X-ray powder diffraction data for the smithsonite agree well with PDF card S-449, and precession photographs lead to a cell size a 4·630 and c 14·994 Å. The refractive indices, $\epsilon = 1\cdot601$ and $\omega = 1\cdot815$, measured on spindle stage are, as expected, less than those of pure smithsonite.

The coronadite was identified by X-ray powder diffraction, which gave a pattern matching Hewett's data (1971). Under the carbonate coating the coronadite shows mixed brownish black and black layers; they gave identical X-ray powder patterns, but a preliminary electron-microprobe analysis indicates that the brownish black layer is richer in PbO.

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Two hydrous-rich aluminous hornblendes

PREVIOUS studies of aluminous hornblendes rich in alumino-tschermakite,

$$Ca_2Mg_3Al_2^{vi}Si_6Al_2^{iv}O_{22}(OH)_2,$$

have shown that no natural amphiboles are known that closely approach this composition (Leake, 1971). From a careful scrutiny of about 1500 analysed amphiboles with at least Ca 1·00 in the half unit cell and from reanalysis of a number of percipiently selected Al-rich samples, it was shown that the maximum possible Al^{vi} in natural amphiboles increased as Al^{iv} increased and it was suggested that the maximum possible Al^{vi} value in natural hornblendes when the half unit cell contained $Si_6Al_2^{iv}$ was not above 1·40 although the highest reliably determined Al^{vi} value known was only 1·35 (Leake, 1971).

Subsequently Bunch and Okrusch (1973) have described a quite extraordinary iron-poor aluminous amphibole (with 22·6 % Al_2O_3), which has

$$K_{0\cdot16}Na_{0\cdot54}Ca_{1\cdot99}Mg_{3\cdot35}Fe_{0\cdot01}Ti_{0\cdot16}Al_{1\cdot47}^{vi}Si_{5\cdot74}Al_{2\cdot26}^{iv}O_{22\cdot13}(OH,F,Cl)_{1\cdot87}.$$
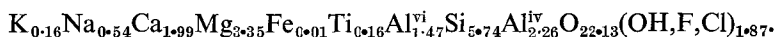
This has just a little less Al^{vi} than the maximum predicted amount ($Al^{vi}_{1\cdot58}$) for an amphibole with $Si_{5\cdot74}Al^{iv}_{2\cdot26}$ and clearly demonstrates partial substitution towards an 'end member' not previously considered, whose composition is

$$(Na,K)Ca_2Mg_3Al^{vi}_2Si_5Al^{iv}_3O_{22}(OH)_2,$$
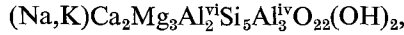
a subsilicic alumino-pargasite. Substitution towards such an end member could partly explain the absence of natural samples approaching alumino-tschermakite.

TABLE I. *Chemical analyses of hydrous-rich aluminous hornblendes*

	CH	Atoms per 24(O,OH)		P41	Atoms per 24(O,OH)	
SiO_2	43·24	Si	6·19 ⎱ 8·00	SiO_2	44·77	Si	6·23 ⎱ 8·00
Al_2O_3	18·06	Al	⎰1·81⎰ 1·24	Al_2O_3	17·16	Al	⎰1·77⎰ 1·05
TiO_2	0·51	Ti	0·05	TiO_2	0·39	Ti	0·04
Fe_2O_3	1·81	Fe^{3+}	0·19	Fe_2O_3	1·23	Fe^{3+}	0·13
FeO	11·20	Fe^{2+}	1·34 ⎱ 5·03	FeO	5·26	Fe^{2+}	0·61 ⎱ 5·19
MnO	0·05	Mn	0·02	MnO	0·13	Mn	0·02
MgO	10·30	Mg	2·19	MgO	16·10	Mg	3·34
CaO	10·10	Ca	1·55	CaO	10·38	Ca	1·55
Na_2O	1·55	Na	0·43 ⎱ 2·07	Na_2O	1·50	Na	0·40 ⎱ 2·02
K_2O	0·49	K	0·09	K_2O	0·37	K	0·07
P_2O_5	0·04			P_2O_5	0·06		
H_2O^+	2·72	OH	2·60	H_2O^+	2·80	OH	2·60
H_2O^-	0·00	O	21·40	H_2O^-	0·00	O	21·40
	100·07				100·15		

CH   Alumino-tschermakite from an amphibole–garnet porphyroblast (5–10 mm) schist with staurolite, kyanite, green-brown biotite, late poikiloblastic oligoclase, quartz, late minor chlorite, zoisite, and calcite. Frodalera, Lukmanier, Ticino, Switzerland. *A* site occupancy, assuming the *C* group excess is transferred into *B*, is 0·10. Calculated on 23(O) similar *A* site occupancy is 0·29.

P41   Alumino-tschermakite from a colourless hornblende with chlorite and surrounding corundum crystals. Timurgara, Dir, Pakistan (Jan *et al.*, 1971). *A* site occupancy, assuming the *C* group excess is transferred into *B*, is 0·21. Calculated on 23(O) similar *A* site occupancy is 0·40.

Petrologically the significance of high Al^{vi} is now well known as an indicator of high-pressure conditions.

In the continued search for high Al^{vi} calcic amphiboles, we have discovered two samples both rich in OH that approach Si_6 with Al^{vi} in excess of 1·0 and have very low occupancy of the vacant (or '*A*') site, a situation very rare in natural amphiboles. One of these samples (CH) comes from the Lukmanier region of the Alps, kindly donated by Dr. B. Chadwick. This contains abundant porphyroblasts of hornblende, garnet, and plagioclase with much staurolite and kyanite, and is clearly both highly aluminous and crystallized in a high-pressure environment. The analysis of CH (Table I) shows a high Al_2O_3 % and gives $Al^{vi}_{1\cdot24}$, which is only a little below the postulated maximum (Leake, 1971) of $Al^{vi}_{1\cdot32}$ for an amphibole with $Si_{6\cdot19}Al^{iv}_{1\cdot81}$. Most interesting is the very low occupancy of the *A* site in the general amphibole formula of

$A_{0-1}B_2C_5(Si,Al)_8O_{22}(OH)_2$, a feature to be expected in pure alumino-tschermakite and rarely found naturally. Two out of the three available published analyses with Si $< 6\cdot25$, $Al^{vi} > 1\cdot00$ and $(Na+K)_A < 0\cdot25$ have been given by Steiger (1961) and come from this same district, one also occurring with staurolite, kyanite, and garnet. The third analysis is of an amphibole formed by reaction between garnet and pyroxene in an eclogite from east Greenland (Sahlstein, 1935). These analyses all come from high-pressure environments and approach pure alumino-tschermakite as regards the low occupancy of the vacant space but are still a long way from having the $Al^{vi}_{2\cdot00}$ of pure alumino-tschermakite.

The other aluminous amphibole investigated forms amphibole-rich envelopes around corundum crystals that are partly altered to margarite in a hornblendite from Timurgara, Dir, Pakistan (Jan et al., 1971). This was kindly supplied by Dr. D. R. C. Kempe. Originally (Jan et al., 1971) this amphibole was described as tremolite, based on its colourless nature, but this seemed unlikely in association with corundum, especially as the nearby banded gneisses contain rutile, a mineral often found in rocks crystallized under high pressure. The analysis (P41; Table I) shows the amphibole to be an alumino-tschermakite with $Si_{6\cdot23}Al^{iv}_{1\cdot77}Al^{vi}_{1\cdot05}$, being similar to several other amphiboles that are in association with corundum and, like them, is rich in Al^{vi} but is neither very near to the maximum possible Al^{vi} of about $1\cdot29$, nor is the vacant site 'A' more than slightly filled.

Both these analyses have their low $(Na+K)_A$ occupancy mainly because of their extremely high (OH) value but also to a small extent because of the rather low Ca. The water analyses have been carried out at $1350\ ^{\circ}C$ and both analyses have been carefully verified, the duplicates agreeing within $0\cdot10\ \%\ H_2O$. The position of excess water above the usual $(OH)_2$ groups per half unit cell in amphiboles has not yet been satisfactorily demonstrated; suggestions range from occupancy of the A site by H_3O^+ to minor replacement of some of the O^{2-} ions of the Si_4O_{11} chains by OH^- ions (Deer et al., 1963). Wherever the extra water is located, it enables the replacement of Si by Al^{iv} to proceed without the charge balance having to be entirely satisfied by Al^{vi}, Fe^3, Ti, and $(Na+K)_A$ substitution and re-emphasizes the extra flexibility in substitutions in amphiboles, which calculation of the cell contents on the basis of $23(O)$ does not allow. If the present amphiboles are calculated to $23(O)$ then their A site occupancy leaps from $0\cdot10$ to $0\cdot29$ and from $0\cdot21$ to $0\cdot40$, very significantly higher. These differences in samples with reliably determined H_2O^+ support the conclusions of Borg (1967) that the $23(O)$ basis of amphibole calculation is not necessarily more appropriate than the $24(O,OH,F)$ basis and points to the necessity of accurate H_2O^+ determinations.

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An occurrence of cymrite in black shale, north-west Nelson, South Island, New Zealand

CYMRITE, $BaAlSi_3O_8(OH)$, a rare barium tectosilicate, was first reported by Smith *et al.* (1949) as colourless crystals associated with a manganese ore body at the Benallt Mine, Caernarvonshire, Wales. Later, Brosgé (1960) recorded it in samples from a pyritized zone in the south-central Brooks Range, Alaska. A further occurrence of cymrite from the Brooks Range, Alaska, was reported by Runnells (1964) from a copper-bearing deposit.

During the course of our investigation of black shales and cherts from an area near Aorangi gold mine, north-west Nelson, South Island, cymrite was identified by X-ray diffraction and optical examination from specimens collected in Waterfall Creek (40° 42′ 57″ S., 172° 26′ 15″ E.). We believe this is the first report of cymrite in New Zealand. Furthermore, we have noted that there appears to be a close similarity in the mode of occurrence of the Aorangi Mine cymrite to that described by Brosgé (1960). The mineral is confined to a pale-coloured band, about 5 mm thick, which is concordant with the bedding. The band contains a narrow layer rich in pyrite, together with quartz, illite, calcite, and mica, and occurs within a condensed graptolite-bearing sequence of black shale and chert mapped as Aorangi Mine Formation (Bishop, 1968), ranging in age from Tremadocian to Upper Arenigian (Lower Ordovician). A full description of the geology of the Aorangi Mine area is in preparation by R. A. Cooper (N.Z. Geological Survey).

Dr. G. A. Challis, Petrology Section, N.Z. Geological Survey, has kindly examined optically the thin sections of the specimens. The largest grain observed is 0·15 mm across, but most of the cymrite crystals are considerably smaller. The grains show the characteristic close-spaced basal cleavage reported and figured by Smith *et al.* (1949). Refractive index measurements gave ϵ 1·616 and ω 1·622 (both ±0·002). However,