Permeability anisotropy at cm-scale in sandstones from De Geerdalen Fm., Deltaneset, Svalbard

Peter Frykman, GEUS, 2012.
Contribution to the BIGCCS SP3 activity

Outcrop samples of sandstones with thin clay laminations were selected during a short field trip to the Deltaneset area in September 2011 (Fig. 1). Sandstone layers in the Upper Triassic De Geerdalen Formation were inspected as an analogue to the projected reservoir layers for the CO2 storage in the Longyearbyen CO2 project.

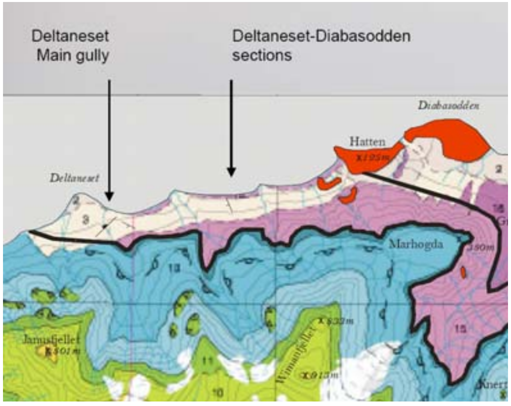


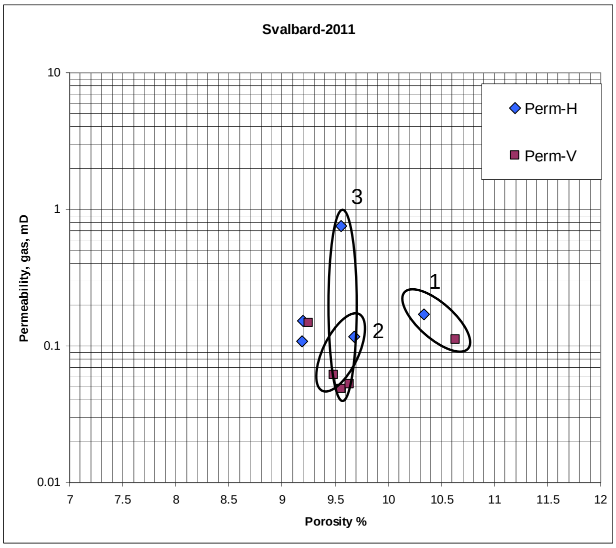
Figure 1. Location of outcrops visited for sampling. (From Mørk et al. 2011, TCCS prsentation).

The inspected section comprises a suite of interbedded shallow marine sands and shales. The samples were selected from layers where thin clay partings or laminae were present either as bed separations or as claydrapes on crossbed foresets. In these oriented samples were drilled horizontal and vertical 1 inch diameter plugs (Fig. 2).

Figure 2. Sample 3 with the two plug directions and clay laminations.

The plugs were cleaned with ethanol to remove any salt and dried before measurements of He-porosity and gas permeability were performed.

The measurements are seen to cluster in a narrow band between 9-11% porosity and 0.05-0.8 mD (Fig. 3). The permeability anisotropy is calculated as kv/kh ratio (Fig. 4).
The very low values are explained by some amount of clay but primarily by diagenetic cementation with quartz? cement evolved during the very deep burial under 4.5 km Tertiary rocks, uplifted during post-Eocene. For all samples the effect from fractures has been avoided by selecting unfractured material.



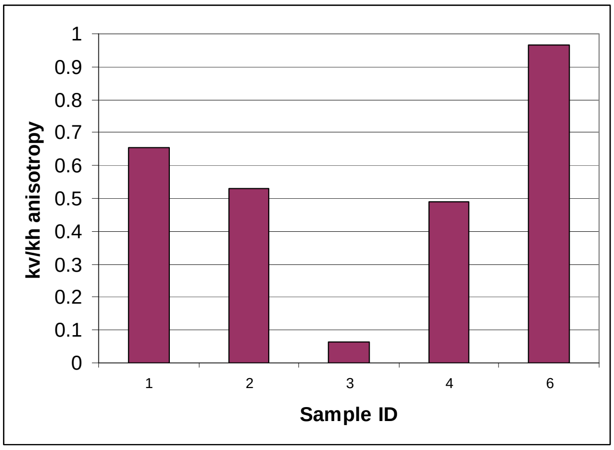


Figure 3. Figure 4.
Figure 3. Plot of porosity and permeability values for horizontal and vertical plugs. Sets of plugs from three samples are shown, and have consistently higher horizontal permeability than vertical permeability.
Figure 4. Calculated anisotropy kv/kh.

Conclusion

All five sample-sets show consistent anisotropy below 1 (Fig. 4), interpreted as being caused by the presence of clay rich laminations in the horizontal direction. This affects the vertical permeability, even if all rock samples have fairly low porosity and permeability compared to normal reservoir sandstones in other regions.
The intrinsic permeability of the clay rich layers could possibly be derived via permeability simulation and matching of the two directional permeabilities.

Appendix 1

GEUS Core laboratory, 12 March 2012

Sample ID	Stykke no.	Plug type	Perm-H mD	Perm-V	Por %	Dens g/ccm
1H	1	Hori	0.171		10.34	2.662
1V	1	Vert		0.112	10.63	2.67
2H	2	Hori	0.117		9.68	2.671
2V	2	Vert		0.062	9.49	2.669
3H	3	Hori	0.752		9.56	2.679
3V	3	Vert		0.049	9.56	2.678
4H	4	Hori	0.108		9.19	2.68
4V	4	Vert		0.053	9.64	2.677
6H	6	Hori	0.153		9.2	2.662
6V	6	Vert		0.148	9.25	2.661

Table 1. Measurements of samples, Vertical and Horizontal plugs.