PROBING THE THERMAL AND DEFORMATION HISTORIES OF CHONDRULES IN A CLUSTER CHONDRITE LITHOLOGY OF NORTHWEST AFRICA 5205 WITH ELECTRON BACKSCATTER DIFFRACTION (EBSD) TECHNIQUES

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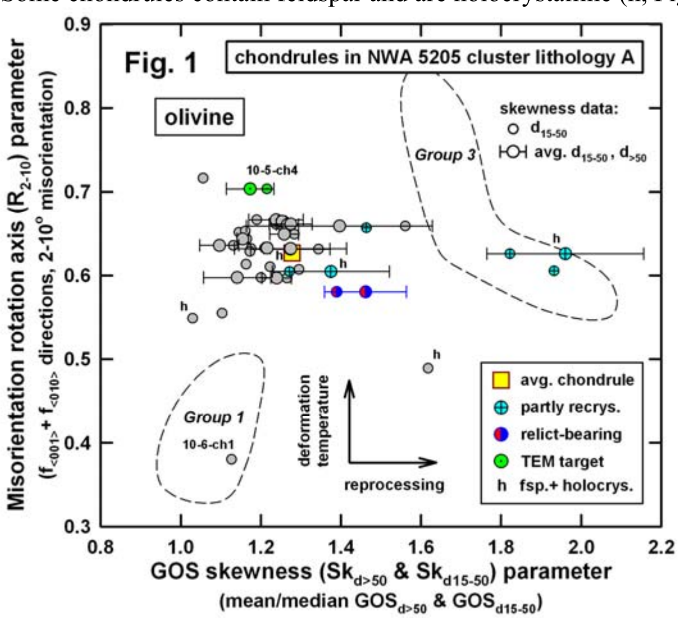
Introduction: Chondrules in type 3 ordinary chondrites have long been interpreted to have experienced varied pre-agglomeration thermal and shock deformation histories based on microstructures in olivine [e.g., 1]. Here we show that electron backscatter diffraction (EBSD) techniques can be used to probe the thermal and deformation histories of chondrules in Northwest Africa (NWA) 5205 (LL3.2), by extending methods used previously to evaluate shock processing effects in type 6 ordinary chondrites [2, 3]. We report on chondrules in a well-formed cluster texture lithology (A) of Northwest Africa (NWA) 5205, which have been interpreted to have accreted while still warm [4-6]. Our data support the idea that most chondrules in this lithology agglomerated while warm, but indicate that some chondrules were cool, and some were deformed and reheated prior to agglomeration.

EBSD Parameters: EBSD methods can be used to probe olivine for deformation temperature and subsequent processing, including post-deformation annealing (recovery) and mixing of variably deformed grains [2, 3]. Relative deformation temperature is based on misorientation rotation axis frequency in different directions in an olivine crystal frame, with a parameter we designate as $R_{2\text{-}10}$, which is related to the proportion of 2-10° misorientation axes in the <010> and <001> directions of olivine. Post-deformation processing is related to the skewness (defined here as *Sk* = mean/median) of Grain Orientation Spread (GOS, the average misorientation of a grain) for larger (effective diameter $d \geq 50$ µm) grains in a sufficiently large grain population [2, 3].

Chondrules in NWA 5205: For type 3 ordinary chondrites, we infer that a grain population of >50 grains is sufficiently large to meaningfully define *Sk* and that d>50 µm and d=15-50 µm grains give consistent results, allowing us to examine both $R_{2\text{-}10}$ and *Sk* for many chondrules in NWA 5205 (Fig. 1). Fig. 1 compares the chondrule data to previously studied type 6 ordinary chondrites, including Group 1, inferred to have been cold-deformed and quickly cooled following strong shock; and Group 3, inferred to have been warm-deformed and subsequently annealed by burial in warm materials [2, 3]. Most chondrules in NWA 5205 have $R_{2\text{-}10}$ values that overlap Group 3, suggesting that most accreted while still warm [5, 6]. However, not all chondrules were equally warm, with barred olivine chondrule 10-6-ch1 being especially cool when it was deformed (Fig. 1). This suggests that chondrules accreted with a mix of thermal states, supporting previous inferences [6]. *Sk* values are highly variable among chondrules, varying between Group 1 and Group 3 (Fig. 1). Elevated *Sk* values are obtained for one chondrule with relict and normal olivine, and for chondrules that show partial recrystallization (or neocrystallization) textures together with more deformed grains (partly recrys, Fig. 1), interpreted as reflecting incomplete thermal re-processing after deformation. Re-processing included some combination of incomplete partial re-melting, annealing, and recrystallization. Some chondrules contain feldspar and are holocrystalline (h, Fig. 1), consistent with protracted thermal processing.



Implications: Altogether, the data suggest that chondrules in the NWA 5205 cluster lithology experienced varied histories prior to final agglomeration, including many that were deformed while warm, some that were deformed while cool, and some that were re-heated. These data have implications for both chondrule and planetesimal formation.

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