PETROGRAPHY AND GEOCHEMISTRY OF A 30-CENTIMETER PYROXENITE NODULE FROM THE BONDOC MESOSIDERITE. L.A.J. Garvie[1], D.R. Bell[2] and P.R. Buseck[2], [1]Center for Meteorite Studies and [2]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287-1404, lgarvie@asu.edu, david.r.bell@asu.edu, pbuseck@asu.edu.

Introduction: The Bondoc meteorite is a large (~800 kg) mesosiderite recovered from the Bondoc peninsula, Phillipines, during the early 1960s. It is dominated by a fine- to coarse-grained matrix of pyroxene, plagioclase, troilite, and Ni-rich metal, together with a host of minor phases [1]. Set within this matrix are metal nodules up to 10 cm in diameter and comprising ~11% by area. Three slices (~60 x 40 cm) cut from the main mass of Bondoc during the early 1960s revealed a large, essentially metal-free, nodule surrounded by the matrix. Only one such large nodule was found. This nodule is composed predominantly of pyroxene. Here we describe the mineralogy, major-element composition, and petrography of this nodule, with a focus on the pyroxenes.

Visual and petrographic observations: The pyroxenite nodule is fine- to coarse-grained, dull green, and roughly lenticular 30 x 15 x 10 cm. The boundary with the Bondoc matrix is sharp. The nodule is a monomict breccia containing >90 % low-Ca pyroxene, with medium- to fine-grained plagioclase, abundant <1-mm silicate-opaque assemblages, and sparse Ca phosphates. No olivine was encountered. The silicate-opaque inclusions consist of one or more of the following – kamacite, taenite, troilite, an unidentified Fe silicate, chromite-spinel, Ca phosphate, and a silica phase. Fe-Ni metal and Fe sulfide occurs as up to 1-mm masses and veins through and around silicate grains. Terrestrial alteration is evident as partial replacement of the metal and sulfide veins by Fe oxides. Three texturally distinct regions are recognizable.

1) a 10-cm area composed of large (to 2 cm) anhedral to euhedral opx crystals (Fig. A); some crystals are rounded to elliptical. Crystal boundaries are sharp, and many form 120° triple junctions. Relatively minor amounts of fine-grained recrystallised pyroxene occurs between the grains. The crystals contain micrometer-sized inclusions.

2) Medium-grained region with a largely equigranular texture and abundant 120° triple junctions. Typical grain size is 2 mm. Visually, pyroxene constitutes >90% by area in regions 1 and 2.

3) Region dominated by veins and fine-grained, recrystallized groundmass dominated by pyroxene, with minor intergranular plagioclase and opaques (Fig. B). Phenocrysts of pyroxene with sutured margins are locally abundant. Sparse mm-sized plagioclase shows polysynthetic twinning.

Pyroxene compositions: Major-element concentrations (Table 1) were measured with a Jeol JXA-8600 electron microprobe, with a 15 kV and 20 nA electron beam. The major-element compositions of the pyroxenes show a narrow range from $Wo_{0.9}En_{82.8}Fs_{16.3}$ to $Wo_{3.2}En_{74.0}Fs_{22.8}$, with a mean of $Wo_{1.8}En_{79.9}Fs_{18.4}$ (n=19). In contrast, the ferrosilite content of the matrix pyroxenes ranges from Fs_{25} to Fs_{32} [1, 2] The CaO content ranges from 0.44 to 1.93 wt%, with a mean of 0.8 wt%. The Fe/Mg ratios are fairly constant (0.19 to 0.31), whereas the Fe/Mn ratios vary from 22.1 to 31.6.

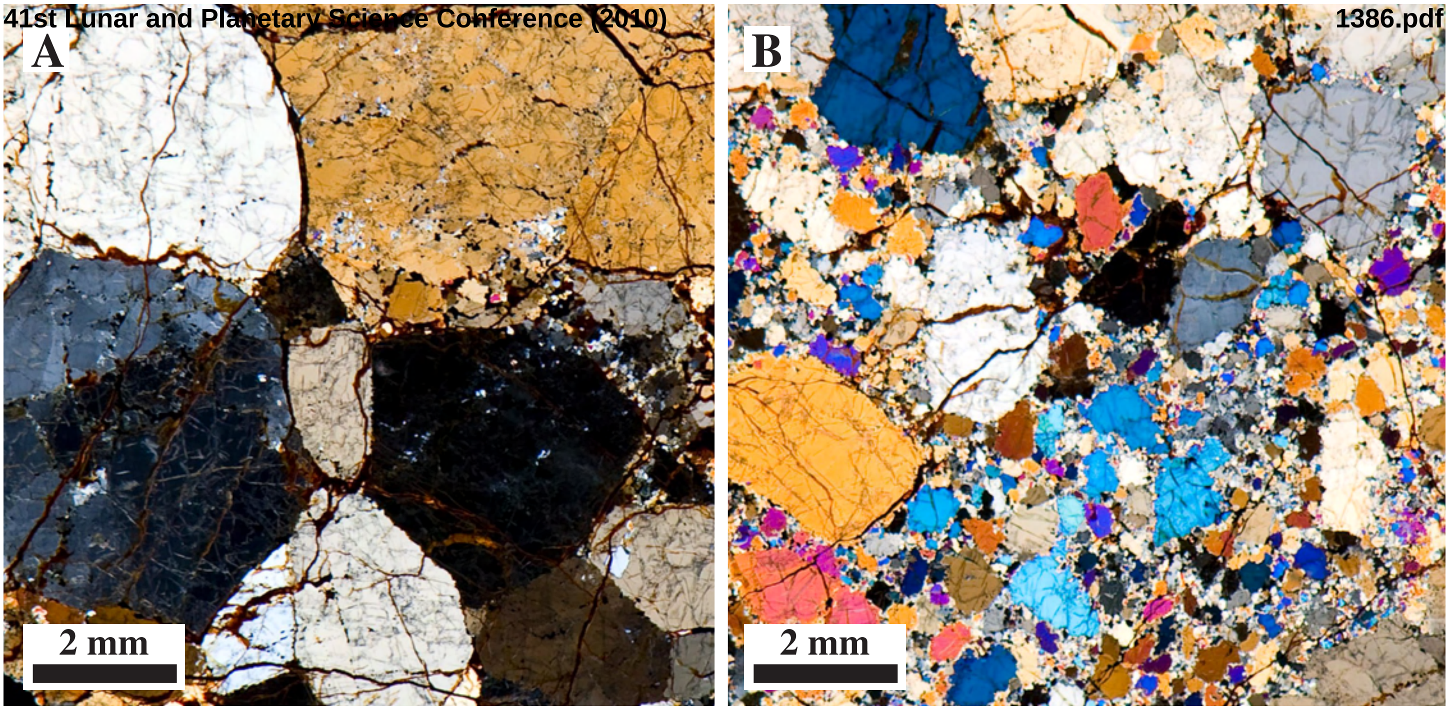
Discussion: The major-element compositions of the Bondoc nodule pyroxenes are similar to those from many mesosiderites and diogenites [3-5], although with a significantly higher mean mg# of 81.3 (Fig. D). Only the Antarctic diogenite MET00425 has a similarly high mg# [6]. The low mean CaO from the nodule is similar to the Shalka and Tatahouine diogenites [3], and the mean wt% of TiO_2, Al_2O_3, Cr_2O_3, and MnO are similar to those of most diogenites and mesosiderites [3-5]. Nodule pyroxenes have a mean Fe/Mn ratio of 28, which is higher than most diogenites and mesosiderites [3-5].

The low Fe/Mn ratio for the mesosiderite pyroxenes, relative to those of the HED meteorites, is attributed to the effects of FeO reduction during crystallization [7]. The nodule pyroxenes have a higher mg# than those in the matrix. Such differences are inconsistent with the greater extents of reductive chemical reaction that might be expected among the more intimately mixed matrix components. Instead, they could imply localized compositional heterogeneity of the mafic region of the differentiated parent body sampled by the Bondoc meteorite. A possibility is that the high-mg# nodule was excavated from a deeper region of a compositionally stratified pyroxenite crust.

The textures indicate the heterogeneous distribution of strain within the nodule, with coarse, relatively undisturbed regions contrasting with areas of cataclasis, many of which also have greater metal abundance, suggesting metal injection. Although 120° triple junctions, coarse grain sizes, and compositional uniformity indicate mature degrees of metamorphic equilibration prior to disruption, the abundant serrated grain boundaries suggest post-impact recrystallization in even the least disturbed regions.

We propose that the Bondoc pyroxenite nodule is an intact fragment of the mafic crust from a differentiated parent body. Although it shows pervasive evidence for being affected by the metal-silicate mixing event that produced the mesosiderite breccia, this fragment survived, perhaps because it was excavated from a deeper and more compositionally primitive region of the crust than that which supplied the bulk of the mesosiderite meteorites.

References: [1] Clay, J.C.J. (1974) MSc Thesis, ASU: Tempe. p. 109. [2] Powell B.N. *(1971) GCA* **35** 5-34. [3] Mittlefehldt D.W. (1994) *GCA* **58** 1537-1552. [4] Mittlefehldt D.W. et al. (1998) Rev Mineral **36** 4-1 to 4-195. [5] Rubin A.E. and D.W. Mittlefehldt (1992) *GCA* **56** 827-840 [6] Barrat, J.A. et al. (2008) *MAPS* **43** 1759-1775. [7] Mittlefehldt D.W (1990) GCA 54 1165-1173.



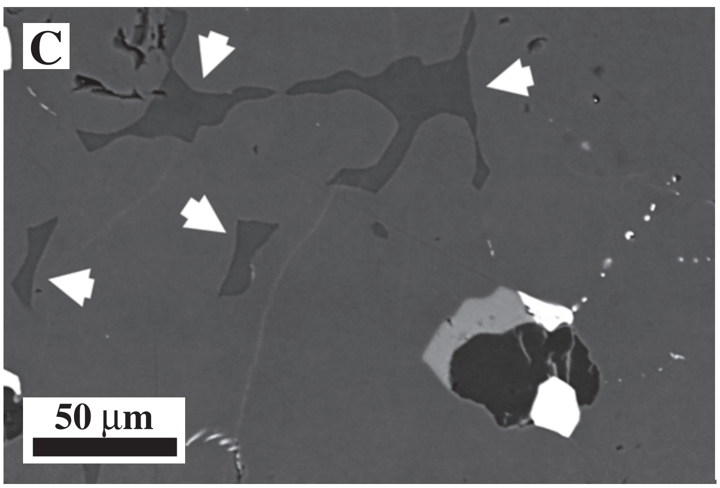
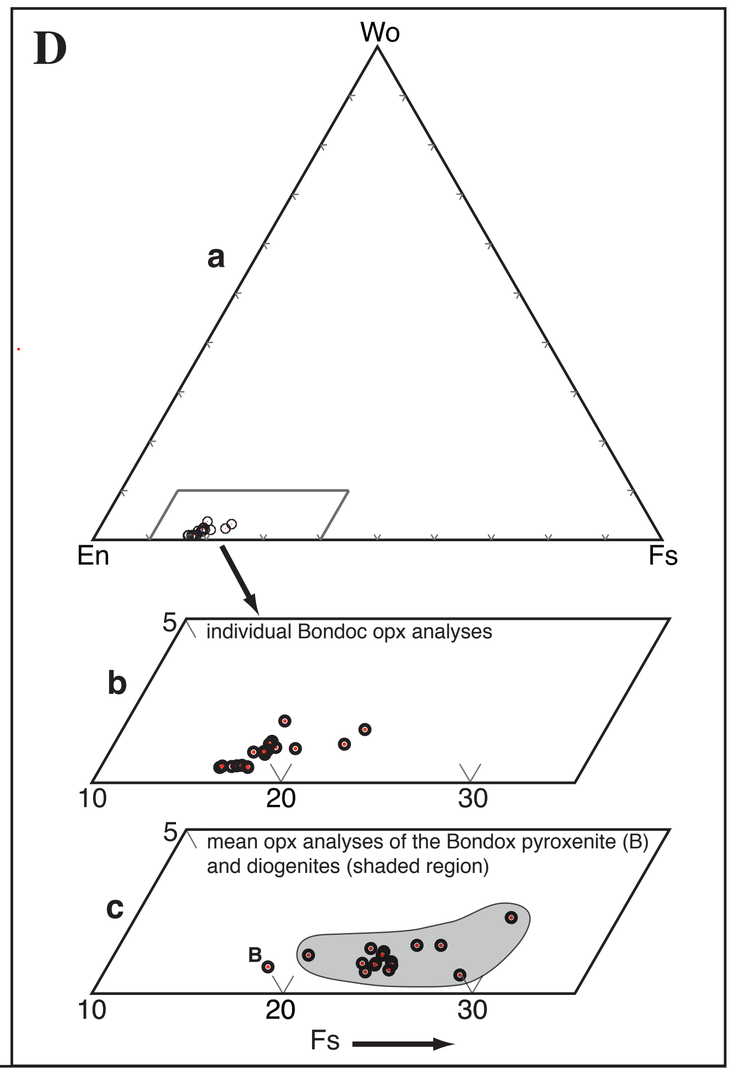


Table 1. Average pyroxene and plagioclase compositions

	Pyroxene (n=30)	Plagioclase (n=10)
SiO_2	55.26	45.50
TiO_2	0.08	0.01
Al_2O_3	0.65	33.77
Cr_2O_3	0.64	0.02
FeO	11.93	0.31
MnO	0.42	0.03
MgO	30.17	0.00
CaO	0.80	17.55
Na_2O	0.02	1.51
Sum	99.97	99.70



A) and B) Photomicrographs from the Bondoc pyroxenite nodule (crossed polars). A) is from Region 1 showing large anhedral to euhedral opx. B) is from Region 3 showing fine- to medium-grained opx. The larger grains show interdigitating boundaries. C) BSE image from Region 3 showing opx (dominant phase), plagioclase (white arrows) and an inclusion composed of troilite (white), Ca phosphate (light grey), and silica (black). D) Ternary plot showing a) and b) the restricted range of opx compositions from the Bondoc nodule, and c) comparison of the mean Bondoc nodule opx composition -B- and that of diogenites (from [3]).