

VOLATILE METAL-BEARING PHASES ASSOCIATED WITH CUMULUS PIGEONITE IN CHASSIGNY - INDICATIONS FOR THE PETROGENESIS

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Introduction: Chassigny is a martian cumulate dunite [1,2], but the petrogenesis of this meteorite, and chassignites in general, remains a matter of debate [2-4]. On the one hand, chassignites reveal a number of mineralogical, petrological and geochemical similarities with nakhlites, suggesting these groups may have formed co-genetically. For instance, both groups have a concordant crystallization age of 1.3 Ga, the same ejection ages and they share isotopic compositions [4-7]. On the other hand, significant geochemical differences exist, mainly in trace and minor element distributions, that cannot be explained if the two groups crystallized as cumulates in a closed-system magma chamber [2,3].

A recent study of the volatile distribution in Chassigny apatites within olivine-hosted melt inclusions and intercumulus mesostasis [8] revealed that the parent magma chamber was metasomatized by Cl-rich LREE fluids during the late stages of crystallization of the Chassigny cumulate horizon. It was suggested by [4,9] that an ingress of fluid could account for the geochemical differences between Chassigny and nakhlites. One of the effects of infiltrating metasomatism in the potential chassignite-nakhlite magma chamber would be the formation of an olivine-pigeonite horizon [9] that is, however, currently unreported in meteorite collections. Here we report on cumulate pigeonite-bearing Chassigny fragments and present mineralogical and petrological characteristics, which are consistent with infiltration metasomatism.

Samples and methods: We have conducted a non-destructive survey of twelve Chassigny fragments (BM.1985,M173 and BM.19972) with 5 fragments of 500-2000 mg and 7 fragments of 20-100 mg. Pyroxene in the fragments was initially identified by non-destructive X-ray microtomography (~10 µm/voxel). Individual fragments proven to host pyroxene were re-scanned by Zeiss XRadia Versa 520 3D X-ray microscope to obtain sub-micron voxel resolution and a contrast sufficient to discriminate between low- and high calcium pyroxenes. The mineralogy and chemical compositions of the same unprepared fragments were analysed using SEM-EDX under low vacuum (30 Pa) with FE-SEM Quanta 650 with an annular SDD. Pyroxene qualitative EDX compositional data were compared to quantitative EPMA analyses collected from thin section UNSM 624-2, which was previously studied by [1,3] and proven to host pyroxene. Detailed mineralogy of the fragments was studied by EDX analysis under high vacuum using ultra-low current conditions using the FE-SEM/EDX Quanta with a 100 nm spatial resolution.

Results: Among twelve surveyed fragments, only two (908 mg and 60.2 mg) contain pyroxene in significant amounts, 7.5 vol% and 35 vol%, respectively. In both fragments the pyroxene clearly forms a cumulus texture and in places it partly poikilitically encloses olivine. The pyroxene is chemically complex, but the dominant phase is pigeonite with the composition $\text{En}_{60-65} \text{Fs}_{22-26} \text{Wo}_{8-18}$; Mg# 0.71-0.75. Pigeonite is rimmed by 20-80 µm wide augite crystals. In some cases, instead of pigeonite the core parts of pyroxene domains form lamellar overgrowths of low-Ca pyroxene ($\text{En}_{65-68} \text{Fs}_{25-29} \text{Wo}_{2-8}$; Mg# 0.69-0.73) and augite ($\text{En}_{46-51} \text{Fs}_{16-19} \text{Wo}_{32-37}$; Mg# 0.74-0.77).

Both pyroxene-bearing fragments host ~10 µm-sized aggregates comprising Pb, Hg, Ag, Au and Sn-phases. No similar assemblages were found in any pyroxene-free fragments of Chassigny. Mineralogically, these assemblages are formed mainly by sulfides (galena, cinnabar, argentite) but oxides are also present. Additionally, there is an as yet undefined Pb,Cl-phase associated with the aggregates. Individual crystals within the aggregates are 1-2 µm in size and of euhedral-subhedral shapes.

Discussion: Based on the 3D texture and chemical composition, the pigeonite, along with olivine, is a cumulate phase. We propose that the fragments originated in the olivine-pigeonite horizon, the formation of which was proposed in the model of [9]. This is strongly supported by the occurrence of Pb, Hg, Ag, Au and Sn sulfides. Since the sulfides occur in clear association with the pyroxene, the metals were most reasonably delivered to the melt after the olivine-chromite cumulate horizon settled but before the pigeonite-olivine horizon crystallized. The elements forming these assemblages are volatile metals, thus they were likely derived by exogenous Cl-rich fluids that metasomatized the magma as suggested by [8,9]. Our results support the model of infiltration metasomatism [9] during crystallization of Chassigny and shed more light on the potentially co-magmatic origin of Chassigny and the nakhlites.

References: [1] Floran R.J. et al. (1978) *GCA* 42: 1213-1229. [2] McSween H.Y. and Treiman A.H. (1998) *Planetary materials* (ed: Papike J.J.): F1-F53. [3] Wadhwa M. and Crozaz G. (1995) *GCA* 59: 3629-3645. [4] Filiberto J. (2008) *GCA* 72: 690-701. [5] Nyquist L.E. et al. (2001) *SSR* 96: 105-164. [6] Carlson R.W. and Boyet M. (2009) *EPSL* 279:147-156. [7] Korochantseva E.V. et al. (2011) *MaPS* 46: 1397-1417. [8] McCubbin F.M. and Nekvasil H. (2008) *Am. Miner.* 93: 676-684. [9] McCubbin F.M. et al. (2013) *MaPS* 48: 819-853.