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Upper-plate deformation following megathrust earthquakes: Holocene slip along the El Yolki Fault in central Chile inferred from deformed coastal sediments

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Great subduction earthquakes are commonly accompanied by motion of upper-plate faults, either during the megathrust event or in the weeks to months that follow. One of the best documented examples of such coupled behavior is probably the 2010 Pichilemu earthquake sequence of central Chile with M_W 6.9 and 7.0 events sourced by a shallow normal fault 11 days after the M_W 8.8 Maule earthquake that originated offshore Chile. Similarly, normal faults ruptured the surface after the 2011 Tohoku earthquake in Japan, and additional examples may exist in other subduction environments. Static stress transfer on optimally oriented faults located at the periphery of high-slip sectors has been suggested as the trigger mechanism for these earthquakes following major plate-boundary earthquakes. Numerous normal and reverse faults have been mapped along the $\sim$500-km-long rupture zone of the 2010 Maule earthquake, but post-seismic upper-plate seismicity was concentrated only at the Pichilemu normal fault, which is immediately to the north of the area where slip reached its maximum of 17 m. To gain insight into the relation between megathrust ruptures and associated motion of upper-plate faults, we studied the El Yolki Fault (ELYF), a normal fault located near the region of lowest megathrust slip in 2010. We attempted to obtain the slip rate of the ELYF integrating field mapping of Holocene coastal landforms and combined airborne and terrestrial LiDAR data. In addition, paleoseismological trenches were dug along the uplifted footwall block where marine lagoonal sediments were back-tilted and uplifted by inferred slip along the ELYF. The trenches reveal basal metamorphic rocks and overlying fluvial sediments into which a stepped sequence of four distinct, decimeter-scale scarps had been sculpted at successively higher positions above bedrock. These erosional scarps are covered by a sequence of onlapping silty and clayey organic-rich intertidal sediments. In turn, these units are overlain by terrestrial sands and a well developed soil profile. We extracted 14 samples of organic material for 14C dating to constrain the depositional history and the relationships between scarps and overlying sediments. Analogous to similar scarps at the interface between the water level of a present-day, nearby lagoon and the lowest section of the coastal plain we interpret the four pronounced steps exposed in the trench to be related to co-seismic slip along the ELYF. Our new radiometric ages suggest that these events clustered during the middle Holocene and were superseded by an episode of shallow-marine sedimentation when the onlapping strata covering the scarps were deposited. The overall configuration of these geomorphic and stratigraphic relationships may be triggered by deep-seated megathrust earthquakes generating subsequent clustered aftershock seismicity associated with upper-plate normal faulting. Considering the relationships revealed in the trench it is possible that the exposure of the normal faults and associated deposits is ultimately related to forearc uplift during another, yet undated megathrust event with a very different slip distribution compared to the 2010 Maule event.