©2004 by Economic Geology
Vol. 99, pp. 789–806

Formation of a Paleothermal Anomaly and Disseminated Gold Deposits Associated with the Bingham Canyon Porphyry Cu-Au-Mo System, Utah

Charles G. Cunningham,†
U.S. Geological Survey, 954 National Center, Reston, Virginia 20192

Gerry W. Austin,
Kennecott Utah Copper Company, P.O. Box 232, Bingham Canyon, Utah 84006

Charles W. Naeser,
U.S. Geological Survey, 926A National Center, Reston, Virginia 20192

Robert O. Rye,
U.S. Geological Survey, MS-963, Box 25046, Denver Federal Center, Denver, Colorado 80225

Geoffrey H. Ballantyne,
Rio Tinto Technical Services, 5295 South 300 West, Suite 300, Murray, Utah 84107

Robert G. Stamm,
U.S. Geological Survey, 926A National Center, Reston, Virginia 20192

and Charles E. Barker
U.S. Geological Survey, MS-977, Box 25046, Denver Federal Center, Denver, CO 80225

Abstract

The thermal history of the Oquirrh Mountains, Utah, indicates that hydrothermal fluids associated with emplacement of the 37 Ma Bingham Canyon porphyry Cu-Au-Mo deposit extended at least 10 km north of the Bingham pit. An associated paleothermal anomaly enclosed the Barneys Canyon and Melco disseminated gold deposits and several smaller gold deposits between them. Previous studies have shown the Barneys Canyon deposit is near the outer limit of an irregular distal Au-As geochemical halo, about 3 km beyond an intermediate Pb-Zn halo, and 7 km beyond a proximal pyrite halo centered on the Bingham porphyry copper deposit. The Melco deposit also lies near the outer limit of the Au-As halo. Analysis of several geothermometers from samples collected up to 22 km north of the Bingham Canyon porphyry Cu-Au-Mo deposit indicate that most sedimentary rocks of the Oquirrh Mountains, including those at the gold deposits, have not been regionally heated beyond the "oil window" (less than about 150ºC). For geologically reasonable heating durations, the maximum sustained temperature at Melco, 6 km north of the Bingham pit, and at Barneys Canyon, 7.5 km north of the pit, was between 100°C and 140°C, as indicated by combinations of conodont color alteration indices of 1.5 to 2, mean random solid bitumen reflectance of about 1.0 percent, lack of annealing of zircon fission tracks, and partial to complete annealing of apatite fission tracks. The pattern of reset apatite fission-track ages indicates that the gold deposits are located approximately on the 120ºC isotherm of the 37 Ma paleothermal anomaly assuming a heating duration of about 10^6 years. The conodont data further constrain the duration of heating to between 5×10^4 and 10^6 years at approximately 120ºC. The $\delta^{18}O$ of quartzite host rocks generally increases from about 12.6 per mil at the porphyry to about 15.8 per mil approximately 11 km from the Bingham deposit. This change reflects interaction of interstitial clays in the quartzite with circulating meteoric water related to the Bingham Canyon porphyry system. The $\delta^{18}O$ and $\delta^{13}C$ values of limestone vary with respect to degree of recrystallization and proximity to open fractures. Recrystallized limestone at the Melco and Barneys Canyon gold deposits has the highest $\delta^{18}O$ values (about 30‰), whereas limestone adjacent to the porphyry copper deposit has the lowest values (about 10‰). The high $\delta^{18}O$ values for the recrystallized limestone at Barneys Canyon and Melco strongly suggest that mineralization was related to low temperature fluids with exceptionally high $\delta^{18}O_{H_2O}$ values such as could be derived from water in a crater lake of an active volcano.

The age of formation of the gold deposits has been interpreted to range from Jurassic to Eocene. The mineralized rocks at the Barneys Canyon and Melco deposits are likely the same age as the geochemically similar deposits that are present in north-striking, late faults that cut the Bingham Canyon porphyry. The patterns of apatite and zircon fission-track data, conodont color alteration indices, solid bitumen reflectivity, stable isotope

† Corresponding author: e-mail, cunningham@usgs.gov

data, and mineral zoning are consistent with the gold deposits being genetically related to formation of the 37 Ma Bingham porphyry deposit. We interpret the disseminated gold mineralization to be related to collapse of the Bingham Canyon hydrothermal system in which isotopically heavy, oxidizing, acidic waters, possibly from an internally draining acidic crater lake, mixed with and were entrained into reduced gold-bearing meteoric water fluids in the collapsing main-stage hydrothermal system. Most of this fluid mixing and cooling was probably located close to the hydrologic interface between the sedimentary basement rocks and overlying volcanic rocks.