NEW DATA ON THE BENCUBBIN POLYMICT STONY-IRON BRECCIA: R. Hutchison Mineralogy Department, British Museum (Natural History), London SW7 5BD, UK.

Each component of Bencubbin on which stable isotopic ratios were measured by Franchi et al. is characterized, sampling having been performed in close collaboration with the Open University group. Samples are from BM No. 1931,536, except for the "carbonaceous chondrite", two fragments of which were kindly supplied by Prof. J.F. Lovering; these are from a single clast that has been widely studied (1-3).

"Ordinary chondrite" From an ovoid, chondrule-rich clast some 3x2x2 cm in size were removed samples for petrological, stable isotopic, trace element (M.E. Lipschutz) and rare gas (S. Kelley and G. Turner) work. A polished thin-section of 2 cm^2 was prepared, and found to comprise mainly chondrules and chondrule fragments of barred, radiating or porphyritic types. Interchondrule areas are dominantly composed of metal/sulfide, but opaque matrix is rarely present. Metal has from 4.6-9.3 wt% Ni and 0.0-0.6 wt% Cr. The sulfide is generally Ni-poor with <1% Ni, but one metal/sulfide intergrowth has 11.1% Ni, the highest measured. The Ni content of metal or metal/sulfide is consistent with that of H-group rather than L- or LL-group chondrite. Along traverses roughly 1.5 mm apart, the core of one olivine or one low-Ca pyroxene was analyzed in each chondrule or chondrule fragment encountered. The ratio of olivine to pyroxene crystals (45:49) is less than that normally found in ordinary chondrites. Olivines range from $Fa_{1.1}$ to Fa_{23}, the mode being Fa_{11}; pyroxenes range from $Fs_{1.4}$ to Fs_{34}, the mode being Fs_{7}. Mean compositions are $Fa_{11.4}$ and $Fs_{10.7}$. The mean of five microprobe analyses of opaque matrix (beam diameter 10-15 μm) is presented (Table 1, No.1). The "metal" content, 18.7 wt%, was calculated by assuming a Ni content of 6%, the mean measured in large grains. The calculated content is high compared with those estimated by Huss et al. (4) in opaque or recrystallized interchondrule matrices in type 3 ordinary chondrites. However, the calculated 100FeO: (FeO + MgO) molecular ratio, 27.5, is close to their ratio for recrystallized matrix in Bremervörde, 32. It is concluded that the chondritic clast is petrologic type 3, but may be related to IIE silicate or Suwahib (Buwah) rather than to ordinary chondrites.

"Carbonaceous chondrite" Part of the larger, sawn, fragment was turned into a demountable polished thin-section, an off-cut having been reserved (? for noble gas work). Part of the PTS will be removed for TEM study (D.J. Barber), the remainder to be returned to J.F. Lovering. The PTS is 10 x 3 mm in area and comprises coarse-grained "augen" with a preferred orientation and length to breadth ratio of about 5:1 set in opaque matrix that contains fine-grained sulfide. The "augen" are probably deformed chondrules; this interpretation is supported by their mineralogy, olivine phenocrysts (Fa_{74-65}) set in pyroxene/plagioclase normative mesostases. The bulk composition of the opaque matrix (Table 1, No.2) was calculated assuming all Ni is present as sulfide; certainly Ni appears to correlate with S in tiny (<10 μm) grains within matrix. The data confirm that Ca is depleted relative to Al compared with known C-chondrite types (2). Most of the limited analyses of "chondrule" mesostases are per-aluminous, so the bulk Ca/Al ratio is almost certainly less than that of matrix. This paucity in Ca seems difficult to explain by either a condensation of a crystal/liquid fractionation mechanism. Little depletion in Na is accompanied by severe depletion in K, which may have been the result of heating and volatilization during the formation of the breccia.

"Aubritic" clasts Material associated with angular metal clasts displays variable degrees of partial melting followed by quenching; textures are reminiscent of those in chondrules. The clasts are often fractured and intruded by glassy veins containing variable proportions of metal droplets, as described by Newsom and Drake (5). Apart from the absence of Si-rich metal, most of their observations were confirmed. These clasts are too rich in FeO and CaO for them to be directly related to aubrites which have less than 0.5% FeO and less than about 1% CaO in their silicate component (6). The Bencubbin "aubrite" comprises enstatite (En_{97} Wo_1), aluminous pigeonite (En_{92} Wo_6), olivine (Fo_{97}), chrome-diopside, and an anorthitic component.

Metal Three angular metal slugs were analyzed, all being Si-poor. One with the "aubrite" has irregular inclusions of sulfide containing <9% Cr. The range of Ni, Co, Cr and P in the metal lies within that established by Newsom and Drake (5).

Matrix Glassy material, that appears to bond aubritic and metallic clasts, was termed "matrix" (5). It has a variable composition (Table 1, Nos. 3-5), and probably represents the lowest temperature fractions of the three silicate components ("aubritic", "O chondritic", and "CC") that were melted and injected throughout the breccia, presumably following shock-melting, especially of the metal. S, K and some Na may have been volatilized and lost. Note the similarity of analyses 5 and 6. Although intimately associated with metal at its margins, the interior of the "O chondrite" clast remained unmelted, testifying to an uneven temperature distribution, so that shock-heating must have been of short duration.

Acknowledgement The author benefited from discussions with A.L. Graham, and I. Franchi and C.T. Pillinger in trying to reconcile petrology with stable isotope systematics.

References (1) A J Easton and J F Lovering, GCA 27, 753-767, 1963. (2) G W Kallemeyn et al., GCA 42, 507-515, 1978. (3) R N Clayton and T K Mayeda, GCA 42, 325-327, 1978. (4) G R Huss et al., GCA 45, 33-51, 1981. (5) H E Newsom and M J Drake, GCA 43, 689-707, 1979. (6) A J Easton, Meteoritics 20, 571-573, 1985.

TABLE 1

	1	2	3	4	5	6
SiO_2	34.9	31.8	38.7	32.2	35.0	35.0
TiO_2	0.08	0.10	0.14	0.10	0.10	0.25
Al_2O_3	2.04	2.78	3.28	3.19	7.65	7.10
Cr_2O_3	0.40	0.50	0.74	0.57	0.95	0.65
FeO	11.4	24.9	25.4	29.5	28.1	26.7
MnO	0.27	0.24	0.18	0.27	-	0.20
MgO	16.9	23.0	28.7	23.6	25.6	26.5
CaO	1.27	1.84	2.43	2.03	1.60	1.15
Na_2O	0.61	0.38	0.22	-	0.34	1.0
Sum	89.9	96.9	99.9	95.4	99.4	98.6

1 Opaque matrix "O chondrite", includes 0.26% K_2O, 18.7% Fe, Ni and 3.1% FeS. 2 Matrix "CC", includes 9.2% FeS and 2.2% NiS. Mean of 10, 50 μm^2 area scans. 3 "Matrix glass".
4 "Matrix" vein, includes 3.94% P_2O_5.
5 "Matrix glass" (ref. 5), includes 0.03% K_2O.
6 Chondrule mesostasis "CC".