PALEOMAGNETISM OF GABBROS OF THE EARLY PROTEROZOIC BLACHFORD LAKE INTRUSIVE SUITE AND THE EASTER ISLAND DYKE, GREAT SLAVE LAKE, NWT: POSSIBLE EVIDENCE FOR THE EARLIEST CONTINENTAL DRIFT

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Abstract. The Caribou Lake gabbro, part of the Blachford Lake Intrusive Suite accurately dated at -2186 ± 10 mA, has a predominant *NW−/SE+* magnetization with a mean, irrespective of sign, of $D = 119°$, $I = 50°$, $\alpha_{95} = 5°$ and a palaeopole 14° N, 064° W, $A_{95} = 5°$; it has not proved possible to determine if the magnetization is primary. The Easter Island dyke, less well-dated in the range −2200 to −2500 Ma, has a predominant *WNW+* magnetization, whose mean, when corrected for an 8° tilt, is $D = 288°$, $I = 46°$, $\alpha_{95} = 5°$ and palaeopole is 32° S, 2° W, $A_{95} = 5°$; the magnetization is probably primary. A vertical magnetization (*D*), not significantly different from the present field, occurs sporadically in both units and is considered to be Late Phanerozoic in age. Palaeopoles from the Caribou Lake gabbro and the Easter Island dyke, together with those already known from Early Proterozoic intrusives of the Archaean Slave Structural Province, roughly define a swath (the Slave Track) which maps the motion of the Slave Province relative to the geomagnetic axis during this interval. The corresponding array of palaeopoles (the Superior Track) from the Superior Structural Province does not fall in the same place. Hence it would appear that Slave and Superior were not in their present relative positions in the Early Proterozoic in disagreement with arguments that have been made for a fixed supercontinent during much of the Proterozoic. Mid-Proterozoic paleomagnetic signatures indicate that Slave and Superior had assumed their present relative position by about −1750 mA. These Early Proterozoic relative motions are the earliest for which there is palaeomagnetic evidence.

1. Introduction

New palaeomagnetic results from the Canadian Shields are described. It is appropriate that a volume in honour of S. K. Runcorn should contain a contribution on this topic because it was he who first initiated palaeomagnetic study of Canadian Shield rocks. This first study, begun in June 1951 and made in collaboration with the senior author, was of the Torridonian sandstone of northwestern Scotland. In the Precambrian, this part of Scotland belonged to an enlarged Canadian Shield. It was through this study, and through essentially contemporaneous work in South Africa on the Pilansberg dykes by Gough (1956), that the existence of a geomagnetic field in the Precambrian was established, that serial reversals in pre-Tertiary rocks were discovered, and that palaeodirections in older rocks systemmatically oblique to the present axis were established (Runcorn, 1955). The latter phenomenon is what we now call apparent polar wandering (apw), the palaeomagnetic signature of continental drift, and it is with this that our paper is mainly concerned.

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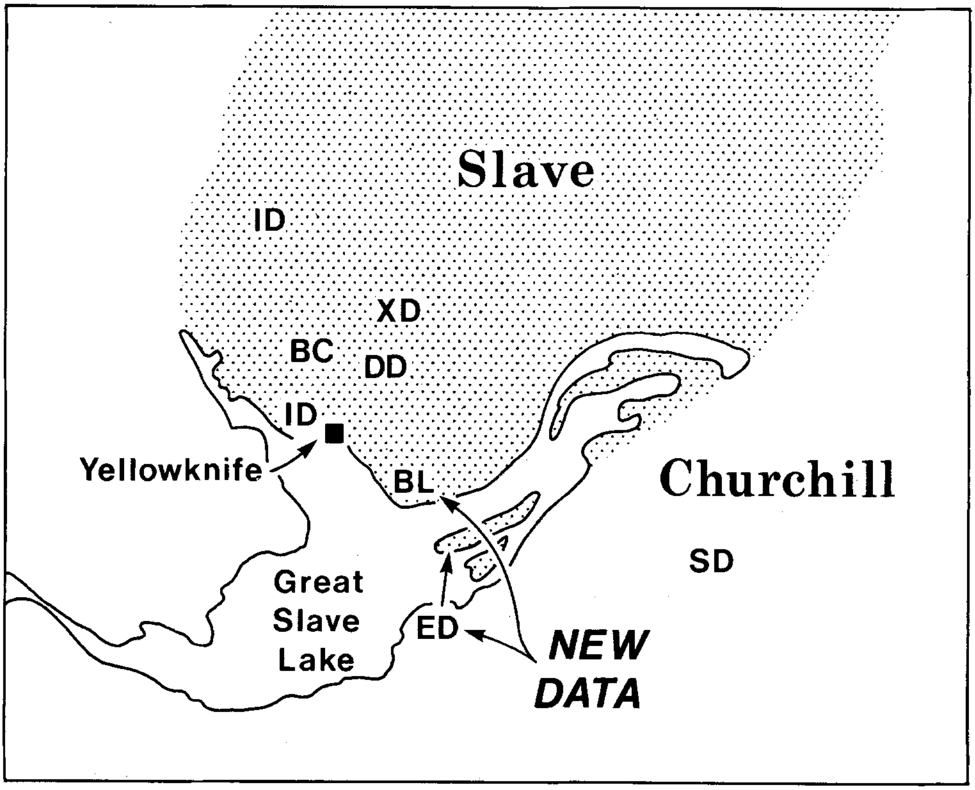

Fig. 1. Early Proterozoic intrusions of the Slave Structural Province that have been studied palaeomagnetically. BC Big Spruce Complex (Irving and McGlynn, 1976); ID Indin dykes, XD 'X' dykes, DD Dogrib dykes (McGlynn and Irving, 1975); SD Sparrow dykes (McGlynn *et al.*, 1974); CL Caribou Lake gabbro of the Blachford Lake Intrusive Suite and ED Easter Island dyke (herein).

The rock-units concerned are Early Proterozoic. They are intrusives into the Archaean Slave Structural Province in the northwestern part of the Canadian Shield (Figure 1, see also Figure 15). Units whose palaeomagnetism already has been described are, the Big Spruce Complex (Irving and McGlynn, 1976), and the Dogrib, Indin and 'X' dykes (McGlynn and Irving, 1975). Our new data are from gabbros of the Blachford Intrusive Suite and the Easter Island dyke, and, together with earlier results, they may be used to suggest the path of apparent polar wander (apw) for the Slave Province during the Early Proterozoic. Such a path may eventually aid correlation and the study of thermal history, but of more immediate interest is the possibility of comparing it with the contemporaneous apw path from the Superior Structural Province to determine if these two Archaean blocks have undergone relative motions, as would be expected if the intervening Hudsonian orogen is the product of plate tectonic processes.

The problem is of general importance because if Early Proterozoic relative motions could be demonstrated they would be the oldest yet recorded – they would be the

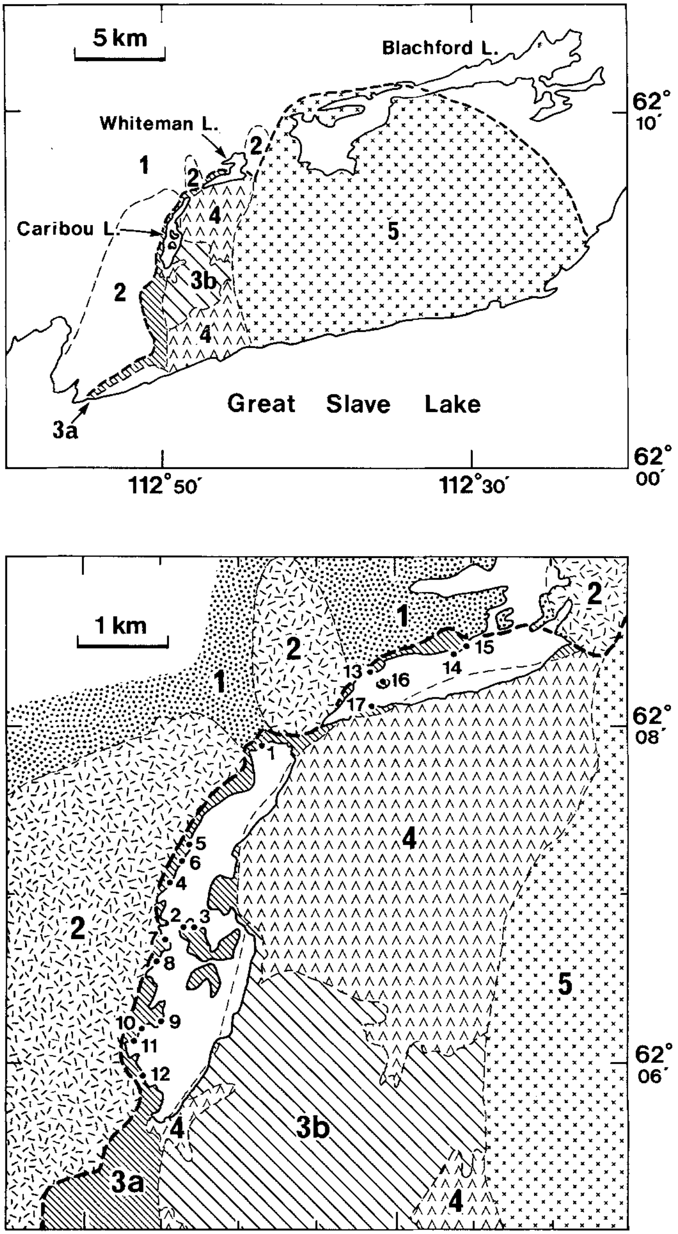

Fig. 2. Above sketch map of the Blachford Lake Intrusive Suite and below of the Caribou Lake gabbro showing sampling sites. The rock-units, numbered in chronological, order are as follows: Proterozoic: Blachford Lake Intrusive Suite: (5) peralkaline granite; (4) metaluminous granite, quartz syenite; (3) Caribou Lake gabbro; (3a) gabbro phase; (3b) leucoferrodiorite phase. Archaean: Slave Province: (2) granite, granodiorite; (1) Yellowknife Supergroup.

earliest quantitative measure of continental drift. Early Proteozoic or Archaean motions of Archaean blocks relative to the pole (apw) have been observed palaeomagnetically for the Superior Province (Irving and Naldrett, 1977) and for the Kaapvaal craton (Layer *et al.*, 1984), but drift of one craton relative to one another so long ago has not yet been demonstrated. This paper will show that although well-defined magnetizations (and corresponding palaeopoles) can be obtained from these Early Proterozoic intrusions, their ages are often not sufficiently well-defined; that is, palaeomagnetism is capable of detecting Early Proterozoic continental drift but definitive answers await the accurate geochronological calibration of apw paths.

2. Geology and Sampling of the Caribou Lake Gabbro

The Blachford Lake Intrusive Suite is a large, composite pluton which was emplaced at high crustal level within Archaean crystalline schists and granitoid rocks at the southern margin of the Slave Province (Figure 2a). It consists mostly of peralkaline granite and syenite (unit 5), which were found to have only soft magnetizations

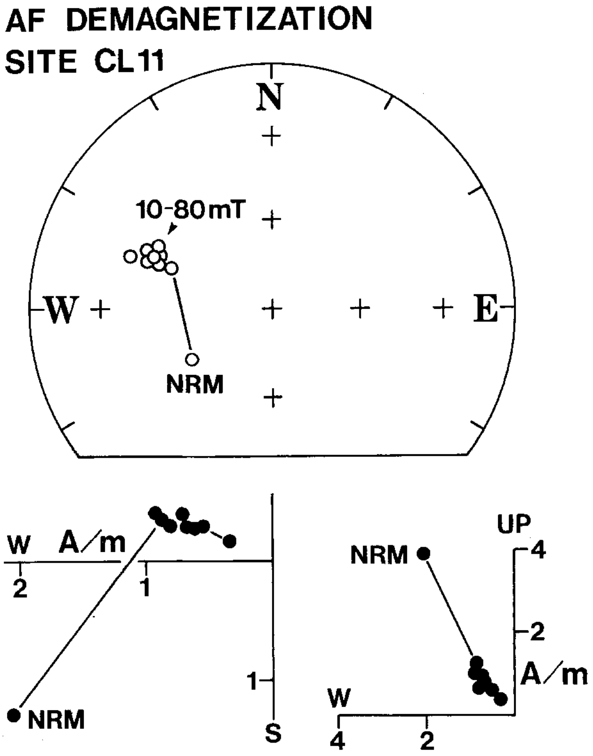

Fig. 3. Changes in direction (above) and orthogonal plots (below) produced by alternating field (af) demagnetization of gabbro of Caribou Lake gabbro, site 11. *NW*— magnetization. Open symbols in the stereonet indicate negative (upward) inclination, solid symbols positive inclination. 1 millitesla = 10 oersted.

scattered about the direction of the present earth's field (PEF) and contained no discernible record of the Precambrian field. On its western side, earlier plutonic phases of metaluminous granite and quartz syenite (unit 4) intrude a somewhat older gabbroic phase, the Caribou Lake gabbro (unit 3), that is chilled against Archaean rocks. This gabbro is an integral part of the Blachford Lake Intrusive Suite (Davidson, 1978, 1982). It contains stable magnetizations strongly inclined to the PEF. There are no age determination for the gabbro itself, but there are for other members of the suite, all essentially coeval. Six K–Ar ages of alkali amphiboles from the youngest peralkaline unit average −2130 ± 50 Ma, and a whole-rock K–Ar age determined for a partially-melted hornfels inclusion contained within it is −2150 ± 50 Ma. Biotite and hornblende K–Ar ages determined for the geologically older metaluminous granites to the west are −2166 ± 47 Ma and −2127 ± 79 Ma respectively. Rb–Sr isochron ages of −2092 ± 50 Ma and −2130 ± 38 Ma have been obtained for two separate bodies of metaluminous granite, and a U–Pb zircon age from the geologically oldest of these is −2186 ± 10 Ma (Wanless *et al.*, 1979). The Caribou Lake gabbro is not older than about −2200 Ma since K–Ar ages of muscovite and biotite in Archaean granite adjacent to its western contact are −2166 ± 47 Ma and −2109 ± 47 Ma respectively. Hence the U–Pb determination is probably a good approximation to its age. Sampling sites of the Caribou Lake gabbro are shown in Figure 2b.

3. Remanent Magnetization of the Caribou Lake Gabbro

The initial directions of magnetization (nrm) are scattered, sometimes with upward directions, sometimes steeply dipping downwards not far from the PEF. An example of the former is shown in Figure 3. After alternating demagnetization (af) in 10–80 mT the direction becomes well-grouped toward the northwest with upward indication. This is referred to as the *NW*− magnetization. The orthogonal plots show excellent linear decay to the origin. The magnetization is simple, consisting of a large soft *PEF* magnetization, readily demagnetized, and a hard *NW*− magnetization that can be cleanly isolated.

Another example is shown in Figure 4, this time obtained by thermal demagnetization. The soft *PEF* magnetization is now much smaller in magnitude, and, after its removal at about 200 °C, there is again excellent linear decay on the orthogonal plots, apparently to the origin. At 650 °C, however, there is a dramatic change to a downward direction. This magnetization is referred to as *D*. *D* is very small and hence produces little deflection of the orthogonal plots. At 700 °C the directions in this and all specimens studied are random.

The third example (Figure 5) is typical of magnetizations which are initially grouped around the PEF owing to a very large soft magnetization (*PEF*) which is readily removed by heating to 300 °C. During heating between 300 and 550 °C (the approximate blocking temperature of magnetite) there is an apparent end-point, but upon further heating an underlying *D* magnetization is revealed. This time *D* is not negligible in magnitude and to obtain an accurate estimate of the direction of the *NW*−

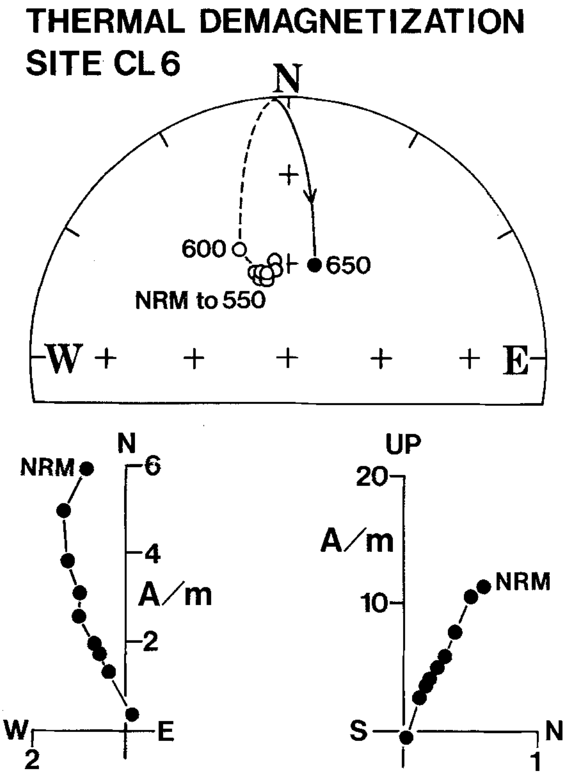

Fig. 4. Changes in direction (above) and orthogonal plots (below) produced by thermal demagnetization of Caribou Lake gabbro, site 6. Small *PEF*, *NW*− and a very small *D* magnetizations are present.

magnetization (R in Figure 5) its effect must be removed. The 'end-point' is not real and does not itself give an accurate estimate of *NW*−.

All specimens have been studied in this detailed way and an attempt made to separate the magnetizations present. At sited 7 and 8 the stability spectra overlapped strongly and no magnetizations could be accurately isolated. The directions of all magnetizations observed are plotted in Figure 6, and their averages listed site by site in Table I. Predominant are *NW*− magnetizations and magnetizations directed to the southeast and downward (*SE*+). Both have unblocking temperatures generally in the range 500 to 600 °C and may be ascribed to magnetite.

When summarizing the results there are weighting problems. A given magnetization may occur in several specimens from a collecting site, sometimes only in one, or it may be absent altogether. To accord specimens unit weight would emphasize too much those sites at which there were many observations of the same magnetization. To give sites unit weight would emphasize too much those sites with only one observation. We suggest that if there are three or more physically satisfactory observations of a given magnetization at a site it can be considered reasonably well-established. In Table I the *NW*−, *SE*+ magnetizations have been averaged first including all results, and then by

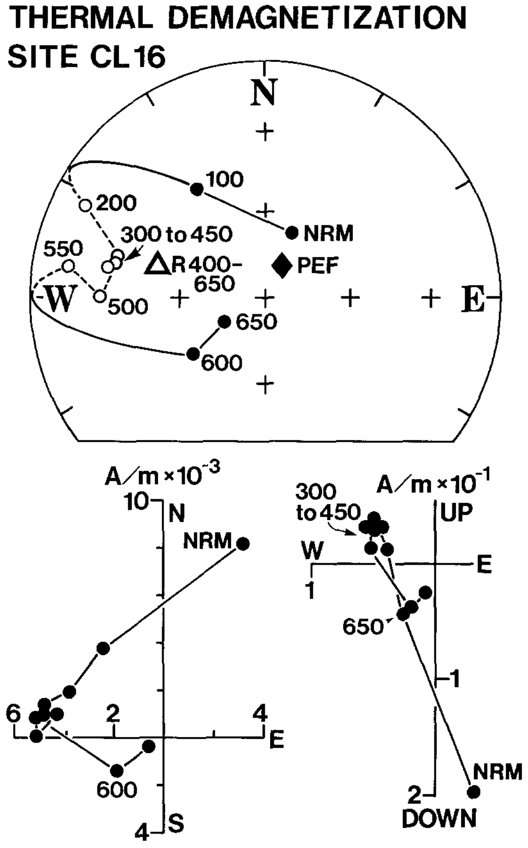

Fig. 5. Changes in direction (above) and orthogonal plots (below) produced by thermal demagnetization of Caribou Lake gabbro, site 16. Large *PEF* and substantial *NW−* and *D* magnetizations are present.

including only those sites for which *s*, the number of observations, exceeds three. We consider the latter the better procedure. The means of the *NW−* and *SE+* groups are statistically antiparallel (Table II). *D* magnetizations occur in 19 specimens, about 20% of specimens studied, and their mean is not significantly different from the present field (29, 82). *D* magnetization only becomes visible after removal of *NW−* or *SW+*. It has unblocking temperatures in the range 650 to 700 °C and may be ascribed to hematite. Its origin is discussed later.

A subordinate magnetization, directed to the southeast and downward, with significantly steeper indication than *SE+*, occurs at one site (*C* Table I). It is identical with the widespread late Hudsonian overprint found throughout the Canadian Shield, and sometimes called the Coronation overprint (Reid *et al.*, 1981) and which was presumeably acquired about −1750 Ma (Schutts and Dunlop, 1981; Irving and McGlynn, 1981).

The *NW−*/*SE+* magnetization may have been acquired during cooling of the

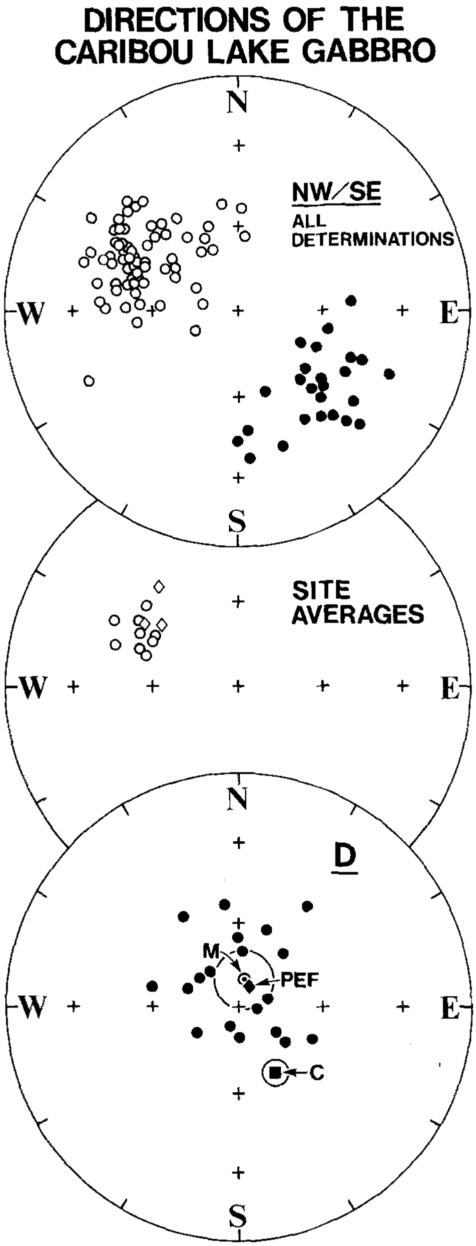

Fig. 6. Above, directions of $NW-$ and $SE+$ magnetizations observed from the Caribou Lake gabbro. Centre, mean site directions ($s > 2$) irrespective of sign. Below, D directions with mean and error circle showing coincidence with the present field (PEF). C is the Coronation overprint. All with respect to present horizontal.

TABLE I

Results from Caribou Lake gabbro of the Blachford Lake Intrusive Suite

Site	Comp.	*c*(*s*)	*D*°, *I*°	*k*	α°_{95}
1	*SE*+	5(8)	142, 44	39	9
2	*NW*−	5(10)	301, −55	32	9
2	*D*	1	145, 50	–	–
3	*NW*−	2(2)	295, −59	–	–
3	*SE*+	4(6)	128, 55	18	16
3	*C*	4(6)	148, 76	27	13
3	*D*	1	175, 80	–	–
4	*NW*−	2(2)	336, −47	11	–
5	*SE*+	5(8)	123, 49	25	11
5	*D*	3(3)	129, 88	17	31
6	*NW*−	5(8)	304, −48	14	15
9	*D*	1	010, 60	–	–
9	*NW*−	5(7)	288, −55	85	7
9	*D*	2(2)	340, 73	45	–
10	*NW*−	5(5)	298, −55	16	20
10	*D*	2(2)	21, 57	19	–
11	*NW*−	6(9)	299, −50	43	8
11	*D*	2(2)	19, 79	10	–
12	*NW*−	3(4)	312, −46	26	18
12	*D*	1	113, 62	–	–
13	*NW*−	2(2)	314, −45	5	–
13	*SE*+	1	136, 48	–	–
13	*D*	2(2)	357, 63	10	–
14	*NW*−	3(5)	298, −39	73	9
14	*D*	1	322, 14	–	–
15	*NW*−	3(4)	289, −43	11	29
15	*D*	1	122, 74	–	–
16	*NW*−	2(2)	296, −39	18	–
16	*SE*+	2(2)	177, 42	209	–
16	*D*	1	239, 73	–	–
17	*NW*−	6(7)	291, −52	34	11
17	*SE*+	2(2)	128, 42	22	–
17	*D*	2(2)	13, 69	10	–

Notes. *c* is the number of oriented drill cores and *s* the number of specimens cut from them. *D*, *I* are the declination and inclination of the mean direction relative to present horizontal, *k* Fisher's estimate of precision, $_{95}$ the error ($P = 0.05$). The data have been obtained as follows: site 1 *SE*+, average 400 to 550 °C (2), ave. 30 to 80 mT(5), R 30–60 mT(1); site 2*NW*− ave. 50 to 80 mT(5), 500–650 °C(5); site 2*D*, 650 °C; site 3*NW*−, ave. 40–80 mT(2); site 3*SE*+ ave. 50–100 mT(2), R 500–650 °C(4); site 3*C* R 100–50 mT(2), R 200–500 °C(2); site 5*SE*+, ave. 30 to 80 mT(5), ave. 400 to 550 °C(2); site 5*SE*+, ave. 30 to 80 mT(5), ave. 400 to 550 °C(1), 500–650 °C(2); site 5*D*, 650 °C; site 6*NW*−, ave. 30 to 60 mT(3), ave. 400 to 500 °C(1), R 20–50 mT(2), R 550–650 °C(2); site 6*NW*−, R 30–60 mT(6), R 500–650 °C (2); site 6*D*, 650 °C; site 9*NW*−, ave. R 30–80 mT(5), R 550–650 °C(1), ave. 300 to 550 °C(1); site 9*D*, 650 °C; site 10*NW*−, ave. 30 to 80 mT(5); site 10*D*, 650 °C; site 11*NW*−, ave. 30–80 mT(8), R 500–600 °C(1); site 11*D*, 650 °C; site 12*NW*−, 30 to 80 mT(3), 550–650 °C(1); site 12*D*, 650 °C; site 13*NW*−, ave. 30 to 80 mT(1), R 20–50 mT; site 13*SE*+, ave. 20 to 50 mT; site 13*D*, 650 °C; site 14*NW*− ave. 30 to 50 mT(3); ave. 300–400 °C(1), R 550–650 °C(1); site 15*NW*−, ave. 40 to 60 mT(2), R 500–650 °C(1); site 15*D*, 650 °C; site 16*NW*−, ave. 40 to 80 mT(1), R 550–650 °C(1); site 16*SE*+, ave. 30 to 50 mT(2); site 16*D*, 650 °C; site 17*NW*−, ave. 500 to 600 °C(1), ave. 30–50 mT(4); R 500–650 °C(2); site 17*D*, 650 °C. No coherent magnetizations were found at sites 7 and 8.

TABLE II

Summary of results from the Easter Island dyke and the Caribou Lake gabbro

	Sites(s)	$D°$,	$I°$	k	α_{95}°	lat°, long°($dm°$, $dp°$)
Easter Island Dyke						
in situ	15*(146)	281,	42	74	5	-
tilt corrected (ED)	15*(146)	288,	46	74	5	32S, 022W(06, 03)
average of site-poles	15*			68	5	32S, 002W
Hearne dyke remagnetization (HC)	1 (06*)	310,	−6	18	16	15S, 061W
Caribou Lake Gabbro						
$NW-$ sites	13*(67)	302,	−49	58	5	13N, 064W(7, 5)
$NW-$ sites $s > 2$	9*(59)	298,	−49	113	5	15N, 061W(7, 4)
$SE+$ sites	6*(27)	139,	48	31	12	7N, 078W(16, 11)
$SE+$ sites, $s > 2$	3*(22)	132,	50	89	13	10N, 072W(18, 12)
$NW-$ and $SE+$ combined, $s > 2$	12*(81)	301,	−50	92	5	14N, 064W(18, 12)
average of site-poles (CL)	12*			71	5	14N, 064W
C Coronation overprint	1 (06*)	149,	76	27	13	37.4N, 095.4W(6, 4)
D magnetization (CLD)	12 (19*)	15,	79	14	9.4	81N, 073W(18, 17)

Symbols as in Table I. The palaeopole is given on the right. The letters in brackets in the first column are the palaeopole labels used in Figures 15 and 16. Asterisk indicates unit-weight.

Blachford Intrusive Suite (−2180 Ma). If it is a thermoremanent magnetization it is unlikely to be younger than the muscovite and biotite ages of −2166 ± 47 and −2109 ± 47 Ma observed in the western contact aureole because its unblocking temperature (500 to 600 °C) is higher than the argon blocking temperature in micas. If it is a chemical remanent magnetization it could substantially post-date the time of intrusion.

4. Geology and Sampling of the Easter Island Dyke

The Easter Island dyke is composed predominantly of alkali gabbro with a syenitic differentiate to the east of Figure 7. It intrudes Archaean basement and is overlain by the Great Slave Supergroup. Its age is post-Archaean (−2500 Ma) and pre-Great Slave Supergroup. The Compton laccoliths in the upper part of the Great Slave Supergroup yield K–Ar ages of −1865 Ma (Wanless *et al.*, 1979). Hence the age of the Easter Island dyke lies between these limits. The oldest K–Ar dates from the dyke itself are −2170 Ma (Leech *et al.*, 1966) and −2200 Ma (Burwash *et al.*, 1963). The dyke is 200 to 300 m wide and 20 km long. Its margins are sub-vertical. The overlying Great Slave Supergroup dips 8° to the northeast.

5. Remanent Magnetization of the Easter Island Dyke

The initial directions in the gabbro are scattered, but are generally directed downward

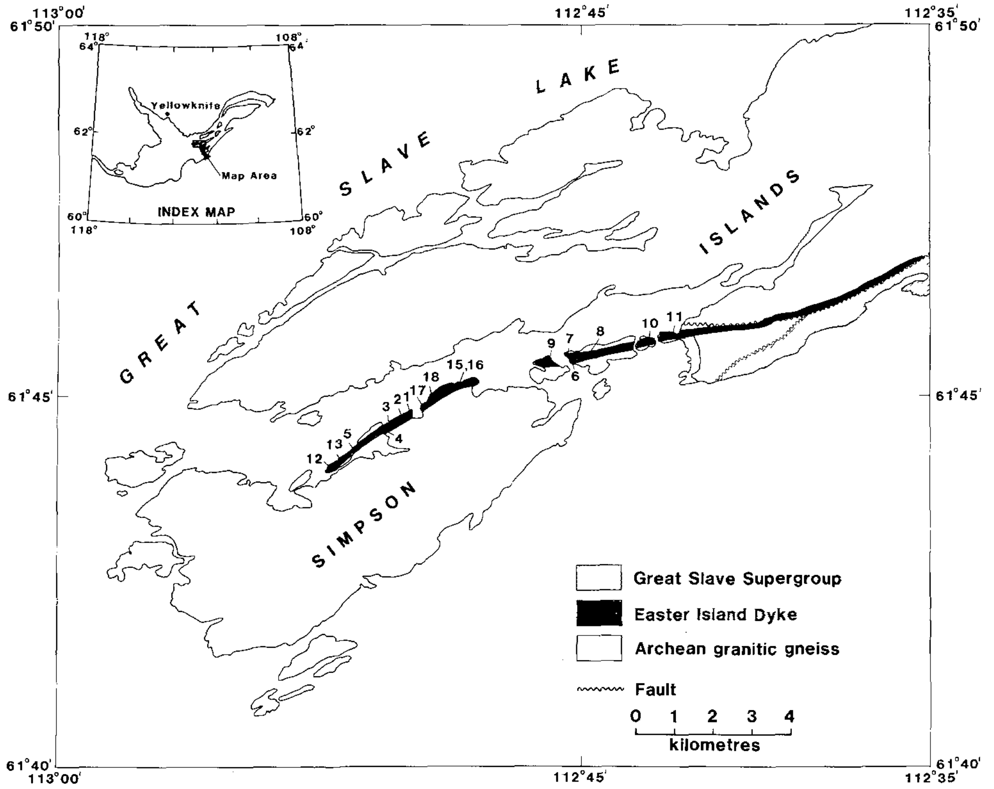

Fig. 7. Easter Island dyke and sampling sites. Site 8 is in baked gabbro, site 16 a granite contact. Site 14 is in syenite and is 2 km off the map to the east.

to the north and west. The directions from the syenite (site 14) are random and no coherent magnetizations were isolated. During AF treatment the magnetization of the gabbro becomes directed toward the west with intermediate inclination (Figure 8). This is referred to as the *WNW+* magnetization. The decay curve is smooth. After treatment in about 50 mT the intensity is reduced one hundred times, and at higher fields the directions begin to scatter as the magnetization becomes increasingly randomized. Orthogonal plots show perfect linear decay to the origin above about 15 mT (Figure 9). Thermal demagnetization yields square-shouldered decay curves and the directions remain coherent up to 575 °C (Figure 10). At higher temperatures the intensity is reduced to a few per cent of its initial value and becomes scattered, usually but not always randomly. Sometimes there is a systematic tendency to become steeply downward (Figure 10). A similar effect can occasionally be observed during af demagnetization (Figure 8).

Apart from a soft component magnetization that is readily removed at low temperatures and in low alternating fields, the remanent magnetization of the Easter Island dyke consists overwhelmingly of a single hard *WNW+* magnetization. It has

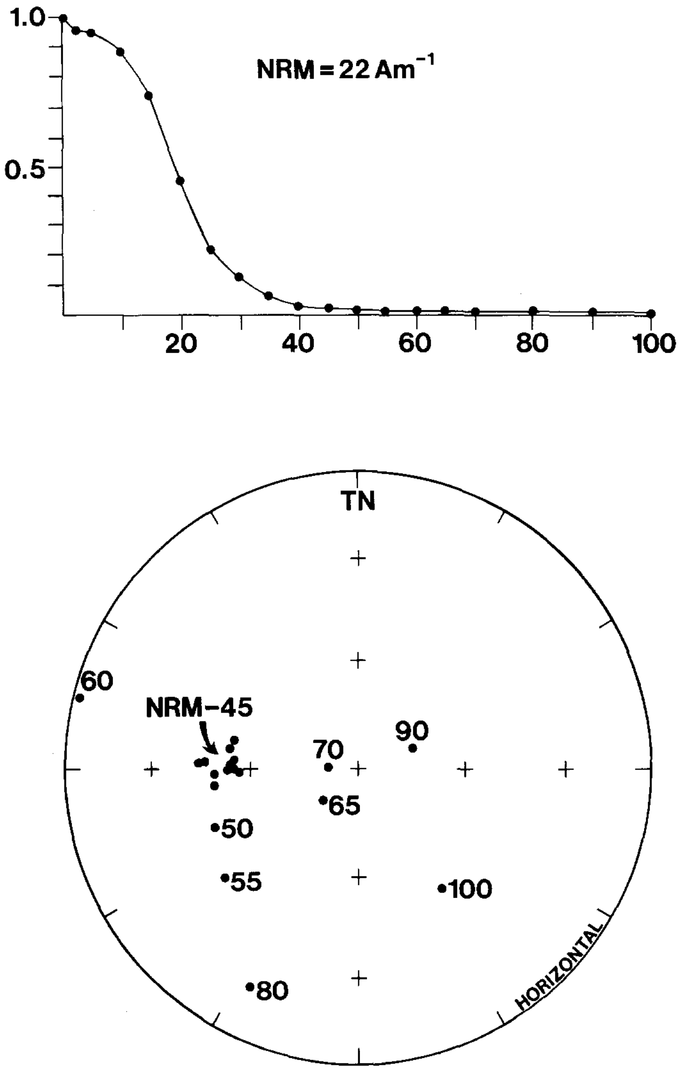

Fig. 8. Changes of intensity (above) and direction (below) of magnetization of gabbro of the Easter Island dyke, site 1, during af demagnetization. Solid (open) symbols denote downward (upward) inclination.

unblocking temperatures in the range 500 to 600 °C, and remanent coercive force typically between 10 and 50 mT occasionally as high as 100 mT. In addition, there is sometimes a very small *D* magnetization, no more than a per cent of the nrm, that is uncovered by heating to 600 °C or above.

The directions of the *WNW*+ magnetizations observed are plotted in Figure 11. The mean directions at each site are listed in Table III, and the overall mean *in situ* and corrected for tilt in Table III.

TABLE III

Results from Easter Island dyke

Site	c(s)	D°, I°	k	α_{95}°	Cleaning
1	5(11)	283, 46	233	3	30 mT, 575 °C
2	5(10)	288, 47	77	6	30, 40 mT, 525 °C
3	5(10)	293, 46	40	8	30, 40 mT, 575 °C
4	5(11)	279, 42	73	5	30, 40 mT, 575 °C
5	6(11)	278, 43	59	6	30, 40 mT, 575 °C
6	5(9)	282, 36	118	5	30, 40 mT
7	6(11)	287, 38	52	6	30, 40 mT
9	5(10)	269, 44	64	6	30, 40 mT
10	4(7)	294, 32	87	7	40 mT
11	5(9)	294, 29	29	10	40 mT
12	5(10)	275, 51	131	4	40 mT
13	5(10)	275, 43	68	6	30, 40 mT
15	5(10)	268, 44	73	6	40 mT
17	4(7)	282, 38	32	11	40 mT
18	6(10)	262, 40	156	4	40 mT, 550 °C

The treatment used is shown on the right. Symbols as in Table I. Sites plotted in Figure 7 but not listed here are where special studies have been undertaken, as detailed in Section 3.

The uniformity of the *WNW*+ magnetization and its high stability indicate that it was acquired in the direction of the palaeofield when the dyke first cooled. To test this assumption two contacts were studied. Samples of pink gneissic granite were taken at site 16 where the dyke cuts the Archaean basement (Figure 7). The intensities are low (less than $10^{-3}\,\mathrm{Am}^{-1}$) and the directions widely scattered. Neither thermal nor af demagnetization produced any coherence. Like many other similar attempts to study baked rocks at intrusive contacts in the Slave Province (McGlynn and Irving, 1975), this contact test failed. Even when reheated by Proterozoic intrusions the Archaean basement, for the most part, seems incapable of retaining a memory of the Precambrian field. At the second contact, samples of gabbro were obtained where a thinner younger Hearne dyke, 10 m wide, cuts the much wider Easter Island dyke (site 8, Figure 7). All samples were taken within 40 cm of the sharp contact. The reheated gabbro of the Easter Island dyke has a highly stable magnetization. After removal of soft magnetizations in low alternating fields there is excellent convergence to the origin on the orthogonal plots (Figure 13) and a true end-point (Figure 12). Thermal demagnetization also yields excellent true end-points with unblocking temperatures mainly between 550 and 600 °C (Figure 14). This very stable magnetization is directed to the northwest with low inclination. Correction for the tilt of the Easter Island dyke causes no significant change. The mean direction *in situ* is 310°, 2°. Corrected for tilt it becomes 310, −6°. This direction is very close to that observed in the *X* dykes (Figures 1, 15). The magnetization was probably acquired at the time this particular Hearn dyke was

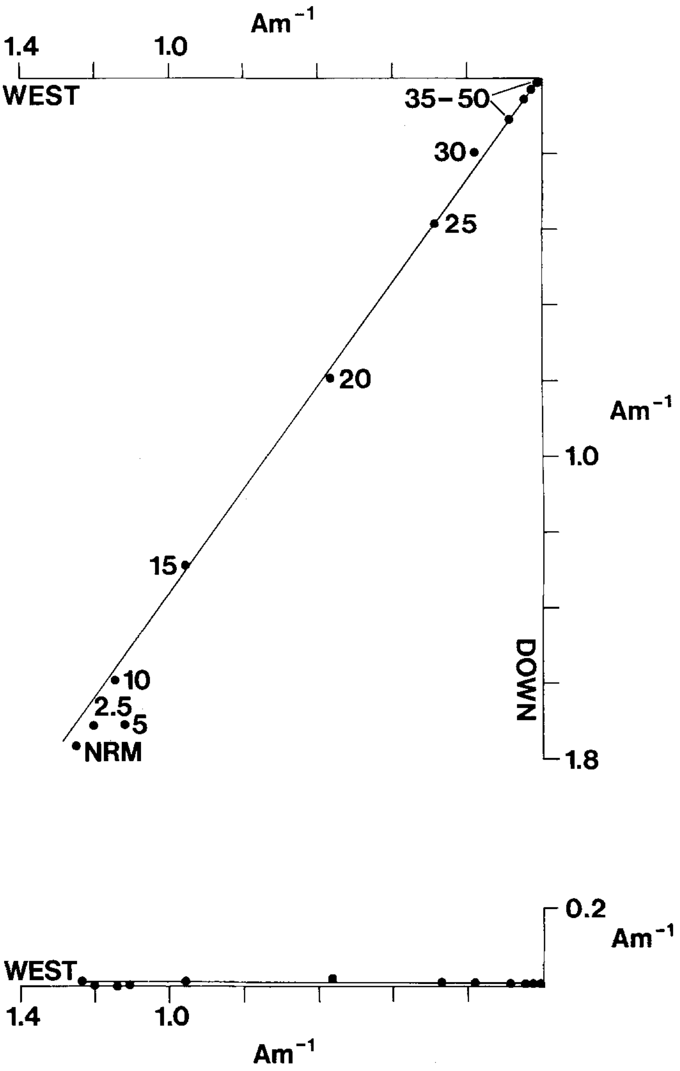

Fig. 9. Orthogonal diagrams showing linear decay of magnetization of gabbro at site 1, Easter Island dyke. Above vertical east-west plane and below horizontal plane. Fields are given in mT. The experimental points for fields greater than 50 mT are close to the origin and indistinguishable at this scale.

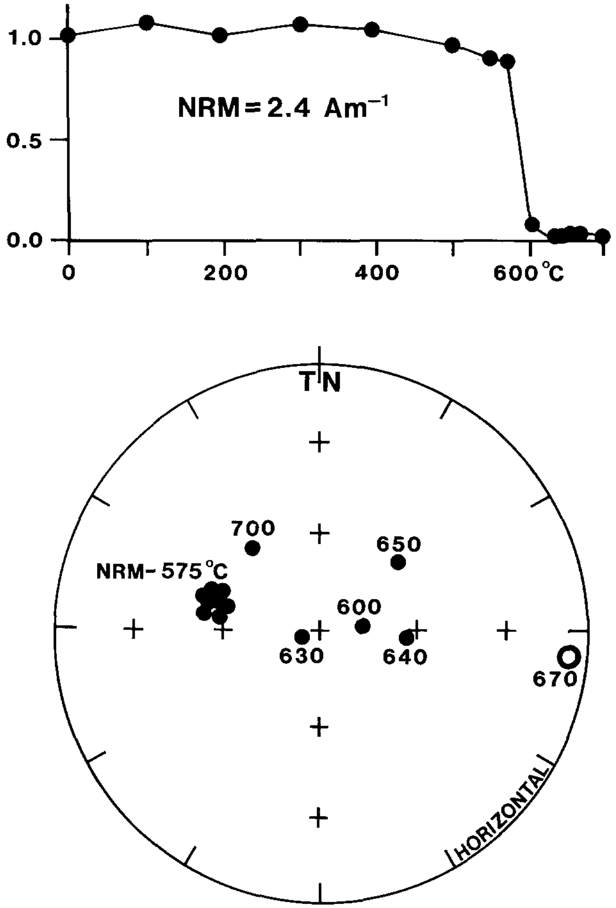

Fig. 10. Changes of intensity (above) and direction (below) of magnetization at site 1, Easter Island dyke, during thermal demagnetization 700 °C.

intruded and cooled, and hence post-dates the magnetization of the unheated Easter Island dyke. The later, therefore, in all probability, predates the intrusion of the Hearne dyke. The Hearn dyke itself is much less stable than the gabbro it bakes. Its magnetization is complex and, despite extensive demagnetization studies, it has not proved possible to resolve it.

Because of very limited geochronological data, the age of the magnetization of the Easter Island Dyke can only be defined within wide limits. The unblocking temperatures are higher than those for argon-loss in micas so the magnetization is probably at least as old as the oldest K–Ar date, −2200 Ma. It must be post-Archaean so the age limits are −2200 to −2500 Ma.

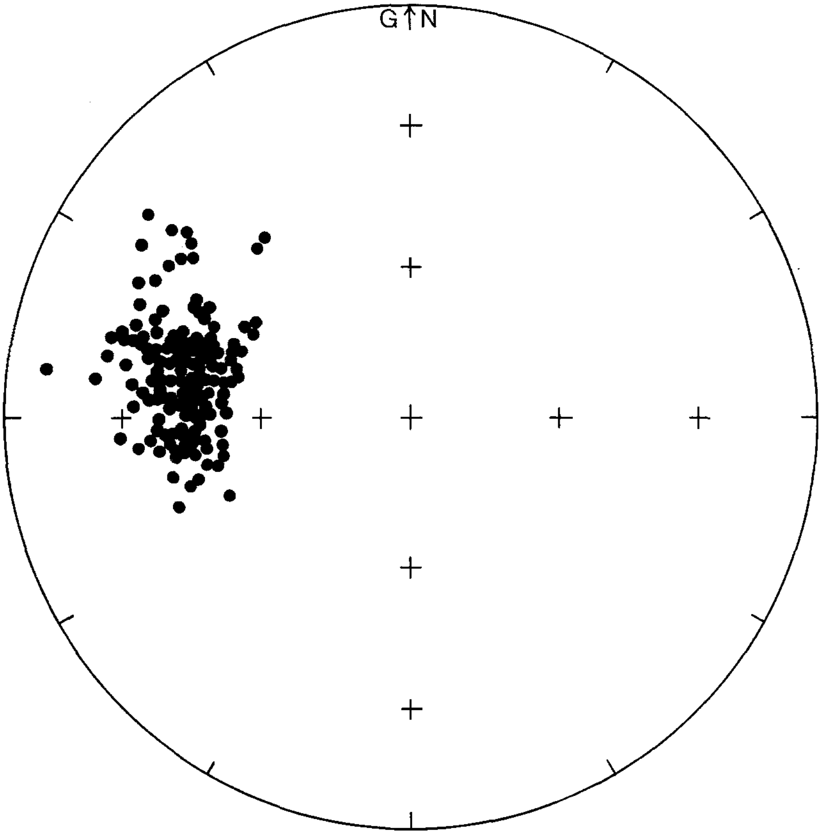

Fig. 11. Directions of magnetization in all specimens from Easter Island dyke after the cleaning specified in Table III. Perimeter is the present horizontal.

6. Early Proterozoic Slave Track

Paleopoles from Early Proterozoic rocks of the Slave Province are plotted in Figure 15. Excepting the D palaeopoles, they form an array stretching from the South Atlantic to the Caribbean. We refer to this as the Slave Track. Most evidence indicates that the trend is from southeast (older) to northwest (younger), but this is not certain. The Dogrib dykes (palaeopole DD) and the Easter Island dyke (ED) are the oldest of the intrusives studied, certainly older than the Indin dykes (palaeopole ID) which cut the Dogrib dykes. The palaeopole for the baked gabbro (HC) is to the northwest of that for the Easter Island dyke, which it post-dates. The northern end of the Slave Track is reasonably well fixed by the Indin dykes (−2050 ± 86 Ma, Gates and Hurley, 1973). Its older limit is tentatively fixed by the Easter Island dyke palaeopole as older than −2200 Ma. Dogrib dykes also falls in the age-range of −2200 to −2500 Ma and their palaeopole is consistent with this proposal. The estimated age of the Big Spruce

Complex is −2066 ± 40 (Rb/Sr (Martineau and Lambert, 1974) and its dominant magnetization yields a palaeopole (BC2) in excellent agreement with the Indin dykes and Caribou Lake gabbro. One of its subordinate magnetization, BC3, yields a palaeopole in the middle of the Slave Track. It would seem therefore that the age of the Slave Track is older than −2050 Ma, probably in part as older as −2200 Ma, and it is certainly post-Archaean. If the trend in age is truly from southeast to northwest, as indicated in Figure 15, and if the *NW-/SE+* magnetization of the Caribou Lake gabbro is primary, then the particular Hearne dyke (site 8) that intrudes the Easter Island dyke should predate the Blachford Lake Intrusive Suite. But in the north, other members of the Hearn dyke swarm are known to cut the suite. Hence the preferred age-trend of Figure 15 is wrong, or the Hearn dykes are not a single swarm but comprises an older

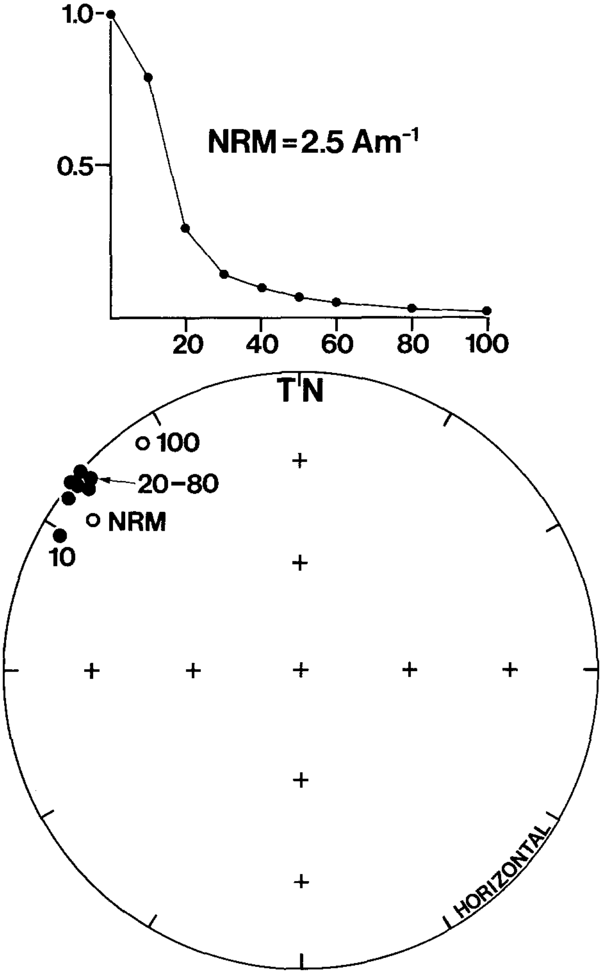

Fig. 12. Af demagnetization of gabbro of Easter Island dyke remagnetized by Hearn dyke, site 8.

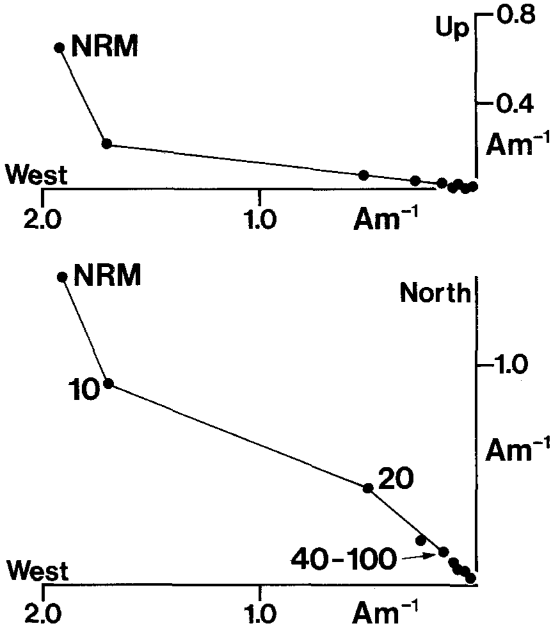

Fig. 13. Orthogonal plots of data of Figure 12.

swarm to the south and a younger one to the north, or the *NW/NW-/SE+* magnetization of the Caribou Lake gabbro is secondary acquired at the time of intrusion of the Indin dykes. Clearly, the accuracy with which the magnetizations are presently dated is insufficient to unambiguously resolve the trend, which will not be firmly established until better age-determinations of the Dogrib dykes and Easter Island dyke are available, and until a palaeomagnetic and age study of the entire Hearne dyke swarm has been made. In the meantime all that can be said is that the Slave Track is early Proterozoic (probably in the range −2200 to −2050 Ma) it is roughly 50° long, and that it is situated as shown in Figure 15.

The palaeopole for the Sparrow dykes (SD) is also plotted on Figure 15 at the north end of the Slave Track. These dykes intrude sedimentary rocks of the Nonacho Group, and are situated within what is now the Churchill Province just south of the exposed southern margin of the Slave Province (Figure 1). SD is indistinguishable from the paleopoles for the Indin dykes the Caribou Lake gabbro, and from the BC2 palaeopole of the Big Spruce Complex. All three rock-units contain reversals. Contact tests for the Indin and Sparrow dykes indicate that the magnetizations date from the times of intrusion. Whole-rock ^{39}Ar/^{40}Ar studies on the Sparrow dykes were indecisive (McGlynn *et al.*, 1974). They yield ages ranging from −2000 to −1700 Ma with a preference stated by the authors for the younger values. Therefore we originally placed the Sparrow dyke palaeopole, not on the Slave Track, but on a younger section of the path, the Coronation Loop. These magnetic similarities however could indicate that the true age of the Sparrow dykes is, in fact, closer to the older than the younger limit of the ^{39}Ar/^{40}Ar results. This would imply that the Nonacho Group and the gneissic 'Hudsonian' basement upon which they rest, is older than –2000 Ma, a conclusion consistent with the fact that muscovites from it have yielded K/Ar ages as old as –2300 Ma (Burwash and Baadsgaard, 1962). Indeed these gneisses may be a reactivated southerly extension of the Archaean Slave Province. A further implication is that there has been no very large relative movement between the Nonacho Basin and the Slave Province since the Sparrow and Indin dykes were intruded. Obviously, it is far from certain that the Sparrow dykes palaeopole should be assigned to the Slave Track.

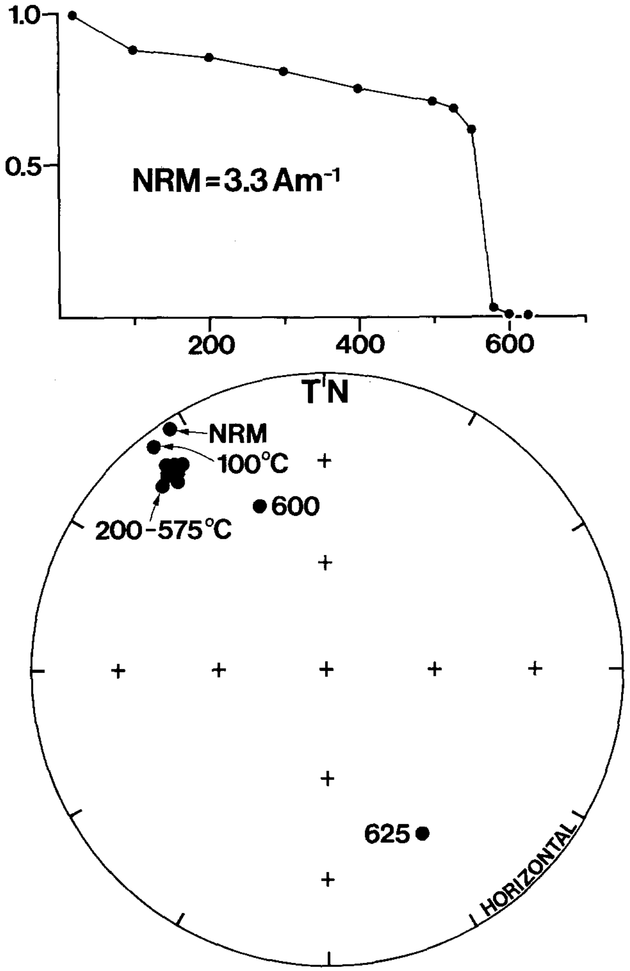

Fig. 14. Thermal demagnetization of Easter Island dyke gabbro remagnetized by a Hearne dyke, site 8.

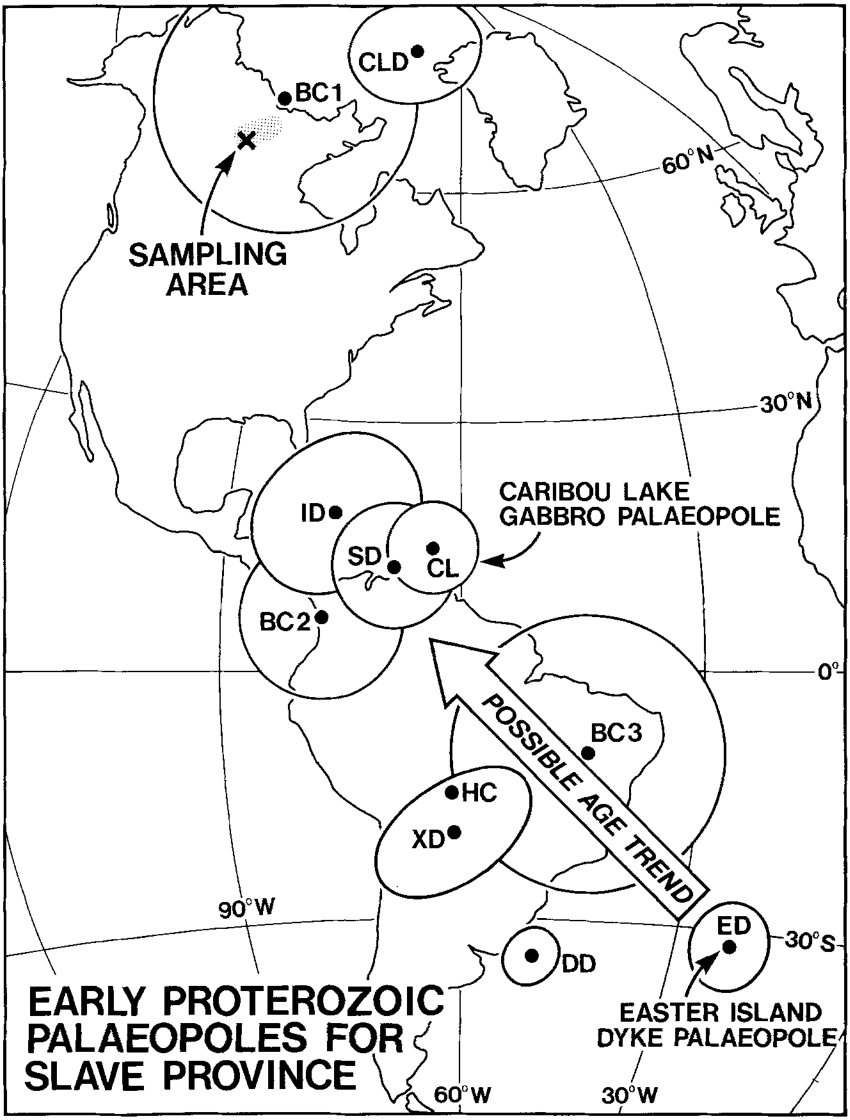

Fig. 15. Early Proterozoic palaeopoles for the Slave Structural Province. BC1, BC2, BC3 palaeopoles from three magnetizations observed in Big Spruce Complex (Irving and McGlynn, 1976); DD Dogrib dykes (McGlynn and Irving, 1975); ED Easter Island dyke, Table 2 herein; ID Indin dykes (McGlynn and Irving, 1975); XD 'X' dykes (McGlynn and Irving, 1975); CL Caribou Lake gabbro mean of $SE+$ and $NW-$ magnetizations, Table II herein; *CLD* from *D* magnetization of the Caribou Lake gabbro, Table II herein. SD is from the Sparrow dykes of the Nonacho Basin (McGlynn *et al.*, 1974). The arrow denotes the suggested age trend of the Slave Track. See text for discussion of age uncertainties.

It is entirely possible, as we have previously assumed, that it lies on a younger segment of the apw path, and that its position on the older Slave Track is coincidental. An accurate age determination for the Sparrow dykes is needed.

The *D* magnetizations are not significantly different from the PEF and have the same direction and properties as the *D* magnetization (BC1 Figure 15) of the Big Spruce Complex. *D* is always small in magnitude compared to other magnetizations present. Similar magnetizations have been observed from younger Precambrian rocks of Victoria and Baffin Island (Palmer *et al.*, 1983; Christie and Fahrig, 1983). They could be produced by incipient weathering, or they could have been produced by repeated cycling through the Morin transition since they occur in areas subject to repeated permafrost during the Pleistocene glaciations, – an interesting unsolved rock magnetic problem.

7. Slave-Superior Comparison

Earlier Proterozoic palaeopoles for the Superior Structural Province are plotted in Figure 16 and define a Superior Track, essentially that drawn by Irving and Naldrett (1977). Several palaeopoles, derived particularly from the Nipissing diabase from what we consider to be secondary magnetization, fall in latitudes of about 20 °S (documented in Irving and McGlynn, 1981), are not included. Palaeopoles such as TS and GG5, that fall to the side of the track, are assumed to have been displaced by local tectonic rotations such as are common in other fold belts (Irving and McGlynn, 1981). The older part of the Superior Track may be as old as –2500 Ma (Matachewan dykes, Figure 16). Its younger end is fixed by the well-dated Abitibi dykes (–2150 ± 25 Ma, Hanes and York, 1979), an age much the same as that of the Slave Track, and indistinguishable from the Blachford Lake Intrusive Suite. The reconstruction of neither the Superior nor Slave Track is unique. As they are drawn in Figure 16 they seem to us to be the simplest and most satisfactory way of explaining the age relationships of the various magnetizations as they are presently known.

The positions of the tracks are different. This implies that the Slave and Superior Provinces were in different relative positions during the Early Proterozoic. That they had amalgamated by about –1750 Ma is almost certain, because the widespread overprints that have been observed in the Slave (Irving and McGlynn, 1976; Schutts and Dunlop, 1981), Churchill (Reid *et al.*, 1981; McGlynn *et al.*, 1974) and Superior (Larochelle, 1966; Pullaiah and Irving, 1975; Schultz and Dunlop, 1981) Provinces yield concordant palaeopoles (review in Schutts and Dunlop, 1981 and Irving and McGlynn, 1981). But when, precisely, in the interval –2100 (approximate younger limit of tracks) to –1750 Ma (approximate age of Coronation overprint) the Slave and Superior Provinces achieved their present relative positions (when the Hudsonian Orogen became stabilized) is unknown.

The reconstruction of Figure 16 requires the existence of a wider gap than at present between the Slave and Superior Provinces in the Early Proterozoic. This interpretation is similar in principle to that given by Burke *et al.* (1976), Cavanaugh and Seyfert

(1978), but is simpler. Two simple segments of apw path for the two provinces replace a complex pattern of loops proposed by these. This simplification is made possible by assuming that the southerly group of palaeopoles from the Nipissing diabase (the *N1* group of Morris (1979) see Irving and McGlynn (1981, Figure 23.10)) are secondary (Mid-Proterozoic) and that the *D1* magnetizations are late Phanerozoic.

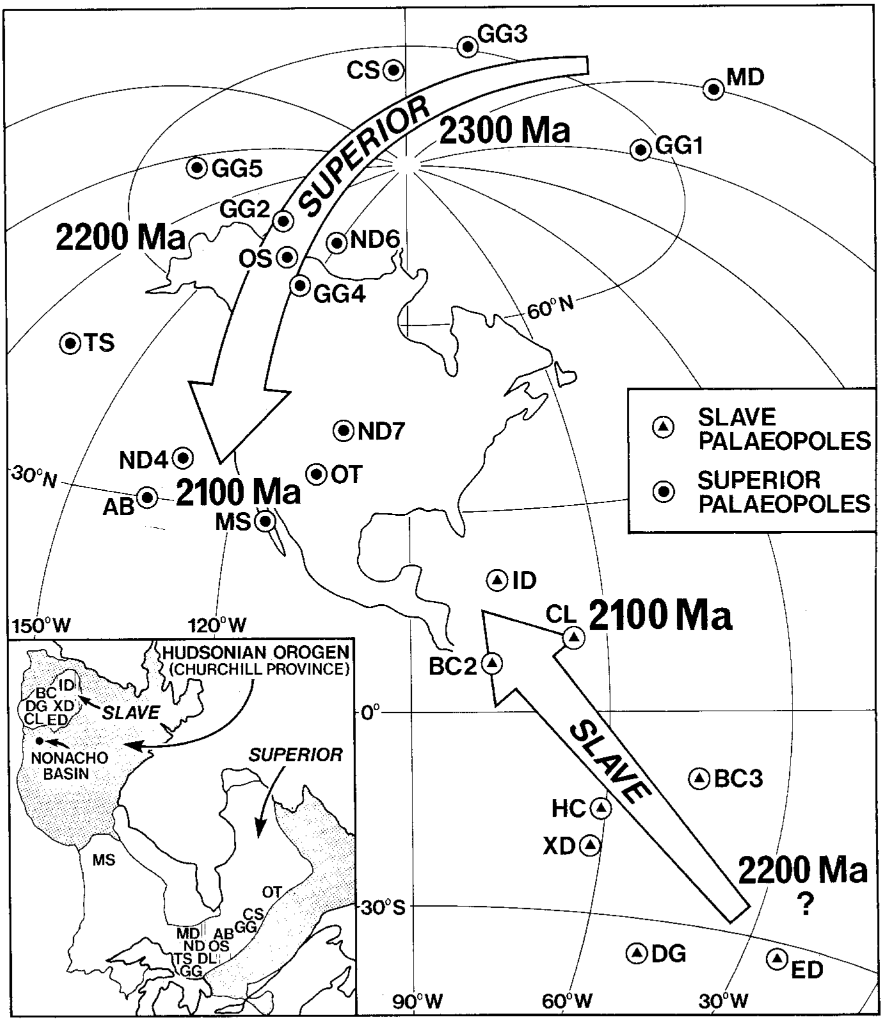

Fig. 16. Tentative Superior and Slave Tracks compared. Slave palaeopoles labelled as in Figure 15. Superior palaeopoles as follows: AB Abitibi dykes (Irving and Naldrett, 1977); CS Chibougamau sills (Ueno and Irving, 1975); GG1 to 5 Gowganda Formation (Symons, 1975; Morris, 1979; Roy and Lapointe, 1976); MD Matachewan dykes (Irving and Naldrett, 1977); MS Molson dykes (Ermanovic and Fahrig, 1975); ND Nipissing diabase (ND4, Symons, 1970; ND6, Symons, 1975, ND7, Roy and Lapointe, 1976)); OS Otto Stock (Pullaiah and Irving, 1975); OT Otish gabbro (Fahrig and Chown, 1973), TS Thessalon Volcanics (Symons and O'Leary, 1978).

This interpretation differs radically from that given earlier (Pullaiah and Irving, 1975; McGlynn *et al.*, 1975; Irving and McGlynn, 1976; Roy and Lapointe, 1976) in which a single south-trending track (then called Track 5) was constructed for the Early Proterozoic for the entire Canadian Shield. We did this because of the excellent agreement between the palaeopole for the Otto Stock (OS) in the Superior Province and the BC1 palaeopole (derived from *D* magnetization which we then assumed primary) of the geochronometrically indistinguishable Big Spruce Complex in the Slave Province. The possibility that *D* may be much younger was discussed at the time but regarded as improbable (Irving and McGlynn, 1976). Our reasons for believing that our initial interpretation of *D* was mistaken have been presented in detail elsewhere (Irving and McGlynn, 1981).

It seems therefore that there is ground for supposing that the Slave and Superior Provincies were separated in the Early Proterozoic and that they had come to their present relative positions by the Middle Proterozoic. That is relative continental drift was occurring then as now. The hypothesis that there was a fixed supercontinent, embracing all continental crust, in existence through the Proterozoic (Piper, 1982) seems incorrect. Piper would connect all palaeopoles of Figure 16 in one continuous highly complex apparent polar wander path. The separate clustering of paleopoles from Early Proterozoic rocks of the Slave and Superior provinces apparently belies this interpretation. However, although the spacial resolution of palaeomagnetic observations is fully adequate to detect Early Palaeozoic drift their timing is not sufficiently accurate to provide a convincing case. The present results therefore, although suggestive of drift do not provide a definitive measure of it. That can only come about through more detailed geochronological studies.

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