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Zinc-lead mineralisation in Ganesh Himal region, central Nepal

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ABSTRACT

Carbonate hosted zinc-lead sulphide mineralisation of economic significance occurs in the Ganesh Himal region, central Nepal. The area lies in between 4,000 m and 4,900 m above msl. The mineralised bodies are situated very close to the Main Central Thrust. The mineralisation occurs in crystalline saccharoidal dolomites within a repetitive sequences of garnetiferous mica schists, quartzites, calcareous schists and amphibolites. These rocks (along with the ore) are folded into an anticlinorium and a tight synclinorium, and have suffered metamorphism of almandine-amphibolite-facies and intense deformation during Himalayan orogeny. Discontinuous bands of graphitic schists occur below the mineralised crystalline dolomites. Confined to a single carbonate stratum, the Ganesh Himal zinc-lead ore appears to be of synsedimentary origin and subsequently suffered from metamorphism. Out of six zinc-lead occurrences, only one at Lari is explored extensively. Detail investigations have confirmed more than 1 million tonnes of ore reserve averaging about 16.4% zinc, 2.5% lead and 32 grammes per tonne silver. The ore is rather simple. It consists of sphalerite, abundant pyrite, subordinate galena and pyrrhotite, and rarely chalcopyrite. X-ray diffractometry suggests possible occurrence of pyrargyrite. Ore texture indicates that the recrystallisation of sulphides took place probably at moderate to high temperature condition. Zinc lead ratio is approximately 6.13:1, with recoverable silver and low cadmium (248 ppm in average). Trace element concentration is rather insignificant. This paper is a synthesis of data on the mineral composition and trace element distribution in the Ganesh Himal zinc-lead ore.

INTRODUCTION

Ore float was reported from Serkaping in 1953. However, the exposed orebody was traced only in 1967 at the Lari valley (28° 14' N, 85° 11' E). The Lari valley is situated at 58 air km towards N13°W of Kathmandu at an altitude of 4,420 m above msl.

Six zinc-lead mineralisation bodies of considerable economic importance have been recorded in an area of 5 km^2 between 4,000 m and 4,900 m above msl on the southern slope of the Ganesh Himal Range in central Nepal (Fig. 1). All the six mineralisations occur in milky white crystalline dolomites with typical saccharoidal texture. Out of these, the Lari Bed No. 1 appears the most important one from surface exposures. It is well explored by tunnelling and extensive diamond drilling (Fig. 2). A 1,400 m long tunnel from Paigutang (4,110 m altitude) intersected the mineralised body at 4,130 m level at about 550 m down the plunge. A recent UNDP study conservatively outlined 811,830 tonnes of ore averaging 16.44% zinc, 2.55% lead and 32.4 ppm silver and recommended further exploration. It is believed that there are 2-3 million tonnes of ore at the minimum in the Lari Bed No. 1, Bed No. 2, Suple and Glacier mineralisation. The ore composition is simple from which very pure zinc and lead concentrates has been produced in laboratory.

REGIONAL GEOLOGY

The Ganesh Himal zinc-lead prospect lies in the central part of Nepal Himalaya. It is situated very close to the Main Central Thrust (MCT). Reports of Department of Mins and Geology (DMG), ESCAP (1993) and others (Chakrabarti, 1982, H.C. Einfalt, personal communication) put it in the Central

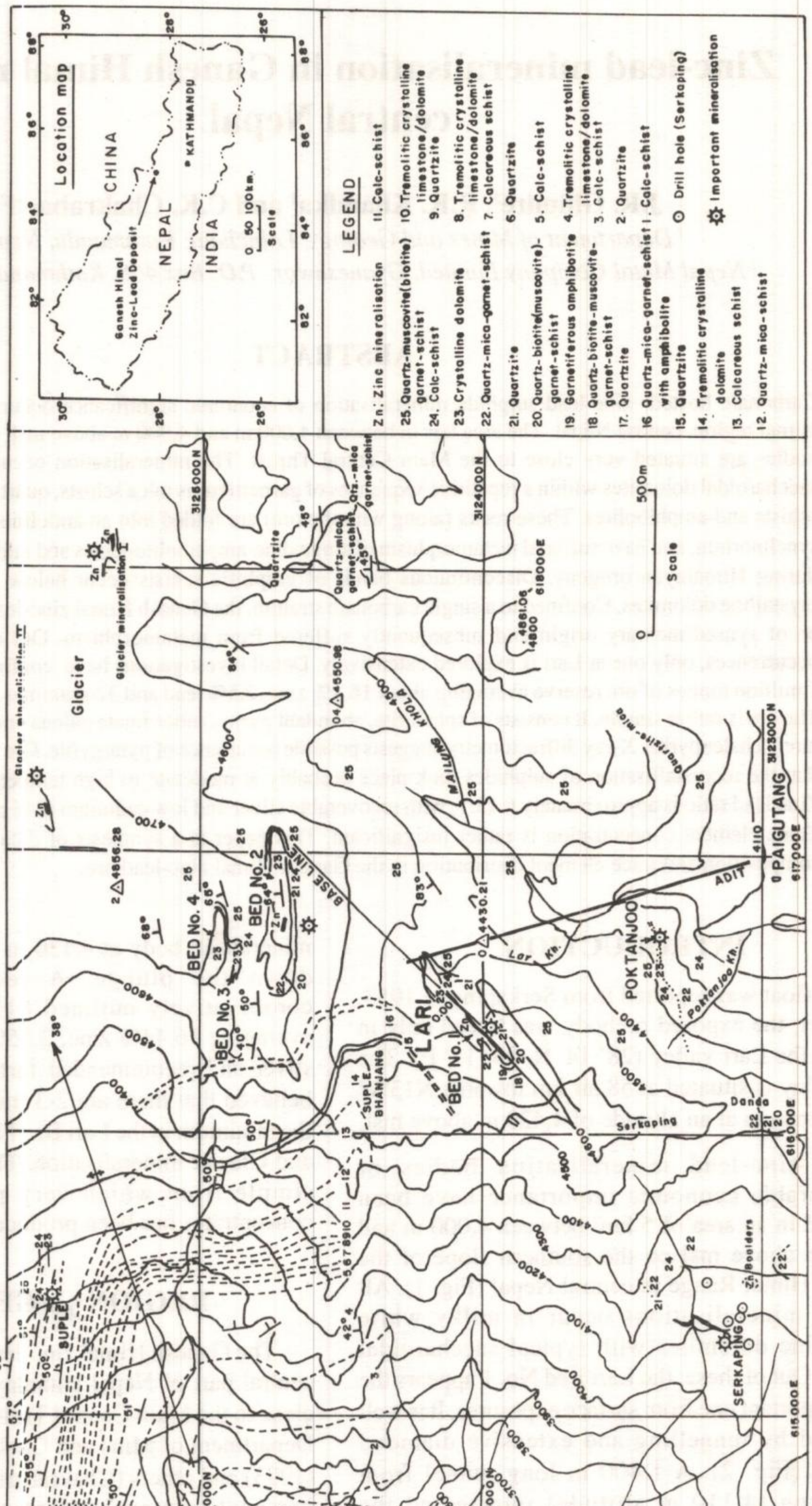

Fig. 1: Geological map of Ganesh Himal zinc-lead deposit

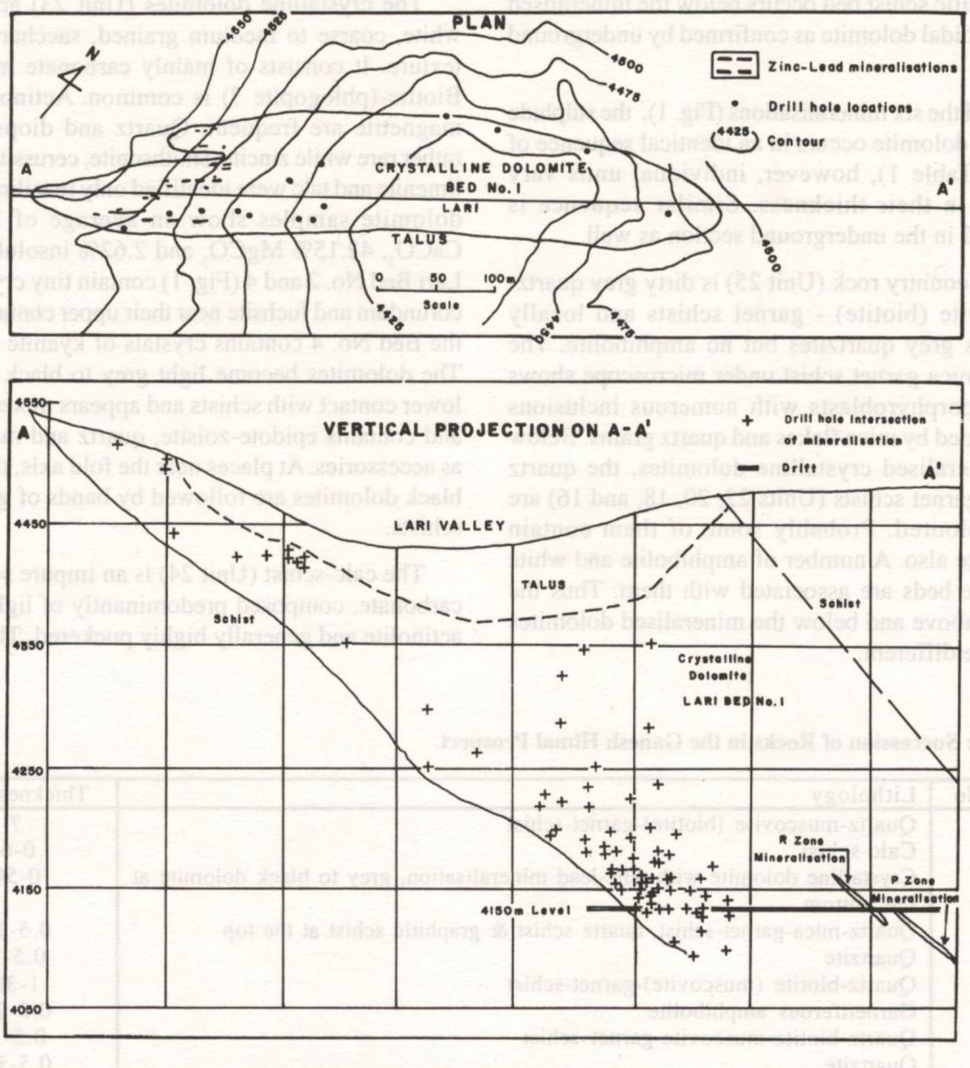

Fig. 2: Plan and projection of Lari Bed No. 1 mineralisation

Crystallines or the Higher Himalaya while Kumar (1984) and Colchen et al. (1986) consider it in the Lesser Himalayan Nuwakot Complex. Japanese geologists put it within the MCT zone (Arita et al., 1973).

Approaching to the deposit from south, chlorite-biotite schists gradually grade to garnet-mica schists, which are followed further north at higher structural level by garnet-biotite-kyanite schists and probably garnet-biotite-staurolite schists (Colchen et al., 1986), showing typical inverted metamorphism of the Himalayas (Ray, 1947, and Gansser, 1964).

GEOLOGY OF THE PROSPECT

Lithology

Geology of the Ganesh Himal zinc-lead prospect is very complex. The area is represented by a wide range of metasedimentary rocks and a number of minor concordant metabasic bodies, all metamorphosed to almandine-amphibolite facies. These rocks had suffered from intense deformation during the Himalayan orogeny. Lithologically, the area consists of a thick succession of alternating schists, amphibolites, quartzites and carbonate rocks.

A graphitic schist bed occurs below the mineralised saccharoidal dolomite as confirmed by underground drilling.

In all the six mineralisations (Fig. 1), the sulphide bearing dolomite occurs in an identical sequence of rocks (Table 1), however, individual units vary widely in their thickness. Similar sequence is recorded in the underground section as well.

The country rock (Unit 25) is dirty grey quartz-muscovite (biotite) - garnet schists and locally contains grey quartzites but no amphibolite. The quartz mica garnet schist under microscope shows garnet porphyroblasts with numerous inclusions surrounded by mica flakes and quartz grains. Below the mineralised crystalline dolomites, the quartz biotite garnet schists (Units 22, 20, 18, and 16) are dark coloured. Probably some of them contain staurolite also. A number of amphibolite and white quartzite beds are associated with them. Thus the schists above and below the mineralised dolomites are quite different.

The crystalline dolomites (Unit 23) are milky white, coarse to medium grained, saccharoidal in texture. It consists of mainly carbonate minerals. Biotite (phlogopite ?) is common. Actinolite and magnetite are frequent. Quartz and diopside are rather rare while zincite, smithsonite, cerussite, rutile, ilmenite and talc were identified only in tailings. Two dolomite samples show an average of 39.54% $CaCO_3$, 42.15% $MgCO_3$ and 2.62% insoluble. The Lari Bed No. 2 and 4 (Fig. 1) contain tiny crystals of corundum and fuchsite near their upper contact while the Bed No. 4 contains crystals of kyanite as well. The dolomites become light grey to black near its lower contact with schists and appears more calcitic and contains epidote-zoisite, quartz and magnetite as accessories. At places near the fold axis, the grey/black dolomites are followed by bands of graphitic schists.

The calc-schist (Unit 24) is an impure schistose carbonate, composed predominantly of light green actinolite and generally highly puckered. This calc-

Table 1: Succession of Rocks in the Ganesh Himal Prospect.

Unit No	Lithology	Thickness (m)
25	Quartz-muscovite (biotite)-garnet-schist	?
24	Calc-schist	0-6
23	Crystalline dolomite with zinc-lead mineralisation, grey to black dolomite at the bottom	0-50
22	Quartz-mica-garnet-schist, quartz schist & graphitic schist at the top	0.5-17
21	Quartzite	0.5-2
20	Quartz-biotite (muscovite)-garnet-schist	1-30
19	Garnetiferous amphibolite	0.5-20
18	Quartz-biotite-muscovite-garnet schist	0.5-7
17	Quartzite	0.5-13
16	Quartz-mica-garnet schist with amphibolite	0.5-30
15	Quartzite	0.5-7
14	Tremolitic crystalline dolomite	30-80
13	Calcareous schist	6
12	Quartz-mica-schist	5
11	Calc-schist	6-30
10	Tremolitic crystalline limestone/dolomite	6-25
9	Quartzite	3-30
8	Tremolitic crystalline limestone/dolomite	5-15
7	Calcareous schist	5-15
6	Quartzite	3-15
5	Calc-schist	5-25
4	Tremolitic crystalline limestone/dolomite	15-60
3	Calc-schist	30-100
2	Quartzite	15-45
1	Calc-schist	5-2

schist band was consistently used as a reliable marker bed during exploration.

Dark coloured amphibolites, with or without garnet, is a very prominent rock unit. It is a medium grained, hard rock containing hornblende, plagioclase, biotite, chlorite, quartz and opaque minerals. The rock is often garnetiferous. Einfalt has analysed two amphibolite samples at Bundesanstalt für Geowissenschaften and Rhostoffe (BGR), Hannover. $MgO-CaO-Fe_2O_3$ plots of the amphibolite has indicated that it is a metamorphosed igneous rock. The Zr-Ti-Y diagram shows its position within a plateau basalt field. It seems, therefore, possible that the amphibolites were originally a basalt generated in a continental setting, perhaps in a rifting environment (H.C. Einfelt, personal communication).

Changes in sedimentary facies are conspicuous in the region. Impure calcareous units predominate towards the lower part. Quartzite beds of varying thickness are prevalent throughout but show a definite increase near the zone of transition. The zinc-lead sulphide mineralisation is associated with only uppermost unit (Unit 23) of the calcareous facies. Zinc contents in other rocks are very low (Table 2).

Table 2: Zinc in different rocks.

Description	Zinc (ppm)
Crystalline dolomite (23)	600 - 6,600
Amphibolite (16, 19)	15 - 80
Schist from boulder (25)	60
Tremolite carbonates (14, 10)	16-70

Structure

Like the definition and identification of MCT, there exists considerable disagreement about the location of the deposits with respect to MCT. Owing to high grade metamorphism, plastic folds and absence of ruptures, the deposit is believed to lie above the MCT (Chakrabarti, 1982; DMG, 1987; ESCAP, 1993; H.C. Einfalt, personal communication). The geological map prepared by Japanese geologists show that this area occurs within the MCT Zone, a schuppen zone bounded by two thrusts (Arita et al., 1973). Kumar (1984) considers these as equivalent to upper part of Chail nappe and Colchen et al. (1986) put these in the Upper Midland formations (Nuwakot Complex).

In and around the prospect, the rocks generally trend NE-SW to almost E-W, dipping steeply towards north-west to almost north. From Suple (about 2 km north-west of Lari) to Poktanjoo (about 1 km south of Lari), the rocks are folded to an asymmetrical anticlinorium followed by a synclinorium, with Lari at the crest of the anticlinorium and Serkaping at the core of the synclinorium, where about 8 km long bed has been folded to fit within a stretch of only 3 km (Fig. 1). No fault or major displacement has been recorded in the area.

At Suple, the rocks show puckers with the regional plunge. At Lari, the sequence is highly folded and the crystalline dolomite (Unit 23) is squeezed out from the limbs into the cores. As a result four lens shaped bodies, which appear to have extensive plunge extensions are formed (Fig. 1). All folds plunge moderately to steeply towards NE to ENE (Fig. 3), the southernmost syncline at Lari Bed No. 1 having plunge of 40^0 due N 40^0 E. Lari Bed No. 1 has been followed along plunge from 4,500 m to 4,030 m above msl for a plunge length of about 650 m by drilling and tunnelling (Fig. 2). In Lari all the four lens shaped bodies of crystalline dolomite occur in synclines at their south-western or western ends, while the other ends are in anticlines (Fig. 1). The present configurations are the result of extreme flowage during deformation probably at high confining pressure. At Serkaping, the sequence is acutely folded.

At glacier mineralisation, a thin mineralised crystalline dolomite occurs in acutely folded sequence. It is similar to Lari except that the dolomite beds are much thinner. The exact structural relation between glacier mineralisation and Lari mineralisation has yet to be established.

No primary sedimentary structure is discernable in the prospect. The schists usually show two sets of deformational structures very prominently. The rocks are folded with a strong axial plane schistosity. The metallic sulphide minerals concentrated in regular bands are reoriented along the schistosity during metamorphism. Kumar (1980, 1984) observed that the ore minerals have undergone three phases of deformation and metamorphism along with the host rocks.

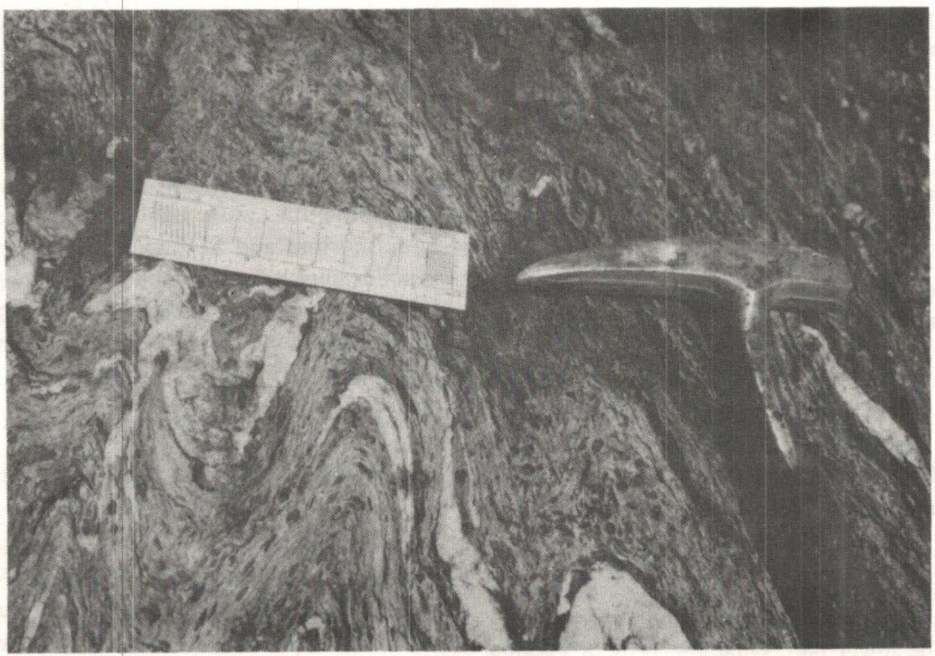

Fig. 3: Quartz-mica-garnet schist (25 ?) with quartz veins show plunging folds.

MINERALISATION

The richest mineralisation occurs at the Lari valley, at the central part of the prospect, where the white saccharoidal dolomite bed is squeezed into four isolated bodies (Fig. 1). The southernmost body, named Lari Bed No. 1, is an oval shaped elongated crystalline dolomite body trending approximately NE-SW and plunging 40° towards N40°E, has been prospected in detail by surface and underground drilling (Fig. 2). The Lari Bed No. 2 is also an oval shaped elongated body plunging north-easterly. Suple mineralisation (4,000 m altitude) occurs at the north-western end of the prospect while glacier mineralisations (4,900 m altitude) occurs at the north-east end. Serkaping and Poktanjoo mineralisations occur towards southernmost region. At all the places rich mineralisations occur at the basal part of the dolomite horizon. Except at Suple, the sequence is highly folded and the mineralisation is repeated at many places due to tight folding (Fig. 4).

Black carbonate mass truncates the orebody in Lari Bed No. 1 at around 4130 m level. Mineralisation continues down the plunge but probably at different stratigraphic level(s). The black carbonate might represent an old reef(?). However, this aspect has not been studied yet adequately.

Nature of mineralisation

The ore occurs in the form of dissemination, massive lenses, veins and veinlets of various dimensions (Fig. 5), which may be broadly divided in three following modes:

(1) Massive sulphide lenses of varying dimensions (0.3 m to 2.75 m wide) occur as isolated bodies, generally associated with disseminated zone, prevalent below 4,300 m.

(2) Veins, 1-9 cm wide, semi-continuous or en echelon, occurring parallel to the schistosity.

(3) Disseminated mineralisation of varying dimensions and grade generally occurring near the lower contact of crystalline dolomite, prevalent above 4,300 m and not recorded yet below 4,060 m level.

Sulphide lenses and veins occur generally parallel to the schistosity. Only at 3 places, in the Lari Bed No. 1, dark brown sphalerite lens cut across the

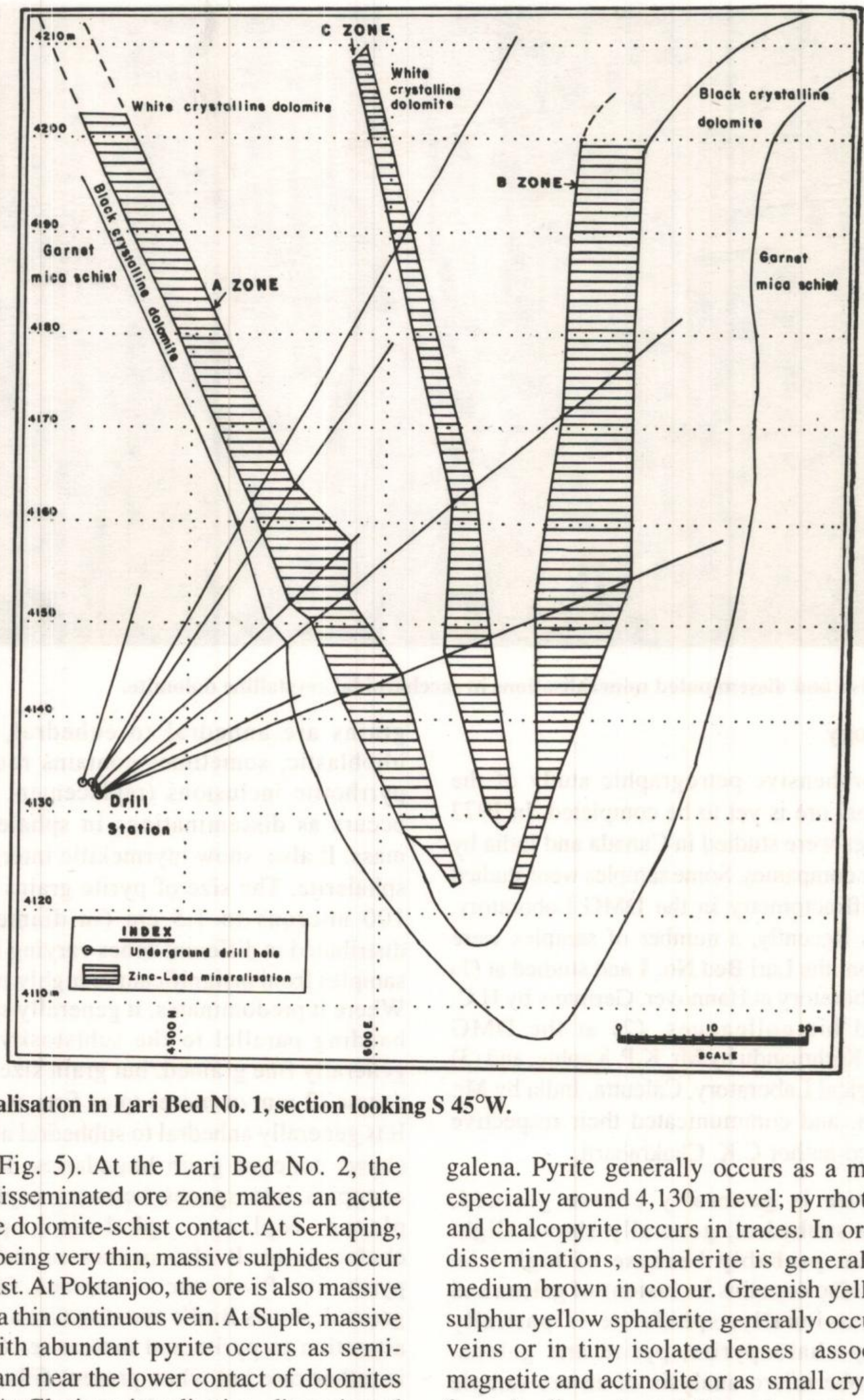

Fig. 4: Mineralisation in Lari Bed No. 1, section looking S 45°W.

schistosity (Fig. 5). At the Lari Bed No. 2, the rectangular disseminated ore zone makes an acute angle with the dolomite-schist contact. At Serkaping, the dolomite being very thin, massive sulphides occur almost in schist. At Poktanjoo, the ore is also massive and occurs as a thin continuous vein. At Suple, massive sphalerite with abundant pyrite occurs as semi-continuous band near the lower contact of dolomites with schists. At Glacier mineralisation, disseminated sphalerite with abundant pyrite forms the ore body.

At Lari massive lenses of ore are composed of dark brown sphalerite with variable amount of galena. Pyrite generally occurs as a major phase, especially around 4,130 m level; pyrrhotite is minor and chalcopyrite occurs in traces. In ore veins and disseminations, sphalerite is generally light to medium brown in colour. Greenish yellow to light sulphur yellow sphalerite generally occurs in small veins or in tiny isolated lenses associated with magnetite and actinolite or as small crystals (about 2 mm) disseminated throughout the crystalline dolomite bodies. In drill cores from barren portions of Lari Bed No. 1, the average zinc content varies from 0.06% to 0.66% (Table 2).

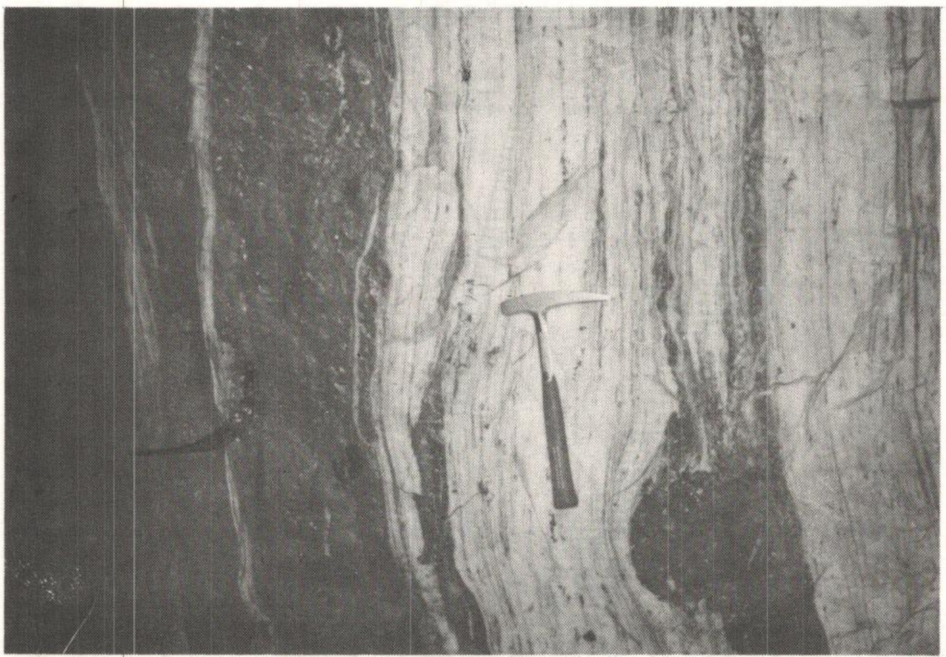

Fig. 5: Massive and disseminated mineralisations in saccharoidal crystalline dolomite.

Ore petrology

A comprehensive petrographic study of the Ganesh Himal ore is yet to be completed. In 1972 some samples were studied in Canada and India by the promoter companies. Some samples were studied by X-ray diffractometry in the DMG Laboratory, Kathmandu. Recently, a number of samples were collected from the Lari Bed No. 1 and studied at (1) the BGR Laboratory at Hannover, Germany by H.C. Einfelt and his colleagues, (2) at the DMG Laboratory, Kathmandu by Mr. K.P. Kaphle, and (3) C.U. Geological Laboratory, Calcutta, India by Mr. A.K. Ghosh, and communicated their respective findings to co-author C.K. Chakrabarti.

Sphalerite is generally coarse grained, anhedral to subhedral, generally shows slight anisotropism probably because of high iron content and also contains inclusions of galena and pyrite. Occasionally, sphalerite is partially replaced by chalcopyrite, pyrite and galena. Electron probe micro analysis of an ore sample has shown 3.24% iron within crystal lattice of sphalerite. Generally, it shows excellent twining. It is dispersed in the carbonate (dolomite) host rock containing minor amount of calcite. *Pyrite* grains are anhedral to euhedral, frequently idioblastic, sometimes contains rounded small pyrrhotite inclusions (replacement relics ?) or occurs as disseminations in sphalerite ground mass. It also show myrmekitic intergrowth with sphalerite. The size of pyrite grains varies from 100 microns to 1.5 cm (in diameter) and is distributed in different zones varying in individual samples from insignificant to highly predominant. Where it predominates, it generally shows a faint banding parallel to the schistosity. *Galena* is generally fine grained, but grain size varies from coarse (2 mm or more) to as fine as 50 microns. It is generally anhedral to subhedral and generally shows concave grain boundaries. Frequently it occupies interspaces between crystals and at places replaces sphalerite, pyrite and chalcopyrite. It also occurs as inclusion with pyrrhotite. *Pyrrhotite* is copious, fine to coarse grained, shows Bird's eye structure and secondary alteration to pyrite and marcasite. *Chalcopyrite* is rather rare but when present fills up the open spaces and interstices. It is subhedral to anhedral, sometimes contain tiny inclusions of sphalerite, and in some sample it is replacing sphalerite. *Magnetite* is also rare and generally occurs as porphyroblast. *Arsenopyrite* is very fine grained and very rare. X-ray diffractometry indicates possible existence of *pyrargyrite* (Fig. 6), a silver bearing sulphide. Table 3 and 4 show microprobe analyses of the opaque and transparent phases investigated in 1972 at the Department of Geology, University of Toronto, Canada.

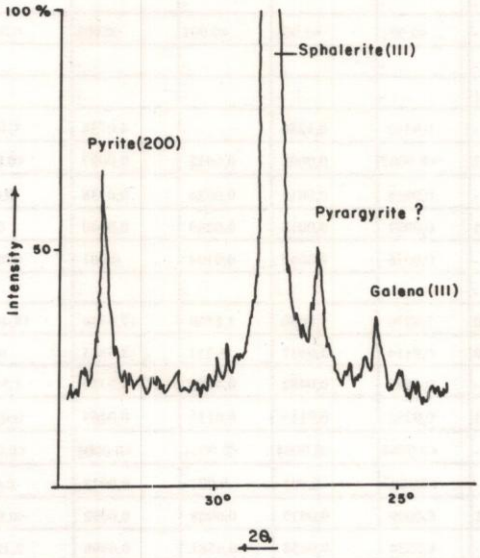

Fig. 6: X-ray diffraction peak-patterns of various are minerals 2Q versus intensity (Cu $K_{\alpha c}$ radiation, 1/2° $2_{\alpha c}$ per min.).

Table 3: Microprobe analysis of sulphide minerals in ore.

Elements	Sphalerite	Galena	Pyrite
Zn	64.43%	-	-
Pb	-	86.10%	
Fe	3.24%	-	-45.59%
S	32.22%	13.83%	53.52%
Total	99.89%	99.93%	9 9.11%

Table 4: Microprobe analysis of silicate minerals in ore.

Mineral	SiO_2	Al_2O_3	TiO_2	FeO	MgO	CaO	K_2O	Na_2O
Biotite	35.81	17.86	2.56	11.01	15.72	0.05	5.93	0.52
Biotite	37.51	16.46	0.92	9.67	17.95	0.09	5.53	0.42
Talc	57.69	1.02	0.02	4.56	26.61	0.01	-	0.31

Study of polished ore specimens show that the ore has suffered metamorphic deformation and recrystallisation (Fig. 7). Grain size of the ore minerals varies from fine to coarse, but most of them are coarse grained. Intergrowth of sphalerite and galena, sometimes embedded in pyrite, exsolution of sphalerite in pyrite and replacement of pyrite by sphalerite have been recorded. The triple point junctions and foam texture are found in both polyphase and monophase assemblages. The pyrite/pyrrhotite paragenesis indicates a high temperature formation of ore, which however, is not necessarily the primary depositional temperature but is probably due to high grade metamorphic reactions and recrystallisation of this part of the Higher Himalayan crystalline (H.C. Einfelt, personal communication).

Ore Chemistry

Microprobe analysis of sulphide minerals shows that sphalerite contains 3.24% iron (Table 3) while zinc concentrates are reported to contain maximum 5.65% iron (Table 6), in galena, lead and sulphur make 99.93% and in pyrite, iron and sulphur make 99.11% (Table 3). Microprobe analysis of silicate minerals shows that composition of biotite varies widely and the talc is relatively low in silica and magnesia (Table 4). Distributions of minor and trace elements have been studied only in a few samples and concentrates. Tables 5 and 6 give distribution of elements and radicals in grab samples and concentrates. Pb:Zn, Ag:Pb and Cd:Zn ratios determined for a large number of ore samples from the prospect are shown in Table 7 while the Fig. 8 shows the zinc vs. lead plots. Average Pb:Zn determined on 575 samples is 0.16315. In individual samples Pb:Zn varies widely (Table 7 and Fig. 8).

Table 5: Distribution of elememts in Ganesh Himal ore.

@	#1 SSA	#2 SSA	#3 SSA	#4 SSA	#5 SSA	#6 SSA	#7 XRF	#8 XRF	#9 XRF	#10 XRF	#11 XRF
Al %	0,5	0,5	1,0	-	-	-	0,0344	0,1402	0,1878	0,0979	0,0556
Sb %	ND	ND	ND	-	-	-	-	-	-	-	-
As %	ND	ND	ND	-	-	-	0,0255	0,0630	0,1166	0,1271	0,0260
Ba %	0,1	0,007	0,1	.005-.03	O.1-O.5	-	0,3200	<0.0050	0,0081	<0.0050	<0.0050
Be %	ND	ND	ND	-	-	-	-	-	-		
Bi %	ND	ND	ND	-	< 0.01	-	<0.001	<0.001	<0.001	<0.001	0,0013
B %	0,003	0,003	0,001	-	-	-	-	-	-	-	-
Cd %	ND	0,1	0,07	0.05-0.3	0.05-.3	.02-.1	-	-	-	-	-
Ca %	1,0	1,0	5,0	-	-	-	0,9362	0,1286	-	4,0738	3,4450
Cr %	ND	ND	0,001	-	-	.005-.03	<0.0007	0,0008	0,0012	0,0027	<0.0007
Co %	ND	ND	ND	-	< 0.01	-	0,0018	0,0015	0,0024	0,0138	0,003
Cu %	0,5	0,1	0,3	0.01-.05	O.2-1.0	0.01-.05	0,0022	0,0018	0,0269	0,0049	0,33
Ga %	ND	ND	ND	-	-	-	0,0076	0,0067	0,0104	0,001	0,0012
Au %	Trace	Trace	Trace	-	-	-	-	-	-	-	-
Fe %	2,0	5,0	Major	2.0-10.0	> 10	> 10	3,4270	5,8050	3,8750	17,9330	18,4000
Pb %	0.5-5.0	0.5-5.0	0.5-5.0	>10	>10	>10	0,9114	3,0351	5,533	3,5843	0,18
Mg %	1.0	1.0	1,0	-	-	-	0,4886	0,0482	0,4162	0,9410	1,5442
Mn %	0,05	0,03	0,03	< 0.01	0.01-.05	.01-0.05	0,0232	0,0155	0,0155	0,0465	0,0387
Mo %	Trace	0,001	0,001	-	-	-	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Nb %	ND	ND	ND	-	-	-	<0.0005	0,001	0,001	0,0012	0,001
Ni %	ND	ND	0,007	-	0.01-.05	< 0.01	0,0009	0,0035	0,0008	0,0092	<0.0007
Si %	3.0	2,0	2,0	-	-	-	0,0234	0,0654	0,4581	0,6498	2,1879
Ag %	0,01	0,001	0,001	-	< 0.01	< 0.01	-	-	-	-	-
Sr %	0,005	0,001	0,001	-	-	-	<0.0005	0,0011	<0.0005	0,0012	<0.0005
Ta %	ND	ND	ND	-	-	-	<0.001	<0.001	<0.001	0,0013	<0.001
Sn %	ND	ND	ND	-	-	-	<0.0030	<0.0030	<0.0030	0,0043	0,0063
Ti %	0,1	0,1	0,1	-	-	-	0,0060	0,0240	0,0240	0,0120	0,0120
W %	9.0	9.0	9.0	-	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
V %	0,001	0,003	0,003	-	-	-	<0.0010	0,0019	0,0014	<0.0010	<0.0010
Zn %	Matrix	Matrix	Major	>10	>10	>10	47,4	36,956	43,0323	1,4016	0.2709
Na %	-	-	-	-	-	-	0,1558	0,0111	0,0148	0,2374	0,0705
K %	-	-	-	-	-	-	0,0249	0,0290	0,1162	0,0207	0,0124
P %	-	-	-	-	-	-	0,0175	0,0153	0,0044	0,0393	0,0153
Ce ppm	-	-	-	-	-	-	<35	<35	<35	<35	<35
Hf ppm	-	-	-	-	-	-	<18	<18	<18	<18	<18
Rb ppm	-	-	-	-	-	-	16	16	25	18	7
Th ppm	-	-	-	-	-	-	<10	<10	<10	<10	<10
U ppm	-	-	-	-	-	-	12	29	<5	6	<5
Y ppm	-	-	-	-	-	-	<5	<5	<5	<5	<5
Zr ppm	-	-	-	-	-	-	13	51	53	284	67

Note: @ : ELEMENT / Sample No. , Method SSA : Semi-quantitative Spectrographic Analysis, XRF : X-Ray Florescence Spectrometer

#1,#2,#3: Sphalerite from Lari, Serkaping & Suple respectively #4 : Core sample from Lari drill hole No. #5 : Poktanjoo Channel sample No.1.

#6 : Suple Channel Sample No.1 #7 : Vein of Dark brown sphalerite in dolomite, 4130 m level (G45)

#8 : Saccharoidal pyrite and dark brown sphalerite interbanded, 4130 m level (G 46) #9 : Dark brown sphalerite (G 47),

#10 : Saccharoidal pyrite in dolomite (G 48) #11 : Coarse grained pyrite in dolomite (G 49)

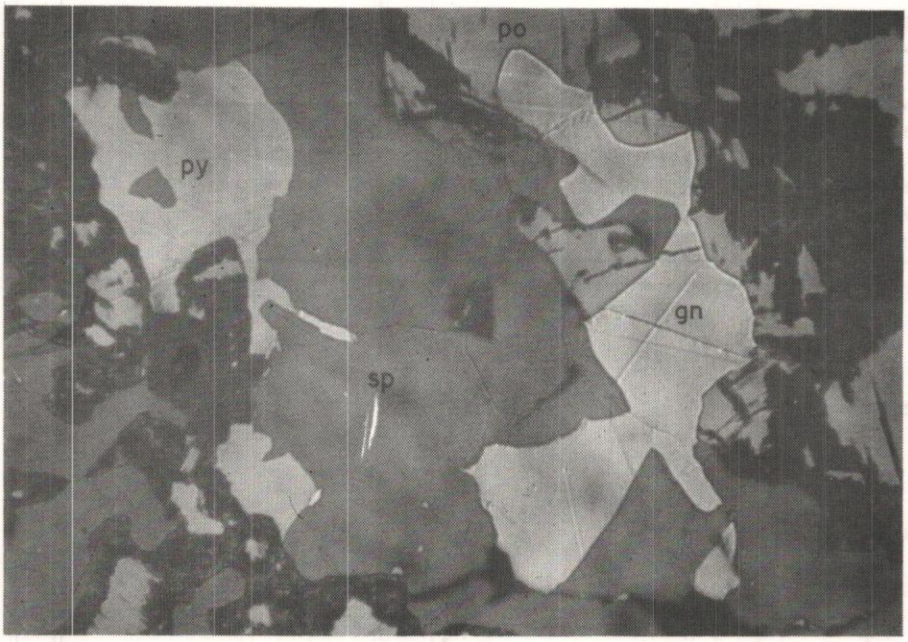

Fig. 7: Reflected light photomicrograph of ore. Sphalerite (sp), galena (gn), pyrite (py) and pyrrhotite (po) (100 x enlarged).

Table 6: Chemical composition of lead and zinc concentrates obtained from Ganesh Himal (Lari 1) ore.

Element	Lead concentrate			Zinc concentrate		
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Pb	79.0%	59.0%	70.30%	1.49%	0.56%	0.15%
Zn	4.0%	16.4%	7.95%	58.7%	59.2%	66.15%
Ag	810 g/t	676 g/t	0.311 g/t	36 g/t	19 g/t	<0.622 g/t
Au	0.11 g/t	0.40 g/t	676 g/t	0.09 g/t	0.03 g/t	<0.311 g/t
S	16.4%	21.1%	15.45%	33.5%	34.1%	32.00%
Fe	0.45%	3.25%	0.22%	4.46%	5.65%	1.15%
MgO	0.02%	0.19%	1.29%	0.22%	0.15%	0.11%
CaO	0.05%	0.19%	1.46%	0.18%	0.25%	0.07%
SiO_2	0.17%	0.25%	0.99%	0.14%	0.13%	0.09%
F		0.01%	0.0008%		0.01%	0.0008%
Al_2O_3		<0.10%	0.057%		<0.10%	0.017%
Cu	91.0 ppm	440.0 ppm	110 ppm	530 ppm	470.0 ppm	200 ppm
Sn		<10.0 ppm	170 ppm		<10.0 ppm	30 ppm
As	7.2 ppm	50.0 ppm	8 ppm	3.5 ppm	<20.0 ppm	10 ppm
Sb	65.0 ppm	140.0 ppm	250 ppm	<5.0 ppm	<20.0 ppm	30 ppm
Cd	50.0 ppm	280.0 ppm	160 ppm	1000 ppm	1000 ppm	1100 ppm
Bi	<5.0 ppm	50.0 ppm	40 ppm	<5.0 ppm	<20.0 ppm	26 ppm
Hg	1.4 ppm	5.3 ppm	2 ppm	22.0 ppm	21.0 ppm	15 ppm
Se		4.0 ppm	2 ppm		<3.0 ppm	0.04 ppm
Te		<5.0 ppm	0.05 ppm		<5.0 ppm	0.1 ppm
Cl		51.0 ppm	n.d.		42.0 ppm	20 ppm
Ge		<10.0 ppm	n.d.		<10.0 ppm	0.1 ppm
Ni		<20.0 ppm	70 ppm		<20.0 ppm	10 ppm
Co		<20.0 ppm	9 ppm		<20.0 ppm	15 ppm

Table 7: Metal ratio values of Ganesh Himal ore samples.

«	Pb:Zn	Ag:Pb	Cd:Zn
Number of samples studied	575	575	80
Mean value	0.16315	0.00403	0.00175
Standard deviation	0.12332	0.02488	0.00063
Maximum value	0.87222	0.49200	0.00573
Minimum value	0.00031	0.00001	0.00063

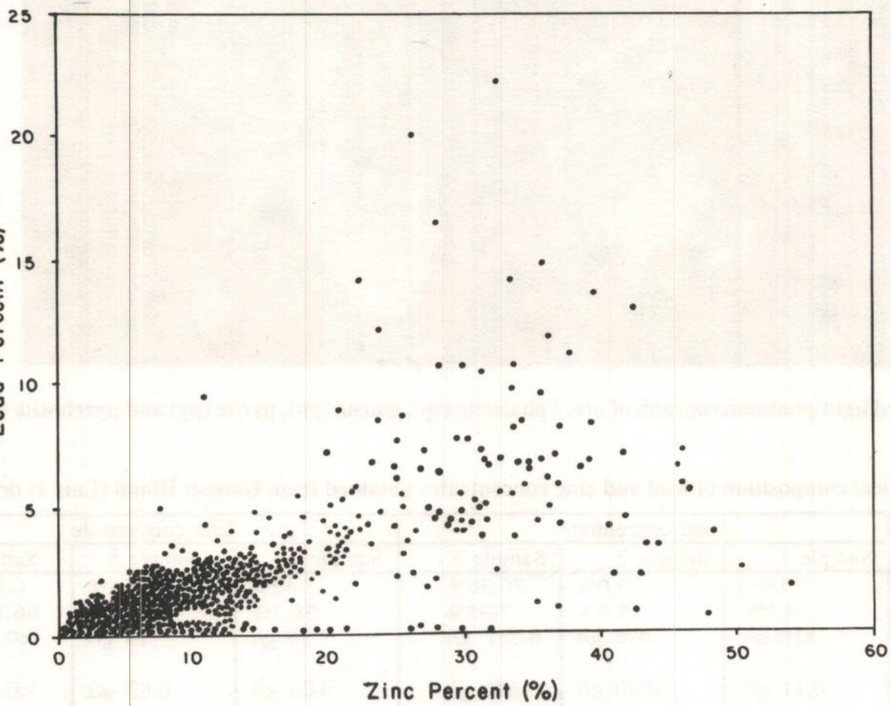

Fig. 8: Zinc vs. Lead content in Ganesh Himal (Lan-1) Zinc-Lead ore.

The silver content in the ore is moderate. Silver is recoverable from the lead concentrate. Cadmium content of zinc concentrate is below recovery limit. The ore is low in mercury and arsenic. Concentrations of Ga (Table 5) and Ge (Table 6) are very low, much below the economic recovery limit. Minor and trace element concentrations of Ganesh Himal zinc-lead ore are very low compared to Phakuwa zinc-lead mineralisation of East Nepal (H.C. Einfalt, personal communication) and polymetallic sulphide deposits of Rangpo, Sikkim (Ghosh, 1975).

CONCLUSIONS

The zinc-lead mineralisations of Ganesh Himal area in Central Nepal although occurring at about 4,000 m are very significant economically because of its high zinc-lead content (16.4% zinc and 2.5% lead in average).

Confinement of the ore to a single carbonate stratum throughout the area in spite of intricate folding and intense metamorphism is a unique feature. This characteristic stratigraphic control suggests that the Ganesh Himal zinc-lead mineralisation should be contemporaneous with the carbonate precipitation, subsequently metamorphosed and remobilised and recrystallised during metamorphism.

The coarse grained nature of the recrystallised ore in an amphibolite facies metamorphism is a characteristic of the deposit. Even the quartzite beds show tight folding without fracturing which may indicate that deformation and metamorphism must have taken place at considerable depth and moderate to high temperature. The tectonic setting of the deposit might have influenced the resultant ore textures.

Lead isotope analysis of only one sample of ore at Broken Hill Prospect (BHP), Australia indicates an Upper Proterozoic age (?) of the Ganesh Himal deposit (N.D. Maskey, personal communication). It is, however, uncertain whether this age represents the age of ore recrystallisation or not.

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