Geophysical Research Abstracts,
Vol. 10, EGU2008-A-03587, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-03587
EGU General Assembly 2008

Spatio-temporal scale of gravity-driven flow in non-saturated fissured and porous media

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It has been demonstrated that a wetting front moved with a constant velocity over a vertical distance of 2 m during infiltration into a homogeneously filled sand. The degree of water saturation in the sand was always distinctly less than unity. Constant velocity means no acceleration, thus, no net force acting on the moving water. From this and other examples, it is concluded that gravity is the only driving force and momentum dissipation due to the water's viscosity is the only force that continuously balances gravity at the local scale. The proposition represents a case of Darcy's law that is restricted to unit hydraulic gradient and that extends into the vadose zone.

The theoretical approach leads to a water content wave, WCW, as the basic unit of mobile water in fissured or porous media. A WCW is characterized by its velocity, amplitude, and trailing. The features depend on the media's internal structure and on initial and boundary conditions. Physically, a WCW may be viewed as a film of mobile water that is completely described by its thickness and length of contact with the surrounding medium. In principle, plane-Poiseuille flow between two parallel plates, Hagen-Poiseuille flow in a cylindrical tube, and Cuette flow along a solid plane, while the other water surface is exposed to the gas phase, differ only by linear factors, thus supporting a more general applicability of the WCW-approach. It provides for the effective life span of a WCW with respect to the duration of water input, and it also explains fingering in the coarser-grained medium when flow arrives from a finer-grained medium. Life span and wave velocity result in the maximum travel distance of

a WCW, while the product of velocity times amplitude gives its volume flux density.

Examples from soil hydrology, flow to shallow groundwater tables, and from flow across fissured chalk and granite will be presented in support of the WCW-approach.