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A NOTE ON THE PALAEOMAGNETISM OF THE LOWER SIWALIKS NEAR CHOA SAIDEN SHAH, POTWAR PLATEAU, WEST PAKISTAN

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Abstract. Forty oriented hand sample were collected from four layers of red shale at the basal part of the continental detrital rocks of the Muree-Siwaliks formations at the Southern edge of the Potwar Plateau near Choa Saiden Shah in order to see whether these rocks are suitable for a palaeomagnetic research. The samples of three beds show consistent stable directions of magnetization after treatment in alternating magnetic fields. The deviating direction of magnetization of the fourth layer is discussed.

The mean characteristic direction of magnetization obtained from three beds has a D (declination) $= 1.4°$ and an I (inclination) $= +28.1°$. The value deviates considerably from the direction of the present geomagnetic axial dipole field at the sampling locality. This preliminary result implies that in Miocene times the Indo-Pakistan subcontinent was still far off from its present position.

The Salt Range—a chain of hills running about E–W and situated between the rivers Jhelum to the E and Indus to the W—is built up of mainly Paleozoic rocks of Cambrium and Permo-Carboniferous ages. The Salt Range is bounded towards the north by the Potwar Plateau. Here one comes across many fine sections of thick series of detrital sediments of Upper Tertiary age.[3,5,6]

The road from Khewra to Chakwal shows the whole succession starting with the Paleozoic rocks which, with an angular unconformity, are overlain by limestones and shales of the Laki formation of Eocene age. These rocks in turn support detrital sediments of the Murree and Siwalik formations. The latter formations consist of alternating bands of sandstones and shales, often with bright red colours. The locally fossiliferous, continental sediments range in age from Lower Miocene up to Pleistocene.

In the southern area of Chakwal the lower part of the Murree formation is not found. The upper part of the Murree formation may be present, but, because of the lithological resemblance with the overlying Lower Siwalik formation the Upper Murree formation is difficult to recognize. No detailed palaeontological research has been carried out in this area.

Palaeomagnetic Sampling. A sampling locality with nice outcrops of red detrital sediments was selected along the main road from Khewra to Chakwal, about 8 km north of Choa Saiden Shah. The locality is situated in the basal part of the detrital series and may belong to the Upper Murree or the Lower Siwalik formation (Fig. 1) This would mean an Upper Burdigalian to Helvetian age.

The steeply northward dipping series consists of an alternation of red shales and thick sandstone layers. From the red shales oriented samples were collected. Because of the softness of the rocks the available portable diamond drill could not be used. Therefore, oriented hand samples were taken with a volume of about 150 cm³ each. These samples were collected from four individual shale beds along a section of

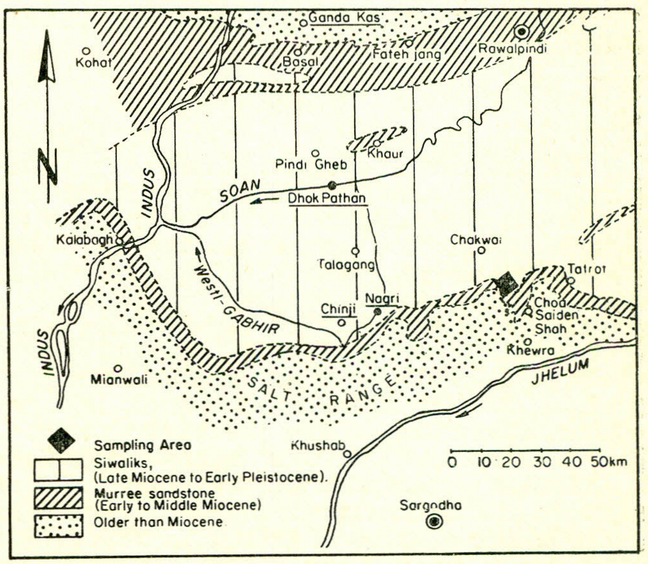

Fig. 1. Schematized geological map of the Potwar Plateau, West Pakistan (after Dehm),[1] with sampling localities.

about 60 m length. As many as ten samples were taken from each bed.

Treatment in the Laboratory. The samples were investigated at these Laboratories. All samples were cast in oriented positions in cubes of paraffine with sides of 10 cm each. The measurements of the natural remanent magnetization and the demagnetization procedures were carried out with highly sensitive astatic magnetometers.

In palaeomagnetic research the natural remanent magnetization, obtained by initial measurement of the rocks samples, is usually composite and consists of both a stable characteristic component and an unstable secondary component(s). The application of a progressive, partial demagnetization procedure, with alternating magnetic fields is often a successful method to eliminate the secondary components of magnetization and to save most of the characteristic magnetic component. All the samples were subjected to this procedure in a number of steps of successively increasing strength of the alternating magnetic fields with a maximum of 3000 Oersted Peak value. For the majority of the samples a treatment with alternating magnetic fields of 2000 Oersted Peak value turned out to be sufficient for the elimination of the secondary component(s) of magnetization.

The results of the demagnetization procedures can be clearly demonstrated by means of a demagnetization diagram, where the end of the resultant magnetization vector can be followed during progressive partial demagnetization (Fig. 2) At our samples, after application of fields at about 2000 Oersted Peak value, the characteristic direction of magnetization has been singled out. After treatment with still higher fields, the intensity of the remaining magnetization only decreased with a further change in its direction. This characteristic component was considered the original magnetization which the sediments had obtained during deposition.

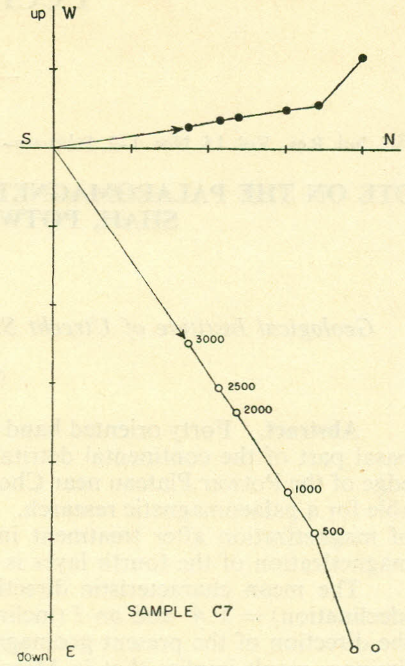

Fig. 2. Demagnetization diagram of a sample of bed C. The points represent in an orthogonal projection the successive positions of the end of the resultant magnetization vector during the progressive partial demagnetization, solid circles and hollow circles are the respective projections on a horizontal plane and on a north-south vertical plane. The maximal Oersted Peak values are indicated at the points on the plane in vertical projection. Each unit on either axis of the diagram represents 1.10^{-1} e.m.u./cm^3.

Results

The characteristic directions of remanent magnetization of the samples of individual beds have been plotted in equal area stereograms; the material of the individual beds show very nice clusters (Fig. 3). For each bed the mean direction of the characteristic magnetization has been computed from the magnetization directions obtained from the individual samples. These mean values show a considerable scatter (Fig. 4). For B, C, and D this can be explained in terms of secular variation of the earth's magnetic field; the mean values of the individual beds can be interpreted as spot readings of the changing geomagnetic field.

Because of its considerably deviating direction of magnetization with respect to those of the other beds, and because of its reverse polarity the characteristic direction of magnetization of layer A cannot be explained in this way. The bed A may have acquired its remanent magnetization during a transitional stage between a period with reversed and normal magnetic polarity. It is assumed that such a period of transition

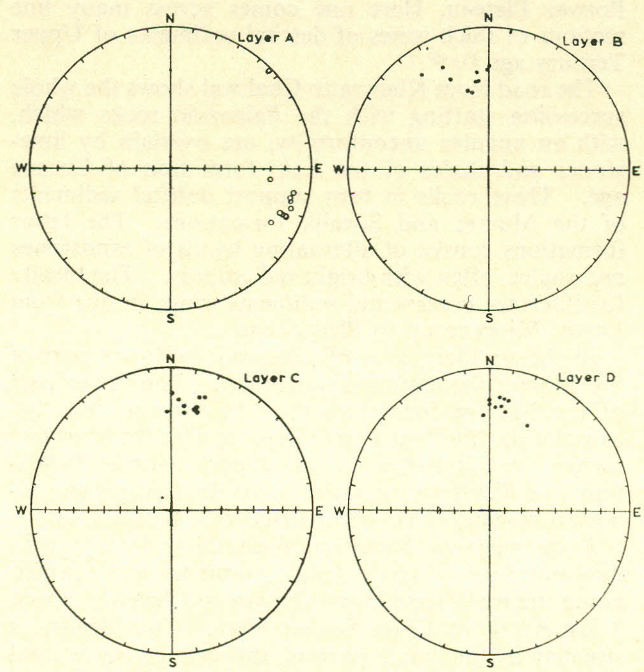

Fig. 3. Equal area projections (Schmidt's nets) with plotted characteristic directions of magnetization of individual samples after the corrections for the tectonics have been applied. Solid circles denote north-seeking directions pointing downwards; hollow circles indicate that the north-seeking directions are pointing upwards.

TABLE 1. MEAN DIRECTIONS OF MAGNETIZATION FOR SITES FROM MURREE-SIWALIK FORMATIONS AFTER TECTONIC CORRECTION.

Initial remanence Beds	N	D°	I°	k	α°95
A	10	93·1	—10·7	8·7	18·5
B	10	350·5	+32·2	28·8	9·1
C	10	8·1	+23·5	72·2	5·7
D	10	6·1	+28·2	54·3	6·6
Overall mean B C D					

After demagnetization	D°	I°	k	α°95
A	106·8	—15·1	94·6	5·3
B	347·1	+32·2	41·3	7·6
C	9·3	+25·2	101·1	4·8
D	6·7	+25·9	95·6	5·0
Overall mean B C D	1·4	+28·1	51·7	17·3

N is the number of samples; *D*°, the declination in degrees east of true north; *I*°, the inclination in degrees measured positive downwards; *k*, the estimate of the precision parameter;[2] α°95, the semi-angle of cone of 95% confidence for mean direction.

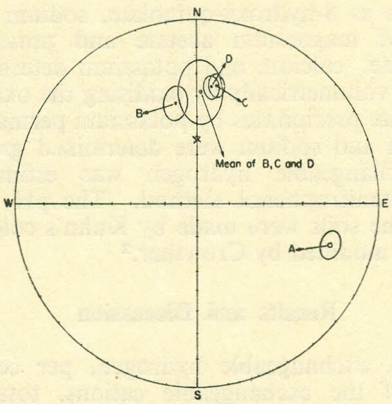

Fig. 4. Stereogram (Wulff's net) with the mean direction of magnetization of the individual layers computed from the values plotted in Fig. 3. The mean directions have been provided with 95% ovals of confidence. Crosses represent direction due to the geomagnetic axial dipole field. For further explanation of symbols see Fig. 3.

may last for c. 10,000 years; then, the intensity of the earth's magnetic field may decrease to zero after which it again increases in the opposite direction.[4] The rocks which acquired their magnetization during such a period will have lower intensities of magnetization and deviating directions of magnetization.

In order to present a reliable mean characteristic direction of magnetization for a rock sequence, sufficient data must be available to average out the scatter in the directions as a result of the secular variation of the geomagnetic field. In this note, we can only give a preliminary result, because the number of beds available are not sufficient to fulfil this condition (Tables 1 and 2).

The earth's magnetic field averaged out over a sufficient long period of time can be represented by a geomagnetic dipole the axis of which coincides with

TABLE 2. VIRTUAL PALEOMAGNETIC POLE POSITION COMPUTED FROM MEAN CHARACTERISTIC DIRECTION OF MAGNETIZATION OF BEDS B.C and D. THE SITE LOCATION IS LAT. 32.8°N, LONG. 73.0° W.

Lat° N	Long° E	δp°	δm°
72.1	248.7	10.3	19.0

δp and δm are the semi-axes of the oval of 95% confidence for the position of the pole.

the rotation axis of the earth. For a given locality the inclination of the magnetization direction is given by the relation $\tan\lambda = \frac{1}{2}\tan I$, where λ is the geometrical latitude and I is the inclination of the direction of magnetization. The inclination of the direction of magnetization, which belongs to the present geomagnetic axial field at the sampling locality, is 52°. This figure is inconsistent with the value of 28° for the inclination of the mean characteristic direction of magnetization computed from the results which have been obtained from beds B, C, and D.

For the sampling area an inclination value of 28° is reasonably correct for the Middle Miocene. This implies that according to the earlier given relation the palaeolatitude of the area is only 15° north during that time. Thus, in Miocene age the Indo-Pakistan subcontinent must still be far off its present position.

Palaeomagnetic research was carried out on the Deccan Traps[7] which were extruded about 60 million years ago. From the palaeomagnetic directions of the Deccan Traps one may conclude that at the beginning of the Tertiary the sampling area was situated at 30°S. A movement with an average speed of 10 cm/year must be accepted if one assumes that the Indo-Pakistan subcontinent has only recently reached its present position. The preliminary palaeomagnetic results obtained from the Miocene red beds of the Potwar Plateau fit in well with this conception.

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