Fault Slip Rates on the Northern Death Valley Fault Zone: Implications for Pacific-North America Plate Boundary Deformation

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The exact slip rate of the northern Death Valley fault zone (NDVFZ) has long been one of the last major missing pieces of the kinematic puzzle in the eastern California shear zone (ECSZ). Published models of geodetic data suggest the NDVFZ is storing much, and perhaps almost all, of the Pacific-North American plate boundary strain in the ECSZ north of the Garlock fault. However, the scarcity of geochronologically defined long-term slip rates has made it difficult to determine whether strain storage and release have been constant along this part of the plate boundary. Here, we present the first geochronologically determined geologic fault slip rate along the NDVFZ zone using high-resolution digital topographic data and cosmogenic nuclide surface exposure ages.

We have acquired 46 square kilometers of airborne laser swath mapping data (ALSM or LiDAR) from two locations along the NDVFZ. We are in the process of obtaining an additional ~400 square kilometers along the remainder of the northern Death Valley and Fish Lake Valley fault zones. The scarcity of vegetation in the study area is ideal for acquisition of ALSM data to survey deformed geomorphic features because removal of data points related to returns from the top of plants does not reduce the point density of bare-earth shots, as it might in a heavily-canopied area. ALSM data facilitate the efficient identification, mapping, and analysis of tectonically active landscapes in unprecedented detail. We use ALSM data to determine late-Pleistocene to Holocene fault offset along the northern Death Valley fault system and illustrate the utility of these data for active tectonics research. Surveying of deformed geomorphic features and the construction of high-precision topographic maps, which would take days to weeks with traditional methods, are accomplished in minutes using ALSM data. Digital elevation models (DEMs) derived from the ALSM data can also be used to generate maps of surface slope, curvature, and roughness to reveal subtle topographic features, produce reconnaissance surficial geologic maps, and measure fault offset. In addition, the DEMs can be artificially illuminated from any azimuth and elevation to highlight previously unrecognizable structures.

The initial focus of our study has been the dextrally-offset Red Wall Canyon alluvial fan along the NDVFZ (see Figure 1). Analysis of ALSM data reveals 297 ± 9 m of right-lateral displacement on the fault system since the late Pleistocene. In situ cosmogenic 10Be geochronology was used to date the Red Wall Canyon alluvial fan and a second, correlative alluvial fan also offset by the fault. 10Be dates from large cobbles and boulders provide a maximum age of ~70 ka for the offset landforms.