DYNAMIC COMPACTION OF ASTEROIDS: IMPACT-INDUCED PREFERRED 3D ORIENTATION OF METAL GRAINS IN L CHONDRITES.

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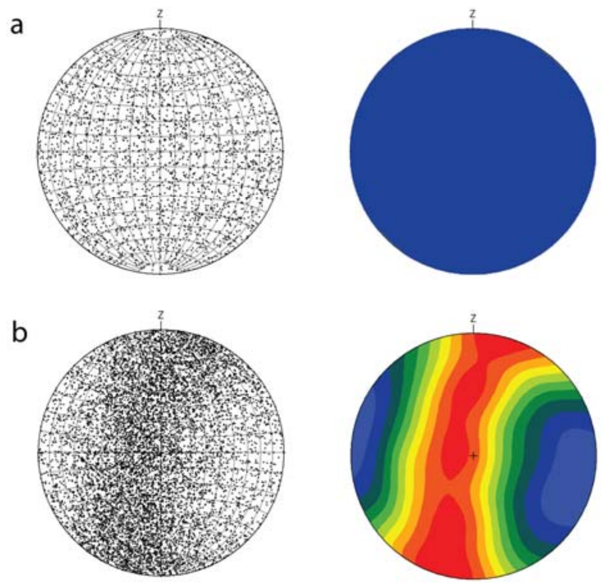
Introduction: Ordinary chondrites originate in the inner asteroid belt [1] and comprise about 85% of all known meteorites [2]. Information about the physical evolution of small solar system bodies can be gathered by examining ordinary chondrites. To examine the role of impacts in the evolution of asteroids, we have performed a three dimensional (3D) petrographic study of the morphology and distribution of Fe(Ni) metal and related sulfide phases in a suite of L chondrites that experienced varying degrees of shock loading. There is already strong evidence that petrofabrics seen in chondrites are impact-related [3]. Here, we use our 3D orientation results to examine peak impact pressures necessary for the development of foliation in the L chondrite parent body or bodies.

Methods: We used synchrotron x-ray computed microtomography (XMT) at the GSECARS 13-BM beamline located at the Advanced Photon Source of Argonne National Laboratory to collect high resolution tomographic data on 29 L chondrites. Volumetric (voxel) resolutions ranged from 8.4 to 18.8μm / voxel. [4 and 5] provide meteorite-specific data collection and post-processing details. To extract quantitative data from our volumetric representations, we used the BLOB3D software tool [6]. After isolating each metal grain within our L chondrite volumes, we constructed a best-fit ellipsoid around them [6] to examine their degree of common orientation. To quantify the degree of orientation independent of the number of particles in our volumes, we use a normalized R (mean vector) metric [7]: the higher the R, the greater the common orientation of ellipsoid major axes within a volume.

Results and Implications: Fig. 1 shows typical orientation results for an extremely mildly-shocked and a highly-shocked sample (see caption). Degree of preferred orientation increases from an R of 0.7% in the case of Baszkówka (L5, S1) to 12.9% in the case of Bluff (L5, S6). Additional samples show a progressive increase in R with higher shock stage.

Our results confirm that deformation resulting from uniaxial dynamic compaction is the most likely mechanism for the development of foliation in chondrites, as was concluded in [3]. By examining the evolving 3D orientation of metal grains in L chondrites exhibiting increasing degrees of shock loading, we will show that that the introduction of petrofabrics to chondritic parent bodies can be accomplished with peak pressures ≤5 GPa, with shock pressure calibrations based on [8]. Additionally, we will speculate on the magnitude of impacts needed to remove inherent pore volumes present in young asteroids [5].

Figure 1. Lower hemisphere, equal area stereographic projections (left) and density distributions (right) of major axis Fe(Ni) metal particle ellipsoid orientations in: a) the mildly-shocked (S1) L5 chondrite fall Baszkówka and b) the strongly-shocked (S6) L5 chondrite find Bluff. Note the absolute lack of orientation density in Baszkówka. In L chondrites, metal particles increasingly develop a preferred 3D orientation with greater degrees of petrographically-identified shock loading.



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