GOVERNMENT OF PAKISTAN

GEOLOGICAL SURVEY OF PAKISTAN

Information Release No. 115

GEOLOGY AND GEOCHEMISTRY OF PART OF HUNZA AREA GILGIT AGENCY

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ISSUED BY THE DIRECTOR GENERAL, GEOLOGICAL SURVEY OF PAKISTAN, QUETTA

1980

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ABSTRACT

Reconnaissance geological mapping and geochemical investigations were carried out at 1:250,000 scale during September and October, 1975 from Bulchi Das to Khunjerab in the Upper Hunza Valley, lying in topographic sheets 42 L and 42 P. During this field season, the reconnaissance mapping was done mostly along the Karakoram Highway.

Two mountain ranges running approximately east-west Karakoram in the south, and Hinduraj in the north. These mountain ranges consist of acidic igneous rocks viz. granite/granodiorite. The region between these ranges consists of sedimentary and metasedimentary rocks including limestone, slate, gneiss, schist and quartzite of probably Upper Carboniferous to Jurassic age. Fossils in the limestone and the slate are not common. Folding within sedimentary and metasedimentary rocks can be seen at some localities.

The contact of the Karakoram granodiorite with the Pasu slate is faulted, but with the metamorphic rocks of Baltit group it is intrusive.

The high grade metamorphic rocks garnet-mica schist, and coarsely crystalline marble, probably indicate thermodynamic regional metamorphism caused by the intrusion of the two huge silicic batholiths (Karakoram & Hinduraj) composed mainly of biotite-granodiorite.

The geochemical analyses of minus 80 mesh of the rock chip and stream sand samples show that the values of copper, zinc cobalt, nickel, lead, gold and silver are quite low to merit any further work in the investigated area.

INTRODUCTION

Purpose and scope

Reconnaissance geological mapping and geochemical sampling were carried out at 1:250,000 scale during September October, 1975 from Bulchi Das to Khunjerab in the Trans-Himalayan region of Gilgit Agency. The area mapped during this period lies mostly along the KaraKoram Highway in Toposheets 42 L and 42p. The reconnaissance geological mapping of about 900 square kilometers was completed during the period mentioned above. The area east of Misgar was previously unmapped due to its high relief, steep slopes and lack of communication. Traverses were made mostely along the right bank of the Khunjerab River. The left bank of the river remained almost unapproachable due to bad weather conditions and lack of communication.

Location and accessibility

Situated in the northeast corner of Pakistan, Hunza is a federally administered area. China is in the east of Hunza and Afghanistan in the northwest (Fig:1). It is linked with China by the all-weather KaraKoram Highway; with Afghanistan accessibility is only through mule - tracks. The foot-path along Shimshal River leading to Shimshal has almost destroyed due to constant land-sliding. Shimshal village is a most difficult place to be approached. The mountains are virgin & very steep, and due to the danger of land slide communication is difficult and unpredictable.

Previous work

Hayden (1914) in a hurried trip of the Hunza Valley noted the presence of slate, quartziteand limestone between Pasu and Misgar. He described these rocks as equivalent of the "Palaeozoic and Mesozoic beds of Chitral and Yasin".

Clark (1948) studied the slate, limestone and quartzite cropping out to the north of Karakoram granodiorite in the Hunza Valley. He named them the "Khaibar series" and placed them in the Upper Carboniferous or the Lower Permian, on the basis of fossils collected from Khaibar, Misgar and the Shimshal Valley.

Ivanac, Traves & King(1956) mapped the Hunza Valley upto Khaibar only. They named the sedimentary and metamorphic rocks of Permo Carboniferous age as "Darkot group", on the basis of their well-developed section near Darkot village in the Yasin area. The type section comprises slate, limestone, quartzite and garnet-mica schist.

Schneider (1957), during 1954, as a member of the Austro-German expedition to the Batura area, reported on the geology of the area lying south of Khaibar village. Danilchik and Tahirkheli (1959) wrote a note, concerning radioactive and heavy minerals in the alluvial deposits of the Lower Hunza Valley.

Abu Bakr (1965) did reconnaissance mapping in the Hunza Valley upto Misgar during the summers of 1951 and 1952. He gave the name "Darkot group" to the sedimentary and meta-sedimentary rocks of Permo-Carboniferous age lying between the Himalayas in south and the Hinduraj Range in north, which have been intruded by the granodiorites of the Karakoram and Kailas Ranges.

Stauffer, K.W. (1968), during the Karakoram expedition in the summer of 1962, described the lithological units in the Baltit-Hispar area, lying south of the Karakoram Range. He gave the name "Baltit group" to a group of rocks consisting of garnet-staurolite schist, garnet-mica schist, garnet amphibolite, coarsely crystalline marble, micaceous quartzite, cut by Layers and lenses of biotite-gneiss. These rocks, described as more metamorphosed than those of the "Chalt schist" comprising of quartzbiotite schist in the vicinity of Chalt in the Hunza River Valley, These rocks were included in the "Darkot group" by Ivanac, Traves & King (1956) and Abu Bakr (1965).

Desio (1972, P.283 and 284), during his Upper Hunza expedition in the summer of 1962, further sub-divided the lithological units which had been described by Ivanac, Traves, and King(1956) and Abu Bakr (1965).

Desio (et el) did more detailed work than the previous workers. He divided the igneous rocks into the following units: Giraf syenite (Eocene); granodiorite of the axial batholith (Pliocene), with pegmatite and aplite dykes (Late Pliocene), syenite prophyry and amphibolite dykes corssing the meta-sedimentary rocks.

The sedimentary rocks of Upper Palaeozoic and Triassic age were divided by Desio (et el) as follows: Misgar slate (probably the oldest); Kilik formation of uncertain stratigraphic and tectonic position; Gircha formation (Permian); Pasu slate of uncertain stratigraphic position; and Gujhal dolomite (Triassic/ Lower Jurassic).

The metamorphic rocks to the south of Karakoram granodiorite were divided by him as follows: Dumordo formation and the migmatitic plagioclase gneiss of unknown age.

These sub-divisions were made on the basis of difference in the lithological character and the presence of fauna. He further correlated the stratigraphy of the Upper Hunza Valley with that of the Shaksgam Valley, both located to the north of the Karakoram axial batholith.

Acknowledgements

The authors are grateful to the local civil authorities for their maximum cooperation. They are grateful to the Resource Development Corporation, Karachi, for performing the metallemetric analyses of geochemical stream sediment and rock samples. S.M. Habibullah also analysed a few rock samples in the laboratory of the Geological Survey of Pakistan, Islamabad.

The authors are also indebted to B.A. Shami, Lecturer, Department of Geology, University of the Punjab, for probable indentification of the micro-fossils.

GEOGRAPHY

Climate and habitation

The mapped area lies in the Trans-Himalayan water shed. It is characterized by very low precipitation, only about 10 cms a year, cold winter and mild summer, and very scanty vegetation. The precipitation is mostly in the form of snow, most of which falls above 5,000 meters in summer and about 2,000 meters in winter. The population is also very sparse and is confined largely to major valleys.

Topography

The mapped area is extremely mountaineous and rugged. The two main ranges, Karakoram and Hinduraj are aligned in a northwest-southeast direction. The high peaks in the area are mostly between 6,000 and 6,700 meters, approximately. The highest peak is approximately 8,513 meters in the Batura area and the lowest contour is of 2,583 meters, approximately along the Hunza River in the Gulmit area. The mountain ranges are permanently snow covered in high altitudes and are the birth place of the glaciers. The rivers (especially Khunjerab, Chapursan, Shimshal) have deeply dissected the topography, thus making narrow gorges with almost vertical walls. High water falls are common in small tributaries. Glaciation also played an important role in producing such rugged topography.

Drainage system

The Hunza River starts from the southern slopes of the Hinduraj Range and runs in a north-south direction, cutting across the Karakoram Range. Its principal tributaries - Shimshal, Batura, Ghujerab, Khunjerab and Chapursan, run longitudinally through the Karakoram and the Hinduraj Ranges and are aligned parallel to the strike of the metasedimentary rocks.

The Karakoram and the Hinduraj Ranges make the watershed. There are several glaciers in these ranges. The tributaries of the Hunza River show parallel drainage. On both flanks of the Hunza Valley are present numerous tributary streams which join with the main one at alsmot right angles. The principal tributary streams are the Chapursan, the Abgarch, the Khunjerab, the Ghujerab, the Shimshal and the Kilik. The Batura, Pasu, Ghulkin, and Gulmit Glaciers occupy the other major tributary valleys. The watershed between these valleys are permanently snow covered.

Lakes

Two glacial lakes were observed in the mapped area; 1. Shishkat Lake 2. Batura Glacier Lake.

The lake near Shishkat village is the result of the daming of the Hunza River by the glacier broken from the Momhil Glaciers which travelled down through the Parthbar Gah. This lake measures about 30 meters in depth and 1.5 km in length and is continuously being filled up with the alluvium brought by the Hunza River and the hill scree.

The Batura Glacial lake is the result of plucking and erosion hollows produced onthe bed rock by the action of the Batura Glacier.

Glaciers and glaciation

The permanent snowline in the Karakoram and the Hinduraj Ranges is at about 5,700 meters. The glaciers in the mapped area are disposed longitudinally to the Karakoram Range, i.e. northwest to southeast.

The glaciers in the mapped area are Batura, Pasu, Gulmit, Chulkin, Parpik, Mintaka and Ghap Kuksel Dur. The Batura, Pasu, Gulmit and Ghulkin Glaciers originate from a common snow field in the Western Karakoram. The Batura Glacier is the fourth largest in the world and has a velocity of 1-2 cms/day at the margins and about 10 cms/day in the central portion (1975, Chinese glaciologist, personal oral communication). The small tributaries of the principal tributaries of the Hunza River also have small glaciers. Some of the valleys show evidence of past-glaciation in being wide and U-shaped. Unsorted accumulation of boulders, lateral and terminal morains and presence of hanging valleys, have been noticed in the area. The terminal morains of Ghulkin and Batura Glaciers are exposed on the Karakoram Highway, while that of the Pasu Glacier is about one km away but its glacio-fluvial deposits reach upto the Karakoram Highway.

GEOLOGY

General Statement

The mapped area is underlain by a sequence of sedimentary and meta-sedimentary rocks, intruded by acidic igneous rocks. The sedimentary and metasedimentary sequence include slate, graphitic schist, quartzite, limestone, marble and gneiss of Upper Carboniferous to Jurassic age. These rocks have been intruded by the acidic igneous mass (mostly granodiorite) of Tertiary age forming the Karakoram and Hinduraj Ranges. Quaternary moraines, stream gravel, and alluvium cover the bedrock in the valleys. The lithostratigraphic units in the mapped area are given in Table 1.

Table-I: Litho-stratigraphic Summary of the Upper Hunza Valley, Gilgit Agency.

Period	Group	Lithology
Quaternary	Quaternary formation	Moraine, stream-gravel alluvium.
Tertiary	Hinduraj granodiorite. Karakoram granodiorite	Biotite-granodiorite/granite, diorite, orthogneiss, pegmatite,
Triassic and Jurassic	Dolomitic limestone	Limestone, dolomitic limestone, marble.
Permo-Carboniferous	Baltit group Darkot group	Slate, limestone, quartzite, gneiss, mica schist, migmatitic gneiss.

The sedimentary and metasedimentary rocks generally strike east-west and west northwest and run almost parallel to the Karakoram and Hinduraj Ranges. The sedimentary rocks towards north of the Karakoram Range show moderate type of metamorphism, thus preserving fossils at certain localities; while those south of the Karakoram Range have been intensly metamorphosed and are devoid of fossils. These high grade metamorphic rocks are the result of thermo-dynamic regional metamorphism.

The intensity of metamorphism in the Permo-Carboniferous rocks gradually increases from the Yasin Valley towards the Hunza Valley (i.e. from west to east). The Mesozoic (Triassic, Jurassic) hard, compact, dolomitic limestone show sharp as well as, gradational contacts with the underlying slate formation.

No ripple-marks or cross-bedding in the sedimentary and metasedimentary rocks has been noticed, which indicate deep sea deposition.

Permo - Carboniferous Rocks

Darkot group:-

The Darkot group comprising of sedimentary and metasedimentary rocks are exposed between the Karakoram and the Hinduraj Ranges in the Hunza area. The rocks of this group also crop out along the Siachan and upper Baltoro Glaciers, in the southeast of the mapped area, where they are interupted by the K-2 gneisses (Gansser, 1964; p.31).

The type section lies between the Darkot village and the Darkot Pass, in the Yasin Valley (Fig.1). This type section comprises of slate, limestone quartzite and garnet-mica schist.

Hayden (1914, in Ivanac, Traves and King,1956; p.6) described the slate, limestone and quartzite of the Darkot group between Misgar and Pasu and considered them to be the equivalent aof the beds of Paleozoic and

Mesozoic ages of Chitral and Yasin.

Clark(1948), during his visit of the Hunza Valley, studied the slate, limestone and quartzite outcropping north of the Karakoram granodiorite. He named them the "Khaibar series" and placed them in Upper Carboniferous or lower Permian Epoch on the evidence of fossils collected from the Khaibar Nala. The name Khaibar series was not suitable for the whole group, as the Khaibar section is extremely faulted and the sequence is not fully known. Therefore, the name "Khaibar series" was rejected and the name "Darkot group" was chosen by Ivanac, Traves and King(1956; p.6). Desio & Martina (1972; p.288) named these sedimentary and metasedimentary rocks outcropping in the upper Hunza Valley as the Misgar slate, the Gircha formation the Kilik formation, the Gujhal dolomite and the Pasu slate, on the basis of the differences in their lithology and fossil contents.

The rock units of the Darkot group include slate, limestone, quartzite, garnet+pyrite schist and graphitic schist. The schists and quartzite are exposed in small outcrops and unmappable on 1:250,000 scale. Thin bands of the limestone and quartzite are widespread in the slate. These slates with alternate bands of calcareous sandstone and impure limestone, may be termed as a flysch, that accumulated in the marine geosyncline or foredeep. The rocks of the Darkot group are dynamo-thermally metamorphosed due to their contact with the Karakoram and Hinduraj intrusive igneous masses.

The dark grey, thinly bedded, tough slate containing almost parallel thin bands of dark grey limestone alongwith thin white quartz veins lying just north of the Karakoram granodiorite, has been named "Pasu slate" by Schneider (1957; p.437) and Desio (1963; p.494). As these slates are limited by tectonic contacts, the exact thickness is unknown. In Khaibar area, the slate is highly limonitized and its colour is brown. Near the Shimshal River mouth, the slate is intensly metamorphosed and grades through phyllite into schistose rocks. These schistose rocks show almost parallel intercalations of grey-brown quartzite with pinkish-brown weathering surface and of grey limestone. The chemical composition of the quartzite is shown in Table-4 (Sample - 26/75). Thinly bedded, dark argillaceous limestone is interbanded with thin bands of amorphous, dark grey, calcareous flint with semi-conchoidal fracture, within the slate in Khaibar Gah. The chemical composition of this flint is shown in Table-4 (Sample 32/75).

The dark grey slate, extending from Morkhun in the south to Bili in the north, of the map (Figure.2) along the Hunza River, has interbedded light and dark grey limestone and light grey, coarse grained quartzite bands. The limestone bands are partially metamorphosed and give yellowish brown colouration on weathering. the bands of limestone dominate over that of the quartzite bands. This formation is better exposed in the vicinity of Gircha village, and therefore it has been named as the "Gircha formation" by Desio, Martina, Galimberti, (1963, in Desio, Martina, 1972; p.296). The slate strikes generally WN W-ESE and it is this trend along which the principal tributaries of the Hunza River flow.

From the Khunjerab area in the east to Kilik River in the West and further westwards, a different type of slate is encountered which may be termed as phyllitic slate. It is very fine grained, dark grey to black, at places micaceous and show phyllitic structure. The chemical composition is shown in Table-4 (Sample 40-A/75 and 49/75). The slate usually soils the fingers, when touched. In Bili-Wadkhun area, the slate is calcareous. The excessive limonitization imparts yellow-brown colouration to the slate, as observed at the Khunjerab Top (Sample G-0/75; Table-4). The light grey quartzite and grey to dark grey argillaceous limestone is interbedded and occasionally folded with the slate. The limestone bands within the slate are commonly present downstream from the junction of Gondur-i-Giraf with the Khunjerab River, while the quartzite bands become common upstream from this junction. The argillaceous limestone bands looks superficially similar to the slate at first glance. The general strike of the slate is east-west. This slate has been mapped as "Misgar slate" by Desio (1963; in Desio & Martine, 1972; p.293).

The garnet-pyrite schist and the graphitic schist is exposed at the mouth of Shimshal River. In the garnet-pyrite schist minute to coarse-grained crystals of red garnet and the pyrite crystals of 0.5-0.7 cms dimension are thickly disseminated. The pyrite crystals are developed also in the interbedded grey limestone. The amorphous graphite in the black graphitic schist soils the fingers. The analysis is given in Table-4 (Sample -27/75).

The contact of the "Pasu slate" with the Karakoram granodiorite in the south and with the limestone in the north is probably faulted. The faulted contact of the "Pasu slate" with the limestone extends northwestwards beneath the Batura Glacier. The exact nature of the contact of the "Misgar slate" with the Hinduraj granodiorite is unknown, because the area was unapproachable.

Due to the intense metamorphism, the fossils are poorly preserved and found only at places away from the contacts with the igneous masses. The fossils are commonly present in the massive, grey argillaceous limestone and phyllitic slate but have been largely destroyed by the metamorphism and dolomitization of the limestone. A list of localities from where fossils have been collected is given in Table-2.

Table-2: Localities of the fossiliferous rock units in the Upper Hunza Valley.

Locality	Fossiliferous Rock	Fossils
Khunjerab Top	Argillaceous limestone	Pelecypod
East of Barakhun	Phyllitic slate	Foraminifers/ conodonts
Barakhun Gah (not in situ)	Phyllitic slate	Foraminifers/ conodonts
Korpuran Gah (not in situ)	Massive limestone	Foraminifers, crinoidal stems belemnites brachiopods, pelecypods
Khaibar Gah	Argillaceous limestone	Foraminifers, brachiopods

The Darkot group is of Permo-Carboniferous age (Ivanac, Traves & King, 1956; p.8). The "Pasu slate" is Carboniferous in age, because it is considered equivalent to the Fenestella shales of the Himalayas (Schneider,1957).

On the basis of different types of fossils collected from the lower Chapursan valley, lower Abgarch and eastern slope of the Mt. Kirilgoz, the "Gircha formation" is considered Upper Carboniferous to Upper Permian in age (Desio & Martina, 1972; p.299).

The exact age of the "Misgar slate" is unknown, but it is probably Palaeozoic (Desio & Martina, 1972; p.293). The fossils collected from the black phyllitic slate, from

Barakhun area include condodonts of uncertain age(1976, Geol. Surv. Pak; Paleontology & Stratigraphy Branch, Oral communication). Microscopic study of the same sossils has revealed intense alternation of the microfissils, and thus no diagnositic features have been found. "It is assumed that the slide resembles with the slides of Eocene, on the basis of congestion of fossils and their size". (Shami, 1976, Geol. Deptt; Punjab Univ; written communication).

Ivanac, Traves & King (1956; p.8-9) collected corals, brachiopods, bryozoans and foraminifera from the dark argillaceous limestone within the slate formation from the southern side of Khaibar Gah, about one kilometer west of the Khaibar village; and on the basis of these fossils they assigned a Permian age to this limestone. It coincides with the age given to these rocks by Clark(1948) as Upper Carboniferous or Lower Permian; and with the findings of Hayden(1915) and Schneider (1957) who also discovered the Permo-Carboniferous fauna in the marl and limestone from the northern border of the Batura Glacier.

Baltit group :-

The formation derives its name after the town of Baltit, headquarters of Hunza District, where it is well-exposed (Stauffer, 1968, p.13). These rocks were previously described as "Darkot group" of permo-Carboniferous age by Ivanac, Traves & King(1956) and Bakr (1965). The rocks of the Baltit group could not be studied in detail, because in the mapped area only a small strip of the rocks of this formation is exposed underlying the Karakoram granodiorite, along the Hunza River.

The part of the Baltit group exposed in the mapped area include biotite gneiss, migmatitic-gneiss and mica schist. The gneiss in the mapped area of the Baltit group, which dominates the other rocks is grey and medium to coarse grained. The minerals present in the rock are quartz, feldspar, biotite, hornblende and garnet. Small sparsely disseminated crystals of aquamarine have been reported within the gneiss in Bulchi Das area. The biotite ranges from 20-40% in the gneiss. The percentage of biotite is higher in Brundbar Gah area. This high percentage of biotite reflects the sedimentary origin of this gneiss. The gneiss commonly contains augens of feldspar and is banded at some places. The migmatitic gneiss is also banded. The mineral constituents are biotite, hornblende, garnet, quartz and feldspar. Ptygmatic folding in the migmatitic-gneiss is seen at certain places. In Brundbar Gah, dark grey, finely laminated mica schist has been found.

The Baltit group towards the southwest of Saret (Figure-2) outside the mapped area, consist predominantly of the para-metamorphic rocks-saccharoidal white marble associated with mica schist and mica-feldspar gneiss (Stauffer, 1968, p.14). Gem quality spinel (ruby) commonly I mm to 1 cm size, and in various shades of red and blue is being mined from this coarse crystalline limestone and marble, in the vicinity of Baltit(Alam & Cheema, 1974, p.8). When its contact with the Karakoram granodiorite is approached, the number of gneissic lenses with migmatitic structure increase.

The contact between the rocks of the Baltit group and the Karakoram granodiorite is highly gradational. Tongues of the granodiorite in the Baltit group and xenoliths of the later in the granodiorite mass are common along the contact. Numerous pegmatite, aplite and granitic veins cut across the foliation in the gneiss near the above mentioned contact.

No fossil was found in the rocks of the Baltit group in the mapped area. This is perhaps due to their regional metamorphism.

Ivanac, Traves & King(1956) included the Baltit group in the Darkot group of Carboniferous and permian age. Desio and Martina (1972, p.292) included them in the Dumordo formation and assigned Permo-Triassic age.

On a regional basis the fossiliferous limestone and shale beds of the Sandhi village (out of the mapped area) 80 kilometers west of Chalt(Figure-1) in the Yasin valley appear to be the continuation along strike of the metamorphic rocks of the Baltit group in the Hunza Valley. The limestone and shale contain fossils of Carboniferous and Permian age and therefore, Stauffer (1968, p.17) considers the Baltit group to be equivalent in age to a part of the Darkot group of Carboniferous - Permian age.

Triassic and Jurassic Rocks

Dolomitic limestone:

The limestone and dolomitic limestone sequence extends over a large area between Pasu and Morkhun villages and also along a small strip running NW-SE at Bili; thus covering the prominant high peaks viz. Mts. Kirilgoz, Jurjur Khona Sar, Tupopdan & Lupghar Ranges (Figure-2).

The limestone is grey, massive, partially dolomitized and metamorphosed, with small inter-calations of red marl. The base of the metamorphosed dolomitic limestone towaards northeast of the Lupghar Range, appears to be a calcareous breccia with angular fragments of quartzite and grey limestone embedded in a white calcareous matrix. Red stainings and fragments of iron oxide are also widespread in the calcareous breccia, which make it a good decorative stone. It seems to be an intraformational breccia, as the fragments of the underlying slate are totally absent.

The highest part of the Mt. Jurjur Khona Sar is underlain predominantly by light coloured limestone and dolomitic limestone with the alternating limestone and shale beds towards the base. This calcareous-dolomitic sequence has not been tectonically disturbed and show low angle dips.

Schneider (1957, in Desio & Martina, 1972, p. 103) presented a schematic cross-section of Mt. Tupopdan, showing some stratigraphic subdivisions of the calcareous-dolomitic sequence. From bottom to top, the sub-divisions are as under :-

a) thin to medium bedded dark grey limestones and thin bedded siliceous limestone with, at the base, conglomerates of Middle Triassic age.

b) grey limestones and massive dolomites, locally containing crystallised cross-sections of Megalodonts of Norian-Rhaetian(?) age.

c) light grey and thick bedded limestone with thick intercalations of black phyllitic schists with crushed Belemnites of Rhaetian-Lias(?)age.

d) thick-bedded, lightgrey limestones and saccharoidal dolomites (Dogger-Malm, Lower Cretaceous in part).

The limestone and dolomitic limestone sequence lying between Pasu and Morkhun has been mapped as "Gujhal dolomite" by Desio & Martina (1972, p.288). The same authors have shown its thickness to be 5,000 metres.

At certain localities, viz. south of the Batura Glacier mouth and upper reaches of the Khaibar Gah, isolated small patches of white, almost saccharoidal marble are present. North of the mouth of the Pasu Glacier the dolomitic limestone (20/75 Table-4) has been metamorphosed to semi-conchoidal, white and grey banded marble.

In Bili area, the arnaceous limestone is well-bedded, slightly dolomitized, semi-conchoidal and is associated with red ferruginous marl (36-A/75&36-B/75, Table 4).

At the higher elevations the limestone contains frequent bands of red marl, which is the characteristic feature of the limestone sequence of this belt. At the base of the arnaceous limestone, black carbonaceous shale is widespread, as seen towards south of the Misgar village. This limestone sequence, with the general similar strike, extend as an elongated belt running NW-SE, between the Misgar slate to the north and the Gircha formation to the south, along lower Chapursan, Kilik and Shikarjera Rivers. This elongated belt of limestone has been mapped as "Kilik formation" by Desio, Martina & Galimberti-1963 (in Desio & Martina, 1972, p.294).

The fossiliferous, grey coloured, well bedded argillaceous limestone interbedded with slate, at the Khunjerab Top, has partially been metamorphosed due to its proximity with the granodiorite. The light to dark green, semi-conchoidal, cherty bands within the metamorphosed limestone are common. The contact of slate and limestone bands with the igneous rock could not be traced due to snow cover and thus the nature of the contact is unknown.

Due to dolomitization and partial metamorphism of the limestone, the fossils are not well-preserved. However they can only be seen within the grey limestone (boulders) in the Korpuran Gah. On the basis of the abundance of belemnites (cephaloped), crinoidal stems, foraminifera and pelecypods, found in boulders of this limestone in the Korpuran Gah, the limestone may be placed in the Mesozoic Era.

Bakr (1965, p.9) has placed all the sedimentary and meta-sedimentary rocks lying between Karakoram and Hinduraj Ranges in Permo-Carboniferous.

Gansser (1964, p.31) placed the huge section of limestone and dolomitic limestone (Gujhal dolomite) in Triassic on the basis of Triassic megalodonts and Jurassic belemnites.

Desio & Martina (1972, p.288) placed the Gujhal dolomite in Triassic and Jurrassic(?) age.

Desio, 1966 (In Desio & Martina 1972, p.295) on the basis of the crinoids collected at the base of Kilik formation, from the confluence of Kilik and Chapursan Rivers, tried to correlate it with the Devonian crinoidal limestone outcropping at Mt. Shogran near Reshun in Chitral area and somewhere else in Afghanistan and also in Pamir. He further referred Ivanac, Traves & King (1956) that the crinoidal limestone is also present in the Carboniferous. So he suggested that the Kilik formation could be either Devonian or Lower Carboniferous, but also be of a different age.

This Kilik formation apparently seems to be younger than that of the Gircha formation and the Misgar slate, which dip steeply under the Kilik formation. As the Gircha formation is of Permian age, so it would be atleast post-Permian. Further, its lithology corresponds to that of the "Gujhal dolomite" of Triassic-Jurassic(?), so it can safely be placed with the Mesozoic Era.

Tertiary

Karakoram granodiorite:

The Karakoram granodiorite forms the core of the Karakoram Range. Due to its great extension, it can be called a batholith. The term Karakoram batholith was first used by Clark (1949) and later by Kazmi (195.), for the igneous rocks which form the Karakoram Range in Hunza. In Hunza Valley the Karakoram granodiorite has a width of approximately ten kms. outcropping between Saret and Ghulkin along the Karakoram Highway. It shows varying contact relations with the invaded rocks. It's southern contact in Bulchi Das area shows a gradation from granodiorite through diorite-gneiss to schistose rock; but its northern contact with the slate is quite sharp without any notable alteration of the c country rock.

The granodiorite is of lightgrey colour, medium to coarse grained with rusty brown weathering coloration. Megascopically, the rock consists of quartz, feldspar, biotite and hornblende. The presence and occassional predominance of the hornblende over the biotite distinguishes the Karakoram intrusive rocks, from most of the Himalayan granite types (Gansser, 1964, p.34).

Tongues of pegmatite and granite-aplite extend from granodiorite mass to gneiss on the southern side of the range.

No foliation in the granodiorite was observed in its northern and the central portions, but on its southern side (south of Gulmit) minor foliation alongwith ptygmatic folding exists; thus showing its gradation towards gneissic rock as described in the Baltit group.

Accompanying the granodiorite, hornblendic rocks (amphibolite/hornblendite) are also present in the Gulmit Gah, having colour index of approx. 85.

In upper reaches of Ghulkin, Pasu & Batura Glaciers xenoliths of slate and micro-granodiorite are present within the porphyritic-granodiorite.

A quite later pneumatolitic phase has impregnated these granodiorite locally with needle-like radiating crystals of black tourmaline alongwith quartz, epidote, pyrite and garnet(mimute crystals) as observed in the Gulmit Gah.

According to Desio & Martina (1972, p.289) absolute age dating by the Rb/Sr method, has revealed the age of the granodiorite as 8.6 million years (Pliocene).

Hinduraj granodiorite:

The name "Hinduraj granodiorite" is given to the igneous rocks comprising the Hinduraj Range in the northern most portion of Pakistan. The range runs almost east-west along the borders of Pakistan with China and Afghanistan. The main rock type of the range in the Hunza area is light grey coloured, coarse grained and unfoliated granodiorite, showing brown weathering colour. The minerals present are quartz, feldspar, biotite, hornblende. The light coloured minerals are dominant in this rock. The granodiorite has intrusive relations with the metasedimentary rocks.

Small intrusions in Wadkhun and west of Khunjerab area have sharp intrusive contact with the invaded rock (slate). These intrusions are mostly acidic & intermediate in composition in Wadkhun area. Near Shakachtar (Wadkhun) a symmetrical laccolith of acidic igneous composition (granite) measuring about 200 meters width is present along the Karakoram Highway. The intrusive magma of this laccolith has domed up the bedding of the overlying calcareous slate, at low angle. Small dykes are also present near this laccolith.

Due to very high altitudes and a rough terrain, these intrusions could not be traced further during reconnaissance. The main Hinduraj granodioritic body runs east-west and crosses the mapped area north of Misgar and Khunjerab Top. Its northern boundry is unknown, where it extends into the Chinese territory.

Desio and Martina (1972, p.288) named the igneous intrusion north of Wadkhun area as "Giraf Syenite" after Condur-i-Giraf (a tributary of Khunjerab River) which cuts across this igneous body.

Pegmatites:

The pegmatites alongwith granite-aplite veins transect the banded biotite gneiss and are widely distributed from Saret to Gulmit. They range in thickness from merely 5 cms. to 12 meters (Brundbar Gah) and in length from 45 meters to one kilometer.

The pegmatites are white in colour and coarse to very coarse in grain size. Megascopically, they contain quartz, feldspar, muscovite (colourless to light blue), red garnet (minute crystals), hornblende (traces) and prismatic crystals of black tourmaline (schorlite). Sparsely distributed blue crystals of aquamarine are reported to have been excavated by the local residents from pegmatites opposite Shiskhat village at a rate of 30 grammes per 10 sq. meters of surface area.

Although local variations are present, pegmatites generally dip at low angles towards west and trike northeast. The host rock (biotite gneiss) has been transected by pegmatites and aplite veins in a randum manner. These intrusions cut across the foliation of the host rock at different angles. Two phases of intrusion prevailed - the early phase represent thick and large pegmatites which often show zoning but are not homogenous; while the second phase (younger) is represented by thin veins of medium to coarse, somewhat prophritic granite-aplite, almost homogenous in character. The later generally strike east-northeast and dip at an angle higher than those of the earlier pegmatites.

In some zoned pegmatites of the earlier phase, big crystals of quartz, feldspar and muscovite are present in the central portion while the finer crystals are on the margins. This marginal portion is almost devoid of mica.

Age of the Intrusive rocks:

The Hinduraj granodiorite and the Karakoram granodiorite are almost similar in composition, lithology, trend, grain size and mode of occurrence. As they are intruded into the Permo-Carboniferous rocks therefore, their age is post-Permian. As in Yasin Valley Cretaceous rocks (limestone, quartzite & slate) are folded with the Permo-Carboniferous rocks, which have been intruded by granodiorite is at least post-Cretaceous (Bakr, A-1965:.11). Therefore, these plutons may be emplaced during the Himalayan mountain building period which existed in Early Tertiary time. The granodiorite of the Karakoram & Hinduraj Ranges probably originated from a common magma of a great batholithic mass at depth.

Quaternary

Alluvium:

Alluvial, illuvial and deluvial deposits consisting of various sizes of boulder, gravel, sand and clay are widespread along the Hunza River and its principal tributaries. These irregular deposits have not been studied and mapped in detail. Immense scree cover extensive area along some steep slopes of valleys, resting at their maximum angle of rest.

Moraines are present in the ancient glaciated areas - with non-stratified boulders, cobbles, gravel sand and clay. At higher altitudes glacial till is present which is rich in glacial silt. This till horizon has been eroded away in the shape of "earth pyramids" as seen in the upper reaches of Bardom Tir (near Khudabad).

GEOCHEMICAL PROSPECTING

Geochemical sampling on a very limited basis had been done as a part of the present field work. The chip samples of the bedrock and the stream sediments samples were collected from suitable places at irregular intervals (Figure-4). The rock samples were crushed to about 80-mesh. The analyses of the samples were made by K.A.R. Ghori, Analyst, Resource Development Corporation, Karachi by the atomic absorption method. The result of the analyses of -80 mesh fraction is shown in Table-3.

The ppm values in rock samples for gold, silver, copper, zinc, cobalt, nickel and lead are quite low and do not show any systematic change from place to place. Although the fresh rock samples show very low ppm values, the weathered limonitic encrustation developed in the cracks of slate (G-0/75, Table-3), show apparently a little higher ppm values especially for cobalt and nickel. As this weathered zone is of very small dimensions, this comparatively higher value warrants no significant importance. The rock samples of slate(49/75 and 40-A/75) collected from the Kunjerab valley, show a little higher value of Zinc over the above mentioned background values. This higher values may be due to the high mobility of zinc and its frequent association with the base metal elements present in slate.

The stream sediment samples were collected from the confluence of major streams. The samples were sieved and only minus 80 mesh fractions were analysed. The ppm value for gold silver and lead are constant being less 0.2 ppm for gold, less than 2ppm for silver and less than 30 ppm for lead in all the samples. The ppm values for other elements range as follow- copper upto 33, zinc upto 30, cobalt upto 18, nickel upto 32.

These low values suggest that the area appears to be barren for the above mentioned elements, according to minus 80 mesh sieved analyses, The coarser fraction might indicate some values of elements particularly that of gold, but no heavy mineral sepration fromthe stream sedments was done.

METAMORPHISM

The Permo-Carboniferous rocks (mostly slates) are probably the product of a low grade dynamothermal metamorphism mainly due to the forceful injection of acidic igneous magma. Also the Himalayan orogeny resulted in an intensive and widespread regional metamorphism in this area and the neighbouring areas towards south.

Pneumatolytic process resulted the formation of needle-like radiating crystals of balck tourmaline, associated with quartz, pyrite & garnet (minute crystals) within cracks. The Permo-Carboniferous rocks, north of Karakoram watershed are less metamorphosed as compared to those lying south of Karakoram watershed. This low grade metamorphism of the Permo-Carboniferous rocks north of Karakoram granodiorite favoured the preservation of fossils in Khudabad and Barakhun areas.

On the other hand, Permo-Carboniferous rocks south of Karakoram watershed are highly metamorphosed resulting in the formation of para-gneisses. These rocks are cut by numerous dykes of granitic composition and pegmatites.

STRUCTURE

The salient structural features of Upper Hunza Valley are:-

1. Parallel mountain-ranges, running generally east-west.

2. Swinging strike of the rocks consequent to that of the ranges. General strike of the rocks being WNW-ESE.

3. Isoclinal folding of the metasedimentary rocks; and in places tending to recumbent folds.

4. Faults in the metasedimentary rocks, trending generally NW-SE and dipping at high angles.

The strike of the metasedimentary rocks is generally parallel with that of the ranges. This may be explained as folding of the rock components around the Karakoram and Hinduraj Ranges, in this area, during the Himalayan orogeny.

Isoclinal folding in the limestone at Pasu and recumbent and fan-folding in the slate and quartzite lying between Wadkhun and Dih were noted. An anticlinal structure along Khunjerab River, about three kms. east of its confluence with the Kilik River, has been noted. This anticline plunges towards south at an angle of about 30^{o}, with a small normal fault parallel to its axial plane, having a throw of about one meter. The Khunjerab River cuts across the axis of this anticline.

It seems that the courses of the principal tributaries of the Hunza River are controlled by the structural trend of the region. The tributaries follow the general strike of the rocks; while the Hunza River itself flows along some major north-south trending fracture or fault. The gradual uplift during the Trans-Himalayan orogeny in Tertiary Period resulted rejuvenation of the rivers, which ultimately caused the extreme topographical relief.

The area experienced much deformation resulting in numerous intraformational and boundary faults among different formations. The evidences of faults are commonly observed in the "Misgar slate" along Khunjerab River. As the intensity of folding is directly related to the plasticity of the various rock formations, so the slates are strongly folded while the resistant limestone beds show minor deformation and are occasionally sub-horizontal.

The gradational contacts of the limestone and the slate show depositional features; while the sharp contacts commonly represent faults. The contact of the Pasu slate with the limestone along Batura Glacier is tectonic(?) as shown by a thrust fault running north west (Geological Map of the Himalayas by Gansser, A. 1964 & Desio, A. 1972).

GEOLOGICAL HISTORY

The Tethys Sea which had spread over parts of northern Pakistan and Turkistan in central Asia during the beginning of Late Carboniferous time gradually began to recede westwards by the middle of the Mesozoic, THe metasedimentary rocks of the Hunza area ranging in age from Permo-Carboniferous to Jurassic were deposited in the Tethys Sea, which extended from Ural to China on one side and Gilgit and Chitral on the other. The predominant slates and distinctive fauna of this area indicate deep-water condition of deposition because of the absence of ripple-marks and cross-bedding. Thus these metasedimentary rocks were deposited under marine conditions alongwith those in northern Baltistan, Hunza and Yasin. According to Auden (1938) and Desio (1930) the same conditions prevailed during the formation of Permo-Carboniferous and Mesozoic rocks of Aghil Range and Shakesgam Valley towards the east of the map (Bakr-1965; p.12). But the Permo-Carboniferous rocks of Despang and Yarkand, according to De Terra (1932, in Bakr, 1965; p.12) include continental as well as marine rocks. This shows the presence of changing land & marine condition in that area.

Reed(1965 in Bakr, 1965; p.12) after examing the fauna of Permo-Carboniferous age from Chitral, Gilgit and Kashmir Valley had remarked that the fauna of the first two places are the same, but that of the third are totally different. Hence, he concluded that the sea of Gilgit-Chitral area must have been disconnected from that of Kashmir area.

During Late Cretaceous period transgression of the sea took place depositing soft Cretaceous limestone in Yasin area (Yasin group). The uplift of the Himalayas and the Trans-Himalayan ranges greatly increased the erosive power of the rivers, thus eroding away soft cretaceous limestone leaving a few isolated exposures, only in Yasin area (Bakr 1965). Intrusion of granite/granodiorite mass of Karakoram and Hinduraj Ranges took place during the Tertiary period exposing parts of a great batholith at depth.

Because of the absence of fossiliferous sediments younger than Cretaceous in the Trans-Himalayan region it is not possible to ascertain the age of folding and the intrusion of granodiorite within the Tertiary Period; but Wadia (1939) and other investigators of Himalayan geology agree that the movements commenced late in the Eocene epoch. The main folding is believed to have occured in the Middle Miocene time. Minor movements have continued into Pleistocene and Recent times.

Thus during the Himalayan Orogeny in Tertiary period the Permo-Carboniferous rocks in the Hunza valley were folded and metamorphosed. These movements initiated the present cycle of erosion, resulting in the accumulation of superficial deposits.

ECONOMIC GEOLOGY

General Statement

The investigated area has no immediate economic potential. Small showings of marble, uranium, gold, pyrite and aquamarine have been located in the mapped area. These showings are described separately below.

Marble

Some small outcrops of white, recrystallized limestone are seen at the following localities:

Pasu Glacier area
Batura Glacier area
Khunjerab Top area
Khaibar Gah area

Pasu Glacier area:

At the mouth of the Pasu Glacier, near the Karakoram Highway, light grey to white marble partially dolomitized, with semi-conchoidal fracture is present. The marble is well-bedded and thinly banded. The bands are alternate grey and white and concordant to the bedding of marble.

Above the surface, the marble measures, about one kilometer in length and about 120 meters in thickness, and dips at 50° NNW (dipping into the hill).

Batura Glacier area:

Milky white marble is present at the mouth of the Batura Glacier towards southern side. It measures about 215 meters in length and 150 meters in thickness.

The marble overlies the dark slate, with a sharp contact. The alignment of marble is not clear; but the underlying slate dips at 65°SW.

The Batura marble and the Pasu marble are probably interconnected with each other beneath the overlying limestone and debris.

Khunjerab Top area:

The limestone in this area has been partially recrystallized and dolomitized. At some localities it has been intensively metamorphosed to white, saccharoidal marble. Generally it has contact with granodiorite intrusion. The dimension is unknown, because of the permanent snow cover.

Khaibar Gah area:

In the upper reaches of the Khaibar Gah, very coarse grained, milky-white, saccharoidal marble is present associated with well-bedded slate.

Its total thickness is unknown, as it could not be traversed further, due to inaccessibility.

The marble would be uneconomical under existing high charges of transportation and comparatively low market value.

Uranium

The mantle sand collected as channel samples, and the gravel from terraces, collected from the Hunza River revealed only 0.001-0.002% (commonly 0.001%) uranium (Danilchik & Tahirkheli, 1959).

This low uranium content suggest that alluvial deposits of Hunza River are economically insignificant for uranium extraction. The detection of zirconium, strontium and rare earths merely reflect the presence of zircon, monazite, uranium and thorium bearing minerals, but their amount is too small to be economical.

Gold

Very small amounts of gold is reported to be recovered sporadically and seasonally by local gold washers from the Hunza River near Pasu, at it's confluence with the Shimshal River. This alluvial gold may have originated in the qurtz veins scattered through much of the country rock, most commonly, through the limestone or slate; or may have been derived from the granodiorite mass underlying the immense glaciated cover in the upper reaches of the Shimshal River.

Pyrite

Pyrite in the form of well-developed crystals of 0.5 - 0.7 cms. dimension, is disseminated in garnet-pyrite schist and limestone at the mouth of the Shimshal River. It is about 15% in the schist and 5-10% in the dark grey limestone bands present within the schist.

Aquamarine

Pegmatite veins extending from Bulchi Das to Gulmit on the right bank of Hunza River, have aquamarine in disseminated form. Small crystals of aquamarine are sparsely dispersed in the pegmatites. The aquamarine is uneconomical, because of its sparsely disseminated form in only a few pegmatites. The other pegmatites are devoid of aquamarine.

Realgar and orpiment

Realgar and orpiment of red and yellow colours respectively have been reported from Ziarat area in the Chapursan River.

Due to the bad weather conditions, the authors could not reach the Babaghundi Ziarat area to carry out the investigation of the mineralized zone. It is suggested to be geochemically investigated in future.

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Table -3 Metallometric analyses of rock chip& stream sand samples from the upper hunza valley.

(Analysed by K.A.R.Ghori)

BATCH 'A' (Rock Chips)

S.No	Sample No	Cu PPM	Zn PPM	Co PPM	Ni PPM	pb PPM	Au PPM	Ag PPM
1.	20/75	∠-20	24	15	15	∠30	∠ 0.2	∠ 2
2.	26/75	∠20	36	∠10	∠10	∠30	∠ 0.2	∠ 2
3.	27/75	∠20	40	∠10	∠10	∠30	∠ 0.2	∠ 2
4.	32/75	∠20	83	∠10	∠10	∠30	∠ 0.2	∠ 2
5.	36-A/75	∠20	95	25	60	∠30	∠ 0.2	2.2
6.	36-B/75	∠20	38	25	25	∠30	∠ 0.2	∠ 2
7.	40-A/75	∠20	170	15	30	∠30	∠ 0.2	∠ 2
8.	49/75	∠20	107	15	30	∠30	∠ 0.2	∠ 2
9.	G-8/75	188	132	485	800	∠30	-	-

BATCH 'B' (Stream Sand)

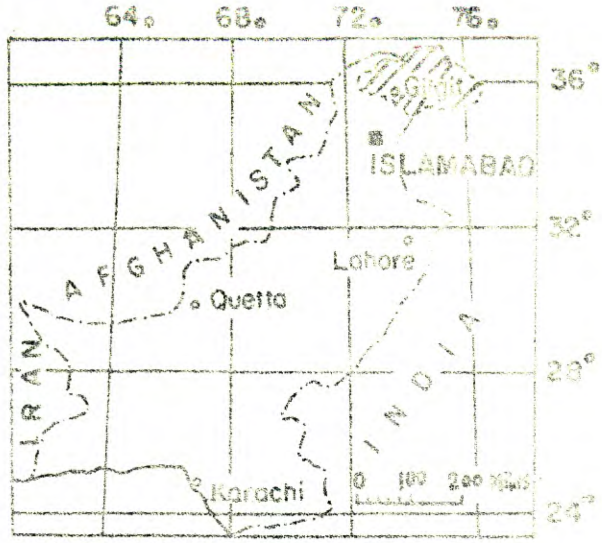
S.No	Sample No	Cu PPM	Zn PPM	Co PPM	Ni PPM	pb PPM	Au PPM	Ag PPM
1.	G-B	∠20	24	10	10	∠30	∠ 0.2	∠ 2
2.	G-G	∠20	∠20	∠10	∠10	∠30	∠0.2	∠ 2
3.	G-K	23	∠20	13	17	∠30	∠0.2	∠ 2
4.	G-L	23	∠20	15	32	∠30	∠0.2	∠ 2
5.	G-M	∠20	24	15	23	∠30	∠0.2	∠ 2
6.	G-N	∠20	30	18	28	∠30	∠0.2	∠ 2
7.	G-P	33	22	13	23	∠30	∠ 0.2	∠ 2
8.	G-Q	33	25	17	32	∠30	∠0.2	∠ 2
9.	G-R	∠20	25	10	13	∠30	∠0.2	∠ 2
10.	G-S	33	20	15	19	∠30	∠0.2	∠ 2

* - ∠ 20 means less then 20.

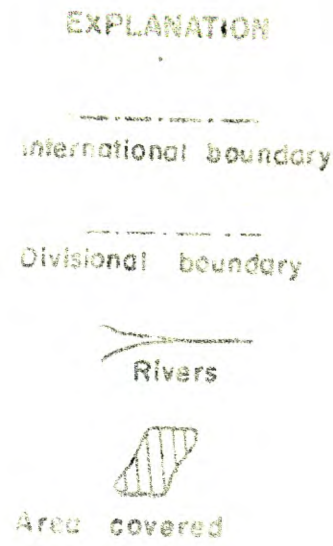
Table 4:- Chemical analyses of rock Chip samples from the Upper Hunza Valley.
(Analysed by S.M. Habibullah)

Sample No.	Rock Name	%SiO_2	%Fe_2O_3	%Al_2O_3	%CaO	MgO	%Carbon	Loss on Ignition	Total:
40-A/75	Slate	71.36	5.88	14.78	2.24	1.70	-	3.20	99.16
49/75	Slate	68.56	6.54	16.72	1.01	2.50	-	3.20	98.53
20/75	Dolomitic-Limestone	0.50	Trace	Trace	33.66 ($CaCO_3$=60.11)	18.77 ($MgCO_3$=39.23)	-	46.98	99.81
C-0/75	Limonite	4.20	32.13	5.20	0.30	Trace	-	39.50	81.33 *
26/75	Quartzite	94.80	0.82	1.88	0.92	Trace	-	1.12	99.54
27/75	Graphitic-Schist	76.86	20.34 (Fe_2O_3+Al_2O_3)		Nil	Nil	2.88	-	100.08
36-A/75	Ferruginous Marly limestone	Trace	4.00	5.00	50.55 ($CaCO_3$=90.26)	Trace	-	40.30	99.85
36-B/75	Arnaceous-limestone	15.80	0.32	0.14	45.95 ($CaCO_3$=82.12)	1.00	-	37.48	99.79
32/75	Calcareous-Chert/flint	88.54	0.40	0.56	4.80	1.60	-	5.10	99.74

* Sample C-0/75 also contains SO_3 = 18.05 % (S=7.22%)



MAP OF PAKISTAN SHOWING
LOCATION OF GILGIT AND BALTISTAN



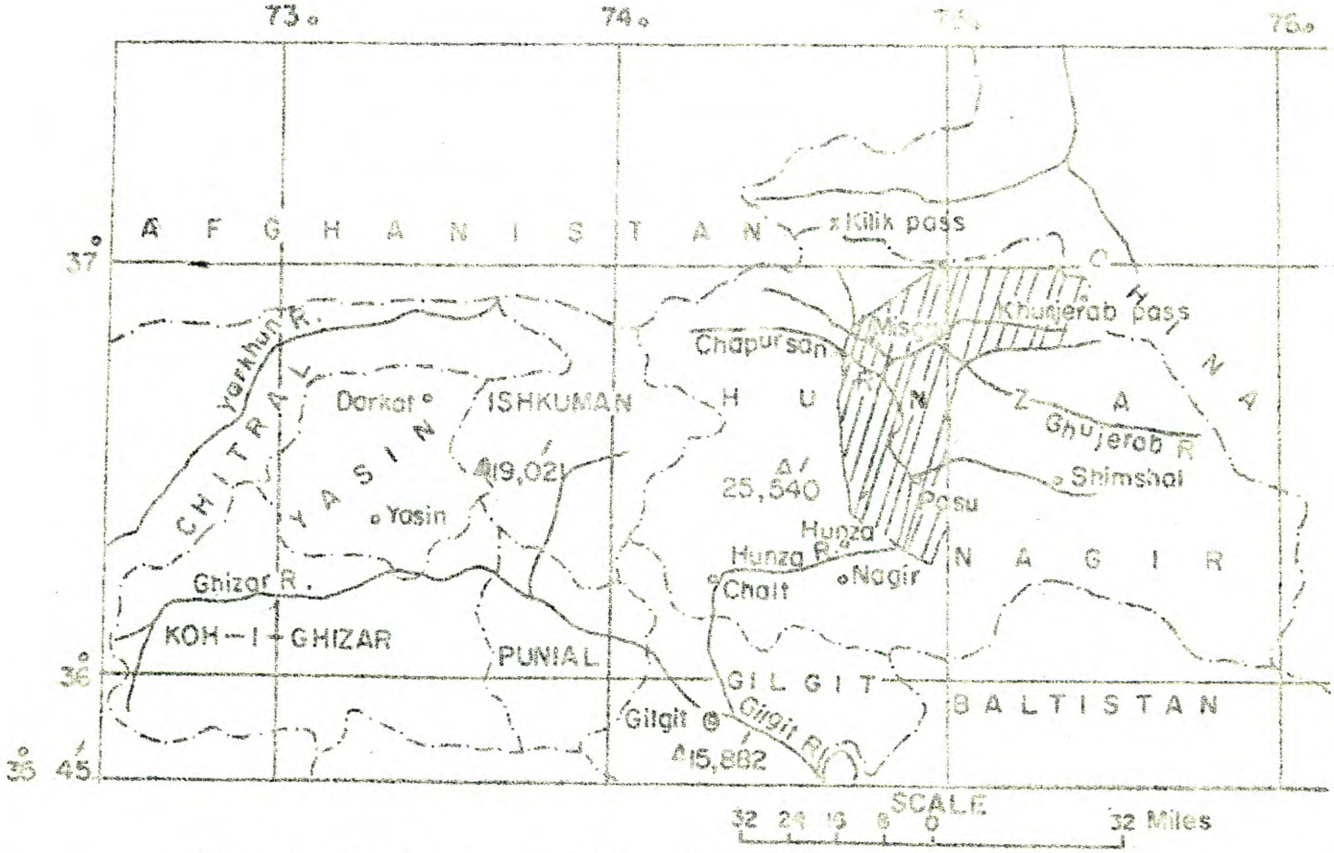


FIG :1— MAP OF GILGIT AGENCY SHOWING THE AREA

COVERED IN THE REPORT

Drafted by AShfaq Ahmed

SCALE

0 1 2 3 4 5 10 15 Miles

Prepared by Sajid Hussain Shah and Sikandar Khan

FIG:2 — GEOLOGICAL MAP OF UPPER HUNZA VALLEY (GILGIT AGENCY)

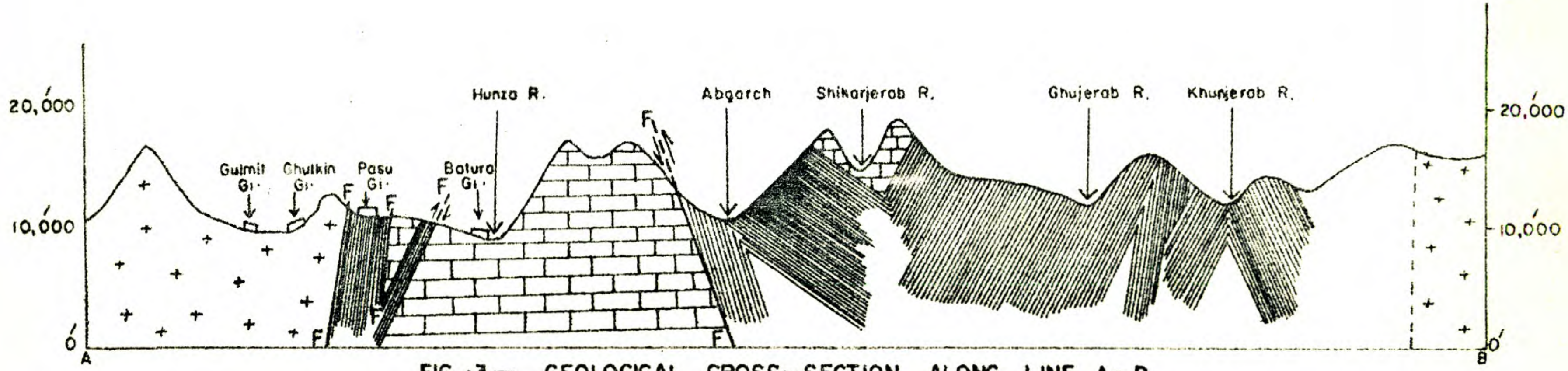


FIG :3— GEOLOGICAL CROSS-SECTION ALONG LINE A—B

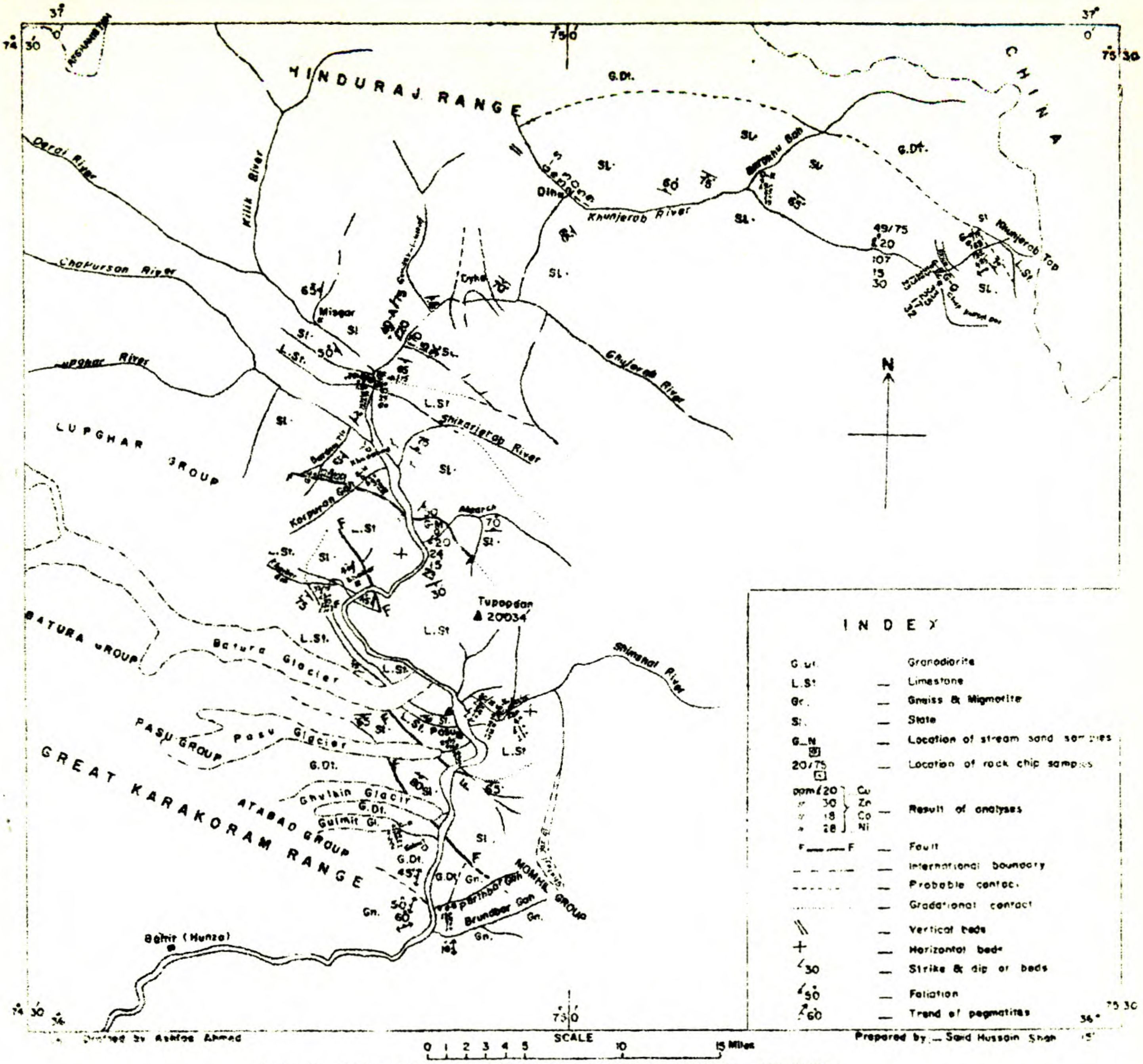


FIG_ 4: MAP SHOWING STATUS OF GEOCHEMICAL STUDIES