1 Introduction

The Monakoff iron oxide-Cu-Au (IOCG) deposit, located to the NE of Cloncurry within the eastern succession of the Mount Isa Inlier, Queensland, Australia, is characterised by high concentrations of F and Ba, with a host of other enriched elements including Co, Ag, Mn, REE, U, Pb, Zn and Sr. This gives the deposit a characteristic gangue assemblage dominated by fluorite, barite and calcite. The nearby E1 deposit, located 25 km to the NNE of Monakoff, and the large Ernest Henry deposit, 3 km to the west of E1, also contain abundant fluorite, barite and calcite in late stage assemblages. The three deposits, therefore, constitute a distinct group of IOCG deposits within the district based on their F-rich geochemistry and mineralogy.

2 Ore Mineralogy

The Monakoff ore zone is hosted in dilational openings along a shear zone developed within metasediments and metavolcanic rocks at the boundary between competent hangingwall rocks of the Toole Creek Volcanics and footwall rocks of the Mount Norna Quartzites.

Four stages of alteration and mineralisation are recognised: Stage 1 garnet-biotite alteration; Stage 2 biotite-magnetite alteration; Stage 3 main F-Ba-ore mineralisation; and a Stage 4 pyrite-alloclasite Au-Co-As overprint. The E1 deposit has a more complex history, but Stage 5 has veins of fluorite-barite-carbonate that are comparable to Monakoff’s main stage.

The Stage 3 assemblage at Monakoff comprises a sheared groundmass of fluorite, barite, manganocalcite, magnetite, chalcopyrite, pyrite, galena and sphalerite, with coarser grained pods of the same mineralogy interpreted to be dilational structures infilled during syn-ore deformation. Accessory minerals include U-Pb-oxides, REE-F-carbonates and Ag-Pb-Bi- sulfosalts, with no discrete Au minerals. The sulfosalts are interpreted to have formed from an immiscible Bi-melt within the mineralising fluid at temperatures higher than the melting point of Bi. The Stage 4 overprint at Monakoff contains pyrite and alloclasite. Laser ablation analyses of the sulfide minerals at Monakoff reveal that Stage 3 sulfides contain only trace amounts of Au (0.04 ppm in pyrite), although galena and chalcopyrite contain significant concentrations of Ag.

Stage 4 pyrite and alloclasite, however, contain ~1 ppm Au in solid solution and mass balance calculations indicate the majority of bulk rock Au to be present in these minerals, although the majority of bulk Ag is present in Stage 3 sulfides. The Stage 5 veins at E1 have an identical gangue and accessory mineralogy to Stage 3 at Monakoff and differ in the sulfide mineralogy only in the lack of galena and sphalerite.

3 Fluid Characteristics

Four fluid inclusion populations are identified within the fluorite at Monakoff: Group 1 are CO₂ rich; Group 2 are complex solid-liquid-vapour inclusions, with two groups based on homogenisation temperature (Th > 450°C and 300-375°C). Laser ablation-ICP-MS analyses indicate these inclusions contain Cu, Pb, Zn, Fe, Mn, Mg, Ag, REE, U and Ba, but significantly no S, Se or Au; Group 3 are solid-liquid-vapour inclusions with a Th of 200-275°C, and contain Ba, Na, Mg, K and Br; and Group 4 are low
The salinity liquid-vapour inclusions. Group 1, 2 and 4 inclusions are also present in fluorite at E1.

The REE geochemistry of fluorite from Monakoff and E1 is comparable and is characterised by a distinct positive Eu anomalies in all analyses, interpreted to indicate oxidising conditions at the time of high temperature ore deposition. The presence of abundant fluorite and barite is indicative of fluid mixing due to the insolubility of barite and fluorite and thus Ba and S, and Ca and F must have been introduced via different fluids.

4 Genetic Model

We propose that the oxidised fluid represented by the Group 2 inclusions, and containing F, Ba, REE, U and base metals, mixed with a reduced, S-bearing fluid in a zone of dilation in the host shear zone (Fig. 1) that acted as a conduit for fluid flow during D3 deformation (Davidson et al. 2002).

The source of the metal and F-rich fluid is likely to be the nearby granitic intrusions of the Williams-Naraku batholith, probably the Malakoff granite (Fig. 1). This granite is also likely to be the source of the CO2 represented by Group 1 fluid inclusions, and the REE, U, base metals and possibly Au, although the high Pb and Zn content of Monakoff and not E1 may suggest a local input of those elements at Monakoff (Fig. 1). Stage 4 mineralisation overprints the F-Ba stage and is characterised by a Co-As-Au signature. At present it is unclear if this is a late stage, more reduced, evolution of the main ore fluid, or a separate mineralising event entirely.

5 Implications for IOCG Mineralization in the Cloncurry District

The presence of this F-Ba-metal-rich fluid has produced a distinctive style of IOCG mineralisation in the area to the north of Cloncurry. The probable link to the Malakoff granite implies that similar deposits may be present within several kilometres of the granite in suitable structural traps. Monakoff illustrates that although structurally controlled, the presence of Na-Ca alteration and ‘red rock’ K-alteration and brecciation are not key exploration criteria for these deposits. In addition, the presence of the overprinting As-Co-Au assemblage may indicate that this is a separate mineralising episode that may be present at other localities in the district. This study has also shown that fluorite can provide a powerful tool for determining ore forming conditions in F-rich IOCG systems.

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References