Interaction of tectonic, sedimentary, and diapiric processes in the origin of chaotic sediments: An example from the Messinian of Torino Hill (Tertiary Piedmont Basin, northwestern Italy)

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ABSTRACT

Geologic mapping and integrated stratigraphic and structural observations of a gypsum quarry from northwestern Italy allow evaluation of the relative contributions, the time relationships, and the causative links between tectonic, sedimentary, and diapiric processes in the genesis of chaotic sediments of Messinian age. Three chaotic units are exposed in the quarry: together, they make up a composite chaotic unit that is unconformably overlain by post-chaotic sediments. Unit 1 is composed of blocks of primary evaporites that are juxtaposed to marine marls by subvertical transpressive faults and are parallel to the fault surfaces. Unit 2 unconformably overlies Unit 1, and consists of a lenticular sedimentary body containing both angular and rounded blocks, randomly distributed in a fine-grained matrix. Unit 3 consists of a 10-m-wide body bounded by transpressive faults, and pierces both Units 1 and 2. It is composed of strongly deformed muddy deposits that envelop blocks of gypsum and carbonate rocks. Between the core and the margins, various zones have been defined based on the increasing amount of deformation toward the margins. The post-chaotic sediments unconformably overlie both Units 1 and 2, sealing the main fault systems.

The composite chaotic unit is related to thrust propagation during a regional phase of deformation, and is the result of different evolutionary stages, in each of which a single genetic mechanism prevailed. Tectonic faulting prevailed during stage 1 and was responsible for the formation of a tectonically disrupted assemblage (Unit 1). During stage 2, gravity-driven sedimentary phenomena, related to slope oversteepening triggered by ongoing thrust propagation, resulted in the deposition of Unit 2. Gravity sliding was favored by the mechanical weakening of sediments caused by tectonic faulting. Overpressure conditions resulting from the rapid deposition of Unit 2 triggered the rise of a diapir (Unit 3) that pierced Units 1 and 2. The involvement of methane-rich fluids in the formation of the diapir is suggested by the occurrence of blocks of methane-derived carbonates, found not in the quarry, but just outside it.

Keywords: chaotic deposits, tectonics, sedimentary processes, diapiric processes, Messinian, Tertiary Piedmont Basin.

INTRODUCTION

Chaotic rock bodies, or mélanges, are common components of ancient orogenic belts and present-day accretionary complexes (e.g., Hsü, 1968; Aalto, 1981; Cloos, 1982; Cowan, 1985; Barber and Brown, 1988; Orange, 1990; Orange et al., 1993; Onishi and Kimura, 1995; Orange and Underwood, 1995; Pini, 1999; Cowan and Pini, 2001). Their origin is commonly attributed to (1) tectonic disruption and mixing of originally coherent sequences, responsible for the formation of tectonic mélanges that, depending on the degree of stratal disruption, retain the original composition of the parent succession (broken formations, Hsü, 1968; type I mélanges, Lash, 1987; tectonosomes, Pini, 1999) or may include exotic blocks (e.g., Hsü, 1973; Raymond, 1984; Şengör, 2003); (2) gravitational submarine downslope movements (olistostromes, Beneo, 1956; Flores, 1956; Abbate et al., 1970; type II mélanges, Lash, 1987); or (3) shale diapirism caused by the rising toward the seafloor of overpressured, fluid-permeated fine-grained sediments (type III mélanges, Lash, 1987).

Despite valuable criteria having been proposed to discriminate among these mechanisms (e.g., Orange, 1990; Orange and Underwood, 1995; Pini, 1999), the recognition of the role played by each of them in the geological record is problematic, due to the strong facies convergence of their products and to the fact that later deformation and metamorphism often obscure the prevailing forming processes. Moreover, these mechanisms are not mutually exclusive, and can coexist and interact in a complex way: for example, tectonic movements provide favorable conditions for gravity sliding through both the creation of topography and the mechanical weakening of sediments, and may also encourage shale diapirism by creating conduits for mud extrusion (e.g., Kopf, 2002; Chamot-Rooke et al., 2005). In the same way, the loading provided by the rapid deposition of slumps and slides may generate the overpressure necessary for the intrusion of mud diapirs (e.g., Collison, 1994) and the extrusion of mud volcanoes (Sautkin et al., 2003) that, in turn, can create a topography able to trigger further sliding (e.g., Clennell, 1992).

The study of both modern (e.g., Brown and Westbrook, 1988; Reed et al., 1990; Barry et al., 1996; Maslin et al., 1998; Bouriak et al., 2000; Diaz del Rio et al., 2003) and ancient examples

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