Cosalite and other lead sulpho-salts at Grainsgill, Carrock Fell, Caldbeck, Cumberland.

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Summary.—Cosalite, aikinite, zinckenite, jamesonite, and boulangerite occur at Grainsgill; the first three minerals have not hitherto been recorded from Britain. The specimens probably come from a series of low-temperature quartz-carbonate veins, later than the original mineralization and also distinct from the east-west copper-lead veins.

THE occurrence of bismuthinite, native bismuth, and the bismuth telluride grünlingite (previously referred to as tetradymite) in the higher temperature suite of veins in Grainsgill, at the western end of Carrock Fell, has been well known for many years. Greg and Lettsom[1] record antimonite (= stibnite) from 'Carrock Fells'[2] (*sic*); this occurrence is also mentioned by T. M. Hall[3] and by J. Postlethwaite.[4] Stibnite has been found in drift clay near Troutbeck, and has been recorded from one or two other localities in this northern part of the Lake District, one of which, also given by Postlethwaite, we have recently confirmed.

Our recent investigations at Grainsgill have proved the occurrence of

[1] R. P. Greg and W. G. Lettsom, Manual of Mineralogy of Great Britain and Ireland, London, 1858, p. 375.

[2] As the result of our investigations in the Lake District, it has become abundantly clear that most of the so-called localities, such as 'Carrock Fells', 'Carrock Fell', 'Brandy Gill', 'Roughtengill', 'Caldbeck Fell(s)', which are given in many of the older records and on labels with old specimens, are used in such a wide and loose manner that they cannot in general be accepted as evidence of a more precise place of origin than the Skiddaw-Carrock-Caldbeck area as a whole, and must all be regarded as synonymous. Compare Greg and Lettsom's references to bismuth at 'Caldbeck Fells' (p. 378), bismuthinite at 'Brandy Gill, Carrock Fells' (p. 380), and molybdenite at five different localities (p. 349); all these references are to one locality.

[3] T. M. Hall, The Mineralogist's Directory, London, 1868, p. 53.

[4] J. Postlethwaite, Mines and Mining in the Lake District, 3rd edn, Whitehaven, 1913, p. 60.

two lead-copper-bismuth sulphides and three lead-antimony sulphides, one or other of which may in the past have been confused with stibnite, though we have also found one small specimen of stibnite.

Identification of these sulpho-salts has been carried out by X-ray study, using specimens from well-known localities as standards, measuring spacings and intensities and checking these with published data; in this connexion it should be emphasized that, except by such X-ray study, these various minerals cannot easily be identified, especially when in massive, fibrous, or plumose forms. Spectrographic examination provides evidence of the presence of certain elements, but is not of itself sufficient to identify the species.

Cosalite ($Pb_7CuBi_8S_{22}$) is the most abundant of the sulpho-salts so far found in Grainsgill. It occurs in small quartz stringers, otherwise barren, in the greisen, or in the greisen itself where it may be accompanied by, but is not always closely associated with, traces of arsenopyrite, pyrite, and chalcopyrite; in the greisen it usually forms minute tufts, rarely exceeding 3–4 mm., of capillary fibres in cavities, while in the quartz stringers it is found in the same habit and also in fibres up to $1\frac{1}{2}$ cm. in length as well as in small compact fibrous patches. Many of the tufts are loose in the cavities and fall out when the matrix is broken; in some cases, single fibres or groups are included in nearly clear quartz surrounding the cavities. The compact fibrous material is generally steel-grey, but the more separate fibres are nearly all very dark grey and often show a bluish or yellowish tarnish.

Aikinite ($CuPbBiS_3$) has been found in small amounts as minute crystals and compact patches in quartz stringers in the greisen; so far it has not been detected in the greisen itself. The mineral is nearly all fresh and resembles the bismuthinite from this locality, though it lacks the more lamellar habit of the latter and is slightly darker.

Cosalite and aikinite occur in the small quartz stringers in the greisen, but cosalite alone is found in the greisen itself; both are minerals characteristic of moderate-temperature hydrothermal mineralization, and their paragenesis suggests that they were deposited during a moderate-temperature stage of the intense hydrothermal mineralization in Grainsgill which, as shown by Hitchen,[1] was undoubtedly responsible for the formation of the greisen.

Zinckenite ($Pb_6Sb_{14}S_{27}$), *jamesonite* ($Pb_4FeSb_6S_{14}$), and *boulangerite* ($Pb_5Sb_4S_{11}$) have also been found in small amounts but under conditions suggesting that they belong to a later stage of mineralization. They all

[1] C. S. Hitchen, Quart. Journ. Geol. Soc. London, 1934, vol. 90, p. 158.

occur as dark grey minute acicular crystals or fibres, tufts or wool-like aggregates, or small fibrous patches, and in the hand-specimen are virtually impossible to distinguish. The matrix consists of quartz, but in several cases small amounts of carbonates are also present together with traces of pyrite, arsenopyrite, chalcopyrite, or galena.

The mineralization in Grainsgill is complex and has been discussed at some length by Hitchen (loc. cit.). The main 'veins' of the so-called granitic suite, having a general north–south trend, are composite in structure and show evidence of reopening and mineralization at different stages. In addition to these there are at least two east–west fissure veins, carrying some galena and copper minerals, which cut and throw the north–south suite and are clearly of later date. Considerable care must be exercised in distinguishing between vein-material from these two sets of veins (for instance, when galena is present in a specimen), but they are nevertheless quite distinct. Careful examination of the vein-material in which the antimony sulpho-salts occur shows that they are associated with neither the north–south suite nor the east–west set of copper-lead veins.

Recent examination of the low-level cross-cut driven during the early part of the 1939–45 war has shown that there is yet another set of cross-veins which carry a quartz-carbonate matrix and small amounts of sulphides. These veins, as far as could be judged in the cross-cut, have an approximate east–west trend and can be seen cutting and throwing the main 'Harding' vein, in one instance nearly 15 ft.; from this it is evident that these veins are also of later formation. Practically no material taken out during the driving of the cross-cut was thrown on the dumps, and there is therefore no new vein-material available for examination that can be traced directly to these cross-veins. Some small specimens were collected *in situ* in the level, but so far they have not revealed any sulpho-salts although some of the associated sulphides are present. The similarity of this vein-stuff to some of that in which we have found antimony sulpho-salts on other parts of the dumps suggests that the latter may have come from some of these quartz-carbonate cross-veins, which are clearly of late-stage, lower-temperature formation. It is also probable that the one small specimen of stibnite we found came from this same set of cross-veins. More recently we have found some extremely interesting quartz-carbonate veins at three other localities in this area; they carry stibnite and sulpho-salts with galena, blende, and other sulphides. The presence of antimony minerals at these localities, at no great distance from each other, in veins having

rather similar characteristics, is of interest as this is the only area in the Lake District with a major concentration of antimony minerals.

Powder-photographs of the stibnite and the five sulpho-salts are reproduced in figs. 1 and 2.

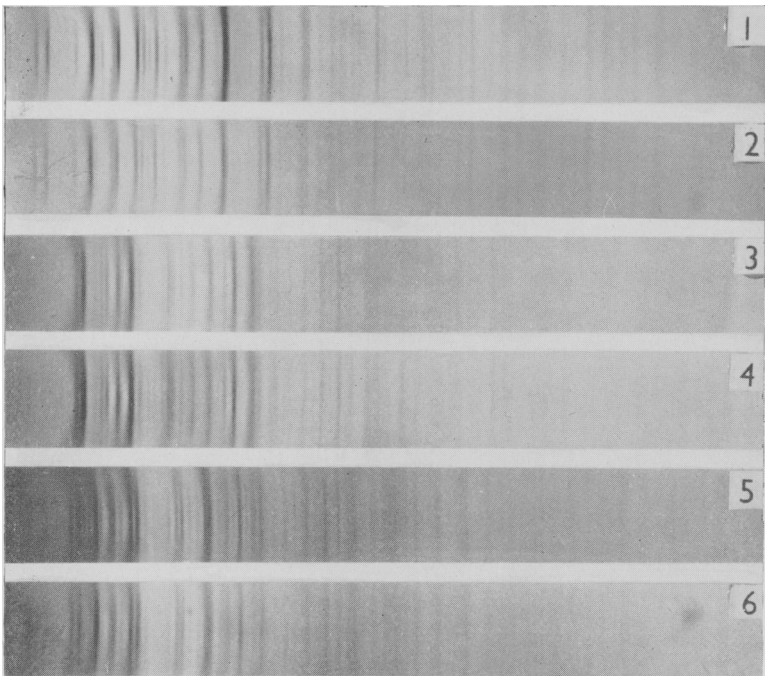

FIG. 1. X-ray powder diffraction patterns; 9 cm. diameter camera; Cu-Kα radiation. 1. Stibnite: Wheal Emily, Wembury, Devon. 2. Stibnite: Grainsgill, Caldbeck Fells, Cumberland. 3. Boulangerite: Endellion, Cornwall. 4. Boulangerite: Grainsgill, Cumberland. 5. Jamesonite: Cleveland Mine, Stevens Co., Washington, U.S.A. 6. Jamesonite: Grainsgill, Cumberland.

Some slight confusion exists as to the previous status of aikinite as a British mineral. 'Aikinite' was included in the list of British minerals presented by Dr. L. J. Spencer at the British Association meeting at Bristol in 1898, on the strength of its appearing in a Handbook or Guide of 1862 issued by the old Museum of Practical Geology in London. Recent inquiries at the Geological Museum and reference to their collections, records, and catalogues, however, show that no British specimen of the lead-copper-bismuth sulphide aikinite (of Chapman, 1843) was ever included in their collections. The name aikinite had also unfortunately

been given by Lévy, but never actually published by him, to a mineral from Wheal Maudlin, Lanlivery, Cornwall, which subsequently proved to be wolframite pseudomorphous after pyramidal scheelite.[1] On discussing this recently with Dr. Spencer, he agreed that the reference

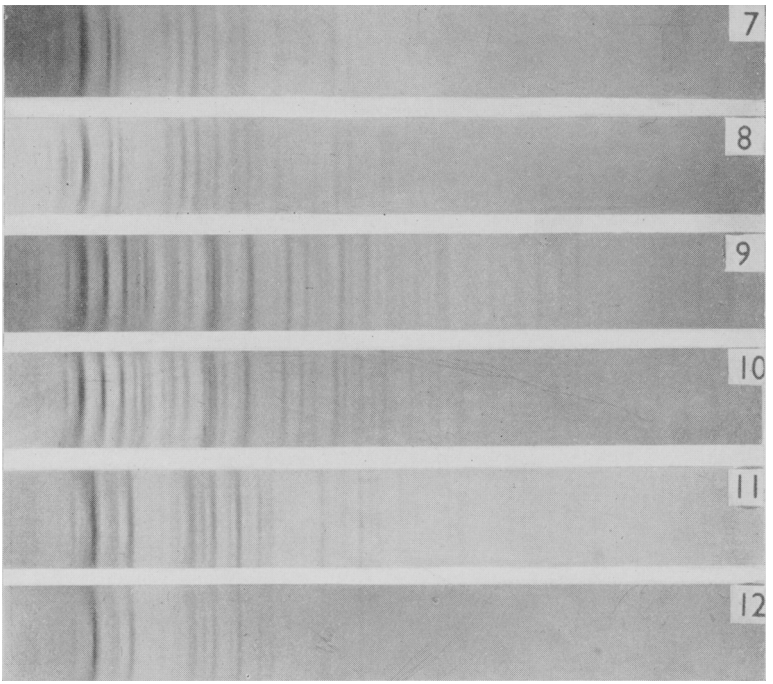

FIG. 2. X-ray powder diffraction patterns; 9 cm. diameter camera; Cu-Kα radiation. 7. Cosalite: Cariboo gold-quartz mine, British Columbia. 8. Cosalite: Grainsgill, Cumberland. 9. Aikinite: Beresovsk, Ural Mountains, U.S.S.R. 10. Aikinite: Grainsgill, Cumberland. 11. Zinckenite: Wolfsberg, Harz, Germany. 12. Zinckenite: Grainsgill, Cumberland.

in the Handbook of 1862 to aikinite almost certainly related to the Wheal Maudlin material, of which there are specimens in the Geological Museum collections. There is no record of the sulphide aikinite having been found in Britain and it appears, therefore, that its occurrence in Grainsgill is the first definite British record. Cosalite and zinckenite have not hitherto been recorded as British species, and none of these five sulpho-salts has previously been recorded from the Lake District.

[1] Greg and Lettsom, loc. cit., p. 354; L. J. Spencer, Min. Mag. 1937, vol. 24, p. 601.