
The slopes of the chasma walls in Valles Marineris are not as steep as would be predicted from analyses of slope stability (Baker and Garber, 1978; Clow and Carr, 1980) for homogeneous common geologic materials (Hoek and Bray, 1977). The chasma wall with the greatest relief and steepest slope that we have found to date is in Noctis Labyrinthus. Relief of this wall is about 6 km and the mean slope is near 46 degrees; slopes are locally as steep as about 48 degrees. Stability analyses for this wall, if we assume a homogeneous dry material and logarithmic spiral failure surfaces, constrain the choices of possible geologic materials beneath the slope (fig. 1). Materials similar to tills, clays, sands, and broken rocks must be excluded, but other rocks like those on Earth are possible; those have paired values of cohesions and angles of internal friction above and to the right of the line for stable-unstable conditions in figure 1; some impact and volcanic breccias may have properties near the dashed portion of the line. The mean slopes of the probable logarithmic spiral failure surfaces for the chasma wall in Noctis Labyrinthus are much steeper than those of the chasmata walls where landslides have occurred, even if the angle of internal friction is assumed to be as low as 20 degrees. Positive pore pressures do not alleviate the problem, because they steepen the failure surface.

In the Tithonium-Ius Chasmata region, several wall failures with small displacements are found (Lucchitta, 1979); the mean slopes of their failure surfaces, inferred from topographic data (U.S. Geological Survey, 1980), are between 25° and 35°. Logarithmic spiral failure surfaces for reasonable values of cohesions and angles of internal friction do not conform with most of these inferred failure surfaces nor are they compatible with slopes elsewhere in the chasmata.

One of these small displacements in Ius Chasma occurs where the slope of the wall is 25°. The inferred failure plane for marginal stability can be approximately fit if the cohesion is 400 kPa and the angle of internal friction is 20° (see fig. 1). Both the low cohesion and small angle of internal friction suggest that, where landsliding is common, materials in the chasma walls may have been locally altered by some weathering or hydrothermal process related to magmatism (Lucchitta, 1987). Other factors that may have contributed to the weakening of the walls include pre-existing planes of weakness combined with pore water pressures and small cohesions.

References


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Figure 1. Conditions for stability of a slope in Noctis Labyrinthus, assuming a dry homogeneous material and logarithmic spiral failure surfaces without base failure. Slope is stable for cohesions and angles of internal friction above and to the right of stable-unstable line; below and to the left of the line, the slope is unstable and would fail. Rectangles represent ranges of cohesions and angles of internal friction of the indicated common terrestrial geologic materials. Dashed part of curve is extrapolated and constrained by the maximum local slope (48°). X indicates the approximate failure conditions for wall failure with small displacement in Ius Chasma.