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Does subduction of mass transport deposits (MTDs) control seismic behavior of shallow–level megathrusts at convergent margins?

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ABSTRACT

We present a critical appraisal of the role of subducted, medium (10–1000 km^2) to giant (≥1000 km^2) and heterogeneous, mud-rich mass transport deposits (MTDs) in seismic behavior and mechanisms of shallow earthquakes along subduction plate interfaces (or subduction channels) at convergent margins. Our observations from exhumed ancient subduction complexes around the world show that incorporation of mud-rich MTDs with a “chaotic” internal fabric (i.e., sedimentary mélanges or olistostromes) into subduction zones strongly modifies the structural architecture of a subduction plate interface and the physical properties of subducted material. The size and distribution of subducted MTDs with respect to the thickness of a subduction plate interface are critical factors influencing seismic behavior at convergent margins. Heterogeneous fabric and compositions of subducted MTDs may diminish the effectiveness of seismic ruptures considerably through the redistribution of overpressured fluids and accumulated strain. This phenomenon possibly favors the slow end-member of the spectrum of fault slip behavior (e.g., Slow Slip Events, Very Low Frequency Earthquakes, Non-Volcanic Tremors, creeping) compared to regular earthquakes, particularly in the shallow parts ($T < 250$ °C) of a subduction plate interface.

1. Introduction

Most large magnitude earthquakes (Mw ≥ 8.5) that occurred in the past are shown to have taken place along the frictional interface between two converging plates at subduction zones (e.g., Byrne et al., 1988; Scholz, 2002; Heuret et al., 2012; Scholl et al., 2015). Several interlinked geological, physical and mechanical factors have been proposed to explain different seismic behaviors of subduction plate interface, such as the coupling strength (e.g., Lay and Kanamori, 1981; see also Uyeda and Kanamori, 1979; Scholz and Campos, 2012; Doglioni et al., 2007), slab retreat (e.g., Doglioni et al., 2007), upper plate motion and the related-stress regime (Peterson and Seno, 1984; Scholz and Campos, 1995; Heuret et al., 2012), down-dip width of a seismogenic zone (e.g., Kelleher et al., 1974; Corbi et al., 2017), megathrust curvature (Bletery et al., 2016), and trench migration velocity (Schellart and Rawlinson, 2013). Among these factors, subduction of thick piles of trench sediments (i.e., thickness ≥ 1 km) appears to play a critical role in facilitating seismic rupture propagation and high-magnitude earthquake occurrences (Mw ≥ 8.5), by smoothing out lateral relief gradient and strength-coupling asperities at a subduction plate interface (Ruff, 1989; Heuret et al., 2012; Scholl et al., 2015; Seno, 2017; Brizzi et al., 2018). However, the occurrence of giant earthquakes (Fig. 1) at convergent plate boundaries, which are characterized by both sediment-flooded (e.g., Sumatra, Central-South Chile, Alaska/Aleutians) and sediment-poor trenches (e.g., Kamchatka, Northern Chile, Northern Peru, Northern Japan) (see, e.g., Kopp, 2013), suggests that some other factors such as the internal architecture and the mechanical properties of subducted material (e.g., composition, friction and strength properties, permeability, stiffness, fracture toughness; Fagereng and Sibson, 2010 and reference therein), as well as the thickness of a subduction plate interface (Rowe et al., 2013), may play a more significant role than sediment supply rates in influencing the seismic behavior at shallow depths in subduction zones. Particularly, subduction of heterogeneous material characterized by strong internal contrast in competence that is typical of mélanges and shear zones has been reported as a significant factor affecting seismic style within a subduction plate interface or in a subduction channel shear zone (e.g., Cloos, 1982; Raymond, 1984; Cowan, 1985; Festa et al., 2010; Codegone et al., 2012; Dilek et al., 2012). Mixing of competent blocks of oceanic crust with

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