Fluid inclusion studies on samples from Kolihan Mines of Khetri Copper Belt

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Abstract

Fluid inclusion studies were carried out on the milky white vein qurtz intimately associated with Kolihan sulphide assemblage. The studies reveal that the deposition should have taken place at a temperature higher than 350°C and the ore-bearing solutions could have had a very high degree of salinity approaching the condition of a 'hydrosaline melt' with 33% NaCl and 17% KCl by weight.

Introduction

Kolihan (28°02′N, 75°47′E) is located on the southern side of Khetri copper belt at a distance of nearly 6.5 km from Madan-Kudan area. The reported grade of the ore at Kolihan is 2.5% copper with small amounts of nickel, arsenic and silver (Sen and Prasad, 1975). An attempt is made here to determine the temperature of formation of the deposit based on the fluid inclusion studies.

Ore Mineralization

The geology of the area has been discussed in detail by Roy Chowdhury and Das Gupta (1965). The formations of the area are represented by phyllites, chlorite schists and andalusite-bearing schists belonging to the (Algonkian) Delhi system. Roy Chowdhury and Das Gupta refer to moderate degree of hydrothermal alteration and also observe that the ore localization is controlled by fractured and faulted shear zone.

The mineral assemblage consists mainly of chalcopyrite, pyrrhotite and pyrite with subordinate sphalerite and galena. Chalcopyrite is generally massive, frequently associated with irregular islands of pyrrhotite. Gangue minerals are usually vein quartz and calcite.

Fluid inclusion studies

Fluid inclusion studies were carried out mainly on milky white vein quartz intimately associated with the sulphide mineralization. Thin flat plates of samples were polished on either sides for visual observation of inclusions. Plate thickness was reduced to nearly 0.5 mm for optimum optical clarity.

Types of inclusions

Inclusions observed were of multiphase character with a dominant homogeneous liquid phase, a few daughter crystals and a small gas bubble (Fig. 1). On heating, the inclusions homogenised invariably in a liquid state. Gas-liquid volume ratios were rather uniform in all the samples studied indicating a homogeneous fluid phase of the mineralizing solutions at the time of entrapment. Primary, secondary and pseudo-secondary inclusions were present in all samples. Bubbles in smaller inclusions showed brownian movement under high magnifications (× 600).

Daughter Minerals

Four different types of daughter crystals were observed in the inclusions studied. Of these, two isotropic crystals were invariably observed in all inclusions, while two other minute birefringent minerals were seen only in larger inclusions. One of the isotropic daughter crystals formed perfect cubes and was identified to be halite, while the other one showed blunt edges and dissolved with a striking rapidity. This mineral was identified to be sylvite. Out of the two birefringent minerals, one revealed a rhombic outline (carbonate ?) and the other was acicular (sulphate ?). These minute birefringent minerals disappeared with very low thermal increase and

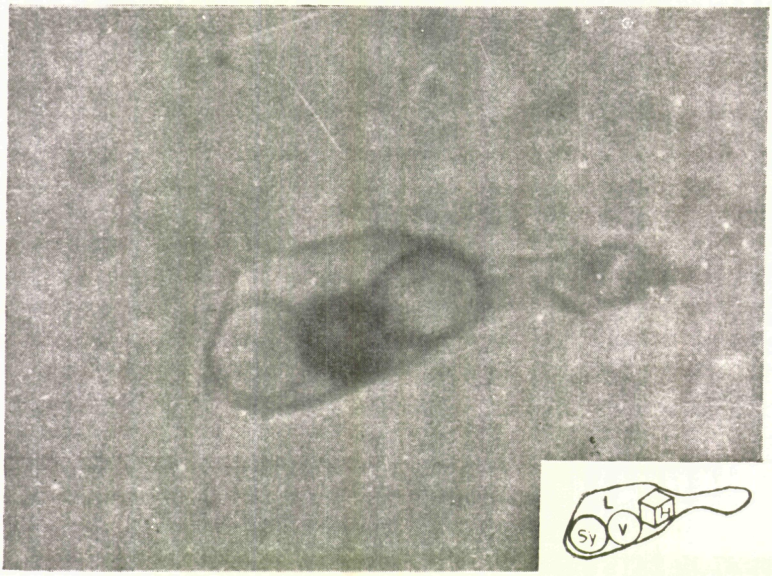

Figure 1 (A). Fluid inclusion in vein quartz with a large halite daughter crystal (H), sylvite (Sy), vapour bubble (V) and saline solution (L).

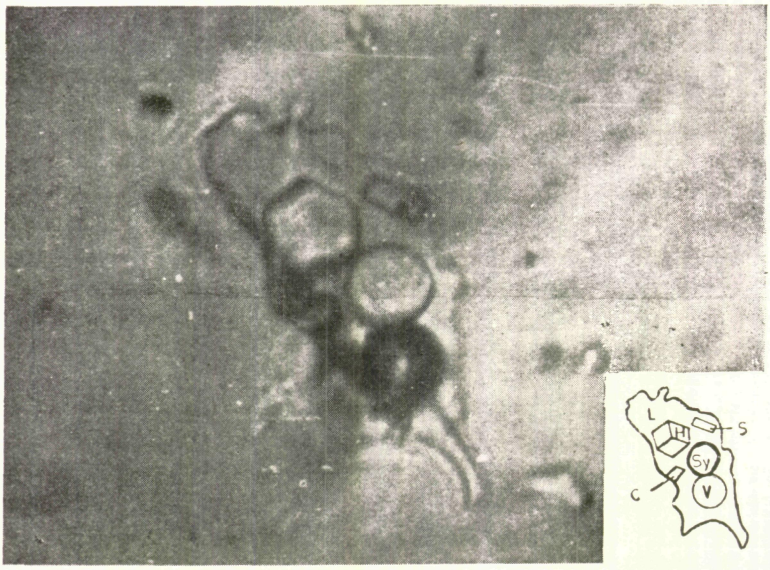

Figure 1 (B). Another inclusion with two birefringent daughter minerals, S, (sulphate ?) and C, (carbonate ?) in addition to halite and sylvite.

the exact temperature of their disappearance could not be determined due to their small dimensions. Halite on heating, dissolved completely after the disappearance of the gas bubble.

Homogenization tests

Primary inclusions which did not show any sign of leakage or considerable volume change after the entrapment were subjected to heating tests on a fabricated hot stage. The stage was first used for the fluid inclusions in the fluorites of Amba Dongar, Gujarat (Balasubramaniam, Panchapakesan and Sahu, 1975) and the results satisfactorily agreed with those of Roedder (Dean *et al*, 1973).

The birefringent minerals disappeared at temperatures below 80°C and sylvite completely dissolved at a temperature around 100°C. While dissolving, sylvite crystals gradually lost their angularities with a rapid reduction in size. The gas phase showed a steady decrease in volume and disappeared completely at nearly 280°C in all primary inclusions. Halite was the last phase to disappear into the *aqueous phase resulting in the homogenization of the fluid inclusions at nearly 350°C.* Measurements were repeated after cooling the sample to the room temperature. Due to lack of data regarding the pressure conditions of crystallization, no pressure correction could be applied to the homogenization temperature. Hence the temperature of complete homogenization of the fluid inclusions should be taken only as the lower limit of the temperature of formation. With additional data on the pressure conditions of deposition, it is possible to define the actual temperature of Kolihan mineralization.

Salinity of ore solutions

For estimating the salinity of Kolihan mineralizing fluids, the trilinear KCl-NaCl-H_2O phase diagram (Fig. 2) with isothermal contour lines constructed by Roedder (1971) was used *ignoring other constituents present in the system. This* does not contribute any serious error in the salinity determinations since the observations made on inclusions which contained only sylvite and halite did not show any appreciable change in the temperature of disappearance of these solid phases.

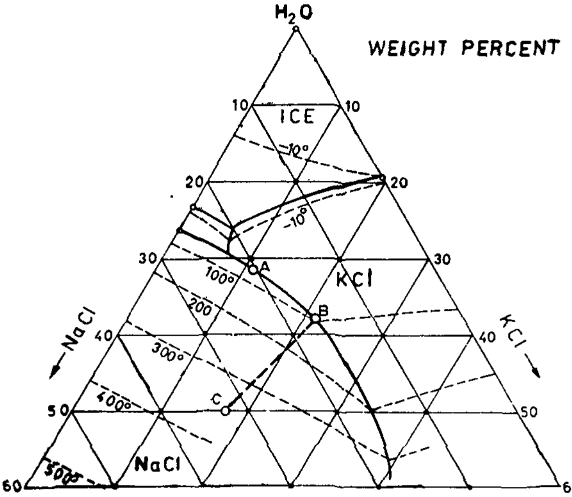

Figure 2. Portion of the trilinear co-ordinate diagram of the H_2O–NaCl–KCl system (after Roedder, 1971).

It has been observed that the sylvite crystals in Kolihan fluid inclusions dissolve completely at 100°C and halite crystals disappear at 350°C. At room temperature the liquid in the inclusion should have the composition represented by a point at the intersection of NaCl-KCl boundary line and the room temperature isotherm. The point 'A' in the diagram approximately represents this composition. On gradual heating sylvite starts dissolving and the liquid composition moves along the boundary line to higher thermal levels and when sylvite finally disappears at 100°C the liquid composition reaches the point 'B' in the phase diagram. On further heating, the only left out solid phase, halite, goes into solution and the composition of liquid migrates towards 100% NaCl point (not shown in the figure). Since halite completely dissolves at 350°C, point 'C' on the 350°C isothermal line should represent the final composition of the homogenized fluid. Further heating will not have any effect on the composition and this point gives a clue for the salinity of the mineralizing fluids responsible for the deposition of Kolihan assemblage. The composition of this point as read from the diagram is 50% H_2O, 33% NaCl and 17% KCl by weight. In chemical terms this corresponds to a molality of 15.9 (11.3 NaCl and 4.6 KCl) giving a sodium-potassium atomic ratio of 2.5.

Since the salinity of these mineralizing fluids is appreciably high accounting for nearly 50% by wt. of dissolved salts, it may be considered that the fluids approached a 'hydrosaline melt' as described by Roedder (1971).

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References

BALASUBRAMANIAM, K. S., PANCHAPAKESAN, V. and SAHU, K. C., (1975) Fluid inclusion geothermometric studies of some Indian fluorites using a fabricated heating stage. *Jour. Geol. Soc. India*, v. 16 (4), pp. 460-464.

DEANS, T., SUKHESWALA, R. N., SETHNA, S. F. and VILADKAR, S. G., (1973) Metasomatic feldspar rocks (potash fenites) associated deposits and carbonatites of Ambadongar Gujarat, India—Discussions and contributions. *Trans. Inst. Min and Met.* Applied Earth Science, v. 82, pp. B 33-B 40.

ROEDDER, E., (1971) Fluid inclusion studies on the Porphyry type ore deposits at Bingham, Utah, Butte, Montana and Climax, Colorado, *Econ, Geol.*, v. 66, pp. 98-120.

ROY CHOWDHURY, M. K. and DAS GUPTA, S. P., (1965) Ore localization in the Khetri Copper Belt, Rajasthan, India. *Econ. Geol.*, v. 60, pp. 69-88.

SEN, S. N. and PRASAD, U., (1975) Copper in India, *Indian Minerals*, v. 29, no. 1, pp. 1-12.

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