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Traverse of Zanskar from the Indus to the Valley of Kashmir — a preliminary note

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With 1 plate and 1 figure

Schlüsselwörter
Structure
Central Crystalline
Tibetan Zone (Zanskar)
Indus Flysch
Ladakh

CONTENTS

Abstract

Geological work along the route Khalsi — Lamayuru — Honupattan — Shillakong — Kangi — Rangdum — Suru — Liddar Valley gave the following results: The Indus Suture Zone consists of several structural units separated from each other by ophiolitic melange zones. The Lamayuru Formation shows that as early as in the Triassic eugeosynclinal series were deposited in that region. Units of the Indus Suture Zone are overthrust onto the Tibetan Zone adjoining in the SW. As proved by a huge outlier, the thrust displacement is at least 30 km. Later compression along the Indus Suture Zone caused steepening, inversion of the series, and led to the origin of counter-thrusts directed towards NE.

Metamorphosed Triassics within the Crystalline of the Nun-Kun area show that the Alpine metamorphism reaches exceptionally high into the Palaeo-Mesozoic Tethys succession. There all the Palaeozoic formations older than the Panjal Trap are converted to gneisses.

Zusammenfassung

Geologische Arbeiten entlang der Route Khalsi — Lamayuru — Honupattan — Shillakong — Kangi — Rangdum — Suru — Liddar-Tal erbrachten Folgendes: Die Indus-Sutur-Zone besteht aus mehreren tektonischen Einheiten, die durch „ophiolitische Melangezonen" voneinander getrennt sind. Die Lamayuru-Formation zeigt, daß in diesem Raum bereits während der Trias eugeosynklinale Serien sedimentiert wurden. Einheiten der Indus-Sutur-Zone wurden auf die

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im SW angrenzende Tibet-Zone überschoben. Wie eine ausgedehnte Deckscholle beweist, betrug die Weite dieser Überschiebung mindestens 30 km. Spätere Einengung im Bereiche der Indus-Sutur-Zone bewirkte Steilstellung und Überkippung der Gesteinsserien und führte zur Entstehung von NE-gerichteten Gegen-Überschiebungen.

Metamorphe Trias im Nun-Kun-Kristallin beweist, daß die Alpine Metamorphose hier ausnehmend hoch in die paläozoisch-mesozoische Tethys-Schichtfolge emporreicht. Alle paläozoischen Formationen älter als der Panjal Trap sind in Gneise umgewandelt.

1. Introduction

Great interest is attained to the Indus Suture Zone (GANSSER, 1964, 1974, 1976, POWELL & CONAGHAN, 1973, Le FORT, 1975 and many others) particularly after the advance of the new global tectonics. The interior parts of Zanskar, however, remained almost unknown. Therefore I visited Ladakh with the intention to study the relationship between the Indus Suture Zone and the Himalayan zones adjoining in the S. Geological mapping in the region of Lamayuru and a traverse from that place via Kangi — Rangdum Gompa — Suru (Panikar) — Chilung Pass to Pahlgam in the Liddar Valley in summer 1976, gave a series of interesting observations. This paper is a preliminary note on the geology of the region as the palaeontological material is not yet worked out.

In the description of my traverse I start in the NE, in the Indus region, and go towards the SW to Kashmir.

2. The Indus Suture Zone

The Ladakh Range NE of the Indus Valley consists of the L a d a k h G r a n i t e a batholitic intrusion of pre-Upper Cretaceous age (GANSSER, 1964, p. 37). The rivers from the N bring down boulders of the coarse-grained biotite-hornblende granite with frequent dioritic inclusions.

The granite is succeeded by a conspicuous multicoloured, banded series, several hundred meters thick, consisting of c o n g l o m e r a t e s, s a n d s t o n e s, and s h a l e s dipping SE at medium angles. This disturbed succession, being probably Early Tertiary, overlies the granite with transgressive contacts according to GANSSER (1976) and COLCHEN (Paris, personal communication).

The bright coloured upper part of the series is described by GANSSER (1976) as Hemis Conglomerates, the lower part transgressing on the Ladakh Granite is termed Indus Molasse; a tectonic boundary between the two formations is assumed.

E of Khalsi the Khalsi Limestone follows the above beds with tectonic contact. The steeply SW dipping, blue-grey limestone is rich in fossils: foraminiferas, bivalves and crinoids. Based on literature and own observations, GUPTA & KUMAR (1975) refer an Aptian age. The Khalsi Limestone shows sedimentary contacts with the overlying flyschoid shales, which contain layers of calcareous belemnite breccia 300 to 400 m above the top of the Khalsi Limestone. The boundary to the Khalsi Limestone may be sharp or the limestone alternates with dark shales, volcanic breccias, or tuffs. This proves that the volcanism was contemporaneous with the deposition of the limestone. The duplication of the Khalsi Limestone SE of Khalsi seems to be caused by tectonics (Pl. 1 [4]).

The flyschoid shales and basic volcanics, overlying the Khalsi Limestone, appear to represent the same level as the volcanic breccias and green sandstones, which are called Indus Flysch. They crop out along the road between Khalsi and the confluence of the Yapola and Indus Rivers.

Shortly up the Yapola River the road to Lamayuru crosses a highly disturbed zone of serpentinite, gabbro, porphyritic volcanics, tuffs, ophicalcite, and flysch shales. Further there are lenticular bodies of blue limestone containing crinoids and megalodon, which indicate Upper Triassic to Liassic age. This zone several hundred meters thick is best termed an ophiolitic melange (GANSSER, 1974, 1976).

Towards the S the road avoids the gorge of the Yapola River, and winds up highly to the orographically left slope. There one crosses a thick (ca. 2000 m) flysch complex — the Dras Flysch (Pl. 1 [3]). Its northern portions consist essentially of green, grey slates, whereas the main part of the series is composed of a thick-bedded alternation of green sandstone, felspatic sandstone, siltstone, and green, laminated shales and slates. There are also a few purple coloured zones in that predominantly green-grey series. Some of the sandstones are brecciacous, containing slate fragments, felspar, quartz, radiolarite, and tuffaceous material. Graded bedding is common. De TERRA's map (1935) shows in all the Yapola gorge Dras Volcanics, whereas GANSSER (1976) designates only the southern parts of the gorge to that formation. I found just subordinate intercalations of basic volcanics (lava beds, agglomerates, tuffs) in the southern (upper) portions of the flysch series, which in my view does not suggest the demarcation of a separate formation. Like the other rock belts of the Indus Zone the Dras Flysch is dipping SW at angles, varying due to large scale folding.

NE and N of Lamayuru the flysch is terminated by another melange zone: Lenticular bodies of serpentinite, diabase, and red radiolarite are intercalated in a groundmass of red and green shales as well as slates, siltstones, and sandstones. A klippe of white to pink, very fine-grained limestone, containing crinoids and corals, is exposed near the road. The highly squeezed zone again indicates a structural break. It is interesting that this ophiolite zone strikes WNW-ESE, whereas the rock series adjoining in the N and in the S meet this structural line obliquely with NW-SE strike.

S of the melange zone follows the Lamayuru Unit, composed of dark argillites — the Lamayuru Formation. The dark grey to black shales, slates, and phyllites are interbedded with thin layers of sandstone, siltstone, or impure limestone. Hieroglyphs and load casts on the s-planes of the sandstones, lamination and graded bedding frequently give the series a flyschoid appearance. Therefore GANSSER (1976) uses the term Lamayuru flysch. But there are also zones where blue limestone, marl, and shale alternate. This lithology reminds very much of the Mukut Limestone of Dolpo (Nepal), which passes into black argillites towards the N, indicating deepening of the basin (FUCHS, 1967, p. 181). The finds of *Daonella* first mentioned by GANSSER (1976) strengthen that correlation. Besides daonellas I found a fragment of an ammonite with ceratitic suture, small brachiopods, gastropods, and crinoids, fossils which seem

to be consistent with a Triassic age. But I also found a belemnite, which shows that the rather monotonous and disturbed formation also comprises Jurassic or even younger beds. Possibly the succession, which indicates deposition in a geosynclinal trough, commenced as early as in the Permian. The Permian limestone referred by TEWARI & PANDE (1970, cit. in GUPTA & KUMAR, 1975), however, might represent a klippe. In this case it does not give the lower age boundary of the Lamayuru Formation. A stratigraphic subdivision of the formation was not possible because of the monotonous lithology and intensive tectonic disturbance. But it is noteworthy that daonellas are found in the northern portion of the Lamayuru Formation close up to the boundary against the terminating ophiolite zone.

Some of the blue limestone bodies found in the argillaceous series (e. g. in the middle Yapola Valley) pass into the surrounding slates by alternation. Others, and particularly the multicoloured limestone — calc schist bodies are klippes. Such klippes are frequent near the south-western boundary of the Lamayuru Formation, where a chain of serpentinites again signals a structural line. Along this vertical or steeply SW dipping thrust the limestones, forming the range S of the Mulbekh-Lamayuru depression, have overridden the argillites N of them. Due to the tectonization bands of the dark slates are found intercalated or intertonguing with the limestones.

3. The Tibetan (Tethys) Zone

In the calcareous range S of the Lamayuru — Mulbekh depression we enter the Tibetan (Tethys) Zone, which forms a wide synclinorium between the Indus Suture Zone and the Central Crystalline Zone of the Great Himalayan Range. This Zanskar Synclinorium shows the Mesozoic-Palaeogene sequence like in Spiti in its southern limb. The northern limb is quite different in its lithology. The only continuous stratigraphic element is the Kioto Limestone. As the rock series are highly compressed it is not easy to find out the stratigraphic relationship between the Kioto Limestone and the formations of doubtful age. I shall describe the series of the Tibetan Zone of Zanskar and will try to establish the stratigraphic order.

The Kioto Limestone (up to 400 m) consists of a well-bedded series of light grey, blue, partly mottled limestones and dolomites. The s-planes frequently are nodular. Oolites, current bedding, and intraformational breccias stress the shallow-water character of the formation. Corals, bryzoans, brachiopods, gastropods, megalodon, lithiotis and other pelecypods as well as crinoids are common fossils. The age of the formation is uppermost Triassic to Mid-Jurassic. Cream to pink layers observed in the Shillakong Valley may indicate a partial intertonguing with the multicoloured formation described below.

This conspicuous formation (up to 1000 m) consists of white, grey, blue, cream, red, and green fine-crystalline, partly flasery limestones alternating with red, purple, and green slates, phyllites, and calc schists. The banded series indicates rhythmic sedimentation (a few meters to 40 m). The formation is barren of

fossils, which seems to be not only the result of the phyllitic metamorphism, because the adjoining Kioto Limestone still shows its characteristic fossils. From the close relation to the Kioto Limestone I conclude that they are also close in age. The Kioto Limestone synclines in the multicoloured series observed near Honupattan suggest that the latter is older — probably Triassic (P. 1 [4]). Certainly the formation represents a peculiar facies restricted to the northern margins of the Tibetan Zone. All the occurrences of these multicoloured limestones in the central parts of the synclinorium are tectonic klippes.

Somewhat towards the S the Kioto Limestone is underlain by the Quartzite Series in its characteristic lithology. White, grey, green quartzites, impure micaceous quartzites, carbonate quartzites, sandstones, breccias, and greenish to dark grey, silty shales alternate with a few blue limestone or dolomite beds. Fossils are corals, brachiopods, and crinoids. The Quartzite Series (up to 50 m) is underlain by dark silty slates and shales, an observation made in the Kangi-Kangi La section (Pl. 1 [2]).

In the south-western portions of the Zanskar Synclinorium — the Rangdum area — the Kioto Limestone and Quartzite Series follow above a rhythmic alternation (ca. 500 m) of blue limestone, light dolomite, cellular dolomite, and dark phyllitic slates. This well-bedded, banded sequence resembles the Triassic S of Zoji La and obviously represents a shelf deposit.

Thus, if my correlation of the formations above is right, a rather complicated facies pattern of the Triassic must be assumed (Fig. 1). Apparantly there existed several platforms separated by troughs.

Another problem are the dark grey to black, silty slates overlying the Kioto Limestone or the multicoloured limestone series (e. g. S of and N of Honupattan). Some of them represent the Spiti Shales (Upper Jurassic, e. g. S of Honupattan), others are overthrust portions of the Lamayuru Formation (e. g. Spongtang, Kangi), whereas others might be Mid-Triassic beds upthrown in steep anticlines (?).

The section NE of Rangdum reveals the complete stratigraphic sequence of the south-western Zanskar Synclinorium. There the Kioto Limestone is succeeded by rusty weathering, grey carbonate quartzites to carbonate sandstones, and blue sandy limestones showing current bedding and ripple marks. Though only crinoids and ill-preserved bivalves were found in the 7 to 10 m thick beds, there is not much doubt that they represent the Mid-Jurassic. The Spiti Shales (ca. 15 m), consisting of black, fissile shales and silty slates overlie the Mid Jurassic formation. The Giumal Sandstone (ca. 250 m, Lower Cretaceous) consists of green glauconitic, grey, dark grey, thick-bedded quartzitic sandstones to quartzites, and dark grey to black, sandy to silty slates. The uppermost layers yielded belemnites. Thick-bedded, blue-grey, nodular limestones (30—40 m) seem to represent the Chikkim Series (Upper Cretaceous).

Above this limestone a thick (up to 1000 m) flysch series follows which I term the Kangi La Flysch. It is composed of grey, green, also rather dark slates, sandy, silty slates and shales, and shaley sandstones. Dark concretions are common. The series weathers in ochre colour. At the top the Kangi La Flysch

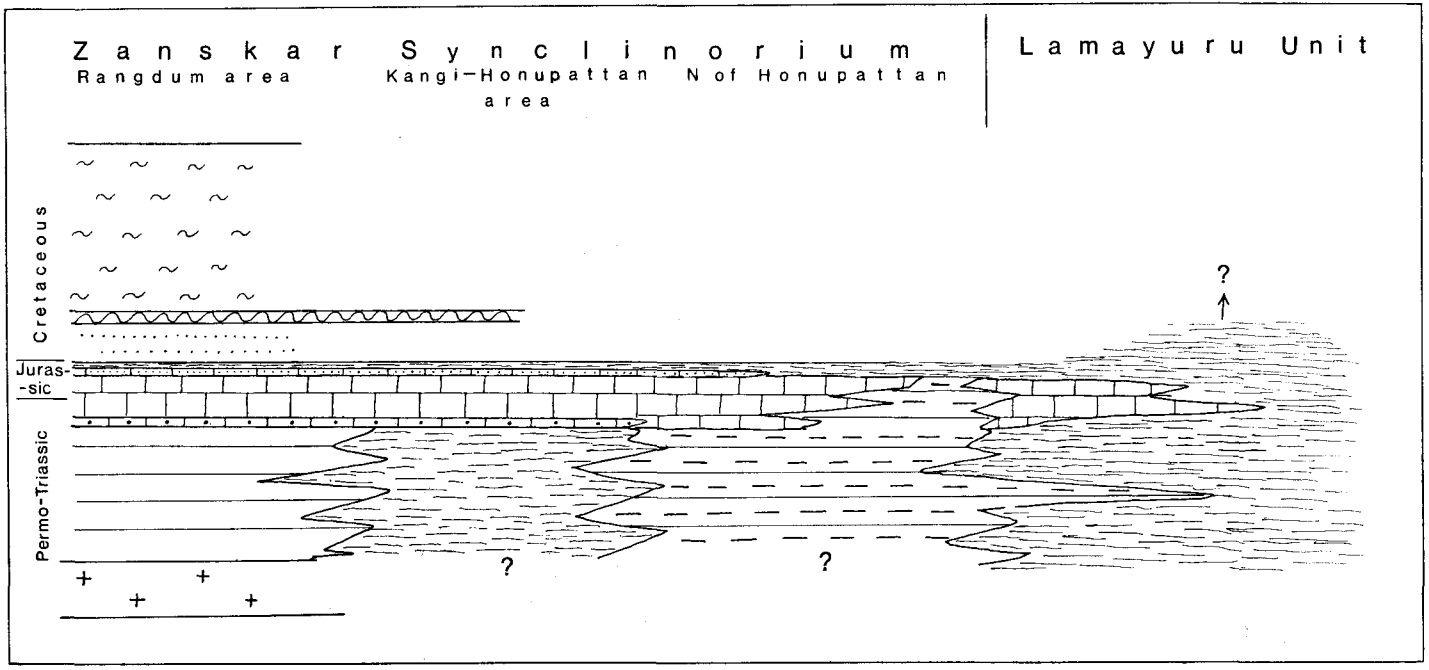

Fig. 1: Tentative Facies Scheme of the Zanskar Syclinorium and the Relations to the Lamayuru Unit (N is on the right hand).

passes into a 200 to 300 m thick series of nummulitic limestones.*) The well-bedded, nodular, dark blue limestones are interbedded with shales and a few beds of quartzite to carbonate quartzite. Besides nummulites*) they contain corals, gastropods, bivalves, and crinoids. The Kangi La Flysch underlying the Paleocene-Eocene limestones probably comprises the upper portion of the Upper Cretaceous and the lower part of the Paleocene. The youngest beds are exposed in a syncline S of the Kangi La region. They consist of at least 200 m of predominantly purple, also green shales, and current-bedded sandstones. The latter are subordinate. The purple colour reminds of the Eocene series E of Kargil, but, in absence of fossils, it is ambiguous whether they represent higher portions of the Eocene or are still younger.

The described complete sequence of the southern Zanskar Synclinorium is missing in its northern parts. No younger beds than the already mentioned Spiti Shales are found except one occurrence of nummulitic rocks, structurally intercalated between Kioto Limestone as a 60 to 100 m band (Kong, Pl. 1 [2]). These cream to greenish, light coloured schists with layers of blue limestone are full of foraminiferas **).

Considering the structures of the Zanskar Synclinorium there is a marked difference between the southern and northern parts. Section 2 (Pl. 1) in the area NE of Rangdum shows the open folds so characteristic for the Tibetan Zone. The fold movements are directed towards the SW. Local strike faults are found related with the Kioto Limestone.

In the Kong Valley, N of Kangi La, Quartzite Series and Kioto Limestone overthrust the Kangi La Flysch along a steep plane of disturbance (Pl. 1 [2]). N of that line all the beds are steeply folded. In the area of Kangi one meets an outlier of the Lamayuru Unit, consisting of black argillites and multicoloured limestones. Where the latter overlie the Kioto Limestone (N of Kangi), distorted lenticular bodies of Flysch sandstone within the multicoloured limestones indicate the thrust zone.

Towards the SE (Chomo, Shillakong) the outlier widens considerably (Pl. 1 [3, 4]). Dark argillites enclose klippes of Kioto Limestone, multicoloured limestones, or occasional serpentinite. Separated from the underlying Kioto Limestone of the Zanskar Synclinorium by a few meters of black slate, multicoloured limestones are particularly important in the lower portion of the Lamayuru Unit. Due to the tight folding of the outlier the latter rocks appear in steep anticlines from beneath the argillites.

In the high region of Spongtang and the drainage divide between the Yapola River in the N and the Oma River flowing SE, a huge outlier of Dras

*) The palaeontological examination of my rock samples most recently has given the result that the foraminiferal limestones on top of the Kangi La Flysch are Maastrichtien (upper Upper Cretaceous) in age. This means that the Kangi La Flysch is entirely Upper Cretaceous and the "Nummulitics" of this preliminary report are really upper Upper Cretaceous. The age of the succeeding multicoloured beds is open. The determination of the foraminiferas was kindly done by Dr. M. Schmid, Geol. B.-A., Vienna.

**) Dr. M. Schmid, Geol. B.-A. Vienna kindly determined them to be Early Tertiary.

Volcanics and Flysch overrides the Lamayuru Unit. The occurrence of basic volcanic rocks in the central part of the Zanskar Synclinorium was already noted by LYDEKKER (1883) and was assumed by him to form an intrusion. Though, the latter assumption does not hold good today, LYDEKKER's note led me to the discovery of the Flysch klippe, which again stresses the high value of these early observations.

In Spongtang (Pl. 1 [4]), where I have studied that klippe, the Kioto Limestone of the Tibetan Zone is separated by a few meters of black argillite from the multicoloured limestones (ca. 100 m), which form a basal thrust sheet of the Lamayuru Unit. Then follows the main mass of the Lamayuru Unit consisting of ca. 1000 m of black argillites with numerous klippes of limestone and quartzites. Serpentinites are bound to the base and the top. Particularly the boundary zone to the overlying Dras Flysch and Dras Volcanics is a typical ophiolitic melange. The serpentinites are associated with radiolarian cherts of green, grey, and bright red colour, flysch rocks, and limestone klippes. The volcanics are mainly coarse-grained peridotite, porphyritic and dioritic rocks. The associated flysch consists of grey, silty or sandy slates, cherty slates, green and grey partly tuffaceous sandstones with flute casts, and fine breccias. The rocks of the flysch outlier are gently dipping or rather horizontal, contrasting to the steeply compressed Lamayuru Unit and Tibetan Zone in the N.

The discovery of that outlier of structural units, derived from the Indus Suture Zone, proves a displacement of 30 to 40 km towards the SW. This is of special importance as at present all the structural planes of the Indus Suture Zone dip steeply SW, thus giving the impression of a NE-ward movement. The recent find is evidence that the movements along the ophiolitic melange zones were directed SW and thus the structural units of the Indus Suture Zone overthrust the Tibetan Zone. This is in accordance with GANSSER's observations from northern Kumaon and adjacent Tibet (see GANSSER, 1964). Compression was very active in the Indus Suture Zone and its neighbouring region after the nappe movements. This has brought the series of the northern Zanskar Synclinorium into a vertical position, the zones in the N thereof became inverted. Probably some slip along the old tectonic lines accompanied these young movements.

Further it is important that the flysch outlier does not continue along the strike towards the NE as shown by the Kangi section (Pl. 1 [2]). This strengthens GANSSER's interpretation (1964, p. 74, 78) of the observations of BERTHELSEN (1951) from the Rupshu region. The latter worker has discovered another ophiolite zone S of the Indus ophiolite belt and took it as a second suture zone. From GANSSER's and my observations, however, it is highly probable that this southern ophiolite zone of Rupshu is likewise an allochthonous mass derived from the Indus Zone.

4. The relation of the Tibetan Zone to the Central Crystalline

After dealing with the Zanskar Synclinorium, its stratigraphy, and tectonics we shall consider the south-western margins of that synclinorium and its rela-

tionship to the adjoining Crystalline of the Great Himalayan Range. One of my intentions, to study the Palaeozoic sequence in the southern limb of the Zanskar Synclinorium was frustrated. Metamorphism already rather strong in the Triassic and Permian series of the Rangdum area has converted all rock series underlying the Panjal Trap into mica schists and gneisses. It is impossible to recognize any of the Palaeozoic formations older than the Panjal Trap.

The Permian is not well-defined and without traces of fossils. Probably it is represented by a 100—150 m thin-bedded alternation of dark blue schistose limestones, calc schists, and black phyllites. Veins of calcite are frequent in the strongly recrystallized and tectonized series.

The Panjal Trap (Upper Carboniferous — Permian) consists of light to dark green, schistose rocks, in which the amygdales are still recognizable. W of Rangdum down the Sankpoo River the Panjal Trap becomes more and more altered and is represented there by biotite-hornblende gneiss and amphibolite. Towards the S of Rangdum the same is to be observed. There a boss of coarse-grained porphyric two-mica metagranite to granite-gneiss is in contact with the Panjal Trap. The Triassics and Upper Palaeozoics of the syncline S of that granite intrusion are altered to amphibolite facies grade rocks.

Principally the same is observed in the region of Suru (Panikar) and the Chilung Pass. In midst of garnet, kyanite, and staurolite bearing mica schists and gneisses we find remnants of folded Triassic series. These are converted to marble or calc-mica schists and are accompanied by amphibolites (± garnet), which appear to represent the Panjal Trap. Thus LYDEKKER (1883) was right in observing the Triassic series in direct contact with the Central Crystallines. The Alpine metamorphism reaches higher up into the Tethys succession in this western part of the Himalayas. All the lower formations have become gneisses of the Central Crystalline. The Triassic and partly also the Panjal Trap, due to their significant lithology, are still recognizable within the crystallines. That the marble series and the amphibolites really represent the Triassic, respectively the Panjal Trap, is evident from the fact that towards the NW they are continuous with the only slightly metamorphosed Palaeo-Mesozoic sequence of northern Kashmir. The gradual decrease in alteration may be clearly observed in the Kainthal Nar Valley, W of the Chilung Pass.

5. Conclusions

The Indus Suture Zone is formed by basic volcanics associated with a series of flyschoid formations of Triassic to Paleogene age. Within that zone and along its margins we find very deep reaching structural planes. These are marked by ophiolitic melange, a tectonic mixture of ultrabasic material from the mantle with different sedimentary formations. The Lamayuru Formation shows that there existed an eugeosyncline as early as in the Triassic adjoining to the Tethys Zone in the N. The limestone klippes within the Lamayuru Formation are not only dragged from the Mesozoic limestones by the overthrust of the Lamayuru Unit, but seem to indicate former facial intertonguings. The eugeosynclinal sequence is intermingled towards the SW with the miogeosynclinal succession of

the Tibetan Zone. Triassic limestone klippes in the Lamayuru Formation, as dark argillites in the Tethys series (e. g. Mid to Upper Triassic, Spiti Shales) hint to such intertonguings. In the Upper Cretaceous the flyschoid environment extended southward to the Tibetan Zone (Kangi La Flysch), whereas the succeeding nummulitic limestones indicate shallowing again. *) Much work, however, is still necessary to get a clear picture of the original facies pattern particularly for the Triassic.

In the course of the nappe movements the units of the Indus Suture Zone have overridden the Tibetan Zone. The discovery of the flysch klippe of Spongtang, proving a thrust displacement of at least 30 km, is in accordance with GANSSER's findings in southern Tibet.

The structure of the Spongtang klippe certainly does not support the gliding mechanism, envisaged by SHAH (1976). This klippe consists of two thrust sheets, directly capping the Triassic-Jurassic series without any autochthonous flysch. The Kangi La Flysch, however, which must be regarded as part of the Tibetan Zone is free of exotic klippes.

After the nappe movements a very strong compression has affected the Indus Suture Zone and the adjoining parts of the Tibetan Zone. The northern boundary of the outlier mentioned above, and the northern portions of the Zanskar Synclinorium (Tethys series) became vertical. The whole structural pile of the Indus Suture Zone became inverted. Thus, during this later phase the Mesozoic limestones of the Tibetan Zone moved towards NE over the adjoining units of the Indus Suture Zone (e. g. Lamayuru Unit). The displacements in opposite directions along rejuvenated older thrust planes, however, were small compared to the earlier nappe movements towards the S.

The fact that the lower portions of the Tibetan (Tethys) succession up to the Triassic have become part of the Central Crystalline, again shows that it is a misconcept to regard the Crystalline as Precambrian. It is a common observation that the metamorphism of the Crystalline dies away in the lower formations of the Tibetan Zone and, thus, can not be considered as a basement. In the Nun-Kun-region, however, the metamorphism reaches up exceptionally high into the Palaeo-Mesozoic succession. Whereas I hold the view of a polymetamorphic nature of the Himalayan Crystalline (FUCHS, 1975, p. 55, 56), there is no doubt that this metamorphism of the Nun-Kun area is entirely Alpine.

Thus, the studies in western Ladakh and Kashmir have yielded results of more than local importance, but at the same time questions have arisen which are still unsolved. In spite of that, I hope that this preliminary report will contribute to the geological knowledge of the western Himalayas.

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*) These foraminiferal limestones are proved to be still Upper Cretaceous by recent palaeontological examination of my specimens.

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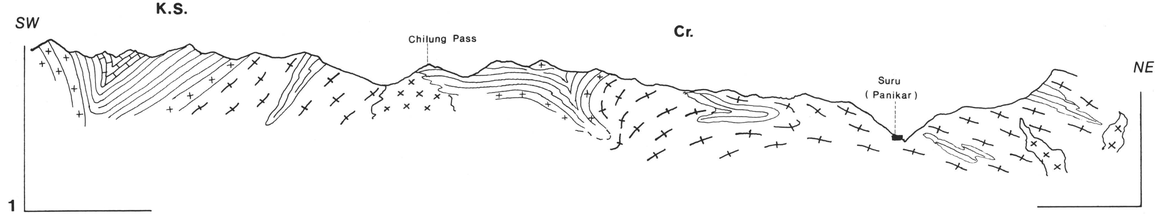
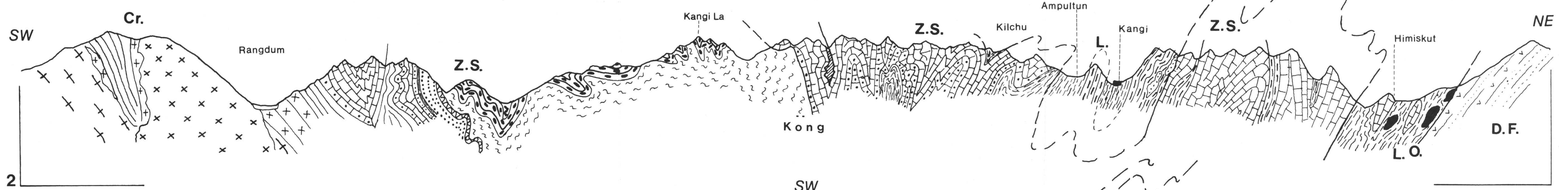
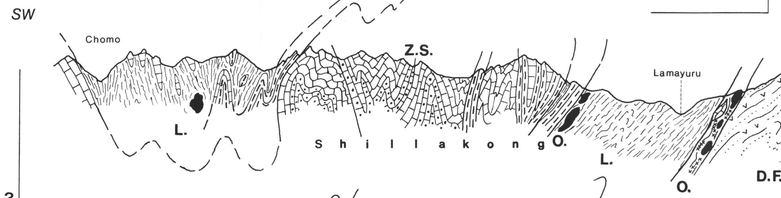
G. FUCHS Plate 1

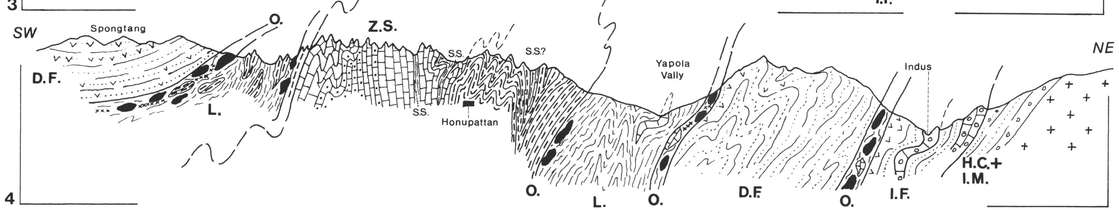
Sections through the Zanskar Mountains

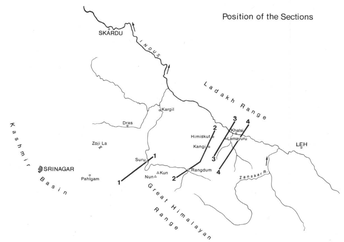
G. Fuchs, 1976











Z.S. – Zanskar Synclinorium (Tibetan Zone)

- Red and green shales and sandstones (Eocene?)
- Nummulitic limestones (Paleocene – Eocene)
- Kangi La Flysch (Up. Cretaceous – Paleocene (?))
- Chikkim Limestone (Up. Cretaceous)
- Marls and limestones (Paleocene – Eocene)
- Giumal Sandstone (Lower Cretaceous)
- Spiti Shales (S.S.)
- Dogger
- Kioto Limestone (Rhaetic – Dogger)
- Quartzite Series (Noric? – Rhaetic)
- Permian to Up. Triassic
- Multicoloured limestones and slates (Triassic?)
- Dark silty slates (Mi.-Up. Triassic)
- Panjal Trap (Permo-Carboniferous)

- Gneisses i.gen.
- Metagranites – granite-gneisses

  Cr. = Crystalline, K.S. = Kashmir Synclinorium
- Ultrabasics (serpentinites)
- Radiolarites

  O. = Ophiolitic melange zones
- Lamayuru Fn. (Triassic – Jurassic) limestone klippe

  L. = Lamayuru Unit
- Flysch; volcanics
- Khalsi Limestone (Mid-Up. Cretaceous)

  D. F. = Dras Flysch
  I.F. = Indus –·–
- Multicoloured conglomerates, sandstones, shales, etc

  H.C. = Hemis Conglomerate
  I.M. = Indus Molasse
- Ladakh Granite

0 1 2 3 4 5 km

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