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Computing Rates and Distributions of Rock Recovery in Subduction Zones

BUCHANAN KERSWELL[1], MATTHEW KOHN[1] AND TARAS GERYA[2]

[1]Boise State University

[2]ETH Zurich

Presenting Author: buchanankerswell@u.boisestate.edu

Bodies of rock that are detached (recovered) from subducting oceanic-plates and exhumed to Earth's surface become invaluable records of the mechanical and chemical processing of subducted material. For example, PT estimates from collections of exhumed HP rocks (the *rock record*) can partially reconstruct thermal gradients along the plate interface through time, and in turn, reveal important thermo-kinematic constraints on seismic cycles, deformation mechanics, and rates of chemical exchange between Earth's crust and upper mantle. Many well-studied bodies of exhumed HP rocks provide copious insights into the nature of rock recovery, yet various interpretations concerning thermal gradients, recovery rates, and recovery depths arise when directly comparing the rock record with numerical simulations of subduction. The crux to constraining recovery rates and distributions directly from the rock record, or by comparison with numerical experiments, stems from small sample sizes of HP rocks—making statistical inference weak. As an alternative approach, this study implements a "soft" clustering classification algorithm to identify rock recovery in numerical simulations of oceanic-continental convergence. Over one-million markers are traced and classified from 64 simulations representing the range of presently active subduction zones on Earth. Marker PT distributions and recovery rates show clear (non)correlations with certain thermo-kinematic boundary conditions. Likewise, PT distributions of recovered markers show a range of (in)compatibility with the rock record depending on the collection of natural samples and suite(s) of numerical experiments. A notable gap in marker recovery is found near 2 GPa and 550 ËšC, perfectly coinciding with the highest-density of exhumed HP rocks. Implications for such a gap in marker recovery include a simplified numerical model failing to capture the full range of recovery mechanisms, inconsistent thermal gradients compared to natural samples, and a potential overabundance of rocks recovered from (natural bias), or studied from (scientific bias), around 2 GPa and 550 ËšC. Most importantly, recovered markers indicate a range of (in)plausible thermo-kinematic boundary conditions for reproducing the rock record and highlight the immediate usefulness of augmenting observational constraints with a large simulated petrological dataset.