# CarDIO

## A Joint Industry Project

## DionisosFlow™ – Carbonate Early Diagenesis

In subsurface exploration and reservoir characterization, a better understanding and prediction of the distribution of geological heterogeneities is essential, especially for carbonate systems. The complexity of the biogeochemical processes that formed the sediment generates heterogeneity distribution, which result from various independent factors.

### IFPEN's approach

Our idea is to provide within DionisosFlow™ – a 3D numerical Stratigraphic Forward Model (SFM) – a predictive model accounting for the early diagenetic modifications undergone by carbonate sediments deposited in a wide range of tectonic and stratigraphic settings.

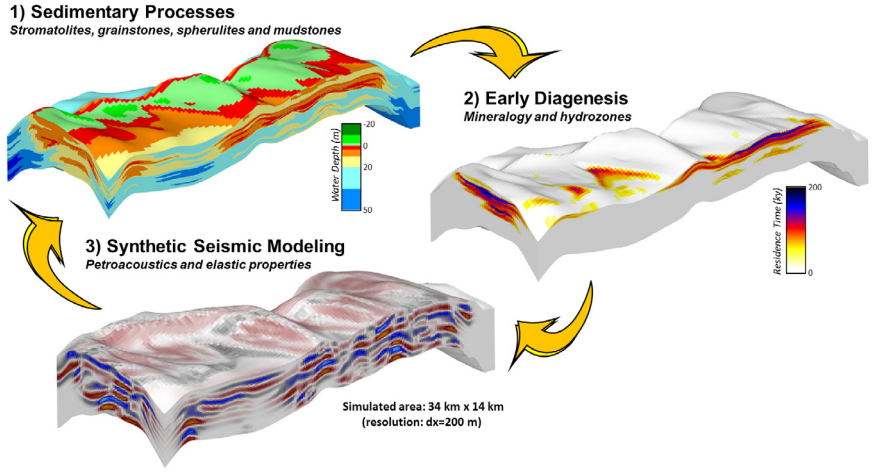
This integrated approach jointly couples stratigraphic, hydrological and diagenetic models, used to estimate the impact of early diagenesis on the primary properties of a carbonate sediment (mineralogy, porosity, etc.).
The understanding and modeling of this initial state is thus a crucial question to tackle, whatever the scale investigated for carbonate plays.

### Key benefits

- IFPEN's large technological background in simulation of stratigraphic processes at regional scale (basin length of tens to hundreds of kilometers, simulated time interval of hundreds of thousands to hundreds of millions of years).
- Use of DionisosFlow™, IFPEN simulator, leader in the stratigraphic modeling market.
- Access to groundwater model developed in the DORS JIP, essential technology innovation to be used in the CarDIO JIP.
- Geological understanding, knowledge and characterization of diagenetic processes.
- Access to new SFM engine fully massively parallel, to be industrialized by IFPEN in 2018.

### Technical program

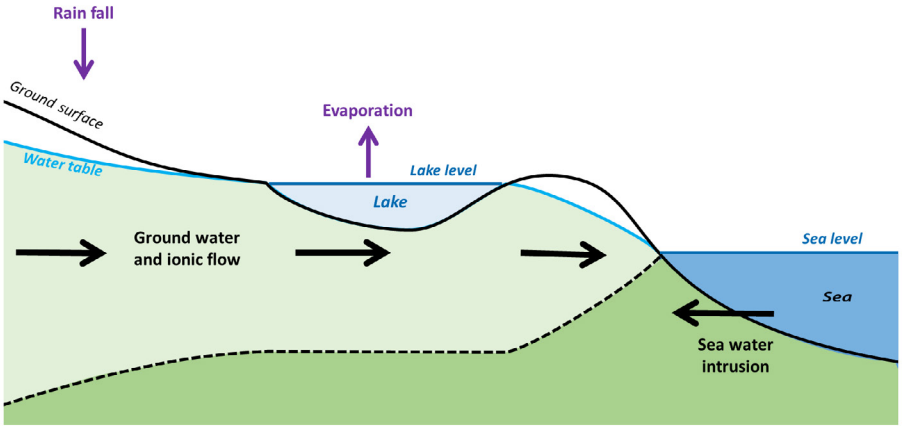
The designed program will consist in developing physical laws for the various diagenetic reactions (cementation, dissolution, recrystallization, etc.) occurring in the different diagenetic environments (marine, lacustrine, hypersaline, meteoric, etc.).




*Application of CarDIO on a pre-salt lacustrine carbonate formation (Campos basin, Brazilian margin)*

IFP Energies nouvelles (IFPEN) is a public research and training player. It has an international scope, covering the fields of energy, transport and the environment. From research to industry, technological innovation is central to all its activities.

These laws will be integrated into DionisosFlow™, adjusted to the spatial and temporal scales of SFM, then validated and calibrated through actual case studies. Two work packages, focusing on the main environments in which early diagenesis occurs, will be performed in three years' time, starting yearly 2018.




*General aim of the CarDIO project*

**Work Package 1 – Ionic transport**

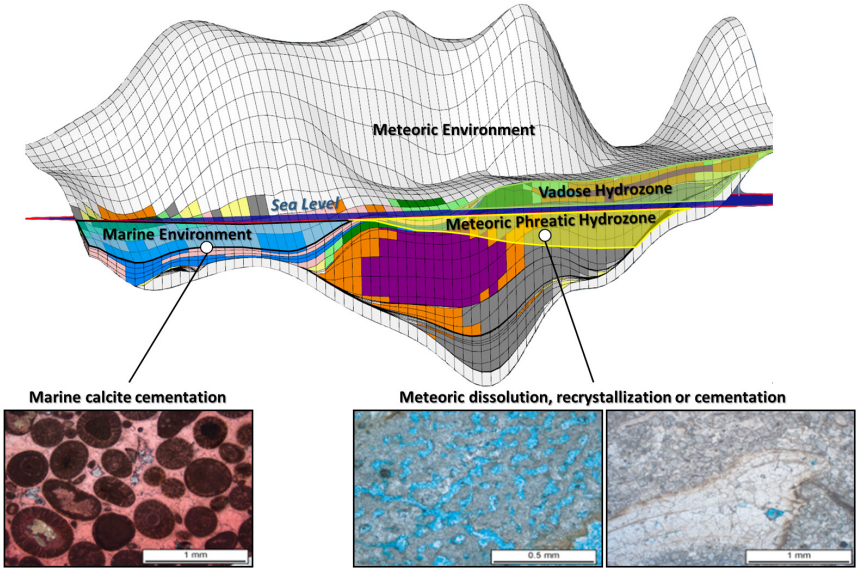
The first work package is dedicated to the development of a non-reactive ionic transport module within DionisosFlow™ to characterize the large-scale geochemical characteristics of groundwater flow.

- Review of modern diagenetic environments and definition of the key chemical parameters that rule diagenetic processes.
- Integration of these laws into DionisosFlow™ (development of an ionic transport prototype module).
- Calibration and validation based on a realistic case study.

**Work Package 2 – Early Diagenesis**

The early diagenesis module developed during this second work package will be able to simulate the effect of the meteoric vadose and phreatic diagenesis on lacustrine and marine carbonate sediments. Reactive transport modeling will be integrated to DionisosFlow™ to realistically represent the spatial distribution of the diagenetic processes resulting from different water chemistries.

- Definition of the conceptual kinetic models that rule early diagenesis (dissolution, cementation, recrystallization) and the associated porosity/mineralogy modifications.
- Integration of these laws in DionisosFlow™, jointly with the groundwater flow model currently developed at IFPEN (ionic transport prototype module).
- Calibration and validation on a realistic case study.




*Stratigraphic modeling of a carbonate platform showing the distribution of the main diagenetic environments and processes.*

## Deliverables

The ionic transport and early diagenesis prototype modules will be delivered as new DionisosFlow™ plug-ins with specific properties simulated at each grid cell such as:

- residual porosity range distribution (post early diagenetic modifications),
- residual mineralogy distribution (post early diagenetic modifications),
- lithification index.

As a follow up, the development of a new lagoonal evaporite and diagenesis prototype module will be envisaged, which will aim to reproduce the crystallization of primary subaqueous evaporite layers and the associated dolomitization of underlying sediments due to brine reflux.

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