# INFLUENCE OF COLLOIDS ON RADIONUCLIDE TRANSPORT IN THE ENVIRONMENT

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# Outline

- Introduction
- Experimental
- Results
- Conclusions
- Further work

# Introduction

- *Influence Of Colloids On Radionuclide Transport In The Environment*

## Colloids

- particles in which at least one of its dimensions lies within the range 1nm to 1000nm
- Colloids are ubiquitous
- Formation of *pseudo-colloids* by sorption of radionuclides to colloidal sized non-radioactive material

# Radionuclide Transport (I)

## Transport Equation

$$\frac{\partial C_i}{\partial t} = -\underline{\nabla}.\left(\underline{q} C_i\right) + \underline{\nabla}.\left(\underline{\underline{D}}.\underline{\nabla} C_i\right) + \sum_{j=1}^{n} S_{ij}\left[\{c\}\right]$$

Rate of Transport

Advective term

Diffusion term

- **Chemical sinks immobilise nuclides by sorption to surfaces**

# Radionuclide Transport (II)

## Colloids

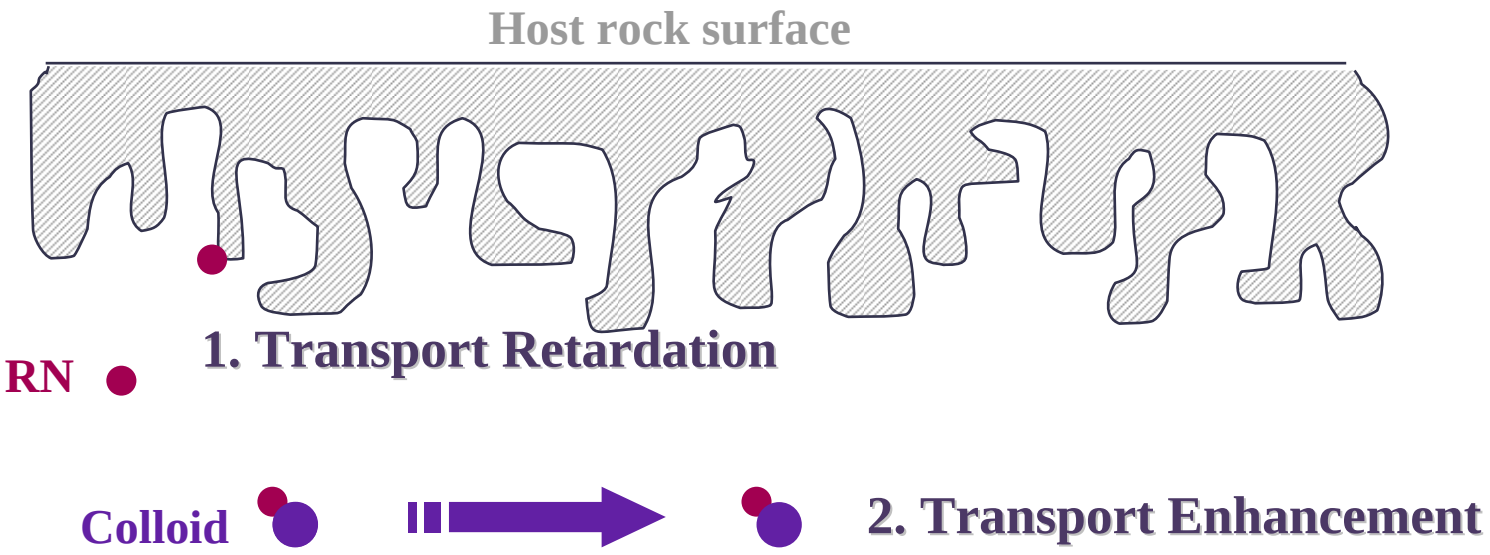
Large surface area to mass ratio

**How??**

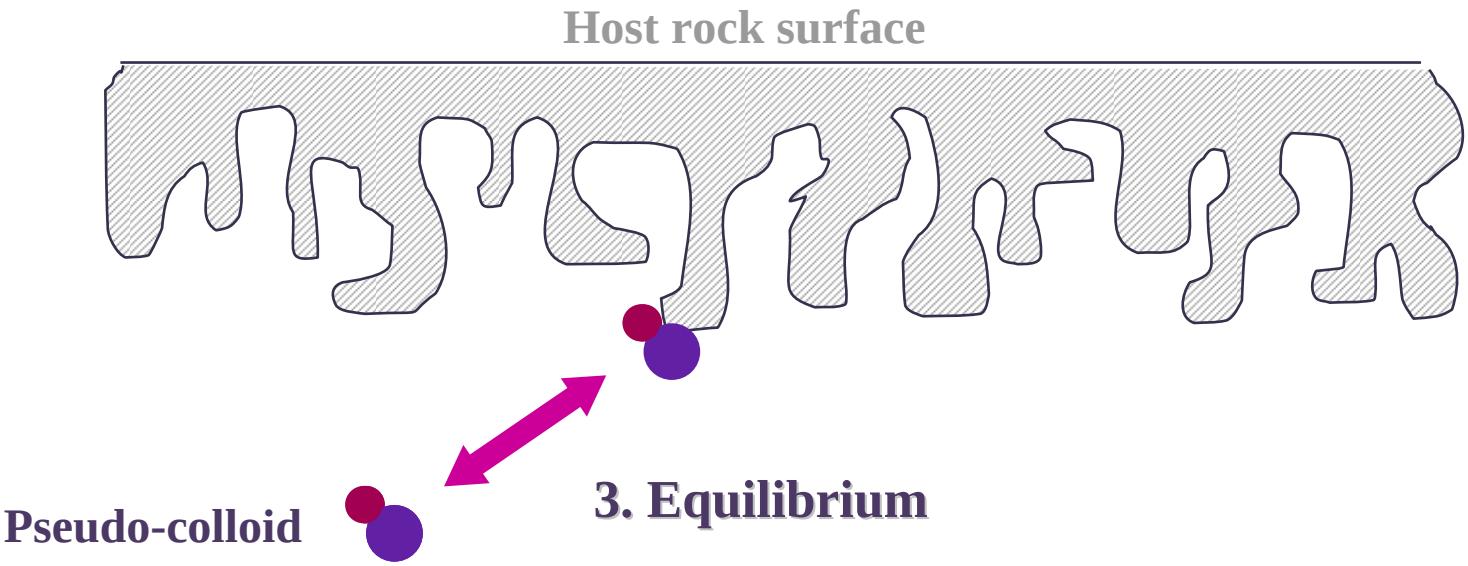
$$\frac{\partial C_i}{\partial t} = -\underline{\nabla}.\left(\underline{q} C_i\right) + \underline{\nabla}.\left(\underline{\underline{D}}.\underline{\nabla} C_i\right) + \sum_{j=1}^{n} S_{ij}\left[\{c\}\right]$$

## Transport Equation

# Radionuclide – Colloid Interactions (I)



# Radionuclide – Colloid Interactions (II)



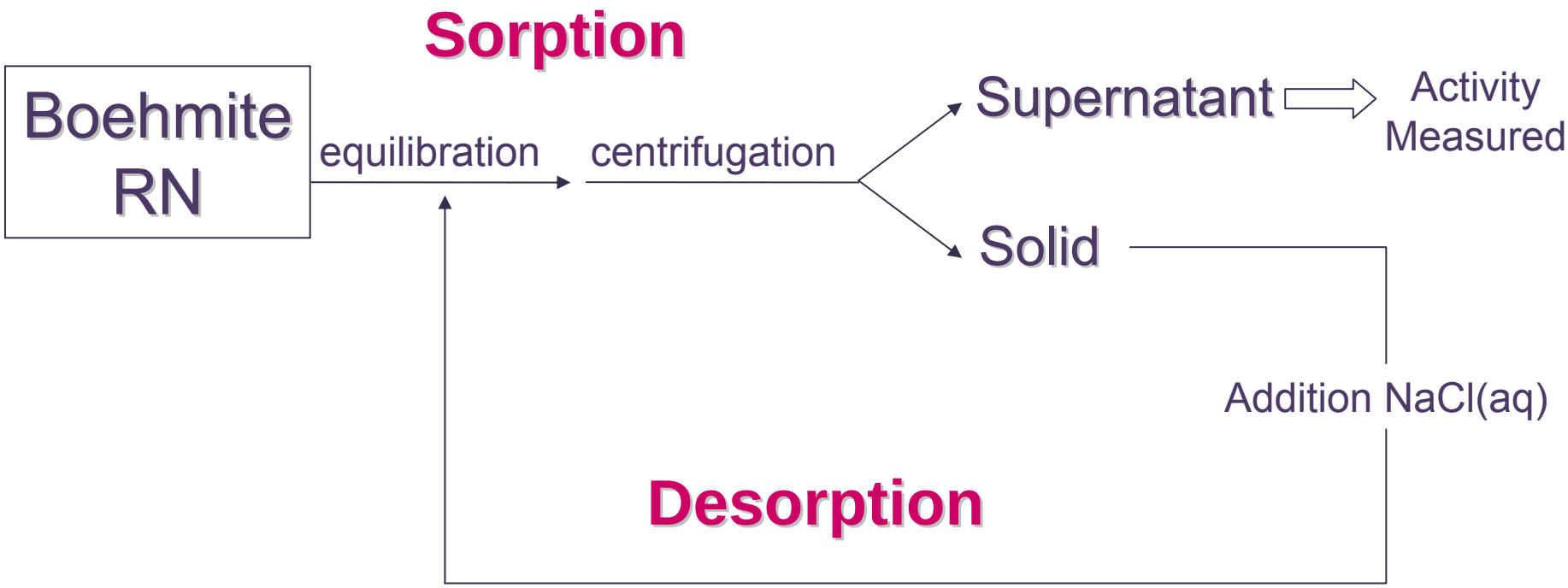

If equilibrium *IRREVERSIBLE* → Transport Enhancement

If equilibrium *REVERSIBLE* → Transport Retardation

# Experimental (I)

- Reversibility Experiments
  - Sorption
    - Boehmite Colloid
    - Cs / Ni / Eu
  - Desorption
    - 3 NaCl(aq) washes

# Experimental (II)



# Results

## 1. Reversibility on Boehmite Colloids

Cs sorption on Boehmite

Ni sorption on Boehmite

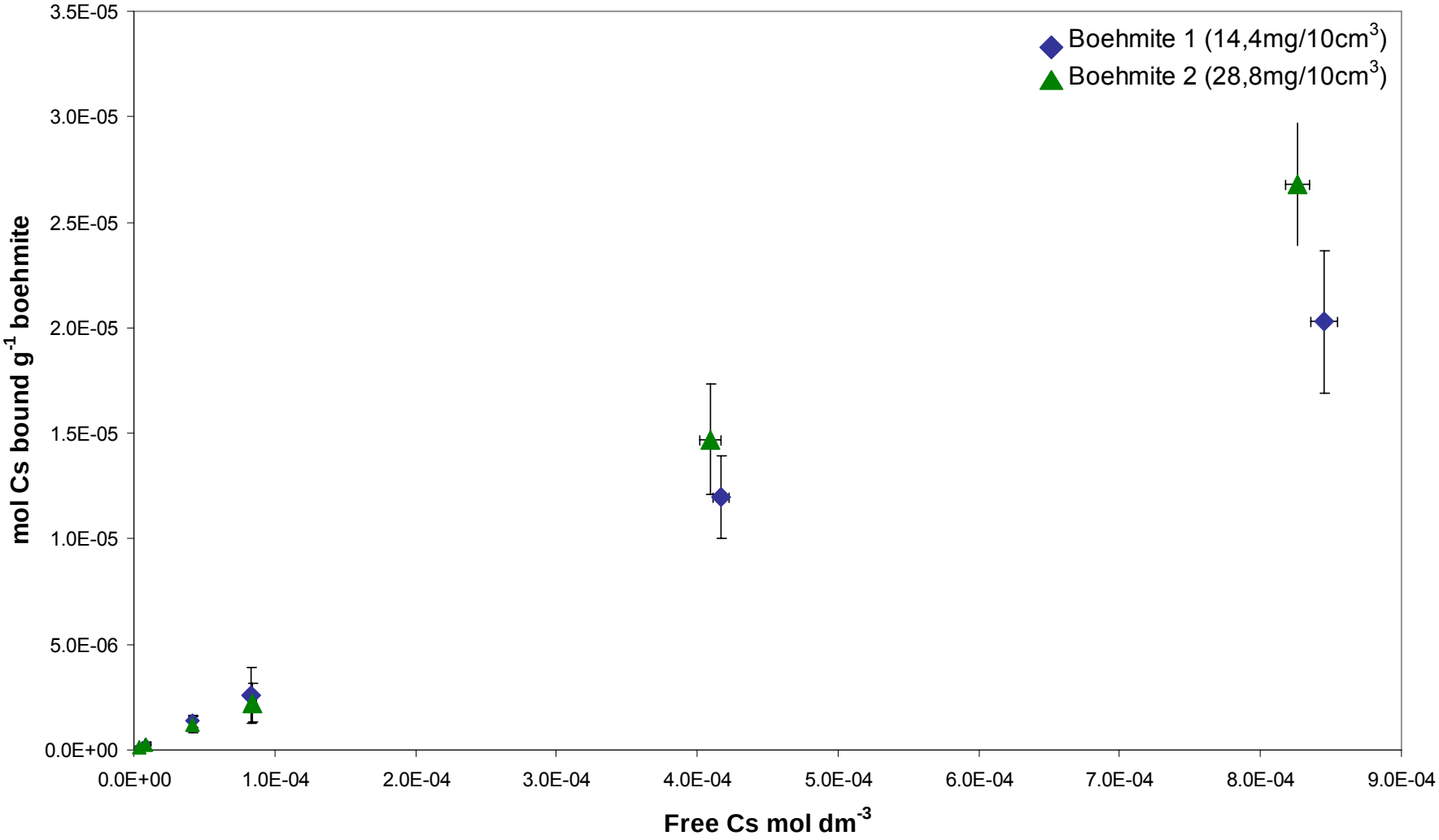
Eu sorption on Boehmite

Cs desorption from Boehmite

Ni desorption from Boehmite

Eu desorption from Boehmite

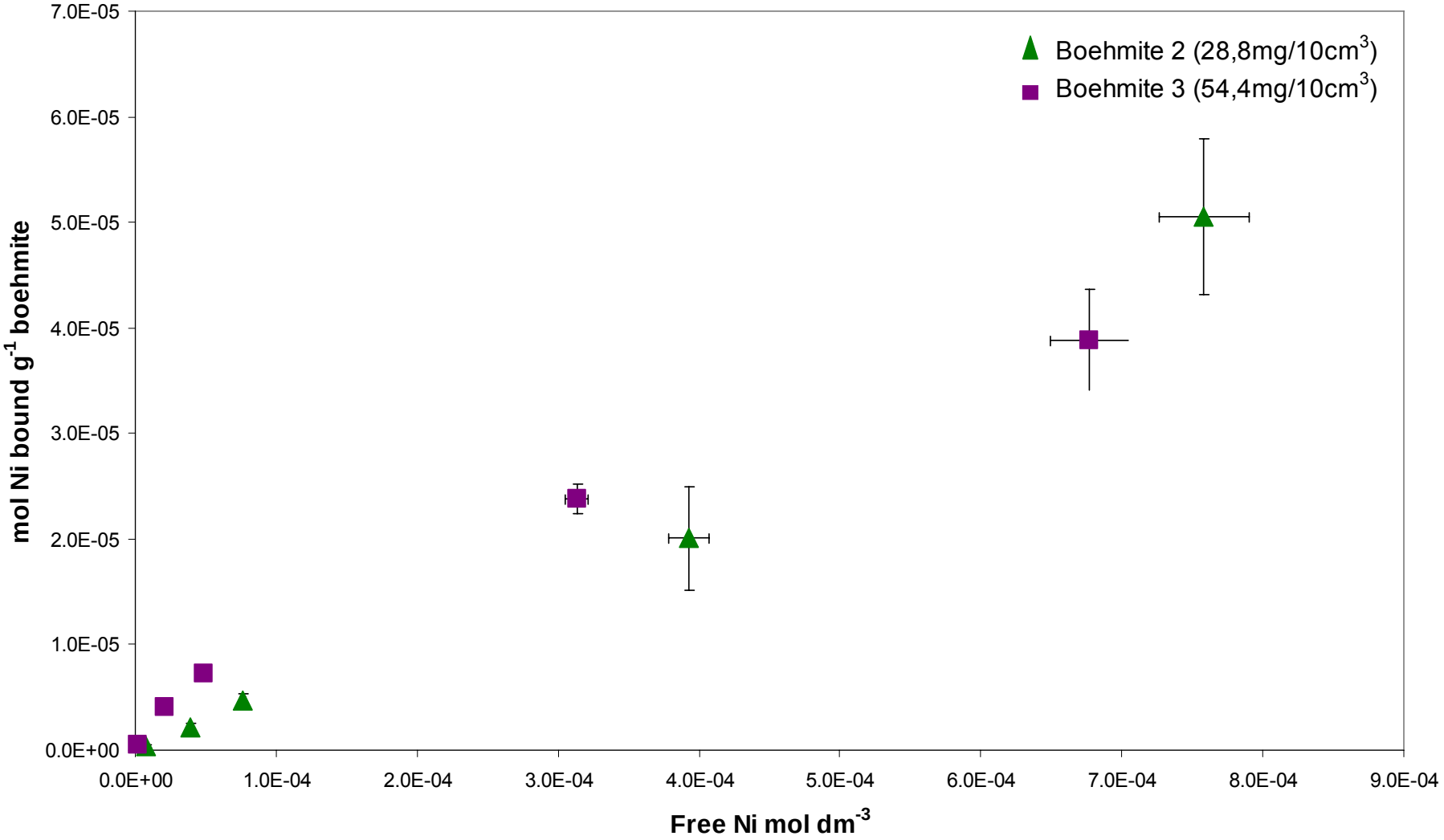
# Cs Sorption on Boehmite (Colloid) (I)



# Cs Sorption onto Boehmite (Colloid) (V)

| | Boehmite 1 (14,4mg/10cm$^3$) | Boehmite 2 (28,8mg/10cm$^3$) |
|---|---|---|
| Linear | $Cs_{bound} = 0{,}0299Cs_{free} + 2 \cdot 10^{-7}$<br>$R^2 = 0{,}9833$ | $Cs_{bound} = 0{,}0231Cs_{free} + 3 \cdot 10^{-7}$<br>$R^2 = 0{,}9933$ |
| Langmuir | $1/Cs_{bound} = 26{,}95\ (1/Cs_{free}) + 4{,}83 \cdot 10^5$<br>$R^2 = 0{,}9997$ | $1/Cs_{bound} = 44{,}13\ (1/Cs_{free}) - 2 \cdot 10^{-6}$<br>$R^2 = 0{,}9995$ |
| Freundlich | $\log Cs_{bound} = 1{,}02 \log Cs_{free} - 1{,}35$<br>$R^2 = 0{,}9889$ | $\log Cs_{bound} = 1{,}02 \log Cs_{free} - 1{,}49$<br>$R^2 = 0{,}9987$ |

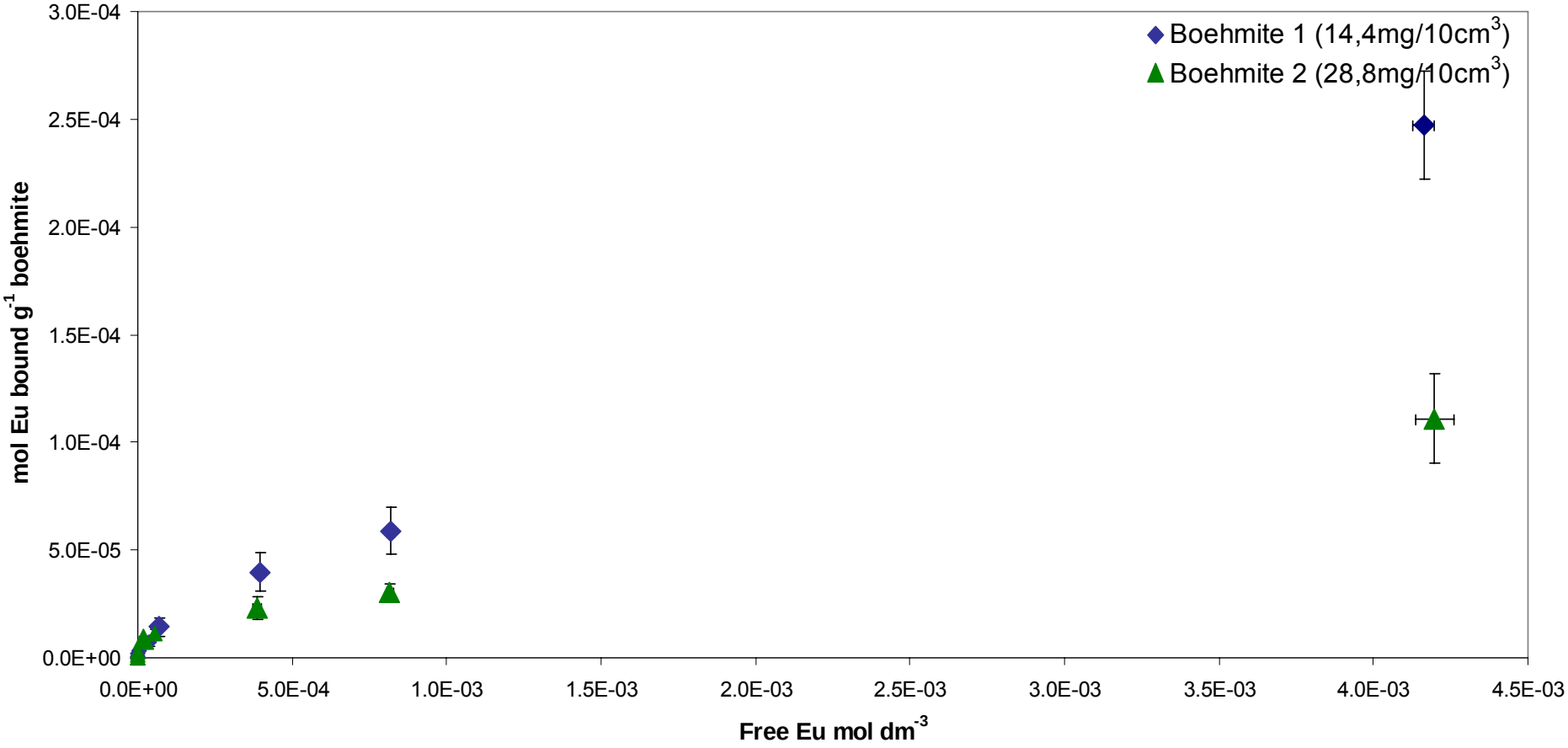
# Ni Sorption on Boehmite (Colloid) (I)



# Ni Sorption on Boehmite (Colloid) (V)

| | Boehmite 2 (28,8mg/10cm$^3$) | Boehmite 3 (54,4mg/10cm$^3$) |
|---|---|---|
| Linear | $Ni_{bound} = 0{,}818\ Ni_{free} - 3 \cdot 10^{-6}$<br>$R^2 = 0{,}9970$ | $Ni_{bound} = 0{,}0458\ Ni_{free} + 3 \cdot 10^{-6}$<br>$R^2 = 0{,}9953$ |
| Langmuir | No fit | $1/Ni_{bound} = 2{,}63\ (1/Ni_{free}) + 2{,}95 \cdot 10^5$<br>$R^2 = 0{,}9998$ |
| Freundlich | $\log Ni_{bound} = 0{,}85 \log Ni_{free} - 1{,}77$<br>$R^2 = 0{,}9656$ | $\log Ni_{bound} = 0{,}80 \log Ni_{free} - 1{,}76$<br>$R^2 = 0{,}9955$ |

# Eu sorption on Boehmite (Colloid) (I)



# Eu Sorption on Boehmite (Colloid) (V)

| | Boehmite 1 (14,4mg/10cm$^3$) | Boehmite 2 (28,8mg/10cm$^3$) |
|---|---|---|
| Linear | $Eu_{bound} = 0{,}069\ Eu_{free} + 3 \cdot 10^{-6}$<br>$R^2 = 0{,}9457$ | $Eu_{bound} = 0{,}039\ Eu_{free} + 3 \cdot 10^{-6}$<br>$R^2 = 0{,}8847$ |
| Langmuir | $1/Eu_{bound} = 0{,}197\ (1/Eu_{free}) + 2{,}22 \cdot 10^5$<br>$R^2 = 0{,}9229$ | $1/Eu_{bound} = 0{,}049\ (1/Eu_{free}) + 3{,}63 \cdot 10^5$<br>$R^2 = 0{,}9188$ |
| Freundlich | $\log Eu_{bound} = 0{,}64 \log Eu_{free} - 2{,}14$<br>$R^2 = 0{,}9712$ | $\log Eu_{bound} = 0{,}51 \log Eu_{free} - 2{,}78$<br>$R^2 = 0{,}9850$ |

# 1. Reversibility on Boehmite Colloids

Cs sorption on Boehmite

Ni sorption on Boehmite

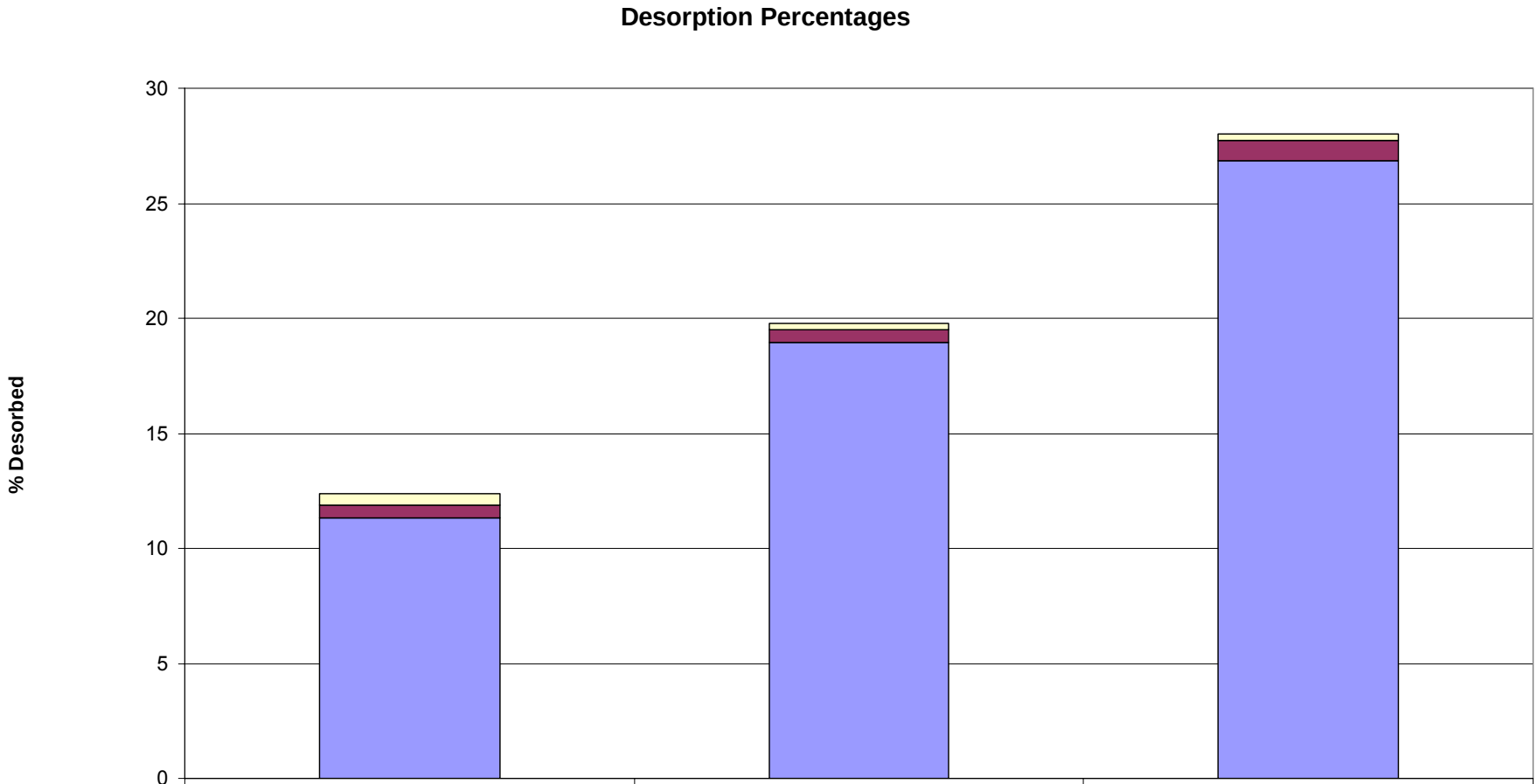
Eu sorption on Boehmite

**Cs desorption from Boehmite**

**Ni desorption from Boehmite**

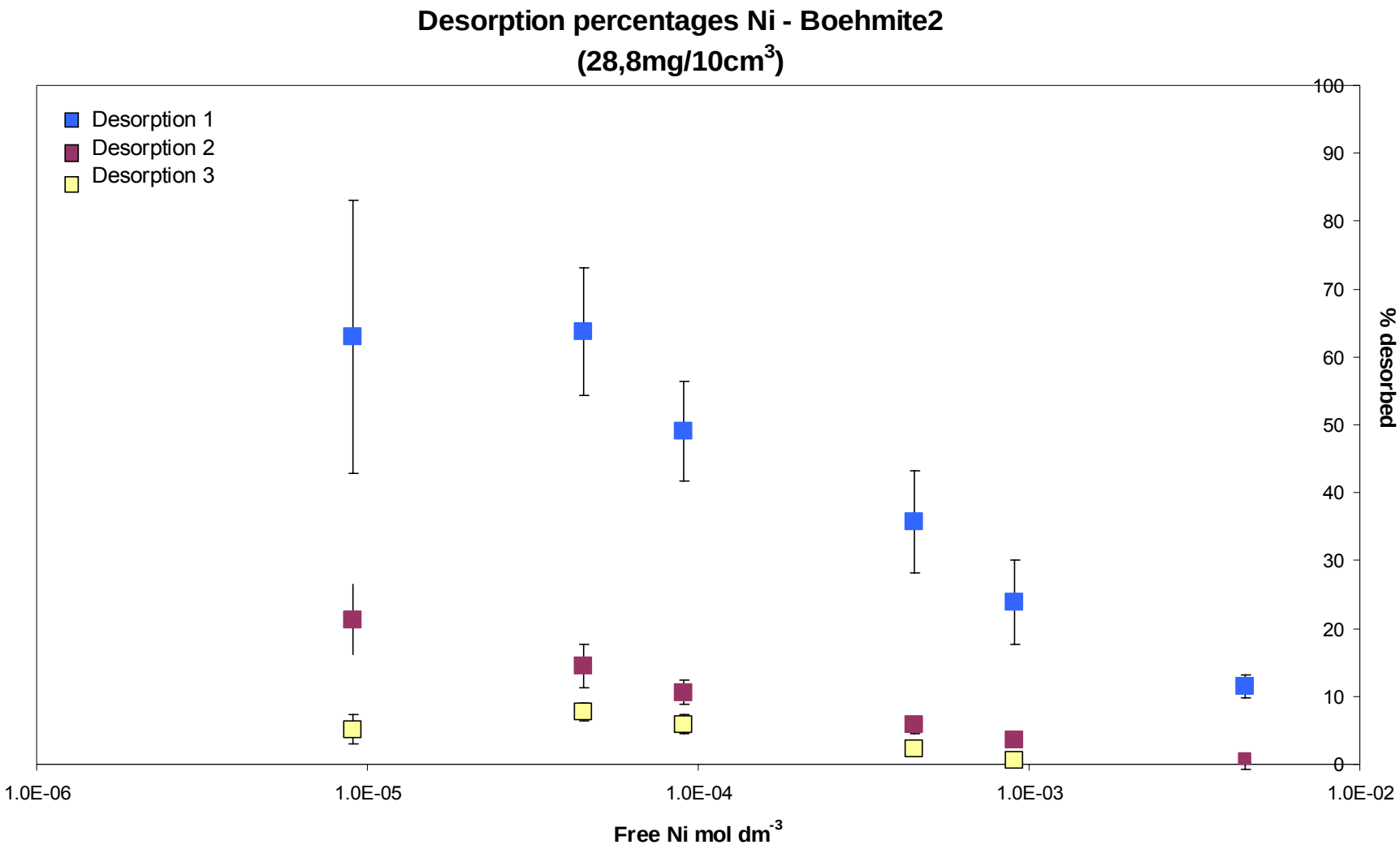
**Eu desorption from Boehmite**

# Cs Desorption from Boehmite (Colloid)

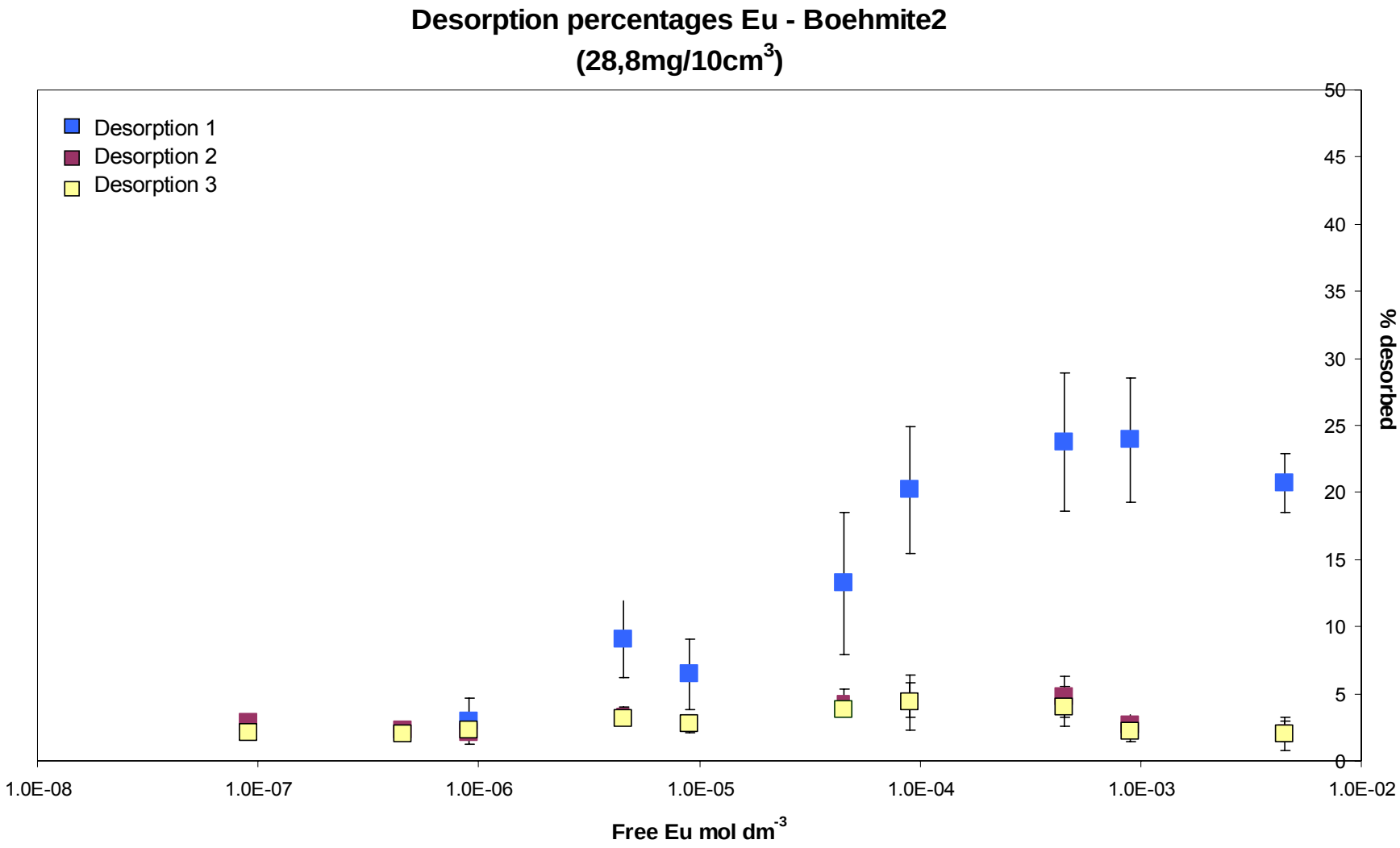



| | Boehmite1 (14,4mg/10cm3) | Boehmite2 (28,8mg/10cm3) | Boehmite3 (54,4mg/10cm3) |
|---|---|---|---|
| Desorption 3 | 0,49 | 0,30 | 0,28 |
| Desorption 2 | 0,57 | 0,53 | 0,89 |
| Desorption 1 | 11,32 | 18,95 | 26,83 |

# Ni Desorption from Boehmite (Colloid)



# Eu Desorption from Boehmite (Colloid) (II)



# Conclusions (I)

- Cs seems to follow Langmuir model
- Ni sorption seems to follow Langmuir model when greater amount of boehmite is present
- Eu sorption seems to follow Freundlich model

# Conclusions (II)

- Most desorption occurs after the first wash
- Cs desorption is independent from the concentration of Cs in solution, but depends on the amount of boehmite present
- Ni and Eu desorption depend on the concentration of metal in solution

# Further Work

- Reversibility studies on boehmite solids are being carried out with Cs, Ni and Eu

- Reversibility studies with clays, i.e. montmorillonite are being carried out with Cs, Ni and Eu

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