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LEAD-ZINC ORE OF KOHISTAN, HAZARA, PAKISTAN

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The Kohistan Pb-Zn mineralization occurs as veins and disseminations of sphalerite, galena and pyrite in Besham at a distance of about 150 km from Abbottabad. Igneous and metamorphic rocks are the main rocks exposed in this geologically complex area. The petrology, chemical and X-ray studies reveal that the major minerals are quartz, galena and sphalerite with minor chalcopyrite.

Key words: Pb-Zn mineralization, Kohistan, Hazara, Pakistan.

INTRODUCTION

The occurrence of Pb-Zn ore in Kohistan was first reported by Engineers Combine Limited, a local consultancy firm, in 1979 [1]. Ashraf *et. al* [2] described the general geology of the area and Pb-Zn-Mo mineralization in Lahor granite gneiss. The objective of this study is to present the geology, petrology, chemical and x-ray studies of the lead-zinc ore and to recommend for its exploration, beneficiation and commercial exploitation.

GEOLOGY AND PETROGRAPHY

The Besham area lies on both sides of the Karakoram Highway at a distance of about 150 Km from Abbottabad. The area is characterised by rugged terrain and high relief. Igneous and metamorphic rocks are the main rocks exposed in this geologically complex area. Igneous rocks consist of granite-gneiss and ultramafics. Metamorphics are composed of schists and marbles.

Lead, zinc and other sulphide mineralizations are spatially and genetically associated with altered granite and pegmatoids exposed in Lahor-Pazang area in Kohistan. The mineralization of lead-zinc and other sulphides is related to igneous and metamorphic rocks immediately south of Main Mantle Thrust in Thakot-Besham area. The inferred reserves of Pb-Zn ore of Pazang have been roughly estimated to the tune of 1 million tonnes, including approximately 0.5 million tonnes of indicated reserves. The inferred reserves of the ore in Lahor area are about 0.5 million tonnes with indicated reserves of 0.1 million tonnes.

Granites and metamorphic rocks form the bulk of the area. The granitic rocks include Lahor granite/pegmatoid complex of possible Pre-cambrian age, Shang granite and Mansehra granite gneiss. Lahor granite is generally medium grained and gneissic. The granite is greyish white, grey and light grey, whereas the weathered rock is grey and brownish grey in colour.

The igneous-metamorphic zone immediately south of Main Mantle Thrust contains a varied assemblage of ores. The following associations of genetic significance have been established by Butt [3].

1. Magnetite – Baryte
2. Magnetite – Baryte - Fluorite - Pyrite
3. Scheelite – Molybdenite

In Ghous Banda area in transition from altered granite to molybdenite bearing wall rock occurs through a zone of pyrite. This zone contains coarsely crystalline pyrite veins invading the skarn bodies.

4. Molybdenite - Pyrrhotite - Pyrite – Galena Sphalerite

This zone is characterised by the appearance of pyrrhotite and sphalerite. These occur both as veinlets and disseminate in the skarns.

5. Sphalerite – Pyrite
6. Sphalerite – Pyrite - Galena

The ore association consists of veins and disseminations of sphalerite, pyrite and galena. Galena occurs as cross cutting veins as well as along the grain boundries. Galena is free of inclusions as compared to sphalerite and pyrrhotite of the ore association.

7. Sphalerite – Pyrite - Melnikovite - Galena

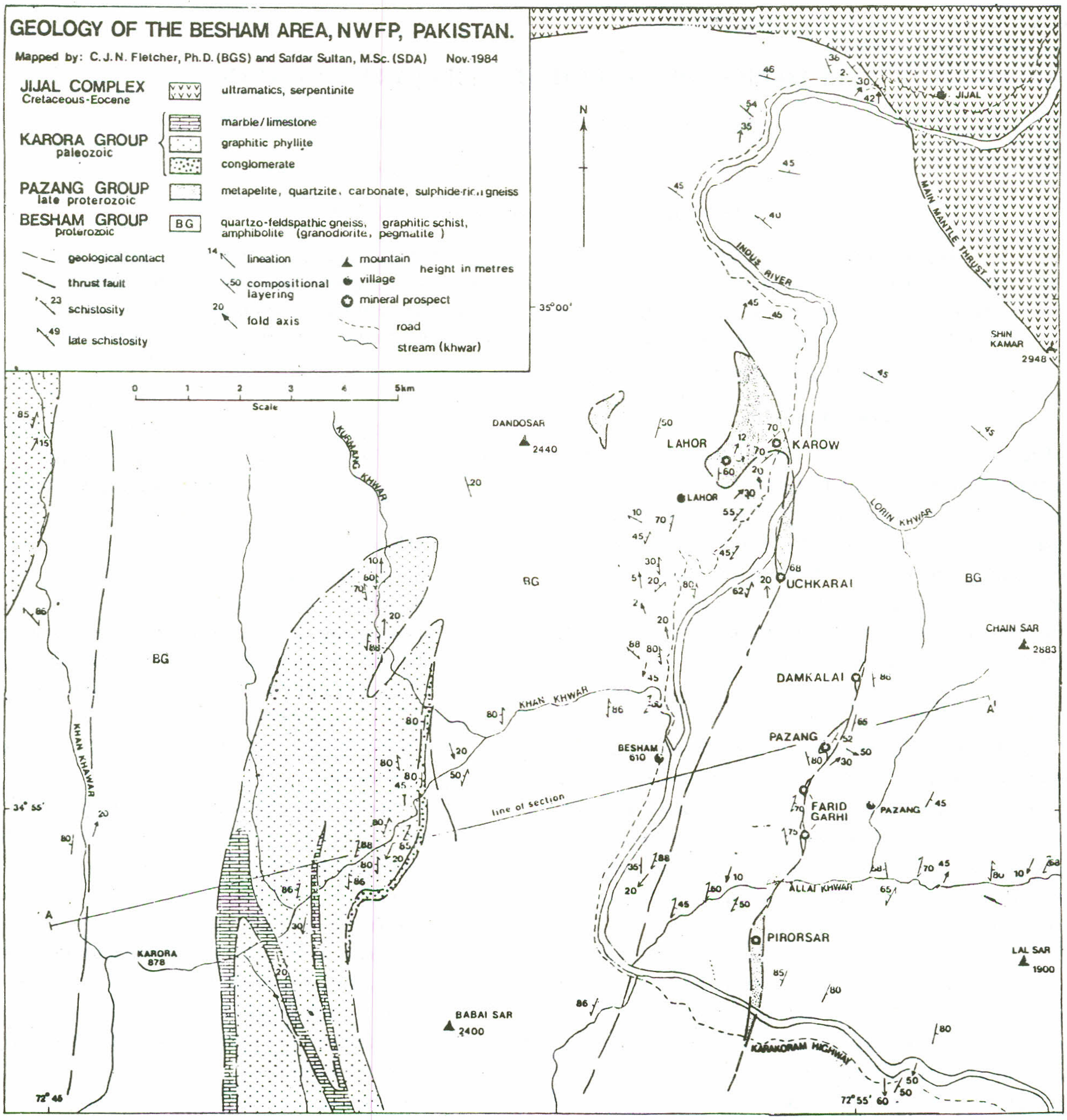
Sphalerite of this association is crystalline along the cleavage planes of galena.

8. Pyrite – Pyrrhotite - Uraninite - Chalcopyrite - Galena

This association contains pyrite as the principal ore in the form of fine veinlets and inerstitial fillings within the pegmatoid as well as associated with biotite granet shists. Occasionally it also occurs as coating on the pyrrhotite grains.

9. Pyrite – Galena - Uraninite

The principal ore is pyrite, galena is rare, it forms up to 50 micron tabular crystals which are diffusely distri-



Geological map.

buted in the rock.

10. Crystalline Magnesite – Talc

11. Baryte – Marble

The petrographic studies of the Pb-Zn samples from the area reveal the following mineral assemblages: Sphalerite with rounded and corroded grains, pyrrhotite, galena with characteristic triangular pits, chalcopyrite, pyrite and magnetite. Pyrite is coarsely crystalline with traces of scheelite.

Pyrrhotite occurs as tabular crystals occasionally replaced by pyrite.

The non-metallic minerals included biotite, quartz, chlorite etc. After having obtained enough geological data warranting the detailed geological exploration of the mineralization traced over a distance of about 5 Km. After physical inspection of the deposits and laboratory tests, it was confirmed by Dr. R.C. Leake of Institute of Geological Sciences, U.K. that these deposits are volcanogenic stratabound and are of considerable economic significance.

The age of the mineralization appears to be lat. Eocene as it is related with the Indo-Pakistan and Eurasian Plate Collision. The period of Post Himalayan orogeny is the most significant period in which subduction of Indian Plate must have been responsible for mineralizing solutions to come on or near the surface. However, further detailed work is essential for determining the definite age.

METHODS

Chemical analyses. The samples of Pb-Zn ore from Kohistan area were analysed for major & trace elements by X-ray fluorescence (XRF) and Atomic Absorption Spectroscopy (AAS). The results are presented in Table 1.

Table 1. Chemical analyses of lead zinc sample from Kohistan

Composition %	Sample I	Sample II	Sample III
SiO_2	35.03	54.08	37.33
Fe_2O_3	6.98	6.15	7.12
Al_2O_3	9.80	5.91	10.98
CaO	9.53	7.04	10.47
MgO	4.40	3.52	3.40
PbO	16.47	11.32	15.30
ZnO	3.10	3.08	2.73
BaO	1.39	0.54	0.48
MnO	3.73	1.88	3.14
CuO	0.14	0.12	0.21
TiO_2	0.09	0.08	0.05
Na_2O	0.16	0.41	0.29
K_2O	0.22	0.36	0.13
P_2O_5	0.27	0.07	0.06
S	7.78	4.70	7.51
Total	99.09	99.26	99.20
DPM			
Zr	42	58	20
Rb	–	–	–
Sr	64	185	97
Y	23	28	10
Ni	–	–	–
Cr	–	–	–
Co	19	35	22
V	–	–	–
Sulphide minerals composition			
Galena	17.64	12.13	16.39
Sphalerite	3.71	3.70	3.28
Pyrite	5.23	4.90	5.34
Pyrrhotite	3.82	3.38	3.91
	30.40	24.11	28.92

X-ray powder diffraction (XRD). The X-ray powder diffraction data were obtained by using Debye-Scherrer Camera (dia 114 mm) on Seifert (XRD) unit. Paste of the samples were made with a drop of collodian and moulded to a tiny cylinder of diameter 0.5 mm and length 10 mm approximately. The samples were exposed to Ni-filtered Cu-radiation for four hours at 35 KV and 20mA. The summary of minerals identified is presented in Table 2.

Table 2. Results of X-ray diffraction analyses of rock samples.

Minerals identified	Sample I	Sample II	Sample III
Galena	++	++	++
Sphalerite	+	+	+
Pyrrhotite	+	+	–
Pyrite	–	+	–
Quartz	+	+	–
Calcite	–	+	–

++ Indicates presence of minerals in major amount
\+ Indicates the presence of minerals
– Indicates the absence of minerals

RESULTS AND DISCUSSION

The calculated average composition have been worked out on the assumption that P_2O_5 is located in apatite. The lime left over after forming apatite and anorthite is assigned to calcite. Potash and soda are present in orthoclase and albite. The alumina is distributed to orthoclase, anorthite an albite. The leftover silica reported as quartz, lead, zinc and iron was attributed to galena, sphalerite and pyrite respectively.

The average composition of the minerals in the ore samples are 27.8% sulphide minerals with galena (15.38%), pyrite (5.16%) and sphalerite (3.56%). The associated minerals are plagioclase (25.0%), orthoclase (5.64%) quartz (15.43%), calcite (9.3%) pyroxene (15.37%) and apatite (0.30%).

In all samples, strong reflections of galena (d= 2.97, 3.43 and 2.10A^{O}) and sphalerite (d= 3.12, 1.91 and 1.63A^{O}) were present. Some weak reflections of pyrrhotite, pyrite and chalcopyrite present indicate the presence of these minerals. However, reflection 3.70A^{O} could not be identified.

Efforts were made to separate galena and sphalerite grains microscopically. The grains of galena could only be separated. The grains were powdered and subjected to X-ray Cu Kα radiation. XRD data of the powdered pattern are given in Table 3. All reflections of the separated grain samples are comparable to those for the galena reported in the A.S.T.M. powder data card no. 5-592.

Table 3. Separated galena from samples.

I			II			III		
hkl	dA^O	I	hkl	dA^O	I	hkl	dA^O	I
111	3.42	100	111	3.36	50	111	3.42	10
200	2.97	100	200	2.93	50	200	2.97	10
220	2.97	100	220	2.08	80	220	1.10	10
311	1.77	80	311	1.78	30	311	1.77	5
222	1.69	80	222	1.71	15	222	1.71	5
400	1.47	80	400	1.47	5	–	–	–
331	1.36	2	331	1.37	2	331	1.37	1
420	1.32	10	420	1.31	30	420	1.32	1

These reflections were indexed and cubic cell parameter have been calculated a = 5.95A^O.

The density was estimated by chemical formula PbS (Molecular wt. M = 239g.) and the volume of the unit cell (210.64A^3). Considering that unit cell contains 4 formula unit the density was calculated [4].

$$D = (1.66 \times 4\ 239)/210.64 = 7.5 g/cm^3$$

The density thus calculated is comparable to that of calculated by hydrostatic balance, which was 7.6g/cm^3.

CONCLUSION

The chemical and mineralogical studies of the Pb-Zn ore reveal that the ore contains galena, sphalerite, pyrite, pyrrhotite and quartz. The deposit is volcanogenic and is of considerable economic significance. The grade of ore has to be established by chemical analysis of various samples both at surface and depth. At present Pakistan imports Pb-Zn worth 400 million rupees in foreign exchange from different countries. The exploration, development and commercial exploitation of the Pb-Zn ore deposit in Kohistan will save huge amounts of foreign exchange.

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