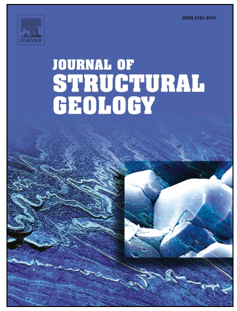

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Seismic cycle feedbacks in a mid-crustal shear zone

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Abstract

Mid-crustal fault rheology is controlled by alternating brittle and plastic deformation mechanisms, which cause feedback cycles that influence earthquake behavior. Detailed mapping and microstructural observations in the Pofadder Shear Zone (Namibia and South Africa) reveal a lithologically heterogeneous shear zone core with quartz-rich mylonites and ultramylonites, plastically overprinted pseudotachylyte and active shear folds. We present evidence for a positive feedback cycle in which coseismic grain size reduction facilitates active shear folding by enhancing competency contrasts and promoting crystal plastic flow. Shear folding strengthens a portion of a shear zone by limb rotation, focusing deformation and promoting plastic flow or brittle slip in resulting areas of localized high stress. Using quartz paleopiezometry, we estimate strain and slip rates consistent with other studies of exhumed shear zones and modern plate boundary faults, helping establish the Pofadder Shear Zone as an ancient analogue to modern, continental-scale, strike-slip faults. This feedback cycle influences seismicity patterns at the scale of study (10s of meters) and possibly larger scales as well, and contributes to bulk strengthening of the brittle-plastic transition on modern plate boundary faults.

Keywords: earthquake cycle, fault rheology, active shear folds, pseudotachylyte, Pofadder Shear Zone, San Andreas analogue

1. Introduction

The seismic behavior of continental-scale faults is controlled by the rheology of materials in mid-crustal shear zones (e.g. Sibson, 1982; Scholz, 1988; Handy et al., 2007), where interactions between fluids, variable lithology and evolving shear zone geometries produce some of the complex fault behaviors observed on faults (e.g. Sibson, 1977, 1984; Chester et al., 1993; Sibson, 1996; Stewart et al., 2000; Holdsworth et al., 2001; Compton et al., 2017).

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