# Underground in the context of energy transition:

*Ensuring the safety and the performance of subsurface uses*

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## Independent expertise on the safety of underground operations

**BRGM is strongly focused on research and technology watch activities to support institutional and economic players in developing the potential of underground to contribute to the energy transition**

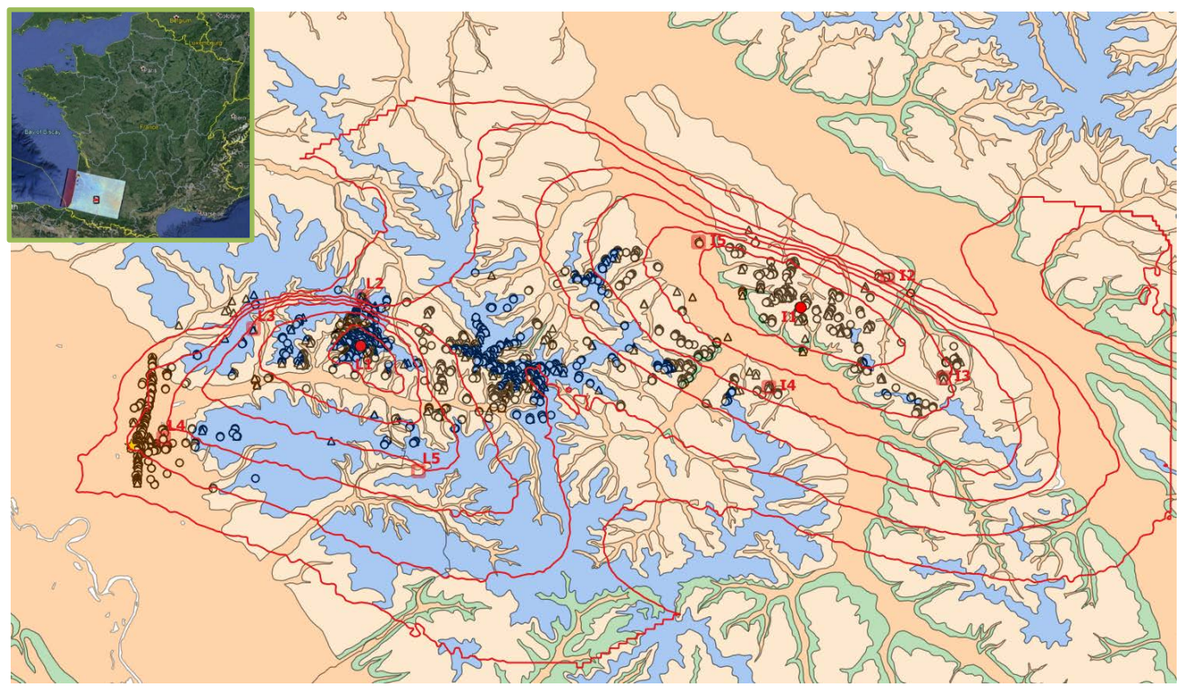
- Public and industrial research on the global performance of operations
- Studies of innovative energy storage concepts
- Technology watch on new underground uses
- Decision-making support

## New approaches and technology watch

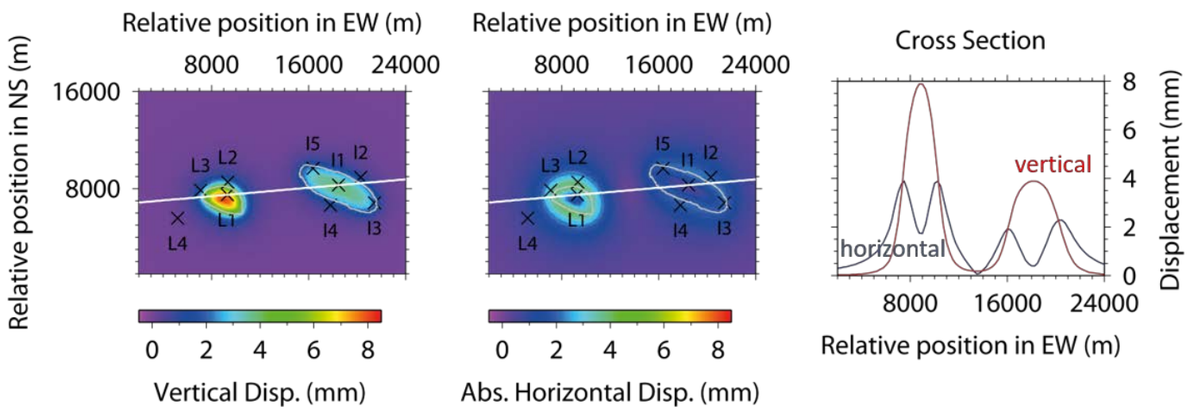
**We develop new methods and numerical tools through our research work and partnerships with industries**

- Risk management methods
- Integrated monitoring tools
- Uncertainties quantification methods and metamodels
- Value Of Information

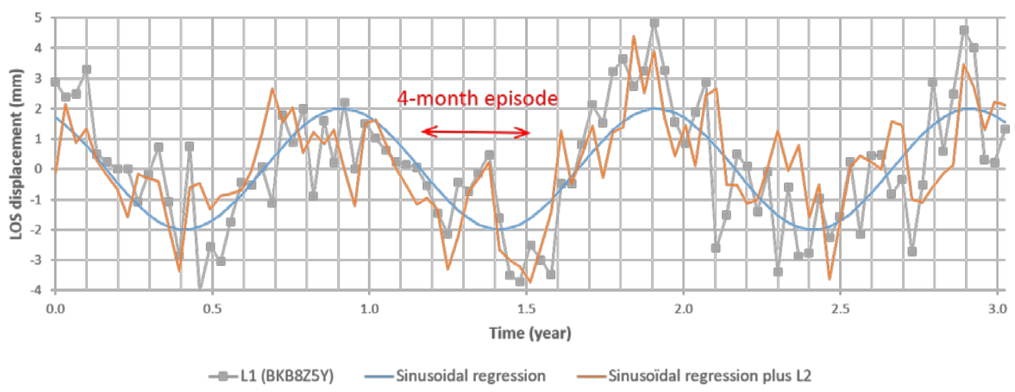
### CITEPH Web-RDS: a geosurveillance platform of a gas storage site



*> Regional setting in Southwestern France that contains modified Copernicus Sentinel data (2016). Geological map showing 1931 measurement points obtained by the SqueeSAR® method and the reservoir isobaths of the double gas storage site (red lines).*

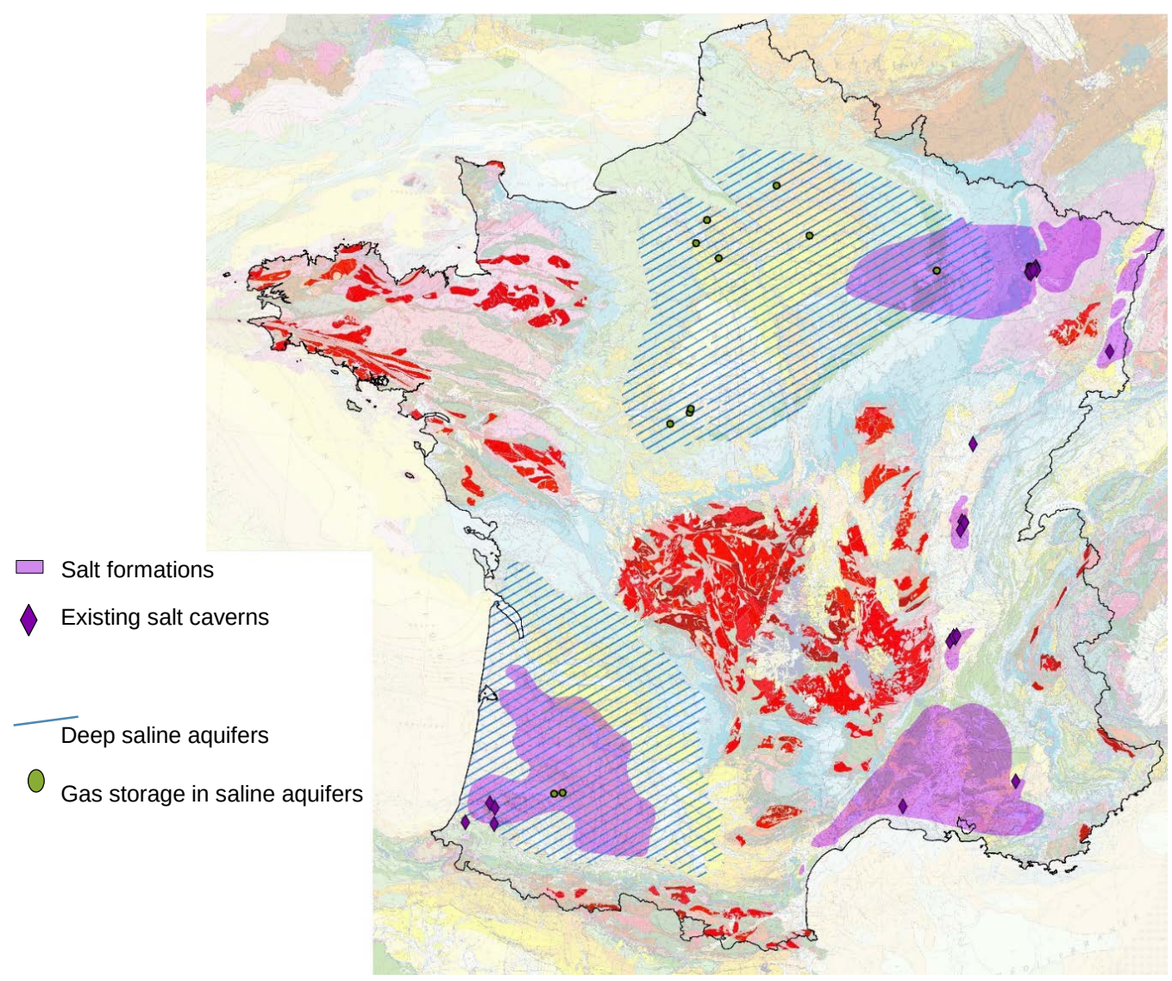



*> Absolute value of the vertical and horizontal ground displacement (mm) during each injection/ production cycle as predicted by an analytical model (Burnol et al., 2019)*

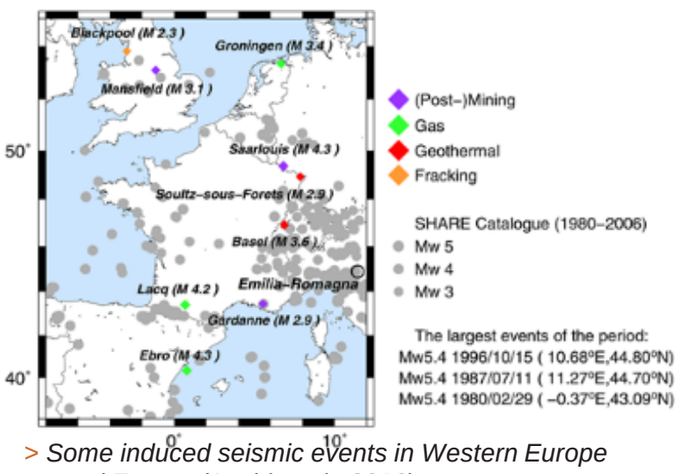



*> Comparison of the time evolution of LOS displacement around L1 (BKKB8Z5Y) with a sinusoidal regression model and the sum of this model with the DInSAR time series near L2 location.*

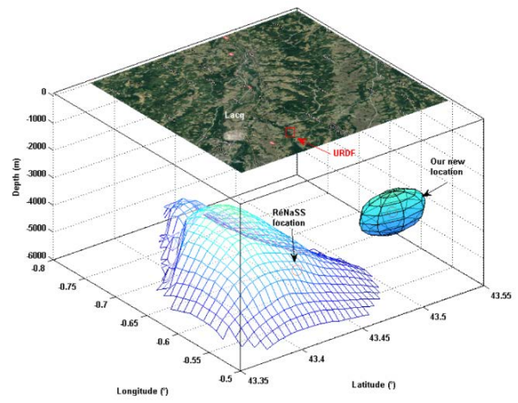
### ANR FluidSTORY: safety of $CO_2$/$O_2$ storage in salt caverns




### Induced or triggered seismicity by subsurface exploitation




*> Some induced seismic events in Western Europe around France (Aochi et al., 2016)*




*> Location of the ML4.0 25th April 2016 earthquake (ellipsoid), comparing to the first routine solution (red circle) and the top surface of the Lacq gas reservoir (2D grid). (Aochi & Burnol, 2018)*

**Bibliographie**

- Burnol, A. et al. Wavelet-based analysis of ground deformation coupling satellite acquisitions (Sentinel-1, SMOS) and data from shallow and deep wells in Southwestern France. Scientific Reports 9, 8812 (2019)
- Aochi, H. & Burnol, A. Mechanism of the ML4.0 25 April 2016 earthquake in southwest of France in the vicinity of the Lacq gas field. J. Seismol. 22, 1139-1155 (2018)
- Aochi, H., Le Guenan, T. & Burnol, A. Developing subsurface energy exploitation strategies by considering seismic risk. Petroleum Geoscience 23, 298-305 (2016)

**Abstract**

The BRGM develops and coordinates independent expert studies for central and local government on the safety of underground operations and on the management of subsurface uses conflicts. We also offer tools and methods to help private energy companies improve the global performance of their exploitations.