THE EFFECT OF MECHANICAL DISPERSION ON MISCIBLE DENSITY-DRIVEN INSTABILITIES IN A HELE-SHAW CELL WITH HORIZONTAL FLOW

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The transport of a miscible pollutant injected in an aquifer with horizontal flow is investigated theoretically and numerically, to understand the effect of the zonal flow on de nsity-driven instabilities and water contamination. We use the model of Rayleigh-Taylor's instability in a vertical Hele-Shaw cell, and analyse the effect of Taylor's dispersion on the growth rate of perturbations arising near the mixing layer between the pollutant and fresh water. Mechanical dispersion, which is a second-order effect in the absence of zonal flow, is no longer negligible when a finite horizontal flow is present. A linear stability analysis shows that the longitudinal dispersion due to transverse velocity gradients has a significant stabilizing effect, and increases the wavelength of the most unstable mode. The phase velocity of waves, which is constant and equal to the zonal velocity in the absence of Taylor's dispersion, is also affected by the longitudinal dispersion: waves travel faster than the zonal flow when the heavy fluid is above. The structure of spatial modes is also affected by mechanical dispersion and is characterized by a vertical phase shift which affects the sinusoidal shape of the interface. These theoretical results agree with numerical solutions of the Orr-Sommerfeld equation (generalized to density-driven instabilities). In addition, numerical simulations of miscible solute transport involving the Darcy equation have been performed, and confirm theoretical results. Comparison with experiments will also be discussed.