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GEOPHYSICAL MEASUREMENTS IN AN ABANDONED OLD RAILWAY TUNNEL (MARSICO NUOVO, Italy)

GREGORY DE MARTINO, LUIGI CAPOZZOLI, VALERIA GIAMPAOLO, AND ENZO RIZZO

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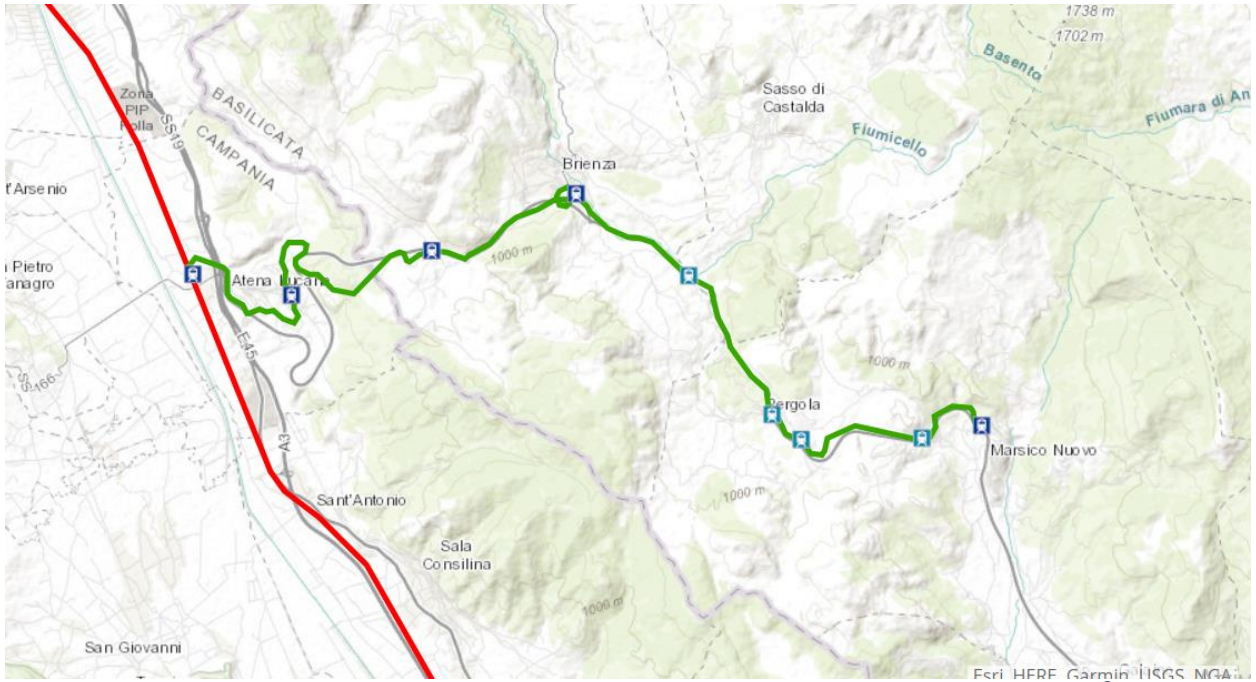
GEOPHYSICAL MEASUREMENTS IN AN ABANDONED OLD RAILWAY TUNNEL (Marsico Nuovo, Italy)

The Atena Lucana-Marsico Nuovo railway was a railway of only 26 km that connected the Italian regions of the Basilicata and Campania. The line was abandoned after just 35 years from its inauguration for the little use which soon made it unsustainable economically. Actually, only some parts of the entire line are existent, but as they are abandoned, are not reusable and dangerous.



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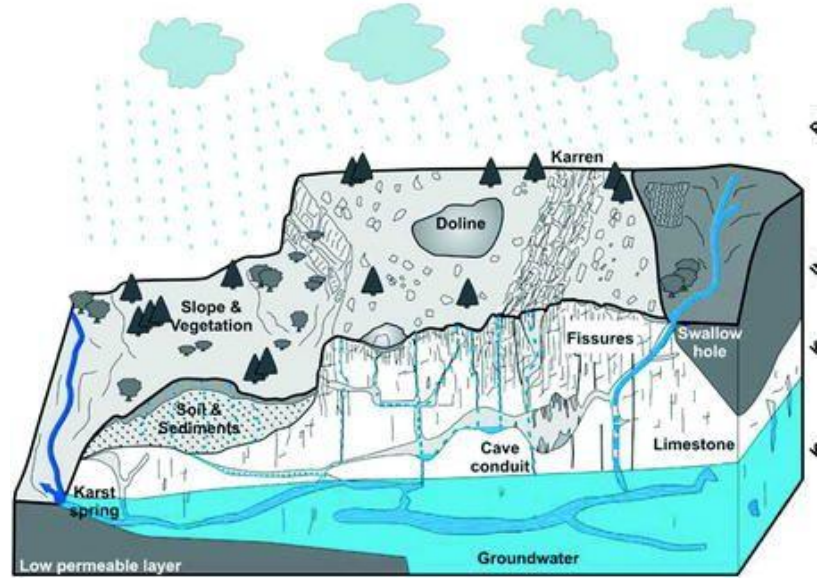
GEOPHYSICAL MEASUREMENTS IN AN ABANDONED OLD RAILWAY TUNNEL (Marsico Nuovo, Italy)

THE TUNNEL: A HYDROGEOPHYSICAL LABORATORY IN A KARST AREA

Karst aquifers are commonly characterized by high heterogeneity and anisotropy. In mature karst areas, rapid infiltration and high flow velocities are commonplace. Contaminants can easily infiltrate into karst aquifers through sinkholes and other epikarst features and spread rapidly over large distances in the conduit network. Characterization and monitoring, improved by the hydrogeophysical techniques, can lead to better management of the natural resources and the understanding of the natural systems dynamic



Near the cave of Castel di Lepre (Pergola, Marsico Nuovo, Italy), a tunnel of a 1km crosses a karst area, where extensive geophysical activities have been performed or are still in progress. The tunnel is little known, and it is possible that intercepts the cave. Further, thanks to its favourable position, the tunnel can play a crucial role in the comprehension of the karst area and its hydrogeological processes and phenomena.

THE TUNNEL AS A NEW HYDROGEOPHYSICAL LABORATORY IN THE KARST AREA OF MARSICO NUOVO

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KARST AREAS INVESTIGATION –ABANDONED TRAIN TUNNEL

Tunnel Entrances

Roadhouse

Concrections (Tunnel wall)

Tunnel's path

Tunnel

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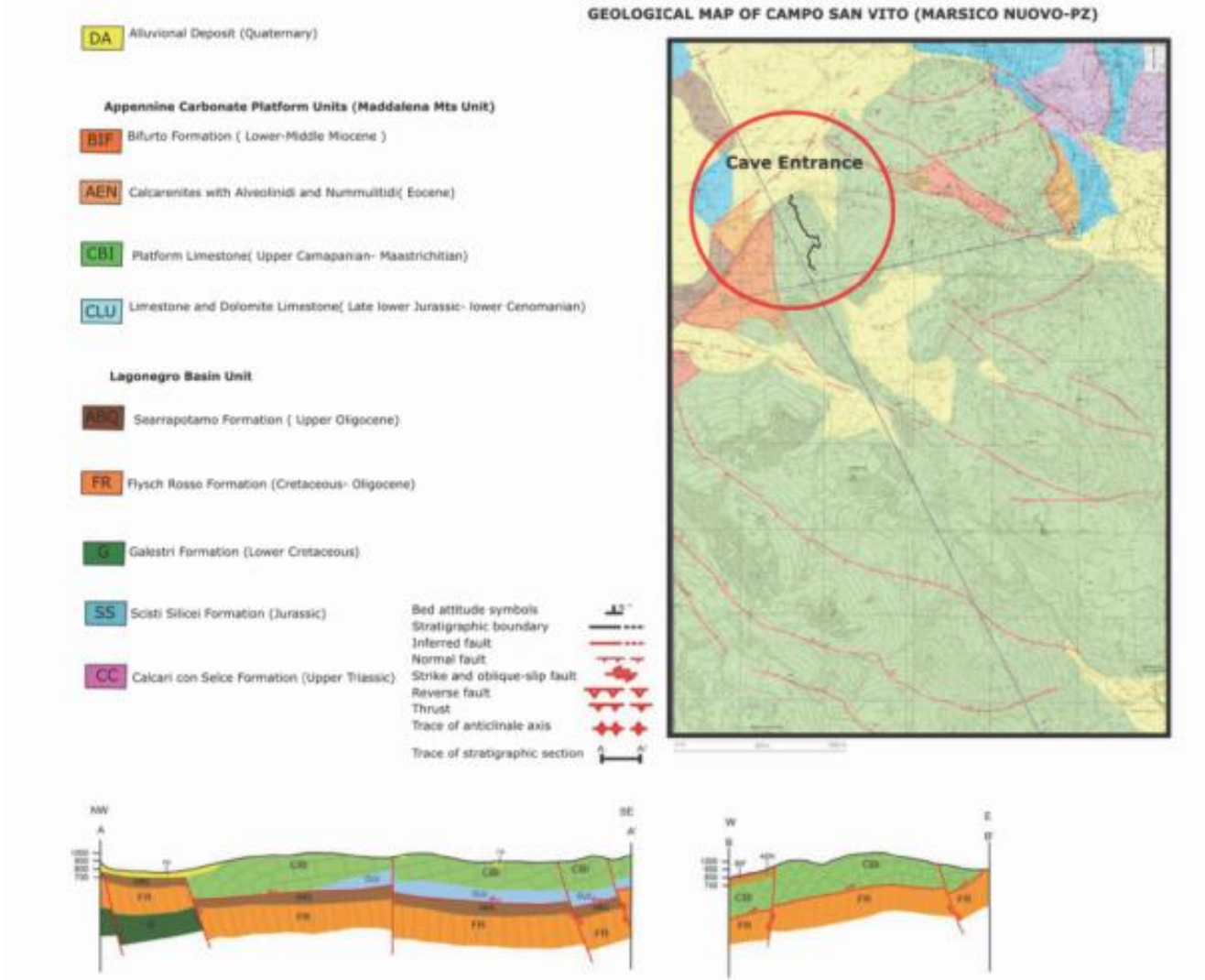
HYDROGEOLOGICAL SETTINGS

Castel di Lepre karst area, located in Marsico Nuovo (Basilicata, Italy) is a karst system developed in the Maddalena Mts, a carbonate morphostructure of the Southern Apennines. Southern Apennines are a thrust-and-fold belt formed between the upper Oligocene and Quaternary (Patacca & Scandone, 2007) as a response to convergence between the African plate and the European and contemporary retreat towards the SE of the ionic subduction (Gueguen et alii, 1998).

In the study area, the Apennine Platform is represented by the Maddalena Mts Unity (D'Argenio et alii, 1973) which constitutes the eastern (external) portion of the Apennine Platform. This unit is formed by a powerful limestone dolomite succession of approximately 1000 m, aged between the upper Triassic and Eocene (Palladino et alii, 2008).

Castel di Lepre karst area falls between two hydrogeological basins: the Agri River basin and the Sele River basin. From the hydrogeological map of High Agri Valley it is possible to notice that the prevailing direction of the groundwater is from Sele River basin towards Agri River basin.



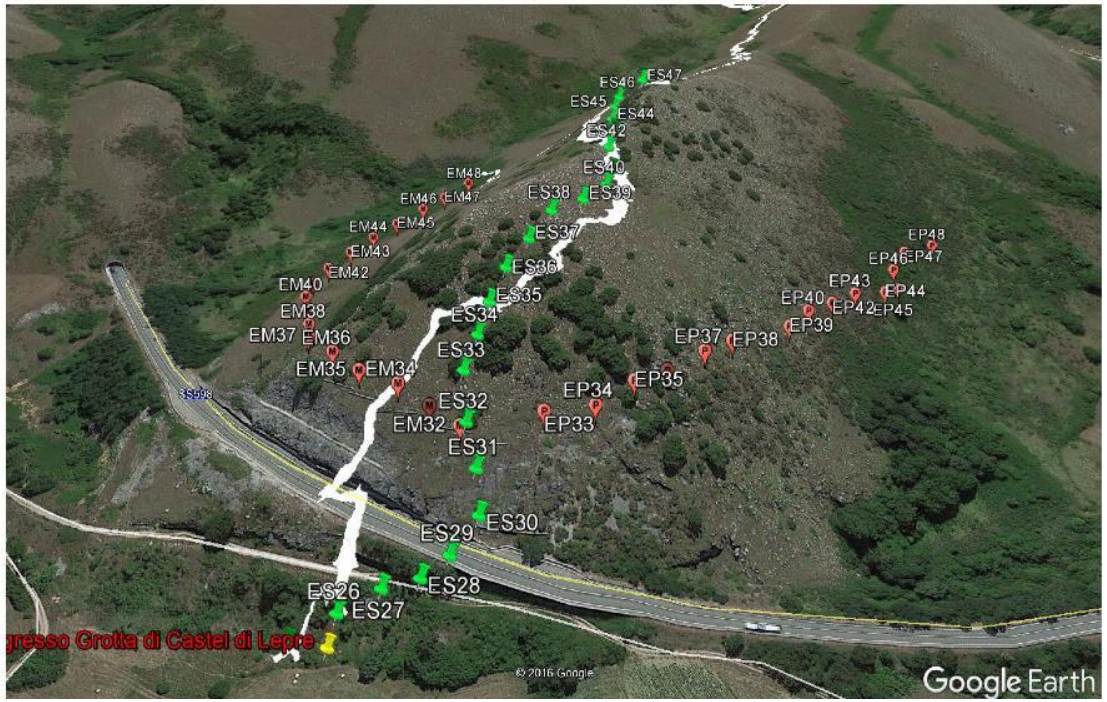
Guerriero et al. 2019, DOI: 10.4408/IJEGE.2019-01.S-10

GEOPHYSICAL MEASUREMENTS IN AN ABANDONED OLD RAILWAY TUNNEL (Marsico Nuovo, Italy)

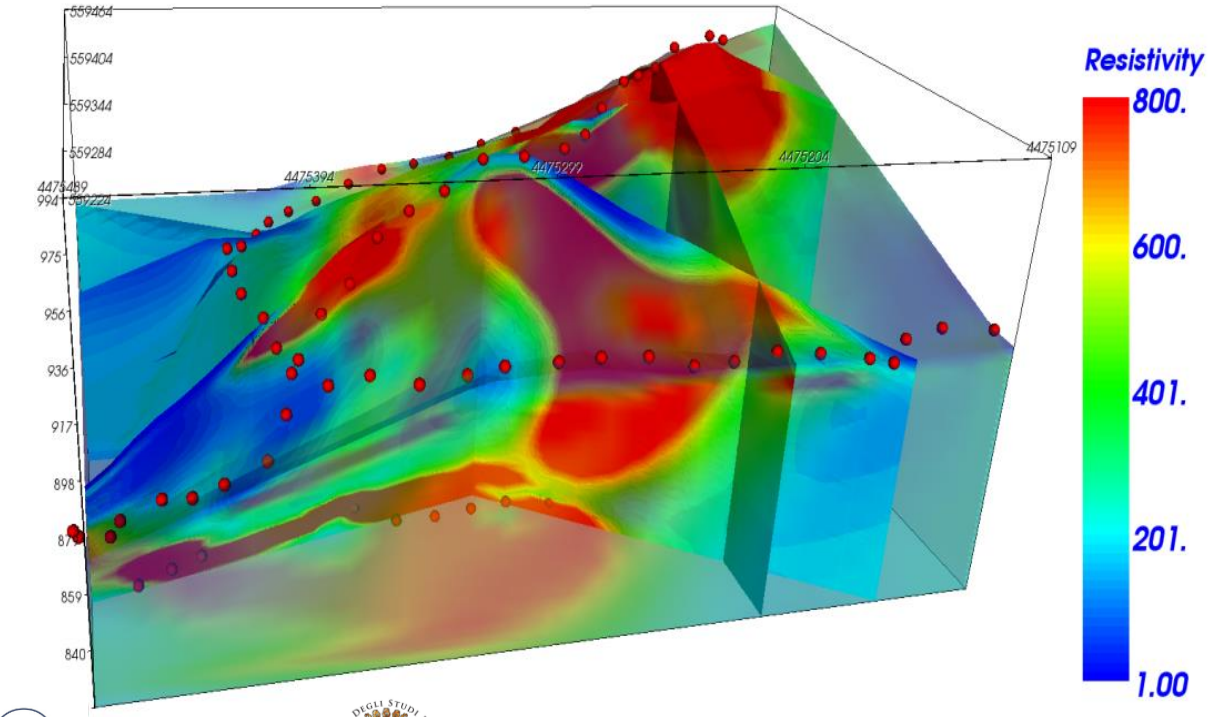
Castel di Lepre Karst system: first geophysical investigation

Castel di Lepre area has a remarkable scientific interest from the researchers. In fact, Guerriero et al (2017) have experienced a new geoelectrical method in the Castel di Leper karst area: a cross-hole ERT acquisition system was applied between the cave's vault and the surface. They results provided a 3D resistivity volume of the karst area. Rizzo et al. (2018) have also characterized the external area of the cave with the use of electromagnetometer measurements coupled to the ground penetrating radar and ERTs identify the presence of a geological fracture near the cave.

Electrode grid for the 3D acquisition



3D resistivity model



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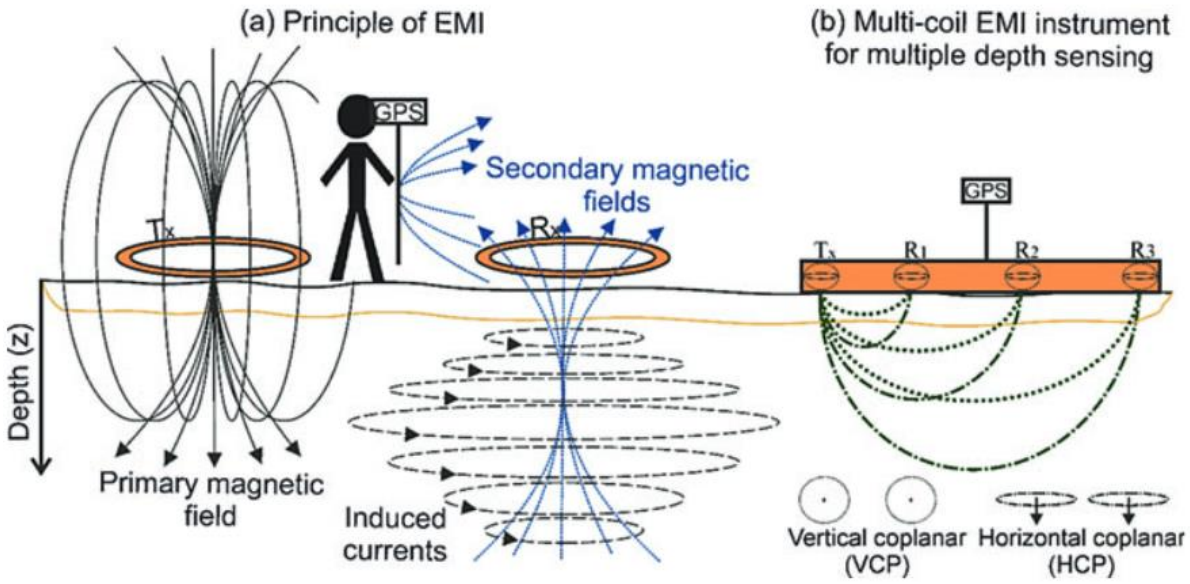
ELECTROMAGNETIC TECHNIQUE

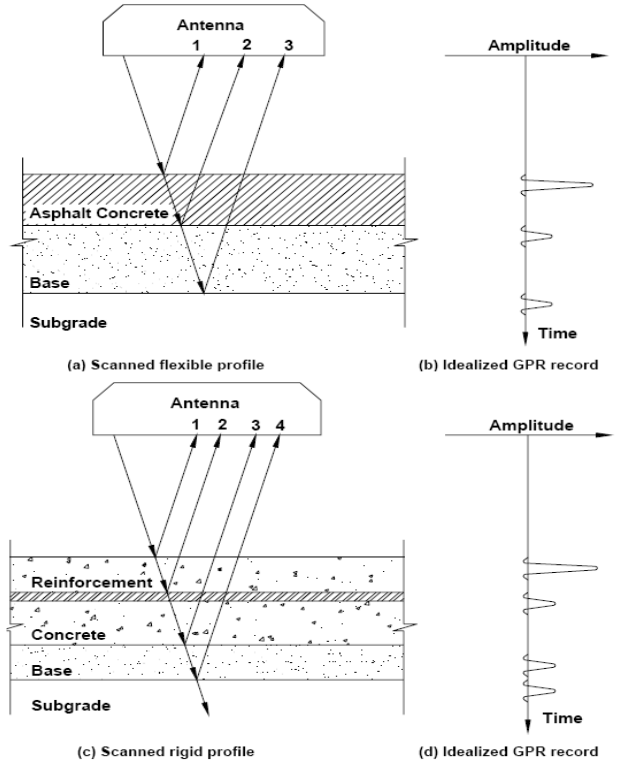
EMI sensors transmit 'primary' electromagnetic (EM) field and receive the 'secondary' EM field through inducing the alternating currents in the soil. Resulting values permit to reconstruct map of electrical conductivity.



Jonard et al., 2019, DOI: 10.1007/978-3-662-48297-1_14

GROUND PENETRATING RADAR

GPR sends into the ground EM pulses that are reflected in the subsoil when EM impedance variations occur. The results can support the research of voids or underground utilities thanks to the different electric permittivity of the materials.



H. Jol, 2013

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GEOPHYSICAL INVESTIGATION ON THE TOP OF THE RAILWAY TUNNEL

GROUND PENETRATING RADAR

- 8 radargrams acquired in direction EW every two meter with 200 MHz antenna
- 16 radargrams acquired in direction EW every meter with 400 MHz antenna

ELECTROMAGNETIC ACQUISITION

Area investigated with size of 60mx70m; 1500 points are measured in GPS mode

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GEOPHYSICAL MEASUREMENTS IN AN ABANDONED OLD RAILWAY TUNNEL (Marsico Nuovo, Italy)

GROUND PENETRATING RADAR

Frequency= 200-400 MHz

Reflection Mode

Profiler EMP-400 GSSI's

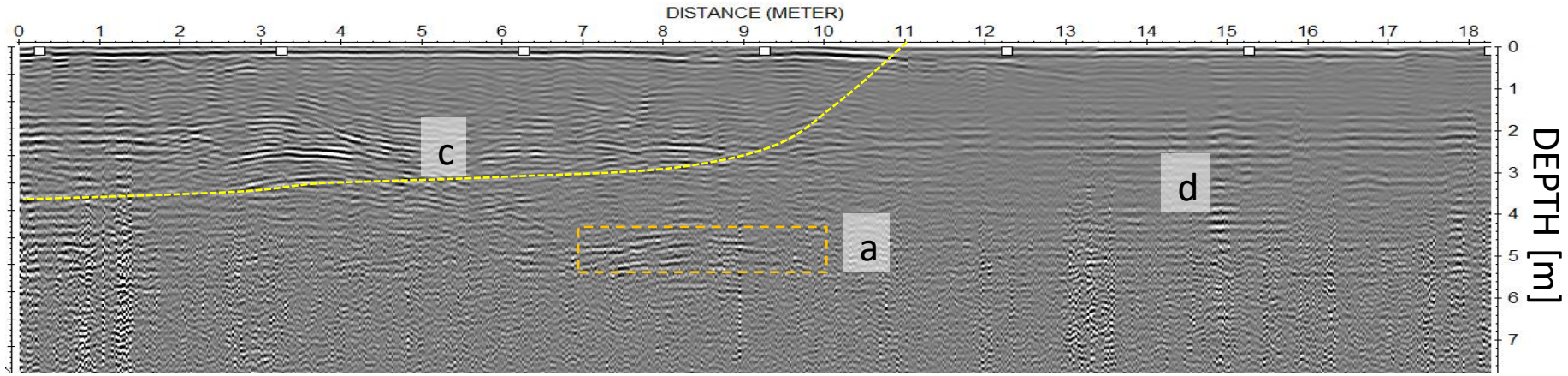
Frequency= 5000-10000-15000 Hz

Vertical Dipole Mode inline

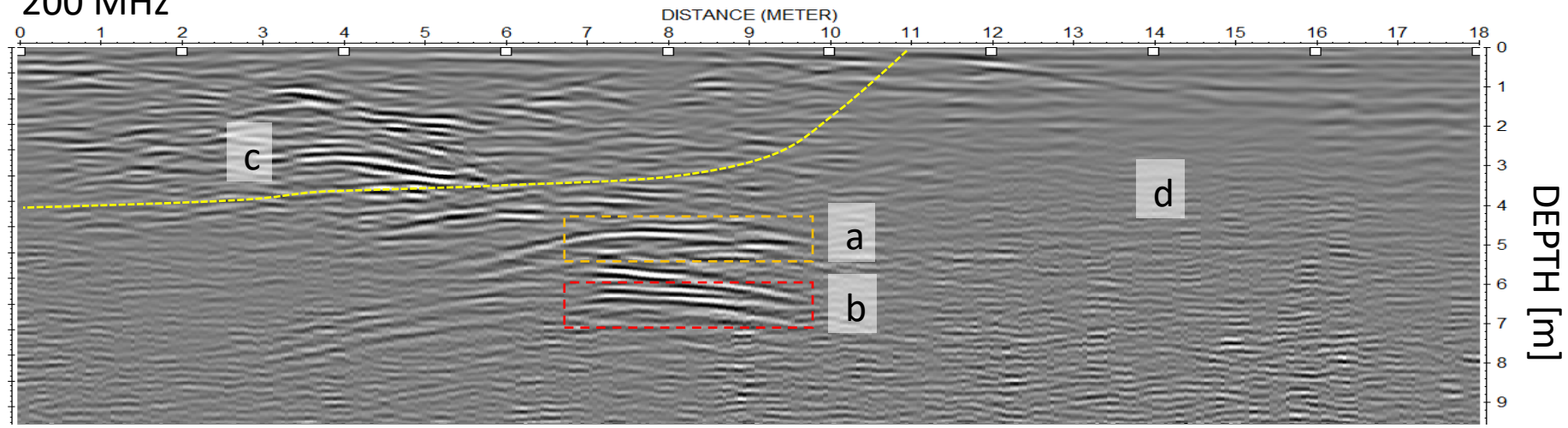
GEOPHYSICAL MEASUREMENTS IN AN ABANDONED OLD RAILWAY TUNNEL (Marsico Nuovo, Italy)

GPR B-SCAN

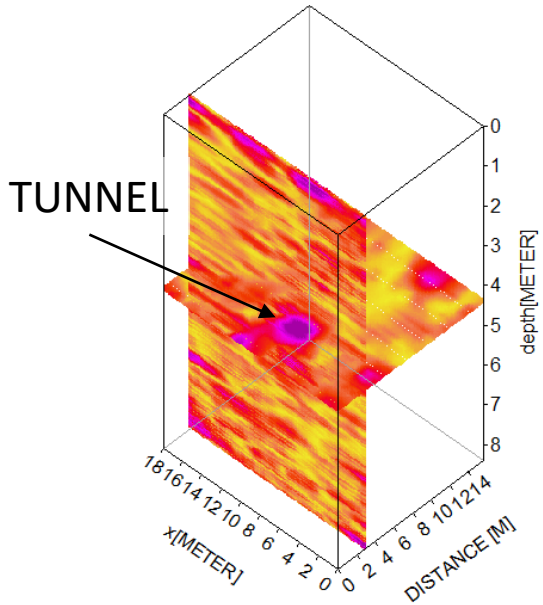
400 MHz



200 MHz



Dieletric permittivity = 6



a- Top of the tunnel (vault arch)
b. Pavement structure
c. Unhomogeneous soil or fractured rocks
d. Rocks (carbonate)

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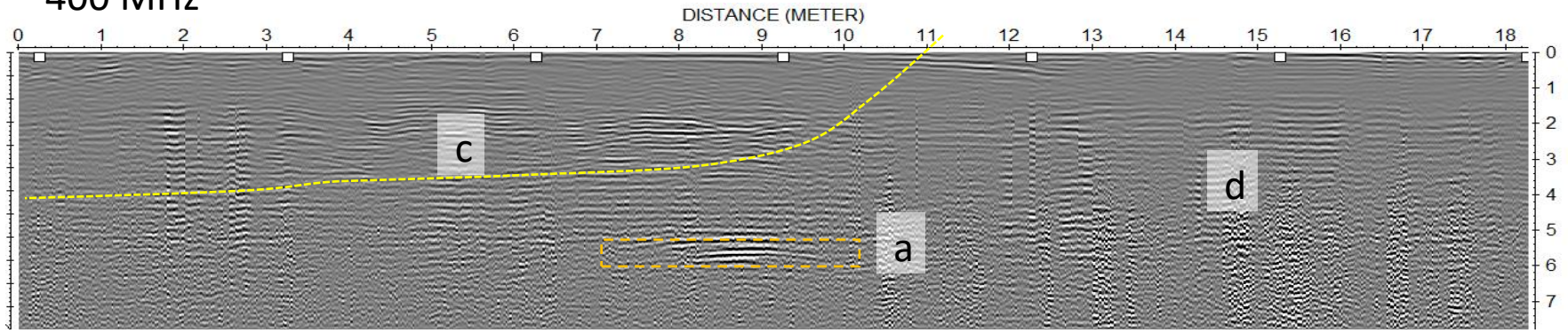
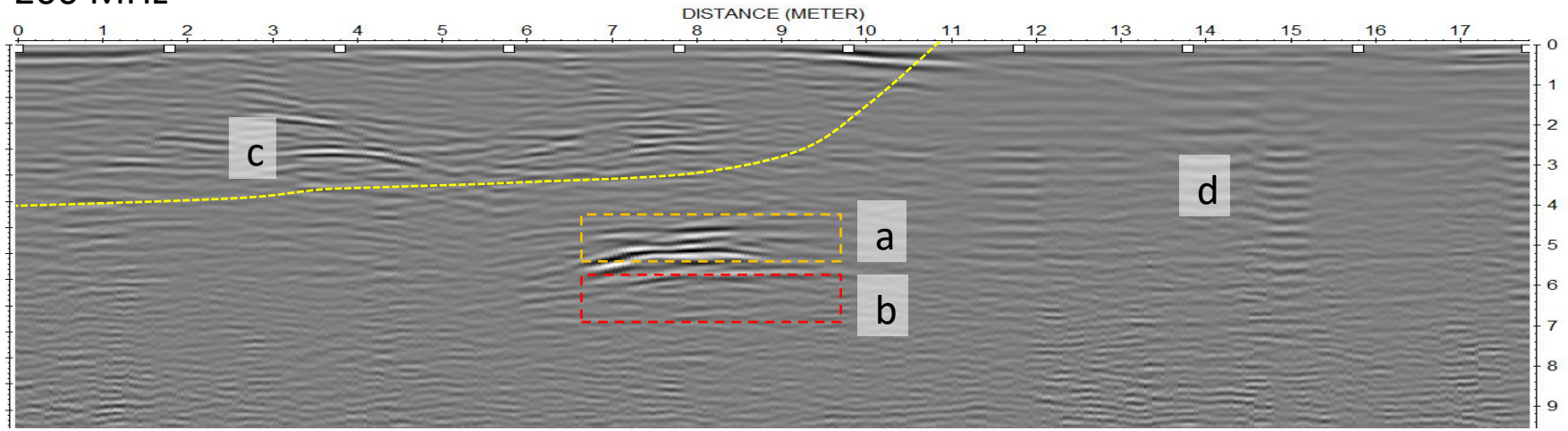
GPR B-SCAN

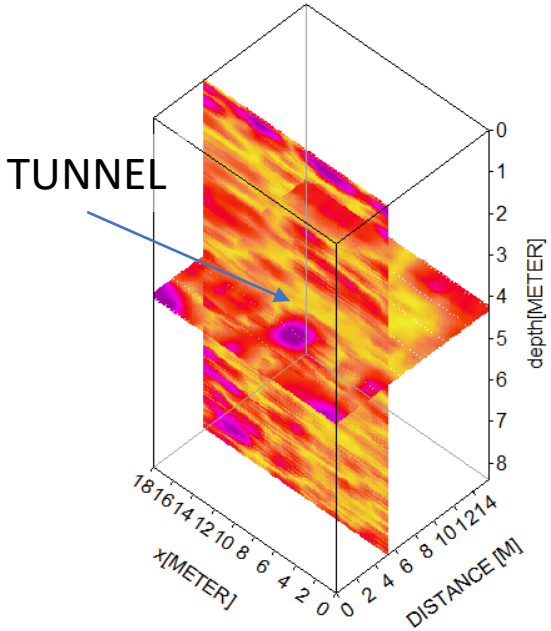
400 MHz



200 MHz



Dieletric permittivity = 5.35



a. Top of the tunnel (vault arch)
b. pavement structure
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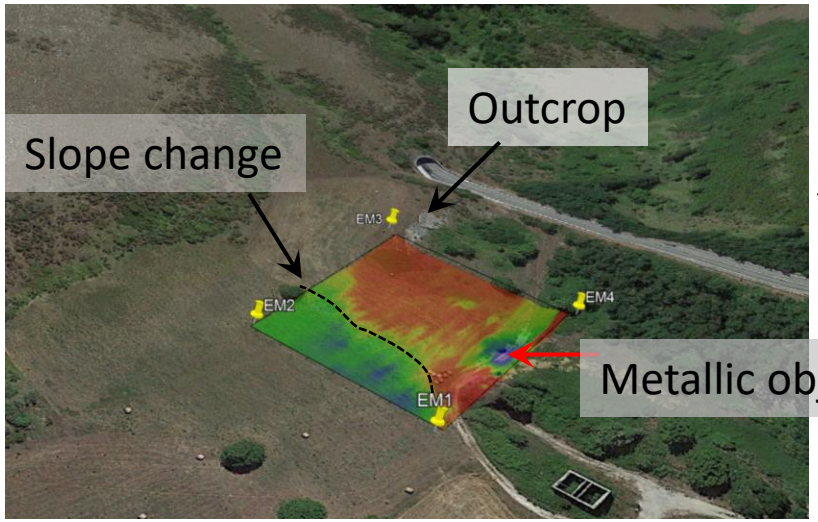
ELECTROMAGNETIC MEASUREMENTS

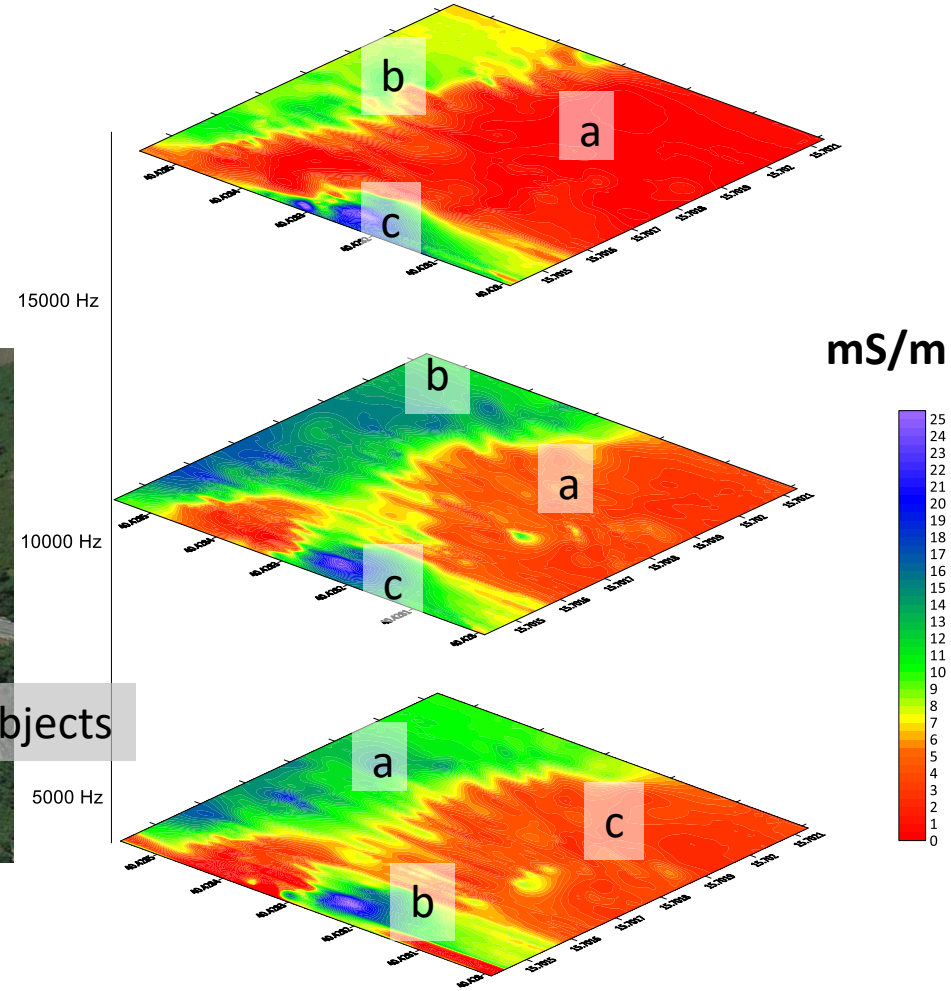
a. Superficial bedrock and rocky outcrop (carbonate)

b. Humid soil, higher water content

c. Metal waste (conductive zone)



APPARENT CONDUCTIVITY



OLD RAILWAY TUNNEL

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Conclusions

- Karst systems play a fundamental role for all living beings. Their protection and safeguard require innovative and non-conventional systems that the geophysics methodologies can offer;
- Castel di Lepre karst area offers a powerful perspective to analyze the hydrogeological processes occurring in the karst aquifer thanks the near presence of a cave and an abandoned railway that cross it;
- Cave-surface 3D ERT have shown interesting geological features of the systems identify electrical anomalies associable to inhomogeneities of the calcareous rocks and the (higher or lower) water content;
- The abandoned railway tunnel was, preliminarily, studied only on the top structure with GPR and EMI;
- GPR results have identified some discontinuities in the first meters of subsoil and allowed to evaluate the dielectric permittivity of the soil above the tunnel;
- EMI results have identified the presence of a strong variation of the subsoil associable to the outcrop and tunnel.