Revision following technical reviews and PDaddow review of 7/24/00

J.B. Paces 7/25/00

QA:NA

DEMONSTRATING SLOW GROWTH RATES IN OPAL FROM YUCCA MOUNTAIN, NEVADA, USING MICRODIGESTION AND ION-PROBE URANIUM-SERIES DATING

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Thinly laminated (<0.01 mm) opal sheets and globules associated with calcite in fractures and cavities in the unsaturated zone at Yucca Mountain, Nevada, have U concentrations of 50 to 300 ppm. Previous uranium-series thermal ionization mass spectrometry (TIMS) analyses of 0.2- to 1-mm-thick subsamples resulted in a model of slow mineral growth at rates of 0.5 to 5 mm/m.y. To test this growth model using finer sampling resolution, in situ microdigestions were performed by applying a drop of hydrofluoric acid directly to opal surfaces within a small area encircled by jeweler's wax. After several minutes, the liquid was removed, spiked with a tracer solution, and analyzed by TIMS for both U and Th using a single rhenium filament with colloidal graphite. Solutions contained about 0.5 nanograms of U, equivalent to opal weights of 1 to 10 micrograms and dissolved-layer thicknesses less than 0.003 mm. Microdigested opal surfaces have Th-230/U ages of 5 to 10 thousand years (ka) in contrast to much older ages of 150 to 250 ka obtained previously from whole-globule digestions.

Additional tests of the growth model were made on cross sections of identical opal globules using the sensitive high-resolution ion microprobe (SHRIMP) with a 0.04-mm-diameter O-minus primary beam. Counting rates for ThO-246 and U-234 varied between 5 and 70 counts per second with Th-230/Th-232 activity ratios typically much greater than a million. The Th-230/U ages in the outer 0.3 mm of the globules ranged from about 30 ka at the outer edge to 400 ka at depth. Ages correlate with microstratigraphic depths and indicate average growth rates between 0.5 and 0.7 mm/m.y. Current U-series data do not resolve differential growth rates related to climate changes during this time period. However, both microdigestion and SHRIMP results confirm the previous TIMS-based model of slow, uniform rates of mineral growth in a hydrologically stable environment.