

Field study on an exhumed lower Devonian high pressure reservoir

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We present a field-based study on a thick lower Devonian deltaic sand-shale sequence. The rocks studied are present in excellent quality outcrops around the shores of the Rur lake (Rhenish Massif, Germany), and allow to study processes occurring in a depth range not yet explored by drilling. We studied microstructure evolution in transmitted light microscopy, combined with fluid inclusion microthermometry and basin modelling. Microstructures indicate that the burial was initially at near-hydrostatic pore pressures. During compaction cohesion was built up by cementation. Then, pore pressure rose to values around the (horizontal) minimum principal stress, as evidenced by a suite of layer-perpendicular quartz veins in the sandstones, which show mode one trans-granular fracturing. The period of overpressuring was long-lived, in a setting of moderate tectonic extension, as shown by up to ten percent layer-parallel extension by crack-seal processes. Basin modelling helped to constrain the influence of gas generation and clay dewatering on overpressure build-up. Onset of tectonic shortening and rotation of principal stress direction is reflected by the development of layer-parallel reverse faults and associated quartz veins. Shear stress levels have increased as indicated by quartz microstructures, probably associated with a rise in pore pressure. Where the reverse faults crosscut bedding in small ramps, large amounts of quartz veins with complicated structures were formed, suggesting that these were major pathways for fluid migration. The early thrusts were overprinted by progressive folding and the development of a slaty cleavage in the pelitic layers.