N89-22251

GEOCHEMISTRY AND ORIGIN OF GOLD MINERALIZATION IN THE KOLAR SCHIST BELT

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The Kolar Schist Belt is the most important gold producing, volcanic-dominated, Archean belt of the Dharwar Craton. Gold occurs here as gold-quartz-sulfide lodes and as gold-quartz-calcite veins, the latter confined only to the eastern part of the belt. Profuse mineralization and extensive mining have been confined to the central part of the belt, Kolar Gold Fields (KGF). Recently, economic concentrations of gold mineralization has been discovered in the southern part of the belt, whereas in the northern part mineralization is reported to be poor and uneconomic.

The gold-quartz-sulfide lodes occur either associated with thin units of banded iron formation interbanded with komatiitic and tholeiitic amphibolites or directly with the latter. There are several parallel lodes in the KGF area. The lodes occur all along the strike, from central to southern parts of the belt discontinuously. The lodes in general are typically banded/layered, are parallel to the schistosity of the amphibolitic host rocks and appear to have been confined to the contacts of different textural varieties of amphibolites. Wall-rock alteration, characterized by the presence of biotite and/or garnet is restricted to a few centimeters on either side of the lodes. In KGF, the sulfide lodes are interbanded with graphitic schists. Graphitic schists are not encountered in the southern part.

Sulfide lodes consist of bands/layers of cherty-quartz, sulfides and mafic silicates. In KGF, the lodes also include magnetite bands. Here the width of the bands decreases towards western margin of the belt. Bands/layers are at places deformed because of complex folding and shearing. The sulfide mineralogy includes dominantly pyrrhotite and arsenopyrite. Minor sulfide phases include loellingite, chalcopyrite, sphalerite and pyrite. Pyrrhotite and arsenopyrite tend to occur as monomineralic layers. Pyrrhotite is present essentially as hexagonal type. Arsenopyrite occurs as coarse to medium grained euhedral crystals which are often deformed. Gold commonly occurs as patchy inclusions within the deformed arsenopyrite crystals and as sub-rounded inclusions within the silicates. In KGF, the sulfide lodes include magnetite, ilmenite and graphite. Although the major sulfide mineralogy is remarkably uniform among the various lodes in the belt, the total sulfide and arsenopyrite contents of the lode matter are quite variable. However, there is no correlation among the total sulfide contents, (5-35 volume per cent) concentration of base metals and that of gold. Base metal concentrations are significantly low except in the westernmost and southernmost lodes. The gold concentration varies between 1 to 6 ppm and does not correlate with arsenopyrite contents of the lodes. However, in the KGF area, among the four sulfide lodes there is a definite mineralogical and geochemical zoning. Base metals, total sulfide, K_2O, Al_2O_3 and graphite increase from east to west; arsenopyrite, magnetite, iron and gold decrease from east to west. The sulfide mineral assemblage represents a minimum temperature of equilibration $\sim 500^{\circ}C$.

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Gold-quartz-calcite lodes, occur exclusively on the eastern side of the belt, close to the felsic schists and gneisses known as the Champion Gneiss. Although the lodes are parallel to the general strike of the belt, at many places they make a small angle with the schistosity of the amphibolitic host rock. The lodes appear to be fracture-filled veins within the country rock with a narrow zone of calcite-biotite alteration. The lodes at many places are also sheared. They consist dominantly of quartz, calcite, albite $\pm$ biotite $+$ sulfide and tourmaline. Sulfide content is usually very small, much less than a per cent. Galena is reported to be the dominant sulfide (1). The average concentration of gold is 10 ppm occurring essentially as native gold. Base metals are present in very low concentration. However, Cr and Ni show much higher abundances, as much as 400-500 ppm for lodes rich in quartz and calcite. The lodes have remarkable depth persistence ($>$ 3.5 km) and there are no observable changes in the gold tenor, nor in the nature of alteration with depth. Fluid inclusion and oxygen isotope data, suggest that the temperature of precipitation was around 300^{o}C and it occurred from a uniform reservoir of fluid at least for 3 km depth (2, 3, 4). Alteration and mineralization in the quartz lodes appear cogenetic and postdate peak metamorphism.

Geological, mineralogical, mineral-textural and geochemical data of the sulfide lodes in the belt indicate that the gold mineralization could be related to low temperature, low Eh and high pH rock-dominated geothermal systems set up in the submarine volcanic pile prior to amphibolite metamorphism. Relatively long-lived geothermal system produced an economic deposit, whereas short-lived ones, because of rapid burial by younger basalts throttled the geothermal system and diffused the discharge yielding low grade ore bodies. The source for gold and iron could be iron enriched tholeiites derived from source regions enriched in komatiitic melt components (5) and komatiitic rocks derived by very low extents of melting of metasomatised mantle sources (6). On the other hand, the geographical restriction of the quartz-calcite lodes, their mineralogical and geochemical data and their estimated temperature of formation all seem to suggest that a major part of the hydrothermal fluids, and a significant portion of gold could have been derived from mantle derived intrusive, sanukitoid type magma sources, similar to the Champion Gneiss occurring on the eastern part of the belt (7). However, the possibility of some input by remobilization of a premetamorphic sulfide protore to quartz lodes cannot be ruled out completely.

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