BOOK REVIEW

GOLD METALLOGENY INDIA AND BEYOND. Mihir Deb and Richard J. Goldfarb (Eds). Narosa Publishing House Pvt. Ltd., 2010, 210p. Price: Rs.

The volume under review is a logical outcome of an International Field Workshop-cum Conference in India, held in December, 2008. It contains fourteen contributions, five (5) dealing with various global perspectives on gold metallogeny and the other nine (9) dealing with the current Indian scenario on gold. In the global scenario, Robert Kerrich and others in their article *"Metallogenic Provinces of Laurentia in a Superplume-Supercontinent Framework with a Focus on Gold"* (pp.1-29) have explained the assembly of 3 supercontinents namely, Kenorland (2.7Ga), Columbia (2.1/1.8Ga) and Rodinia (1.2-0.7Ga). They have opined that metallogenic provinces are the product of interplay of superplume and plate tectonics within the larger framework of the supercontinent cycle and have explained the preservation potential of gold in Neo-Archaean (Central Canada, Dharwar, Baltica, Kaapvaal, Yilgarn); Paleoproterozoic (The Flin Flon terrane Athabasca Freeland basin) and Neoproterozic (Rodinia)

Ross R. Large in his article *"Evidence for a two stage process in the genesis of sediment hosted gold-arsenic deposits"* (pp.30-47) based on textural and chemical association of both gold and arsenic in pyrite in certain carbonaceous shale facies and banded iron formation facies, has proposed a two stage process of gold and arsenic concentration. The first stage involves pre-concentration of gold and arsenic in black mudstone facies or banded iron formation facies of continental margin sedimentary basins. Gold is present as either invisible gold trapped in diagenetic arsenian pyrite or micro-nuggets of free gold associated with fine grained clays and organic matter. Values range from 5 to 100 ppb gold, 10 to 100 ppm arsenic and 0.2 to 2.0% by weight organic carbon. The second stage of concentration occurs during the late diagenesis and metamorphism of the sediments associated with deformation basin inversion and/ or granitic intrusion. Metamorphic fluid transports the gold and arsenic through the permeable silts and sand facies sedimentary rocks, to become concentrated in zones of intense fluid flow and related pressure release, such as anticlinal fold axes, shear zones, or dilatent quartz-vein reefs or stock works.

Pyrite textures and LA-ICPMS maps of gold and arsenic of Sukhoi Log, Carlin upper mud member and Bendigo carbonaceous shale and LA-ICPM element count on images covering BIF from KGF has indicated preconcentration in host sediments in the first stage and upgradation on the second stage. A consequence of this model is that the gold and arsenic concentrations are not sourced from deep fluids at the base of the crust, mantle or core of earth but are derived from sedimentary rocks in the same basin.

In the paper on *"Controls of the global distribution of orogenic gold and their significance in relation to India"* (pp.48-57) R.J. Goldfarb and others have analysed the metal produced from giant orogenic gold deposits in metamorphic belt of Late Archaean, Paleoproterozoic and Phanerozoic age of the world including those found in India. They have indicated that Dharwar craton may be favourable site for future large scale open pit mining of lower grade gold ores, with low risk of mining. They have pointed out that limited drilling programs, milling technologies, poor quality laboratories and the government policy continue to hinder large scale exploration program.

Daniel J. Kontak et al. in their paper on *"A Multi-stage Origin for the Meguma Lode Gold Deposits, Nova Scotia, Canada: A Possible Global Model for Slate Belt-hosted Gold Mineralization"* (pp.58-82) have suggested a model for slate belt-hosted gold mineralization in a Lower Paleozoic fold belt dominated by metaturbidite rocks, that were deformed in Devonian (410-400 Ma, Acadian orogeny) and subsequently intruded by meta to peraluminous granitic batholith at 380 Ma indicating two stage vein formation, an earlier one connected with regional deformation (408 Ma) and a later event related to the emplacement of granite batholiths (380 Ma) vein mineralogy is simple with over 90% quartz with minor carbonate (Ca-Fe-Mg), and sulphide (Fe-As-S) phases and silicates.

K. Howard, Poulsen in his paper on *"Polymictic Conglomorate as a Guide to Gold in Archaean Greenstone Belts with reference to Hutti and Kolar, Eastern Dharwar Craton, India"* (pp.83-94) briefly overview the conglomerates that have close spatial association with gold as at the Timiskaming, Abitibi belt, Seine conglomerates in the Superior Province, Jackson Lake (Canada); Kalgoorlie (Australia), Kurrawang Mar-Musoma (Tanzania) and Kavirondian (Kenya). Poulson suggests that these are the youngest preserved supracrustal units in the local greenstone belt succession deposited along preexisting structural lines (i.e., faults) and subsequently folded into synclines attributable to second period of deformation. Author in his model has suggested that conglomerates represent the youngest strata in a greenstone belt and mark areas of best crustal preservation and has a relevance to gold metallogeny because it suggests a shallow crustal level of deposition of many of the related gold deposits.

S.C. Sarkar in his paper "Gold Mineralization in India: An introduction" (pp. 95-122) gives an exhaustive overview of all the known gold prospects and deposits in different regions of the country followed by critical comments on the Indian situation in the background of the present status of our knowledge about gold metallogeny in metamorphic terrains. He has described the gold mineralization in Western Dharwar, Eastern Dharwar, Southern granulite, which holds the major prospects for gold. In Central India he has described the gold occurrences in the belts of Mahakosal, Kotri, Sonakhan, Sakoli and Malanjkhand (Cu-Mo & Au). In Western India he has described the gold mineralization in the Proterozoic Aravalli sequence associated with amphibolites bearing dolomitic marble, calc silicate rocks, mica schist and quartzite. He has pointed out that an Australian Mining company has established a gold deposit of economic significance (38.5 mt of ore with average tonne ore of 1.4g/t) and awaits Government permission to operate.

In Eastern India he has described the gold mineralization in the Archaean greenstone belt in the greenschist facies at Kunder Kocha, in the basal conglomerate (QPC) of the Dhanjori Group. The author while commenting on the status of gold metallogeny in metamorphic tectonites in India has suggested the formation of Gold Institutes or Gold Authority of India as advocated by B.P. Radhakrishna and Curtis (1999).

A. Chattopadhyay in his paper on "A review of the structural characteristic of orogenic gold deposits with special reference to Indian gold fields" (pp.123-153) has described in detail the structure of important gold deposits of the world and compared them with structure of orogenic Gold deposits of KGF, Hutti, Ajjanahalli and Gadag gold fields. Based on the study of metamorphic conditions of gold deposits of Dharwar craton he has proposed regional geodynamic model involving oblique subduction of the eastern portion of Dharwar craton beneath the western part. He has pointed out that limited absolute dating of mineralization and stable isotope studies to identify possible fluid sources hinder the establishment of a coherent metallogenic model.

B. Mishra in his contribution on "*Metamorphism and Hydrothermal Fluid Evolution in Relation to Gold Metallogeny, Dharwar Craton, Southern India*" (pp.154-167) evaluates the metamorphic conditions of the greenstone belts in the Dharwar craton based on phase petrology and multiequilibrium thermobarometry to understand the gold forming fluids. Gold formation in Dharwar craton (except for the Uti deposit) has been attributed to low salinity H_2O $+CO_2$$+CH_4$+NaCl+Au$(HS_2)$ post-peak metamorphic fluids, which underwent fluid immiscibility and precipitated gold in a broad P-T of 0.65 – 2.5 kb / 250-320°C due to reductions in total sulphide and/or mineral fluid reactions". The Uti deposit, Dharwar, however, formed from highly saline fluid during post-peak metamorphic conditions.

C.G. Nevin et al. in their paper "*Modeling the Hutti Gold Deposit: Challenges and Constraints*" (pp. 168-190) based on regional stratigraphy, structure, mineralization and fluid inclusion studies have suggested four phases of deformation and the lodes are structurally controlled by the features related to shearing. The authors have concluded that "the fluids that generated the early (D_1) quartz veins are identical to those that led to the deposition of the laminated (5 m) quartz veins and the ore mineralization". The composition of fluids in scheelite is similar to the fluids drawn from similar sources during the entire period of the first phase of deformation and mineralization is the result of shearing and specific physico-chemical changes that took place during the later part of the first phase of deformation.

Ram Mohan and D. Srinivasa Sarma in their paper on "*Geochemistry and Evolution of the Hutti-Maski Greenstone Belt*: *Link between Archaean Crustal Evolution and gold Mineralization*" (pp. 191-205) based on the HFSE and LILE data for the volcanic rocks and surrounding TTG has suggested subduction zone processes in an island arc setting for the derivation of these rocks. The gold mineralization event at Hutti is correlated with widespread plutonism event dated as 2547±10 Ma in the EDC. Mineral assemblages and structural control on mineralization at Hutti (re)clarifies the orogenic nature of this deposit and would fall within the time range of the late Dharwar magmatic event.

M. Deb and K. Bheemalingeswara in their article "*A Model for Gold-Sulphide Mineralization in the Kottapalle Mining Block of the Ramagiri Greenstone Belt, Eastern Dharwar Craton, Southern India: Constraints from Stable Isotope Geochemistry and Fluid Inclusion Studies*" (pp. 206-221) provide stable isotope and fluid inclusion data on three bore hole samples, drilled by Geological Survey of India in carbonaceous phyllite intercalated with both mafic and felsic metavolcanic rocks. These studies indicate that an aqueous carbonic hydrothermal fluid, produced during metamorphic devolatilization of mafic volcanic pile transported the gold as bisulphide complex deposited in the quartz in association with sulphides at a maximum P-T of 2Kb/275°C / 1.6 Kb / 250°C. The authors have suggested future research on the role of differentiated character of the volcanics or the tectonic framework of eruption or both in the gold mineralization and its low concentration compared to Kolar belt.

R. Krishnamurthi et al. in their paper on "Gold Mineralization in the Southern Granulite Terrane of Peninsular India" (pp. 222-233) have given an account on primary gold mineralization in the southern granulite terrain (SGT) with an emphasis on the Attapadi deposit and have presented a genetic model, based on the important mineralization features of all the gold prospects in the SGT namely Wynad-Nilgiri, Malappuram and Attapadi. According to them the iron-rich tholeiitic protoliths, served as source of gold in these gold-quartz veins in the SGT. The circulating hydrothermal fluid leached gold from mafic rocks and the fluids transported gold as $Au(HS)_2$ pointing to an event of fluid flow along shear fractures and separation of CO_2- H_2O phase components. Primary gold deposition as discrete gold grains along with sulphide minerals within the quartz veins took place due to wall rock alteration or phase separation.

S. Deol et al. in their paper on "*Geology of the Bhukia–Jagpura prospect, Banswara District, SE Rajasthan, India and a model for Gold Mineralization*" (pp.234-255) have indicated that the gold prospect is hosted in Paleoprotorozoic Aravalli Supergroup lying in close. Proximity to basement cover contact gold mineralization occurs in hydrothermally altered metasedimentary calc silicate, albite and tourmaline bearing rocks. Geological and structural setting of host rocks, hydrothermal alteration, ore textures, element correlation coefficients, metamorphism and fluid inclusion have been studied by authors to suggest sequence of rifting, basin development, emplacement of granite and deformation. Mineralization has taken place during D_1 deformation and upgraded during D_2 deformation.

Anupendu Gupta in his review paper on "*Gold Mineralization in the Eastern Segment of India Precambrian shield* (pp. 256-304) has given a succinct account of all the important gold prospects in the (i) Balampahar – Gorumahisani greenstone belt (ii) North Singhbhum mobile belt with available details on their geological set up, petrochemistry, ore mineralogy, deformation, metamorphism and metallogenic aspects.

Description of Kunderkocha, Mosabani, Rakha Surda, Narwapahar, Lawa, Mayasera, Bubaikundi, Parasi Gold deposits give an overall account and indications to possible prospects for further detailed prospecting.

The first part of the book has noteworthy contributions by well known geologists from Canada, Russia and Australia outlining the controls of global distribution of orogenic gold deposits with their significance to India. The second part provides account of well known gold deposits of India. Data on Indian deposits on regional geology, deformation history, petrochemistry, fluid inclusion and age date of associated rocks gives an excellent data base for further study of selected deposits. Universities, Research Institutions, Exploration companies, postdoctoral students engaged in research on gold metallogeny should procure the hard and soft copies of this important book to pursue their studies. The book is very well produced and should be a very useful reference material in all libraries.

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