Monument Hill Fault System and Tectonics of the Red Rock Valley, Southwestern Montana

David Anastasio » Earth and Environmental Sciences, Lehigh University
Frank Pazzaglia » Earth and Environmental Sciences, Lehigh University
Christine Regalla » Earth and Environmental Sciences, Lehigh University

The Monument Hill fault (MHF) in the Red Rock graben, southwestern Montana, is a youthful, active extensional fault system in the Basin and Range north of the Snake River Plain. Data from geologic mapping, geomorphic metrics, and fault scarp profile modeling for the MHF show evidence for temporal clustering of Pleistocene seismic events. This evidence suggests that the system has the potential for mechanical and seismogenic linkage between fault strands in various stages of development. The distribution and geometry of surface ruptures of the MHF are consistent with diffusion modeling of scarps in alluvium profiled with precision GPS with support from UNAVCO and using diffusivity values calculated for dated Red Rock fault (RRF) scarps. Results show a clustering of related events on the three strands of the MHF in the latest Pleistocene (~25 ka) and possibly also in the late Pleistocene (>160 ka). The integrated, long-term effect of Quaternary activity is reflected in mountain front landforms and stream long profiles. Active fault segments have elongate drainage basins, irregular hypsometries, and channel long profiles with anomalously steep reaches not coincident with rock-type changes. The planimetric distribution of four newly identified alluvial units along the MHF reflect a change in fault kinematics from dip-slip in the south to oblique slip in the north. Surface rupture geometries are consistent with analogue models for mechanical linkage and suggest the potential for mechanical and seismogenic linkage between MHF strands. A change in polarity between the east-dipping RRF and the west-dipping MHF, as well as a northward decrease in extension across the Red Rock Valley, are accommodated by a complex structural crossover zone at Kidd. The geometry and alluvial depositional patterns of the two fault systems are consistent with an anticlinal accommodation zone at Kidd, and focal plane solutions from the 1999 Red Rock Valley earthquake indicate that this zone contains a south-southwest dipping, blind, normal fault.

The unique rupture histories of the MHF and RRF suggest that the fault systems are not seismogenically linked and that the Kidd accommodation zone may be serving as a temporary rupture barrier. The structure, interconnectivity, and kinematics of faults in the Red Rock Valley may represent a snapshot of the early stages of extension for other Basin and Range grabens north of the Snake River Plain.

Figure 1. Perturbations in GPS profiled channel long profiles, highlighted in the box, correspond with peaks in Slope-Length (SL) index, highlighted in the oval.

Publications:

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