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# Mélanges and chaotic rock units: Implications for exhumed subduction complexes and orogenic belts

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A B S T R A C T

Most of mélanges occurring in exhumed subduction complexes and orogenic belts are commonly interpreted as the product of tectonic processes (e.g., underplating and return flow) acting at intermediate to great depths ($T$ > 250 °C, depth >10–15 km). Conversely, observations on modern and ancient non- to poorly metamorphosed subduction complexes around the world, clearly show that the largest part (c. 64.7%) of mélanges and chaotic rock units are already formed at shallower structural levels ($T$ < 250 °C, depth <10–15 km). They mainly consist of broken formations (>21.5%), sedimentary (c. 20%), polygenetic (>13.7%), and diapiric (c. 6.7%) mélanges. Tectonic mélanges are limited to about 2.7%, suggesting that tectonics is not an efficient mixing process at shallow structural levels. We document that the subduction of structural inheritances (e.g., ocean-continent transition zones, and ocean plate stratigraphy) plays a significant role in forming and differentiate the different types of chaotic units at shallow depths, also controlling the location of the plate interface and the dynamics of the wedge front (i.e., tectonic accretion vs. erosion). However, not all chaotic units that formed at shallow structural levels can be subducted and, as subducted, their fate could be very different if they become part of the plate interface or if they share the fate of the lower plate. Our findings demonstrate that the evidence that the larger part of mélanges and chaotic units form at shallow depths has significant implications for a better understanding of the tectonic evolution of subduction complexes and orogenic belts, ranging from the mode and time of Precambrian Earth evolution and the onset of plate tectonics to the role of mélanges in controlling the seismic behavior.



## 1. Introduction

Mélanges and, chaotic units are a significant component of most of subduction complexes (i.e., accretionary, and not-accretionary margins) and orogenic belts around the world, regardless of their age (from Precambrian to present day), tectonic evolution, and location (e.g., from the circum-Pacific region to the circum-Mediterranean area, up to the Alpine-Himalayan and Asian orogenic belts and suture zones). Tectonic, sedimentary, diapiric processes and their interaction have been documented to form different types of mélanges and/or chaotic units (i.e., tectonic, sedimentary, diapiric and polygenetic; Raymond, 1984, 2019; Cowan, 1985; Pini, 1999; Bettelli and Vannucchi, 2002; Remitti et al., 2007; Wakabayashi, 201, 2019; Festa et al., 2019 and references therein). Nevertheless, most of the chaotic units preserved in exhumed subduction complexes, particularly metamorphic ones, are commonly interpreted as the product of tectonic processes acting from intermediate (250 °C < $T$ < 400 °C, corresponding to about 10–15 km depth) to great depths ($T$ > 400 °C, corresponding to >15 km depth) during convergent stages. The transfer of isolated slices and blocks, detached from the downgoing slab to the upper plate and/or within the plate boundary interface due to tectonic underplating (Dickinson, 1971; Platt et al., 1985; Kimura et al., 1996; Ernst et al., 2009; Meneghini et al., 2009), and the return flow (flow mélanges, *sensu* Cloos, 1982, 1986; Cloos and Shreve, 1988a, 1988b), undoubtedly represents an effective mixing mechanism

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