ANNEALING AFTER SHOCK: EVIDENCE FROM OLIVINE MICROSTRUCTURES IN PORTALES VALLEY.

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Introduction: TEM dislocation analysis of olivine grains in the Portales Valley (PV) metallic-melt breccia [1] provide an opportunity to test whether post-shock annealing could have lowered optically-determined shock stages and contributed significantly to the thermal metamorphism of chondrites [e.g., 2]. Various pre-annealing peak shock pressures have been proposed for PV ranging from S2 [1], to S3 [3], to S6 [2], followed by annealing to the current shock stage of S1 [1, 2, 3].

Results and Discussion: Twelve olivine grains were examined from an area of typical PV matrix. The coarsest olivine grain in this region is ~100μ across. Dislocation densities range from no dislocations to 7.9×10^9 cm^{-2}, with an area-weighted average of 1.1×10^8 cm^{-2}. The character of the dislocations varies from region to region, with straight dislocations predominant. Most dislocations are straight b=[001] screws, sometimes connected with short edge segments, consistent with high strain rate deformation at relatively low temperatures (roughly ≤1000°C [4]). Curved or jogged dislocations and those located at subgrain boundaries are interpreted as having formed by recovery as a result of annealing.

In PV, the ratio of dislocations that are not part of a subgrain boundary to those in a subgrain boundary (free to bound ratio) varies from region to region and inversely with dislocation density, consistent with annealing. Some dislocations evidently were removed by annihilation during recovery. Thus we interpret the range of dislocation densities to be partly the result of annealing, with a decrease in dislocation densities in a few areas by 1 to 2 orders of magnitude from the maximum value.

The dislocation densities in PV are clearly lower than those observed in heavily shocked (S6) chondrites [5] and higher than those reported for weakly shocked (S1) chondrites [6]. Our observations support the idea that optical evidence for shock in PV is low in part due to annealing effects. However, many regions have few or no dislocations, with no dislocations in subgrain boundaries, suggesting that shock effects were nonuniform from grain to grain and that the maximum shock intensity experienced by PV as a whole was low, possibly S2 to S3 based on comparison to other chondrites [5, 6, 7]. It appears that annealing in PV was only moderately effective at lowering its apparent shock stage.

References: [1] Ruzicka A. et al. 2005. *Meteoritics & Planetary Science* 40:261-295. [2] Rubin A.E. et al. 2001. *Geochimica et Cosmochimia Acta* 65:323-342. [3] Kring D.A. et al. 1999. *Meteoritics & Planetary Science* 34:663-669. [4] Phakey P et al. 1972. In Heard H.C. ed., *Flow and Fracture of Rocks*, 117-138. [5] Langenhorst F. et al. 1995. *Geochimica et Cosmochimica Acta* 59:1835-1845. [6] Töpel-Schadt J. and Müller W.F. 1985. *Earth and Planetary Science Letters* 74:1-12. [7] Ashworth J.R. and Barber D.J. 1975. *Earth and Planetary Science Letters* 27:43-50.