Economic Geology
Vol 96, 2001, pp. 1535-1566

The Geology of the Nifty Copper Deposit, Throssell Group, Western Australia: Implications for Ore Genesis

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Abstract

The Nifty syndeformational, sediment-replacement Cu deposit is located approximately 450 km southeast of Port Hedland, Western Australia, in subgreenschist-grade rocks of the Neoproterozoic Paterson orogen. The resource of 99 million metric tons (Mt) @1.7 percent Cu is hosted in a syncline within carbonaceous and dolomitic shales of the upper Broadhurst Formation.

The Cu mineralization occurred during Neoproterozoic D_{Y2} deformation and formed at the center of a zoned hydrothermal alteration system. Interbedded dolomitic and carbonaceous shale of the upper and lower units of the Nifty member was altered S in two stages. Early siliceous S alteration with minor chlorite, pyrite, hematite, sericite, and stilpnomelane, which was replaced by syntectonic black quartz in the core of the deposit. On the fringes of the alteration, framboidal pyrite in the carbonaceous shale was replaced by quartz, chalcopyrite, euhedral pyrite, sphalerite, and galena. Inward is a sequence of interlayered hydrothermal quartz-dolomite and unaltered shale beds. The hydrothermal quartz-dolomite first appears as spots and 2- to 4-mm-thick veins with light gray diffuse margins. In areas of intense spotty alteration, dolomitic alteration forms bedding-parallel zones. Farther inward and proximal to the highest ore grade is silicified dolomitic shale, which grades into fine-grained quartz and chalcopyrite, with minor fluorapatite and carbonaceous material.

Synmineralization fluid inclusions are small (10 μm) liquid-vapor inclusions with homogenization temperatures between 200° to 370°C (median 270°C) and salinity of 8 to 27 wt percent NaCl equiv (median 15 wt % NaCl equiv). Sulfur isotope data from framboidal pyrite range between $\delta^{34}S_{CDT}$ of –27 and +16 per mil, chalcopyrite $\delta^{34}S_{CDT}$ ranges between –6 and +6 per mil, and $\delta^{34}S_{CDT}$ for euhedral, synmineralization pyrite ranges between –12 to +12 per mil. Carbon and oxygen isotope results from synmineralization vein stage carbonates and dolomitic alteration overlap with $\delta^{13}C_{VPDB}$ values from +2 to –10 per mil and $\delta^{18}O_{VSMOW}$ values from 14 to 21 per mil. It is likely that decarbonation of host rock caused the large shift in $\delta^{13}C_{VPDB}$ values.

The formation of the Nifty Cu deposit is linked to deformation (tectonic loading) associated with the Miles orogeny driving fluids from deep in the Yeneena basin. Hydrothermal fluids were focused along D_{Y2} thrust faults. During tightening of the Nifty syncline, thrust faulting penetrated carbonaceous and dolomitic shales, allowing hydrothermal fluids to react with the Nifty member. Early fluid pulses were weakly oxidized and contained low concentrations of base metals. These fluids altered the host rock and precipitated "green" quartz. The fluid evolved to a hotter, more saline, reduced and moderately acidic fluid with significant Cu concentration. These fluids reacted with the dolomite-dominated Nifty member, forming the dolomitic alteration and siliceous replacement of carbonaceous shale and dolomitic mudstone. Chalcopyrite precipitation was controlled mainly by changes in pH accompanied by a slight decrease in temperature. The mineralization and alteration styles at Nifty are similar to the copper orebodies at Mount Isa.