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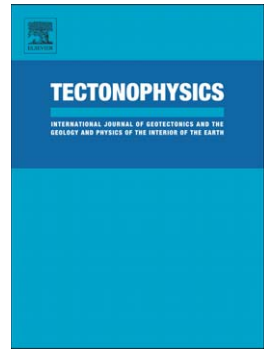

Workflow for the integration of a realistic 3D geomodel in process simulations using different cell types and advanced scientific visualization: Variations on a synthetic salt diapir

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Workflow for the integration of a realistic 3D geomodel in process simulations using different cell types and advanced scientific visualization: Variations on a synthetic salt diapir

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Abstract

The purpose of this study is to use one complex geological 3D model for numerical simulations of various physical processes in process-specific simulation software. To do this, the 3D model has to be discretized according to different cell types, depending on the requirements of the simulation method. We used a salt structure with a diapir and its deformed host rock to produce two 3D models describing the boundary surfaces of the structure: one very simplified model consisting of cuboid surfaces and a realistic model consisting of irregular boundary surfaces. We provide a workflow for how to generate hexahedral, tetrahedral and spherical volume representations of these two geometries. We utilized the volume representations to simulate temperature, displacement and transient electromagnetic fields. We can show that the simulation results closely reflect the input geometry and that it is worth the effort to produce geometric models that are as realistic as possible. Additionally, we provide a workflow for simultaneous visualization and analysis of the simulation results. Scientific visualization is an important tool for deriving knowledge from complex investigations.

Keywords: geological 3D modeling, structured grid, tetrahedral mesh, distinct elements, electromagnetic monitoring, displacement and thermal fields, salt diapir

1. Introduction

The geological subsurface is of utmost economic importance for the production of mineral resources, drinking water, geothermal energy or even for traffic. Economic exploitation of the subsurface reservoirs requires a careful risk assessment, e.g. to prevent perforations of barriers between formations and mixing of aquifers (e.g., brines with fresh water) or the formation of sinkholes, landslides and structural damage around mines. The swelling of rocks like clay or anhydrite may also cause land movements and damage to buildings.

The structure and physical properties of the subsurface must therefore be investigated in detail before any commercial use in order to avoid hazards. The effect of human actions has to be validated, taking into account superimposed or triggered geological processes. Exploitation requires that the subsurface domain is monitored in order to detect tectonic movements, water ingress or pollution and structural damage. These investigations usually include simulating the physics of processes which control the structure and properties of the Earth's crust as preliminary studies or monitoring tools.

To that end, numerical simulations are a powerful tool for understanding how geological processes operate and which effects they cause. In addition to the physical laws applied, the geometry and petrophysical properties of the geological bodies heavilly influence physical fields in the subsurface as well as the simulation results. Therefore, the simulation of geological and physical processes can only yield meaningful and feasible results, if all available information about the structure and lithology of the modeling domain is included in a realistic model. Process modelers often face practical problems when they want to set up a realistic detailed subsurface geometry, since many software packages can only generate bodies with known geometry and topology and an arbitrary amount of available data.