



iah
Australian National
Chapter
NSW Branch



IAH-NSW, Sydney, 15th January 2008

Arsenic mobilisation in groundwater in the Red River floodplain, Vietnam

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Technical University of Denmark

Arsenic in drinking water

WHO's limit for arsenic in drinking water is 0.01 mg /L.

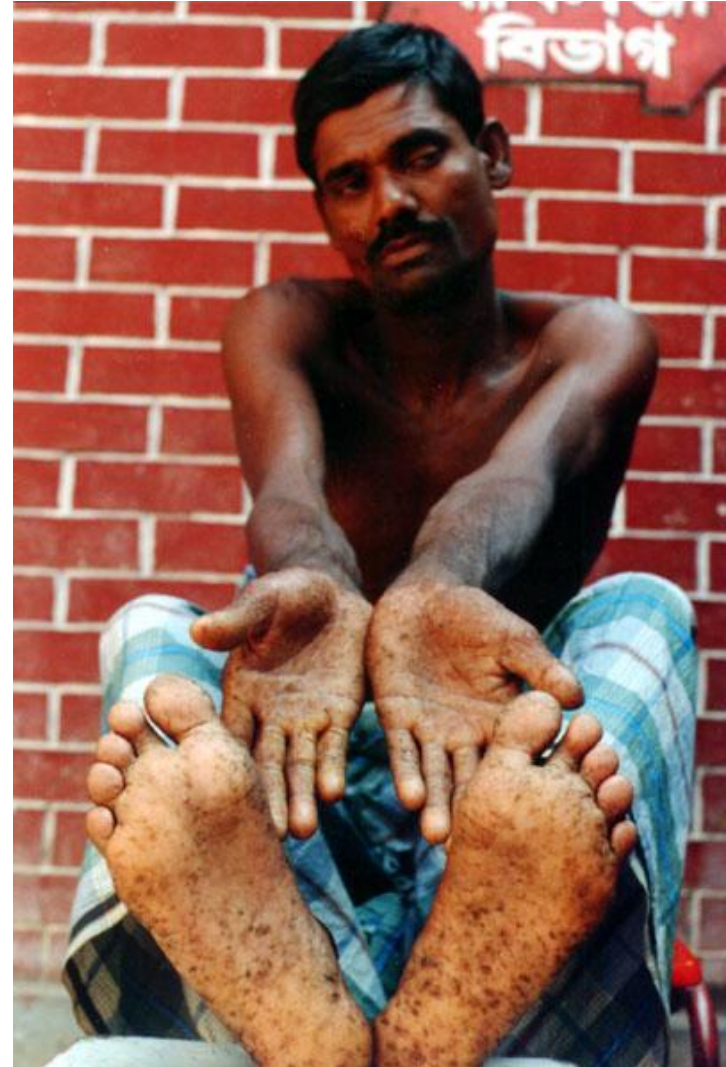
WHO: "This figure is limited by the ability to analyse low concentrations of arsenic in water."

WHO: Drinking arsenic-rich water over a long period (5-20 years) results in arsenicosis or arsenic poisoning

World wide ~100 mill. people are exposed to a too high arsenic concentration in their drinking water

Arsenicosis

colour changes
on the skin



Arsenicosis

**Black Foot
Disease**



Arsenicosis

Cancers

skin
bladder
kidney
lung

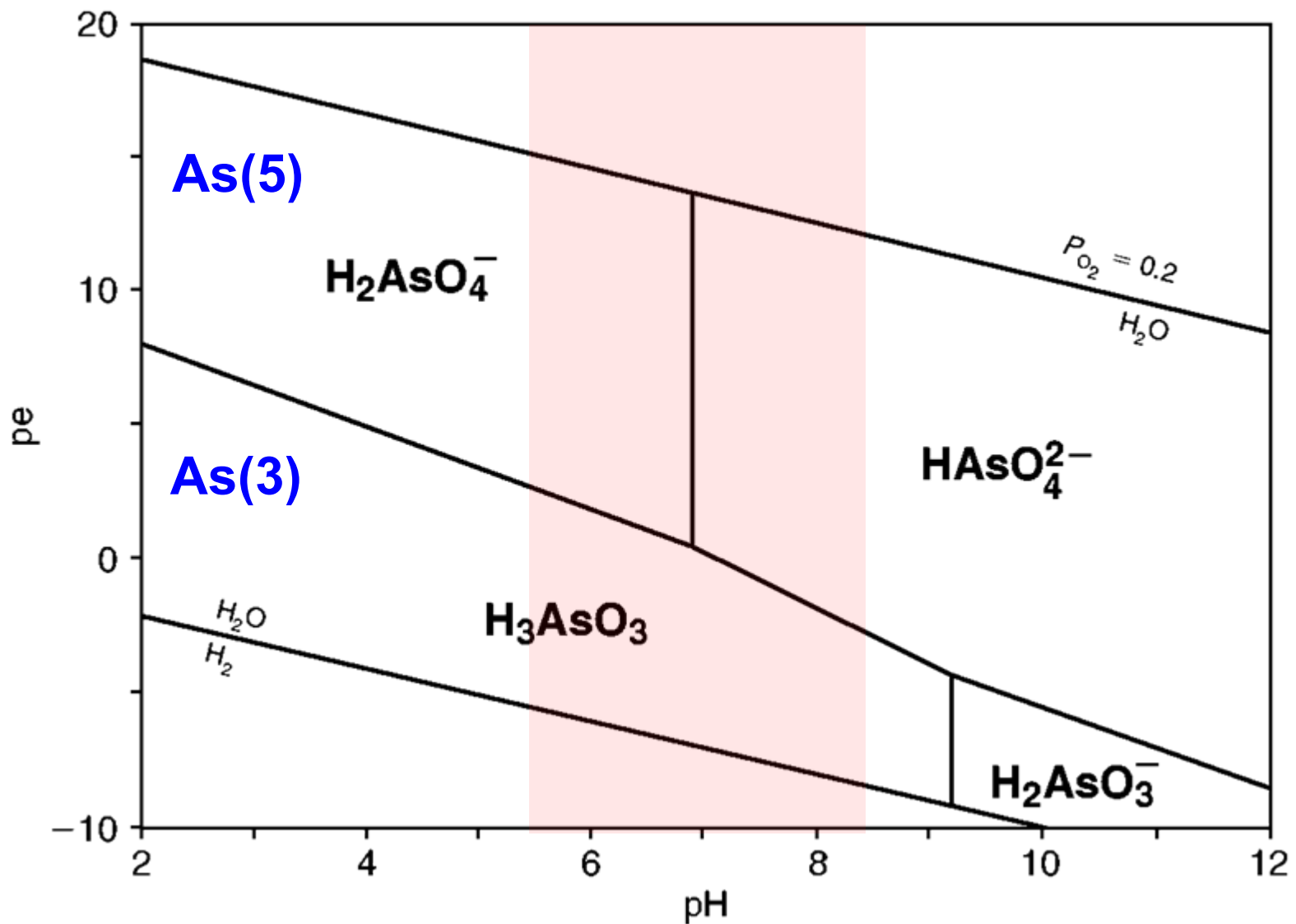


WHO: “Approximately 1 in 100 people who drink water containing 0.05 mg arsenic per litre or more for a long period may eventually die from arsenic related cancers.”

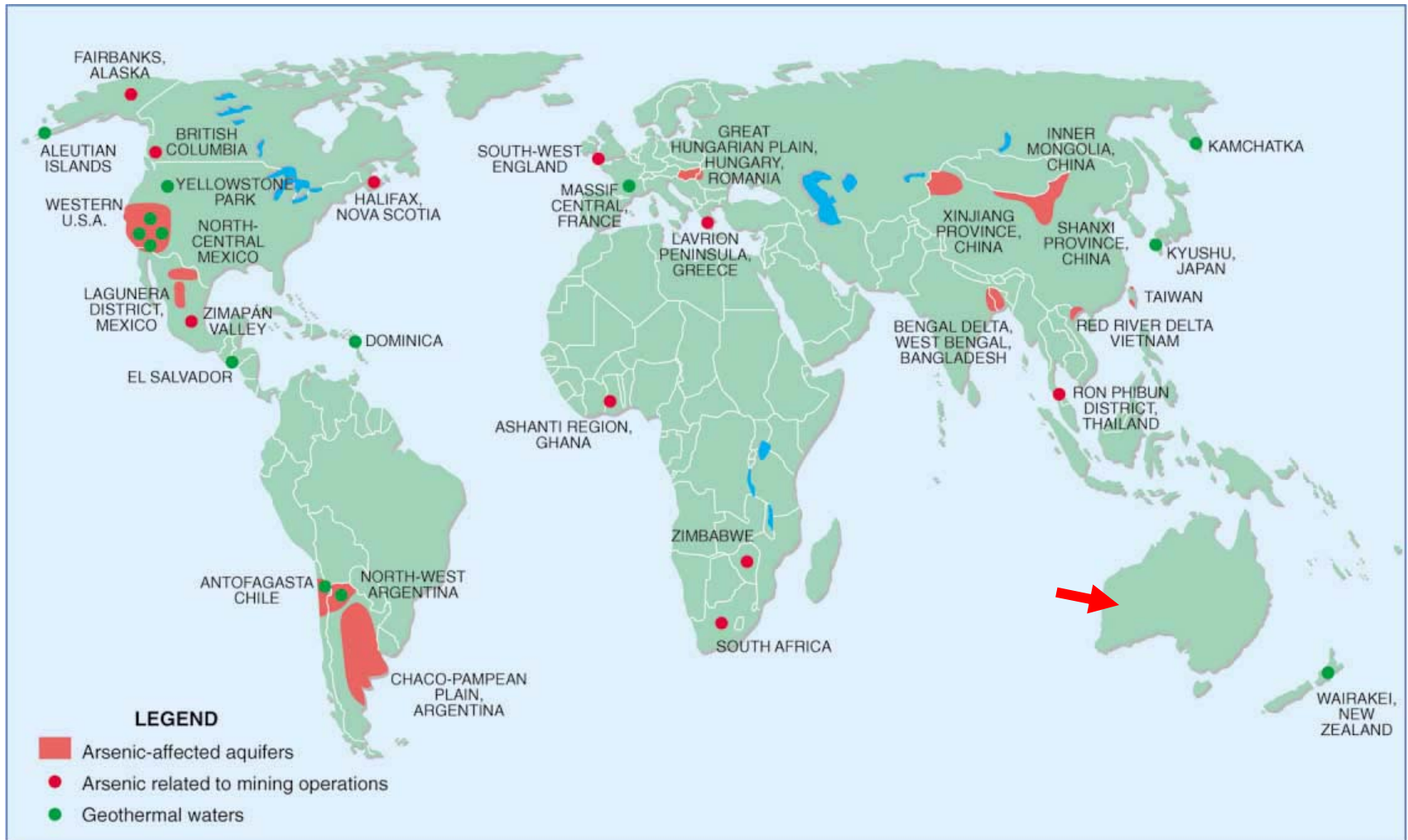
Sources of arsenic

- Sulfide minerals
 - arsenopyrite FeAsS
 - pyrite $(\text{Fe}(\text{S},\text{As})_2)$
- Iron oxides
 - hematite
 - goethite
- Silicate minerals
 - biotite
 - amphibole

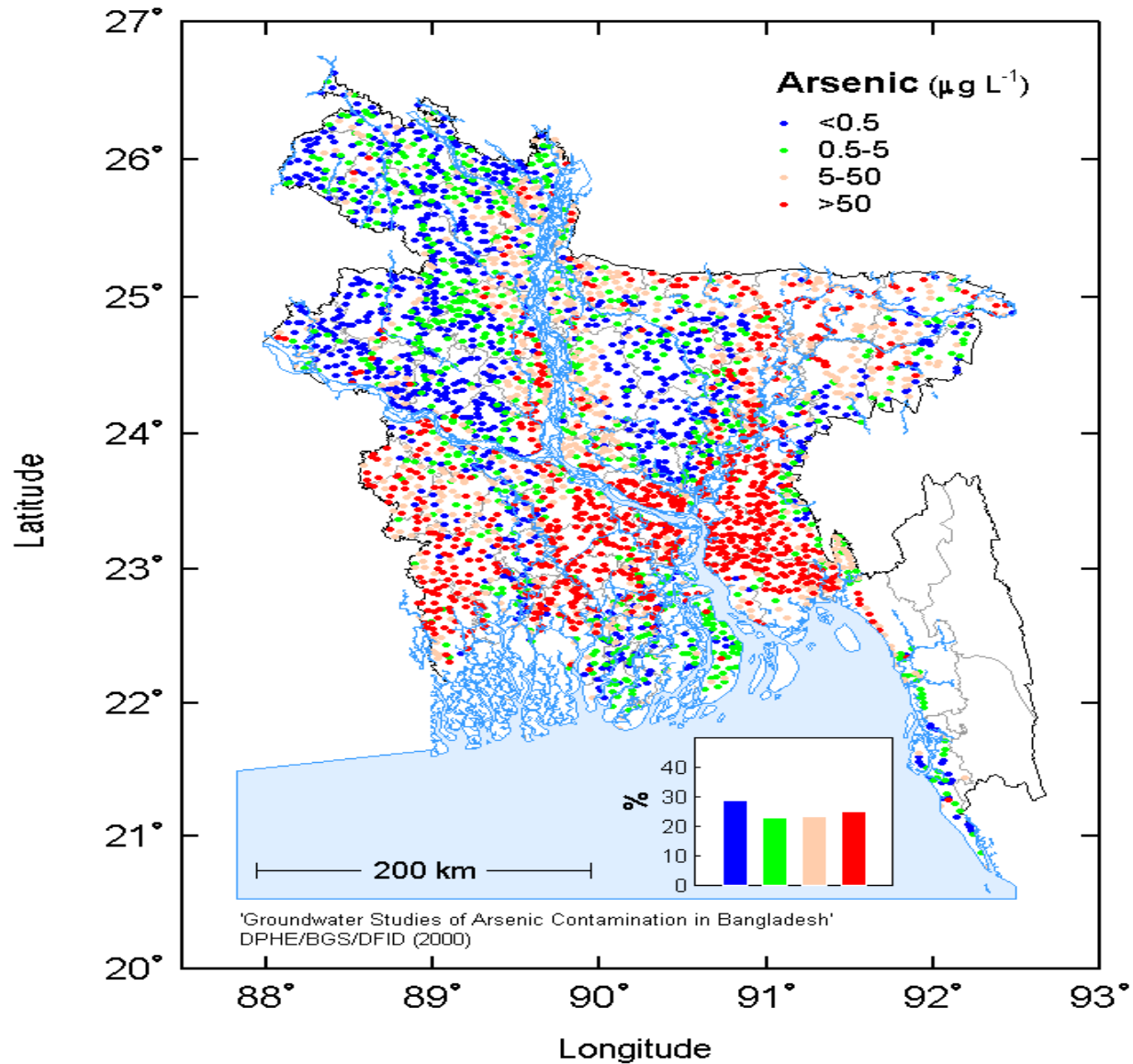
Arsenic in solution



The Global Arsenic Problem



Bangladesh Groundwater



Red River, Vietnam



Mobilization of arsenic in a Red River floodplain aquifer, Vietnam

**Dieke Postma, Flemming Larsen, Nguyen Thi Minh Hue,
Mai Thanh Duc, Pham Hung Viet, Pham Quy Nhan ,
Søren Jessen**

**Water Resources Research
in Vietnam
a Danida Enreca Project**

phase I
VietAs
2004 - 2007

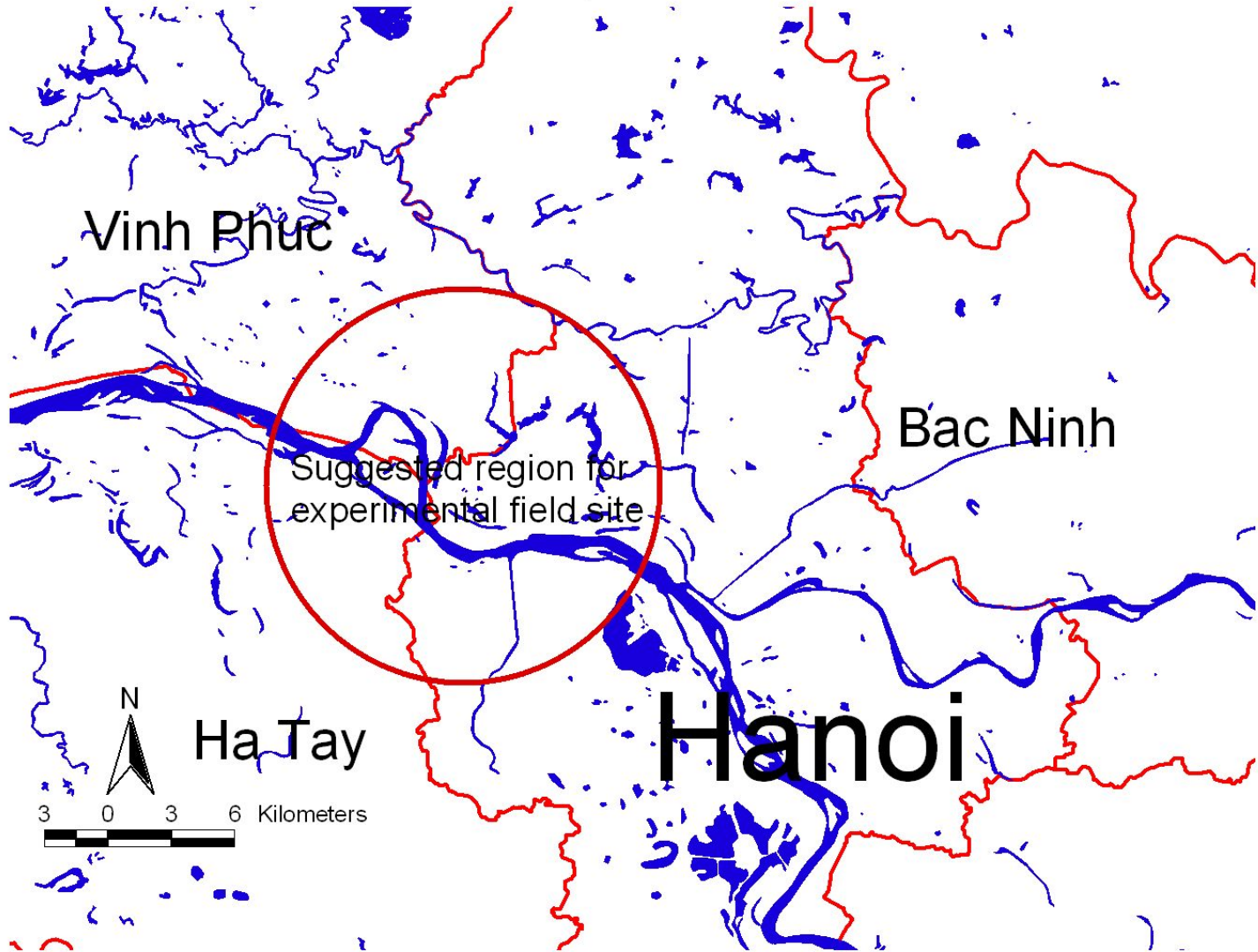




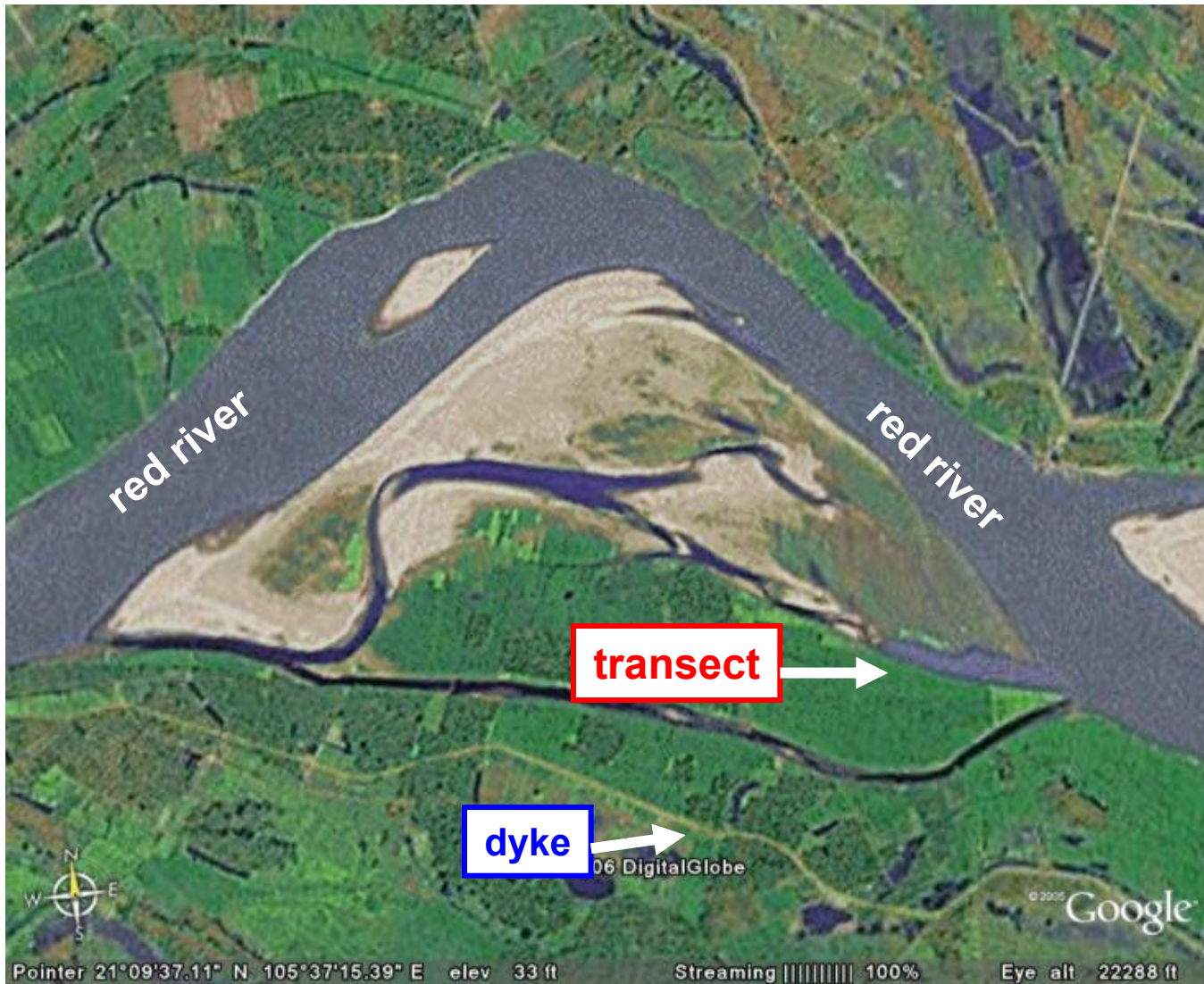
Nguyen Thi Minh Hue

Mai Thanh Duc

RED RIVER DELTA, provinces, Red river and location of field site



Dan Phuong field site

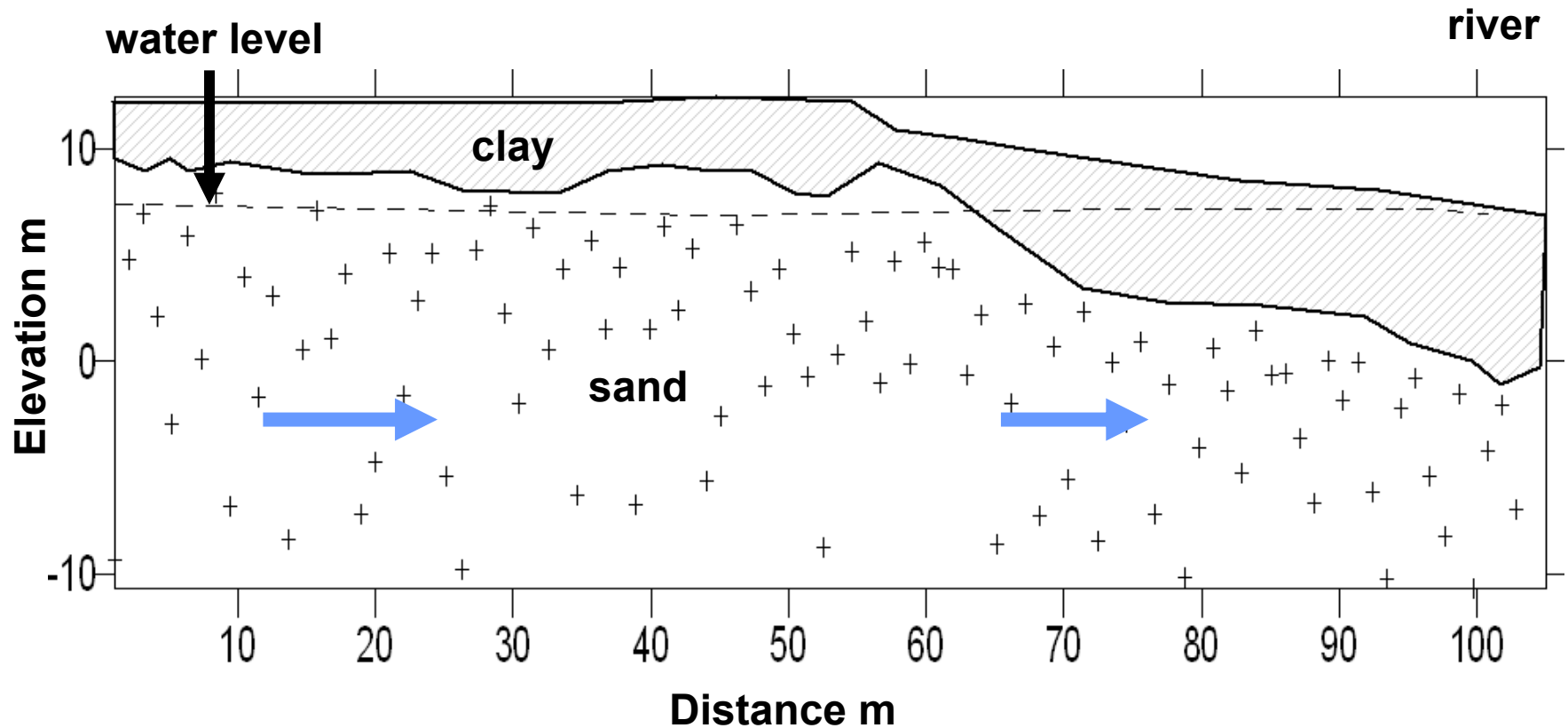


The Dan Phuong Transect

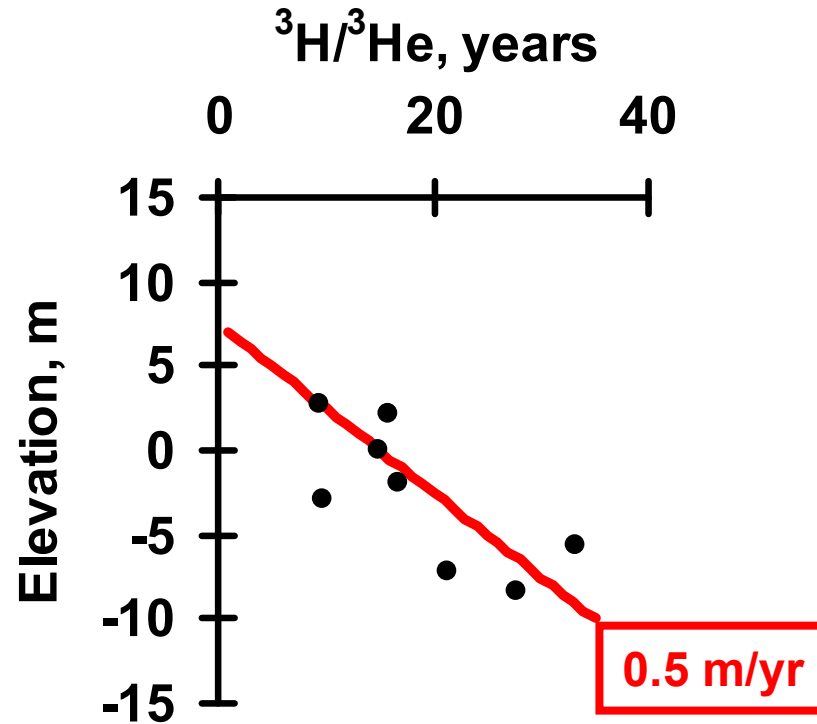
- PVC casing 60 mm Ø
- Variable depth -22 m
- Screen 30 cm
- Seal through clay layer



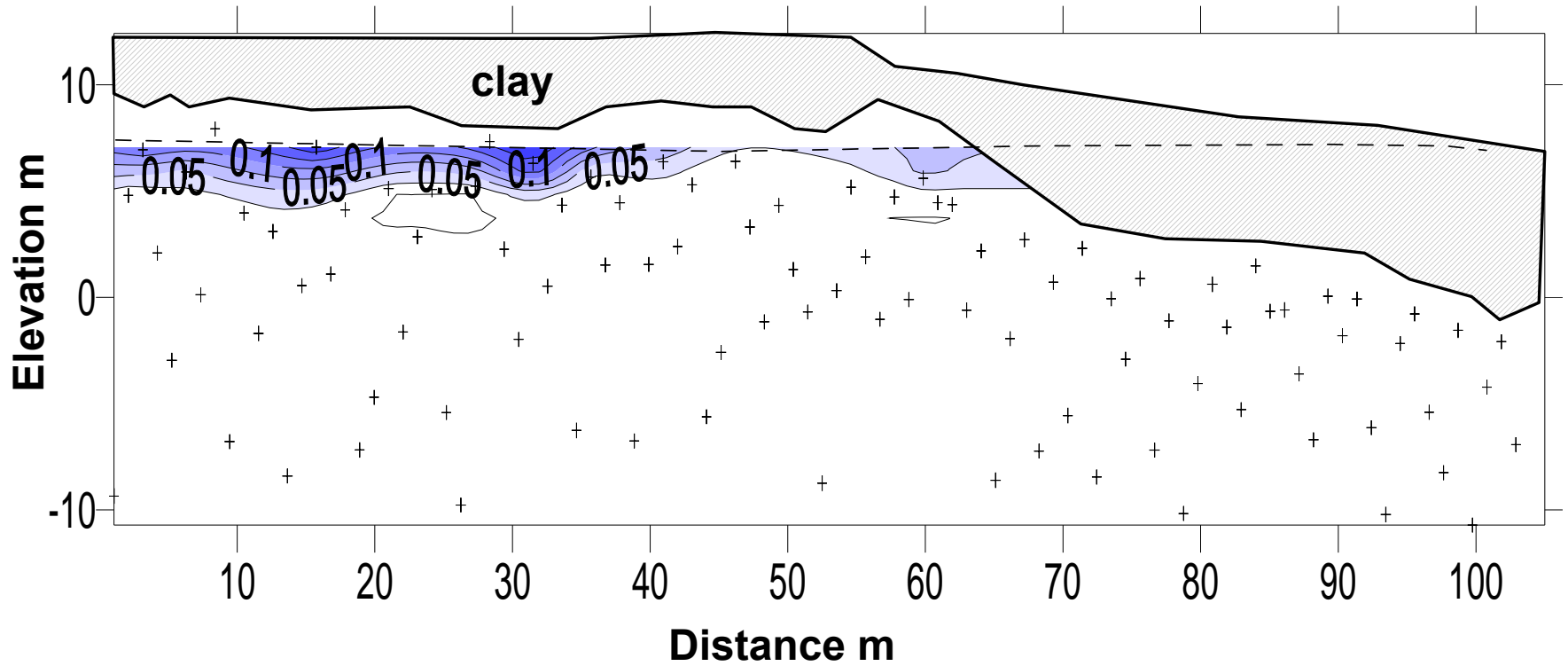
Transect and sampling points



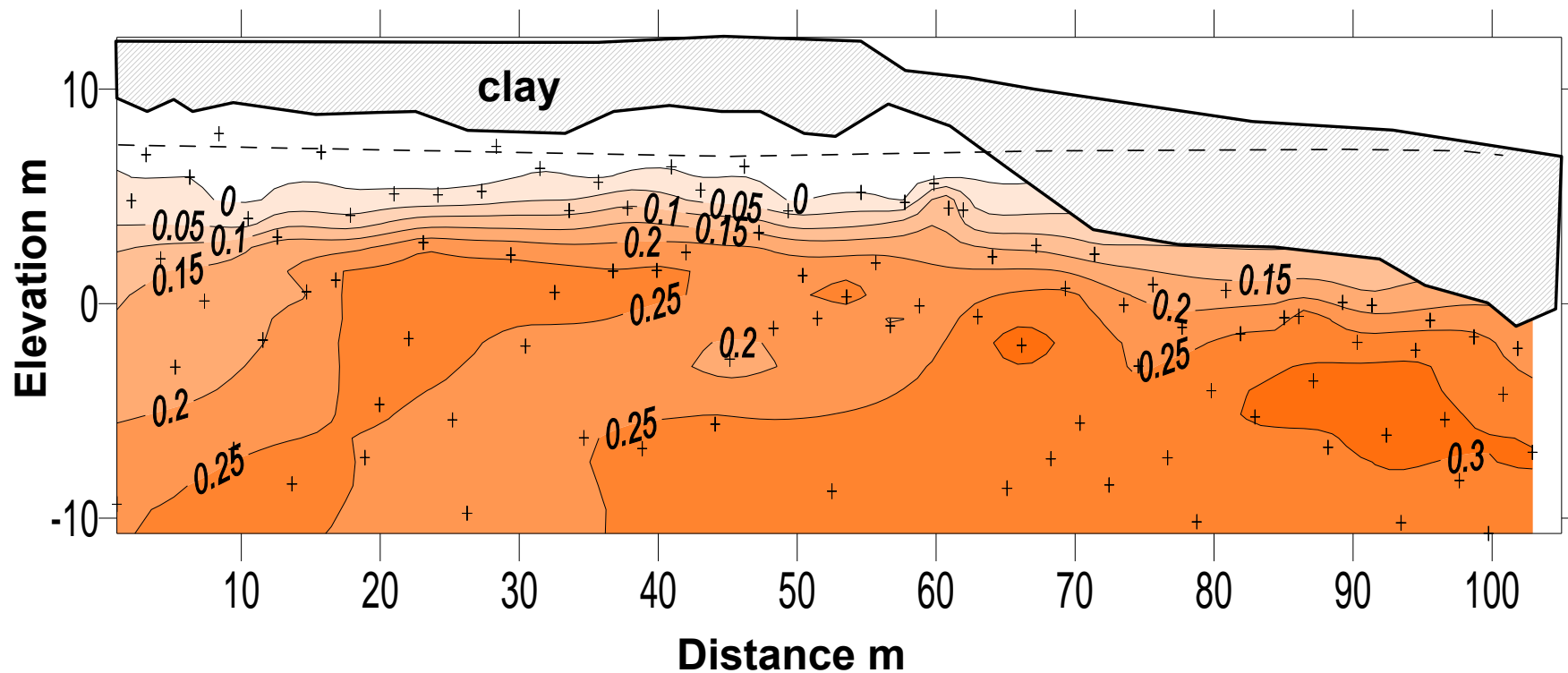
Groundwater dating



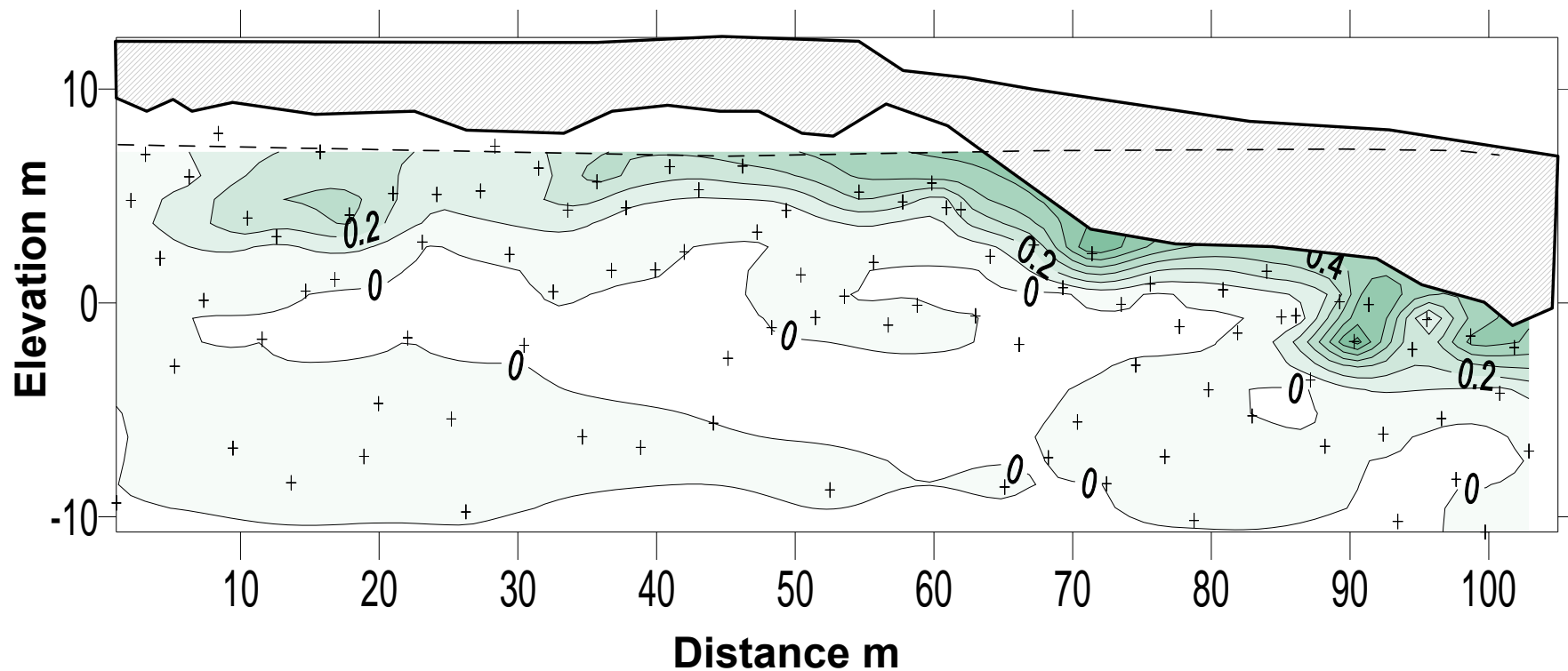
O₂ mmol/L



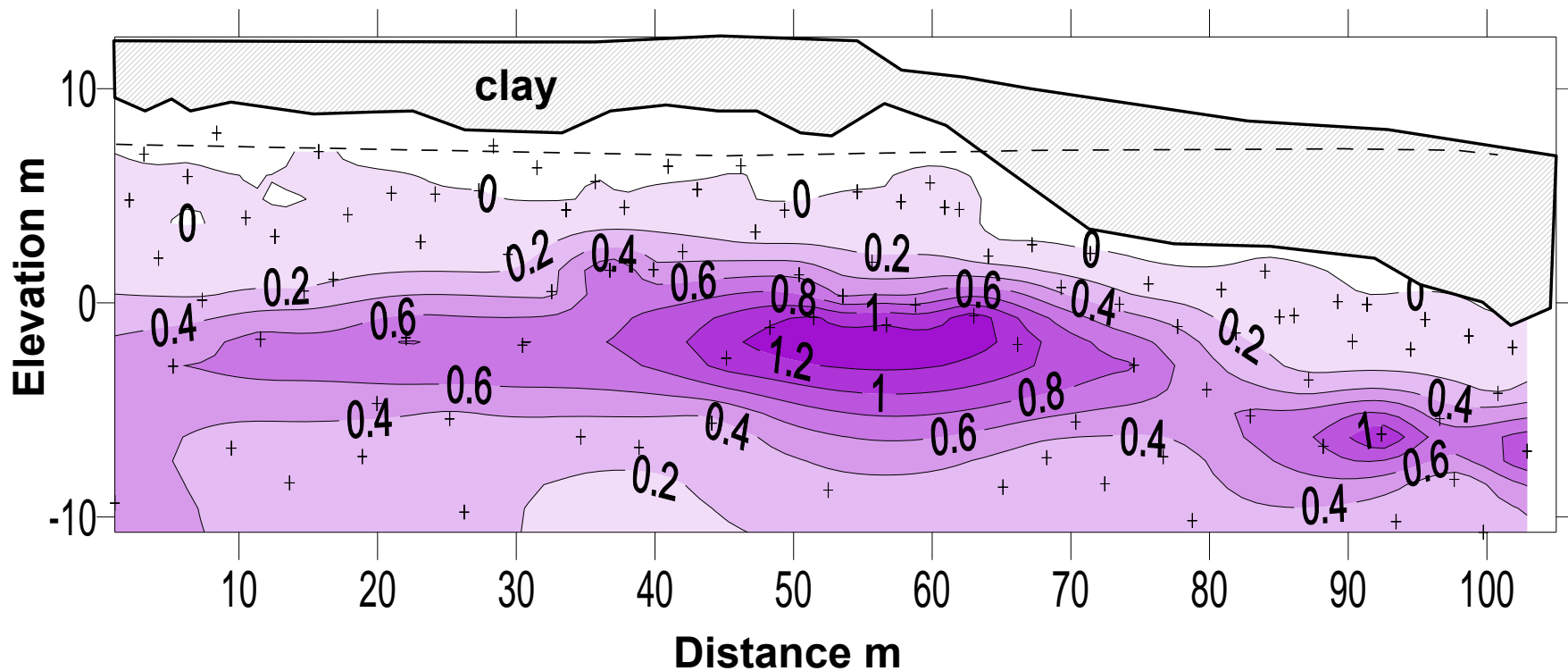
Fe²⁺ mmol/L



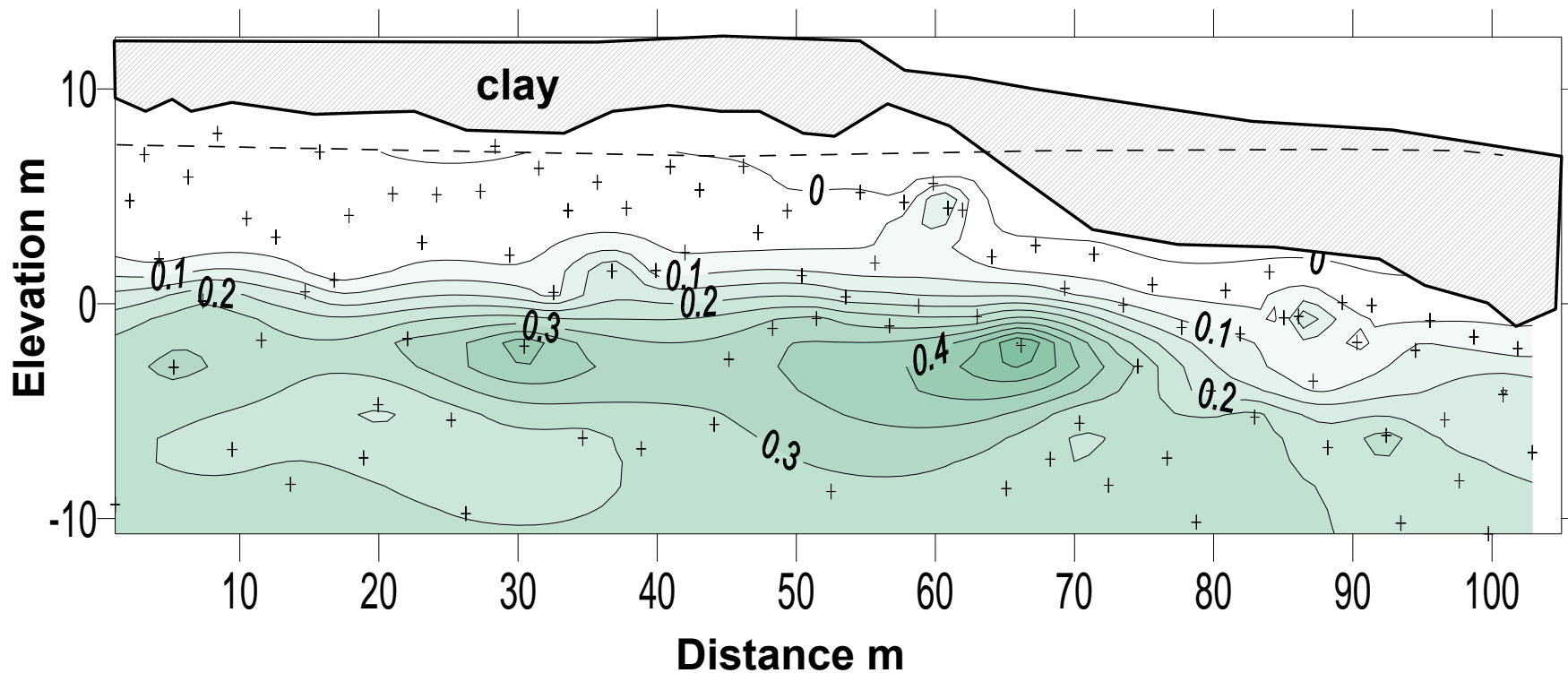
SO₄ mmol/L



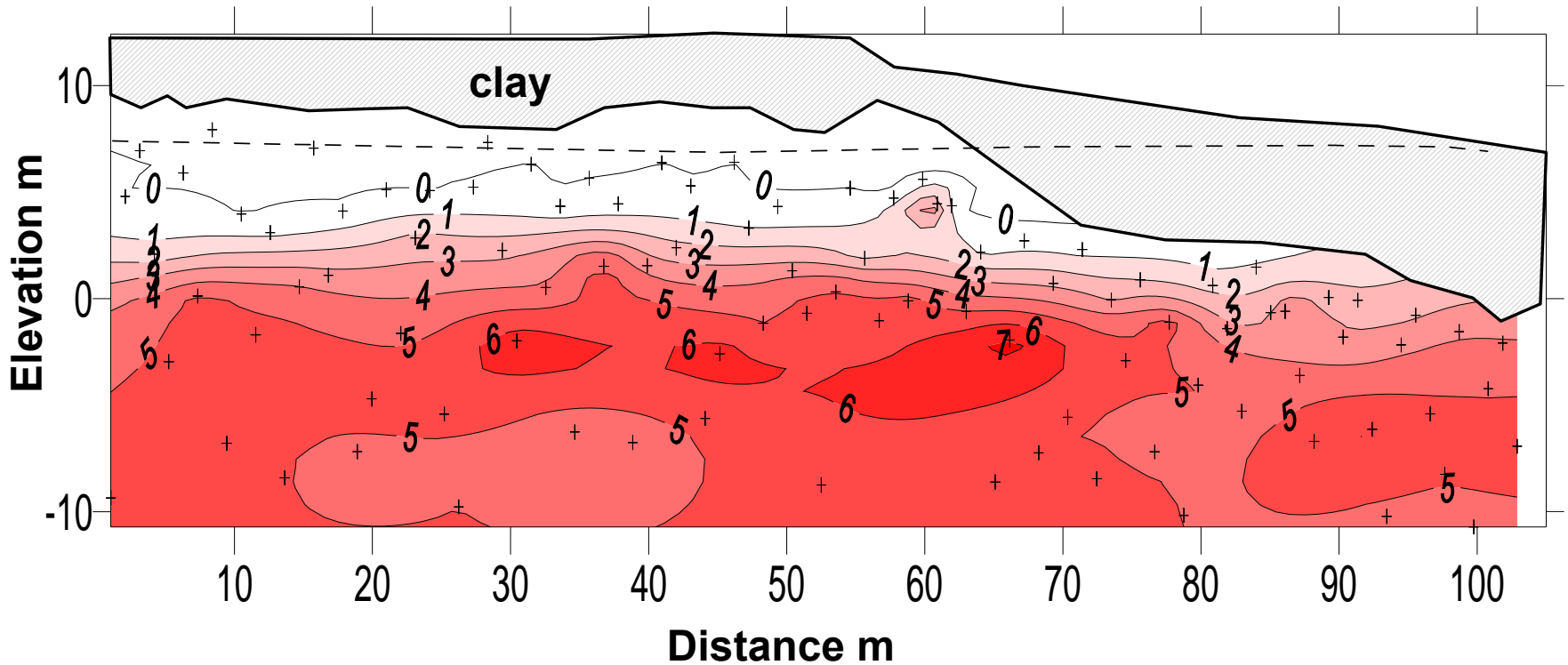
CH₄ mmol/L



NH₄ mmol/L

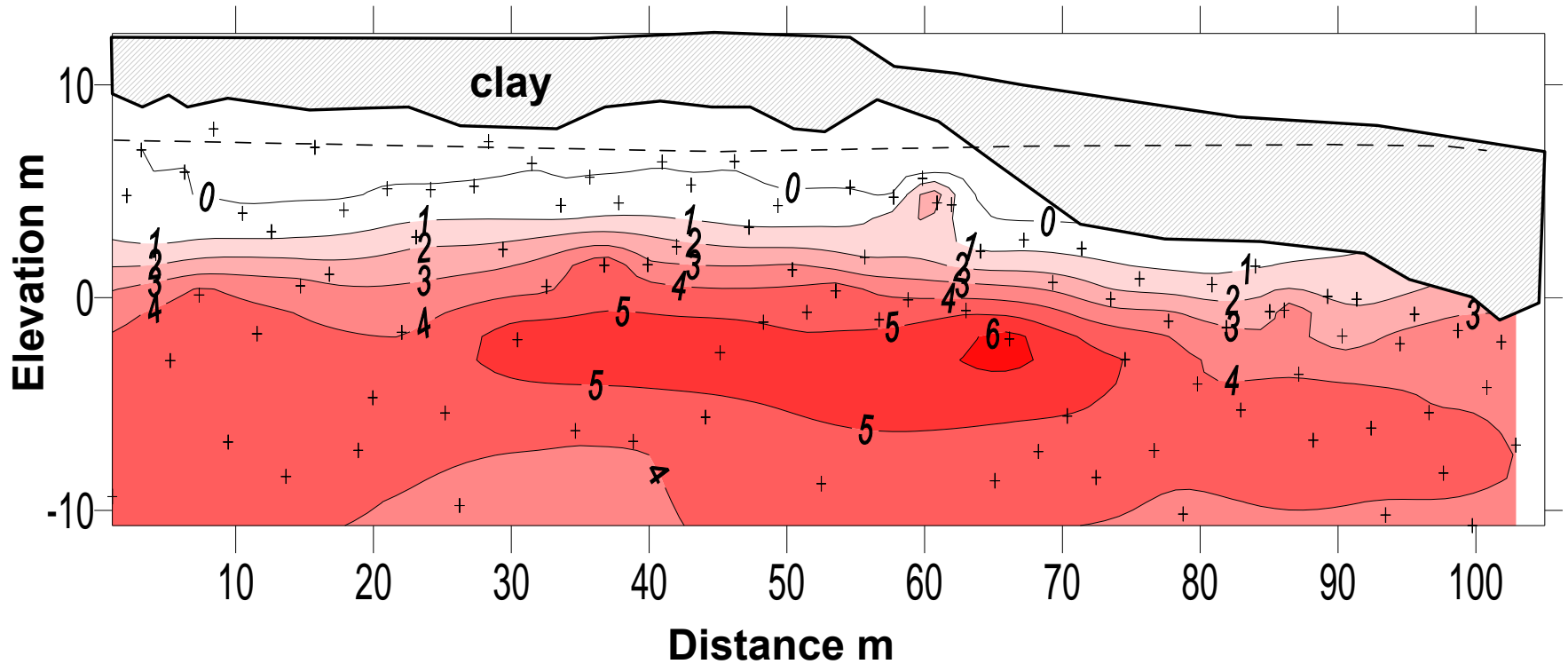


As-total, $\mu\text{mol/L}$



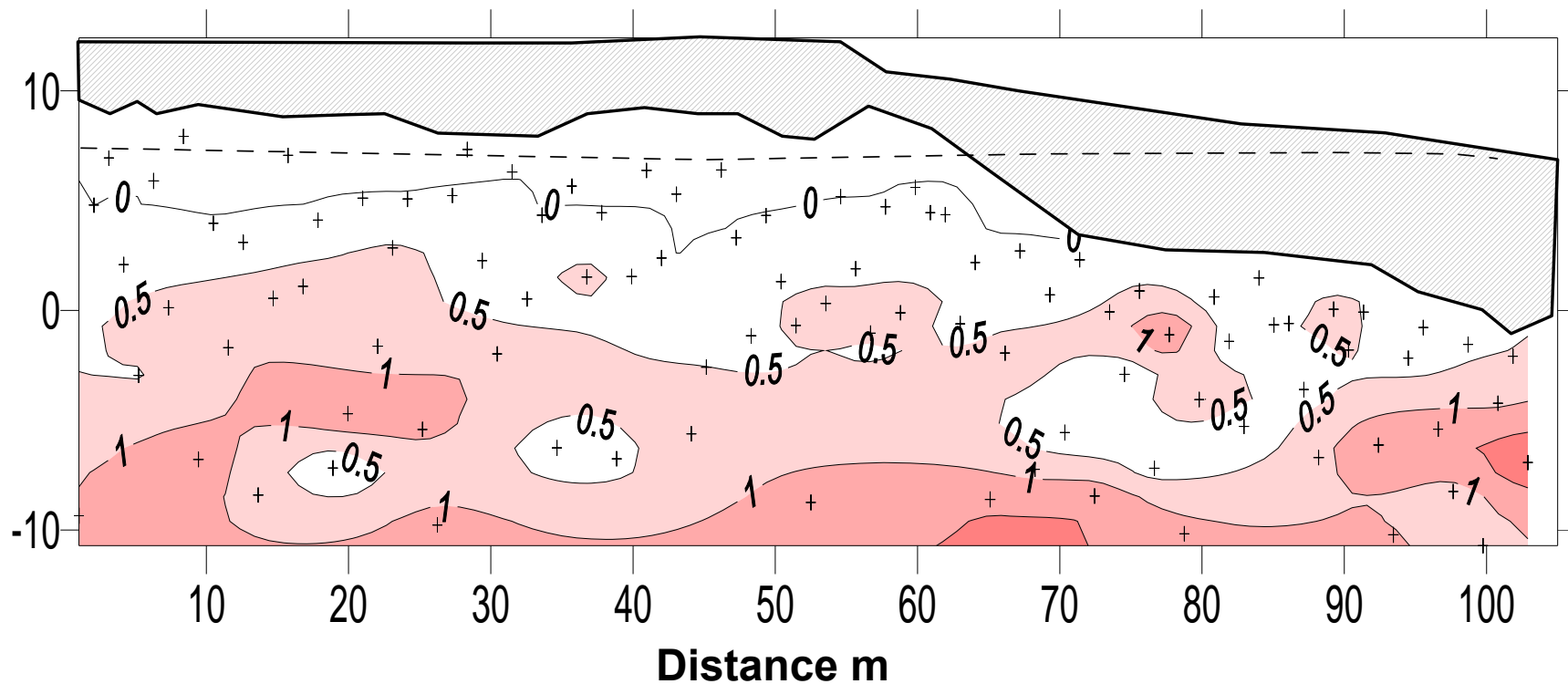
1 $\mu\text{mol/L}$ As = 75 $\mu\text{g/L}$ As

As(3) $\mu\text{mol/L}$

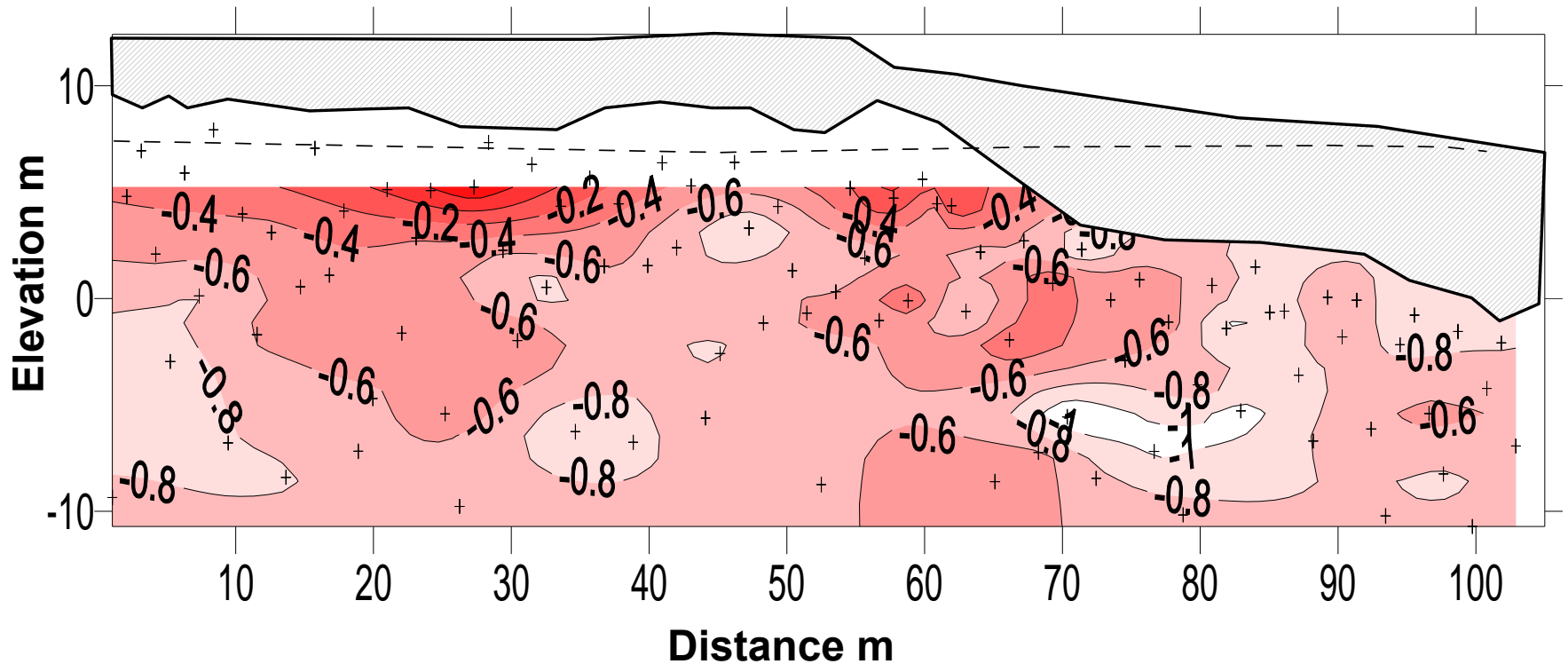


$1 \mu\text{mol/L As} = 75 \text{ ug/L As}$

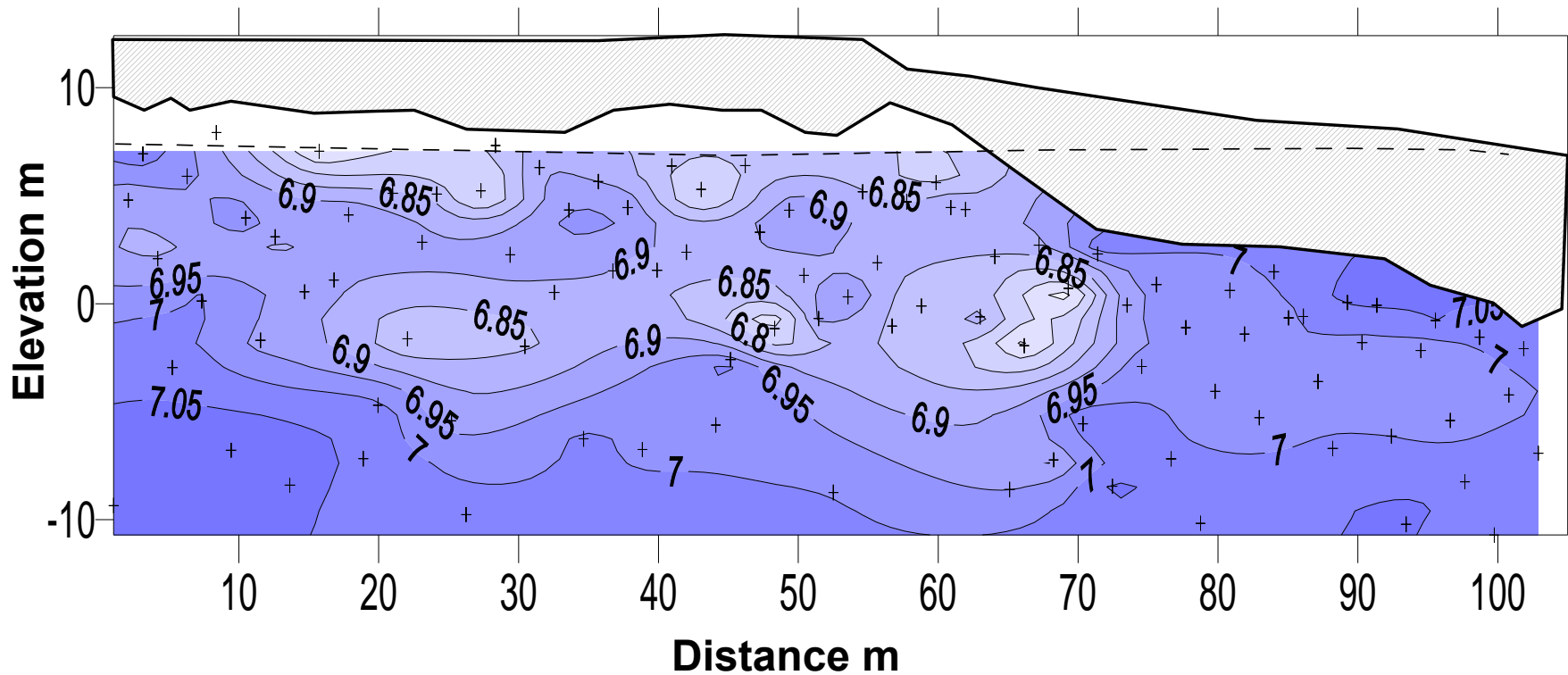
As(5) $\mu\text{mol/L}$



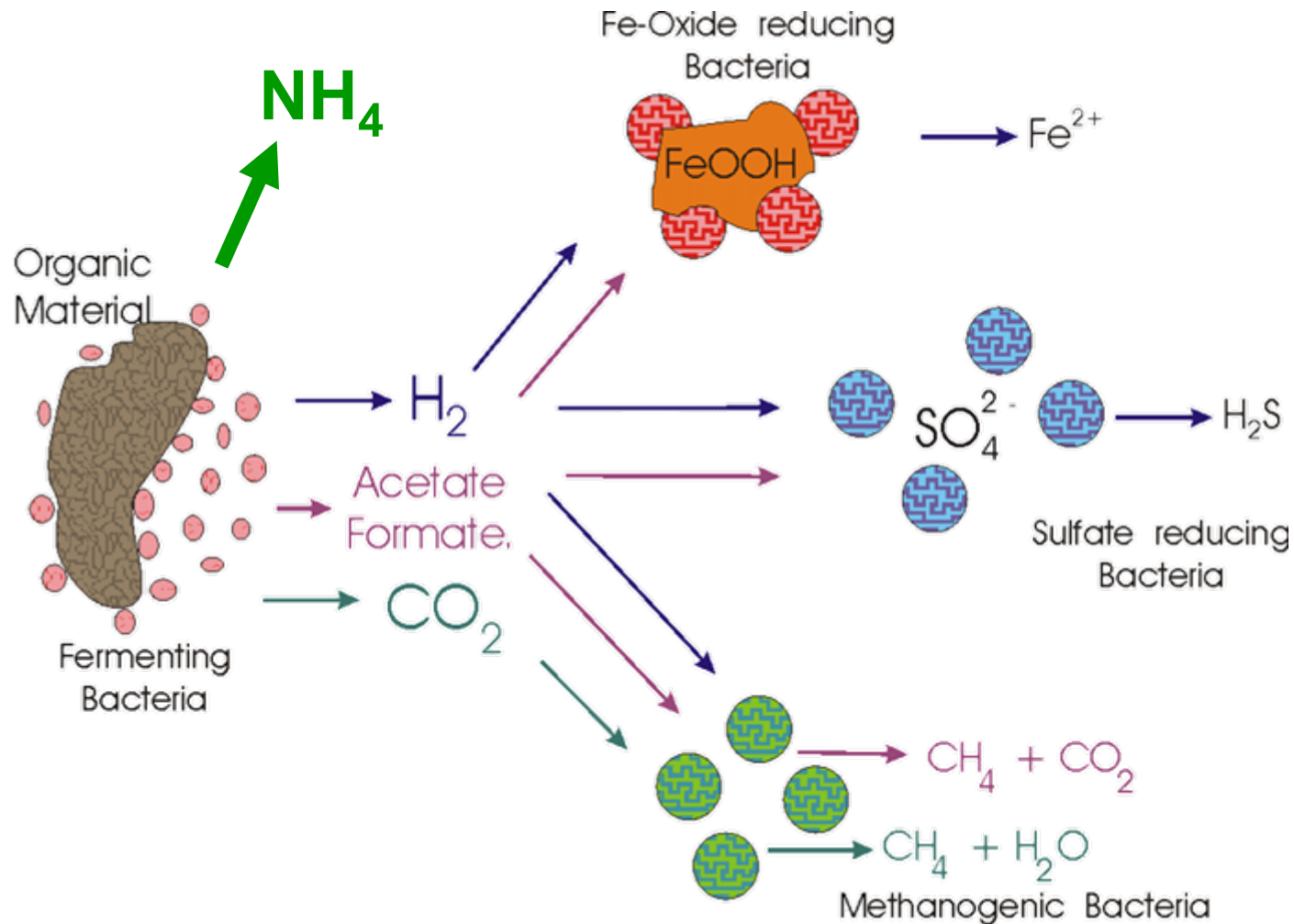
pe As(5)/As(3)



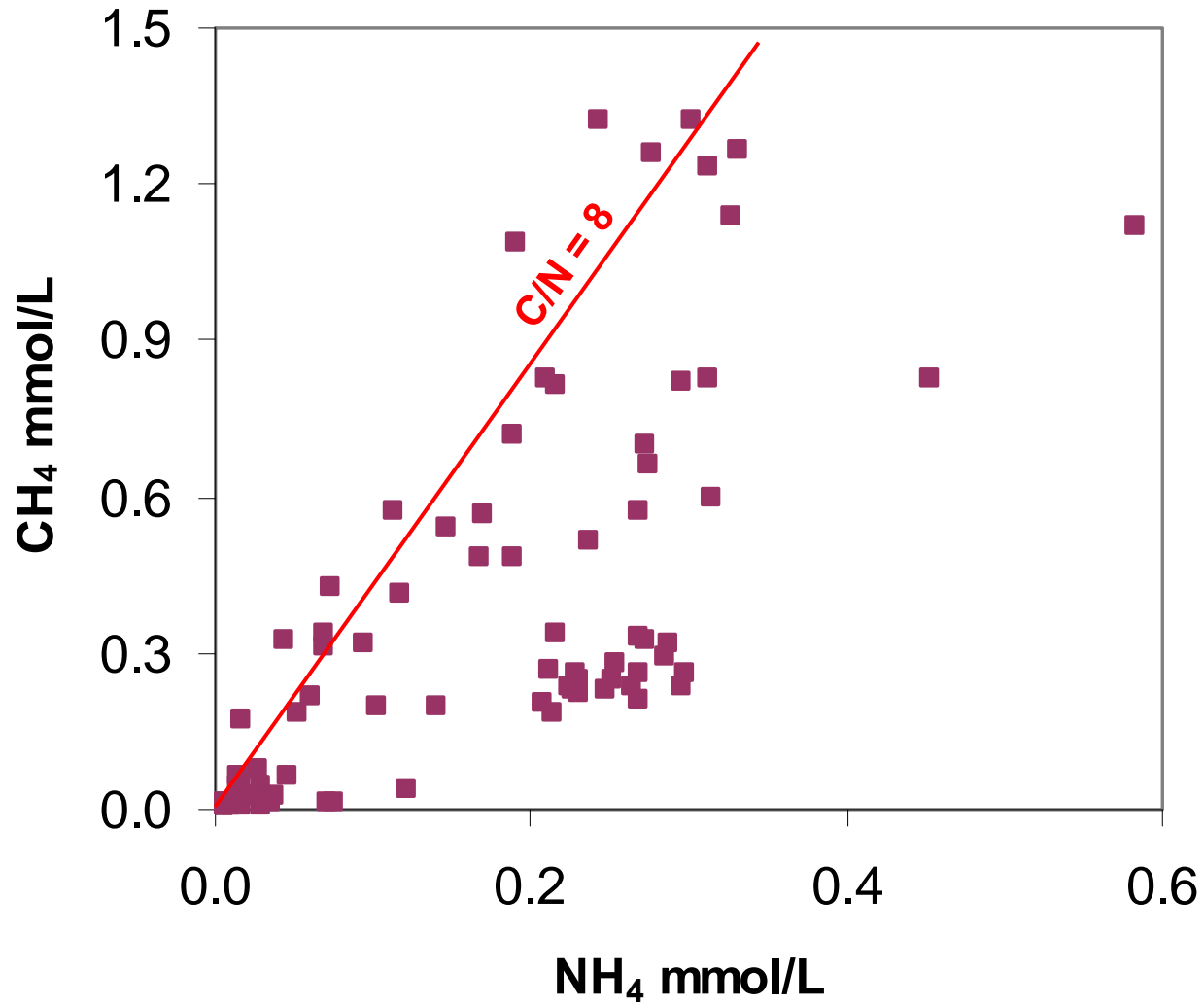
pH



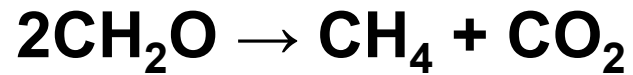
Degradation of organic carbon



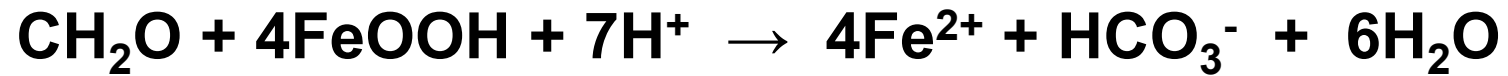
Organic matter degradation and ammonia



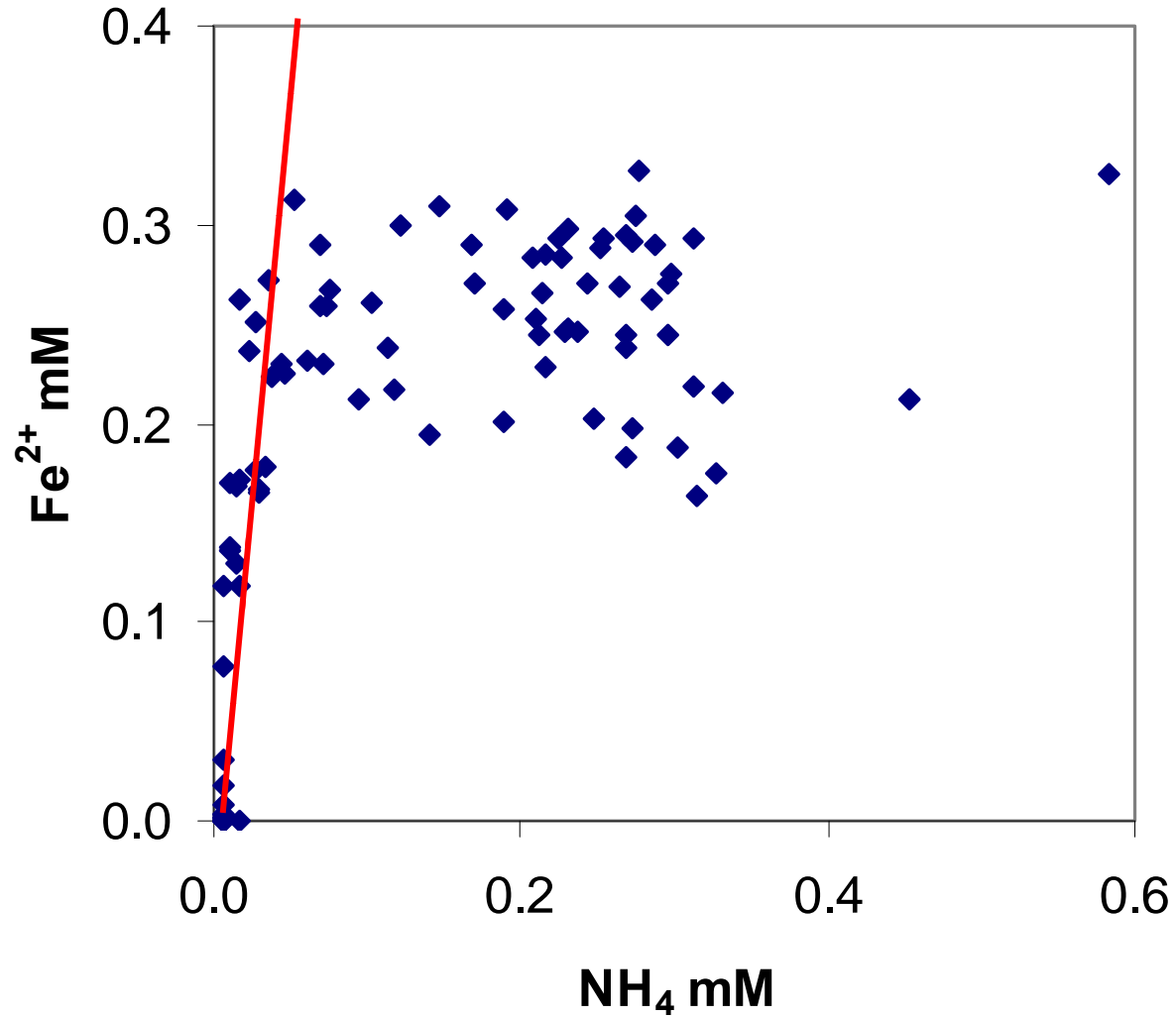
Methanogenesis



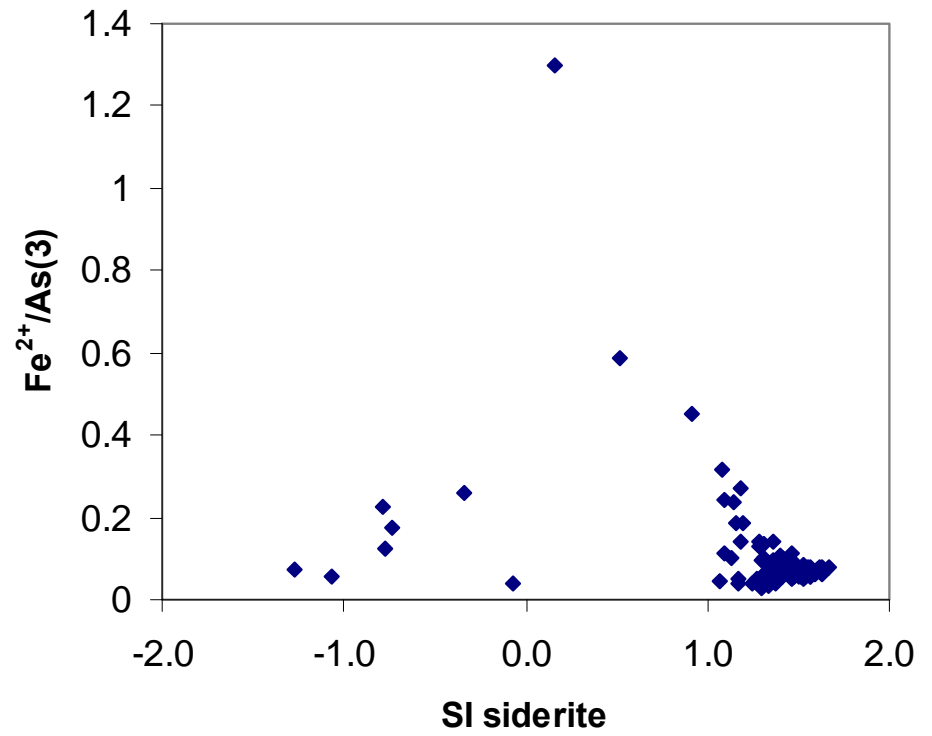
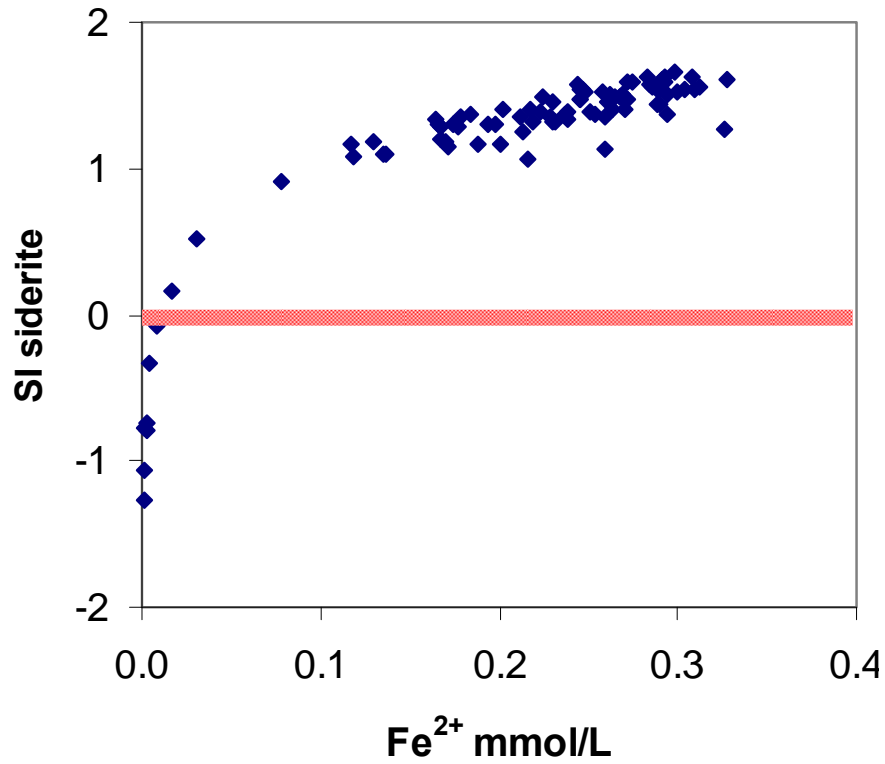
Iron reduction



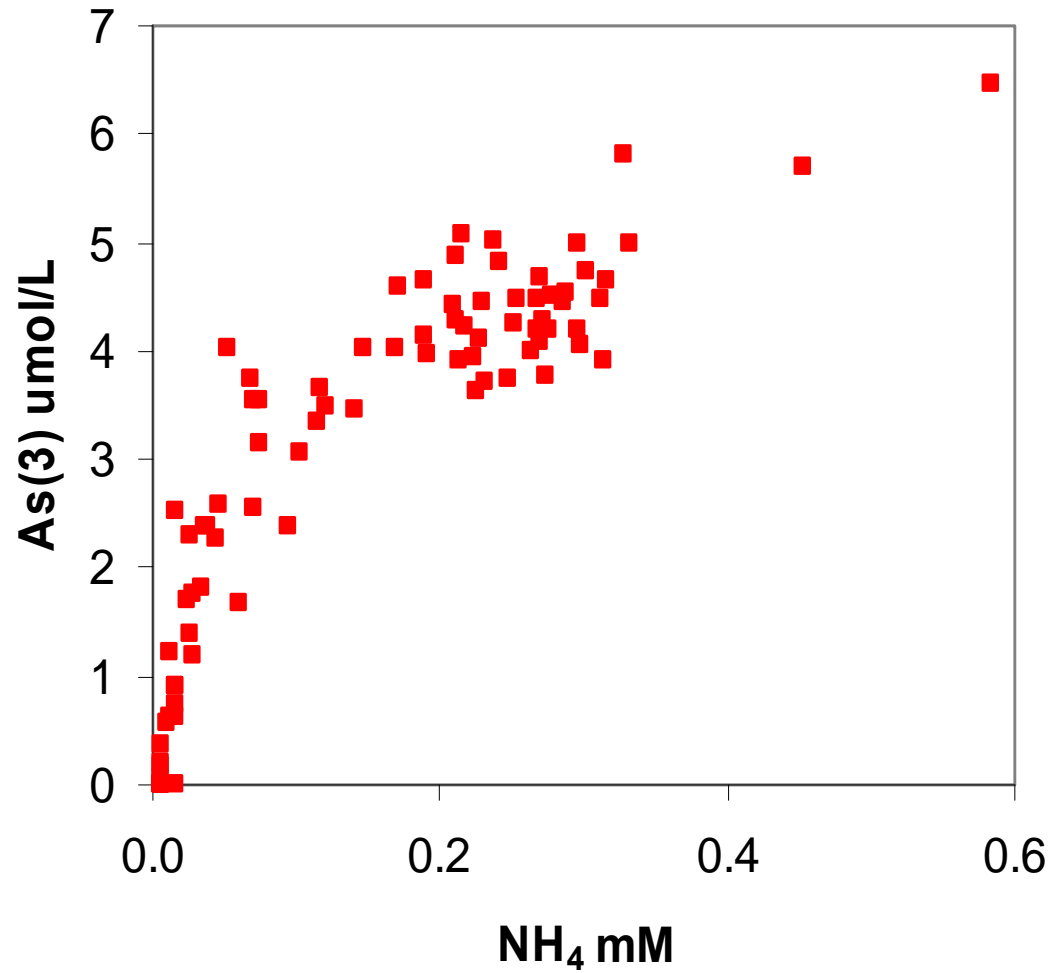
Organic matter degradation and iron



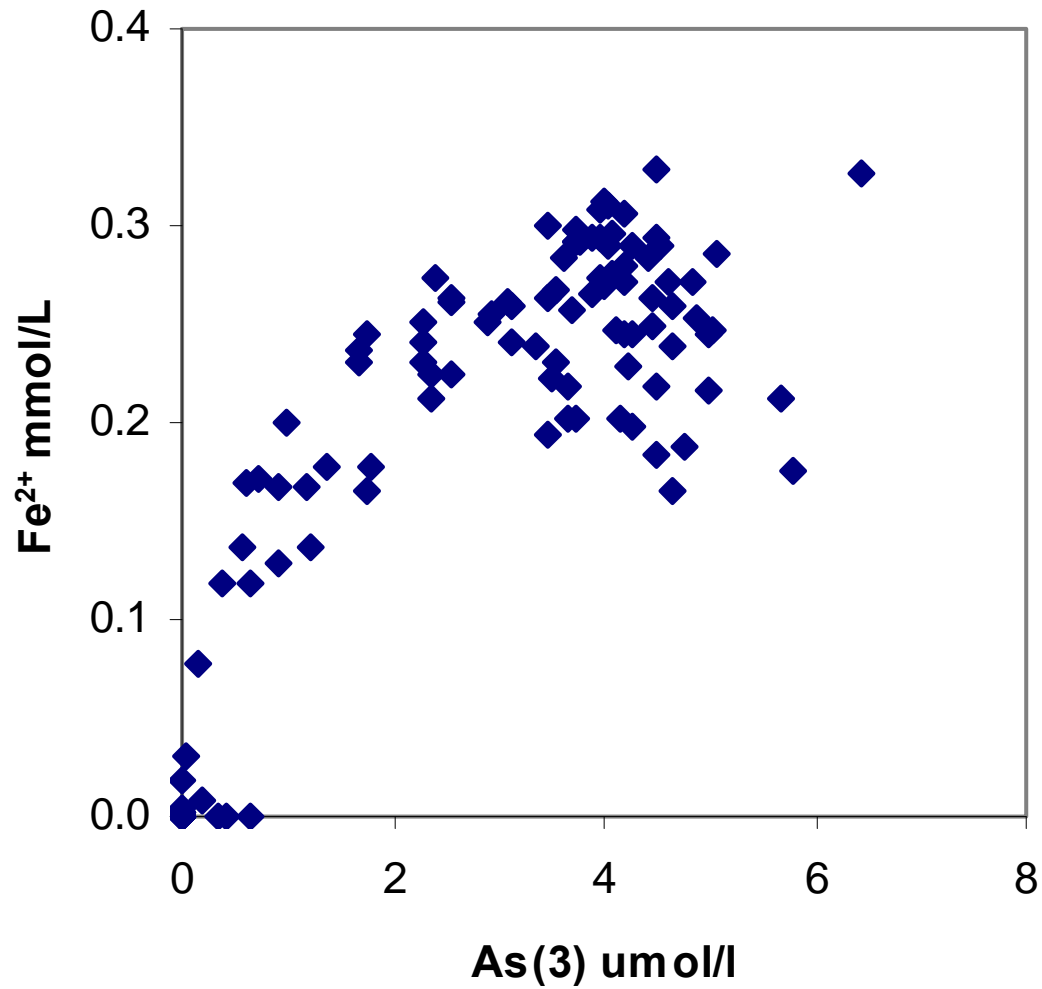
Precipitation of siderite FeCO_3



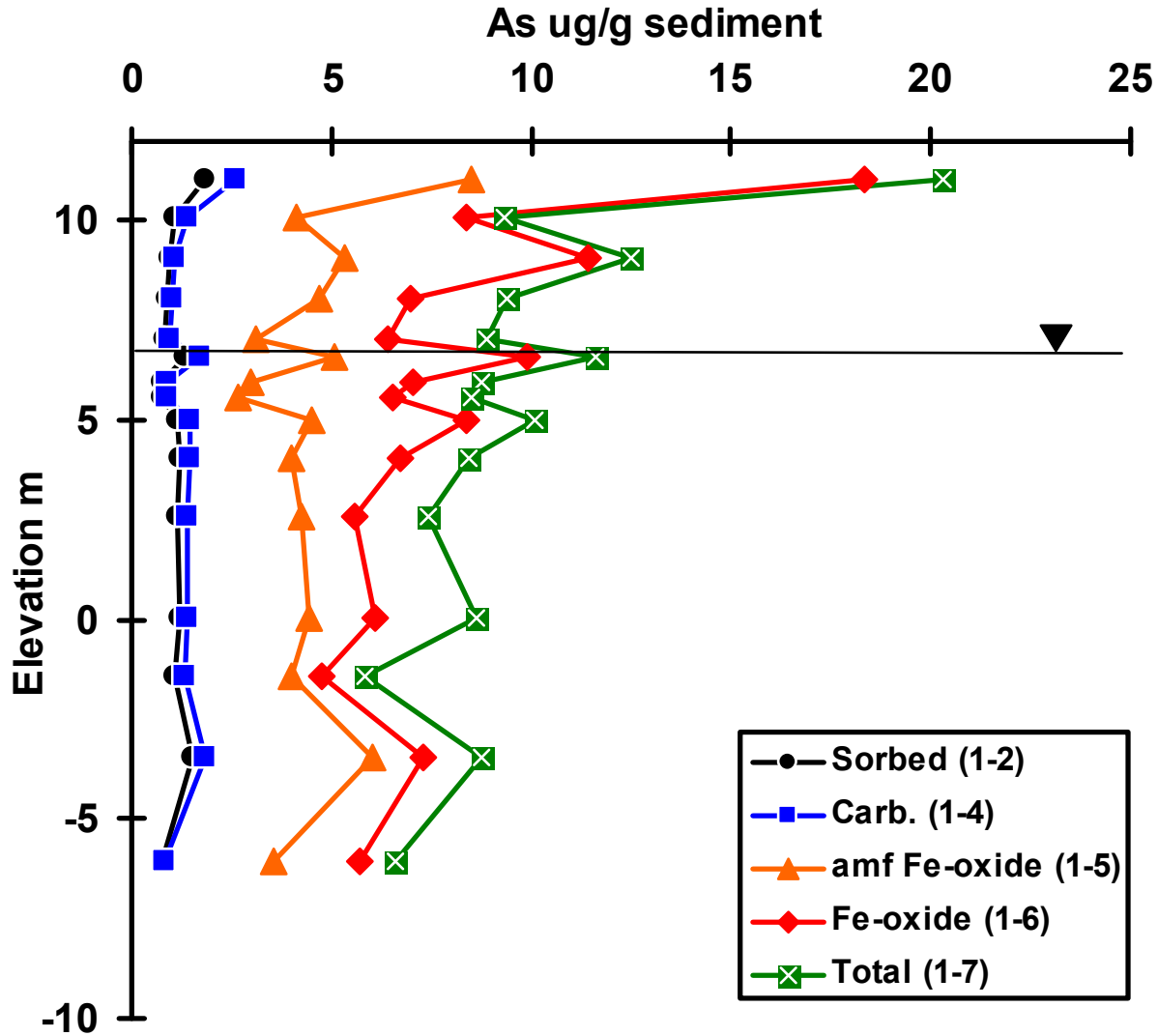
Organic matter degradation and arsenic



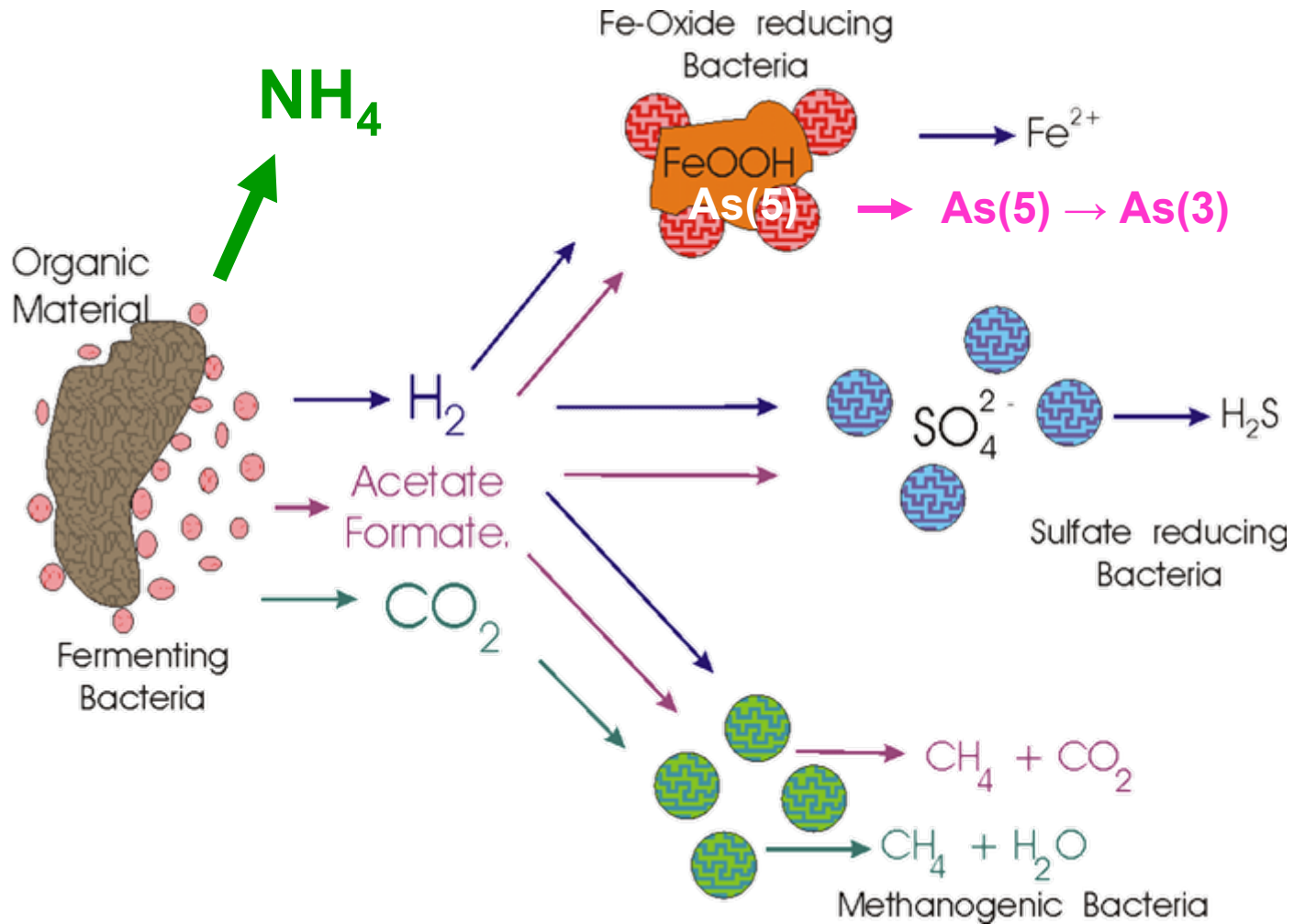
Reduction Fe-oxide and As release



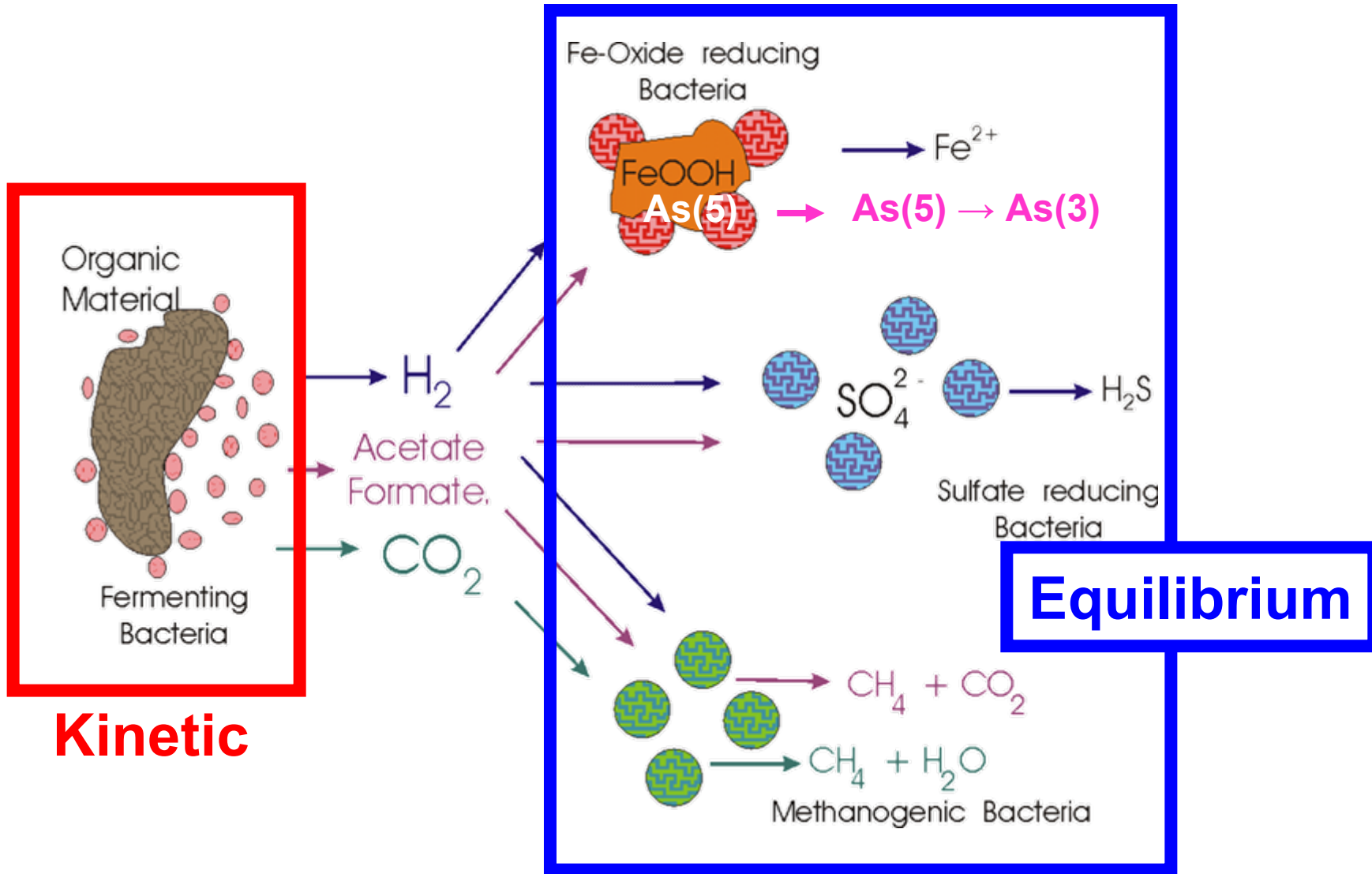
Arsenic in Sediment



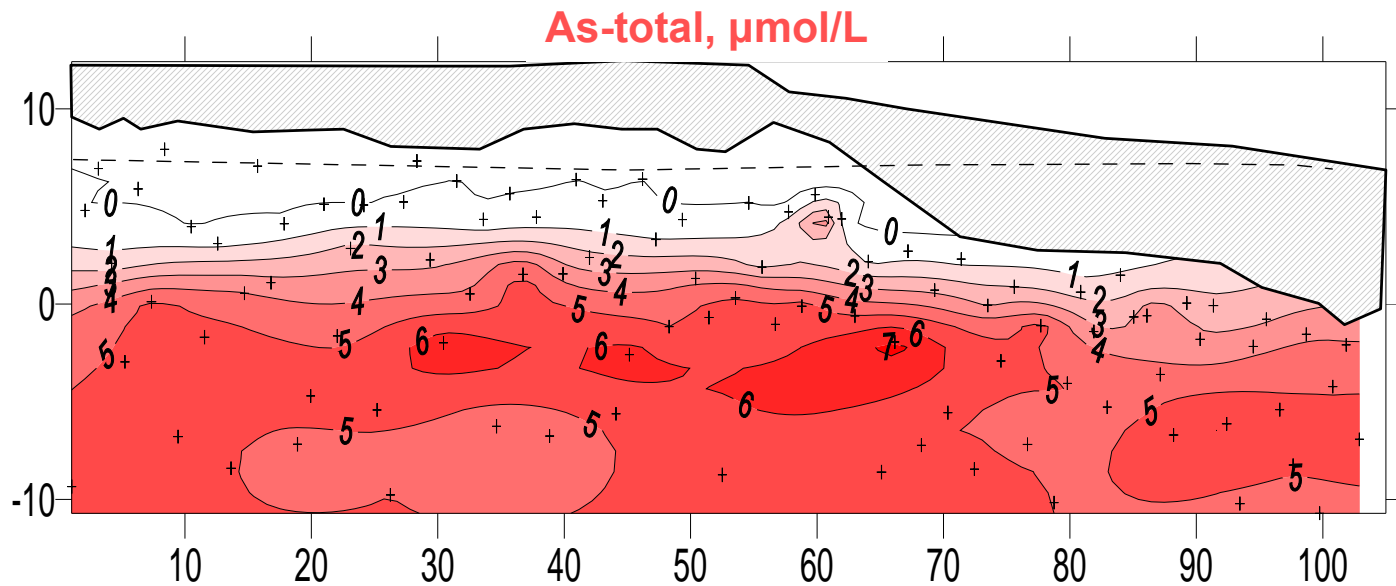
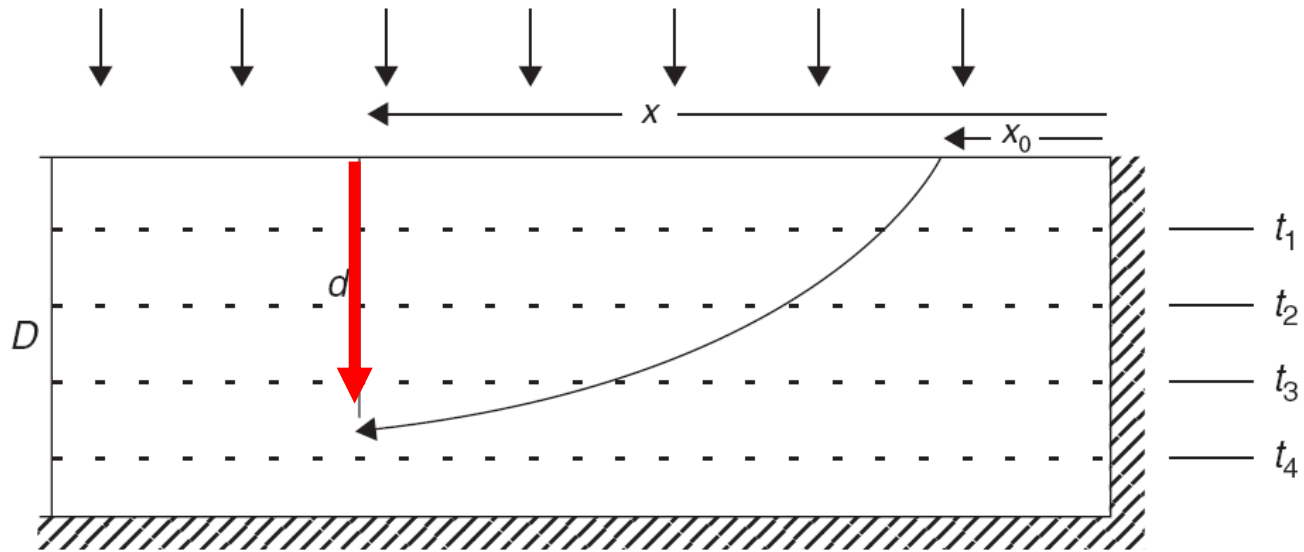
Arsenic mobilization



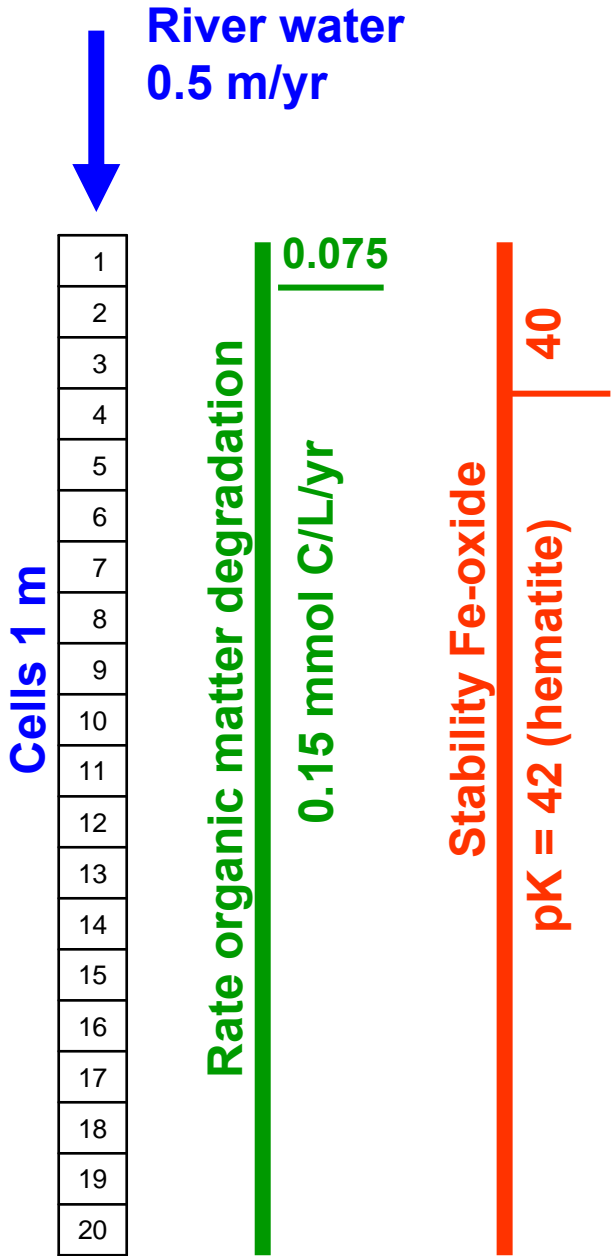
Partial Equilibrium Model



Reactive transport: modeling the vertical component

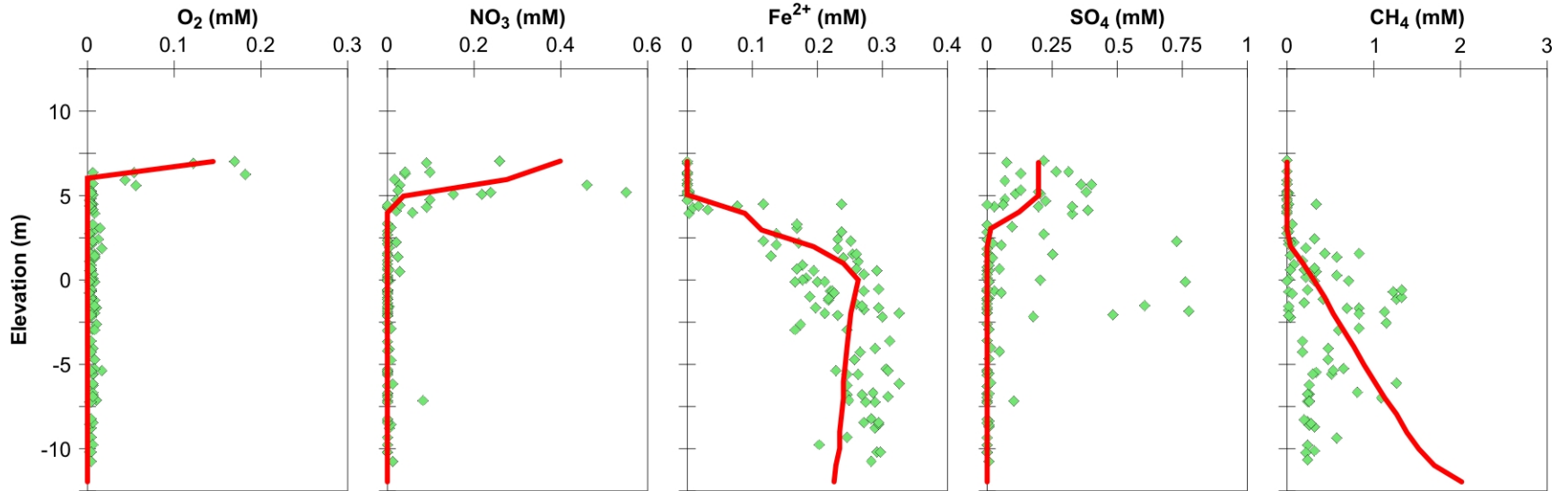


PHREEQC model

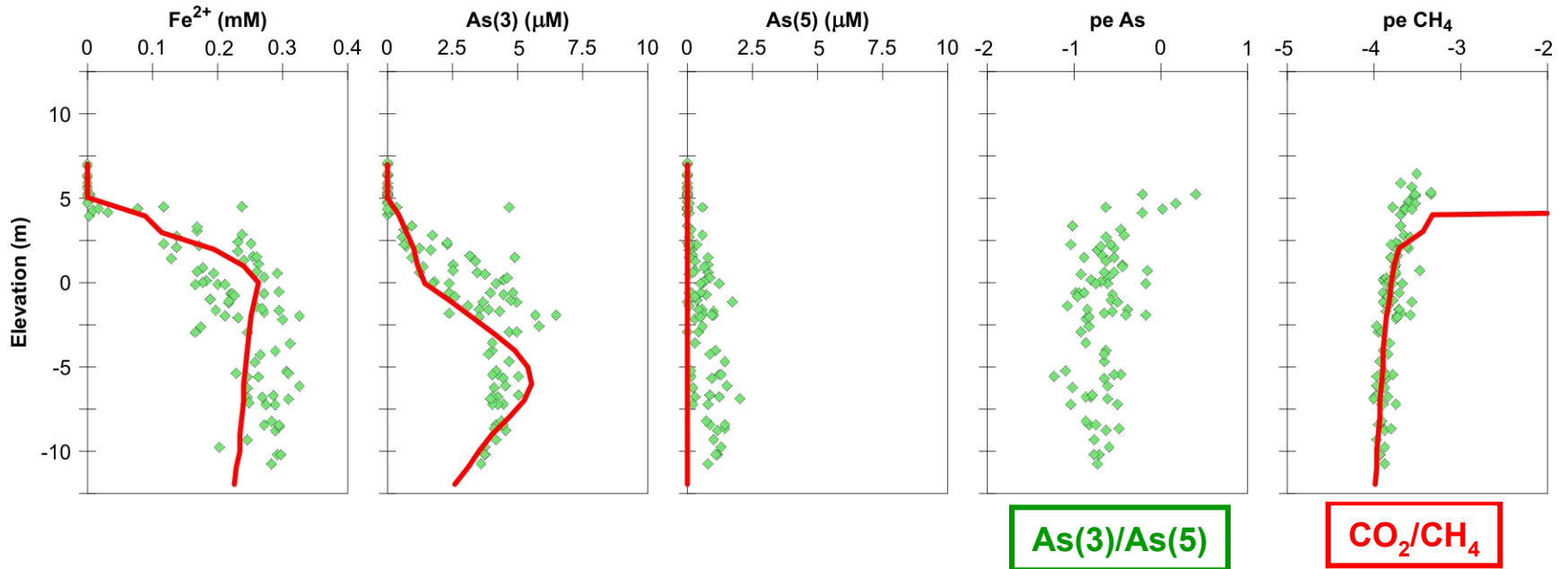


Eq Calcite SI = 0.2
Eq Siderite SI = 1.4
40 years

The redox sequence



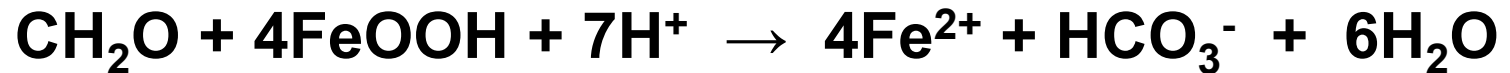
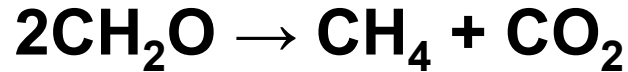
Arsenic mobilization



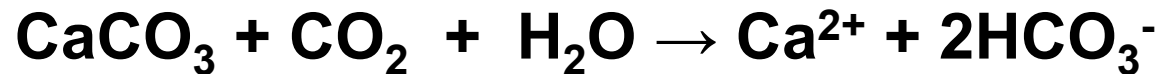
**2.5 ‰ As(5) in FeOOH
Surface Complexation
0.1 mmol sites/mol Fe**

The pH Buffer System

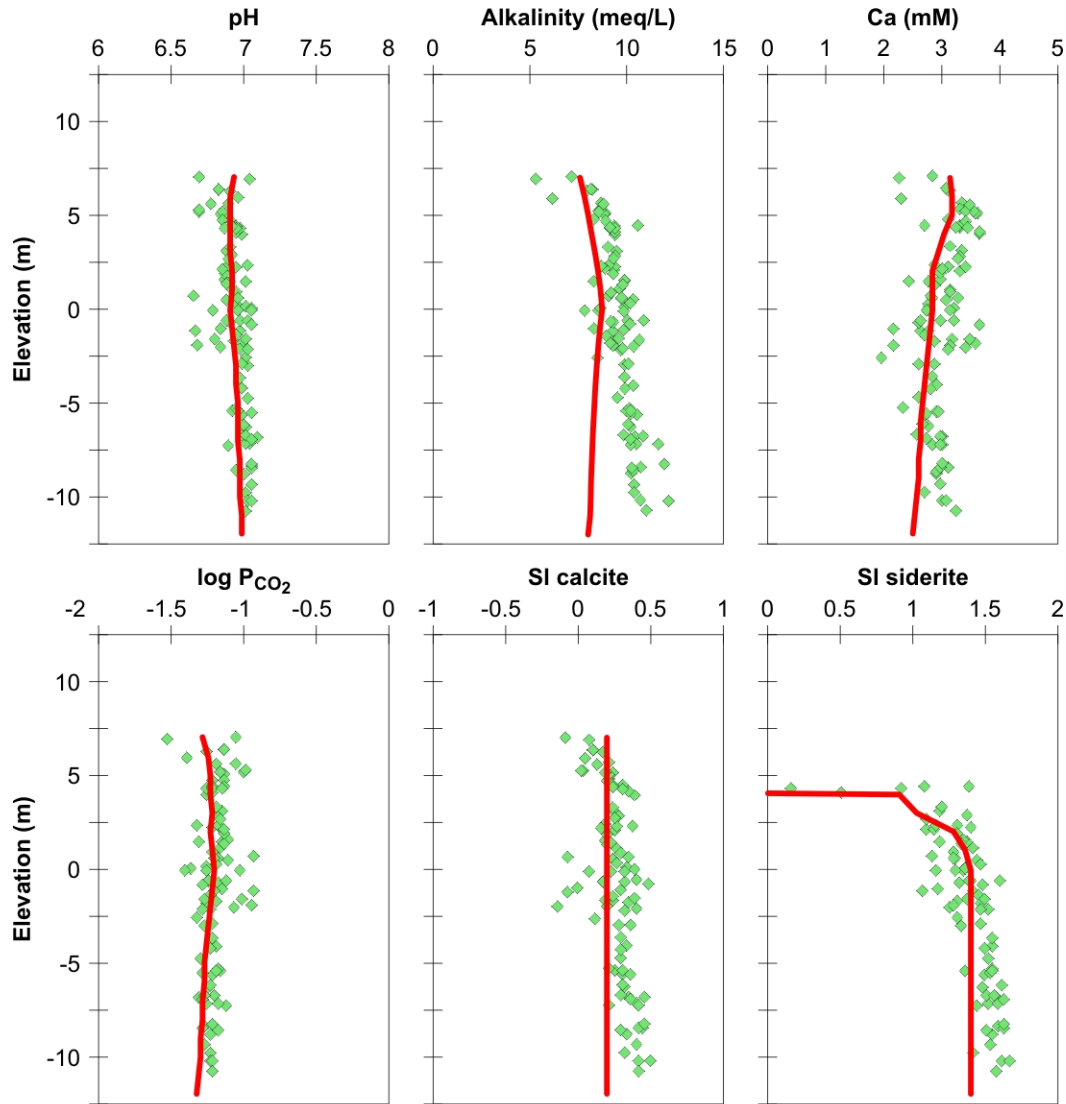
Redox



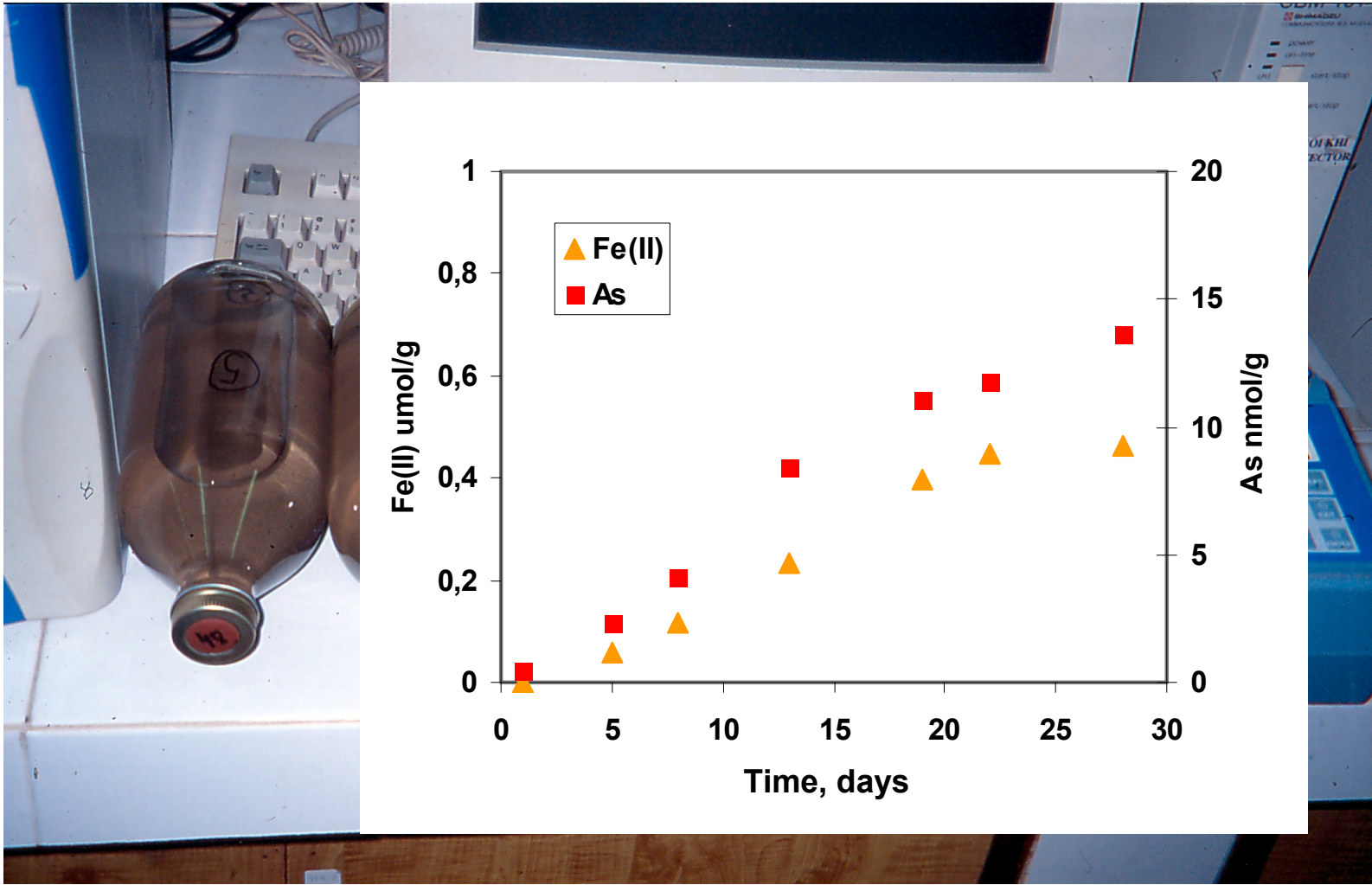
Mineral Equilibria



The pH Buffer System



Incubation of recent Red River sediment



Conclusions

- Arsenic is derived from Red River sediment
- Arsenic is released to anoxic groundwater during organic matter degradation
- Originally As(5) is contained in hematite/goethite and is released during Fe-oxide reduction
- Arsenic release may continue for thousands of years