Building a geological reference platform using sequence stratigraphy combined with geostatistical tools

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Overview

- **Objective and context**
  - The French Geological Reference platform
- **Methodology for drill holes validation**
- **Results on two test areas**
- **Conclusion, perspectives**

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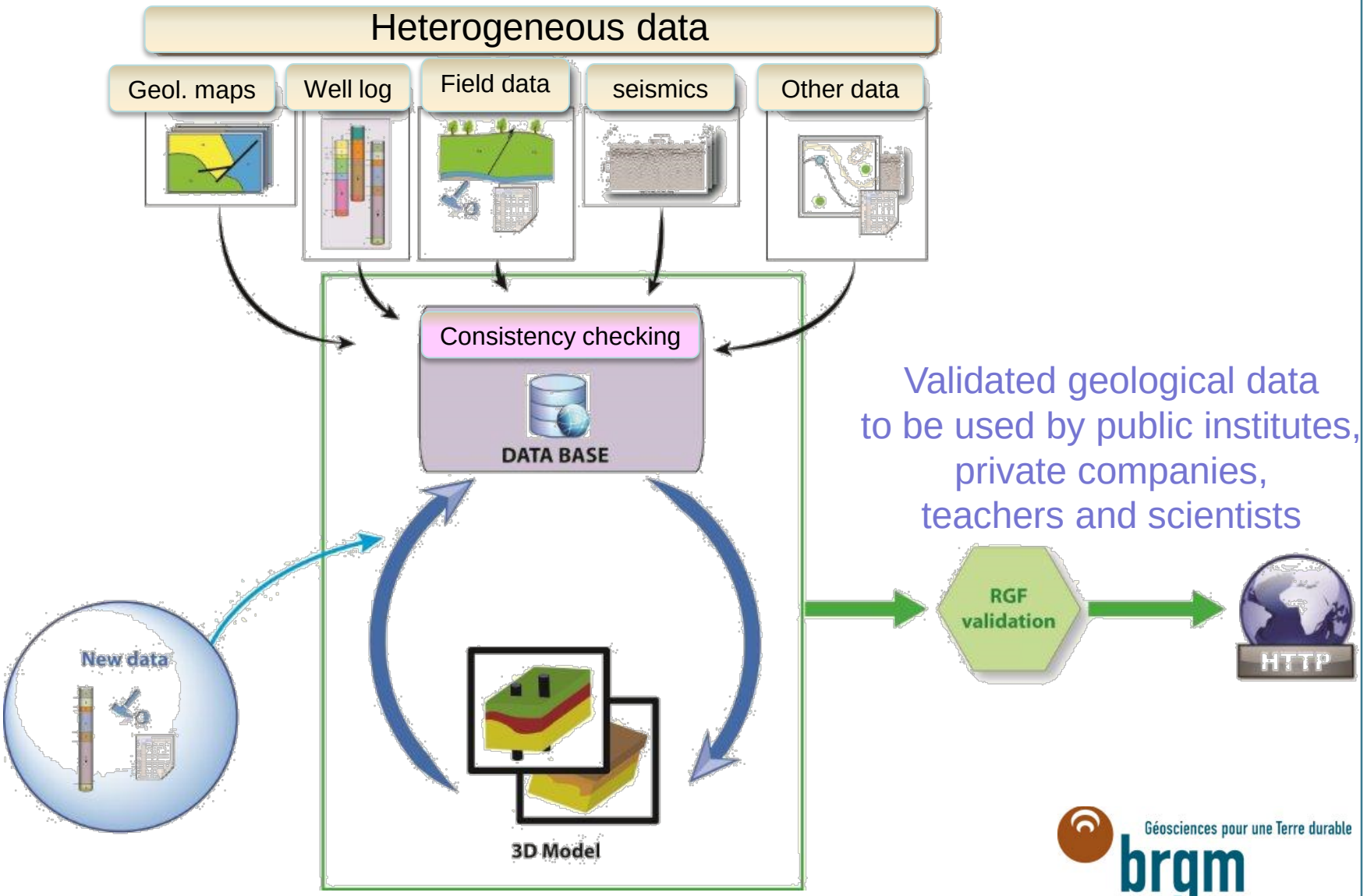
The French Geological Reference Platform (RGF)



Validated geological data
to be used by public institutes,
private companies,
teachers and scientists

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Objective of the work

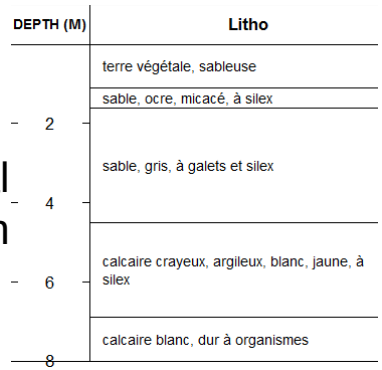
> Set up a methodology for drill holes validation

- national drill holes database
- many drill holes :

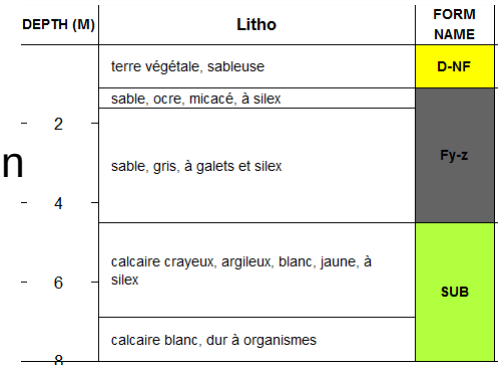
800 000 ; >90 000 with a preliminary litho-stratigraphic interpretation

- reliability: very good to very low … but unknown
- **<u>to be validated: main geological interfaces interpretation</u>**
- **automatise** the process of validation

initial description



interpretation



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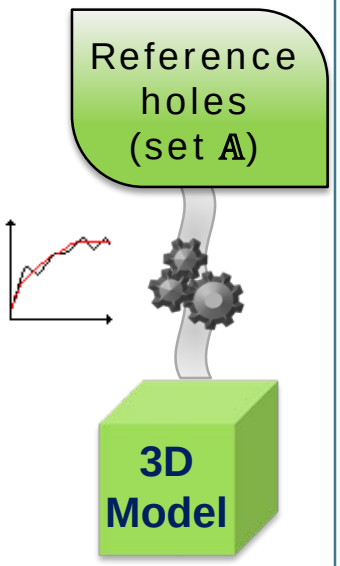
Methodology for drill hole validation

> Step 1: Build a preliminary reference (set 𝔸)

- loose network of holes owning a well log (gamma ray)
- correlation of well logs using sequence stratigraphy
- accurate litho-stratigraphy interpretation
- geostat analysis
- preliminary 3D model



> Step 2: Test other drill holes (set 𝔹)

- 𝔹 holes : unknown quality, unchecked reliability
- (cross) validation against reference set
- add validated 𝔹 drill holes to reference set 𝔸
- iterate
- update 3D model

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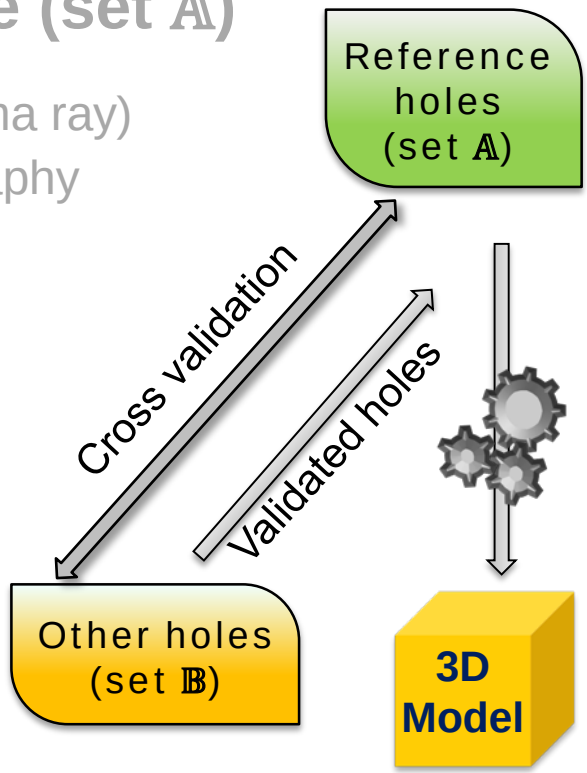

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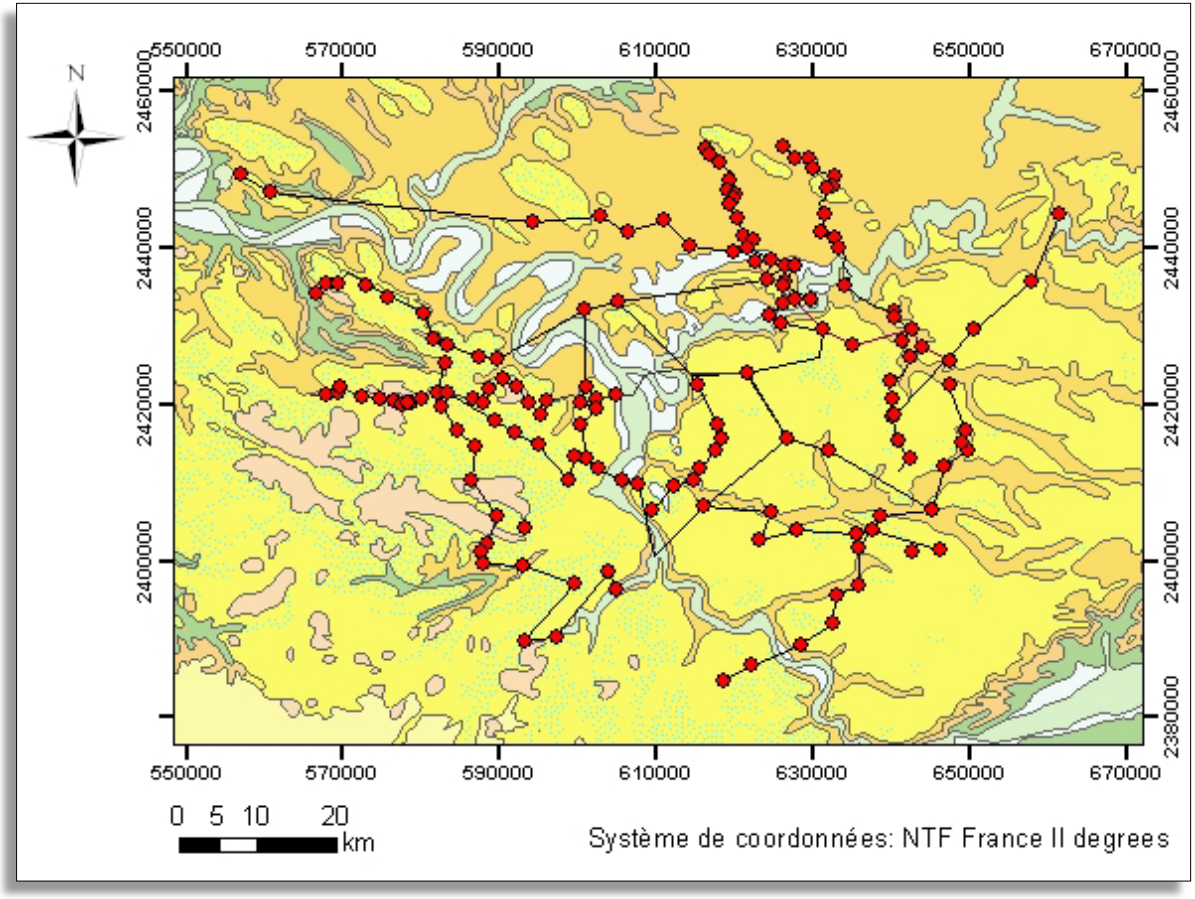
Step 1: Build a preliminary reference set (𝔸)

> select holes with well log

- Example Paris area: 168 holes among ≫ 7 000 holes

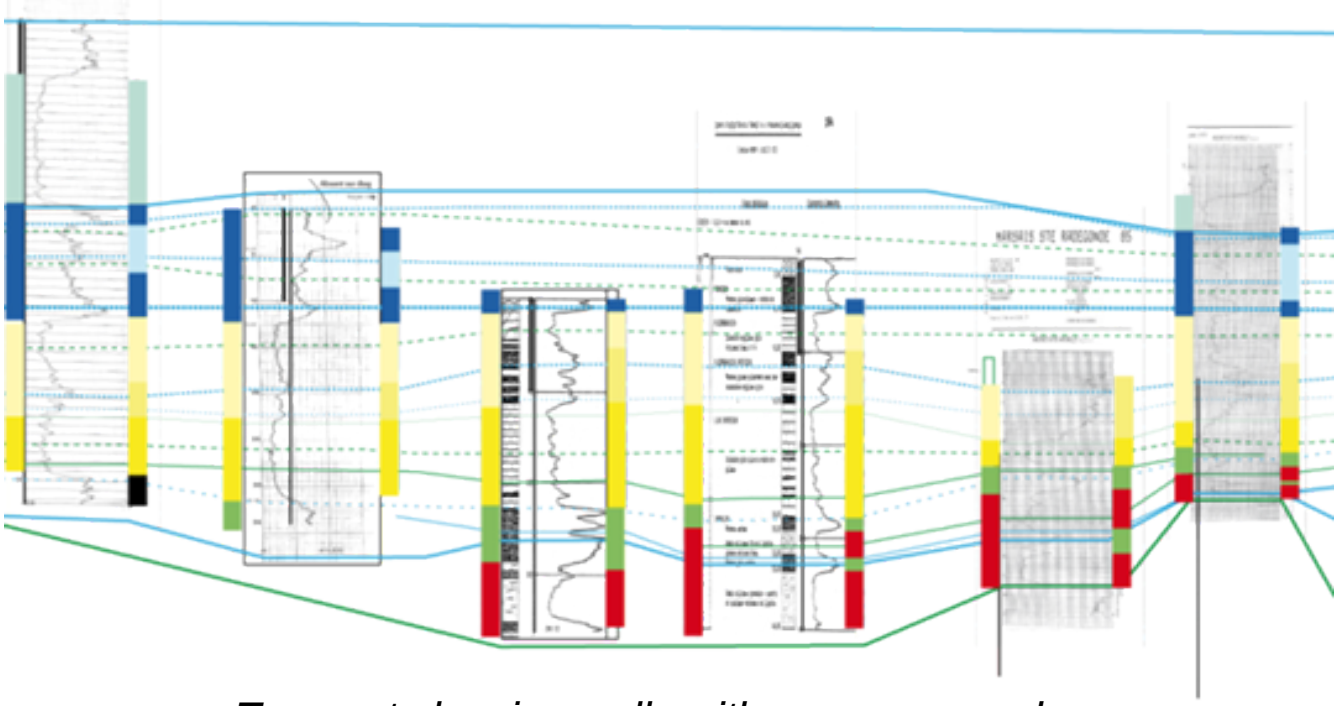


120 km × 80 km area

Step 1: Build a preliminary reference set (𝔸)

> Sequence stratigraphy correlation along transects

- surfaces (time- lines) corresponding to deposition context change
- restore sedimentary bodies geometry
- enables facies simulation within each body



Transect showing wells with a gamma ray log

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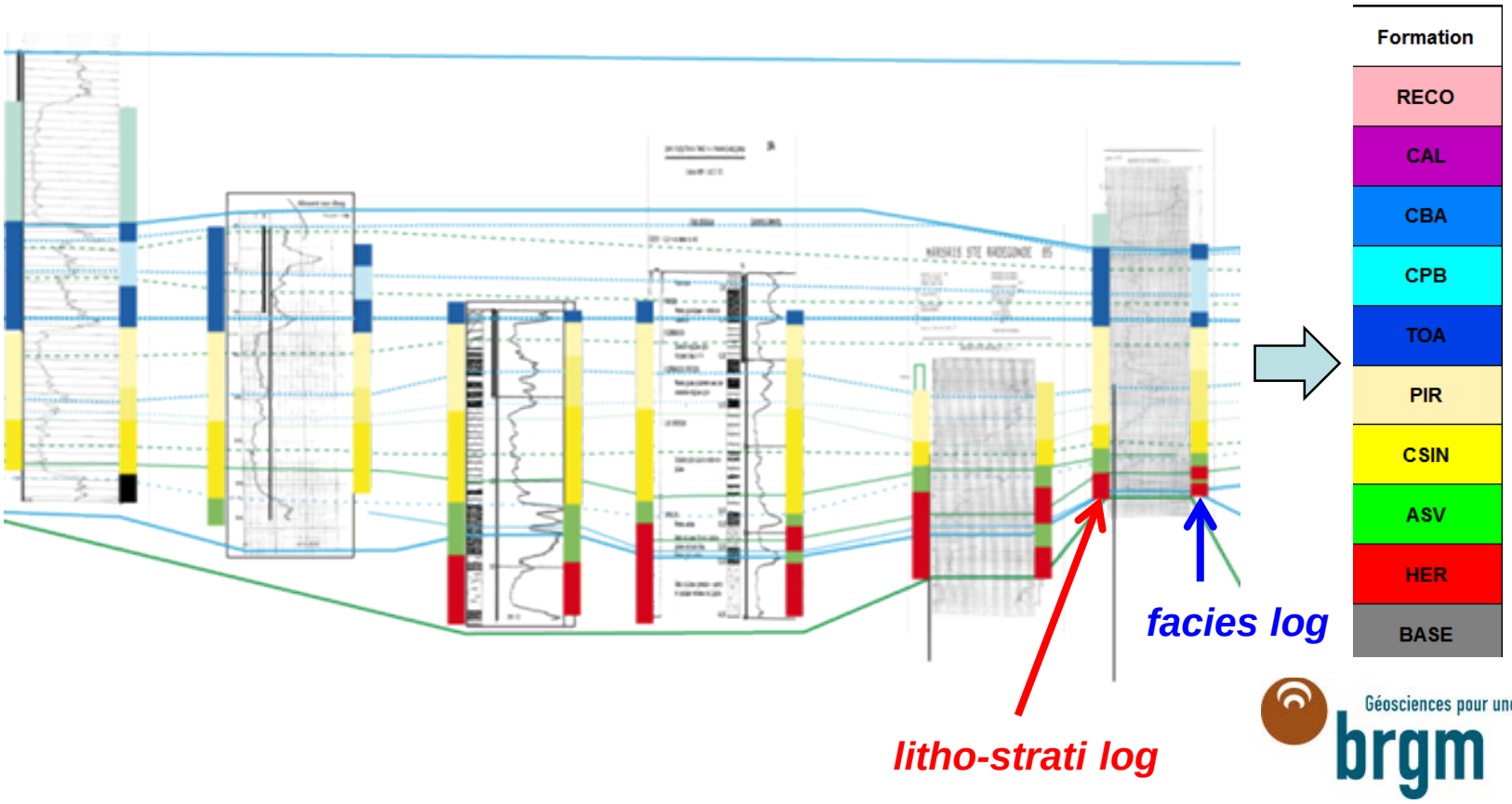
Step 1: Build a preliminary reference set (𝔸)

> Litho stratigraphic pile

- correct litho-stratigraphic surfaces deduced from sequence stratigraphy



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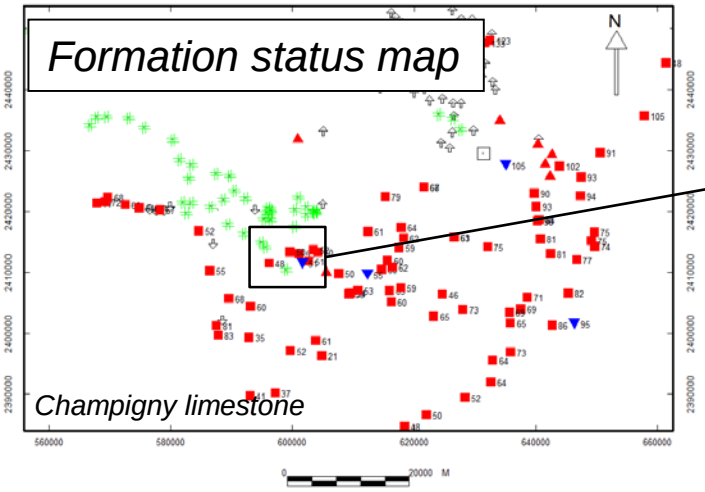
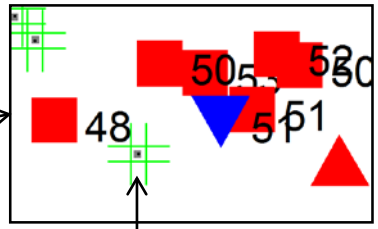
Step 1: Geostatistical analysis of reference drill holes

> Top or Base of each formation of the « pile »





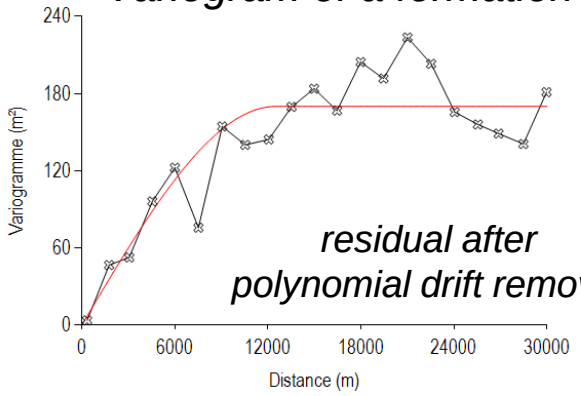
formation GAP

■ TOP and BASE intersected

▼ TOP only

▲ BASE only

Variogram of a formation Top



> Consistency check

- cross validation
- inequality constraints
- other info (DTM, geological map)

> Process the whole pile

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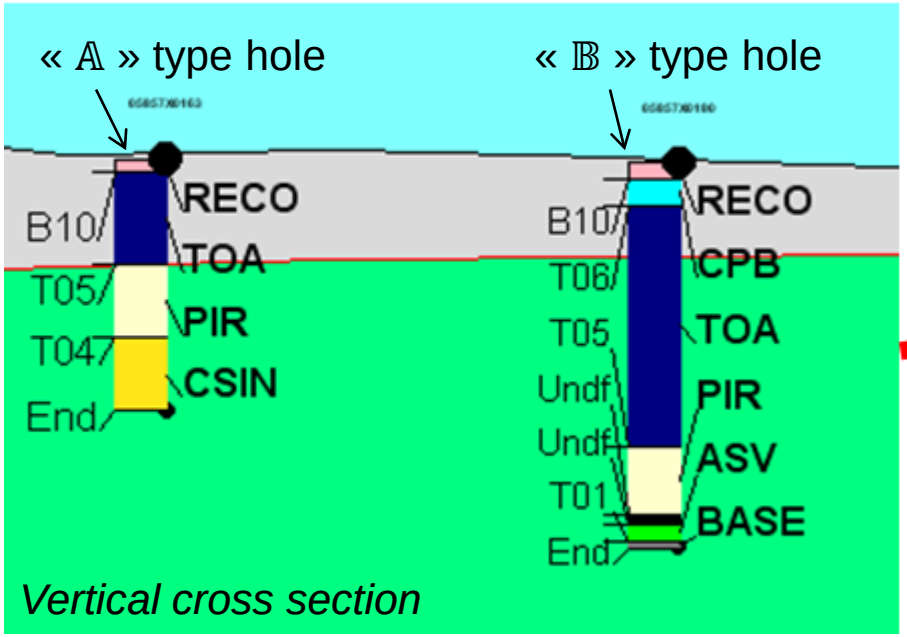
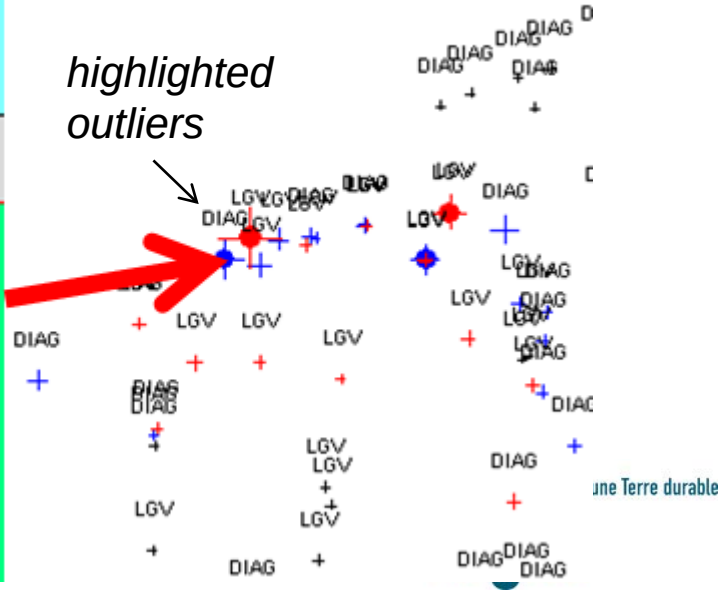
Step 2: Test other drill holes ($\mathbb{B}$)

> Cross validation of $\mathbb{B}$ against reference set ($\mathbb{A}$)

- $T_{\mathbb{A}}$ = top of a formation on « $\mathbb{A}$ » holes (resp. $T_{\mathbb{B}}$ for « $\mathbb{B}$ » holes)

- estimate $T_{\mathbb{B}}$ from $T_{\mathbb{A}}$ only
- compute $(T^*_{\mathbb{B}} - T_{\mathbb{B}})$ and $(T^*_{\mathbb{B}} - T_{\mathbb{B}})/\sigma_K$ — *kriging standard deviation*
- holes with inequality constraint on $T_{\mathbb{B}}$ taken into account
- automatic maps and cross sections highlighting potential errors





Step 2: Test other drill holes ($\mathbb{B}$)

> Validating drill holes « $\mathbb{B}$ »

- consistent holes are validated automatically ⇒ added to set « $\mathbb{A}$ »

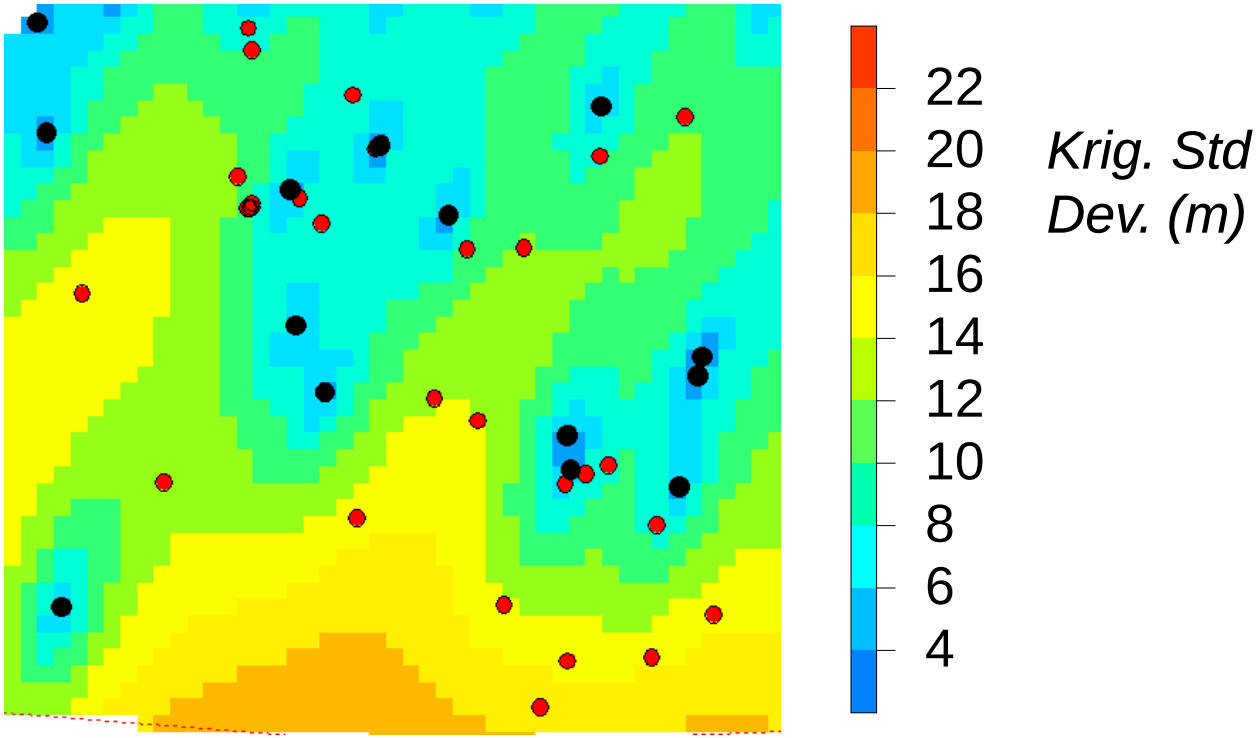
		Estimation error	
		Low $\lvert T^*_{\mathbb{B}} - T_{\mathbb{B}} \rvert$	**High** $\lvert T^*_{\mathbb{B}} - T_{\mathbb{B}} \rvert$
Deviation to the model	$\lvert T^*_{\mathbb{B}} - T_{\mathbb{B}} \rvert / \sigma_K < 2$	hole $\mathbb{B}$ validated	hole $\mathbb{B}$ to be verified
	$\lvert T^*_{\mathbb{B}} - T_{\mathbb{B}} \rvert / \sigma_K > 2$	hole $\mathbb{B}$ to be verified	hole $\mathbb{B}$ to be verified

- other holes: to be verified manually later
- iterate process

Step 2: Test other drill holes (set 𝔹)

> Holes to check manually

- outliers of cross validation, critical areas or formations
- kriging standard deviation map → next candidate for validation



- Reference holes + already validated « 𝔹 » holes
- « 𝔹 » holes waiting for validation

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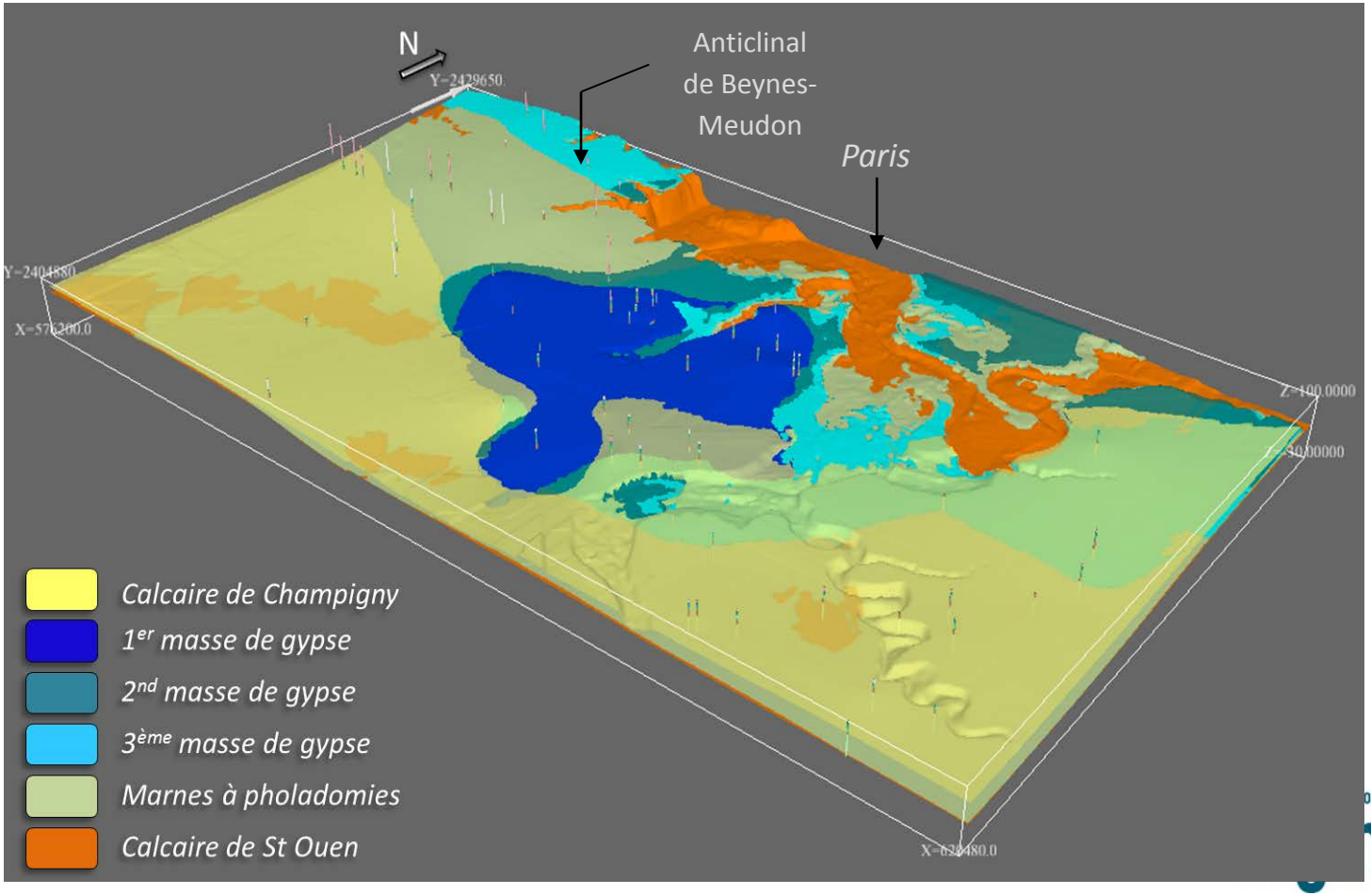
Step 2: Test other drill holes (𝔹)

> 3D model from « 𝔸 » + validated « 𝔹 »

- → cross sections and isopach maps ⇒ model verification

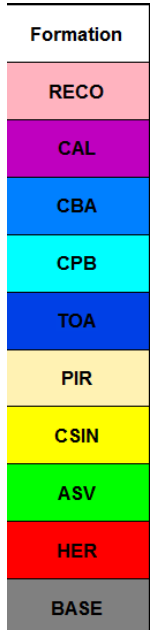


Methodology for drill hole validation

> Automatisation

- R-scripts and Isatis batch for methodology testing
- In-house software (**GDM-MultiLayer**) to be used by geologists
  - data consistency verification
  - geostat analysis
  - cross validation,
  - automatic 3D model buiding
  - automatic maps and sections

geological pile



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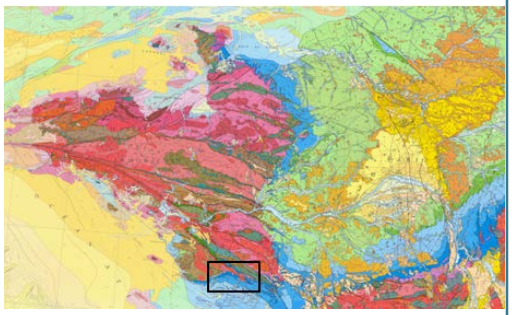
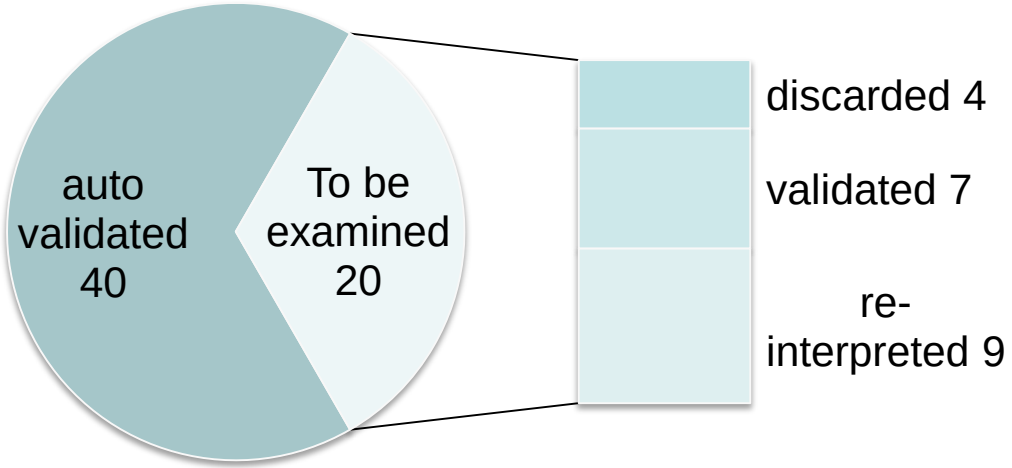
North-aquitanian basin test zone

> Holes used/validated

- 117 reference wells (set 𝔸) – 10 formations
- 60 drill holes to be validated (set 𝔹) for Toarcian :



Jurassic formation
Carbonate ramp



30% reduction for average kriging standard dev.

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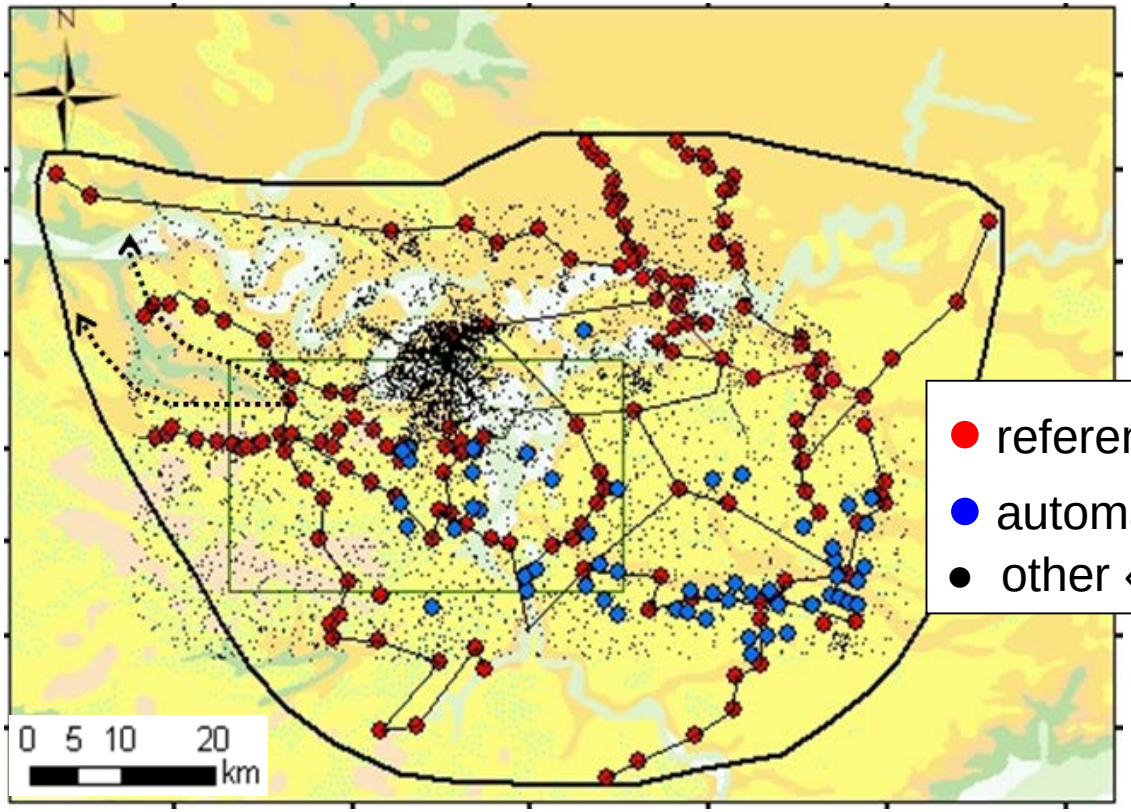
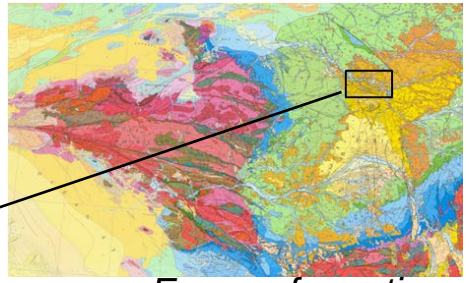
Paris basin test zone

> Drill hole validation

- 7000 holes to be validated (set 𝔹) - 168 holes in reference set (𝔸)
- « *Champigny* » formation : 137 holes tested in set 𝔹
- 48% of holes automatically validated





Eocene formations
Lacustrine/Shallow sea

- reference holes
- automatically validated «𝔹» holes
- other «𝔹» holes

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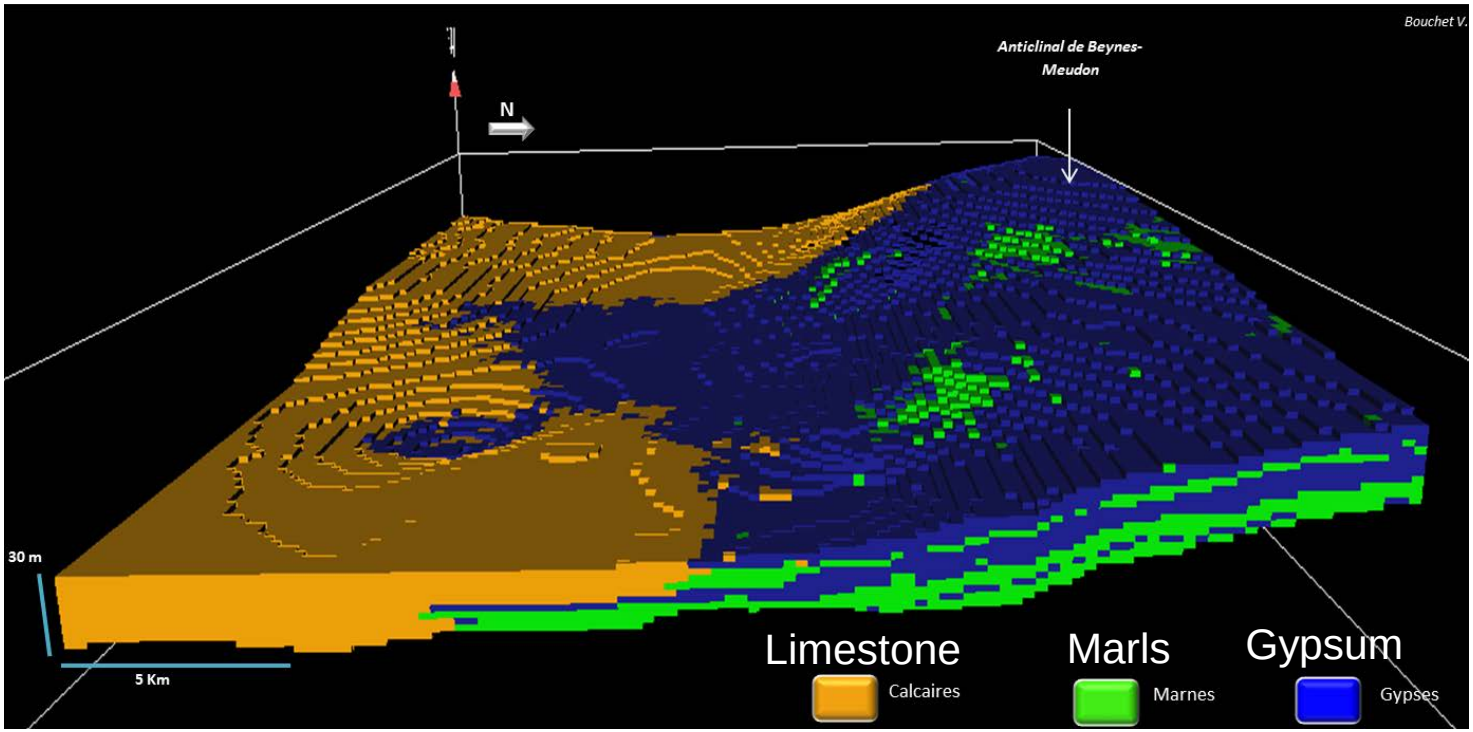
Paris basin test zone

> Facies (plurigaussian) simulation

- Assess overal interpretation



30km * 20km * 30m

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> Methodology for drill holes validation

- geological concepts + geostatistics basic tools
- helps finding quickly « good » drill holes and eliminating « bad » drill holes in a large dataset

> Semi automatic procedures

- time saving
- repeatability
- accessible to non geostatistician

> Perspectives

- improve automatisation
- what to do with non « auto-validated » holes ?
- assign a « quality index » to validated and non validated holes ?
- more facies simulation / 3D model

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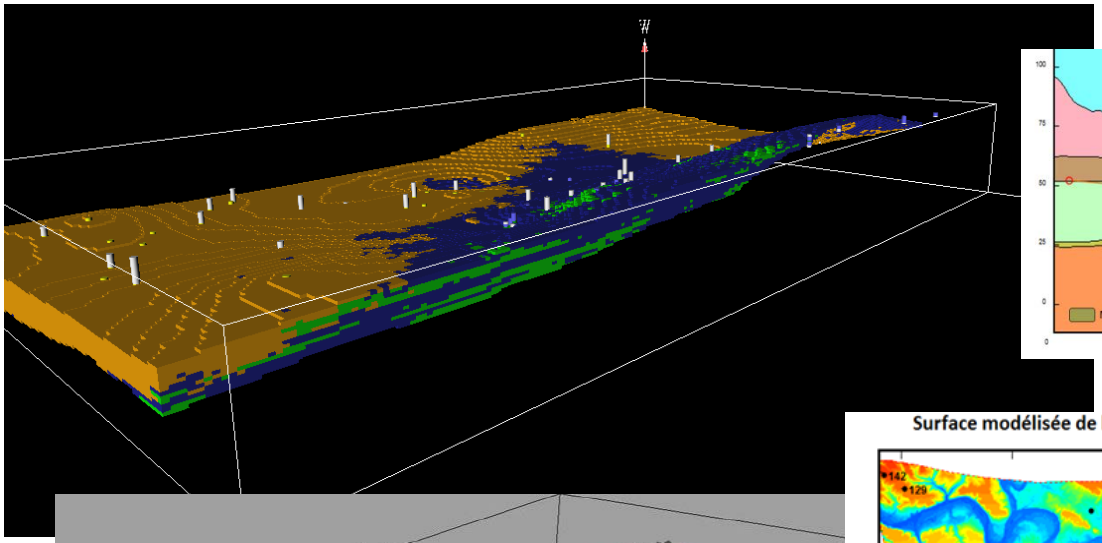
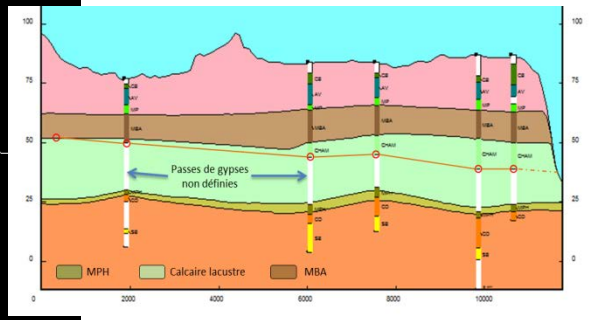
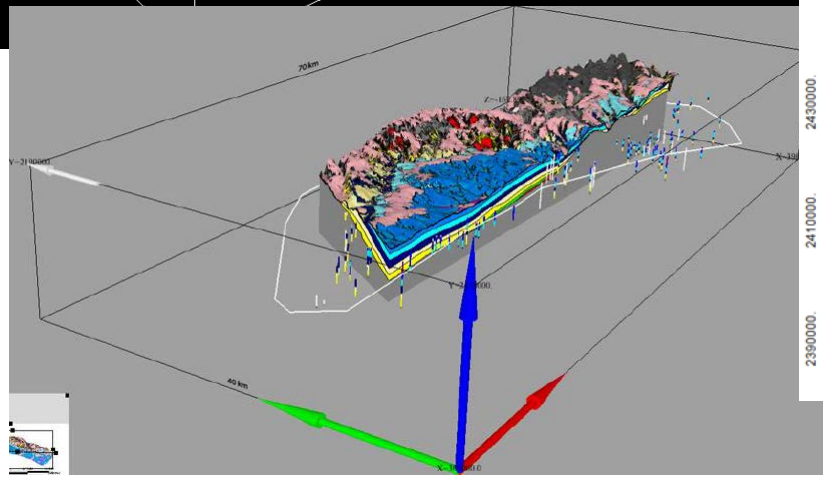
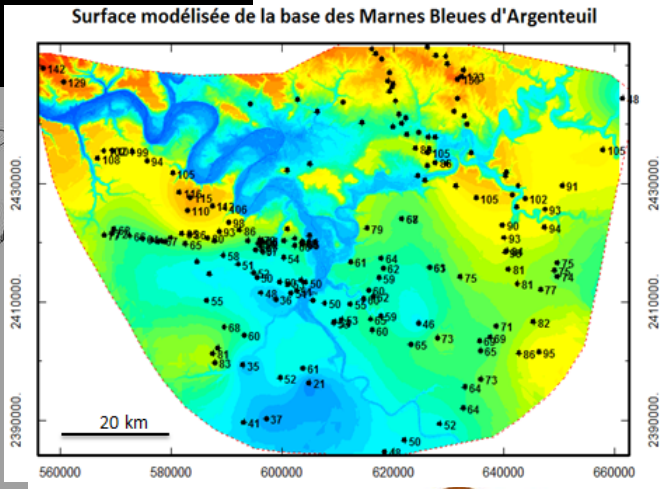
Thank you for your attention !









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