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Forward mechanical modeling of the Rupes Recta normal fault in eastern Mare Nubium, the Moon

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Individual normal faults are rare on the Moon and their presence likely implies an anomalous geologic history of the region where these faults occur. The best-known example is Rupes Recta; it is also known as the Straight Wall because it is both remarkably linear over its ∼120 km length and is not part of a graben. It is located in eastern Mare Nubium on the near side. Rupes Recta formed within a ∼200 km diameter pre-Nectarian crater, named Ancient Thebit. Topographic profiles derived from gridded Lunar Orbiter Laser Altimeter (LOLA) topography have a shape characteristic of normal faults and show that the relief of the fault-related scarp is ∼380 m, consistent with previous measurements based on shadow length.

Several hypotheses for its formation have been suggested, including reactivation as an Imbrium-radial fault, differential settling of mare basalts over a crater rim, and subsidence of the basin due to infilling by mare basalts. The mode of formation can be used to gain insight into the geologic history of Mare Nubium and Nubium Basin.

Before the formation mechanism can be determined, it is important to know basic parameters about the normal fault that forms Rupes Recta. To do this, the forward mechanical dislocation pro¬gram Coulomb was used to calculate surface displacements which provide a means to determine these parameters, in-cluding dip angle, displacement magnitude and sense, and depth of faulting. This approach has been used successfully to model the surface displacements of faults on Mercury, Earth, and Mars. In these models, a fault surface is idealized as a rectangular plane for which the sense of slip, magnitude of dis-placement, fault dip angle, depth of faulting, and fault length are specified, and material displacements are calculated. The initial displacement magnitude is estimated from the relief of the scarp and adjusted based on model output. Model parameters are determined based on the correspondence between ob-served (measured LOLA) and predicted (modeled) topography of the footwall flexural uplift. A Young's modulus E of 100 GPa and Poisson's ratio ν of 0.3 are assumed for the basaltic rock mass that comprises the upper surface of Mare Nubium.

Topographic profiles were derived from gridded LRO LOLA data (512 ppd; ∼57 m/px). The mean to-pography was calculated by stacking and averaging seven individual profiles and the regional topog-raphic slope was removed.

The best-fit parameters from the models indicate that the fault dips at 85°, accommodates 400 m of dis-placement, and extends to a depth of 35 km. Steeply-dipping normal faults are not common, but have been observed in Iceland; the steep fault dip and down-slope extension direction may explain why Rupes Recta formed as an individual normal fault rather than a graben. The depth of Ancient Thebit, calculated using lunar crater scaling laws, is likely to be ∼5 km. This, together with a basalt thickness of 1.5 km, implies that the fault cuts through the basalt fill, through the floor of Ancient The-bit, and into the underlying pre-impact material. The depth of faulting also indicates that the stresses responsible for forming the fault likely did not arise locally and that an origin related to large-scale (100s km) features, such as long-wavelength topographic slopes, on the lunar nearside is implied.