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Remanent Magnetism of the Cretaceous Basalts of Madagascar

A GENERAL study of the remanent magnetism of volcanic rocks from Madagascar has been undertaken since the beginning of 1958 under the direction of Dr. H. Besairie, chief of the Geological Department of Madagascar.

From various places in the island, more than a hundred oriented samples have been collected by one of us (L. C.) and seven samples by J. Boulanger and P. Bussiere. Forty samples belong to flows or dykes well dated from the upper Cretaceous. Their ages have been proved to vary between Cenomanian and Santonian[1].

The samples were taken in places widely distributed along the eastern coastal district and the western part of the island. They were generally collected in quarries or trenches, some metres below ground-level, but sometimes at ground-level in river beds. The rocks are dolerites, basalts or sakalavites.

In some places, Ampijoroa, Amborompotsy, Antsalova (part), the directions, as well as the values of the intensities of magnetization, proved widely scattered. Values as high as 33×10^{-3} c.g.s. units/gm. were found. It is believed[2,3] that lightning currents were responsible for these magnetizations. For the other places the intensities as well as the directions of magnetizations showed good consistency.

For samples originated from the same flow or dyke, the differences between the individual values obtained and the mean value vary from 0 to 4 deg. for inclination and from 0 to 20 deg. for declination.

According to the places, the mean values found for the intensities of magnetization vary from $0{\cdot}8 \times 10^{-3}$ to 9×10^{-3} c.g.s. units/gm.

The magnetic stability of the samples was tested by E. Thellier's method[4], that is, turning over the sample in the Earth's magnetic field for one to several months and comparing the values obtained before and after turning over. Except for two samples, the magnetization showed no variation.

The nature of the magnetization was tested on some samples by successive heatings in a non-magnetic furnace. Only one Curie point was observed between 400° C. and 600° C. for each sample. The magnetization is thought to be thermoremanent[5] and acquired at the time of cooling of the rocks.

All the samples are magnetized according to the sense of the present geomagnetic field at Madagascar.

Table 1

	Inc.	Dec.
Northern districts		
Sambava	−49° 30′	15° E.
Antalaha	−55°	39° E.
Samanavaka	−48°	18° W.
Central districts		
Fenerive	−62°	19° E.
Andramy	−51°	7° E.
Andafiha	−57°	18° E.
Antsalova	−47°	4° E.
Southern districts		
Manakara	−70°	36° E.
Vineta	−53°	26° E.
Tongobory	−56°	15° E.

The mean values of the directions of magnetization for the stable samples at each place are given in Table 1. The inclinations are termed negative when the extremity of the magnetization vector points above the horizon.

The inclinations are systematically steeper by 2–10 deg. than those of the present magnetic field for the places on the eastern coast (Sambava, Antalaha, Fenerive, Manakara), but generally lower for the western districts (the differences from the present magnetic field being less than 7 deg.). Notwithstanding a dispersion of some degrees, the magnetic inclination of the samples increases with increasing latitude.

On the whole there is not much difference between the distribution of the magnetic inclination of the samples and that of the present geomagnetic field in the island, as we noticed in our first studies.

The declinations of the samples are all easterly, except for one place (Samanavaka). They differ widely from those of the present geomagnetic field in the island (which vary from 7° W. to 19° W.), the mean difference being nearly 30 deg.

The calculation of the orientation of the dipole axis corresponding to the magnetization of the rocks gave the values for the co-ordinates of the north geomagnetic pole as shown in Table 2.

Table 2

	Lat.	Long.
Northern districts	70° N.	161° W.
Central districts	70° N.	165° W.
Southern districts	64° N.	177° W.
Mean	68° N.	168° W.

The place calculated is in the vicinity of the Behring Strait (Fig. 1). S. K. Runcorn[7] has given results he obtained from the Cretaceous Dakota Sandstones the magnetization of which could correspond to a north geomagnetic pole at latitude 77° N. longitude 127° E., the sense of magnetization being reversed compared with that of the present terrestrial magnetic field.

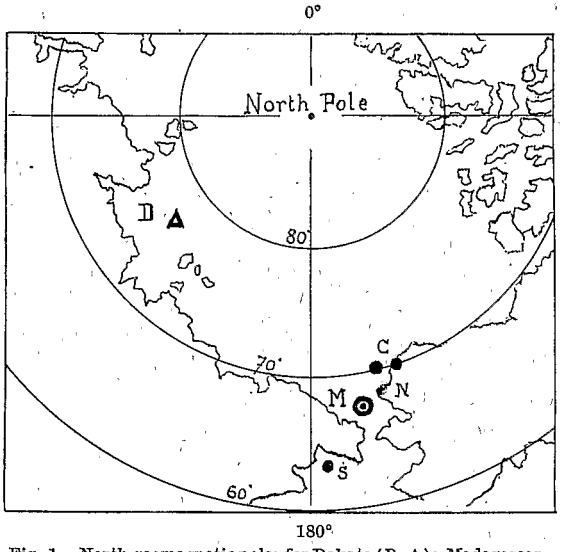

Fig. 1. North geomagnetic poles for Dakota (D, △); Madagascar, mean (M, ⊙); Madagascar, parts (N, C, S, ●)

The north geomagnetic pole for Madagascar is thus at a distance of less than 1,500 miles from the north geomagnetic American pole as given by Runcorn, and a little farther from the present geographical north pole.

This can be interpreted in different ways.

(1) The geomagnetic field, though having a dipole character for the main part, may have presented at times in the past a more or less complicated pattern, and the anomalies were smoothed out by taking the means of values scattered over long periods (of perhaps thousands or millions of years).

Therefore our results would have no significance in the perspective of polar wandering or continental drift.

(2) According to Runcorn's hypothesis[8], the mean geomagnetic field obtained by taking the mean of values scattered over a long period is a geocentric dipole field; our results would give the mean orientation of the dipole relative to Madagascar during a part of the upper Cretaceous.

(*a*) If the axis of the dipole had undergone, in the past, angular displacements of limited amplitude comparatively rapidly, say, for example, 10–20 deg. in one or a few million years, then the difference between our results and those of Runcorn could be most simply interpreted by the fact that the samples of America and of Madagascar do not belong exactly to the same period and the results give a picture of the orientation of the dipole at two different periods of the Cretaceous.

The opposed polarities of magnetization for the samples of Dakota and Madagascar give support to this hypothesis.

(*b*) If the dipole axis has undergone in the past displacements only at a slow rate (whether the dipole coincided or not with the axis of rotation of the Earth), we would have to think of relative continental drift for Madagascar and North America. From the Cretaceous up to the present time, according to calculation, the drift for Madagascar would have been about 1,500 miles in amplitude with a direction north-north-easterly.

Though displacements of much larger amplitude have been contemplated for Australia[9] and the Deccan peninsula[10], this hypothesis is considered by us as less likely than that of paragraph 2*a* above.

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