Constraints on the formation process of the ungrouped NWA 6704 primitive achondrite

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NWA 6704 is an ungrouped primitive achondrite found in Algeria in 2010. It is composed mainly of low-Ca pyroxenes, less abundant Ni-rich olivine, feldspar, chromite, awaruite, heazlewoodite, pentlandite and whitlockite. The U-Pb dating of this meteorite shows the crystallization age of 4563.75 ± 0.41 Ma [1]. This ancient primitive achondrite provides unique insights into growth and differentiation of planetesimals in the very early stage of solar system evolution. To better understand the formation processes of this meteorite, we have conducted textural and mineralchemical study of two polished thin sections (TS-1, TS-2) using SEM-EDS-EBSD, EPMA and LA-ICP-MS.

The texture of this meteorite is properly represented by aggregates of orthopyroxene megacrysts ($Fs_{40-42}En_{53-57}Wo_{3-7}$: opx) with interconnected hollows filled with finer interstitial phases rather than poikilitic textures as previously reported [2]. Other phases, i.e., olivine (Fa_{50-53}), chromite, awaruite (78-81 wt% Ni), and feldspar ($Ab_{91-93}An_{5-6}Or_2$) occur in the interstices and the hollows. Olivine also occurs as vermicular inclusions within the opx megacrysts. In TS-1, opx grains are generally <6.2 mm long and several of them include vermicular olivine, whereas opx megacrysts in TS-2 are >4.5 mm and up to 1.56 cm across and only a few of them inclue vermicular olivine. The negative correlation between the opx size and the number of vermicular-olivine bearing opx, the hollow morphology, and optical continuity of interstitial and hollow-filling feldspars suggest that the vermicular olivine and its host opx acted as nuclei for rapid growth of skeletal megacrysts under extreme supercooling. Some pigeonite rimming opx megacrysts, however, contain submicrometer–size augite ($Fs_{17}En_{45}Wo_{39}$) exsollution lamellae. We obtained ~1050°C temperatures with two-pyroxenes [3] and 770°C with olivine-spinel $FeMg_{-1}$ exchange geothermometers [4]. The cooling rate between 1100-950°C was estimated to be ~0.02°C/hr from the thickness and wavelength of multiple exsolution lamellae [5], indicating significant decrease in the cooling rate at a later magmatic - subsolidus stage.

[1] Iizuka et al. (2013) *LPSC* **44**, #1841. [2] Irving et al. (2011) *MetSoc* **44**, #5231. [3] Lindsley & Andersen (1983) *Geophys. Res.* **88**, 887-906. [4] Ballhaus et al. (1991) *CMP* **107(1)**, 27-40. [5] Takagi et al. (2014) *JPGU Abstr*.