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Magnetic characteristics of the largest impacts on the Moon, Mars, and Earth

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The magnetic signature of impact craters can be complex, but in general two types of features are often apparent. Short-wavelength, relatively intense magnetic anomalies that occur near the center of the structure are the first of these types of features. Impact craters also disrupt the pre-existing magnetic signature, and that disruption is the second feature that can sometimes be recognized. Impacts alter the magnetic character of the affected rocks. The impacts also disrupt the pre-existing magnetic fabric and they are often characterized by broad magnetic lows because the coherence length of the magnetic features is not well-matched to the magnetic observations.

The largest crater impacts from Earth (d>30 km), Mars (d>400km) and Moon (d>300km) were identified by their quasi-circular features from most recent and detailed topographic maps (SRTM30, MOLA and LOLA respectively) and superposed on their magnetic maps, after. The high-precision topographic gridded data set revealed the presence of the largest quasi-circular depressions (QCD) as any depression set to be at least somewhat circular. These features were compared with known or possible ringed impacts database. Some large craters are obvious impact craters, strongly visible in images and covering the full spectrum of crater modification. Some of them, looking like topographic depressions with no corresponding visible structural feature on the surface, might be surface representation of completely buried impact craters and their topographic feature was compared with crustal thickness model, in the case of Mars.

An analysis tool, GRIDVIEW, created by NASA Goddard Space Flight Center, Planetary Geodynamics Lab, which can view, measure and make graphics of gridded data, was used to study the magnetic character of 37 multi-ring basins on the Moon, 36 large basins on the Mars and 27 complex craters on the Earth. Ideal body theory helped us to establish bounds on quantities such as the magnetization strength required to explain a magnetic field distribution. We document systematic trends in the amplitude and frequency of the magnetic patterns inside and outside of these basins, and note planet/satellite wide patterns. While the topographic data for these three bodies is adequate for this analysis, the magnetic data for Mars and the Moon has limitations driven primarily by its limited frequency content. If crustal thickness variations are ignored, magnetizations of the crustal rocks within impact basins vary by three orders of magnitude between Mars, Earth, and the Moon. The origin of these differences remains enigmatic, but presumably reflect differences in magnetic petrology, the magnitude of the core field, and the crustal thickness.