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OCCURRENCE OF SULPHIDE MINERALIZATION
IN NOMAL AREA (42 L/8)
GILGIT DISTRICT, PAKISTAN

By

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GOVERNMENT OF PAKISTAN
GEOLOGICAL SURVEY OF PAKISTAN

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Abstract

Massive sulphide mineralization zone have been found in volcanics and metasedimentary rocks (Greenstone Complex) of Lower Cretaceous age in Nomal area about 25 km north of Gilgit (toposheet No.42 L/8). The mineralization is exposed in an area of 7.5 sq.km. approximately. This sulphide zone is recognized as highly weathered and altered product of original rocks being pale, brownish, reddish and black in colour in the upper portion of the outcrop. During geological mapping of the area, 29 samples were collected and chemically analysed. Majority of samples show very encouraging anomalies of massive sulphide mineralization.

The metallic content of analysed samples (Table-1) shows that out of 29 samples, all samples contain Fe (averaging 4.17%), 27 samples with Mn (944 ppm), 25 samples have Cu, (353 ppm), 22 samples average in Zn (108 ppm), 6 samples with Pb (550 ppm), 2 samples show content of Au (as 0.65 and 1.03 ppm), two samples have Ag (one with 69 ppm content and other with traces) and finally 9 samples show traces of Mo.

Two samples collected from Naltar Gah, northwest of Nomal where volcanics are exposed contain Mn (as 848 and 986 ppm) and Cu (as 7900 and 350 ppm),(Table-1).

This report is based on field investigations and chemical analyses, and will be followed by a more comprehensive account of field work and laboratory studies which may prove the area promising for further study of sulphide mineralization.

Introduction

Purpose and Scope of the Study

The purpose of this report is to give a brief idea about the massive sulphide zone of Nomal area in Gilgit District. The hydrothermally altered zone of sulphide mineralization was observed during the regional geological mapping of Rakaposhi quadrangle (42 L/8) on scale 1:50,000 in October - November 1984. The zone spreads over an area of 7.5 sq. km. (approx.) and has developed in volcanic and metasedimentary rocks which, in turn, are intruded by a granodiorite body. The samples were collected during the field work from different mineralized locations and were analysed by GSP Laboratory, Lahore.

Out of 29 samples, most of them have anomalous value of Cu, Mn, Zn and Pb with Au and Ag content. The detailed geological map on scale 1:50,000 prepared by M/s. Ibrarul Hasan Khan, Abdul Latif Leghari and Amir Khan Wazir has been used as a base map.

At two locations in Naltar Gah, to the northwest of Nomal, Mn and Cu are confirmed by the chemical analyses.

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

Location and Accessibility

The sulphide mineralization zone of Nomal is located about 25 km north of Gilgit along Hunza river (Toposheet No.42 L/8). Gilgit is about 620 km from Rawalpindi. It is connected by a all weather famous Karakoram Highway and PIA operates a Foker Service between Rawalpindi - Gilgit. The Nomal sulphide mineralization zone can be approached from Gilgit by a fair weathered Shingle road (old Gilgit-Hunza road).

Previous Work

Ivanac et al, (1956) reported occurrence of pyrite mineral in Nomal area. Some hematite which forms brilliant red weathering product of pyrite and arseno pyrite, visible on hills near Nomal also mentioned by them and they described these deposits as only stains on hill sides and of no commercial use. Clark (1951) reported the occurrence of gold in alluvial gravels near Nomal in Hunza river but did not find it in outcrops around the area. Many other workers have investigated the lower Hunza valley but none of them reported the said sulphide mineralization zone. Jancovic (1984) has given some possibilities of massive sulphide mineralization in Nomal area on the basis of previous data.

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gratitude to the Chemistry Division, GSP, Lahore for timely analyses of the samples.

General Geology

The Rakaposhi quadrangle (42 L/8) is a part of Kohistan Island Arc which comprise largely of volcanic and metasedimentary rocks in southern and northern parts and is intruded by Ladakh Intrusives mainly in the south. The famous Main Karakoram Thrust passes through this area, close to the northern margin of the quadrangle. Chalt Schist have faulted contact with Greenstone Complex. Three major units of rocks are exposed in the area, with Chalt Schist as the oldest consisting mainly of schists of various types, and the volcanic and metasedimentary rocks of Greenstone Complex consisting mainly of andesite, basalt, rhyolite and dacite as volcanics while gneisses, schists amphibolites, quartzite, marble and limestone as meta-sedimentary rocks.

The Nomal sulphide mineralization zone has been developed in the Greenstone Complex. This Complex has been intruded by the Ladakh granitic Batholith and its geology favours the Island Arc environments. The geology of these two major units exposed in the area is described below:

General stratigraphy of the area is as follows:-

	Quarternary deposits
Pleistocene	Unconsolidated sediments, alluvium terraces, river deposits with moraines.
Late Cretaceous to Miocene	Ladakh Intrusives Granodiorite, diorite, pegmatite with basic dykes.
Lower Cretaceous	Greenstone Complex Volcanics with metasediments, andesite mainly, schists, gneisses and marble.
Lower Cretaceous	Chalt Schist Slates, graphitic schist, quartz chlorite schist, biotite schist, talc schist, quartzite and marble.

Green Stone Complex:

The term "Greenstone Complex" was introduced by Ivanac et al, (1956 p.9) for a large group of volcanic rocks mixed with some metamorphic rocks which crop out over a large part of the Gilgit District. The complex owes its name to its colour and the lithology of the complex, makes its divisions 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, epidote and serpentine minerals. The volcanic rocks are andesite, rhyolite, dacite and basalt while the metasedimentary rocks are schists, gneisses, quartzite, slate, phyllite, limestone and marble, etc.

South of Nomal a band of rocks is exposed consisting of folded schists and marble with some volcanics which is part of Greenstone Complex. The granodiorite has intruded on both sides of this Greenstone Complex band. The schists were probable biotite quartz schists but have now been altered to greenish schists containing much hornblende, serpentine and talc (Stauffer 1968 p.20). The marbles are white and coarse grained. The same lithology is exposed on opposite side of Hunza river which have been mapped as schist, marble and meta volcanics. In Dainyor Nala, south east of Nomal Kazmi (1951) has mapped slates, schists and quartzite. The sulphide zone of Nomal is developed in the Greenstone Complex which has intrusive contact with granodiorite in the vicinity of Nomal area. The alteration on opposite side of Hunza river has not been noticed. However, a sulphide zone is present in Dainyor Nala (Manu Gah) near Barit, which is probably of same origin (Sajid Hussain Shah 1979).

The age assigned to Greenstone Complex by Tahirkheli (1982 p.26) on the basis of fossil content of *Glaubo Truncana* is Lower Cretaceous.

Ladakh Intrusives:

Ladakh Granodiorite of Ivanac et al (1956, p.2), Kailas granodiorite of Stauffer K.A. (1968, p.24) and Bakr, M.A, (1965) and Ladakh Kohistan Granitic Belt of Jan et al (1981) has been renamed as Ladakh Intrusives by Tahirkheli (1982, p.45).

The composition of this rock unit varies from basic to acidic and in order of abundance, they are granodiorite, diorite, granite, aplite, pegmatite and gabbro with dolerite dykes of younger age. The colour is greyish white to white on fresh surface and yellowish brown on weathered surfaces.

Between Gilgit and Nomal, the granodiorite body is composed of granodiorite and quartz monzonite with most abundant mafic minerals like hornblende and biotite (Stauffer 1968). Thin section study by Stauffer (1968) reveals that some of plagioclase twin lamellae are bent, alongwith the presence of granet indicates the rocks has suffered some post intrusive metamorphism.

In most of the outcrops, hornblende is more abundant than biotite. In the vicinity of Nomal, biotite granodiorite is dominant rock type. Near the contact with volcanic rocks of Greenstone Complex, the igneous rocks become more basic and commonly show marked gneissose structure. The northern most margin of this granodiorite, about 3 km north of Nomal, also contains gneissic hornblende, diorite and hornblendite.

The basic dolerite dykes are prominent feature on the both sides of of Hunza river near Rahimabad, Jutal and Nomal. The more basic rocks near the contacts probably represent the mixing and assimilation of intruded basic volcanic rocks Stauffer (1968 pp. 25-27).

The age assigned to this magmatism on the basis of A/Kr dating by Gasnedi, Rex and Qasim Jan is Late Cretaceous to Miocene (63 to 19 m.y.).

Geotectonic Setting and Metallogenic Evolution

The sea floor spreading from Mid Oceanic ridge near south Africa opened up the Indian ocean and northward travel of Indian Continent is confirmed on the basis of survey by D.P. Meckanzie (1971). During the collision, the active subduction from mid Jurassic to Paleocene along Indus suture trench margin resulted the closure of Tethyan sea and is marked by ophiolites and flysch of Indus suture zone, Ganser (1974). Sea floor spreading recommenced about 35 million years ago in Lower Miocene and northward movement induced under thrusting of Eurasian plate by northern margin of Indian plate, along the Himalayas resulting in southward nappe emplacement and violent uplift. During the volcanism, pillow lavas, basalts, andesites, dacites, etc., in Island Arc environments were outpoured.

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

The Kohistan-Ladakh island arc is well defined geotectonic unit of

particular metallogenic importance. It is located between Indo-Pakistan and Eurasian Continent as identified by Tahirkheli (1979). It is marked by low-dipping Main Mantle Thrust (MMT) separating Kohistan-Ladakh Island Arc from Indo-Pakistan plate, and the Main Karakoram Thrust (MKT) marks the boundary between Kohistan-Ladakh island arc and Eurasian plate Tahrikheli (1979).

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

Tahirkheli (1979) and Bard, et al (1980) described several lithologic units distinguished from bottom to top of the Kohistan sequence which are southern amphibolite belt exposed in southern part of Kohistan, pyroxene granulitic belt (10-15 km thick), northern amphibolite belt, volcano-sedimentary series, Utror and Rakaposhi volcanic and plutonic complexes and the Kohsitan-Ladakh granitic belt.

Since 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 some of scanty data, several genetic type of ore mineralization have been described by Jancovic (1984).

1. Podiform magmatic chromite mineralization associated 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 genetic type.

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

Some occurrences of pyrite mineralization in Gilgit area (Nomal, Jutal and Kargal Nalas near Batur) reported by Ivanac's et al (1956) may be some indications of massive sulphide mineralization. Chalcopyrite - pyrite - pyrrhotite boulders have been found at Dikit and Pasu but their source is unknown, Ivanac et al (1956). Nomal sulphide mineralization zone has been explored which probably belongs to this genetic type of ore mineralization. The result of chemical analyses show that copper, manganese, zinc, lead with some silver and gold content, are present in this zone and prove it a massive sulphide zone. This sulphide zone is a product of alteration of original rocks by hydrothermal solutions.

4. The metallogeny of diorite, granodiorite and leucogranite is uncertain. Tahrikheli (1980) has mentioned Pb-Zn-Sb occurrences in Ushu valley, Swat in association with diorites. 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 deposits (Cu, Pb, Zn) in

in the volcano-sedimentary and volcanogenic rocks.

Sillitoe (1979) has described copper mineralization in Henzal (20 km towards northwest of Gilgit) and Singal (50 km away) along the Gilgit river, of the probable metamorphic origin. Henzal copper is present in the form of 4 m wide quartz vein containing chalcopyrite, bornite, magnetite, garnet, epidote and actinolite having probable faulted contact of marble and biotite schist. This mineralization is of earlier than one deformational phase. In case of Singal, copper mineralization is present in narrow quartz veins with minor faults containing oxidized copper in the granite host rock.

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

The possibility of encountering tin-tungsten deposits in Himalayas has been considered by some workers.

Jancovic (1984 p.21) concluded that Kohistan-Ladakh Island arc may contain volcanogenic and volcano-sedimentary deposits of base metals (the Kurukotype) 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 Nomal sulphide Zone

The sulphide mineralized zone of Nomal is the oxidized product of the possible massive sulphides which are syn volcanic with lava flows. The volcanics (andesites, mainly) and meta sediments of Greenstone Complex with intrusive granodiorite are exposed in the mineralized area. The surface appearance is highly weathered being a prominent feature of the area and altered due to the hydrothermal solutions. In this area, the lavas, andesite, dacite, rhyolite, etc., outpoured in the Lower Cretaceous age with syndepositional phase which has been altered to massive sulphide mineralization zone. The metasediments i.e. biotite quartz schist, garnet schist, calcareous schist, talc schist are dominated by the said volcanics. A marble band is also present near the sulphide zone. This sulphide zone is a result of the hydrothermal alteration of lava flows as the talc schist is associated with metallic sulphide dissemination. In this area, pyrite and chalcopyrite are disseminated in the volcanics and the colour indicates the presence of limonite, hematite, goethite, jarosite. Some metallic content is also recognized in the fractures and joints of the volcanic rocks near alteration zone.

Along Naltar Gah, northwest of Nomal sulphide zone, the volcanics exposed with granodiorite body, shows anomalous values of copper and manganese content with zinc traces (Table 1). The pyrite and chalcopyrite are recognised in this outcrop which are in disseminated form. The ratio of metallic content is higher along fractures and joints.

Mode of Formation of Sulphides

In the ophiolite zones, the pillow lavas are altered to give rise to the massive sulphide zones. The surface geology shows that the process of oxidation has occurred in this sulphide zone because on the surface limonite, goethite and jarosite can be seen clearly. The mode of formation of this sulphide zone is considered to be the hydrothermal alteration of the original rocks. Sillitoe (1979) has described 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 cordilleran or island arc setting above the subduction zones, are unlikely to originate in the Kohistan-Ladakh island arc.

Janocovic (1984) proposed four different genetic type ore mineralization in the Kohistan-Ladakh Island arc and suggested volcanogenic and volcano-sedimentary mineralization in the investigated area of Nomal on the basis of pyrite minerals reported by Ivanac et al (1956). This mineralization is related to andesite-dacite-rhyolite complexes and he pointed out some indications of massive sulphide mineralization in Nomal area.

The Cretaceous lava flows of Greenstone Complex were metamorphosed and hydrothermally altered by the granitic emplacement.

Extent of Mineralization Zone

The finding of the massive sulphide mineralization in volcanic and metasedimentary rocks in Nomal area and its behaviour and extension as indicated by geochemical anomalies is encouraging. A limited area of about 7.5 sq. km. could be investigated because of the constraints of time and rugged

topography. It is expected that the detailed geological investigations and regular gride sampling would yield more encouraging results. It was observed during the investigations that the mineralization is quite widespread in this zone and believed to be the form of hydrothermal replacement lodes possibly flanked by disseminated mineralization.

The fact that the exposed zone is oxidized and weathered, suggests that secondary enrichment zone may be found more developed at depth but the factor of the rapid erosion does not favour this idea. Two prominent sulphide zones have been observed during the field investigations near Nomal in the same quadrangle. Garesh sulphide zone is exposed about 10 km north of Nomal in the rocks of Grenstone Complex while Barit sulphide zone is located about 15 km towards east, also confirmed by Shah Sajid Hussain (1979) on the basis of chemical analyses. Au has been confirmed on the basis of chemical analysis in Garesh area along Hunza river.

Metallic Content in the Sulphide Zone

During the investigations, samples were taken from different locations of highly weathered and oxidized zone of the mineralization. Although sampling was carried out randomly in N-S Channel yet efforts were made to give it a maximum coverage.

The chemical analysis giving the average content of each metal collectively for a group of samples is listed as below:

Metal	Average content in the group		No. of samples in the group.
	%age	PPM	
Fe	4.17	-	29
Mn	-	944	27
Cu	-	353	25
Zn	-	108	22
Pb	-	550	6
Au	-	(0.65 and 1.03)	2
Ag	-	(69 and Traces)	2
Mo	-	Traces	9

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

The presence of Au and ag in Hunza river sediments is well known but its presence insitu rocks of Gilgit area has not been reported so far. Now on the basis of the present investigations, their occurrence is confirmed and a better appreciation of precious metals is expected through future exploration.

Suggestions and Recommendations

1. The presence of Manganese (Mn), Copper (Cu), Zinc(Zn), Lead(Pb) and also of Gold(Au) and Silver(Ag) warrants further investigations of the area.
2. Detailed geological mapping on 1:10,000 scale alongwith extensive geochemical sampling substantiated by geophysical survey will be of utmost importance to know the mineral potential of the area.
3. The surface alterations and presence of massive sulphides over a large area, are suggestive of massive copper sulphide deposits underneath.
4. The Zn values seem quite encouraging for further prospection.
5. If later studies prove the area promising, the drilling will be required to investigate thoroughly.
6. If the presence of an economic masive sulphide deposit in the area is proved, it may lead to a significant discovery since such types of massive deposits are widespread in the area.

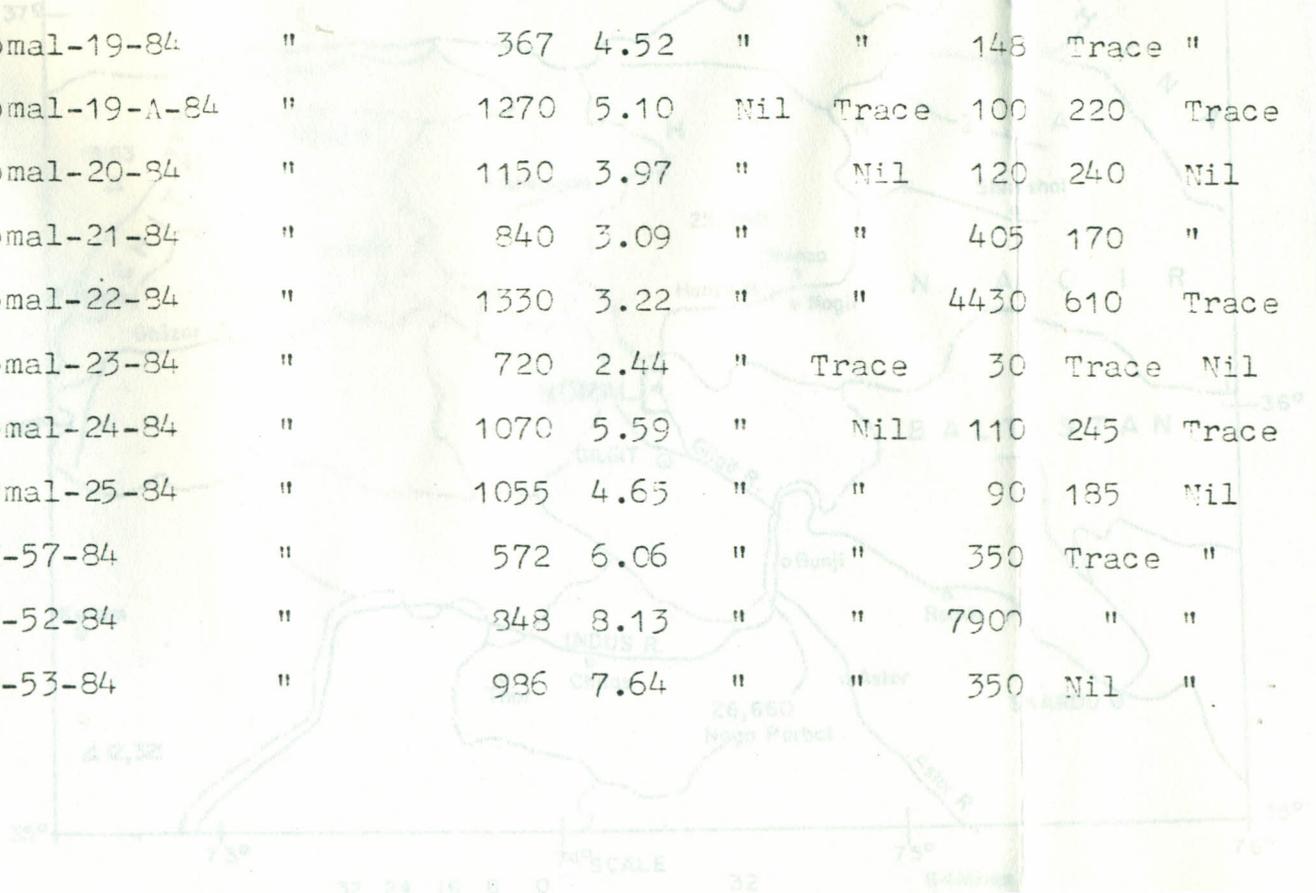
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TABLE-1:- CHEMICAL ANALYSES REPORT OF NOMAL SULPHIDE ZONE (42 L/8)
GILGIT DISTRICT PAKISTAN

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
S.No.	Sample No.	Type of Sample.	Mn ppm	Fe %	Co ppm	Ni ppm	Cu ppm	Zn ppm	Mo ppm	Ag ppm	Au ppm	Pb ppm
1.	Nomal-1-84	Surface	840	5.01	Nil	Nil	180	Nil	Nil	Nil	Nil	Nil
2.	Nomal-1A-84	"	229	2.99	"	"	40	"	"	"	"	"
3.	Nomal-2-84	"	534	3.38	"	"	75	Trace	"	"	"	"
4.	Nomal-3-84	"	244	2.73	"	"	60	"	"	"	"	"
5.	Nomal-4-84	"	412	5.33	"	"	95	"	"	"	"	"
6.	Nomal-5-84	"	2964	4.75	"	"	275	100	"	"	"	"
7.	Nomal-6-84	"	310	2.02	"	"	30	Nil	"	"	"	"
8.	Nomal-7-84	"	1528	7.12	"	"	169	120	"	"	"	820
9.	Nomal-8-84	"	1222	6.76	"	"	551	Nil	"	69	"	510
10.	Nomal-9-84	"	458	3.80	"	"	424	Trace	"	Nil	"	Nil
11.	Nomal-10-84	"	Nil	0.83	"	"	Nil	Nil	Trace	"	"	"
12.	Nomal-10A-84	"	703	6.97	"	"	127	"	"	"	"	"
13.	Nomal-11-84	"	92	3.33	"	"	Nil	"	"	"	"	"
14.	Nomal-12-84	"	214	5.20	"	"	106	Trace	"	"	"	"
15.	Nomal-13-84	"	Nil	2.29	"	"	64	"	Nil	"	"	"
16.	Nomal-14-84	"	336	2.55	"	"	Nil	"	"	"	"	"
17.	Nomal-15-84	"	2659	7.49	"	"	594	140	Trace	Trace	"	630

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
18.	Nomal-16-84	Surface	2506	4.32	Nil	Nil	35	200	Trace	Nil	Nil	Nil
19.	Nomal-17-84	"	519	3.33	"	"	64	Nil	Nil	"	"	570
20.	Nomal-8-84	"	458	2.34	"	"	Nil	160	"	"	"	Nil
21.	Nomal-19-84	"	367	4.52	"	"	148	Trace	"	"	"	310
22.	Nomal-19-A-84	"	1270	5.10	Nil	Trace	100	220	Trace	"	0.65	Nil
23.	Nomal-20-84	"	1150	3.97	"	Nil	120	240	Nil	"	Nil	"
24.	Nomal-21-84	"	840	3.09	"	"	405	170	"	"	"	"
25.	Nomal-22-84	"	1330	3.22	"	"	4430	610	Trace	"	1.03	460
26.	Nomal-23-84	"	720	2.44	"	Trace	30	Trace	Nil	"	Nil	Nil
27.	Nomal-24-84	"	1070	5.59	"	Nil	110	245	Trace	"	"	"
28.	Nomal-25-84	"	1055	4.65	"	"	90	185	Nil	"	"	"
29.	II-57-84	"	572	6.06	"	"	350	Trace	"	"	"	"
30.	II-52-84	"	348	8.13	"	"	790	"	"	"	"	"
31.	II-53-84	"	936	7.64	"	"	350	Nil	"	"	"	"



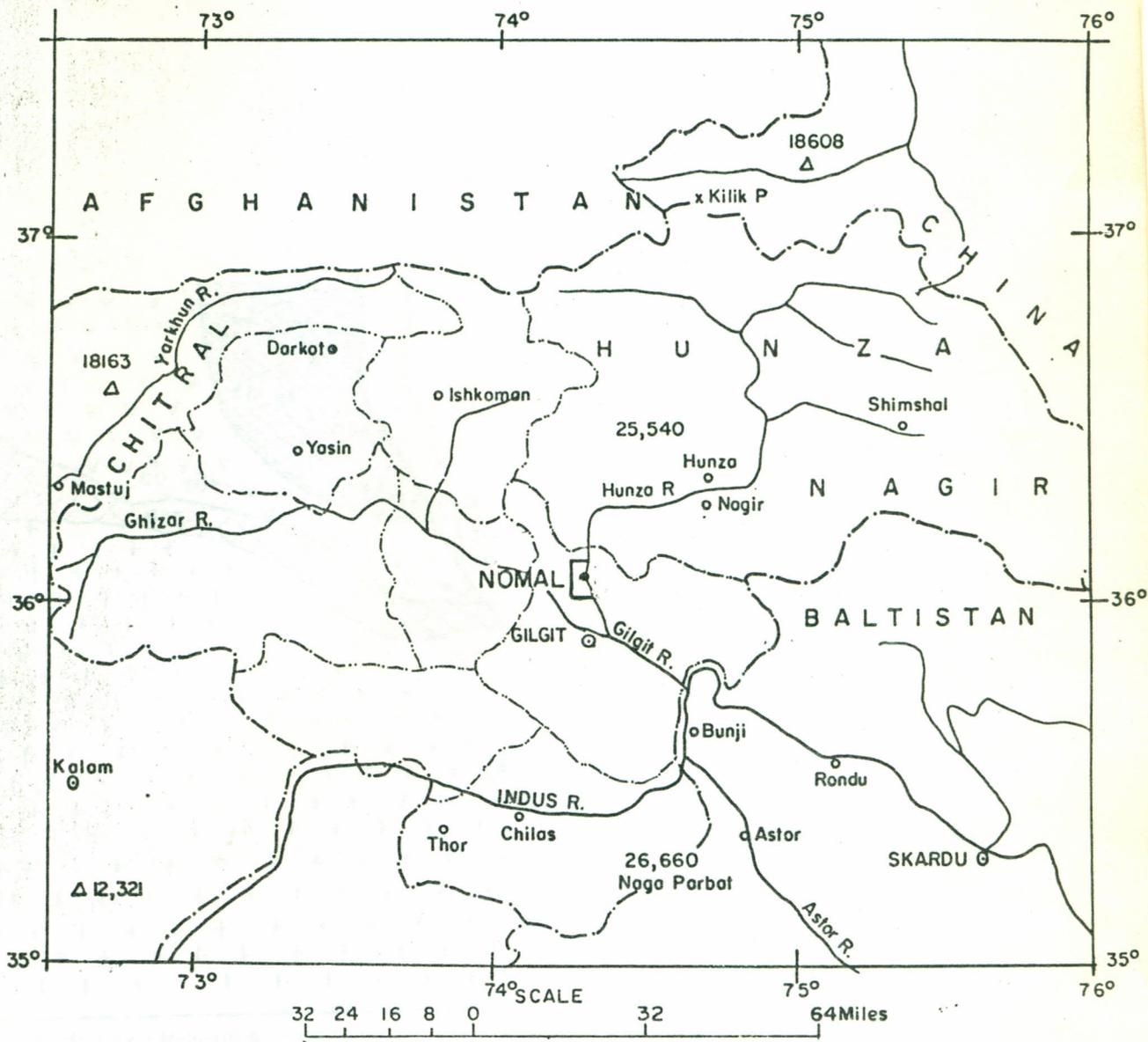
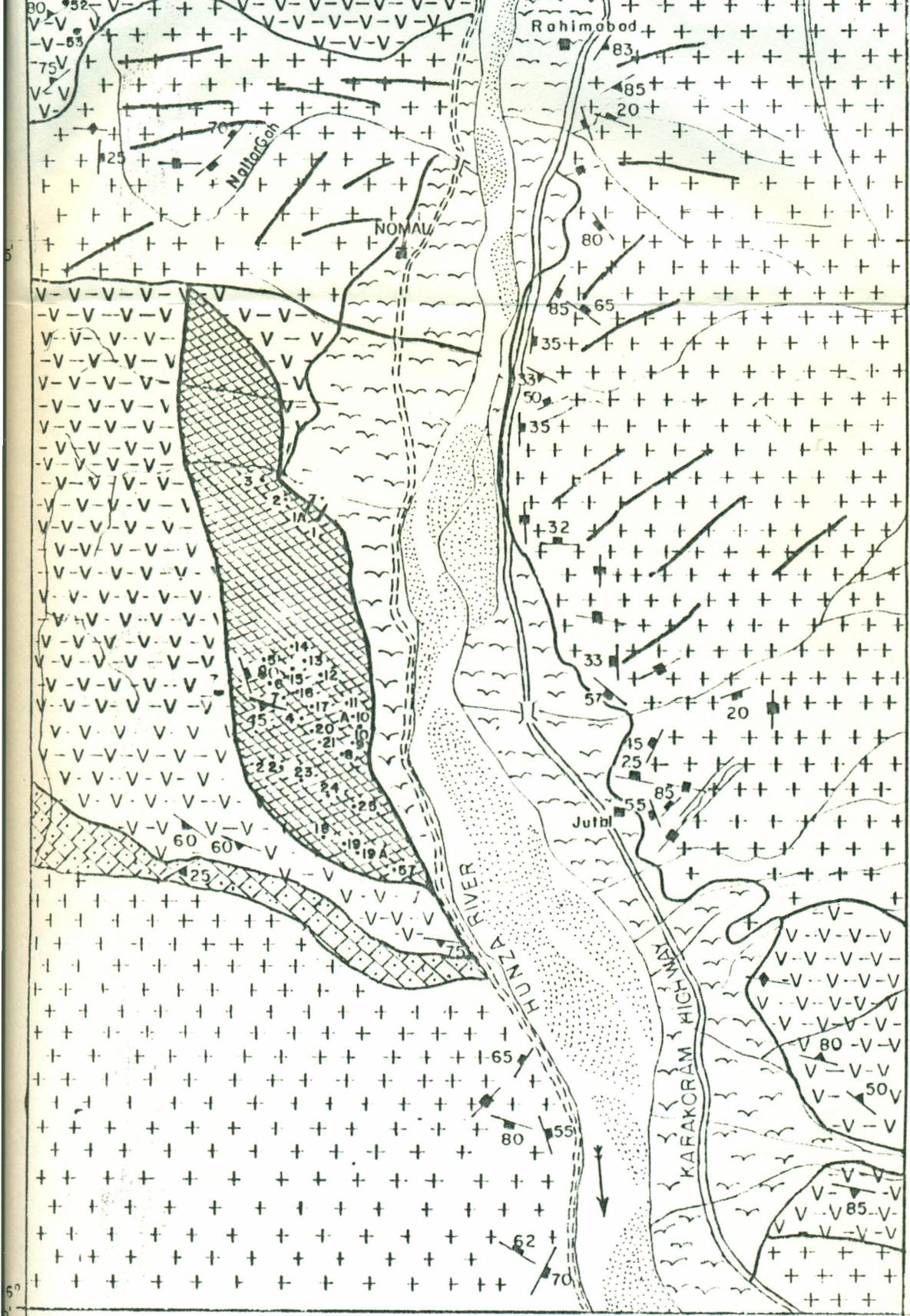


Figure 1: Location Map of Nomal Sulphide mineralization Zone.



EXPLANATION

QUATERNARY
 Quaternary alluvium.

CRETO-TERTIARY
 Lódokh Intrusives.
 Granodiorite, diorite, pegmatite with basic dykes.

LOWER CRETACEOUS
 Greenstone Complex.
 Volcanics with metasediments, Andesite mainly, schists, and marble.

ALTERATIONS
 Sulphide mineralization zone

GEOLOGICAL SYMBOLS
 • 87 Sample location.
 Pegmatite.
 Dyke.
 Contact.
 Foliation.
 Vertical Foliation.
 Joint
 Vertical Joint

NON-GEOLOGICAL SYMBOLS
 Karakoram Highway.
 Old Hunza Road.
 Hunza River.
 Nala.
 Habitation.

Drafted by :- Muhammad Shafi Geology by :- Abdul Latif Leghari
 Ibrar-ul-Hasan Khan
 Amir Khan Wazir

SCALE 1 : 50,000



FIGURE No.2 GEOLOGICAL MAP OF NOMAL SULPHIDE ZONE & SURROUNDING AREAS (42 L/8) GILGIT DISTRICT, PAKISTAN.