Structural constraints on the subduction of mass-transport deposits in convergent margins

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Abstract: The subduction of large and heterogeneous mass-transport deposits (MTDs) is discussed to modify the structure and physical state of the plate boundary and therewith exert an influence on seismicity in convergent margins. Understanding which subduction-zone architectures and structural boundary conditions favour the subduction of MTDs, primarily deposited in oceanic trenches, is therefore highly significant. We use bathymetric and seismic reflection data from modern convergent margins to show that a large landslide volume and long runout, in concert with thin trench sediments, increase the chances for an MTD to become subducted. In regions where the plate boundary develops within the upper plate or at its base (non-accretionary margins), and in little-sedimented trenches (sediment thickness <2 km), an MTD has the highest potential to become subducted, particularly when characterized by a long runout. On the contrary, in the case of a heavily sedimented trench (sediment thickness >4 km) and short runout, an MTD will only be subducted if the thickness of subducting sediments is higher than the thickness of sediments under the MTD. The results allow identification of convergent margins where MTDs are preferentially subducted and thus potentially alter plate-boundary seismicity.

Submarine landslides occur on all types of continental margins and geological provinces in the oceans where inclined seafloors are present (Fig. 1). They include the largest sedimentary movements on Earth, forming different types of mass-transport deposits (MTDs). Such MTDs cover areas of hundreds to thousands of square kilometres in the oceans and range from tens to hundreds, and up to thousands of metres in thickness (Moscardelli and Wood 2016 and references therein). The Ruatoria Debris Avalanche off the coast of New Zealand (Fig. 2a), for example, moved around 2000 km^3 of sediment and basement rocks (thickness of the MTD up to *c.* 2000 m; Collot *et al.* 2001). The Storrega Slide off Norway affected around 3000 km^3 of slope material (Haflidason *et al.* 2004). MTDs related to large landslides (>1000 km^2) can have runout distances of some hundreds of kilometres (Urgeles and Camerlenghi 2013; Moscardelli and Wood 2016).

Along convergent margins, submarine landslides can mobilize both the sediments that drape the forearc slope and the underlying basement rock of the upper plate. As a consequence, their MTDs often consist of debris-blocky flows (Fig. 2a) with kilometre-sized megablocks embedded in a mud-rich to debrite matrix (Collot *et al.* 2001). Field studies on exhumed ancient analogues of convergent margins also documented mud-rich MTDs with block-in-matrix deposits, such as sedimentary mélanges or olistostromes (Pini 1999; Remitti *et al.* 2011; Pini *et al.* 2012; Festa *et al.* 2016; Ogata *et al.* 2019, 2020). They are commonly characterized by centimetre- to metre-sized lithic blocks that are randomly distributed in a clay- or shale-rich matrix, which may sustain bedding packages that locally reach tens of metres or up to kilometres in size (floaters or over-sized blocks; e.g. Festa *et al.* 2016, 2019).

Based on the observation that earthquake rupture during the moment magnitude (M_w) 9.5 Great Chile (1960) and M_w 8.8 Maule (2010) earthquakes decreased across the region where the MTDs of large submarine slope failures are currently subducted (Fig. 3b), Geersen *et al.* (2013) suggested that submarine landslides may affect seismicity at the plate boundary. In their model, the subduction of a section of chaotic MTDs, up to 700 m in thickness and including kilometre-scale blocks of upper-plate basement rocks, contributes to the development of a rough, structurally and lithologically complex plate boundary (Fig. 2c–e). Such a complex plate

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