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Late Oligocene–early Miocene olistostromes (sedimentary mélanges) as tectono-stratigraphic constraints to the geodynamic evolution of the exhumed Ligurian accretionary complex (Northern Apennines, NW Italy)

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In the Northern Apennines of Italy, mud-rich olistostromes (sedimentary mélanges) occur at different stratigraphic levels within the late Oligocene–early Miocene sedimentary record of episutural/wedge-top basins. They are widely distributed along the exhumed outer part of the Ligurian accretionary complex, atop the outer Apenninic prowedge, over an area about 300 km long and 10–15 km wide. Olistostromes represent excellent examples of ancient submarine mass-transport complexes (MTCs), consisting of stacked cohesive debris flows that can be directly compared to some of those observed in modern accretionary wedges. We describe the internal arrangement of olistostrome occurrences in the sector between Voghera and the Monferrato area, analysing their relationships with mesoscale liquefaction features, which are commonly difficult to observe in modern MTCs. Slope failures occurred in isolated sectors along the wedge front, where out-of-sequence thrusting, seismicity, and different pulses of overpressured tectonically induced fluid flows acted concomitantly. Referring to the Northern Apennines regional geology, we also point out a gradual lateral rejuvenation (from late Oligocene to early Miocene) toward the SE and an increasing size and thickness of the olistostromes along the strike of the frontal Apenninic prowedge. This suggests that morphological reshaping of the outer prowedge via mass-transport processes balanced, with different pulses over a short time span, the southeastward migration and segmentation of accretionary processes. The latter were probably favoured by the occurrence in the northwestern part of the Northern Apennines of major, inherited palaeogeographic features controlling the northward propagation of the prowedge. Detailed knowledge of olistostromes, as ancient examples of MTCs related to syn-sedimentary tectonics and shale diapirism, and of their lateral variations in term of age and size, provides useful information in regard to better understanding of both the tectono-stratigraphic evolution of the Apenninic prowedge and the submarine slope failures in modern accretionary wedges.

Keywords: olistostromes; sedimentary mélanges; mass-transport complexes; ancient and modern accretionary wedges; Northern Apennines

1. Introduction

Observations on modern accretionary complexes in convergent plate boundaries show that the outer wedge is highly sensitive to changes of the dynamic equilibrium (e.g. Davis *et al.* 1983; Platt 1986; Del Castello *et al.* 2004, 2005; von Huene *et al.* 2004; Sage *et al.* 2006; Vannucchi *et al.* 2012). In this framework, mass-transport processes are leading agents in maintaining the dynamic equilibrium by reshaping the accretionary wedge topography and producing high concentrations of small- to medium-scale submarine landslide accumulations (McAdoo *et al.* 2004; Mosher *et al.* 2008; Camerlenghi *et al.* 2009; Moore *et al.* 2009; Harders *et al.* 2011; Strasser *et al.* 2011) and megaslides (Moore *et al.* 1976; Goldfinger *et al.* 2000; Cochonat *et al.* 2002; von Huene *et al.* 2004; Hühnerbach *et al.* 2005; von Huene 2008; Yamada *et al.* 2010). Earthquake shaking, as well as long-term causal factors (i.e. sea level variations, rate of sedimentation, gas hydrates instability, tectonic oversteepening), may exert a primary role in triggering slope failures (e.g. Keeper 1984; Hampton *et al.* 1996; Cochonat *et al.* 2002). The latter may have devastating consequences in terms of natural hazards (i.e. earthquakes plus landslide-induced tsunamis; e.g. Kawamura *et al.* 2012 and reference therein) and potential socio-economic loss (e.g. failure of submarine cable network; see, e.g. Hsu *et al.* 2008). Thus, improving our understanding of the mechanisms and processes able to promote and propagate submarine slope failure, and of related mass-transport deposit (MTD) emplacement, is one of the most urgent and challenging tasks faced in the Earth Sciences.

Although recent studies in modern accretionary wedges have provided excellent results on the comprehension of the complex interplay between tectonic and submarine mass-transport processes (e.g. Kawamura *et al.* 2009, 2011; Moore *et al.* 2009; Strasser *et al.* 2011;), some complexities

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