

## THE HOLOCENE MARINE DEPOSITIONAL EVENT IN THE HISTORICAL CENTRE OF PALERMO

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**ABSTRACT:** Di Stefano E., Bonomo S., Incarbona A., *The Holocene marine depositional event in the historical centre of Palermo.* (IT ISSN 0394-3356, 2004).

Recent data have pointed out that, above the classical depositional sequence of the Quaternary marine sediments of the Palermo Coastal plain, post-Tyrrhenian sediments occur. In order to determine the age of these sediments and to confirm the deposition of a recent sedimentary cycle, microfossil assemblage of several samples, coming from geognostic drillings, have been analysed. Using the calcareous nannofossil ecobiozone scheme recently proposed for the last deglaciation of the central Mediterranean (Sicily Channel), examined sediments can be ascribed to the Holocene. Radiocarbon analysis confirmed such an attribution providing a more accurate stratigraphic determination.

**RIASSUNTO:** Di Stefano E., Bonomo S., Incarbona A., *The Holocene marine depositional event in the historical centre of Palermo.* (IT ISSN 0394-3356, 2004).

*Studi recenti hanno indicato come al di sopra della classica sequenza del Quaternario marino della Piana di Palermo ricorra, in alcuni siti del Centro Storico, un limitato spessore di depositi marini di età post-tirreniana. Con lo scopo di precisare l'età di tali depositi sono state studiate le associazioni di microfossili di campioni provenienti da sondaggi geognostici. Utilizzando lo schema ecobiozonale a nannofossili calcarei recentemente proposto per l'ultima deglaciazione nel Mediterraneo centrale (Canale di Sicilia) detti depositi contengono nannoflore attribuibili all'Olocene. Un'analisi al radiocarbonio ha confermato tale attribuzione, limitando alla parte bassa dell'Olocene la pertinenza stratigrafica di tali depositi.*

**Keywords:** Holocene, Calcareous Nannofossils, Foraminifera, Radiocarbon Convention Age, Northern Sicily.

**Keywords:** Olocene, Nannofossili Calcarei, Foraminiferi, Età radiocarbonio, Sicilia Settentrionale.

### INTRODUCTION

Since the last century, Palermo's coastal plain has been considered as a classical reference for marine Quaternary studies. After Doderlain (1872), several authors developed studies on Pleistocene chronostratigraphy, biostratigraphy and palaeoclimatology, based on these marine sediments (De Stefani 1891-2; Gignoux 1913; Emiliani *et al.* 1958; Gradstein 1970; Ruggieri & Sprovieri 1977; Di Stefano & Rio 1981; Buccheri 1984).

The central part of the coastal plain consists of a series of little plateau, moulded by marine action during the Late Quaternary. During the Last Glaciation (Würm), they were isolated from each other for the deepening of two converging river-beds (Kemonia fossil river and Papireto fossil river). Till historic age, when the town was confined within the "Paleopoli" and the "Neapoli", the mouths of these two rivers flowed together in a deep inlet used as a seaport (Fig. 1). Then these rivers were hidden by human settlement, even though their course is also observable by the topographical and town-planning structure of the Historical Centre (Fig. 2).

Several geognostic drillings were carried out during the last decades, to safeguard the main sites of monumental interest, contributing to improving the stratigraphic knowledge of the area (Todaro 1995; Giammarinaro *et al.* 2000). Micropaleontological data based on calcareous nannofossils and foraminifera, coming from several core segments, will now be presented.

### GEOLOGICAL FRAMEWORK

Marine quaternary sediments settled in Palermo's coastal plain can be ascribed to two main lithologies: silty-clays and/or calcarenites having a maximum thickness of about 80-100 metres. They cover the Tectonic Units of Panormide Carbonate Platform and Imerese Basin, which are orogenetically deformed. These Tectonic Units are overlain by the Oligo-Miocene Numidian Flysch deposit (Catalano *et al.* 1998).

Roughly, the calcarenitic facies lies on the silty-clays, except for the eastern part of the coastal plain, where the fossiliferous silty clays outcrop (Acqua dei Corsari and Cava Puleo - Ficarazzi - Sicilian Strato-type) (Fig. 3). These two litho-facies are part of a depositional sequence, chronostratigraphically spanning the upper part of the Emilian, the entire Sicilian and the lowermost part of the Medium Pleistocene (Di Stefano & Rio 1981; Catalano *et al.* 1998). Recent micropaleontological data pointed out, for the first time, that the classical sequence just described is overlain by post-Tyrrhenian marine sediments (Di Stefano 1998a). The aim of the present note is to specify the age of post-Tyrrhenian marine sediments, making use of a recent calcareous nannofossil ecobiozonation (Sprovieri *et al.* 2003) and of a <sup>14</sup>C radiocarbon dating.

## MATERIALS AND METHODS

Analysed material comes from two cores (indicated as cores 1 and 2 in Fig. 2). Core 1 was recovered in the northern part of a depression, known as “Conca del Papireto”, bordering a promontory of sicilian calcarenites where the Paleopoli (VII-VIII century B.C.) was founded. The studied materials were sampled at -16 and -4 metres from the roadway. The second drilling is located in a street (Via dei Candelai) whose line coincides with the last part of the Papireto bed-river, reclaimed in the XVI century. The studied samples were collected at -22 and -16 metres from the roadway.

The calcareous nannofossil assemblages were studied following the standard procedure on the smear slide preparations and without performing any process that could affect the natural status of the sediment. Quantitative analyses were conducted using a polarized microscope (transmitted light and crossed nicols) at about 1000 X magnification. The occurrence of *Emiliana huxleyi* was checked by Scanning Electron Microscope (SEM) observations.



Fig 1 - Satellite photo of Palermo. In white the traces of Kemonia and Papireto fossil river-beds. Arrow points out the location of the “Paleopoli - Neapoli” (modified from La Duca 1999).

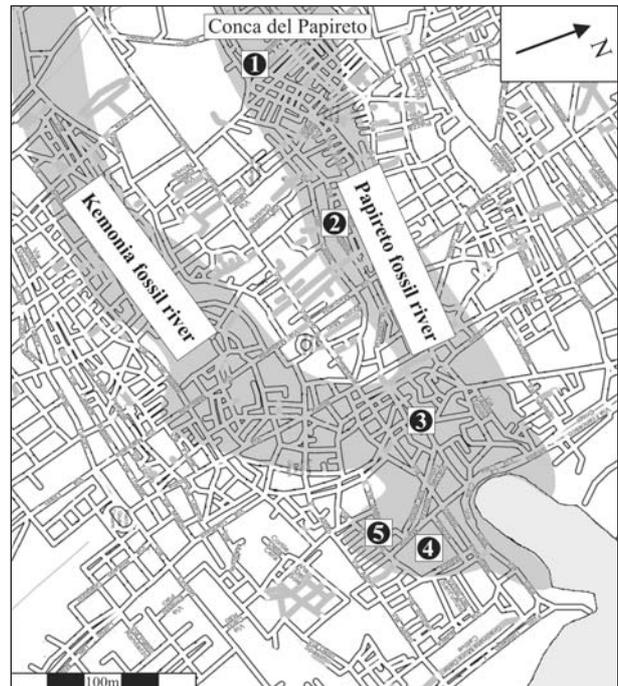


Fig 2 - City plan of the Historical Centre of Palermo and location of the geognostic drillings. In grey the track of the fossil river-beds hidden by human settlement.

The foraminifera study was performed washing about 25 cc of dried sediments with a 63  $\mu\text{m}$  sieve.

To evaluate the absolute age ( $^{14}\text{C}$  method) of the post-Tyrrhenian fossiliferous clay level of “Conca del Papireto”, about thirty specimens of epiphyte benthic foraminifera (*Cibicides lobatulus*, *Elphidium crispum*, *Rosalina* sp.) were picked. The selected specimens were perfectly preserved and at a different ontogenetic development degree. The analysis was performed at the Center for accelerator mass spectrometry of Lawrence (Livermore National Laboratory).

## RESULTS

### Conca del Papireto

Examined samples are representative of two lithologic levels located at -16 and -4 metres. They are respectively grey sandy-clays with fossils and vegetable remains and blue clays with small molluscs, echinoderm remains and vegetable carbonaceous remains.

*Calcareous nannofossils:* (-16 metres sample) Examined sample indicated the total absence of autochthonous nannofloras. Only very rare specimens of reworked paleogenic taxa, coming from the Numidian Flysch deposit, were observed.

(-4 metres sample) The calcareous nannofossil assemblage is scarcely diversified but rich in specimens, characterized by the dominance of *E. huxleyi* (Fig. 4a). Quantitative analyses, by countings on the first 300 specimens, pointed out that this taxon occurs with abundance values exceeding 45%. Common specimens of *Gephyrocapsa oceanica* (Fig. 4b) and rare

ones of small *Gephyrocapsa* and *Braarudosphaera bigelowii* were also detected. Genus *Helicosphaera* occurs with common helicoliths belonging to three different species. On the basis of the above compositional and quantitative data, the assemblage was ascribed to the MNN21b biozone (Rio *et al.* 1990). Moreover, quite a shallow marine environment with a temperate climate can be supposed. A slightly lowered salinity can be invoked on the basis of the occurrence of *B. bigelowii* that has been often reported as a species of coastal environment and/or low salinity (Bukry 1971; Müller 1979). Again specimens of reworked paleogenic taxa (*Sphenolithus conicus* and *Sphenolithus sp.*) occur.

The following taxa were recognized:

- Braarudosphaera bigelowii*
- Calcidiscus leptoporus*
- Emiliana huxleyi*
- Gephyrocapsa oceanica*
- small *Gephyrocapsa*
- Helicosphaera hyalina*
- Helicosphaera carteri*
- Helicosphaera wallichii*

*Foraminifera*: (-16 metres sample) Only few species and specimens of coastal benthic foraminifera were observed, representative of a very reduced bathy-

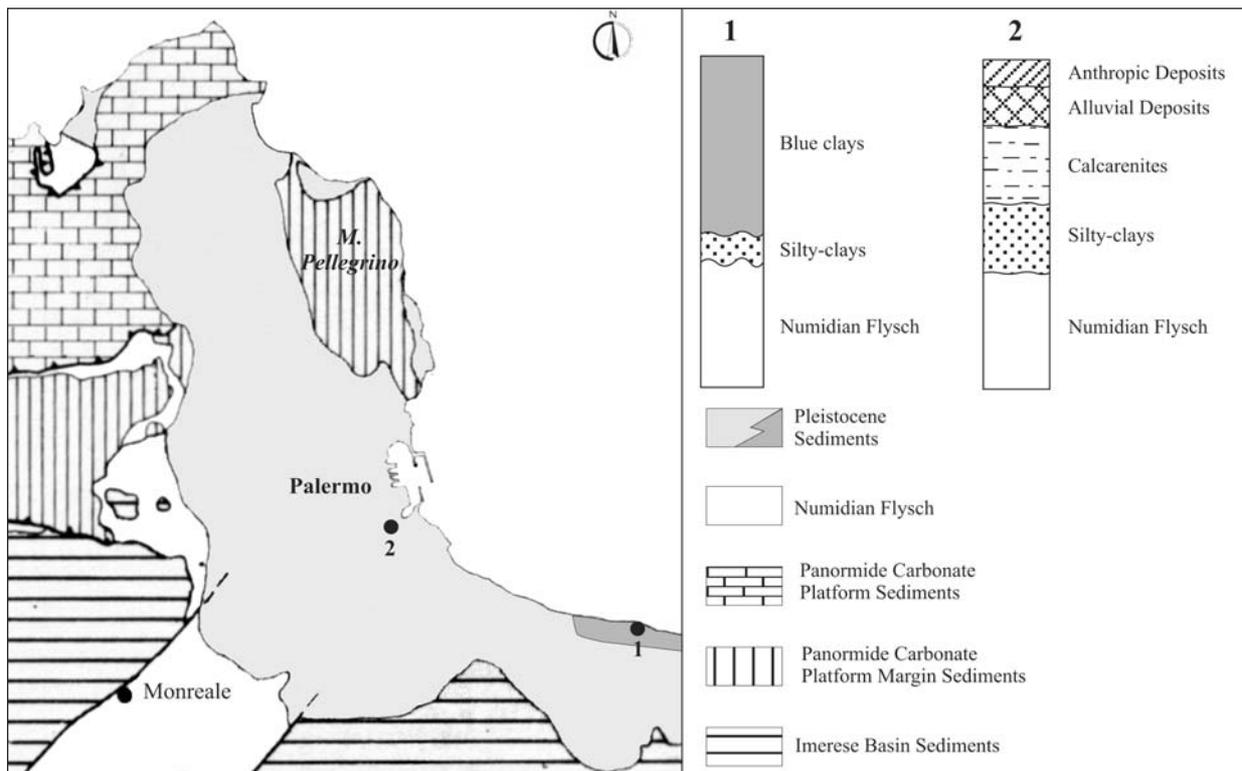


Fig 3 - Simplified geologic map of Palermo's coastal plain and schematic stratigraphic columns (modified from Abate B. *et al.* 1982).

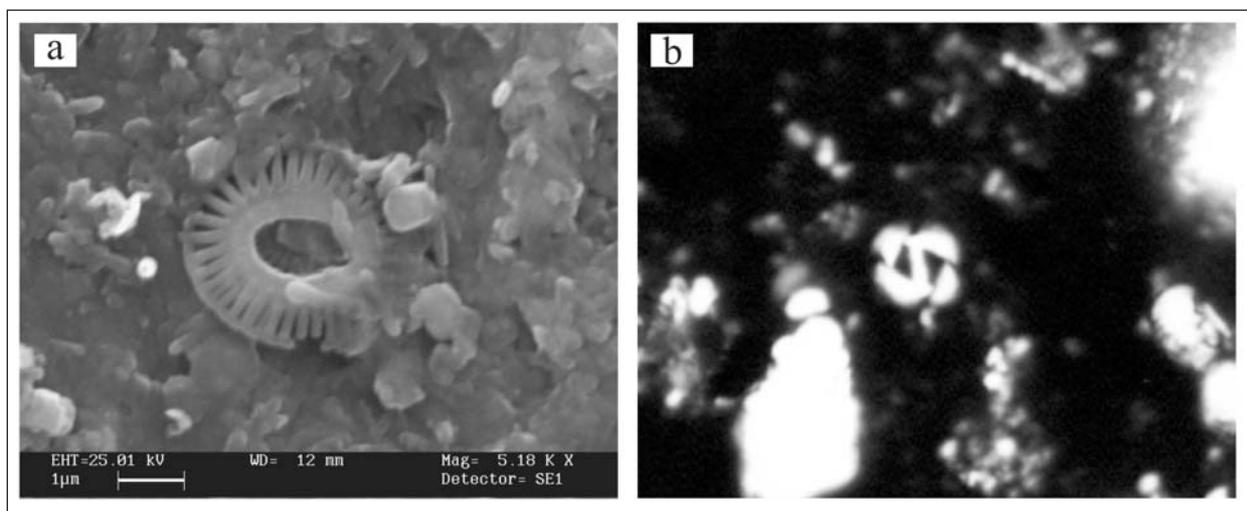


Fig 4 - a - *Emiliana huxleyi* (SEM). b - *Gephyrocapsa oceanica* (MOP, X nicols).

metry. Among them *Ammonia beccarii*, *Elphidium crispum* and rare Miliolids.

(-4 metres sample) A diversified assemblage, with well preserved specimens at different ontogenetic levels, were observed. Benthic foraminifera are very abundant, characterized by the dominance of epiphyte taxa: *Planorbulina mediterranensis*, *Rosalina* sp., *Cibicides lobatulus* together with *A. beccarii*, *E. crispum* and Miliolids. This assemblage testifies an evolution in the depositional environment towards deeper conditions (several tens of metres). Such a consideration is in agreement to the occurrence of very few specimens of planktonic foraminifera: *Globigerina bulloides* and *Globorotalia inflata*.

#### Via dei Candela

Examined samples are representative of two sedimentary levels located at -22 and -16 metres. They are respectively representative of fossiliferous grey sandy-clays and dark silty-clays with small molluscs.

**Calcareous nannofossils:** (-22 metres sample) The nannofloral assemblage is not well diversified with over 45% of small placoliths of *E. huxleyi*. *G. oceanica* and *B. bigelowii* are also significantly present. On these basis the assemblage might be again considered as indicative of the biozone MNN21b and belonging to a stratigraphic level correlatable with the considered higher sample of "Conca del Papireto".

(-16 metres sample) Furthermore, the calcareous nannofossil assemblage resulted less diversified, almost entirely constituted by small placoliths of *E. huxleyi* and representative of the biozone MNN21b.

#### STRATIGRAPHY

In the two investigated sites, calcareous nannofossil assemblages pertaining to the biozone MNN21b were detected. Such data can be considered as an innovation relative to the known stratigraphic framework. Firstly, the younger marine sediments which settled in the coastal plain were ascribed to the blue clays and/or to the calcarenites that are in transgression on the Oligo-Miocene deposits (Numidian Flysch). Both lithofacies belong to a sedimentary cycle begun with the marine transgression of the Emilian substage and they are bounded in the upper part by a erosive surface that is surely more recent than the Marine Isotopic Stage (MIS) 22 (Di Stefano & Rio 1981; Buccheri 1984; Di Stefano 1998b). The first mention of the existence of more recent marine sediments, although with a relatively little thickness, is linked to the detection of *E. huxleyi* acme in sediments referable to the MNN21b biozone (Di Stefano 1998a). This biozone covers the uppermost part of the Latest Pleistocene and Holocene. Using recent biochronologic data, mainly obtained by sediments recovered during the cruise of the Ocean Drilling Program (ODP - Leg 160), *E. huxleyi*'s increase in abundance always occurs above MIS 5 and sapropel S3 in the Mediterranean Sea (Castradori 1993; Sanvoisin *et al.* 1993; Flores *et al.* 1997; Di Stefano 1998b; Sprovieri *et al.* 1998; de Kanel *et al.* 1999). Therefore these sediments are an insight that a post-Tyrrhenian sea re-entrance occurred, at

least in the central sector of Palermo's coastal plain.

Quantitative abundance data on the calcareous nannofossil assemblages of the uppermost Late Pleistocene-Holocene and the recently proposed eco-biozonation of the last ca. 20 kyrs in the Sicily Channel (ODP-Site 963) strongly enhanced the stratigraphic resolution of the upper part of the biozone MNN21b. On these basis, the above mentioned transgression of sea water on the coastal plain can be restricted to the Holocene. Infact, the occurrence of several specimens of *G. oceanica*, is compatible only with ecozones 3N, 2N and 1N (Sprovieri *et al.* 2003).

This taxon marks a re-entrance event just above the base of the Holocene (Di Stefano & Incarbona 2004) (Fig. 5) after an interval of virtual absence that covers the entire Würm (Di Stefano & Incarbona - unpublished data).

#### AGE DATING

In order to reach a more accurate age determination of the above mentioned depositional event, a  $^{14}\text{C}$  radiocarbon analysis was performed. About thirty specimens of epiphyte benthic foraminifera (*C. lobatulus*, *E. crispum* and *Rosalina* sp.) at a different ontogenetic development were selected. The obtained result was  $7780 \pm 60$  B.P. (radiocarbon convention age) (Tab. 1).

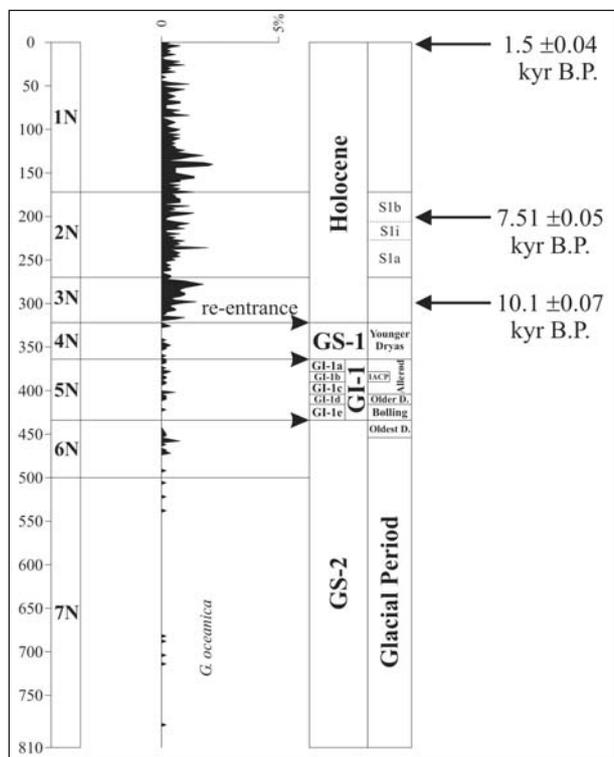


Fig 5 - Quantitative distribution pattern of *Gephyrocapsa oceanica* in the sedimentary record of ODP Hole-963D compared with calcareous nannofossil ecozones, with the Stages of the Event Stratigraphy and with the stratigraphic subdivision of Mangerud *et al.* 1974. On the right the available age control based on three age determinations (radiocarbon convention age) is reported (modified from Di Stefano & Incarbona 2004).

Tab. 1 - Report on <sup>14</sup>C radiocarbon analysis, performed on the Papireto sample

| <b>CENTER FOR ACCELERATOR MASS SPECTROMETRY</b> |                                |          |                   |                 |        |                   |     |                     |    |
|---|--------------------------------|----------|-------------------|-----------------|--------|-------------------|-----|---------------------|----|
| <i>Lawrence Livermore National Laboratory</i>   |                                |          |                   |                 |        |                   |     |                     |    |
| CAMS #  | Sample Name                    | Other ID | δ <sup>13</sup> C | fraction Modern | ±      | δ <sup>14</sup> C | ±   | <sup>14</sup> C age | ±  |
| 52363   | Papireto Hole S/1<br>4m .17mgC |          | 0                 | 0.3797          | 0.0028 | 620.3             | 2.8 | 7780                | 60 |

- 1) Delta <sup>14</sup>C values are the assumed values according to Stuiver and Polach (Radiocarbon, v. 19, p.355, 1977) when given without decimal places. Values measured for the material itself are given with a single decimal place.
- 2) The quoted age is in radiocarbon years using the Libby half life of 5568 years and following the conventions of Stuiver and Polach (ibid.).
- 3) Radiocarbon concentration is given as fraction Modern, δ <sup>14</sup>C and conventional radiocarbon age.
- 4) Sample preparation backgrounds have been subtracted, based on measurements of samples of <sup>14</sup>C-free calcite. Backgrounds were scaled relative to sample size.
- 5) Comment: The relatively large uncertainty in this result is due to the small sample size.

So the sediments can be referred to the lower part of the Holocene during the last phase of the deglaciation, while the sea-level was reaching the maximum highstand (Bjørck *et al.* 1998). Such an age is nearly correspondent to that obtained in the middle part of the ecozone 2N (7510 ± 60 B.P. - radiocarbon convention age) of Sprovieri *et al.* (2003) (Fig. 5).

**DISCUSSION**

The marine sedimentation established at least in the central sector of Palermo’s coastal plain at about 7.8 kyrs B.P. (radiocarbon convention age), provides remarkable indications on the possible depositional history of this coastal region.

Recent palaeoclimatic studies outlined the sequence of the most important fluctuations in the climatic system during the last deglaciation, mainly on the basis of the isotopic record of Greenland ice cores (Chappelaz *et al.* 1990; Alley *et al.* 1993; Bond *et al.* 1993; Grootes *et al.* 1993). A significant warming event marked the end of the Younger Dryas (GS-1) (Fig. 6) and characterized the lower part of the Holocene. As a consequence a fast sea level raising has been reported on the eustatic curves. The raising of the sea level was evaluated in about 120 metres in coincidence of the deglaciation culmination (Fairbanks, 1989). The radiometric age obtained for “Conca del Papireto” sample, links the deposition of Holocene Palermo’s coastal plain sediments to the deglaciation culmination event. Sea waters flowed on the coastal sectors of the plain using as a preferential way the fossil river-beds of Kemonia and Papireto, lowered during the glacial Würm period. Further samples, coming from small segments of cores of the Historical Centre, with nannofloras again referable to the Holocene has been recently recovered, demon-

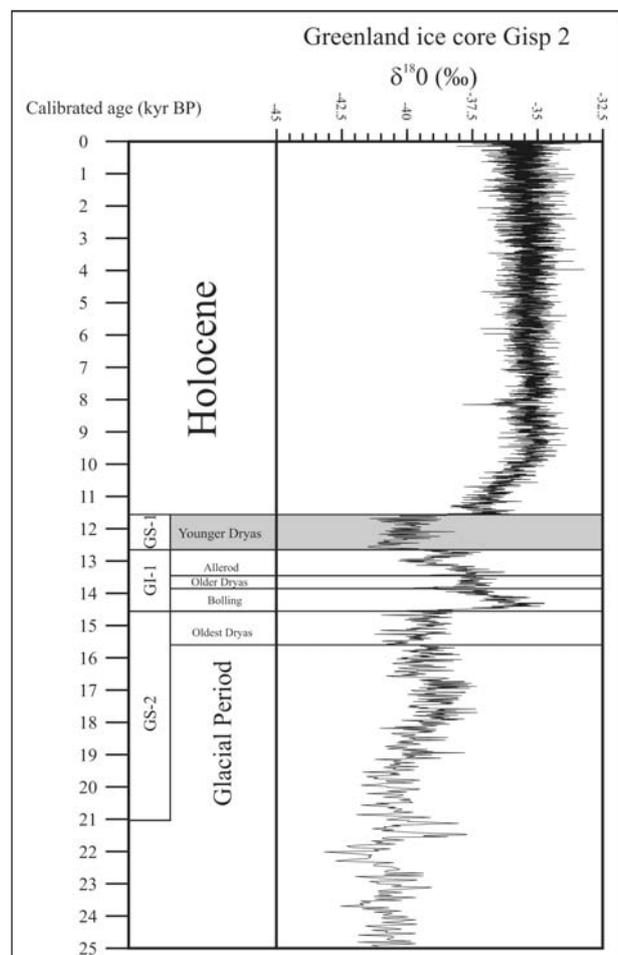


Fig 6 - δ<sup>18</sup>O profile from Greenland ice core GISP2, compared with the classical sequence of events related to the last deglaciation (Mangerud *et al.* 1974).

strating that the sea re-entrance interested several places and had therefore a significant extension (Fig. 2).

The collected foraminiferal data infers that during this sea water re-entrance, a water column estimated in several tens of metres existed on the sea floor in the Papireto site.

## CONCLUSIONS

Micropaleontological analyses based on calcareous nannofossils and foraminifera were carried out on some samples of the Historical Centre of Palermo, selected as possible indicators of a post-Tyrrhenian depositional sequence. Samples within the Papireto fossil river-beds are characterized by the dominance of *E. huxleyi* together with the occurrence of several specimens of *G. oceanica*. They are compatible with Holocene nannofossil ecozones. Moreover, faunistic and floristic assemblages point out a shallow water marine environment and a temperate climate. An age determination was performed and the result was  $7780 \pm 60$  yrs BP (radiocarbon convention age). It confirms that, in this area, marine sediments were deposited during the lower part of the Holocene. This age is indicative of the last phase of the deglaciation and is almost coincident with the maximum high-stand of the sea level. We suggest that the sea water flowed on the coastal plain of the Historical Centre of Palermo using as a preferential way the Kemonia and Papireto fossil river-beds, deeply eroded during the Würm glacial period.

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