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ON THE SECONDARY MAGNETIZATION OBSERVED IN THE NAWAKOT COMPLEX ROCKS, MALEKHU AREA, CENTRAL NEPAL

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ABSTRACTS

Paleomagnetic investigation on some Lesser Himalayan low-grade metasediments in the Malekhu area deteceted no primary magnetization while two distnct secondery magnetization components of its own type have been revealed. These components area interpreted as a recent field component (post-tectonic) and a pre-tectonic component probably of Eocene time.

A clockwise rotation of the Malekhu area by about 45° with respect to the Indian Shield since the early Tertiary time is inferred too.

INTRODUCTION

Preliminary remarks have been made on magnetic remanence measurements data obtained from the Late Precambrian to Paleozoic rocks of the Nawakot Complex. Samples were collected from road cut and river exposures along a 5 Km NE-SW route running parallel to the Thaple Khola and Malekhu Khola rivers in the vicinity of a small town Malekhu (27.8°N, 84.8°E). The town is situated on the left bank of the Trishuli river, Central Nepal. The area belongs to one of the best studied area in the Lesser Himalaya and a detailed geological description can be found in a paper by Stocklin (1980). According to it, the Nawakot Complex consists almost exclusively of low-grade metasediments and it is discordantly overlain by highly metamorphosed garnetiferous schists of the Raduwa Formation, which forms the base of the Kathmandu complex. The discordance is interpreted as thrust (Mahabharat Thrust). The Nawakot Complex rocks form the peripheral part of the large WNW-ESE trending structure called "Mahabharat Synclinorium", while the Kathmandu Complex rocks consitute the core of the structure. On the basis of some algae of Early Paleozoic age found in the Dhading Dolomite and lighological correlation with units elsewhere the Nawakot Complex is regarded as the Upper Precambrian to Paleozoic in age. The metasediments rarely exceed chlorite-sericite grade of metamorphism.

Figures 1-a and l-b show the location of Malekhu and the ideal stratigraphic columm of the Nawakot Complex rocks after Stocklin and Bhattarai (1980). A geological sketch map with sampling sites is presented in Figure 2. Sampling details are given in Table 1.

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Table 1. Sampling details of Nawakot Complex rocks, Malekhu

Formation	Site Index	Rock Type (Sampled)	Bedding Strike/Dip of strata*
Robang	R1	Hematite schist	N 68 E/84 SE
	R2	Phyllite, amphibolite	N 73 E/73 SE
	R3	Chloritic phyllite	N 70 E/75 SE
Malekhu	ML	Fine-crystalline limestone	N 85 E/82 NW (OVT)
Benighat	BG	Quartzose slate	N 86 W/85 NE (OVT)
Dhading	D1	Sparry dolomite	N 72 W/90 SW
	D2	Bluish-grey dolomite	N 88 W/65 NE
Nourpul	N1	Semi-pelitic phyllite	N 88 W/85 NE (OVT)
	N2	Quartz phyllite	N 86 W/62 NE (OVT)

*** OVT - overturned**

Table 2. Results of magnetic measurements

Site	n(N)	NRM Intensity (mA/m)	Demag status (mT)	Mean direction (uncorr) D	I	K	a95	(corr) Dc	Ic	components and polarity	
R1	3(7)	235-762	30	234	34	64	10	212	-9	S2	(R)
BG	3(7)	0.64-1.47	53	327	70	116	7	196	10	S2	(R)
D1	3(3)	0.19-0.42	20	000	43	81	8	-	-	S1	(N)
N1	3(7)	25.5-47.9	30	096	-50	123	7	41	1	S2	(N)
N2	3(7)	4.1-16.8	0-20*	007	51	17	19	-	-	S1	(N)
	3(6)		50	134	-61	44	12	26	7	S2	(N)

Mean of S2 component (after bedding correction):
(Normal & Reverse combined)
D = 028, I = 1, K= 36, a95 = 11

n and N are the number of samples and specimens, respectively;D, I and Dc, Ic are the declinations and inclinations in degrees before (uncorr.) and after (corr.) bedding correction K is the estimate of Fisher's precision parameter and a95 is the semi-angle of cone of 95 % confidence, in degrees. Parameters calculated giving unit weight to samples. (N) and (R) in the last column denote normal and reverse polarities, respectively.

* Direction calculated from NRM to 20 mT(demagnetization) data.

PALEOMAGNETIC MEASUREMENTS

In the field, 3 block samples were collected from each site. Normally, three cylindrical specimens (2.5 cm in diameter, 2.5 cm in length) were drilled from each sample in the laboratory. The remanent magnetization of specimens was measured using a fluxgate spinner agnetometer (Schonstedt SSM-1A). Alternating field (AF) demagnetization of speciemens was done with an apparatus which utilizes a 400 Hz alternating field and is capable of producing peak fields up to 53 mT. Thermal (TH) demagnetization of specimens was done by heating the specimens in a furnace to the specified temperature and subsequent cooling to the room temperature. The heating-cooling process was carried out in air. Both AF and TH demagnetizations were carried out in a reasonably field-free space created by compensating the ambient geomagnetic field by Helmholtz coils.

Measurements of natural remanence of the specimens showed that the rocks from sites ML and D2 possess too weak magnetization such that reliable measurement is not possible. The sample collections from sites R2 and R3 were found to be very inhomogeneous so that even the specimens within a sample did not show any consistent direction. Therefore, the samples from these sites were rejected and the following discussion is limited only to the samples from the remaining sites.

The NRM intensity for the samples from 5 sites shows a variation between 0.19 to 762 mA/m (Table 2). Hematite schist specimens are characterized by the highest intensity values while dolomite specimens possess the lowest values. The NRM directions were found to be quiet variable even within the samples from one single site. Therefore, specimens from each site were subjected to AF demagnetization up to 53 mT. In general, the demagnetization path showed removal of soft components within the range of applied field leading to a constant stable direction. However, some specimens were found to possess one or several unstable components with hardness above or equal to 40 mT, such that the judgment regarding the character of the remaining direction was difficult (See Fig. 3, specimens N2-3B, BG-3C).

Another set of specimens (one from each site) was subjected to thermal demagnetization. Most of the specimens showed either almost no change in direction and intensity during thermal treatment up to 500-550°C (e. g., specimens from sites N1, N2, D1) or rapid decay of intensity after few steps of heating without attaining stable direction. Taking this into consideration all remaining specimens were treated in alternating magnetic fields. Stable directions were obtained after treatment at specific peak fields which varied for different sites (see column "status", Table 2.). Specimens from site N2 showed in average 30% increase in intensity at 50 mT demagnetization level. Specimens from site BG showed decrease in intensity by 30-40 % during demagnetization up to 50 mT. For other sites no significant change in intensity was observed. In order to ensure the validity of stable directions, which could be attained for majority of specimens only at the final steps of AF demagnetization, subsequent thermal demagnetization was applied. From such TH demagnetization experiments, it was confirmed that only single component was remained after AF cleaning, because the data defined linear segments directed towards the origin in zijderveld (zijderveld, 1967) plots (Fig. 3, curves for specimens N1-2A, N2-1C, D1-3B and BG-3A).

The directions from specimens were combined to give a sample mean and the mean direction for the site was calculated giving unit weight to sample mean directions, applying Fisherian statistics. The mean directions are presented in Table 2. The specimens from site

N2 showed the presence of a well-determinable soft component. For the specimens from site R1, the criteria of stability is the maximum grouping of the remanent direction at 30 mT peak field (Fig. 4).

INTERPRETATION

The mean direction from site D1 and the softer component from site N2 are very close to the dipole field direction at present for Malekhu (I=47°). So these directions are interpreted to represent the recent field component S1 of secondary origin. Such a component could be identified in some of the specimens from other sites as well (e.g. specimen BG-3C, Fig. 3). The remaining directions from 4 sites were corrected for the bedding tilt. A plot of the directions before and after bedding correction is shown in Fig. 5. A visual inspection of the diagram shows that the directions form two groups which are almost antipodal to each other. These two groups are assumed to represent the "Normal" and "Reverse" polarities of the same direction. Under this assumption, the mean direction is calculated by reversing the directions from sites R1 and BG and combining with the other two. This resulted in a mean direction with NNE declination and almost horizontal inclination (I=1°). This direction is designated as component S2. The grouping of the individual site directions after tilt correction suggests that this component was acquired prior to folding of the rocks.

No paleomagnetic data from the Nepal Himalayas directly comparable to the direction in question are reported so far. The lack of precise age determination of the formations in the Himalayas and the different amounts of rotation of individual thrust sheets from which the paleomagnetic data are reported, makes a distant correlation unjustified. So, an attempt is made to interpret this direction by comparing the inclination with the inclinations to be expected in the area from the Indian APWP as practiced by other researchers in the Himalayan region (Basse et. al., 1984, Klootwijk et. al, 1985). For such a comparison, the expected directions for the town of Malekhu were calculated from the Indian APWP data, simulated from India-Africa relative movement data with Africa fixed to a hotspot frame (Klootwijk et. al., 1985, Table 2C) under the hypothetical assumption that no relative latitudinal movement of the Malekhu area has occurred relative to the Indian Shield after the acquisition of the magnetization in question. Such a comparison (Fig. 6) shows that the direction S2 may have been acquired during 45-55 Ma and the Malekhu area may have experienced approximately 45° clockwise rotation relative to the shield. The possible age range suggests the secondary nature of the observed direction S2.

Macroscopic and microscopic examinations of the samples and the Curie temperature determinations suggest the carrier of the remanence to be hematite. A probable origin of hematite in the Nawakot complex rocks during regional metamorphism in Eocene time or recrystallizaton of the existing hematite with complete remagnetization in the ambient geomagnetic field is suspected. If this assumption is valid, the magnetization may be of thermochemical origin. Such an interpretation and the inferred approximate clockwise rotation of the Malekhu area relative to the Indian Shield is in accordance with the similar magnitudes of rotations in the various parts of Northwestern and Central Himalayan region determined paleomagnetically on the basis of observed secondary components dated at 50 Ma to less than 60 Ma. Those components are attributed to thermo-chemical effects associated with the initial India-Asia collision (Klootwijk et. al., 1980; 1982; 1986).

CONCLUSIONS

The following conclusions are drawn from the present study:

a) No primary magnetization directions could be detected in the studied rock samples.

b) Secondary magnetization components of two types were found to be present in the rocks studied: one - a recent field component acquired probably during the recent geological past, and the other - acquired previous to the regional folding probably in Eocene time. The latter component is interpreted to be of thermo-chemical nature, originated probably during a regional metamorphic event which took place in Eocene time. An approximately 45° clockwise rotation of the Malekhu area with respect to the Indian Shield since the Early Tertiary time is inferred.

c) Further paleomagnetic investigations of the rocks of Nawakot and Kathmandu Complexes should confirm the regional consistency of the inferred rotations. Furthermore, such studies may be invaluable in resolving the long-disputed problem of allochthony or autochthony of the whole or the parts of the Himalayan region.

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Figure Legends:

Fig. 1-a Index map showing Malekhu sampling locality.
1-b Lithostratigraphic column of the surveyed area after Stocklin and Bhattarai (1980).

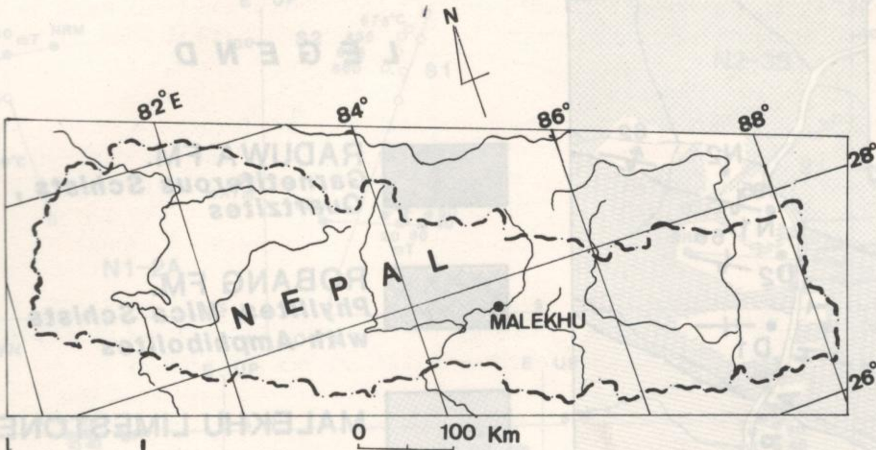
Fig. 2 Geological sketch map of the area showing sampling sites.

Fig. 3 Zijderveld diagrams of some representative specimens. The circles indicate orthogonal projections of the end-points of the resultant magnetization vector during alternating field demagnetization (AFD) upto 53 mT followed by thermal demagnetization (THD). Solid and open circles denot projections on horizontal plane and N-S vertical plane, respectively. The path during AFD is shown by solid lines with peak field values (in mT) placed besides the solid circles and the path during THD is shown by dotted line with tempreature (in °C) besides open circles. S1 and S2 denote the components and are placed against the linear segment where the corresponding component is being removed.

Fig. 4 Schmidt's equal area projection of mean specimen directions for site R1 before and after AF demagnetization at 30 mT.

Fig. 5 Schmidt's equal area projection of mean S2 directions: triangles - before bedding correction, circles after bedding correction. Solid and open symbols are projections in the lower and upper hemisphere respectively. Star - dipole field direction for Malekhu. Provided are the ovals of 95 % confidence.

Fig. 6 Comparison of the mean direction S2 (triangle) with the directions (circles) expected in Malekhu for the period 10 to 80 Myr according to Indian APWP (Klootwijk et. al; 1985, Table 2C). Other conventions as before.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84°
86°
88°
28°
26°N
N E P A L
MALEKHU
0
100 Km

Fig 1-a

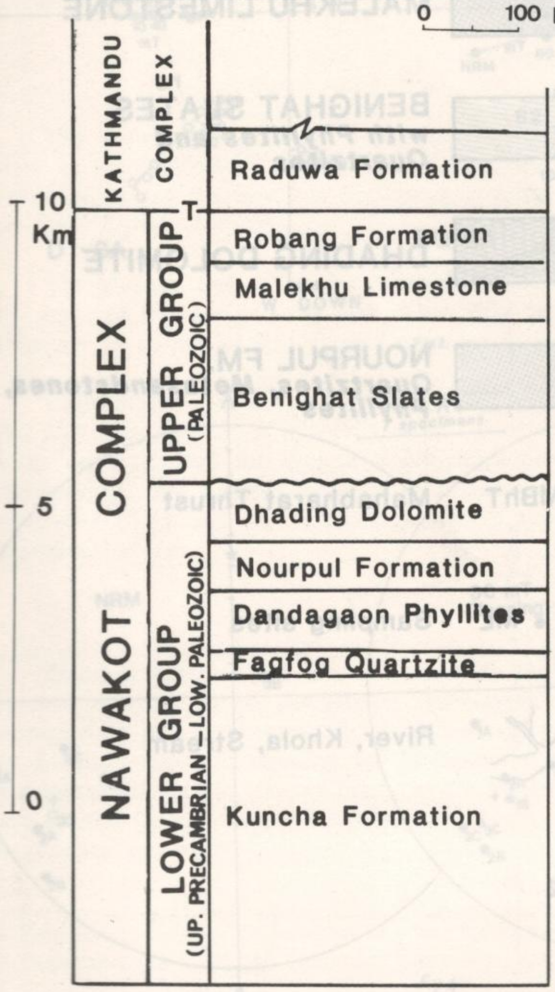

KATHMANDU COMPLEX
NAWAKOT COMPLEX
UPPER GROUP (PALEOZOIC)
LOWER GROUP (UP. PRECAMBRIAN–LOW. PALEOZOIC)
10 Km
5
0
T
Raduwa Formation
Robang Formation
Malekhu Limestone
Benighat Slates
Dhading Dolomite
Nourpul Formation
Dandagaon Phyllites
Fagfog Quartzite
Kuncha Formation

Fig 1-b

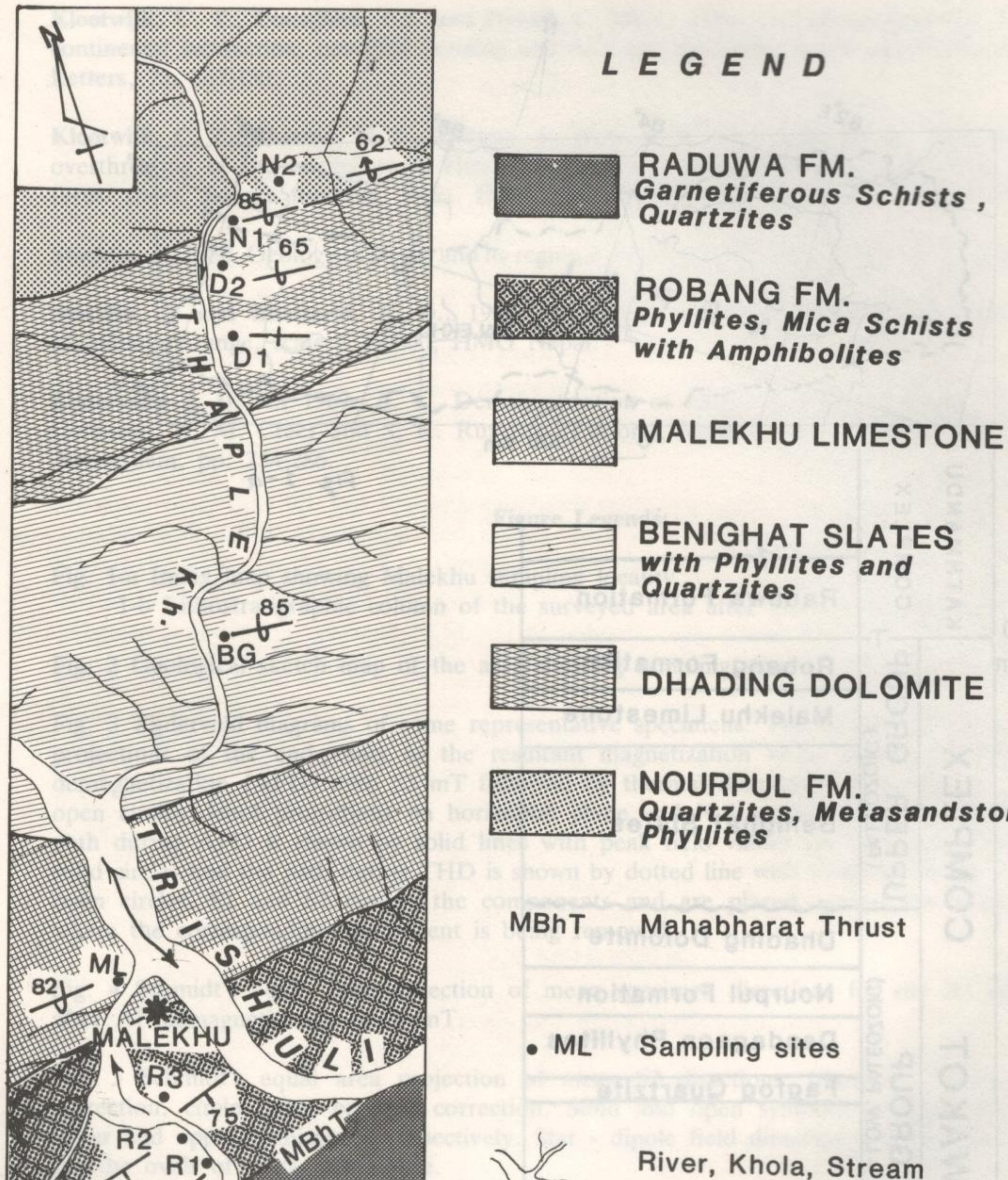
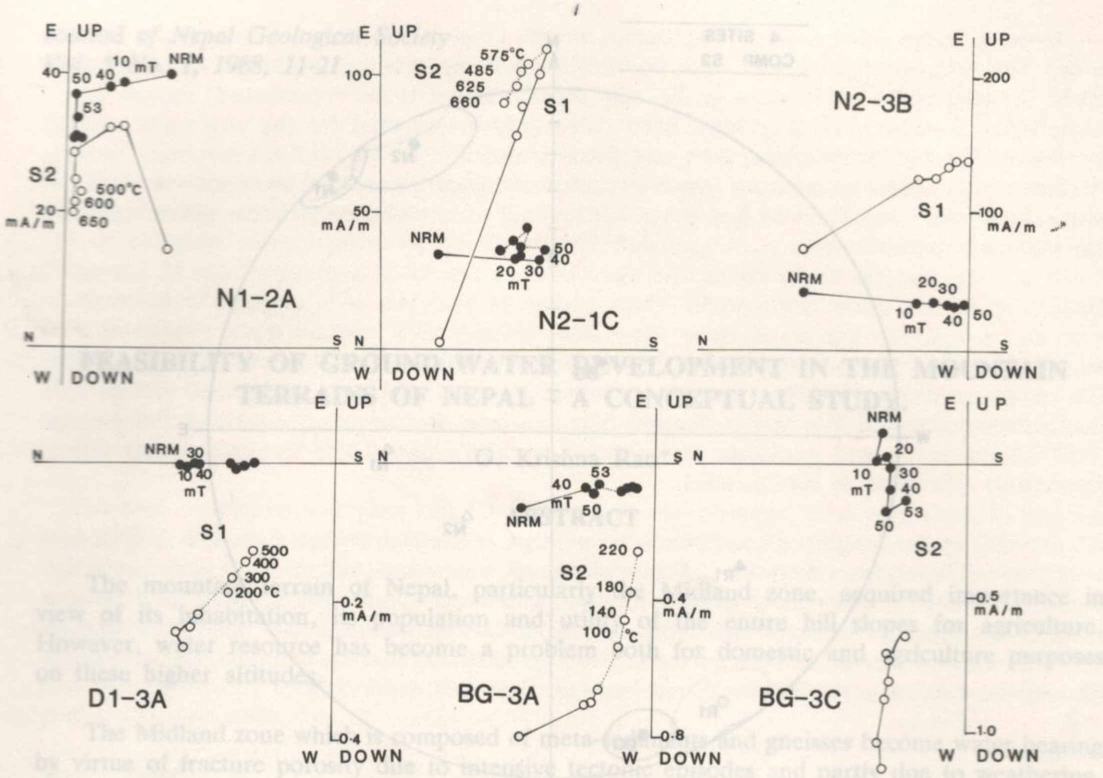

N
N2
62
85
N1
65
D2
D1
THAPLE Kh.
85
BG
TRISHULI
ML
82
MALEKHU
R3
75
R2
R1
MBhT
73
84
500 m
LEGEND
RADUWA FM.
Garnetiferous Schists , Quartzites
ROBANG FM.
Phyllites, Mica Schists with Amphibolites
MALEKHU LIMESTONE
BENIGHAT SLATES
with Phyllites and Quartzites
DHADING DOLOMITE
NOURPUL FM.
Quartzites, Metasandstones, Phyllites
MBhT Mahabharat Thrust
• ML Sampling sites
River, Khola, Stream

Fig. 2


E UP
NRM
10
mT
40
50
53
S2
500°C
600
650
mA/m
N1-2A
N
W DOWN
S2
575°C
485
625
660
S1
NRM
50
40
20 30
mT
N2-1C
S
N
W DOWN
E UP
-200
N2-3B
S1
-100
mA/m
NRM
20
30
10
mT
40
50
S
W DOWN
NRM
30
10
40
mT
S1
500
400
300
200°C
-0.2
mA/m
D1-3A
-0.4
W DOWN
E UP
53
40
mT
50
NRM
S2
220
180
140
100 °C
-0.4
mA/m
BG-3A
-0.8
W DOWN
E UP
NRM
20
10
mT
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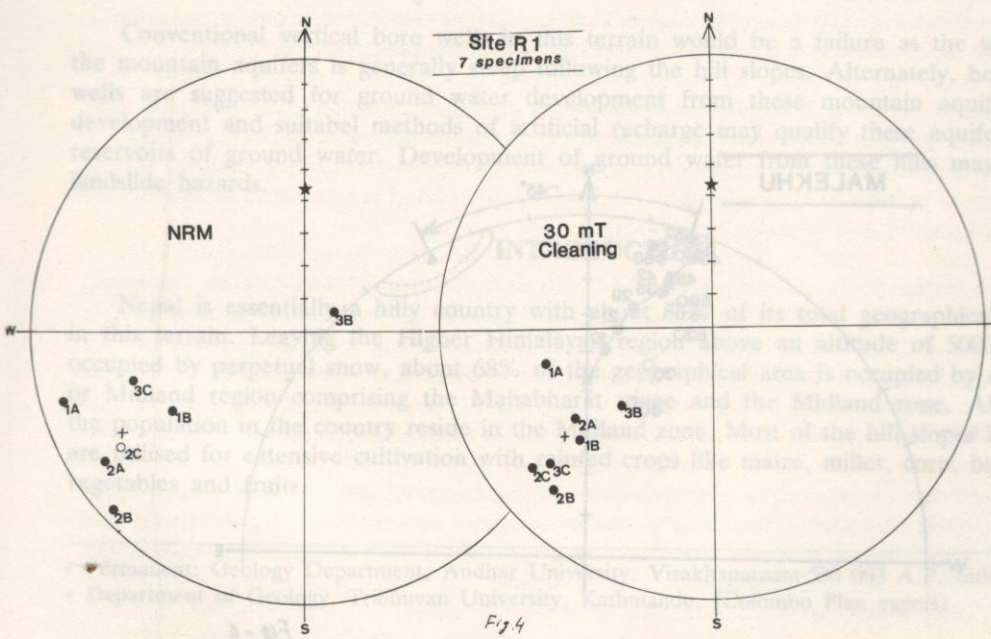
40
53
50
S2
-0.5
mA/m
BG-3C
-1.0
W DOWN

Fig 3


N
Site R1
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30 mT
Cleaning
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E
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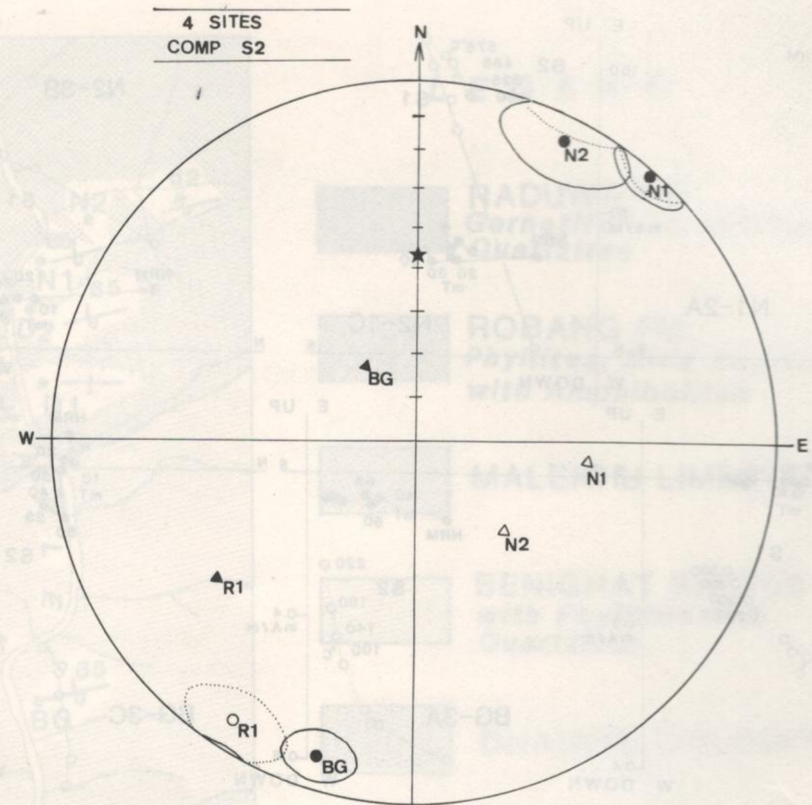
3B
1A
3C
1B
2C
2A
2B

Fig.4


4 SITES
COMP S2
N
N2
N1
BG
W
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N2
R1
R1
BG
S

fig. 5

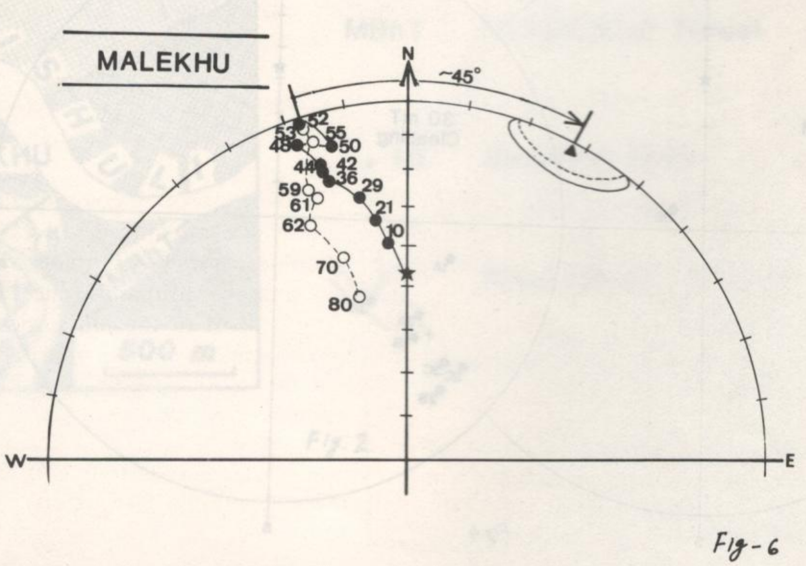
MALEKHU
N
~45°
53
52
55
48
50
44
42
36
59
29
61
21
62
10
70
80
W
E

Fig - 6