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Landscape Records 25 Million Years of Tectonic Evolution at an Oblique Convergent Margin, Marlborough Fault System, New Zealand

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The landscape at the NE end of the South Island, New Zealand, records oblique plate collision over the last 25 million years. Using low-temperature thermochronology, geomorphic analyses, and cosmogenic ^{10}Be data, we document the landscape response to tectonics over long (10^6) and short (10^2 – 10^3) timescales in the Marlborough Fault System (MFS) and related Kaikōura Mountains. Our results indicate two broad stages of landscape evolution that reflect a changing plate boundary through time. In the eastern MFS, Miocene folding above blind thrust faults generated prominent Kaikōura Mountain peaks and formed major transverse rivers early in the plate collision history. By the Pliocene, rotation of the plate boundary led to a transition to dextral strike-slip faulting and widespread uplift that led to cycles of river channel offset, deflection and capture of tributaries draining across active faults, and headward erosion and captures by major transverse rivers within the western MFS. Despite clear evidence of recent rearrangement of the western MFS drainage network, rivers in this region still flow parallel to older faults, rather than along orthogonal traces of younger, active strike-slip faults. Such drainage patterns emphasize the importance of river entrenchment, showing that once rivers establish themselves along a structural grain, their capture or avulsion becomes difficult, even when exposed to new weakening and tectonic strain. Over short timescales (hundreds to thousands of years), apparent catchment-wide average erosion rates derived from ^{10}Be data show an increase from SW to NE, along strike of the Seaward Kaikōura Range. These rates mirror spatial increases in elevation, slope, channel steepness, and coseismic landslides, demonstrating that both landscape and geochronology patterns are consistent with an increase in rock uplift rate toward a subduction front that is presently locked on its southern end. Remarkably, the form of the topography, hillslopes, and rivers across much of

the MFS appears to faithfully record the complex and changing tectonic history of a long-lived, oblique convergent plate boundary.