

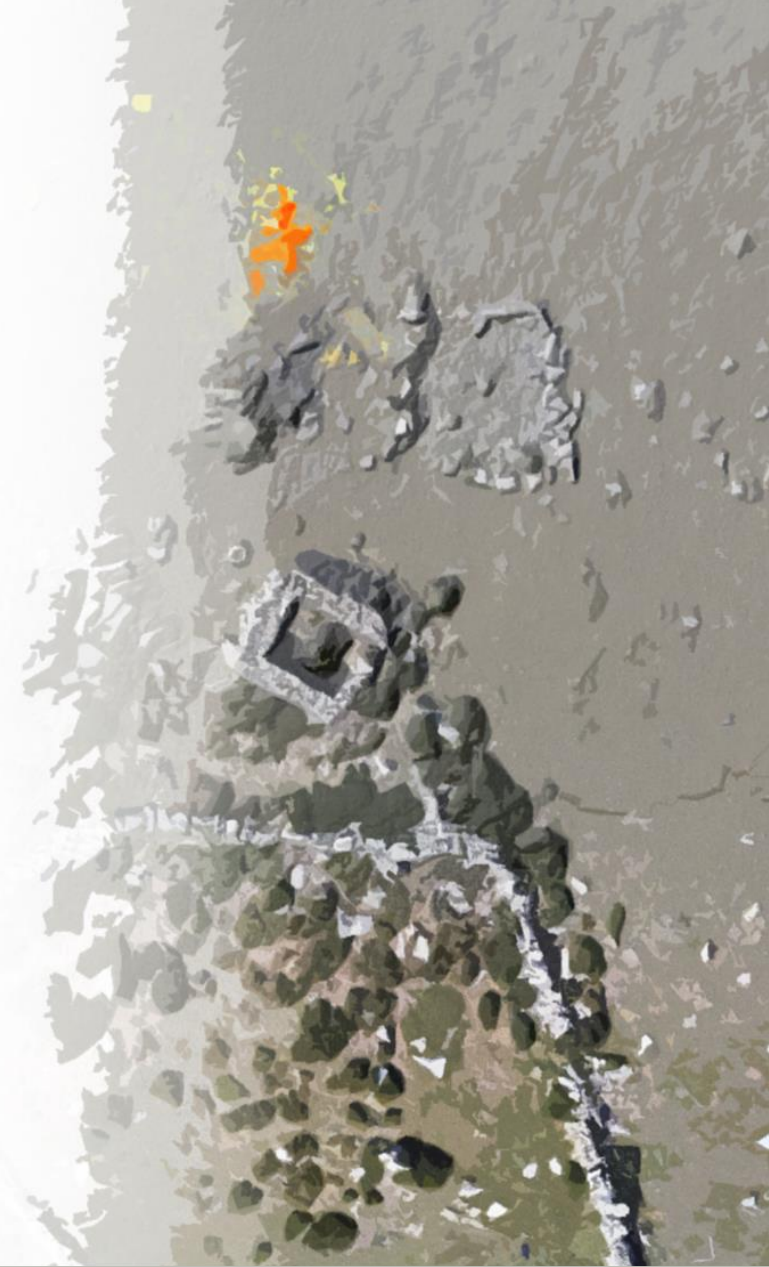
# Inspecting high altitude areas

Development of a multi-source procedure for the archaeological prospection of high altitude areas

European Association of Archaeologists  
Kiel 2021

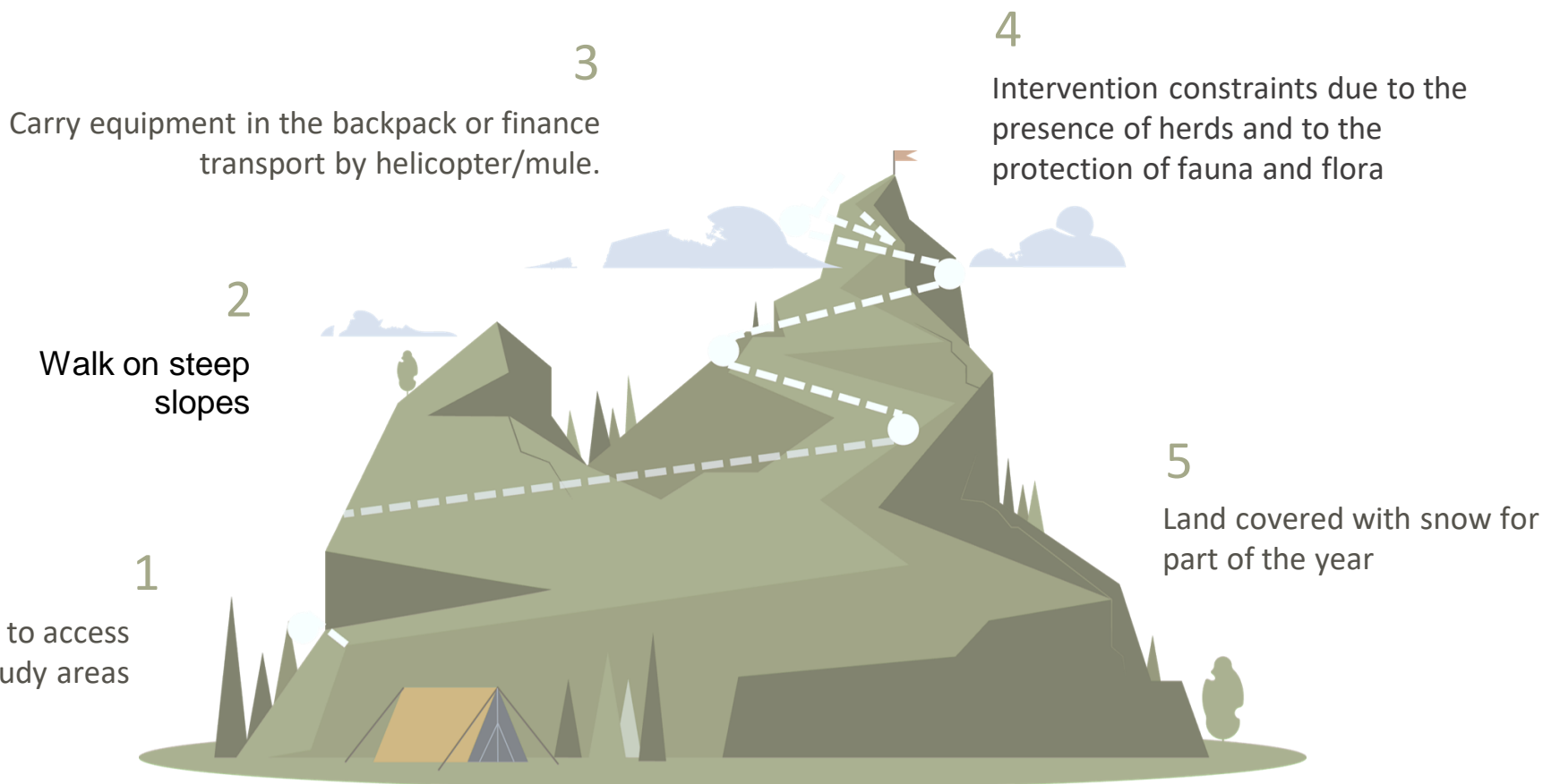
Calastrenc Carine<sup>1, 2</sup>, Baleux François<sup>1</sup>, Poirier Nicolas<sup>1</sup>, Laurent Antoine<sup>1</sup>, Philippe Magali<sup>3</sup>, Rendu Christine<sup>2</sup>

1. CNRS - TRACES Laboratory, UMR 5608, Toulouse
2. CNRS - FRAMESPA Laboratory, UMR 5136, Toulouse
3. CNRS - GEODE Laboratory, UMR 5602, Toulouse





## Specificities of high mountain works





# Specificity of the archaeological objects sought



Plans of buildings made of dry stone



Secteur : Cailloulat  
Ens. 182 Str. 450



Secteur : La Glarote et La  
Glère  
Ens. 27 Str. 14



Secteur : La Glarote et La Glère  
Ens. 3 Str. 8



Secteur : La Glarote et La Glère  
Ens. 27 Str. 63



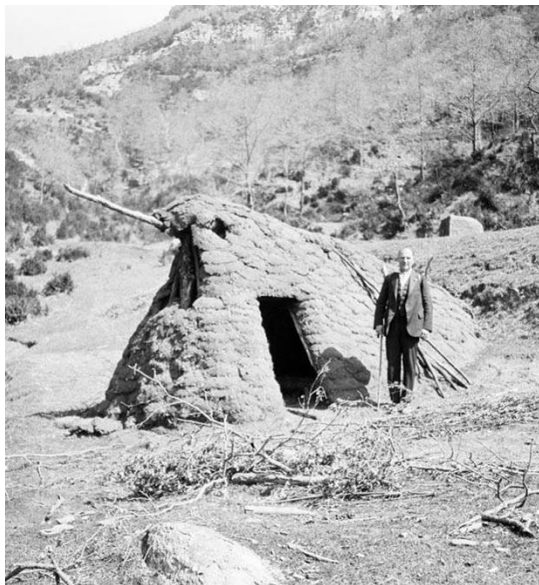
Secteur : Tourmont  
Ens. 149 Str. 348 à 350





# Specificity of the archaeological objects sought

How can we identify pastoral infrastructures built, whole or in part, from perishable materials?



Vic (Catalogne – Spain)  
1920-30 - Photographer : Blasi



Guarrinza valley (Aragon Spain) – 1933 -  
Photographer : Compairé



Arpington mountain (Savoie, France) 2018  
(*La Maurienne Journal*, 5 July 2018 - Autor : C. V)





## High archaeological density

Mean density in plain



1 archaeological site per Km<sup>2</sup>

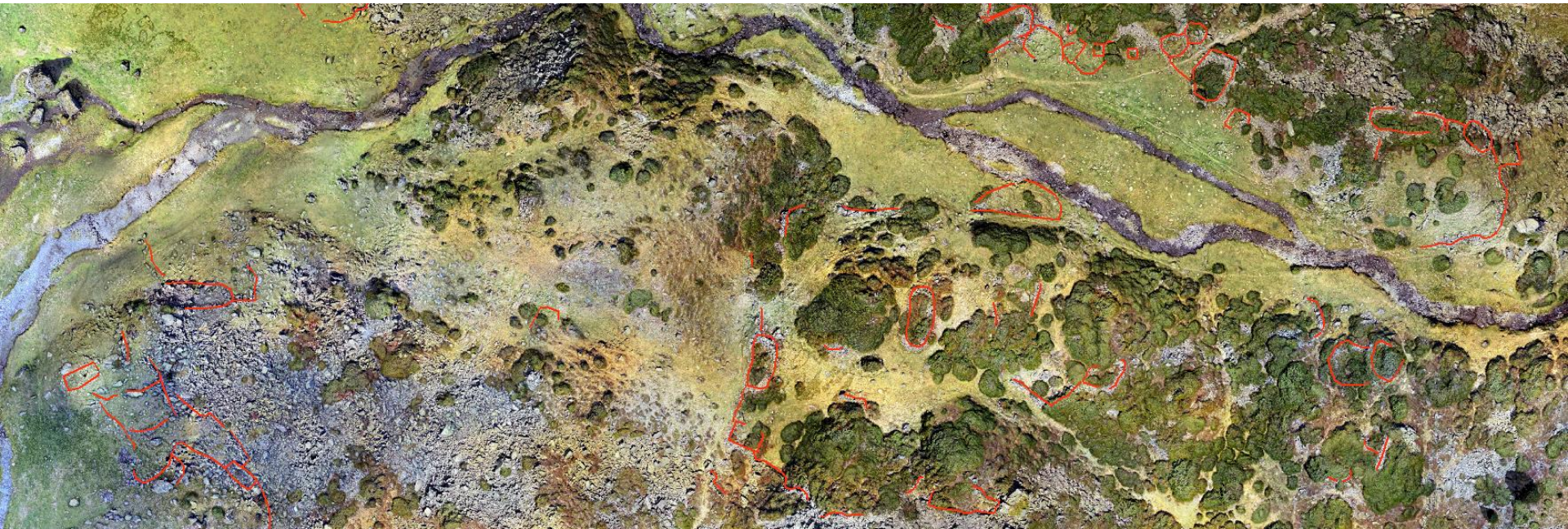
Mean density in mountain

(Pyrenees)



70 archaeological site per Km<sup>2</sup>

(Between 0.94 and 330 pastoral units/ 100 hectares)







## Time-consuming work

### Anéou

*Rendu, Calastrenc, Le  
Couédic*

1300 hectares

4 months with 2  
people



### Benasque

*Calastrenc, Rivas, Ona  
Gonzalez*

1400 hectares

3 months with 2  
people

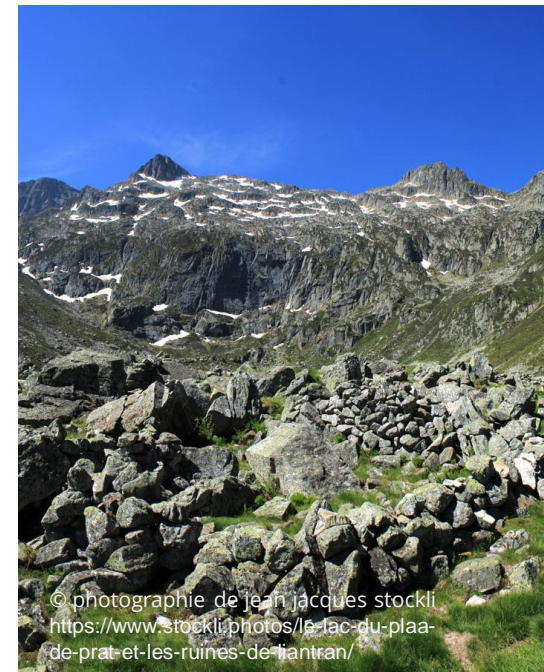


### Liantran

*(Calastrenc et al.)*

3 hectares

1/2 month with ± 1 people





## Methodological lock

- How can larger areas be archaeologically addressed in a shorter time ?
- How can we get a statistically significant and solid inventory, which includes structures made of dry stones, those made of perishable materials and those covered by vegetation, colluvium or destroyed by human activity?







T.A.H.M.M.

Archaeological Remote Sensing in the High and Middle Mountains ([www.tahmm.fr](http://www.tahmm.fr))

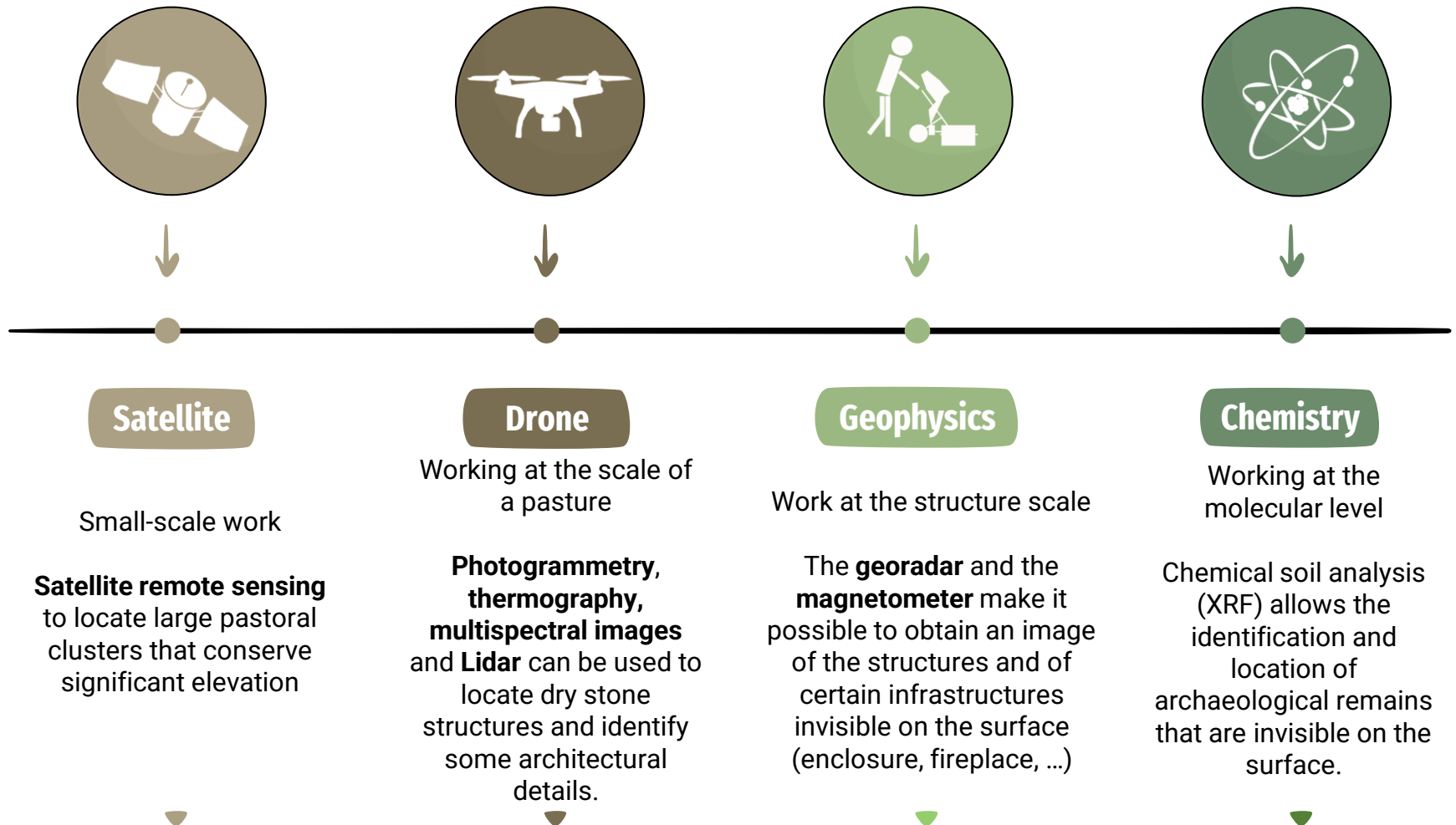
# Are the actual methods for archaeological survey of these areas the most appropriate?







## Scientific equipment

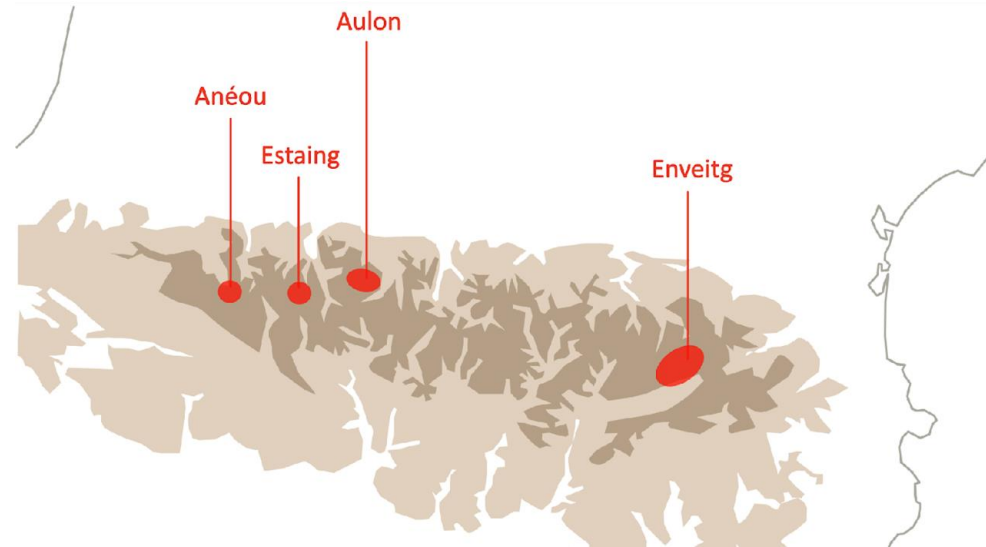




## Fields of application

### « Calibration » areas

- Enveitg Mountain (Oriental-Pyrenees)
- Anéou pasture (Atlantic-Pyrenees)



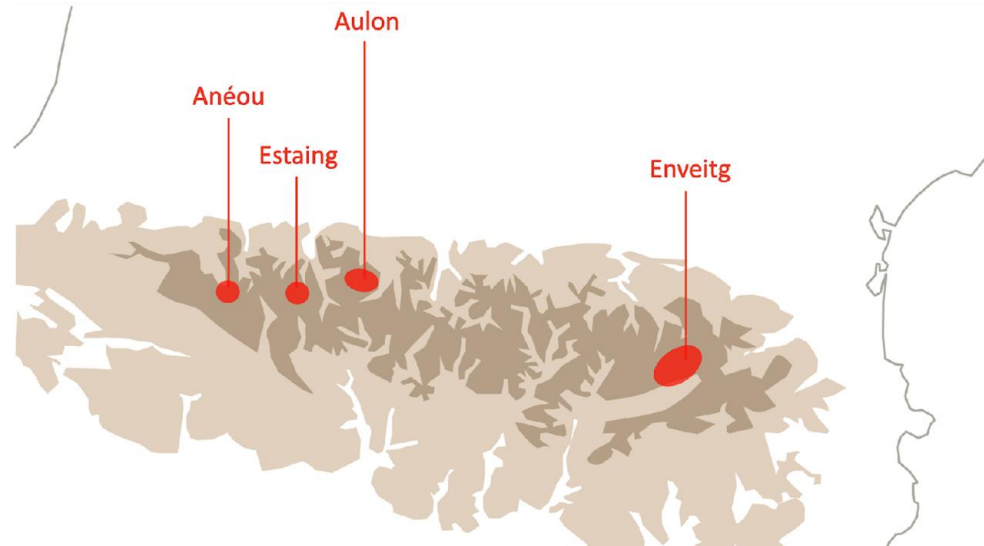


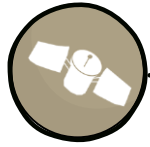


## Fields of application

### Test areas

- Liantran area, Estaing (Highs-Pyrenees)
- Natural reserve of Aulon (Highs-Pyrenees)





## Remote sensing

2019-2020 → ISIS scientific support programme

**Technological limitation**

=> Spatial resolution

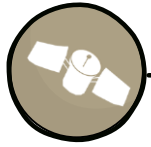
Panchromatic = 0,50 m

Multispectral = 2,00 m

=> Partial detection

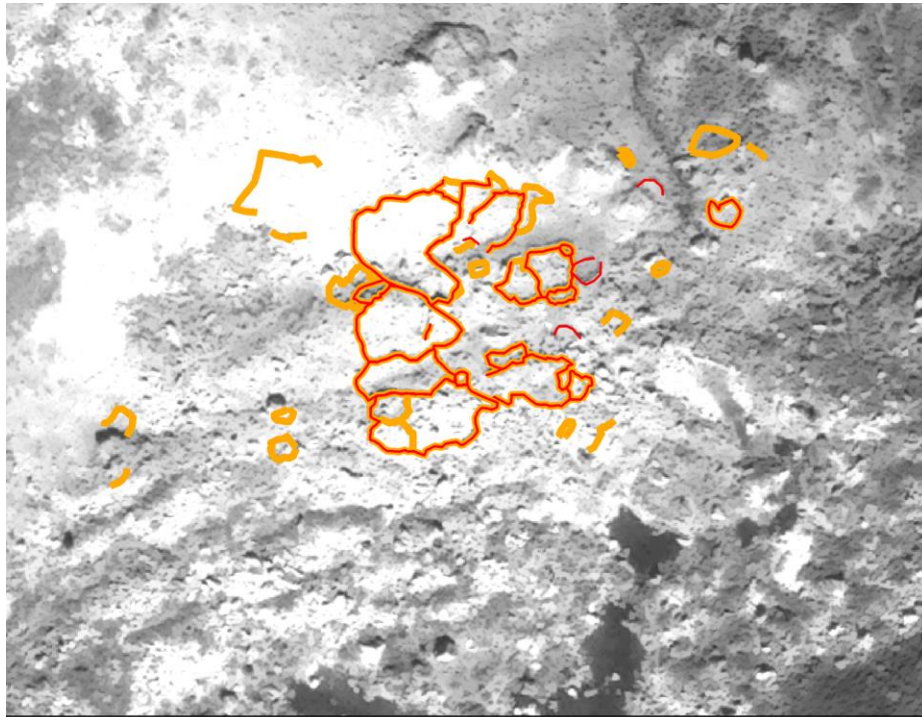






# Remote sensing

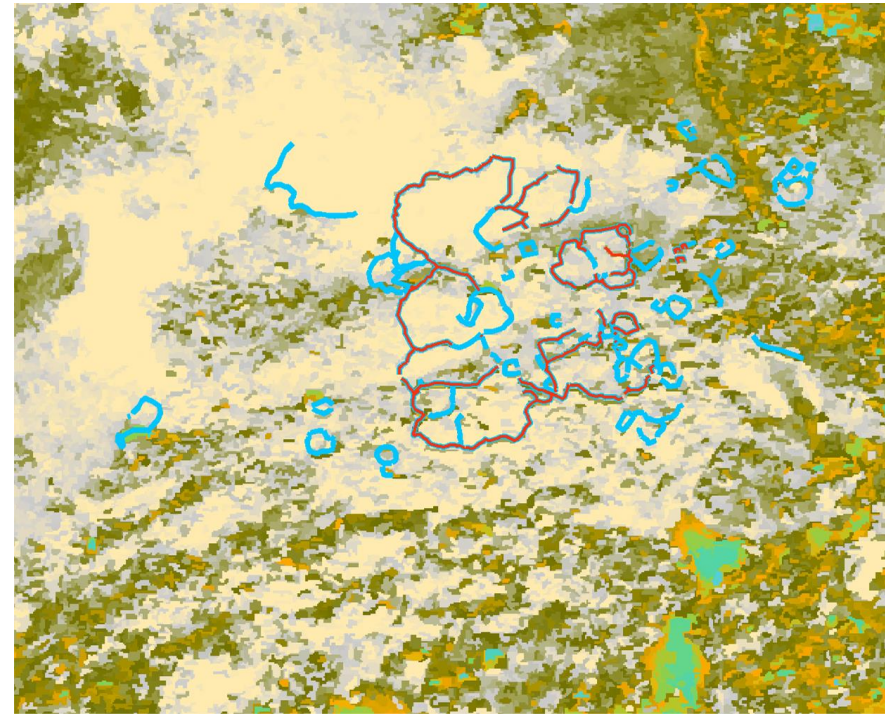
2019-2020 → ISIS scientific support programme



— Archaeological structures visibles on the K Mean  
 — Field reality

**Morphological feature extract**  
 High : 813  
 Low : 0

0 50 100 m



— Archaeologicals structures identified on the CSM result  
 — Field reality

**Mean Shift Clustering**  
 High : 880  
 Low : 0,0206473

0 150 m



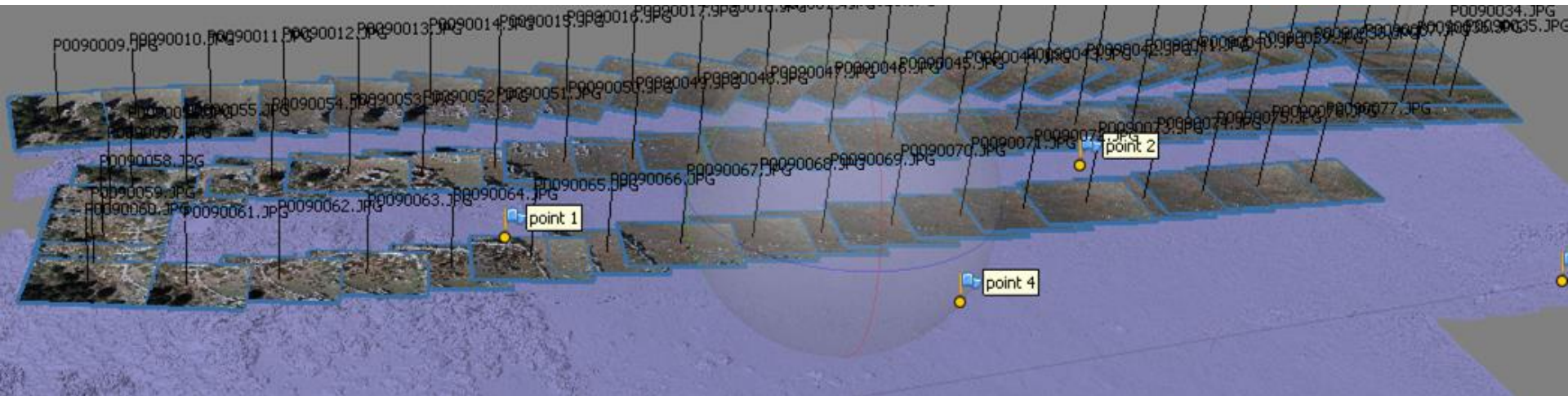
## Photogrammetry

Technology widely used in archaeology

Software = Avoid button clicking and black boxes

= Ensure model accuracy

= Evaluate the quality of the 3D model

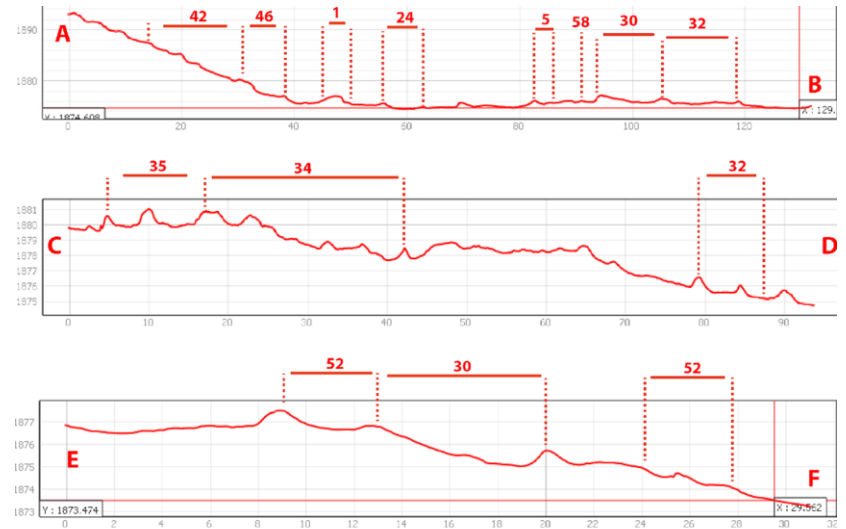
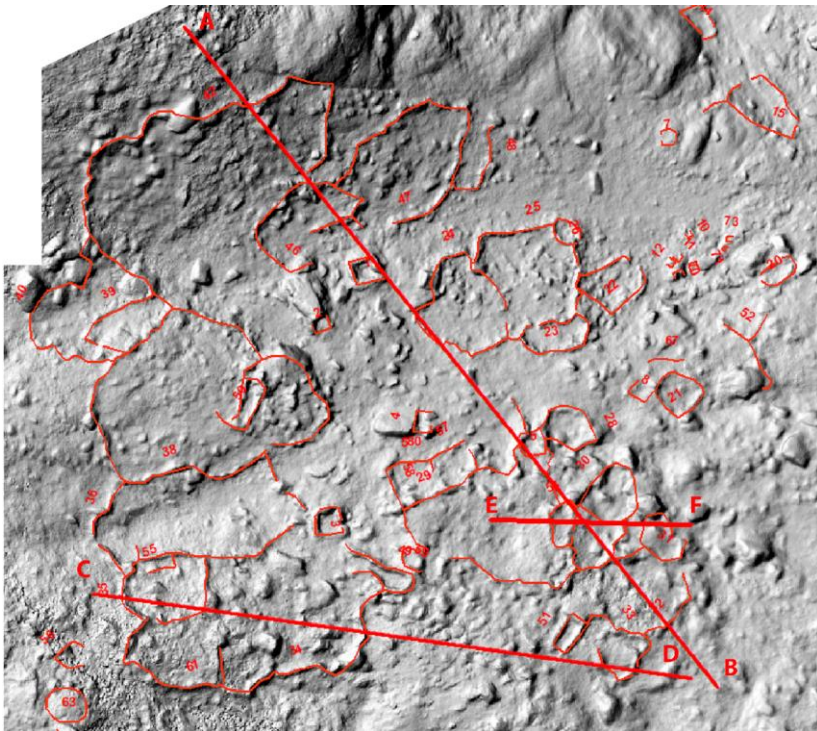






# Photogrammetry

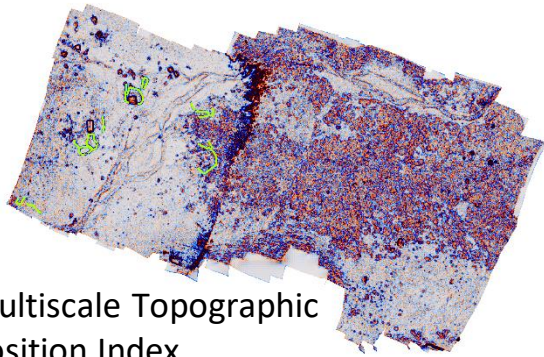
Tool for the detection and description (excluding structures under rock)



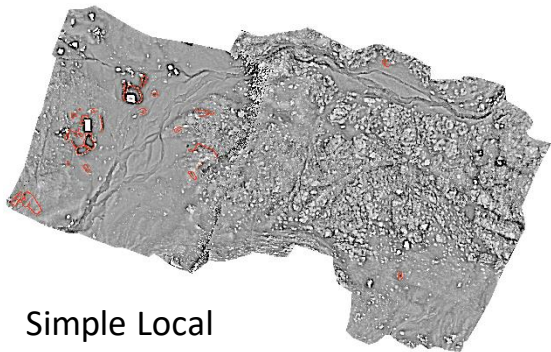


# Photogrammetry

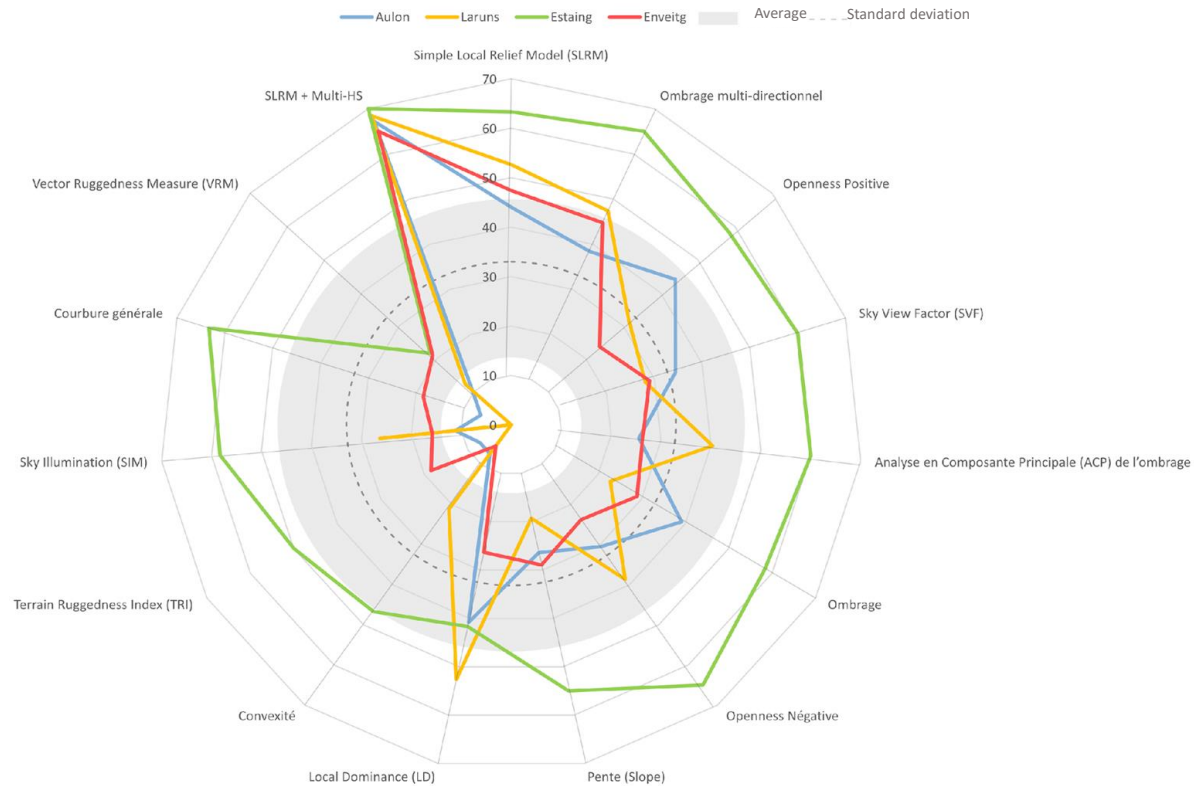
## Use of Digital Elevation Models (DEM)



Multiscale Topographic Position Index



Simple Local Relief Model







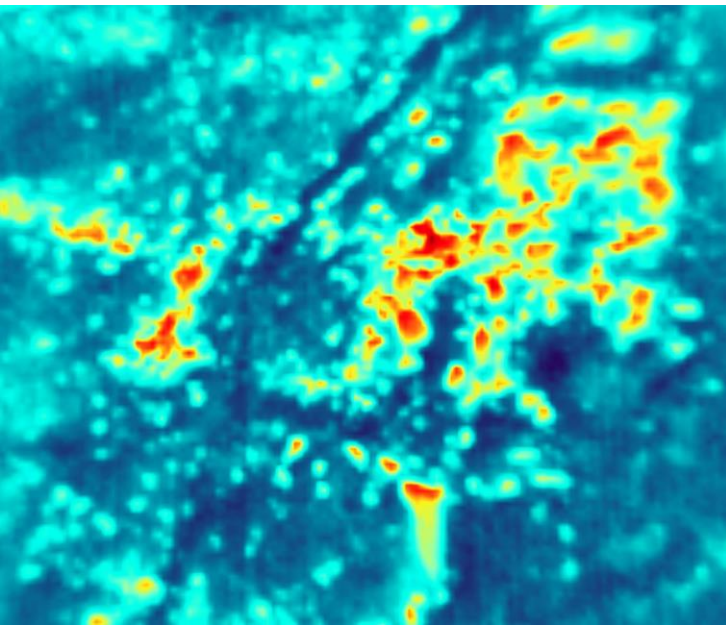
## Thermography

### The thermal camera - FLIR T620

- Detection of temperature deltas: 0.04 °C
- 640 x 480 pixels images
- Real-time radio transmission of the captured images

### Parrot – Anafi Thermal

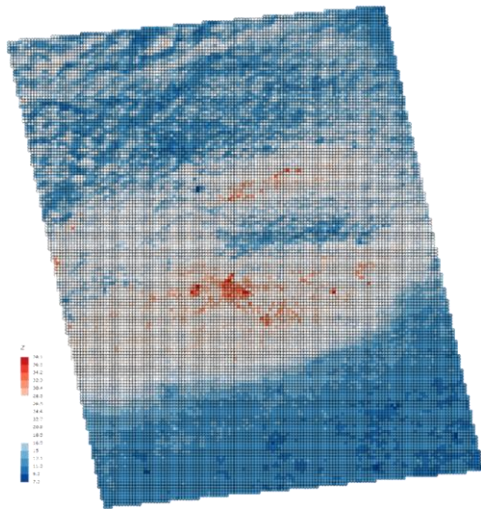
- Weight: 320g
- Battery life: 26 minutes
- Flir camera 160 x 120 px



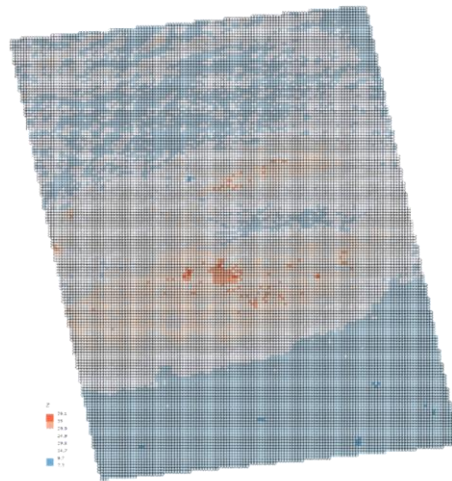


## Thermography

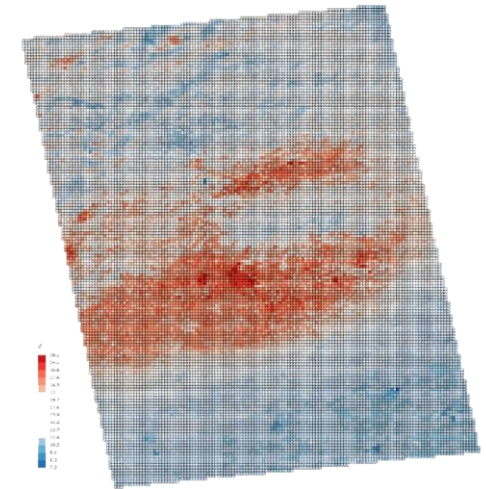
Refining the classification of thermographic data for better visibility of information



Equal intervals – 16 classes



Standard deviation – 7 classes

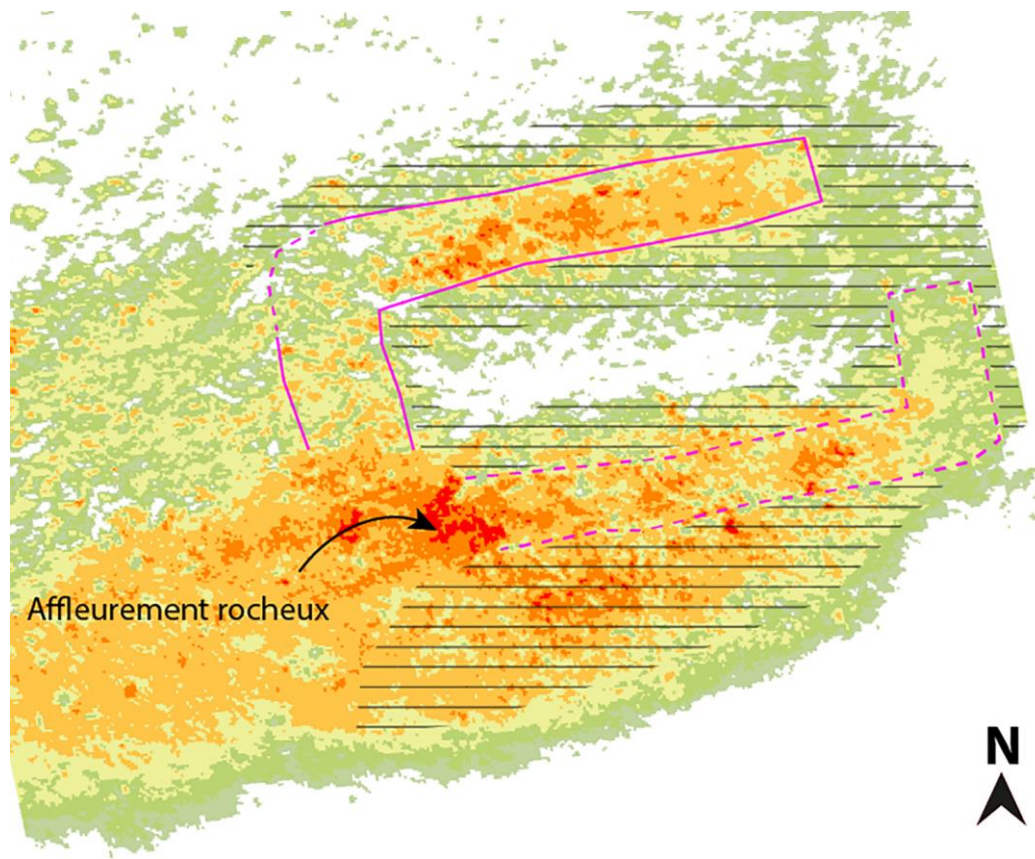


Geometric – 16 classes





## Thermography



### Digital thermographic model (degrees) - Classified



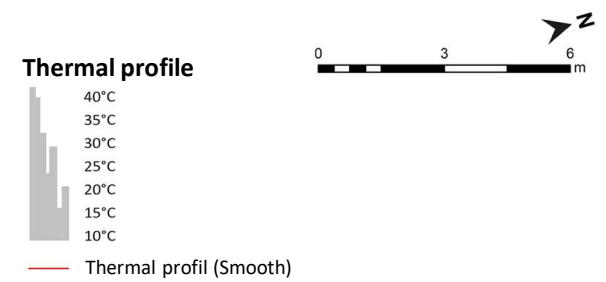
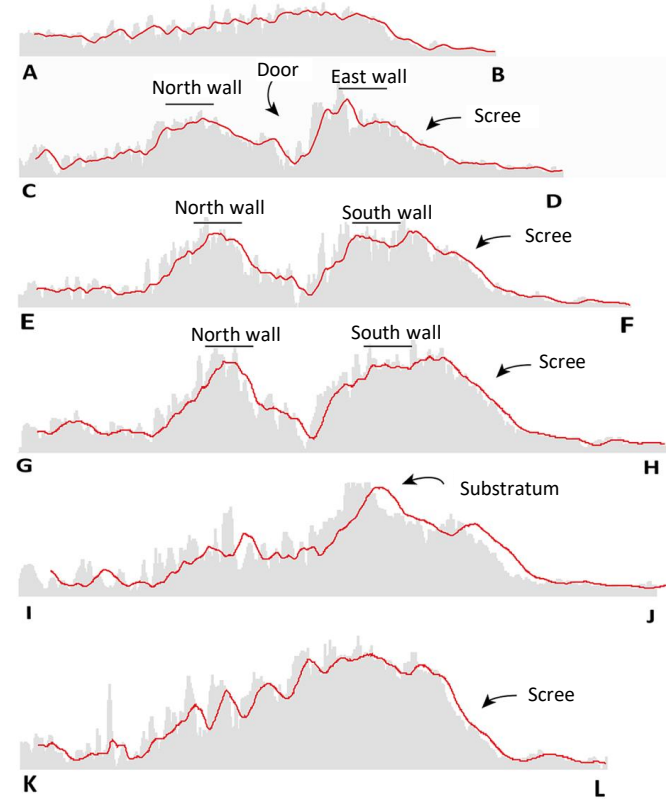
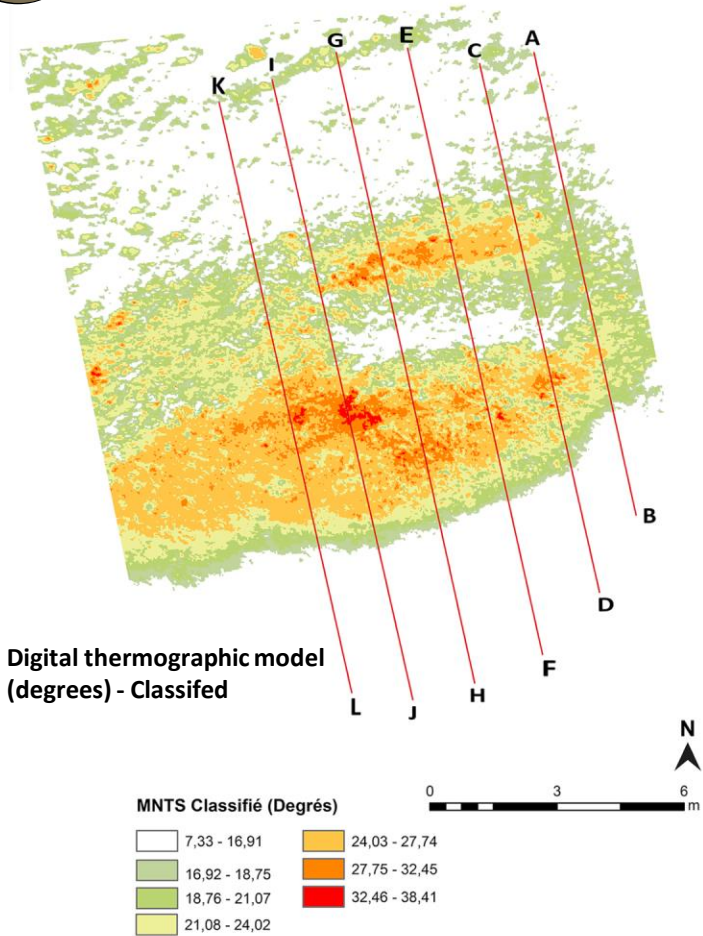
### Archaeological interpretation

- Outer line of the wall
- Possible outer line of the wall
- Wall fall area





# Thermography



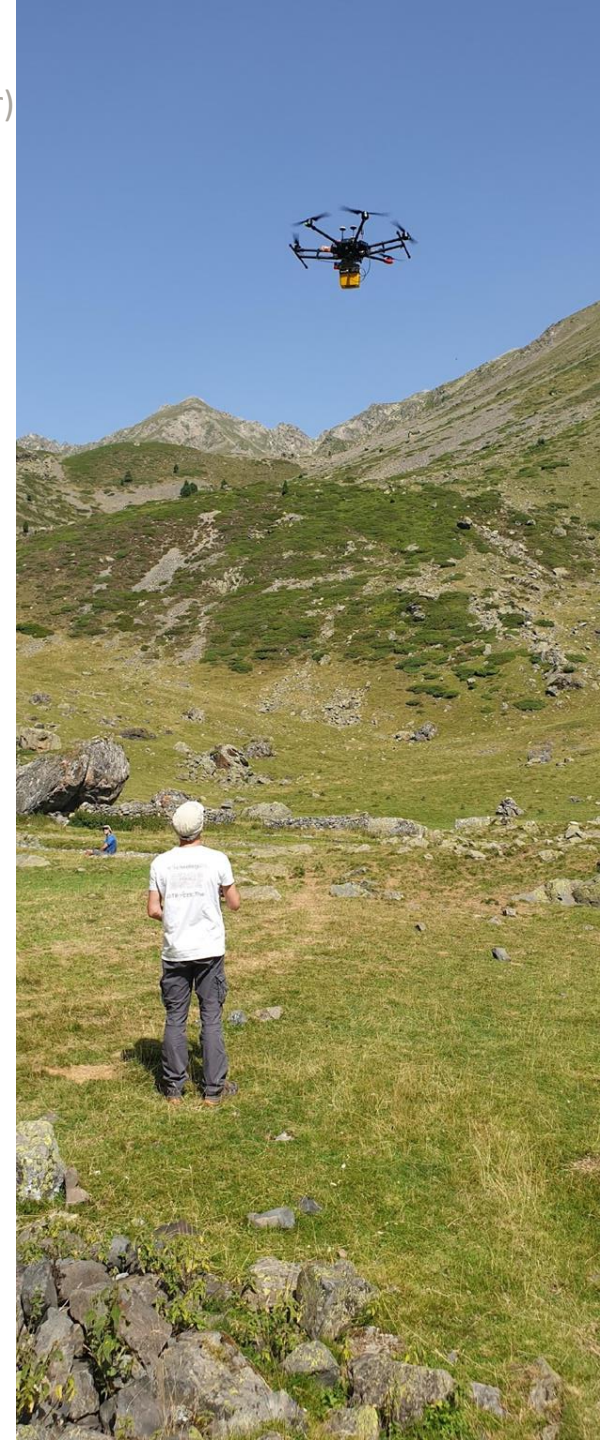




## Lidar

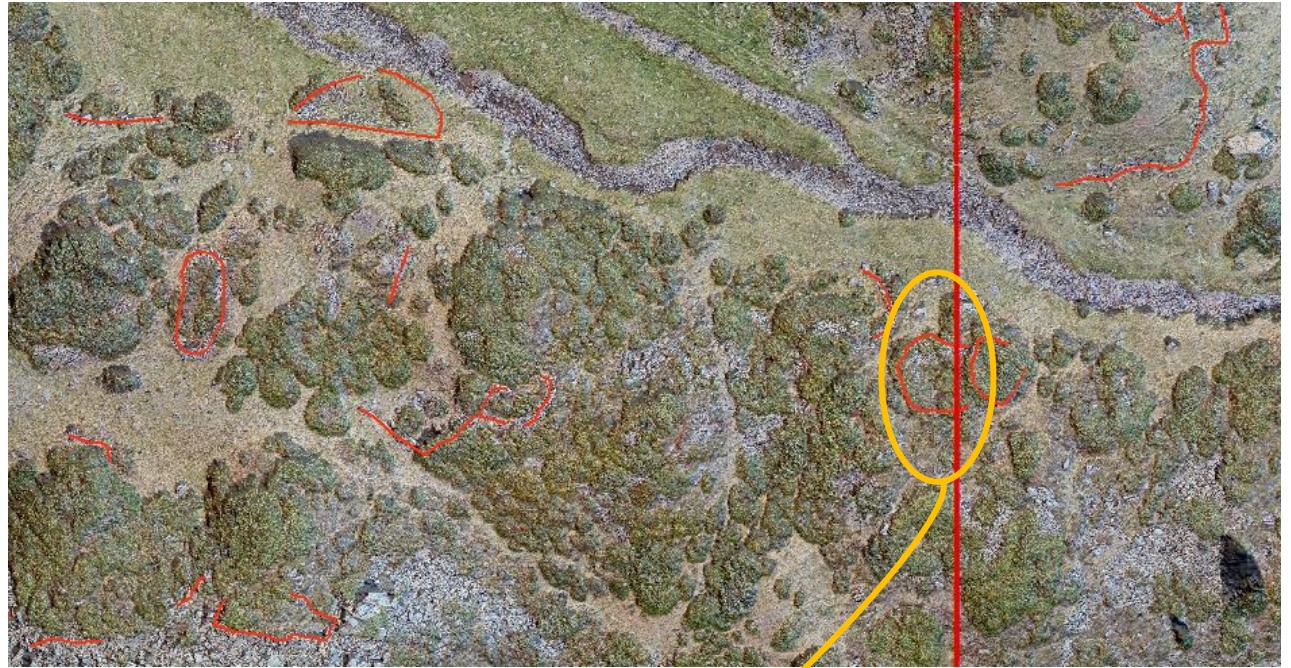
### Lidar YellowScan Mapper II

- Ibeo Lux Laser Scanner
- GNSS Inertial Station
- 10 cm (X/Y) and 5 cm (Z)
- Autonomy 1,5 h





Lidar



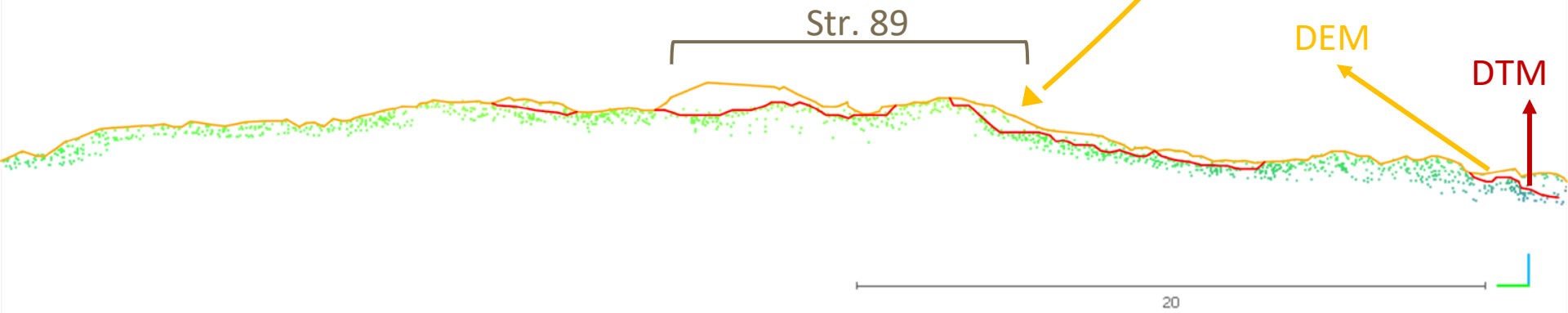
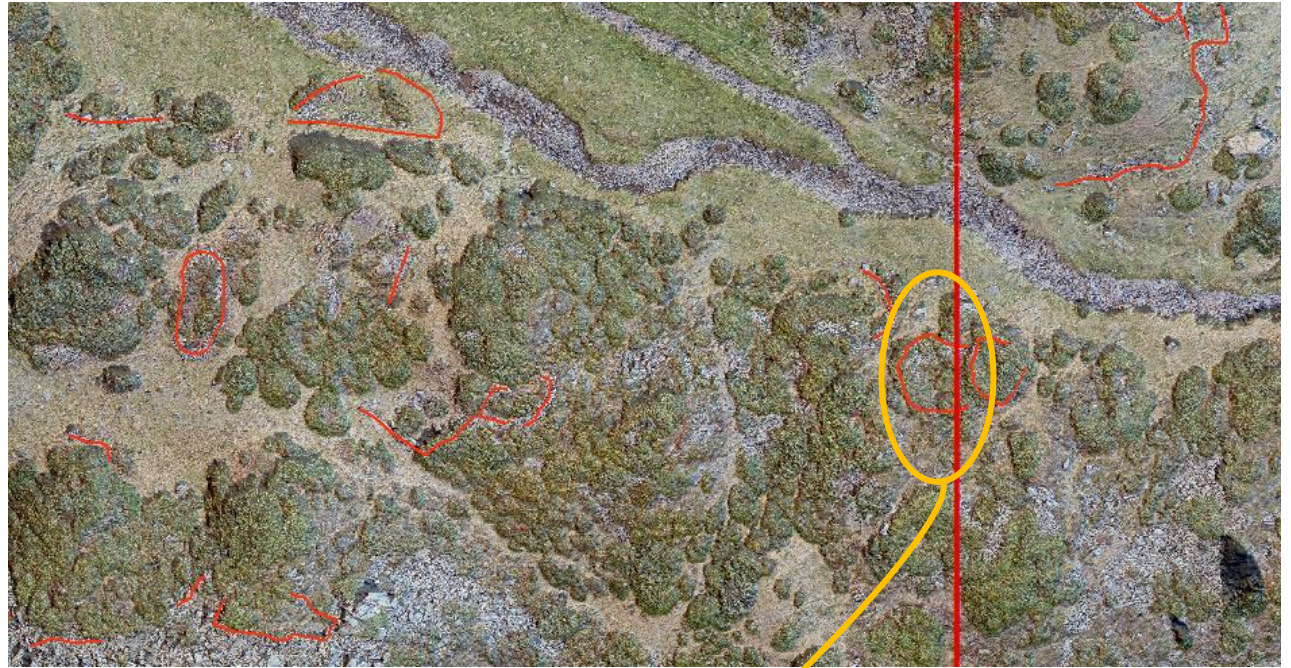
Str. 89

10 – 25 cm





# Lidar





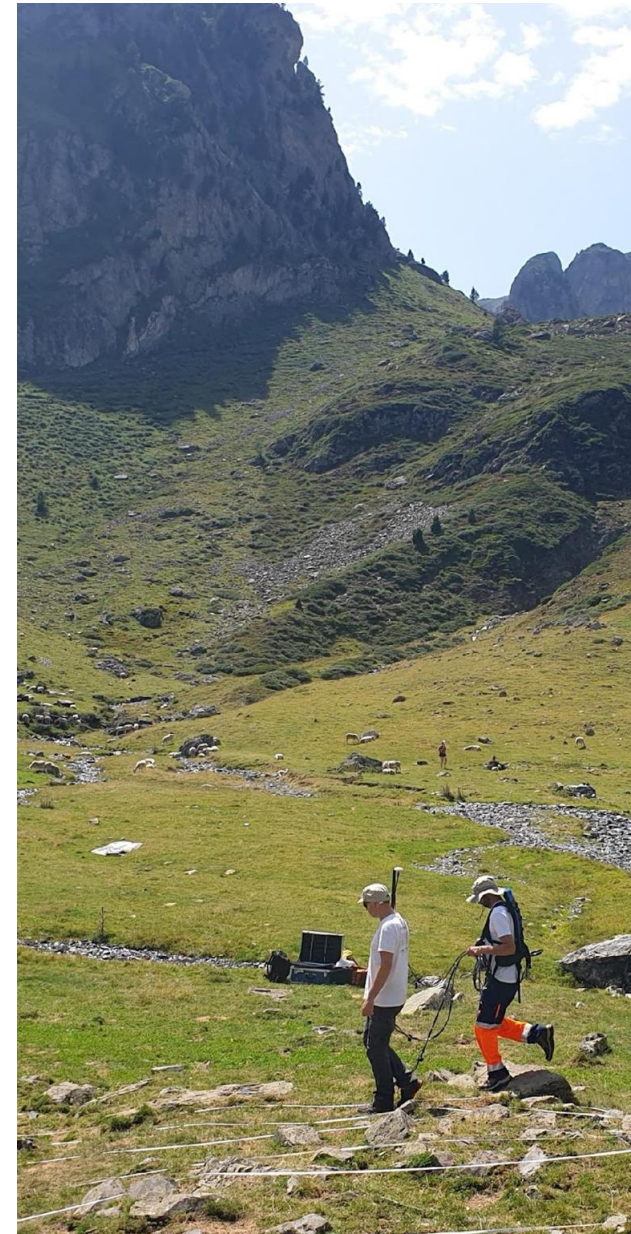
Geophysics

Gradiometer

GSM19

Georadar

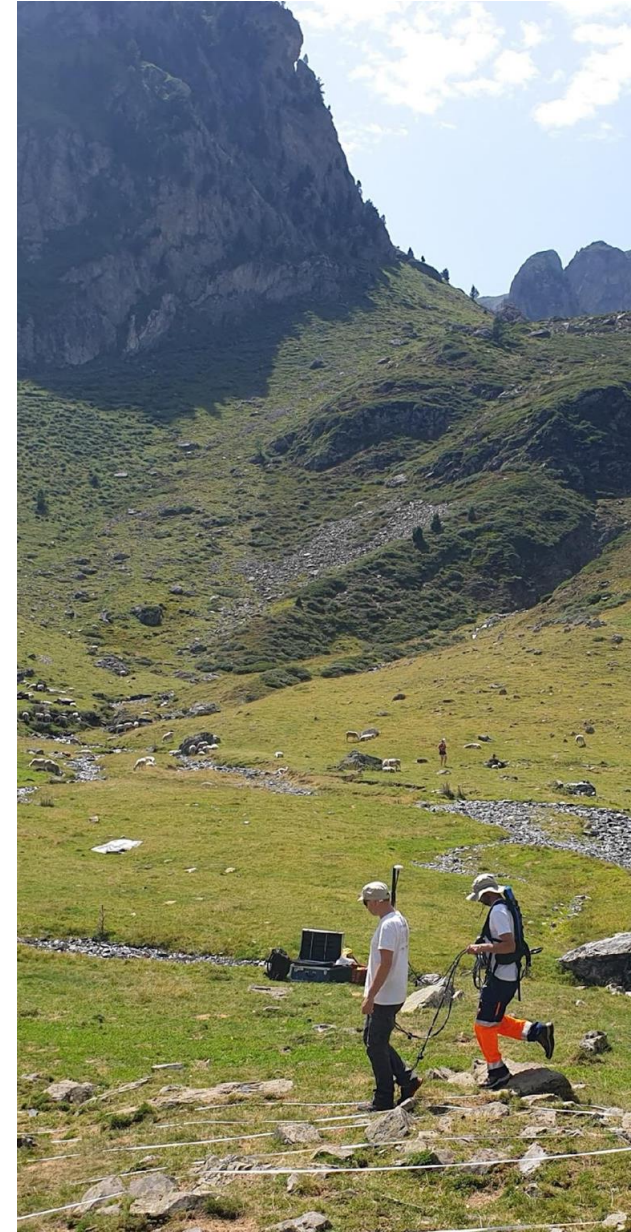
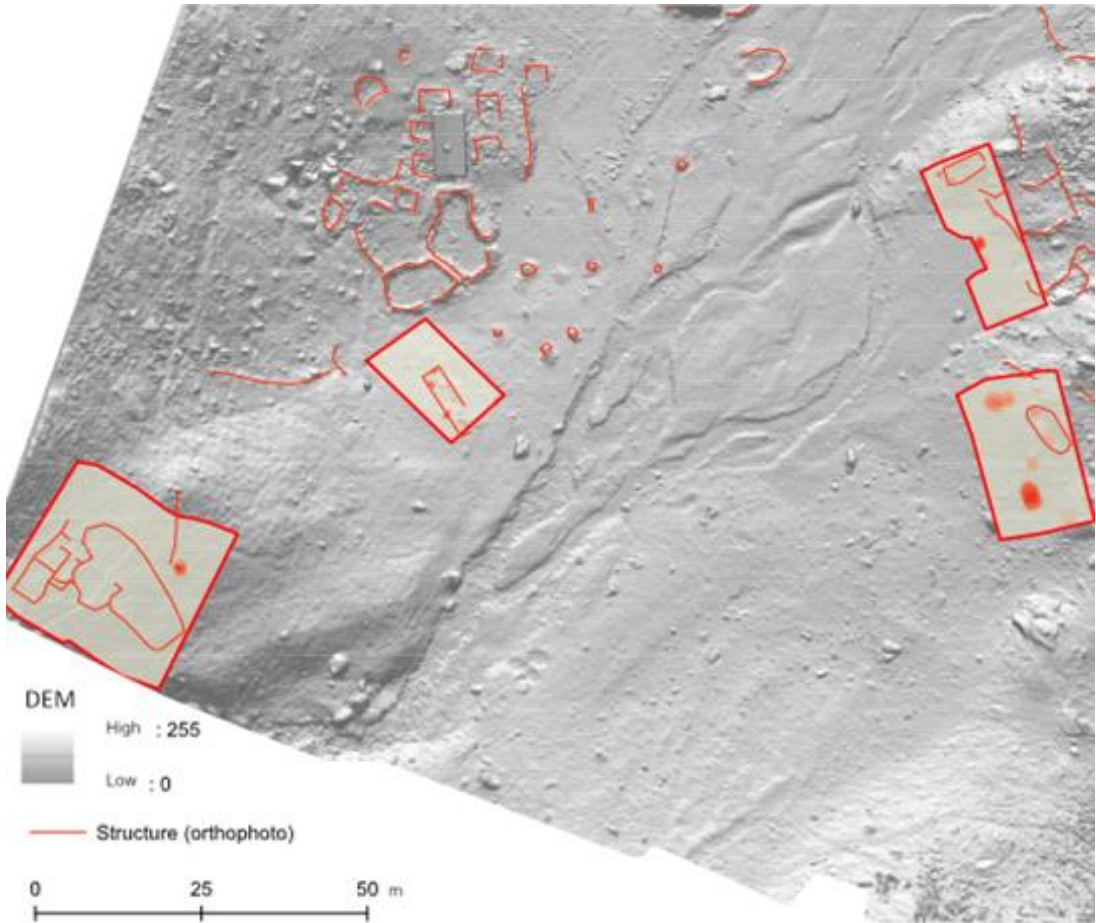
GSSI – SIR 4000 → 4 antennas (200, 400, 900 MHz)







Geophisic







XRF

# X-ray fluorescence spectrometer

## Detection of enclosure areas



**PERIODIC TABLE OF ELEMENTS**

GROUPE		NUMÉRO DU GROUPE RECOMMANDATIONS DE L'IUPAC (1985)																NUMÉRO DU GROUPE CHEMICAL ABSTRACT SERVICE (1985)																			
PÉRIODE		1 IA		2 IIA		3 IIIA 4 IVA 5 VA 6 VIA 7 VIIA										8 VIIIB 9 IB 10 IIB										18 VIIIA											
1		1 H 1.0078																								2 He 4.0026											
2		3 Li 6.941		4 Be 9.0122																						10 Ne 20.180											
3		11 Na 22.990		12 Mg 24.305																						18 Ar 39.948											
4		19 K 39.098		20 Ca 40.078		21 Sc 44.956		22 Ti 47.867		23 V 50.942		24 Cr 51.996		25 Mn 54.938		26 Fe 55.845		27 Co 58.933		28 Ni 58.693		29 Cu 63.546		30 Zn 65.39		31 Ga 69.723		32 Ge 72.64		33 As 74.922		34 Se 78.96		35 Br 79.904		36 Kr 83.80	
5		37 Rb 85.468		38 Sr 87.62		39 Y 88.906		40 Zr 91.224		41 Nb 92.905		42 Mo 95.94		43 Tc (98)		44 Ru 101.07		45 Rh 102.91		46 Pd 106.42		47 Ag 107.87		48 Cd 112.41		49 In 114.82		50 Sn 118.71		51 Sb 121.76		52 Te 127.60		53 I 126.90		54 Xe 131.29	
6		55 Cs 132.91		56 Ba 137.33		57-71 La-Lu Lanthanides		72 Hf 178.49		73 Ta 180.05		74 W 183.84		75 Re 186.21		76 Os 190.23		77 Ir 192.22		78 Pt 195.08		79 Au 196.97		80 Hg 200.59		81 Tl 204.38		82 Pb 207.2		83 Bi 208.98		84 Po (209)		85 At (210)		86 Rn (222)	
7		87 Fr (223)		88 Ra (226)		89-103 Ac-Lr Actinides		104 Rf (261)		105 Db (262)		106 Sg (266)		107 Bh (264)		108 Hs (277)		109 Mt (268)		110 Ds (281)		111 (272)		112 (285)		114 (289)		115 (290)		116 (292)		117 (293)		118 (294)			
		Lanthanides																																			
		57 La 138.91		58 Ce 140.12		59 Pr 140.91		60 Nd 144.24		61 Pm (145)		62 Sm 150.36		63 Eu 151.96		64 Gd 157.25		65 Tb 158.93		66 Dy 162.50		67 Ho 164.93		68 Er 167.26		69 Tm 168.93		70 Yb 173.04		71 Lu 174.97							
		Lanthane		Cérium		Praseodyme		Néodyme		Prométhium		Samarium		Europium		Gadolinium		Terbium		Dysprosium		Holmium		Erbium		Thulium		Ytterbium		Lutétium							
		Actinides																																			
		89 Ac (227)		90 Th 232.04		91 Pa 231.04		92 U 238.03		93 Np (237)		94 Pu (244)		95 Am (243)		96 Cm (247)		97 Bk (247)		98 Cf (251)		99 Es (252)		100 Fm (257)		101 Md (258)		102 No (259)		103 Lr (262)							
		Actinium		Thorium		Protactinium		Uranium		Neptunium		Plutonium		Americium		Curium		Berkélium		Californium		Einsteinium		Fermium		Mendelevium		Nobelium		Lawrencium							

La masse atomique relative est donnée avec cinq chiffres significatifs. Pour les éléments qui n'ont pas de nucléides stables, la valeur entre parenthèses indique le nombre de masse de l'isotope de l'élément ayant la durée de vie la plus grande.

Toutes les lettres pour les trois éléments Th, Pa et U qui ont une composition isotopique terrestre connue, une masse atomique est indiquée.





## XRF

Parameter	Soil	Cow dung
pH	5.86	-
Nitrate	4.66g/Kg	1.81%
Organic carbon	54.75g/Kg (H)	-
Phosphate	-	0.53%
Average phosphorus	6.52mg/Kg (L)	-
Exchangeable aluminium	0.5 C mol (+)/Kg	-
Calcium	8.86 C mol (+)/Kg	0.28%
Magnesium	0.69 C mol (+)/Kg	0.14%
Potassium	0.55 C mol (+)/Kg	1.04%
Sodium	0.18C mol (+)/Kg	0.22%
Manganese	17.9mg(+)/Kg	2160 mg(+)/Kg
Iron	224mg(+)/Kg	17.5 mg(+)/Kg
Copper	1.34mg(+)/Kg	15.05 mg(+)/Kg
Zinc	7.83mg(+)/Kg	1625 mg(+)/Kg
Silt	1560g/Kg	-
Clay	116g/Kg	-
Sand	728g/Kg	-

**Cassava leaf area (cm<sup>2</sup>)**

Chukwuka KS, Okechukwu RU, Umukoro BO, et al. Arbuscular mycorrhiza fungi, NPK (15-15-15) and cow dung interaction in sustainable cassava production and food security. *Adv Plants Agric Res.* 2017;7(4):328-335.

DOI: [10.15406/apar.2017.07.00262](https://doi.org/10.15406/apar.2017.07.00262)





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XRF

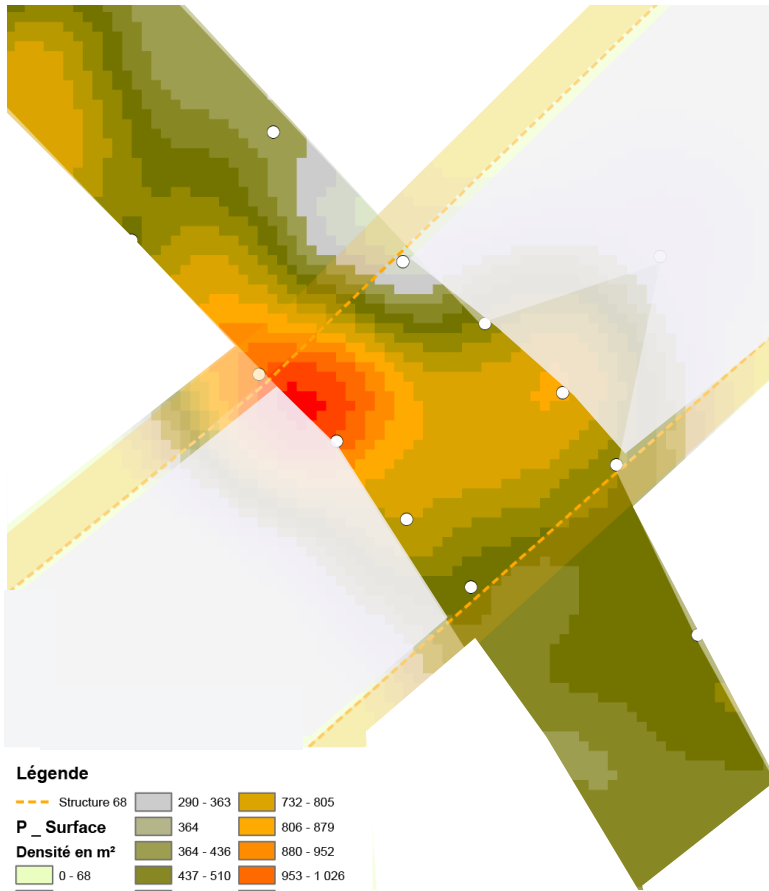
Enveitg



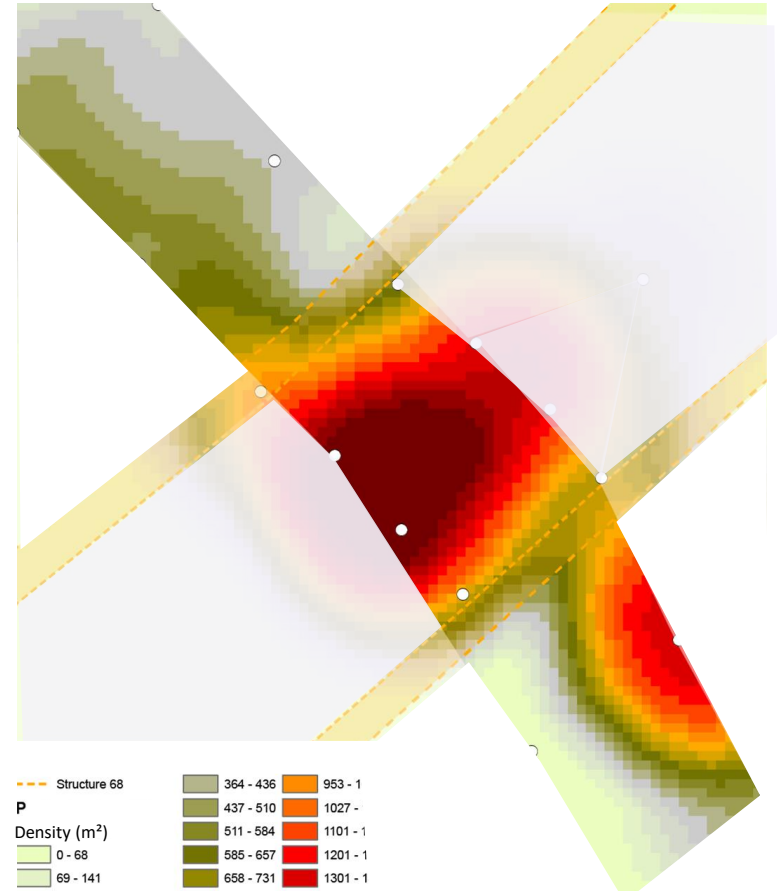
Medieval milking corridor

Surface

- 10 cm



0 1 2 Mètres



0 1 2 m



### Calastrenc. C (Dir)

Engineer - CNRS - TRACES (UMR 5608)/FRAMESPA (-UMR 5136)

Archaeologist, specialized in agro-pastoral areas and in the detection of archaeological remains using not invasive methods.

### Baleux. F

Engineer - CNRS - TRACES (UMR 5608)

Engineer in 3D, geomatics, remote sensing. He works on the characterization of the positioning error of spatial data.

### Rendu. C

Researcher - CNRS - FAMESPA (UMR 5136)

Archaeologist and ethnologist, specialist in the transformation of summering systems in the mountains of southern Europe and in the social and landscape dynamics of high and medium mountain areas.

### Laurent. A

PhD

Works on the integration of 3D in all phases of archaeological research, from the territory to the object, from prospection to scientific valorization and towards the general public.

### Philippe. M

Assistant engineer – CNRS - GEODE (UMR 5602)

She works on the study of environmental dynamics of sentinel environments through approaches in ecology and paleoecology as well as in soil geochemistry

### Poirier. N

Researcher - CNRS - TRACES (UMR 5608)

Medieval archaeologist specializing in the dynamics of settlements and territories. His research focuses on the settlement of medieval villages, approached through a micro-historical and diachronic approach.



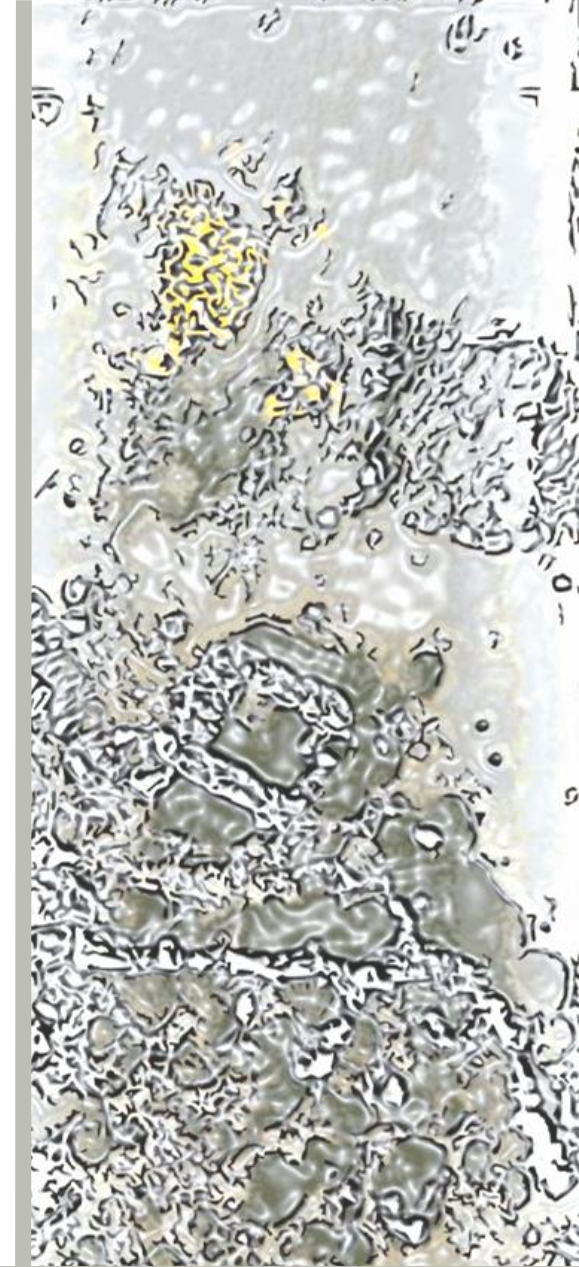


# Inspect high altitude areas

Development of a multi-source procedure for the archaeological prospection of high altitude areas

European Association of Archaeologists  
**Kiel 2021**

**Calastrenc Carine<sup>1, 2</sup>, Baleux François<sup>1</sup>, Poirier Nicolas<sup>1</sup>, Laurent Antoine<sup>1</sup>, Philippe Magali<sup>3</sup>, Rendu Christine<sup>2</sup>**



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