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Stratigraphy and strontium geochemistry of Messinian evaporite-bearing successions of the southern Apennines foredeep, Italy: implications for the Mediterranean "salinity crisis" and regional palaeogeography

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Abstract

An integrated study, comprising detailed mapping, stratigraphy, evaporite facies analysis, strontium content, and $^{87}Sr/^{86}Sr$ ratio data, is presented for two Messinian evaporite-bearing units cropping out in Irpinia-Daunia Mountains (southern Apennines, Italy). These units record the tectonic and palaeogeographic evolution of the Messinian southern Apennine foreland basin system during the abrupt salinity crisis which occurred in the Mediterranean region. The Daunia unit comprises the Monte Castello evaporites, formed by euxinic diatomitic marls, evaporitic limestones, and shallow-water gypsum, having a $^{87}Sr/^{86}Sr$ average value of 0.70898 ± 0.00005, close to the Sr isotopic value of the coeval seawater. These marginal evaporites are capped by an erosional unconformity and continental clastic deposits. The Vallone del Toro unit is made up of thin-bedded marls, claystones, calcilutites, and diatomite layers with small gypsum crystals, laminated gypsum, and gypsarenite, testifying deposition in relatively deep-water settings. Gypsum has variable Sr isotopic data with an average value of 0.70899 ± 0.00005 for the "Argilliti policrome del Torrente Calaggio" formation and an average value of 0.70863 ± 0.00014 for the "Argilliti di Mezzana di Forte" formation, reflecting major riverine freshwater input. The different patterns of lithofacies and Sr isotopic composition of gypsum discriminate two distinctive evaporite units, reflecting the tectonic and palaeogeographic controls within the Apennines mountain belt and the Mediterranean. Data for evaporites of the southern Apennines testify the presence of basins in the central and eastern Mediterranean Sea, which never desiccated during the entire salinity crisis and evolved to widespread Lago-Mare conditions in the latest Messinian.

Keywords: Messinian salinity crisis; stratigraphy; strontium isotopes; evaporites; foreland basin system; southern Italy

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1. Introduction

During the Messinian stage the Mediterranean region was affected by a pervasive "salinity crisis" which resulted in the deposition of a huge volume of evaporite sediments (Selli, 1960; Hsü et al., 1977). Onset of the salinity crisis resulted from a complex combination of tectonic and glacio-eustatic processes, which progressively restricted and partly isolated the Mediterranean Sea from the Atlantic Ocean (Hsü et al., 1973b; Krijgsman et al., 1999a,b; Vidal et al., 2002; Duggen et al., 2003).

Two major Messinian sedimentary cycles separated by a deeply incised erosion surface are recognised in various Mediterranean basins. The classic Messinian composite stratigraphic succession in Sicily (Ogniben, 1957; Decima and Wezel, 1973) has been used to correlate the deep-sea sections from various Mediterranean DSDP and ODP sites (Decima and Wezel, 1973; Hsü et al., 1973a, 1977; Cita and Corselli, 1990; Müller and Mueller, 1991). It starts with alternations of open marine marls, sapropels, and diatomaceous shale (Tripoli Formation), and passes to the "lower evaporites" comprising evaporitic limestone, gypsum ("lower gypsum"), and halite. The lower evaporite cycle is separated by an erosional unconformity from the "upper evaporites" comprising gypsum ("upper gypsum") and marls, and overlain by Lago-Mare (Ruggieri, 1967) facies. The lower evaporites preserve the Sr isotope signature of the open Messinian ocean water, mainly at their base (Flecker et al., 2002), whereas the upper evaporites show reduced $^{87}Sr/^{86}Sr$ ratios reflecting either isolation from the Atlantic and an input of low $^{87}Sr/^{86}Sr$ continental runoff (Müller et al., 1990; Müller and Mueller, 1991).

For many years the controversy over the salinity crisis has received diverse interpretation, summarizing in two main models: the "deep desiccated basin" (Hsü et al., 1973a,b) and the "shallow basin" (Nesteroff, 1973). More recently, other proposals have appeared, in response to the diachroneity of evaporite deposition in the various marginal basins of Sicily (Butler et al., 1995, 1999) and between marginal and deep-basin evaporites in the Melilla (Morocco) and in the Sorbas (Spain) basins (Cunningham et al., 1997; Riding et al., 1998, 1999); moreover, a comprehensive two-step model for evaporite deposition has been proposed (Clauzon et al., 1996).

The Apennine foredeep stratigraphy suggests a different model for the salinity crisis, which implies evaporation only in shallow and silled marginal basins, while deep portions of the basin never desiccated (Roveri et al., 2001). The occurrence of "lower evaporites" is limited to the Romagna and Emilia sectors of northern Apennines (Fig. 1) with shallow-water facies (Vena del Gesso basin; Vai and Ricci Lucchi, 1977) and to the Marche and Abruzzi sectors with resedimented evaporites (Ricci Lucchi, 1973). The large sea-level drop related to the evaporative episodes did not significantly modify the depositional features in some external sectors. For example, in the Laga Basin (Fig. 1), deep-water siliciclastic turbidites were deposited before, during, and after the salinity crisis, and the period of evaporite deposition elsewhere is marked here only by euxinic marls and gypsarenite layers (Cantalamessa et al., 1983; Centamore et al., 1992; Patacca et al., 1990). In northern Apennines the upper evaporites are not present and the post-evaporitic Messinian deposits

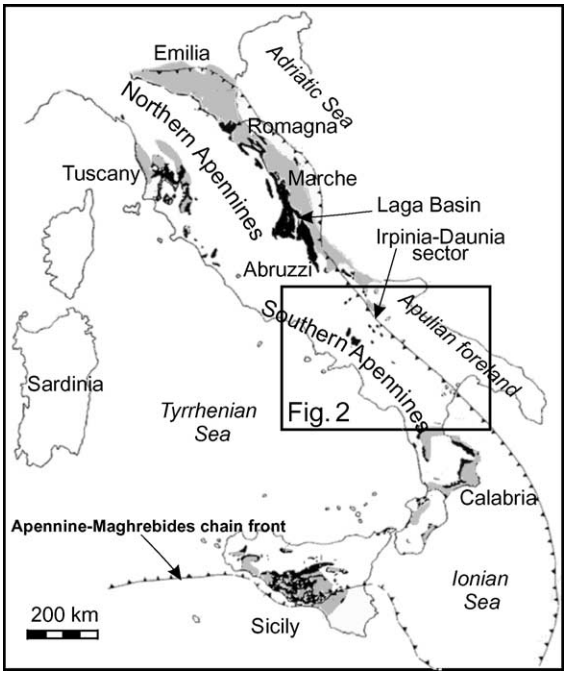

Fig. 1. Distribution of Messinian deposits (black: outcrops; gray: buried deposits) within peninsular Italy and Sicily (modified after Selli, 1973 and Roveri et al., 2001).