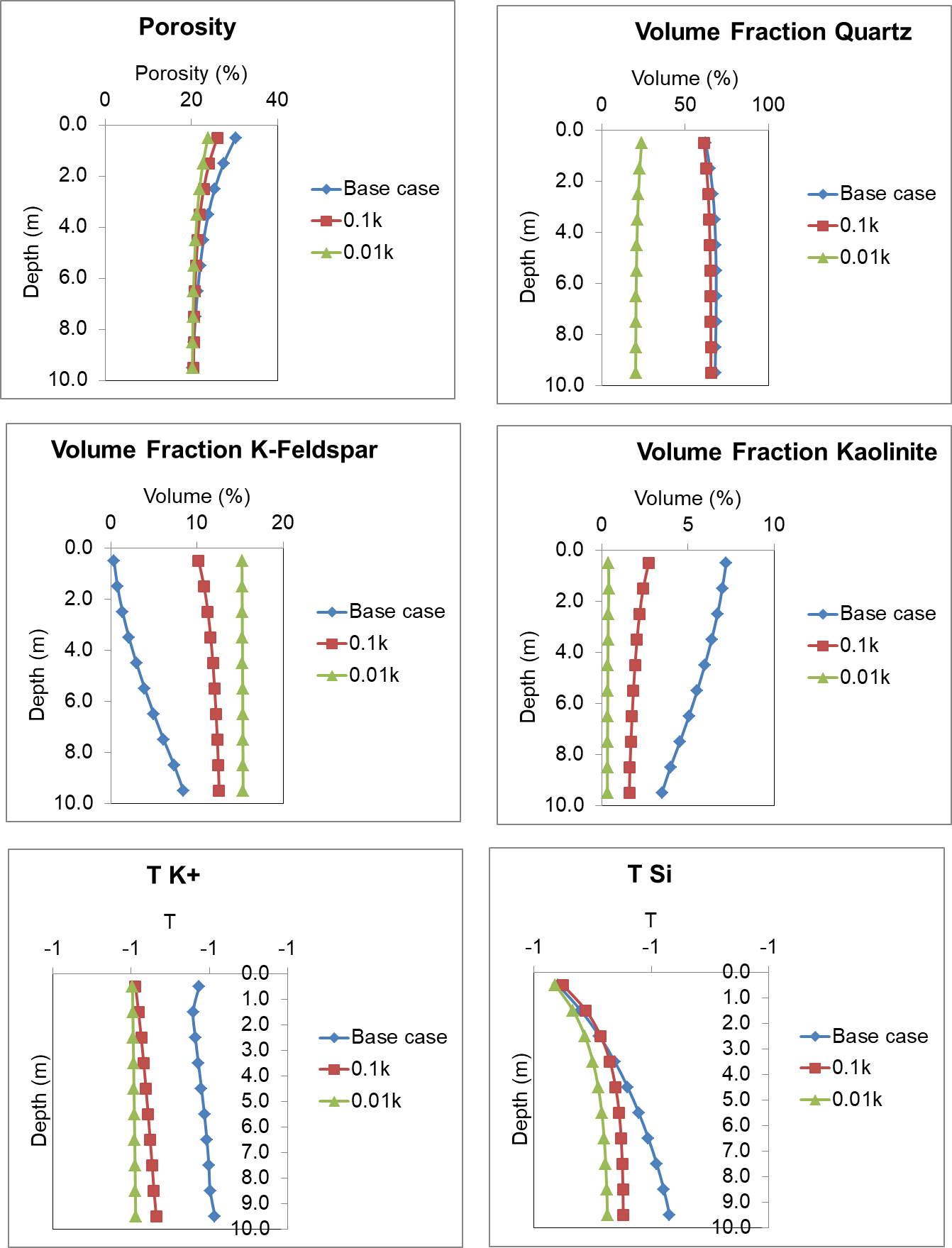
HW 9 Chemical Weathering

Question 1.All plots are at 100,000 years.

1.1 K-Feldspar dissolution rates altered

The effects of changing the K-Feldspar dissolution rates changes the porosity by increasing the porosity with increasing the dissolution rates from the initial porosity of 0.2. At the slowest dissolution rates of K-Feldspar 0.01k, we observe the smallest fractions of quartz through the column since the K-Feldspar is not dissolving as much but the quartz dissolution rates have not changed, decreasing their relative fractions. K-Feldspar has been completely depleted at the top of the column by 100,000 years as compared to the slower rates causing increasing surface level fractions of the mineral. Kaolinite plots are directly opposite those of the K-Feldspar since the mineral precipitates as the K-Feldspar dissolves – thus demonstrating opposite trends. The tau plots are only different up to the 7th decimal point. I think this might have to do with the fact that I did not calculate these correcty from the output data but also the fact that at 100,000 years for K+ we will see values around -1 signifying that the mineral phase was completely depleted due to chemical weathering, whereas the silica has not been completely depleted at the bottom of the column yet at that time. (Sorry about the axes on the tau plots. I could not figure out how to best fit 7 decimal places onto the graph legibly to see any differences).

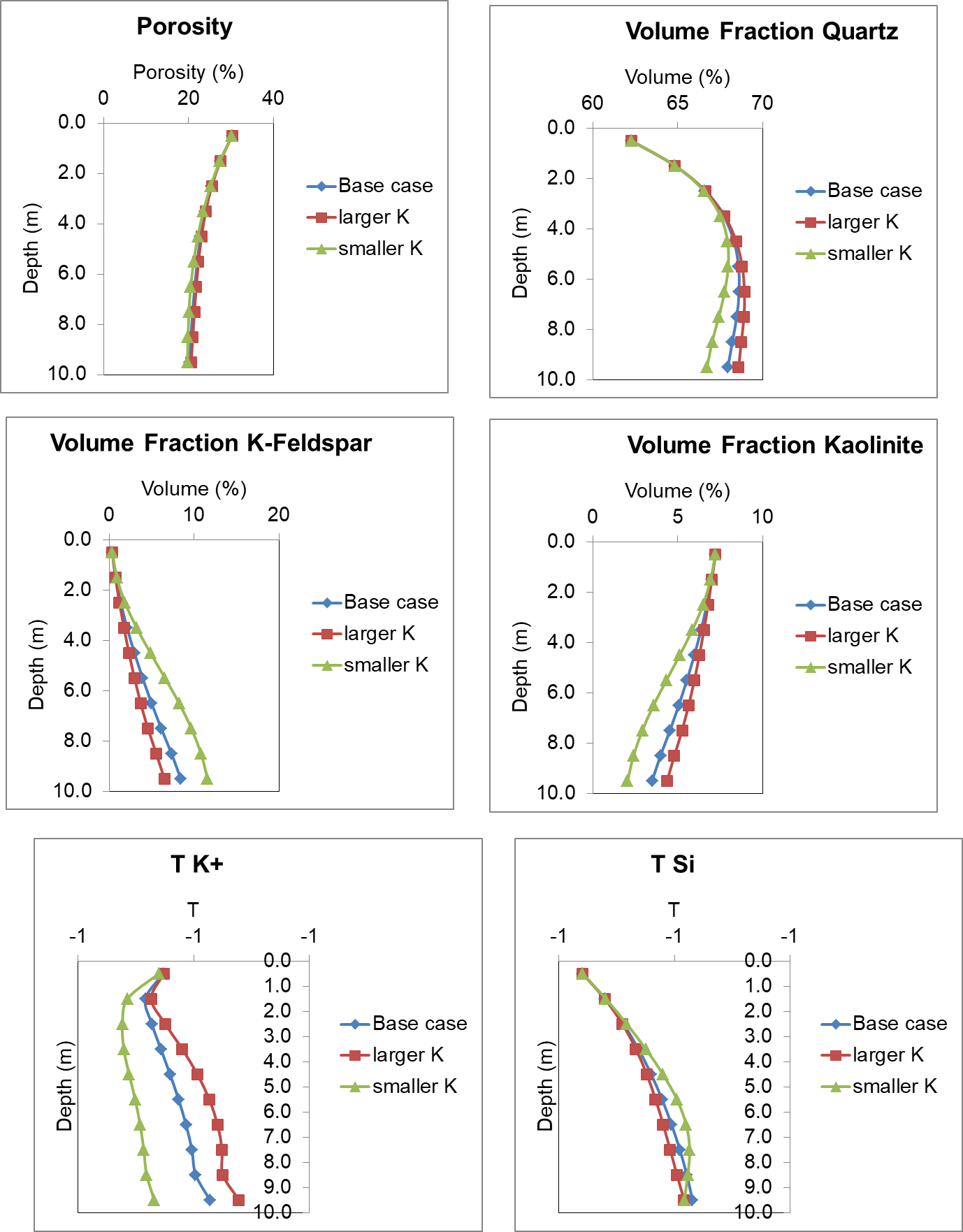
See plots following on next page.



1.2 K-Feldspar equilibrium constants altered

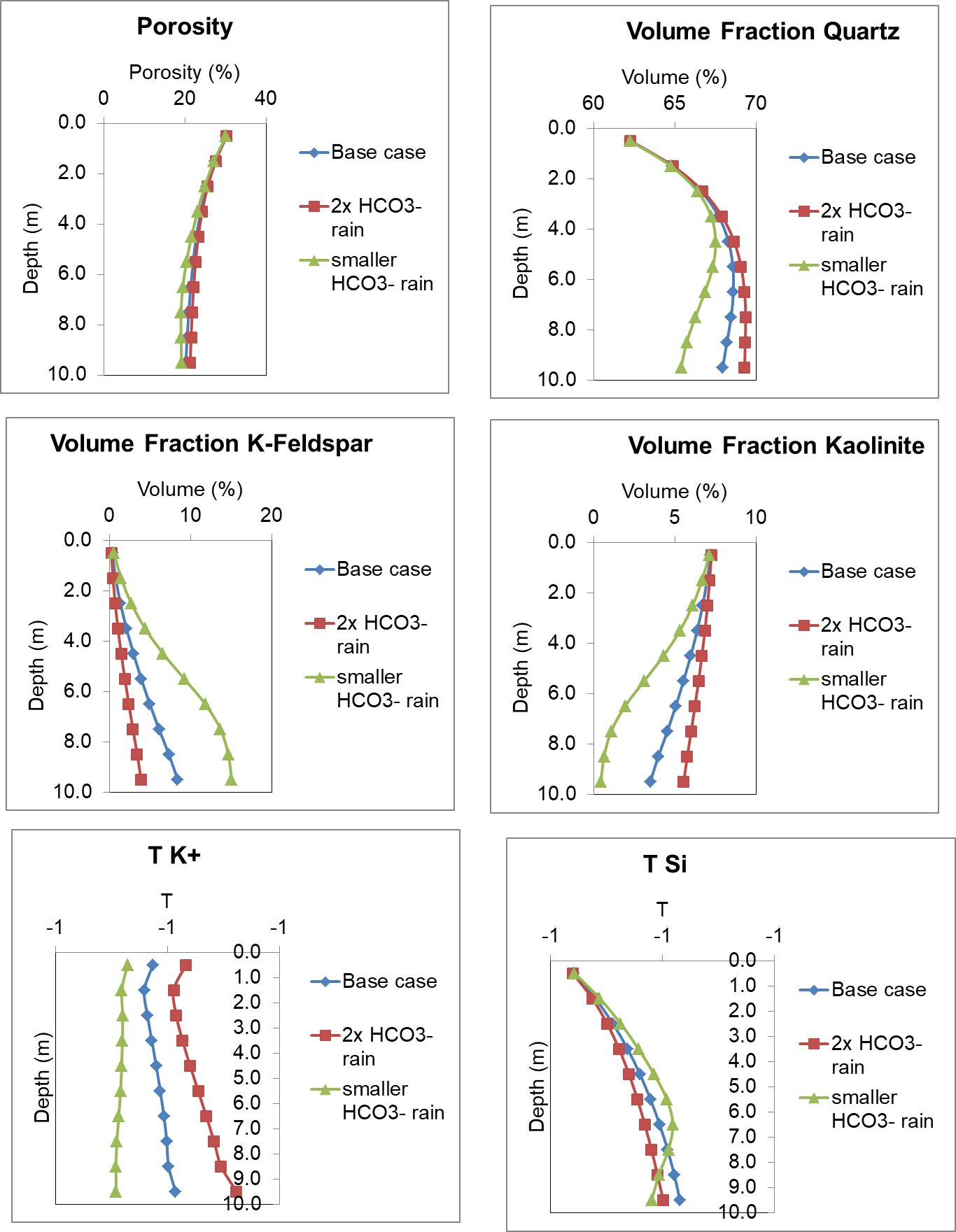
The equilibrium constant for K-Feldspar was increased and decreased by a magnitude from the base case. Altering this parameter had no visible effect on the porosity of the column. At a depth of around 4m we see a differentiation in the volume fraction of quartz with increasing fractions of quartz with the larger equilibrium constant for K-Feldspar and vice versa for the smaller K. It makes sense to see K-Feldspar nearly depleted at the surface and increasing through the column at one time point, 100,000 years with the smallest K value exhibiting the largest remaining volume fractions of K-Feldspar towards the bottom of the column compared to the other cases. Kaolinite again trends opposite K-Feldspar. Only the tau plots for K+ look distinctly different with the larger K logically having higher tau values since there is the potential for more dissolved K+ species from weathering than at a smaller K value.

See plots on following page.



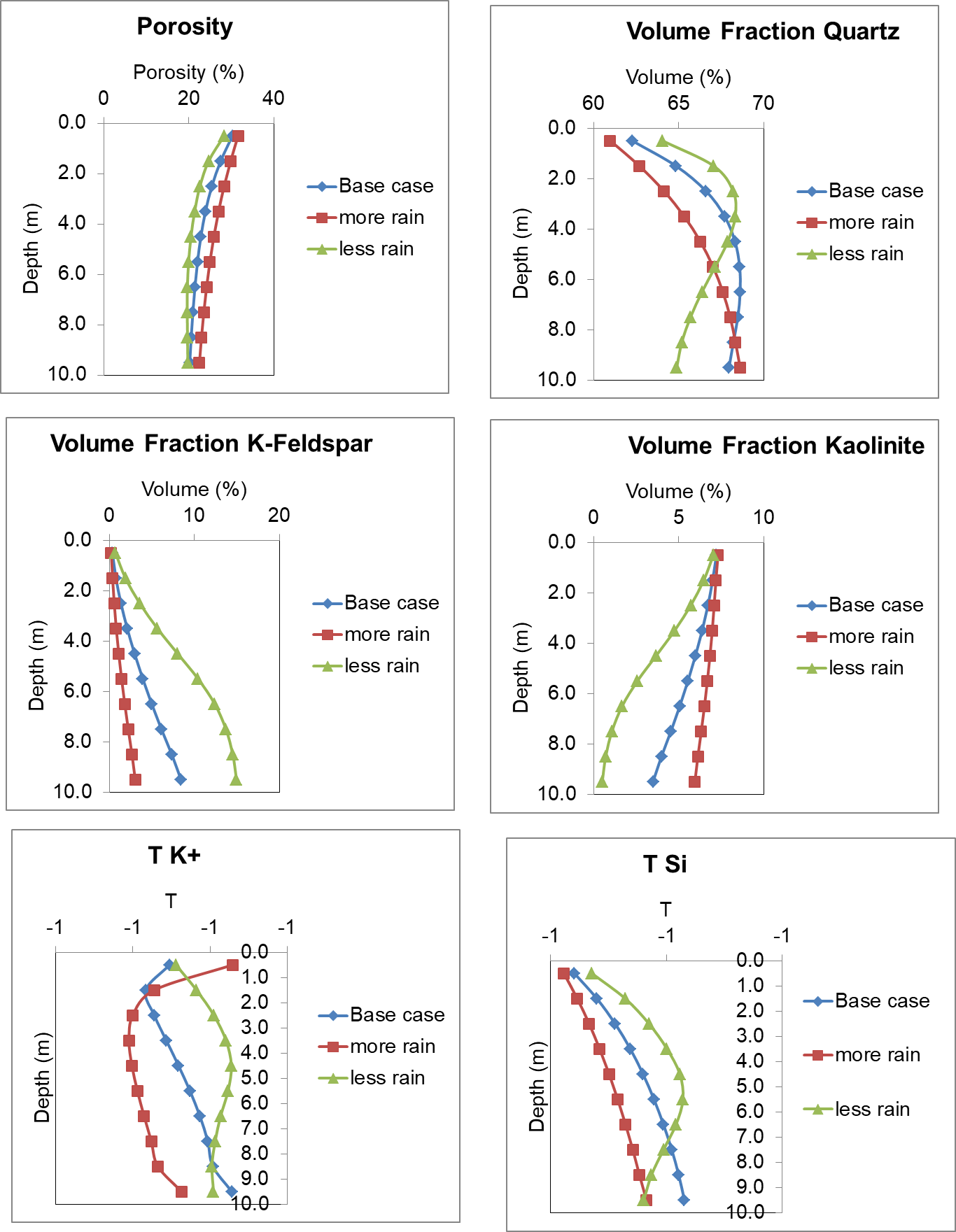
1.3 HCO3- initial concentrations in rainwater altered

Adding more HCO3- into the initial rainwater condition creates a more acidic rainwater which in turn drives the dissolution of K-Feldspar within the column. With increasing dissolution of K-Feldspar due to this phenomenon we see similar trends as in the previous simulations with less volume fraction of K-Feldspar at the surface and increasing Kaolinite volume fraction at the surface directly opposite K-Feldspar.



1.4 Annual rainfall (flow velocity) altered

By increasing the rainfall we see an increased porosity at the surface due to increasing dissolution of minerals in the column. The volume fractions of quartz increase due to their respective increases with decreasing K-Feldspar volume percentages. With less rain we observe more K-Feldspar and less Kaolinite in the column as compared to the condition with increased annual rainfall.

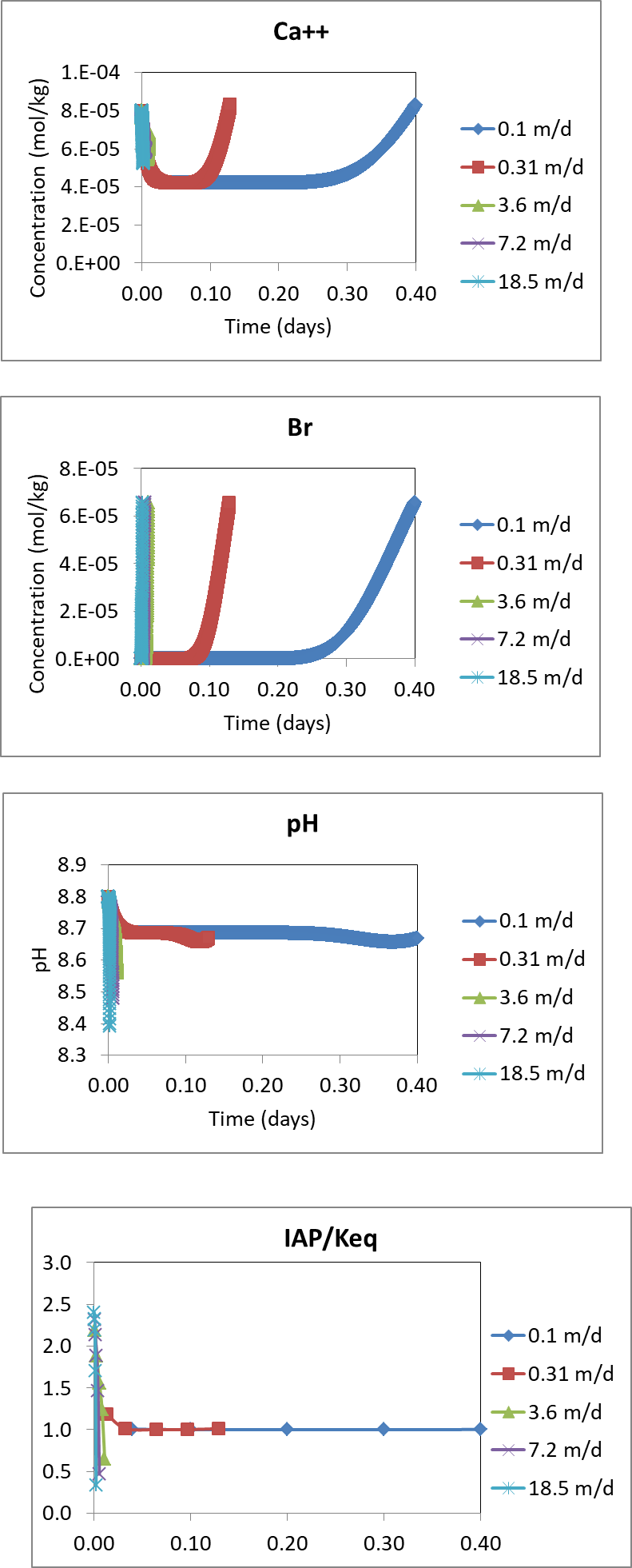


Question 2. Calcite dissolution in a column (short time scale)

2.1 Calculations

2.2 Flow velocity alteration simulations

The flow highly impacts calcite dissolution as seen in the Ca++ free species plots which reach equilibrium at the breakthrough very rapidly compared with changing the flow velocity to a very small flow which takes much longer to see the same concentrations. The IAP/Keq reaches equilibrium much slower in the slower velocity systems to around 1 whereas the faster velocities do not appear to reach equilibrium at the respective residence times as they trend below 1 indicating a change from precipitation to dissolution. The system does not appear to have enough time to stabilize before the flow has left the column. The rainwater also has a lower pH than does the column which increases the potential for dissolution of the calcite.



2.3 Calculate column-scale rates, R

2.4 Calculate DaI and DaII for each flow velocity. I assumed the area of the calcite given divided by the volume of the column for A, Ceq I found experimentally as 1.498E-4 mol/m^3, assumed a k indicative of reactions at higher pH of 7.24E-9 mol/m^s-s.



2.5 Table of calculated values and plots



The following plots depict the relationship between the R and the dimensionless Peclet and Da numbers. As Pe increases, the advective transport dominates and dispersive/diffusive transport becomes negligible and the R increases too. The DaI and DaII numbers are large, indicating that the reaction times are much faster than the advective or diffusive/dispersive transport mechanisms and these have an opposite effect on the R values which decrease with increasing Da numbers. These systems are transport controlled due to the rapid calcite dissolution reactions.

