

PHOSPHATE CHEMISTRY IN BRACHINITES AND BRACHNITE LIKE METEORITES.

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Introduction: Chlorine is an unusual isotopic system, being essentially unfractionated ($\delta^{37}\text{Cl} \sim 0\%$) between bulk terrestrial samples and chondritic meteorites [e.g., 1-2], yet showing large variations in lunar, martian, and eucrite samples (from ~ -4 to $+81\%$, [e.g., 3-6]). Previous works have invoked magma ocean processes as the culprit for fractionation of chlorine isotopes on some planetary bodies. For example, on asteroid 4 Vesta magma ocean degassing of metal chlorides and/or KCl has been suggested [6] and on the Moon either degassing of metal chlorides directly from the LMO or from the LMO residuum ‘urKREEP’ (potassium, rare earth elements, and phosphorous) component is invoked [3,7-8].

To date little progress has been made studying the volatile records (H and Cl isotopes) encased in primitive achondrites. Such samples can provide important insights to volatile origins and fractionation early in the solar system history since primitive achondrites bridge the gap between chondrites and materials from fully differentiated parent bodies. Recently, brachinite-like meteorites Graves Nunataks (GRA) 06128 and 06129, have been studied for volatiles [9]. Those authors found that Cl isotopes in apatite in GRA 06128/9 are distinct from planetary mantles (i.e., Earth, Moon, and Mars) and most chondrites. They suggested such fractionated values might be related to addition of D and HCl-rich ice to the GRA parent body and precipitation of apatite from Cl-bearing brines.

While major advances have been made to understand the potential role and sources of volatiles to the parent body of GRA 06128/9, the uncertain linkage of these meteorites to the brachinites and other brachinite-like achondrites highlights the need to investigate more samples for their volatile systematics if we are to fully understand melt processes in the interiors of ancient FeO-rich asteroids, parent body processes involving volatiles (e.g., metasomatism), and their ultimate sources. In this work, we investigate the textural occurrence of phosphates and their chemistry in brachinite and brachinite-like meteorites.

Samples and Methods: We studied polished thin sections of the meteorites Northwest Africa (NWA) 3151, NWA 4969, and NWA 5400 using a Cameca SX100 electron microprobe (EPMA) at the University of Arizona. We first collected X-ray (Si, Al, Ti, Ca, Fe, Mg, K, Na, P, Ni, Cr, S, Ba, and Zr) and backscattered electron (BSE) mapping of each sample. These maps were used to determine mineral modal abundances of major phases (i.e., olivine, pyroxene) and minor to trace phases (i.e., apatite) using the threshold method and quantified using ImageJ. The maps were also used to locate P and Ca hotspots indicating phosphates. We examined the textural setting of the phosphates using BSE and energy dispersive spectroscopy. We then performed EPMA spot analyses to determine mineral chemistry following procedures we have employed in our prior work and analyzing for Ca, P, Fe, Mn, Mg, Na, Ce, Y, F, Cl, and S.

Initial Results and Future Work: Three phosphates occur in our samples (apatite, merrillite, and an Fe-phosphate) and in some cases they are intergrown. The latter contains $\sim 48-50$ wt.% FeO and ~ 30 wt.% P_2O_5 . Textural analysis using BSE imaging indicates that these form via terrestrial alteration and possible leaching of chlorine from apatite. Consistent with prior work, apatite and merrillite contain low abundances of Ce and Y, and merrillite is Na-rich (~ 0.5 to 3 wt.% Na_2O). Apatite in NWA 3151 and NWA 4969 contain <1 wt.% F and between ~ 3 and 4.5 wt.% Cl. Northwest Africa 5400 on the other hand displays much more variable apatite chemistry. We are continuing our textural analysis to pinpoint the source of the observed intra-grain and intra-sample variations in apatite chemistry. In the future we will measure the Cl-isotope compositions by ion probe.

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