Appendice II

CAUNE DE L'ARAGO: HUMAN FOSSILS, ARCHAEOLOGY AND, LAST BUT NO LEAST, A LONG SEQUENCE OF LARGE MAMMAL FAUNAS

par
Jan VAN DER MADE*

Half a century of excavations at the Caune de l'Arago, under the direction of H. de Lumley, yielded over one hundred thousand determinable bones and teeth and nearly one hundred and twenty thousand pieces of lithic industry from over 50 stratigraphic units, as well as 147 human fossils. It goes without saying, that this is one of the most important paleoanthropological, paleontological and archaeological localities of Europe. Hundreds of papers describe the results of research on this cave, as reported in Volume 1 of a series of twelve volumes (H. de Lumley, 2014). This monumental monograph will bring this information together and the present volume (Volume 6 ; H. de Lumley, *in press*) is dedicated to the stratigraphy of its deposits.

After a small chapter on methodology, one big chapter of Volume 6 deals with the stratigraphic units (and super- and subunits) as observed in the transverse sections and another one does the same for the longitudinal sections. In these chapters the criterions defining the limits between the units are described. A fourth big chapter describes the archeological and paleontological content of the units and gives brief interpretations of the environment at the time of deposition. Even though the detailed descriptions of the fauna will appear in Volume 7 of this series, this chapter contains a wealth of paleontological information.

At present, close to 60 units and subunits are recognized (fig. 759) and for nearly each of them, a series of statistics are given, such as: numbers of determinable bones, indeterminable bone fragments, teeth, lithics; the same as percentages of the total; representation of different taxa (usually genera) of large mammals, expressed as a percentage of the determinable remains; percentages of tool types and primary material of the lithic industry; etc. Some of the units have been excavated in small areas and yielded only small collections (Subunits A1-4, P1, P3-5), and others have not yet been excavated at all (units R-U), but of 42 (sub)units a faunal list is given and the representation of the taxa as a percentage of the total determinable remains. I do not know another sequence with so many levels with fossils of large mammals in superposition in the Quaternary of Europe; more than one hundred thousand determinable fossils. This allows to do other types of paleontological research than usual, to ask different questions and to test hypotheses, which up to now were difficult to test.

From the pollen record we know that in large parts of Europe, during glacials the trees disappeared and herbs were predominant, while in the following interglacial one after the other tree species re-appeared. The exact sequence in which the trees arrive in an area, is probably a function of their speed of dispersal and the distance to their nearest refuge. Often birches were the first to re-appear in an area, while elms, oaks and beeches arrived later. Usually, a tree species became very abundant shortly after re-appearing, while its abundance dropped after the next tree species appeared. This gave a sequence of environments with different vegetation, which must have had an important impact on the fauna.

Faunas may have responded to changing vegetation and climatic parameters along the glacial-interglacial cycles in much the same way as plants did. Caune de l'Arago gives for the first time the opportunity to see how the composition of the faunas changed along glacial cycles, and this in one place in a single long sequence of many superposed faunas.

All levels in this sequence are archaeological sites (fig. 760), so prey selection or other taphonomical biases may have played a role. The index of the number of specimens of lithic industry and fossils (teeth and determinable bones) might be interpreted as an indicator of the intensity of human activity. This index (fig. 760) has very high values in the uppermost and lowermost units, but varies very little in the main part of the sequence. So at least, fluctuations in the intensity of human activity should not, a priori, be invoked to explain variations in the faunal composition.

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* Jan VAN DER MADE – CSIC, Museo Nacional de Ciencias Naturales, c. José Gutiérrez Abascal 2, 28006 Madrid, Spain. E-mail : mcnjv538@mncn.csic.es.

Though Volume 6 is not dedicated to dating, this information is mentioned at the relevant places. A stalagmite layer on the cave floor forming the base of the sediment infill was dated by ESR to 690 ka and has normal paleomagnetism. Teeth from the Superannuate II ("Ensemble II", units J to H) have been dated by ESR to 480 to 520 ka. A human fossil from Subunit Gm2 was dated by ^{230}Th/^{234}U to about 450 ka, but with an large error margin. The stalagmite layer IV-1 on top of Unit D, was dated by 230Th/234U to about 400 ka. A stalagmite layer below unit RFO was dated by ^{230}Th/^{234}U to about 250-260 ka. Geomagnetic excursions were detected in : Unit W (about 670 and 660 ka), between Units T and S, Superunit I ("Ensemble I") (about 600 ka) Unit L (Big Lost excursion, 560-580 ka), between Units I and H (Calabrian Ridge 2, 520 ka), the base of Unit Fi (Emperor, 470 ka), and Unit E (a not yet known excursion). These dates and correlations are included as arrows in figures 759 et 760.

As a result of the dating, the Lower Complex (with Units R-W) is assumed to range in age from 600 to 680 ka. This Complex did not yet yield fossils. The Middle Complex consists of Superunit I (Units K-Q), which is assumed to have an age of 520 to 580 ka corresponding to stages 14 and 15, Superunit II (Units J-H), which is assumed to have an age of 480-520 ka and which is correlated to isotope stage 13, and Superunit III (Units G-D), which are correlated to stage 12. This implies that there should be two complete glacial cycles, starting with warm stage 15 and ending with cold stage 12. Then a much less sampled section (Upper complex, Units A-C) and then the considerably younger Uppermost Complex (Units RFO + RFB).

In addition information on the pollen was reported. The environments at the time of formation of the stalagmite at the base of the sequence and the Lower Complex were interpreted as forest, while in the case of the Middle complex this is grass steppe with groves of pine trees and juniper (Unit F) to cold steppe with herbs (Unit D).

Figure 760 shows the changing faunal composition along the Arago sequence. It is based on the data given in Chapter 4. The different Carnivora were lumped, as were the large rodents (mainly beaver, but also some porcupine and marmot) and the goats and chamois. The variation in relative abundance of the taxa is given as a bar diagrams, but the scales are different for the very rare (< 1 %), rare (1-10 %), and common species (> 10 %). The animals that are generally considered to be "glacial", or at least present in mid-latitude Europe during glacial times, are given in blue. The animals that are considered to be "interglacial" are given in red. Animals with less pronounced biogeographic fluctuations are given in grey. The expected climatic conditions are indicated by light blue and red back grounds below the bar diagrams.

The Arago sequence covers a long period and it could be expected, that several taxa would appear by dispersal or go extinct in this period. This is the case with *Capra*, which appeared in western Europe during the time of the Arago sequence (Crégut-Bonnoure, 2007), and which here is absent in the lower and present in the upper units. More such events may be masked by the fact that genera are given, while there is a replacement at the species level. For instance, depending on the ages of the units, the replacement of *Stephanorhinus hundsheimensis* by *S. hemitoechus* (Van der Made, 2010) or *Equus suessenbornensis* by *E. ferus mosbachensis* (Lister *et al.*, 2010), could be expected. For this type of information, we have to await the publication of Volume 7.

The most striking observation is that one taxon after the other appears or becomes common in the sequence, but only few taxa (*Equus* and *Ovis*) show at least two peaks in the Middle Complex (Units D-Q), as would be expected in two glacial cycles. Instead, the reindeer *Rangifer* and muskox *Praeovibos* have each a peak, but in a different cold period, separated by the peaks of *Dama* and *Cervus* in an intermediate warm period.

A closer look shows that, *Rangifer*, which is expected to appear each cold period and disappear during the warm periods, is present in nearly all units (save for B and Ei5). In the lower part of the sequence (partially corresponding to cold stage 14) it is a very common species, represented by up to 85 % of the fossils, but from unit J onward its relative abundance is mostly 3-4 %, irrespective of the interpreted warm or cold conditions. This is not due to sample size, since some of the levels reflecting this pattern have thousands of determinable fossils (fig. 760). The musk ox (*Praeovibos*) is another "glacial" taxon. It appears near the middle of the sequence in unit L with 0.03 % (invisible in the graph) and is constantly present from unit Gi to Es1, reaching a peak of 15.2 %. It appears in those units where *Rangifer* is rare, or absent (including units B and Ei5). *Mammuthus* is another "glacial" taxon and appears in Units Q and P2, when *Rangifer* is becoming common, but before it reaches its peak. This means that "glacial taxa" are present in all units, or at least in all with enough fossils to be included in the statistics (lacking are Unit A and some subunits of Unit P).

Today, the same species of reindeer lives in northern Eurasia and northern America. In Europe the wild reindeer has it southernmost distribution in southern Norway (Aulagnier *et al.*, 2009), while it is introduced in Scotland. If the range of the wild reindeer is limited because of human presence, the domestic reindeer, might be expected to live further south, but this is not the case. *Rangifer* is not a very common genus in the European fossil record, and in mid-latitudes (as in France and Germany) it occurs in faunas that are interpreted as glacial. Its presence in the very south of France would suggest cold conditions, even if it is not a very common taxon in the faunas.

The *Praeovibos* from Arago is a different species and even genus of the living muskox, so the interpretation of its environmental preferences has to be more cautious. Today, the musk-ox lives mainly within the arctic circle in North America and Greenland. However, in the Early Pleistocene of the south of Spain, in the locality Venta Micena, a still more primitive species of *Praeovibos*, than the one from Arago, occurred together with *Hippopotamus* (Alberdi et Ruiz-Bustos, 1985; Moyà-Solà, 1987). In any case, the Middle Pleistocene faunas with *Praeovibos* are generally interpreted as glacial.

The mammoth is extinct and last living mammoths belonged to the species *Mammuthus primigenius*, but the species from Arago is older and has an age corresponding to *M. trogontherii*. In mid-latitude Europe, this species is interpreted as "glacial" and it alternated with the "interglacial" *Palaeoloxodon antiquus* (Stuart, 1982; Kahlke, 1999).

The three "glacial" species do not peak at the same time, but in different units. One or the other is present in each of the units of Arago, suggesting cold conditions for all these levels. Animals living in mountainous areas are often adapted to cold conditions and are "pre-adapted" to glacial environments. This might apply to the sheep and thar. *Ovis* is present in all the sequence, but shows to broad peaks, when it becomes very abundant. The tahr *Hemitragus* is present in nearly all the sequence, but becomes common in the upper part. These peaks do not coincide with those of the peaks of the typically "glacial" taxa, save for the first peak of *Ovis*, which partially overlaps with the earlier part of the *Rangifer* peak. *Bisons* appear to be less restricted by cold conditions than the aurochs (*Bos primigenius*) and are present in all the Arago sequence, but are mostly rare, while the aurochs is absent.

A striking absence is the wooly rhinoceros *Coelodonta*, which appeared in Europe mainly, but non only, in glacial periods, and which during subsequent glacials reached further west into Europe and arrived in Spain in the later Pleistocene (Van der Made, 2010; Álvarez-Lao & García, 2011). Maybe this pattern has something to do with its absence in the Arago sequence. Let us look at the "interglacial taxa". These include *Palaeoloxodon*, *Dama*, *Sus* and *Macaca* (Stuart, 1982).

Palaeoloxodon is a typical "interglacial" taxon, which in mid-latitude Europe alternated with *Mammuthus* during the climatic cycles. When present in Arago, it is a very rare element. It is present in some levels near the bottom of the sequence (Q1 and Q2), where it coincides with *Mammuthus*, and in some near the middle.

The common fallow deer *Dama dama* lives as far north as southern Sweden and Latvia and nearly reaches the area with the reindeer, but does not arrive to be not sympatric (2009). Fossils of fallow deer are common in mid-latitude Europe from localities that are interpreted as interglacial. The only locality, that I know of, where it coincides with reindeer is in the Upper Pleistocene locality of Can Rubau in NE Spain. Its ancestor *Dama clactoniana* coincides with reindeer only in Arago. In the Arago sequence, it peaks in Unit J, just after the main peak of *Rangifer* in Units K, L, and M. In any case, when it appears it always coincides with *Rangifer*.

Suids search their food under or close to the soil; they root and their body shape does not allow them to browse very high. Their geographic distribution tends to be limited by a thick snow cover or frozen soil in winter. The living species *Sus scrofa* occurs as far north as southern Sweden and Finland (Aulagnier *et al.*, 2009). It is not a common fossil species and occurs in interglacial faunas. In Arago, it is rare and restricted to three units in the upper part of the sequence.

The barbary macaque *Macaca sylvanus* lives in the north of Africa and is introduced in the south of the Iberian Peninsula (Aulagnier *et al.*, 2009). In Japan, another species of the genus lives as far north as about the center of France (Ohdachi *et al.*, 2009). However, *M. sylvanus* has a long fossil record in Europe, where it went extinct at the onset of the last glacial (isotope stages 2-4) and its fossils are known from as far north as Tegelen in The Netherlands and Hoxne in England (Stuart, 1982). The macaque appears since in unit D in Arago. It is present also in C and in the fissure sediments RFO and RFB.

Several of the remaining taxa, could be expected to be severely restricted by cold conditions. The different species of *Stephanorhinus* tend to alternate with the wooly rhinoceros *Coelodonta* (Stuart, 1982; Van der Made, 2010). Here *Stephanorhinus* is present in nearly the whole sequence. *Cervus elaphus* lives as far north as Norway, where it is sympatric with *Rangifer*, and southern Sweden (Aulagnier *et al.*, 200). In the Arago sequence, it is present in all levels, but it peaks at the same time as *Dama*.

So all together "glacial" or at least "cold" taxa are predominant throughout the Arago sequence, while "interglacial" or "warm" taxa tend to be rare. The presence of the latter can be explained by the nearby presence of their likely refuge area. So far, the faunal compositions suggests predominantly cold conditions. However, the datings and interpretations of paleomagnetic excursions suggest a long time period including several warm stages. Possible explanations for this paradox include:

- Warm periods are represented by hiatuses in the sequence.
- The presumed "cold" taxa had not yet fully adapted to cold conditions and were not limited by warm temperatures.
- There are more paleomagnetic excursions than previously recognized resulting in different correlations of the sequence.
- Stage 14 is not a relatively warm glacial, but instead, stages 13 and 15 are relatively cold interglacials.

As usual, more research is needed. If we would have many such rich and detailed sequences as the one of Arago, problems like this paradox would have been solved since long.

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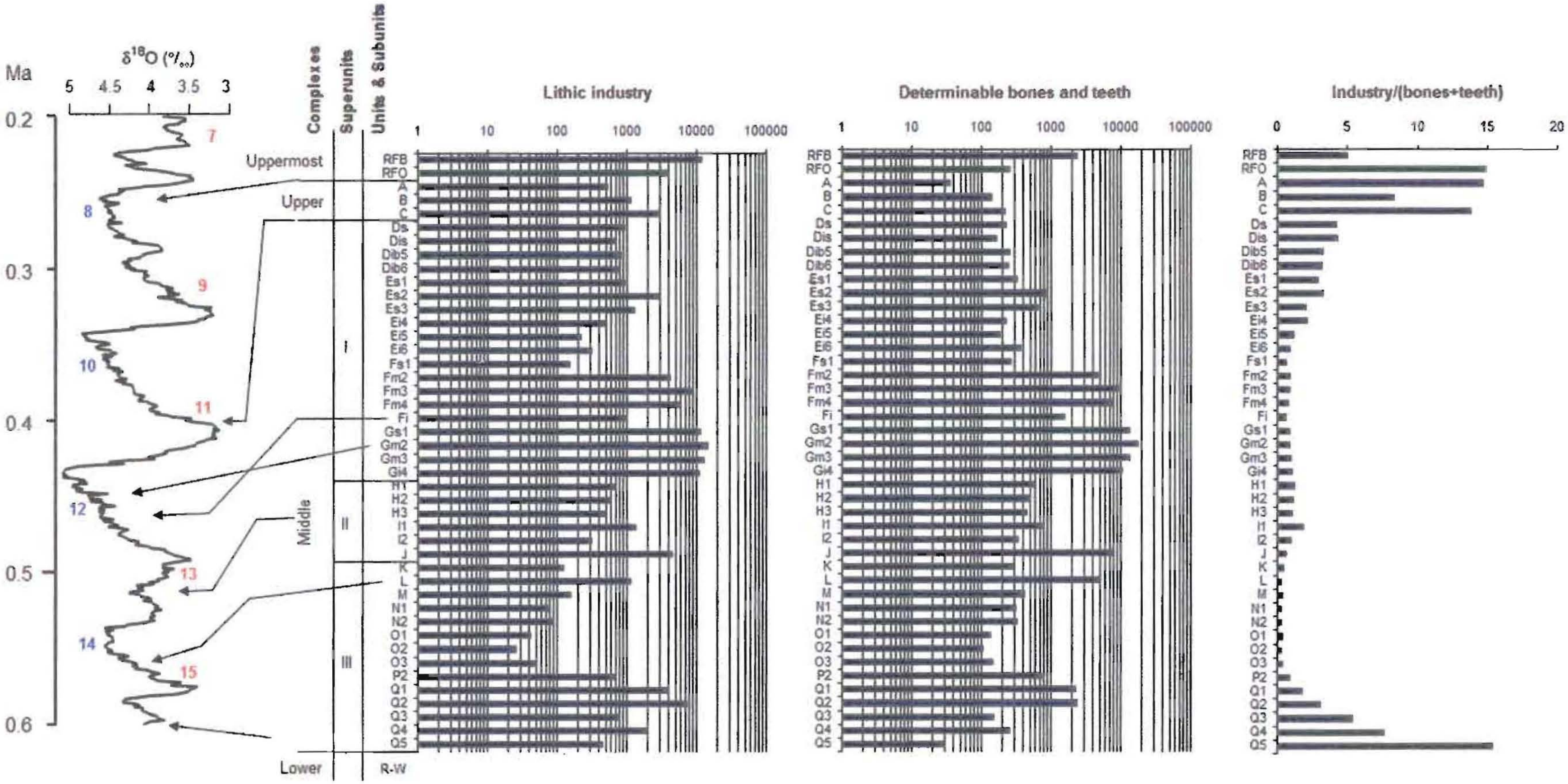


Figure 759 : *The abundance of lithic industry and fossils and the ratio between the two in the different units of the Caune de l'Arago. The numbers of specimens of lithic industry and determinable bones plus teeth are indicated on a logarithmic scale. To the left of the figure the age in millions of years and an oxygen isotope curve and stages (from Lisiecki & Raymo, 2005). Arrows indicate correlations from Arago to the isotope curve based on paleomagnetics and Thorium/Uranium and ESR dating reported in this volume.*

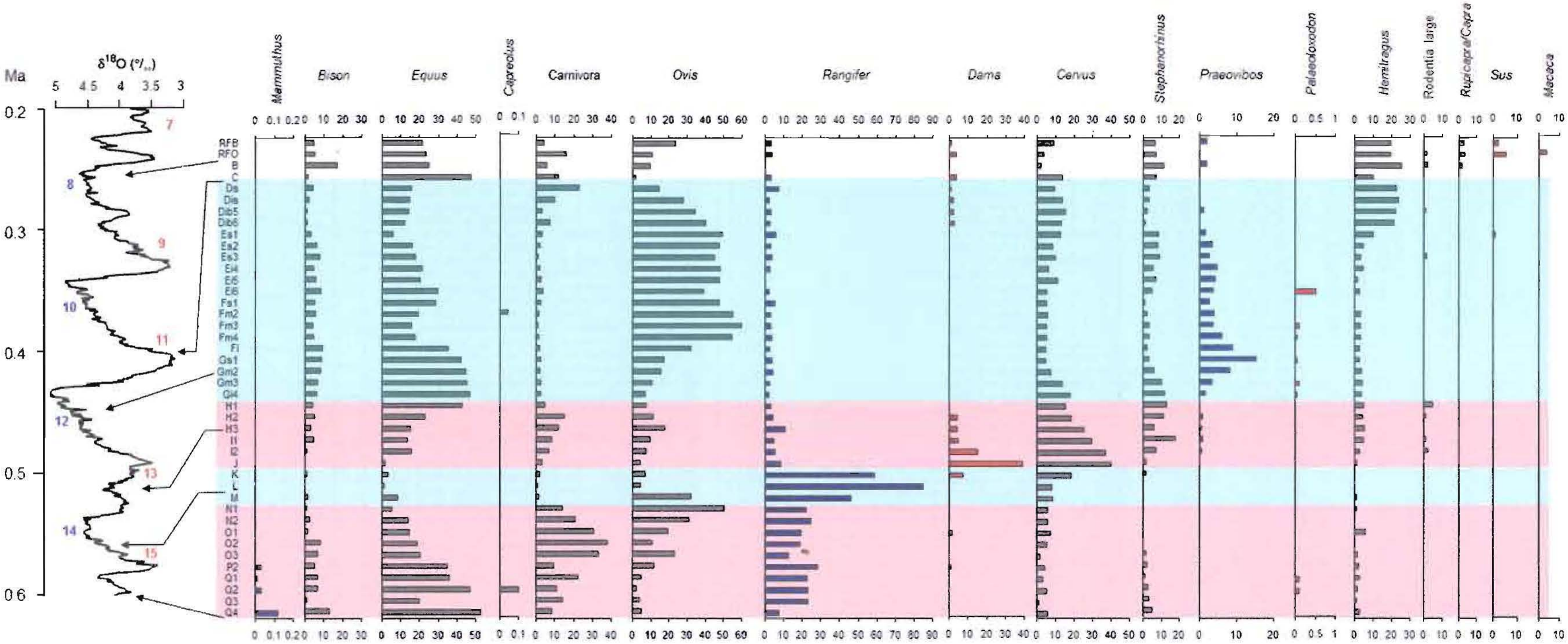


Figure 760: *The representation of the different taxa in the stratigraphic units of the Caune de l'Arago. The values indicated are the percentages of the total of determined bones and teeth per stratigraphic unit. The data are from chapter 4 of this volume. Left hand side of the figure as in figure 759.*

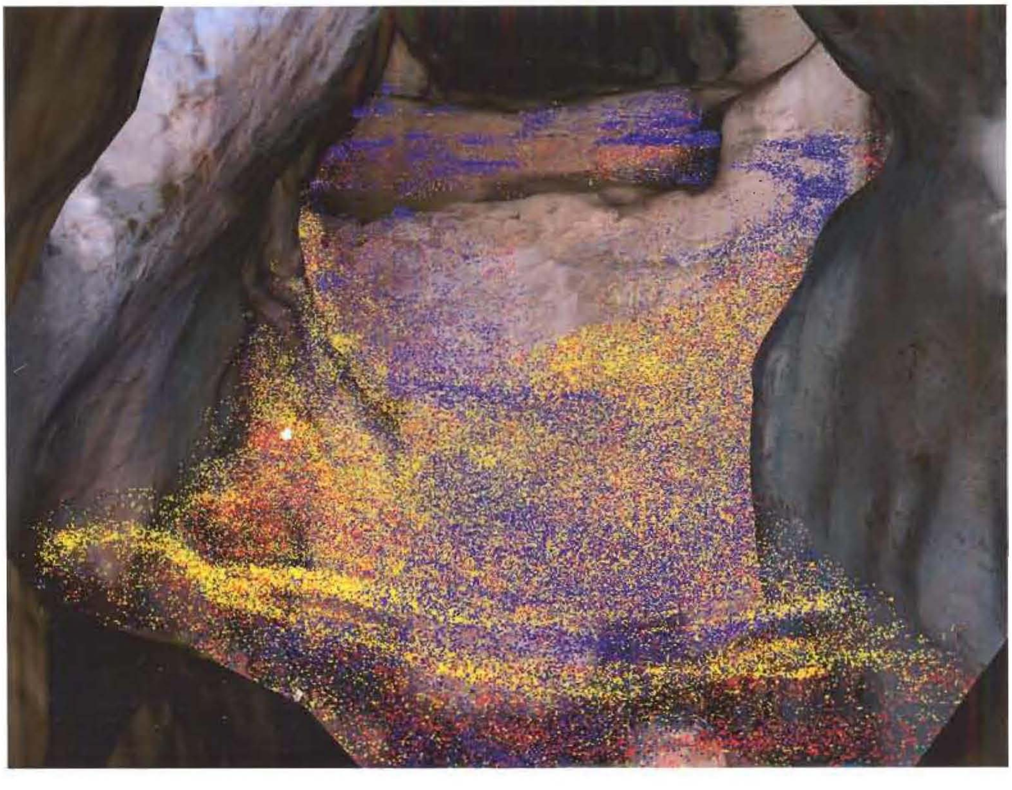
Caune de l'Arago

Tautavel-en-Roussillon
Pyrénées-Orientales, France
TOME VI

Individualisation des unités archéostratigraphiques

CNRS EDITIONS

Sous la direction de **Henry de Lumley**



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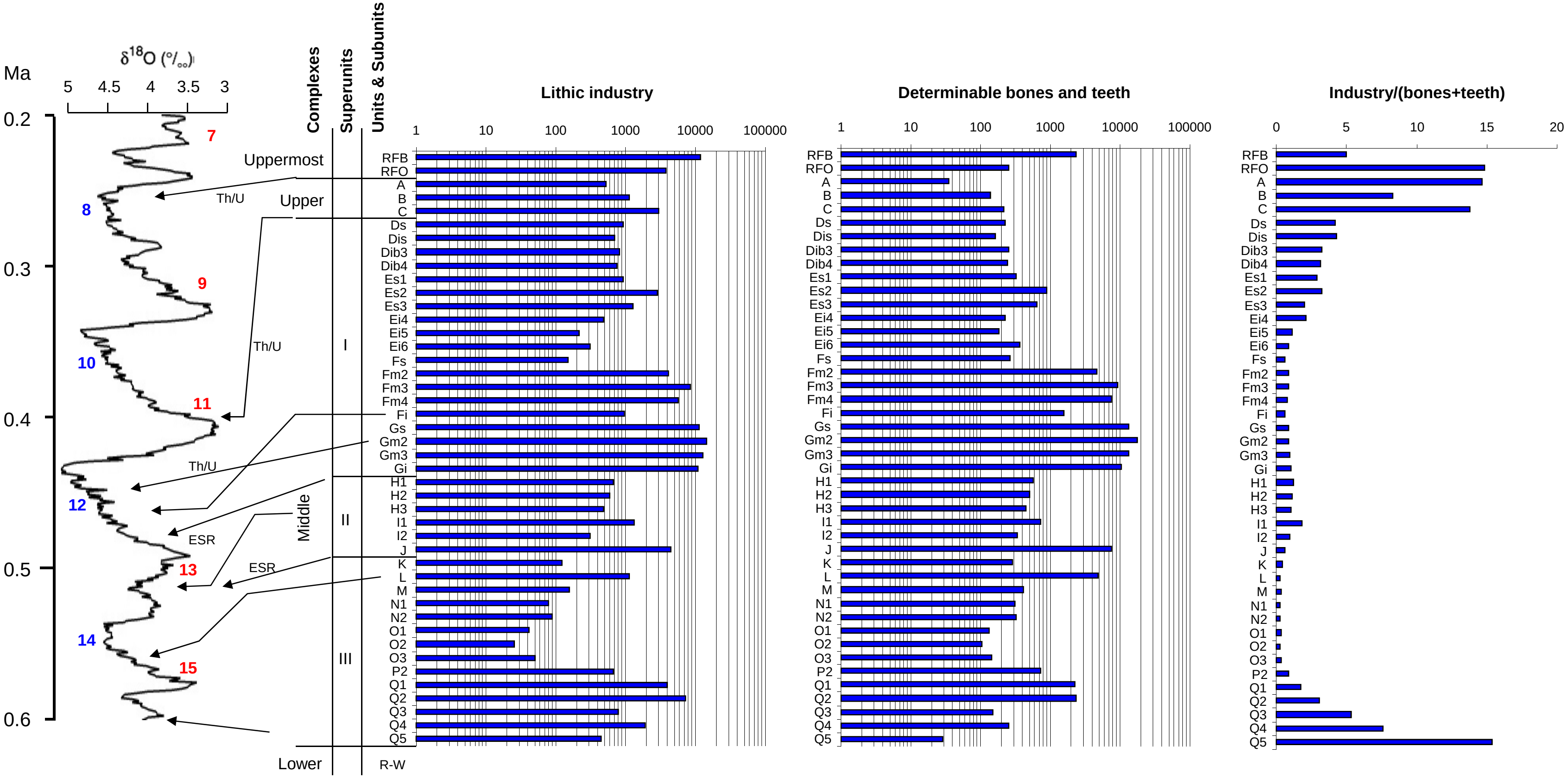
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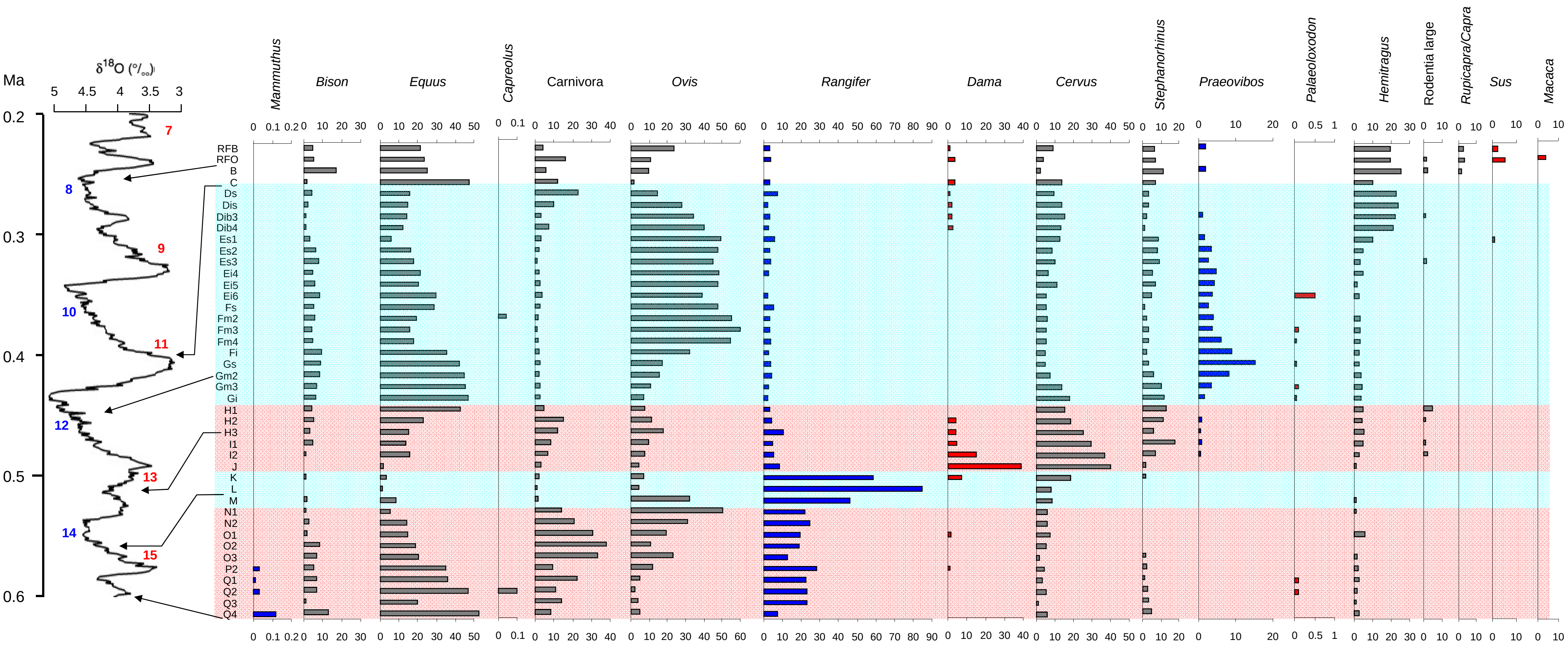
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Rangifer
Dama
Cervus
Stephanorhinus
Praeovibos
Palaeoloxodon
Hemitragus
Rodentia large
Rupicapra/Capra
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