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Prediction of sub-seismic faults and fractures to ensure carbon traps - joint project PROTECT

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Deformation in the form of fractures and faults affects many reservoirs and their overburden. In a 3-D seismic data set we can identify faults on the large scale, while in well data we observe small-scale fractures. A large number of faults at the intermediate scale (sub-seismic space) also plays a very important role, but these are not detectable with conventional geophysical methods. Therefore, we use the retro-deformation approach within the context of long-term CO_2 storage integrity to determine the characteristics of potential fluid migration pathways between reservoir and surface. This allows to produce strain maps, in order to analyse fault behaviour in the sub-seismic space.

As part of the PROTECT (prediction of deformation to ensure carbon traps) project we focus on the sub-seismic faults of the CO_2CRC Otway Project site in Australia. We interpreted a geological 3-D model of 8 km x 7 km x 4.5 km that comprises 8 stratigraphic horizons and 24 large-scale faults. This confirmed the site to contain a complex system of south-dipping normal faults and north-dipping antithetic normal faults. The most important aspect is that two different types of fault kinematics were simultaneously active: Dip-slip and a combination of dip-slip with dextral strike slip movement.

After the retro-deformation of the 3-D model we calculated strain tensor maps to locate highly deformed or fractured zones and their orientation within the stratigraphic volume. The e1-strain magnitude shows heterogeneous distribution. The south of the study area is at least twice as much fractured on a sub-seismic scale. Four major faults act as „controlling faults“ with smaller faults in between. The overburden is tilted northwards after retro-deformation. Thus, we believe that the area was affected by an even larger normal fault outside of the study area.

In summary, this study reveals that good knowledge of the kinematics of the large-scale faults is essential to predict sub-seismic structures.

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