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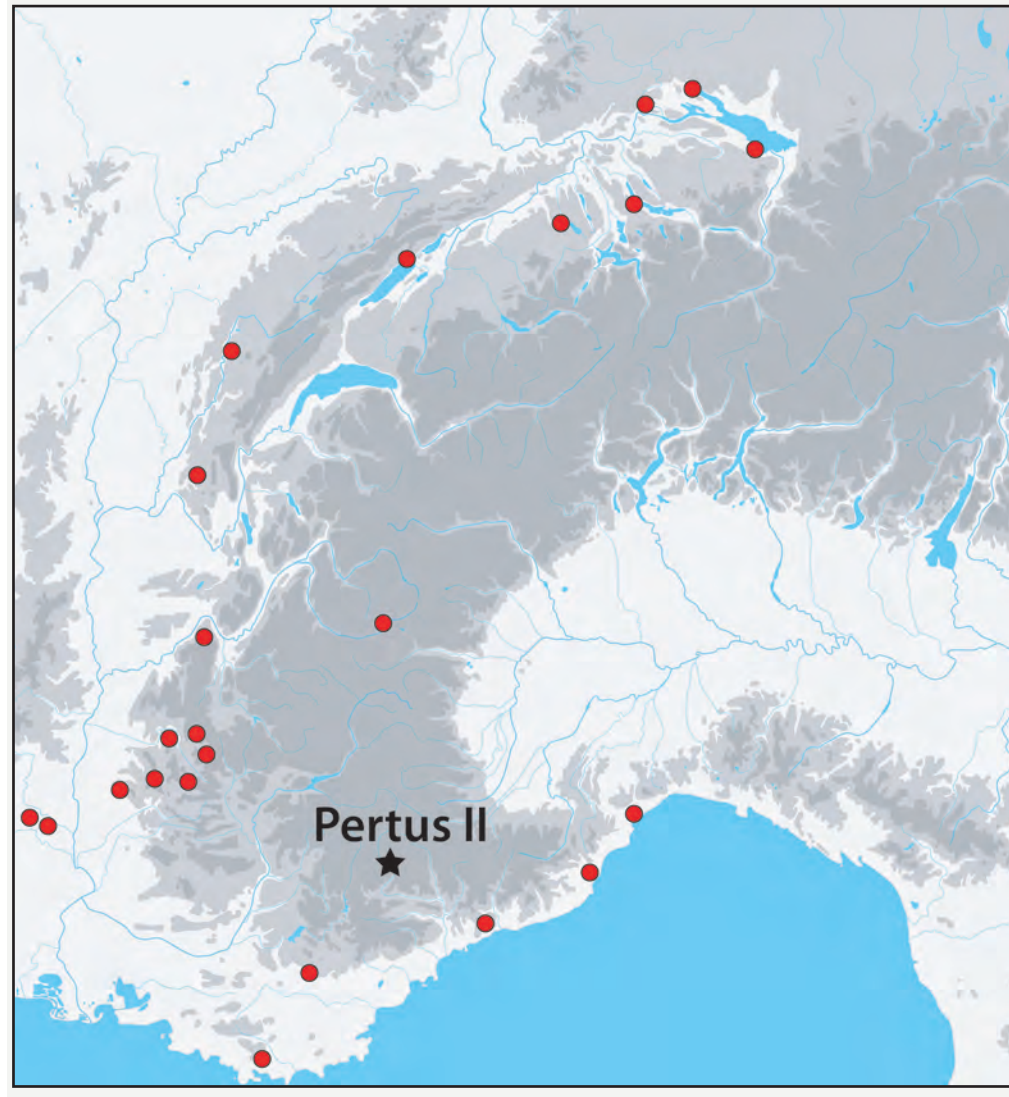
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Feeding the earth, feeding the herd: bioarchaeological and isotopic approaches to Neolithic agropastoral systems

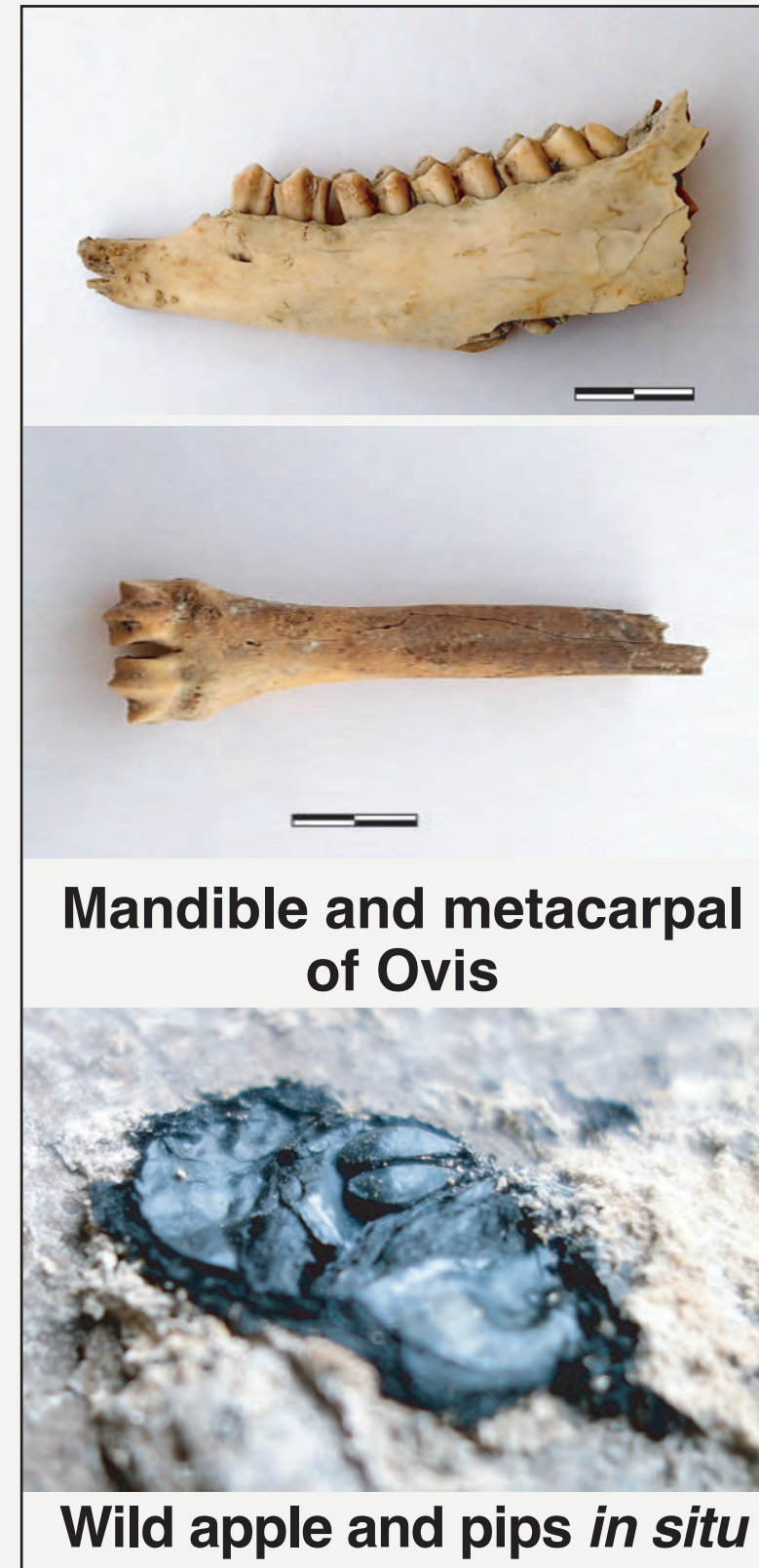
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Localisation of Pertus II in the Western Alps. The red dots indicate other known "grottes-bergeries"



Fossil dung levels in Pertus II



Mandible and metacarpal of Ovis

Wild apple and pips in situ

Agropastoral practices during the Neolithic in the Alps

Many Neolithic caves and sheltered sites show sedimentary, archaeological and bioarchaeological evidences of their use for keeping livestock, mainly small ruminants (sheep and goats). These so-called "grottes-bergeries" (sheepfold cave) show characteristic layers of fossil dung, which are valuable records of herd life and zootechnical practices. On several sites located above 1000 m a.s.l., abundant remains of cultivated plants (cereals and pulses) suggest probable in situ cultivation, which requires the use of rustic species (einkorn, barley) and agrarian practices adapted to a harsh climate and poor soils. Thus, alpine agropastoral system seems based on the exploitation of a large territory, between the plains and the mountains, including both seasonal movements and perennial occupations.

Our research questions the existence, during the Neolithic, of elaborate farming techniques allowing the maintenance of soil productivity and the cohabitation of crop growing and pastoral activities.



View of Pertus II from the facing slope

Pertus II, a "grotte-bergerie" as a laboratory

The cave of Pertus II (Méailles, dpt. 04) located at 1000 m a.s.l., below a plateau currently cultivated and grazed, was occupied in the Middle and Late Neolithic, between 3850 and 3000 BCE. It presents very characteristic and well-preserved layers of fossil dung, alternating with installations linked to an important production of ceramic.

Animal husbandry was supplemented by hunting and the shepherds also exploited a broad range of plants, both wild and cultivated.

The agropastoral system seems sophisticated, combining cereals and legumes with livestock (dominated by sheep/goats). Archaeobotany suggests that herds were fed with hardwoods branches and leaves but also, perhaps, with by-products of cereals and/or with legumes. The diversity of agricultural production led us to consider, as a hypothesis, the existence of field fertilisation practices.

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Stable isotopes of biological remains from the site of Pertus II are used as tracers of Neolithic agropastoral practices, in particular to highlight agricultural soil enrichment and herd feeding practices. The corpus currently consists in 103 analysed plant remains and 66 bones ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$). The remarkable preservation of fragile archaeobotanical remains allowed isotopic analyses of isolated plant organs (chaff of cereals) and direct measurements on wild taxa (oak buds, fir needles, apples...). Specific analyses of amino-acids extracted from the animal bone collagen will target more precisely the isotopic signal of sheep and goat diet to better relate them to the data obtained on available plant resources.

Moreover, experimental cultivation started two years ago aim to evaluate the effect on the $\delta^{15}\text{N}$ of cereals grown with legumes. The researchers involved in this project are archaeologists, bioarchaeologists, and isotope specialists from the CEPAM (Nice), LAMPEA (Aix-en-Provence), LOV (Villefranche-sur-Mer) and EDYTEM (Chambéry) laboratories.



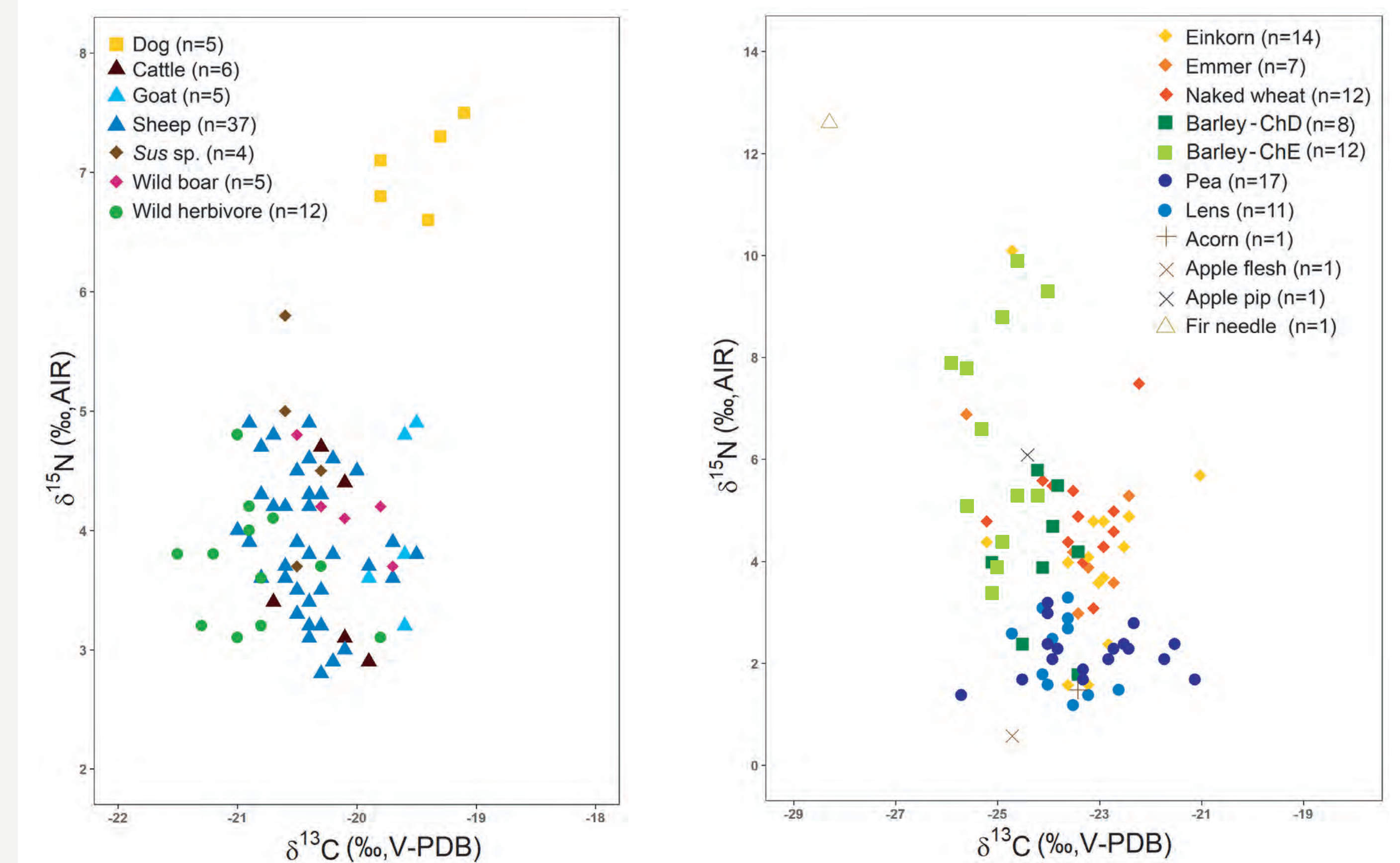
First interpretations of isotopic data

The project is ongoing and only selected results are presented here: those concerning archaeobotanical and archaeozoological remains (total collagen of mature individuals).

Fauna

The relative isotopic distribution of herbivore and carnivore (dog) taxa is consistent with their position in the food web. The carbon and nitrogen values of suids (wild boar or without specific identification) are generally consistent with the highest values found in herbivores and are always higher than those of wild ungulates. $\delta^{13}\text{C}$ values point to a relatively open environment, which contrasts with the rather forested environment described by charcoal analysis, suggesting a mosaic landscape around the site and thus a range of possibilities of pasturing areas for the shepherds. The wild herbivores $\delta^{13}\text{C}$ values reflect a rather more forested environment than those of the domestic ones.

A slight difference between goats and sheep may indicate varied feeding habits related to husbandry practices. Goats (browsers) show the highest carbon values which refer to the most open environment, while sheep (grazers) show values closer to those of wild herbivores. Sheep might have grazed in the more or less wooded areas, probably on the plateau just above the site, where soils can develop well, while goats might have fed on shrubby vegetation such as that which currently grows on outcropping rocks and shallow soils on the western edge of the plateau. The use of tree fodder, suggested by the charcoal analyses, may also have contributed to decrease the $\delta^{13}\text{C}$ of sheep.



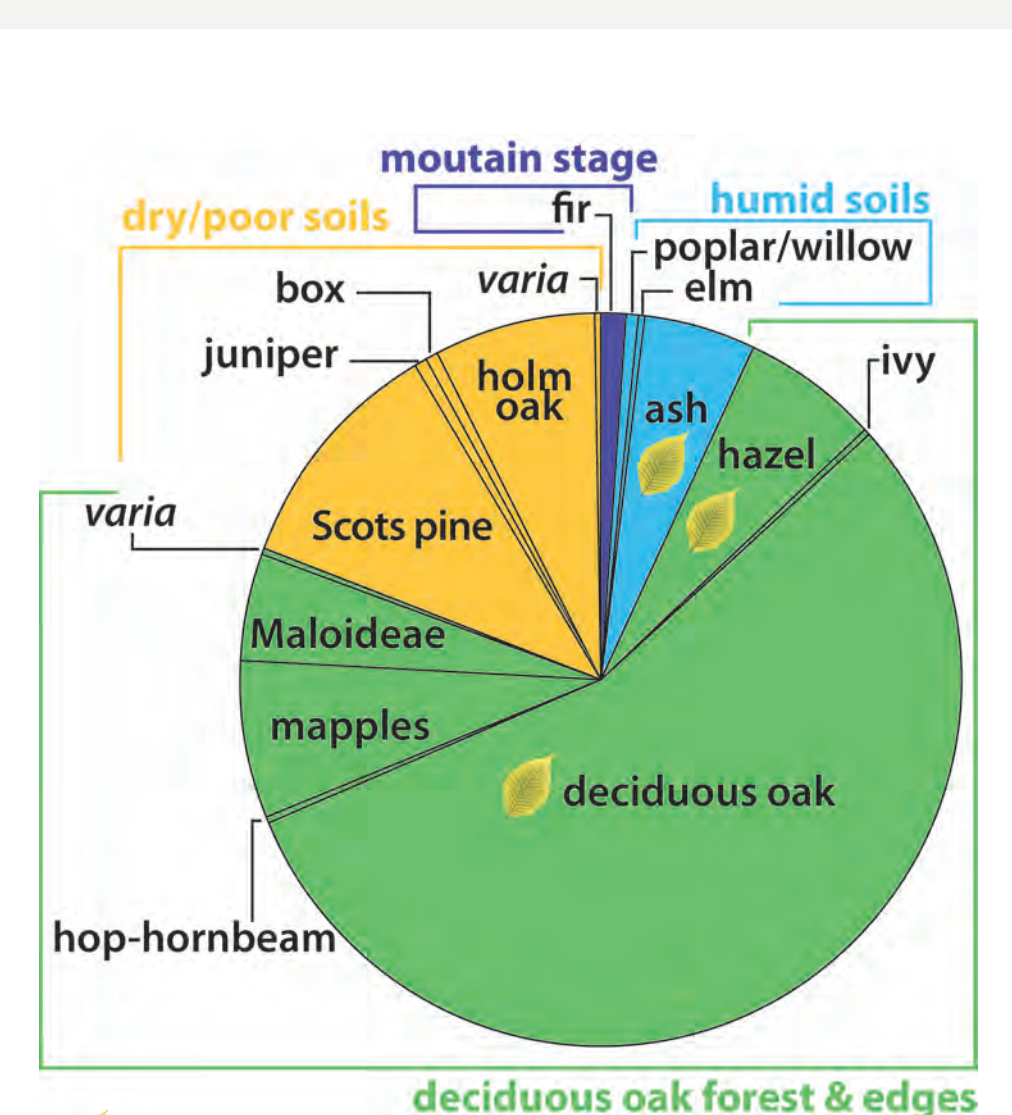
Animal and plants stable carbon and nitrogen isotope ratios from Neolithic layers of Pertus II cave. ChD: Chasséen D/ChE: Chasséen E

Plants

There is a wide dispersion of values and, as expected, the $\delta^{15}\text{N}$ of legumes (fixing atmospheric N_2) are lower than those of cereals.

Among cereals, wheat (einkorn, emmer and naked wheat) and barley respond differently. While wheat shows a rather homogenous signal, barley splits in two groups, according to their chronological origin. Indeed, barley from the Chasséen D (dark green squares in the graph above, 3850-3650 BCE) levels has lower $\delta^{15}\text{N}$ values while barley levels from the Chasséen E (light green squares, 3650-3300 BCE) are much higher. As wheat is not concerned, we question a specific change in farming practices concerning barley: did it received manure during the Chasséen E period?

Some barley and einkorn samples show very low $\delta^{15}\text{N}$ values, overlapping those of legumes (pea and lentil). The possibility of a co-cultivation cereal/legume or the use of legumes as green manure must be investigated, but reliable comparison data are currently lacking.



Charcoal analyses: chart showing the ligneous species identified in the Neolithic layers of Pertus II

Conclusion and continuation of the project

The first results presented here are very promising and, above all, raised many questions about the agropastoral system of Neolithic alpine societies. Ongoing work will help answering some of them.

- Concerning the herbivores, specific isotopic analysis (C and N) of amino-acids will give a better view of their diet and thus, for the domestic ones, on the zootechnical practices linked with their feeding (types of pastures and possible foddering).
- Concerning plants, isotopic analyses of modern crops (experimental co-cultures of einkorn and barley with and without legumes, over several years) will set up a reference framework; archaeobotanical corpus is being refined by the analysis of isolated cereal chaff (in order to track differences between grains and by-products) and of additional remains from wild taxa, in particular broadleaved trees buds.

This set of data will be able to clarify the agrarian techniques and the livestock feeding methods at Pertus II. More broadly, it will highlight new practices and how pastoral communities were able to take advantage of their environment, both wild and cultivated, within an already highly developed farming system.