Detection and identification of archaeological features using aerial LIDAR data in a forested environment (Châtillon-sur-Seine, Côte-d'Or, France).

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Detection and identification of archaeological features using aerial LiDAR data in a forested environment (Chatillon-sur-Seine, Côte d'Or, France)

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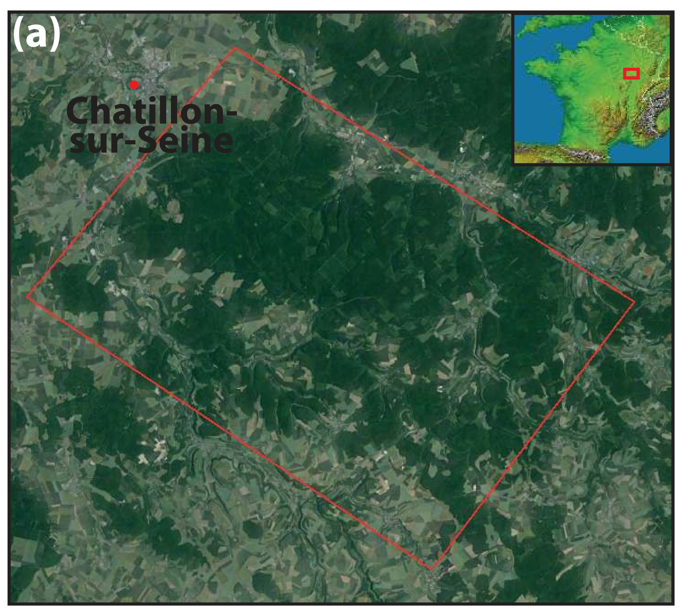
(a)

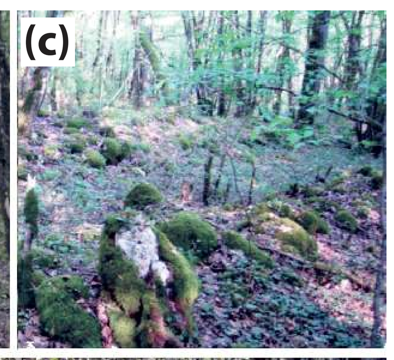


The study area is located in the northern part of the Côte-d'Or (Burgundy, France) in the state forest of Châtillon-sur-Seine (a). The place is covered by sets of protohistoric to medieval dry-stone structures were GPS prospection investigations were performed during 10 years (Vix Program). To complet this prospection, LiDAR data were acquired by PNF (Parcs Nationaux de France) in 2012, on a 400 km² area.

The objective of this work is to identify feature types defined for GPS prospection from LiDAR data indices. To evaluate the recognition of feature type with LiDAR data, we used two indices calculated on the LiDAR DEM (50 cm resolution). The local slope map highlights morphological variations of each feature, leading to define feature type. As some features present the same appearance on slope map, the topographic positive openness was calculated to determine the negative or positive elevation of features. For openness index, we used 8 directions on a 20 pixels radius distance (10 m diameter).

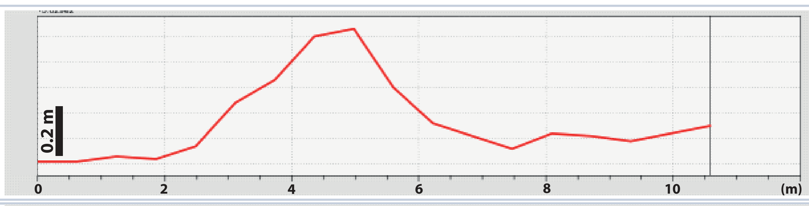
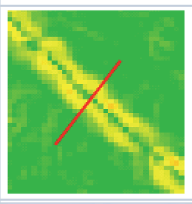
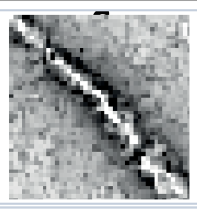
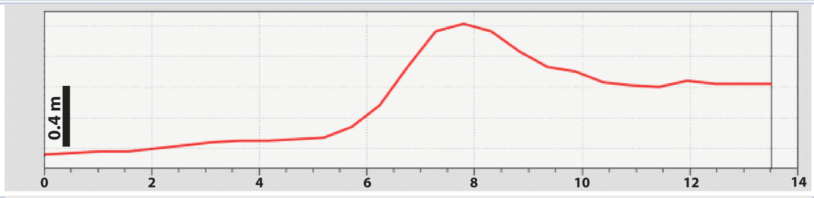
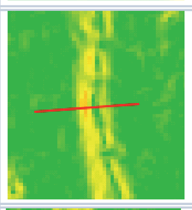
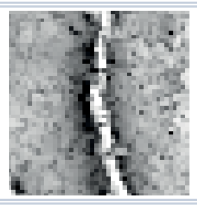
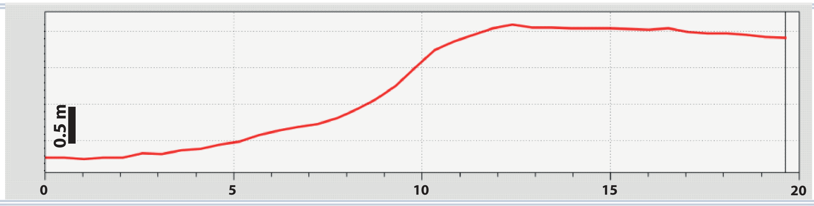
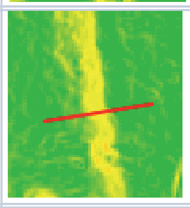
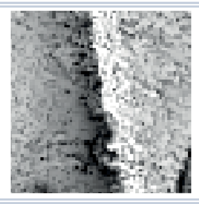
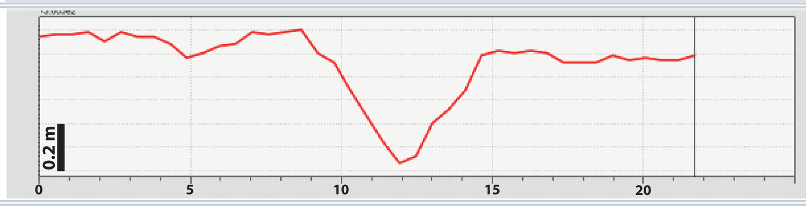
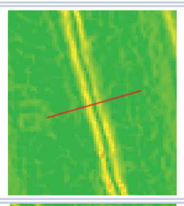
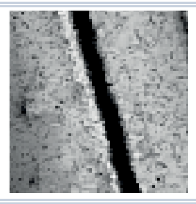
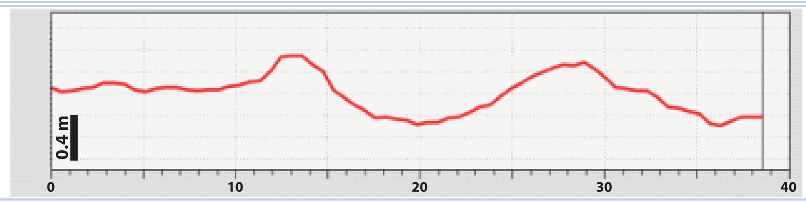
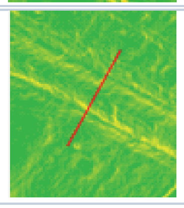
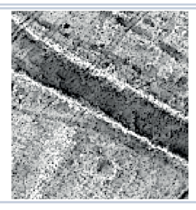
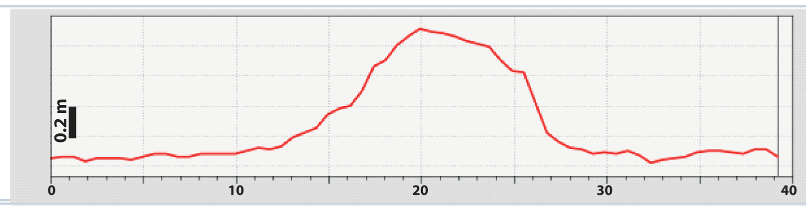
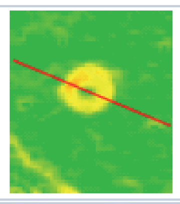
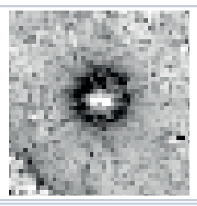
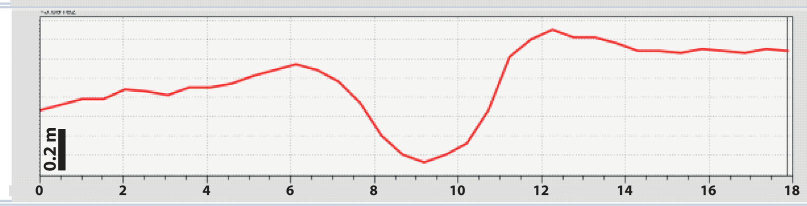
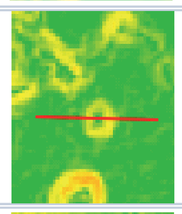
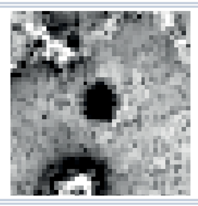
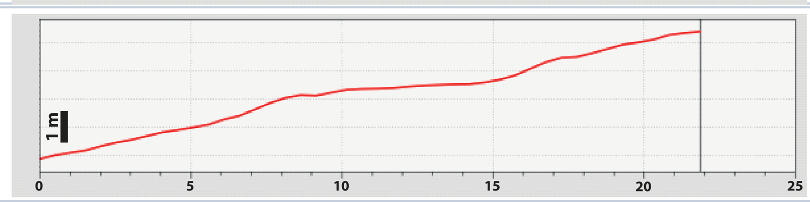
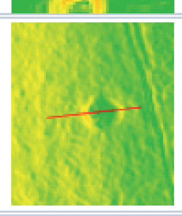
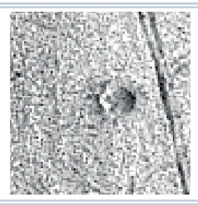
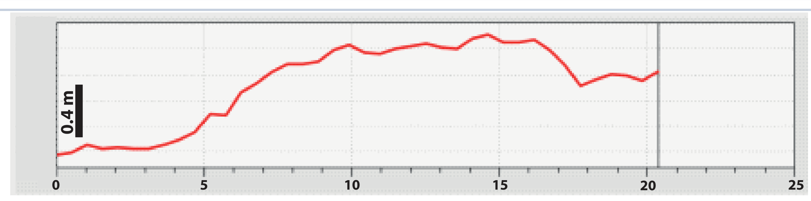
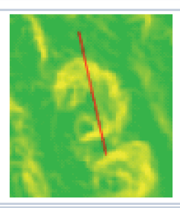
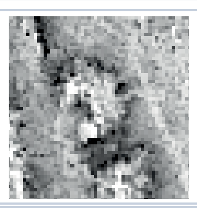
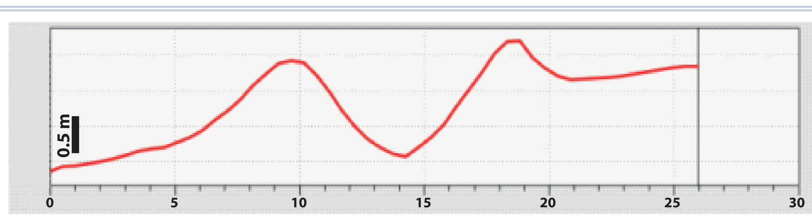
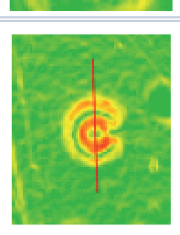
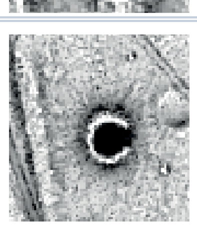
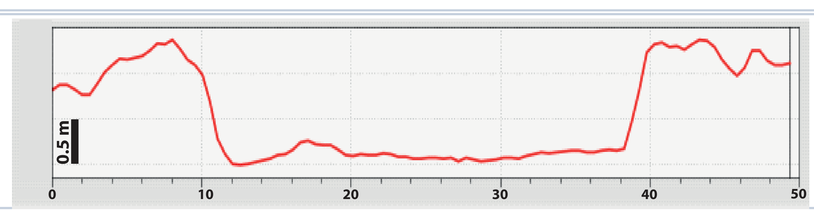
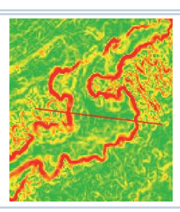
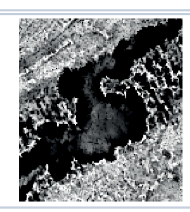
(b)

(c)



(d)

GPS typology VS LiDAR data

	GPS Typology	Definition	2D representation	Local slope	Positive openness	Key factors of recognition
Linear forms	Murée (b)	Dry-stone wall; plot limits				**low** slope in centerline = **top** of the wall; **medium** slope with the **same** footprint around centerline = **two sides** of the wall
	Murée sur épaulement	Dry-stone wall located on a naturel or anthropogenic embankment; plot limits				**low** slope in centerline = **top** of the wall; **medium** slope with **wide** footprint = **embankment** and wall side; **medium** slope with **small** footprint = **wall** side
	Epaulement	Naturel or anthropogenic embankment; plot limits				**medium** slope with **wide** footprint = **embankment**
	Fossé	Ditch; plot limits				**low** slope in centerline = ditch **bottom**; **medium** slope with the **same** footprint around centerline = **two sides** of the ditch
	Chemin/Voie (c)	Path/Roman road; communication road				**low** slope in center area (3 to 10 m width) = **path/road** footprint; two **parallel lines** with **medium** slope around center area = two **edges** of the path or two **dry-stone walls**
Point forms	Tertre (d)	Dry-stone mound; sree or plot limit (aligned) or tumulus				**Circular** to ovoid forms (rarely quadrangular); **low** slope in center = **top** of the mound, **medium** slope **surrounding** center = mound **sides**
	Excavation (minière ou lavière)	Excavation; mining or quarry				**Circular** form; **low** slope in center = **bottom** of the **excavation**, **medium** slope **surrounding** center = excavation **sides**
	Place à feux	Charcoal burning, charcoal place production				**Circular** form; **low** slope in center area = fire place, **two medium** slope surrounding center area with **crescent shaped** = one is **dug border** and the other is **backfilled border**
Surface forms	Tertre surfacique	Surficial dry-stone mound, more than 10 m diameter; probably tumulus				**Circular** to ovoid forms higher than 10 m diameter; **low** to **medium** slope in center = **top** of the mound, **medium** to **high** slope **surrounding** center = mound **sides**
	Four à chaux	Lime kiln; lime place production				**Circular** form higher than 10 m diameter; **high** slope in the center = **excavation**; **low** slope around center = **top** of the **mound**; **medium** slope outside = **side** of the **mound**; **access** area to center feature
	Carrière	Quarry, place of stone extraction				No particular form; **high** slope with small footprint = **quarry face**, **low** slope = **extracted** area

Application and validation

This method was applied on a 2,5 km² area, where:

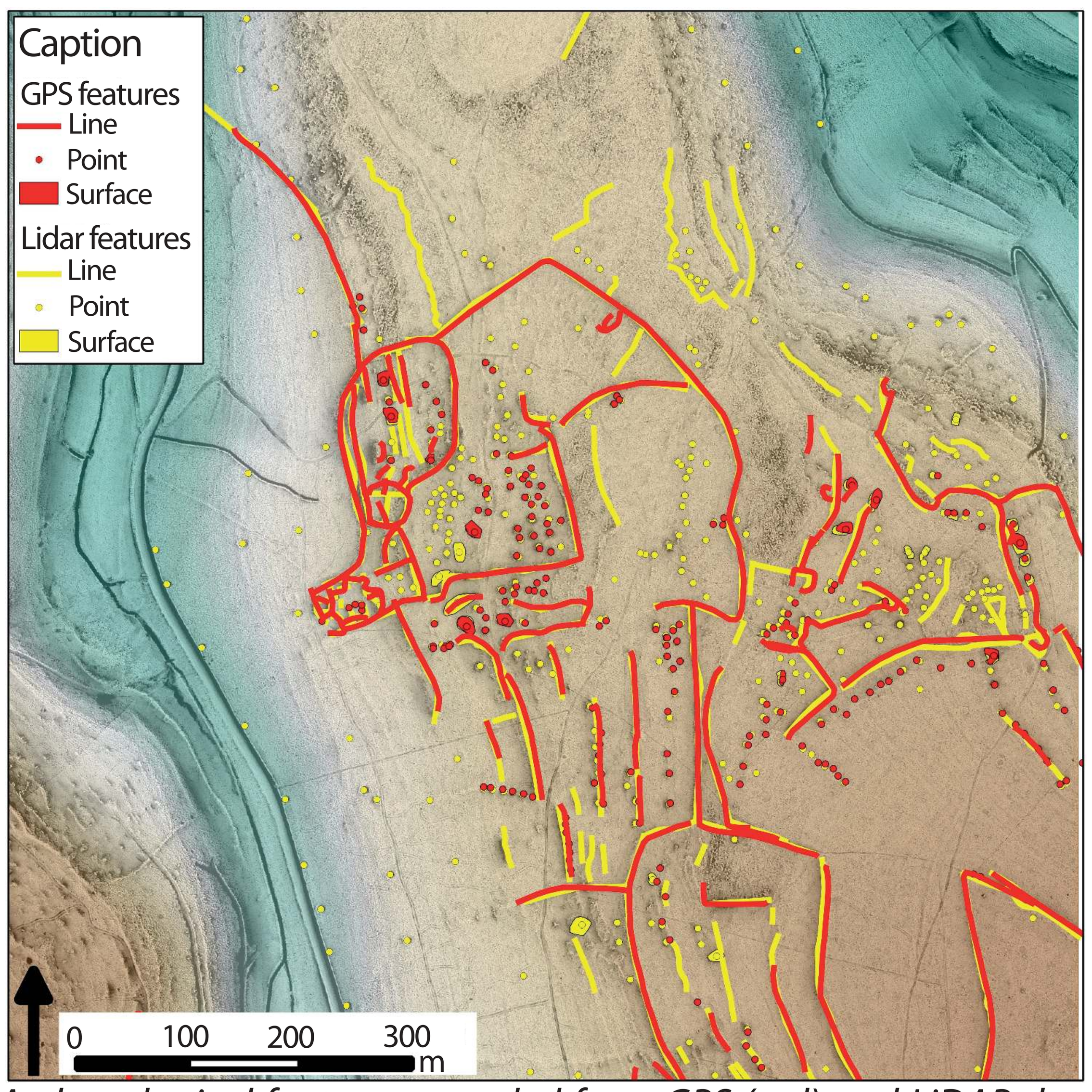
- 106 line, 192 point and 12 surface features were recorded by GPS
- 164 line, 398 point and surface features were recorded by LiDAR

Feature types recognized by LiDAR were compared to GPS records.

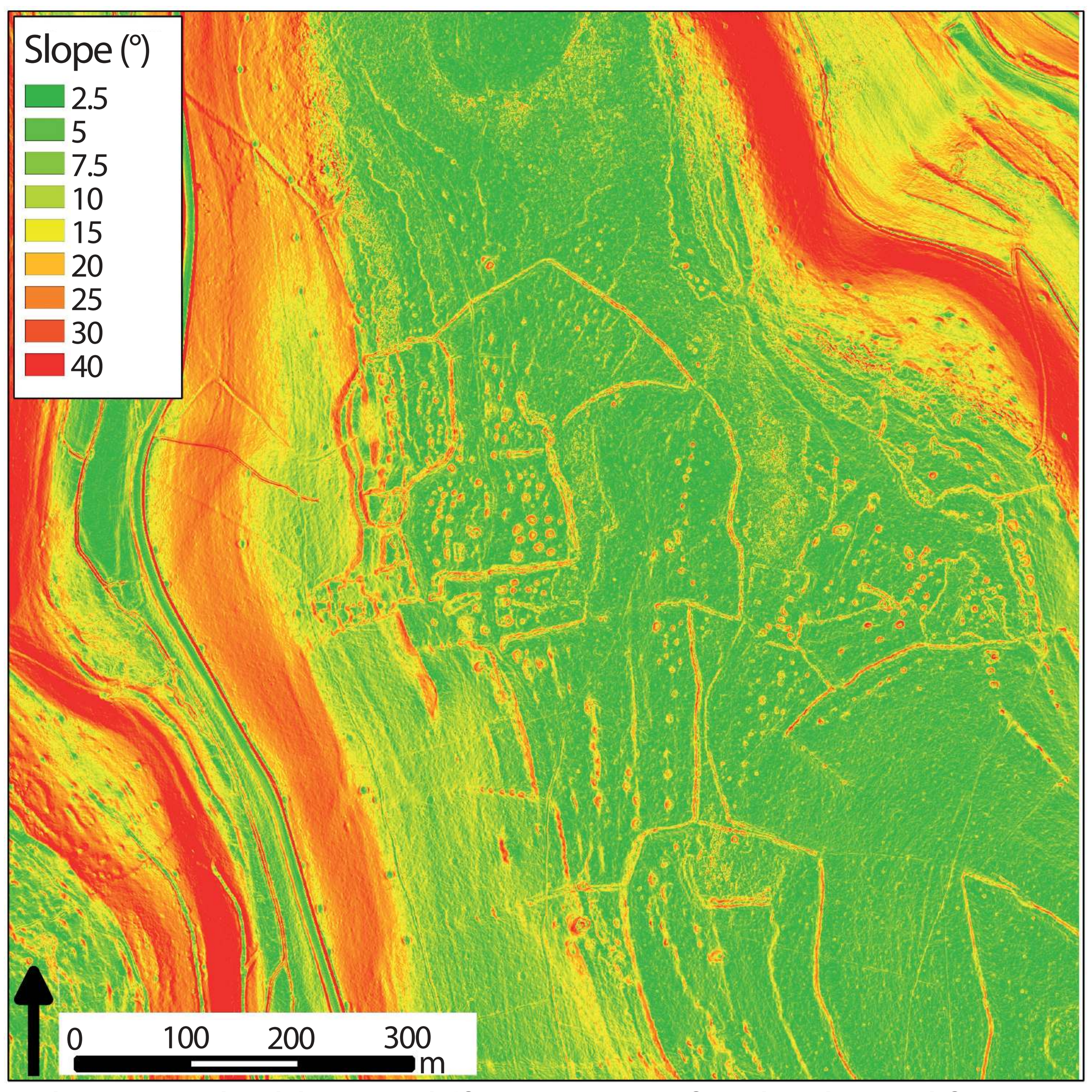
- **70 %** of **linear** features observed with LiDAR were great classified
  - => 1 % forgotten
  - => 5 % misclassified «Murée <=> Epaulement»
  - => 10 % misclassified «Epaulement <=> Murée sur épaulement»
  - => 14 % misclassified «Murée <=> Murée sur épaulement»
- **81 %** of **point** features from LiDAR were great classified
  - => 5 % forgotten
  - => 5 % not visible
  - => 3 % double GPS acquisiton on the field
  - => 6 % misclassified (elongated mound were classified as small embankement)
- **84 %** of **surface** features from LiDAR were great classified
  - => 8 % classified as multi features
  - => 8 % misclassified with GPS (lower than 10 m diameter)

To evaluate GPS and LiDAR classification availability, 2D cross-sections were performed on the LiDAR DEM for all misclassification areas.
The results show that LiDAR data recognition is conform to 2D topographical profil.

The misclassification of features observed on GPS data may be due to:
- a bad estimation of low topographical variations on the field
- a «continuous» record on the field, which do not take into account all morphological changes (observable on LiDAR) on a linear structure



Archaeological features recorded from GPS (red) and LiDAR data (yellow) (GPS data, ENVIX BD, 2012)



Slope map highlinting different types of archaelogical features

Discussion

This work shows that local variations of slope values combined with topographic positive openness facilitate the detection of new structures and their assignments to one of the typology defined by the GPS prospection.
The high altimetric resolution of LiDAR data allows to observed low topographical changes, with decimetric variations. However, the location of these features is not easy to be assessed, and the determination of feature types is almost impossible. Therefore, a return to the field is needed to validate the assumptions from LiDAR data.