Geophysical Research Abstracts
Vol. 21, EGU2019-17648, 2019
EGU General Assembly 2019

Constructing a 3D geomechanical model of an active subduction zone: a case study from the Nankai Trough, SW Japan.

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The Nankai Trough Subduction Zone offshore Kii Peninsula, Japan has long been known for presence of great earthquakes (>8 magnitude). It has also been a subject to extensive scientific drilling and geophysical surveys performed by the International Ocean Drilling Programme (IODP) and JAMSTEC. As a result of these, there are currently several hypotheses about the origin, evolution and development of Nankai Trough.

The geomechanical modelling is currently primarily reserved for commercial purpose. Well centric 1D, geological and geomechanical 3 and 4D models are regularly utilised by the oil and gas industry not only to optimise production / well placement in the existing fields, but also to avoid costly field/borehole failure. However, there is no research done on computer-based spatial geomechanical modelling of an active subduction zone.

We present here preliminary results from Nankai geomechanical modelling. Initial results from constructed 1D wellbore stability models well predicted pore pressure, stress profiles and breakouts orientation in the boreholes. The 3D seismic inversion data from the Nankai Trough area was used to construct preliminary 3D geological model covering in total, area of 12 km x 25 km. Additionally, the 1D geomechanical models served later as calibration points for the subsequent 3D seismic derived geological and geomechanical models. The 3D seismic derived geological model was subsequently translated into the 3D geomechanical model which consists of core area surrounded by the far field stress zone. Physical and mechanical properties of the substrata were derived from seismic data and calibrated where available with measured log data. The geomechanical model covers 50 km x 80 km x 12 km area and consists of 3.3 million elements with 150 m x 150 m horizontal resolution and varying vertical resolution (60 – 150 m). 3D geomechanical model initial results show spatial distribution of regional tectonic stress, pore pressure, mechanical and physical properties such as Young's Moduli, Poisson's ratio, density, and others. Furthermore, the initial model shows distribution of fault criticality and slip tendencies along major fault planes.

The geomechanical model of the Nankai Trough will act as a basement of an "early warning system " for the anticipated earthquake in the area. As for the future perspective, the model will be run/updated in Real-Time and with transient (future) time steps in order to predict stress magnitude and orientation, assessing fault criticality and slip tolerance. We hope it will give local population invaluable time to prepare and evacuate from hazardous areas saving lives and property.