The "Satin Spar" of Alston in Cumberland; and the Determination of massive and fibrous Calcites and Aragonites.

By L. J. SPENCER, M.A., F.G.S.,
Assistant in the Mineral Department of the British Museum.

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OWING to the fact that aragonite frequently occurs in fibrous aggregations, as in "flos ferri," it seems to have been sometimes assumed that all fibrous specimens of calcium carbonate are aragonite.

On these grounds the "satin spar" from Alston Moor in Cumberland is often referred to aragonite, although it has more than once been shown to be really calcite. Miller[1] refers to it under aragonite, as being from "Dufton in Cumberland,"[2] saying that it contains 4·25 per cent. of manganese carbonate: these figures are those given by J. Holme[3] in a very crude analysis of the satin spar of Alston. This error is copied from Miller into Greg and Lettsom's *British Mineralogy* and into Dana's *System of Mineralogy*. The mineral in question seems to have been first definitely determined by A. Aikin, who published an account of it in 1802 in the Proceedings of the British Mineralogical Society.[4] Here an analysis is given, and the density determined as 2·709 – 2·721, the mineral being placed amongst other varieties of calcite. J. Holme in his analysis[5] found no water, which he supposed to be essential to aragonite. G. Rose,[6] from his determination of the hardness and specific gravity (2·720; in powder 2·724), points out that the mineral is calcite, and not

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[1] *Min.* p. 569.

[2] Dufton is in Westmoreland.

[3] *Trans. Linnæan Soc.* XI. 164, 1815.

[4] Tilloch's *Phil. Mag.* XII. 364, 1802. The British Mineralogical Society, referred to above, was started in 1799; references to it are to be found in the *Phil. Mag.* VI. 369, 1800; IX. 282, 1801; XII. 284, 1802; XIV. 289, 1802; XIX. 85, 1804. The objects of the society were especially connected with the mineralogy of the British Isles. The society seems to have fallen through shortly before the foundation of the Geological Society in 1807, and in the first list of the latter society are to be seen the names of many of the 25 members, mineralogical papers by whom were published in the Transactions of the Geological Society.

[5] *Loc. cit.*

[6] *Abhandl. Akad. Berlin*, pp. 7, 11, 1856.

aragonite. The Comte de Bournon, in his *Traité de la Chaux Carbonatée* (I. 166), also describes it under calcite.

The Alston satin spar occurs in straight, regular veins, two or three inches across, in a black shale of Carboniferous age, containing also veins of decomposing pyrites; the veins are parallel to the lamination of the shale. It is of a snow-white colour, with sometimes a delicate rosy tinge, and has a satiny lustre which is strongly brought out on surfaces parallel to the fibre when highly polished. The mineral consists of an aggregation of long, very fine fibres, quite straight and parallel, and arranged perpendicularly to the sides of the vein; it is quite distinct from the coralloidal aragonite of Dufton in Westmoreland, which also has a more or less satiny lustre, but not nearly so marked as in the Alston mineral.

When a fragment is finely crushed and examined under a $\frac{1}{12}$ inch immersion in oil, long, thin, cleavage rhombs of calcite are seen, the directions of optical extinction bisecting the cleavage angles, and thus being oblique to the length of the fibre. In convergent polarised light the usual eccentric uniaxial interference figure of a calcite cleavage flake is seen. The fibres of the satin spar, therefore, consist of calcite crystals enormously elongated in the direction of one of the edges of the primitive rhombohedron. A thin section cut at about 45° to the length of the fibres did not show any interference figure near the centre of the field, as would be expected; this, however, was due to the overlapping of the very fine fibres, which also for this reason did not show any definite extinction. Des Cloizeaux[1] mentions that the fibres are excessively fine, and not sufficiently transparent to have any marked action on polarised light. A thin section cut perpendicular to the fibres showed small interlocking areas of irregular outline, but longer in one direction than in the direction at right angles; each gave definite extinction, but in various directions for the different areas, giving the whole section, as seen between crossed nicols, the appearance of a mosaic. The specific gravity of the fine powder was roughly determined as 2·70.

In fibrous calcite the direction of optical extinction is usually parallel to the length of the fibre, showing that we are here dealing with crystals elongated in the direction of the trigonal axis. The direction of elongation parallel to one of the edges of the primitive rhombohedron seems to be rather unusual for calcite; but an approach to it is sometimes seen in

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[1] *Manuel de Min.* II, p. 118.

the isolated crystals of "Iceland spar" from Iceland, which show $r(100)$ with narrow $v(20\bar{1})$ and $w(410)$, and have sometimes a length three or four times the breadth and seven or eight times the thickness, as measured along the rhombohedron edges. Calcite of the same habit as the Alston satin spar, that is occurring in veins, and consisting of straight parallel fibres elongated parallel to a rhombohedron edge, has been noticed in specimens from Andrarum, Skåne, Sweden, and from Neutitschein, Moravia; the former occurs in a black alum-shale with veins of pyrites, and is strikingly similar to the Alston occurrence; the latter occurs in serpentine; the fibres of both are, however, too coarse to show any marked satiny lustre.

As before mentioned, polished surfaces of the larger, massive pieces of coralloidal aragonite from Dufton, Westmoreland, show a satiny lustre, which however is not nearly so marked as in the Alston calcite; also on the smaller branches are often numerous very fine crystals, regularly arranged at a small angle to the surface, these giving a fine satiny lustre to the surface of the branches. The name "satin spar" may, therefore, be applied to both calcite and aragonite, as well as to selenite.

In the examination of these fibrous and massive minerals, with the object of distinguishing and separating calcite and aragonite, the specific gravity and the microscopical characters of crushed fragments were most relied on. G. Rose[1] has shown that the specific gravity of a piece of fibrous aragonite taken as a whole may approach that of calcite; it is therefore necessary to take the specific gravity of the fine powder,[2] or of very small fragments, those having the most compact and homogeneous appearance being selected. If such a small fragment is placed with calcite (sp. gr. 2·72) and aragonite (sp. gr. 2·93) indices in methylene iodide, its specific gravity can be approximately judged by taking the times it floats after calcite and before aragonite, whilst the liquid increases in density owing to the evaporation of the benzene with which it is mixed. Fragments which have a specific gravity appreciably greater than that of calcite may then be considered to be aragonite, as the specific gravity of calcite could only be increased by impurities, which would be easily detected either under the microscope or by the action of acids. The same fragment that had been used for the specific gravity determination was

1 *Abhandl. Akad. Berlin*, p. 10, 1856.

2 This was done by H. C. Sorby (*Quart. Journ. Geol. Soc.*, XXXV. proc. 56, 1879), and was the test he mainly relied upon in distinguishing calcite and aragonite in shells, corals, &c.

then finely crushed, and examined under a $\frac{1}{12}$ inch immersion in oil. If the mineral be calcite it is in nearly all cases easy to find small pieces showing the calcite cleavages, with the direction of extinction bisecting the cleavage angle, and in convergent light showing a uniaxial interference figure, usually towards the edge of the field of view. Aragonite, on the other hand, shows no cleavages, and indeed nothing very characteristic, unless a fragment be found which shows the biaxial interference figure near the centre of the field. The difference in the strength of double refraction of the two minerals does not seem to be great enough to be used as a characteristic test, as the fragments under examination are of such variable thickness; bright interference colours are, however, often seen in aragonite, but rarely in calcite.

By these methods it has been shown that many specimens labelled as massive and fibrous aragonite were really calcite. Amongst these were various *onyx* and *stalagmitic marbles;* thus confirming the recent work of G. P. Merrill,[1] who has shown by specific gravity determinations that the onyx marbles consist in nearly all cases of calcite. The *pisolite* of Carlsbad, Bohemia, as is well known, consists of aragonite; sometimes, however, the outer shell consists of radially fibrous calcite, which has all the appearance of having been produced by the paramorphic alteration of the aragonite; and as this shell increases in thickness, the whole spherule may become altered into calcite. The occurrence of calcite with aragonite in the banded sprudelstein of Carlsbad has been described by G. Rose;[2] he. however, considered the calcite to be original.

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1 *Smithsonian Report* (*U. S. National Museum*) for 1893-4, 539, 1895. See this vol. p. 165.

2 *Loc. cit.* p. 57.