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Geophysical inversion and machine learning of dense 3D seismic and resistivity models for imaging deep landslide structures.

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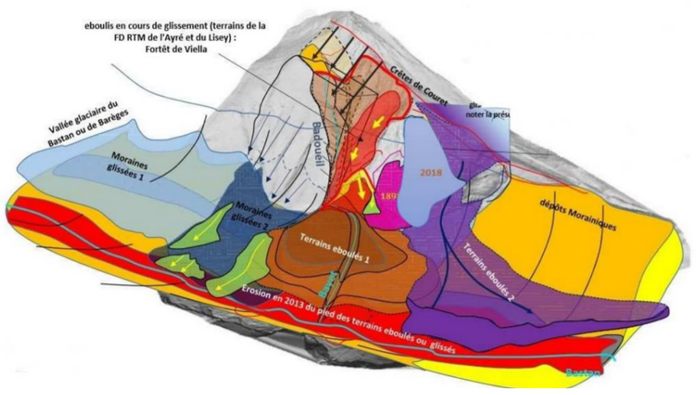
Objective

- Joint interpretation of resistivity and seismic travel time dataset using 3D geophysical inversion and machine learning
- Better representation of the spatial variation of structures, heterogeneities and water pathways
- 3D geometrical models as input for landslide hydro-mechanical modelling

The Viella landslide, Central Pyrénées

- Large landslide affecting unconsolidated sediments (moraine, rockslide deposits, alluviums)
- Estimated depth > 80 m, reactivation in 2018
- Surface velocity up to several cm.yr^{-1} with damage to buildings and infrastructures



3D conceptual representation of the slope material (Batailles et al., 2019)

The Viella landslide: geomorphology, region of interest for the geophysical survey and geological sketch

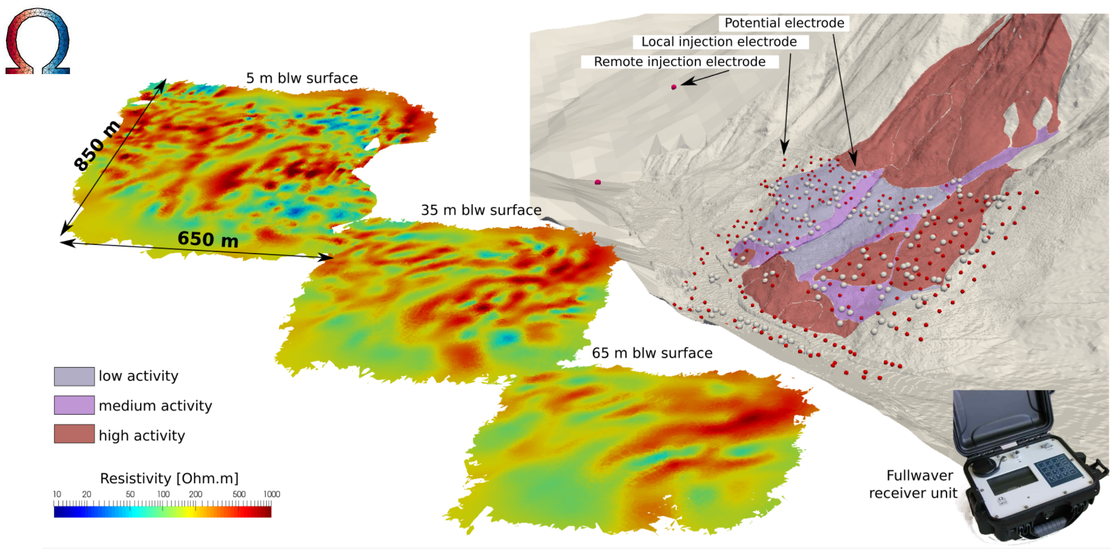
Survey

- > 15 boreholes, inclinometers and piezometers and hydrogeological tracing
- 3D resistivity survey (153 electrodes, 235 injection points, TDIP and Fullwaver system)
- 3D seismic survey (72 geophones / DENSAR; > 200 seismic sources – vibroseis, PEG-90kg, Sissy-shots)
- Geophysical acqusition carried out in June/July 2020

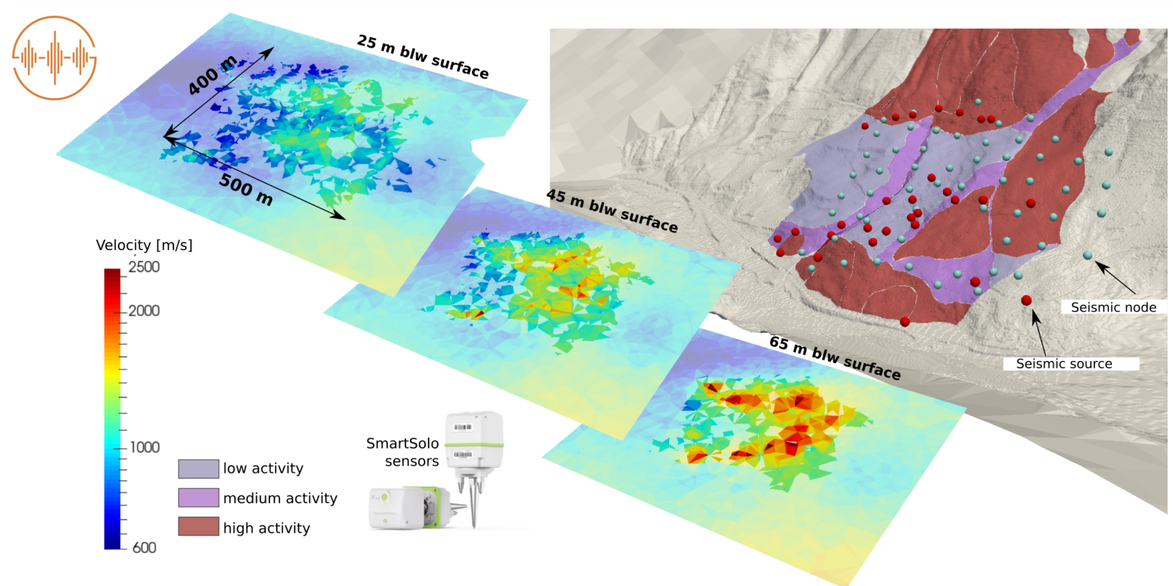
PEG-90 shot

3D ERT injection control

3D ERT model (BERT inversion) and 2D resistivity slices at several depths



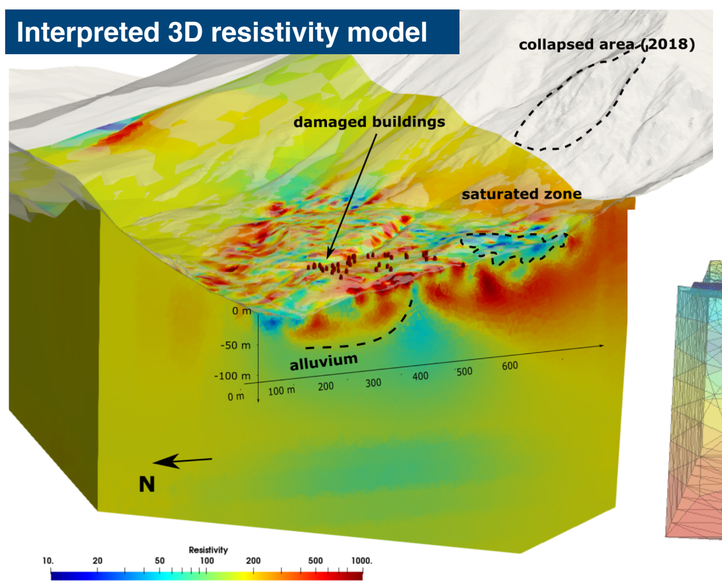
3D P-wave travel-time model (PyGimly inversion) and 2D velocity field at several depths



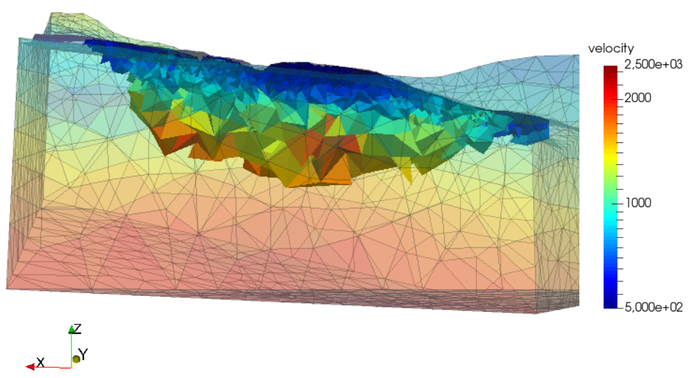
Geophysical inversion

- 3D models allow documenting the complex structures of the slope at several spatial scales
- Relation between resistivity and lithological / hydrogeological units
- Relation between seismic velocity and compacity of the slope sediments

Interpreted 3D resistivity model

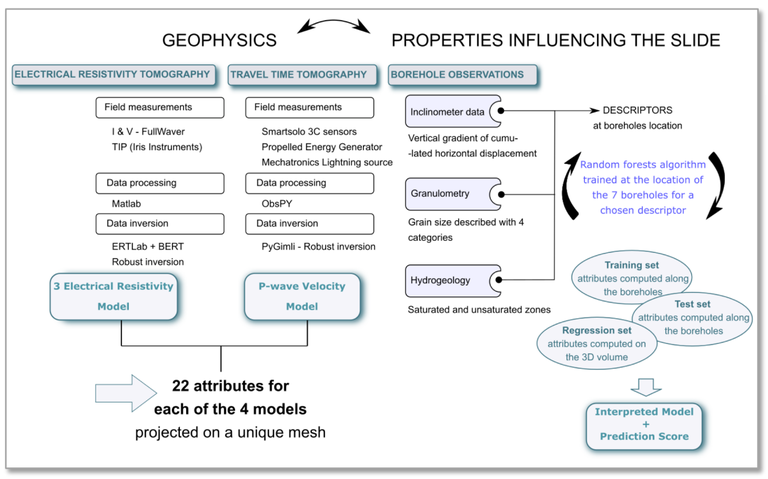


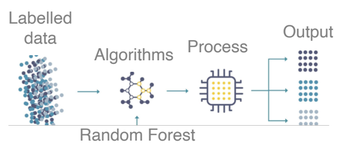
Interpreted 3D P-wave seismic model



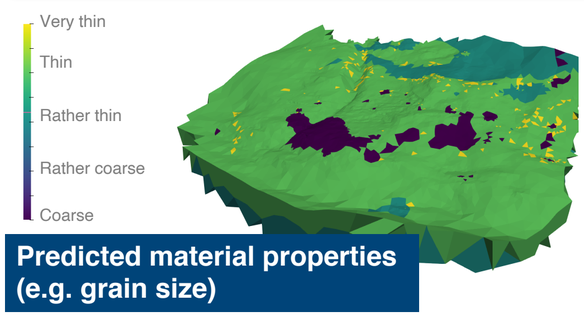
Multi-data fusion with machine learning

- Geophysical attributes derived from the models
- Hydrogeological (water saturation) and lithological (material compacity and granulometry) information from boregoles
- Regression using a Random Forest classifier

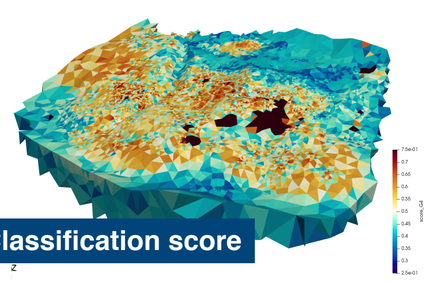




- Computation of 88 geophysical attributes
- Extraction of lithological and hydrogeological attributes at borehole locations
- Machine learning algorithm: training - 75% of obs. validation - 25% of obs.



Predicted material properties (e.g. grain size)



Classification score

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