Abstract Submitted
for the DFD05 Meeting of
The American Physical Society

Onset of convection in a gravitationally unstable diffusive boundary layer, in a porous medium MARC HESSE, AMIR RIAZ, HAMDI TCHELEPI, LYNN ORR, JR., Stanford University — We present a linear stability analysis of density driven, miscible flow in porous media in the context of CO_2 sequestration in saline aquifers. CO_2 dissolution into the underlying brine leads to a local density increase that results in a gravitational instability. The physical phenomenon is analogous to the thermal convective instability in a semi-infinite domain, due to step change in temperature at the boundary. We present a solution, based on the dominant mode of the self-similar diffusion operator, which can accurately predict the critical time and the associated unstable wavenumber. This approach is used to explain the instability mechanisms of the critical time and the longwave cutoff in a semi-infinite domain. For large times, both the maximum growth rate and the most dangerous mode decay as $t^{1/4}$. The instability problem is also analyzed in the nonlinear regime by high accuracy direct numerical simulations. The nonlinear simulations at short times show good agreement with the linear stability predictions. A dimensional analysis for typical aquifers shows that for a permeability variation of 1 - 3000 mD, the critical time can vary from 2000 yrs to about 10 days while the critical wavelength can be between 200m and 0.3 m.

Marc Hesse
Graduate Student Member

Date submitted: 01 Sep 2005 Electronic form version 1.4