tication has been confirmed for a few (arbitrary selected) cases by computing the plume migration for more than ten thousand years. We also observe that in some cases the residual volumes *decrease* after injection ceases. This is an artifact and is caused by mobile CO_2 invading zones of residual CO_2, thereby turning residual volumes into mobile volumes according to the definition of residual trapping used herein. These cases are therefore likely to be influenced by hysteresis effects [1, 28, 49], which for simplicity have been disregarded in this study.

3.2.3 Connected CO_2 volumes

In the next section, we will study the risk of leakage through the caprock. To this end, we will use a simplistic model which assumes that all mobile CO_2 connected to a leakage point will escape through that point. Hence, it is preferable if the total mobile CO_2 volume is split into smaller plumes rather than forming a big mobile plume. Moreover, the surface area per volume increases by splitting the plume (assuming constant plume shape) and this helps residual trapping (and mixing of brine and CO_2).

During injection, the flow support from the well builds a connected mass of CO_2 shaping one or a few big plumes. When the injection ceases, the CO_2 starts distributing in the medium and plumes may split because of branches in the flow paths created by heterogeneity. The plot to the left in Figure 11 shows how the number of plumes increases significantly in most cases during the migration phase, except for a few low-aggradation cases for which the injected plumes stay intact or reform into a single plume.

The right plot in Figure 11 shows the volume of the largest CO_2 plume versus the residual trapping. Here, we see two major trends indicated by a solid and a dashed line. The solid line, having a positive slope, represents cases that loose CO_2 through the open boundaries, mainly through the one closest to the injection point. As a consequence, less CO_2 volume exists in the system and the size of the largest plume will be smaller. Hence, less volume will be swept while the plume migrates upward (if it does), which again means that less CO_2 is residually trapped. In particular, we notice the cases inside the ellipse which are the same cases that had large CO_2 volumes escaping through the down-dip boundary as shown in Figure 6. The dashed line with negative slope corresponds to cases for which almost all of the injected CO_2 stays inside the domain. These cases show a small range of variation for the largest plume size and are reflecting the effect of different heterogeneity features on the residual trapping process. Because equal volumes of CO_2 are injected in all cases, we notice that the bigger the main plume is, the smaller the residual volume will be (mainly because the fraction of CO_2 that corresponds to saturation below 0.2 inside the movable plume is not considered to be residually trapped according to the definition used herein).

4 Analysis of Parameter Impact

The main purpose of the current study is to investigate how geological heterogeneity impacts the formation of a CO_2 plume during injection and during the early-stage migration after injection ceases. In this section, we will therefore perform a simple 'sensitivity analysis' that will tell us something of how the different geological parameters impact the flow responses discussed in the previous section. The five geological parameters impact the flow responses to different degrees; some parameters are more influential during injection, others take effect when the migration starts after injection has ceased, and some are influential both during injection and migration. Comparing the relative impact of the different parameters will indicate which of the parameters are most important to represent accurately when modeling a specific aquifer of the type considered herein.

To quantify the relative impact of each geological parameter, we will define normalized sensitivities that measure how much each of the basic flow responses discussed in the previous section change due to a unit change in a normalized geological parameter. We emphasize that these sensitivities cannot be interpreted as gradients in the strict mathematical sense. We will use barriers as an example to explain the analysis. There are three levels of barriers: low, medium and high. Suppose that we want to calculate the sensitivity of the number of plumes with respect to the level of coverage for the barrier sheets. We do this in two steps: first we average the number of plumes for cases of the same level of barriers. Having three levels of barrier, this results in three averaged plume numbers corresponding to each level of barriers. In the next step, we fit a line through these three points and calculate the