An integrated approach to understanding granulite-hosted gold: Tropicana deposit, Western Australia

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Exploration models for orogenic gold deposits have emphasized the relative low prospectivity of regions dominated by high-metamorphic grade gneisses relative to granite-greenstone terranes. The Tropicana gold mine is the first world-class gold discovery in upper amphibolite to granulite facies gneissic rocks at the eastern margin of the Yilgarn Craton, Western Australia.

Reserves as at December 31, 2013 total 54.8 million tonnes grading 2.13 g/t Au for 3.76 Moz of gold. The mineral resource totalled 7.72 Moz of contained gold, including measured resources of 28.6 Mt at 2.06 g/t Au for 1.89 Moz, indicated resources of 76.4 Mt at 1.94 g/t Au for 4.75 Moz and inferred resources of 11.9 Mt at 2.83 g/t Au for 1.08 Moz. Mineral resource is inclusive of that mineralization included in the ore reserves.

The gold deposit is hosted within the Tropicana Gneiss, a fault-bound assemblage of orthogneiss and subordinate paragneiss with a distinct geological history that is ascribed to the newly defined Plumridge Terrane. The history of the Tropicana Gneiss falls into two principal periods. During the first period, emplacement and metasomatism of the precursor mafic to felsic rocks at ~2638 Ma and was followed by amphibolite to lower granulite facies metamorphism and deformation (D1) in the period ~2638 to ~2520 Ma.

The second period commenced with exhumation and juxtaposition of the Archean Tropicana Gneiss (lower crust) against and over upper crust of the Yilgarn Craton. The Tropicana Gneiss was exhumed to into the greenschist facies window and a W to NW verging thrust system developed regionally during D2. The geometry and kinematics of the mineralized shear zones developed during D3 is interpreted as a lateral and frontal thrust zone geometry that formed during NE-SW compression and reacted during subsequent deformation events (D4, D5). The oldest statistically significant population of rutile ages (2521±5 Ma) is interpreted to record the formation of W-rich rutile during gold mineralization. Re–Os of pyrite from Tropicana returned an age of 2505±50 Ma and overlap with those from less precise Pb/Pb pyrite analyses (2.4–2.5 Ga). The pyrite dates are within error of the biotite analyses from biotite-pyrite assemblages hosting gold. The dehydrated nature of granulite-facies gneisses under retrograde conditions suggests mineralizing fluids were
introduced from an external source at c. 2.5 Ga. The fluid-induced event (Tropicana Event) impacted on the retrograde path from peak metamorphism.

The age of mineralization in the Tropicana Gneiss contrasts with that of peak gold mineralization in the Laverton greenstone belt (~2.65 Ga), and Eastern Goldfields Province (~2.64 Ga) of the Yilgarn Craton. The Tropicana mineralization occurred at c. 2.5 Ga, a period that coincides with a subordinate peak in juvenile continental crustal production and orogenic-gold deposit formation. The timing of the Tropicana mineralization is similar to that recognized in the Eastern Dharwar Craton, India.

The likeness in the position of Tropicana gold deposit and the granulite-hosted Renco gold deposit in Zimbabwe relative to their adjacent cratons is marked.