Il Quaternario
Italian Journal of Quaternary Sciences
12(2), 1999, 207-214

VEGETATION DYNAMICS AND CLIMATE CHANGES AT CAMEROTA (CAMPANIA, ITALY) AT THE PLIOCENE-PLEISTOCENE BOUNDARY

E. Russo Ermolli
Dipartimento di Scienze della Terra, Università di Napoli Federico II, L.go S. Marcellino 10, 80138 Napoli - Italy
tel. 0815473312; fax ..39.081.552.56.11; e-mail: ermolli@unina.it

ABSTRACT - *Vegetation dynamics and climate changes at Camerota (Campania, Italy) at the Pliocene-Pleistocene boundary* - The Camerota basin is a structural depression identified in the central part of the Bulgheria massif during the Upper Pliocene extentional tectonics that affected the eastern margin of the southern Tyrrhenian basin. Pollen analysis of two cores drilled in the Camerota palaeolacustrine succession pointed out the vegetational pattern of the Bulgheria massif during a short period probably close to the Pliocene-Pleistocene boundary. The noticeable presence of *Tsuga* and *Cedrus*, elements of the altitudinal coniferous forest, suggets that the deposition of both portions of the lacustrine succession occurred during interglacial-glacial transitional phases characterized by a temperature decrease with the maintenance of high moisture.

RIASSUNTO - *Dinamica della vegetazione e variazioni climatiche a Camerota (Campania, Italia) al limite Pliocene-Pleistocene* - Il bacino di Camerota è una depressione strutturale identificatasi nel Monte Bulgheria in seguito alle fasi distensive che nel Pliocene superiore interessarono il margine orientale del bacino tirrenico meridionale. L'analisi pollinica realizzata su due carote prelevate nella successione paleolacustre di Camerota ha permesso di evidenziare i piani di vegetazione del Monte Bulgheria durante un breve periodo probabilmente prossimo al limite Pliocene-Pleistocene. La presenza significativa di *Tsuga* e *Cedrus*, elementi della foresta di conifere d'altitudine, testimonia che entrambe le porzioni di successione analizzate si sono deposte durante fasi di transizione interglaciale-glaciale, caratterizzate da diminuzione di temperatura in condizioni di alta umidità.

Keywords: climatic cycles, pollen, southern Italy, Pliocene-Pleistocene boundary
Parole chiave: cicli climatici, polline, Italia meridionale, limite Pliocene-Pleistocene

1. INTRODUCTION

Pliocene-Quaternary climatic history of the northwestern Mediterranean area is characterized by the establishment of glacial-interglacial cyclicity at 2.6 Ma BP after the fluctuations occurred between 5.3 and 2.6 Ma BP. (Suc & Zagwijn, 1983; Suc *et al.*, 1995). During Pliocene and Lower Pleistocene (between 2.6 and 1 Ma) cycles showed a dominant period of 41 kyr (Raymo *et al.*, 1989; Ruddiman *et al.*, 1989; Combourieu-Nebout & Vergnaud-Grazzini, 1991) and were characterized, in terms of regional vegetation changes, by rapid forest-steppe alternation (Suc, 1982 and 1984; Ablin, 1991; Leroy & Seret, 1992; Combourieu-Nebout, 1990 and 1993). From Middle Pleistocene climatic cyclicity showed a dominant period of 100 kyr (Ruddiman *et al.*, 1989). The glacial-interglacial alternation remains the same (forest-steppe alternation) as during the previuos period (Follieri *et al.*, 1988; Pons & Reille, 1988; Russo Ermolli, 1994) but the floral composition of pollen spectra reveals a general temperature decrease both during cold and warm intervals. In fact, from Pliocene a progressive cooling caused the progressive extintion, from North to South, of the more thermophilous species (Bertoldi *et al.*, 1989; Suc *et al.*, 1995).

Southern Italy seems to have experienced the same evolution but the scarcity of available palynological data (Brenac, 1984; Bertoldi *et al.*, 1989; Combourieu-Nebout, 1990 and 1993; Russo Ermolli, 1994) do not allow a Pliocene-Quaternary climatic and environmental history to be reconstructed in detail. Because of the strict relation connecting climatic and vegetational variations, pollen analysis seems to be one of the best methods for reconstructing palaeoclimatic changes. This analysis performed on two cores drilled in the lacustrine sediments of Camerota represents a contribution to the Pliocene-Pleistocene palaeoenvironmental evolution of southern Italy.

2. GEOLOGICAL AND GEOMORPHOLOGICAL SETTING

Mount Bulgheria represents the southwestern end of the Cilento promontory (Fig. 1). It reaches 1225 m a.s.l. and is formed by a thick carbonatic succession ranging in age from Upper Triassic to Lower Miocene (Scandone *et al.*, 1963). The carbonate rocks are unconformably overlain by Lower Miocene flysch deposits. The present structural setting seems to be the result of compressive and extentional events occurring during Miocene (Tozzi *et al.*, 1996). The complex Pliocene-Quaternary evolution of this massif shows subsidence, uplift and block-faulting events one of wich was responsible for the Camerota basin formation. In particular, this structural depression was identified in the central part of the Bulgheria massif during the Upper Pliocene extentional tectonics that affected the eastern margin of the southern Tyrrhenian basin (Ascione *et al.*, 1997; Ascione & Romano, 2000).

The Camerota basin is bordered by NNE-SSW, NW-SE and E-W fault scarps; the latter representing old

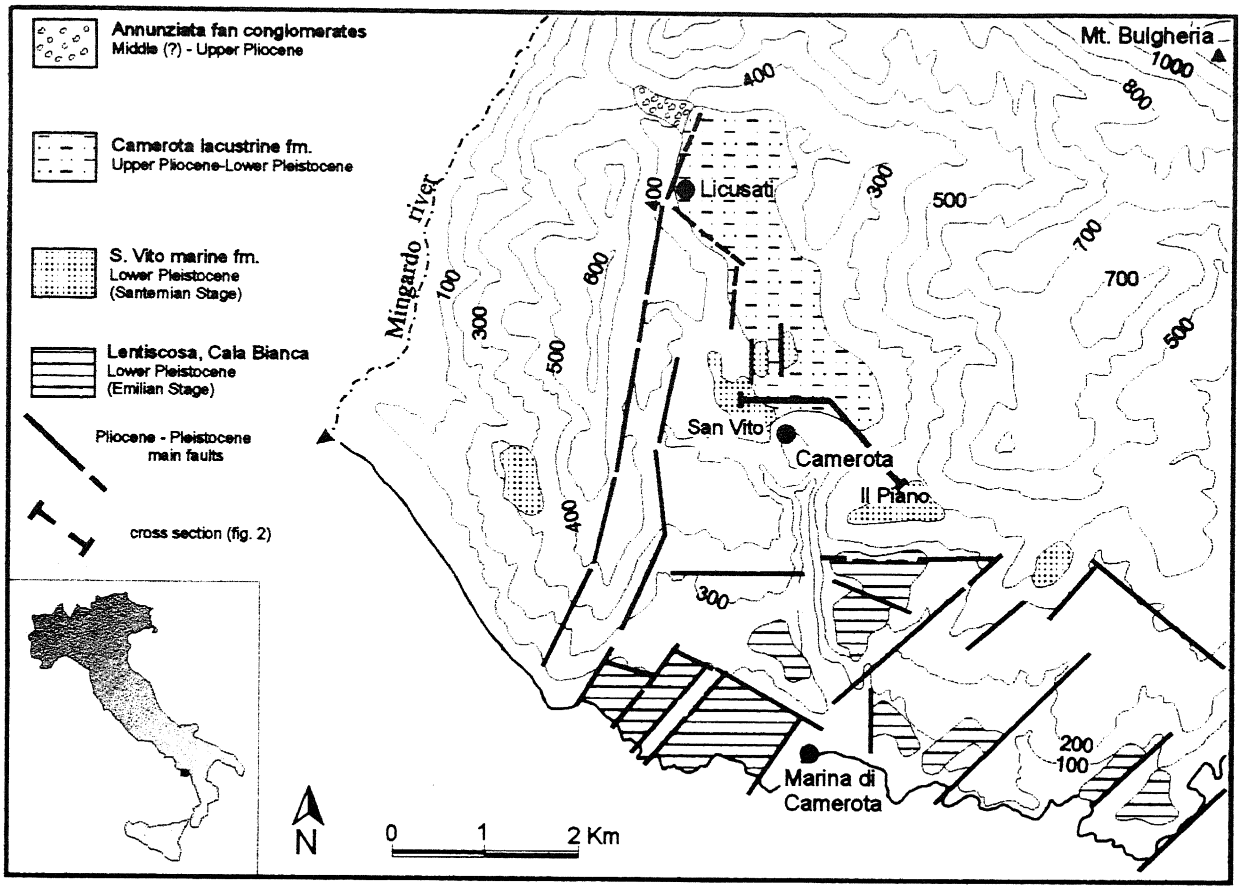

Fig. 1. - Geological scheme of Mount Bulgheria.

Schema geologico del Monte Bulgheria.

faults partly reactivated during the formation of the depression (Ascione *et al.*, 1997). The establishment of a lacustrine environment is testified by a thick lacustrine succession, informally named the "Camerota formation", whose top now reaches 340 m a.s.l. at the northern end of the basin. The succession is mainly formed by grey clays and yellowish marls passing upward to whitish marls with frequent tephra and peat layers (Borelli *et al.*, 1988). Lower Pleistocene ("Santernian": Ruggieri & Sprovieri, 1979) marine clays, sands and pebbles, unconformably resting on top of the lacustrine deposit, give it a chronological upper limit (Ascione & Romano, 2000). The age of the marine sediments is constrained by the occurrence of *small Gephyrocapsa* among the nannofossils and of *Bulimina elegans marginata* among the foraminifera. After the lake extiction, the lacustrine sediments were deeply eroded and tectonically disturbed. Although the difficulty in precisely reconstructing the stratigraphy of the lacustrine succession, a maximum thickness of 40-50 metres was suggested by Borrelli *et al.* (1988).

Previous pollen studies in the Camerota basin were realised by Baggioni *et al.* (1981) and Brenac (1984) on cropping out material which was ascribed to the Plio-cene-Pleistocene boundary on the basis of both the age of the marine sediments at the top of the lacustrine succession (Upper Calabrian) and the composition of pollen spectra. In particular, the analysed portion was correlated to the Tiglian of northern Europe and to zone PIV-PI.I of north-western Mediterranean (Suc, 1982). The ill-defined position of the outcrops analysed by Brenac (1984) does not allow the precise correlation with the portion of succession investigated in the present study. However, the uppermost part (samples 16 to 25) of the pollen diagram established by Brenac (1984) is very consistent with the results obtained in the present study, in particular concerning the strong similarities in the prevailing taxa (*Quercus* t. deciduous, *Carpinus*, *Ulmus*, Poaceae, Asteraceae including *Artemisia*). These uppermost exposed sediments should correspond to the cored succession. The most important difference concerns the lowermost part of the Brenac's pollen diagram (samples 1 to 15) rich in thermomediterranean elements, which has no comparative assemblage within the here presented pollen record. This could mean that the two cores do not represent the entire lacustrine record but it is rather difficult to understand the stratigraphical position of the lowermost exposed sediments in respect to the cored material.

3. MATERIALS AND METHODS

The material used in this study was collected from two cores drilled in the lacustrine deposits of the Camerota basin (Borelli *et al.*, 1988). Core S1, 37 m long, is

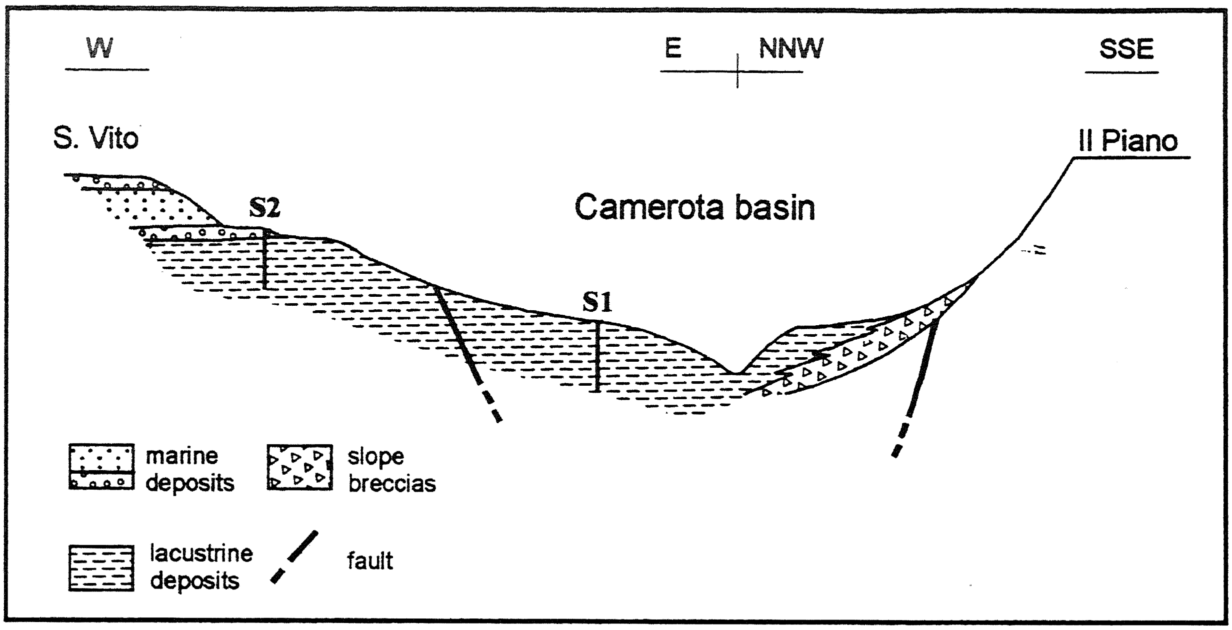

Fig. 2. - Schematic cross section of the Camerota basin and position of the cores.

Sezione schematica del bacino di Camerota e posizione dei sondaggi.

located in the Vallone Fornaci valley floor (Fig. 2 and 3), 1.5 km SE of Licusati. From the base up to 31.7 m it is formed by brownish silts with gravels. From 31.7 m up to the top it is mainly formed by grey silts with scattered levels of sands, pyroclastic material and gravels. Core S2, 20 m long, is located in the western side of the basin (Fig. 2 and 3), 0.3 km N of San Vito. From the base up to 15.75 m the bedrock limestones are found. From 15.75 to 9.2 m whitish marls alternate with grey silts. From 9.2 to 2.65 m the whitish marls alternate with pyroclastic material and fine sands. From 2.65 m up to the top it is formed by sandy silts with gravels. According to Borelli *et al.* (1988) the S1 core represents the lower part of the lacustrine succession whereas the S2 core the top

The analysis of the tephra layers was unsuccessful since all the samples (glass and minerals) resulted too altered to be chemically defined or dated (Dr. E. Juvigné, personal communication). Only the tephra layer at -1.95 m in core S2 resulted in being a potassic riodacite (Dr. E. Juvigné, personal communication) but the glass shard population was not suitable for the fission tracks dating method (Dr. J. Westgate, personal communication).

Pollen analysis was only performed on 15 samples from S1 core and 14 samples from S2 core. In fact, most of the investigated levels resulted barren or with bad preserved pollen grains. Standard chemical treatments (HCl 20%, HF 40%, HCl 30%) and concentration procedures (filtering on 10 μ sieve, heavy liquid separation) were used to remove the inorganic fraction and to concentrate the pollen grains in the residue. At least 300 pollen grains were counted for each sample.

Pollen analysis results are presented in detailed diagrams (Fig. 4) where the percentages of the 66 recognised taxa are plotted against depth.

4. PRESENT-DAY VEGETATION IN CAMPANIA

The present-day vegetation pattern in Campania is closely linked to bioclimatic conditions and its organisation in vegetational belts mainly depends on temperature and moisture variations due to the altitude. From the sea-level four vegetational belts have been recognised (La Valva *et al.*, 1985):

1. The Mediterranean belt, from the sea-level up to 500 m, is now mainly occupied by anthropic settlements and activities, the natural vegetation being only preserved in few fragmentary stands of mediterranean maquis.
2. The Submediterranean belt, from 500 to 1000 m a.s.l., is mainly represented by the *Quercus pubescens* or *Quercus cerris* woods, pure or mixed with *Castanea sativa*, *Carpinus orientalis*, *Ostrya carpinifolia*, *Acer neapolitanum* and *A. monspessulanum* (deciduous hardwood forest series).
3. The Mountain belt, from 1000 to 1800 m a.s.l., is dominated by two different associations of *Fagus sylvatica* (*Fagus sylvatica* series).
4. The Mountain peak belt, over 1800 m a.s.l., is occupied by high altitude grasslands.

The present distribution of vegetation and its floral composition have been acquired during time due to important global climatic variations. Representatives of the modern mediterranean flora are already present in Lower Miocene (Bessedik, 1985) whereas the vegetational belt setting seems to develop in Pliocene when pollen analyses reveal the coexistence of elements belonging to different vegetation belts (van der Hammen *et al.*, 1971; Suc, 1984 and 1989; Bertoldi *et al.*, 1989; Combourieu-Nebout, 1993).

The present-day vegetation of Mount Bulgheria differs from this general scheme. Mediterranean elements dominate in all vegetational belts (Moggi, 1960)

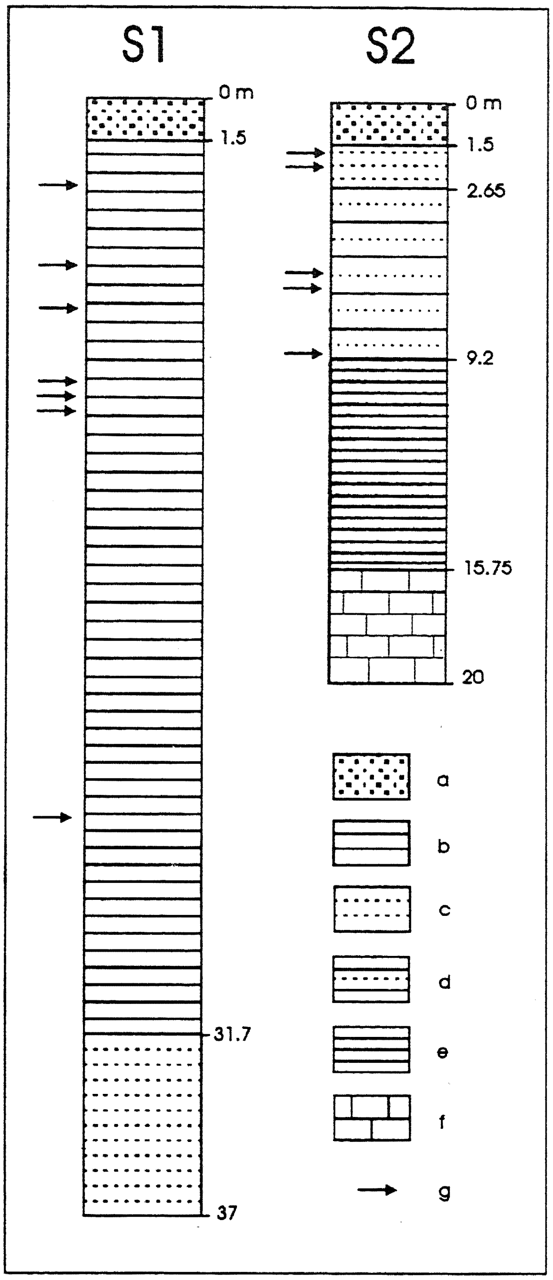

Fig. 3. - Lithologic log of the S1 and S2 cores. a. soil; b. grey silt with scattered levels of sands and gravels; c. silt with gravels; d. whitish marl with fine sands; e. whitish marl with grey silts; f. limestone; g. pyroclastic level.

Log litologico delle carote S1 e S2. a. suolo; b. limo grigio con rare intercalazioni sabbiose e ghiaiose; c. limo ghiaioso; d. marne biancastre con intercalazioni sabbiose; e. marne biancastre con intercalazioni di limo grigio; f. calcare; g. livelli piroclastici.

but, it is rather probable that the modern structure of vegetation has been influenced by human action since prehistorical times.

5. POLLEN DIAGRAMS AND CLIMATIC SIGNIFICANCE

In the lower part of S1 core (Fig. 4) pollen analysis pointed out the presence of a deciduous forest association, dominated by *Quercus* t. deciduous (4 - 27%), *Carpinus* (2.1 - 20.4%) and *Ulmus* (2 - 18.1%). The upper levels of this lower portion show the development of a forest association dominated by *Tsuga* (up to 21.9%) and *Cedrus* (up to 9.2%). After some metres of barrennes the spectra are dominated again by the deciduous forest association but, in this case, the most representative taxa are *Alnus* (up to 38.7%) and *Carya* (up to 22.5%). In the same levels *Abies* shows its first peaks (up to 9.8%). Herbaceous and steppe elements are well represented in the basal portion of the core.

The vegetation changes highlighted in core S1 suggest a transition from warm to colder and more humid climatic conditions. In fact, the deciduous forest association is replaced at first by *Tsuga* and *Cedrus* probably indicating a more oceanic climate and secondly, in the topmost levels, by *Carya* and *Alnus* indicative of high soil moisture probably linked to edaphic conditions in the surrondings of the lake. What is more, a general humidity increase, perhaps accompanied by a temperature decrease, seems to have occurred as testified by the development of *Abies* at higher altitudes. Herbaceous and steppe elements tend to decrease in connection to the humidity increase.

In the lower part of the S2 core (Fig. 4) deciduous forest dominates the pollen spectra with *Quercus* t. deciduous (20.5 - 42.1%), *Carpinus* (3.4 - 12.4%), *Ulmus* (8 - 19.3%), *Zelkova* (up to 7.6%) and *Carya* (up to 4%). The herbaceous and steppe elements at these levels play a significant role. A sudden increase of *Cedrus* (up to 14.2%) at about 9 m of depth, is followed, after some metres of barrennes, by the increase of *Tsuga* (up to 20.3%). At the same level the elements of the deciduous forest almost disappear and *Pinus* records its highest percentages. This vegetational change seems to testify to a temperature decrease in a period of high humidity.

The vegetational variations identified in the deposits of Camerota can be correlated with the cyclic climatic changes started 2.6 Ma B.P. (Suc *et al.*, 1995). Both in the Mediterranean and western Europe, temperature and humidity variations during the glacial-interglacial cyclicity seem to follow two different cycles (van der Hammen *et al.*, 1971). Temperature increase and decrease always precede the humidity fluctuations. As a consequence, the beginning of interglacials and the end of glacials are characterized by low humidity values whereas the beginning of glacials and the end of interglacials record high humidity values. Both of the portions of the investigated lacustrine succession seem to represent a transition from warm to cool conditions with the maintenance of high moisture. This can be interpreted as an interglacial-glacial transition during which the temperature decrease preceds the humidity decrease. A similar vegetational dynamic was observed at Crotone, in ionian Calabria, where the analysis of the Semaforo and Vrica marine sections, spanning from 2.4 to 1.1 Ma B.P. (Combourieu-Nebout, 1990 and 1993), pointed out the increase of altitudinal coniferous forest elements (*Abies*, *Cedrus*, *Picea* and *Tsuga*) during the interglacial-glacial transitional phases. In particular, a progressive regression of thermophilous gymnosperms (Taxodiaceae and *Cathaya*) was recorded, close to the Pliocene-Pleistocene boundary, in connection to the development of altitude gymnosperms (*Tsuga* and *Cedrus*). Also in the Val-

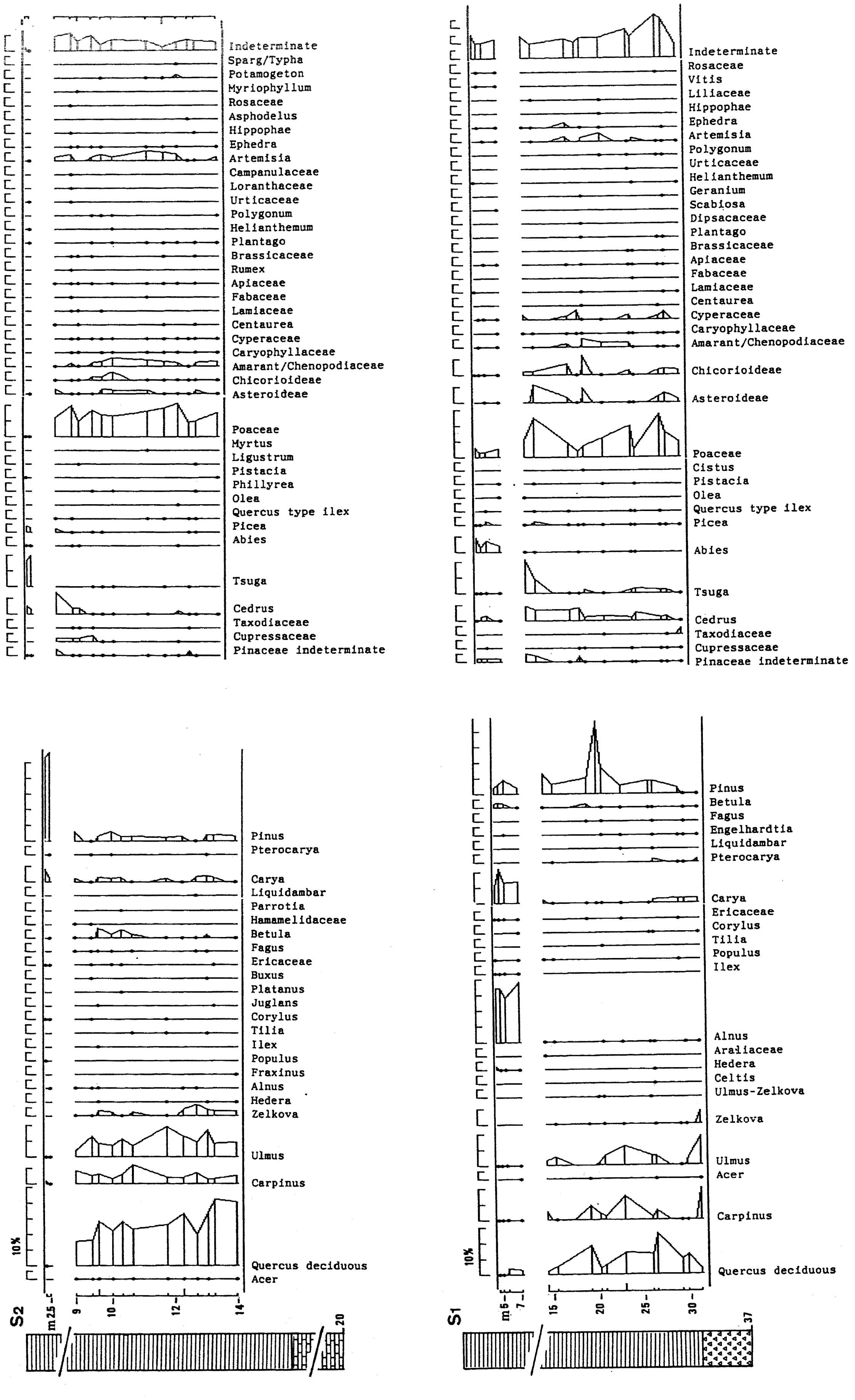

Fig. 4. - Detailed pollen diagrams of the S1 and S2 cores. Pollen percentages are plotted against depth (m).

Diagramma pollinico di dettaglio delle carote S1 e S2. Le profondità sono espresse in metri.

darno basin, in Toscana, an increase in *Tsuga, Abies, Picea* and *Cedrus* was recorded during a cold and humid phase which was ascribed to the Pliocene-Pleistocene boundary (Albianelli *et al.*, 1995). Along the Calabrian sections subtropical humid forest elements (mainly Taxodiaceae: *Sequoia* type) show very high percentages during warm periods and during cold and transitional phases they reduce their frequences but never disappear. At Camerota the absence of subtropical elements can be explained by the particular physiographic situation lacking a suitable environment for the Taxodiaceae growth. In particular, the genus *Sequoia*, abundant in the Calabrian sections, comprises species which live in biotopes close to littoral zones (Heusser & Balsam, 1977) and the Camerota basin is an intramountain depression.

6. PALAEOFLORA AND PALAEOVEGETATION

The floral composition highlighted by fossil pollen spectra was characterized by present-day still lasting elements (*Quercus* type *ilex*, *Olea*, *Phillyrea*, *Quercus* t. deciduous, *Carpinus*, *Ulmus*, *Tilia*, Ericaceae, *Pinus*, among others) and by forest elements now disappeared from the Italian peninsula (*Cedrus*, *Zelkova*) or from the Mediterranean basin (*Tsuga*, *Carya*, Taxodiaceae).

The genus *Cedrus* is now present in northern Africa, eastern Mediterranean and Himalaya in high altitude environments characterized by high humidity values throughout the year. Although within the genus *Tsuga,* now living in North America, Japan, China and Himalaya, some species live under warm-temperate or fresh-temperate climates, it is probable that at Camerota both the elements, *Tsuga* and *Cedrus,* due to their concomitant increase in pollen diagrams, occupied a high altitude vegetational belt characterized by high moisture. The highest forest belt was most likely occupied by *Abies*, *Picea* and *Betula*.

The genus *Carya* today lives in north-eastern America and China. *Zelkova,* still living as a residual species in the Mediterranean basin in Creta and in Sicily (Di Pasquale *et al.*, 1992), is more expanded in eastern Asia and around the Black and the Caspian Seas. It disappeared from central Italy during the transition between Oxygen Isotope Stage 3 and 2 (Follieri *et al.*, 1986). The presence of *Carya* and *Zelkova* pollen grains in the sediments of Camerota could suggest the presence of humid environments around the lake shores even if some species of both genus live under relatively dry climates.

The identified taxa were grouped in eight classes according to their ecological requirements in the attempt to give an idea of the vegetation organisation during the deposition of the lacustrine succession. The classification used in this study is that firstly adopted by Suc (1984) for the western Mediterranean and then by Combourieu-Nebout (1990 and 1993) for the Calabria region. During the time period represented in the Camerota succession the floral distribution in vegetational belts, similar to those now largely represented in Campania, is testified by the pollen spectra here presented and was certainly favoured by the presence of the Mt. Bulgheria which reaches high altitudes not far from the sea-coast.

1. Subtropical elements: the only representative of this group is the Taxodiaceae family (*Taxodium* type) sporadically present both in the S1 and S2 cores. It cannot be excluded that this finding could represent a reworking of older deposits due to the almost total absence of this taxon throughout the succession.
2. Deciduous forest: it includes present-day still living elements such as *Quercus* t. deciduous, *Carpinus* and *Ulmus* but also trees like *Zelkova* and *Carya* now disappeared and indicative of thermic and hydric conditions higher than today. This association should occupy the lowest mountain belt surronding the Camerota lake and characterized by high moisture values and well-drained soils. This association can tolerate temperature and humidity variations. Infact, it is present, in different percentages, all over the investigated time, that seems to have experienced climatic changes.
3. *Pinus* and indeterminate Pinaceae: this class has no particular ecological meaning due to the low determination level of *Pinus* and Pinaceae pollen grains. The *Pinus* pollen grains seem to all belong to the *P.* sbg. *diploxylon* (sensu Rudolph, 1935).
4. Middle altitude forest (*Tsuga* and *Cedrus*): at higher altitudes the deciduous forest is progressively enriched in elements more resistant to lower temperatures like *Tsuga* and *Cedrus.* During some periods this association dominates the pollen spectra indicating a climatic shift towards colder and more humid conditions.
5. High altitude forest (*Abies*, *Picea* and *Betula*): it represents the highest forest association which lived on the mountains surronding the Camerota basin. The forest elements indicate high humidity and withstand low temperatures. The constant presence of these elements in southern Italy during the Pliocene-Pleistocene (Combourieu-Nebout, 1993) seems to indicate a very southern incursion of high latitude and/or altitude mountain elements due to the rapid elevation of the Apennines from the sea-coast.
6. Mediterranean forest: it includes all the mediterranean taxa. The mediterranean forest indicates the persistence of dry summers and wet winters. The presence of these elements in the Camerota basin indicate that in Pliocene-Pleistocene seasonal conditions were already established in the Mediterranean area (Suc, 1984 and 1989). This association at Camerota should occupy some stands of the decidouos forest or represent a long-distance supply coming from the sea-coast.
7. Herb-dominated vegetation: because of their determination level mostly limited to the family, herbaceous elements cannot give precise palaeoenvironmental informations with the exception of the Cyperaceae family which can indicate moist soils. The main families found in the Camerota deposits are Poaceae, Asteraceae, Chenopodiaceae and Cyperaceae.
8. Steppe elements: they include *Artemisia*, *Ephedra* and *Hippophäe*. In the Mediterranean area the percentage increase of herbaceous and steppe elements in the pollen spectra clearly indicates a climatic shift towards glacial conditions (Suc & Zagwin, 1983). At Camerota the herbaceous elements should occupy the highest mountain tops

(grasslands) or cohexist with the other elements in the different vegetational belts.

7. DISCUSSION AND CONCLUSIONS

Despite the discontinuity of pollen data obtained from the analysis of the two cores, it was possible to interpret the diagrams in terms of vegetation dynamics and climatic significance. The deposition of the analysed portions seem to have occurred during a period of transition from interglacial to glacial conditions. In fact, the high percentages of *Tsuga* and *Cedrus* found in both the diagrams, suggest a climatic situation in which a temperature decrease occurred in a period of high moisture availability. The comparison with the Crotone sections in Calabria (Combourieu-Nebout, 1990 and 1993), partly covering the same time period, seems to support this hypothesis. The absence of subtropical humid forest elements, such as the Taxodiaceae, well represented in the Mediterranean during Pliocene and Lower Pleistocene, could be due to the physiographic situation of the Camerota basin, confined within mountains, where no suitable environment was available around the lake shores for the Taxodiaceae growth. The absence of subtropical elements could also be linked to the climatic situation of both the investigated sedimentary portions which never recorded the warmest part of an interglacial period. In fact, at Crotone the Taxodiaceae marks the *optimum* of several climatic cycles (Combourieu-Nebout, 1990 and 1993).

As a matter of fact, the floral composition of the Camerota succession does not yield clear elements for its chronological assessment, being rather impoverished in "Tertiary" elements in respect to other Pliocene-Pleistocene Italian successions, and thus resulting more similar to a general Lower Pleistocene environment. But, its chronological position is constrained by the age of the marine deposits found at its top (Santernian stage: 1.78-1.48 Ma BP). The Camerota succession recorded at least 1.5 climatic cycles as the two analysed portions both show an interglacial-glacial transition. In this case the minimal duration of the lacustrine environment can be estimated at around 60 kyr on the basis of the duration of the dominant climatic cycles (41 kyr) from 2.6 to about 0.8 Ma (Ruddiman *et al.*, 1989). Considering the total thickness of the lacustrine succession (40-50 m), as proposed by Borelli *et alii* (1988), the mean sedimentation rate of the Camerota formation should be about 0.7 mm/yr, similar to that calculated for the Vallo di Diano and the Acerno lacustrine basins (Russo Ermolli, 1994 and 1999), located in the southern Apennines in similar geographical contexts.

Despite the limits linked to the absence of absolute dating, as well as to the discontinuity of the data, the pollen analysis of the Camerota succession represents a contribution for the reconstruction of the Pliocene-Pleistocene history of the Bulgheria massif. In particular, the presence of elements coming from different vegetational belts indicates that during the deposition of the lacustrine succession the massif had already acquired a high relief that allowed for the existence of high altitude forest elements such as *Abies*, *Tsuga* and *Cedrus*.

ACKNOWLEDGMENTS

The author is indebted to Prof. Mattia Guida who kindly provided the cores, to Dr. Etienne Juvigné who analysed the tephra layers and to Dr. John Westgate who tried the fission tracks dating method. Prof. A. Paganelli and Dr. C. Ravazzi are thanked for the critical review of the manuscript.

REFERENCES

Ablin D., 1991 - *Analyse pollinique des dépots lacustres de Ceyssac, Plio-Pléistocène du Velay (Massif Central, France).* Cahiers de Micropaléontologie **6**, 21-38.

Albianelli A., Bertini A., Magi M., Napoleone G., Sagri M., 1995. - *Il bacino plio-pleistocenico del Valdarno superiore: eventi deposizionali, paleomagnetici e paleoclimatici.* Il Quaternario **8**, 11-18.

Ascione A., Caiazzo C., Hippolyte J.C., Romano P., 1997 - *Pliocene-Quaternary extensional tectonics and morphogenesis at the eastern margin of the southern Tyrrhenian basin (Mt. Bulgheria, Campania, Italy).* Il Quaternario **10**, 571- 578.

Ascione A. & Romano P., 2000 - *Vertical movements on the eastern margin of the Tyrrhenian basin. New data from Mt. Bulgheria (southern Apennines, Italy)* Tectonophysics, in press.

Baggioni M., Suc J.P. & Vernet J.L., 1981 - *Le Plio-Pléistocène de Camerota (Italie méridionale): géomorphologie et paléoflores.* Géobios **14**, 229-237.

Bertolani Marchetti D., 1977. *The Vrica section (Calabria, Italy). A potential Neogene-Quaternary boundary stratotype.* Giornale di Geologia **42**, 181-204.

Bertolani Marchetti D., 1978. *Possibile significato paleogeografico e paleoecologico delle Taxodiaceae nei diagrammi pollinici del Pliocene terminale e dell'Eopleistocene.* Giornale Botanico Italiano **112**, 296-297.

Bertoldi R., 1995. *Palinostratigrafia dei bacini intermontani dell'Appennino nord-occidentale.* Il Quaternario **8**, 61-70.

Bertoldi R., Rio D. & Thunell R., 1989 - *Pliocene-Pleistocene vegetational and climatic evolution of the south-central Mediterranean.* Palaeogeography, Palaeoclimatology, Palaeoecology **72**, 263-275.

Bessedik M., 1985 - *Reconstitution des environnements miocènes des régions nord-ouest méditerranéennes à partir de la palynologie.* Ph.D. Thesis, University of Montpellier II, France.

Borelli A., Ciampo G., De Falco M., Guida D. & Guida M., 1988 - *La morfogenesi di M.te Bulgheria (Campania) durante il Pleistocene inferiore e medio.* Memorie Società Geologica Italiana **41**, 667-672.

Brenac P., 1984 - *Végétation et climat de la Campanie du Sud (Italie) au Pliocène final d'après l'analyse pollinique des dépots de Camerota.* Ecologia Mediterranea **10**, 207-216.

Combourieu-Nebout N. 1990 - *Les cycles glaciaire-interglaciaire en région méditerranéenne de -2.4 à -1.1 Ma: analyse pollinique de la série de Crotone (Italie méridionale).* Paléobiologie continentale **17**, 35-59.