Fourth Annual Conference on Carbon Capture & Sequestration

Developing Potential Paths Forward Based on the Knowledge, Science and Experience to Date

Geologic Sequestration

Carbon Dioxide Sequestration in Saline Aquifers: Evaporation, Precipitation and Compressibility Effects

Mohammad Piri, Jean H. Prévost and Richard Fuller

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Outline

- Introduction
- Our model - *Dynaflow*
- One-dimensional radial flow simulations

  Evaporation & precipitation

  Effects of salinity

  Effects of compressibility

Two dimensional simulations

  Hysteresis in relative permeabilities

  Gravity segregation

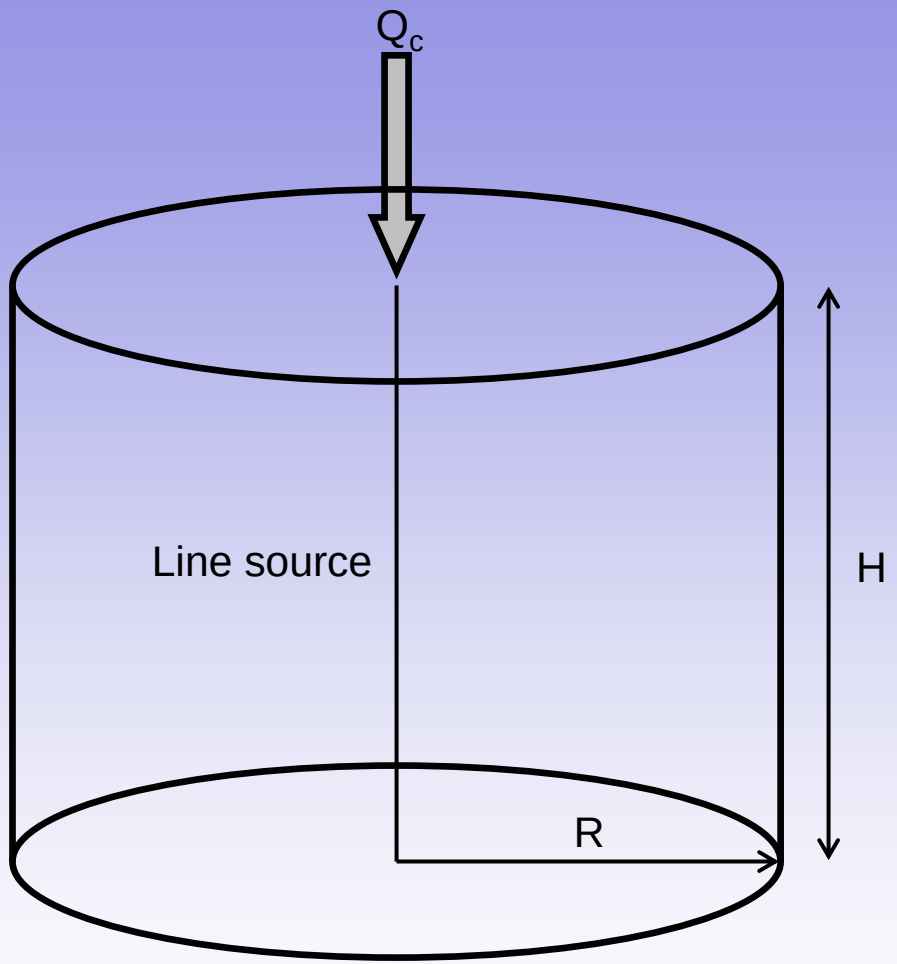
Our model - *Dynaflow*

A compositional, multiphase, multicomponent reservoir simulatror that has been developed at Princeton University which:

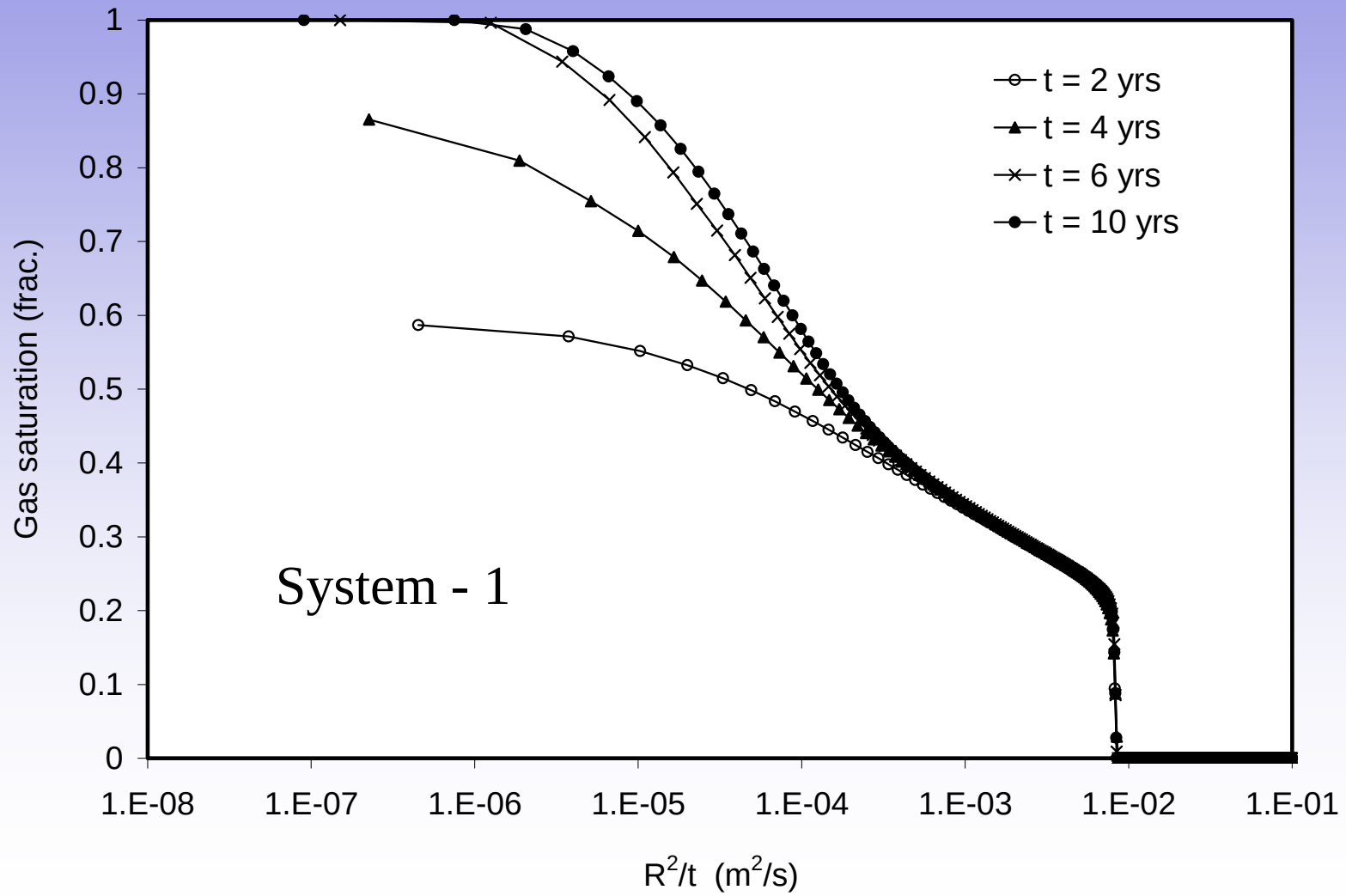
- Benefits from a robust flash module that has been specifically developed for CO_2/Salt/Water system which assumes
  - Aqueous phase may contain salt, water and CO_2
  - CO_2 rich phase may contain water vapor but not salt
  - Precipitated salt is pure
- Transports salt and CO_2
- Evaporation of water
- Precipitation of salt due to evaporation
- Effects of pressure and temperature on solubility of CO_2 in the brine
- Effect of change in salinity of the brine on CO_2 solubility
- Porosity change due to salt precipitation and matrix compressibility
- Permeability change due to change in porosity
- Matrix & fluid compressiblities

Radial Injection

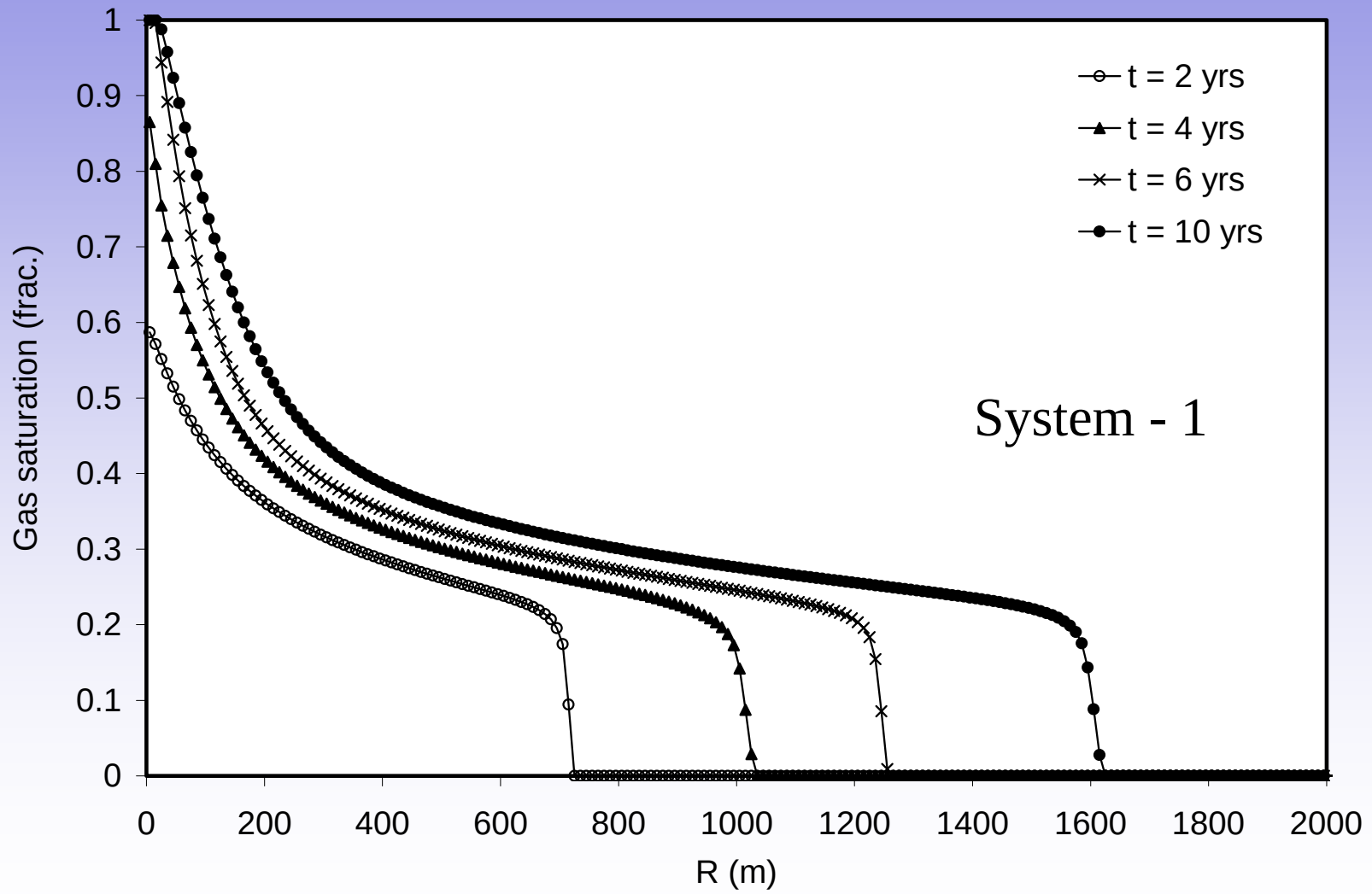
- T = 50 °C
- P = 1.6E+7 Pa
- K_{abs} = 100 mD
- ϕ = 0.15
- Salinity = 0, 5 & 15 wt%
- q = 1 kg/m s
- R = 100 km
- H = 100 m
- S_{lr} = 0.24
- Pore compressibility = 6.5E-10 Pa^{-1}



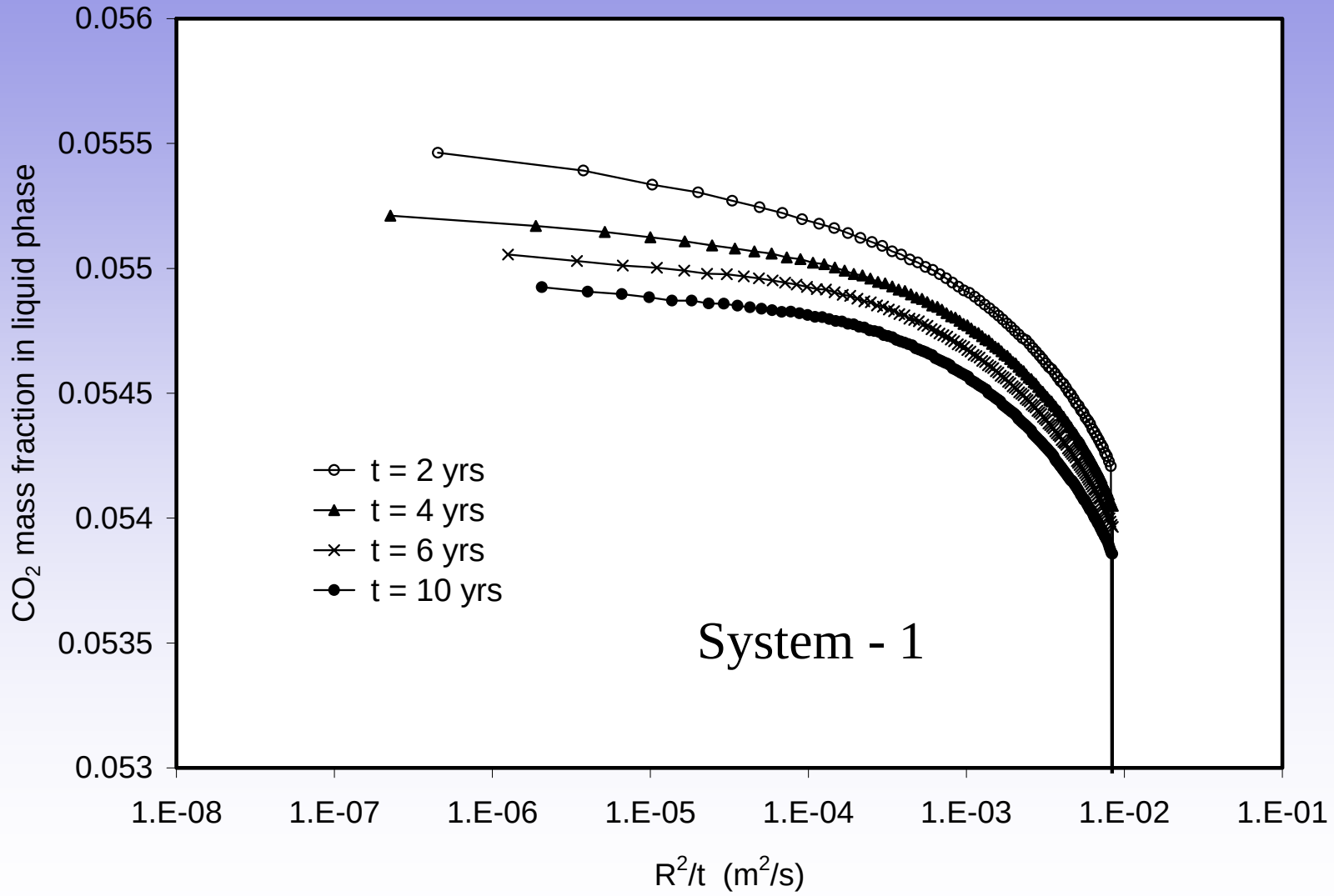
Radial injection – zero salinity



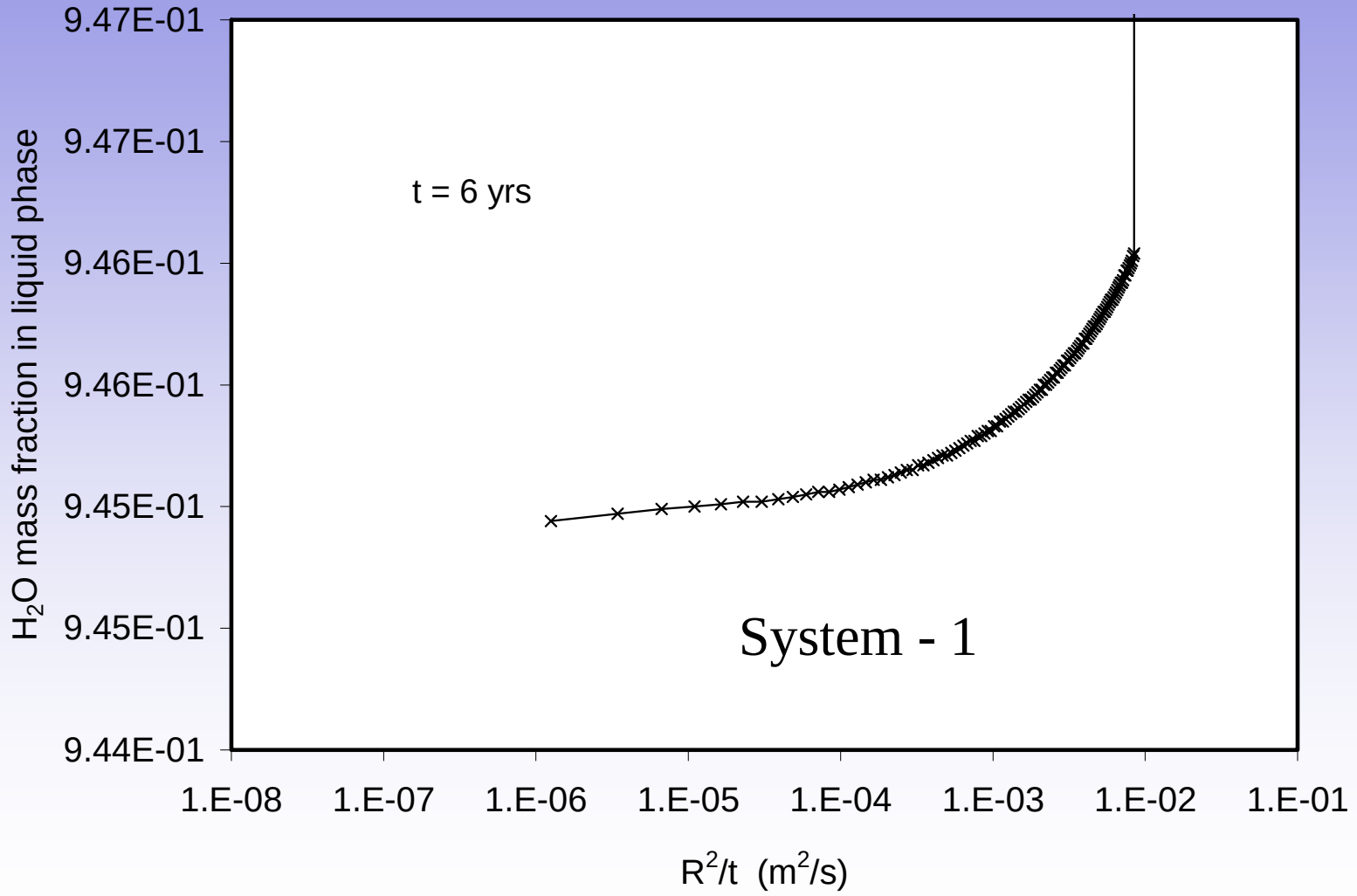
Radial Injection – zero salinity (cont'd)



Radial Injection – zero salinity (cont'd)

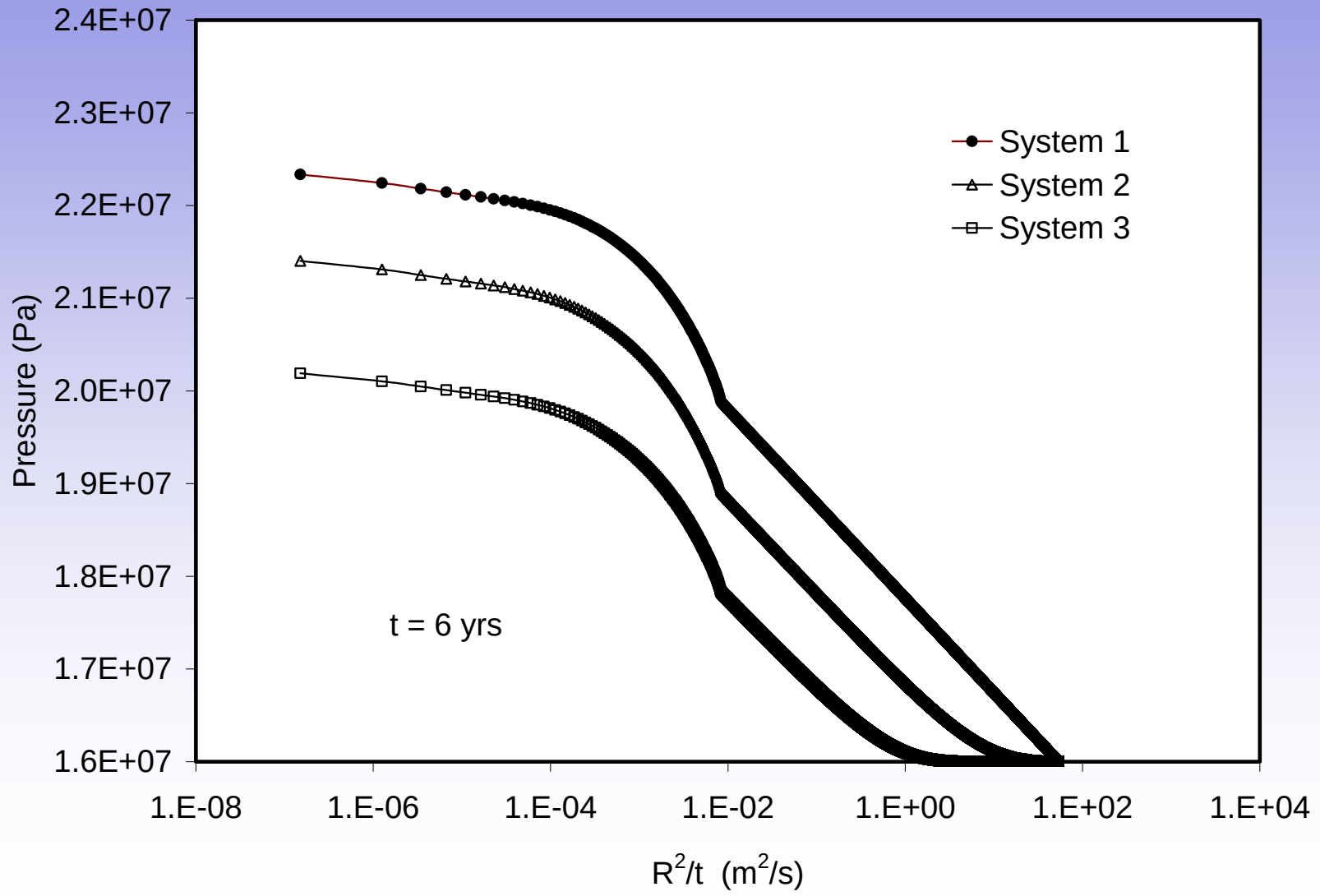


Radial Injection – zero salinity (cont'd)

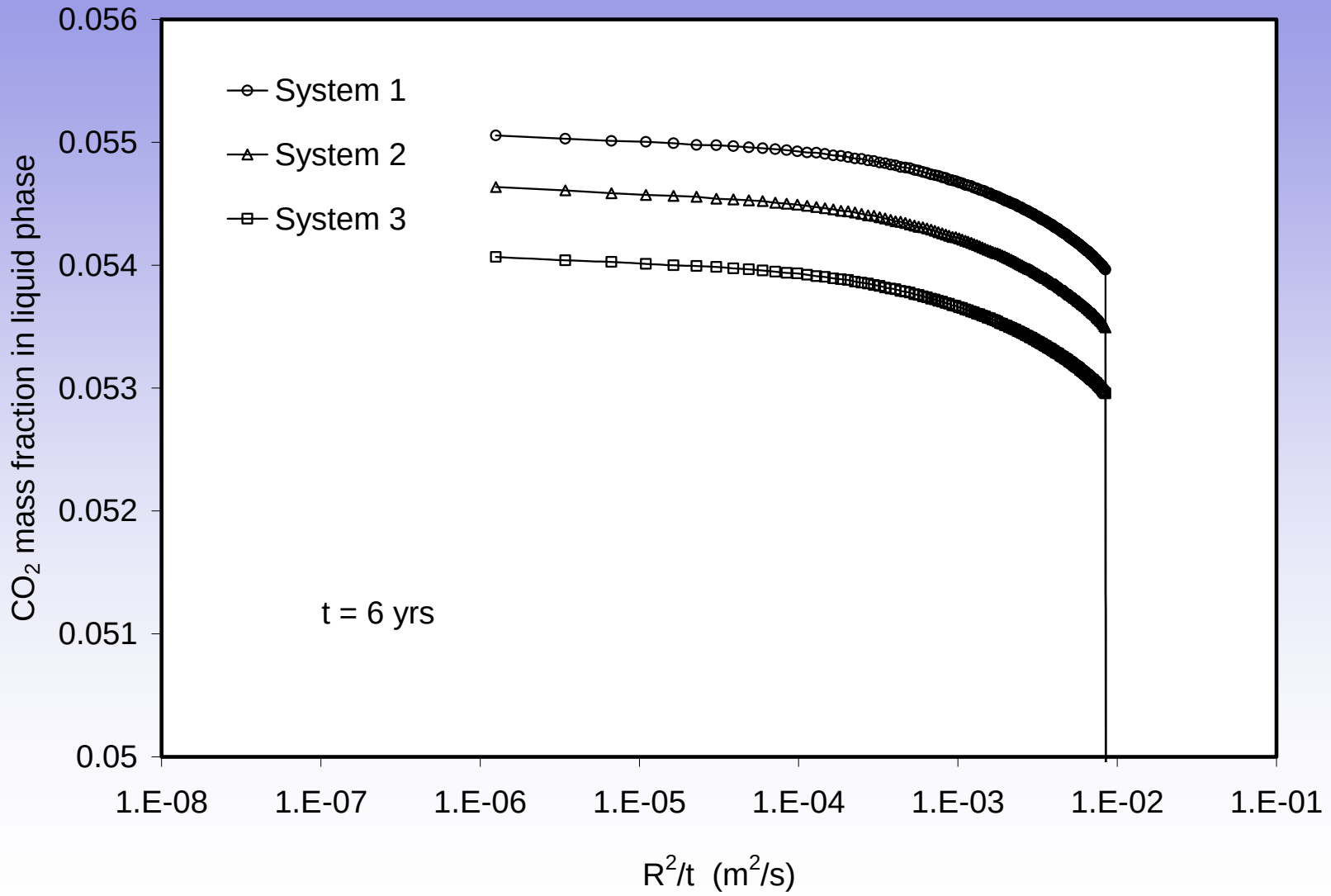


Radial Injection – zero salinity (cont'd)

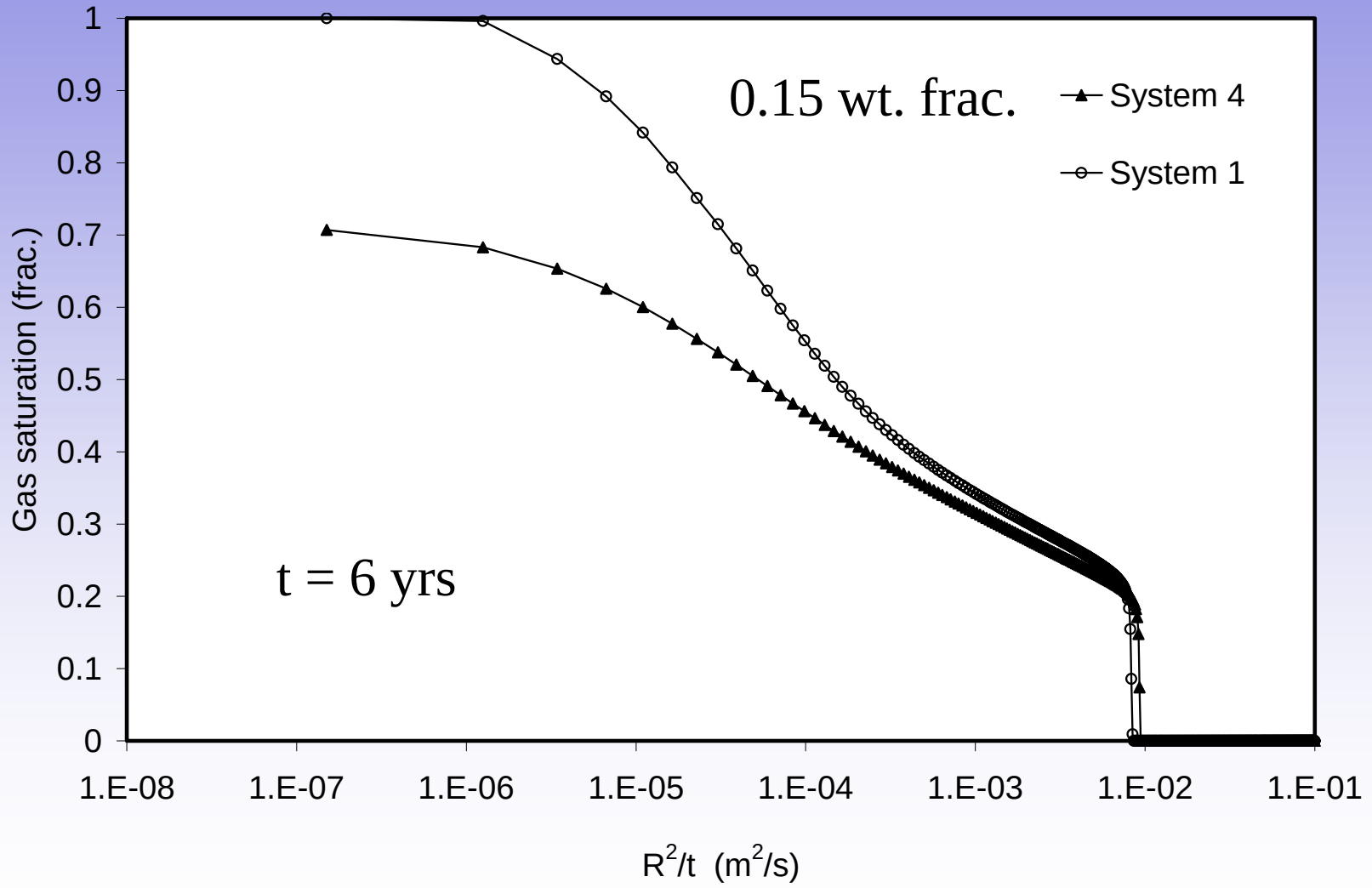
Effect of compressibility on pressure



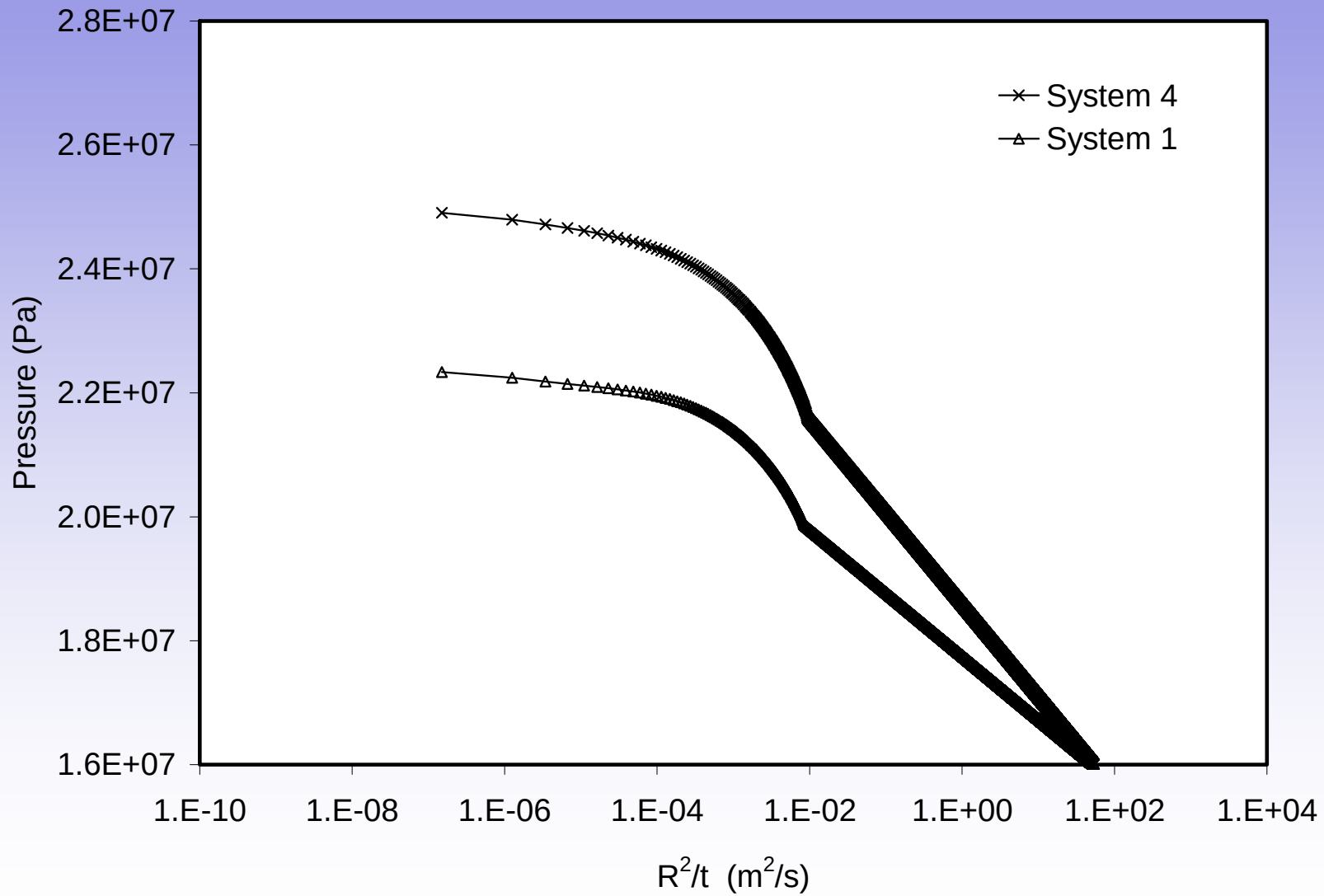
Radial Injection – zero salinity (cont'd)



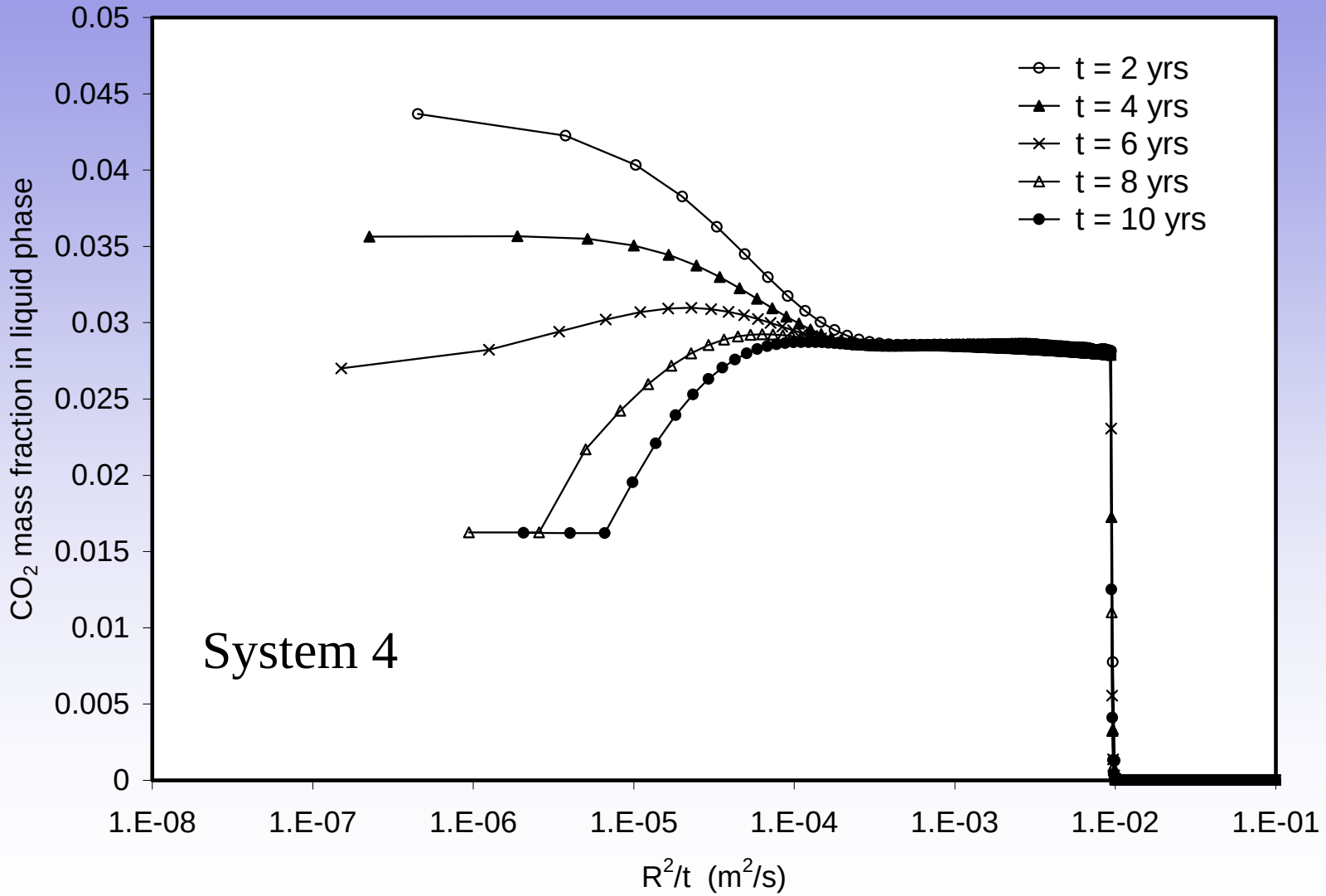
Radial Injection – effects of salinity on emergence of the dry region



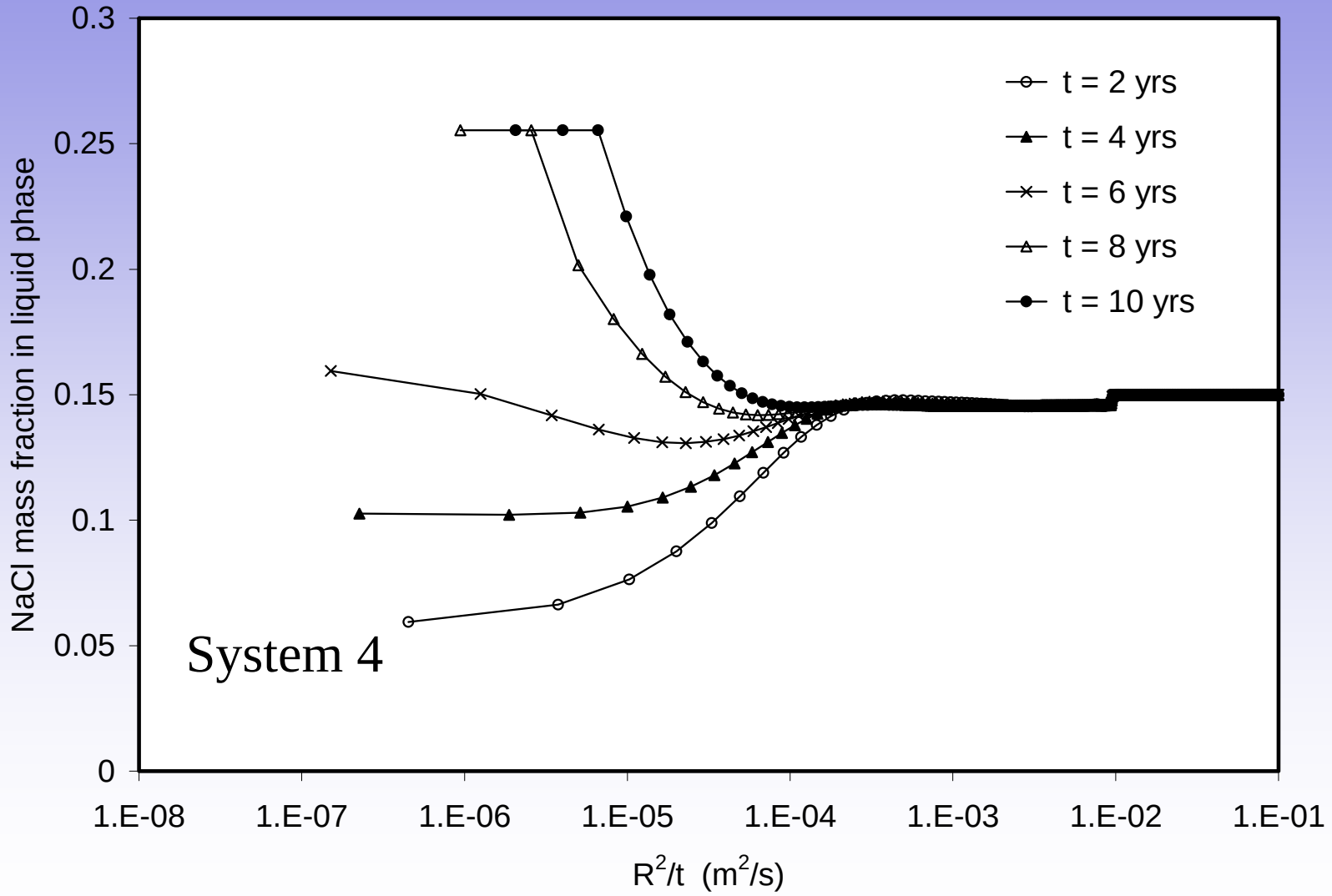
Radial Injection – effects of salinity on pressure



Mass fraction of CO_2 in the liquid phase



Mass fraction of salt in the liquid phase



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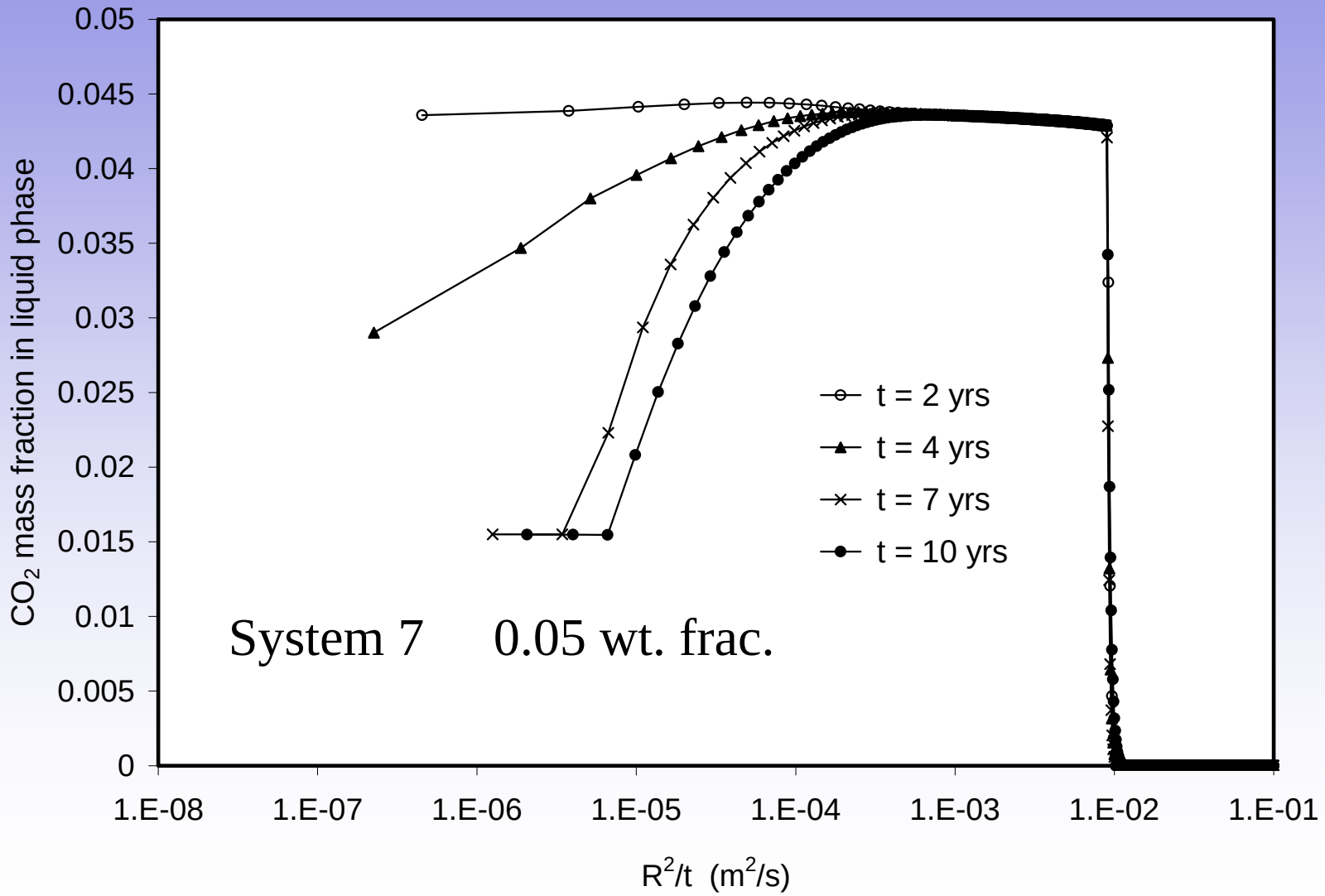
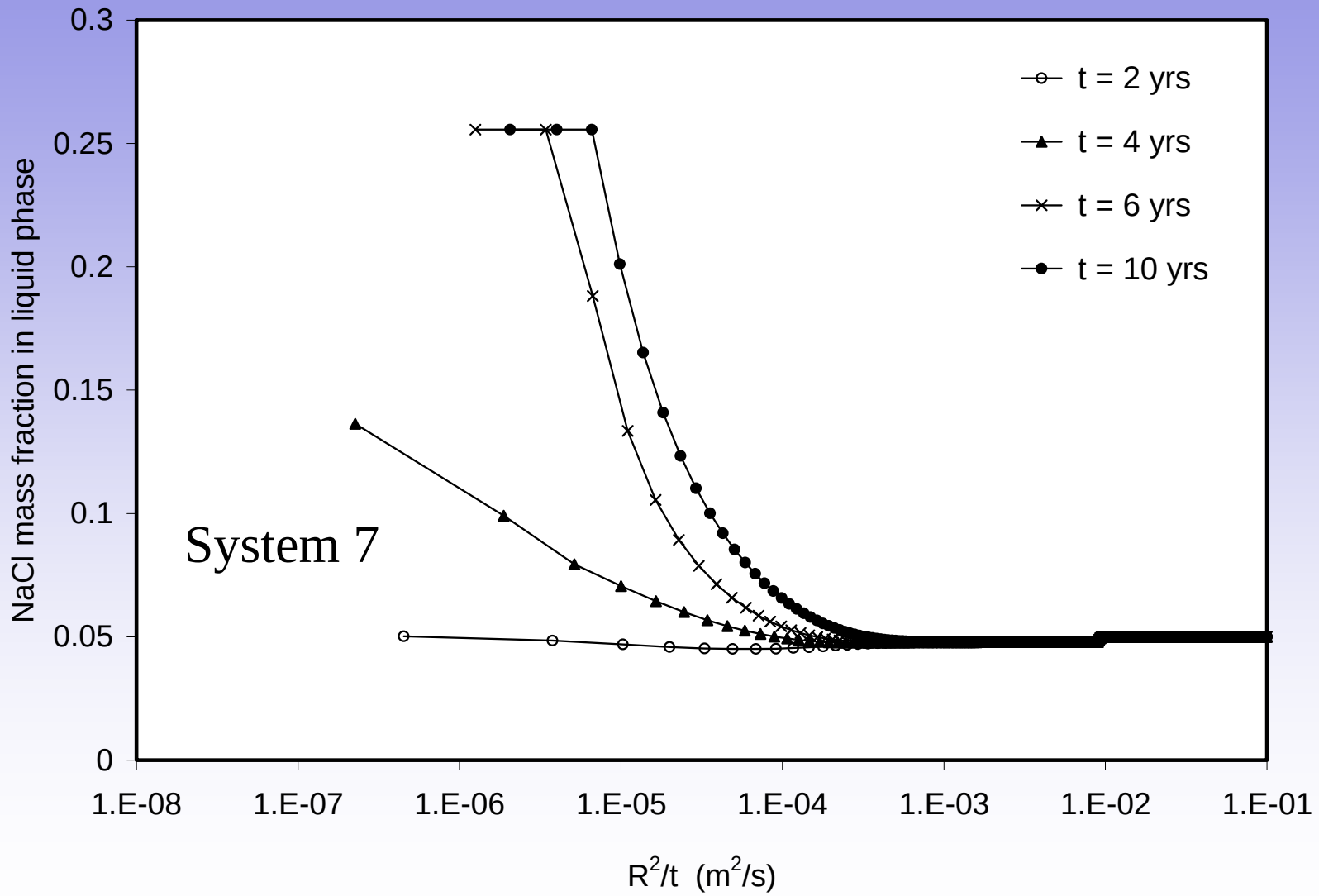
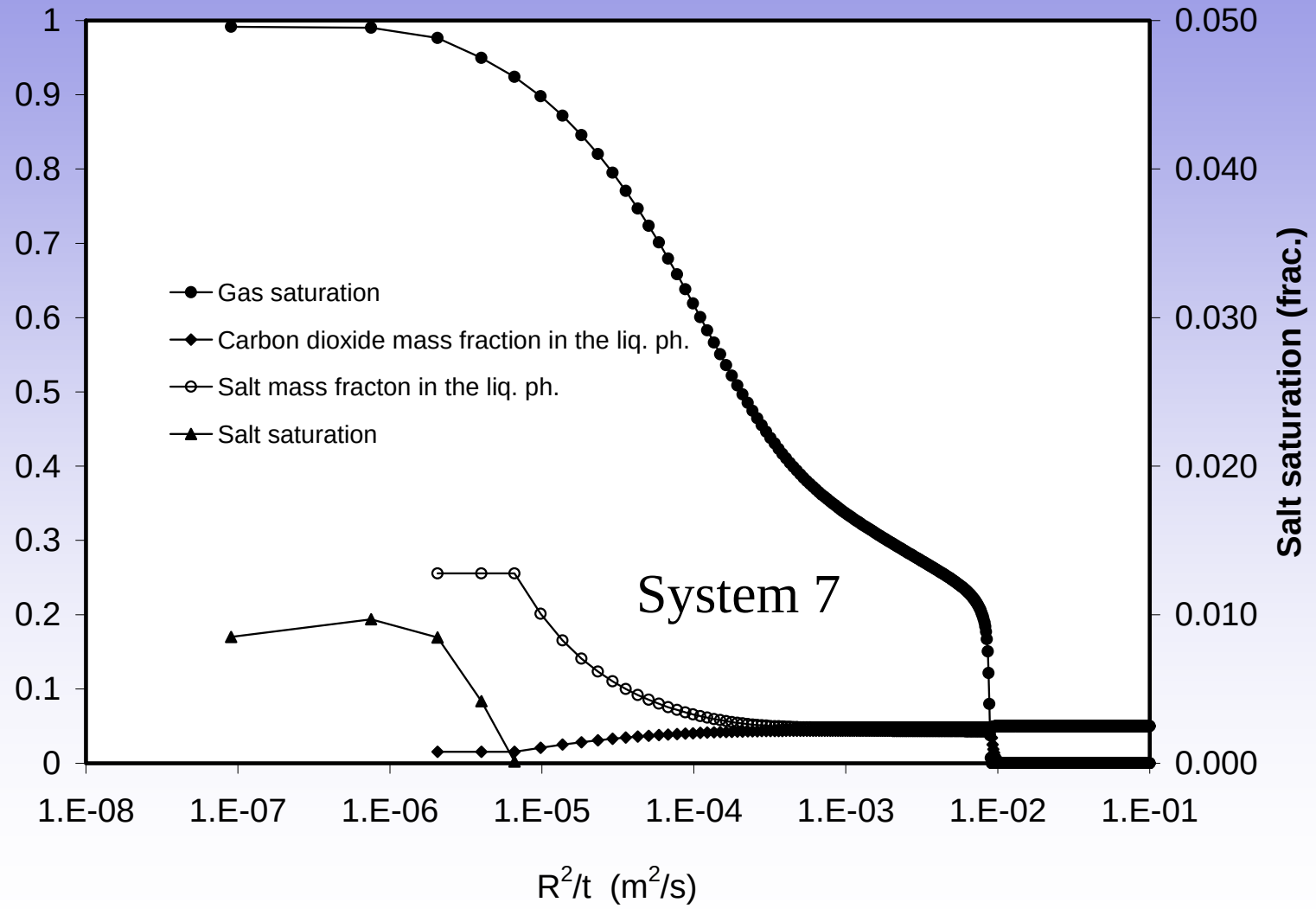


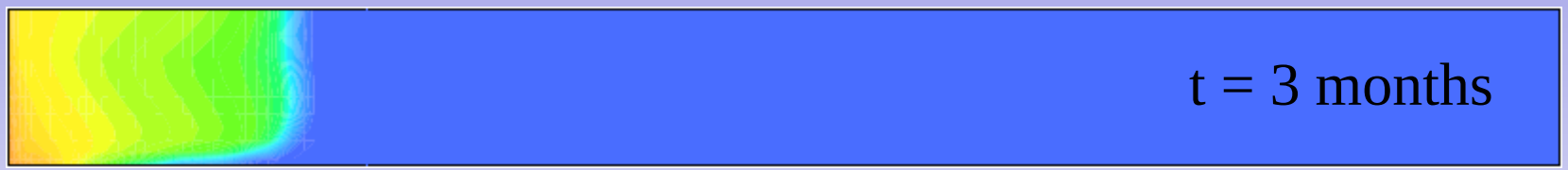
Mass fraction of salt in the liquid phase

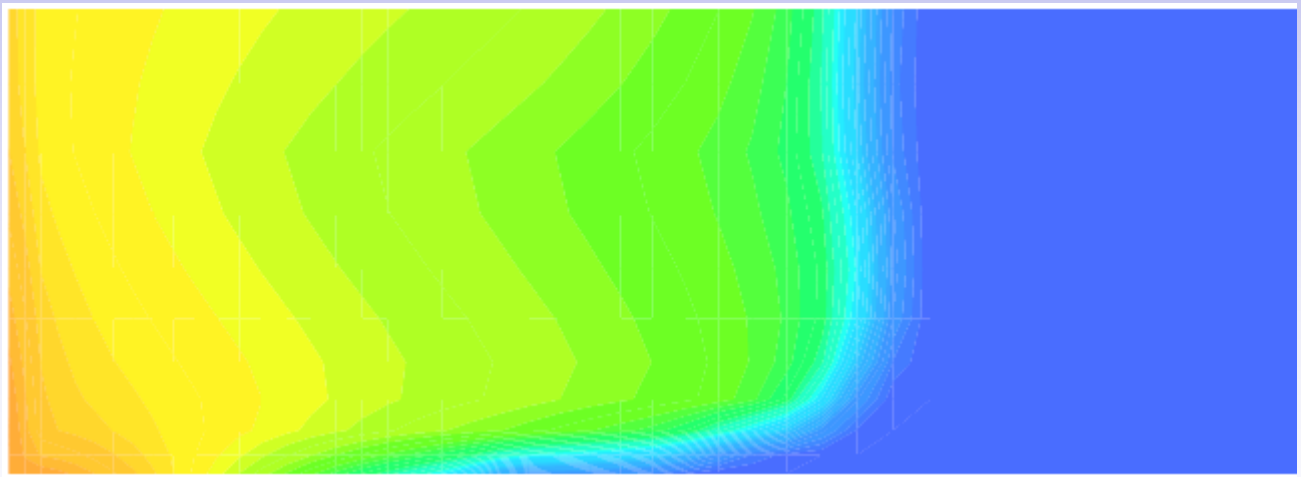


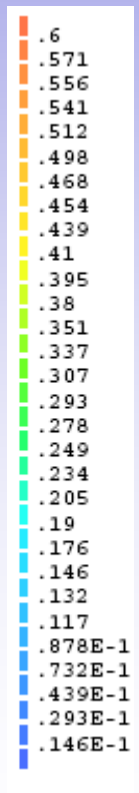
Mass fractions and saturations



Two-dimensional simulations
System 1

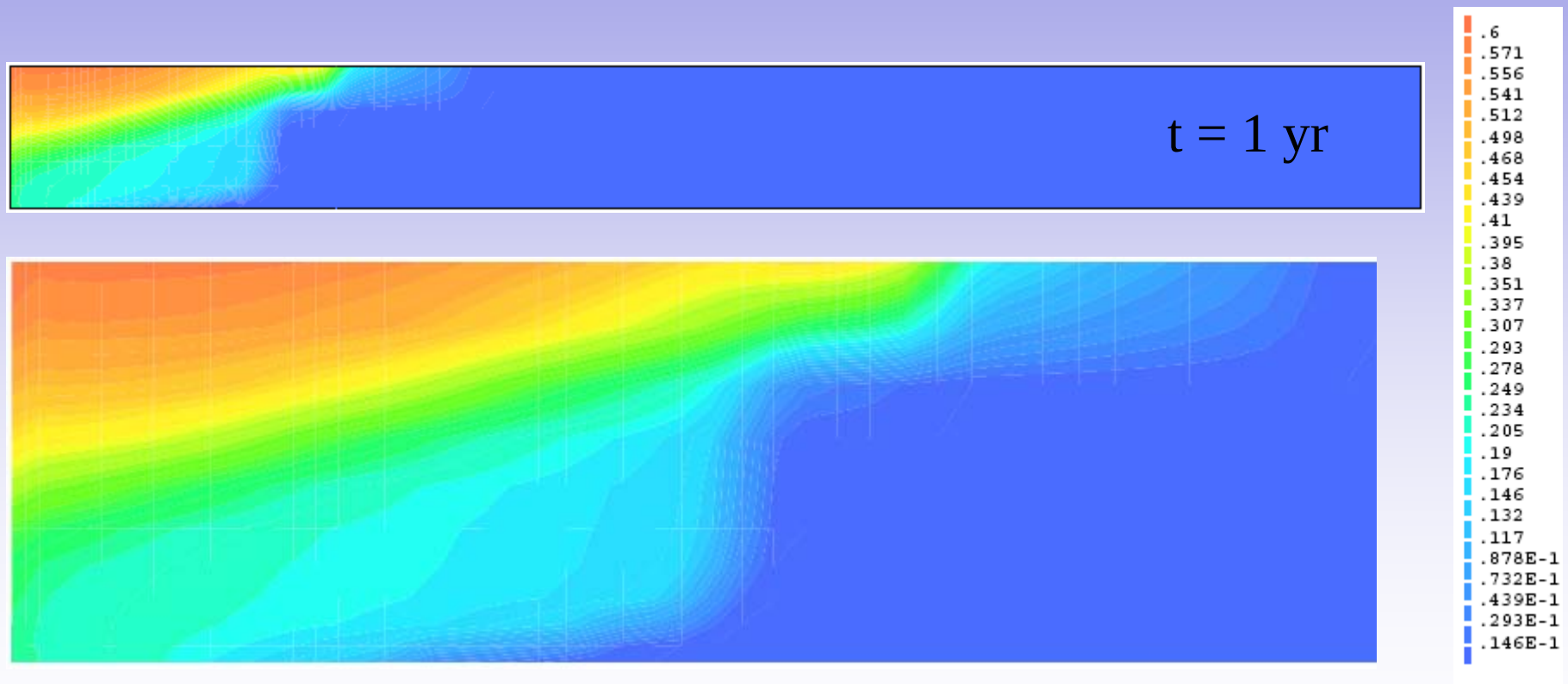




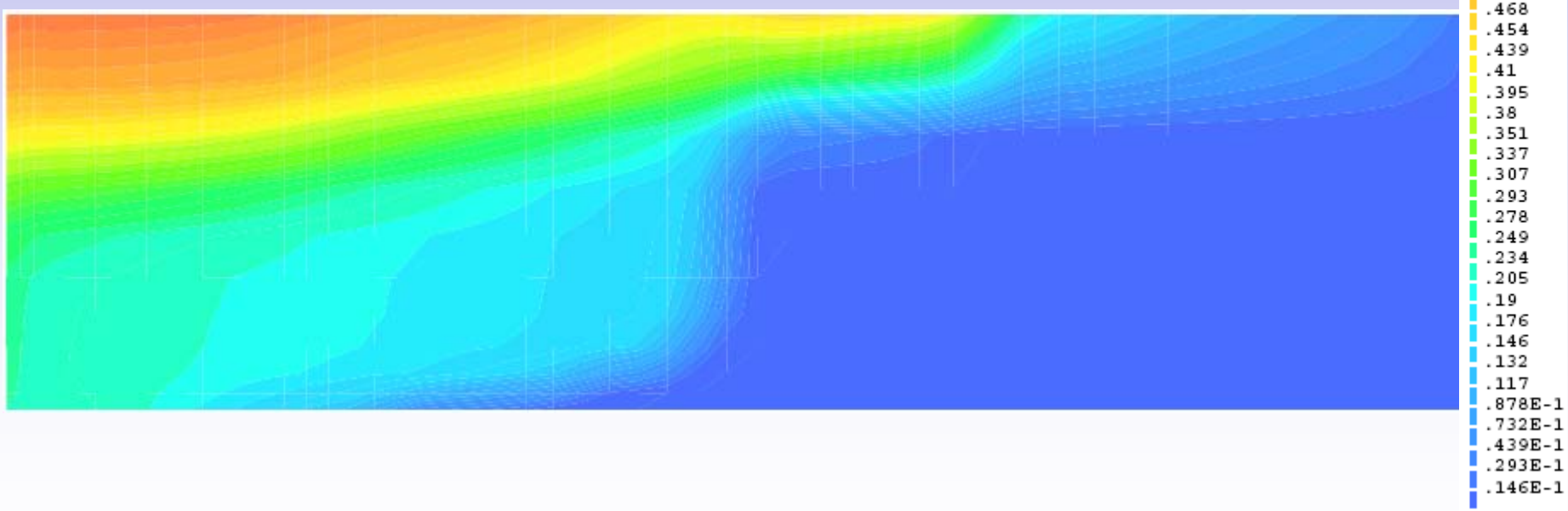


S_{gr}=0.3 & S_{lr}=0.2, t_{inj} = 3 months

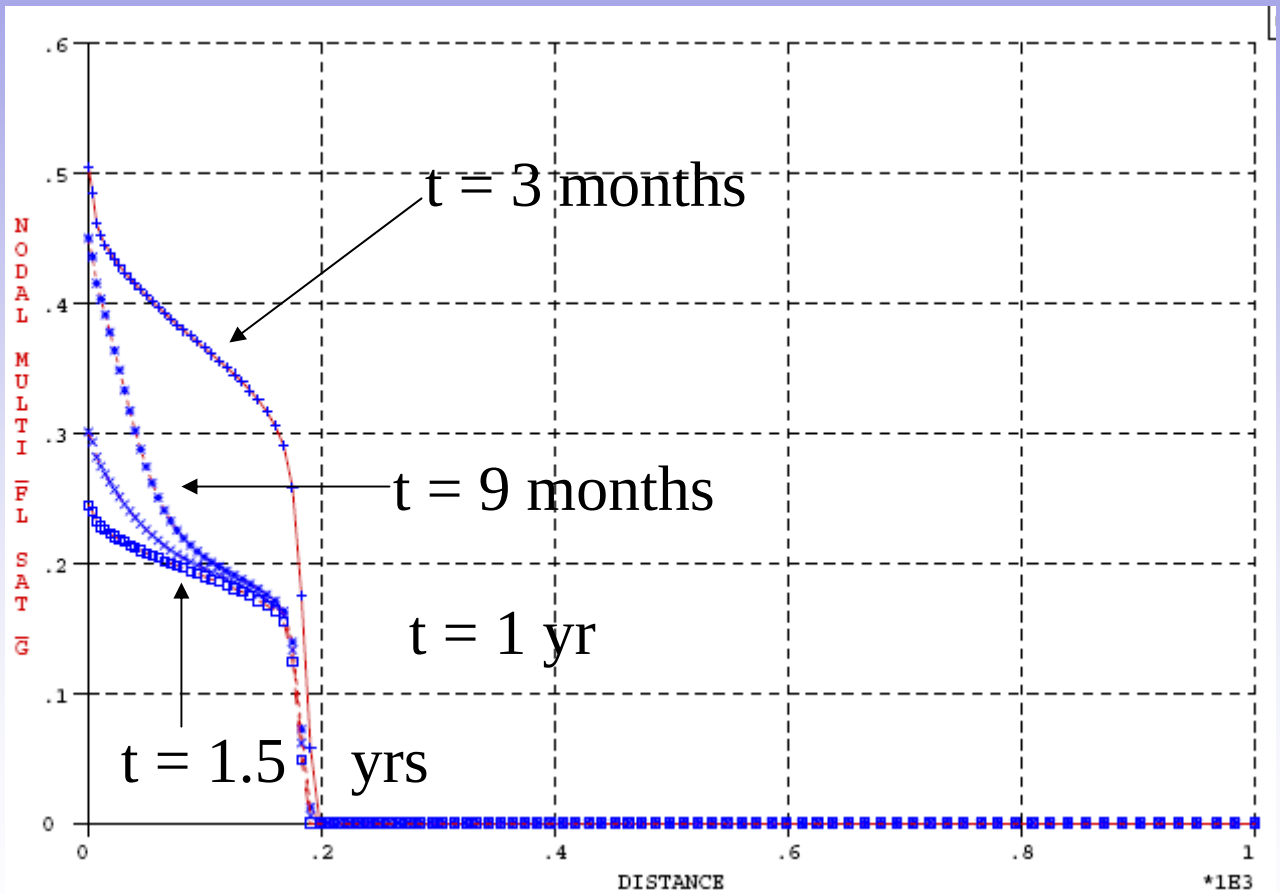
Two-dimensional simulations
System 1 (cont'd)



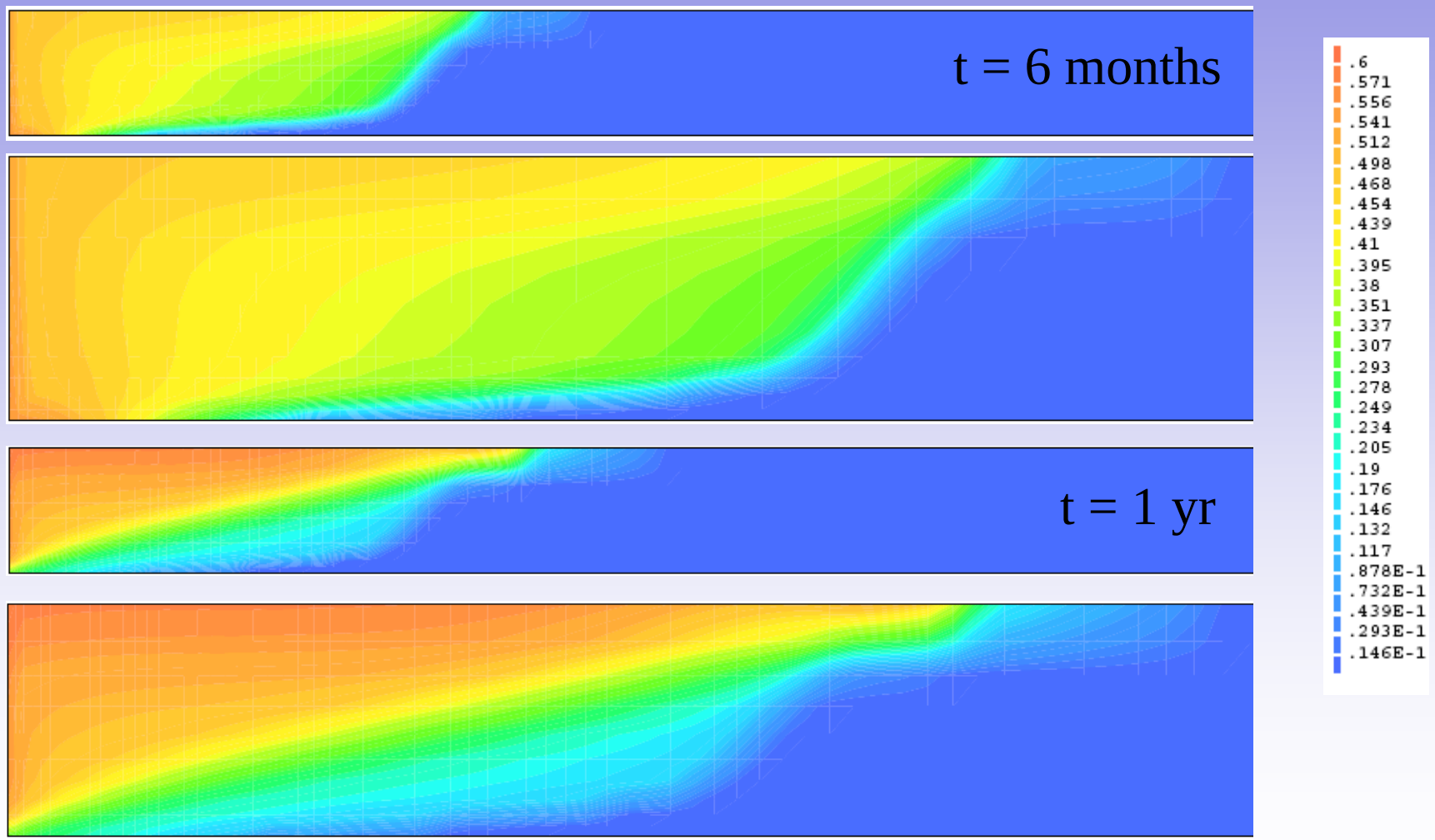
Two-dimensional simulations
System 1 (cont'd)



Two-dimensional simulations System 1 (cont'd)

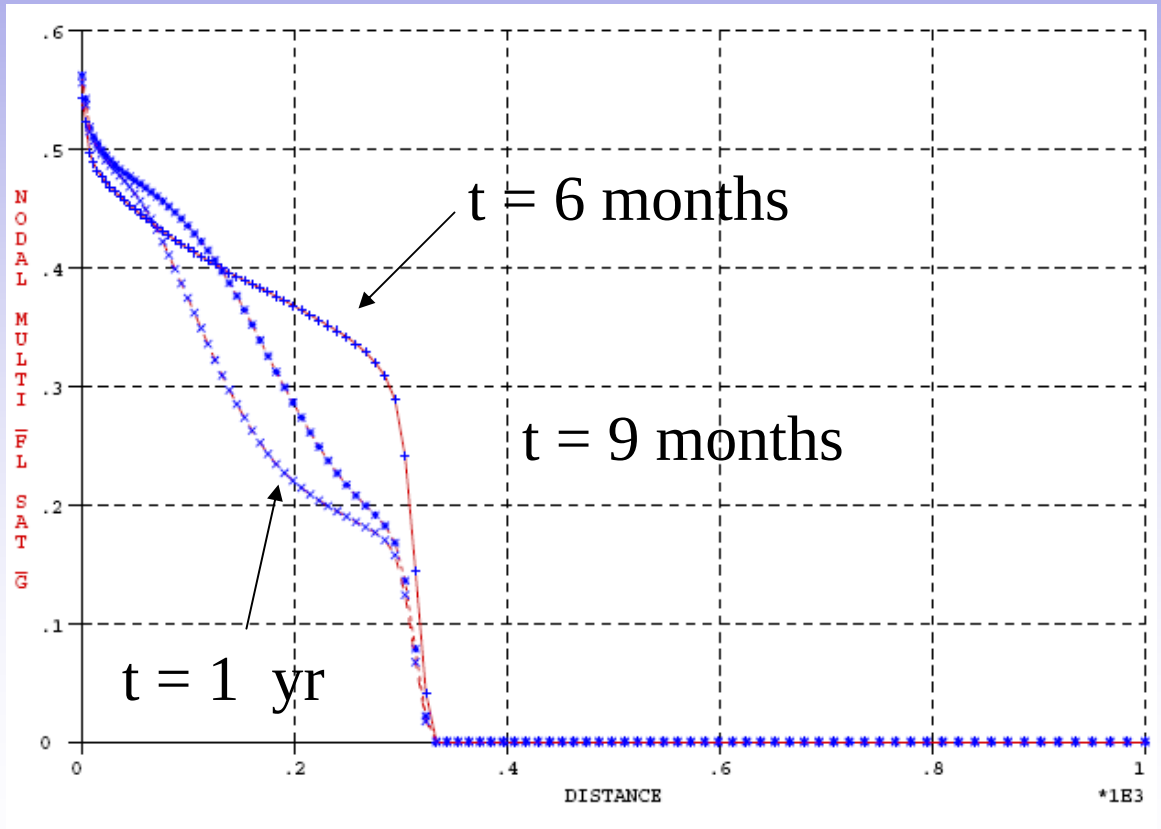


Two-dimensional simulations
System 2

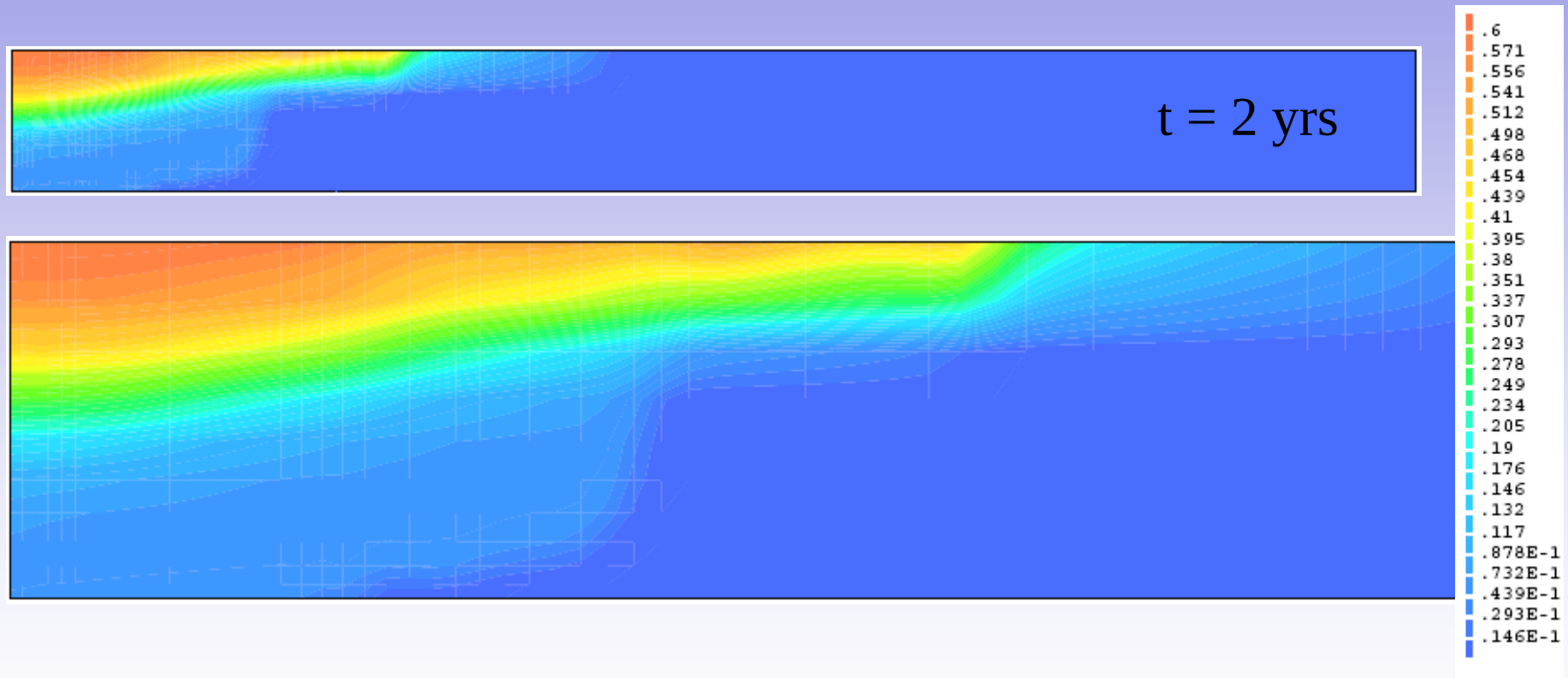


S_{gr}=0.3, S_{lr}=0.2, t_{inj} = 6 months

Two-dimensional simulations
System 2 (cont'd)

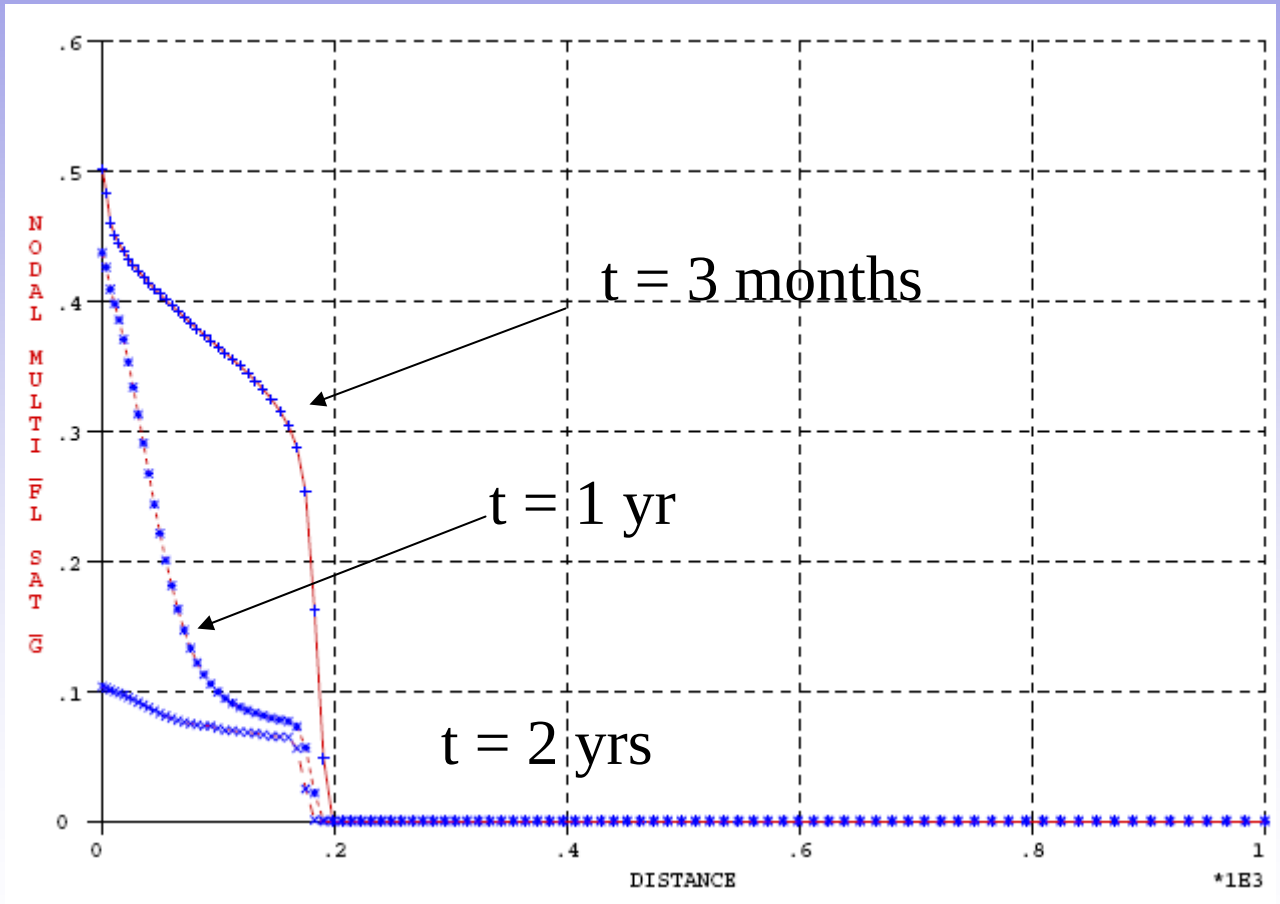


Two-dimensional simulations
System 3



S_{gr}=0.05, S_{lr}=0.2, t_{inj} = 3 months

Two-dimensional simulations
System 3 (cont'd)

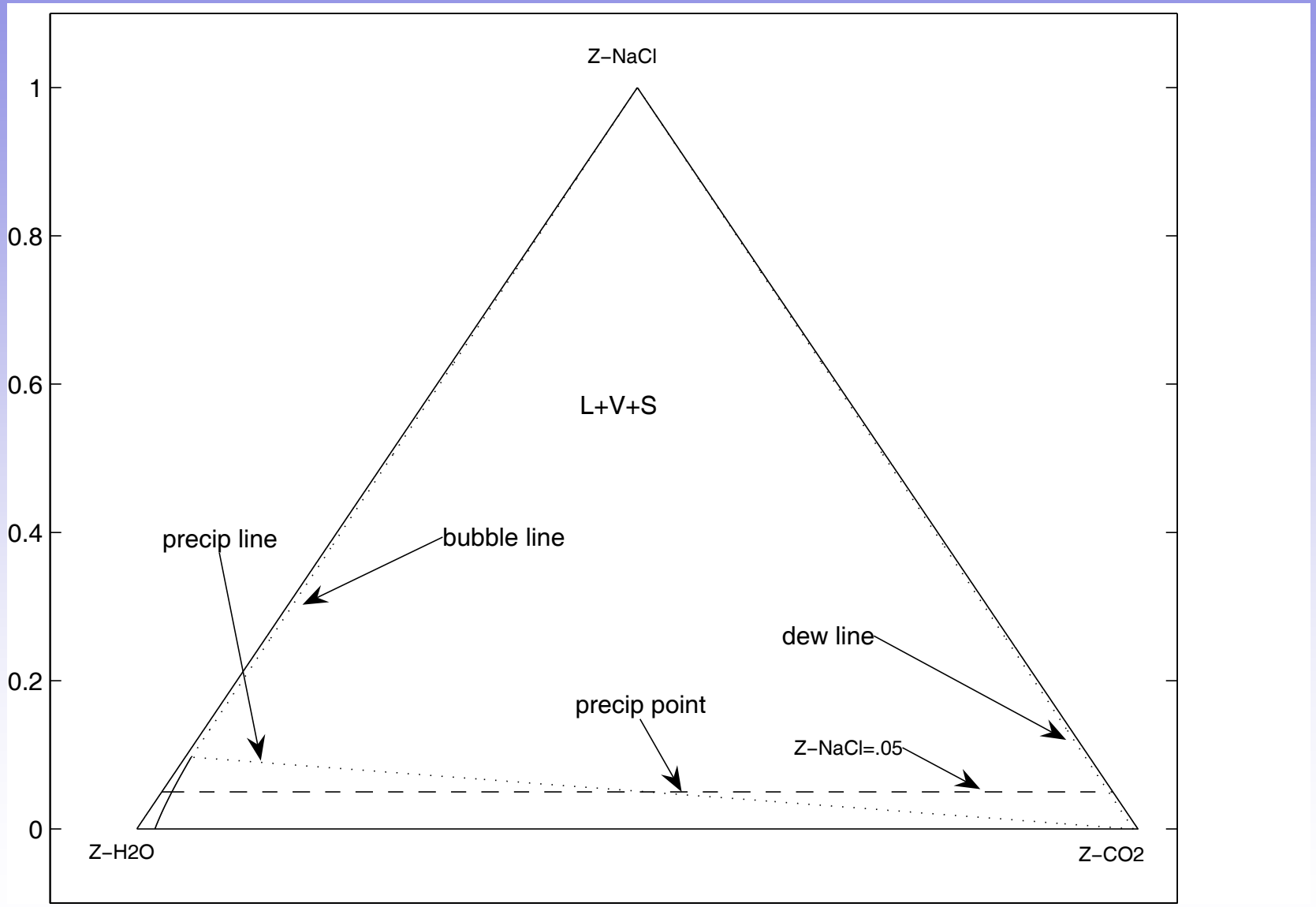
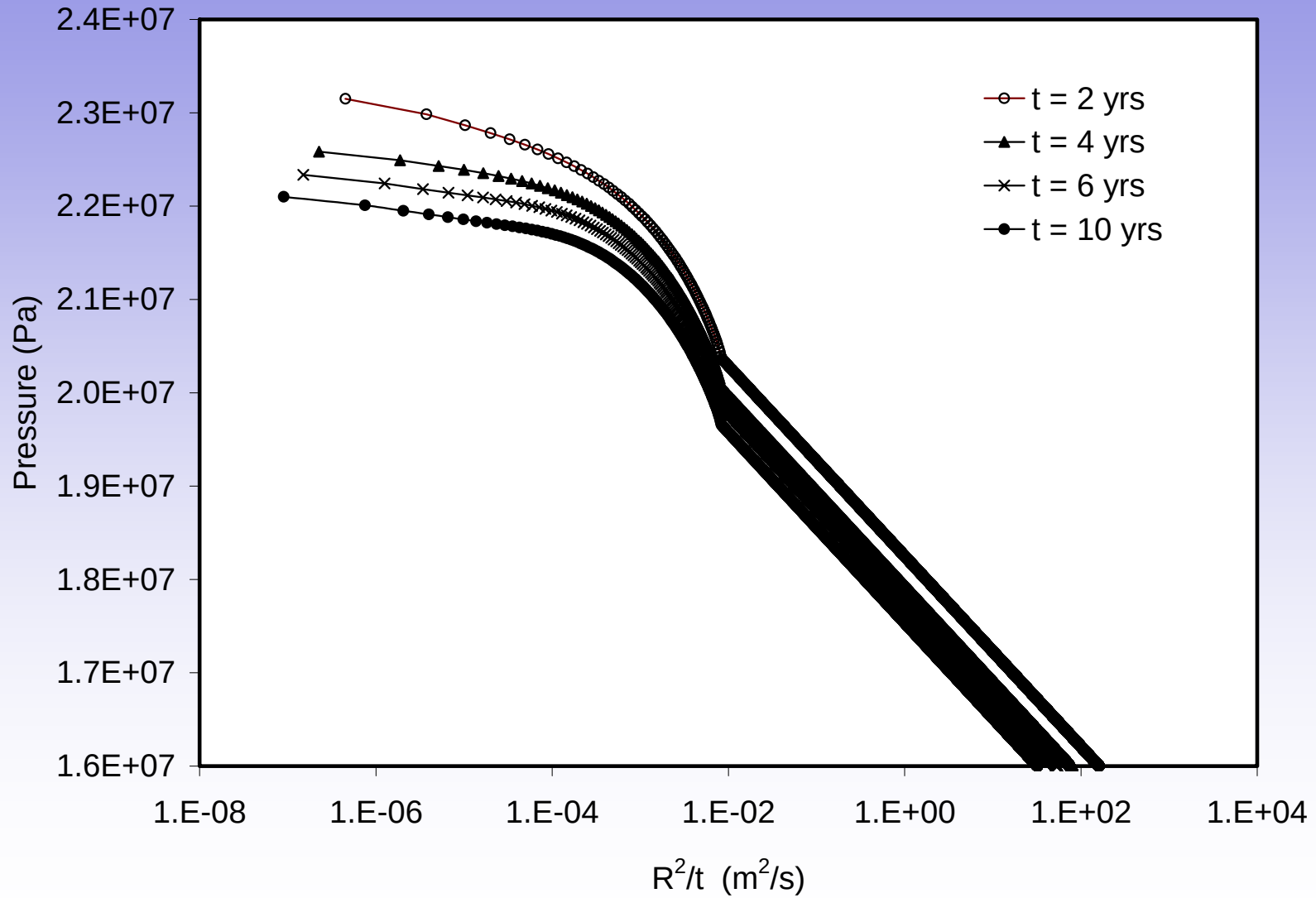


Conclusions

- Evaporation effects are not created by imposing drying out
- Our flash calculation works with full three-phase reservoir simulation
- CO_2 storage is affected by evaporation (salting out effect)
- CO_2 trapping is controlled by the maximum gas saturation reached during injection period and maximum residual gas saturation.

Thank you

Ternary phase diagram



Radial Injection – zero salinity (cont'd)