RELATIONSHIPS AMONG PHYSICAL PROPERTIES INDICATE THE IMPACT ORIGINS OF FRIABLE ORDINARY CHONDRITES.

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Introduction: Collisions were important for the compaction of asteroidal-sized bodies, including those from which ordinary chondrites were derived. After primary accretion, parent bodies would have retained significant amounts of ancient porosity, owing to their small diameters. High velocity impact deformation alters the physical properties of materials in two ways: by reducing porosity, and by introducing foliation, both as a result of compaction [1-8]. During a high-energy collision on a high porosity (e.g. >20-25%) body, porosity is reduced, but in low (≤2-3%) porosity bodies, the shock cracks the brittle silicates which actually reintroduce porosity to a rock. Approximately 5-7% porosity can be reintroduced by such micro-cracking [9, 10]. Metal foliation, or planar grain shape preferred orientation of metal in ordinary chondrites has been observed and the strength of foliation correlates with increasing shock intensity recorded in a rock [4,5,8]. All of this leads to a simple model [see 11] in which metal foliation is inversely related to porosity. Previously, Friedrich et al. [11] examined a suite of ordinary chondrites that deviated from the simple model. They concluded that low-porosity, weakly foliated, and apparently weakly-shocked chondrites experienced either post-shock annealing or experienced impacts occurred under warm conditions which allowed more reduction of porosity. In this work, we place a suite of high porosity and friable ordinary chondrite chondrites into the context of the porosity and foliation scheme from [11].

Samples and Methods: For this study, we imaged four ordinary chondrites with the 3D technique x-ray computed microtomography (µCT). Samples of Bjurböle (L/LL4, S1), Quenggouk (H4), Saratov (L4, S2), and Tennasilm (L4, S3) from the AMNH collection were studied. Each of these have been noted for their friability or lack of cohesion in hand sample [12-15]. We collected µCT data at the GeoSoilEnviro Center for Advanced Radiation Sources (GSE-CARS) beamline 13-BMD at the Advanced Photon Source at Argonne National Laboratory. Typical data collection parameters and procedures can be found in [5]. µCT data were collected at resolutions ranging from 2.8 to 15.9 µm/voxel edge. Lower resolutions were used for qualitative inspection and quantitative foliation investigation [5,11]. Higher resolutions are sufficient to see all of the porosity in a chondrite [10] and the images can be used to investigate the small-scale porosity or "microcracks"[9], in the samples. For our investigations, total porosity data [11,16] and quantitative foliation data [5,11] were taken from the cited works.

Results: Total porosity in the four friable chondrites range from 10.7% (Tennasilm) to 19.8% (Bjurböle). Foliation in the friable ordinary chondrites is moderate: higher than that seen in high porosity uncompacted chondrites such as Baszkówka [6] or Miller (AR) [17], but clearly less than the most compacted ordinary chondrites.

Discussion and Conclusions: Our µCT results show that the four friable ordinary chondrites have high porosity, but also some degree of metal grain foliation evident. We postulate that prior to a gentle crushing impact, the friable equilibrated ordinary chondrites such as Bjurböle, Quenggouk, Saratov, and Tennasilm were composed of high-porosity (~20%) uncompacted material. The mild impact occurred post metamorphism when the chondrites were cool. The impact was intense enough to slightly deform the metal grains and cause breakage of the brittle silicates. Some primordial porosity, like that found in the high porosity uncompacted chondrites, was removed but an equal amount was created during the impact due to crushing of silicate mineral grains.

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