Reconstruction with high spatio-temporal resolution of past forest dynamics and charcoal-making activities in an upper metallurgical valley in the eastern Pyrenees : first geoarchaeological, dendro and anthracological results

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Reconstruction with high spatio-temporal resolution of past forest dynamics and charcoal-making activities in an upper metallurgical valley in the eastern Pyrenees: First geoarchaeological, dendro- and anthracological results

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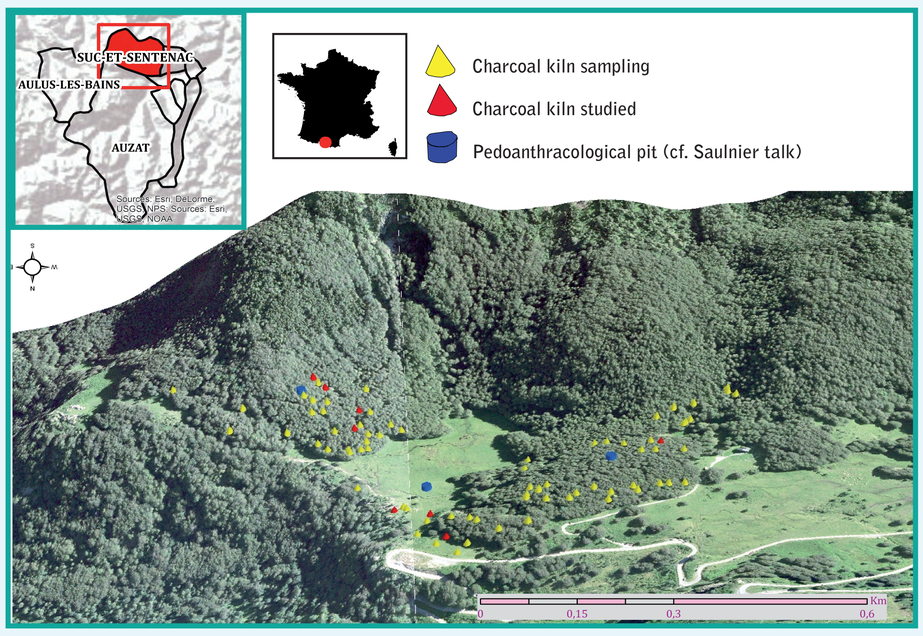


Fig.1: Localisation of the 81 charcoal kilns in the Bernadouze forest

Context of study

This study aims to reconstruct with high spatiotemporal resolution the history of a forest located in the High Vicdessos valley where mining and iron ore processing activities are attested from the Roman period to the 19th century. The study area (Fig. 1) is located on the west part of the Suc-et-Sentenac Commune in the beech forest of Bernadouze (Fig. 2) where 81 charcoal kilns were detected by field investigation(Fig. 3). They range between 1300 and 1500 m asl in an area of 32 ha.

Main Objectives

1. Reconstruct the main phases of charcoal burning activity;
2. Characterise charcoal makers forestry management;
3. Measure their impact on forest cover evolution;
4. Better understand the interspecific dynamics between fir and beech;
5. Reconstruct afforestation morphology evolution;
6. Bring to light sylvicultural practices and the charcoal making's "chaîne opératoire" and its temporalities.

Fig.2: Bernadouze beech forest

Fig.3: Grésigne forest (Tarn) charcoal makers (Source: DDM, 1920)

A multiproxy approach

1.Sampling: 81 charcoal kilns were sampled (Fig. 4) with a pedological auger (Fig. 5);
2. Anthracological approach: 2497 charcoals from 8 charcoal kilns dated by radiocarbon analysis were studied: (i) taxonomic identification, (ii) radial cracks (RC, Fig. 6) counting on the transversal section (number of RC/cm²) to discriminate green or seasoned wood, (iii) infestation level by fungal hyphae (Fig. 7) to determine the phenological state of wood before carbonisation, (iv) vitrification (Fig. 8) and (v) the bark location in the last ring (Fig 8) to determine the tree felling season;
3. Dendroanthracological approach: the measurement of curvature radius with AnthrocoloJ application (Fig. 9) .

Fig. 5: Carbonaceous layer

Fig.4: Charcoal kiln sampling

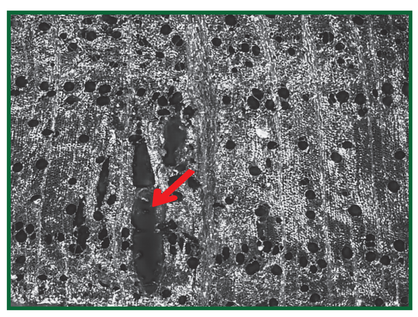


Fig.6: Charcoal with radial cracks

Fig.7: Charcoal with hyphae (Level 2)

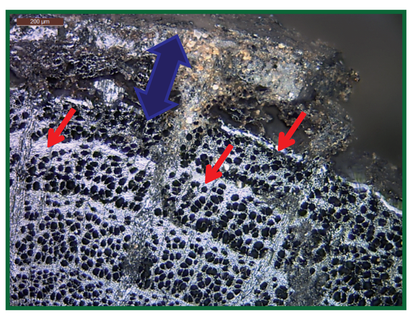


Fig.8: Charcoal with vitrification (red arrow) and bark (blue arrow)

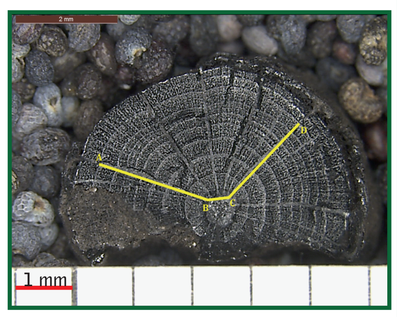


Fig.9: Dendroanthracological measures

Results and interpretation

Charcoal burning since the Late Middle Ages

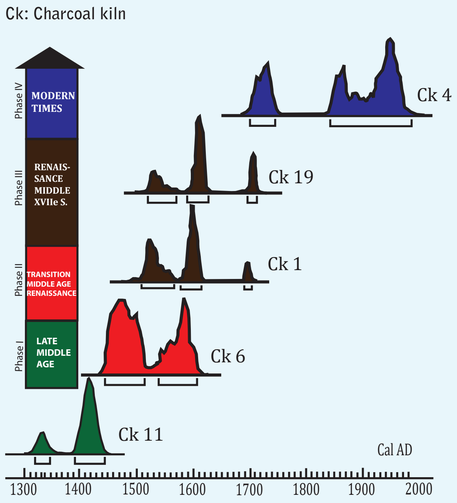


Fig.10: Radiocarbon calibration curve of charcoal kiln

^{14}C AMS dates (Fig. 10) show 4 phases of charcoal burning activity: the Late Middle Ages, transition Middle Ages-Renaissance, 16th to 17th and 19-20th c.

The elimination of fir

The anthracological diagram (Fig. 11) shows a quasi-exclusive use of beech in the late Middle Ages, then the use of beech and fir together from the Renaissance to the middle of the 17th c. The use of fir for charcoal production was prohibited in the Middle Ages but this restriction was abandoned from the Renaissance (Davasse 2000). Then, only the beech was used during the last phase. This assumes that the fir was deliberately eliminated to create a monospecific industrial forest with beech coppice more productive.

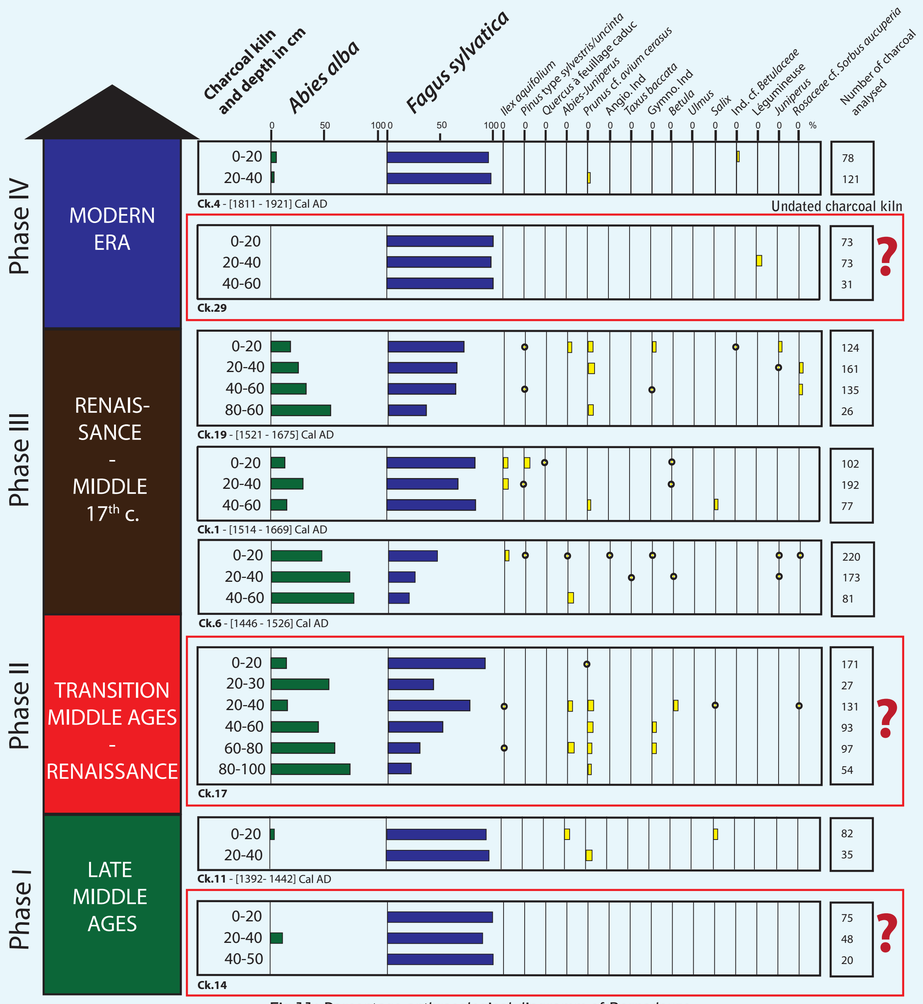


Fig.11: Percentage anthracological diagramm of Bernadouze

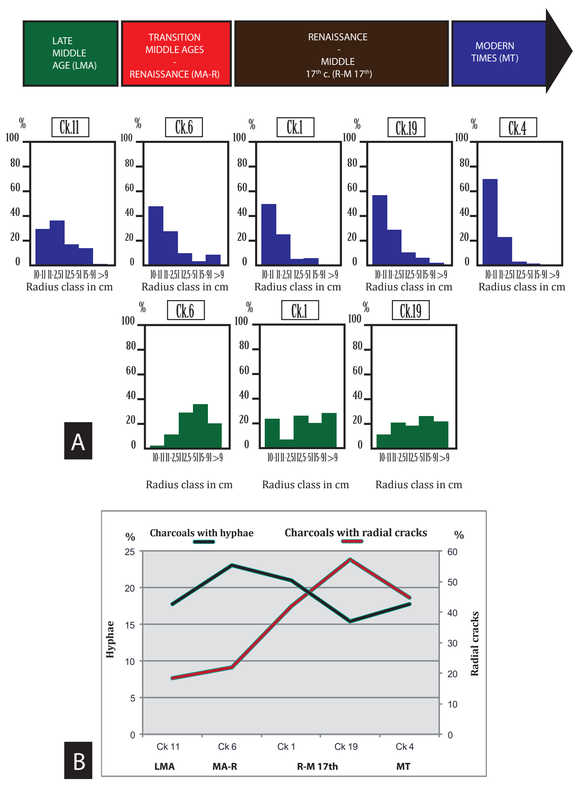


Fig.12: The chronological evolution of (A) diameter classes' distribution and (B) charcoals with hyphae and radial crack proportions (%)

Practices evolution over time

The dendroanthracological analysis shows the use of a mix of wood logs with minimum diameters between 2 cm and 18 cm for beech and 5 cm to more than 18 cm for fir. These results could suggest several sylvicultural practices: beech coppice, coppice-with-standards and/or high forest. Furthermore, the evolution of log size shows a significant decrease of diameters used over time (Fig. 12A). This assumes the evolution of simple beech coppice into short rotation coppice. The frequencies of charcoals with hyphae (45%) and radial cracks (15%) could suggest a storage period and a marginal use of green wood. Finally, the comparison between the curves of charcoals with hyphae and radial cracks (Fig. 12B) suggests a reduction of drying period over time and a changing of practices related to the intensification of charcoal-making activity from 17th c.

The annual charcoal burning cycle

The comparison between anthracological data and the phenological cycle of fir and beech (Fig.13) allows to elaborate the annual charcoal burning calendar (Fig. 14). It suggests that wood harvesting was done during the summer/autumn transition and late autumn or even winter. The cut wood was stored in the forest at least one year and carbonised at the beginning the following autumn. This assumes that charcoal manufacturing was practiced during the closed season of agropastoral activities.

Fig. 13: Phenology of the fir and and beech in the Pyrennee area

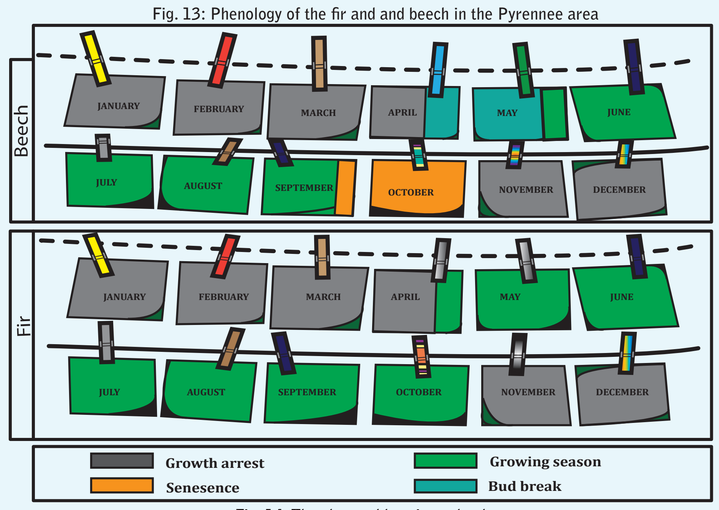
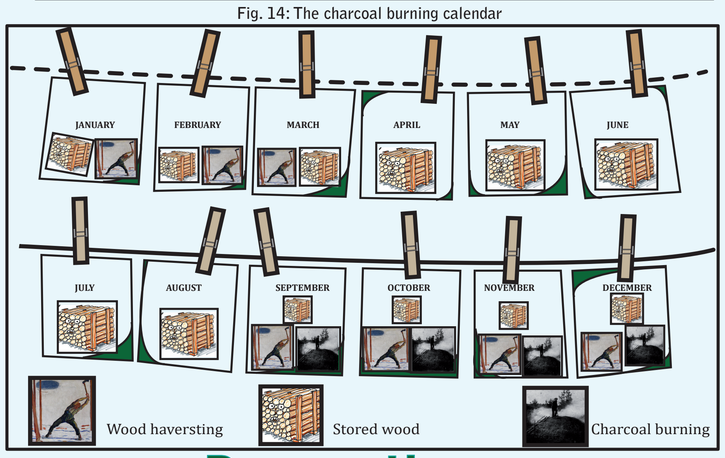


Fig. 14: The charcoal burning calendar



Perspectives

The anthracological and dendroanthracological study of new dated charcoal kilns and data comparison with new references from experimental carbonisations (green wood, seasoned, cutted at different seasons and stored in forest during 1 year...) will allow us to improve our knowledge about forest cover evolution and complete this annual charcoal-making calendar.