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RESEARCH ARTICLE
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Fast Liquiñe-Ofqui Fault Slip Rates and Rapid Uplift Above the Subducted Chile Ridge

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Key Points:

- Light detection and ranging data allow us to see fault scarps under dense rainforest above the subducted Chile Ridge for the first time
- Combining offsets with well dated glacial records provides fast slip rates of ∼14 mm/yr dextral strike slip, and ∼6 mm/yr vertical
- Rapid tectonic uplift driven by Chile Ridge subduction with vertical signals of the fault strongest where associated with the slab window

Supporting Information:

Supporting Information may be found in the online version of this article.

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Abstract The influence of an oceanic ridge spreading center being subducted on the overlying plate is poorly known. At Chile's Laguna San Rafael, we collected a novel airborne light detection and ranging (lidar)-derived topographic data set near where an oceanic spreading center, the Chile Ridge, is being subducted under South America. In these data and with corroborative field observations (including fault rocks), we map Quaternary deposits presumably displaced vertically and horizontally along the Liquiñe-Ofqui Fault Zone's (LOFZ) master fault scarp. Utilizing dated glacier deposits from the well-researched San Rafael Glacier (among the best studied in Patagonia) with our lidar-derived offest data (validated in the field) we estimated Holocene horizontal dextral strike slip rates of 13.8 ± 4.9 and 14.1 ± 1.0 mm/yr based on displaced moraine and landslide deposits. The lidar-derived topographic data set further guided analysis outside of the lidar area, but along strike of the fault, and we document a major vertical fault scarp south of Laguna San Rafael, which have young scarps showing some of Earth's fastest vertical slip rates (∼6 ± 3 mm/yr). Exhumed metamorphic rocks here show long term strike slip displacement and longevity of the LOFZ in Chilean Patagonia. Because the dip slip component is nearly zero 750 km to the north along the LOFZ, the rapid neotectonic surface uplift here is likely controlled and sustained by oblique subduction of the Chile Ridge and associated slab window and contributes to the highest topography in Patagonia (∼4 km).

Plain Language Summary The Patagonian Andes of Chile is the only place on Earth where the ocean is spreading apart and forming new oceanic crust, and is being subducted underneath a continent. This subduction of the Chile Ridge, is oblique, and leads to strike slip movement of a major fault, the Liquiñe-Ofqui. Because of abundant rainforest, it is difficult to see how this fault interacts with and modifies the landscape. We collected a novel data set using light detection and ranging data (i.e., lidar data), or lasers sent from a plane to the surface over the fault, which allowed us to filter away the dense vegetation and see faulting. The fault scarps are clear with vertical and horizontal deformation. Because Laguna San Rafael is one of the best dated sites in Patagonia, we tie the fault displacements from the lidar, with glacier landform dates to obtain slip rates, or how fast the fault moves over time. Here it moves fast, at around 14 mm/yr horizontally, and about 6 mm/yr vertically and provides important insight into what happens when you subduct an oceanic spreading center below a continent (or perhaps somewhat similar to taking Iceland today and shoving it underneath another continent).

1. Introduction and Background

Oblique subduction can cause major crustal strike-slip faults to form in the upper crust, oftentimes with significant associated crustal seismic hazards, like the Liquiñe-Ofqui Fault Zone (LOFZ) in Chilean Patagonia (e.g., Mw 6.2 in 2007; Astudillo et al., 2021; De Pascale et al., 2021; Vargas et al., 2013; Villalobos et al., 2020) and the Sumatran Fault in Southeast Asia (e.g., Mw 7.6 in 1933 and Mw 6.4 in 2007; Bradley et al., 2017). At ∼47°S latitude, a unique tectonic setting occurs: the oblique subduction of a triple junction between the Antarctica, South American, and Nazca Plates. This location, known as the Chile Triple Junction (CTJ; Figure 1; Forsythe & Nelson, 1985; Spitzak & DeMets, 1996), is the only place on Earth where an actively spreading oceanic ridge (something that today can be seen onshore in Iceland or Djibouti)—specifically, the Chile Ridge/Rise—is being subducted, in this case beneath the South American Plate. Convergence rates at this junction are recorded at 20 mm/yr for the Antarctic Plate and between 66 and 81 mm/yr for the Nazca Plate (Lara et al., 2018; Somoza, 1998). Because triple junctions are key features of plate tectonics, what occurs in the upper crust (and when) and the influence on uplift as these spreading centers migrate is a source of considerable debate (Bourgois et al., 2021; Husson et al., 2019; Stevens Goddard & Fosdick, 2019). Quantification of how fast crustal faults slip