

CSIRO

INSTITUTE OF MINERALS, ENERGY AND CONSTRUCTION
DIVISION OF EXPLORATION GEOSCIENCE

APPLICATIONS OF ROCK MAGNETISM TO MINERAL EXPLORATION

AMIRA PROJECT P96B
(1985-1988)

FINAL REPORT

1. AIMS OF THE PROJECT

This project was designed to improve the interpretation of magnetic surveys by elucidating the relationship between geology and magnetic signatures. Case study areas, for which the geological significance of magnetic anomalies was incompletely understood, were selected on the basis of exploration interest, availability of high quality magnetic survey data, and accessibility of outcrop and/or availability of drill core. The dependence of magnetic properties and magnetic signatures on lithology, metamorphic grade, alteration and structure were assessed and the relative importance of induced magnetisation, remanence, susceptibility anisotropy and self-demagnetisation were evaluated for the different geological environments. The results from each case study area were integrated into a computerised catalogue of magnetic properties of rocks, along with results from proprietary studies and other research projects.

During the course of the project sponsors were also informed of other relevant research by the rock magnetism group, including fundamental studies of the magnetic properties of pyrrhotite, evaluation of the effects of superparamagnetic and viscous grains in soils and rocks on TEM responses, methods of incorporating magnetic property measurements into quantitative modelling of magnetic anomalies, and determination of the cause of high frequency noise in towed proton precession magnetometers.

2. CASE STUDY AREAS

Sampling programmes were carried out in six study areas:

- (i) Hamersley Basin - BIFs and iron ores,
- (ii) Tennant Creek Au-bearing ironstones and host rocks,
- (iii) Broken Hill area,
- (iv) Kalgoorlie-Kambalda-Norseman belt + Ora Banda,
- (v) Davyhurst area (Great Ophir and Homeward Bound),
- (vi) Eastern Mt Isa Block (Trough Tank and Starra).

3. SAMPLING

A total of 513 samples were collected for the above case studies, which is an average of 85 per study. During the period of the project 245 samples from 30 different localities were also processed for proprietary studies. Thus results from a total of 743 samples were used to augment the catalogue of magnetic properties during the project.

4. REPORTING

Results were communicated to sponsors in the form of CSIRO Restricted Investigation Reports, sponsors' meetings, quarterly AMIRA reports and informal reports and reprints circulated with the quarterly reports or with minutes of sponsors' meetings. The following Restricted Investigation Reports were distributed to sponsors during this project:

- 1571R - Intrinsic magnetic properties of pyrrhotite
- 1602R - Palaeomagnetic data presentation and analysis
- 1608R - Catalogue of magnetic properties of Australasian rocks II
- 1638R - Magnetic properties of the BIFs of the Hamersley Basin, W.A.
- 1639R - Geological structure and magnetic signatures of Hamersley BIFs
- 1691R - Magnetic properties of ironstones and host rocks from the Tennant Creek area
- 1693R - Theoretical rock magnetism of monoclinic pyrrhotite
- 1743R - Magnetic properties, magnetic stratigraphy and magnetic fabric of rocks from the Northern Leases, the Redan/Farmcote area, the Rise and Shine area and the Rupee Trend, Broken Hill Block
- 1744R - Magnetic properties of gold-bearing greenstones and associated rocks from the Eastern Goldfields of Western Australia
- 1745R - Magnetic properties and magnetic signatures of the Trough Tank and Starra copper-gold deposits, eastern Mt Isa Block.
- 1746R - Catalogue of magnetic properties of Australasian rocks III.

The following informal reports were also distributed to sponsors:

- * TEM response over a magnetically viscous half-space,
- * Calculating B_m from B_T ,
- * Interpretation of magnetics using magnetic property data - case histories from Australia,
- * Source of high frequency noise in towed proton precession magnetometers.

Research papers circulated to sponsors included:

- * Continuous versus stepwise thermal demagnetization and theories of thermoremanence,
- * Magnetic and gravity anomalies due to a triaxial ellipsoid (originally circulated in preprint form),
- * The use of electrical conductivity and magnetic susceptibility tensors in rock fabric studies,
- * The magnetisation of the Elura orebody, Cobar, NSW,
- * Low latitude of deposition for Late Precambrian periglacial varvites in South Australia: implications for palaeoclimatology,

- * Prefolding and pre-megakinking magnetisations from the Devonian Comerong Volcanics, NSW, and their bearing on the Gondwana pole path,
- * Comments on "Plate tectonics with fixed continents: a testable hypothesis - II",
- * The accumulation of palaeomagnetic results from multicomponent analyses,
- * A critique of palaeomagnetic results from Australian fold belts and displaced terranes,
- * Pre and post folding magnetisations from the Devonian Snowy River Volcanics and Buchan caves Limestone, Victoria.

5. MAIN RESULTS

5.1 Hamersley Basin

The magnetic signatures of the Hamersley BIFs are profoundly influenced by susceptibility anisotropy and by remanence. Magnetic properties of the four major BIF units are broadly similar. The effective anisotropy is typically ~3 and the Q values are generally 1-2. The NRM of flat-lying units is directed ~NW and is subhorizontal. The high anisotropy greatly suppresses the dip dependence of the anomaly shape (see Figs.1-2) and the effect of remanence is strike dependent, being negligible for NW strike and attaining a maximum for NE-striking units. Except for ~NW-striking BIF units, the dip-dependence of anomaly form is greatly influenced by the relative ages of remanence and folding. In areas of low metamorphic grade the BIFs were found to carry an essentially monocomponent, pre-folding (possibly primary) remanence, whereas in the relatively high grade Tom Price/Turner Syncline area the NRM was found to be predominantly post-folding. This study achieved three breakthroughs:

(i) The bulk remanence of the BIFs, uncontaminated by surface effects, was determined for the first time by using orientable drill core samples.

(ii) Enigmatic magnetic signatures over the Turner Syncline were explained using the magnetic properties determined from BIF samples, opening the way to reliable modelling of geological structure in the Hamersley Basin, with application to the search for structures favourable for iron ore formation (see Figs. 3-4).

(iii) The age and duration of iron ore formation was found to vary significantly across the Basin, on the basis of the palaeomagnetism of the Paraburdoo, Tom Price and Mt Newman deposits. Broadly speaking, Paraburdoo ore seems to have been formed relatively early and rapidly (in the Early Proterozoic), Mt Newman ore is inferred to be significantly younger (probably by several hundred Ma) and Tom Price ore appears to have undergone a long and complex genesis, spanning the time interval between formation of the Paraburdoo and Mt Newman ores.

5.2 Tennant Creek Field

The contributions of susceptibility and remanence to the magnetic signatures of the Tennant Creek ironstones and of magnetic sediments were characterised and were shown to be reasonably predictable. Knowledge of ironstone susceptibility is crucial to quantitative modelling for drill targetting, because the form of the anomaly is greatly affected by self-demagnetisation (see Fig.5). Remanence directions and Q values of ironstones and magnetic sediments are fairly consistent across the Field because the remanence is dominated by a thermal overprint of regional extent. This remanence component is subvertical upwards and is interpreted to correspond to a major isotopic event at 1650 Ma. An underlying harder component of remanence, which corresponds to the initial metamorphism at ~1800 Ma, is also carried by many samples, but usually makes only a minor contribution to the NRM. Within the magnetite-facies zone of the field, ironstone susceptibilities are typically ~0.45 G/Oe (cgs) and $Q \sim 1$. The magnetic fabric defined by the susceptibility anisotropy of the host rocks correlates with the local geological structure and appears to provide an indication of the attitude of nearby ironstone bodies (see Fig.6).

5.3 Broken Hill Area

A total of 201 samples were collected from surface traverses and drill holes and the results were integrated with those of 87 samples collected previously. The main results of the study were:

(i) Extensive sampling within the Broken Hill Block has failed to find any characteristic remanence direction, even on a mesoscopic scale, although individual samples may have intense NRM and high Koenigsberger ratio. The form of both short and long wavelength features in ground and aeromagnetic surveys is almost always consistent with magnetisation parallel to the present geomagnetic field, suggesting that induced magnetisation dominates remanence on a macroscopic scale. Q values of magnetic subsurface samples are usually less than unity, suggesting that surface samples with high Koenigsberger ratios have been affected by lightning and that their NRMs are unrepresentative of the bulk of the rock unit. The inconsistency of raw and cleaned remanence directions in samples which are unaffected by palaeomagnetic noise is probably due to the prolonged complex thermal history of the Broken Hill Block. Although the bedrock lithologies do not appear to carry a useful palaeomagnetic signal, palaeomagnetic dating of ferricrete formation seems to be feasible.

(ii) Most lithologies present in the Broken Hill Block can be locally magnetic, but magnetic rocks represent only a minor component of the total volume. The magnetic mineral causing almost all substantial anomalies is magnetite. Prominent curvilinear anomalies are usually subparallel to geological boundaries, but are often slightly discordant. Magnetic horizons tend to be confined to particular stratigraphic intervals, within

which individual magnetic units are sometimes very persistent but more often have short strike length. Within such magnetic zones individual anomalies tend to build up and attenuate along strike, dropping out altogether then reappearing at a slightly different stratigraphic level. A generalised magnetic lithostratigraphy can be devised for the Broken Hill Block. There are, however significant differences in magnetic character between different areas, which can be used to subdivide the Broken Hill Block into various magnetic domains.

(iii) Measurement of magnetic properties of samples collected from magnetic zones confirmed that otherwise "normal" rocks, including pelitic and psammitic metasediments and composite gneisses, quartzofeldspathic gneisses and amphibolites (all of which are generally weakly magnetic) often contain substantial amounts of magnetite and hence are magnetic. Such rocks are often adjacent to, or enclosing, or stratigraphically equivalent to, magnetite-rich chemical sediments such as quartz-magnetite rocks and bifs. Quartz-magnetites and bifs are invariably strongly magnetic, but are often very thin. Individual units of such rocks may therefore produce relatively small aeromagnetic anomalies, although the ground magnetic response over outcropping or subcropping units is spectacular. Much of the aeromagnetic response over stratigraphic intervals which contain these rocks arises from the generally elevated level of magnetite in the surrounding rocks. Individual magnetic units within magnetic zones are generally thin and may be impersistent, causing sampling problems. The paramagnetic susceptibilities of amphibolites are consistently greater than those of metasediments and quartzofeldspathic gneisses, which in turn are greater than the paramagnetic susceptibilities of leucocratic quartzofeldspathic gneisses. The differences arise from the different proportions of mafic minerals in these rocks. It has been shown that in magnetically quiet areas, where magnetite is absent, rock units may be directly mappable using high resolution magnetic surveys to detect the low amplitude anomalies arising from the small, but systematic, susceptibility contrasts.

(iv) The magnetic fabric of samples from the Northern Leases area correlates very well with the mapped structures and mesoscopic fabrics. Except for the site within the Globe-Vauxhall Schist Zone, the magnetic foliations clearly reflect overprinting of bedding-parallel S1 by the axial plane schistosity of second generation folds (S2). Minor susceptibility axes either cluster near the pole to the dominant schistosity or are streaked between the S0/S1 and S2 poles, reflecting varying degrees of overprinting of schistositities. Magnetic lineations (major susceptibility axes) are parallel to the F2 fold axes. There is some evidence that paramagnetic and ferromagnetic fabrics are overprinted to different extents, indicating that petrofabrics of lower symmetry than orthorhombic could be studied from analysis of paramagnetic and ferromagnetic fabrics of individual specimens, as well as by examining total magnetic fabric data from suites of specimens. Retrograde schist samples have magnetic fabrics which reflect retrogression, with magnetic foliation

parallel to S3 schistosity and magnetic lineation parallel to the petrofabric lineation. The correlation between magnetic fabric and structure obtains within all the structural subareas of Laing et al (1978) from which samples were collected.

(v) The magnetic fabric data from the Rise and Shine and Rupee Trend areas are not as straightforward as those obtained from the Northern Leases, but nevertheless often show a clear relationship with local structure. There is a fairly consistent NE subvertical mean magnetic foliation in the Rise and Shine area, parallel to the predominant S0 and S2 planes, except for the northeastern part of the EL where there is a change in geological strike. The magnetic foliation poles show some streaking (a partial girdle distribution) away from the dominant direction, reflecting variations in bedding/schistosity attitude and overprinting of schistositities. The magnetic lineations are generally orthogonal to this girdle and are interpreted to indicate fold axis plunges. Where plunges are mapped there is reasonable agreement between the magnetic lineations and fold axes. Local plunges are generally to the NE or SW and the magnetic fabric data suggest that steep plunges predominate. The scale of this folding appears to be quite small and the relationship between these local structures and the regional structure of this area is not clear. In the traverse across the Rupee Antiform the magnetic foliations are found to be NE subvertical, parallel to the predominant S0 and S2 planes. Magnetic lineations are subvertical, or else plunge in the SW quadrant parallel to the mapped axes of minor folds.

(vi) A refined magnetic stratigraphy, based on sampling and ground and aeromagnetic surveys, is proposed for the Rise and Shine and Rupee Trend areas (see Fig.7). The dominant magnetic feature of the Rise and Shine area is the broad zone of high amplitude anomalies associated with the Sundown Group, which lies between interpreted Broken Hill Group of the Eastern and Western Lodes. This zone as a whole has great strike length, but consists of at least two magnetic horizons which persist typically for 1 km before dropping out. Other magnetic horizons appear at slightly different stratigraphic levels and disappear in turn. The magnetic zone appears to commence within the lower Sundown Group, but above the basal contact with the Broken Hill Group. There is a fairly persistent subsidiary magnetic horizon within the Hores Gneiss of the Western Lode. This horizon is slightly transgressive, but generally lies in the middle to upper Hores Gneiss, and does not continue up to the contact with the Sundown group. A minor, somewhat impersistent, magnetic horizon, which lies stratigraphically close to the main lode horizon, is also associated with the Parnell Formation of the Western Lode. The Thackaringa Group to the west of the Western Lode is also associated with substantial anomalies. To the east of the Eastern Lode, however, the upper exposed Thackaringa Group rocks, represented by the Stephens Creek Granite Gneiss, are generally weakly magnetic. In the Eastern Lode the upper Hores Gneiss is absent and the only persistent magnetic horizon lies within the Parnell Formation.

(vii) In the Rupee Trend area there are a number of very persistent magnetic zones which define approximate stratigraphic intervals. The largest anomalies are associated with the Cues Formation of the Thackaringa Group which contains quartz-magnetites and lode horizon rocks. Other formations from the Thackaringa Group that are represented in this area (Rasp Ridge Gneiss, Alma Gneiss) are non-magnetic. A prominent, continuous magnetic feature is also associated with the Sundown Group. The general magnetic character of the Thorndale Composite Gneiss qualitatively resembles that of the Cues Formation, but with much lower amplitude anomalies. The Clevedale Migmatite exhibits a noisy magnetic response, associated with a multiplicity of moderately to strongly magnetic sources. Within the Broken Hill Group, the Parnell Formation is associated with a magnetic anomaly which persists from the nose of the Broken Hill Synform along the NW limb. The Freyers Metasediments exhibit a relatively minor anomaly, which arises from a very narrow, strongly magnetic, horizon on the SE limb of the Broken Hill Synform, which continues around the nose of the structure and builds up along the NW limb. On the SE limb of the Rupee Antiform this magnetic horizon is absent from the Purnamoota Subgroup of the Broken Hill Group.

5.4 Yilgarn Block Goldfields

The magnetic properties of a total of 116 drill core samples from five areas in the Eastern Goldfields of Western Australia were measured. The areas were Kalgoorlie (including Hannan Lake), Kambalda, Norseman, Davyhurst and Ora Banda. Many of the drill core samples were oriented using cleavage or schistosity. Magnetic properties measured were remanence, including incremental alternating field and thermal cleaning, low-field susceptibility and the anisotropy of susceptibility. The major findings were:

There appears to be a good (inverse) correlation between metamorphic grade and susceptibility seen in greenstone rocks from Kalgoorlie, Kambalda and Norseman.

Magnetic remanence from these areas seems to be unimportant, although this must be confirmed using underground hand-samples because drill core samples have acquired a drilling induced remanence (DIR). Even so, the DIR intensities rarely gave rise to Koenigsberger ratios greater than unity.

There is a sharp contrast in magnetic properties between Homeward Bound and Great Ophir, at Davyhurst. High remanent intensities are present at Homeward Bound. This was most dramatically displayed in the lode zone where Koenigsberger ratios greater than 20 are present. The effect on the magnetic anomaly can be seen in Fig.8.

The alteration of basalts at Ora Banda is also responsible for high Koenigsberger ratios. The determination of the

palaeomagnetic direction of this intense remanence, carried by pyrrhotite, may provide some age constraints on the alteration.

The most magnetic rocks encountered were the banded cherty sediments from Kambalda and Norseman. These rocks have high remanent intensities and high susceptibilities. They also possess high anisotropy of susceptibility.

Overall there was excellent agreement between visible rock fabric (cleavage, schistosity, etc.) and magnetic fabric as determined from the anisotropy of the susceptibility.

Future rock magnetic work should concentrate upon confirming the low remanent magnetisations in the largely unaltered basaltic rock types at Kalgoorlie, Kambalda and Norseman by avoiding drilling induced remanence. Higher grade metamorphic grade rocks should be investigated. The study of the effects of alteration should be extended to other areas. The palaeomagnetic signature of the alteration may provide age constraints on the alteration.

5.5 Eastern Mt Isa Block

Mineralised Au-Cu bearing quartz-magnetites (bifs) from the Starra and Trough Tank deposits of the Eastern Mt Isa Inlier are intensely magnetised and give rise to large magnetic anomalies, which significantly perturb the ambient geomagnetic field. The mean susceptibility of the Starra samples is 1.7 G/Oe. The mean susceptibility of the Trough Tank ironstone samples is 0.58 G/Oe, whereas the susceptibility estimated from the anomaly, constrained by the drilling information, is 0.47 G/Oe. Within bodies of such high susceptibility the induced magnetisation is attenuated and deflected away from the regional geomagnetic field direction by self-demagnetisation. Remanence makes only a minor contribution to the total magnetisation of these ironstones. The estimated Koenigsberger ratio is ~0.2. The remanence is predominantly directed steeply upwards and appears to be ancient.

Failure to incorporate the effects of self-demagnetisation into interpretation of magnetic anomalies arising from such bodies can lead to serious errors, particularly in interpreted dip. The induced magnetisation of the Trough Tank ironstones is deflected towards the plane of the sheet-like units by ~50°, leading to a comparable error in interpreted dip if self-demagnetisation is neglected (see Fig.9). Failure to take into account deflection of the local geomagnetic field by the intense anomaly contributes an additional error of about 5° to the interpreted dip. These effects account for the original mis-targetting of drill holes at Trough Tank.

The general theory of self-demagnetisation and modelling of large amplitude anomalies was presented in the report. It is recommended that existing software for the calculation of total field magnetic anomalies be modified, in a straightforward manner, so that the calculated anomaly corresponds to what is actually measured by total field magnetometers. Software for

processing magnetic anomaly maps, including upward/downward continuation, reduction to the pole and derivative calculations may also have to be modified to correct for departures of the measured field from the assumed potential field behaviour.

5.6 TEM response over a Magnetically Viscous Half-space

It was shown that rock magnetic determinations of parameters relating to magnetic viscosity in basalts are consistent with values assumed by T. Lee in his theory of the TEM response over a viscous half-space. Thus the anomalous decay predicted by the theory should be observable in the field and may significantly affect interpretation of TEM surveys.

5.7 Source of Noise in Towed Proton Precession Magnetometers

Stockdale Prospecting Ltd observed an enigmatic high frequency ripple on traces produced by a helicopter-towed PPM. The noise was not electronic and was clearly related to motion of the bird. Testing of components showed that magnetic contamination in the magnetometer did not explain the phenomenon. A re-examination of the principles of operation of PPMs demonstrated that rotation of the sensor in the Earth's field produces a shift in the apparent precession frequency which is dependent on the angular velocity and the orientation of the axis of rotation. The theoretically predicted effect is of the correct order of magnitude to account for the observed quasiperiodic ripple in magnetometer output, given reasonable assumptions about the motion of the bird. The effect is therefore fundamental and cannot be obviated by redesign of sensors. Use of PPMs in a towed bird for high resolution aeromagnetics therefore requires improvement of aerodynamic design to improve the stability of the bird.

5.8 Susceptibility Calibration Standards

A set of susceptibility calibration standards, in the form of blocks and cores of various diameters was sent to the W.A. Geological Survey and is available for checking instruments owned by companies operating in W.A.

5.9 Magnetic Properties of Pyrrhotite

Pyrrhotites are characterised by strong antiferromagnetic coupling between adjacent Fe layers. Structures with no vacancies (e.g. troilite, FeS), disordered vacancies (e.g. high-temperature 1C hexagonal pyrrhotite, Fe_{1-x}S) or vacancies distributed equally over both Fe sublattices (e.g. 5C intermediate pyrrhotite, Fe_9S_{10}) are antiferromagnetic. On the other hand the 4C and 3C superstructures, for which the vacancies are ordered onto alternate Fe layers, have inequivalent magnetic sublattices and are ferrimagnetic. This accounts for the high susceptibility and spontaneous magnetisation of 4C monoclinic pyrrhotite (Fe_7S_8). At room temperature the spins and the net magnetic moment of 4C pyrrhotite are confined to the basal plane by powerful

magnetocrystalline anisotropy. Thermomagnetic curves of pyrrhotites are characterised by a number of magnetic and crystallographic transitions which are generally diagnostic of composition (see Fig.10), although the Néel temperature is $\sim 325^{\circ}\text{C}$ for compositions ranging from FeS to Fe_7S_8 . There is evidence of partial, and possibly full, self-reversal of thermoremanent magnetisation in natural pyrrhotites.

Application of single domain and simple multidomain theory to monoclinic pyrrhotite shows that fine-to-medium grained monoclinic pyrrhotite is capable of carrying a hard, stable and intense remanence, associated with a high Q value. This is consistent with petrophysical and palaeomagnetic studies. The remanence carried by pyrrhotite, whilst very stable at ambient temperatures, is relatively easily reset by low grade thermal events and is therefore a sensitive recorder of the thermal history of a pyrrhotite-bearing rock.

Fig.1. Dip-dependence of the magnetic anomaly arising from isotropic induced magnetisation of a 2D sheet-like body.

ISOTROPIC DIPPING SHEETS ($Q=0$)

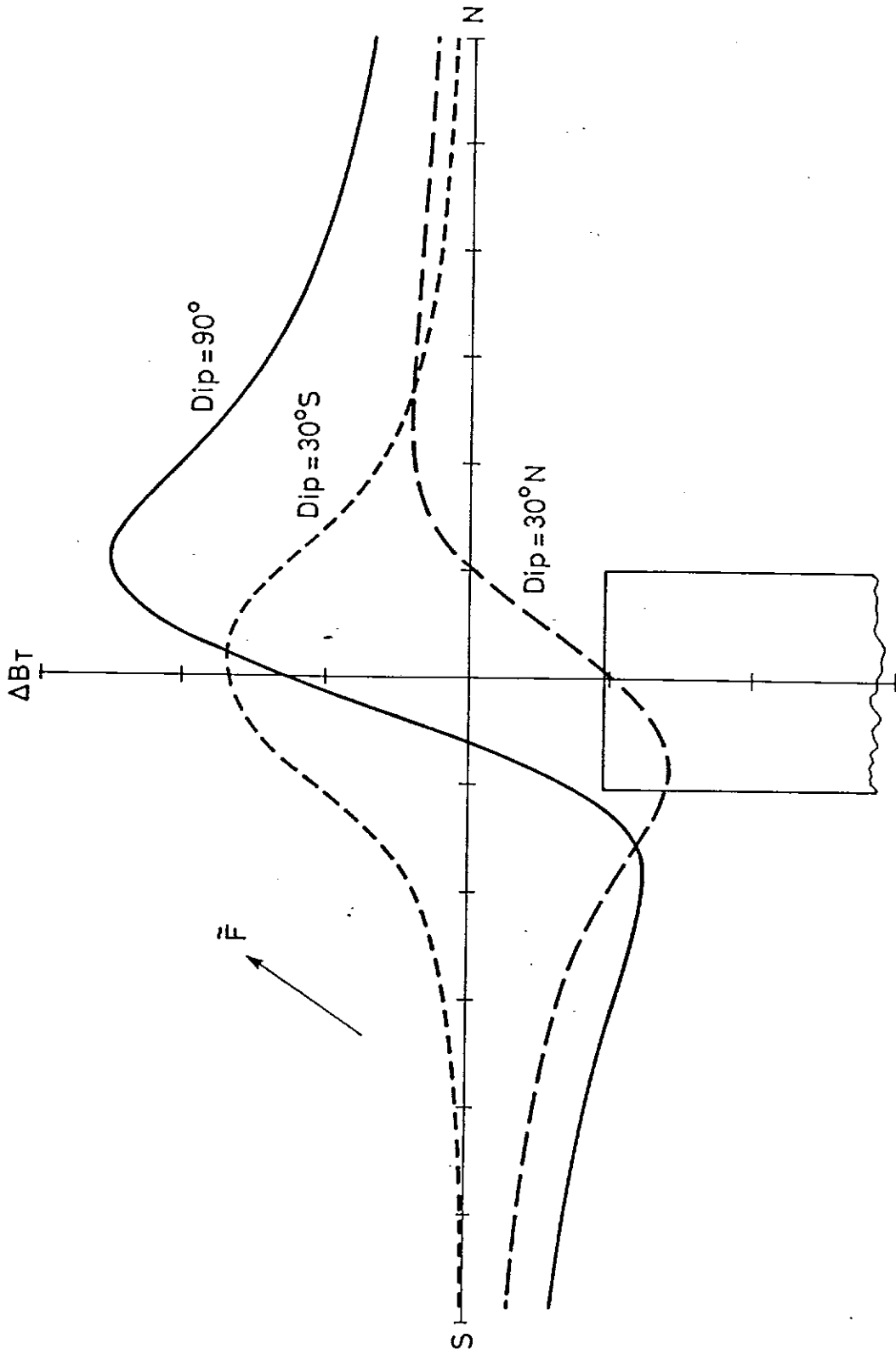


Fig.2. Dip-dependence of the magnetic anomaly arising from the anisotropic component of induced magnetisation of a 2D sheet-like body. The susceptibility within the plane of the sheet is isotropic and the susceptibility normal to the sheet is negligible compared to the parallel susceptibility.

ANISOTROPIC DIPPING SHEETS ($A=\infty, Q=0$)

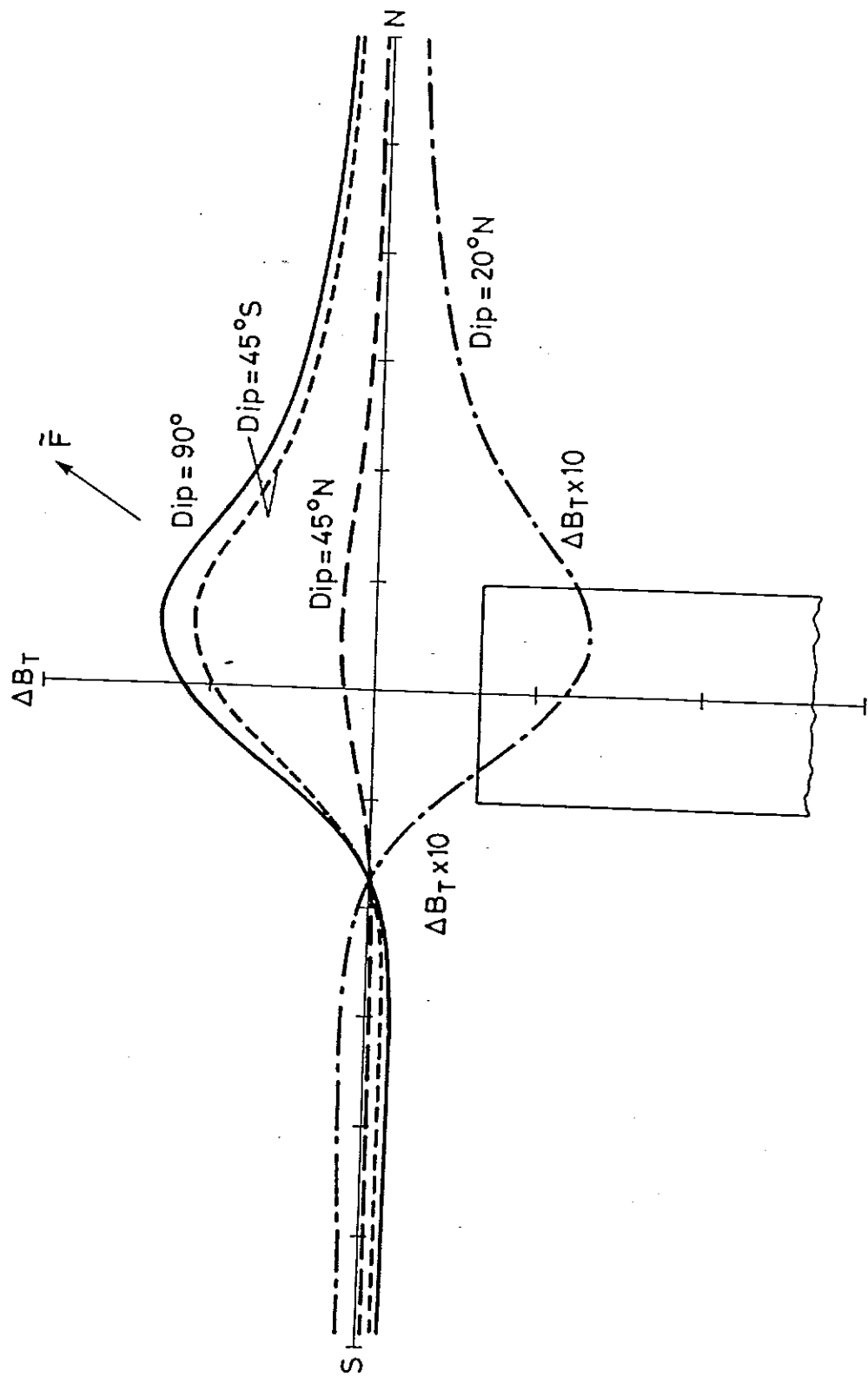
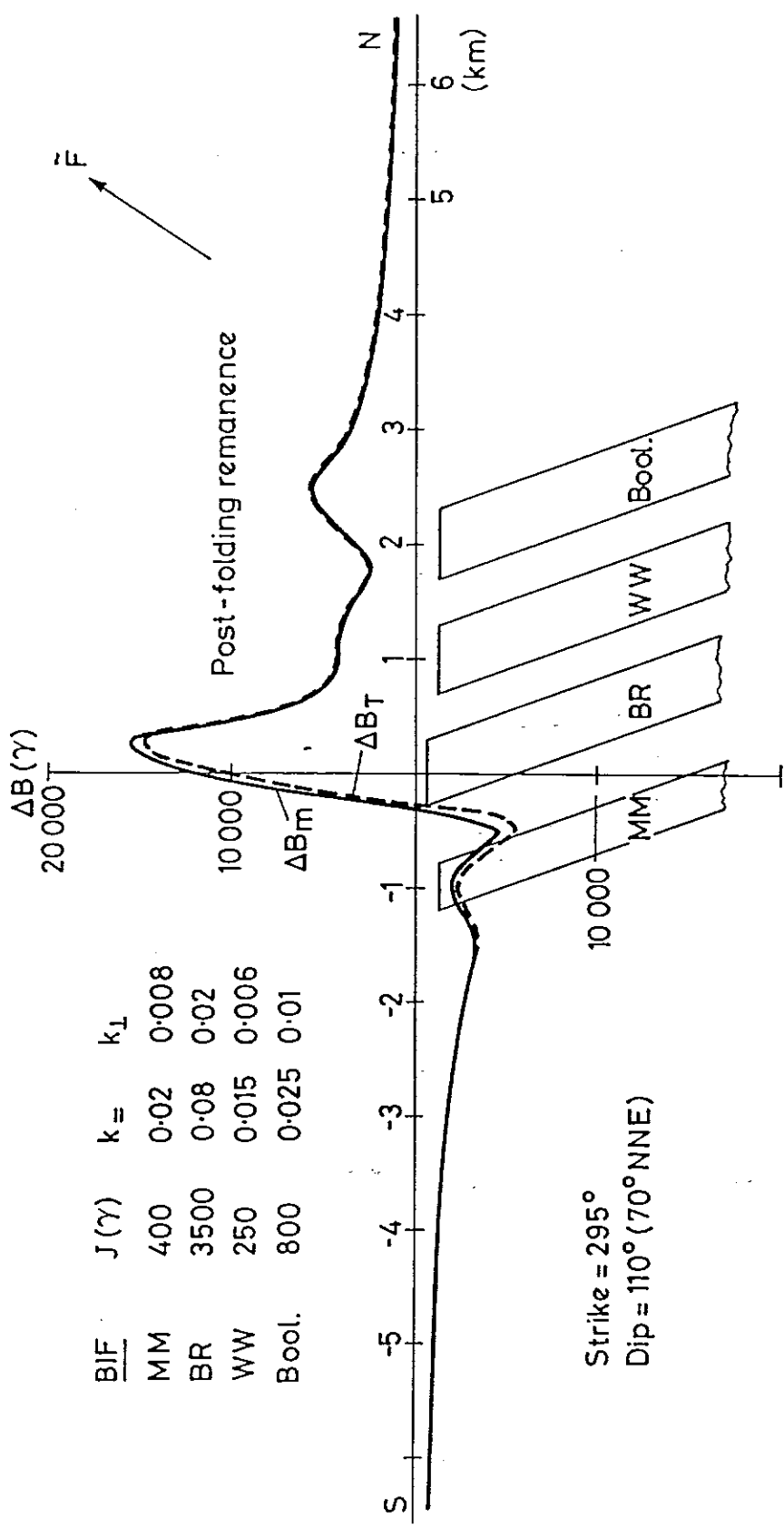


Fig.3. Magnetic model for the SW limb of the Turner Syncline. Susceptibility anisotropy suppresses the magnetic low to the south, compared to the corresponding anomaly for isotropic susceptibility. The apparent dip is to the south, if anisotropy is not taken into account.

TURNER SYNCLINE (SW LIMB)



BIF	J (γ)	k =	k_{\perp}
MM	400	0.02	0.008
BR	3500	0.08	0.02
WW	250	0.015	0.006
Bool.	800	0.025	0.01

Fig.4. As for Fig.3, but for the SE limb of the Turner Syncline. The shallower dip produces a magnetic low and the change in strike allows the effect of remanence to become important. The assumption of post-folding remanence produces an asymmetrical anomaly which fits the observed anomaly much better than the symmetrical low which arises from assuming pre-folding remanence.

TURNER SYNCLINE (SE LIMB)

Strike = 270°
 Dips: 150° (30° N) BR
 130° (50° N) Bool.
 BR + Bool.: J = 2000γ,
 k = 0.045
 k_⊥ = 0.015

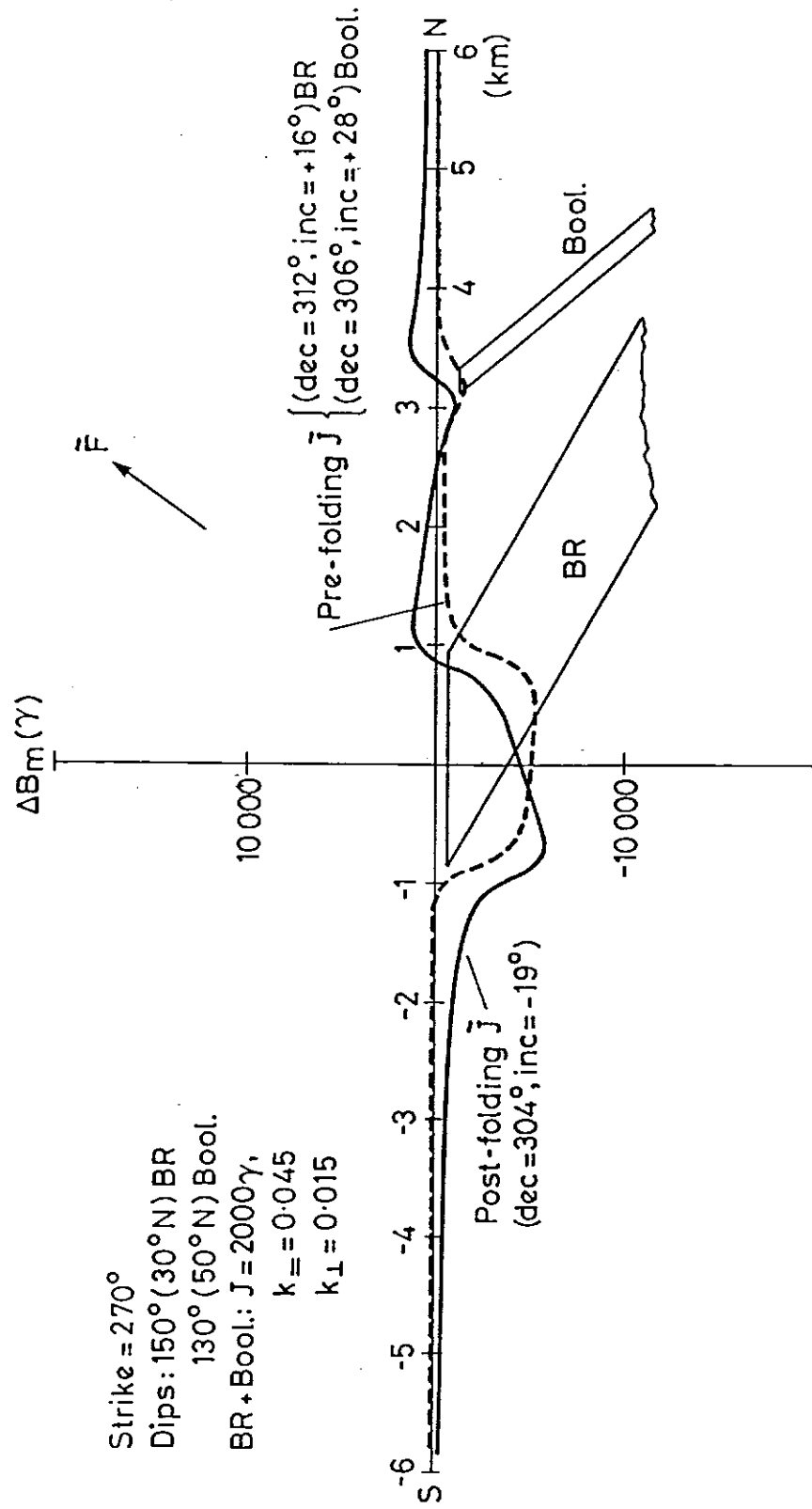


Fig.5. Magnetic model for the Warrego orebody, incorporating measured magnetic properties.

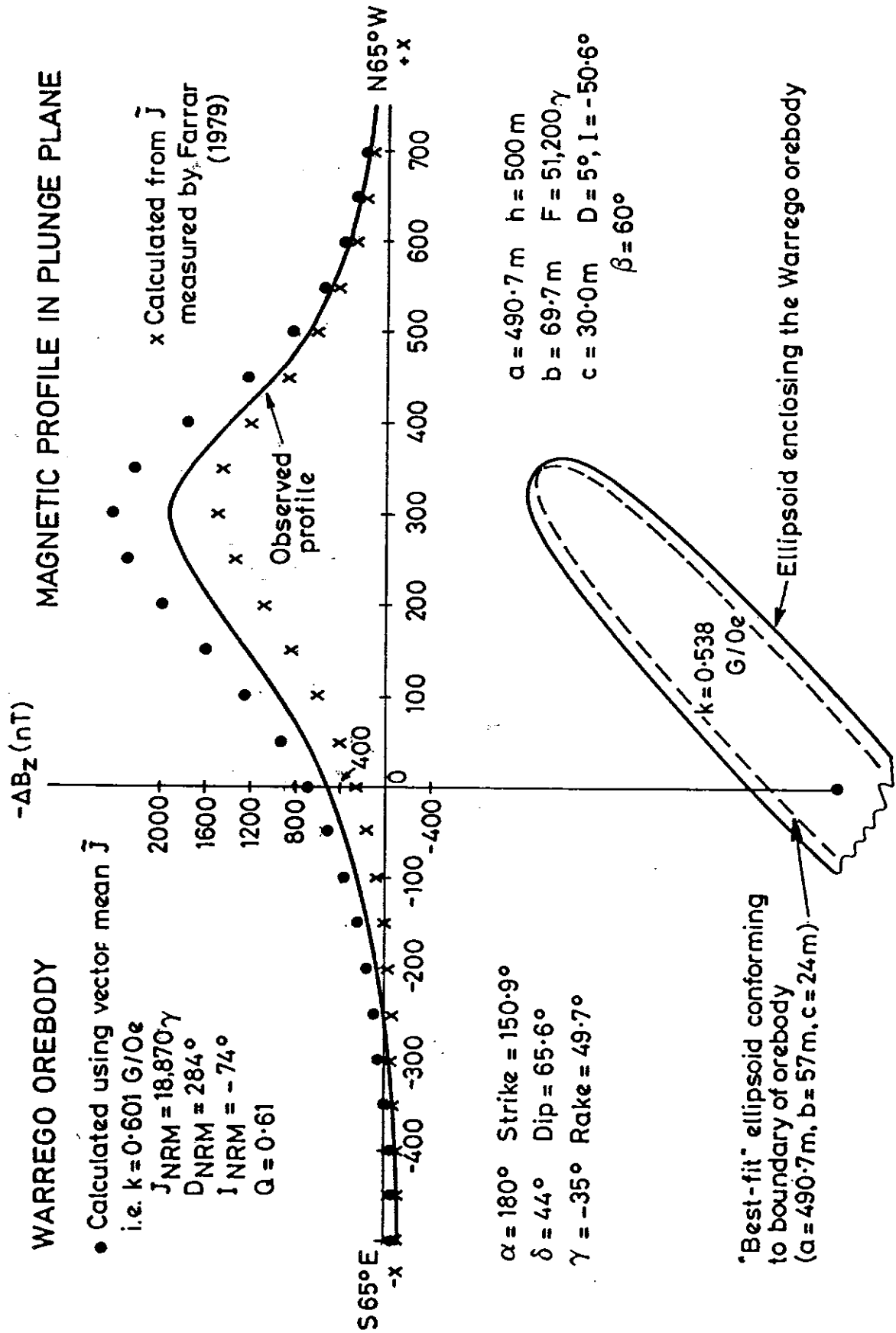


Fig.6. Magnetic fabric defined by susceptibility anisotropy of the host rocks to the Warrego orebody. The ironstone pipe plunges to the SE, parallel to the magnetic lineation within the enclosing sediments.

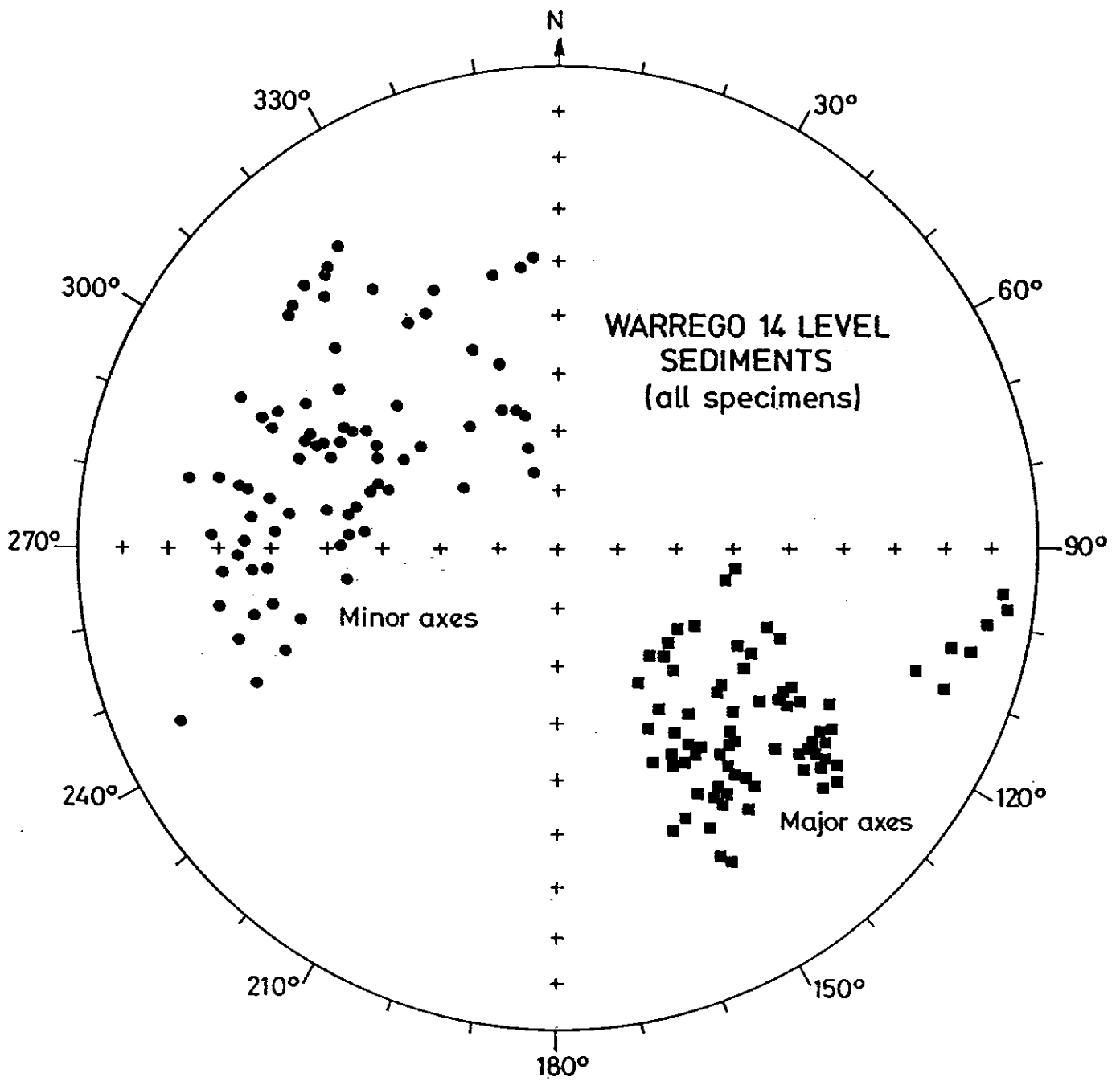


Fig.7. Magnetic stratigraphy of the Rise and Shine and Rupee Trend areas, Broken Hill, based on sampling and ground and airborne magnetic surveys.

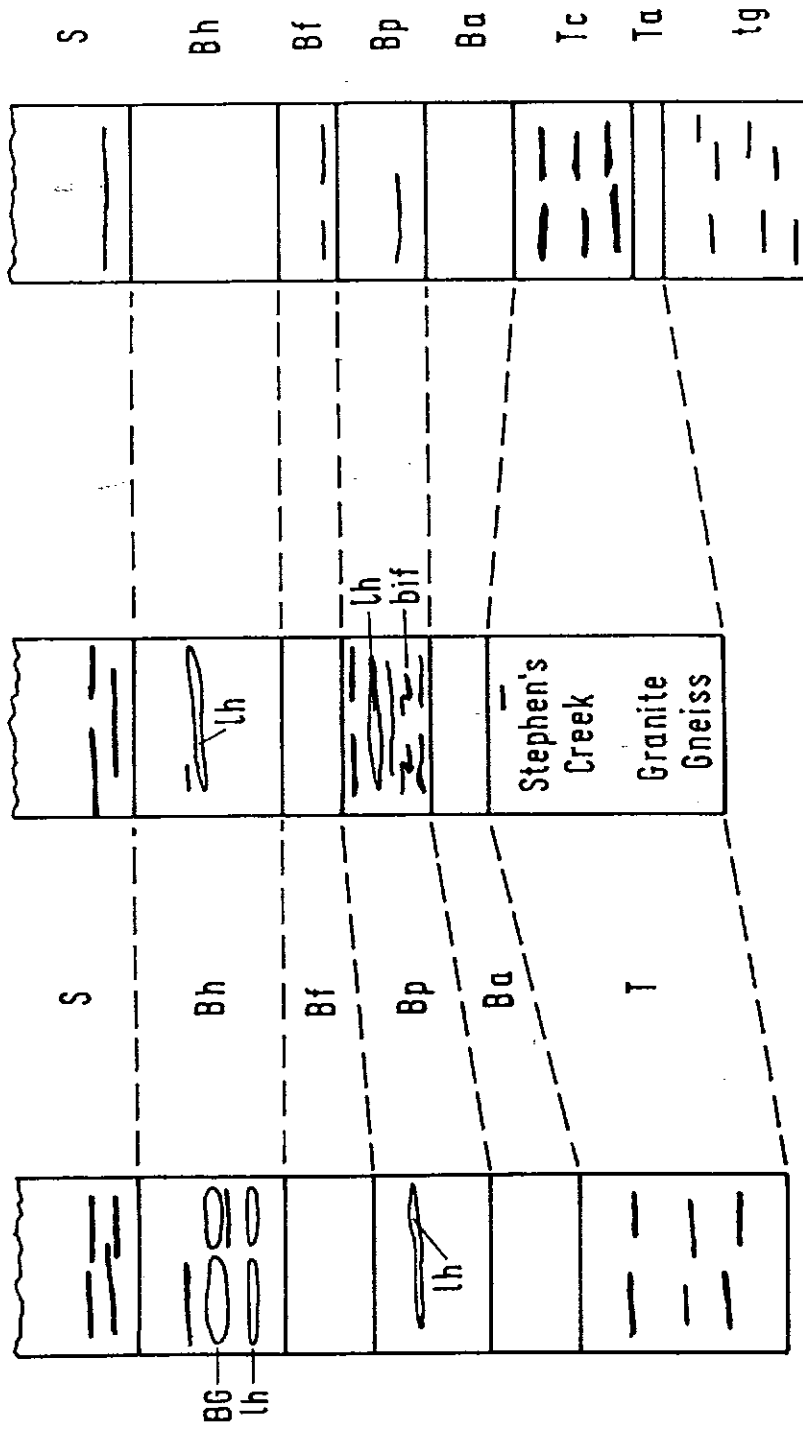
MAGNETIC STRATIGRAPHY

RUPEE TREND

RISE AND SHINE

Western Lode

Eastern Lode

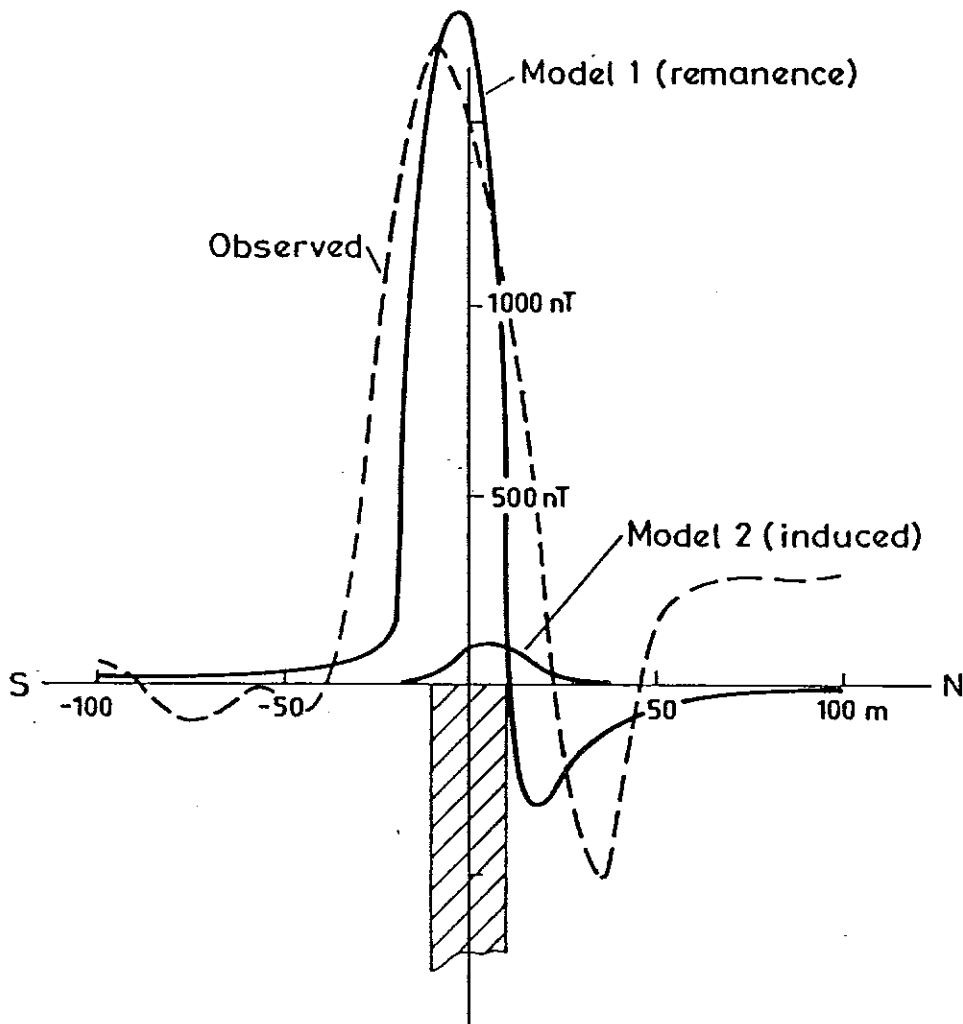


— Magnetic horizon

— Strongly magnetic horizon

Fig.8. Preliminary magnetic model of the mineralised zone at Homeward Bound, Davyhurst area, Yilgarn Block, showing the importance of the intense, stable and ancient remanence carried by pyrrhotite.

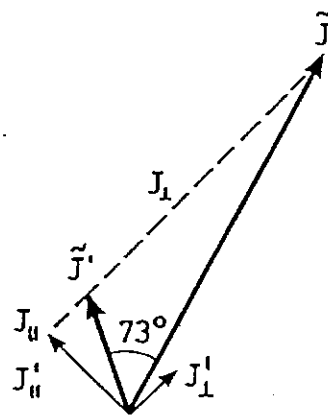
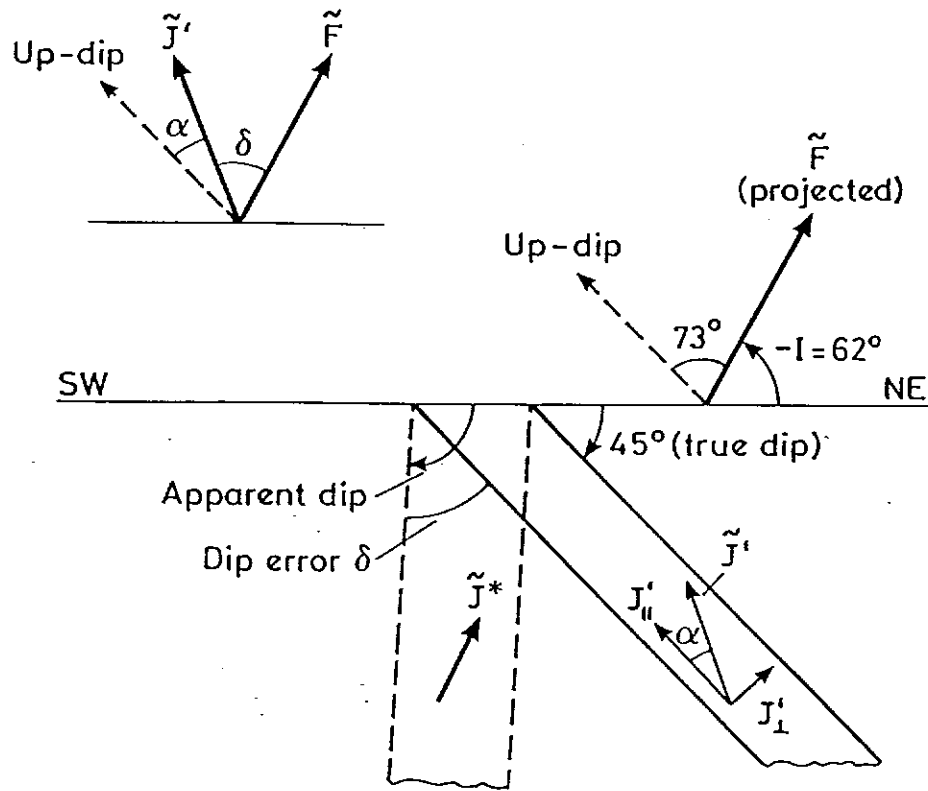
DAVYHURST
HOMEWARD BOUND



Homeward Bound magnetic models. Model 1 includes remanence while model 2 assumes induced magnetisation only. The dashed curve represents an observed anomaly. The remanent magnetisation is southeasterly shallow up (Dec=158, Inc=-26) with an intensity of 0.03 G ($30,000 \times 10^{-6}$ emu/cc).

Fig.9. Error in interpreted dip of the Trough Tank ironstone,
Eastern Mt Isa Block, due to neglect of self-demagnetisation.

ANOMALOUS APPARENT DIP OF TROUGH TANK BIF



Without self-demagnetisation:

$$J_{||} = kF \cos 73^\circ$$

$$J_{\perp} = kF \sin 73^\circ$$

With self-demagnetisation:

$$J'_{||} = J_{||} \quad (N_{||} = 0)$$

$$J'_1 = \frac{J_{\perp}}{1 + 4\pi k} \quad (N_1 = 4)$$

$$\therefore \tan \alpha = \frac{J'_1}{J'_{||}} = \frac{\tan 73^\circ}{1 + 4\pi k}$$

Fig.10. Characteristic low-field thermomagnetic (k-T) curves for different types of pyrrhotite: (a) monoclinic 4C pyrrhotite, Fe_7S_8 , (b) intermediate ("hexagonal") 5C pyrrhotite, Fe_9S_{10} , (c) Elura pyrrhotitic ore consisting of intergrowths of types (a) and (b).

