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Investigation into the aqueous history of C2-ung carbonaceous chondrite meteorites

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As widespread products of aqueous alteration, carbonates are a valuable tool for investigating hydrous processes on the parent bodies of primitive carbonaceous chondrites (CC) [1]. By analysing different generations of carbonates petrographically, chemically, and isotopically, environmental condition changes can be inferred throughout the alteration sequence, notably changes in temperature and fluid composition [2][3].

Ungrouped CCs are samples that defy classification into one of the established CC groups (although they may share affinities with one or more groups). The study of ungrouped samples is important for uncovering the geological diversity of the outer solar system and developing our current classification system. C2-ungrouped sample Essebi has been studied to investigate this geological history.

Essebi is clastic breccia that mostly comprises phyllosilicates (~63 vol%) and anhydrous silicates (~20 vol%) giving an alteration extent of 1.5 based on previous methods [4]. A multigenerational sequence of carbonates was found. First-generation calcites, termed “GA” are characterised by anhedral morphology, porous texture and ^{16}O-poor isotope compositions (33.2 - 42.0‰ δ^{18}O, 18.3 – 25.8‰ δ^{17}O), while the later generation, termed “GB”, are characterised by sub-euhedral morphology, higher levels of Mg (<2.5 wt.%), Mn (<1.5 wt.%) and Fe (1.7 wt.%) and ^{16}O-rich compositions (14.4 – 27.3 ‰ δ^{18}O, 5.7 – 16.7‰ δ^{17}O). Using an assumed water composition (δ^{18}O: 2.0 – 8.1 ‰ [5]) calcite formation temperatures are calculated reaching +40°C.

Whilst CM chondrites also show multi-generational carbonates recording different alteration stages, these carbonates are petrographically distinct from Essebi. Notably Essebis GA calcites lack tochilinite-cronstedtite intergrowth rims found on their CM equivalent (T1 calcites). Later carbonate generations occurred post-brecciation on Essebi unlike CMs where alteration predates brecciation.

The petrographic differences and isotopic similarities to CM chondrites suggests CM alteration processes are more ubiquitous across the early solar system than previously thought.

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