Regional mudstone compaction trends in the Vienna Basin: Implications for potential geological storage leakage

Skerbisch, Lukas[1]; Misch, David[1]; Drews, Michael[2]; Stollhofen, Harald[3]; Sachsenhofer, Reinhard[1]; Arnberger, Klaus[4]; Schuller, Volker[4]; Zamolyi, Andras[4]

1 Chair of Petroleum Geology, Montanuniversität Leoben, Peter-Tunner-Straße 5, A-8700 Leoben, Austria; 2 Technical University of Munich, D-80333 Munich; 3 Friedrich-Alexander University Erlangen-Nürnberg, D-91054 Erlangen, Germany; 4 OMV Exploration & Production GmbH, Vienna, Austria.

Lacking core material poses a major challenge for seal capacity estimation particularly in basins with limited geological information. In such cases the threshold breakthrough pressure, at which capillary displacement of hydrocarbons into the seal may occur, can be estimated by using established empirical normal compaction trends. However, such trends only deliver semi-quantitative results and need to be calibrated for a specific basin setting. Therefore, this work aimed at calibrating existing normal compaction trends and resulting seal capacity models for Miocene (Pannonian, Sarmatian, and Badenian) seal rocks of the well-explored Vienna Basin, finally linking the estimated seal capacity with actual geochemical evidence for hydrocarbon leakage through the respective mudstone interval. To do so, 41 core samples from the Vienna Basin, covering a broad depth interval from 720 m to 3,270 m, were investigated with X-ray diffraction, mercury intrusion capillary porosimetry (MICP), He-pycnometry, and Rock-Eval pyrolysis to capture the free hydrocarbon content of the samples. Decreasing porosity depth trends are visible throughout all stratigraphic intervals. Sarmatian and Badenian samples show well-defined depth trends, while a wider porosity scattering is observed for Pannonian samples. Bulk mineralogy has no clear influence on the porosity and pore throat depth trends. MICP porosity plotted against calculated maximum hydrocarbon column heights (HCH) revealed a comparable trend to modeled seal capacity curves. Most low-porosity samples from great burial depths range at estimated HCH > 3,000 m, where capillary seal failure seems unlikely. Rock-Eval parameters S1 and production index (PI = S1/(S1+S2)) indicate present free hydrocarbons in all investigated mudstone intervals. These free hydrocarbons are clearly a sign of oil staining, as all samples can be considered as organic lean and shallower samples as thermally immature. Both parameters correlate well with the estimated HCH particularly for the Badenian sub-set of samples. These trends indicate that hydrocarbons from underlying reservoirs may have been vertically migrating through these seal layers, possibly implying a higher-than-expected vertical fluid mobility also in the fine-grained and lowpermeable sections of the Miocene Vienna Basin infill. Overall, the petrophysical data acquired in this study show that established mudstone normal compaction trends are generally suitable to estimate seal capacity in the Vienna Basin. Free hydrocarbon indicators (Rock-Eval S1 and PI) show clear signs of oil staining correlating with the estimated seal capacity. This supports the general validity of seal quality estimations based on normal compaction trends. The suggested significant vertical mobility of fluids in mudstone intervals may represent an additional contribution to the primarily faultcontrolled secondary hydrocarbon migration in the Vienna Basin. Furthermore, it must be considered in the planning of underground gas storage activities.