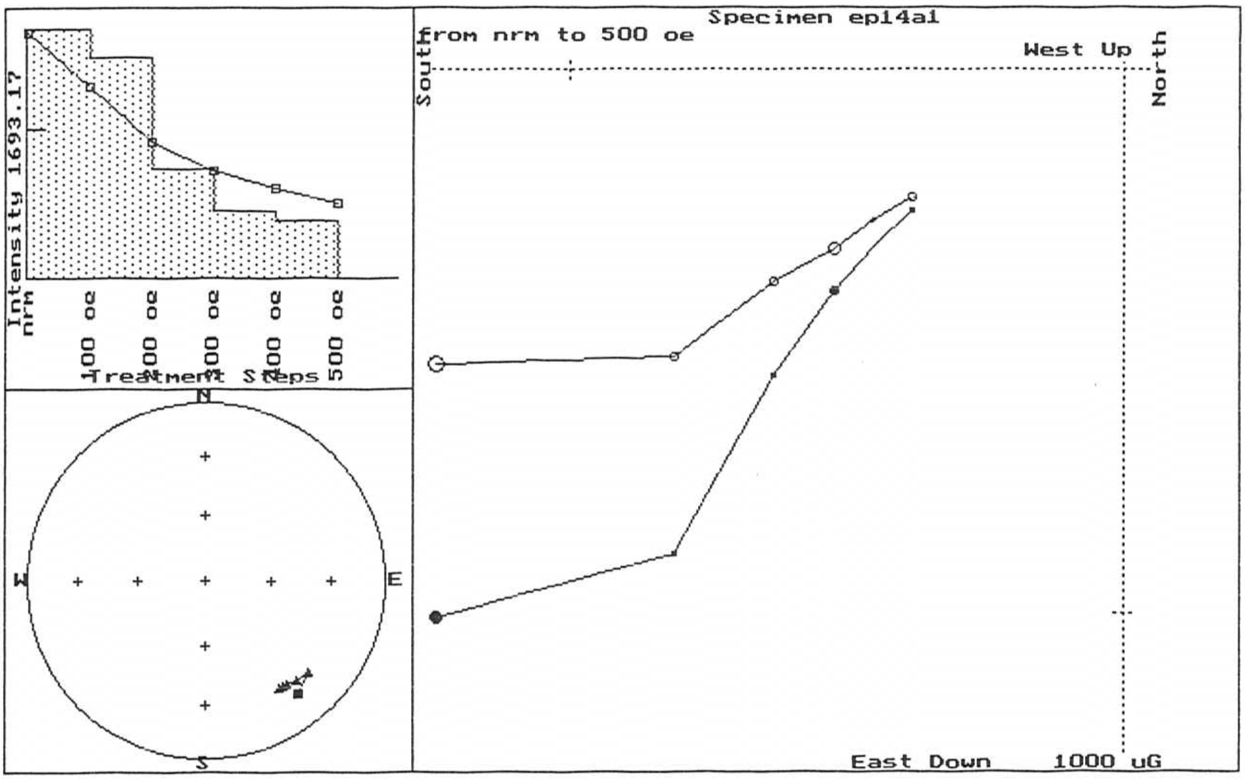
Australian apparent polar wander path for the period 3.5-2.0 Ga.

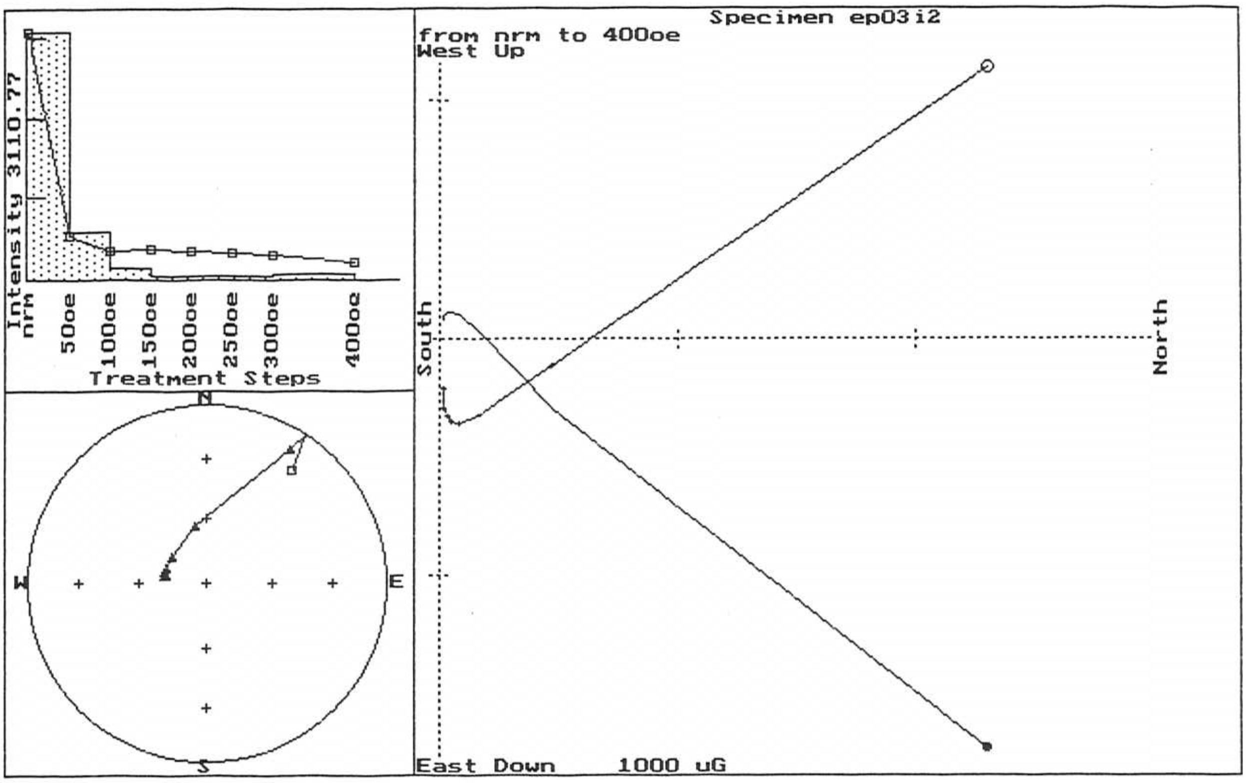
FIGURE 5

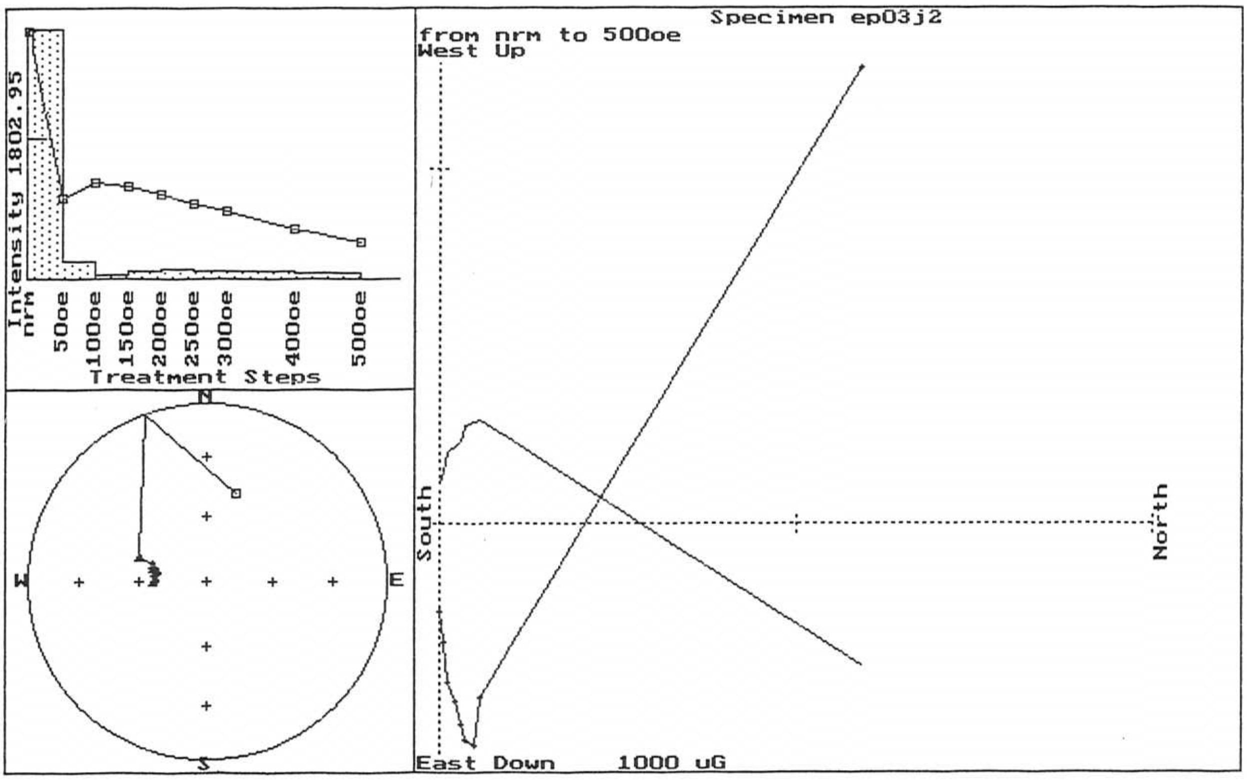
Australia's Precambrian apparent polar wander path which is often used to date rock units. Poles from this study are identified with the locality number. Results from this and related studies indicate that the path is in serious need of upgrading.

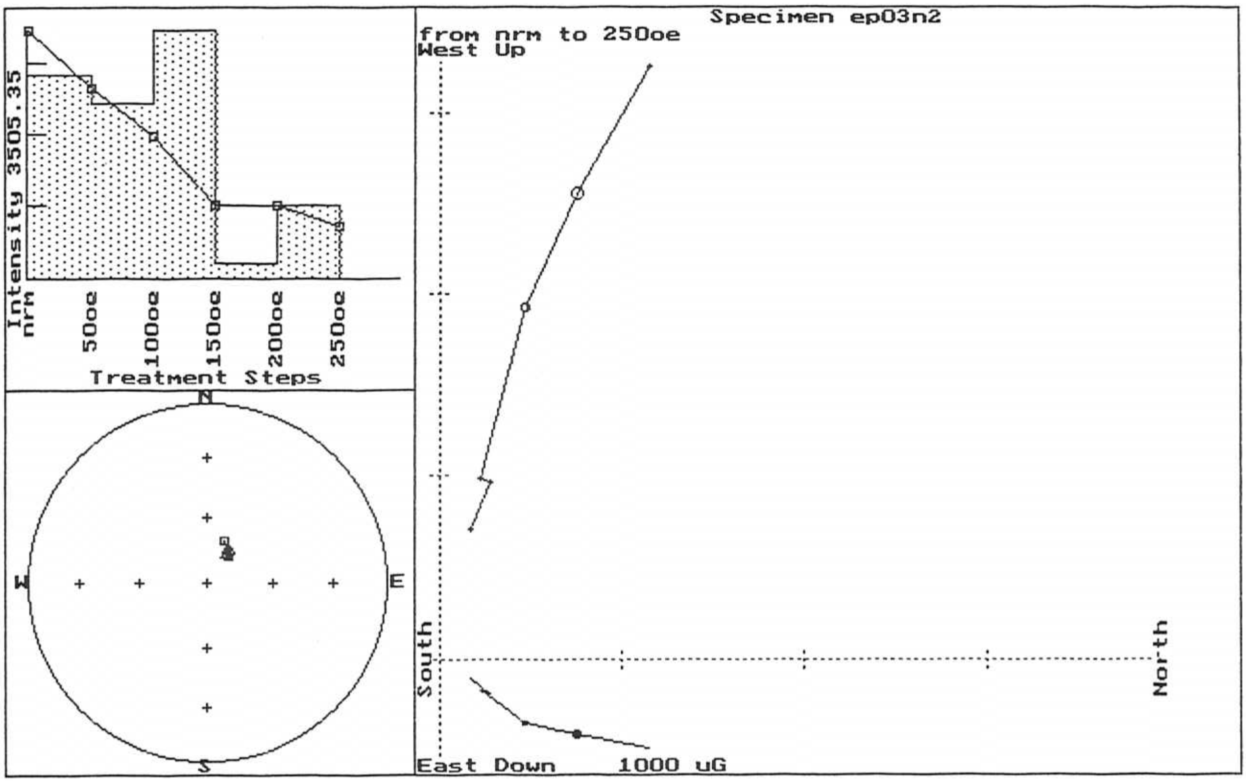
APPENDIX I

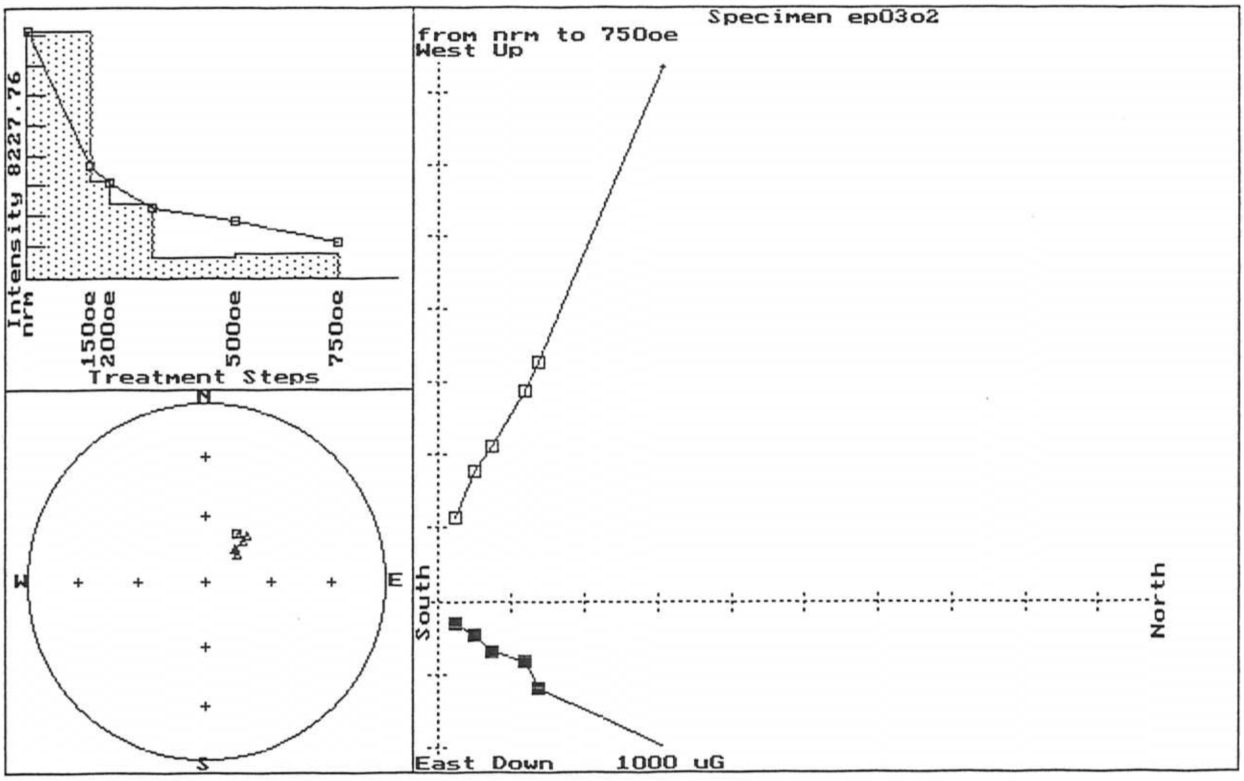

Specimen ep01j2
from nrm to 250oe
West Up
South
North
East Down
10000 uG
Intensity 14044.5
nrm
50oe
100oe
150oe
200oe
250oe
Treatment Steps
N
W
E
S

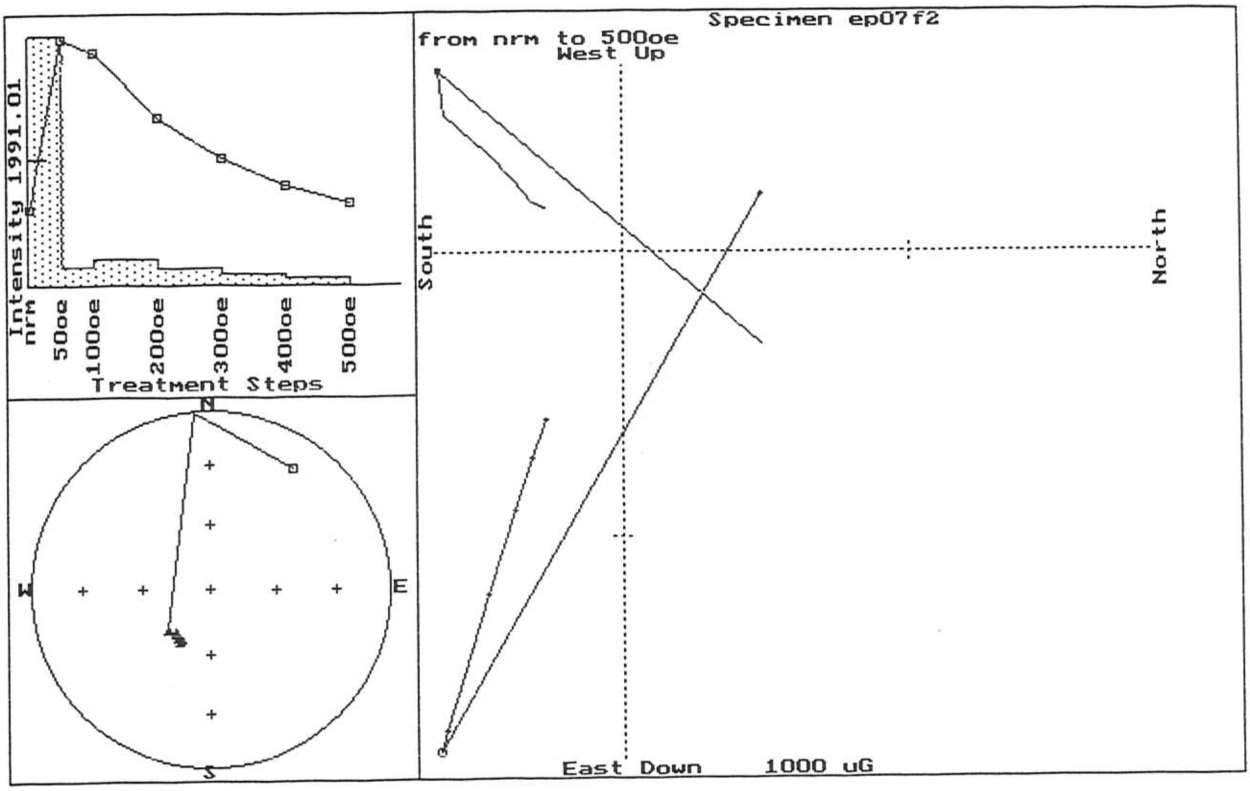

Specimen ep14a1
from nrm to 500 oe
West Up
South
North
East Down
1000 uG
Intensity 1693.17
nrm
100 oe
500 oe
Treatment Steps
N
W
E
S

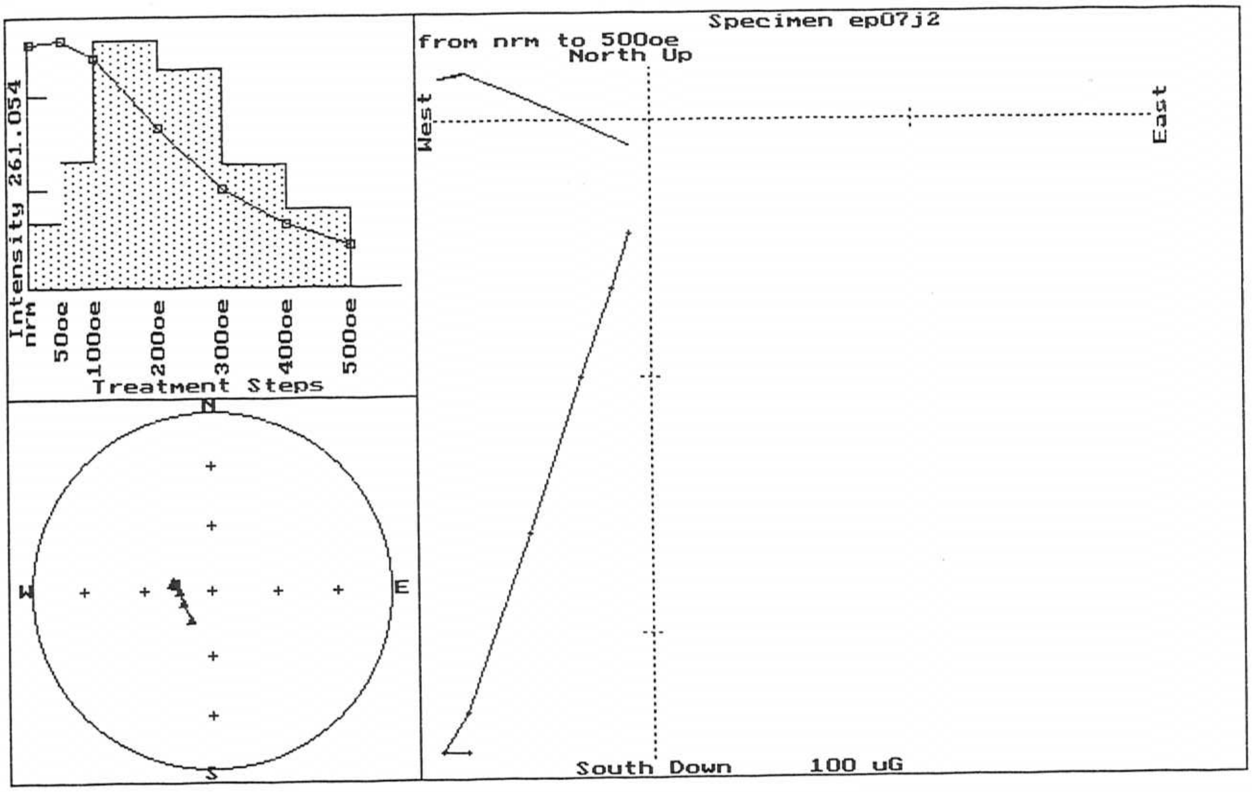

Intensity 3110.77
nrm
50oe
100oe
150oe
200oe
250oe
300oe
400oe
Treatment Steps
N
W
E
S
Specimen ep03i2
from nrm to 400oe
West Up
South
North
East Down
1000 uG

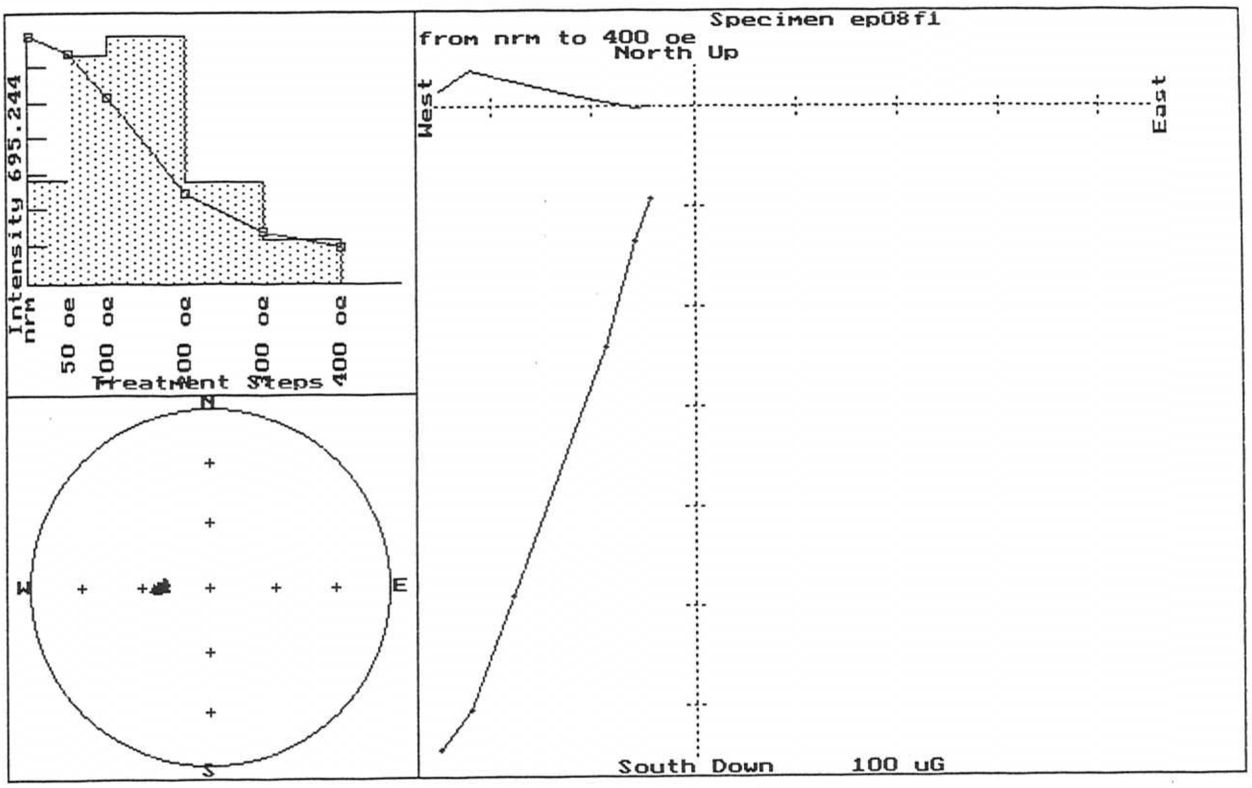

Intensity 1802.95
nrm
50oe
100oe
150oe
200oe
250oe
300oe
400oe
500oe
Treatment Steps
N
W
E
S
Specimen ep03j2
from nrm to 500oe
West Up
South
North
East Down
1000 uG

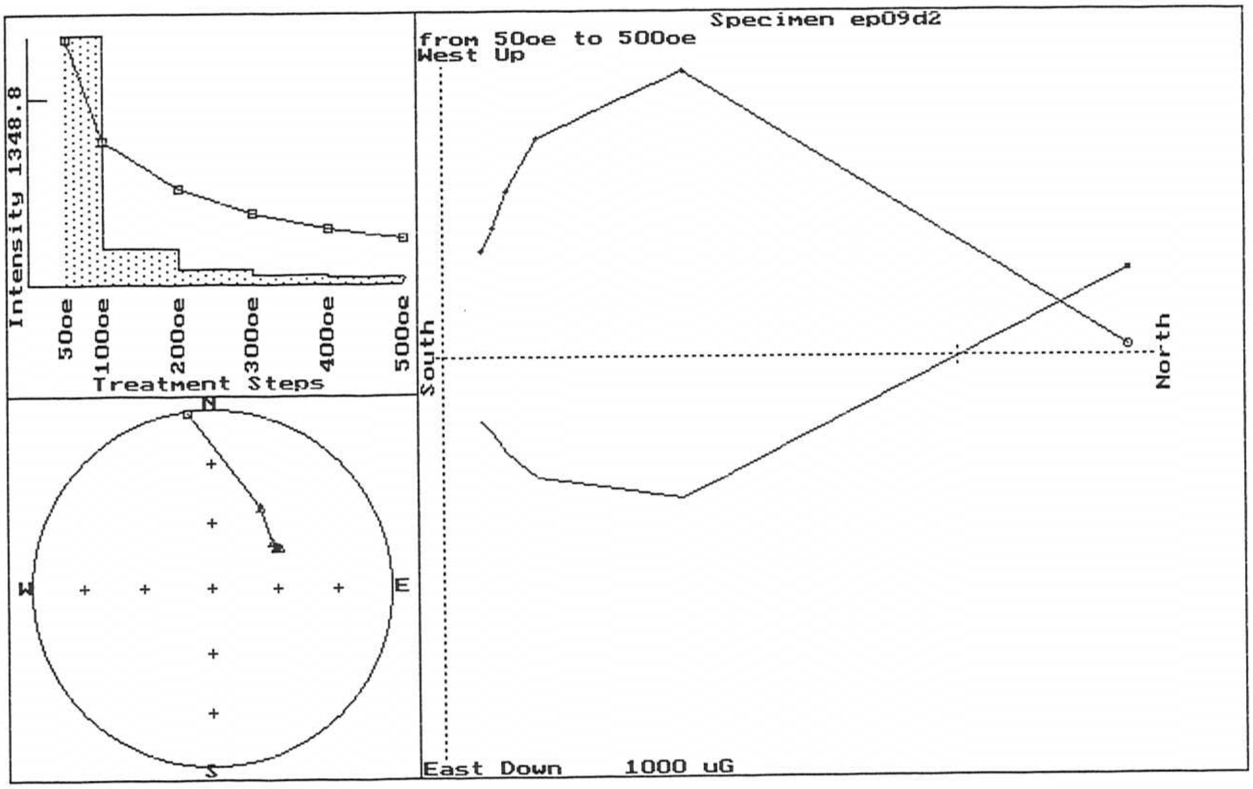

Specimen ep03n2
from nrm to 250oe
West Up
Intensity 3505.35
nrm
50oe
100oe
150oe
200oe
250oe
Treatment Steps
N
W
E
S
South
North
East Down
1000 uG

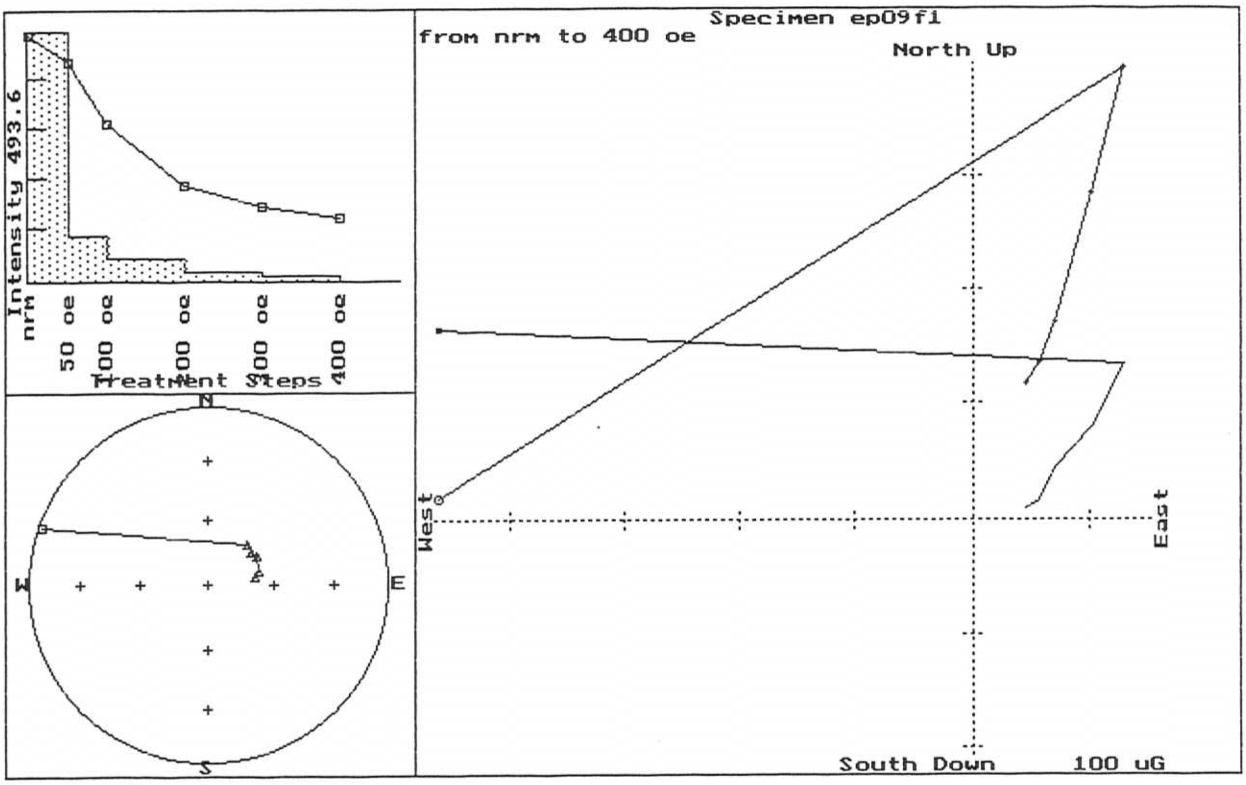

Specimen ep03o2
from nrm to 750oe
West Up
Intensity 8227.76
nrm
150oe
200oe
500oe
750oe
Treatment Steps
N
W
E
S
South
North
East Down
1000 uG

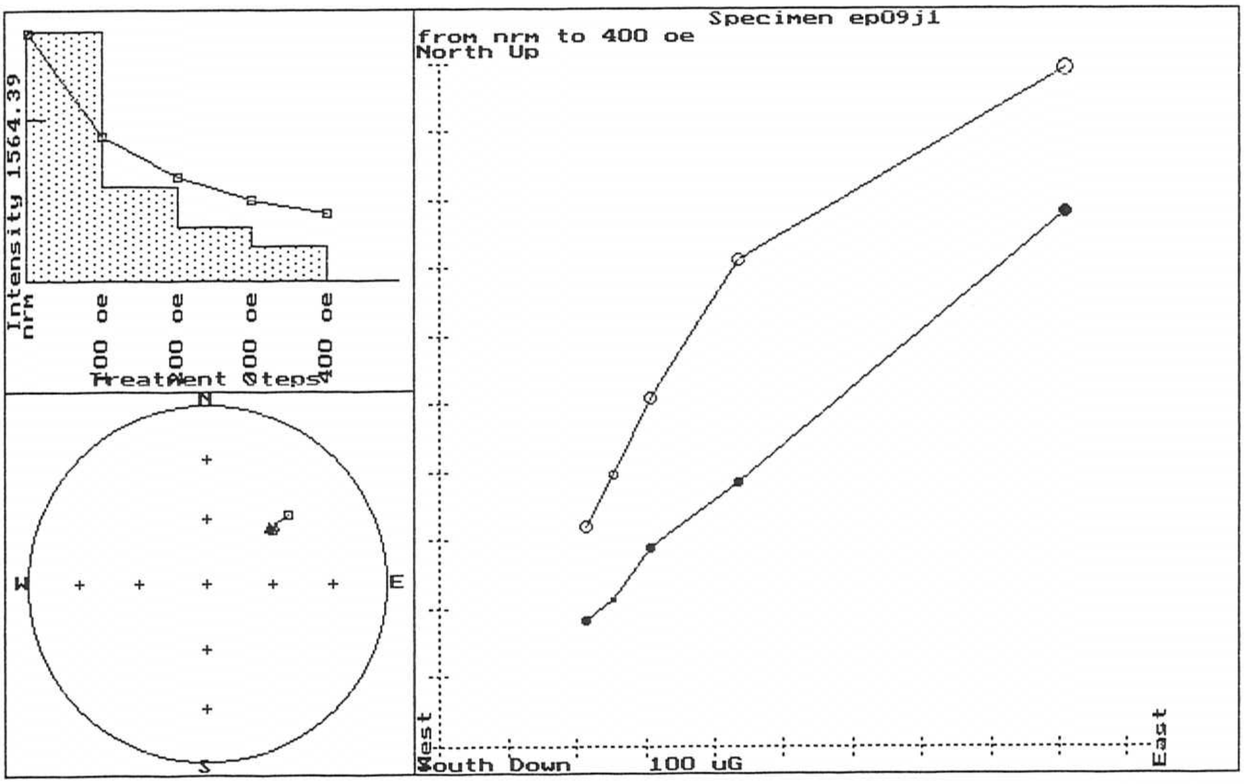

Specimen ep07f2
from nrm to 500oe
West Up
South
North
East Down
1000 uG
Intensity 1991.01
nrm
50oe
100oe
200oe
300oe
400oe
500oe
Treatment Steps
N
W
E
S

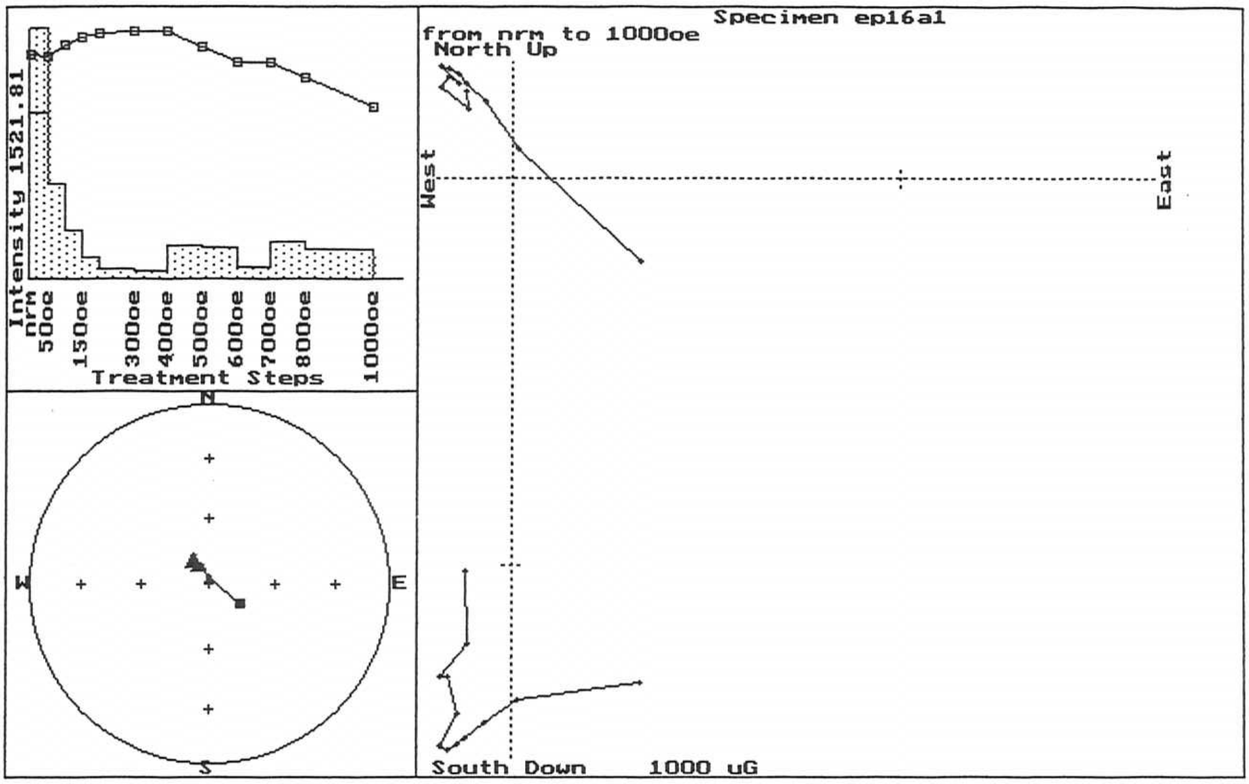

Specimen ep07j2
from nrm to 500oe
North Up
West
East
South Down
100 uG
Intensity 261.054
nrm
50oe
100oe
200oe
300oe
400oe
500oe
Treatment Steps
N
W
E
S

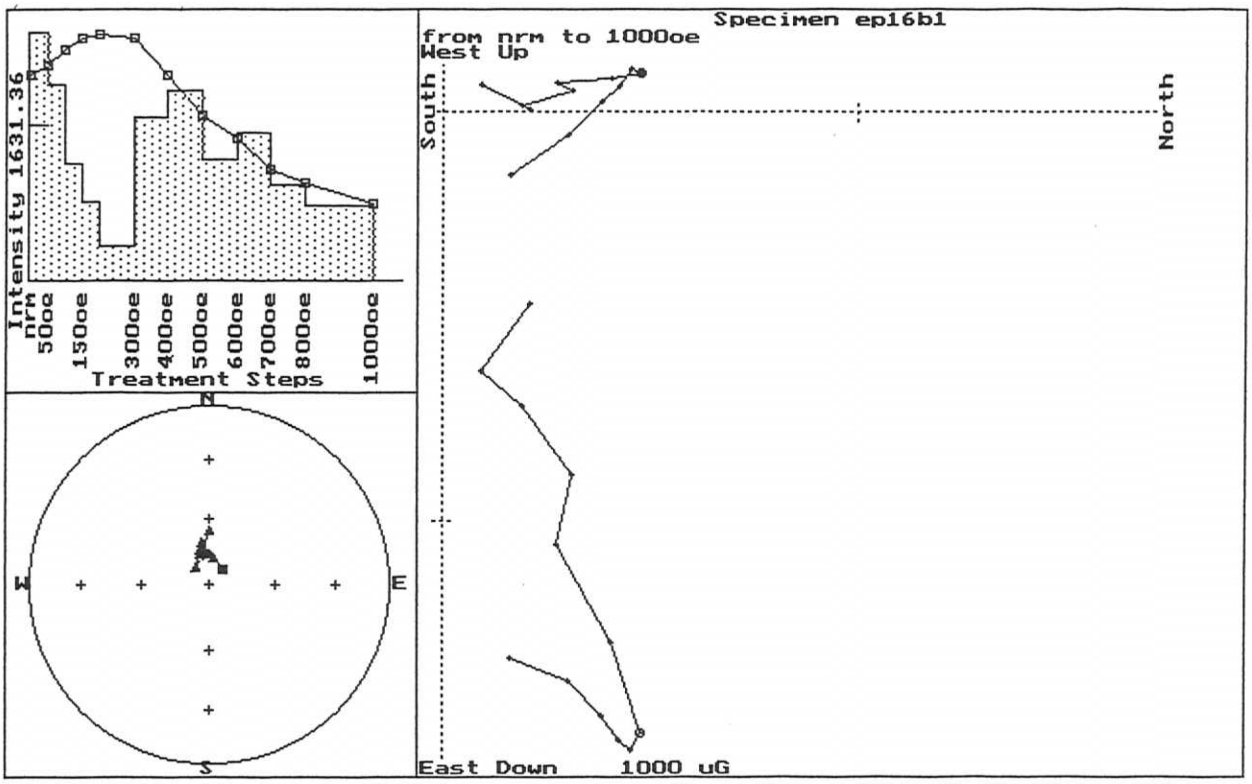

Specimen ep08f1
from nrm to 400 oe
North Up
West
East
South Down 100 uG
Intensity 695.244
nrm
50 oe
100 oe
200 oe
300 oe
400 oe
Treatment Steps
N
W
E
S

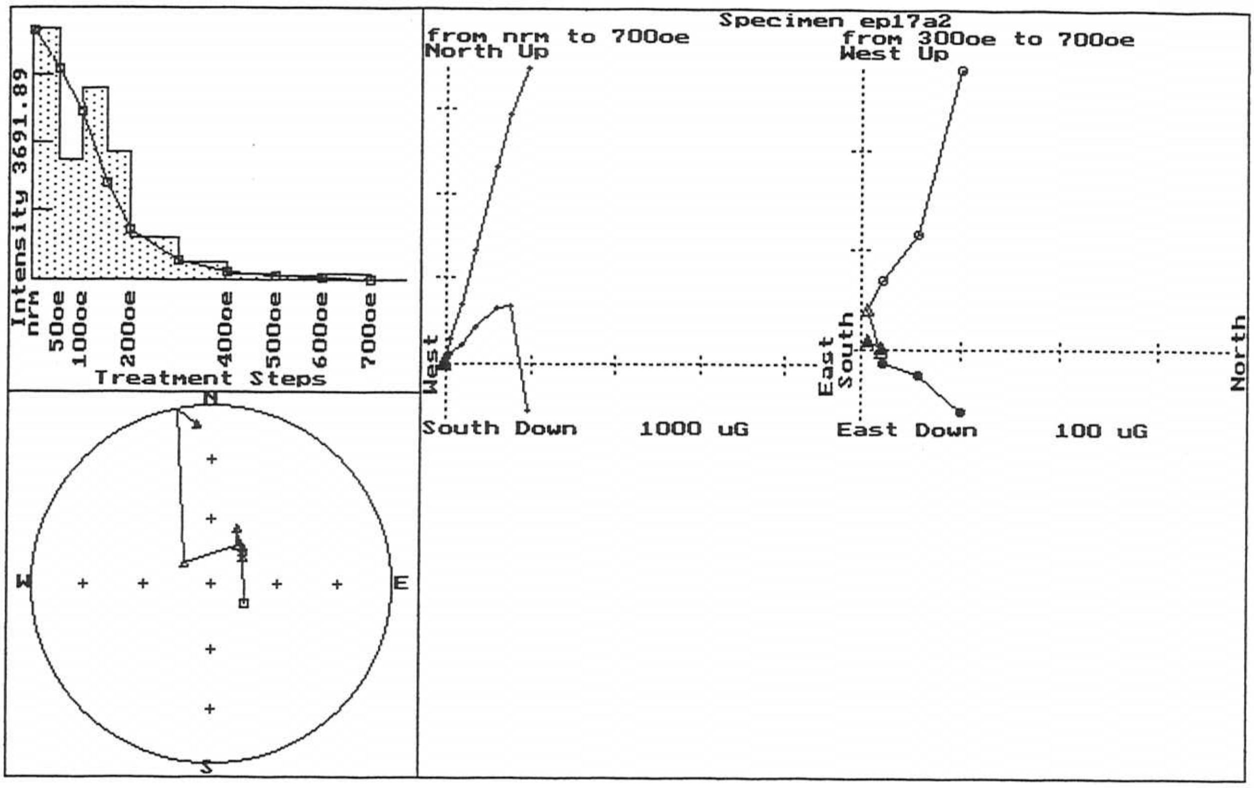

Specimen ep09d2
from 50oe to 500oe
West Up
South
North
East Down 1000 uG
Intensity 1348.8
50oe
1000oe
2000oe
3000oe
4000oe
5000oe
Treatment Steps
N
W
E
S


Specimen ep09f1
from nrm to 400 oe
North Up
West
East
South Down
100 uG
Intensity 493.6
nrm
50 oe
100 oe
200 oe
300 oe
400 oe
Treatment Steps
N
E
S
W

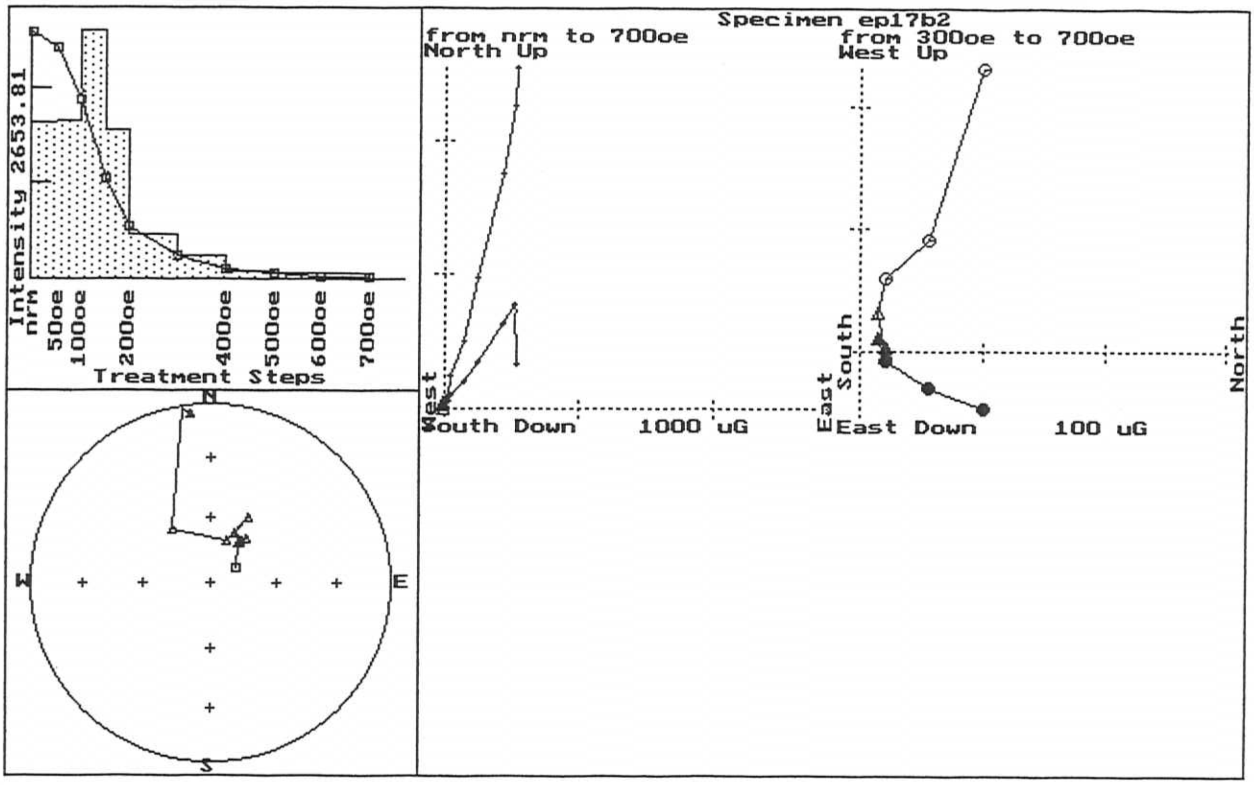

Specimen ep09j1
from nrm to 400 oe
North Up
West
East
South Down
100 uG
Intensity 1564.39
nrm
100 oe
200 oe
300 oe
400 oe
Treatment Steps
N
E
S
W


Specimen ep16a1
from nrm to 1000oe
North Up
West
East
South Down
1000 uG
Intensity 1521.81
nrm
50oe
150oe
300oe
400oe
500oe
600oe
700oe
800oe
1000oe
Treatment Steps
N
W
E
S

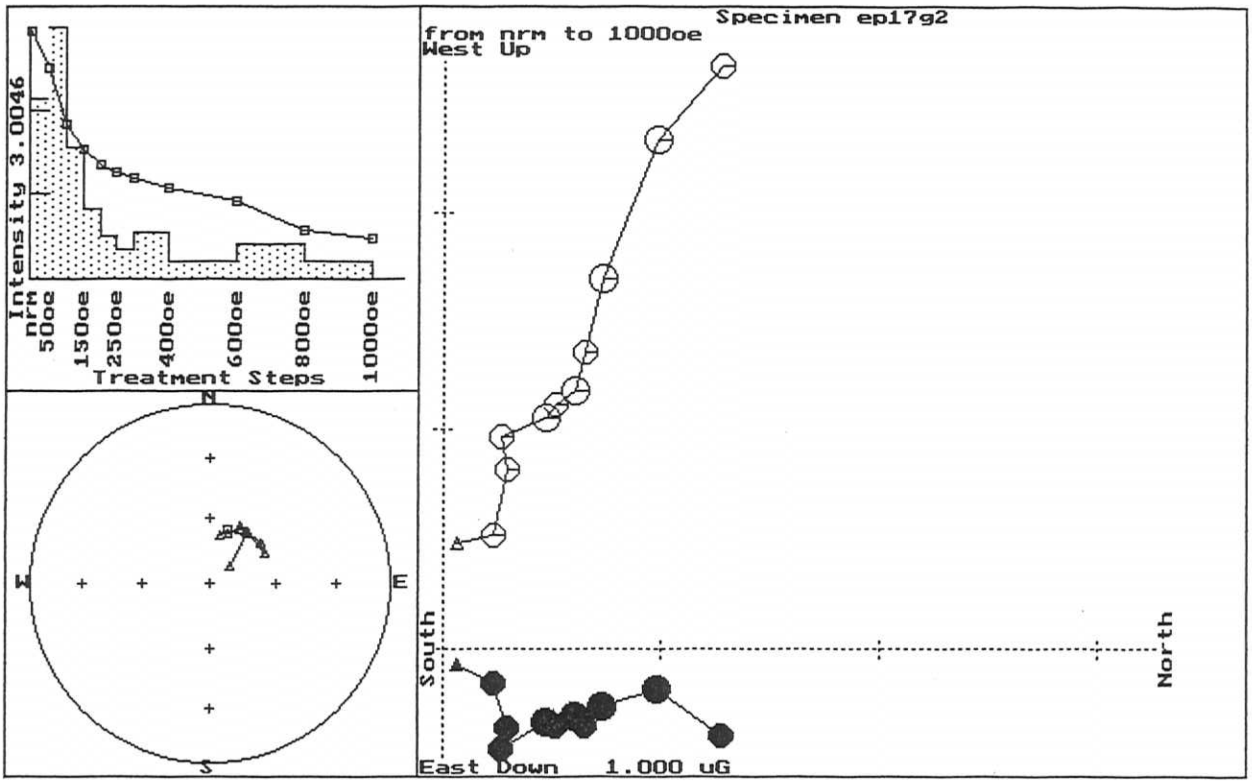

Specimen ep16b1
from nrm to 1000oe
West Up
South
North
East Down
1000 uG
Intensity 1631.36
nrm
50oe
150oe
300oe
400oe
500oe
600oe
700oe
800oe
1000oe
Treatment Steps
N
W
E
S

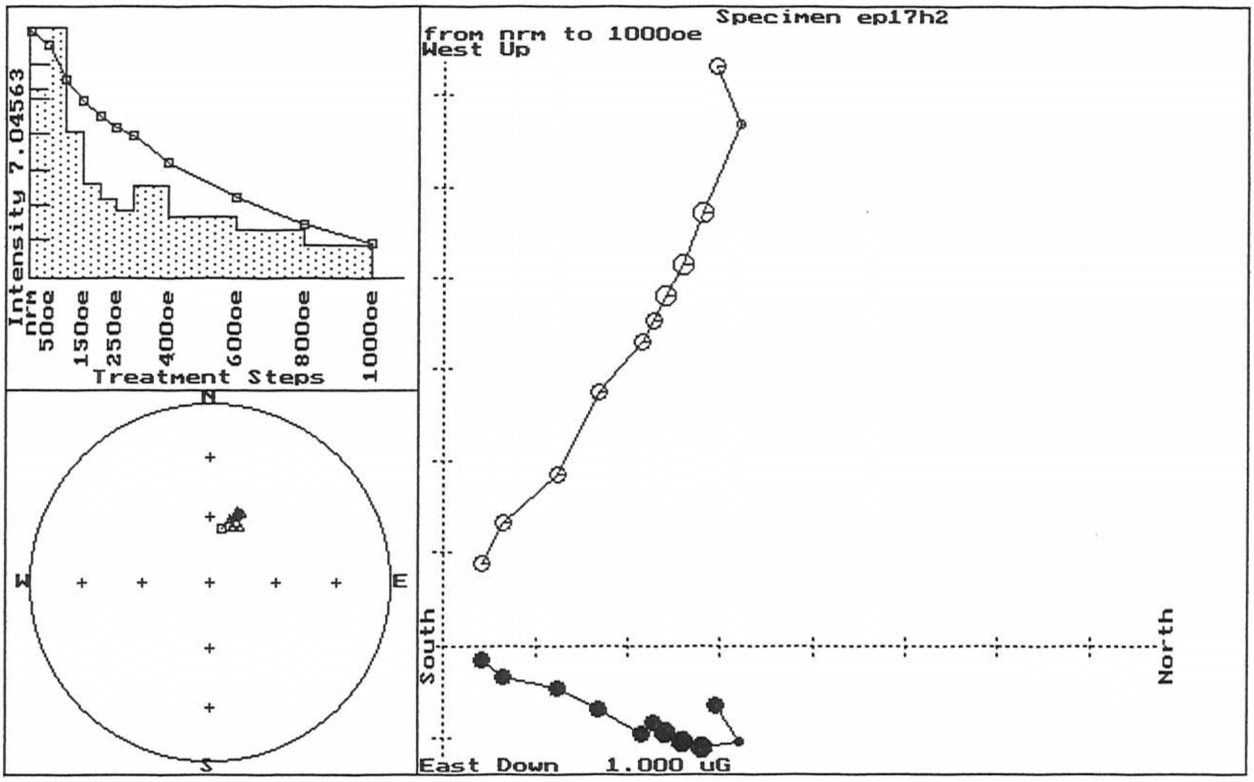


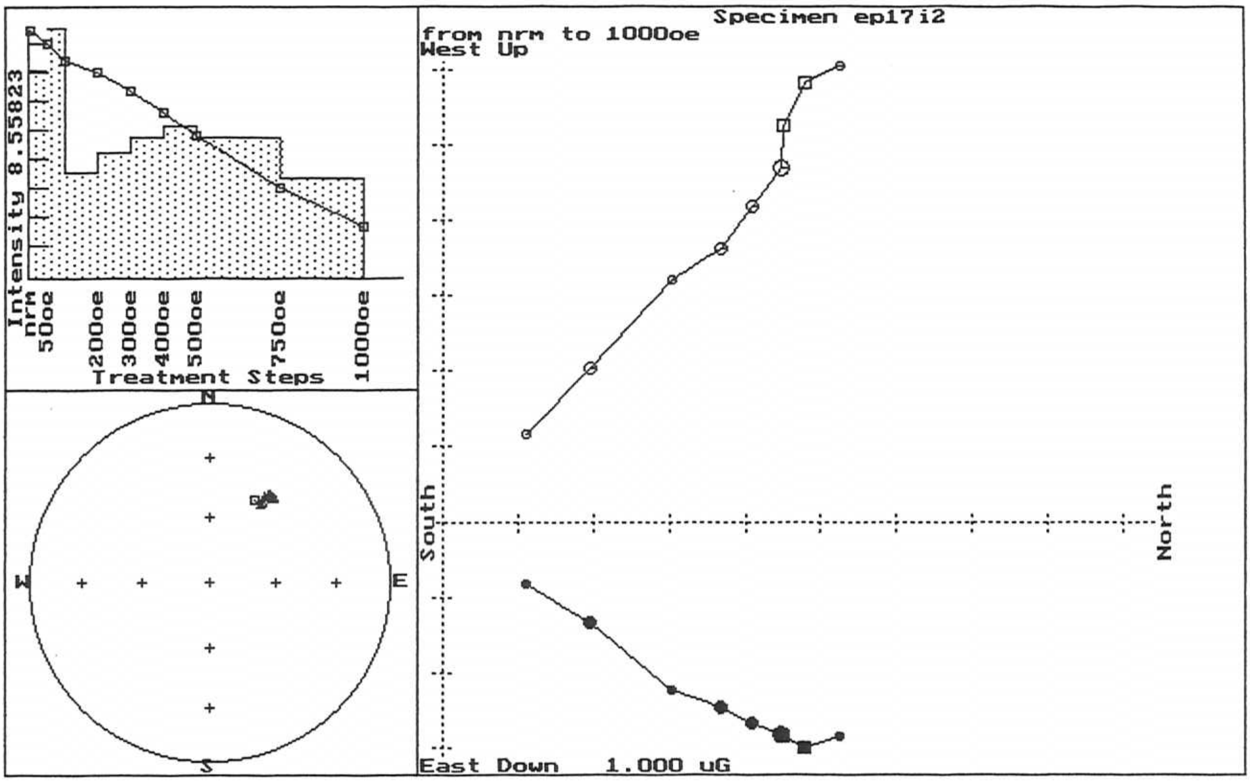
Specimen ep17a2
Intensity 3691.89
nrm
50oe
100oe
200oe
400oe
500oe
600oe
700oe
Treatment Steps
N
W
E
S
from nrm to 700oe
North Up
West
South Down
1000 uG
from 300oe to 700oe
West Up
East
South
North
East Down
100 uG

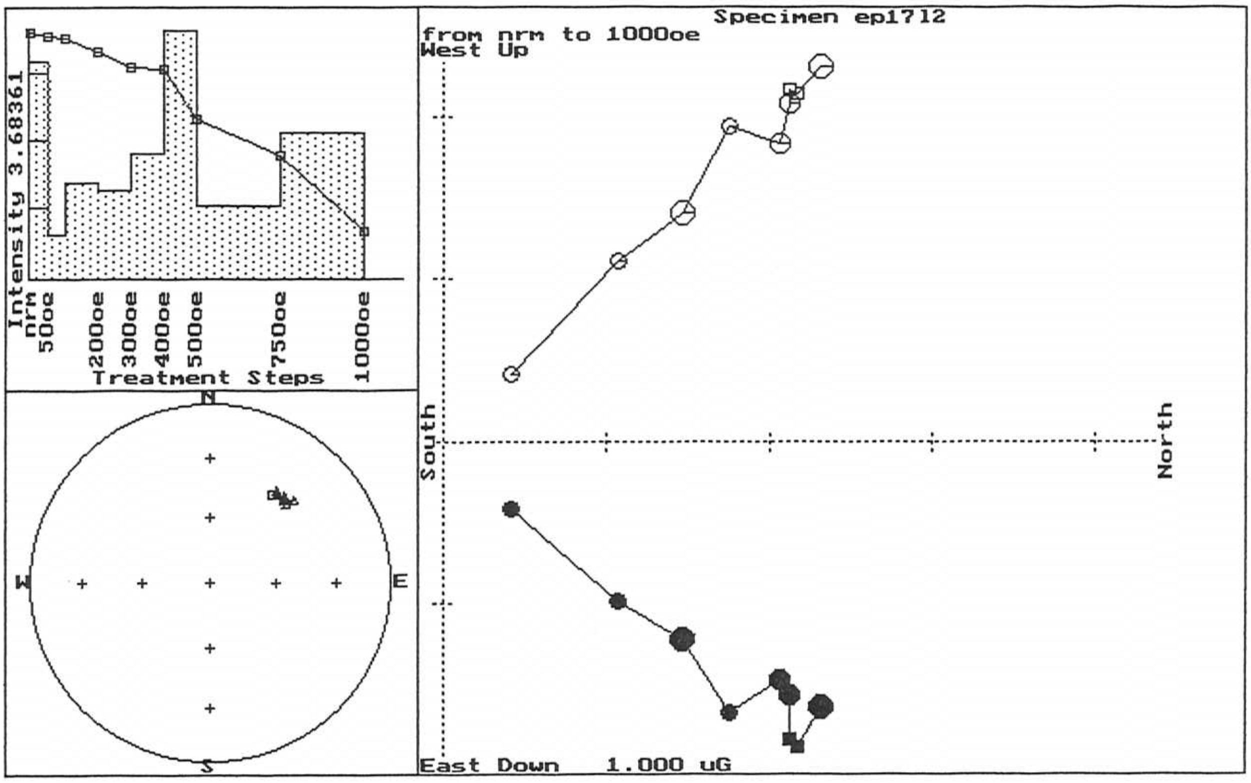


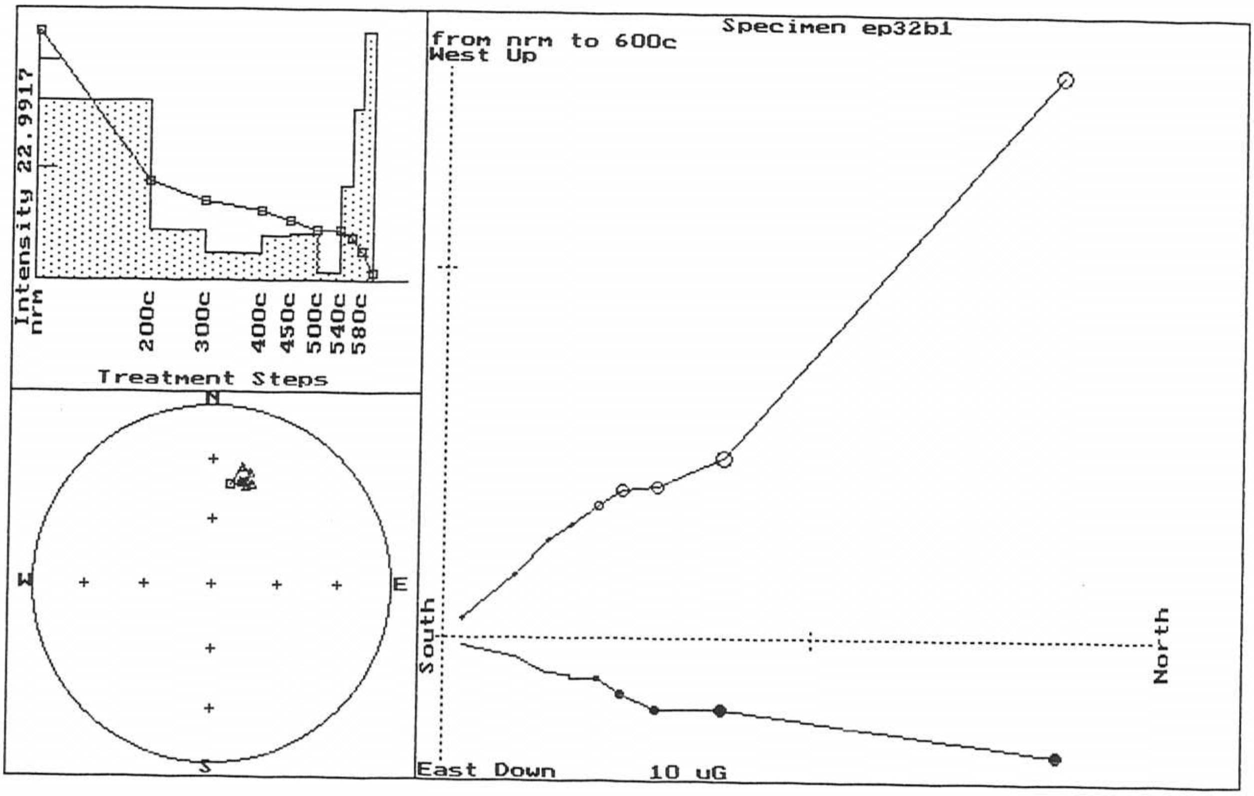
Specimen ep17b2
Intensity 2653.81
nrm
50oe
100oe
200oe
400oe
500oe
600oe
700oe
Treatment Steps
N
W
E
S
from nrm to 700oe
North Up
West
South Down
1000 uG
from 300oe to 700oe
West Up
East
South
North
East Down
100 uG

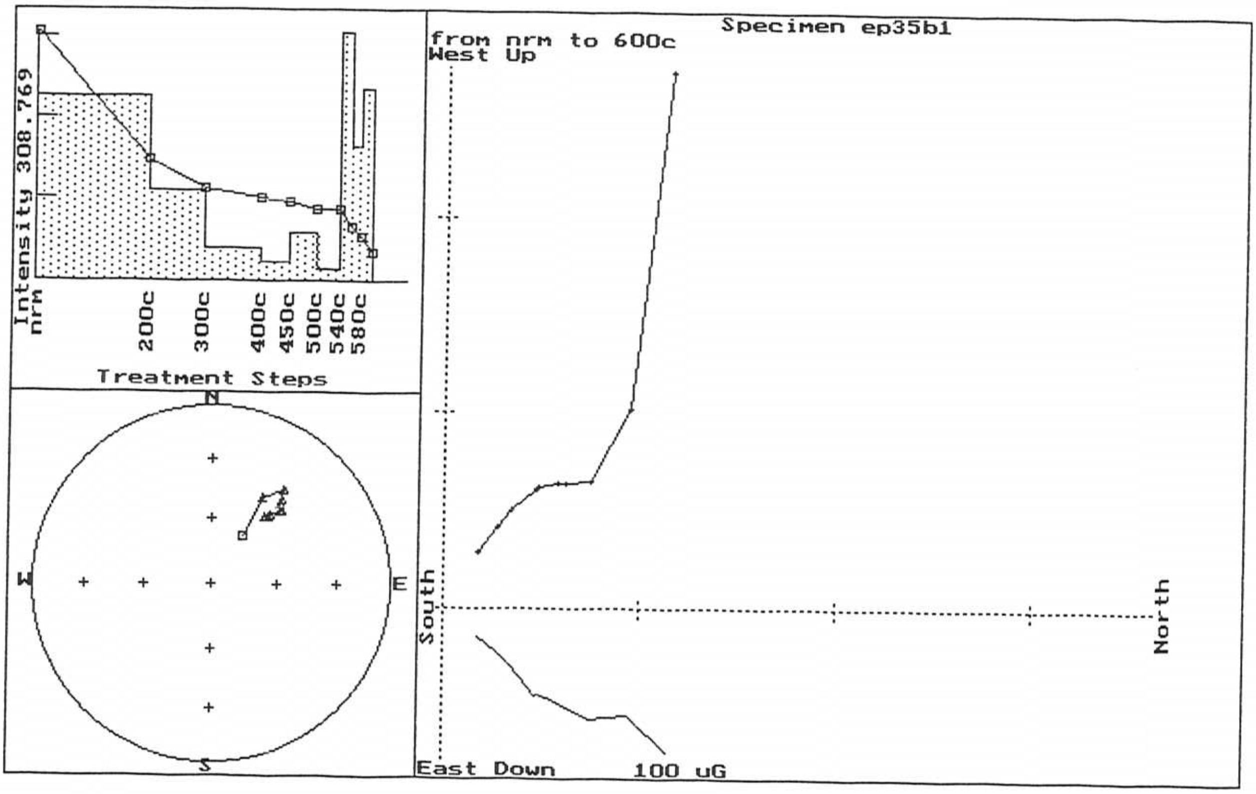

Specimen ep17g2
from nrm to 1000oe
West Up
South
North
East Down 1.000 uG
Intensity 3.0046
nrm
50oe
150oe
250oe
400oe
600oe
800oe
1000oe
Treatment Steps
N
E
S
W

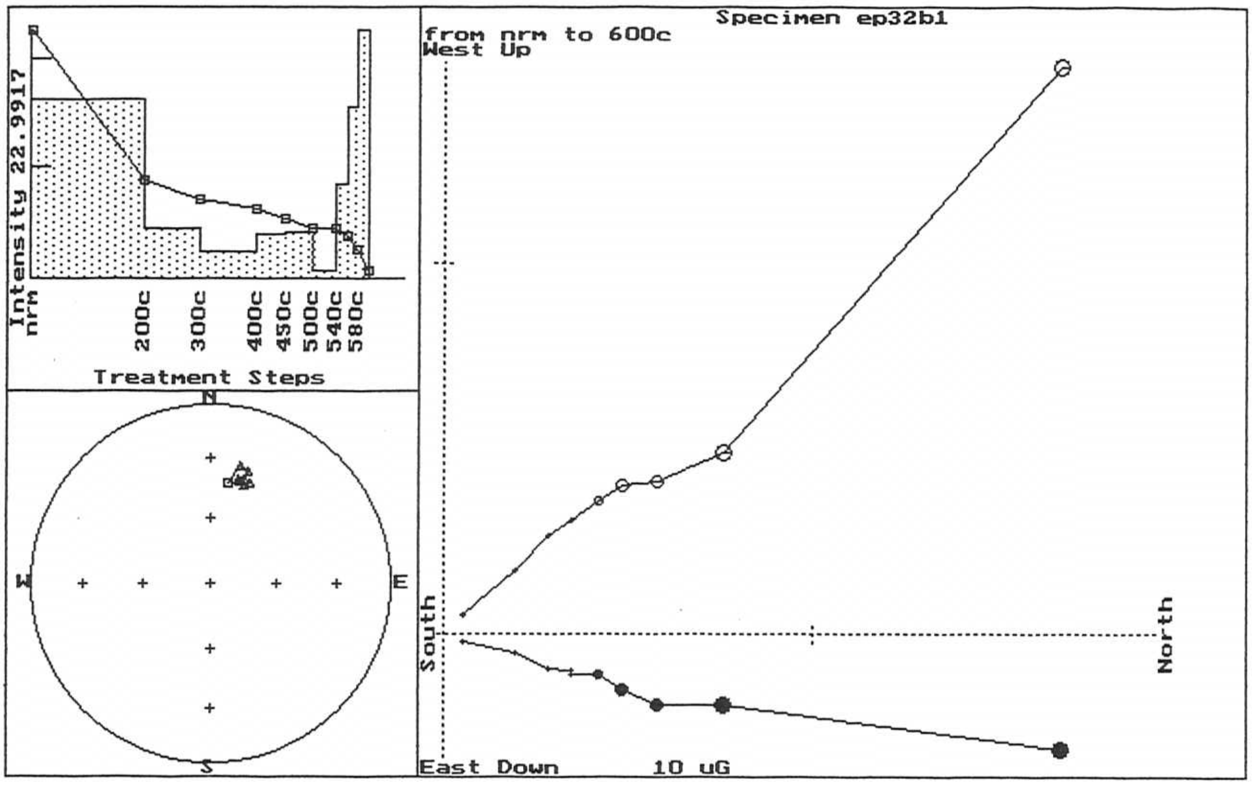

Specimen ep17h2
from nrm to 1000oe
West Up
South
North
East Down 1.000 uG
Intensity 7.04563
nrm
50oe
150oe
250oe
400oe
600oe
800oe
1000oe
Treatment Steps
N
E
S
W

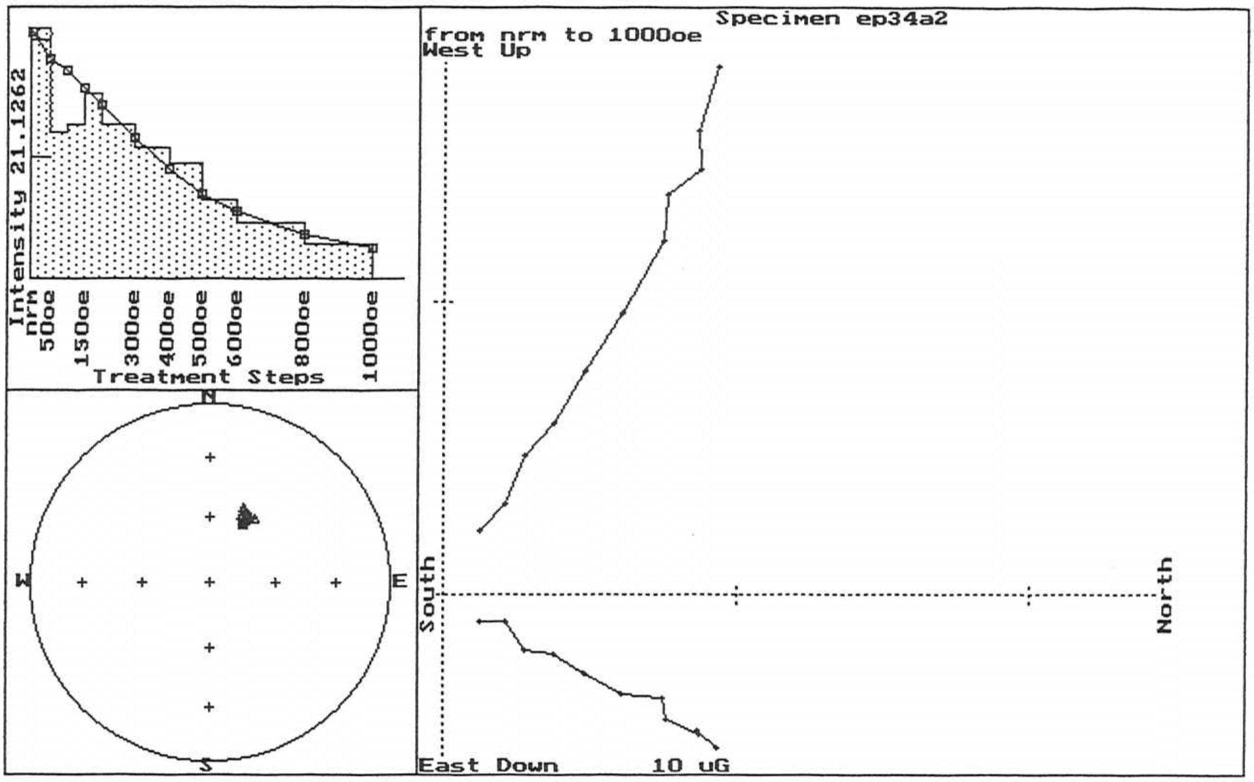

Specimen ep17i2
from nrm to 1000oe
West Up
South
North
East Down 1.000 uG
Intensity 8.55823
nrm
50oe
200oe
300oe
400oe
500oe
750oe
1000oe
Treatment Steps
N
W
E
S


Specimen ep17l2
from nrm to 1000oe
West Up
South
North
East Down 1.000 uG
Intensity 3.68361
nrm
50oe
200oe
300oe
400oe
500oe
750oe
1000oe
Treatment Steps
N
W
E
S


Specimen ep32b1
from nrm to 600c
West Up
South
North
East Down
10 uG
Intensity 22.9917
nrm
200c
300c
400c
450c
500c
540c
580c
Treatment Steps
N
W
E
S

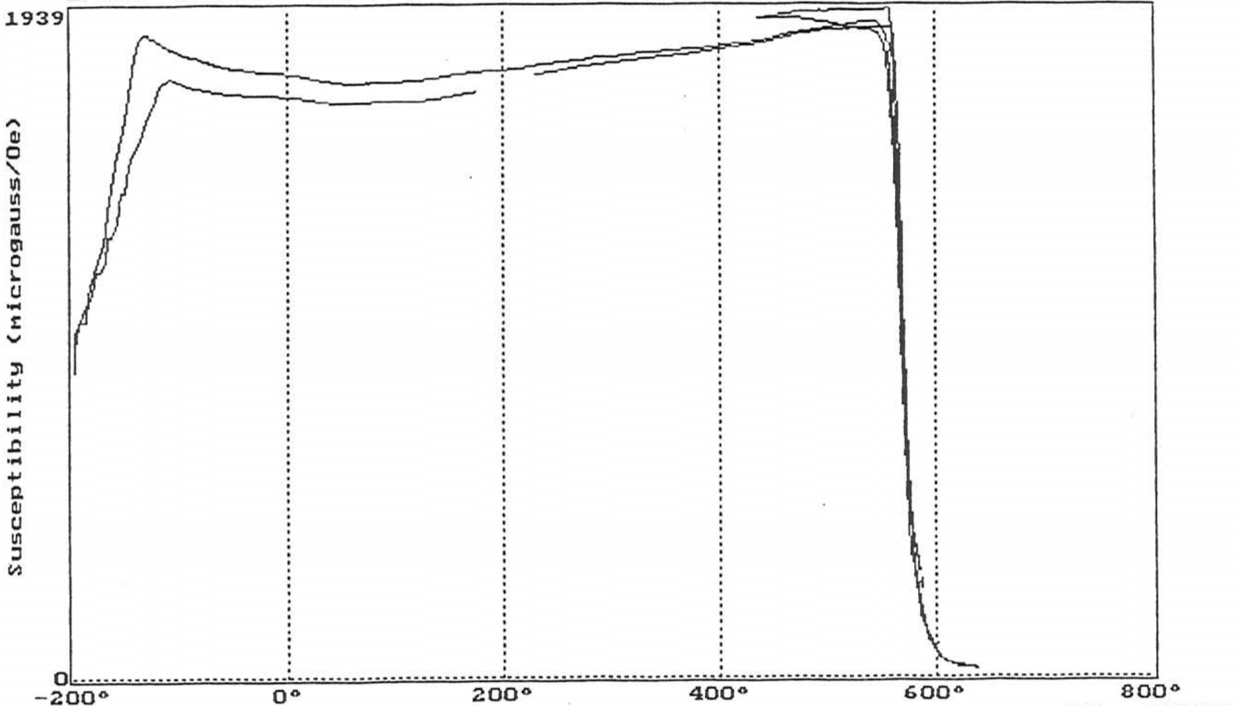

Specimen ep35b1
from nrm to 600c
West Up
South
North
East Down
100 uG
Intensity 308.769
nrm
200c
300c
400c
450c
500c
540c
580c
Treatment Steps
N
W
E
S


Specimen ep32b1
from nrm to 600c
West Up
South
North
East Down
10 uG
Intensity 22.9917
nrm
200c
300c
400c
450c
500c
540c
580c
Treatment Steps
N
W
E
S

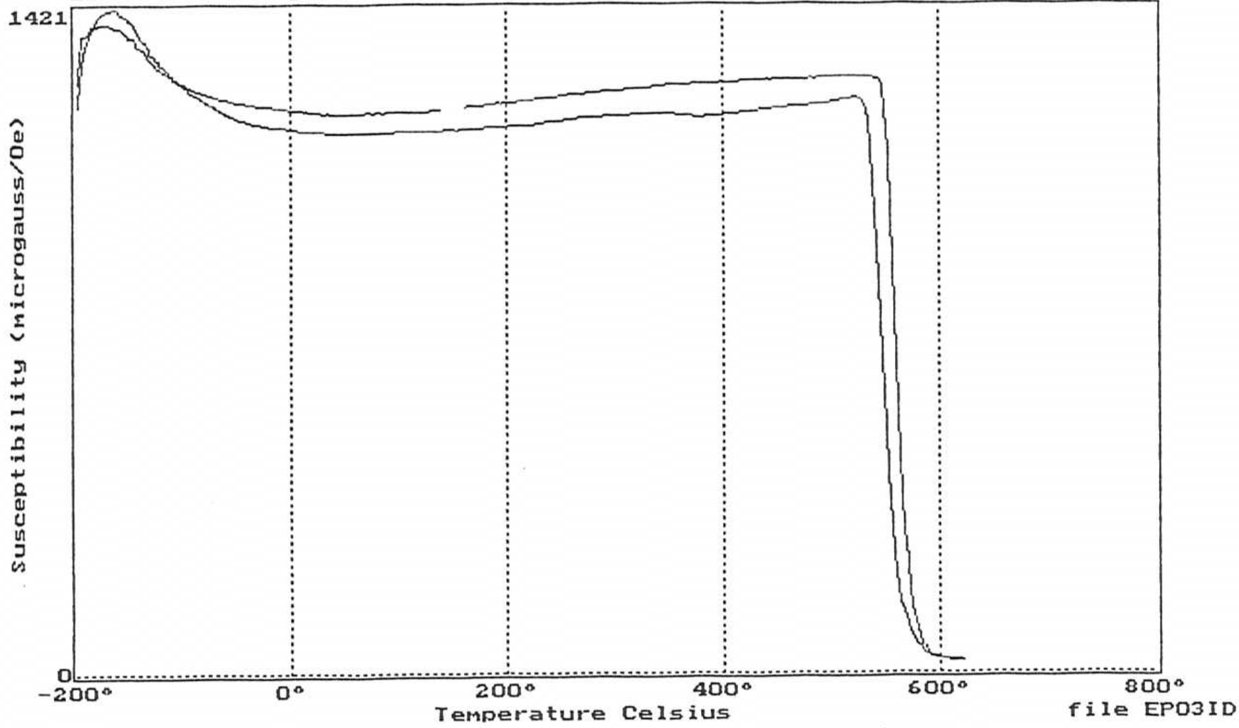

Specimen ep34a2
from nrm to 1000oe
West Up
South
North
East Down
10 uG
Intensity 21.1262
nrm
50oe
150oe
300oe
400oe
500oe
600oe
800oe
1000oe
Treatment Steps
N
W
E
S

APPENDIX II

Low-Field Thermomagnetic Curve
EP01d Gneiss - Port Neill Mylonite Zone

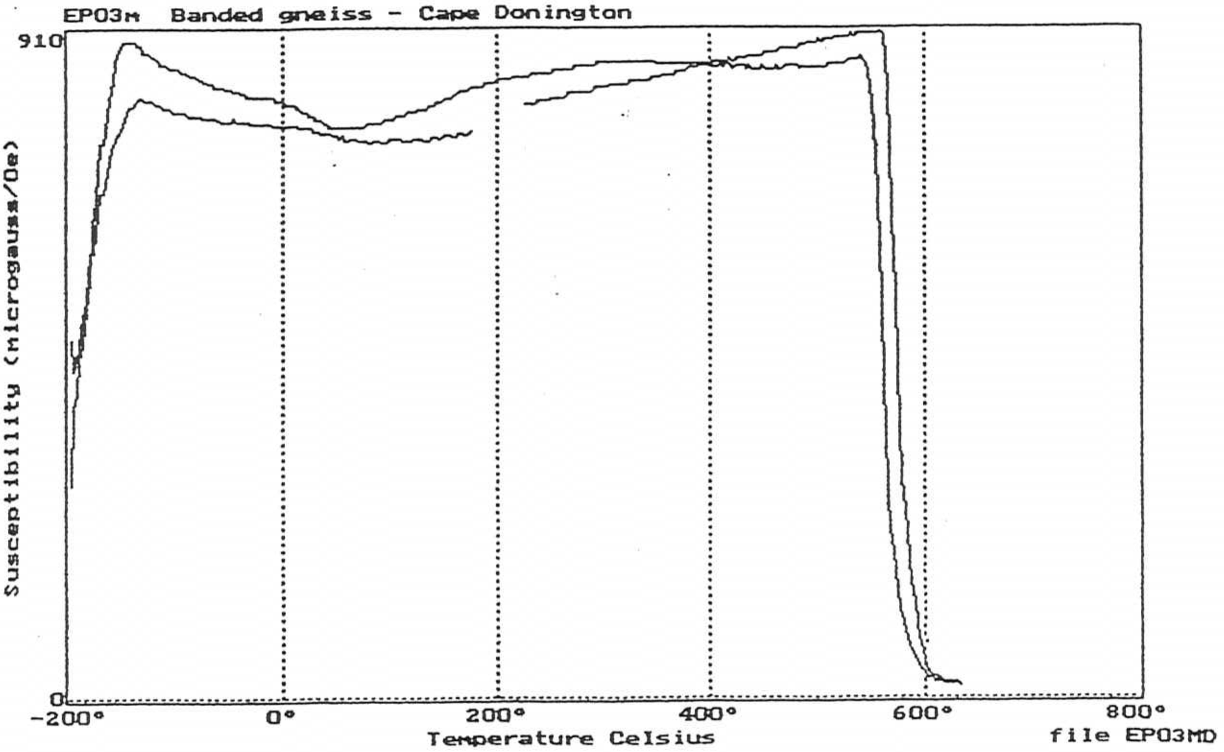


Low-Field Thermomagnetic Curve
EP03i Mafic dyke - Cape Donington



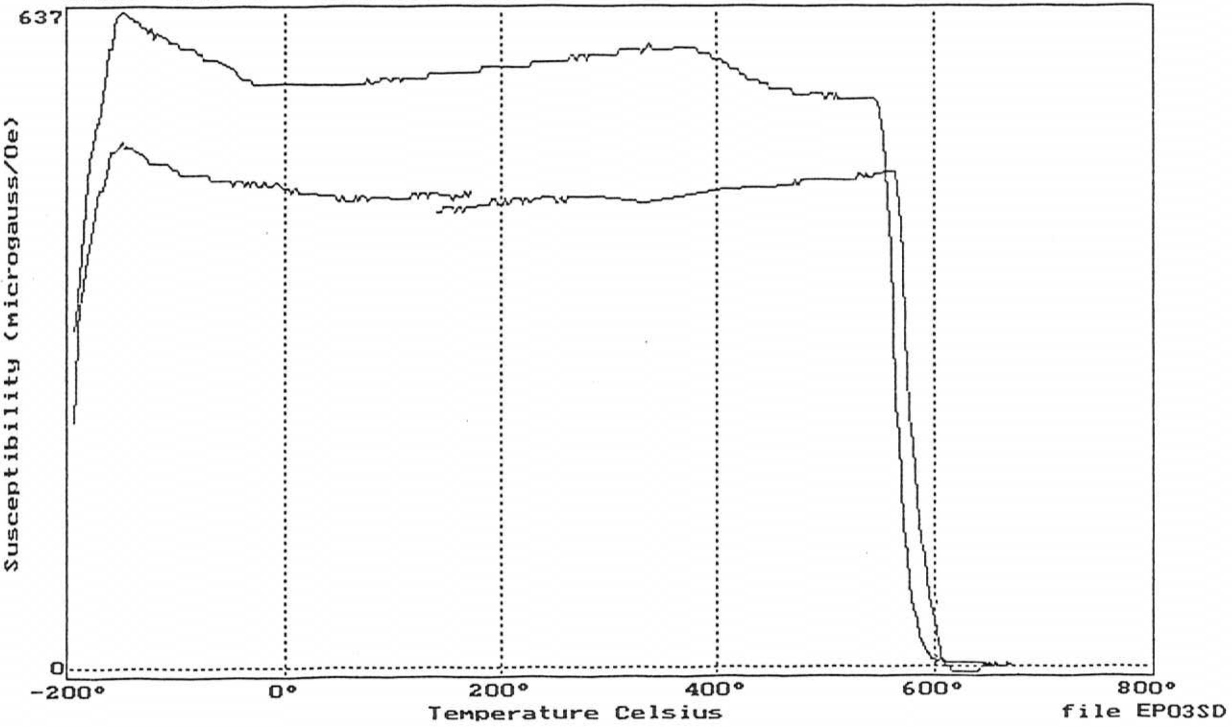
Low-Field Thermomagnetic Curve

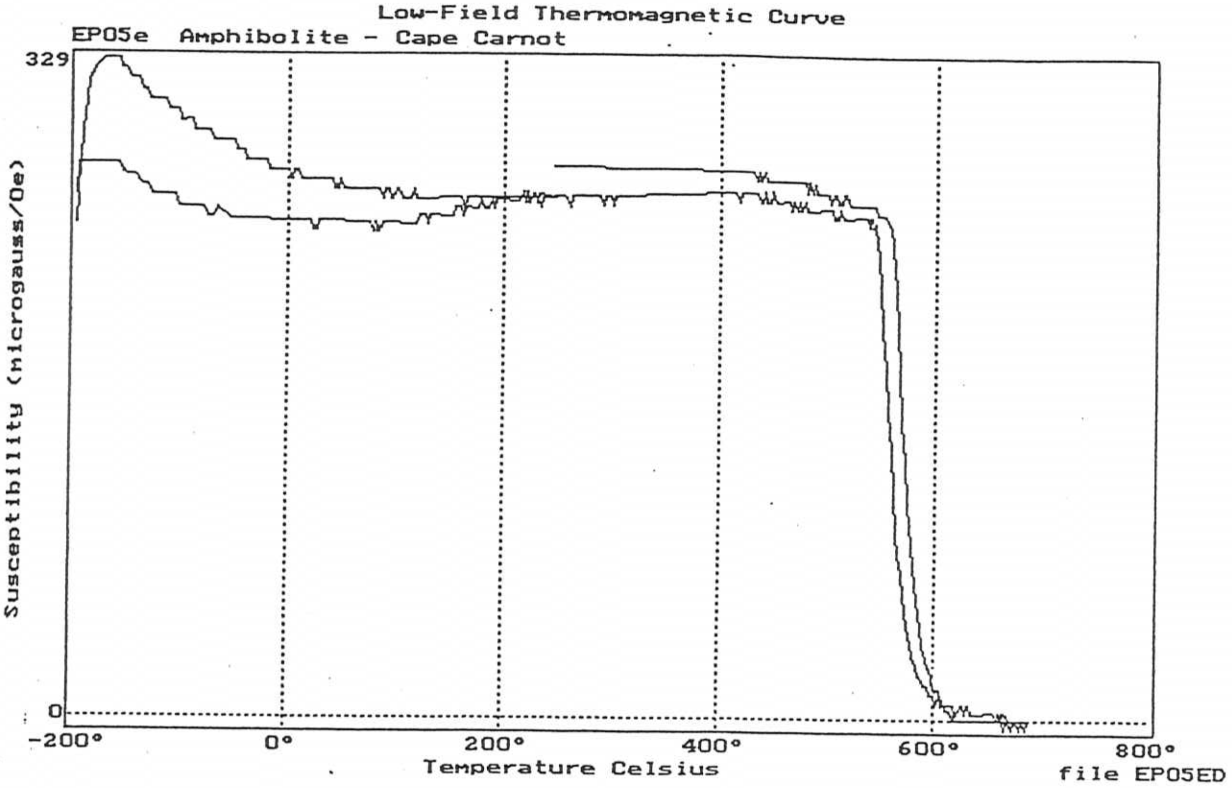
EP03m Banded gneiss - Cape Donington

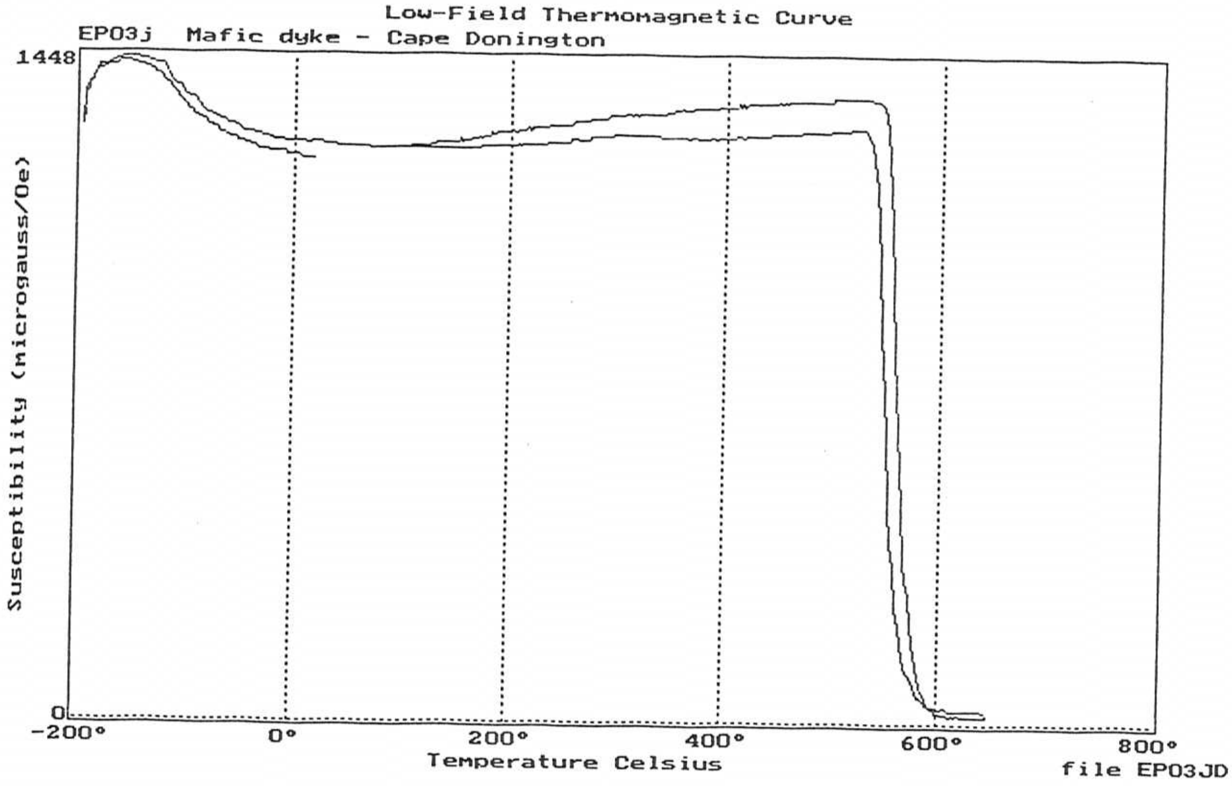


Low-Field Thermomagnetic Curve

EP03s Gneiss - Cape Donington

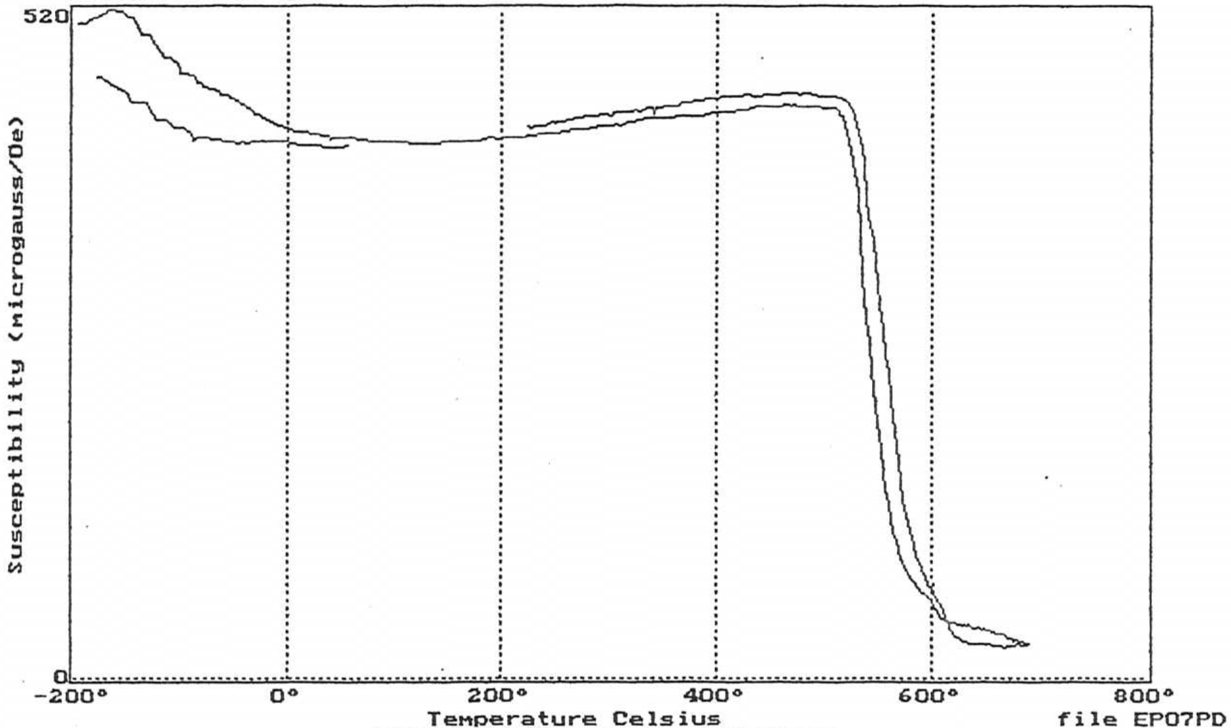



Low-Field Thermomagnetic Curve
EP05e Amphibolite - Cape Carnot
329
0
Susceptibility (microgauss/Oe)
-200°
0°
200°
400°
600°
800°
Temperature Celsius
file EP05ED


Low-Field Thermomagnetic Curve
EP03j Mafic dyke - Cape Donington
1448
0
Susceptibility (microgauss/Oe)
-200°
0°
200°
400°
600°
800°
Temperature Celsius
file EP03JD

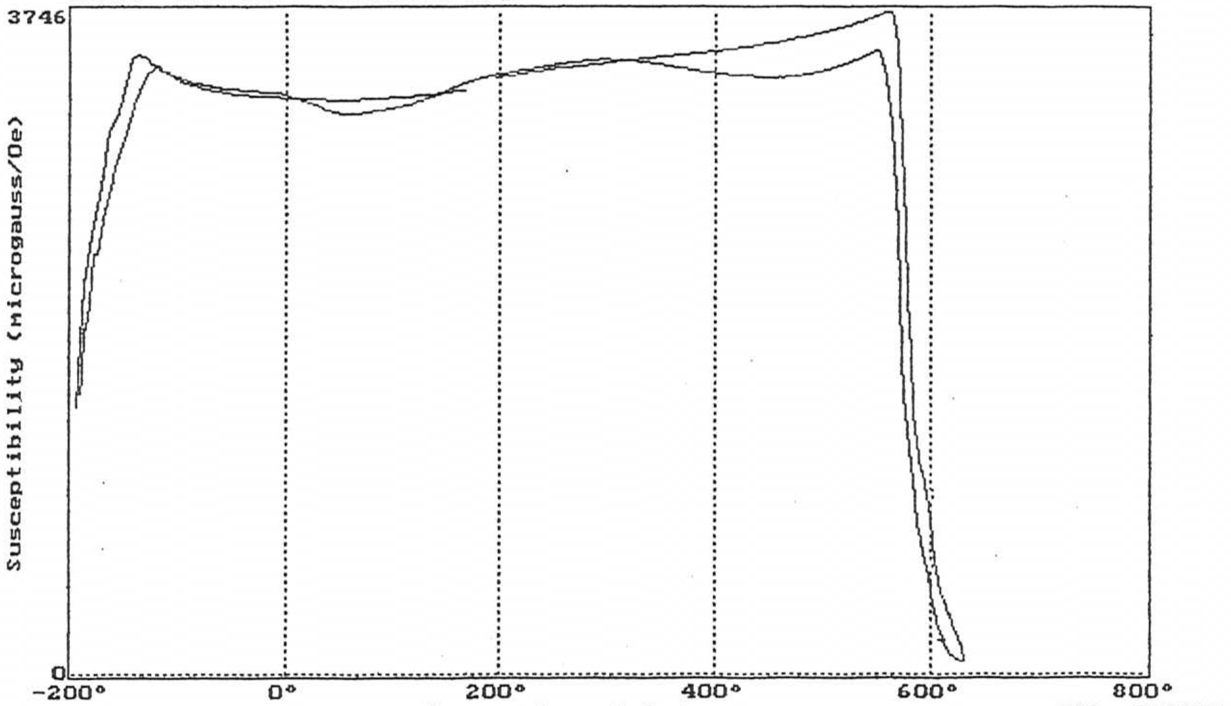
Low-Field Thermomagnetic Curve

EP07p Mafic dyke - Cape Colbert



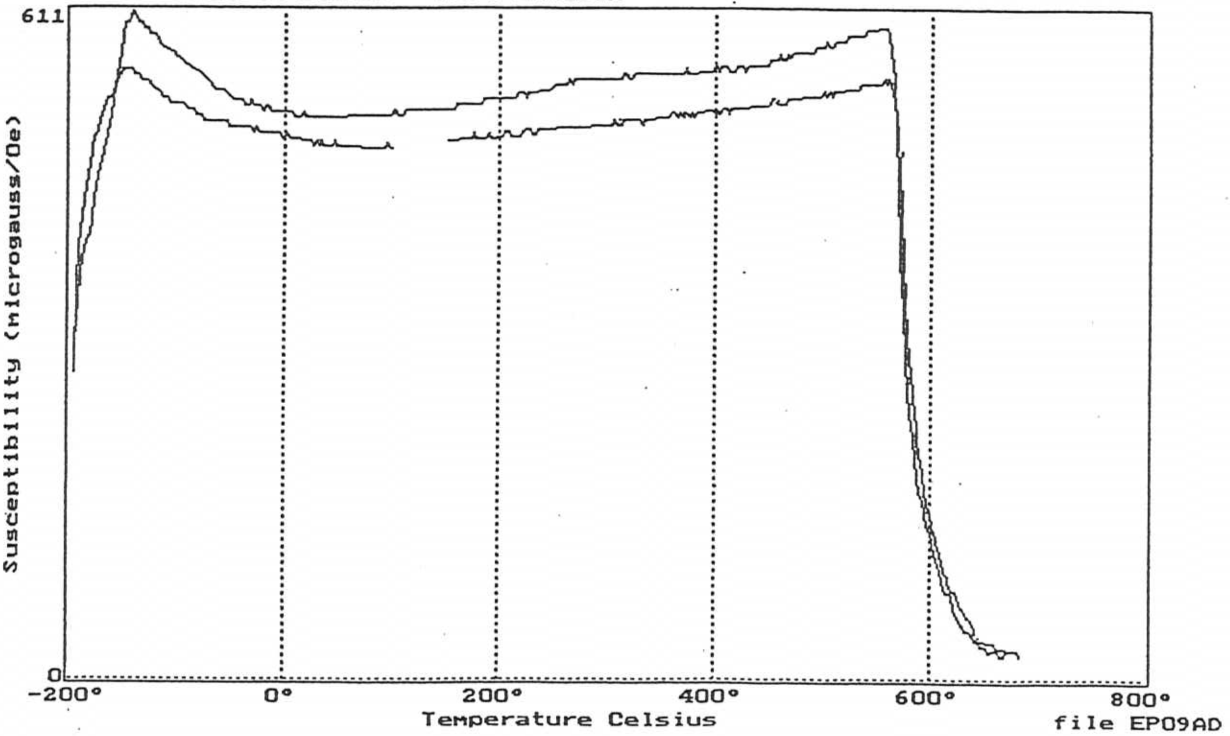
Low-Field Thermomagnetic Curve

EP06f Granite - Sleaford Bay



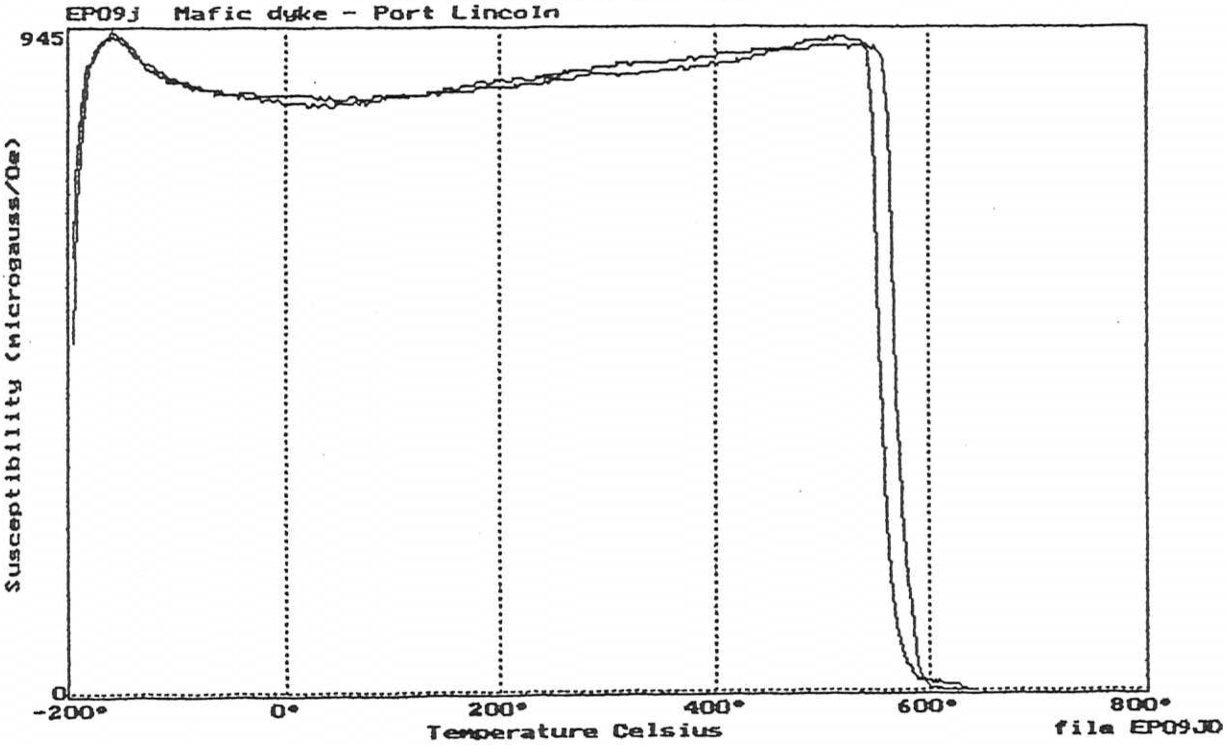
Low-Field Thermomagnetic Curve

EP09a Granite Gneiss - Port Lincoln

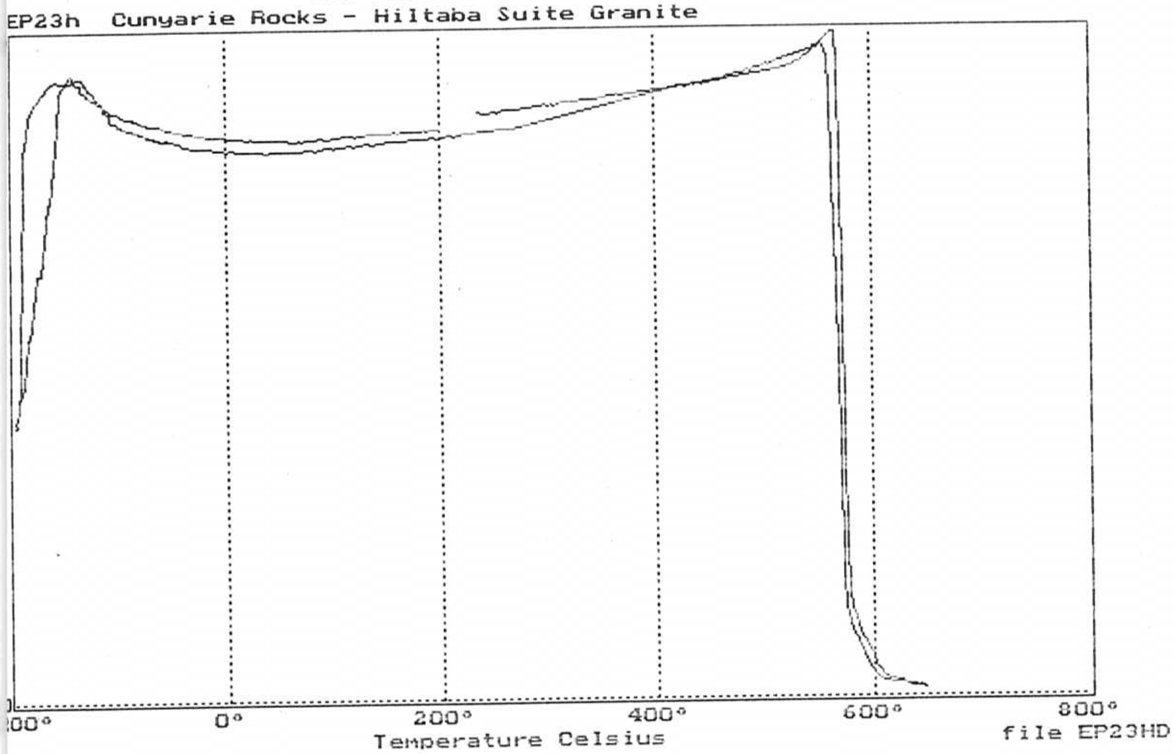


Low-Field Thermomagnetic Curve

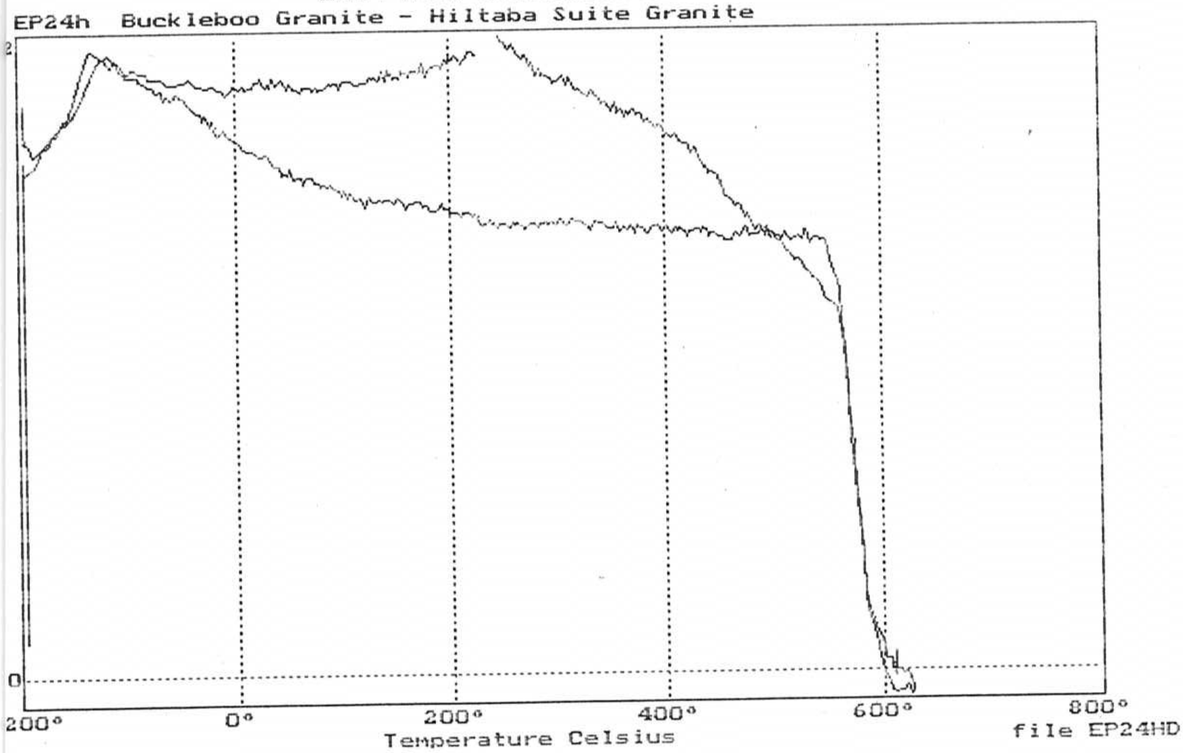
EP09j Mafic dyke - Port Lincoln

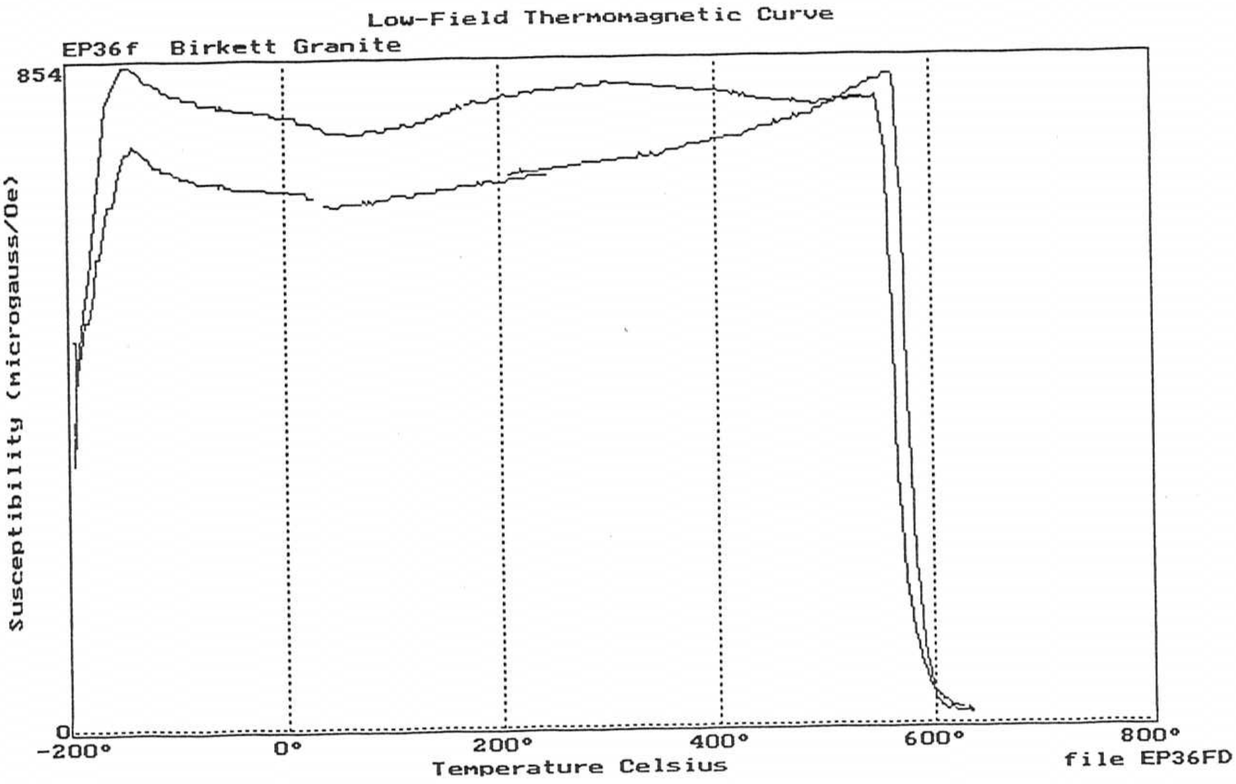


Low-Field Thermomagnetic Curve
EP23h Cunyarie Rocks - Hiltaba Suite Granite



Low-Field Thermomagnetic Curve
EP24h Buckleboo Granite - Hiltaba Suite Granite




Low-Field Thermomagnetic Curve
EP36f Birkett Granite
854
Susceptibility (microgauss/Oe)
0
-200°
0°
200°
400°
600°
800°
Temperature Celsius
file EP36FD