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# Rapid planetesimal cooling after core formation: Pallasite meteorites

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Pallasite meteorites consist of olivine-metal mixtures and accessory minerals (chromite, sulfide, phosphide, phosphate, phosphoran olivine) and represent core-mantle interaction zones in early differentiated planetesimals. They can be linked to five distinct planetesimals, indicating that they are default differentiation products, but their formation modes (deep, shallow, and impact environments) and age are elusive. Using new trace element, Cr isotope, and previously published datasets, we re-interpret some Main-group pallasites (low-MnO and high-FeO subgroups, e.g. Brenham and Springwater types respectively) as samples of core-mantle reaction zones. These meteorites host rounded olivine and near-solidus phosphate minerals, which record back-reaction of metal and silicate reservoirs during decreasing temperature after core formation and removal of primitive silicate melts. These phosphates form via late oxidation of phosphorus, which is siderophile at high temperature but lithophile at low temperature. Mn-Cr dates this event to before $\sim$2.5 to 4 Myr after Solar System formation (range is model-dependent). Importantly, this is in agreement with Hf-W ages for very early metal-silicate (i.e. core-mantle) separation, but also indicates rapid planetesimal cooling within a few million years. Near-solidus silico-phosphate melts probably formed before most known planetesimal crusts (eucrite and angrite meteorites) and are among the earliest evolved planetary silicates. Similar phosphates in non-Main-Group pallasites from other parent bodies also suggest that core-mantle reaction zones are generic, datable features of differentiation. The absence of near-solidus phosphates in common cluster pallasites suggests that these were quenched from high temperature and are mechanical mixtures, rather than samples of genuine core-mantle boundaries.