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Overfolds and Block-Faults in the Frontal Part of the Inner Lesser Himalayas, Western Central Nepal

Harutaka SAKAI

Abstract

The Kali Gandaki Supergroup in the southern part of the inner belt of the Lesser Himalayas, western Central Nepal, is structurally characterized by overturned folds and longitudinal normal faults. The folds show a S-shaped pattern, when viewed from east, or a south-side-down pattern in shear sense, being opposite to the Z-shaped one in the inverted limb of the Angha Khola Recumbent-Fold in the outer belt. The supergroup exposed in the inner belt represents a normal limb of one and the same large-scale recumbent fold continued from the Angha Khola Fold Belt.

The folded rocks in the inner belt are segmented by longitudinal faults into several, parallel to subparallel lengthwise blocks. The faults are nearly vertical or dip north steeply. The Bari Gad Fault bounding the inner and outer belts is the largest of them and its dip-slip separation is estimated more than 1400 m. Thereby the northern Himalayan side has been lowered down relative to the southern Mahabharat Range. The Pindi Khola Fault Zone typified along the Pindi Khola, situated at 8 km north of the Bari Gad Fault, constitutes another major fault, into which the Tansen Group of late Paleozoic to probable early Miocene rocks has been introduced narrowly to discontinuously. It extends more than 20 km with a maximum width attaining 1.5 km within the surveyed area. The dip-slip separations of the boundary faults on both sides are estimated more than 500 m. Some other longitudinal faults run in parallel to subparallel with the faults cited above. This faulting and associated tectonic insetting of the younger Tansen Group along the fault have occurred after the folding of the Kali Gandaki Supergroup.

The block-faulting in the inner belt is inferred to have been generated by release of strain on the rear side of the southerly driven Angha Khola Recumbent-Fold accompanying the Main Boundary Thrust. The regional lowering of the Midland and the development of topographic depression zones in the frontal part of the Midland are largely due to the downthrow of the faulted blocks and significant effect of erosion of sheared rocks resulted from subsequent strike-slip movements along the faults.

I. Introduction

The importance of block-faulting in the tectonic development of the Himalayas is emphasized by EREMENKO and NOMOKONOV (1967) and HASHIMOTO *et al.*, (1973). However, little accounts on attitudes, dip-slip displacements and deformation styles of the faults are given. HAGEN (1969) and FRANK and FUCHS (1970) explain the tectonic history of the Nepal Himalayas by nappe tectonics

rather than by block-faulting. There seems to be no room for compromise between both ideas. I demonstrated that the rocks of the Midland in the western Central Nepal show both compressional and tensional structures, and proposed a model of the tectogenesis of both structures (SAKAI, 1985). The compressional structure is represented by a large-scale overturned fold of the Kali Gandaki Supergroup. The rocks exposed in the Kali Gandaki river and the Andhi Khola area were revealed to exhibit the normal limb of it. The overfold structure is transected by E-W trending longitudinal, high-angle normal faults or fault zones. These faults divide the rocks of the inner belts into a large number of lengthwise blocks, and a fault itself is usually marked by a distinct linear valley or a depression zone owing to differential erosion. This system of block-faulting can be referred to as the tensional structure. In relation to this structure especially noteworthy is that the Tansen Group of Carboniferous to Miocene ages (SAKAI, 1983) has been tectonically wedged into a fault zone along the Pindi Khola valley.

In this paper I describe major geologic structures of the frontal part of the Midland, emphasizing on the longitudinal fault system.

II. Structural Features of Longitudinal Faults

A. Pindi Khola Fault Zone

1. General Remarks

In my last paper (SAKAI, 1985, p. 384, fig. 4) I recorded a small occurrence of the Lower Gondwana Sisne Formation of the Tansen Group along a fault in the Pindi Khola valley and to the north of Udiyachaur. It was suggestive of wider distribution of the Tansen Group in the area and of being an important key to know the genesis of faulting. Having jointed the research project "Study on crustal movement on the Nepal Himalayas" lead by Professor K. Kizaki in 1984, I could have mapped the area along the Pindi Khola valley and in the middle reaches of the Andhi Khola. As the results, it was found, as shown in the geological map (SAKAI, 1986, fig. 1; this volume), that the Tansen Group, not only the Sisne Formation but also the Amile and Dumri Formations, are narrowly distributed for more than 20 km in length within a fault zone. This fault zone is typically exposed along the Pindi Khola, and is consequently named the Pindi Khola Fault Zone.

The Pindi Khola Fault Zone varies in width from 250 m to 1500 m between Setibeni and Gurunggaon in the Pindi Khola valley. Within this zone there occur the Dumri Formation along the main valley and the Amile Formation in the northern tributary area near Kholakharak. This fault zone extends further east to Raskhola in the upper reaches of the Andhi Khola with a breadth less than 100 m, where diamictite of the Sisne Formation is sandwiched as a narrow strip (SAKAI, 1986, fig. 1).

2. Boundary Faults

Both the southern and northern boundary faults have sharp fault planes inclining 80 to 90 degrees north. The Dumri Sandstone along these faults is

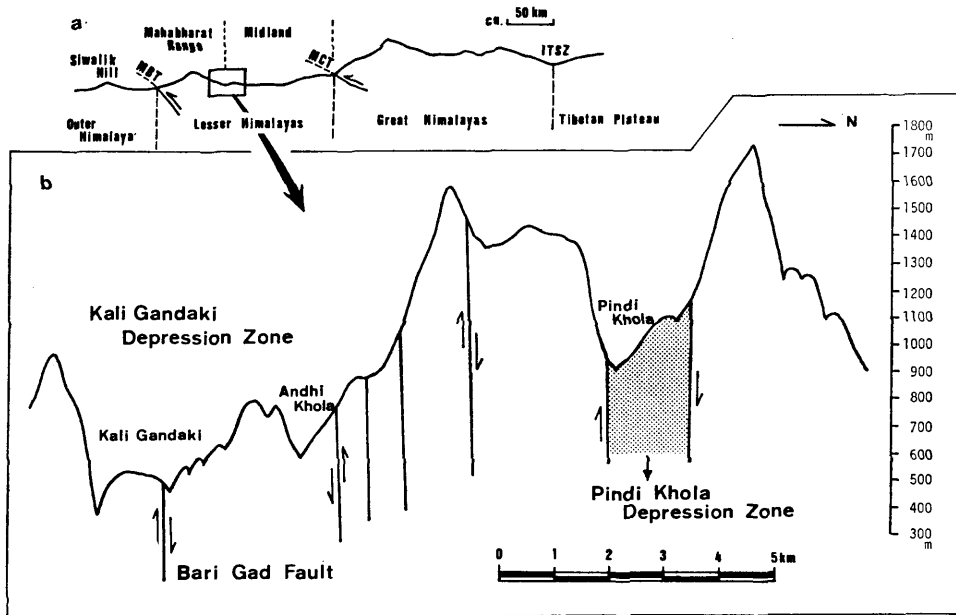


Fig. 1. a. Profile showing topographic and geological divisions of the Himalayan Range.
 b. Profile showing the relationships between longitudinal faults and depression zones in the southern part of the inner belt of the Lesser Himalayas, western Central Nepal.

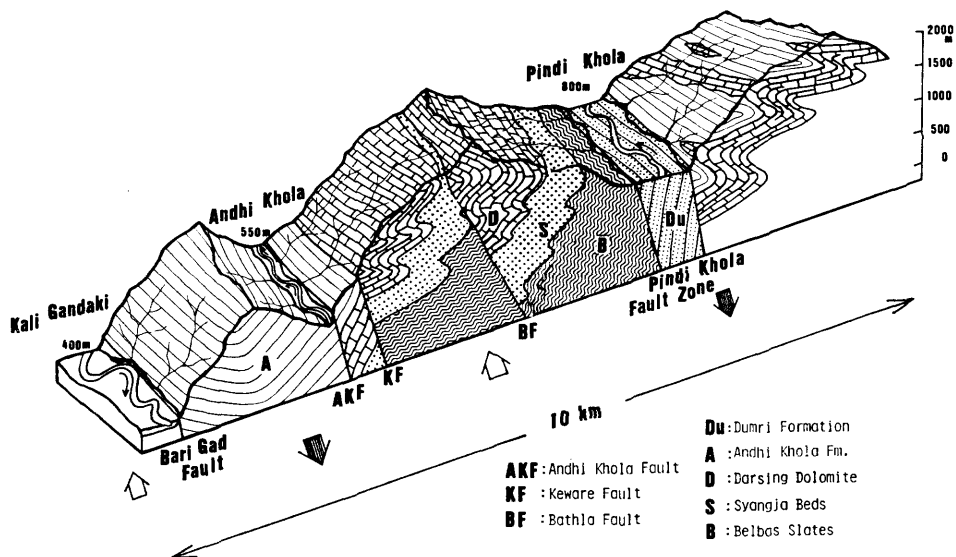


Fig. 2. Idealized block-diagram, looking from east, showing the geologic structure of the southern part of the inner belt crossing the Kali Gandaki, Andhi Khola and Pindi Khola valleys.

strongly sheared in a width more than 6 m. Carbonaceous limy slate of the Andhi Khola Slates exposed north of Setibeni is crushed to form an about 50-cm fault-gouge zone (Pl. 11, Fig. 4). The northern boundary fault zone cropping out on the western bank of a large meander of the Andhi Khola near Udiyachaur has a wide shear zone represented by a 3-m wide fault-clay, a 5-m fault breccia, and a 10-m sheared clay slate zone. Around Raskhola, the Belbas Slates adjoining south to the fault is pervasively sheared for a width 50 m. Segregation lenses of quartz are formed parallel to the cleavages. The northern boundary fault is displaced about 1 km north by a NW-SE trending transverse fault in the west of Kholakharak, where a wedge of the Amile Formation is introduced (SAKAI, 1986, fig. 1). The western boundary of the formation can be traced even in jungles by sporadic exposures of characteristic conglomerate. The conglomerate adjoining to the faults is strongly brecciated and mixed with a hematitic muddy matrix (Pl. 11, Fig. 3) which weathers reddish-brown.

No superimposed strong deformation by faulting of the Tansen Group and the adjoining Kali Gandaki Supergroup have been observed other than shearing along the boundary faults.

3. Lithofacies of the Tansen Group in the Pindi Khola Fault Zone

The above-mentioned three formations of the Tansen Group sliced into the Pindi Khola Fault Zone cannot be differentiated in lithofacies from those in the Tansen area in the outer belt. The thickness of the Dumri attains 300 m at maximum near Setibeni, and it possibly increases westward. The Amile is at least 100 m thick, and the thickness of the Sisne cannot be measured. Although stratigraphic and structural relationships among these formations have not been ascertained, all of these formations strike obliquely to the general trend of the fault zone and steeply incline north. Neither significant folds nor faults were observed within them, but fracture cleavages are common in argillaceous rocks. It is noticeable that the cleavage planes are clearly oblique not only to the general strike of those formations but also to that the Kali Gandaki Supergroup. These facts indicate that the Tansen Group have fallen into the fault zone after folding of the Kali Gandaki Supergroup.

The Sisne Formation is made largely of diamictite containing clasts of dolomite and granite. Greenish-gray slate is present in places. Southeast of Gurunggaon there occur conglomerates 3 to 6 m thick which are composed of subrounded to subangular pebbles of white quartzite and chert. They are accompanied by a subordinate amount of graded quartzose sandstones. The stratigraphic relationship of these conglomerates and sandstones to the Sisne Diamictite is uncertain. It should be marked, however that the lithology of the conglomerates resembles that of the basal conglomerate of the Taltung Formation in the western end of the Tansen Synclorium in the outer belt.

The Amile Formation consists mostly of medium- to thick-bedded sandstones with granules and pebbles in some portions. These sandstones are quartzose arenite, and some calcareous siltstone beds with dirty ferruginous mottles are accompanied. The pebbly sandstones are poorly-sorted and contain subangular grains of pink quartzite and red agate other than white quartzite. These litho-

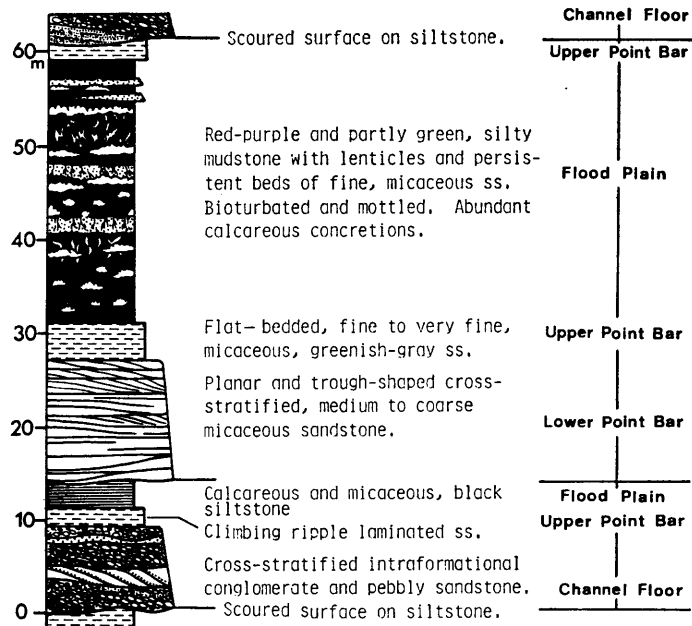


Fig. 3. Columnar section of the Dumri Formation in the Pindi Khola of typical meandering river deposits.

logies are similar to those of the Lower Member of the Amile Formation in the Tansen area. There are, however, some other sandstones of wacke-type whose lithology is similar to those of the Upper Member of the Amile Formation in the outer belt.

The Oligocene to lower Miocene Dumri Formation shows characteristic fining-upward cyclic sequences comprising channel-fill conglomerate, cross-bedded point bar sandstone and overbank floodplain deposits of reddish-purple and green shale in ascending order (Fig. 3). There are, however, some differences between the Dumri Formation in the outer and inner belts. The average thickness of one cycle is a few tens of meters in the outer belt, whereas it reaches more than 50 m in the inner (Fig. 3). The Dumri sandstone in the inner belt contains a considerable amount of muscovite flakes, which are, in turn, scarce in the outer belt. The paleocurrent directions obtained from the cross-bedding of the Dumri sandstone in the inner belt demonstrate that the clastic materials were transported from north to south, likewise in the outer belt.

B. Bathla Fault

Bathla Fault runs in W-E to WSW-ENE direction, passing villages Bathla, Karaundi, Gola and Sarbhanjyang, where it separates the Darsing Dolomites into two parts (SAKAI, 1986, fig. 1). In the vicinity of Bathla, where the rocks on both sides of the fault take overturned attitudes, a narrow, lengthwise strip of pink quartzite, dolomite and purple slate of the Syangja

Beds has been squeezed up along the fault (SAKAI, 1986, fig. 1). In the east of Gola, the Bathla Fault demarcates the tectonic boundary between the Syangja Beds on the north and the Darsing Dolomite on the south, although vertical and lateral displacements along its are small, and seems to converge into the Pindi Khola Fault Zone to the south of Waling.

The fault plane is sharp (Pl. 11, Fig. 2), and accompanied fault-clay less than 1 cm wide, which weathers yellow-brown. Both the Darsing Dolomites and Syangja Beds on the fault have been only weakly sheared. Thus the deformation along the Bathla Fault is of much lesser degrees as compared with other faults which have been subsequently affected by lateral slip movement after block-faulting.

C. Longitudinal Faults in the Syangja area

Several longitudinal fault zones are recognized in the Syangja area in the upper reaches of the Andhi Khola. They are 100 to 500 m wide, and extend in a W-E to WSW-ENE direction. Figs. 6a and b are local sketch maps showing a bare outline of two examples of these fault zones. The area of Fig. 5a is located

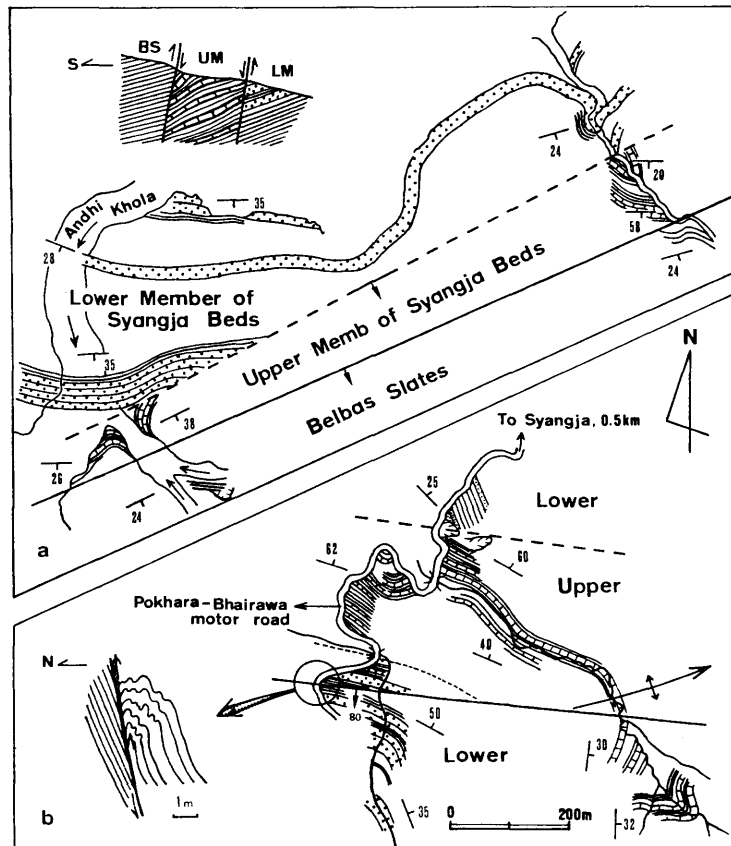


Fig. 4. Route maps and cross-section of Syangja area in the inner belt.

at 5 km SW of Syangja, where the Upper Member of the Syangja Beds is faulted down in between the Belbas Slates on the south and the white quartzite of the Lower Member on the north. Interlayered pink dolomites and purple slates of the Upper Member are structurally discordant with the folded quartzites of the Lower Member and the Belbas Slates. No strong shear is detected within them. The same type of faulted-down structure occurs at Syangja as shown in Fig. 5b. The southern boundary fault has a sharp plane and is accompanied by a small drag fold which indicates relative rise of the southerly block.

D. Kali Gandaki Fault Zone

The Bari Gad Fault is a fault bounding the inner and the outer belt in this area and seems to be of the largest extent in the Lesser Himalayas. Along this fault the northern block has been lowered about 1400 m relative to the southern block, as mentioned below. About 3.5 to 5 km north of the Bari Gad Fault are two closely spaced faults, named the Keware and the Andhi Khola Faults (Fig. 2; see also SAKAI, 1986, fig. 1). The Keware Fault separates the Darsing Dolomite on the north from the Andhi Khola Formation on the south. It is vertical or nearly so, and along it the southern block has been displaced down relative to the northern block. The amount of displacement is probably more than 100 m. The Andhi Khola Fault runs in parallel with the Keware Fault less than 1 km apart and transects the Andhi Khola Formation. It is also nearly vertical and along it the southern block has been displaced downward relative to the northern block, although the amount of displacement cannot be known because of absence of marker beds.

The area between the Bari Gad and the Keware Faults and the tract just southerly adjoining to the Bari Gad Fault forms a 4- to 6-km wide zone of topographically lowest altitude within the Lesser Himalayas, herein named the Kali Gandaki Depression Zone (Fig. 1). As for this depression zone, I presented a model that the depression of the frontal part of the Midland has resulted from longitudinal faults with large displacements (SAKAI, 1985, fig. 19). There was, however, a discrepancy in the model; namely I mentioned (SAKAI, 1985, p. 374) that along the Bari Gad Fault the Andhi Formation on the north side has gone up relative to the rocks of the southerly adjoining Mahabharat Range, notwithstanding I have drawn it in the geologic profiles (SAKAI, 1985, fig. 4 A-A' section; fig. 14, B-B' and C-C' sections) and in the generalized structural section (op. cit., fig. 19) that the overall frontal part of the Midland (inner belt) has been lowered relative to the Mahabharat Range (outer belt). This inconsistency has arisen from that I placed the stratigraphic position to the Andhi Formation in the lowest part of the Kali Gandaki Supergroup. However, this discrepancy was dissolved by that the Andhi Formation (renamed Andhi Khola Formation) was rectified to occupy the upper part of the Kali Gandaki Supergroup (SAKAI, 1986). Anyhow, it has become clear that the region of the Andhi Khola Formation in the frontal part of the inner belt has gone down along the Bari Gad Fault against the outer belt. The dip-slip separation caused by the Bari Gad is estimated at least 1400 m.

E. Remarks on the relationship between longitudinal faults and depression zones

I emphasized that the longitudinal block-faulting is the essential cause for the formation of a low topography in the Midland behind the southwardly upthrusting Mahabharat Range (SAKAI, 1985). Many of the longitudinal fault traces are marked by a distinct linear valley or a depression zone. Fig. 1 depicts the coincidence of longitudinal fault zones and topographic depressions.

The largest and deepest among the depression zones in the Midland is of along the Kali Gandaki river that flows as meandering across the Bari Gad Fault trace and forming a longitudinal valley from Riri Bazar to the confluence of the Trisulu Ganga river for 100 km. The altitude of the river beds is about 300 m, and that of the frontal part of the Midland between the Bari Gad Fault and the Keware Fault ranges from 500 to 800 m, whereas the Mahabharat Range standing on the south has an altitude of 1700 to 2000 m. Thus the relative height between the Kali Gandaki valley area and the Mahabharat mountain ridges reaches 900 to 1200 m, at most exceeds 1400 m. This relative height nearly coincides with the amount of the dip-slip separation of the northerly block against the southerly block along the Bari Gad Fault.

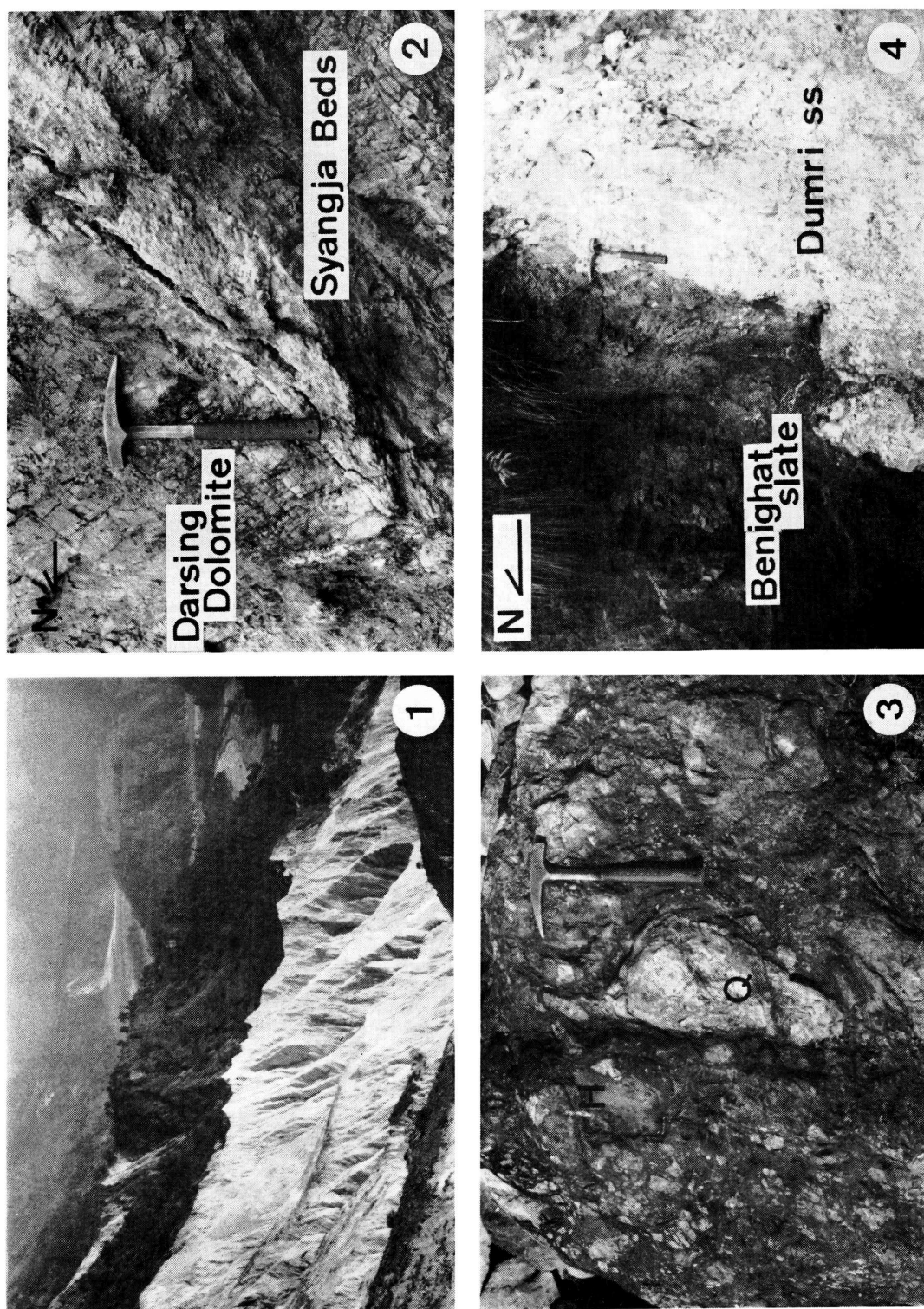
The Pindi Khola Fault Zone constitutes another distinct depression zone, and the relative height between the zone of the tectonically intercalated Tansen Group and the mountain ridges of the Kali Gandaki Supergroup reaches about 1000 m.

It is no doubt that the effect of erosion of the crushed or sheared materials along the faults or within the fault zones is very significant for the development of depression zones or linear valleys. It would have been particularly effective along the faults with strike-slip displacements, because they are associated with a wide sheared and brecciated zone along their traces.

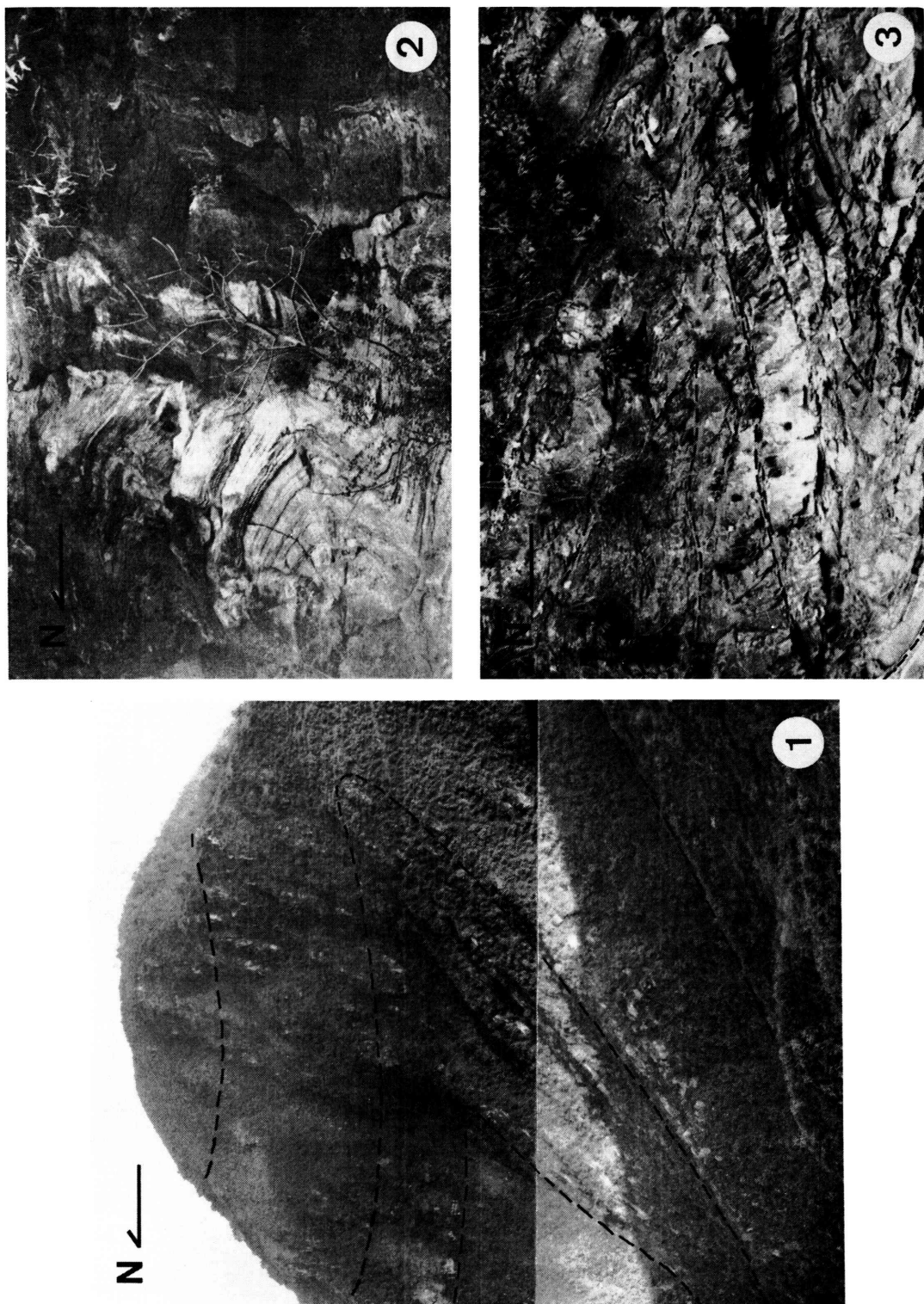
Actually, the Bari Gad Fault is an active fault with a horizontal displacement of more than 200 m and is marked by a zone of sheared and kink-folded rock as much as 200 m wide. The Keware Fault is accompanied by a shear zone for a width of about 200 m. The brecciated dolomite and limy slate form grounds like a pressure ridge from which gullies and landslides are often originated. The Andhi Khola Fault is also associated with a wide shear zone with

Explanation of Plate 11

- Fig. 1: A huge landslide occurred from the shear zone along the Bari Gad Fault on the northern mountainside of the Kali Gandaki river. Voluminous debris is intensely eroded to form a bad land. East of Waiga.
- Fig. 2: Bathla Fault with a sharp fault contact between the Darsing Dolomite and pink quartzite of the Syangja Beds on the eastern bank of the Kali Gandaki; Bathla.
- Fig. 3: Consolidated fault-breccia of the Pindi Khola Fault Zone between the Amile Quartzite and the Andhi Khola Slates. Quartzite breccia is mixed with ferruginous mudstone.
- Fig. 4: Northern boundary fault of the Pindi Khola Fault Zone. Benighat slate in the photo should be read as the Andhi Khola Slates; Setibeni.



H. SAKAI: Overfolds and Block-Faults in the Inner Lesser Himalayas



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fault gouge. Kink-type drag folds commonly occur along the fault. The rocks of the zone between the Keware and the Andhi Khola Faults are so pervasively sheared that the original sedimentary structures and bedding planes are hardly observable. These faults may have undergone lateral movement associated with the Bari Gad Fault, because the deformation along these faults is too strong in spite of their small dip-slip offsets.

III. Overfolds in the Inner Belt

The northern half of the outer belt constitutes two fold belts, a recumbent fold on the south and an overturned fold on the north, and are named the

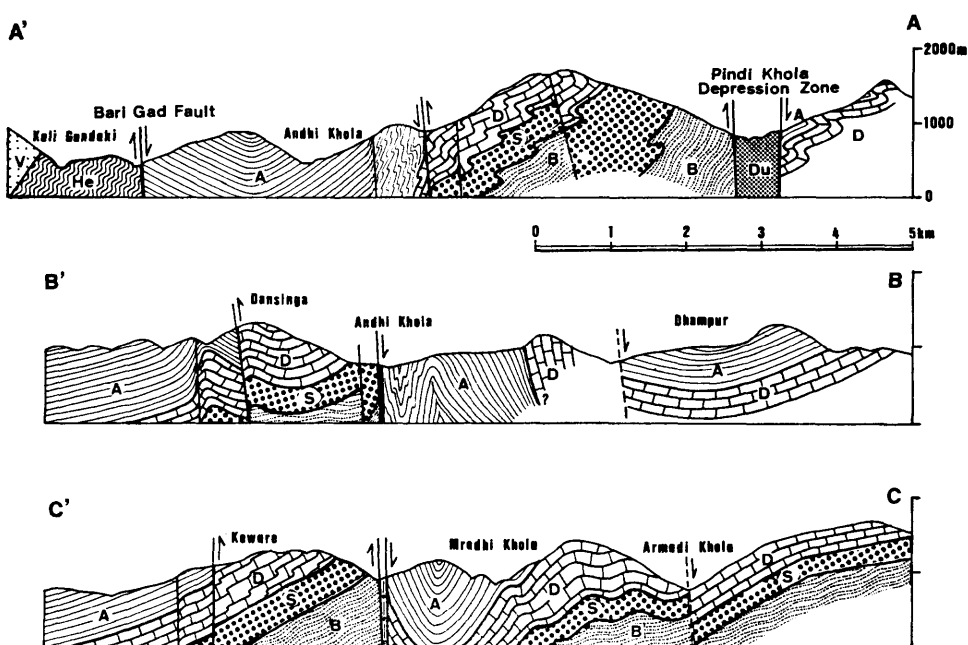


Fig. 5. Cross sections of the southern part of the inner belt. As for the symbols and location, refer to Fig. 2. and SAKAI (1986), fig. 1.

Explanation of Plate 12

- Fig. 1: A large-scale overfold of the probable Darsing Dolomite and Syangja Beds near the summit of northern mountain of the Pindi Khola valley. The axial plane strikes N 70°W, and dips 35°N. The steeply dipping limb is overturned. Viewed from the west.
- Fig. 2: Z-shaped or south-side-up overfolds of black, banded carbonaceous limestone of the Andhi Khola Slates at Kholakharak (viewed from the east). The axial planes strike N 60°W and dip 18°N. Enveloping surface strikes N 80°E and dips 25°S.
- Fig. 3: Recumbent fold of dolomitic quartzite and shale of the Darsing Dolomite (=Khoraidi Formation) on the river bank of the Seti Khola. Slaty cleavage (N 45°E, 14°SE) obliquely cuts the folded beds.

Angha Khola Fold Belt and the Khoraidi Fold Belt, respectively (SAKAI, 1985). Overturned structures are also noticed near Tallathum village in the inner belt (SAKAI, 1985, fig. 4). However their extent and basic structures have been unknown. As the results of survey in the Pindi and Andhi Khola valleys it was manifested that overturned folds are regionally developed in the inner belt north of the Bari Gad Fault, although detailed structures of the Andhi Khola Formation cannot be given because of monotonous lithology and gentle inclination of the formation. I herein describe mainly their general pattern in the Pindi and Andhi Khola valleys.

A. Northern mountainside of the Pindi Khola

One of the best profiles of the overfolds can be seen on the northern mountainside of the Pindi Khola as shown in the geological map (SAKAI, 1986, fig. 1), where three fold axial surface traces run parallel to one another with a wavelength of 700 to 800 m. They are near the Pindi Khola river bed at 670 m in altitude, in the middle of the mountainside at about 1070 m, and near the summit of the mountain at about 1670 m (Pl. 12, fig. 1), respectively. Thus these fold traces lie at 400 to 600 m intervals. Their enveloping surface dips south at 20 degrees and is nearly parallel to the gradient of the mountain surface. As the boundary surface between the Darsing Dolomite and Andhi Khola Slates runs subparallel to the mountain surface, it is rather difficult to define their exposed area. Their exposures are roughly visualized in Fig. 2.

The overturned folds cited above show a south-side-up pattern in cross-section (S-shaped pattern in case viewed from east) and consist of a gently southerly-dipping long limb with a normal sequence and a steeply northerly-dipping short limb with an inverted sequence. Smaller-scale folds of the same pattern are observable in many exposures (Pl. 12, Fig. 2). Subsidiary recumbent folds are accompanied in the axial part of large folds (Pl. 12, Fig. 3). Slaty cleavages dipping south or east at angles of 10 to 40 degrees obliquely cut these folded beds. The attitude of the cleavages seems to have developed in association with larger folds.

B. Area between the Pindi and Andhi Khola

Overfolded structures are extensively recognized in the area between the Andhi and Pindi Khola, and are best exposed along the bluff river-banks of the Kali Gandaki between Setibeni and Andhimohan. They are asymmetrical folds showing the same pattern as those in the northern mountainside of the Pindi Khola valley, and have a wavelength of about 200 m. However, precise inclination of enveloping surfaces has not been measured. Similar overturned structures were also widely ascertained by the aid of overturned stromatolites in the northern mountainside of the Andhi Khola (SAKAI, 1986, fig. 1, pl. 10, fig. 4), where four anticlines are inferred to present at 300-m intervals in altitude. It is difficult to precisely define their enveloping surface because of no marker bed in the Darsing Dolomite.

The Belbas Slates (stratigraphic equivalents to the Lower and Middle Members of the Chappani Formation) is widely distributed in the southern

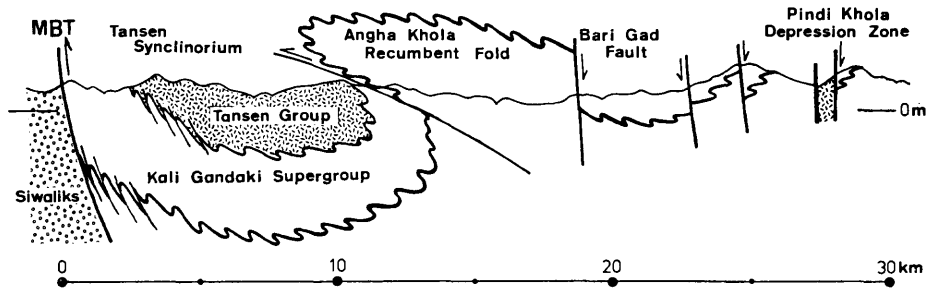


Fig. 6. Diagrammatic section explaining the structural outline of the overfolded and block-faulted inner belt.

mountainside of the Pindi Khola (SAKAI, 1986, fig. 1). Its apparent thickness is about 800 m, being nearly three times as thick as type-section (SAKAI, 1986, fig. 2). There must be repetition of beds by folding. It is difficult to draw the profiles of this formation, because there are no marker beds and the bedding planes are strongly destroyed by cleavages. However, small-scale south-side-up chevron folds are commonly encountered. They are obliquely cut by cleavages consistently dipping south at angles of 50 to 60 degrees. This bedding plane-cleavage relationship suggests that the enveloping surface of the folds in the southern mountainside of the Pindi Khola inclines much steeper than that in the northern mountainside (Fig. 2).

IV. Discussion

A. Relationship of overfolds between the outer and inner belts

The overfolds belt in the frontal part of the inner belt is evidently the continuation of the Angha and Khoraidi Fold Belts in the outer belt. Wavelengths and amplitudes of the overturned folds in both belts are very similar in every order of folds. Asymmetric folds with a longer gently dipping limb and a shorter steeply inclined limb are in common to both belts, and their average interlimb-angles range from 30 to 60 degrees. An important difference between the Angha Khola Recumbent-Fold Belt and the overfold belt of the inner belt is that overfolds in the former exhibit the Z-shape (in case when we see from the east), whereas those in the latter show the S-shape. Furthermore, steep northerly dipping fore-limb is overturned in the inner belt, whereas gentle, northerly dipping back-limb is overturned in the outer belt. Therefore, the overfolds in the inner belt must form the upper limb of a huge recumbent fold as I predicted before (SAKAI, 1983). The vergence of overfolds and the shear cleavages of folded rocks generally dip south. A major axis of strained stromatolite dips south at 30 to 40 degrees. These facts possibly indicates that the axial plane of the major recumbent fold dips south.

B. Relationship between major structures and block-faults

The folded rocks in the inner belt are transected by longitudinal faults (SAKAI, 1986, fig. 1 and Fig. 2). Therefore, the faulting of this system evi-

dently occurred after folding and associated thrusting. The faults in the inner belt and the up-thrusts in the frontal part of the outer belt certainly control the distribution of rocks in the Lesser Himalayas. The Belbas Slates, Darsing Dolomite and Andhi Khola Formation which correspond to the Chappani, Khoraidi and Ramdighat Formations, respectively, in the outer belt extensively crop out in the Midland of the inner belt. The lower Virkot and Hekland Formations seem not to be distributed there. On the contrary, the Virkot and Heklang Formations are exposed along the just rear side of the MBT. These facts mean that a great amount of uplift by up-thrusting along the MBT and a large-scale depression by block-faulting in the inner belt were taken place.

The occurrence of the Tansen Group in the Pindi Khola Fault Zone strongly supports my opinion that "the structure of the inner belt is characterized by block-faulting" (SAKAI, 1986). The Tansen Group there seems to tilt toward the south, because the stratigraphic tops of the Dumri and Amile Formations are directed south and older rocks lie on the northern side. It is situated in the area 30 km north of the MBT. Nevertheless its lithology shows no differences from that of the type sequence of the group in the outer belt. This fact suggests that the Tansen Group had been widely distributed at least up to the Midland area.

It is ascertained by photogrammetric and topographic studies of NAKATA (1982) and NAKATA *et al.* (1984) that most of active faults in the Nepal Lesser Himalayas are normal faults, and that by those faults the Midland area has been lowering relative to the Mahabharat Range. Then, block faulting seems to have occurred extensively in the Nepal Lesser Himalayas. The intra-mountain basins such as the Pokhara and Kathmandu valleys may have undergone tectonic movements similar to the depression zone in the Kali Gandaki and Andhi Khola valleys. They are located on the rear side of the nappe fronts, and thick Quaternary deposits accumulated there.

Acknowledgements

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References

- ARITA, K., SHARMA, T. and FUJII, Y. (1984): Geology and structure of the Jajarkot-Piuthan area, central Nepal. *Jour. Nepal. Geol. Soc.* 4, *Special Issue*, 5-28.
- EREMENKO, N. A. and NOMOKONOV, V. P. (1967): Report on the mission to Nepal in connection with the proposed oil and gas exploration scheme, (unpublished). 13 p.
- HAGEN, T. (1969): Report on the geological survey of Nepal, 1, Preliminary reconnaissance. *Denkschr. Schweiz. naturf. Ges.*, 86, 159 pp.
- HASIMOTO, S., OHTA, Y. and AKIBA, Ch. (eds.). (1973): *Geology of the Nepal Himalayas*. Saikon Publ., Tokyo, 292 p.
- NAKATA, T. (1982): A photogrammetric study on active faults in the Nepal Himalayas. *Jour. Nepal. Geol. Soc.*, 2, *Special Issue*, 67-80.
- , IWATA, S., YAMANAKA, H., YAGI, H. and MAEMOKU, H. (1984): Tectonic landforms of several active faults in the western Nepal. *Ibid.*, 4, *Special Issue*, 177-199.
- SAKAI, H. (1983): Geology of Tansen Group of the Lesser Himalaya in Nepal. *Mem. Fac. Sci., Kyushu Univ.* [D], 25, (1), 27-74.
- (1985): Geology of the Kali Gandaki Supergroup of the Lesser Himalayas in Nepal. *Mem. Fac. Sci., Kyushu Univ.* [D], 25, (3), 337-397.
- (1986): Stratigraphic equivalence and lithofacies comparison of the Kali Gandaki Supergroup between the inner and outer Lesser Himalayas. *Mem. Fac. Sci., Kyushu Univ.*, [D], 26 (this volume), (1), 69-79.