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PYRITE DEPOSITS OF NAZ BAR AREA, YASIN  
VALLEY, GILGIT DISTRICT, NORTHERN AREAS,  
PAKISTAN

By

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## I L L U S T R A T I O N S

Fig. 1 - Geological map of Yalter Bar - Multan Bulang Bar area, Naz Bar (Yasin valley), showing location of pyrite.

Fig. 2 - Geological map of pyrite body at Location A, Yalter Bar.

## ABSTRACT

Pyrite deposits are located in the Yalter Bar Multan Bulang Bar area of Naz Bar at a distance of about 23 miles from Yasin village, Gilgit Agency. The deposits are in the form of 3 lenses and 12 pockets, exposed at 5 locations at high elevation ranging from 13,500 feet to 16,000 feet A.S.L.

The pyrite is hydrothermal in origin and is developed within the quartzites and phyllites of the Permo - Carboniferous Darkot group. Geological reserves are estimated at 1.7 lakh tons. Out of these, 1.54 lakh tons are present in one lense (Location A) with average sulphur and iron content of 30 and 45 percent, respectively. Pyrite also contains copper from 0.476 to 0.834% and cobalt from 0.061 to 0.976 per cent.

## INTRODUCTION

### Purpose and scope

Evaluation study of the pyrite deposits of Naz Bar valley, Gilgit Agency was undertaken during September and October, 1972 on the request of Resident, Gilgit and Baltistan Agencies under project P-3(5) of the Geological Survey of Pakistan, Punjab Circle, Lahore. The deposits were considered promising by WPIDC (1971) who recommended its further exploration leading to evaluation of the deposits.

In order to evaluate the deposits, all the lenses and pockets were studied in detail which included plotting of the occurrences on quarter inch topographic sheet, large scale (1" = 20') mapping with tape and compass, prospecting through pitting, trenching and channel sampling, and mineralogical & chemical analysis of the samples. The present report incorporates results of the above mentioned studies, in terms of geological reserves and their economic considerations.

### Location and accessibility

The pyrite deposits are located in Yasin valley of Gilgit Agency and fall in 1:250,000 sheet 42H of the Survey of Pakistan. The Yasin valley, sometimes referred to as Gupis - Yasin valley, is the northwestern most valley of the Agency, adjoining Chitral with which it is linked through 15010 feet high Darkot Pass (Lat.  $73^{\circ} 25' N$ , Long.  $36^{\circ} 45' E$ ). It joins

the Ishkuman River valley near Gakuch (6130' A.S.L.), about 48 miles northwest of Gilgit Town (4500' A.S.L.) and the resulting valley known as Gilgit Valley extends in a southeasterly direction. Villages of Yasin (8730' A.S.L.) and Gupis (7070' A.S.L.) are the main villages of the Gupis - Yasin valley and are at distance of 85 and 68 miles respectively, to the northwest of Gilgit Town. The pyrite deposits are located in two nalas, ~~Multan~~ Bulang Bar and Yalter Bar, at a distance of 16 and 32 miles, respectively to the west of Yasin village. These two nalas are tributaries of Naz Bar Nala which drains into Yasin River at village Yasin.

The 85 miles long road connecting Yasin village with the Gilgit Town is partly a dirt and partly a single road. It is jeepable in fair weather and runs on either sides of the Yasin and Gilgit rivers, though mostly on the right side. At number of places the road has been cut in the vertical cliffs on river-sides and two-way traffic is a tricky proposition. Wooden suspension bridge are used for crossing over the rivers.

From the Yasin village, 20 miles long mule track, running along the right side of the Naz Bar for the first 6 miles and along its left side for rest of the distance, leads to Yalter Kach. The Yalter Kach (12000' A.S.L.) is a place at the confluence of Yalter Bar and Khamit Bar with the Naz Bar. From

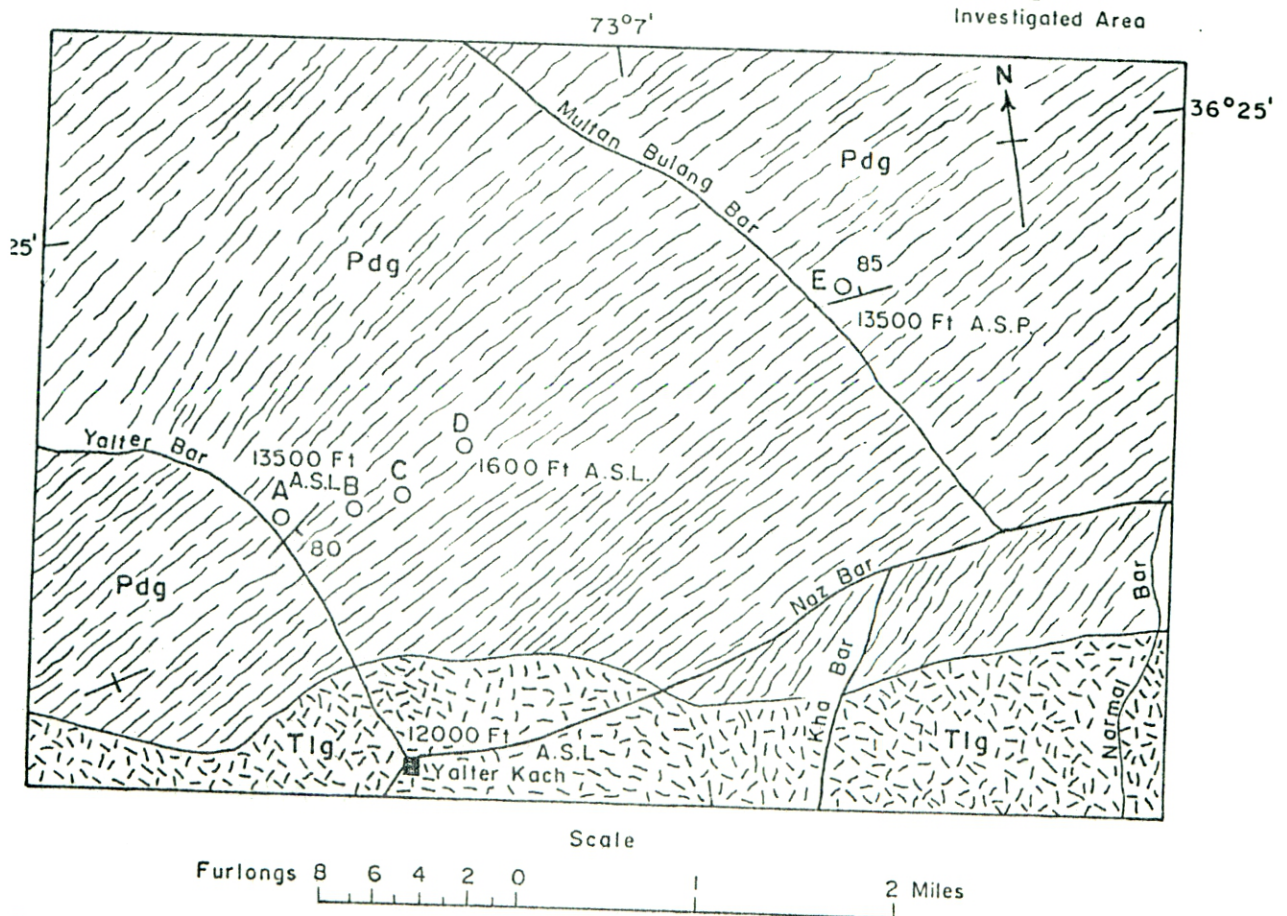
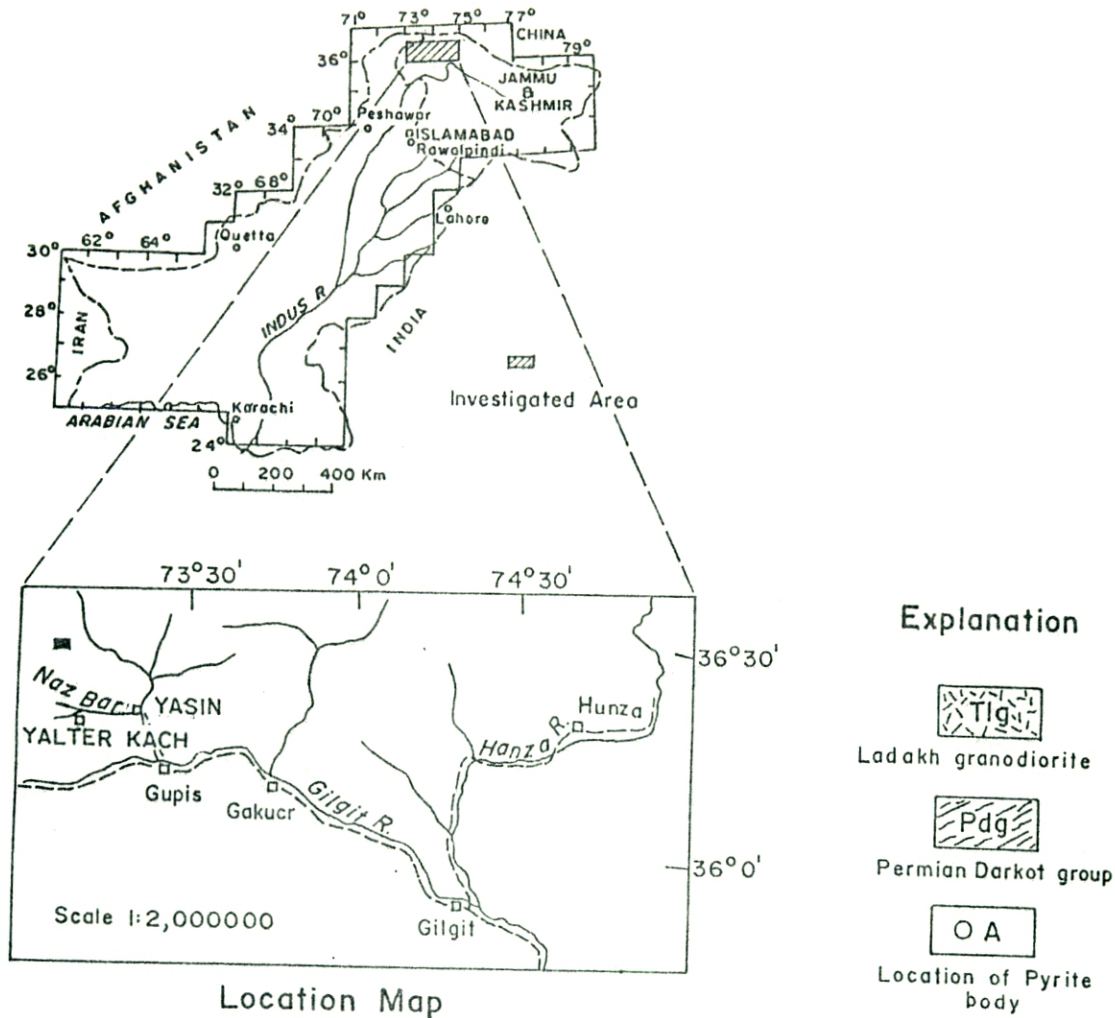


FIG.1 GEOLOGICAL MAP OF NAZ BAR AREA, YASIN VALLEY, SHOWING LOCATION OF PYRITE.

the Yalter Kach, the pyrite deposits of Yalter Bar can be approached by a 2 miles long feet path. A total number of 3 lenses and 7 pockets are present at 4 locations on the left side (north - eastern) of the Yalter Bar, over a total distance of about one mile (Fig. 1). The first exposure of these pyrite occurrences, is at an elevation of 13500 feet while the last one has an altitude of about 16000 feet.

The pyrite deposits of the Multan Bulang Bar are in the form of a group of five pockets, exposed at a distance of about  $2\frac{1}{2}$  miles from its confluence with the Naz Bar (Fig. 1). These deposits are located at an altitude of about 13500 feet, on the left bank of Multan Bulang Bar.

#### Topography

The Yasin valley is a part of Central Himalayan region and as such, has extremely rugged topography. In the area under report, the relief is very high, being 5699 feet and 5876 feet to the north and south of pyrite bearing Yalter Bar - Multan Bulang Bar area, respectively. The pyrite occurs at heights ranging from 13500 feet to 16000 feet on the slopes grading  $35^{\circ}$  due south - southwest. The over all drainage pattern in the Yasin valley is dendritic while the tributaries of Naz Bar constitute trellis pattern. The streams occupy deep and narrow gorges and have perennial flow due to ice and snow melting. The Naz Bar has an average gradient of 1 into 32.

### Previous investigations

The pyrite deposits of Naz Bar valley were first recorded by Ivanac, Traves and King (1956) who were accompanied by geologists of the Geological Survey of Pakistan and visited these in 1951. They regarded these as "a replacement of crushed quartz-mica schist at its contact with massive quartzite". The deposits were considered as "too small and too inaccessible to be exploited" by them. Abu Bakr (1965) who accompanied Ivanac et al, described the geology of the Gilgit area but did not mention the occurrence of the Naz Bar pyrite.

WPIDC (1971) were first to investigate the deposits in detail and reported that "About ten deposits of different dimensions have been located in an area of 6 to 8 miles, between Yalter Kach and Multan Bulang Bar". These were supposed to be a result of contact metamorphism. Chemical analysis of 13 samples has been recorded indicating an average of 1% copper, 55% iron and 33% sulphur with cobalt from nil to 1.5% and zinc from nil to 1.2%. An attempt to calculate the reserves has also been made and reserves of only one lense (lowermost occurrence of Yalter bar) have been calculated and they are recorded as quarriable reserves of 7 lakh tons to a depth of 200 feet. This estimate is made for the exposed length of 500 feet and average thickness of 40 feet of the lense. Considering the exposed length of the host rock, they have assumed the depth of the lense along dip to be

upto 1000 feet and have thus calculated the reserves as upto 30 lakh tons. Further work on the deposits was recommended by them.

#### Acknowledgements

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#### GEOLOGY

##### Regional Geology

A thick sequence of metasedimentary, sedimentary and igneous rocks, ranging in age from Permo-carboniferous to Cretaceous periods are exposed in the Yasin valley. These rocks have been introduced by a boss of granodiorite of Tertiary age (Ladakh granodiorite of Ivanac et al, 1956) that forms an east-west trending ridge on the southern side of Naz Bar (Fig. 2). A generalized stratigraphical sequence of the area is as follows, after Ivanac et al (1956).

A g e	Lithostratigraphic Unit	Lithology	Thickness
Tertiary	Granodiorites	Pale grey	Unknown

Cretaceous	Yasin Group	Limestone, slates, +2000 ft. sandstone, tuffs, agglomerates and lava flows.
Trias- Jurassic	Greenstone complex	Volcanics, limestone, 1000 ft. slate & quartzite
Permo- carboniferous	Darkot group	Schists, phyllites, quartzite and limestone. "

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The Darkot group has acted as host to the Naz Bar pyrite deposits. In the Yasin-Yalter Bar area, the group mainly consists of schists, phyllites, massive and recrystallized limestone and quartzites. The rocks represent low-grade metamorphism and have a general trend of N. 70°E with dips ranging from 55°N to vertical.

#### Geology of Pyrite Deposits

The pyrite occurs as lenses and pockets within the quartzites and phyllites of the Darkot group. The occurrences were studied at four locations on the northeastern slopes of the Yalter Bar and at one location on the northeastern slopes of the Multan Bulang Bar (Fig. 1). The locations are described separately as under.

#### Location A

At a distance of about 2 miles from the Yalter Kach and at an elevation of about 13500 feet, a lenticular body of pyrite is located (Fig. 1). The body is confined by quartzites

on its southeastern side and by phyllites on its northwestern side (Fig. 2). At places, however, quartzites bound it on its northwestern side. The quartzites have a general trend of  $N.48^{\circ}E$  and dip of  $75^{\circ}$  to  $85^{\circ}SE$ . The quartzites are mainly light grey, weathering light rusty brown to greyish brown, thick to massive and have a rich development of highly indurated garnets and some actinolite. The garnets range in size from less than 1 mm to 6 mm, are in the form of red to maroon crystals (Rhombdodecahedron and combination of Rhombdodecahedron and trapezohedron) with near perfect faces, opaque and have innumerable fractures which render them unattractive for economic consideration. Size and frequency of garnets decreases away from the contact towards country rock. The phyllites are light grey. Trend of their foliation varies from  $N.40^{\circ}E$  near the southwestern end (lower) to  $N.50^{\circ}E$  at about 20 feet above the northeastern end (upper) of the lense where vertical dips prevail. Pockets of schist are also present near the contact of pyrite body and may be defined as quartz-mica schist, garnet-mica schist and garnet-actinolite schist.

The lense generally has a trend of  $N.50^{\circ}E$  and length of 240 feet. It is thickest (69 feet) near its lower end and abruptly disappears under thick cover of scree further downwards. The scree merges downwards into the gravels and boulders of the Yalter Bar. Although nothing positive can be said about extension of the body underneath this scree, however, the observations taken on pockets No. 4, 5 and 6 of location C, which are

exposed end to end, indicate that this lense may not extend over any appreciable distance under the scree. The lense tapers irregularly upwards and has a thickness of 7 feet at its upper end where it is pinching abruptly. The pinching is indicated by the presence of phyllites further 15 feet upwards, truncating the the trend of the lense.

#### Location B

The location B is about 1500 feet east of location A and is occupied by a small lense of pyrite. It is bounded on both sides by near vertical dipping quartzites which are light grey in colour, weather rusty brown and have few light green specks of chlorite. Pockets of garnet-mica schist are also present at same places, along the contact of the lense and the quartzites.

This lense has a general trend of N. 25°E and is 13 feet long. Its maximum thickness is at its lower end (south - eastern) where it is 4 feet. The body tapers upwards so that it is about 8 inches thick at its upper end.

#### Location C

A total number of 7 pockets are exposed at Location C which is about 1300 feet east of location B at a higher altitude. Three of these pockets are exposed about 1000 feet upslope from location B. Another three pockets are exposed about 400 feet

further upslope and are followed by the seventh pocket about 200 further upslope. Trend of these seven pockets is in line with that of locations A and B. Quartzite is the country rock for all the pockets of Location C.

The first group of three pockets is exposed within a total distance of 20 feet and their dimensions are as follows :

Pocket 1= 3' x  $\frac{1}{2}$ '

Pocket 2= 2' x  $1\frac{1}{2}$ '

Pocket 3= 4' x 2'

The second group of three pockets is exposed within a total distance of about 50 feet and have the following dimensions;

Pocket 4= 1' x  $1\frac{1}{2}$ '

Pocket 5= 2' x  $1\frac{1}{2}$ '

Pocket 6= 3' x  $1\frac{1}{2}$ '

Trenching and pitting of the three pockets revealed that these do not extend down for more than  $1\frac{1}{2}$  feet and are not extensive laterally beyond their exposed limits.

The seventh pocket has a dimension of  $2\frac{1}{2}$ ' x  $2\frac{1}{2}$ '.

#### Location D

Location D is at an elevation of about 16000 feet and was mostly covered by snow at the time of visit which rendered the exact measurements difficult. The dimensions given below are,

therefore, only approximate. The pyrite lense of location D is about 1500 feet upslope to the northeast of location C. Grey, weathering rusty brown quartzite, similar to the country rocks of other locations, bound the body on both sides.

The general trend of this body is E.NE. Starting from its lower end (southwestern), the body trends N 63°E for about 125 feet, then it swing northwestwards for about 20 feet after which it again changes over to its previous trend and extends upslope with the bearing N 81°E. The distance over which it extends with N 81°E trend could not be observed because of thick cover of snow. But the body was again seen exposed in the cliff face at a distance of about 500 feet. The body is 13 feet thick near its lower end and taper upwards to 5 feet at the point where its trend changes to N 81°E.

#### Location E

Five pockets are exposed on the left (northeastern) side of the Multan Bulang Bar at a distance of about 2½ miles from the junction point of Naz Bar and Multan Bulang Bar. These are located at an elevation of about 13500 feet in a gorge of high gradient due southwest that joins the Multan Bulang Bar. Light grey quartzites, weathering rusty brown are the country rocks. The quartzites have garnets near the contact with the body. The general trend of the quartzites is N 80°E and an average dip of 85°N.

All the five pockets trend approximately E - W and are exposed within a total distance of 100 feet. Their dimensions are as follows :-

Pocket 1= 11' x 4½'

Pocket 2= 1½' x ½'

Pocket 3= 4½' x 1'

Pocket 4= 20' x 2½'

Pocket 5= 25' x 2½'

## ECONOMIC GEOLOGY

### Prospecting

Prospecting was initiated from the Yalter Bar occurrences and was continued to the Multan Bulang Bar deposits. The lower most lense of the Yalter Bar was mapped with the help of Brunton Compass and tape while the dimensions of all the other bodies were measured and their locations were marked on 1:250,000 scale toposheet. Trenching and pitting was carried out at three pockets of location C.

### Sampling

Hammer and Chisal were used for sampling. Channel and grab samples were taken at appropriate places from the occurrences of the Yalter Bar and Multan Bulang Bar.

The first lense of location A was sampled along three channels at different levels i.e. from lower end, middle end upper end (Fig. 2). A total of 7 samples were taken from its lower end, out of which 4 (SC-72/2 to 5) represented the entire thickness (60 feet) of body and the rest from the country rock. From the middle channel, 10 samples were collected. 7 of these (SC-72/10 to 16) represented the total thickness of (55 feet) pyrite while the 3 were grab samples of the country rock. The third channel is located near upper end of the body where it is 11 feet thick. One channel sample of the ore (SC-72/18) and 2 of the host rocks

were taken from this place.

From the body of Location B one channel sample (SC-72/20) representing its total thickness of 4 feet at its lower end was taken. Besides, one sample from country rock of the either side was taken.

The lower group of three pockets of location C was sampled together as one sample (SC-72/23) by means of channels. One channel sample (SC-72/24) was taken from the seventh pocket which represented its total thickness of  $2\frac{1}{2}$  feet.

One grab sample (SC-72/25) was taken from the middle of the 13 feet thickness of the body of location D, at its lower end. Another grab-sample (SC-72/26) was taken from the point where trend of the body changes to northwestwards. 2 grab samples were taken from the country rocks.

One channel sample (SC-72/30) from the entire thickness ( $4\frac{1}{2}$  feet) of the first pocket of location E was taken.

### Mineralogy and genesis

In handspecimen, the ore is steel - grey on fresh surface, weathers to rusty brown, gives grey streak and is massive. It is mainly composed of very fine to fine grains of pyrite. At places, peacock staining of Bornite is also visible.

In polished section, the ore exhibits distinct lineation which represents the original foliation of phyllites. Some phyllite pieces, which were found in the polished section, show the same lineation trend as found in the ore itself. The polished section studied had the following mineralogy.

1. Pyrite: 50-60% Bronze yellow with shining metallic lustre.
2. Pyrrhotite: 25-30% Brownish grey with dull lustre.
3. Fragments of phyllite and few grains of quartz and brown mica representing the remnants of the original rock (phyllite) that has been replaced by pyrite and pyrrhotite.

The lenses and pockets of the ore appear to be hydrothermal in origin and formed along the crushed zone at the contact of phyllites and quartzites beds. It is indicated by fine texture of the ore and parallellism between lineation of the ore and foliation of the country rocks which, when taken in conjunction with the occurrence of remnants of phyllites in the ore, further suggest replacement of phyllites along the crushed zone. The development of actinolite, garnet and mica in the host rocks at

their contact with the ore body reflects contact - metamorphism of moderately high grade, caused by the hydrothermal ore - bearing solutions.

#### Chemical analysis

Chemical analysis has been carried out by PCSIR Laboratories, Lahore on the payment of Rs. 1,700/=. 17 samples of the pyrite have been analysed for sulphur and iron while 4 have been analysed in detail.

Following are the results of the analysis for S and Fe. For conversion of Fe into  $\text{Fe}_2\text{O}_3$ , a conversion factor  $\text{Fe} \times 1.43$  may be used.

<u>S.No.</u>	<u>Location</u>	<u>Sample No.</u>	<u>Percent S.</u>	<u>Percent Fe.</u>
1.	A	SC-72/2	7.33	51.76
2.	A	SC-72/3	28.82	53.33
3.	A	SC-72/4	13.20	52.80
4.	A	SC-72/5	14.92	52.08
5.	A	SC-72/10	17.23	25.20
6.	A	SC-72/11	42.10	39.20
7.	A	SC-72/12	42.52	36.40
8.	A	SC-72/13	31.23	39.20
9.	A	SC-72/14	45.22	47.60
10.	A	SC-72/15	42.20	55.72
11.	A	SC-72/16	43.97	40.32
12.	B	SC-72/20	11.81	58.23
13.	C	SC-72/23	11.32	55.80
14.	C	SC-72/24	33.33	52.00
15.	D	SC-72/25	34.92	50.12
16.	D	SC-72/26	8.75	56.48
17.	E	SC-72/30	27.72	52.80

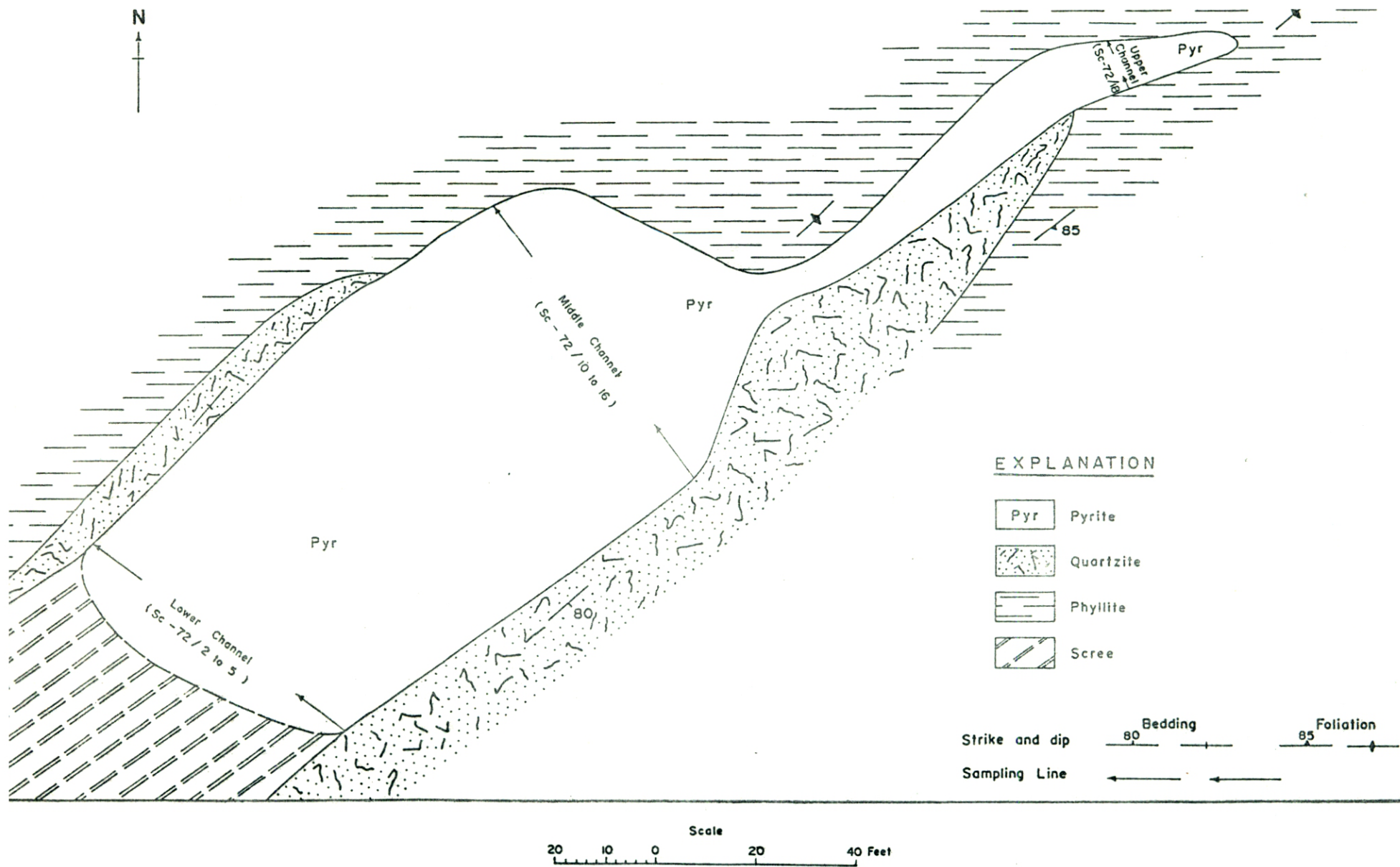


FIG. 2 GEOLOGICAL MAP OF PYRITE BODY AT LOCATION A, YALTER BAR.

Out of the above listed samples, 4 were analysed in detailed by PCSIR Laboratories, Lahore for copper, cobalt, nickle, zinc, manganese, platinum and gold. Volumetric methods were employed for this analysis and polarographic technique was used to counter check the results. The results reveal that the "samples do not contain gold and platinum, however, nickle, zinc and manganese are present in traces. The measurable quantity of copper and cobalt is present in all the samples." Percentage presence of copper and cobalt is as follows :

<u>S.No.</u>	<u>Location</u>	<u>Sample No.</u>	<u>Percent Cu.</u>	<u>Percent Co.</u>
1.	A	SC-72/3	0.476	0.061
2.	A	SC-72/11	0.754	0.795
3.	D	SC-72/25	0.834	0.976
4.	E	SC-72/30	0.794	0.084

The above recorded results show that in the Naz Bar Pyrite deposits, sulphur ranges from 7.33 to 45.22%, iron from 25.20 to 58.23% copper from 0.476 to 0.834% and cobalt from 0.061 to 0.976%. These results compare favourably with WPIDC (1971) who reported that sulphur ranges from 14.5 to 38.5%, iron from 31.3 to 56.7%, copper from 0.1 to 1.3% and cobalt from nil to 1.5%.

## Reserves

Reserves of lenses and pockets of all the five locations have been calculated by the formula as given below :

$$\text{Reserves: } \frac{\text{Length} \times \text{thickness} \times \text{depth}}{\text{Tonnage factor}}$$

The depth has been inferred on the basis of the length of the body and its behaviour. The tonnage factor of 7 cubic feet per tone has been used, following WPIDC (1971) for this ore with specific gravity of 4.5

Location A

Maximum length	=	240'	
Depth	=	120'	
Area	=	9000 sq. feet	(calculated through graphic method).
Reserves	=	$\frac{9000 \times 120}{7}$	= 154,000 tons

WPIDC (1971), however, has calculated the reserves of this lens as 700 thousand tons, taking a length of 500 feet, average thickness of 40 feet and depth of 200 feet. The factual position is that the body having a total length of only 240 feet can be divided into two parts for the sake of reserves calculation (Fig. 2). The lower part having a length of 130 feet has an average thickness of 65 feet, while the upper part having a length of 110 feet has an average thickness of 9 feet. Regarding depth, a body having a length of 240 feet can be assumed to have a depth of only 120 feet according to generally accepted practice.

Location B

Length	=	13'	
Average thickness	=	2'	
Depth	=	5'	
Reserves	=	$\frac{13 \times 2 \times 5}{7}$	= 19 tons

Location C

Seven small pockets are present at this location. Length of these pockets vary from 1 foot to 4 feet and thickness ranges from 1½' to 2½'. The total reserves of these may be taken as 7 tons.

Location D

The deposit was covered under thick snow, therefore, its exact measurements could not be taken.

Exposed length	=	150'	
Average thickness	=	9'	
depth	=	75'	
Reserves	=	$\frac{9 \times 150 \times 75}{7}$	= 14,464 tons

Location E

At this place, five pockets of different dimensions are exposed. The reserves are as follows :-

<u>Pocket No.</u>	<u>Length</u>	<u>Thickness</u>	<u>Depth</u>	<u>Reserves</u>
1	11'	4½'	5'	50 tons
2	1½'	½'	½'	-
3	4½'	1'	2'	1 ton
4	20'	2½'	10'	71 tons
5	25'	2½'	12'	107 tons

The total reserves at location E = 229 tons. The total reserves of the pyrite occurrences of the Yalter Bar and Multan Bulang Bar come out to be 168,719 tons or 170 thousand long tons.

#### Economic Considerations

The present studies have proved reserves of 170 thousand long tons of the complex ore of pyrite, pyrrhotite and bornite. Out of these reserves, 154 thousand tons are available in the lens at location A, while the remaining 16 thousand tons are present as lenses and pockets at locations B, C, D and E. Chemical analysis by PCSIR Laboratories, Lahore indicate that sulphur present in this ore ranges from 7.33 to 45.22, iron from 25.20 to 58.23, copper from 0.476 to 0.834 and cobalt from 0.061 to 0.976.

Presence of copper and cobalt is significant for the purpose of economic considerations. These two metals are, perhaps, the only metals for which detailed geological exploration of the Naz Bar Pyrite deposit is warranted. In addition to these, iron and sulphur can be won as by products, depending upon the method used for metallurgical treatment of the ore.

It is recommended that the Geological Survey of Pakistan may undertake further study of these deposits to prove the extension of the deposits, both laterally and vertically before any development works are undertaken. It may also be pointed out that any further scheme for the exploration of this deposits shall have to embody heavy expenditure, involved in the construction of a 23 miles road to contact the deposits from an altitude of 16,000 feet (Location E) with Yasin village. The village Yasin is 8730 feet above mean sea level and lies at a distance of 85 miles northwest of Gilgit to which it is connected by shingle (Kacha) road. This road will also require considerable expenditure for improvement.

It is also pointed out that no mining will be possible during winter season (October to April) as the deposit will be burried under a heavy blanket of snow.

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