The effects of glacial-interglacial loading on the 3D pore pressure evolution in sedimentary basins: case study from the Central European Basin System

Maximilian Frick¹, Mauro Cacace¹, Volker Klemann², Lev Tarasov³, and Magdalena Scheck-Wenderoth¹,4

¹Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Section 4.5 – Basin Modelling, Potsdam, Germany
²Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Section 1.3 - Earth System Modelling, Potsdam, Germany
³Memorial University of Newfoundland, Dept. of Physics and Physical Oceanography, St. John’s, Canada
⁴RWTH Aachen, Faculty of Georesources and Material Engineering, Aachen, Germany

This study deals with modelling the distribution of the subsurface pore pressure in space and the respective evolution in time in response to variations in hydromechanical surface loading during a full glacial-interglacial cycle. The aim here is to better understand (i) the feedback mechanisms between the atmosphere and solid earth components, and (ii) to which degree this coupling might be relevant for subsurface hydromechanical modelling studies. The study area is the Central European Basin System (CEBS) in northern and Central Europe and state-of-the-art ice reconstructions for the last glacial-interglacial period have been used to model the surface hydromechanical loading conditions. Thereby, investigations on how transient ice coverage influences the pore pressure distribution with depth and over time within a heterogeneous sedimentary cover were carried out. The subsurface beneath the CEBS consists of more than 10 km thick sediments, which have been heavily restructured by salt movements during the whole Mesozoic evolution. Our 3D geological model resolves all major sedimentary and crustal domains, and we relied on the GLAC1-D (1.0 degree longitude by 0.5 degree latitude spatial resolution) ice sheet chronology. Starting from ice-free initial conditions, transient simulation runs are performed (hydraulic vs hydromechanical) which cover the entire last glacial cycle, i.e. encompassing 122ka BP till present day conditions. Results are discussed in terms of pore pressure evolution over time and space. The focus will lie on quantifying subsurface conditions favourable to the establishment and maintenance of overpressure evolution and the related equilibration time within the sedimentary pile. We also investigate how these transient conditions influence the subsurface hydrodynamics, showcasing representative time steps during the evolution of the system. We will finally attempt to quantify the memory effect of such loading conditions on the basin-wide hydromechanics, a feedback mechanism that has been neglected so far in 3D subsurface studies.