AAPG HEDBERG CONFERENCE
"Deformation History, Fluid Flow Reconstruction and Reservoir Appraisal in Foreland Fold and Thrust Belts"
May 14-18, 2002, Palermo - Mondello (Sicily, Italy)

Methodology for Basin Modeling in Complex Area: Examples from Eastern Venezuelan and Canadian Foothills

F. Schneider, J.L. Faure and F. Roure

(Institut Français du Pétrole, 1 & 4 avenue de Bois Préau, 92852 Rueil-Malmaison Cedex)

Introduction

Basin modeling aims at reconstructing the time evolution of a sedimentary basin in order to make quantitative predictions of geological phenomena leading to hydrocarbons accumulations. It accounts for porous medium compaction, heat transfer, hydrocarbon generation and fluid flow. Nevertheless, classical basin models handle simple geometry and were not usable for the objectives of the SubTrap consortium. This is why the numerical prototype *Ceres*, which is able to model three-phase flow in a 2D section of a basin, whose geometry changes due to deposition, compaction, erosion of the sediments, salt or mud creeping, and block displacement along faults (Schneider et al., in prep), has been applied within the frame of this consortium. *Ceres* has been used in order to (1) define a methodology for basin modeling in thrust area and (2) to perform evaluation of the pressure and the fluid flow history at some reservoir levels.

The section is organized as follows. The first part deals with the methodology for basin modeling in thrust area. This methodology has been defined within the frame of this consortium. Some results of the Ceres simulations are given for the Eastern Venezuelan foothills and for the Canadian foothills.

Methodology

The resulting methodology is the fruit of tests performed for an Alberta transect and an Eastern Venezuelan transect. A first attempt to model the Alberta transect with a classical approach using *Locace* and *Ceres* leads us to define an intermediate methodology using *Locace*, *Thrustpack* and *Ceres*. Modifications of both *Thrustpack* and *Ceres* have been necessary in order to design the new methodology that has been validated with the two transects.

The old methodology consists in balancing the initial section at present day with *Locace* and then to import this balanced cross section in *Ceres*. The edition of the section, the restoration and the simulations are performed with *Ceres*. The main drawback of this methodology is that the user has to restore the section without any constrain. In the case of the Banff transect, where several kilometers of erosion occurred from –55 Ma and –20 Ma, the reconstruction of the section for previous time intervals is rather impossible.

In order to balance the section during time and to constrain the eroded parts of the section, we decided to use *Thrustpack* (a forward kinematic modeling tool). Thus, from a section before thrusting built with *Locace*, the use of *Thrustpack* allows to construct intermediate sections during time, which are consistent from a kinematics point of view. The final section of *Thrustpack*, which is supposed to be equivalent to the initial section at present day, is then imported in *Ceres*. The edition of the section, the restoration and the simulations are still performed with *Ceres* as it was in the old methodology.

In order to improve the previous methodology, some modifications have been done both in *Thrustpack* and *Ceres*. The objective of these modifications was to improve the communications between these two prototypes. Thus, the addition of export facilities in *Thrustpack* and the possibility to import templates during the restoration in *Ceres* allow to better constraining the restoration in *Ceres*. Indeed, the intermediate geometries built with *Thruspack* can directly be used as templates into *Ceres* in order to draw the eroded parts or to perform the displacements along the faults.

Venezuelan Foothills

As defined in the new methodology, the first work to do at the beginning of a *Ceres* study is the definition of the initial section. This is generally performed with data coming from the seismic interpretation, well data, field data, core data… For the Eastern Venezuelan Transect, this work has been done within the phase I of the SubTrap consortium.

The available initial section and *Thrustpack* scenario have been used to build the dataset for *Ceres*. The lithology distribution was not studied in detail and only the main units were considered (Fig. 1).

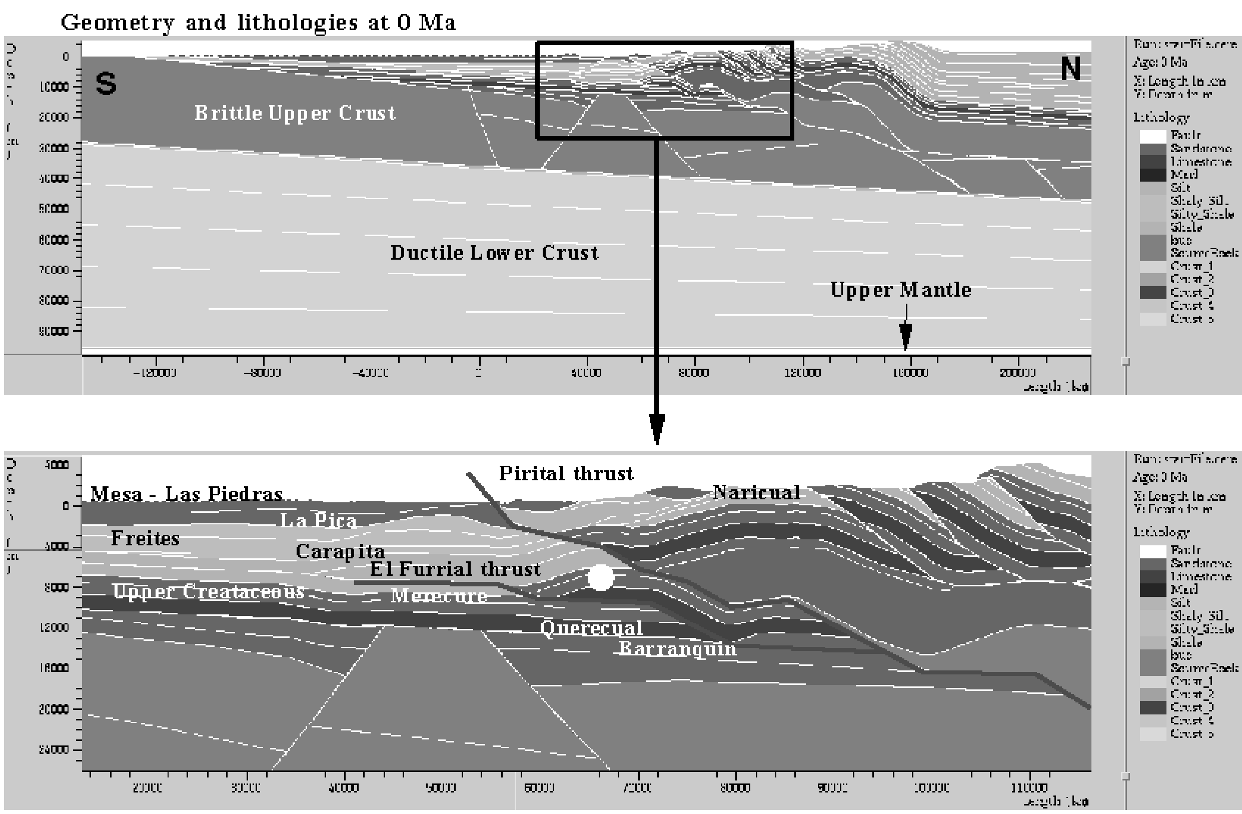

Fig. 1: Geometry and lithology distribution of the section at present day. The white dot indicates the El Furrial structure.

When considering the origin of the fluids in the Oligocene sandstones of the El Furrial structure, four steps should be considered.

1. From –65 Ma to –20 Ma: fluids are in equilibrium with the sediments. They are being continuously expelled toward the surface during the compaction related dewatering.

2. From –20 Ma to –12 Ma: because of the tilting and the deposition of the synflexural Naricual formation, the Oligocene sandstones of the El Furrial structure will receive fluids from the north. These fluids that are in equilibrium with the Oligocene sandstones at the north should have higher temperatures than the sediments at the El Furrial structure. The average Darcy velocity of these fluids decreases from 20 km/Ma to 5 km/Ma.

3. From –12 Ma to –8 Ma: Fluids are expelled laterally from the Cretaceous sediments of the hangingwall Pirital unit located immediately north of the El Furrial. These fluids should be in chemical disequilibrium and their temperature should be higher than the temperature of the sediments. The Darcy velocity decreases to zero after having reached a peak around 20 km/Ma.

4. A reduction of the intensity of the flow and then an inversion of this flow mark the closure of the southern structural closure of the structure at around –8 Ma. Then the closure of the northern flank occurs at around –5 Ma as indicated by present velocity close to zero in the El Furrial structure.

Canadian Foothills

As defined in the new methodology, the first work to do at the beginning of a *Ceres* study is the definition of the initial section. This is generally performed with data coming from the seismic interpretation, well data, field data, core data… For the Alberta Transect, this work has been done within the phase II of the SubTrap consortium

The available initial section and *Thrustpack* scenario have been used to build the dataset for *Ceres*. The lithology distribution was not studied in detail and only the main units were considered (Fig. 2).

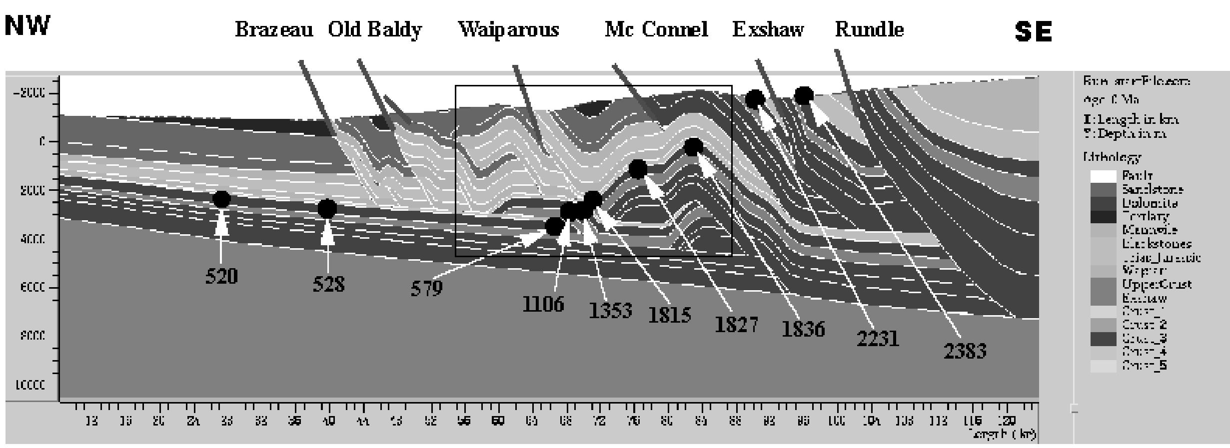

Fig. 2: Geometry and lithology distribution of the section at present day. The black dots indicate some cells from Mississipian dolomite that are considered in this study.

When considering the origin of the fluids in the Mississipian dolomite of the area, three steps should be considered:

1. From deposition to -100 Ma: fluids are in equilibrium with the sediments. They are continuously expelled toward the surface during the compaction dewatering.

2. From -100 Ma to -63 Ma: because of the tilting and thrusting with the deposition of synflexural sediments, the Mississipian sediments of a considered area will receive fluids from the West with velocity reaching 2 km/Ma. These fluids are in equilibrium with the Mississipian dolomite at the West and should have higher temperatures than the considered sediments.

3. From -59 Ma to present: due to the thrusting, the structure became closed and there is no flow any more.

References

Schneider F., Devoitine H., Faille I., Flauraud E., Willien F. (in Prep). Ceres 2D: A numerical prototype for HC potential evaluation in complex area.