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The Churia(Siwalik) Group in the Western Part of the Arung Khola Area, West Central Nepal

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In the present study area, the Churia Group is divided into the Arung Khola, Binal Khola, Chitwan and Deorali Formations in ascending order which attains a total thickness from 3,000 to 5,000 meters and ranges in age from about 16 Ma to Recent. In the adjoining area to the east, TOKUOKA *et al.* (1986) have established the standard stratigraphy of the Churia Group on the basis of paleomagnetic study. The stratigraphy and structures are very well traceable to the present study area. The lower member of the Arung Khola Formation is distributed to the north of Central Churia Thrust (C.C.T), whereas the strata from the middle member of the Arung Khola Formation to the top of the Deorali Formation occur to the south of the Thrust. The C.C.T. has an E-W trend and is very well exposed at two locations, where the steeply dipping Arung Khola Formation of the northern belt is thrust over the gently dipping Deorali Formation of the southern belt. At Parewa Pahar Khola, one meter wide zone of fault-clay has been developed along the thrust. Some basaltic fragments have been discovered from the fault-clay. These fragments are interpreted to have been sqeezed out from the deeper part along the thrust plane.

Introduction

The Siwalik Group consists of the sediments which have been transported from the Himalayas and deposited at their southern front since the Neogene Period. In Nepalese Himalayas these are distributed in the southern frontal hilly areas called the Churia Hills and the name of the Churia Group is given to them. The Churia Group of the Arung Khola area located between Butwal and Narayangarh as shown in Fig. 1 was studied as one of the themes of the project "*Study on the Crustal Movement in the Nepal Himalayas*", which was conducted by Prof. Koshiro KIZAKI of the University of Ryukyus, and was reported by TOKUOKA *et al.* (1986). The study area of the present paper is the western extention of the area reported in the previous one, and the field survey was mainly performed by Shinji TAKEDA for his graduation thesis of Shimane University in 1987 academic year. The additional survey was done by all authors in

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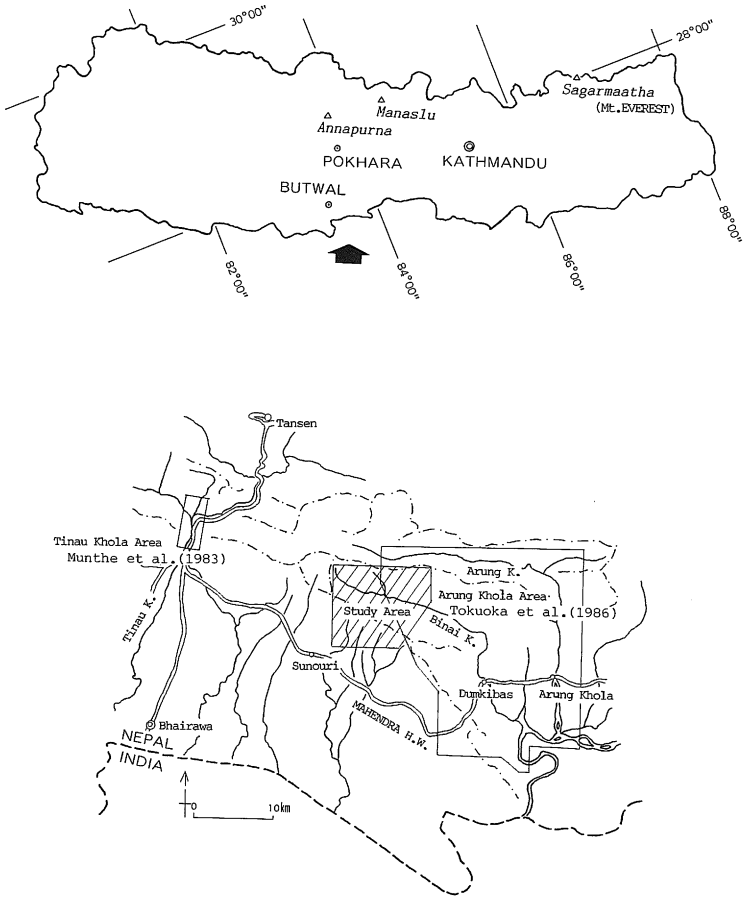


Fig. 1. Index map.

January, 1988.

The stratigraphy of the Churia Group has been established in the Arung Khola area by TOKUOKA *et al.* (1986), where sedimentologic, paleontologic and paleomagnetic studies have been done as well as precise field mapping. Paleomagnetically we can correlate the Churia Group to the Siwalik Group of the Potwar Plateau, Pakistan (OPDYKE *et al.*, 1982; JOHNSON, N. M. *et al.*, 1982; TAUXE and OPDYKE, 1982), although neither mammalian fossils nor radiometric age-data from the volcanic ash have been obtained yet. An important fossil of hominoid, *Sivapithecus* (*Ramapithecus*) *punjabicus*, was reported by MUNTHE *et al.* (1983) at the Tinau Khola, north of Butwal along with paleomagnetic data from a locality 20 km west to our surveyed area. Then, if we can fill the blank between the two areas, it will be more fruitfull to the study of the Siwaliks in Nepal. The present study is one in that direction.

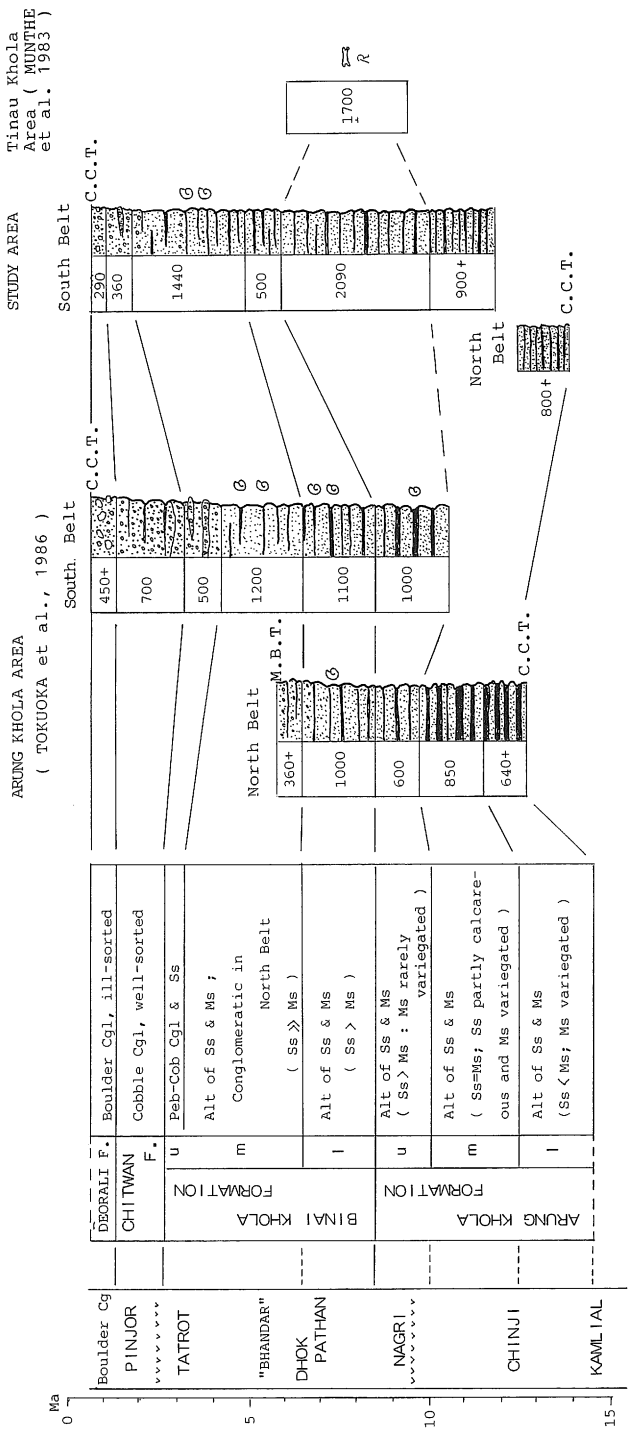


Fig. 2. Stratigraphic and lithologic divisions of the Churia Group. Correlation with the Siwalik Group in Potwar Plateau, Pakistan shown in left collumn is from TOKUOKA *et al.* (1986).

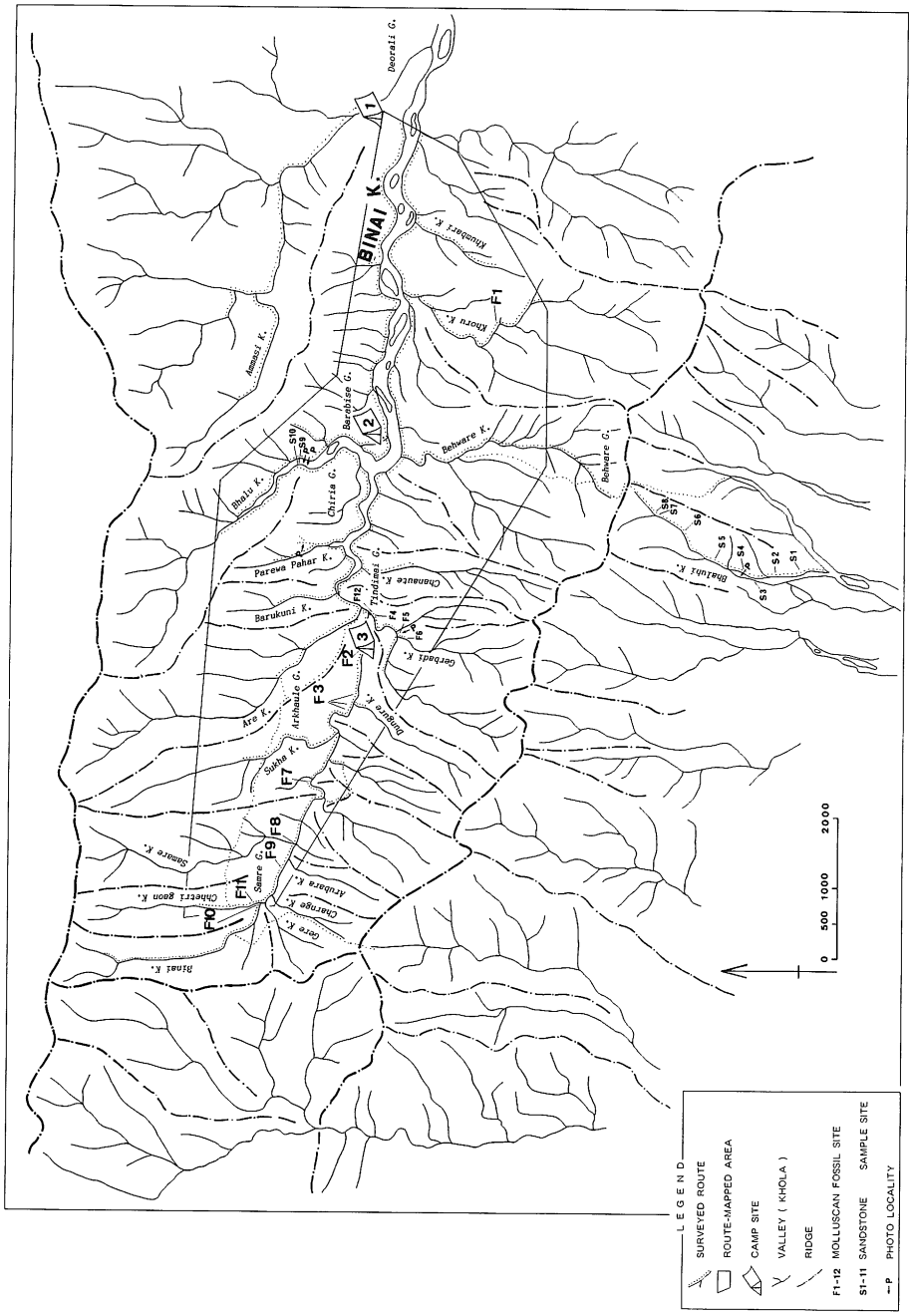
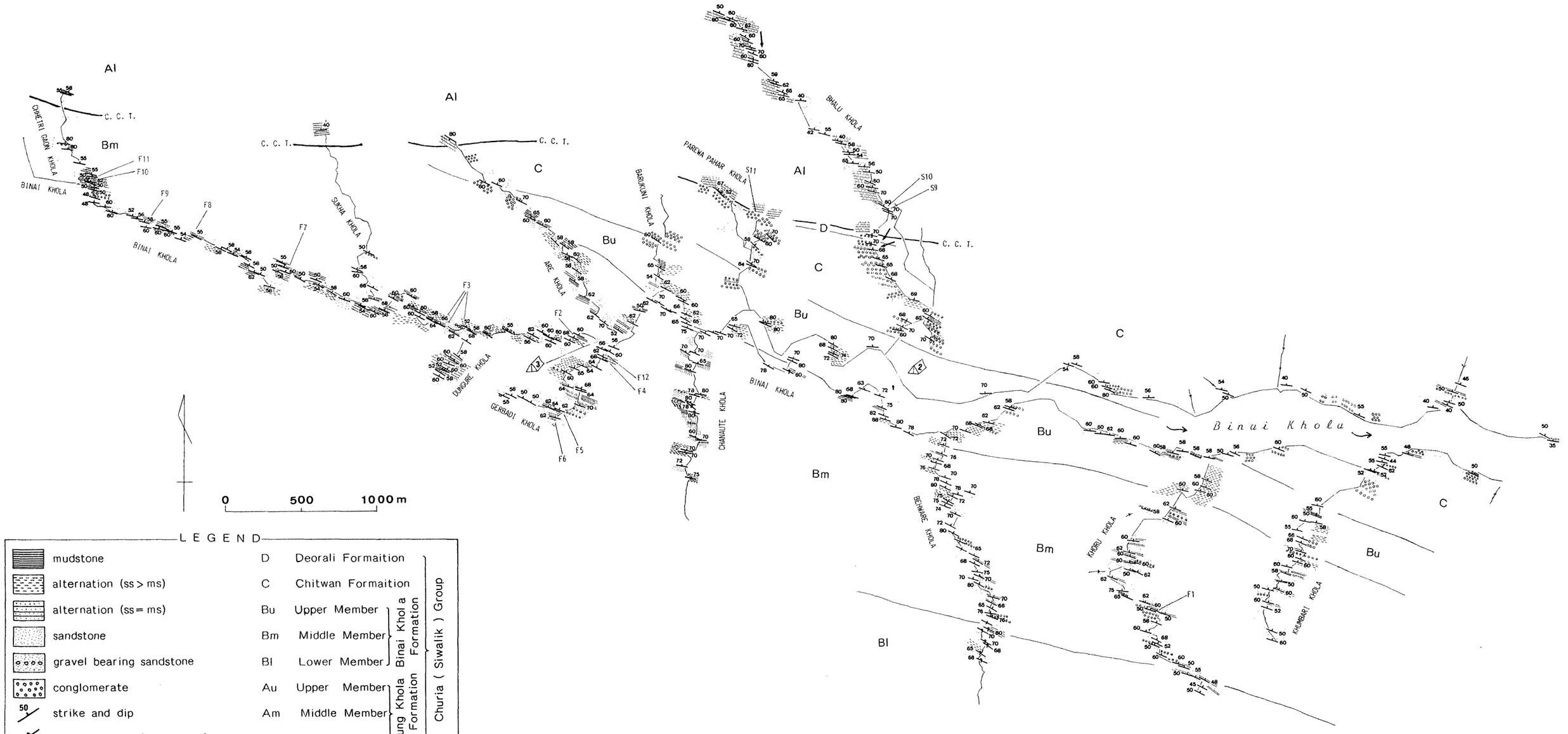


Fig. 3. Locality Map and surveyed routes in the area.



LEGEND

mudstone	D	Deorali Formaition		Churia (Siwalik) Group
alternation (ss > ms)	C	Chitwan Formaition		
alternation (ss = ms)	Bu	Upper Member	Binai Khola Formation	
sandstone	Bm	Middle Member		
gravel bearing sandstone	Bl	Lower Member		
conglomerate	Au	Upper Member	Arung Khola Formation	
50 strike and dip	Am	Middle Member		
85 strike and dip (overturned)	Al	Lower Member		
C. C. T. Central Churia Thrust	F1-12	Molluscan fossil site		
	S1-11	Sandstone sample site		
		Solemarks		
		Camp site		

Fig. 4. Route-maps surveyed by S. TAKEDA.

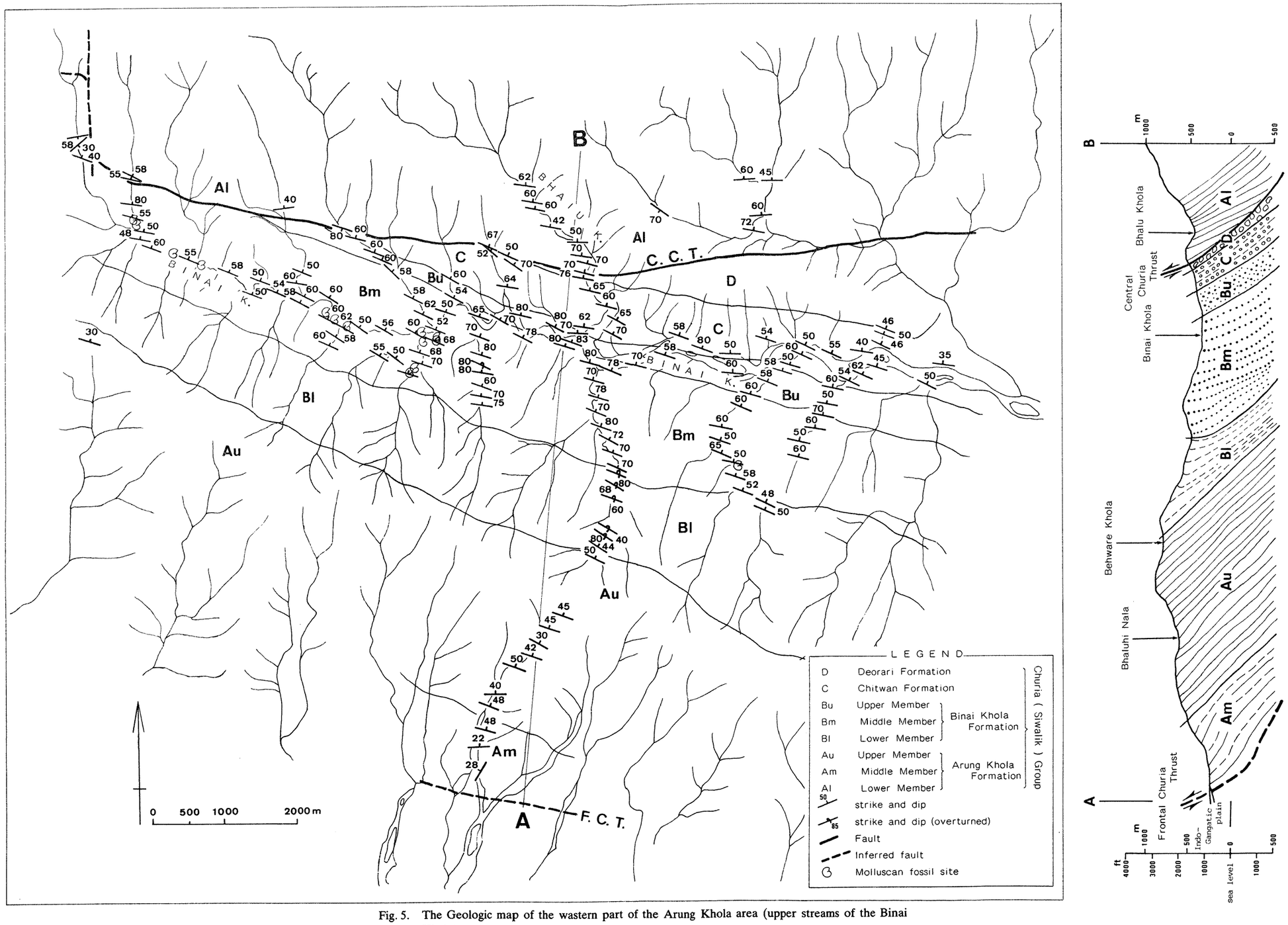


Fig. 5. The Geologic map of the wastern part of the Arung Khola area (upper streams of the Binai Khola).

Acknowledgements We are grateful to Drs. K. TAKAYASU and K. HISATOMI, collegues for the study of the Siwaliks, for identification of molluscan fossils and for analysis of sandstone, respectively. Sincere thanks are also expressed to Prof. K. KIZAKI of the University of Ryukyus, Dr. M. P. SHARMA of the Tribhuvan University for their support in the study and Mr. TAMANG and his associates who so skillfully managed our field work.

2. General Geology of the Churia Group

The Churia Group is bounded by the Main Boundary Thrust (M.B.T.) to the north and by the Frontal Churia Thrust (F.C.T.) to the south, and is divided lithostratigraphically into the Arung Khola Formation, Binai Khola Formation, Chitwan Formation and Deorali Formation in ascending order, that is, in order of A, B, C and D in their capital letters. The group is distributed in the North and South Belts, which are separated from each other by the Central Churia Thrust (C.C.T.). In the former belt the strata up to the middle part of the Binai Khola Formation are distributed, and in the latter the strata down to the upper part of the Arung Khola Formation are distributed. Their lithologic characteristics, thickness and correlation to the Siwalik Group in the Potwar Plateau, Pakistan on the basis of paleomagnetic polarity stratigraphy are collectively shown in Fig. 2.

The Churia Group has a steeply inclined homoclinal structure in the North Belt, whereas it has gently dipping and folded structures in the South Belt. Freshwater molluscs have been discovered in several horizons and sedimentary structures such as flute casts, cross-beddings are developed in them.

3. Stratigraphy and Geologic Structures

We have surveyed the area covered by the topo-sheet No. 63M/10 of 1 inch/1 mile scale. The surveyed routes and important localities are collectively shown in Fig. 3. The route-maps and geologic map are shown in Figs. 4 and 5. The Churia Group reported in the former paper (TOKUOKA *et al.*, 1986) is completely traceable not only stratigraphically but also structurally to the present area. The correlation between the Arung Khola area (TOKUOKA *et al.*, 1986) and the present area is shown in Fig. 2. The lower Member of the Alung Khola Formation is only distributed in the North Belt, whereas the other Members of the Churia Group are extensively distributed in the South Belt.

A. Stratigraphy

NORTH BELT

Arung Khola Formation

Lower Member (Al) is distributed only (its lowest part only) to the north of the

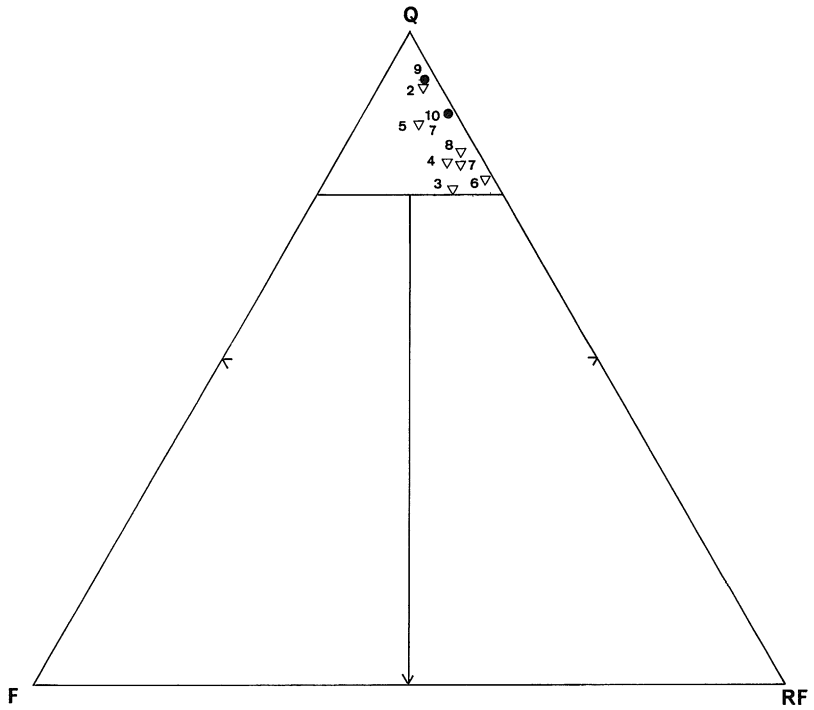


Fig. 6. Q(quartz)-F(feldspars)-RF(rock fragments) diagram of sandstones of the Churia Group. (Analized by Dr. K. HISATOMI).

C.C.T. in the surveyed area. It consists of alternating beds of calcareous sandstone and variegated mudstone, attaining more than 800 m in thickness. Along the C.C.T. the strata are highly disturbed (Plate I, Fig. 6).

SOUTH BELT

Arung Khola Formation

Middle Member (Am) is distributed in the most southern part of the surveyed area and is cut by the F.C.T. It is outcropped well at the Bhaluhi Khola, and is composed of alternating beds of sandstone and mudstone in which variegated mudstones are sometimes intercalated. The thickness is more than 900 m. The strata near the F.C.T. are disturbed.

Upper Member (Au) is well exposed at the Bhaluhi Khola, forming the summit-range of the surveyed area. It consists of lithmically alternating beds of sandstone and mudstone of 1 to 2 m thick(Plate I, Fig. 2). Variegated mudstones are sometimes intercalated in them. In the upper part sandstone becomes *pepper-and-salt* type. It attains to 2,090 m in thickness.

Binai Khola Formation

Lower Member (Bl) is composed of alternating beds of thick-bedded *pepper-and-*

salt sandstone, fine sandstone and mudstone. These are only examined at the Behware Khola and Khoru Khola, as rugged cliffs or falls make it difficult to be approached. Fining-upward sequences of several to more than ten metres thick are found in the member. It attains to 500 m in thickness.

Middle Member (Bm) is mainly composed of thick-bedded massive, *pepper-and-salt* sandstone which are intercalated with thin mudstones. Pebble conglomerates are sometimes intercalated in sandstones. Fining-upward sequences of several metre thick are frequently found in the member (Plate I, Fig. 3). Molluscan fossils have been found at 12 localities in this member. It has the thickness of 1440 m.

Upper Member (Bu) is well exposed along the Binai Khola. It consists mainly of massive sandstones intercalated with conglomerates of 5 to 10 cm thick. The thickness is 360 m.

Chitwan Formation (C)

The formation is distributed along the Binai Khola and is composed of semi-consolidated alternations of conglomerate, sandstone and mudstone(Plate II, Fig. 7 and Plate I, Fig. 4). Comglomerates are pebbly to sometimes cobbly and consist mostly of quartzites and attain sometimes more than 10 or 20 m thick. The formation attains to 290 m in thickness.

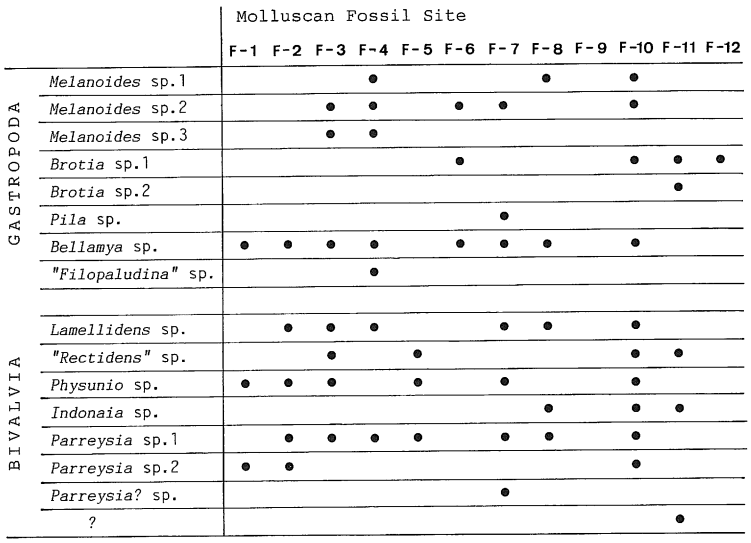


Fig. 7. Freshwater molluscs and their stratigraphic distribution in the upper streams of the Binai Khola (Identified by Dr. K. TAKAYASU).

Deorali Formation (D)

The formation is distributed only in the eastern part of the area and in the west it is

being cut by the C.C.T. It consists mostly of weakly consolidated, ill-sorted cobble to boulder conglomerates which are accompanied with some sandstones and mudstones (Plate I, Figs. 4, 5 and 6;Plate II, Fig. 7). The formation is differentiated from the Chitwan Formation by containing many clasts derived from the Churia Group (especially of the Arung Khola Formation) itself. It crops out well along the Bhalu Khola and Parewa Pahar Khola, where we can observe the thrust contact between the Deorali Formation and overlying Arung Khola Formation (Plate I, Fig. 6 and Plate II).

B. Geologic Structure

The Churia Group is divided tectonically into the North and South Belts separated by the C.C.T. In the North Belt, Arung Khola Fromation has E-W trend dipping 40° to 70° northward. In the South Belt, the group has WNW-ESE trend dipping 50° to 80° northeastward, and is cut by the C.C.T.

Central Churia Thrust (C.C.T.) was named in the Arung Khola area by TOKUOKA *et al.* (1986), where Al Member in the North Belt is thrust onto the Deorali Formation in the South Belt, although the thrust plane is not exposed there. Geomorphologically it is also traceable extensively, indicating its active nature. It is one of the most important thrusts systems in the Siwalik belt of the Frontal Himalayas (Sub-Himalayas). It can be traced in the present area in E-W trend and is dislocated secondarily by N-S trending fault in the most western part. Fortunately we have found excellent exposures of the thrust contact at the Bhalu Khola and Parewa Pahar Khola.

At the Bhalu Khola, the Deorali Formation consisting of 5 to 50 cm thick conglomerates is thrust by Al Member of alternating beds of sandstone and mudstone(Plate I, Fig. 6). The latter has been crushed extensively along the C.C.T. forming a sheared zone about 100 m in wide. The C.C.T. has N64°W strike and 50°N dip.

At the Parewa Pahar Khola, the situation is same as mentioned above. Here the crush zone of more than 200 m wide, which is made of Al Member, is outcropped extensively, forming a big cliff (Plate I, Fig. 6). We can see a fantastic exposure of the C.C.T. (Plate II, Fig. 1). Fortunately we can observe here the thrust plane itself in detail (Plate II, Figs. 2 and 3).

Frontal Churia Thrust (F.C.T.) was named in the Arung Khola area by TOKUOKA *et al.* (1986). It is the boundary between the Churia Hills and Indo-Gangetic Plain beneath which the Churia (Siwalik) Group is known to be distributed. Although its exact boundary is not found subareally, it is assigned one of the biggest thrust systems in the Frontal Himalayas. The Arung Khola Formation in the most southern extremity of the Churia Hills has been disturbed considerablly. In the studied area Au Member near the F.C.T. along the Bhaluhi Khola has been disturbed tectonically.

4. Conclusions

Stratigraphy of the Churia Group, which has been established in eastern adjoing

area by TOKUOKA *et al.* (1986), is completely traceable to the present area. The most interesting is that the Deorali Formation is more frequently intercalated with sandstones and siltstones in the present area than in the former area. The above-mentioned may represent more distal facies of the Deorali Formation.

Central Churia Thrust is also clearly traceable in E-W trend in the present area. Furthermore, it outcrops very well at the Bhaluhi Khola and Parewa Pahar Khola. At the Parewa Pahar Khola, highly dipping Al Member is thrust over gently dipping Deorali Formation (Plate II, Figs. 1 and 2). The former has been sheared, whereas the latter has not been disturbed. In between the fault clay is observed in less than 1 m wide zone, which is mostly made from the materials of Al Member (Plate II, Fig. 3). The discovery of basaltic fragments (Plate II, Fig. 5) in the fault clay seems very interesting. As the occurrence of basaltic rocks are unknown in the Siwaliks, they can be interpreted to have been squeezed out from deeper part along the thrust plane. Highly sheared sandstone fragments (Plate II, Fig. 4), occurrence of which is abundant, in fault clay are also assingned to have been brought by same processes. The strata of the South Belt with NW-SE trend are clearly cut by E-W trending C.C.T., representing obviously younger generation of the C.C.T. itself. Geomorphologicaly it is also traceable in the surveyed area.

Sandstones were collected at 11 localities shown in Fig. 3 and were point-counted by Dr. K. HISATOMI. The results shown in Fig. 6 are in good accordance with those obtained in the former area by TOKUOKA *et al.* (1986).

Paleocurrents were obtained at two localities of the Deorali Formation at the Bhalu Khola. The data are shown in Fig. 4, that is, from NE to SW and ENE to WSW. These are same with the data obtained in the eastern adjoining area by TOKUOKA *et al.* (1986), that is, dominantly from N to S. Distal facies of the Deorali Formation in the present area compaired with proximal one in the former area is in good accordance with these data.

Molluscan fossils were obtained at 12 localities shown in Fig. 3. They were identified by Dr. Takayasu and are listed in Fig. 7. Their stratigraphic horizons belong to the Middle Member of the Binai Khola Formation. These fossils mostly yield at the top of each fining-upward sequence as shown in Plate I, Fig. 3. All species are same as already reported from Bu and Bm Members in eastern adjoining area by TOKUOKA *et al.* (1986).

Ramapithecus (Sivapithecus) punjabicus reported by MUNTHE *et al.* (1983) from the Tinau Khola, north of Butwal is still far more than 10 km from the present area. The strata area dislocated at the most western part of the area by N-S fault and the correlation of the strata between two areas is not possible yet, however, we can estimate lithologically that its horizon must belong to the Upper Member of the Arung Khola Formation, that is, the magnetic polarity zone of Chron 9 by MUNTHE *et al.* (1983).

References

JOHNSON, N. M. , OPDYKE, N. D., JOHNSON, G. D., LINDSAY, E. H. and TAHIRKHELI, R. A. K, 1982. Magnetic polarity stratigraphy and ages of Siwalik Group rocks of the Potwar Pakistan. *Palaeogeogr. Palaeocli. Palaeoecol.*, **37**, 17–42.

JHONSON, N. M., STIX, J., TAUXE, L., CERVENY, P. FL. and TAHIRKHELI, R. A. K., 1985. Paleomagnetic chronology, fluvial processes and tectonic implications of the Siwalik deposits near Chinji Villege, Pakistan. *Jour. Geol.*, **93**, 27–40.

MUNTHE, J., DONGOL, B., HUTCHISON, J. H., KEAN, W. F., MUNTHE, K. and WEST, R. M., 1983. New fossil discoveries from the Miocene of Nepal include a hominoid. *Nature*, **303**, 331–333.

OPDYKE, N. D., JOHNSON, G. d., LINDSAY, E. H. and TAHIRKHELI, R. A. K., 1982. Paleomagetism of the Middle Siwalik formations of northern Pakistan and rotation of the Salt Range Decollement. *Paleogeogr. Palaeocli. Palaeoecol.*, **37**, 1–15.

TAUXE, L. and OPDYKE, N. D., 1982. A time framework based on magnetostratigraphy for the Siwalik sediments of the Khaur area, northern Pakistan. *Palaeogeogr. Palaeocli. Palaeoecol.*, **37**, 43–61.

TOKUOKA, T., TAKAYASU, K., YOSHIDA, M. and HISATOMI, K., 1986. The Churia (Siwalik) Group of the Arung Khola Area, West Central Nepal. *Mem, Fac, Sci., Shimane Univ.*, **20**, 135–210.

Explanation of Plates

Plate I

Fig. 1. A distal view of the Arung Khola Formation at the Bhaluhi Khola in the South Belt.

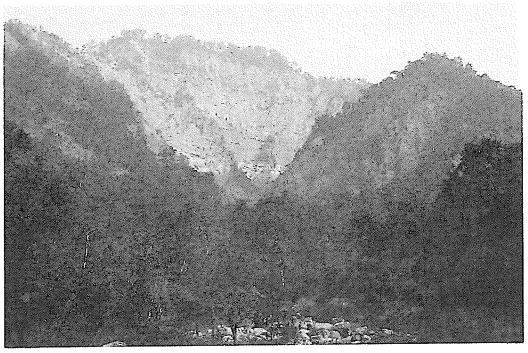
Fig. 2. Thick-bedded alternations of sandstone and mudstone of the Upper Member of the Arung Khola Formation at the Bhaluhi Khola.

Fig. 3. Typical fining-upward sequences of the Upper Member of the Binai Khola Formation at the entrance of the Gerbadi Khola. Mollucan fossils yield in mudstone at top of several sequences.

Fig. 4. The boundary between the Chitwan Formation (C) and the Deorali Formation (D) at the Bhalu Khola. The latter is assinged to be debris-flow deposits eroding underlying Chitwan Formation, although the structure is parallel to each other.

Fig. 5. Conglomerates of the Deorali Formation forming bad-land at the Bhalu Khola. Sandstones and siltstones are sometimes intercalated in thick-bedded conglomerates of debris-flow origin.

Fig. 6. A distal view of the Arung Khola Formation (Al) at the Parewa Pahar Khola in the North Belt. The Central Churia Thrust is running in E-W trend behind the bad-land which is formed by conglomerates of the Deorali Formation. The Al Member is highly disturbed along the C.C.T. about 200 m in width.



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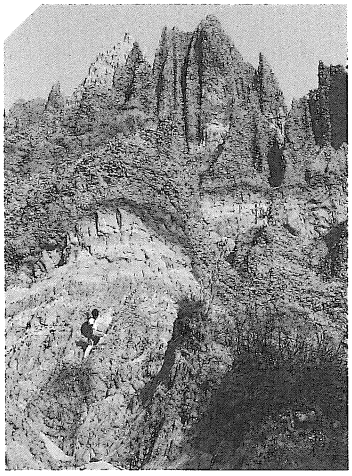

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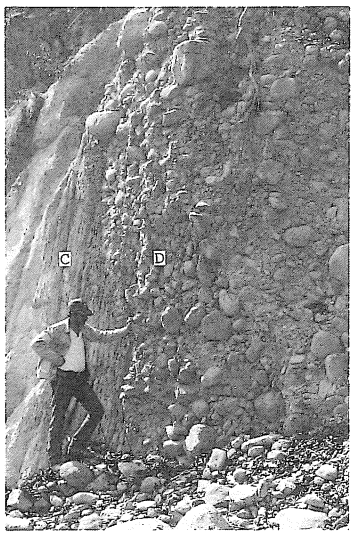

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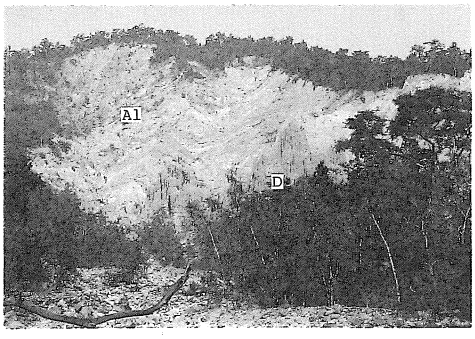

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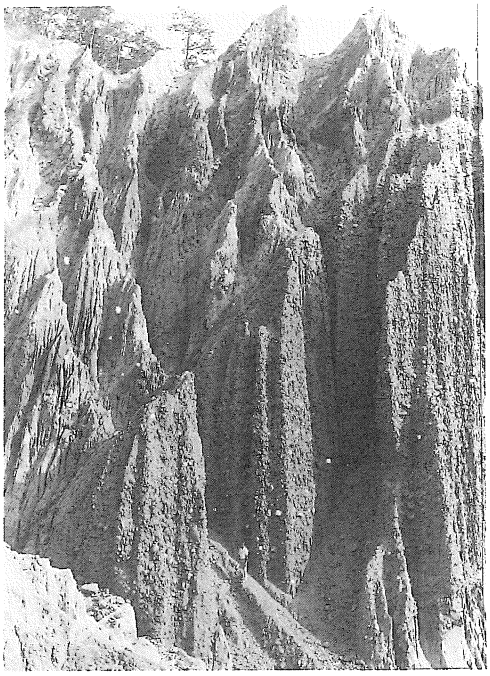
Plate II

Fig. 1. The Central Churia Thrust at the Parewa Pahar Khola.
Fig. 2. Sketch of Fig. 1.
Fig. 3. Close-up of Fig. 2.
Fig. 4. Photomicrograph of fault clay with breccias. Highly sheared fragments mostly of Al sandstones (a) are mixed with non-sheared ones in clayey part.
Fig. 5. Photomicrograph of a fragment of basalt (b) of unknown origin, probably squeezed out from deeper part along the thrust plane.
Fig. 6. The Central Churia Thrust (C.C.T.) at the Bhalu Khola. The Al Member has been disturbed about 200 m in width. The Deorali Formation (D) is extended to the left, and is shown in Fig. 7.
Fig. 7. The Chitwan Formation (C) and Derali Formation (D) in the Bhalu Khola. The boundary between them is shown precisely in Plate I, Fig. 4.



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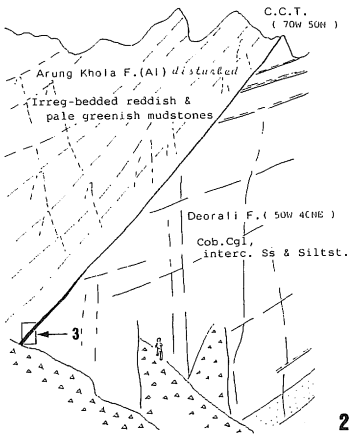
C.C.T.
(70W 50N)
Arung Khola F.(Al) disturbed
Irreg-bedded reddish &
pale greenish mudstones
Deorali F.(50W 4CNE)
Cob.Cgl.
interc. Ss & Siltst.
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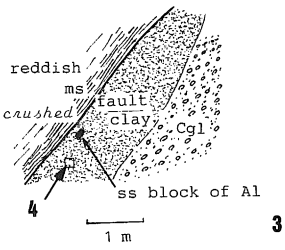
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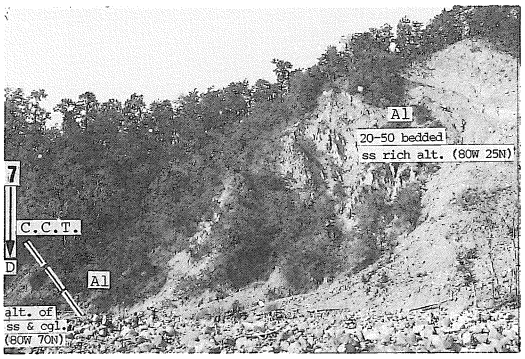
Al
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C.C.T.
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ss & cgl.
(80W 70N)

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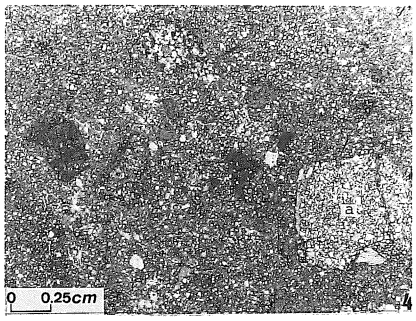
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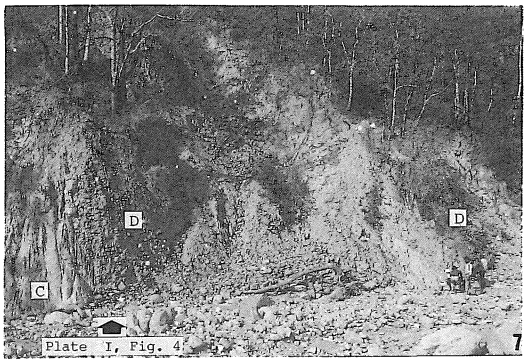
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Plate I, Fig. 4

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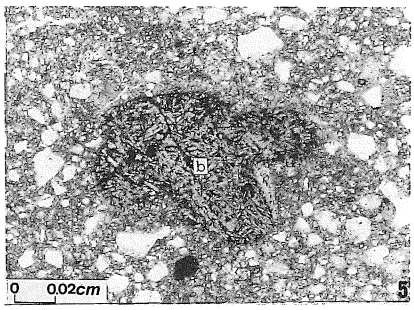
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