



FIGS. 1 and 2. FIG. 1 (left). Electron micrograph of grunerite asbestos down the c -axis. A quintuple lamella to the right of the figure side-steps along (150) and (130) planes, and terminates incoherently at its lower end into three double lamellae. At its upper end the quintuple lamella probably dissociates in the manner shown in fig. 2. Scale bar = 50 Å. FIG. 2 (right). Model of the structure in fig. 1. Note that the structure on opposite sides of the odd-multiple lamellae is displaced by $c/2$.

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MINERALOGICAL MAGAZINE, JUNE 1982, VOL. 46, PP. 274-5

The occurrence of cebollite in kimberlite and included zeolitized crustal xenoliths—a correction and discussion of the occurrence of pectolite

IN a previous report (Kruger, 1980) I described two parageneses of a fibrous, radiating, colourless to red-brownish mineral with moderate birefringence, parallel extinction, and length-slow character from the Letseng-La-Terae kimberlite in Lesotho and the De Beers mine in Kimberley.

I concluded the mineral was cebollite in view of a close fit of some seventeen lines determined from Debye-Sherrer diffraction photographs and the available optical data.

A microprobe analysis of the mineral is now available which shows it to have distinctly different

chemistry to that of cebollite [$\text{Ca}_4\text{Al}_2\text{Si}_3\text{O}_{12}(\text{OH})$]. The composition given in Table I shows the mineral to have a high Na_2O concentration and very little Al_2O_3 whereas the reverse is expected. The SiO_2 concentration is also higher than expected. The chemical data necessitate a reassessment of the optical and diffraction data. A close fit of the diffraction data is provided by *pectolite* [$\text{NaCa}_2\text{Si}_3\text{O}_8(\text{OH})$] (JCPDS card no. 12-238). The fit is in fact better than provided by *cebollite* (JCPDS card no. 16-695) as the intensities correspond better. However, *pectolite* has inclined extinction (Deer *et al.*, 1978) and the mineral described here has parallel extinction and is thus unusual for *pectolite*. Nevertheless the bulk of the available data including a close chemical correspondence (Table I) indicate the mineral to be *pectolite*.

TABLE I. *Microprobe analysis of pectolite*

	1	2	3
SiO_2	54.98	54.2	30.1
Al_2O_3	0.30	—	17.0
Fe_2O_3	0.24	—	—
MnO	0.03	—	—
CaO	33.51	33.8	46.8
Na_2O	8.83	9.3	—
K_2O	0.02	—	—
H_2O	—	2.7	6.0
Total	97.91	100.0	100.0

1. *Pectolite* from a crustal xenolith included in the Letseng-La-Terae kimberlite.

2. Ideal *pectolite* composition, $\text{NaCa}_2\text{Si}_3\text{O}_8(\text{OH})$.

3. Ideal *cebollite* composition, $\text{Ca}_4\text{Al}_2\text{Si}_3\text{O}_{12}(\text{OH})_2$.

Pectolite is a secondary mineral usually occurring as an alteration product of basic rocks. It has, however, been recorded as a primary mineral in a mica peridotite by Franks (1959) and in phonolite by Carr *et al.* (1976). Mountain (1931) recorded the mineral in kimberlite.

In the previous report (Kruger, 1980) the paragenesis of the mineral is described in detail; it occurs as an alteration product of plagioclase in crustal xenoliths and as an apparently primary mineral in the kimberlite matrix. Minerals associated with the *pectolite* in the kimberlite matrix are *serpentine*, *phlogopite*, and *calcite*. In the crustal xenoliths plagioclase reacted to form *natrolite* and *pectolite*. *Natrolite*, *pectolite*, *serpentine*, and *phlogopite* indicate that the final liquids in the kimberlite magma was hydrous, while the presence of *calcite* indicates that CO_2 was also present.

The mineral assemblage can be used to put quite close constraints on the conditions prevailing during the final crystallization of the kimberlite groundmass. Assuming the pressure in the diatreme facies kimberlite after eruption to be less than 500 bar [<2 km depth (Dawson, 1971)], the following temperatures for the formation of the various minerals are available in literature. *Serpentine* forms at less than 350°C from *forsterite* (Johannes, 1968), the reaction of *labradorite* and water to form *pectolite* occurs at 224°C at 890 bar and thus at somewhat lower temperatures at <500 bar (Juan *et al.*, 1968) and Senderov (1974) shows that *natrolite* is stable below 250°C . The assemblage present in the kimberlite groundmass and in crustal xenoliths thus indicates temperatures of formation of roughly 200 to 250°C .

Experimental synthesis of *natrolite* and *pectolite* are accomplished under very high pH conditions (Senderov, 1974; Clark and Bunn, 1940) and this indicates similar pH conditions in the final kimberlite liquids.

The development of *pectolite* in the groundmass of kimberlite indicates that there is an enrichment in sodium in the final liquids to crystallize. Sodium is largely excluded from other phases crystallizing in kimberlite (*phlogopite*, *olivine*, *serpentine*, *calcite*).

Acknowledgements. I am grateful to Mr E. M. W. Skinner of the De Beers Corporation for bringing to my attention an internal report by D. Smith which showed that the original identification as *cebollite* might in fact have been in error and that the mineral is probably *pectolite*.

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[Manuscript received 16 June 1981;
 revised 28 September 1981]

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