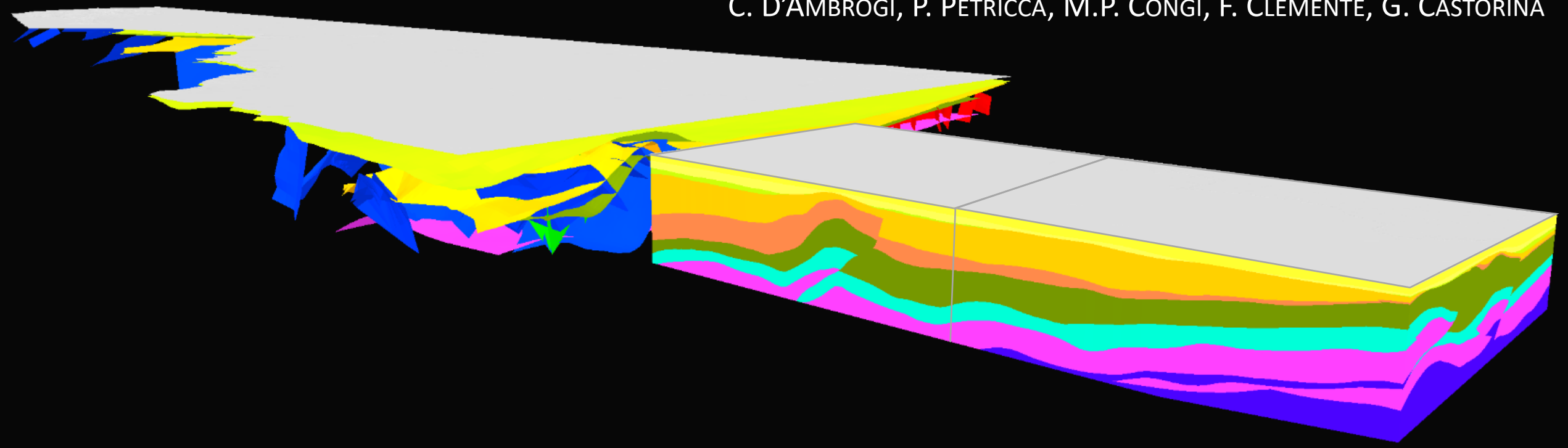
ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

Piece by piece: building the 3D geological model of Italy

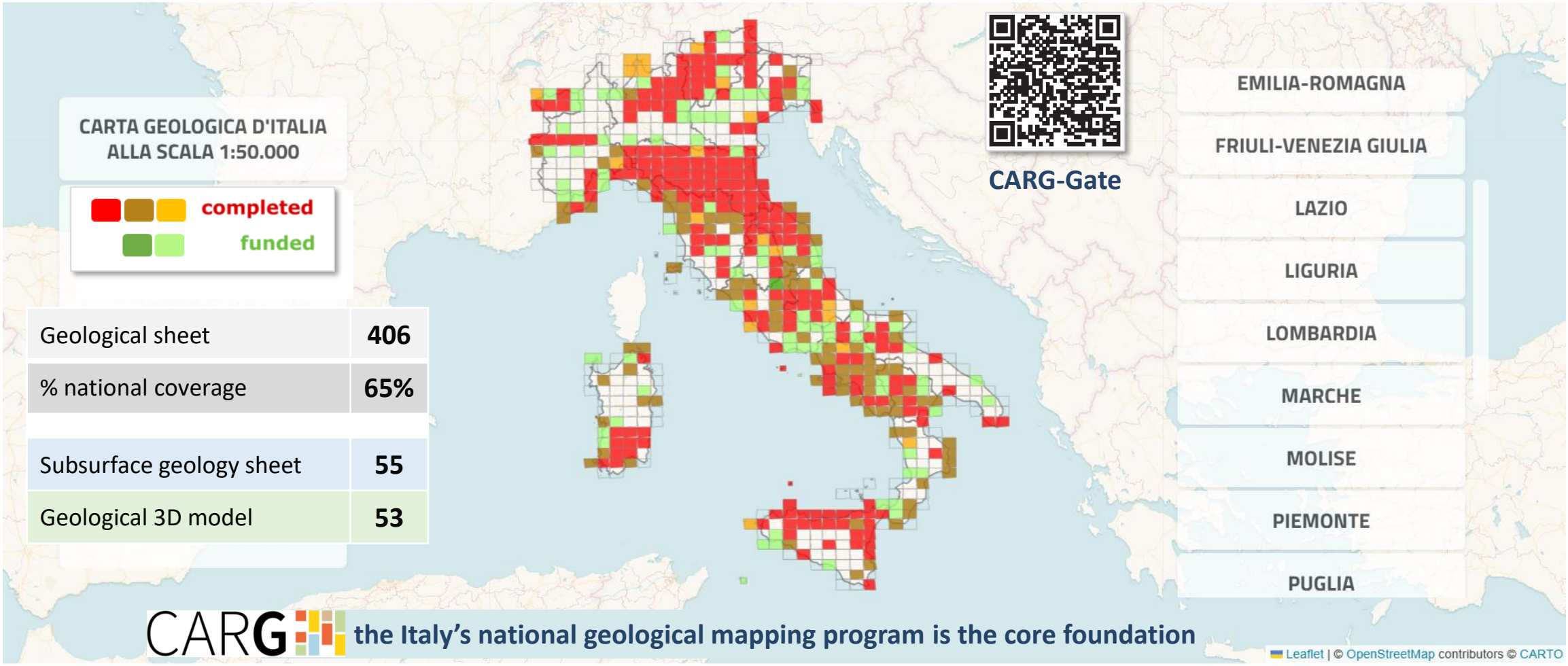
C. D'Ambrogi, P. Petricca, M.P. Congi, F. Clemente, G. Castorina



GSEU Workshop: Towards a 3D Geomodel of Europe, 12 - 13 October 2026

CARG

CARG Program: beyond 2D mapping



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ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale
Sistema Nazionale per la Protezione dell'Ambiente

Contatti Privacy Note legali

CARG ISPRA Istituto Superiore per la Protezione e la Ricerca Ambientale Sistema Nazionale per la Protezione dell'Ambiente

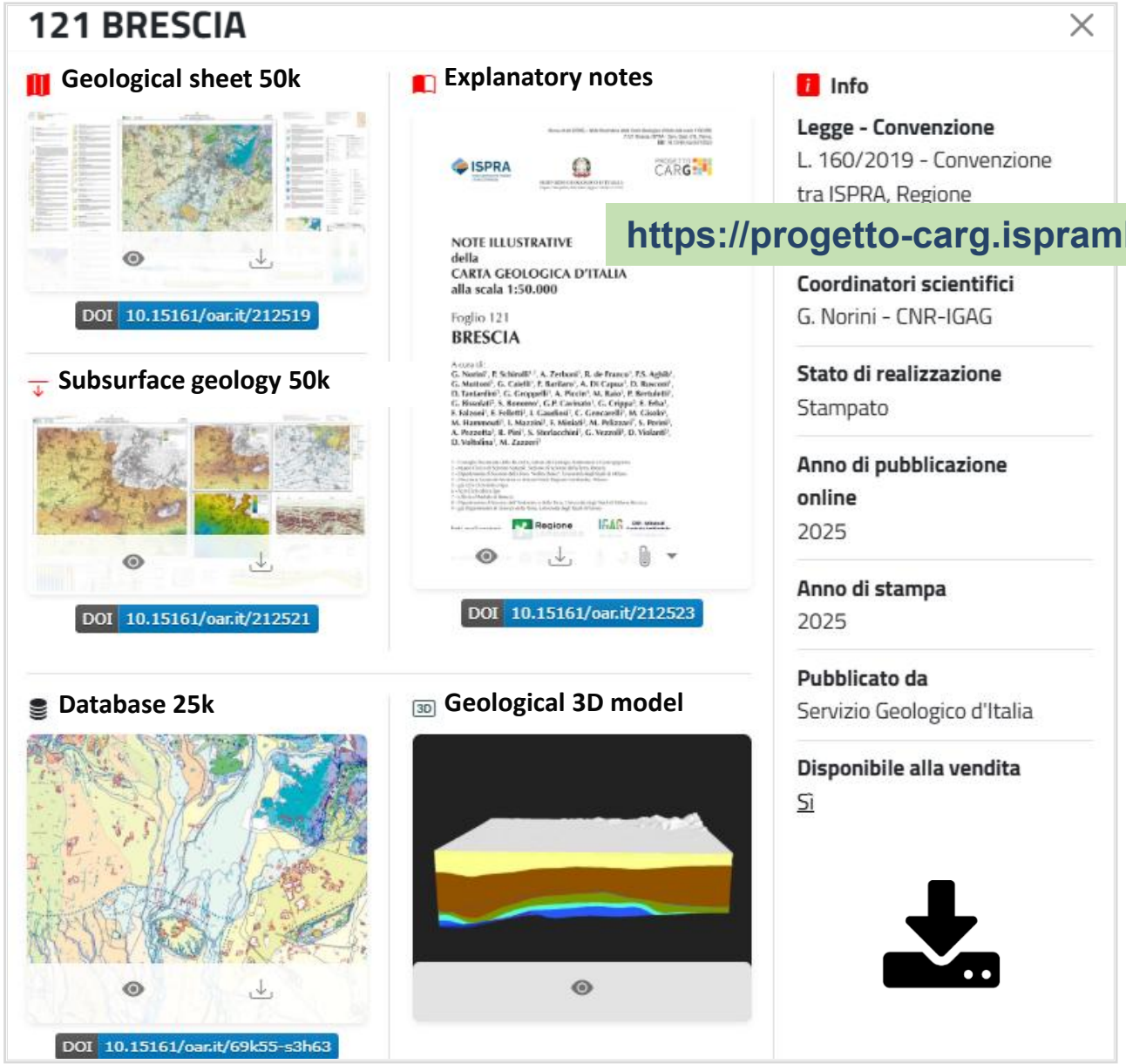
RETHINKING GEOLOGICAL MAPPING

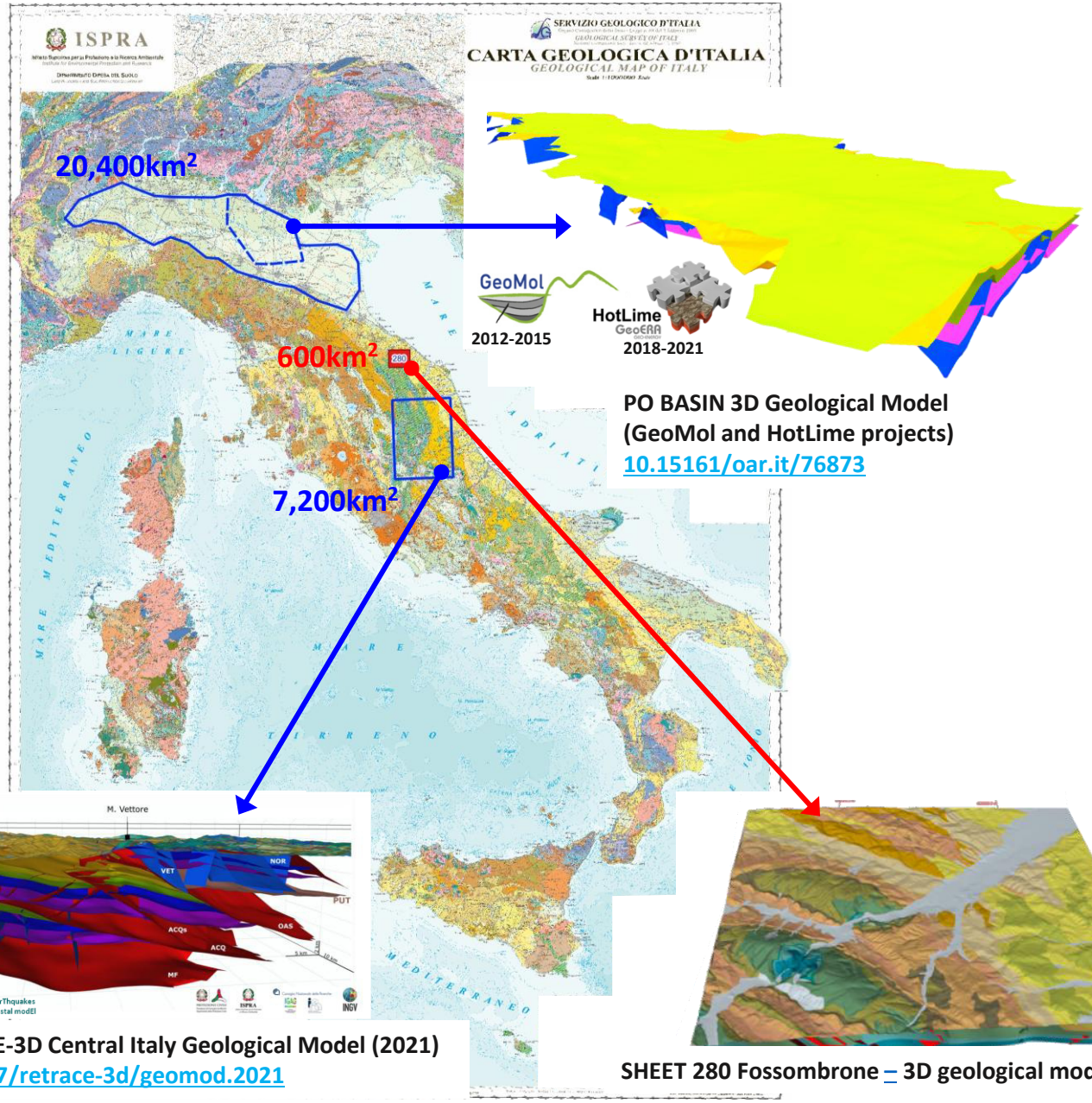
CARG

Bridging 2D and 3D
moving beyond traditional surface maps without replacing them

A holistic view
Integrating surface geology with subsurface interpretation for a complete structural framework

Two side of the same coin
2D maps and 3D models are complementary deliverables





PO BASIN 3D Geological Model (GeoMol and HotLime projects)
10.15161/oar.it/76873

RETRACE-3D Central Italy Geological Model (2021)
10.13127/retrace-3d/geomod.2021

SHEET 280 Fossombrone – 3D geological model (2004)

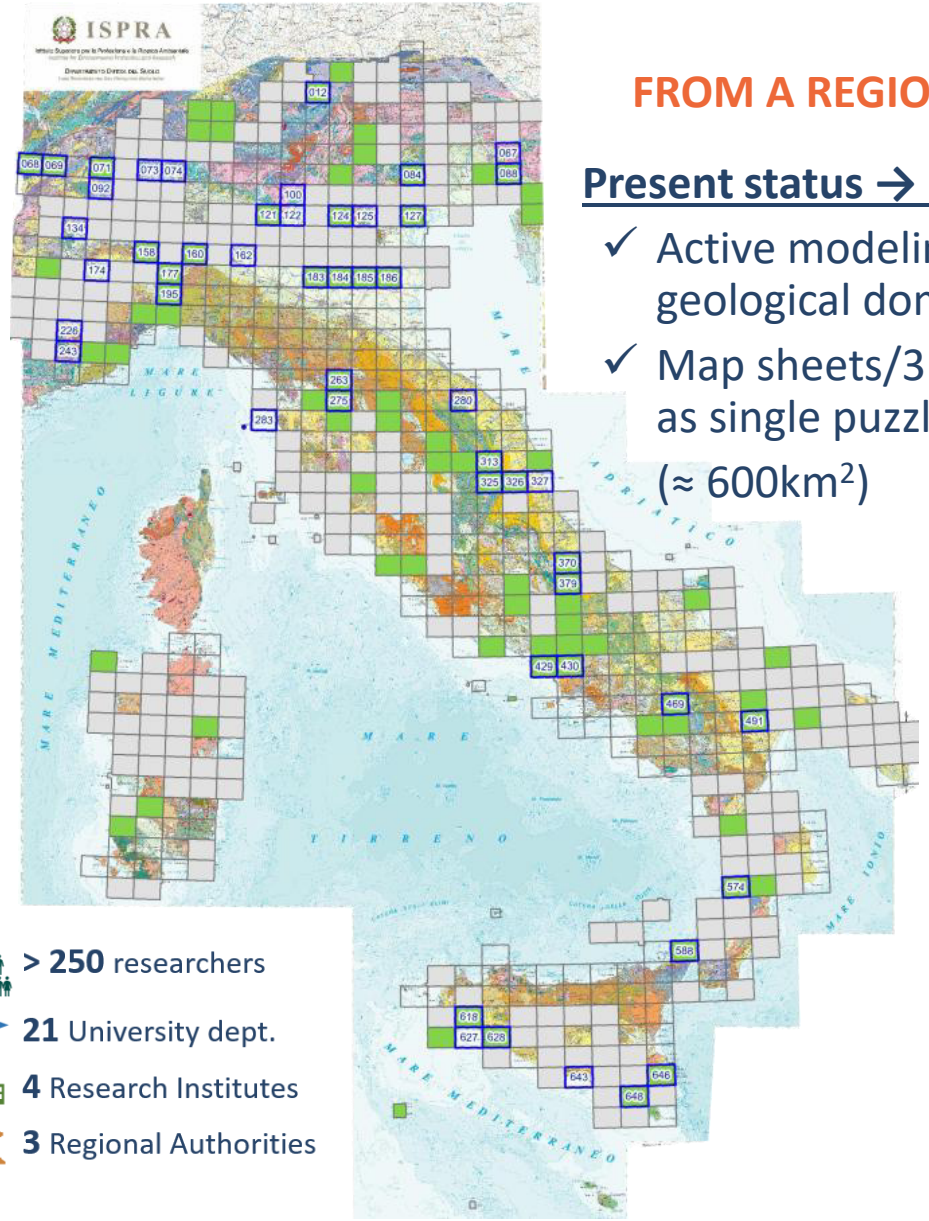
BUILDING ON SOLID FOUNDATIONS

Local pioneer
the Sheet 280 *Fossombrone* proving 3D modeling viability at standard sheet scale

Regional legacy
Leveraging large-scale multi-regional experiences (GeoMol, HotLime, RETRACE-3D)

Lessons learned
data integration and shared workflows

CARG Program: the 3D paradigm



FROM A REGIONAL MOSAIC



TO A NATIONAL DATABASE

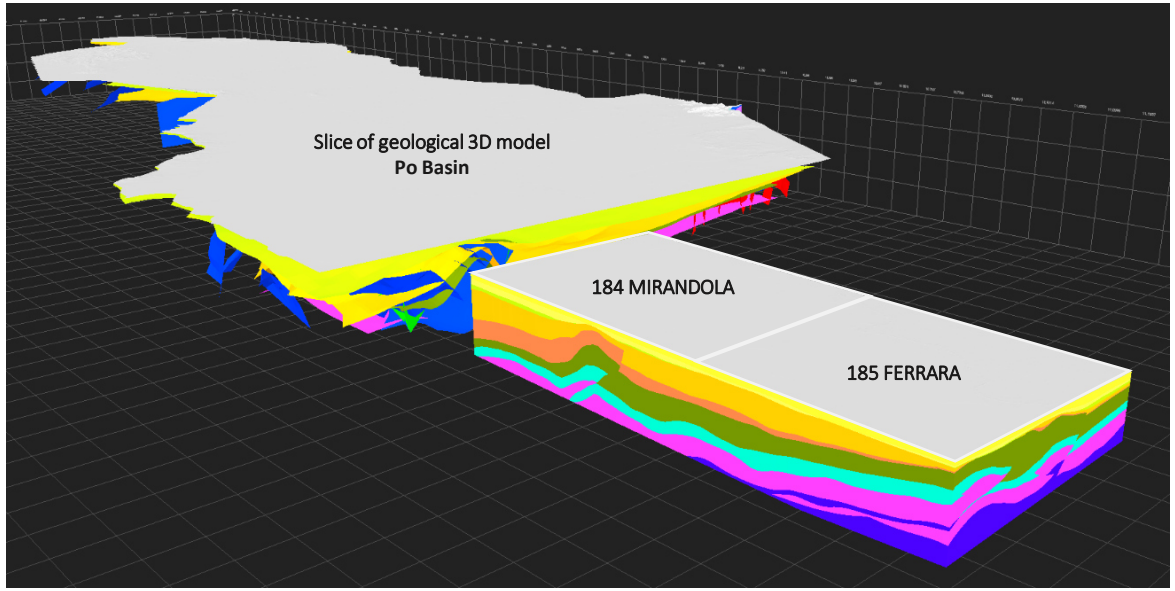


Present status → 53 geomodels

- ✓ Active modeling across diverse geological domains
- ✓ Map sheets/3D models treated as single puzzle pieces (≈ 600km^2)

Target vision

- A unified National 3D Geological Model Database
- Seamless continuity across Italian territory



- **> 250** researchers
- **21** University dept.
- **4** Research Institutes
- **3** Regional Authorities

3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS

prevailing or typical **INPUT DATA**				
Geological field/map data	✓	✓		
Boreholes	✓	✓	✓	
E&P wells		✓	✓	✓
Airborne ElectroMagnetic		✓	✓	
Seismic lines		✓	✓	✓
Velocity data		✓	✓	✓
Gravimetric data		✓	✓	✓
Aeromagnetic data		✓	✓	✓



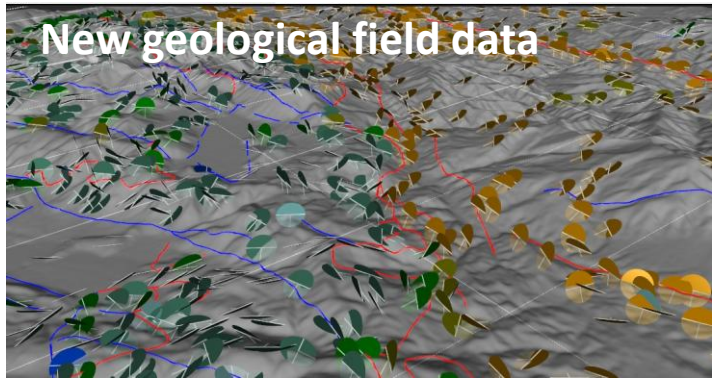


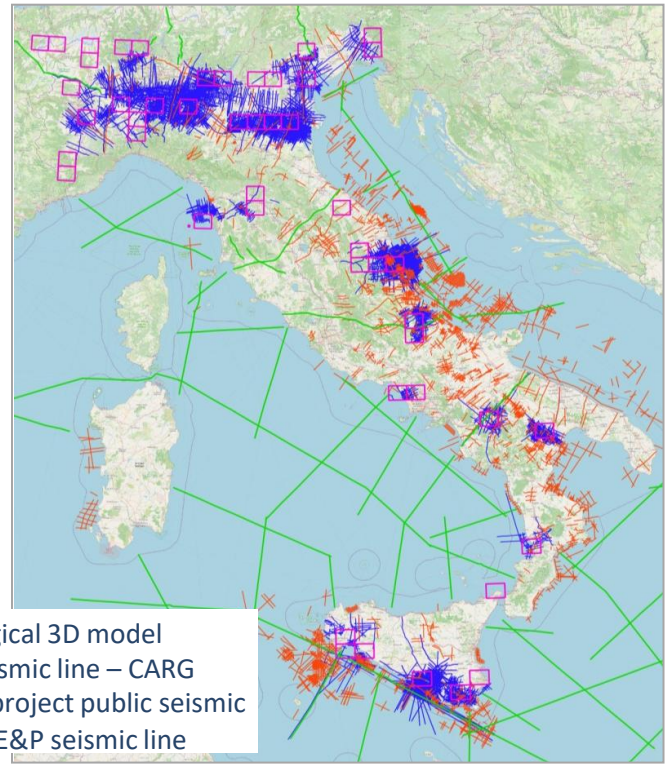


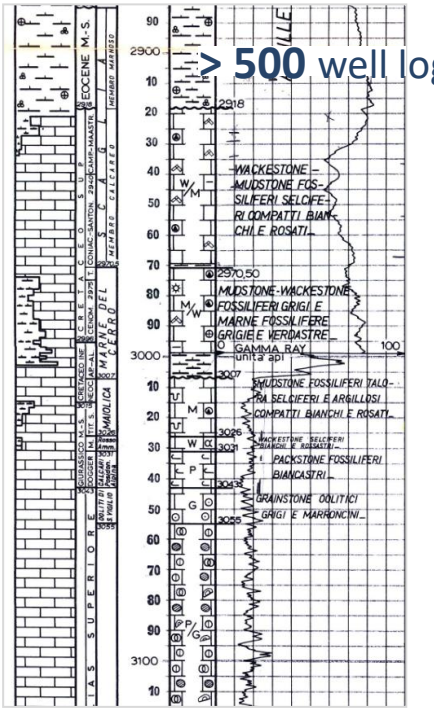


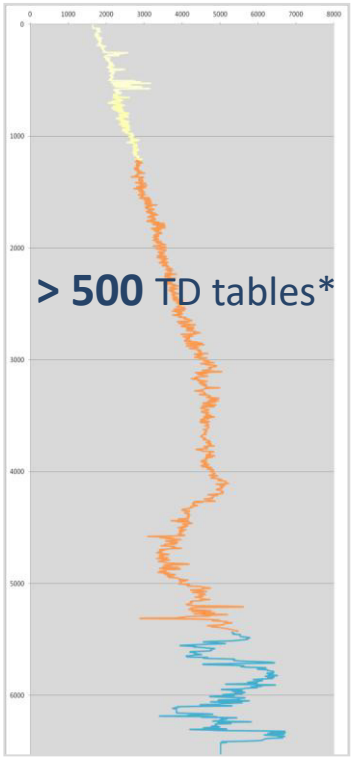
Tackling Italy's geological complexity

3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS



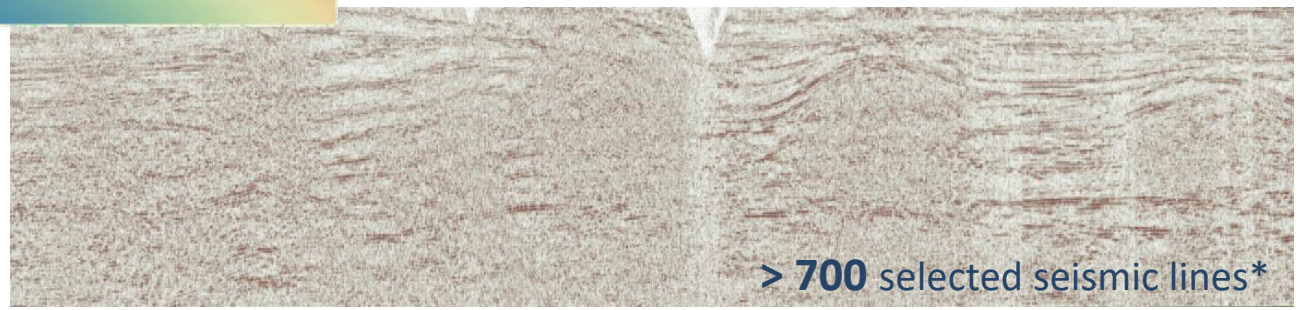


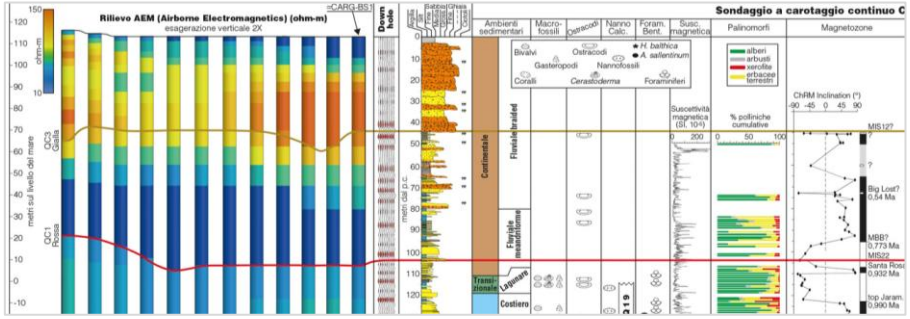




Grid grav* & mag*

Multiscale & multidisciplinary data integration





AEM survey*, CPT soundings, specialistic analyses

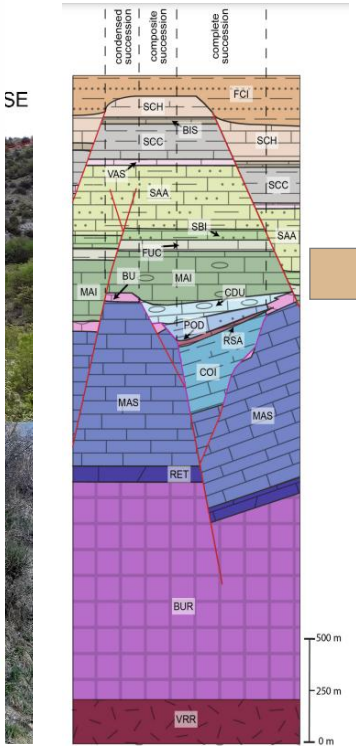
*** Data under confidentiality agreement**

3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS

Tackling Italy's geological complexity

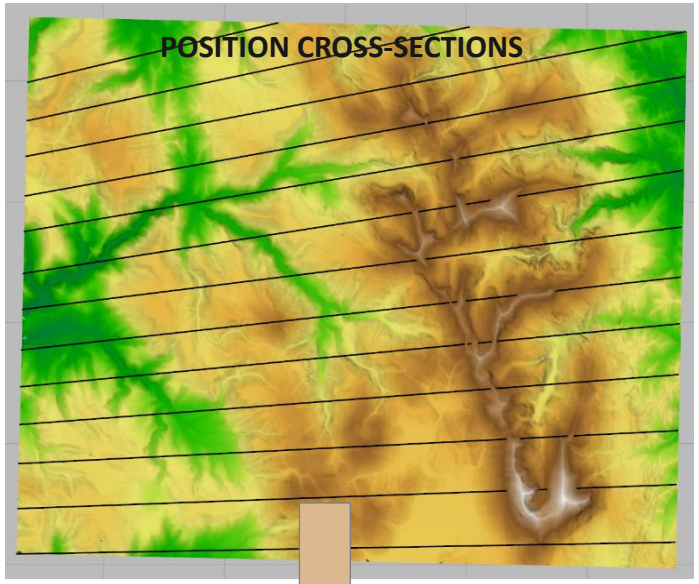


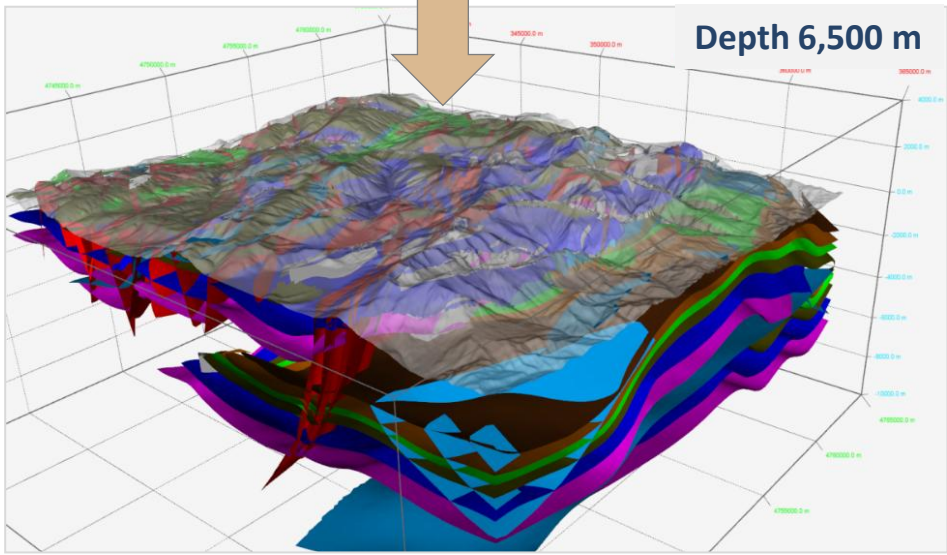
CONCEPTUAL MODEL



t al., IJG 2023

mic lines (ENI data)



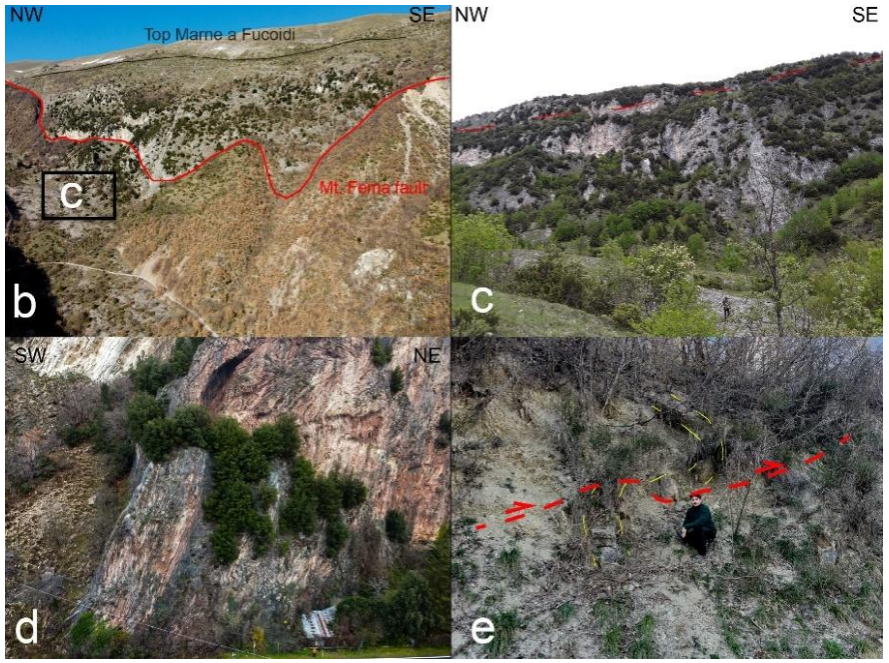


Geological 3D model Sheet 325 http://doi.org/10.15161/oar.it/agrn1-h0649

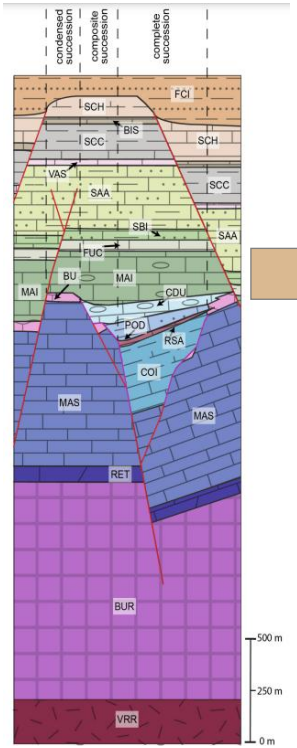
3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS

Tackling Italy's geological complexity

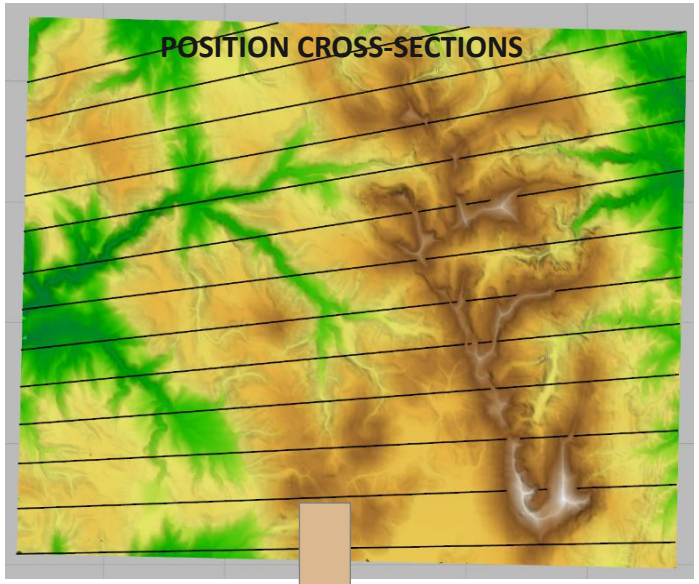
CONCEPTUAL MODEL

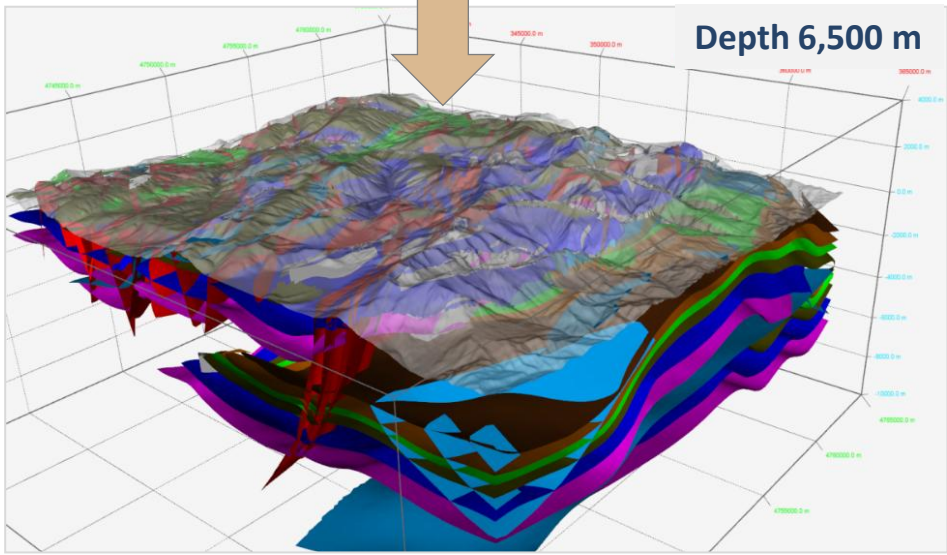


GEOLOGICAL FIELD DATA



Basilici et al., IJG 2023





Geological 3D model Sheet 325 http://doi.org/10.15161/oar.it/agrn1-h0649

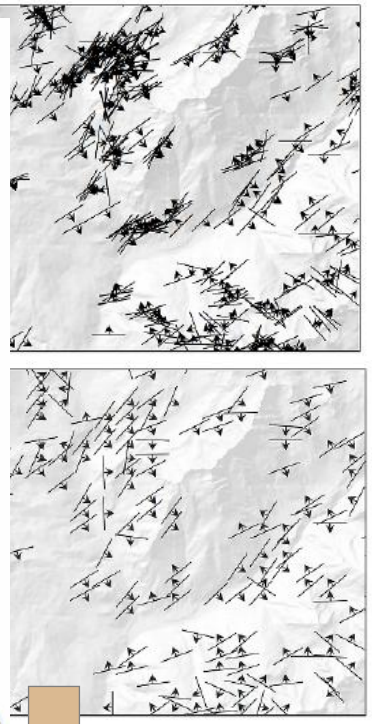
- Geometrical constraints from surface geology
- 13 balanced geological cross-sections + 2 seismic lines (ENI data)
- Software: MOVE and Petrel
- Modeling team: University of Camerino

Tackling Italy's geological complexity

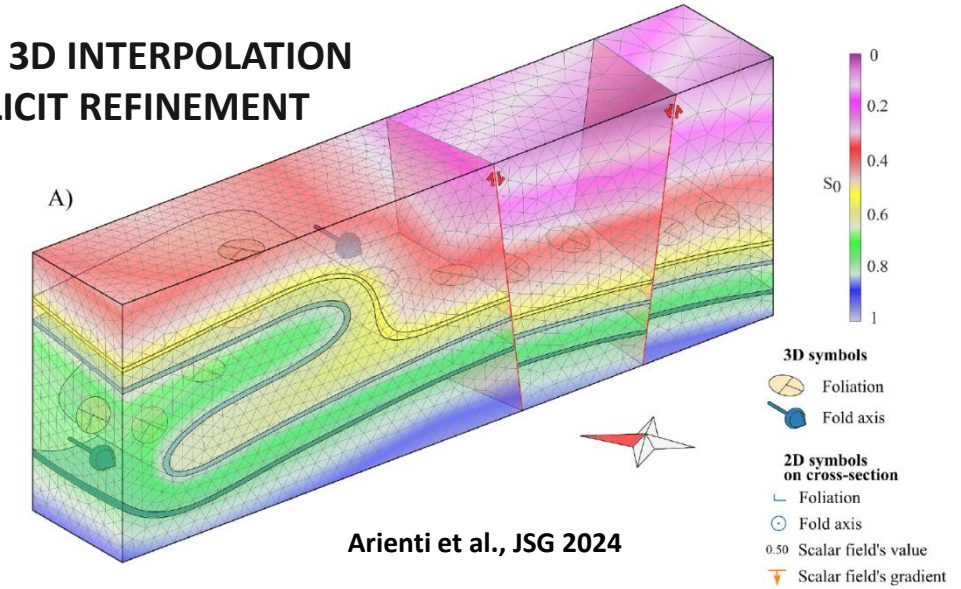
3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS



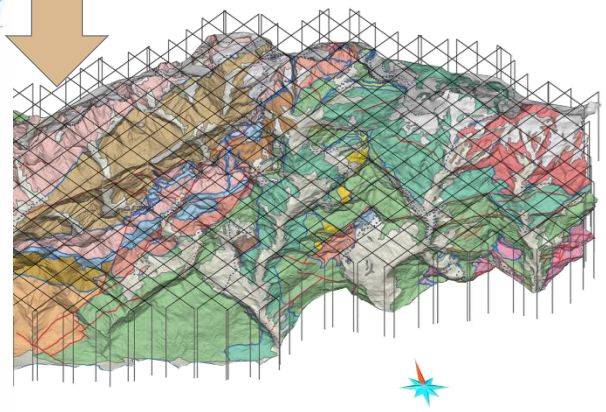
STRUCTURAL DATA



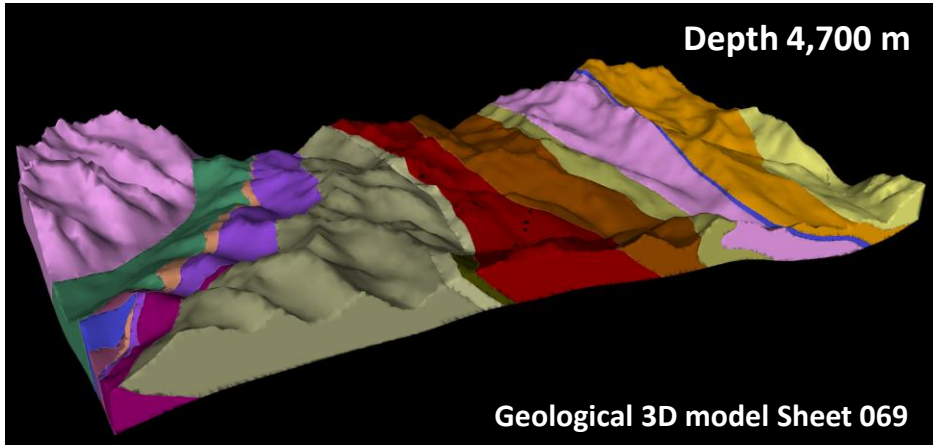
IMPLICIT 3D INTERPOLATION
+ EXPLICIT REFINEMENT



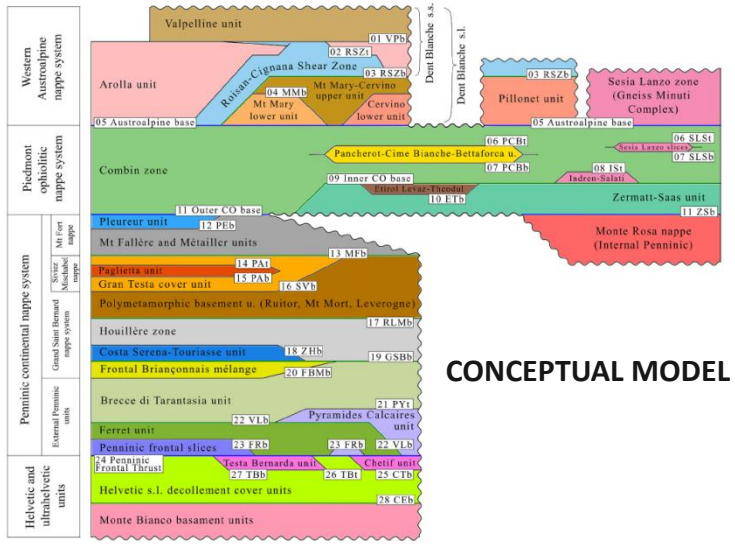
Arienti et al., JSG 2024



ORK CROSS-SECTIONS



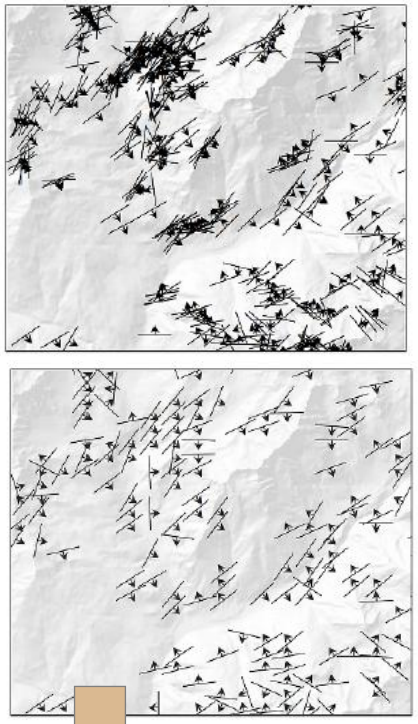
3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS



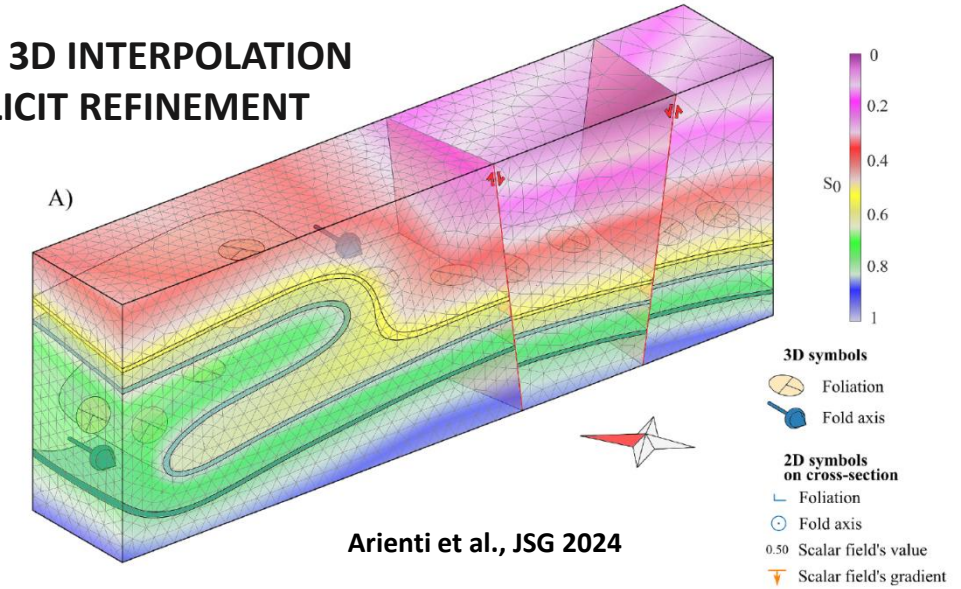
CONCEPTUAL MODEL

- Structural data from field survey
- Geological cross-sections
- Software: Pzero
- Modeling team: University of Milano Bicocca

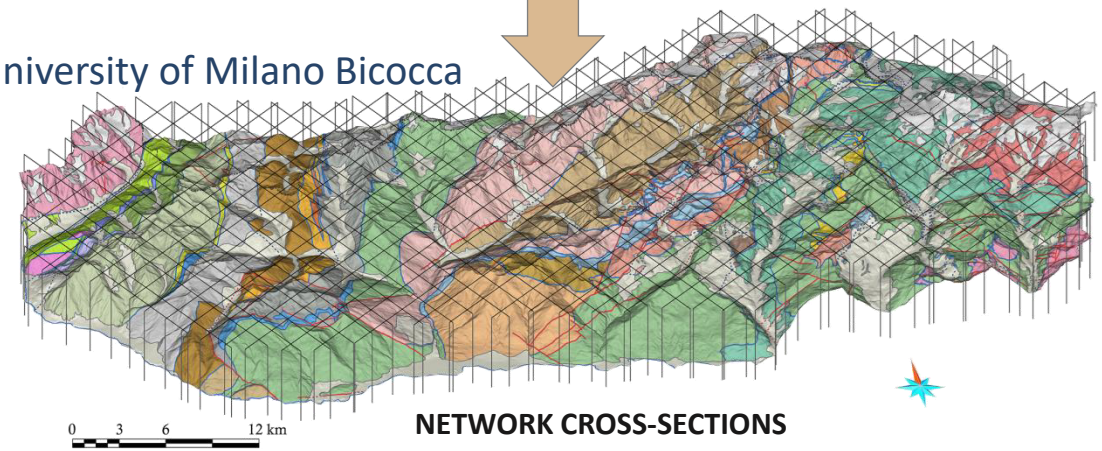
STRUCTURAL DATA



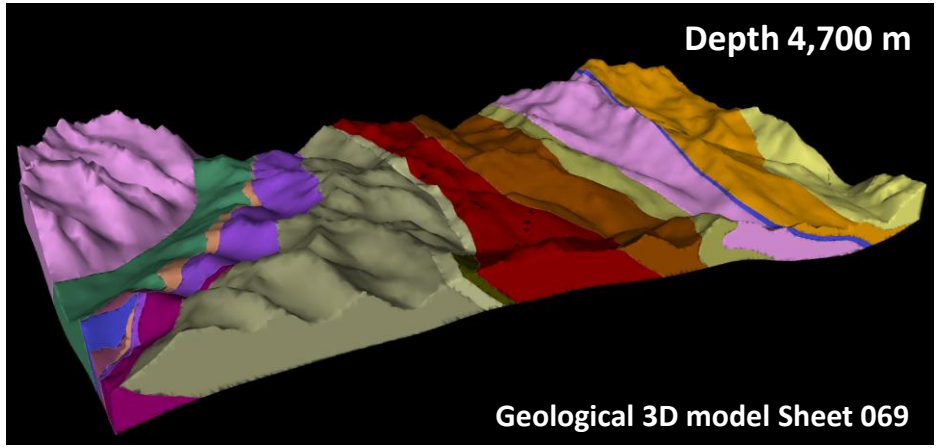
IMPLICIT 3D INTERPOLATION + EXPLICIT REFINEMENT



Arienti et al., JSG 2024



NETWORK CROSS-SECTIONS

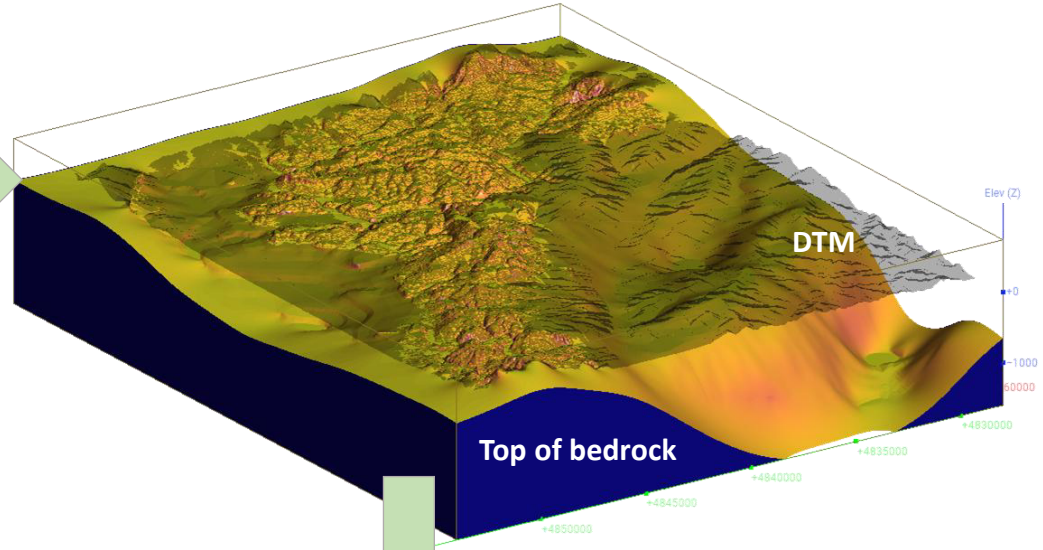


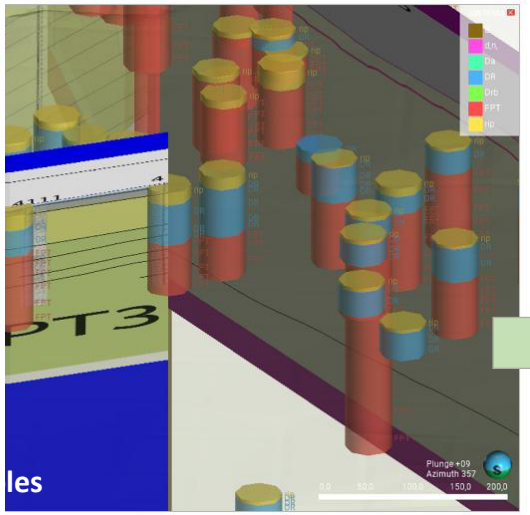
3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS

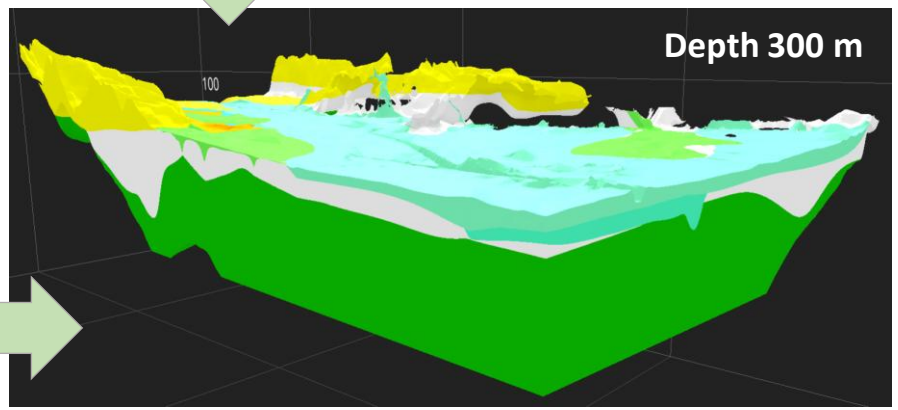
Tackling Italy's geological complexity



ıer anomaly (ENI dataset)
ıysical investigations
g borehole stratigraphies
orehole - CARG funds
e geology
ɡical cross-sections
ıre: Leapfrog
ing team: University of Firenze



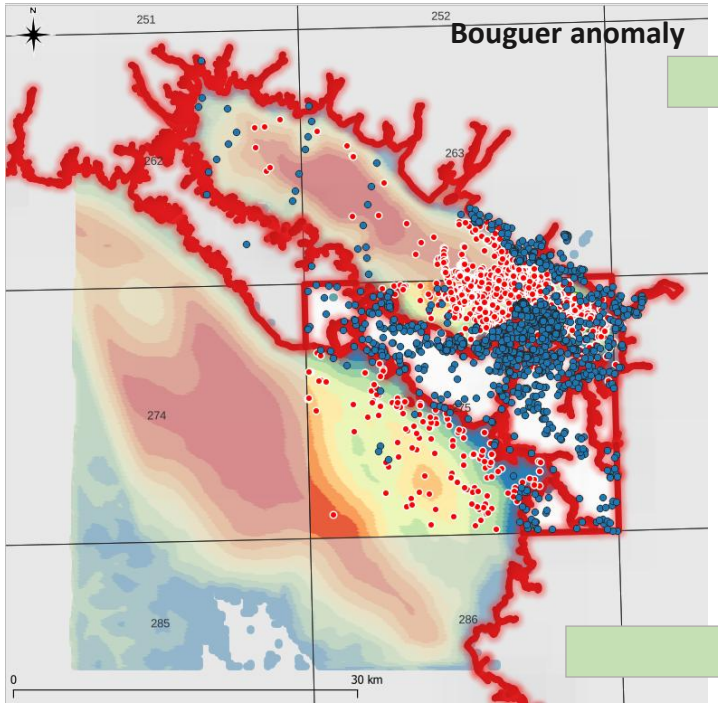




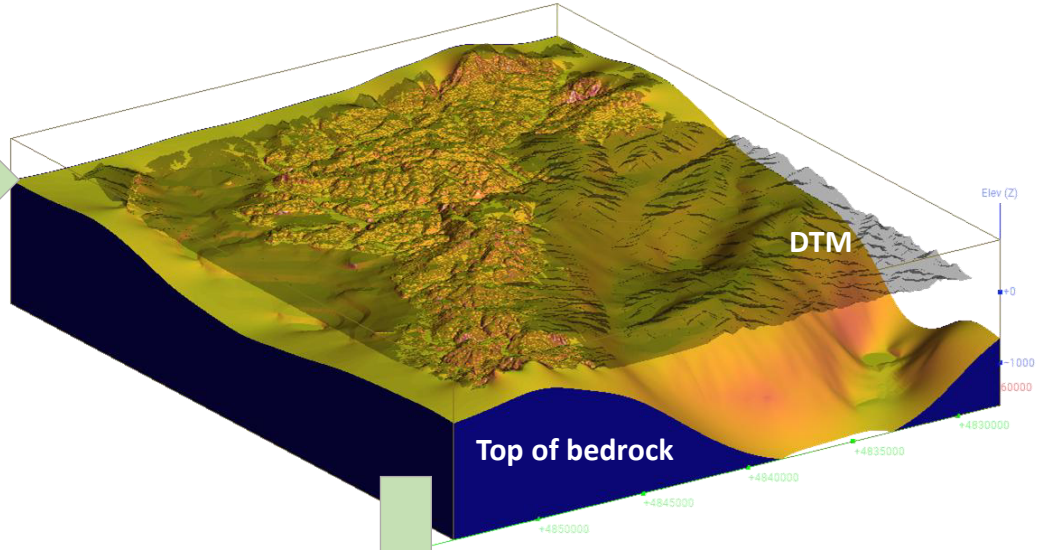
Geological 3D model Sheet 275

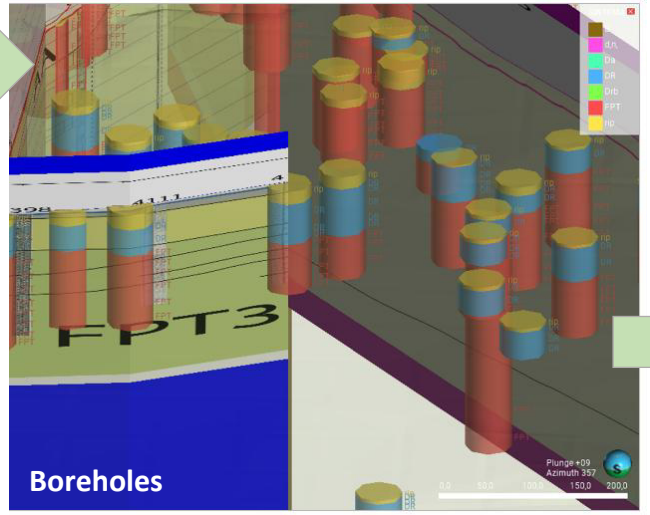
3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS

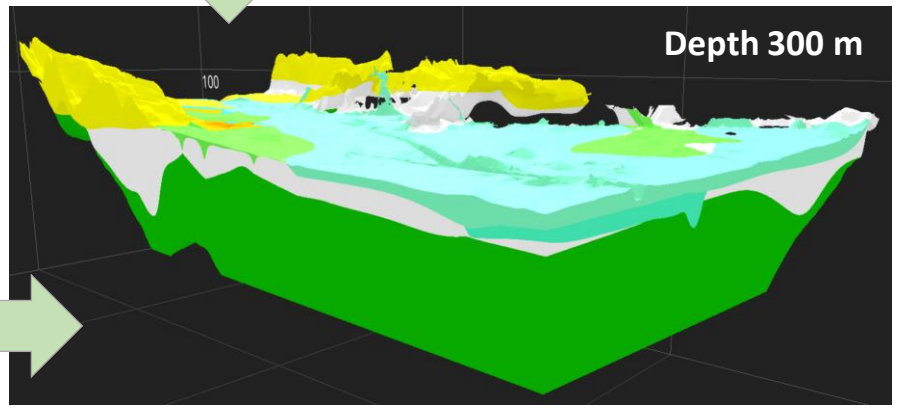
Tackling Italy's geological complexity



- Bouguer anomaly (ENI dataset)
- Geophysical investigations
- Existing borehole stratigraphies
- New borehole - CARG funds
- Surface geology
- Geological cross-sections
- Software: Leapfrog
- Modeling team: University of Firenze





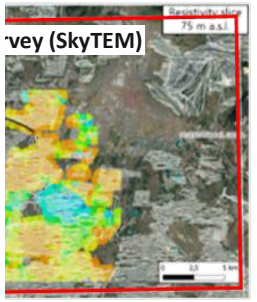


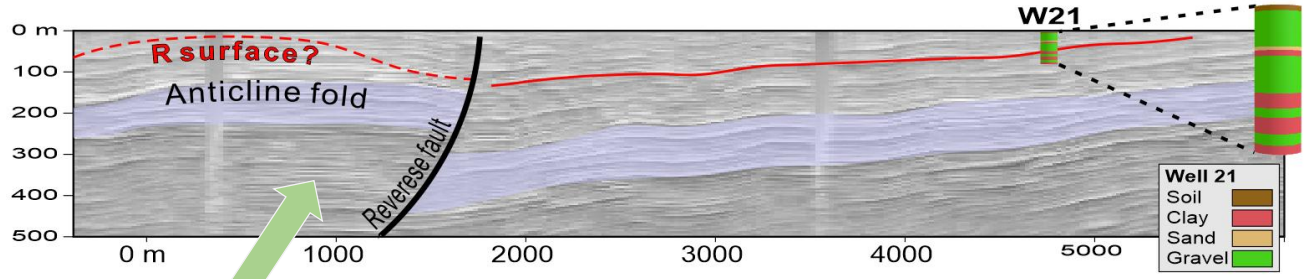
Geological 3D model Sheet 275

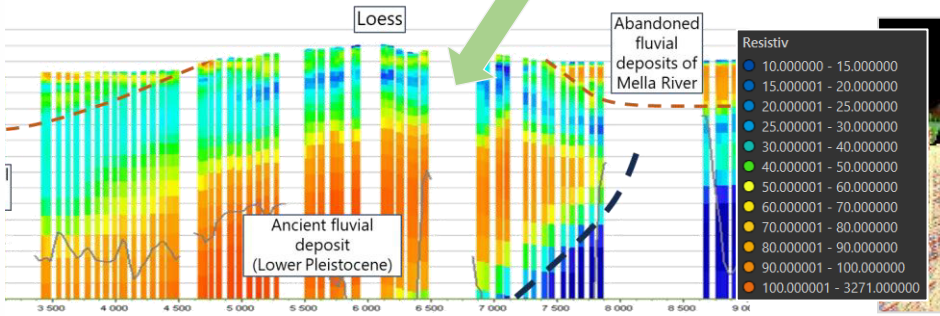
3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS

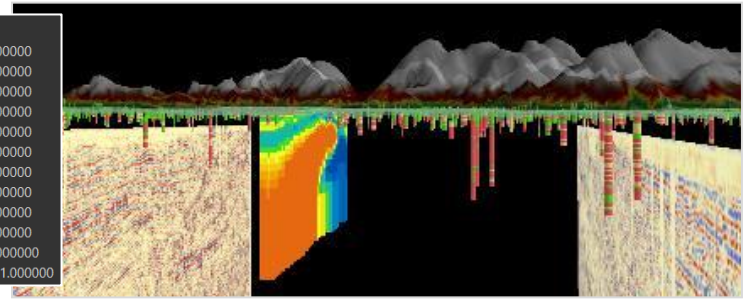


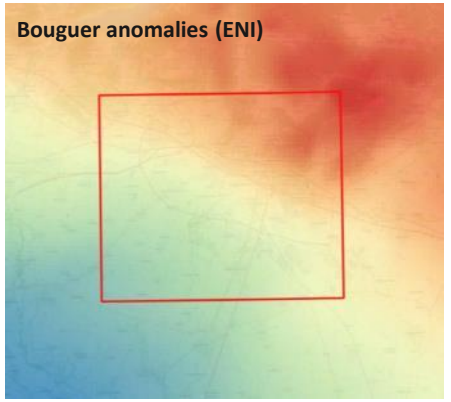
Surve
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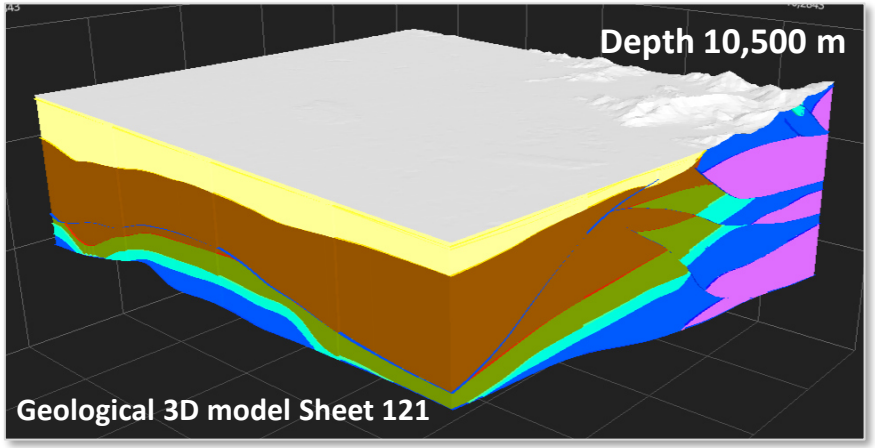






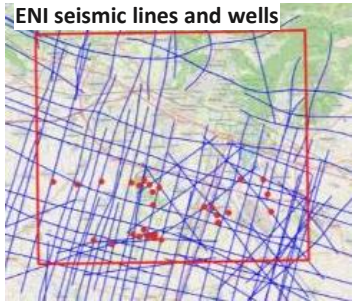


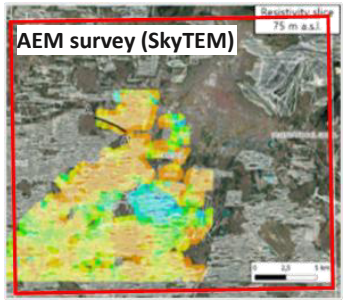


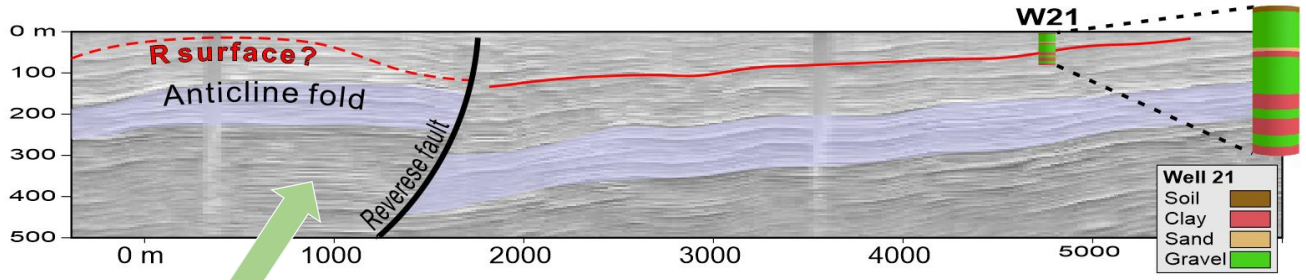


3D MODELING ACROSS DIVERSE GEOLOGICAL SETTINGS

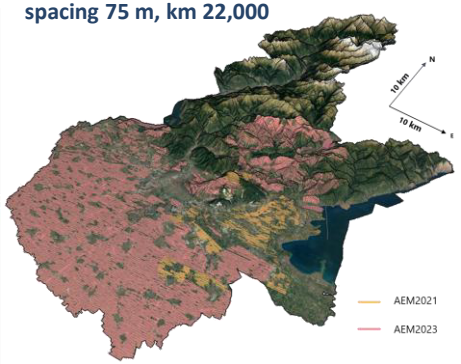
Tackling Italy's geological complexity

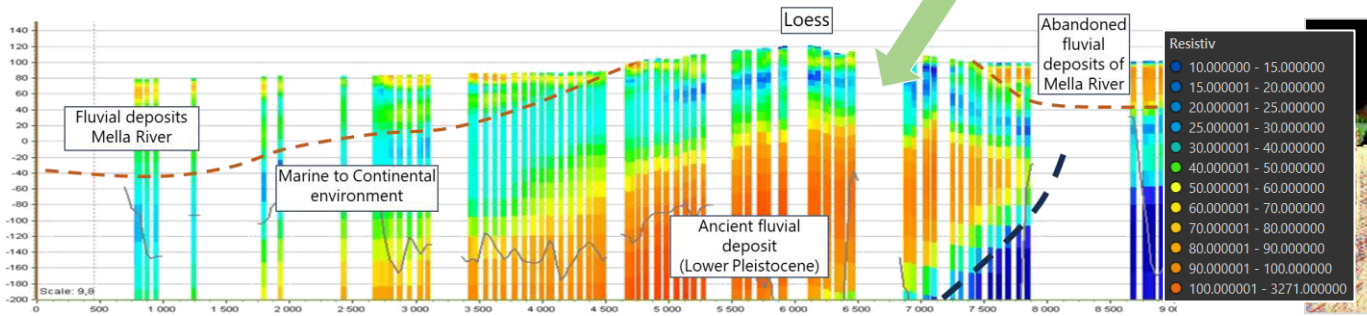


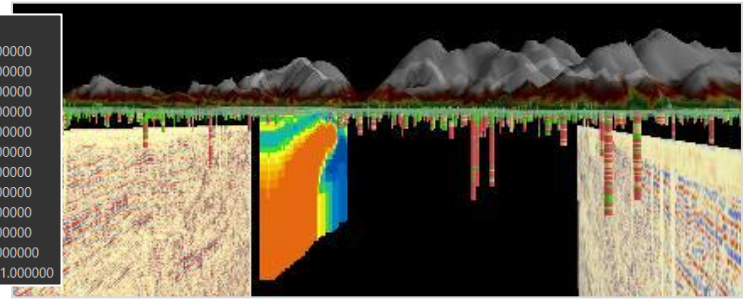




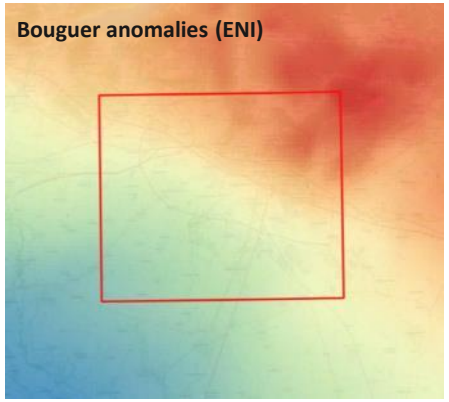
Survey AEM (SkyTEM) – prov. BS
spacing 75 m, km 22,000

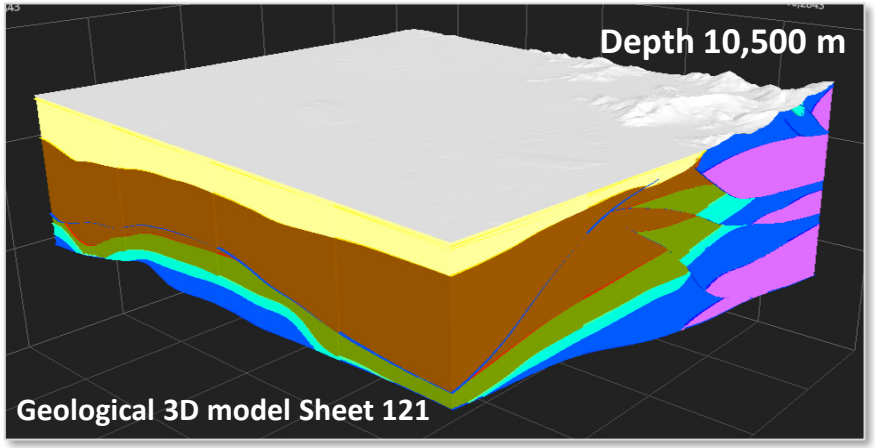






- Seismic lines
- Borehole stratigraphies
- Bouguer anomalies
- AEM survey
- Software: ArcGIS and Move
- Modeling team: CNR

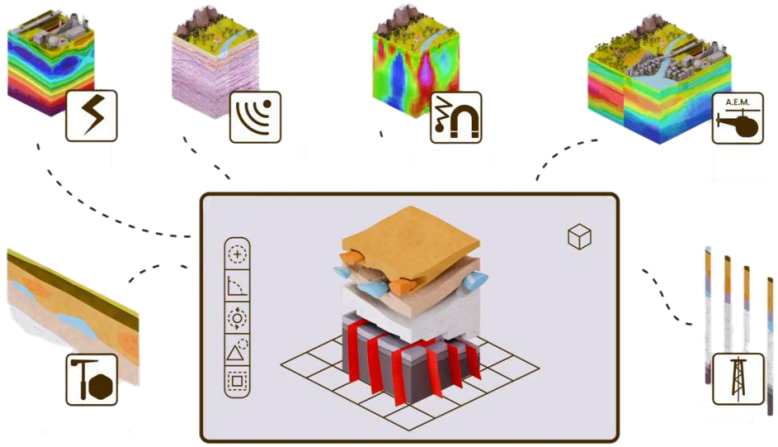




Diverse geological settings

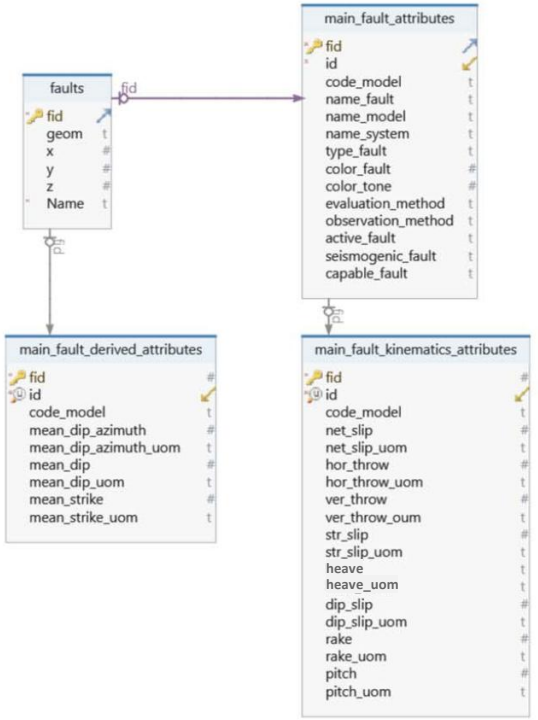
National DB of 3D Geological Models

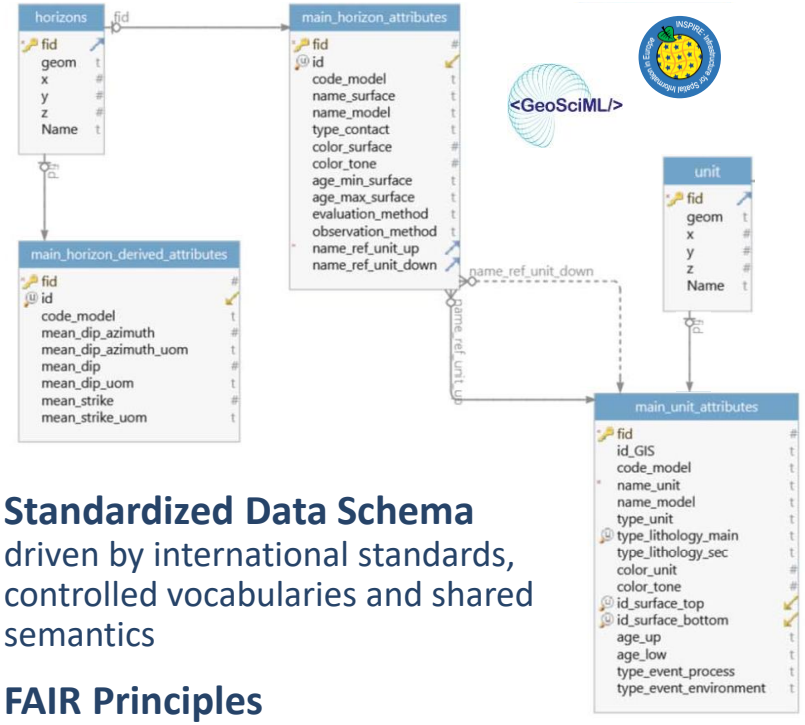
✓ **Heterogeneous input**
combining surface geology, cross-sections, boreholes, seismic lines, potential fields



✓ **No single legend**
preserving local geological realism through flexible data structures

✓ **No single software – same output**
providing flexibility for modeling teams while ensuring standardized deliverables





✓ **Standardized Data Schema**
driven by international standards, controlled vocabularies and shared semantics

✓ **FAIR Principles**
ensuring models are Findable, Accessible, Interoperable, and Reusable

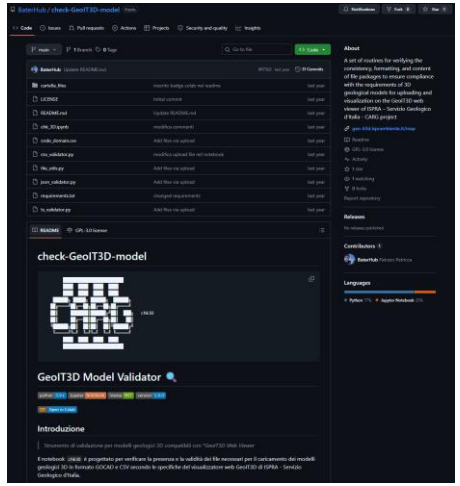
Geology & Stratigraphy
- Lithology
- Age of rocks and events
- Depositional environments

Tectonics & Hazards
- Kinematic parameters
- Fault system
- Activity

Physical properties
- Temperature
- Density
- Vp and Vs parameters

Custom open-source tool for database compliance (Petricca, 2025)

https://github.com/BaterHub/check-GeoIT3D-model




```
/ --
  |-- descriptor.json
  |-- dem.ts
  |-- faults.ts
  |-- horizons.ts
  |-- units.ts
  |-- main_fault_attributes.csv
  |-- main_fault_derived_attributes.csv
  |-- main_fault_kinematics_attributes.csv
  |-- main_horizon_attributes.csv
  |-- main_horizon_derived_attributes.csv
  |-- main_unit_attributes.csv
```

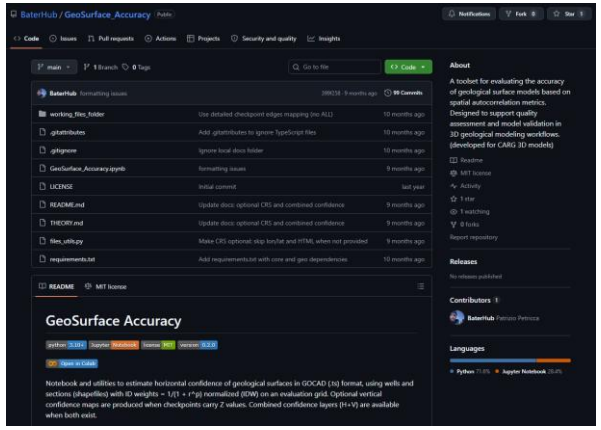
-> Open and reproducible Python notebooks
-> Based on interoperable formats

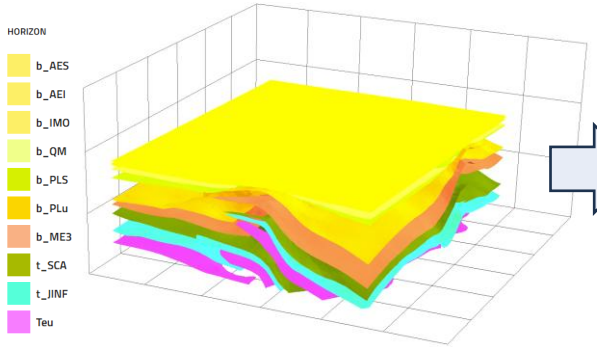
§INPUT FILES format:
- GOCAD .ts (structured surfaces)
- Tabular data .csv

§OUTPUT FILES:
- passed/failed status .log

Accuracy evaluation of modeled features based on spatial autocorrelation (Petricca, 2026)

https://github.com/BaterHub/GeoSurface_Accuracy



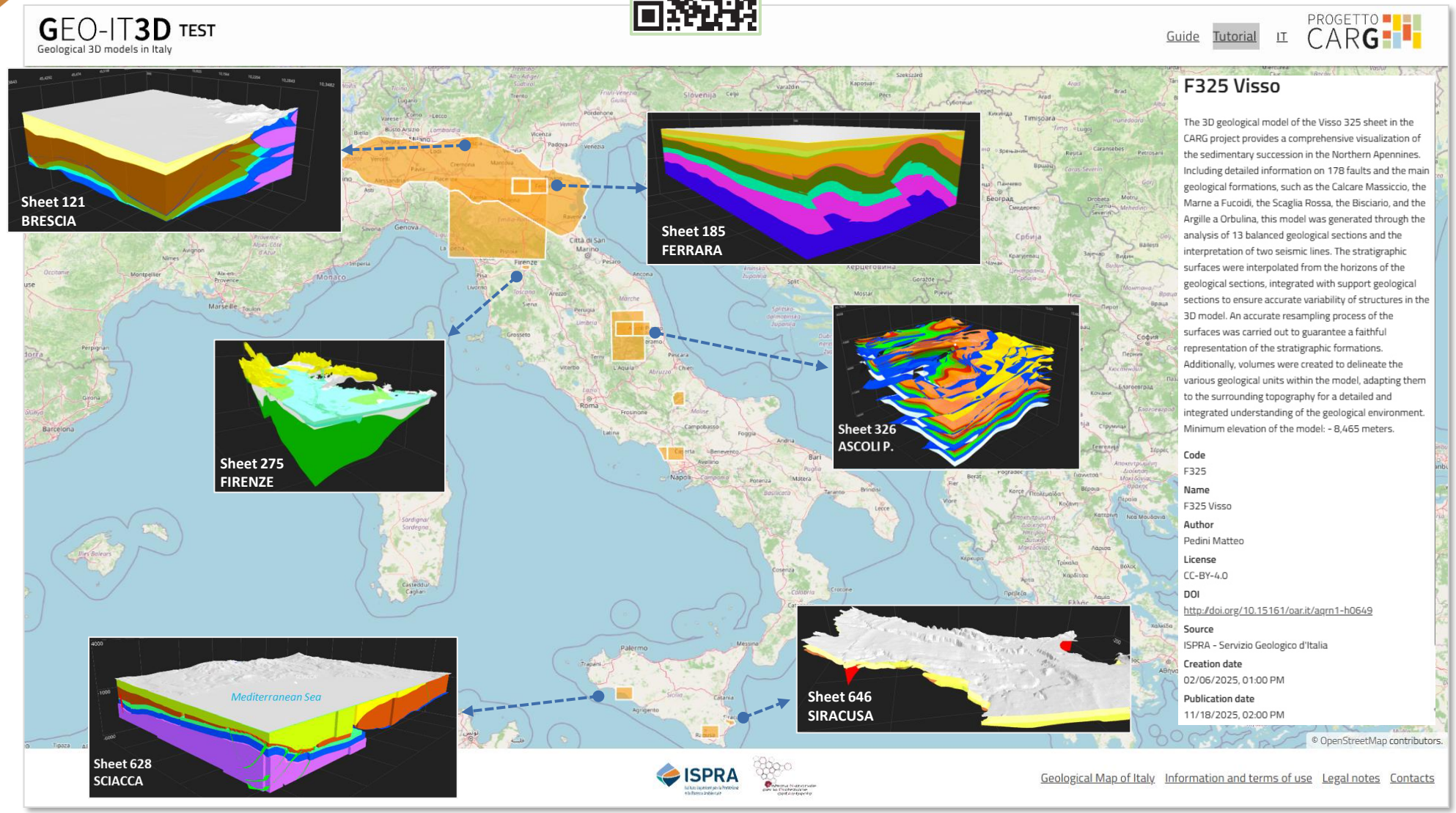


§INPUT FILES format:
- GOCAD .ts (structured surfaces)
- ESRI Shapefile .shp
- Tabular data .csv or .txt

§OUTPUT FILES:
- confidence maps .png
- numerical outcomes .csv
- statistics .csv

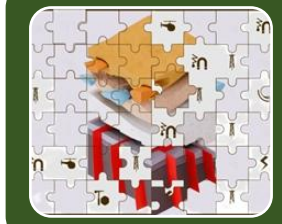
Validation & Open science

https://geo-it3d.isprambiente.it



Geo-IT3D Viewer adhering to FAIR principles (Findable, Accessible, Interoperable, Reusable)

Standardized metadata, OGC download services, and permanent DOIs for scientific traceability



Production scale

Massive technical and organizational effort required to cover the national territory



Subsurface data

Persistent need for continuous, accessible, and high-quality subsurface data



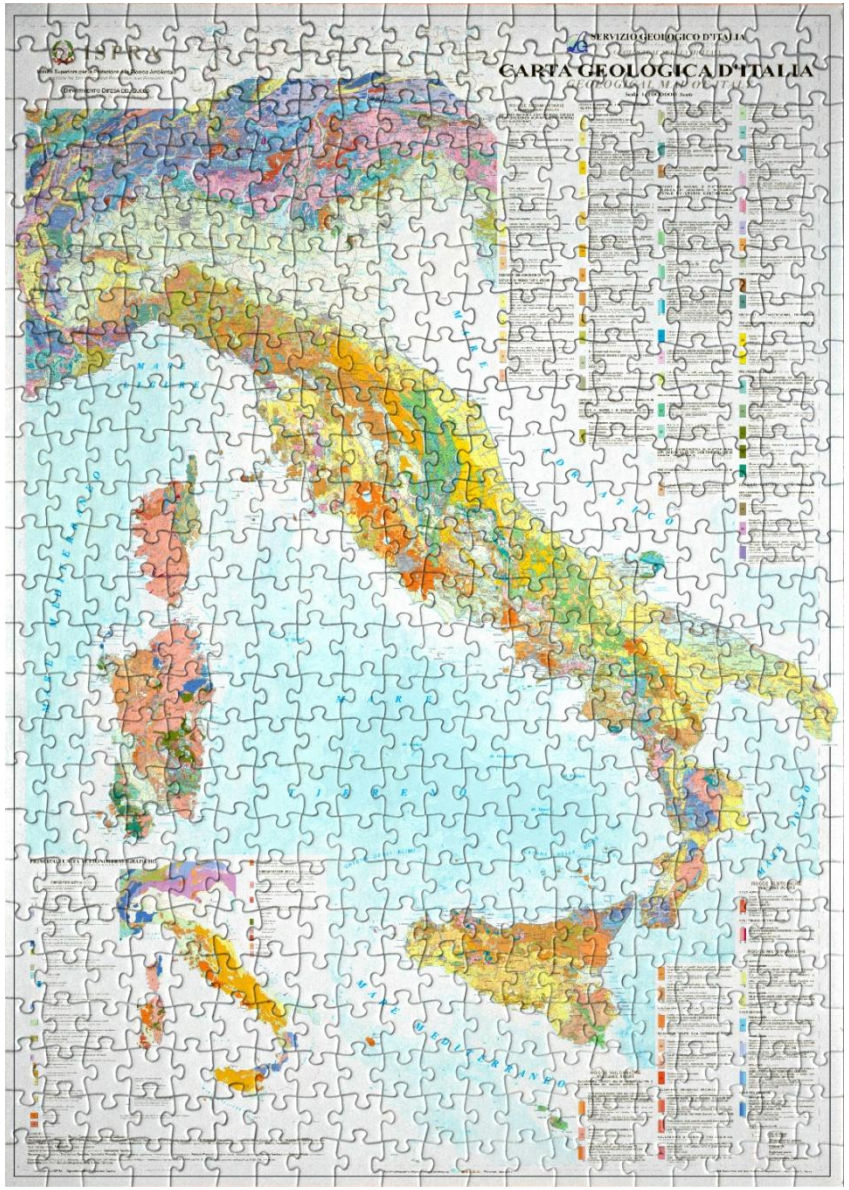
Nationwide Seamless Integration

Moving from a collection of 53 individual models to a single continuous Italian 3D model



3D Geological model of Europe

The Italian 3D geomodel as a building block of interoperable ecosystem of 3D models



ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

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