

angle and bond length distortions may be tested by established statistical procedures. Two examples are given below:

For $M(1)$ and $M(2)$ site coordination octahedra in $\alpha\text{-Co}_2\text{SiO}_4$ (olivine structure type), σ^2 (Morimoto, Tokonami, Watanabe, and Koto, 1974) is 114.5 and 97.7 respectively, and Δ is 0.000277 and 0.001076 respectively. Thus, the $M(1)$ site has a slightly greater bond angle distortion but a markedly less bond length distortion.

Δ parameters for a variety of T site tetrahedra in feldspars have been calculated from the data organized by Smith (1974, Table 4-2) and are compared in fig. 3 with σ^2 parameters calculated from Smith's data (Table 4-5). Using all of the data as one population, Δ is essentially independent of σ^2 . However, distinct and characteristic fields are evident for many of the minerals and mineral groups recognized, for example, for celsian and anorthite. Thus, although the Δ values are numerically small compared to data for polyhedra showing pronounced bond length variations, as in Jahn-Teller distorted CuII salts, they are nevertheless quite significant.

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An occurrence of vesigniéite in Leicestershire

IN 1968 an inclined road was driven on the north-eastern face of Newhurst Quarry, near Shepshed (SK 488179), to provide access to new lower working levels.

Towards the top of this incline a number of hypogene copper-rich quartz-carbonate veins were cut. These veins, confined to one of three large north-westerly-trending shear zones, connected with late movements in the so-called Long Cliff Reversed Fault System (Watts, 1947), were here seen cutting intrusive granophyric diorite

(Snowball, 1952) and hornfelsed fine-grained volcanic tuffs, the Blackbrook Beds, of the Charnian Succession (Watts, 1947).

Primary copper minerals in the veins consisted of an intimate association of bornite, chalcocite, and chalcopyrite. As the working face was cleared horizontal mineralogical zonation within individual veins became apparent: bornite–chalcocite above, giving way below to chalcopyrite, with galena at the visible base, all set in a gangue of quartz and ferroan dolomite.

The upper portions of these veins had been subjected to strong supergene processes and a boxwork structure of oxidized copper salts and goethite with relic sulphides was commonly all that remained of the original bornite–chalcocite association. It is possible that this modification took place in Middle Keuper time, for the veins have been planed off below a visible thickness of 7.2 m of unconformably overlying sandstones and mudstones of the Waterstones Formation (Warrington, 1970). There is

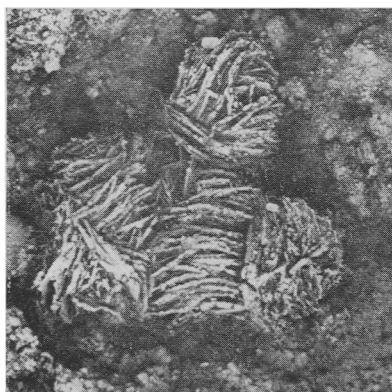


FIG. 1. Rosettes of crystals of vesigniéite in a cavity of oxidizing bornite. The upper rosette is 1.9 mm in diam.

crystal plate width observed was 2.1 mm, and the crystal thickness did not exceed 0.4 mm.

A few crystals of vesigniéite separated from the oxidized bornite–chalcocite veins were powdered and mounted on a glass fibre. The powder photograph¹ obtained confirmed the initial identification of vesigniéite, comparing very well with a similar photograph obtained for vesigniéite at the British Museum, London.² The measured values, obtained for the *d* spacings of the specimen, after a small correction for film shrinkage, also gave good agreement with those obtained for vesigniéite by Guillemin (1956).

A Joyce-Loebl MK III double-beam recording microdensitometer was used to obtain numerical intensity values for the reflections. A few discrepancies between the intensity data of this study and that of Guillemin were noted. We find the 3.45 Å and 2.95 Å (Guillemin 3.47 Å and 2.97 Å) reflections about equal in intensity (25 % of the

also evidence of re-cycling and re-precipitation of copper salts at the unconformity and below it in the production of mineralized pipe-like bodies, within the underlying igneous and meta-volcanic rocks, filled with Charnian and Triassic debris.

In the cavities of the oxidized bornite–chalcocite veins tiny rosettes (up to 2.4 mm in diameter) of thin tabular crystals in sub-parallel orientation, yellowish-green in colour (30B6—Kornerup and Wanscher, 1967) of vesigniéite, $\text{Cu}_3\text{Ba}(\text{VO}_4)_2(\text{OH})_2$, were found dispersed on the corroded surfaces (fig. 1).

No distinct form of individual crystal was apparent due to the development of a multiplicity of vicinal faces and polysynthetic twinning, though roughly hexagonal outlines were visible towards the edges of the rosettes. Maximum

major 3.21 Å reflection) and weaker than the 2.56 Å reflection (intensity 50), whereas Guillemin quotes these as having intensities of 10, 50, and 50 respectively. We also find the 2.71 Å (Guillemin 2.72 Å) intensity about equal to that of the 2.56 Å reflection with a value of 50, compared with values of 75 and 50 respectively by Guillemin. These discrepancies in reflection intensities are almost certainly due to differing degrees of preferred orientation of the crystallites.

The Leicestershire material, though more strongly developed, resembles that described by Guillemin from Friedrichrode in the Thüringer Wald of East Germany (1955 and 1956). Unlike Guillemin's descriptions, the local occurrence shows no association of vesigniéite with malachite, carbonates being completely absent from the material examined. Guillemin's descriptions of material from Perm and Agalik in the U.S.S.R., possibly also from the Colorado Plateau Area of the U.S.A., and from Marchand in Morocco, on the other hand, are dissimilar, the vanadates being confined to arenaceous deposits. All are, however, the product of supergene activity.

The writers consider it likely that the source of both barium and vanadium is the overlying sediments of the Waterstones Formation. Baryte is present as the cementing agent of certain sandstone bands, while dispersions of wad carrying traces of vanadium frequently coat the upper surfaces of mudstone units in the same Formation, and strong concentrations of wad occur below the unconformity in the pipe-like bodies.

Johan (1960) reported the occurrence of vesigniéite as the weathering product of vanadium-rich cuprite in northern Bohemia. It may be significant to note that vanadium-rich cuprite is known in Triassic sediments at Bardon Hill, 5.5 km to the south-west of Newhurst Quarry (King, 1967). No cuprite has to date been found at Newhurst Quarry, though its common associate, native copper, has been recorded (King, 1967).

As far as the writers can ascertain this is the first known occurrence of vesigniéite in the British Isles.

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¹ X-ray powder diffraction photograph 504, X-ray Diffraction Film Library, Geology Department, University of Leicester; 57.3 mm radius camera, Cu-K radiation.

² BM 1964, 773, Vesigniéite. Monument No. 2 Mine, Navajo Co., Arizona, U.S.A. Film No. 2142 F.

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