The Great Oolite Formation (Middle Jurassic) from the Upper Rhine Graben: sedimentological and mineralogical characterization from the Chalampé Well, and implications for geothermal reservoir

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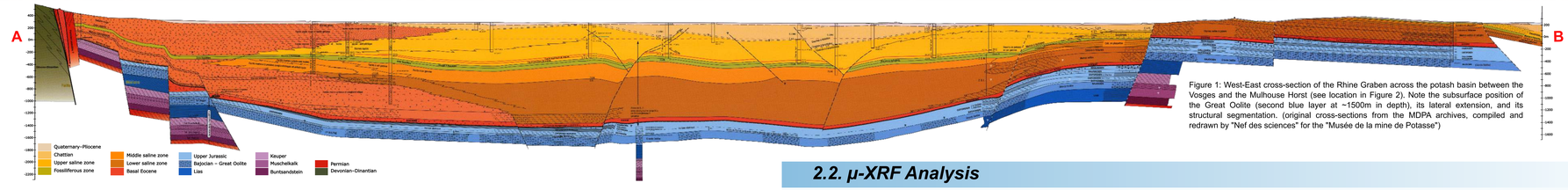


Figure 1: West-East cross-section of the Rhine Graben across the potash basin between the Vosges and the Mulhouse Horst (see location in Figure 2). Note the subsurface position of the Great Oolite (second blue layer at ~1500m in depth), its lateral extension, and its structural segmentation. (original cross-sections from the MDPA archives, compiled and redrawn by "Nef des sciences" for the "Musée de la mine de Potasse")

1. Introduction to Great Oolite Formation

- Middle Jurassic (Dogger) - upper Bajocian to lower Bathonian
- Carbonate, tide-influenced shallow epicontinental sea
- Low-temperature geothermal reservoir in the Paris Basin

In the Upper Rhine Graben (URG):

- Potential intermediate-depth for geothermal reservoir
- Possible reinjection reservoir
- Depth to GO: ~500 - 2500m increasing northward
- Thickness: ~120 - 0m decreasing northward
- Partial surface exposure along rift shoulders
- Low matrix porosity & medium to high fractured permeability
- Geothermal gradient: 50 - 80°C

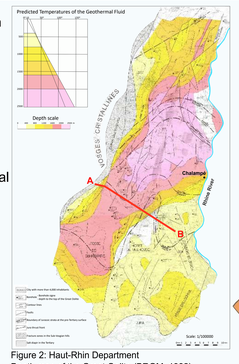


Figure 2: Haut-Rhin Department
Depth map of the Great Oolite (BRGM, 1982)

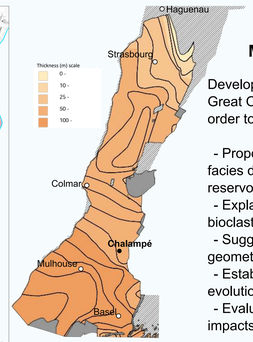


Figure 3: Thickness map of the Great Oolite / Hauptrogenstein Formation (GeORG, 2012)

Main objectives

Develop geological knowledge of the Great Oolite Formation in the URG in order to :

- Propose facies model to predict facies distribution, thickness, and reservoir properties
- Explain fine-grained muddy bioclastic and oolitic intervals
- Suggest a reservoir stratal and geometrical model
- Establish porosity and permeability evolution
- Evaluate fractures and stylolites impacts

2. Materials & Methodology

64 core samples from the Chalampé key reference borehole

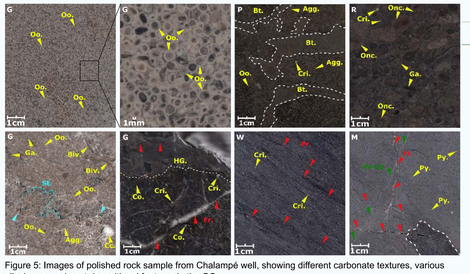
Borehole Fully penetrates GO in the URG (to ~1500 m depth)

Integrated petrographic and micro-XRF analyses



Figure 4: Core samples from the Great Oolite of the Upper Rhine Graben, Chalampé well, BRGM Orléans-La source core facility

2.1. Petrographic Analysis



Grain Components Identified	Post - Depositional Features	Texture Classification (Dunham, 1962)	Image code
Skeletal Grains • Crinoid - Cri. • Echinoderm - Ech. • Bivalve - Biv. • Foraminifera - Fram. • Gastropod - Ga. • Coral - Co. • Sponge - Sp. • Algae - Alg.	• Stylolite - St.	Grainstone	G
	• Bioturbation - Bt.	Packstone	P
	• Micritization - Mic.	Rudstone	R
Non-Skeletal Carbonate Grains • Ooid - Oo. • Oncoid - Onc. • Peloid - Pel. • Aggregate - Agg.	• Fracture - Fr.	Wackstone	W
	• Pyritization - Py.	Mudstone	M
	• Hardground - HG.		
Non Carbonate Grains • Pyrite - Py.			

Figure 5: Images of polished rock sample from Chalampé well, showing different carbonate textures, various allochems, and post-depositional features in the GO

2.2. µ-XRF Analysis

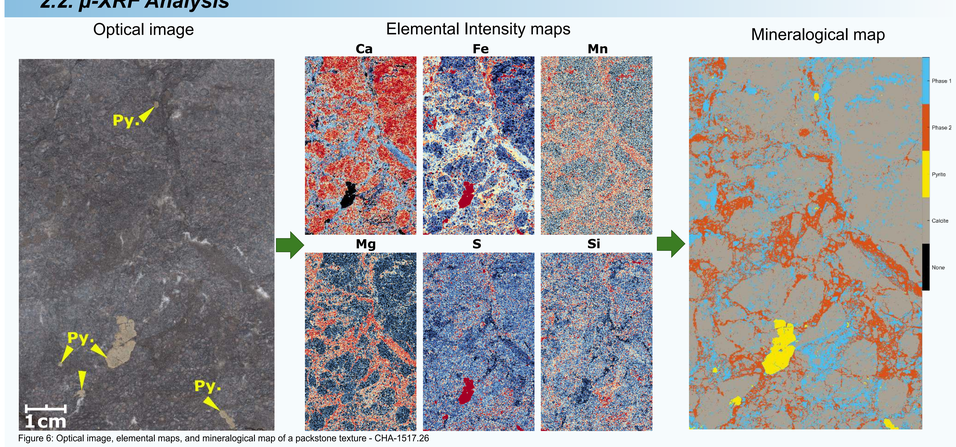


Figure 6: Optical image, elemental maps, and mineralogical map of a packstone texture - CHA-1517.26

Implication for Diagenetic History from Mineralogical Map: Deciphering the processes of formation of the rock based on observation and mineralogical maps

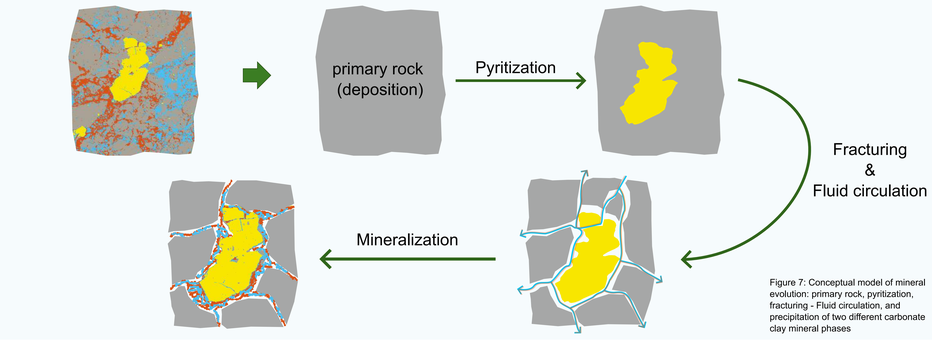


Figure 7: Conceptual model of mineral evolution: primary rock, pyritization, fracturing - Fluid circulation, and precipitation of two different carbonate clay mineral phases

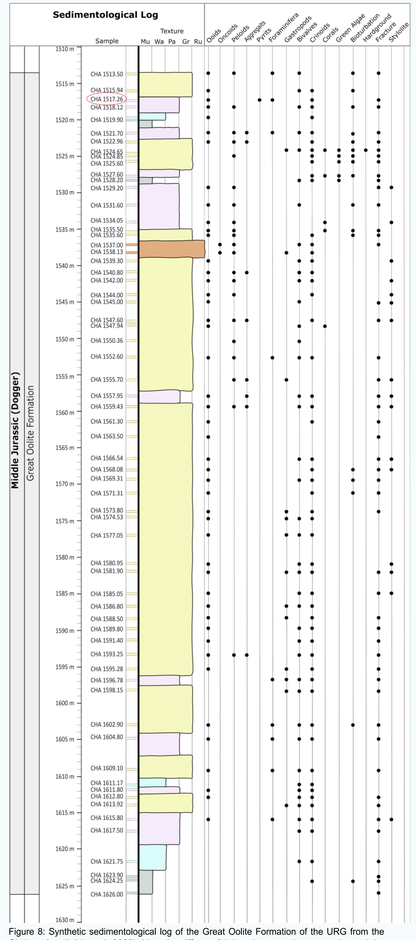
4. Preliminary Conclusions

- Detailed petrographic examination reveals:
  - Five distinct mud- to grain-supported bioclastic fabrics
  - high diversity of skeletal to non-skeletal biological content
  - GO in the URG : much more heterogeneous than previously recognized
  - Stratigraphic + matricial heretogeneities have impact on the reservoir potential (in addition to spatial and structural heterogeneities)
- Mineralogical maps indicats:
  - Strong micritization of allochems
  - Calcite-prone textures
  - Two main phases of minerals: carbonate and non-carbonate
  - A complex diagenetic history involving fluid migration and mineral precipitation
  - high diversity of mineral phases

3. Preliminary Results

Newly produced log (2025, in progress)

Previous reference log (Gillet, 1937)



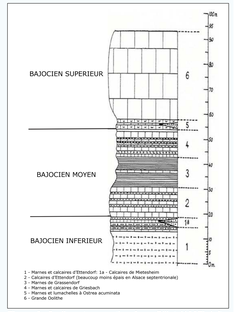
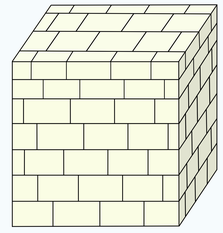


Figure 9: Sedimentary section from Gillet (1937) (after Menillet, 2015) showing a massive, monolithologic Upper Bajocian limestone unit with no variation in depositional setting or sedimentation

Figure 8: Synthetic sedimentological log of the Great Oolite Formation of the URG from the Chalampé well (Nasseri, 2025). Note the different fabrics, the strata heterogeneity, and the diversity of features (components, stylolits, ...)

Implication on Reservoir :

From an homogeneous reservoir based on reference log by Gillet from (1937)



to an heterogeneous reservoir based on ongoing study (Nasseri, 2025)

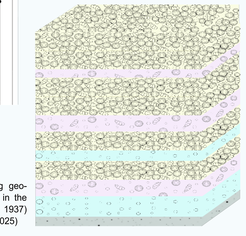


Figure 10: Two interpretations of the resulting geo-reservoirs based on two well logs for the GO in the URG. A homogeneous reservoir model (Gillet, 1937) and a heterogeneous reservoir model (Nasseri, 2025)

5. References

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6. Acknowledgments

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