Mineralogy and trace element chemistry of gold from the western Capricorn Orogen — implications for exploration

by

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The Capricorn Orogen is a major zone of Proterozoic deformation, metamorphism, and magmatism between the Archean Yilgarn and Pilbara Cratons (Cawood and Tyler, 2004). It contains a number of small gold-bearing hydrothermal veins in a variety of geological settings. These include low-grade Paleoproterozoic pelitic, psammitic, and mafic schist of the Padbury Group at the Egerton Mining Centre (Egerton), Mesoproterozoic dolerite and Edmund Group sedimentary rocks at the Bangemall Mining Centre (Bangemall), and vein and stratabound gold mineralization associated with variscite in the Edmund Group at Low Hill.

Gold grains from the Egerton and Bangemall mining centres, and Low Hill were examined in terms of their size, morphology, silver content, trace element distribution, and internal structure (Table 1). Chemical data were obtained using a Scanning Electron Microscope with Energy Dispersive X-ray system (SEM-EDX) and Laser Ablation Inductively Coupled Mass Spectrometry (LA-ICP-MS).

Both bedrock-hosted gold and alluvial gold associated with Paleoproterozoic rocks at Egerton have similar chemistry, and are characterized by their low silver concentrations, high Cu/Ag ratios, and low Hg/Pb ratios. These similarities are also apparent using principal components analysis based on the elements Cu, Ag, Sb, and Hg. The mineralogy of bedrock-hosted and alluvial gold is characterized by the presence of recrystallized twinning (Figs 1, 2) that reflects relatively high-pressure and high-temperature formation (Petrovskaya, 1973). The gold also includes high-purity segregations and intergranular veins formed during subsequent supergene alteration.

Based on the wide variation in gold morphology and trace element chemistry, at least two populations of alluvial gold are present at Egerton. These could be derived from separate sources, with the gold being introduced either at the same time or during different periods (Knight et al., 1999).

Bedrock-hosted gold and alluvial gold associated with Mesoproterozoic rocks at Bangemall differ from the Egerton gold in that they are associated with relatively unweathered pyrite and milky quartz, have a higher silver content, and also have a relatively simple monocrystalline internal structure. In terms of trace element chemistry, bedrock-hosted and alluvial gold from Bangemall are characterized by higher Ag/Cu ratios and higher Hg and Sb levels than the gold from Egerton. These features are consistent with primary mineralization in a slightly oxidized, non-lateritic environment, rather than in a deeper crustal, hypogenic setting. Later supergene alteration is expressed by the formation of high-purity veinlets and corrosive rims.

Small variations in the size, roundness, Ag content, and trace element distribution indicate a single source for the Bangemall alluvial gold. This source is likely to be similar to the quartz and pyrite-veined host rocks present at the nearby Cobra workings; however, the high degree of rounding and the depleted trace element chemistry suggest that this gold has undergone several transport cycles before being incorporated into the present-day alluvium.

Gold associated with variscite at Low Hill has a distinctive spongy morphology and very high purity, quite unlike the gold from either Egerton or Bangemall. Textural evidence indicates that the gold and variscite are co-precipitates (Nickel et al., in press). These workers showed that spongy gold flakes were formed by remobilization and redeposition of stratiform gold by low-temperature, saline hydrothermal solutions in a supergene environment.

Gold mineralogy and trace element chemistry can be used to significantly improve the understanding of mineralization events in the Capricorn Orogen. The results have highlighted important differences between gold from the Egerton and Bangemall centres, and from Low Hill. This, together with the different geological setting of these deposits indicate that the Capricorn Orogen underwent at least two periods of hydrothermal gold mineralization during the Proterozoic, and at least one period of secondary gold formation, probably during the Phanerozoic.

The host rocks at Egerton are low-grade, metasedimentary and metamafic igneous rocks that have been correlated with the 2.0 to 1.65 Ga Padbury Group. They have experienced a protracted history of deformation and metamorphism during the Paleoproterozoic to Neoproterozoic. Gold from Egerton reflects this complex geological history and is characterized by the presence of a relatively high-pressure and

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Table 1. Summary of mineralogical and geochemical characteristics of gold from the Capricorn Orogen

Location	*Gold grains*	*Size in mm (mean)*	*Shape*	*Surface*	*Roundness*	*Ag (wt%)*	*Trace elements (>1000 cps)*	*Internal structure*
Egerton–Hibernian (alluvium)	19	0.1 – 1.8 (0.55)	Rounded, cemented, and semi-idiomorphic	Even, pitted, rugged	Sub-medium to well-rounded	<0.5 – 2.0	Ag, Cu, Hg, Ti, V, Mn, Fe	Recrystallization, twinning, high-fineness segregation
Egerton – Gaffney Find (lode)	8	0.1 – 0.9 (0.7)	Irregular, cemented, lumpy	Uneven, pitted	Slightly rounded and subrounded	2.5 – 4.0	Ag, Cu, Hg, Sb, V, Mn, Fe	Recrystallization, twinning, intergranular veinlet, high-fineness segregation
Egerton–Gaffney Find (alluvium)	2	1.3, 1.6	Well-rounded, originally lumpy or semi-idiomorphic	Even, with grooves and scratches	Well-rounded	<0.5	Ag, Cu, Hg, Ti, Fe	–
Low Hill (lode)		0.07 – 1.0 (0.2)	Fine films of spongy gold	Spongy	No	<0.5	–	–
Bangemall–Cobra (lode)	50	0.1 – 2.7 (0.3)	Irregular, cemented, lumpy, cellular	Uneven, spongy, cellular, platy	Angular, slightly rounded	9.2 – 19.0 (mean 10.7)	Ag, Cu, Hg, Zn, Sb, Pb, V, Mn, Fe, Co, Ni	High-fineness intergranular veinlets, partly recrystallized
Bangemall – McCarthys Patch (alluvium)	21	0.4 – 1.8 (0.9)	Rounded, originally semi-idiomorphic or cemented	Even, pitted	Well-rounded	5.6 – 7.8	Ag, Cu, Hg, Sb, Ti, Fe	Intergranular veinlets, irregular high-fineness rim

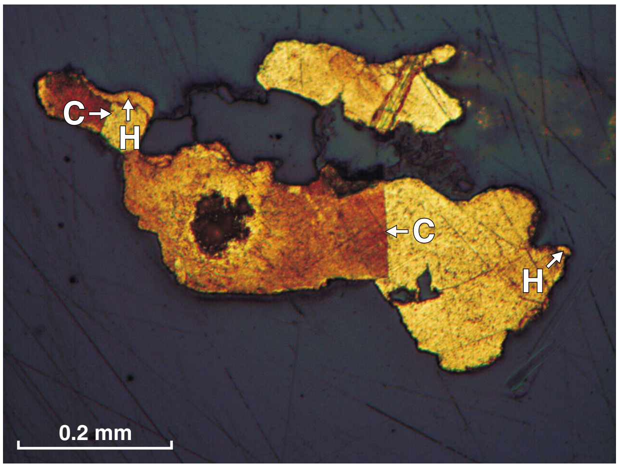

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Figure 1. Cross section of Egerton–Hibernian gold grain after leaching in aqua regia. C = coherent twin plane; H = high-purity segregation

high-temperature mineralogy and a complex recrystallization history. In contrast, gold mineralization at Bangemall is hosted by Edmundian age (1030 to 950 Ma) quartz veins in the Edmund Group and Narimbunna Dolerite. Both the host rocks and quartz veins have experienced limited deformation and only very low grade metamorphism. The geological history of the host rocks is also reflected in the mineralogy and chemistry of the gold, which indicates that it formed at relatively low-pressure and low-temperature conditions and any subsequent hypogenic recrystallization was insignificant.

Gold associated with variscite at Low Hill is distinct from both the Bangemall and Egerton occurrences. It is a secondary deposit that resulted from the remobilization of gold during a low-temperature hydrothermal event that post-dates local Edmundian structures. Nickel et al. (in press) argued that this event probably occurred during the Phanerozoic.

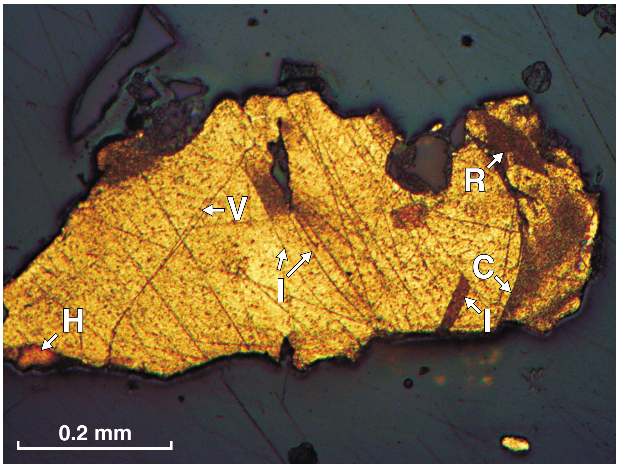

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Figure 2. Cross section of Egerton – Gaffney Find gold grain after leaching in aqua regia. C = coherent curved twin plane; H = high-purity segregation; I = incoherent curved twin plane; R = recrystallization; V = intergranular veinlet

Although the chemistry of alluvial gold shows important similarities to bedrock-hosted gold from the same area, subtle chemical variations and morphological differences in the alluvial gold can be used to improve exploration strategies. At Egerton, the wide variation in gold morphology and trace element chemistry indicates the presence of at least two populations of alluvial gold derived from separate, nearby sources. In contrast, small variations in size, roundness, silver content, and trace element distribution, suggest a single, distant source for the Bangemall alluvial gold. However, the sample location is less than 1 km from the local drainage watershed, so the alluvial gold may originally have been sourced from outside the present drainage system, or it has been subject to several periods of reworking.

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