Notes on British barytes.

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WHEN the slip catalogue of the barytes specimens in the British Museum collection was in the course of preparation, a few observations were made which may be of sufficient importance to place on record.

The lists of localities of the barium minerals, barytes, witherite, alstonite, and barytocalcite, in the collection show that rather more than half of the specimens (573 out of 975) come from the British Isles. Hence it would seem that there is a special concentration of these minerals in this part of the world. Possibly this is fictitious, as the collection cannot be considered to be completely representative. Nevertheless, it is evident from statistics that Great Britain, for its area, is one of the chief commercial producers. This may be illustrated by the figures given below showing the production of barium minerals for 1913 and 1926 [1] in some of the leading countries.

	Year 1913.	Year 1926.
United States of America	40,445	212,388 long tons.
Germany	155,525	178,522
Great Britain	50,045	42,775
France	12,039	38,197
Italy	12,762	31,342
Spain	2,999	7,137
Belgium	11,807	6,004

Two concentrations of barium minerals in Great Britain are of especial interest, namely those in the north of England and in Derbyshire. Barium minerals have been known in these districts for many years, but in the days when lead and zinc mining flourished they were considered merely as waste products as was also the fluorite from neighbouring localities. It has been thought for some time that the

[1] Imp. Min. Res. Bureau, Statistical Summary, London, 1921 and 1929.

modes of origin of these two minerals are closely related, especially as in both areas they are associated with basic igneous rocks.

The rocks of the north of England belong to the Carboniferous System, and into these the Whin Sill and its related dikes have been intruded. The geological structure of the area is represented diagrammatically in the E.–W. section in fig. 3 *a*, showing that the whole region forms a syncline. Dr. J. A. Smythe[1] has already pointed out that the barytes localities form a ring following the outcrop of the Whin Sill, while the fluorite localities are concentrated in the centre of the area. This fact is clearly brought out in the accompanying map (fig. 1). Specimens showing both fluorite and barytes in close association are exceptional, as may be gathered by reference to the detailed lists of localities on pp. 261–4.

The other area under consideration is in Derbyshire, where there appears to be a similar intimate connexion between barytes and fluorite and the local igneous rocks. Central Derbyshire is composed of Carboniferous Limestone with interbedded toadstones. These have an anticlinal structure with a roughly elliptical outcrop (fig. 3 *b*). The deposits form part of a ring round the igneous area, which is cut off on the west by a series of faults. In this instance the barium localities lie within the fluorite localities[2] (fig. 2), which is the reverse of the conditions in the north of England.

The reason for this definite arrangement in the distribution of these minerals is an interesting problem, and the following is offered as a possible explanation. At the time of formation of the lodes, juices or vapours given off by the molten magma penetrated along fissures in the surrounding rocks. The heavy minerals, such as barytes, were deposited first, while the more volatile fluorine compounds, by their action on the limestones, deposited fluorite higher up in the veins. This was followed by the folding and subsequent denudation of the area. In a synclinal area, as in the north of England, the barytes would then surround the fluorite; whereas in an anticlinal area, as in Derbyshire, the fluorite would be outside the deposits of barytes.

One would expect to find in these rocks an appreciable amount of barium compounds, but the detailed analyses of Dr. H. F. Harwood[3]

[1] J. A. Smythe, Minerals of the North Country. The Vasculum, Newcastle-upon-Tyne, 1922, vol. 8, p. 91. [Min. Abstr., vol. 3, p. 24.]

[2] Mem. Geol. Survey, Special Reports on the Mineral Resources of Great Britain, Barytes and witherite, 3rd edition, 1922, vol. 2, p. 64.

[3] A. Holmes and H. F. Harwood, Min. Mag., 1928, vol. 21, p. 530.

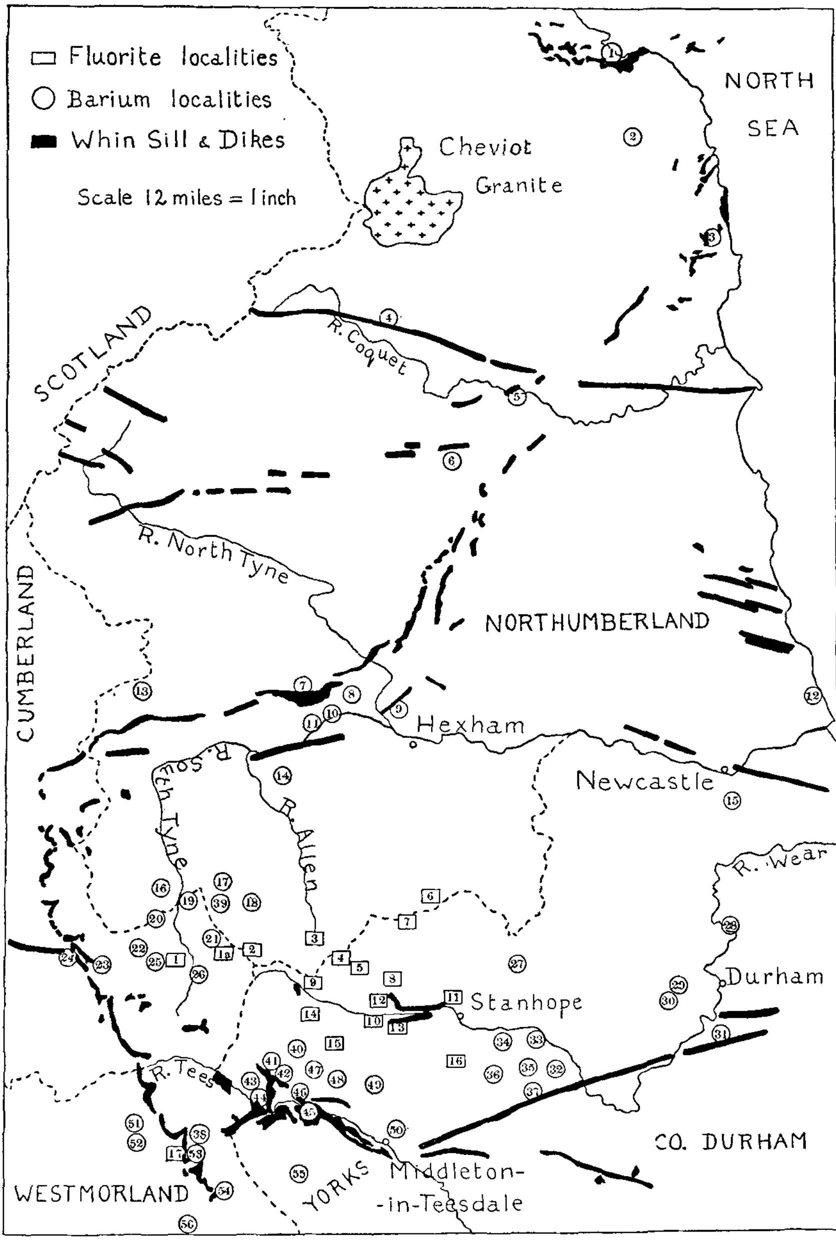

FIG. 1. Map of the north of England showing the distribution of barytes and fluorite localities (pp. 261–3) in relation to the outcrop of the Whin Sill and dikes.

of the Whin Sill show an average of only 0·03% BaO, as against an average of 0·079% deduced by F. W. Clarke and H. S. Washington[1] for the whole of the earth's crust. This lower percentage may

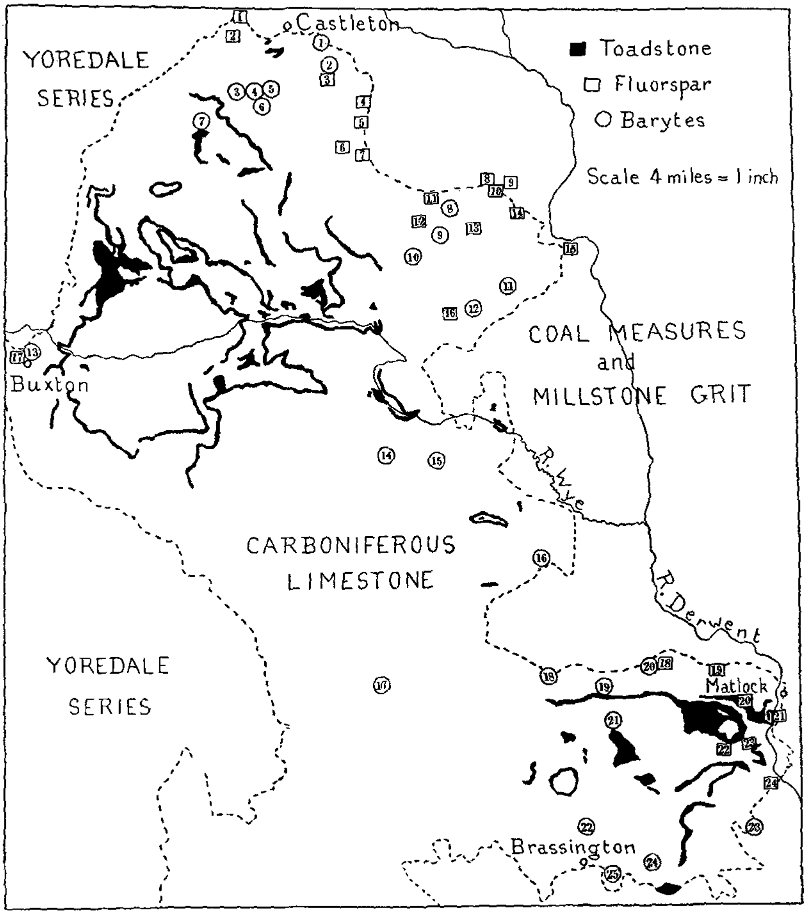

FIG. 2. Map of central Derbyshire showing the distribution of barytes and fluorite localities (pp. 263–4) in relation to the outcrop of the toadstones.

possibly be due to the fact that the barium compounds have already been to a large extent extracted.

To make the maps (figs. 1 and 2) as detailed as possible, lists of localities of barium minerals and fluorite have been culled from

[1] Min. Abstr., vol. 2, p. 60.

various sources. The resulting lists are given below, together with a reference to the authority for each locality. The first source made use of is the British Museum topographical lists, for specimens that are definitely localized, other than merely labelled 'Derbyshire', 'Matlock', 'Cumberland', 'Alston', &c. (these are referred to as 'B.M.'). Then the Memoirs of the Geological Survey, Special Reports on Mineral Resources of Great Britain,[1] were consulted for further localities not represented in the British Museum collection (marked in the lists 'G.S.'); thirdly, the papers by Dr. J. A. Smythe,

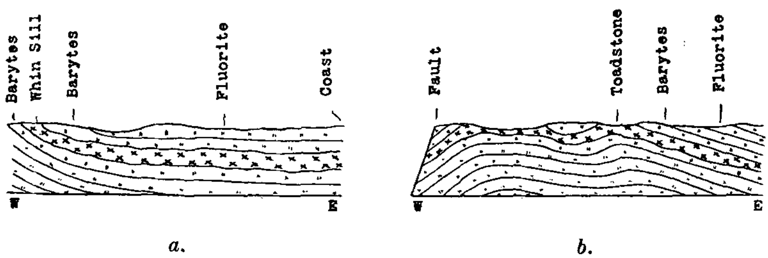

FIG. 3. Diagrammatic geological sections across (*a*) the north of England syncline; (*b*) the central Derbyshire anticline.

'Minerals of the North Country'[2] ('J. A. S.'), which is likewise exclusive of the first two; and finally R. P. Greg and W. G. Lettsom, Mineralogy of Great Britain and Ireland, 1858 ('G. & L.'). Each locality is given a number by which it is represented on the corresponding map. These numbers run approximately from north to south and west to east.

List of Barium localities in the Whin Sill area of the North of England.

(Including the species barytes, witherite, alstonite, and barytocalcite.)

1. Budle Bay, Belford, Northumberland. (J.A.S.)
2. Burton, Belford, Northumberland. (G. & L.)
3. Howick, Alnwick, Northumberland. (J.A.S.)
4. Barrow Scroggs, Alwinton, Northumberland. (J.A.S.)
5. Whitton Dene, Rothbury, Northumberland. (J.A.S.)
6. Redpath, Fallowlees Burn, Northumberland. (J.A.S.)
7. Tepper Moor, Fourstones, Hexham, Northumberland. (G.S.)

[1] 3rd edition, 1922, vol. 2 (Barytes and witherite); 2nd edition, 1917, vol. 4 (Fluorspar).

[2] J. A. Smythe, The Vasculum, Newcastle-upon-Tyne, 1922, vol. 8, pp. 90, 113 and 1927, vol. 14, pp. 15, 16.

8. Walwick Fell, Fourstones, Hexham, Northumberland. (G.S.)
9. Fallowfield mine, Hexham, Northumberland. (B.M.)
10. Stonecroft, Fourstones, Hexham, Northumberland. (B.M.)
11. Settlingstones mine, Fourstones, Hexham, Northumberland. (B.M.)
12. Marden, Cullercoats, Tynemouth, Northumberland. (J.A.S.)
13. Thirlwall Common, Greenhead, Haltwhistle, Northumberland. (J.A.S.)
14. Langley Barony mine, Haydon Bridge, Hexham, Northumberland. (B.M.)
15. Felling, Gateshead, Co. Durham. (J.A.S.)
16. Ayle Burn mine, Ayle, Northumberland. (B.M.)
17. Mohope Head, West Allendale, Northumberland. (B.M.)
18. Carrshield low level mine, West Allendale, Northumberland. (B.M.)
19. Blagill mine, Alston, Cumberland. (B.M.)
20. Park mines, Alston, Cumberland. (G.S.)
21. { Nentsbury mine, Nenthead, Alston, Cumberland. (B.M.)
  Brownley Hill mine, Nenthead, Alston, Cumberland. (B.M.) }
22. Scarberry Hill, Alston, Cumberland. (G.S.)
23. Hartside mine, Alston, Cumberland. (G.S.)
24. Long Cleugh, West Allendale, Northumberland. (B.M.)
25. Rotherhope mine, Alston, Cumberland. (G. & L.)
26. Crag Green, Garrigill, Alston, Cumberland. (G.S.)
27. Burnhill, Waskerley, Wolsingham, Co. Durham. (G.S.)
28. Lumley colliery, Durham, Co. Durham. (G.S.)
29. Ushaw Moor colliery, Durham, Co. Durham. (B.M.)
30. New Brancepeth colliery, Durham, Co. Durham. (B.M.)
31. Croxdale colliery, Durham, Co. Durham. (G.S.)
32. { Black Band Plant Wood, Wolsingham, Co. Durham. (G.S.)
  Knitsley Fell mine, Wolsingham, Co. Durham. (G.S.) }
33. Wiserley, Wolsingham, Co. Durham. (G.S.)
34. Sunnyside Allotment, Wolsingham, Co. Durham. (G.S.)
35. { Harthope Hill, Wolsingham, Co. Durham. (G.S.)
  Cabin Hill, Pikestone Moor, Wolsingham, Co. Durham. (G.S.) }
36. North Grain Beck, Wolsingham, Co. Durham. (G.S.)
37. Black Hill Top mine, Hamsterley, Wolsingham, Co. Durham. (G.S.)
38. Murton Fell, Appleby, Westmorland. (B.M.)
39. Wellhope, West Allendale, Northumberland. (G.S.)
40. Highfield Hushes, St. John's Chapel, Co. Durham. (G.S.)
41. Willy Hole mine, Harwood Fell, St. John's Chapel, Co. Durham. (G.S.)
42. Grasshill Common, St. John's Chapel, Co. Durham. (G.S.)
43. Greenhurth mine, Harwood Fell, St. John's Chapel, Co. Durham. (G.S.)
44. Dubby Sike mine, Harwood Fell, St. John's Chapel, Co. Durham. (G.S.)
45. Widdy Bank Fell, Middleton-in-Teesdale, Co. Durham. (G.S.)
46. Cow Green mines, Harwood Fell, St. John's Chapel, Co. Durham. (G.S.)
47. Bands mine, Langdon Fell, St. John's Chapel, Co. Durham. (G.S.)
48. Ettersgill mines, St. John's Chapel, Co. Durham. (G.S.)
49. Flushiemere mine, Middleton-in-Teesdale, Co. Durham. (G.S.)
50. Snaisgill mine, Middleton-in-Teesdale, Co. Durham. (G.S.)
51. Silverband mine, Dufton, Appleby, Westmorland. (B.M.)
52. Dufton Fell mines, Dufton, Appleby, Westmorland. (G.S.)
53. Scordale mines, Hilton, Appleby, Westmorland. (B.M.)
54. Long Fell mine, Warcop, Appleby, Westmorland. (B.M.)

55. Lunehead mines, Lunedale, North Riding, Yorkshire. (G.S.)
56. Hayber Gill, Warcop, Appleby, Westmorland. (J.A.S.)

List of Fluorite localities in the Whin Sill area of the North of England.

1. Rotherhope mine, Alston, Cumberland. (G.S.)
1*a*. Brownley Hill mine, Nenthead, Alston, Cumberland.[1]
2. Killhope mine, Heathery Cleugh, Weardale, Co. Durham. (B.M.)
3. Allenheads, East Allendale, Northumberland. (B.M.)
4. Groverake mine, Rookhope, Weardale, Co. Durham. (G.S.)
5. Wolfcleugh mine, Rookhope, Weardale, Co. Durham. (G.S.)
6. Derwent mines, Hunstanworth, Co. Durham. (B.M.)
7. Bolt's Burn mine, Hunstanworth, Co. Durham. (J.A.S.)
8. { Stotfield Burn mine, Rookhope, Weardale, Co. Durham. (G.S.)
   { Boltsburn mine, Rookhope, Weardale, Co. Durham. (B.M.)
9. Sedling mine, Cowshill, Weardale, Co. Durham. (B.M.)
10. { Cumnock Isle mine, Eastgate, Weardale, Co. Durham. (G.S.)
    { Rigg mine, Westgate, Weardale, Co. Durham. (G.S.)
11. { Stanhope Burn mine, Stanhope, Co. Durham. (B.M.)
    { Crawley Spar mine, Stanhope, Co. Durham. (G.S.)
    { Hope level, Stanhope, Co. Durham. (G.S.)
12. Heights mine, Westgate, Weardale, Co. Durham. (B.M.)
13. Billing Hills mine, Eastgate, Weardale, Co. Durham. (G.S.)
14. Barbary mine, Ireshopeburn, Weardale, Co. Durham. (G.S.)
15. Greenlaws mine, Daddry Shield, St. John's Chapel, Co. Durham. (B.M.)
16. Yew tree mine, Bollihope Burn, Stanhope, Co. Durham. (G.S.)
17. Scordale mines, Hilton, Appleby, Westmorland. (B.M.)

List of Barytes localities in Central Derbyshire.

1. Pindale, Castleton. (G.S.)
2. Hall mine, Castleton. (G.S.)
3. Portaway mine, Castleton. (G.S.)
4. Hazard mine, Castleton. (G.S.)
5. Holland Twine mine, Castleton. (G.S.)
6. Old Moor mine, Castleton. (G.S.)
7. Oxlow End, Castleton. (G.S.)
8. Foolow, Tideswell. (G.S.)
9. Dirty Rake, Middleton Moor, Tideswell. (G.S.)
10. White Rake, Wardlow, Tideswell. (G.S.)
11. Sallet Hole mine, Combs Dale, Stony Middleton. (G.S.)
12. Longstone Edge, Great Longstone. (G.S.)
13. Buxton. (G. & L.)
14. Magpie mines, Sheldon, Bakewell. (G.S.)
15. Magshaw Rake, Sheldon, Bakewell. (G.S.)
16. Alport, Youlgreave. (G.S.)
17. Newhaven, Youlgreave. (B.M.)
18. Elton, Winster. (G.S.)
19. Winster. (G.S.)

[1] Collected by Dr. L. J. Spencer, 1909.

20. Mill Close mine, Wensley, Darley Dale, Matlock. (B.M.)
21. Bonsall Moor, Winster. (G.S.)
22. Westerhead, Longcliff, Brassington. (G.S.)
23. Bradwell mines, Middleton Cross, Wirksworth. (G.S.)
24. Golconda mine, Griff Grange, Wirksworth. (G.S.)
25. Great Rake mine, Brassington. (G.S.)

List of Fluorite localities in Central Derbyshire.

1. Odin mine, Castleton. (G.S.)
2. Blue John mine, Treak Cliff, Castleton. (B.M.)
3. Smalldale Head, Bradwell, Castleton. (G.S.)
4. Hill Rake, Bradwell Dale, Castleton. (G.S.)
5. Hazlebadge Hall, Bradwell Dale, Castleton. (G.S.)
6. Intake Dale mine, Bradwell, Castleton. (G.S.)
7. Netherwater, Bradwell, Castleton. (G.S.)
8. Broadlow mine, Eyam. (G.S.)
9. Ladywash mine, Eyam. (G.S.)
10. Pasture mine, Eyam. (G.S.)
11. Waterfall mine, Foolow, Tideswell. (G.S.)
12. Stanley Moor, Tideswell. (G.S.)
13. Needham's Hanging Flat mine, Eyam. (B.M.)
14. Glebe mine, Eyam. (G.S.)
15. Calver mine, Stony Middleton, Bakewell. (G.S.)
16. Longstone Edge, Great Longstone. (B.M.)
17. Buxton. (B.M.)
18. Mill Close mine, Wensley, Darley Dale, Matlock. (B.M.)
19. Ox-close Pipe, Snitterton, Matlock. (G.S.)
20. High Loft (= Knowles) mine, Masson Hill, Matlock. (G.S.)
21. Long Tor, Matlock. (B.M.)
22. Stubbin (= Low) mine, Bonsall, Matlock. (G.S.)
23. Hopping Pipe mine, Matlock Bath. (B.M.)
24. Mole-trap Lode, Cromford. (G.S.)

Having given some account of the distribution of barytes, it may be interesting to examine a few of the British specimens, which vary considerably both in colour and habit. White opaque crystals (including botryoidal and plumose forms) come from Shropshire; Staffordshire; Derbyshire; the Lake District; Settlingstones mine, Northumberland; Nentsbury mine, Cumberland; New Brancepeth colliery, Co. Durham; Wanlockhead, Dumfriesshire, &c. Clear colourless crystals are found chiefly at Silverband mine, Dufton, Westmorland, and Wotherton mine, Chirbury, Shropshire. The Cornish specimens are generally either honey-yellow or greenish-grey, while pinkish lamellar crystals are found at Babbacombe Bay, Devonshire, and Nether Stowey, Somerset. A deep chocolate-brown, stalactitic variety comes from Newhaven, Derbyshire. But the most beautiful specimens in the collection are those from the west Cumberland iron mines, and it is these that will now be considered in greater detail. They occur in deposits that have no genetic relation with those considered above in the Whin Sill area some fifty miles to the east, and for this reason these localities are not included in the list on pp. 261–3.

The crystals from the Dalmellington and Parkside mines at Frizington [1] vary in colour from a clear pale-yellow to a rich chocolate-brown and may have either a tabular or prismatic habit. The variation in colour is due to inclusions of haematite and iron hydroxides, which sometimes permeate the entire crystal, but in other cases they occur just beneath the surface and are distributed along certain faces only.

The crystals from Mowbray mine, Frizington, are varied in colour. They range from colourless, pale-yellow and yellow-brown through many shades of greenish-blue and greenish-yellow to sky-blue. They are usually tabular in habit. An interesting yellowish-green curved crystal in the British Museum collection has been described by Dr. Spencer.[2] This curvature is due to a sub-parallel grouping of individual crystals. Some of the crystals from this mine show an interesting colour-change, which has not been previously recorded. There are, in the collection, several specimens which were bought from Mr. J. Graves of Frizington in 1909 and 1913. Entries in the Museum Register show that at the time of purchase these specimens were pale-yellow or amber-yellow in colour, whereas, when the slip-catalogue was made in 1928, their colours varied from pale-green to sky-blue. Dr. Spencer kindly provided pale-yellow crystals, which he had collected in 1909 and had since kept in the dark. One specimen was exposed to bright sunlight at 10.30 a.m. on June 25, 1928, and another kept in the dark for comparison. The exposed crystal was kept under close observation. At 12 noon there was no appreciable change, but at 2.15 p.m. the entire crystal had become pale greenish in colour and at 4.20 p.m. it was observed to be distinctly blue-green. The specimen was kept in the window for some time, and by July 2 it had become completely blue.

No explanation can be offered to account for this striking change in colour in barytes. Though yellow crystals from Cumberland are

[1] These mines are situated close to the Frizington railway station and are now amalgamated.

[2] L. J. Spencer, Min. Mag., 1921, vol. 19, p. 266, and pl. 8, fig. 11.

common, it is only those from Mowbray mine that exhibit this peculiarity. Many examples are known of the changes in colour of minerals when exposed to light, the emanations of radium, or to changes in temperature.[1] But in only a few cases can any satisfactory explanation be given. The striking change undergone by cerargyrite and the silver halides, on which indeed the whole process of photography is based, is of course well known. Other examples which may be mentioned here are the changes in colour of certain fluorites. The miners in Weardale expose specimens to the sunlight for the express purpose of 'improving the colour', thus effecting a change from green to purple. The purple fluorite, on heating, becomes completely decolorized. Another interesting change in colour by exposure to light has been recently observed in the British Museum collection in the case of a large crystal of topaz from Cairngorm, Banffshire. This crystal, formerly in the collection of Thomas Allan, was figured and described by James Sowerby in 1811.[2] He says: 'It is the more curious, as part of it is of a fine light blue colour, and part cinnamon-coloured, with a beautiful soft glowing warmth; and the disposition of the two colours seems almost to explain the nature of the crystallization. I thought therefore it would be instructive to give a figure of the base of the crystal, showing nearly the form the colours are disposed in.' This specimen came into the possession of the British Museum in 1860. The cinnamon colour referred to has now completely disappeared, leaving the whole crystal pale blue.

While the subject of colour is being discussed it is interesting to note the variation in distribution of colour in individual crystals. This, of course, is caused by a slight change in composition of the solution from which the barytes crystallized, and it gives rise to very decided zoning effects. Three of the more interesting types of zoning are represented more or less diagrammatically in fig. 4 *a–c*.

(*a*) A tabular crystal (B.M. 61426) from Crowgarth mine, Egremont, zoned in varying shades of yellowish-green. The innermost crystal had the forms *c d m*; as it grew in the direction of the *b*-axis it developed a pair of *o* (011) faces, and these eventually became cut out again by the *m* faces.

(*b*) A tabular crystal (B.M. 1913,406) from Mowbray mine, Friz-

[1] See, for example, the section 'Colour of minerals' in Min. Abstr., vol. 1, p. 227; vol. 2, p. 491; vol. 3, p. 115; vol. 4, p. 251.

[2] J. Sowerby, British Mineralogy, 1811, vol. 4, p. 117 (tab. 363).

ington, with a deep-yellow centre and pale-yellow edge. It will be observed that during the early stages of growth there was a good development of the *b* (010) face, but that this was gradually cut out during later stages.

(*c*) A tabular crystal (B.M. 85620) from Mowbray mine, Frizington, zoned in shades of brown, but showing clear tips. The *b* (010)

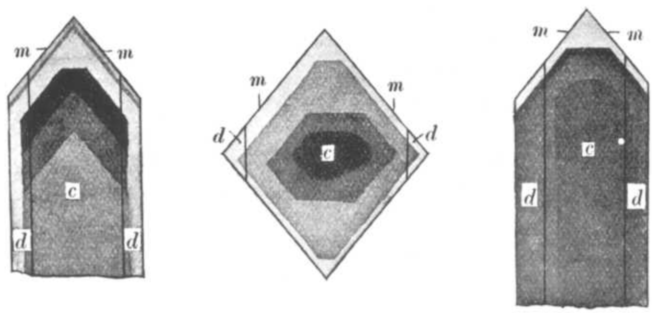

FIG. 4. Zoned crystals of barytes from Frizington, Cumberland, showing the stages of growth marked out by different colours.

face has been cut out during the later stages of growth. This type is of very common occurrence.

From observations on these banded crystals it seemed probable that some idea of the relative rate of growth normal to the crystal faces might be determined. Approximate measurements of the width of the bands parallel to the *m* and *b* faces were made on eleven different crystals. In eight of these crystals the ratio b/m varied from 1–1·5 (where b = growth normal to the *b* face and m = growth normal to the *m* face). Three other crystals gave much higher values for b/m, viz. 2·1, and two of 2·8. It was observed that in the last cases the *b* face was becoming rapidly cut out by the *m* faces. Hence the ratio b/m is not a constant, but varies with the relative rate of growth of the crystal, which in its turn depends on changes in the physical and chemical conditions under which the crystal is growing. Outline drawings were made for the purpose of demonstrating geometrically the effect of changing rates of growth on the sizes of the faces, and it was found that the sizes of the faces depend on their relative rates of growth. Fig. 5*a* is drawn with $b : m = 1{\cdot}2 : 1$ (the mean of the measurements on eight crystals), and fig. 5*b* with $b : m = 2{\cdot}8 : 1$. The former shows a regular increase in the *b* face, and is illustrated by the growth of the dark band in fig. 4*c*. The latter shows a rapid and regular diminution in the *b* face, illustrated by the banding in fig. 4 *b*. It follows from this that there must be relative rates of growth of the *b* and *m* faces for which the size of the *b* face remains constant. Such a condition is represented in fig. 5 *c*, where the lines joining the ends of the *b* faces are parallel. Here the ratio b/m is 1·583, as given by cosec θ, where θ is half the barytes angle $mm = 78° \, 22\frac{1}{2}'$.

Another interesting feature of the west Cumberland crystals is a

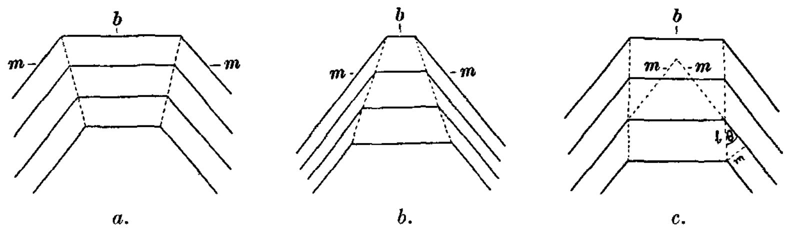

FIG. 5. Diagrams of crystals showing the effect of a varying relative rate of growth on the size of the *b* (010) face.
(*a*) $b : m = 1{\cdot}2 : 1$. (*b*) $b : m = 2{\cdot}8 : 1$. (*c*) $b : m = 1{\cdot}6 : 1$.

rich development of lines of growth on the various faces. Fig. 6 is an attempt to represent those seen on a crystal (B.M. 1907,384) from Dalmellington mine, Frizington, but it is almost impossible to reproduce the minute delicacy of the surface markings. On the *c* (001) faces the striations often show a simple 'herring bone' pattern parallel to the *m* (110) faces with a suture approximately parallel to *a* (100). Often there are also other sutures at right angles to the first, on the other side of which the striations slope in the opposite direction, thus forming rhomb-shaped figures or very low pyramids of growth. Other markings suggestive of 'terraces of growth' are bounded by striations parallel to the *a* (100) faces as well as the *m* (110) faces.

A considerable number of crystal-forms are represented on the west Cumberland specimens, but as the crystals are usually too large for goniometric measurement and the faces often uneven, a detailed study of these has been deferred. The common forms, determined with the contact-goniometer, are *c* (001), *d* (102), *m* (110), *o* (011), and *z* (111),[1] and these are present on almost every crystal. Special atten-

[1] Letters and indices as in Dana (1892) with the axial ratios $a : b : c = 0{\cdot}8152 : 1 : 1{\cdot}3136$ of R. Helmhacker (1872).

tion must, however, be drawn to two unusual forms occurring on crystals from Parkside and Dalmellington mines at Frizington. In habit these crystals are prismatic in the direction of the *b*-axis, and they show faces with the form of acute scalene triangles placed at the corners between *d* (102) and *m* (110), but not lying in any prominent zone on the crystal. These faces are usually small and are always furrowed and grooved, giving no sharp reflection on the goniometer. They are evidently forms developed during the growth of the crystal and on larger specimens tend to become eliminated. In most cases these faces are striated parallel to their intersection with *d* (102) as indicated in fig. 7, but sometimes they show wavy oscillations in the zone between *u* (101) and *z* (111) (fig. 6).

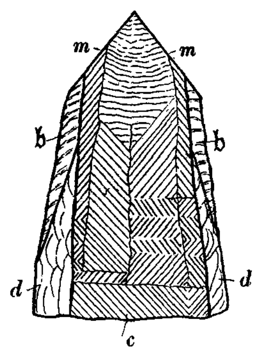

FIG. 6. Sketch illustrating the lines of growth on the faces of a crystal of barytes from Frizington, Cumberland.

Forms of this character with the indices π (916), n (718), I (14.2.9), *X* (15.3.10), δ (414), b (28.7.24), *t* (11.3.6), ω (313), γ (312), (15.5.12), &c., have been previously recorded from other localities, but apparently not from Cumberland. Amongst the 737 figures of barytes copied in V. Goldschmidt's 'Atlas der Krystallformen' (vol. 1, 1913) fourteen show faces of this character, the localities being Saxony, Hungary, Bohemia, Scotland, and Norway. In the British Museum collection thirteen specimens from Dalmellington and Parkside mines, Frizington; two from Pallaflat mine, Egremont; two from Příbram, Bohemia; and one from Marienberg, Saxony, show faces of this description. Fig. 7 *a* represents a crystal (B.M. 1907,383) from Dalmellington mine, 10 cm. in length with only a small point of attachment and equally developed on all sides, all eight faces of the (*hkl*) form being present. Approximate measurements with the contact-goniometer suggest the form b (28.7.24). Fig. 7 *b* represents a crystal (B.M. 1907,391) from Parkside mine, small enough for measurement on the reflecting goniometer, but the pyramid faces gave only blurred reflections of the signal. These seem to be nearer the form I (14.2.9). The directions of the somewhat rounded edges in the plane (001) were measured under the microscope. On the next page are given the observed and calculated measurements:

	Obs.	Calc. (R. Helmhacker, 1872.)
b(28·7·24) : b(28·7·$\bar{2}\bar{4}$)	54°	55° 4′
Edge [(28·7·24), (28·7·$\bar{2}\bar{4}$)] : [(100), (001)]	11	11 31
l(14·2·9) : *c*(001)	67½	68 23
Edge [(14·2·9), (14·2·$\bar{9}$)] : [(100), (001)] ...	6½	6 39

The form b (28.7.24) was first observed by R. Helmhacker in 1872 [1] on crystals from Dĕdova Hora (Giftberg) and Krušná Hora, Bohemia, and the form l (14.2.9) by A. Lévy [2] in 1837, from Freiberg, Saxony.

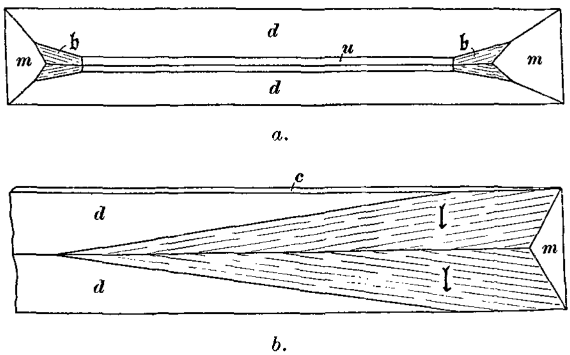

FIG. 7. Crystals of barytes from Frizington, Cumberland, showing the development of acute pyramids with high indices.

In spite of the wealth of material no detailed account of the barytes crystals from the west Cumberland iron mines has ever been attempted. In V. Goldschmidt's 'Atlas' not a single crystal represented is stated to be from this district.[3]

In conclusion I should like to thank Dr. L. J. Spencer for suggesting this subject, and for his encouragement and help throughout, especially in the determination and drawing of the crystal-forms. I am also indebted to Mr. M. H. Hey for suggestions relating to crystal-growth.

[1] R. Helmhacker, Denkschr. Akad. Wiss. Wien, 1872, vol. 32, part 2, pp. 34, 36, and pl. 2, figs. 15, 17, 21.

[2] A. Lévy, Description d'une collection de minéraux formée par M. H. Heuland 1837, vol. 1, p. 200, no. 69, and pl. 16, fig. 14.

[3] A crystal from 'Cumberland' figured by F. J. Wiik, Öfv. Finska Vet. Soc. Förh., 1884, vol. 26 (for 1883–4), p. 112, fig. 1, is possibly from the Frizington district. The figure shows curved lines of growth on the *d* (102) faces.