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Permeability in deep North Sea sandstones as predicted from NMR

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Introduction

We used Nuclear Magnetic Resonance spectrometry and Mercury Injection Capillary Pressure porosimetry to estimate pore and pore throat size distribution of four samples from two deep North Sea fields. We then modelled permeability increments to find which pore sizes control permeability.

Methods

We measured gas porosity and permeability and derived liquid permeability by using Klinkenberg correction. We measured NMR T_2 relaxations and used end-trims to derive pore size distribution from MICP. We determined mineralogical composition by X-Ray Diffraction and recorded backscatter electron micrographs. We derived pore size distribution from NMR T_2 data by assuming a surface relaxivity, ρ, of 3 $\mu m/s$. In accordance with Hossain et al. (2011) and Rosenbrand et al. (2015) we modelled the contribution from each pore size to permeability as: $k_{i,NMR} = c_i \rho^2 \phi f_{NMR,i} T_{2,i}^2$, where c is Kozeny's factor, ϕ is porosity, and f_{NMR} is the fraction of ϕ that corresponds to a given T_2 increment $T_{2,i}$. We then cumulated from the smallest pores until the measured permeability was matched.

Results and Discussion

XRD and BSEM-images show that quartz is the dominating mineral in both sandstones and that sandstone A tends to be more cemented and have smaller pores than sandstone B (Figure 1a, 1b). MICP overlay well with NMR for sandstone A, but is much more scattered for sandstone B (Figure 1c and 1d). For sandstone A only the smallest half of the pores are needed for modelling permeability, although a good match is seen between NMR and MICP (Figure 1c and 1e). By contrast, in spite of the poor match between NMR and MICP for sandstone B, almost the entire pore space is needed in order to model permeability (Figure 1d and 1f).

Conclusions

For the cemented sandstone A we can match permeability by cumulating contributions from the narrowest half of the pore size distribution. The largest pores do not contribute because they are shielded behind pore throats. For the less cemented sandstone B almost the entire range of pores contribute to permeability.

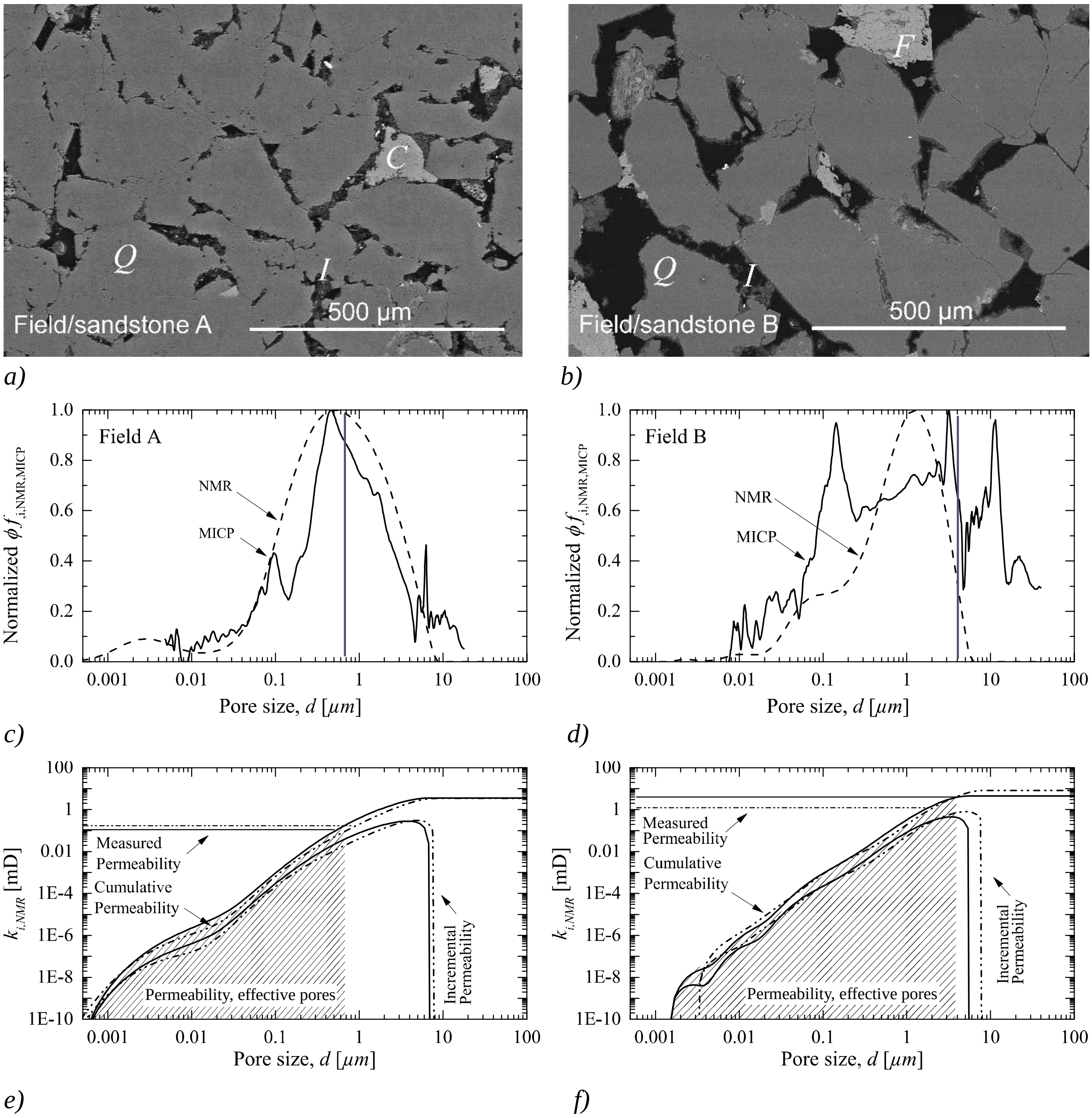

Figure 2: a) and b) BSEM-images, Q=Quartz, C=Calcite, F=Feldspar, P=Pyrite, I=Illite. c) and d) examples of NMR and MICP pore size distribution for field A and B, using ρ = 3 µm/s. e) and f) Klinkenberg permeability, incremental and cumulative NMR permeability versus pore size for all samples.

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References

Hossain, Z., Grattoni, C. A., Solymar, M., Fabricius, I.L. (2011). Petrophysical properties of greensand as predicted from NMR measurements Petroleum Geoscience, Vol. 17 2011, pp. 111–125

Rosenbrand, E., Fabricius, L.I., Fisher. Q., Grattoni. C. (2015). Permeability in Rotliegend gas sandstones to gas and brine as predicted from NMR, mercury injection and image analysis. Marine and Petroleum Geology. 64; pp. 189-202