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THE PLIO-PLEISTOCENE BOUNDARY AND THE LOWER/MIDDLE PLEISTOCENE TRANSITION: TYPE AREAS AND SECTIONS

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THE PLIO-PLEISTOCENE BOUNDARY SESSION

SMALL MAMMALS OF TRANSBAIKALIA AND PLIOCENE-PLEISTOCENE BOUNDARY

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In our study we accept the Plio-Pleistocene boundary, which has been proposed to place at the 1.8 Ma horizon by general agreement at the XI INQUA Congress.

In Transbaikal area this geological event is characterized by cooling which we can trace in the continental deposits and in the composition of mammalian faunas. During last decades in the key sections of the region several successive faunistic horizons were determined. So in the fossiliferous localities of Tologoi - 13 faunas, in Zasukhino - 9 and in Dodogol locality - 6 faunas, ranged from the Pliocene to the end of Late Pleistocene or Holocene were established.

Almost all of the Pleistocene strata are accumulated on the Pliocene deposits, but the Pliocene-Pleistocene boundary is established only in the Zasukhino locality. Here the upper Pliocene Chikoi Formation is replaced by the Early Pleistocene sediments. Upper Pliocene strata are represented by reddish-brown loam with rubble (Zasukhino 1) and includes mammalian remains of Itantsa faunistic complex with *Itanzatherium angustirostre* Beliajeva, *Equus* ex gr. *sanmeniensis* Teilhard de Chardin et Piveteau, *Gazella* cf. *sinensis* Teilhard de Chardin et Piveteau, *Spermophilus itancinicus* Zazhigin, *Clethrionomys* sp. (Vangengeim et al., 1990). Among arvicolids the only rooted voles *Villanyia klochnevi* Erbajeva and *Mimomys* cf. *reidi* Mehely are characteristic for this fauna (Erbajeva, 1998).

Early Pleistocene sediments overlying the Late Pliocene one are presented by pink reddish, yellowish-brown loam (Zasukhino 2). These strata correspond magnetostratigraphically to reverse polarity of Matuyama Epoch interval whereas underlying layer corresponds to normal polarity (?Olduvai or ?Reunion) (Zudin, 1980). The mammalian fauna of this age is Dodogolian one. It is known from the localities Zasukhino 2, Dodogol (type locality), Tologoi 1.2 and include *Equus* ex gr. *suessenbornensis* Wuest-*verae* Sher, *Coelodonta* sp., *Homotherium* sp., *Ochotona zasuchini* Erbajeva, *Marmota* sp., *Borsodia laguriformes* Erbajeva, *Allophaiomys pliocaenicus* Kormos, *Mimomys* cf. *pusillus* Mehely, *Prosiphneus* cf. *youngi* (Teilhard de Chardin). The first appearance of the genera *Allophaiomys* and *Borsodia* is characteristic for Dodogolian fauna. The rootless arvicolid *Allophaiomys pliocaenicus* is typical representative of the Early Pleistocene faunas. In this fauna progressive type *Borsodia laguriformes* replaced the late Pliocene *Villanyia klochnevi*. To the mid of Early Pleistocene *Borsodia* disappeared, it was replaced by the rootless and cementless genera *Lagurodon* and *Prolagurus* of which the latter survived to the beginning of the Middle Pleistocene.

Thus, the Pliocene-Pleistocene boundary in the West Transbaikalia lies between strata with mammalian faunas of Itantsa complex and strata with Dodogolian faunas (1.8 Ma).

LARGE MAMMAL FAUNA OF SOUTHWESTERN SIBERIA ON THE PLIO-PLEISTOCENE AND LOWER/MIDDLE PLEISTOCENE BOUNDARIES

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Pliocene—Lower-Pleistocene (Eopleistocene ones according to Russian scheme) sediments, thick and various in composition, occur on the South and Southeast of Western Siberia (WS). Their natural exposures are known in the Pavlodar Irtysh region, in Priobie and Pre-Altai plains. In various regions of SW they are distinguished as various layers, bands, suites, and sub-suites of different genesis and and unified to Kulunda (KL) and Kochkovo (KC) regional horizons. In WS, the N/Q border (on the level of 1,8 m.y., under Apsheron regional stage and its stratigraphical analogs) is drawn in the bottom of KC-horizon with mammal fauna of Odessian (Late Villafranchian) level. The KL-horizon, corresponding to Upper Pliocene (Gelasian), includes sediments with fauna of Podpusk-Lebiazhie complex (Khapry = Middle Villafranchian) with typical locality in Podpusk village on Irtysh river. The fauna comprises: *Archidiskodon gromovi, Equus ex gr. stenonis, Gazella cf.sinensis, Mimomys pliocaenicus, Villanyia petenuii, Cromeromys irtyshensis.*

The most complete Quaternary sections, from the beginning of Pleistocene (Lower Eopleistocene) to Holocene, are exposed in coal-mining pits of Kuznetsk Basin. In this region, the author traced, almost in a continuous section, the deposits of Lower Pleistocene (Lower and Upper Eopleistocene) and Middle Pleistocene (Lower Neopleistocene) with rich mammal fauna (see Table). In the most ancient Mokhovo suite, only the upper layers (with fossil soil in their basement) are characterised by the fauna that correlated to Odessian (Late Villafranchian) fauna. The age of the resting part of the suite is undefined. Hence, the N/Q boundary in the Kuznetsk Basin is placed in the upper part of Mokhovo suite, under the layers with mentioned fauna. Upper Eopleistocene is represented by Sagarlyk suite that contains fauna of Razdolean—Early Tamanian—Early Galerian type. Jaramillo event is found in the upper part of the suite. The interval from Jaramillo to the B/M inversion, i. e. the time of transition from Eopleistocene to Neopleistocene (from Lower to Middle Pleistocene), is represented by deposits of Sergeevo and partly Kedrovka suites. They contain fauna correlated with Late Tamanian, Karai-Dubina, and Petropavlovsk faunas of Eastern Europe, as well as with Middle Galerian and Early Cromerian faunas of Western Europe. Lower part of Kedrovka suite (Krasnogorsk layers) corresponds to Middle Pleistocene (Lower Neopleistocene). It includes typical representatives of Viatkian—Tiraspolian—Late Cromerian fauna: *M. trogontherii, E. mosbachensis, B. ex gr. priscus*, cold-resistant forms (*Gulo cf. schlosseri, Rangifer sp., Ovibos sp.*) appearing.

The history of West-Siberian mammal fauna in the end of Pliocene and beginning of Pleistocene implies substantial climatic and landscape changes, traced all through Eurasia.

Table. **Mammal fauna of Early and Middle Pleistocene on the southeast of Western Siberia (Kuznetsk Basin)**

THE PLIO-PLEISTOCENE IN THE HIGH ARCTIC

Funder S.[1)], Bennike O., Böcher J., Feyling-Hanssen R., Strand Petersen K. & Símonarson L.[1)]

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The sediments of the Kap København Formation, northern Greenland, have yielded an unparalleled detailed view into Early Pleistocene/Late Pliocene terrestrial and shallow-marine environments of the world's northernmost land. A cyclostratigraphical age estimate, as well as other evidence, tentatively date the sediments within the interval MIS 96-91at c. 2.32 ma. The main part of the 100 m thick sequence of sediments accumulated in a shallow fresh-water influenced embayment during a rise of relative sea level, probably reflecting the demise of the Praetiglian ice sheet over Greenland, and an early phase of the following Tiglian interglacial, a total duration of c. 20 ka.

The sediments contain a rich record of both terrestrial and marine life and 15 years of palaeontological studies by a large number of experts have yielded an unusually detailed list of taxa, representing a wide range of ecosystems that existed in this geographical region more or less at the same time. The taxa comprise: insects: 257, vascular plants: 85, foraminifers: 65, marine molluscs: 49, ostracodes: 43, bryophytes: 20 as well as smaller amounts of vertebrates and brachiopods. These figures exceed the total fauna and flora living in the area at the present, where the area is polar desert bordering on a permanently ice covered Arctic Ocean. However, there is a discrepancy between the climatic signals from terrestrial and marine organisms: while the majority of terrestrial organisms are boreal and no longer extant in the area (extant are less than 5% of the insects, and less than 25% of the vascular plants), the shallow marine fauna has great similarities the present (probably more than 75% extant species).

This shows that in general the North Atlantic oceanic surface circulation followed the same pattern as at present, where the coasts of Northern Greenland are washed by Polar water from the Arctic Ocean. The high interglacial-peak terrestrial temperatures, with a forest tundra ecotone bordering on the Arctic Ocean more than 1000 km to the north of the northernmost treeline at present, are surprising because interglacial peak temperatures at mid latitudes at the same time apparently were similar to the present. The explanation may lie in the importance of the obliquity cycle at high latitudes in the "40 kyr period", and in the fact that at this time the ice sheets waxed and waned in phase with the insolation - whereas in the present "100 kyr period" the interglacial peak insolation occurs when there are still large ice sheets present on land, and much of the warmth goes into melting these ice sheets.

ENVIRONMENTS OF UKRAINE AT THE TRANSITION FROM PLIOCENE TO PLEISTOCENE AND FROM LOWER TO MIDDLE PLEISTOCENE

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The Pliocene-Pleistocene boundary (1.8 Myr) in Ukraine corresponds to the transition from Beregov paleosol unit to Berezan loess unit of the Ukrainian Stratigraphical Framework of the Pleistocene (Veklitch et al.,1993). The data on paleosols and paleovegetation have been obtained for the northern, western and eastern regions of Ukraine. The environments of the Beregov unit were similar to the submediterranean type. In the Transcarpathians, the reddish-brown soils were formed under broad-leaved-pine forests. *Quercus* and *Carpinus* were mainly spread, though thermophilic *Ostrya, Juglans, Rhus*, Moraceae, *Ilex, Hedera, Myrica*, as well as moisture-loving *Abies*, occurred. At the very end of the stage both *Abies* and thermophilic taxa disappeared indicating a climatic deterioration. In the northern Ukraine, the leached reddish-cinnamonic soils were formed under oak-pine parklands with admixture of *Ulmus, Celtis, Myrica* and Moraceae. In the eastern Ukraine, parklands were more sparse and xeric, though still with thermophilic taxa, carbonate and saline cinnamonic soils were spread. The climatic continentality increased from the west to the east.

The Berezan unit is represented by loesses or loams (up to 2 m thick) with mainly non-arboreal pollen spectra. Boreal forest-steppe dominated in the western and northern parts of Ukraine, steppes were spread in the eastern regions. Meadow steppes replaced to the east by xeric Chenopodiaceae-Asteraceae coenoses The composition of arboreal vegetation was poor in the north and east (*Pinus, Betula* and *Alnus*). In the Transcarpathians, a share of *Picea* at the beginning of the time unit was rather high. The climatic conditions got drier at the second half of the Berezan time. Some climatic improvement, recorded by an embryonic soil, is also registered by pollen data (small number of broad-leaved species, and in the Transcarpathians of *Abies)*. Thus, the Plio-Pleistocene transition was marked by climatic deterioration - loess accumulation instead of soil formation, replacement of warm-temperate forest by boreal steppe and forest-steppe.

The Brunhes-Matuyama reversal (the Lower-Middle Pleistocene boundary) corresponds to the Shyrokyno unit of the Ukrainian Pleistocene Magnetostartigraphic Framework (Tretyak et al., 1994). The unit consists of two pedocomplexes separated by loess subunit. In the Transcarpathians, the lower pedocomplex is represented by gley forest soils formed under oceanic climatic conditions (*Carpinus* forest with small admixture of *Taxus*, *Ostrya, Ilex* and *Pterocarya).* In the northern regions, brown forest soils were spread under oak-pine forest with small number of *Pterocarya, Myrica* and Moraceae. In the eastern regions, more xeric brown-cinnamonic soils dominated under oak-pine parklands with some *Juglans* and *Rhus*. The Shyrokyno loess subunit is most expressed in the east and represented by steppe pollen spectra, though with small number of broad-leaved *Quercus* and *Ulmus.* The loess subunit indicates a significant aridification and climatic deterioration. The upper Shyrokyno pedocomplex is represented by meadow or chernozem-like soils. In the Transcarpathians, wet meadows with *Salix* and *Myrica* alternated with broad-leaved forests. In the northern regions, broad-leaved-pine forest-steppe was spread, and in the eastern regions, steppes with *Quercus* in the river valleys dominated. The number of thermophilic elements was sharply reduced as compared with the lower Shyrokyno pedocomplex indicating a cooler climatic conditions.

PLIOCENE TO EARLY MIDDLE PLEISTOCENE FLUVIAL DEPOSITS IN SOUTHWESTERN POLAND AND THEIR CORRELATION WITH FLUVIAL SYSTEMS IN WESTERN EUROPE

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The pale, kaolin- and gravel-bearing, quartz-rich to quarz-dominating deposits wich commonly occur in southwestern Poland above the Late Miocene/Early Pliocene Poznan Formation (Clay) and below the Plesitocene tills, known also as "preglacial series" or "white gravels", have been classified as the Ziebice Group. The Ziebice Group comprises several formations, defined by their heavy mineral content and non-quartz gravel-clast petrography, which represent sequences deposited by specific fluvial systems originated in the Sudetes Mountains. Six main river systems have been recognised, each with characteristic heavy mineral assemblages: pre-Odra (zircon-rutile), pre-Biala Glucholaska (staurolite-amphibole), pre-Nysa Klodzca (staurolite-garnet), pre-Bystrzyca (zircon-syllimanite), pre- Strzegomka (syllimanite-garnet) and pre-upper Bobr/Kaczawa (andalusite). These river systems originated during Early Miocene and continued in more or less similar position across Sudetes and western Carpathians during the Pliocene. Additionally, some other river systems have been found, but their occurrency is more local and evidence more ambiguous. Some rivers that accumulated the Ziebice Group sequences extended to north and northwest at least 200 Km away from the Sudetes margin. They represented tributaries of the regional major Baltic River system, and are synchronous with western rivers accumulating Scheemda and Kieseloolite Formations.

The complete sediment succession of the formations of the Ziebice Group comprises up to four members, wich are believed to be synchronous. The members I-III of the Ziebice Group are most probably of late Early Pliocene to Late Pliocene age, whereas the member IV is, most probably, of early Middle Pleistocene (Cromerian) age. The members I-III represent sequences deposited mainly in sinuous rivers, thought with varying paleodischarge both regionally and temporally. The sediments of the member IV were deposited in braided rivers. All members contain gravel-dominated alluvial fan sequences near the mountain margin. The gravel-bearing Ziebice Group was probably formed due to subsequent mountain uplift and increased tectonic activity in the Sudetes and its Foreland and it replaced more fine-grained sediments of the Poznan Formation formed during the stability period (Late Miocene-Early Pliocene). During the Late Pliocene, this tectonic activity was minor to moderate, but accelerated during the Early Pleistocene. The latter tectonic event caused a complete re-organisation of the fluvial system, wich can be interpreted as the precursor of the recent one.

In Poland, beside the fore-Sudetic rivers, there is evidence for at least three other major Plio-Pleistocene fluvial systems. One of them is the pre-upper Vistula system in SE Poland, documented near Krakow as so known Witow. It was drained to South East. Another fluvial system has been documented in the Belchatow outcrop. Although as yet with very local occurrence along the Kleszczow Graben, this series documents a continuous sedimentation since the late Miocene to the pre-Tiglian, with some changes in sediment charateristics suggesting cooling at the Pliocene/ Pleistocene boundary. The main fluvial system, however, is in central and eastern Poland (so known "preglacial series"). It was formed by the large river sytem flowing from the east. This series lies above the late Miocene/early Pliocene Poznan Formation and its upper age boundary was documented hitherto for Waalian, but it may extends up to early Middle Pleistocene. There is no virtual difference in sediment characteristics or erosion at the Pliocene/Pleistocene boundary, and it seems that fluvial accumulation was continuous despite drastic climatic change.

The Baltic river and most of the German rivers, including Rhine and the Belchatow river in Poland were active since Late Miocene. In turn, the fore-Sudetic and central Poland rivers originated only during the late Early Pliocene. This discrepancy is somewhat striking. It seems that the age equivalent to the Late Miocene-Early Pliocene kaolin-and and gravel bearing sediments in Northwestern Europe is in Poland the Poznan formation (Belchatow is located beyond the limit of this formation). The deposits of the Poznan formation represent probably an anastomosing river or inland-delta sedimentary environment. Heavy mineral assemblages indicate Scandinavian material down to Southern Poland . It is very possible that the Late Miocene/Early Pliocene Poznan Formation represents a part of the early Baltic river system, which was then, during the late Early and Late Pliocene shifted to the north by fore-sudetic and Eastern rivers and replaced by gravel-bearing suites.

The formation of coarse grained sediments in SW Poland may be connected with an increased erosion in the Sudetes, which have followed incipient tectonic activity after a long period of stability during the Late Miocene and Early Pliocene . This palaeogeography well explains why sediments of the Ziebice Group are so fresh in comparison to other kaolin- and gravel-bearing deposits, as those of the Rhine river valley and Baltic river. They simply were deposited during a very short period of the late Pliocene (c. 1-2 Ma) and under the relatively cooler climatic conditions than the older sequences. Indeed the sediments of the Poznan Foramtion are much more weathered (all clays are oxidized and almost pollen free) and often include red to spottered weathering horizons.

All of kaolin-bearing river systems in Europe ceased around the Pliocene/Pleistocene and they were trasformed or replaced by rivers with more fresh material. This change was either due to climate or tectonics or both of them. In the Sudetic Foreland tectonics have played a major role in the change of fluvial environments and river pattern re-orientation. However the central and eastern Poland sequences suggest continuous fluvial sedimentation throughout Late Pliocene and Early Pleistocene, that probably follow quite different tectonic history of this part of Poland.

BOUNDARY TERTIARY/QUATERNARY AND PRECLACIAL PALAEOGEOGRAPHY IN POLAND

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A glacial part of the Pleistocene in Poland is much better examined than the pre-Pleistocene part of the Quaternary. Setting of the boundary Tertiary/Quaternary is still controversial, because it does not possess any direct and reliable dating. In western Europe this boundary has been set up at the turn of the Gauss and Matuyama palaeomagnetic epochs i.e. 2.48 mln years ago (e.g. Brunnacker 1978, Zagwijn 1979). In eastern Germany and Poland this boundary has been located commonly at bottom of the Olduvai palaeomagnetic event i.e. 1.87 mln years ago (e.g. Wiegank 1982, Lindner 1988). In eastern Europe it is ascribed to a top of the Olduvai palaeomagnetic event i.e. 1.67 mln years ago (Nikiforowa et al. 1984, Yakubovskaya, Nazarov 1993; Paškevičius 1997) or occasionally, it is set at 2.4 mln years ago (Nazarov, 1995).

On the basis of the pollen analysis of lake and fluvial sediments, the Tertiary/Quaternary boundary has been established in central Poland in several sections. The pollen flora of the Upper Pliocene is rich in thermophilous taxa such as Taxodiaceae, *Sequoia, Nyssa, Liquidambar, Sciadopitys, Aesculus, Engelhardtia* and *Symplocos.* The characteristic vegetation communities were a mixed deciduous-coniferous forest with *Quercus, Castanea, Carpinus, Tilia, Pinus, Sequoia, Picea* and *Sciadopitys,* a swamp forest with *Alnus, Nyssa* and Taxodiaceae, and open assemblage with Gramineae. The climatic deterioration caused changes in floral composition. Warm-loving tree taxa typical for the Upper Tertiary disappeared gradually, but share of boreal elements (*Picea, Pinus, Betula*) increased. The forest opened up as marked by the increased pollen of herbs.

The very beginning of the Quaternary (e.g. according to the Dutch stratigraphy) is located at the first drastic increase of pollen of Gramineae and Cyperaceae, and the first open assemblage is referred to the Praetiglian cold stage. The Lower Quaternary pollen flora is characteristic for a lack of *Nyssa, Sciadopitys, Sequoia, Liquidambar, Aesculus* and Taxodiaceae. Thus, the Quaternary begins in Poland with several episodes when tundra and cold steppe vegetation predominated, intervened with expansion of birch or birch-pine, and occasionally also mixed forest communities (Winter 2000).

Still very little is known about a palaeogeography of the huge interval just after the very beginning of the Quaternary and which lasted until the first Pleistocene glaciation (Narewian Glaciation). The latter must have occurred some 900 ka ago, because palaeomagnetic evidence suggests that the following i.e. the first Pleistocene interglacial (Augustovian) corresponds provisionally either to the Bavelian (Leerdam) or the Cromerian II (Westerhowen), and occurred just before the Brunhes/Matuyama boundary (cf. Ber 1997, 1999; Ber et al., 1998). In any case the gap in palaeogeographic and stratigraphic information is equal about 1.2 to 0.9 mln years, depending on the setting of the boundary Tertiary/Quaternary. Otherwise, the available information is so dispersed that at present any reasonable sequence of the Early Quaternary events in Poland can be established.

THE CONTINENTAL PLIO-PLEISTOCENE SERIES OF THE GUADIX-BAZA BASIN (SOUTH-EASTERN SPAIN)

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The intramontane Guadix-Baza Basin, situated in the south eastern of the Iberian Peninsula, records an almost complete continental succession from at least the early Pliocene to the late Pleistocene, with more than 70 fossiliferous sites. The early Pliocene is represented in a number of sections such as Botardo and Gorafe, which present a typical early Ruscinian fauna including *Ruscinomys lasallei*, *Apocricetus barrierei*, *Apodemus gorafensis*, etc. The level of Gorafe 4 has delivered also remains of large mammals including *Gazella borbonica* and *Sus arvernensis*. Recently a new series which include levels of the early Ruscinian age has been found in the surroundings of the town of Baza. One of these levels, which is in a current systematic excavation, has a very important assemblage of small and large mammals (*Apodemus* aff. *gorafensis*, *Paraethomys* sp., *Trilophomys* cf. *vanderweerdi*, *Mamut borsoni*, *Anancus arvernensis*, *Hipparion* sp., *Stephanorhinus* sp., among others). The late Ruscinian is well represented and calibrated in the sections of Galera, Zùjar and Gorafe, with abundant micromammalian sites. The early Villanyan is again represented at the sections of Galera and Zújar. The first remains of *Equus* in the Basin are found at the top of the section of Zújar, at the lower part of Matuyama chron. Several late Pliocene, late Villanyan levels with small mammals are found in a number of sections close to the towns of Galera and Orce. Notably, the locality of Fuente Nueva-1 delivered an association of small and large mammals including *Gazella borbonica*, Bovidae gen.et sp. indet., *Equus stenonis vireti*, *Mimomys* sp., (aff. *M. medasensis*), *Castillomys crusafonti* ssp. and *Apodemus dominans*. The levels above these late Villanyan faunas are included in the *Mimomys oswaldoreigi* Zone and record the first entry of unrooted arvicolids (*Tibericola vandermeuleni*) and Ovibovini (cf. *Praeovibos* sp.). Several localities of the *Allophaiomys pliocaenicus* Zone are present in the Orce-Fuente Nueva-Venta Micena triangle, bestly represented by the important site of Venta Micena. Besides *Allophaoimys pliocaenicus*, this level presents the first entry of *Hippopotamus antiquus*, *Megantereon whitei*, *Soergelia* and other early Biharian elements. The following biozone (*Allophaiomys burgondiae* Zone) is present at the sections of Barranco León (BL-5), Fuente Nueva (FN-3), Cañada de Murcia (Loma Quemada), Huéscar-1, and Puerto Lobo. It is in this zone where the first evidences of early human occupation of the basin are found. Finally the middle Pleistocene (Toringian) is present in the sections of Cúllar-Baza and Solana del Zamborino.

THE VRICA SECTION (CALABRIA, ITALY): THE NEOGENE-QUATERNARY AND PLIOCENE/PLEISTOCENE STRATOTYPE SECTION

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The Plio-Pleistocene continuous, highly fossiliferous bathyal sequence at Vrica – consisting mainly of silty marly claystones – in the extensive badlands located south of the Crotone (Italy), was ratified as the type section of the Pliocene/Pleistocene Boundary Stratotype by the IUGS in 1985. The Vrica area is an emergent portion of the Crotone sedimentary basin, and is located in a monocline, dipping 5-15° westward. I will describe sintethically the sedimentology, paleoecology, biostratigraphy, biochronology, absolute datings, magnetostratigraphy and astronomical calibration of the Section, based on research of scholars of different countries.

According to criteria established by prior reccomandations of the INQUA Subcommission 1-d "Pliocene/Pleistocene Boundary" at the Working Group of IGCP Project n° 41 "Neogene/Quaternary Boundary" (two organisms of which I was a scientific secretary), the IUGS accepted that *the physical location of the Pliocene/Pleistocene boundary stratotype coincides with the base of the claystone conformably overlying sapropelitic marker bed* e *of the Vrica section*. This level is very close the geomagnetic polarity reversal at the top of the Olduvai normal polarity subzone, and is approximately coeval with thtr beginning of a cold-climate phase marked by the first appearance in the Mditerranean of the "northern guest" *Arctica islandica*. Exactly in correspondance of marker bed e an important floristic modification, identified as the transition from the "Tiglian interglacial phase" to the "Eburonian glacial phase", is also recorded.

PLIO-PLIOCENE AND LOWER-MIDDLE PLEISTOCENE BOUNDERIES IN THE TYPE SECTIONS OF THE BLACK SEA AND CASPIAN SEA REGION

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During Early-Middle Pleistocene different types of basin sediments (marine, demimarine, brackish, freshwater) in the Ponto-Caspian region was developped. Mostly changes of basin environment and biota (molluscs, forams, coccoliths) coinsides with stratigraphical limits, as well as with tectonic movements and climatic changes.In the Black Sea N-Q boundary passes between basin beds of Koujalnikian and Gourian stages. Both basins were populated by brackiswater and freshwater fauna without any connection with marine basins. But on this boundary was happened big changes of environment and fauna. Koujalnikian brackish basin (salinity 10-15%) was populated by endemic mollusc fauna, developping longtime during Pontian, Kimmerian and Koujalnikian. This fauna was entirely extincted on reason complete refreshening of Late Koujalnikian basin. Just above the N-Q limit new brackish mollusc fauna of Gourian Stage was appeared: Digressodacna, Tshaudia, Submonodacna. This fauna was developped later during Early and Middle Pleistocene in Black Sea basins during Tsvemagalian and Tshaudian.In the Caspian basin N-Q boundary passes on the level of Olduvay event between stages Archagylian and Apsheronian. This limit coinsides with abrupt changes of marine biota. Marine molluscs of Archagylian related to Mactridae, Cardiidae and Potamides (endemic generas Andrussella, Kirgisella, Akchagylia, Avimactra, Avicardium etc.) are extincted, as well as foraminiferas (including planctonic species Globigerina bulloides and others) coccoliths Braarudosphaera, Coccolithus etc. are extincted finally and marine biota never more appeared in the Caspian basin. This marine biota reflects marine basin environment (20-25 %0 salinity) with rather broad connecdion with Mediterranean via Euphrat strait.Just on the N-Q boundary level this connection along the Euphrat Channel was stopped, possible due of tectonic movements along the East Anatolian and North Anatolian faults, and this marine water way was closed. On this reason Archagylian marine basin changed to the freshwater one of Apsheronian /molluscs Corbicula Apsheronica, Unio,Anodonta, Zymnaea etc/.In the alluvial consequensis of Ponto-Caspian area N-Q boundary settled within ancient fluvial sediments of Dniester,Don, Kuban rivers. This boundary marked by change of mollusc fresh-water fauna of Polivadin thermocomplex with last typical Levantian sculpted molluscs (Ebersininaia, Wensiella, Potomida etc.) by Domashka cryocomplex with boreal type fauna and cooling, related to Eburonian. Mammal fauna of Middle Villafranchian (Khaprovian) to late Villafranchian (Psecupsian) was changed on N-Q limit in alluvial sequenses.Lower-Middle Pleistocene transition in the Black Sea type sections passed on the base of Tshaudian stage above Tsvermagalian stage just below Matujama-Bruhnes limit. Above this limit the first marine biota and marine salinity (up to 10-20 %0) environment was firstly appeared in the Black Sea basin. Marine waters penetrated to here from Mediterranean via Bosphorus area and Sea of Marmara. This connection appeared due of crust movements along the North-Anatolian fault.In the Caspian basin Lower-Middle Pleistocene transition coinsides with boundary between Apsheronian and Bacunian stages. Though both basins /Black Sea and Caspian/ was isolated brackish lakes, the fauna of molluscs was different. On this transition all Apsheronian generas (Apsheronia, Parapsheronia, Hyrkania) was extincted, and later in Bakunian basin appeared new molluscs generas: Didacna, Potodidacna, Adacna, Monodacna. The reason of this remarcable changes is not yet known. In alluvial consequenses L-M Pleistocene transition passed in the base of Mihailovka terrase of Dniester where appeared

Tiraspol complex of mammals (Mammuthus trogontherii) on the change of Tamanian complex /Epivillafranchian/ with Archidiscodon meridionalis tamanensis and molluscs (Viviparus tiraspolitanus, Pseudunio moldavica etc.).

THE ROLE OF THE MAMMALIAN FAUNA-TRANSITIONS IN NORTHWESTERN EUROPE IN THE PLIO-PLEISTOCENE BOUNDARY DEBATE.

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The dawn of the Quaternary is an intriguing period in the light of faunal evolution and dispersion of species. A comparison between the late Pliocene faunas from Hambach and Frechen (Germany) and the early Pleistocene[1] faunas from Tegelen and Zuurland (The Netherlands) shows how distinct the faunas change in Northwestern and Central Europe is. The rodent fauna from Hambach is characterized by at least four different flying squirrels of the Subfamily Petauristinae, a group which is completely absent in the fauna from Tegelen. The larger voles of the fauna from Hambach are assigned to *Mimomys hassiacus*, the one from Frechen to *Mimomys* cf. *polonicus*. Both species are more primitive than the larger voles from Tegelen assigned to *Mimomys pliocaenicus*. The vole spectrum from the Tegelen fauna is with 6 different species (*Mimomys pliocaenicus, M. reidi, M. tigliensis, M. pitymyoides, Clethrionomys kretzoi* and *Ungaromys dehmi*) more diverse than the spectra from Hambach and Frechen. Borehole Zuurland between –62 and –66 m. yielded a fauna with about the same age as the fauna from Tegelen and an identical broad vole spectrum. The Zuurland fauna includes in addition another medium sized vole *Mimomys hordijki*.
Allophaiomys appears at Zuurland in the levels –50 to –56 and –42 to –46. The negative enamel differentiation, the low A/L ratio and the high B/L ratio indicate that the fossil *Allophaiomys* from both levels should be assigned to *Allophaiomys deucalion*. Assuming that the fauna from Tegelen can be correlated with the Olduvai Event we have to conclude that *Allophaiomys* appears during the late Tiglian or early Eburonian just after the Olduvai Event. However, there is no consensus about the age of the Tegelen fauna. Tesakov prefers to date the Tegelen fauna before the Olduvai Event between 2.0 and 2.1 Ma. The Villanyian-Biharian transition, marked by the appearance/first dominance of *Allophaiomys*, might therefore be much older; it might be older than the 'official' Plio/Pleistocene boundary. What are the alternatives? That will be discussed during the lecture.

The Late Pliocene – Early Pleistocene terrestrial mammalian biochronology is apparently still controversial at some points. However, it is important to realize that, despite of the controversies, it is crucial for the applicability of the Plio/Pleistocene boundary on the continent that we include the mammalian biostratigraphy in the debate on the position of Plio/Pleistocene boundary since it is a major tool for long distance correlation between terrestrial deposits.

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[1] The Plio-Pleistocene boundary in the Dutch stratigraphical scheme is still at the transition of the Reuverian to the Praetiglian at about 2.4 Ma.

REVISITING THE PLIO-PLEISTOCENE BOUNDARY?

Lithological and environmental transitions in the Reuver-Tegelen and Meinweg area, The Netherlands

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In the southeastern part of The Netherlands, tectonically part of the Lower Rhine Embayment, Reuverian deposits can be clearly distinguished from those of the Tiglian by using plant macrofossil remains, pollen, mammals and non-marine molluscs. The clear replacement of forest by herbaceous vegetation as recorded in the pollen assemblages from clay layers in the Meinweg borehole is traditionally explained as a climatic signal. This climatic deterioration in the fossil record has been important for providing evidence for the definition of the Pliocene-Pleistocene boundary in NW Europe.

At the Pliocene-Pleistocene transition, a gradual change took place from extensive floodplains with vast backswamps, where clay and browncoal accumulated, into a fluvial depositional environment where deposition of clay predominantly took place in abandoned channels and floodplain depressions.

Due to sufficient accommodation space in the depositional area and the ample supply of sediments derived from the Rhine-Meuse drainage basin an up to about 200 m thick sequence of fluvial deposits was formed during the Pliocene. Within this period two major phases of extensive clay deposition are observed, i.e. Brunssumian and Reuverian. The fluvial deposits formed during the Early Pleistocene are characterized by a frequent alternation of gravel-sand and clay and it seems that the amplitude of these coarse-fine cycles gradually diminishes towards younger ages.

Existing and newly-recovered data from the Reuverian and Tiglian type-areas, together with research recently carried out on a new cored-borehole at the Meinweg site, emphasize these significant changes in the sedimentary environment. Vegetational changes as recorded around the Pliocene-Pleistocene transition in the study area seem to be in concordance with a changing fluvial environment.

However, the mainly fluvial sediments in this area show a large variation in their lithological, geochemical and mineralogical composition, as well as in their sedimentological characteristics. These variations hamper the unequivocal recognition and correlation of the really important paleo-environmental signals from the sedimentary record. The complex tectonic situation of the study area (the Reuverian-Tiglian and Meinweg area is dissected by many faults) makes this even more harmful. In addition to the sedimentary sequence, the fossil assemblages too provide evidence that ranges from local paleo-ecological significance to the impact of supraregional, or even global climatic and evolutionary changes. However, one should realize that fluvial sequences are not the result of a gradual and continuously evolved process and so the fossil evidence derived from it. A main question to be answered is whether the signals of paleo-environmental changes in this area are a result of long-term (supra)-regional change or of a local and possible momentary condition of environmental change.

Therefore a thorough knowledge of the local and regional depositional setting is a vital prerequisite for understanding of the interrelationships of individual localities (boreholes and exposures) where significant changes are recorded.

THE LOWER/MIDDLE PLEISTOCENE TRANSITION SESSION

LOWER-MIDDLE PLEISTOCENE FAUNAL TRANSITION IN THE WEST TRANSBAIKALIA

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The Early-Middle Pleistocene boundary in the West Transbaikalia is well defined by mammal faunas transition known from the several localities. This evidence was confirmed by the paleomagnetic studies in the middle sequence of the Tologoi key section. The Brunhes-Matuyama paleomagnetic boundary (0.78 Ma) was established below layer of the Middle Pleistocene Tologoi fauna (Gnibidenko et al., 1976). The reverse Jarmillo zone was observed in the uppermost Early Pleistocene deposits of this site (Zudin, 1980).

In the Tologoi section the Early Pleistocene strata are represented by sandy-loam with coarse sand and carbonates. In this layer cryogenic deformations were determined for the first time. Small mammalian fauna includes *Crocidura* sp., *Ochotona tologoica* Habaeva, *Ochotona* sp. (small size), *Spermophilus tologoicus* Erbajeva, Pokatilov, *Prolagurus pannonicus* Kormos, *Lasiopodomys* sp., *Prosiphneus* cf. *youngi* Teilhard de Chardin a.o. This species composition is characteristic for the Early Pleistocene.

To the beginning of the Middle Pleistocene accumulation of pink-brownish fossil soil took place above the previous strata. In this soil normal zone is determined by paleomagnetic study (Gnibidenko et al., 1976). The pink-brownish fossil soil is overlaid by fine pale-yellow sandy-loam containing abundant remains of small mammals. The small mammalian fauna of that time is characterized by the first appearance of the genera *Myospalax* and *Meriones*, by the diversity of microtin voles and by the abundance of *Ochotona gureevi* Erbajeva, *Allactaga sibirica transbaikalica* Erbajeva, *Eolagurus simplicidens* (Young). This faunal association is referred to Tologoi faunistic complex (Vangengeim et al., 1966; Erbajeva, 1970).

Comparative analysis of strata and faunas of the Early and Middle Pleistocene show, that they differ much by species composition and by reversed and normal polarity of time interval horizons.

Thus the Early and Middle Pleistocene boundary we provide below horizon with Tologoi faunistic complex.

MIDDLE PLEISTOCENE MARINE SEDIMENTATION IN MARCEDUSA AREA (CROTONE BASIN, CALABRIA, SOUTHERN ITALY)

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The Crotone Basin (Calabria, Southern Italy) is well known for the widely outcropping early Pleistocene deep water marine sediments, that have served as reference for the Chronostratigraphy of the interval. In addition, a well-known series of 4-5 marine terraces, mainly late Pleistocene in age, records the recent uplift of the region. The occurrence of Middle Pleistocene marine sediments in the area has been documented only recently in the inner central part of the basin (San Mauro Marchesato area), where the Brunhes-Matuyama (B/M) boundary has been detected within mid-outer shelf sediments. In correspondance with the B/M there is an ash layer (Pitagora ash), above which the sedimentation is represented by 5-7 cyclothems consisting of shallow-marine to continental deposits that contain a second prominent ash layer (Parmenide ash). The chronology of the Brunhes cyclothems and the Parmenide ash could not be established in the area of San Mauro Marchesato. Therefore, we traced the Pitagora and Parmenide ash beds with the aid of calcareous nannofossil biostratigraphy southwards, i.e. basinwards, in the area of Marcedusa, some 10 km from San Mauro Marchesato. The succession we have studied to date is ca. 172 m thick and is composed of 5 segments because the presence of faults prevents sampling along a single profile. Most probably short gaps are present in the spliced record we have reconstructed. However, in the area of Marcedusa the two ash layers occur in upper-slope/outer-shelf sediments where conventional chronostratigraphic tools used in marine sediments can be applied. Specifically, we derived an high resolution calcareous nannofossil biostratigraphy, and we are collecting quantitative data on benthic and planktonic foraminifera and pollen contents, and we are deriving a stable oxygen isotope stratigraphy (OIS). The data so far collected allow to infer that the Parmenide ash was deposited in the early part of the transition from MIS 12 to MIS 11 (ca. 400 Ka). This inference is based on the position of Parmenide ash with respect to the climatic cycles evidenced by planktonic foraminifera and OIS above the Pitagora ash (=B/M boundary). Specifically, the B/M boundary is in correspondance to an interglacial that we correlate with MIS 19 and above it we could recognize interglacials MIS 17, MIS 15 (marked biostratigraphically by the LCO in the Mediterranean of Gephyrocapsa sp3) and MIS 13. *Pseudoemiliania lacunosa* becomes extinct at the top of the MIS12-MIS11 termination (Termination V), apparently in slight contrast with data in other areas. At least another strong glacial ~~interval is present in the upper part of the mainly silty ca. 70 m thick~~ sediments overlying the Parmernide ash, that suggest the presence in the section of MIS 10 or 8. Above the section we have studied sedimentation becomes shallow marine and is represented by at least other two cyclothems. Considering the oldest marine terrace in Crotone area, previously correlated to MIS 7, and our finding in Marcedusa area, it appears that the marine Pleistocene ~~record is remarkably complete in the Crotone peninsula. The~~ finding of the marine outer-shelf/upper-slope sediments correlatable to MIS 11 is noteworthy considering the interest that sorrounds this intriguing interval of the Pleistocene. The fact that the pollen are abundant and well preserved might allow to link marine and continental climatic evolution.

THE MIDDLE - LOWER PLEISTOCENE STRATIGRAPHY IN THE NORTHEASTERN POLAND BASED ON RECENTT DATA

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Stratigraphy of the Middle-Lower Pleistocene deposits in the northeastern Poland was established on the base of analyses of the older and new boreholes, paleobotanical analyses and lithologic - petrographical investigations. Generally in the northeastern Poland there are 8 to 11 glacial horizons of the Narevian (Menapian), Nidanian, Sanian 1 (Elsterian 1), Sanian 2 (Elsterian 2), Liviecian (Führe), Odranian (Drenthe), Wartanian (Warthe) and Vistulian (Weichselian), glaciations. On the other hand, there are organic sediments of the Augustovian, Mazovian (Holstein), Zbójno (Dömnitz) and Eemian interglacials.

In the last ten years detailed geologic - cartographic studies have been carried out in the Augustów Plain area. Within the framework of these studies, 12 full-cored boreholes were drilled in the Quaternary sequence (the thickness of deposits to 300 m) that reached the older substrate. In the boreholes made in Szczebra, Kalejty, Janówka, Sucha Wieś and Zielone Królewskie a series of interglacial lake deposits of the Augustovian Interglacial, oldest in Poland, was evidenced by the results of the palynological and geological studies (A.Ber, 1996; Z.Janczyk - Kopikowa, 1996; A.Ber, Z.Janczyk - Kopikowa, D.Krzyszkowski, 1998).

In the exploratory borehole made at Szczebra, situated in the west - southern part of the Augustów Plain (NE Poland, about 12 km north - west of Augustów), a series of interglacial lake deposits of the Augustovian Interglacial, which thickness reaches 16,7 meters, are composed of sands, silts and clays with thin organic laminaes and intercalations of fossils: mollusces and snails.

These lake sediments contains quite new pollen succession, named as mentioned above the Augustovian. It comprises three cold and two temperature substages. Cold substages are characterised generally by boreal and subarctic vegetation. However, the uppermost cold substage contains additionally a short phase of climatic amelioration, marked by an increase of some trees.

The lower (I) temperature substage of the Augustovian is characterised by boreal vegetation with domination *Pinus-Betula-Larix* and *Picea* (PAZ 3, 4, 5, 6, 7). Aquatic flora - *Azolla filiculoides* suggest rather mild climate.

The upper (II) temperature substage has a typical interglacial pollen succession, with thermophilous taxons *Carya, Juglans, Celtis, Eucommia, Salvinia, Trapa* in the optimum phase (PAZ 9, 10). This pollen succesion differs distincly from pollen succession of other Polish interglacials and is very similar with Pastonian Interglacial in England or Bavelian (Leerdom) Interglacial.

The Augustovian Interglacial sediments are underlain by a till of the Narevian (Menapian?) Glaciation and are overlain by the till of the Nidanian (Elsterian 1?) Glaciation. The lowermost (Narevian) till horizon is grey, concise and its values of petrographical coefficients are as following: K/W=0,86, O/K=1,23; A/B=1,12 and Dp/Wp=0,46. Typical local rocks of this till are Palaeocene marls and their contents is very high (to 32,2%). The upper (Nidanian) till horizon (N) is greenish-grey, heterogeneous, with intercalations of silt and clay. In the lowermost part this till is horizontally interbedded by thin layers of silts. The values of petrographical coefficients are K/W=0,61, O/K=1,70, A/B=1,58. The dominant local rocks are Palaeocene and Cretaceous marls and limestones which contens is up to 5,8%. The lithostratigraphy of the tills was established on the base of petrographic and lithologic studies

(J.A.Czerwonka, D.Krzyszkowski, 1995) and its result is correlated to results of the palynological studies.The age estimates based on palaeomagnetism indicate, that Augustovian Interglacial lake sediments at Kalejty borehole developed during the time interval between the Bruhnes normal polarity and the Matuyama reversal polarity. Therefore these sediments correlate to the oxygen isotope stage 18/19. This correlation corresponding with Cromerian II Interglacial (Westerhoven) position.

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BENTHIC FORAMINIFERA ASSEMBLAGES AND OXYGEN ISOTOPE RECORDS OF EARLY AND MIDDLE PLEISTOCENE LAND-BASED STRATIGRAPHIC SECTION FROM YHE MONTALBANO JONICO AREA (BASILICATA, SOUTHERN ITALY)

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Quantitative analyses of benthic foraminiferal assemblages and oxygen isotopic analyses of the benthic *Cassidulina carinata* from the Montalbano Jonico Composite Section have provided continuous records of paleoceanographic and paleoenvironmental events occurred in the southernmost part of the Bradano Trough during the Early and Middle Pleistocene. The quantitative analysis has been carried out on the whole succession, over 400m thick, while the isotopic study has been restricted to the 230 metres placed in the middle of the Montalbano Section.

The results of the two different analyses have been compared and show a striking positive correlation: the "cold" isotopic peaks correspond to periods of shallowing and high oxygenation.

A cyclic variation of both the sea level and the oxygenation has been inferred by means of the Principal Component Analysis. Oxygen isotopic analysis shows a cyclic sequence of alternating "cold" and "warm" peaks. In some cases the □^{18}O variations are too intense to be only attributable to paleoceanographic factors and an intensification of precipitation and run-off volume can have contributed to the negative oscillations of the isotopic signal.

The correlation suggests that during the deposition the climate played an important role determining the changing of the two principal environmental parameters, depth and oxygen content. It turns out that during the cooling climatic the high ventilation of marine waters leads the mixing of the different oxygenated layers of the marine masses, thus determining well oxygenated marine waters. The positive correlation between "cold"-"warm" climatic episodes and shallowing-deepening phases suggests that these fluctuations can be related to the change in the global continental ice volume reflected by global climatic changes.

As it is highly probable that the oscillations observed in the records can be the result of climatic processes governed by astronomical cycles, they could be suitable for an orbital tuned chronostratigrapy of the Montalbano Section.

VEGETATIONAL HISTORY ACROSS THE BRUNHES - MATUYAMA BOUNDARY IN THE CROTONE BASIN (CALABRIA, SOUTHERN ITALY)

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Recent work has shown that Middle Pleistocene sediments are widely outcropping in the Crotone Basin (Calabria, Southern Italy). Specifically, in the area of San Mauro Marchesato, the Brunhes/Matuyama boundary has been confidently recognized in the Valle di Manche section, where slope to outer shelf sediments are present [Rio et al., Geology, 24, pg. 743-746, 1996]. In this work we report the results of the study of the pollen contents of this section that spans the interval from MIS 22 to 18. The pollen content of the 53 analyzed samples is fairly good (total sum ranging from 200 to 1050 pollens per sample, average of 350 grains per sample). A total of 89 pollen types were determinated, thus indicating the great floristic diversity in the Central Mediterranean during the time span considered. Some archaic taxa (Haploxylon-type Pine, Cedrus, Tsuga, Zelkova, Juglandaceae, Hamamelidaceae) are found up to the base of the Middle Pleistocene. Previous literature data indicated these plants disappeared from Europe during the early Pleistocene. We interpret that most probably Southern Italy might have acted as a refugium for these taxa. Except for the aforementioned taxa, the retrieved pollen assemblages resemble the present day flora of Calabria. Pinus percentages are remarkably high as for most of Mediterranean marine sediments, therefore it was removed from the total sum for the statistic analysis. All of the other taxa were then split into 7 ecological groups:

1. Mediterranean vegetation: evergreen trees and shrubs (mainly ilex-type oaks; olive tree, ash, etc);
2. Mesic oak forest: broad-leaved, deciduous trees (mainly oaks; elm, hornbeam, lime, etc);
3. Mountain elements: altitude conifers (silver fir and spruce) and broad-leaved trees (beech and birch);
4. Other AP: riparian trees and tall shrubs (alder, poplar, willow);
5. Steppe plants: herbs and low shrubs typical of arid and coastal environments (Artemisia, Ephedra and Chenopodiaceae);
6. NAP (Non Arboreal Plants): herbs forming common grasslands.

Meaningful climatic information are derived from the distributions of combined group 1 and 2 (Mediterranean and mesic oak forest elements), group 3 (mountain elements), and the combined groups 5 and 6 (NAP). Three major climatic cycles are evidenced by vegetational changes that match cycles evidenced by physical stratigraphy . Specifically, transgressive ~~surfaces (TS) occur during the late glacial conditions, whereas maximum flooding surfaces~~ (MFS) correlate with climatic optimum similar to present day conditions. Each vegetational cycle is structured into three major phases:

1. Mesic forest dominance: testifies a warm and moderately humid climate (strictly seasonal precipitation rates at about 600 mm/yr.), hence resembling early to full interglacial conditions (present day climate in southern Italy);
2. Mountain elements dominance: typical of cool and moist climate (regular, non-seasonal precipitation rates at more than 1000 mm/yr.) which marks the transition from interglacial to glacial conditions (late interglacial);
3. NAP dominance: indicates cold and dry climate (precipitation rates at less than 400 mm/yr., irregularly scattered over the year) correlated with full glacial conditions.

The onset of the Brunhes Chron occurs in interglacial conditions, in agreement with deep-sea sediments results and contrary to what established in loess sequences of China. By considering other biomagnetostratigraphic constrains it appears that there is a good match between vegetational cycles and deep sea oxygen isotope stratigraphy, as already shown by other authors in long Pleistocene pollen records. Specifically, our data allow to confirm that within the section MIS 22, 21, 20, 19, and part of 18 are present. In addition, pollens seem to reflect in some instances also minor climatic oscillations within oxygen isotope stages. In particular, the two-folded MIS 19 (19.1 and 19.3) seem to be represented in the pollen spectra, whereas it seems to be more difficult to identify the three peaks of MIS 21 (21.1, 21.3 and 21.5). Finally, it is worthy mentioning the good preservation in the section of glacial deposits that is unusual for a shelf setting. Evidently subsidence, enhanced by the positive feedback of sediment loading, was high enough to keep pace with sea level lowering.

THE COMPOSITE SECTION OF MONTALBANO JONICO: A CONTINUOUS MARINE QUATERNARY SUCCESSION IN SOUTHERN ITALY

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In the southernmost part of inner border of the Southern Apennine Foredeep (Montalbano Jonico, in Basilicata) a continuous succession Lower and Middle Pleistocene in age has been studied with different methodologic approaches. The succession forms a monocline setting gently dipping towards the Gulf of Taranto. The composite section, over 470 m thick, has been reconstructed by means of the correlation of several stratigraphic sections: *Entalina*, *Fosso Giuseppe*, *5 Agosto*, *Venus bassa*, *Dito del Diavolo*, *Ideale*, *Vecchietto* and *Molino*). These are characterised by some volcaniclastic layers and by related peculiar macrofossil assemblages that have been used as guide horizons for correlations: other lithostratigraphic features and biostratigraphic data further improved the reconstruction of the whole succession.

The composite Section mainly consists of badly stratified muds and silty muds, whose lowest part (*Fosso Giuseppe*, *5 Agosto* sections) is characterised by several mass deposition events. Near the top (*Vecchietto* p.p. and *Molino* sections) the succession mainly consists of stratified sandy silts. Biostratigraphic analisyes on nannoflora assemblages allowed to recognize three biozones: large *Gephyrocapsa* Zone p.p., small *Gephyrocapsa* Zone and *Pseudoemiliania lacunosa* Zone p.p.. The potential GSSP of the Lower-Middle Pleistocene could be located within the *5 Agosto* Section at the small *Gephyrocapsa* and the *Pseudoemiliania lacunosa* zonal boundary.

The upward changing of the facies sequence, from the upper slope hemipelagic muds in the basal part to the inner shelf coarser silty muds and silts in the upper part, supported by biocoenotic assignment of paleocommunities and by taphofacies identification, suggests a general regressive trend. More detailed sedimentologic, paleoecologic and taphonomic analyses indicate a higher frequence cyclicity testified by several shallowing-deepening episodes. Detailed isotope geochemical analyses, together with changes recorded in benthic foraminiferal and macrofaunal assemblages, suggest fluctuations of depth of the sedimentary basin and of the oxigen content in the bottom waters and in the sediment, confirming the above-mentioned higher order cycles. The observed cyclicity could be related to climatic fluctuations probably linked to change in orbital parameters.

NEW CHRONOSTRATIGRAPHIC AND PALEOCLIMATIC DATA FROM THE 'ISERNIA LA PINETA' SITE, MOLISE, ITALY.

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The archaeological deposits of Isernia la Pineta are a milestone in the European context, being composed of more than one very rich and large-sized occupation layer. The archeological remains are characterized by the use of anvil in a framework of a very opportunistic and rapid way to produce a large number of flakes and residual cores, usually of very small size. The analysis under a scannner microscope demonstrate that the flakes are real instruments utilized to take the flesh off the bone and for wood works. The lithic instruments are associated with remains of large mammals which give a clear indication of the diet.

They are represented by *Bison schoetensacki* Freudenberg, *Stephanorhinus hundsheimensis* Toula, *Elephas (Palaeoloxodon) namadicus* Falconer e Cautley, *Ursus deningeri* von Reichenau, *Hippopotamus* cf. *antiquus* Desmarest, *Sus scrofa* L., *Hemitragus* cf. *bonali* Harlè e Stehlin, *Megaceroides solilhacus* Robert, *Cervus elaphus* cf. *acoronatus* Beninde, *Dama dama* cf. *clactoniana* Falconer, *Capreolus* sp., *Panthera leo fossilis* von Reichenau.

The rodent fauna is represented by *Clethrionomys* sp., *Pliomys episcopalis* Mèhely, *Pliomys lenki* Heller, *Microtus* aff. *arvalis* Pallas, *Microtus brecciensis* Gieber, *Microtus (Terricola)* gr. *multiplex-subterraneus*, *Arvicola cantiana* Hinton. The insectivores are *Talpa* sp., *Sorex* cf. *runtonensis* Hinton, *Crocidura* sp.

Two main archaelogical layers have been identified. The lower one (sector I, lay.3c) rests on a phytoclastic travertine passing laterally to a phytohermal travertine which generated a small step in the watercourse. A sandy silt layer probably of lacustrine environment associated with travertine pools cover this layer. The second layer (Lay.3a) rest on these sediments as well as on phytohermal travertine. Cross bedded fine gravelly sands covers the deposits and are interlayered with tuffs very rich in pyroxens and sanidine. The latter gave an Ar/Ar age of 505+/-10 ka (2σ error). The layers are covered by cross bedded gravels lately weathered by Alfisols. Inside the uppermost part of the series composed of gravels and colluvia another pyroclastic layer crops out. Sanidines of this layer have been Ar/Ar dated at 503+/-12 ka.

The Isernia travertines, not associated with hot water springs, indicate that the area was frequented at the end of an Interglacial period. The new ages suggests that the human frequentation occurred at the beginning of the Middle Pleistocene.

THE SEQUENCE OF GRAN DOLINA AT ATAPUERCA AND THE EARLY-MIDDLE PLEISTOCENE TRANSITION

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The transition of the Early to the Middle Pleistocene coincides with a turnover in the European mammalian fauna without comparison in the past 30 Ma. The turnover coincides with, and probably results from, the establishment of the glacial cycles and consists of a series of dispersal and extinction events that followed each other rapidly in the period between about 1.2 and 0.7 Ma. Most of the events can be well calibrated with the aid of palaeomagnetism.

The sequence of Gran Dolina (abrreviated as TD) in the Sierra de Atapuerca (Burgos, Spain) is well known for the Early Pleistocene remains of Homo antecessor that were described from the level TD6. The locality is a fissure filling with a stratigraphic thickness of over 18 m and with eleven stratigraphic units: TD1 (bottom) to TD11 (top). The Brunhes-Matuyama boundary, and thus the Early-Middle Pleistocene transition, has been identified in unit TD7. Units TD3/4to TD6 have reversed polarity. Arvicolid fossils suggest a major hyatus in TD8; the lower part of this unit is earliest Middle Pleistocene. The fossil bearing units TDW3/4, TDE5, TD6, TD7 and TD8 inf. provide a sequence that crosses the Early-Middle Pleistocene transition.

A sequence of events can be recognized in the Gran Dolina section, as well as in other European localities that permit a detailed biostratigraphy around the Early-Middle Pleistocene transition.

1) The late early Pleistocene is characterised by the cladogenesis of the unrooted arvicolid rodent *Microtus* s.l. The *Microtus* diversification may have started around the Jaramillo paleomagnetic event in Spain, which is earlier than in northern Europe, and the main lineages of this group are found in units TD3/4-6: *Microtus* s.s., *Terricola*, *Iberomys*, and *Stenocranius*.

2) The dispersal towards western Europe of the red deer *Cervus elaphus* (present in TDW4, TD6 and TD8 inf.) and the wild boar *Sus scrofa* (in TD6, and possibly even in TDE5).

3) The last appearance of *Allophaiomys* (still present in TD3/4-6), Stenocranius (still present in TD3/4-6) and the giant cervid *Eucladoceros giulii* (TD3/4-6). Material from TD8 inf. either belongs to the latter species or to *Megaloceros soleilhacus* (= *M. verticornis*), which is certainly present in Huescar 1 and Voigtstedt. These events may more or less coincide with the appearance of a new ovibovine. In TD7 a large and robust ovibovine is found, that differs from the gracile *Praeovibos* sp. from Venta Micena. The fossils probably belong to either *Ovibos suessenbornensis* or *Preovibos* priscus.

4) The replacement of the rhino *Stephanorhinus etruscus* (present in TD4W-TD8 inf. as well as in Huescar 1) *by S. hundsheimensis* (present in Voigtstedt).

5) The replacement of the arvicolid *Mimomys savini*, which has its last record in the earliest Middle Pleistocene localities as Atapuerca TD8 inf., Huescar 1, Kärlich F, Voigstedt, Sussenborn, West Runton, and Westbury Sub Mendip, by *Arvicola cantianus* (present in Isernia la Pineta, Mosbach 2, etc). Some authors use this transition as the biostratigraphical marker of the early/middle Pleistocene boundary in Europe.

Events 2-5 cover a period of probably less than 100 ka on each side of the Brunhes-Matuyama boundary (between events 3 and 4), which means that they are on average some 50 ka apart. This implies that mammal biostratigraphy has the potential to correlate the Early / Middle Pleistocene boundary with great precission

PLEISTOCENE DEEP-SEA DEPOSITS IN THE BRADANO TROUGH (BASILICATA, SOUTH ITALY). MACROBENTHIC ASSOCIATIONS AND PALAEOENVIRONMENTAL EVOLUTION.

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A silty-clayey succession over 500 m thick, ranging in age from the Lower to the Middle Pleistocene crops out in the Bradano Trough near Montalbano Jonico. It presents a general regressive trend from bathyal to shallow sublittoral, with several shallowing-deepening cycles.

In the present paper the bathyal part of the succession, consisting of three Sections whose total thickness is about 180 m, has been studied, focusing on macrobenthic associations and palaeoenvironmental evolution. The basal part – so-called Entalina Section, 12 m thick – is referred to the "large" *Gephyrocapsa* Zone; the intermediate one – Fosso Giuseppe Section, 110 m thick – belongs to "small" *Gephyrocapsa* Zone and is topped by a volcaniclastic layer (V 1) used as a guide-horizon in the area. The uppermost part – 5 Agosto Section - includes the V 1 horizon and is exposed for a thickness of 56 m: the lower part of this section is still Lower Pleistocene in age ("small" *Gephyrocapsa* Zone), while the upper one is referable to the Middle Pleistocene (*Pseudoemiliania lacunosa* Zone).

The analyses were carried out mainly in the field, observing in continuum faunal distribution, trace fossils, sedimentary features and collecting significant macrofauna specimens from each 2 dm^3/1 m in volume; in addition several bulk samples have been examined. In the studied succession the macrofauna is highly dispersed, locally absent and often badly preserved; trace fossils rarely show high diversity and the bioturbation index is strongly variable. The muddy sediments, generally massive, present some laminated intervals whose bedding planes are covered by more or less continuous films of fine sands.

The muddy sediment at the base of Entalina Section contains an association strongly dominated by articulated and dispersed molluscs belonging to bathyal species (i.e *Dentalium agile*, *Entalina tetragona*, *Bathyspinula excisa*, *Delectopecten vitreus*). The shelly content rapidly decreases upward and *Chondrites* ispp. become dominant: molluscs suggest a palaeodepht of 500-600 m, while ichnofossils indicate bottom disaeroby.

The composite Section (Fosso Giuseppe plus 5 Agosto Sections) consists of massive muddy sediments alternated with thin siltier muddy beds - rich in bioclastic debris and marine plants remains- marked by very fine sandy laminae or lenses.

Taphonomical and physical features of silty muds strongly suggest mass deposition events. Trace fossils diversity and abundance are strongly variable and clearly related with cyclic fluctuations in the oxygen content. The macrofaunal associations indicate ciclyc changes of depth with ranges from 300-400 m up to 150-200 m. The deeper associations are characterized by *Katadesmia confusa*, *Neilonella pusio*, *Dentalium agile*, *Bathyspinula excisa*, *Delectopecten vitreus*, the shallower ones by *Alvania testae*, *Nassarius cabrierensis*, *Abra longicallus*, *Kelliella abyssicola*, *Fissidentalium "rectum"*.

The major cycles involving fluctuations of both sea-level and oxygen content, seem to be mostly climatically controlled since oxygen depletion and shallowing are accompanied by organisms indicator of cooling phases.

THE PLIO-PLEISTOCENE DEPOSITS IN THE SOUTHERN FORE-URALS: TYPE AREAS AND SECTIONS

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The Upper Pliocene, Early Mid-Pleistocene scheme in the Southern Fore-Urals is as follows:

General Stratigraphic scale (ISC of Russia, 02.02.1995)	Horisons The East European Platform (Krasnov, Zarrina, 1987; Alexandrova, 1988)	The Southern Fore-Urals		The Netherlands (W.H. Zagwijn, 1996)	The Southern Europe (Berggren et al., 1995)
		Suites / Layers (Yakchemovitch et al., 1981, 1988; RISC, 1999)	Type sections		
Lower Neopleistocene	Oka	Chusovskoye	Sultanaevo	Cromerian	
	Muchkap	Chui-Atasevo	Chui-Atasevo		
	Don				
	Iljinsk				
	Pokrovsk	Minzityarovo	Minzityarovo		
	Petropavlovo	Oktober	Oktyabrskyi		
Upper Eopleistocene		Karmasan	Symbugino	Bavelian	Calabrian
Lower Eopleistocene		Davlekanovo	Akkulaevo		
			Ulushevo	Menapian	
		Dema	Akkulaevo	Waalian	
				Eburonian	
Upper Aktchagyl	Kryzhanovka	Voevodskoje	Voevodskoje	Tiglian	Gelasian
Middle Aktchagyl	Akkulaevo	Akkulaevo	Akkulaevo		
	Chistopol	Zilim-Vasiljevo			

Zilim-Vasiljevo suite of the Middle Aktchagyl. Deposits formed by black coal clay with gravel and shingle in it's base. Blue-gray, green-gray, brown aleurite clays (4-40 m) with sand's interlayers are above. Flora of this period was closely to the modern one: it was akchagyl flora proper. *Picea-Pinus* forests predominated in the north, *Picea* forests with *Tsuga, Pinus* grew in the south. Ostracoda fauna developed from euryhaline to brackish-water. Deposits correlated with the lower part of the paleomagnetic r-Matuyama epoch: their top coinsided often with the base of n-Reunion episode.

Akkulaevo suite of the Middle Aktchagyl. The lower marine part (8-25 m) of these deposits represented by sands and clays formed during second (maximum) Aktchagyl ingration contained brackish-water, marine molluscs (*Cerastoderma, Aktschagylia, Clessiniola ets.*) and ostracoda ~~(Yakchemovitch et al., 1992, Danukalova, 1996). The upper part (5-15 m)~~ formed by deltaic sands with clay's and shingle's lens, with marine and fresh-water (levantine) molluscs and small mammals fauna of the Haprov complex. This period characterised by akchagyl flora. *Picea* forests with small numbers of *Abies, Pinus* and *Tsuga* grew at the beginning of this time; *Betula*-broad leaf forests and xerophytic steppe changed them; then coniferous appeared, and taiga ~~phase became. The end of this time was warm and *Betula*-~~ broad leaf forests with herbage steppe grew. Deposits correlated with the paleomagnetic r-Matuyama epoch.

Voevodsky suite of the Upper Aktchagyl overlie the marine deposits (Akkulaevo layers of the Middle Aktchagyl) with the erosion. A lower part represented by alluvial sediments with disseminated of iron hydroxides (2,5 m). The upper — by estuarine facies of the third Aktchagyl ingration (2,8-10 m), where one can see: a) transgresive deposits — shingle, coquina and marly aleurite with *Cerastoderma, Aktschagylia, Dreissena,* ostracoda and foraminifera (Danukalova, 1996); b) regressive deposits of the drying estuary. This period characterised by *Graminea*-herbage steppe and forest-steppe at the beginning then *Betula-Pinus* forests and *Picea* forests (taiga) at the end. Deposits correlated with the upper part with the rn-Ilchembet episode of the paleomagnetic r-Matuyama epoch.

Dema suite of the Lower Eopleistocene. A lower part represented by alluvial, lacustrine sediments (2-10 m); the upper cold part — by red-brown lacustrine loams (1-3 m) with marlaceous concretions. This period characterized by *Pinus-Betula* forests and herbage steppe at the beginning; singles pollens of *Pinus sect. Cembrae, Picea excelsa Link.* and herbage determined from sediments of the end of this period. Small mammals fauna of the lower part corresponds with Odessa complex with *Promimomys moldavicus jachimovichi Suchov, Prolagurus (P.) cf. praepannonicus Topač., Allophaiomys cf. pliocaenicus Kormos.* Typical molluscs are *Bogatchevia ex gr. sturi (Horn.), Corbicula apscheronica Andrus., Viviparus aff. tiraspolitanus Pavl., V. subcrassus Lung., Lithoglyphus neumayeri Brus., Bithynia vucotinovici Brus.* The upper part contains *Candona aff. candida (O.Müll.), Eucypris ex gr. horridus (Sars), E. famosa (Schn.)* and *Denticulocythere producta (Task. et Koz.).* Subaerial deposits formed on the interfluves. The paleomagnetic Olduvai Event which correlated with the Pliocene-Pleistocene boundary located in the lower part of this unit.

Davlekanovo suite of the Lower Eopleistocene. A lower part represented by alluvial sediments of small rivers (0,6-2 m); the upper part — by lacustrine loams (0,2-3 m). Small mammals fauna of the lower part corresponds with Odessa complex with *Lagurus (Lagurodon) cf. praepannonicus Topač., Allophaiomys pliocaenicus Kormos* and molluscs — *Bogatschovia scutum Bog., B. subscutum Tshep., Microcondylaea apsheronica Tshep., Pseudosturia brusinaiformis Modell, Unio chasaricus Bog., U. apscheronicus Alizade.* This period characterised by broad leaf forests in river valleys; interfluves were covered by open woodlands. This period correlated with the n-Jaramillo event of the paleomagnetic r-Matuyama epoch.

Karmasan suite of the Upper Eopleistocene. A lower part represented by alluvial shingles and sands (0,9-1,5 m). This period characterised by forest-steppe (small forests consisted of *Pinus, Picea,* broad leaf taxa, *Betula, Alnus*) on the north of the region and by steppe with herbage, *Artemisia, Chenopodiaceae* and *Gramineae* on the south. Climate was warm and dry. The upper part represented by dark-brown, red-brown lacustrine loams (1,8-2,1 m) with white-pink marlaceous concretions.

Oktober layers of the Lower Neopleistocene. These deposits are in deep river valleys below their modern level (10-40 m); represented by alluvial cobble in the base and sands with pebble lens (6-8 m). Climate of this period was warm. Mammals fauna corresponds with Tiraspol complex: *Archidiskodon trogontherii wüsti (Pav.), Elasmotherium sibiricum Fischer, Panthera sp., Megaloceros sp.*

Minzityarovo layers of the Lower Neopleistocene. Represented by lacustrine loams (3-4 m) with *Archidiskodon trogontherii (Pohl.).* It's upper part was of periglacial genesis.

Chui-Atasevo suite of the Lower Neopleistocene. Represented by sand-cobble alluvium, lacustrine-talus periglacial deposits and alluvial deposits (4-6 m). The lower (warm) alluvial part characterised by fauna of freshwater and terrestrial molluscs and Tiraspol fauna of small mammals: *Microtus (Pitymys) gregaloides Hinton, Mimomys (Microtomys) pusillus Mehely, Mimomys (Cromeromys) intermedius Newton, Lagurus transiens Janossy.* The middle part of these deposits formed in the cold climate. The upper alluvium with *Arvicola mosbachensis Schmidtgen* formed in the warm climate.

Chusovskoye layers of the Lower Neopleistocene. In the extraglacial region they represented by lacustrine and lacustrine-talus periglacial deposits (sands and loams) (8 m).

LOWER-MIDDLE PLEISTOCENE BOUNDARY IN BOSO PENINSULA,JAPAN

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The Internal Research Group for the Lower-Middle, Middle-Upper Pleistocene Boundary, Japan Association for Quaternry Research was organized as a formal research group by Japan Association for Quaternary Research. Mostof the group members belong to the Association. After the XI INQUA International Congress, highly resolved analyses were carried out by the group. The studies are not only lithostratigraphic but also bio-, magneto-, chrono-stratigraphic based on the International Stratigraphic Guide.The candidate stratotype of the Lower-Middle Pleistocene boundary is situated along the middle course of the Yoro River, in the middle part of the Boso Peninsula, about 80km southeast of Tokyo. The boundary is defined in the Kokumoto Formation which is in the Kazusa Group. The greater part of the formation is marine sediment and intercalated tuff beds. About 5m of magnetic intermediate beds were recognized between Matuyama reversed beds and Brunhes normal beds. The Shirao Ash bed intercalated 1m below the boundary between normal and intermadiate zones. We propose the base of the Shirao Ash bed as the Lower-Middle Pleistocene Boundary.
According to the analysis of planktonic foraminifera, the warm Kuroshio current has been intensified just above the boundary, and also the horizon of the first appearance of the calcareous nannofossil Reticulofenestra asanoi is recognized just below the boundary. The isotopic age of the Ku 5B Tuff, which is intercalated about 130m below the boundary is 0.87 + 0.17 Ma. The type locality is situated alng the river and is easily visited. The boundary is established in continuous marine sediments which can be observed along the river bank and river bed. It is very clear because the bottom of the tuff bed can be traced around a wide area. The location and ease of tracing are due to the characteristic rock facies which includes hornblende.

RODENT (RODENTIA) FAUNAS ON EARLY - MIDDLE PLEISTOCENE TRANSITION BY MATERIALS FROM THE RUSSIAN PLAIN

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The number of localities with rodent remains related to the Early-Middle Pleistocene transition have been found on the Russian Plain. Their analysis permitted to establish the principal stages in the evolution of rodents during Early – Middle Pleistocene on the basis of the appearance of new taxa (Markova, 1992, 1998). The multi-disciplinary studies were carried out on the most of these localities. They included geological, paleopedologic, and paleomagnethic investigations. These complex studies permitted to elucidate the main features of rodent species composition below and above the Brunhes-Matuyama boundary.

Several localities were found below Brunhes-Matuyama boundary: Karai-Dubina (Dnieper basin), Petropavlovka, Krasnyi Log (Don basin), Priozernoe (Taman Peninsula). Their species composition includes a few late *Mimomys* (*M.savini, M.pusillus*) and advanced *Allophaiomys*; abundant steppe and yellow lemmings (advance type of *Prolagurus pannonicus* and *Eolagurus argyropuloi*), numerous *Microtus (Stenocranius) hintoni* and the first representatives of *Microtus* genus – *M.* ex gr. *oeconomus* (Markova, 1982; Agadjanian, 1992, Rekovetz, 1994). These type of faunas were described first by L.Alexandrova (1976).

It had been established before that *Microtus* species were absent in older Morozovian Assemblage, where only primitive *Terricola*-like voles were found (Markova 1998).

Kairian small mammal Assemblage which is still older than Morozovian small mammal faunas corresponds to the Jaramillo paleomagnethic event and contains only *Allophaiomys pliocaenicus*. The *Terricola* and *Microtus* voles are absent here (Iosifova et al., 1998; Dodonov et al., 1998, Markova, 1998). The morphology of *Allophaiomys* from these localities is very close to that of this species from Colle Curty (Italy), which also correlates with Jaramillo (Masini et al., 1998)

There are also some localities on the Russian Plain that contains more advanced faunas than the Petropavlian one. The Shamin locality (Don basin) has yielded teeth of *Microtus arvalinus* as well as remains of *Microtus (Stenocranius) hintoni* and *Prolagurus posterius*. This site is correlated with the very end of Matuyama Chron. Shamin fauna is more advanced than Petropavlian ones and has been attributed to the Early Tiraspolian fauna (Markova, 1982,1998).

Some small mammal localities were found above the Brunhes-Matuyama boundary. The earliest of them contains the rodent faunas closely resembling the Shamin fauna. One of them is Early Tiraspolian fauna from Litvin locality (Taman Peninsula) has been discovered from the Chauda marine deposits dated to the beginning of Brunhes Epoch and has yielded the remains of *Mimomys savini, Allophaiomys pliocaenicus, Prolagurus pannonicus, Eolagurus simplicidens gromovi, Microtus (Stenocranius) hintoni* and *Microtus (Microtus) arvalinus* (Markova, 1992).

Thus, the numerous data permitted to establish the history of rodent faunas during Early-Middle Pleistocene transition on the Russian Plain.

DISTRIBUTION OF *RETICULOFENESTRA ASANOI* AND *GEPHYROCAPSA* SP. 3 AT MONTALBANO JONICO SECTION (SOUTHERN ITALY) AND ODP SITE 964 (IONIAN SEA): BIOSTRATIGRAPHIC TOOL AT THE LOWER-MIDDLE PLEISTOCENE BOUNDARY

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The composite section of Montalbano Jonico, about 500 metres thick, consists of silty clays to muddy silts belonging to the Argille subappennine Formation. The whole section extends from the large *Gephyrocapsa* Zone to the *Pseudoemiliania lacunosa* Zone and may represent a potential Lower-Middle Pleistocene boundary stratotype section (see discussion in Cita & Castradori,1994).
The FO of *Gephyrocapsa* sp. 3, which can be considered as a primary marker for the recognition of the potential Lower/Middle Pleistocene boundary is recorded in this section. In addition the usefulness of supplementary bioevents which occur close to the Lower/Middle Pleistocene boundary has been tested both in the Montalbano Jonico section and in the ODP Site 964 (Ionian Sea). In particular, the abundance pattern of *Reticulofenestra asanoi* is documented and compared between the two sequences. The biostratigraphic meaning of FO and LO of *R. asanoi* is subject of controversy: unclear taxonomy has greatly prevented so far the evaluation of potential utility of FO and LO of *R. asanoi* as well as of correlation of these events among different geographic areas. Our results indicate that circular to subcircular specimens of *R. asanoi* > 6 micron in size show a well distinct abundance pattern which may improve the biostratigraphic resolution in the Lower/Middle Pleistocene interval. Consistent dilution of nannofossil assemblages from the on-land section, caused by reworking and inorganic input, do not prevent the events to be detected; moreover the stratigraphic relationships among the FO and LO of *R. asanoi* and the FO of *Gephyrocapsa* sp. 3 are well comparable between deep-sea cores of Site 964 and the Montalbano Jonico section.
The oxygen isotope curve from Site 964 provides the opportunity to correlate the distribution of *R. asanoi* to the isotope stages of Sprovieri et al. (1998). In this framework, abundance patterns of *Gephyrocapsa* sp. 3 and *R. asanoi* could provide calibration points for the interpretation of the available isotope record for the Montalbano Jonico section.

Reference

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THE LEAF FLORA OF ORIOLO: AN INSIGHT INTO THE VEGETATION AND CLIMATE OF THE LOWER TO MIDDLE PLEISTOCENE TRANSITION

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In the years 1980s and 1990s the sandy succession of in the quarry "La Salita", near the village of Oriolo (Faenza, prov. Ravenna), assumed a considerable palaeontological importance due to the recovery of several Mammal remains, more or less complete, assigned to: *Mammuthus meridionalis* cf. *vestinus, Bison* cf. *schoetensacki, Stephanorhinus hundsheimensis, Hippopotamus* sp., *Pseudodama* sp.. In the meantime a rich collection of reddish leaf impressions (and a few fruits and seeds) was gathered from several fine grained layers of the basal half of the same succession. This material, conserved at the Museo Civico di Scienze Naturali di Faenza, is now under the investigation by ~~the~~ present authors.

The age of the section, which is nearly 20 m thick, has been recently fixed by integration of Mammal biochronology and magnetic stratigraphy (Marabini et al., 1995; Torre et al., 1996): the palaeomagnetic analysis showed a reversed interval followed by a normal one, while the Mammal association indicated a latest Villafranchian to early Galerian age, and suggested to correlate the foregoing magnetic reversal with the Matuyama/Brunhes boundary. Therefore the fossil flora of Oriolo may be considered a key-record of the vegetational and climatic conditions at the Lower to Middle Pleistocene transition.

The leaf assemblages of Oriolo represent masses of continental plant debris drifted into the shallow-marine basin during distinct flood events, each one recorded by a fine-grained layer containing chaotically disposed leaf laminae. Several samples contain mainly whole leaf specimens, suggesting that fragmentation during transport has not been dramatic. The completeness of leaves and the prevalence of specimens with distinctive leaf architectural features permits to assign them to about three dozens of taxonomic groups. In addition, by comparison with the architectural features and intraspecific variability observed in leaf samples of modern species, we have been able to suggest the botanical affinity of most of these groups, in order to draw ecological and environmental conclusions.

Some of the leaf taxa distinctly indicate the existence of a riparian forest (*Salix, P. alba, P. nigra, Alnus.*); other forms indicate a forest grown under more mesic conditions, possibly on a floodplain (*Carpinus betulus, Pterocarya* sp., *Carya* sp., *Parrotia* cf. *pristina, Zelkova* sp., *Fraxinus* cf. *oxycarpa* etc.). Furthermore, the sediments of Oriolo have incorporated leaf remains originating from the surrounding slopes, covered by woody plants requiring very well-drained soils: *Quercus petraea, Hedera cf. helix, Quercus cerris, Tilia* sp., *Acer opalus, A. campestre, A.* aff. *palmatum*). Interestingly, a set of species which could grow in such an environment, seem to indicate clearings with sunny conditions: *Berberis, Acer monspessulanum, Coriaria, Pyracantha* cf. *coccinea, Acer opalus, Carpinus orientalis, Crataegus* cf. *monogyna.*

To conclude, the flora of Oriolo shows a very special composition, with a dominance of plants which are identical or similar to the ones growing today in the same region, accompanied by a few exotic taxa (*Carya* and *Tsuga*: Eastern North America and East Asia; *Pterocarya, Zelkova* and *Parrotia*: East Asia, Caucasus, *Z.* relic in S-Europe; *Acer* aff. *palmatum* and a bamboo type: East Asia). From the climatic point of view this situation suggests temperature and rainfall values very close to the modern ones: There is no indication either in favour of summer draught (the typical Mediterranean plants are lacking) or in favour of severe winter frost.

TIMING AND DISPERSAL PATHWAYS OF THE LATE VILLAFRANCHIAN SABER-TOOTHED TIGERS *MEGANTEREON* AND *HOMOTHERIUM.*

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The comparative anatomical and morphometrical analyses of the Early Pleistocene Machairodont genus *Meganteron* from the sites of Venta Micena, Apollonia and Dmanisi (Martínez-Navarro & Palmqvist 1995; 1996) revealed the occurrence of the African species *Meganteron whitei* Broom in these sites. This African form substituted the late Pliocene the European species of the same genus *Meganteron cultridens* Cuvier. The occurrence of this species outside Africa is related to the first evidences of human presence in the Iberian Peninsula (Orce), the Caucasian Region (Dmanisi) and probably also in the Middle East ('Ubeidiya).

The analysis of *Meganteron* remains from Pirro Nord (Puglia, Southern Italy) has revealed the presence of this same African species in this Italian Early Pleistocene faunal assemblage.

Similar studies are in progress concerning the comparative anatomical and morphological analyses of *Homotherium*, the other Early Pleistocene Machairodont genus recorded in most of the European sites.

THE PLEISTOCENE SUCCESSION OF S. MAURO MARCHESATO (CROTONE BASIN, CALABRIA, SOUTHERN ITALY)

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A deformed, markedly cyclical, Lower- to Middle Pleistocene succession is present in the territory of S. Mauro Marchesato (Crotone area, southern Italy), showing an overall shallowing trend from slope mudstones to marginal marine and continental deposits. Preservation and high resolution of sequences were allowed by the interaction between high-amplitude relative sea-level fluctuations, a particular pattern of differential subsidence due to intrabasinal tectonics, and high rates of sediment supply.

The lower part of the succession (H. sellii and "large Gephyrocapsa" Zones, from ca. 1.65 to ca. 1.25 Ma) is represented by slope to outer-shelf monotonous muds. A major angular unconformity resulting from regional tectonic warping is thought to mark the onset of development of the S. Mauro sub-basin within the Crotone basin and is accompanied by a major biostratigraphic gap suppressing locally the entire "large Gephyrocapsa" Zone (1.608-1.238 Ma). Sediments above the unconformity are referred to the "small Gephyrocapsa" Zone (1.238-0.96 Ma). The S. Mauro sub-basin developed in a dextral transtensile bend of an extensional fault system, with gentle folding and variable stratal tilting resulting from hangingwall deformation related to listric fault geometry of boundary faults.

Within the "small Gephyrocapsa" Zone a number of sequences developed in an outer- to inner-shelf environment. Bio-magnetostratigraphic constraints strongly support a correlation of the transgressive events of the sequences with MIS (Marine Isotope Stage) 33 to 25, and an origin linked to glacio-eustatic fluctuations with periods of about 40 ky. Shell concentrations and microbenthic assemblages of this interval display characteristic patterns related to different systems tracts of the sequences.

From the base of P. lacunosa Zone (at ca. 0.96Ma) onwards, the succession is dominated by shelf to nearshore deposits and a change from an essentially pelitic to sand-dominated sedimentation occurs. This sedimentary record is remarkably cyclothemic, characterized by a stack of simple or composite (polycyclic) seaward-prograding tongues, made up of sand or sandy gravel, mixed with a locally high bioclastic fraction, with intervening aggrading deposits, related to transgressive-deepening episodes. Two tephra layers, named Pitagora and Parmenide ash, provide mappable isochronous surfaces across the sub-basin, and are extremely useful for correlation purposes. The change from muddy to sand-dominated sedimentation can be confidently correlated with the major climatic shift associated with MIS 24-22. Presence of abundant "cold guests" like Arctica islandica provide evidence that shoreface tongues of the lower part of S. Mauro succession were built out for the most part during the falling stages of glacioeustatic cycles. A correlation with the oxygen isotopic record is definitely feasible up to the Matuyama-Brunhes inversion, i.e. up to stage 19.

The upper part of S. Mauro succession shows a progradational stacking pattern of the sequences, with incorporation of increasing amounts of marginal-marine to continental deposits. This reflects a progressive slowing down of the subsidence rate. As a result, sequences are increasingly incomplete. Dating cyclothems of this part of the succession is more problematical, as chronological constraints are poorer, and probability of some sequences or parts of sequences being missing is remarkably high. However an important age-constraining datum has been obtained in the much deeper-water coeval succession of Marcedusa area (southern part of the Crotone basin), where the last occurrence of P. lacunosa has been definitely ascertained in a package of marine muds with warm-water planktonic fauna overlying the Parmenide ash, thus allowing to establish a correlation of the transgression including the Parmenide ash with Termination V (transition from the strong glacial MIS 12 to the enigmatic MIS 11).

Several lines of direct and indirect evidence lead to conclude that the cyclothems of S. Mauro area were basically controlled by glacioeustatic sea-level fluctuations. This conclusion can be reached in spite of compelling evidence that active intrabasinal tectonics controlled geometry of sedimentary bodies and facies associations within systems tracts, particularly favouring the preservation of falling-stage units by creating intraplatform accommodation space. It may be argued that the identified cyclothems represent, although certainly incomplete, the record of a large part of the history of Pleistocene sea-level fluctuations in the interval comprised between stage 19 and possibly stage 7.

THE PLIO-PLEISTOCENE BOUNDARY IN THE TARQUINIA AREA (NORTHERN LATIUM, CENTRAL ITALY).

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The area included between Mignone river at SE and Arrone river at NW, nearby Tarquinia, is characterised by the widespread outcropping of a sandy-clayey succession. From a chronostratigraphical point of view, this succession is limited at the bottom by the Lower Pliocene clays and at the top by the volcanic rocks of the Sabatini complex, approximately dated 600ka.

The Lower Pliocene clays of circalittoral environment pass through the Middle Pliocene transgression to the Middle-Upper Pliocene calcarenitic-sandy succession of infra-circalittoral environment. Generally the Lower Pleistocene succession, characterised mainly by calcarenites and clays bearing *Cladocora caespitosa*, outcrops directly on the Lower Pliocene. Only in two localities it was possible to recognize the complete succession.

At Colle Calvigioni, north of Tarquinia village, Upper Pliocene marine conglomerates underlie Lower Pleistocene fluvial conglomerates. In these latter deposits some vertebrate remains have been collected. In particular the occurrence of *Equus altidens* Reichenau allows to define as biochronological interval the latest Villafranchian-Galerian mammal ages (late Early-Middle Pleistocene). Moreover, the absence of volcanic elements suggests an age older than 600ka.

A more complete succession outcrops at Monte Riccio. At the bottom the Middle-Upper Pliocene calcarenites of upper infralittoral environment pass to Lower Pleistocene clays and calcarenites bearing a rich mammal fauna. The faunal association is referable to the Late Villafranchian mammal age (Tasso Faunal Unit - Early Pleistocene) and includes: *Prolagus* sp., Elephantidae cf. *Mammuthus meridionalis* (Nesti), *Sus strozzi* Major, *Hippopotamus antiquus* Desmarest, *Leptobos* cf. *Leptobos etruscus* (Falconer), *Procapreolus* sp., *Eucladoceros ctenoides* (Nesti), *Axis nestii* (Major), *Stephanorhinus* cf. *Stephanorhinus etruscus* (Falconer), *Equus stenonis* Cocchi, *Vulpes* cf. *Vulpes alopecoides* Major, *Canis etruscus* Falconer and *Megantereon cultridens* (Cuvier *partim*).

The stratigraphical and palaeontological evidences in these localities allow to better define the Plio-Pleistocene transition and the palaeoenvironmental evolution in the area. Moreover the stratigraphical relationship between marine and continental deposits of this area turns out to be a valuable tool for the definition of an integrated biochronological scheme.

THE SANTERNIAN/EMILIAN GSSP: A PROPOSAL

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The Santernian is the basal substage of the Pleistocene (the older substage of the Calabrian stage), accordino to the Quaternari chronostratigraphic scale proposed in 1991 by the "Working Group for the Quaternary Stratigraphy" of the Italian Geological Society.
In this apper the authors propose to locate in the >Vrica section (Calabria, Southern Italy) the Santernian-Emilian boundary stratotype, in coincidence with the first appearance (FA) of *Hyalinea balthica*, a benthic foraminifer prposed by Ruggieri & Sprovieri (1997) as the marker for this boundary, so avoiding upsetting of geological literature. Being *H. balthica* a benthic form, its FA is penecontemporaneous only in the sediments of the Mediterranea Sea, but is diachronous with respect to the sediments of the oceans. However, in the same sample of the Vrica section in which the FA of *H.balthica* is recordewd, also the FA of the "large" *Gephyrocapsa* was recognized. The FA of the calcareous nannofossils named "large" *Gephyrocapsa* is practically synchronous in the Mediterranean and oin the oceans: this would allow the worldwide correlation of the proposed Santernian/Emilian boundary-stratotype.
H. balthica first appears in the Vrica section 71.1 meters above the Pliocene/Pleistocene boundary stratotype (base of the claystoce conformably overlying sapropel e), and 6 m above the top of sapropel o:
If the presnt proposal is accepted by the International Commission on Stratigraphy and ratiefied by the International Union for Geological Sciences, in the Vrica section is is possible to locate also the Santernian stratotype because: 1) in the Vrica section would be located both the Pliocene-Pleistocene (Gelasian-Santernian) boundary and the Santernian-Emilian boundary; 2) in thes section the Santernian sediments are stratigraphically continuous (unlike in the Santerno section, previously proposed as Santernian stratotype by Ruggieri & Sprovieri, 1977); 3) the Vrica section shows all the requisites requested by the International Stratigraphic Guide (Hedberg,1976; Salvador,1994) for the definition of a stratotype.

THE LACUSTRINE SUCCESSION OF RANICA (EARLY MIDDLE PLEISTOCENE, ITALIAN PRE-ALPS): MULTIDISCIPLINARY STRATIGRAPHY AND BASIN EVOLUTION

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Near the village of Ranica (Bergamasc Pre-Alps, Northern Italy), a succession of lacustrine, laminated clay and vetusols was exploited for about two hundred years. A basal portion of a left shed antler, and a braincase with wide frontals with big pedicles, where antlers were shed, were discovered in the quarry and both identified as *Libralces latifrons* (Johnson 1874) by Azzaroli (1979). Based on these fossils, he referred the lacustrine deposition either to the 'Galerian warm period' or to the 'Mindel cold period'. The basin originated from fluviatile obstruction of a small valley during the 'Mindel period', as proved by marked weathering on terrace surface, reputed significant for the 'Mindel-Riss interglacial' (Venzo, 1955).

Recently, the stratigraphy of the Ranica basin deposits has been re-investigated by means of a detailed revision of Museum collections, field survey, large diggings and several corings in the brick factory area. The complete stratigraphy is shown by a 13 m core, documenting the onset of palustrine deposits on the Cretaceous bedrock (Sass della Luna flysch) to the subsequent deepening of water level which led to lacustrine sedimentation. Palynological, magnetostratigraphic, rock magnetic and geochemical investigations were performed on this core. A pollen diagram of 58 samples was drawn. Pollen extracted from the clay matrix preserved in the elk skull made available further paleoenvironmental and stratigraphic data. The initial susceptibility and the NRM intensity were measured at 5 cm resolution. Stepwise alternating field demagnetization was applied. NRM direction was calculated by means of standard least-square analysis on Zijderveld demagnetization diagrams.

The skull identification was confirmed by comparison with the neotype of *L. latifrons* kept in the Brit. Mus. Nat. Hist., London. The lake deposits show normal fossil magnetization, whereas possible reserved magnetizations have been found in the basal slope deposits overlying the bedrock. The magnetic properties are still under study. The pollen record shows an overall dominance of conifer tree pollen (*Picea* and *Pinus sylvestris/mugo*). Pollen of thermophilous trees, including *Quercus*, *Carpinus* and *Carya*, is very sporadic. At the base of the record, a moderate peak of *Tsuga* and continuous *Abies* curve occur. NAP includes both local wet plants (Cyperaceae), including cold spring and wet tundra species (*Pinguicula*, *Utricularia*, *Saxifraga stellaris*) and extralocal, steppe vegetation (*Helianthemum*, *Artemisia*, Chenopodiaceae). Pollen and carpoflora point to a landscape partially covered by boreal conifer forest and forest-steppe. Tundra, wet forbs (Umbelliferae) and aquatic communities of cold climate were surrounding the pond. Based on pollen and geochemical correlation, the skull was originally deposited in the lower clay of palustrine origin. This environmental frame agrees with the ecological requirements of elks, as judged from living ones.

The lacustrine deposits are attributed to the early Middle Pleistocene on the basis of the following elements: (i) the presence (*Tsuga*) and absence (*Cedrus* and *Carya* - only sporadic grains) of some good pollen producer *taxa*, (ii) the occurrence of mainly normal magnetic polarity directions, which point to the deposition during the Brunhes Epoch; (iii) the presence of *L. latifrons*, which occurs in faunal associations of early Middle Pleistocene age. The complete interdisciplinary study of the Ranica site will provide the first reference continental succession of early Middle Pleistocene age so far directly dated with different methods from the Italian Alps.

MICROTHERIOFAUNAS CHANGINGS ON THE PLIOCENE-PLEISTOCENE BOUNDARY IN UKRAINE.

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The Pliocene-Pleistocene boundary on the scheme accepted in Ukraine is indicated on the level of 1,8 mil. years. It devides Khaprovian faunas (Villanian, MN 16) and Tamanian faunas (Biharian, MN 17) corressondingly. Several well-known localities of microtheriofauna such as Kotlovina 1, 2, Tiligul, Boshernitsa and others belong to this period of time. Fauna changings related to qualitative and quantitative species composition, the level of evolutional development and taxa ecological distribution.

In older Khaprovian faunas (Kotlovina) species (and subspecies) unknown in subsequent times, for example, *Pliolagomys danubicus, Pliopetaurista sp., Pseudoalactaga minuta, Orientalomys sp., Allocricetus praebursae, A. ehiki kujalnikensis, Pliomys jalpugensis, P.ucrainicus topachevskii, Dolomys nehringi, D. milleri, D. ondatroides, Mimomys pliocaenicus, Villanyia petenyi cotloviensis, V.fejervaryi palaeodanubica* are present.

At the same time in younger Tamanian faunas (Boshernitsa, Tiligul) new taxa appear: *Desmana meridionalis, Pliopygerethmus brachidens, Spalax minor, Allocricetus ehiki tiliguliensis, Ellobius palaeotalpinus, Mimomys milleri) (= intermedius), Villanya petenyi lagorodontoides, V. fejervaryi tiligulica. Allophaiomys pliocaenicus.* Quantitative fauna composition changings make up 30-40% of species, average another 60-70% of species are the common ones for Pliocene and Pleistocene.

According to the levels of evolutional development of Arvicolidae M/1 and M\3 morphotipical variability, A/L index, tracks correlation, enamel characteristic, degree of root development discussed boundary is not so clear determinated. The levels replect gradual character of evolutional changings in separate phylogenetic lineages mainly Mimomys and Villanyia genera (date are given in tables and diagrams). Species of these genera are represented by different subspecies.

Studied microtheriofaunas in ecologocal plan are represented by associations that were established basing on the principle of taxa quantitative predomination of various biotopical belongings. The older associations (Kotlovina 2) is known where *Villanyia, Pliomys* and *Nannospalax* predominate retlect development of open spaces of mezophilic type with the fosest. Another association (Kotlivina 1) with *Villanyia* as predominant species retlects charp climatic aridization on the final etap (stage) of Pliocene. In early Pleistocene (Tiligul) prevalent groups of *Villanyia* and *Allophaiomys* show the picture of more mezophilic landscapes development. As a result basing as on ecological data as on qualitative composition, the Plio-Pleistocene boundary is established more clearly

TAPHOFACIES ANALYSES OF MIDDLE PLEISTOCENE MOLINO SECTION (MONTALBANO JONICO –SOUTHERN ITALY): CLUES FOR A SEQUENCE STRATIGRAPHIC INTERPRETATION.

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The uppermost part of the Lower and Middle Pleistocene Montalbano Jonico terrigenous succession is represented by the Molino Section; it is about 15 m thick and consists of silts and sands topped by marls.

A detailed study on preservation modes of skeletal remains and shell beds attributes observed in this section confirms the usefulness of taphonomic approach for paleoenvironmental reconstructions as well as for the recognition of relative sea-level oscillations.

The taphonomic analyses, performed on both intrinsic preservation features of skeletons and biofabric, allow to characterize six taphofacies mainly related to depth changes and rate of sedimentation. The upward stratigraphic distribution of the taphofacies mirrors a sea level drop followed by a deepening trend. The taphofacies that indicate relatively high rate of background sedimentation and reflect a progressive increase in frequency of both physical events and hydrodynamic disturbance are overlaid by taphofacies that suggest moderate rates of background sedimentation together with a decreasing influence of the storm effects.

Such pattern permits to rank strata in the sequence stratigraphic palimpsest: stacked taphofacies that reflect relatively faster deposition of sediment as well as more frequent reworking of skeletal remains are related to the late regressive system tract. The transgressive system tract is characterized by the overlapping of taphofacies that indicate a progressive deepening of seafloor below maximum storm wave base and environments with moderate-low rate of background sedimentation. The shallowest water taphofacies (represented by a thick amalgamated shell bed) overlies an erosive surface, marked by scattered sub-vertical pods, that highlights the transgressive surface. The taphofacies that reflect the more distal and starved settings, consisting of *in situ* epibionts clumps, outlines the flooding surface. The inferences from this taphonomic approach are supported by paleoecological and sedimentological data.

BENTHIC FORAMINIFERAL ASSEMBLAGES IN THE PALEOENVIRONMENTAL RECONSTRUCTION OF THE MONTALBANO JONICO SECTION

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A quantitative analysis on benthic foraminifera assemblages have been carried out on more of 400 samples collected in the Montalbano Jonico Composite Section.

For a paleoecological interpretation, two multivariate statistical analyses were applied: Hierarchical Cluster Analysis and Principal Component Analysis.

The analyses support the suggestion that the most important paleoecological factors influencing the benthic foraminiferal distribution are depth and oxygen content both at the water – bottom interface and in the sediment.

The interpretation of Cluster Analysis data pointes out difference in the assemblages and distribution of benthic foraminifera that can be attributed principally to change in bathymetry and, secondarily, in oxygen concentration. Principal Component Analysis, whose first factor ihas been correlated to depth, supports the effective influence of bathymetry, as principal controlling parameter.

The dominance in the lower part of the succession of an assemblage typical of deep marine waters (lower circalittoral – upper bathyal zone) and the dominance in the upper part of an assemblages commonly referable to shallow waters (upper circalittoral zone) suggest the deposition during a marine regression characterised by several shallowing – deepening minor cycles.

The generalised regressive trend is also confirmed by the Plancton/Benthos ratio.

Alternance of oxic - suboxic conditions testifies a clear cyclicity trends in the sedimentary deposition.

The statistical analyses allow to put in evidence a good correlation among the peaks of high oxygenation and the shallow phases suggesting that the shallowing phases correspond to lowstand due to cooling climatic.

POSTERS SESSION

THE CONTINENTAL RECORD FROM LACUSTRINE BASINS OF SOUTHERN ITALY: THE STATE OF KNOWLEDGE

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In the Southern Apennines, several, widespread, intramontane basins were created during Plio-Quaternary times. Formation of the various basins, where continental sedimentation mostly of lacustrine environment took place, occurred during different stages of the belt's evolution, in response to tectonic events characterised by different deformation regimes.

Due to the intense tectonics affecting the belt during this period, lacustrine sedimentation in each basin did not last for a long time period. Nonetheless, the lacustrine successions offer a continuous, although confined, sedimentary record suitable to climato-stratigraphical studies. Furthermore, the occurrence, in southern Italy, of an intense Quaternary volcanic activity gives the chance of matching the climato-stratigraphical reconstruction with tephrostratigraphy and also of constraining the successions with absolute dating, thus allowing land-sea correlation to be attempted.

Geomorphological and stratigraphical studies we carried out in the last years allowed the relative ages and evolution stages of the southern Italy intramontane basins to be established. Some of the basins, as, from the South, Mercure, Noce, Camerota, Alta Val d'Agri, Melandro, Tanagro, Acerno and Isernia basins, were filled and subsequently deeply incised while, in other cases, as for the Vallo di Diano, Buccino-S. Gregorio Magno, Boiano and Venafro basins sedimentation is still occurring or their dissection has just begun. On the basis of the morpho-stratigraphical studies, three deep cores were drilled in the Camerota, Vallo di Diano and Acerno basins. For each basin, pollen analyses allowed the duration and rate of the lacustrine sedimentation to be estimated and paleoclimatic curves to be reconstructed. Tephrostratigraphy, in some cases integrated by absolute dating, allowed a better definition of the chronostratigraphical position and also correlation with the $\delta^{18}O$ isotopic marine record.

In the Camerota basin, the 50m thick lacustrine succession is covered by Santernian marine sediments, thus being confined to the Pliocene, probably close to the P/P boundary. Due to the diffuse barrenness, a continuous pollen curve could not be reconstructed. Nonetheless the pollen floral composition, rich in subtropical elements, as well as the occurrence of vegetation changes from interglacial to transitional types, led to ascribe the Camerota lacustrine succession to the period characterised by the 40ky ciclicity.

Pollen analysis carried out on the 200m deep core drilled in the Vallo di Diano, pointed out the alternation of steppic and forested phases in the lacustrine sediments drilled from 180m to 40m, suggesting the occurrence of three glacial/interglacial cycles. Tephrostratigraphy, isotope stratigraphy and an $^{39}Ar/^{40}Ar$ dating allowed correlation of the pollen curve to the isotopic stages 16 to 10. With the aim of unravelling the complex tectono-stratigraphical setting of the basin, where two unconformably superposed lacustrine successions are present, a further 25m thick core was recently drilled in order to better defining the stratigraphy of the upper portion of the succession.

In the Acerno basin, pollen analysis of the drilled 100m thick succession revealed the occurrence of one climatic cycle through the alternation of steppic and forested phases. The tephrostratigraphical identification of the WTT marker level (dated 300ky) allowed correlation of the climatic cycle with part of the isotopic stages 9 and 8.

THE LOWER PLEISTOCENE SEDIMENTS IN LATIUM: PALEOECOLOGICAL EVIDENCES

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Basins of Tyrrhenian Central Italy during the Late Pliocene-Early Pleistocene time interval are characterised by complicate paleomorphology and shallow water environment (infralittoral-circalittoral). The chronological attribution of these sediments is very difficult for the lacking of planktic markers. For this reason often is not possible to apply the biostratigraphic schemes, usually utilised for the Mediterranean area. A new regional stratigraphical model, having a chronological value, is singled out on characteristic foraminiferal associations. It will be possible to utilise this model like reference for other basins with the same environmental characteristics.

The synthesis of the great amount of data collected in the '90s on the Neogene-Quaternary sequences of Latium by "La Sapienza" University of Rome evidenced the most important sedimentary processes and paleoenvironmental conditions. Therefore three different stratigraphic settings for the Late Pliocene-Early Pleistocene time interval are singled out: 1) continuous sedimentation with significant stratigraphical species; 2) sedimentation without evidences of hiatus; 3) sedimentation with hiatus having a maximum width corresponding to the Zanclean pp.-Santernian pp. time interval (Carboni & Di Bella, 1997; Borzi *et al.*, 1998)

The first situation, recognised near Rome (Valle Ricca), is characterised by clay with a circalittoral assemblage with planktic markers (*Globigerina calabra*, *G. cariacoensis*), associated with *Bulimina* spp., *Bulimina etnea*, *Bolivina* spp. and *Uvigerina* spp. The N/Q boundary was detected (Carboni *et al.*, 1993) and there are not environmental changes between Pliocene and Pleistocene assemblages. In other sites of the same area (Fiano Romano, M. Mario) similar assemblages are present) although the N/Q boundary was not localised.

The second setting, detected in Northern Latium (Bracciano and Montalto di Castro) and middle-lower Tiber Valley (Bagnoregio, Orte and Nazzano), is marked by sandy clay with a Pleistocene assemblage, related to infralittoral/circalittoral environment (Carboni & Palagi, 1998a). It is mainly constituted by *Valvulineria bradyana, Cassidulina neocarinata, Bulimina* spp., *Bulimina etnea, Bolivina* spp. and *Dorothia gibbosa.*

The last stratigraphic situation was found in Northern Latium (Montalto di Castro and Tarquinia) and Southern Latium (Tor Caldara – Anzio) where the lower Pleistocene clayey sands contain an infralittoral assemblage (Carboni & Palagi, 1998b) . The most abundant species are *Ammonia* spp., *Elphidium* spp., *Lobatula lobatula* and *Florilus boueanus.* In the Anzio area, at the base of the Pleistocene sequence, a thin sandy level with *Elphidiella* spp. is present. In some sites of middle and lower Tiber Valley (Liano and Nazzano) the infralittoral environment gradually evolves to a brackish environment characterized by a low diversity assemblage with *Ammonia tepida, Ammonia parkinsoniana, Aubignyna perlucida* and *Haynesina depressula.*

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FISH OTOLITHS FROM THE PLIO-PLEISTOCENE VRICA SECTION (CALABRIA, ITALY)

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The Vrica section, located 4 km South of the town of Crotone (Calabria, Southern Italy), consists of Plio-Pleistocene grey silty-marly claystones with 14 intercalated layers of sapropelic laminites, 3 sandy layers and 1 cineritic level. The samples collected in clay sediments up sapropelic layers a, c (upper Pliocene), e and q (lower Pleistocene) provided otoliths (collected by H. Cappetta) belonging to 26 teleost taxa of which 24 could be identified at specific level and 2 at family level. The relationships of these Plio-Pleistocene teleost faunas to the middle Pleistocene and Recent Mediterranean faunas are analysed. These comparisons are based exclusively on data obtained from the otoliths, because of major problems subsist in matching otolith-based species with those based on osteological material from Vrica localities. The association includes the first fossil record of the recent eastern Mediterranean species *Lobianchia gemellari*. In the Pleistocene interval of the Vrica section, we also observe the first unquestionable occurrence of the subpolar-temperate species *Benthosema glaciale* which is very common in Pleistocene deep water associations and in the Recent western Mediterranean fauna. Previous studies demonstrated that *B. glaciale* is represented in the Lower Pliocene of Belgium but not occur in the Mediterranean Pliocene, suggesting its entrance in this basin due to climatic variations during the early Pleistocene. However, specimens identified as *B.* aff. *glaciale* are known from the Mediterranean Miocene. The Vrica fauna is also characterised by the persistence, until in the Pleistocene, of fossil species as *Rhynchoconger pantanelli*, *Parascombrops mutinensis* and *Coryphaenoides sicilianus* which are typical of deep water associations from Mediterranean Pliocene. The occurrence of the endemic fossil Pliocene species *C. sicilianus* and *Scopelopsis pliocenicus* until the lower Pleistocene referable to large *Gephyrocapsa* biozone (the first) and small *Gephyrocapsa* biozone (the latter) in other southern Italian exposures suggests that the extinction of Pliocene species occurs gradually during the early Pleistocene. The recognised associations, throughout the Vrica section, are ecologically homogeneous in composition and structure, and are essentially constituted of mesopelagic and bathybenthic fishes (mostly myctophids, gadid and macrurids) indicating a bathyal environment. The presence of the macrurids *Trachyrhynchus scabrus*, *Nezumia sclerorhynchus* and *Coryphaenoides,* living at depths below 400 metres, suggests a middle slope palaeoenvironment.

THE BATHYAL OTOLITH ASSOCIATIONS FROM MONTALBANO JONICO SECTION (LOWER PLEISTOCENE, SOUTHERN ITALY)

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Previous study on otolith associations from the middle-upper part of the Montalbano Jonico Section (*Pseudoemiliania lacunosa* biozone) have pointed out paleobathymetric changes that ranges from deep circalittoral to transitional zone to bathyal.

In this study, detailed analyses carried out on seventeen bulk samples collected from the lowermost part of the Montalbano Jonico Section ("large" *Gephyrocapsa* and "small" *Gephyrocapsa* biozones) allowed to discriminate three groups according to their ecological meaning among eleven otolith associations.

The first group is composed by macrurid fishes, *Coryphaenoides sicilianus* and *Nezumia scleroryrinchus*, and a significant number of myctophid species; benthic neritic fishes are absent. This association is peculiar of the upper part of the middle bathyal zone.

The second group, once again lacking in benthic neritic fishes, is represented by gadoid fishes, dominated by *Gadiculus argenteus* and *Micromesistius poutassou*, and myctophids suggesting a shallower environment referable to deep epibathyal zone.

The last group is characterised by the co-occurrence of epibathyal benthonectonic fishes and sublittoral benthic fishes; these latter, in favourable conditions, preferably inhabit the deeper part of their bathymetric range. As consequence, a setting in the transitional zone from bathyal to sublittoral can be inferred.

Otolith associations represent a significant tool to discriminate among different depht zones within the bathyal, thus allowing to recognise sea level fluctuations and corroborate the potential usefulness of such an analysis for paleoenvironment reconstructions.

STRATIGRAPHY AND PALEOECOLOGY OF THE LATE PLIOCENE AND EARLY PLEISTOCENE IN THE OPEN-CAST MINE 'HAMBACH' (LOWER RHEIN BASIN; GERMANY).

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The present Pliocene/Pleistocene Boundary (PPB) was defined at Vrica, Italy, at the top of the Olduvai normal event at 1.77 Ma. However, there are strong biostratigraphical, magnetostratigraphical and climatostratigraphical arguments against this boundary (see Zagwijn 1992, 1998, Suc *et al.* 1997, Partridge 1997). Already in 1974 Zagwijn put forward evidence for the age of the earliest northern hemisphere glacial period (the Pretiglian in the Netherlands) immediately after the Gauss-Matuyama boundary. There is a proposal by the INQUA Commission on Stratigraphy for lowering of the PPB to the vicinity of the Gauss/Matuyama palaeomagnetic reversal contained within the oxygen isotope stage 104 approximately 2.6 Ma (Partridge 1997). The problem of the PPB has been not solved yet.

Recent sedimentological and paleobotanical investigations in the open-cast mine 'Hambach' near Cologne provide detailed information about the development of the vegetation and climate during that time. For a clear correlation within the Lower Rhein Basin which is part of both The Netherlands and Germany we use the stratigraphical terminology by Zagwijn.

The climatic deterioration between the Reuverian and Pretiglian can clearly be seen by the palaeobotanical signal and confirm his interpretation to define the PPB with the beginning of Pretiglian cold stage:

The lower part of the sequence, the so-called Kieseloolith-Formation, is characterised by a very diverse macroflora: *Sequoia* sp., *Sciadopitys* sp. *Taxodium* sp., Cupressaceae, *Pinus timleri, Picea latisquamosa, Liquidambar europaea, Magnolia sinuata, Juglans bergomensis, Carya ventricosa*, *Pterocarya limburgense*, *Carpinus betulus*, *Fagus decurrens*, *Quercus robur*, *Vitis sylvestris* and other has been observed. The results indicate a warm temperate climate which is typical for the upper Pliocene (Reuverium A).

The Reuver-Clay which covers the Kieseloolith-formation, is intercalated by three remarkable coal seams. Palynological data have shown that the typical Tertiary elements such as *Nyssa*, *Pterocarya*, *Sequoia*, *Sciadopitys*, *Taxodium* and Cupressaceae decrease continuously and disappear at the upper coal seam. The decrease of thermophilous elements indicates a gradual cooling at the end of the Pliocene (Reuverian B up to the end of Reuverian C).

The uppermost part of the sequence shows a very poor flora consist of low values of *Alnus* and *Pinus* and the absence of thermophilous elements whereas the herb values including Gramineae and Ericaceae increased up to 70 %. This feature indicates clearly cold climatic conditions which are typical for the Pretiglium.

THE PLIO-PLEISTOCENE BOUNDARY: PATTERNS OF EXTINCTION AND TURNOVER IN THE ICHTHYOFAUNAS OF SOUTH-CENTRAL ITALY

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The faunal list of Plio-Pleistocene teleosts (Pisecs) of Italy, compiled on the basis of both direct analysis of fossil ichthyofaunas of south-central Italy (published and unpublished data) and the critic examination of literature, is composed of 203 taxa (the presence of other 46 taxa may be inferred on the basis of lower and middle Pliocene fossil record of and their current presence in the Mediterranean).

The comparison between the 112 taxa of upper Pliocene and the 146 taxa of lower-middle Pleistocene shows that 55 taxa (corresponding to 49% of the Pliocene fauna and to 38% of the Pleistocene fauna) are common; besides, other 51 taxa have been reported in Pleistocene and lower-middle Pliocene, even not in the upper Pliocene deposits, to a total of 106 taxa recorded in the Pleistocene but not exclusive of it. At the P/P boundary, 57 species (51% of the Pliocene fish fauna) become extinct; for 12 species this represents a final extinction, for 12 a local disappearance and for 33 could be a lack in the fossil record since these taxa presently live in the Mediterranean. Anyway this extinction event did not cause a decrease in biodiversity which, on the contrary, is higher in the Pleistocene, whose faunal list consists in the group of taxa already present in the upper Pliocene plus other 91 taxa (40 of them new for the basin, and 51 already recorded in lower-middle Pliocene). The turnover rate between upper Pliocene and Pleistocene is T1=18.6 and the ones of middle-upper and lower-middle Pliocene respectively are: T2=34.6 and T3=16.3; the low value of T3 is due to the fact that in the transition between lower and middle Pliocene the high number of extinctions is not counterbalanced by a comparable number of new taxa. Pliocene and Pleistocene ichthyofaunas and the groups of taxa which appear or disappear at the P/P boundary and the ones that overcome it have been investigated in relation to their trophic niches, environments, climatic and biogeographic affinities. This analysis shows the poorly selective character of the extinction which involved different trophic and ecologic categories; only the biogeographic structure of the fauna points out an increment of the atlantic taxa to the detriment of the indo-pacific ones. In fact, between the taxa with tropical affinity we recognise an appreciable reduction (5 taxa out of 9, considering the ones presently not living in the Mediterranean) counterbalanced only by one new appearance (*Saurida* sp.); at the same time we observe an increase in the cold-temperate taxa (from 4 to 10%); these two trends can be related to climatic events of the Plio-Pleistocene transition. The pattern of extinction in the ichthyofaunas at the P/P boundary is, however, more complex: if the amount of data relative to the different ecologic categories is analysed, the higher extinction rate (47 taxa out of 57) is found among eurytherms of benthic, bathypelagic or epipelagic habitat and the 57 extinct taxa are balanced by 40 new appearances distributed in different ecologic categories: 7 cold-temperate taxa, 28 eurytherms both benthic and pelagic, 1 extramediterranean tropical component and 4 presently living in the Mediterranean.

The extinction mechanisms resulting on the basis of data reported above, seem to better fit in a turnover model with a recharge of the system interesting all the ecological categories, even if with different intensity. The diversity of taxa, habitats and life history strategies as well as timing of the exchange argues against a single mechanism of extinction, even if the climatic deterioration could have act as a cause-effect relation on the tropical-subtropical component.

The biogeographic structure of the fish fauna, as resulted after the P/P transition and the recharge of the system is slightly modified in respect to the Pliocene one; in particular the atlantic component rises from 41 to 47% while indo-atlantic and indo-pacific taxa decrease respectively from 4 to 3% and from 4 to 1%, no modification is observed in the cosmopolites (41 %), while the endemics change from 4 to 3% (even if their absolute number is unchanged). The final result of the P/P turnover is the reorganisation of the ecologic and biogeographical composition of the fish fauna which assumes an higher subtropical-temperate affinity. The complex structure of the basin, however, permits the survival of tropical taxa and does not exclude few new entries (i.e. *Saurida* sp., *Chaetodon hoefleri*). The last indo-pacific taxa in the Mediterranean became extinct presumably only during the glacial Pleistocene (data lacking), but some of them (i.e. *Etrumeus teres*) are to be considered lessepsian immigrants because of their re-entrance in the Mediterranean through the Suez channel.

PRELIMINARY STUDY OF THE FOSSIL BOVIDAE ASSEMBLAGE FROM THE LATE LOWER PLEISTOCENE ARCHAEOLOGICAL SITE OF GESHER BENOT YA'AQOV (NORTHERN ISRAEL).

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The Acheulian site of Gesher Benot Ya'aqov is situated in the northern sector of the Dead Sea Rift. Outcrops of the Benot Ya'akov Formation are located in the course and on the two banks of the Jordan River, some 4 km south of the Hula Valley Basin in northern Israel. New paleomagnetic data place the site at 780 Ka (Oxygen Isotope Stage 19). The archaeological data from the site portray strong affinities with African stone tools traditions.

The revision and study of the large mammal assemblage from this site yields new information concerning the bovids species in the assemblage. Five species have been identified: Bovini gen. et sp. indet. (cf. *Bison*), *Pelorovis* sp. (small size, cf. *P. turkanensis*), Ovibovini indet., Caprini indet. and *Gazella* sp.

Pelorovis is an African genus of Bovini well known from the African continent, including the Magreb, where it is recorded from the late Pliocene until the late Pleistocene. The only known record outside Africa is that of the Lower Pleistocene archaeological site of 'Ubeidiya, Israel, where the large species *Pelorovis oldowayensis* was identified.

The occurrence of the small *Pelorovis*, cf. *P. turkanensis* species in the late Lower Pleistocene site of Gesher Benot Ya'aqov yields additional information about faunal and human dispersal events in the Levant.

A SMALL MAMMAL FAUNA FROM THE LACUSTRINE SUCCESSION OF SAN LORENZO (SANTARCANGELO BASIN, BASILICATA) AND REMARKS ON PLEISTOCENE RODENT CHRONOLOGY.

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The Sant'Arcangelo basin is located in the southermost part of the Apennine chain (Basilicata); it is filled by a siliciclastic sequence 3500 m thick, dated to the time interval late Pliocene-middle Pleistocene (Pieri *et al*, 1996; Sabato, 1998). In this basin an early-middle Pleistocene fluvial-lacustrine sequence, known as San Lorenzo Cycle, has been recognised (Pieri *et al*, 1996; Sabato, 1998). In the upper part of the sequence, in locality Rifreddo, a fairly diversified small mammal assemblage has been recovered.

The remains have been referred to the following taxa: Leporidae indet., *Allocricetus* sp., *Apodemus* sp., *Pliomys* sp., *Mimomys* cf. *savini*, *Microtus (Terricola) arvalidens*, *Microtus (Iberomys)* cf. *brecciensis*, *Talpa* cf. *romana*, *Crocidura kornfeldi*, *Sorex* gr. *subaraneus-runtonensis*, *Macroneomys brachygnatus*. *Microtus (Terricola) arvalidens* is the most abundant species.

The assemblage contains elements suggesting an age ranging from the end of early Pleistocene to the beginning of middle Pleistocene. As a matter of fact the occurrence of *M. (T.) arvalidens*, *M. (I.) cf. brecciensis*, *Mymomys* cf. *savini* and of *Macroneomys brachygnathus* allow to refer the fauna of Rifreddo to the upper part of the late Biharian Mammal Age (Maul *et al*., 1998; *sensu* Fejfar & Heinrich 1990). In many European localities the sediments containing late Biharian faunas are correlated to the upper part of magnetochron Matuyama and to the lower part of Bruhnes (*e.g.* Atapuerca in Spain Cuenca Bescos *et al*., 1995, 1999; Voigtstedt in Germany, Maul, 1990, and Isernia in Italy, Sala ,1996). Taking into account the positive magnetisation of the sediments outcropping at locality Rifreddo (Sabato *et al*., 1988), the chronological referral of the mammal assemblage can be restricted to the early Brunhes and therefore to the early-middle part of middle Pleistocene.

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FROM PLIO/PLEISTOCENE TO EARLY/MIDDLE PLEISTOCENE TRANSITIONS: STRUCTURAL CHANGES IN LATE VILLAFRANCHIAN LARGE MAMMAL ASSEMBLAGES IN ITALY

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A schematic range-chart of the late Pliocene – Pleistocene large mammal genera is presented and the main faunal events recognisable within this time span are discussed. The first faunal event occurs around the Gauss/Matuyama transition, with the beginning of the middle Villafranchian, and is characterised by the arrival of *Mammuthus (Archidiskodon)* and *Equus* (the so-called "elephant-*Equus* event"). The following faunal event occurs at the Plio-Pleistocene transition (the so-called "wolf event"). It is marked by a strong contraction in the diversity of the ruminants and by a renewal in the carnivore diversity with the arrival of social carnivores. The Villafranchian – Galerian transition is characterised by the lowermost values in mammal richness. This could be in part due to a undersampling of this time interval in Italy, but in any case the trend since the beginning of Late Villafranchian until the Early Galerian is that one of a richness contraction. The low diversity in ruminant assemblage persist until the end of middle Pleistocene when, with new arrivals, mammal richness abruptly increases again reaching a diversity comparable to that one of earliest Late Villafranchian communities.

A LOWER-MIDDLE PLEISTOCENE LACUSTRINE SEQUENCE IN THE SANT'ARCANGELO PIGGYBACK BASIN (SOUTHERN ITALY)

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A lacustrine system developed in a NW-SE trending synclinal basin formed during the late tectonic-sedimentary evolutionary phases of the Sant'Arcangelo piggyback basin (southern Apennines) as a result of the growth of a ramp fold. In the depocentral area, the sequence is represented, above gravel layers, by thinly stratified clays and silty clays which alternate with sandy packets and interbedded carbonates and volcaniclastic layers. These latter, up to some tens of decimeters thick, are present throughout the sequence; their content is of vitric ashes, and some that have been analyzed resulted phonolitic in composition, and yelded a K-Ar age of 1.1±0.3 Ma. The fossil content is represented by Ostracods, Gastropods, plant and vertebrate remains.

Facies analyses shows that sedimentation developed in the inner zone of a relatively deep, terrigenous dominated diluite fresh water lake; the minor occurrence of organic matter-rich laminites suggests the episodic setting of meromictic, water stratified conditions, while minor carbonate deposits may record a more concentrated lake water body. Stratigraphic data also suggest that tectonics had been active during sedimentation. Therefore it is suggested that lacustrine sedimentation was synchronous to syncline generation. Furthermore, the major normal fault bounding the lacustrine deposits to the west controlled geometries and facies development, forming an asymmetric arrangement of the entire lacustrine system with reduced sediment thickness eastward.

The pollen analysis carried out in several layers along the lower part of the sequence shows repeated alternations between two distinct vegetational phases: one dominated by steppe formations, the other by forest taxa. The steppe, characterized by *Artemisia*, Poaceae, Chenopodiaceae, with scarce presence of *Pinus* and deciduous trees, indicating arid climate, is correlated to a glacial phase. The forest, dominated by oaks (deciduous principally) followed by *Carpinus, Ulmus, Zelkova* indicating a warm and relatively humid climate, suggests an interglacial phase. The forest flora lacks of elements such as *Nyssa, Engelhardia,* Sapotaceae, etc which characterized the Pliocene pollen assemblages. Moreover *Taxodium* shows a scattered occurrence. *Picea* and *Abies* as well as *Tsuga* and *Cedrus* don't have significant occurrences. *Tsuga* in particular shows a decline or disappearance along the sequence.

~~The faunal assemblage, collected in the upper part of the sequence, is composed by rare~~ remains of a medium sized deer, reptiles, amphibians and a fairly diversified small mammal assemblage including Leporidae indet., *Allocricetus* sp., *Apodemus* sp., *Pliomys* sp., *Mimomys* cf. *savini*, *Microtus* (*Terricola*) *arvalidens*, *Microtus (Iberomys) brecciensis*, *Talpa* cf. *romana*, *Crocidura kornfeldi*, *Sorex* gr. *subaraneus-runtonensis*, *Macroneomys brachygnatus*. The occurrence of *M.* (*Terricola*) *arvalidens*. *Microtus (Iberomys) brecciensis*, *Mymomys* cf. *savini* and of *Macroneomys brachygnathus* allow to refer this faunal assemblage to the late Biharian mammal age. The former species has been recovered at site Atapuerca (Spain) from sediments spanning around the Brunhes/Matuyama boundary.

Some paleomagnetic samples have been collected in order to verify the possibility to calibrate this continental sequence to the Geomagnetic Polarity Time Scale: three magnetic polarity intervals were recognized. Taking into account the stratigraphic data, the K/Ar dating, the pollen and faunal content, a tentative magnetostratigraphic framework can be settled. The lower normal polarity interval is belonging to the Jaramillo subchron, the upper normal polarity is in the lower Brunhes magnetochron.

The bulk of geological data and palynological, faunal and magnetostratigraphic preliminary results suggest that the lacustrine deposit is early-middle Pleistocene in age, in accordance with the evolutive history of the entire Sant'Arcangelo Basin.

Furthermore, all these data can contribute to obtain a model of development of a lacustrine system in a tectonically active basin during a period of rapid changes of climate and relative sea-level. In fact, the lacustrine system was formed during the early-middle Pleistocene, a time characterized by well marked alternations of glacial/interglacial phases. Furthermore, the occurrence of volcaniclastic layers (datable by K/Ar or Ar/Ar methods), Vertebrate remains (useful for paleoenvironmental reconstruction), flora remains (directly indicative of the climatic phases which occurred during the infill of the lacustrine basin), provide a data set to obtain a paleoclimatic curve of the early-middle Pleistocene.