Palaeomagnetism, by G. E . Morgan - St. Kilda: an illustrated account of the geology

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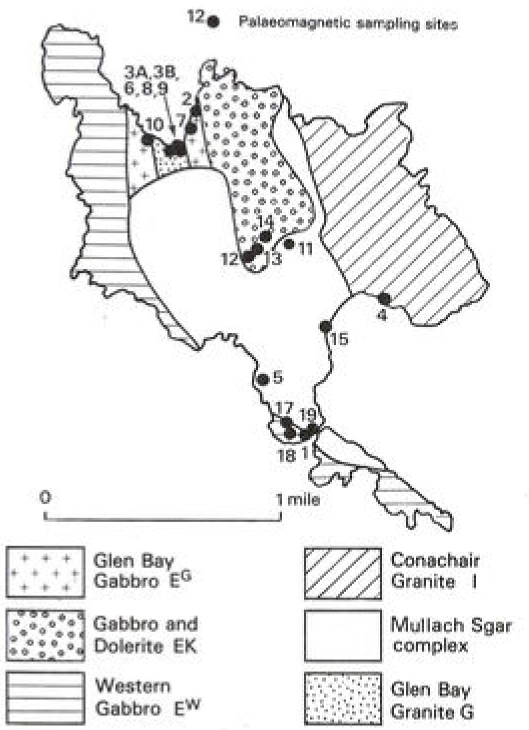

Figure 38 Simplified geological map of St Kilda showing the palaeomagnetic sampling sites

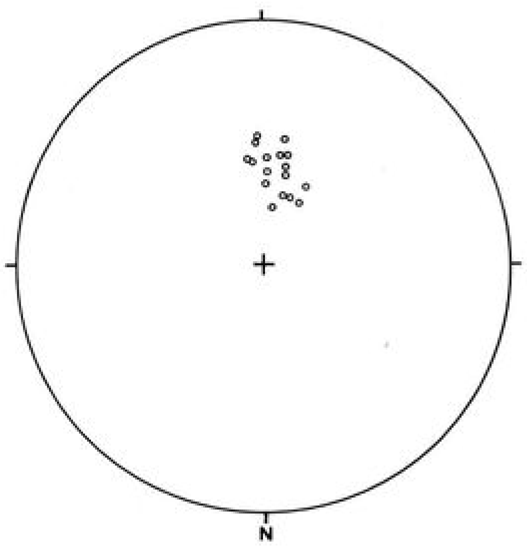

Figure 39A The cleaned site-mean directions of magnetisation. Equal area projection; open circles indicate upper hemisphere

(negative inclinations)

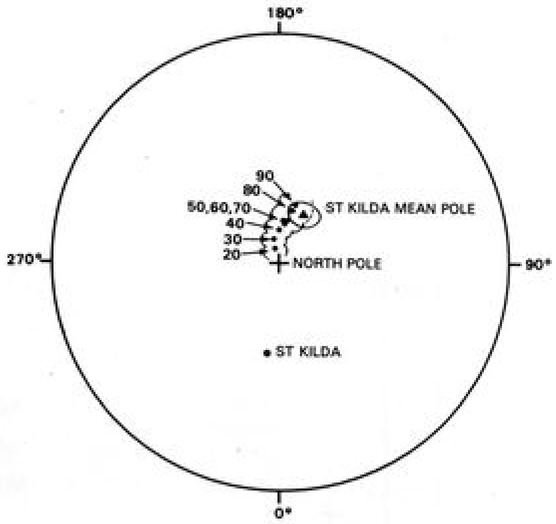

Figure 39B The St Kilda palaeomagnetic pole with its oval of 95% confidence and the apparent polar wander path for the last 90 million years (Irving, 1977). The arcs of 95% confidence are part drawn around the individual poles; polar equal area projection.

Chapter 21 Palaeomagnetism

Keywords: sampling, statistics, reverse magnetisation, Tertiary pole

Oriented cores for palaeomagnetic investigations were obtained from 19 sites in a variety of lithologies on the main island (Figure 38A). Samples from 17 of these sites responded extremely well to alternating-field (af) demagnetisation and yielded stable well-grouped end points. These stable magnetisations were approximately reversed with respect to the present day field direction, having southerly declinations and moderately steep negative (upward) inclinations. The palaeomagnetic statistics of each of these 17 sites, together with the overall final statistics, are given in (Table 38).

At most sites the total NRM (that is, uncleaned) directions of the individual samples were already moderately or well grouped with southerly declinations and negative inclinations, and af demagnetisation simply improved the grouping and generally slightly steepened the inclinations. At some sites, however, the total NRM directions were either loosely grouped around the earth's present Field direction: they had northerly declinations and steep positive inclinations, or they were more or less randomly distributed, but in both cases af demagnetisation caused the directions to move to stable well grouped end points with southerly negative inclinations very similar to those shown by the other sites. A number of samples were subjected to thermal demagnetisation and this technique produced stable directions indistinguishable from those obtained using af demagnetisation.

The two sites which gave unsatisfactory results were site 1, a rusty-weathering dolerite sheet in the Dun Passage, and site 4, in the Conachair Granite. The total NRM directions at site 1 were well grouped, almost exactly parallel to the earth's present field direction, and af and thermal demagnetisation did not produce any appreciable change in the mean direction, but caused the grouping to deteriorate and also indicated that the stability or remanence was much less than for any of the 17 reversed sites. Although it is of course impossible to be entirely certain that the loose grouping of cleaned directions does not represent a primary normal remanence, it is felt that the balance of evidence suggests that this magnetisation is of very recent origin, and consequently this site was excluded from the overall statistics. At site 4 the cleaned directions were spread out between the earth's present field direction and the reversed direction found in the 17 stable sites, suggesting that this site contains both these components, but with overlapping stability spectra so that they cannot be isolated by demagnetisation. This site was also excluded from the final statistics; whether its northerly component is of recent origin or represents a primary normal remanence is difficult to decide.

Thus all 17 sites which showed good stability have stable magnetisations with southerly declinations and moderately steep negative inclinations. The sites cover a variety of lithological types and include the Western Gabbro, the gabbro on Mullach Geal, the Glen Bay Gabbro, the Glen Bay Granite, and the rocks in the Mullach Sgar Complex. At each site at least 7 separately oriented cores were analysed, and (Table 38) shows that the within-site grouping of cleaned directions was always good, with most sites having a circle of confidence (α 95) of less than 5°, and no site having an α 95 of more than 12°. The 17 cleaned site mean directions are plotted in (Figure 39A), which shows that there was also very close between-site grouping.

The fact that all the stable magnetisations on St Kilda are of reversed polarity suggests that the intrusion of the whole complex occurred over a fairly short time period during one polarity interval. The most recent version of the Cainozoic polarity reversal time scale (Lowrie and Alvarez, 1981) shows an uninterrupted reversal interval of longer than average duration between about 53.7 and 55.8 Ma, so it is evident that a suitable period of reversed polarity occurred at the time which radiometric dating (pp. 40–1) indicates is the most probable age of intrusion. The pole corresponding to the overall mean direction from St Kilda is shown in (Figure 39B), together with a recent version of the Cainozoic and late Mesozoic apparent polar wander (apw) path for northern Eurasia. Although both the apw path and the St Kilda pole are quite precisely defined, the confidence limits associated with both, together with the relatively slow rate of apw during this period, preclude using the position of the pole for accurate dating. It is noted however, that the St Kilda pole is indistinguishable at the 95% probability level from the 55 Ma pole, and so is consistent with this age assignment. The position of the St Kilda palaeomagnetic pole on the far side of the geographic pole implies that Britain has drifted about 19° northwards in the last 55 million years.

(Table 38) Palaeomagnetic results from St Kilda

	–	Total NRM	Total NRM					Cleaned	Cleaned			
Site	Lithology	N	K	α 95	Dec	Inc	Demag Field (mT)	N	K	α 95	Dec	Inc
1	Dolerite	9	49.0	7.4	4.0	70.7						
2	Dolerite	8	92.3	5.7	181.9	−43.5	40	8	164.7	4.3	189.5	−48.0
3A	Dolerite	9	103.6	5.0	194.4	−56.0	20	9	242.0	3.3	193.6	−60.6
3B	Microdiorite	7	44.8	9.1	95.2	87.8	60	7	170.9	4.6	171.2	−54.5
4	Granite	11	7.9	17.2	258.3	45.8						
5	Microdiorite	8	6.2	24.0	29.6	68.5	20	8	609.0	2.2	182.8	−59.8
6	Dolerite	8	182.3	4.1	207.6	−57.7	20	8	559.4	2.3	208.1	−61.1
7	Gabbro	8	40.4	8.8	171.4	−35.5	20	8	527.6	2.4	181.7	−54.8
8	Granophyre	8	3.9	31.9	173.6	29.9	60	8	177.3	4.1	173.5	−56.1
9	Dolerite	8	150.2	4.5	175.7	−43.0	30	8	643.7	2.1	176.5	−49.7

10	Gabbro	8	6.4	23.7	174.6	−23.9	60	8	67.1	6.8	177.6	−47.6
11	Dolerite	8	1.8	58.5	185.2	65.4	50	8	117.3	5.1	181.4	−63.7
12	Gabbro	8	36.0	9.3	156.9	−67.5	20	8	108.8	5.3	188.4	−70.9
13	Gabbro	8	179.0	4.1	209.5	−65.8	20	8	229.4	3.6	201.1	−66.7
14	Gabbro	8	80.1	6.2	188.6	−59.8	20	8	160.3	4.3	192.7	−57.3
15	Dolerite	8	1.6	64.9	229.2	31.6	40	8	75.3	6.4	194.9	−66.6
17	Gabbro	7*	1.9	59.5	231.9	−23.6	50–100	7*	164.0	4.7	192.9	−53.4
18	Gabbro	9	1.8	54.7	154.7	47.0	60	9	19.3	12.0	188.3	−53.4
19	Diorite	8	1.8	59.1	251.6	−46.4	20	8	239.8	3.5	209.0	−67.0

* Overall cleaned mean direction N = 17, K = 80.0, α 95 = 4.0°. Dec = 187.3°, Inc = −58.7°
• Corresponding mean pole (reversed) 71.0°N, 153.8°E (dp = 4.6°, dm = 6.0°)
• *Notes* N **=** number of samples (number of sites in overall statistics), K **=** Fisher's precision parameter, * = α 95 = radius of 95% confidence about mean direction, Dec and Inc = the declination and inclination of the mean direction, dp and dm = the minor and major semi-axes respectively of the oval of 95% confidence about the palaeomagnetic pole. (*One sample with an anomalous direction omitted from the statistics of site 17)

References

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