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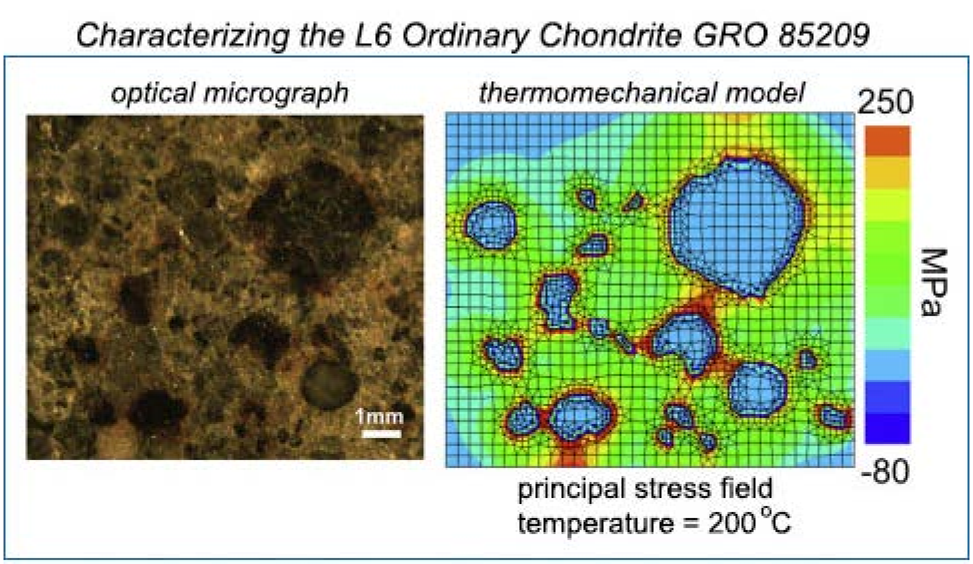
What Cycling Temperatures Have To Do With Making Regolith on Asteroids

Research and results on asteroids and space debris are featured in 18 articles in a special April, 2018 issue of *Icarus*, ***Volume 304***. Included among them is an investigation of how cracks can grow in rocks during thermal cycling on a chondritic asteroid with implications for regolith particle size, shape, and composition. Kavan Hazeli (The Johns Hopkins University and The University of Alabama), Charles El Mir (Johns Hopkins), Stefanos Papanikolaou (Johns Hopkins and West Virginia University), Marco Delbo (Observatoire de Côte d'Azur, France) and K. T. Ramesh (Johns Hopkins) ran experiments on the mechanical properties of a sample of the ordinary chondrite GRO 85209 [***Meteoritical Database link***] as proxy material for near-Earth asteroids, such as 25143 Itokawa (see **PSRD** article: ***Samples from Asteroid Itokawa***).

Hazeli and coauthors subjected the meteorite sample to several hundred cycles of heating and cooling between 28^{o}C to 200^{o}C at a rate of 2^{o}C per minute, simulating conditions an asteroid such as Itokawa experiences in space. They monitored the cracking and strain fields on the surface as a function of temperature and microstructure. With X-ray Computed Tomography they characterized the internal 3D structure of the sample, and confirmed that features seen on the surface reasonably represent microstructures throughout the sample. And they used a nano-indentation technique on individual mineral grains to assess the effects of physical and mechanical properties on crack paths.

The team used the results of their detailed mechanical characterizations and strain analyses of the bulk sample and major grain types, along with numerical models of strain and stress fields, to explain the numerous smoothly-fractured, single-mineral fragments seen among the Itokawa samples returned by the JAXA Hayabusa mission. Hazeli and coauthors found that thermal fatigue of the materials promotes high stress concentrations at inclusion/matrix interfaces, meaning fractures occur preferentially along grain boundaries. The results support previous work on thermal fragmentation of chondritic materials (for example, by Delbo and colleagues in 2014), finding that rock disaggregation by thermal fatigue (from diurnal temperature swings) dominates over impact processes to make regolith on asteroids.



(From Hazeli *et al.*, 2018, *Icarus*, v. 304, doi: 10.1016/j.icarus.2017.12.035.)

[LEFT] Photomicrograph of GRO 85209 showing chondrules, inclusions, and matrix.
[RIGHT] Color-coded Plot of the principal stress field at 200^{o}C calculated from thermomechanical model. High stress concentrations (red) occur at interfaces. Hazeli and coauthors found these stress concentrations establish favorable crack pathways.

See Reference:
· Hazeli, K., El Mir, C., Papanikolaou, S., Delbo, M., and Ramesh, K. T. (2018) The Origins of Asteroidal Rock Disaggregation: Interplay of Thermal Fatigue and Microstructure, *Icarus,* v. 304, p. 172-182, doi: 10.1016/j.icarus.2017.12.035. [***view abstract***]

See also:
· Delbo, M., Libourel, G., Wilkerson, J., Murdoch, N., Michel, P., Ramesh, K. T., Ganino, C., Verati, C., and Marchi, S. (2014) Thermal Fatigue as the Origin of Regolith on Small Asteroids, *Nature,* v. 508, p. 233-236, doi: 10.1038/nature13153. [***view abstract***]

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