The Division between Himalaya and Karakorum

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Abstract. The 5000 km long Peri-Indian Suture Zone has doubled in the western Himalaya and the northern branch forms the division between the Himalaya and the Karakorum.

The northward directed Nanga Parbat-Haramosh crystalline spur controls structure and petrology of both the Suture Zones. It divides the over 2000 km long Transhimalayan batholith into the eastern Ladakh and the western Swat batholith.

Geology and petrology of the Karakorum north of the Northern Suture Zone strongly contrast with the Himalaya to the south of it.

I. INTRODUCTION

The division between the Karakorum and the Himalaya is marked by northern branch of the Peri-Indian Suture Zone (Gansser, 1980). For over 5000 km can we follow this major lineament from the Andaman Island in the SE to Karachi in the SW. The junction between the Karakorum in the north and the Himalaya in the south is, however, still somewhat controversial. We have realized that from the eastern Ladakh region to the west, the suture zone has doubled, one running along the Indus valley (southern branch) the other along the Shyok and Nubra rivers in the north (Gansser, 1977). It is difficult to decide if this doubling is due to tectonic causes only, or if two different belts existed originally with a different composition and possibly in a different age (Stocklin, 1977).

Compared to the central and eastern Himalaya, the western Himalaya within Pakistan is further complicated by the remarkable north-northeast directed basement spur of the Nanga Parbat–Haramosh, which is truncated in the north by the wide arch of the Karakorum range, and which may be related to the western Himalayan syntaxis. Desio (1979) regards his "upper Indus Suture line" east of the Nanga Parbat-Haramosh Spur and his "Kohistan line" (both corresponding to my southern suture zone) west of the massif as the main division, while I take the northern suture zone as the actual structural divide. Apparently the geological and the geographical Karakorum do not completely coincide.

During summer 1977 and fall 1978, I visited the suture zone of the western Himalaya (Pakistan) and surrounding areas between the lower Shyok river in the east and the Chitral area in the west. In the following observations I present the preliminary results of the reconnaissance, which is an extension of similar investigations carried out in the Ladakh region (Frank *et al.*, 1977).

In order to shorten the description, many of the observed facts are presented in sketches drawn directly in the field (Fig. 2—17).

II. THE NORTHERN SUTURE ZONE EAST OF THE NANGA PARBAT—HARAMOSH SPUR

In the Ladakh area two suture zones exist. They are separated by the large Ladakh batholith, the western equivalent of the 2000 km long Transhimalayan batholith. While the southern suture zone along the Indus valley is well known — actually it is the best known part of the total belt — the northern branch, long suspected by earlier reports and the study of satellite pictures, has only recently been investigated (Sharma and Gupta, 1978). Surprisingly thick (up to 8 km reported) volcanics and volcano-clastics follow north of the Ladakh batholith. They were first mentioned by Stolickza (1874), who compared them to the Panjal traps. They are well developed north of Khardung and range from basalts to trachytes together with rhyolites showing ignimbritic flow features. They seem to be different from the well known Dras volcanics of the southern suture along the Indus. Further eastwards, north of Chang-La, which crosses the Ladakh batholith, De Terra (1932) has observed "diallagites" with amphibolites as well as porphyroids with diabases and well bedded tuffites. Along a sharp thrust (the Nubra-Shyok thrust of Sharma and Gupta) gneisses and granites of the Karakorum are thrust over the volcanics. Small sheared relics of serpentine suggest the actual trace of the northern suture zone. The thrust hades with about 40° to 50° to the north and is followed by a conspicuous row of hot springs. It contrasts with the steep south hade of the thrusts along the southern suture zone. It is most significant that ultramafic rocks occur only as thin, highly sheared relics along this northern suture zone, a fact well established further to the west.

Still unknown is the region between the Nubra and the western Shyok on the Pakistan side. Possible

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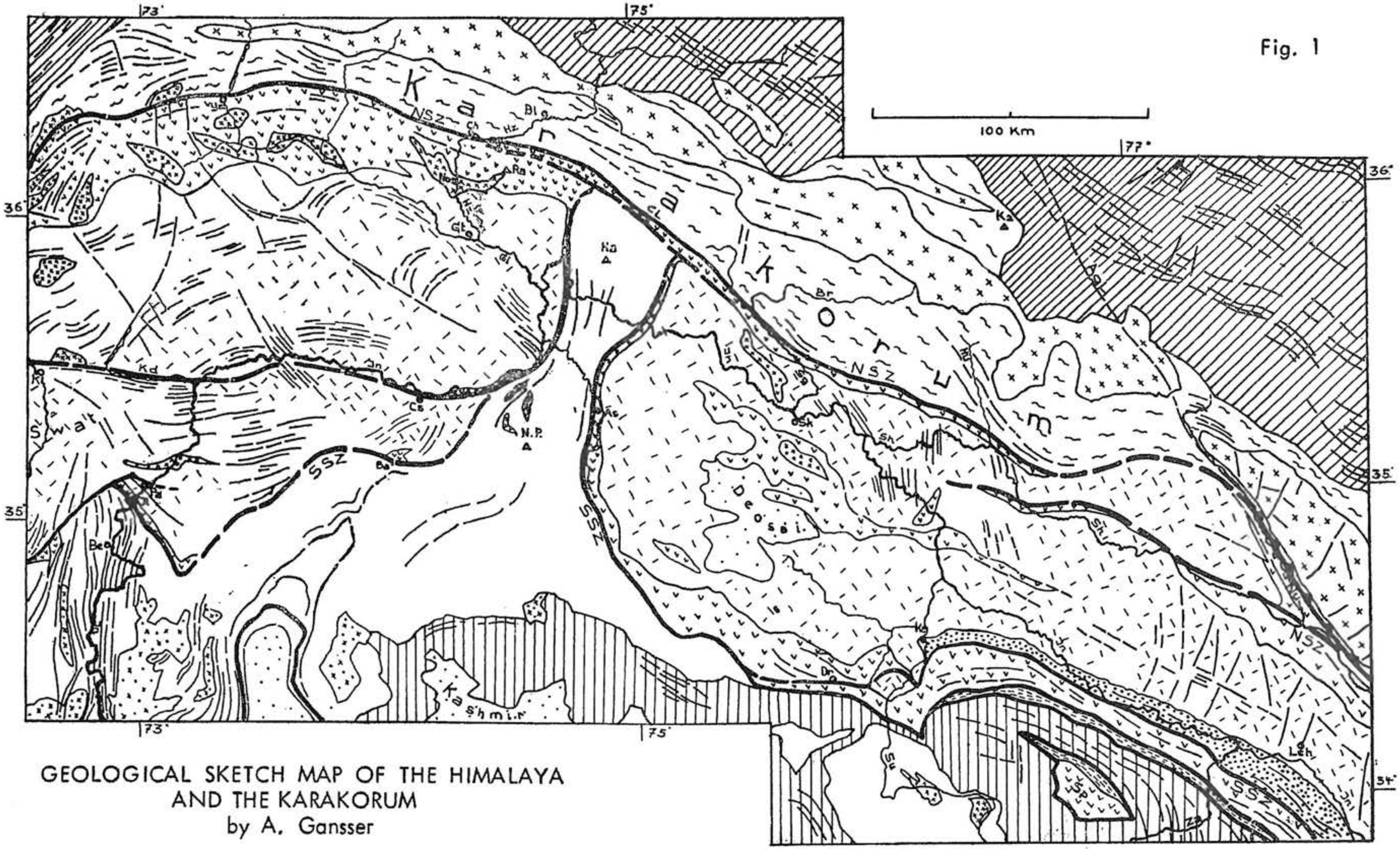
Fig. 1



GEOLOGICAL SKETCH MAP OF THE HIMALAYA
AND THE KARAKORUM
by A. Gansser

Legend for Fig. 1.

northern platform sediments (N Karakorum S Pamir)

southern platform sediments (Zanskar, Kashmir.)

Karakorum central batholith

south Karakorum schist, marble and gneiss zone (Dumordo or Baltit Group)

Sutur Zone: volcanics +pelagic sediments, ultramafics and melanges part. metamorphosed

Transhimalayan Pluton : Ladakh and Swat batholith, included large enclaves of "basement" and sediments

Basement type crystalline (Precambrian to Lower Paleozoic)

Leucogranites, mostly Tertiary

Himalayan granites (Mansera type, 500 my)

Ladakh Molasse (Kailas Molasse) in E, Jalipur "Molasse" in W

Tertiary to recent sediments (in Syntaxis belt, Kashmir and Deosai basins)

Main Suture Lines along Sutur Zones lineaments with fault zones

Ba	Babusar Pass
Be	Besham
Bl	Baltit
Ch	Chalt
Cs	Chilas
Dr	Dras
Gt	Gilgit
Ji	Jijal
Ka	Kargil
Kl	Kalam
No	Nomal
Pa	Patan
Sk	Skardu
Ya	Yasin

Br	Braldo
Gi	Gilgit
Hu	Hushe
Hz	Hunza
In	Indus
Kd	Kandia
Nu	Nubra
Sh	Shyok
Su	Suru
Za	Zanskar

Ha	Haramosh
NP	Nanga Parbat
Ra	Rakaposhi
CL	Chogo Lungma

NSZ	Northern Suture Zone
SSZ	Southern Suture Zone
AgL	Aghil Line
Spo	Spongtang Nappe

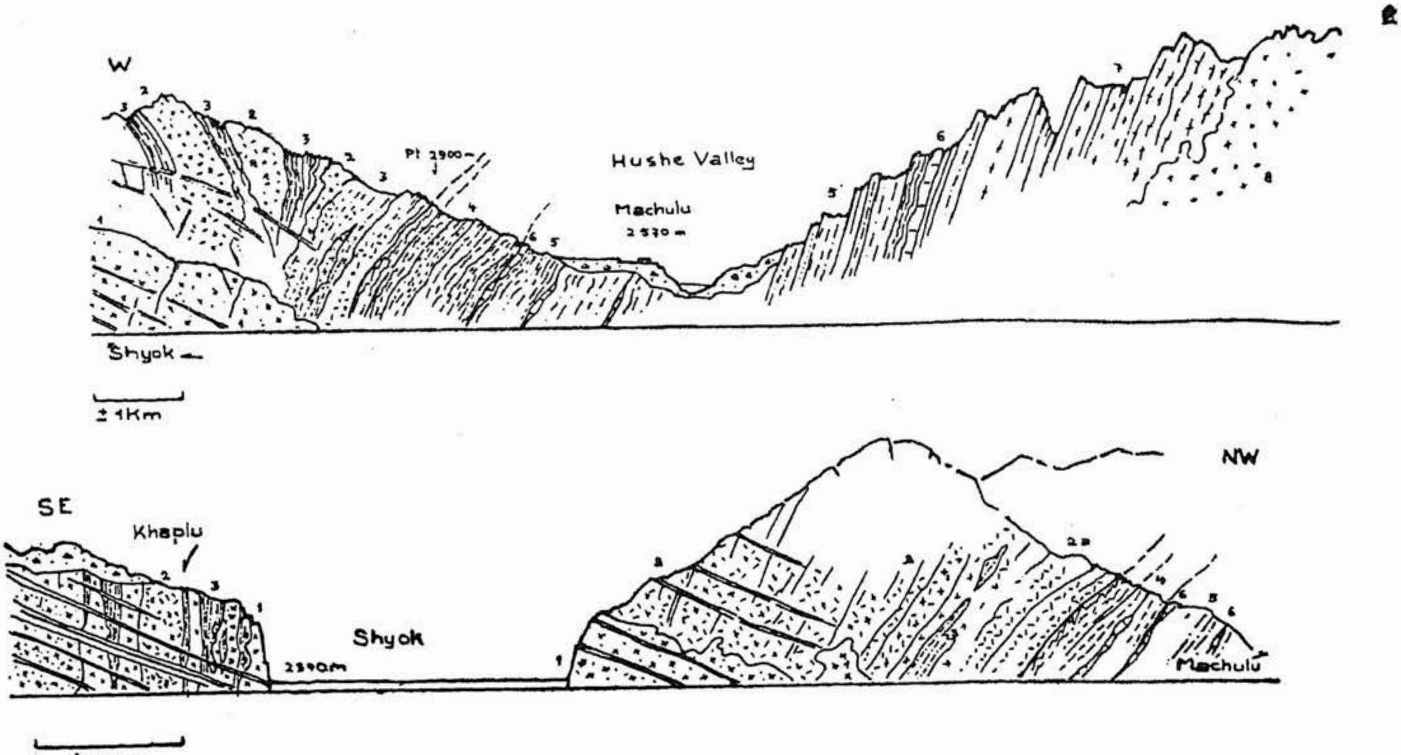


Fig. 2. Khaplu-Machulu section (Shyok river) and lower Hushe valley.

1 tonalites with aplites and meta-dolerite dykes, the latter often intruding the aplitic dykes forming a basic core
2 gabbros cut by tonalites with same dykes as in 1
2a microgabbros to meta-dolerites and diabases
3 biotite schists and finegrainde gneisses with chlorite schists
4 epidote chlorite schists, partly prasinitic (mylonitic)
5 phyllites, quartzites and schists
6 white marbles
7 biotite augengneisses
8 biotite granite, often with large alkalifeldspar phenocrysts

traces are indicated on the sketch map (Fig. 1) partly based on satellite pictures. The Aghil fault zone running through the Nubra Valley to the Aghil pass may have displaced the suture zone as well as the continuation of the Ladakh batholith.

I found the northern suture zone again in the lower Shyok river at the confluence with the Hushe river at Machulu (Fig. 2). The steep thrust hades here to the south with chlorite schists thrust northwards on mylonitic phyllites and thin marbles, which become more metamorphic towards the main Karakorum batholith [Baltit group of Stauffer (1968) or Dumordo group of Desio (1974)]. The Karakorum rocks are well displayed along the Hushe valley and on the south face of Masherbrum (Fig. 3). South of the suture zone the green schists pass through diabases and microgabbros into the main gabbro body belonging already to the western continuation of the Ladakh batholith. Tonalite cut into the gabbro and are traversed by parallel dykes of aplitic granites and dolerites (Fig. 2). The batholithic rocks are particularly well exposed along

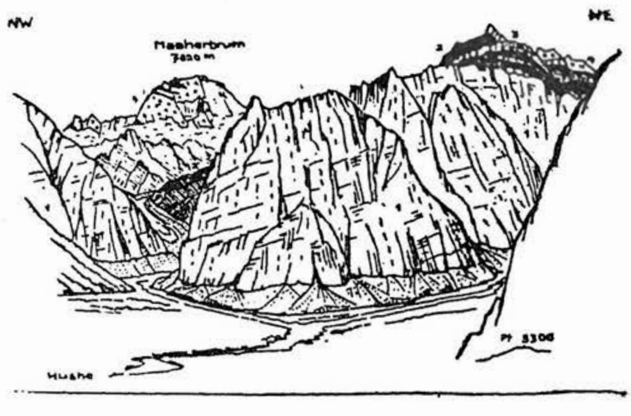


Fig. 3. The southflank of Masherbrum, seen from the upper Hushe valley.

1 migmatized biotite granite gneiss
2 brown weathered calcschists (Paleozoic)
3 white marble bands
4 Baltoro type granites with basic dykes

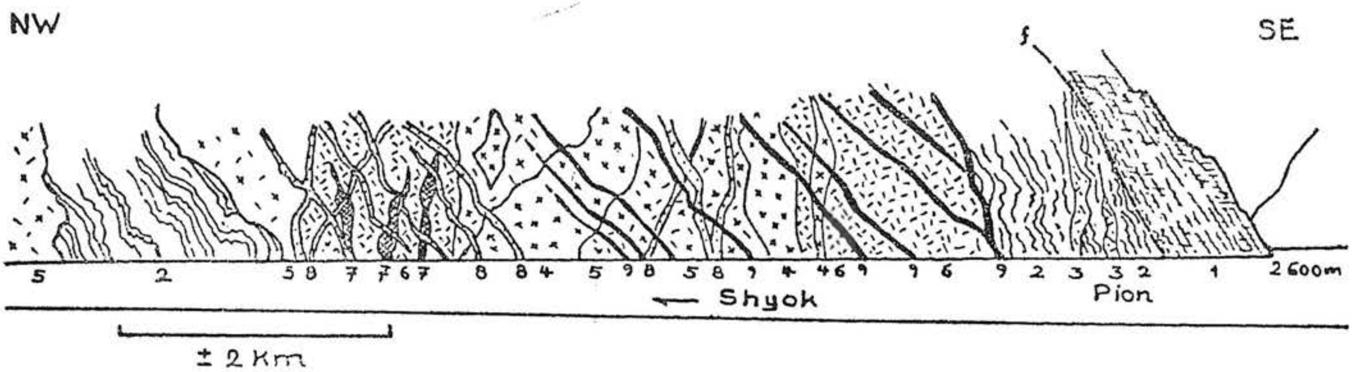


Fig. 4. Section along the Shyok river near Pion

1 steep belt of mylonitic chlorite epidote schists with prasinitic layers thrust southwestwards on gneisses (2). Could be part of the northern Suture Zone continuing into the Shyok/Nubra zone
2 folded biotite gneisses and schists, rich in quartz veins, locally migmatitic with some Cu mineralisation. Could represent older "basement" striking mostly northwards
3 small bands and lenses of diorite within the gneisses
4 white to slightly pinkish biotite granite representing youngest undeformed intrusions
5 tonalite
6 gabbros to norites cut by the tonalites
7 irregular pyroxenite lenses in gabbro
8 pegmatitic and aplitic veins and dykes
9 doleritic dykes, mostly parallel and southwards handing locally intruded and brecciated by youngest aplite granite dykes

the lower Shyok river as well as along the Indus. I followed the Shyok river for about 70 km upstream to beyond Pion and the Indus river for about 40 km towards Khurmang. The outline of the plutonic rocks is much more complex in this western extension of the Ladakh batholith, particularly by the frequent enclaves of metamorphic, volcanic and sedimentary rocks. The batholithic rocks composed of pyroxenites, norites, tonalites and younger granite intrusions are cut by numerous dykes, with a predominance of meta-dolerites clearly cutting aplites and pegmatites.

I observed the following enclaves: Intensely folded old biotite gneisses and schists, which are locally migmatized. They frequently strike in a northerly direction. Sediments are well exposed near Tolti in the Indus, where they form an impressive antiform with an axial plunge to the north. The sediments consist of limestones and dolomites altered to marble and tremolite marble and black slates. Locally they expose badly sorted and streched (north-south) pebbles of quartzites, dolomites and slate fragments, not unlike some agglomeratic slates. Youngest dolerite dykes cut through the sediments, and both flanks are intruded by plutonic rocks, gabbros on the north flank and younger granites on the south flank. Note also the description by Auden (1935) further upstream along the Indus river. In the Shyok river near Pion a possible branch of the suture zone contains metavolcanics thrust steeply to the northwest on biotite gneisses belonging to an enclave of metamorphic rocks. This section also exposes the complicated relations of the various plutonic rocks and the dyke intrusions (Fig. 4).

Westwards, the continuation of the northern suture zone can be traced from Hushe over the Thalle pass into the Shigar valley (see Fig. 1). Ebblin (1976), who investigated this section on structural grounds distinguishes a volcanic and a sedimentary sequence, with some conglomerates in contact with "gabbrodiorites" of the main pluton in the south. The suture zone enters the Shigar valley just west of Shigar and disappears below the alluvial flats. Apart from chlorite schists and coarse prasinites, lenticular marbles, locally with an intense flow-folding, are of particular interest, together with smaller fragments of serpentine, which outline the character of the suture zone. Along the western end of the Shigar valley, near the confluence with the Braldo river coming from the Baltoro region, the northern suture zone is again well displayed in the western mountain ranges. The imbricated section is rich in sediments with various volcanic intercalations (Fig. 5). The contact against the crystalline of the Karakorum is sharp and outlined by hot springs. Biotite granite gneisses form a large antiform with migmatites in the core (Dassu antiform (see also Zanettin, 1964)).

From here, westwards to the Hunza area, the suture zone passes through the wild and highly glaciated Chogo Lungma range (Kick 1956). This geologically practically unknown area is of particular interest, since

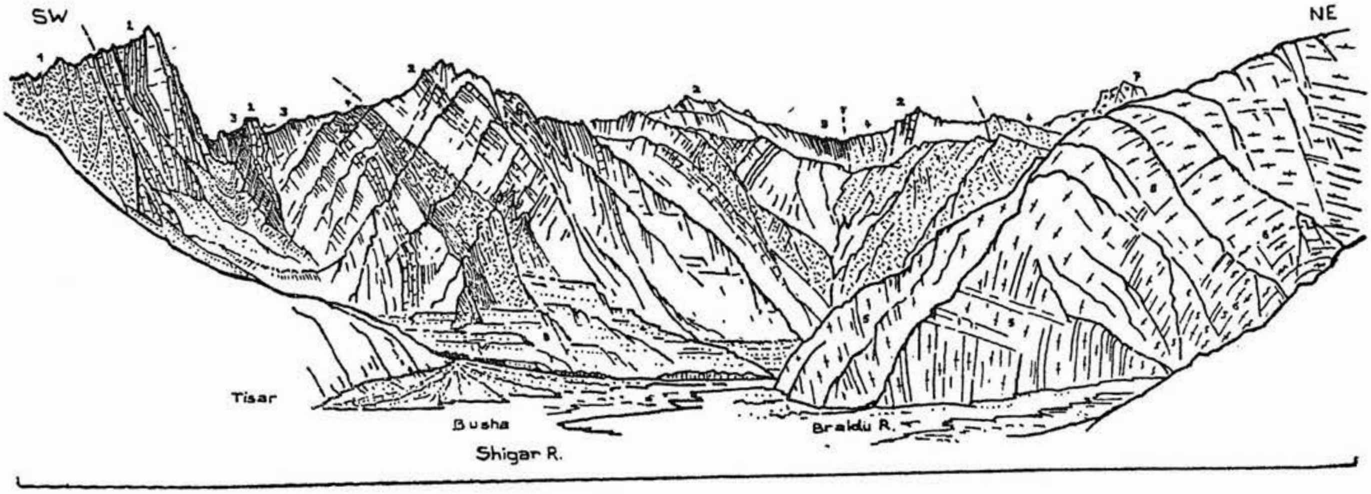


Fig. 5. The west end of Shigar valley with the westward continuation of the northern Suture Zone.

1 gabbros and norites, including some tonalites
2 dolomitic limestones and calcschists with fossil traces
3 dark shales and calcschists (2 and 3 probably Mesozoic)
4 meta-volcanics, probably of Dras type (green schists)
5 biotite granite gneiss of Dassu (forms large antiform)
6 migmatitic granite gneiss in core of antiform
7 Karakorum type granite
8 fluvio-glacial terraces

it is here that the northern suture zone is cutting sharply the large north-south striking Nanga Parbat-Haramosh basement spur. The western extension of the Ladakh batholith as well as the southern suture zone merge into this narrow section (see Fig. 1). Along the Chogo Lungma glacier one may expect a highly tectonized suture zone or zones with the Haramosh "basement" to the south and the southern Karakorum rocks to the north.

III. THE NORTHERN SUTURE ZONE WEST OF THE NANGA PARBAT-HARAMOSH SPUR

South of Baltit (Lower Hunza) the northern suture zone is exposed in the wild north flank of the Rakaposhi range, where I investigated two sections along the Minapin and Pisan glacier valleys (Fig. 6). The Rakaposhi-Diran range consists of a complex section of metavolcanics, beautifully exposed in the Hunza river gorge south of Chalt (see below). Actually the Rakaposhi with its 7800 m is the highest ophiolite mountain in the world, in spite of some young granite intrusions (Nomal type), which seem to reach the summit ridge. To the north, the Rakaposhi volcanics border with a sharp tectonic contact on isoclinally fo'ded calcschists. At this contact outcrop actinolite-talc schists with small serpentinite lenses representing the actual trace of the suture, again narrow and sharp, as typical for this northern accident. Within the sedimentary section, I noted conglomerates well developed along the lower Minapin glacier. The badly sorted, sub-

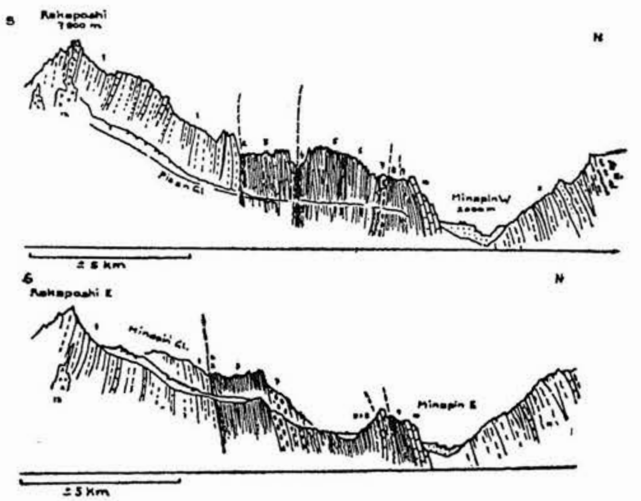


Fig. 6. Section through northern Suture Zone along Minapin glacier, northern flank of Rakaposhi.

1 Rakaposhi "green schists" (meta tuffs, diabases, pillowlavas, amphibolites, calcschists and marble bands intruded by granites of Nomal type)
2 thrustzone with green schist boudins in calcschist mylonites
3 dark banded calcschists, isoclinally folded
4 thrustzone with talc actinolite schists and some serpentinite lenses (main Suture)
5 black, partly quartzitic slates
6 quartzites
7 sedimentary conglomerate with quartzites and dolomitic lenses (faulted to N)
8 black scistose slates
9 same slates as phyllonites and mineralized (FeS)
10 yellow, banded marbles and dolomites (cipollin type)
11 garnet schists, biotite gneisses, quartzites and marbles of southern Karakorum (Dumordo series)

rounded pebbles, averaging fist size, consist of quartzites, black and gray limestones, yellow dolomites and slates. Crystalline rocks are practically absent. Locally a copper mineralization was observed in the slaty matrix. With a marked, yellow banded marble (cipollin type) the sedimentary section borders sharply the schists, marbles and gneisses of the southern Karakorum. They become migmatitic towards Baltit and are criss-crossed by aplitic and pegmatitic dykes as well as intruded by small bodies of young aplite granites. Further northwards they are intruded by the central Karakorum batholith (Fig. 7) (Schneider, 1957; Desio, 1964). The petrological difference between the Karakorum igneous association and the Transhimalayan type batholiths (Ladakh batholith and its western continuation) is here obvious. The rock types, the initial Sr^{87}, Sr^{86} ratio as well as the isotopic ages stress this point. The younger Karakorum pluton originates from a more continental crust in contrast to the Transhimalayan batholith, where an oceanic crust is involved.

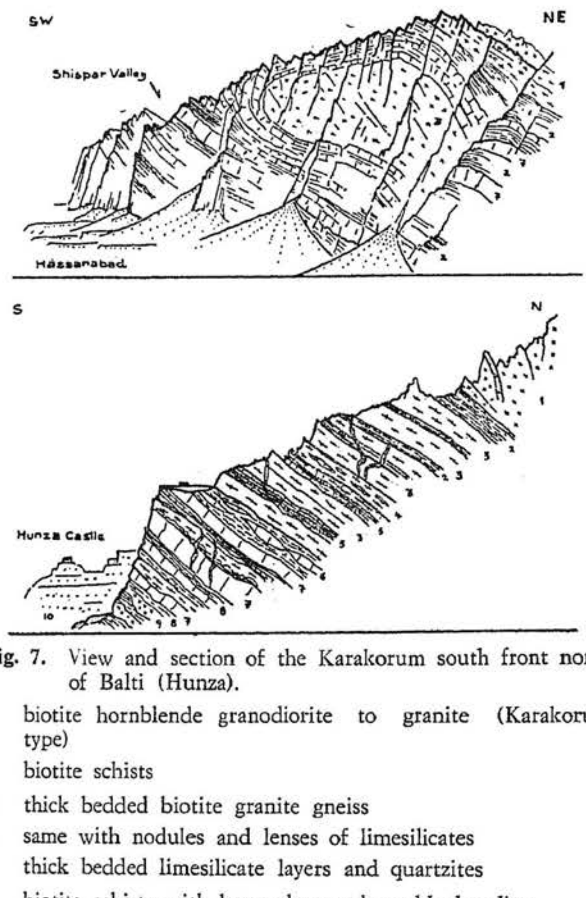


Fig. 7. View and section of the Karakorum south front north of Balti (Hunza).

1 biotite hornblende granodiorite to granite (Karakorum type)
2 biotite schists
3 thick bedded biotite granite gneiss
4 same with nodules and lenses of limesilicates
5 thick bedded limesilicate layers and quartzites
6 biotite schists with large elongated marble boudins
7 thick bedded coarse gray white marbles (contain rubies)
8 alternation of well bedded limesilicates and psammite biotite gneisses
9 lenses and dykes of finegrained biotite granite with aplites and pegmatites cutting biotite schists and all visible structures
10 high gravel terraces of Baltit castle

Over Chalt, where we recognize a section similar to one mentioned from Minapin, the northern suture zone continues into the Ishkuman valley north of Phakar and passes through Yasin, where the sedimentary section is well developed with conglomerates, slates and Aptian limestones, discovered already by Hayden (1916). I have not yet visited this part of the suture zone, and I refer to the publications by Ivanac et al. (1956), Desio *et al.* (1977) and Casnedi (1976a). The further continuation towards Chitral can be deducted from Matasushita and Huzita (1965), Desio *et al.* (1977) and is represented as "northern Megashear" on the map by Tahirkheli and Jan (1978). Of special interest is the fact that from the Lower Shyok region in the east to the southwestern Chitral a Mesozoic sedimentary section is following the northern suture zone to the north with shales, conglomerates and reefal type limestones.

IV. SOME REMARKS ON THE AREA TO THE SOUTH OF THE NORTHERN SUTURE ZONE

The direct continuation of the sharp northern suture to the south is well exposed in the spectacular Hunza river gorge south of Chalt (Fig. 8). Over a suite of lightly metamorphosed (lower greenschist facies), well bedded pelagic carbonates we enter a volcanoclastic section grading into altered lava flows with three main pillow horizons (Fig. 9). The deformation of the pillows increases southwards together with an increase in metamorphism. The first (southern) pillow zone is highly streched and fully altered to amphibolite, locally with rims of siliceous hornfels. Towards Nomal the amphibolitic volcanics are intruded by several stocks of fine to medium grained garnet bearing and quartz rich biotite granite (Nomal granite), which cuts all visible structures. Striking are here some meta-dolerite dykes cutting the granite, while further to the south only aplitic and pegmatitic dykes dominate. At Nomal we also note the change from meta-volcanics to plutonic rocks with norites and tonalites belonging already to the large but highly complex body of the wider Swat area, the western equivalent of the Ladakh batholith (Transhimalayan batholith) west of the remarkable *Nanga Parbat-Haramosh spur.*

This dominant basement cross high is known through the investigations of Wadia (1933) and later Misch (1935, 1949). Little known are still the relations of the suture zones with this cross high. Coming from the Dras region in the east, one notes a gradual change into a northwards strike of the southern suture zone and the Ladakh batholith (Casnedi 1976b). This area was previously investigated by Wadia (1933, 1937), though his interpretations need some revision. I visited the area coming from Skardu over the Deosai plateau to Astor, where I was able to travel as far south as the Kumri pass.

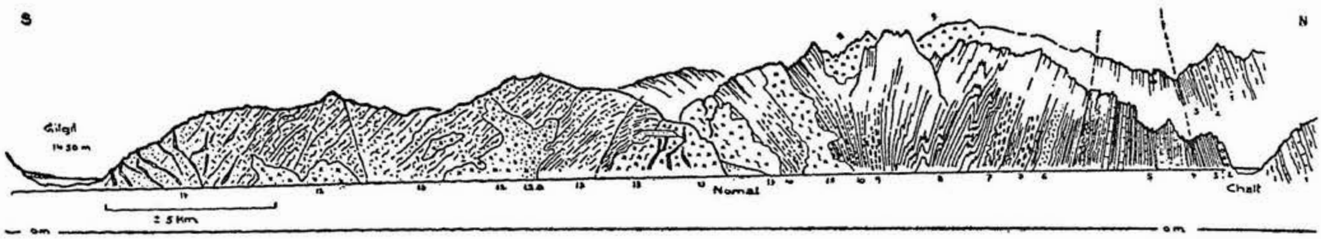
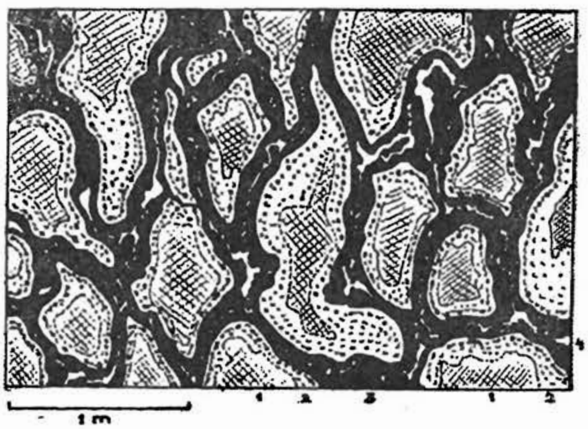


Fig. 8. Section between Chalt and Gilgit.

1 gneisses, schists and marbles of southern Karakorum (Dumordo section)
2 sed. conglomerate of Chalt
3 black flyschoid slates with fine graded bedding, strongly sheared
4 actinolite/talc band with serpentine lenses (Suture Zone)
5 plately calcschists, quartzitic fine graywac and cipollin type marbles
6 metavolcanics (tuffs, diabases hyaloclastites and marbles with flow features and small finegrained diorite bodies
7 meta-pillows with mandelstein diabases and banded tuffs
8 well banded meta-tuffs with carbonaceous intercalations, folded
9 streched pillows, amphibolitic, with some cherty borders
10 banded amphibolites with highly streched pillows (amphibolitic)
11 biotite granite, finegrained with garnets (Nomal type)
12 fine grained biotite garnet granite rich in quartz, with rhyolitic borders (12 a)
13 hornblende diorite to tonalite, becoming sheared towards north
14 gabbros rich in acide dykes, grading into diorites northwards

Fig. 9. The third pillow horizon south of Chalt. Recrystallized pillows in higher greenschist facies.

1 pillow core with actinolitic hornblende and epidote
2 pillow rim with variolites filled with quartz
3 hyaloclastite zone consisting of finegrained actinolitic hornblende with some epidote
4 intermediate bands (septa), disharmonically subfolded, rich in carbonate, epidote and some actinolite; the pillows, though fully recrystallized, are not much deformed while the intermediate hyaloclastite zones were highly mobile



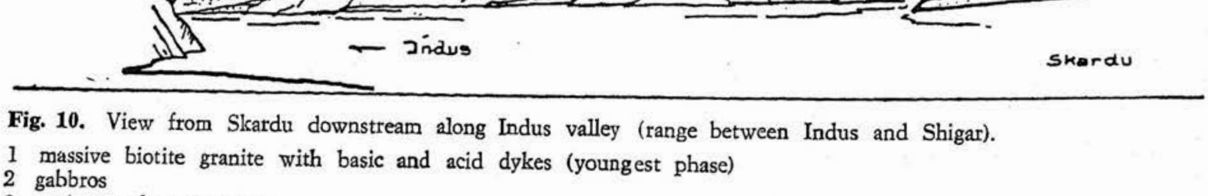


Fig. 10. View from Skardu downstream along Indus valley (range between Indus and Shigar).

1 massive biotite granite with basic and acid dykes (youngest phase)
2 gabbros
3 norites and pyroxenites
4 green schists with marbles and some dark slates
5 shistose gabbro, cut by acid dykes

In the Skardu region we note the same complex composition of the batholithic rocks as already mentioned from the Shyok and Indus rivers (Fig. 10). An outstanding fact is the *Deosai plateau,* a geological as well as a morphological anomaly in the middle of the widest bulge of the Ladakh batholith (Desio, 1978). Already the section along the Satpora valley (S of Skardu) exposes Dras volcanics, well bedded tuffites with breccias and algal limestones. They are cut by younger biotite granites and followed at the northern rim of the plateau by conspicuous ignimbritic rhyolites.

Tonalitic rocks with some granites and gabbros are widespread in the Astor region, just east of Nanga Parbat. Dras volcanics are only locally present. The contact zone against the Nanga Parbat crystalline is well exposed in the lower Rupal valley (south of Astor) (southern suture zone). Noritic gabbros from the Ladakh pluton become progressively sheared, when approaching the steep thrust. They are followed by chlorite actinolite garnet schists (partly chenopoditic) with an intense folding and lineation (rod like), dipping gently northwards, parallel to the thrust contact. This contact is characterized by mineral springs with alum and Cu mineralisation. The Nanga Parbat crystalline begins with biotite phyllonite schists, followed by irregularly folded garnet amphibolites and biotite garnet gneisses representing the main crystalline body. No Dras type volcanics are present in the Rupal section (see also profiles of Misch, 1935). Towards the Kumri pass, further to the south along the contact zone, Dras volcanics set in together with serpentine lenses, black slates, siliceous marbles and well developed intercalated conglomerates (Fig. 11). The pebbles are relatively well sorted, semirounded from fist to head size and surprisingly not stretched. Dominant are various types of limestones, some with fossil traces such as thick shelled lumachelles, echinoderms, brachiopodes and very doubtful rudists (det. Dr. Beckmann), together with green and red siliceous slates and siltstones, banded green

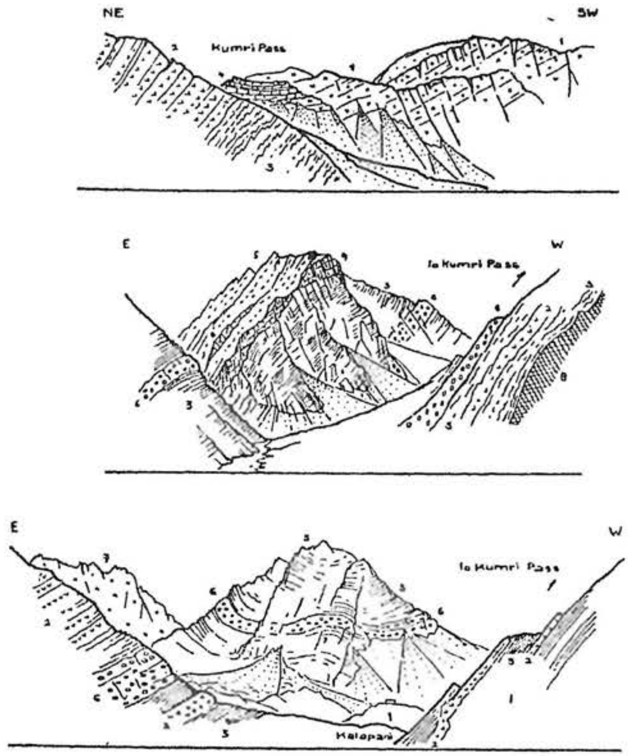


Fig. 11. The geology between Kalapani and Kumri pass (south of Astor).

1 fine grained hornblende diorite
2 Dras type volcanics
3 black slates (Salkhala after Wadia)
4 gray, banded siliceous limestones
5 green schists (meta-tuffs)
6 limestone conglomerate (Mesozoic)
7 tonalite to biotite granite
8 serpentine (harzburgite) with chromite

Fig. 12. General view from Kumri Pass towards SE.

1 Triassic limestones of Kumri (after Wadia)
2 Salkhala type dark slates
3 Dras volcanics
4 tonalites of Minimarg region, intrusive into Dras

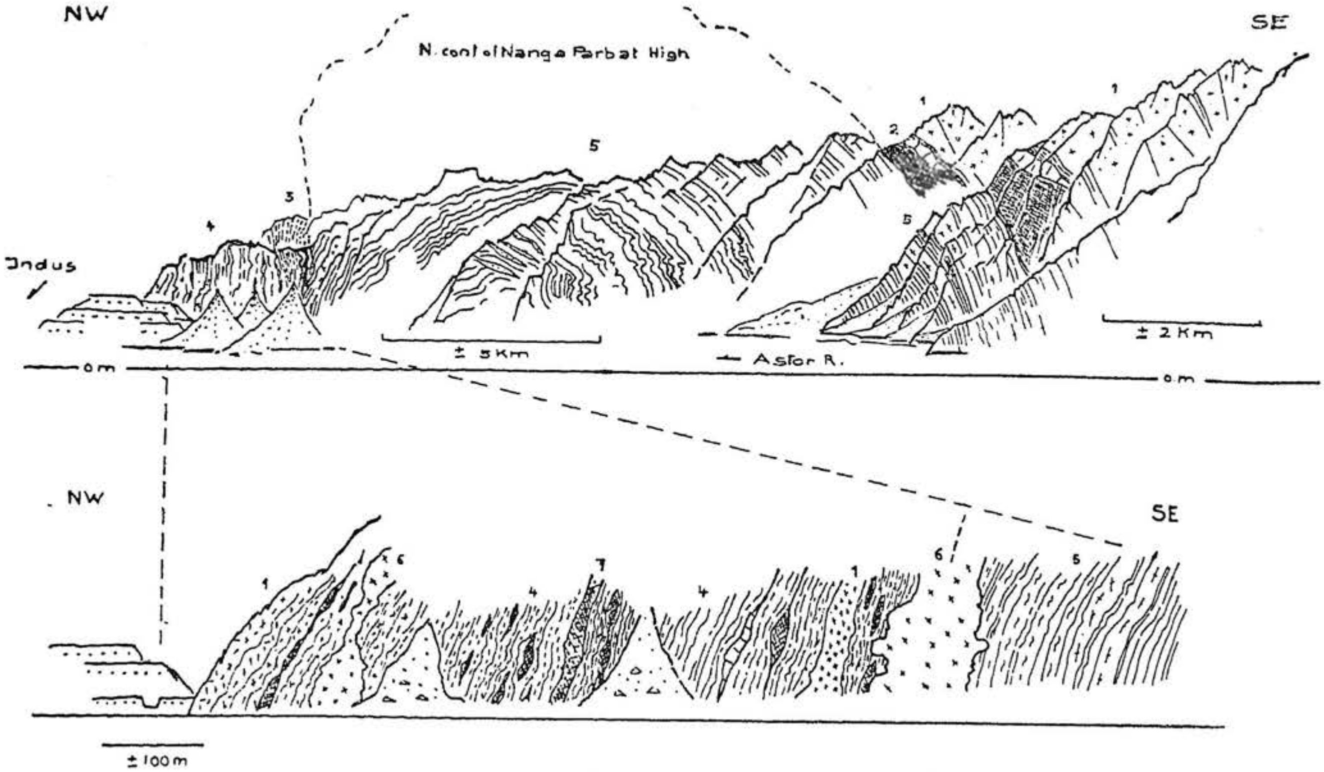


Fig. 13. The Nanga Parbat-Haramosh crystalline high between Astor and the Indus valley (detailed section on western flank).

1 main gabbro, includes some tonalites
2 amphibolites with white marble layers
3 highly sheared green schists with gabbro and pyroxenite boundins (partly serpentinized)
4 chlorite schists, highly sheared with lenses of pyroxenites and marbles
5 biotite muscovite garnet granite gneisses, partly as larger augengneisses
6 tonalites
7 layer of garnet amphibolite

tuffs, diabases, melaphyrs, reddish porphyrites and quartz porphyries. Gneisses, schists and granites are missing. The high Nanga Parbat crystalline uplift most likely did not exist during the deposition of the conglomerates, which, from the scanty fossil content, could be of Cretaceous age, equivalent to the Minapin, Chalt and Yasin conglomerates. These conglomerates can be followed to the northeast side of the Kumri pass, where the Dras volcanics increase considerably towards the southeast (Fig. 12).

North of Astor, the contact of the suture zone with the Nanga Parbat-Haramosh spur is again well exposed along the Astor river and in the Indus gorges north of the confluence of the Indus with the Gilgit river. The Astor river cuts through a depression of the crystalline spur between the Nanga Parbat high in the south and the Haramosh high in the north. Along this section one can recognize the antiform, characteristic for this crystalline uplift (Fig. 13). The metamorphism has already increased from a greenschist facies to a medium hornblende facies. Marble and amphibolites are exposed along the flanks. Similar conditions are excellently exposed in the Indus gorge, cutting through the 7400 m high Haramosh uplift (Fig. 14). The profuse intrusions of aplite granite and pegmatite dykes clearly display several phases of compression and intrusions within the old crystalline. The dykes cut through the already tectonized metamorphics and have been refolded in a later phase. Along the west flank of this uplift the contact (suture zone) is outlined again by conspicuous marble bands with amphibolites. The actual trace of the suture is shown by highly sheared and mylonized retrograde chlorite schists. They are faulted against a thick section of noritic gabbros. Apart from an intrusion of a peculiar, biotite rich anorthositic pyroxene gabbro, the norites expose a steep lineation cut by spectacular, mostly parallel acide dyke intrusions. They originate in the south, near the junction of the Indus and the Gilgit rivers, where irregular lenses and small plugs of an aplitic leucogranite represent the roof of larger plution in depth. The granite is unaffected by later movements (Fig. 15).

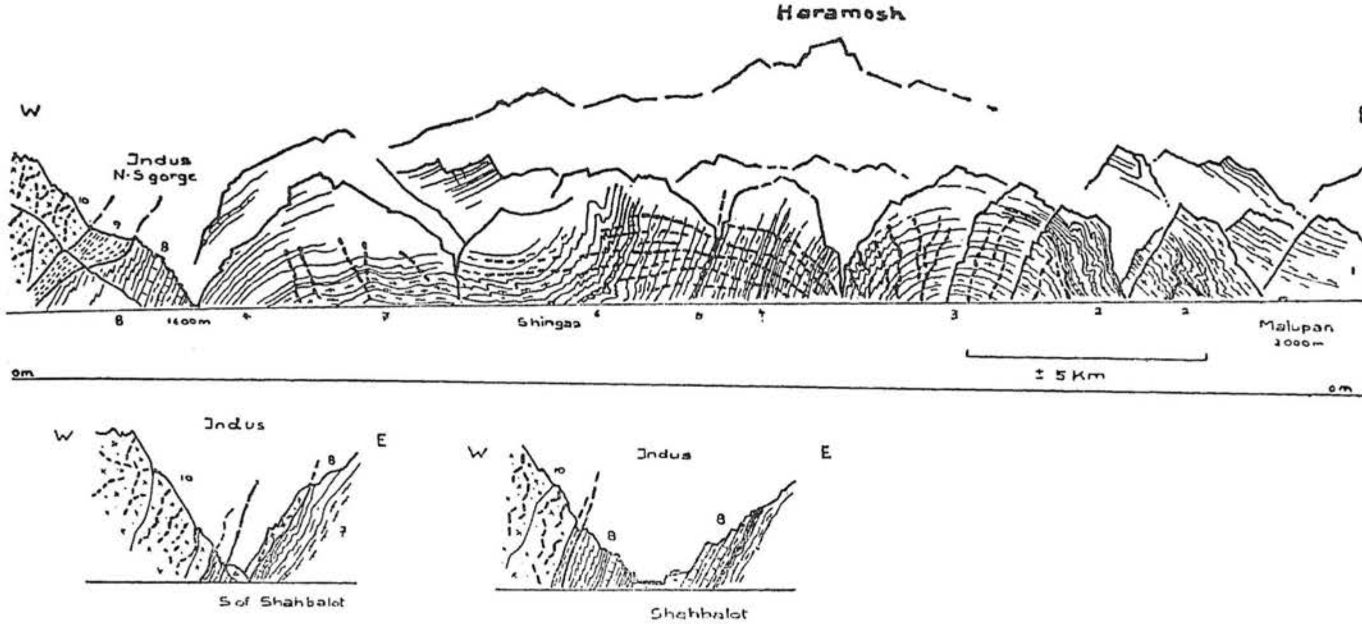


Fig. 14. Section through Nanga-Parbat/Haramosh uplift (western part) along Indus gorge.

1 thick bedded biotite augengneiss
2 biotite granite gneiss with subfolded amphibolites and limesilicates intruded by tourmaline granites and cut by metadolerites
3 biotite augengneiss cut by aplites and pegmatites
4 similar to 2 with diopside marble layers and cut by acid dykes
5 well bedded biotite psammite gneiss with biotite muscovite schists and marbles
6 folded psammite gneisses and marble layers
7 biotite granite gneisses similar to 1 with abnormal strike
8 marble zone with amphibolites and biotite schists, near thrust
9 highly sheared chlorite schists
10 hornblende pyroxene gabbros cut by acid dykes

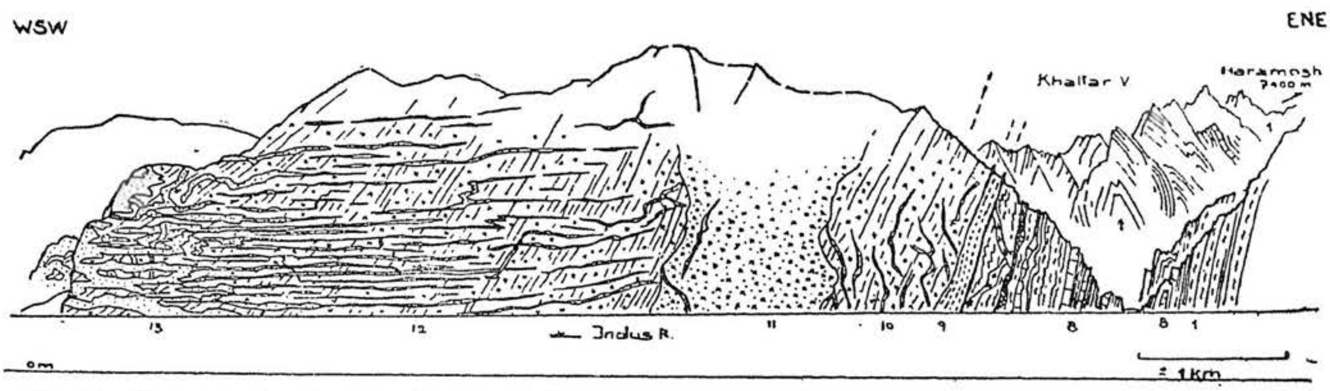


Fig. 15. Western continuation of section along Indus west of Khaltar valley.

11 anorthositic pyroxene biotite gabbros
12 pyroxene gabbros to norites, cut by acid dykes
13 biotite leucogranites and muscovite (biotite) pegmatites intruding gabbros, striking parallel dyke systems

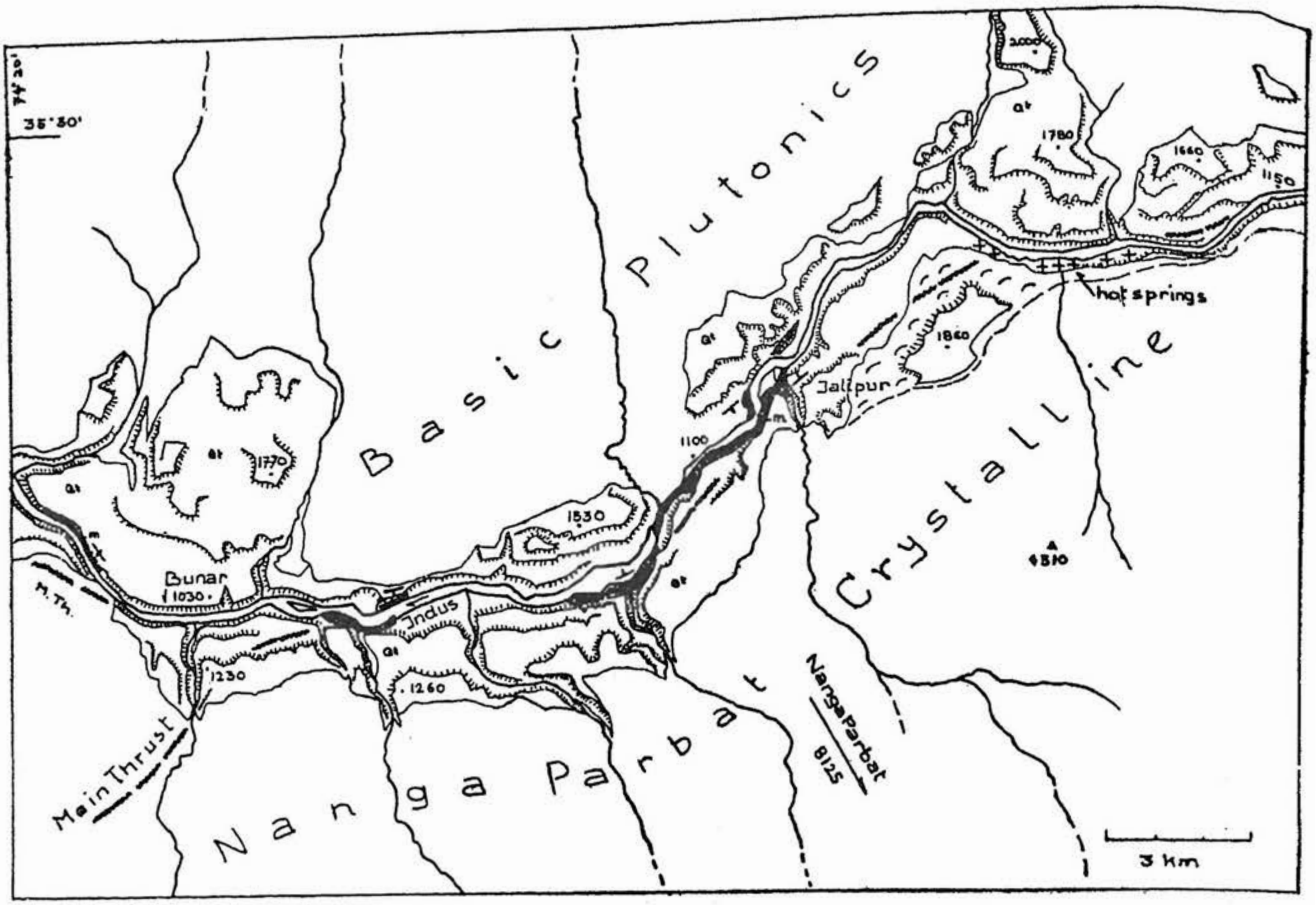


Fig. 16. The Indus valley northwest of Nanga Parbat with thrust line, hot springs and Jalipur molasse.
(Topography from Misch, 1936) (heights in meter)
Qt Indus terraces with elevations (in meters)
m Jalipur molasse of Upper Siwalik affinities
The thrust line devides the Nanga Parbat crystalline from the gabbroid rocks of the basic belt. (Southern Suture Zone)

Along the various contacts mentioned above, we noted the near absence of Dras type volcanics. This is true for the north-south striking contacts along the Nanga Parbat-Haramosh spur. Dras type volcanics may occur again further west, in the wide meta-volcanic belts south of the northern suture zone, however, with a higher degree of metamorphism and certainly in a somewhat different facies. Of special interest is furthermore the fact that from Kargil westwards we miss the Ladakh molasse corresponding to the Kailas molasse, which transgresses the south side of the Transhimalayan plution for neraly 2000 km. In a similar position, though of much younger age, we note the peculiar *Jalipur "molasse"* outcropping along the middle Indus river. First described by Misch (1936), it forms a steep synform following the Indus river for about 20 km and is covered by the spectacular Indus terraces (Fig. 16). The badly sorted conglomerates and sands originated partly from the Nanga Parbat crystallines and less from the basic plution in the north. Foreign to the near surroundings are black and violet porphyrites, porphyries and trachytes, the latter ophitic and fluidal and not unlike the ignimbritic trachytes from the northern Deosai plateau. The steep, partly vertical belt of "molasse" follows the steep thrust line dividing the Nanga Parbat crystalline in the south from the basic pluton in the north, the thrust marked by several hot springs (southern suture zone). We do realize that the structural emplacement of the Jalipur "molasse" is surprisingly similar to that of the Kailas molasse in general, though the Jalipur sediments resemble much more the Upper Siwaliks. A molasse type sedimentation in such a deeply eroded valley is still surprising, particularly since Jalipur is the spectacular place, where we find within a short distance, the largest difference in elevation known in the world (from the Indus to the Nanga Parbat summit along 21 km 7025 m of elevation).

The western continuation of the above mentioned suture zone is difficult to follow. One branch may run towards the ultramafic rocks of the Babusar pass, the other probably continues along the east-west directed Indus valley through Chilas, with its spectacular dunites and cumulate norites. It may end up in the Kandia river, at the south bend of the Indus, with ultramafic lenses and a conspicuous schist belt (see Fig. 1) (Jan, 1970). South of the Kandia river thrust zone dominates a

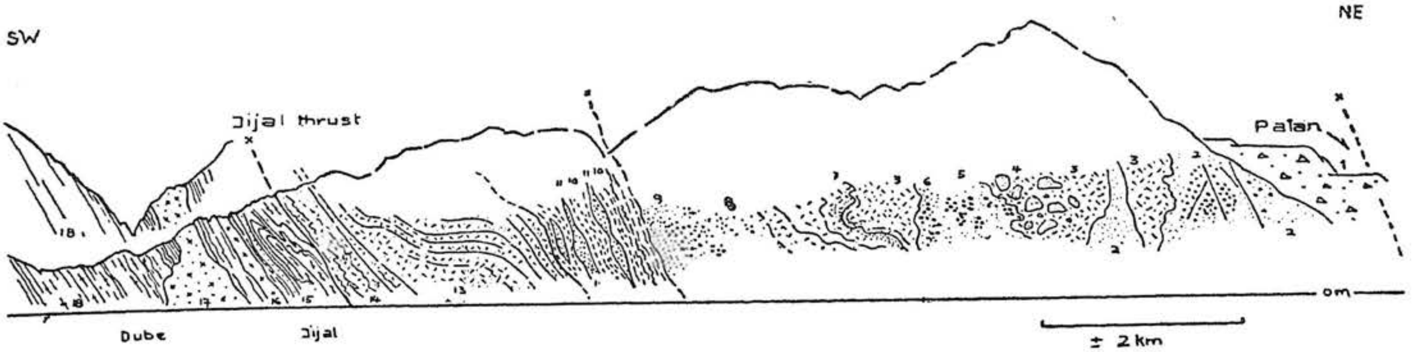


Fig. 17. Section from Patan to Jijal (Duber).

1 large fanglomeratic terraces of Patan
2 pyroxene garnet granulite
3 hornblendite
4 hornblendite with inclusions of pyroxene garnet granulite
5 pyroxenite with patchy garnet fels
6 garnet pyroxenite
7 garnet pyroxene granulite, with primary (?) layering
8 pyroxene garnet fels
9 garnet pyroxenite (somewhat eclogitic ?)
10 sheared amphibolites with lenses of garnet pyroxene granulite
11 pyroxenite and garnet pyroxenite layers
12 olivine fels with large olivine cryst
13 olivine fels (dunitic) and pyroxenite with primary layering
14 serpentinized pyroxenite thrust on 15
15 banded augengneis, amfibolites, schists locally graphitic
16 banded aplite granite
17 biotite hornblende granite
18 biotite schists, quartzites and graphitic schists

retrograde greenschist facies gradually changing into amphibolites and hornblende gneisses. It is intruded at Kamila by irregular white, locally garnet bearing biotite (muscovite) granites not unlike the young Nomal granites of the Hunza valley. After Patan (fracture zone covered by large terraces) one enters the spectacular granulite zone faulted against the ultramafic rocks of jijal and finally we reach the jijal thrust, where this whole section of deepest crust and mantle rocks — strikingly similar to the Ivrea slice in the southern Alps — is thrust southwards onto the gneissic basement (Fig. 17). It is also the location of the large earthquake of December 1974, where focal mechanism solution indicated a clear SSW thrusting (Pennington 1979).

The relations of these major thrusts to the suture zone or zones is still highly uncertain. This is equally the case for the blueschists and the ultramafics of the Shang-La (pass). Following partly Jan and Tahirkheli (1969), Desio (1977), Tahirkheli and Jan (1978), and based on my own observations, some connections have been tentatively drawn (Fig. 1). They are still very doubtful. The Shang-La and the Jijal-Patan accidents are all located on the north end of the outstanding Indus anomaly with its dominating north-south lineaments. Much work is still necessary in order to understand this picture, which is the product of various tectonic events of very different rock types of very different ages.

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