

**SPECIAL COLLECTION: OLIVINE**

**Phosphoran olivine overgrowths: Implications for multiple impacts to the Main Group pallasite parent body†**

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**ABSTRACT**

Phosphoran olivine (1–7 wt% P<sub>2</sub>O<sub>5</sub>) is a metastable phase known from fewer than a dozen meteoritic or terrestrial occurrences. We have thoroughly examined phosphoran olivine in the Springwater pallasite to characterize its distribution, textural relationships, and geochemistry. Phosphoran olivine is abundant in Springwater as randomly distributed millimeter-scale partial overgrowths on the P-free olivine crystals. Geochemical analyses support the substitution mechanism of P into the tetrahedral Si site with octahedral site vacancies for charge balance; observed trace element variations, on the other hand, are not related to P substitution. Element mapping reveals fine-scale oscillatory P zoning in unusual serrate patterns, indicating rapid crystal nucleation from a melt as proposed by Boesenberg and Hewins (2010) and a subsequently variable rate of crystallization. The timing of phosphoran olivine formation in Springwater is constrained to after the period of macroscopic olivine rounding but before the cooling of the metal matrix; because the phosphoran overgrowths overprint specific host grain boundary modifications, we suggest that the episode of extremely rapid cooling necessary to crystallize and preserve this rare phase may have been triggered by an additional impact to the parent body.

**Keywords:** Phosphoran olivine, Springwater pallasite, petrography