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Towards a non-linear theory for fluid pressure and osmosis in shales

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In exploiting deep hydrocarbon reservoirs, often injections of fluid and/or solute are used. To control and avoid troubles as fluid and gas unexpected diffusions, a reservoir characterization can be obtained also from observations of space and time evolution of micro-earthquake clouds resulting from such injections. This is important since several among the processes caused by fluid injections can modify the deep matrix. Information about the evolution of such micro-seismicity clouds therefore plays a realistic role in the reservoir analyses. To reach a better insight about such processes, and obtain a better system control, we here analyze the initial stress necessary to originate strong non linear transients of combined fluid pressure and solute density (osmosis) in a porous matrix. All this can indeed perturb in a mild (i.e. a linear diffusion) or dramatic non linear way the rock structure, till inducing rock deformations, micro-earthquakes or fractures. I more detail we here assume first a linear Hooke law relating strain, stress, solute density and fluid pressure, and analyze their effect in the porous rock dynamics. Then we analyze its generalization, i.e. the further non linear effect of a stronger external pressure, also in presence of a trend of pressure or solute in the whole region. We moreover characterize the zones where a sudden arrival of such a front can cause micro-earthquakes or fractures. All this allows to reach a novel, more realistic insight about the control of rock evolution in presence of strong pressure fronts. We thus obtain a more efficient reservoir control to avoid large geological perturbations. It is of interest that our results are very similar to those found by Shapiro et al.(2013) with a different approach.