

**ORIGIN OF THE LUNAR HIGHLAND CRUST.** P.D. Lowman, Jr., Goddard Space Flight Center (Code 921), Greenbelt, MD 20771. [Paul.D.Lowman@nasa.gov](mailto:Paul.D.Lowman@nasa.gov).

**Introduction:** Understanding the origin of the oldest lunar crust was a main scientific objective of the last three Apollo missions, 15, 16, and 17, all of which landed in or near highland exposures. Starting with Apollo 15, the astronauts took hundreds of 70 mm surface photographs. These pictures have been re-studied, and reveal pervasive layering in the lunar highland crust visited by the Apollo 15, 16, and 17 missions.

**Results:** The best exposure of the highland crust was on the Apennine Front at the Apollo 15 site. Although some “layers” proved to be lighting artifacts, most others are clearly genuine structures. Photo-geologic sketches of the layers on Silver Spur and adjacent areas have been prepared by Tiffany Yang. Over 90 layers were distinguished, averaging 16 meters thickness. Their number and thickness are not explainable as overlapping layers of ejecta from craters or mare basins. They are structurally similar to basalt flows of the Columbia Plateau.

Similar layers were found on Stone Mountain, south of the Apollo 16 Descartes site, although not as well expressed. Apollo 17 EVA photographs of the Sculptured Hills, north of the Taurus Littrow Valley, show distinct layers dipping away from the Serenitatis Basin, similar in thickness and structure to those at Silver Spur. It is concluded that this pervasive layering is the expression of lava flows. The lunar megaregolith studied by various authors, estimated to be 2-3 km thick, is much younger than the layered rock studied here, and there is no contradiction between it and the volcanic origin proposed.

**Composition:** The lunar highland crust was never sampled from in situ outcrops, only from the impact-formed regolith. However, several lines of evidence converge to permit estimation of the highland crust composition. X-ray fluorescence surveys from Apollo 15 and 16 rule [1] rule out anorthosite as the major constituent of the exposed highland crust, pointing instead to a feldspathic basalt [2]. Earth-based reflectance spectroscopy [3] indicates a noritic composition for the upper highland crust, other types (anorthosite and troctolite) being exposed only in large craters. Returned highland samples, especially from Apollo 17, are chiefly norites or noritic breccias. Surveyor VII, landed on highland crust on the north rim of Tycho, returned alpha-backscattering analyses and close range TV images indicating a feldspar-rich basalt or gabbro. Lunar meteorites found on Earth are

largely feldspar –rich breccias. Finally, the Luna 20 mission returned highland samples, also feldspar-rich.

**Conclusions:** The evidence from photogeology of exposed highland crust, remote sensing, and returned samples collectively points to a composition equivalent to high alumina hypersthene basaltic lava flows. The stratigraphic position of these flows implies formation between 4.5 and 4 billion years ago. It is concluded that the first lunar crust was formed by global eruption of hypersthene basalts, forming perhaps 25 kilometers of crust. Anorthosites, troctolites, and other uncommon rocks were formed by magmatic processes as intrusives.

**References:** [1] Adler, I., et al., *Science*, 175,436-440,1972. [2] Lowman, P.D.,Jr.J. *Geol.* 80, 125-166, 1972. [3] Pieters, C., *Rev. Geophys.*,24, 557-578, 1986.