ABSTRACT

Gold is one of the most sought after metal which provides security at both national and personal levels. This precious metal is also inter-linked with the international economy and gold reserves of a country have become a measure of it's economic stability. This precious metal possesses a combination of physical and chemical properties which render it unique. The metal is extremely malleable and ductile and is a very efficient conductor of electricity. It also has complete resistance to the common corrosive agents and therefore very resistant to oxidation and tarnishing. As a result of these properties, coupled with a relative scarcity of deposits (Clarke of Gold is 0.3 ppb) containing adequate concentration of the metal to make extraction viable (at least 3 g of gold per ton of rock), gold has commanded great value since time immemorial. Unlike other metals where there is a pronounced mineralogical control, gold mostly occurs as free gold, in the native state in quartz veins and to a certain extent as dissemination in sulfides.

Although gold occurs throughout geological record from Archean to Quaternary, the late Archean period (2700 - 2500 Ma) was the principal period for gold mineralization. Most of the gold deposits from Archean terranes occur within the greenstone belts and two general types of gold deposits can be recognised. One is quartz-carbonate vein associated deposits mainly in metavolcanic rocks (e.g. Eastern gold fields province, Western Australia; Eastern Dharwar craton, South India; Abitibi belt, Canada) but also in metasedimentary rocks (e.g. Barberton belt, South Africa, Kolar and Gadag schist belts, south...
This type is also called as the Archean "Lode gold" deposit and is the most important type of gold deposit. The other is stratiform - stratabound deposit in Banded-Iron-Formation (BIF) or Fe-rich chert. (e.g. Murchison Province, Western Australia; Zimbabwe; Kolar Schist Belt, South India). These two types may be spatially or temporally separate, but in some areas, deposits of both types occur in close proximity as in the case of Kolar Schist belt, South India (Siva Siddaiah and Rajamani, 1989) and Mt. Magnet area, Western Australia (Groves et al 1983).

There are two major problems associated with Archean gold-quartz vein mineralization, such as (1) the source for gold and (2) the nature of the fluid and concentration mechanism responsible for mineralization. The present work involving petrogenetic study of the host metavolcanics in the Hutti Schist Belt and their comparison with the already existing petrogenetic information on the host metavolcanics of the auriferous schist belts of Kolar and Ramagiri also in the eastern Dharwar craton suggest that there could be a genetic link between the host high iron tholeiites and gold mineralization. Firstly, the generation of Fe-rich tholeiitic magmas from mantle sources by melt metasomatism, could have enriched the gold and sulfide content of the resulting melt by two orders of magnitude. Secondly, the metamorphism of the tholeiites to amphibolite grade resulted in the formation of Fe-Ti oxide phases besides forming sulfide phases such as pyrrhotite and pyrite. These oxide and sulfide phases could have quantitatively retained gold, although the rocks underwent metamorphism.
The Fe-rich tholeiites also seem to have provided a suitable geochemical environment by precipitating sulfides from fluid-wallrock reactions which removed sulfur from the ore fluid resulting in the deposition of gold. The rheological properties of the host Fe-rich tholeiitic amphibolites were such that they were susceptible for brittle-ductile fracturing, even under amphibolitic facies metamorphic conditions which enabled a strong focusing of the ore fluid leading to quartz vein formation and gold deposition along with or because of sulfide deposition.

Thus the petrogenetic study of the host metatholeiites of the auriferous schist belts indicates that they had the appropriate chemical and physical characteristics to be potential source as well as host rocks for gold-quartz vein mineralization under different physical conditions of deformation and metamorphism.

The geochemical nature of wallrock alteration in all the three auriferous schist belts of Kolar, Ramagiri and Hutti in the eastern Dharwar craton, indicates that fluid alteration invariably resulted in the addition of CO₂, K₂O, Na₂O, H₂O and sulfur to the immediate host rock, among the major components. CaO, MgO and to some extent FeO are removed from the immediate host rock. The rare earth element abundances and the patterns of unaltered host rock, wallrock alteration zone and ore veins and sulfides from the ore vein and wallrock alteration indicates that fluid alteration invariably resulted in the addition of rare earths to the host rocks, and the fluids had a LREE enriched pattern. This is a quite different situation as compared to the volcanogenic massive sulfides where there is commonly extensive LREE depletion which indicates that the fluids responsible for gold
mineralization were of higher temperature origin, so that REE can be mobilized along with gold and deposited because of temperature decrease and wallrock alteration. However, there are differences between schist belts in terms of the fluid temperature as indicated by the mineral assemblage and rare earth abundance in the alteration zones and ore veins. In the Kolar and Hutti schist belts, the potassic alteration is represented by biotitization of amphiboles whereas in the Ramagiri belt potassic alteration is in the form of sericite formation, thus indicating a relatively lower temperature of the fluid for the Ramagiri belt. Moreover, sulfidation process in the Kolar and Hutti schist belts are represented by high temperature phases such as pyrrhotite and arsenopyrite respectively whereas in the Ramagiri belt it is represented by the formation of abundant pyrite. The relatively lower temperature of the fluid in the Ramagiri belt could be due to shallower level of formation of the deposits as compared to the Kolar and Hutti schist belts.

High temperature fluid alteration as inferred from mineralogy and REE data, seems to have a positive correlation with the tenor of gold in the deposits of eastern Dharwar craton. A characteristic feature of alteration in all the auriferous schist belts is the lack of mobility of most major elements and base metals and this rules out the possible involvement of brines where these elements are mobilized significantly.

Apart from the role played by the temperature of the ore bearing fluids, the intensity of fluid alteration also seemed to have played a significant role in concentrating gold. The higher the fluid / rock ratio, and higher the intensity of alteration, the better it is in terms of tenor of gold. In both Kolar and Hutti schist belts, the fluid alteration is a more
localised phenomenon commonly restricted to a few centimetres on either side of the vein and the fluid has imposed it's signature on the immediate host rock giving rise to a relatively high grade ore in these two schist belts. Whereas in the Ramagiri Schist Belt, the fluid has not generally imposed it's signature on the host rock, leading to a relatively low grade ore in this belt. The higher fluid/rock ratio in Hutti and Kolar schist belts could be due to the strongly focused fluid flow in narrow brittle shear zones and the lower ratio in the Ramagiri belt could be due to a not so strongly focused fluid flow because of a wider shear zone in this belt. Lower temperature of the fluid could also have contributed to this lower grade as gold solubility has shown to be strongly temperature dependent.

This study also indicates that there could be at least a temporal connection between accretion of different terranes in the schist belt area and the granulitization process of the region. In the Kolar Schist Belt, the accretion of terranes have occurred between 2520 Ma and 2420 Ma. (Krogstad et al, 1989). In the Ramagiri Schist Belt, the accretion of terranes reportedly occurred between 2520 and 2450 Ma (Zachariah et al, 1995). The time interval between 2520 and 2420 Ma also coincides with the period of crustal thickening and stabilisation an essential part of which is granulitization. Mineralization probably occurred during this peak period of granulitization as suggested by Cameron (1988) and that CO₂ streaming with LILE depletion under relatively oxidised conditions permitted a free CO₂ vapour to exist in the crust which favoured dissolution of gold and associated sulfide and their transfer to the mid-crust in a CO₂ - H₂O fluid, the H₂O being provided by the dehydration of amphibolite. The LREE enriched - HREE fractionated pattern of the fluids as inferred from the bulk sulfides
suggests that the fluids are crustally derived and are of high temperature, possibly from lower crust, related to accretion of terranes and granulitization.

As regards the gold exploration in the schist belts of Dharwar craton, future exploration targets should be zones of intense fluid alteration which are usually very narrow and are characterised by LREE enriched - HREE fractionated REE patterns. The southern part of Hutti Schist Belt near Pamankallur, on the Pamankallur- Lingusugur road appears to be a very promising target for gold exploration as suggested by the chemistry of sample # 17 collected from a surface outcrop in this area.