3D petrographic imaging and diagenetic modelling of reservoir formations

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The Utsira High (Norwegian North Sea) has been a petroleum exploration target since late 1960s. It is a large basement high (about 200x50 km) located 190 km west of Stavanger, flanked by the Viking Graben to the West and Stord Basin to the East.

The southern part of the Utsira High complex ("Haugaland High") gained new interest when Lundin Norway in 2007 discovered commercial hydrocarbons in deposits of Permo-Triassic and Early Cretaceous age.

A detailed mineralogical and sedimentological study of these rocks is carried out. These include sedimentological core logging and petrographical analyses e.g. optical mineralogy, XRD (bulk & clay) and SEM.

The present study focuses on the application of high-resolution 3D micro-CT scans in order to provide new insights into the diagenetic processes which has taken place in the reservoir rocks. In particular, the heterogeneous cores samples (e.g. conglomerate) exhibit a range of mineral phases (particularly quartz, feldspar, ferromagnetic minerals, clays) and have significant primary and secondary porosity often filled in by authigenic clays. The non-destructive high-resolution 3D micro-CT technique may improve our knowledge of the evolution of inter-connectivity of primary and secondary porosity through time ("4D diagenesis").

The development of CT methods has improved significantly during the last years, enabling us to get detailed petrographical information across scales; from nanometer to centimeter scale. The determination of different mineralogical phases in the grey scale CT images still remains a challenge due to similarities in material composition and density, i.e. different minerals with similar density appears as the same grey tone. To get additional mineral information additional imaging techniques are required, e.g. SEM-EDS analysis. Polished surfaces of the micro-core samples previously imaged by CT, are subsequently scanned by SEM-EDS producing a quantified representation of the minerology. The 2D mineral map can then be registered to the corresponding slice of the CT scan. This approach allows us to get more accurate quantification of mineral and diagenetic phases in the 3D CT data. By combining these methods a diagenetic 3D reconstruction model can be made making it possible to quantify the porosity evolution through time. The project goal is consequently better prediction of reservoir characterization through time.