MOL.20000913.0137

7/27/00

QA:NA

ISOTOPE GEOCHEMISTRY OF CALCITE COATINGS AND THE THERMAL HISTORY OF THE UNSATURATED ZONE AT YUCCA MOUNTAIN, NEVADA

MARSHALL, Brian D., bdmarsha@usgs.gov; WHELAN, Joseph F., U.S. Geological Survey, Federal Center MS 963, Denver, CO 80225-0046, USA

Calcite and opal coatings found on fracture footwalls and lithophysal cavity bottoms in the volcanic section at Yucca Mountain (exposed in a tunnel) contain a record of gradual chemical and isotopic changes that have occurred in the unsaturated zone. The thin (less than 6 cm) coatings are composed primarily of calcite, opal, chalcedony, and quartz. Fluid inclusions in calcite that homogenize at greater than ambient temperatures provide impetus for geochronologic studies in order to determine the thermal history. In the welded Topopah Spring Tuff (12.7 Ma), U-Pb ages of opal and chalcedony layers provide evidence of a long history of deposition throughout the past 10 m.y. However, these ages can constrain the ages of associated calcite layers only in samples with an easily interpretable microstratigraphy.

Strontium isotope ratios in calcite increase with microstratigraphic position from the base up to the outermost surface of the coatings. The strontium incorporated in these coatings records the systematic change in pore-water isotopic composition due to water-rock interaction primarily in the overlying nonwelded tuffs. A one-dimensional advection-reaction model simulates strontium isotope ratios measured in pore water extracted from core in three vertical boreholes adjacent to the tunnel. By calculating the strontium isotope compositions of the rocks at various past times, the model predicts a history of the strontium isotope ratios in the water that matches the record in the calcite and therefore provides approximate ages.

Oxygen isotope ratios measured in calcite gradually increase with decreasing model strontium age. Assuming that the oxygen isotope ratio of the percolating water was relatively constant, this trend indicates a gradual cooling of the rocks over millions of years, in agreement with thermal modeling of magma beneath the 12-Ma Timber Mountain caldera just north of Yucca Mountain. This model predicts that temperatures significantly exceeding current geotherm values occurred prior to 6 Ma. We find no evidence for Quaternary or recent thermal perturbations to the cooling rocks.