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Investigating Mercury's Crustal Magnetic Field

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The evolution of Mercury in its early stages is still not well known. Core-dynamo models usually predict that the field would be predominantly dipolar with a slow secular variation, with the dipole axis aligned with the rotation axis. In addition, because of the long cooling time following a basin-forming impact, the strong anomalies within the Caloris rim are interpreted as implying the existence of a core dynamo at the time when this basin formed. A valuable data set for investigating crustal magnetism on Mercury was obtained by the NASA MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) Discovery mission during the low-altitude campaign. We obtain altitude normalized maps of the crustal field constructed from low-altitude magnetometer data using an equivalent source dipole technique. Some magnetic anomalies appear to correlate with impact crater/basin locations, where the strongest anomalies at 40 km altitude have amplitudes of about 8 nT within Caloris, and about 6 nT over Rustaveli and Vyasa. However, many of craters/basins have no associated magnetic anomaly. These maps suggest that at least some of Mercury's crustal sources consist of impact melt rocks within impact basins and in externally deposited ejecta, as has also been inferred from lunar studies. The occurrence of anomalies associated with only some impact basins/craters is a new observation that will help in constraining impactor or subsurface target composition. We investigate further these isolated anomalies estimating magnetic paleopole positions, assuming that the anomalies are primarily remanent rather than induced. We use a unidirectional equivalent source dipoles method (also called Parker's method) to invert for the direction of crustal magnetization associated with isolated hermean magnetic anomalies. From the direction of magnetization, we calculate the corresponding magnetic paleopole position, which corresponds to the north magnetic pole of a predominantly dipolar core-generated field when the anomaly was formed. This method largely bypasses the non-uniqueness associated with specifying the geometry of the magnetic sources. The only assumption is that when the region acquired a remanent magnetization, the main field was constant in direction. For the anomalies investigated, the obtained magnetic paleopole positions within uncertainties are located near the current geographic South pole. Exhaustive investigation of other magnetic anomalies suitable for inversion will allow to evaluate the impactor composition, true polar wander and possible core dynamo history.