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The Paleomagnetic Pole for Nairobi Phonolites

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Abstract: *Specimens of the Nairobi phonolites, of lower tertiary age dated at 5.2 my, from four 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 phonolites, for the intermediately magnetized sites is calculated at declination $D=251.0^o$, inclination $I=0.1^o$ and longitude 126.49^o E, latitude 18.9^o S and for the reversedly magnetized sites at $D=169.6^o$, $I=2.5^o$ ($\alpha_{95}=9.6^o$) and 127.3^o E, 79.6^o S with errors ($\delta m=9.6^o$, $\delta p=4.8^o$) , respectively. These results may assist in stratigraphic correlation of Nairobi area rocks.*

Keywords: *Amphiboles, Remanence, Stratigraphy, Phenocrysts.*

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.

The Nairobi phonolites are believed to have been caused by isolated, spasmodic local eruptions which gave rise to coarse and fine grained types of bedded tuffs. They are exposed over 260 km^2 of the athi plains including parts having a thin covering at a very low gradient. It overlies the Mbagathi phonolitic trachytes in the Mbagathi river valley and its tributaries, appears to be about 120 m thick under Nairobi and may consist of two main sheets as believed by Sikes (1939). The field appearance of the phonolites exhibit long conspicuous crystals of feldspar and small nephelines. A fissile trachytic texture is sometimes found with fluxion arrangement of minute feldspar laths around microphenocrysts of nepheline, which themselves often have a border of soda-amphiboles. Nepheline occurs in small phenocrysts, but is frequently replaced by sodalite.

II. Sampling

The Nairobi phonolites crop out to the east of Nairobi , Kenya. Four sites were sampled at a road cutting on the Nairobi- Mombasa road about 8 km from Nairobi, yielding 10 oriented block samples. It was observed that most surface units of the natural outcrops were badly weathered and were therefore not sampled. Average sampling location was at latitude 1^0 21'S , longitude 36°54'E.

A site is described as a small area of exposure of a single lava flow or intrusion from which a number of oriented block samples have been taken and which is assumed to represent a single point in time and a spot reading of the paleomagnetic field.

Freshly exposed rocks at road cuttings, stream beds, railway cuttings or quarries were sampled whenever possible but outcrops with obvious geological displacements (e.g. boulders) or those which are badly weathered were avoided, as they are unsuitable for paleomagnetic analysis. The block samples were first dislodged from the parent position with a sledge hammer, then carefully replaced in their original position before noting the orientation angles.

The collection and orientation of the block samples has been 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 bearing measurement it is up to 1° (degree).

III. Measurements

The directions and intensity of remanent magnetization of several 2.5cm long specimens at all steps demagnetization were measured using a 5Hz Foster (1966) spinner magnetometer. Cleaning of the specimens was done utilizing the alternating field (a.f) demagnetizing equipment. The optimum cleaning field of a site was pre-determined using site pilot specimens. The pilot specimens for each site were demagnetized up to 100mT or until the optimum cleaning field was attained, in steps of 5mT at each step of demagnetization, the natural remanence was measured. The demagnetization vector plots and the stability curves were then plotted. The optimum field intensity, the field required to clean the secondary magnetism of the rocks of a given site was then deduced from the plots using the method of Briden (1972). The stability index (SI) is defined for successive equal increments of alternating fields of 5mT and the field at which stability Index is at a maximum chosen as the most suitable cleaning field. All specimen were then demagnetized with a field of 10mT below and above this chosen field and the field which gave the smallest α_{95} (radius of cone of confidence) is selected finally as the true site cleaning field. In some sites, a single field suitable for all specimens could not be found and this necessitated a 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 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 levels before discarding.

IV. Results And Discussions

The paleomagnetic results of the four sites of the Nairobi phonolites, numbered sites 17 - 20, are tabulated in Table 3 below. One specimen for every site was demagnetised up to about 50 mT in steps of 5 mT in order to determine the cleaning field for each of the sites.

The characteristic stability index (SI) curves for each pilot specimen are plotted in Fig. 3(a). The optimum field deduced from these curves using Briden's (1972) criteria varied between 25 - 35 mT for different sites of the phonolites. The curves illustrated by NP 2 - 251 and NP 1 - 552 indicated stable natural remanent magnetism(N.R.M) throughout their demagnetisation range. This stable N.R.M is inferred from the plots of the directional changes in Fig. 3(b) of the specimens which show good grouping of the directions at demagnetization fields between 5 mT - 50 mT. The stability index (SI) curve for the specimen NP 4 - 451 tends to oscillate about an apparent mean value between 0.5 - 0.8.

TABLE 3 - NAIROBI PHONOLITES

		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
17	2	1.97	170.3	15.9	30.8	46.7	1.998	171.8	2.95	468.1	11.57	25	125.9	-81.3	11.6	5.8	R
18	2	1.95	162.7	2.6	19.4	60.21	1.992	167.4	2.14	131.0	22.0	25	128.0	-77.4	22.0	11.0	R
19	3	2.2	234.98	15.02	2.5	105.2	2.96	274.04	5.37	52.5	17.2	25	124.3	-4.1	17.3	8.7	I
20	3	2.78	43.3	28.5	9.1	43.5	2.93	228.04	-5.2	26.7	24.3	35	129.5	42.0	24.4	12.2	I

The demagnetization decay curves are illustrated in Fig. 3(c) from which it is deduced that the. mean destructive fields (Mdfs) for the Nairobi phonolites ranges between 25 - 40 mT. The magnetic intensity of the phonolites rises initially above the intensity of the virgin specimens between 5 mT- 15 mT fields of demagnetization. This behavior is suspected to be caused by a large secondary component of low coercivity, aligned in opposition to the primary magnetic component.

Most viscous magnetizations appear to have been well cleaned after about 15 mT after which the intensity decay is generally non-oscillatory.

The site mean directions before and after alternating field (a.f.) demagnetization given in Table 3 are plotted on equal area stereo nets in Fig. 3(d). The total N.R.M directions are observed to be randomly scattered on the net for the virgin samples. The scatter of these directions is reduced on a.f. cleaning as reflected by the significant increase in the values of the precision parameter k, after a.f. treatment although the results of sites 18 and 19 could not be improved further owing to the large scatter observed within their samples. It was also observed that the inclination vector I, for all sites became shallower on demagnetization.

The cleaned directions have been classified as 'intermediate' or reversed' such as sometimes occur in sequences of lava flows (Dagley et al. 1967). It is generally assumed that intermediate directions occur during the process of a magnetic reversal. Sites 17 and 18 have accordingly been classified as reversed while sites 19 and 20 are intermediate. No site samples from the Nairobi phonolites gave a normal direction. These results appear in accord to the deduced polarity of the Kirikiti basalts, dated 5.1. my whose polarity has been published by Patel (1977).

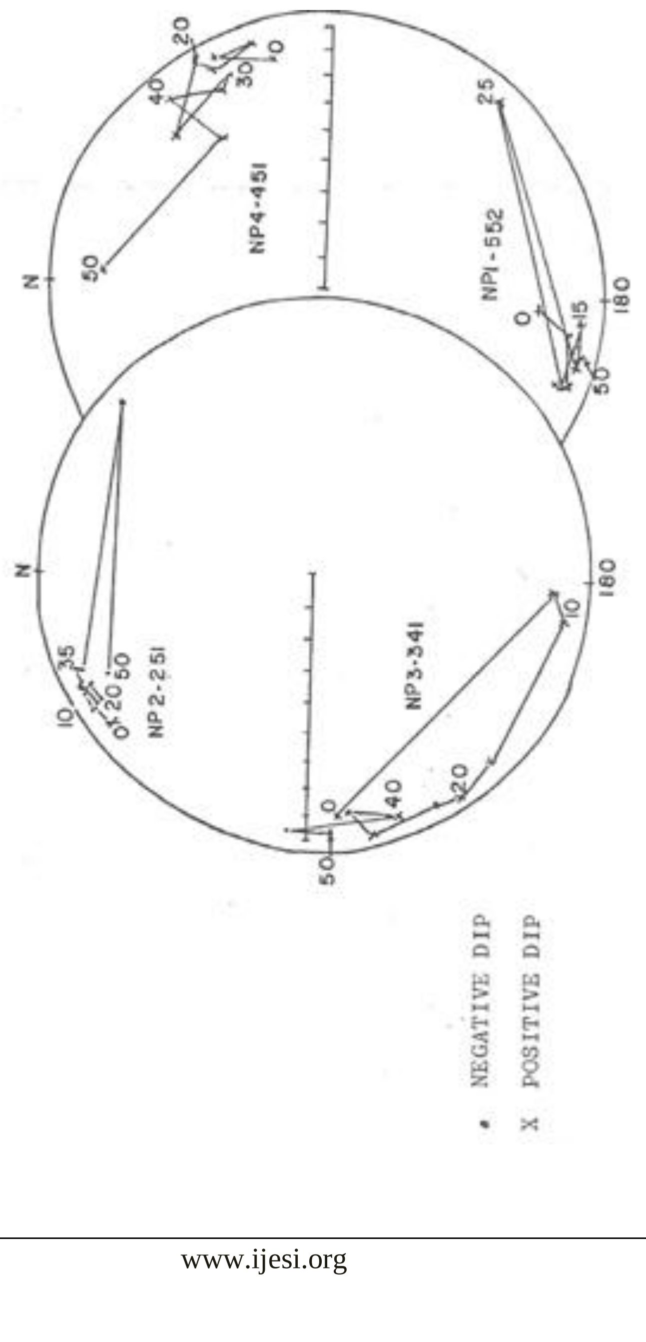

FIG 3b PLOT OF DIRECTIONAL CHANGES OF PILOT SPECIMENS FROM NAIROBI PHONOLITES

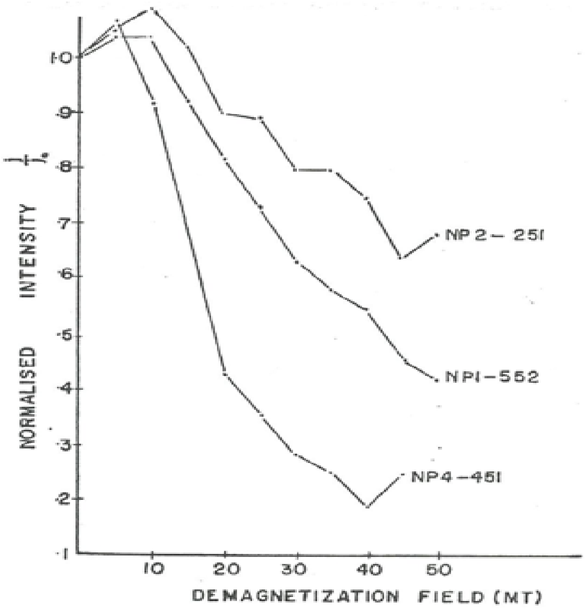

FIG. 3C: NORMALISED DEMAGNETIZATION CURVES FOR PILOT SPECIMENS OF NAIROBI PHONOLITES.

The directions obtained for the sampled sites may therefore represent those of multiple flows. Similar scatter in directions has also been reported for Kapiti phonolites by Patel and Gachii (1972).

All sites were non-random according to Watson's (1956) criteria of randomness at 95% probability. The directions and circles of confidences of sites 17 and 18 overlap suggesting that the two sets of results may be combined. Subjection to the F-ratio test concluded that the two sites are not significantly different at 5% level of significance and are therefore combined to yield a reversed direction. Sites 19 and 20 both gave intermediate directions.

The site mean directions used were obtained by averaging the sample mean directions of the site. Then a unit weight was assigned to the site mean direction in the evaluation of the mean direction of the rock unit. The paleomagnetic pole for each site was evaluated using the site mean direction. The average of the site mean directions yielded the mean paleomagnetic pole for the rock unit.

The mean direction and corresponding pole for the reversedly magnetized sites is calculated at declination D = 169.6 °, inclination, I = 2.5 ° (α_{95} = 9.6 °) and longitude 127.3° E, latitude 79.6 ° S with errors ($\delta m=9.6^o$, $\delta p=4.8^o$) and for the intermediately magnetized sites at D =251.0 °, inclination 1 = 0 . 1 ° and longitude 126.49 ° E, latitude 18.9 °S, respectively.

V. Conclusion

The Nairobi phonolites have been grouped as mid-pliocene with a whole rock K/Ar isotopic date of 5.2my and, from this research, has the mean direction and corresponding pole position , for the intermediately magnetized sites calculated at declination D=251.0^o, inclination I=0.1^o and longitude 126.49 ^{o} E, latitude 18.9^{o}S and for the reversedly magnetized sites at D=169.6^o, I=2.5 ^{o} (α_{95}=9.6^o) and 127.3^o E, 79.6^o S with errors ($\delta m=9.6^o$, $\delta p=4.8^o$) , respectively. These results show a perfectly reversed polarity for two sites 17 and 18 while sites 19 and 20 yielded an intermediate direction.

The results of the reversed sites (17, 18) are in accord with the reversed epoch between 5.42- 4.87 my, Cox (1968) scale; although the intermediate pole exhibited by sites 19 and 20 cannot be harmonised in this scale unless the flows are regarded as much younger or older than the radiometric age above, or that there must exist a polarity change around 5.1my, or that the results of sites 19, and 20 are spurious.

Using the Heirtzler et al. (1968) scale, the two polarities reversed and intermediate, easily fit in as there is a reversed epoch between 5.61-5.01 my and a normal one between 5.01 -4.81my. In this scale then, the flow representing the reversed sites, (17, 18) precedes in age the flow representing the intermediate directions (19,20). The reversed flow then needs to have been extruded just before the transition while the intermediate one would then have been extruded during the transition from the reversed to normal epochs.

It is hoped that these results may be useful in correlation of the stratigraphy of Nairobi area rocks.

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