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Air permeametry on outcrop analogues: a composite image of the Neogene aquifer, Belgium.

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Saturated hydraulic conductivity (Ks) is one of the most important parameters determining groundwater flow and contaminant transport in both unsaturated and saturated porous media. While several well-established laboratory methods exist for determining Ks, in-situ measurements of this parameter remain very complex. Since the 50's, and increasingly from the late 80's, air permeameters are being used effectively as an indirect method to determine Ks on outcrop sediments. In this paper, the heterogeneity within outcrop sediments that are analogues for the Neogene aquifer hydrostratigraphic units in northern Belgium is studied with a hand-held air permeameter. This aquifer, representing a major groundwater source, consists of several sandy geological units from Miocene to Pleistocene age with a marine to continental origin. Moreover, it plays an important role in the Belgian deep geological radwaste disposal studies, and is the subject of a safety assessment for a future low-level radwaste surface repository. To characterise the variability between and within the different lithostratigraphical aquifer units, 804 air permeability measurements at cm-scale were performed on several outcrops that are analogues for the sandy aquifer sediments and a highly heterogeneous aquitard. Equivalent meter-scale Ks tensors were calculated numerically through the law of flow conservation to obtain the vertical anisotropy factor. The off-diagonal tensor components were shown to be negligible.
To validate the air permeametry data, 18 additional constant head permeameter tests on 100 cm^3 cores and 27 grain size analyses based Ks assessments were performed on outcrop material. The comparison indicates that hand-held air permeameters are very effective and useful tools to characterise the magnitude of hydraulic conductivity, as well as it's small-scale variability and anisotropy, on a broad range of sediment types.
However, a comparison with data from a previous borehole campaign on similar though not identical aquifer sediments reveals that the Ks values predicted at the outcrops are systematically higher by at least a factor of 10 than the corresponding Ks distributions determined from the borehole cores. One explanation is the weathering state of several-cm thick clay lenses, i.e. much less weathered in the aquitard than in the analogous outcrop with correspondingly lower conductivities for the aquitard. This shows that transferring outcrop data to the subsurface should be done with care because of different degrees of compaction, weathering states, etc.