

Could the landscape preserve traces of a deep underground nuclear waste repository over very long time ?

"What we can learn from the archaeology of old mines"

Dominique Harmand

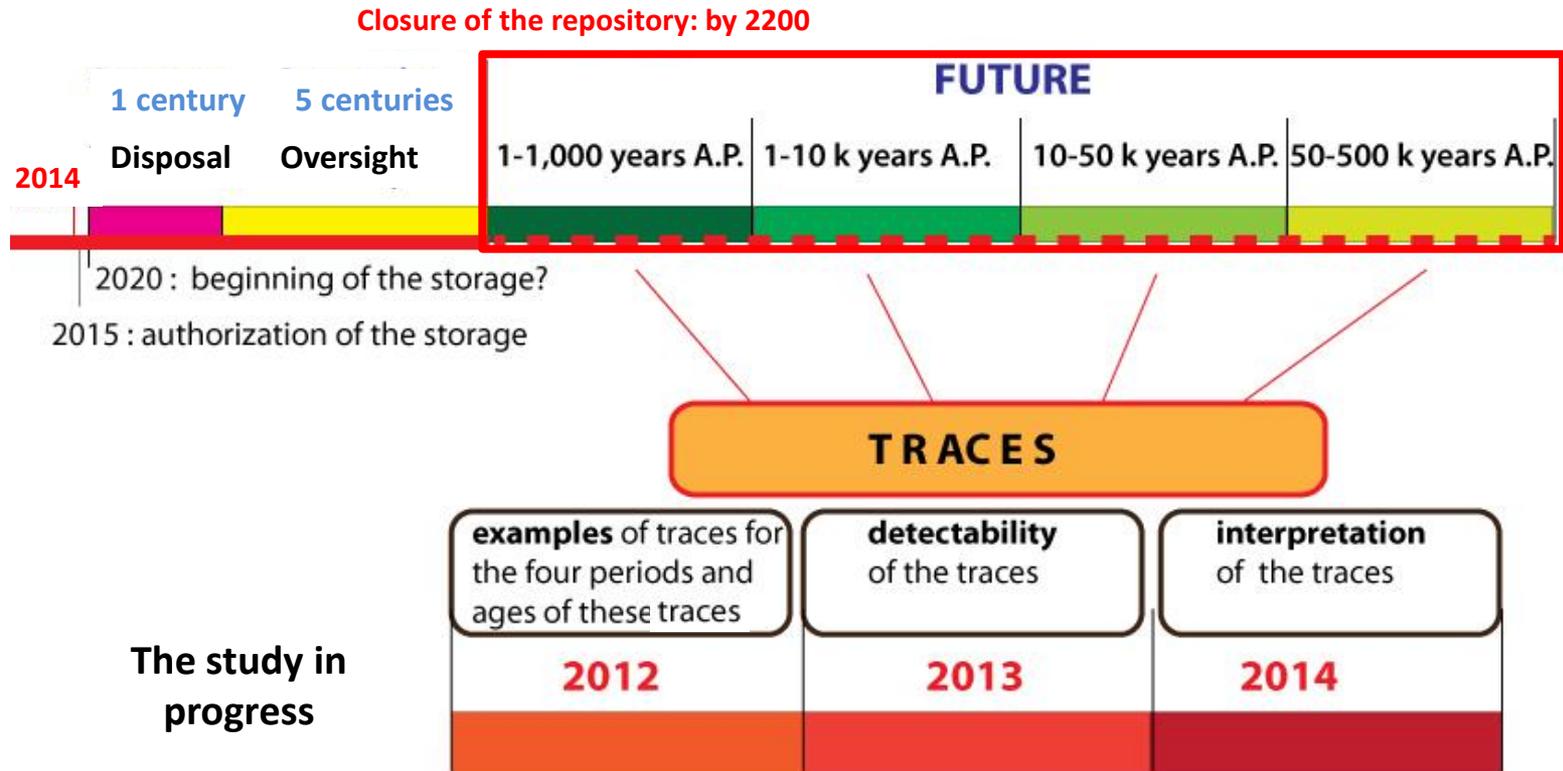
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The evolution in time of Cigeo Project



The analysis takes into account future natural evolution of the site

→ 2 scenarii / possible future climate and geomorphological evolutions

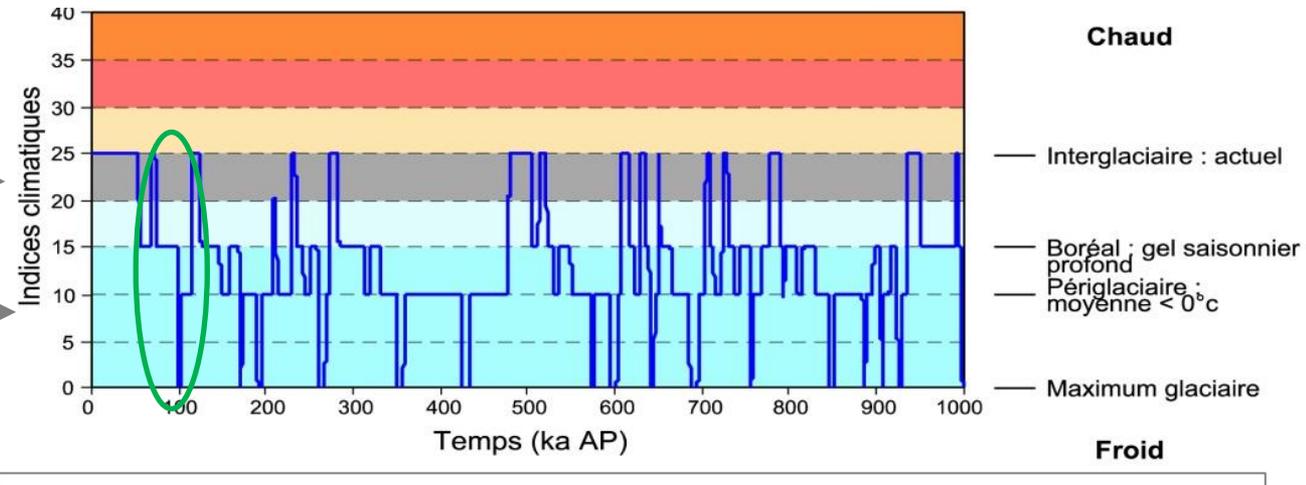
The 2 scenarii taken into account for future climate change (Bioclim)

Natural evolution

→ Beginning of the next glaciation in 50 kyrs

Current time climate

Cold climates

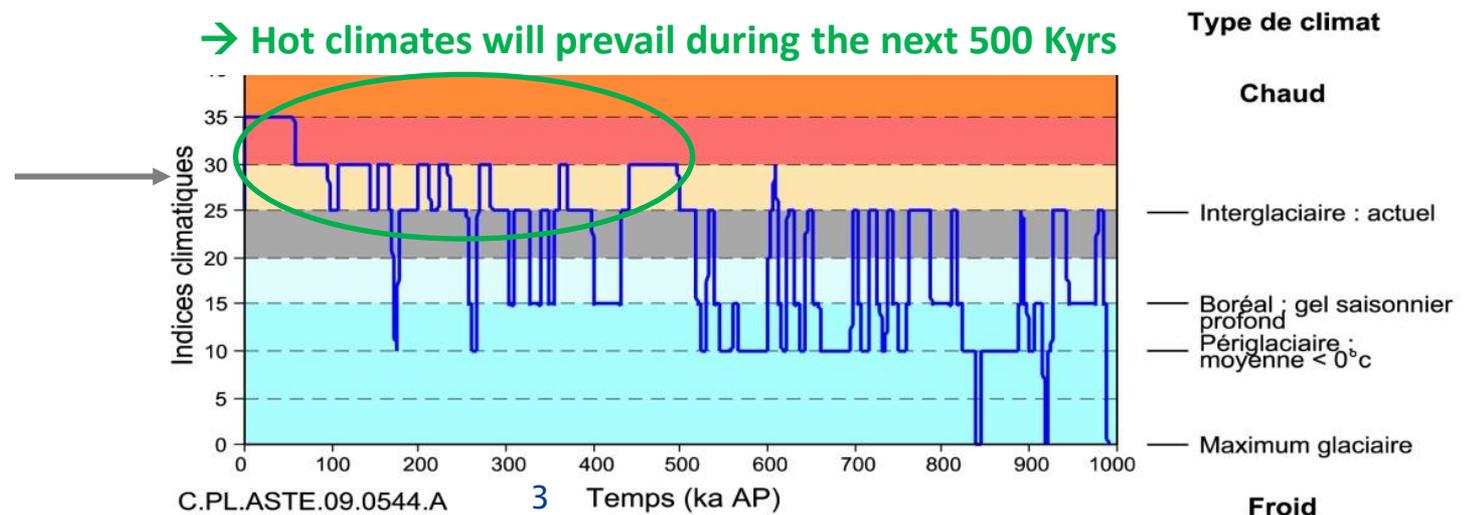


Modified evolution of the climate due to large impact of human activities

5000 GT of fossil carbon injected into atmosphere during the next 325 years

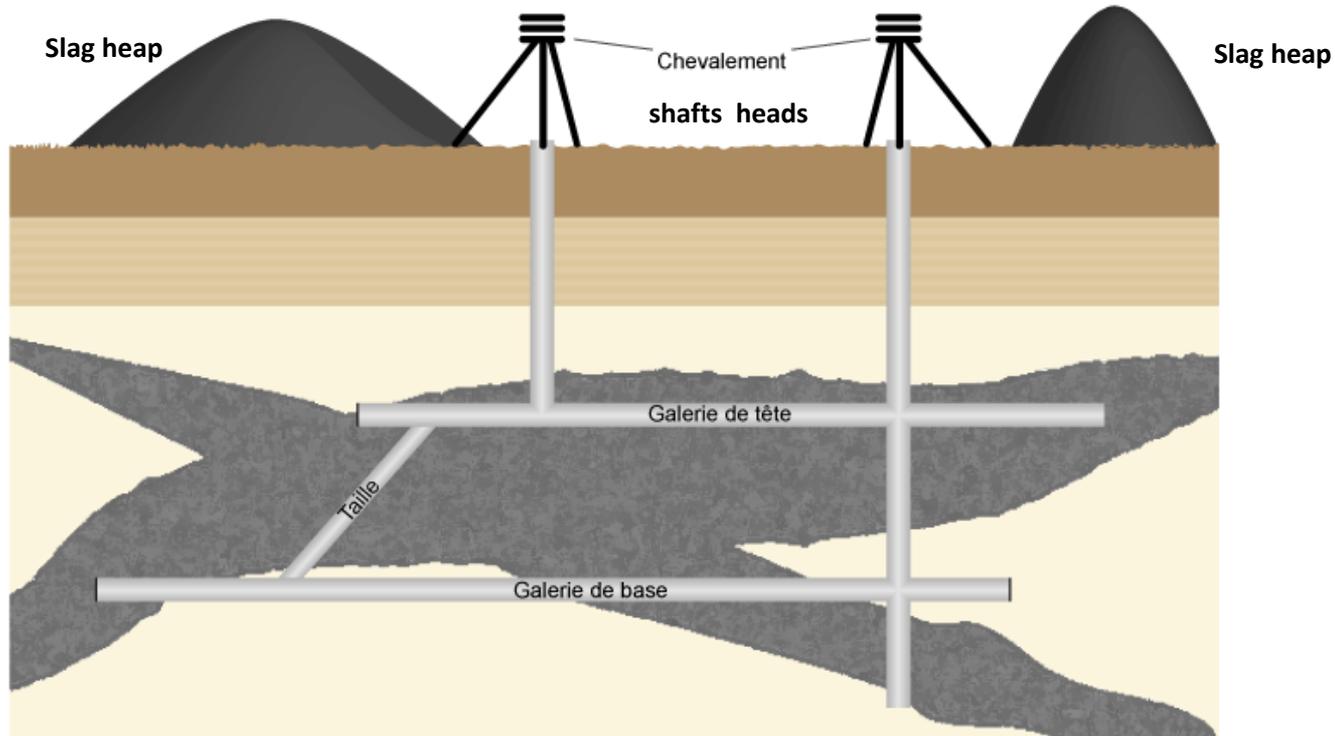
→ Hot climates will prevail during the next 500 Kyr

Hot and wet climates

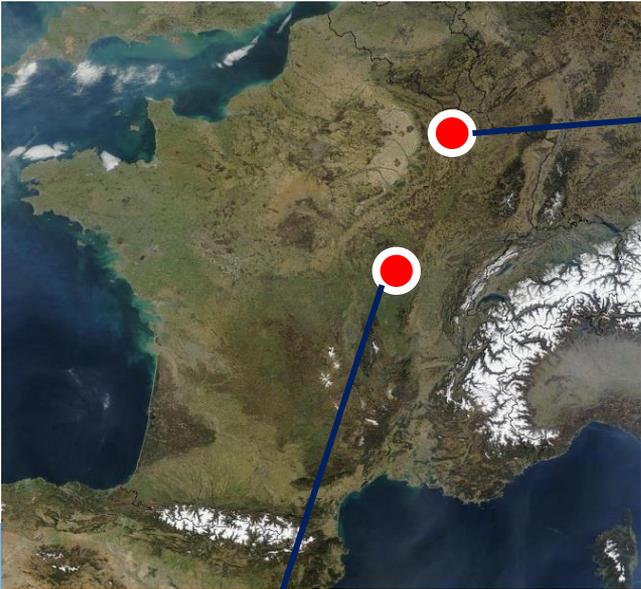
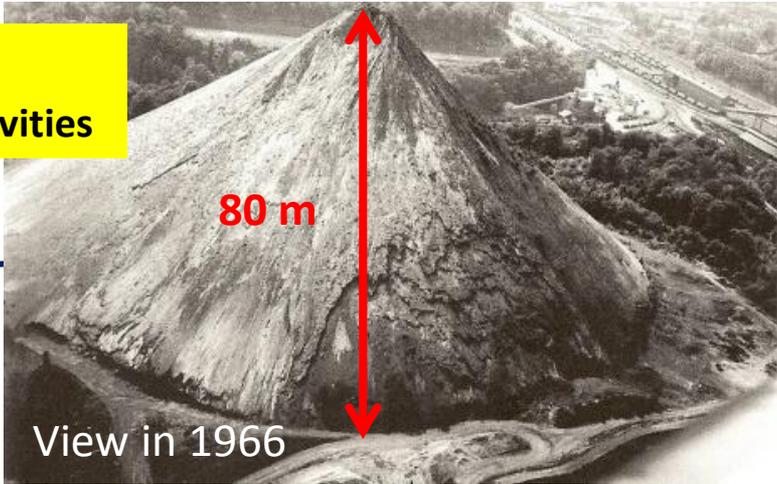


Usually, abandoned underground mines exhibit at surface a lot of traces over millenniums

Do traces of ancient mines represent valid analogs for Cigeo project ?



Slag heaps :
Big traces ; but possible short life, due to human activities



Examples in the Longwy iron mining basin :
This big slag heap does not exist any more today...
Today the surface of the plateau is flat !



At 1,000 years time scale, traces could be well preserved in a woody landscape

Slag heaps

Entrance of a mine gallery

Rolling way



Exemple of a copper mine forgotten since the XVIIth century, **discovered** at the end of the XXth century (ph. J.-P. Fizaine)

Traces of ancient mines 1,000 to 10,000 years old still exist

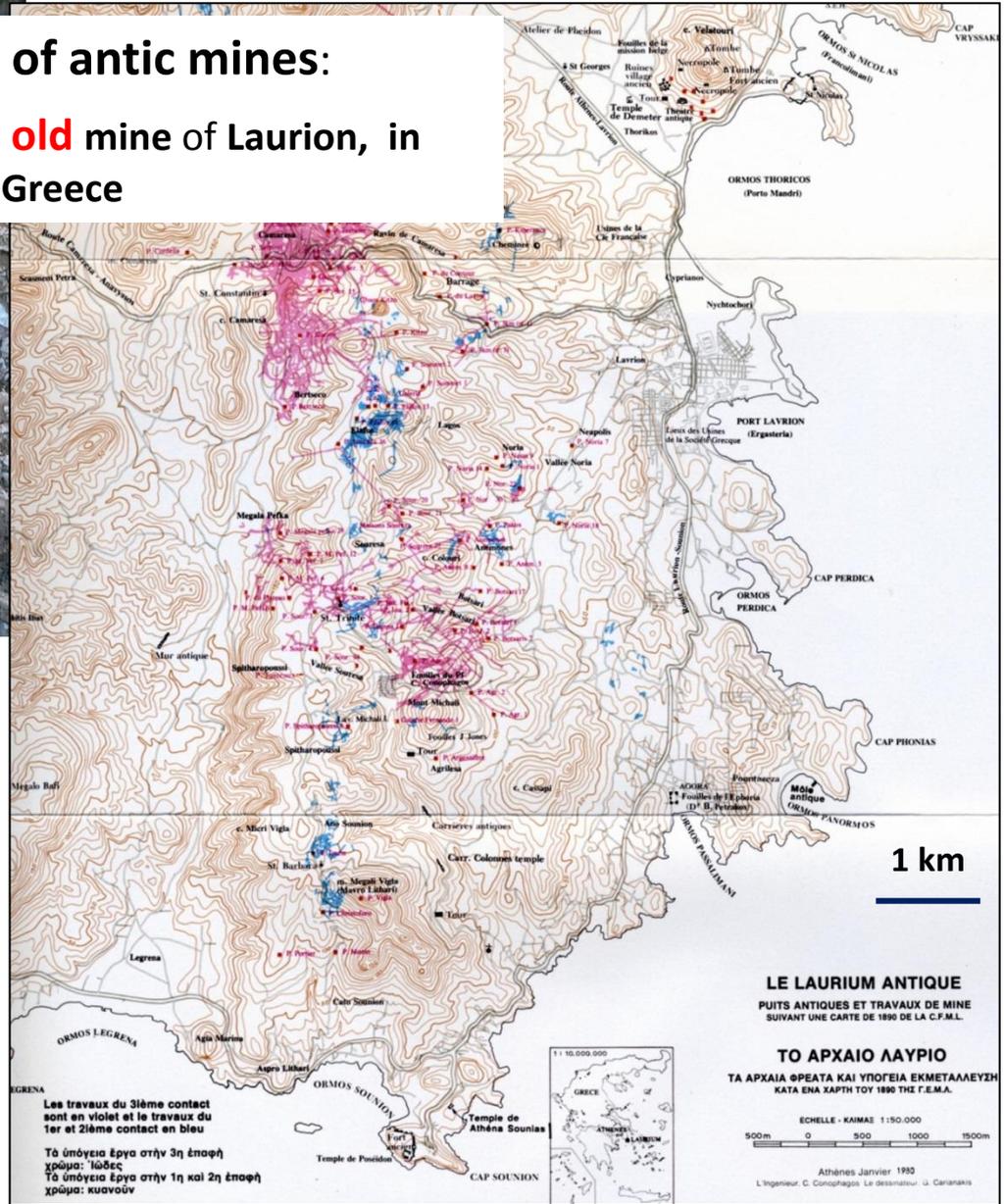


Excavation in a coarse slag heap of the silver mine of Laurion



Head of one of the antic shafts

Examples of antic mines:
The **3,500 years old** mine of Laurion, in Greece



(photos J.-P. Fizaine)

Traces of ancient mines 1,000 to 10,000 years old still exist

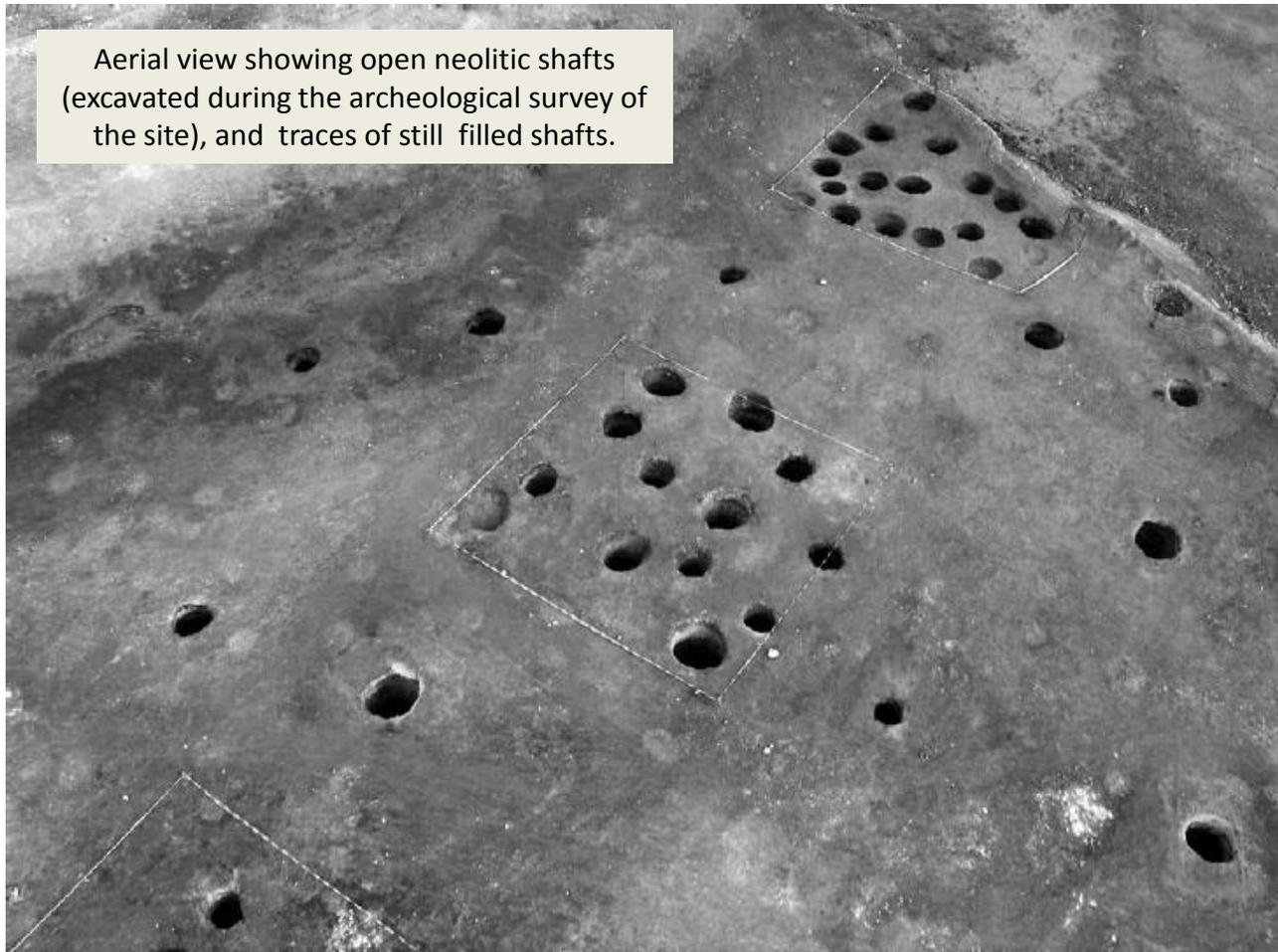
Archeological studies in an ancient copper mine slag heap 3,000 years old
in the Jordanian desert



Khirbat en-Nahas

The oldest known « mines » ≈ traces up to 10,000 years ago ?

**Example of the Neolithic flint mine of Casa Montero (SE of Madrid)
An open-area excavation of 4,2 ha has been documented over 3,500 vertical shafts .**





Traces of ancient mines exist
also in **temperate countries**

A 4,000 years old copper mine in UK :
Great Orme, Llandudno, Wales

robert-thewanderer.blogspot.co.il



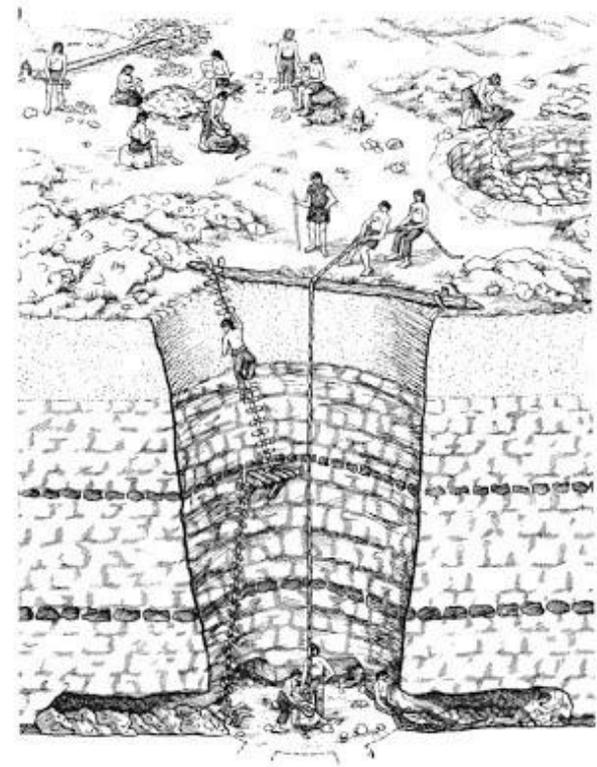
The Neolithic flint mining complex of
Brandon, East of England
5,000 to 4,000 years old



Ron Strutt - From geograph.org.uk

The remains of mineshafts, pits, and heaps

http://www.pastscape.org.uk/hob.aspx?hob_id=382869

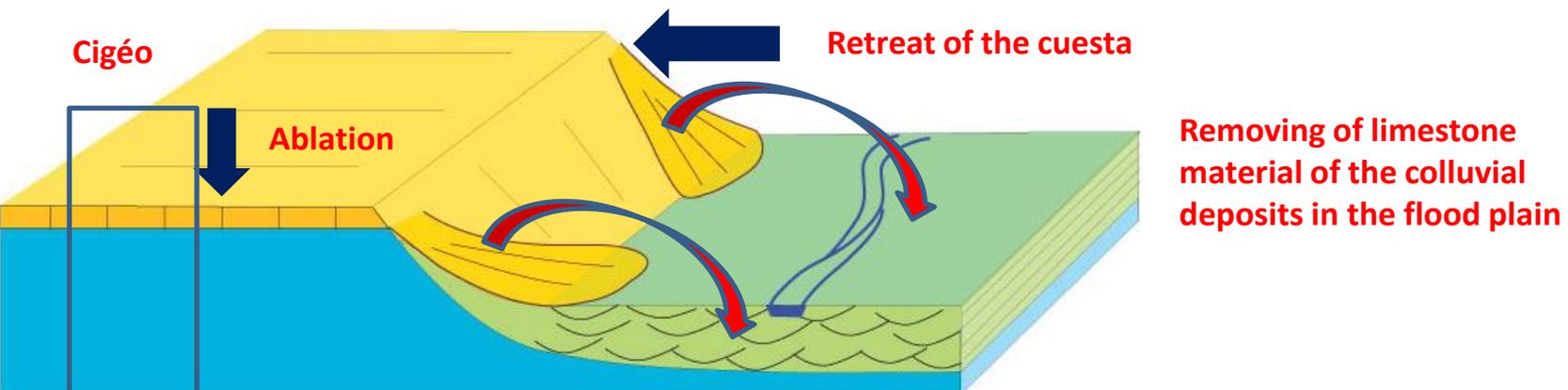
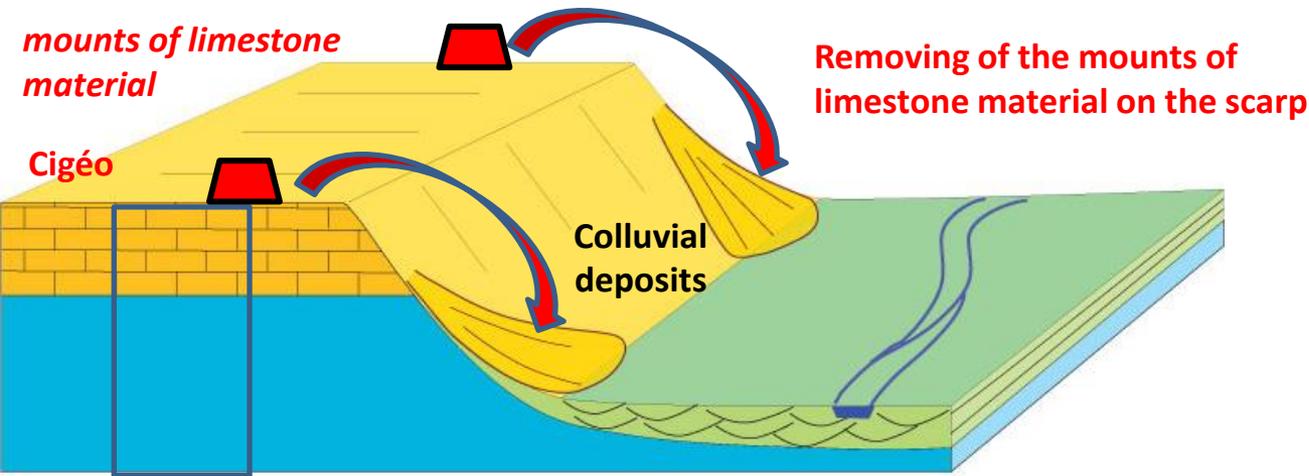


<http://neoagebc.blogspot.fr/>

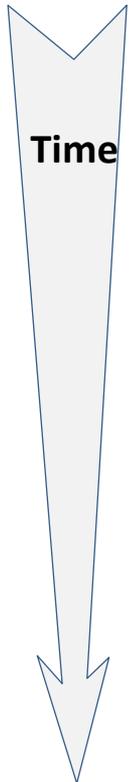
Geological evolution will gradually remove the traces of Cigéo ...

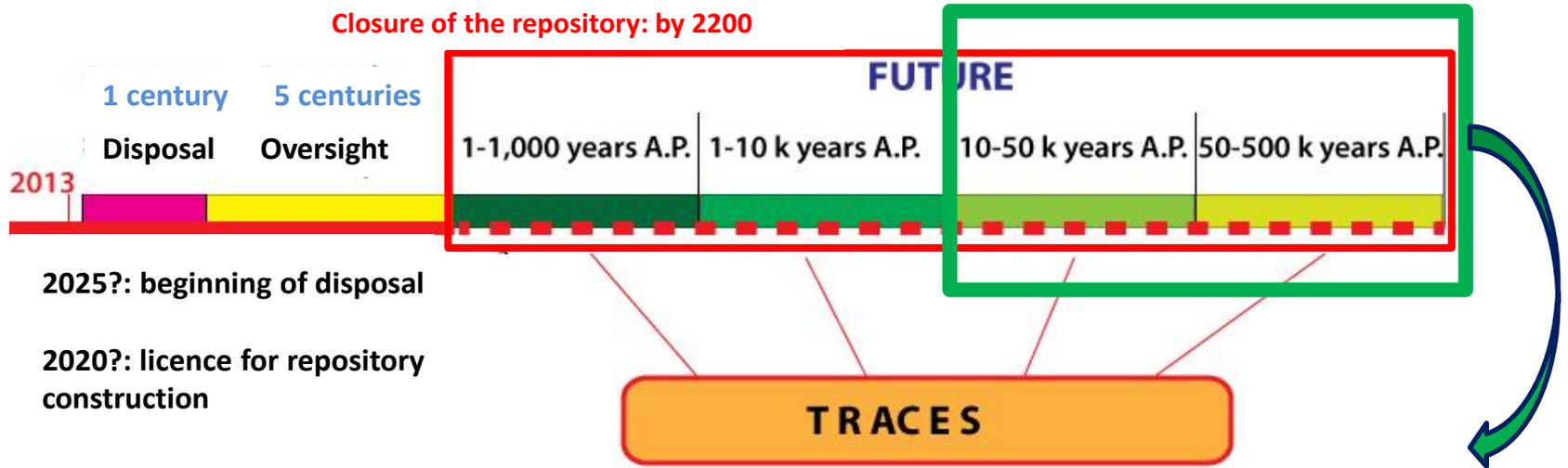
Cigéo

The « Côte des Bars »



Time





Conclusion : in a very distant future, traces of the heads of shafts and of inclined tunnels will still exist

→ **Natural examples**



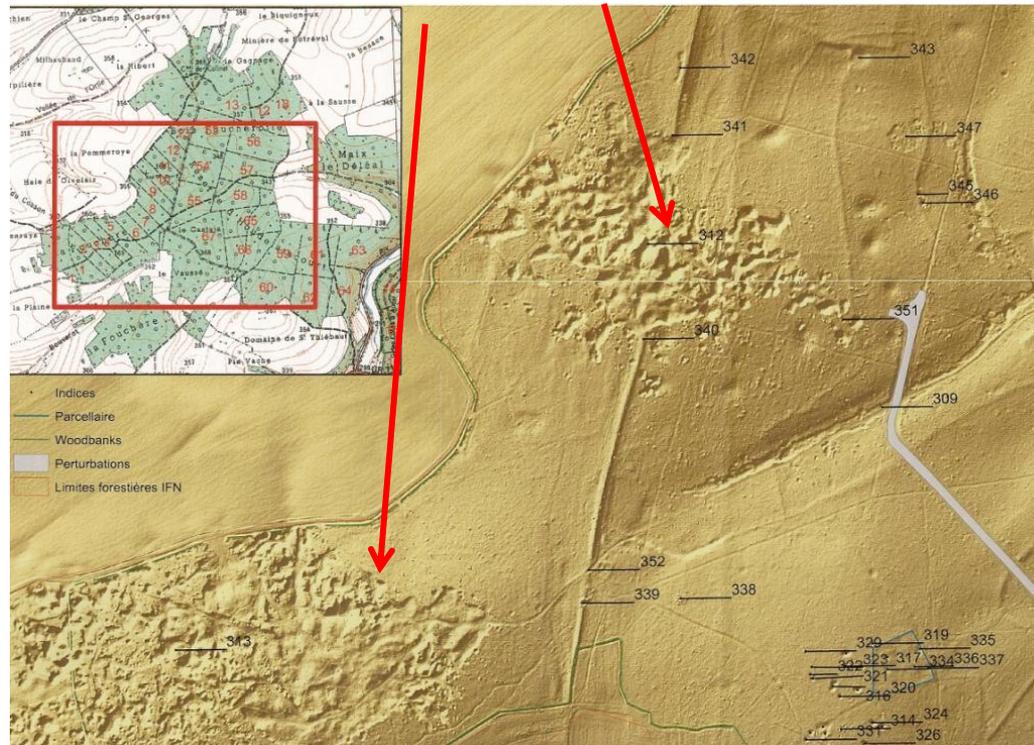
Karstic depression



Filled karstic wells

The traces of Cigeo will be mixed with other human traces of all ages

Exemple : LIDAR image (« light detection and ranging »)
→ Detection of ancient mines on the Barrois plateau



The main question :

How could these traces be well interpreted by archeologists and geomorphologists in a far future ?



How to avoid traces to be misinterpreted as some natural geomorphological features?

A very large karstic « shafts » network , 120 million years old, exists on the Bure plateau ...

Quaternary karstic wells will exist on the Bure plateau, close to the Cigeo project site ...



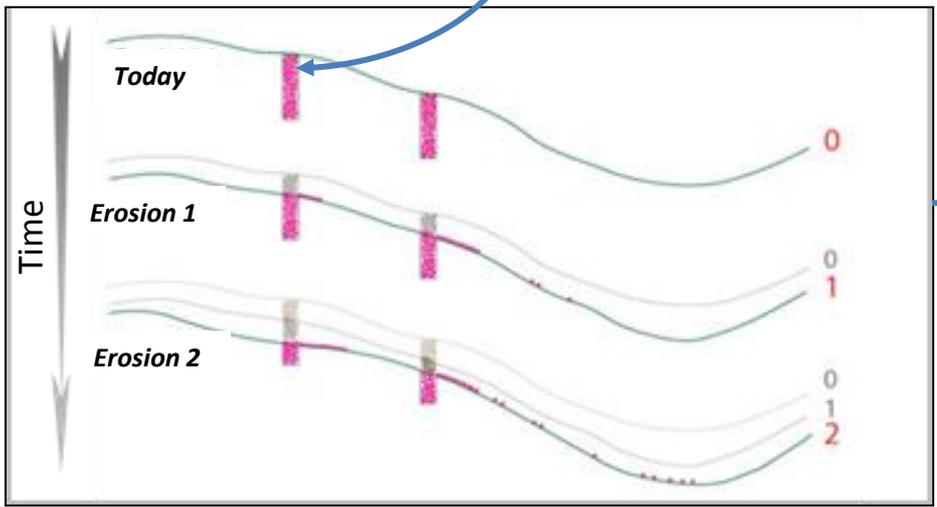
A possible solution :

Marking the site and the long lived traces (heads of the shafts and inclined tunnels) over very long time with long lived small anthropological elements (ceramic pieces for example)



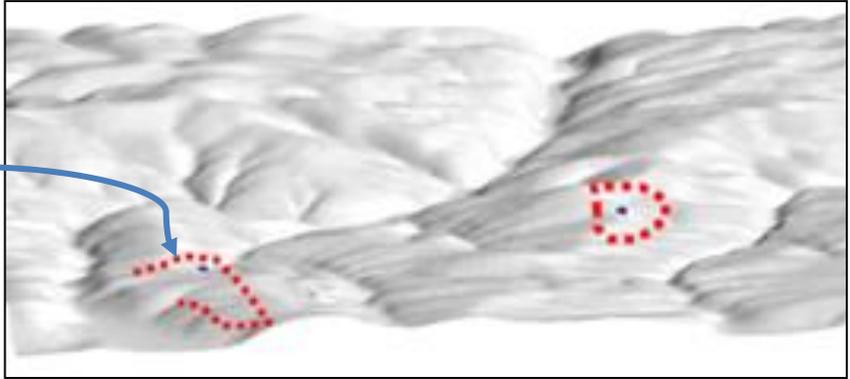
1) The material which could be used to mark the Cigeo site

- Small engraved pieces
- Included in some geologically exotic material (for example : siliceous sand / limestone plateau)



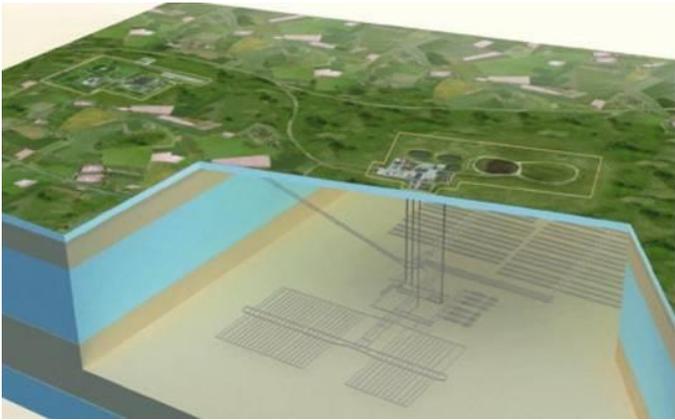
2) The marks design

The material could be included in some few meters long drill holes, This concept allows pieces distribution at surface over a long time period despite natural erosion of the site



3) Spatial distribution of the marks in the landscape

Markers could be distributed around the main Cigeo surface facilities



Thank you for your attention

