REFINED STRAIN ANALYSIS AND MAGNETIC ANISOTROPY MEASUREMENTS FOR THE PARNALLEE CHONDRITE. Deana S. Sneyd[1], Harry Y. McSween, Jr.[1], Nicholas B. Woodward[1], Niogi Sugiura[2], and David W. Strangway[2].
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Preliminary strain analysis measurements have been made previously on slab faces of the ordinary chondrite Parnallee (1). We report here the results of a refined method of strain analysis using three orthogonal thin sections of Parnallee, as well as new magnetic anisotropy data for this meteorite. This is the first time a three-dimensional strain ellipsoid and magnetic susceptibility ellipsoid have been measured on the same chondritic sample. The thin sections permit chondrule shapes to be determined with higher accuracy than the previous slab measurements, and a computerized procedure reduces subjectivity in measurements. The strain analysis technique utilizes the ellipse tracing, Rf/ϕ and PASE 5 computer programs of the Kligfield software package (2). Photomosaics of the thin sections were initially oriented in an orthogonal reference system. The ellipse tracing program computes maximum and minimum axial ratios of chondrules traced on a digitizing tablet. The previous analyses of strained chondrites utilized the arithmetic mean of chondrule axial ratios to define the strain ellipse on individual sample faces. The Rf/ϕ program computes the harmonic mean of axial ratios from the ellipse tracing program to produce a mean final axial ratio. The harmonic mean has been shown to produce results that more closely match the true ellipticity of the strain ellipse (3). Final axial ratio (R_f) of chondrules and provisional directions of strain are then calculated. Strain magnitude is determined when a set of R_s (strain imposed on chondrules) and R_i (predeformational axial ratio of chondrules) values generate a curve that most closely fits the data points. These Rf/ϕ plots are the key to analyzing the geometries of deformed chondrules and are crucial in making the distinction between strained and initially ellipsoidal chondrules.

When this technique was applied to the Parnallee thin sections, the data points plotted on the Rf/ϕ graph resulted in a symmetrical pattern about the mean ϕ. This indicates that the chondrules were randomly oriented prior to deformation. The cluster of data points near the maximum mean R_f demonstrates the degree of preferred orientation caused by the strain imposed on Parnallee.

The PASE 5 program calculates the mean strain ellipsoid from the previously generated, two-dimensional strain ellipse data. The shape of the mean ellipsoid is plotted on a Flinn diagram (Fig. 1), whose abscissa is defined as the ratio of the intermediate to minimum axes (Y/Z) and ordinate as the ratio of the maximum to intermediate axes (X/Y). The mean ellipsoid generated from Parnallee clearly falls within the oblate spheroid field. The axial ratios (X, Y, Z) of the mean ellipsoid (1.32:1.24:1) quantitatively describe the geometric plot.

Magnetic anisotropy was measured using procedures employed in (4) on the same cube of Parnallee from which oriented thin sections were taken, and magnitudes of the principal axes of the susceptibility ellipsoid were determined. The parameters R1=Xmax/Xmin = 1.503 and R_2 = Xmax·Xmin/Xint^2 = 0.709 can be used to characterize the intensity and dominant type of the anisotropy (Fig. 2). Parnallee has a high magnetic anisotropy, as indicated by its high R1 value, which is exceeded by only a few measured chondrites. The shape of the susceptibility ellipsoid, like that of the strain ellipsoid, is almost a pancake and defines a strong foliation and possibly a weak lineation. Because of uncertainty in the calculated position of the Z (shortened) axis of the strain ellipsoid, it is not possible to compare directly the orientations of the shortened axes in both the magnetic and strain ellipsoids, but we expect that they have similar orientations. These two strain indicators are only indirectly linked, as the magnetic anisotropy is controlled by the orientation of metal grains, which commonly are situated between chondrules.

These new strain and magnetic anisotropy measurements indicate a fairly pervasive degree of uniaxial shortening in Parnallee. The pancake-shaped strain and susceptibility ellipsoids show only very minor lineations (if at all), and are consistent with the hypothesis that deformation was caused by uniaxial compaction due to overburden. A previous study of Leoville (5) also reached this conclusion, but without the support of quantitative data on the shape of the 3-dimensional ellipsoids. Further studies of the strain mechanisms in Parnallee may provide insight into the physical conditions in the interior of an ordinary chondrite parent body.

References
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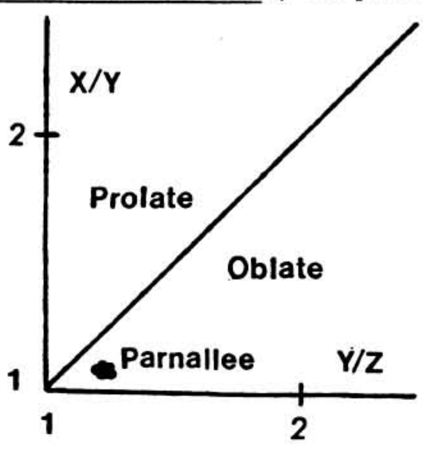

Fig. 1. Flinn diagram illustrates 6 possible solutions for the shape of the strain ellipsoid.

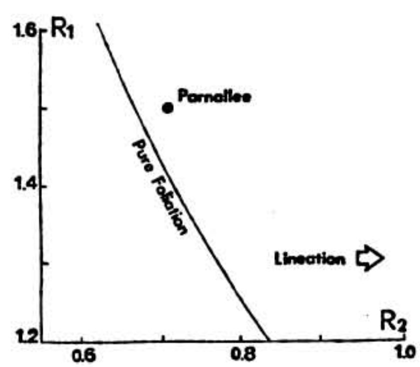

Fig. 2. Magnetic intensity (R1) vs. shape parameter (R2) indicate Parnallee has a strong foliation and possibly a weak lineation.