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Research Note

A Pilot Study of the Palaeomagnetism of some Pre-Cambrian Dykes from East Antarctica

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Summary

Rock samples were collected from 11 dolerite dykes which outcrop in the Vestfold Hills of East Antarctica at 68·5° S, 78° E. Partial demagnetization (using the alternating field technique) indicated that all samples contained stable magnetic remanence and the presence of normal and reversed polarities permit the definition of an axis of magnetization with declination 107·5°, inclination −42·5° and $\alpha_{95} = 11°$. The remanence is believed to date from the time of dyke intrusion, put at about 1000 My.

1. Introduction

The Vestfold Hills is a large ice-free area of rock at about longitude 78° E on the coast of Eastern Antarctica. The margin of the continental ice sheet is nearly 30 km inland from the Australian Antarctic Research Station which is at lat. 68° 35′ S, long. 77° 58′ E. A swarm of well over 100 dolerite dykes has intruded the country rock of gneiss and granulite (Ravich 1960). Six total rock samples of dolerite have been analysed for Rb–Sr by Harding & McLeod (1967), giving an isochron of 1030±220 My, and initial $87_{Sr}/86_{Sr}$ ratio of 0·7052±0·0010.

One of us (P.A.A.) took part in the Australian National Antarctic Research Expedition to Davis during the summer of 1972, and collected 11 oriented hand samples for a pilot study of the palaeomagnetism of the dolerite dykes. The results to be described are so consistent that a more extensive sampling program is clearly warranted, to obtain more precise measurement of the palaeomagnetism and geochronology of the dolerite dykes.

All samples were taken from surface outcrop and were fresh, having suffered little weathering since the time of recession of the ice sheet. Lightning strike is unknown in Antarctica under present climatic conditions, and the remanent magnetism of the samples will therefore be free from the perturbations sometimes suspected to arise from this source. The material for the pilot study was collected along the north-facing hill slopes south of Lake Stinear.

2. Palaeomagnetic results

Directions and intensities of natural remanent magnetization were measured in 43 specimens cut from the 11 hand samples. The data are summarized in Table 1 (NRM Data) and specimen directions of magnetic remanence are represented stereographically (on a Wulff net) in Fig. 1(a). Within-sample directions were often consistent though they tended to spread towards the axis of the present geomagnetic field (PFA) from some position in the south-east quadrant of the stereogram. It was

Table 1

Summary of Palaeomagnetic data

	NRM data					'Cleaned' data (300–325 Oe)				
Sample No.	N* (specimens)	R	Dec.°	Inc.°	Int. $\times 10^{-6}$ Gauss	N (specimens)	R	Dec.°	Inc.°	Int. $\times 10^{-6}$ Gauss
82A	3	2·912	319·0	−82·0	485·0	3	2·850	98·0	−31·5	39·7
82B	4	3·950	95·5	−54·5	485·5	4	3·995	120·0	−36·5	258·7
82C	4	2·288	193·0	−35·5	1016·3	4	3·441	281·0	+37·5	30·4
82E	4	2·301	161·5	−37·5	498·9	4	3·927	232·0	+67·0	37·2
82F	4	2·340	43·5	−69·5	659·2	4	3·852	185·5	−30·0	42·0
17A	4	3·933	33·5	−61·5	396·5	4	3·964	106·0	−31·0	88·8
17B	4	3·902	26·5	−85·5	725·9	4	3·971	108·0	−48·5	128·5
17C	4	3·930	91·5	−69·5	1750·9	4	3·812	105·0	−42·0	524·7
17D	4	3·832	137·0	−51·5	425·1	4	3·985	121·0	−40·0	106·3
17F	4	3·792	119·0	−61·0	202·7	4	3·987	127·0	−39·5	72·8
17G	4	3·617	137·0	−44·5	550·7	4	3·973	198·0	−4·0	76·8

Sample-mean direction of remanent magnetization.

	N +(samples)	R	Dec.°	Inc.°	α_{95}
(a)	7	6·903	112·0	−39·0	7·5
(b)	9	8·654	107·5	−42·5	11·0

* N = number of unit vectors of which R is the resultant; Dec.° = declination and Inc.° = inclination; Int. = sample arithmetic mean intensity of remanent magnetization. Directions of magnetization were analysed following the method of Fisher (1953). α_{95} = the semi-angle of the cone of confidence at the 95 per cent probability level.

+ (a) includes samples 82A, B, 17A, B, C, D and F.

(b) includes samples in (a) plus 82C and E (reversed).

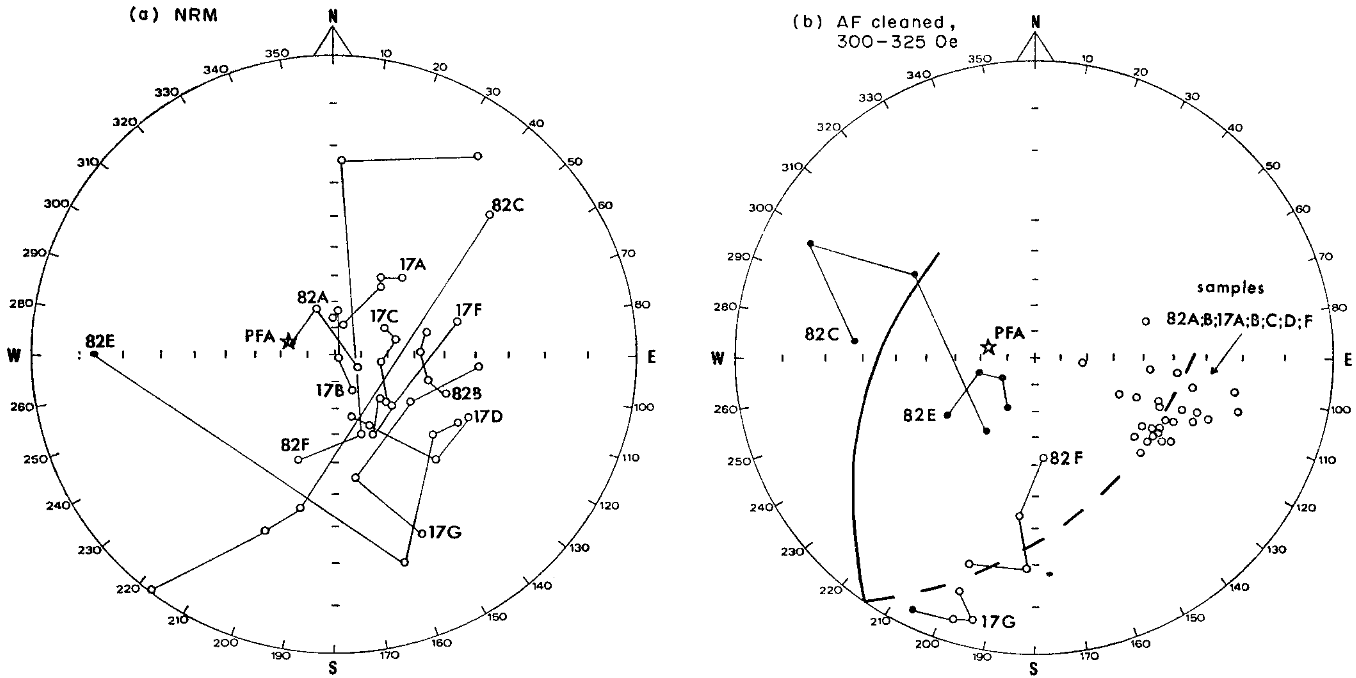

FIG. 1. Specimen directions of magnetization before AF treatment (a) and after AF treatment (b). Specimens from the same sample are joined by a thin line. Open circles represent directions pointing up (negative) and dots represent downward pointing directions (positive). PFA is the present field axis, pointing upward.

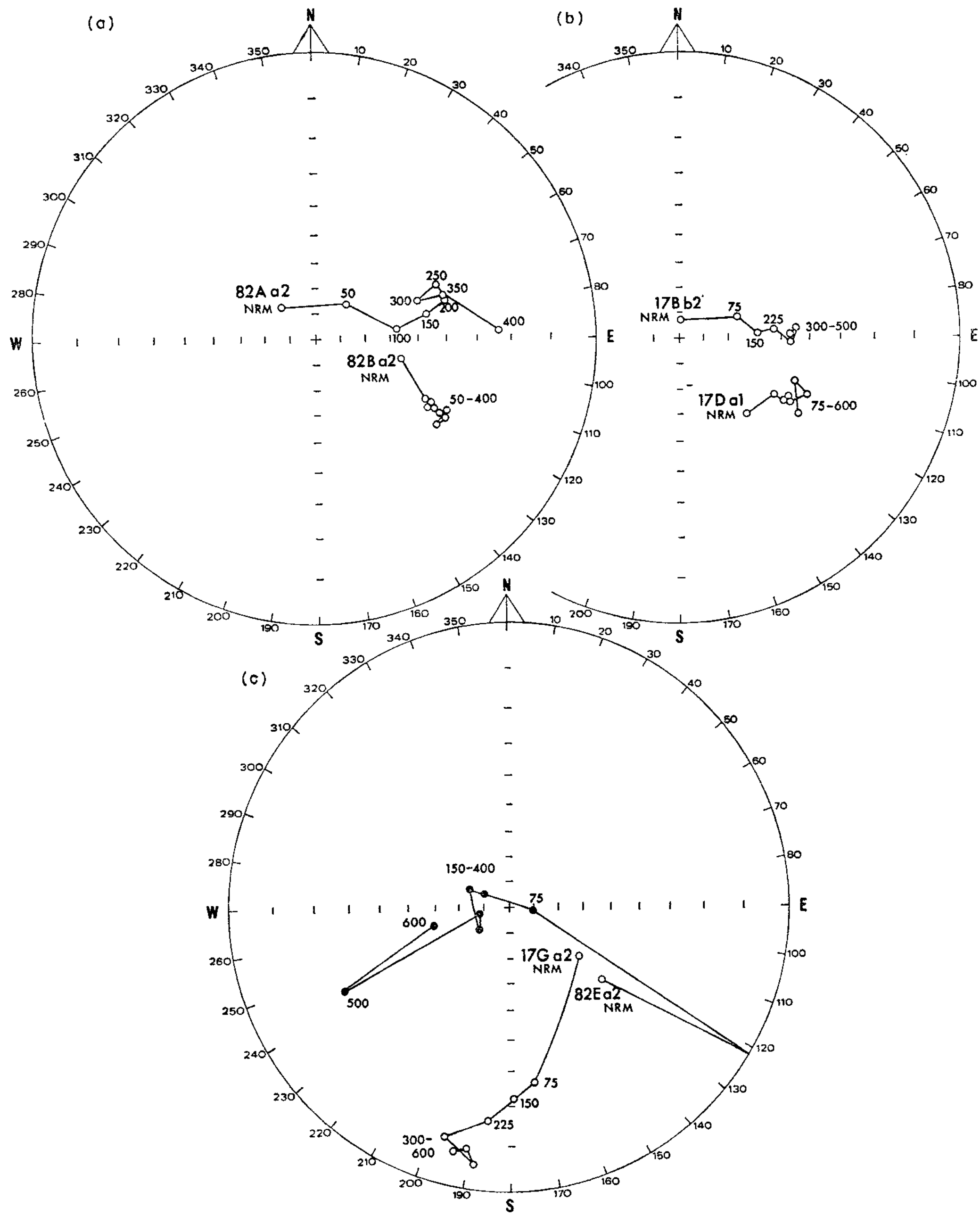

FIG. 2. Some examples of changes in direction of magnetic remanence during the stepwise cleaning technique. Numbers refer to the peak alternating magnetic fields (Oersteds) at which the points labelled were obtained. The significance of the stable directions of magnetization is described in the text.

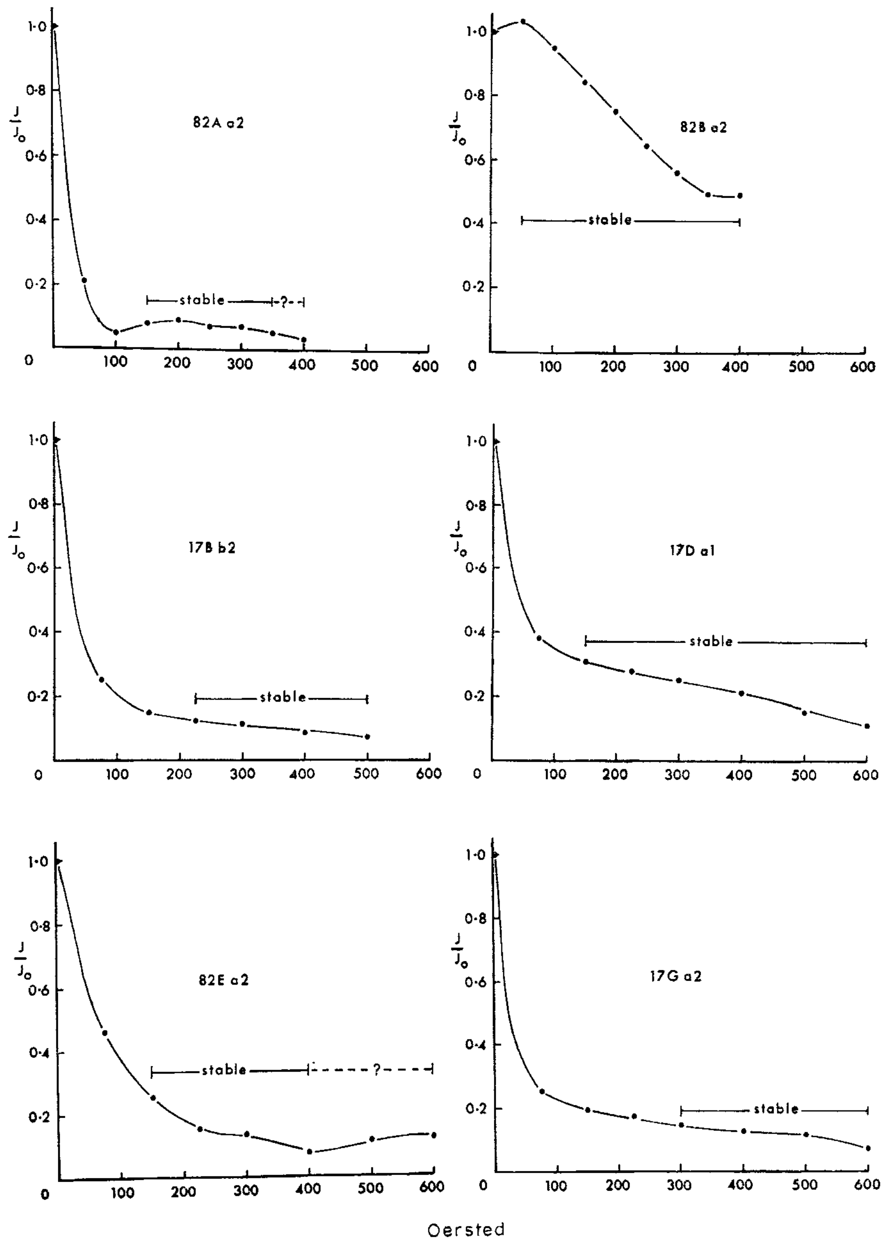

FIG. 3. Demagnetization–intensity curves relating to the specimens plotted in Fig. 2. In each case the range of alternating fields used in the cleaning procedure over which the magnetic remanence was judged to be stable (through inspection of the direction data shown in Fig. 2) is indicated.

suspected that this distribution constituted a degree of 'streaking' (a condition which results from specimens acquiring more than one component of magnetic remanence—usually a secondary component superimposed upon a primary) since the NRM directions did not cluster about the present field axis. Specimens from three samples (82 C, E and F) however, displayed scattered NRM directions; 82C and E were later shown to be magnetized approximately in a reversed sense with respect to the main population and sample 82F was shown to be magnetized in an oblique direction.

One specimen was chosen from each sample (plus an additional specimen from samples 82C, E, F and 17G) and subjected to alternating field (AF) cleaning (Collinson & Creer 1960) for an analysis of the coercive force spectrum and to test the stability of the magnetic remanence. Examples of behaviour in response to the magnetic cleaning technique are shown in Figs 2 and 3. The main observations are briefly as follows:

(1) Specimens which were initially magnetized in a direction close to the present field axis (situated at 73° W, 73° S), lost a higher proportion of their intensities of remanence in the early stages of cleaning than did specimens whose NRM directions have remained oblique to the present field axis.

(2) All specimens were shown to contain stable components of magnetic remanence which were isolated after AF treatment at about 300 Oe.

(3) Specimens from two samples were magnetized in a direction approximately reversed with respect to the main population (an example obtained during the pilot treatment was 82Ea2, Fig. 2(c)).

(4) Specimens from two samples contained stable components of magnetic remanence oriented obliquely to the principal axis (17Ga2 in Fig. 2(c) is an example of such behaviour).

Upon inspection of the pilot specimen data the remaining specimens were magnetically cleaned in both 160 Oe and 325 Oe peak fields. The results are summarized in Table 1 and specimen directions of magnetization are shown in Fig. 1(b). In almost all cases, within-sample scatter was reduced after cleaning. The principal group of directions was defined by samples from seven dykes, two dykes were reversely magnetized and two dykes obliquely magnetized, although their directions plotted along a great circle joining the positive and negative groups. The presence of a reversal suggests that the stable magnetic remanence constitutes the primary component, i.e. is that acquired when the dykes were injected. Interpretation of the oblique directions is somewhat less straightforward. They may represent (a) a resultant vector through addition of the positively and negatively polarized components, or (b) a real geomagnetic field direction which was maintained for some period at about the time of a geomagnetic field reversal. They do not appear to result from superposition of a present geomagnetic field component on either the positive or negative directions.

3. Conclusions

Although few data are available, the results are remarkably consistent in that nine of the 11 dykes sampled yield sufficient information to define an axis of magnetization believed to refer to the ambient geomagnetic field at the time of dyke formation. The prime indication is the obvious use of the material for further palaeomagnetic investigation.

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