A ROBUST ELECTRON BACKSCATTER DIFFRACTION ANNEALING METRIC FOR OLIVINE.

A. M. Ruzicka[1] and R. C. Hugo[1], [1]Cascadia Meteorite Laboratory and Department of Geology, Portland State University, Portland, OR, 97201-0751, U.S.A., ruzickaa@pdx.edu.

Introduction: Electron Backscatter Diffraction (EBSD) data can provide information on the extent of shock damage within crystals. The average misorientation within a grain is characterized by Grain Orientation Spread (GOS) [1]; for a population of grains with a distribution of GOS, skewness (Sk = mean GOS/median GOS) with Sk>1 (positive skewness) indicates a small number of more-deformed grains amidst many less-deformed grains. Elevated Sk is seen for larger olivine grains (d > 50 µm, where d = equivalent grain diameter) in some heavily annealed type 6 chondrites that were interpreted to have been buried in warm materials following shock [2]. But a similar signature can arise by impact-admixture of more deformed material into less-deformed material [2], and some type 3 ordinary chondrites too have elevated Sk that is more likely caused by deformation heterogeneity than annealing [3]. Thus, one needs a more reliable way to distinguish between annealing and other effects. Here we use EBSD data for olivine in ordinary chondrites to suggest a more robust annealing metric that should be generally applicable to assess significant post-deformation annealing.

Skewness ratio: The more robust EBSD annealing metric is related to Sk for different grain sizes, specifically $Sk_{larger\ d}/Sk_{smaller\ d}$, or skewness ratio. During annealing, dislocations within a crystal migrate until they either combine with other dislocations to create a subgrain boundary or annihilate at a grain boundary or free surface. Smaller grains are more likely to lose their dislocations at nearby grain boundaries, so an annealed microstructure will contain large grains with sub-boundaries and high GOS, large grains with no sub-boundaries and low GOS, and small grains with uniformly low GOS. Thus, an annealing signature will be elevated GOS skewness ratio (>1), and generally low GOS. In contrast, there is no reason to expect that admixture of more deformed material into less deformed material would result in these systematics.

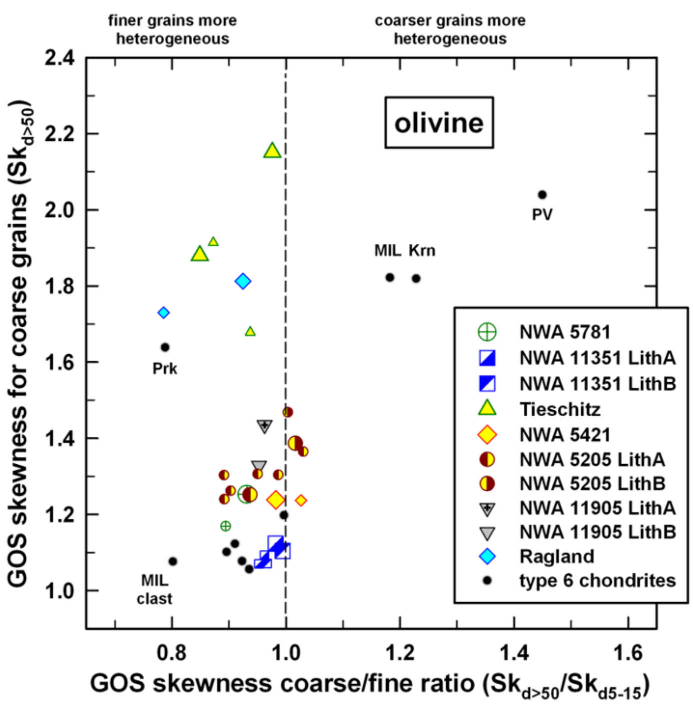

Fig. 1 shows data for type 3 and type 6 ordinary chondrites we have analyzed [2,3,4], which compare the previous metric for annealing ($Sk_{d>50}$) to the new proposed metric for annealing, $Sk_{d>50}/Sk_{d5\text{-}15}$. We use d=5-15 µm as the smaller grain size because this size is often accessed in EBSD maps for step sizes of ≤4 µm that we use and are the most numerous grains in most maps, giving good statistics for their GOS distributions. The plot shows datapoints for both large area maps (LAMs, larger symbols) and smaller-area but still representative maps (mini-LAMs, smaller symbols). As can be seen, most chondrites of both type 3 and type 6 have both low $Sk_{d>50}$ and $Sk_{d>50}/Sk_{d5\text{-}15}$ values, suggesting they have not been significantly annealed after deformation. Four type 6 chondrites (Park, MIL 99301, Kernouvé, Portales Valley) and two type 3 chondrites (Tieschitz and Ragland) have high $Sk_{d>50}$, but only MIL 99301, Kernouvé, and Portales Valley also have high skewness ratio consistent with other optical, EBSD, and TEM signatures of annealing. For Park, Tieschitz and Ragland, deformation heterogeneity not caused by annealing is apparently resulting in high $Sk_{d>50}$. The new assessment for Park is more consistent with TEM data for this meteorite, which suggested elevated deformation temperature but no significant role for dislocation recovery associated with annealing [5].

Conclusion: GOS skewness ratio is a more robust EBSD metric for annealing in olivine than the previous metric based on GOS skewness of coarse grains alone.

References: [1] Brewer L.N. et al. (2009) In *Electron Backscatter Diffraction in Materials Science*, pp. 251-262. [2] Ruzicka A.M. and Hugo R.C. (2018) *Geochimica et Cosmochimica Acta* 234:115–147. [3] Ruzicka A.M. et al. (2020) *51st LPSC*, Abstract #1308. [4] Hugo R. C. et al. (2020) *Meteoritics & Planetary Science* 55: 1418-1438. [5] Ruzicka A. et al. (2015) *Geochimica et Cosmochimica Acta* 163:219-233.