

## A WHITE CHLORITE FROM COBARGO, N.S.W.

F. C. LOUGHNAN AND G. T. SEE, *New South Wales University of Technology, Kensington, N.S.W., Australia.*

### ABSTRACT

A white chlorite from Cobargo, N.S.W., previously described as pyrophyllite, is shown to be of approximate composition  $Mg_5Al(Si_3Al)O_{10}(OH)_8$ . The chlorite is associated with small amounts of montmorillonite, talc, vermiculite, mica, rutile and pulverized feldspar. The mineral assemblage has resulted from magnesium solutions of hydrothermal origin, acting on a fine to medium grained albitite, a differentiate of the Bega granodiorite.

The Cobargo deposits have been worked sporadically for many years as a source of a white filler clay for the manufacture of rubber and paint. Whitworth (1949), and later Fisher and Canavan, described the deposit, referring to the material as pyrophyllite, though Whitworth suggested that gibbsite may be present in quantity. The suggestion was based on one chemical analysis which showed a high alumina value (53.4%) while the magnesia content was insignificant (1.1%). Material corresponding to this analysis was not encountered in the present survey.

### OCCURRENCE

The deposits, which are located a few miles to the south of Cobargo, occur as relatively small lenticular masses in granodiorite (Brown 1933) and pits have been opened out on three of these lenses, two on Portions 73-80 Ph Narira Co. Dampier, and the third, a disused pit, on Portion 13 of the same Parish. Several small shears parallel the strike of the lenses and thin cross-fibred veins, up to an inch or two in width, follow the fissures. Quartz veins, showing obvious signs of a later shearing movement, are located within the fissures while large masses of unaltered fine to medium grained albitite occur throughout the deposit.

The more westerly pit on Portions 73/80, the only lens being worked at present, has been opened out for a distance of 40 ft. along the strike and to a depth of 20 to 25 ft. while the maximum width reached is 18 ft. The walls appear to be still in clay.

The following samples were obtained from the three pits for analyses.

1. "Run-of-mine" clay from the more westerly pit on Portions 73/80. The clay is white, dense, soapy and unstressed. Comparative reflectance value was 87% of MgO.
- 1A. Same pit as above. Soft powdery clay hand picked from within the shear planes.
- 1B. Same pit as above. Pale greenish material occurring in cross-fibred veins paralleling the fissures.

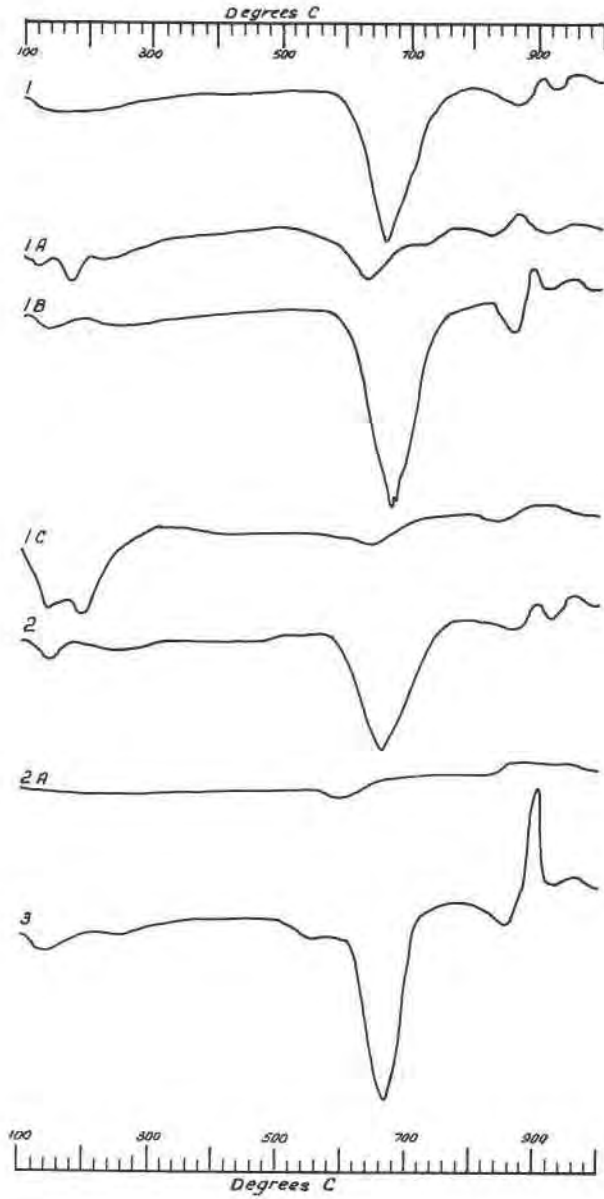


FIG. 1. Differential thermal curves of chlorite and associated minerals from Cobargo, N.S.W.

- 1C. Same pit as above. Small blebs of dark brown and light yellow material obtained from in and about the shear planes.
2. "Run-of-mine" clay from a disused pit located 100 yds. east of pit 1. Shearing is less pronounced. Comparative reflectance value was 85% of MgO.
- 2A. Soft powdery material obtained from small cross fissures in pit 2.
3. "Run-of-mine" clay taken from a disused pit on Portion 13, half a mile north of pits 1 and 2. Comparative reflectance value was 82% of MgO.

#### MINERALOGY

The samples were examined by differential thermal, *x*-ray and chemical techniques.

*Differential Thermal Analysis:* The differential thermal curves (see Fig. 1) for samples 1, 1B, 2 and 3 show the characteristic reactions for chlorite. However the presence of small but definite endothermic reactions in the region of 120° to 180° C. suggests the presence of other minerals, possibly montmorillonite and/or vermiculite. Sample 1A has weak chlorite and montmorillonite and/or vermiculite reactions while sample 1C is that typical of a montmorillonite. The indeterminate graph given by sample 2A indicates the presence of a considerable amount of a non-reactive mineral shown by *x*-ray data to be feldspar.

*X-ray Data:* X-ray analyses were made on untreated clay, glycerol treated clay and on clay preheated to 700° C. for 2 hours. Data are given in Table 1. Samples 1, 1B, 2, 2A and 3 remained unaffected by glycerol treatment, indicating the absence of montmorillonite.

From the *x*-ray data the following conclusions regarding the mineralogy may be made.

1. Chlorite with a little vermiculite.
- 1A. Talc, montmorillonite and chlorite in approximately equal amounts with some feldspar.
- 1B. Chlorite with a little talc and vermiculite.
- 1C. Montmorillonite with a little chlorite.
2. Chlorite with a small amount of vermiculite.
- 2A. Predominantly feldspar but talc is abundant and chlorite present in a small amount.
3. Chlorite with a small amount of mica and vermiculite.

*Chemical Analyses:* Chemical data are given in Table 2. Applying the rational analysis technique described by Brindley and Gillery to sample 1, the chlorite has the composition  $Mg_5Al(Si_3Al)O_{10}(OH)_8$ . The presence of a small amount of vermiculite, approximately 5% in this sample, though not seriously affecting the results, nevertheless renders the composition, as determined, an approximation only.

Fine needles and somewhat coarser stumpy crystals of rutile were present to a small extent in all samples, while zircons, though rare, were noted similarly.

TABLE 1. X-RAY DATA

Sample 1				Sample 1A				Sample 1B				Sample 1C				Sample 2				Sample 2A				Sample 3					
a		c		b		c		a		c		a		b		c		a		c		a		c		a		c	
d	I	d	I	d	I	d	I	d	I	d	I	d	I	d	I	d	I	d	I	d	I	d	I	d	I	d	I	d	I
14.0	9	14.4	10	17.7	8	14.6	10	14.4	10	14.4	10	17.7	10	14.0	10	14.4	10	14.1	1	14.0	10	14.4	10	14.0	10	14.4	10	14.4	10
7.10	10	9.4	2	14.6	4	9.5	7	9.3	10	9.6	2	14.3	1	7.10	10	9.6	2	9.3	7	10.2	1	9.6	2	10.2	1	10.1	1	10.1	1
4.74	10	7.25	4	7.20	3	7.10	10	7.10	10	7.15	1	7.4	1	7.10	1	7.05	10	6.40	3	7.10	10	7.20	2	7.10	10	7.10	10	7.10	10
4.59	1	4.61	4	6.40	1	6.44	1	6.40	1	6.44	1	4.78	3	4.78	1	4.72	10	4.72	10	4.72	1	4.70	2	4.72	1	4.72	1	4.72	1
4.26	1	4.51	4	4.80	2	4.82	1	4.59	1	4.77	4	4.51	6	4.51	6	4.59	8	4.59	1	4.59	1	4.55	2	4.59	1	4.59	1	4.59	1
3.90	1	4.04	1	4.04	2	4.55	4	4.04	3	4.05	1	4.24	1	4.24	1	4.29	1	4.04	6	4.04	6	4.29	1	4.04	6	4.04	6	4.04	6
3.55	10	3.56	6	3.58	4	3.75	2	3.69	1	3.70	2	3.55	1	3.55	1	3.58	3	3.55	10	3.55	10	3.56	4	3.55	10	3.55	10	3.55	10
3.35	1	3.36	2	3.36	1	3.23	3	3.35	1	3.36	2	3.36	1	3.36	1	3.35	2	3.36	2	3.36	2	3.36	1	3.36	2	3.36	2	3.36	2
2.85	4	2.85	8	2.86	1	3.14	4	2.95	1	3.19	5	2.96	1	2.96	1	3.20	1	2.96	1	3.20	10	3.20	10	3.20	10	3.20	10	3.20	10
2.59	1	2.61	1	2.62	1	2.68	1	2.85	4	2.84	4	2.88	1	2.84	4	2.88	1	2.84	4	2.88	1	2.84	4	2.84	4	2.84	4	2.84	4
2.55	5	2.55	2	2.55	1	2.49	6	2.59	2	2.61	1	2.59	2	2.61	1	2.59	2	2.61	1	2.61	1	2.61	1	2.61	1	2.61	1	2.61	1
2.44	3	2.46	6	2.48	2	2.48	2	2.53	5	2.56	1	2.45	1	2.45	1	2.53	6	2.45	1	2.53	6	2.53	6	2.53	6	2.53	6	2.53	6
2.38	1	2.27	2	2.44	1	2.44	2	2.44	1	2.46	6	2.45	1	2.45	1	2.44	4	2.45	1	2.44	4	2.46	6	2.45	1	2.45	1	2.45	1
2.25	1	2.27	2	2.39	1	2.27	3	2.37	1	2.46	6	2.45	1	2.45	1	2.38	2	2.45	1	2.38	2	2.46	6	2.45	1	2.45	1	2.45	1
2.03	1	2.21	2	2.21	2	2.13	1	2.26	1	2.27	3	2.26	1	2.26	1	2.27	2	2.26	1	2.27	2	2.26	3	2.26	2	2.26	2	2.26	2
2.00	4	2.01	2	2.11	2	1.90	2	2.14	1	2.14	1	2.01	1	2.01	1	2.14	1	2.01	1	2.14	1	2.01	2	2.01	2	2.01	2	2.01	2
1.88	1	1.89	2	1.88	1	1.88	2	1.99	3	1.99	1	1.82	1	1.88	2	1.88	2	1.82	1	1.88	2	1.89	2	1.88	2	1.88	2	1.88	2
1.83	1	1.83	1	1.82	1	1.82	1	1.82	1	1.82	1	1.78	1	1.82	1	1.82	1	1.82	1	1.82	1	1.82	2	1.82	2	1.82	2	1.82	2
1.57	2	1.67	1	1.60	1	1.53	1	1.57	3	1.57	3	1.73	1	1.56	1	1.57	1	1.73	1	1.56	1	1.57	1	1.56	1	1.56	1	1.56	1
1.53	4	1.55	5	1.54	3	1.53	1	1.54	4	1.54	4	1.54	1	1.54	1	1.53	3	1.54	1	1.54	1	1.55	6	1.54	1	1.54	1	1.54	1
1.50	1	1.51	2	1.51	2	1.51	2	1.50	1	1.52	3	1.51	1	1.52	3	1.51	1	1.50	1	1.52	3	1.55	6	1.54	3	1.53	6	1.55	4

a—Untreated.  
 b—Glycerol treated.  
 c—Pre-treated 700° C. 2 hours.

TABLE 2. CHEMICAL ANALYSES

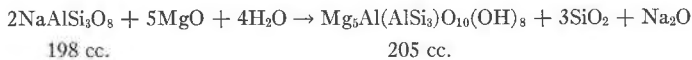
	Albitite*	1	1A	1B	2	3
SiO <sub>2</sub>	62.8	33.0	52.0	33.7	34.1	35.7
Al <sub>2</sub> O <sub>3</sub>	20.5	22.8	18.1	21.0	24.5	28.9
Fe <sub>2</sub> O <sub>3</sub>	0.5	0.2	0.2	0.5	0.3	0.4
TiO <sub>2</sub>	0.6	0.4	0.3	0.4	0.4	0.9
CaO	Tr	0.1	0.4	0.3	0.1	0.1
MgO	4.5	29.7	16.9	28.2	25.9	20.4
Na <sub>2</sub> O	8.2	—	—	—	—	—
H <sub>2</sub> O	2.8	11.9	7.2	12.0	12.7	12.4
H <sub>2</sub> O <sup>-</sup>		0.5	2.8	0.7	1.3	1.2
Total	99.6	98.6	97.9	96.8	99.3	100.0

\* After Whitworth (1949).

#### ORIGIN

As Whitworth (1949) suggested, the parent material for the formation of the mineral assemblage is a fine to medium grained albitite, a differentiate of the Bega granodiorite. A gradation may be seen in thin section from the unaltered rock, which contains sphene and apatite to the extent of one or two per cent in addition to albite, through sections with chlorite filled vugs, to relatively pure chlorite. The partly altered rock shows obvious signs of shearing with granulated albite, coarse and chalcedonic quartz together with wisps of chlorite infilling the fissures. The quartz, unlike the albite, does not display undulous extinction. Skeletal grains of sphene altering to rutile may be seen in thin section also.

As shown by the following reaction,



for the chloritization of the albite, a considerable amount of magnesia and water must enter the system with a corresponding loss of all the soda and half the silica. Magnesium metasomatism at the expense of soda and silica has been recorded frequently elsewhere, the only surprising feature in this instance is the paucity of iron.

The unstressed nature of the quartz infilling the fractures in the partly altered rock suggests that the alteration postdated the fissuring, for the intimate association of quartz and chlorite can leave little doubt that the former is the product of silica released during the chloritization process.

An unusual feature is the occurrence of fine pulverized feldspar along

the shear zones, for it would be expected that if fissuring preceded the alteration, then the fine state of subdivision of the feldspar would have rendered it more reactive and hence more readily convertible to chlorite than the massive rock. There appears to be no simple explanation for this unless it be accepted that the chloritization proceeded in different parts of the mass at different times interspersed with a period or periods of shearing. This would account for the sheared nature of the quartz veins (as distinct from the unstressed quartz in the partly altered rock) for these veins must have intruded early in the alteration process. A further possibility is that these veins also represent silica released by the chloritization process.

## REFERENCES

- BRINDLEY, G. W., AND GILLERY, F. H. (1956) X-Ray Identification of Chlorite. *Am. Mineral.*, **41**, 169-186.
- BRINDLEY, G. W., AND ROBINSON, K. (1951) X-Ray Identification and Crystal Structures of Clay Minerals. Mineralogical Society, London (Clay Minerals group), 173-198.
- BROWN, I. A. (1933) The Geology of the South Coast of N.S.W. with Special Reference to the Origin and Relationships of the Igneous Rocks. *Proc. Linn. Soc. N.S.W.*, **58**, 339-362.
- FISHER, N. H., AND CANAVAN, F. (1950) Talc, Steatite and Pyrophyllite. *Bur. Min. Res. Aust.*, Sum. Rept. **15**.
- MACEWAN, D. M. C. (1944) Glycerol-montmorillonite. *Nature*, **154**, 577.
- WALKER, G. F. (1951) X-Ray Identification and Crystal Structures of Clay Minerals. Mineralogical Society, London (Clay Minerals group), 199-223.
- WHITWORTH, H. F. (1949) The Pyrophyllite Deposits of the Cobargo and Pambula Districts. N.S.W. *Dept. Mines. Ann. Rept.*, 101-102.

*Manuscript received October 9, 1957*