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Pallasite formation after a non-destructive impact. An experimental- and image analyses-based study

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The formation conditions of pallasite meteorites in the interior of terrestrial planetesimals have been matter of debate over the last 40 years. Among other characteristics, the simple mineralogical composition (i.e., olivine, FeNi, FeS +/- pyroxene) and the dualism between fragmental and rounded olivine-bearing pallasites must be successfully reproduced by a potential formation scenario.
This study incorporates a series of annealing experiments with olivine plus Fe-S, and digital image analyses of slabs from Brenham, Brahin, Seymchan, and Springwater pallasites. Additionally a 1D finite-difference numerical model was employed to show that a non-destructive collision followed by mixing of the impactor's core with the target body silicate mantle could lead to the formation of both fragmental and rounded pallasite types. Specifically, an impact occurring right after the accomplishment of the target body differentiation and up to several millions of years afterwards allows for (i) average grain sizes consistent with the observed rounded olivine-bearing pallasites, (ii) a remnant magnetization of Fe-Ni olivine inclusions as measured in natural pallasites and (iii) for the metallographic cooling rates derived from Fe-Ni in pallasites.
An important result of this investigation is the definition of the grain growth rate of olivine in molten Fe-S as follows: dn – d0n = k0 exp(-Ea/RT) t, where, d0 is the starting grain size, d the grain size at time t, n = 2.42(46) the growth exponent, k0 = 9.43•E06 μm n s-1 a characteristic constant, Ea = 289 kJ/mol the activation energy for a specific growth process, R the gas constant, and T the absolute temperature. The computed olivine coarsening rate is markedly faster than in olivine-FeNi and olivine-Ni systems.