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TRANSGRESSIVE OFFSHORE DEPOSITS ON THE CENTRAL ADRIATIC SHELF: ARCHITECTURE COMPLEXITY AND THE RECORD OF THE YOUNGER DRYAS SHORT-TERM EVENT

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RIASSUNTO - *Depositi di mare aperto trasgressivi sulla piattaforma dell'Adriatico centrale: complessità di architettura e la registrazione dell'episodio freddo dello* Younger Dryas - Il Quaternario *Italian Journal of Quaternary Sciences,* 9(2), 1996, 753-762 - I depositi trasgressivi tardo quaternari in Adriatico Centrale raggiungono uno spessore di circa 25 m. Presentiamo i primi risultati di uno studio interdisciplinare di questi depositi in piattaforma e nel bacino adiacente profondo 250 m e caratterizzato da una successione marina continua dall'ultimo massimo glaciale. In piattaforma i depositi trasgressivi tardo quaternari comprendono un'unità progradazionale fuori sequenza compresa tra due unità fangose in *onlap* verso terra. Dati paleontologici, sedimentologici e di suscettività magnetica, accompagnati da datazioni tramite AMS ^{14}C, permettono di attribuire questa unità progradazionale in piattaforma all'episodio freddo dello *Younger Dryas*. Questa unità progradazionale si correla in bacino con un deposito di circa 1 m di spessore caratterizzato da un aumento di velocità di sedimentazione e da un netto raffreddamento delle acque superficiali. L'unità progradazionale in piattaforma raggiunge uno spessore di 18 m e mostra una geometria interna complessa. La superficie al tetto di questa unità è marcatamente erosiva nella piattaforma interna e testimonia una fase di caduta degli apporti e di aumentato rimaneggiamento sul fondo. In piattaforma esterna questa superficie coincide con quella di *downlap* alla base dell'unità. In quest'area, carote che hanno attraversato la superficie documentano uno *hiatus* di quasi 4 ka (tra 13 e 9 ^{14}C ka BP); questo *hiatus* è stato causato in parte da erosione delle unità più vecchie durante lo *Younger Dryas* e in parte da deposizione condensata successiva.

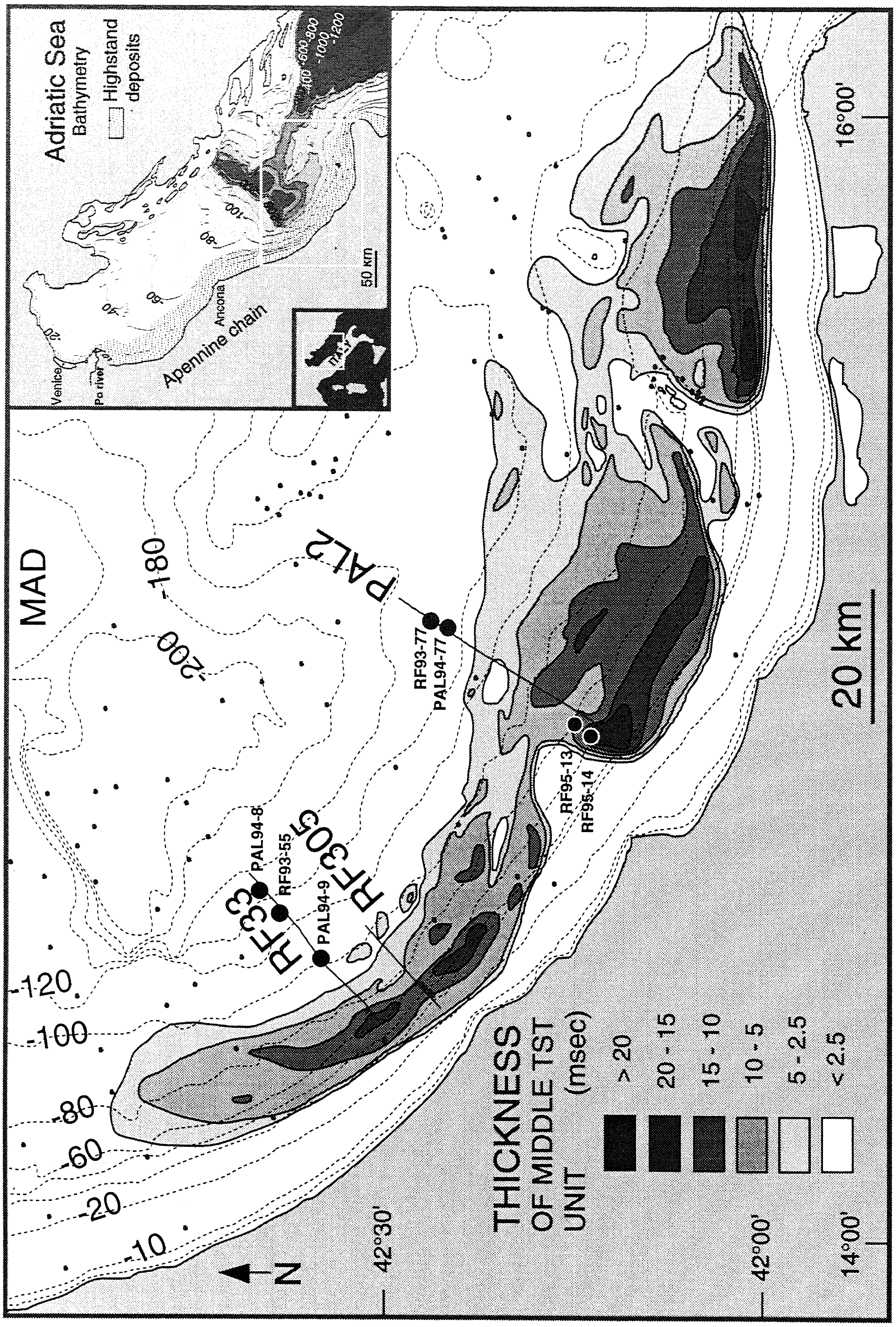
SUMMARY - *Transgressive offshore deposits on the Central Adriatic shelf: architecture complexity and the record of the Younger Dryas short-term event* - Il Quaternario *Italian Journal of Quaternary Sciences,* 9(2), 1996, 753-762 - The late-Quaternary transgressive deposits on the Central Adriatic shelf are as much as 25 m thick. This transgressive record includes an "out-of-sequence" prograding deposit that is sandwiched between two landward-stepping units composed of offshore mud. Sedimentologic, paleontologic, and magnetic susceptibility data, with calibrated AMS ^{14}C dates allow to ascribe this progradational unit to the Younger Dryas short-term event. This progradational unit on the shelf correlates with a 1-m-thick deposit, characterized by increased sediment accumulation rates, within the continuous marine section of the adjacent slope basin (the Meso Adriatic Depression). The prograding unit within the transgressive record (TST) is up to 18 m thick and shows a composite geometry. The surface at the top of the unit is erosional across the inner shelf marking a phase of decreased supply and increased reworking on the sea floor. On the outer shelf, this upper surface merges with the downlap surface at the base of the progradational unit. In this area, cores cross-cutting through the erosional surface document a gap of as much as 4 ka (between 13 and 9 ^{14}C ka BP) caused by erosion of older units during the Younger Dryas interval and subsequent condensed deposition above it.

Key words: Paleoenvironmental reconstruction, Late-Quaternary, sequence stratigraphy, AMS radiocarbon datings, Central Adriatic, Italy
Parole chiave: Ricostruzioni paleoambientali, tardo-Quaternario, stratigrafia sequenziale, datazioni ^{14}C AMS, Adriatico Centrale, Italia

1. INTRODUCTION

Changes in continental ice volume during the last deglaciation induced a world-wide sea level rise from about 120 m below its modern position (Martinson *et al.*, 1987; Fairbanks, 1989). This sea-level rise occurred at very high, although varying, rates between about 16 and 5 ^{14}C ka BP. Maximum melting rates occurred during two distinct time intervals from 14 to 12 ^{14}C ka BP and from 10 to 7 ^{14}C ka BP separated by a mid-deglacial interval (Duplessy *et al.*, 1981; Fairbanks, 1989). Biostratigraphic data in the Central Mediterranean basin and surrounding land areas show consistent evidence of a cooling in the Younger Dryas (Rossignol-Strick & Planchais, 1989; Rossignol-Strick, 1995). In particular, sediment cores in the Southern Adriatic and Ionian basins show evidence of the Younger Dryas event in dynoflagellates (Zonneveld, 1995), $\partial^{18}O$-isotope curves (Vergnaud-Grazzini & Pierre, 1992) and planktonic foraminifera (D'Onofrio, 1972; Jorissen *et al.*, 1993). In several crater lakes in Central Italy, pollen records show a return to cooler and dryer conditions through the clear increase in abundance of *Pinus, Juniper* and *Artemisia* (Watts, 1985; Huntley *et al.*, 1996).

On the low-gradient Central Adriatic shelf (Fig. 1) the variations in the balance between relative sea-level change and sediment supply result in enhanced depositional or erosional responses during the late-Quaternary high-rate sea-level rise (Trincardi *et al.*, 1994; Correggiari *et al.*, 1996). The following two additional reasons make the Adriatic basin well suited for the study of the late-Quaternary transgressive record: i) the sediment section on the shelf correlates with a continuous marine unit within an adjacent slope basin (the 250-m-deep Meso-Adriatic Depression; Asioli *et al.*, this volume); ii) deposition following the end of the late-Quaternary sea-level rise is confined to a restricted portion of the inner shelf on the western side of the basin (Figs. 1 and 2), allowing easier coring through the transgressive record on the mid-outer shelf (Trincardi *et al.*, 1994). We pre-


THICKNESS
OF MIDDLE TST
UNIT
(msec)
> 20
20 - 15
15 - 10
10 - 5
5 - 2.5
< 2.5
MAD
PAL2
RF33
RF305
RF93-77
PAL94-77
RF95-13
RF95-14
PAL94-8
RF93-55
PAL94-9
-10
-20
-60
-80
-100
-120
-180
-200
20 km
N
42°30'
42°00'
14°00'
16°00'
Adriatic Sea
Bathymetry
Highstand deposits
Venice
Po river
Apennine chain
Ancona
50 km
ITALY

sent new results from the stratigraphically-expanded transgressive record on the Adriatic shelf and document the covariance of sediment flux, pollen and planktic foraminifera assemblages during the Younger Dryas event (Figs. 1 and 2).

2. SETTING

The Adriatic sea is a semi-enclosed, storm-dominated and microtidal basin. Modern cyclonic circulation forces riverine waters to flow southwards against the western side of the basin (Malanotte Rizzoli & Bergamasco, 1983). Sediment supply during sea-level high-stand is approximated by the mean suspended sediment discharge from modern rivers; this is negligible on the eastern side of the basin, very small in the north (where rivers deliver only 0.3×10^7 t/yr) and maximum on the western side of the basin, where the Po river and several smaller Apennine rivers provide altogether 3.9 $\times 10^7$ t/yr (Frignani *et al.*, 1992). At the onset of the relative sea-level rise, following the last glacial maximum (LGM), only 1/7[th] of the modern basin was under waters, while most of it was subaerially exposed (Correggiari *et al.*, this volume). Bathymetric data show that during LGM and the early portion of the following sea-level rise the basin was connected to the rest of the Mediterranean sea through a shallow sill to the south. This connection was less than 50 m deep and did not allow full exchange of intermediate and deep water masses. A consequence of this morphologic confinament is the lack of planktonic foraminifera and the dominance of fresh-water input during LGM times (Trincardi *et al.*, 1994).

3. METHODS

The stratigraphic framework for this study is provided by sediment cores positioned on a closely-spaced grid of high-resolution seismic profiles (Trincardi & Correggiari, in press). These profiles were digitally recorded firing a 300-joule UNIBOOM and a 3.5-kHz GeoPulse sound sources every 1/4 and 1/8 seconds, respectively. We present a selection of cores across two transects normal to the regional bathymetric contour (Fig. 1). Piston cores were positioned on specific targets detected on seismic profiles with a 10-m accuracy using a land-based positioning systems and a D-GPS. Correlation between cores relies on seismic stratigraphy and is refined by magnetic susceptibility measurements and preliminary tephra recognition (Fig. 2); the chronologic frame is based on AMS ^{14}C uncalibrated dates on planktonic foraminifera (Fig. 2). Foraminifera biostratigraphic schemes are also reported in Figure 2. Pollen spectra are based, on average, on 400 pollen per sample and *Pinus* is represented separately following Rossignol-Strick & Planchais (1989).

4. HIGH-RESOLUTION SEISMIC STRATIGRAPHIC FRAMEWORK

High-resolution seismic profiles, sediment cores and AMS ^{14}C dates provide a refined stratigraphic framework for the late-Quaternary Transgressive Systems Tract (TST) in the Adriatic semi-enclosed basin (Trincardi *et al.*, 1994). Continuous marine deposition took place in the MAD where transgressive mud onlaps the upper slope and correlates with a transgressive offshore mud unit on the central Adriatic shelf (Fig. 3). This transgressive record on the shelf rests above a regional erosion surface that truncates older low-stand deposits and below the maximum flooding surface (mfs, Figs. 2 and 3) that is a regional downlap surface marking a major increase in sediment accumulation rates (Trincardi & Correggiari, in press). Available ^{14}C dates in the vicinity of the lower erosion surface and the upper mfs show that the time interval encompassed by the TST spans about 12 ^{14}C ka, between 16 and 4-5 ^{14}C ka BP (Trincardi *et al.*, 1994). Although this time interval is quite short, the late-Quaternary TST reveals high internal complexity rather than a simple backstepping or draped geometry.

Piston cores on the outer shelf show that the transgressive erosion surface (TS1, Figs. 2 and 3) at the base of the TST is a sharp contact with bioclastic or polymictic sand fining upward into offshore mud (Trincardi & Correggiari, in press). The marine TST, above this erosional surface, consists of three units: 1) The *lower unit* pinches out landward, about 90-100 m below present sea level. In the North this unit records the early stages of relative sea level rise in an oversupplied setting. A thick prograding wedge shows an aggradational component on the shelf. The shelf area to the South was comparatively undersupplied during this interval. The lower unit in this area is less than 10 m thick and shows short-distance variations in thickness that are controlled by the roughness of the underlying erosional surface. 2) The *middle unit* records a landward shift of the coastal onlap with respect to the lower unit but represents a phase of seaward progradation (Figs. 2 and 3). The unit consists of three elongated depocenters (exceeding 15 m) that parallel the coast and reflect the interaction between major sediment entry points and longshore-drift dispersal.

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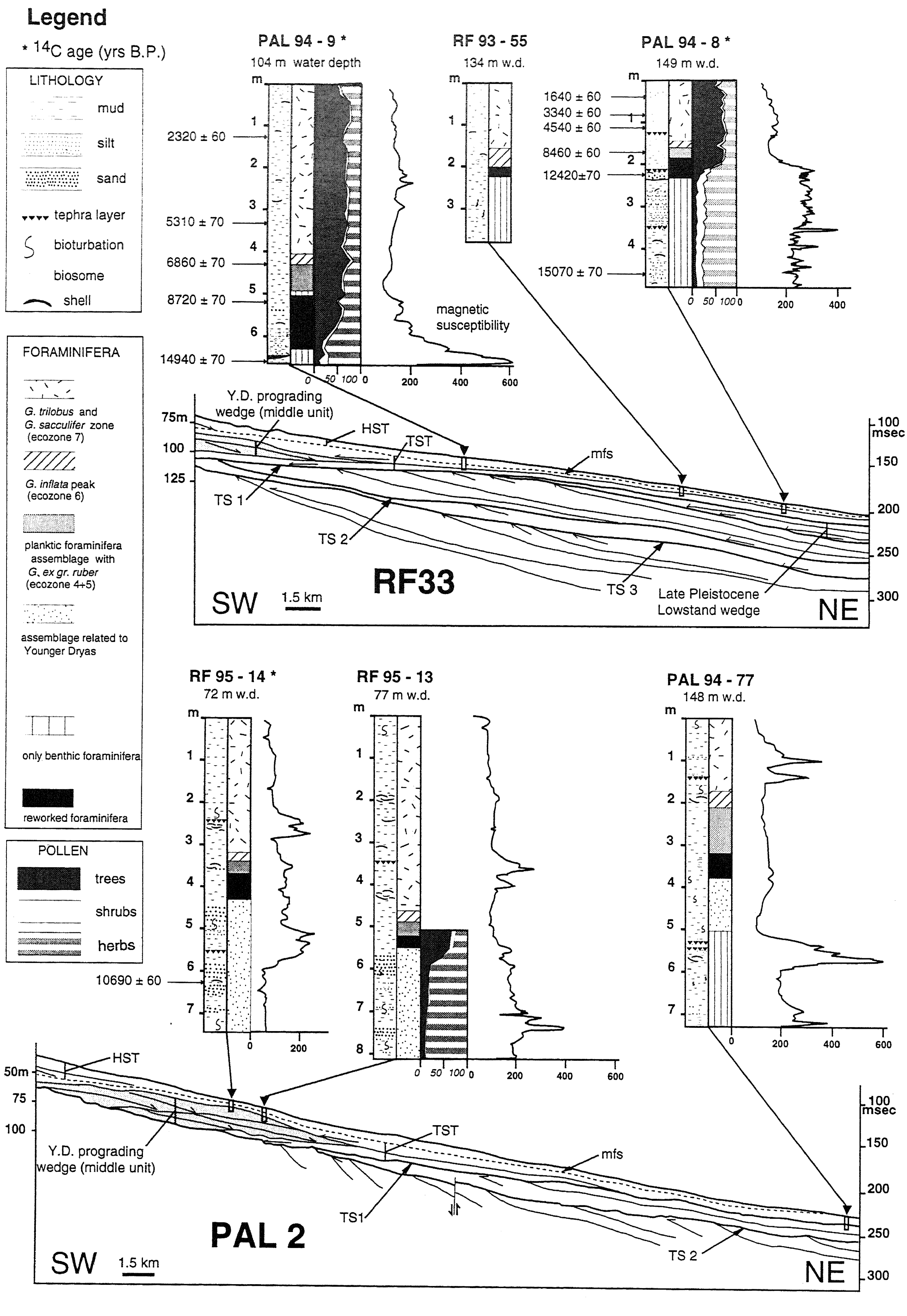
Fig. 1 - Bathymetry of the study area showing the isopach map of the middle unit of the transgressive systems tracts (TST) on the Adriatic shelf and the location of the cores shown in figure 2. Inset: modern simplified bathymetry of the Adriatic basin showing that the late-Holocene high-stand systems tract (HST, wavy pattern) is confined within 15 miles from the modern coastline; this confinement results from the shore-parallel component of the cyclonic gyre affecting the water column in the Adriatic basin as well as from the location of the main sediment entry points.

Isocronopache dell'unità intermedia del TST (transgressive systems tract) riferite alla batimetria dell'Adriatico Centrale e ubicazione delle carote mostrate in figura 2. Inserto: batimetria semplificata del bacino Adriatico e distribuzione dei depositi di stazionamento alto (high stand systems tract, area ondulata) sul lato occidentale del bacino; questa distribuzione e' causata dalla posizione dei sistemi deltizi e dall'effetto di confinamento dovuto alla componente parallela alla costa della circolazione ciclonica in Adriatico.


Legend
* 14C age (yrs B.P.)
LITHOLOGY
mud
silt
sand
tephra layer
bioturbation
biosome
shell
FORAMINIFERA
G. trilobus and G. sacculifer zone (ecozone 7)
G. inflata peak (ecozone 6)
planktic foraminifera assemblage with G. ex gr. ruber (ecozone 4+5)
assemblage related to Younger Dryas
only benthic foraminifera
reworked foraminifera
POLLEN
trees
shrubs
herbs
PAL 94 - 9 *
104 m water depth
2320 ± 60
5310 ± 70
6860 ± 70
8720 ± 70
14940 ± 70
magnetic susceptibility
RF 93 - 55
134 m w.d.
PAL 94 - 8 *
149 m w.d.
1640 ± 60
3340 ± 60
4540 ± 60
8460 ± 60
12420±70
15070 ± 70
Y.D. prograding wedge (middle unit)
HST
TST
mfs
TS 1
TS 2
TS 3
Late Pleistocene Lowstand wedge
RF33
SW
NE
1.5 km
100 msec
RF 95 - 14 *
72 m w.d.
10690 ± 60
RF 95 - 13
77 m w.d.
PAL 94 - 77
148 m w.d.
PAL 2

Progradational geometries characterise all the three depocenters (Fig. 3). Thickness variations on the outer shelf reflect the roughness of the underlying surface indicating that deposition was not a simple drape that would show constant thickness and an even distribution (Fig. 3). The unit is capped by a sharp surface indicative of drowning and erosion (Fig. 3). Truncation above the middle unit generated a rough topography in waters shallower than 80 m and a smoother surface down to 100 m (modern bathymetry); no evidence of erosion is found across this surface in deeper waters. 3) The *upper unit* extends across the depocenter of the middle unit as a thin mud veneer and shows two separate depocenters (Figs. 2 and 3). The depocenter located landward is wedge-shaped and shows low-angle progradational foresets. A secondary depocenter lies seaward of that of the middle unit, and is characterised by faint, plane-parallel and low-amplitude reflectors that onlap the underlying depositional relief in water depths greater than 90 m (Fig. 3).

5. SEDIMENT CORES

Three complementary stratigraphic records provide information on the style of deposition during the late-Quaternary sea-level rise in the study area. Deeper-water cores show a continuous and mud-dominated marine record for the entire interval (see CM92-43 in Asioli *et al.*, this volume). Outer-shelf cores reached the *lower unit* and offer evidence of condensed deposition and possible erosion replacing laterally the *middle unit* (PAL94-8 and PAL94-9, Fig. 2). Inner-shelf cores reached the *middle unit* of the TST yielding key information on the more proximal and higher-energy marine facies where this unit reaches its maximum thickness (RF95-13 and RF95-14, Fig. 2). Lithologic correlations are not obvious where cores are muddy and homogeneous; erosion surfaces and coarser (sandy) intervals are, however, easier to identify. Additional support for correlation comes from chemical and mineralogical definition of tephra layers recognized on magnetic susceptibility logs.

5.1 Planktic foraminifera assemblages

The cores collected in the study area can be interpreted by following the biostratigraphy established for the Central Adriatic basin on planktonic foraminifera assemblages (Borsetti *et al.*, 1992; Jorissen *et al.*, 1993; Asioli *et al.*, 1995; Asioli *et al.*, this volume). The above cited biostratigraphy, chronologically controlled by uncalibrated AMS ^{14}C dates and stable Oxygen isotope records, allows for a synthesis of the major changes into the following ecozones (Fig. 2):

1) LGM - 13 ka: very scarce to absent planktonic forams, mainly consisting of *Globigerina quinqueloba* and *Globigerina bulloides;*

2) 13 - 11 ka: substantial increase in concentrations of planktonic foraminifera with assemblages characterized by the occurrence of *Globigerinoides ex gr ruber* with *G. bulloides* and *Neogloboquadrina pachyderma;*

3) 11 - 10.5 ka: only subpolar planktonic species occur in this interval dominated by *G. bulloides* and *G. quinqueloba;*

4) 10.5 - 9 ka: *Globorotalia inflata, Globorotalia truncatulinoides* with persisting *G. ruber, G. bulloides* and *N. pachyderma;*

5) 9 - 8 ka: *G. ruber, Orbulina, G. bulloides* and *Globigerina praecalida* and *Globigerinella aequilateralis;*

6) 8 - 6 ka: *G. inflata* peak concurrent with secondary occurrence of *G. ruber, Orbulina, G. bulloides* and *N. pachyderma;*

7) 6 ka to present: last *G. ruber, Globigerinoides trilobus, Globigerinoides sacculifer, Orbulina, G. praecalida* and *G. bulloides*

The above ecozones are fully developed only in deeper cores within the MAD (Asioli *et al.*, 1995; this volume). On the contrary, the cores on the shelf and upper-slope region show an incomplete sequence of the aforementioned ecozones, likely as a response to the reduced water depth in the area. In particular, ecozones 1, 2 and 3 are represented by only benthic associations. Ecozone 3 is recognizable in core PAL94-77 through a peak of *G. bulloides* at the base of an otherwise entirely

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Fig. 2 - Profile line drawings and schematic stratigraphic correlation of shelf cores (see Fig. 1 for location). Dates are uncalibrated ^{14}C years; left column is lithology, central column is the scheme of foraminifera zonation and right column is tree/shrub/herbs ratio in percentage form, where available. Magnetic susceptibility is plotted in 10^{-6} SI Units. Both profiles show that on the inner shelf the TST rests above an erosional transgressive surface (TS1) and includes a progradational middle unit (grey pattern) that is more than 15 m thick. Across the outer-shelf region the TST is much thinner and the middle unit is replaced by a sandy bed characterised by reworked foram assemblages (black pattern). Beneath this distal deposit all cores reached sediment older than the Younger Dryas event. This reworked sandy bed correlates to the 1-m-thick Youger Dryas interval in core PAL94-77 on the upper slope and in core CM92-43 (Asioli *et al.*, this volume), in the MAD (Fig. 1). Cores RF95-13 and RF95-14 penetrated ca. 3 m below the top of the middle unit showing a sandy succession with sharp erosional contacts and mud drapes. Facies changes downslope (from core RF95-14 to RF95-13) indicate that this deposit likely originated in a storm-dominated lower shoreface environment. Pollen assemblages in core RF95-13 are dominated by *Artemisia* and very low frequencies of *Quercus;* one AMS ^{14}C date performed on a bivalve shell (*Nucula* sp.) within this unit (Core RF95-14) yielded an age of 10.690±60.

Rappresentazione schematica delle carote in piattaforma riferita a profili sismici interpretati (ubicazione in Fig. 1). Le datazioni ^{14}C riportate non sono calibrate. Per ogni carota tre colonne rappresentano rispettivamente: la litologia (sinistra), la zonazione a foraminiferi plantonici (centro) e il rapporto alberi/arbusti/ erbe in percentuale, quando disponibile (destra). La suscettività magnetica è riportata in 10-6 Unità SI. Entrambi i profili mostrano che i depositi trasgressivi poggiano sulla superficie di trasgressione TS1 e comprendono una unità progradazionale (in grigio) che supera i 15 m di spessore in piattaforma interna. Questa unità trasgressiva intermedia si assottiglia in piattaforma esterna, dove e' sostituita da un livello sabbioso caratterizzato dalla presenza di foraminiferi bentonici rimaneggiati (in nero negli schemi stratigrafici). Al di sotto di questo deposito, tutte le carote hanno raggiunto sedimenti più vecchi dello Younger Dryas. Questo livello rimaneggiato in piattaforma esterna si correla in bacino all'intervallo dello Younger Dryas che raggiunge circa 1 m di spessore nelle carote PAL94-77 e CM92-43 (Asioli et al., *questo volume).*

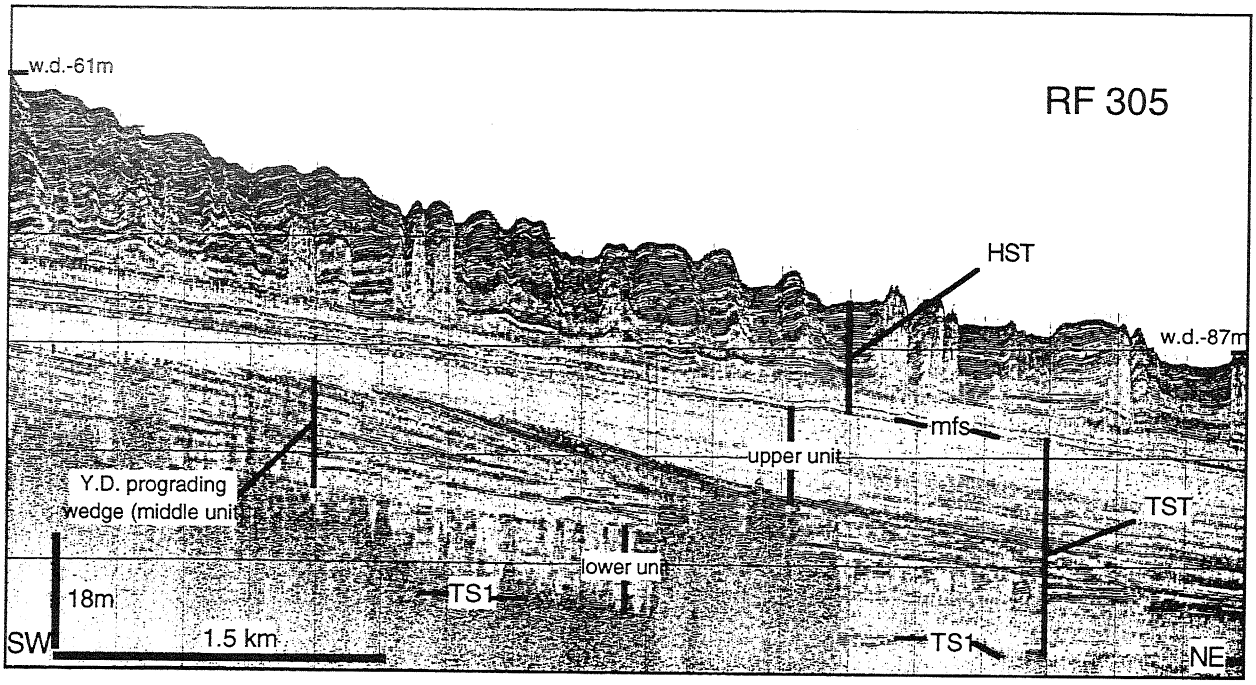

Fig. 3 - Very high-resolution reflection seismic profile RF95-305 showing the inner-shelf expression of the middle unit of the late-Quaternary TST. This unit appears composite and convex upward and includes shingled downlapping reflectors. The unit is capped by a sharp surface of erosion.

Profilo sismico ad ampio spettro di frequenza RF95-305 che illustra le geometrie interne all'unità intermedia del TST in piattaforma ed i suoi rapporti con le unità trasgressive sotto e soprastanti. Si nota la netta superficie erosiva che tronca la geometria progradazionale al tetto.

benthic assemblage. ^{14}C dates and preliminary pollen spectra allow an independent definition of the Younger Dryas deposit where planktonic foraminifera are lacking (in the shallower-water cores RF95-13 and RF95-14).

5.2 Stratigraphic definition of seismic units

Ecozones 1 and 2 (vertical ruled pattern), correspond to the *lower unit* of the TST defined on seismic profiles. On the shelf and upper-slope region, ecozones 1 and 2 are represented by only benthic assemblages composed of *Ammonia perlucida, Bulimina elongata, Bulimina ex gr. marginata* and *Elphidium decipiens* indicative of fresh water runoff and high concentrations of organic matter (Jorissen, 1988) in cores PAL94-8 and RF93-55. During this interval, pollen spectra indicate persisting arid and cold conditions with Gramineae, Cyperaceae, *Artemisia* and Chenopodiaceae. *Juniperus* and several species of *Pinus* represent the most common shrub/tree component. In this interval herbs dominate on the shrub-tree component and abundant reworked pollens indicate strong influence of river-borne sediment. The early phases of the deglaciation are not well defined in these shelf cores if compared to CM92-43 from the MAD slope basin (Asioli *et al.*, this volume).

Ecozone 3 corresponds to the *middle unit* defined on high-resolution seismic profiles (Fig. 2). The Younger Dryas interval (dotted pattern in Fig. 2) was sampled in a core transect along profile PAL94-2 (Fig. 1). In core PAL94-77 even benthic foraminifera are extremely scarce (*A. beccarii* and *C. lobatulus*), whereas abundant pyrite and plant debris characterize this interval. At its base, the interval shows a planktonic assemblage dominated by *G. bulloides.* A tephra layer is detected from peak in magnetic susceptibility immediately below this interval and has been ascribed to the Neapolitan Yellow Tuff (C2; 12.4 ka ^{14}C BP; Calanchi, Lucchini & Dinelli, pers. comm.). The same sequence has been referred to the Younger Dryas cold event in core RF93-77, located 2 km downslope. In fact, the limits of this sequence are 10160±90 (upper limit) and 11990±60 (lower limit) AMS uncalibrate ^{14}C years BP (Asioli *et al.*, 1995). In core PAL94-77, the Younger Dryas interval shows also increased sediment accumulation rates that compare to those observed in the MAD (up to as much as 1.8 mm/a; Asioli *et al.*, this volume); this interval shrinks to a few centimeters of condensed deposition on the outer-shelf to the North (core PAL94-8).

The lower 3 m of core RF95-14 and the lower 2.5 m of core RF95-13 recovered sandy deposits with sedimentary structures indicative of a lower shoreface storm-dominated environment (Fig. 2). One uncalibrated AMS ^{14}C date (10.690±60 BP) is available from a worn valve of *Nucula* sp. confirming that this deposit prograded during Younger Dryas times. Pollen spectra on core RF95-13 show dominance of herbs over trees and high concentrations of *Artemisia, Ephedra* and Chenopodiaceae, indicative of a dry period when trees were confined in small refugees. The benthic foraminifera show two alternating assemblages with *A. beccarii, Ammonia papillosa, Elphidium crispum* and *A. perlucida, Ammonia tepida, A. beccarii, E. decipiens,* respectively. The first association is typical of the shoreface (Tomadin *et al.*, 1984), whereas the second reflects the influx of fresh water (river floods) in a low energy offshore environment. A short interval of mixed microfauna marks the top of this unit and heralds the entrance of the planktonic assemblage referable to ecozones 5 and 6.

Within the *middle unit*, contrasting sedimentary responses developed across the margin: on the inner shelf sediment accumulation rates were extremely high with the deposition of up to 18 m of sandy progradational deposits; on the outer shelf, erosion and non-deposition characterised the interval; and in the basin sediment accumulation rates were 10 times greater than during the rest of the transgression. No conventional coring device can penetrate the middle unit in its depocentre and our cores provide information on the upper 2.5 m of the unit. If the whole unit is ascribed to the Younger Dryas interval, sediment accumulation rates reached as much as 18 mm/a.

Ecozones 4 to 6 in the planktic stratigraphy correspond to the *upper unit* of the TST on seismic reflection profiles and are present in all cores (Fig. 2). The base of this unit is marked by a rapid increase in *Quercus* and other species of broad-leaf trees. In detail, however, pollen abundances show significant fluctuations (Accorsi *et al.*, 1995). The planktonic assemblage indicates warming of surface waters, while the benthic assemblage indicates cold bottom waters. *G. inflata* is a relatively deep dweller planktonic species (Pujol & Vergnaud-Grazzini, 1995), which likely reached the shallowest portion of the basin after a time lag with respect to its first occurrence in the adjacent slope basin. For this reason we consider as time-transgressive the lower limit of ecozone 6, which is about 8 ^{14}C ka old in the deepest parts of the basin and progressively younger on the shelf. The upper limit of the ecozone is, however, synchronous at Central Adriatic basin scale (Asioli *et al.*, 1995).

Ecozone 7 is well represented in all the cores and corresponds to the HST overlying the maximum flooding surface (Trincardi *et al.*, 1994) that is approximated by the top of ecozone 6 (Figs. 2 and 3). Benthic assemblage is commonly composed of *Brizalina spathulata* in both core PAL94-9 and all the cores collected in deeper waters. On the contrary, shallower-water cores RF95-14 and RF95-13 show a benthic assemblage dominated by *Val-vulineria complanata, Nonionella turgida, B. ex gr. marginata.* This assemblage is typical of the modern mud belt characterised by low Oxygen concentration and high organic matter contents (Jorissen, 1988). The upper sections of the shallower cores confirm that the modern mud belt originated about 6-5 ^{14}C ka BP controlled by a counterclock gyre dispersal system.

5.3 Evidence of shelf erosion

Across the shelf edge region, the middle unit is entirely or partially replaced by an erosional surface followed by condensed deposition during the lower portion of the upper unit (Fig. 2). Cores PAL94-9, RF93-55 and PAL94-8 define an interval characterized by silty mud or sand with littoral or circalittoral reworked benthic microfaunas (in black in Fig. 2). All the cores collected on the transect of profile RF93-33 display a very condensed succession within the time interval encompassing ecozones 2, 3 and 4, and spanning in age between ca. 14 and 9 ^{14}C ka BP. The condensed section encountered in core PAL94-8 seems replaced landward by an erosional surface that is possibly carved into stratigraphic levels as deep as the Etna tephra layer (14.2 ^{14}C ka BP; Paterne *et al.*, 1988), which is missing at this site but is characteristic of deeper cores (Calanchi *et al.*, 1996). This condensed interval may encompass an erosional gap of increasing magnitude landward, where core PAL94-9 documents a sharp erosional contact on the underlying muds. Although markedly erosional, this surface shows no evidence of preserved shoreline sedimentary facies or benthic associations. Rather, a bioclastic sand rests on this surface and shows an overall fining upward trend that indicates a phase of offshore reworking and shelf drowning. In all cores where the Younger Dryas unit is present, the interval containing mixed fauna shrinks to the top of ecozone 3. In this case, the reworked interval marks only the process of transgressive reworking that took place when the sea-level rise recovered, during the second step of the deglaciation.

6. DISCUSSION

Although deposited during a short interval, the marine TST on the Central Adriatic shelf reveals great internal complexity with a shingled regressive unit encased into an overall mud-dominated transgressive succession (Fig. 2 and 3). This regressive unit reflects a change in the balance between sediment supply and oceanographic regime. Two factors concur to increase sediment accumulation rates during the Younger Dryas as documented by complementary records in the MAD (Asioli *et al.*, this volume) and on the inner shelf (Figs. 2 and 3): 1) a decrease in the rate of base-level rise or even a short-term reversal to a relative fall of small magnitude (a few m fall may go undetected on global ∂^{18}O isotope curves); and 2) a deterioration in the vegetation cover in response to a return to harsh glacial-like climate.

While during Termination 1a the rates of base-level rise outpaced sediment flux to the shelf and river bedload was trapped into drowned valleys and aggrading alluvial plains, during the Younger Dryas no further accommodation space was created causing sediment spillover to the shelf. Termination 1b was another phase of rapid base-level rise with channel aggradation and flood plain construction. Significant sediment storage in aggrading alluvial plains or paralic environments soon after the Younger Dryas may have determined the dearth in sediment supply evidenced by topset erosion on the middle unit of the TST. Alternatively, a decreased clastic supply may reflect a change in vegetation cover and decreased soil erosion.

Geomorphic thresholds can, however, induce fluvial systems to maintain their equilibrium profile during base-level changes through more complex responses rather than just incising or aggrading (Wescott, 1993). Modification in stream pattern, sinuosity and channel geometry may be at work. Purely intrinsic changes in fluvial systems may result in changes in supply to the shelf regardless of how base-level is changing. Furthermore, base-level change affects chiefly the lower trunks of fluvial systems and does not influence their upper valleys (Blum *et al.*, 1994). Changes in climate and vegetation cover within drainage basins are the major controlling factor even in the case of large base-level changes, such as those observed during the Quaternary (Blum *et al.*, 1994). For all these reasons, climate change during the Younger Dryas may itself represent a key control to increase sediment yield to shelf and basin areas.

A deterioration in climatic conditions during the Younger Dryas cold episode, as documented by pollen spectra and planktonic foraminifera, may have generated a reduction in vegetation cover, with increased rates of erosion in mountainous areas and enhanced sediment flux. River discharge rates may have increased relative to melt-water times because the landscape was less stable and the reduced land cover allowed for efficient soil erosion. Pollen abundance in the Adriatic region confirm a phase of cooler and dryer conditions (Rossignol-Strick & Planchais, 1989; Huntley *et al.*, 1996; Asioli *et al.*, this volume) as observed on a world-wide scale (Broecker, 1994). Cooler and dryer climatic conditions are also indicated by increased atmospheric dust up to values 7 times higher than during the preceding and following melt-water intervals (Alley *et al.*, 1993).

In both cases, river equilibrium profiles react to climatic cooling trend and sea-level stillstand by shedding increased amounts of bedload to the shelf that resulted in the outbuilding of the progradational middle unit on the shelf and in the increase of sediment accumulation rates in the slope basin to values up to one order of magnitude greater than during the preceding and subsequent episodes of high-rate sea level rise (Terminations Ia and Ib, respectively).

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