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The usefulness of CPTs for deterministic, spatially heterogeneous, large-scale aquitard parameterisation

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Abstract Aquitards can be effectively parameterised and incorporated in a groundwater flow model by using standard cone penetration tests (CPTs). Several conceptually different realizations of an aquitard's hydraulic conductivity field were evaluated based on: (i) conventional methods of soil behaviour type classification, (ii) recent relationships from the literature, and (iii) novel site-specific relations with hydraulic conductivity. We show that use of most of these CPT-based hydraulic conductivity estimations in groundwater flow modelling effectively enhance model performance based on absolute head values and gradients across the aquitard. Conceptual models that considered a spatially heterogeneous hydraulic conductivity for the aquitard performed better than the reference case with a uniform aquitard hydraulic conductivity. However, the hydraulic conductivity of thin heavy clay lenses, characteristic of the aquitard present in our study area, cannot be captured using these continuum approaches. The latter leads to a bias in the direct hydraulic conductivity predictions; an alternative is to invoke inverse modelling with the heterogeneous parameter fields. To address this issue, the concept of the boundary energy associated with the CPT signal is also introduced for characterising the presence of heavy clay lenses. Overall, the CPT-based concepts provide more accurate, robust, and high-resolution data-based parameterisation of the studied aquitard.

Key words groundwater modelling; hydraulic conductivity; soil behaviour types; cone resistance; friction ratio; geostatistics; inverse optimisation; upscaling; cone penetration tests; model performance