BELLS-A CARBONACEOUS CHONDRITE RELATED TO C1 AND C2 CHONDRITES;
Andrew M. Davis[1] and Edward Olsen[2]. [1]James Franck Institute, University of Chicago, 5640 South Ellis Avenue, Chicago, IL 60637; [2]Department of Geology, Field Museum of Natural History, Chicago, IL 60605.

The Bells, Texas meteorite fell on September 9, 1961. It was classified as a Type II carbonaceous chondrite by Mason [1]. Bulk samples of Bells have been found to contain 13 to 16 wt% magnetite by magnetic methods [2,3]. This is far more magnetite than is normally found in C2 chondrites and is slightly higher than the levels found in C1 chondrites [3]. McSween and Richardson [4] measured the bulk composition of "matrix" in many carbonaceous chondrites (including Bells) by broad beam electron microprobe analysis. They found a range of compositions among the phyllosilicate matrices of C1 and C2 chondrites. Bells and the C1 chondrites are at the Fe-poor, Mg- and Si-rich end of this range. McSween [5] point-counted many C2 chondrites and found Bells to be among the most matrix-rich of them. He found a correlation between the composition of matrix and vol% matrix and suggested that increasing degree of alteration of chondrules and inclusions leads to increasing matrix fraction and decreasing Fe content of the matrix. According to his model, Bells should be among the most heavily altered of the C2 chondrites.

Until recently, most of the recovered samples of Bells have been in the private collection of Mr. Oscar Monnig and the only sample available for petrographic study has been a tiny thin section. Larger samples recently became available, so we were able to make a detailed examination of a 1 cm^2 polished thin section of Bells using a petrographic microscope and a scanning electron microscope equipped with a backscattered electron detector and an x-ray analysis system. This work is part of a broad study of Bells arranged by Prof. C.B. Moore of Arizona State University.

Bells has a brecciated texture, consisting of ∿2 mm clasts that are most easily recognized by variations in their magnetite content. Bells has fewer chondrules and inclusions than most other C2 chondrites we have examined.

The matrix of Bells consists of phyllosilicate with abundant framboidal magnetite and minor calcite, troilite and pentlandite. The magnetite is similar in appearance to that in C1 chondrites and occurs as 10 to 100 μm aggregates of 0.1 to 1 μm crystals. It is pure Fe_3O_4 with <0.2 wt% of other elements. The fine-grained nature of the magnetite makes point-counting difficult, but 13 to 16 wt% [2,3] seems reasonable. McSween [5] concluded that there is much less magnetite in Bells than indicated by magnetic methods, but in his point-count of Bells, he included only the altered regions around metal grains, which are not magnetite. Apparently, he was unable to detect the abundant framboidal magnetite because of its small grain size. The matrix phyllosilicate in Bells has less Fe than matrix phyllosilicate in other C2 chondrites, but is remarkably similar in composition to Orgueil matrix phyllosilicate (Table).

Fragments of barred olivine, excentroradial and porphyritic chondrules (≤500 μm) are much more common than complete droplet chondrules (≤300 μm) in Bells. Although most chondrules are broken, the phases within them are relatively unaltered. The glass in barred olivine chondrule fragments is devitrified, but it has not been altered to the "spinach" phyllosilicate commonly seen in other C2 chondrites [6]. A few chondrules have an unusual "swiss cheese" texture, consisting of olivine (Fo_{98-99} with 0.3 to 0.5 wt% Cr_2O_3) with 2 to 3 μm holes. The holes are aligned with the extinction direction of the host olivine. In one such chondrule, the only other phase found was a single 2 μm glass inclusion containing at least 86 wt% SiO_2. Nearly all chondrules are composed of forsterite, clinoenstatite and glass, with occasional minor diopside. Many of them have inclusions of metal and sulfide.

Monomineralic grains of forsterite, enstatite and diopside are common and range in size from <1 to 100 μm. Only one 5 μm grain of spinel was found. The olivine sometimes has an unusual crystal habit, appearing on the surface as ∿15 x ∿30 μm rectangles with parallel extinction. One 200 μm grain of phyllosilicate was found. It is richer in Mg and poorer in S than matrix phyllosilicate (Table). Perhaps matrix phyllosilicate has unresolvable Fe-, S-rich phases that contribute to analyses of it. Metal grains up to 500 μm across occur in Bells. They often have a 20 to 50 μm thick band at their edges that has been altered to an ill-defined iron oxide or hydroxide phase. The metal contains many 0.2 to 10 μm spherical inclusions of troilite with 2 to 3 wt% Cr. The troilite beads survive alteration, as they are also found in the alteration zone around each metal grain. The metal contains 5 to 7 wt% Ni, 0.1 to 0.2 wt% Cr and <0.02 wt% Si. Metal from Murchison is similar in Ni content, but contains more Cr (0.7 wt%) and Si (0.09 to 0.14 wt%) [7].

Inclusions found in Bells include a few 10 to 30 μm loosely-packed aggregates of 1 to 2 μm forsterite grains and several 50 μm to 1 mm irregularly shaped forsterite-enstatite objects with minor glass and diopside. The latter have beads of metal and sulfide around their outer edges and seem to be unbroken. One type of object notable by its absence in Bells is the amoeboid inclusion. These occur in all other C2 chondrites we have examined. They are often altered to green phyllosilicate and sometimes contain Ca-, Al-rich inclusions. Isolated Ca-, Al-rich inclusions are fairly easy to find in most C2 chondrites, but none were found in Bells.

The phyllosilicate matrix of Bells is closer in composition to that of C1 chondrites than to that of C2 chondrites. Bells contains abundant framboidal magnetite similar in appearance to and in even greater abundance than that in C1 chondrites. The Bells inclusions and chondrules are similar to those in C2 chondrites, but they are less abundant. Bells is certainly not as heavily altered as McSween's [5] model suggests. Bells has properties in common with both C1 and C2 chondrites, blurring the distinction between the two types.

REFERENCES: 1. Mason B. (1963) *Space Sci. Rev.* 1, 621. 2. Watson D.E., Larson E.E., Herndon J.M. and Rowe M.W. (1975) *Earth Planet. Sci. Lett.* 27, 101. 3. Hyman M. and Rowe M.W. (1983) *Lunar and Planetary Science XIV*, 341. 4. McSween H.Y. and Richardson S.M. (1977) *Geochim. Cosmochim. Acta* 41, 1145. 5. McSween H.Y. (1979) *Geochim. Cosmochim. Acta* 43, 1761. 6. Fuchs L.H., Olsen E. and Jensen K.J. (1973) *Smithson. Contrib. Earth Sci.* No. 10. 7. Grossman L., Olsen E. and Lattimer J.M. (1979) *Science* 206, 449. 8. Kerridge J.F. (1976) *Earth Planet. Sci. Lett.* 29, 194. 9. Bunch T.E., Chang S., Frick U., Neil J. and Moreland G. (1979) *Geochim. Cosmochim. Acta* 43, 1727.

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	Cr_2O_3	MnO	FeO	NiO	Total
A	0.26	19.00	2.71	34.63		2.60	0.10	0.63	0.04	0.30	0.22	22.98	1.30	84.77
B		25.26	3.05	37.27		0.30				1.01		19.07		85.96
C	0.32	19.62	2.72	33.87	0.35	5.60	0.08	0.16	0.04	0.56	0.21	20.26	2.51	86.30
D	0.43	16.0	2.35	28.0		6.59	0.04	1.04	0.09	0.33	0.15	30.9	0.97	86.89
E		15.0	3.1	23.4				0.9		0.3	0.2	34.1	1.5	78.5

A-Bells matrix (small areas without magnetite, 5 analyses). B-Bells phyllosilicate grain (2 analyses). C-Orgueil matrix [8]. D-Murray matrix [9]. E-Murchison matrix [6].