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CELESTITE AND CALCIOSTRONTIANITE FROM WISE COUNTY, VIRGINIA

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ABSTRACT

Celestite and calciostrontianite occur in vugs in dolomite of the Cayuga group (Silurian) in a quarry one half mile east of East Stone Gap, Wise Co., Virginia.

Light blue, well developed celestite crystals average about one inch in length. Most crystals are elongated parallel to the *a* axis, and the {011} faces predominate. Vectorial etching is common. A blue fibrous crust of celestite was also observed.

The calciostrontianite occurs as radiating globular masses up to a half inch in diameter. A quantitative spectrographic analysis shows approximately 10% CaO. *X*-ray diffraction data show a significant departure from pure $SrCO_3$.

OCCURRENCE

Although strontium minerals are known to occur at several places in the United States, only recently have they been found in Virginia. One of the writers (RFP) first noticed celestite and calciostrontianite in Wise County in 1958. A preliminary report on this occurrence was presented at the 1959 meeting of the Virginia Academy of Science, and has been published in abstract form (Pharr and Mitchell, 1959).

Both celestite and calciostrontianite occur along State Road 613 about one half mile east of East Stone Gap, Wise County, in a quarry in dolomite of the Cayuga group (Upper Silurian) owned by Mr. G. H. Belton. The beds here consist of a succession of intercalated, fine-grained, medium- to dark-gray, dolomites and magnesian limestones which are nearly horizontal. Eby (1923) described the geology of the region and also gave a section of the formation at a place some yards west of the quarry. In his description there is no mention of strontium minerals.

The strontium minerals are found in vugs in thick-bedded dolomite. The vugs range from very small to over 10 inches across, and occur in a horizontal zone across the quarry. The vugs examined by the writers were rather barren of good material. They did contain etched celestite crystals and small globular calciostrontianite masses. Most of the better celestite crystals described in this paper were collected by Mr. Belton and his son over a period of several years, and their exact location in the quarry is not certain.

DESCRIPTION OF THE CELESTITE

Most of the celestite is pale-blue in color and occurs as well-developed crystals which average from $\frac{1}{2}$ to $\frac{3}{4}$ inch in length with a maximum of

about 2 inches. Most of the crystals are elongated parallel to their *a* axes, and the {011} faces predominate. They can be conveniently classified into two main habits.

Habit A (Figs. 1A and 2A) is the most common, and exhibits the greatest number of crystal forms. In addition to the prominent {011} faces, which are frosted due to slight etching, they have relatively large, bright {101} faces and small {122}, {210}, {211}, {100}, {001}, and {010} faces. Lying between {122} and {210} (also {211}) is a dull flat

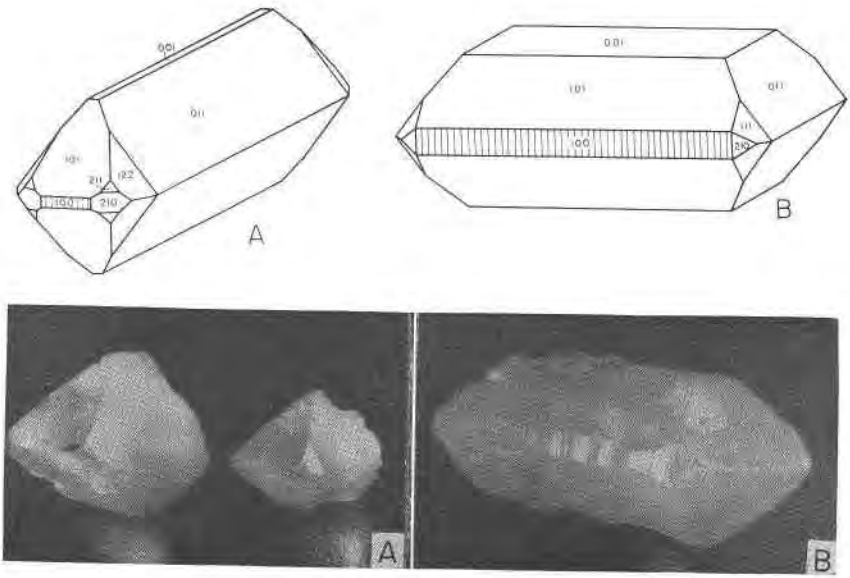

FIG. 1 (above). Idealized drawings of the two habits exhibited by celestite crystals from Wise County, Virginia.

FIG. 2 (below). Celestite crystals illustrating fig. 1.

nonreflective area which may correspond to {111}. This plane, which may be a result of etching, is not represented in Fig. 1A. The {100} faces characteristically show vertical striations. On some crystals, reflections from these faces in the optical goniometer are continuously blurred for several degrees parallel to the *b* crystallographic axis. In this blurred region the brightest light falls at the {100} position and at positions approximately 11° on each side of it, or at positions near the {810} form. Other crystals show striations due in part to re-entrant {210} faces on the {100} plane.

A common modification of this habit has only three forms. The large {011} faces are conspicuously etched. The {101} faces are brilliant, and the {100} faces vertically striated. A second modification is similar, but

without the brilliant {101} faces. The {011} faces are frosted and exhibit deep irregular etch pits. Several of these crystals have globular calciostrontianite attached to them. These two modifications may represent progressive etching.

Habit B (Figs. 1B and 2B) is less common. They are elongated parallel to *b*, and flattened parallel to {001}. Other important faces are {101}, {011}, {111}, {210}, {010}, and vertically striated {100}. No evidence of etching was observed.

The vectorial etching is an outstanding property of the type A crystals. The area between {122} and {210}, which may correspond to {111}, is affected the most, {122} is next, and then {011}. Contrasted with these are the bright {100}, {101}, {210}, {211}, and {001}. Apparently the faces have different susceptibilities to natural acids (probably carbonic) which circulated in the rock. Solution channels, roughly parallel to {010}, deeply penetrate some of the crystals. No good etch figures were observed.

A fragment of blue fibrous celestite, resembling satin spar gypsum, was found loose in the quarry. The piece is tabular, measuring about an inch across and $\frac{1}{8}$ inch thick, and probably represents a cross-fiber vein; the fiber axes being perpendicular to the tablet surface. A study of thin sections of this material showed that the fibers are all elongated parallel to *c*. Thin sections cut perpendicular to the fibers showed bundles with nearly parallel orientation, but adjacent bundles may have quite different orientation of the *a* and *b* axes. The individual fibers measure from 0.02 to 0.12 mm. across, and the bundles are from 1 to 2 mm. across. Quite perfect cleavage, {001}, was observed across the fibers, and less perfect inclined cleavage, presumably prismatic, {210}, was observed in thin sections cut perpendicular to the fiber direction.

Cleavable masses of blue and white celestite up to 1×4×5 inches were also observed filling veins and vugs in the quarry. Thin sections of the dolomite show embedded microscopic euhedral celestite crystals.

X-ray diffraction powder data for the celestite showed no significant departure from that of pure strontium sulfate as reported by Swanson and Fuyat (1953). However, a semiquantitative spectrographic analysis of a specimen did reveal 0.15% CaO and 0.002% BaO.

Description of the Calciostrontianite

Calciostrontianite occurs intimately associated with celestite in the quarry, especially with celestite which is frosted or deeply corroded. Calciostrontianite forms vitreous to dull globular masses which possess an internal radial structure (Fig. 3). The size of the globules ranges from very small to a half inch in diameter. They vary in color from a light

grayish-white to light buff. Bright pale-green to cream fluorescence is exhibited under long-wave ultraviolet light (3600 to 3650 A. U.). The majority of the globules are rough and are terminated by small acicular crystals. Because of their extremely small size (width from 0.02 to 0.08 mm. and length from 0.1 to a little over 0.3 mm.) a precise determination of the morphology was not obtained. However, goniometric measurements, combined with measurements made on the microscope stage, show that the crystal needles consist mainly of an orthorhombic bipyra-

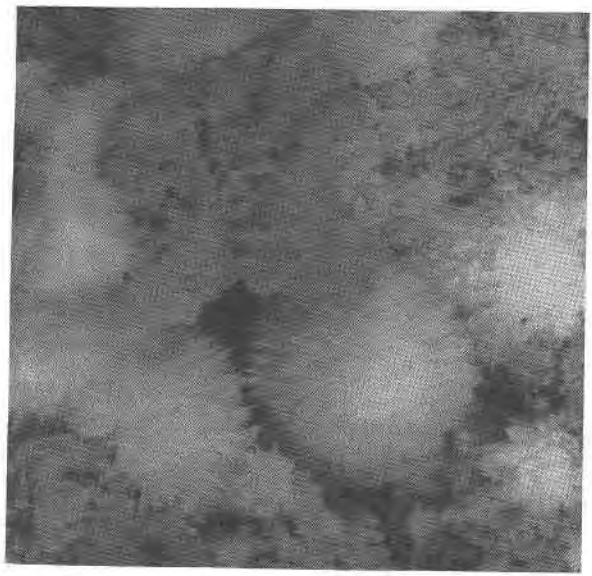

FIG. 3 (left). Calciostrontianite globular masses attached to porous dolomite.
FIG. 4 (right). Idealized drawing of pseudohexagonal calciostrontianite crystal.

mid, either {881}, or a form close to it, and a brachydome, possibly {0.15.1}. These forms combine to give a steep pseudohexagonal pyramid (Fig. 4). In some cases the pyramidal needles were somewhat curved and at times showed horizontal striations like material from Tyrol, described by Cathrein (1888). According to Palache, Berman, and Frondel (1951) steep pyramidal forms are frequently found in highly calcian strontianite.

The presence of considerable amounts of calcium in the strontium carbonate was first suspected from the x-ray diffraction data. Quantitative spectrographic analyses of specially selected and cleaned material revealed $10.6 \pm 1.0\%$ CaO for a tan colored specimen, and $9.1 \pm 1.0\%$ CaO for a white specimen.* Traces of Ba, Mg, Al and Cu, listed here in the

* These quantitative analyses were performed by the American Spectrographic Laboratories, Inc., San Francisco, California.

order of decreasing amounts, were also noted by semiquantitative spectrographic analyses. The name calciostrontianite was introduced into the literature by Cathrein (1888) for a type of strontianite, from Brixlegg, Tyrol, which contains up to 7.36 per cent CaO. The name emmonite was given by Thomson (1836) to a material from "Massachusetts" (probably from New York, according to Palache, Berman, and Frondel, 1951) with nearly an identical amount of CaO. Although the name emmonite was introduced earliest, the writers prefer to use calciostrontianite.

TABLE I. A COMPARISON OF *X*-RAY POWDER DATA FOR CALCIOSTRONTIANITE FROM WISE COUNTY, VIRGINIA WITH PURE $SrCO_3$
CuKα radiation; camera diameter 11.46 cm.

hkl	Calciostrontianite		$SrCO_3$* *d* Å	*hkl*	Calciostrontianite		$SrCO_3$* *d* Å
	d_{obs} Å	I_{obs}			d_{obs} Å	I_{obs}	
110	4.33	vw	4.37	132	1.88	m	1.91
020	4.16	vvw	4.21	113	1.81	mw	1.83
111	3.51	vvs	3.54	023	1.79	w	1.81
021	3.40	vs	3.45	222	1.75	vw	1.77
002	2.98	mw	3.01	042	1.70	vvw	1.73
012	2.81	m	2.84	310	1.65	vw-	1.67
102	2.58	w	2.60	311	1.60	mw	1.61
200	2.53	mw	2.55	241	1.55	mw	1.57
130	2.46	m	2.46	151	1.53	w	1.54
022	2.43	s-	2.45	004	1.49	vvw	1.51
211	2.25	vw	2.26	223	1.47	vvw	1.48
220	2.16	mw	2.18	330	1.44	vw	1.46
040	2.07	vw	2.10	242	1.41	vw	1.43
221	2.04	s	2.05	060	1.38	vvw	1.40
041	1.96	mw	1.99	332	1.30	mw	1.31
202	1.93	mw	1.95	313 134	1.27	mw	1.28

* Taken from Swanson, Fuyat and Ugrinic (1954).

The *x*-ray data in Table I represent an average of measurements made on four films from four different specimens. The unit cell constants are $a_0 = 5.070$, $b_0 = 8.300$ and $c_0 = 5.970$ Å (all $\pm$ 0.005 Å); $a_0 : b_0 : c_0 = 0.611:1:0.719$. These data show a significant departure from pure $SrCO_3$. The data of Swanson, Fuyat and Ugrinic (1954) for pure $SrCO_3$ are also given in Table I. Their values are $a_0 = 5.107$, $b_0 = 8.414$ and $c_0 = 6.029$ Å. No significant departure of refractive indices from values reported in the literature for natural strontianite was found.

Calciostrontianite globules occur attached to the large blue celestite crystals, especially in the vicinity of solution channels, or along seams

where two crystals are joined. Masses of porous dolomite also contain globules of calciostrontianite attached to the walls of cavities, as well as tiny gemmy celestite crystals up to $\frac{1}{8}$ inch, and gemmy calcite scalenohedrons. Most evidence suggests that the calciostrontianite is secondary after celestite, and was probably formed by the reaction of carbonic acid on the sulfate. A thin section across a spherulite, which was situated at the junction of two celestite crystals, showed a channel leading out from the celestite with the globule perched at the orifice. Perhaps these relationships suggest a mechanism whereby the globule of radial needles was formed.

Associated Minerals

Other minerals found in the quarry include sphalerite, fluorite, glauconite, illite, dolomite and quartz. A white efflorescent material, which had formed on dolomite, gave *x*-ray patterns for starkeyite ($MgSO_4 \cdot 4H_2O$) (Grawe, 1956) and hexahydrite. Because the iron analogs of these compounds have nearly identical diffraction patterns, the presence of magnesium was verified by semiquantitative spectrographic analyses.

Other Occurrences of Celestite and Calciostrontianite in Virginia

Lozenge-shaped celestite crystals, up to $\frac{1}{2}$ inch across occur in vugs in a quarry in Tonoloway limestone, of the Cayuga group, at Hayfield, Frederick County. Near Fulks Run, Rockingham County, small vugs and cavities in Tonoloway limestone contain celestite crystals. The discovery of these three occurrences of celestite in rocks of the Cayuga group in widely separated sections of Virginia strongly suggests that strontium minerals may be found at other places in the state in rocks of this age.

Dietrich (1960) has recently reported calciostrontianite, with small amounts of celestite, in vugs and on joint surfaces in dolomite (Elbrook limestone, Cambrian), from the Salem Rock Corporation Quarry south of Dublin, Pulaski County. One of the writers (RFP) has recently noticed thick fibrous veins of celestite, as well as vugs containing good crystals up to $\frac{1}{4}$ inch across, in a road cut near the same quarry. Dietrich (1960) also observed calciostrontianite in vugs in a limestone drill core from the Athens formation (Middle Ordovician) obtained near Harrisonburg, Rockingham County.

Acknowledgments

The writers wish to express their gratitude to Mr. G. H. Belton for his cooperation in allowing them to examine and collect from his quarry; and also for making all the specimens he and his son collected for several

years available for study. Special thanks are due Dr. Bruce Hobbs, of the Virginia Division of Mineral Resources, for taking the photographs of celestite and calciostrontianite which are reproduced in this paper.

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