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Mars: Statistical characteristics of topography and implications for the past climate

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Mars Orbiter Laser Altimeter onboard Mars Global Surveyor has provided researchers with an excellent data set on topography of Mars. The data have global coverage, high vertical precision, and uniform 0.3 km spacing of measurements along the orbit tracks. The data set is well suited for statistical analysis of topography at kilometer and subkilometer scale. Mars possesses not only a wide range of topographic roughness, but also a very wide diversity of its dependence on scale. Maps of properly chosen statistical characteristics of topography aid in geomorphologic analysis and geological mapping.

Many statistical characteristics of Martian topography unexpectedly reveal prominent latitudinal zonality. This strongly suggests that climate conditions had immense influence on surface-shaping processes through the long geological history of the planet.

The strongest topographic latitudinal trend is a trend in occurrence of the steepest slopes on Mars: slopes steeper than 20 degrees are almost absent at high latitudes, but are preserved in the equatorial zone for billions of years; in narrow transitional mid-latitude zones only pole-facing steep slopes are absent, which produces strong asymmetry of topographic features. Effective removal of steep slopes is probably assisted by seasonal thawing and refreezing of upper surface layer (permafrost active layer processes). At the present climate conditions there is no summer-time thawing on Mars. However, celestial mechanics predicts periods of high obliquity of the planet's spin axis in the past. Under high obliquity the summertime insolation at high latitudes is much higher, and summertime thawing is probable. Thus, the latitudinal trend in steep slopes indicates repeated high obliquity peaks and related climate conditions in the past. The slope asymmetry in the mid-latitude zones indicates the role of direct surface insolation and hence points to persistently low atmospheric pressure through billions of years.