MICROFAULTING OF CAI RIM LAYERS AND RELATIONSHIP TO THE FABRIC OF THE LEOVILLE (CV3) CHONDRITE; A. Ruzicka and W.V. Boynton, Dept. Planetary Sciences, University of Arizona, Tucson, AZ 85721

Leoville has long been known to contain chondrules and Ca,Al-rich inclusions (CAIs) that are oriented, evidently as a result of a "global" deformation (1,2). CAI rim layers in Leoville are locally displaced by what are obviously shear fractures (3), and these allow measurement of displacement orientations and magnitudes. The faults often displace not only rim layers but also adjacent matrix surrounding CAIs, and sometimes can be traced into the interiors of CAIs. The cross-cutting relationships suggest that faulting occurred relatively late—either after the formation of accretionary rims on CAIs or after the agglomeration of the meteorite, or both.

A geometrical analysis of microfaulting and the fabric of Leoville was carried out for one section of the chondrite obtained from Arizona State University. This section contains numerous CAIs and displays a visually apparent fabric, comprised of preferentially oriented chondrules and CAIs. The mean elongation directions for both chondrules and CAIs are essentially the same (Fig. 1), and the standard deviation (S.D.) of the elongation direction for both classes of objects is much less than that for a random distribution (52°) (4), indicating a high degree of preferred orientation. Orientations are somewhat more variable for chondrules than for CAIs, and a small number of chondrules lie nearly perpendicular to the dominant trend (Fig. 1). Such large deviations can be explained by rotation during deformation, which could on average have affected chondrules more than CAIs if the former were less irregularly-shaped prior to deformation. The aspect ratio is defined as the ratio of the maximum dimension to the minimum perpendicular dimension and is a measure of elongation. On average, CAIs have larger and more variable aspect ratios than do chondrules (Fig. 2). The most highly elongate CAIs (aspect ratios ≈−3-19) are all fine-grained objects. Analysis of the data suggest axial ratios of apparent strain ellipses of ≈2.5-3.0 for CAIs and ≈1.8 for chondrules, and initial (pre-deformation) axial ratios of ≈2.0-2.3 for CAIs and ≈1.4 for chondrules. This suggests that CAIs were both more elongate than chondrules prior to deformation and that they underwent more flattening during deformation. The fine-grained nature of many CAIs may have made them more susceptible to flattening.

Microfault strikes (Fig. 3) show considerable scatter but tend to be concentrated ≈−30° to either side of the mean elongation direction for CAIs (≈0°; "+" and "−" values indicate clockwise and counterclockwise deviations, respectively, from this reference line). A third maximum in strike frequency at +70-90° is mainly caused by faults in one CAI (L-6). Faults striking at +10-50° have the greatest measured offset, followed by those at −20-30° and +80-90° (Fig. 3, bottom). The combination of strike and displacement data allow a good estimate to be made of the orientation of the average stress ellipsoid corresponding to the deformation, which is given by the orientations of the maximum, intermediate, and minimum principal stress directions, σ1, σ2, and σ3, respectively (Fig. 4). The model average stress ellipsoid (σ1, azimuth −90° plunge 5°; σ2, azimuth +175° plunge 20°; σ3, azimuth +5° plunge 80°) can be used to predict the formation of two faults at 30° to σ1 and containing σ2 that have strikes of +38° and −28°, with apparent offset greater for the former fault because of its more shallow dip. It is important to note that the inferred average stress ellipsoid is consistent not only with the dominant trends of microfaulting but also with the trace of the inferred strain ellipsoid, which is given by the shapes of chondrules and CAIs.

In general, it appears that the stress and strain ellipsoids in Leoville are related simply to one another and that a single deformation episode can explain both the fabric of Leoville and the microfaulting. Deviations between the observed and model strike directions indicate some combination of physical rotation of objects during deformation, local variations in the stress field, and the influence of anisotropies in the objects. Microfaulting is characteristic of high-strain-rate deformation, such as might be expected to accompany shock metamorphism, and the data presented here suggest that the preferred orientations of chondrules and CAIs in Leoville were also caused by shock. This is contrary to earlier assertions for Leoville (2), but it is consistent with a growing body of evidence that shock was an important mechanism for creating fabrics in chondrites (5,6).

Acknowledgments: Many thanks to Carleton B. Moore for loan of the Leoville section. This work supported by grant NAG 9-37 to W.V. Boynton.

Fig. 1 (upper left); Fig. 2 (upper right); Fig. 3 (lower left); Fig. 4 (below) Stereonet showing model principal stress directions, fault orientations, and corresponding strain ellipse for CAIs; net offset along faults indicated by bulls-eye patterns.