

THE RECORD OF THE LAST DEGLACIATION IN TWO DEEP-SEA CORES FROM THE SICILY CHANNEL OFF CAPO ROSSELLO (CENTRAL MEDITERRANEAN)

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RIASSUNTO - *La storia dell'ultima deglaciazione registrata in due carote di mare profondo prelevate nel Canale di Sicilia al largo di Capo Rossello (Mediterraneo centrale)* - Il Quaternario *Italian Journal of Quaternary Sciences*, 9(2), 1996, 493-498 - Due carote prelevate dalla nave olandese TYRO nel 1993 da una profondità d'acqua di 472 e 502 m nel Canale di Sicilia al largo di Capo Rossello sono state studiate dal punto di vista sedimentologico e micropaleontologico e calibrate con 4 datazioni AMS. L'area è pianeggiante e situata a quote più alte del territorio circostante, su un blocco delimitato da faglie normali, così da non essere raggiunta da correnti di torbidità. La composizione dei sedimenti è monotona e uniforme, con fanghi grigi fini come litologia dominante. Lo studio micropaleontologico dei campioni ha permesso di identificare il passaggio da condizioni fredde "glaciali" a condizioni temperato-calde "post-glaciali". Ha anche mostrato che, dopo l'inizio della deglaciazione, vi è stato un breve episodio di ritorno a condizioni più fredde, tentativamente correlato con lo "younger Dryas". È stata così stabilita una cronologia relativa per le due carote e calcolata la velocità di sedimentazione, che varia da 20 a 30 cm/1000 anni. Quattro campioni scelti da intervalli critici della carota più lunga (MT 11) sono stati datati con il metodo AMS confermando la cronologia relativa stimata e permettendo di ubicare esattamente il limite convenzionale Pleistocene/Olocene nella carota. L'età dello "younger Dryas" risulta essere 12000 ± 13000 anni BP. Questo studio è stato compiuto come parte del "Site Survey Package" per un pozzo previsto per il Leg 160 ODP, che è stato perforato con pieno successo nel 1995.

ABSTRACT - *The record of the last deglaciation in two deep-sea cores from the Sicily Channel off Capo Rossello (central Mediterranean)* - Il Quaternario *Italian Journal of Quaternary Sciences*, 9(2), 1996, 493-498 - Two cores raised by the Dutch R/V TYRO in 1993 from a water depth of 472 and 502 m in the Sicily Channel off Capo Rossello (Sicily) have been investigated from a sedimentological and micropaleontological point of view, and calibrated with 4 AMS datings. The area is flat-lying and is higher than the surrounding territory so that it cannot be reached by turbidity currents. The composition of the sediments is monotonous and uniform, with grey, fine to very fine silty mud as dominant lithology. The micropaleontological study of the sand-size sediment fraction allowed to identify the transition from the cold water "glacial" time to warm-water "postglacial" time. It also showed that — after the onset of deglaciation — a short duration episode characterized by cooler conditions occurred, tentatively attributed to the "Younger Dryas". A relative chronology was thus established for two cores, and the sedimentation rate was calculated, ranging from 20 to 30 cm/1000 y. High precision radiometric dating (AMS) on four samples selected from critical intervals of the longest core confirmed the relative chronology derived from the foraminiferal study and permitted to precisely locate the conventional Pleistocene/Holocene boundary. The age of the "Younger Dryas" is of approximately 12000 ± 13000 y. BP. The study was performed as part of the "Site Survey Package" for a drillsite planned for ODP Leg 160, which was successfully accomplished in 1995. Site 963 penetrated in the subbottom for 200 m and recorded an undisturbed, expanded succession of hemipelagic sediments ideally suited for high resolution paleoceanographic studies, and containing a strong paleomagnetic signal.

Key-words: Deep-sea cores, Pleistocene/Holocene, Sicily Channel, central Mediterranean Sea

Parole chiave: Carote, Pleistocene/Olocene, Canale di Sicilia, Mediterraneo centrale

1. BACKGROUND

A drilling proposal on "Mediterranean Sapropels" was submitted to the JOIDES Office of the Ocean Drilling Program in the early Nineties. It is well known since the mid Century that the eastern Mediterranean underwent repetitive short duration episodes in which organic-rich sediments were laid down basin-wide, the so-called sapropels. Notwithstanding extended multidisciplinary investigations, the problem of their origin is still debated: are they the result of basin-wide stagnation resulting from lack of vertical mixing in the water mass (Olausson, 1961; Ryan & Cita, 1977) or by sudden increases of primary productivity (Calvert, 1983; Sarmiento *et al.*, 1988)? Well known in piston cores from the Holocene and Pleistocene of the eastern Mediterranean and from deep-sea drilling (Hsu *et al.*, 1978; Ryan *et al.*, 1973; Kastens *et al.*, 1987) in the Ionian, Levantine and Tyrrhenian basins, their occurrence in the western basins was uncertain.

An E-W transect across the entire Mediterranean was planned, with seven drillsites, each one with multiple

holes in order to guarantee a full recovery, penetrating 200 m in the subbottom.

The Sicily Channel plays an important role in controlling the water exchange between the western and the eastern Mediterranean. Sapropels were not known from this area from previous studies (Maldonado & Stanley, 1978; Ross & Kennett, 1984; Muerdter & Kennett, 1984; Vergnaud-Grazzini *et al.*, 1988). A suitable location for high resolution paleoceanographic studies should provide a continuous succession of tectonically undisturbed sediments devoid of turbidites and other re-sediments that would disturb the paleoclimatic and paleoceanographic signals.

The selected location (Fig.1) lies seaward of Capo Rossello, where spectacular exposures of Plio-Quaternary strata cyclically modulated are well known (Cita & Gartner, 1973; Langereis & Hilgen, 1991; Hilgen, 1991; Di Stefano *et al.*, 1993a). The multichannel seismic lines recorded in the area, recently published and interpreted by Argnani (1989) and Trincardi & Argnani (1990) showed a 200 milliseconds thick undisturbed succes-

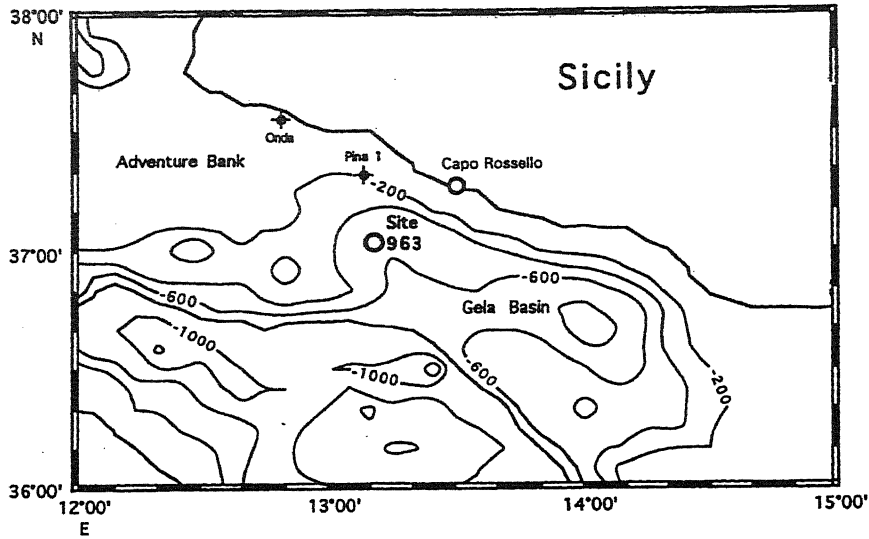
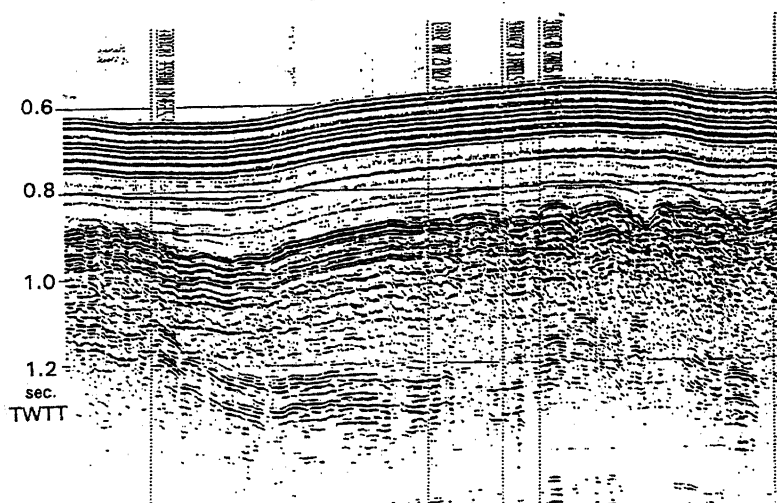
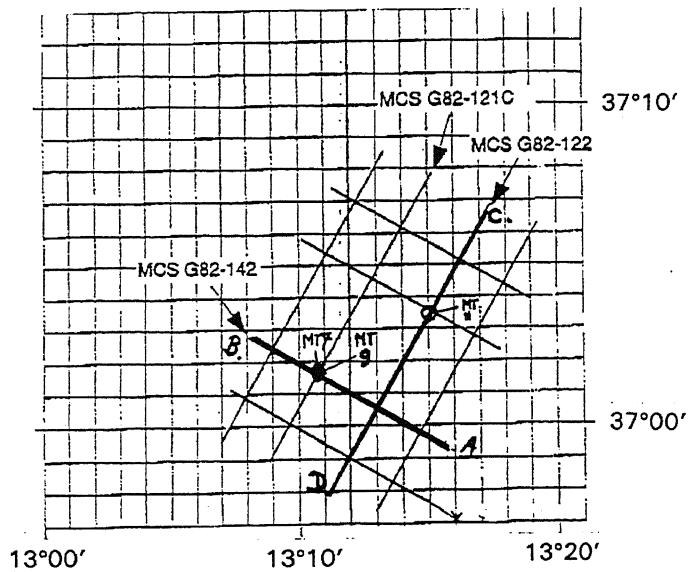


Fig. 1 - Location map of ODP Site 963 (= piston Core MT 7) in the Sicily Channel. Also shown is the position of wells Onda and Pina 1, investigated by Di Stefano *et al.* (1993b).

*Ubicazione del pozzo ODP 963 (Carota MT 7) nel Canale di Sicilia. E' pure indicata la posizione dei pozzi Onda e Pina 1 studiati da Di Stefano *et al.* (1993b).*



sion, belonging to the Gela nappe, that appeared suitable for the planned drillsite. ODP Site Survey, however, required additional documents, *i.e.* high resolution seismic profiles with a crossing, a 3.5 kHz record and a sediment core. All the necessary operations were performed by one of us (G.d.L.) from the Dutch R/V Tyro in April 1993 (see Fig. 2), as part of the Marflux Mast Project, funded by the European Community. The sparker profile at the bottom of Figure 2 documents the regular setting of the layered sequence in an uplifted block, which is bounded by normal faults.

Purpose of the present paper is to present and discuss the Late Quaternary biochronology and radiocarbon chronology worked out for the two piston cores.

Fig. 2 - Sketch showing the location of the multichannel seismic lines interpreted by Trincardi & Argnani (1990), of the sparker lines recorded by the R/V TYRO in April 1993, and of the piston Cores MT 7 and MT 11 discussed in this paper. Also shown at the bottom is the sparker line A-B.

Lo schizzo mostra la posizione delle linee sismiche multitraccia (linee sottili) interpretate da Trincardi & Argnani (1990), delle linee sparker (linee grosse) rilevate dalla nave TYRO nel 1993 e delle carote a pistone MT 7 e MT 11, discusse in questo lavoro. In basso è riprodotta la linea sismica monotraccia A-B.

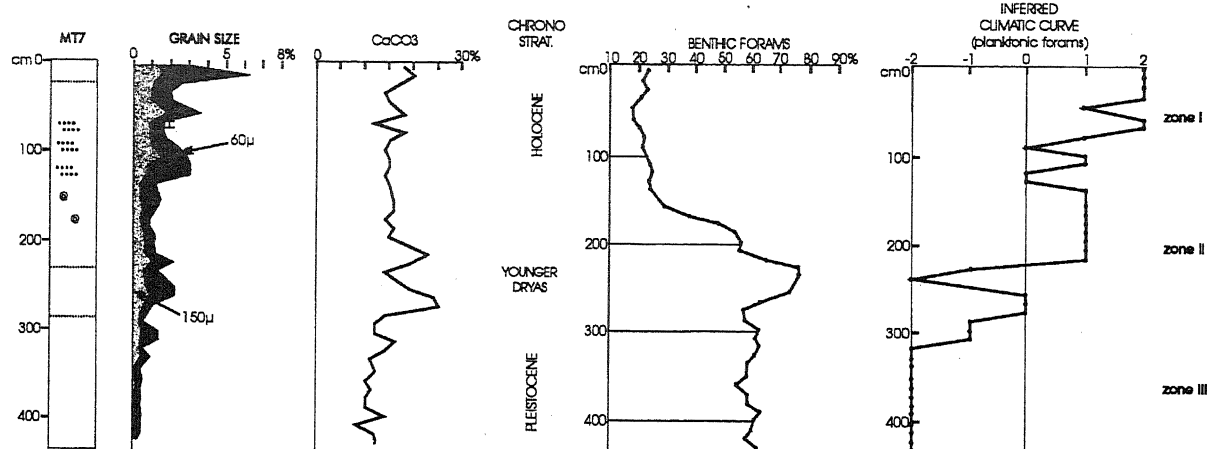


Fig. 3 - Columnar log of Core MT 7, grain-size distribution, carbonate content, chronostratigraphy, percentage of benthic foraminifera (smoothed curve, three points running average), and inferred climatic curve based on quantitative studies on 40 samples and the three faunal zones after Savoye *et al.* (in press).

Colonna litologica della carota MT 7: distribuzione granulometrica: tenore in carbonati; cronostratigrafia; percentuale dei foraminiferi bentonici sul totale dei foraminiferi (curva smussata a tre punti); curva climatica stimata basata sullo studio quantitativo di 40 campioni e distribuzione di tre zone faunistiche (secondo Savoye *et al.* (in stampa).

2. MATERIALS AND METHODS

The two piston cores considered in this study are:

- MT 7, raised from a water-depth of 472 m at 37°01.50' lat. N, 13°10.50' long. E, with a recovery of 445 cm.

- MT 11, raised from a water depth of 502 m, at 37°03.50' lat. N, 13°15.44' long. E, with a recovery of 1005 cm.

The cores have been split, visually described, photographed and sampled at regular spaced intervals of approximately 10 cm. The 122 samples were dried, weighed, soaked in oxygen peroxide, wet sieved in order to separate three different fractions (>150 µ; 150-60 µ; < 60 µ), which were weighed again. One gram of sediment was used to analyse the carbonate content with a calcimeter mod. Pizzarelli modified.

The coarse sediment fraction was then investigated at a binocular microscope for a characterization of the sediment composition and micropaleontological content (planktonic and benthic foraminifera being the prevalent biota).

After completion of these analysis at the Milano University, four samples from Core MT 11, carefully selected in order to check the relative chronology worked out, were used for precise radiometric datings with AMS by picking monospecific assemblages of planktonic foraminifera. The AMS measurements were performed at the Utrecht University.

3. RESULTS AND DISCUSSION

The sediments contained in both cores consist of fine- to very fine-grained mud to silty mud, olive grey in colour, with occasional submillimetric sand layers, very uniform and monotonous, without any discrete layer of

either sapropels or tephtras. No turbidites nor erosional surfaces were observed.

Volcanic glass in colourless or coloured shards is commonly recorded dispersed in the sediment, along with fine-grained angular quartz and mica flakes, but does not constitute distinct layers.

Figure 3 shows, from left to right, the columnar log of Core MT 7, the grain-size distribution, CaCO₃ content, percentage of benthic foraminifera, an inferred climatic curve and the distinction of three foraminiferal assemblage zones (see below).

An upward increase in grain size is noticed, with marked fluctuations starting from 3 m from core top upwards. A similar behaviour is noticed in the carbonate curve, that reflects the abundance of planktonic foraminifera, which are more abundant and larger in size in the upper part of the core.

The inferred climatic curve is based on visual estimates of cold-water indices (namely *Globigerina bulloides*, *Neogloboquadrina pachyderma*, *Globorotalia scitula*) considered as negative and warm-water indices (namely *Globigerinoides ruber*, *Orbulina universa*, *Hastigerina siphonipera*) considered as positive.

The dominance of *G. bulloides* and *N. pachyderma* in the lower part of the core (445-277 cm from core top) agrees well with the most advanced paleoceanographic interpretations of the last glacial maximum in the Mediterranean (Jorriksen *et al.*, 1993; Rohling *et al.*, in press) and with assemblage zone III of Savoye *et al.* (in press).

Indications of deglaciation are recorded from 277 to 257 cm from core top: the dominant taxon in this interval is *Globorotalia inflata*. According to Jorriksen *et al.* (1993) a change from stratified (dominance of *N. pachyderma*) to well-mixed conditions in the water column (dominance of *G. inflata*) is suggested (Zone II of Savoye *et al.*, in press).

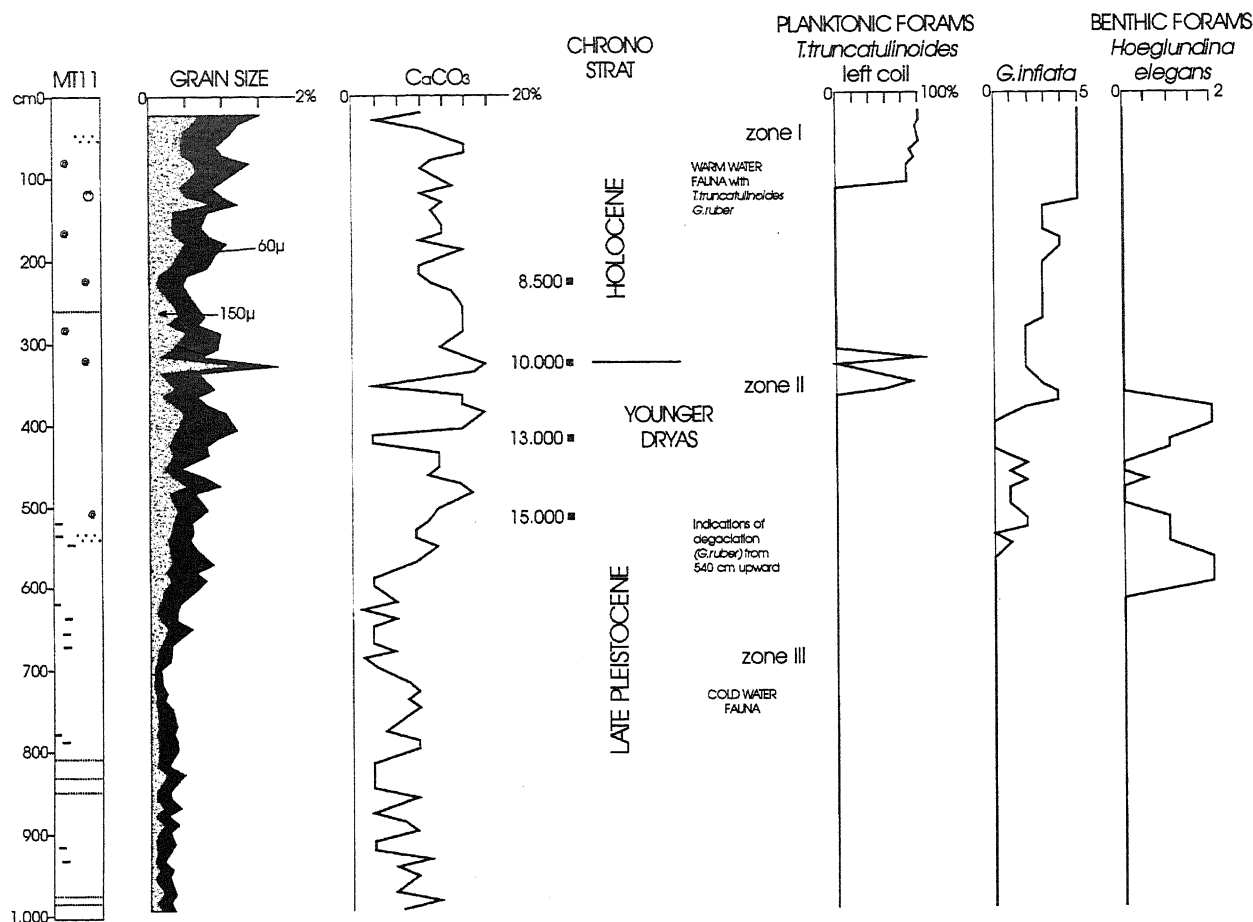


Fig. 4 - Columnar log, grain-size distribution, and carbonate content measured on 80 samples from Core MT 11. Squares indicate the position and the AMS ages obtained from four samples across the late Pleistocene/Holocene boundary. The abundances of *Globorotalia inflata* (0-5) and of *Hoeglundina elegans* (0-2) are based on visual estimates.

Colonna litologica della Carota MT 11, distribuzione granulometrica e tenore in carbonati misurati su 80 campioni. I quadratini indicano la posizione dei 4 campioni analizzati con il metodo AMS a fianco delle età ottenute. Nella parte destra della figura si trovano cronostratigrafia, zone a foraminiferi (come in Fig. 3) e osservazioni sulle associazioni a foraminiferi planctonici. Le due curve sulla destra sono basate su stime visuali dell'abbondanza relativa di *Globorotalia inflata* (0-5) e *Hoeglundina elegans* (0-2).

From 257 to 218 cm a return to cold conditions is noticed, which we tentatively correlated to the "Younger Dryas". Peak abundances of the benthic forms *Hyalinae balthica* and *Hoeglundina elegans* are recorded in this interval, supportive of cold conditions.

The warming trend resumes higher in the core, and a conspicuous re-entry of *Globorotalia truncatulinoides* is recorded (Zone I of Savoye *et al.*, in press).

Figure 4 shows, from left to right, the same parameters as in Figure 3, with the exception of the micropaleontological observations that were less accurate in Core MT 11. Anyway, they show the same trends with the same faunal changes recorded in Core MT 7.

Zone I (dominated by *G. truncatulinoides*), Zone II (dominated by *G. inflata*) and Zone III (dominated by *G. bulloides/N. pachyderma*) could be identified easily with changes recorded one meter lower in the sediment core. The only difference versus Core MT 7 is that sedimentation rate is here slightly higher.

Again, the very clear indication of the deglaciation,

followed upwards by a short duration cooling trend correlatable with the "Younger Dryas" and by a resumed warming episode, was recorded.

In order to support the tentative chronology deriving from the sedimentological and micropaleontological observations, four samples were selected for AMS dating. The results are shown to the left of the chronostratigraphic column.

Figure 5 shows the resulting sedimentation rate, which ranges from 22 to 25 cm/1000 y, is steady and consistent with the observations.

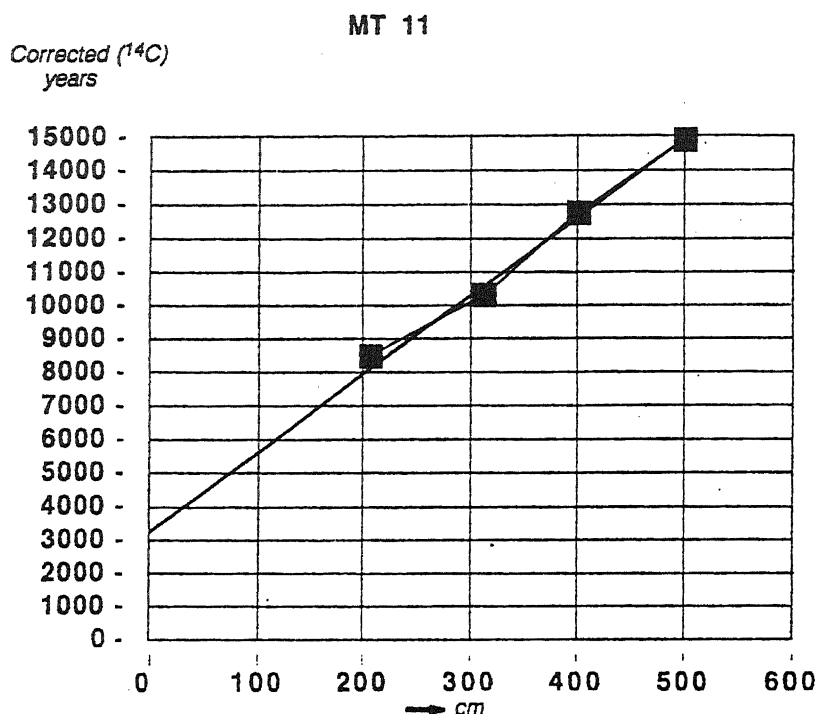
The conventional Pleistocene/Holocene boundary at 10,000 y BP can be located at 325 cm from the top of Core MT 11.

4. CONCLUSIONS

Our research confirmed previous findings that the "Younger Dryas" episode is present and well recogniz-

Fig. 5 - Sedimentation rate resulting from four AMS (corrected) ages measured in Core MT 11 ranges from 22 to 25 cm/1000 y (average 23.5).

Grafico età/profondità nella carota MT 11 in base alle età AMS ottenute. La velocità di sedimentazione per questo intervallo varia fra 22 e 25 cm/1000 anni (media 23,5)



able in the Sicily Channel (Vergnaud-Grazzini *et al.*, 1988), even with a very simple quantitative analysis. The only condition for recognizing such a short-duration event is that the sedimentation rate is high enough to permit an observation point every 200-300 years or so. In the low-sedimentation rate situation characteristic of the eastern Mediterranean deep-sea record, where sedimentation rates of around 2 cm/1000 years are recorded (Cita *et al.*, 1982), this kind of studies is almost impossible, also because the youngest (Holocene) stagnation episode complicates the issue.

The planned ODP drillsite has been successfully performed in the spring 1995 at the location of Core MT 7, recovering a high-sedimentation rate (expanded) succession of hemipelagic sediments that were judged perfectly suited for paleoceanographically oriented investigations (Emeis *et al.*, 1996). The 200 m-thick succession penetrated into the lowermost Pleistocene (pre-Jaramillo) without encountering turbidites and/or other re-sediments. Sapropels were encountered from 125 m down.

Sedimentation rate ranges from a minimum of 8.5 cm/1000 y for the basal part of the section to a maximum of 25.5 cm/1000 y for its upper part. These data are well comparable with those obtained from Cores MT 7 and MT 11.

An unanswered question so far is where the sediment supply comes from. We look forward future studies to elucidate this interesting problem.

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