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GEOLOGY OF THE NEPAL HIMALAYA : DEFORMATION AND PETROGRAPHY IN THE MAIN CENTRAL THRUST ZONE

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The author wants to underline in this paper some of the phenomena of an important zone of the Nepal Himalaya, the break zone of the Indian plate known as the Main Central Thrust zone. Field observations have been collected from 1972 to 1975 for the R.C.P. 253 of the French National Research Council. A quadrangle of approximately 150 km. W to E and 50 km. N to S has been studied on the South side of the Annapurna-Manaslu-Ganesh Himal range. Field data from P. Le Fort and J.L. Lasserre, have also been used.

Regional geology and global geometry of the area will be first summarized : deformations and thermic phenomena directly related to the Main Central Thrust will then be more closely examined.

A) THE FORMATIONS

1) Lithostratigraphy

3 main units can be distinguished in the area studied :

a) The Tibetan Sedimentary series (Colchen,M., 1974) : only the lowermost sandstones and limestones outcrop, under the fossiliferous Tethyan Cambro-Ordovician.

b) The Tibetan Slab (Hashimoto,S. et al., 1973 - the Himalayan Gneiss zone) : it is the highly metamorphosed basement of the Tethys sediments. It consists of 3 formations (Le Fort,P., 1975a), viz. from top to bottom :
- Formation III (t=1000 m.) is mainly characterized by a level of coarse augen gneisses.
- Formation II (t=3500 m.) consists of marbles and calcic gneisses. It grades into Formation I through a level of pure quartzites, a few tens of meters thick.

- Formation I mainly consists of migmatitic 2m-gt-ky or sill-gneisses (less than 2000 m. thick in the Kali Gandaki area, to the West, to more than 5000 m. in the Marsyandi or Bhuri Gandaki sections). It shows several interlayed, thin layers of calcic gneisses similar to formation II. Some of Them, located near the top of the formation may come from isoclinal folding of the F.I-F.II contact : some others, near the bottom of the formation are more probably local lithologic variations in the felsic gneisses.

East of the Darondi khola river, gneisses become more and more quartzic; in the Bhuri Gandaki - Ganesh Himal area formation I is chiefly made of impure quartzites (fig.1), and then difficult to distinghish from the upper quartzites.

c) The midlands formations (the Midland zone, Hashimoto,S., 1973, the Nepalese Series, Remy,M., 1972) often regarded as a juxtaposition of differents units (Hagen,T., 1969 : parautochthonous Pokhra window overlain by the four nappes of Nawakot; Bordet,P., scale zone). It has been possible to trace most of the levels all along the 150 km. of the mapped area; as seen before by S. Hashimoto this group is clearly made of a continuous series. It is subdivided into :

- a lower formation (Kunchha schists and sandstones, Bordet,P., 1972; lowermost and lower subgroups, Hashimoto,S., 1973), 1500 m. thick to the West, 5000 m. or more to the East. It is made of schists, of sandstones with often very typic purplish or bluish quartz, and of some conglomerates. The lowermost levels are olive green or grey-blue talcschists with amphibolites or alkaline gneisses (i.e. metamorphosed nepheline syenites, Lasserre,J.L., 1976). They underlay the basal quartzites (Birethanti quartzites). In its upper part, this formation exhibits a remarkable, lenticular level of augen gneisses : the Ulleri gneisses, previously endowed with tectonic significance (a scale of allochtonous gneisses for P. Bordet; diaphtoritic gneisses associated with a secondary thrust for S. Hashimoto). Here, they are regarded as an interbedded level of volcano-sedimentary rocks (Le Fort,P. and Pecher,A., 1973). In the Eastern part of the area (Ankhu Khola valley) other gneissic layers are probably similar.
- The lower formation grades into an upper formation (middle and upper subgroup, Hashimoto,S., 1973) which outcrops as two separate bands North and South of the Pokhra - Gorkha anticlinorium. Comparaison between Northern and Southern upper formations is difficult as they are highly transformed rocks on the North side, (in the Main Central Thrust zone) and nearly unmodified rocks on the South side.

Nevertheless, they are most probably identical as identified by lithologic parallelism and lithostratigraphic position. This formation begins with a single or double quartzitic layer (=Hashimoto middle subgroup) followed by various schist (often carbonaceous), by more or less dolomitic limestones (with stromatolites to the South only), and by quartzites.

The logs here shown (fig.2) apply to the Northern series, near the Main Central Thrust. The apparent increase in thickness (from 1500 m. to the West to more than 5000 m. to the East) may be partly due to variations in shearing, but more likely to prior sedimentary variations.

No fossils have yet been found in the Midland Formations, and their age is one of

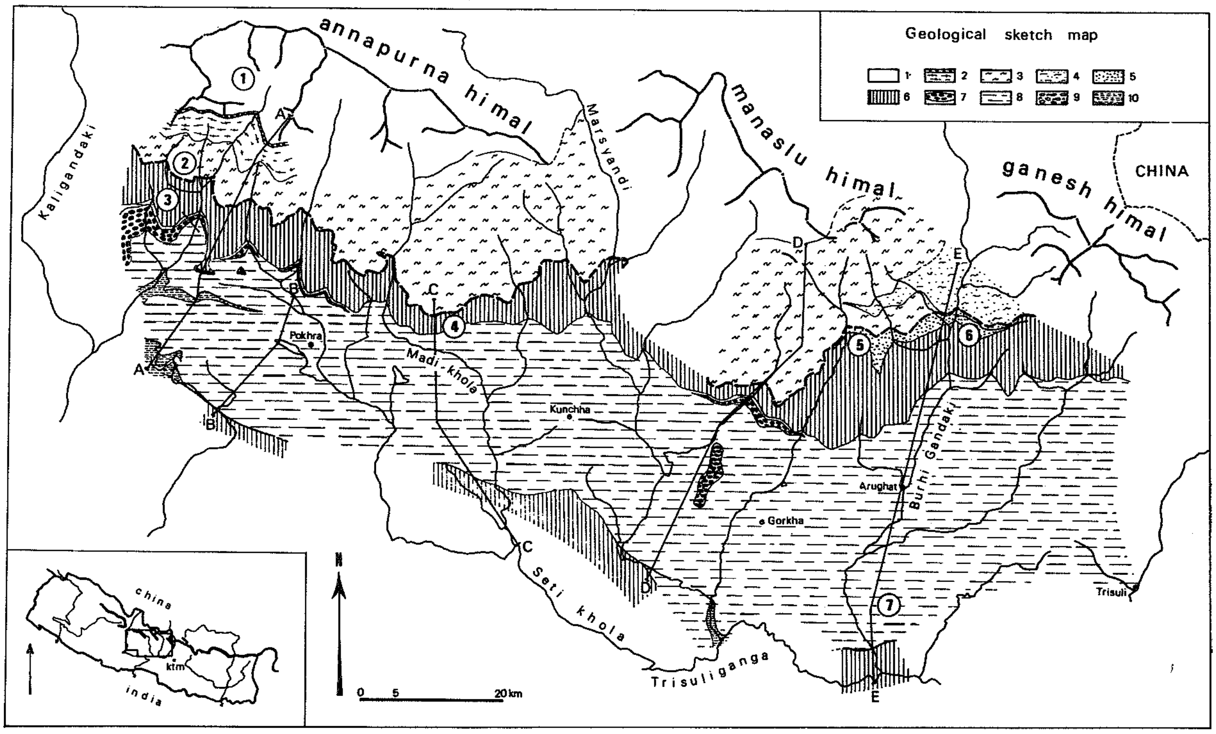

Figure 1 - Geological sketch map.1 = Tibetan Sedimentary Series; 2-4 = Tibetan Slab (2 = F.II and III; 3 = F.I; 4 = F.I, quartzitic gneisses); 5-10 = Midlands Formations (5 = uppermost quartzites (Bhuri area); 6 = upper formation; 7 = Ulleri augen gneisses; 8 = lower formations; 9 = alcalic gneisses; 10 = lowermost talcschists and quartzites). Circled numbers refer to the D2 fabric diagrams.

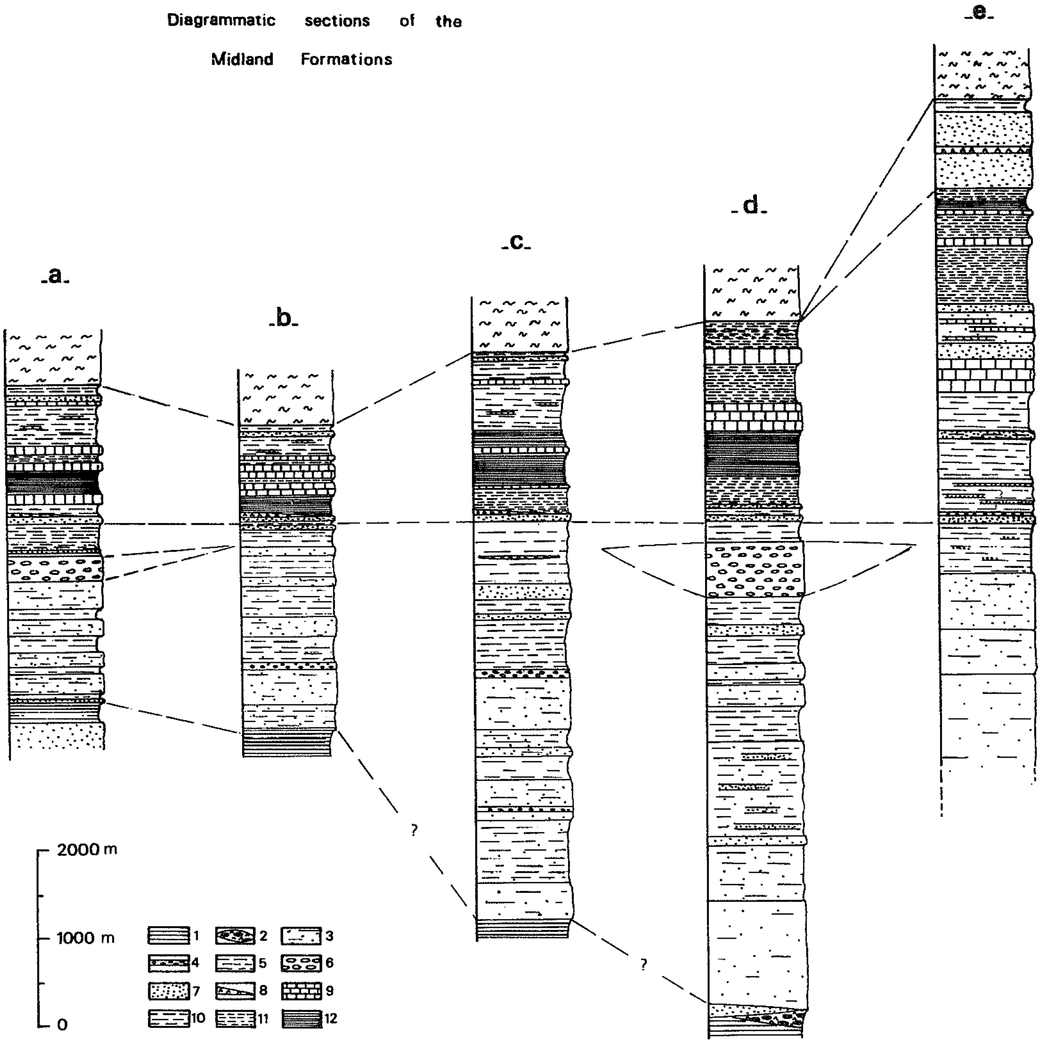

Figure 2 - The midlands formations, North side of the Pokhra - Gurkha anticlinorium; thickness measured along cross-sections AA(a), CC(b), Marsyandi khola (c), DD(d), EE(e). 1 = lowermost talcschists; 2 = alcalic gneisses; 3 = sandstones (and subordinate schists); 4 = conglomerates; 5 = schists; 6 = Ulleri augen gneisses; 7 = quartzites; 8 = amphibolites; 9 = (dolomitic) limestones; 10 = light-colored schists; 11 = dark schists; 12 = carbonaceous schists.

the major unknowns in the Himalayan range.Mostly from lithologic correlations, it is usually assumed to be either Eocambrian or Paleozoic.

S. Hashimoto regarded them as Eocambrian or older for the following reasons :

- lack or fossils, surprising if the formations are Mesozoic or Paleozoic; occurences of stromatolitic Limestones, as in the Asian Eocambrian.
- the Paleozoic Katmandu formations are supposed to overlay unconformably the Midlands Formations; N 30° mineral lineation does not exist in the Katmandu formations (i.e.in Hashimoto's mind the lineation indicates an antepaleozoic tectonic).

Some remarks may be made :

- the sedimentation is mainly of volcanodetritic type, very unfavourable to life; even if the age is earlier than Eocambrian, the lack of fossils is not surprising. Stromatolites must be used with great care in datations; furthermore, fossils plants have been found in the associated carbonaceous schists (Mascle,G. and Pecher,A., pendant study).
- the Katmandu formations are allochtonous (probably a klippe of Tibetan formations rather than a distinct nappe - Brunel,M., 1975); thus they cannot be used to assess the age of the underlying formations. The N 30° lineation is characteristic of the formations under the MCT - and related to it - but poorly visible or not present above the thrust; its absence in the Katmandu formation is chiefly a reason to consider them as a group tectonically different of the Midland formations. Notwithstanding direction parallelism, the recent NNE lineation must not be related with the Precambrian structures of India.

Following P. Le Fort, 1975b,a paleozoic age (or even mesozoic for the upper part) seems highly probable.

2) Present geometry

3 tectonic domains are distinguished from North to South :

- a domain with large overturned tight folds, which corresponds to the Tibetan Sed. Series.
- a monoclinal domain, gently dipping Northward. It corresponds to the Tibetan Slab and to the Northern part of the Midlands formations. The Main Central Thrust is assumed to be located in this domain.
- further to the South, in the Midlands formations, all the still-recognizable sedimentary features (graded bedding, channels...) shows the layers to be right-side-up. There are no overturned folds, but only a large, plain, anticlinorium, which can be traced from the Modi Khola to the Bhuri Gandaki rivers. This is the Pokhra - Kunchha - Gorkha anticlinorium. Southside, it usualy ends by a large knee-like flexure (sections C, D, E, fig.3) sometimes faulted (section B; it is the Hashimoto's Nawakot - Bulii fault). Further to the West (section A) some overturned folds herald the recumbent Southern folds (Mascle's data).

These structures result from three main successive deformations stages moving from North to South; they evidence the Southward migration of the orogeny during the China-India collision.

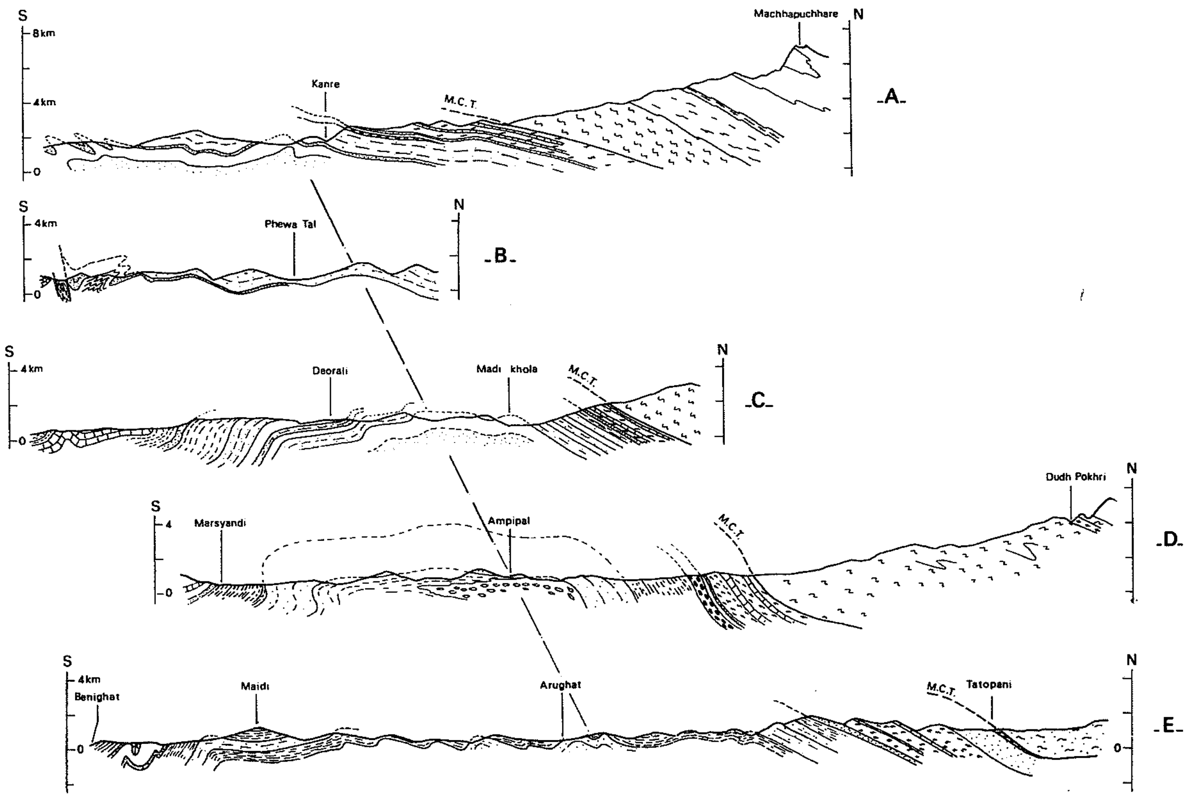

Figure 3 - Cross sections (see fig.1) through the Gorkha anticlinorium.

B) THE DEFORMATIONS

B1) Deformation 1

D1 overturned or isoclinal folds of all sizes are seen in the Tibetan Sed. series. They strike parallel to the range. Southward, D1 is soon obliterated by D2 deformation. In the Tibetan Slab its presence and its characters are hardly recognizable. In the Midlands Formations, D1 deformation might have never occured.

B2) Deformation 2

1°) In the Tibetan series, extensive overturned B2 folds, parallel to the regional trend of the belt, are superimposed to B1 folds. They are associated with a latter Northward dipping cleavage, S2, cutting S1 cleavage.
2°) Tibetan Slab and Midlands formations. In respect to D2 tectonic, these two domains have been put together as they show many similar characters.

a) The D2 tectonic landmarks

S2 cleavage

Downward, S2 strain-slip cleavage of the higher levels progressively becomes a more penetrating cleavage, in which metamorphic neocristallizations appear. Still lower, in the Tibetan Slab, S2 is then a metamorphic cleavage (gneissic foliation). The base of the Slab seems to be parallel to S2.

In the Midlands Formations, a cleavage is also present. It is roughly parallel to the So initial bedding. Detailed field studies in the transition zone show no petrographic gap between the lower feldspathic gneisses of the Tibetan Slab and the upper Midlands metamorphic schists (through about ten meters it is impossible to state whether the rocks are still the schists or already the gneisses). The cleavage clearly continues from the gneisses to the schists : the main cleavage seen in the Midlands Formations, under the assumed MCT is the S2 cleavage seen in the Tibetan Slab, over the MCT. Its evenness gives to this zone its characteristic monotonous monoclinal aspect.

L2 Lines

The main lines observed in the field are :

- B2 minor folds axes.
- intersections $S_0 - S_2$ or $S_1 - S_2$, equivalent to the former ones but seldom observed except in the Tibetan Sedimentary Series.
- the stretching lineation. It can be defined by preferred orientations of pebbles or of quartz grains in sandstones, by pinch and swell textures, by mullions structures.
- the mineralogical line : minerals underlining a kind of "metamorphic fluidality". In the detail, this line may vary in direction from one cleavage plane to another; but the resulting crossed-line aspect is not the marker of two deformations.

On a regional scale, the mineralogical line and the mechanical line are parallel and may be indifferently used as a first approximation to the direction of transport.

b) Sliding on S2

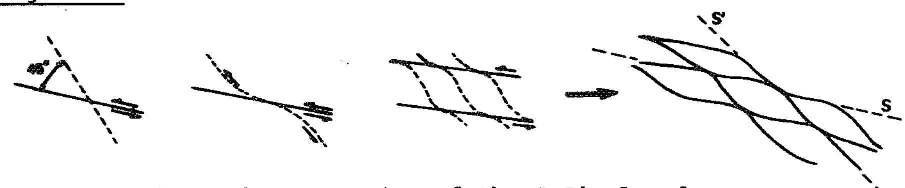

Figure 4 - Formation of the S-S' almonds.

In the Tibetan Slab, and mostly in the Midlands formations, S2 appears as a mesoscopic to microscopic juxtaposition of almond-shaped bodies; they give a characteristic cupular aspect to the rocks. These almonds result from the association of the main S2 cleavage plane with another one, which will be called S'2 ($S_2 - S'_2$ = 0 to 40°). In thin section, these two planes can also be seen : S_2 and S'_2 are underlined by the same metamorphic neocristallizations and must be nearly of the same age.

The appearance of S'_2 (and almonds) can be explained by sliding processes on S_2 planes, most of them acting as unit shear zones (fig;4). Ramsay,J.G. and Graham,R.H., 1970; Schwerdtner,W.M., 1973). The almonds, a characteristic feature of the Central Thrust zone, are the indices of a peculiar type of deformation where sliding prevails upon folding.

3°) From the Tib. Sed. Series to the Midlands Formations : a continuous phenomenon

At the lower part of the Tibetan Sed. Series, B2 folds are numerous. They are parallel to the regional trend of the belt (sharp maximum at N 100°, 10°E for the axis, N 115°, N 40° for the S2 cleavage); L2 is parallel to B2.

Downward in the Tibetan Slab, large scale B2 folds are rare, but many small folds, often barely measurable, still subsist. Stereogram number 2 (fig.5) shows a dispersion of their axes in the S2 metamorphic cleavage, and a migration of the line toward a SSW-NNE direction; this phenomenon is clearly seen near the base of the Slab, where almonds appear. In the upper part of the Midlands formations, the line fabric (fig.5, diagram 3) now shows a sharp ENE (N 0° to N 40°) maximum in the S2 plane; B2 minor folds (folds, with S2 as axial cleavage) are rare; when present, they are mainly grouped near the L2 NNE maximum (diagram 3).

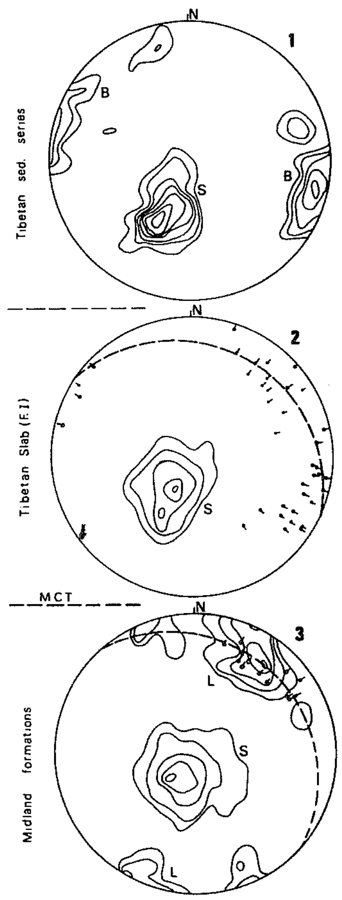

Figure 5 - Evolution of the D2 geometry. Diagram 1 : B2 folds (40 m.) and S2 cleavage (52 m.). Diagram 2 : S2 (133 m.), L2 (dots), B2 minor folds (circles). Diagram 3 : S2 (83 m.), L2 (35 m.), B2 minor folds (circles). Lower Schmidt hemisphere, percentage of contours : 2, 5, 10, 15, 20...% The dotted great circle corresponds to the S2 maximum.

This S2, B2 and NNE L2 association is very constant and can be regarded as the main tectonic fact of the Midlands formations. Comparison of stereograms 3, 4, 5a and 6 underlines the evenness of this feature (Hashimoto's Lm stereograms - 1973, p. 180 - are also very typical. Lf diagrams of fold axes are more questionable as they seem to group together B2 and B3 folds : for example, see diagrams P5-6 or P7-8 constructed with data from a zone with no visible B2 folds, but numerous B3 ones). This association exists all along the belt under the MCT (review in Le Fort,P., 1975b).

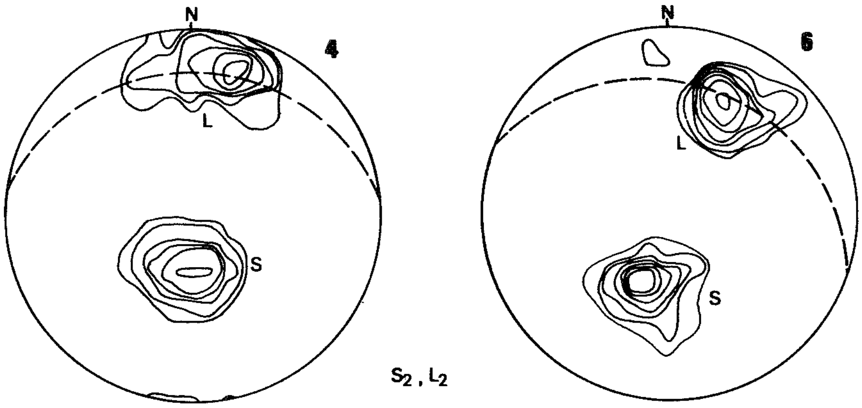

Figure 6 - Homogeneity of deformation in the Midlands formations. Diagram 4 : 111 S2, 32 L2; diagram 6 : 100 S2, 40 L2. Contours 2, 5, 10, 15, 20...%. Location of diagrams : see figure 1.

Few outcrops shows enough B2 minor folds to allow study of their relations with S2 and L2 (fig.7) : B2 axes are dispersed all along the S2 plane, but with a maximum exactly the same as the maximum of the lines.

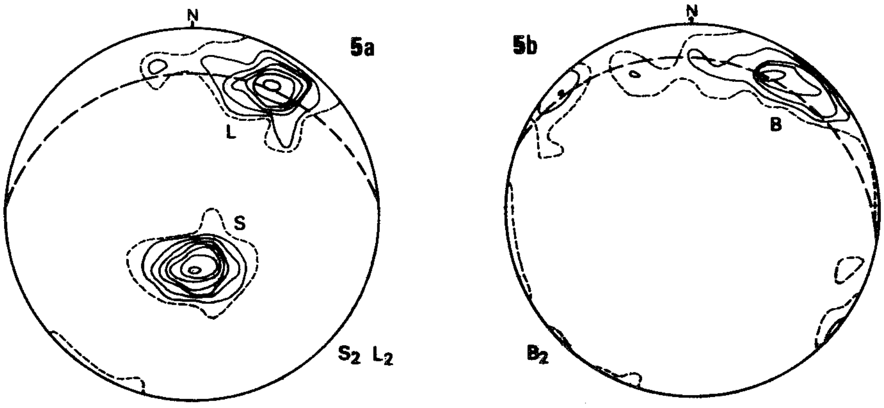

Figure 7 - Geometry of one outcrop near Barpak village. 5a : S2 (71 m.), L2 (33 m.); 5b : B2 minor folds (41 m.). The great circle of B2 dispersion is nearly the same as the S2 maximum circle. B2 and L2 show exactly the same maxima.

As we see it, this clearly indicates deformation of early B2 folds by sliding in the S2 plane (slided folds, and perhaps also few folds caused by the sliding. As a direct consequence L2 is the sliding line; it can be used together with S2 to define the general cinematic reference (1) (fig.8, from Hansen,E., 1971, in Vialon,P., 1976).

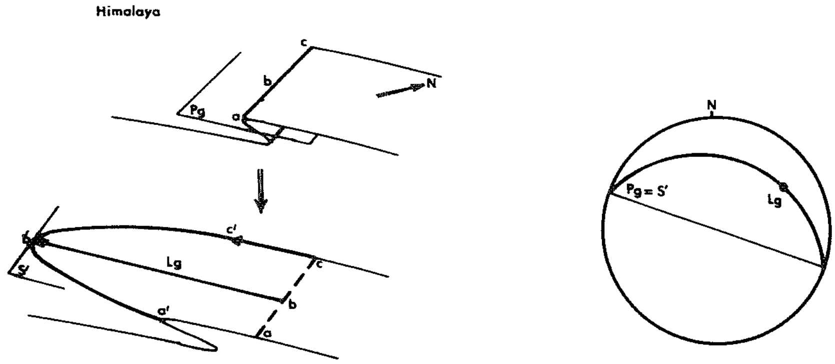

Figure 8 - A possible interpretation : formation or deformation of folds by sliding. Pg and Lg : sliding plane and line; S' : axial cleavage of the new folds. Himalaya seems a simple case, with Pg S' confused and Lg = L2 (deformed folds rather than new folds).

4°) <u>Location of the Main Central Thrust</u>

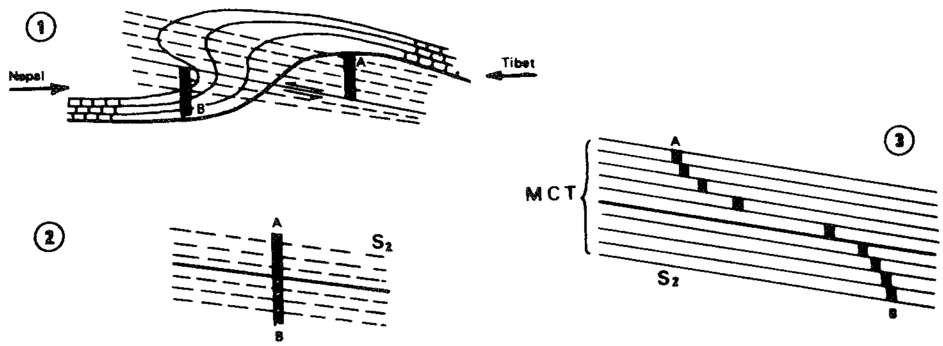

Figure 9 - A schematic vision of the Central Thrust zone; A = Tibetan Slab, B = Midlands formations.

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(1) Kinematic references are the sliding line (L2) and the sliding plane (S2), both easily recognizable in the field or on a hand-sample. The here studied deformation is the amount of predominant simple shear and subordinated flattening. The axes will be called a', b', c' to prevent confusion with a, b, c which commonly design the axes defining translation by simple shear (Ramsay,J.G., 1967). X, Y, Z, the measured ellipsoïd axes from deformed bodies, will be also used.
In practice, a', parallel to L2, is near X,
b', perpendicular to a' and also in S2, = Y (as deformation is irrotational in YZ sections : see C4, p.),
c', perpendicular to S2, is near Z.

As global deformation around the MCT is absorbed by sliding on many parallel planes, the location of the thrust raises a problem. As a matter of fact, it is a large and complex crustal shear zone : S2 planes must probably be related to an initial movement (1 and 2, fig.9). As soon as formed, they become sliding planes and possibly absorb more deformation than the initial phenomenon (3, fig.9). Therefore the problem of location of the MCT plane is to some extent a false problem, and one must actually speak of a main Central Thrust zone (as already done by some authors). However it seems to us wrong to speak of several scale or shuppe sheets as the lithologic succession corresponds to a normal stratigraphic succession (the Midlands formations) overlain by another normal one (Tibetan Slab and Tibetan Sed. Series).

If the MCT is regarded as a shear zone, a way to learn the minimum displacement might be the study of the angular relationships between S2 and the ideal thrust plane with respect to the thickness of the sheared zone (Ramsay,J.G. and Graham,R.H., 1970); in the 10 km-thick Tibetan Slab and Sedimentary series known to the author, the S2 plane diverges 25° from the value in the more strongly sheared zone (fig.5).

B3) Deformation 3

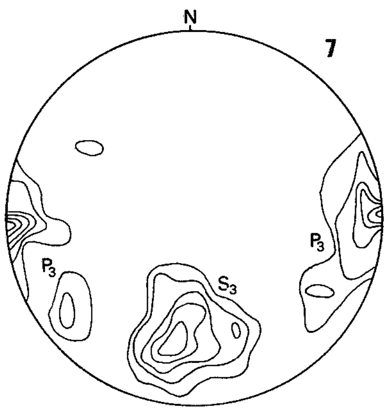

Figure 10 - Maidi area : diagram of B3 folds (35 m.) and S3 strain slip cleavage (67 m.). Lower Schmidt hemisphere; Contours 2, 5, 10, 15, 20 %.

The B2 folds are followed by B3 folds (axes : N 60° to N 150°) clearly visible in the Midlands formations. The largest B3 structure is the Pokhra-Kunchha-Gorkha anticlinorium (fig.3); it is accompanied by minor chevron folds, associated to an S3 strain-slip cleavage (diagram 7, figure 10; maximum of axes at N 90°, 0°, of cleavages at N 100°, N 60°); it is usually well-marked in the Southern slightly metamorphosed part of the Midlands formations, and poorly visible (crenulation on S2 planes) in the more metamorphosed part and in the Tibetan Slab.

B4 folds can also be observed : they are late, gentle large folds, usualy trending SSW-NNE, and seldom associated with an S4 strain slip cleavage.

During D3 deformation, new sliding occurs in the MCT zone on the S2 plane. This is "cold" sliding, marked by :

- slickensides striae.
- Riedel's fractures (breaking associated with shearing - Hancok,P.L., 1972), cutting across the old S_2 -S'_2 almonds; new "Riedel almonds" may then appear the dissymmetry of which is reverse of the former one, but indicates the same regional orientation of sliding. (fig.11).
- retromorphic minerals (e.g. chlorite).

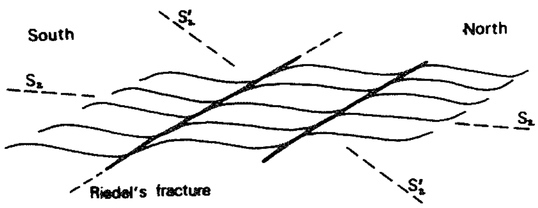

Figure 11 - Dissymetry due to Riedel's fractures.

C) METAMORPHISM IN THE THRUST ZONE : PETROGRAPHY OF THE DEFORMED ROCKS

C1) Thrust-connected metamorphism

Figure 12 shows the distribution of some typical syn D2 minerals, tracked in more than 500 thin-sections. It aims to give an idea of the thermal environment during the thrust deformation. It also underlines the well-known reverse metamorphism in the Midland formations, followed by the successive apparition of : brown biotite-garnet - kyanite and staurolite - sillimanite, near the top the Tibetan Slab. Higher in the series, the upward decrease is marked by the disapearance of these minerals. Some remarks should be added :

- The reverse metamorphism is characterized by medium pressure type parageneses; andalusite, although previously reported (Hashimoto,S., 1973, reports its presence in one sample) has not been found (but for a doubtful retromorphosed crystal in a highly peculiar environment of dolomitic limestones).
- Sillimanite is linked to a migration of the branitic mobilisates.Its mapped distribution does not reflect the upper thermal zone during D2. This zone is located lower in the Tibetan Slab, in the migmatic gneisses of Formation I.
- Kyanite and Staurolite do not exist only in the Tibetan Slab, but also in the Midlands formations. This obliquity of metamorphic isogrades versus lithologic

boundaries underlines once more the absence of gaps : it goes against the idea of sheets of shuppen gneisses and schists.

- The values of the thermal gradient on both sides of the hot zone are difficult to know (there are no isobar reactions, and the P-T curves are difficult to use in a shear zone, where the significance of the pressure is not well known). Nevertheless gradient seems to be higher for the reverse metamorphism than for the normal one.

C2) Textural zones

An attempt has been made to define the state of deformation and recrystallization by the study of mineral microstructures observed in thin-sections. Quartz has been chosen as sandstones and quartzites are here very wide-spread. The following microstructural zones have been defined (Pecher,A. and Bouchez,J.L., 1976); they correspond to a progressive evolution from sedimentary rocks to highly deformed and recrystallized metamorphic rocks; they are :

I - Sedimentary microstructures

IIa - Recrystallization beginning in the sandstones : mosaic textures in pressure shadows, polygonization of a few detrital grains.

IIb - More recrystallizations : polygonization of most of the old detrital grains.

III - Residual porphyroclastic microstructures : porphyroclastic cores in old grains still recognizable with one nicol.

IV - Mosaic microstructures.

V - Exaggerated grain growth microstructures.

These zones have been mapped (fig.13) : the map shows a strong parallelism with the metamorphic map, and underlines the gradual increase in deformation from the Southern part of the Midlands formations to the Tibetan Slab. A similar evolution has also been seen in preferred orientations of c-axes in quartz grains.

In the lower, fairly recristallized sandstones (zones I-III), quartz grains provide the finite strain ellispoid. Some of its value are shown in Table 1 and fig.13.

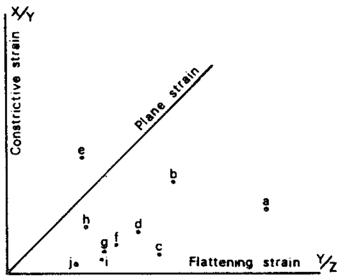

Figure 14 - Flinn (1962) diagram with X/Y plotted against Y/Z. Each plot is the average of 80 to 150 measurements in XZ and YZ thin sections.

Table 1

Sample	X	Y	Z	X/Y	Sample	X	Y	Z	X/Y
a	5,31	3,33	1	1,59	f	2,41	1,97	1	1,25
b	4,49	2,48	1	1,81	g	2,23	1,86	1	1,20
c	2,75	2,36	1	1,16	h	2,42	1,70	1	1,42
d	2,96	2,17	1	1,36	i	2,10	1,85	1	1,13
e	3,41	1,67	1	2,04	j	1,74	1,61	1	1,08

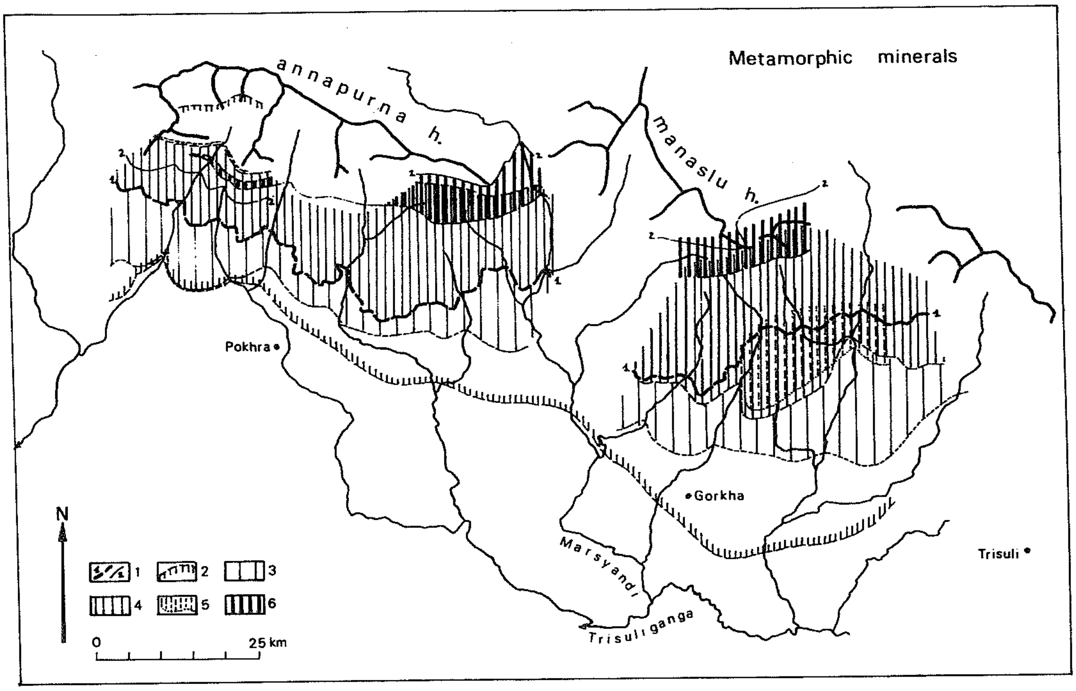

Figure 12 - (top.) Repartition of some characteristic minerals. (1) = lower limit of the Tibetan Slab-1- and upper limit of formation I -2-; (2) = biotite apparition; (3) = garnet (also present in the Tibetan Slab); (4) = kyanite; (5) = staurolite; (6) = sillimanite (fibrolite).

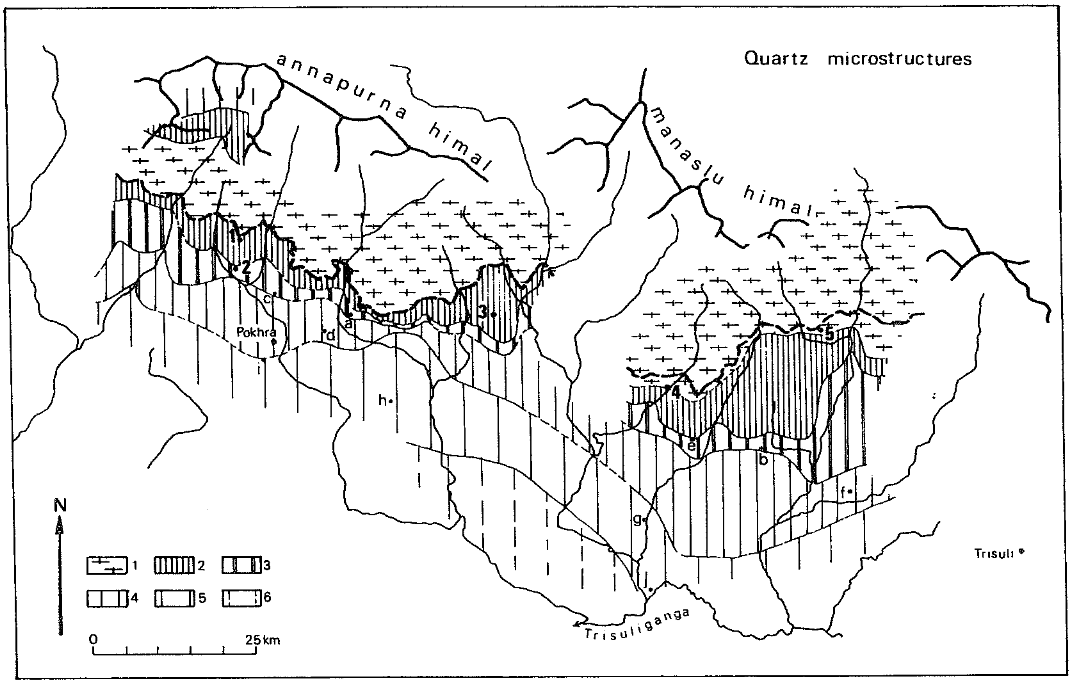

Figure 13 - (bottom.) Quartz microstructures. (1) : exaggerated grain growth. (2) : mosaic. (3) : residual porphyroclasts. (4) and (5) : residual sedimentary structures. (6) : sedimentary textures. Numbers 1 to 5 refer to figure 16 and 17, letters a-j to figure 14 and table 1.

C3) Shearing orientation : some petrographic criteria

As the orientation of shearing is known in the Himalayan Main Central Thrust zone, special attention has been given to the correlations between shear orientations and microstructures : the following microstructures have been investigated :

1) Rotated minerals (see Zwart,H.J., 1960, Spry,A., 1969); the main syndeformation minerals, with a rotated inner schistosity, are here garnets, chloritoids, epidotes, amphiboles, and feldspars.

2) Almonds S_2 -S'_2 almonds directly mirror a polarized sliding. They result from the plastic deformation of the rock (fig.15, left). Other almonds are due to the presence of heterogeneous "hard bodies" (previously- or early-crystallized minerals, with pressure shadows filled up by neocrystallizations). The form dissymmetry of the latter almonds (fig.15, right) is not the same that the former ones, and one must beware of misinterpretations.

The dissimmetry of the almonds is maximum in XZ sections and statistically nil in YZ sections. When the shearing is too strong (microstructural zones IV and V, paragraph C2) the microscopic S_2 -S'_2 almonds usually disappear.

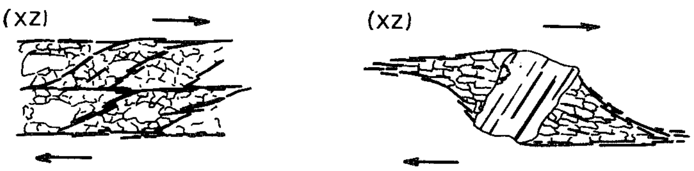

Figure 15 - Different dissymmetries for a same shear sense.

3) Quartz c-axes preferred orientations (fig.16 and 17). In strongly deformed and recrystallized zones (especially mosaic microstructural zones), the c-axes of quartz show dissymmetrical preferred orientations, sharper and sharper when getting up toward the Tibetan Slab (compare diagram 1 and 2, fig.16). The diagrams show cross-girdle type fabrics, with many more points on one of the girdles than on the other one, or even with only one girdle. The mechanism of plastic deformation of quartz will not be discussed here. Let it only be said that these fabrics can be explained by mechanisms of quartz basal planes sliding; they indicate a flow with a rotational component in XZ planes, and can thus give the orientation of shearing (Bouchez,J.L. and Pecher,A., 1976).

The fabric dissimetry is more easily seen in XZ thin sections; figure 17 presents some star diagrams (directions of the projections of quartz basal planes on the XZ plane) constructed from measurements made on samples collected all along the Central Thrust zone : dissymmetry is strong and fits with the regional shear orientation (the upper part always moves Southward). In YZ thin sections (perpendicular to the line) there is usually no dissimetry. This shows the irrotational character of flow in the YZ plane.

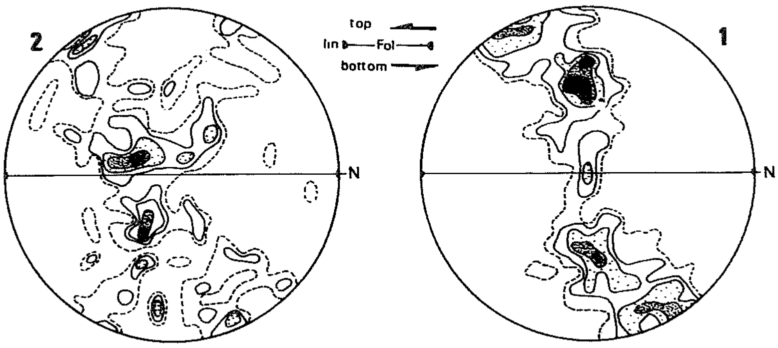

Figure 16 - (top) Statistical quartz c-axis orientations. Diagrams refer to points 1 and 2 (fig.13); 125 measurements of each diagram. Lower Schmidt hemisphere, counting area = 1/220 of the hemisphere area.

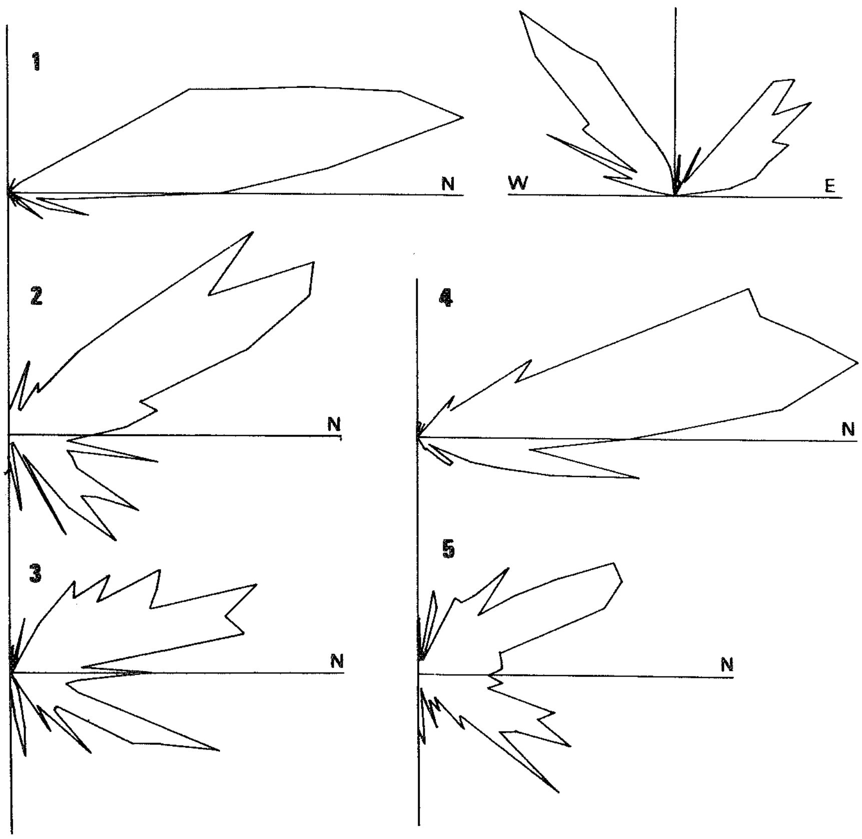

Figure 17 - (bottom) Dissymetry of quartz orientations in YZ thin-sections (1, right) or in XZ thin sections (1, left, and 2-5). Numbers refer to figure 13. Each diagram = 180 or 240 measurements.

D) AS A CONCLUSION : DEFORMATION, PETROGRAPHY AND DEFINITION OF THE MCT

In this paper, some results of a more detailed pending study of the Nepalese Central Thrust Zone are sketched; they can be summarized as follows :

1) As previously stated by S. Hashimoto, the Midlands formations are not a pile of nappes or slices, but one single, thick, autochtonous series. It is easily subdivided into a lower formation, mainly quartzic, and upper more calcareous formation. The latter can be seen in different recrystallization and deformation stages on the North and South limbs of the Pokhra-Gurkha anticlinorium.

2) The present geometry is mainly due to D3 or D4 post metamorphic deformations. But the main microstructural and petrographic features are related to the former D2 deformation : break of the Indian plate along the Central Thrust Zone, a very large crustal shear zone. Such a mechanism of global deformation is probably one of the major tectonic features of the Himalayan range.

3) The following points have to be taken into account in defining and/or modelizing the Central Thrust zone :

- Deformation mainly due to sliding : the cinematic references of the plastic flow are S2 and L2 (flow direction). Deformation is continuous in a thick band (more than 10 km.), and seems to be strongest in a zone located near the base of the Tibetan Slab (zone defined by : best parallelization between B2 folds and L2 line; more acute and dissymetric quartz fabrics; flatter almonds. But in the Tibetan Slab, exaggerated grain growth may obliterate stronger former plastic deformation).
- No thermodynamic gap between the Tibetan Slab and the Midlands formations, but
    - Domains of mineral stability (in first approximation : isotherms) oblique to the thrust (i.e. to the initial break plane, the trace of which is very likely the base of the Tibetan Slab).
    - Thermal maximum higher than this plane.
    - From this maximum decrease of temperature more slowly upward than downward.

4) Age of the MCT : the intrusive granites known in the Tibetan Sed. Series derive from migmatization of the Tibetan Slab; the migration of the mobilisats is slightly later than D2 deformation, as shown by its relations with B2 folds; the age of the granite (28 m.y. for the Manaslu granite, Hamet,J. and al., 1976) is younger - but close to the limit for the D2 deformation, i.e. the thrusting.

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