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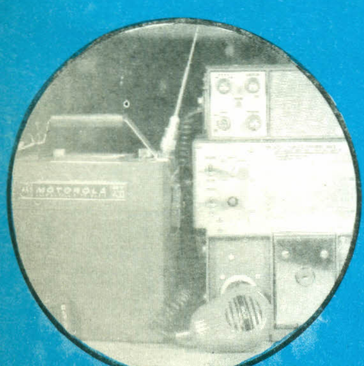

ENGINEERING GEOLOGICAL
SURVEYS

A PRELIMINARY REPORT ON OCCURRENCE OF SULPHIDE MINERALIZATION IN SINGAL AREA (42 H/16) GILGIT DISTRICT, PAKISTAN

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ABSTRACT

Massive sulphide mineralization zone has been found in volcanic and metasedimentary rocks of Lower Cretaceous age in Singal area about 50 km. northwest of Gilgit (Toposheet No. 42 H/16). The mineralization occurs in Rakaposhi volcanic complex and is exposed in an area of 2.5 sq. km. approximately. This sulphide zone can be recognized as an altered product of original rocks that weathers to pale, brownish, reddish and dark grey material in the superficial part of the outcrops. The mineralization is also observed in the form of dissemination in the volcanics and dolerite dikes mostly along the surface of joints and fractures. During the geological investigations of the area, 15 representative samples were collected and chemically analysed. Majority of samples show encouraging results of anomalous massive sulphide mineralization. The metallic content of analysed samples generally indicate the presence of Fe, Zn, Cu, Mn, Co and Mo in above-average quantities.

This report is based on field investigations and chemical analyses and may be suggested to be followed by a more comprehensive field and laboratory studies to prove the economic potential of sulphide mineralization.

ACKNOWLEDGEMENTS

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Purpose and Scope of the Study

The purpose of this report is to give a brief idea about the massive sulphide mineralization occurrence in Singal area, Gilgit district. The hydrothermally altered sulphide mineralization was earlier observed in 1984 during geological mapping of Singal quadrangle (42 H/16) on 1:50,000 scale. The studied part of this mineralization spreads over an area of 2.5 sq. km. and has developed in the volcanic and metasedimentary rocks, which are intruded by granodiorite body. The samples were collected from different locations and were chemcially analysed. A total of 15 samples were analysed and studied. Most of them show an anomalous value of Mn, Cu, Zn with Co content. The geological map on scale 1:50,000 prepared by M/s. Naseer Ali Khan and Sajid Hussain Shah has been used as base map.

This report is submitted with the recommendation for detailed geological investigations to appreciate the prospects and determine the sulphide mineral potential of the area.

Location and Accessibility

The Singal sulphide zone is located about 50 km. northwest of Gilgit along the Gilgit river (Toposheet No. 42 H/16). It can be approached from Gilgit which is connected with Rawalpindi by an all-weather Karakoram Highway.

Previous Work

Sillitoe (1979) in his research paper "Himalayan Metallogeny based on the Evidence from Pakistan" has described oxidized copper minerals of probable metamorphic origin in granite host rock with narrow quartz veins and minor faults. Ivanać et al. (1956) reported occurrence of pyrite minerals in Nomal area in the east where Leghari et al. (1986) have also reported the occurrence of Cu, Mn, Zu, Pb, Mo, Fe with Au and Ag concentrations in hydrothermally altered sulphide mineralization zone of same origin. Janković (1984) has suggested some possibilities of volcanogenic and volcano-sedimentary mineralization in the Kohistan island arc sequence in this area.

GENERAL GEOLOGY

In the Singal quadrangle (42 H/16), the volcanic and metasedimentary rocks intruded by porphyritic granodiorite of Ladakh batholith, from a part of the Kohistan island arc sequence with the Main Karakoram Thrust (MKT) in the north. The Rakoposhi volcanic complex consists mainly of andesite, rhyolite, dacite, altered diorite, gneisses, schists, amphibolites, greywackes, limestone and marble.

The Singal sulphide mineralization occurrence has developed in the Rakaposhi volcanic complex along a fault zone. The geology of these two major units exposed in the area is described below:

Pleistocene	Quaternary deposits: Unconsolidated sediments, alluvium terraces, river deposits with moraines.
Late Cretaceous to Miocene	Ladakh intrusives: Granodiorite (porphyritic), pegmatite with basic dykes.
Early Cretaceous	Rakaposhi volcanic complex: Andesite, rhyolite and dacite as volcanics and gneisses, schists, amphibolites, greywackes, slate, limestone and altered diorite.

Rakaposhi Volcanic Complex

The term "Rakaposhi volcanic complex" was introduced by Tahirkheli (1982) for Greenstone complex of Ivanac et al. (1956) which comprises of a large group of volcanic rocks croping out over a large part of the Gilgit district. This complex owes its name to its colour and lithology which makes its division into further units difficult. Essentially, however, the group consists of sedimentary and volcanic rocks that have been subjected to metamorphism causing their enrichment in hornblende and epidote group of minerals. The volcanic rocks are andesite, rhyolite, basalts, dacite, and metasedimentary rocks are gneisses, schists, amphibolites, slates, quartzite/greywackes, limestone and marble. Diorite of this complex exposed near the sulphide mineralization zone is of earlier age than Ladakh intrusives. This has been considered to be the magmatic chamber of volcanic activity because it is altered and so epidotization is more pronounced in this diorite rock. Some malachite staining is widely observed associated with this diorite and concentrated along the fractures and joints.

Ivanac̆ et al. (1956) reported the volcanics with metasediments from Slipi to Hasis areas located north of Singal. The sulphide zone has developed in andesite, dacite, quartzite, gneisses with dolerite dikes which cut the rocks near sulphide zone. The alteration present along a fault has been observed across the Gilgit river. The rocks of Rakoposhi volcanic complex have intrusive contact with granodiorite body.

Ladakh Intrusives

Ladakh granodiorite of Ivanac̆ et al. (1956), Kailas granodiorite of Stauffer (1968) and Bakr (1965) and Ladakh-Kohistan granitic belt of Jan et al. (1981) has been renamed as Ladakh intrusives by Tahirkheli(1982).

The composition of this rock unit varies from basic to acidic comprising of granodiorite, diorite, granite, aplite, pegmatite and gabbro with diorite dikés of younger age. These rocks are exposed in the major parts of Gilgit district. The colour is greyish white to white on fresh surface and yellowish brown on weathered surface.

The granodiorite exposed in the area is porphyritic in texture, and pegmatites are common near the contact of granodiorite and volcanic rocks. Some quartz veins which are thin and scattered, are observed in the sulphide mineralization and surrounding area

Thin section study carried out by the authors shows that porphyritic granodiorite is composed of orthoclase, albite, oligoclase, quartz, hornblende and biotite. Albite and orthoclase are responsible for development of phenocrysts which occur mostly in euhedral and subhedral form. The secondary minerals are epidote, chlorite and biotite. The biotite is partly altered to chlorite. The hornblende is mostly altered and zoaning is also developed.

The age assigned to this magmatic complex on the basis of Ar/K dating by Casnedi, Rex and Qasim Jan (1978) is Late Cretaceous to Miocene.

ECONOMIC GEOLOGY

Geotectonic Setting and Metallogenic Evolution

The sea floor spreading from mid oceanic ridge near south Africa which opened up the Indian ocean and consequently the northward drift of Indian continent is confirmed on the basis of survey by Mckenzie (1971). The active subduction from Mid Jurrassic to Paleocene along the Indus suture trench margin resulted in the closure of Tethyan sea and is marked by ophiolites and flysch of Indus suture zone (Gansser, 1974). Sea floor spreading recommenced about 35 million years ago in Lower Miocene and northward movement indcued underthrusting of Indian plate along its northern margin giving rise to the uplift of Himalayas. Concurrently, the volcanism caused the outpouring of pillow lavas, basalts, andesites, dacites, etc., in island arc environments.

Jancovic' (1984) has divided the northern areas of Pakistan into two geotectonic units: (i) Karakoram-south Pamir-Hindukush zone which is partly developed in Pakistan, (ii) Kohistan-Ladakh island arc which mostly lies within Pakistan.

The Kohistan-Ladakh islanad arc is a well defined geotectonic unit of particular metallogenic importance. It is located between Indo-Pakistan and Eurasian continents, as identified by Tahirkheli(1979). Sandwiched by Eurasian and Indian plates it is bounded in the south by the low dipping Main Mantle Thrust (MMT) and in the north by the Main Karakoram Thrust (MKT).

The Kohistan-Ladakh island arc represents (about 40 km) thick Jurassic-Cretaceous complex of calcalkaline plutonic, volcanic and volcano-sedimentary rocks which have undergone low to high grade metamorphism.

Tahirkheli (1979) and Bard et al. (1980) described several distinguishable lithologic units of the Kohistan sequence. They include, from bottom to top, the southern amphibolite belt, the pyroxene granulite belt, the northern amphibolite belt, the volcano-sedimentary series, the Utror and Rakaposhi volcanic and plutonic complexes, and the Kohistan-Ladakh granite belt.

Since the northern areas of Pakistan have not been systematically studied and prospected from metallogenic point of view, the metallogeny of Kohistan-Ladakh volcano-intrusive complexes and the volcano-sedimentary series is little known.

On the basis of geotectonic setting and composition of magmatic complexes of this region, as well as on the basis of scanty data, several genetic types of ore mineralization as described by Jancović (1984) can be recognized as under:-

1. Podiform magmatic chromite mineralization with dunite and peridotite rocks of Jijal ultramafic complex.

2. Volcanogenic-sedimentary massive copper mineralization (cyprus type) not known. The copper mineralization near Boy Scout Post, Shinkai area, North Waziristan (Tahirkheli 1978) may belong to this group.

3. Volcanogenic and volcano-sedimentary mineralization related to andesite-dacite-rhyolite complexes (massive sulphide deposits, pyrite, chalcopyrite, galena, sphallerite, the Kuroko type manganese deposits).

Some occurrence of pyrite mineralization in Gilgit area(Nomal, Jutal and Kargah nalas near Batura) reported by Ivanać et al. (1956) may be some indications of massive sulphide mineralization. The presence of gold and silver is confirmed in the rocks of Nomal and Garesh sulphide mineralization zones by Leghari et al. (1986) on the basis of chemical analyses. These are associated with copper, iron, manganese, zinc, lead and molybdenum found as massive sulphide minerals and such occurrence has also been confirmed on the basis of chemical analyses in Singal area (42 H/16). These sulphide zones are the product of alteration of original rocks by hydrothermal solutions and commonly observed along the fault plane. Since the origin of sulphide zone of Singal area is same as that of the Nomal sulphide zone where the presence of Au and Ag are confirmed, further detailed geological investigations may lead to the discovery of an important precious metal-bearing zone in the project area.

4. The metallogeny of diorite, granodiorite and leucogranite is uncertain. Tahirkheli (1980) has mentioned the occurrence of Pb, Zn and Sb associated with diorites in Ushu valley of Swat. The composition of magmatic complexes, their evolution and favourable geotectonic setting is probably indicative of the significance of island arc, for magmatic chromite mineralization and massive sulphide base metal (Cu-Pb-Zn) deposits in volcano-sedimentary and volcanogenic rocks.

Sillitoe (1979) has described copper mineralization in Henzal (20 km. towards northwest from Gilgit) and in Singal (50 km. towards northwest of Gilgit) possibly of metamorphic origin. Henzal copper is present in the form of 4 m. wide quartz vein containing chalcopyrite, bornite, magnetite, garnet, epidote schist. This mineralization is of earlier age than the deformational phase. In the case of Singal, the copper mineralization is present in narrow quartz veins with minor faults containing oxidized copper in the granite host rock. Sulphide minerals confirmed by present investigations are in the form of disseminated and hydrothermally altered rocks of volcanic type mainly the andesites and dacites, with metasediments. These volcanic and metasedimentary rocks belong to Rakaposhi volcanic complex and both zones are located along a fault.

It is possible that the metallogeny accompanying continental collision and its related effects are on a small scale, and that the major ore types, such as porphyry copper, epithermal precious metals and Kuroko type massive sulphide deposits, found in Cordilleran or island arc setting above subduction zones, are unlikely to be found (Sillitoe, 1979).

Sawkins (1984) has pointed out that the collision tectonic events are important in terms of generation of lithophile element deposits such as tin, uranium, and so certain amounts of base metals may also be involved in these systems, but their economic importance is at best minor.

Sillitoe (1978, 1980) gives possibility of metallogeny in collision events and collision terraines, and describes three types of metal deposits to be originated in the collision tectonics:

1. Metallogeny of oceanic type crust (Cuprus type massive sulphide deposits and chromite deposits in ophiolite complexes).

2. Metal deposits associated with early stages of continental rifting (hydrothermal copper deposits, rift related molybdenum deposits, rift related stratiform copper deposits, rift related magmatic copper-nickel deposits, carbonate hosted lead zinc deposits in relation to rifting, Mississippi valley type deposits, Alpine type lead-zinc deposits and Irish type lead-zinc deposits).

3. Metal deposits related to advance stages of rifting (sediment-hosted massive sulphide deposits and massive sulphides in high grade metamorphic terrains).

The possibility of encountering Sn-W deposits in Himalayas has also been considered by some workers. Jancovic' (1984) concluded that Kohistan-Ladakh island arc may contain volcanogenic and volcano-sedimentary deposits of base metals (Kuroko type) and manganese and perhaps Sn, W, Mo mineralization is related to Oligocene-Neogene granite of crustal origin. Ultramafites (dunitic varieties) may host significant chromite deposits.

Geology of Singal Sulphide Zone

The volcanics like andesite, dacite and rhyolite with metasediments of Rakaposhi volcanic complex, intruded by granodiorite and diorite of Ladakh intrusives are exposed in the mineralized as well as in surrounding areas. The surface appears highly weathered and is a conspicuous feature of the area. This alteration may be attributed to the action of hydrothermal solutions. It is considered that the lavas, andesite, dacite, rhyolite, etc., outpoured in the Lower Cretaceous age with syn-depositional phase, have been altered to form massive sulphide mineralization zone. The metasediments include gneissic tuffs, schist, metagreywackes, quartzite and amphibolite, etc. In the Japuka Gah, marble and mica schist are interbedded with each other. This sulphide zone is the result of hydrothermal alteration of lavas since the talc has been found associated in the cracks which is the initial stage of alteration of proxene. The dolerite dikes have intruded the metasediments and granodiorite. The pyrite and chalcopyrite are disseminated in the volcanics (andesite, rhyolite and dacite) and dolerite dikes. The alteration noticed in the zone is in the form of calcite, epidote, and silica in the metasediments while the volcanics and dolerite dikes are sericitized in the mineralized zone. The quartz veins are present in the sulphide zone. The colourful appearance indicates the presence of limonite, hematite, goethite and jarosite. The malachite staining is observed widely distributed in the form of veins and also along joints and fractures mostly in the epidotized diorite, volcanics and metasediments of the area. The sulphide mineralized zone of Singal is the oxidized product of the possible massive sulphides which are syn-volcanic with lava flows.

Mode of Formation of Sulphides

In the ophiolite zones, the pillow lavas are altered to give rise to massive sulphides. In the case of Singal area, the surface geology shows that the process of oxidation has occurred in the sulphide zone because on the surface, limonite, goethite and jarosite can be observed clearly. The mode of formation of this sulphide zone is considered to be the hydrothermal alteration of original rocks. Sillitoe(1979) has described the copper minerals of this area probably of metamorphic origin. He gave the idea that metallogeny accompanying the continental collision and its related effects on a small scale and also the major ore types such as porphyry copper, epithermal precious metals and Kuroko type massive sulphide deposits found in the Cordilleran or island arc setting above the subduction zones, are unlikely to be originated in the Kohistan-Ladakh island arc.

Jancović (1984) has proposed four different genetic types of ore mineralization in the Kohistan-Ladakh island arc and suggested that volcanic and volcano-sedimentary mineralization may have originated in these rocks. This mineralization is related to andesite-dacite-rhyolite complexes and the probable occurrence of massive sulphide mineralization in the area has also been referred to.

Extent of Mineralization Zone

The finding of the massive sulphide mineralization in volcanic and metasedimentary rocks in Singal quadrangle (42 H/16) and its possible extension as indicated by geochemical analyses is encouraging.

A limited area of about 2.5 sq.km. could possibly be investigated because of technical constraints and rugged topography. It is expected that the detailed geological investigations and regular sampling would yield even more encouraging results. It was observed during the investigations that such mineralization was quite widespread in the surrounding area. It is probably of the form of hydrothermal replacement lodes flanked by disseminated mineralization. In Japuka area, the mineralization is mostly observed along the dolerite dikes and dacitic type rocks because the granodiorite intrusion has taken place near the zone.

The fact that the exposed mineralization is oxidized and weathered, suggests that secondary enrichment zones may be found more developed at depth but the factor of rapid erosion does not favour this idea. The sulphide mineralization occurrence in Nomal and Garesh area (42 L/8) has also been confirmed by Leghari et al. (1986) which is located 40 km. southeast of these zones and probably of the same origin, this is indicative of the fact that further detailed geological and geochemical investigations would certainly give more encouraging results. The Nomal sulphide zone extends westward in Hachina area (42 L/4).

Metallic Content in the Sulphide Zone

During the field investigations, samples were taken from highly weathered, and from altered and oxidized zone of the mineralization at different locations.

The chemical analyses determining the average content of each metal for a group of samples is tabulated below:

Metal	Average content in the group		No. of samples in the group
	%age	ppm	
Fe	5.0		15
Zn		103	15
Mn		1044	14
Cu		247	15
Co		440/traces	2
Mo		traces	4

The metallic content exhibited by the above data is generally low but Mn, Cu, Zn, Co anomalies are, however, encouraging. The massive sulphide zone suggested by these results may prove to be the base for future prospection of sulphide minerals in the area.

As Au and Ag has been confirmed by Leghari et al. (1986) in Nomal area with other sulphide minerals, the Singal sulphide zone being of the same origin may prove promising in future on further detailed geological and geochemical investigations for its content of precious metals.

Suggestions and Recommendations

1. Presence of Mn, Cu, Zn, Co and Mo warrants further investigations of the area.

2. Detailed geological mapping on scale 1:10,000 with extensive geochemical sampling substantiated by the geophysical survey will be of utmost importance to know the mienral potential of the area.

3. The surface alterations and presence of massive sulphides in large area, are suggestive of massive copper sulphide deposits underneath.

4. The Zn values seem quite encouraging for further prospection.

5. If the later studies prove the area to be promising, the drilling will be required to investigate it thoroughly.

6. If the presence of an economic massive sulphide mineral deposit in the area is proved, it may lead to a significant discovery since such types of massive deposits are widespread in the area.

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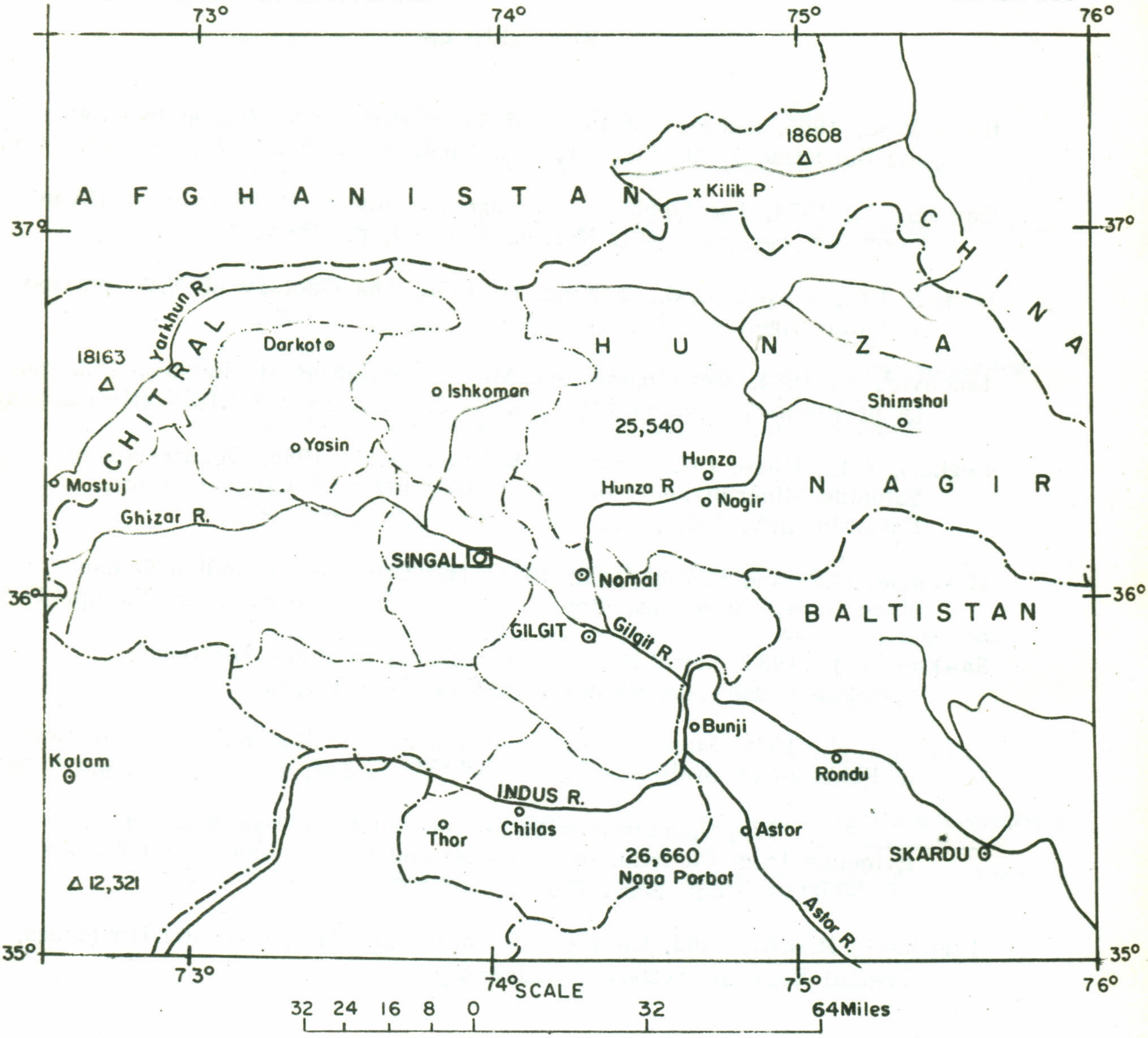

Figure I:-Location Map of Singal Sulphide mineralization Zone.

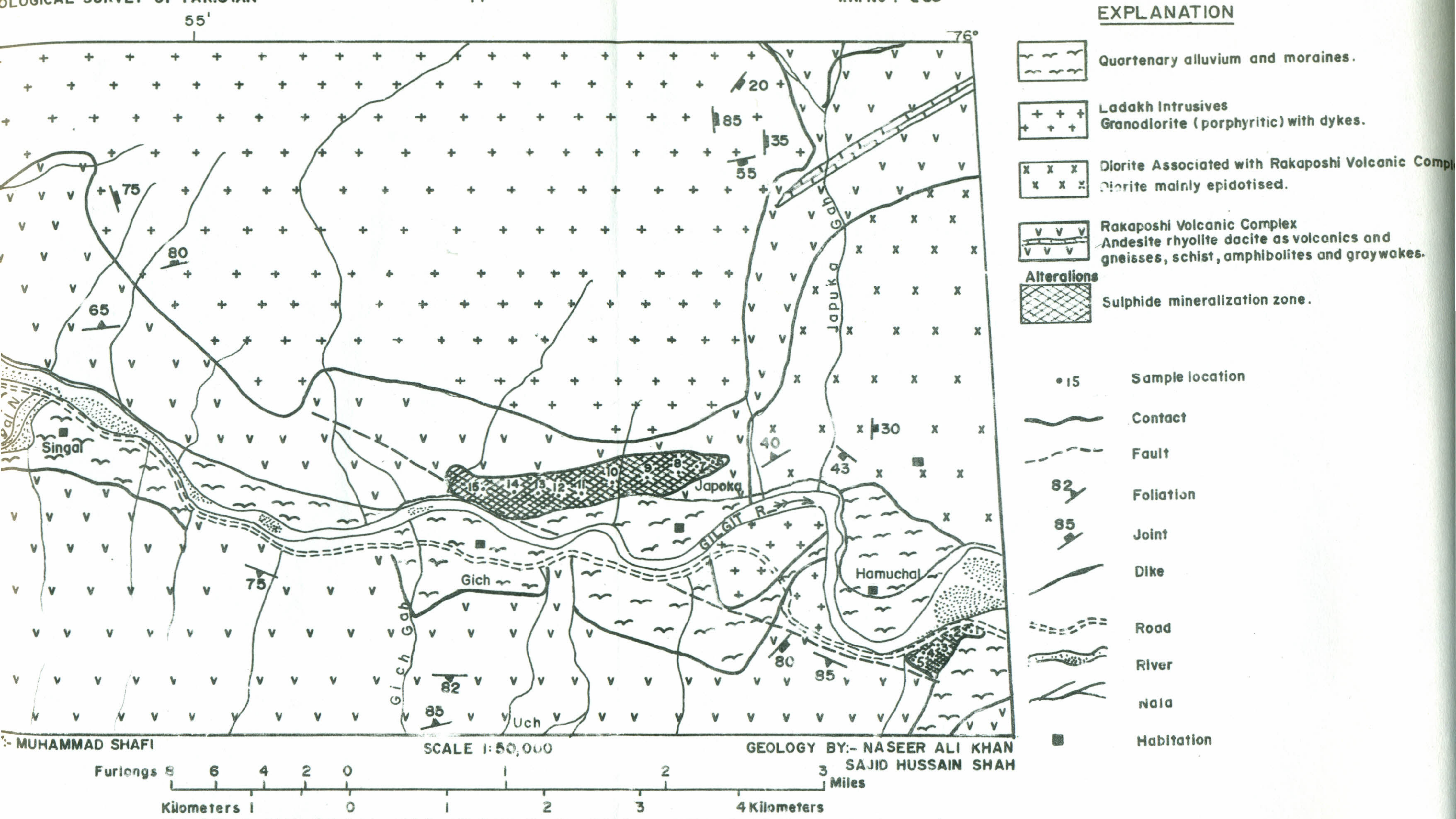

FIGURE 2. GEOLOGICAL MAP OF SINGAL SULPHID MINERALIZATION ZONE AND SURROUNDING AREAS (42H/16) GILGIT DISTRICT PAKISTAN.

Table 1 : Table showing Chemical Analyses Result of Singal Sulphide Mineralization(42 H/16) Gilgit District, Pakistan.

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S.No.	Sample No.	Type of sample	Fe %	Mn ppm	Au ppm	Ag ppm	Co ppm	Cu ppm	Mo ppm	Ni ppm	Pb ppm	Zw ppm
1.	Ns - 84 - 1	Surface	2.62	349	Nil	Nil	Trace	107	Nil	Nil	Nil	90
2.	Ns - 84 - 2	"	2.62	137	"	"	Nil	49	Trace	"	"	73
3.	Ns - 84 - 3	"	4.92	1720	"	"	"	132	Nil	"	"	196
4.	Ns - 84 - 4	"	3.09	473	"	"	"	206	"	"	"	233
5.	Ns - 84 - 5	"	3.25	1072	"	"	"	99	"	"	"	136
6.	Ns - 84 - 6	"	2.25	424	"	"	"	140	"	"	"	33
7.	Ns - 84 - 7	"	2.46	1496	"	"	"	132	Trace	"	"	100
8.	Ns - 84 - 8	"	6.34	Nil	"	"	"	124	Nil	"	"	23
9.	Ns - 84 - 9	"	6.75	623	"	"	"	256	Trace	"	"	90
10.	Ns - 84 -10	"	7.01	5860	"	"	440	1115	"	"	"	156
11.	Ns - 39 -11	"	9.32	1345	"	"	Nil	35	Nil	"	"	100
12.	Ns - 88 -12	"	6.54	570	"	"	"	125	"	"	"	70
13.	Ns - 99 -13	"	8.79	870	"	"	"	170	"	"	"	120
14.	Ns - 99 -14	"	3.35	220	"	"	"	310	"	"	"	50
15.	Ns - 110-15	"	5.39	500	"	"	"	700	"	"	"	70