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Mechanisms and processes of stratal disruption and mixing in the development of mélanges and broken formations: Redefining and classifying mélanges

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ABSTRACT

The terms *mélange* and *broken formation* have been used in different ways in the literature. The lack of agreement on their definition often leads to confusion and misinterpretations. An evaluation of the various uses of these terms allows us to consider several types of chaotic rock bodies originated by tectonic, sedimentary and diapiric processes in different tectonic settings. Our review of stratal disruption and mixing processes shows that there exists a continuum of deformation structures and processes in the generation of mélanges and broken formations. This continuum is directly controlled by the increase of the degree of consolidation with burial. In tectonically active environments, at the shallow structural levels, the occurrence of poorly consolidated sediments favors gravitational deformation. At deeper structural levels, the deformation related to tectonic forces becomes gradually more significant with depth. Sedimentary (and diapiric) mélanges and broken formations represent the products of punctuated stratal disruption mechanisms recording the instantaneous physical conditions in the geological environment at the time of their formation. The different kinematics, the composition and lithification degree of sediments, the geometry and morphology of the basins, and the mode of failure propagation control the transition between different types of mass-transported chaotic bodies, the style of stratal disruption, and the amount of rock mixing. Tectonically broken formations and mélanges record a continuum of deformation that occurs through time and different degrees of lithification during a progressive increase of the degree of consolidation and of the diagenetic and metamorphic mineral transformation. Systematic documentation of the mechanisms and processes of the formation of different broken formations and mélanges and their interplay in time and space are highly important to increase the understanding of the evolutionary history of accretionary wedges and orogenic belts.

1. Introduction

Mélanges and broken formations represent a significant component of most convergent margins and orogens around the world (Fig. 1), and the details of their block-in-matrix character reflect a close relationship between the processes and the tectonic setting of their formation (Festa et al., 2010a; Suzuki, 1986). However, the lack of agreement on the definition of mélange (e.g., Rast and Horton, 1989; Silver and Beutner, 1980; also compare Şengör, 2003 with Cowan and Pini, 2001; Festa et al., 2010a; Pini, 1999; Wakabayashi, 2011) has lead to some confusion and misinterpretations in the literature. At shallow structural levels in tectonically active environments, sediments are subject to small-scale deformation immediately after deposition at rates and in ways dependent on the interplay between gravitational deformation and tectonic burial (e.g., Byrne, 1994; Maltman, 1994). The downward increase in both the consolidation and lithification of buried sediments and tectonic forces controls the progressive increase in deformation and, in cases, stratal disruption (Maltman, 1994 and references therein; Onishi and Kimura, 1995; Yamamoto et al., 2012a). The result of these conditions is a continuum of development of structures in the originally coherent stratigraphic successions via stratal disruption and mixing processes, which play a major role in the genesis of broken formations and mélanges (e.g., Cowan, 1985; Hsü, 1968; Raymond, 1984).

Time-progressive evolution of deformation structures in chaotic rock units, such as broken formations to mélanges, has been rarely described in the literature (see, e.g.,Cowan, 1985; Harris et al., 1998; Lucente and Pini, 2003; Needham, 1995; Ogata et al., 2012a; Pini et al., 2012; Raymond, 1984; Smith et al., 1979; Yamamoto et al., 2012a). This is in part due to the fact that collisional and post-collisional shortening, magmatism, extensional deformation, and

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