

COMPREHENSIVE SURVEY OF LUNAR AND MARTIAN METEORITE PHYSICAL PROPERTIES TO IMPROVE INTERPRETATION OF SPACECRAFT GRAVITY DATA.

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Introduction: For the past several years, we have been compiling data for the density, porosity and magnetic susceptibility of lunar and martian meteorites [cf. 1,2,3] in order to improve the interpretation of gravity data from orbiting spacecraft such as GRAIL [e.g. 4,5], with the goal of better characterizing the crust of the Moon and Mars. In the case of the Moon, we supplement the breadth of surface geologies sampled in meteorites with the specific context provided by samples returned to Earth during the Apollo lunar missions. For Mars, we are limited to meteorite data for the moment.

This study spanned numerous public and private collections, including museums, university collections, and others. The data-gathering phase of the study is nearing completion. We summarize the data from our study 192 individual lunar specimens (including 61 from Apollo) and 71 martian meteorites covering a wide range of lithologies and source regions. For each, we measured grain density (the density of the solid component, without contributions from pore space), bulk density (the density of the whole volume enclosed by the outer envelope of the meteorite, including pore space), porosity (calculated from the two densities: $P = 1 - \rho_{\text{bulk}}/\rho_{\text{grain}}$), and magnetic susceptibility.

Measurement: All measurements were performed using non-destructive and non-contaminating techniques that have been widely applied in other meteorite studies [cf. 6]. Grain density was measured using ideal-gas pycnometry. Most samples were measured on a Quantachrome Ultrapycnometer, though some pieces that were too large for the commercial device were measured in a custom-built instrument that operates on the same principles [7]. Bulk density of earlier measurements employed the Archimedean glass bead method [6], but after October 2014 were done by 3D laser scanning using a NextEngine ScannerHDPro [cf. 8]. Magnetic susceptibility measurements were conducted with a ZH-instruments SM30 meter with volumetric corrections according to [9] and [6].

Lunar samples: The 192 lunar specimens represent 155 named meteorites and Apollo specimens, or 119 paired groups. They sample a wide variety of geologic sources, including both high-Ti and low-Ti basalts, feldspathic breccias, anorthosites, impact-melt breccias, and others. The Apollo specimens come from all 6 missions and include Imbrium basin ejecta sampling different depths.

Martian samples: The 71 martian specimens come from 46 named meteorites, or 42 paired groups. These include 30 shergottites of various subtypes, 7 nakhlites, 3 chassignites, an orthopyroxenite (Allan Hills 84001), and a regolith breccia (Northwest Africa 7034).

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