AQUARIUS

A Joint Industry Project

Architecture and QUAntification of a Reservoir In lacUstrine System

Subsalt reservoirs are difficult to image, both in terms of physical properties, geophysical signature and facies distributions. Reservoir outcrop analogues are commonly used to characterize reservoir architectures (including facies and heterogeneity distributions). Sedimentology and geophysical approaches make it possible to assess the physical reservoir properties and to evaluate the parameters required to build accurate reservoir models. However, occurrence of heterogeneity at many embedded scales in these subsalt reservoirs makes the definition of upscaling rules very challenging to obtain a relevant reservoir model that can be inputted into a flow simulator.

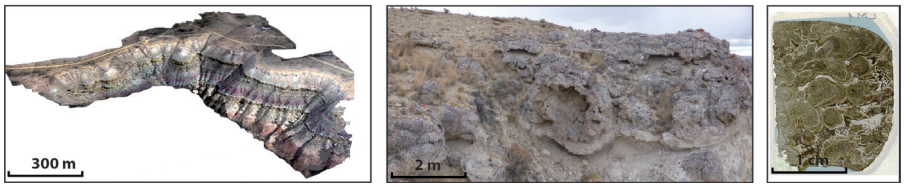

Figure 1: Multi-scale outcrop analysis of the microbial-rich lacustrine carbonates of the Green River Fm.

IFPEN's approach

We combine data collection, characterization and modeling in a workflow well-suited for microbial dominated marginal lacustrine systems, using the Eocene LaClede Beds from the Green River Formation as outcrop analogue. A key point for achieving an accurate understanding of the reservoir is the characterization of 3D multi-scale heterogeneity distributions from both a sedimentological and a physical point of view (petrophysics and geophysics). Describing such multi-scale heterogeneities is a first necessary step to evaluate their impact on fluid flow. A second involves defining appropriate upscaling rules to transfer all relevant information from fine to coarse scale so as to end up with a reservoir model which can be used as input for flow simulators. The joint analysis and integration of sedimentological characterization, physics and geophysics will provide a set of rules for upscaling the main parameters from a high resolution to a lower resolution reservoir model.

Key features and differentiators

- IFPEN's vast experience in geological modeling.
- Use of photogrammetry as an alternative to LIDAR technology, which is faster and simpler to acquire and to process data, in addition to being more cost effective.
- Access to well proven technology in other industries: brought to the Oil and Gas by IFPEN, using a unique proprietary interpretation software (**Virtuoso**) with advanced editing features.
- Use of an integrated characterization workflow combining laboratory to field data.

Methodology

Main topics that will be tackled in the workflow are:

- Characterization of facies distributions at reservoir scale (12 x 12 km^2, 50 m in thickness):
  - 3D sedimentological analysis of facies distributions,
  - architecture of lacustrine deposits,
- Quantification of reservoir bodies and reservoir properties:
  - for the calibration of geostatistical parameters,
- Imaging of reservoir units:
  - shallow seismic refraction acquisitions,

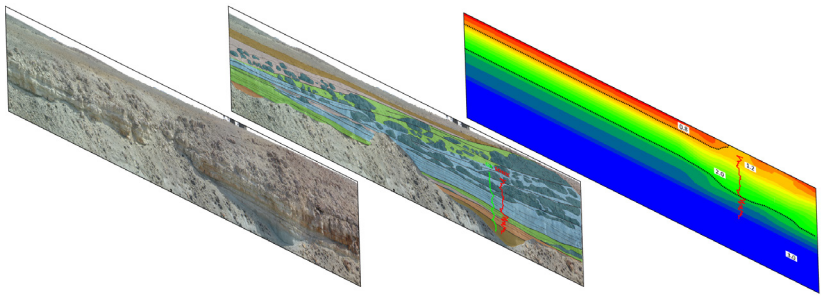

Figure 2: An integrated geological and geophysical approach to characterize lacustrine systems.

  - sonic log acquisition on outcrops and petroacoustic measurements on plugs to calibrate the link between sedimentological attributes and their acoustic signatures,
- Definition of upscaling rules:
  - from "plug" scale to seismic scale,
- Integration of sedimentology, 3D outcrop modeling and seismic data:
  - design a reservoir modeling workflow dedicated to lacustrine carbonate reservoirs, calibrated on the basis of the Green River Fm.

Work program

Three complementary Work Packages, dedicated to lacustrine reservoirs characterization from multi-scale integration of geological and geophysical data, will be performed in three years' time, starting yearly 2018.

Work Package 1 (WP1): Sedimentological characterization and 3D outcrop model quantification

WP1 is dedicated to the characterization of the microbial-dominated reservoir architecture using 3D outcrop model interpretations that will be calibrated to sedimentological observations. We will focus on the LaClede Beds, which correspond to the main carbonate-dominated microbialite-rich interval outstandingly outcropping in the La Barge area. Pictures from outcrops will be acquired with UAV (Unmanned Aerial Vehicle) to build 3D outcrop models. Geological interpretation (facies interpretations, horizon line-drawing, etc.) will be performed for the area of interest based upon the 3D outcrop model. This interpretation phase will be used as a basis for the mapping and the quantification of reservoir characteristics.

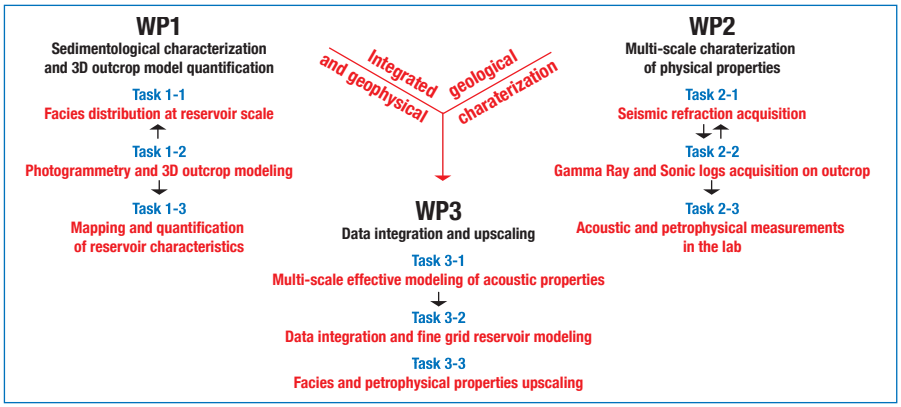

Figure 3: AQUARIUS project workflow

Work Package 2 (WP2): Multi-scale characterization of physical properties

WP2 is dedicated to the development of a workflow for the acquisition and characterization of rock physical parameters (petroacoustic and petrophysical parameters). This characterization will rely on three geophysical set of data acquired from field to laboratory: seismic refraction profiles, sonic log acquisition on selected sedimentological sections and petroacoustic measurements on plugs.
The objective is to provide seismic data characterizing the outcrops, constrained by the acoustic properties of rocks and by sedimentological description made in WP1.

Work Package 3 (WP3): Data integration and upscaling (from outcrop to reservoir model)

WP3 is dedicated to the determination of upscaling rules allowing integration of the multi-scale heterogeneities into a coarse grid reservoir model built for fluid flow. It will rely on the use of the relative proportions of each facies and simplified flow responses to upscale reservoir properties at the scale of a reservoir cell (i.e. 50x50x1 m).

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