Electron microprobe analysis. Chemical analyses were done on a Jeol JXA-3 instrument, with a beam diameter of about 10 μm, generated by an accelerating voltage of 20 kV and giving a specimen current of 0·1 μA. Two point analyses in each crystal flake for each element were averaged to give one result. The standards used were pure elements, periclase, and topaz, and the data corrected for atomic number, mass absorption, and secondary fluorescence effects. The results are listed in Table II, as well as the calculated formula based on 36 (O, OH). The $Fe^{2+}:Fe^{3+}$ ratio of 1:1·6 was determined by chemical analysis of a purified sample.

Conclusions. The nickel-bearing component at Woodline Well, Western Australia, is a nickel-bearing aluminium serpentine (septechlorite) containing 11·5 wt % Ni (14·6 wt % NiO). Little variation in composition occurs between grains, or across individual grains. The calculated formula (Table II) assumes the remaining component to be water.

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Existence of 3T muscovite in low-grade metamorphic rocks of the Sanbagawa metamorphic belt, Japan

THE presence of muscovite with a wide range of $2V_\alpha$ has been reported from a few metamorphic terrains (Spry, 1963; Ansilevsky, 1966; Mimuro, 1971). It was found that muscovites in pelitic and basic schists of the Sanbagawa metamorphic belt in Japan also show various $2V_\alpha$ values in different grains in the same hand-specimen, or sometimes in different portions of single muscovite flakes (Mimuro, 1971). We have carefully examined a muscovite flake with $2V_\alpha \approx 2°$ and concluded that it is a

3T polytype as will be described below. This is the first confirmation of 3T muscovite from metamorphic rock, although a report without single crystal data has been published (Velde, 1970). As muscovite with small $2V_\alpha$ is widespread and abundant in the Sanbagawa metamorphic rocks, it follows that 3T muscovite is rather common there and probably in many other low-grade metamorphic rocks.

The host rock of the muscovite studied is a pelitic schist from the Bessi area, Sikoku, Japan, which has the mineral assemblage: carbonaceous matter+garnet+chlorite+muscovite+albite+quartz, along with accessories, and belongs to the albite–epidote amphibolite facies (Banno, 1964). Chemical composition was determined by an electron-probe microanalyser: SiO_2 51·2, Al_2O_3 27·5, total Fe as FeO 2·2, MgO 2·1, Na_2O 0·3, K_2O 10·3, H_2O n.d., total 93·6 %. Although the grain used for single crystal work was not analysed, the compositions of muscovites in this specimen are rather uniform regardless of their $2V_\alpha$ values, and hence the above analysis can be applied to the crystal to be discussed below.

Sadanaga and Takéuchi (1961) have derived the possible types of polysynthetic twins in micas and discussed their bearing on the identification of mica polytypes by means of X-ray diffraction. Polysynthetic twinning of 1M mica on a [310] axis, with composition plane (001), gives an X-ray diffraction pattern similar to that from 3T mica. Therefore, attention was directed towards finding the criteria to distinguish 3T from twinned 1M muscovite.

The oscillation photographs (Cr-$K\alpha$) around the c-axis show little diffuseness, but the reflections spread out into Debye-Scherer lines, thereby suggesting mechanical distortion of the crystal. Three single crystals were examined but all of them showed this feature. Considering that this mechanical distortion could not be avoided since we were dealing with flakes from regionally metamorphosed schists, we continued our experiments on the least distorted muscovite grain.

Precession photographs (Mo-$K\alpha$) were taken at various orientations. A set of precession photographs ($h0l$, $0kl$, and $\bar{h}hl$) taken at every 60° around the c-axis show the same diffraction pattern with plane point group $2mm$. Furthermore, three photographs of hhl, $2\bar{h}.h.l$, and $h.2\bar{h}.l$, taken at every 120° show the same pattern with plane point group 2. It follows that the crystal is trigonal. The c-axis zero-level precession photograph exhibits plane point group $6mm$, whereas the upper level photographs (1st and 2nd) show plane point group $3m$. Thus, the diffraction symmetry is $\bar{3}m$. The two-fold axis is normal to the a-axis (5·2 Å). The reciprocal lattice rows that are composed of reflections with $h-k = 0 \pmod 3$ contain weak but clear reflections corresponding to a c repeat of 30 Å, and systematic absences are observed only in the $00l$ reflections with $l = 3n$. Thus, the possible space groups are $P3_112$ or $P3_212$.

If 1M mica twins spirally with $\omega = 120°$, only reflections corresponding to a 10 Å repeat should appear in the reciprocal lattice rows along c^* with the condition $(h-k)_{3T} = 0 \pmod 3$ (see Sadanaga and Takéuchi, 1961). In the case of octophyllite micas, the diffraction pattern of the 3T structure is identical with that of the twinned 1M as far as the mode of appearance of diffraction spots is concerned, and they are only distinguishable by the intensity distribution along particular reciprocal lattice rows. In the case of heptaphyllite micas, however, the 3T structure is distinguishable from twinning by the appearance of the reflections corresponding to a 30 Å repeat in the rows along c^*, with the condition $h-k = 0$ (mod 3). Muscovite with the 3T structure from Sultan Basin, Washington, which is the only confirmed case (Güven and Burnham, 1967), gives such reflections in the rows with the condition $h-k = 0$ (mod 3). This is a powerful criterion, distinguishing 3T muscovite from spirally twinned ($\omega = 120°$) 1M muscovite. Such reflections are also observed for the present muscovite and the possibility of twinned 1M muscovite is therefore excluded.

Confirmation of the 3T structure is also provided by careful study of intensity distributions. In Table I, the observed intensities of the $10l$ row of the present 3T

TABLE I. *Comparison of intensity distribution along the* $(10l)_{3T}$ *row of the 3T muscovite in pelitic schist (No. 29) with that observed and calculated for the 3T muscovite from Sultan Basin, Washington, and with the corresponding set for the twinned 1M muscovite calculated by Güven and Burnham (1967)*

Twin composite Güven and Burnham, 1967		Observed this study	3T polytype Güven and Burnham, 1967			Twin composite Güven and Burnham, 1967		Observed this study	3T polytype Güven and Burnham, 1967		
hkl	$\|F_c\|^2$	F_0^2	F_0^2	$\|F_c\|^2$	*hkl*	*hkl*	$\|F_c\|^2$	F_0^2	F_0^2	$\|F_c\|^2$	*hkl*
(020)A	176	160	77	104	100	(022)A	503	480	410	689	106
$(1\bar{1}0)$B	66	270	230	204	101	$(1\bar{1}2)$B	446	446	406	360	107
$(\bar{1}\bar{1}1)$C	25	51	20	45	102	$(\bar{1}\bar{1}3)$C	509	582	721	563	108
(021)A	23	63	63	47	103	(023)A	193	138	144	217	109
$(1\bar{1}1)$B	138	270	221	220	104	$(1\bar{1}3)$B	261	89	120	127	1.0.10
$(\bar{1}\bar{1}2)$C	349	289	212	290	105						

muscovite are compared with the values observed and calculated for the 3T polytype from Sultan Basin, and corresponding ones of the twin composite by Güven and Burnham (1967). The intensities, corrected for *Lp* factors and scaled to the values calculated by them, are in better agreement with those observed for 3T from Sultan Basin than those calculated for possible twinned 1M.

The crystallographic and optical data of the crystal may be compared with those of 3T muscovite from Sultan Basin, Washington, as described by Güven and Burnham (1967):

Sanbagawa	a 5·24 Å	c 30·1 Å	$2V_\gamma$ ca 2°	γ 1·599±0·002	$P3_112$ or $P3_212$
Sultan Basin	5·1963	29·9705	—	1·592±0·002	$P3_112$ or $P3_212$

The slight differences in refractive indices and cell dimensions between them may be ascribed to the chemical difference: the muscovite we studied is more phengitic than the Sultan Basin specimen (Deer, Howie, and Zussman, 1962, p. 16).

Muscovite with $2V_\alpha \approx 40°$ was also examined and found to be $2M_1$ polytype. The details of petrological and mineralogical discussion will appear elsewhere.

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Epidote minerals in ophiolites near Coolac, N.S.W., Australia

OCCURRENCES of epidote minerals, and particularly of orthorhombic members of the group, are reported below from the Mooney Mooney Range, near Coolac, south-eastern N.S.W. At this locality an incomplete sub-vertical ophiolite sequence lies between granodiorite and a volcanic-sedimentary series, both of Silurian age (fig. 1). Keratophyres pass down into unaltered basalts admixed with metabasalts containing greenschist facies assemblages. Serpentinite is associated. The underlying augite- and hornblende-gabbros are variably albitized, uralitized, chloritized, saussuritized, and epidotized, in places associated with foliated amphibolite containing plagioclase and hornblende, and in the north are separated from subjacent harzburgite by clino-pyroxenite (Golding, 1969). Harzburgite partly altered to antigorite, talc, and carbonates in the north appears to override higher-level members of the sequence, which occur as thin septa or inclusions within lizardite–chrysotile serpentinite to the south (Golding, 1971).

Epidote minerals. Green pleochroic epidote is restricted to some quartz keratophyres and highest-level metabasalts of the sequence. Colourless clinozoisite is the characteristic epidote mineral of the underlying metabasites and associated epidosite veins but is notably heterogeneous. It forms polygonal granular masses and radiating prismatic groups. The grains, up to 0·5 mm wide, show lamellar twins, common patchy zoning, less common regular zoning, and polarization colours with the frequency: anomalous blue > anomalous brown > anomalous greenish yellow > normal. Diffractograms of vein material (Samples 3 and 5, fig. 1) indicate clinozoisite ± subordinate orthorhombic epidote minerals, but the latter occur to the exclusion of