Lidar reveals uniform Alpine fault offsets and bimodal plate boundary rupture behavior, New Zealand

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De Pascale et al. (2014) present four dextral offsets (fluvial terrace risers and channels) identified from an unnamed creek 800 m southwest of Gaunt Creek (one of the best-studied outcrops on the Alpine fault). They interpret these offsets to record three cumulative single-event displacements associated with the last three major surface-rupturing earthquakes on the central Alpine fault and use these data to draw conclusions about the seismogenic behavior of the Alpine fault overall.

Herein I argue (1) their apparent dextral offsets occur on a steep dextral-normal fault subsidiary to the main dextral-thrust trace of the Alpine fault at this location, (2) that the subsidiary fault in question is kinematically incapable of producing single-event displacements on the order of 6–8 m, and thus (3) that their discussions and conclusions regarding more complex or bimodal behavior on the Alpine fault are unfounded in light of their data.

The nature of complex near-surface fault segmentation on the Alpine fault in the Gaunt Creek–Darnley Creek area has been well established by previous workers. Serially partitioned dextral-thrust and linking strike-slip slip surfaces segment the main Alpine fault plane at a map scale of 1–10 km and to a depth of ∼1–2 km (e.g., Norris and Cooper, 2007, and references therein). Superimposed on this serial partitioning are parallel partitioned dextral-thrust and dextral-normal faults defining 100–500-m-wide fault wedges in the near surface (Barth et al., 2012).

All of the measurements by De Pascale et al. are clearly made on a subsidiary dextral-normal fault (Southern Alps side-down motion) and not the main dextral-thrust Alpine fault plane at this location (Fig. 1; cf. their figure 3). This particular subsidiary fault had previously been observed in the field and three-dimensionally modeled by Easterbrook (2010). Barth et al. (2012) used the same 2010 lidar dataset as the study in question to show that these southeast-facing, dextral-normal sense fault scarps are ubiquitous along the length of the 34-km-long central Alpine fault lidar swath, and when tied to outcrop observations (e.g., Norris and Cooper, 2007; Easterbrook, 2010), indicate the presence of parallel partitioning between a dominant (but poorly preserved) outboard dextral-thrust and a subsidiary steep dextral-normal fault (better preserved because the fault plane is steeper and its scarp is inboard of the rangefront). Structural contouring of the Alpine fault in this region by Norris et al. (2012) indicates the fault trace in question is subsidiary to the main Alpine fault plane and likely terminates into it at an intersection angle greater than 50° and at a shallow depth of ∼100 m.

Barth et al. (2012, their figure 9A) used a simple vector summation of fault plane/slickenline measurements and a plate boundary vector of 251° and at a shallow depth of ∼100 m. To show that the (frontal) basal dextral-thrust plane is expected to accommodate greater than three times the displacement of the corresponding fault wedge-bounding dextral-normal fault. A single-event dextral displacement of 7 m on one of these subsidiary dextral-normal faults would kinematically require there to be greater than three times more displacement on the corresponding dextral-thrust trace, a value wholly unrealistic with known Alpine fault behavior.

With no direct evidence for the timing of their apparent dextral offsets, De Pascale et al. compile measured offset data along the Alpine fault and near-fault/on-fault paleoseismic proxies to fit their measurements to. Note that all of their compiled offsets occur in locations where the surface geometry of the Alpine fault is considerably less complex than the area in question and strike-slip motion is more dominant overall. Their catalog of paleoseismic events relies on how they chose to define their 20–220 yr uncertainty range for events, yet no explanation of the necessary interpretations of the various proxies and how they were selectively weighted was presented in the paper, or as a supplement in the GSA Data Repository, so readers are left unknowing.

The logical solution to De Pascale et al.’s introduced conundrum of apparent Alpine fault slip rates greater than plate boundary rates is neither of the two explanations proposed in their discussion and conclusions, but rather that the apparent dextral offsets they measure are not cumulative single-event displacements. While the discussion De Pascale et al. present regarding Alpine fault rupture behavior is worthy of being pursued, more high-confidence data is required before such broad assertions regarding the long-term seismogenic behavior of the Alpine fault are warranted, especially in light of what is currently known of its long quasi-regular paleoseismic record and temporally stable slip rates.

REFERENCES CITED

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