

Sodium-zippeite from Geevor mine, St. Just, Cornwall

SODIUM-ZIPPEITE, $\text{Na}_4(\text{UO}_2)_6(\text{SO}_4)_3(\text{OH})_{10} \cdot 4\text{H}_2\text{O}$, is the most common member of the zippeite group which includes six naturally occurring hydrated basic uranyl sulphates, distinguished by the monovalent or divalent cations they contain. Zippeite itself is the potassium form, $\text{K}_4(\text{UO}_2)_6(\text{SO}_4)_3(\text{OH})_{10} \cdot 4\text{H}_2\text{O}$.

The name 'zippeite' was first applied by Haidinger (1845) to an earthy yellow uranyl sulphate from Joachimsthal, Czechoslovakia, which had earlier been described by John (1821). However, the presence of potassium as an essential cation was not recognised, nor were the other group members described, until the comparatively recent work of Frondel *et al.* (1976). The early nomenclature and mineralogy of zippeite and related minerals were confused owing to difficulties in their study (Frondel, 1952; 1958; Frondel *et al.*, 1976). British records of 'zippeite' prior to 1976 (e.g. Greg and Lettsom, 1858; Collins, 1871; Dines, 1930; James, 1947; Robson, 1948) should be regarded as references to unspecified minerals, either of the zippeite group, or merely of zippeite-like appearance. The crystallography of the group remains poorly characterised (Smith, 1984).

Zippeite and sodium-zippeite are the only members with a monovalent cation and only limited substitution between the K and Na members occurs (Frondel *et al.*, 1976).

In the course of several visits to Geevor mine during the early part of 1991, zippeite-like minerals were collected from a number of underground locations. Samples representing a range of habits and colours from the various locations were examined by energy-dispersive X-ray analysis and X-ray diffractometry. All specimens were confirmed to be sodium-zippeite and no other members of the zippeite group were identified. The habits and mineral associations of the sodium-zippeite were rather variable and are discussed by location below.

14 Level, No. 2 Branch. Pale lemon-yellow sodium-zippeite from this location occurred on a granitic matrix (largely quartz and orthoclase) in the roof of a drive along the lode, generally forming masses of broad, but extremely thin, translucent, interlocking leaves of indistinct

shape (Fig. 1), but also as stouter laths and spindles. Associated minerals included gypsum, atacamite, chalcocite and brochantite. On some specimens, johannite underlay sodium-zippeite, and on one of these, antlerite was observed as a powdery blue-green deposit on the matrix.

16 Level, Hanging Wall Vein West. Here sodium-zippeite occurred as a cream-yellow efflorescence composed of minute tabular crystals (similar to Fig. 2), following joints in altered killas. Spots of chalcopyrite occurred within the killas. Gypsum was abundant and some of the sodium-zippeite was found intergrown with small aggregates of atacamite crystals.

17 Level, Peeth Lode. An area along the drive on Peeth lode, close to the intersection with Whiskey Central lode, was particularly rich in secondary uranium minerals. The distribution of species was zoned along the drive, extending over a distance of approximately 20 m. Schröckerite and andersonite occurred towards the western end of the mineralised area (Elton and Hooper, 1992). These species were generally not observed in close association with other uranium minerals, although scattered blobs of sodium-zippeite were seen on one or two specimens. Around the centre of the area, johannite occurred in close association with sodium-zippeite which was present in two habits: small pale-yellow globular aggregates of randomly orientated acicular crystals of indistinct shape, and as radiating groups of thicker, darker laths. The matrix was typically quartz vein material spotted with sulphide minerals (mainly chalcopyrite), with gypsum as a common associate. Further east along the drive, sodium-zippeite was found on the joint planes of unaltered granite forming bright lemon-yellow mats and spherules, composed of short indistinct spindles, widely scattered over the surface of the granite. Johannite also occurred in this area, together with a finely crystallised, but unidentified, hydrated sodium uranyl sulphate. However, these species were not frequently accompanied by sodium-zippeite.

17 Level, Levant North Lode East (No. 2 Branch, adjacent to 17W3 cross-cut). This location produced sodium-zippeite in the widest range of

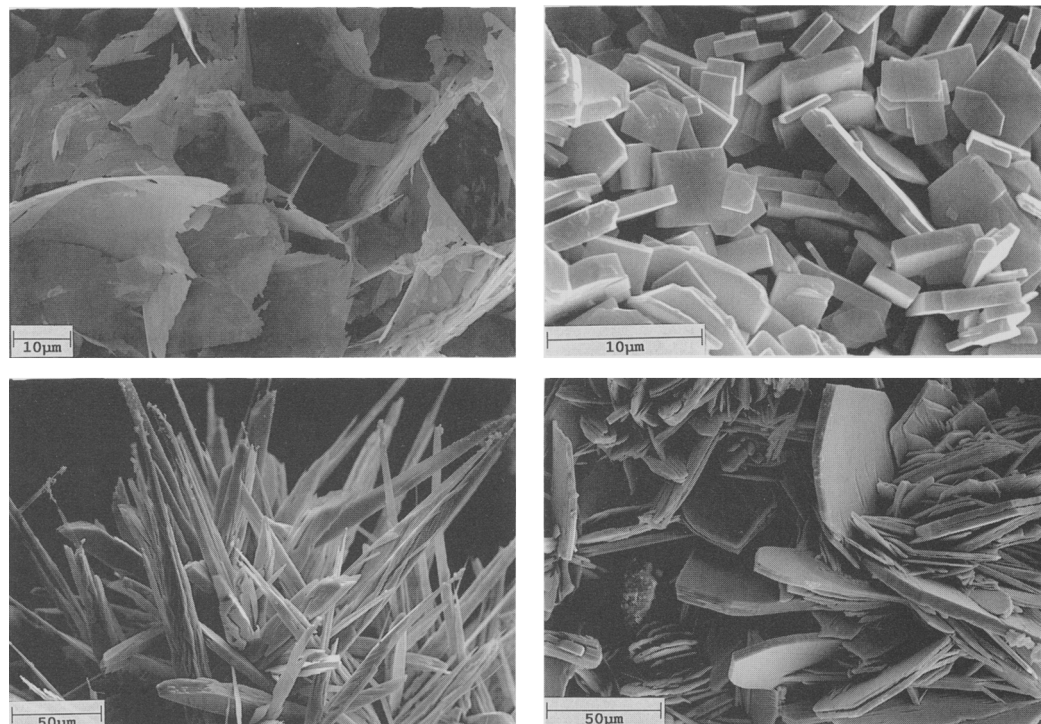


FIG. 1. (Top left). Intergrown mass of extremely thin and indistinct leaves of sodium-zippeite. 14 level, no. 2 branch, Geevor mine. FIG. 2 (Top right). Tabular crystals of sodium-zippeite forming powdery deposits. 17 level North lode, Geevor mine. FIG. 3 (Bottom left). Divergent group of tapering laths and parallel aggregates of poorly terminated laths of sodium-zippeite. 17 level North lode, Geevor mine. FIG. 4 (Bottom right). Intergrowth of tabular crystals of sodium-zippeite. 17 level North lode, Geevor mine.

habits and colours. Specimens were collected from a small area of partially altered and collapsed wallrock, traversed by a narrow vein carrying various sulphide minerals, notably chalcocite, but also chalcopyrite, and more rarely, arsenopyrite. Most of the sodium-zippeite was found on a matrix of quartz and pinky-red orthoclase and occurred as intergrowths of fine translucent, petal-shaped laths to around 1 mm, forming booklets and 'desert rose' aggregates. It was found also as sprays of very fine narrow laths and spindles (Fig. 3) and as stacks of stout plates (Fig. 4). On a few specimens, sodium-zippeite also occurred in an opaque earthy form composed of microcrystalline tablets (Fig. 2). Sodium-zippeite frequently encrusted atacamite, but many specimens also showed small crystals of atacamite scattered over the sodium-zippeite. In addition to the minerals noted above, gypsum, chalcantite, brochantite, antlerite, and rarely, metazeunerite and scorodite, were also recorded from the same area (approximately 3 m in extent).

Fron del *et al.* (1976) contrasted the 'yellow' colour of sodium-zippeite with the 'golden-yellow' colour of zippeite. The colour of the Geevor sodium-zippeite varied from lemon-yellow to orange-yellow. The colour of powdered material was more consistent, and some of the apparent colour variation of the crystallised material appears to be due to variations in matrix colour and transparency of the crystals. The orange-yellow colour of certain crystals, notably vermicular aggregates of thin tabular crystals from North Lode, can be attributed to a light staining of iron oxide.

The areas described above are all on levels which extend beneath the seabed. Percolating water in the mine at these levels is very saline, creating an abundance of sodium ions. This may explain the apparent absence of zippeite proper. Fron del *et al.* (1976) observed that zippeite placed in a concentrated solution of NaCl slowly recrystallises to sodium-zippeite, the reaction being irreversible. The copper chlorides, atacamite, and less commonly, paratacamite were

observed in close association with the sodium-zippeite on several specimens and are probably derived from the action of salt water on primary sulphides. Botallackite was also recorded within the mine, but not in association with sodium-zippeite.

Gypsum, johannite and andersonite have been found associated with sodium-zippeite at other localities (Fron del *et al.*, 1976). Synthesis and stability studies show that andersonite is only stable when the activity of Na is very high and that of Ca and Mg very low (Alwan and Williams, 1983). It is likely that such conditions within Geevor mine would favour the formation of sodium-zippeite rather than zippeite.

Samples of sodium-zippeite have been lodged with The Natural History Museum, London.

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Cordierite–K-feldspar–quartz–orthopyroxene symplectite from southern Algeria: new evidence for osumilite in high-grade metamorphic rocks

IN recent years, osumilite, $(K,Na)(Mg,Fe,Mn)_2(Al,Mg,Fe^{3+})_3(Si,Al)_{12}O_{30}$, has been reported from a number of high-temperature granulite facies terranes (for example, Berg and Wheeler, 1976; Ellis *et al.*, 1980; Grew, 1982a; Arima and Gower, 1991). In addition, there are a few localities where osumilite is thought to have been stable as evidenced by its characteristic

breakdown products (Ellis *et al.*, 1980; Grew, 1982b; Nicollet, 1988). In this paper, a new occurrence of this type is reported in granulite facies rocks from the In Ouzzal block, southern Algeria. The stability of the primary mineral association involving osumilite is then discussed in the light of preliminary experimental results in the KFMAS system.