Geophysical Research Abstracts
Vol. 21, EGU2019-6570, 2019
EGU General Assembly 2019

Relating spatial and temporal fault complexity to landscape development: comparing the Mw 7.8 Kaikoura Earthquake of 2016 to past behaviour of the Marlborough Fault System, New Zealand

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The Mw 7.8 Kaikoura Earthquake of 14th November 2016 was characterised by a surprising degree of spatial complexity in the surface displacement field. This included a high degree of variability in apparent slip along strike of individual faults over relatively short distances, involvement of at least 12 faults, as well as apparent sub-parallel thrusting and normal faulting.

The Marlborough Fault System (MFS) is located within New Zealand at the transition from subduction along the Hikurangi Interface to the north, to a transpressional transform (Alpine Fault) to the south. The Marlborough region comprises several mountain ranges that were constructed by thrusting on a series of sub-parallel thrust faults; these have subsequently evolved to accommodate strike-slip motion, and evidence suggests that these can also undergo normal dip-slip. The location and tectonic setting of the MFS is useful, displaying active deformation of a convergent margin on land providing good access and visibility. The region represents an accretionary wedge, subject to shape adjustments that balance the tendency to thicken by compressive thrusting with topographic reduction caused by gravitational loading, as a function of the frictional properties of the faults involved. Slip rate estimates for several MFS locations show temporal complexity with significant variations over multiple earthquake cycles. We examine different possible explanations for these observations, comparing spatial and temporal variations in slip, considering their implications for mountain building and landscape evolution.