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# Carbon and Oxygen Isotope Halo in Carbonates Related to the McArthur River (HYC) Zn-Pb-Ag Deposit, North Australia: Implications for Sedimentation, Ore Genesis, and Mineral Exploration

ROSS R. LARGE, STUART W. BULL, AND PETER R. WINEFIELD
*Centre for Ore Deposit Research, University of Tasmania, GPO Box 252-79, Hobart, Tasmania, Australia*

## Abstract

A study of carbon and oxygen isotope ratios in fine-grained sedimentary dolomite in the Barney Creek Formation of the McArthur basin demonstrates the presence of an extensive isotope halo surrounding the giant stratiform HYC Zn-Pb-Ag deposit. Dolomite within the halo shows an $^{18}O$-enriched and $^{13}C$-depleted isotope signature ($\delta^{18}O$ = 23 to 26‰ SMOW, $\delta^{13}C$ = –2 to –3.5‰ PDB), relative to normal Proterozoic sedimentary dolomite beyond the halo ($\delta^{18}O$ = 20–23‰ and $\delta^{13}C$ = 0 to –2‰). The C-O isotope halo within the dolomitic siltstones extends at least 15 km southwest of the HYC deposit and approximately coincides with a previously defined lithogeochemical halo of elevated Fe, Mn, Zn, Pb, and Tl. Dolomitic siltstone lamellae within the stratiform Zn-Pb-Ag ores at HYC exhibit an isotopic range similar to that of the halo dolomites, suggesting that the ore and halo equilibrated with the same hydrothermal fluid.

Modeling of isotopic exchange accompanying fluid-rock interaction suggests that the halo dolomites equilibrated with low-temperature fluids (50°–120°C), which were enriched in $^{18}O$ ($\delta^{18}O$ = 5 ± 5‰) but with an average crustal carbon isotope signature ($\delta^{13}C$ = –6 ± 1‰). Our preferred interpretation is that the oxygen and carbon isotope halo at HYC is related to the development of an extensive brine pool. This pool was deepest in the vicinity of the HYC deposit adjacent to the Emu fault, and it became shallower to the southwest away from the fault. Using the carbon isotope fractionation equation between dolomite and $HCO_3^-$, it is possible to estimate the temperature variation at the base of the brine pool during the accumulation of the Barney Creek Formation. Brine pool temperatures were highest in and adjacent to the HYC deposit (40°–70°C) and decreased to values of 17° to 30°C remote from the deposit. These temperatures are similar to those recorded in the Red Sea brine pool associated with the Atlantis II metalliferous sediment deposit.

Based on our work at HYC and Lady Loretta, strata-bound $^{18}O$-enriched carbonate lithogeochemical halos may be a characteristic of the Proterozoic stratiform Zn-Pb-Ag deposits of northern Australia. These halos are more extensive than the narrow $^{18}O$-depletion halos recorded in dolomites surrounding skarn, Mississippi Valley-type and Irish-style Zn-Pb deposits. This fundamental difference in the isotopic halo characteristics of these groups of zinc deposits is probably related to the low-temperature, synsedimentary brine pool origin of the North Australian SEDEX deposits in contrast to the various replacement and open space fill origins of skarn, Mississippi Valley-type, and Irish-style deposits.