Partition coefficients of trace elements: from the ocean to the models

M. Roy-Barman

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Outline:

- what is a K_d ?

- Thorium

- Neodymium

- K_d in models

- recommendations

$$K_d = \frac{mass\ of\ particulate\ tracer\ per\ mass\ of\ particles}{mass\ of\ dissolved\ tracer\ per\ volume\ of\ seawater}$$

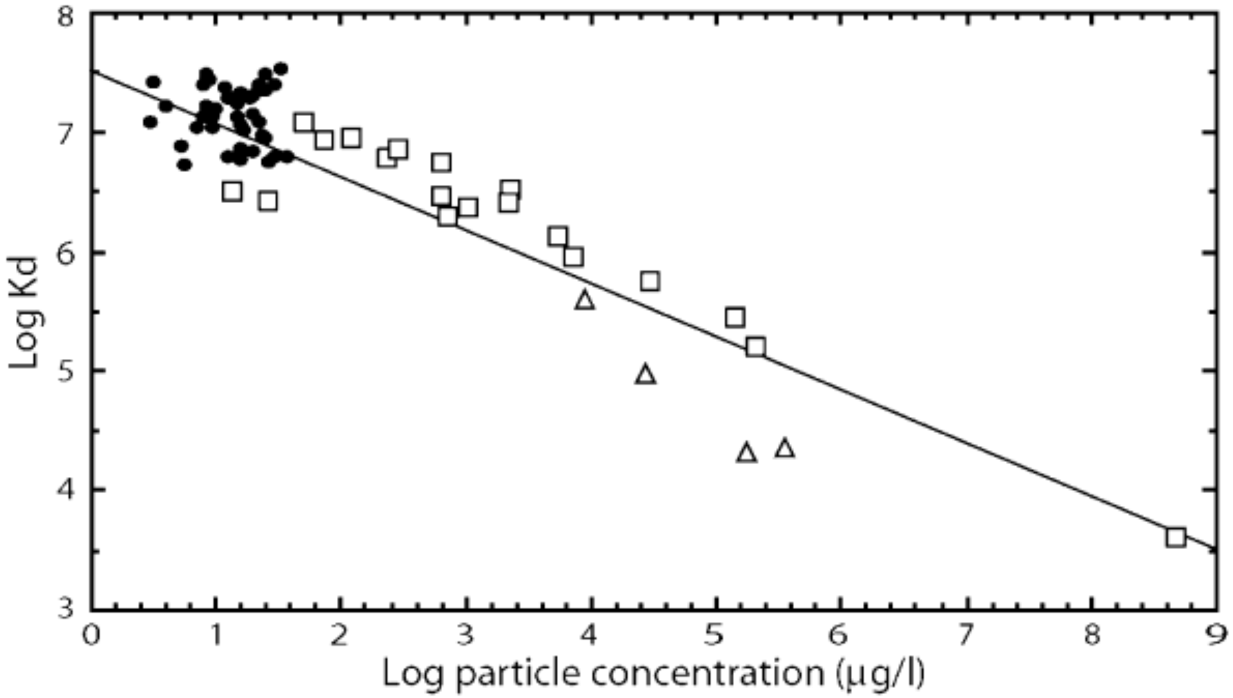
depends of the particle composition

$$K = \frac{mass\ of\ particulate\ tracer\ per\ volume\ of\ seawater}{mass\ of\ dissolved\ tracer\ per\ volume\ of\ seawater}$$

depends of the particle composition
the particle concentration

$$K = K_d \times C_p$$

Particle concentration effect on K_d due to colloids



Honeyman et al., 1988

^{230}Th, ^{234}Th

CaCO$_3$ + Litho

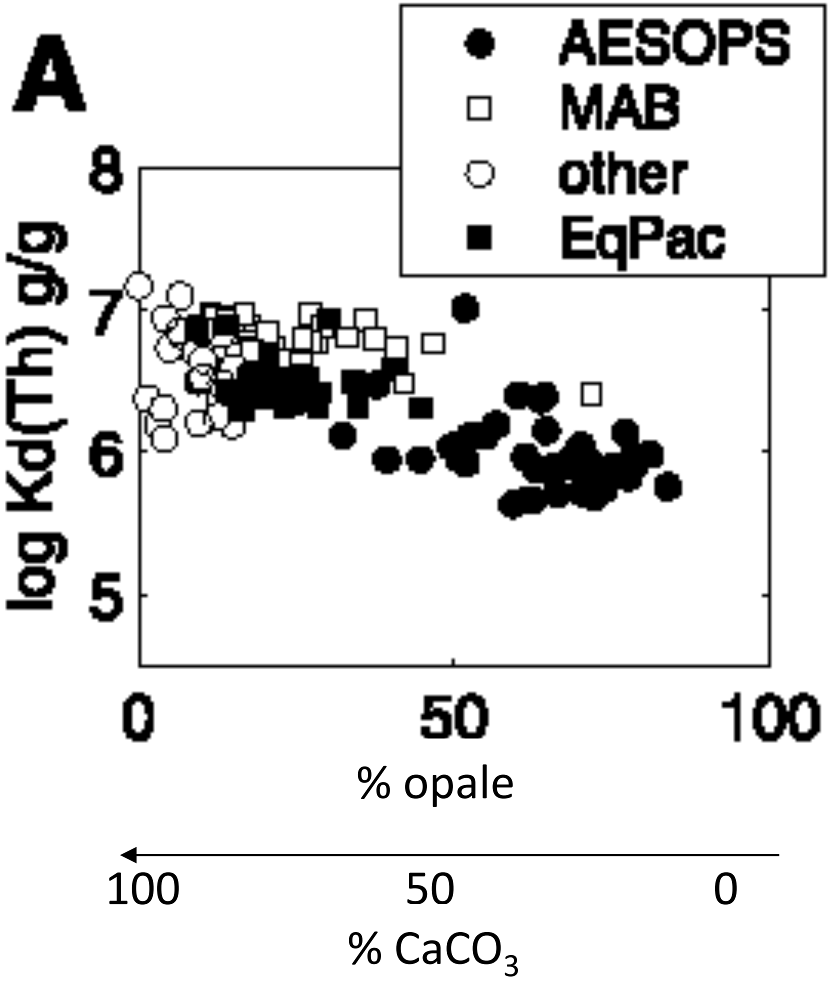
Sediment trap data

Litho →

2002

The influence of particle composition and particle flux on scavenging of Th, Pa and Be in the ocean

Zanna Chase[a,b,*], Robert F. Anderson[a,b], Martin Q. Fleisher[a], Peter W. Kubik[c]



temps

Sediment trap data

CaCO$_3$ + Litho → Litho

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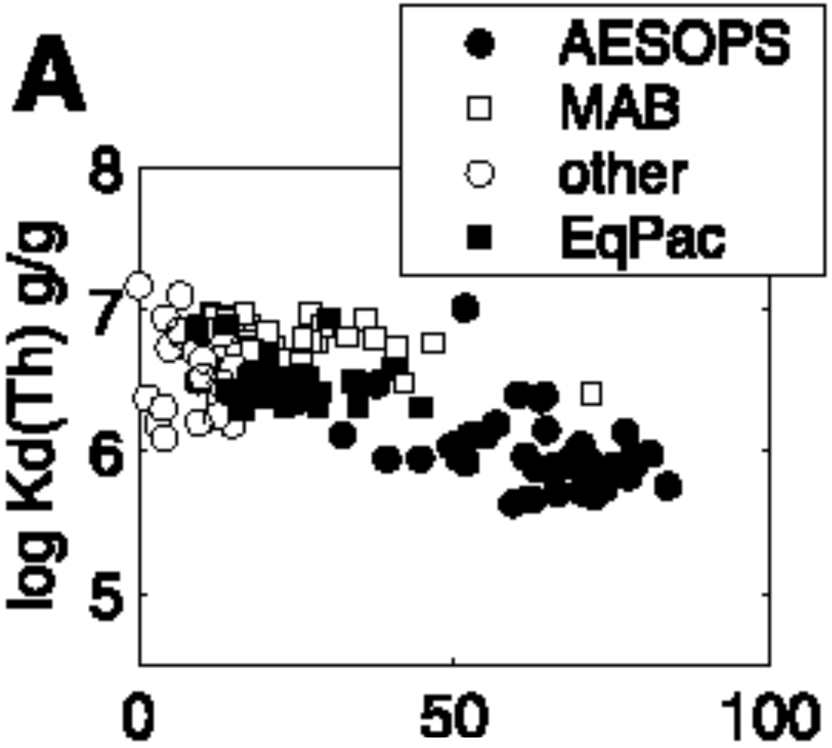
On the importance of opal, carbonate, and lithogenic clays in scavenging and fractionating ^{230}Th, ^{231}Pa and ^{10}Be in the ocean

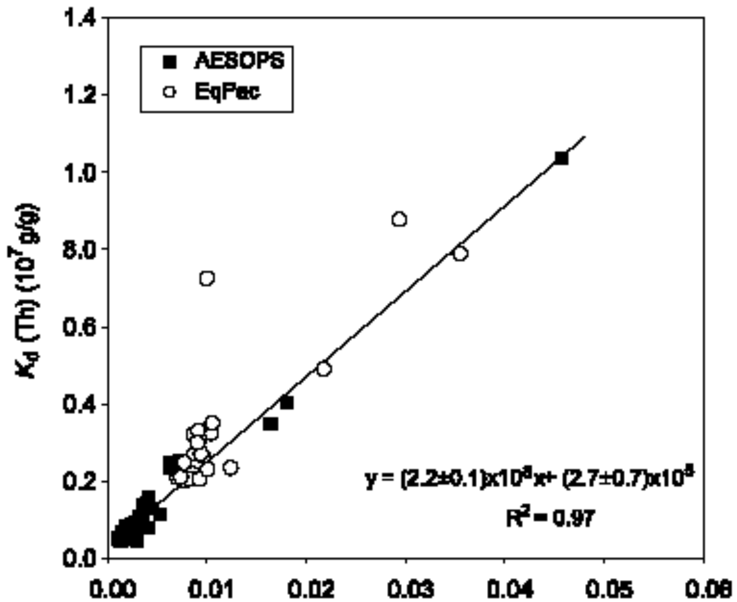
Shangde Luo*, Teh-Lung Ku



% opale

100 50 0

% CaCO$_3$



Fraction litho

Sediment trap data

$CaCO_3$ + Litho

Litho

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$CaCO_3$ + Litho — Litho

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Controversy over the relationship between major components of sediment-trap materials and the bulk distribution coefficients of ^{230}Th, ^{231}Pa, and ^{10}Be

Yuan-Hui Li*

Sediment trap data

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Controversy over the relationship between major components of sediment-trap materials and the bulk distribution coefficients of ^{230}Th, ^{231}Pa, and ^{10}Be

Yuan-Hui Li*

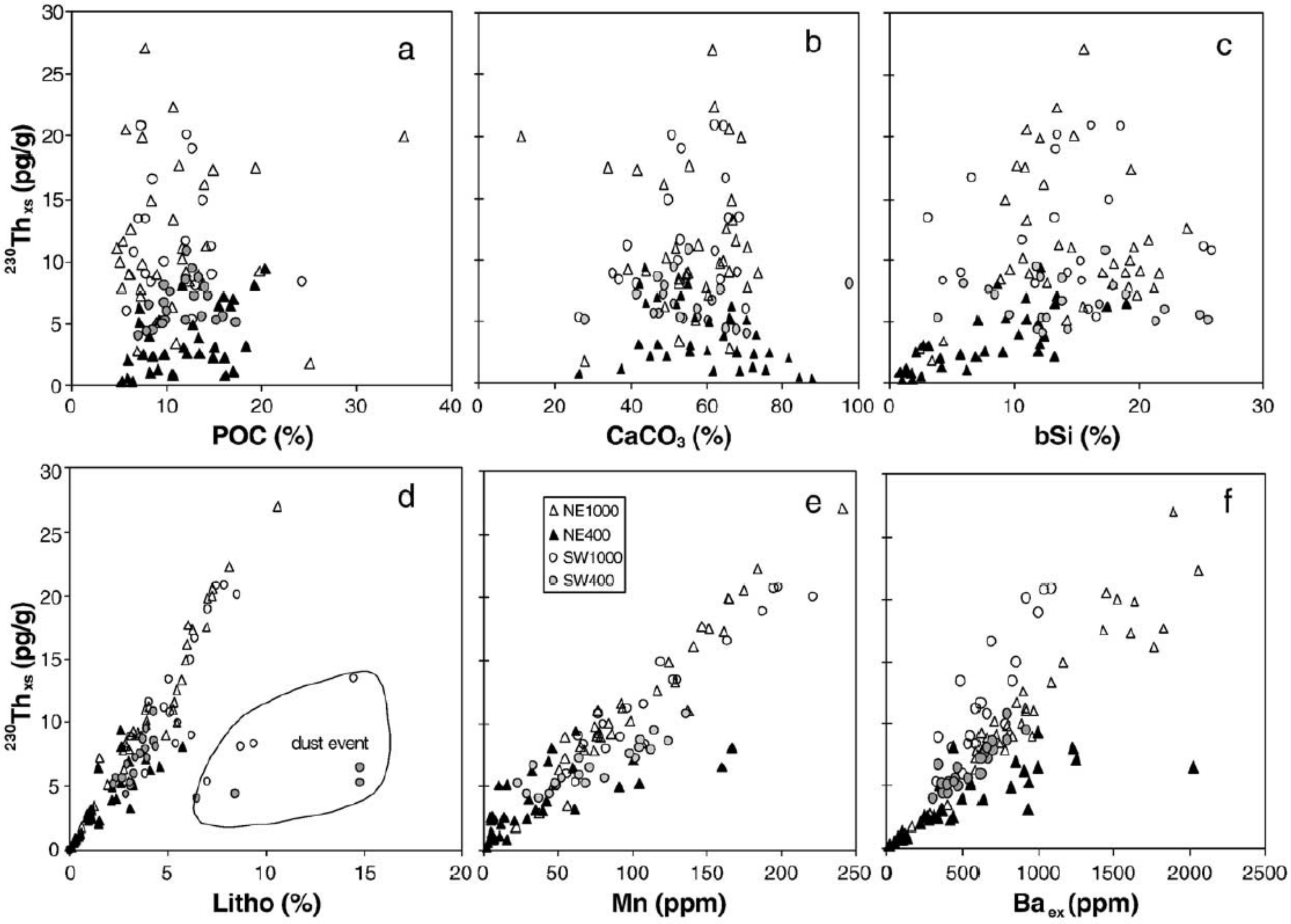
Radionuclide fluxes in the Arabian Sea: the role of particle composition

J.C. Scholten[a,*], J. Fietzke[a,1], A. Mangini[b], P. Stoffers[a], T. Rixen[c], B. Gaye-Haake[d], T. Blanz[e], V. Ramaswamy[f], F. Sirocko[g], H. Schulz[h], V. Ittekkot[c]

The influence of particle composition on thorium scavenging in the NE Atlantic ocean (POMME experiment)

M. Roy-Barman[a,*], C. Jeandel[b], M. Souhaut[b], M. Rutgers van der Loeff[c], I. Voege[c], N. Leblond[d], R. Freydier[e]

Sediment trap data



intercorrelation problem: mixture of large and small particles

How to choose the right phase?

Roy-Barman et al, 2005

Kd (Th)_MnO_2 variability

Partition coefficient of Th between lithogenic particles, MnO_2 and seawater.

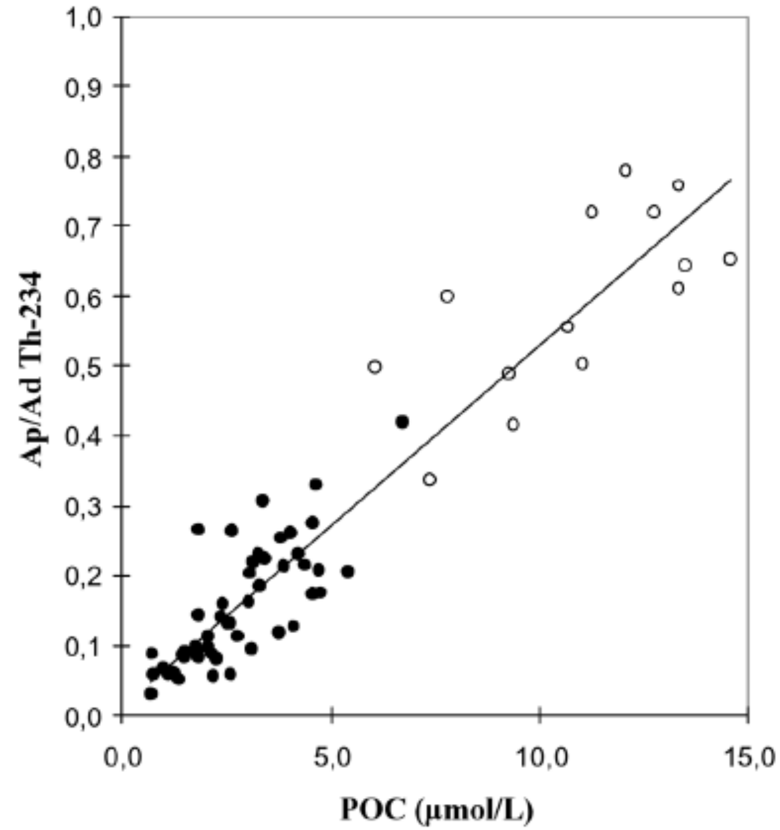
	$K_{d\text{-}litho}^{Th}$ (10^7 ml/g)	$K_{d\text{-}MnO2}^{Th}$ (10^{10} ml/g)
DYFAMED 1000 m, main correlation (this work)	0.8 ± 0.2	1.1 ± 0.4
DYFAMED 1000 m, winter samples (this work)	0.42 ± 0.04	0.6 ± 0.1
Eastern North Atlantic[a]	5	2
Eastern North Atlantic[b]	0.5–10	0.7–4.2
North Atlantic[c]	1	
Equatorial Pacific and Southern Ocean[d]	23	
Equatorial Pacific and Southern Ocean[e]	20	3.5
Panama Basin[f]	2–4	0.6–3.7

K_d varies by a factor 60 6

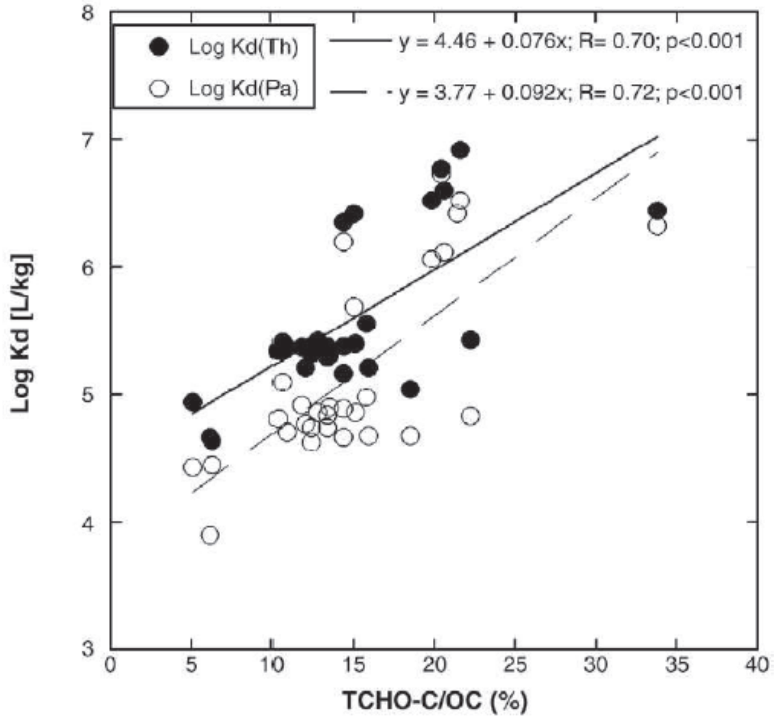
could be used
for modelling

Roy-Barman et al., 2009

What about organic matter?

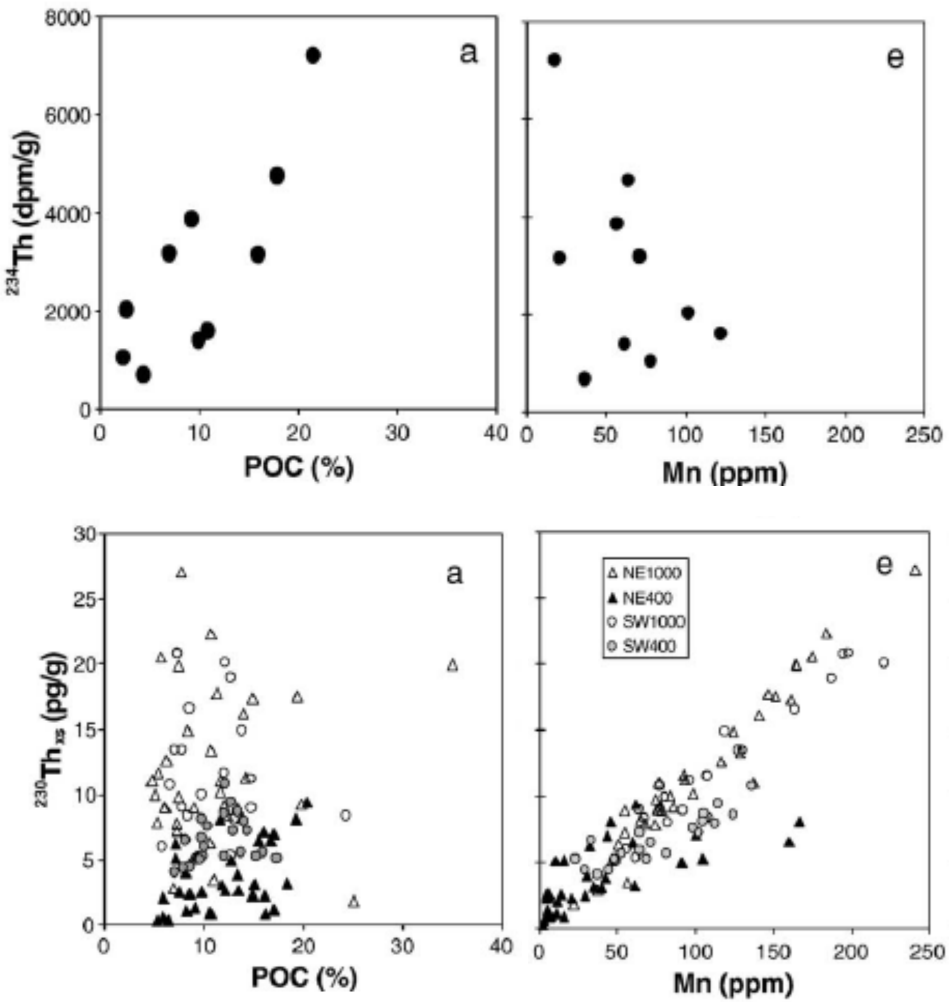


Rutgers van der Loeff et al., 2002



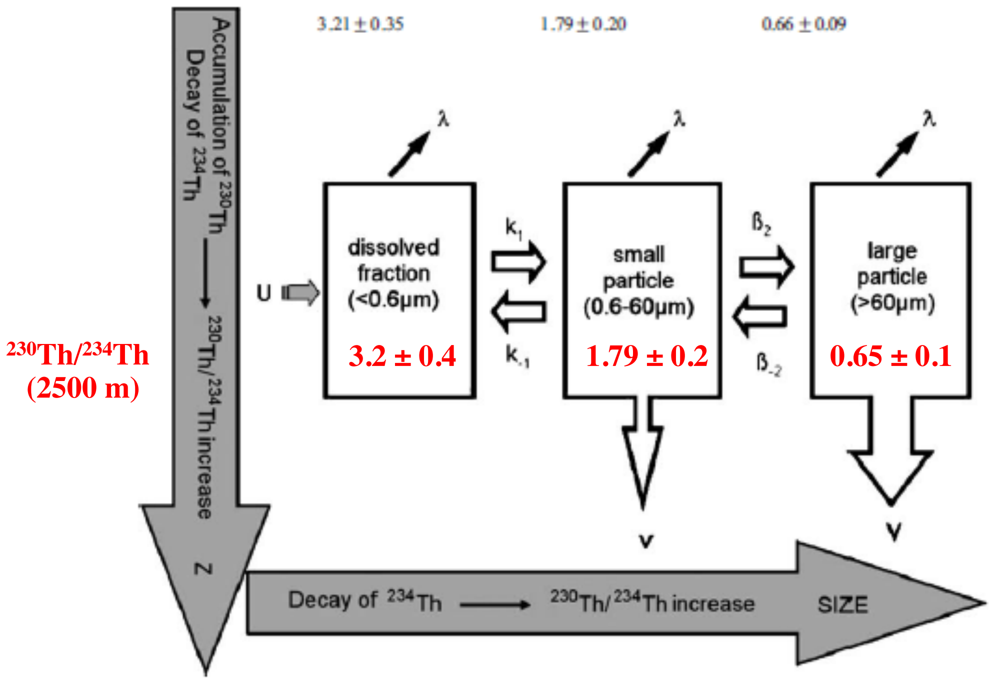
Roberts et al., 2009

Timescale problem?



Roy-Barman et al., 2005

Timescale problem?
equilibrium versus disequilibrium

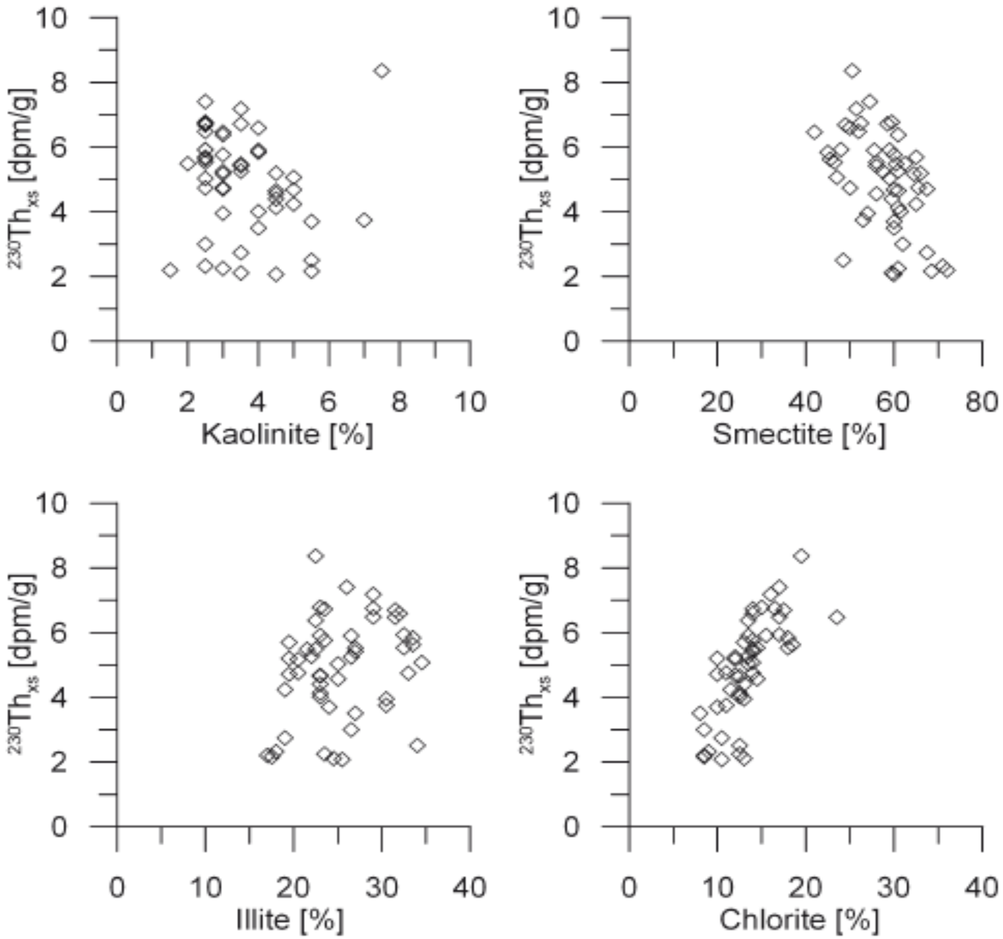


Coppola et al., 2006

But

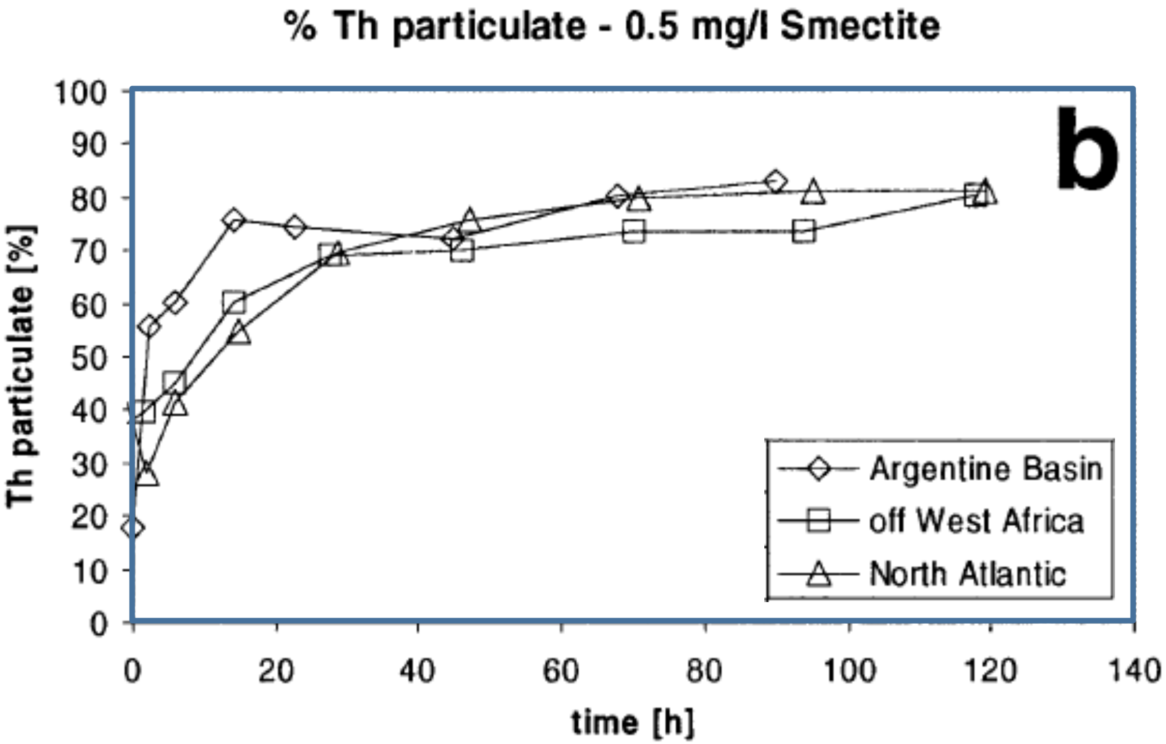
not confirmed by Venchiarutti et al., 2011

Do all phases have the same affinity for ^{230}Th?



Kreshtmer et al., submitted to paleoceanography

Sorption experiment



Geibert et al., 2002

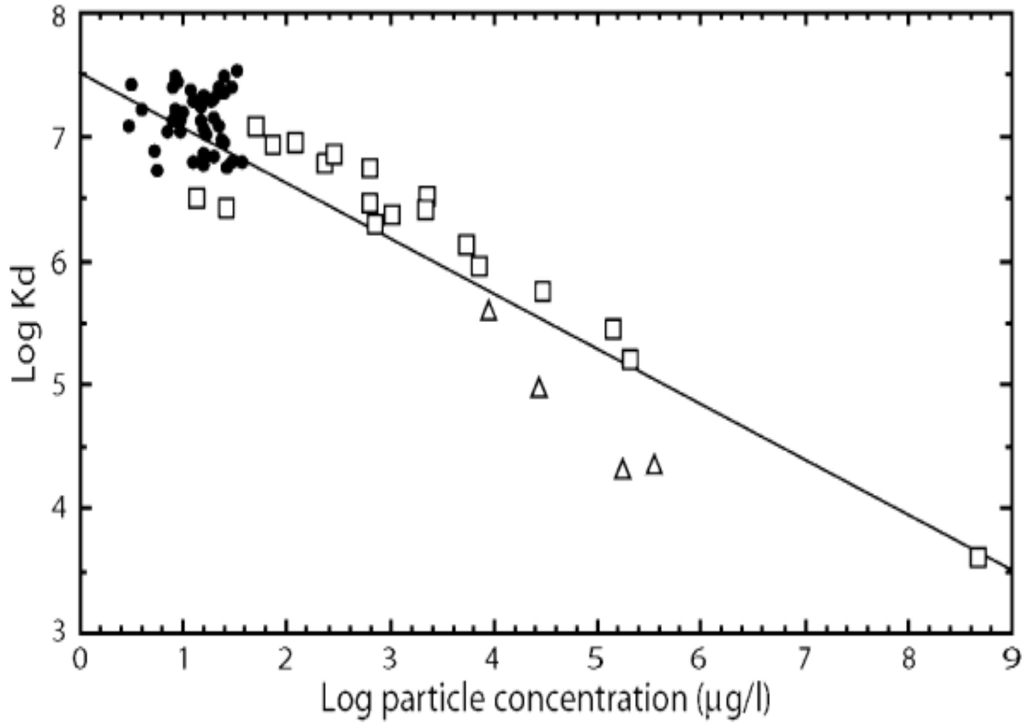
Sorption experiment

Mineral or organic phase	$\log K_d$	References[a]	$-\log C_p$	f_p (predicted)
SiO_2	3–5	1	8	$<10^{-3}$
$CaCO_3$	4–5	2, 3	8	$<10^{-3}$
Al_2O_3/clays	5.6–6.8	4, 8	9	$<10^{-2}$
FeOOH	5.1–5.8	3, 5	9	$<10^{-3}$
MnO_2	4.4–7.6	3, 6, 8	10	$<10^{-2}$
APS-EPS at 100% PS	8	7	8	0.5

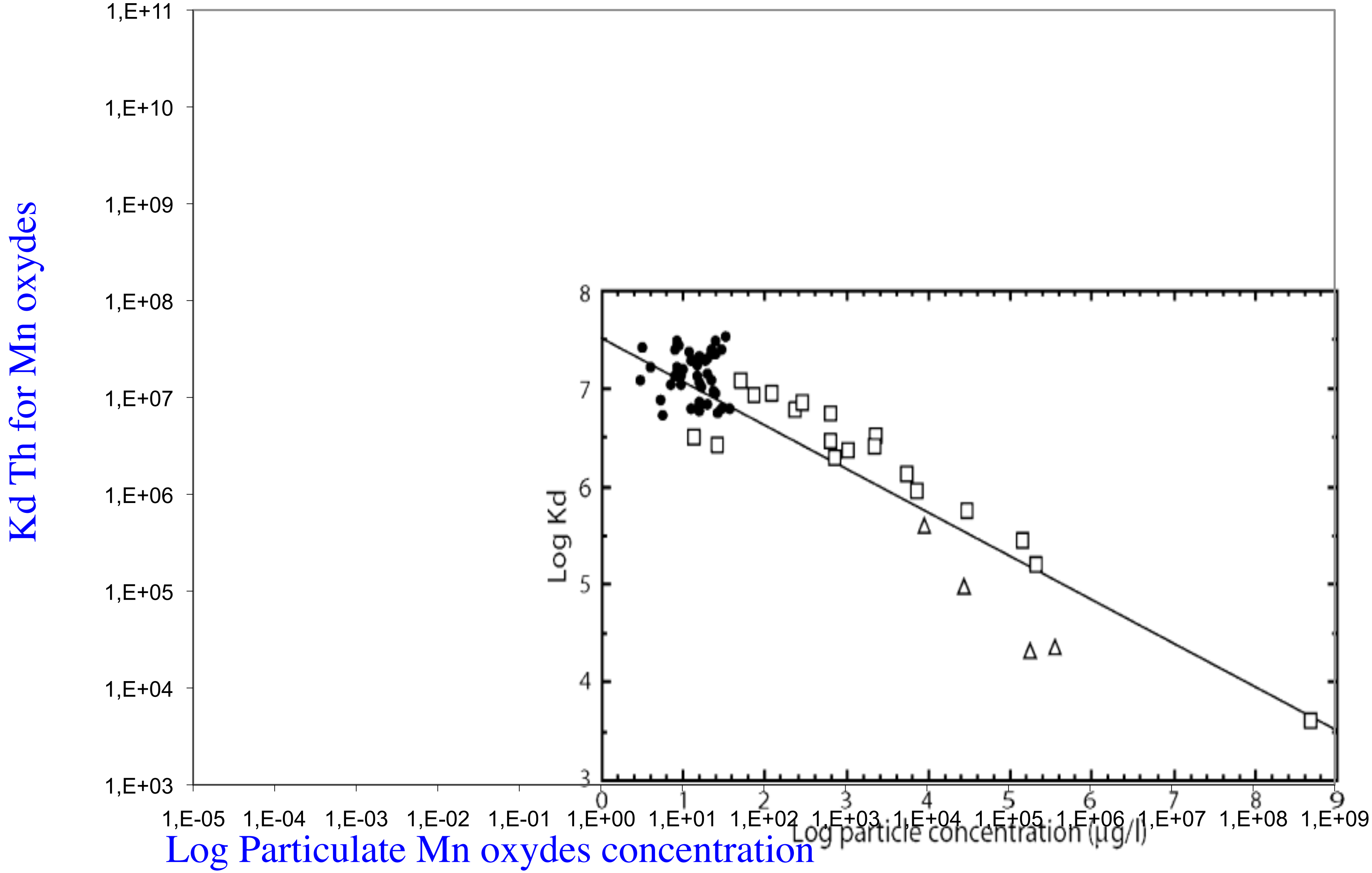
Relatively low affinity of inorganic phases
High affinity for organic matter.

Santchi et al., 2006

Particle concentration effect for sorption experiments of ^{234}Th on Mn oxydes



Particle concentration effect for sorption experiments on Mn oxydes



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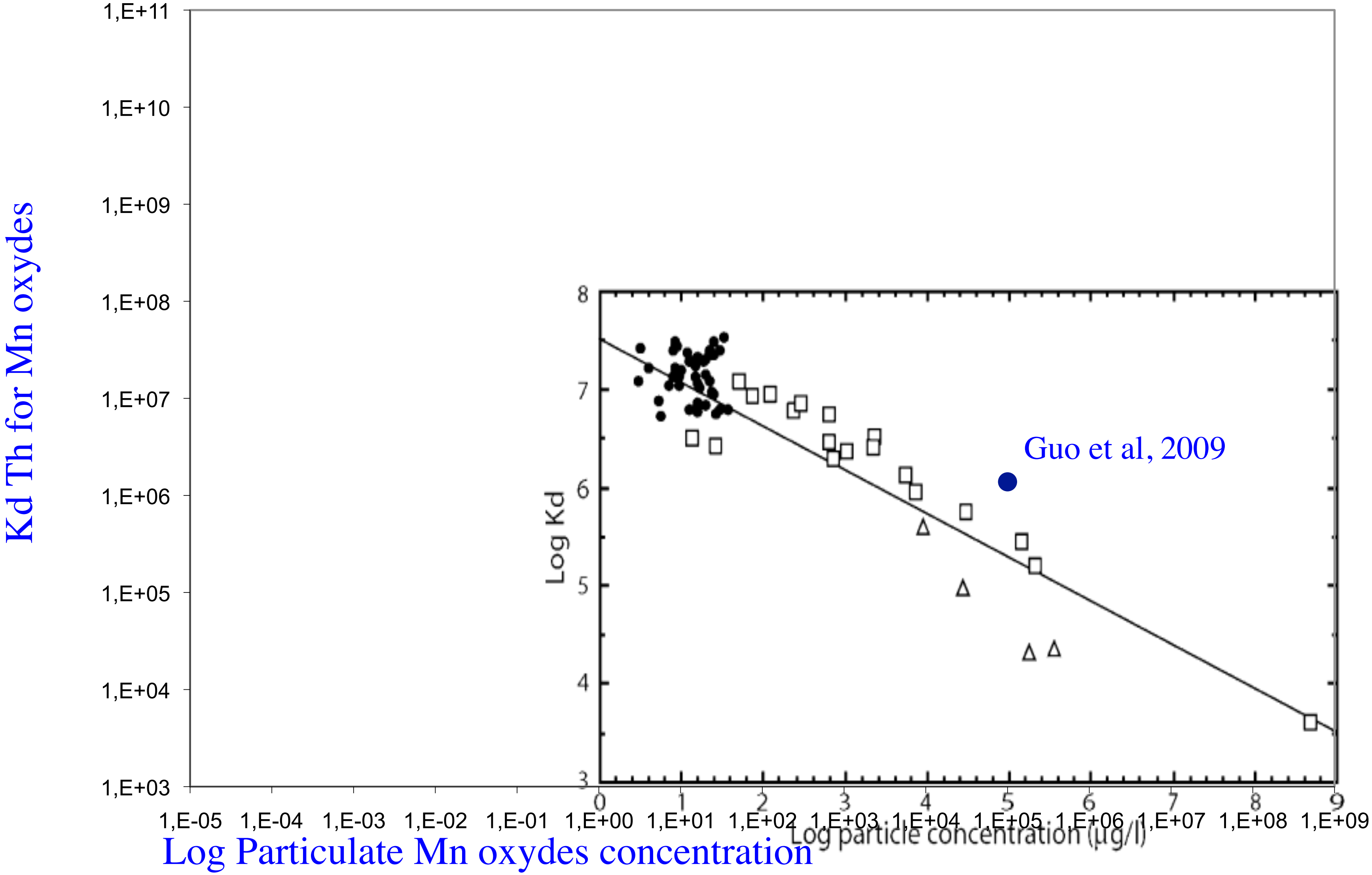

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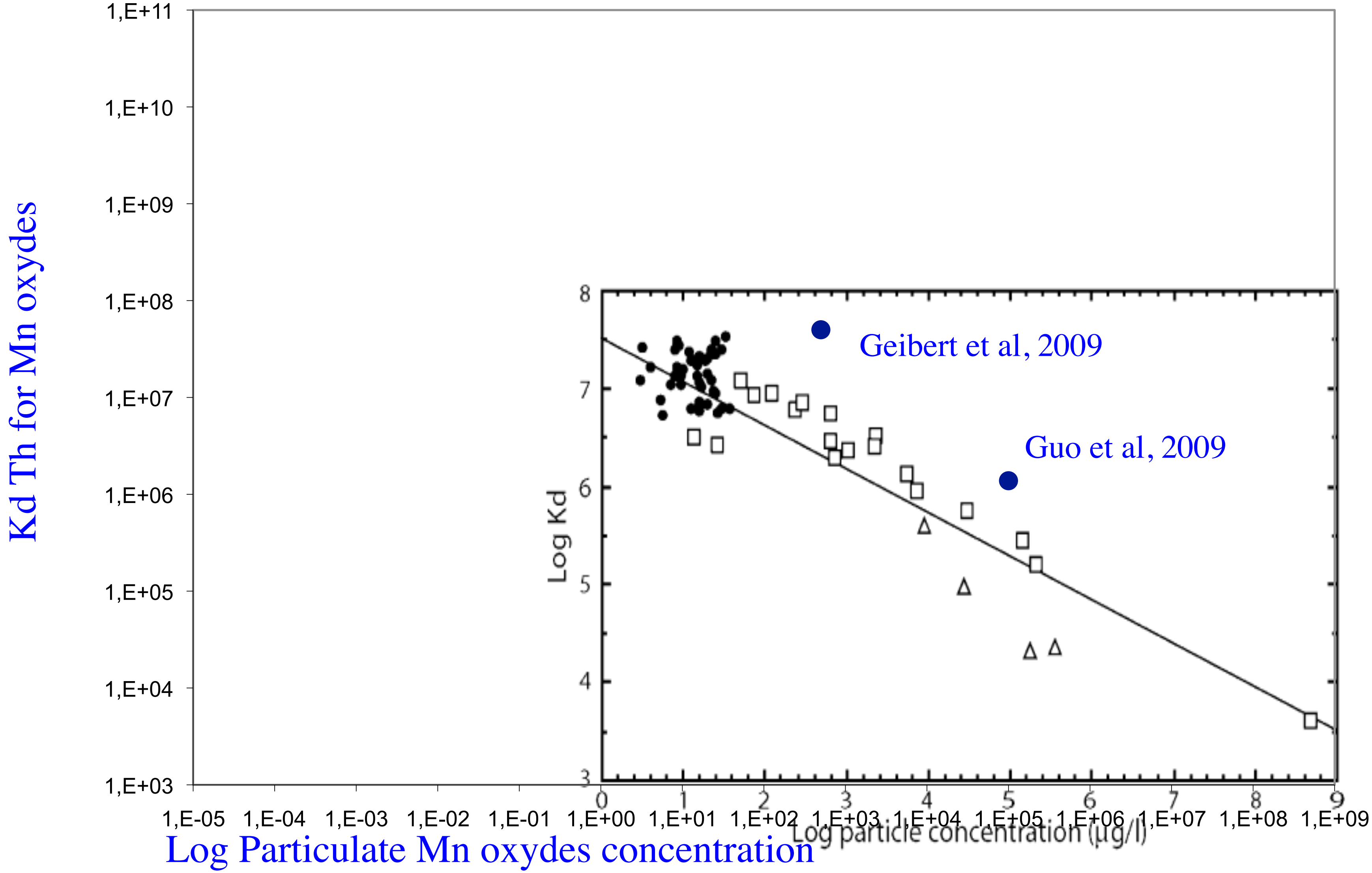

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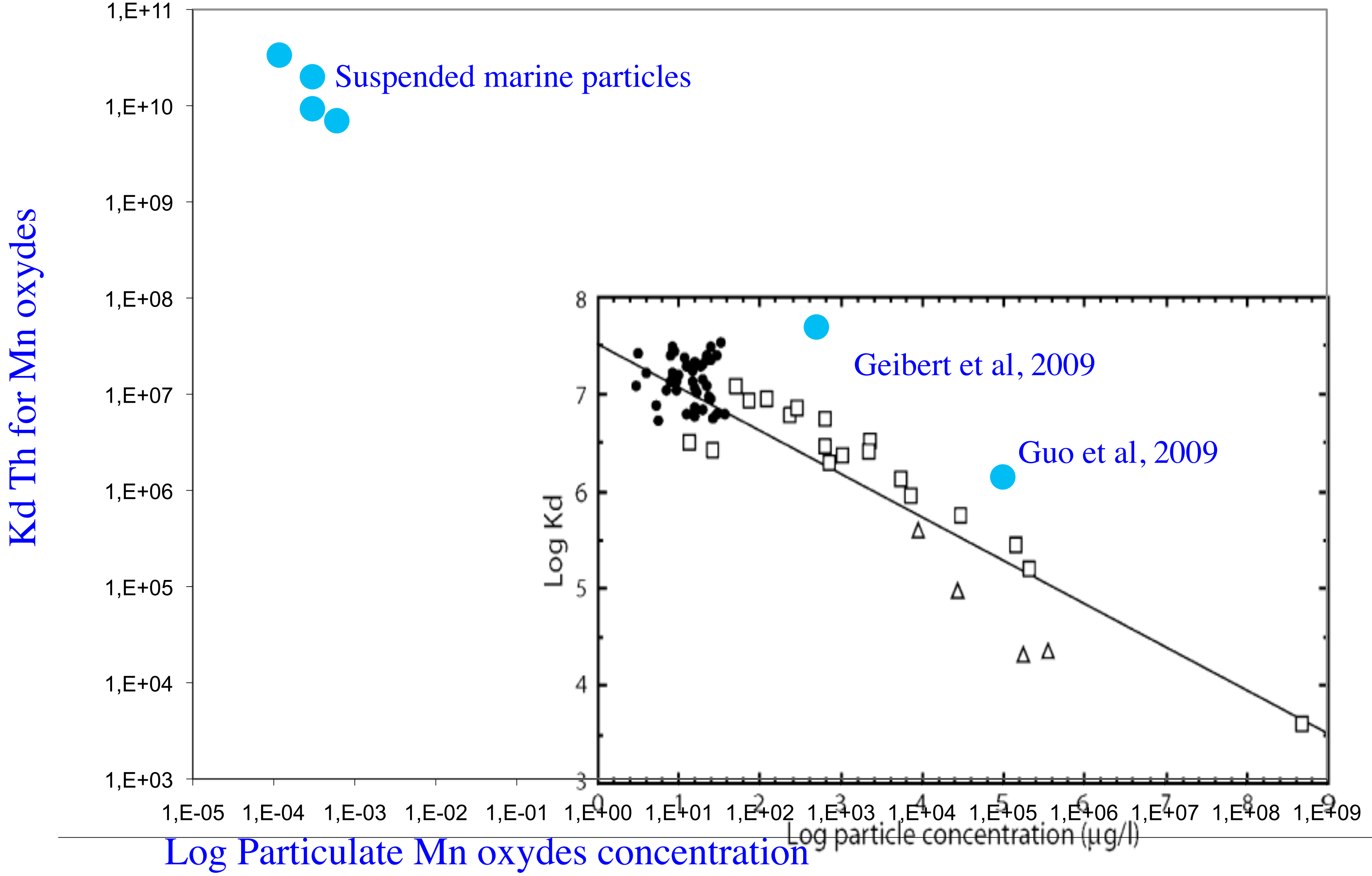

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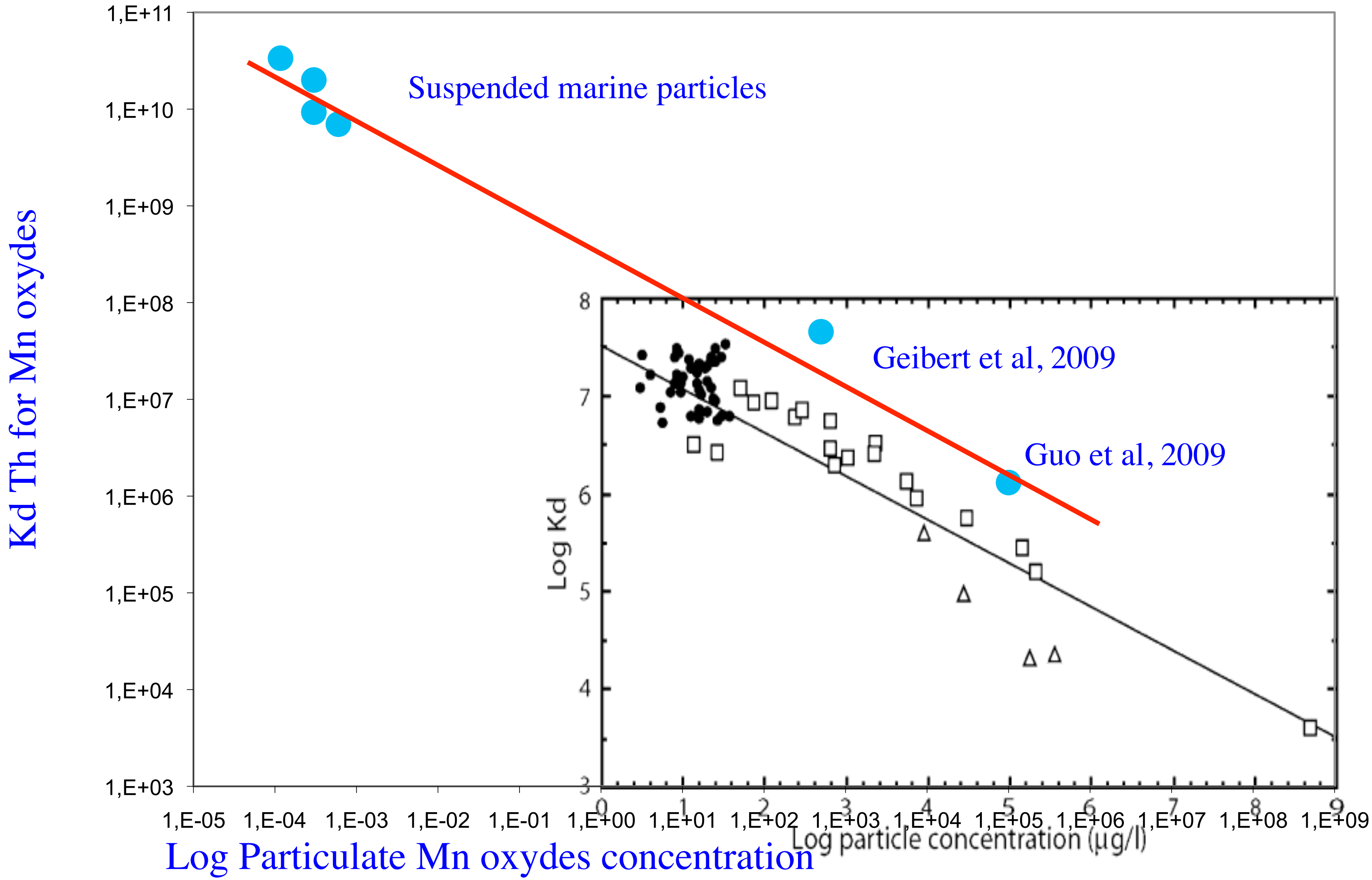
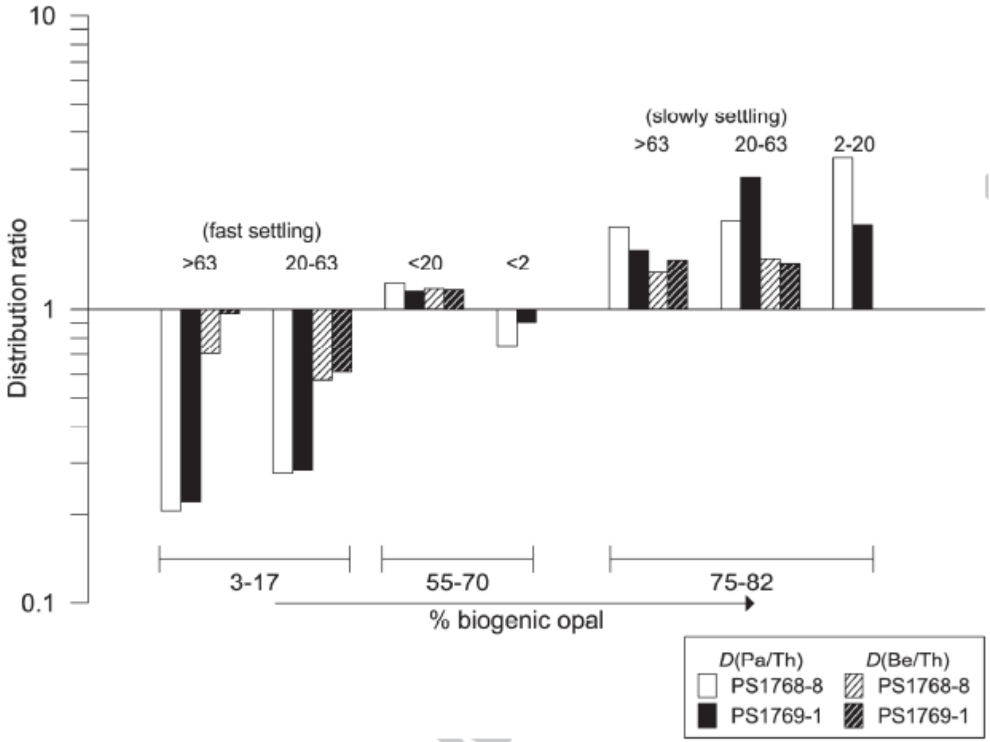
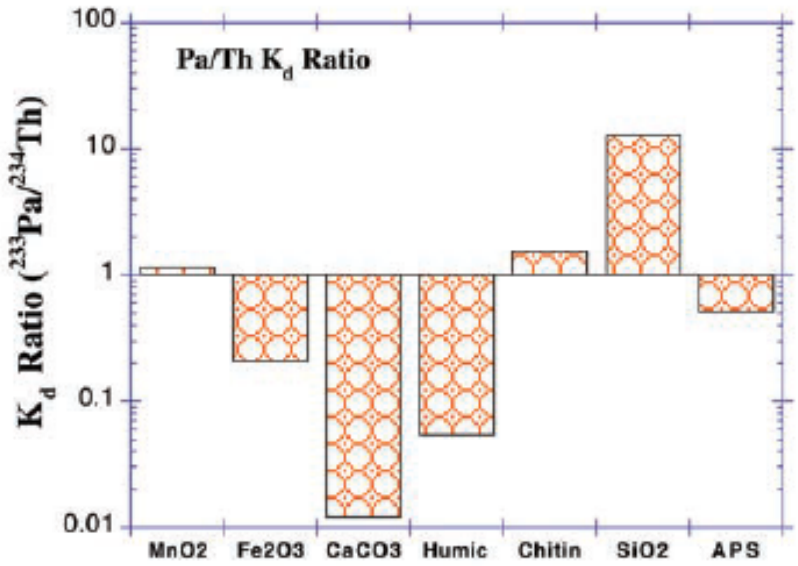


Fractionation coefficient

$$F_{Pa/Th} = K_{d\_Pa} / K_{d\_Th}$$
$$= K_{Pa} / K_{Th}$$



Kretshmer et al., 2011

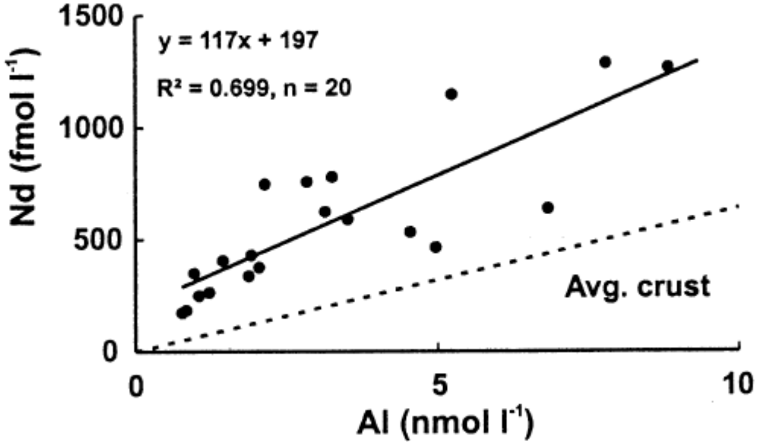


Guo et al., 2002

Neodymium

Determination K_d for Nd: 2 methods

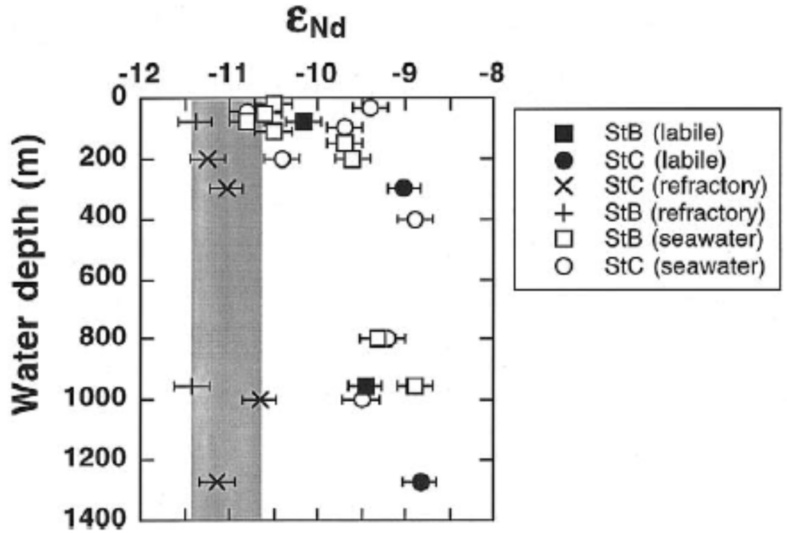
Substracting the lithogenic fraction



$$X_{auth} = 1 - \left(\frac{Al}{REE}\right)_{bulk} \cdot \left(\frac{REE}{Al}\right)_{lith\,2}$$

Kuss et al, 2001

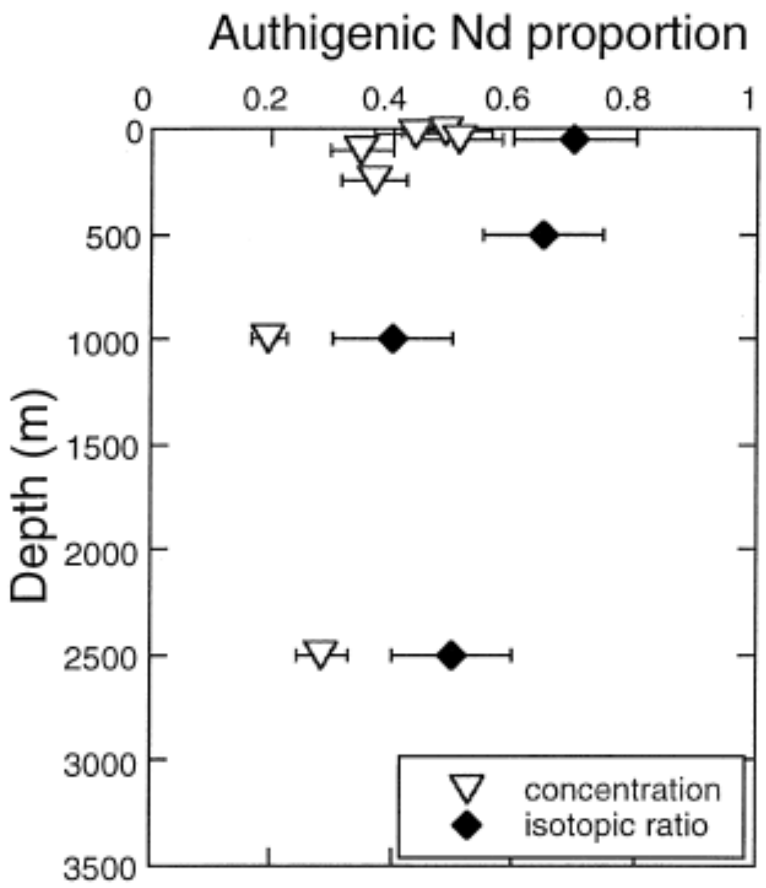
leaching



$$X_{auth} = \frac{(\varepsilon_{Nd})_{bulk} - (\varepsilon_{Nd})_{lith\,2}}{(\varepsilon_{Nd})_{auth} - (\varepsilon_{Nd})_{lith\,2}}$$

Tachikawa et al., 2004

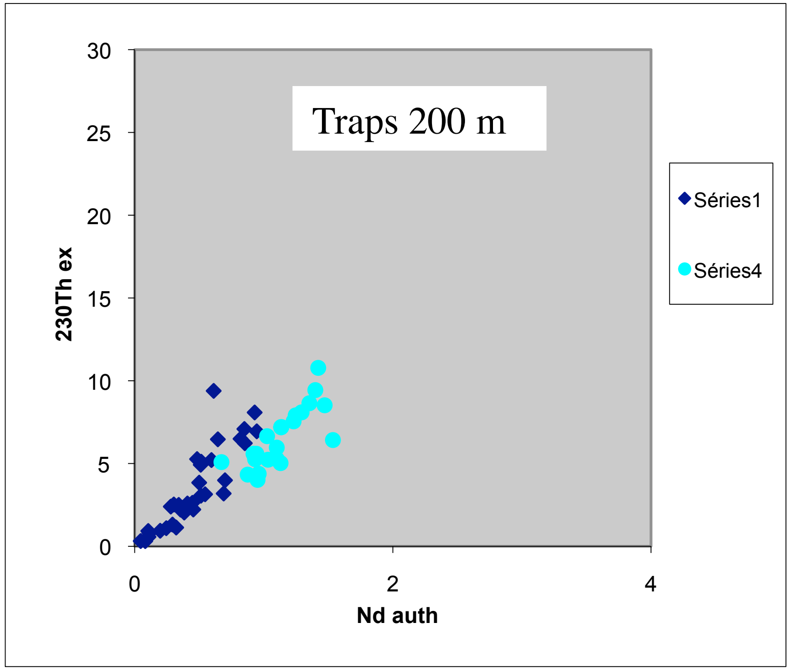
Determination K_d for Nd: Comparison of the 2 methods

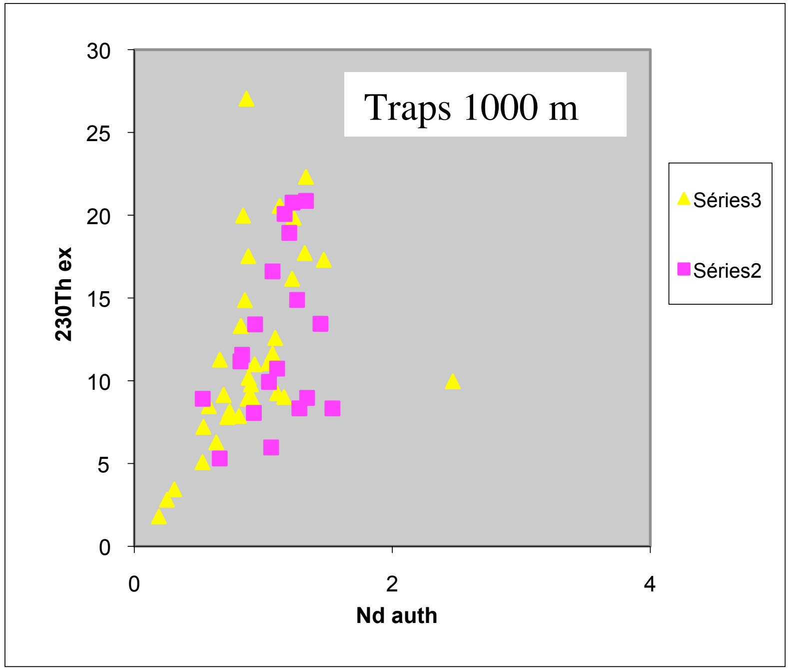


Tachikawa et al., 1999

Do all phases have the same affinity for Nd?

- Low affinity for organic matter (Elderfield, 1981, Fu et al., 2000)
- Similarities with ^{230}Th

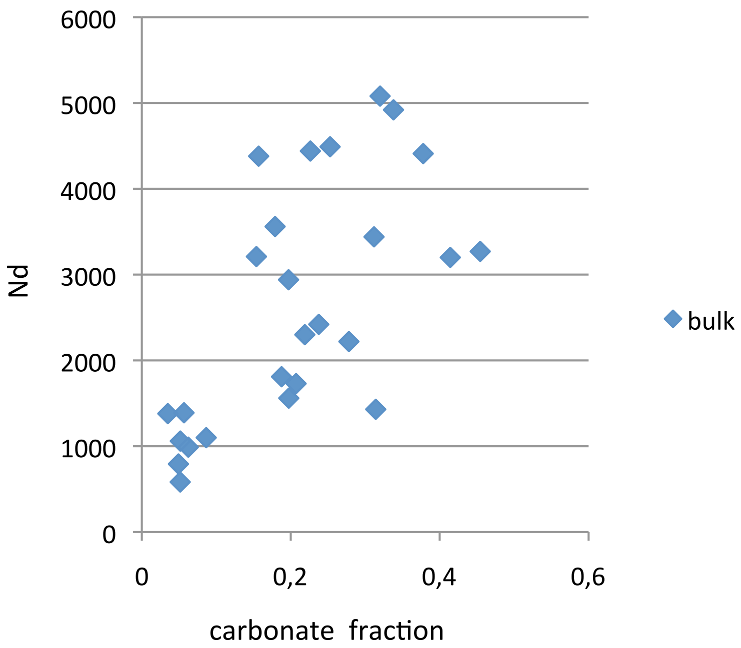


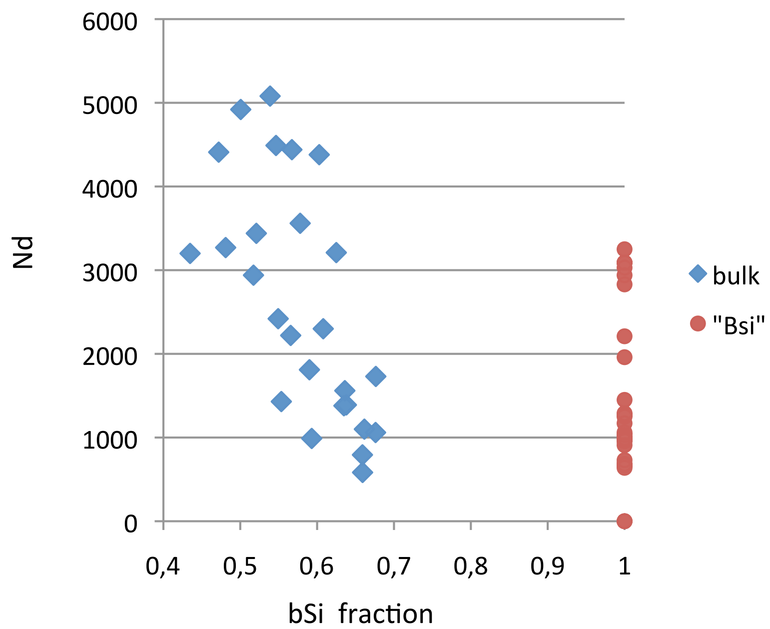


Adapted from Roy-Barman et al., 2005 and Guieu et al., 2004

Determination K_d for Nd: Do all phases have the same affinity for Nd?

Carbonate versus bSi





Akagi et al., 2011

Which phases carry ^{232}Th and Nd?

< 30% lithogenic Th and Nd is carried by accessory phases. The remaining is dispersed in major phases (clays)?

Marchandise et al., in prep.

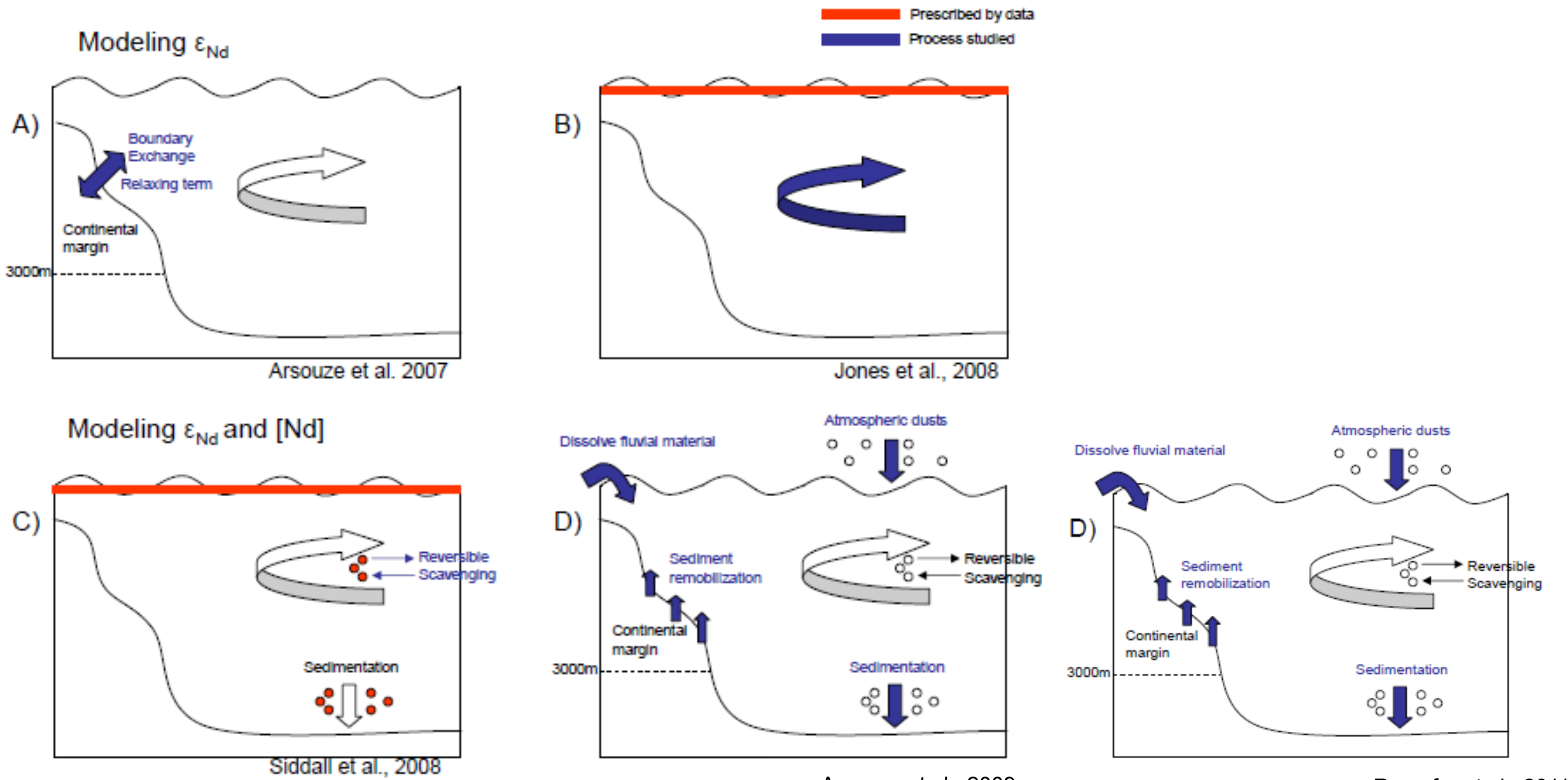
K_d in models

what appears in models
(~30-50 m/y)

$$\frac{d[\text{tracer}]_{total}}{dt} = \text{Source} - \frac{d(\overbrace{S \times \mathbf{K_d} \times \mathbf{C_p}}\,[\text{tracer}]_{\mathbf{d}})}{dt}$$

Nd modeling: the role of particles

No particles



Arsouze et al., 2009

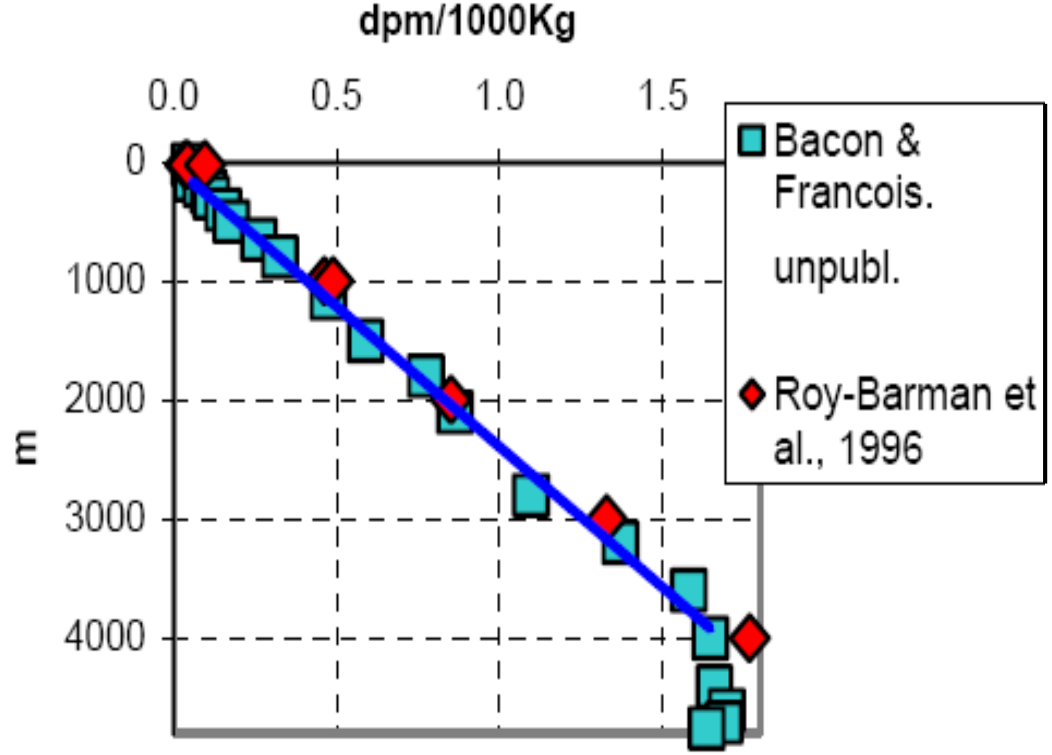
Rempfer et al., 2011

Oka et al., 2009

Particles composition	**bSi/CaCO$_3$/litho**	**OM/litho**	**no**
Boundary imput	**No**	**yes**	**yes**

Adapted from Arsouze et al., 2009

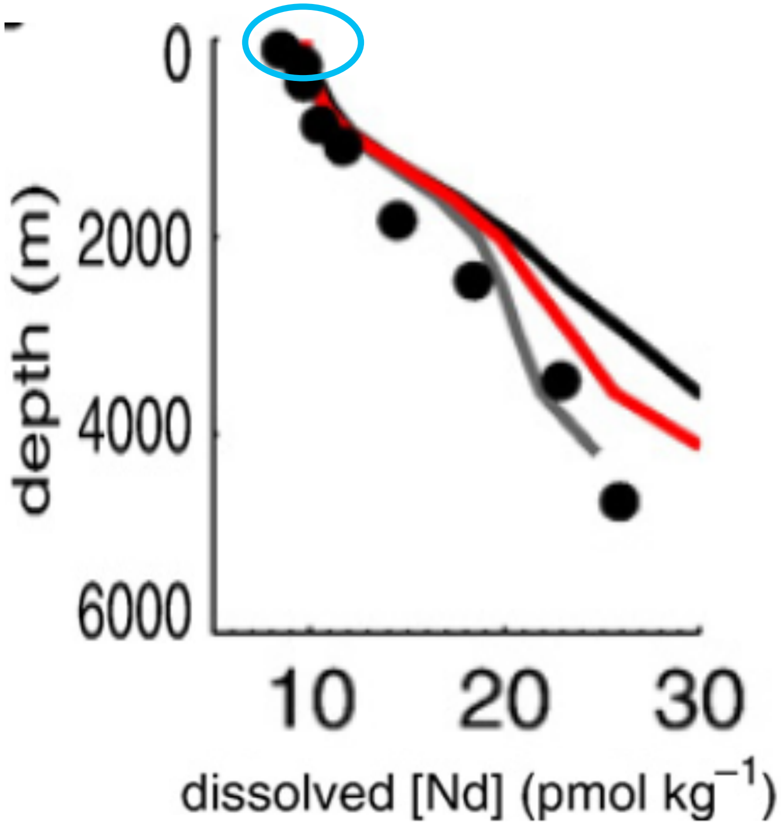
^{230}Th argues against strong change of the Th bearing phase flux



^{230}Th and Nd are correlated so Nd bearing phases cannot be strongly dissolved.

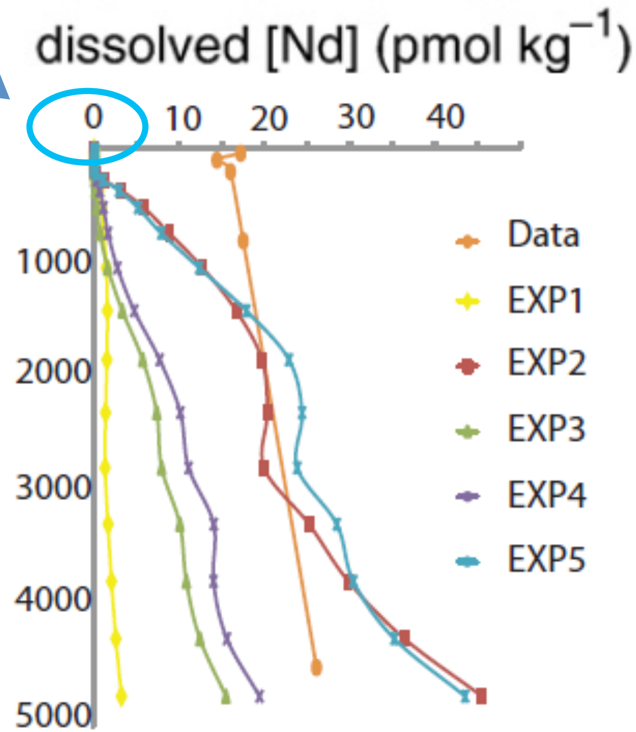
Nd modeling: the role of particles

Forced value



Sidall et al., 2008

Reversible scavenging effect



Arsouze et al., 2009

Conclusions and recommandations

- **Obtaining K_d from suspended particles**
  → Complete analysis of the suspended particles (including major phases!!)
  → Difficulties to measure small ^{230}Th quantities (intercalibration)

- **Better caracterisation of the particles**

  → Complete analysis of the particles
  → phases constituting the particles
  → profils/sections of carbonate, bSi, POC…

- **Equilibrium versus adsorption/desorption model**
  → Th based estimation of k_1 and k_{-1}
  → Ambiguity with mixed layer depth