

NWA505: A NEW LL3.0 CHONDRITE WITH EVIDENCE FOR CHONDRULE FORMATION IN A DUST-RICH ENVIRONMENT.

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Introduction: We report the results of a detailed petrographic and mineralogical study of NWA505 (LL3.0). This meteorite records chondrule formation in a region of enhanced dust-to-gas ratios relative to both solar composition and the environments in which chondrules in Semarkona (LL3.0) and Bishunpur (LL3.1) formed.

Techniques: The meteorite was surveyed using optical microscopy, X-ray mapping, and electron microprobe analysis (EMPA). An area of the thin section measuring 1.8 x 1.6 cm was quantitatively mapped for Na, Mg, Al, Si, P, S, K, Ca, Ti, Cr, Mn, Fe, and Ni. Silicates and opaque assemblages were analyzed by EMPA using two different calibration schemes. The petrographic subtype of the meteorite was determined using thermoluminescence (TL) [1]. Details of the TL analysis are given in [2]

Results: TL data indicate that the petrographic type of NWA505 is 3.0. Carbonate veins occur in the meteorite and some of the metal in the matrix has been oxidized. Troilite is unaffected by terrestrial weathering and there is still appreciable metal in the matrix. Metal in chondrule interiors is largely unaffected by terrestrial oxidation. These observations suggest a weathering stage of W2 [3]. Olivine grains show sharp optical extinction and contain irregular fractures, consistent with an S1 shock stage [4].

Olivine compositions range from Fo₁₄ to Fo₉₄. Metal grains in chondrule interiors are dominantly kamacite containing 2.9 to 7.8 % Ni and 0.05 to 0.43 % Co (atomic). Most of the metal grains in the matrix are Ni rich and contain 51 to 60 % Ni and 0.4 to 1.4 % Co. Kamacite in the matrix is rare. Four kamacite grains in the matrix have compositional ranges of 4.3 to 4.7 % Ni and 0.15 to 0.28 % Co.

The texture of NWA505 is distinct from that of Semarkona or Bishunpur, two other primitive LL chondrites, in that it contains a high proportion of compound chondrules. Out of 431 chondrules surveyed, at least 115 of them (~27%) are compounded. In many cases, there are multiple chondrules compounded together. In one assemblage there appears to be over a dozen chondrules that are embayed upon each other. Both type-I and type-II chondrules are compounded together.

Metal grains exposed at chondrule boundaries are highly corroded. The corrosion product is dominantly troilite with minor phosphate, chromite, magnetite, and fayalite. The troilite is euhedral and compact and occurs in intimate contact with the metal. Together, the metal and troilite have nearly circular, 'droplet' morphologies, suggesting that metal sulfurization occurred above the Fe-FeS eutectic (988 °C). This requires pressures greater than 10⁻⁴ bars and dust-to-gas ratios between 100 and 1000x solar [5].

The combination of the high proportion of compound chondrules, the large numbers of chondrules that are compounded together, and the formation of liquid FeS during sulfurization of kamacite all support the idea of formation in a region of enhanced dust-to-gas ratios. Any model of chondrule formation must be able to explain both the high collision rate of chondrules and the relatively high sulfur fugacity recorded by this meteorite.

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