SHORT COMMUNICATIONS

MINERALOGICAL MAGAZINE, DECEMBER 1987, VOL. 51, PP. 733-5

Discovery of scapolite in the Bishunpur (LL3) chondritic meteorite

DURING a study of unequilibrated ordinary chondrites, a granular textured clast was found in a thick polished section of Bishunpur (off specimen no. BM 80339) (Fig. 1A). The clast is free from chondrules, is a few millimetres across, sub-rounded to angular in outline, and is partly rimmed by very fine-grained material. Such fine-grained, opaque material typically occurs as rims around chondrules and clasts in this meteorite and its relatives (e.g. Allen *et al*., 1980; Huss *et al*., 1981). The granular texture of the clast is unusual in unequilibrated ordinary chondrites and testifies to a more prolonged period of crystallization ('metamorphism'?) than the other components of the meteorite.

The clast is dominantly composed of intergrown olivine (Fo_{81}), Ca-poor pyroxene (En_{83}), sulphide and metal with a grain-size of 10–50 μm. In addition, some randomly distributed oval areas up to about 100 μm long contain a mineral of low reflectivity and low mean atomic number (Fig. 1, A and B) and high Al and Cl abundances. Fig. 1 (Cl and Al) indicates that these elements are positively correlated in the low atomic number mineral, which occurs as anhedral grains, up to 10 μm across, intergrown with the neighbouring silicates. Microprobe analysis, Table 1, shows the mineral to have the composition of a scapolite with 83 mol. % of the Na end-member, marialite. An attempt was then made to identify the mineral *in situ* by an X-ray diffraction technique.

One of us (HY) mounted the section on a microdiffractometer manufactured by the Rigaku Denki Company. A 30 μm collimator was used in obtaining diffractograms of two adjacent areas, one 'scapolite'-rich (Fig. 1B), the other, lacking the low atomic number phase, was used as a background. Of 84 lines obtained from the 'scapolite'-bearing area, nine are absent from the background. Because of the large size of the section, three-axis oscillation could not be used, so the relative intensities of the lines may not be standard if the grains have a preferred orientation. The extra peaks in the diffraction pattern that are absent from the background do not correspond particularly closely with the limited JCPDS Powder Data File (cards 2-0412 and 31-1279) for marialite-rich members of the scapolite group. This is likely to be due to chemical variations. Therefore no close comparison was found with data for chemically authenticated material in the JCPDS file. However, a close match to the nine lines of the 'scapolite' in Bishunpur was obtained with a previously unpublished diffraction pattern from a dark blue gem scapolite of unknown composition from Burma. New material for microprobe analysis was not available, but an energy dispersive microprobe technique was applied to the original X-ray mount. The analysis obtained has a total of only 43.1% because the mount contains rubber gum of low atomic number and because the sample surface was unpolished. Therefore the analysis is considered to be only semi-quantitative. However, the structural formula of the Burmese gem (Table 1, no. 2) is consistent with its being scapolite with 73% of the marialite end-member. Clearly, both chemically and structurally, the mineral in Bishunpur closely resembles the Burmese scapolite (Table 1). We conclude that a scapolite, close in composition to end-member marialite, is present in the granular clast in Bishunpur.

To our knowledge, no member of the scapolite group is known from a meteorite, although Gooding (1985*a*, *b*) suggested that it might occur in some unequilibrated ordinary chondrites. The texture of the clast in Bishunpur indicates that the rock crystallized before it became incorporated in its chondritic host. Crystallization was presumably accompanied by chlorine metasomatism and the formation of the scapolite. However, the absence of scapolite elsewhere in the meteorite does not prove that the metasomatism predated accretion.

Chlorapatite is a common accessory mineral in the ordinary chondrites (Fuchs, 1969; Murrell and Burnett, 1983). With the phosphate, merrillite, it is often associated with metal and sulphide, and interpreted as having resulted, during cooling, from the expulsion of P from the metal, followed by

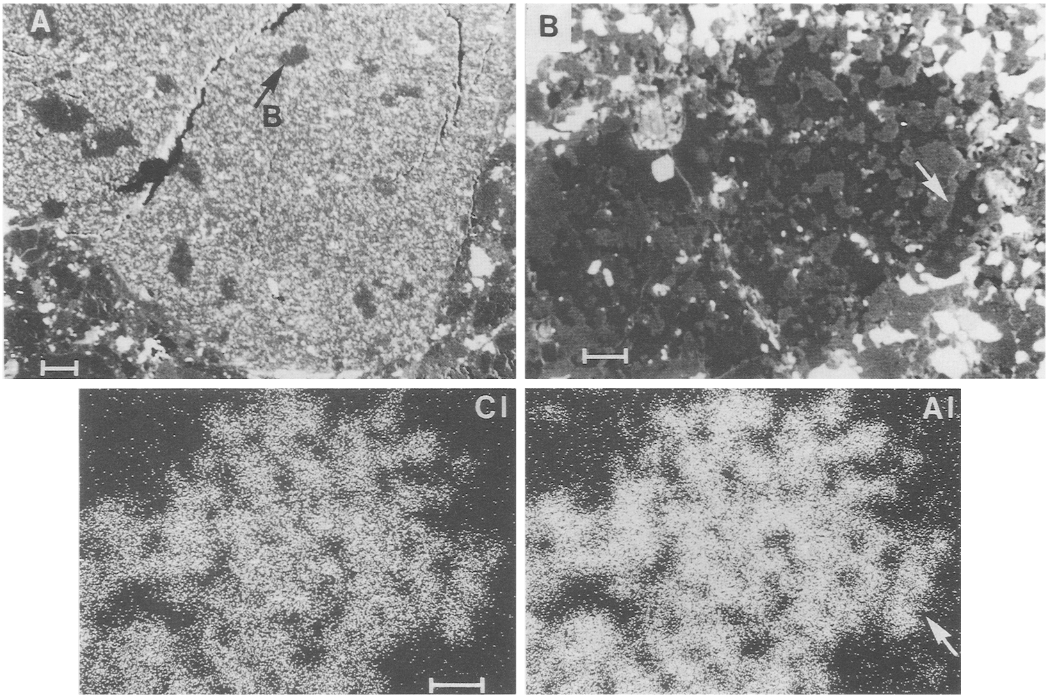

FIG. 1A and B. Back-scattered electron images of clast in the Bishunpur chondrite. FIG. 1A, scale bar 100 μm. Note the fine-grained granular texture with dark areas indicative of a low mean atomic number, that arrowed, 'B', appears in FIG. 1B, scale bar 10 μm. Mid-grey, olivine or pyroxene, dark grey, scapolite. FIG. 1Cl and Al, X-ray distribution maps of Cl and Al respectively. Scale bar 10 μm. Note that the scale differs slightly from Fig. 1B. The white arrow in Fig. 1B indicates the same area of scapolite, with high Al, arrowed in the X-ray map. Clearly, the low atomic number areas correlate with high Al and Cl.

TABLE 1. Electron probe analyses and X-ray powder pattern for scapolite

	1a		1b		2		1c dÅ	1c I/Io	2c dÅ	2c I/Io
SiO_2	59.0	Si	8.54	12.00	8.46	11.96				
Al_2O_3	20.3	Al	3.46		3.50					
FeO	3.22	Fe	0.39		0.01		3.568	60	3.55	50
									3.456	100
MgO	0.40	Mg	0.09		0.00		3.056	100	3.057	90
CaO	3.05	Ca	0.47	4.18	0.76	3.86			3.006	70
									2.834	50
Na_2O	11.0	Na	3.08		2.82		2.732	60	2.720	40
K_2O	0.81	K	0.15		0.24		2.685	70	2.686	80
									2.358	30
Cl	3.67	Cl	0.90		0.92		2.300	85	2.298	50
Sum	101.45						2.191	70	2.194	30
									2.140	50
Less O≡Cl	0.83						2.005	85	2.011	40
Total	100.62						1.902	80	1.907	80

Notes:

1a. Wavelength dispersive microprobe analysis of scapolite, area in Fig. 1B, accelerating voltage 20 kV, electron beam $2.5.10^{-8}$ Amp. Analyst, R. Hutchison.

1b. Structural formula, scapolite, no. 1, with (Si + Al) = 12.00 atoms.

2. Structural formula, gem scapolite from Burma (BM 1973,375) from semi-quantitative energy dispersive microprobe analysis. Analyst, R. Hutchison.

1c. d-spacings (Å) and relative intensitites corresponding to eight of nine lines present in the diffractogram of area B, but absent in the background.

2c. d-spacings from powder diffraction photograph [no.2351F, in the Mineralogy Department, British Museum (Natural History)], no. 2. The strongest peak at 3.456 Å coincides with a weak peak from magnesian olivine and is present with moderate intensity in both 'scapolite' and background diffractograms, so is omitted from no. 1c.

oxidation and reaction with Ca and Cl (Rubin and Grossman, 1985). Thus, most ordinary chondrites may be viewed as having undergone a form of chlorine metasomatism.

If, on accretion, the clast contained crystalline plagioclase of the composition typical of the ordinary chondrites ($Ab_{82}An_{12}Or_6$; Van Schmus and Ribbe, 1968), but no P, scapolite locally could have formed in preference to chlorapatite as the product of post-accretion chlorine metasomatism. Certainly one small area of the clast appears to comprise intergrown diopside and plagioclase, $Ab_{85}An_{15}$, with no detectable P.

Acknowledgements. We thank Mr J. G. Francis of the Mineralogy Department, British Museum (Natural History), for his assistance in the X-ray identification and for allowing us to publish his data (Table 1, no. 2c). We thank also Dr G. C. Cressey for discussion.

KEYWORDS: scapolite, meteorite, chondrite, Bishunpur.

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[*Manuscript received 6 April 1987; revised 1 June 1987*]

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MINERALOGICAL MAGAZINE, DECEMBER 1987, VOL. 51, PP. 735–8

Metasomatic phenomena adjacent to a granite pegmatite, Garry-a-siar, Benbecula, Outer Hebrides

REGIONAL metasomatism associated with Proterozoic deformation and amphibolite facies retrogression is a major feature of the Lewisian gneiss complex in northwest Britain (Drury, 1974; Beach and Tarney, 1978). The Garry-a-siar headland on the western coast of Benbecula provides some of the best exposures of Lewisian rocks in the southern Outer Hebrides (Dearnley and Dunning, 1968; Coward, 1973). It is an area of relatively low Early-Proterozoic Laxfordian deformation where discordant relationships are preserved between pre-Laxfordian basic dykes (Scourie dykes) and older 'Scourian' grey gneisses. Late Laxfordian granite pegmatites which are probably equivalent to post-tectonic intrusions elsewhere cut both dykes and gneisses. The purpose of this contribution is to describe some remarkable metasomatic phenomena which are intimately associated with one of these pegmatites.

The pegmatites at Garry-a-siar consist of megagraphic intergrowths of quartz and potassium feldspar with biotite and several accessory minerals including magnetite and columbite (Coward, 1973). A complex irregular pegmatite near grid reference NF756533 contains concentrations of magnetite crystals up to 2 cm in diameter near its margins. Similar magnetite crystals with distinctive quartz–plagioclase coronae locally occur *outside* the pegmatite, near its contact with an amphibolite dyke (Fig. 1a, b). The external magnetite crystals have