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Characterization and geochemical modelling of caprocks for CO_2 sequestration - Nordland Shale case

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The storage of CO_2 in permeable rock is one of the most promising ways to reduce accumulation of greenhouse gases in the atmosphere and thus to mitigate its climatic consequences. Our investigatin is focused in the Saline aquifer in Utsira formation (North sea), where 1 million tons of CO_2 is injected per year in the area of the Sleipner field, since 1996.

Several studies were developed to understand the capacity of host rocks and the rate of CO_2 storage . In contrast, the sealing capacity and quality of caprocks or barrier levels present with respect to the injected gas were much less investigated. To understand the capacity of caprocks to effectively seal injected $CO_{2,}$ we need to know parameters such as sedimentological characters and geologic context, mechanical and petrophysical propertiers of these caprocks. Mineralogical composition and geochemical reactivity with respect to fluids likely to be present in CO_2 storages among solid, liquid and gas phases that composed the processus of CO_2 storage. The geochemical behaviour were investigated by numerical modelling. We simulate reactions among silicates, carbonates, clay minerals such chlorite, kaolinite and illite/smectite and formation water enriched in dissolved CO_2.

For Sleipner field in north Sea, we simulated the same kind of water-rock interaction with data obtained by British Geological Service (BGS) and Geological Survey of Denmark and Greenland (GEUS) on the Nordland Shale (50 to 100 m thick sequence in this area). This unit is composed by grey-green, laminated clay-rich shales. XRD whole-rock analysis showed that quartz, mica and kaolinite are the main mineral constituents of the Nordland Shale. Other minerals are muscovite, biotite, illite, ilite/smectite and chlorite, which occur in minor quantity. Results of cation exchange capacity (CEC) analyses show values about 12 meq/100g and surface areas of $80 m^2/g$.

Primary and secondary porosity aver very limited and frequently they're infilled by pyrite, dolomite and ankerite. (Kemp *et al.* , 2002).

The software used to simulate geochemical interactions was DIAPHORE, elaborated by the Institut Français du Pétrole (IFP) and partners (Bildstein, 1998; Le Gallo *et al.* 1998). As it was impossible to collect formation water related to the considered rocks. We used data published by Sanjuan & Gaucher (1999) on the Mont Terri site in Switzerland , which is a site where many of studies were undertaken on the behaviour of clay units as barrier for nuclear waste repositories (Sanjuan & Gaucher, 1999 ; Thury & Bossart, 1999). The rocks examined by these authors are buried at shallower depths than the aimed for for CO_2 injection in this study. Other water compositions were tested from data collected in the Utsira aquifer and used in the geochemical simulations elaborated by the Institut français du Pétrole (IFP) and Bureau de recherches géologiques et minières (BRGM). Finally we could simulate rock-fuide-gas interactions for the two cases and for two considerations, i.e., for Nordland shale mineralogical data we put formation water from Utsira formation and from Mont Terri site. The results indicate that is possible to arrive near to equilibrium between all phases about 10.000 to 1 million of years and with the variation of CO_2.

An another side, preliminary considerations were performed about the capacity of these caprocks to serve as a barrier against possible upward migration of CO_2 injected in the Utsira Formation. According to Lindeberg (1997), the worst scenario is the scape of CO_2 of almost 20% during 2000 years.

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