COORARA AND COOLAMON METEORITES: RINGWOODITE AND MINERALOGICAL DIFFERENCES.

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The presence of ringwoodite and majorite in certain shocked L6 chondrites (Tenham, 1,2; Coorara, 3; Catherwood, 4) is important (a) in relation to laboratory static (5,6) and shock (7) experiments on olivine and pyroxene, and (b) as a potential measure of high-pressure events (2) in meteorite history. We follow up the earlier reconnaissance of Coorara (which was limited by hand operation of an electron microprobe) with new electron microprobe analyses, and compare results with new data for Coolamon meteorite (8) whose similarity was pointed out by Brian Mason to whom we are also indebted for thin section NMNH-5733. Table 1 summarizes general mineralogy.

Ringwoodite [$(Mg,Fe)_2SiO_4$:spinel structure] occurs in thin ($<$1mm), dark, irregular veins traversing the L6 chondritic body of all four meteorites. Existing data (1,2,3,4) indicate a composition similar to that of olivine, but Binns (2) recorded a variation of cell dimension for ringwoodite grains with the same electron microprobe analysis. Fig. 1 and Table 2 show that the olivines in the Coorara and Coolamon meteorites have major elements indistinguishable within experimental error, and similar minor elements except for a gross difference in NiO (0.68 vs. 0.03 wt.%) and perhaps a minor difference in MnO (Fig. 2). The high NiO content (0.68%) of Coolamon olivine is high for a chondrite, whereas the value for Coorara olivine is suitably small (0.03) Dodd (9) measured $<$0.01-0.1 for olivines in H3 Sharps chondrite, and related the low values to reduced state and occurrence of Ni in metal phase. Taenite could not be found in Coorara meteorite, whereas tiny amounts occur in Coolamon. Cr analyses in the olivines match the lowest values found in Sharps (9). The ringwoodite grains of Coolamon are mostly richer in Fe than corresponding olivines (Fig. 1) and have much lower MnO (Fig. 2). Data for Coorara ringwoodite indicate a similar Mg/Fe ratio to the olivine, and the MnO content of the ringwoodite (0-0.4) reaches up to the olivine values (0.3-0.4). Other important differences between Coorara and Coolamon meteorites are (a) Coorara has a Cl-rich apatite, whereas Coolamon has a Cl-poor apatite which contains substantial Na and Mg, (b) Coorara chromite has higher TiO_2 ($\sim$5%) than Coolamon ($\sim$2%). These preliminary observations demonstrate that there are significant differences between the ringwoodite-containing chondrites, and that detailed comparison of all four meteorites is needed: specifically the Ni distribution needs careful study.

The black veins containing ringwoodite and majorite have many features common between the four meteorites: (a) tiny troilite•Ni,Fe beads are dispersed throughout the vein, but always with the largest ones at the center, and with no indication of deformation; (b) large silicate grains do not match across the veins indicating relative movement across the veins of at least 0.5mm; (c) all minerals in the main body occur as isolated, subround or recrystallized grains in the matrix; (d) olivine grains within and adjacent to the veins have various shades of purple indicative of ringwoodite, and individual grains are often olivine-ringwoodite composites. Ringwoodite in Coolamon and Tenham is pale purple in contrast to deep purple to black in Coorara. The cause of the color is unknown, and speculation that it derives

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from Mn^{3+} would require consideration of redox conditions and mechanisms for Mn migration (is sulfide involved?).

Details of Coolamon chondrite follow. It is inhomogeneous but a rough mode matches that for Catherwood (55% ol 25% low-Ca px 7% pl). Minerals are homogeneous. Three conspicuous areas stand out within an equigranular matrix: (a) a round body (chondrite) of ol-opx-cpx-chromite with vague boundaries, (b) a maskelynite area with large grains of low-Ca px, kamacite, and chromite, all almost equally abundant, (c) another plagioclase-rich area but with chromite, apatite and low-Ca pyroxene. These three areas do not have sharp boundaries possibly because of annealing.

The Coolamon and Coorara meteorites give evidence of equilibration near 700°C prior to shock, which lies within the range previously proposed for grade 6 chondrites (e.g. 12). The coexisting pyroxenes indicate a temperature below 810°C (10) and the coexisting low-Ca pyroxene and ilmenite in Coolamon indicate a temperature of 700°C + 5° per kilobar pressure (11).

The failure of Jeanloz and Ahrens (7) to transform olivine into spinel in shock-wave experiments is puzzling. Binns (2) suggested that ringwoodite formed in Tenham chondrite where shock waves overlapped. We suggest that the meteorites might have been at ~700°C when shock occurred, and propose this as a starting temperature for further experiments. In the meteorites, it appears that the olivine-ringwoodite transformation is not exactly isochemical: is a vapor phase involved?

In conclusion, we emphasize the need for further detailed studies of Tenham and Catherwood meteorites to further delineate the similarities and differences associated with this group of shocked L6 chondrites.

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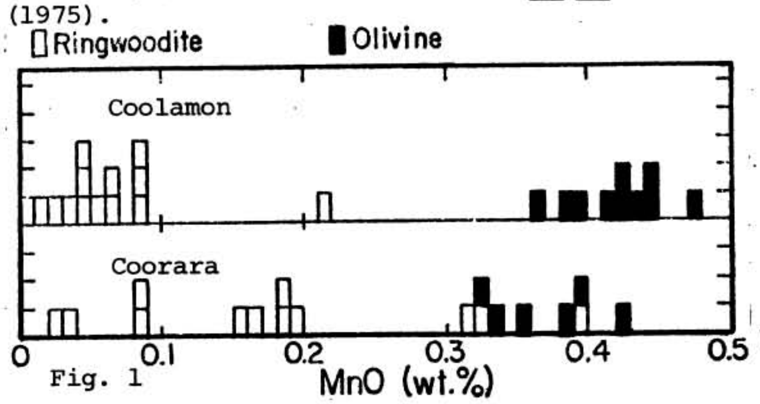

Fig. 1

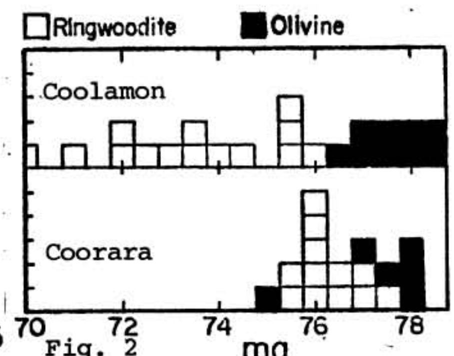

Fig. 2

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Table 1: General Mineralogy

	Tenham	Catherwood	Coorara	Coolamon
Olivine (mg)	0.74-0.75	0.73-0.75	0.77-0.78	0.77-0.78
Plagioclase	An_{10-12}	$An_{10}Or_8Ab_{82}$	x	$An_{10}Or_7Ab_{83}$
Low-Ca Pyx (mg)	0.78	0.78-0.79	0.74	0.77
High-Ca Pyx	nr	(x)	(x)	$En_{46}Eo_{47}Fs_7$
Kamacite	x	x	x	x
Taenite	x	x	np	x
Troilite	x	x	x	x
Apatite	nr	(x)	(x)	(x)
Ilmenite	nr	nr	np	tr
Goethite	nr	nr	x	x
Chromite	nr	(x)	(x)	(x)
Ringwoodite (mg)	0.74	0.73-0.75	0.76-0.77	0.70-0.76
Majorite	x	x	x	?

tr = trace; np = not present; nr - not reported; x = present; (x) = present but minor.

Table 2: Mineral Data for Coolamon and Coorara.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
K_2O	0.01	0.01	0.03	0.02	na	na	na	na	na	1.2	nd
CaO	1.04	1.01	22.2	21.3	0.09	0.06	0.12	0.06	na	2.0	nd
TiO_2	0.13	0.12	0.43	0.31	na	na	na	na	56.1	na	2.9
Cr_2O_3	0.18	0.09	0.64	0.67	0.03*	0.03*	na	na	nd	na	58.6
MnO	0.45	0.31	0.14	0.17	0.42	0.35	0.04	0.02	1.7	na	0.7
FeO	13.1	15.0	4.14	6.46	20.5	20.9	23.3	21.6	39.4	nd	29.9
NiO	0.27*	0.25*	0.05	na	0.68*	0.03*	na	na	na	na	nd
Al_2O_3	0.14	0.19	1.13	0.50	na	na	na	na	na	21.4	6.3
SiO_2	56.5	53.8	55.5	52.6	39.0	38.6	39.3	39.8	na	66.1	nd
Na_2O	0.03	0.05	0.71	0.55	na	na	na	na	na	9.8	nd
MgO	28.9	28.0	16.9	16.5	39.7	39.1	37.0	38.3	3.8	nd	2.4
Sum	100.75	98.83	101.87	99.08	100.42	99.07	99.76	99.78	101.0	100.5	100.8

All data by WDS unless (EDS) indicated: (1) low-Ca px Coolamon; (2) low-Ca px Coorara; (3) Cpx Coolamon; (4) Cpx Coorara; (5) ol Coolamon; (6) ol Coorara; (7) ringwoodite Coolamon; (8) ringwoodite Coorara; (9) ilmenite Coolamon (EDS) (10) maskelynite Coolamon (EDS); (11) chromite Coolamon (EDS). *Special analyses with high accuracy; some variation - see full paper.