Presence of planetesimal material among the precursors of magnesian chondrules.

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It is generally inferred that chondrules formed about 4.56 billion years ago within 5 AU from the proto-Sun as solidified melt droplets freely floating in space by melting of fine-grained solid precursor materials, and that during these melting events chondrules behaved as closed systems, both chemically and isotopically; i.e., the observed range in chondrule bulk chemistry and modal mineralogy was entirely inherited from solid precursor materials that experienced melting to various degrees followed by igneous crystallization.

Our petrologic survey of Type I chondrules in the CV carbonaceous chondrite revealed the presence of olivine-rich aggregates showing granoblastic textures and composed of coarse-grained forsteritic olivines and Fe,Ni-metal nodules. In two dimensions, the aggregates consist of polygonal, misoriented, olivine grains showing triple junctions with interfacial angles around ~120°. In some of these aggregates, olivine-olivine and olivine-metal grain boundaries are dry, i.e., lack any layer of glassy mesostasis. In lithic clast-bearing, Type I chondrules with high abundance of glassy mesostasis, some of the olivine-olivine grain boundaries in lithic clasts are separated by thin layers of glass (i.e., wet), whereas others remain dry. Olivine grains with wet contacts have rounded outlines, indicating dissolution in chondrule glass. The aggregates are surrounded by shells of low-Ca pyroxene and glassy mesostasis, commonly observed in Type I chondrules in ordinary and carbonaceous chondrites, and by fine-grained, matrix-like rims.

Formation of the granoblastic textures requires sintering and prolonged, high-temperature (>1000°C) annealing – conditions which are not expected in the solar nebula during chondrule formation, but could have been achieved on parent bodies of olivine-rich differentiated meteorites e.g., ureilites and brachinites. From their mineralogy, petrology and their oxygen isotopic composition, we thus infer that these metal-olivine aggregates are relict, dunite-like lithic fragments which resulted from fragmentation of differentiated planetesimals. The very old absolute Pb-Pb and relative Al-Mg ages of chondrules in CV chondrites suggest that such planetesimals may have formed as early as the currently accepted age of the solar system (4567.2±0.6 Myr).