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Further data on the occurrence of pectolite in kimberlite

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ABSTRACT. Pectolite has been identified, using petrographic, chemical, and X-ray methods, in kimberlites from the De Beers and Dutoitspan Mines, Kimberley, South Africa and the Letseng-La-Terai Mine, Lesotho. It occurs as radiating aggregates of fibrous or acicular crystals not only in the groundmass of certain kimberlites but also in altered xenoliths included within kimberlite. The occurrence of Na-rich minerals in kimberlite is unusual. It is suggested that it can occur as an apparently primary mineral resulting from the incorporation and assimilation of foreign Na-bearing material prior to final consolidation, and/or as a secondary mineral after metasomatic introduction of Na-bearing fluids.

THIS study presents petrographic, chemical, and X-ray diffraction data for a mineral which occurs as a groundmass constituent of kimberlite and in altered xenoliths included in kimberlite. It is concluded that this mineral is pectolite, the same mineral as that discussed by Kruger (1980, 1982).

Four samples from the De Beers and Dutoitspan Mines, Kimberley, South Africa and the Letseng-La-Terai Mine, Lesotho are included in this study. Sample 173/33/K3/73 is considered to be either similar to or the same sample as that examined by Kruger (1980, 1982) which was provided by the Geology Department De Beers Consolidated Mines Ltd., Kimberley. In addition to the localities noted above, probable pectolite has been observed by the authors in several other kimberlites.

Petrography

Sample 173/33/K3/73. De Beers Mine (720 metre level, DB3 kimberlite). The sample is composed of numerous partially serpentinized olivine macrocrysts and microphenocrysts in a groundmass of phlogopite, monticellite, perovskite, opaque oxide minerals, and carbonate. A few altered xenoliths also occur. The kimberlite is classified as a hypabyssal-facies phlogopite kimberlite (after Skinner and Clement, 1979, and Clement and Skinner, 1979). Another mineral identified as pectolite is also abundant in this sample and is concentrated in irregular patches or segregations (up to 7 mm in size). It occurs as radiating aggregates of colourless, acicular or fibrous crystals set in a base of pale green to colourless serpentine (fig. 1). The aggregates have a pale brown colour where crystals are abundant.

The optical properties of this mineral are difficult to determine considering the habit but it has high birefringence, medium relief, straight extinction, and is length slow. These features are consistent

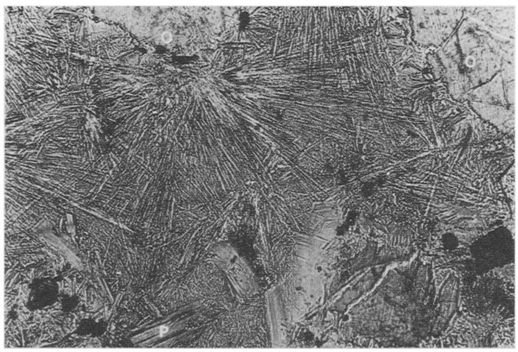

FIG. 1. Sample 173/33/K3/73 from De Beers Mine, Kimberley, South Africa. Numerous acicular or fibrous crystals of pectolite are the main constituent of the groundmass. Phlogopite (*p*), and opaque minerals including perovskite are associated with the pectolite. Olivine (*o*) can also be seen. Plane polarized light. Width of field = 0.6 mm.

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with it being pectolite except for the straight extinction. According to Deer *et al.* (1978) pectolite has inclined extinction. The serpentine occurs both as 'glassy' isotropic and as cryptocrystalline low birefringent material. Small 'pools' dispersed throughout the groundmass are composed predominantly of serpentine but do enclose some pectolite. Other groundmass minerals such as phlogopite and perovskite, and to a lesser extent, microphenocrysts of olivine are sometimes associated with the pectolite. The mode of occurrence of the pectolite in this sample suggests that it is a primary groundmass constituent of this kimberlite. The crystallization of pectolite appears to be late-stage and associated mainly with serpentine segregations or 'pools' which probably represent pockets of residual fluid.

Sample 173/33/K3/72. De Beers Mine (720 metre level, DB3 kimberlite). This sample is similar to 173/33/K3/73 except that pectolite is not as common in this sample. Groundmass pectolite occurs only in small amounts associated with carbonate. This sample contains some small inclusions which probably represent substantially altered and recrystallized xenoliths. Pectolite, together with phlogopite, also occurs in patches which appear to represent altered xenoliths.

Sample 173/33/K6/38. Dutoitspan Mine (580 metre level, D5 kimberlite). This sample is composed of numerous anhedral partially serpentinized olivine macrocrysts, numerous serpentinized olivine microphenocrysts, macrocrysts and microphenocrysts of phlogopite in a finer-grained groundmass of phlogopite, apatite, perovskite, opaque oxide minerals, clinopyroxene, and serpentine. The sample can be classified as a hypabyssal-facies, phlogopite kimberlite. Pectolite is common in thin section, occurring in patches (up to 0.5 mm in size) composed of one or more radial aggregates of fibrous or acicular crystals and has a similar habit to the pectolite described above from sample 173/33/K3/73.

Sample 137/1/K1/4. Letseng-La-Terai (55 metre level, K2 kimberlite). The main constituents of this specimen are serpentinized olivines, groundmass phlogopite, serpentine, and perovskite. The K2 kimberlite is classified as a diatreme-facies phlogopite kimberlite. Radiating aggregates of pectolite are not common in this sample but do occur both in the groundmass and within occasional altered xenoliths. Altered, country-rock xenoliths are common.

Mineral chemistry

Mineral analyses were obtained using an ARL SEMQ electron microprobe at the Anglo American Research Laboratories. The habit of the mineral in these samples is such that it is not possible to obtain analyses for a single crystal. Areas where the groundmass appeared to be composed of a felt of crystals with little or no interstitial material were analysed and the results are given in Table I. The mineral did not decompose under the electron beam. The composition and mineral formula (Table I) suggests that the mineral is pectolite ($Ca_2NaHSi_3O_9$). Analyses which show significant FeO and MgO contents (e.g. analysis 80-556, Table I) incorporate a certain amount of interstitial serpentine (analysis 80-561, Table I).

X-ray diffraction

Parts of radiating aggregates of this mineral were removed from a polished thin section of sample 173/33/K3/73. A ball-mount was prepared of the powdered material and X-rayed using a 57.3 mm Debeye-Scherrer camera. The results are presented in Table II. These data also suggest that the mineral is pectolite. Re-interpretation of the X-ray diffraction data given by Kruger (1980) is also consistent with the mineral being pectolite. It should be noted that these data were not rigorously determined and are included for identification purposes and should not be used as a standard.

Discussion

It is unusual to find Na-rich minerals in kimberlite and it is interesting, therefore, to consider the paragenesis of this mineral. Unfortunately this is difficult to interpret in the specimens examined because of different modes of occurrence and it may, in fact, result from two separate processes.

First, in some cases, the pectolite is interpreted as a primary groundmass constituent when it appears to be in textural equilibrium with other groundmass minerals. In some instances the pectolite is confined to areas surrounding altered xenoliths. This spatial relationship with xenoliths and the general lack of Na in kimberlites suggests that xenolithic material was incorporated and digested in the hot kimberlite magma thus modifying the composition of the magma, notably by the introduction of Na. Two variations of this process can occur. The xenoliths are incorporated during a late stage of the kimberlite intrusion. The xenolith is then partially digested and modification of the magma is localized within the vicinity of the xenoliths. Pectolite crystallization is then confined to the groundmass surrounding the xenolith. On the other hand, xenoliths can be included within the magma at an earlier stage which allows a greater degree of digestion and compositional

Table I. Mineral Chemistry

All pectolite analyses represent felts of fibrous or acicular crystals. Analysis 80-556 incorporates some of the serpentine base similar to analysis 80-561. Analyses 80-564 and 81-132 are of minerals occurring within xenoliths while the others are of groundmass minerals. (n.d. = not detected).

MINERAL	PECTOLITE							SERPENTINE
SAMPLE NUMBER	173/33/K3/73			173/33/K6/38		173/33/K3/72	137/1/K1/4	173/33/K3/73
ANALYSIS NUMBER	80-558	80-560	80-556	80-411	80-413	80-564	81-132	80-561
SiO_2	52.47	50.38	50.10	51.46	50.61	52.42	52.63	40.86
TiO_2	0.17	0.74	0.05	0.09	0.07	0.10	0.01	nd
Al_2O_3	0.35	0.39	0.68	0.22	0.36	0.25	0.16	0.78
Cr_2O_3	nd	nd	nd	nd	nd	nd	nd	nd
FeO	0.21	1.51	1.16	0.34	0.29	0.45	0.14	6.49
MnO	0.06	0.07	0.08	0.09	0.07	0.22	0.18	0.10
NiO	nd	nd	0.01	nd	nd	0.01	0.01	nd
MgO	0.05	0.08	4.35	0.07	0.12	0.03	0.03	36.42
CaO	33.08	33.05	28.20	33.14	32.52	28.81	33.21	0.52
Na_2O	8.66	7.82	7.52	7.20	8.09	8.30	8.45	0.10
K_2O	0.01	0.03	0.02	0.02	0.04	0.05	0.01	0.03
TOTAL	95.06	94.07	92.17	92.63	92.17	90.64	94.83	85.30
	Structural Formulae on Basis of 17 Oxygens							
Si	5.947	5.825	5.814	5.975	5.927	6.145	5.978	
Ti	0.014	0.065	0.006	0.008	0.006	0.008	-	
Al	0.048	0.054	0.093	0.031	0.051	0.034	0.023	
Cr	-	-	-	-	-	-	-	
Fe	0.020	0.147	0.113	0.034	0.028	0.045	0.014	
Mn	0.006	0.006	0.008	0.008	0.006	0.023	0.017	
Ni	-	-	-	-	-	-	-	
Mg	0.008	0.014	0.754	0.011	0.020	0.006	0.006	
Ca	4.018	4.094	3.505	4.122	4.080	3.618	4.043	
Na	1.904	1.754	1.691	1.620	1.836	1.870	1.861	
K	0.003	0.006	0.003	0.003	0.006	0.008	0.003	
TOTAL	11.968	11.965	11.987	11.812	11.960	11.757	11.945	

Table II. X-Ray Diffraction Data (Å)

THIS STUDY	PECTOLITE[1]	KRUGER (1980)	CEBOLLITE[2]
—	7.83	—	—
—	7.03	—	7.27
5.5	5.50	—	—
—	4.98	—	—
—	4.55	—	—
—	4.00	—	—
3.85	3.90	—	3.87
—	3.77	3.67	—
3.5	3.52	3.49	3.64
—	3.43		3.47
3.35	3.33 }	3.29	3.28
—	3.28 }	—	3.24
—	3.16	—	—
*3.10	3.10	*3.08	3.05
*2.9	2.921	*2.90	3.01
2.72	2.739	2.73	2.93
2.58	2.600	2.58	2.90
2.41	2.430	2.47	*2.88
2.3	2.338	2.33	*2.73
—	—	—	2.59
—	2.298	2.28	2.51
—	2.227	—	2.45
—	2.191	2.14	2.31
2.17	2.166	—	2.27
—	2.090	2.09	2.14
1.75	1.752	—	2.12
—	—	—	2.08
1.71	1.716	—	2.00
1.54	1.554	—	1.76
—	—	—	1.74
1.465	—	—	1.70
—	—	—	1.66
—	—	—	1.62
—	—	—	1.55

* = main reflections 1 = Hildebrand (1953)
2 = Neumann and Bergstol

modification. If the magma has a homogeneous composition pectolite will crystallize in the groundmass with a uniform distribution through the rock. These textures are gradational and intermediate variations are observed.

Both these processes result in the crystallization of pectolite at low temperatures as an apparently primary groundmass mineral. During crystallization of the groundmass, Na is concentrated in the residual fluid and therefore pectolite is often confined to pool-like segregations where it is commonly associated with carbonate and serpentine. Also, alteration of included xenoliths by the kimberlite groundmass may result in the presence of pectolite together with other kimberlitic groundmass minerals. Such replacement of xenoliths is commonly observed in other hypabyssal kimberlites and has been referred to as kimberlitization.

Secondly, pectolite may be entirely secondary replacing primary constituents of the rock, particularly groundmass minerals and/or xenolithic material. This reflects an introduction of material or metasomatism of selected parts of the original rock probably close to the time of intrusion. Either kimberlite-related or unrelated fluids may be responsible for this variety of pectolite crystallization. Also, at Wesselton Mine, South Africa, cross-cutting pectolite-bearing veins may also be derived from this type of process. These veins vary from 0.5 m in width down to bifurcating veinlets and are intrusive into both the kimberlite and the country rock. Pectolite is also present within the kimberlite.

Conclusions

The petrographic, geochemical, and X-ray diffraction data presented here shows that pectolite occurs in kimberlites. Much of this data suggests that the mineral investigated here is the same as that discussed by Kruger (1980, 1982).

The occurrence of a Na-bearing mineral in kimberlites is unusual. The mode of occurrence of the pectolite is difficult to interpret but it may have two different parageneses. First, it may occur as an apparently primary crystallization product of a kimberlite magma where the composition has been modified by the partial digestion of, and reaction with, included xenoliths. Secondly, it may occur as a secondary mineral where it replaces the original crystallization products of the kimberlite through some metasomatic event.

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