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Jonhattan Vidal

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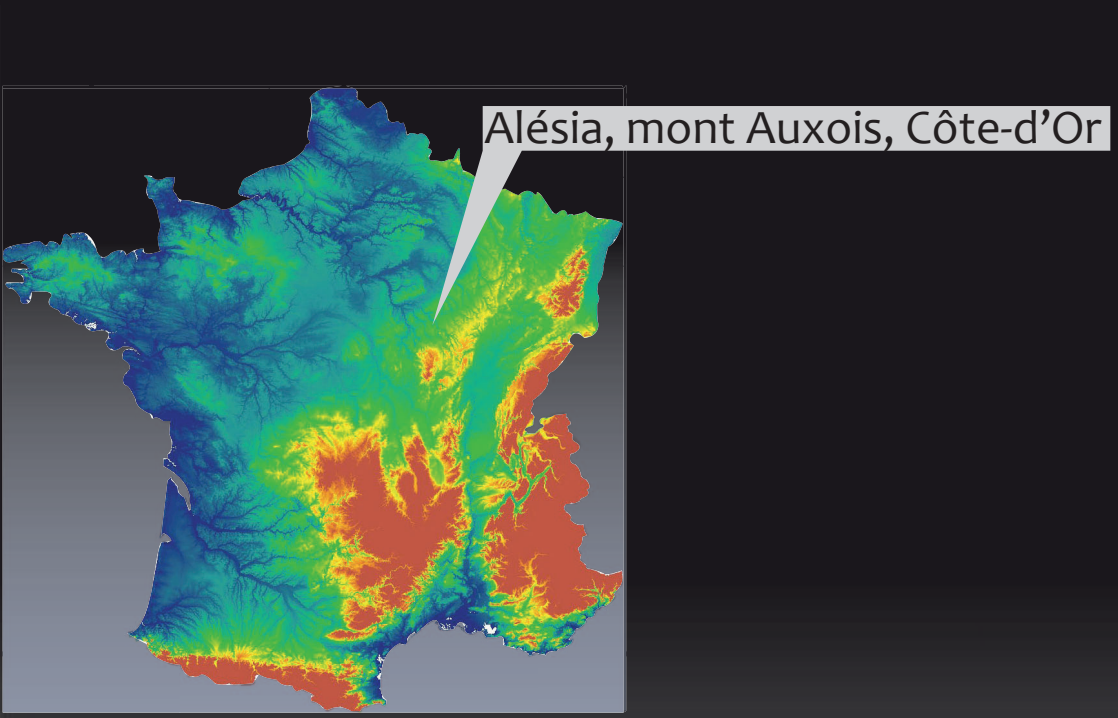
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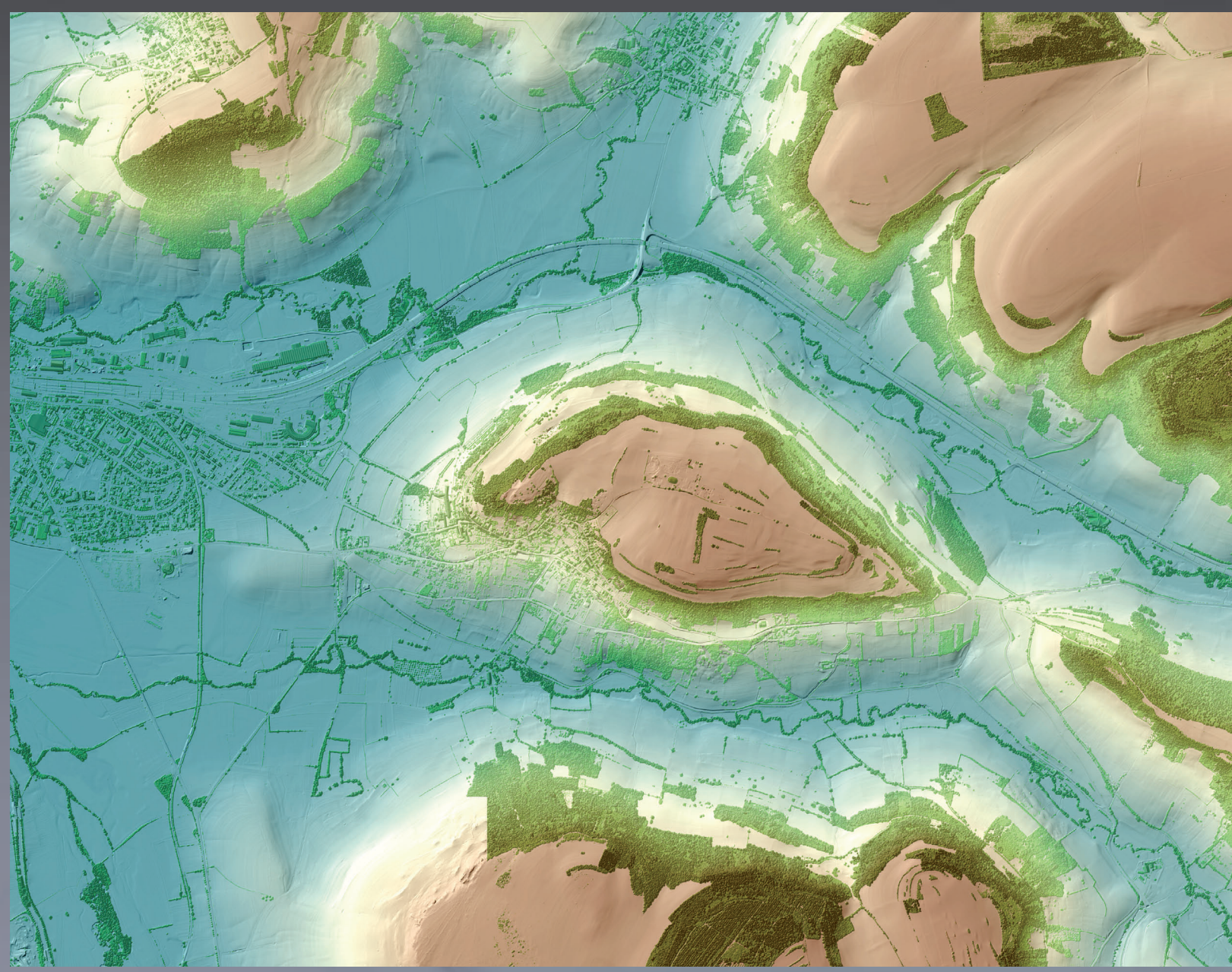
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# LiDAR at ALESIA : methodology and first results

**Jonhattan Vidal**

Doctorant, université de Bourgogne, UMR ArTeHis CNRS  
 jonhattan.vidal@wanadoo.fr  
<http://artehis-cnrs.academia.edu/JonhattanVidal>



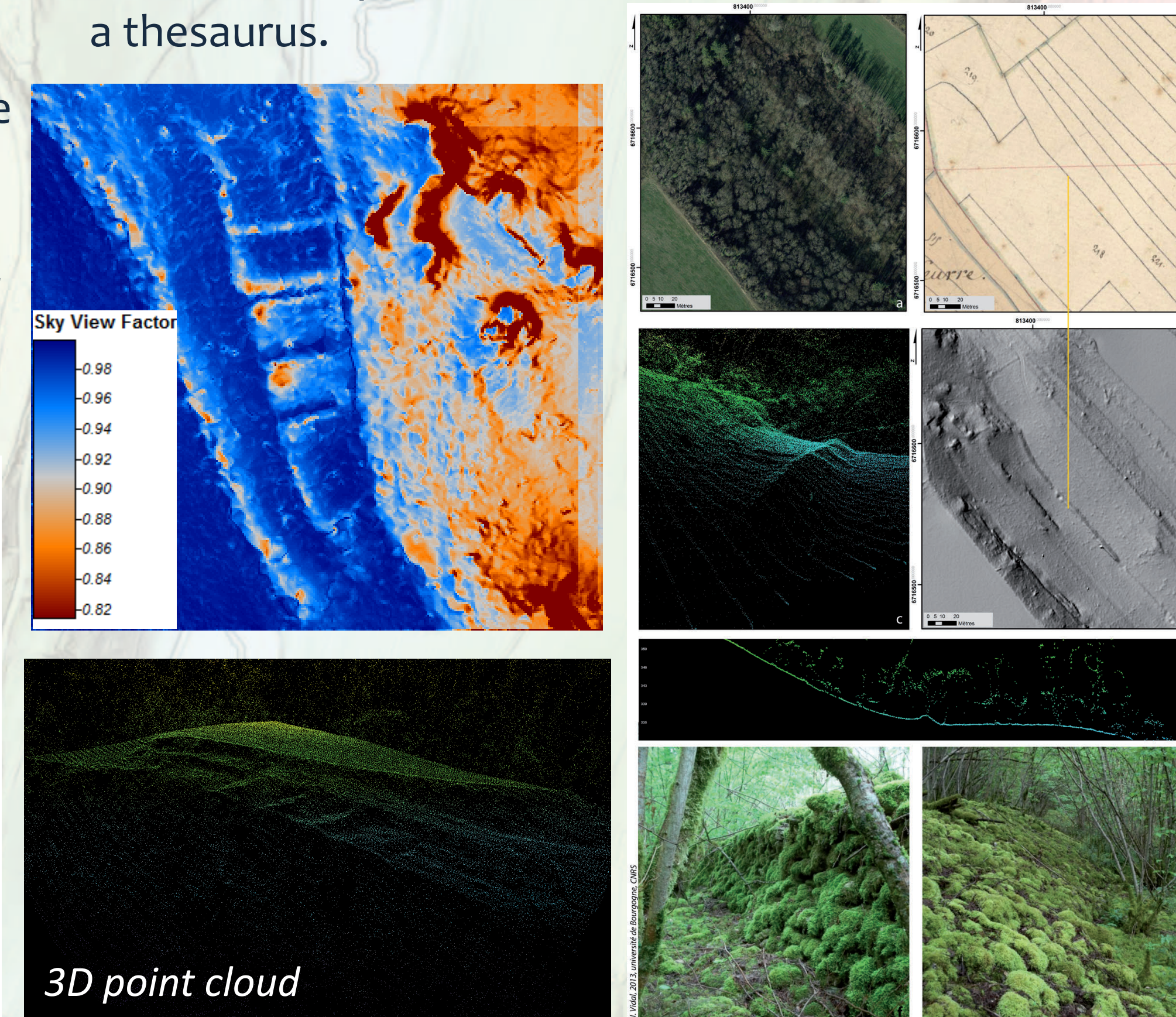
For more than 400 years, a gallo roman town of 90 ha in size, at its maximal expansion, occupied the oppidum of Alesia. As one of the most important archaeological sites in France, the mount Auxois has been studied for 150 years with many field-based researches. Within the framework of a diachronic research, based on cartography and spatial analysis of a large amount of archaeological data, we conducted a LiDAR survey in 2011 (PhD of the author). The survey density is 10 points per square meter, on a 30-km<sup>2</sup> area centred on the oppidum. The covered landscape is composed of limestone plateaus, incised by two rivers. Cultivated plateaus are edged by cliffs, at the foot of which small forests stretch to a hedge environment at the bottom of the valley.

## 1. Viewing and data processing

Below is a presentation of the methodology used in order to analyse LiDAR data with an archaeological perspective. Nowadays, several works are seeking to develop new data processing, in order to allow a global vision of all ground abnormalities at the same time ; indeed most of our actual algorithms are suitable for a unique category. Thus, with a diachronic view that leads us to identify all types of anomalies, we use several basic or complex processing data. Working scale is also something to take into account. On the one hand, we use a couple of processing tools for large areas detection (slope analysis and PCA of hill shades) and, on the other hand, other ones to focus on precise anomalies (Sky View Factor and – soon - Local Relief Model). In the latter case, the analysis is targeted to permit statistical calculation. Furthermore, although the 0.25 meter resolution DTM is still the most analysed, we also use the 0.50 and 1 meter DTM to detect long anomalies. To conclude, slope analysis offers a good vision of general morphology and also allows to detect features in contradiction with the geomorphology. The PCA of hill shades is a good way to work with shaded relief despite orientation problems. And the easy band control is also really adapted for an exploratory approach. Then, detected anomalies are more specifically analysed in focused areas by SVF and soon by LRM, in order to integrate Z values. At last, every mark or vestige is observed in 3D (in fact 2.5D) through the unclassified point cloud from LAS data, so that to prevent any confusion with fake artefacts or natural anomalies (lying tree, etc.).

## 2. Interpretation

Detailed analysis of the survey are completed with field prospectings. Back and forth working between data and field reality contributes to refine our reading of topographic marks, and leads to a better characterisation of some signs in the landscape of Alesia. These allow a good reliability when interpreting the structures. From this experience, a normalised process of vectorisation and interpretation of visible structures is used with a thesaurus.



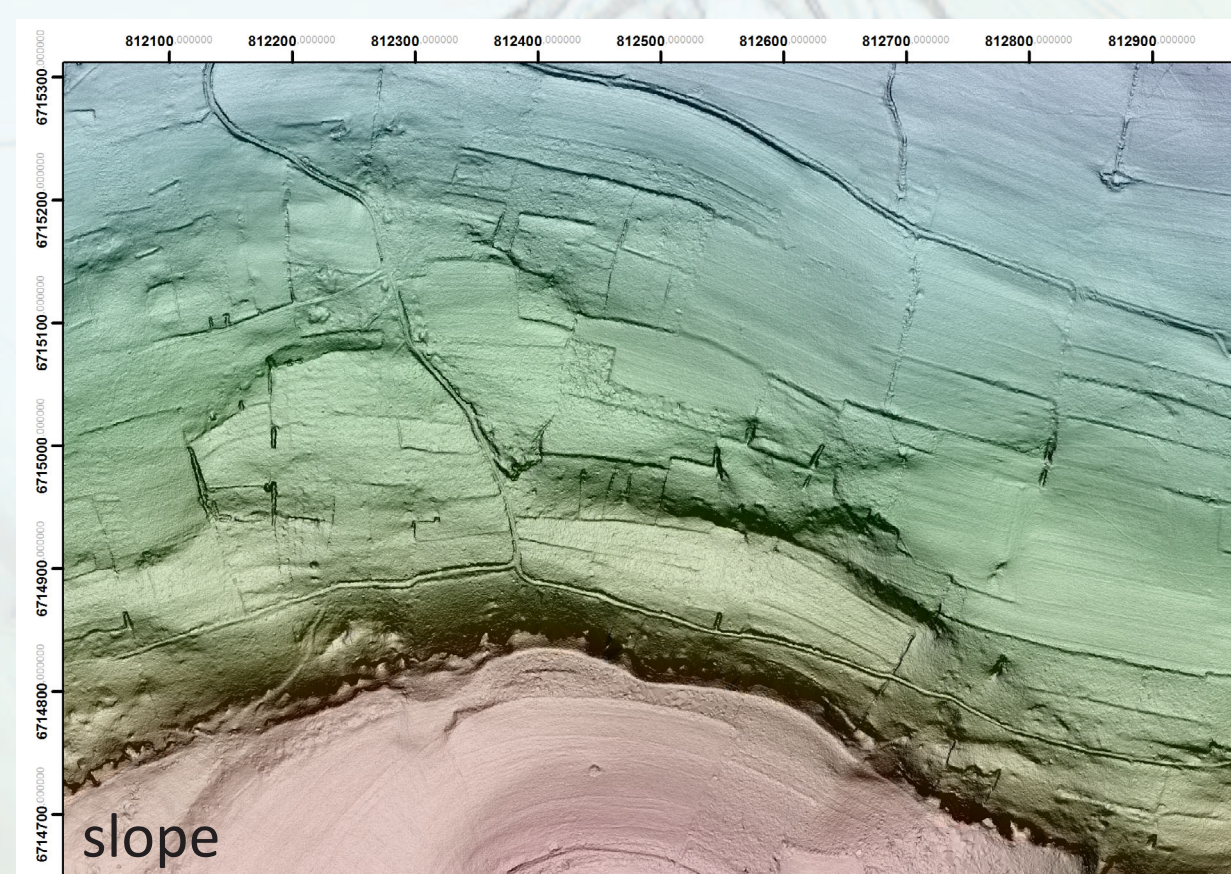
slope analysis

PCA of hill shades

3D point cloud

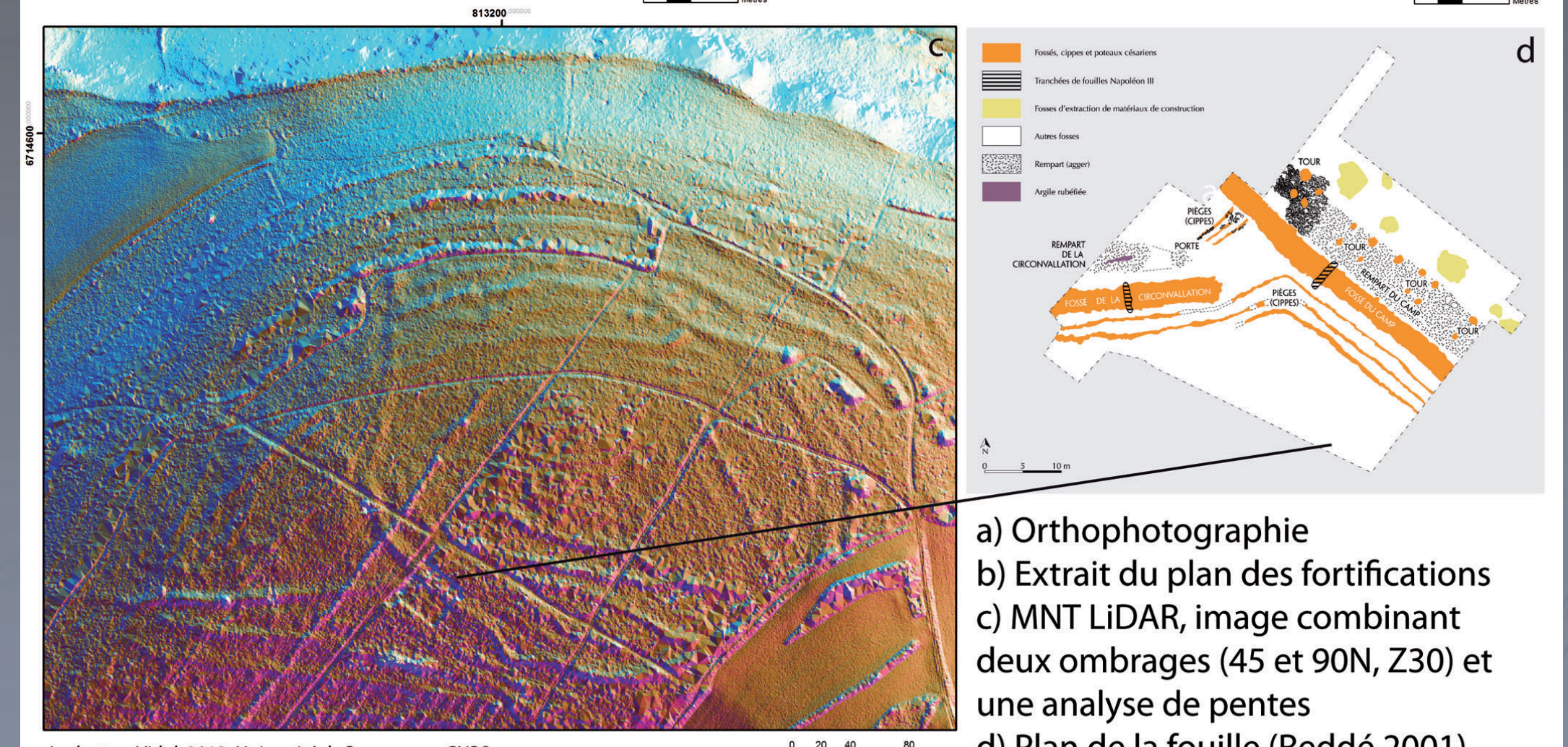
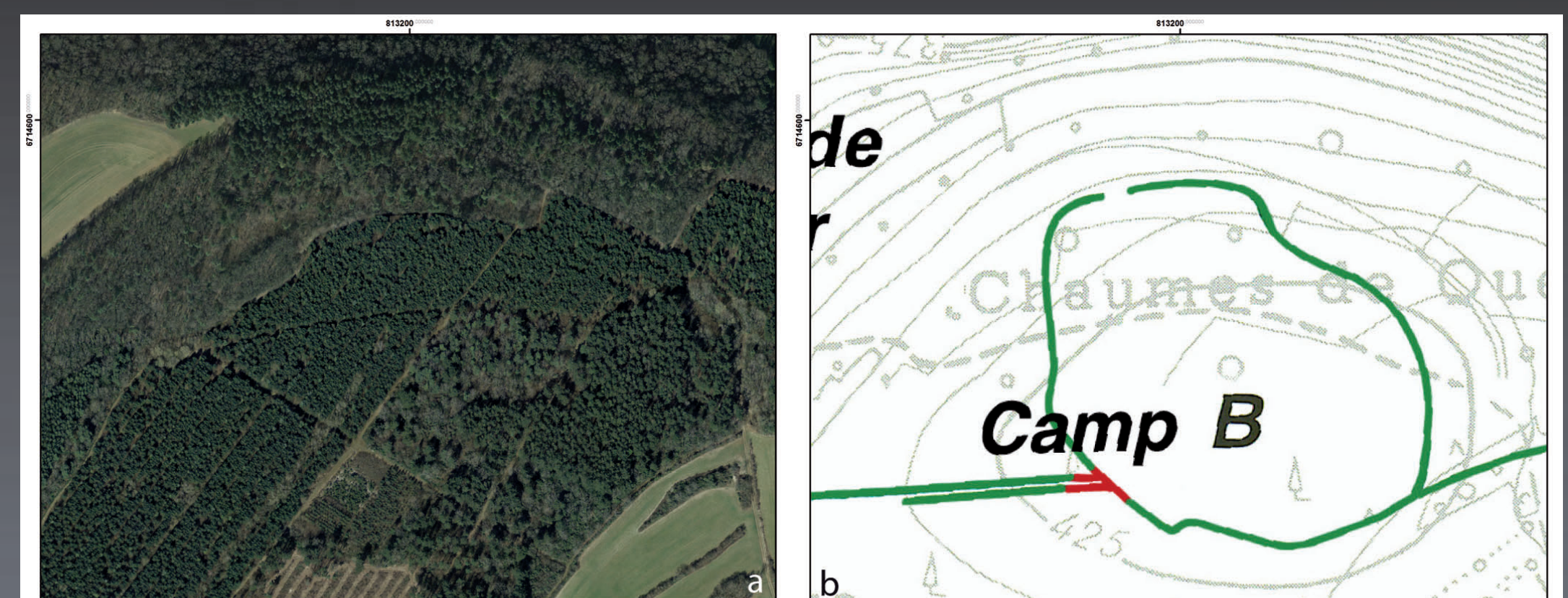
## 3. First results

The LiDAR of Alesia is highly instructive, several types of marks are visible : below are the essential categories.



The LiDAR highlights a lot of ridge and furrows. Topographic anomalies point out ancient boundaries parcels. Part of these signs are recognizable on the « napoleonian » land registry (1835). However, our study goes further than a simple lecture of the cadastre. Indeed, the comparison reveals a relative chronology of plots of lands. In particular, under forest cover, formerly cultivated areas are brought to light.

Alesia entered the history books for having been the place of a brief event ; the siege in 52 BC, which led Cesar's legions to win the final battle against a gallic coalition headed by Vercingetorix. In order to ensure their victory, the Romans built two fortifications lines and set up campaign camps around the mount Auxois. "A brief event, a lasting scar", wrote M. Réddé in 2003. Today, identifying some camps and fortification lines in the topography allows to confirm it. These reliefs, "invisible" with the naked eye, have actually been preserved by woodland. They represent a remarkable testimony of temporary roman fortifications. More than 2000 years later, topography seems to have preserved Cesar's mark.

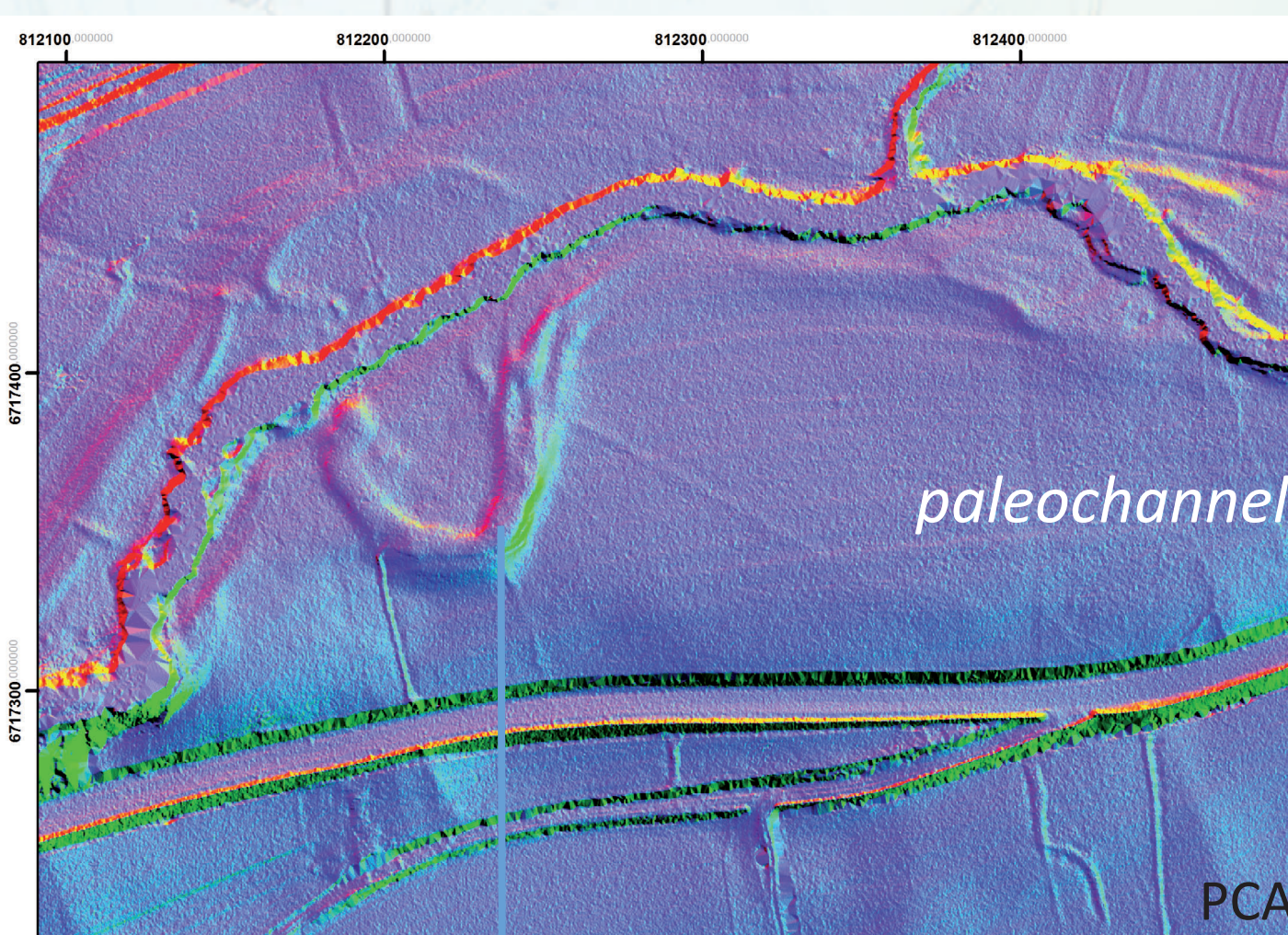


a) Orthophotographie  
 b) Extrait du plan des fortifications  
 c) MNT LiDAR, image combinant deux ombrages (45 et 90N, Z30) et une analyse de pentes  
 d) Plan de la fouille (Reddé 2001)

Some unknown archaeological structures have been detected in wooded areas : constructions of Modern period, like limekilns for example, and also remains which sometimes are imprints of antique monuments.

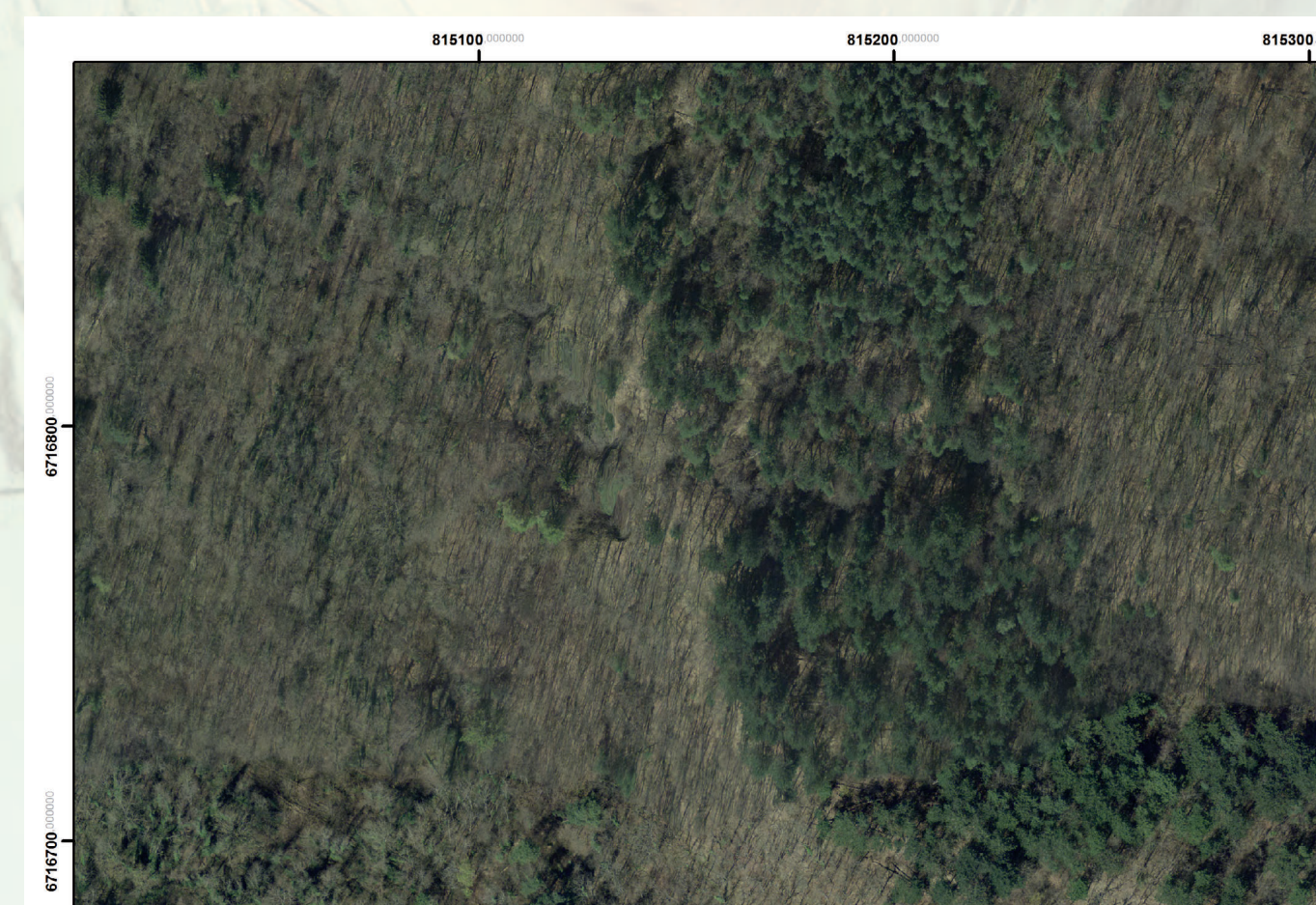
We also improve our understanding of the natural site morphology thanks to highlighting the dynamic of the environment ; for example with the evolution of rivers position.

A good visualisation of geomorphology leads as well to point out some anomalies as a result of human exploitation of natural resources, like ancient quarries.

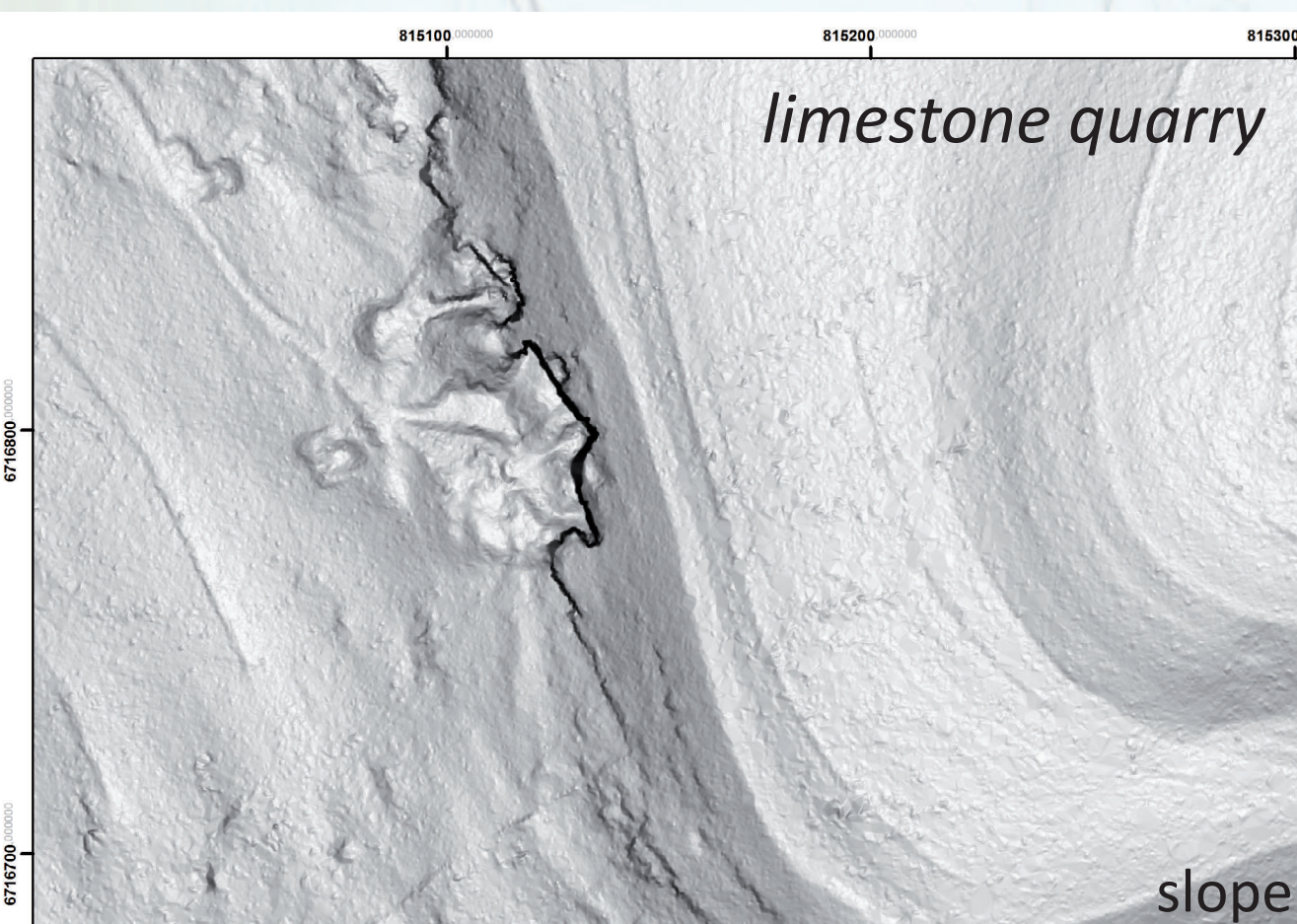


paleochannel

PCA



limestone quarry



slope

