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Rare accessory uraninite in a Sierran granite

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Abstract

Uraninite occurs as a minor accessory constituent in a Sierran granite. The mineral is rare; one grain was found in a single thin-section, and no further uraninite has been noted in heavy mineral concentrates from other rocks of the local area. Electron and ion microprobe analysis gives UO_2 85.4, ThO_2 6.8, PbO_2 1.8, Y_2O_3 1.7, Nd_2O_3 0.6, and H_2O 3.0, sum 99.3 weight percent. UO_3 could not be analyzed directly, but approximate cell-edge data suggest $UO_{2.15}$ as a composition. Because additional possibly uranium-bearing minerals (*e.g.*, zircon, apatite, allanite) are present in the rock, it seems unusual that a discrete uranium-rich mineral should coexist with them. The U–Pb age calculated for the uraninite is, however, not greatly different from the K–Ar age of the unit in which it occurs; it therefore is suggested that the mineral is primary and not reworked from a preexisting rock.

The uraninite was found in a granitic sample collected a few miles northwest of the center of the Bass Lake 15′ quadrangle, Mariposa County, in the southwest part of section 10, T6S, R21E (lat. 37°25′, long. 119°40′). A previous study (Snetsinger, 1966) of heavy minerals from granite rocks of surrounding areas did not detect uraninite as an accessory, although it would easily have been noted as the only opaque mineral in the nonmagnetic heavy fraction. The rock in which uraninite occurs was not included in the initial accessory mineral study; uraninite was identified in it only recently in thin section, and then tentatively verified by X-ray methods in heavy concentrates from the rock.

Although uraninite has been noted in scattered pegmatitic concentrations elsewhere in the Sierras, this is believed to be its first occurrence as a minor accessory mineral in an otherwise ordinary intrusive rock. The rock is a biotite granodiorite which is a southern member of the Yosemite-type intrusive rocks, as shown on the map of Evernden and Kistler (1970, plate 1). Brown biotite forms a planar fabric in the rock. Accessory zircon and apatite are common as inclusions in the biotite. Sphene and allanite are closely associated with the mica, but not included in it. The uraninite occurred in biotite, in apparent contact with a large (200 micron) apatite grain. The uraninite grain was equant, somewhat rounded, and 50 microns in diameter. It formed, according to the classification by Gentry (1973), a ^{238}U halo in the biotite. After removal of the thin-section cover slip, the underlying rock slice was polished for electron and ion microprobe work. Analysis of the uraninite gave UO_2 85.4, ThO_2 6.8, PbO 1.8, Y_2O_3 1.7, Nd_2O_3 0.6, and H_2O 3.0, sum 99.3 weight percent. With the exception of hydrogen, these values are fully-corrected ARL-EMX electron-probe results. Hydrogen was done with an ion probe (an ARL-IMMA instrument), and owing to standardization problems, a ±30 percent error is possible here. On a basis of 4.00 oxygens, the water-free analysis recalculates to $U_{1.73}Th_{0.14}Pb_{0.04}Y_{0.09}Nd_{0.02}O_4$. Ion-probe work showed that in addition to the major elements, small amounts (less than about 0.1 percent) of Ca, Na, Mg, Al, Si, K, Ti, Mn, Fe, Co, Ba, La, Pr, Ce, Sm, Eu, and Li were present; Zr and He were not noted. Although a local area of somewhat higher concentration of Y was seen in the uraninite grain during ion probe analysis, neither this nor any other zoning effect was found by electron probe. UO_3 could not be

measured directly, but Brooker and Nuffield (1952) have found that the cell edge of pure pitchblende decreases with increasing UO_3 content because of the smaller size of the six-valent as compared with the four-valent uranium ion. Therefore attempts were made, using magnetic separation and heavy liquids (including Clerici solution) to concentrate uraninite from the rock for X-ray study. In one of several such attempts a few spotty lines, tentatively attributed to uraninite, were observed in a film pattern. This would suggest the uraninite is not completely metamict, but the spots were so coarsely distributed that centers of arcs could only be estimated, and the *d* spacings obtained were only approximate. They yielded $a = 5.45 \pm 0.01$ A (compared to 5.47 A for pure UO_2), which according to a plot given by Brooker and Nuffield (1952, Fig. 22) would give $UO_{2.15}$ as a composition. But these authors considered only pure pitchblende and uraninite in their study, whereas the Sierran uraninite contains other elements besides uranium. In view of this and the uncertainty of the X-ray data, it can only be mentioned that this uraninite probably contains UO_3, the amount being in doubt. An attempt was made to refine this by lifting out the actual grain analyzed and X-raying it, but unfortunately the grain was lost.

The apparent age of this uraninite, using the simplified U–Pb method of calculation (Rankama, 1954, p. 377) is 160 million years, analytical uncertainties giving rise to approximately a ±10 percent error in this value. Although strictly speaking it may not be proper to compare U–Pb with K–Ar ages, and the uraninite age is not especially accurate, the uraninite does appear to be comparable in age to the biotite–hornblende K–Ar age of a nearby (six miles due south) portion of this same granodiorite. The biotite in that rock yields 104 m.y., while hornblende gives 144 m.y. (Evernden and Kistler, 1970); as the hornblende and biotite ages are discordant, 144 m.y. is a minimum age, and the actual figure may be nearer that of the uraninite. It is also possible the uraninite is really somewhat younger than calculated because, though the rock in which it occurs seems perfectly fresh, Stuckless *et al.* (1975) have shown that even the slightest weathering of granites may cause some loss of uranium, and this would result in a high age in the present case.

Regarding origin of the uraninite, if the mineral were appreciably older than the host unit, "reworking" of the mineral from a preexisting rock would be indicated. Although the above calculated ages do not allow definite conclusions, there is at least no reason to assume from the data that any great incompatability exists. It therefore seems possible the uraninite crystallized in the rock in which it occurs. Although the grain is somewhat rounded, suggesting resorption, such a reaction could have taken place after crystallization in the host granodiorite, and need not indicate reworking. Furthermore, no evidence of reworking exists in the accompanying major or accessory minerals. As against a primary origin, however, zircon, sphene, allanite, and apatite, all of which may accommodate uranium, coexist with uraninite in this granodiorite, and all have, with the exception of sphene, been shown to contain small amounts of uranium in their occurrences in nearby rocks (Snetsinger, unpublished Ph.D. thesis, 1966). It seems unusual that a uranium mineral should form in the presence of other accessories which could have absorbed the presumably small amount of uranium available. On the other hand, some feature of the environment during crystallization of the granodiorite may have allowed uraninite to form with, and coexist with, other possible uranium-bearing accessories. Without stability data for uraninite in a complex silicate melt, it is difficult to be precise about this. We tentatively suggest that the uraninite crystallized in the granodiorite melt and was not reworked from a preexisting rock.

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