Geogr. Fis. Dinam. Quat.,
14 (1991), 209-219, 9 figg.

LUIGI CAROBENE (*) & GIANLUCA FERRINI (**)

THE LOWER PLEISTOCENE MONTE CARPINOSO TERRACE (TYRRHENIAN COAST OF CALABRIA, SOUTHERN ITALY)

Abstract: CAROBENE L. & FERRINI G., *The Lower Pleistocene monte Carpinoso Terrace (Tyrrhenian Coast of Calabria, Southern Italy).* (IT ISSN 0391-9838, 1991).

Plio-Pleistocene marine terraces occur along the Tyrrhenian coast of Calabria (Southern Italy) and display intense, recent uplift connected with formation of the Calabrian Arc. The Monte Carpinoso terrace is characterised by a wide surface (maximum width 3,300 m) covered by a sedimentary deposit composed of different superimposed depositional events. The formation of the wave-cut platform is related to several sea level stands due to the glacio-eustatic fluctuations of the Lower Pleistocene, occurred during a long lasting slow subsidence phases of the coastal area. The regressive phase and the emersion of the terrace started about 1 - 1.1 m.y. ago at the same time of the strong uplifting of the whole region; the mean uplift rate is about 0.5 mm/y. Before uplift, the terrace was probably represented by a smooth surface, gently dipping seaward, later dissected by fluvial erosion and by normal faults.

KEY WORDS: Geomorphology, Marine terrace, Sedimentology, Tectonics, Littoral sedimentation, Pleistocene.

Riassunto: CAROBENE L. & FERRINI G., *Il terrazzo marino del Pleistocene inferiore del Monte Carpinoso (Costa Tirrenica della Calabria).* (IT ISSN 0391-9838, 1991).

La costa tirrenica della Calabria è caratterizzata dalla presenza di terrazzi marini che testimoniano il sollevamento quaternario, spesso intenso, connesso con la formazione dell'Arco Calabro. In questo articolo è stato preso in considerazione il terrazzo del M. Carpinoso (località Diamante), caratterizzato da un'ampia superficie e da depositi sedimentari sia marini che continentali. La formazione della piattaforma di abrasione è imputabile al succedersi di alti livelli di stazionamento del mare, dovuti alle fluttuazioni glacio-eustatiche del Pleistocene inferiore (*partim*), durante un lungo periodo di lenta subsidenza dell'area costiera. La fase regressiva e l'emersione del terrazzo iniziò forse 1-1,1 milioni di anni fa, all'incirca coincidente con il forte sollevamento dell'intera regione; il tasso di sollevamento medio del terrazzo è oggi pari a 0,5 m/anno. Prima del sollevamento, il terrazzo era probabilmente rappresentato da un'ampia superficie, leggermente inclinata verso mare; successivamente il terrazzo è stato suddiviso in tante superfici terrazzate sia dalle incisioni vallive che dall'attività delle faglie.

Lo studio dell'alto terrazzo del M. Carpinoso ha portato ad una mappatura geomorfologica delle sue caratteristiche salienti (limiti litologici e morfologici, pedogenesi), ad una carta neotettonica che evidenzia tre sistemi di faglie e che permette il calcolo dei rigetti e ad uno schema litostratigrafico di correlazioni. In questo i depositi trasgressivo-regressivi vengono riferiti ad almeno tre differenti eventi deposizionali, succedutisi nel tempo durante il sollevamento e l'emersione del terrazzo; il più antico di essi è riconoscibile nella parte alta del terrazzo (margine interno), il più recente nella parte bassa (orlo esterno).

TERMINI CHIAVE: Terrazzo marino, Geomorfologia, Sedimentologia, Tettonica, Sedimentazione litorale, Pleistocene.

INTRODUCTION

Raised marine terraces are surfaces, lying above sea level, comprising a wave-cut platform covered by marine and/or continental deposits. These features give useful evidences of the elevation of past sea levels and provide a basis for the study of coastal uplift and eustatic changes.

Pleistocene marine terraces occur along the Tyrrhenian coast of Calabria (Southern Italy), and show intense and recent uplift and faulting connected to the formation of the Calabrian Arc. This paper presents Quaternary lithostratigraphical and geomorphological data, correlates ancient sea-level stands and analyses the uplift rate and magnitude of coastal deformation in the field area.

RAISED MARINE TERRACES

A raised marine terrace is usually characterised by a gently sloping seaward surface bounded by slopes or scarps; the intersection between the upper slope and the terrace surface marks the *inner margin* (or inner edge or shoreline angle) corresponding to the highest ancient shoreline. The intersection between the downslope scarp and the terrace

(*) *Dipartimento di Scienze della Terra, Università degli Studi di Genova, Corso Europa 26 - 16132 Genova, Italy.*
(**) *Dipartimento di Scienze della Terra, Università degli Studi della Calabria - 87036 Arcavacata di Rende (CS), Italy.*
Funds for this research project were provided by «Ministero dell'Università e della Ricerca Scientifica e Tecnologica» of Italy at University of Calabria (Project 40%: «Geologia del Pleistocene calabro» and Project 60%: «Antiche linee di riva quaternarie della costa calabrese»).

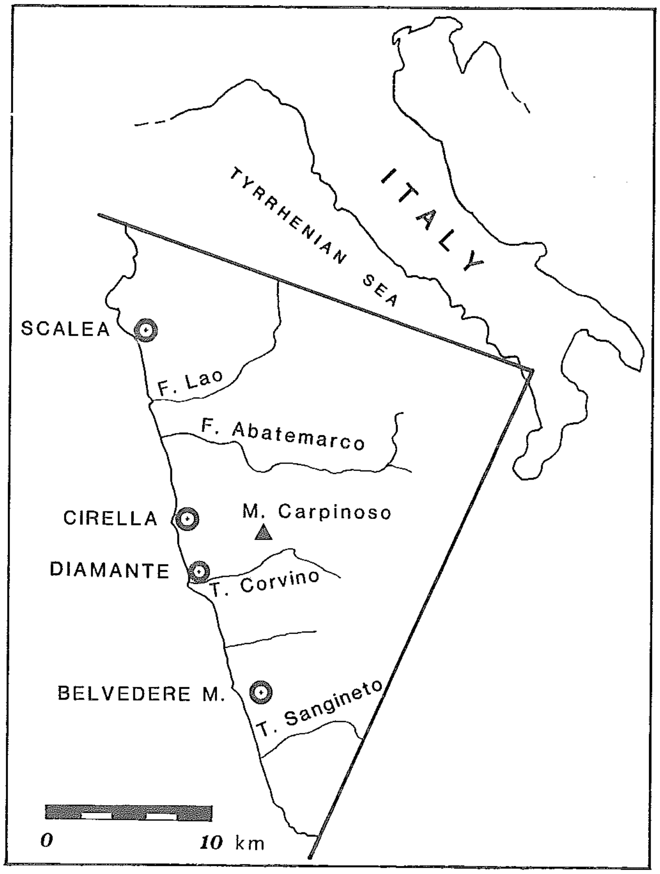

FIG. 1 - Index map of the field area.

surface marks the *outer edge*; its elevation varies according to the erosion rate which reduced the terrace width. The downslope scarp generally corresponds to a degraded palaeo-sea cliff.

Laterally a marine terrace is usually bordered by erosional scarps and valleys of fluvial origin; when these valleys grow in width, the terrace is laterally reduced to a flat and narrow subhorizontal ridge (fig. 3).

The terrace sedimentary cover may be of marine and/or continental origin and soils and palaeosol horizons can be present. In the absence of sediments, a terrace consists of an eroded abrasion platform only.

The age of a terrace is determined by the interval of time required for its formation and then the terrace surface is to be considered diachronous. The highest shoreline, corresponding to the inner margin, represents the level of the maximum high stand and can be taken to represent the terrace altitude; its age probably corresponds to an interglacial high sea-level stand.

A raised marine terrace can be considered as a complex planation and sedimentation surface formed by the interaction between tectonic movements (uplift, faulting and tilting) and long lasting sea level still-stands during interglacial periods.

MARINE TERRACE IN THE FIELD AREA

Raised marine terraces are easily recognised along all the Calabrian coast; in the field area they are particularly evident between the villages of Cetraro and Praia a Mare (see CAROBENE, 1987, fig. 1). In this area, ancient raised marine terraces have been recognised and described by several authors (CORTESE, 1886; DE FIORE, 1937; PATA, 1956; BRANCACCIO & VALLARIO, 1968; DAMIANI, 1970; DAMIANI & PANNUZI, 1979).
The different tectonic uplift rate which increases from

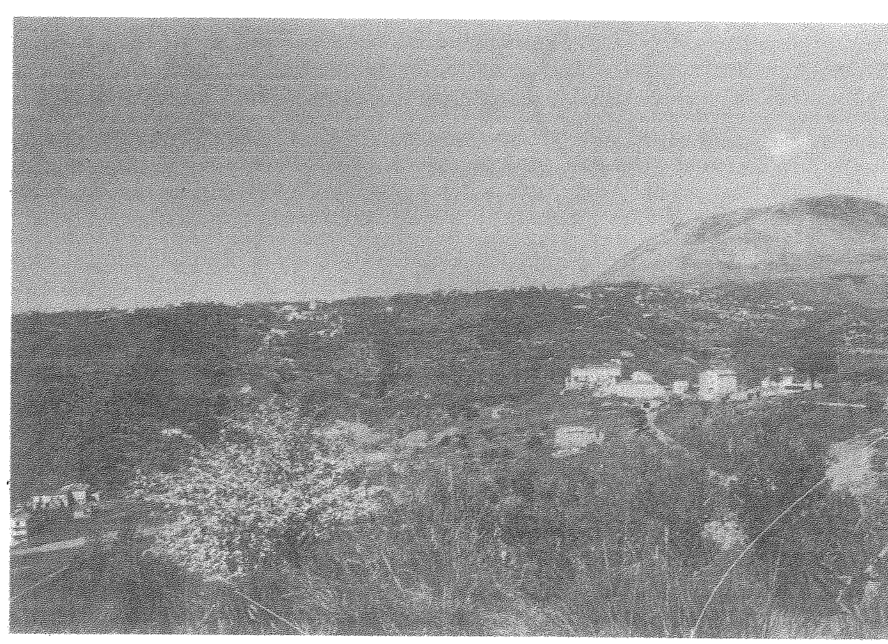

FIG. 2 - Partial view of the terrace. The Monte Carpinoso in the distance.

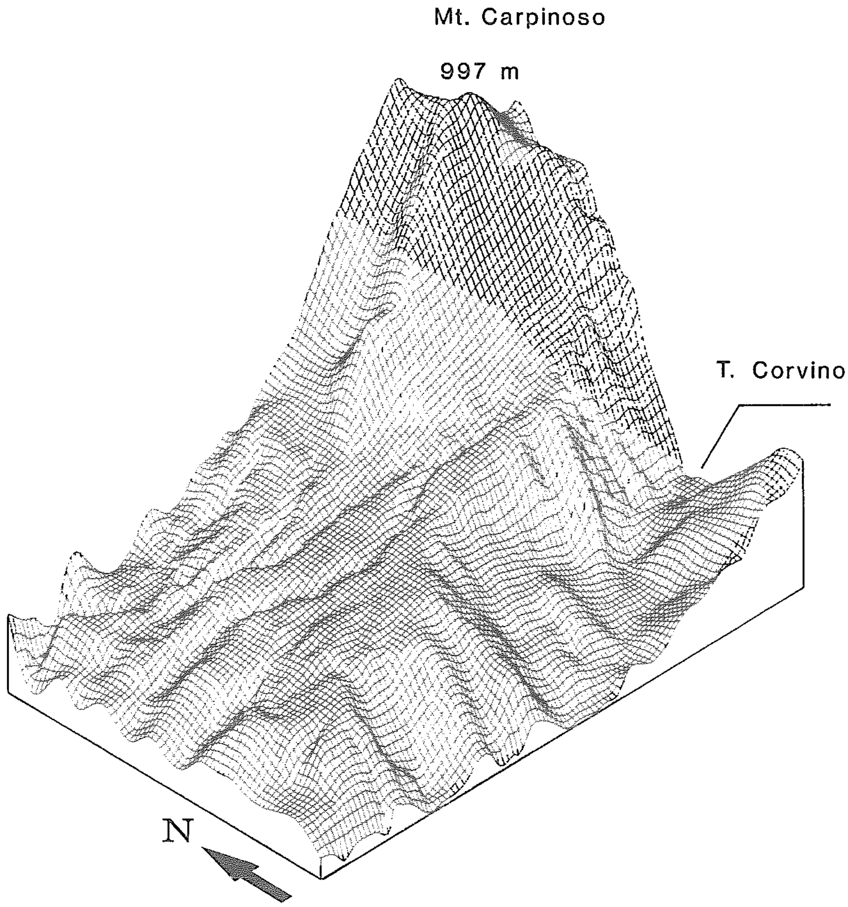

FIG. 3 - Block diagram of the field area (orthographic projection); rotation about *z* axis: 220°; tilt after rotation: 30°; *z* scale factor: 3. The diagram point out the width and smooth slope of Monte Carpinoso; the terrace surface dissected into several portions by stream erosion; the deep Corvino valley at South.

North to South makes the correlation between ancient terrace surface difficult. In the area two morphological key levels were recognised:

— the first is a pre-Tyrrhenian shoreline (230Th/234U age > 306,000 yr (LB 69)) which varies in altitude from 19 (North) to 35 (South) m a.s.l. (CAROBENE & *alii*, 1986);

— the second is a series of well developed high raised terraced surfaces which have been recognised in the area between the mouths of the Corvino and the Noce rivers (the Monte Carpinoso raised terrace); the elevation of this terrace, correlated on morphological basis (CAROBENE & DAI PRA, 1991) increases from North (110 m a.s.l.) to South (550 m a.s.l.).

Two terraces are present between the two levels described above: the highest decreases in altitude from 300 m (near Cetraro) to 70 m a.s.l. (South of the Lao river mouth); the other varies in altitude from 100 m (South) to 25 m (North) a.s.l. Pebbly and sandy deposits are commonly preserved on the terraced surfaces; the marine origin of the deposits of the highest terrace is determined by fauna (fossils and *Lithodomus* holes) and by the presence of an alignment of sea caves along the inner margin.

LITHOLOGY, MORPHOLOGY AND TECTONICS

The surfaces aligned to the Monte Carpinoso Terrace lie between the T. Vaccuta (North) and the T. Corvino (South) (partially reproduced in figs. 3 and 4).

The rivers flowing westward have divided the original terrace into elongate surfaces and syn- and post-sedimentary faults have generated transverse scarps which dissect the terrace into several portions. This fragmentation is clearly visible in the northern part, while in the South the surface still shows a good areal continuity (from 270 to 510 m a.s.l.). Small morphological steps are present at altitudes of 320, 360 and 390 m a.s.l.

The maximum width of the terrace (southern portion) is 3,300 m; the mean inclination is 3° in the outer edge area, 4° in the middle section and 5° in the inner area.

The terrace is limited inland by the M. Carpinoso slope (mean inclination 28°) and resulting from the erosion of a fossil cliff. The ancient shoreline at the foot of this feature is still recognisable (up to 550 m a.s.l.) by the presence of marine sediments and *Lithodomus* holes.

The terrace was originally described by DAMIANI (1970) who observed the *Lithodomus* holes up to an altitude of

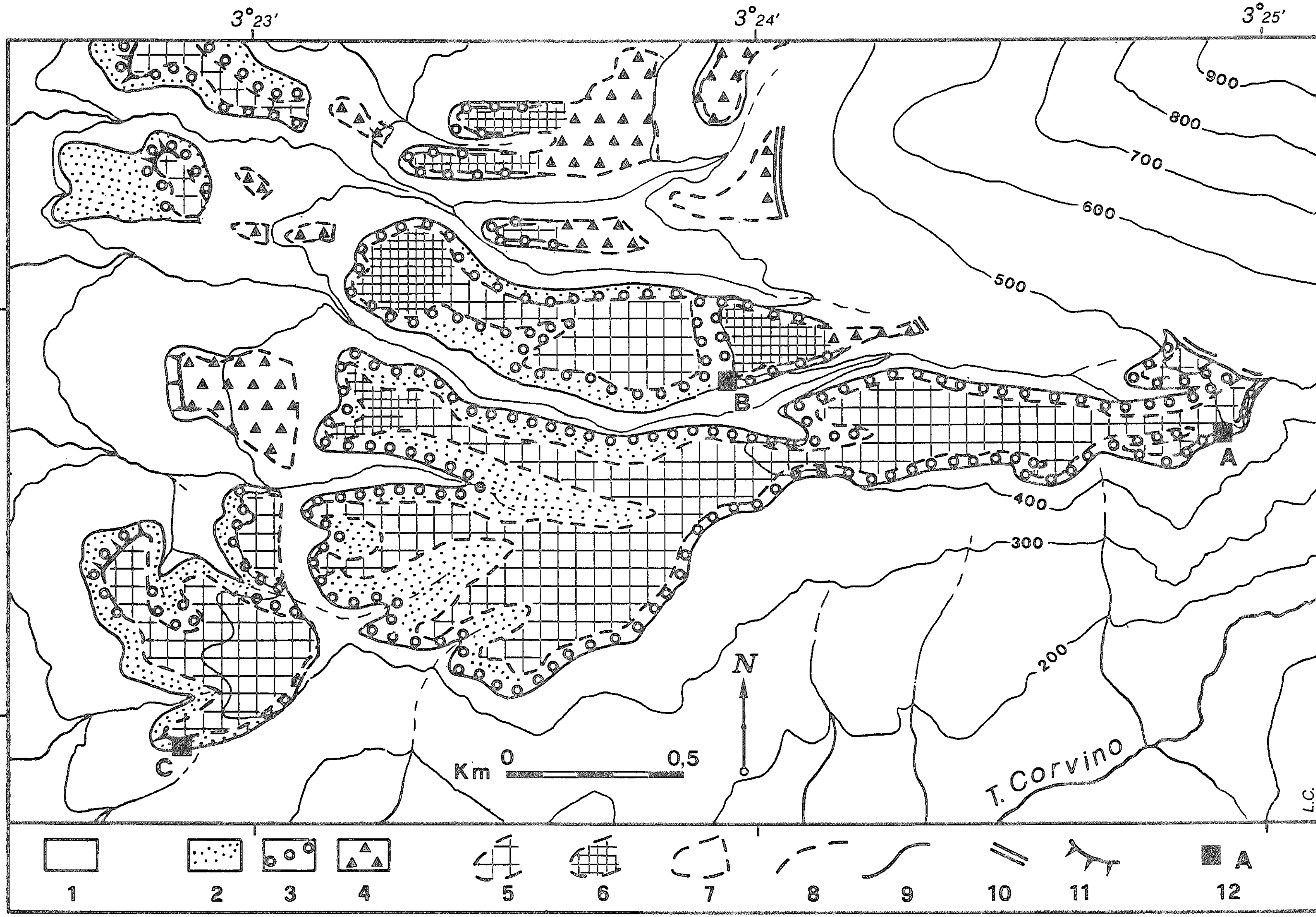

FIG. 4 - Geomorphological map of the Monte Carpinoso raised Terrace (southern part). Fluvial erosion and tectonic movements reduced the terrace into several surfaces actually recognisable along the ridges; the sedimentary deposit on the wave-cut platform has a mean thickness of less than 15/20 m. Legend: 1) pre-Quaternary bedrock, 2) sandy/silty deposits, 3) rudite deposits, 4) weathered regolith, 5) sedimentary cover pedogenized in the upper portion, 6) sedimentary cover completly pedogenised, 7) absence of sedimentary cover, 8) morphological boundary of the terraced surfaces, 9) Pleistocene sedimentary deposits boundary, 10) inner margin, 11) outer edge, 12) contour line (in metres), 13) location of sedimentological sections (see Fig. 6).

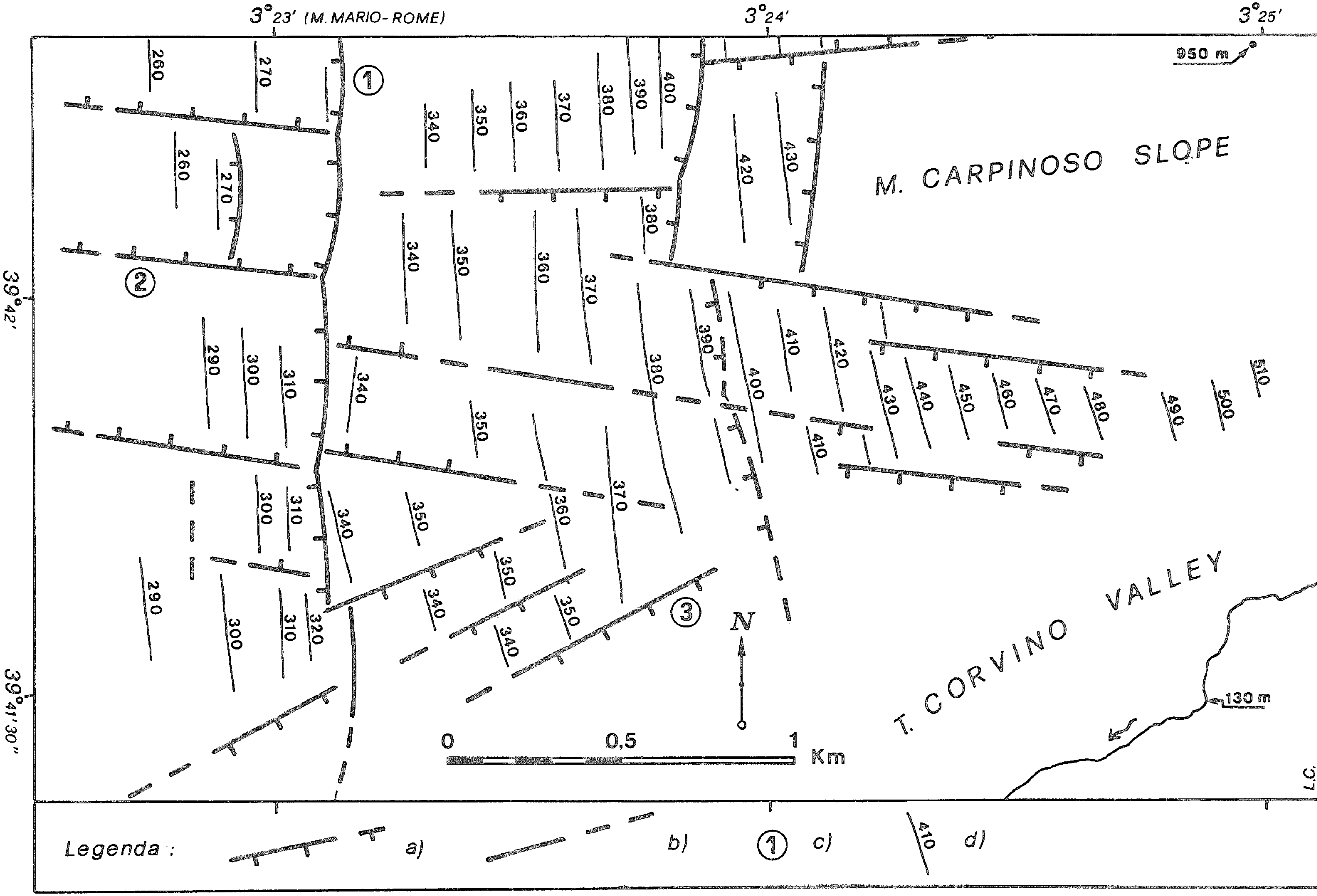

FIG. 5 - Neotectonic map of the Monte Carpinoso terrace (southern part): a) normal fault, b) master joint, c) fault systems, d) linear contour-line segments, tangential to the topographic map contour-line and perpendicular to the dip of the terrace surface. The segments were drawn only in corrispondance of still preserved terrace surface.

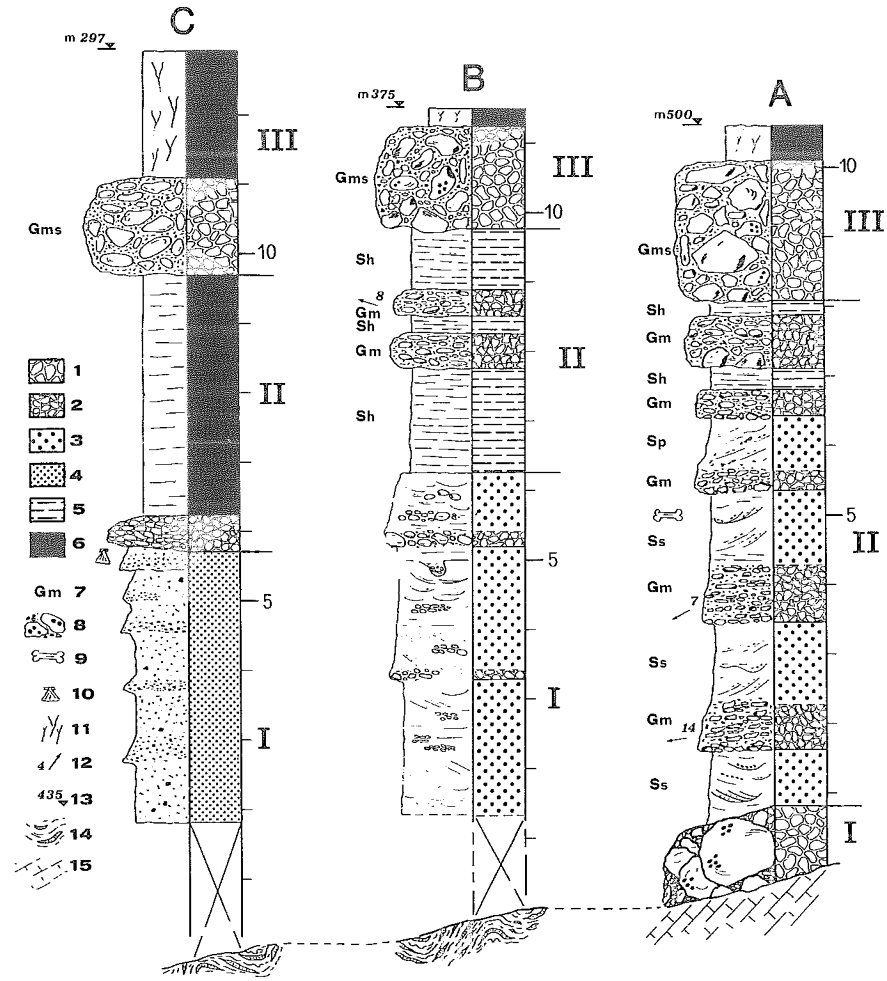

FIG. 6 - Sedimentological sections of the terrace sedimentary cover (for location see fig. 3); lithology: 1) large clasts rudite, 2) conglomerate, 3) coarse-grained sand, 4) medium-grained sand, 5) fine-grained sand, 6) silt/very fine-grained sand, 7) Miall lithofacies, 8) clast with *Lithodomus* holes, 9) bone fragments, 10) marine fossil fragments, 11) pedogenetic figures, 12) palaeocurrents direction, 13) section top altitude, 14) metamorphic bedrock, 15) calcareous bedrock. I, II, III: lithostratigraphic subdivisions.

410 m a.s.l. and correlated the sedimentary deposits lying on the abrasion platform with the Pliocene-Calabriano shelf clay outcropping at Fornace San Nicola (Scalea).

Terrace deposits mapping

A detritical deposit lies on the abrasion platform of the terrace (cut on Mesozoic dolostone, Miocenic marls and metamorphic rocks). The thickness of this deposit varies from 10-20 m to a maximum of 70 m, corresponding to areas of tectonic depression or subsiding palaeovalleys. The deposit (of marine and/or continental origin) can be partially or totally pedogenised. Five different situations have been recognised and mapped:

1) absence of deposit or regolith (bedrock);
2) surface covered by partially/totally weathered regolith;
3) unweathered marine or continental deposit;
4) unweathered deposit pedogenised in the upper portion only;
5) complete pedogenetically altered deposit;

The lithologies have been described as follows:

a) rudites prevalent
b) silt/arenites prevalent

The pedogenesis formed a soil sequence later truncated by erosion; for this ancient soil the term *vetusol* («...soils actually at the surface, which underwent the same or very similar processes of soil formation over a generally long period of time, including at least some part of the Pleistocene». CREMASCHI, 1987) is better than the term *paleosol.*

Geomorphological mapping

The mapping of the terrace surfaces was based on the following distinctions:

1 - morphological boundary of the terraced surface;
2 - terrace deposit boundary; this boundary is often marked by a slope break and locally by springs;
3 - outer edge; this line was drawn in correspondence with the ridges, where the scarp connecting two different

orders of terraces is a degraded ancient sea cliff. Other scarps are of fluvial origin;

4 - inner edge; this line runs at the foot of the M. Carpinoso slope where the first gradient change is evident (Figs. 3, 4). For the lowest terraces the line is at the base of the scarp along the ridge.

Pleistocene tectonics

To define the dislocations which occurred during the terrace uplift, morphological and stratigraphic data have been used; scarps, linear valleys and gradient variations have provided first indications about neotectonic elements. After that, using the elevation data from the 1:10,000 topographic map, contour line segments, perpendicular to the downslope dip of the surface remains were drawn (fig. 5). Where the contour line segments do not fit laterally, a transverse fault is probably present (systems 2 and 3 in fig. 5). When the distance between two lines is small, or a line is absent, a fault scarp trending as contour line can be assumed (system 1 in fig. 5).

Before uplift the terrace was probably represented by a regular gently dipping seaward surface which was later dissected by fluvial erosion in several relicts; normal faults, with throws varying from 5 to 30-40 m, affected these surfaces.

The faults of system 1 (fig. 5) lowered the blocks westward with an increasing throw toward north; the faults of system 2 have no defined dip trend and faults of system 3 cut the terrace in a SE direction along the T. Corvino valley. Determination of throws was controlled by comparison of the altitude of abrasion platform outcropping on the slopes bordering the terrace.

The amount of the seaward tilting is unclear, but the inclination of the surfaces varies from 2° to 6°.

LITHOSTRATIGRAPHIC ANALYSIS

The lithostratigraphic analysis of the sedimentary cover of the terrace pointed to the presence of different superimposed depositional events, separated by unconformities. This sequence represents the result of terrace uplift/sea level changes interaction.

To understand the sedimentary evolution of the terrace deposits three type sections are produced here (for location see fig. 4). The measured sections (fig. 6) illustrate the sedimentary evolution of the inner- and outer-edge areas (sect.s A and C) and of the middle portion of the terrace (sect. B).

Section A

The sedimentary sequence which caracterises the inner margin area is composed of three superimposed different episodes showing a regressive trend. The section was measured in a quarry located at an elevation of 500 m a.s.l. (see Carobene, 1987: stop 9).

The basal portion of the sequence (I - fig. 6) is represented by a ruditic horizon lying directly on the calcareous bedrock and characterised by a marked variable thickness.

Facies analysis - The deposits are composed of rounded limestone boulders (with diameter up to 3 metres); the interstices between the main elements is filled by tightly-packed gravel (fig. 9). The gravel elements (average diameter 3,5 cm), mainly of carbonate, are well rounded, spherical in shape and surronded by a white coarse grained sandy matrix with calcite cement.

Biogenic structures and fauna - In this area the limestone boulders and the bedrock has a locally abundant presence of *Lithodomous* holes. The boreholes are locally filled with

Fig. 7 - Cluster structure in the fluvial conglomeratic member (I) (Gm lithofacies, Miall, 1977, 1980) of section A.

fine- to medium-grained sandstone; their shape is cylindrical with an average diameter of 20 mm. Locally, along the terrace inner margin coarse-grained sandstones level is found with the basal conglomeratic layer up to a maximum altitude of 510/515 m a.s.l.

Interpretation - Sea cliffs base deposits; this deposit originated during the highest sea level stand at the latest stage of the wave-cut platform carving.

The middle part of the section (II - fig. 6) is represented by an alternation of conglomerates and coarse-grained to pebbly sandstone.

Facies analysis - The gravelly lithofacies (*Gm* according to MIALL, 1977, 1978) is predominant in this portion of the sequence. The conglomeratic levels form laterally extensive tabular sheets which commonly present a conformable basal contact. These levels are composed of coarse gravel (average clast diameter 8 cm) with a poor matrix content; the clasts show a little internal grading and are clearly imbricated. The palaeocurrent pattern shows a mean transport direction from the NE (fig. 7). The conglomeratic bodies pass upward to flat-laminated (*Sh*), planar cross-bedded (*Sp*) sand with local subordinate amounts of gravel. The sandy levels are rarely laterally continuous; shallow (< 40 cm deep) scours (*Ss*) are frequently filled with cosets of planar cross-bedded sand. The infillings exhibit lateral accretion indicating a cross-channel flow.

Biogenic structures and fauna - Scarce bone fragments are occasionally found in the sandy levels.

Interpretation - The conglomeratic beds can be interpreted as parts of «bars cores» (BLUCK, 1974); similar deposits have been recognised in straight or low sinuosity rivers (STEEL & THOMPSON, 1983; RAMOS & SOPENA, 1983; BILLI & *alii*, 1987). The presence of a flat lamination in the sandy levels suggests deposition by shallow and low velocity flows; the channel-form scours can be related to unidirectional currents.

This continental sequence is related to the sea regression (Bsg and Bgs in fig. 8-A) and we suggest an erosional gap between these deposits and the basal boulders (fig. 9).

The sequence ends with the deposition of a ruditic deposit capped by a soil horizon (III - fig. 6).

Facies analysis - This last reddish ruditic deposit (mean thickness 200 cm) is formed of large cobbles and pebbles in an abundant sandy matrix (*Gms* facies in MIALL, 1977, 1978). A slight trend to inverse grading is present and many cobbles have a vertical *b* axis. The clast are well rounded and some calcareous elements are bored by *Lithodomous*.

Biogenic structure and fauna - *Lithodomous* holes on clast are present.

Interpretation - These deposits appear to represent a debris flow which reworked clasts belonging to an ancient shoreline. They indicate a climatic and environmental change. It is not possible to date this debris flow emplacement.

Section B

The middle portion of the terrace is characterised by a regressive sedimentary sequence; the type section was measured in a fluvial exposure.

The sequence is characterised by a thick basal portion of coarse- to medium-grained sand with interbedded conglomerate bands (I - fig. 6).

Facies analysis - This part is constituted by hummocky-stratified sand with interstratified conglomerate levels; it is mainly composed of a series of superimposed, shallow, concave-upward scours. These irregulary shaped features are as much as 2 m wide and 0,4-0,5 m deep and are filled with gently inclined laminae (less than 10°). Concentrations of small pebbles are present along some of the laminae. The conglomeratic beds are thin and laterally discontinuous with pebbles organised along low angle cross-laminae; the laminae commonly have a gently convex-upward outline. The conglomerates are generally matrix-supported and composed of moderately well- to well-rounded pebbles; the high sphericity of the clasts prevents the true alignment and/or imbrication to be discerned. Locally the sandy beds are cut by conglomerate-filling high-angle scours. These features show an asymmetric cross-section with one wall at an angle close to vertical. The three-dimensional geometry of the scour is difficult to understand but it seems to resemble a large flute rather than a channel. The scour is filled mainly with gravel in medium- to coarse-grained sandstone and it is floored by cobbles.

Biogenic structures and fauna - Not found.

Interpretation - The low-angle cross-stratified conglomerates were probably deposited within low-amplitude migrating bedforms; the presence of convex-upward surfaces suggests that they represent bars produced in a onshore wave translation zone. The cross-bedded pebbly sandstone is due to an unidirectional migration of megaripples in zone above wave base and can be considered part of the upper shore facies of a high energy nearshore environment.

The abundance in the deposits of pebble and cobble conglomerates with well rounded clasts suggests deposition near a fluvial source. We don't correlate this episod with the marine deposits of section A because: a) between the two sections there is an altitude difference of 120 m mainly due to the tectonic uplift; b) the shallow water deposits described above are related to an ancient shoreline few metres higher; the absence of back-and fore-shore deposits suggest the presence of a hiatus.

The marine sedimentation ends abruptly and the shore facies is overlain by an alternation of massive medium- to fine-grained sand and conglomerates (II - fig. 6).

Facies analysis - The conglomerates are composed of well rounded pebbles (mean diameter 35 mm) in laterally extensive sheet-like bodies; the clasts are imbricated with poor sandy matrix (*Gm* facies in MIALL, 1977, 1978). The medium- to fine-grained interbedded sand shows a flat planar crossbedding (*Sh*).

Biogenic structures and fauna - Not found.

Interpretation - These sediments are interpreted as migrating bars overlain by laminar flows in a braided or low sinuosity river and represent the continental episod following the marine regression. This deposit is then considered to be younger (fig. 8) than the fluvial sequence (II) of section A (fig. 6).

As with the previous section (A) this sequence ends with a reddish ruditic episode (III - fig. 6).

Facies analysis - Well rounded boulders and cobbles occur in an abundant sandy matrix (*Gms* facies in MIALL., 1977, 1978). Larger clasts are present at the top of the deposit, many having vertical *b* axis.

Biogenic structures and fauna - *Lithodomous* holes are present in larger calcareous clasts.

Interpretation - This episode (III) appear to be a debris flow in alluvial fan environment which also reworked clasts derived from a higher ancient shoreline; the horizon has the similar stratigraphic position of the debris flow in section A and it is possible that the two levels can be correlable.

Section C

This section was measured in a road cut at the rim of the outer edge of the terrace; the contact with the underlying metamorphic bedrock is not clearly exposed.

The section comprises a basal yellowish sandy portion (I - fig. 6):

Facies analysis - Massive medium-grained sand, with scattered oversized clasts, interbedded with coarsening beds showing upward gradation. The sands are capped by well sorted micro-conglomeratic bands with a variable thickness (from 30 to 100 cm) showing a good areal continuity.

Biogenic structures and fauna - The massive sands are locally colour mottled and include scattered shell fragments (*Ostrea* sp.); micro-palaeontological specimens indicate a Lower Pleistocene age (COLALONGO M.L., personal communication, 1990). In the coarser deposit only few broken shell remains were found.

Interpretation - Upper shoreface/beach environment; the coarser graded beds interbedded in the massive sands may have originated by deposition during a single high-energy event («storm layers»). This deposit marks a sea level stand 85 m lower than that indicated by the marine sequence in section B (I). The difference in altitude is mostly due to the tectonic uplift and the sequence C (I) is therefore younger than sequence B (I).

The sequence passes upward abruptly into a massive fine grained sandy horizon (II) capped by a ruditic level (III) (fig. 6).

Facies analysis - Massive structureless very fine grained sandy/silty deposit enriched in coal debris. It includes a root horizon at the top the reddish ruditic deposit (III) (mean thickness 200 cm) is composed of large cobbles and pebbles in an abundant sandy matrix (*Gms* facies in MIALL, 1977, 1978). A slight trend to inverse grading is present and many of the cobbles have a vertical *b* axis.

Biogenic structures and fauna - Not found.

Interpretation - These horizons represent a lagoonal/back shore environment (II) with debris flow deposits at top (III), representing the regression followed to the high sea level described above. Not sedimentary gaps are present between I and II level (fig. 6 - C). The debris flow (Fc in fig. 8) is younger than the other levels (Dc - fig. 8 - B) because its deposition followed a transgressive episod (seen sect. B - fig. 8) which cut the rudite deposits (B-III in fig. 6) up to an elevation of about 375 m (shoreline).

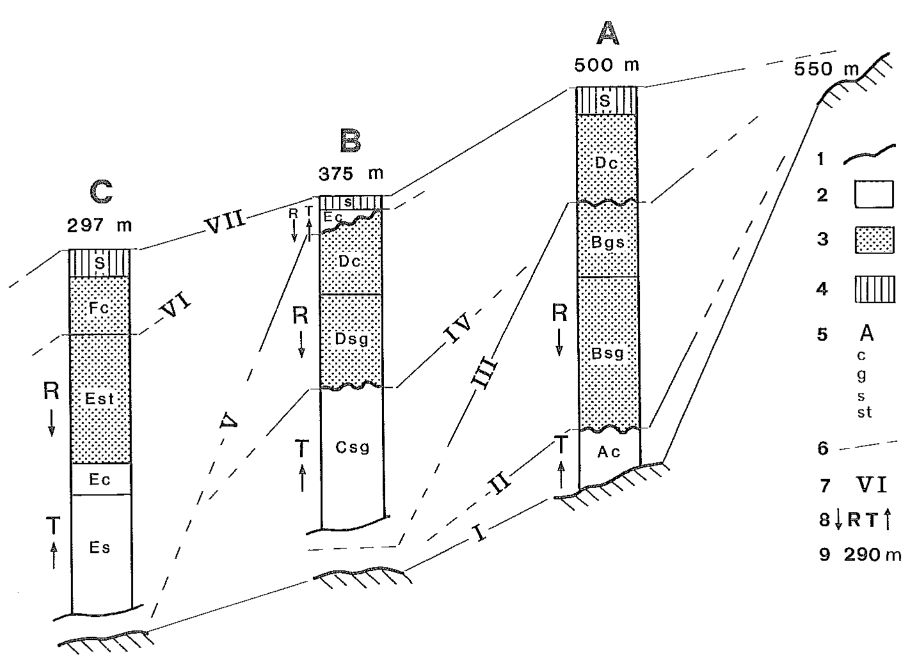

FIG. 8 - Lithostratigrafic scheme and correlation of the terrace sedimentary cover: 1) transgression surface on ancient bedrock, 2) marine deposits, 3) alluvial/lagoonal deposits, 4) soil horizon, 5) A, B, ecc. = members lithology: c = conglomerate, g = gravel, s = sand, st = silt, 6) correlation line, 7) correlation line order, 8) regression/transgression, 9) section top altitude; (for explanation see «Lithostratigraphic analysis»).

TERRACE GENESIS AND AGE

The Monte Carpinoso high Terrace is characterised by a wide surface (maximum width 3 300 m) with a mean inclination of 4°; the comparison between these data and the inclinations of wide wave-cut platforms described in the literature (BRADLEY & GRIGGS, 1976; TRENHAILE, 1980), which suggest a mean inclination of less than 2-3°, may indicate a slight seaward tilting of the surface. The considerable terrace width and the difference of level between the inner and the outer edge (240 m) and the lithostratigraphy of the sedimentary cover point out a complex terrace history: the formation of the wave-cut platform may be related to several sea level stands that occurred during a long lasting slow subsidence phase of the coastal area. This subsidence period is well known throughout the Calabrian region and is represented by clay deposits of Lower Pleistocene (Emilian) age characterised by the presence of *Hyalinea baltica, Globigerina pachyderma, Globorotalia inflata* and *Elphidium crispum.*

The wave-cut platform is covered by sedimentary deposits recording several transgressive/regressive cycles; the emersion of the platform started about 1 - 1,1 m.y. and corresponds to the strong uplift of the whole region (CIARANFI & *alii*, 1983). The highest shoreline (terrace inner margin at 510 m a.s.l.) can also be considered of that age (CAROBENE & DAI PRA, 1991). The mean uplift rate since that date is therefore 0,5 mm/yr. At the beginning, the uplift rate of the platform was probably more than 0,5 mm/yr, because the youngest shoreline (IV order terrace) was uplifted at a rate of about 0,1 mm/yr (CAROBENE & *alii*, 1986). The full emersion of the terrace lasted for a period long enough to permit:

- the partial erosion of the transgressive sedimentary deposits;
- the influence of new transgressive phases during interglacial high stands of the sea.

These facts are well recorded in the sedimentary sequence outcropping on the abrasion platform characterised

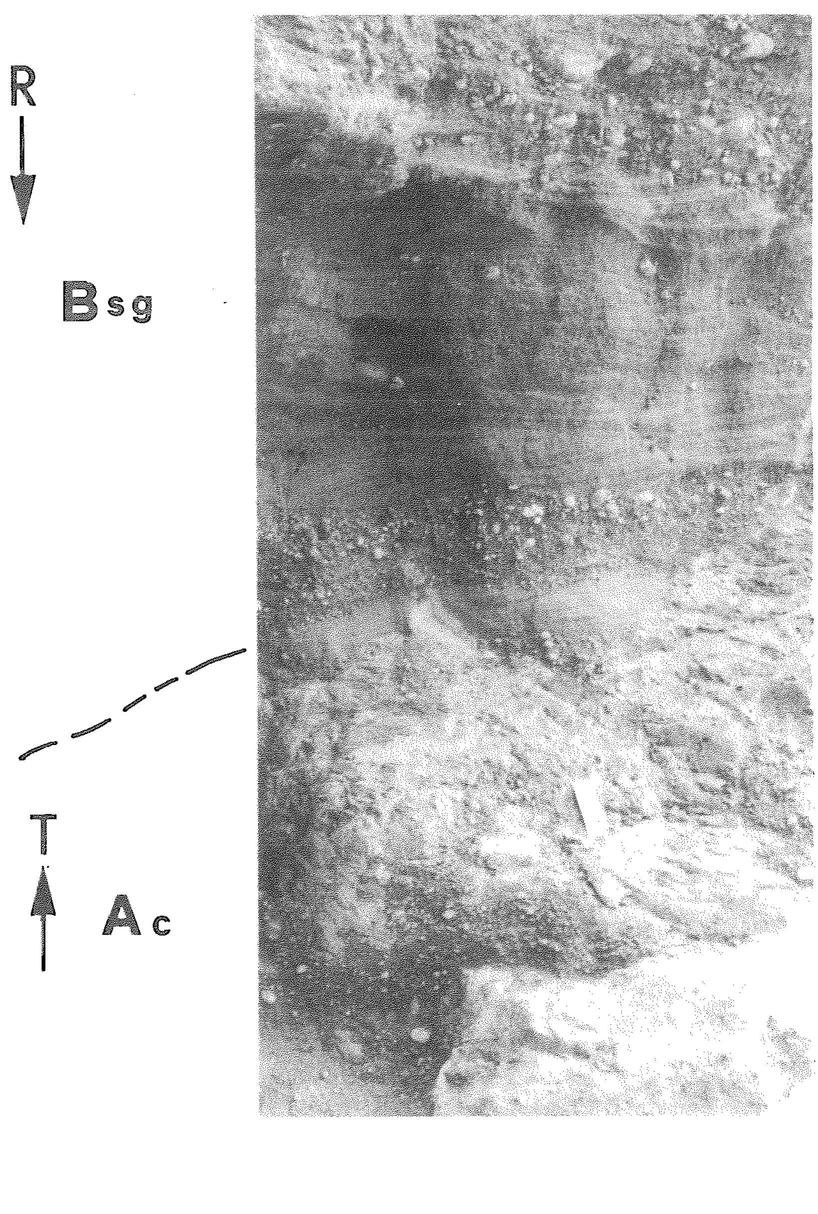

FIG. 9 - Basal portion of section A (I) showing the fluvial member superimposed on the sea-cliff boulders (for symbols see fig. 8).

by three or more transgressive/regressive phases (fig. 8).

Then the Monte Carpinoso Terrace includes:

— a diachronous wave-cut platform formed by the action of several high sea level stands with an increasing altitude, during a long subsiding phase of the bedrock;
— a sedimentary deposit composed of three or more diachronous bodies related to transgressive/regressive episodes.

The formation of this wide terrace was thus a result of the interaction between tectonic subsidence/uplift movements and high sea level stands related to the glacio-eustatic fluctuations of the Lower Pleistocene, as documented by the oxygen isotope records (WILLIAMS & *alii*, 1988).

CONCLUSION

This study of the Monte Carpinoso raised terrace suggests:

a) the terrace reflects the recent evolution of this complex Southern Apennines sector where the studied area is located; during Middle-Upper Miocene the Thyrrenian Sea opened and the subsiding Paola and Gioia Basins developed; the northern portion of Calabria uplifted following the outward migration of the compression front (FABBRI & *alii*, 1984). The uplift prevails during the Pliocene and Quaternary; the tectonic regime is compressive up to Lower Pleistocene and extensive from Middle Pleistocene (CIARANFI & *alii*, 1983).

The M. Carpinoso Terrace formation suggests on the other hand a long lasting subsidence phase (Early Pleistocene) followed by a strong uplift starting at about 1 m.yr.; this rate of uplift has actually decreased, as documented by the study of the younger terraces of the area (CAROBENE & FERRINI, 1991), testifing to the E-SE migration of the maximum uplift axes. In Southern Calabria the uplifting is still occurring, with Early Pleistocene terraces recognisable, in the Aspromonte area, up to 1 000 m a.s.l. and Eu-Tyrrhenian deposits raised up to 150 m a.s.l. (DUMAS & *alii*, 1988).

b) The morphological study allowed the compilation of a new detailed scheme for mapping of the terraced surfaces (fig. 4) and the recognition and measurement of fault throuws (fig. 5).

c) The sedimentological analysis of the sedimentary cover emphasised the presence of 3 transgressive/regressive members that became progressively younger from the inner to the outer edge (fig. 8).

d) The pattern of morphotectonic features (fig. 5) and structural data confirm the strong uplift (about 500 m in the last one million years) of the terrace.

REFERENCES

BILLI P., MAGI M. & SAGRI M. (1987) - *Coarse-grained low-sinuosity river deposits: example from Plio-Pleistocene Valdarno basin, Italy.* In ETHRIDGE F., FLORES R.M. & HARVEY M.D., Eds.), «*Recent developments in fluvial sedimentology*», S.E.P.M. Spec. Pubbl., 197-203.

BLUCK B.J. (1974) - *Structure and directional properties of some sandur deposits in southern Iceland.* Sedimentology, *21*, 533-554.

BRADLEY W.C. & GRIGGS G.B. (1976) - *Form, genesis and deformation of central California wave-cut platform.* Geol. Soc. Am. Bull., *87*, 433-449.

BRANCACCIO L. & VALLARIO A. (1968) - *Osservazioni geomorfologiche nel tratto di costa compreso tra le foci dei fiumi Noce-Castrocucco e Lao.* Boll. Soc. Geol. It., *77*, 303-325.

CAROBENE L. (1987) - *Antiche linee di riva e aspetti di geologia del Quaternario.* AIQUA, *Guida alle escursioni nella Calabria settentrionale*, Marra, Cosenza, pp. 48.

CAROBENE L. & DAI PRA G. (1991) - *Genesis, chronology and tectonics of the Quaternary marine terraces along the Tyrrhenian coast of Northern Calabria. Their correlation with climatic variations.* Il Quaternario, *3*, 75-94.

CAROBENE L., DAI PRA G. & GEWELT M. (1986) - *Niveaux marins du Pléistocene moyen-supérieur de la cote tyrrhénienne de la Calabre (Italie méridionale). Datation Th/U et tectonique récente.* Zeit. Geom. N. F., suppl. - Bd *62*, 141-158.

CAROBENE L. & FERRINI G. (1991) - *Morphological, sedimentological and tectonic features of Diamante-M. Carpinoso marine terrace flight (Tyrrhenian coast of Northern Calabria).* Earth Surf. Land Proc., in press.

CIARANFI N., GUIDA M., IACCARINO G., PESCATORE T., PIERI P., RAPISARDI L., RICCHETTI G., SGROSSO I., TORRE M., TORTORICI L., TURCO E., SCARPA R. & GUERRA I. (1983). *Elementi sismotettonici dell'Appennino meridionale.* Boll. Soc. Geol. It., *102*, 201-222.

CORTESE E. (1886) - *Osservazioni sopra i terrazzi quaternari del litorale tirreno della Calabria.* Boll. R. Comm. Geol. It., *17* (11), 480-487.

CREMASCHI M. (1987) - *Paleosols and vetusols in the central Po plain (Northern Italy). A study in Quaternary Geology and soil development.* UNICOPLI, Milano.

DAMIANI A.V. & PANNUZI L. (1979) - *Terrazzi marini e neotettonica pleistocenica della costa tirrenica calabro-lucana tra Maratea e Cetraro.* Mem. Soc. Geol. It., *19* (1978), 597-604.

DAMIANI V.A. (1970) - *Terrazzi marini e sollevamenti differenziali fra i bacini del Lao e del Corvino (Calabria Settentrionale).* Boll. Soc. Geol. It., *89*, 145-158.

DE FIORE O. (1937) - *La regione dei terrazzi quaternari ed il paleolitico di Scalea (Calabria).* Ist. Geol. Paleont. Un. Catania, *3*, pp. 54.

DUMAS B., GUÉRÉMY P., HEARTY P.J., LHÉNAFF R. & RAFFI J. (1988) - *Morphometric analysis and amino-acid geochronology of uplifted shorelines in a tectonic region near Reggio Calabria, South Italy.* Paleogeogr. Palaeoclim. Palaeoec., *68*, 273-289.

FABBRI A., ROSSI S., SARTORI R. & BARONE A. (1984) - *Evoluzione neogenica dei margini marini dell'Arco Calabro Peloritano: implicazioni geodinamiche.* Mem. Soc. Geol. It., *24*, 357-366.

MIALL A.D. (1977) - *A review of the braided-river depositional environment.* Earth Sc. Rev., *13*, 1-62.

MIALL A.D. (1978) - *Lithofacies types and vertical profile models in braided river deposits: a summary.* In Miall A.D. (ed.) «Fluvial Sedimentology», Can. Soc. Petrol. Geol., Mem. *5*, 597-604.

PATA O. (1956) - *I terrazzi quaternari adiacenti alla foce del fiume Lao (Cosenza).* Actes IV Congress. Int. Quatern., Roma-Pisa, 970-975.

RAMOS A. & SOPENA A. (1983) - *Gravel bars in low sinuosity stream, (Permian and Triassic, Central Spain).* In COLLISON J.D. & LEWIN J. EDS «Modern and ancient fluvial systems: Sedimentology and Process», I.A.S. Spec. Pubbl., pp. 301-312.

STEEL R.J. & THOMPSON D.B. (1983) - *Structures and texture in Triassic braided stream conglomerates in the Sherwood Sandstone Group, North Staffordshire, England.* Sedimentology, *30*, 341-368.

TRENHAILE A.S. (1980) - *Shore platform: a neglected coastal feature.* Progr. Phys. Geogr. 4, 1-23.

WILLIAMS D.F., THUNELL R.C., TAPPA E., RIO D. & RAFFI I. (1988) *Chronology of the Pleistocene oxygen isotope record: 0-1.88 my B.P.* Palaeogeogr. Palaeoclim. Palaeoec., *64*, 221-240.