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LATE-MIDDLE PLEISTOCENE MAMMAL FAUNAS OF LATIUM (CENTRAL ITALY): STRATIGRAPHY AND ENVIRONMENT

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Mammal faunas referred to the late-Middle Pleistocene have been known for a long time from Latium, especially from the 'Bassa Campagna Romana', where the explosive products of the Sabatinian and Alban volcanic districts are interbedded with sedimentary cycles, that represent alluvial fills. The faunas have been examined by several authors but discordant opinions have been expressed about the age of the beds where the faunas were found. The faunal associations of Castel di Guido-La Polledrara-Malagrotta, Riano Flaminio and Torre in Pietra (lower beds) belong to the first sedimentary cycle named the Aurelia Formation, which is related to oxygen isotope stage 9. The character of these faunas suggests several cool-temperate oscillations within this stage and the presence of an open environment along the coast, whereas, inland, deciduous forests, indicating moist temperate conditions, were present. The associations of Torre in Pietra (upper beds), Vitinia, and Sedia del Diavolo are referred to a second sedimentary cycle, named the 'Vitinia Formation', related to oxygen isotope stage 7; these associations are modern in character, and are generally dominated by fallow deer. The climatic conditions were warm-temperate and wet, with an expansion of thermophilous forests.

GEOLOGICAL BACKGROUND

The available data on the geological setting of the 'Bassa Campagna Romana' (Fig. 1), lying between Rome and the Tyrrhenian Sea (Conato *et al.*, 1980; Malatesta and Zarlenga, 1986, 1986a, 1988), allow us to ascribe the sediments of the sections presented and discussed in this paper to a period between 0.48 and 0.15 My, which covers the middle and upper parts of the Middle Pleistocene. The deposits represent several orders or cycles of alluvial fills of the Tiber river valley and the complex palaeonetwork of its tributaries. These sedimentary cycles rest unconformably on those of the lower Middle Pleistocene (= the Ponte Galeria Formation) and still older cycles; they were also recently described as 'depositional fourth-order sequences' by Milli (1992). They are linked to high-stand phases of sea level during the interglacial periods and defined as Formations: from the oldest to the youngest they are the San Cosimato, Aurelia and Vitinia Formations, respectively, corresponding to the deep-ocean oxygen isotope stages 11, 9 and 7 (Cavinato *et al.*, 1993; Conato *et al.*, 1980; De Rita *et al.*, 1991; Malatesta and Zarlenga, 1986, 1986a, 1988).

The lack of uplift phases between the depositional cycles produced an absence of alluvial terraces and, instead, the presence of several overlapping alluvial fills, *sensu* Leopold *et al.* (1964). The top of these deposits reaches an elevation of 50–80 m above present sea level, according to their greater or shorter distance from the sea.

Only one terrace *sensu stricto*, is at present observable along the Tiber River Valley, in fact its scarp cuts across the whole sequence of deposits, linking the high morphological surface with the alluvial flood plain, which is Holocene in age. The depositional cycles show interbedded layers of brackish and marine facies in the outcrops near the coast and in the highest part of the sequences as at Torre del Pagliaccetto, San Cosimato (this section is not discussed in the present work, further information is available in Conato *et al.*, 1980) and Vitinia. The cycles are separated by three deep erosion surfaces, mostly palaeovalleys or erosion channels, which were formed during the low phases of sea level and have been correlated with isotope stages 12, 10 and 8. De Rita *et al.* (1991, 1993) have shown how, during these phases of low sea level, the most important volcanic episodes of the Albano volcano have also taken place. In fact, during stage 12, the 'Second pyroclastic flow of the Tuscolano-Artemisio phase', according to the classification of De Rita *et al.* (1988) (='lower pozzolanas' auct., 0.48 My), and during stage 10 the 'Third and Fourth pyroclastic flows of the Tuscolano-Artemisio phase' (=*Tufo litoide lionato* and *Tufo di Villa Senni* auct. 0.366–0.338 My) were deposited.* During this last stage the Sabatinian *Tufo rosso a scorie nere*, which will be referred to here as the TRSN was also deposited. These volcanic products represent marker horizons of considerable importance for the reconstruction of Middle Pleistocene events. Indeed, in some sections, where all depositional cycles are present, it is quite easy to recognise their succession, whereas reconstructing the stratigraphy is difficult and uncertain, where one or two of them are lacking. In such cases only by ascertaining a relationship between volcanics *in situ* or their reworked materials and the

*Radiometric data from De Wit *et al.* (1987) do not seem to be consistent with the stratigraphical and palaeontological data and cannot be related to the recent extensive published data on the stratigraphy and geochemistry of the Latium region.

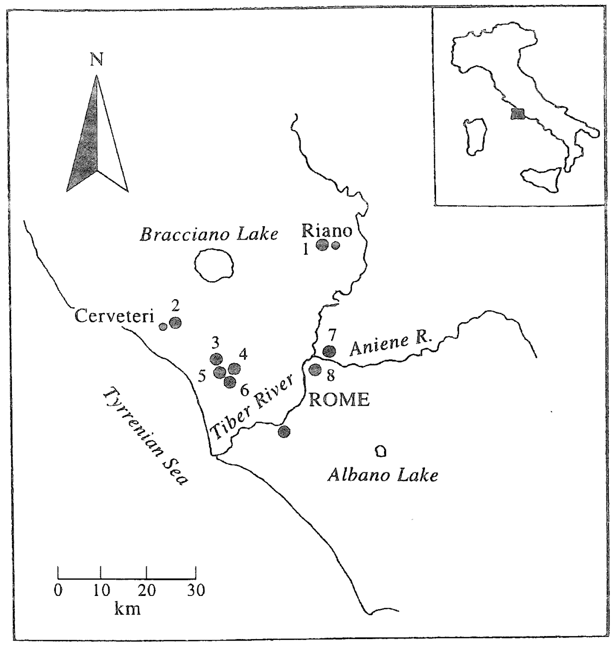

FIG. 1. Location map of the sections mentioned in the text: (1) Riano Flaminio; (2) Migliorie di San Paolo; (3) Torre del Pagliaccetto; (4) La Polledrara; (5) Castel di Guido; (6) Malagrotta; (7) Monte delle Gioie-Prati Fiscali; (8) Sedia del Diavolo; (9) Vitinia.

sedimentary cycles is it possible to distinguish one cycle from another.

CLIMATIC AND PALAEOENVIRONMENTAL FEATURES

In this geographical area the proposal has been made to subdivide the Middle Pleistocene into two time units, the Galerian and the Rianian, on the basis of mammalian stratigraphy (see Caloi and Palombo, 1995). The Galerian, equivalent to the early-Middle Pleistocene, isotope stages 22 to 11/10 and to the Faunal Units of Slivia, Isernia and Fontana Ranuccio, corresponds, at least in part, to the palynologically based Dutch 'Cromerian Complex' (Zagwijn, 1985, 1992; Gibbard *et al.*, 1991), whilst the Rianian relates to the late-Middle Pleistocene, isotope stages 10/9 to 6 and to the Faunal Units of Torre in Pietra and Vitinia. This younger Rianian interval also relates to the sections and faunas of the Campagna Romana discussed in this paper.

Turning to records from the marine environment, oxygen isotope curves from the open oceans show a major change in character at about 0.9 Ma (Williams *et al.*, 1988). A deep sea core (ODSP Site 353) from the Tyrrhenian Sea (Rio *et al.*, 1990; Vergnaud Grazini *et al.*, 1990) shows a similar pattern. Between approximately 1.6 and 0.9 Ma the $\delta^{18}O$ record is characterised by low amplitude (less than 1.0‰) glacial/interglacial cycles. In contrast the last 900,000 yr was a period of high amplitude ($\sim$1.5‰) $\delta^{18}O$ fluctuations. Above oxygen isotope stage 12 the glacial/interglacial cycles are more well-defined and of slightly larger amplitude than those of the previous 400,000 yr' (Rio *et al.*, 1990). Similar patterns are shown in a climatic curve deduced from micropalaeontological investigations of another deep-sea core (KC01B) raised from the Calabrian Ridge (Sanvoisin *et al.*, 1993). Warming seems to have been particularly marked during oxygen isotope stage 11 and substage 5e. Although oxygen isotope stage 7 showed only moderate warming, nevertheless at this period certain warm-water faunal elements (e.g. *Marginopora* sp.) entered the Mediterranean for the first time (Gliozzi, 1990; Gvirtzman, 1987). Such species became even more widely distributed during substage 5e, when they characterised the typical Tyrrhenian warm faunal association ('Senegal fauna').

During the late-Middle Pleistocene, the coastal areas of the region of Latium were apparently characterised by lagoons and streams, with vegetational conditions oscillating between forested and open environments as conditions of temperature and precipitation varied during the interglacial–glacial cycles.

In Latium, the most detailed information about the vegetational history of the Middle and Late Pleistocene comes from the sites of Torre in Pietra and Riano Flaminio and Valle di Castiglione. At Riano Flaminio, the sequence begins with cool climatic conditions (as indicated by the presence of the diatom *Stephanodiscus astraea* var *minutula* in lacustrine deposits). Warmer conditions are indicated by the development of the so-called 'Colchic forest', which has been compared to the modern forests of the Caucasus region and included the tree *Pterocarya fraxinifolia*, now confined to that area. Later, cooler conditions returned once again, as shown by the progressive increase of *Abies* and *Fagus* pollen and the decrease of that of *Pterocarya* (Ambrosetti and Bonadonna, 1967; Follieri, 1961, 1962). At Torre in Pietra (beds 1, i and h; Malatesta, 1978) there is evidence for a period of cool, arid climate, at first with Compositae dominant, then Chenopodiaceae, next Compositae again with *Salix and Pinus*, and finally Umbelliferae heralding the spread of forest trees (such as *Quercus*, and *Pterocarya*) (Follieri, 1979). In the Valle di Castiglione (Rome), a long pollen sequence provides evidence for a long series of vegetational changes covering approximately the past 250,000 yr (Follieri *et al.*, 1988). The pollen diagram suggests that this time span was characterised by periods of steppe vegetation alternating with forested periods. It is suggested that the oldest zones of the pollen diagram (zones VdC1–2), which are dominated by *Artemisia* and Gramineae but interrupted by a weak expansion of forest trees, can be correlated with isotope stage 8. Zones VdC3–7 may be correlated with the complex oxygen isotope stage 7. Zone VdC3 (Roma I) is characterised by development of a thermophilous mixed-oak forest, zone VdC5 (Roma II) by a lusher forest with beech *Fagus*, elm *Ulmus* and oak *Quercus*. The weaker forest expansion of zone VdC7 (Roma III) may represent the third peak of warming of isotope stage 7, seen in the oceanic record. A return to steppe conditions

and/or montane vegetation (VdC8) would represent part of oxygen isotope stage 6.

THE MOST IMPORTANT GEOLOGICAL SECTIONS IN THE LOWER CAMPAGNA ROMANA

The Torre del Pagliaccetto Section (Torre in Pietra)

At its base this section (Fig. 2) shows 'prevolcanics' sediments (i.e. sediments lacking any volcanic material), which may be correlated with the Ponte Galeria Formation (Malatesta, 1978). These are truncated by an erosion surface on which has been laid down a further complex succession of sediments. Of this succession the lowest gravels and sands are rich in reworked pyroclastic materials derived from the TRSN, which outcrops in neighbouring areas. At the top this sedimentary cycle is completed by interbedded white brackish lagoonal marls and travertines. A Lower Palaeolithic (Acheulean) industry was recovered from the gravels and sands. This discovery, together with the stratigraphical position of the deposits and the character of the vertebrate fauna led Malatesta (1978) to correlate this first cycle, which he defined as the Aurelian Formation with the late Middle Pleistocene.

Afterwards Conato *et al.* (1980) and Malatesta and Zarlenga (1986, 1986a, 1988) correlated the Aurelian Formation with isotope stage 9. On the top of the sediments just described, a further well-marked erosion surface (assigned to isotope stage 8) is overlain by gravels and sands, containing a Middle Palaeolithic industry, and by brackish lagoonal marls (recognised by the presence of *Cerastoderma edule*) and travertines.

This second sedimentary cycle was correlated by Malatesta (1978) with the Maspinian, *sensu* Ambrosetti *et al.* (1972), who considered it to be the continental equivalent of the Tyrrhenian *sensu lato*. Afterwards Conato *et al.* (1980) and Malatesta and Zarlenga (1986, 1986a, 1988) considered it to be contemporaneous with the 'Eutyrrhenian', 0.2 Ma in age, following the hypotheses, then current and discussed in those papers, and therefore correlated this cycle with isotope stage 7.

At the same time, Hearthy and Dai Pra (1986a,b, 1987) published a new section from Torre del Pagliaccetto, in which they recognised only one sedimentary cycle, in which the uppermost beds (6 and 7) were correlated with their aminozones E and F, respectively, on the basis of dating of *Cerastoderma edule* by the isoleucine epimerisation technique — bed 6 to the penultimate interglacial or stage 7 (0.2 Ma) and bed 7 to the last interglacial. The erosion surface, infilled by fluvial gravels and containing a 'Pre-Mousterian industry' and mammal faunas, should then correspond to the Versilian.

This interpretation is improbable for the following reasons:

(1) The reconstruction of the stratigraphy is not correct. In fact, they fail to recognise a quite distinct erosion surface (see Malatesta, 1978, p. 243, Fig. 4

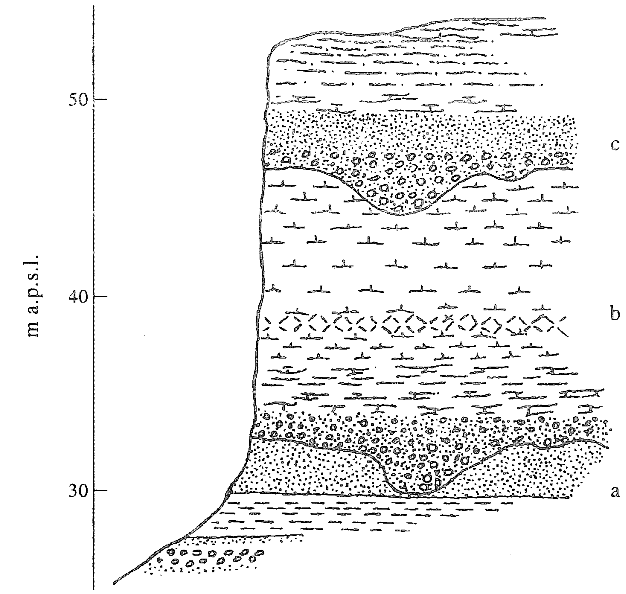

FIG. 2. The Torre del Pagliaccetto section: (a) Sicilian sediments; (b) Aurelia formation; (c) II sedimentary cycle of Torre del Pagliaccetto (redrawn and modified from Malatesta, 1978).

and p. 241, Fig. 2) overlain by gravels and brackish-lagoonal marls. We can quite understand the difficulties for inexpert geologists, faced with particular sections in archaeological excavations, but the general stratigraphical situation is well exposed in other sections where the deposits have been well described as outcropping in the surrounding area (for example at Castello di Torre in Pietra and at Fosso del Lupo, both recorded by Malatesta, 1978).

(2) An important fall in sea level (related to isotope stage 8) occurred between the penultimate and the last interglacial, that has produced in this coastal area an important erosion surface. On theoretical grounds this must be reflected in stratigraphical sequences in Latium, but Hearthy and Dai Pra take no account of this. In fact, between their beds 6 and 7 there is no trace of any discordance.

(3) It is not possible to correlate bed 7 with the Tyrrhenian because:
   - (3.1) The distance between the section of Torre del Pagliaccetto and the Tyrrhenian sediments, or rather between the mouth of the ancient stream (and/or lagoon) and the present position of the palaeovalley is about 300 m.
   - (3.2) The deposits in the section outcrop at 48–60 m a.s.l. (upper surface of the bed), whereas the Tyrrhenian sediments outcrop at 25–30 m a.s.l.
   - (3.3) The occurrence of tectonic activity, which might have produced such variations in the stratigraphical relationships, cannot be demonstrated.
   - (3.4) These considerations would produce a stream profile with an altitude of 25–30 m a.s.l. at 300 m from its mouth; if we consider the pre-

sent river, its mouth is, of course, at sea level, but at a distance of 300 m upstream the top surface of alluvial sedimentation in the floor of the valley reaches a height of 2–3 m a.s.l. at the maximum.

(3.5) If the correlation with Tyrrhenian cannot be accepted for bed 7, it is much less acceptable to correlate bed 9 with the Versilian. In fact, at present, the distance between the section of Torre del Pagliacetto and the modern coastline is 1.5–2 km, with a fall of 60 m in altitude. The present-day river channels, at that distance from their mouth show the top surface of alluvial sedimentation in the floor of the valley at 20 m a.s.l.

Milli and Zarlenga (1991) recently noted that in this area the Tyrrhenian sediments *sensu stricto* — that is those which, according to Hearthy and Dai Pra (1986a, b) are correlated with oxygen isotope substage 5e and dated to ca. 0.125 Ma — are, at an altitude of 30 m above present sea level, banked up against an erosion scarp cut into the relief constituted by older sediments.

In conclusion, in the Torre del Pagliaccetto section, we can determine two distinct Middle Pleistocene sedimentary cycles. The older one (the Aurelia Formation), which succeeds the TRSN, should be correlated with oxygen isotope stage 9 (0.37–0.27 Ma) (cf. Williams *et al.*, 1988). These are the ages of the erosion surfaces at the bottom and at the top of the Formation. The second cycle is correlated with oxygen isotope stage 7 because it is older than Tyrrhenian and its age therefore lies between 0.27 and 0.15 Ma.

The Vitinia Section

This is the most complete section (Fig. 3) present in this area and here, in fact, all three late-Middle Pleistocene cycles are present. It was first described by Conato *et al.* (1980) and was also investigated by Caloi *et al.* (1983) who studied the vertebrate fauna.

The section shows in the lower part the eroded sequence of the Ponte Galeria Formation (lower-Middle Pleistocene) and in the middle and upper part, three depositional cycles separated by deep erosion surfaces and by a bank of the *Tufo litoide lionato* auct. (Alban Volcano). The cycles represent alluvial fills showing here very well an overlapping stratigraphical relationship; these cycles were correlated by Conato *et al.* (1980) to the San Cosimato Formation (= oxygen isotope stage 11); to the Aurelia formation (= oxygen isotope stage 9) and to the Vitinia Formation (= oxygen isotope stage 7), the last of them is here defined. Again in this case the Vitinia Formation was interpreted as the continental equivalent of the Eutyrrhenian *sensu lato.* (0.2 Ma) and correlated to the oxygen isotope stage 7 by Conato *et al.* (1980) and Malatesta and Zarlenga (1986, 1986a, 1988).

Finally, Milli and Zarlenga (1991) carried out a high-resolution facies analysis of the Tyrrhenian sediments outcropping along the coast south of the Tiber River and concluded that these sediments were unrelated to the Vitinia Formation. In that case the latter Formation is older than the Tyrrhenian *sensu stricto* (oxygen isotope substage 5e) and would thus be correctly correlated with oxygen isotope stage 7.

The Sedia Del Diavolo Section

This section, formerly visible within the city of Rome, is no longer exposed, so this reinterpretation is based on a reconstruction of the section put forward in a previous study by Caloi *et al.* (1980) (Fig. 4).

The oldest sedimentary cycle consists of interbedded gravels and sands with volcanic minerals at the bottom of the sequence; a well-developed erosion surface cutting across these sediments is overlain by a bed of *Tufo litoide lionato.* A second cycle formed by epivolcanites, silts and sands, with reworked fragments of the TRSN, covers this bed. In the higher part of the succession, gravels, sands and silts, that represent the third depositional cycle, overlie another erosion surface.

The sequence described is comparable with that at Vitinia. In fact the gravels at the base can be related to the San Cosimato Formation and the two cycles

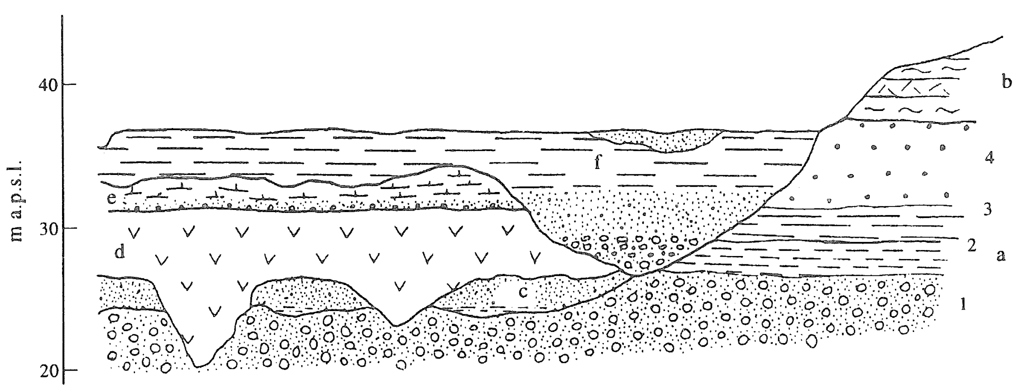

FIG. 3. The Vitinia section: (a) Ponte Galeria Formation — a1 prevolcanic gravels and sands, a2 brackish clays with *Cerastoderma edule*, a3 lacustrine clays with *Bithynia*, and a4 pisolithic tuffs (*Tufi grigi inferiori*); (b) palaeosols and epivolcanites; (c) I Middle Pleistocene sedimentary cycle (San Cosimato Formation); (d) *Tufo litoide lionato*; (e) II Middle Pleistocene sedimentary cycle (Aurelia formation); (f) III Middle Pleistocene sedimentary cycle (Vitinia formation).

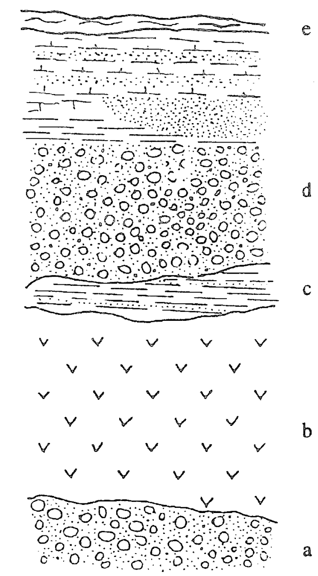

FIG. 4. The Sedia del Diavolo section: (a) I sedimentary cycle consisting of gravels and sands with volcanic minerals (San Cosimato formation); (b) *Tufo litoide lionato*; (c) II sedimentary cycle consisting of clays and silts (Aurelia Formation); (d) gravels and sands, clays, epivolcanites, marls and travertines of the III sedimentary cycle (Vitinia formation). (N.B. The drawing of this section, which is now no longer exposed, lacks an altitude scale, since this information is missing on the manuscript diagram by A.C. Blanc, from which this figure has been redrawn).

overlapping the *Tufo litoide lionato* to the Aurelia and Vitinia Formations respectively.

The Castel Di Guido-La Polledrara-Malagrotta Sections

There are several sections that relate to the deposits of the same cycle which is very well developed in this area, as shown on the Geological Map 1 : 50.000 F. Cerveteri (Compagnoni *et al.*, 1988) and in a survey by Malatesta (1978).

Many authors (Anzidei *et al.*, 1989, 1993; Anzidei and Arnoldus, 1991; Caloi and Palombo, 1980; Capasso Barbato and Petronio, 1993; Compagnoni *et al.*, 1988; Malatesta, 1978) have studied these sections because of the presence of a Lower Palaeolithic industry and of a rich vertebrate fauna. These authorities considered the deposits to be younger than the TRSN because in places they overlie it, or contain reworked fragments of it. In all sections, the sediments consist of interbedded white marls, epivolcanites, silts and travertines. Locally, as at La Polledrara, changes are also observable (Anzidei *et al.*, 1989; Anzidei and Arnoldus, 1991). Therefore, concurring with Malatesta (1978) and Compagnoni *et al.* (1988), we relate the sediments outcropping in the sections to the Aurelia Formation.

The Monte Delle Gioie-Prati Fiscali Section

This section has never been studied in detail; only unpublished observations by A.C. Blanc and a rapid

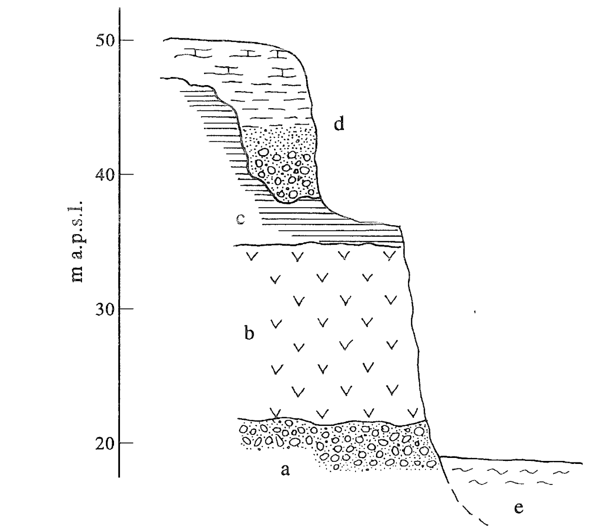

FIG. 5. The Monte delle Gioie-Prati Fiscali section: (a) gravels and sands with volcanic minerals of the I sedimentary cycle (San Cosimato formation); (b) *Tufo litoide lionato*; (c) II sedimentary cycle consisting of clays and silts (Aurelia formation); (d) III sedimentary cycle consisting of gravels and sands, clay and silts, marls and travertines (Vitinia formation); (e) recent alluvial clay.

survey report carried out for the 'Soprintendenza Archeologica di Roma', are available.

Gravels, sands and epivolcanites (first sedimentary cycle) (Fig. 5) outcrop with a thickness of about 2 m at the base of the section. On an erosion surface, that cuts these deposits, rests a bank of *Tufo litoide lionato* with a thickness of 5 m. Another deposit (second cycle), consisting of epivolcanites, muds and clays with a thickness of 5 m, is present overlying the *Tufo litoide lionato.* A well-defined erosion surface cuts the clays and the palaeosurface is covered by later fluvial deposits, namely by gravels that contain blocks of reworked *Tufo litoide lionato* epivolcanites, sands and travertines. Remains of vertebrate fauna were found within the gravels and sands.

This succession, that here again represents three superimposed sedimentary cycles, is, from a stratigraphical point of view, closely similar to those outcropping at Vitinia and at Sedia del Diavolo. It is consequently possible to correlate the basal gravel, preceding the *Tufo litoide lionato*, with the San Cosimato Formation; the clayey deposits that cover the aforementioned tuff with the Aurelia Formation and the last cycle with the Vitinia Formation.

Principal Sections Located Outside the Bassa Campagna Romana

The sections in question lie close to Riano Flaminio and Cerveteri and the deposits there can be correlated to those of the Campagna Romana.

The diatomaceous deposit of Riano has been studied by Ambrosetti *et al.* (1972) and by Bonadonna and Bigazzi (1969). It was these authors who proposed the Formation name 'Rianian' to cover the upper Middle

Pleistocene in the stratigraphical scheme for the Tyrrhenian margin in Central Italy.

On the basis of stratigraphical relationships and faunal characteristics, Malatesta (1978) regarded these deposits as strictly representing the continental facies equivalent to the fluvio-lacustrine-brackish-marine sediments that form the Aurelia Formation. We perfectly agree with Malatesta's conclusions and therefore correlate this deposit with oxygen isotope stage 9.

Capasso Barbato *et al.* (1981) described the Migliorie di San Paolo succession, near Cerveteri. This succession shows on top of the Sabatinian TRSN a deep erosion surface overlain by '*tufiti di disfacimento*' in which vertebrate remains have been found. Unfortunately, the field survey evidence does not allow the stratigraphical position of this deposit to be firmly determined. Although it is certainly younger than the TRSN, the evidence is lacking, as to whether it should be correlated with the Aurelia or alternatively with the Vitinia Formation.

Mammalian Faunas

The whole post-Galerian fauna of the late-Middle Pleistocene (Rianian, *sensu* Caloi and Palombo, 1995) shows relatively modern characteristics on account of the disappearance of some of the persistent Galerian forms that occur in the Faunal Unit of Fontana Ranuccio (*Ursus deningeri*, stenoid horses, megacerines of the *Megaceroides verticornis* group) and the appearances, though at different points in time, of, amongst others, *Ursus spelaeus*, *Canis lupus*, *Stephanorhinus hemitoechus* (doubtfully recorded in a more ancient fauna, Fortelius *et al.*, 1993), a large horse with derivate morphology, *Megaloceros giganteus* and a fallow deer with affinities with living forms. The persistent forms generally show a higher level of evolution or are replaced by subspecies of a more advanced character, thus *Cervus elaphus rianensis*, with a complete crown but with relatively archaic features, replaced *C. elaphus eostephanoceros*).

Within this faunal complex, two distinct types of associations can be distinguished. For these, Caloi and Palombo (1995) have proposed the introduction of the Faunal Units of Torre in Pietra and of Vitinia, the latter characterised by the abundance of fallow deer and the appearance of *Cervus elaphus* with features similar to those of modern forms of red deer.

The Faunal Unit of Torre in Pietra

In the Campagna Romana the associations that come from the beds of the Aurelia Formation, or are correlated with it, can be referred to this Unit. The more representative beds are those of Torre in Pietra (lower limnic-brackish series) (Malatesta, 1978), Malagrotta, Cava Rinaldi (upper levels), Castel di Guido km 19 and 20, Riano Flaminio (Caloi and Palombo, 1988 and references therein), as well as La Polledrara di Cecanibbio (Anzidei *et al.*, 1989) and Via Aurelia km 18 and 19 (Anzidei *et al.*, 1993; Caloi and Palombo, 1995). The mammalian remains found are generally characterised by the association of *Elephas* (*Palaeoloxodon*) *antiquus* (features still relatively archaic) with large *Bos primigenius* accompanied by cervids. The cervids are represented by both the still persisting Galerian form *Dama clactoniana*, by the archaic form of red deer *Cervus elaphus 'rianensis'*, as well as by the giant deer and roe deer, which are less frequent. Horse may be present, at times in abundance, as also rhinoceros (both *Stephanorhinus hemitoechus* and *S. kirchbergensis*), *Hippopotamus*, wild boar, small carnivores, whilst the big carnivores (bears, lions and leopards) are rarer. The overall composition of the fauna varies at the different sites. The horse is particularly abundant at Torre in Pietra, while the urus and the ancient elephant are the dominant forms at La Polledrara. The Clacton fallow deer, absent at La Polledrara, Torre in Pietra and Castel di Guido, is, however, abundant at Via Aurelia. The red deer *Cervus elaphus* is always present, but its percentage varies from site to site (it is, for example, abundant at Torre in Pietra and Riano, scarce at La Polledrara and Via Aurelia). The giant deer is present at Torre in Pietra, Castel di Guido, as well as inland, at Pontecorvo (Biddittu and Cassoli, 1968). The occurrence of hippopotamus is noteworthy with sparse remains at Via Aurelia, Castel di Guido and Malagrotta; the urus *Bos primigenius* is generally abundant in all the associations.

The individual faunal associations from different sites show proportional differences in the frequency of occurrence of species that lived in open or forested environments. Sites apparently belonging to the same stratigraphical horizons and showing similar stratigraphical relationships, do not necessarily possess faunas of similar composition. Such an example is provided by the faunal associations from Castel di Guido km 19 and 20, and from Via Aurelia (Table 1). In the case of beds, for which a clear stratigraphical relationship cannot be determined it can be hypothesised that the variability might be explained in terms of human activity, random variations, or short-term changes in local climate or even microclimate.

Isotope stage 9 in the oceanic record appears to cover two peaks of warming (Vergnaud Grazzini *et al.*, 1990). On the basis of the available data, and taking into account the wide ecological tolerances of many of the taxa present, a precise referral to one or the other interval of warming does not seem possible. Nevertheless, it can be observed that at Torre in Pietra, in the higher levels of the lower limnic-brackish series, the malacofaunas and the flora, which contains dominant open-ground or steppe elements, indicate cooler climatic conditions than the present-day ones. Soliflucction and cryoturbation phenomena occur both in the levels underlying the lower bone beds and in the closing levels of the cycle (Biddittu *et al.*, 1984). These data agree with the indications provided by the mammal

TABLE 1. Selected Middle and Late Pleistocene mammal fauna sites in the 'Bassa Campagna Romana' area

	Late-Middle Pleistocene Rianian														
	Torre in Pietra F.U.							Vitinia F.U.							
	Riano Flaminio	Via Aurelia km 18 and 19	La Polledrara	Malagrotta	Castel di Guido km 19	Castel di Guido km 20	Torre in Pietra (lower beds)	Prati Fiscali	Sedia del Diavolo	Monte delle Giole	? Cerveteri	Torre in Pietra (upper beds)	Vitinia	Campo Verde	Via Flaminia
Macaca sylvana LINNAEUS												●			
Martes foina (ERXLEBEN)												●			
Meles meles (LINNAEUS)												●			
Ursus sp.						●						●		●	
Ursus spelaeus ROSENMULLER							○								
Crocuta crocuta (ERXLEBEN)												●			
Canis sp.														●	
Canis mosbanchensis SOERGEL															
Canis lupus LINNAEUS			●	○			○		○			○	●		
Vulpes vulpes (LINNAEUS)							●						●		
Panthera leo (LINNAEUS)							●								
Mammuthus chosaricus DUBROVO														○	●
Elephas antiquus FALCONER & CAUTLEY	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Equus caballus ssp.			●	●		●	●		○		●	●		●	
Equus hydruntinus REGALIA									●					●	
Stephanorhinus kirchbergensis (JAEGER)		○													
Stephanorhinus hemitoechus (FALCONER)					●	●	●		●	○		●			
Stephanorhinus sp.	●		●	●									●	●	
Sus scrofa LINNAEUS				●	●	●	●		●			●			
Hippopotamus sp.				●	●									●	
Hippopotamus ex gr. *H. amphibius* LINNAEUS		●							●	●		●			
Cervus clactonianus FALCONER	●	●		○	□	○									
Cervus dama LINNAEUS								●	●	○	●	●	●	●	
Cervus elaphus rianensis LEONARDI & PETRONIO	●	○	○	○	○	○	●								
Cervus elaphus 'modern form'								○	●	○	●	●	●	●	●
Megaloceros giganteus (BLUMENBACH)						○	○							□	
Capreolus capreolus (LINNAEUS)				●								●		●	
Bos primigenius BOJANUS		●	●	●	●	●	●	●	●	●	●	●	●	●	
Caprinae gen. and sp. indet.														●	
Lepus europaeus LINNAEUS												○			
Oryctolagus cuniculus (LINNAEUS)				□			●					●			
Castor fiber LINNAEUS				○								●			
Cletrionomys glareolus SCHREBER												●			
Arvicola terrestris (LINNAEUS)		●										●	●		
Myoxux glis LINNAEUS							●					●			
Talpa ex gr. *T. europaea* LINNAEUS												●			

● occurrence.
○ occurrence of a similar form.
□ occurrence of a form of doubtful systematic attribution.

fauna, suggesting the presence of open spaces and moderate woodland cover. The faunal association of Torre in Pietra might nevertheless be referred to the second and less marked peak of warming of oxygen isotope stage 9; likewise perhaps the Castel di Guido km 20 fauna, since at both sites *Megaloceros giganteus* is present. At Riano, the palaeovegetational evidence suggests that the climate was both warm and humid, which could correspond to the first more marked positive oscillation, of stage 9. The faunas of Via Aurelia, on the basis of the presence of amphibious, indicators of mild climatic conditions can also be referred to the same oscillation. The palaeoenvironment of Malagrotta, which was frequented by aquatic birds, beavers and hippopotamuses, probably resembled the present 'Maremma' of Tuscany, with expanses of open water. Although the fauna indicates a relatively temperate climate, it is not really possible to suggest an exact oscillation within stage 9. Similarly, it is difficult to assign a firm stratigraphical position to the association of La Polledrara, but the presence in this place of an Acheulean industry of archaic nature could justify a correlation with an earlier oscillation, as at Torre in Pietra.

FAUNA OF THE VITINIA FORMATION

In the Campagna Romana, the associations coming from beds of the Vitinia Formation (Conato *et al.*, 1980), or those correlated with it, are basically characterised by abundant fallow-deer similar to the modern form, and by the presence of *Elephas* (*Palaeoloxodon*) *antiquus* with relatively evolved dental features, by red deer with general characteristics close to those of the modern form, and by the sporadic appearance of *Equus hydruntinus*. Amongst the sites which can be referred to this Faunal Unit are Vitinia (level e; Caloi *et al.*, 1983) Torre in Pietra (upper limnic-brackish complex, bed d; Malatesta, 1978), Sedia del Diavolo, Monte delle Gioie and Campo Verde (cf. Caloi and Palombo, 1995, and references therein). From the gravel and overlying clay of Quartaccio (Vitinia), comes a relatively rich and diverse fauna characterised by an abundance of fallow-deer. The faunal association suggests temperate, warm and moist climatic conditions (cf. Caloi *et al.*, 1983). The fallow-deer is abundant likewise at Torre in Pietra (Caloi and Palombo, 1978) and in the gravel of Sedia del Diavolo (Caloi *et al.* 1980).

The faunal association from Sedia del Diavolo (Caloi *et al.*, 1980) gives a mild signal about climatic conditions, but probably climate was cooler than at present. There was open woodland rather than forest, as also suggested at Monte delle Gioie (Segre and Segre Naldini, 1984), where clear indications of climatic deterioration are shown by the avifauna found in the yellow travertine sands which overlie gravel from which the mammalian remains were recovered (Blanc, 1955). At both sites occurs a lithic industry, which shows a remarkable affinity with that from Casal de' Pazzi (Rome), of Mousterian type but with indications of Levallois technique virtually absent (Mussi, 1992). The fauna of Casal de' Pazzi (Anzidei *et al.*, 1984), which has not been studied systematically, does not appear to differ in any significant way from that of Sedia del Diavolo and Monte delle Gioie. Sparse remains of mammals, elephant *Elephas antiquus*, urus *Bos primigenius* and a primitive form of *Dama dama*, have also been collected from the gravel outcropping in the Via dei Prati Fiscali (Rome), near its crossing with the Via Salaria (*unpublished data*). At Torre in Pietra the mammal fauna suggests a temperate or warm-temperate and relatively humid environment, as demonstrated by the presence in the same beds of numerous remains of fallow-deer, fresh water turtle *Emys orbicularis* and frogs. Also present were macaque *Macaca sylvana* and *Hippopotamus*. Notably absent from this assemblage is horse, which, by contrast, was numerous in the lower levels (Caloi and Palombo, 1978). Considering the avifauna, the most abundant taxa indicate a temperate Mediterranean climate, whilst the few forms with a northern range belong to species that generally winter in Italy (Cassoli, 1978). Turning to the archaeology, the Levallois technique is certainly demonstrated in the lithic industry at this site (Mussi, 1992).

On the basis of these considerations, the faunal associations of Sedia del Diavolo, Monte dello Gioie and Casal de' Pazzi might be referred to the first warm peak of oxygen isotope stage 7, and that of Vitinia and of Torre in Pietra would be referable to the second, more pronounced peak. To this oxygen isotope stage 7 may perhaps also be referred the mammal fauna from Cerveteri, which is also characterised by an abundance of fallow-deer (Capasso Barbato *et al.*, 1983; Caloi and Palombo, 1988).

CONCLUSIONS

In the 'Bassa Campagna Romana' the two more recent sedimentary cycles following the deposition of the beds of the Ponte Galeria Formation can be referred to the late-Middle Pleistocene (Rianian, oxygen isotope stages 10–7/6 of the ocean record). The two sedimentary cycles (Aurelia Formation and Vitinia Formation) are later than the deposition of the TRSN and *Tufo litoide lionato* and underlie beds of Tyrrhenian age *sensu stricto* (i.e. oxygen isotope substage 5e); they can be correlated with glacio-eustatic oscillations of sea level and are separated by deep erosion surfaces more or less corresponding to the low stands of sea level correlated to oxygen isotope stages 10 and 8. The sedimentary cycles are represented by two alluvial fills related to the valley of the River Tiber and the complex palaeonetwork of its tributaries, where it is also possible to recognise local brackish and marine facies that indicate the proximity of the sea.

The faunas of the two cycles can be assigned to two different Faunal Units; Torre in Pietra and Vitinia. The main difference is in the appearance of a primitive form of *Dama dama* and a modern form of *Cervus elaphus* in the Vitinia Faunal Unit. During the periods of deposition of the two cycles, the climate of the temperate stages and substages tended to become milder, even if the glacial stages remained severe. The faunas of the Torre in Pietra Faunal Unit (Riano Flaminio, Via Aurelia, Castel di Guido, Malagrotta, La Polledrara and the lower beds at Torre in Pietra) indicate open environments, whereas the faunas of the Vitinia Faunal Unit (Prati Fiscali, Sedia del Diavolo, Monte delle Gioie, the upper beds at Torre in Pietra, Vitinia, Campo Verde and Cerveteri), indicate a mild climate and substantial areas of woodland.

ADDENDUM

Italian vertebrate palaeontologists have now agreed to apply the term Aurelian Mammal Age for mammalian faunas of the Late-Middle Pleistocene and Late Pleistocene (Gliozzi *et al.* (1995) *Biochronology of selected large Mammals from Early Pliocene to Late Pliocene* (Poster). INQUA, XIV International Congress, Berlin, 3–10 August 1995).

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STRATIGRAPHICAL AND CHRONOLOGICAL CORRELATIONS BETWEEN MONTE VULTURE VOLCANICS AND SEDIMENTARY DEPOSITS OF THE VENOSA BASIN

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A new chronostratigraphic reconstruction of Vulture activity was used to correlate its volcanic products and relevant lacustrine–fluviolacustrine beds deposited in the nearby basins of Venosa, Melfi and Atella. The Acquatraversa erosional phase precedes the beginning of volcanic activity. The Flaminia erosional phase occurred during the period of volcanic quiescence before the buildup of the Vulture-San Michele stratovolcano. Reworked mammal remains are found in the upper bed related to the Nomentana erosional phase. This erosional phase took place after the main period of volcanic activity, when the stratovolcano was fully constructed.

INTRODUCTION

Vulture is the southernmost apparatus among the Quaternary potassic volcanoes of Italy, and the only volcanic edifice sited on the eastern flank of the Apennines. Lacustrine–fluviolacustrine deposits with volcanic elements outcrop around Vulture, in the areas of Melfi and Atella and mostly in the Venosa basin northeast of the volcano.

A detailed tephrostratigraphic reconstruction of the volcanic series (La Volpe and Principe, 1990), coupled with old and new Ar/Ar data on minerals (Villa, 1985, 1991; Laurenzi *et al.*, 1993) allow one to investigate the relationships between the volcanic and fluviolacustrine domains.

In this first attempt to carry out such an investigation, emphasis was placed on the main depositional units in lacustrine-fluviolacustrine facies of the Venosa basin.

STRATIGRAPHY AND CHRONOLOGY OF THE VULTURE VOLCANICS

The oldest volcanic products outcropping in the area are the pumice and ash flow and surge deposits known as the Fara d'Olivo unit (Fig. 1, La Volpe and Principe, 1990), formerly ignimbrites A and B (Crisci *et al.*, 1983). The volcanic activity continued with some minor scattered episodes. The Vulture volcanic edifice was gradually built up by a sequence of pyroclastic flows and surges and subordinate lava flows and pyroclastic falls, belonging to three distinct stratigraphic units, known as Masseria Boccaglie, Rionero-Barile and Vulture-San Michele (La Volpe and Principe, 1990). Volcanic activity resumed with the explosive breccia, pyroclastic surges and flows of the Case Lopes-Masseria Granata unit. The last-known volcanic episode determined the emplacement of the Monticchio Lakes surges.

The Fara d'Olivo unit exhibits a trachy-phonolitic composition (Crisci *et al.*, 1983). The chemistry of the Masseria Boccaglie unit ranges from tephritic-phonolitic to tephritic. The tephra and lavas of the Rionero-Barile and Vulture-San Michele units, as well as the pyroclastic deposits of the Case Lope-Masseria Granata unit are phono-tephrites, tephrites, basanites and foidites. The magmatic fraction of the Monticchio Lakes tephra exhibits the most primitive chemical character in the area and can be classified as alvikite-melilitite (Paiotti, 1993), following Le Maitre (1989).

The distribution of major and trace elements in phono-tephrites and tephrites suggests that they have originated through fractional crystallisation from a foiditic magma, whereas the early trachy-phonolitic products are not ascribable to the same fractionation series (De Fino *et al.*, 1986).

One of the peculiarities of the Vulture volcanics is their enrichment in some volatile elements, such as sulphur, which reflects in the ubiquity and abundance of a somewhat unusual feldspathoid: hauyne. This prevails over nepheline and leucite.

New radiometric data on the Vulture volcanics have been obtained at the Istituto di Geocronologia e Geochimica Isotopica-CNR, Pisa. Phlogopite, leucite and sanidine, belonging to lavic and pyroclastic samples, were selected according to their stratigraphic position. Mineral phases were separated from the whole rock or from the magmatic fraction of tephra using conventional magnetic and gravimetric techniques and final hand-picking. Age determinations were performed by the $^{40}Ar/^{39}Ar$ radiometric method (for more details see De Vita *et al.*, this issue). The age monitor was FCT biotite, 27.55 Ma (Lanphere and Fleck, 1990).

The Fara d'Olivo Ignimbrite exhibits an age of 730 ± 20 ka (Villa, 1985). Among the minor episodes following emplacement of basal ignimbrites, we have dated the Rupe di Gallo member of this unit, obtaining