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Antimony, Gold and Polymetallic Deposits of the Awireth-Krinj Area, Chitral/Pakistan

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With one Figure in text and one Geological Map
Sheet Shoghor, 1:25,000 Enclosure
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Zusammenfassung: Anhand des beiliegenden Kartenblattes **Shoghor**, 1:25.000, wird die Geologie der weiteren Umgebung von Shoghor im Rahmen der geologischen Entwicklung NW-Chitrals (Pakistan) sowie die Gold-Vererzung von Awireth und die Antimon-Vererzung von Krinj genauer beschrieben. Beide Lagerstätten liegen in dem auf der geologischen Karte dargestellten Gebiet.

Summary: Based on the attached geological sheet **Shoghor**, 1:25,000, the geology of the Shoghor area within the framework of the geological development of the North-West-Chitral area (Pakistan) is described. Particular room is given to the gold-mineralization of Awireth and the antimony-mineralization of Krinj, both situated in the area of the Shoghor geological map.

1. Introduction

Based on fieldwork carried out in the regions of the western Karakorum and the Hindukush Range in the years from 1965 to 1976 a considerable quantity of various data have been accumulated and partly made available to reports and papers. A comparatively small area covered by the geological sheet **Shoghor**, 1:25,000, and containing the two most prominent mineralizations (Awireth and Krinj) of the Chitral District, shall be presented by this paper.

The area ist located a couple of miles (about 17 km) northwest of Chitral Town at the confluence of the Lutkho and Arkari River directly south of the granitic masses of the Tirich Mir massif, 7706 m.

The Shogor area is fairly easy accessable by road, the deposits and surroundings, however, are mountain regions, several hundred meters high above valleys and villages.

The topography of the central portion has been worked out by R. KOSTKA, 1974, TU Graz, based on the stereo-photogrammetric evaluation of aerial photographs. The topography of the northern section and the southernmost portion is a compilation on the basis

Figure 1: Aerial Photograph of the Shogor Area, Scale 1:100,000 approximately, with clearly discernable tectonic structures.

of enlarged Pakistani maps (No. 38 M, Chitral, 1:250,000, and No. 38 M/9, Chitral, 1:50,000; No. 37 P, Zebak, 1:250,000). The degree of accuracy of these portions is therefore of a low standard.

Morphological and geological data derive from fieldwork on site supplemented by the evaluation of aerial photographs (see Fig. 1), ERTS and LANDSAT imageries.

In the north, the geological map has been tied up in the geological map „Tirich Mir", 1:50,000, BUCHROITHNER in BUCHROITHNER & GAMERITH, 1986.

2. General Geological Setting

The geological map SHOGHOR is a quite small section and due to this fact it is felt advisable to additionally include the important geological units in this description although not all of them are actually represented on the map.

The area is dominated by the north-east/south-west running main grain of the mountain ranges. This tendency ist prevalent in the wider region along both sides of the border line between Afghanistan and Pakistan along the main ridge of the Higher *Hindukush*.

Compressed, folded and faulted, thick geosynclinal and meta-volcanic series are penetrated by numerous magmatic instrusions (GAMERITH 1972, 1979, 1980; GAMERITH & KOLMER 1973; BUCHROITHNER & GAMERITH 1978, 1986). Whilst the individual geological units of the wider Shogor area are described in brief (for more details it is referred to the cited literature), the Au-desposit of Awireth and the Sb-deposit of Krinj are described in detail.

From the North to the South and divided by tectonic lineaments or fault zones or bordered by intrusives the following eight geosynclinal-sedimentary units can be distinguished in Chitral:

I. A Mesozoic sequence of dark-grey slates to siltstones and fine-grained quartzites with intercalations of limestones and calcareous schists (Arkari Series/Atak Series, BRIEGLEB, 1976).

II. An Upper Paleozoic sequence of middle- to dark-grey slates to siltstones and fine-grained quartzites, light greenish or brownish-greyish argillaceous-arenaceous-calcareous schists with large lenses of varying thickness consisting of light- to middle-greyish limestones or white to light yellowish-brownish dolomites; to a smaller extent intercalations of green meta-volcanics and volcano-sedimentary rocks (Awireth Series, Series of Owir, HAYDEN 1916; VOGELTANZ 1968, 1969; VOGELTANZ & SIRONI-DIEMBERGER 1969).

III. A thick Upper Paleozoic to Lower Triassic sequence of dark-grey slates and some siltstones with marker beds of light quartzites; rare, thin lenses of ferrogenous limestones or calcareous schists; distribution from the Afghan Pamir (Wakhan) to west of the Tirich Mir (Wakhan Formation, MIRWALD & RÖMER 1967; DESIO, GUY & PASQUARE 1968; GAMERITH 1972; BUCHROITHNER 1978, 1979, 1980; BUCHROITHNER & KOLMER 1979).

IV. A Cretaceous to Tertiary sequence with frequently changing facies in strike direction consisting of white to light-grey, partly reddish limestones and, to a lesser extent, also dolomites.

In the southwest of Chitral with transitions to sandstones, conglomerates and red calcareous schists (Shoghor Limestone/Reshun Formation/Reshun Conglomerate, HAYDEN 1916; DESIO 1959, 1963; CALKINS et al. 1969, 1981).

V. A Cretaceous to Tertiary sequence of dark-grey slates to siltstones and fine-grained quartzites. To a lesser extent greywacke and conglomerates with light-grey to whitish calcareous schists or limestones and partly thick intercalations of green schists and (meta-)volcanics occur (Chitral Slates, HAYDEN 1916; TIPPER 1924; DESIO 1959).

VI. An Upper Paleozoic sequence of middle-to dark-grey slates and light- to middle-grey argillaceous-arenaceous-calcareous schists, partly with lenses and beds of white to light-grey limestones and dolomites, probably also (meta-)volcanics and greenschists (Golen Gol Series, COWPER-REED 1911, 1922).

VII. An Upper Paleozoic (?) sequence of dark-grey slates to siltstones and fine-grained quartzites with carbonatic intercalations of varying thickness (Series of Mastuj = ? Darkot Series/Darkot Group, DESIO 1966, 1975; IVANAC, TRAVES & KING 1956; MATSUSHITA & HUZITA 1955; GAMERITH 1972).

VIII. A Cretaceous to Tertiary sequence of middle-grey slates and reddish to violet calcareous slates to calc-schists with intercalations of mostly thin lenses or beds of light limestones, red sandstones to quartzites, partly thick greenish (meta-)volcanics, tuffs and tuffites in the southwestern portion (Shishi Series, BRIEGLEB 1976).

A number of (batholitic) intrusive bodies, which mostly follow the main strike direction with their longitudinal extension occur in Chitral, marking many of the higher summits of the region. They are basically of granitic to quartz-dioritic composition and, regarding to their emplacement, they can be distinguished between pre- to syntectonic quartz-diorites and late- to posttectonic granodiorites, granites and pegmatite-granites (GAMERITH & KOLMER 1973; BUCHROITHNER & SCHARBERT 1979).

Between the Tirich Mir Granite in the north and the Series of Owir in the south the Momi Gneiss is exposed along a northeast-southwest striking zone (DIEMBERGER 1968).

In the north-west of the Tirich Mir batholite a belt of basic/ultra-basic rocks such as gabbro-amphibolites and serpentinites occur and follow the main strike trend north-east/south west (BRIEGLEB 1978).

3. Structural Development

By comparison of the above-described geosynclinal units a certain correlation is possible and consequently a correspondence with certain synclinal and anticlinal structures can be stated. The Mesozoic geosynclinal basins (Arkari/Atak Series, Reshun Formation, Chitral Slates, Shishi Series) are thought to correspond with synclinoria whilst the other sedimentation areas (Awireth Series, Series of Owir, Darkot Series, Golen Gol Series) may correspond with orogenetic anticlinorial structures (BUCHROITHNER & GAMERITH 1986).

The Alpidic orogenetic activities during Cretaceous to Tertiary have strongly compressed, folded and faulted the geosynclinal structures, whereby a distinct south to south-east trend can be observed. Prominent longitudinal fault zones have developed between the individual series. In Central Chitral between the Reshun Formation and the Chitral Slates an overthrust has developed from a longitudinal fault in southwestern Chitral (DESIO 1979).

Regionally important longitudinal faults which in particular occur along contact zones of rock inhomogenities (limestone – slate) are common in these series. Such faults also feature the mineralizations of Awireth and Krinj (WERNECK 1975) and others such as the Pb-Zn mineralization of Pakhturi.

The emplacement of the Tirich Mir batholitic body, discordantly intruding the Upper Paleozoic to Lower Mesozoic sedimentary series is assumed to be partly controlled by a pre-existant anticlinal structure and (re-activated?) longitudinal and/or cross faults (cf. DESIO 1976; EBBLIN 1976, 1978; BARTOLE 1978).

4. Metallogenetic Aspects

From the metallogenetic point of view, it appears that base-metal mineralizations, which locally occur in Chitral, are directly related to mostly epi-hydrothermal solutions derived from the late magmatic activity. As a guidepath, these solutions favoured faults developed along rock inhomogenities. This is particularly featured by the situation in Awireth and Krinj in Central Chitral.

The numerous and scattered tungsten occurrences and a few molybdenite outcrops, e. g. at Shah Jinali Gol, are of contact-metamorphic and contact-metasomatic origin (AUSTROMINERAL 1975, 1978).

Scheelite showings in the area west of the Tirich Mir indicate that some source of tungsten contained in the scheelite mineralization is to be found in sedimentary-volcanogenic environments. Such a genesis would be in line with conceptions of origin of initially strata-bound scheelite deposits in Austria and elsewhere (TUFAR 1980, 1981).

5. The Deposits

5.1. The Awireth Gold Deposit

5.1.1 Location

The deposit area lies rather favourably with regard to Chitral township and can be reached via Shoghor Village in the Lutkho Valley. To transport heavy mining equipment a jeepable 7 km long road was built from Shoghor to a distance of 800 m from the deposit, in the upper Awireth Gol. The outcrops occur on a conspicuous steep dolomite cliff at about 2800 m a.s.l.

5.1.2 Geology

The deposit occurs on the western slope of the Shoghor Limestone belt, in a highly displaced series of dolomites, slates, dark shales and quartzites, bordered in the west by the Awireth green schist series/Series of Owir (c.f. CALKINS et al. 1981). The dip of strata is almost vertical with slight variations to steep north-west or south-eastward inclination. Occasionally meta-volcanics were noted in the limestone.

The mineralization appears to be tied to a zone of intensive faulting and shearing where most of the regional northeastern faults and thrusts along and within the Shoghor-Krinj Limestone belt are converging to a sort of structural hinge forming a horse-tail pattern of converging structures.

Apart from the main northeast faults and thrusts a number of transversal faults generally trending around the east-west direction were noted, cutting up and displacing the individual strata in a block-like manner.

Along the main structural lines intensive shearing, mylonitisation and brecciation is a common feature.

The map covers the NW-border zone of the Cretaceous Shoghor Limestone belt and the SW-part of the upper-Paleozoic Awireth series, both separated by a major fault zone. The contact zone has been mapped between the upper part of the Awireth Gol in the SW and the lower Ojhor Gol in the NE.

a) The Shoghor Limestone

This limestone is generally light coloured, slightly stratified or banded; outcropping in bulky masses or, mainly, undistinctly banked, in wide intervals.

In the Lutkho valley as well as at the Awireth prospect, there are intercalations of grey, fine crystallized dolomites with fluid transitions to the Shoghor Limestone, for which they seem to be a substitute of a different facies, however, of the same age. In the vicinity of the Awireth mine these dolomites are heavily tectonized and partly pyritized.

Starting already at the Awireth Gol but developed mainly north of the Lutkho valley, is a second facies-substitute in the form of red shales, with which the Shoghor Limestone gets increasingly intercalated towards NE.

b) The Awireth Series

This sequence consists of grey shales, siltites, quartzitic shales and bedded quartzites with intercalations of limestones and dolomites. The latter may reach a thickness of several 100 meters.

Intercalations of yellowish-brown to reddish, limy shales, dolomites and quartzites, with a combined thickness of up to 100 meters are known as „Awireth Red Formation“. This series usually has a certain amount of pyrite; Cu-sulfides have also been observed as isolated accessory minerals.

c) The Awireth Green Series

This series develops gradually out of the proper Awireth series towards NW, parallel with a relatively rapid increase of metamorphism from anchimetamorphic to epimetamorphic facies. Typical rocks of this series are greenschists (sericite-chlorite schists), quartzitic schists and green meta-volcanics.

d) Structure

The most prominent tectonic element of the whole area is the high rising Shoghor Limestone belt. Southwest of the Luthko river it strikes NNE, with steep dips towards NNW. Northeast of the Lutkho river its strike bends to NE and ENE and dips towards NW is gradually flattening.

The regional longitudinal fault along the northern border of this belt is accompanied by numerous secondary faults. In general, these secondary faults are controlled by the contacts between the schist sequences and the more massive dolomite lenses.

Perpendicular and diagonal cross faults are also numerous both in the Awireth series and the Shoghor Limestone. Major cross faults are displacing both units. Foliation and local folding up to dimensions of several meters and tens of meters are common in the Awireth series near major faults.

Possible larger folds of regional size have been totally compressed and are not easily discernable.

5.1.3 Mineralization

The known Sb-Pb-Au-Ag mineralization (Paar, 1975) is controlled by the main fault between Shoghor Limestone and Awireth series. The mapping of 12 kilometers of the fault zone did not indicate any other sulfosalt mineralization than that already known Awireth mine, and the two small occurrences some 3000 m NE.

Along the fault and in close relation with the Awireth mineralization occurs a dolomite which is interpreted as a border facies of the Shoghor Limestone. Owning to the inherent physical characteristics it is heavily fractured and in places even mylonitized.

Strong fracturing made this „contact dolomite" the preferred migration path for ascending hydrothermal solutions. The boulangerite and related minerals of the high grade massive ore zone are emplaced in the dolomite, together with the disseminated and weakly auriferous pyrite mineralization.

There are 3 types of mineralization:

- complex sulfosalts and sulfides forming usually massive lenticular ore bodies along the structure between shales-slates-quartzites and the dolomite facies of the Shoghor Limestone,
- auriferrous pyrite dissemination on the border of above massive ore (impregnations in quartzites and in dolomite) but particularly in dolomite adjacent to Shoghor Limestone,
- pyrite with traces of Cu and other base metals in the so-called „Red Formation".
  The latter occurs outside the main mineralization.

a) The sulfide ore body is exposed in the old incline and was intersected by a new tunnel (1975/76). On surface the ore body could be followed in what looks like isolated outcrops and old workings for about 400 m. The thicknes varies from stringers to over 1 m in the tunnel and in the central part of the old incline.

Mineralogical examinations revealed besides boulangerite as main component, bournonite, jamesonite, freibergite, sphalerite, galena, pyrite, chalcopyrite, bindheimite. Along the outcrop there is usually a secondary gossan development mainly featuring limonite. Gold was already noted in 1974 in the form of native Gold (plus silver) as isolated grains in fractures of the sulfide. The average Au-content in the lenticular sulfosalt-sulfide deposit appears to be around 50 g/t, with peak values attaining even 100 g/t.

The gold grains occur in sizes of 10 to 20 microns. Quartz, dolomite and calcite are the main gangue minerals.

From the area a total of 136 samples were analysed. In the sulfide ore body following average metal content was computed:

Sb 14%	Ag 470 g/t
Pb 38%	Au 50 g/t

In a vertical sense the mineralization is exposed by underground workings over about 30 to 60 m.

b) Auriferrous pyrite dissemination was noted in the quartzite bands intercalated with the slates in the footwall of the sulfide ore body, however, mainly in the brecciated dolomite, i. e. in the immediate hanging wall and in a second zone close to the Shoghor Limestones. There, the impregnation varies in intensity, limonite and sometimes boulangerite being also associated in tiny pockets and stringers.

This impregnation zone in the dolomite could be traced for at least 450 m along the coutcrop. Based on chemical analyses performed on pyritic rock samples taken at random in the impregnation zones an average gold content of about 5 g/t was determined. The native gold refers to a somewhat younger hydrothermal activity whereas pyrite acted as refractory precipitator.

c) Random sampling in the „Red Formation" the color of which is caused by the oxidation (limonitization) of ferrous constituents, did not yet prove gold contents. Besides pyrite, galena and chalcopyrite were observed in spotty and irregular occurrences both in dolomite and limestone.

5.1.4 Reserves Potential

The exploration work carried out in 1975, 1976 and 1977 by tunnelling and drifting proved a maximum depth extension of the known boulangerite lense of about 60 m. In this lense the average gold content assuming a stoping width of 1 m amounts to about 2.4 g/t. The reserves left behind after the mine was robbed by the Chitral Mining Comp. in previous years are not enough to justify modern mining and milling.

The boulangerite as main ore mineral is a complex mixture of Pb, Sb. Gold occurs as late hydrothermal phase in both boulangerite and pyrite. Technologically speaking only gold can be extracted while the separation of Pb or Sb would necessitate a complex metallurgical process. For neither of the process do the reserves suffice. The gold content in the so-called disseminated pyrites also proved to be too low to plan a separate operation for the exploitation and cyanide treatment of this type of mineralization.

It can not be excluded that further ore lenses of complex gold-bearing sulfosalts do occur in depth along the Awireth main fault. To prove such a mineralization would require tunnelling in excess of 500 m.

5.2. The Krinj Antimony Mine

5.2.1 Location

The antimony mineralization of Krinj is situated at the southern contact of a limestone belt, which crosses the Lutkho Valley in direction NE-SW between Krinj and Shoghor. The direct distance to the Awireth mine measures only 7 km. The ore found is stibnite, bound to a distinct fault zone some 3 km long, between the Lutkho Valley in the SW and Bokhtul Gol in the NE.

Krinj (elevation 1750 m), a settlement of a few houses only, is located at 12 km on the road from Chitral Town to Shoghor and Garam Chasma. The mine itself is situated on the southern slope of the Shoghor Limestone range at an elevation of about 2,400 m. The mine is accessible by a steep jeepable road of 3 km length.

5.2.2 Geology

Basically, the geological units exposed in the Krinj area are the same as described under para 5.1.2. The Krinj Sb-mineralization is controlled by a system of faults in the Chitral Slates, which run sub-parallel to the main thrust fault of the Shoghor Limestones over the Chitral Slates. The Shoghor limestone strikes NNE and dips steeply toward NNW, while the Chitral Slates strike ENE and dip less steep towards NW. The angle of disformity along the contact of the two tectonic units increases towards NE (c.f. CALKINS et al. 1981).

In the area of the Sb-mineralization the Chitral Slates consist mainly of grey shales, siltites and some breccias. The shales are thin bedded, platy and show lineation at millimeter scale in the direction of b-axes. Barren quartz veins are common.

The Shoghor Limestone is of white to light grey colour, is thick bedded or compact, and of a fine grained recrystallized texture. Near its contact with the Chitral Slates some thin (cm. to dm. scale) grey shaly-limy schists were found. The possibility that these intercalations represent a transition facies between the Shoghor Limestone and the Chitral Slates is not proved due to the lack of fossils.

The stibnite found along some of the bundle of secondary sub-parallel faults to the south of the main thrust fault is of epimagmatic origin, formed at low temperatures and associated with quartz and some pyrite.

Three different occurrences are kwown:

a) The proper Krinj Antimony Mine in the upper Kamal Gol, also known as „Number Two Mine“ or the „Kamal Mine“ at an elevation of 2400 meters.
b) „Number One Mine“ or the „Angarum Mine“, which is situated some 500 m SW of the latter mine, at an elevation of 2280 meters.
c) „Number Three Mine“, or the „Bakht Mine“ located in the Bakht Gol, some 1500 meters in straight line NE of the Krinj Antimony Mine.

In former times all three sites have been worked intensively (particularly during the second world war) by an Indian company employing very primitive exploitation methods.

Studies of the mineralization were only possible at the Krinj Antimony („Kamal“) Mine. The old workings of the two other mines have collapsed and are not accessible.

There are numerous other abandoned adits and trenches in the area between the three main mining sites. To the greater part these are not accessible any more and no records on the geological situation are available.

5.2.3 Mineralization

The antimony mineralization at Krinj extends over a distance of at least 2 kilometers between the Lutkho and Bokhtul Valley along a narrow ore zone within the Chitral Slates immediately below the contact to the Shoghor Limestone. This zone is considered to be highly prospective, in particular in the vicinity of the already known occurrences in the Kamal Gol (Number Two Mine and Number One Mine) and in the Bokhtul Gol (Number Three Mine).

The antimony mineralization in the area of the Krinj Mine consists of a number of ore lenses of various size which belong to structurally controlled deposits, but are nevertheless isolated bodies with no connection between each other.

The ore bodies between the upper adits I and II and the main adit IV are most probably mined out to a certain extent. Therefore, this portion of the deposit is likely of no economic importance any longer. The ore body in the northern part of main adit IV is of small size and also partly mined out.

The main ore zone in adit IV increases in width towards the depth and shows the maximum thickness at the lowest levels of the mine. The main ore has a strike of N 30E and a dip of 50 to 60° toward WNW. This ore body has a lenticular shape and has a lateral extension of at least 30 m. It was traced at several levels over a vertical distance of 10,5 m. The ore body pinches out in a vertical and lateral sense, where it measures only a few centimeters. The maximum thickness of 110 cm was found at the deepest level. In addition to the main lense a few minor ore lenses are indicated.

Mineralized veins of a thickness of 20 cm or more, usually consist of rich ore with a content of 45% stibnite or more. The veins partly consist of compact ore of about 90% stibnite, as for instance in the lowest level of the main adit.

Some mineralized veins, in particular the smaller ones, are showing a transition into lean ore and sometimes to non-mineralized quartz veins, or can fade out within a very short distance. Other mineralized veins have a typical sequence of ore and gangue, whereby the ore was found at the upper and the lower portion of the vein. The lenticular ore bodies are parallel or sub-parallel to the general strike and dip of the adjacent slates and are distinctly controlled by a system of longitudinal faults. The mineralized veins are accompanied by numerous non-mineralized quartz lenses or veins, which probably belong to a younger hydrothermal phase. The ore is usually fine grained, compact and shows up to 50% gangue quartz.

The mineralogical investigation revealed a fine intergrowth of the stibnite with gangue minerals. Liberation with satisfying results can be expected at a grain size of –200 μ.

The assay of a composite bulk ample proved the following contents:

Sb	15.22%
Pb	0.09%
S	6.79%
Cu	0.01%
Fe	1.25%

5.2.4 Reserves Potential

With proven reserves (AUSTROMINERAL, 1978) of close to 3,000 t of ore averaging 15–20% Sb and an additional potential not clearly determined at present, the Krinj mineralization can be classified as a medium-size antimony deposit. The difficult access in an mountainous and remote area makes it look not too attractive for a major investment which would, however, be prerequisite for efficient mining. In addition, the region is a border zone to the eastern Afghanistan provinces (less than 40 km to the border from Shoghor), notorious for unstable conditions and with a vague future in the present post-war status.

Due to the fact that antimony belongs to that type of commodity with considerable price fluctuations consequent on changing demands, the future of the Krinj mine will be very likely that of a mine only intermittantly excavated with low investment during periods of increased antimony demand and prices.

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