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How clay layers control basin-scale fluid and heat flow

Reza Taherdangkoo (1), Elco Luijendijk (2), Albertine Potter van Loon (2), and Tom Gleeson (3)

(1) Department of Applied Geology, Geosciences Center, University of Goettingen, Goettingen 37073, Germany, (2) Department of structural geology and geodynamics, Geosciences Center, University of Goettingen, Goettingen 37077, Germany, (3) Civil Engineering, University of Victoria, Victoria, British Columbia V8P 5C2, Canada

The extent of groundwater flow in the subsurface is strongly controlled by low permeability strata. The presence of low permeability layers (e.g. clay layers) affects regional groundwater flow, resulting in different flow patterns and temperatures in sedimentary basins. This contribution explores the role clay layers play on restricting groundwater flow on basin and continental scales. We developed a two-dimensional model that couples groundwater flow and heat transport at the basin-scale. A parametric study is carried out to investigate how clay layers influence fluid and heat flow in sedimentary basins. The models are based on permeability and stratigraphy data compilations of North America and Europe. The studied key parameters include drainage density, recharge, hydraulic gradient, clay layer properties (i.e. thickness, depth, mineralogy, and anisotropy), continuity of clay layers, and permeability of the non-clay layers. Simulation results indicate that even a 1–10 cm thick continuous clay layer blocks groundwater flow. Moreover, we find that clay layers in most scenarios impair fluid and heat flow compared to clay-free basins. The results are used for a first order estimate of the extent of meteoric groundwater flow in the subsurface in North America and Europe. The numerical results demonstrate that both basin and clay layer characteristics influence groundwater flow and heat transfer.