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Helical Groundwater Flow in Braided-River Sediments and its Effects on Solute Mixing

Olaf Arie Cirpka (1), Jeremy Paul Bennett (1), Claus Haslauer (1), Yu Ye (1), Massimo Rolle (2), and Gabriele Chiogna (3)

(1) Eberhard Karls Universität Tübingen, Center for Applied Geoscience, Tübingen, Germany (olaf.cirpka@uni-tuebingen.de), (2) Technical University of Denmark, Department of Environmental Engineering, Lyngby, Denmark, (3) Technical University of Munich, Faculty of Civil, Geo and Environmental Engineering, Munich, Germany

Spatially variable orientation of anisotropy can cause helical flow in porous media. In previous studies (Chiogna et al., 2015; Cirpka et al., 2015; see also Figure 1), we analyzed hydraulic conductivity fields with blockwise constant anisotropic correlation structure showing that macroscopically helical flow evolves, and leads to enhanced solute dilution in steady-state advective-dispersive transport. While these studies demonstrated the potential importance of helical flow in heterogeneous porous media, the likelihood of its occurrence remained unclear. In particular, natural sediments do not exhibit extended stripes of materials with diagonally oriented internal anisotropy.
In the present study, we generated realistic looking sedimentary structures mimicking scour fills that may be created in braided-river sediments. The individual geobodies are filled with anisotropic porous material. Cross-sections show typical cross-bedding. In particular we analyzed how the variability in bulk hydraulic conductivity between the geobodies and the differences in the orientation of anisotropy affect flow and transverse solute mixing. While the variance of log-hydraulic conductivity controls longitudinal spreading, the variability in the orientation of anisotropy is decisive for folding and mixing perpendicular to the mean flow direction.
The importance of non-stationary anisotropy for transverse mixing poses a challenge for the hydraulic characterization of sediments when predicting lengths of mixing-controlled quasi steady-state plumes.

References

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