

## RAPIDCREEKITE, A NEW HYDRATED CALCIUM SULFATE-CARBONATE FROM THE RAPID CREEK AREA, YUKON TERRITORY

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### ABSTRACT

Rapidcreekite, ideally  $\text{Ca}_2(\text{SO}_4)(\text{CO}_3)\cdot 4\text{H}_2\text{O}$ , is a new secondary mineral species from the Rapid Creek area, northern Yukon Territory. It occurs on bedding planes and joint surfaces of a quartz-rich iron formation, as crystal-line coatings and sprays of white to colorless acicular crystals. The symmetry is orthorhombic, space group *Pcnb*, with  $a$  15.49(1),  $b$  19.18(1),  $c$  6.157(4) Å,  $a:b:c$  0.808:1:0.321,  $Z = 8$ . Individual crystals have a maximum length of 2 mm and are elongate [001], with forms {010} broad and {100}, {001} minor. The streak is white; lustre vitreous; brittle, fracture splintery; Mohs hardness 2; cleavage {010} perfect and {100} good;  $D(\text{meas.})$  2.21(1),  $D(\text{calc.})$  2.239 g/cm<sup>3</sup>; nonfluorescent in ultraviolet light. Rapidcreekite is biaxial positive,  $\alpha$  1.516(1),  $\beta$  1.518(1),  $\gamma$  1.531(1),  $2V_x$  (meas.) 45(3)°,  $2V_x$  (calc.) 43°, indicatrix orientation  $X = c$ ,  $Y = a$ ,  $Z = b$ . The strongest eight lines in the X-ray powder-diffraction pattern [ $d$  in Å(1)( $hkl$ )] are 7.78(100)(200), 4.31(70)(221), 3.88(70)(311,400,231), 3.11(80)(421,002), 2.917(50)(431), 2.797(60)(161), 2.555(50)(142,322) and 1.899(50)(303,580,233,082). Microprobe analyses and TGA-EGA gave CaO 36.3, SO<sub>3</sub> 26.1, CO<sub>2</sub> 14.0 and H<sub>2</sub>O 23.6, sum 100.0 wt.%. The name refers to the general locality.

**Keywords:** new mineral species, rapidcreekite, calcium sulfate carbonate tetrahydrate, Yukon, Rapid Creek, X-ray data, chemical composition.

### SOMMAIRE

La rapidcreekite, dont la formule idéale est  $\text{Ca}_2(\text{SO}_4)(\text{CO}_3)\cdot 4\text{H}_2\text{O}$ , est une nouvelle espèce minérale secondaire découverte dans la région du ruisseau Rapid, dans le Nord du Yukon. On la trouve sur les plans de stratification et de séparation d'une formation de fer riche en quartz, sous forme d'enduits ou de gerbes de cristaux aciculaires blancs ou incolores. La symétrie est orthorhombique, groupe spatial *Pcnb*,  $a$  15.49(1),  $b$  19.18(1),  $c$  6.157(4) Å,  $a:b:c$  0.808:1:0.321,  $Z = 8$ . Les monocristaux ont, tout au plus, 2 mm de longueur et sont allongés [001], la forme {010} est large et les formes {100} et {001} sont étroites. Ces cristaux sont fragiles, à trait blanc, éclat vitreux et cassure esquilleuse; de dureté 2 sur l'échelle de Mohs. La rapid-

creekite présente un bon clivage {100} et un clivage parfait {010}. Sa densité est de 2.21(1) (mesurée) et 2.239 (calculée); elle n'est pas fluorescente sous l'ultraviolet. Elle est biaxiale positive,  $\alpha$  1.516(1),  $\beta$  1.518(1),  $\gamma$  1.531(1),  $2V_x$  (mesuré) 45(3)°,  $2V_x$  (calculé) 43°; l'orientation de l'indicatrice est:  $X = c$ ,  $Y = a$ ,  $Z = b$ . Les huit raies les plus intenses du diagramme de poudre obtenu par diffraction X [ $d$  en Å(1)( $hkl$ )] sont les suivantes: 7.78(100)(200), 4.31(70)(221), 3.88(70)(311,400,231), 3.11(80)(421,002), 2.917(50)(431), 2.797(60)(161), 2.555(50)(142,322) et 1.899(50)(303,580,233,082). Les analyses à la microsonde électronique et l'analyse thermogravimétrique - analyse des gaz émis (TGA-EGA) donnent: CaO 36.3, SO<sub>3</sub> 26.1, CO<sub>2</sub> 14.0 et H<sub>2</sub>O 23.6, total 100.0% (en poids). Le nom rappelle l'endroit où la nouvelle espèce a été trouvée.

**Mots-clés:** nouvelle espèce minérale, rapidcreekite, sulfate et carbonate de calcium tétrahydraté, Yukon, Rapid Creek, données de rayons X, composition chimique.

### INTRODUCTION

The Rapid Creek - Big Fish River area of the northern Yukon Territory is best known for the unique assemblages of phosphate minerals that occur in a sequence of Lower Cretaceous (Albian) ironstones and shales. However, recent surface-weathering has resulted in the formation of many secondary sulfate and carbonate minerals, most of which have not been reported to date. Among these are aragonite, nesquehonite, dypingite, hydromagnesite, gypsum, hexahydrate, halotrichite, epsomite, jarosite, natrojarosite and diadochite (a sulfate-phosphate).

Rapidcreekite, ideally  $\text{Ca}_2(\text{SO}_4)(\text{CO}_3)\cdot 4\text{H}_2\text{O}$ , is a new mineral species first encountered in 1983, and to date found only at one locality along the valley of a tributary (unofficially, Crosscut Creek) of Rapid Creek, at latitude 68°33'45"N, longitude 136°47'30"W. Rapidcreekite occurs as a secondary phase on dilated joint-surfaces and bedding planes in a blocky, quartz-rich bed in the sideritic iron-formation. Minor amounts of gypsum and aragonite

are associated with rapidcreekite, and kulanite is found on the holotype specimen.

The mineral is named for the general locality; both name and mineral have been approved by the Commission on New Minerals and Mineral Names, I.M.A. The holotype specimen, consisting of a few grams of material on matrix, is housed in the Systematic Reference Series of the National Mineral Collection, at the Geological Survey of Canada, Ottawa, under catalogue number 64346. Additional specimens of rapidcreekite are preserved at the Geological Survey and at the Mineral Sciences Division, National Museum of Natural Sciences, Ottawa.

#### PHYSICAL AND OPTICAL PROPERTIES

Rapidcreekite occurs most commonly as radiating sprays of white to colorless acicular crystals, in both isolated clusters and pervasive coatings on rusty-weathering quartz-rich iron formation. Individual crystals are colorless, transparent and acicular, elongate parallel to [001], with forms {010} broad and {100}, {001} minor (Fig. 1), and approach 2 mm in maximum length. The coarser material has a length-to-width ratio of about 50:1. Bundles of individual crystals appear lath-shaped. The mineral is brittle with a white streak, vitreous lustre, splintery fracture, and a Mohs hardness of 2. Observed cleavages are {010} perfect and {100} good. Rapidcreekite is nonfluorescent under both long- and short-wave ultraviolet radiation. Although the mineral dissolves

slowly in heavy liquids, a measured density of 2.21(1) g/cm<sup>3</sup> was obtained, in reasonable agreement with the calculated density of 2.239 g/cm<sup>3</sup> for Ca<sub>2</sub>(SO<sub>4</sub>)(CO<sub>3</sub>)·4H<sub>2</sub>O.

Optical measurements were made on a spindle stage using sodium light ( $\lambda$  589 nm). Rapidcreekite is biaxial positive,  $\alpha$  1.516(1),  $\beta$  1.518(1) and  $\gamma$  1.531(1). The measured  $2V_x$  is 45(3)°, close to the calculated value of 43°. Optical orientation is  $X=c$ ,  $Y=a$  and  $Z=b$ .

#### CRYSTALLOGRAPHY

Precession single-crystal studies employing Mo radiation of two crystal fibres show that rapidcreekite is orthorhombic, space group  $Pcnb$ , with measured unit-cell parameters  $a$  15.45,  $b$  19.16 and  $c$  6.165 Å. The levels collected are  $hk0 \rightarrow hk2$ ,  $0kl \rightarrow 5kl$  and  $h0l \rightarrow h5l$ . The X-ray powder-diffraction data (Table 1) were refined on 18 reflections between 3.005 and 1.655 Å for which unambiguous indexing was possible, based on precession single-crystal films. The refined unit-cell parameters are:  $a$  15.49(1),  $b$  19.18(1),  $c$  6.157(4) Å,  $V$  1829.2 Å<sup>3</sup>, and  $a:b:c$  0.808:1:0.321. The strongest diffraction-lines are close to those of gypsum, but the complete powder-pattern is significantly different from any mineral of the gypsum group. However, the powder data are very similar to the unnamed calcium arsenate (P.D.F. 29-294) described by Walenta (1972) from the Johann mine, Wittichen region, Germany. There seems little doubt that this latter mineral is the arsenate analogue of rapidcreekite. This is further supported by the near-identity of their optical properties.



FIG. 1. Scanning-electron photomicrograph of rapidcreekite showing typical habit of crystals. Length of bar is 10  $\mu$ m.

TABLE 1. X-RAY POWDER-DIFFRACTION DATA FOR RAPIDCREEKITE

Test	dÅ meas.	dÅ calc.	hkl	Test	dÅ meas.	dÅ calc.	hkl
100	7.78	7.75	200	5	2.312	2.316	342
20	5.49	5.48	111			2.253	371
5	4.91	4.91	121	30	2.253	2.245	551
10	4.68	4.67	211	5	2.213	2.218	062
70	4.31	4.31	221			2.212	181
		3.88	311	5	2.173	2.170	512
70	3.88	3.87	400	10	2.091	2.093	561
		3.85	231	20	2.070	2.071	711
		3.68	141			2.047	072
40	3.66	3.66	321	10	2.044	2.039	480
		3.40	241			2.035	103
40	3.41	3.23	411	5	2.009	2.010	740
20b	3.22	3.20	060	40	1.986	1.988	542
		3.10	421	40	1.951	1.949	291
		3.08	002			1.907	303
20	3.005	3.002	251			1.896	580
50	2.917	2.917	431	50	1.899	1.895	233
		2.880	122			1.892	082
10b	2.871	2.861	202	10	1.833	1.833	245
		2.791	161	5	1.786	1.787	491
60	2.797	2.754	351			1.766	722
10b	2.743	2.730	132	10	1.761	1.758	652
		2.659	521			1.757	680
30	2.661	2.555	142	5	1.710	1.711	503
50	2.555	2.549	322	5	1.684	1.683	742
20	2.449	2.444	332	5	1.655	1.656	4101
		2.398	080				
		2.391	412				
10b	2.386	2.370	180				

114.6 mm Debye-Scherrer powder camera, Cu radiation Ni filter ( $\lambda$  CuK $\alpha$  1.54178 Å), bs=brodif line indexed with  $a$  15.49,  $b$  19.18 and  $c$  6.157 Å.

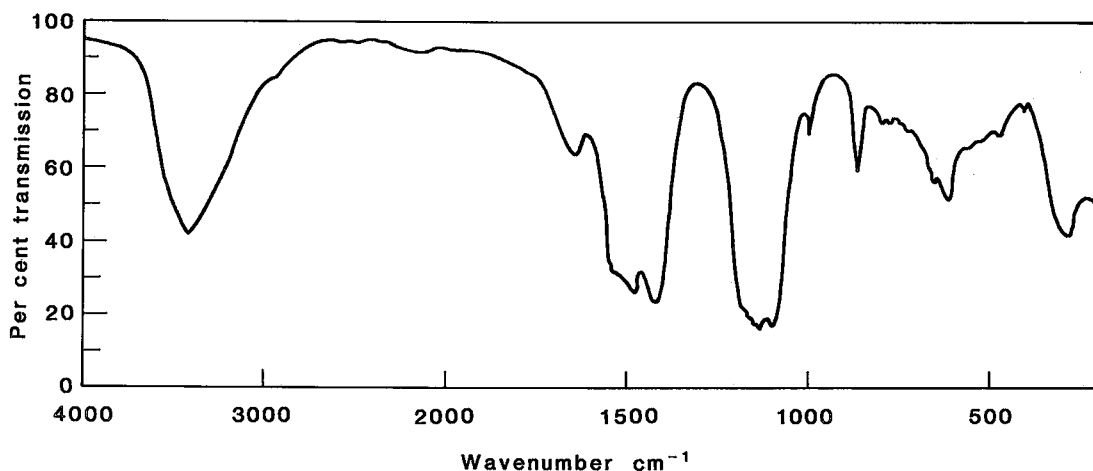


FIG. 2. Infrared-absorption spectrum for rapidcreekite.

#### CHEMISTRY

Rapidcreekite was analyzed by means of a Materials Analysis Company (MAC) electron microprobe equipped with a KEVEX energy-dispersion spectrometer (M. Bonardi, analyst). Accelerating voltage was 20 kV with a sample current of 10 nA as measured on kaersutite. To minimize sample degradation and compositional change due to electron bombardment, a slightly defocused beam was used over a counting time of 100 seconds.

An energy-dispersion scan on a hand-picked crystal aggregate indicated that Ca and S are the only elements present with atomic number greater than 10. Subsequent energy-dispersion analyses were made using gypsum (NMC 17182, Moose River, Ontario) as a standard. Analytical data were corrected with EDDI, an in-house energy-dispersion data-reduction program written by G.J. Pringle. TGA-EGA (Evolved Gas Analysis) determinations for H<sub>2</sub>O and CO<sub>2</sub> were made on 3.605 mg of sample using the Mettler thermal analyzer and integrated mass-spectrometer at the Royal Ontario Museum. Major peaks at 230°, 660° and 1105°C are ascribed to the evolution of H<sub>2</sub>O, CO<sub>2</sub> and SO<sub>3</sub>, respectively.

A 25 mg sample of rapidcreekite was checked for the presence of other anions using a Dionex anion chromatograph. Results of one analysis were: F<sup>-</sup> 0.09, Cl<sup>-</sup> 0.03, PO<sub>4</sub><sup>3-</sup> 0.07 and NO<sub>3</sub><sup>-</sup> 0.15 weight %, most likely attributable to contamination.

Combined analytical results gave CaO 36.3, SO<sub>3</sub> 26.1, CO<sub>2</sub> 14.0 and H<sub>2</sub>O 23.6, total 100.00 weight %. Assuming S = 1, the empirical formula for rapidcreekite is Ca<sub>1.99</sub>(SO<sub>4</sub>)<sub>1.00</sub>(CO<sub>3</sub>)<sub>0.98</sub>•4.02H<sub>2</sub>O or,

ideally, Ca<sub>2</sub>(SO<sub>4</sub>)(CO<sub>3</sub>)•4H<sub>2</sub>O with Z = 8. The mineral dissolves slowly in 10% HCl with slight effervescence.

Calculations using the Gladstone-Dale relationship yielded  $K_C = 0.232$  and  $K_P = 0.233$  for constants reported by Mandarin (1981); hence  $1 - (K_P/K_C)$  is 0.0043, indicating superior compatibility (Mandarin 1979).

An infrared-absorption analysis (Fig. 2) indicates that the formula Ca<sub>2</sub>(SO<sub>4</sub>)(CO<sub>3</sub>)•4H<sub>2</sub>O is to be preferred over Ca<sub>2</sub>(SO<sub>4</sub>)(HCO<sub>3</sub>)(OH)•3H<sub>2</sub>O. No positive evidence was found for the presence of HCO<sub>3</sub><sup>-</sup> or OH<sup>-</sup> in rapidcreekite. However, a crystal-structure determination would be necessary to verify the correct formula.

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