LAVA FLOODING OF ANCIENT PLAÑETARY CRUSTS: GEOMETRY, THICKNESS, AND VOLUMES OF FLOODED LUNAR IMPACT BASINS

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Abstract. Estimates of lava volumes on planetary surfaces provide important data on the lava flooding history and thermal evolution of a planet. Lack of information concerning the configuration of the topography prior to volcanic flooding requires the use of a variety of techniques to estimate lava thicknesses and volumes. A technique is described and developed which provides volume estimates by artificially flooding unflooded lunar topography characteristic of certain geological environments, and tracking the area covered, lava thicknesses, and lava volumes. Comparisons of map patterns of incompletely buried topography in these artificially flooded areas are then made to lava-flooded topography on the Moon in order to estimate the actual lava volumes.

This technique is applied to two areas related to lunar impact basins; the relatively unflooded Orientale basin, and the Archimedes–Apennine Bench region of the Imbrium basin. Artificially flooding the Orientale basin to the Cordillera Mountains (outer basin ring) produces a lava fill geometry with two components; (a) the *basin interior* (within the inner Rook ring) where the area covered is small but lava thicknesses are large (6–8 km), and (b) the *basin edges* where larger areas are covered but thicknesses are less, averaging about 2 km. Detailed examination of the Archimedes–Apennine Bench area (Imbrium basin edge) also shows average thicknesses in this region of basins of approximately 2 km.

On the basis of these analyses it is concluded that early flooding of the basin interior places a major load on the lithosphere in the same geographic region where mascon gravity anomalies are concentrated. Mare ridges and arches are concentrated at the outer edge of the region of thickset fill and appear to be related to tectonic activity accompanying basin loading and downwarping. Lava thicknesses in most areas of flooded impact basins (> 2 km) exceed the thickness of lava where vertical mixing of underlying non-mare material is possible. Thus, vertical mixing is not likely to have been an important process in mare deposits within flooded impact basins. Thickness estimates derived from this technique exceed those derived from the morphometry of buried or partially buried craters by at least a factor of two. Examination of the assumptions employed in the latter technique show several sources of variability (e.g., initial rim height variability in a fresh crater) which may result in significant underestimation of lava thicknesses.

1. Introduction

Recognition of the volcanic origin of surface deposits on ancient cratered planetary surfaces provides important information on the presence and significance of melting in the interior. Establishment of the composition, age, and volume of such deposits provides additional clues concerning the characteristics of the thermal history of the planet. In addition, the thickness, geometry, and volumes of volcanic deposits provide important data for understanding sources and styles of volcanism and relationship between tectonics and lithospheric deformation (Solomon and Head, 1979, 1980). Only a portion of the magma generated at depth, however, is extruded out to the surface. Some may remain

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