HAMMADAH AL HAMRA 237

CB3b chondrite, bencubbinite

Found October 18, 1997
28° 36.56' N., 13° 02.95' E.

A single mass of 3,173 g was found in the Libyan Sahara Desert in the fall of 1997. This breccia consists of a mechanical mixture of silicate and metal fragments that are similar to those in Bencubbin but smaller sized. While the FeNi-metal abundance in HaH 237 is exceptionally high, >70 vol%, the opposite is true for the abundance of fine-grained matrix. Compositionally and isotopically the bencubbinites are most similar to carbonaceous chondrites.

HaH 237 is a member of the newly designated CB group, the bencubbinites, with an especially close relationship to QUE 94411. HaH 237 is a metal-rich chondritic breccia formed from a combination of two separate nebular condensates; one being a metal-rich chondritic component and the other a volatile-depleted metallic component. These highly primitive components underwent a size-sorting process within a nebular region favorable to metal-enrichment, leading to the accretion of the bencubbinites. The bencubbinites have been divided into two petrologic subgroups, CBa and CBb, representing those with cm-sized metal and silicate chondrules (Bencubbin, Weatherford, and Gujba), and those with mm-sized chondrules (HaH 237 and QUE 94411), respectively.

Large polycrystalline, chondrule-like metal spheres (up to 5 mm) and their fragments are present. The nearly solar Ni/Co ratio and strong Ni-zoning is indicative of a nebular condensation origin at a total pressure of only one one-thousandth of a bar (100 Pa) with only mild metamorphism, but reduction processes may also have contributed to a portion of the metal fraction, particularly unzoned metal aggregates. Silicates are present in the form of mm-sized cryptocrystalline and barred olivine chondrules and chondrule fragments, similar to those in the CH group. In light of their non-igneous textures, absence of relict grains, depletion in volatiles, unfractionated REE patterns, and absence of FeNi-metal, the chondrules in HaH 237 are thought to represent first generation chondrules condensed

directly from a vaporized region of the solar nebula at pressures low enough to allow silicate to condense before metal. As an illustration of this scenario, some FeNi-metal grains contain inclusions of cryptocrystalline chondrules. After the condensation of chondrules and metal grains, they were radially transported by the solar wind to a colder, isolated region of the nebula, prior to the condensation of volatile elements.

A clear, isotropic glass component is found within some chondrules, reflecting the unequilibrated, type-3 nature of the meteorite. Other shock-melted silicate glass containing tiny metallic blebs occurs between metal and silicate fragments, similar to that found in Bencubbin and Weatherford. CAIs are a minor constituent in HaH 237, QUE 94411, and Gujba, but none have yet been found in Bencubbin or Weatherford. While CAIs have also been found in the CH-group segment of the CR clan, CAIs from the CB group have textural and mineralogical characteristics that exclude them from an origin on the CR asteroid.

Similar to the CAIs, hydrated lithic clasts are present in the CBb group, as well as in the CH group, but none have been identified in the CBa group. These hydrated lithic clasts consist of magnetite, sulfides, and carbonates embedded within a hydrous phyllosilicate matrix of serpentine and minor smectite. These hydrated lithic clasts are very similar in composition to carbonaceous chondrite matrix material of types 1 and 2, and they were formed independently of the anhydrous CB components. Following aqueous alteration, the lithic clasts were accreted together with the high-temperature components in a cooler region of the solar system, or through regolith gardening on the CB parent body, and then shock-lithified to form the meteorite that we have now.

As with all bencubbinites, HaH 237 contains an abundance of isotopically heavy N. The main N carrier phase in this meteorite is molten metal, possibly residing in submicroscopic carbide and nitride within kamacite. Another N carrier is taenite or less often, carbide around Cr-rich sulfide. More rarely, silicate glass and gas within vesicles are also found to contain heavy N. The hydrated lithic clasts are also being investigated as a carrier of heavy N. The CRE age of HaH 237 is calculated to be greater than 3 m.y. The above specimen of HaH 237 is a 1.1 g thin partial slice.