EXPERIMENTAL SIMULATION OF REGOLITH DEPOSITIONAL FEATURES

J. Stewart Nagle, Lunar Curatorial Laboratory, Northrop Services, Inc., P.O.Box 34416, Houston, Texas 77034

Lunar core soils, soil breccias, and regolithic meteorites are commonly structured, rather than homogeneous. Because of the low degree of metamorphism of core soils, and because of the fragility of such features in core soils, it appears that inhomogeneities in core soils are primary depositional structures, not the result of metamorphic alteration. In terrestrial sedimentary rocks, structures reflect depositional processes (9); primary structures should likewise reflect depositional processes in non-terrestrial sedimentary rocks. Structures in low grade breccias and core soils have been described since the days of Apollo 11 (1), (5), but it has taken the opening of many cores to establish that there are common patterns that occur in many soils. Interpretation of such patterns, or structures, is limited because extant studies of processes that could produce such structures -- ballistic deposition, avalanching, or slumping -- are not relevant to core-size deposits. (Most of the Apollo cores are approximately 60 cm long and 4 cm in diameter.) Experiments into cratering processes (2), (7), deliberately used even-sized sand, to minimize substratum variability in crater formation. The resulting deposits are not easily compared to lunar regolith, which is poorly sorted, with a wide variety of particle sizes. Studies of heterogeneous terrestrial ejecta deposits (3), (7) were concerned with large craters and may not be relevant to small scale features, such as those observed in lunar cores. Studies of terrestrial deposits created by mass movement are concerned with distribution of hazardous boulders (8) or mechamisms of landslide, not avalanche, emplacement (4), (11).

This study attempts to experimentally determine if there are identifiable differences in structures produced by ballistic deposition, avalanching, or slumping, the processes known to produce deposits of meter-or-less thickness on impact-dominated surfaces such as the moon.

Although more work needs to be done, some results of fundamental applicability have been obtained; these results are useful in distinguishing ejecta from other kinds of deposits.

Ballistic deposition, similar to ejecta formation, is produced with a catapult, avalanching is produced with a long rough ramp, and landsliding (short-distance mass wastage) is produced with a tilt box. For all tests, a similar starting pattern is used, a 4X4 cm grid of alternating dry mortar cement and plaster of paris, both of which can be artificially colored, and both of which can be stabilized with water mist. The test "projectile", a color-gridded rectangular solid that is 32X50X4 cm is deposited (1) ballistically, (2) by avalanching, or (3) by sliding, onto a receiving tray filled with dry mortar that is colored differently from the projectile. Separation of the projectile source and depositional test bed in the catapult experiment guarantees that material must move ballistically before deposition, and cannot roll or slide along the ground before landing.

During ballistic processes, the projectile moves through the air as a dense tabular wall or semi-solid cloud of dust, sand grains and dirt clods. During flight the projectile mass is overturned, but all particles land in quick succession, and roll a short distance after landing, as evidenced by small craters and short downrange grooves made by the few pebbles that happened to be in the ballistic test mixture. During avalanching, individual clods of semi-cohesive material can be seen to roll independently, but the entire mass moves as one unit.

EXPERIMENTAL REGOLITH DEPOSITION

Nagle, J. S.

Long distance rolling with minor bouncing is the principal mode of transport of individual particles; and some of the smaller particles lag behind the larger ones when the surface is very rough. During short-distance sliding, a form of landsliding, the entire projectile mass moves as one upright unit, with individual grains retaining the same position relative to each other. There is some fracturing and distortion of the grid pattern, especially at the edges, but it is minor compared to the extensive to total disruption of ballistic and avalanche deposits.

During ballistic deposition, friable clods that were isolated from the main mass of material created individual secondary craters, and the spattered clods lined the craters, exactly as described by (10). Cross-sections through the main mass of ballistically-deposited material show basal flat or bowl-shaped lenses of light-colored material, abruptly overlying (with little mixing) the depositional substratum. The basal lenses of light-colored material are succeeded upward by equidimensional clods of soil that are loosely packed and appear either as individual rounded monogeneous clods of light plaster or grey cement, or as partially rolled, grey and white clods that appear in cross-section as arcuate patches of multicolored material radiating from a common center. This sem-radial, semi-concentric lapillar structure is reminiscent of a spiral, but the individual arcuate clumps of soil form only short arcs, not the 360 degree arcs required for a true spiral. This structure is reminiscent of lapilli in volcanic ejecta (5). It appears to originate by accretionary clods rolling a short distance, in contrast to clods which have rolled a long distance. Such clods show a concentric coating rather than a radial arcuate lapillar structure. In a downrange cross-section, it can be seen that all radial arcuate lapillar structures are coiled in the same direction; by mentally "unwinding" the lapilli, one can determine the direction of the source.

Laboratory-scale avalanche deposits are loosely packed, as are ejecta, but because of long-distance rolling, avalanche deposits contain very well rounded clasts (or clods, depending on cohesiveness of material). Surficially, such clods contain a coating of coarse fines, but such might not be easily observed in cross-section. Because some of the finer material lags behind the main avalanche, there is a tendency for the final deposit to be finer-grained at the top; however, a well-defined size grading is not present. Some relatively thick, artifically-produced avalanche deposits show laterally smeared friable clasts throughout the deposit.

Although short-distance sliding introduces some randomness into a well-defined test pattern, it produces no features that could be easily diagnosed in a relatively chaotic lunar cross-section.

The radial-arcuate lapillar structure, and succession of flattened clasts grading up to clasts with unidirectional radial-arcuate lapillar structure is common in lunar core soils, some lunar breccias, and some meteorites. The sequence of smeared and rounded clasts, characteristic of avalanche deposits, is uncommon, but has been observed in drill stems 70003 and 70002 (6).

References

(1) Fryxell R. et al. (1970) Proc. Apollo 11 Lunar Sci. Conf. p. 2121-2126. (2) Gault D. E. et al. (1968) In Shock Metamorphism of Natural Materials p. 87-99 Mono Book Corp. (3) Hörz F. et al. (1977) In Lunar Science VIII, p. 457-459. The Lunar and Planetary Institute, Houston. (4) Hsu K. J. (1975) Geol. Soc. Am. Bull.86 , p. 129-140. (5) McKay D. S. et al. (1970) Proc. Apollo 11 Lunar Sci. Conf. p. 673-694. (6) Nagle J. S. (1981) Proc. Lunar Planet Sci. Conf. 12th. (7) Oberbeck V. R. (1975) Rev. Geophys.Space Phys. p. 337-362. (8) Porter S. C. and Orombelli G. (1981) Am. Sci. 69, p. 67-75. (9) Potter P. E. and Pettijohn F. J. (1964) Atlas and glossary of primary sedimentary structures. 370 p. Springer Verlag. (10) Schultz P. H. et al. (1980) In Lunar Planet. Sci. XI, p. 1006-1008. The Lunar and Planetary Institute, Houston. (11) Sharp C. F. S. (1962) Landslides and related phenomena. 104 p. Cooper Square, N. Y. (12) Stöffler D. (1981) Apollo 16 workshop vol. The Lunar and Planetary Institute, Houston.