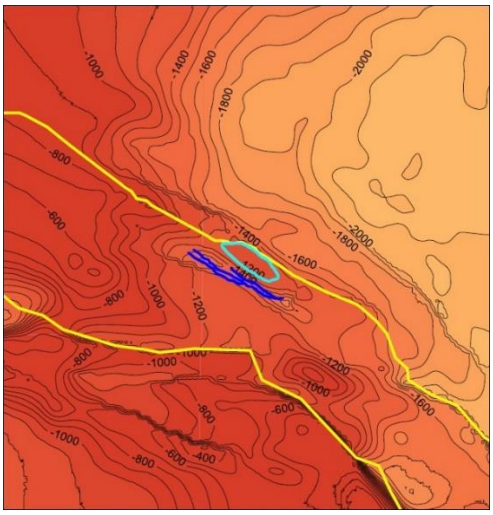
Geomechanical modelling of hydrocarbon production from an off-shore field

Project summary



Client:	Po Valley Operations Ltd
Year:	2016
Service:	Computer Modelling
Sector:	Geomechanical Engineering
Site:	Offshore, 25 km far from the coastline
Geological setting:	Sedimentary basin
Constitutive law:	Isotropic hypo-plasticity with mechanical hysteresis
Project in numbers:	3,559,398 degrees of freedom

Abstract

The object of this study is the development of a numerical model to predict the geomechanical effects induced by hydrocarbon extraction from an off-shore gas field.

The geomechanical analysis is performed with the aid of a state-of-the-art 3D finite-element numerical model developed by the M3E team with the main objective of predicting the sea bottom displacements over the field.

Project description

The gas field of interest is located off-shore, about 25 km far from the coastline, at a depth between 1300 and 1600 m. From a lithological point of view, the mineralized levels are made up of sands and silts interwoven into thin layers of clay and silty clay.

M3E has developed and maintains a state-of-the-art 3D Finite-Element geomechanical model for the simulation of the stress and displcaments induced by the exploitation of hydrocarbons from underground reservoirs. The model solves the equilibrium equations for saturated porous media under the action of pore pressure variations in time and space. The host rock is characterized by an elastoplastic or hypo-plastic anisotropic behavior selected at the elemental level.

The model is built by using a fully unstructured tetrahedral grid, thus allowing for a very accurate reproduction of the volumes and the complex

geometries that often characterize the geological structures of interest.

A high resolution grid is necessary inside and near the producing field, while the overall model is characterized by a regional scale. In this project, the computational domain has a 40 km × 40 km areal extension, with the reservoir located in a nearly barycentric position.

The average elemental spacing is approximately 100 m in the reservoir zone, consistent with the discretization used in the dynamic reservoir model. The 3D computational grid was obtained by using an automatic grid generator specifically developed by the M3E team for geological applications. The 3D domain is confined below by a rigid bedrock at 5 km depth and above by the sea bottom bathymetry. The discretization is able to accurately reproduce the volumes of the Mineralized pools, GWC quotas, and aquifer geometries hydraulically connected to the reservoir.

The grid consists of 1186466 nodes and 7014887 elements. Starting from this grid, the single waterdrives hydraulically connected to each producing layer were "extracted" as sub-models and used to simulate the propagation of the pressure variation to the active aquifer. The properties of the waterdrive were calibrated by using the mass balance equation for esch layer. The resulting pressure propagation, along with the expected drop due to the extraction program provided by the Client, was used to simulate the future geomechanical behavior of the field.

The hydrocarbon extraction from the reservoir produces a variation of the effective stress which propagates in the surrounding rocks, thus causing a local deformation of the reservoir which propagates up to the sea bottom.

The development of an accurate geomechanical model allows for the reliable prediction of deformations at both a local and a regional scale which are of interest for both the oil company managing the reservoir and the administration responsible of the authorization process.

Project outcome

The services provided to the client are the following:

- Development and calibration of a 3D geomechanical finite-element model.
- Forecast of the displacements induced by the hydrocarbon removal.