Gujba and Origin of the Bencubbin-like (CB) Chondrites. Michael K. Weisberg[1,2], Joseph S. Boesenberg[2] and Denton S. Ebel[2]. (1) Department of Physical Sciences, Kingsborough College of the City University of New York, Brooklyn, NY 11235 (mweisberg@kbcc.cuny.edu). (2) Department of Earth and Planetary Sciences, American Museum of Natural History, NY, NY 10024.

Introduction: The CB (Bencubbin-like) chondrites are metal-rich chondritic meteorites having characteristics that sharply distinguish them from all other chondritic meteorites [1]. The CB chondrites include Gujba, Bencubbin, Weatherford, Hammadah al Hamra 237 (HH 237) and QUE 94411. Their remarkable characteristics include (1) high metal abundances (60-80 vol.% metal), (2) large (cm-size) chondrules in some members of the group, (3) most chondrules have cryptocrystalline or barred textures, (4) moderately volatile lithophile elements are highly depleted and (5) nitrogen isotopes are highly enriched in the heavy isotope. The extraordinary characteristics of these meteorites greatly extend the range of known primitive materials. However, their origin and significance have generated much controversy. Are they highly primitive nebular materials containing metal that condensed directly from the nascent nebular gas [e.g., 1-6] or did they form in a vapor cloud produced during an impact event on a chondritic planetesimal [e.g., 7, 8]? Here we present the preliminary results of our petrologic study of Gujba, a new metal-rich CB chondrite that is petrologically and oxygen isotopically similar to Bencubbin and Weatherford, and is the only CB fall [9]. The Gujba meteorite has important features that provide further clues to the origin of the Bencubbin-like chondrites.

Results: We studied a 3 by 5cm polished slab of Gujba. Gujba is petrologically similar to Bencubbin and Weatherford containing about 60 vol. % metal and 40% silicate chondrules. The majority of the chondrules (metal and silicate) are complete spheres, with a slight elongation. This is in contrast to Bencubbin and Weatherford in which most chondrules are fragmental and highly deformed. Metal chondrules in Gujba are up to ~1cm in size and the largest silicate chondrule is about 1.5 x 1cm and is cryptocrystalline in texture. Interstitial to the large metal and silicate chondrules are smaller mm-sized silicate chondrule fragments that are texturally and compositionally similar to the larger ones. Silicate chondrules are cryptocrystalline, barred olivine or barred pyroxene in texture. Barred chondrules consist of olivine or low-Ca pyroxene bars with interstitial feldspathic glass. Olivine is $Fa_{2.0\text{-}3.2}$ and contains 0.3 to 0.6 wt. % Cr_2O_3. The olivine is compostionally similar to olivine in other CB chondrites, which have average compositions that range from $Fa_{2.5\text{-}3.4}$, with Cr_2O_3 from 0.3 to 0.6 % [1]. Interstitial glass contains (in wt. %) up to 27 Al_2O_3, 18 CaO and 0.4 Na_2O. Some barred olivine chondrules contain small (several µm) subhedral Mg-Al-rich spinel grains. In some chondrules, the olivine bars have bends suggesting that they were plastically deformed (Figure). As in the other CB chondrites, the silicate chondrules are completely free of metal or sulfide phases. Metal chondrules are aggregates of low-Ni metal grains that contain µm-size blebs of Cr-bearing troilite. In some metal chondrules, the troilite occurs at boundaries between, and outlining, metal grains. The metal chondrules are similar to those in Bencubbin and Weatherford and to the large metal aggregates in QUE 94411 and HH 237. Each metal chondrule is homogeneous in composition, but compositions vary among chondrules. Metal chondrules of sharply different composition are commonly in contact with each other and they show no evidence of diffusion (e.g., Ni zoning) between them, even where the contact between the chondrules has been flattened. In addition to the metal and silicate chondrules, we found a refractory-rich inclusion containing melilite, spinel and fassaite. Refractory inclusions have previously been described in QUE 94411 and HH 237 [10], but have not yet been found in Bencubbin or Weatherford.

Discussion: Gujba is a primitive meteorite containing metal and silicate chondrules and at least one CAIs. Based on its petrologic characteristics and oxygen isotopic composition [9], Gujba is a member of the CB chondrite group. The presence of metal chondrules with different Ni contents found in sharp contact and showing no evidence of diffusion (e.g, zoning) suggests that Gujba accreted cold and did not experience high degrees of thermal metamorphism. This is supported by the presence of glass in some barred olivine chondrules. Yet, the slight elongation of the metal and silicate chondrules and the deformed olivine bars in some chondrules suggest that the components of Gujba were plastically deformed. Deformation may have resulted from heating during compaction and accretion or during impact heating following accretion.

Weisberg et al. [1] divided the CB chondrites into CB_a (Bencubbin and Weatherford) and CB_b (HH 237 and QUE 94411) subgroups based on petrologic differences. Gujba clearly belongs to the CB_a subgroup because it has large (cm-size) metal and silicate chondrules. Chondrules in the CB_a subgroup are cm-size and the components in the CB_b chondrites are much smaller (mm-size), with the exception of large metal aggregates. Another differerences between these subgroups is the absence of refractory inclusions in the CB_a chondrites. However, the finding of a CAI in Gujba eliminates this difference. Additionally, the presence of CAIs in Gujba lends support to a primitive origin for CB_a chondrites, which have been considered to be products of impact processes.

The origin of Bencubbinites remains an enigma. It has been argued that HH 237 and QUE 94411 are highly primitive nebular materials based, in part, on the presence of CAIs and zoned metal grains. The zoned metal has chemical trends that are consistent with condensation from a gas of solar composition [1-6]. It has also been argued that the unusual characteristics of the CB chondrites are best attributed to impact processes on a metal-rich, chondritic planetesimal, possibly of CR chondrite parentage. The metal aggregates in Gujba, Bencubbin and Weatherford show volatility-controlled depletions in moderately volatile siderophile elements (Cu, Ga, Ge, Sn) and positive correlations between the most refractory platinum group elements (Os, Ir, Pt, Ru, Rh) and Ni that are consistent with a condensation origin. However, modeling of these elemental trends appears to require a gas with extremely high partial pressures of the siderophile elements (up to $\sim10^7\times$solar) [8]. The requirement of high pressure has led to the suggestion that the metal condensed as liquids in a vapor cloud generated in an impact event involving a metal-rich and silicate-rich planetesimal [8]. It has also been suggested that the CB_a chondrites are the products of impact onto a CB_b-like precursor (A. N. Krot, personal communication). The high abundance of completely spherical chondrules and the presence of CAIs in Gujba are characteristics similar to those of other chondrites thought to have formed in the nebula, making impact models less probable. However, the high pressures required for the condensation of siderophile elements into metal cannot be explained easily in nebular models, unless prolonged shock episodes are considered. Alternatively, we may need to turn to new scenarios for formation of the CB chondrites, such as a degassing plantesimal.

References: [1] Weisberg M. K. et al. (2001) MAPS 32, 401-418. [2] Newsom H. E. and Drake M. J. (1979) GCA 43, 689-707. [3] Weisberg M. K. and Prinz M., (1999) Symp. Antarct. Meteor. 24 187-189, NIPR. [4] Meibom A. *et al.*, 2000 MAPS 35, A107. [5] Petaev M. I. *et al.*, 2001 MAPS 36, 93-107. [6] Campbell A. J. et al. (2001) GCA 65, 163-180. [7] Wasson J. T. and Kallemeyn G. W. (1990) EPSL 101, 148-161 [8] Campbell A. J. et al. (2001) GCA, in press. [9] Rubin A. E. *et al.* (2001) LPSC XXXII #1779 [10] Krot A. N. *et al.* (2001) MAPS 36, 1189-1216.

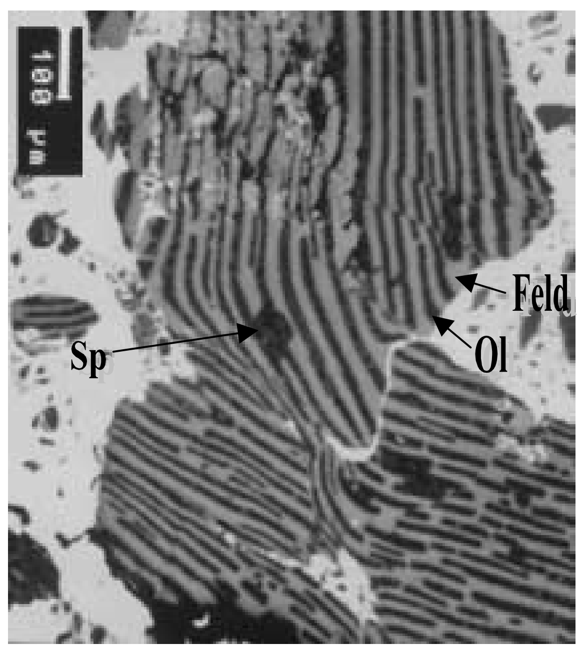

Figure. BSE image of a barred olivine chondrule fragment in Gujba. Olivine bars (dark gray) have bends suggesting that they were plastically deformed. (Ol-olivine, Feld-feldspathic glass, Sp-MgAl Spinel.)