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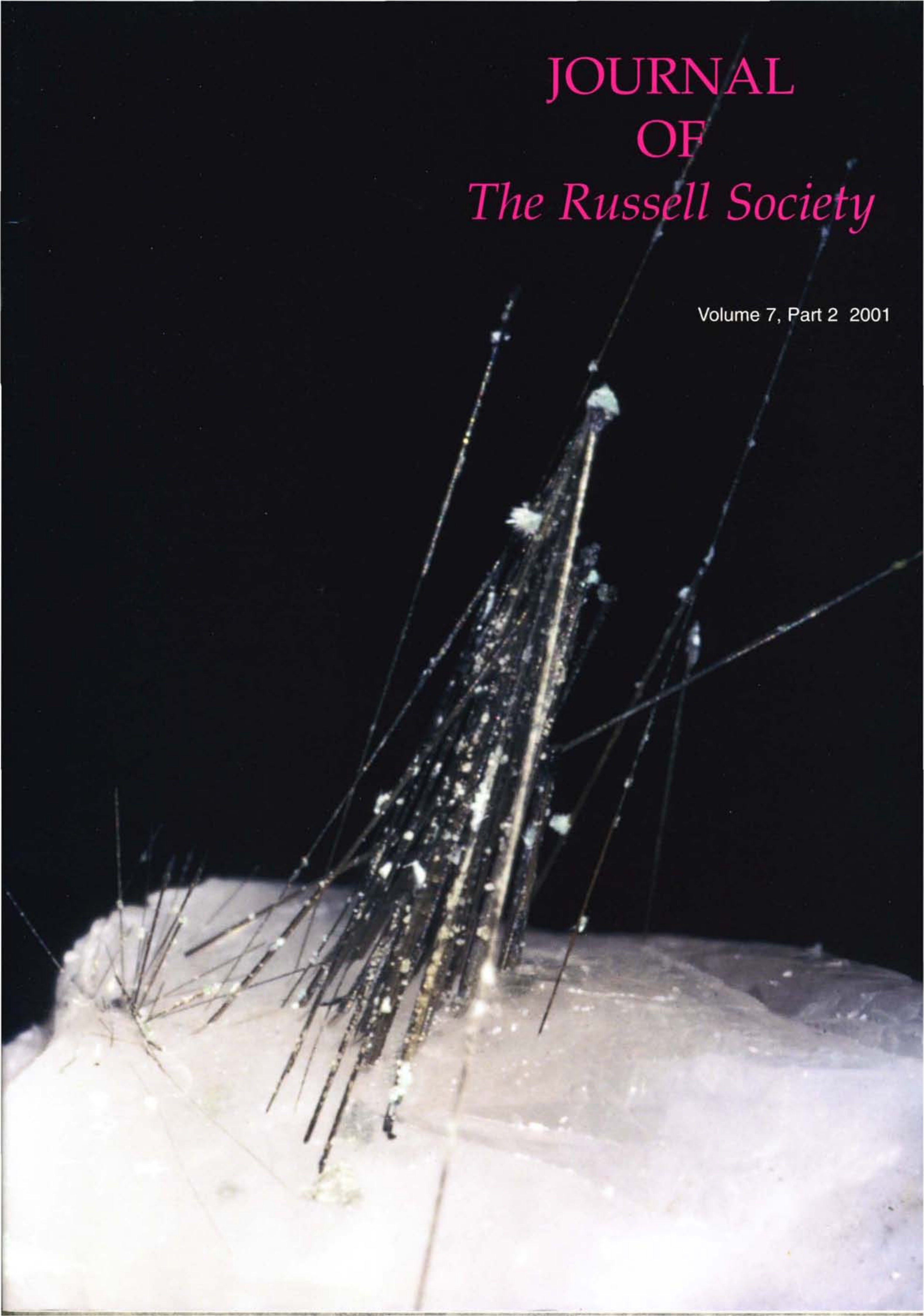

JOURNAL OF THE RUSSELL SOCIETY

The journal of British Isles topographical mineralogy

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Aims and Scope: The Journal publishes refereed articles by both amateur and professional mineralogists dealing with all aspects of mineralogy relating to the British Isles. Contributions are welcome from both members and non-members of the Russell Society. Notes for contributors can be found at the back of this issue, or obtained from the editor.

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FRONT COVER: Millerite, acicular crystals 9 mm long on calcite. Fall Hill quarry, Ashover, Derbyshire. Collected 1979. Roy Starkey specimen (M1722-006) and photograph.

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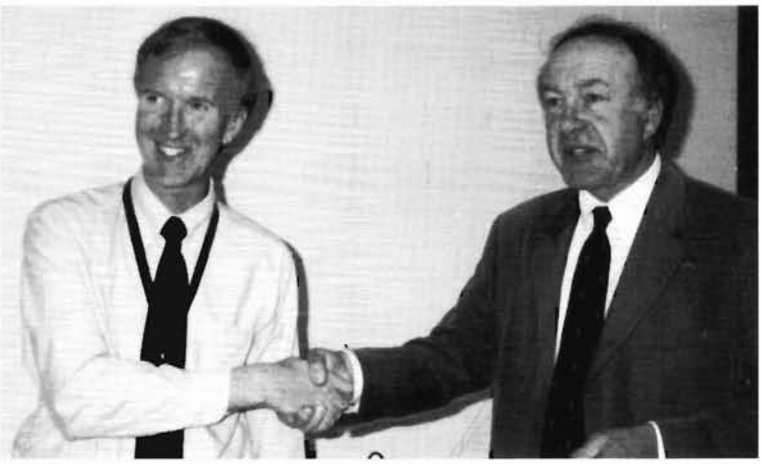
THE RUSSELL MEDAL

Like many scientific societies the Russell Society is proud to acknowledge, from time to time, the outstanding contribution made by individuals in the society's field of interest. The Russell Society Medal was established to recognise distinguished contributions within the field of field or specimen-based mineralogy, or to acknowledge truly outstanding work in furtherance of the aims of the Russell Society. The rules allow the medal to be awarded not more frequently than annually. In practice, the medal has been awarded much less frequently, not through any parsimonious interpretation of the criteria for its award, but rather as a means of emphasizing the esteem in which its chosen recipients are perceived.

In deciding to award the Russell Medal in 1998 the Society Council recognise that Roy Starkey amply fulfills all the criteria for which the medal was established.



Roy Starkey (left) receiving the medal from Brian Young, President of the Russell Society, at the Bakewell Mineral Show. (Photo: Austin Lockwood)

Roy is surely one of the most widely known members of the Society, though his reputation extends far beyond our membership. Over the years Roy has established himself as one of the foremost amateur mineralogists in this country. He is well-known and respected amongst fellow collectors, museum curators and academics. It would be difficult to identify a major museum which has not in some way benefited from Roy's collecting flair and generosity in sharing both material and information. Roy is a collector who genuinely attempts to understand the minerals he enjoys so much. His collecting so often begins not on a remote hillside or spoil heap, but months or years before in the mineralogical section of a science library. His enthusiasm for communicating the results of his fieldwork, reflected in numerous papers and articles published across a wide spectrum of the mineralogical literature, are an excellent model of the best of collecting and curatorial practice.

Roy has for many years served and strenuously promoted the Russell Society and its activities, and has been highly successful in the roles of Journal Manager and Vice-President. Roy is equally well-known in his current capacity as President of the British Micromount Society, in the founding of which he took a leading role. In all respects Roy is a most deserving recipient of the Russell Medal.

A work commitment took Roy out of the country for the 1998 AGM and it was not possible to present Roy with his medal on that occasion. However, the organisers of the Bakewell Mineral Show willingly allowed business to be interrupted to make the medal presentation and to pass on our congratulations to Roy.

A line-up of all the Russell Medallists at the Bakewell Mineral Show, October 1998: Bob Symes (1995), Bob King (1992), Roy Starkey (1998) and Trevor Bridges (1993). (Photo: Austin Lockwood)

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A.W.G. KINGSBURY'S SPECIMENS OF BRITISH MINERALS. Part 1: SOME EXAMPLES OF FALSIFIED LOCALITIES

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Arthur Kingsbury (1906–1968) was a respected English collector credited with finding many rare and unusual minerals at British localities. 43 such claimed occurrences, covering 21 species and 29 localities, have been investigated, using Kingsbury's specimens now in The Natural History Museum, London. 26 of the claimed occurrences are discredited or very doubtful, 15 are doubtful or suspect, one may be correct, and for one published occurrence no corresponding specimen could be found. In the majority of cases, specimens of 'classic' foreign material from old collections appear to have been re-labelled by Kingsbury as having been collected by him from British localities.

INTRODUCTION

In the late 1940s, Arthur W.G. Kingsbury (1906–1968) was a respected amateur collector, a member of the Mineralogical Society with published work on the minerals of Somerset (Kingsbury, 1935, 1939, 1940, 1941; Kingsbury and Friend, 1939), and a friend of the famous collector of British Isles minerals, Sir Arthur Russell (1878–1964). Abandoning his career as a solicitor, and his wartime occupation managing a precision engineering works, he became a research assistant to the Reader in Mineralogy at the University of Oxford, to work on the mineral collections in the University Museum. He continued collecting British minerals, particularly in Cornwall, Devon and the Lake District. (See obituaries: Embrey, 1973a, 1973b. See also photograph on p.70.)

From about 1949 he began a collaboration, first with H. Neumann and soon after with J. Hartley, both at the University of Leeds, whereby he sent them large numbers of samples for checking by X-ray diffraction, later publishing some of the more interesting results (with J. Hartley's name added to papers dealing with Lake District minerals). Kingsbury himself, however, carried out all the field work and preliminary examination of specimens (Kingsbury, 1954). In the late 1950s he broke off all correspondence with Hartley, and thereafter submitted specimens for XRD to the British Museum (Natural History). The X-ray work led, eventually, to the identification of over 60 species new to Britain (and many new occurrences of already recorded British species); to 23 further papers; and to the award of the Bolitho medal of the Royal Geological Society of Cornwall and other honours. He came to be regarded as second only to Sir Arthur Russell as an expert on British minerals.

It has become apparent, however, that from about 1951 Kingsbury began to pass off classic foreign material from old collections as having been found by him at British localities, though the deception was not detected during his lifetime. Serious misgivings were first voiced in the 1980s, e.g. by collectors who could not duplicate Kingsbury's finds at the claimed localities, and the fraud was formally exposed in 1998 (Ryback *et al.*, 1998). It is the purpose of this paper to describe in detail the evidence on which our conclusions were based, with additional examples, and thus to correct some of the errors now embedded in the literature on British minerals. As a rule, correcting flawed or fraudulent scientific work requires much care and effort, and results in longer papers than the original erroneous publications. This case is no exception.

The original intention was not to include in this paper any claimed occurrences that had not previously appeared in the literature, but they often provide interesting examples bearing on the pattern of falsifications, and this restriction has been abandoned. Moreover, unpublished records based on Kingsbury specimens currently registered in The Natural History Museum collections are in the public domain and also require appropriate corrections. It is strongly recommended, however, that such items should not be mentioned again, except in the context of supporting or contradicting the opinions expressed here on their authenticity.

The following abbreviations will be used below: A.K. = A.W.G. Kingsbury; NMNH = National Museum of Natural History, Smithsonian Institution, Washington, D.C: NHM = The Natural History Museum, London, formerly British Museum (Natural History). Numbers for registered specimens in the NHM have the prefix "BM"; from 1905 the year of acquisition forms part of the number. For brevity, specimens in the Russell Collection in the NHM are labelled "R" (e.g. R8394); in full, they should carry the prefix "BM 1964," (e.g. BM 1964,R8394). All other material from Kingsbury, acquired by the NHM in 1969, is referred to as the "A.K. Collection".

METHODS OF INVESTIGATION

The principal method was detailed examination of suspect specimens under a stereomicroscope, comparison with other material from the same locality in the A.K.

Collection, and comparison with authentic specimens from British and foreign localities in the NHM collections. XRD. IR, or probe analyses provided additional information where appropriate. Thus our conclusions are based almost exclusively on the evidence of the specimens themselves and their associated labels. Only limited use has been made so far of documents acquired by the NHM in 1969 with the A.K. Collection, except for the "X-ray notebooks". This is a set of notebooks in which A.K. recorded the samples sent for XRD examination, initially to Leeds University and later to the NHM, assigning to them various coded numbers also stuck to specimens or written on labels. The results of the examinations are also available for many of the entries, though both sample lists and results lists are incomplete.

Most but not all such identifications can be dated from the X-ray notebooks. The date of collection – A.K. nearly always gave the year, or month and year, on his labels – cannot be independently verified, but for the BM registered specimens the date of accession is known.

The A.K. material available for examination consists of specimens donated to the NHM; specimens given to Sir Arthur Russell, now also in the NHM (Russell Collection); and the entire A.K. Collection, now occupying nearly 400 large drawers (see Ryback *et al.*, 1998). This amounts to most of what A.K. collected during his lifetime, and there is now an opportunity, not anticipated by A.K., to bring together and compare all the specimens from a given locality. When this is done, "suspect" specimens often stand out conspicuously. Moreover, it seems to have been A.K.'s habit to break up a specimen into several pieces, donating a piece or two to the NHM, sometimes a piece to Russell, and retaining the rest either all together or dispersed through his collection. In many cases it is possible, with patience, to reassemble the original specimen. In the descriptions below, pieces are said to "fit" each other if they can be re-joined exactly across a fracture; they are said to "match" if, under the stereomicroscope, they look alike as regards the colour, habit, etc. of the mineral under discussion as well as any associated species and matrix, and "match" is used in the same sense in comparisons with, e.g., foreign reference specimens.

When a broken-up specimen is reassembled, it is usually easy to distinguish between the original, aged outer surface and any remaining fresh fractures. If the outer surface has the characteristics of a specimen from an old collection – e.g. rounded and greasy corners due to handling, a dirtier and duller 'top' surface than the underside – this will be referred to as "museum patina". Also noted below are specimens, reassembled from pieces or complete as found, that carry exposed vulnerable crystals, which are unlikely to have survived undamaged and unweathered in a mine dump from which they are supposed to have been collected by A.K.

To identify possible sources of A.K.'s suspect specimens, they were compared with reference specimens from other localities in the NHM collections, taking care to use only material that would have been available before 1968. Many of A.K.'s specimens were, in fact, found to match authentic specimens from "classic" foreign localities, i.e. to distinctive material regularly found in 19th century collections, and in most cases mentioned in, e.g., the 6th edition of Dana's *System* (Dana, 1892). It must be emphasised, however, that neither the correctness of such assigned 'true' localities nor, indeed, the incorrectness of A.K.'s claimed localities, can be proved absolutely. At best, sufficient evidence can be accumulated to indicate beyond reasonable doubt that a specimen's provenance has been falsified, and to suggest possible or probable alternatives.

ADAMITE, $Zn_2(AsO_4)(OH)$

Specimens of adamite from Cumberland and Cornwall were exhibited by A.K. at a Mineralogical Society meeting in January 1958 (*Mineralogical Magazine*, **32**, xliv: Spencer, 1958). They were then donated to the NHM and registered as BM 1958,53 to 60, representing the first five of the eight localities listed below (as confirmed by the preserved display labels in A.K.'s handwriting). A.K. also donated adamite specimens to the NHM in 1956 and 1968. The Caldbeck Fells occurrences are recorded by Hartley (1984), Young (1987), and Cooper and Stanley (1990), the three Cornish ones by Golley and Williams (1995).

SANDBED MINE, CUMBRIA

This was supposedly collected by A.K. in 1951 from the middle level dumps of Sandbed mine, Caldbeck Fells, and is labelled as the first British adamite. There are four registered specimens (BM 1956,71; 1956,427; 1958,54; and R8394) and 15 similar pieces plus fragments in the A.K. Collection; the largest specimen is 8 cm across. The adamite occurs in radiating bunches of colourless to pale yellow, terminated prisms up to 4 mm long, in vugs or embedded in a reddish-brown, vuggy, microcellular ochreous matrix enclosing small grains and crystals of quartz.

Very similar material was claimed by A.K. to have come from Netherrow Brow (see below, B), and one of the unregistered pieces from "Sandbed mine" actually *fits* R8393, from "Netherrow Brow". This discredits both claimed localities. Moreover: (a) The adamite crystals are implausibly large and abundant for this locality. (b) The ochreous matrix, described by A.K. as "iron-stained quartz", is heterogeneous but consists largely of a mineral giving an as yet unidentified X-ray powder pattern. (c) A.K.'s material matches BM 52317 from Lavrion (Laurium), Greece, the matrix of which gives the same unidentified powder pattern.

NETHERROW BROW, CUMBRIA

A) BM 1958,60 consists of two pieces (Fig. 1) showing adamite as pale greenish, botryoidal, fibrous crusts 2 mm thick, with a distinctly crystallised surface;

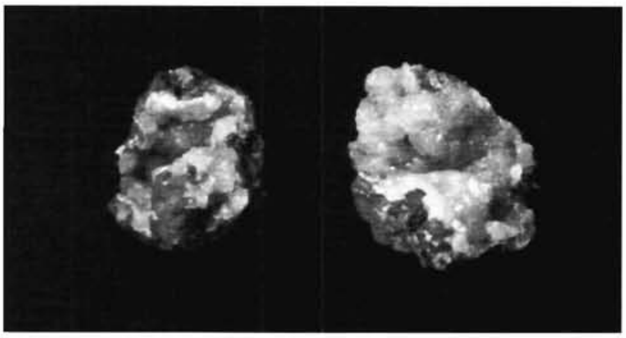

FIGURE 1. Adamite, pale greenish botryoidal crusts lining cavities in limonite, "Netherrow Brow, Caldbeck Fells, Cumbria" (BM 1958,60). The larger piece is 30 mm long.

they are portions of adamite-lined vugs in a brown spongy limonitic matrix enclosing additional adamite. BM 1956,70 and two specimens plus fragments in the A.K. Collection are smaller pieces of the same material, all supposedly collected by A.K. in 1952 from dumps at the cross-cut level by the 'Dumpy Stone', Netherrow Brow, Caldbeck Fells. To have found such rich adamite at this locality seems highly implausible. Intensive collecting in recent years has yielded only cuprian adamite, as minute spherules on quartz or baryte (e.g. specimens in British Micromount Society Reference Collection; *cf.* photograph on cover of *Journal of the Russell Society*, **6**, Part 1, 1995), which may be stray material from Potts Gill mine (M. Leppington, *Russell Society Newsletter* No. 29, 1996). A.K.'s specimens are similar to classic ones from Lavrion, Greece.

B) Quite different material, also supposedly collected by A.K. in 1952 from the 'Dumpy Stone' level, is represented by BM 1958,59, R8393, and a small piece in the A.K. Collection. It is very similar to that from "Sandbed mine", though of poorer quality, and R8393 fits one of the unregistered "Sandbed mine" specimens (see above). Thus this claimed occurrence is also discredited. There are a few tiny chlorargyrite cubes on BM 1958,59.

POTTS GILL MINE, CUMBRIA

A) BM 1958,57 and a piece in the A.K. Collection are two halves of a specimen (5.5 × 4.5 × 1.5 cm) of limonite encrusted with earthy malachite, supposedly collected by A.K. in 1952 from Potts Gill mine, Caldbeck Fells, and more precisely from the old No.1 crosscut dumps [at National Grid Reference NY 319_5 362_0] at the head of Gill Beck. Adamite forms light green, transparent spherules (<0.5 mm) with a crystallised surface, scattered on the malachite and locally coalescing into small areas of crust. Spherules of adamite of just such size and appearance, usually on a quartz matrix, have been independently collected in recent years from several localities on Caldbeck Fells (*cf.* Netherrow Brow, above). From Potts Gill mine itself (though from another dump), adamite is mentioned without a description by Neall and Leppington (1994), and earthy malachite is common in the area. Thus there are no specific grounds for doubting A.K.'s claimed locality for this specimen, although direct confirmation is lacking.

B) Very different material, supposedly from the same locality but collected in 1951, is represented by BM 1958.58 (two pieces) and a specimen plus fragments in the A.K. Collection. These carry abundant pale greenish adamite as intergrown crystals (<1 mm) lining vugs and embedded in a matrix of reddish-brown microcellular limonite. The adamite is associated with white to pale greenish globular smithsonite and very thin white unidentified crusts.

BM 1956,231, supposedly from Penberthy Croft mine, Cornwall (see below) is very similar and, in fact, this specimen and the three specimens from "Potts Gill mine" were found to fit together (5.5 × 4.5 × 3 cm when reassembled). This discredits both claimed localities and the material is, again, most likely to be from Lavrion, Greece. This is the second example of pieces of a single, probably foreign, specimen being labelled by A.K. as coming from two different localities – in this case from entirely different parts of England.

WANTHWATE MINE,CUMBRIA

A) BM 1958,55 was supposedly collected by A.K. in 1955 from dumps at the No. 3 level on South vein, Wanthwaite mine, St John in the Vale. It is a piece of yellowish-brown, somewhat granular, ochreous limonite, with more than half its surface, on all sides, covered with radiating bunches and continuous crusts of pale-bluish stubby prisms of adamite up to 1.5 mm long (Fig. 2). A small piece of the adamite crust detached from the main specimen is in the A.K. Collection. It is incredible that this single, rich and entirely undamaged specimen could

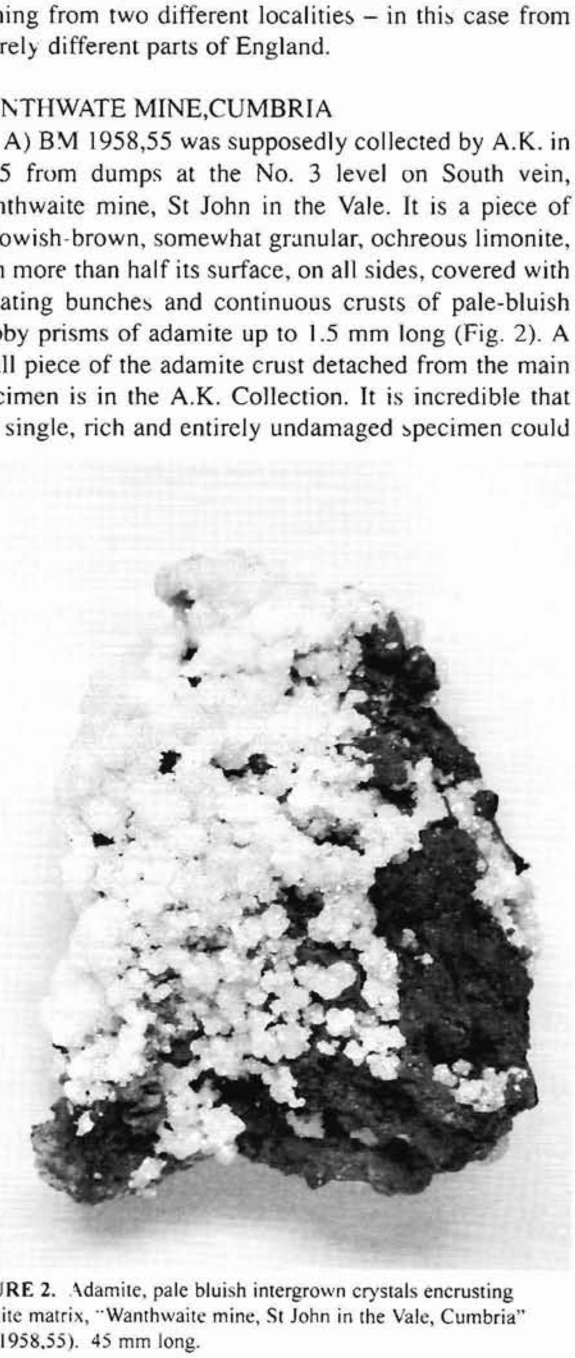

FIGURE 2. Adamite, pale bluish intergrown crystals encrusting limonite matrix, "Wanthwaite mine, St John in the Vale, Cumbria" (BM 1958,55). 45 mm long.

have been collected from a dump at the stated locality. Very little has been published about the mineralisation at Wanthwaite mine, from which A.K. has claimed a remarkable range of minerals that are awaiting re-examination, although other collectors have found the dumps very disappointing. At outcrop, the sphalerite–arsenopyrite–pyrite–chalcopyrite mineralisation (Stanley and Vaughan, 1982) is fresh and unweathered, and there is no zinc-rich gossan that could have yielded the adamite specimen. The specimen is most probably from Lavrion, Greece.

B) BM 1958,56 (two pieces), R8395 (one piece), and seven pieces plus fragments in the A.K. collection differ from the specimen decribed above. They were supposedly collected by A.K. in 1953 from the South vein at Wanthwaite mine. Adamite forms clear, colourless, terminated prisms up to 4 mm long, in divergent or randomly oriented bunches, in small vugs in yellow to orange-brown cellular matrix with a ribbed structure. The matrix, though described as limonite on the labels, is smithsonite, and a little micro-globular smithsonite is also present. As in the case of "A", above, the claimed locality is implausible and the specimens are probably from Lavrion.

WHEAL CARPENTER, CORNWALL

This is represented by BM 1958,53 and eight pieces in the A.K. Collection, supposedly collected by A.K. in 1952 from Wheal Carpenter, Gwinear (the dumps of which are now obliterated). Emerald-green, translucent cuprian adamite forms warty 1-mm spherules, singly or intergrown as rich crusts, in a vuggy matrix of iron-stained, microcrystalline smithsonite enclosing some azurite. Small, colourless, rounded crystals of smithsonite and traces of a pale-greenish acicular mineral are present in some vugs. Wheal Carpenter was a small copper mine that also produced a little sphalerite. but there is no evidence for the existence of a zinc-rich gossan such as A.K.'s specimens would indicate. The only other zinc-containing mineral on record from here is philipsburgite (Golley and Williams, 1995). A.K.'s material is very similar to classic 'cuproadamite' specimens from Lavrion, Greece.

PENBERTHY CROFT MINE, CORNWALL

A) R8392 and seven pieces in the A.K. Collection fit together to form a specimen *ca* 5.5 × 4.5 × 3.5 cm in size, and were supposedly collected by A.K. in 1952 from dumps near Duke's shaft, Penberthy Croft mine, St Hilary. Light green, transparent, globular crystal aggregates (<1 mm) of cuprian adamite are associated with malachite, massive and crystallised azurite, small calcite crystals, and traces of aurichalcite(?). The heterogeneous matrix is mainly brownish smithsonite and white endellite (halloysite-10A), on massive cuprite which locally encloses azurite and malachite. This assemblage is reminiscent of that at Natalievsky mine, Sichote Alin, Siberia (e.g. BM 1923,260. 261 and 263; *cf.* Weigl, 1914). Adamite has not been confirmed at Penberthy Croft mine, the matrix of A.K.'s specimen is uncharacteristic for the locality (Betterton, 2000), and there is nothing similar amongst the rest of Penberthy Croft material in the A.K. Collection.

B) Very different material constitutes a specimen (BM 1956,231) supposedly collected by A.K. in 1952 from dumps at Buckett's shaft of the same mine. This, however. fits material labelled as from Potts Gill mine, Cumbria (see above. B), discrediting both localities. This specimen was not among those examined by Betterton (2000).

PENGENNA MINE, CORNWALL

BM 1968,157 (2.5 cm across) and nine pieces in the A.K. Collection (up to 5.5 cm across) were supposedly collected by A.K. in 1959 from Pengenna (= Trewethen) mine, St Kew. They show abundant, small, colourless to greenish adamite crystals on botryoidal. iron-stained smithsonite in a vuggy light-brown smithsonite matrix. The best vug (*ca* 3.5 × 1.5 cm) is lined with greenish adamite crystals up to 3 mm long; on another piece, a flat face ~5 cm across is largely covered with a crust of small greenish adamite crystals. Neither such abundant and well-crystallised adamite nor the massive smithsonite matrix are likely to have come from Pengenna mine. This small mine produced lead and antimony and. apart from sphalerite. no other zinc minerals from this locality are in the A.K. Collection, nor have any been reported by other workers. The material is, again, most probably from Lavrion, Greece.

WHEAL TRELAWNY, CORNWALL

A clean, undamaged specimen (8 cm across) in the A.K. Collection is labelled in A.K.'s handwriting "? small whitish crystals on ?smithsonite. Wheal Trelawny. Menheniot. 1965." This has now been identified by XRD as adamite, forming a rich crust of lustrous, colourless but partly yellow-stained prisms (<1.5 mm) on a thick crust of greyish, subtranslucent, botryoidal smithsonite (also confirmed by XRD). The mines in the Menheniot area are well known to collectors, and it is highly unlikely that this specimen could have come from this area; smithsonite occurs only rarely and sparsely in Cornwall, and there are no records of it from east Cornwall. This specimen is undoubtedly foreign, though no matching material could be found in the NHM collections.

COMMENTS ON ADAMITE

With one exception, A.K.'s adamite occurrences are either dubious or discredited. That at Potts Gill mine, Caldbeck Fells, if genuine, would represent the first occurrence in the British Isles, but must be treated with caution. The first reliable published records of (cuprian) adamite in the British Isles were from Tynagh mine, Co. Galway, Ireland (Sarp *et al.*, 1987; de Haller, 1989) and Higher Longrigg mine, Hartley Birkett. Cumbria (Braithwaite, 1988). An unpublished earlier identification of adamite from Driggith mine, Caldbeck Fells, was made by XRD at the NHM on an enquiry specimen submitted in 1975 (film no. 18279), and it has been found in small amounts since about 1987 by many collectors at several localities in the Caldbeck Fells (*cf.* Cooper and Stanley, 1990). Adamite has not been confirmed from Cornwall.

The evidence for the classic locality of Lavrion (Laurium), Greece, being the probable source of most of A.K.'s specimens ranges from convincing to somewhat speculative, but the match with material from Ojuela mine, Durango, Mexico, another prolific locality for adamite, is less good, and other known sources are even less probable. A more definitive provenance study would require extensive and detailed comparisons of crystal habit and matrix mineralogy. "Lavrion" is a mining field embracing many individual mines (see articles in *Lapis*, 1999, No. 7–8, pp. 11–78 and 90), and adamite specimens from here show considerable diversity. We thank Dr R.S.W. Braithwaite for making available a suite of specimens collected by him in 1967 at Kamariza, Lavrion, which usefully complemented the mostly older Lavrion specimens in the NHM. An intriguing but unanswered question is where A.K. obtained so many and such varied Lavrion adamite specimens. Did he visit Lavrion himself?

AERUGITE, $Ni_{17}As_6O_{32}$, and XANTHIOSITE, $Ni_3(AsO_4)_2$

SOUTH TERRAS MINE, CORNWALL

These closely associated minerals were described by C. Bergemann in 1858 from Johanngeorgenstadt, Saxony, Germany, and named by G.J. Adam in 1869, but were regarded as doubtful species until their validity was established by Davis *et al.* (1965). In this study Davis *et al.* examined two topotype specimens (BM 32590 and BM 1907,103), synthetic aerugite and xanthiosite, and new material (BM 1963,481) supposedly from South Terras mine, St Stephen-in-Brannel, provided by A.K.

A.K's material from "South Terras mine" consists of (a) the small pieces (largest ~1.8 cm across) studied by Davis *et al.* (1965), BM 1963,481; (b) a larger piece of the same, BM 1963,482; and (c) a pill-box with two 2-cm pieces, in the A.K. Collection. The date of collection is not recorded for the two BM specimens, but is given as 1952 on the label for (c). All these can be fitted together; the original specimen, before being broken up, was a somewhat rounded, brightly-coloured mass ~4 cm across, with 'museum patina' on the surface. It is earthy to microcrystalline, with patches of mainly dark to bright green (the aerugite) and greenish- to canary-yellow (the xanthiosite).

A.K. stated (in Davis *et al.*, 1965) that "I found the xanthiosite and aerugite a few years ago in comby quartz vein-material ... They were accompanied by various Ni-Co-As minerals, traces of decomposing pitchblende, and various alteration products ...", but this is somewhat misleading. There is no matrix on the A.K. specimen, nor any signs that it had been recently broken out of a matrix. The "accompanying" minerals are on separate specimens, collected on various occasions between 1931 and 1958. Examination of all the available specimens from South Terras mine failed to detect any more aerugite or xanthiosite, nor are we aware of any further finds of these minerals in Cornwall.

On the other hand, A.K.'s specimen from "South Terras mine" and the two specimens from Johanngeorgenstadt are strikingly similar in appearance. The X-ray powder patterns are identical, line for line (Davis *et al.*, 1965). The chemical analyses (Davis *et al.*, 1965) are also very similar: compare the minor element contents of aerugite and xanthiosite from "South Terras mine" and (in brackets) Johanngeorgenstadt: aerugite, CoO 0.7 (1.2), CuO 0.7 (0.3), FeO 0.6 (1.3) wt %; xanthiosite, CoO 1.0 (1.5), CuO 0.7 (0.6), FeO 0.5 (0.7) wt %. Moreover, all the specimens have very small patches of orange-red micro-crystals, shown by XRD on both the "South Terras" and Jonanngeorgenstadt samples to be xanthiosite, of a colour not previously reported for this species.

These results leave little doubt that A.K.'s aerugite with xanthiosite from "South Terras mine" was an old museum specimen from the type locality, Johanngeorgenstadt. Until recently, no other natural occurrences of these minerals appear to have been reported; a crystal structure determination and revision of the formula of aerugite used the synthetic compound (Fleet and Barbier, 1989), but xanthiosite has now been identified at Lavrion, Greece (Rieck, 1999).

ARDENNITE, $Mn_4(Fe^{2+},Mg)_6(SiO_4)_2(Si_3O_{10})(AsO_4,VO_4)(OH)_6$

BRANDY GILL HEAD, CUMBRIA

This is a hitherto unpublished claimed occurrence, based on a large tray of specimens in the A.K. Collection containing: (a) A specimen broken into eight pieces (~5 cm across reassembled) of greasy, translucent quartz, blackened in places, enclosing lustrous, orange-brown, compact fibrous ardennite, also with black patches. (b) Two similar specimens (5–6 cm across), also broken up, very rich in ardennite. (c) A box of small ardennite-rich fragments, and three more small pieces of quartz matrix with traces of ardennite, all similar to the above. (d) Two completely different, matrix-free pieces (<3 cm), consisting of dark-grey, metallic, crystalline unidentified minerals, possibly manganese oxides but not examined further.

This tray has two pencilled labels, in A.K.'s writing: "Mn–Quartz vein at head of Brandy Gill. Aug. 1953" and "?? From Qtz–Mn vein at head of Brandy Gill. 1955." The locality is marked "N- S Qtz–Mn vein" on A.K.'s annotated 6-inch O.S. map of the Caldbeck Fells, and "Quartz vein with Manganese outcrops along west bank" on an undated pencilled sketch-map of Brandy Gill (both in the Mineralogy Department, NHM). It is 150–200 m above the better known "higher Brandy Gill" locality that provided many of A.K.'s claimed rare minerals. In addition, the entry for 12 July 1955 in a small notebook (a fragmentary diary – A.K. does not appear to have written detailed field records) reads: "Veins at very head of Brandy Gill – main vein up to 4 ft wide of spongy & massive quartz with much manganese. Collected several specs of a brown to yellow-brown fibrous mineral (?Mn) in quartz."

The only other material in the A.K. Collection from "Head of Brandy Gill 1955", is: (e) Black, massive, somewhat vuggy romanèchite (XRD identification) with botryoidal surfaces in the vugs, enclosing abundant irregular quartz grains, with some crystallised quartz; there are seven pieces (<5 cm) which appear to have come from a single boulder. (f) A lump of yellowish-brown massive limonite, and two lumps of white opaque massive quartz.

The yellow mineral was labelled as an unknown by A.K., but was identified by XRD as ardennite in 1989, the blackened portions also giving the same powder pattern.

The ardennite from "Brandy Gill" was judged to be too doubtful to be included in *Minerals of Caldbeck Fells* (Cooper and Stanley, 1990). Detailed comparison with examples from the type locality. Salm-Château, near Ottrez. Luxembourg, Belgium. a classic source of specimens in old collections (e.g. BM 45985 and 45986), confirms Cooper's opinion (*personal communication*) that AK's material most probably came from Salm-Château rather than Brandy Gill. We suggest that A.K. broke up three or four rather fine museum specimens of ardennite and falsified the locality. It is unbelievable that A.K. would not have instantly recognised a typical Salm-Château ardennite, several examples of which he had in fact catalogued while curating the collections at Oxford.

There remains only one confirmed occurrence of ardennite in the British Isles, at Merehead quarry, Cranmore, Somerset (Embrey, 1977).

BISMUTOFERRITE, $BiFe^{3+}_2(SiO_4)_2(OH)$

SOUTH TERRAS MINE, CORNWALL

Bismutoferrite from South Terras mine, St Stephen-in-Brannel, was exhibited at a Mineralogical Society meeting in November 1963 (*Mineralogical Magazine*, **33**, xc; Embrey, 1977). It is represented by seven pieces registered as BM 1964,413 and five pieces in the A.K. Collection, all supposedly collected in 1951. They are part of a single specimen, several cm across, that had been broken up, and show olive-green, opaque, massive veinlets and patches in a matrix of quartz, native bismuth, and possibly other phases. No trace of anything similar has been found among the other material from South Terras mine in the A.K. Collection, nor has bismutoferrite been independently confirmed from this locality. The specimen from "South Terras" closely resembles classic material from the type locality, Schneeberg, Saxony, Germany (e.g. BM 828) except that the "South Terras" bismutoferrite is harder than that on BM 828, and IR spectroscopy shows it to contain considerable amounts of admixed quartz. It is very likely that A.K.'s bismutoferrite is, again, merely a specimen from the type locality obtained from an old collection.

In the British Isles, bismutoferrite, identified by XRD, has been found at Buckbarrow Beck, Corney Fell, Cumbria (Young *et al.*, 1986), and is also listed, without details, from Hingston Down quarry, Calstock, Cornwall (Golley and Williams, 1995).

CARPHOLITE, $Mn^{2+}Al_2Si_2O_6(OH)_4$

Kingsbury and Hartley (1957) briefly described the discovery of carpholite at the four localities given below, three of which may have been falsified, while the fourth could not be investigated for lack of specimens.

GRAINSGILL, CUMBRIA

This was supposedly collected by A.K. in 1955 from the "dumps from Emerson vein, behind the old smithy", Grainsgill, Caldbeck Fells. On A.K.'s annotated copy of the 6-inch O.S. map of the Caldbeck Fells (in the NHM), "Smithy" is marked just NE of the confluence of Brandy Gill and Grainsgill Beck. The carpholite forms thin but extensive radiating fibrous pale-yellow coatings on white vein-quartz. There are several specimens, each *ca* 2.5–3.5 cm in size: BM 1956,65; BM 1958,92 (two pieces); R10629; and an unregistered piece in the A.K. Collection. Only three of the pieces fit together (7 × 3.5 × 3.5 cm reassembled) but from their appearance the others are likely to have come from the same specimen, with much material missing.

The "Grainsgill" carpholite closely matches classic specimens from the type locality, Slavkov (Schlaggenwald), Bohemia, Czech Republic, which is probably the true source of A.K.'s specimens. Although the quartz matrix is insufficiently distinctive to exclude Grainsgill as the locality, the facts that the carpholite on A.K.'s specimens is conspicuous and relatively abundant, and that there has been intensive collecting in this area for many years, without any finds of carpholite known to us, argue against its occurrence there.

STENNAGWYN MINE, CORNWALL

This occurrence is represented by four specimens supposedly collected by A.K. in 1952 from Stennagwyn mine, St Stephen-in-Brannel. BM 1958,91, R10628, and a piece in the A.K. Collection fit together (~7 cm across, reassembled) and consist of greisen covered on two sides with pale yellow, very finely fibrous, radiating carpholite, aggregated into 0.5–1.5-mm thick crusts and in places passing into a more lustrous, more coarsely fibrous radiating form. The fourth specimen, in the A.K. Collection, is labelled "Wavellite on altered granite" but is, in fact, yellow fibrous radiating carpholite, covering most of one face (9 × 5 cm) of a flat piece of matrix similar to that on the other specimens.

Some of the carpholite specimens from Slavkov, Bohemia (see above) also have a matrix of greisen rather than quartz (e.g. BM 96847), and the greisen of the "Stennagwyn" carpholites is more similar in appearance to the Slavkov greisen than to various other examples of greisen from Stennagwyn mine in the A.K. Collection. Moreover, the formation of carpholite requires a source of manganese, for which there is no evidence at Stennagwyn mine (whereas at Slavkov carpholite is associated with, e.g., hübnerite). The claimed origin of A.K.'s carpholite should therefore be regarded as suspect.

HINGSTON DOWN CONSOLS, CORNWALL

A specimen of carpholite (R10627) in the Russell Collection, and 9 pieces labelled as an unknown in the A.K. Collection, all fit together and were supposedly collected by A.K. in 1951 from dumps by the south shaft, Hingston Down Consols (mine), Calstock. This is presumably the carpholite "of a slightly greenish colour ... in joints in greisen" recorded by Kingsbury and Hartley (1957), but the skimpy description is somewhat misleading. The reassembled specimen (Fig. 3) is a portion of a 2.5-cm thick vein of compact fibrous carpholite, with lustrous, parallel but slightly curved fibres of a light olive-green colour with brown patches, associated with a little quartz. One side (facing camera in Fig. 3) is freshly broken, indicating that this is part of a larger specimen, but the missing portion has not yet been located.

This specimen is identical in appearance to the classic and distinctive ferroan carpholite from Wippra, Harz, Germany (e.g. BM 48207 and 48208, acquired in 1874). Further evidence of their similarity was obtained by IR spectroscopy. Between 350 and 4000 cm^{-1}, the IR spectrum of carpholite shows 15 distinct absorption maxima, with slight differences in position (probably due to cation substitution effects) for samples from Wippra and from Slavkov, Bohemia: ten of the peaks are shifted by 2–10 cm^{-1}, all except one to higher frequencies in the Wippra sample. The IR spectrum of the "Hingston Down" carpholite was found to be identical with that from Wippra, the peak positions differing by only 1–3 cm^{-1} for three peaks and by <1 cm^{-1} for twelve peaks. Thus it is very probable that A.K.'s material is part of an old specimen from Wippra rather than from Hingston Down Consols.

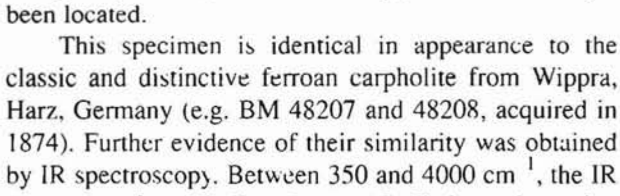

FIGURE 3. Carpholite, compact fibrous, light olive-green with brown patches, "Hingston Down Consols, Calstock, Cornwall" (Reassembled from pieces; BM 1964,R10627 is the last piece on the right). ~6 cm long.

KIT HILL, CORNWALL

Kingsbury and Hartley (1957) recorded pale-yellow carpholite in joints in greisen in an old opencast on Kit Hill, Stokeclimsland. No corresponding specimens have been found so far in the collections. R.W. Barstow collected a yellow fibrous mineral which he labelled "carpholite" from Kit Hill (N. Hubbard, *British Micromount Society Newsletter* No. 7, 1983, and *personal communication*, 2000). The XRD of a Barstow specimen in Hubbard's collection shows it to be cacoxenite, not carpholite. There are no other records of carpholite from the British Isles.

CHURCHITE-(Y), $YPO_4.2H_2O$

TRETOIL MINE, CORNWALL

Churchite was first described and named in 1865, entered the textbooks as a hydrated cerium phosphate, and only in 1953 was shown to be a hydrated *yttrium* phosphate (Claringbull and Hey, 1953). It had been found in about 1862 by the Cornish mineral dealer Richard Talling (1820–1883) in a copper-lode near Lostwithiel in Cornwall, but the exact locality was never revealed. Sir Arthur Russell long suspected that Tretoil mine near Lostwithiel might have been Talling's source, and both he and A.K. looked for churchite there. "Many hours of searching proved fruitless, and many hundredweights of likely-looking matrix were broken up, without success" (Kingsbury, 1964). However, A.K. claimed to have found a specimen of churchite in 1955 at Tretoil mine, virtually confirming this as the probable type locality (Kingsbury, 1956). Later, Kingsbury (1964) gave the year of discovery as 1952, but this may have been a simple slip or misprint.

The NHM has several samples of churchite supposedly collected by A.K. in 1955 from Tretoil mine: BM 1956,86, BM 1957,443 (2 pieces), BM 1957,444, and R7304. Specimen BM 1956,86 and one piece of BM 1957,443 are fragments (<8 mm), the rest are ~1.5 cm across. All these can be fitted together, resulting in a specimen about 2.5 × 2 × 1 cm in size, with a continuous, almost flat, 1-mm thick crust of greyish bladed crystals on one face. The crystals and matrix are exactly similar to those on old specimens from Talling (e.g. BM 40636, bought from Talling in 1867; R7303, given to A. Russell by Prof. A.H. Church), as already pointed out by Kingsbury (1956). Apart from an obviously missing piece, perhaps 1–2 cm across, the reassembled specimen looks complete, showing no signs of having been recently broken out of a cavity, and the crust of crystals is unweathered and undamaged. Since A.K.'s 1955 specimen was supposedly "investing the side of a small cavity" (Kingsbury, 1956), there is a discrepancy which casts doubt on its provenance – it could be an old Talling specimen misrepresented as one found at Tretoil mine – and thus on the confirmation of Tretoil mine as the probable type locality for churchite.

CINNABAR, HgS

Following the discovery of cinnabar in Derbyshire and Yorkshire in 1962 (Braithwaite *et al.*, 1963), A.K. collected a range of mercury minerals from the Greenhow Hill and Grassington areas of north-west Yorkshire, exhibited them at a Mineralogical Society meeting in March 1968 (*Mineralogical Magazine*, **37**, xlii; Embrey, 1977), and deposited specimens in the NHM. Only a preliminary re-examination of these has been made so far, suggesting that the majority is likely to have been genuine finds at the localities stated. (There are now many confirmed records of small amounts of supergene cinnabar associated with Pb–Zn–F mineralisation throughout the English Pennines). However, several specimens looked suspicious, and two of them are described below: cinnabar from Craven Cross and metacinnabar from Cockhill mine.

CRAVEN CROSS, NORTH YORKSHIRE

BM 1968,79 is cinnabar supposedly collected by A.K. in 1963 from "near Craven Cross, Greenhow Hill, Pateley Bridge". It consists of brick-red earthy cinnabar, in patches up to 1 cm across and as fine-grained disseminations, in white chalky kaolinite which also encloses greyish, translucent, randomly oriented crystals of baryte up to 1 cm long. Locally there is white opaque porcellanous kaolinite between the baryte crystals. The specimen is broken into several pieces, the largest ~5 cm across, and was one of those exhibited in 1968. No other specimens labelled Craven Cross were found in the A.K. Collection, nor anything similar from the entire Pateley Bridge area.

The "Craven Cross" specimen is quite untypical of cinnabar from the English Pennines, but it closely resembles cinnabar specimens from Berehove (BM 1958,431) and Dubrinihi (BM 1958,432), Transcarpathia, Ukraine. The white earthy matrix of these specimens is a mixture of quartz and kaolinite; on the Berehove specimen alunite is also present, both as a crystalline phase and admixed in the quartz–kaolinite matrix. Berehove (or Beregovo, formerly Beregszász, Hungary) is a classic locality for alunite, sometimes with baryte crystals. Although no alunite was detected on the "Craven Cross" specimen, it is very likely that the specimen is from the Berehove–Dubrinihi area rather than from Yorkshire. The matrix mineralogy in this study was determined by IR spectroscopy.

DESCLOIZITE, $PbZn(VO_4)(OH)$

A.K. professed to have collected descloizite at three localities: Brandy Gill, Caldbeck Fells, Cumbria, in 1951 (Kingsbury and Hartley, 1956); Engine vein, Alderley Edge, Cheshire, in 1963 (unpublished); and Higher Longrigg mine, Kirkby Stephen, Cumbria, also in 1963 (unpublished). The first two occurrences were mentioned in our preliminary paper (Ryback *et al.*, 1998).

Disregarding A.K.'s specimens, the status of descloizite in the British Isles is rather confused. The "descloizite" listed by Spencer (1898) and Macpherson and Livingstone (1982) refers to light grey-yellow to brown spherules from Wanlockhead, south Scotland, identified by Frenzel (1875) as descloizite. But in an overlooked second paper, Frenzel (1881) re-examined his material and concluded it was calcian phosphatian vanadinite, i.e. like that analysed recently by Livingstone (1994). (Frenzel's material was not the same as the *dark*-brown spherules and crusts from the same locality, which are duftite–mottramite intermediates.) The "dechenite(?)" (arsenatian descloizite) listed by Spencer (1931) refers to a specimen from Wanlockhead so labelled by Heddle (Heddle, 1901, vol. **2**, p. 162) but, in the absence of any data its identity is very uncertain. The only undoubted descloizite, confirmed by XRD and EPMA, was described by Alabaster (1989) from Wesley mine, Westbury-on-Trym, Avon (now Bristol); it is a cuprian variety with 2–6 wt% CuO and some Mn substituting for Zn and Cu. There have been unpublished reports of descloizite from several other localities, all apparently based on identifications by powder XRD and, perhaps, colour. Since the powder patterns of descloizite, arsendescloizite and mottramite are very similar, confirmation by EPMA or IR would be desirable before these claimed occurrences are added to the British Isles list.

BRANDY GILL, CUMBRIA

According to Kingsbury and Hartley (1956), "On the dump from the eastern cross-cut [in higher Brandy Gill, Caldbeck Fells] ... descloizite, a little mottramite, and vanadinite have been found in a spongy quartz matrix ... Both the descloizite and the mottramite form aggregates of small greenish-brown, brown, or reddish-brown crystals; mottramite is by far the rarer. Vanadinite sometimes accompanies mottramite or descloizite or occurs alone ..." There are four registered specimens, 2–3.5 cm across, in the NHM (BM 1957,479, 480 and 481; R8409), but a profusion of very similar material has been found in five separate locations in the A.K. Collection: (a) a labelled tray of 10 pieces (1.5–3 cm across); (b) an unlabelled tray of 21 pieces (1–5 cm across), two of which fit BM 1957,480 and R8409, respectively; (c) an unlabelled 3.5-cm specimen which fits one of the pieces in tray (b); (d) an unlabelled 4-cm specimen broken into three pieces; (e) an unlabelled tray of six pieces (1–3 cm across); and (f) a small unlabelled box of fragments (<1.5 cm across). Close comparison suggests that the unlabelled pieces are almost certainly part of the same material as the labelled specimens. Although a considerable number of the pieces have been fitted together, it is still unclear how many original specimens had been broken up.

These specimens range from pieces of spongy or solid quartz matrix with scattered descloizite crystals, to almost monomineralic, spongy aggregates of descloizite crystals, up to 3 cm across. Individual crystals are nearly square bevelled tabular, rarely more that 0.5 mm across and 0.18 mm thick; in aggregates they tend to be slightly larger, more complex, and more equant. The colour ranges from light yellow-brown to very dark brown. A few pieces carry small, buff-coloured, opaque tapered prisms of vanadinite and, very rarely, minute black acicular unidentified crystals, but no obvious mottramite was seen.

A.K.'s claimed find of descloizite in such abundance on the Brandy Gill dumps is highly implausible. Many years of intensive searches by many collectors have failed to produce a single further specimen. The breaking up of one, or probably more than one, fine large specimen into many pieces, of which he donated three modest ones to the NHM and a small one to Russell, is bizarre, as is the casual way in which the remainder of this important material was stored. Both are consistent with intentional falsification of the locality. Comparison with foreign specimens suggests that the most likely source of A.K.'s material was Mammoth mine, Tiger, Pinal Co., Arizona, USA, where large aggregates of small brown descloizite crystals occurred in association with vanadinite. Roebling Collection no. R5355 (15 cm across), from Pinal Co., in the NMNH, Washington, provides a good match for the richer A.K. pieces. However, rather similar aggregates occurred at Los Lamentos, Mexico, and further work would be needed to identify the source with more confidence.

ALDERLEY EDGE, CHESHIRE

Four items were presented and registered under one number, BM 1968,163: two pieces of sandstone with orange- red to light-brown crystalline encrustations, and two plastic boxes (here called A and B) of matrix-free fragments. They were supposedly collected by A.K. in 1963 from the Engine vein opencast, Alderley Edge, Cheshire. Closer examination, however, shows that two quite dissimilar materials are present:

A) Box A contains pieces (<20 mm across) of orange-red, subfibrous, 1-mm thick crust with a lustrous crystallised surface, and the crusts on the sandstone pieces are similar though less well developed. The fragments are strikingly similar to fragments constituting BM 26521, 'dechenite' from Niederschlettenbach, Lauterthal, Rhenish Bavaria (now in Rheinland-Pfalz, Germany), acquired in 1851 (see Fig. 4). This is the specimen shown by Bannister (1933) to be arsenatian descloizite. IR spectra of this 'dechenite', the fragments in box A, and the crusts on both pieces of matrix are essentially identical and also indicate arsenatian descloizite. Descloizite of very similar appearance also occurred in Pinal Co., Arizona, USA (e.g. Roebling Collection no. R5355 in the NMNH, Washington) but an IR spectrum shows it to contain little or no arsenate.

B) Box B contains pieces (<17 mm across) of flattened stalactitic growths, orange-red fibrous internally with an earthy, buff-coloured, botryoidal surface. They are strikingly similar to fragments constituting BM 40488, descloizite ('eusynchite') from Hofsgrund, Freiburg, Baden, Germany, acquired in 1866 (see Fig. 4), and both give identical IR spectra, corresponding to normal descloizite.

It is suggested that A.K. used German specimens of 'dechenite' and 'eusynchite' from an old collection and falsified the locality, though why he mixed the two distinct varieties remains unexplained. There is other evidence that his material did not come from Alderley Edge. Thus, it is an easily accessible and much studied locality (Braithwaite, 1994), so it seems strange that such a conspicuous and seemingly plentiful mineral has not been reported by others. (See also the remarks under heterogenite, below). Indeed, it is uncertain whether substantial amounts of vanadium are present at Alderley Edge (in contrast to the nearby locality of Mottram St Andrew). No vanadium mineral has been positively identified from here. Neither are zinc minerals common; from Engine vein, Braithwaite (1994) records only sphalerite (uncommon), smithsonite (very rare) and hemimorphite (very rare). Copper, on the other hand, is abundant so that mottramite is more likely to form than descloizite.

FIGURE 4. Top left: Descloizite ('dechenite'), Niederschlettenbach, Germany (part of BM 26521); 25 mm long. **Top right:** Descloizite, "Engine vein, Alderley Edge, Cheshire" (part of BM 1968,163, box A). **Bottom left:** Descloizite ('eusynchite'), Hofsgrund, Germany (part of BM 40488). **Bottom right:** Descloizite, "Engine vein, Alderley Edge, Cheshire" (part of BM 1968,163, box B).

HIGHER LONGRIGG, CUMBRIA

This is represented by a single large specimen, broken into seven pieces, supposedly collected by A.K. in 1963 from Higher Longrigg, Hartley Birkett, Kirkby Stephen, formerly in Westmorland. The reassembled specimen is shown in Fig. 5. It is registered as vanadinite on descloizite on silicified limestone (BM 1968,177). The largest face of the grey, shattered, cherty matrix is covered by a continuous crust ~1 mm thick of orange-brown descloizite, with a grey dusty surface of small (<1 mm) intergrown sharp crystals; on this are perched yellowish-brown, opaque to translucent, hexagonal

FIGURE 5. Vanadinite on descloizite, "Higher Longrigg, Hartley Birkett, Cumbria" (BM 1968,177, reassembled from pieces). ~12 cm wide. The entire top surface is covered by a thin crust of crystallised descloizite, on which are perched vanadinite crystals up to 4 mm in size.

tabular crystals of vanadinite up to 4 mm across and 2 mm thick, singly or in groups. IR spectra indicate a little AsO_4 in the vanadinite, and none in the descloizite. The vanadinite crystals are very much larger than any found elsewhere in Britain. There are no further such specimens, nor anything with similar matrix, among other material from Higher Longrigg in the A.K. Collection.

The small old workings in limestone at High or Higher Longrigg contain baryte, fluorite, calcite, galena, chalcopyrite and zincian tennantite, with conspicuous azurite and malachite, and rare cuprian adamite (Dunham and Wilson, 1985; Braithwaite, 1988). A.K.'s other material from Higher Longrigg is consistent with its claimed origin, but the descloizite–vanadinite specimen is almost certainly not from these workings; the possibility that A.K. discovered some other site on High Longrigg for these minerals cannot be excluded but is implausible (note that no vanadium minerals appear to have been reported by others from the entire Northern Pennines). A.K.'s specimen is likely to be from a foreign locality, but could not been matched in the NHM collections.

DUMORTIERITE, $Al_7(BO_3)(SiO_4)_3O_3$

FORD FARM QUARRY, DEVON

This previously unpublished claimed occurrence is represented by BM 1958,786, consisting of nine pieces of pegmatite, the largest ~4 cm across, with prominent, deep-lilac, fibrous radiating dumortierite. It was supposedly collected by A.K. in 1936 from Ford Farm quarry, Sticklepath, and was identified by XRD in 1958. These pieces match in every respect classic material from Dehesa, San Diego Co., California, USA, which is common in many collections. There is nothing similar from Ford Farm quarry in the A.K. Collection; all the coarse granite on specimens of andalusite from the shale–granite contact, also collected in 1936, is characterised by abundant black tourmaline. A.K.'s claimed locality for dumortierite should be regarded as very doubtful.

Macroscopic dumortierite does not appear to have been reported from the British Isles, though the mineral was identified long ago as tiny grains in the heavy mineral fractions separated from various igneous and metamorphic rocks, and as detrital grains in sediments (e.g. Mackie, 1925; Groves, 1928).

GOLD, Au

Many specimens of gold claimed to have been collected by A.K. from more than 20 localities are in the A.K. Collection and/or registered in the NHM systematic collection. All these occurrences need to be validated, but re-examination of one case has been completed and is reported here.

PORTHCURNICK BEACH, CORNWALL

Gold from "Porthcurnick beach" was described and figured in our preliminary paper (Ryback *et al.*, 1998). The specimen, BM 1965,83, is in four pieces (3.5–7.5 cm across) plus fragments, showing tiny gold *crystals* on a manganiferous conglomerate, and was supposedly collected by A.K. in 1950 "from a manganiferous band in raised beach deposit, north end of Porthcurnick beach, Portscatho, Cornwall.". There is no further material from this locality in the A.K. collection. A piece of BM 1965,83 was acquired by R.W. Barstow by exchange in 1980, and is now in the City of Plymouth Museum & Art Gallery, registered as NH 1986.11.870 (Helen Burchmore, *personal communication*). The Plymouth specimen is referred to by Camm (1995, pp. 42 & 95), though misleadingly as "tiny flakes of gold". In addition, reflectance data and an analysis of "Porthcurnick beach" gold (BM 1965,83) were published by Criddle and Stanley (1986).

A.K.'s specimen matches a specimen (BM 85942) from Kanowna, near Kalgoorlie, Western Australia, presented by the Government of Western Australia in 1902. Comparison under a stereomicroscope together with the tests detailed below confirm the identity of these striking and unusual specimens. On both:

a) The matrix is a cavernous, rather friable conglomerate of mostly creamy-white clayey pieces cemented by black Mn oxide crusts showing microcrystallised surfaces in cavities. The clay is predominantly endellite (halloysite-10A).

b) Random sampling of the black crusts gave almost identical EDX spectra, with major Mn, minor Fe and Co, and trace Ni. Three random samples from each specimen gave the following XRD results. "Porthcurnick": todorokite (+ impurity), birnessite + ?pyrochroite (twice); Kanowna: near birnessite (+ impurity), birnessite, chalcophanite. The differences are not thought to be significant in view of the small number of sampling

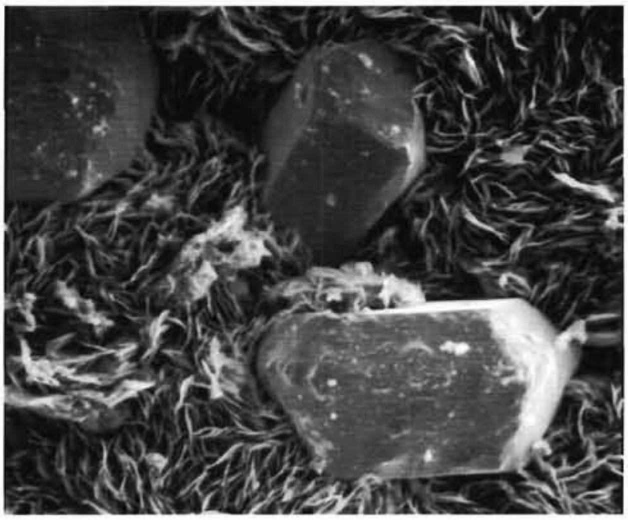

FIGURE 6. Gold, crystals 0.1 mm long on manganese oxide, "Porthcurnick beach, Portscatho, Cornwall" (BM 1965,83). SEM photo.

points and the often observed inhomogeneity of manganese pans.

c) Under the SEM, a very thin continuous layer of a rare earth mineral, with La>Nd>Pr>Ca, can be seen just under parts of the Mn oxide crusts. It was not possible to isolate samples for XRD.

d) All the visible gold is in the form of small (<0.4 mm), bright, slightly rounded crystals, scattered on the Mn oxide crusts in the cavities (Fig. 6).

At Kanowna, in addition to ordinary alluvial and quartz-vein gold, there was a bed of auriferous clay, locally known as 'pug' and described as practically pure kaolin; it occurred under auriferous ironstone gravels partially cemented in places by kaolin and oxide of iron, filling an old watercourse (Maitland, 1900). Contemporary accounts in the *Reports of the Department of Mines, Western Australia* (e.g. for the years 1898, 1901, 1903) mention the 'pug' and the difficulties of extracting the gold from it. The only published reference to gold matching the two specimens discussed above appears to be by Maclaren (1908), who describes "the most perfect crystals found in Western Australia" as single octahedra, not exceeding 1/50 inch (0.5 mm) across, embedded in asbolite (asbolane) in the Kanowna 'pug'.

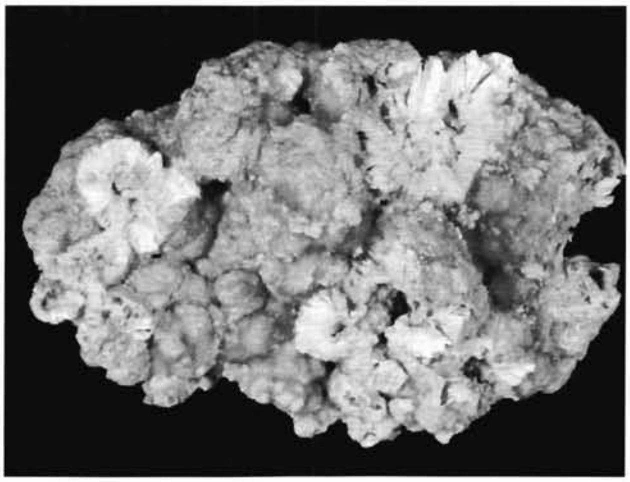

FIGURE 7. Halotrichite, silky yellowish fibrous aggregates, "Mealbank quarry, Ingleton, North Yorkshire" (BM 1968,173). 9 cm long.

It seems likely that supplies of the cavernous manganiferous pan with gold crystals were limited, and only available about 100 years ago, prompting one to wonder how A.K. obtained his specimen. It is intriguing to find that, as one of his early curatorial duties at Oxford, A.K. registered eight specimens of gold from Kanowna (nos. 19564 to 19571) as part of a collection presented to the Museum by Professor Frederick Soddy in 1945 (Monica Price, *personal communication*). The Oxford specimens are being re-examined.

HALOTRICHITE, $Fe^{2+}Al_2(SO_4)_4.22H_2O$

MEALBANK QUARRY, NORTH YORKSHIRE

This previously unpublished claimed occurrence is based on a fine specimen, BM 1968,173, supposedly collected by A.K. in 1963 from Mealbank quarry, Ingleton. The specimen (Fig. 7) consists of a matrix-free nodular crust, the nodules when broken showing silky yellowish radiating fibres up to 5 or occasionally 8 mm long, and either hollow or partly filled messy centres. It looks like a complete specimen from an old collection, without freshly broken surfaces. Apart from the whewellite described below, there is no other material supposedly collected by A.K. at this locality in the NHM.

Mealbank quarry is noted for copious quantities of earthy or powdery jarosite, mostly associated with the fireclay below a coal-seam in the Carboniferous limestone (Cosgrove and Hodson, 1963), but no other iron sulphate has been reported. There is a strong suspicion that A.K.'s specimen was not collected at Mealbank quarry but is an old specimen, probably from a foreign locality, although no matching material has been found in the NHM collections.

Halotrichite was recorded from Scotland by Greg and Lettsom (1858) and has since been identified at about a dozen localities in the British Isles.

HETEROGENITE, CoO(OH)

ALDERLEY EDGE, CHESHIRE

This was included in our preliminary paper (Ryback *et al.* 1998), and was previously mentioned by Ryback and Tandy (1992) and by Braithwaite (1994), in both publications being incorrectly described as "on mineralised Permo-Triassic sandstone." The specimen (BM 1968,162) is, in fact, matrix-free, and was supposedly collected *in situ* by A.K. in 1963 from the Engine Vein opencast, Alderley Edge, Cheshire. It is 4 × 3 × 1.5 cm in size, consists of intergrown irregular stalactitic sheets with a shiny black botryoidal surface (Fig. 8), is broken at the two ends, and shows pronounced onion-shell internal structure, with brown and yellow

FIGURE 8. Heterogenite, "Engine Vein opencast (*in situ*), Alderley Edge, Cheshire" (BM 1968,162). 43 mm long.

limonitic material in the cores of the sheets and botryoids. There is no more such material in the A.K. Collection.

It is highly unlikely that A.K.'s specimen could have come from Alderley Edge, where there are no voids large enough to have allowed its free growth, and where crusts of secondary minerals rarely attain 1 mm in thickness. Moreover, if such a large single piece could be broken off in 1963 (supposedly *in situ*), why was not more collected, then or later? Although cobalt does occur at Alderley Edge, as fairly abundant asbolane, rare erythrite, and probably cobaltite, heterogenite has not been reported by others from here (or from elsewhere in the British Isles).

A.K.'s specimen most closely resembles heterogenite from Katanga (Shaba), Congo (Zaire), the classic and most prolific source for this species; in particular, BM 1979,21 from Katanga and BM 1998,96 from Kabolela, Katanga, show onion-shell structures and limonitic cores exactly like those on A.K.'s specimen.

A.K.'s descloizite (see above), heterogenite, and plancheite (see below) stand out conspicuously among the very few and very ordinary other specimens collected at Alderley Edge in 1963, and the circumstances of their supposed discovery are also strange. The occasion was a Mineralogical Society field excursion to Derbyshire and Alderley Edge on 26 September 1963. R.S.W. Braithwaite, one of the leaders, who knew A.K. and shared with him an interest in rare minerals, had many conversations with A.K. that day and, on the next day, left with A.K. on a joint collecting expedition to the Pateley Bridge area in North Yorkshire. At no time did A.K. mention the three manifestly remarkable minerals he had supposedly collected. Only later, in a letter dated 10 December 1963, did A.K. inform Braithwaite that he "got either Planchéite or Shattuckite from Alderley", and confirmed it as plancheite, "collected on the Sept. Min. Soc. trip", in a letter dated 31 January 1964; no mention was ever made of the descloizite and heterogenite. We are grateful to Dr. Braithwaite for this information.

HYDROMAGNESITE, $Mg_5(CO_3)_4(OH)_2.4H_2O$

KENNACK SANDS, CORNWALL

This is a specimen (accompanied by many fragments) in the A.K. Collection, supposedly collected by him in 1966 from "veins in serpentine in the central foreshore of Kennack Sands, Lizard, Cornwall". It is 4.5 × 2.5 × 2 cm in size, and shows a very rich, snow-white, convoluted, fibrous crust 3 mm thick, with a surface of projecting minute thin bladed crystals, and a small amount of matrix adhering to the back side. A similar specimen was presented by A.K. to Oxford University Museum (No. 22367). This claimed occurrence has not been previously published.

Hydromagnesite has not been independently recorded from the Lizard peninsula (Vincent Holyer, *personal communication*) and, although hydromagnesite is common world-wide, localities yielding specimens as fine as that described here are rare. AK's specimen closely resembles those from localities in California (with a particularly close match to BM 1907,1023, from Devil's Hole, Alameda Co.), and almost certainly originated from one of these sources rather than from Cornwall.

LINDGRENITE, $Cu_3(MoO_4)_2(OH)_2$

BRANDY GILL, CUMBRIA

Kingsbury and Hartley (1955) reported the finding in 1952 of the rare mineral lindgrenite in the higher part of Brandy Gill, Caldbeck Fells – a locality from which A.K. recorded many other interesting minerals. Lidgrenite has been one of the most sought-after of Kingsbury's claimed species, and the locality has been intensively dug over by collectors for over 40 years, without yielding a single further specimen.

A.K. supposedly found the lingrenite on a dump "as a result of breaking up a considerable amount of material"; the crystals were said to occur in several small cavities in altered granophyre from the wall-rock of the E–W- trending Cu–Pb vein. The actual specimens, however, do not match this description. The registered specimens (BM 1956,80, two pieces; BM 1956,432; and R11121) can be fitted together to give a reassembled specimen (*ca* 4 × 3 × 1 cm) with lindgrenite crystals (up to 2.5 mm long) exposed on both front and back and not confined in cavities. Two further pieces (~1.5 cm size) in the A.K. Collection are very similar, fit together but do not appear to fit the rest, and may be part of the same specimen, with some material missing.

In all respects except the habit of the lindgrenite crystals, A.K.'s material matches that from the type locality, Chuquicamata, Chile. Goniometric measurements by P.G. Embrey (in Kingsbury and Hartley, 1955) showed the "Brandy Gill" crystals to be tabular-prismatic parallel to *a*(100), whereas those from Chuquicamata and from Helena mine, Idaho, USA, are tabular parallel to *b*(010), and show other differences. A specimen from Chuquicamata (BM 1974,162) acquired since that study provides a particularly close match to the "Brandy Gill" specimens as regards the texture and colour of the quartzose matrix, and the colour, size and distribution of the lindgrenite crystals, but the crystals are, again, thin, markedly striated plates corresponding to the original description (Figs 3b and 5 in Palache, 1935), unlike those from "Brandy Gill".

While there is strong evidence that A.K.'s lindgrenite came from Chuquicamata rather than Brandy Gill, the difference in crystal morphology remains a puzzle. Examination of more Chuquicamata specimens than are available to us would be desirable.

MALACHITE, $Cu_2(CO_3)(OH)_2$

There are, of course, many specimens of malachite amongst the Kingsbury material. One very dubious specimen is reported below.

DRIGGITH MINE, CUMBRIA

The malachite specimen BM 1957,785, already mentioned in our preliminary paper (Ryback *et al.*, 1998), was supposedly collected by A.K. in 1951 from "near the beck below the 30-fathom level dumps [NY 327 353] (below the new mill)", Driggith mine, Caldbeck Fells. It is very similar to a specimen from Zellerfeld, Harz, Germany (BM 59292, registered in 1883), and detailed comparison confirms the view that both come from the same locality. A.K.'s specimen is a slab of massive coarsely crystalline galena (11 × 6 cm) covered on one face by a reniform crust 2 mm thick of fibrous malachite. On the crystallised surface of the malachite are scattered small (1-2 mm) colourless crystals of cerussite, as twinned stubby prisms and, less abundantly, as distinctive pseudohexagonal star-shaped lensoids (Fig. 9). There are no fresh fractures, and the specimen shows all the characteristics of one from an old collection. The specimen from Zellerfeld is identical in all respects, and in particular also carries very similar star-shaped cerussites. Such cerussites appear to be very rare – no other examples have been found so far in the NHM collections, and other specimens from Zellerfeld do not show this habit.

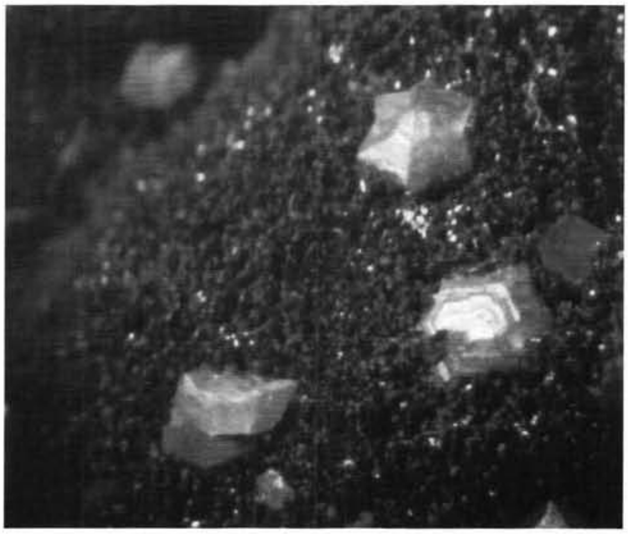

FIGURE 9. Cerussite, star-shaped twinned crystals up to 2 mm across on malachite, "Driggith mine, Caldbeck Fells, Cumbria" (BM 1957,785).

Although malachite, cerussite and galena are not uncommon in this part of the Caldbeck Fells, there is little doubt that this particular specimen came from Zellerfeld and not from Driggith mine. Moreover, it is very unlikely that the exposed malachite and cerussite could have survived undamaged and unweathered in a mine dump or even buried in soft ground.

METACINNABAR, HgS

Cf. introductory paragraph under cinnabar.

COCKHILL MINE, NORTH YORKSHIRE

BM 1968,80 is metacinnabar supposedly collected by A.K. in 1963 from the Cockhill mine, Bewerley, Pateley Bridge. The three pieces and fragments show dark-grey shiny metallic masses of metacinnabar up to 6 mm across, some altering to brick-red earthy cinnabar, in a matrix of white lamellar baryte which also encloses colourless to pale-violet fluorite. Patches of colourless micro-acicular quartz are also present. BM 1968,80 was one of the specimens exhibited in 1968 (see under cinnabar). No further similar material has been found in the A.K. Collection, nor has metacinnabar been independently identified in the English Pennines.

The "Cockhill mine" metacinnabar is similar in all respects to classic material ('guadalcazarite') from Gauadalcazar, San Luis Potosi, Mexico (e.g. BM 52423, BM 1924,368), and it is almost certain that AK's claimed locality was falsified.

PLANCHEITE, $Cu_8Si_8O_{22}(OH)_4.H_2O$

The three claimed occurrences given below, based on A.K. specimens donated to the NHM, were mentioned in our earlier paper (Ryback *et al.*, 1998). No further material has been found in the A.K. Collection. They were never published by A.K., but appear in compilations by Carlon (1979), Young (1987), Cooper and Stanley (1990), Ryback and Tandy (1992), Braithwaite (1994), Anthony *et al.* (1995), and Golley and Williams (1995).

DRIGGITH MINE, CUMBRIA

BM 1958,221, supposedly collected by A.K. in 1952 from the 30-fathom level dump at Driggith mine, Caldbeck Fells, and claimed as the first plancheite from the British Isles, is a specimen (3 × 2 × 1 cm) broken into two pieces which fit together (Fig. 10). It shows deep sky-blue fibrous radiating plancheite forming a spherule of 8 mm radius, embedded in dull-green, opaque, massive plancheite (which resembles pseudomalachite), with some light-buff, compact, earthy silicate matrix; some patchy

FIGURE 10. Plancheite, deep sky-blue radiating, in matrix, "Driggith mine, Caldbeck Fells, Cumbria" (the two halves of BM 1958,221). The larger piece is 27 mm long.

blackened areas are present. The outer surfaces are undamaged, with a suggestion of 'museum patina'.

In appearance, A.K.'s specimen matches typical plancheite from the Katanga (Shaba) area, Congo (Zaire), well represented in many old collections. Some of these (e.g. BM 1930,979) are also blackened in parts. Given the size of A.K.'s plancheite spherule, it is surprising that this species has not been independently reported from the Caldbeck Fells, an area of prolonged and intensive collecting. A supposed recent find of plancheite at Driggith mine (*British Micromount Society Newsletter* No. 37, 1994) was a mis-identification (Eddie Foy, *personal communication*, 1995). A.K.'s specimen is therefore almost certainly foreign, most probably from Katanga.

GUNHEATH PIT, CORNWALL

BM 1968,159 is registered as dark blue grains of plancheite in turquoise, and was supposedly collected by A.K. in 1958 from Gunheath china-clay pit, St Austell. The grains are abundant but small ($\leq$1 mm), irregular or angular, dark greyish-blue, and opaque, and are embedded in a pale-blue chalky matrix with small white earthy patches. Though rather deeper in colour, the matrix resembles the chalky turquoise–kaolinite mixtures, associated with kaolinite patches and quartz, that were abundant in large masses at Gunheath pit in the 1950s, and are well represented in the A.K. and Russell Collections. There is no plancheite on any of those specimens.

XRD and IR examination of the matrix revealed that it consists of chrysocolla plus calcite (probably with other, amorphous, phases), and that no turquoise or kaolinite is present. Neither chrysocolla nor calcite occur at Gunheath pit except, perhaps, in traces (Weiss, 1994), and A.K.'s specimen is almost certainly not from here.

BM 1968,159 consists of three pieces which fit together. The surface of the reassembled specimen (~3 cm across) shows clear 'museum patina', suggesting that it came from an old collection but had originally been part of larger mass. No matching material has been found in the NHM collections. Plancheite from most localities is sky-blue and fibrous, but it is recorded as blue tablets in chrysocolla at the San Manuel mine, near Mammoth St Anthony mine, Tiger, Arizona, USA (Anthony *et al.*, 1977), or as indigo-blue sprays of very small size embedded in chrysocolla at Mammoth mine (Bideau, 1980). These are the only localities found in the literature for this unusual form of plancheite, suggesting a possible source of A.K.'s specimen.

ALDERLEY EDGE, CHESHIRE

BM 1964,412 consists of 15 matrix-free fragments of spherules up to 13 mm in diameter, mostly of light-blue silky, fibrous, radiating plancheite, but in parts replaced by a pale blue-green, earthy substance which XRD and IR also identify as plancheite (Fig. 11). There is a little malachite in minute bright-green crystals and flat aggregates on the broken internal surfaces of the spherules. These pieces were supposedly collected by A.K. in 1963 from the Engine vein opencast, Alderley Edge. The strange circumstances of their discovery, and the improbability of any mineral crystallising to such a large size at this locality have been discussed under heterogenite, above. Moreover, it is surprising for any mineral from Alderley Edge not to have adhering sandstone or sand grains. On the other hand, A.K.'s specimen is, again, very similar to those from Katanga, Congo, some of which (e.g. BM 1957,592) also show tiny malachite crystals on broken internal surfaces of the plancheite spherules. It is very likely that A.K.'s plancheite is from Katanga and not from Alderley Edge.

As regards the status of plancheite as a British Isles mineral, all three of A.K.'s claimed occurrences are thus shown to be very dubious. There remains the very small fragment of plancheite found by Stuart Clark in 1976 at Engine vein, Alderley Edge (Braithwaite, 1994). Since this was matrix-free and found loose on the surface, further confirmation of its occurrence here would be desirable.

FIGURE 11. Plancheite, light-blue fibrous radiating and earthy, "Engine Vein opencast, Alderley Edge, Cheshire" (the three largest pieces of BM 1964,412). The largest spherule is 13 mm across

ROCKBRIDGEITE, $(Fe^{2+},Mn)Fe^{3+}_4(PO_4)_3(OH)_5$

Rockbridgeite was described as a new species distinct from dufrenite $[Fe^{2+}Fe^{3+}_4(PO_4)_3(OH)_5.2H_2O]$ by Frondel (1949), who also confirmed dufrenite from the only then known British locality, Wheal Phoenix, Linkinhorne, Cornwall. Kingsbury (1957) reported that material collected by him from Wheal Phoenix was mostly dufrenite, but that two specimens were shown by XRD to be rockbridgeite. Kingsbury (1957) also recorded a second British occurrence of rockbridgeite, at East Wheal Russell, near Tavistock, Devon, and there is rockbridgeite from other localities in the A.K. Collection.

A.K.'s rockbridgeites are still under investigation, but one result is mentioned here as it provides a third example of pieces of a single specimen being labelled by A.K. as coming from two completely different localities. (For others see adamite, above).

RESTORMEL MINE, CORNWALL
EAST WHEAL RUSSELL, DEVON

BM 1956,87 is a matrix-free piece of dark-brown, compact, fibrous, thinly-banded rockbridgeite, supposedly collected by A.K. in 1936 from East Wheal Russell. A tray of six very similar pieces was found in the A.K. Collection, but labelled as rockbridgeite from Restormel iron mines, Lanlivery, Cornwall, collected by A.K. in 1938. All *seven* pieces can be fitted together to form a specimen *ca* 7.5 × 4 × 4 cm in size (Fig. 12), with one nodular surface and a suggestion of 'museum patina'; a piece needed to complete the original specimen appears to be missing.

It is, of course, possible that, after donating BM 1956,87 to the NHM, A.K. made an uncharacteristic mistake in labelling the remaining pieces with the wrong locality and collection date. However, such a specimen (250 grams of solid fibrous rockbridgeite!) must have come from a rich deposit of the mineral, and neither claimed locality is plausible. Nothing similar is known from Restormel mine. At East Wheal Russell, rockbridgeite occurs in a black fibrous radiating form (<8 mm radius) in vugs in ironstained quartz; the two authentic specimens (R8853 and R8854) were collected from the dumps in 1904, as "dufrenite", by Sir Arthur Russell.

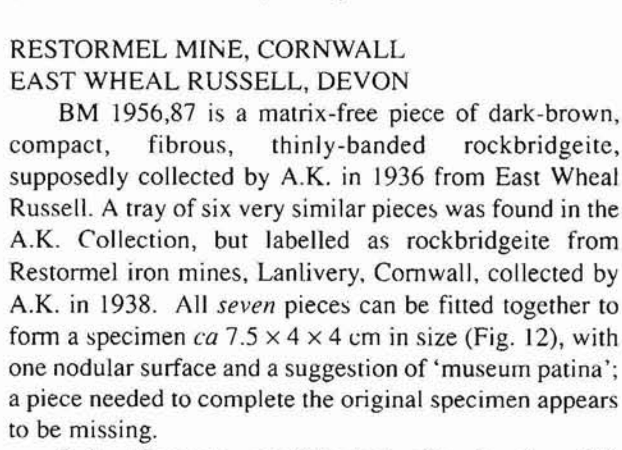

FIGURE 12. Rockbridgeite, fibrous nodular massive, dark brown with thin pale banding. **Top:** Unregistered, from "Restormel mine, Lanlivery, Cornwall" (reassembled, 8 cm long). **Bottom:** BM 1956,87, from "East Wheal Russell, near Tavistock, Devon", which fits on to the larger mass.

A.K.'s specimen appears to be from an old collection, and almost certainly from the original locality near Lexington, Rockbridge Co., Virginia, USA (Frondel, 1949), where several tons of what was then called dufrenite were found in an irregular bed of nodular masses up to 8 inches (20 cm) across (Campbell, 1881; Gordon, 1920; *cf.* BM 5353, BM 1927,1944).

VANADINITE, $Pb_5(VO_4)_3Cl$

A.K. claimed to have found vanadinite at Brandy Gill, Carrock mine, Ingray Gill and Potts Gill mine, in the Caldbeck Fells, Cumbria (Cooper and Stanley, 1990), and at Higher Longrigg near Hartley Birkett, Cumbria. The occurrences at Brandy Gill and Higher Longrigg have been dealt with under descloizite, above; that at Carrock mine is discussed below; the provenance of the Potts Gill vanadinite is suspect but more work is needed: and no specimens from Ingray Gill have been traced (*cf.* Cooper and Stanley, 1990).

Vanadinite is a rare mineral in the British Isles except at the well-known and once prolific locality of Wanlockhead in south Scotland. There are no more than about ten other confirmed localities, where it occurs sparingly and in very small crystals.

CARROCK MINE, CUMBRIA

Kingsbury and Hartley (1956) described an occurrence of "slightly arsenical" vanadinite in "material from an old cross-cut driven close to the point where an east–west copper–lead vein meets an ankerite vein and the Emerson vein", near the foot of Brandy Gill near its junction with Grainsgill, Caldbeck Fells. This is in the area of Carrock mine, and it is listed under that name by Cooper and Stanley (1990). The occurrence is represented by one registered specimen 7 cm long (BM 1957,459), and three trays in the A.K. Collection containing a specimen 5.5 cm long and eleven small pieces, all similarly labelled and supposedly collected in 1953; many of the small pieces carry much richer crusts of vanadinite than BM 1957,459.

All this material shows small (<1 mm), pale yellow, often zoned, stubby hexagonal prisms, intergrown as crusts or scattered singly, on a maroon-coloured compact hard ironstone. Such matrix looks unlike any found in the Carrock mine area, but is very characteristic of classic specimens of 'endlichite' (arsenatian vanadinite) from Hillsboro, Sierra Co., New Mexico, USA (e.g. BM 1985,MI21184 and MI21190). The vanadinite crystals on A.K.'s specimens also match Hillsboro 'endlichite' in size, colour and habit, and have identical IR spectra, with a significant peak at ~415 cm^{-1} due to absorption by AsO_4^{3-}. There is little doubt that A.K.'s specimens are from Hillsboro and not Carrock mine, and probably represent one or more broken up specimens from an old collection.

WHEWELLITE, $CaC_2O_4.H_2O$

MEALBANK QUARRY, NORTH YORKSHIRE

BM 1965,101 consists of an irregular lump of fairly hard coal with intergrown, clear, colourless crystals of whewellite up to 7 mm long which, with small whitish crystals of calcite, occurs in patches up to 2.5 cm across in the coal. It was supposedly collected by A.K. in 1963 from Mealbank quarry, Ingleton, North Yorkshire, and this claimed occurrence was noted by Ryback and Tandy (1992) and by Hofmann and Bernasconi (1998). Apart from the halotrichite described above, A.K. does not seem to have collected anything else at this locality. Mealbank quarry is a frequently visited collecting locality, and it is surprising that such a conspicuous mineral has not been reported independently. Moreover, the coal at Mealbank quarry is well-cleaved and notorious for falling apart on storage, whereas the matrix of AK's specimen shows uneven fracture and appears to be quite stable. A.K.'s "Mealbank quarry" specimen is most likely to have come from one of the classic localities in Saxony, Germany. Indeed, the coal matrix of BM 77542, whewellite from Zwickau, Saxony, is similar to that of A.K.'s specimen, both showing a distinctive pattern of very small brown wavy veinlets.

In the British Isles, whewellite occurs at rock–lichen interfaces in NE Scotland and on Mull (Wilson *et al.*, 1980; Livingstone, 1993). It has also been reported as a small crystal in an ironstone nodule from Coal Measures at Lower Writhlington, near Radstock, Avon (now North-East Somerset) (Morse, 1994).

DISCUSSION

Table 1 summarises the results. This study involved over 260 Kingsbury specimens (not counting those used for comparison), but the pattern of falsification that has emerged is also representative of the many further examples flagged as suspect and awaiting detailed examination. Some comments are appropriate at this stage.

a) The most common falsification appears to consist of taking a foreign specimen from an old collection and re-labelling it as having been collected from a British locality.

b) Many of the specimens used in this way are of 'classic' material (see under Methods of Investigation). Some are so characteristic and well-known that it is surprising that no comment was made at the time (e.g. some of the Lavrion adamites; the Salm-Château ardennite; the Dehesa dumortierite; the Hillsboro vanadinite).

c) However, some of the specimens are rarities that are not usually found in an average old collection (e.g. aerugite with xanthiosite; Kanowna gold; plancheite in chrysocolla from ?Arizona). It would be interesting to investigate the possible sources of such material.

d) A.K.'s unconventional habit of breaking up fine specimens into several pieces (sometimes across a crystal-covered face!) raises suspicions, especially when the piece(s) donated to the NHM or to Russell are less rich and less indicative of the true locality than the pieces retained by A.K. Sometimes such 'offcuts' of rare minerals are found in rather casually labelled or even unlabelled trays scattered through the A.K. Collection (e.g. "Brandy Gill" descloizite).

e) No records of which specimens had been falsified have been found among A.K.'s papers in the NHM, nor can such specimens be distinguished from the undoubtedly genuine material by their labels or by the entries in the 'X-ray notebooks'. In the case of the Caldbeck Fells minerals, A.K. added them all to his annotated 6-inch map of the area. The deception seems to have been carried through even in documents not meant for other eyes (e.g. the diary mentioning "Brandy Gill" ardennite).

f) Three examples were uncovered of pieces of a single, probably foreign specimen being claimed by A.K. from two different British localitites (see under adamite and rockbridgeite). Their labelling is quite unambiguous, but whether such duplication was intended or was the result of oversight is not known.

g) A subsequent independent identification of a species at a locality does not necessarily validate the material that A.K. claimed to have found there, which may be quite unlike the genuine material (e.g. adamites from Caldbeck Fells localities). Examination of his actual specimens is essential in every case.

The significance of A.K.'s falsified localities extends beyond questions of mere 'topographical mineralogy' interest, e.g. whether a certain mineral occurs in Britain, or the priority of its first discovery there. The uncertainty now attached to the study by Ixer and Stanley (1987) of Ag–Ni–Co minerals from "Tynebottom mine, Cumbria" was mentioned earlier (Ryback *et al.*, 1998). Further examples of published work for which A.K. supplied specimens, now to be treated with caution, are the age determination of pitchblende from "South Terras mine" and "Wheal Owles", Cornwall (Pockley, 1964; *cf.* Darnley *et al.*, 1965); a study of durangite from "Cheesewring quarry, Cornwall" (Foord *et al.*, 1985); and a study of lithium aluminium silicates and petalite, incidentally furnishing the first British record of eucryptite, from "Meldon aplite quarry, Devon" (Drysdale, 1991).

This investigation is continuing, and we would welcome comments on the results published so far, and further information on any aspect of Kingsbury's life and work. We would also be glad to hear from curators who have Kingsbury material in their collections.

TABLE I. Summary of results. (For species in italics, only selected specimens have been examined. For other species, all available Kingsbury material has been evaluated).

Species	Claimed locality(1)	Locality status	Possible/probable true locality
Adamite	Sandbed mine, Cumbria	Discredited(2)	Lavrion, Greece
Adamite	Netherrow Brow, Cumbria (A)	Very doubtful(2)	Lavrion, Greece
Adamite	Netherrow Brow, Cumbria (B)	Discredited(2)	Lavrion, Greece
Adamite	Potts Gill, Cumbria (A)	May be correct(2)	
Adamite	Potts Gill, Cumbria (B)	Discredited(2)	(Lavrion, Greece?)
Adamite	Wanthwaite mine, Cumbria (A)	Very doubtful	(Lavrion, Greece?)
Adamite	Wanthwaite mine, Cumbria (B)	Doubtful	(Lavrion, Greece?)
Adamite	Wheal Carpenter, Cornwall	Doubtful	Lavrion, Greece
Adamite	Penberthy Croft mine, Cornwall (A)	Doubtful	(Natalievsky mine, Siberia?)
Adamite	Penberthy Croft mine, Cornwall (B)	Discredited	(Lavrion, Greece?)
Adamite	Pengenna (Trewethen) mine, Cornwall	Doubtful	(Lavrion, Greece?)
Adamite	Wheal Trelawny, Cornwall	Doubtful	(Probably foreign)
Aerugite	South Terras mine, Cornwall	Very doubtful	Johanngeorgenstadt, Saxony
Ardennite	Brandy Gill head, Cumbria	Very doubtful	Salm-Château, Belgium
Bismutoferrite	South Terras mine, Cornwall	Doubtful	Schneeberg, Saxony
Carpholite	Grainsgill, Cumbria	Doubtful	Slavkov, Bohemia
Carpholite	Stennagwyn mine, Cornwall	Suspect	Slavkov, Bohemia
Carpholite	Hingston Down Consols, Cornwall	Very doubtful	Wippra, Germany
Carpholite	Kit Hill, Cornwall	Unknown(3)	
Churchite-(Y)	Tretoil mine, Cornwall	Suspect(4)	
Cinnabar	Craven Cross, North Yorkshire	Very doubtful	Berehove area, Ukraine
Descloizite	Brandy Gill, Cumbria	Very doubtful	(Pinal Co., Arizona?)
Descloizite	Alderley Edge, Cheshire (A)	Very doubtful	Niederschlettenbach, Germany
Descloizite	Alderley Edge, Cheshire (B)	Very doubtful	Hofsgrund, Germany
Descloizite	Higher Longrigg, Cumbria	Doubtful	(Probably foreign)
Dumortierite	Ford Farm quarry, Devon	Very doubtful	Dehesa, California
Gold	Porthcurnick Beach, Cornwall	Very doubtful	Kanowna, Western Australia
Halotrichite	Mealbank quarry, North Yorkshire	Suspect	(Probably foreign)
Heterogenite	Alderley Edge, Cheshire	Very doubtful	Katanga, Congo
Hydromagnesite	Kennack Sands, Cornwall	Doubtful	California (Alameda Co.?)
Lindgrenite	Brandy Gill, Cumbria	Suspect	(Chuquicamata, Chile?)
Malachite	Driggith mine, Cumbria	Very doubtful(2)	Zellerfeld, Germany
Metacinnabar	Cockhill mine, North Yorkshire	Very doubtful	Guadalcazar, Mexico
Plancheite	Driggith mine, Cumbria	Very doubtful	Katanga, Congo
Plancheite	Gunheath pit, Cornwall	Very doubtful	(Tiger, Arizona?)
Plancheite	Alderley Edge, Cheshire	Very doubtful(2?)	Katanga, Congo
Rockbridgeite	Restormel mine, Cornwall	Discredited	Lexington, Virginia
Rockbridgeite	East Wheal Russell, Devon	Discredited(2)	Lexington, Virginia
Vanadinite	Brandy Gill, Cumbria	Very doubtful(2)	(Pinal Co., Arizona?)
Vanadinite	Carrock mine, Cumbria	Very doubtful	Hillsboro, New Mexico
Vanadinite	Higher Longrigg, Cumbria	Doubtful	(Probably foreign)
Whewellite	Mealbank quarry, North Yorkshire	Doubtful	Saxony (Zwickau?)
Xanthiosite	South Terras mine, Cornwall	Very doubtful	Johanngeorgenstadt, Saxony

Notes: 1) Where two distinct types of material from one locality are present, they are distinguished as A and B.
2) Applies only to specified Kingsbury specimens; the mineral has been independently reported from this locality.
3) No specimens found in the collections.
4) May be an old specimen from the original unspecified Cornish locality.

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Arthur Kingsbury in Meldon quarry, Devon, June 1955.
(Photo: G. Ryback)

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MICA QUARRYING AND PROCESSING IN SCOTLAND DURING THE SECOND WORLD WAR

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An outline is given of mica quarrying and processing in the Highlands of Scotland during the Second World War, illustrated with contemporary photographs of the operations and recent photographs of the sheet mica produced.

In 1942, when the Battle of the Atlantic was at its height and Allied merchant shipping losses for the year were running at 1,664 ships, the transport of strategic resources from all over the world was seriously disrupted. At home, the Geological Survey of Great Britain working with the Ministry of Supply was involved in the search for a range of strategic mineral resources. One such mineral, normally obtained from India, was mica. Used extensively in the electrical industries, especially for radio parts, it was in very great demand. Joint investigations began into possible economic deposits of mica between the Survey and both the Non-Ferrous Minerals Development Control and the Mica Control of the Ministry of Supply. These investigations were initially focused on the mica deposit in the Knoydart district of the western Highlands, discovered in 1938 by the Geological Survey of Great Britain (now British Geological Survey, BGS).

This brief article is written to accompany a selection of Geological Survey photographs taken to record the mining and processing operations of the industry that arose out of the investigations, and recent photographs of actual samples of processed mica from the Pitlochry Depot held in the BGS rock and mineral collection. The BGS also holds many mica specimens from most of the deposits that were under investigation or worked during the war.

DISTRIBUTION OF MICA IN SCOTLAND

Mica is widely distributed in many common rocks, but is rarely found in sufficient quantities and of adequate quality to be of economic significance. In Scotland, the only muscovite-rich pegmatites suitable for sheet mica production are those cutting the Moinian rocks in two areas: in a western belt extending from Knoydart southwards to Loch Shiel and Loch Sunart; and an eastern group in the Strathpeffer and Garve districts, west of Dingwall in Ross-shire. Both provided sites for commercial production of sheet mica during the Second World War.

As well as investigating the possibility of working mica-bearing pegmatites in Knoydart in late 1942, the Geological Survey conducted an intensive search for new mica occurrences in 1943. As a result the Eastern Mica Co. Ltd. looked at deposits at Acharacle and Loch Shiel, Ben Resipol, Ardarie (Loch Shiel), Kinlochquoich and Glenfinnan in the west; and three sites in the eastern (Strathpeffer–Garve) district: Little Scatwell, Carn Gorm and Brae Tollie. (The positions of these localities are given in the publications cited below.) Apart from the Knoydart deposit only the Little Scatwell deposit reached the production stage.

FIGURE 1. View of Sgurr Coire nan Gobhar mica workings, Knoydart. No. 3 Working, Upper Bench, showing highly inclined bands of mica-bearing pegmatite (white) and schist (grey). (BGS Photograph C03796)

FIGURE 2. View of the Sgurr Coire nan Gobhar mica workings, Knoydart. No. 1 Working, showing workmen excavating mica books from the west end of the Lower Bench. Note the small scale of the workings. (BGS Photograph C03807)

FIGURE 3. Samples of mica books after rough dressing (rough cobbed), as sent for processing to the Pitlochry Depot. Note 15-cm scale at base of the middle specimen. (BGS Photograph C03804)

FIGURE 4. Rough splitting of dressed mica books by two workers at the Pitlochry sorting factory. Preparation of mica for the market was a comparatively simple but skilled operation, carried out entirely by hand with the aid of a special splitting knife. Note the heavy gauntlets worn to protect the hands. Any adhering rock was removed before the books were split into plates 3 mm or less in thickness. (BGS Photograph C03808)

FIGURE 5. Cutting and trimming mica. The split mica sheets were trimmed of all flaws, structural imperfections or, less serious, inclusions. The cutting knife was held at a low angle to the cleavage so the plates were consequently bevelled. (BGS Photograph C03811)

FIGURE 6. Selecting mica sheets for grade and quality. The cut and trimmed mica was sorted into piles of different grade and quality. The grader may also have removed some stained films, etc. to improve the quality. (BGS Photograph C03812)

FIGURE 7. Packing graded sheet mica for despatch. Each packing case contained about 50 lb (22–23 kg) of mica, packed in layers with the edges overlapping to prevent damage in transit. (BGS Photograph C03814)

FIGURE 8. A consignment of sheet mica ready for despatch. (BGS Photograph C03815)

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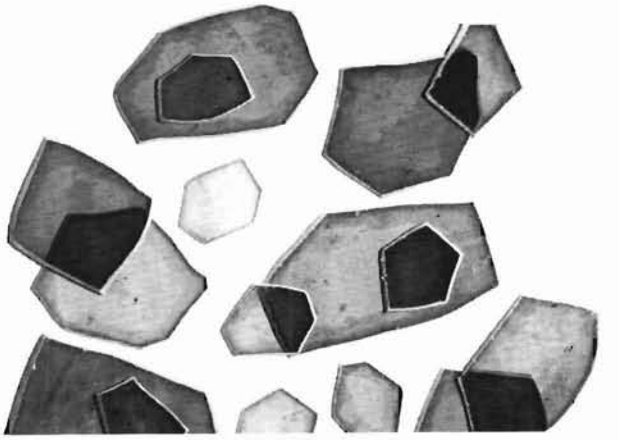

FIGURE 9. A recent photograph of cut and trimmed mica specimens from the Pitlochry Depot, held in the BGS mineral collections. Note the transparency in the overlapping pieces. The length of the largest piece in the centre is 10 cm. (BGS Photograph Z00082)

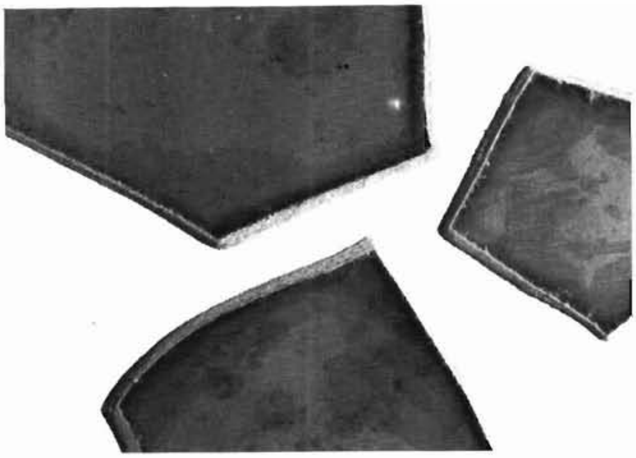

FIGURE 10. A close-up photograph of some of the mica sheets seen in Figure 9. The mica clearly shows bevelled edges caused by trimming with a knife. The length of the top edge of the lower specimen is 5 cm. (BGS Photograph Z00083)

KNOYDART MICA DEPOSIT

The deposit illustrated in Figs 1 and 2 is the quartz-mica pegmatite, at an altitude of 520–550 m on Sgurr Coire nan Gobhar (National Grid Reference NM 798 961), 80 km WSW of Fort Augustus. The area is very remote and accessible only by sea. The deposit was opened up in May 1943, at first working the original pegmatite discovered by the Geological Survey, but later four other quarries opened up in the vicinity. During the life of the operations the original quarry remained the most important, supplying almost 70% of the total production. The mica zone in the pegmatite was about 1 m wide and was proved for a length of about 80 m.

The muscovite mica sent for processing was of a high quality, brownish ruby in colour, hard, substantially flat, and glossy. A small proportion had light vegetable staining and mineral dots. Overall, the mica from this deposit was graded as 'stained' or better. The mica 'books' were normally 18–20 cm in diameter, but not uncommonly ranged to 50 or 60 cm. They were about 2.5 cm thick. Three mica books are shown in Fig. 3.

The rock was blasted and quarried, and the mica was transported by pony down a track constructed by troops who were training in the area. The mica was rough-dressed in a shed and carried from a jetty by boat to Mallaig, from there by rail to Rannoch, and finally by bus to the sorting factory at Pitlochry in Perthshire.

PROCESSING AT PITLOCHRY

The main sorting factory at Pitlochry was opened in August 1943. It had a staff of six, for the first few weeks under the direction of Mr A.B. Mudie of the Eastern Mica Company and later under Mrs D.G. Readdie (the wife of Mr D.G. Readdie, of the Ministry of Supply, Mica Control Department). The staff complement increased to 36 in November 1943.

The mica was sourced from two main areas, Sgurr Coire nan Gobhar in Knoydart and Little Scatwell (NH 380 573) in the Strathpeffer–Garve district. Small quantities of block mica were also obtained from Carn Gorm (NE of Loch Garve), and from Brae Tollie (8 km NW of Alness), both of which could be regarded as little more than extensive trials.

The preparation of block mica for industrial use was a highly specialised task and the workers employed, young girls recruited locally, had to undergo many weeks of training, though it was possible to judge after only a few days if a girl had the aptitude for the work. The trainees' first task was to master the technique of cutting the mica quickly and cleanly, and from there they learnt how to extract the largest possible plate with the minimum of waste, how and when to remove interlaminar stains by splitting, and how to remove damaged films from the surface of the block as thinly as possible. Once trained, a worker could produce daily from 2 kg for the smaller grades to 7 kg for the larger grades.

The equipment used consisted of various types of knives, each of which had a distinct and separate purpose. Ancillary equipment consisted of nothing more than grading charts, white cardboard used for inspection purposes, overalls, protective clothing and gloves, along with the shallow wooden trays for holding the mica as it passed through the different processes.

After the mica 'books' were extracted from the quarry the first process they underwent was rough dressing. This was initially done near the quarry at Knoydart but soon transferred to the Pitlochry depot. It consisted of splitting the books into sheets and the removal by cutting of the flaws, incrustations and striations. The mica would then be passed to the cutters who, using skill and great care, would remove the remaining flaws and trim the edges, leaving block mica of irregular shape with a curved and indented outline (Figs 4 and 5). Further fine splitting to remove stains and spots required great judgement to balance loss in weight against the possibility of improving the quality of the block. The final process was the grading for size and quality (Fig. 6). Size was defined by the area of the largest rectangle that could be cut from it, while quality was based on clearness, hardness and flatness. Typical remaining imperfections such as air spots, mineral or vegetable spots or lines, softness or waviness would affect the electrical and/or mechanical properties of the mica. Finally, mica to the weight of around 50lb (22–23 kg) would be placed into wooden packing cases before despatch to London (Figs 7 and 8). To prevent damage in transit the mica blocks would be packed in layers with overlapping edges. Examples of the factory product are shown in Figs 9 and 10.

The mica was used for a wide range of radio, electrical and scientific purposes. Typical items included condenser plates, valve bridges, cathode ray plates and discs, commutator separators, wrappings and washers, heater plates and stove plates. In addition to the block mica the depot produced a large amount of scrap mica. This consisted of material from the mine which was found unsuitable for processing, waste material from the rough dressing, or trimmings from the cutting process. It was ground for use as a filler in the manufacture of rubber and insulating boards.

SUMMARY OF PRODUCTION AT PITLOCHRY

Production at the Pitlochry Depot totalled 7,122 lb (3.23 tonnes) of block mica and 85 tons (86 tonnes) of scrap mica. The quality was stated to be equal to that from India and other sources but the production costs per lb of block mica were many times that of India. The production data for the two main areas are shown in Table I.

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TABLE I. Production data for crude mica.

Deposit	Rock quarried (tons)	Crude mica produced (lb)	Crude mica yield (lb/ton)	(%)
Knoydart	3,606	74,606	20.69	0.92
Little Scatwell	7,079	117,778	16.6	0.74
Total	10,685	192,384	18	0.8

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COPPER MINERALISATION IN THE PERMIAN MAGNESIAN LIMESTONE AT RAISBY, COXHOE, COUNTY DURHAM, ENGLAND

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Epigenetic copper mineralisation, hosted within Upper Permian limestones, is present in the Butterknowle Fault System at Raisby in eastern County Durham. This mineralisation, which is unlike the more widespread baryte–fluorite dominated mineralisation within the Permian rocks of County Durham, may be a member of a small number of peripheral centres of copper mineralisation in the outer parts of the Northern Pennine orefields. The mineralogy and structural setting compares closely to similar small copper deposits in Upper Permian limestones in Yorkshire.

INTRODUCTION

The common and relatively widespread occurrence of baryte and fluorite, locally accompanied by galena, sphalerite, pyrite, etc., within the Permian rocks of County Durham was first described by Fowler (1943, 1956). Brief reference to mineralisation in these rocks was also made by Dunham (1948). More recently the geographical and stratigraphical distribution of epigenetic mineralisation, including copper mineralisation, within the Permian limestones has been reviewed by Smith and Francis (1967), and detailed studies of baryte, fluorite and lead–zinc mineralisation have been published by Jones and Hirst (1972) and Hirst and Smith (1974). A study of the Raisby Formation, formerly known as the Lower Magnesian Limestone, by Lee (1990) provided further descriptive details and interpretive models for these occurrences.

The presence of copper mineralisation, unaccompanied by lead or zinc minerals, baryte or fluorite, has long been known in the Raisby area (Smythe, 1924; Dunham, 1948) though no descriptions of the occurrences or of the minerals present have yet been published. Raisby lies approximately 1 km east of the village of Coxhoe, on the west-facing escarpment of the Permian Magnesian Limestone, about 10 km south-east of Durham City (Fig. 1).

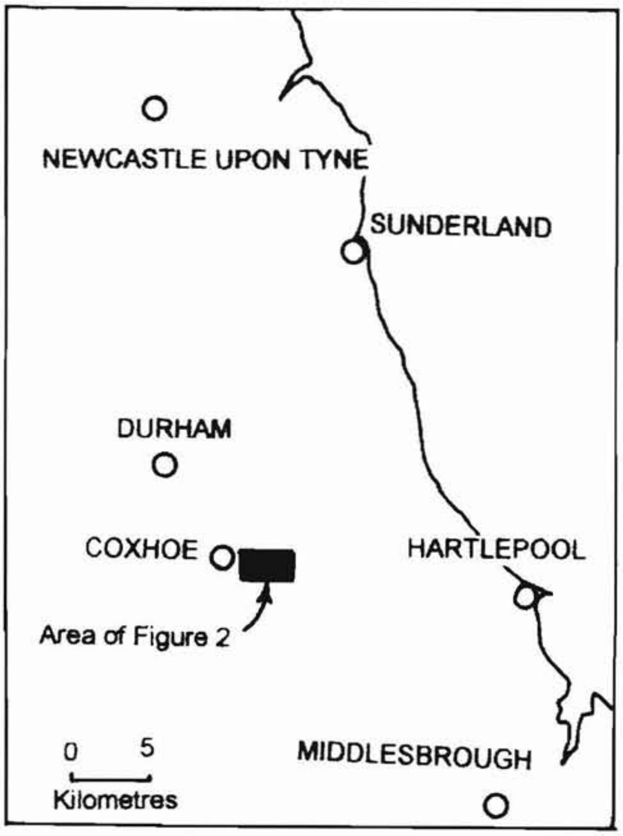


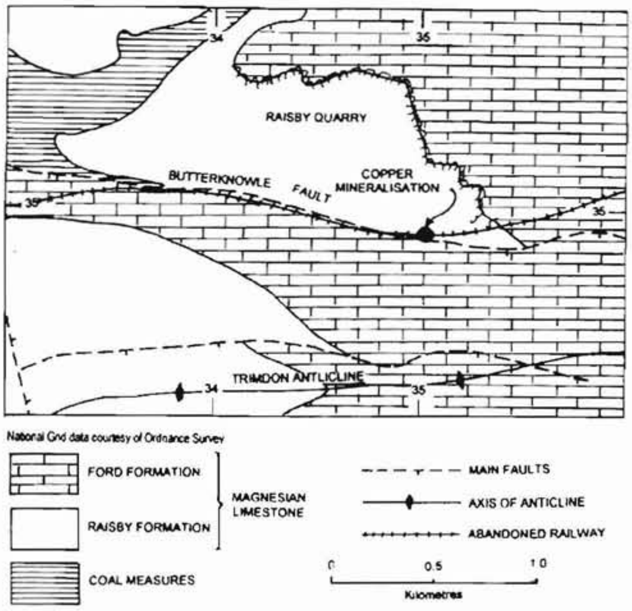
FIGURE 1. Location map.

GEOLOGICAL SETTING

The Permian rocks of east Durham lie unconformably upon Upper Carboniferous rocks. In the Coxhoe area these comprise the Middle Coal Measures (Fig. 2). Detailed descriptions of both the Carboniferous and the Permian rocks have been given by Smith and Francis (1967).

The lowest Permian rocks comprise a sequence of weakly-cemented aeolian sands, known as the Yellow Sands, of Lower Permian age. These form a series of roughly NE–SW orientated dunal ridges which may be up to 48 m thick: they are locally absent. The records of numerous boreholes through the base of the Permian rocks in this area give a clear impression of the distribution, form and orientation of these dunal ridges (Smith and Francis, 1967; Steele, 1983; Yardley, 1984). The work of Smith and Francis (1967, fig. 18) reveals that the Raisby area lies above the north-eastern extremity of one such pronounced Yellow Sand ridge. Borings reveal that the Yellow Sands are up to 4 m thick in the Raisby area though they are locally absent at outcrop between here and Coxhoe.

Overlying the Yellow Sands or, where these are absent, the Coal Measures, is the Upper Permian Marl Slate. This unit, which typically comprises well-laminated and rather



National Grid data courtesy of Ordnance Survey

FIGURE 2. Geology in the neighbourhood of Raisby quarry.

bituminous silty dolomitic shale or shaly dolomite, is regarded as the English equivalent of the Kupferschiefer ("Copper shale") at the base of the German and east European Upper Permian successions. Deans (1950) has demonstrated that the Marl Slate locally carries base metal concentrations over 100 times greater than normal background geochemical values, and notes that it contains a trace-element assemblage similar to that of the Kupferschiefer. Hirst and Dunham (1963) suggest that the variable content of lead, zinc and copper in the Marl Slate may be the result of an intermittent influx of these metals from submarine springs into the Marl Slate lagoon during sedimentation. The depositional environments, mineralogy, geochemistry and metallogenesis of the Kupferschiefer, including its English equivalent, have been comprehensively reviewed by Vaughan *et al.* (1989). The Marl Slate, which is also well known for its well-preserved, and locally abundant, fish fauna (Westoll, 1941) varies from 0.6 to 5.4 m in thickness. The unit is up to 2 m thick in borings in the Raisby area.

The Marl Slate passes upwards into the bedded, commonly dolomitic, limestones of the Raisby Formation (previously referred to as the Lower Magnesian Limestone). This formation, which is up to about 70 m thick in the Coxhoe area, is in turn overlain by the Middle Magnesian Limestone, known further north in County Durham as the Ford Formation.

The Magnesian Limestone typically gives rises to a very pronounced west-facing scarp feature along much of its outcrop, in which numerous quarries have been worked. The lower units of the Magnesian Limestone, the Raisby and Ford Formations, are currently worked on a very large scale at Raisby Quarries, east of Coxhoe. In recent years opencast coal workings in the floor of the quarry have penetrated the Marl Slate and Yellow Sands.

To the south-east of Coxhoe the Coal Measures and Magnesian Limestone outcrops are cut by the Butterknowle Fault, a part of the Lunedale–Butterknowle Fault System which in the Coxhoe neighbourhood has a downthrow to the south of at least 100 m in the Permian strata. The throw is greater in the underlying Coal Measures. Although the latest movement on the fault is clearly of post-Permian age, the Lunedale–Butterknowle Fault System as seen today at outcrop is the surface expression of a major fault zone which, during Carboniferous times, acted as a hinge zone which separated the Alston Block to the north from the Stainmore Basin to the south.

Adjacent to the Butterknowle Fault in the Coxhoe area, the gentle easterly regional dip of both the Coal Measures and Magnesian Limestone is disrupted. On the north, or upthrow, side of the fault these beds dip gently to the north or north-east. On the south, or downthrow, side the beds dip comparatively steeply north towards the fault, forming the northern limb of the E–W orientated Trimdon Anticline (Smith and Francis, 1967).

The Butterknowle Fault, or fractures closely associated with it, are exposed cutting the Magnesian Limestone in the abandoned railway cutting south of Raisby quarry.

DESCRIPTION OF MINERALISATION

Smythe (1924) commented on the presence of chalcopyrite, malachite and limonite in fissures in the Lower Magnesian Limestone (Raisby Formation) at Raisby quarry, and Dunham (1948) noted that native copper is said to have been found here. Neither of these authors gave descriptions of the occurrences. Although the present author found a few loose fragments of chalcopyrite encrusted with malachite in the south-eastern part of the quarry about 10 years ago, no copper mineralisation was then seen *in situ* and it is understood that none has been seen since. Smith and Francis (1967) commented briefly on the presence of malachite and chalcopyrite within brecciated dolomite and dolomitic limestone, close to the Butterknowle Fault, between the then eastern end of the quarry and the railway line. This area has for many years been obscured beneath quarry spoil.

Geological mapping reveals that the Butterknowle Fault crosses the old railway cutting at an oblique angle (Fig. 2). The limestones exposed in the cutting lie on the north, or upthrow, side of the fault and are conspicuously brecciated. An exposure of "cupriferous dolomitic limestone breccia" (National Grid Reference NZ 3502 3492) in the abandoned cutting, noted on British Geological Survey 1:10560 scale Sheet NZ 33 SE, is not described further in the Durham Memoir (Smith and Francis, 1967). Although the sides of the cutting are now rather overgrown, this exposure may still be seen today.

It comprises a low craggy outcrop, on the north side of the cutting, consisting of pale yellowish buff brecciated dolomitic limestone. Patchy, thin (<1 mm) crusts of malachite and azurite are conspicuous. On the eastern side of this outcrop copper mineralisation is concentrated within a roughly E–W striking vein-like structure up to 18 cm wide which dips steeply to the north. This consists of angular fragments of yellowish buff dolomitic limestone locally cemented by malachite stringers up to about 5 mm across. Much of the malachite is compact and finely crystalline though locally it forms clusters of dark green radiating acicular crystals up to 4 mm long. In places the widest malachite stringers exhibit a core of a bright grey silvery mineral, identified by X-ray diffraction as djurleite (Oxford University Museum X-ray no. 18-3-91MTP/BY1+BY2). Much of this is in an advanced stage of alteration to malachite though a few pockets of comparively fresh djurleite up to 5 mm across have been collected. Very locally this breccia contains small (<2 mm across) patches of reddish brown crystalline cuprite, accompanied in places by tiny (<1 mm across) irregular masses of native copper. The only other mineral observed here is a little white calcite.

Although considerably overgrown, the sides of the cutting for at least 15 m west of this craggy outcrop reveal abundant copper mineralisation in a belt at least 1 m wide parallel to the mapped outcrop of the Butterknowle Fault. A few small exposures reveal pale grey to buff brecciated dolomitic limestone, commonly with angular-sided cavities up to 15 mm across, which may represent weathered-out, or leached-out, limestone clasts. Within these cavities spheroidal aggregates of deep blue azurite crystals up to about 2 mm across are locally common. A little colourless or white rhombohedral calcite lines a few of these cavities. Fracture surfaces within the limestone are commonly stained bright blue by azurite. Isolated azurite spheroids are commonly found loose in the soil which covers the sides of the cutting.

A striking feature of the mineralisation exposed in the Raisby cutting is the absence of any of the other metalliferous or gangue minerals, such as galena, sphalerite, fluorite and baryte, which are characteristic of the mineralisation seen in the Magnesian Limestone elsewhere in the neighbourhood.

Dunham (1990, p.273) has drawn attention to the widespread occurrence of mineralisation along the length of the Lunedale–Butterknowle Fault and in fold structures associated with it. Smith (1981, fig. 2) illustrates the widespread presence of mineralisation in the Westphalian Coal Measures on the downthrow side of the fault, revealed by numerous boreholes in the Fishburn area, though no details of the minerals present are discussed.

DISCUSSION

Epigenetic mineralisation is comparatively common in the Magnesian Limestone of the Coxhoe area. Mineral assemblages within these small deposits typically contain variable proportions of baryte and fluorite, locally with much smaller amounts of galena, sphalerite and pyrite (Fowler, 1943, 1956; Jones and Hirst, 1972; Hirst and Smith, 1974). Although Smith and Francis (1967, p.168) comment on the presence of both chalcopyrite and malachite at several quarries along the Magnesian Limestone escarpment they give no specific sites. Moreover, published descriptions of mineralisation within the Durham Magnesian Limestone, together with this author's observations, suggest that copper minerals are generally extremely rare or absent within this widespread baryte–fluorite dominated mineralisation. The mineralisation in the Raisby cutting is distinguished by abundant copper, unaccompanied by other metals or fluorite or baryte gangue.

Dunham (1990, p.98) has suggested that mineralisation within the Magnesian Limestone may be genetically related to the widespread lead–zinc–fluorite–baryte mineralisation of the nearby Northern Pennine Orefield, especially in view of its close association with the Lunedale–Butterknowle Fault System, which is known to have acted as a main channel for mineralising fluids in the main orefield. Hirst and Smith (1974), however, considered that the fluorite mineralisation may be unrelated to the Northern Pennine deposits.

Within the ore deposits of the Alston Block copper mineralisation, typically with major chalcopyrite, is characteristic of small deposits near the centre of the orefield, which are believed to have formed early in the mineralising episode from comparatively high-temperature mineralising fluids, perhaps above emanative centres (Dunham, 1990). Elsewhere, small concentrations of copper mineralisation are known from peripheral parts of both the Alston and Askrigg portions of the Northern Pennines. Such deposits include those of the Kirkby Stephen and Mallerstang areas of Cumbria and the Richmond and Middleton Tyas areas of North Yorkshire. In most of these the presence of small amounts of galena, fluorite, and/or baryte serve to link them with those of the main Northern Pennine mineralisation. In a review of these deposits, based in part upon a discussion of Small (1978), Dunham and Wilson (1985) conclude that whereas these deposits comprise part of the Northern Pennine suite, they may be regarded as marginal deposits which demonstrate a small recrudescence of copper mineralisation, late in the Northern Pennine mineralising episode.

The nature and location of the copper mineralisation described here is consistent with this too being a member of this suite of small centres of copper mineralisation peripheral to the Northern Pennine orefields. Although the Kupferschiefer (the counterpart of the Marl slate) is locally very copper-rich in parts of eastern Europe, it is not known to be notably rich in copper in County Durham and seems an unlikely candidate for the source of the copper in the Raisby deposits.

Concentrations of copper mineralisation, hosted within limestones of the Upper Permian Cadeby Formation (theYorkshire equivalent of the Raisby Formation), were formerly worked on a very small scale near Farham, North

Yorkshire (Marshall, 1826: Sedgwick, 1829; Hunt, 1884). Early accounts of these deposits (Marshall, 1826) suggest that the copper occured as nodular masses "seldom exceeding the size of a potato". Harwood and Smith (1986) note that chalcopyrite, bornite, covellite and malachite occur here both as nodules and as joint coatings. They conclude that the deposits are of epigentic origin and draw attention to their occurrence within the faulted Farham Anticline, the axis of which follows the eastern continuation of the Craven Fault Zone. This major structural zone, which forms the southern margin of the Askrigg Block, is associated with important concentrations of lead, baryte and fluorite mineralisation in the Grassington and Greenhow districts. In view of the marked structural control exhibited by the Farnham deposits, these authors suggest that mineralisation may have resulted from the tapping of hydrothermal fluids from sub-Carboniferous basement, along these major structural zones.

Thus there appear to be considerable similarities between the copper mineralisation at Raisby and Farham. Both are hosted by Upper Permian limestones and are characterised by abundant copper minerals with few, if any, gangue minerals other than a little calcite. These occurrences are clearly associated with the major structural zones which mark the edge of Carboniferous 'blocks'. They may represent small distal centres of copper mineralisation in the very outer zones of the Northern Pennine centres of mineralisation.

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WAVELLITE AND VARISCITE ON GOWER, SWANSEA, SOUTH WALES

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Wavellite is widely distributed on the Gower peninsula. It occurs within the Upper Carboniferous limestone shales and siliceous sandstones of Namurian age. Most of the original sites are no longer accessible, but a recent field survey has recovered further good specimens of the mineral. Variscite is also reported for the first time from Wales.

INTRODUCTION

Wavellite, $Al_3(PO_4)_2(OH,F)_3.5H_2O$, was first described from Barnstaple in Devon (Davy, 1805). The actual source was High Down quarry, Filleigh, ~10 km ESE of Barnstaple, where it occurs in joints in grey to black mudstones and cherts of Lower Carboniferous age. Dixon and Vaughan (1912) suggested that these beds could be related to similar chert and shale beds near the base of the Namurian on the Gower peninsula , the geology of which is shown in Fig. 1. (The peninsula is now within the unitary authority of Swansea, but was formerly in the county of West Glamorgan). The first reported occurrence of wavellite on Gower was by Logan (1837). Wavellite was noted at Cilifor Top, a hill near Llanridian, and was also abundant in most of the quarries for 3 km east of Cilifor to the hamlet of Llethrid. Strahan (1907) refers to further wavellite localities between Bishopston and Clyne Common (2 km to the NE), and also at the top of the limestone quarries on Pwll du Head.

Wavellite occurrences on Gower are restricted to the upper limestone shales of Lower Carboniferous age through to siliceous sandstones of the Namurian. This group of rocks stretches from WNW to ESE across the north of the peninsula. Several outliers of Namurian rocks also occur at Port Eynon, Oxwich and Oystermouth. They are generally poorly exposed because of a thick covering

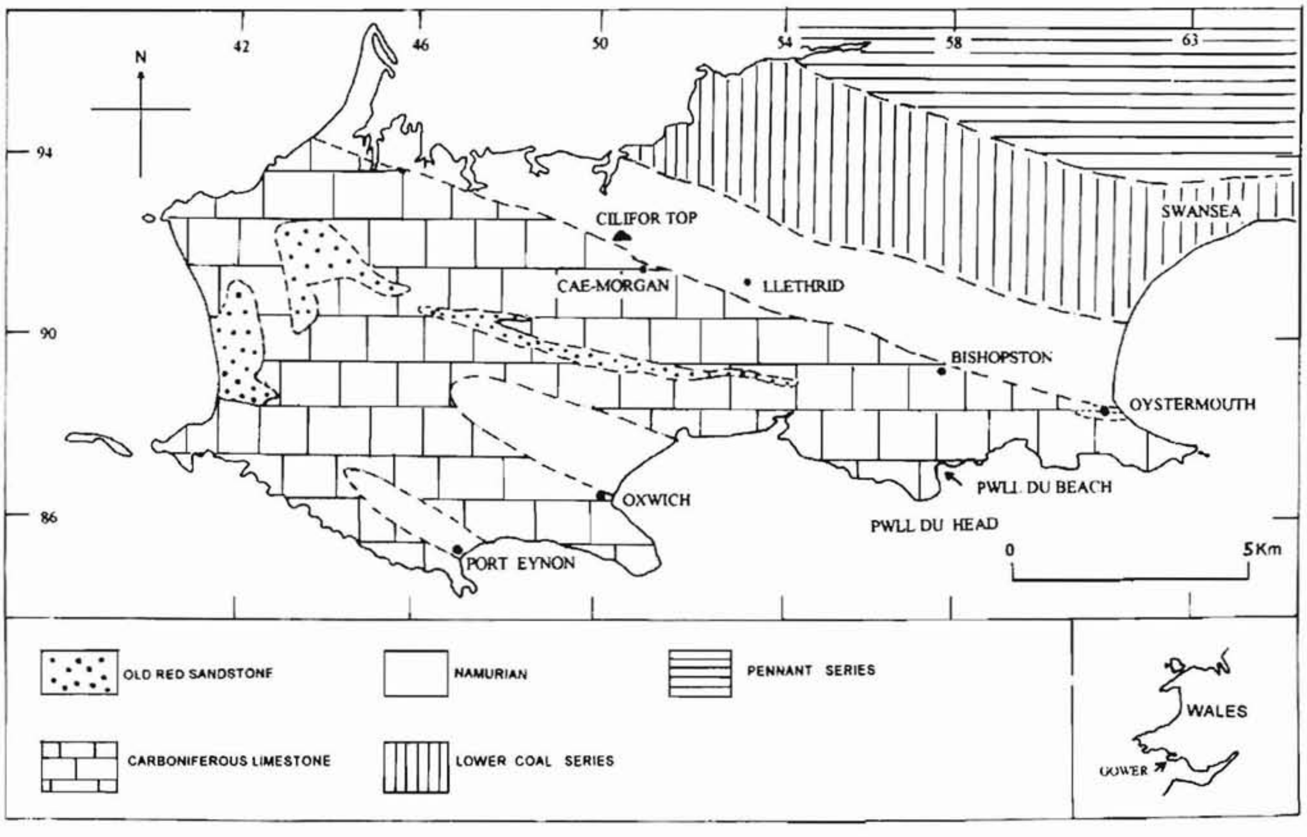

FIGURE 1. Geological map of the Gower peninsula.

of boulder clay. Temporary road sections have, in the past, afforded much of the information on the stratigraphy.

No wavellite-bearing rocks are now exposed *in situ*. All original sites have long been re-vegetated, although abundant scree material on the slopes of Cilifor Top and the beach deposits at Pwll du still yield wavellite specimens. A survey of wavellite localities on Gower has been made with the aid of Geological Survey 1:10,560 maps (sheets SS 59 SW, SS 59 SE, and SS 58, dated 1964).

LOCALITIES

BISHOPSTON

A noticeable feature of the upper limestone shale beds formerly exposed at Bishopston (National Grid Reference SS 581 895) was that the original dark limestone bands interspersed with shale and chert horizons had been decalcified and locally brecciated and altered to a siliceous white to yellow clayey material called rottenstone. The most notable exposure of these rottenstones, now unfortunately no longer accessible, was in a roadside cutting on the road from Clyne Common to Bishopston, which exposed the uppermost beds of the Carboniferous limestone dipping 50–60° to the NNE. These topmost beds had been decalcified and replaced with at least 10 metres of white to yellow clays followed by more bedded clays interspersed with chert and limestone bands. Wavellite occurred within the joints of these harder bands as characteristic discs of radiating structure (Trueman, 1930).

PWLL DU HEAD

Rottenstones, similar in appearance to those from the Bishopston exposure, have been recorded from pockets within the Oxwich Head limestones at the top of the cliff (SS 573 868) above Pwll du quarry. This exposure, no longer accessible, was in an eastward-facing bank above the main quarry workings. Four specimens of wavellite, collected at this locality by Sir Arthur Russell in 1916, are in the Natural History Museum (BM 1921,246 and Russell Collection): three show sea-green hemispheres of wavellite 4–5 mm across, covering areas up to 7.5 cm across, the fourth shows discs up to 3 cm across of golden radiating crystals. (Note that BM 1921,246 bears an additional number "46" of unknown origin.)

Pieces of wavellite of the sea-green variety can be found occasionally in the quarry debris at the foot of the bank. One such specimen, collected in 1998, revealed small (<1 mm), colourless to orange-yellow rosettes of variscite, $AlPO_4.2H_2O$ (confirmed by XRD, National Museum of Wales X-1156). This is the first reported occurrence of variscite in Wales.

PWLL DU QUARRY

Pwll du was an important limestone port in the 17th–19th centuries. Exports grew significantly after 1600 with increasing demand for lime from Devonshire farmers. Large quantities of limestone and coal could be exported far more cheaply by sea from the coast of south Wales to the north Devon coast and, during its heyday, up to thirty sailing ships could be seen in the bay at any one time (Jenkins, 1977).

FIGURE 2. Hemispheres and radiating discs of lime-green wavellite up to 2 cm across, with clear quartz on a chert base, Pwll du beach. (Coin is 24 mm diameter).

Pwll du quarries (SS 574 868) rise precipitously up to 100m above the sea, and the slides used to lower limestone blocks to the waiting ships can still be seen. Up to 100 quarrymen and women were employed here during the prosperous times. They were well catered for, as there are records of five public drinking houses in the bay and lower valley. Two of these remain today as private houses, the Beaufort Arms and the Ship Inn. In days gone by these were adequately supplied with illicit liquor by the once thriving smuggling trade.

Smaller rocks from the quarrying operations have gathered into a great storm beach at Pwll du bay. Several thousand tonnes of well-rounded pebbles of limestone make up most of the beach, but occasional pebbles of chert and siliceous breccia can be found. The irregular fractured rock fragments making up the breccia are sometimes veined with white or green wavellite. The wavellite typically occurs as intergrown discs up to 15 mm across, and exceptionally as lime-green discs and hemispheres up to 25 mm across; they are rarely emplaced on a base of small, integrown, clear gemmy quartz crystals (Fig. 2).

It is known that some of the pebbles on the beach are foreign to the locality. Ballast from incoming ships would

FIGURE 3. Wavellite-bearing, waterworn, brecciated chert pebble (12 × 7 cm), Pwll du beach. (Coin is 17 mm diameter).

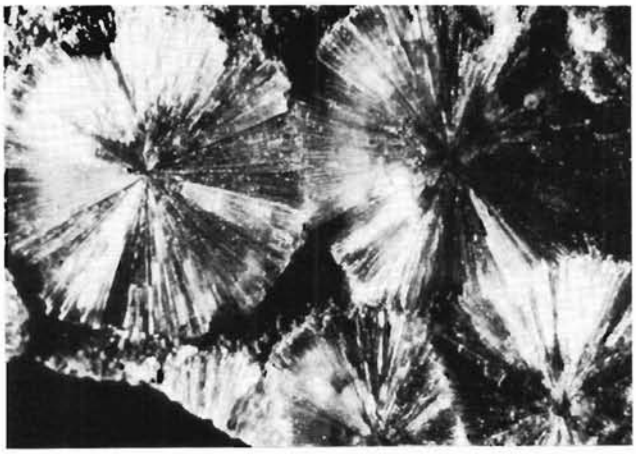

FIGURE 4. Golden-yellow radiating discs of wavellite (up to 1 cm diameter) on siliceous sandstone, Cilifor Top.

be dumped before loading the next consignment of limestone. The matrix in which the wavellite occurs (Fig. 3) does not appear to resemble material from the type locality at Filleigh near Barnstaple, where a large part of the the limestone was traded. Until a detailed petrological investigation of the pebbles is carried out some caution is required in assigning all the wavellite-bearing pebbles to the Pwll du area.

CAE-MORGAN

Fossiliferous rottenstones bearing wavellite have been recorded from a roadside exposure near Cae-Morgan farm (SS 506 918). The site is no longer exposed.

CILIFOR TOP

Cilifor Top (SS 504 926), crowned by the prominent earthworks of an Iron Age hilltop settlement, is made up of fine-grained sandstones and thinly bedded shales, much faulted and disturbed. Wavellite occurs on joint planes as typically golden-yellow acicular radiating crystalline discs up to 10 mm in diameter (Fig. 4).

DISCUSSION

To the authors' knowledge, no detailed geochemical investigation of the upper limestone shale sequence on Gower has been carried out. Nevertheless, we have attempted to present a brief outline of the possible mode of genesis of wavellite on Gower.

Wavellite, a basic hydrated aluminium phosphate with possible substitution of fluoride for hydroxyl, is usually associated with aluminium-rich sedimentary rocks, although it can also be found associated with kaolinised granite (Weiss, 1994, p.32). The Namurian chert–shale facies on Gower were laid down in shallow seas during cycles of advancing and retreating shorelines, which provided good conditions for the concentration of organic-rich sediments. Phosphate, in the form of organic skeletal structures, was released to form amorphous carbonate-fluorapatite (Lucas and Prevot-Lucas, 1997). This sedimentary phosphate was incorporated within shale-rich horizons and was ultimately the source of phosphate for wavellite. The source of aluminium was the clay mineral assemblage associated with the shale bands. The interaction of clay minerals with phosphate ions derived from sedimentary phosphate is not fully understood, but has an important bearing on the fixation of phosphorus in soils (Low and Black, 1950). During burial diagenesis, hydrolytic decomposition of the carbonate-fluorapatite would liberate phosphate ions into solution, which would then initiate the decomposition of the clay minerals. Phosphatolysis of the clay minerals under acid conditions would result in the formation of aluminium phosphates and silica (Nriagu, 1976). This secondary silicification of the mineral constituents is readily apparent in the samples of rottenstones collected on Gower. The brecciated nature of the rottenstones in the Bishopston area suggests that some of the material may be solution-cavity infill within the underlying Carboniferous limestone.

Wavellite is known for its variety of colours, from colourless and white to yellow and various shades of green. The green wavellite from the famous Dug Hill phosphate deposits in Arkansas, USA, has been attributed to the presence of vanadium (Foster and Schaller, 1966). Further work is necessary to determine the trace chemical composition of the Gower wavellites.

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BOOK REVIEWS

Nesse, W.D., *Introduction to Mineralogy*. Oxford & New York (Oxford University Press), 2000. xvi + 422 pp. Price £27.50. ISBN 0-19-510691-1.

This book aims to provide a comprehensive text for teaching mineralogy to undergraduate students in the geosciences, and is divided into three parts. The first part concerns crystallography (Bravais lattices, point groups, space groups, Miller indices, and crystal forms) and crystal chemistry (chemical bonding, crystal structures, polymorphism, and crystal growth). Part 2 covers mineral properties, study and identification (physical properties, optical mineralogy, X-ray crystallography and the various methods of chemical analysis now available); it ends with a brief discussion of strategies and tactics to adopt in mineral identification.

The largest part of of the book (222 pp) is given over to mineral descriptions, covering >100 species and following a standard format of a crystal sketch accompanying outline data, then details on structure, composition, form, cleavage, twinning, colour, optical characteristics, alteration, distinguishing features, occurrence and, notably, use. The chapter on silicates begins with a brief outline of igneous, sedimentary and metamorphic processes before embarking on the major silicate groups. The coverage of non-silicates is fairly extensive, particularly for carbonates, oxides and sulphides.

Some minor criticisms could be made (though not in this very brief review), but there are very few misprints and, overall, this is an excellent, well-produced and stimulating work, clearly written and well illustrated. The price is attractively low, but the book has just one serious drawback – its 'coffee-table' size: at 28.5 ˘ 21.5 ˘ 2.8 cm it is large (as large and heavy as the laptop computer on which this review is being prepared!).

Hurlbut, C.J., Jr. and Sharp, W.E., *Dana's Minerals and How to Study Them* (4th edition). Chichester & New York (John Wiley & Sons), 1998, vii + 328 pp. Price (paperback) £32.50. ISBN 0-471-15677-9.

This book is intended mainly for beginning students and amateur mineralogists. Although, in the interval of almost fifty years since the third edition, great strides have been made thanks to new, elaborate and sophisticated instrumental techniques, the authors feel that, while the students must indeed be informed of these new techniques and what they can accomplish, there remains a place for the old, simple, easy-to-make tests. Thus after chapters giving hints on how to study minerals, and an introduction to crystals and crystallography, the fundamental properties of minerals, mineral chemistry (including blowpipe and borax bead tests), and mineral genesis are described. Individual descriptions of some 150 mineral species (in 150 pages) are followed by determinative tables. There are numerous photographs and line-drawings as well as eight colour plates. An appendix lists 100 species which should be in a mineral collection of a school or university, of which 59 are designated as important for someone just starting mineralogy to have in a collection.

Cribb, S. and Cribb, J., *Whisky on the Rocks Origins of the 'Water of Life'*. Keyworth, Nottingham (British Geological Survey: Earthwise Publications), 1998, 72 pp. Price £6.50. ISBN 0-85272-290-7.

In this pamphlet we are treated to a somewhat whimsical tour round the Highlands and Islands, and reminded that the siting of malt whisky distilleries is controlled primarily by the need for a reliable source of pure water. This falls in abundance on Scotland, but its geochemistry is then influenced by its subsequent passage through the peat and underlying country rocks. Traditionally it used to be considered that 'soft water, through peat, over granite' gave the best water for distilling, but water percolating through sandstones or schists is also used. We are taken on a lightning tour of Scotland (and Northern Ireland), ranging from the Argyll Islands (Laphroaig), the Grampian Highlands (Speyside: Glenlivet, Glenfiddich), the 'Far North' (Glenmorangie), the 'Deep South (Glengoyne) and finally to the 'Wild West' (Talisker).

The text is illustrated by over 100 original water-colours, covering everything from kilted highlanders to schematic cross-sections through Scottish geology, peat cutting and stacking, Celtic crosses, hand specimens of Insch gabbro, Hugh Miller's house, an Ailsa Craig curling stone, and Highland cattle. These illustrations are woven in with the text to introduce readers to the concepts of faults and folds, plate tectonics, and to both Caledonian and Tertiary igneous activity, all the while linking in with the great variations in flavour of the whiskies distilled in each district. A sketch of the Talisker distillery in Skye is accompanied by a quotation from Dr Johnson describing it as "the sort of place where a hermit might expect to grow old in meditation without the probability of disturbance or interruption". Finally readers are advised that to appreciate fully the flavour of the whisky, the addition of *a little water*, ideally from the same source as the whisky, releases the aromatics and increases the perception of both taste and smell.

R.A. Howie

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GISMONDINE-Ba, A ZEOLITE FROM THE WEATHERING OF SLAGS

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Natural weathering of lead smelting mill slags in Yorkshire and Derbyshire has produced small, colourless, interpenetrant twinned crystals of gismondine-Ba. This is its first natural occurrence though related material is known as a synthetic product. The crystals have been characterised by microprobe analyses, X-ray powder diffractometry and infrared spectroscopy, and have the formula $(Ba_{1.84}Na_{0.13}Ca_{0.03})_{\Sigma=2}Al_4Si_4O_{16}.nH_2O$, corresponding to the ideal formula $Ba_2Al_4Si_4O_{16}.nH_2O$, where $n = 4–6$. They are monoclinic with *a* 14.896, *b* 9.951, *c* 7.613 A, β103.25°.

INTRODUCTION

Among material collected by one of us (R.P.H.L.) from the dumps of Marrick Low lead smelting mill, Marrick (National Grid Reference NZ 079 995), Whashton smelting mill, Whashton (NZ 144 055), and Surrender smelting mill, Reeth (NY 990 000), all in North Yorkshire; and by one of us (J.I.W.) from similar lead smelting slags in the bed of the River Derwent at Cromford, Derbyshire (SK 298 571), and derived from Cromford smelting mill, are small (up to ~0.5 mm across), colourless, transparent, bipyramidal crystals displaying the curious interpenetrant twinning characteristic of gismondine (Fig. 1). These crystals are associated not with other zeolites, but with barium-containing thiosulphates, a sulphite and a trisulphide – e.g.

$BaS_2O_3.H_2O$,
$BaS_2O_3.BaF_2$,
$BaSO_3$,
$(Ba,Sr,Ca)S_3.Ba(OH)_2.2Al(OH)_3.5H_2O$ – as well as baryte and witherite (Braithwaite *et al.*, 1993).

CHEMISTRY

The crystals dissolve slowly in dilute hydrochloric acid, leaving a gelatinous residue, typical of silicates; addition of sulphuric acid gives a milky precipitate, characteristic of the presence of barium.

Electron microprobe analyses of crystals from Cromford (Table I) indicate a composition expected for the barium analogue of natural gismondine, with a small proportion of sodium and a trace of calcium substuting for barium. The analyses were performed using a Cameca Camebax electron probe microanalyser fitted with an Oxford Instruments (Link) An 10000 energy-dispersive analyser, at an operating voltage of 15 kV and a sample current of 3 nA. These analyses show a lower state of hydration than is indicated by infrared spectroscopy, suggesting dehydration in the apparatus; the Ba^{2+} ion being larger than the Ca^{2+} ion, dehydration would be expected to be easier than in the case of gismondine-Ca. This ease of dehydration was confirmed during attempts to get good SEM photographs, degassing causing charge build-up which interferes with the electron beam, with the crystals becoming porous and exfoliating. The new phase has the formula $(Ba_{1.84}Na_{0.13}Ca_{0.03})_{\Sigma=2}Al_4Si_4O_{16}.nH_2O$, corresponding to the ideal formula $Ba_2Al_4Si_4O_{16}.nH_2O$, where *n* is probably near 4–6 from infrared evidence (see below). To avoid confusion, natural gismondine, which is Ca-dominant, is referred to in this paper as gismondine-Ca (following the recommendations of the International Mineralogical Association, Commission on New Minerals

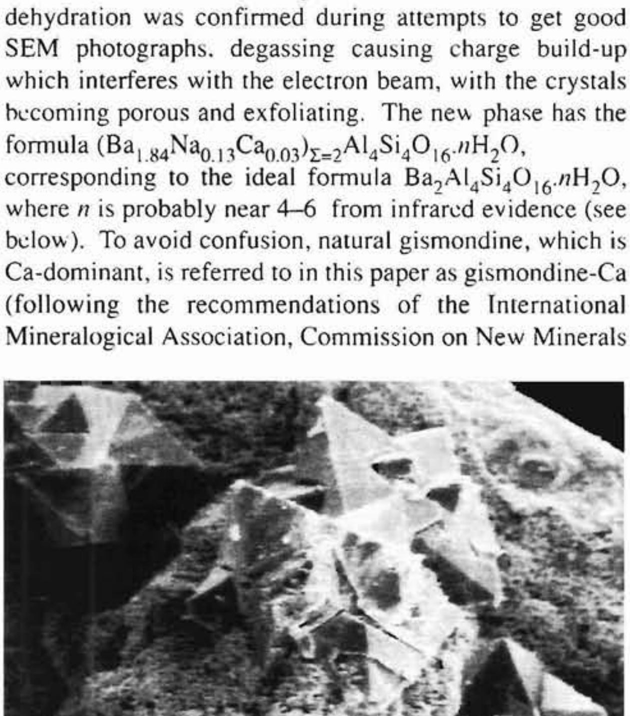

FIGURE 1. SEM photomicrograph, showing twinned crystals of gismondine-Ba on slag, from Marrick Low lead smelting mill, North Yorkshire. Scale bar 0.1 mm.

TABLE I. Analyses of gismondine-Ba.

	1	2	3	4	5
Ba	34.1	34.3	34.2	1.84	35.75
Na	0.45	0.35	0.40	0.13	–
Ca	0.17	0.16	0.17	0.03	–
Al	14.4	14.5	14.5	3.97	14.1
Si	15.3	15.4	15.4	4.04	14.6

1. Gismondine-Ba, Cromford. Analysis 1 (weight %).
2. Gismondine-Ba, Cromford. Analysis 2 (weight %).
3. Average of analyses 1 and 2.
4. Atoms per formula unit. (Ba+Na+Ca) = 2.00. T_{Si} = 0.50.
5. Calculated for $Ba_2(Si_4Al_4O_{16}).H_2O$ (weight %).

and Mineral Names subcommittee on zeolites: Coombs, 1998), although this is not an approved mineral name.

The infrared spectrum of the material is closely related to that of gismondine-Ca (Table II). Infrared spectra of samples were measured in Nujol mulls, between KBr plates, using a Philips Analytical PU 3600 Fourier Transform infrared spectrometer. The spectra show the presence of considerable amounts of water in the structure of the barium zeolite, but somewhat less than in the gismondine-Ca ($Ca_2Al_4Si_4O_{16}.9H_2O$) from Osa, Rome, Italy. Comparison of the relative intensities of the O–H stretching and H–O–H 'scissor' bending absorptions with those of the strongest silicate absorptions in these spectra suggest a formula water content (*n* above) of about 4–6 in the gismondine-Ba studied.

X-ray diffractometry of a sample from the Cromford slags was carried out at the University of Salford by Jon Newton, using a Siemens 5000 X-ray Powder Diffractometer (Table III). The results confirm that the

TABLE II. Infrared spectra of gismondine-Ba and gismondine-Ca.

Gismondine-Ba, Cromford RSWB 91-164		Gismondine-Ca, Osa, Rome, Italy RSWB 71-184		Assignments
~3480	sh			O–H stretch
3375	s, br	3395	s, br	
3270	sh	~3240	w sh	
3200	w sh			
1675	sh			H_2O 'scissor'
1650	m, f sp	1649	ms, f sp	
1091	s, sh	~1080	w sh	Silicate vibrations
1045	sh	~1030	sh	
980	vs, sp	1000	vs	
		~980	w sh	
960	s, sh	956	sh	
~935	w sh			
		880	sh	
650	w m			
565	m	577	ms, f sp	
440	ms, fsp	444	ms, f sp	

w = weak; m = medium; s = strong; sp = sharp; br = broad; sh = shoulder; f = fairly.

TABLE III. Powder X-ray diffraction data for gismondine-Ba and gismondine.

GBa			GBaSyn		GIS	
d_{obs}	I/I_0	h k l	d_{obs}	I/I_0	d_{obs}	I/I_0
9.934	64.5	0 1 0	9.84	1	10.00	3
7.798	47.3	*				
7.254	42.2	2 0 0	7.25	73	7.30	63
6.532	36.4	*				
5.896	43.2	-1 1 1			5.94	7
					5.77	15
					5.32	4
5.173	29.2	1 1 1	5.17	5		
			5.02	5	5.00	17
4.983	28.1	0 2 0			4.91	52
4.673	35.9	2 0 1			4.68	17
4.500	29.5	*				
					4.46	10
					4.33	6
					4.27	100
4.237	28.9	2 1 1			4.21	51
			4.14	9	4.18	34
					4.05	30
					4.02	6
3.625	25.9	4 0 0	3.67	1	3.642	6
					3.606	8
			3.56	1	3.587	5
3.503	29.7	*				
3.402	28.0	2 2 1			3.431	16
3.382	3.7	-4 1 1			3.383	8
3.322	29.8	0 3 0	3.29	19	3.338	47
3.163	100	-3 1 2	3.18	100	3.186	90
					3.132	71
					3.064	4
3.002	23.4	4 0 1			3.022	5
			2.992	27	2.993	16
2.938	48.3	-5 0 1			2.955	1
					2.873	4
					2.825	5
					2.782	11
					2.744	76
2.703	23.7	2 3 1	2.703	18	2.714	59
					2.693	78
					2.662	69
2.659	91.2	3 0 2			2.658	72
					2.624	17
					2.607	11
					2.567	7
					2.521	15
			2.498	18	2.492	7
					2.475	8
					2.467	9
					2.458	8
			2.403	1	2.407	13
					2.389	7
2.346	17.7	3 2 2	2.366	1	2.340	16
					2.293	4
2.275	16.9	4 1 2			2.265	6
					2.242	5
2.198	19	-5 3 1			2.193	15
			2.150	2	2.167	20
					2.133	8
					2.102	6
					2.080	6
			2.057	3	2.046	10
2.028	23.7	7 1 0			2.033	10
					2.011	12
					1.967	8

GBa = Gismondine Ba, Cromford, indexed. (* = impurity lines).
GBaSyn = Ba-exchanged synthetic gismondine of formula $Ba_4(Si_8Al_8O_{32}).20.35H_2O$ (Allen, 1996).
GIS = Gismondine, Montalto di Castro, Viterbo, Italy, of formula $Ca_{3.91}(Si_{8.22}Al_{7.77}O_{32}).17.57H_2O$ (Gottardi and Galli, 1985).

material studied is a barium gismondine, and could be indexed by Merfyn Jones of UMIST on a monoclinic unit cell with *a* 14.896, *b* 9.951, *c* 7.613 Å, β 103.25, volume 1098.42 A^3. The unit cell of a gismondine-Ca with near-ideal composition is also monoclinic, with *a* 10.020, *b* 10.637, *c* 9.832 Å, β 92.57, volume 1046.87 Å^3 (E. Passaglia and R. Rinaldi, *written communication in* Gottardi and Galli, 1985). The flexible gismondine framework is able to accommodate the large size of the barium cation, with a distortion of the unit cell and a small increase in its volume (*cf.* Bauer and Bauer, 1998). The extra lines in the pattern of our material are probably due to the presence of an impurity but have not been identified: the closest zeolite pattern is that of brewsterite, a zeolite containing strontium and barium as major cations and therefore a plausible candidate.

DISCUSSION

The source of the barium in the formation of gismondine-Ba in these lead smelting mill slags is doubtless from baryte contamination of the ore smelted, baryte being difficult to separate by gravity from the galena, owing to its high density. On smelting, the baryte would be reduced to barium sulphide, whose solubility under acidic conditions gives a ready source of barium ions, which under the right conditions could interact with silicate from the slag in the water-rich weathering environment to give the zeolite. The gismondine framework is easily formed, certainly under mild hydrothermal conditions, as is evidenced by the commercial production of 'zeolite MAP' (gismondine-Na) which is included as a water softener in up to 30% of the composition of household detergent packs (Adams *et al.*, 1997). Synthetic analogues of the other Ba zeolites edingtonite and harmotome can also be made under mild hydrothermal conditions (Barrer, 1982). Barium would compete successfully with other available s-block elements (i.e. those of Groups I and II of the periodic table) in the environment, as it is the preferred ion among these for exchange into the gismondine structure. This is illustrated by the facile and complete exchange of the sodium cation by the barium cation in 'zeolite MAP' (Allen, 1996).

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NOTES

RAMSBECKITE WITH SCHULENBERGITE FROM CORNWALL AND CUMBRIA, ENGLAND

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Ramsbeckite, $(Cu,Zn)_{15}(SO_4)_4(OH)_{22}.6H_2O$, is a rare mineral which is typically found in the mineral assemblages that form when mixed copper, zinc and iron sulphides oxidise in mine spoil. It was first described as equant, bright green crystals up to 2 mm long from the Bastenberg mine near Ramsbeck, and four other localities in Germany (Hodenberg *et al.*, 1985). The first British occurrences were in the dumps of Waterbank mine, Staffordshire; Dylife mine, Powys; and Brynarian mine, Ceredigion (Rust, 1992). Ramsbeckite was visually identified from Nantycagl mine, Ceredigion (J.S. Mason, *personal communication* in Bevins, 1994), and Ystrad Einion mine, Ceredigion (Mason and Rust, 1997), on the basis of its characteristic pseudo-orthorhombic diamond-shaped crystal habit. It occurs in similar emerald-green pseudo-orthorhombic crystals at Frongoch mine, Ceredigion (Green *et al.*, 1996), and as exceptionally large crystals (up to 3 mm in size) at Penrhiw mine, Ceredigion (Mason and Green, 1995).

Schulenbergite, $(Zn,Cu)_7(SO_4,CO_3)_2(OH)_{10}$, is somewhat more widespread than ramsbeckite. It occurs with ramsbeckite at all the localities mentioned above, typically as sub-millimetre sized groups of bluish to green foliated hexagonal crystals. It has also been recorded on specimens collected from the level walls in Smallcleugh mine and Nentsberry Haggs mine, Cumbria (e.g. Bridges and Young, 1998).

Ramsbeckite was recently identified by X-ray diffractometry at the University of Manchester (X-ray no. MANCH:XRD585) on a single specimen from Prince of Wales mine, Calstock, Cornwall (National Grid Reference SX 401 705). It occurs as flattened, emerald-green, pseudo-orthorhombic crystals up to 0.5 mm long, in cavities in partly oxidised sphalerite. Abundant greenish blue, feathery aggregates (0.2–0.3 mm) of schulenbergite are present on the same specimen (identified by XRD at the Natural History Museum, London, no. 8198F). It was on the basis of this identification that Ryback and Tandy (1992) first reported schulenbergite from Cornwall.

Ramsbeckite and schulenbergite have also been found at Driggith mine, Caldbeck Fells, Cumbria (NY 327 353), where they occur in thin carbonate-bearing veinlets in oxidised sphalerite. Ramsbeckite forms typical emerald-green, pseudo-orthorhombic crystals up to 0.4 mm in size (MANCH:XRD600). These are associated with crudely hexagonal, foliated aggregates of schulenbergite up to 0.3 mm across (MANCH:XRD601), subhedral blue grains of posnjakite (MANCH:XRD602), serpierite, and linarite. A similar supergene assemblage, comprising ramsbeckite crystals up to 2 mm long (MANCH:XRD611) with schulenbergite and langite (C.M. Leppington, *personal communication*: identified by XRD), is present on a few specimens from the dumps of Sandbed (lead) mine (NY 330 359). Since the two mines worked the same vein and were connected underground it is not surprising that similar post-mining mineral assemblages developed on the dumps.

Ramsbeckite and schulenbergite are probably ephemeral minerals. At the localities described above, they crystallised as a result of the post-mining oxidation of mine spoil, an environment that is far from chemical equilibrium. At Driggith mine, both minerals were found in thin carbonate-rich veinlets, crystallising in the open spaces left when carbonates were leached by acid Pb–Cu–Zn-bearing solutions. This environment is very similar to that noted at Penrhiw mine by Mason and Green (1995). The thin spaces resulting from the dissolution of carbonate minerals by acid Cu–Zn-rich solutions seem particularly favourable to their formation. The association of ramsbeckite and schulenbergite with the langite group minerals posnjakite and langite is noteworthy. These minerals are closely associated at Driggith mine, Sandbed mine, and a number of localities in mid-Wales. Very similar conditions are clearly required for their formation.

A small suite of specimens from the localities in the Caldbeck Fells is preserved in the Manchester Museum collection.

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MILLERITE AND ASSOCIATED MINERALS FROM BRIXHAM, DEVON, ENGLAND

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The beautiful golden needles of millerite are well known as a British mineral, having been found at a considerable number of localites, under a wide range of geological conditions. The best-known localities, where the mineral is most common, are in various coalfields, especially that of South Wales, where it is found relatively commonly in the shrinkage cracks in septarian nodules in the ironstone bands above certain coal-seams (see e.g. North and Howarth, 1928). In other environments it tends to be less common, and is usually of sparse occurrence, e.g. associated with the Pennine medium-temperature hydrothermal mineralisation, as in Weardale, in Derbyshire and at Ecton, Staffordshire.

In south-west England it is known from various mines, associated with the well-known metalliferous mineralisation, and also from a few localities away from the mined area, such as at Gerrans Bay, Cornwall, where three specimens were collected from one cavity, lined with pink calcite, in a vein in black Silurian schist (Collins, 1878). Its occurrence in Devon is similar, on quartz at Brookwood mine (M.G.H. Merry, *personal communication*) and at Combe Martin mines (Greg and Lettsom, 1858; Hall, 1868; Collins, 1871; Dines, 1956), and also from "near Ilfracombe", from where hematite and aragonite in Devonian slate and limestone are also reported (Greg and Lettsom, 1858; Hall, 1868; Collins, 1871). It is not clear whether this last locality is away from the mines, or is at the Combe Martin mines, which these authors describe as at Ilfracombe.

At Brixham, millerite is found in quartz bedding-plane pods in a blackish Middle Devonian (c^2) shale outcropping on the beach in St Mary's Bay, at National Grid Reference SX 932 550. The only reported mineralisation in the vicinity is of hematite–goethite deposits in the adjacent limestones, worked from a number of small mines in the 19th century (Collins, 1871; listed in Brooke, 1975). The quartz pods are up to about 20 cm thick, and may extend nearly horizontally for several metres. They consist largely of milky quartz, with occasional small cavities into which clear quartz crystals up to 1 cm long may project.

The millerite crystals can be spectacular, are sometimes over 1 cm long, and vary considerably in thickness. They are sometimes fresh and bright golden, sometimes tarnished, and sometimes altered partly or completely into pseudomorphs of a translucent green mixture of variable composition (Gandolfi XRD by T.M. Seward; also infrared spectroscopy). The millerite crystals are found in fracture planes, and projecting into the cavities. Associated with them are other sulphides, commonly pyrite cubes, often oxidised to limonite. Chalcopyrite is much less common, filling parts of some thin fractures, and occasionally forming small crystals; traces of galena are also found. Sphalerite occurs sporadically as a late-generation mineral, in very pale brown, almost colourless, translucent to transparent tetrahedra, often twinned or otherwise modified, varying from microscopic to nearly 3 mm across; it also occurs in small rounded masses. EDAX analyses show that this sphalerite is zinc sulphide of unusually high purity, despite the iron-rich environment with associated pyrite, etc.

Other common associated minerals include siderite of several generations, in small pale to mid-brown rhombohedra; earlier generation crystals tend to be more oxidised and of more platy habit, those of later generation are smaller, and can be nearly colourless. A few late-generation rhombohedra of siderite were found containing hematite inclusions, giving a superficial resemblance to rhodochrosite. Some pink calcite veinlets may also be mistaken for rhodochrosite. A white, shiny, talc-like material common in fractures and cavities proved to be muscovite; in the vicinity of millerite this is sometimes pale green. Veinlets and irregular masses of palygorskite-like material in and around the quartz pods also proved to be muscovite. Bunches and crusts of small colourless needles of aragonite coat some surfaces, particularly those of oxidised siderite. Oxidation of the chalcopyrite has produced sparse tiny spherules of malachite.

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ROSIAITE FROM BWLCH MINE, DEGANWY, CONWY, WALES

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Bwlch mine (National Grid Reference SH 787 794) is a small, isolated and long-abandoned antimony mine near Deganwy, 3 km south of Llandudno, formerly in Caernarvonshire, north Wales (Russell, 1944). Antimony minerals occur here with quartz in patches and veinlets in an Ordovician nodular ignimbrite. Stibnite, semseyite, zinkenite, plagionite, jamesonite, robinsonite(?), boulangerite(?), sphalerite, galena, pyrite, and marcasite have been recorded, with small amounts of secondary bindheimite, stibiconite(?), anglesite, and red coatings dubiously called kermesite (Russell, 1944; Bevins *et al.*, 1988; Bevins, 1994). The mention of stibnite from "Castell Diganwy, near Conway" by Smyth *et al.* (1864) no doubt refers to the Bwlch mine.

A loose specimen of mineralised ignimbrite collected (by G.R.) in 1955 close to the open shaft revealed, on breaking up, a cavity several mm across lined with a very thin, light orange-brown crust coating stibnite and buff-coloured cellular bindheimite. The surface of the crust shows stacked rounded platelets <50 µm across (Fig. 1). An IR spectrum taken in 1985 and an X-ray powder pattern in 1989 could not be matched to available standards, but the crust has now been identified as rosiaite, $PbSb_2O_6$, a new species recently described from the Cetine mine, Tuscany, Italy (Basso *et al.*, 1996). The X-ray pattern matches the published data for rosiaite, and the identity was confirmed by comparison of the X-ray pattern and IR spectrum with those of a specimen of rosiaite from the Tafone mine, Tuscany (a second locality mentioned by Basso *et al.*, 1996). Both X-ray and IR showed the presence of some bindheimite in the Bwlch mine sample.

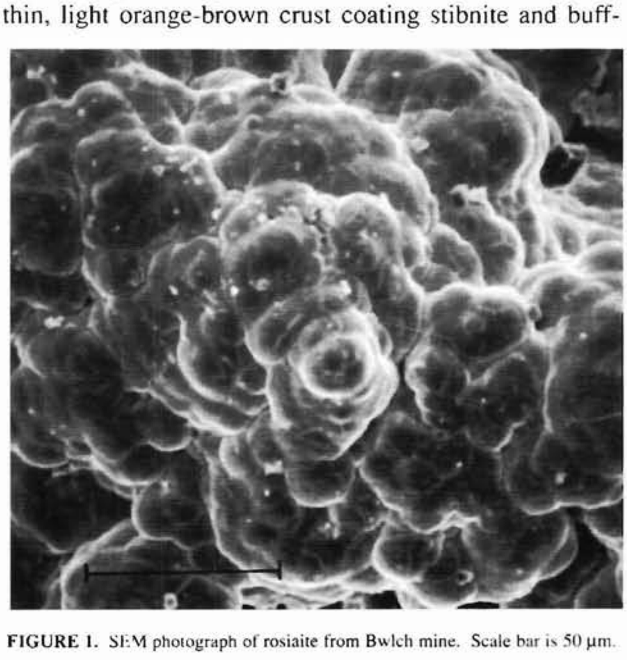

FIGURE 1. SEM photograph of rosiaite from Bwlch mine. Scale bar is 50 µm.

This appears to be the first occurrence of rosiaite in the British Isles. The specimen is deposited in The Natural History Museum, registered as BM 1998.97. On our reference specimen from Tafone mine, rosiaite occurs as tiny crystals, with tripuhyite, valentinite and bindheimite, in cavities of a slag composed of greyish polycrystalline β-Sb_2O_4. Although the matrix of the original rosiaite from Cetine mine (Basso *et al.*, 1996) is not described, the mineral there is presumably of natural origin, as is certainly that at Bwlch mine.

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NATROLITE FROM CALTON HILL, DERBYSHIRE, ENGLAND

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The Carboniferous succession of Derbyshire includes a number of volcanic and intrusive rocks of basaltic composition, which were commonly referred to by the Peak District miners as 'toadstones'. Descriptions of their form, petrography and distribution include works by Bemrose (1907), Garnett (1923), Tomkeieff (1926, 1928), Wilcockson (1932), Varvill (1937), Traill (1940), Shirley (1948, 1958), Smith *et al.* (1967), Walters and Ineson (1981), and MacDonald *et al.* (1984). The main minerals found within these rocks have recently been reviewed briefly by Ford *et al.* (1993).

The presence of undetermined zeolite group minerals within the Derbyshire 'toadstones', though without reference to specific localities, was noted by Farey (1811), and Tomkeieff (1926) suggested that a white fibrous mineral found within the Miller's Dale lavas may be "some variety of zeolite". Wilkinson (1967) also made reference to unspecified zeolites in the Lower Miller's Dale Lavas at Wormhill, and in the Cave Dale Lavas in Cave Dale. Adam (1846) commented on the presence of an unspecified zeolite in association with wad at Elton, though in the shale, rather than the 'toadstones'.

Reported here is the presence of natrolite filling vesicles within the analcime-basalt at Calton Hill quarry (National Grid Reference SK 118 712), near Buxton. The mineral occurs as white to pale salmon-pink, compact, radiating, fibrous, crystalline masses completely filling ovoid vesicles up to 10 mm across. Apart from very small amounts of an undetermined chlorite intergrown with the natrolite crystals near the centre of a few vesicles, no other mineral has been observed in these vesicles. Identification of the natrolite was by X-ray diffraction using a Phillips PW1710 coupled to a Microvax 3100 and employing the Zeolite File written by Dr C.D. Williams of Wolverhampton University. Differential thermogravimetry, using a Mettler TG50 with the heating rate at 10°C/min, revealed the characteristic peak showing water loss at 330°C which is unique to natrolite (Gottardi and Galli, 1985).

Calton Hill is a disused roadstone quarry which formerly worked analcime-basalt from a vent intrusion of Lower Carboniferous age. The intrusion has been described by Bemrose (1910) and Tomkeieff (1928). Major rock types within this intrusion include agglomerates and tuffs, highly altered vesicular olivine-basalts, and analcime-basalt, for which the quarry was worked. These latter rocks, which clearly intrude the earlier volcanic rocks at Calton Hill, have long attracted interest for the occurrence within them of lherzolite and harzburgite nodules of upper mantle origin (Bemrose, 1910; Hamad, 1963; Donaldson, 1978). The presence of natrolite-filled vesicles has not hitherto been reported.

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MILARITE FROM SHAP GRANITE QUARRY, CUMBRIA, ENGLAND, WITH A DISCUSSION OF MILARITE OCCURRENCES IN CORNWALL AND DEVON

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Milarite, $(K,Na)Ca_2AlBe_2Si_{12}O_{30}.H_2O$, an uncommon mineral that typically crystallises at a late stage in miarolitic cavities in granitic rocks and pegmatites, and in alpine-type veins, has recently been identified on specimens collected at the Shap granite quarry, Shap, Cumbria (National Grid Reference NY 558 084). It occurs as colourless, transparent, prismatic crystals up to 2 mm long in miarolitic cavities in coarse porphyritic adamellite. The crystals display prism faces $\{10\bar{1}0\}$, which are commonly modified by the pyramid $\{10\bar{1}1\}$ and terminated by a prominent pinacoid $\{0001\}$. They typically occur on feldspar, and are associated with fluorite, titanite, pyrite, anatase and biotite. In some cases they were enclosed in later carbonate, which was removed to reveal milarite using dilute hydrochloric acid. Milarite was identified by X-ray powder diffractometry at Manchester University (No. MANCH:XRD586).

Milarite is the second beryllium mineral to be reported from Shap granite quarry. Bavenite, a beryllium species, with a similar composition to that of milarite, was recorded by Wirth (1995) as colourless platy crystals. More recently, bertrandite has been identified by XRD as subhedral platy crystals. Incompatible elements such as beryllium tend to be concentrated into the final stages of crystallisation of granitic magmas. This may explain the presence of the beryllium minerals in the late-stage miarolitic cavity assemblage at Shap. A more detailed review of the cavity mineralisation is in preparation.

A.W.G. Kingsbury claimed to have found milarite at Cheesewring quarry, Linkinhorne, Cornwall, and at the Old Aplite quarry, Meldon, Devon (Embrey, 1978; Kingsbury, 1964, p.249). In view of the discreditation of many rare or unusual British minerals supposedly collected by Kingsbury (Ryback *et al.*, 1998, 2001), these occurrences have been re-investigated.

The Cheesewring quarry occurrence is represented by >40 small (0.8–8 mm long), detached, colourless transparent prisms, labelled as collected in 1951–52 from small clay-filled vugs in a vein of tourmalinised granite at the top of the NE centre of the quarry. Seven crystals had been donated to The Natural History Museum, London (BM 1958,80) and the rest were located in Kingsbury's private collection, now also in the NHM. There are specimens of the tourmalinised granite in his collection, but none with milarite on matrix. It is difficult to make judgements on matrix-free specimens but, in habit and general appearance, the crystals are very similar to those from the type locality at Val Giuf or Giuv, Tavetschtal, Switzerland. Val Giuf milarite is commonly found in old collections, often as detached single crystals. Furthermore, no specimens of milarite other than Kingsbury's are known to us from Cheesewring quarry, in spite of extensive collecting having taken place there for over 50 years. This claimed occurrence is therefore regarded as suspect.

There is only one specimen (BM 1965,81, broken into several pieces) of Kingsbury's milarite from the Meldon Old aplite quarry, supposedly collected in 1959. It shows clear, colourless, thin prisms up to 3 mm long, lying flat on the surface of snow-white, fine-grained aplite with abundant minute cavities; the milarite is easily overlooked on cursory inspection. Although macroscopically and in thin section the matrix appears to be distinctly different from the typical fine-grained aplite from Meldon, there is insufficient evidence to adjudge the provenance of this specimen.

Milarite that differs from Kingsbury's has, however, been collected from the Old aplite quarry in the early 1970s by Mr Peter Edwards, who kindly brought in his specimen recently for examination; it had been identified by XRD at the NHM in 1990 (X-ray no. 7970F). The milarite forms white, opaque, somewhat rough prisms, mosly ~2 mm long but some reaching 12 mm, which accompany small albite crystals on a joint in off-white, fine-grained aplite, close to its contact with dark country-rock. There is some light iron-staining and, on the back of the specimen, prominent specks of dark-violet fluorite.

Other beryllium minerals (bavenite, beryl, beryllonite and herderite) are known to occur in the Old aplite quarry (Dearman and Claringbull, 1960; von Knorring and Condliffe, 1984), but those reported only by Kingsbury (chrysoberyl, eudidymite and rhodizite) (Embrey, 1978; Kingsbury, 1964, p.249) will, like his milarite, require re-examination.

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RASPITE FROM CARROCK MINE, CALDBECK FELLS, CUMBRIA, ENGLAND: A FIRST BRITISH OCCURRENCE

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Raspite, the monoclinic polymorph of $PbWO_4$, has been reported from only a very few localities worldwide. The type locality is at Broken Hill, New South Wales, Australia, where raspite is found with stolzite in manganiferous gossan. It also occurs at Cerro Estaño, near Guanajuato, Mexico, in tin-bearing veins, and near Sumidoura, Minas Gerais, Brazil, in gold-bearing placers.

While examining quartz veinstone samples collected at Carrock mine, Caldbeck Fells, Cumbria, one of us (T.N.) noticed a few small, lustrous, yellow, prismatic crystals, with an apparently monoclinic habit, associated with similarly coloured bipyramidal stolzite. The largest of these, a pale yellow prism about 0.3 mm long, with a few attached stolzite crystals up to about 0.2 mm in size, was detached and examined by SEM EDAX. Lead and tungsten were the only elements detected with atomic number >10. The monoclinic crystal was removed from the SEM stub, ground to a fine powder, and applied as a thin film to a glass slide. Its XRD pattern was recorded using a Phillips diffractometer at the University of Manchester (X-ray no. MANCH:XRD581). Comparisons with stolzite and raspite powder diffraction patterns, using standard pattern matching software, showed the mineral to be raspite.

Stolzite, the tetragonal polymorph of $PbWO_4$, has been recorded at a number of localities in the British Isles (see Green *et al.*, 1996, and references therein), but this appears to be the first report of raspite. In common with stolzite, it seems to have formed by supergene oxidation of lead- and tungsten-bearing minerals. The source of the tungstate was undoubtedly the slightly altered scheelite on which the raspite crystallised. The source of the lead is less obvious. Several small lead- and zinc-bearing veins cut the tungsten veins at Carrock mine, and stolzite has been found in these and in the nearby lead veins in Poddy Gill and Brandy Gill (Cooper and Stanley, 1990). There is also a minor late-stage assemblage comprising primary pyrite, galena and sphalerite present in the tungsten-bearing quartz veins themselves. Supergene oxidation of either of these assemblages could have produced the lead-bearing solutions required for raspite and stolzite to form.

Stolzite is relatively widespread in the tungsten-bearing veins, where it is commonly found on oxidised scheelite, as reported by Cooper and Stanley (1990) and also described above. Since stolzite and raspite are similar in colour to scheelite, they are easily overlooked. Further detailed examination of this assemblage would be useful, especially since the only well-formed crystal collected was destroyed during analysis.

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PARASYMPLESITE, A MINERAL NEW TO BRITAIN, FROM WET SWINE GILL, CALDBECK FELLS, CUMBRIA, ENGLAND

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INTRODUCTION

The quartz–antimony vein mineralisation exposed in Wet Swine Gill, Caldbeck Fells, Cumbria, was first described by Fortey *et al.* (1984). The primary ore minerals comprise an early Sb–As–Fe assemblage (mainly stibnite and berthierite, with lesser arsenopyrite, sphalerite, jamesonite and traces of antimony) and a later Sb–Pb assemblage (zinkenite with lesser fülöppite and semseyite). In addition to these, a small number of supergene minerals have been reported. Bindheimite, stibiconite, senarmontite and sulphur were identified by Fortey *et al.* (1984), and the rare mineral claudetite was recently reported by Leppington and Green (1998).

EXPERIMENTAL

As part of an investigation of the mineralisation at Wet Swine Gill, a small amount of quartz veinstone which had been collected from the vein outcrop at National Grid Reference NY 3144 3215 was examined. Samples were taken for qualitative probe analysis by SEM EDAX. If the result was interesting, further material was hand-picked with a needle, finely ground, and applied in solvent suspension to a glass slide. The thin, uniform film so produced was mounted in an X-ray diffractometer (CuKα radiation, 40 kV, 20 mA) and its diffraction pattern was recorded from 5° to 50° in 2θ.

MINERALOGY

The primary mineralogy of the specimens examined during this study was similar to that described by previous workers. However, in some of our specimens arsenopyrite was more abundant, locally often forming almost pure quartz-arsenopyrite selvages to the vein. The only material we could find with a fülöppite-type XRD pattern comprised rare, dark red, resinous to submetallic, equant, subhedral to euhedral crystals associated with stibnite. This phase is clearly different from the fülöppite previously reported from this and other localities worldwide, and requires further detailed investigation before it can be identified with certainty.

The supergene assemblage at Wet Swine Gill is considerably more complex than previously described. Scorodite, pharmacosiderite and beudantite are commonly present as small patches in iron oxide crusts that fill joints in the quartz. Cavities in the stibnite-rich quartz veinstone contain well-crystallised valentinite, barium pharmacosiderite, and an as yet unidentified iron antimony arsenic oxide, as well as bindheimite, stibiconite, senarmontite, sulphur, and claudetite. In addition, the rare mineral parasymplesite was collected from one large block of arsenopyrite-rich veinstone.

Parasymplesite occurs as pale to dark blue or green monoclinic crystals, forming radiating aggregates up to 2 mm across. The largest crystals show a distinct yellow to blue pleochroism. It is also found as radiating rosettes up to 3 mm across of green fibres, on fracture surfaces in quartz. Both crystal habits were identified by X-ray diffractometry (nos. MANCH:XRD534 and 536). Since vivianite group minerals exhibit extensive substitution, but are similar structurally, the composition was investigated by SEM EDAX. This showed that iron and arsenic were the only elements present with atomic number >10. The oxidation state of the iron was shown to be Fe^{2+} by wet chemistry, differentiating parasymplesite from the poorly defined mineral ferrisymplesite (Gaines *et al.*, 1997).

DISCUSSION

Parasymplesite, $Fe^{2+}_3(AsO_4)_2.8H_2O$, is a member of the vivianite group of minerals. These are monoclinic or triclinic phosphates and arsenates with general formula $A_3(XO_4)_2.8H_2O$, where A is normally a divalent transition metal cation, and X is P or As.. Parasymplesite was first described from Kiura, Japan (Ito *et al.*, 1954) and has subsequently been reported from the supergene zones of arsenic-rich orebodies at a few other localities worldwide (e.g. Gaines *et al.*, 1997). It is the arsenate analogue of vivianite, which it closely resembles, and is dimorphous with symplesite.

Whereas symplesite has been recorded at a number of localities in Britain, including several in the Lake District (Thomson, 1997; Young *et al.*, 1992; Young, 1987), this is the first British record of parasymplesite, although the mineral was recently reported from the dumps of Muckross mine, Co. Kerry, Ireland (Moreton *et al.*, 1999).

At Wet Swine Gill, parasymplesite is almost always associated with residual arsenopyrite. The area from which the specimens were collected was saturated with groundwater at all times, and parasymplesite was found only in those parts of the exposure below the water line, while scorodite and pharmacosiderite dominated in the drier areas. It seems likely that the constant saturation coupled with arsenopyrite oxidation allowed mildly anoxic conditions to develop in cracks in the vein, reducing the Eh to the point where ferrous arsenate (parasymplesite) rather than the more usual ferric arsenates (scorodite or pharmacosiderite) is stable. The occasional occurrence of small sprays of parasymplesite on corroded stibnite suggests that this mineral might also act as a focus for reduction.

The parasymplesite-bearing matrix also contains abundant claudetite and it is likely that this mineral also owes its existence to localised reduction. Arsenate(V) (arsenate) anions are soluble in acid solution provided there is a suitably low concentration of cations that would otherwise precipitate them. The more reduced arsenate(III) (arsenite) anions, on the other hand, decompose to relatively insoluble arsenic(III) oxides (claudetite or arsenolite) in acid solution. A low pH and the absence of interfering cations such as Fe^{2+} appear to be the requirements for claudetite to form. This may explain why claudetite is found in the same matrix as parasymplesite but is associated with residual stibnite rather than arsenopyrite, and does not occur in direct association with parasymplesite.

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VESIGNIÉITE FROM CASTLETOWN MINE, LOCHGILPHEAD, ARGYLL AND BUTE, A FIRST SCOTTISH OCCURRENCE

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Vesigniéite, $BaCu_3(VO_4)_2(OH)_2$, is an uncommon mineral that is occasionally found in the supergene zones of copper-rich orebodies. It was first recorded in Britain at Newhurst quarry, Leicestershire, as rosettes of thin, tabular, yellow-green crystals (King and Wilson, 1976). Similar greenish crystal aggregates have since been identified from Bardon Hill quarry and New Cliffe Hill quarry, also in Leicestershire (identified by XRD at Manchester Museum).

Castletown mine is a small abandoned copper mine that was developed in a roughly SW–NE trending orebody near Loch Gilp, about 3.5 km SSE of Lochgilphead, Argyll and Bute. The principal workings are several hundred metres inland and a copper-rich portion of the orebody crops out on the lochside at National Grid Reference NR 8740 8465.

A suite of supergene minerals including botallackite, clinoatacamite, and connellite, together with the uncommon copper sulphide anilite, were recorded at this locality by Starkey and Hubbard (1998). While examining further specimens collected from the lochside exposure, one of us (N.H.) noted a few unusual yellow-green spherules in quartz–sulphide veinstone typical of the deposit. Analysis by SEM EDAX showed Ba, Cu and V to be the only elements present with atomic number >10, and an X-ray powder pattern obtained from this material, although faint, showed it to be vesigniéite (X-ray no. MANCH:XRD578).

Vesigniéite occurs rarely in narrow fractures in quartz as minute, thin, yellow to yellow-green crystals forming radiating aggregates that are mostly <0.3 mm across. It is typically associated with malachite, on which it is locally crystallised, and with connellite. Clinoatacamite, dickite and hematite are also commonly present on specimens. This is the first record of a vanadium mineral from the mines in the Loch Gilp area and is the first record of vesigniéite from Scotland.

Oxidation of copper sulphides in the presence of sea water was responsible for the formation of the clinoatacamite and connellite that are associated with vesigniéite at Castletown mine (Starkey and Hubbard, 1998). The barium and copper needed to form vesigniéite are almost certainly also produced by oxidation and leaching of the quartz-sulphide orebody. The source of the vanadium has not yet been established.

The ore deposits in the Dalradian of Kintyre are relatively little studied and the discovery of a vanadate mineral at one of them suggests that further studies of the mineralogy and geochemistry are merited. A suite of minerals from Castletown mine, including a specimen of vesigniéite, is preserved at the Manchester Museum.

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OTAVITE FROM BISHOPTON, RENFREWSHIRE, SCOTLAND

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OCCURRENCE AND PROPERTIES

Otavite ($CdCO_3$) has been found in small quantities, associated with greenockite, at Bishopton, in Renfrewshire, the first reported Scottish occurrence. It occurs in highly vesicular lavas in the scree below the railway cutting (National Grid Reference NS 425 725) leading to the tunnel. This is immediately above the 'borrow pit' for the M8 motorway described by Meikle (1992). It forms creamy white crusts coating greenockite crystals or partially dissolved greenockite grains. It also forms hemispheres (up to 0.5 mm across) and botryoidal crusts on prehnite near greenockite grains, and, in one case, white rhombohedral crystals coating a steeply pyramidal greenockite crystal. It shows a bright orange fluorescence under short-wave UV light, and weaker pale greenish to orangeish fluorescence under long-wave UV. This provides a quick method of detecting the otherwise unspectacular otavite.

The botryoidal and spheroidal otavite consists of clusters of tiny rhombohedra (Fig 1), rather similar to those reported by Rock *et al.* (1994) in studies of synthetic $CdCO_3$. Semi-quantitative EDAX analyses of an unpolished carbon-coated spheroidal grain indicate compositions in the range $Cd_{0.95-0.8}Ca_{0.05-0.2}CO_3$. Zn and Mg were below detection limits, while Fe may be present at around the 0.1% level. The material gave X-ray diffractometer traces very similar to those of otavite in the JCPDS index.

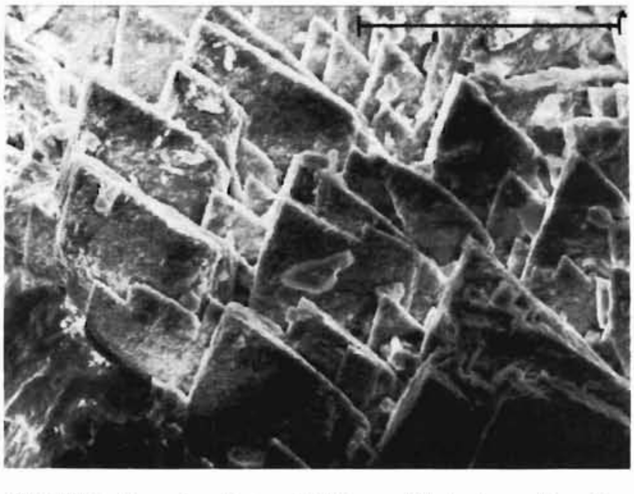

FIGURE 1. Secondary electron SEM image of the broken surface of an otavite spheroid from Bishopton. Scale bar is 20 µm.

Specimens of the material are preserved in the collections of the Hunterian Museum, University of Glasgow (GLAHM 100822), and in Neil Hubbard's private collection.

DISCUSSION

Otavite was first described from Tsumeb, Otavi, Namibia (Schneider, 1906) and has since been reported from a few other localities inlcuding: the Mo Ba lead–zinc deposit in Vietnam (Johan, 1962); the Orenberg area in the Russian Urals (Bur'yanova *et al.*, 1969); Blanchard Mine, New Mexico, USA (De Mark, 1992); Hromnice, Czech Republic (Pašava *et al.*, 1993); Broken Hill, Australia (Birch and van der Hayden, 1997); and Coldstones quarry, Pateley Bridge, North Yorkshire, England (Young *et al.*, 1997).

The new occurrence at Bishopton is extremely unusual, and perhaps unique, in that otavite is here found in minute traces in rocks of normal basaltic bulk composition, viz. lavas of the Clyde Plateau Volcanic Formation of the Strathclyde Group (Chadian to Brigantian, Viséan, Carboniferous). At Bishopton, greenockite is the most abundant sulphide present but, even so, it is extremely scarce, although crystals up to 1 cm have been found (Meikle, 1992). Minute traces of pyrite, chalcopyrite, bornite and galena accompanying greenockite were reported by Meikle (1992).

Most otavite occurrences are associated with sulphide orebodies with unusual bulk-rock and groundwater chemistry. Otavite at Bishopton has formed directly from the solution of greenockite under ordinary conditions of groundwater Eh and pH. This is unusual: significant quantities of Cd are normally only mobilised under extreme conditions resulting from the oxidation of sulphide orebodies.

Calcite is a major component of the prehnite ± other zeolites ± greenockite assemblage at Bishopton. During deposition of these minerals, both calcite and greenockite appear to have been stable phases, although whether they were actually in equilibirium is impossible to say. However, at some later stage, perhaps during recent weathering, both greenockite and calcite seem to have become unstable with respect to otavite:

$$CdS_{(solid)} + CaCO_{3\,(solid)} + nH_2O \leftrightarrow CdCO_{3\,(solid)} + Ca^{2+}{}_{(aq)} + S^{2-}{}_{(aq)}$$

This equation is not intended to represent any actual reaction (calcite and greenockite do not react directly together, and S^{2-} is not an important sulphur ion in nature), but it does illustrate some of the factors involved. Essentially, otavite (the right hand side of the equation) will be favoured by reactions which remove sulphide from the system (e.g. oxidation), whereas increased sulphide concentrations (e.g. reducing conditions, or increase in total S in the water), will favour greenockite, driving the reaction to the left. Indeed, increasing the sulphide content is one way of treating cadmium-contaminated waters (Daskalakis and Helz, 1992).

Why is otavite so rare at Bishopton? While greenockite is not exactly common here, otavite is extremely rare. It seems that what is controlling the formation of otavite is not the availability of Cd – there are plenty of greenockite grains about - - but either difficulty in crystallizing the carbonate, or difficulty in mobilising Cd^{2+}.

The solubility of carbonates in groundwaters is controlled by the complex interaction of pH, CO_2 and the minerals themselves. The pH of water in equilibrium with calcite at atmospheric concentrations of CO_2 is around 8.3 (e.g. Garrels and Christ, 1965). If the pH is lower than this, calcite will dissolve. At pH >8.3, and in the absence of sulphide species, any Cd^{2+} present will partition into calcite, rather than precipitating as otavite (e.g. Rock *et al.*, 1994). Similar calculations have been carried out for otavite, using the REACT software of Bethke (1996). These indicate that pure otavite will dissolve in groundwaters under atmospheric concentrations of CO_2 until the pH is above 7.1, when the groundwaters will be saturated with around 12 mg l^{-1} of $CdCO_3$. Crystallisation of otavite thus requires a pH of between 7.1 and 8.3, and a Cd^{2+} concentration in the water of >8 ppm.

Solution of greenockite will not directly produce waters with such high Cd concentrations. Greenockite is a famously insoluble sulphide, and reactions of the type

$$CdS_{(solid)} + nH_2O \leftrightarrow Cd^{2+}_{(aq)} + HS^-_{(aq)} + OH^-_{(aq)}$$

typically result in parts per billion levels of Cd^{2+}, or lower (Daskalakis and Helz, 1992). However, if sulphide species are removed by oxidation, greenockite solubility is in effect the same as the extremely soluble salt cadmium sulphate. Under these circumstances solubility becomes a matter of kinetics: how fast can sulphide be oxidised to sulphate, either at the greenockite grain surface, or in solution? Surface effects are very slow, and as the solubility of greenockite as sulphide is very low, rates of oxidation in solution will also be very low. In order to accumulate the necessary levels of Cd in solution, a very restricted flow of water (probably almost zero) is needed, so that Cd^{2+} can accumulate without being carried away and diluted.

Crystallisation of significant quantities of otavite probably requires a repeated hydrate–react–evaporate cycle involving oxidising groundwaters with a pH between 7.1 and 8.3. Under such conditions greenockite solubility will be greater than that of otavite, so that the former incrementally dissolves on each cycle, without removing otavite.

We cannot be sure of the chemistry of the waters present during the formation of the otavite. However, analyses are available of bottled still spring water (Sainsbury's Caledonian Spring) from similar Clyde Plateau Volcanic Formation basalts in the nearby Campsie Fells, and it is likely that most intrabasaltic groundwaters in the area are similar. The analysed water has a pH of 7.4, exactly in the range we would predict for the occurrence of otavite.

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Robert McDonald assisted with specimen coating and use of the SEM in the Division of Earth Sciences, University of Glasgow. Dr A.J. Hall assisted with running the REACT program, under the Geochemists Workbench software suite.

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BOTALLACKITE, INCLUDING GOOD CRYSTALS, FROM IRELAND

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The only botallackite recorded from Ireland is that collected in recent years from Dooneen mine, Allihies, Co. Cork (Moreton and Aspen, 1993). This material forms a part of the green coatings visible on the rocks on the north face of the southernmost of the two narrow inlets in which the mine adit portals emerge at beach level. Collectors have culled some of these encrustations, and many specimens have been marketed as "botallackite". We have studied a considerable number of samples, using infrared spectroscopy, and find that they are an intimate mixture of atacamite with variable amounts of botallackite (see Braithwaite, 1990, for their spectra), and amorphous material. Most samples contain little or no botallackite, and only a few are botallackite-rich, the original identification having been serendipitous, using a fortunately rich sample. The appearance of these crusts varies from smooth darker green, through knobbly to compact intergrown crystalline. The smooth darker green material is atacamite-rich, but the appearance of most of the material has no clear relationship with its composition. Only in one specimen (RSWB 98-31) can botallackite be separately distinguished, where it forms a thin layer of compacted blades looking much like langite, overgrown by a dark green fairly smooth layer of a mixture of botallackite and atacamite. Paler green, distinctly microcrystalline material is found a few metres inside the mine; this is pure atacamite, associated with late crusts of chalcanthite.

At Knockmahon, Co. Waterford, a series of near-parallel lodes trending NW–SE have been worked for copper, as in the Tankardstown mine sett (see Cole, 1922; O'Brien, 1959; Ryback and Moreton, 1991), and a number of these lodes outcrop on the coastal cliffs, in which numerous mine entrances are visible, some at considerable heights above sea-level. Dr George Ryback (*personal communication*, 1991) collected green crusts from the roof of a sea-level adit into part of the Stage lode complex in Cuan (Stage) Cove; powder XRD at The Natural History Museum, London (8880F) showed a sample to be a mixture containing botallackite, with atacamite and clinoatacamite.

Examination of another outcrop of the Stage lode complex in the next cove to the east, at National Grid Reference X 444 986, revealed a complex of quartz veinlets carrying chalcopyrite. At beach level, supergene alteration of the chalcopyrite has produced small pods and thin veinlets of massive cuprite with traces of native copper, in fractures in the vein-quartz, and rimmed with malachite, which latter is also found in cavities and fractures as small patches of bright green needles and in massive form. Botallackite crystals were found associated with this material in some places. These vary from deep green transparent to pale blue-green and near-opaque, and in size from microcrystalline to ~2 mm long. The larger crystals tend to be separate, in small clusters or in parallel-growth complexes, and lie flat on the quartz surfaces of fractures, but project into cavities. The smaller crystals sometimes form rich crusts superficially resembling devilline. Fourier Transform infrared spectra confirm that both types of material are botallackite. Apart from those mentioned above, the only associated mineral is traces of connellite, which is not uncommon at other localities in the area (Ryback and Moreton, 1991).

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NOTES FOR CONTRIBUTORS

TYPESCRIPTS

Papers should be typed, preferably on A4 paper, on one side only, with double spacing and wide margins. All pages should be numbered. Three complete copies should be submitted to the Editor. Each paper will be reviewed by two referees. Submission of a paper to the Journal is taken to imply that it has not been considered for publication elsewhere. Material accepted for publication can not be published elsewhere in the same form without the consent of the Editor.

The submitted material should normally contain original observations or experimental results relating to mineral occurrences in the British Isles, although other suitable topics may be considered. Full articles should include an abstract of up to 250 words summarising the significant points of the paper; notes (up to 1500 words) do not require an abstract. Review articles, which are usually invited, are also published occasionally.

FORMAT AND PRESENTATION

Papers should be submitted in the style and format of the Journal, and divided into appropriate sections and subsections. A recent issue of the Journal should be consulted for examples. Words to be printed in italics should be underlined in the typescript. Titles of papers should be adequately informative.

Authors should present their material with clarity and conciseness. Results and discussion should not normally be intermingled. Identification of the less common minerals should be supported by sufficient proof (X-ray diffraction, analyses, etc.). It may not be necessary to reproduce such data in full in the text, but they should be supplied to the Editor if required by the referees in the course of their assessment. For mineral occurrences of particular note (e.g. new occurrences in the British Isles or at a particular locality) authors are strongly encouraged to record the specimen number and the institution or collection where the specimen is lodged. National Grid References should be given for localities described in the text (the format is, e.g.: ST 4015 7185, ST 401 718, ST 40 71).

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All figures should be numbered with consecutive Arabic numbers, and referred to in the text as Fig. 1, etc. Figures must have descriptive captions, and a list of these is to be typed on a separate sheet of the typescript.

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Draft line diagrams and good photocopies of photographs will suffice for attachment to the submitted typescripts, but a set of original photographs must be supplied at the time of submission; fair-drawn line diagrams will be needed only after acceptance of the paper.

TABLES

Tables should be numbered consecutively with Roman numbers, and referred to in the text as Table I, etc. Each table should have a descriptive title, separated from the table by a horizontal line. Another horizontal line should mark the end of tabulated data; any footnotes should be placed below this.

TERMINOLOGY

Authors should adhere to the nomenclature and terminology of the International Mineralogical Association. The most recent Glossary of Mineral Species (at present the 7th edition, by Fleischer and Mandarino, 1995) can be used as a guide to mineral nomenclature, but where this conflicts with Hey's Mineral Index (1993) or Mineralogical Magazine and Mineralogical Abstracts usage, the Editor will advise on the preferred nomenclature. Chemical nomenclature should conform to the rules of the International Union of Pure and Applied Chemistry. Crystal structure studies should be reported in the manner outlined by the International Union of Crystallography (Acta Crystallographica, **22**, 45 (1967)).

ABBREVIATIONS

Except for common non-scientific abbreviations and those for standard units of measurement, abbreviations should be spelt out in full at their first mention in the article, e.g. 'platinum group mineral (PGM)'. If used, 'n.d.' in tables must be defined ('not determined' or 'not detected'). The following abbreviations may be used without explanation:

XRD = X-ray diffraction
XRF = X-ray fluorescence analysis
EPMA = electron probe microanalysis (electron microprobe analysis)
EDX = energy dispersive analysis (same as EDA, EDAX, EDS)
SEM = scanning electron microscope or microscopy
TEM = transmission electron microscope or microscopy
IR = infrared
UV = ultraviolet
NGR = National Grid Reference

REFERENCES

References should be indicated in the text thus: (Brown, 1967) or 'as stated by Brown (1967)'; (Green and Brown, 1985) for two authors; (Green et al., 1986) for three or more authors. If two or more references would give rise to identical citations in the text, they may be distinguished by appending 'a', 'b', etc. to the publication year.

A list of references in alphabetical order should form the last section of each paper. Some examples of the style used are given below; note that journal names are given in full. Papers in press may be included provided they have been accepted for publication and the journal name is given. Personal communications and unpublished work (except M.Sc. and Ph.D. theses), should not be included here but can be cited in the text, thus: (A. Brown, personal communication or personal communication, 1992), (B.C. Green, unpublished work). Likewise, references to Newsletters and similar publications will normally be cited in the text but not included in the reference list.

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