OVERVIEW

**Goal** – To understand the origin and evolution of volatiles (H, Cl, F, S, etc) in the early solar system through studies of brachinites and brachinite-like achondrites (BLA) [1-2].

**Problem** – Volatiles in FeO-rich achondrites are largely unconstrained, however, assessing their inventories and isotope ratios is not straightforward since all are ‘finds’.

**Approach** – We are conducting a detailed textural and chemical study of apatite (Ca$_5$(PO$_4$)$_3$(F,Cl,OH) in brachinites and BLA. The results will guide future microstructural studies and ion probe measurements.

**Key Takeaway** – Unravelling the indigenous volatile chemistry of FeO-rich achondrites is not straightforward due to complex formation, metamorphic, and alteration histories.

SAMPLES

We studied standard polished thin sections of 1) three brachinites Northwest Africa (NWA) 3151, NWA 4969, and NWA 5471, and 2) two paired ungrouped achondrites that have affinities to brachinites (i.e., BLA) NWA 5400 and NWA 6292.

METHODS

- Optical microscopy using a Keyence Digital Microscope (PPL, XPL, RL) (Fig. 1)
- Electron probe microanalysis (EPMA) using a Cameca SX100 for X-ray mapping, imaging, and spot measurements [e.g., 3]
- Modal Mineralogy using ImageJ

PHOSPHATE TEXTURES & ASSEMBLAGES

- Apatite is the main host of F and Cl, and it co-exists with merrillite and Fe- and P-rich phase, likely Fe-hydroxide.
- Textural analysis indicates replacement of apatite by merrillite.
- Apatite is dominated by nano-scale Fe-rich veins and blebs (Fig. 4)

PHOSPHATE CHEMISTRY

- Apatite display varied X-site chemistries (Fig. 5).
- NWA 3151 & 4969 are consistent with prior studies of apatite in brachinites [4-5] and Graves Nunatak 06128/9 [6] whereas the other samples are more Cl-rich.
- Merrillite is more Na-rich (>2.5 wt%) in brachinites than in BLA (<2 wt% Na$_2$O).
- Fe-alteration phases in all samples are P-rich.

FINDINGS & FUTURE WORK

- Phosphates in FeO-rich achondrites display complex textures and chemistry that are the culmination of their formation, metamorphism, and alteration histories.
- In order to use apatite as a tool for constraining the abundance and origin of volatiles in olivine rich parent bodies, we will finalize our textural and chemical analysis of phosphates and perform microstructural analysis to identify apatites that most likely retain indigenous volatiles.