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The East Kaibab Monocline as a Lobate Scarp on Earth

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The surfaces of Mercury, Mars, and the Moon show substantial evidence of crustal shortening. A principal manifestation of this tectonic deformation, usually in response to global contraction from interior cooling and/or volcanic loading, are cliff-like escarpments termed “lobate scarps”. These landforms are highly asymmetric in transverse view, with steep slopes on one side and gentle backslopes on the other; in map view they typically show a broadly lobate outline. Analogues to another widespread class of extraterrestrial shortening structure, so-called “wrinkle ridges”, have been reported at various locations across Earth, but so far no Terran counterparts to lobate scarps have been documented. We conducted a field survey and performed forward modeling to test the hypothesis that a major intraplate shortening landform in southern Utah—the East Kaibab monocline—is an eroded lobate scarp. Our field observations indicate that the fault-related folding that characterizes the monocline at the kilometer scale is accommodated by substantial brittle deformation at meter- to decameter scales, from distributed sets of small fractures to highly localized high-angle reverse faults. With the COULOMB elastic dislocation program we modeled topographic transects perpendicular to the strike of the monocline, using published parameters of the underlying Butte Fault, and restored the eroded portion of the monocline. When reconstructed, the monocline has a steep forward-facing escarpment and a gentle backslope, and bears a strong morphologically similarity to lobate scarps on Mercury, Mars, and the Moon. The attitudes of the deformed model rock volume at specific stratigraphic levels match our field measurements of dip angle for corresponding stratigraphic units in the monocline, verifying our model solutions. Our results strongly imply that the landforms historically termed “lobate scarps” on other planetary bodies are monoclines and asymmetric anticlines. The geometry, kinematics, and interior structure of such landforms on Earth thus provide new insight into this abundant type of extraterrestrial shortening structure; conversely, studies of large-scale intraplate crustal shortening on Earth will be augmented by the recognition of preserved examples of monoclines and anticlines on other planetary bodies.