Regolith production on asteroid surfaces via thermal fatigue fragmentation

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Classically, regolith is believed to be produced by impacts of small particles hitting asteroid surfaces. However, crater ejecta velocities are typically greater than several tens of centimetres per second [1,2], which corresponds to the gravitational escape velocity of kilometre-sized asteroids. Impact debris reaccumulation, therefore, fails to account for the ubiquitous presence of regolith on small asteroids.

It is known that temperature cycles can lead to mechanical load cycles producing stresses in surface rocks. Cracks could form and propagate due to temperature variations and the resulting temperature gradients set up by the thermal cycles. Several works have suggested that such thermal fatigue may play an important role in the evolution of airless landscapes on bodies such as the Moon, Mercury, and on (433) Eros [3,4,5].

We will describe laboratory experiments and numerical modelling devoted to investigating whether thermal fatigue is active on asteroid surfaces [6].

First we calculate typical temperature variations on the surfaces of near-Earth asteroids due to the diurnal cycles. We then perform laboratory experiments of thermal cycling of meteorites — taken as analogues of asteroid surface material — to study under which conditions rock cracking on near-Earth asteroids (NEAs) occurs. The temperature cycle period and magnitude of the temperature excursion in the experiment thermal cycles were typical of those of NEA surfaces. Finally, using a micro-mechanical model, validated via a direct comparison to our experiments, we extrapolate our results to different cycle periods, to larger rocks and to smaller temperature variations (for example for main-belt asteroids).

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