

# Eggletonite, the Na analogue of ganophyllite

DONALD R. PEACOR

Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan 48109

PETE J. DUNN

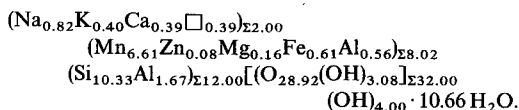
Department of Mineral Sciences, Smithsonian Institution, Washington, DC 20560

AND

WILLIAM B. SIMMONS

Department of Earth Sciences, University of New Orleans, New Orleans, Louisiana 70148

**ABSTRACT.** Eggletonite is a new mineral, the Na analogue of ganophyllite. Type material has composition



It occurs as prismatic crystals elongated along [100] in miarolitic cavities in nepheline syenite at the Big Rock Quarry, Little Rock, Arkansas. Single-crystal X-ray diffraction data are consistent with space group *I2/a* or *Ia*;  $a = 5.554$ ,  $b = 13.72$ ,  $c = 25.00$  Å,  $\beta = 93.95^\circ$ ;  $Z = 2$ ; this is equivalent to the substructure of ganophyllite. Physical properties include cleavage: {001} perfect; colour: dark brown; translucent; streak: light brown; hardness (Mohs): 3-4; brittle; observed density 2.76, calculated density 2.76 g/cm<sup>3</sup>. Optically, eggletonite is biaxial negative, with optical parameters  $2V_x = 9(3)^\circ$ ;  $r < v$ , weak; indices of refraction  $\alpha = 1.566(2)$ ,  $\beta = 1.606(2)$ ,  $\gamma = 1.606(2)$ ; pleochroism is very weak,  $\gamma \approx \beta > \alpha$ ;  $\alpha =$  pale brown to colourless,  $\beta \approx \gamma =$  pale yellow brown. Principal lines in the X-ray powder diffraction pattern are ( $d$ ,  $I/I_0$ ): 12.4, 100; 3.45, 15; 3.13, 30; 2.854, 15; 2.691, 25; 2.600, 20; 2.462, 20; 2.387, 15. The name is in honour of Dr Richard A. Eggleton, Australian National University.

THE mineral described here was sent to us for examination by Mr Cecil Cosse in 1977. The X-ray powder diffraction data were extremely similar to those of ganophyllite and the sample was tentatively labelled ganophyllite until it was examined years later as part of a study of the chemistry of ganophyllite (Dunn *et al.*, 1983). It was then noted that this material has  $\text{Na} > \text{K}$  and is therefore the Na analogue of ganophyllite. Subsequent investigation has confirmed this relation. We have named this new mineral eggletonite in honour of Dr Richard A. Eggleton of the Australian National University, in recognition of his contributions to

mineralogy, particularly the crystal chemistry of the stilpnomelane group, to which eggletonite is closely related. The mineral and the name were approved by the Commission on New Minerals and Mineral Names, IMA, prior to publication. Type material is preserved in the Smithsonian Institution under catalogue no. 137143.

*X-ray crystallography.* Single crystals were studied using precession and Weissenberg techniques. These showed that eggletonite is monoclinic, extinctions being consistent with space groups *I2/a* or *Ia*, with unit cell parameters  $a = 5.554$ ,  $b = 13.72$ ,  $c = 25.00$  Å,  $\beta = 93.95^\circ$ . These data are equivalent to those of the substructure of ganophyllite (Kato, 1980) such that the superstructure has  $a' = 3a$ ,  $b' = 2b$ , and  $c' = 2c$ , space group *A2/a*. Crystals of eggletonite are extremely small, and long exposures were therefore used in order to detect the presence of superstructure reflections. None was observed. It is not possible, however, to unambiguously determine if extremely weak reflections are present or not due to the small crystal size. It is therefore possible that a super cell exists for eggletonite equivalent to that for ganophyllite. This ambiguity can be definitively resolved only when larger crystals can be studied. The diffraction patterns of all crystals studied showed the presence of twinning on {001}.

Powder diffraction data were obtained using a polycrystalline sample in a 114.6 mm diameter Gandolfi camera, utilizing Cu-K $\alpha$  radiation and Si as an internal standard. The data are listed in Table I. Only a part of the pattern is indexed because the relatively large lattice parameters and low symmetry combine to give multiple, similar, calculated  $d$  values for each observed value. The powder data could therefore not be used as a source

TABLE I. X-ray powder diffraction data for *eggletonite*

<i>d</i> (obs)	<i>I</i> / <i>I</i> <sub>0</sub>	<i>d</i> (calc)	<i>hkl</i>
12.4	100	12.47	002
5.13	5	5.14	110
4.16	10	4.16	006
3.98	5	4.01	033
3.45	15	3.45	017
		3.43	13 $\bar{2}$
		3.43	040
3.13	30	3.14	116
		3.13	13 $\bar{4}$
		3.12	008
		3.01	134
3.01	2	3.01	044
		2.854	028
2.854	15	2.838	028
2.743	2	2.745	20 $\bar{2}$
		2.744	118
2.691	25		
2.600	20		
2.462	20		
2.387	15		
2.290	2		
2.230	1		
2.204	5		
1.961	1		
1.754	2		
1.609	5		
1.574	2		

of data for least-squares refinement of lattice parameters.

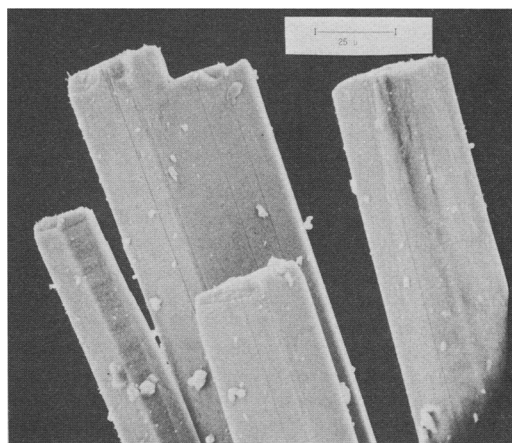
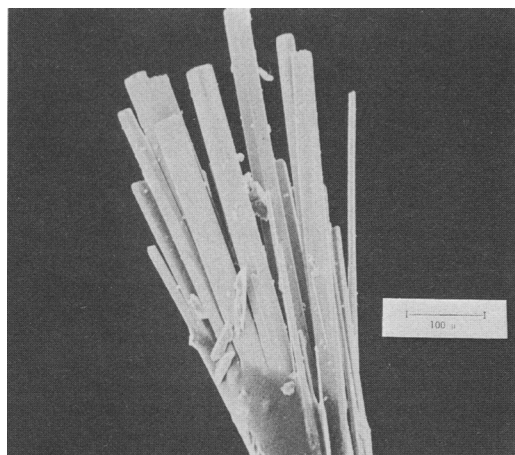
**Morphology.** *Eggletonite* occurs as acicular radiating sprays of prismatic crystals up to 1.5 mm

in length, twinned on {001}. Crystals are elongated parallel to *a*, and have a pseudo-hexagonal cross-section, with faces making angles of approximately 60–65° with one another. The forms present are the prism {011} and the pinacoid {001}. SEM photomicrographs of *eggletonite* are shown as figs. 1 and 2 and show the radial, divergent habit of the clusters and the composition plane of the twinning.

**Physical and optical properties.** *Eggletonite* is dark brown to golden brown in colour with a light brown streak. The luster is vitreous. Cleavage is perfect, parallel to {001}, and easily produced. The hardness (Mohs) is 3–4. *Eggletonite* is very brittle. The density, determined using heavy-liquid techniques, is 2.76 g/cm<sup>3</sup>, compared with the calculated value of 2.76 g/cm<sup>3</sup>. *Eggletonite* is not fluorescent in ultraviolet radiation.

Optically, *eggletonite* is biaxial negative, with  $2V_{\alpha} = 9(3)^{\circ}$ , and indices of refraction  $\alpha = 1.566(2)$ ,  $\beta = 1.606(2)$ , and  $\gamma = 1.606(2)$ . Dispersion is weak,  $r < v$ . The optical orientation is  $\alpha \simeq c^*$ ,  $\beta \simeq a$ ,  $\gamma = b$ . Pleochroism is very weak;  $\beta \simeq \gamma =$  pale yellow brown,  $\alpha =$  pale yellow to colourless. Absorption  $\gamma \simeq \beta > \alpha$ .

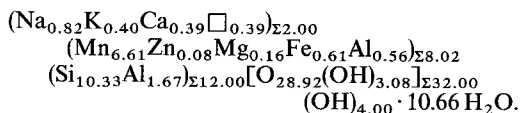
**Chemistry.** *Eggletonite* was chemically analysed using an ARL-SEM-Q electron microprobe utilizing an operating voltage of 15 kV and a sample current, standardized on brass, of 0.025  $\mu$ A. The standards used were hornblende (Si, Al, Fe, Mg, Ca, K, Na), manganite (Mn), and synthetic ZnO (Zn). The data were corrected using standard Bence-Albee factors. The analyses were performed with a 20  $\mu$ m diameter beam spot to minimize volatilization, after first checking for homogeneity with a small diameter beam spot. Water could not be directly determined due to paucity of material; it



FIGS. 1 and 2. SEM photomicrographs. FIG. 1 (*left*). Cluster of divergent *eggletonite* crystals. FIG. 2 (*right*). *Eggletonite* crystals showing the prismatic habit and twin plane.

was calculated by difference. The analysis yields SiO<sub>2</sub> 41.5, Al<sub>2</sub>O<sub>3</sub> 7.6, FeO 3.0, MgO 0.4, ZnO 0.2, MnO 31.4, CaO 1.5, Na<sub>2</sub>O 1.7, K<sub>2</sub>O 1.3, H<sub>2</sub>O [11.4]%. These results are given 'as-determined' and not normalized.

Calculation of unit-cell contents using the observed density and measured unit-cell parameters leads to a sum of 42.22 octahedrally and tetrahedrally co-ordinated cations (excluding Na, Ca, and K). Because the total should be forty in accordance with the crystal structure determination of the substructure of the isostructural mineral ganophyllite (Kato, 1980), we assume that the 'as-determined' wt. % oxides have been enhanced due to volatilization of H<sub>2</sub>O during microprobe analysis. This assumption is based, in part, on the fact that ganophyllite (Dunn *et al.*, 1983) has very loosely bound H<sub>2</sub>O. Ganophyllite can lose up to 5% H<sub>2</sub>O at room temperature and it seems reasonable to infer that some loss of water is incurred during microprobe procedures. Accordingly, we have normalized the wt. % oxides to yield 40.0 octahedral plus tetrahedral cations. The normalized unit cell contents are:



We emphasize that the exact amount of water in eggletonite remains unknown. Indeed, in the K analogue, ganophyllite, TGA-EGA analyses of a sample from Franklin, New Jersey, showed that it lost 5.3 (± 1.0) wt. % H<sub>2</sub>O in vacuum, at 21 °C, after it had been exposed to conditions of 100% relative humidity at room temperature. Furthermore, H<sub>2</sub>O was lost continuously from room temperature to 190 °C (Dunn *et al.*, 1983). It thus appears as if the H<sub>2</sub>O content of ganophyllite, and therefore of eggletonite, is partially zeolitic, a major part of it can be reversibly lost or gained at room temperature.

The proportions of the large cations also deserve some comment. Dunn *et al.* (1983) showed for ganophyllite that the sum of K + Na atoms per cell, and the number of Ca atoms per cell, are approximately constant. This implies that they are ordered on different equipoints. Ordering of large cations in the structure of bannisterite (Threadgold, 1979) is indeed observed, and was supported by Dunn *et al.* (1981). Because the structures of bannisterite and eggletonite are closely related, this further suggests that Ca is ordered relative to Na and K in eggletonite. As the substructure of ganophyllite has all large cations on a single equipoint (Kato, 1980), ordering of those cations implies that there may be a superstructure, relative to which the single equi-

point of the large cations for the substructure must be divided into more than one site. This is indirect evidence for the occurrence of a superstructure in eggletonite, even though the corresponding reflections could not be observed in single-crystal X-ray photographs due to the small size of the crystals.

We call attention to the fact that the original analysis of ganophyllite, from Pajsberg, Sweden, had Na > K. However, re-study of Pajsberg material by Dunn *et al.* (1983) found that all studied samples have K > Na and, furthermore, that samples of massive material have abundant inclusions of acmite which serves to increase the Na<sub>2</sub>O content of analyses of massive material by wet-chemical techniques. Eggletonite is the first member of this series with Na > K.

*Occurrence and paragenesis.* Eggletonite occurs in the Big Rock Quarry in Little Rock, Arkansas. The authors have not collected the material themselves and little is known of its precise geologic relations. However, the quarry is operated for crushed stone using a massive, rather uniform nepheline syenite as a source rock. The nepheline syenite is medium- to coarse-grained and dark grey in colour. It consists of approximately 65% K-feldspar, 5% biotite, and 5% analcime with accessory clinopyroxene, titanite, pyrite, zircon, and magnetite. The eggletonite and other usual minerals occur in small pegmatite or miarolytic pockets. Eggletonite is very rare and has been found in only a few pockets.

The pegmatite pockets are surrounded by a bleached zone of altered syenite, which grades into pegmatitic texture and forms the inner surface of the cavities. Encrusting these wall minerals are albite, biotite, amphibole, titanite, apophyllite, radiating sprays of natrolite, sprays of acicular acmite, zircon, large trapezohedra of analcime, and in some instances sprays of eggletonite.

The holotype specimen consists of massive albite with grain size approximately 1.0 mm. There are minor amounts of accessory biotite, acmite, titanite, and magnetite. The surface of the specimen, where eggletonite crystals grew freely into pockets, consists of albite crystals up to 15 mm, with numerous late-state minerals in the interstices. Most abundant among these are an unanalysed amphibole and second-generation albite, with minor amounts of natrolite, apophyllite, and eggletonite. The sequence of formation appears to be late eggletonite and albite, followed by amphibole, and lastly, eggletonite and natrolite.

*Acknowledgements.* We thank Mr Cecil Cosse for calling this mineral to our attention and providing additional samples for study.

## REFERENCES

- Dunn, P. J., Leavens, P. B., Norberg, J. A., and Ramik, R. A. (1981) *Am. Mineral.* **66**, 1063-7.
- Peacor, D. R., Nelen, J. A., and Ramik, R. A. (1983) *Mineral. Mag.* **47**, 563-6.
- Kato, T. (1980) *Mineral. J. (Japan)*, **10**, 1-13.
- Threadgold, I. (1979) Mineral. Soc. New South Wales and Mineral. Soc. Victoria seminar.

[Manuscript received 28 February 1983]