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A Paleomagnetic Study of The Mbagathi Phonolitic Trachytes of Kenya

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Abstract: *This paper presents results of paleomagnetic study of the mbagathi phonolitic trachytes, volcanic rocks of lower tertiary age, dated 5.7 my, from Kenya. Specimens of the mbagathi phonolitic trachytes, from five sites were sampled and treated in alternating field up to 100mT, stable primary components of the natural remanence isolated and various magnetic parameters analyzed. The cleaned mean directions have been classified as intermediate or reversed. The mean direction and corresponding pole position of the phonolitic trachytes, for the reversedly magnetized sites, is calculated at declination D=151.1^0, inclination I=24.2 ^{0} (α_{95}= 21.0 ^{0}) and longitude 104.0 ^{0} E, latitude 59.2 ^{0} S (δm=22.5 ^{0}, δp=12.0 ^{0})and for the intermediately magnetized sites at D=73.71^0 I= 39.97 ^{0} (α_{95} = 17.3 ^{0}) and longitude 102.9 ^{0}E,latitude 14.4 ^{0}N,(δm = 20.8 ^{0},δp =12.5^0)respectively. These results may, together with others, assist in developing a magnetostratigraphic correlation of Nairobi area rocks.*

I. Introduction

The geology of the east African rift system as a whole has been summarized by Baker et al. (1972) and the sequences and geochronology of the Kenya rift system discussed in Baker et al. (1971). The Kenya rift volcanic erupted nearly continuously from early Miocene to holocene times producing mainly nephelinites, alkali basalts and phonolites in the Miocene period. Pliocene activity was trachytic, nephelinitic to basaltic in most parts of the Kenyan rift system. The formations of which the country surrounding Nairobi area is built for the quaternary and tertiary include limuru trachytes, Nairobi phonolites, ngong basalts, tuffs and agglomerates, mbagathi phonolitic trachytes, Nairobi trachytes and kerichwa valley trachytes. Mbagathi phonolitic trachytes are exposed over an area of about 130 km2 in the vicinity of Mbagathi River and southward of it. The eruptions were associated with pyroclastic ejections. In different parts, the base rests on the basement complex and the kapiti phonolites. Their thickness is believed to be small. In the field, mbagathi trachytes exhibit numerous closely spaced laths of feldspar in a rather coarse trachytic base. At the surface, it is vesicular and easily weathered. As is the case with most phonolites, the texture and prevalence of individual minerals vary considerably in different parts of the same mass. Pyroxenes are uncommon as compared to amphiboles. The lava is considered intermediate between the more acidic phonolites and the quartz free trachytes.

II. Sampling

For this study, the mbagathi Phonolitic Trachytes was sampled in the vicinity of Mbagathi River at latitude 1° 24’S, longitude 36°47' E about 15 kilometres south of Nairobi, Kenya. The blocks were first dislodged from their parent position with a sledgehammer, and then carefully replaced in their original position noting their orientation angles. The collection and orientation of the block samples was done as described by Collinson et al. (1964). Each individual block sample was oriented in situ using a compass and an inclinometer, recording the dip and strike of the formation. The bearing, latitude and longitude were also noted for every sample. The maximum error in strike, dip and position angles is less than 2% of a degree while in the bearing measurements; it is up to 1o. A total of 5 sites from two quarries were sampled yielding 17 samples. The rock unit is vesicular and weathers easily.

III. Measurements

The block samples collected in the field were taken to the laboratory and re-oriented in the same position as in situ and cores of diameter 2.5cm drilled out. The cores were then cut into sizeable specimens of length about 2.5cm, which were then used in magnetic analysis of the remanence. Each specimen had its natural remanence measured at zero field and at each demagnetization step. Cleaning of the specimens was done utilizing the alternating field (a.f.) demagnetizing equipment All rock specimens were demagnetized and at each demagnetization step, their remanence was measured using a spinner magnetometer. The optimum cleaning field of a site was pre-determined using site pilot specimens. The pilot specimens for each site were demagnetized up to 100 mT or until the optimum cleaning field was attained, in steps of 5mT using the

Forster(1966) alternating field demagnetization equipment, the spinner magnetometer. At each step of demagnetization the natural remanence was measured. The demagnetization vector plots and the stability curves were then computed. The optimum field intensity, the field necessary to clean the secondary magnetism of the rocks of a given site was then deduced from the plots. The choice of the optimum field from the stability index curves is as explained by Briden (1972), the stability index (S.I) is defined for successive equal increments of alternating fields of 5mT. During the successive demagnetization, the field at which the stability index (S.I.) is maximum is chosen as the most suitable cleaning field. All site specimens were then demagnetized with a field 10 mT below and above this chosen field. The field which then gave the smallest α95 (radius of cone of confidence) is selected finally as the true site cleaning field. All further samples of the site were cleaned and their magnetism measured at this field. In some sites, a single field suitable for all site specimens could not be found. Most of the specimens then required full step by step demagnetization before an end point could be identified. In addition, it was necessary to discard a number of specimens which behaved erratically either by not giving a distinct grouped end direction on the stereo nets, decay curves, or stability index curves. In such cases, the specimens were subjected to Watson's (1956) test for randomness at 5% significant level before discarding.

IV. Results And Discussion

Seventeen (17) block samples of the Mbagathi phonolitic trachytes were collected from sites labeled 1-5. At least one pilot specimen for every site was demagnetized fully in steps of 5 mT in order to determine the cleaning field for the rest of the specimens of the site.Table 5 gives the mean site directions before and after alternating field demagnetization. In the analysis site means were calculated giving unit weight to the samples. The paleomagnetic results indicate at least two distinct flows. The clustering of the cleaned directions in Fig. 5(d) and the overlapping of circle of confidences would seem to suggest that the results of sites 1 and 3 may be combined and similarly those of sites 2, 4, 5 . These sites were subjected to Watson's(1956) F-ratio test. It was observed that sites 1 and 3 are not significantly different at 5% level of significance and are therefore combined to obtain an intermediate direction and the corresponding paleomagnetic pole. Similar results were found for sites 2, 4 and 5 which are also combined to give a reversed direction and a corresponding pole for the Mbagathi phonolitic trachytes.

TABLE 5 - MBAGATHI PHONOLITIC TRACHYTES

		Before a.f. Cleaning					After a.f. Cleaning						Pole Position				
ST.	N	R	D	I	K	α_{95}	R	D	I	K	α_{95}	He	Long.	Lat.	δm	δp	Polarity
1	3	2.83	60.11	38.3	12.0	37.2	2.97	71.6	43.6	63.0	15.6	30	153.1	-19.2	19.5	12.1	I
2	3	2.61	145.8	30.8	5.15	61.1	2.96	143.8	31.3	49.7	17.7	35	101.1	-51.1	19.8	11.1	R
3	3	2.66	265.7	37.5	5.9	56.1	2.99	75.6	36.3	146.0	10.2	20	147.2	-14.0	11.9	6.9	I
4	4	2.85	73.4	36.8	2.6	71.5	3.89	145.6	13.8	27.5	17.8	40	116.5	-55.3	18.2	9.3	R
5	4	2.85	132.6	40.4	2.61	72.1	3.84	164.1	26.7	18.2	22.1	45	87.0	-69.8	24.0	13.0	R

(Symbols same as in table 2).

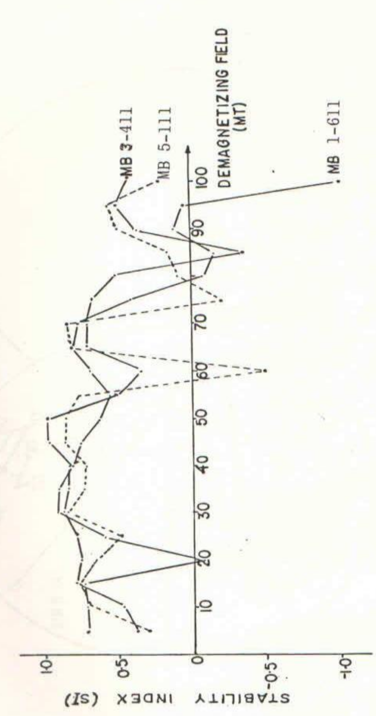

FIG. 5a: STABILITY INDEX CURVES FOR PILOT SPECIMEN OF MBAGATHI PHONOLITIC TRACHYTES.

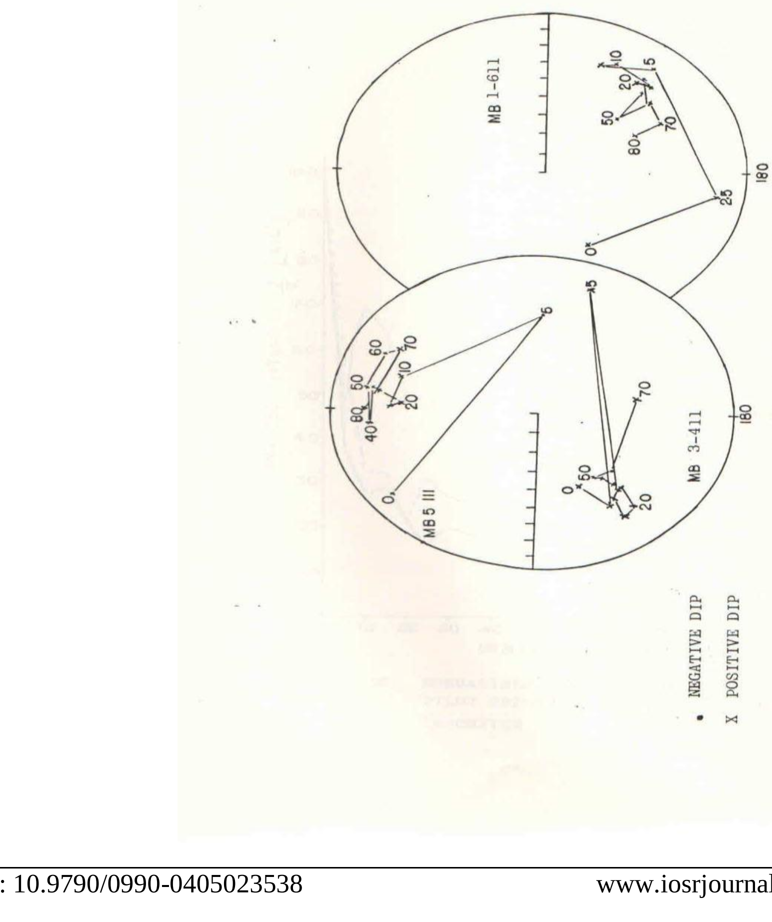

FIG 5b : A PLOT OF DIRECTIONAL CHANGES OF PILOT SPECIMENS OF THE MBAGATHI PHONOLITIC TRACHYTES

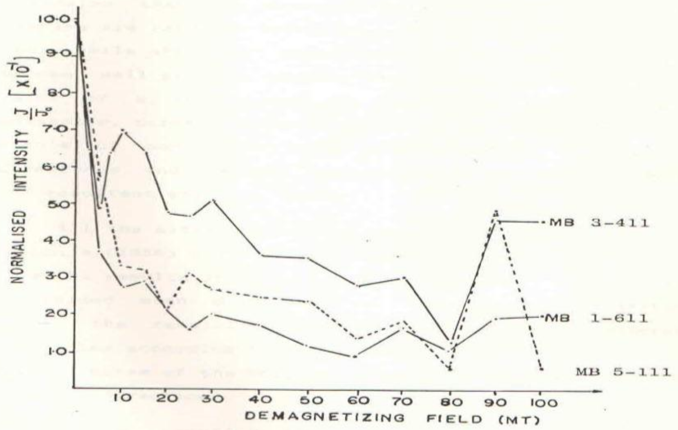

FIG. 5C: NORMALISED DEMAGNETIZATION CURVES FOR PILOT SPECIMENS OF MBAGATHI PHONOLITIC TRACHYTES.

The mean direction and corresponding pole for the reversedly magnetized sites is calculated at declination D=151.1°, Inclination 1=24.2° (α95 = 21.0°) and longitude 104.0° E, latitude 59.2° S (δm = 22.5°, δp=12.0°) and for the intermediately magnetized sites at D =73.71°, I = 39.97° (α95 = 17.3°) and longitude 102.9°E, latitude 14.4 0 N (δm = 20.8 0 , δP=12.53 °) respectively.These directions are believed to be primary as the specimens were adequately cleaned in each case. They therefore, represent a good estimate of the mean field direction and paleomagnetic pole for the sampled part of the phonolitic trachytes. Sampling was done over a large area in order to average out possible errors due to secular variations.

V. Conclusion

The mbagathi phonolitic trachytes have been tentatively included in the group of mid Pliocene phonolites and trachytes represented by two main formations of kabarnet trachytes(6.7-7.3 my) and Thomson fall phonolites (6.5 my) dated by Baker et al. (1971), though comparatively younger. The phonolitic trachytes rest upon the upper Miocene phonolites and are overlain by local representatives of the plio- Pleistocene group, the limuru trachytes.The majority of the specimens of the mbagathi phonolitic trachytes posses low coercivity , ranging between 7.5- 15 mT of remanence and directions of some specimens remained scattered at all fields of demagnetization. Paleomagnetic analysis yielded mixed directions of reversed and intermediate polarities for the five sampled sites of mbagathi river valley. The grouping of directions suggest two thin sheets for the formation since sampling was done at approximately same horizontal level. K/Ar determination assigns an age of about 5.7my to the phonolitic trachytes which implies that the flow representing the reversed sites 2, 4 and 5 must have extruded on the reverse epoch between 5.69- 5.78 my just before the normal epoch between 5.69-5.43 my while the flows representing the intermediate sites 1 and 3 were formed during the transition period between the two epochs. If the normal polarity assigned to ol-Esayeiti tephyrites (5.7my) by Reilly et al. (1976) represents the polarity of the top flow, it is presumed that this is older than the top flow which yielded an intermediate direction from the mbagathi phonolitic trachytes.These results appear in accord to those published by Reilly(1970) and those obtained for kapiti phonolites by Patel and Gachii (1972).

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