1) $2Chl + 3Ms + 6Qtz = 3Crd + Bt + (12\text{-}3n)\ H_2O$ (n ..... Anzahl der Mole $H_2O$ in Cordierit)
2) $4Crd + 3Ms = Bt + 10And + 11Qtz + 4nH_2O$
3) $Ms + Qtz = Kfs + And + H_2O$
4) $9Qtz + 2Bt + 6And = 3Crd + 2Kfs + (2\text{-}3n)H_2O$
5) $Qtz + Kfs + Plg + H_2O = L$

Die P-T Abschätzung der Kontakmetamorphose erfolgte vorläufig mittels experimenteller Daten von Reaktion 5. Demnach müssen für die Schmelzbildung in den Paragneisen (Reaktion 5) Minimaltemperaturen von 650° C angenommen werden (WINKLER, 1976). Sillimanit-Einschlüsse in Cordierit weisen auf Minimaldrucke von 1 Kbar (650° C) hin (HOLDAWAY, 1971).

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## ION-MICROPROBE ANALYSIS OF GOLD IN ARSENOPYRITE/LÖLLINGITE: EVIDENCE FOR SYNMETAMORPHIC GOLD MINERALIZATION IN THE MT. YORK DISTRICT (AUSTRALIA)

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The timing of gold mineralization with respect to the age of the metamorphic events in the hosting terrane has been a contentious issue for some time. Various models from premetamorphic, synmetamorphic to postmetamorphic timing of gold mineralization are suggested for different deposits. In this study, the distribution of gold in sulpharsenides, determined using the superior sensitivity of the secondary ion mass spectrometry (SIMS), and the implications of the gold distribution for the timing of gold mineralization relative to the peak of amphibolite facies metamorphism are discussed for the Main Hill gold deposit (Pilbara Craton, Western Australia).

Gold mineralization in the Main Hill deposit is located in the Archaean Pilgangoora greenstone belt which contains metavolcanic rocks of the ca. 3.46 Ga Warrawoona Group and metasedimentary sequences of the ca. 3.33 Ga Gorge Creek Group (THORPE et al., 1990), including the gold-hosting banded iron formation (BIF) at Main Hill. Peak metamorphic conditions were determined using biotite-garnet and amphibole-plagioclase thermometry, phengite barometry and mineral stabilities as 500 - 640° C and 2.5 - 4 Kbar (NEUMAYR et al., 1993a).

Gold mineralization at Main Hill is hosted in: i) quartz-breccias with a sulphide matrix, and ii) in sulpharsenides in the wallrock adjacent to quartz-biotite-amphibole ± diopside veins (NEUMAYR et al., 1993a). In both types, the alteration is zoned with distal pyrrhotite alteration, with pyrrhotite and composite arsenopyrite/löllingite grains increasing in abundance proximal to gold mineralization (NEUMAYR et al., 1993b). The ore assemblage comprises pyrrhotite, arsenopyrite, löllingite and minor chalcopyrite and sphalerite. Coarse-grained Fe-As-S phases occur commonly as composite arsenopyrite-löllingite aggregates which are zoned from a core of löllingite to a rim of arsenopyrite, and are hosted in a matrix composed of pyrrhotite. The reverse zonation with a core of arsenopyrite and a rim of löllingite is never developed. The sulpharsenide textures indicate a progressive replacement of löllingite by arsenopyrite, leaving remnants of unreplaced löllingite behind.

Most of the microscopically visible gold (5 - 25 μm in length) at Main Hill is concentrated at the arsenopyrite-löllingite grain boundary (NEUMAYR et al., 1993b). It rarely occurs within arsenopyrite or at the arsenopyrite-pyrrhotite grain boundary. Samples containing composite arsenopyrite-löllingite grains from Main Hill have been investigated using SIMS to test for the presence and distribution of "invisible", i.e. submicroscopic, gold. The SIMS has been used for: i) isotopic imaging for $^{75}$As, $^{32}$S and $^{197}$Au to examine the spatial distribution of gold, ii) quantitative spot analyses for $^{197}$Au, iii) line-scans for $^{75}$As, $^{32}$S and $^{197}$Au across arsenopyrite-löllingite grain boundaries, and iv) quantitative depth profiles for $^{197}$Au in single spots, to test whether gold is present as subsurface inclusions.

Line-scans across arsenopyrite-löllingite grain boundaries (Fig. 1) and isotopic images clearly show that submicroscopic gold is associated with the phase with high As and lower S content (i.e. löllingite, $FeAs_2$), whereas S-rich, relatively As-poor grains (i.e., arsenopyrite, FeAsS) show no detectable gold with this method. Quantitative spot analyses of gold confirm that 20 - 33 ppm gold are hosted in löllingite, whereas only 0.16 - 1.04 ppm gold are hosted in arsenopyrite.

Ore textures and SIMS analyses indicate that gold precipitated together with löllingite and pyrrhotite and was included either structurally or as colloidal gold into löllingite. A subsequent, possibly slightly retrograde reaction between löllingite and pyrrhotite resulted in the formation of arsenopyrite. During this reaction gold was liberated from the löllingite and concentrated at the reaction front between arsenopyrite and löllingite. Crystallization temperatures of arsenopyrite of 460 - 540° C, determined using the arsenopyrite thermometer of SHARP et al. (1985), represent the lower temperature limit for the gold precipitation. Other possibilities to explain the ore textures include i) increase of both $a_{H_3AsO_3^\circ}$ and $a_{H_2S^\circ}$ in the ore fluid, or ii) oxidation of the ore fluid during mineralization. The first possibility would necessitate the reaction of the ore fluid with unusually S- and As-rich rocks or mixing with S- and As-rich fluids. Although the arsenopyrite stability field is expanded at high oxidation states, oxidation of the ore fluid alone cannot account for the change from löllingite- to arsenopyrite-saturated conditions.

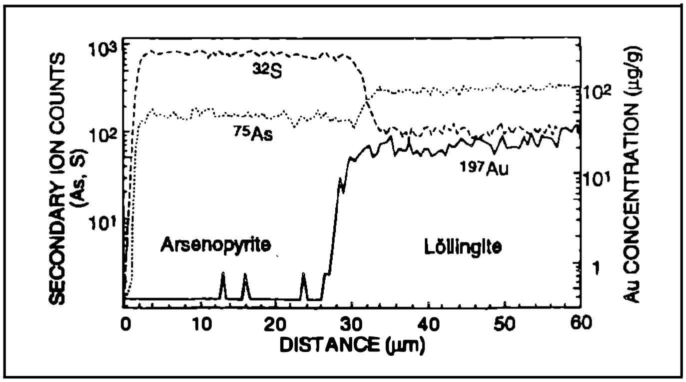

Fig. 1: Ion-microprobe scans across arsenopyrite-löllingite grain boundary for a sample from Main Hill (Fig. 5a of NEUMAYR et al., 1993b).

Therefore, it is concluded that gold precipitated during the peak of amphibolite facies metamorphism together with löllingite and the gold was concentrated along the löllingite-arsenopyrite grain boundary during a slightly retrograde reaction. The study demonstrates that particulate gold, alone, does not indicate the true paragenetic position of initial deposition of gold in the Main Hill deposit.

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