

## THE CLIMATE VARIABILITY DURING MARINE ISOTOPE STAGE 19: EVIDENCES FROM A WEST-EAST MEDITERRANEAN TRANSECT

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**ABSTRACT:** New high temporal resolution data on calcareous nannofossil and planktonic foraminifera assemblages, alkenone-derived sea surface temperature and stable oxygen and carbon isotopes are acquired on the Montalbano Ideale section (southern Italy) and at the Ocean Drilling Program (ODP) sites 975 and 976 through Marine Isotope Stages (MIS) 20-18. Results describe accurate climate pattern and distinct orbital-suborbital up to millennia-scale oscillations across the investigated interval.

**KEYWORDS:** MIS 19, calcareous plankton, SST, pollen, stable oxygen and carbon isotopes, Mediterranean

### 1. INTRODUCTION

MIS 19 is the mid-Pleistocene interglacial considered the best analogue of MIS 1 due to their similar orbital configuration (extraordinarily low eccentricity and obliquity maximum close to the precession minimum) and (paleo)climate signal (Tzedakis et al., 2012). A strong likeness between the climate trends through Termination IX (I) and the onset of full interglacial 19 (1) has been recently suggested (Maiorano et al., 2016) based on marine and terrestrial biological proxies at the inland marine succession of Montalbano Jonico. Several issues are however still debated, mainly concerning i) the beginning of MIS 19, as recorded by oxygen isotope records or biological proxies, ii) the duration of MIS 19c (full interglacial), iii) the mode and timing of glacial MIS 18 inception. With the aim to improve the comprehension of climate evolution through this crucial time interval, which includes the chronostratigraphic boundary of the Lower-Middle Pleistocene, new investigations are carried out on the Montalbano Jonico section (southern Italy). It is a continuous reference succession for the Lower-Middle Pleistocene transition spanning MIS 37-16 interval. In particular, the Ideale partial section yet relies on an exceptional multi-proxy high-resolution data set across Termination IX to the inception of MIS 18 (Fig. 1A) (Maiorano et al., 2016). The authigenic <sup>10</sup>Be/<sup>9</sup>Be data (Simon et al., 2017) and <sup>40</sup>Ar/<sup>39</sup>Ar age for tephra layer

V4 (773.9 ± 1.3 ka, Petrosino et al., 2015) at the MIS 19c/19b transition in the Ideale section (Fig. 1A) represent additional invaluable stratigraphical constraints within the Matuyama-Brunhes transitional period. Moreover, new studies are performed at the western Mediterranean ODP Site 976 (Alboran Sea) and Site 975 (Algero-Balearic Sea) (Fig. 1B) in order to have a west-east record of the climate variability during MIS 19 in the Mediterranean basin.

### 2. MATERIAL AND METHOD

The Montalbano Jonico Ideale section (southern Italy) is 74 meters thick and consists of dark-light grey silty clays. The sediments from the ODP sites 976 and 975 consist of nannofossil and foraminifera-rich clays. High-resolution quantitative analyses were performed on calcareous plankton assemblages, in the same samples used to measure the new stable oxygen and carbon isotope ratios carried out on *Melonis barleeanum* and *Cassidulina carinata* at the Montalbano Jonico section, and on *Globigerina bulloides* at the sites 975 and 976. Isotope analyses at the Site 975 are still in progress whereas alkenone analyses were performed at the Balearic core as well as at the Montalbano Jonico Ideale section with the aim to obtain high-resolution Sea Surface Temperature (SST) and signals of terrestrial molecular biomarkers strictly linked to climate on land and hydrological setting.

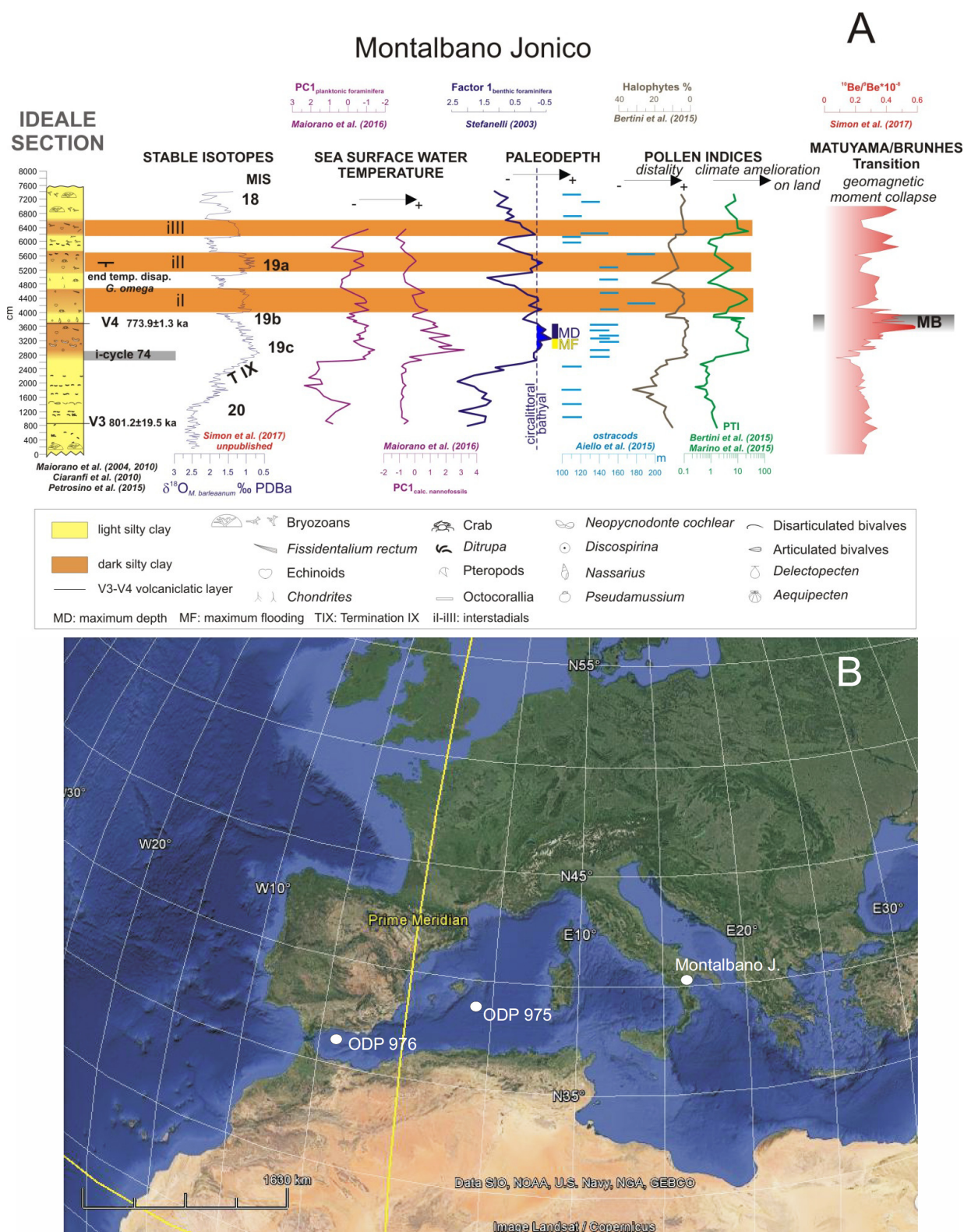


Fig. 1 - A) Main chronological and environmental constraints at the Montalbano Jonico Ideale section. PC1 curves represent Factor 1 obtained by Principal Component analysis performed on planktonic foraminifera and calcareous nannofossils, and on benthic foraminifera. B) location map of the study successions.

### 3. RESULTS

An original astronomical tuning of the  $\delta^{18}\text{O}$  record, adjusted by the radiometric dating of tephra V4, is performed at the Ideale section, using the strong analogies between MIS 1 and MIS 19c in terms of orbital forcing and  $\text{CO}_2$  level (Nomade et al., submitted). The overall results reveal a distinct climate pattern of MIS 19c and at least three millennial-scale oscillations (il-iii, Fig. 1A) superimposed on the long-term drying and cooling trend leading to MIS 18 taking place in one single precession cycle, suggesting a non-linear response of western Mediterranean climate to orbital forcing during this period (i.e. MIS 19a). Results from Site 976 and Site 975 (Fig. 1B) further improve the knowledge on the mode and timing of the climate phases during MIS 20-18. In detail, the  $\delta^{18}\text{O}$  records from the deep sea undisturbed sections clearly depict stages and substages, and stadial and interstadials, which are in excellent agreement with climate oscillations documented by the isotope and biological data at the Montalbano Jonico Ideale section. Key taxa of calcareous plankton assemblages record distinctive patterns that are mainly related to sea-surface water temperature changes and to water exchange rates between Atlantic Ocean and Mediterranean during glacial (MIS 20)-interglacial (MIS 19) phases and short-term climate episodes at the Termination IX. Variations in turbidity and salinity as well as mixing and stratification or nutrient content in the sea surface waters have been reconstructed based on the pattern of selected coccolithophore and planktonic foraminifera taxa. Among pollen assemblages, the Mediterranean/Temperate broad-leaved deciduous forest taxa exhibit higher abundances during interglacials and interstadials (Bertini et al., 2015) when warm-water calcareous plankton taxa increase (Fig. 1A). While, the expansion of steppes and semi-desert vegetation cover, as well as the incursion of polar-subpolar calcareous plankton taxa, occur during cooler periods possibly associated to atmospheric and North Hemisphere ice-sheet dynamics. Shorter-lived climate changes are also detectable at the millennial time-scale. In the Montalbano Ideale record, unequivocal evidence of the shallow water analog of ghost sapropel i-cycle 74 (784 ka) has been documented based on minima in  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ , and the occurrence of planktonic and benthic invertebrate taxa indicating water column stratification and oxygen deficiency at the sea bottom (Maiorano et al., 2016; Nomade et al., submitted). Similar results occur at the Site 975, whereas such palaeoceanographic event is not recorded at Site 976 in the Alboran Sea, thus highlighting a different response to precessional forcing of the surface and deeper water mass hydrological pattern in the westernmost Mediterranean.

### 4. DISCUSSION AND CONCLUSION

The correlation among the different study sections enables to compare the response of marine (coccolithophores and planktonic foraminifera) and terrestrial proxies to climate changes through a west east transect, in different hydrological regimes of Mediterra-

nean. As a whole, the climate pattern observed at the Montalbano Jonico Ideale section and deep-sea cores is well comparable to the synthetic Greenland temperature curve (Barker et al., 2011) and Antarctic ice core deuterium record (Jouzel et al., 2007), highlighting the interconnection between the North Atlantic and the Mediterranean climate during MIS 19 and the global scale correlation of events and phases.

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