Inner structure of the Puy de Dôme : cross-comparison of geophysical models (ERT, Gravimetry, Muonic Imagery)

Angélie PORTAL
TOMUVOL collaboration

Laboratoire Magmas et Volcans, Laboratoire de Physique Corpusculaire, Clermont-Ferrand, France
Institut de Physique Nucléaire de Lyon

Plan

Introduction

1- Electrical Resistivity Tomography

- a – Method
- b – Puy de Dôme prospecting
- c - Resistivity models
- d – Projected complementary surveys

2 – High Resolution Gravity Survey

- a – Method
- b – Field survey description
- c – Data correction
- d – Bouguer anomaly map

3- Comparison of geophysical models

Conclusion

Introduction

Puy de Dôme :

-11,000 years old composite dome in the Chaine des Puys

- dome characteristics : ~400m high, 1.8 km wide at its base

- formation : two lava pulses and partial destruction of the first construction

Introduction

The Puy the Dôme has been selected as an experimental site because :

- Proximity with the labs in Clermont-Ferrand
- Good accessibility
- Possibility to use existing shelters during experiences

Introduction

Geophysical surveys

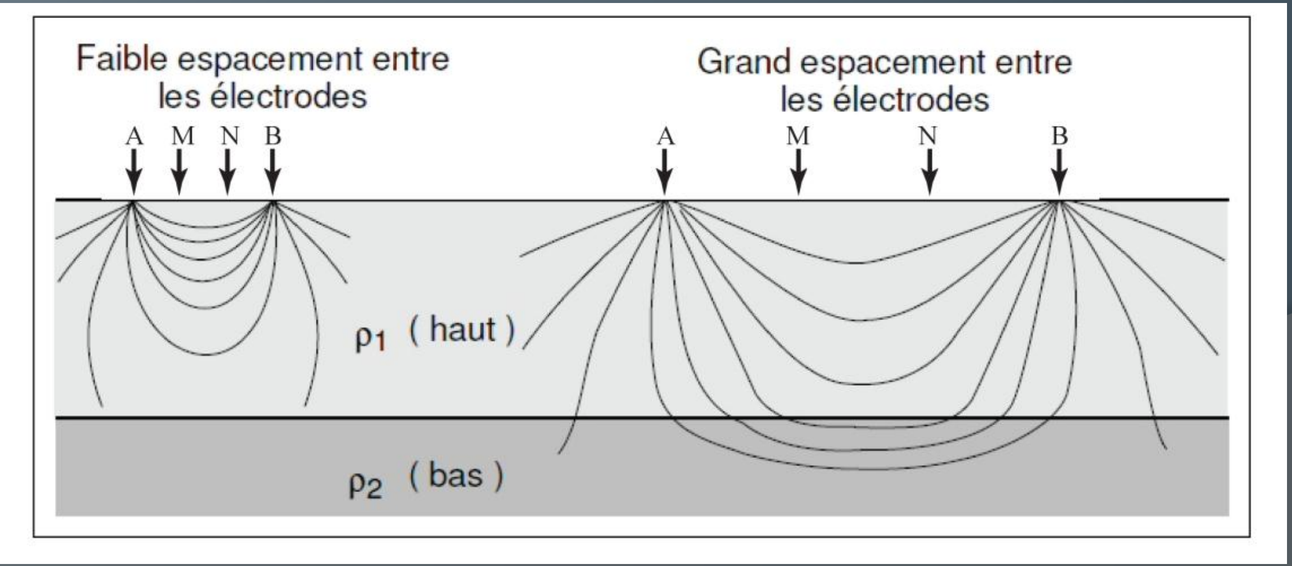
- ERT : Electrical Resistivity Tomography (June 2011)
- High Resolution Gravity Survey (March 2012)

Goal

- Define inner structures of Puy de Dôme volcano
- Compare models from this two methods
- Compare models from classical geophysical methods with muonic models

1- Electrical Resistivity Tomography
a - Method

- Electric current injection by two electrodes A and B
- Electric field -> Potential difference
- Potential difference measure by M and N electrodes
- Ohm law -> Apparent Electrical Resistivity



1- Electrical Resistivity Tomography

a - Method

Data acquisition

↓

Noise correction
(RES2DINV software)

↓

Data files concatenation

↓

Topography incorporation

↓

Selection of inversion parameters →

- inversion method
- number of iteration
- resistivity limits
- ….

↓

INVERSION PROCESS

↓

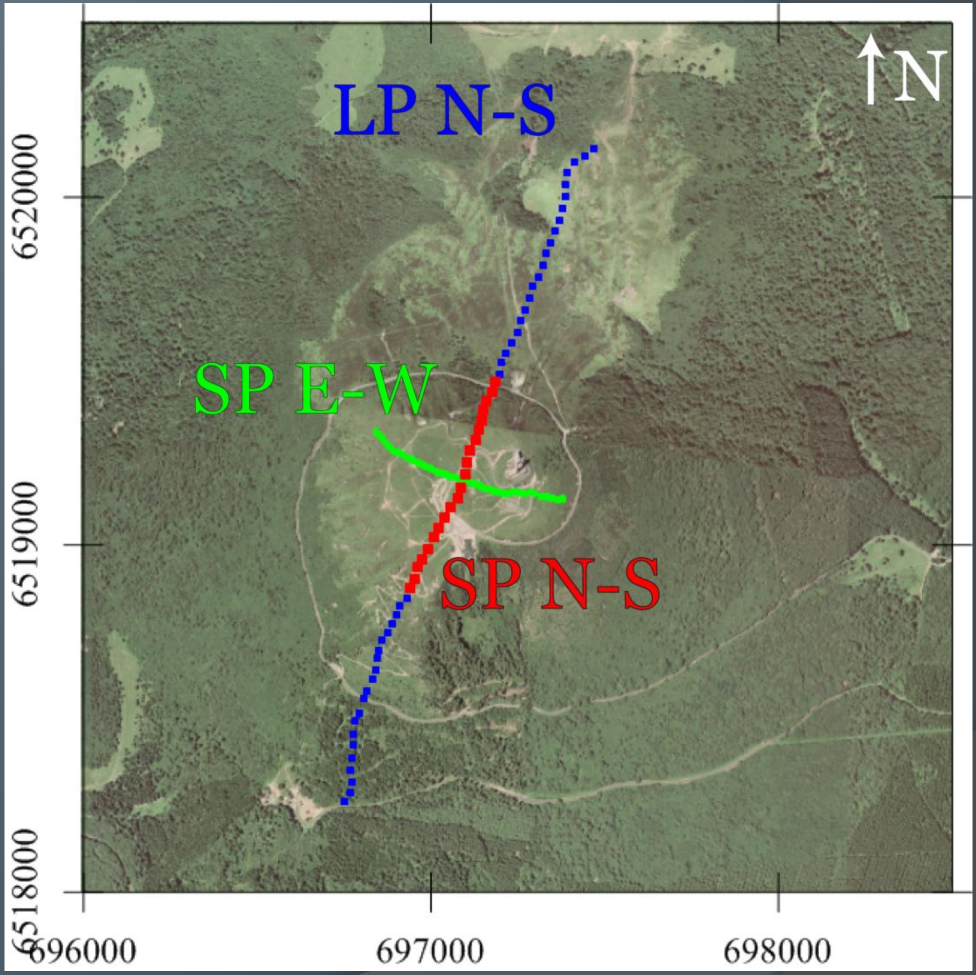
True Resistivity Model → Reliability : RMS error

1- Electrical Resistivity Tomography
b – Puy de Dôme prospecting

- 2011, June

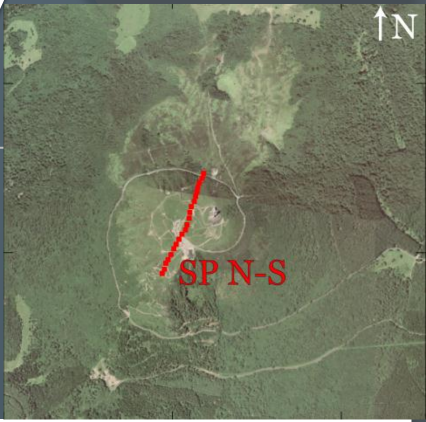
1 profile oriented N-S
~2km long
64 electrodes,
35m spacing between
↓
Constrain deep structures of Puy de Dôme

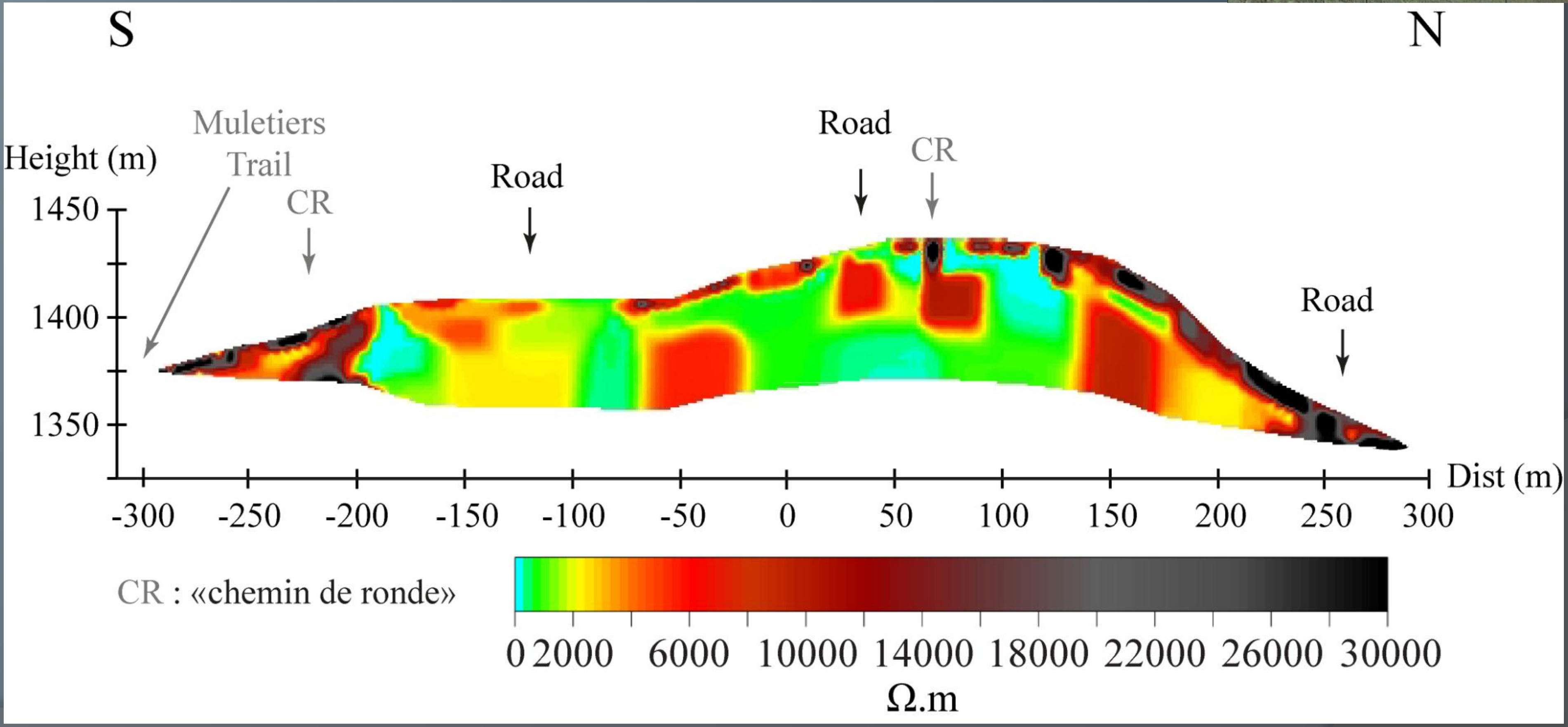
2 profiles oriented N-S and E-W
~300m long
64 electrodes
5m spacing between
↓
Improve our knowledge of subsurface geology in the summit area



1- Electrical Resistivity Tomography
c – Resistivity models

- S-N profile, electrode spacing is 5m





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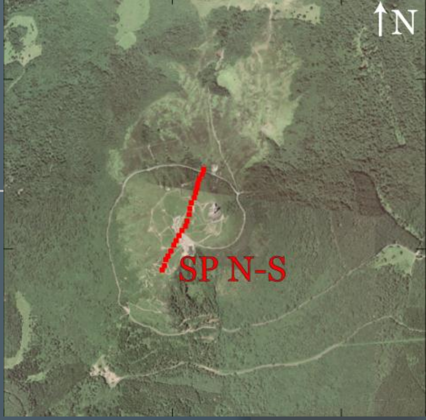

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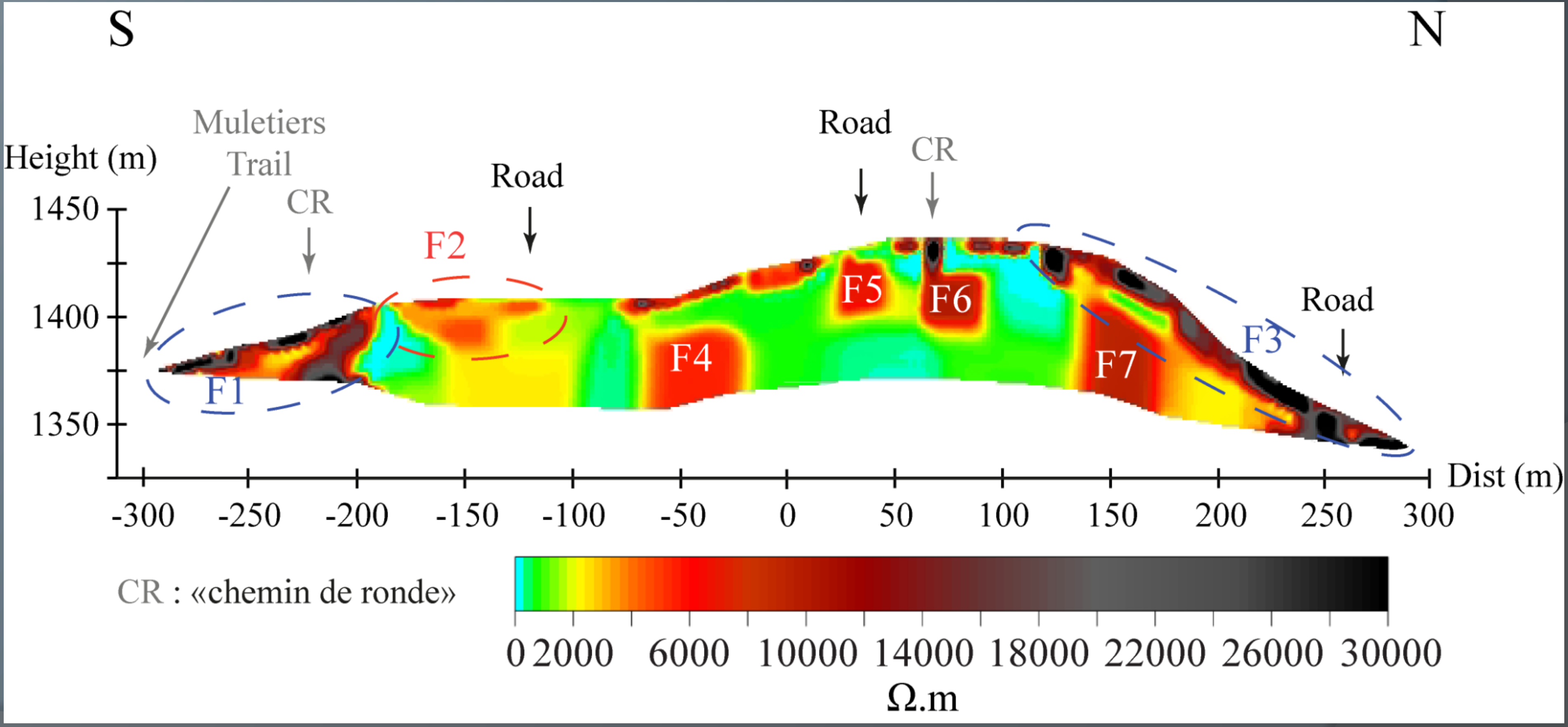
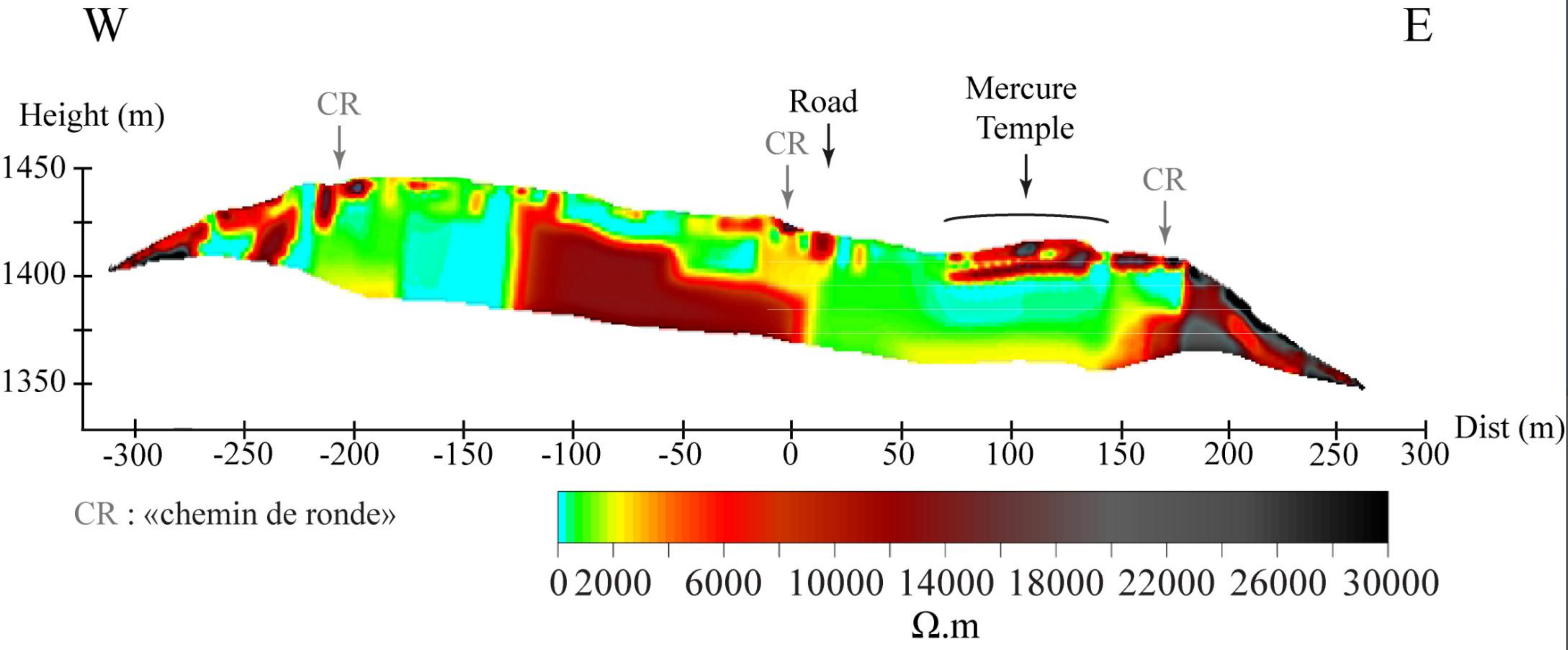


1- Electrical Resistivity Tomography
c – Resistivity models

- E-W profil, electrode spacing is 5m



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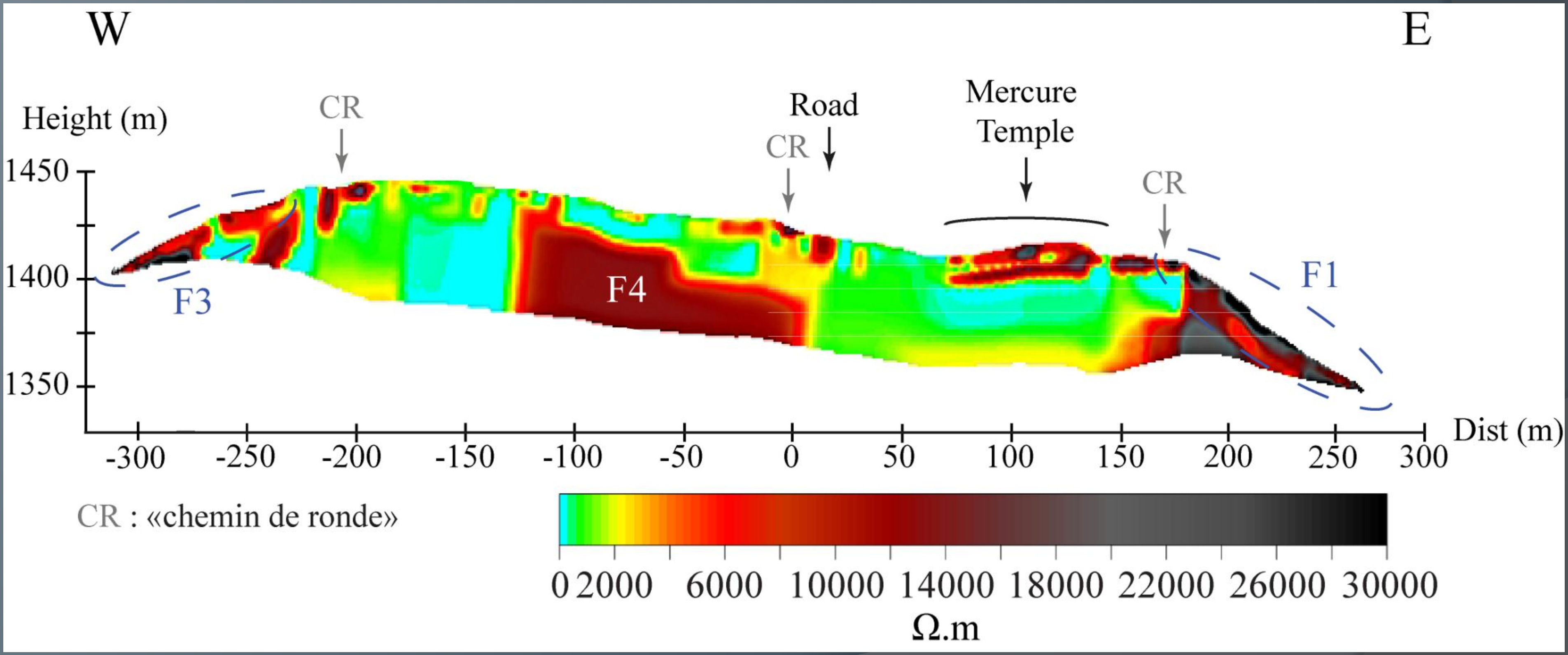
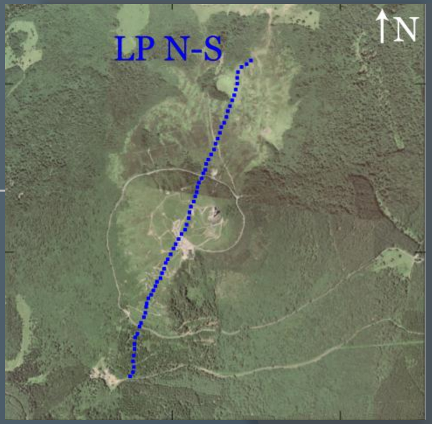
c – Resistivity models

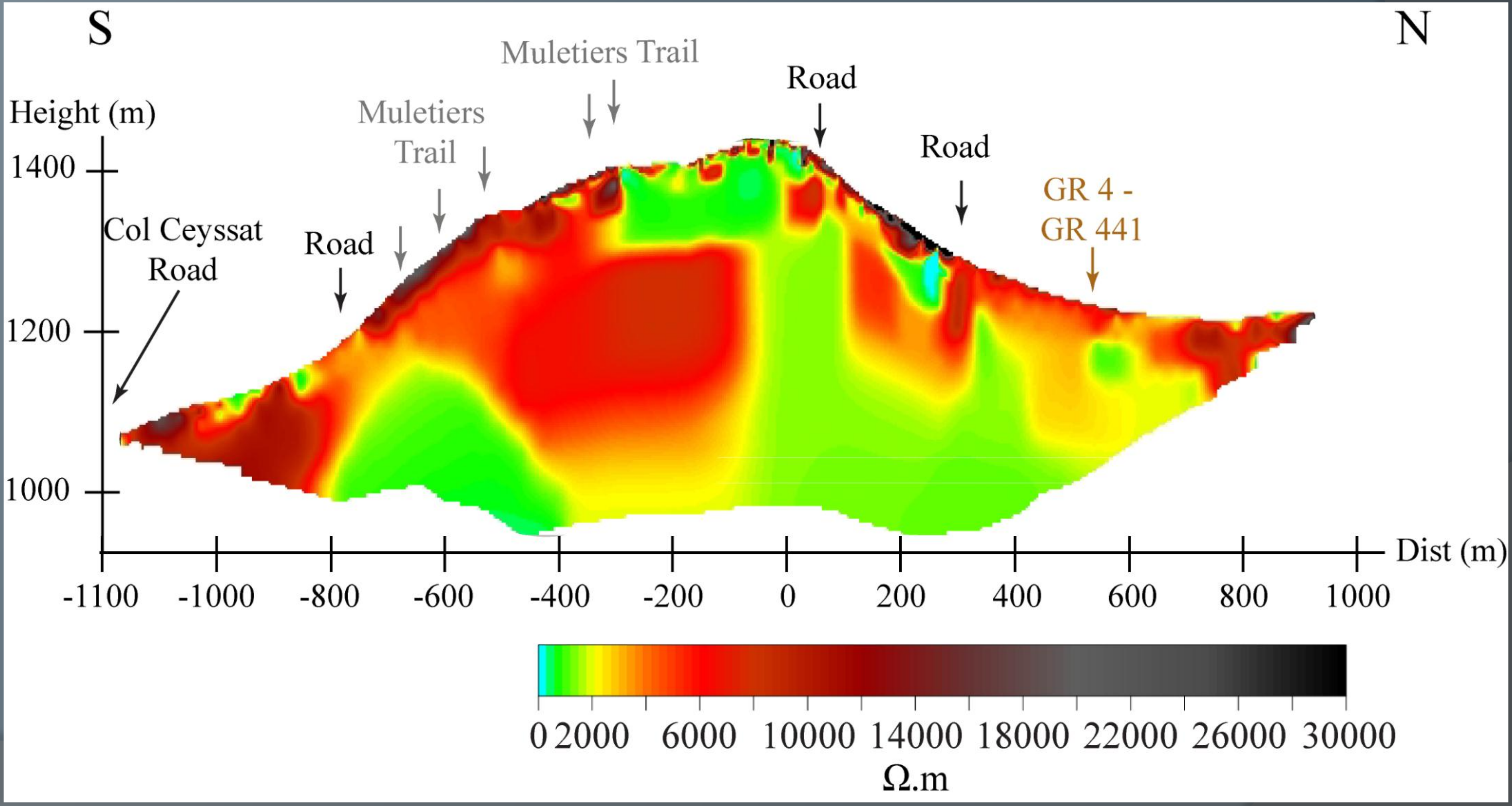
- E-W profil, electrode spacing is 5m



1- Electrical Resistivity Tomography
c – Resistivity models

- S-N profil, electrode spacing is 35m





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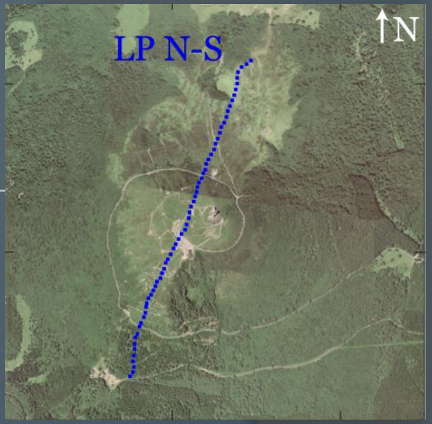
c – Resistivity models



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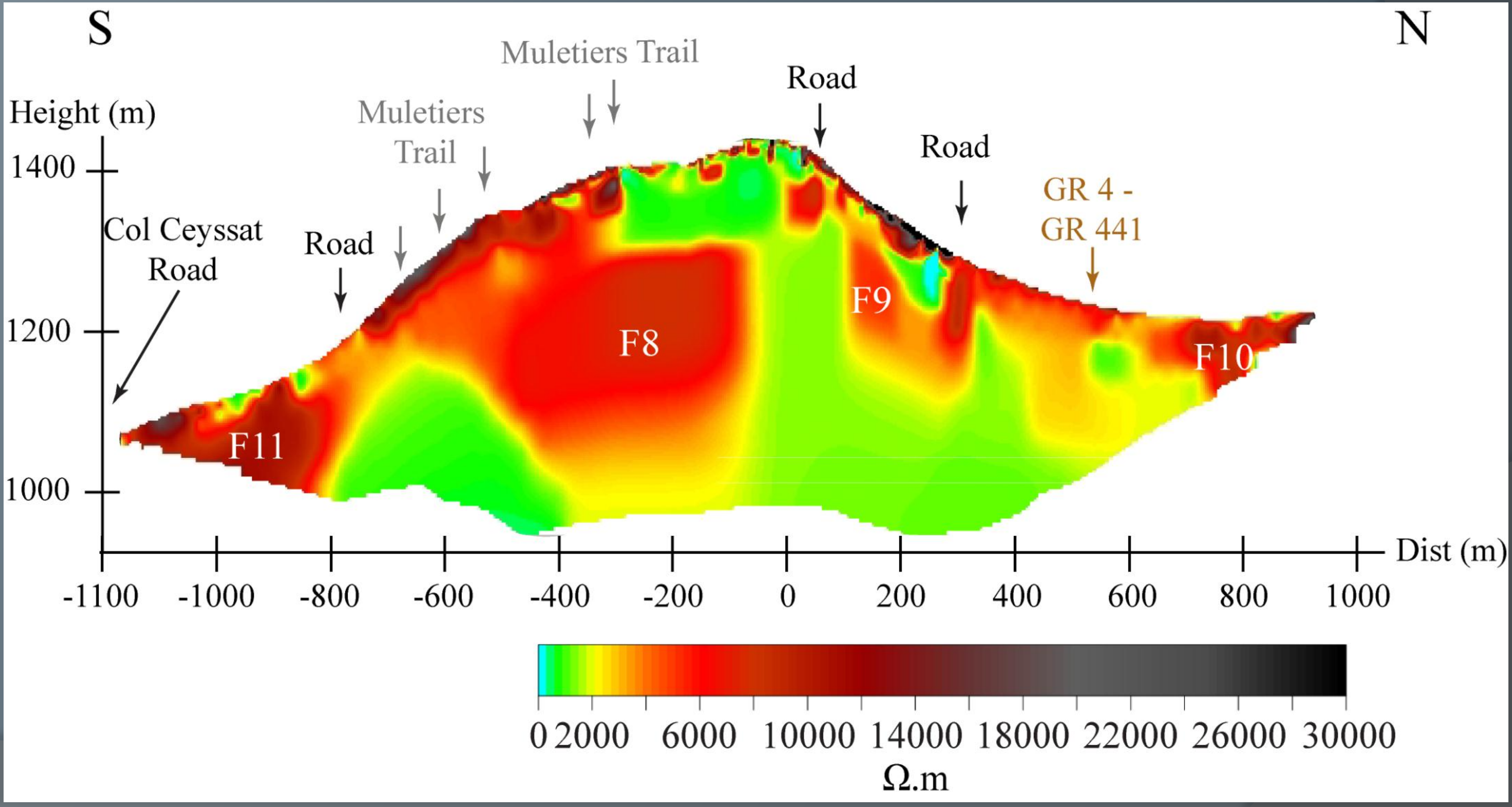
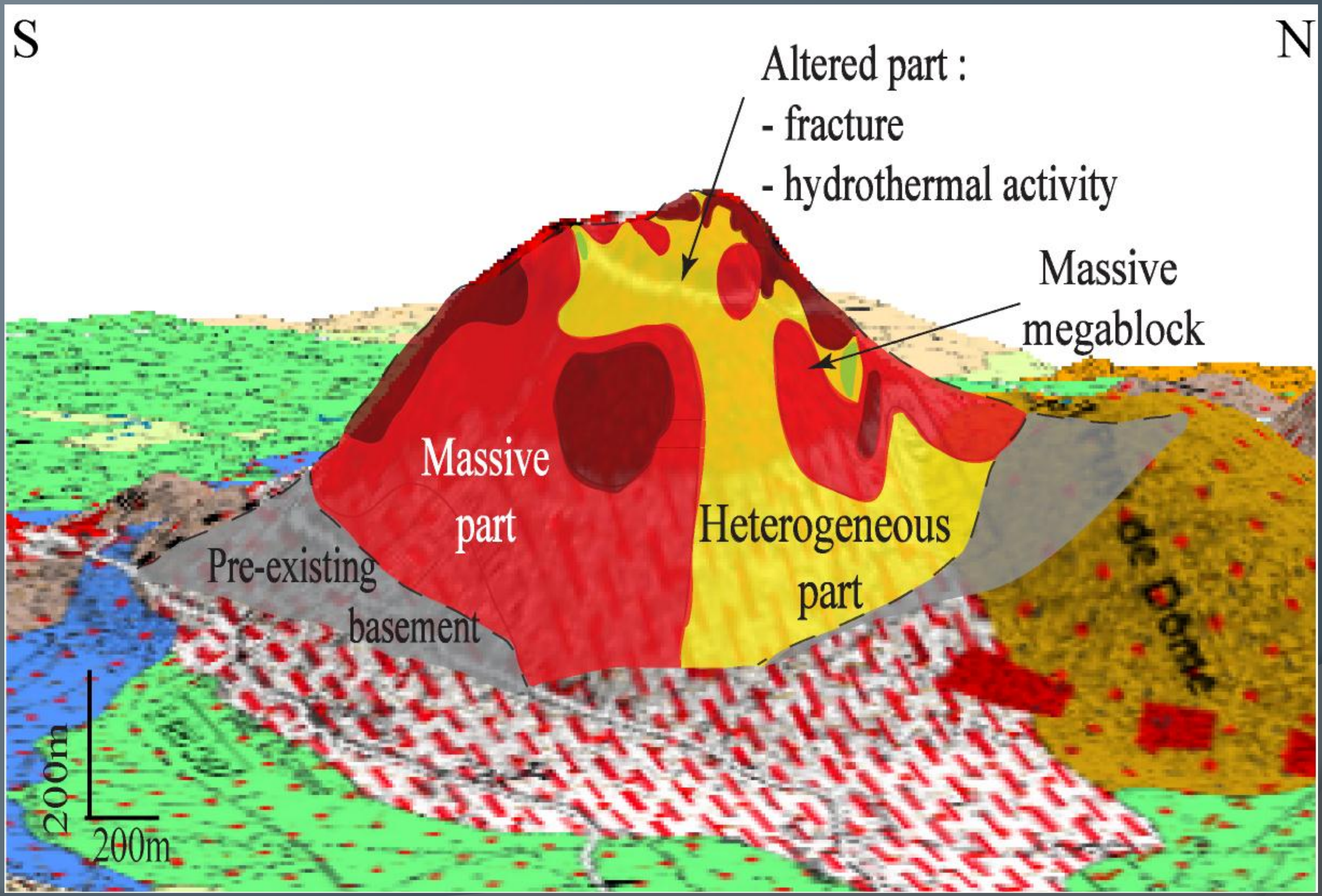


1- Electrical Resistivity Tomography
c – Resistivity models

Simple geological cross-section of the Puy de Dôme based on ERT observations



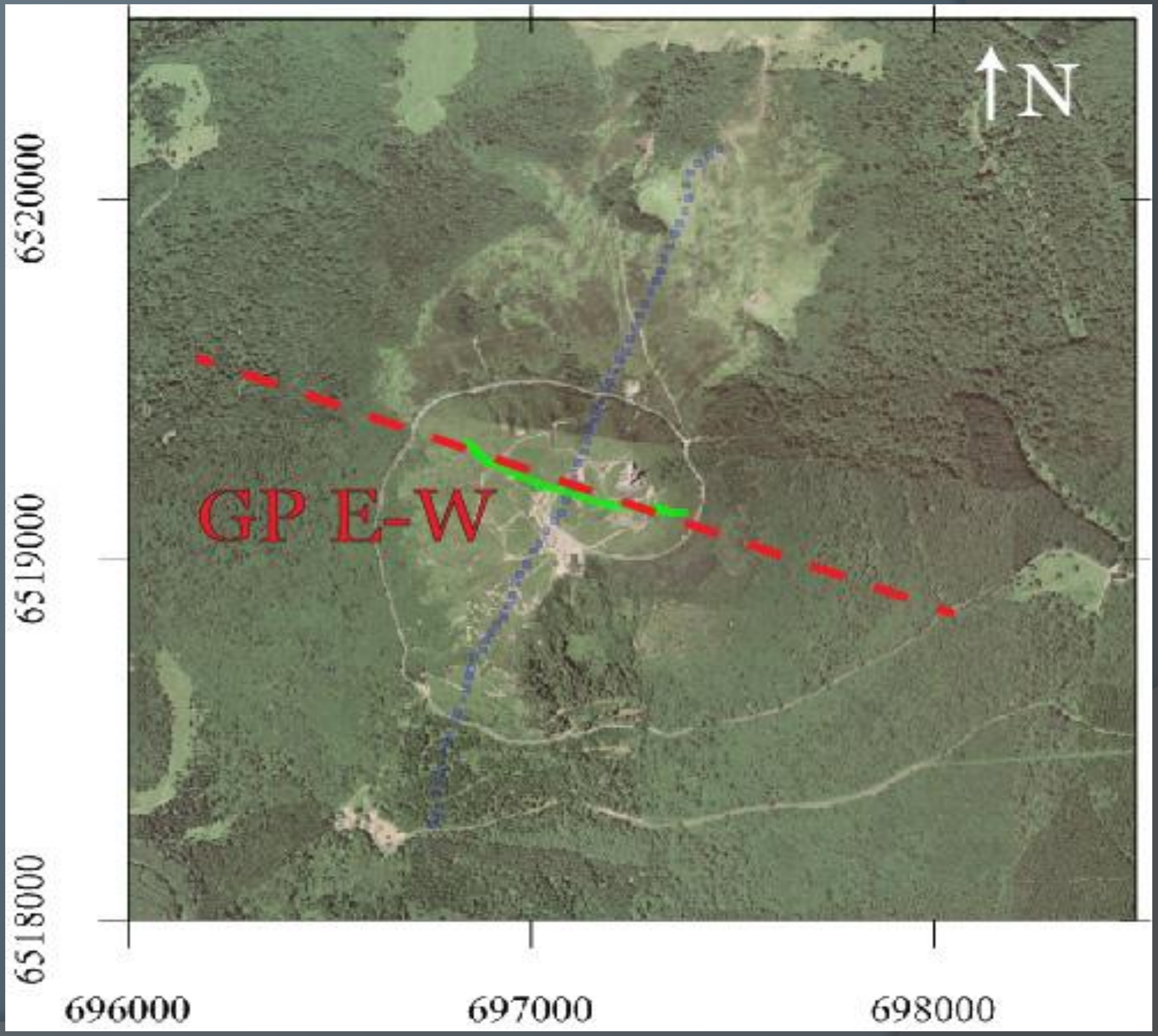
1- Electrical Resistivity Tomography
d – Projected complementary surveys

- 2012, May

E-W profile :

64 electrodes

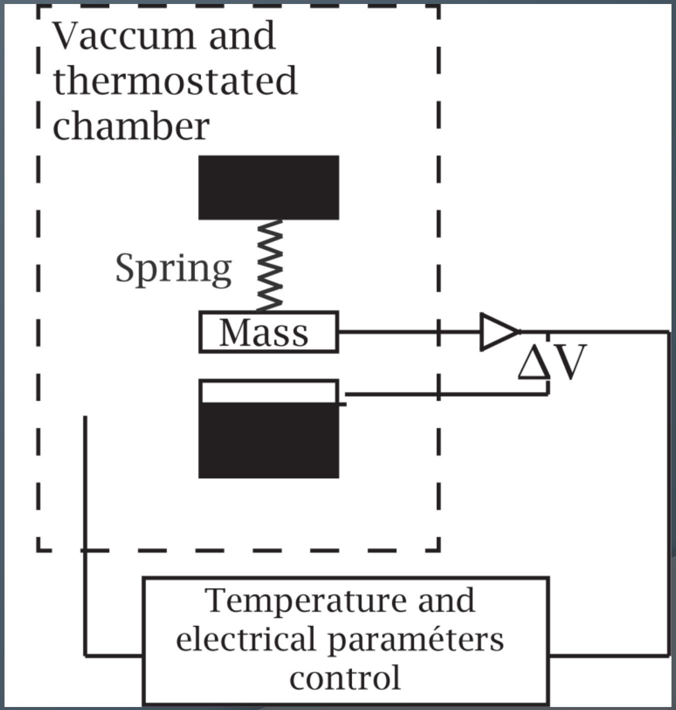
Electrode spacing = 35m



2- High Resolution Gravity Survey
a - Method

- Relative Gravimeter Scintrex CG-5

Spring displacement measure → **Gravity estimate**



Dimension : 1 mGal = 10^{-3} Gal = 10^{-3} cm.s^{-2}

2- High Resolution Gravity Survey
b – Survey description

- Gravity survey

Station spacing :

- around 250m in the distal zone (between 1 and 2 km far from the summit)

- between 250 and 100m in the proximal zone (1km around the summit)

Two bases measures everyday :

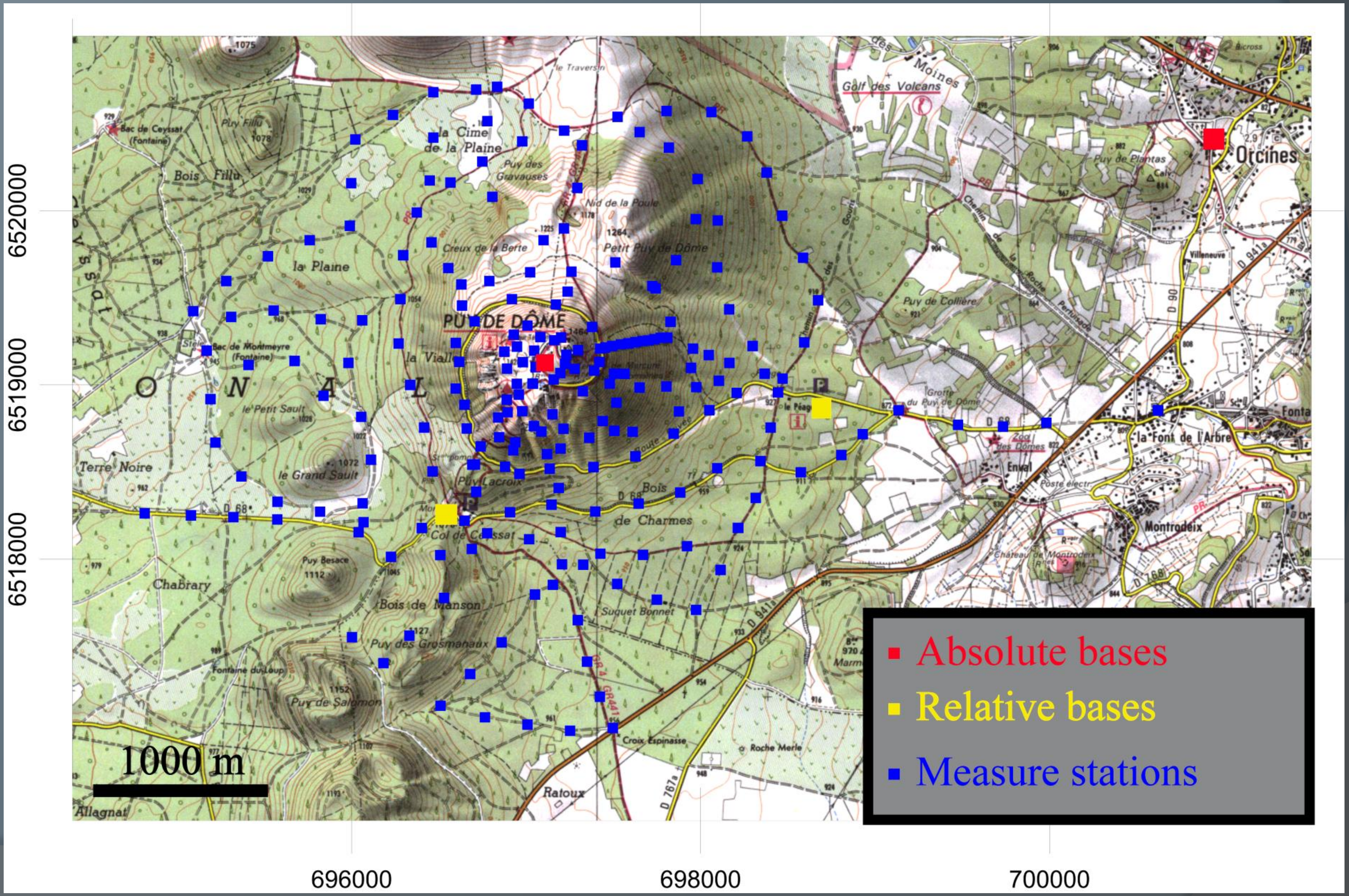
- an absolute gravity base
- a relative base

- GPS measurements

GPS in differential rapid static mode at the tripod center

2- High Resolution Gravity Survey
b – Survey description

- Stations positions



2- High Resolution Gravity Survey
c – Data correction

Data acquisition

↳ Tide correction (Moon and Sun attraction)

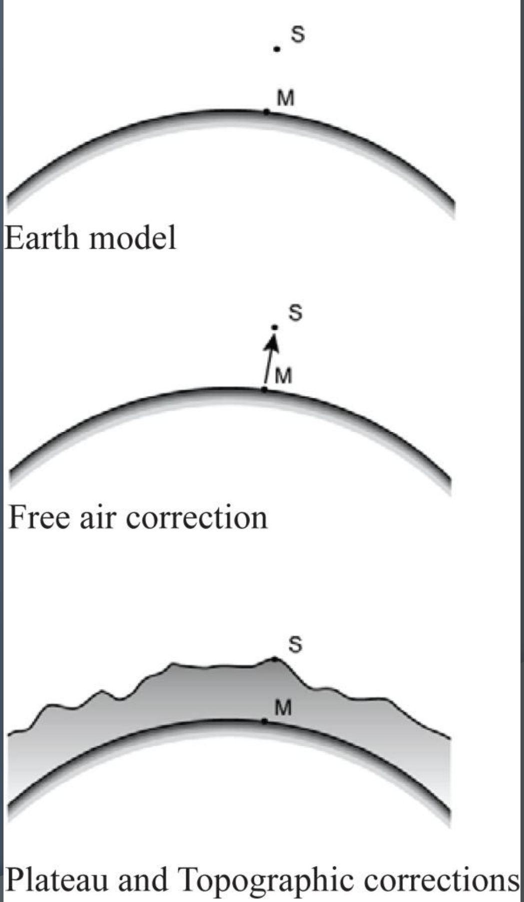
↳ Drift correction (spring fatigue)

↳ Latitude correction (reference ellpsoïde)

↳ Free Air correction (real station height)

↳ Plateau correction (density dependence)

↳ Topographic correction (density dependence)



Modified from *Gailler, 2012*

2- High Resolution Gravity Survey
c – Data correction

Corrected data

↓

BOUGUER ANOMALY MAP

↓

Density distribution in the ground (models)

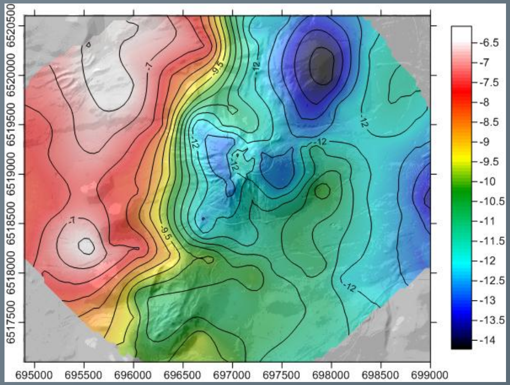
Accuracy on Bouguer anomaly values : around **0,09mGgal**

2- High Resolution Gravity Survey
d – Bouguer anomaly map

Models with different values of the density correction (ρ_{corr})

- With the regional component

2.0



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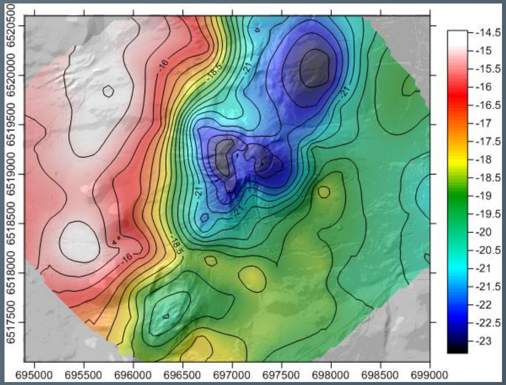

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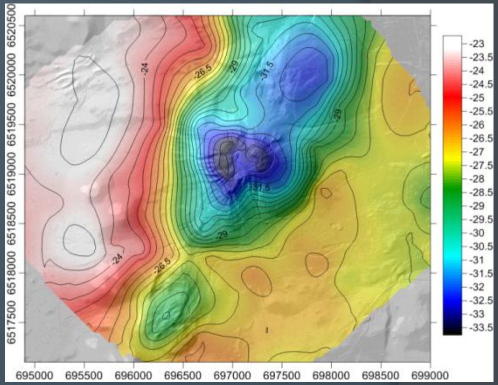
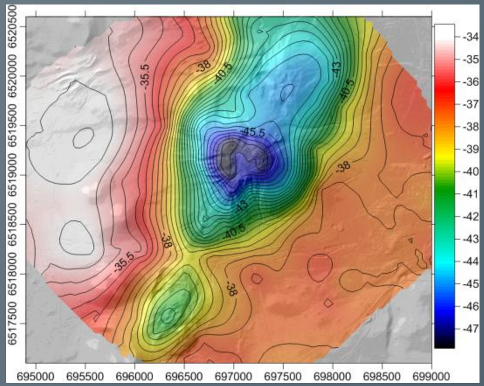


2.67



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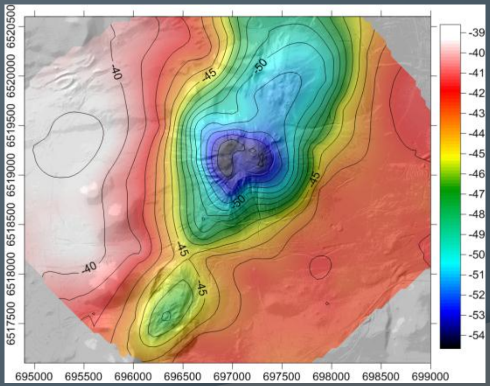
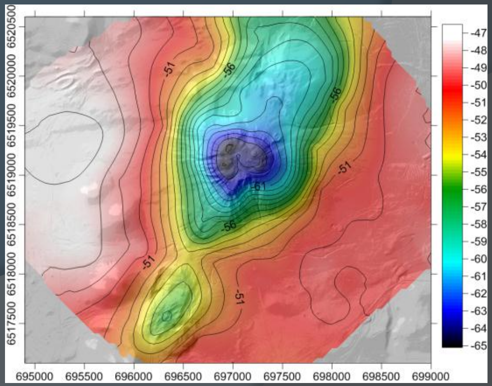


3.0

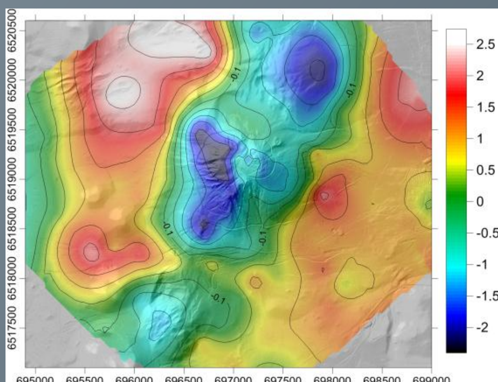


2- High Resolution Gravity Survey
d – Bouguer anomaly map

Models with different values of the density correction (ρ_{corr})

- Without the regional component

2.0



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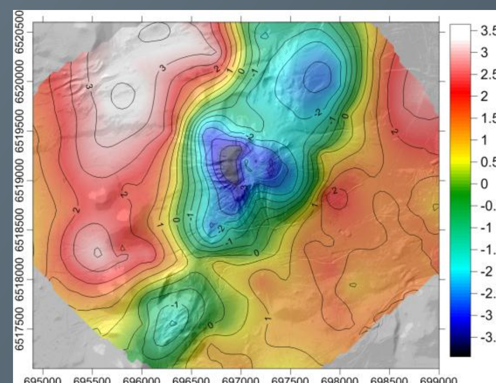

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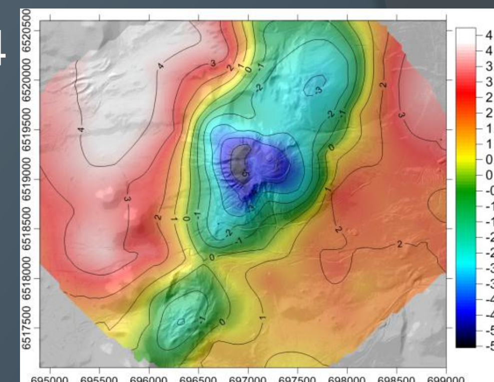

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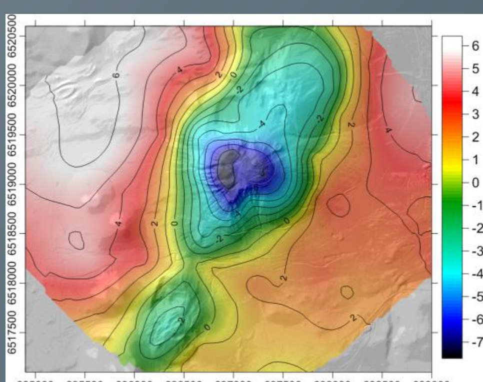

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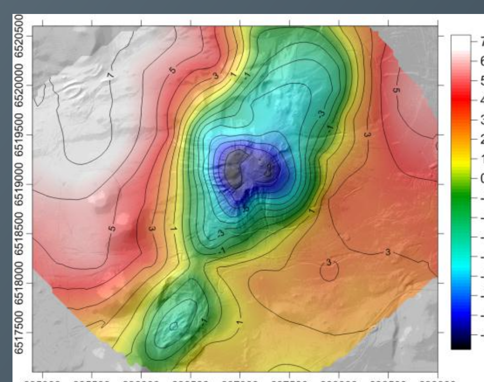

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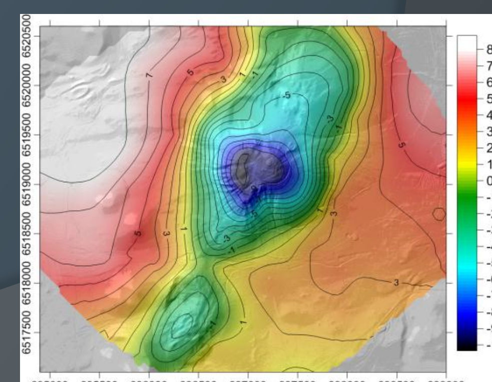
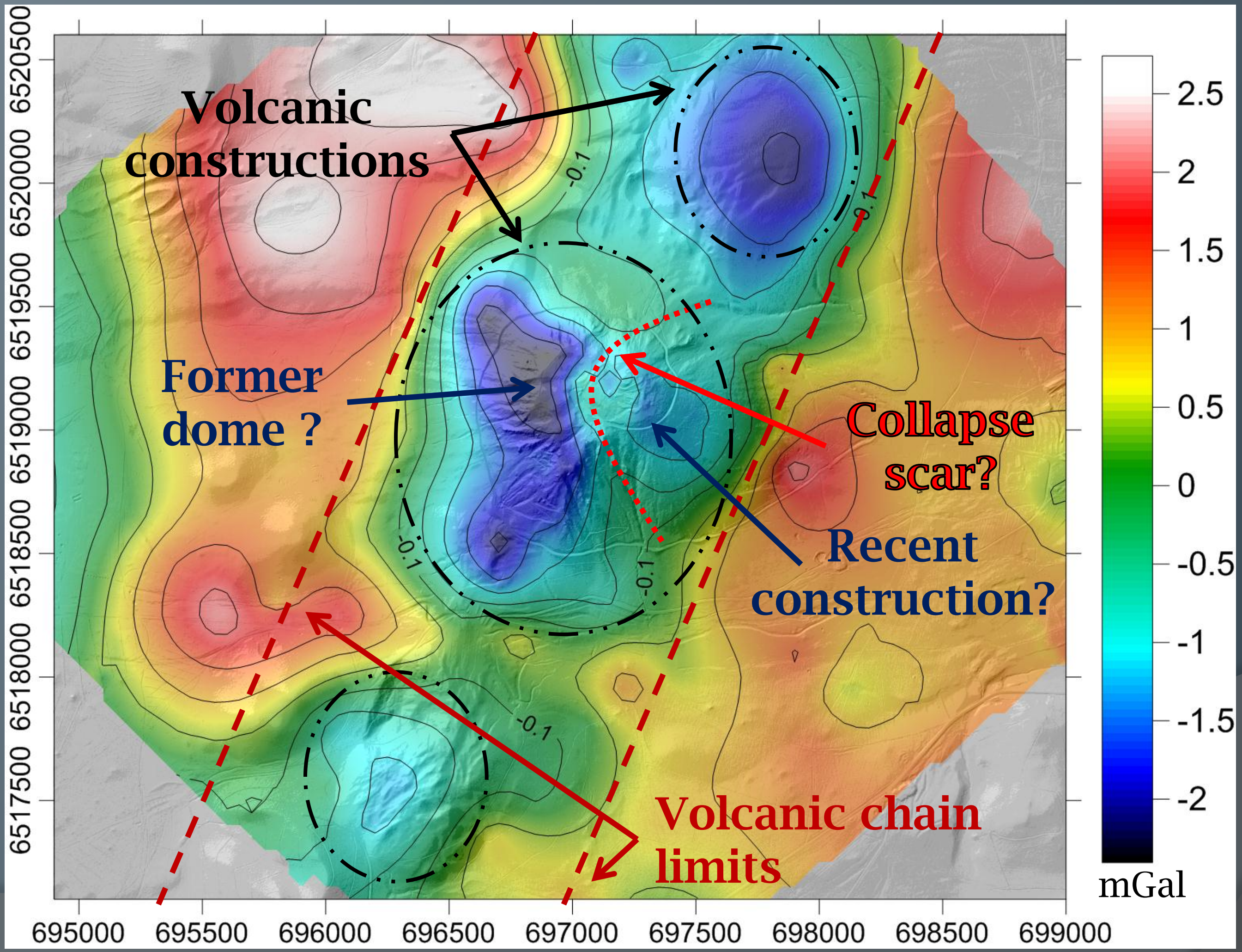


2- High Resolution Gravity Survey
d – Bouguer anomaly map

Bouguer anomaly map with different values of the density correction (ρ_{corr})

$\rho_{corr} = 2.0$



2- High Resolution Gravity Survey
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Bouguer anomaly map with different values of the density correction (ρ_{corr})

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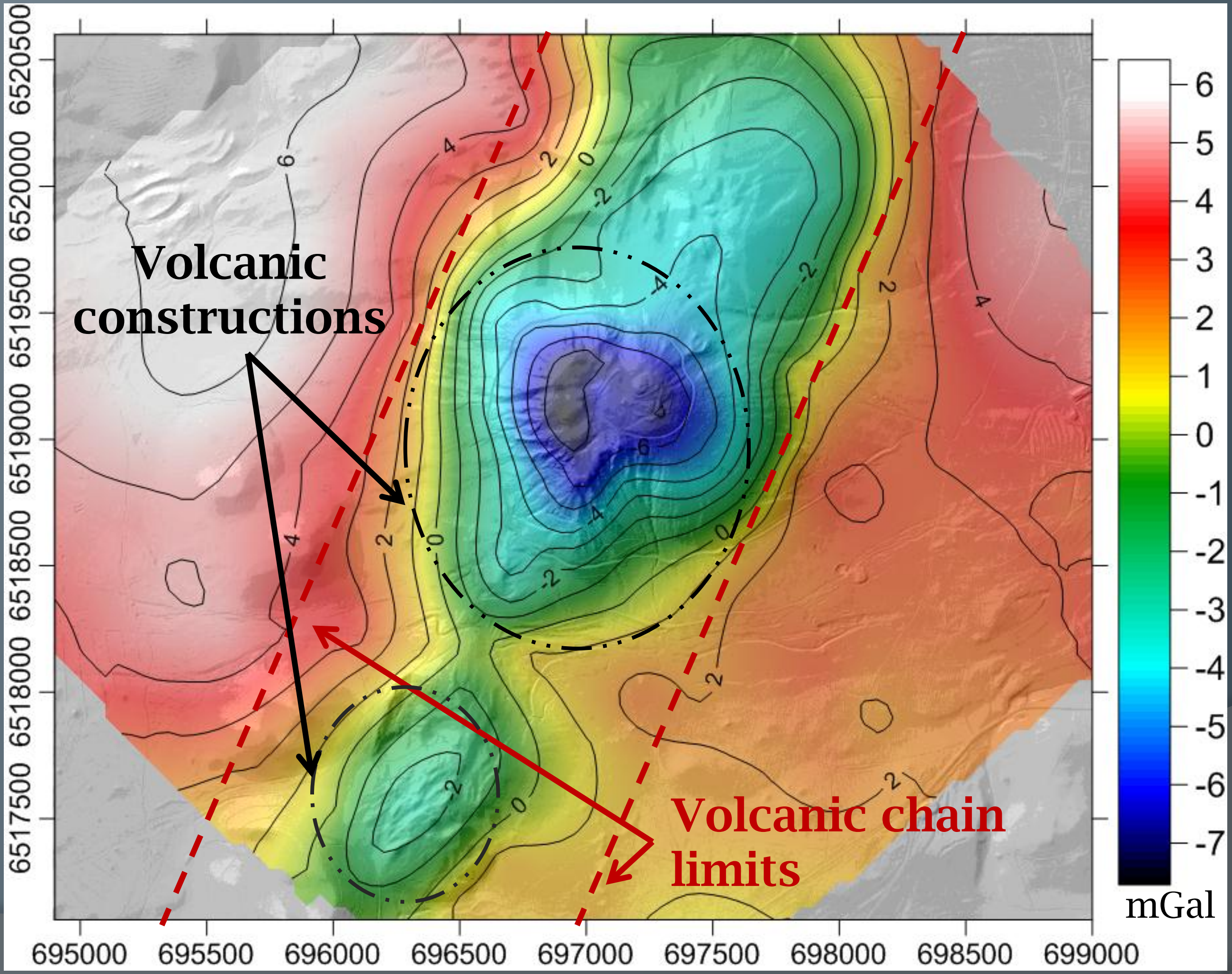

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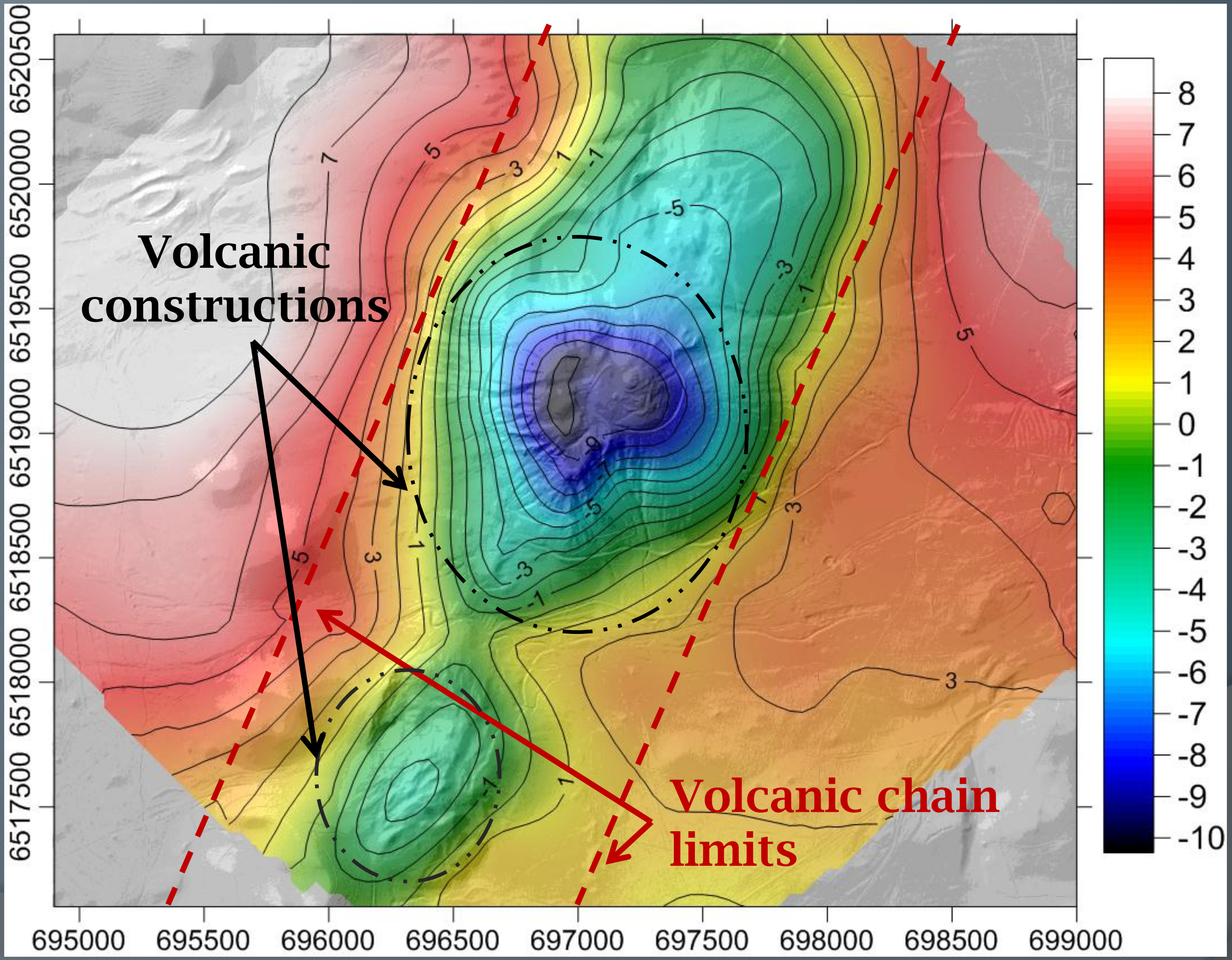


2- High Resolution Gravity Survey

d – Bouguer anomaly map

- Preliminary Bouguer anomaly map shows that the Puy de Dôme (and the other volcanic constructions) have a lower density than that of the granitic basement

  → **negative anomalies associated wih the volcanic constructions**

- A first qualitative analysis of the Bouguer anomaly over the Puy de Dôme shows that the anomaly does not mimic the construction.

  → the dome has not an homogeneous density.

  → in agreement with the electrical resistivity data which clearly show the heterogeneous nature of the interior of the dome.

2- High Resolution Gravity Survey

d – Bouguer anomaly map

! The results presented here should be considered as preliminary (gravity data have just been acquired during the last weeks)

↓

A detailed interpretation of the data will be carried out to refine the gravity models

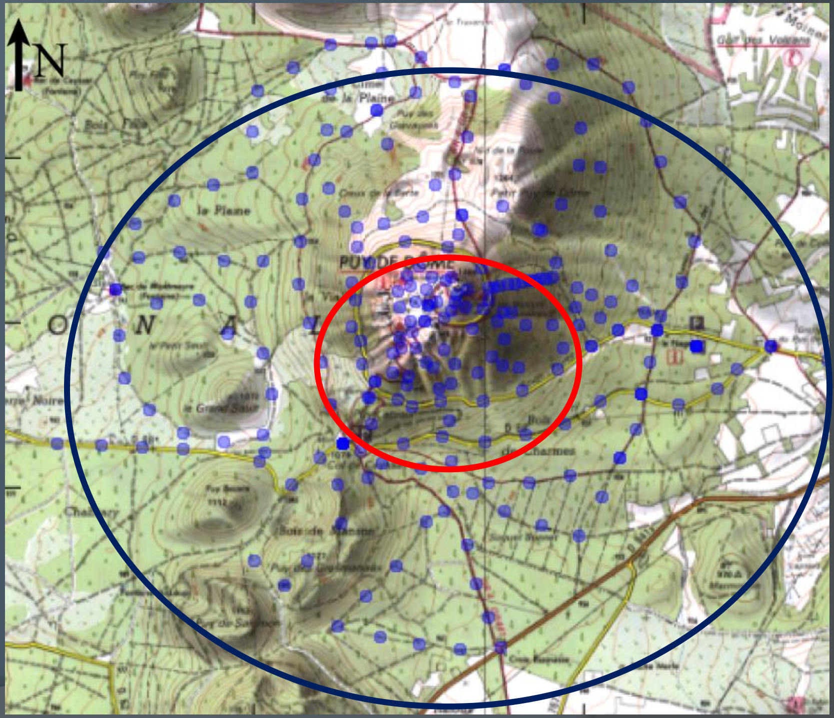
2- High Resolution Gravity Survey
d – Bouguer anomaly map

- Next prospecting

- Central area will be covered with a higher density of data

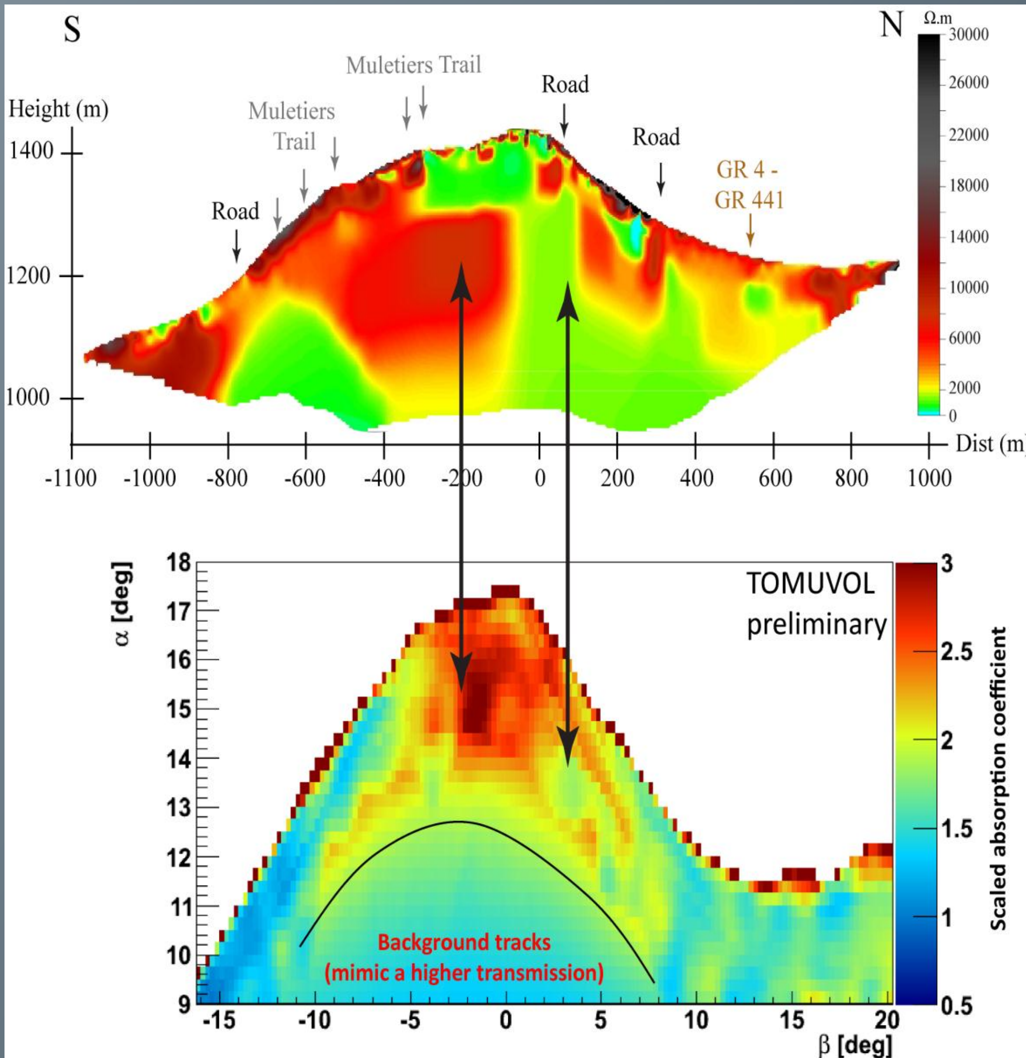
  → Radial and circular profiles

- Complementary data on lower slopes of the dome and surrounding areas to better define the volcanic constructions and the regional component of the signal



3- Comparison of geophysical models

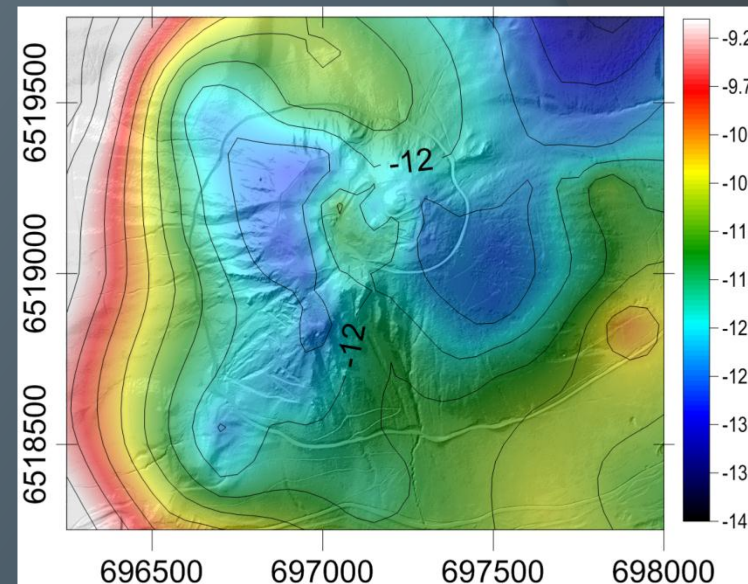
Resistivity model



V. Niess, MNR 2012

Model from muonic imagery (*TOMUVOL*)

Bouguer anomaly map



- Resistive and dense superficial structures
- Massive part near the sommital area
- Heterogeneity of Puy de Dôme

Conclusion

- Puy de Dôme is an **heterogeneous** dome
- Its density is low : $\mathbf{d_{moy} \sim 1.8\text{-}2.0 * 10^3\ kg.m^{-3}}$

Objectives

- Multidimensionnal inversion of geophysical datas :
  - Use data from different geophysical methods
  - Insert this data in a single inversion process
- Cross-comparison of models obtain by classical methods and models from muonic imagery


Thank you for your attention