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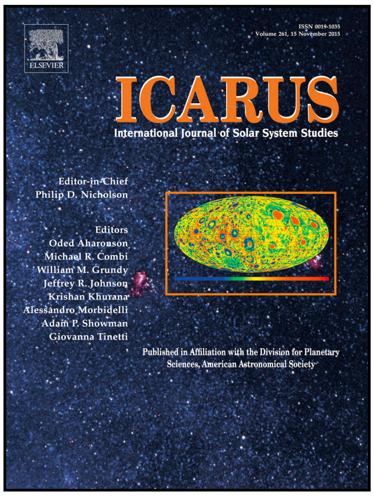

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The Origins of Asteroidal Rock Disaggregation: Interplay of Thermal Fatigue and Microstructure

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Abstract

The distributions of size and chemical composition in regolith on airless bodies provide clues to the evolution of the solar system. Recently, the regolith on asteroid (25143) Itokawa, visited by the JAXA Hayabusa spacecraft, was observed to contain millimeter to centimeter sized particles. Itokawa boulders commonly display well-rounded profiles and surface textures that appear inconsistent with mechanical fragmentation during meteorite impact; the rounded profiles have been hypothesized to arise from rolling and movement on the surface as a consequence of seismic shaking. This investigation provides a possible explanation of these observations by exploring the primary crack propagation mechanism during thermal fatigue of a chondrite. Herein, we present the evolution of the full-field strains on the surface as a function of temperature and microstructure, and examine the crack growth during thermal cycling. Our experimental results demonstrate that thermal-fatigue-driven fracture occurs under these conditions. The results suggest that the primary fatigue crack path preferentially follows the interfaces between monominerals, leaving the minerals themselves intact after fragmentation. These observations are explained through a microstructure-based finite element model that is quantitatively compared with our experimental results. These results on the interactions of thermal fatigue cracking with the microstructure may ultimately allow us to distinguish between thermally