GOOSECREEKITE, A NEW CALCIUM ALUMINUM SILICATE HYDRATE POSSIBLY RELATED TO BREWSTERITE AND EPISTILBITE

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ABSTRACT

Goosecreekite, $CaAl_2Si_6O_{16} \cdot 5H_2O$, is monoclinic, space group $P2_1$ or $P2_1/m$, with a 7.52(2), b 17.56(3), c 7.35(2) Å, β 105.71°, $Z = 2$. Microprobe and DTA-TGA analyses yield CaO 9.3, Al_2O_3 17.2, SiO_2 59.3, H_2O 15.0, sum 100.8 percent. This yields the calculated formula $Ca_{2.02}Al_{4.10}Si_{12.00}O_{32.17} \cdot$ $10.12H_2O$, in agreement with the theoretical composition given for $Z = 2$. Goosecreekite is colorless and occurs in euhedral but highly curved crystals resembling some epistilbite. Goosecreekite is optically biaxial (−) with refractive indices α 1.495(2), β 1.498(2), γ 1.502(2); dispersion is indiscernible; orientation: Y parallel to b, and $c \wedge Z = 46°$. The cleavage is perfect, parallel to {010}. The density is 2.21 (obs.); 2.16 g cm^{-3} (calc.). Goosecreekite is found in the Luck Company Goose Creek quarry, Loudoun County, Virginia, in association with stilbite, epidote, babingtonite, titanite and chlorite, in varied parageneses. The name is for the locality. The unit-cell parameters and composition strongly suggest a structural relationship between goosecreekite and epistilbite and brewsterite.

Keywords: goosecreekite, Luck Company Goose Creek quarry, Loudoun County, Virginia, zeolite group, new mineral.

SOMMAIRE

La goosecreekite, $CaAl_2Si_6O_{16} \cdot 5H_2O$, est monoclinique, $P2_1$ ou $P2_1/m$, a 7.52(2), b 17.56(3), c 7.35(2) Å, β 105.71°, $Z = 2$. Les mesures à la microsonde électronique et la thermobalance donnent: CaO 9.3, Al_2O_3 17.2, SiO_2 59.3, H_2O 15.0, total 100.8%. La formule calculée $Ca_{2.02}Al_{4.10}Si_{12.00}$ $O_{32.17} \cdot 10.12$ H_2O donne la formule stœchiométrique simplifiée pour $Z = 2$. La goosecreekite est incolore; idiomorphe (cristaux à faces courbes qui ressemblent à certains cristaux d'épistilbite); biaxe (−), α 1.495(2), β 1.498(2), γ 1.502(2), dispersion non discernable, $Y \parallel b$, $c \wedge Z = 46°$. Le clivage est parfait suivant {010}. D_{obs} 2.21, D_{calc} 2.16. On a trouvé la goosecreekite dans la carrière Goose Creek de la Luck Company, dans le comté de Loudoun, en Virginie, E.U.A., associée à la stilbite, l'épidote, la babingtonite, la titanite et la chlorite, en diverses paragenèses. Le nom rappelle la localité. Les paramètres de la maille cristalline et la composition chimique font soupçonner une relation structurale entre la goosecreekite d'une part, l'épistilbite et la brewsterite d'autre part.

(Traduit par la Rédaction)

Mots-clés: goosecreekite, carrière Goose Creek de la Luck Company, comté de Loudoun, Virginie, groupe zéolite, nouvelle espèce minérale.

INTRODUCTION

The new mineral described here was brought to our attention by Mr. George Brewer of Columbia, Maryland, who discovered it while collecting zeolites in Loudoun County, Virginia; he recognized it as being possibly a new species. We concluded from the apparent uniqueness of the X-ray powder-diffraction pattern that it was a new mineral. Subsequent detailed characterization confirmed this working hypothesis.

Goosecreekite is named for the locality where it was found, the Goose Creek quarry, Loudoun County, Virginia. The mineral and the name were approved by the Commission on New Minerals and Mineral Names, I.M.A. Type material is preserved in the Smithsonian Institution under catalog no. 145880. Additional portions of the holotype sample are preserved in the Royal Ontario Museum in Toronto, The American Museum of Natural History, The British Museum (N.H.) and the Mineralogical Museum at Harvard University.

OCCURRENCE

Goosecreekite was found in February 1979 in the Luck Company Leesburg quarry, better known by the local name, the Goose Creek quarry. The particular quarry in which the mineral was found is the newer of two local quarries that have been called by the same name. The older Goose Creek quarry, also known as the Arlington–Belmont quarry, has been inoperative since 1973. The newer quarry, adjacent to the older one, was opened in 1972 and has been in almost continuous operation since then. The quarry is operated for the recovery of road-metal derived from trap rock. The trap rock is a Triassic diabase, the mineralogy and petrology of which were described by Shannon (1924).

Goosecreekite was found in several different yet related parageneses within the quarry. The type material was obtained from small 2–4 cm vugs that occur in random distribution within a seam of altered rock approximately 15–20 cm wide that cuts through a boulder of trap rock. The emplacement of the boulder precluded any *in situ* observation of the occurrence. The seam of altered rock consists of kaolinized feldspar, actinolite, chlorite, epidote, babingtonite, quartz, titanite and stilbite. All the vugs contain chlorite and epidote, and some, located 1.5–2.0 metres from the new mineral, also contain euhedral sulfides, such as galena and sphalerite. Goosecreekite occurs in one of the vugs that does not contain sulfides. The vug that contained the type material was lined with euhedral quartz and fine-grained chlorite, which were coated, in turn, with acicular crystals of actinolite followed by albite, chlorite and goosecreekite.

Subsequent to the discovery of the sample, Mr. Brewer found a number of samples in different parts of the quarry, spatially separated by up to 100 metres. These additional occurrences, some of which were along seams, consisted of crystals of goosecreekite that were of similar morphology to the type material, having severely curved crystal faces. Sequences of crystallization of these subsequent finds are: (1) prehnite followed by apophyllite and goosecreekite, (2) albite and epidote followed by prehnite, babingtonite, stilbite and goosecreekite, (3) chlorite followed by albite, actinolite, prehnite, babingtonite, stilbite and goosecreekall specimens, goosecreekite is the last mineral to form. An exception to this is one specimen on which goosecreekite is followed by calcite crystals. In general, goosecreekite is a late-stage

mineral that occurs both in vugs in the diabase and also with prehnite in a zeolite assemblage as fissure fillings. To date, only about 25 samples have been found. Hence, goosecreekite must be considered rare at the type (and only) locality.

PHYSICAL AND OPTICAL PROPERTIES

Goosecreekite is colorless to white with a white streak. The lustre is vitreous, somewhat pearly on crystal faces. The Mohs hardness is approximately 4½. There is a single, perfect cleavage parallel to {010}, and it is easily produced. The density, determined using heavy-liquid techniques, is 2.21(2) g/cm³, in good agreement with the calculated value of 2.16 g/cm³. Goosecreekite does not fluoresce in ultraviolet radiation.

Goosecreekite is biaxial (−) with $2V = 82(5)°$. The refractive indices are α 1.495(2), β 1.498(2), γ 1.502(2). There is no discernible dispersion. The orientation is Y parallel to b,

TABLE 1. X-RAY POWDER DIFFRACTION DATA FOR GOOSECREEKITE

| d(obs)	d(calc)	hkl	I/I₀
8.75	8.78	020	5
7.19	7.24	100	50
5.59	5.59	1̄20	50
4.91	4.91	1̄21	50
4.53	⎡ 4.55	1̄30	100
	⎣ 4.51	031	
4.36	4.35	111	5
4.17	4.17	1̄31	15
4.00	4.00	121	10
3.75	3.75	1̄40	5
3.617	⎡ 3.622	200	5
	⎣ 3.586	1̄02	
3.526	⎡ 3.540	002	25
	⎢ 3.528	1̄41	
	⎣ 3.514	1̄12	
3.350	⎡ 3.370	221	40
	⎣ 3.348	220	
3.277	3.283	022	25
3.147	⎡ 3.139	141	20
	⎢ 3.146	051	
	⎣ 3.160	1̄50	
3.073	⎡ 3.080	2̄30	25
	⎣ 3.058	1̄32	
3.022	⎡ 3.030	032	25
	⎣ 3.022	1̄51	
2.925	2.923	2̄12	10
2.866	⎡ 2.880	211	5
	⎣ 2.849	112	
2.775	⎡ 2.777	1̄42	20
	⎣ 2.770	211	
2.698			20
2.610	2.613	231	15
2.501			5
2.438			10
2.395			5
2.351			20

approx. 20 more lines below d = 2.351
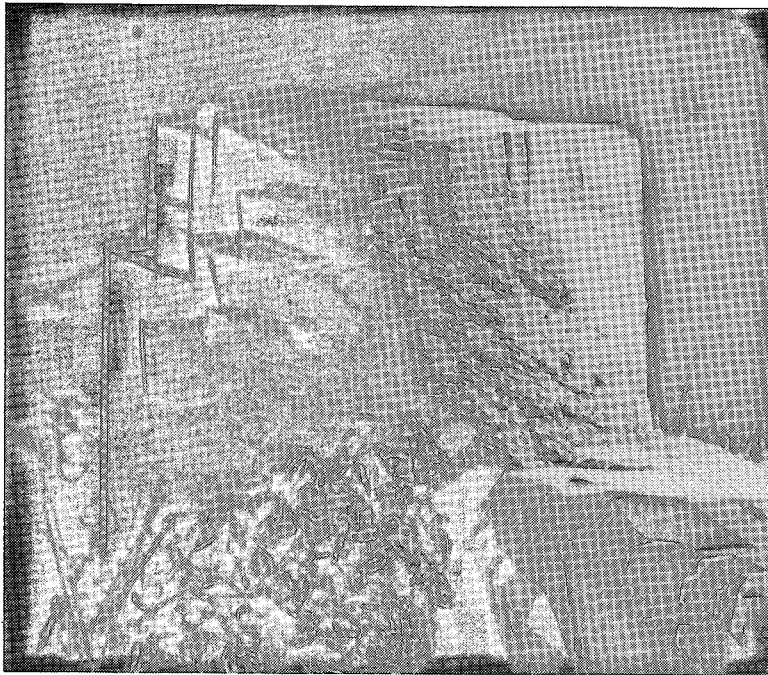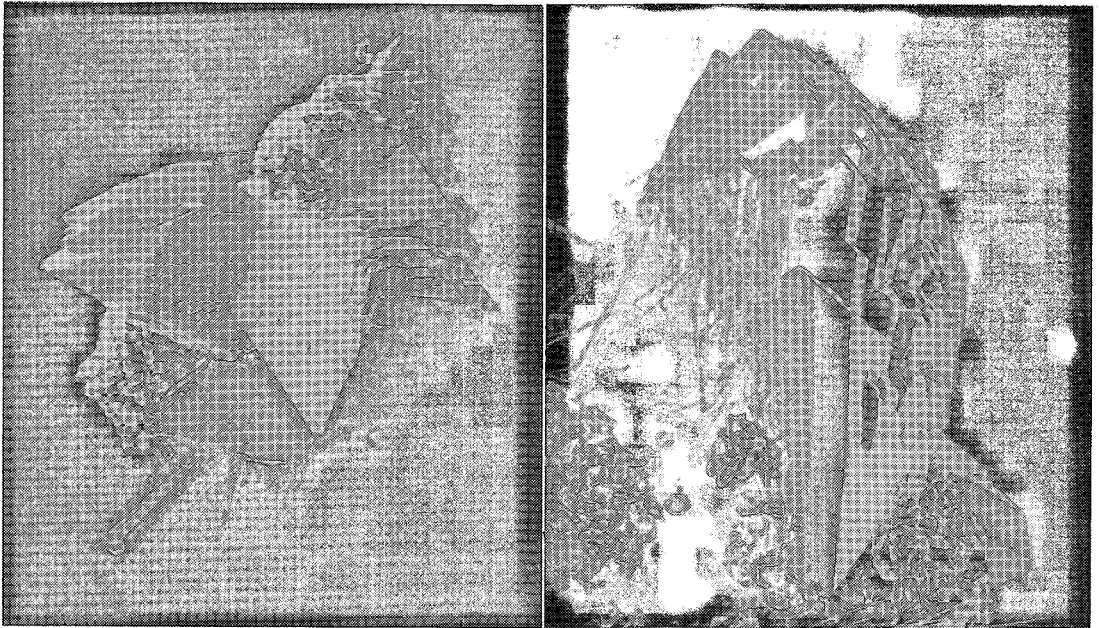
FIG. 1. Scanning-electron photomicrographs of goosecreekite showing (a) the general habit and intergrown nature of the crystals (64x), (b) the composite parallel growth of large crystals (120x); the platy crystals are chlorite, the acicular mineral is actinolite; (c) the severe curvature of the crystal faces (110x).

X and Z are in the plane of the cleavage; $c \wedge Z = 46°$. Goosecreekite is transparent and does not respond to ultraviolet radiation. Calculation of the Gladstone–Dale relationship using the constants of Mandarino (1976) yields $K_c = 0.229$ for the chemical data and $K_p = 0.228$ for physical properties, indicating superior agreement of the analytical and physical data (Mandarino 1979).

X-Ray Crystallography

Goosecreekite was studied using standard single-crystal Weissenberg and precession techniques. It is monoclinic, with space group $P2_1$ or $P2_1/m$. Least-squares refinement of powder X-ray-diffraction data (Table 1) gives unit-cell parameters a 7.52(2), b 17.56(3), c 7.35(2) Å, with β 105.71°. These data were obtained using a polycrystalline ball mount with NBS silicon as an internal standard, mounted in a 114.59 mm Gandolfi cameda (Cu $K\alpha$ radiation).

Morphological crystallography

Goosecreekite occurs both as polycrystalline aggregates and as imperfect single crystals up to 2.0 mm in diameter. Optical goniometric measurements led to the assignment of the indices {100} and {001} to the two pinacoids. Indices could not be assigned to the other faces because they are severely curved and yield only very broad and diffuse reflections. Scanning-electron photomicrographs of some goosecreekite crystals, shown in Figure 1, clearly demonstrate the highly curved nature of the crystal faces and the almost equant habit.

Goosecreekite is similar in morphological development to some specimens of epistilbite. The epistilbite crystals from Castle Eden, near Hartlepool, Durham, England, are very similar to goosecreekite in general habit, but lack the pronounced curved crystal faces seen on all goosecreekite crystals noted to date. The morphological similarity suggests that goosecreekite may have been overlooked; a rechecking of epistilbite specimens may uncover additional goosecreekite samples and reveal additional information about the mineral.

Chemistry

Goosecreekite was chemically analyzed using the ARL–SEMQ electron microprobe of the Smithsonian Institution, utilizing an operating voltage of 15 kV and a beam current of 0.15 μA. The standard used for the analysis was synthetic anorthite (An_{80}). The data were corrected using Bence–Albee factors. The analysis was performed with a beam spot 20 μm in diameter to minimize the loss of water. Additional analyses with a 3 μm beam spot indicated that goosecreekite is chemically homogeneous at that level of resolution. A wavelength-dispersive microprobe scan indicated the absence of any detectable elements with atomic number greater than 10 except those reported herein.

A 7 mg powdered sample of goosecreekite was analyzed for volatile constituents by simultaneous TGA–evolved gas analysis, using a Mettler TA-1 Thermoanalyzer equipped with an Inficon IQ 200 quadrupole mass spectrometer. The sample was initially weighed while in equilibrium with moderately dry air (20–30% humidity) at 20°C. It was then subjected to a high vacuum for 70 hours at 25°C, during which time it lost 2.7% water. The sample was next heated in high vacuum at 2°/min. to 1000°C, and lost another 12.3% H_2O in two steps: between 55 and 222°C, then up to 328°C. The corresponding H_2O vapor-pressure maxima were observed at 177 and 235°C. Thus, the total water loss was 15.0 wt.%. A further loss of 0.4% was noted between 328 and 820°C. However, owing to a slow rate of loss (0.1 μg/min.), the evolved gas could not be identified.

Calculation of cell contents, using the observed density and cell parameters, yields $Ca_{2.02}Al_{4.10}Si_{12.00}O_{32.17} \cdot 10.12H_2O$, in excellent agreement with the theoretical composition of $CaAl_2Si_6O_{16} \cdot 5H_2O$ with $Z = 2$. Goosecreekite is insoluble in 1:1 HCl or HNO_3 with a one-hour immersion time. The resultant analysis is presented in Table 2.

Related Species

Goosecreekite, $CaAl_2Si_6O_{16} \cdot 5H_2O$, is chemically closely related to epistilbite. Indeed, a structure analysis (Perrotta 1967) shows that ideally, epistilbite has the formula $CaAl_2Si_6O_{16} \cdot 5\frac{1}{3}H_2O$. However, Galli & Rinaldi (1974) reviewed the crystal chemistry of epistilbite and found that it is generally deficient in H_2O, with as little as $5H_2O$ per formula unit. Therefore, certain epistilbites may be polymorphic with goosecreekite, but most are not, as they have slightly different water contents.

Brewsterite has the formula $(Sr,Ba,Ca)(Al_2Si_6O_{16}) \cdot 5H_2O$ and cell parameters that are closely related to those of goosecreekite (Table 3). The

TABLE 2. CHEMICAL ANALYSIS OF GOOSECREEKITE

	$CaAl_2Si_6O_{16} \cdot 5H_2O$	GOOSECREEKITE
CaO	9.21	9.3
Al_2O_3	16.75	17.2
SiO_2	59.26	59.3
H_2O^*	14.78	15.0
Total	100.00	100.8

Accuracy of data: ±3 percent of the amount present. * Water determined by DTA/TGA.

TABLE 3. UNIT-CELL DIMENSIONS FOR SELECTED MEMBERS OF THE HEULANDITE GROUP

	GOOSECREEKITE [1]	EPISTILBITE [2]	BREWSTERITE [3]
$\underline{a}$ Å	7.52	9.089 – 9.102	6.77
$\underline{b}$ Å	17.56	17.741 – 17.802	17.51
$\underline{c}$ Å	7.35	10.205 – 10.242	7.74
β	105.71°	124.55 – 124.68°	94°18'

[1] Present Study. [2] Galli & Rinaldi (1974). [3] Perrotta & Smith (1964).

overall similarities in both cell parameters and chemical formulas seem to imply that goosecreekite and brewsterite may be different end-members of a solid-solution series. However, the differences in lattice parameters are so great that this is unlikely, especially since goosecreekite has a cell volume slightly greater than that of brewsterite, but has smaller cations. Nevertheless, the *b* translation of approximately 17.5 Å requires that goosecreekite have a structure that places it in the heulandite–stilbite group with epistilbite and brewsterite. A structure analysis is necessary in order to determine unambiguously the relationship of goosecreekite to other members of the heulandite group.

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