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From Seismic Interpretation to Reservoir Model: An Integrated Study to Tackle the Structural Complexity of the Vienna Basin

The purpose of this study was to interpret and model a regional-scale structural framework. A fully unstructured reservoir grid was created from a water-tight structural model, in order to accurately simulate gas injection scenarios and to assess the sealing capacity of the bordering faults. This project, managed by NFR Studies GmbH (www.nfrstudies.com) is part of a larger research project on Carbon Capture and Storage (CCS), sponsored by the Austrian Government Funding Agency for Applied Research (FFG) and the Austrian oil and gas company OMV, and performed at the Montanuniversitaet Leoben (MUL), Austria.

The Challenge

The reservoir candidate for CCS is a depleted oil reservoir (produced mainly in the 1970's), located at about 1500 m depth and about 200 m thickness. It consists of a clastic sedimentary sequence, mainly pro-grading deltas. In the seismic volume, these are easily recognized by a series of onlaps (unconformities). The trap consists of a gentle anticline structure, closed by a complex fault system on its Eastern flank. From surface outcrop studies and Lidar surveys, it is known that the fault system is still active today (Gutdeutsch and Aric, 1988; Hinsch et al, 2005b). In order to assess the sealing capacity of the faults, the structural model must integrate the full vertical extent of the faults, from basement to ground surface (Figure 1). About 80 vertical wells have been drilled through the crest of the anticline, with multiple interpretations of the stratigraphic marker.

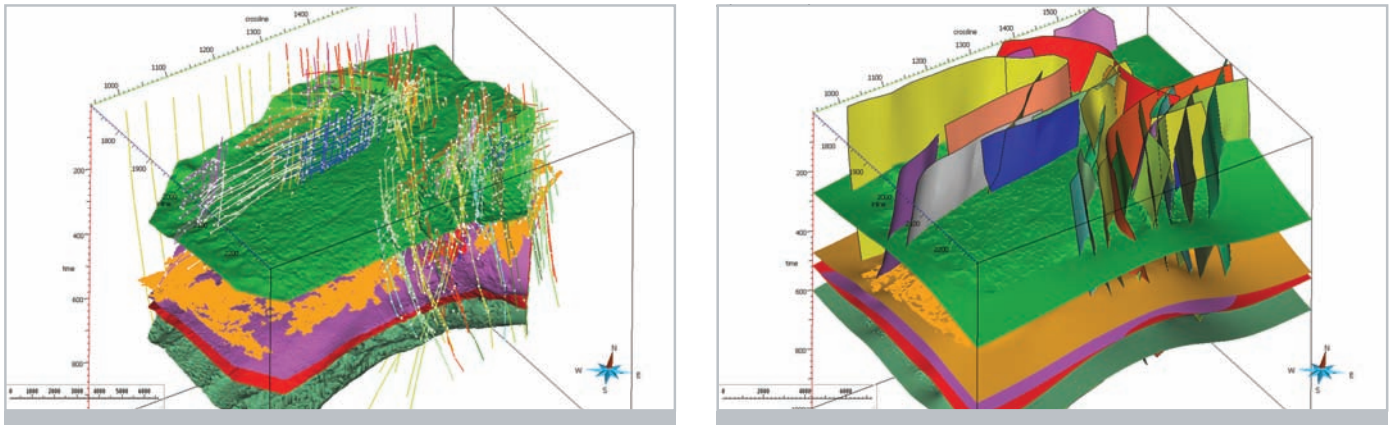
The Assessment

Most of the acquired data is relatively old; neither structural nor detailed reservoir models are available. Five main stratigraphic horizons and a regional seismic amplitude volume were made available in the two-way time domain. Fault interpretation was non-existent and some stratigraphic markers were missing or duplicated.

The Solution

Using the seismic interpretation and modeling workflow of the Paradigm® SKUA® volume-based modeling system, a quick and reliable interpretation of the fault network was made. The seismic amplitude volume was used to generate a semblance volume in order to identify the faults (discontinuities) and perform the picking. Verification of the stratigraphic markers on the wells, and interpretation of the missing ones were performed easily using Paradigm StratEarth®. The cleaned stratigraphic markers served to calculate pseudo-velocities, which were then used as the main input for the 3D velocity model. The full structural model (faults and horizons) was converted to depth domain in a single operation. The depth model was checked and updated in order to honor the well marker locations.

The resulting water-tight structural model was the base for the creation of a fully unstructured reservoir grid (tetrahedra, aligned along faults and horizons) (Figure2). In parallel, the geologic grid was populated with properties, using facies maps as trends. Finally, porosity and permeability were mapped onto the reservoir grid.

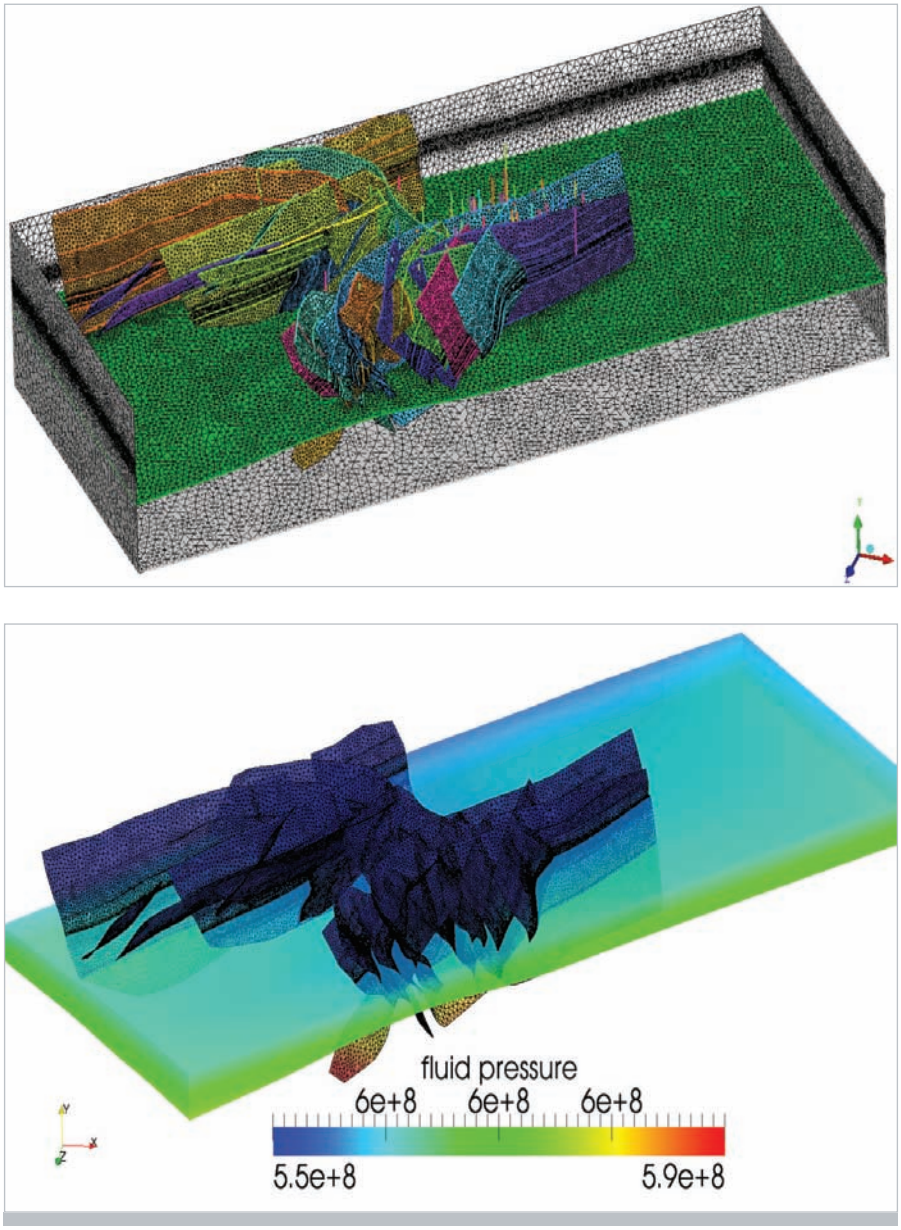


▲ Figure. 1: In two-way-time domain: fault interpretation as fault sticks and main stratigraphic horizons (left), from basement (dark green) to ground level (top); water-tight structural model (right), honoring the complex fault system and the stratigraphic unconformity (onlapping deltaic sand series) between red and purple horizons. (View set-up: vertical exaggeration x2)

The Results

Within two weeks, 40 faults were interpreted and modeled, together with the main five stratigraphic horizons (Figure 1). The tight integration between the interpretation and modeling enabled the correct representation of a complex system of fault arrays, for realistic assessment of the sealing capacity of the reservoir faults.

The final reservoir model has an area of 32 km x 13 km and is 6 km thick. It contains 12 million tetrahedra. Fluid pressure could be initialized in the model, using the CSMP++ reservoir simulator, developed by the MUL. The next step in this project is to run multiphase simulations, in order to compare several gas injection scenarios.



▲ Figure 2: Reservoir grid, with tetrahedral mesh for honoring the complex fault structure, with a discrete well representation (left), and with pressure initialization in the main reservoir unit and along fault planes (right)

Gutdeutsch, R., Aric, K., 1988, Seismicity and neotectonics of the East Alpine-Carpathian and Pannonian area, American Association of Petroleum Geologists, Memoir 45, 183–194.

Hinsch, R., Decker, K., Peresson, H., 2005, 3-D seismic interpretation and structural modelling in the Vienna basin: implications for Miocene to recent kinematics