The Benton LL6 chondrite: formation and evolution of a brecciated and shocked meteorite

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The Benton LL6 chondrite is a relatively unweathered, brecciated meteorite that was witnessed as a fall at Benton, New Brunswick, on 16 January 1949. Two stones were recovered (1.5 kg and 1.34 kg) showing good fusion crusts. Internally, the meteorite comprises light-coloured, subangular to subrounded clasts embedded in a dark grey matrix. The matrix consists predominantly of olivine, subordinate orthopyroxene and plagioclase, and accessory apatite and clinopyroxene. Opaque phases include troilite, taenite, tetrataenite, kamacite, chromite and ilmenite. The mean matrix grain size is 23 microns. Clasts comprise the same mineral phases as the matrix, as well as chondrules and larger (50-100 micron) single mineral grains (mainly olivine and orthopyroxene). Composite (polyphase) clasts can be several millimetres in length. Following brecciation, the whole sample was thermally metamorphosed (annealed), with the matrix and clasts yielding subrounded grains with 120° triple point junctions.

Numerous examples of post-brecciation and post-annealing shearing and displacement at the micron to millimetre scale can be discerned in the form of shock veins. Most of these veins are defined by remobilized opaque minerals. Shock effects are also present throughout the sample in the form of undulose extinction, irregular and planar fractures, slight mosaic patterns, and planar deformation features in orthopyroxene.

Benton reveals a sequence of events that reflect a complex history: (1) chondrule formation and initial assembly; (2) brecciation; (3) thermal metamorphism and (4) shock veining. Events (2) and (4) can be equated with distinct impact events; the former representing bombardment of target material that remained in-situ, the latter probably with release from the source body to yield a meteorite. Thermal metamorphism was probably due to a combination of the following heat sources; the decay of short-lived radionuclides, electromagnetic induction during an early T-Tauri stage of the sun, or possibly the brecciated in situ target material being in proximity to an impact-generated melt sheet. Comparisons with terrestrial impact-related lithologies allow analogies to be made regarding the geological history of Benton, with implications for chondritic meteorite evolution.