OPAL AS A URANIUM-LEAD GEOCHRONOMETER. Yu. Amelin[1], and L. A. Neymark[2], [1]Department of Earth Sciences, Royal Ontario Museum, Toronto, Ontario M5S 2C6, Canada (yuria@rom.on.ca), [2]Mail Stop 963, Pacific Western Technologies, DFC, Denver CO 80225, USA (lneymark@usgs.gov).

Introduction: Records of ancient water flow in arid environments are preserved in precipitated from ground water mineral crusts, composed largely of calcite and amorphous silica (opal and chalcedony). These minerals have been dated by the ^{14}C and $^{230}Th/U$ methods [1]; however these methods are limited to ages ≤50 ka and ≤500 ka, respectively. The U-Pb system in opal and chalcedony allows dating in the age range from ~50 ka to millions of years and older [2,3]. For opals younger than ca. 500 ka it is possible to apply combined U-Pb and $^{230}Th/U$ dating to the same materials, thus allowing better evaluation of closed system conditions, determination of initial $^{234}U/^{238}U$ ratios, and examination of continuous vs. episodic growth of opal [4].

Recently, U-Pb dating of opal has been used to study paleohydrology at Yucca Mountain, Nevada, a potential site for high-level radioactive waste repository [3,4]. Further application of this geochronometer requires evaluation of its robustness in a series of experiments with large homogeneous opal samples, some of which may subsequently be used as standard samples. We have selected three large (ca. 1-20 g) opal samples from the mineral collection of the Royal Ontario Museum and studied their U-Pb and ^{230}Th-U systems.

Samples and methods: Two of the analyzed opal samples are visually homogeneous; one of them (E1989) is clear, another one (M21277) is translucent. The third sample (M21006) comprises a translucent opal matrix with clear opal veins. All three samples show relatively bright green fluorescence in short-wave UV light.

Combined U-Pb and $^{230}Th/U$ isotopic determinations [4] were made from single small (1.5-8.1 mg) digestions spiked with a mixed ^{205}Pb-^{229}Th-^{233}U-^{236}U tracer solution of high isotopic purity. U, Th, and Pb concentrations and $^{234}U/^{238}U$, $^{230}Th/^{238}U$, $^{206}Pb/^{238}U$, and $^{207}Pb/^{235}U$ ratios were determined simultaneously. Procedure blanks were 1.0-1.5 pg Pb, and about 2 pg ^{238}U and ^{232}Th.

Results: Uranium concentrations vary from 2.2 to 850 ppm, Th from 0.015 to 350 ppb, and common Pb from 7 to 500 ppb. The $^{238}U/^{204}Pb$ ratios are from $8.8*10^4$ to $2.8*10^6$. Variations of U concentrations of 2-4 times are observed in all three samples. In all cases fractions with brighter fluorescence in UV light have higher U concentrations.

Pb isotopic compositions are radiogenic with measured $^{206}Pb/^{204}Pb$ between 100 and 1000, and $^{207}Pb/^{204}Pb$ between 20.2 and 62. The $^{207}Pb/^{235}U$ ages of two homogeneous opals are 15.3 Ma for E1989 and 2.20 Ma for M21277 and are reproducible between fractions. Errors of $^{207}Pb/^{235}U$ ages are between 1.4-5.6% (2σ). The heterogeneous sample M21006 yielded a $^{207}Pb/^{235}U$ age of 8.83±0.07 Ma for the matrix, and 2.71±0.02 Ma for the vein.

All fractions have $^{206}Pb/^{238}U$ ages slightly older than $^{207}Pb/^{235}U$ ages. This reverse discordance may indicate that all studied opals precipitated from water with elevated $^{234}U/^{238}U$ activity ratio. The measured $^{230}Th/^{238}U$ and $^{234}U/^{238}U$ ratios in all fractions are in secular equilibrium, thus suggesting that the U-Th (and presumably U-Pb) isotopic systems have not been disturbed during the last 500 ka.

Discussion: The results of this study, together with previously published data from Yucca Mountain [3,4] and the earlier study by Ludwig et al. [2] suggest that opal is a promising U-Pb and U-series chronometer. Using these methods in combination is essential for both "young" samples with disequilibrium $^{230}Th/^{238}U$ and $^{234}U/^{238}U$, and "old" ones in secular equilibrium. In the latter case the classical concordia diagram cannot be used as a check for closed system behavior because of unknown initial excess of ^{234}U.

Ages of "old" opals can be determined from $^{207}Pb/^{235}U$ ratios that are not affected by initial uranium isotopic disequilibrium. The $^{207}Pb/^{235}U$ ratios are much more sensitive to common Pb correction than the $^{206}Pb/^{238}U$ ratios, therefore low analytical blank and finding opals with low common Pb are crucial. One problem that remains to be solved is finding low-U/Pb mineral phases cogenetic with opal, which Pb isotopic composition can be used for the common Pb correction.

The first data from the three large opal samples suggest that some of these or similar samples can be possibly used as interlaboratory standards if U-Pb dating of opal becomes a commonly used technique.

References: [1] Paces J. B. et al. (1996) *GSA Abstr. Progr. 28(7)*, A-139. [2] Ludwig K. R. et al. (1980) *EPSL, 46*, 221-232. [3] Neymark L. A. et al. (1998) *Mineral. Mag. 62a*, 1077-1078. [4] Neymark L. A. et al. (1997) *EOS 46(18)*, F788.