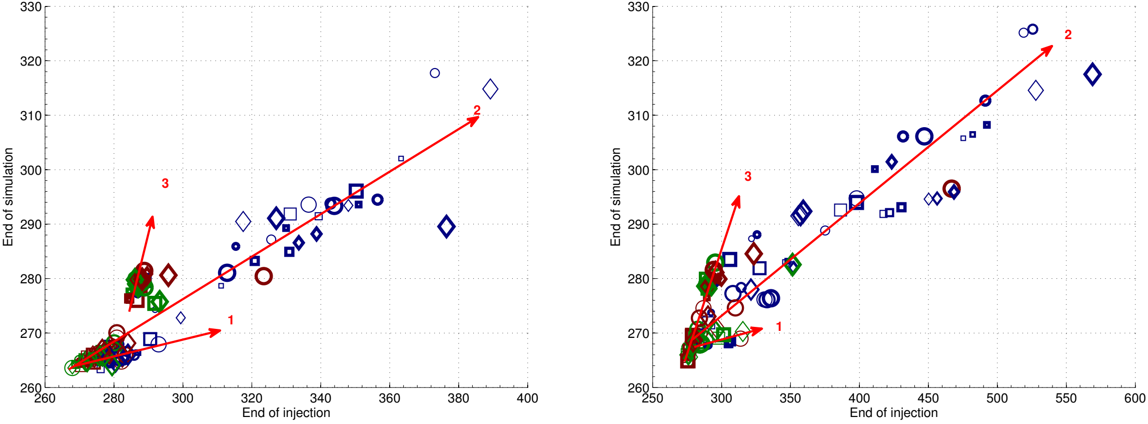

Figure 3: Cross-plot of average aquifer pressure at the end of simulation versus at the end of injection for linear (left) and quadratic (right) relative permeabilities.

displacement front for the quadratic case; compare the size of the two plumes in Figure 2. This means that the CO_2 plume will spread easier in the medium resulting in less flow through the boundary closest to the injector. Because of the lower mobility values in the quadratic case, more mass of CO_2 will be almost immobilized in the medium and the CO_2 plume will migrate very slowly compared with the linear case. Secondly, we observe higher pressures in the system during injection for quadratic permeabilities. The curvature of the quadratic curve gives lower mobility of CO_2 for small saturation values, and thence higher injection pressure is required to move the flow in the medium.

3.2 Pressure responses

The average aquifer pressure in general shows a sharp jump at the start of injection and a declining trend during injection and plume migration caused by pressure release through the open boundaries. (Specifying different boundary conditions would have resulted in different pressure trends). Figure 3 shows cross-plots of the average aquifer pressure at the end of injection and end of simulation for our two different choices of relative permeability functions. In both plots, one can recognize three different trends which have been indicated by three straight lines. The first trend, which has the lowest slope, represents cases with large pressure variation during injection and small range of pressure variation during the migration phase that follows after the end of injection. In these cases, the heterogeneity of the medium forms channels towards the open boundaries through which the injection pressure is released, resulting in low aquifer pressure at the end of simulation. The second trend, represents cases in which the heterogeneity affects injection, gravity segregation, and flow through open boundaries. In particular, we observe that most cases that have high injection pressure correspond to a low aggradation angle, for which low vertical permeability forces the injected CO_2 plume to move relatively slow in the lowest, poor-quality layers before migrating up towards the caprock. This increases the pressure in the domain during injection and keeps a higher pressure gradient to the open boundaries. In the third trend, the heterogeneity makes chambers and compartments in which the pressure increases during injection and then remains high. Cases with closed faults are of this class. The heterogeneity in these cases affects the gravity segregation process more than in the two other trends because of faults and a high level of barriers.

We also see the effect of curvature in the relative permeabilities by comparing the two plots. Higher range of pressure variations is observed during injection for the nonlinear relative permeability runs. Moreover, nonlinear relative permeability gives lower mobility which leads to higher pressure build-up during injection. This means that longer time is required for the pressure to be released through the open boundaries after injection and more cases therefore follow the second and third trend.

More details about the bottom-hole pressure will be given in a forthcoming paper, in which we also will discuss more realistic constraints on the injection operation.