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EGU General Assembly 2020

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# The project FLUIDS: Detection and tracking of crustal fluids by multi-parametric methodologies and technologies



imaa istituto di metodologie per l'analisi ambientale

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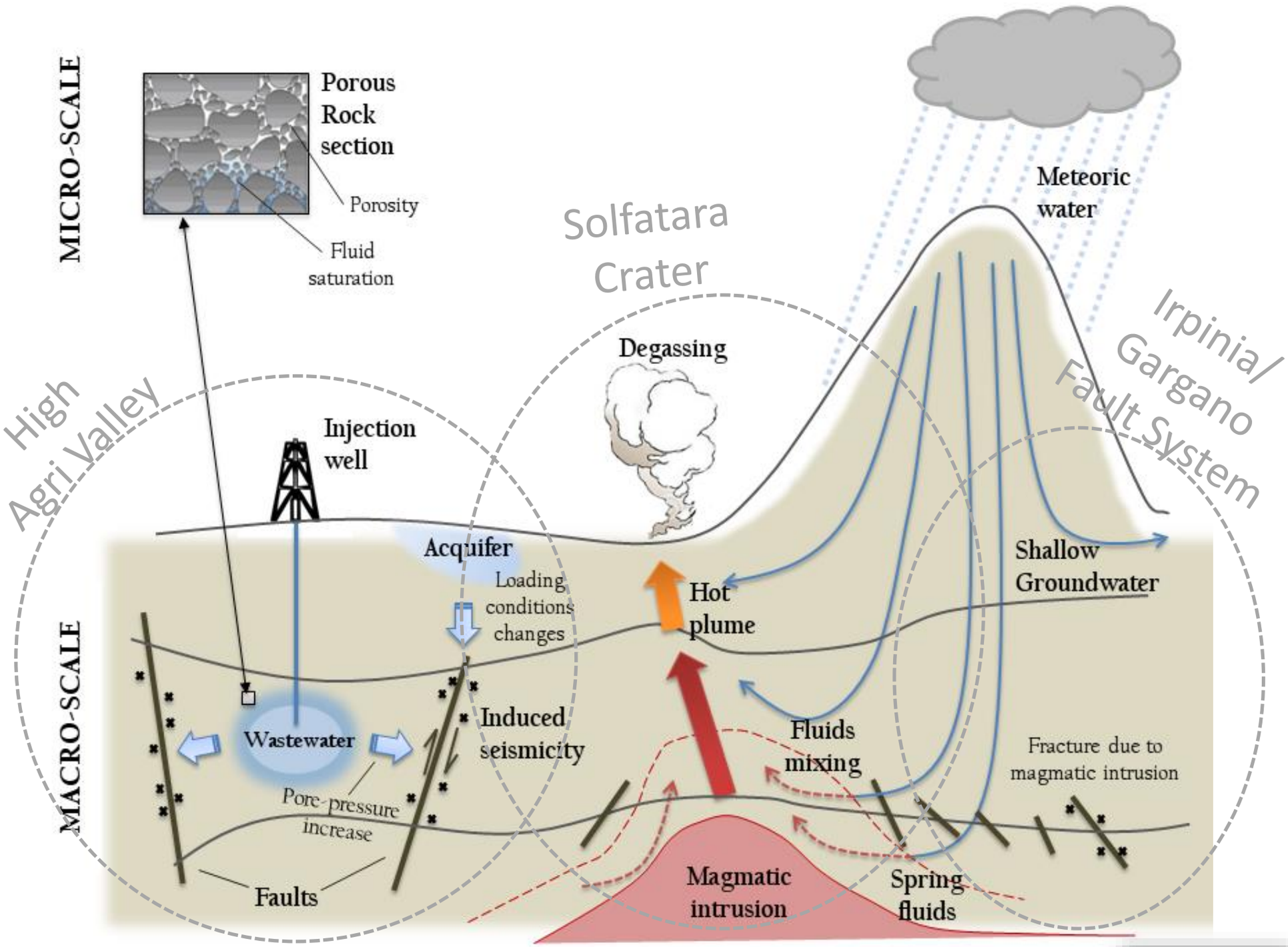
ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Fluids play a key role in geological and geochemical processes of the crust.

The main objective of the project is to develop and apply at selected test-sites an integrated, **multi-parametric and multi-disciplinary approach** to image and track crustal fluids in volcanic, tectonic and industrial exploitation environments.

This will be pursued developing and implementing innovative methodologies and technologies to reconstruct the 4D (space and time) variations of rock physical and geochemical properties in a fluid-filled porous medium, and detecting fluid-related effects as induced micro-seismicity, electric properties changes and surface ground deformation.

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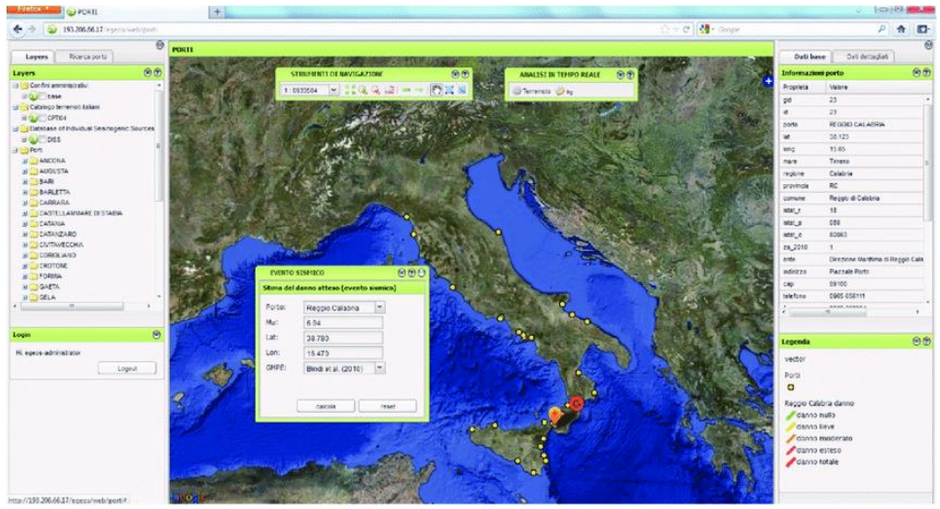
# Work Packages

| | | Aimed at… |
|---|---|---|
| WP1 | Multi-parametric data acquisition and management | data acquisition, integration and sharing/publishing for scientific and public information purposes |
| WP2 | 4D multi-parametric crustal imaging | set up and testing methodologies for underground imaging in space and time, and at comparing the obtained images for an effective and robust tracking of fluids |
| WP3 | Induced phenomena and/or triggered effects by fluid diffusion | investigating fluid properties and movements, developing methods to detect and track them through their effects correlated with geophysical observables |
| WP4 | Test-sites from regional to local scale: characterization and modeling of fluids migration | applying the developed multi-parametric, multi-disciplinary approach to different test-sites in volcanic, tectonic and industrial exploitation environment |

# WP1 Multi-parametric data acquisition and management

- **Task 1.1. Standardization and integration of data into the EPOS framework**
  - Set and implement standards of all the raw fata, data formats and metadata,
  - Provide data access through standard and non-standard services developed in EPOS.



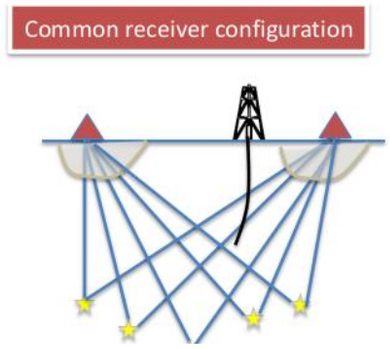
- **Task 1.2. WebGIS platform based on service oriented architecture**
  - Objective: share geo-spatial products of the projects
  - Implement a webGIS platform compliant with the OGC (Open Geospatial Consortium) standards, (eb Map services and Web Feature Services)
  - open-access by third party applications.

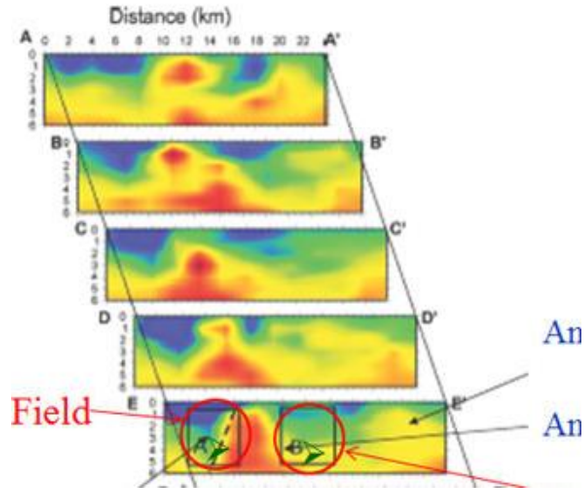
The platform will allow to:

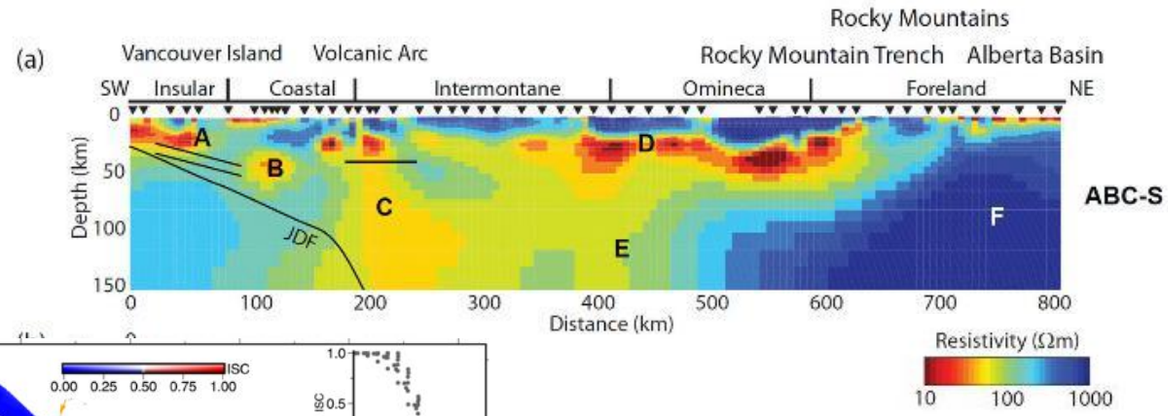
1) achieve a multi-parametric and multi-disciplinary study of the investigated sites.
2) provide information to the Regional and National Civil Protection.

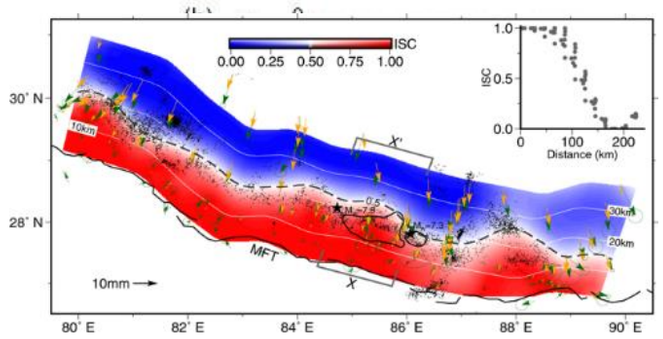
# WP2 4D multi-parametric crustal imaging

- **Task 2.1. 4D seismic imaging (UNINA , CNR)**
  - 3D elastic/anelastic seismic tomography methods
  - Time-lapse tomography and fast, single station methods.(**D2.1**)
- **Task 2.2. 3D magnetotelluric studies (UNIBA)**
  - Analyze of the signals recorded at MT stations in order to discriminate transients with highest SN ratio
  - 4D MT inversion methods will be implemented to map shallow crustal resistivity changes. (**D2.2**)
- **Task 2.3. Time-dependent strain rate imaging (INGV)**
  - Construction of time-dependent maps of distributed strain rate and associated elastic stress perturbations from continuous GPS time series (D2.3)
- **Task 2.4. Integration of multi-parametric data for the rock physical modeling (UNINA,UNIBA,CNR)**
  - Rock physics-based method for the multi-parametric modeling the of geophysical parameters images, allowing to constrain the rock parameters including the fluid presence and type. (**D2.4**)




The implementation and integration of methodologies will provide a useful demonstration of how multi-parametric methods can be applied in practical cases to detect and characterize the crustal fluids.

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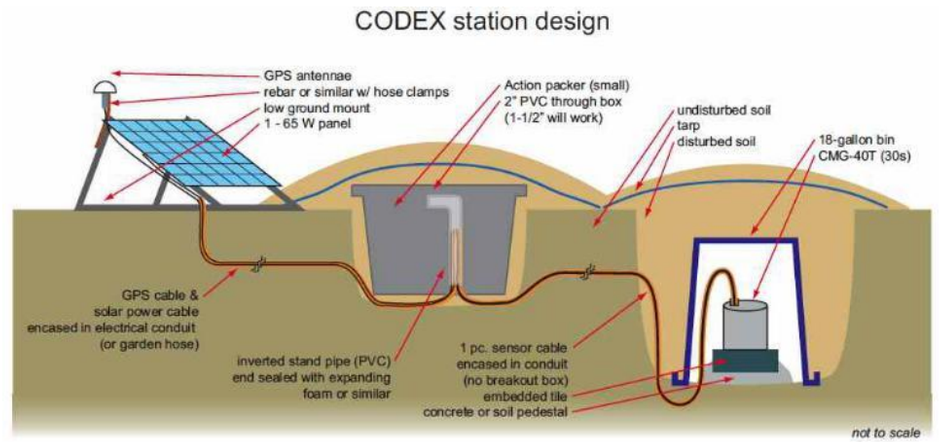
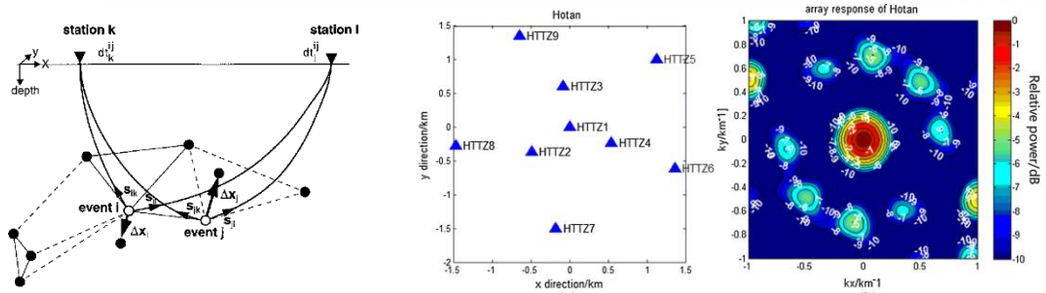
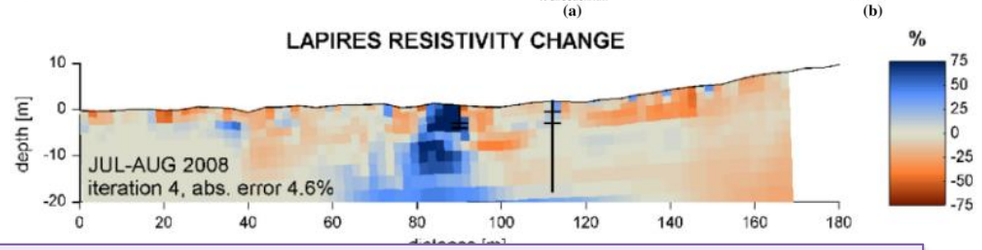
# WP3 Induced phenomena and/or triggered effects by fluid diffusion

- **Task 3.1**: **New technologies for fluid detection and tracking (UNINA,UNIBA,UNIBAS)**
  - A prototype small-scale, dense monitoring seismic arrays;
  - A mixed seismic-electromagnetic sensor network;
  - A multi-parameter device, installed in a thermal water well to detect conductivity, temperature, pressure data, gas output and water level.(**D3.1**)
- **Task 3.2**: **Proxies for fluid detection and tracking: Methods for data analysis and modeling (UNINA+all)**
  - 4D High precision relative/absolute and array location techniques
  - Spectral domain methods for the refined estimations of source parameters, focal mechanism and local and regional stress field
  - Tracking of the resistivity changes in the fluid-saturated medium
  - Geochemical analyses of natural fluids will be applied.(**D3.2**)
- **Task 3.3**: **Statistical analyses and data mining to identify fluid perturbations(CNR,INGV,UNINA,UNIBA)**
  - Pattern recognition analysis for each individual multi-parametric data set (**D3.3**)




The analysis of fluid-induced effects will

1) Improve the current knowledge about the fluid role in earthquakes triggering,
2) Identify geophysical, geochemical and statistical parameters that could be used to characterize the fluid induced seismicity.

# WP4

# Test-sites from regional to local scale: characterization and modeling of fluids migration

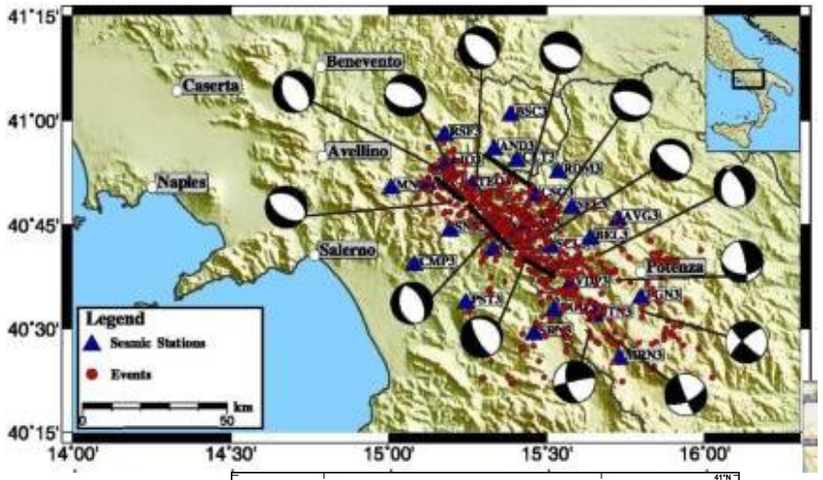
- **Task 4.1. Irpinia & Gargano: Hydrological and deep-generated fluid effects in tectonic environment(UNINA+all)**

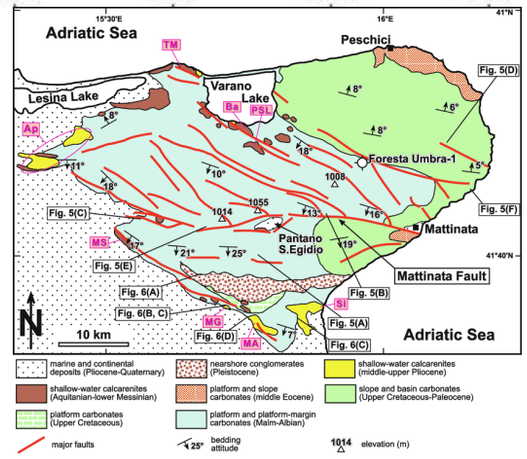
**Irpinia:**

- 4D seismic velocity, attenuation and rock micro-parameters models
- Chemical and isotopic analyses of gases and water.
- Earthquake source parameters including static/dynamic stress drop, seismic energy and seismic efficiency
- Repeated seismic sequences analysis
- Seasonal modulation of seismicity and geodetic displacements

**Gargano:**

- Refined seismicity location and source parameters.
- Maps of attenuation coefficient and a 2D crustal model
- Observed geodetic and seismicity transient episodes will be interpreted in view of the others geophysical and geochemical analysis results and a
- 2D/3D thermo-rheological model for the area will be obtained.
- Resistivity crustal model in the area of the local heat flow anomaly (**D4.1**).



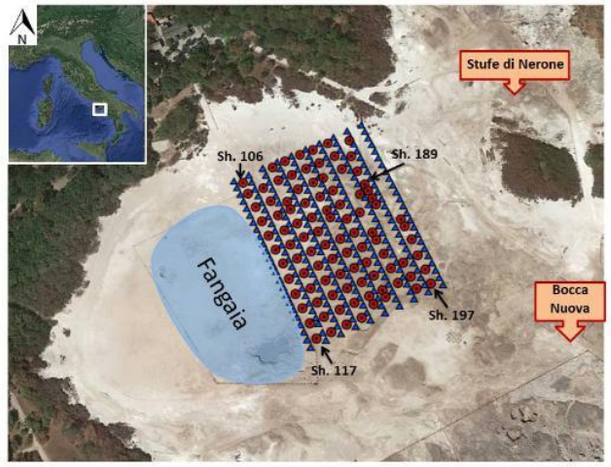

The experimentation of different methods and integration of the results at the different project test-sites will strengthen their potential application at other tectonic, volcanic or exploitation areas in Italy and worldwide.

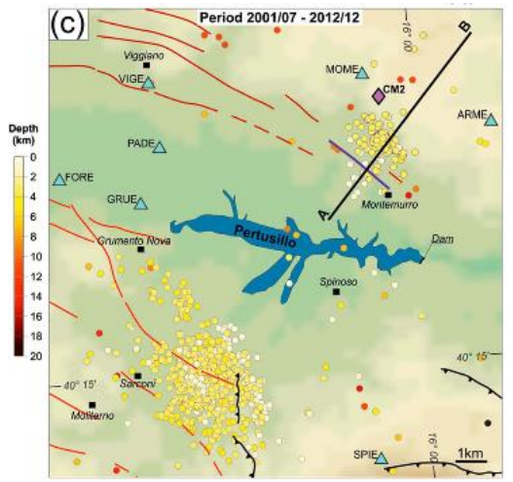
# WP4

# Test-sites from regional to local scale: characterization and modeling of fluids migration

- **Task 4.2. Solfatara volcano: Hydrothermal fluid circulation in volcanic environment(CNR+all)**
  - Integrate seismic attenuation images with the other geophysical/geochemical observations to infer a comprehensive multi-parametric subsurface model.
  - Newly 3D resistivity soundings will be analyzed to correlate spatial attenuation with well-known volcanic emissions in the shallow Solfatara crater.
  - Seismic and electric tomographies will be integrated in a rock physics model of the volcanic structure.
  - All information will be used to build a 2D/3D finite element model to predict temperatures, rheology and active stress induced by both deep thermal source and shallower hot fluid migration beneath the Solfatara crater (**D4.2**).

- **Task 4.3. High Agri Valley oil & gas exploitation area: monitoring natural and induced fluid circulation(CNR, UNINA, UNIBAS, UNIBA)**
  - A joint interpretation of 3D resistivity model and seismic velocity/attenuation tomographies of the High Agri Valley
  - The chemical and isotopic composition of free and dissolved gases and water will be determined with discrete sampling on a seasonal basis.
  - An automatic multiparametric device will be installed
  - Geochemical, seismological and geophysical studies will be integrated for fluid tracking and their relationships with the energy technologies hosted in the area (**D4.3**).

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# Perspective

Results of this project are expected to have a broad scientific-technological impact through the development and application of new, integrated multi-parametric methods; technologies for fluid detection and space-time tracking. As for its socio-economic impact, the project will deliver “best practice” recommendations for managing fluid-induced seismicity for a sustainable and safe exploitation of all the energy resources that involve injection/withdrawal of fluid into/from the subsoil. Forecasts of induced seismicity using multi-parametric observed systems of induced seismicity represent the planning and decision making tools for mitigating the associated risk for population living nearby industrial sites but also active hazardous tectonic and volcanic regions.