ATOM PROBE TOMOGRAPHY OF NANOSCALE STRUCTURES IN CARBONATES FROM THE QUEEN ELIZABETH RANGE (QUE) 93005 CM2 CARBONACEOUS CHONDRITE: IMPLICATIONS FOR THE EVOLUTION OF PARENT BODY FLUIDS.

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Introduction: Determining the timing of aqueous alteration in carbonaceous chondrites, and constraining the nature of the fluids responsible, is crucial to our understanding of the early evolution of planetesimals. Carbonate minerals precipitated during aqueous alteration are particularly informative despite their relatively low abundance [1, 2]. Petrographic relationships between carbonate phases reveal their relative ages and the evolution of the fluids, while the short lived ^{53}Mn-^{53}Cr geochronometer allows these fluid rock reactions to be dated [1, 2]. While the macro-scale relationships between phases have been described in detail [1, 2] the nanoscale chemical and isotopic signatures are poorly constrained. Here we apply atom probe tomography (APT) to a suite of carbonate minerals including dolomite and breunnerite in the CM2 carbonaceous chondrite Queen Alexandra Range (QUE) 93005 in order to evaluate any nanostructures present, which have the potential to provide new insights into aqueous alteration.

Methods: Fifteen atom probe needles were extracted and prepared from two carbonate grains in QUE 93005 (eight breunnerite needles/six dolomite needles; Fig. 1a,-c) using a Ga Focused Ion Beam (FIB) at the University of Sydney following the approach of [3]. The specimens were analysed on the CAMECA Local Electrode Atom Probe (LEAP) 4000X Si atom probe at the University of Sydney. Approximately 1-20 million ions were collected per specimen and the 3D distribution of these ions was reconstructed using the IVAS software package.

Results: APT reconstructions of breunnerite reveal a complicated multiphase assemblage at the nanoscale with 2 nm thick lamella of dolomite regularly spaced at 10 nm intervals within the breunnerite (Fig. 1d). Within the dolomite lamellae are also two varieties of 1-2 nm size nuggets; Sc-rich and ScF-rich (Fig. 1d). APT reconstructions of the dolomite reveal that it is chemically homogeneous (Fig. 1e).

Discussion and Conclusions: The macro-scale petrography of these carbonates suggests that dolomite predates the breunnerite [1]. However, the dolomite lamellae observed here suggest that they formed later through a reaction with a chemically distinct fluid as evidenced by the F- and Sc-rich nano-nuggets decorating these lamellae along rational crystallographic planes. Mn and Cr isotope peaks are clearly defined within the breunnertie mass spectrum. We are currently investigating whether meaningful ^{53}Cr/^{52}Cr and ^{55}Mn/^{52}Cr ratios from these regions can be obtained to enable dating via the ^{53}Mn-^{53}Cr system and using the approach for APT isotopic analysis devised by [4]. The ^{53}Mn-^{53}Cr results of this will be discussed.

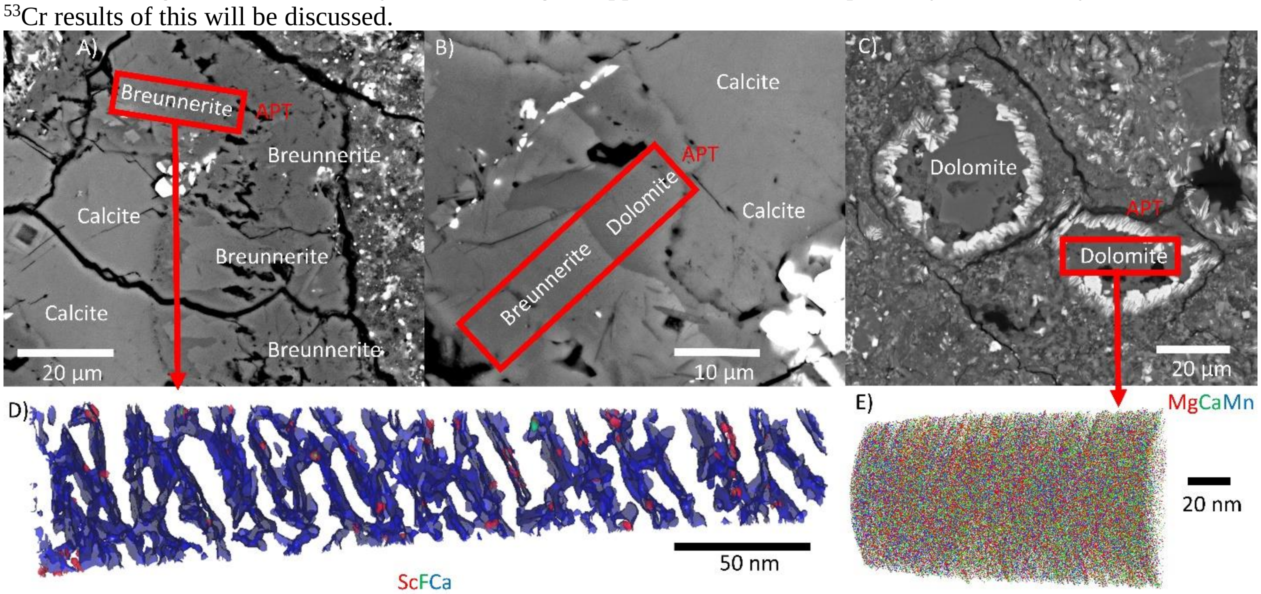

Figure 1. A and B) Backscattered electron (BSE) images of two regions within a multi-phase carbonate assemblage in QUE 93005. C) BSE image of a dolomite grain QUE 93005. D and E) APT reconstruction of a breunnerite and dolomite respectively. APT data reveal multiple nanoscale phases within breunnerite.

References: [1] Lee M.R., et al., (2012), *Geochim. et Cosmochim. Act.*, 92, 148-169. [2] Fujiya W. et al., (2012), *Nat. Comms.*, 3, 262. [3] Thompson, K., et al., (2007), *Ultramic*. 107, 2, 131-139. [4] Daly et al., (in press) *G&GR*.