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The Nevoria Gold Skarn Deposit, Southern Cross Greenstone Belt, Western Australia: II. Pressure-Temperature-Time Path and Relationship to Postorogenic Granites

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Abstract

The Nevoria deposit (production 11.88 t Au, 0.41 t Ag) is one of more than 20 gold skarns mined in the 3.1 to 3.0 Ga Southern Cross greenstone belt. The belt constitutes part of the continental foreland of the 2.7 to 2.6 Ga Norseman-Wiluna fold belt, the youngest Archean orogen of the Yilgarn craton. The Nevoria skarns are confined to iron formations at the limb of a regional F_1 anticline bent around the Ghooli orthogneiss dome. The refolding (F_2) took place at 2775 to 2724 Ma during batholith emplacement and contact metamorphism at estimated P-T conditions of 610° ± 50°C and 400 ± 100 MPa (14-km burial depth). This structural setting differs from that of the mezozonal lode gold deposits in the adjacent fold belt, which are controlled by fault-vein arrays in crustal-scale shear zones. The Nevoria orebodies (6–7 g/t Au), composed of pyrrhotite-rich hedenbergite-actinolite and almandine-hornblende skarns, are dated by a concordant U-Pb age (2635.7 ± 1.2 Ma) and by a less precise Pb-Pb errorchron age (2630 ± 13 Ma, MSWD = 5.9, n = 7), both defined by allanite-bearing almandine and by cogenetic scheelite. These ages demonstrate that the skarns formed 90 m.y. after amphibolite-facies metamorphism in the Southern Cross greenstone belt and at least 20 m.y. after transpressional faulting related to late-orogenic deformation in the Norseman-Wiluna fold belt.

The peak fluid temperature during skarn formation is estimated at 550° to 600°C, based on the Fe-Mg exchange thermometry of almandine-biotite and almandine-hornblende pairs. Calcic-potassic mineral assemblages in skarn hosted by amphibolite constrain the pressure to 300 to 400 MPa, based on the reaction of biotite + cummingtonite + anorthite to almandine + grossular + biotite. The pressure estimate confirms that the Nevoria deposit formed at considerable depth (11–14 km) in a midcrustal environment. Substantial uplift did not take place until 2565 ± 25 Ma, when biotite in the associated granite closed to Rb-Sr diffusion at 300°C ambient temperature.

The Nevoria orebodies are cut by pegmatite dikes and are underlain by a 500-m-thick pluton of peraluminous two-mica granite. The concordant zircon U-Pb age (2634 ± 4 Ma) of the granite is indistinguishable from the age of the skarn. The abundance of pegmatite in the main intrusion, increasing upward to a more than 80-m-thick roof zone, indicates that an aqueous fluid separated from the melt. The enrichment of aluminum, Au, As, Bi, Cu, Nb, W, and Zn in the upper pegmatite suggests that these elements were transported to the roof by an early magmatic fluid (700°–600°C), prior to the development of disseminated muscovite-epidote-carbonate alteration at a lower temperature (400°C). The major and trace elements elevated in the pegmatite are also enriched in the ore skarn, implicating the granite as the fluid source. Fluid inclusion data indicate that the magmatic fluid was CO_2 bearing, aqueous, and of moderate salinity (about 10 wt % $CaCl_2$ + NaCl equiv). Gold skarn formed in the iron formations above when the infiltrating fluid became progressively reduced during the replacement of grunerite.

Other gold skarn deposits in the continental foreland of the Norseman-Wiluna fold belt show a similar space-time relationship to differentiated I-type granites (Thornton-Tuttle index >90). These granites (2.66–2.62 Ga) postdate the compressional deformation in the fold belt and are thus classified as postorogenic. The scheelite-bearing Archean gold skarns share characteristic features such as gangue-sulfide mineralogy and granite association with the deep-seated (150–250 MPa), reduced tungsten skarns located on the continental side of the North American Cordillera. Cretaceous deposits such as MacTung contain up to 2 g/t gold, locally.

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