Special Publication of the Palaeontological Society of India, No.2, 2005, pp. 289-294

SULPHIDE MINERALISATION IN KUMAUN LESSER HIMALAYA: STRATIGRAPHIC AND STRUCTURAL CONTROL

S.C. TRIPATHI and J.S. MEHTA
GEOLOGICAL SURVEY OF INDIA, SECTOR-E, ALIGANJ, LUCKNOW

ABSTRACT

Sulphide mineralisation at some localities of Nainital and Champawat districts, Uttaranchal, has been studied for its stratigraphic and structural control. Sulphide mineralisation at Galpakot and Kimkhet are associated with sheared quartzite and quartz veins of Bhimtal Formation. Mineralisation at Khansun is noticed in the quartz veins within the gneisses of Ramgarh Group. At Amritpur, dissemination and veins of primary sulphides are associated with granitoids. These occurrences characteristically show proximity either to Ramgarh Thrust or Main Boundary Thrust. Structural studies suggest that the primary sulphides were possibly remobilised during third phase of deformation and deposited along shears and fractures with remobilised quartz veins.

Key words: Kumaun Himalaya, Sulphide mineralisation.

INTRODUCTION

Sulphide mineralisation has been noticed at several localities of Kumaun Lesser Himalaya. These localities, though not proved economic so far, provide valuable information regarding deformation vis-à-vis mineralisation. The sulphide mineralisation is associated either with Bhimtal Formation or with Ramgarh Group near their contact (Ramgarh Thrust) or with Amritpur granitoids and porphyry near Main Boundary Fault (Prashad *et al.*, 1991; Mehta and Tripathi, 2001). The localities of Galpakot, Kimkhet, Khansun and Amritpur in Nainital and Champawat districts of Uttaranchal have been studied for the stratigraphy, structure, mineral potentials, and possible origin of mineralisation.

REGIONAL GEOLOGICAL SET-UP

The geology, stratigraphy and structure of the Lesser Himalaya of Kuman have been studied by several workers (Gansser, 1964; Valdiya, 1980; Kumar, 1981; Singh, 1979; Agarwal, 1994; Bhattacharya, 1999 and others). It exposes, to the north of Main Boundary Fault (MBF), a volcano-sedimentary sequence of Bhimtal Formation, crystallines of Ramgarh and Almora groups and sedimentaries of Krol Group having thrusted contact with each other. The Bhimtal Formation is separated by Ramgarh Thrust (RT) with Ramgarh Crystalline which, in turn, is separated by South Almora Thrust (SAT) from the Almora Crystalline. The Krol Thrust separates Baliyana and Krol groups from Bhimtal Formation. The Bhimtal Formation consists of basaltic flows including amygdular, vesicular and massive basalt with coarse-grained, thickly bedded to massive lenticular quartzite, oligomictic conglomerate, medium to thickly bedded medium grained quartzite and thin bands of limestone. Ramgarh Group is constituted of phyllites, quartzites, limestones, gneisses and quartz porphyry (mylonitised along the thrust). The Almora Group consists of phyllites, quartzites and schists with the development of garnet at higher stratigraphic level. Baliyana (Shanker *et al.*, 1993) and Krol groups are disposed as nappe over Bhimtal Formation with Krol thrust at the base and

consist of siliclastics followed upward by carbonates. The Amritpur granite complex is intrusive into Bhimtal Formation and is exposed along MBF (Valdiya, 1980). The 'S'-type granite is represented by biotite and hornblende granite, leucocratic granite, granite porphyry and muscovite-tourmaline granites with xenoliths of meta–volcanics and quartzites (Mehta, 1995; Table-1).

At least four phases of deformation have been observed in the metamorphics. The first phase is represented by symmetric to asymmetric, tight isoclinal, reclined to recumbent type of folds with axes trending approximately NNW-SSE and plunging moderately towards NE direction. The linear features developed are intersection lineations, mineral lineations, mullions and rods. The second phase of deformation produced upright folds with broad smooth hinges co-axial (but not co-planar) with F_1 folds. Puckers, minor fold axes and intersection lineations are developed. The third phase is most dominant and produced broad open antiform and synform folds with axes trending NW-SE plunging moderately in NW or SE directions. The Almora syncline belongs to F_3 phase of deformation. The F_3 produced S_3 strain slip cleavage but is less pervasive and no appreciable recrystallisation is seen. Fourth phase developed broad open warps plunging in east or west direction. The Ladhiya River flows along a NNW-SSE trending transverse fault, which displaced Ramgarh thrust for over 7 km.

MINERAL OCCURRENCES

Galpakot, Kimkhet, Khansun and Amritpur areas of Nainital and Champawat districts expose noticeable sulphide mineralisation and have been studied in detail for their stratigraphy, structural control of mineralisation and possible origin (Mehta and Tripathi, 2001). It has been observed that these occurrences show NW-SE distribution and proximity to Ramgarh thrust or Main Boundary Thrust (fig. 1). Under the microscope, the sulphide minerals observed are chalcopyrite, bornite,

Table 1: Generalised Tectonostratigraphy of Kumaun Lesser Himalaya, Nainital and Champawat districts, Uttaranchal

North		
ALMORA GROUP	Pegmatite and quartz veins, Devidhura granitoid, garnetiferous mica schist, mica schist, micaceous quartzite, quartzite muscovite gneiss, phyllite interbedded with quartzite.	(Nainital Section)
---------- South Almora Thrust ----------		
RAMGARH GROUP	Leucogranite Debguru granitoid augen gneiss, porphyritic gneiss and mylonitised gneiss Recrystallised limestone, quartzite, schist and phyllite with bands of amphibolite.	KROL GROUP BALIYANA GROUP
---------- Ramgarh Thrust ----------		
		----Krol Thrust---
BHIMTAL FORMATION	Quartzite with penecontemporaneous basic volcanics, amygdular and vesicular basalt, chlorite schist, slate and limestone, Amritpur granitoid	BHIMTAL FORMATION
---------- Main Boundary Fault ----------		
SIWALIK SUPERGROUP	Sandstone, purple and grey shale	

chalcocite, covallite, bismuthenite and hematite. The chalcopyrite and bornite are the predominant minerals in the Galpakot area. The crystallographic intergrowth, in which chalcopyrite lamellae are parallel to the octahedral directions of bornite, has been commonly seen. Dots, rods and emulsion of chalcopyrite within bornite are also observed. The exsolution lamellae of chalcopyrite in bornite are possibly due to the fall of temperature. Chalcocite and covallite solid solution is characteristically present. Bornite-chalcopyrite, chalcopyrite -chalcocite and bornite - chalcocite replacement textures are also seen. The geological descriptions of these occurrences are as follows.

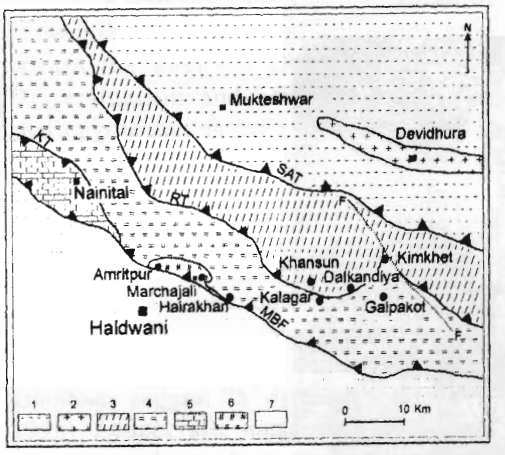

Fig.1. Generalised geological map of Kumaun Himalaya in the Nainital and Champawat districts, Uttaranchal, showing locations of sulphide mineralisation (Closed circles indicate locations of mineralisation, while closed squares indicate geographical locations).

1-Almora Group; 2- Devidhura granitoid; 3-Ramgarh Group; 4- Bhimtal Formation;

5- Baliyana and Krol groups; 6- Amritpur granitoid; 7- Siwalik Supergroup

MBF- Main Boundary Fault; KT- Krol Thrust; RT- Ramgarh Thrust; SAT- South Almora Thrust; F-F -Ladhiya Fault

Galpakot

Sulphide mineralisation near Galpakot, Nainital district, as noticed in Ladhiya valley, occurs within the rocks of Bhimtal Formation. The Bhimtal Formation consists of massive to thinly bedded quartzite with basic volcanics. In general, the rocks trend E-W with steep (55° to 70°) northerly dips. Minor folds belonging to third generation have been observed. The sulphide mineralisation is noticed within the brecciated quartzite associated with quartz veins and chlorite phyllite. In the brecciated quartzite the mineralisation is in the form of fracture fillings, stringers and blebs of pyrite, chalcopyrite, bornite and covallite (fig. 2A). Stains of malachite and azurite are also observed. At least three phases of quartz veins have been noticed in Galpakot area. The mineralised quartz veins trend ENE-WSW with steep (75°-80°) northerly dips. These milky white to brownish quartz veins are emplaced within brecciated quartzite and metavolcanics. These quartz veins are also fractured containing sulphide minerals. NNW - SSE trending quartz -epidote veins associated with metabasics also show sparse mineralisation. However, white NNE-SSW trending veins do not show any mineralisation. The analyses of grab samples show Cu-2.72% and Au-70 ppb.

Kimkhet

The copper occurrence at Kimkhet, Nainital district, is also within the Bhimtal Formation exposed in Ladhiya valley. The rock types include metavolcanics and quartzite of the Bhimtal Formation. Gneisses of Ramgarh Group come in contact with Bhimtal Formation along the Ramgarh thrust. The greenish grey gneisses are foliated, puckered and crushed at places. The regional foliation trend WNW-ESE to ENE-WSW with moderate to steep (25° to 55°) northerly dips. Mesoscopic folds plunging moderately (20°-35°) towards NW to WNW are also observed. Fracture cleavages are parallel

to folds. A major shear zone trending WNW-ESE to ENE-WSW with parallel to major fold system shows steep to sub-vertical (70°-80°) dip towards north. The copper mineralisation is located along this shear zone. The maximum width of the shear zone is about 4 m and is juxtaposed against the Ladhya fault. Intense shearing, silicification and limonitisation has been observed along this shear zone. Two old workings are found at both the ends of the shear zone (fig. 2B). Analyses of grab samples show copper up to 0.43 %.

Khansun

Sulphide mineralisation at Khansun (fig.1), is associated with the rocks of the Ramgarh Group consisting of chlorite schist, quartz biotite gneiss, and quartzite. The strike of the rocks trend NW-SE to E-W with moderate (25°-40°) northerly dips. The quartz veins are

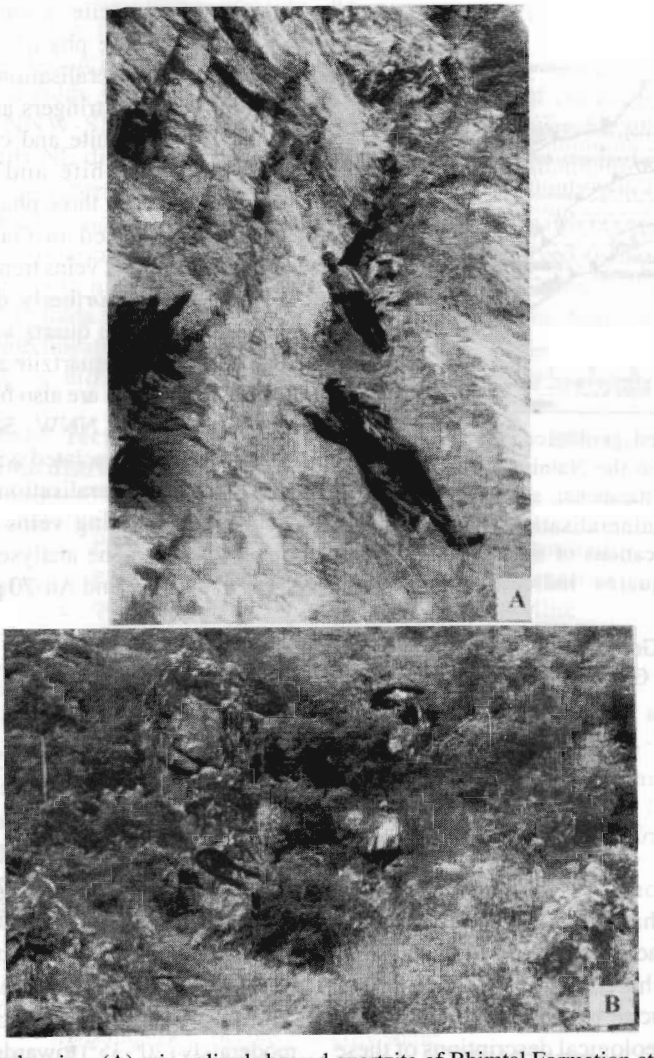

Fig. 2. Photographs showing: (A) mineralised sheared quartzite of Bhimtal Formation at Galpakot showing sulphide mineralisation, (B) Old workings within Bhimtal Formation at Kimkhet.

profusely developed in schists and gneisses. Three types of quartz veins have been noticed: (a) quartz veins along the foliation planes showing pinch and swell structure, (b) quartz veins emplaced along WNW-ESE direction following axial plane fractures and shears (c) quartz veins along axial planes of cross folds trending NW-SE to E-W with moderate dips (28°-25°). Mesoscopic faults trending WNW-ESE are also observed. The sulphide mineralisation is associated with quartz veins within the gneisses (Ramgarh Group). Dissemination and stringers of pyrite, chalcopyrite and galena are found. The grab samples show copper up to 870 ppm and lead 645 ppm.

Amritpur

The Amritpur granite complex, exposed along the MBF, is intrusive into Bhimtal Formation. The chemical characteristics of the granitoids suggest "S"-type granite (Mehta, 1995). Leucocratic muscovite granite and granite porphyry show dissemination and stringers of pyrite, chalcopyrite, with stains of malachite. Quartz veins emanating from tourmaline-bearing muscovite granite also contain primary sulphides and malachite stains. Dissemination and veins of pyrite associated with NE-SW trending shear south of Marchajali is also observed. The xenoliths of metavolcanics within the granitoids also show pyrite desseminations. The felsite near Hairakhan shows evidences of sulphide mineralisation in an approximately 40 m wide zone. Extensive development of quartz veins with stains of malachite and some primary sulphides characterise this zone.

Besides these prominent occurrences, the sulphide mineralisation is also noticed at Dalkandia and Kalagar. Specks, veins and stringers of galena, chalcopyrite, and pyrite occur in the mylonite porphyry of Ramgarh Group near the Ramgarh thrust. The grab sample analyses show Pb - 0.14%, Cu - 0.12% and Au-110 ppb. Pyrite along with minor chalcopyrite occurs as specks within the brecciated quartzite and quartz veins of Bhimtal Formation at Kalagar .

SULPHIDE MINERALISATION

The study of structural elements of sulphide mineralisation in Outer Kumaun Lesser Himalaya suggests that the third phase of deformation was the most important tectonic event which has remobilised the primary mineral contents from the parent rock. The primary syngenetic sulphide mineralisation was associated with the acidic or basic igneous rocks which was remobilised during the third phase of deformation and concentrated along the NW-SE, WNW-ESE, and ENE-WSW trending shear zones. The remobilised quartz veins exchanged the primary sulphides and got deposited along fractures and shears. The ore-microscopic study reveals the presence of at least three generations of chalcopyrite and two generations of bornite. Simultaneous crystallisation of chalcopyrite with bornite (second generation) and chalcopyrite (third generation) is predominant.

REFERENCES

Agarwal, K.K. 1994. Tectonic evolution of Almora crystalline zone, Kumaun Lesser Himalaya: A reinterpretation. *Jour. Geol. Soc. India*, **43**: 5-14.

Bhattacharya, A.R. 1999. Deformation regimes across the Kumaun Himalaya: A study in strain pattern. In: A. K. Jain and R.M. Manikavasagam (Eds.), Geodynamics of Northwestern Himalaya, *Gondwana Research Group Mem.* **6**: 81-90.

Gansser, A. 1964. *Geology of the Himalaya.* Interscience Publication, London, pp.289.

Kumar, Gopendra 1981. Stratigraphy and tectonics of Lesser Himalaya of Kumaon, Uttar Pradesh. In: A.K.Sinha (Ed.), *Contemporary Geoscientific Research in Himalaya*, Bishen Singh Mahendra Pal Singh, Dehradun, p.61-70.

Mehta, J.S. 1995. Classification and petrogenesis of Almora, Champawat and Amritpur granite of Kumaun Himalaya. *Rec. Geol. Surv. India*, **128**(8): 171-172.

Mehta, J.S. and Tripathi, S.C. 2001. Specialised thematic mapping of Khansun - Guliaritha area, Nainital and Champawat districts, Uttaranchal. *Rec. Geol. Surv. India*, **134**(8): 77-78.

Prashad, M., Srivastava, R., Yadava, P.K., and Tripathi, A.K. 1991. Final report on geochemical appraisal for copper, lead, zinc tin, tungsten and gold in the area around Galpakot, Kimkhet, Khansun and Amritpur Pithoragarh and Nainital districts, Uttar Pradesh. *Unpub. Report, Geological Survey of India*, Northern Region, pp. 27.

Shanker, R., Kumar,G., Mathur, V.K. and Joshi, A. 1993. Stratigraphy of Blaini, Infra–Krol and Krol succession, Krol Belt, Lesser Himalaya, *Indian Jour. Petroleum Geology*, **2**(2): 99-138.

Singh, I.B. 1979. Environment and age of Tal Formation of Mussoorie and Nilkanth areas of Garhwal Himalaya. *Jour. Geol. Soc. India*, **20**: 214-225.

Valdiya K.S. 1980. *Geology of Kumaon Lesser Himalaya*. Wadia Instt. of Himalayan Geology, Dehradun, pp. 291.