RATES AND PATTERNS OF COSEISMIC AND POSTSEISMIC SURFACE DEFORMATION MEASURED BY TERRESTRIAL LASER SCANNING OF THE SOUTH NAPA EARTHQUAKE

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ABSTRACT

The 2014 M6.0 South Napa Earthquake, despite its moderate magnitude, caused significant damage to the Napa Valley in northern California. Surface rupture occurred along several mapped and unmapped faults. Field observations following the earthquake indicated that the magnitude of postseismic surface slip was likely to approach or exceed the maximum coseismic surface slip and as such presented ongoing hazard to infrastructure. Using a laser scanner, we monitored postseismic deformation in three dimensions through time along 0.5 km of the main surface rupture. A key component of this study is the demonstration of proper alignment of repeat surveys using point-cloud based methods that minimize error imposed by both local survey errors and GNSS georeferencing errors. Using solid modeling of natural and cultural features, we quantify lateral postseismic slip at several hundred points near the main fault trace. We also quantify total lateral slip of initially straight cultural features. Total right-lateral slip from both coseismic slip and the first 2.5 days of postseismic slip ranges from 22 to 29 cm. These values increased to 33 to 42 cm at 59 days post-earthquake. Furthermore, we are able to map up to 15 cm of vertical deformation in the first 2.5 days post-earthquake which then increased by ~2 cm by 59 days post-earthquake. This vertical change is not expressed as a distinct step or scarp at the fault trace but rather is expressed as a broad up-to-the west zone of increasing elevation change spanning the fault trace over a ~50 m width. Integrating these analyses provides three-dimensional mapping of surface deformation, and identifies spatial variability in slip along the main fault trace that we attribute to distributed slip via subtle block rotation. These results indicate the benefits of 3D surveys along active faults, and demonstrate that fine scale variability in fault slip have been missed by traditional earthquake response methods.