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NOVEL APPROACHES TO IN-SITU LOCALIZATION, EXTRACTION, PROCESSING, AND UTILIZATION OF MARTIAN REGOLITHIC IRON

Abstract

Mars has emerged in recent years not only as the next goal for human exploration in space, but as a prominent candidate for the study of the origin of life and the formation of celestial bodies in the early solar system. Long term in-situ study of the Martian surface will necessitate utilization of in-situ resources to weather the hostile Martian environment and economize long-term mission consumable constraints. A review of literature considered the localization, abundance, seasonality, properties, ease of access, and market utilization of each resource, equally weighted. This determined that, relative to radiation protective environments, solar photons, explosive compounds, atmospheric constituents, water and water ice, and clay minerals, regolithic iron ores are the highest priority resource for future study. Comprehensive concept development was carried out to develop novel mission-scale methods of localization, extraction, and in-situ utilization of iron from Martian regolith, tempered by quantitative feasibility studies and interdisciplinary impact studies. Analyses demonstrated that remote observation of the Martian aurorae leveraged with contemporary developments in machine learning could be used to locate high-concentration iron deposits in the magnetized Martian crust, and that the extraction thereof could benefit from biomining using the S. Oneidensis bacteria, particularly in an early habitative mission concept. The identification of applications of iron ores in-situ expanded beyond typical structural and manufacturing applications. Novel utilization cases — metallic fuels and carbothermal reactions, triboelectric nanogenerators, and in-situ optoelectrical system development — would enable not only long-term surface habitation and exploration, but further expeditions into deep space. The business considerations of Martian regolithic iron's expansionary impacts on the modern space economy were contrasted with their impact on the heritage terrestrial iron market, while further highlighting ambiguities of the role of long-term deep space operations and extraterrestrial resource appropriation in existing space governance frameworks.