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The MINEDOR Project

Archaeological and palaeoenvironmental characterization of the ancient Arvernian gold mines of Haute-Combraille (Auvergne, France)

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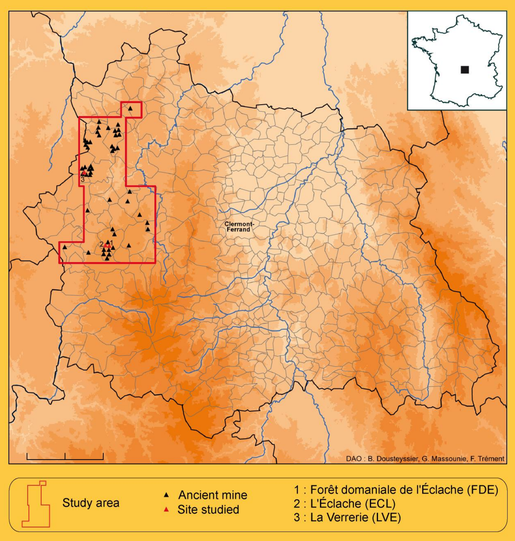
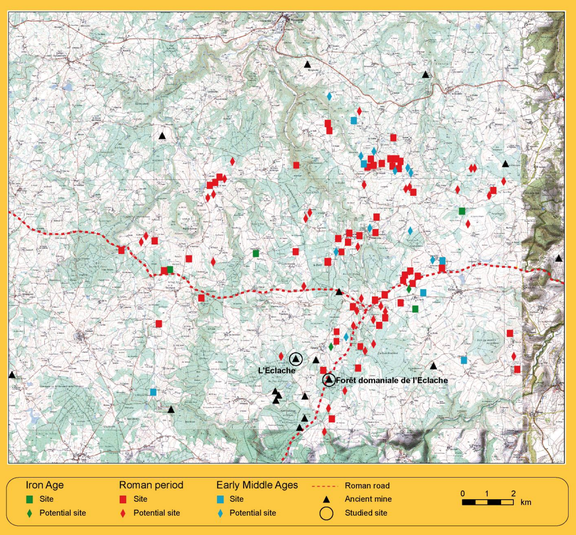
OBJECTIVES

The MINEDOR project is conducted since 2010 in the frame of the call for proposals "Interdisciplinary Project" of the Maison des Sciences de l'Homme of Clermont-Ferrand. It aims to study from an interdisciplinary and diachronic point of view the ancient gold mines, traditionally attributed to the Gallic period, discovered in large numbers at the fringes of the Arverni and Lemovices territories, in the area of Upper Combraille. Mining might have also be operational during the first two centuries AD in these highlands (900-1000m), at the onset of Roman occupation, as suggested by numerous settlements recently discovered. Our goals are 1) to accurately identify the mines through fieldwalking and aerial surveys, analysis of vertical aerial photographic coverage and localization by dual-frequency DGPS, 2) to assess their environmental impact using palaeoenvironmental (palynology, microfossils) and geochemical (heavy metals, trace elements, lead isotopes) analyses made at high resolution from cores extracted in wetlands (bogs, marshes, ponds), and 3) to date transient phases of exploitation. These new data shall highlight important features of the ancient economy of the Massif Central and the transient environmental impact of mining operation on watershed quality.

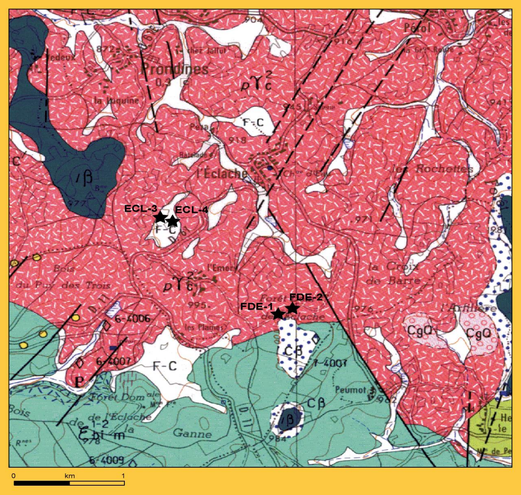


More than 50 ancient mines have been located in the study area. Most of them are open pit mines operating surface deposits.



The hypothesis of an exploitation of these gold mines in Roman times could explain the high density of settlements identified by prospections in recent years in this highlands area (900-1000 m), and whose occupation dates from the first two centuries AD.

This stone fountain in the shape of a dolphin has been discovered on a Roman villa located near the mine of Forêt domaniale de l'Éclache. This monument reflects the wealth of local landowners. On this villa, excavations have revealed the presence of a basin for washing the ore.



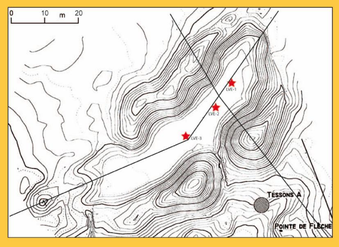
Geological map with localization of sites studied. In red : porphyritic granite.

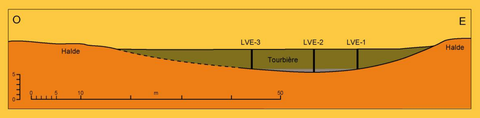
METHODS

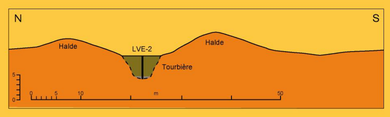
Peat sequences have been collected for high resolution analyses and dating. The comparison of archaeological, palynological and geochemical data shall help discriminate specific local imprints and identify possible long-range contribution from distant anthropogenic sources.

Archaeology: The objective is to detect, map and characterize the mining areas by means of aerial prospections, fieldwalking and microtopography in order to understand the typology of the various kinds of structures (circular and oval mining, parallel trenches) and the organization of the technical processes.
Geomorphology: The aim is to understand through macroscopic and sedimentological analyses the origin and development of peat bogs in the study area, and to discriminate natural and anthropogenic factors.
Paleobotany: The objective of paleobotanical methods implemented (mainly palynology and analysis of non-pollen microfossils and plant macrofossils) is to characterize as accurately as possible the dynamics of vegetation and wetlands in order to identify and date (thanks to carbon-14) the major phases of opening of the environment (deforestation, drainage) that may coincide with the phases of mining.
Isotopic Geochemistry: There are four stable Lead (Pb) isotopes, 204Pb, 206Pb, 207Pb, 208Pb, the last three being radiogenic end-members of Uranium (U) and Thorium (Th) natural decay chains. Crustal rocks and ores display different Pb isotope imprints depending on their age and initial U-Th content. Here we intend to use Pb impurities in Gold ores as markers of mining activities in two dated peat cores (FDE2 and ECL4).
Geology: The aim is to identify the rocks and veins that have been exploited.

SITES SELECTED







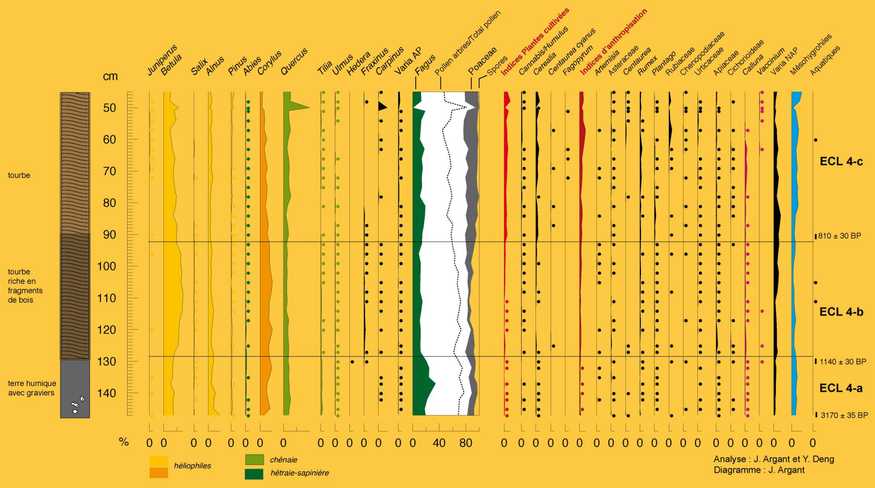
The ancient mine of La Verrerie (Villosanges).
The mine is visible on vertical aerial photographs. The microtopography shows that the excavation was more than 60 meters long and 10 meters deep. Three cores (red stars) from 4 to 4.50 meters were taken from the bog that has formed inside. The dating of the peat base by radiocarbon shows that the mine was abandoned during the Second Iron Age, since the peat has formed between the 4th and the 1st century BC. It is therefore a Gallic mine.

The ancient mine of L'Éclache (Prondines).
Discontinuous black line: mining area. Yellow: peat bog.
FDE-1: core taken in the mining deposits (blue star).
FDE-2: core taken in the peat bog (red star).

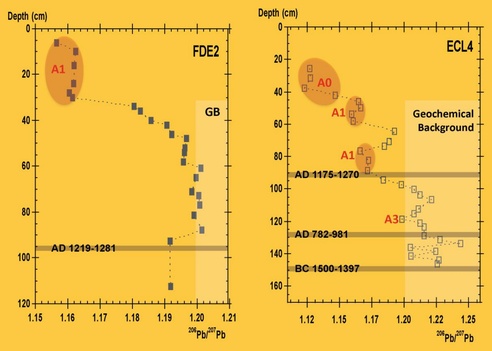
The ancient mine of Forêt domaniale de l'Éclache (Prondines).
Discontinuous black line: mining area. Yellow: peat bog.
ECL-3/4: cores taken in peat bog (red stars).

The peat bogs are always contiguous to the ancient mines. Their formation could result from the disruption of flows in the heads of watersheds caused by mining works.

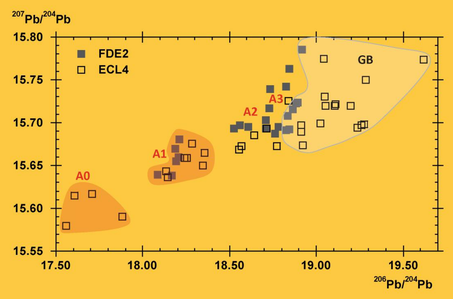
PRELIMINARY RESULTS



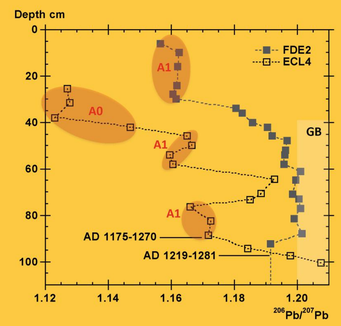
Pollen analysis of the core ECL-4 extracted in the peat bog of L'Éclache (Prondines, 952 m). Is shows an important deforestation during the Middle Ages. These results seem to coincide with isotopic geochemistry. Unfortunately, no sediment corresponds to Roman period.



Transient evolution of Pb Isotope imprint (206Pb/207Pb) in FDE2 and ECL4 peatbogs.
We have identified the so-called Geochemical Background (GB) in these profiles that corresponds to Pb "natural" imprint from non-contaminated aerosols (and possibly from erosion of the bedrock in the deep section of the peats). All other signatures in the profiles likely indicate Pb enrichment that could be associated with nearby mining activities in this remote region. ECL4 and FDE2 show a first clear anthropogenic imprint starting during the XII-XIIIth c. AD (A1 imprint in both ECL4 and FDE2). The most unradiogenic signature (A0 at the top of ECL4) likely evidences atmospheric deposition from long-range transport of polluted Pb. A possible early anthropogenic impact might have been recorded during the X-XIth c. AD in ECL4 (A3).



Pb isotopic imprints in FDE2 and ECL4 peatbogs.
From a three isotope plot we can define very distinctive Pb isotope imprints with the "atmospheric source" A0, and a "mining source" A1. A2 also correspond to anthropogenic imprints that are dispersed between A1 and the GB, and could therefore correspond to a mixture between both components (A1 and GB). Pb and Aluminum (Al) analyses will help resolve this uncertainty and better define various anthropogenic signatures and mixture thereof.



Evolution of isotopic Pb imprint since the XIIIth c. AD in FDE2 and ECL4peatbogs.
This is a blow up of the previous figure that shows the transient evolution of Pb imprints since the Middle Ages in both cores. While more dates are needed, these preliminary results show that both cores seem to have recorded different mining activity phases.