Wall rock sulphidation during Amphibolite facies Gold mineralization at Hira Buddini, South India

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The Hira Buddini Gold Mine is situated in the Hutti-Maski Greenstone Belt of the Archean Dharwar Craton. Gold mineralization is located in a narrow, ENE-trending, steep dipping reverse shear zone at the lithological contact of metabasalt, -dacite and –gabbro.

Within the shear zone, amphibolite facies gold mineralisation is mainly confined to the selvages of quartz and calcite bearing lenticular extension veins, and to the altered host rocks. The first stage of mineralization is overprinted by a second stage of gold mineralization during strike slip reactivation of the shear zone at greenschist facies condition.

In metabasalt, a distal alteration zone can be distinguished from a proximal alteration zone. Metamorphic hornblende is replaced by chlorite and tourmaline in the former, and by actinolite, biotite and tourmaline within the latter. Plagioclase is altered to more calcic varieties during the alteration process. Pyrite and chalcopyrite are the only sulphide minerals associated with the gold mineralisation.

The mineralization formed retrograde at T = 550 $\pm$ 40°C and p = 0.4 $\pm$ 0.1 GPa, with respect to the peak of regional metamorphism. Associated fluid inclusions are hypersaline, with up to 38 wt. % NaCl eq. and T_h(LV→L) > 500°C. However, the presence of CO_2 in the fluid is indicated by the stability of calcite within the veins and alteration assemblages. Pseudosection modelling of the alteration zones demonstrates that XCO_2 of the fluid did not exceed 0.35 within the proximal zone (Hellmann, 2005). Calculated boron isotopes of tourmaline at 550°C and 0.4 GPa indicate fluid mixing of a metamorphic fluid at δ^{11}B= +1 ‰ and a magmatic fluid at δ^{11}B = +10 ‰, which may have originated from the intrusion of I-type granitoids (Krienitz et al., 2008).

The stability of metamorphic ilmenite and hydrothermal magnetite + pyrite in weakly altered host rock constrain log fO_2< -18.2 bar at a neutral pH = 4.6 (T = 550°C and p = 0.4 GPa). The absence of magnetite and ilmenite in the proximal alteration zone and the overall presence of pyrite points to an increase of sulphur fugacity during wall rock sulphidation to log aH_2S >-0.6 to -0.17 bar. Gold shows a strong positive correlation with sulphur (r = 0.98) in bulk rock geochemical analysis of metabasalt, which indicates the transport of gold as a bisulphide complex. The solubility of gold in an aqueous fluid is calculated for the $Au(HS)_2^-$ complex to be in the range of 10 ppm to 100 ppb. Lowering the sulphur fugacity at an order of one magnitude will lead to the decrease of the gold solubility at an order of 2 magnitudes. Therefore, gold precipitation due to wall rock sulphidation is a likely process for the precipitation of gold at Hira Buddini.

References

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