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Research paper

Integrated stratigraphy of the St. Thomas section (Malta Island): A reference section for the lower Burdigalian of the Mediterranean Region

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ABSTRACT

The 91.15 m thick St. Thomas section belongs to the Middle Globigerina Limestone, which is the intermediate member of the Globigerina Limestone Formation, and crops out along the eastern cliff of the Delimara Peninsula (the south-eastern part of Malta Island). The sedimentary record is composed of alternating calcareous marls and marly limestones with subordinated prominent bioturbated indurated limestones that are deposited in a pelagic environment.

For the first time paleomagnetic analyses of a Burdigalian succession have provided reliable data that allow the identification of five magnetozones that have been correlated to the Astronomically Tuned Neogene Time Scale, spanning the Early Miocene C6n–C5Dn interval. Calcareous plankton quantitative analyses integrated with paleomagnetic analyses, allowed us to identify and date several bioevents that have great potential for Mediterranean and extra-Mediterranean correlations in the interval between ~19.7 and ~17.2 Ma. In particular, the complete distributional range of the calcareous nannofossil *Sphenolithus belemnos* has been recorded as follows: the First Occurrence (FO) at 19.12 Ma, the First Common Occurrence (FCO) at 19.05 Ma, the Last Common Occurrence (LCO) at 18.44 Ma, and the Last Occurrence (LO) at 18.02 Ma. In addition, the FO and the FCO of *Sphenolithus heteromorphus* have been documented at 18.29 Ma and at 17.99 Ma, respectively. A new paracme interval in the lower part of the range of this species is described between 17.56 and 17.31 Ma.

Concerning the planktonic Foraminifera, the main bioevents are the Common Interval top of *Paragloborotalia siakensis* at 19.55 Ma, a Common Interval of *Globoquadrina dehiscens* between 19.34 and 18.48 Ma, the *Globigerinoides subquadratus* FO at 18.43 Ma, and the onset of an acme interval of *Paragloborotalia acrostoma* that changes its coiling from random to prevalently sinistral at the same time, at 18.40 Ma. These new biostratigraphic data allowed us to place the succession in the standard Mediterranean calcareous plankton zonal schemes and to make some amendments to these schemes. The FCO of *S. belemnos* was revealed a more reliable marker than its FO for the base of the MNN3a Zone. With regard to the planktonic Foraminifera, the *P. acrostoma* AB-r/s has been used as a subzonal marker of the *G. dehiscens*/*Catapsydrax dissimilis* Zone, which now comprises three subzones instead of two.

The deep marine paleoenvironmental setting, the excellent outcrops and the recognition of a continuous succession of bio-magnetostratigraphic events suggest that the St. Thomas section should be considered as a reference section for the lower Burdigalian of the Mediterranean area and for future studies in the definition of the Burdigalian GSSP.

1. Introduction

Beginning with the pioneer works that were conducted in the second half of the last century (Bertolino et al., 1968; Cati et al., 1968; Röth et al., 1971; Müller, 1978), several studies have focused on the definition and the improvement of the Neogene Mediterranean biostratigraphic schemes based on calcareous plankton bioevents (e.g., Rio et al., 1990; Sprovieri, 1992, 1993; Fornaciari and Rio, 1996; Fornaciari et al., 1996; Raffi et al., 2003; Iaccarino et al., 2007; Di Stefano et al., 2008; Di Stefano and Sturiale, 2010; Iaccarino et al., 2011). At present, the Early Miocene calcareous plankton biostratigraphy has been properly reconstructed only for the Chattian/Aquitanian (base of the Early Miocene) and Burdigalian/Langhian (base of the Middle Miocene) boundaries,

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with the definition of the Global Stratotype Section and Point (GSSP) of the Aquitanian (Steininger et al., 1997) and the identification of two possible candidate sections for the Langhian GSSP (Iaccarino et al., 2011). Several authors have studied the Burdigalian sections cropping out in the Mediterranean area (Fornaciari and Rio, 1996; Fornaciari et al., 1996; Coccioni et al., 1997; Deino et al., 1997; Montanari et al., 1997; Myftari and Bako, 1998; Dall'Antonia et al., 2001; Mancin et al., 2003; Lirer et al., 2007; Di Stefano et al., 2008; Hakyemez and Toker, 2010; Di Stefano et al., 2011; Foresi et al., 2011; Turco et al., 2011; McCay et al., 2013), but only the middle–upper part of this age was represented in most of these works. In addition, the shallow-water environmental setting of the historical Burdigalian stratotype section (Cahuzac et al., 1997; Poignant et al., 1997; Pouyet et al., 1997), does not contribute to improve the knowledge of the Early Miocene calcareous plankton biostratigraphy, and is the main reason for the low resolution of the corresponding zonal schemes, particularly for planktonic Foraminifera. Recently, the work of Hakyemez and Toker (2010) allowed an increased biostratigraphic resolution of the Burdigalian by identifying four planktonic foraminiferal biozones rather than the two proposed in Iaccarino's (1985) Mediterranean standard zonal scheme. The low resolution of the Mediterranean standard zonal schemes is also combined to the poor magnetostratigraphic data that are available for the Mediterranean area in the Moria section (Deino et al., 1997) and the Contessa section (Montanari et al., 1997).

In spite of the unreliable biochronological framework for the Burdigalian of the Mediterranean, the ages of the oceanic bioevents were also applied to the Mediterranean sections (e.g., Hakyemez and Toker, 2010; McCay et al., 2013), although isochronism of the

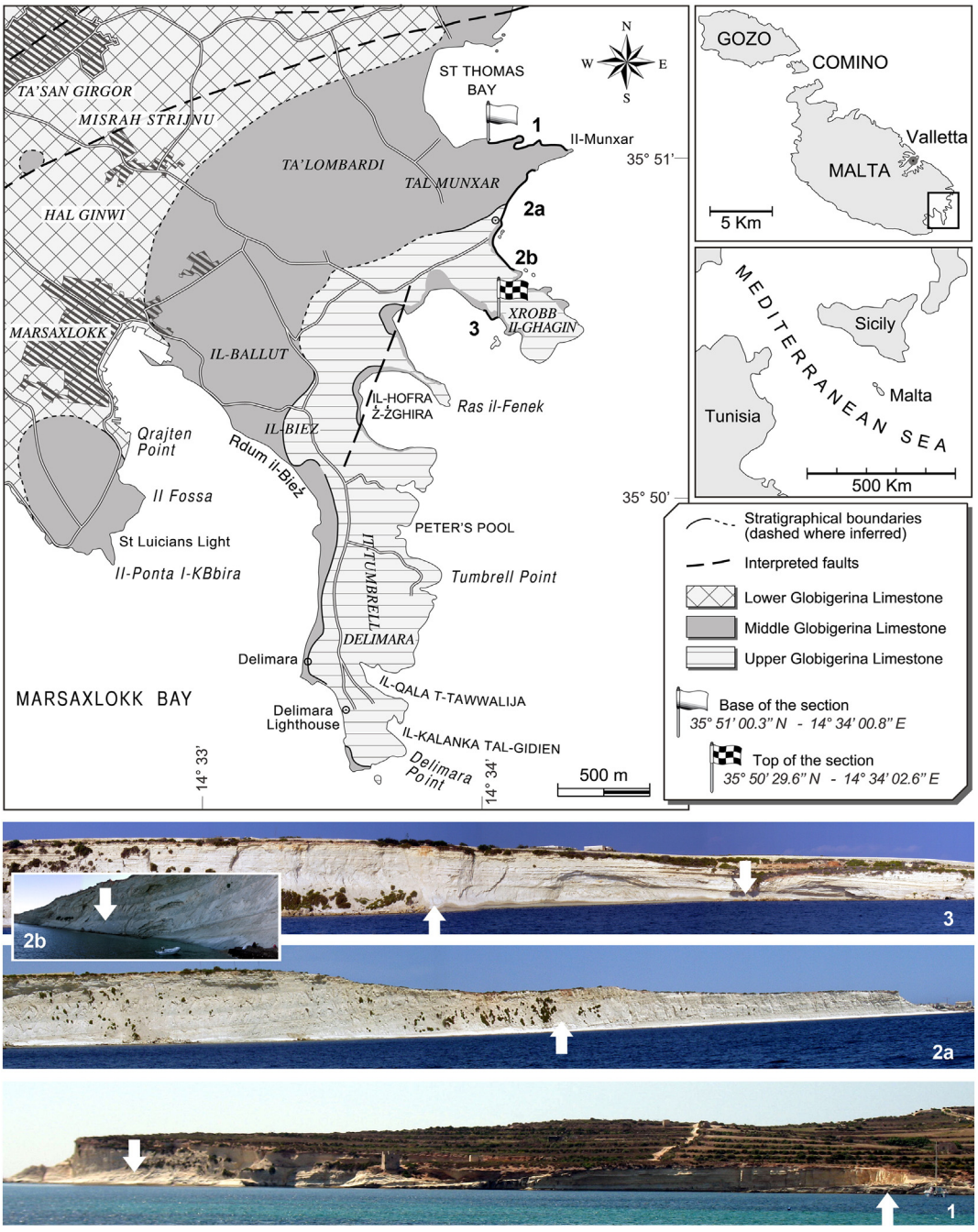

Fig. 1. Location map of the studied section. Geology of the Delimara Peninsula from Oil Exploration Directorate (1993). The lower part of the figure shows the panoramic pictures of 1) the St. Thomas Bay subsection, 2) the Munxar Cliff subsection and 3) the Xrobb il Ghagin subsection. The up arrows and down arrows indicate the base and the top of the subsections, respectively.