The impact of pore-occluding cementation and chemical compaction on the reservoir quality of deeply buried sandstones

Alexander Monsees[a], Benjamin Busch[a], and Christoph Hilgers[a]

a. Structural Geology and Tectonics, Institute of Applied Geosciences, Karlsruhe Institute of Technology – KIT, Adenauerring 20a, 76131 Karlsruhe, Germany

alexander.monsees@kit.edu

Keywords: Reservoir quality, Diagenesis, Matrix Permeability

ABSTRACT

Authigenic quartz cementation and chemical compaction can have a deteriorating effect on the flow properties of potential reservoirs. The prediction of reservoir quality in sandstones can depend on grain coat coverage, authigenic cement types, and on the time exposed to various temperatures and thus the subsidence history. The deterioration of a reservoir due to compaction and cementation can thus be modeled and predicted (Busch et al. (2018); Lander and Bonell (2010); Lander et al. (2008)). Based on a Rotliegend case study from two wells (5200-5500 m) in Northern Germany, we present a workflow to assess porosity-permeability trends in siliciclastic reservoir rocks.

55 thin sections were sampled from core material to quantify the porosity, mineralogy, quartz cementation and grain coating coverage. The porosity and permeability of related core plugs was measured to obtain reservoir-related flow data. The modeled subsidence history of the reservoir plays an important role to predict the amount of cementation (Busch et al. (2018); Becker et al. (2017)).

Our samples mainly consist of sublitharenites, feldspathic litharenites and litharenites after Folk (1980). Besides mechanical compaction, pore-occluding authigenic quartz and chemical compaction are two primary factors that deteriorate reservoir quality. Continuous illite grain coatings inhibit quartz cementation and thus preserve porosity. Helium porosities range from 0.6% - 14.5%, and are highest in samples with most continuous illite grain coatings (>75% grain coating coverage). Chemical compaction was observed to occur more frequently if tangential illite was present on contacts between detrital grains (see Kristiansen et al., 2011). Permeability (0.009 mD - 780 mD) is mainly reduced by either an increase in quartz cementation or intense chemical compaction.

As a result, diagenesis is a key parameter that needs to be understood in order to successfully evaluate the reservoir potential of porous sandstones for geothermal and hydrocarbon exploration. Our workflow enables reservoir quality assessment in a system considering detritus, authigenic quartz and clay minerals. Reservoir-quality prediction modelling is currently developed towards more complex sedimentary and structural systems.

REFERENCES

Becker, I., Wüstefeld, P., Koehrer, B., Felder, M., and Hilgers, C., 2017. Porosity and permeability variations in a tight gas sandstone reservoir analogue, Westphalian D, Lower Saxony Basin, NW Germany: Influence of depositional setting and diagenesis. Journal of Petroleum Geology, 40 (4): 363-389. DOI: 10.1111/jpg.12685

Busch, B., Hilgers, C., Lander, R. H., Bonnell, L. M., and Adelmann, D., 2018. Reservoir quality and burial model evaluation by kinetic quartz and illite cementation modeling: Case study of Rotliegendes, north Germany. AAPG Bulletin, 102 (2): 293-307. DOI: 10.1306/0503171605217075

Folk, R. L., 1980. Petrology of sedimentary rocks. Hemphill Publishing Company.

Kristiansen, K., Valtiner, M., Greene, G. W., Boles, J. R., and Israelachvili, J. N., 2011. Pressure solution – The importance of the electrochemical surface potentials. Geochimica et Cosmochimica Acta, 75 (22): 6882-6892. DOI: 10.1016/j.gca.2011.09.019

Lander, R. H., and Bonnell, L. M., 2010. A model for fibrous illite nucleation and growth on sandstones. AAPG Bulletin 94 (8): 1161-1187. DOI: 10.1306/04211009121

Lander, R. H., Larese, R. E., and Bonnell, L. M., 2008. Toward more accurate quartz cement models: The importance of euhedral versus noneuhedral growth rates. AAPG Bulletin 92 (11): 1537-1563. DOI: 10.1306/07160808037