

**GOVERNMENT OF PAKISTAN
GEOLOGICAL SURVEY OF PAKISTAN
INFORMATION RELEASE No. 224**



**GEOLOGY AND MINERAL INVESTIGATION
OF THE
PARRI QUADRANGLE (43-I/9)
GILGIT DISTRICT
NORTHERN AREAS
PAKISTAN**

BY

**SAJID HUSSAIN SHAH
S. SAEED SHAH**

**Issued by the Director General, Geological Survey of Pakistan
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ILLUSTRATION

Fig. 1. Geological map of the Parri quadrangle (43-I/9), Gilgit District, Pakistan.

ABSTRACT

The investigated area lies within the Kohistan island arc sequence, bordered by two megathrusts viz. the Main Mantle Thrust (MMT) on southern side and the Nanga Parakorum Thrust (NPT) on northern side. Towards eastern extremity of the quadrangle, the bedded variety of Kamila amphibolite is exposed, which was considered a part of the Salkhalas, by previous workers. The rocks of the Greenstone complex are developed on the northern periphery of the Kohistan island arc; while the Kamila amphibolite which form the base of the arc is the product of an intraoceanic subduction in the fore-arc basin.

The Nanga Parbat-Haramosh massif which lies towards southeast of the quadrangle, is largely composed of more or less intensely metamorphosed metasediments of the Salkhala formation.

The area around the Gilgit - Indus Rivers confluence is composed of hornblende granodiorite, melanochromatic diorite, inclusions and xenoliths of amphibolite, hornblendic paragneiss and ortho-amphibolite bodies of various dimensions. These rocks are perhaps the result of assimilation and hybridization processes occurring along the marginal zones of the Kailas granodiorite batholith. The effects of dynamothermal metamorphism are more pronounced along the marginal zone of the batholith and resulted the formation of paragneiss and granite gneiss. Such rock types are common in the neighbouring Nanga Parbat. Tectonically, the area has been greatly disturbed which resulted a number of anticlines and synclines associated with faults. Due to proximity with the Main Mantle Thrust (MMT), the Hurban area has been severely

affected by tight folding and faulting.

The intrusions of pegmatites alongwith the granitic and aplitic dykes and sills are quite profuse from Jalalabad along Gilgit River, and Shuta along Indus River, down streamwards upto Jaglot (out of the quadrangle). The pegmatites are mostly uneconomical, with the exception of some showings of beryl near Jalalabad and potash feldspar near Aftab camp, which may prove to be of economic significance by later detailed exploration. Significant stratified sulphide zones alongwith a gossan, have been observed in the Bilchhar and Cinnakar areas, which need further prospecting. Workable marble deposit is present in the Hurban - Shahbatot area, within the metasedimentary rocks of the Kamila amphibolite.

The reserve estimation has been calculated with the following formula (Mc Kinstry, 1968, p.60).

Reserves (in metric tons) = Volume in m^3 x Sp. gravity*

* - The specific gravity for marble taken to be 2.7.

INTRODUCTION

Purpose & Scope

The Northern areas consisting of the highest peaks of Pakistan have always been a challenge to the Geologists. Being very remote and inaccessible most of this is yet unmapped. Realizing the geologic importance of these areas, the Geological Survey of Pakistan has started systematic mapping and mineral investigation of these unexplored areas.

This report is the outcome of the geological work. The purpose is not only to prepare the geological map of the investigated area, but also to search for any mineral in that area.

The geological mapping of the investigated area, quadrangle 43-I/9, was carried out at a scale 1:50,000. The aerial photographs covering a portion of the area were used as base for plotting the geology. Later on the geology was transferred to the topographic sheet.

Location & Accessibility

The area of the quadrangle 43-I/9 is situated between latitudes $35^{\circ} 45'$ and $36^{\circ} 00'$ and longitudes $74^{\circ} 30'$ and $74^{\circ} 45'$. The two major rivers of the area, the Indus and the Gilgit flow through this area. The principal town is Parri, which is connected by an all-weather Karakoram Highway (KKH) with Chilas and Gilgit, lying at distance of about 110 kms and 30 kms respectively; and by a 270 kms unmetalled road with Skardu, which is being metalled at present. The KKH passes through the western extremity of the quadrangle.

The jeepable roads constructed by the local P.W.D connect the Karakoram Highway with the small villages in the valleys of the Gilgit River and its tributaries.

Physiography

Topographically the area is very rough with high peaks and steep slopes. The Indus flows from south towards north upto Hurban, where an abrupt diversion occurs into its course, and then it flows towards west and southwards until its confluence with the Gilgit River near Parri. Deep gorges are present in the area specially along the Indus River. The major tributaries are Sai Nala, Bagrot Gah, Bilchhar Gah, Batkor Gah, Darchan Gah and Phuparash Gah. The highest peak is 5364 meters above sea level, which serves as water divide for the tributaries, viz. Bilchhar Gah, Shatui Gah, Khaltaro Gah and Batkot Gah. Deep gorges and the remnants of old terraces reveal that once the river Indus used to flow at that level, before the upheaval of the Himalaya. The moraines present at the high levels, indicate the past glaciation period. Large alluvial screes, at their maximum angle of rest, have formed on the steeper slopes.

Climate & Habitation

The climate is almost arid. The height of the Great Himalaya becomes the barrier for the monsoon, so all the area of trans-Himalaya is almost barren. The vegetation is very scarce. Weather is of extreme type and the winter is specially very cold. Rainfall is quite low. The precipitation is also in the form of snow during the winter at mountain peaks. Due to rough terrain and high peaks, the population is sparsely distributed in the valleys. Wheat and maize are the major crops. Malbury, apple, apricot and walnut are grown and sold in Gilgit, which attract the tourists the world over.

Previous Work

Wadia (1932, 1952) and Gansser (1964) are among the pioneer workers in the Northern areas, which described the geology of the Nanga - Parbat and the adjacent areas. Later on, Desio (1974) and the workers of Peshawar University (1979 & 1981) contributed in the geology of the area, with special emphasis on the mega-structures, such as the Indus Suture line and the Main Mantle Thrust (MMT). Bakr (1965) and Ivanac, et al. (1956) wrote a brief and general geology of Gilgit and Baltistan Agencies.

Saleemi et al. (1975) worked on the investigation of pegmatites mostly adjacent to the Shengus area, lying along the Skardu road at a distance of about 60 kms from Parri. The work on the engineering geological problems for the Karakoram Highway had been done by Frontier Works Organization.

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Field guidance and supervision particularly during the reconnaissance work in the area and later on the critical review of the report and help in the petrographic studies by Mr. M. Saeed-uz-Zafar Khan is gratefully acknowledged. The authors are also indebted to M/s. Zaki Ahmad, Director and M. Ishaque Ghaznavi for giving valuable suggestions in writing of the report. Mr. Mushtaq Hussain, Superintending Chemist, Resource Development Corporation, Karachi conducted the metallometric analysis of the soil samples of the mineralized zone. Fruitful discussions on various technical matters with M/s. Naseer Ali Khan and Ibrarul Hassan Khan are gratefully acknowledged.

REGIONAL GEOLOGY

The mapped area comprises of the metasedimentary rocks of Kamila amphibolite, ortho - and para-gneisses and the intrusive rocks - granodiorite, diorite, and aplitic veins alongwith pegmatites. Small amphibolite inclusions within para gneisses are also present. All these above mentioned rocks are so common in the Parri - Hanuchal area that this may be termed as a mixed zone. Acidic pegmatites of intrusive as well as recrystallized nature are quite profuse around the Parri area, lying in the lower left corner of the quadrangle. Around Parri - Hanuchal area, the diorite has quite abundant hornblende, thus termed as hornblende diorite, which is marked as the marginal zone of the Kailas granodiorite batholith.

The bedded variety of the Kamila amphibolite is exposed in this quadrangle, while its banded and massive varieties are confined to Kohistan and Dir areas. This amphibolite is in direct contact with the Indo-Pakistan marginal mass along the MMT Zone, which lies towards east of this quadrangle.

Wadia (1932) correlated the Nanga Parbat-Haramosh massif, lying towards south east of the quadrangle, which comprises the metamorphosed and gneissified rocks of the Salkhala formation with the Archean rocks of the Rajputana and Singhbhum region of the Indian Shield. If so, the present Nanga Parbat-Haramosh massif should be considered a kind of protuberance of the Indian Subcontinent inserted as a wedge into the flysch deposits of the Karakoram (Desio, 1964 c, in Geodynamics of Pakistan, p. 122). The Salkhalas in the Nanga Parbat - Haramosh massif and its

continuation along the Great Himalayan Range, have been converted into paragneiss, micaceous and graphitic schists, and saccharoidal marble, with intrusive biotite gneiss of later age, and hornblende granite of still younger - Eocene to post-Eocene age (Wadia, 1952, p. 110-111).

Different anticlinal and synclinal axes, parallel to each other are present along the Gilgit River, Bagrot Gah and at major Indus bend at Hurban. Thick unconsolidated moraine and stratified river terraces are quite wide spread along the river of Gilgit and confluence of Indus and Gilgit Rivers.

The generalized succession of the area is given below:

Unconsolidated sediments

Alluvium and Terraces

Sub Recent

Moraine deposits

Pleistocene

Intrusive Rocks

Pegmatites and acidic intrusions

Late Cretaceous (?) to Pliocene.

Kailas granodiorite and Diorite

Late Cretaceous to Miocene.

Mafic intrusions

Cretaceous and Eocene

Meta-igneous Rocks

Ortho gneiss

Late cretaceous?

Metasedimentary Rocks

Greenstone complex

Lower Cretaceous

Kamila amphibolite

Jurassic to Early Cretaceous

GEOLOGY

Metasedimentary Rocks

Kamila Amphibolite

The name Kamila amphibolite had been introduced by Jan (1977, in Tahirkheli, 1979) as the subdivision of the Upper Swat Hornblendic Group of Martin et al. (1962), which occupy a large part of Kohistan and extend westwards into Dir; while towards east of Nanga Parbat, after looping around the Nanga Parbat-Haramosh anticline, it extends southward towards Astor. Earlier workers (Wadia, 1932, pp. 212-234 and Gansser, 1964 p.62) had described these metasediments as the extension of the Precambrian Salkhalas which are highly metamorphosed and granitized to granite gneiss in the neighbouring Nanga Parbat area.

The Salkhalas are part of the Archean rocks of the Indian Shield which moved northwards and collided with the Eurasian plate along the Main Mantle Thrust (MMT). As this quadrangle, lies towards north of the MMT, with the metasediments comprising of the pronounced amphibolite alongwith the schistose rocks, quartzite, banded paragneiss; hence the name Salkhalas misfits to these metasediments and the name Kamila amphibolite has been adopted at this stage.

Tahirkheli (1982, p.27) concluded that the Kamila amphibolites form the base of the Kohistan island arc, and it constitute part of an oceanic crust which is the product of an intraoceanic subductiuon in the fore-arc basin. He described three main types of the amphibolites viz. massive & homogeneous, banded

& sheared, and bedded, which are products of prograde metamorphism of the basic & intermediate plutonic and volcanic rocks which were associated with the oceanic sediments and tuffs.

In this quadrangle, the bedded variety of the Kamila amphibolite is exposed, which cover its eastern part. This variety constitute the metasedimentary rocks comprising of the schistose rocks, amphibolite, phyllite, banded paragneiss and quartzite, which have been intercalated by the marble bands between Hurban and Burumdoir along both banks of the Indus.

Amphibolites are light coloured, fine to medium grained, well foliated and thinly banded. They are intermingled with the paragneiss and the schistose rocks. Its mineral constituents are hornblende (45%), ca - plagioclase, zoisite, quartz and garnet.

The schistose rocks consist of hornblende schist, biotite schist, chlorite schist, quartz-mica schist, talc schist and phyllitic schist.

Hornblende schist is dark grey to black, medium grained, well foliated and is a dominant rock type. Megascopically, the rock is composed of quartz, hornblende, feldspar and small biotite.

Biotite schist is composed of biotite, feldspar and quartz. It is fine grained and dark grey having 30% - 50% biotite. The biotite schist is well foliated and thin laminated.

The quartz-mica schist is grey, medium grained and at places garnetiferous.

Chlorite - and talc schist are light green, fine grained, well-foliated and laminated. On weathering the talc schist shows

white colouration, soft and at places it is limonitized.

Phyllite and phyllitic schist of green to brown colour, with usually brownish colouration on weathering surface, are common within the metasedimentary rocks.

The banded paragneisses are interbedded with schistose rocks and are common in the metasedimentary zone. They are grey, medium to coarse grained, well foliated and banded. Generally they consist of quartz, feldspar, biotite, garnet, hornblende and epidote. The muscovite is present as accessory mineral. In Hanuchal nala, paragneiss shows small lenticular hornblendite pockets. Gneiss is hard, tough and compact rock.

Impure quartzite bands of white to light grey and pinkish in colour are present at few places within the Kamila amphibolite. The impure quartzite has mica, epidote and amphibole as impurity.

The marble bands are conformably interbedded with the schists and amphibolite. The bands are best exposed towards south of Hurban on both banks of the Indus. The marble bands are white to grey in colour with greyish linings. A few thin bands extend northeast wards towards Phuparash Gah. In the Indus Valley different marble bands measure in average 30 cm to 1.5 meters in thickness, each band dips at high angle and extending along the strike for many kilometers covering the both flanks of the Indus from Burumdoir to Hurban and then crosses Indus, with a few bands continued upto Bunji (quadrangle 43-I/10). Towards east, these marble bands merge with calcareous schist with same general trend.

The Kamila amphibolite has been assigned Jurassic-Early Cretaceous Age (Tahirkheli, 1982, in map).

Greenstone Complex

The term "greenstone complex" was introduced by Ivanac et al (1956, p.9) to the heterogenous and multi-lithological assemblage of rocks with predominant greenish hue - metasedimentary rocks mixed with large group of volcanic rocks, extending from Hindukush in west to Baltistan in the east. The equivalent of greenstone complex in Chitral has been described as Greenstone volcanics by Calkins et al. 1969, (in Tahirkheli, 1979, p.14). Later on, Tahirkheli (1982, p.26) assigned it the new terminology as "Rakaposhi volcanic complex", which originated as a thick oceanic crust formed in the Tethys, between the converging Indo-Pakistan and Eurasian plates. It is developed on the northern periphery of the Kohistan island arc.

The rocks of the Greenstone complex cover the major part of the quadrangle, and located between the Sai Nala in south and the glaciated area in north, while a small band extends upto south of Shuta Nala along the Skardu road.

The rock components of the Greenstone complex within the quadrangle, are paragneiss, quartzite, phyllite, mica schist, hornblende schist, & phyllitic schist, which have been intruded by thin dykes of diorite, dolerite, basalt, and-osite and hornblendite. Prominent green colouration at a few localities within this composite unit is due to alterations such as serpentization, chloritization and epidotization.

Paragneiss is the major component among the metasediments of the complex, which occupies almost the central area in the quadrangle. Paragneiss is greyish, fine to medium grained, well foliated and banded. Fine laminations and varvings are also observed at places. The dark bands consist of biotite and hornblende; while the light bands consist of quartz, feldspar and minor muscovite. Little garnet and epidote are also present at places. The gneiss is psammitic, which is due to the metamorphism of argillaceous sandstone. Near Jalalabad and along the Batkor Gah, lit-par-lit gneiss with highly ptigmatic folding has been found. Para-gneiss at contact with granodiorite show recrystallization feature due to augmentation of biotite flakes.

Towards west of the quadrangle, along the Karakoram Highway, the paragneiss is spotted. These spots are ellipsoidal and composed of quartz. Near the confluence of the Bagrot Gah with the Gilgit River, along the Karakoram Highway, para-gneiss contains about 1 meter thick band of snow-white, slightly foliated quartzite and having inclusions of light grey, rhombohedral crystals of calcite.

The para-gneiss with abundant amphibolite inclusions has been found in Parri and Shuta area; where amphibolite portion comprises 20% to 30% of the para-gneiss. However, a few small amphibolite inclusions with sharp boundaries are also present within para-gneiss elsewhere. Trend of amphibolite is variable as compared with that of gneiss. The amphibolite is dark-grey to black, with colour index 50 to 80, foliated and fine to coarse

grained. The coarse grained bands are comparatively less foliated as compared with the fine to medium grained bands. At places it is of gneissic appearance. The presence of lamination, stratification, common quartz, biotite and absence of garnet reveal the sedimentary origin of the amphibolite.

The paragneiss is abundantly intermingled with the schistose rocks, phyllite and impure quartzite, in Bilchhar area and Bagrot Gah. A small exposure of these rock components is found along the Sai Nala. The schistose rocks comprise of the micaschist, hornblende schist and phyllitic schist. These metasediments serve as the host rocks for multicoloured, weathered sulphide zones in Bilchhar area and along the Bagrot Gah at Sinnakar and Hope villages. Thin igneous intrusions of diorite, andesite basalt, dolerite and hornblendite in form of both sills and dykes are common along the Bagrot Gah. On right bank of the Bagrot Gah, towards north-west of Hope village, the hornblende schist has been intruded by dark grey basalt having small inclusions of hornite.

The Greenstone complex had been assigned Triassic(?) age by Stauffer (1968, p.21). However, Tahirkheli (1982, p.26) named the Greenstone complex as the "Rakaposhi Volcanic Complex" and on the basis of fossil discovery, assigned Lower Cretaceous age.

Intrusive Rocks

Mafic intrusions

Small bosses of mafic intrusions, in mappable size, have been found at two localities within the quadrangle, one opposite Jalalabad, village along the KKH, while the other near Shuta village along the Skardu road. Here, the mafic intrusions include hornblendite and ortho amphibolite. However, small irregular hornblendite intrusions as lenses and dykes are also scattered within the metasedimentary rocks in Jalalabad and Parri area.

The hornblendite boss along the KKH, is dark green and has megacrystalline texture. It extends for about 200 meters along the KKH. Its mineralogy being hornblende, plagioclase feldspar and minor biotite. This hornblendite boss is post-pegmatitic in age, as no pegmatite has intruded in it; although they are in plenty within the paragneiss host rock.

The ortho-amphibolite, boss exposed along the Skardu road about two kms. west of Shuta Nala, is due to the low-medium grade metamorphism of some mafic volcanic rock. It is dark green, coarse to very coarse grained, unfoliated and having high density. Because of high density, it might have been tectonically emplaced from the upper mantle. It measures about half kilometer in width along the road and extends on both banks of the Indus in almost E-W direction. The mineralogy is predominantly actinolitic-hornblende, with minor amount of sphene and epidote. Epidotization of amphiboles is a common feature. Its contact with the country rock-paragneiss is

intrusive. As this orthoamphibolite has been cut across by the pegmatites, so it is older than the pegmatites.

This orthoamphibolite boss has been described under the "Metamorphic ophiolites" (Desio, 1974, pp.122-124), which he defined as basic volcanic and plutonic rock complex such as basalt, dolerite, gabbro, norite and ultrabasic rocks - peridotite, hornblendite and serpentinite etc. As it occurs in proximity with the MMT, and lies within the obducted zone of the Kohistan island arc, thus the mafic intrusion may have been metamorphosed to the ortho-amphibolite. The ophiolites were emplaced during Cretaceous and Eocene times (Tectonic Map of Pakistan, 1982).

Kailas granodiorite and Diorite

The name Kailas granodiorite was first introduced by Bakr (1965, p.10) as this dominating granodiorite form the backbone of the Kailas Range, west of Gilgit. The name Kailas granodiorite has been used, because it is the best descriptive name, for the batholithic intrusion of the Gilgit area (Stauffer, 1968, p.24). The dominating rock component of the Kailas granodiorite is biotite granodiorite, with lesser amount of a variety of other si-saturated intrusive rock types viz. quartz diorite, tonalite, quartz monzonite and granite. These rocks have been cut by swarms of aplite and pegmatite.

The Kailas granodiorite, in the quadrangle, is exposed in the upper margin of Bagrot Gah near Hope village and as small patches intermingled with diorite in Parri and Shuta areas. In Shuta area it is exposed on both banks of the Indus River. Along the Bagrot Gah this rock probably extends eastwards towards the glaciated area, which was not accessible.

The granodiorite rock is light grey, coarse grained and slightly foliated at places and composed of quartz, feldspar, biotite, muscovite, epidote and garnet. Quartz as megacrysts is present in granodiorite at northwest of Hope village along the Bagrot Gah. Exfoliation is visible in granodiorite near Aftab Camp. Granodiorite also shows lateral flow structure, as visible along the KKH, opposite Bagrot Gah. The granodiorite exposed around Parri and around the Gilgit-Indus Rivers confluence, is mainly the biotite - hornblende granodiorite. Along the left

bank of the Indus, near the Gilgit-Indus Rivers confluence, this granodiorite gradually changes into banded hornblende gneiss.

Near the Farhad Bridge and along the KKH opposite Bagrot Gah, the granodiorite and other acidic intrusions show prominent recrystallization feature giving rise to the pegmatites under action of volatiles evolving from cooling magmatic chamber and penetrating into upper horizons of intrusive masses that had congealed earlier (Zavaritsky, in Dorokhin et al., 1969, p. 36). Along with these recrystallized pegmatites, the intrusive pegmatites and other thin acidic dykes (mostly aplite and leuco-granite) have intruded the metasedimentary rocks and the earlier granodiorite body. In the recrystallized area, granodiorite and aplite show common feature of recrystallization and segregation of coarse minerals either as stringers, veinlets, pods, lenses or linings in which there is a marked gradual coarseness of minerals with indefinite boundaries.

Diorite exposed along Shuta - Hanuchal area is grey, medium to coarse grained, slightly gneissic with colour index above 40. It is composed of quartz, feldspar, hornblende and biotite. Biotite occur at places as small clusters. At certain localities epidote is also present. The diorite alongwith the enclosed pegmatites, in contact with moraines along the KKH upstream of Parri, is quite sheared and kaolinized due to burden of glacier and action of water at the glacier floor.

Near Aftab Camp, the diorite is melanocratic and show gradual transition towards hornblendite. Its mineral composition being feldspar, hornblende, biotite (minor) with colour index

upto 80 and is termed as hornblende diorite. This is perhaps on the marginal facies of the granodiorite because the marginal facies of intrusion is a dark coloured hornblende diorite which changes gradationally into normal grey granodiorite. Effects of metamorphism and assimilation are seen in this portion of batholith, where a wide variety of metamorphics and hybrid types have been produced by reactions with volcanic country rocks (Ivanac, Traves & King, 1956, p.12). This is true in Parri - Hanuchal area, where granodiorite intrusions richer in mafic minerals are associated with hybrid diorite and include irregular hornblendite masses. Bakr (1965, p.10) described the rocks from Gilgit to Hanuchal, specially north of the Gilgit River, as hornblende granite, hornblende gneiss and hornblendite - all profusely intersected by biotite granite, aplite and pegmatite. Jan et al. (1981, p.172) described all the Si-saturated intrusive rocks under the heading "Ladakh-Kohistan Granitic Belt" which extends from Dir in the west, to the Ladakh Range in the east. They have assigned the late Cretaceous to Miocene age, on the basis of radiometric, petrographic and geochemical data.

Tahirkheli (1982, p.28) named these intrusive rocks as the "Ladakh Intrusives", having multicycle magmatic phases, and on basis of K/Ar dating, assigned lower Eocene to Miocene (50 to 19m.y) age.

As the ages assigned by Jan et al. (1981) are based upon more comprehensive data and radiometric dating of some samples showing 63 m.y. may be the start of the magmatic intrusion; while

the ages assigned by Tahirkheli (1982) on the basis of K/Ar method is coming within the range of ages of various intrusions (63-19.m.y) assigned by Jan et al. Hence, the magmatic intrusion of this granitic batholith occurred during late Cretaceous to Miocene period and belong to more than one phases of evolutionary history.

Pegmatites and acidic intrusions:-

These rocks have been found profusely in the area downstream from the confluence of Gilgit River with Batkor Gah and downstream of Shuta village along the Indus River, and extend upto Jaglot (outside the quadrangle). However, a few pegmatites are also located near Jalalabad and Hunuchal. The fine to medium grained acidic intrusions aplite and leuco-granite alongwith pegmatites have profusely intersected the host rocks viz. paragneiss, amphibolite, diorite, orthoamphibolite and the metasedimentary schistose rocks. The pegmatites range in thickness from mere stringers of less than 2cm. to about 6 meters. The pegmatites are both of intrusive and recrystallized type. The recrystallized pegmatites are located opposite the Chhamungarh village, near Farhad Bridge and Aftab Camp. They are formed after recrystallization of the acidic intrusive rocks viz. granite, granodiorite and aplite under action of volatiles from the cooling magmatic chamber (Zavaritsky, in Dorokhin et al. 1969, p.36). The recrystallization took place either on the margin or in the centre, or throughout the acidic intrusive body. The homogenous intrusive pegmatites are younger than the recrystallized pegmatites.

Two phases of formation of pegmatites have been established. Near Shuta village, the comparatively fine grained pegmatite is enclosed in parallel within the coarse grained pegmatite. In a 5 meters thick pegmatite opposite Parri, on left bank of Gilgit River, a second phase pegmatite is characterized by comparatively abundant and big flakes (2-8 cms) of green mica, in a 30 cms. thick upper portion of this pegmatite and having sharp contact.

Zoning is present in some pegmatites in the form of either wall and intermediate or intermediate and core. Zoning is not symmetrical and at places wall and intermediate zones are repeatedly intermixed with each other. Core has generally the mineralization of quartz, feldspar and spodumene.

Mineralogically the pegmatites in this area are both simple and complex type. The complex types have quartz, feldspar, biotite, muscovite, garnet, with occasional beryl, secondary calcite, hematite, magnetite, epidote, spodumene, and copper colouration mostly in form of malachite. Potash feldspar is quite abundant as big laths upto 15 cms in length, in the area opposite Parri and near Aftab Camp. At shuta, along the Skardu road, thin hornblende-rich pegmatites are present which are older than the other pegmatites.

The thin granitic intrusive dykes, opposite Chhamungarh, shows slight banding and flow structure.

Near Batkor Gah, the trend of pegmatites is generally E-W, while near the Gilgit - Indus Rivers confluence it swings N NW-SSE.

Some basic pegmatites, having feldspar and hornblende, are present within amphibolite in upper reaches of the Shatui Gah.

The pegmatites and the related acidic intrusions are of later magmatic stage. The termination of magmatism of felsic and mafic sills and dykes might be even younger to 19 m.y i.e. upto Pliocene (Tahirkheli, 1982, p.28).

Unconsolidated Sediments

Moraine deposits :-

The glaciated consolidated and unconsolidated moraine deposits are quite wide spread in the valleys, and at higher levels. The consolidated moraines are commonly light-green to rusty brown and greyish coloured, compact, slightly cemented by silt and clay. They are composed of particles of nearly all the dimensions viz. clay to cobble size. The thickness at places in the valleys varies from 30 to 100 meters.

The unconsolidated moraines are also wide-spread along the major valleys and cover comparatively an extensive area than the consolidated moraines. They are loose, brownish to buff in colour, and consist of material of almost every size. (The lowest observed terminal moraine is 1,230 meters, above sea level, near the Indus-Gilgit Rivers confluence.) At Batkor village, erratic boulders of paragneiss are wide spread in the opening valley, in the form of different heaps.

Alluvium and Terraces :-

The river terraces which are mostly well stratified are wide spread along the Gilgit River and also along lower Bagrot Gah. The terraces found at different levels along the river valleys, are due to the blockage of rivers by glacial or landslide debris. The stratification is in the form of alternate horizontal bedding of fine to coarse grained material deposited during the winter precipitation and summer melting seasons respectively. The thickest

terrace lies along the Gilgit River upstream of Chhamungarh village, measuring about 50 meters. A quite wide spread river terrace is encountered along the Skardu Road, at the confluence of the Indus & Gilgit Rivers. It consists of stratified river deposit, with the surface covered by wide-spread sand mantle.

The upper most surfaces of the river terraces along Gilgit River and that of moraines in Hurban - Shahbatot area of the Indus valley have been transformed into alluvium. The thickness of alluvium is quite thin. Small alluvial fans are scattered on both the banks of the Gilgit River around Parri. A large alluvial fan measuring 3 kms in extension is present at the termination of the Parri nala.

STRUCTURE

The quadrangle lies within the two major suture zones viz. the Main Mantle Thrust (MMT) and the Main Karakoram Thrust (MKT), and is in the vicinity of the MMT.

Parallel synclines and anticlines with their general axes running in NW-SE direction, are located in the western part of the quadrangle, between Sinnakar and Gilgit River. A small anticline with almost E-W axis, runs from Beanja Nala in Bilchrar area, towards Bagrot Gah. A small asymmetrical syncline, with axial trend NE-SW, runs within the metasedimentary rocks along the Bagrot Gah towards north of Sinnakar. The axis of this syncline also carries the sulphide mineralization. These small anticlines and synclines having their axis almost at right angle to the major trend of the axis, are due to the later orogenic phase.

At the major bend of the Indus, in Hurban area, the tight folding within the steep dipping metasedimentary rocks produced small parallel anticlines and synclines with their general axis running in almost N-S direction. The folding is so tight that it resulted faulting parallel to the fold axis. An almost vertical fault runs from Shahbatot to Hurban along the Indus and runs further in NNE direction along the Phuparash Gah. This fault is auxiliary to the Main Mantle Thrust (MMT) which runs, adjacent to this area, in NNE direction, in the quadrangle 43-I/13 (Tahirkheli et al, 1979). The MMT zone and its adjacent areas are tectonically disturbed which is manifested in the form of tight folding and faulting.

The intrusive contact between diorite and paragneiss with acidic intrusions along the KKH opposite Batkor Gah, is quite gouged and pulverized due to intensive intrusive force. This contact has partially been covered by the moraine.

GEOLOGIC AND TECTONIC HISTORY

Kamila amphibolite form the base of the Kohistan island arc, which originated between the Indo-Pakistan and Eurasian platforms.

The Precambrian Salkhala metasediments which occur within the Nanga Parbat - Haramosh massif, lying towards southeast of the quadrangle, is a part of the northern margin of the Archean rocks of the Indian Shield (Wadia, 1932, in Geodynamics of Pakistan, 1979, p.122; Gansser, 1964, p.235). Tahirkheli et al.(1979, p.125) concluded that during Late Cretaceous the Indian plate moved northward towards the Eurasian plate and obduction of the oceanic rock sequence of the Kohistan arc occurred onto the Paleozoic cover of the Indian Shield over a large overthrust (MMT).

The Flysch type marine sediments (metasediments of the Greenstone complex) were laid down in the Tethys on the northern periphery of the Kohistan island arc, and coupled by pronounced basic submarine volcanic activity during Cretaceous period. During the main Himalayan orogeny, the northern Flysch belt must have been compressed by underthrusting of Indian shield against the Kohistan island arc, during middle and upper part of Eocene, thus resulting the creation of a sharp tectonic line (MMT) along which large areas disappeared. During post Upper Cretaceous, the Eurasian plate underthrust the Kohistan island arc, along the northern megashear (MKT).

The multiphase intrusions of the basic and acidic rocks (mostly Si-Saturated rocks) took place during late Cretaceous to Miocene period (Jan et al. 1981, p.172). However, the termination of magmatism of felsic and mafic dykes (Swarms of aplites, pegmatites and hornblendite boss) might be even younger i.e. upto Pliocene (Tahirkheli, 1982, p.28). The earlier acidic intrusions were metamorphosed to give rise to the orthogneiss.

The subduction period of the Indo-Pakistan continent under the Kohistan arc commenced in late Cretaceous. The first Himalayan orogeny started in late Paleocene; the second major orogeny occurred in Oligocene; while the third orogeny accompanied by end of subduction occurred in Pliocene to Pleistocene time. The upheaval of the mountain belt began in the late Neogene and is still occurring (Desio, in Geodynamics of Pakistan, 1979, p.111).

During Quaternary period glaciation started which gave rise to the consolidated and unconsolidated moraines, some of which are seen at the hill peaks. The uplift of the trans-Himalayan ranges, resulted in the abrupt increase in the erosive power of the rivers, which deposited their transported material, in form of river terraces and alluvium.

ECONOMIC GEOLOGY

The quadrangle is important for the sedimentary supergene sulphide enrichment, the pegmatites and the marble.

Sedimentary Sulphide

The multicoloured Supergene Sulphide enrichment zones in the form of weathered soil is exposed at different places in the Bilchhar area and extends further northwest towards Sinnakar area, in Bagrot Gah (Fig. 1). The total mineralized zone covers an area of approximately 7.2 sq. kms, among which about 6.8 sq. kms. lie in the Bilchhar area; while 0.4 sq.kms. in the Sinnakar area. The thickness of the mineralized zones varies from mere thin pockets upto a maximum of about 75 meters (north of Taisot village). But the thickness from 10 meters to 50 meters are common.

The mineralization is spread throughout the stratified metasedimentary rocks, but the major host rock units are talc schist, biotite schist, quartz-mica schist, hornblende schist, chlorite schist, calcareous schist, phyllite & quartzite. Due to mineralization in these rocks, various colour shades have been developed viz. brown, yellow, pink, white, grey, blue, green and also their combination; but more pronounced colours being brown and yellow. Yellow coloration is due to the surficial coating of sulphur on alum, which is common along the entire mineralized zones. Brown coloration is due to the limonitization, while the white probably due to kaolinization or presence of nickle. Wherever alum is present

the mineralized zone is moisturized and swelled. A peculiar small reddish brown coloured gossan has been encountered in the centre of the big mineralized zone towards north of Taisot.

Alum, a hydrated binary sulphate of aluminum and alkalis, occurs in very small quantity, as surface encrustations and crack fillings within the sulphide zones. It's colour being white and light bluish on fresh surface, but weathers to yellow. At places near Taisot, a hairy salt, halotrichite, a hydrated sulphate of iron and aluminum has been found with asbestos - like veinlets of snow white colour with silky chatoyancy. It is formed under condition of acute deficiency of free oxygen below the oxidised zone of pyrite (Betekhtin, A. page-301). Such strata-bound base metal sulphides of Pb, Zn, Cu, Ag, may have formed syngenetically i.e. in the early stages of sedimentation, by deposition in sedimentary pile rather than by hydrothermal replacement, as proposed in early 1950's (Commonwealth Science Council Newsletter, Oct. 1981, pp. 6-8). Gustafson (in Newsletter, October, 1981, pp. 6-8) concluded that most of the sulphide deposits are diagenetic (formed after sedimentation and before compaction) with metals derieved from within sedimentary sequence, but outside the area of deposition. They often imply low-temperature deposition with the involvement of biological activity in mineralization. It is well established that bacterial sulphate reduction is a significant and rapid bio-chemical process in modern anoxic sediments.

Metallometric analyses were requested from R.D.C. Karachi, for Ag, Au, Pb, Zn, Cu, Ni, Co, Sb, Fe, Se and As, but only Ag, Pb, Zn, Cu, Ni & Fe were checked. The analyses result is doubtful, as

sample taken from reddish brown gossan near Sharda Gali in Bilchhar area, shows only 7.21% iron; while the sample taken from yellow coloured zone on left bank of Bilchhar Gah, show the highest amount of iron (21.18%). The limit of values for the elements is as under: Copper from Nil to 351 PPM., Zinc from 20 to 1492 ppm; Nickel from - 20 to 307 ppm; Lead from Nil to 141 ppm; Silver - 20 ppm everywhere; and iron 1.14 to 21.18 percent.

Detailed study of the mineralized zone, alongwith accurate metallometric analyses for even the trace elements is suggested in future, to know the amount and general behaviour of elements.

Pegmatites

Immense pegmatites are scattered in the south-western portion of the quadrangle, around Parri and Shuta area. Economically they are not rich, but only minor showings of magnetite, transparent quartz, beryl, garnet, epidote and some radioactive mineral along with feldspar and mica are present.

Magnetite as minor crystals is dispersed within a few pegmatites near Jalalabad & along Skardu Road. However, a few pegmatites, along Skardu Road, about one km. from the Farhad Bridge, contain immense magnetite as linings with dimension upto 2 cms thickness.

Spessartite garnet along with transparent quartz and magnetite in form of small bunches with radiating shape crystals is located in simple pegmatites at Farhad Bridge, and opposite Parri along left bank of the Gilgit River.

Partly developed transparent quartz crystals and smoky quartz is found within pegmatites between Shuta & Aftab Camp, Farhad Bridge and along the KKH opposite Chhamongarh village.

Beryl as small grains and thin stringers is found in pegmatites near Jalalabad and near an ortho-amphibolite boss along the Skardu Road. Near Jalalabad, beryl is well concentrated in pegmatites. Here, a 15 cm thick pegmatite contain upto more than 20% beryl as small dispersed grains and thin stringers. This area needs further exploratory work for its behaviour in depth.

Red Garnet is common in pegmatites; but those present along the KKH have also in the form of small clusters. Green epidote crystals are found in a thin pegmatite vein found near the ortho-amphibolite boss along the Skardu Road.

Greyish black uranium mineral has been located in pegmatites along Skardu Road, and opposite Parri, on left bank of the Gilgit River. It is present in the form of small grains, or most commonly in the form of thin stringers and veinlets. Along the Skardu Road, between Hanuchal & Darchan Gah, a one meter thick lensoid pegmatite containing this mineral as 1 cm - 10 cms. thick linings and veinlets with about $\frac{1}{2}$ meter extension.

Microcline & Orthoclase as large crystals, are common within a few zoned pegmatites around the confluence of Indus and Gilgit Rivers. Near Aftab Camp, euhedral crystal of microcline, measured about 10 cms in length. It is present in the intermediate zone and core, in the form of sub hedral to anhedral crystals upto 15 cms in length. It may have its use in the ceramic industry, if feldspar & quartz ratio is found to be suitable. Green biotite as

large flakes measuring 5cm-15cmx2cm-8cm. is present in a few zoned pegmatites located opposite Parri and near Aftab Camp. Here, it can be economically exploited with careful mining, subject to its behaviour remains the same in depth. Lightgrey to lightgreen, fibrous, tremolite-actinolite surrounded by good quality soapstone within amphibolite has been reported by Saleemi et al, 1975 about 3 kms NE of Hanuchal village. Both may have little importance due to small quantity and remoteness of occurrence.

Marble

Marble bands of white and lightgrey in colour with greyish linings have been located within the banded para gneiss of the Kamila amphibolite, towards south of Hurban. They are present along both the banks of the Indus upto Burumdoir (for about 8 kms), then crosses the Indus and a few bands are continued upto Bunji (in toposheet 43-1/10). A few thin bands extend NE towards Phuparash Gah. These marble bands towards east merge with calcareous schist with the same general trend. Between Shahbatot & Hurban four marble bands have been encountered with average thickness of each band being about 1 meter 30 cm, and height above surface being 5 meters. The marble bands are also present across the Indus, with 5 meters general thickness.

The chemical analyses of the white marble bands reveal the composition as silica 0.6%, alumina 0.8%, Fe_2O_3 0.3%, CaO 50.5%, MgO 4.1% and loss on ignition 43.7%, while the grey marble bands reveal the composition as silica 9.1%, alumina 0.9%, Fe_2O_3 0.4%, CaO 38%, MgO 15.9% and loss on ignition 35.7%.

The reserve estimation of the four marble bands located near roadside between Hurban & Shahbatot has been calculated to be about 70,000 metric tons above the surface; while about 4,600 metric tons has been calculated for each 30 cm depth and one km length, across the Indus.

The total reserves of the marble bands located on both banks of the Indus towards south of Hurban, in the investigated area have been calculated to be 200,000 metric tons for each one meter depth.

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