Effects of uncertainties in fault and seismic interpretations on CO2 storage pressure distribution and pressure control

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Abstract

When injecting CO2 into a reservoir for underground storage, the pressure changes in the subsurface will affect larger areas, depending on the injected volumes and rates, reservoir and possible fault and fracture properties. This can be quantified in conceptual models, but uncertainties in a real case will increase excessively. For example, the potential CO2 storage reservoirs may span a wide range of geological ages, experienced burial histories and physical properties. With increasing depths, the geophysical characterisation becomes more challenging and reservoir units will generally have more faults acting as barriers, which control pressure propagation and define pressure compartments. Shallower, and possibly younger, reservoir rocks will have fewer or no barriers and thus good hydraulic connectivity. For these units, uncertainty is mainly related to the sealing properties of the caprock units, while uncertainty for the deeper units to a significant extent originates from incomplete information and understanding of the sealing properties of faults.

To be able to model reliable pressure distribution and pressure build-up, the uncertainty in the geomodel must be addressed, including the progression of uncertainty from seismic data and geophysical analysis into the fault interpretation and the sedimentary model.

For the analysis and interpretation of seismic data, a number of factors contribute to uncertainty. First of all, inherent noise in the acquisition of the seismic data has a strong influence on interpreted subsurface features. Such noise originates from the seismic sources and receivers themselves, but also from an uncertainty in how they are positioned. In addition, any geophysical survey provides an insufficient amount of information to determine unambiguously subsurface features at the desired resolution. Poor seismic illumination will in general be particularly clear towards the borders of the studied area, but even in better illuminated areas, information is insufficient and certain assumptions always have to be made to analyse the data in a robust manner. An approach to quantify uncertainty in subsurface features (such as seismic velocity) and in the position of structures (e.g. seismic horizon) has been developed (Eliasson and Romdhane, 2017). Secondly, the geomodel is often constructed using interpreted seismic lines from both 2D and 3D surveys, where the different data sets have different uncertainties. Then, the seismic interpretations, combined with well data, are used as input for the sedimentary facies distribution. The uncertainty in the reservoir heterogeneities, will play a role in the pressure distribution and control (Lothe et al. 2016).

For the faults and fractures, we know that in practice, only faults with throw larger than around 20 meters, are interpreted. Major faults are usually associated with a fault zone characterized by minor faults below seismic resolution that can influence the fluid flow as a continuation of larger faults. For reliable uncertainty modelling, this needs to be included, resulting in several reservoir model
realisations, varying the possible fault pattern within their range of uncertainty. In addition, the effect of varying the depth of seismic horizons should be modelled.

The different approaches will be tested on a dataset from the Smeaheia/Troll region, offshore Norway. The final output is better constraints on the uncertainty range one should expect laterally in a sedimentary basin, and an evaluation of how important this would be for modelling and controlling pressure build-up related to CO₂ storage.

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