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Queitite, a mineral new to Britain, from the Caldbeck Fells, Cumbria

QUEITITE, $Pb_4Zn_2(SO_4)(SiO_4)(Si_2O_7)$, was first described by Keller *et al.* (1979) from a single find from Tsumeb, Namibia, where it is associated with willemite, melanotekite, alamosite, larsenite, leadhillite and quartz. The mineral may also occur at Tombstone, Cochise County, Arizona, USA, since specimens from this locality are listed in a mineral dealer's catalogue. However, this occurrence is otherwise unrecorded and unconfirmed.

In 1987 queitite was identified on a small specimen from the dumps of the Old Dutch (or No. 2) level of the Red Gill mine, Caldbeck Fells, Cumbria (NGR NY 298 357). The specimen was collected by Dr M. Rothwell of Liverpool and brought to the attention of one of us (M.P.C.), currently engaged in a study of Caldbeck Fells mineralization. Only one specimen was found, which broke during collection into several fragments. No further material has been identified despite careful examination of specimens from the area in several substantial public and private collections.

The material consists predominantly of massive cerussite with subordinate quartz, and represents the contents of a small cavity from the Red Gill vein. The cavity also contains leadhillite, susannite and caledonite in addition to the queitite, all deposited after the cerussite. The queitite forms a white, drusy and minutely botryoidal encrustation (with a silky fibrous fracture) about 0.5 mm thick, on leadhillite and susannite, the latter in typical pale blue steep rhombohedra. A thin discontinuous layer of a somewhat granular yellow unidentified material, perhaps pyromorphite–mimetite, underlies some of the queitite, but was not seen in association with the leadhillite-group minerals. Caledonite was the last mineral to form, as minute acicular crystals. The habit of the queitite is distinct from that of the Tsumeb occurrence, where it forms white to yellow bladed crystals to 15 × 4 × 1 mm (Keller *et al.*, 1979; Keller, 1984), and this may reflect the difference in paragenesis, the Tsumeb material being an alteration product of alamosite.

The queitite from Red Gill was first suspected to be mattheddleite, which has recently been identified in similar assemblages from Red Gill and elsewhere in the Caldbeck Fells (Cooper *et al.*, 1988). However, an infrared spectrum of our material was found to be very close to that of the Tsumeb queitite (see below), and this identification was confirmed by X-ray powder diffraction at Leeds University (Dr D. I. Green) and at the British Museum (Natural History).

Chemistry. Owing to the small amount of material available, only a few fragments (about 100 µm in size) were detached from the main specimen and mounted on double-sided adhesive tape on a glass slide. After coating with carbon, the grains were analysed using a Cambridge Instruments Geoscan electron microprobe analyser equipped with a Link Systems energy dispersive analytical facility. The results were processed using the Link Systems ZAF 4-FLS matrix correction program.

In spite of the grains not having been polished, the average of two analyses gave a result in reasonably good agreement with the published analysis of type queitite (Keller *et al.*, 1979) and the theoretical values (Table 1).

Table 1. Analyses of queitite, wt.%

	1	2	3
PbO	67.9	66.9	69.9
ZnO	12.4	12.7	12.7
SO_3	6.1	6.1	6.3
SiO_2	13.7	14.4	11.9
Total	100.1	100.1	100.8

1. Theoretical for $Pb_4Zn_2(SO_4)(SiO_4)(Si_2O_7)$.
2. Queitite, Tsumeb (Keller et al., 1979)
3. Queitite, Red Gill mine.

Energy Dispersive Microprobe Analysis, 15kV and 0.5nA.

Specimen current measured on cobalt. Analyst A D Hart

Infrared spectroscopy. The infrared spectrum of a sample of the Red Gill queitite was measured in Nujol mull, over the range 400–4000 cm^{-1}, between KBr plates, using a Perkin–Elmer PE397 spectrophotometer. The resulting spectrum is similar to that published for Tsumeb queitite (Povarennykh *et al.*, 1982) with minor differences in detail. No appreciable absorptions were recorded in the 1500–4000 cm^{-1} range, confirming the absence of OH and H_2O. The main differences are the presence of a broad band, of weak medium intensity, overlapping the Nujol bands near 1400 cm^{-1}, ascribed to a ν_3 absorption of carbonate ion, a broadening of most absorptions in the 800–1200 cm^{-1} range, and the presence of extra absorptions, mostly weak or shoulders. These differences are probably due to sample impurity.

Discussion. Our analysis shows an increase in S/Si ratio over the stoichiometric ratio. This is most likely to be apparent and to be due to experimental inaccuracies in our analysis, arising from unpolished, non-flat samples. If, however, the difference is real, it is possible, but unlikely, that limited solid solution can take place between SO_4^{2-} and SiO_4^{4-} ions in the queitite structure. Although both of these ions are tetrahedral, with similar ionic radii, it is difficult to visualize how their major charge difference can be accommodated without further balancing substitutions that are not evident in our analyses. Replacement of any SiO_4^{4-} units by SO_4^{2-} (or CO_3^{2-}), would require an appropriate number of extra anions in unlikely extra sites, or cation vacancies, to restore charge balance.

The infrared spectrum indicates the presence of carbonate in our sample. This may be present as an impurity or replacing another anion. Likely carbonate impurities such as cerussite and the leadhillite polymorphs have strong sharp absorptions near 680 cm^{-1} in the infrared, where our spectrum shows very weak absorption. Our low SiO_2 analysis value suggests the possibility of carbonate replacing orthosilicate, but the charge balance problem discussed above militates against this possibility. Replacement of sulphate seems more likely, but our sulphate analysis is slightly high. We do not have enough evidence to determine whether carbonate is compositional or an impurity.

The occurrence of queitite in the Caldbeck Fells is of particular interest owing to its extreme rarity, and its not having been previously recorded from the British Isles. The composition of queitite bears comparison with that of mattheddleite, $Pb_{20}(SiO_4)_7(SO_4)_4Cl_4$ (Livingstone *et al.*, 1987), which has also been found at Red Gill mine (Cooper *et al.*, 1988), and their formation is likely to require rather similar conditions.

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References

Cooper, M. P., Green, D. I. and Braithwaite, R. S. W. (1988) *UK Journal of Mines and Minerals* **1**, [5], 21.

Keller, P. (1984) *Lapis* **9**, 13–63.

——Dunn, P. J. and Hess, H. (1979) *Neues Jahrb. Mineral. Mh.* **5**, 203–9.

Livingstone, A., Ryback, G., Fejer, E. E. and Stanley, C. J. (1987) *Scot. J. Geol.* **23**, 1–8.

Povarennykh, A. S., Keller, P. and Kristiansen, R. (1982) *Can. Mineral.* **20**, 601–3.

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