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When TCN meet high school students: deciphering western Cévennes landscape evolution (Lozère, France) using TCN on karstic networks

A. Sartégou¹, A. Mialon², S. Thomas², A. Giordani², Q. Lacour², A. Jacquet², D. André, L. Calmels², D.L. Bourlés¹, L. Bruxelles³, R. Braucher¹, L. Leanni¹ and ASTER Team*¹.

¹Aix-Marseille Université, CNRS-IRD-Collège de France, UM 34 CEREGE, France ; ²Lycée Émile Peytavin, Mende, France ; ³School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, South Africa ; French National Institute for Preventive Archaeological Research (Inrap).

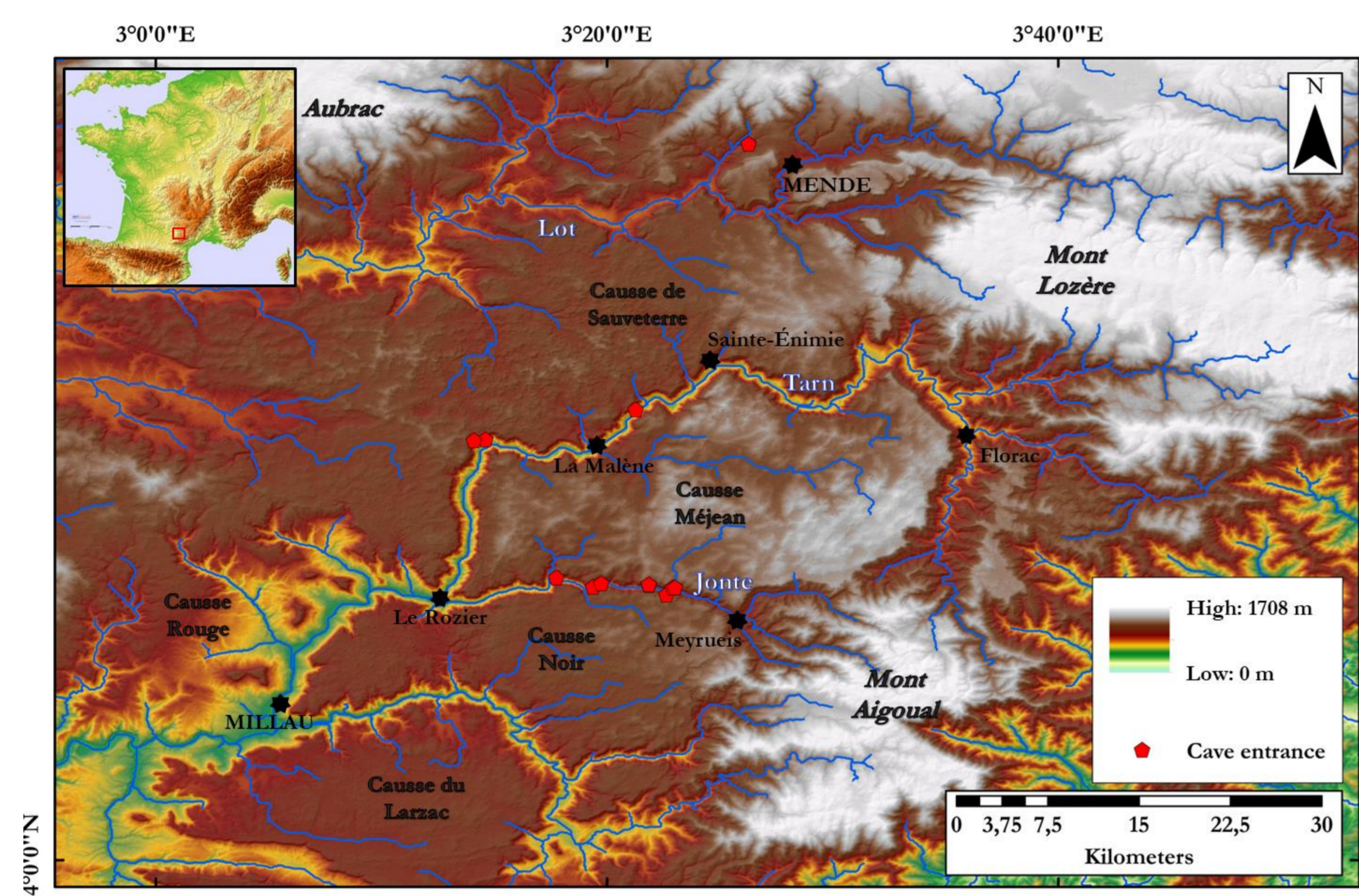
Aims of the study

The Neogene evolution of the Cévennes, the southernmost part of the French Massif Central, is poorly constrained. According to Séranne *et al.* (2002), most of its incision is due to a topographic uplift between the Langhian (16 Ma) and the Messinian (5.32 Ma) due to Mediterranean geodynamics as well as eustatic variations. Studies performed at the Montagne Noire and east of the Massif Central (*e.g.*, Olivetti *et al.*, 2016) suggest in addition a marked Pliocene incision. Finally, the Mediterranean facade (Ardèche) records a marked incision during the Messinian and the Pliocene controlled by eustatic fluctuations (Tassy *et al.*, 2013).

With the aim of quantifying the incision rates in the western Cévennes area since the Miocene, alluvium-filled horizontal epiphreatic passages in limestone karstic networks were studied. Such landforms are used as substitutes of fluvial terraces because they record the transient positions of former local base levels during the process of valley deepening. In the study area, the Jonte, Tarn and Lot valleys contain stepped cavities particularly well-suited for such purpose.

Furthermore, the "Live on the karst" project allows high school students, as part of an advanced examination of the French A-levels, to study the biodiversity and geodiversity of the Grands Causses karsts (southern Cévennes), and to compare them to other European karsts in interactions with Italian and Slovenian high school students. In this project, most of the cosmogenic nuclide concentrations were acquired by high school students supervised by members of the CEREGE team.

The western Cévennes: a key area to quantify incision rates



- SW of the French Massif Central, not affected by the Messinian Salinity Crisis (connexion to the Atlantic Ocean) or glaciation events → incision process driven by internal forcings;
- In the study area, the Jonte, the Tarn and the Lot valleys contain stepped caves well-suited to perform burial dating on intrakarstic alluvial deposits;

The « Live on the karst » program



Work performed in the framework of the European Erasmus + "Live on the Karst" project → aims to enable high school students from European countries to characterize the biodiversity and geodiversity of their environment (in our case : France, Italy, Slovenia) through collaborations with government agencies and public laboratories

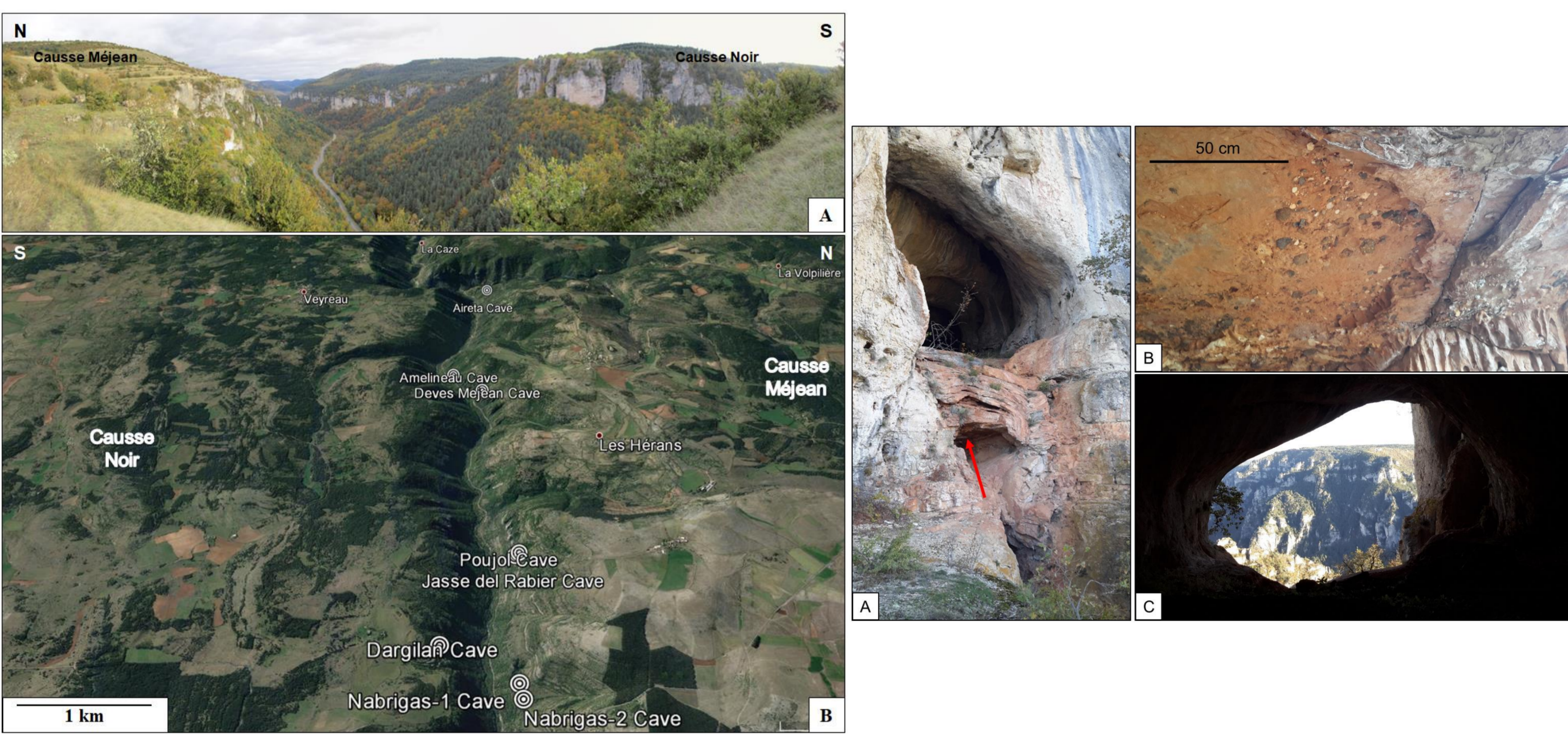
This study allowed four high school students to interact with the research community, on the one hand, and to learn about karst morphologies, petrography and TCN dating, on the other hand.



Students performed the entire process: sampling and *in situ* observations (karstic morphologies and petrography of deposits), physical and chemical treatments of the samples to extract ²⁶Al and ¹⁰Be from quartz, interpretation of the obtained results.

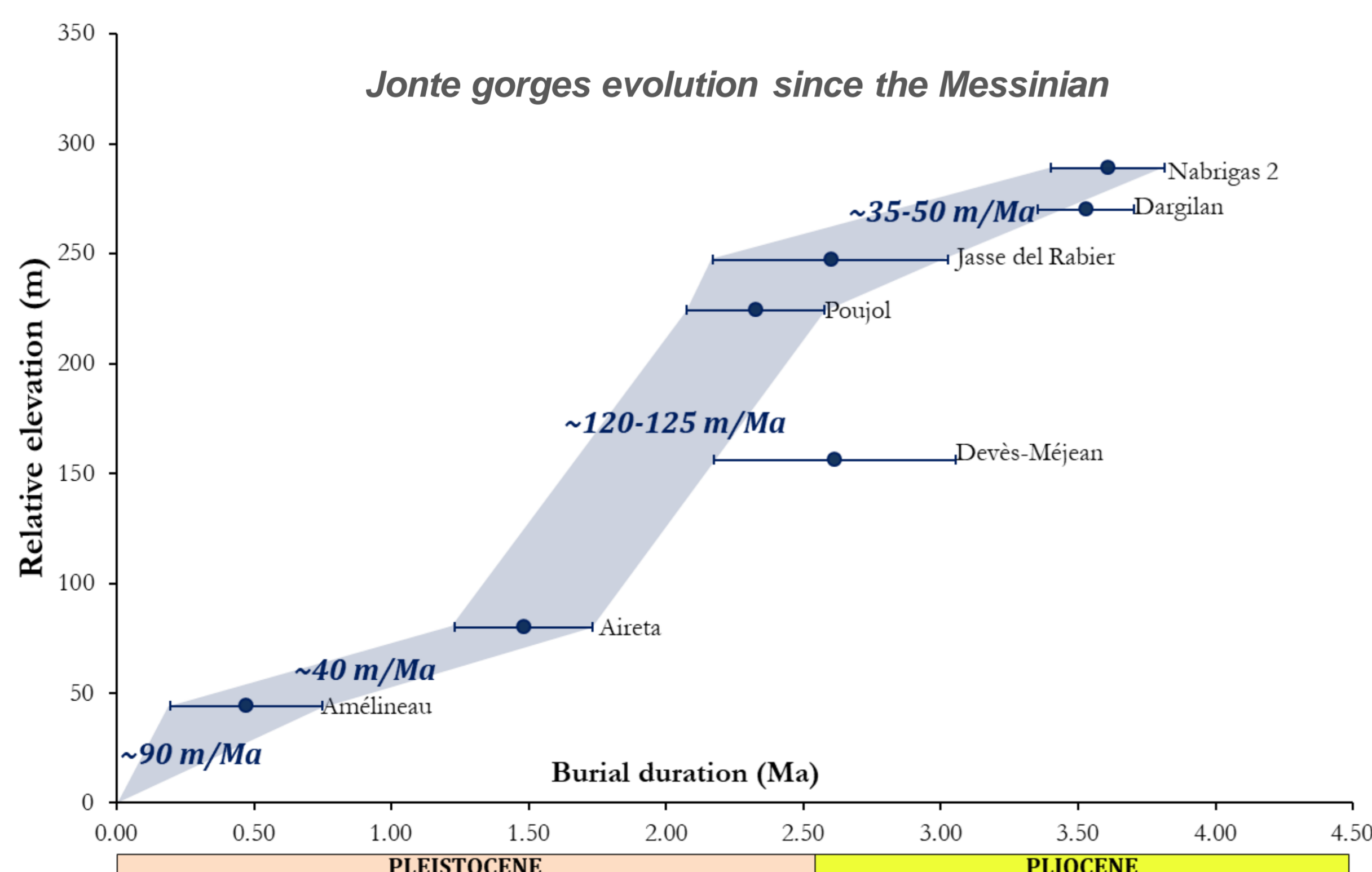
Example of sampled deposits:

- A) Massive conglomeratic deposits of the Poujol cave from which the POU1 sample was extracted;
- B) Conglomeratic deposits of the Jasse del Rabier cave, with alluvium trapped beneath a stalagmitic floor;
- C) Coarse sandy deposits of the Amélineau cave (AM1 sample location);
- D) Conglomeratic deposits at the entrance of the Aireta cave (AIR2 sample location);
- E) Hole into the coarse sandy deposits of the Nabrigas-2 cave (NG2-2 sample location);
- F) Sandy deposits of the Dargilan cave (DAR3 sample location).



- The burial durations of alluvial sediments from 13 caves located in the Jonte, Tarn and Lot valleys were determined using cosmogenic ²⁶Al/¹⁰Be and ¹⁰Be/²¹Ne ratios.
- Seven levels were sampled in the Jonte gorges, in 300m-height;
- Three levels were sampled in the Tarn gorges, in ~400m-height;
- A single cave was sampled around Mende to investigate the evolution of the Lot river.

Evolution of the western Cévennes area since the Miocene and implications



- The perched surfaces of the Causse de Sauveterre is thus at least from the middle Miocene, that is to say the Tortonian, as supposed by Séranne *et al.* (2002);
- The calculated Pliocene to middle Pleistocene paleo-denudation rates (1,5 to 50 cm/ka) are similar to those determined in the French Pyrenees (Sartégou *et al.*, 2018) and in the eastern French Massif Central (Olivetti *et al.*, 2016), which is part of the Hercynian orogenic belt;
- At the opposite side of the Aigoual Mount, Malcles *et al.* (2018) calculated incision rates on the order of 85±11 m/Ma for the Rieutour River over the last 4 Ma → same order of magnitude than those discussed in this study → Most of the digging of the Cévennes canyons may therefore be attributed to a recrudescence of the tectonic activity since the Miocene.

- The obtained results allow documenting the incision processes since the Tortonian (~ 11-8 Ma) in the Tarn gorges, and the Zanclean (~4 Ma) in the Jonte gorges.
- In both valleys, the estimated incision rates that could be related to uplift rates range from 40 to 120 m/Ma;
- Regarding the Jonte gorges, the digging would then be posterior to the Messinian and could result from changes in the drainage systems or even from the closure of the valley;
- Concerning the Tarn valley, the incision of the Causse de Sauveterre and the Causse Méjean would have started at least 10Ma ago;
- The perched surfaces of the Causse Méjean and the Causse Noir would therefore be at least from the upper Miocene, that is to say the Messinian, in good agreement with previous geomorphological observations (Séranne *et al.*, 2002);

