ACTINIDES IN GEOLOGY, ENERGY, AND THE ENVIRONMENT

Cabvinite, Th$_2$F$_7$(OH)$_3$·3H$_2$O, the first natural actinide halide

PAOLO ORLANDI$^1$, CRISTIAN BIAGIONI$^{1,*}$, AND FEDERICA ZACCARINI$^2$

$^1$Dipartimento di Scienze della Terra, Università di Pisa, Via S. Maria 53, I-56126 Pisa, Italy
$^2$Resource Mineralogy, University of Leoben, Peter Tunner Str. 5, A-8700 Leoben, Austria

ABSTRACT

The new mineral species cabvinite, Th$_2$F$_7$(OH)$_3$·3H$_2$O (IMA 2016-011), has been discovered in the Mo-Bi ore deposit of Su Seinargiu, Sarroch, Cagliari, Sardinia, Italy. It occurs as white square prismatic crystals, up to 100 μm in length and 40 μm in thickness, associated with brookite and iron oxy-hydroxides in vugs of quartz veins. Electron microprobe analysis gave (mean of five spot analyses, in wt%): ThO$_2$ 82.35, F 19.93, H$_2$O$_\text{calc}$ 10.21, sum 112.49, O=F –8.40, total 104.09. On the basis of 2 Th atoms per formula unit, the empirical formula of cabvinite is Th$_2$F$_7$(OH)$_3$·3H$_2$O. Main diffraction lines in the X-ray powder diffraction pattern are [d (Å) (relative visual intensity) hkl]+: 8.02 (ms) 110; 3.975 (s) 121,211; 3.595 (m) 310,130; 2.832 (m) 400,321,231; 2.125 (m) 402; 2.056 (m) 332; and 2.004 (ms) 440,521,251. Cabvinite is tetragonal, space group $I4/m$, with $a = 11.3689(2)$, $c = 6.4175(1)$ Å, $V = 829.47(2)$ Å$^3$, $Z = 4$. The crystal structure has been solved and refined to $R_I = 0.021$ on the basis of 813 reflections with $F_0 > 4σ(F_0)$. It consists of Th trigonal prismatic prisms, connected through corner-sharing, giving rise to a framework hosting [001] tunnels. Cabvinite is the first natural actinide halide, and the site of discovery appears to provide a natural laboratory for the study of Th mobility and sequestration.

Keywords: Cabvinite, halide, thorium, fluorine, crystal structure, Su Seinargiu, Sardinia, Italy

INTRODUCTION

Actinide mineralogy is an interesting research field, owing to several applications of Th and U in geoscience and their technological importance, related both to the nuclear power production and to the management of nuclear wastes. Whereas uranium forms more than 250 different mineral species, only a few minerals having Th as an essential component have been described (e.g., Hazen et al. 2009). In addition, these species belong to only some classes, i.e., oxides, carbonates, phosphates, and silicates (Table 1). Recently, advance in the knowledge of Th mineralogy has been achieved through the study of the mineral assemblages occurring at the small Mo-Bi prospect of Su Seinargiu, Sarroch, Cagliari, and Sardinia, Italy, with the description of the first natural thorium molybdates.

Su Seinargiu, with more than 60 different mineral species so far reported (Orlandi et al. 2015a) and 12 distinct Mo minerals described, can be considered as a reference locality to study Mo mineralogy. Indeed, among these 12 Mo minerals, 7 have their type locality at Su Seinargiu, i.e., the Bi-Mo oxides sardignaite, gelosaita, and mambertiite (Orlandi et al. 2010, 2011, 2015b), the REE molybdate tancaite-(Ce) (Bonaccorsi and Orlandi 2014, 2015c), and the two thorium molybdates ichnusaite, Th(MoO$_4$)$_2$·3H$_2$O, and nuragheite, Th(MoO$_4$)$_2$·H$_2$O (Orlandi et al. 2014, 2015d). The finding of the first two natural thorium molybdates focused our attention on Th minerals, with the identification of other phases (thorbastnäsite, thorite; Orlandi et al. 2015a) and the first natural thorium halide, cabvinite, herewith described.

This new mineral species (IMA 2016-011) and its name were approved by the IMA-CNMNC. The holotype material of cabvinite is deposited in the mineralogical collections of the Museo di Storia Naturale, University of Pisa, Italy, under catalog number 19711. The name honors two Italian mineral collectors, Fernando Caboni (b. 1941) and Antonello Vinci (b. 1944), for their contribution to the knowledge of the Su Seinargiu mineralogy. Cabvinite is the acronym after their surnames, CABoni and VINci.

OCCURRENCE AND MINERAL DESCRIPTION

Cabvinite was identified on only two small specimens from the Su Seinargiu prospect, Sarroch, Cagliari, Sardinia, Italy. The Mo-Bi mineralization is hosted within Variscan leucogranites (Cabi et al. 1978; Ghezzo et al. 1981), and it is dated to 288.7 ± 0.5 Ma on the basis of the Re-Os age of molybdenite (Bon et al. 2003). Several Mo mineralizations are associated with Variscan leucogranites in Sardinia (Ghezzo et al. 1981) and Su Seinargiu is one of the smallest prospects. Curiously, Caboi et al. (1978) stated that a peculiar feature of the Su Seinargiu Mo-Bi mineralization was related to the small number of different mineral species, with the mineral assemblage formed exclusively by quartz and molybdenite, with trace amounts of chalcopyrite, pyrite, “wolfamite,” and yellow ochres of Mo. On the contrary, a careful investigation of the Su Seinargiu mineralogy pointed out an outstanding mineral variety, with more than sixty different species, among which are unusual Bi-Mo-Th compounds (e.g., Orlandi et al. 2015a). The majority of these minerals seems to be related to the alteration (probably a low-$T$ hydrothermal...