



Early impact event and fluid activity on H chondrite parent body registered in the Pułtusk meteorite

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Impact is one of the most important processes affecting asteroids, but it is neglected as a source for heat of these bodies. Recent modeling work show, however, that impact into warm planetesimals is able to cause global-scale temperature increase to the point of melting of silicates [1]. An obvious consequence of this fact is that the impact activity in early evolution of asteroids may promote formation of melt and its differentiation.

H chondrites provide some lines of evidence for an early, 4.4 Ga impact event on their parent body. The event resulted in formation of heavily shocked and melted H chondrites with old gas retention ages [2, 3], including Portales Valley, an unique metal-rich breccia [e.g. 4]. The impact led also, very likely, to unmixing of silicate and metal-sulfide melts and to formation of silicate-iron non-magmatic IIE meteorites [5]. Additional evidence for this event, and for melting it caused, may come from highly equilibrated and recrystallized fragments of the Pułtusk meteorite containing vein-like metal accumulations [6].

In the Pułtusk, vein-like metal accumulations are kamacite-rich, and basically depleted in sulfides. They form many tendrils into the equilibrated, well recrystallized chondritic rock. Marked feature of the chondritic rock at the contact with accumulations is presence of unusually large phosphate and feldspar grains. The minerals bear record of crystallization from melt. Both vein-like metal accumulations and chondritic rock record, however, slow cooling rate.

Phosphates are in the meteorite represented by merrillite and apatite, predominantly intergrown with each other. Merrillite poikilitically encloses silicate grains. It is probably of magmatic origin, since it contains detectable amount of potassium and high content of sodium. Apatite contains varying concentrations of chlorine, fluorine and missing structural component. Content of Cl and F are negatively correlated and both elements are heterogeneously distributed in the mineral, forming complex, patchy compositional zoning.

Formation of vein-like metal accumulations in the Pułtusk requires impact activity, since under static conditions metal would have formed isolated patches or globules, rather than veins. The impact event must have affected warm parent body in its early evolution, what resulted in slow cooling. Association of phosphate minerals with metal accumulations suggests that they were also formed in response to impact activity. The most likely source of phosphorous to form merrillite was oxidation of P from metal alloys. Merrillite was magmatic rather than metamorphic in origin, whereas apatite overgrowing it was probably formed by interaction between merrillite and a halogen-rich residual fluid or vapor derived from an impact melt.

References: [1] Ciesla F.J. et al., 2013. *MaPS* 48: 2559–2576. [2] Swindle T.D. et al., 2009. *MaPS* 44: 747–762. [3] Wittmann A. et al., 2010. *JGR* 115: E07009. [4] Ruzicka A. et al., 2005. *MaPS* 40: 261–295. [5] Ruzicka A., 2014. *Chem der Erde* 74: 3–48. [6] Krzesińska A., 2011. *Meteorites* 1: 3–12.