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Newton's shear flow in permeable media

Peter Germann and Christina Bogner
Bern, Geography, Bolligen, Switzerland (pf.germann@bluewin.ch)

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Peter F. Germann, Prof. em. University of Bern (Switzerland), pf.germann@bluewin.ch
Christina Bogner, Dr. habil., University of Bayreuth (Germany), christina.bogner@uni-bayreuth.de

One-dimensional Darcy and two-dimensional Dupuit-Forchheimer approaches to flow in saturated permeable media as well as Hagen-Poiseuille flow in thin tubes are spin-offs from Newton's law of shear. The law introduces viscosity as the parameter of momentum dissipation during laminar flow. Shear flow is here extended to flow in unsaturated permeable media. A complete set of analytical expressions and experimental procedures have evolved that allow for the parametrization of shear flow in finger-flows, preferential flows in soils, and in drainage flows from lysimeters. The analytical expressions and the superfluous representative elementary volume greatly facilitate shear-flow modeling in partially saturated permeable media across traditionally presumed spatio-temporal scale boundaries and scale restrictions. However, the approach is limited to gravity driven infiltration at low Reynolds numbers and it does not account for redistribution of soil moisture due to capillarity. The principles of Newtonian shear flow will be introduced. Their application to preferential flow and conservative tracer transport will present a novel mechanistic approach to the long-standing hydrologic problem of pushing out old water from non-saturated permeable media. Further, the relationship between Newton's shear flow and Richards' capillary flow will be elucidated.