their diamond plating on the blade and reported a very little diamond wear and slight smearing of the plating metal.

A trial on a specimen of granite gneiss was equally successful and the cutting rate was three times faster by either area or depth of cut.

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Spectroscopic evidence for the siting of lithium ions in a riebeckite

IN an infra-red study of the hydroxyl bands of some clino-amphiboles Burns and Strens (1966) reported that iron-free tremolite shows a single sharp peak in the hydroxyl-stretching region. Since the hydroxyl group in the amphibole structure is co-ordinated to three cations (M_1, M_2, M_3) (Whittaker 1960), to form a pseudo-trigonal pyramid, the substitution of Mg^{2+} by a second cation causes a maximum of four bands to be observed. The positions of these bands depend upon the electronegativity of the substituting ion. The relative intensities of these bands have been used to give information about the extent of any cation ordering within the M_1 and M_3 sites (Strens, 1966).

A similar study of the hydroxyl stretching region for members of the riebeckite series, $Na_2Fe_2^{3+}(Fe^{2+},Mg)_3Si_8O_{22}(OH)_2$, showing varying substitution in the M_1 and M_3 sites has been carried out. The fundamental O–H stretching vibration was recorded on a Perkin-Elmer model 521 spectrophotometer in the region 3600 to 3700 cm^{-1}, the KBr disc method being employed. The spectra were obtained at room temperature and are shown in fig. 1. The positions of the bands are shown in table I together with the content of the sites M_1 and M_3 as calculated from the analytical data. It has been assumed that the M_4 sites are occupied by sodium ions and M_2 by iron (III) ions in accordance with the suggestions of Ghose (1965).

The results obtained show that the band *A* at 3620–3624 cm^{-1} is common to all the specimens investigated. This is attributed to the hydroxyl group co-ordinated to (Fe Fe Fe) and the higher frequency bands *B, C, D* are caused by progressive replacement of Fe^{2+} by the less electronegative Mg^{2+}.

The *B** band of the New Hampshire riebeckite, fig. 1 (i), cannot, how-

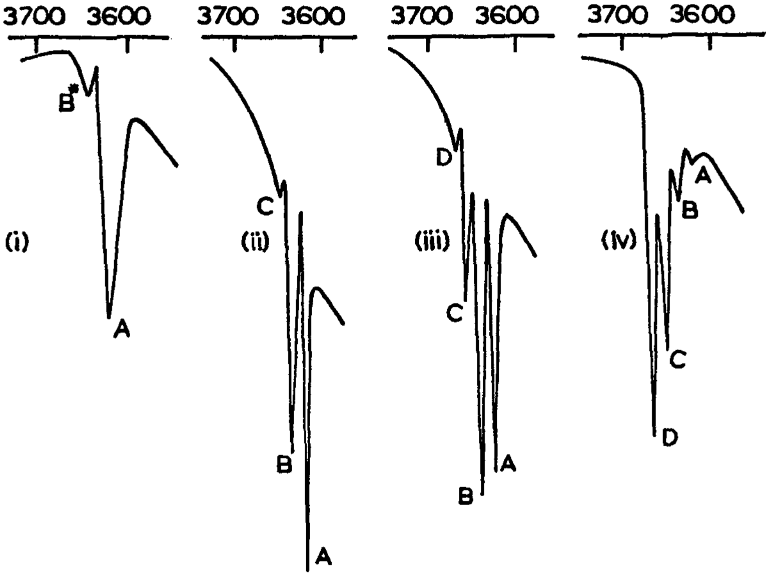

Fig. 1. The fundamental O–H stretching band in some riebeckites (for source of samples, see table I).

Table I

Specimen	Cation content of M_2 and M_3 sites		O–H stretching band A	B	C	D
(i) Riebeckite from New Hampshire, U.S.A.	Fe 2·40 Li 0·23	Mg 0·00	3621	3646	—	—
(ii) Crocidolite from Koegas, South Africa	Fe 2·65	Mg 0·37	3620	3636	3651	—
(iii) Crocidolite from Wittenoom, W. Australia	Fe 1·90	Mg 1·00	3624	3640	3653	3668
(iv) Crocidolite from Cochabamba, Bolivia	Fe 0·58	Mg 2·62	3621	3636	3652	3666

ever, be attributed to this substitution since analysis showed magnesium to be absent. The band is therefore attributed to the substitution of some Fe^{2+} by Li^{+}. This band is at a higher frequency than the other *B* bands and this is a consequence of the lower electronegativity of lithium (0·97) compared to magnesium (1·23) and iron (1·64) (Allred and Rochow, 1958). The lithium ions in riebeckite are therefore seen to substitute for similarly sized iron (II) ions in M_1 and M_3 sites rather than to replace the similarly charged sodium ions in M_4.

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Optical properties and composition in the orthopyroxene series

THE general relationship between optical properties and composition in the orthopyroxene series has been well established for some years. Deer *et al.* (1963) have given a recent summary of the previous work and presented new diagrams relating refractive indices, birefringence, and optic axial angle with $mg = Mg^{2+}/(Mg^{2+}+Fe^{3+}+Fe^{2+}+Mn^{2+})$ for 37 selected orthopyroxenes. The refractive indices, specific gravity, and cell sizes of natural En_0Fs_{100}, $En_{50}Fs_{50}$ and $En_{100}Fs_0$ have been calculated by regression both for pure, Al and Ca-free compositions and for compositions including added Al and added Al with Ca (Winchell and Leake, 1965) using over 200 analysed orthopyroxenes.

None of the previous diagrams relating composition and optical properties have used more than a small selection of the available data and many do not give the data upon which the correlations are based (e.g. Poldervaart, 1950). It is difficult, therefore, to ascertain the accuracy with which *mg* can be estimated from optical properties. Accordingly the relationship between refractive indices and *mg* was computed for 240 orthopyroxene analyses by reduced major axis regression, using a programme written by P. Harvey.

The results, which are plotted in fig. 1, were $mg = 15{\cdot}315-8{\cdot}661\alpha$ with a standard error of $0{\cdot}07mg$ and $mg = 14{\cdot}082-7{\cdot}870\gamma$ with a standard error of $0{\cdot}05mg$. These lines agree very well with those given by Deer *et al.* (1963). The standard error $= \sqrt{\Sigma(mg-mg_c)^2/(n-1)}$ in which *mg* is the chemically determined *mg*; mg_c is the calculated *mg* from the refractive index and *n* is the number of samples.

A manually drawn line on a plot of optic axial angle against *mg* (fig. 2) is similar to that given by previous workers including Deer *et al.* (1963) except that the inflection is less acute with the lowest $2V_\alpha$ being 52·5° compared with 48·5°. It is, however, significant that the 19 volcanic orthopyroxenes plotted show no consistent difference of 2V