

## **Thermal and Isotopic Profiling of Hydrothermal Systems: Application to Mineral Exploration**

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New exploration techniques are vital to the search for new orebodies in mature terranes, as well as for extensions of existing orebodies. Low-temperature dating techniques (primarily apatite fission-tracks) and stable isotope measurements (carbon and oxygen in carbonate rocks) in and around the Pipeline deposit, Chukar deposit, and the Bald Mountain area illustrate that these techniques can provide exploration vectors that should be used in conjunction with other geologic, geochemical, and geophysical techniques in the exploration for Carlin-type (and other) deposits. At Pipeline, geochronometry and stable isotope measurements yield a clear indication of the elevated temperatures and fluid flows associated with the fossil hydrothermal system. The pattern is one of a central target (Pipeline deposit) with decreasing thermal and oxygen isotopic effects as far as several kilometers laterally from the known ore zone. Carbon isotopes do not show a pattern. Because of the irregular nature of fluid flow through fractures, a significant number of samples is required to discern this pattern, but the pattern is quite clear from the ~100 samples in and around the Pipeline pit. Both techniques provide a "footprint" of the Pipeline system that is several diameters larger than the ore zone (as presently known). Similar measurements of stable isotopic parameters at the Chukar deposit in the Carlin gold belt have been used to identify fluid flow paths at a somewhat smaller scale. Low oxygen isotope values correlate with elevated precious metals and trace elements, clearly indicating the paths of fluid flow and mineral deposition.

Although none of the isotopic and thermochronological techniques provide a direct indication of the metal content of the fossil hydro-thermal fluids, they do provide an indication of the robustness of fluid flow and the potential size of a hydrothermal system. In addition, the data for Pipeline suggest an age of the mineralization near 40 Ma, consistent with other Carlin-type deposits.