Metamict Fergusonite-(Y) in a Spessartine-Bearing Granitic Pegmatite from Adamello, Italy

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A granitic pegmatite, which is associated with the Monte Bruffione granodiorite (Adamello Massif, Italy), consists primarily of albite, potassium feldspar, muscovite, quartz, and spessartine. The pegmatite contains the following accessory minerals: magnetite, pyrophanite, monazite-(Ce), uraninite, xenotime-(Y), zircon, and fergusonite-(Y). This yttrium niobate mineral holds inclusions of Th-rich uraninite, and is itself rich in UO_2 (average 7 ± 1 wt%, n=34) and ThO_2 (average 4 ± 1 wt%). Many fergusonite crystals display growth zoning, characterized by a general increase towards the rim in the contents of Y and REE at the expense of U and Th. Irregular or patchy zoning as well as sector zoning are also observed in some of the crystals. Due to the alpha-decay of the U and Th hosted by fergusonite, the mineral is metamict, as documented by transmission electron microscopy (TEM) and micro-Raman spectroscopy. Nevertheless, the mineral could be identified as fergusonite-(Y) on the basis of a canonical discriminant analysis of its chemical composition and on the basis of the close similarity of its Raman spectrum with that of a reference *beta*-fergusonite. The crystalline-to-metamict transition was associated with macroscopic swelling, as indicated by microfractures that are arranged radially around fergusonite inclusions in pyrophanite. The TEM data revealed that the amorphous fergusonite contains U-rich nanocrystals (5-15 nm across), which in most cases are distributed randomly and which probably nucleated after metamictization. The TEM investigations further revealed the ubiquitous presence of nano-sized, nearly circular features, which are typically 5-25 nm across and which exhibit a low diffraction contrast. We interpret these low-contrast circular features as nanopores and propose that they represent former bubbles of radiogenic He. The data presented here allowed us to determine that the critical amorphization dose of fergusonite is $\leq 0.97 \times 10^{16}$ alphas/mg, i.e., lower than that of other actinide-rich oxide minerals (e.g., pyrochlore). The presence of the U-rich nanocrystals indicates that fergusonite is able to retain actinides even when it is entirely metamict and even if it is surrounded by microfractures, which represent potential fluid pathways.

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