THE SURFACE PROPERTIES OF ASTEROIDS

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Introduction: Asteroids are covered by regolith (Greek *rhegos* blanket + *lithos* stone), "the mantle of fragmental and unconsolidated rock material that nearly everywhere overlies bedrock". But asteroids vary hugely in three important parameters that drive their surface properties and the development of regolith: (1) Their mineralogy varies between the extremes of nearly 100% iron-nickel to what areessentially soggy dirt clods. (2) Their surface gravity is much lower than our terrestrial or lunar experience, with most asteroids being laboratories of micro-gravity. (3) Finally, because of collisional evolution most asteroids are either highly fractured or loosely bound piles of rubble. Chemistry, gravity, and structure are major inputs into the surface properties of asteroids.

Asteroids and the Space Environment: Asteroids weather in response to their exposure to the space environment. These processes include shock and heating from impacts, chemical disequilibria from exposure to vacuum and reducing conditions, comminution, agglutination, crystal damage and spallation from cosmic rays, irradiation, solar-wind implantation, sputtering, charging to name a few. These weathering processes have a range of effects on surface properties. For small asteroids comminution has a twist since they have very low gravity, they have very low escape velocity. As asteroids get smaller low gravity allows progressively larger particle sizes of ejecta debris to escape as a result of micro-meteorite impacts. The result would be that smaller asteroids have progressively courser regoith soil, essentially a coarsening with decreasing size and gravity. Another effect would be that the larger particle sizes (cobbles and boulders) would be preferentially retained, potentially creating a lag deposit analogus to the deflation and armoring seen in terrestrial "desert pavement". The much higher thermal inertia of small asteroids points to this effect.

What is the regolith like below the surface? Asteroid rotation-rate data provides some insights. Rubble piles are literally held together by the cohesive forces between their smallest grains since small grains dominate in surface area. At some depth larger boulders and cobbles are coated in a matrix of finer grains that provides a small asteroid's cohesive strength. Cohesive strength lower than the lunar regolith soil can allow ~10 m rubble piles to spin rapidly and survive. Probably regolith particle sizes probably drop quickly with depth in small asteroids.

The strength of the surface materials will vary hugely depending on the mineralogy of the asteroid. For example, many ordinary chondrites have compressive strengths up to 20 times stronger than concrete. On the other hand, some carbonaceous chondrites have compressive strengths on the order of dirt clods.

Conclusions: Our knowledge of the surface properties of asteroids are informed by data from regoth meteorites, telescopic observations of asteroid mineralogy and thermal properties, asteroid rotation rates, spacecraft images of asteroid surfaces, and theortical studies of interpartical coheasion. With these data we can predict and explain a range of asteroid surface properties.