

Seismically-induced slumps in Lower-Maastrichtian peritidal carbonates of the Apulian Platform (southern Italy)

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Abstract

In the southeastern Murge (Apulian Foreland, southern Italy), a Lower-Maastrichtian carbonate section showing soft-sediment deformation structures is composed of peritidal lithofacies associations developed in a wide low-energy inner-platform system. Shear-induced soft-sediment deformation structures correspond to multilayer deformed horizons, 1.5 to 2 m in thickness, sandwiched between undeformed layers. Overturned and recumbent folds lying on décollement surfaces and asymmetrical fault-inception folds allow us to interpret the observed deformed horizons as slump sheets. The detailed description of the main morphological features of the deformed beds and the recognition of unconformable surfaces and undeformed beds between slumped beds allow us to distinguish three different events of deformation. Preferential orientation of slump folds has been measured and every slumped bed shows a different direction of shortening. Randomly oriented direction of shortening suggests that each deformation event was driven by the presence of local very gentle gradients developed in peritidal settings. By excluding other potential trigger mechanisms of deformation, the observed slumps are interpreted as seismically-induced slides. Even if no data about the distance of the seismic source may be obtained, near-field earthquake tectonics affected the Apulian Platform during Late Cretaceous times.

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1. Introduction

Complex soft-sediment deformation structures were observed in Lower-Maastrichtian peritidal limestones

belonging to the Apulian Platform in the Murge area (Apulia, southern Italy). Commonly, soft-sediment deformation structures are the result of loss of shear resistance in water-saturated granular materials and the loss of resistance is basically induced by an increasing of pore water pressure related to liquefaction and/or to fluidization (Allen, 1982; Owen, 1987). Because liquefaction and fluidization can result from many common natural processes (e.g. cyclic and/or impulsive effect of storm waves, earthquakes, overloading, sudden changes in artesian spring level, etc.), interpreting which type of trigger mechanism induced soft-sediment

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deformation in each “fossil” example needs a detailed sedimentologic and stratigraphic study. It must be highlighted that transitional and shallow-marine carbonate successions can contain sedimentary structures due to desiccation (*see* Pratt, 2002) or other non-physical deformations such as bioturbations (*see* for example Fornòs et al., 2002), which may be easily confused with some soft-sediment deformation structures induced by loss of shear resistance.

Moreover, peritidal carbonates, like those described in the present work, often possess syndepositional features which could inhibit soft-sediment deformation since these deposits: i) often undergo rapid lithification, which does not permit mechanical deformation; ii) are mainly characterized by fine- and very-fine-grains, which possess low-susceptibility to liquefaction (*see* Moretti et al., 1999); iii) develop on tidal flats, which are not characterized by gravitationally-unstable slopes (except locally along banks of tidal channels e.g. Daley, 1972). On the other hand, soft-sediment deformations were observed in carbonate successions (Demico and Hardie, 1994), and, after the paper of Weaver and Jeffcoat (1978), some were interpreted as seismically-induced (Spalletta and Vai, 1984; Lorenz, 1992; Dugué, 1995; Pope et al., 1997; Pratt, 1998a,b, 2001, 2002; Kahle, 2002; Attou and Hamoumi, 2004; Jewell and Ettenshon, 2004; André et al., 2004; McLaughlin and Brett, 2004), even if the main deposits involved in seismic liquefaction processes seem to be siliciclastic silts and sands of lacustrine and fluvial environments (*see* Moretti et al., 1999; Ettensohn et al., 2002a,b, and references therein). It should be noted that soft-sediment deformation structures interpreted as being induced by seismic shocks have been increasingly

recognized in the geological record and have been reported from all sedimentary environments. The recognition of seismically-induced soft-sediment deformations in shallow-water limestones is often the only possibility of demonstrating tectonic activity during the development of carbonate platforms (Cisne, 1986; Pratt, 1994; Tisljar et al., 1998).

In order to contribute to the discussion about the origin of some soft-sediment deformation structures developed in carbonate successions, the analysis of structures in Lower-Maastrichtian peritidal limestones of the Murge area is reported in the present work whose aims are: i) to describe the soft-sediment deformation structures; ii) to interpret the mechanism of deformation on the basis of the field data; iii) to discuss the most likely trigger-mechanisms of deformation; iv) to propose a palaeogeographic/tectonic scenario in which the structures formed. It should be noted that Cretaceous peritidal limestones of the Apulian Platform developed in the interior of the Adria Plate, on a mature passive continental margin (Ricchetti et al., 1988) whose main tectonic activity was concentrated in Turonian time (Mindszenty et al., 1995), although previous work has been described soft-sediment deformation structures as probably seismically-induced in a Cenomanian peritidal succession of the Apulian Platform (Iannone, 1996) and suggested the presence of tectonic structures whose activity began at least during the Late Cretaceous (Festa, 2003).

Moreover, the whole study represents a general method to interpret in a reliable way the trigger mechanism for deformation in similar sedimentary environments; our study shows that a detailed facies

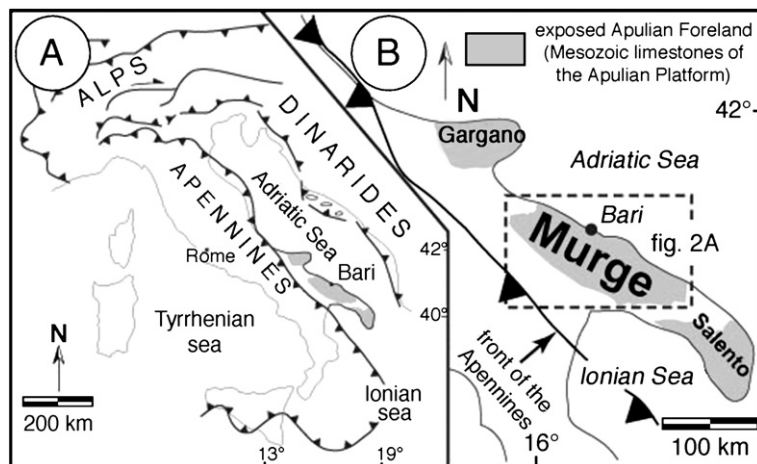


Fig. 1. A) Location of the Apulian Foreland. B) Location of the Murge area in the exposed part of the Apulian Foreland (southeastern Italy).

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