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Regional Geochemical Prospection for Minerals in Chitral, Northern Pakistan

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ABSTRACT: *A comprehensive regional geochemical survey was carried out in Upper Chitral area. This survey was based on panned concentrates sampling techniques, during which a total of 68 samples were collected from most of major rivers and their tributaries covering an area of more than 1000 km^2.*

The aim of this geochemical investigation was to determine metals dispersion, their relation to mineralization, and regional distribution in the drainage system of the area. Our research reveals that Chitral area has a high potential for mineralization. Some valleys contain polymettalic anomalies while others have either precious or base metals.

Strong anomalies of precious and base metals, together with As and Sb were detected in the northernmost part (Tirich Gol valley) of the surveyed area in which the respective ranges of Au, Ag, As, Sb, Cu, Pb, and Zn are 20- 2500 ppb, 2-22 ppm, 2-1500 ppm, 1-18 ppm, 50-400 ppm, 100-1200 ppm, and 50-550 ppm. The significant mineral occurrences are found north of Reshun Formation. The central part (Barum, Pasti and Shoghor) of the survey area shows polymetallic signature with significant enrichment of precious metals Au=10-200 ppb, Ag=1-12 ppm, As=10-200 ppm and Sb=1-10 ppm). The southern part, mainly Kafiristan valley, is hig in Pb (100-1800 ppm) with some anomalies of Au (1-100 ppb) and Ag (2-17 ppm).

New targets for mineral prospecting were located at several localities of Chitral valley. Important regional structures, such as faults, and their significance regarding mineralization were also defined during this investigation.

INTRODUCTION

Chitral district lies in the northwestern part of the northern Pakistan on the leading southern edge of the Asian Plate (Fig. 1). It is connected to Peshawar, the capital of N.W.F.P. province by road and plane service. The plane service is often subject to bad weather and the road from Peshawar to Chitral town is closed for several months in winter due to snow on the 3,200 metre high Lowari Pass through which the road passes. The area is extremely mountainous and rough. Accessibility to the remote valleys of Chitral is difficult and usually takes several days walk on foot. The Chitral area (Karakoram terrane) is separated from the Kohistan arc terrane by the Northern Suture Zone. The rock units of Chitral area are dominated by argillaceous succession and carbonate units of Ordovician to lower Cretaceous age (Austromineral, 1978a; Calkins et al., 1981, Tahirkheli; 1982, Pudsey et al., 1985).

Due to its remoteness and inaccessibility this part of northern Pakistan has not been so far systematically investigated either geologically or metallogenically. First attempt on mineral exploration programme based on stream sediments sampling techniques was carried out by Austromineral during 1974-1978. Their main objectives were to explore the area for base metals and scheelite mineralization. They analysed stream sediments for base metals and tungsten and concluded that there was little potential for these metals in Chitral area. Leak (1984) and Leak and Haslam (1985) undertook panned-concentrate survey in some of the valleys of Chitral area for base metals and tungsten and concluded that such survey was effective in the area for detecting anomalies of mentioned metals. The present study is mainly aimed at locating gold and precious metals in the area in contrast to the previous studies carried out for base metals only.

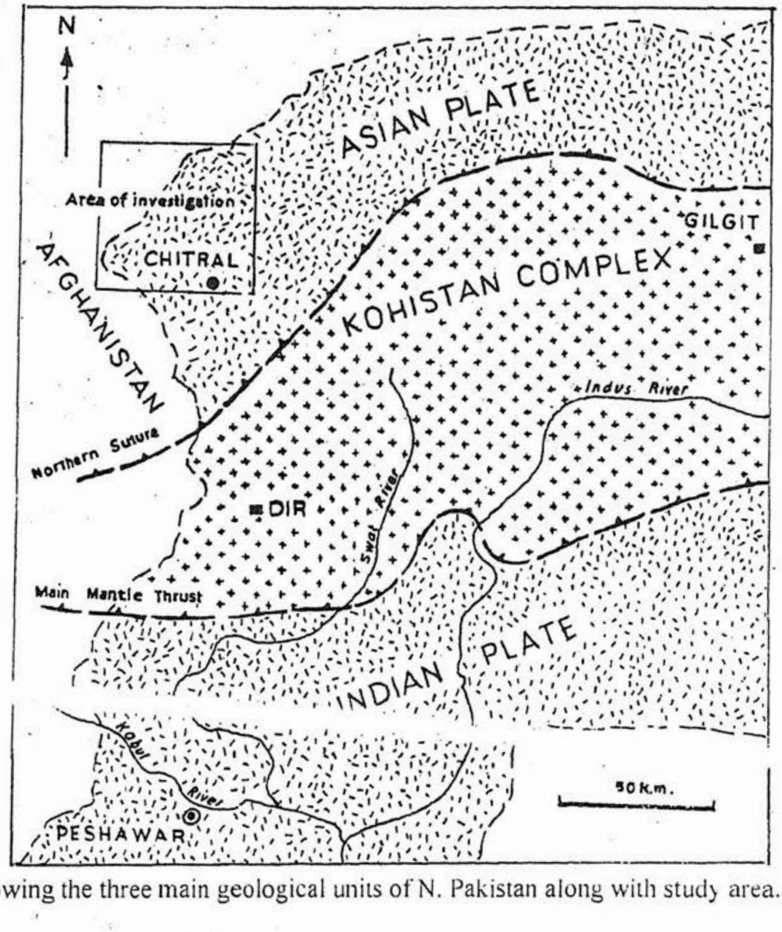

Fig. 1. Showing the three main geological units of N. Pakistan along with study area.

An orientation study carried out around the known gold prospects at Shoghor area (Chitral) demonstrated that of the three sampling methods, panned- concentrates give the best anomaly/ background contrast (Khaliq & Moon, in press). On this basis a comprehensive regional panned concentrates sampling programme was carried out in the upper Chitral during which 68 panned- concentrate samples were collected from most of the major rivers and their wet tributaries covering an area of 1000 sq. km. along strike north and southwards from the known mineralization of Shoghor area (Fig. 2). The aim was to test the extension of the Shoghor mineralization towards the previously reported Pb- Zn shows at Pakhturi in the NE and the Pb anomalies in Kafiristan reported by Leake and Haslam (1985).

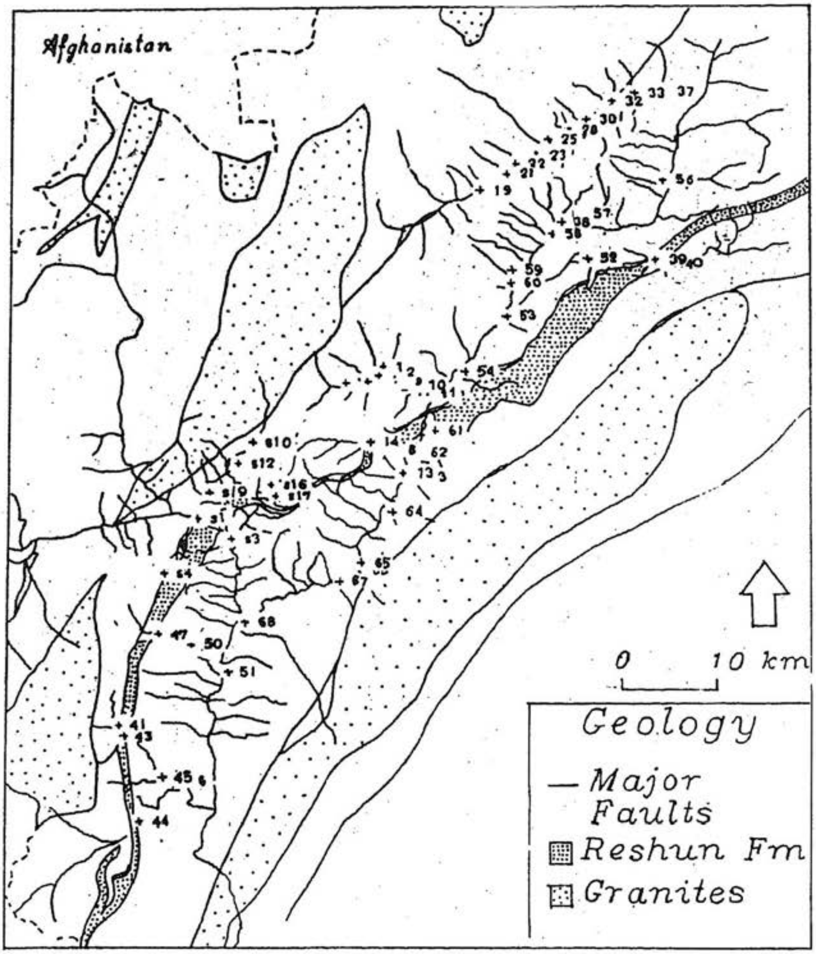

Fig. 2. Location map for regional panned-concentrate samples, Chitral area.

Moreover, to have a complete picture of the area, samples were also collected from Mastuj valley and Koghozi areas south of Reshun Formation. Sampling in the area is extremely difficult and needs several hours walk on foot to collect 2 to 3 samples per day. An index map of Chitral showing various valleys of the survey area is shown in Fig. 3.

GENERAL GEOLOGY

The Asian Plate lies north of the Northern Suture and covers mainly the Chitral district and adjoining areas in Pakistan. The highly mountainous Chitral district is characterized by Palaeozoic- Mesozoic series of sedimentary, volcano- sedimentary and intrusive rocks with a varying degree of metamorphism. The metamorphic rocks are mainly those of greenschist facies of regional metamorphism, increasing to the amphibolite facies as the granite bodies are approached (Calkins et al., 1981). Rocks of low metamorphic grade include slate, marble, chlorite- quartz schist, volcanic greenstone, graphitic schist and other types. Higher grade metamorphic rocks of the amphibolite facies and its equivalent include garnet-biotite schist, garnet- biotite- staurolite schist and other types. These units have a general strike from west to east and are dominated by an argillaceous succession containing thick carbonate units of Devonian to

Lower Cretaceous age (Austromineral, 1978a; Calkins et al., 1981, Tahirkheli, 1982). In the investigated area general geology is comprised of the following lithologies.

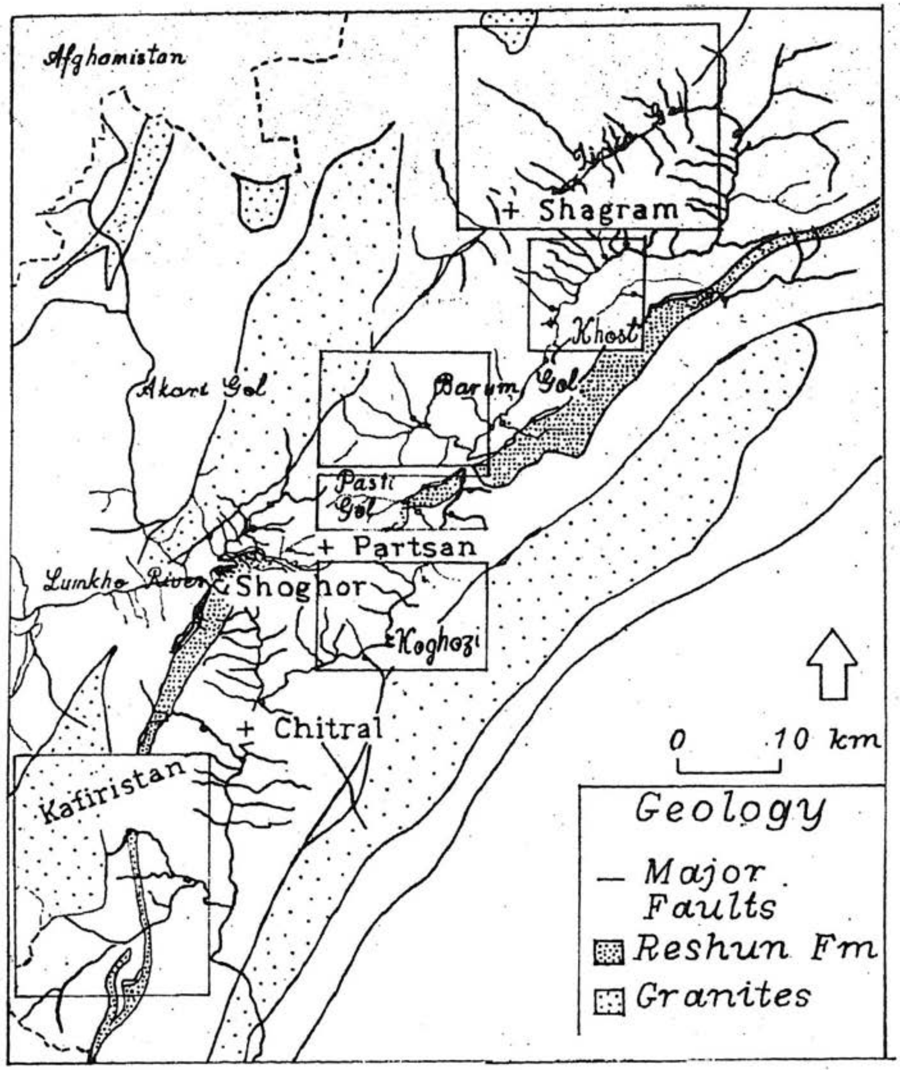

Fig. 3. Index map of Chitral showing subdivision of the survey area.

(a) Arkari-Atak Group

This unit is a (?) Mesozoic sequence of dark-grey slates to siltstones and fine- grained quartzite with intercalations of thick layers of limestones and calcareous schists. This group extends from west of Baroghil- Pass at the northeastern boundary between Chitral and Afghanistan through Shah- Jinali Pass, Turkho Valley, upper Tirich Gol, Arkari Gol and right up to Hot spring in the north west of Chitral district. In the area of Tirich Gol, the sequence is intruded by Tirich Mir massif and obtains a higher metamorphic grade. There are several outcrops of crystalline limestones between upper Tirich Gol and west of Shah- Jinali Pass, some of which outcrops are several kilometers thick and extend laterally for several kilometers.

(b) Owir-Awireth Group

This is an upper Palaeozic sequence of dark to dark grey slates to siltstones and fine- grained quartzites, calcareous schist, limestone and dolomites with small intercalations of green meta- volcanics. This group parallels the Arkari- Atak Group and extends from east of Baroghil Pass through the south of Shah- Jinali Pass, Lower Valleys of Turkho and Tirich Gol, Owir Pass, southern slopes of Tirich Mir massif, Awireth Gol and into Kafiristan. It contains several outcrops of fossiliferous limestones throughout of its length. Calkins et al. (1981) mapped a continuous Devonian carbonate unit at the southern boundary of this group.

(c) Devonian carbonate unit

This unit is dominantly carbonate and lies at the southern boundary of Owir- Awireth group and is a part of the same sequence. Southwards it is bounded by the Reshun fault. This carbonate unit possibly extends from Partsan area in the west all the way to Baroghil Pass in the east. It includes the Shogram Formation described by Stauffer (1975), which consists of massive dolomite with fine- grained quartzites overlain by bedded dolomite with fossiliferous limestones and thin shales and is 800 metres thick. The most complete section of this unit is that found at Koragh along Mastuj river.

(d) Shoghor limestone

This limestone lies south of Devonian carbonate unit and has an eastern contact with Chitral slates. It extends from the Pakistan-Afghan border in the southwest of Chitral district northwards up to Partsan area where it interfingers tectonically with the Reshun formation. This subvertical to vertical limestone forms a high ridge flanked by very steep and high cliffs. It may be traced over 50 km through the Chitral district and develops steep gorges where intersected by tributaries of Chitral River. In the Lutkho gorge near Shoghor village the limestone is approximately 2 km thick. The limestone is massive, light grey to pink recrystallised marble at places and no original sedimentary texture or bedding features are recognisable. The contact of this limestone with Chitral slate is a vertical fault (Stauffer, 1975). Desio (1959) reported Orbitolinas from this limestone and on the basis of these fossils they assigned a Cretaceous age to this limestone.

(e) Reshun Formation

This formation extends from the southwest of Reshun to northeast all the way to Baroghil Pass and consists of massive light- brown conglomerate and beds of red siltstone and shales. The name Reshun Formation was used by Stauffer (1975). Southwest of the Reshun, near Partsan, this formation interfingers with Shoghor limestone. The conglomerate contains pebbles and cobbles of limestone, quartzite, greenstone, sandstone, acidic and intermediate volcanic rocks, and rare granites. The beds of conglomerate range from 3 to 15 m in thickness. Additional lithologies include red calcareous shales and massive pale grey micritic limestone with rudist remains of Aptian- Albian age (Talent et al., 1982, Pudsey et al., 1985). Common among the pebbles are greenstones of various types which are predominant in the lower part of conglomerate while limestone and dolomite are dominant in the upper part (Stauffer, 1975). The age of Reshun Formation is considered to be Cretaceous or early Tertiary on the basis of the fossils found in limestone cobbles of Reshun Formation (Hayden, 1915; Tipper, 1922).

(f) Chitral Slate

Hayden (1915) was the first to report the Chitral Slate which he described as the 'Slate Series of Chitral' whereas Tipper (1922) termed this slate the 'Chitral Slate Series'. It forms a belt extending from the Pakistan-Afghanistan border in the southwest of Chitral district northeastward up to Reshun and consists mainly of fine- grained dark- grey slate and thinly liminated phyllite. Quartzite and dark limestone layers are also found (Ivanac et al., 1956, Calkins et al., 1981). The quartzite layers are medium- grained and generally a few cm thick, but at some places, reach up to several metres. The layers of limestone within Chitral slate are generally dark grey to black, medium-grained, recrystallized, unfossiliferous, and range in thickness from a few cm to a few metres. The thinly laminated phyllite is greenish and consists of micaceous minerals occurring in thin laminae. The Chitral Slate has a maximum thickness of 6 km in central part of Chitral Valley. Tipper (1922) collected some fossils from the Chitral slate from a calcareous layer within the Chitral slate in the valley of Chitral Gol. On the basis of these fossils he gave a Palaeozoic age to Chitral slate.

(g) Koghozi Greenschist

This unit lies between Chitral slates in the north and Gahiret limestone in the south and extends from Pakistan- Afghanistan boarder in southwest of Chitral district up to Reshun in the northeast, almost parallel with the Gahiret limestone and Chitral slate. The Koghozi greenschist consists of fine- grained pale green thinly laminated schists containing varying amounts of plagioclase, actinolite, epidote, chlorite and quartz and probably represents metamorphosed chloritic and somewhat calcareous, sedimentary beds and volcanic tuffs (Calkins et al., 1981). Other rock types of this unit are quartzose sandstone, marble, calcareous phyllite and slate. Although different petrographically, the greenschists unit may be equivalent to the volcanic greenstone unit of Shishi Valley which is Cretaceous in age (Calkins et al., 1981). It lies in conformable succession SE of the Chitral Slate and is probably of Palaeozoic age (Stauffer, 1975).

(h) Gahiret Limestone

This limestone was first reported by Hayden (1915), who found a badly crushed fault slice of Orbitolina- bearing limestone near the town of Drosh. It extends northeastwards from the Pakistan- Afghanistan boarder near Mirkhani Fort, in the southwest of Chitral district, up to Barnis Gol and runs parallel to the greenschist unit. The limestone is dark- grey to mid- grey, massive to thin bedded and coarsely crystalline marble (Calkins et al., 1981, Pudsey et al., 1985). It is interbedded with dark phyllite and calcareous shale. Orbitolina are reported by Hayden (1915) and confirmed by Calkins et al., (1981). The reported fossils confirm a Cretaceous age for this limestone.

(i) Mastuj Group

This upper Palaeozoic unit is dominated by middle to dark grey slates and light to middle grey argillaceous and calcareous schists. There are also lenses and beds of white to light grey limestones, dolomites, meta- volcanics and green schists. This group extends from the northern end of Gahiret limestone and runs parallel to the Reshun Formation up to Mirgram in the upper Mastuj Valley. Towards northeast and southwest this unit becomes strongly metamorphosed and partly granitized. It contains outcrops of crystalline limestones which range in thickness from less than one kilometre to more than 2 km and runs for several kilometers in east- west direction. This series may be equivalent to Darkot group which is Permian- Devonian in age (Austromineral, 1978a).

(j) Plutonic rocks in the survey area

The Asian Plate metasediments are intruded by a number of large, generally elongated, granitic plutons in the investigated area of Chitral. The plutons are the Hot Spring, Tirich Mir and Kafiristan constitute the Hindu Kush ranges in the area. They are of various ages, most of them Cretaceous resulting from the subduction of Indian Plate under Eurasian Plate. The Tirich Mir granite which lies on the northwestern border of Chitral district forms an elongated NE trending belt that pinches out in a SW direction, and intruded calcareous and phyllitic rocks of Wakhan Formation of Lower Triassic age and the Atak group of Mesozoic age (Diemberger, 1968). The batholith has a heterogeneous structure of several intrusive phases. In the central part of the batholith granites to aplites are predominant, whereas towards the southwest granite shows a gradual transition to granitic gneisses (Buchroithnerand Gamerith, 1986). Desio et al. (1968), on the basis of Rb- Sr dating, assigned an age of 115 ± 4 million years to this pluton.

The plutons of Kafiristan are much older and belong to the Nuristan plutonic belt of Afghanistan. This belt consists of peraluminous, more or less gneissic and rather often blastoporphyritic, biotite or two- mica granites, adamellites and granodiorites and have sub- alkaline or calc- alkaline characteristics and has a Rb- Sr age of 483 Ma (Debon et al., 1987). According to Buchroithner and Gamerith, 1986) some similarity exists between the Tirich Mir and the Kafiristan batholith with regard to their mineral composition. From their geographical positions, the Kafiristan batholith can be considered as an indirect continuation of the Tirich Mir batholith, but on the basis of their age they are very different. Very little is known about the Hot Spring pluton. According to Desio (1964) the Hot Spring and Tirich Mir plutons are gneissose and well foliated and may be of the same age and origin.

RELIEF, CLIMATE AND WEATHERING CONDITIONS

Relief, climate and weathering are the important factors which play important roles in releasing and dispersing minerals grains from host rocks into the drainage system of an area. Relief of Chitral area is extreme and rough, forming up to several thousands metres high ridges at places. Steep gorges are found where major rivers and their tributaries incise the lithologies. Overall, slopes are steep and show rockfall- scree, mass movements and slumped structures at many places. Quaternary deposits are found in the form of alluvial sand, gravel, and boulders in the stream beds; scree, talus, and landslide debris on the slopes; and upland alluvium, including boulder fields in the high basins and upper reaches of the main creeks. Alluvial fans and terraces are the common points of the human settlement and cultivation.

Climate is arid to semi arid and the overall precipitation is low, but climate changes with altitude as well as with season. Rainfall and temperature data for the Chitral area are show the mean annual rainfall for northern and southern Chitral is 250- 370 and 370- 500 mm respectively. During winter, from end of November to March, all of the mountains and low lands receive precipitation mainly in the form of snow while in summer the area gets sporadic torrential rains, mostly in the form of high floods, which cause catastrophic changes in fans, scree and flood plains in the valleys. Sometimes after torrential rainfall the high floods wash out all of the suspension bridges and disrupt the communication system for many weeks. During the winter period the area remains cut off from the rest of the province and sometimes there is no communication between different valleys.

Weathered material in this region can be seen in the form of either blocks ranging from a few cm to several metres or finer fraction such as sand and silt. Probably, the first type which is dominant in the area, is caused by mechanical weathering (Hewitt, 1968; Whalley, 1984) and the latter by chemical weathering (Reynold and Johnson, 1972; Wellman and Wilson, 1965; Goudie, 1984).

According to these workers a major factor that controls the impact of temperature change on geomorphological activity is the large upslope variation of moisture availability, which in low altitudes (about 3000- 2000 m and below) causes chemical weathering in the form of salt efflorescence, desert varnish, and weathering rinds, while in high altitudes 4000 m and above, mechanical breakdown of rock is predominant although chemical weathering can be observed in the form of desert varnish and weathering rinds (Whalley, 1984; Whalley et al., 1984). Hewitt (1968) noted that in the vicinity of snowline, `freeze' condition cause mechanical weathering in the form of shattered cliffs, rockfall, and blocky products of rock while in semi- arid, sub- nival zone 'thaw' is predominant and causes chemical weathering.

Drainage system of a region is the major factor which controls the dispersion of elements and minerals in the secondary environment. The drainage system of the area is well developed and structurally controlled. The streams are widest in the areas where they cut soft lithologies such as shales, phyllites and slates but become narrower when pass through limestone and marble. Water is cold and alkaline and a pH of 8 was measured for most of the streams during sampling. In the area of orientation study most of the catchments are underlain by limestones, phyllites, and shales which host the mineralization in the area.

RESULTS AND DISCUSSION

The results of target elements i.e. base and precious metals along with arsenic and antimony are considered in detail in this study. Statistical summary for analytical results is given (Table 1) for this survey which demonstrates that the area is enriched both in base and precious metals.

To see the overall distribution and concentration of different elements their results are given in the following section. Base metal anomalies (above 90 percentile) are widely distributed in the survey area. The significant anomalies are found in Tirich Gol, Barum, Pasti Gol and Kafiristan area. The analytical data indicate that copper concentration ranges from 40 ppm to 400 ppm with median and mean of 120 ppm and 140 ppm respectively. The map of copper distribution is shown in Figure 4. The distribution map shows that high values of copper are found in Tirich Gol, Barum Gol, and Khost areas while low to moderate concentrations are found at Koghozi and Kafiristan, south of the Reshun Formation including Shoghor limestone.

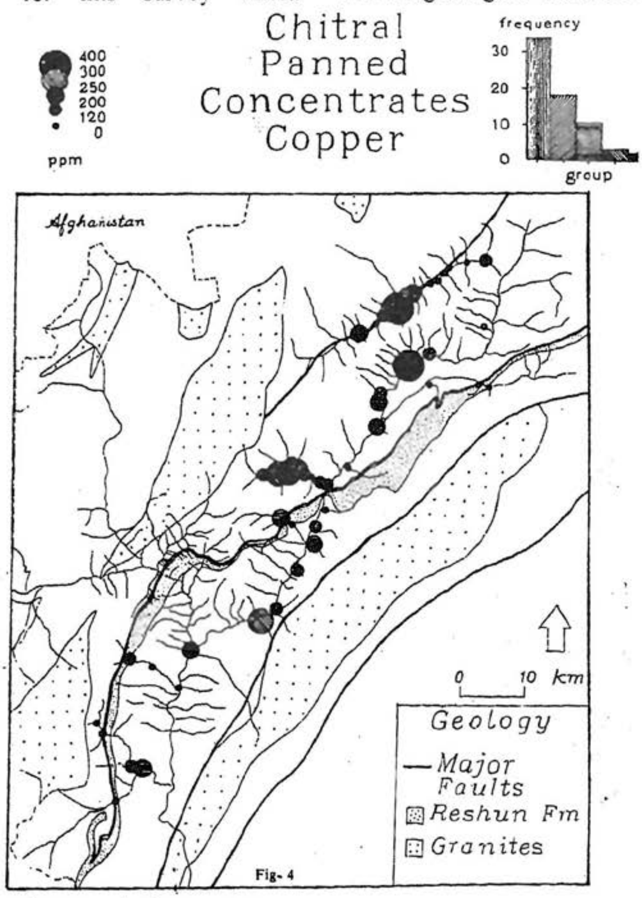

Fig. 4. Chitral panned concentrates copper.

TABLE 1. STATISTICAL SUMMARY OF ANALYTICAL DATA

Elements	Range	Medi	Mean	St.D
Cu ppm	40-400	115	135	75
Pb ppm	33-2045	225	355	385
Zn ppm	30-960	140	215	215
Au ppb	0-2400	20	85	305
Ag ppm	0-21	1.2	2.5	5
As ppm	2-1500	25	135	330
Sb ppm	0-17	1.5	2.2	2

In the present survey the concentration of Pb ranges from 30 ppm to 2050 ppm with median of 115 ppm and mean of 140 ppm. The high values are found in Barum Gol, Pasti Gol, Tirich Gol and Kafiristan areas as shown on the map of lead (Fig. 5). The distribution of Pb indicates that its high concentration coincides with copper in Tirich Gol, Barum Gol and Kafiristan valleys. The map of the Pb distribution indicates that the area south of Reshun Formation is very low in lead except the Kafiristan, where high Pb values coincide with Ag, As and Cu.

Anomalous zinc values are not widely distributed (Fig. 6) compared to copper and lead anomalies and high values of Zn are clustered around Barum, Pasti Gol and the Khost areas while moderate values are found in Tirich Gol and one sample in Kafiristan is high containing (> 360 ppm) Zn. The concentration of zinc ranges from 30 ppm to 950 ppm. The three high anomalies of Zn in Barum Gol are associated with Owir Gol, the southern tributary of Barum Gol. Two out of these anomalies contain > 900 ppm Zn while the third anomaly reaches up to 550 ppm. The high values of Zn in Owir Gol coincide with both Cu and Pb.

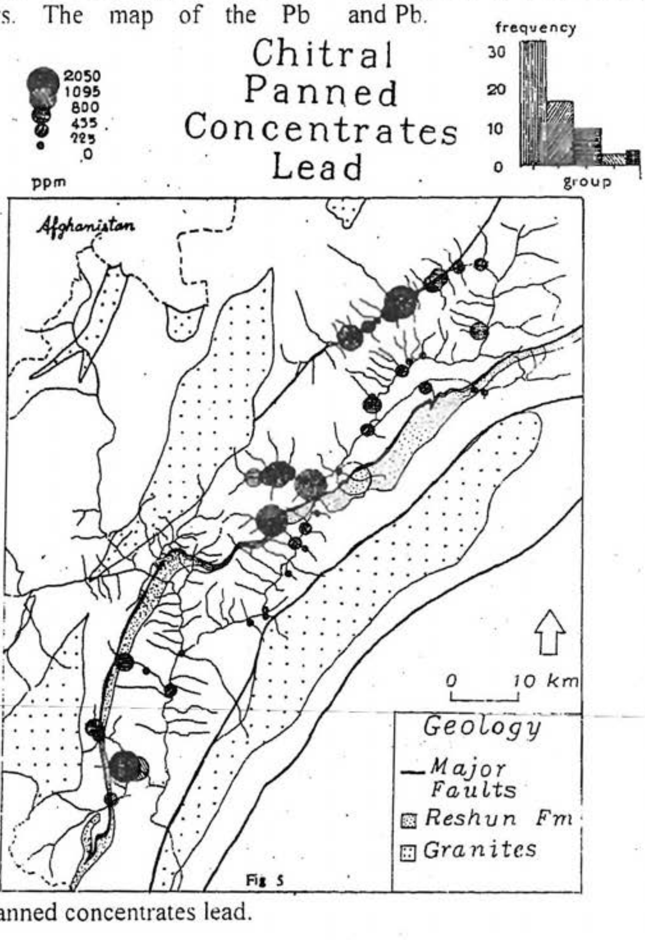

Fig. 5. Chitral panned concentrates lead.

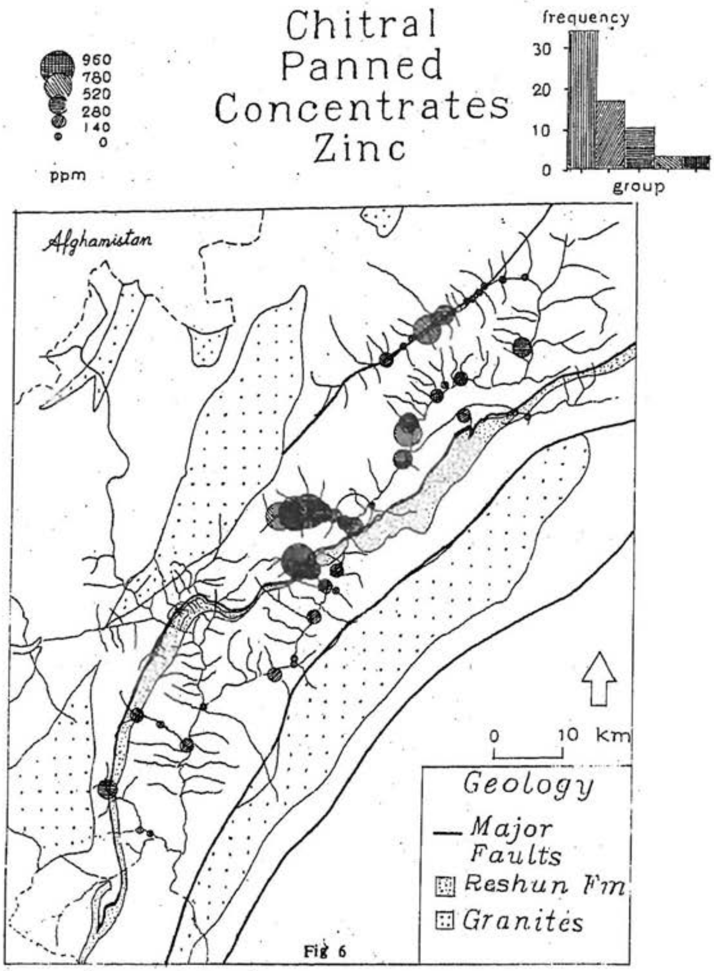

Fig. 6. Chitral panned concentrates zinc.

Precious metals, arsenic and antimony are high north of Reshun Formation like base metals. Nevertheless, the Kafiristan area, south of Reshun Formation, has a similar signature of anomalies. In the present survey the gold is high in Tirich Gol and Barum Gol areas and one sample from Kafiristan contains a moderately high value as shown in the map for gold (Fig. 7). The overall concentration of gold ranges from 0- 2400 ppb with median of 20 ppb and mean of 85 ppb. The Pasti, Khost and Koghozi valleys show background values for gold. Although, in regional panned samples gold anomalies were found in Tirich Gol, Barum Gol and Kafiristan areas, it is considered that these areas may be much anomalous if they would have been sampled by wet- sieving method. It is also possible that some of the tributaries of Tirich Gol, Barum Gol, and Kafiristan might contain gold anomalies but they were not picked up by panned- concentrates and it is possible that gold anomalies may be found if they were sampled by wet- sieving method as was discussed by Khaliq and Moon (in press). The sampling techniques and the size of sample to be taken has always been a problem in the exploration of gold and the present survey is not an exceptional case. Sampling also requires some precautions, as the sample representativity can be hampered by the scarcity of gold particles in the sampled materials. However, these problems can be reduced to acceptable level by taking a sample containing more than 20 gold grains especially if coarse grained gold is sought (Day and Fletcher, 1986, 1989). For disseminated gold deposits the fine fraction of stream sediment will be most useful in regional exploration.

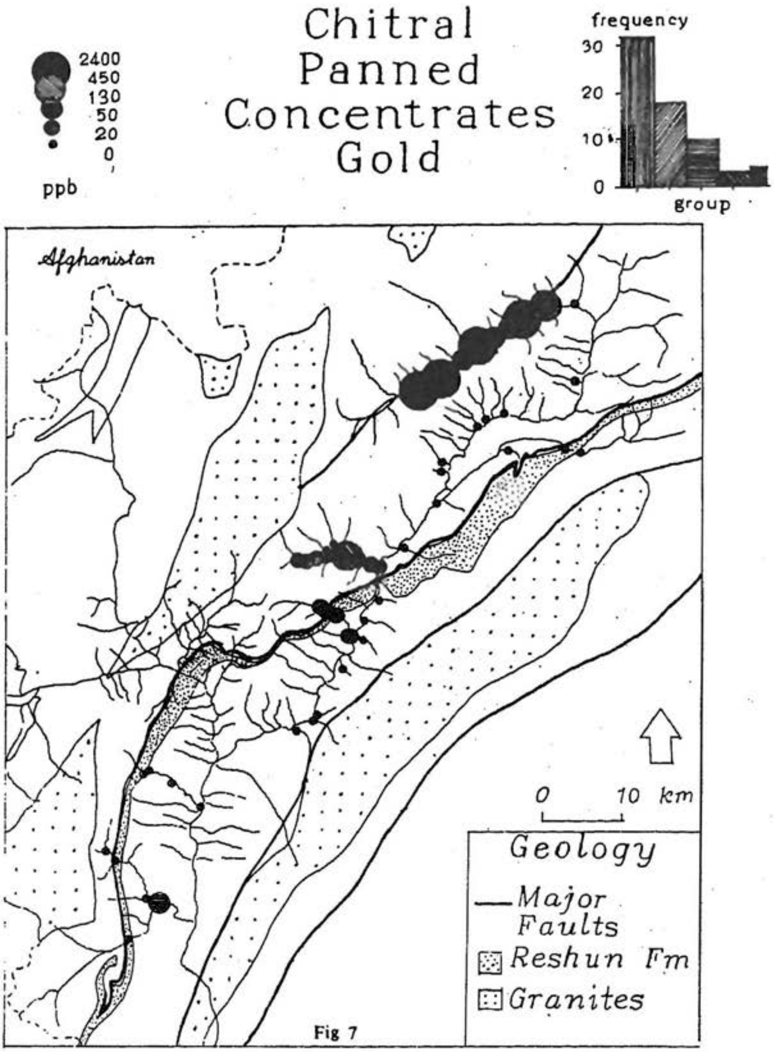

Fig. 7. Chitral panned concentrates gold.

High silver anomalies are widely distributed in the survey area both north and south of the Reshun Formation. The concentration of silver ranges from 0 ppm to 21 ppm in the survey area. The median and mean of silver is 1.2 ppm and 2.5 ppm respectively. The highest concentrations of silver are found at Tirich Gol, Barum Gol and Kafiristan areas as displayed in the map of silver (Fig. 8). High silver values in Kafiristan coincide with high values of lead in the area.

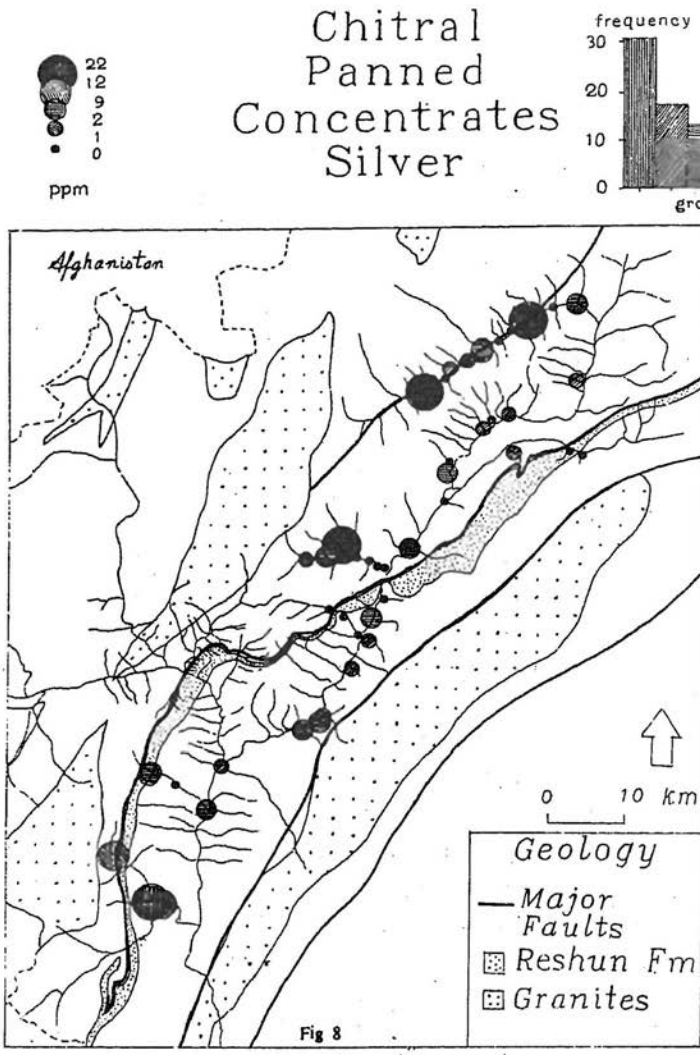

Fig. 8. Chitral panned concentrates silver.

The arsenic distribution is similar to precious metals as displayed on the map of arsenic (Fig. 9). The areas high in Au and Ag also have enhanced values of arsenic. The concentration of arsenic is from 2 ppm to 1500 ppm with a median value of 25 ppm and mean value of 135 ppm. The high values of arsenic are found at Tirich Gol, Barum Gol and Kafiristan areas. The Pasti, Koghozi and Khost areas are low in arsenic.

The concentration of antimony ranges from 0 ppm to 18 ppm with a median and mean values of 1.5 ppm and 2.2 ppm respectively. High concentrations of Sb are widely distributed in the survey area and is displayed in Fig. 10. The highest concentrations are found in Tirich Gol, Barum Gol and Kafiristan. The northeastern part of Khost and Koghozi areas are generally low in antimony.

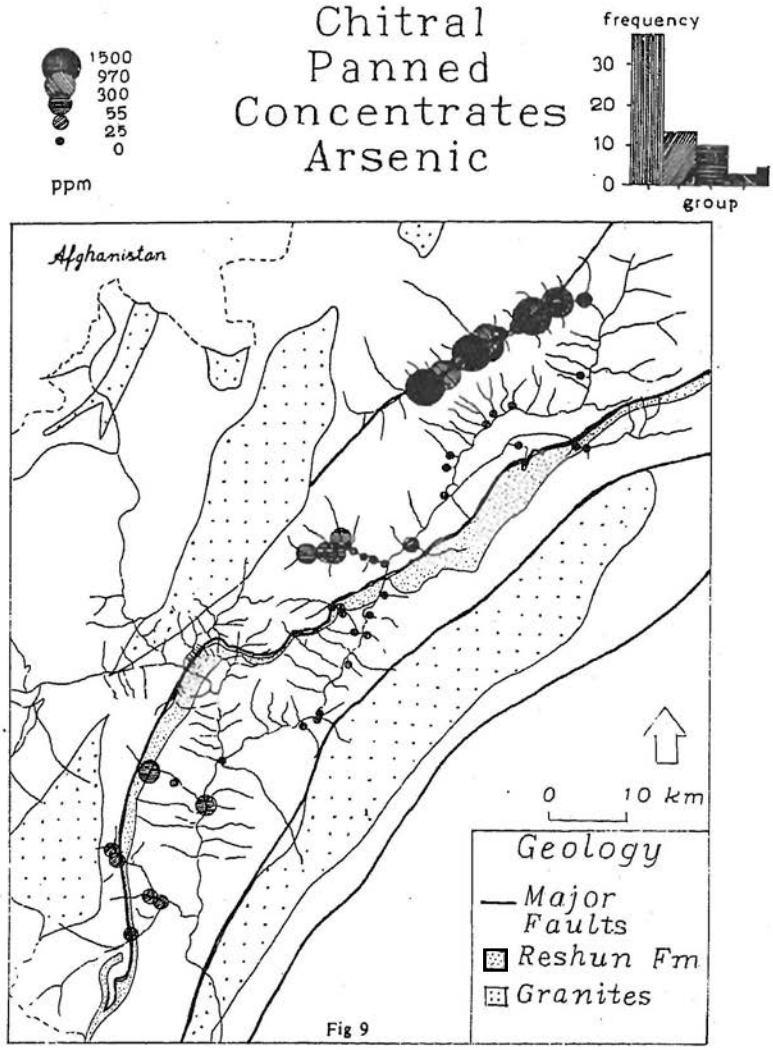

Fig. 9. Chitral panned concentrates arsenic.

This survey indicates that the northern parts (Tirich Gol and Barum Gol) of the investigated area are high in both precious and base metals but the areas such as Pasti, Khost and Koghozi which lie south of Barum Gol shows anomalies only for base metals. However, this table also reveals that Kafiristan area has similarities with Tirich Gol and Barum Gol.

DISCUSSION

The regional survey of the Chitral area revealed promising areas for minerals prospects. The prominent anomalies of base and precious metals with different valleys highlights the minerals potential of this rugged terrane. On the basis of this survey some of the areas are selected as new targets for detailed mineral investigations. In order of priority these areas and their mineral potentials are described as follows:

Tirich Gol area
This area has high a potential for gold mineralization with its association of Ag, Pb, As and Sb. The mineralization is polymetallic and is associated with the northern tributaries. It is suggested that this area should be a major target for gold exploration. All of the northern tributaries and their sub- tributaries should be sampled carefully. The other suggestion is that Tirich fault should be investigated along its whole length. The results of this study and the mineral shows reported by other workers seem to be related to this fault. In addition, the southern tributaries of Tirich Gol should be investigated for base metals.

Barum Gol area
The southern tributaries of the Barum Gol are the target for polymetallic mineralization. All of the tributaries and their sub- tributaries should be sampled in detail as the area has a similar signature to the Shoghor area. There is also a high possibility of finding more Pb-Zn mineralization. The limestone units are the probable source for this mineralization because the samples are very high in Pb and Zn downstream from the limestone units. As the known shows of Pb and Pb-Zn at Baig and Pakhturi respectively are far away from the sites of these anomalies, there is the possibility of other mineralization of a similar source in the limestone units.

Pasti and Khost areas
These areas are underlain by similar lithologies. They are the new targets for base metals specially for Cu and Zn but needs no investigations for precious metals.

Kafiristan area
This area is high in Pb, Ag, Sb and Au. The adjacent area with Awireth Gol, the southern part of the orientation study, is high in Pb, Ag and Sb and should be for these elements. However, the Bumboret valley of Kafiristan is a new target for Pb, Ag, and gold. The high cobalt value associated with these elements probably indicate the source area in the ultramafic rocks of the melange zone and needs further investigation.

CONCLUSIONS

The regional survey of the Chitral district reveals that the area has a high potential for mineralization. The survey delineates a variety of anomalies some of which consist of polymetallic mineralization while others have either precious or base metals. The significant mineral occurrences are found north of Reshun Formation. However, the Kafiristan area, south of Reshun Formation, shows similarity with the aforesaid area. The mineralization in the northmost part (especially in Tirich Gol) of the survey area is dominated by precious metals, arsenic, antimony and tungsten. The central part of the survey (Barum Gol, Pasti Gol and Shoghor) shows a polymetallic signature with significant enrichment of precious metals. The southern part mainly Kafiristan is high in Pb with some anomalies of gold and silver.

The mineralization appears to be controlled mainly by major faults. The significant faults in the survey area are the Tirich, Reshun, Barum and Pasti faults. The Tirich fault separates the Arkari- Atak Group of (?) Jurassic age from the Owir- Awireth Group of Devonian- Permian age. In the Tirich Gol area mineralization is associated with this fault. The Barum fault runs along Barum Gol valley and the mineralization in the valley seems associated with it. However, the polymetallic mineralization in the southern tributaries of Barum Gol may be linked with Pasti fault which passes through the area. The mineralization in Pasti Gol is associated with Reshun and Pasti faults. It is very difficult to follow and investigate these major structure due to various difficulties in particular the ruggedness and inaccessibility of these areas. Anyhow, there is high possibility of finding more mineral occurrences along them if they were carefully investigated.

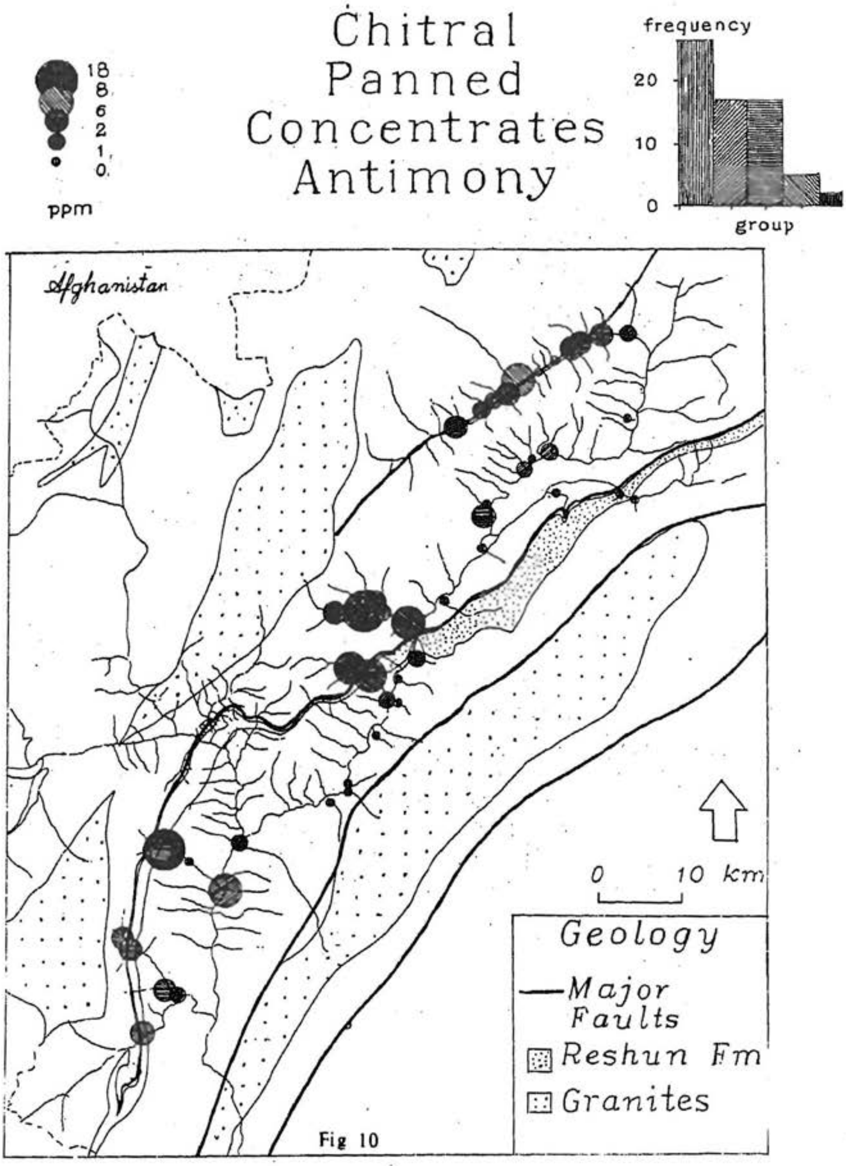

Fig. 10. Chitral panned concentrates antimony.

As far as lithological control on mineralization is concerned, the Arkari-Atak group is high in precious metals while Owir-Awireth Group have polymetallic and base metal occurrences. In the lithologies of the latter group slices of limestone seems to be the main source of mineralization. This study reveals that area north of Reshun Fault is of main interest which shows mineralization over a strike of 80 Km from the Known mineralization of Shoghor area. However, the mineralization is zoned and probably represents more than one association.

Tirich Gol area is highly anomalous both for base and precious metals. Although, they may be from different sources. Probably the precious metals association is found north of Tirich Fault and base metals south of it. The area is much higher in gold in panned-concentrates than the known auriferous mineralization of Shoghor area. It is also high in silver and arsenic and probably has more potential for minerals than any other area in the Chitral district.

Barum area has a similar signature of Shoghor polymetallic mineralization especially the Owir Gol which drains the southern part of the valley. The northern part of the Barum Gol is high in base metals. Pasti area is high in Pb, Zn and Sb and probably indicates a different suite than Barum area. The Khost area NE of Barum is high in Cu and Zn and falls well north of Reshun Fault and the contact of Shoghor limestone which probably indicates a source in the dark grey slates and shales. Koghozi area seems to be barren except some low amplitude anomalies for Cu associated with greenschist series. The Kafiristan area is high in Cu, Pb, Ag and Sb and shows similarities with Awireth Gol, the southern section of the Shoghor orientation study. This probably indicates the extension of Awireth Gol mineralization into Kafiristan area. But the Bumboret valley, southern part of Kafiristan, is also high in gold. Bumboret valley is also high in Pb, Ag, and As. There is the possibility of some mineralization associated with suture melange zone.

RECOMMENDATIONS

The following recommendations are made for future minerals prospecting in the area:

(a) Tirich Gol valley should be followed up for precious metals as well as for arsenic and antimony. All of these elements show strong association in the valley. Gold should be the major exploration target. The southern tributaries of Tirich valley need to be systematically explored for base metals.

(b) All of the regional faults should be investigated for mineralization using the air photography and satellite images as a geological base. The Tirich Fault should be investigated for arsenic and scheelite mineralization eastward from the Tirich Gol, however, westward this fault should be explored for gold, silver, lead, arsenic and tungsten.

(c) The limestone units associated with Owir-Awireth Group should be checked for Pb-Zn mineralization and the Owir Gol of Barum valley needs investigations for gold and polymetallic mineralization.

(d) All of the tributaries of Bumboret valley of Kafiristan should be carefully sampled and investigated for gold. Moreover, the suture melange zone in the valley also needs detail investigations for both precious and base metals.

(e) Tirich Mir granites should be investigated for tin, tungsten and uranium mineralization.

REFERENCES

Austromineral. 1978a. Mineral exploration and mine development, Chitral district. Report for Sarhad Development Authority, Peshawar, Pakistan.

Buchroithner, M. F. & Gamerith, H., 1986. On the geology of Tirich Mir area, Central Hindu Kush (Pakistan). Jb. Geol. B. A. 128, 367-381.

Calkins, J. A., Jamiluddin, S., Bhuyan, K. & Hussain, A., 1981. Geology and mineral resources of the Chitral- Partsan area, Hindu- Kush range, N. Pakistan. U. S. Geol. Surv. Prof. Paper. 761C. 1-31.

Day, S. J. & Fletcher, W. K., 1986. Particle size and abundance of gold in selected stream sediments, Southern British Columbia, Canada. J. Geoch. Explo. 26, 203-214.

Day, S. J. & Fletcher, W. K., 1989. Effects of valley and local channel morpholgy on the distribution of gold in stream sediments, from Haris Creek, British Columbia, Canada. J. Geoch. Explo. 32, 18-31

Debon, F., Lefort, P., Dautel, D., Sonet, J. & Zimmermann, J. L., 1987. Granites of western Karakoram and northern Kohistan: a composite mid- Cretaceous to upper Cenozoic magmatism. Lithos. 20, 19-40.

Desio, A., 1959. Cretaceous beds between Karakoram and Hindu Kush Range (Central Asia). Riv. Ital. Paleont. Stratigr. 65, 221-229.

Diemberger, K., 1968. Ein Apfel auf dem Tirich Mir. Hindu Kush- Kundfahrt. Geologische Ergbnisse. Jb. Osterr. U. Deutscher Alpenverein. 93, 143- 147.

Goudie, A. S., 1984. Salt efflorescences and salt weathering in the Hunza Valley, Karakoram mountains, Pakistan. In: The International Karakoram Project (K. J. Miller, Ed.), Cambridge University Press. 2, 607- 615.

Hayden, H. H., 1915. Notes on the geology of Chitral, Gilgit, and the Pamirs. Geol. Surv. India Recs. 45, Pt. 4, 271- 335.

Hewitt, K., 1968. The freeze-thaw environment of the Karakoram- Himalaya. Canadian Geographer. 12, 85- 98.

Ivanac, J. F., Traves, D. M. & King, D., 1956. The geology of the Gilgit Agency. Geol. Surv. Pak. Recs. 8, Pt. 2, 1- 27.

Leak, R. C., 1984. Geochemical exploration in the northern part of the Kohistan island arc, Chitral district, NWFP, Pakistan. Report for Sarhad Development Authority, Peshawar.

Leak, R. C. & Haslam, H. W., 1985. Tungsten and other mineralization in the Hindu Kush, Chitral district, NWFP, Pakistan. Report for Sarhad Development Authority, Peshawar.

Pudsey, C. J, Schroeder, R. & Skelton, P. W., 1985. Cretaceous (Aptian/Albian) age for island arc volcanics, Kohistan, N. Pakistan. Cont. Himalayan Geol. 3, 150-168.

Reynolds, R. C. & Johnson, N. M., 1972. Chemical weathering in temperate glacial environment of the Northern Cascade Mountains. Geochim. Cosmochim. Acta. 36, 537- 554

Stauffer, K. W., 1975. Reconnaissance geology of the central Mastuj Valley, Chitral State, Pakistan. U. S. Geol. Surv. Open file report 75- 556.

Tahirkheli, R. A. K., 1982. Geology of the Himalaya, Karakoram and Hindu- Kush in Pakistan. Geol. Bull. Pesh. Univ. Spec. Issue. 15, 18- 21.

Talent, J. A., Conaghan, P. J., Mawsan, R., Molloy, P. D. & Pickett, J. W., 1982. Intericacy of tectonics in Chitral (Hindu-Kush): Faunal evidence and some regional implications. In Himalaya Geology, Sect. 11A. 77-110. Geol. Surv. India. Misc. Pub 141.

Tipper, G. H., 1922. General report. Record. Geol. Surv. India Vol. LXIV.

Wellman, H. W. & Wilson, A. T., 1965. Salt weathering, a neglected geological erosive agent in coastal and arid environments. Nature. 205, No. 4974, 1097- 1098.

Whalley, W. B., 1984. High altitude weathering processes. In: Miller, K. (ed.), The International Karakoram Project. 2, 365-377. Cambridge University Press. Cambridge

Whalley, W. B., Mc Greevy, J. P. & Ferguson, R. I., 1984. Rock temperature observations and chemical weathering in the Hunza region, Karakoram: Preliminary data. In: Miller, K. (ed.), The International Karakoram Project. 2, 616-633. Cambridge University Press.