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Magnetic anomalies and landing site evaluation for STEP1 on Mars

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Magnetic field observations of Mars have revealed the presence of strong magnetic anomalies arising from crustal remanent magnetization, estimated to be up to ten times stronger than that of Earth's crust. A detailed understanding of these magnetic anomalies offers valuable insights into the history of Mars' magnetic field, interior dynamics, and surface environment. Martian magnetic anomalies have been investigated using magnetometers onboard spacecraft such as the Mars Global Surveyor and MAVEN (Mars Atmosphere and Volatile EvolutioN), as well as by landers and rovers like the InSight lander and the Zhurong rover. While spacecraft data provide a global view of the distribution of magnetic anomalies, the observation altitudes are relatively high compared to the depth of the magnetic sources and the spatial scales of the geological features. Notably, surface magnetic fields measured by the InSight lander and the Zhurong rover differ significantly from values predicted by orbital data: the predicted/observed field values are 700 nT/2013 nT (Johnson et al. 2020) and 81 nT/5.2 – 39.8 nT (Du et al. 2023) for InSight and Zhurong sites, respectively. This discrepancy highlights the need for direct, surface-based magnetic observations to achieve a more accurate and detailed understanding of Martian magnetic anomalies. The STEP1 concept, developed by the Japan Aerospace Exploration Agency, aims to deploy landers on the Martian surface equipped with fluxgate magnetometers. Based on current knowledge of Martian geology and magnetism, we are evaluating potential landing sites for the STEP1 lander, with a focus on regions favorable for magnetic anomaly investigations. Accurate interpretation of magnetic anomaly data requires an understanding of the events and timing during which the crustal rocks acquired their remanent magnetization. In this study, we focus on magnetic anomalies associated with impact craters. During crater formation, shock waves propagate through crustal rocks, potentially inducing remanent magnetization. Furthermore, because the ages of craters can be estimated, they can serve as chronological markers for magnetization events. We are currently identifying potential landing sites by referencing the geological map of Mars published by Tanaka et al. (2014) and crater age data compiled by Robbins and Hynek (2012). In this presentation, we will share the current status of our evaluation of candidate landing sites for the STEP1 mission in the context of magnetic anomaly exploration.