

Aragonian: the Stage concept versus Neogene Mammal Zones

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The system of Neogene Mammal Zones, as originally created by Mein (1975), is discussed, and found to be confusing. The Aragonian in the type section and in the surrounding area is discussed, and the evolution of its fauna described in some detail. It appears dubious to apply the MN-zones to the faunules of the Aragonian type area. On the other hand, the type section may well serve as a basis for correlation of Miocene vertebrate localities in Spain and France and — may be — in other parts of Europe.

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Introduction

After making extensive collections from Middle and Upper Miocene mammal-bearing localities in the type area of the Aragonian and adjacent areas, it was attempted to establish a biostratigraphy for the sediments of the Cala-

tayud-Daroca-Bañon Basin. Nine zones are distinguished in the Aragonian and the Lower Vallesian. Our sequence of localities (Fig. 1) is based on lithostratigraphic and local biostratigraphic evidence. This local zonation was compared to the zonations of Daams, Freudenthal & van de Weerd, 1977, and Mein, 1975. It appeared that the 'biozonation' of Mein (MN-zones) could not be applied to our faunas because the alleged usefulness for correlation in the Mediterranean area turned out to be very restricted. In fact, the MN-zones do not represent a real biozonation. We suggest that each faunal province have its own biostratigraphic subdivision, resulting in a more reliable correlation over larger distances.

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The type Aragonian

At the Munich symposium on mammalian stratigraphy (1975) it was agreed to define the Aragonian as a (super)stage for continental deposits of Middle Miocene age. The lower boundary would be the entry of *Anchitherium*, the upper boundary the entry of *Hipparion*. Since the best succession of strata comprising this interval is hitherto known to be situated in the Daroca-Villafeliche area (Zaragoza, Spain), we chose one of the sections described by Freudenthal (1963) to be the type section of the Aragonian.

Starting 1976 extensive collections from mammal-bearing levels have been made in the type section and in the immediate surroundings. At present about ten superposed rich fossiliferous levels in the type section have been sampled. Nearby sections and localities yielded another twenty fossiliferous levels which were correlated with the type section biostratigraphically and/or lithostratigraphically. We now have a series of over 30 useful Middle and Upper Aragonian localities in stratigraphic order, plus on top of this series a sequence of four localities which belong to the Vallesian. The lower Aragonian is not present in the type area and therefore we sampled a section about 30 km to the south-east which contains five superposed levels. The higher two of these (Caseton 1A and 2B) have been correlated biostratigraphically with the Middle Aragonian of the type area. The lower three levels (Bañon 5, 2, 11 A) are evidently older than the oldest localities in the type area. These faunules are considered to belong to the Lower Aragonian, and it may turn out to be

possible to define the lower boundary of the Aragonian in the area of Bañon.

In the type area the transition from the Aragonian to the Vallesian has been documented in detail. Contrary to previous opinions there is no trace of a hiatus between the Aragonian and the Vallesian in the Daroca-Villafeliche area. Sedimentation seems to have been continuous, and there are no sudden changes in evolutionary lineages of rodents, nor is there an immigration wave of any importance among the micromammals. The only new element in the rodent fauna in the area is the introduction of beavers in the very top of the Aragonian, indicating a change of biotope.

Not counting the 60 localities that were rejected because of their poor fossil content, we sieved 50000 kg of sediment from 37 localities, yielding nearly 30000 rodent teeth. Preliminary results of the study of these rodents are given in Fig. 1. In the first column the locality names are given in stratigraphic sequence. Most localities are marked by either an asterisk, a cross, a circle, or an X. Localities with a circle are situated in the type section. Each other symbol represents a different section. The relative position of localities marked with the same symbol has been established lithostratigraphically in the field. The sequence in which localities from different sections have been arranged in the figure was established by biostratigraphic correlation, and may be subject to slight alterations. For locality details see Daams & Freudenthal (in preparation).

The study of the repartition, relative abundance, entry and exit, and evolutionary stages of taxa leads to a grouping of the faunas into nine zones. Each zone is characterized by its faunal content and will be defined formally as a biozone in a future paper (Daams & Freudenthal, in preparation). The zonal boundary criteria are given in the columns 'entry' and 'exit' of Fig. 1. The geographical extent of these zones may vary greatly.

DESCRIPTION OF THE ZONES

A – This zone is characterized by the abundance of *Ligerimys*. *Glirudinus modestus*, *Peridyromys murinus* and *Pseudodryomys simplicidens* are common representatives of this zone. *Melissiodon*, though rare, is the only cricetid present.

B – *Democricetodon* is the only cricetid present. *Ligerimys* is present, but not dominant. Gliridae are dominant, such as *Glirudinus modestus*, *Peridyromys murinus*, *Pseudodryomys*, and *Praearmantomys*.

C – *Megacricetodon*, *Fahlbuschia* and *Eumyarion* are the most abundant cricetids. *Ligerimys ellipticus* is a major constituent, and Gliridae are less abundant.

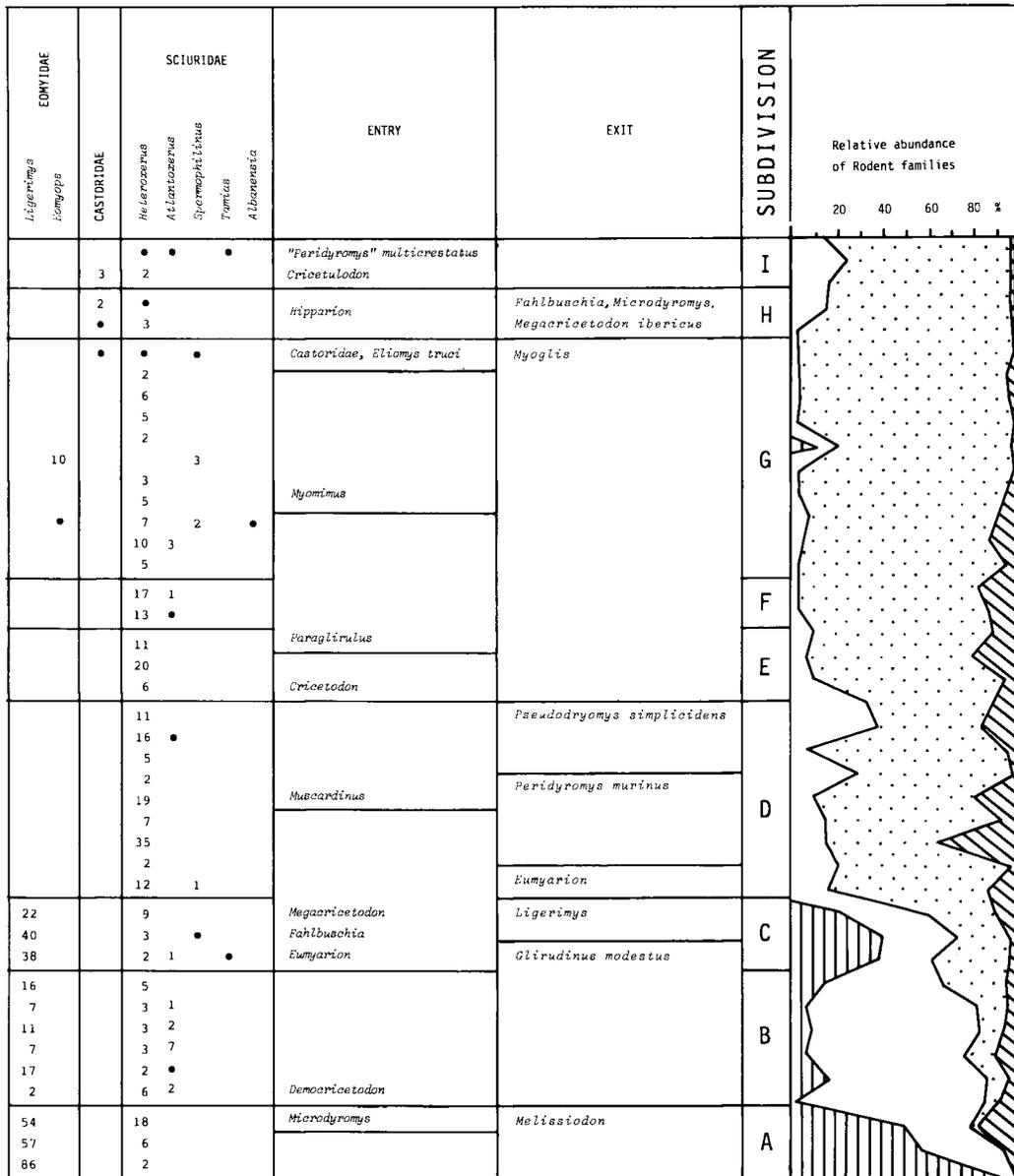
D – *Megacricetodon* and *Fahlbuschia* are the dominant taxa. The Sciuridae are well-represented by *Heteroxerus*, but *Ligerimys* is absent. *Armantomys*, though not common, *Pseudodryomys simplicidens* and *Microdyromys* are the dominant Gliridae.

E – *Cricetodon* is present though not common. *Megacricetodon* and *Fahlbuschia* are still the dominant taxa, and *Heteroxerus* is also common. The Gliridae fauna is poor. *Microdyromys* is present and one locality of this zone contains *Paraglrulus*.

F – This zone is characterized by the presence of two *Megacricetodon* species.

STAGES	LOCALITIES	N of M 1, M 2 of rodents	GLIRIDAE										CRECETIDAE											
			<i>Gliracinae</i>	<i>Pseudoryzomys merrius</i>	<i>Pseudoryzomys espinosidensis</i>	<i>P. robustus</i>	<i>Armanomys</i>	<i>Fraserianomys</i>	<i>Pseudoryzomys tibeticus</i>	<i>Microrhynchomys</i>	<i>Pseudoryzomys</i> sp.	<i>Muscardinus</i>	<i>Paraglitirinus</i>	<i>Myglis</i>	<i>Ryomimus</i>	<i>Zemquetia</i>	<i>Lilomys truesi</i>	<i>"Pseudoryzomys" multicaecatus</i>	<i>Melittastodon</i>	<i>Demoircetodon</i>	<i>Lungurton</i>	<i>i. Alabastrina</i>	<i>Isogaurmetodon</i>	<i>Lyxerodon</i>
LOWER VALLESIAN	PEDREGUERAS 2C	767								8			6					5		24	22	34		
	PEDREGUERAS 2A	614											13				10	1		13	46	11		
	CARRILANGA 1	647								4			12							61	19			
	NOMBREVILLA	233											15							44	37			
UPPER	SOLERA	773																			4	80	15	
	LAS PLANAS 5H	290								2											3	80	13	
	TORIL	745								1	2										11	79	1	
	ALCOCER 2	187								1											5	77	11	
	VILLAFELICHE 9	511																			2	95	2	
	LAS PLANAS 5K	152																	5		63	10		
	LAS PLANAS 5L	159																			2	90	2	
	BORJAS	917									2										21	71	2	
	MANCHONES 1	2397									7										31	47	6	
	VALALTO 1	75										3									5	71	4	
	LAS PLANAS 5B	483									3										2	89		
	VALALTO 2C	879																			5	72	2	
	VALALTO 2B	179																			2	77	3	
	MIDDLE	LAS PLANAS 4C	61								8		2									7	70	1
		LAS PLANAS 4B	126																			8	23	50
		LAS PLANAS 4A	82																			39	47	1
VILLAFELICHE 4B		84		16	6					8											24	31		
VILLAFELICHE 4A		838		28	5					7											19	25		
CASETON 2B		342																			78	8		
CASETON 1A		990			8	4		1	17												36	32		
VALDEMOROS 3E		443			5	2				4												25	46	
VALDEMOROS 3D		322			10	2				4												13	64	
VALDEMOROS 3B		708			6	2				9												10	39	
VALDEMOROS 1A		189				4		4	12													27	50	
OLMO REDONDO 9		432			2				5	10											1	8	27	
OLMO REDONDO 8		496			13	1		4	18	2												2	29	
OLMO REDONDO 5		488			16			2	12	2											3	3	5	
VARGAS 1A		1799		1	8			3	12												1	18	16	
VILLAFELICHE 2A		229	3	12	13	8		10	5												28			
SAN ROQUE 2	869	20	14	2	25	10	4													13				
SAN ROQUE 1	926	3	25	14	3	16	10	3												10				
OLMO REDONDO 3	119	2	24	33	5	3	3													13				
OLMO REDONDO 2	286	11	18	19	3	8	10													10				
OLMO REDONDO 1	175	17	8	39	15	5														6				
LOWER	BAÑON 11A	278		9	8	1	7													2				
	BAÑON 2	298		4	25	1	2	5																
	BAÑON 5	131		6	5	2																		

Fig. 1. Distribution chart of rodent genera and species in localities from the Aragonian type area and the Bañon area. Several localities are marked by either an asterisk, a cross, a circle, or an X. Each symbol represents a separate section. Localities with a circle are situated in the type section.



In the last column the rodent families are indicated as follows: Eomyidae (vertical lines), Gliridae (white), Cricetidae (dotted), Sciuridae (oblique lines), and Castoridae (black).

However, these two species overlap in size and in dental pattern, and can therefore not be separated completely.

G – Two *Megacricetodon*-species are present which can be separated on the basis of size and of dental pattern. The larger species is dominant, the smaller one is always rare. Quantitatively the Gliridae are a minor constituent of this zone, but there are relatively many genera. This zone is furthermore characterized by the first appearance of *Myomimus dehmi* and *Eliomys truci*. Castoridae are present in the upper part.

H – This zone, characterized by the presence of *Hipparion*, is the lowest zone of the Vallesian. Important rodents are *Hispanomys*, *Megacricetodon ibericus*, *Myomimus dehmi*, and beavers.

I – Apart from *Hipparion* and *Hispanomys*, *Cricetulodon* is important. *Megacricetodon debruijini* is present, *M. ibericus* is absent. Among the Gliridae, *Myomimus dehmi*, *Peridyromys multicrestatus* and *Muscardinus* are common.

CHRONOSTRATIGRAPHY

After the localities have been grouped in biozones, the biozones are assembled in chronostratigraphic units. Of the nine zones distinguished seven belong to the Aragonian, the other two to the Vallesian.

The lowest zone (A) represents the Lower Aragonian, characterized by the absence of modern Cricetidae (Cricetinae and Cricetodontinae), and the abundance of *Ligerimys*.

N.B. In this paper the lower limit of the Aragonian is still defined by the entry of *Anchitherium*. Recent discoveries of Early Aragonian and older faunas revealed that this criterion has been an unfortunate decision of the Munich Symposium because of the scarcity of this taxon. In a future paper a redefinition of the lower boundary of the Aragonian will be considered, possibly resulting in the elimination of this zone 'A' from the Aragonian, and its incorporation in the preceding stage.

The next four zones (B, C, D, E) form the Middle Aragonian, characterized by the successive appearance of the typical Miocene Cricetidae, and the expansion and evolution of these groups.

The Upper Aragonian, containing two biozones (F, G), is characterized by considerable changes in the glirids, appearance of modern eomyids, fundamental changes in the composition of the cricetid fauna, and in the Lagomorpha.

The uppermost two biozones (H, I) belong to the Lower Vallesian. An important feature is the presence of *Hipparion*.

Perhaps it seems ill-balanced to recognize only one biozone in the Lower Aragonian, four in the Middle Aragonian, two in the Upper Aragonian, and two in the Lower Vallesian. However, these zones represent mainly biotopic units and there is no linear relation between time and the thickness of the biozones.

At the Munich symposium Aragonian was meant to be a superstage, comprising two stages: Orleanian and Astaracian. Apart from the fact that these two stages have never been defined properly, we have found that a tripartition of the Aragonian is much more logical and easy than a bipartition. If we would try to place Orleanian and Astaracian in Fig. 1, the boundary would have to be somewhere through the middle of the Middle Aragonian, and it

would be extremely difficult to decide which of the minor faunal events in that stretch should serve as a criterium for distinction. Maybe such a bipartition is useful in France, in the Aragonian type area it is not. One of the outstanding features of the Aragonian type area is that continental sedimentation and faunal representation are continuous throughout most of the Aragonian time. Zonation takes place on the basis of a continuous sequence of faunal changes. In the Valles-Penedes (NE. Spain) the continental sedimentation is discontinuous due to a marine transgression in the Middle Aragonian (Agusti, 1981). In this area a bipartition of the Aragonian seems appropriate because no mammal faunas are known in this marine interval. In France the fossil record is even more fragmentary than in the Valles-Penedes; the supposed bipartition of the Aragonian may well be a misinterpretation of these fragmentary data. We therefore recommend not to use such indeterminate terms as Astaracian and Orleanian for Spanish faunas.

The Neogene Mammal Zones

The MN-Zones, as defined by Mein, 1975 (see Fig. 2), seem to be biozones as they are based on 1) appearances, 2) associations, and 3) evolutionary stages of palaeontological taxa. However, they do not correspond to the definition of a biostratigraphic unit which must be 'a body of rock strata unified by its fossil content or palaeontological character and thus differentiated from adjacent strata' (Hedberg, 1976, p.48, C, 3). Nor are the MN-zones chronostratigraphic units, since such units also must have a body of rock strata as their basis. They pretend to be chronological units, but it is clear that the boundaries between MN-zones may be — and often are — diachronic. This leads to the conclusion that in the sense of the International Stratigraphic Guide the MN-zones are no stratigraphic units at all. We will try to give some examples of the confusion caused by the use of the MN-zones.

ZONE MN 3 A

Zone MN 3 A (reference locality for MN 3 is Wintershof-West, Bavaria) is defined according to Mein (1979) by the spreading over Europe of *Anchitherium*, *Brachyodus*, *Amphimoschus*, *Procervulus*, *Lagomeryx*, *Palaeomeryx*, *Stephanocemas*. Estrepouy (Gers, France) is attributed to MN 3 A, but of all these newcomers only *Lagomeryx* and *Anchitherium* are known from Estrepouy. According to Mein the typical association of MN 3 is *Brachyodus* + *Anchitherium*, but *Brachyodus* has not been found in Estrepouy. *Eucricetodon infralactorensis* is considered to be a characteristic species for zone MN 3 A. However, apart from Lisboa 1 (Portugal) and Estrepouy, none of the localities attributed to zone MN 3 A by Mein (1979) contains this species. In fact, by placing Estrepouy, Wintershof-West, Ateca 1 (Zaragoza, Spain), etc. in one zone, an important biostratigraphic event is obscured and lost: throughout Europe there are a number of localities of roughly the same age that do not contain any Eucricetodontinae, Cricetodontinae or Cricetinae at all. Com-

	SPAIN/PORTUGAL	FRANCE	Characteristic forms of evolutionary lineages	Associations	Appearance
Astaracian	6	Madrid Manchones Arroyo del Val	<i>Cricetodon sansaniensis</i> <i>Cricetodon jotae</i> <i>Megaericetodon grusafonti</i> <i>Democricetodon gailiardi</i> <i>Eumyarion medius</i> etc.	<i>Platybelodon danovi</i> + <i>Listriacodon splendens</i>	<i>Deinotherium levius</i> <i>Platybelodon</i> <i>Listriacodon</i> <i>Habanochœrus</i> <i>Conochyus</i> <i>Heteropnox</i> <i>Paleoacricetus</i> <i>Crouselia</i> <i>Dryopithecus</i>
	5	Las Planas 4b Lisboa Vb	<i>Megaericetodon bavaricus</i> <i>Democricetodon mutilus</i> <i>Palaeomyx m. pontileviensis</i> <i>Pliopithecus pibeteaui</i>	<i>Dicroceros</i> + <i>Bumolistriodon</i>	<i>Dicroceros</i> <i>Giraffokeryx</i> <i>Pliopithecus</i> <i>Hispanotherium</i> <i>Chilotherium</i>
Orleanian	b	Suèvres Vieux-Collonges	<i>Megaericetodon collongensis</i>	<i>Megaericetodon</i> <i>Melissoodon</i>	<i>Cricetodon</i> <i>Micromeryx</i> <i>Sansanosmilus</i>
	4 a	Baigneaux La Romieu Artenay	<i>Ligerimys florancei</i> <i>Eotrachus artensis</i>	<i>Eotrachus</i> <i>Amphitragulus</i>	----- <i>Megaericetodon</i> <i>Democricetodon</i> <i>Fahlbuschia</i>
3	Rubielos de Mora Moli Callopa	Chilleurs	<i>Euricetodon infralectorensis</i> <i>Ligerimys antiquus</i>	<i>Anchitherium</i> +	<i>Neocometes</i> <i>Ligerimys</i> <i>Myoglis</i> <i>Blackia</i> <i>Paleomeryx</i> <i>Anchitherium</i>
	Ateca 1 Lisboa 1 (Univ)	Estrepouy Chitenay	<i>Ligerimys lophidens</i> <i>Vasseuromys rugosus</i> <i>Cordylodon intercedens</i>	<i>Brachyodus</i>	<i>Procerovulus</i> <i>Amphimoschus</i> <i>Semigenetta</i> <i>Miomephittes</i> etc.
Aragonian	b	Bouziques Laugnac	<i>Euricetodon aquitanicus</i> <i>Ritteneria manca</i>	<i>Titanomys</i> <i>Prolagus</i>	<i>Prolagus</i>
	2 a	Montaigu Lespignan Caunelles	<i>Euricetodon gerardianus</i> <i>Melissoodon schlosseri</i>	----- ----- -----	----- ----- <i>Marquinomys</i>

Fig. 2. Extract from the biozonation of the Mediterranean Neogene on the basis of mammals, as compiled at the Bratislava Neogene Congress (1975).

parison of the faunal lists of Estrepouy on one hand and of Navarrete del Rio (Teruel, Spain) on the other, shows a remarkable resemblance; *Anchitherium* is the only new element in the Estrepouy faunule. Navarrete is considered to belong to MN 2, and Estrepouy may logically be placed in the same faunal unit as Navarrete.

ZONE MN 4

The reference locality of zone MN 4 is La Romieu (Gers, France). La Romieu is in the lower part of MN 4, called MN 4 A; Vieux-Collonges (Rhône, France) is placed in the upper part of zone MN 4, called MN 4 B. In fact it is the only rich locality in MN 4 B, and if a reference locality should be chosen for MN 4 B we suppose that it would have to be Vieux-Collonges, despite the fact that it is a fissure filling, which is not a good stratigraphic basis.

In La Romieu 10 rodent species have been found, in Vieux-Collonges 36. Of these five are identical or closely related. It is, however, striking that Vieux-Collonges contains several stratigraphically important species that do not occur in La Romieu. The differences of the faunas of Vieux-Collonges and La Romieu are such that they can certainly not be considered as belonging to one faunal unit. By placing them in two subdivisions of one zone these differences are undervalued.

On the basis of presence/absence of *Cricetodon* and *Fahlbuschia* Vieux-Collonges appears to be younger than La Romieu; on the basis of *Megacricetodon* (generally considered to be one of the most important genera for the biostratigraphy of Miocene deposits) no decision can be taken. In both localities *M. minor collongensis* is supposed to occur, and since the size of the La Romieu specimens is on the average larger, La Romieu seems to be younger than Vieux-Collonges.

Recently Bulot described *M. primitivus* and *M. bavaricus bezianensis* Bulot, 1980 from Bézian, a locality of about the same age as La Romieu, and at a short geographical distance from La Romieu. *M. primitivus* is very rare (we think most of the material Bulot attributes to *primitivus* belongs to *bezianensis*), but Bézian definitely contains two species of *Megacricetodon*. The La Romieu specimens fall within the range of the Bézian population, and the possibility cannot be excluded that the La Romieu material belongs to *bezianensis* instead of *collongensis*.

Several authors have attempted to give an evolutionary scheme for *Megacricetodon* (Freudenthal, 1963, 1965; Fahlbusch, 1964; Aguilar, 1980). Parts of these schemes may be correct, as long as they are restricted to limited geographical areas, and as long as a local evolution is not interrupted by migrations. But correlating and interpreting relationships between various areas is quite hazardous in this group where at least three evolutionary lineages exist simultaneously. The relationships between these lineages are not known, and in several cases, like e.g. La Romieu, it is dubious to which lineage the *Megacricetodon* population belongs.

On the basis of Lagomorpha Rubielos de Mora 2 (Teruel, Spain) is placed in the same zone as La Romieu (Lopez Martinez, 1977), but on the score of rodents La Romieu is correlated with Spanish localities much younger than Rubielos; for the time being the position of Rubielos de Mora remains uncer-

tain. La Romieu may be correlated with any fauna between Vargas 1 A and Las Planas 4 A, with a preference for Valdemoros 3 B (see Fig. 1). The comparison of Vieux-Collonges with Spanish localities leads to a correlation with Valdemoros 3 B or Las Planas 4 A/B on the basis of *Megacricetodon*. On the score of *Cricetodon* and *Fahlbuschia* Las Planas 4 seems to come closest.

ZONE MN 5

In the original set-up of the MN-zones (Fig. 2) Las Planas 4 B served as a reference locality for zone MN 5. In 1976 at the Madrid congress on mammalian Neogene stratigraphy Las Planas 4 B was replaced by Pontlevoy (Loir-et-Cher, France). Ginsburg (1976) states that the "sites of Pontlevoy-Thenay present the incomparable advantage of containing a rich fauna of terrestrial mammals and marine invertebrates. Furthermore the mammalian fauna, until now represented by larger mammals only, has been enriched recently by a faunule of micromammals." This micro-mammalian faunule is described by Ginsburg & Sen, 1977.

We are now faced with two problems:

1. Which of the sites of Pontlevoy-Thenay is the real reference locality designated in Madrid, and subsequently accepted by Ginsburg, 1977, Mein, 1979, etc.?

2. Do the various mammal-bearing localities in the Pontlevoy area really represent a homogeneous faunal assemblage?

Ad 1. Pontlevoy is evidently not a single fauna, but a complex of localities that may vary considerably in age. Such a complex can hardly serve as a reference locality, so one of the Pontlevoy localities should be chosen, and we have the impression that Thenay was meant to be the reference locality.

Ad 2. In view of the supposed depositional environment of the Pontlevoy "faunule" (near-shore, almost littoral), it is unacceptable to consider all mammal fossils found in it at various sites as a homogeneous fauna, and even the homogeneity of a single faunule like Thenay is not certain.

Furthermore, Collier & Huin (1977) state that the Pontlevoy basin contains two fossiliferous levels or facies, one fluvatile, the other one marine. Any reference to exact provenance is missing in the older collections. Collier & Huin describe a faunule from the fluvatile bed at Les Gandes and note the fact that *Pliopithecus*, *Chalicotherium*, and *Dicroceros* are not found in this locality. All other forms considered by Mein (1979) to be characteristic for zone MN 5 are lacking from their faunal list too. Since these forms do occur in other Pontlevoy collections we think there is a good possibility that "Pontlevoy" in general represent two faunal units at least.

Since Pontlevoy-Thenay replaces Las Planas 4 B as reference locality of zone MN 5 a comparison of these two faunules seems appropriate: the main advantage of Thenay is supposed to be that it contains both large and small mammals, whereas Las Planas only contains small ones. But, the scarce material of larger mammals from Thenay is hardly useful for stratigraphic correlations. As far as the small mammals are concerned none of the elements of the Thenay faunule coincides with those from Las Planas 4, with the exception of *Prolagus*.

On the other hand a comparison of Thenay with Vieux-Collonges leads

to remarkable results; the six rodent species found in Thenay all closely resemble or are identical to forms from Vieux-Collonges.

Rejecting the usefulness of the few larger mammal specimens from Thenay we come to the conclusion that Vieux-Collonges and Thenay belong to the same faunal unit. If Thenay is regarded as reference locality of MN 5, this means either that Vieux-Collonges also belongs to MN 5, or that Thenay is placed in zone MN 4, and that MN 5 is eliminated.

DISCUSSION

The discussion on the boundary between MN 2 and MN 3 has shown that sharp lines like those drawn between MN-zones are always dubious; they may be drawn higher or lower, but in every case they obscure valuable facts by their rigidity. To describe the actual situation properly a multiple of the amount of zones used at present would be necessary, and this multitude would make the system unworkable.

But not only the boundaries are dubious. A comparison of the reference localities of some of the MN-zones among each other, and with a number of Spanish localities shows a lot of contradictions in the system of MN-zones. Some of the factors involved are:

1. The known localities of mammals in France provide a very fragmentary record of the fossil fauna. Little is known about the influences of climate and biotope. E.g. the reference locality La Romieu contains a *Megacricetodon* species that is possibly unknown elsewhere; furthermore it contains two cricetid genera, *Eumyarion* and *Melissiodon*, that are absent or very rare in most known localities, and which we suppose to represent an uncommon biotope. Such a locality is not representative for faunas of the same age, and choosing it as a reference locality is not a good idea.

2. Immigrations and evolutionary processes are diachronic features. A genus may appear in France earlier than in Spain, so taking its arrival as a marker leads to drawing diachronic lines. Or, a genus may arrive in Spain earlier than in France, but afterwards in France, or in part of France, it may show a much faster evolution than elsewhere, which would not only lead to drawing diachronic lines, but even to the upper and lower boundaries of a zone crossing each other over a certain geographic distance.

Fig. 3 is a theoretical — and quite exaggerated — example of what might happen in the system of MN-zones as used at present: A-B-C-D represent four MN-zones in their supposed vertical sequence. The horizontal axis is geographic distance. The oblique lines are isochronic lines. So, the supposed sequence is A-B-C-D, the chronological sequence is D-C-B-A.

A questionable correlation has been made by Antunes & Mein (1977), and this correlation is used by Aguilar (1980) to set up a most confusing stratigraphic scheme. Reference locality for zone MN 6 is Sansan (Gers, France). The fauna of Manchones 1 (Aragonian type area) is correlated with that from Sansan. In Portugal the faunas from Póvoa de Santarém, Pero Filho and Chões have been correlated by Antunes & Mein (1977) with the fauna from Manchones 1 and consequently placed in MN 6. These Portuguese localities are situated on top of oyster beds which do not contain any stratigraphically useful fossils, but which are correlated with the 'apogée' of the transgression,

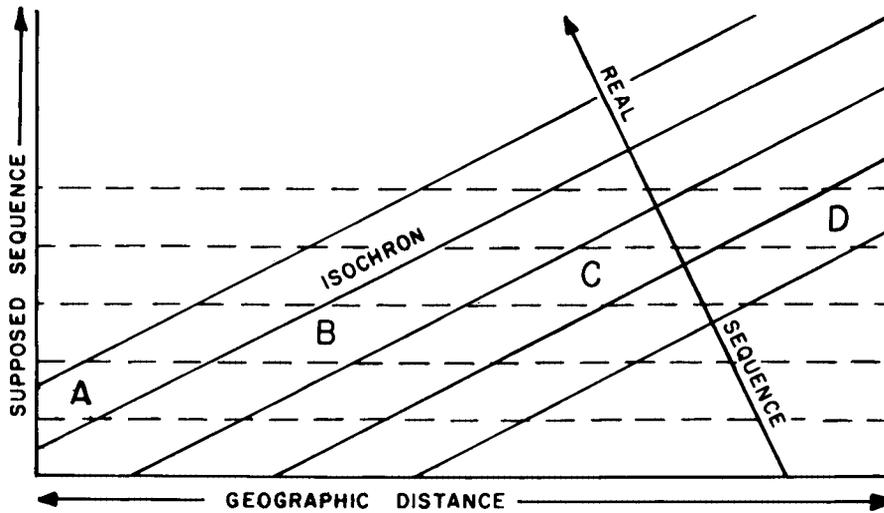


Fig. 3. Possible relation of MN-zones versus time.

dated in the neighbouring Tagus Basin on the basis of planktonic foraminifera between zone N 10 and N 14 of Blow. They conclude that the oyster beds must therefore be placed in zone N 11 or N 12 approximately.

Aguilar (1980) correlates the fauna from Sansan with Blow's N 7 or lower N 8 zone by means of marine intercalations in the sections of Leucatte Butte I and Luc-sur-Orbieu, as the faunas from these two localities seem to agree with that from Sansan. As Las Planas 4 B was the reference locality for MN zone 5, its fauna must be older than that from Sansan. Hence Aguilar (1980) places the fauna from Las Planas 4 B in the lower part of Blow's N 7 zone. Then he quotes Antunes & Mein (1977) who placed the fauna from Manchones in zone MN 11. Consequently he states that the evolution of *Megacricetodon* in Spain is not well known since there is an enormous hiatus in documentation between Las Planas 4 B and Manchones. However, in the type area of the Aragonian there is no hiatus whatsoever, neither in sedimentation, nor in documentation.

Mammal localities are forced artificially into MN zones. Underlying or overlying marine beds without stratigraphically useful fossils are correlated with other marine beds that contain such forms, e.g. on the basis of palaeogeography. And so it is demonstrated that Las Planas 4 and Manchones, two localities in a basin with continuous sedimentation, and geographically less than a kilometre apart must be separated by a considerable hiatus. The chain of arguments is: the Portuguese locality of Póvoa de Santarém is as old as Manchones; the underlying oyster beds are correlated with the Tagus Basin; the correlated beds belong to Blow's zone N 11. N 11 is younger than N 7; the French locality of Leucatte Butte belongs to N 7 (or 8); Sansan is correlated with Leucatte Butte; Las Planas must be older than Sansan. So, Las Planas belongs to lower N 7 and Manchones to N 11.

CONCLUSION

The MN-zones as used today are not only invalid according to the guide of stratigraphic nomenclature, they are also useless as they may lead to false conclusions. They might be used in geographically restricted areas (each area having its own set of zones), but they are not useful at a continental scale, not to speak of "être reconnues à distance intercontinentale" as stated in resolution 9 of the Colloque sur stratigraphie mammalienne du Néogène méditerranéen, Madrid, 1976 (see Alberdi & Aguirre, 1977).

Faunal lists

NAVARRETE DEL RIO (ADROVER, 1975, 1978)

Marsupialia

Peratherium sp.

Insectivora

Paratalpa aff. *micheli*
'*Sorex*' *pusilliformis*

Soricella discrepans
Heterosorex neumayrianus

Chiroptera

Myotis sp.

Rodentia

Heteroxerus cf. *paulhiacensis*
Heteroxerus vireti
Xerini indet.
Eucricetodon aff. *occitanus*
Ligerimys antiquus

Peridyromys murinus
Pseudodryomys meini
Pseudodryomys aguirrei
Armantomys sp.

Lagomorpha

Prolagus cf. *vasconiensis*

Lagopsis penai spiracensis

Artiodactyla

Cainotherium miocaenicum

ESTREPOUY (GINSBURG, 1974)

Marsupialia

Peratherium sp.

Insectivora

Plesiodimylus hurzeleri Muller

Galerix sp.

Lagomorpha

Prolagus vasconiensis Viret
Lagopsis penai Royo

Amphilagus ulmensis Tobien

Rodentia

Heteroxerus vireti Black
Heteroxerus sp.
Paleosciurus sp.
Steneofiber sp.
Melissiodon cf. *dominans* Dehm
Eucricetodon infralactorensis Viret

Ligerimys aff. *lophidens* Dehm
Peridyromys cf. *occitanus* Baudelot et de Bonis
Pseudodryomys cf. *ibericus* de Bruijn
Pseudodryomys cf. *brailloni* (Thaler)
Heteromyoxus sp.

Carnivora <i>Palaeogale minuta</i> (Gervais)	<i>Semigenetta</i> cf. <i>repelini</i> Helbing
Perissodactyla <i>Anchitherium aurelianense</i> (Cuvier) Rhinocerotidae indét. petite taille	Rhinocerotidae indét. grande taille
Artiodactyla <i>Palaeochoerus aurelianensis</i> Stehlin <i>Cainotherium</i> sp.	<i>Amphitragulus aurelianensis</i> Mayet <i>Lagomeryx parvulus</i> (Roger)
LA ROMIEU (GINSBURG, 1974)	
Insectivora <i>Proscapanus sansaniensis</i> (Lartet) <i>Trimylus?</i> sp.	<i>Miosorex grivensis</i> Depéret
Chiroptera <i>Hipposideros collongensis</i> (Depéret)	<i>Myotis</i> sp.
Lagomorpha <i>Prolagus</i> cf. <i>vasconiensis</i> Viret	<i>Lagopsis penai</i> Royo
Rodentia <i>Getuloxerus blacki</i> de Bruijn <i>Melissiodon dominans</i> Dehm <i>Cotimus?</i> cf. <i>helveticus</i> (Schaub) <i>Megacricetodon minor collongensis</i> (Mein) <i>Democricetodon minor romieviensis</i> (Freudenthal)	<i>Ligerimys florancei</i> Stehlin et Schaub <i>Pseudodryomys ibericus-simplicidens</i> de Bruijn <i>Microdryomys koenigswaldi</i> de Bruijn <i>Glirudinus modestus</i> (Dehm) <i>Steneofiber depereti carnutense</i> Ginsburg
Carnivora <i>Amphicyon giganteus</i> (Schinz) <i>Pseudocyon sansaniensis</i> Lartet	<i>Pseudaelurus quadridentatus</i> (Blainville)
Proboscidea <i>Trilophodon angustidens</i> (Cuvier)	<i>Deinotherium cuvieri</i> Kaup
Perissodactyla <i>Anchitherium aurelianense</i> (Cuvier) <i>Aceratherium</i> cf. <i>platyodon</i> Mermier	<i>Brachypotherium brachypus stehlini</i> Viret
Artiodactyla <i>Palaeochoerus aurelianensis</i> Stehlin <i>Hyootherium soemmeringi</i> Meyer <i>Bunolistriodon lockharti</i> (Pomel) <i>Cainotherium</i> sp.	<i>Dorcatherium</i> cf. <i>nauï</i> Kaup <i>Procervulus dichotomus</i> (Gervais) <i>Lagomeryx</i> cf. <i>rutimeyeri</i> Thenius <i>Palaeomeryx kaupi</i> Meyer
VIEUX-COLLONGES (GUERIN & MEIN, 1971)	
Marsupiala <i>Peratherium</i> sp.	
Chiroptera <i>Megaderma lugdunensis</i> <i>Rhinolophus</i> aff. <i>delphinensis</i> <i>Hipposideros collongensis</i> <i>Asellia mariaetheresae</i>	<i>Palaeophyllophora</i> sp. <i>Miniopterus fossilis</i> <i>Pipistrellus</i> sp.

Insectivora

Galerix exilis
Mioechinus sansaniensis
Erinaceus sp.
Plesiodymylus sp.
Talpa minuta
Proscapanus sp.

Scaptonyx edwardsi
Miosorex aff. *grivensis*
Hemisorex ? *collongensis*
 "Sorex" *dehmi*
Heterosorex sansaniensis
Limnoecus sp.

Lagomorpha

Prolagus cf. *oeningensis*

Lagopsis penai

Rodentia

Cricetodon meini
Cricetodon aureus
Cricetodon sp.
Megacricetodon minor collongensis
Megacricetodon bourgeoisi
Megacricetodon (Collongomys) lappi
Democricetodon cf. *mutilus*
Fahlbuschia cf. *darocensis*
Eumyarion sp. 1,2
Lartetomys mirabilis
Lartetomys zapfi
Melissiodon sp.
Neocometes sp.
Anomalomys sp.
Heteroxerus rubricati
Heteroxerus sp.
Spermophilinus sp.
 "Sciurus" cf. *fissurae*

Miopetaurista sp.
Cryptopterus lappi
Blackia pliocaenica
Eomys rhodanicus
Keramidomys thaleri
Ligerimys florancei
Microdyromys sp.
Peridyromys sp.
Eomuscardinus sp.
Miodyromys sp.
Pseudodryomys cf. *simplicidens*
Pseudodryomys sp.
Armantomys sp.
Myoglis meini
Glis sp.
Muscardinulus sp.
 Gliridae indet.

Carnivora

Amphicyon sp.
Pseudarctos sp.
Hemicyon vincenti
Ursavus elmensis
Ischyrictis zibethoides
Ischyrictis (Laphictis) mustelinus
Plesiogale postfelina
Alopecocyon getti
Proputorius pusillus
Martes filholi
Martes cadeoti
Martes delphinensis

Martes munki
Trocharion albanese
Paralutra jaegeri
Semigenetta aff. *repelini*
Viverra aff. *modica*
Herpestes aurelianensis
 ? *Jourdanictis* sp.
Progenetta cf. *praecurrens*
Progenetta gaillardi
Progenetta aff. *crassa*
Pseudailurus quadridentatus
Pseudailurus turnauensis

Perissodactyla

Anchitherium aurelianense
Phylotillon sp.

Rhinocerotidae indet.

Artiodactyla

Taucanamo sansaniense
Palaeochoerus aff. *waterhousi*
Cainotherium miocaenicum
Micromeryx flourensianus

Procervulus dichotomus
Eotragus sansaniensis
Lagomeryx sp.

Pholidota

Necromanis sp.

THENAY (GINSBURG & SEN, 1978)

Insectivora

Gen. indet. sp. indet.

Primates

Pliopithecus piveteaui

Lagomorpha

*Prolagus vasconiensis-oeningensis**Amphilagus* cf. *antiquus*

Rodentia

*Cricetodon aureus**Megacricetodon* (*Megacricetodon*) *bourgeoisii**Lartetomys* cf. *zapfei**Miodiromys* cf. *ibericus**Megacricetodon* (*Collongomys*) cf. *lappi**Spermophilinus* nov. sp.

Perissodactyla

Chalicotherium grande

Artiodactyla

Dicrocerus elegans parviceros

Cervidae indet.

? *Procervulus dichotomus*

LAS PLANAS 4 A+B (DAAMS ET AL., 1977, DAAMS, 1981)

Rodentia

*Armantomys aragonensis aragonensis**Fahlbuschia darocensis**Armantomys aragonensis giganteus**Cricetodon jotae**Microdyromys legidensis**Heteroxerus* sp.*Megacricetodon minor collongensis*

Lagomorpha

*Lagopsis penai**Prolagus oeningensis*

Proboscidea

'*Mastodon*' sp.

Artiodactyla

Cainotherium miocaenicum

Cervidae indet. small size

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