Geometry of the Callovo-Oxfordian claystone formation from depth-converted 3D-high resolution seismic data: modeling and spatial uncertainty

Béatrice Yven (Andra), Jean-Baptiste Mathieu (KIDOVA), Michel Garcia (KIDOVA)

Andra 1/7 Rue Jean Monnet, 92298 Châtenay-Malabry Cedex, France
KIDOVA, 155, avenue R. Salengro, 92370 Chaville, France

The research conducted by the French Radioactive Waste Management Agency over the past 20 years has served to demonstrate the feasibility and safety of deep disposal of high-level wastes and intermediate-level long-lived wastes. Today, this research is helping prepare for industrial disposal centre's construction and operation. The Callovo-Oxfordian claystones (COX) have been selected as a potential host formation. Therefore, the geometry of this formation is required to position the repository, design its shape and numerically simulate its behaviour.

This article will present the structural model of the COX formation, estimated from a depth-converted 3D-high resolution seismic cube acquired in the contemplated repository area (ZIRA). As no borehole is located inside this area, the calibration process was performed using three 2D-seismic lines passing through the 3D seismic cube and three boreholes located 2-3km away from the ZIRA. Three strong reflection events were picked on the seismic data within the COX. The deepest event is correlated with the base of the COX (LS0), whereas the two other events represent the limits of the third-order depositional sequences (LS1, LS2) (Figure 1). The primary aim of structural modelling was to estimate the top of the claystone formation (SNC). Furthermore, the limits of the main petrophysical units, defined in a previous study from borehole log data and cores [1], also had to be estimated within the ZIRA. The petrophysical units are the Clayey unit (UA), the Transitional unit (UT) and the silto-carbonated unit (USC) as shown in Figure 1. They are essential to better understand and characterize the spatial variability of rock properties within the COX formation. The associated article of Garcia *et al.* (2015) shows how the petrophysical units were taken into account to quantify the spatial variability of rocks properties within the seismic cube [2].

The estimation of the different key horizons relies on marker data from boreholes where all the horizons are identified. They were used to establish relationships between non-seismic and seismic (reflecting) horizons in terms of (smoothed) bivariate histograms between either unit thicknesses or horizon elevations (Figure 2). The bivariate histograms were then used to estimate and quantify the spatial uncertainty of the non-seismic horizons within the ZIRA. A seismic facies analysis was eventually carried out to verify that the estimated horizons were matching the facies changes. This analysis proved to be efficient to confirm the major transitions from the Dogger to the COX, and from the COX to the Oxfordian limestones platform. As expected, however, it showed that there is no clear transition between the two units UA2 and UA3 at the seismic scale within the ZIRA (Figure 1). Figure 3 represents the elevation map of the base (LS0) and thickness of the COX formation in the ZIRA. These results confirm that the thickness increases in the north-east direction and that the dip is low (1°) and oriented nord-west.

An important challenge of this study was to quantify spatial uncertainty associated with estimated horizons. The article will detail the method used to quantify overall spatial uncertainty and will present results for different estimated horizons.

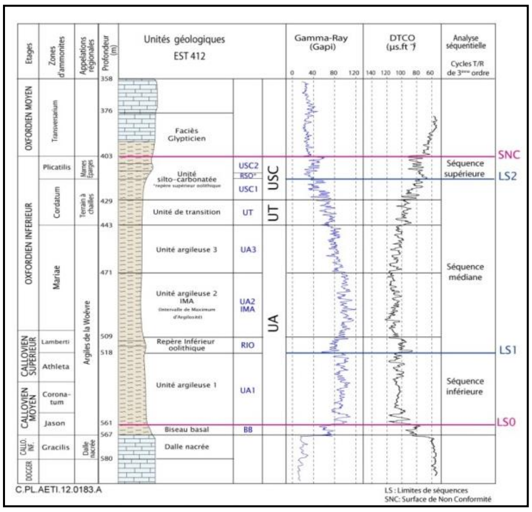

Figure 1: Geological units and stratigraphic sequence of the Callovo-Oxfordian formation: Clayey unit (UA), Transitional unit (UT), silto-carbonated unit (USC), top and base of the formation (SNC, LS0 respectively), 3rd-order T-R sequences limits (LS1, LS2).

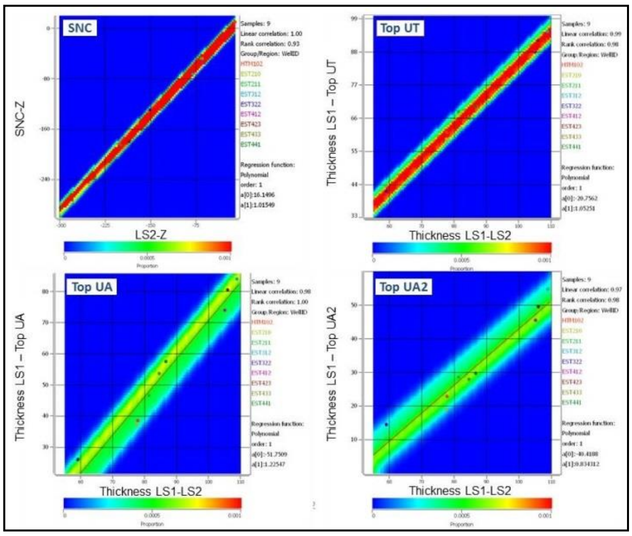

Figure 2: Scatterplots and associated smoothed bivariate histograms (density maps), between horizons (top left) or thicknesses, allowing to estimate SNC and the top of UT, UA and UA2 units.

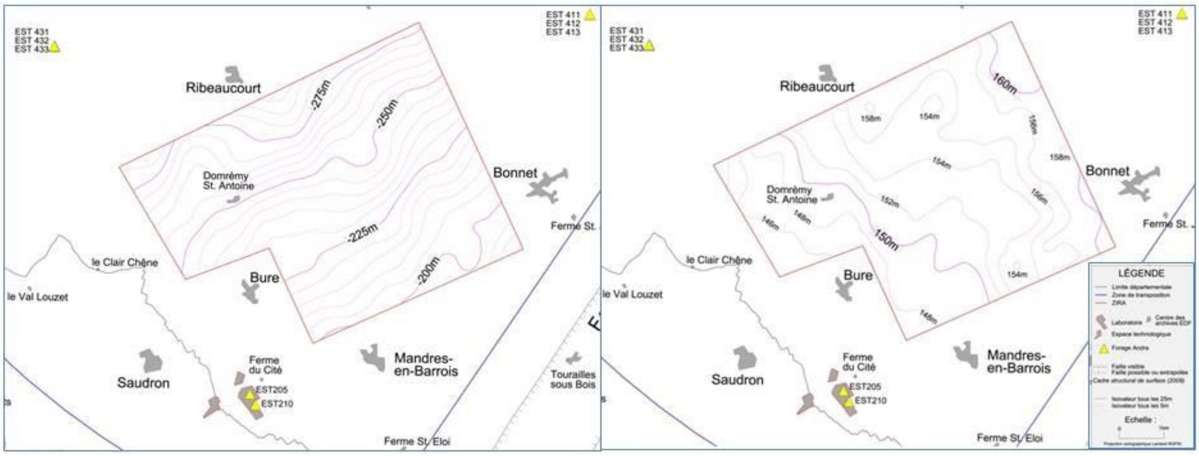

***Figure 3:** Elevation map of the base (LS0) and thickness of the COX formation in the ZIRA.*

References

[1] Garcia M.H., Rabaute A., Yven B. and Guillemot D., 2011. Multivariate and spatial statistical analysis of Callovo-Oxfordian physical properties from lab and borehole logs data: Towards a characterization of lateral and vertical spatial trends in the Meuse/Haute-Marne Transposition Zone, Physics and Chemistry of the Earth, Vol. 36, Issues 17–18, 1469–1485.

[2] Garcia M.H., Mathieu J.B. and Yven B., 2015. Analysis and modeling of spatial trend and spatial uncertainty of physical rock properties in the Callovo-Oxfordian claystone formation from a 3D high resolution impedance cube. Submitted at the 6th conference on Clays in Natural and Engineered Barriers for Radioactive Waste Confinement, Brussels, Belgium.