Iron solubility during dust transport : Role of mineralogy

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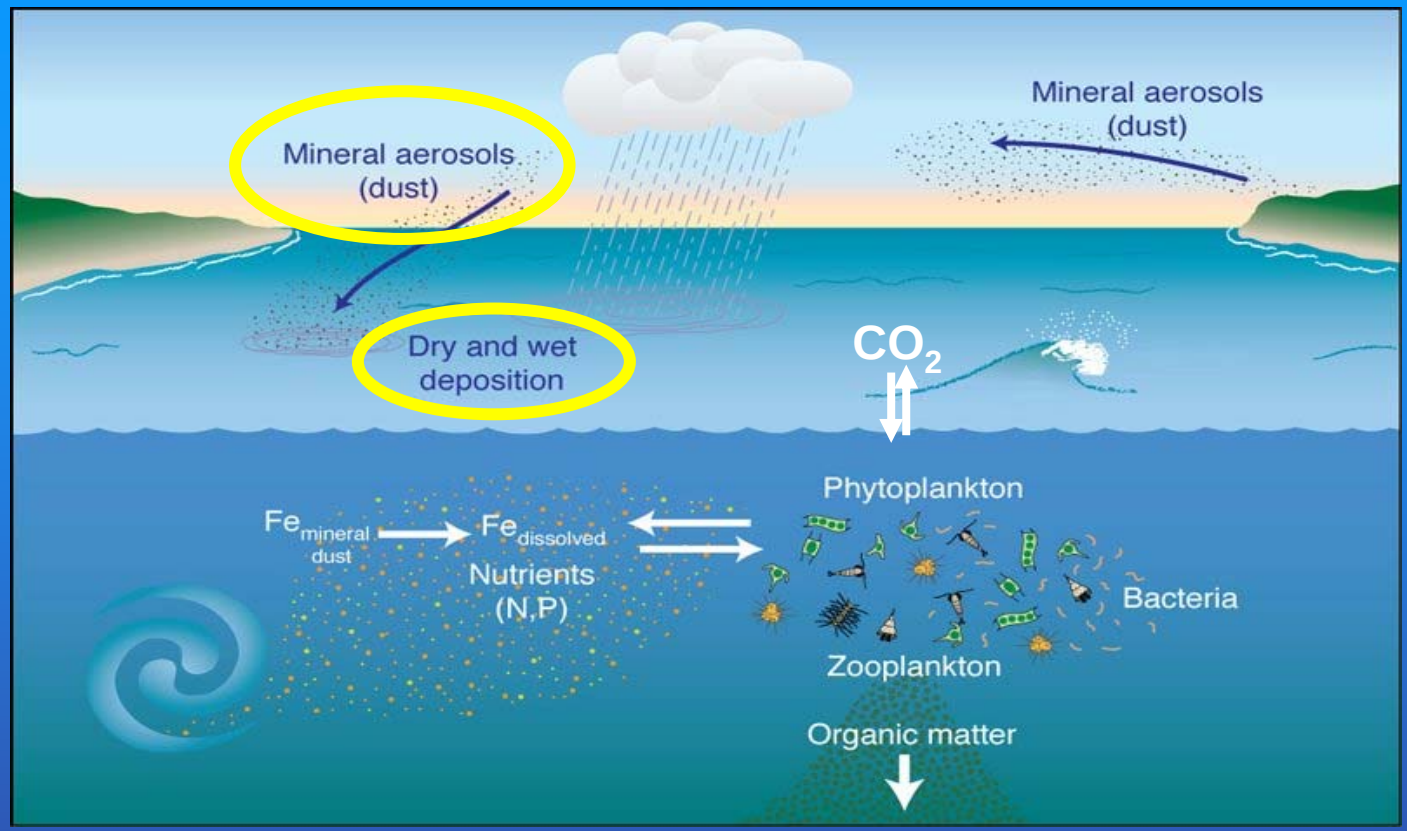
Dust, Iron and climate



Dust input to surface ocean → ✓ **Iron supply** ✓ **Fertilisation**

Uncertainties :

The extent to which the iron dust fluxes are bioavailable,

i.e. soluble in seawater

Iron solubility : 0,01-80%

(Mahowald et al., 2005)

- **chemicals processes**

Photochemistry, cloud processes, organic complexation, …. (Hand et al., 2004; Desboeufs et al., 2001, Jickells et al, 2001)

- **Physicals processes**

Size splitting up by sedimentation (Baker et al., 2006)

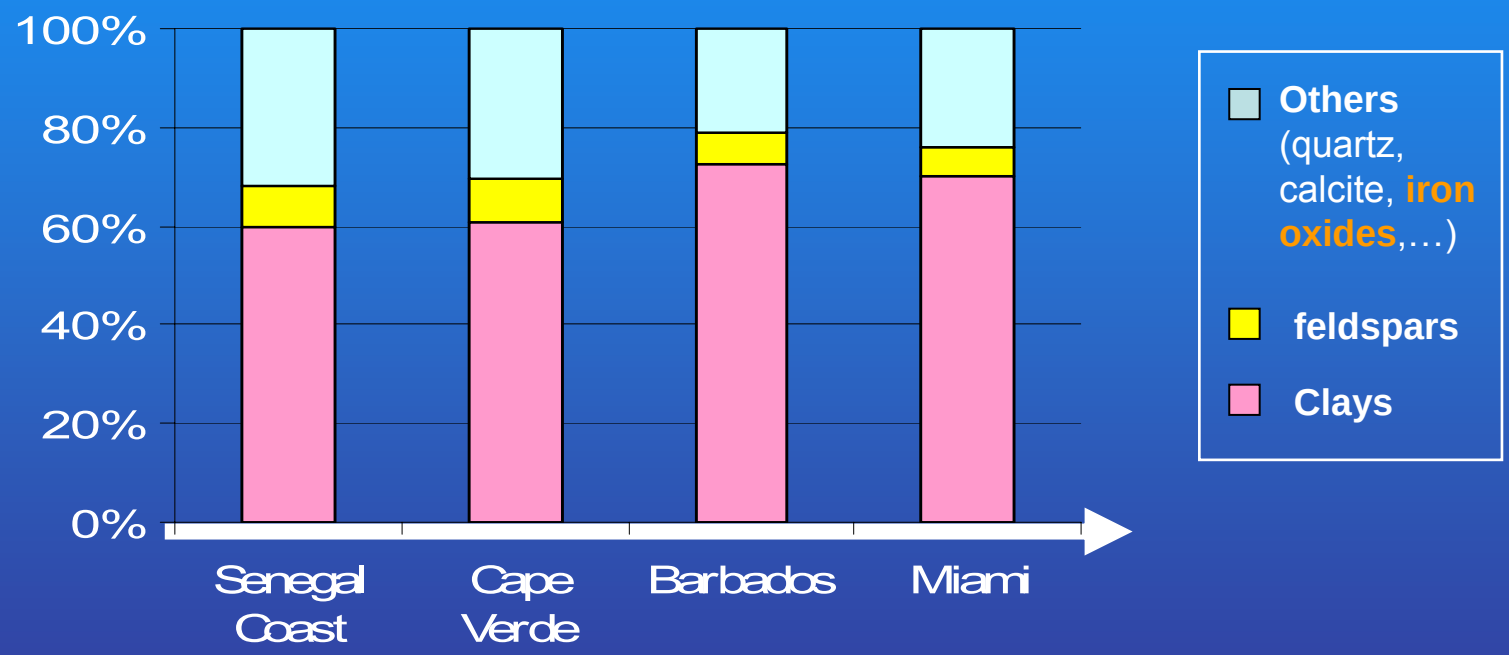
→ **Modification of the mineralogical compostion of dust** (Johnson et al, 1976; Glaccum et al., al 1984)

? What is the link between mineralogical composition and iron solubility?

An example : sedimentation process effect

Mineralogical composition of Saharan dust collected between Senegal Coast and Miami

(Glacum et Prospero, 1980; Johnson *et al.*, 1986)



Relative clay content increases with distance from the source.

It is due to a preferential sedimentation of coarse particles (quartz)

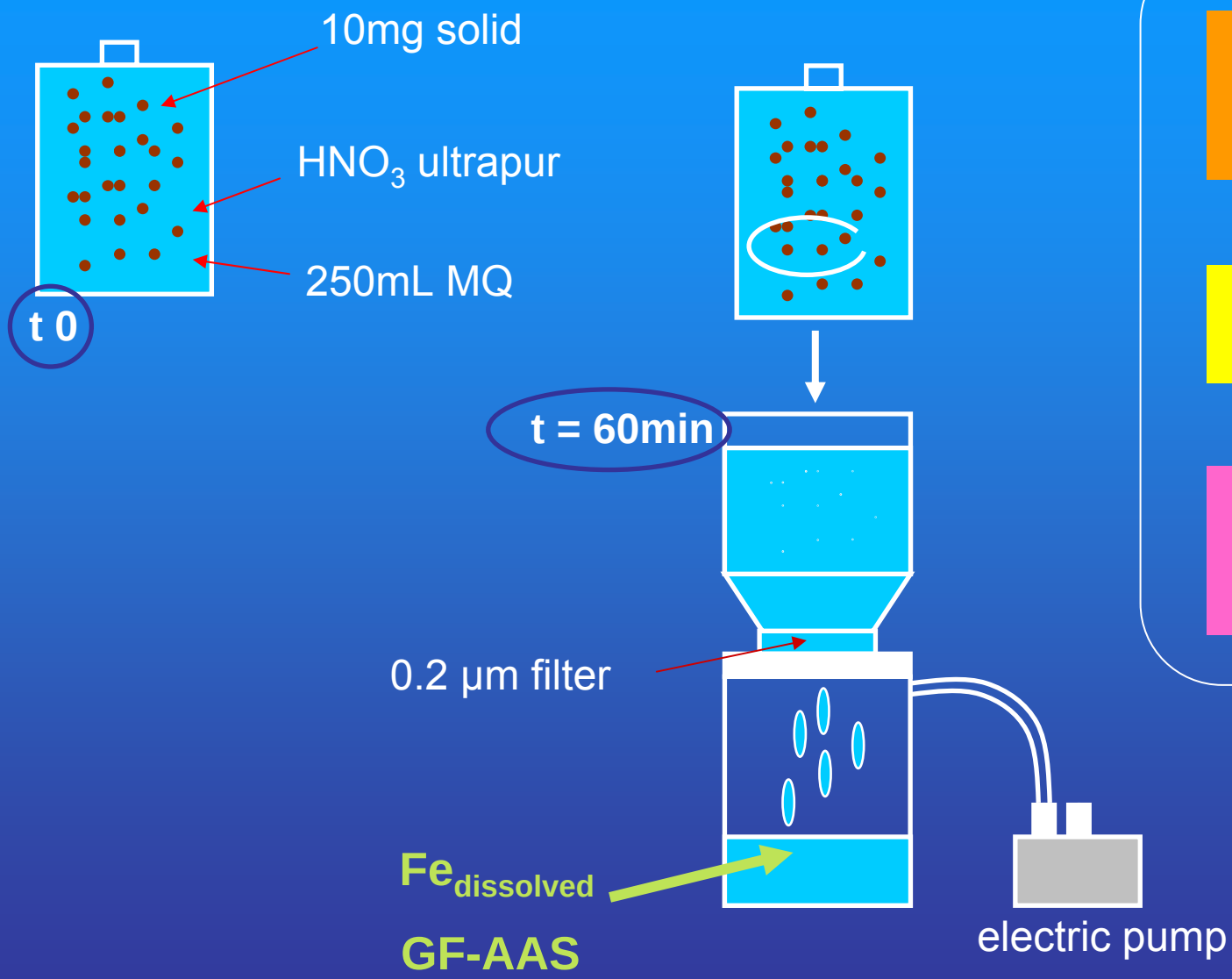
Iron and mineralogy in dust

Iron oxides & hydroxides are considered to be the main supplier of iron in dust due to their large iron content

Fan *et al.*, 2006; Meskhine *et al.*, 2005

But what are the minerals which release more dissolved iron in atmospheric water and in seawater?

Dissolution experiments



(hydr-)oxides

Hematite
Magnetite
Goethite

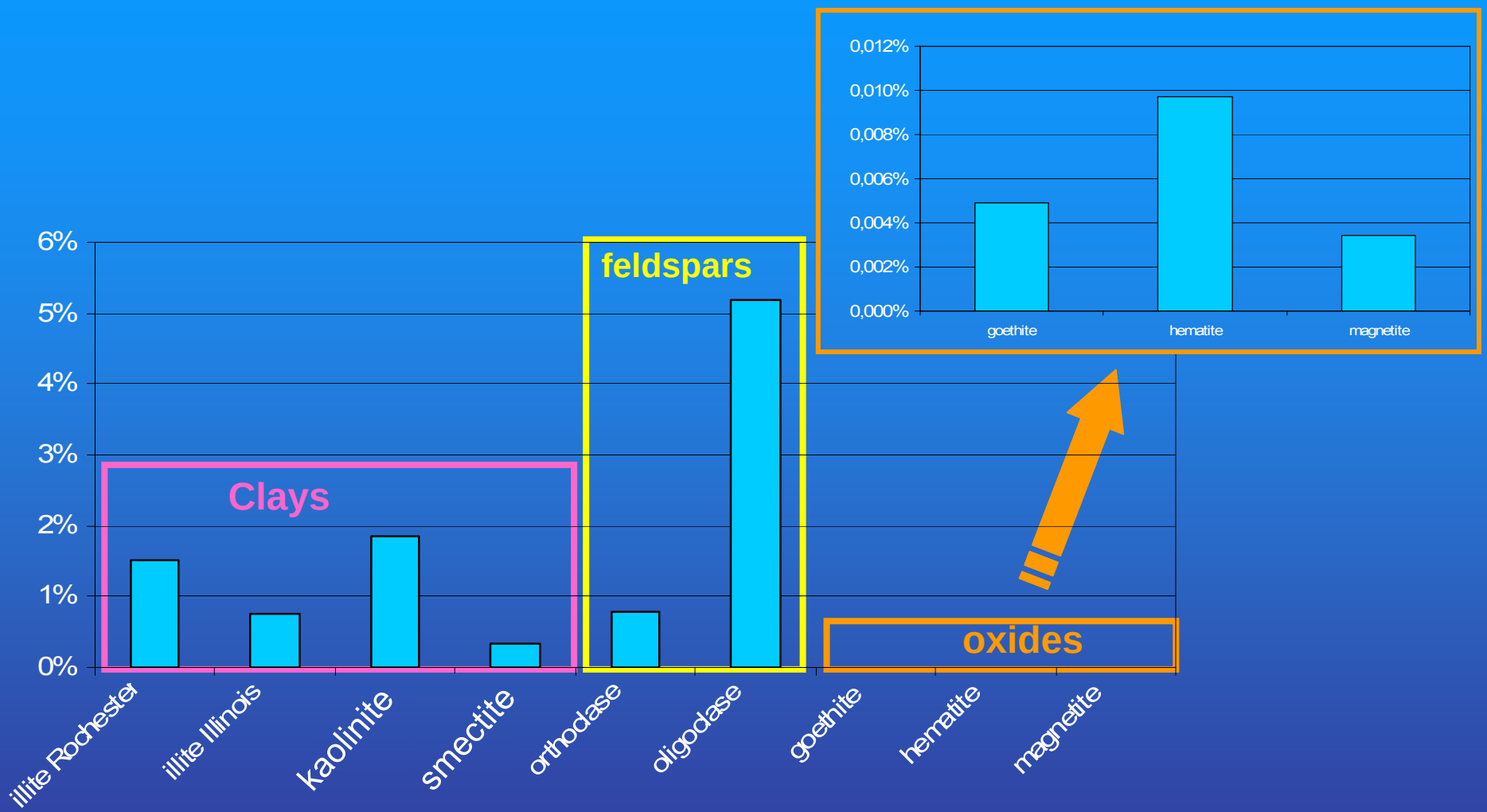
Feldspars

Oligoclase
Orthoclase

Clays

Illites
Kaolinites
Smectites

Dissolved Iron fraction (DIF)

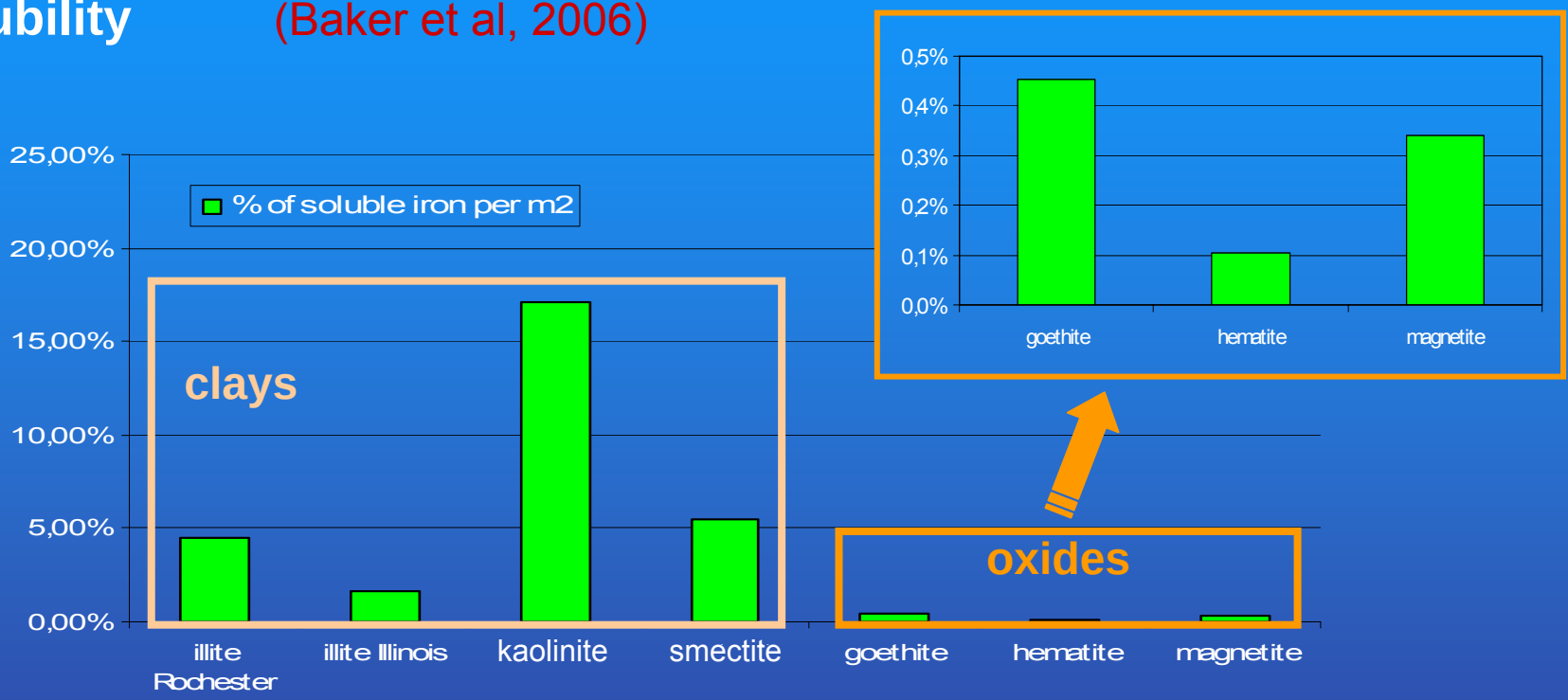


Iron solubility is more efficient for alumino-silicates (feldspars+clays) than for oxides

Specific surface effect

Specific surface by BET method for clays and oxides

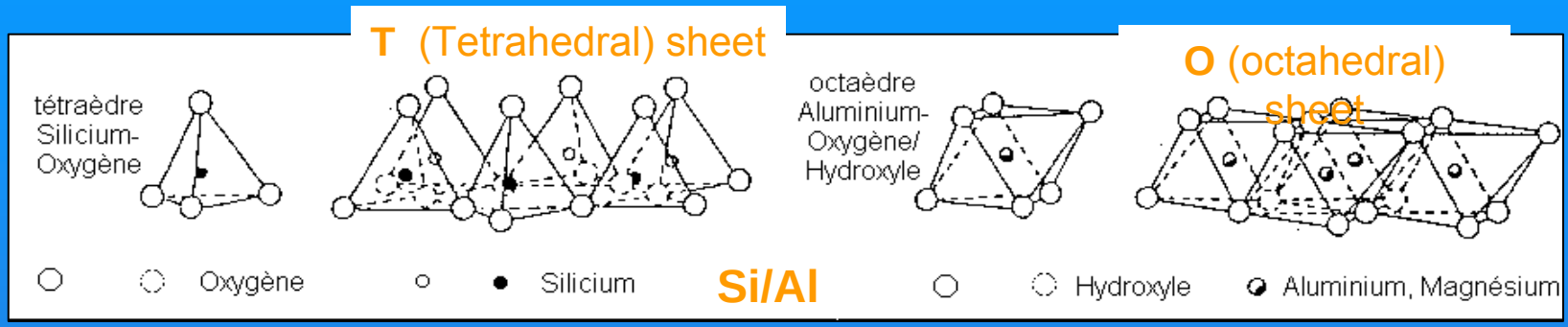
➢ **specific surface = factor influencing solubility** (Baker et al, 2006)

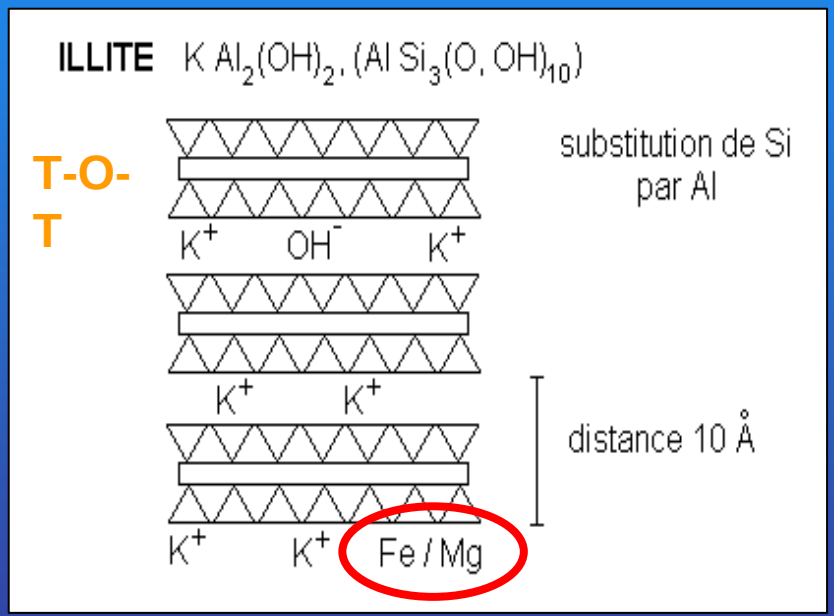


- **Iron dissolution process is more important for clays than for oxides**
- **Globally, specific surface variations between minerals cannot explain the large differences of solubility between clays and oxides**

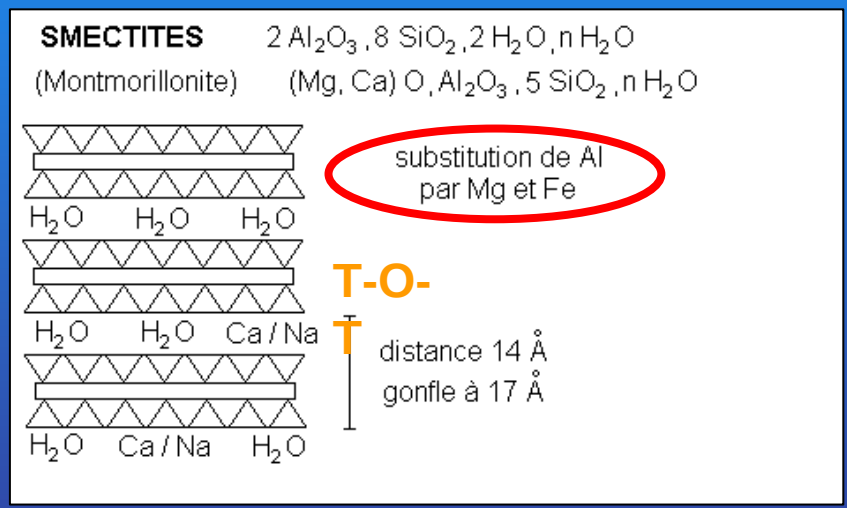
Different minerals = Different iron states

alumino-silicates structures





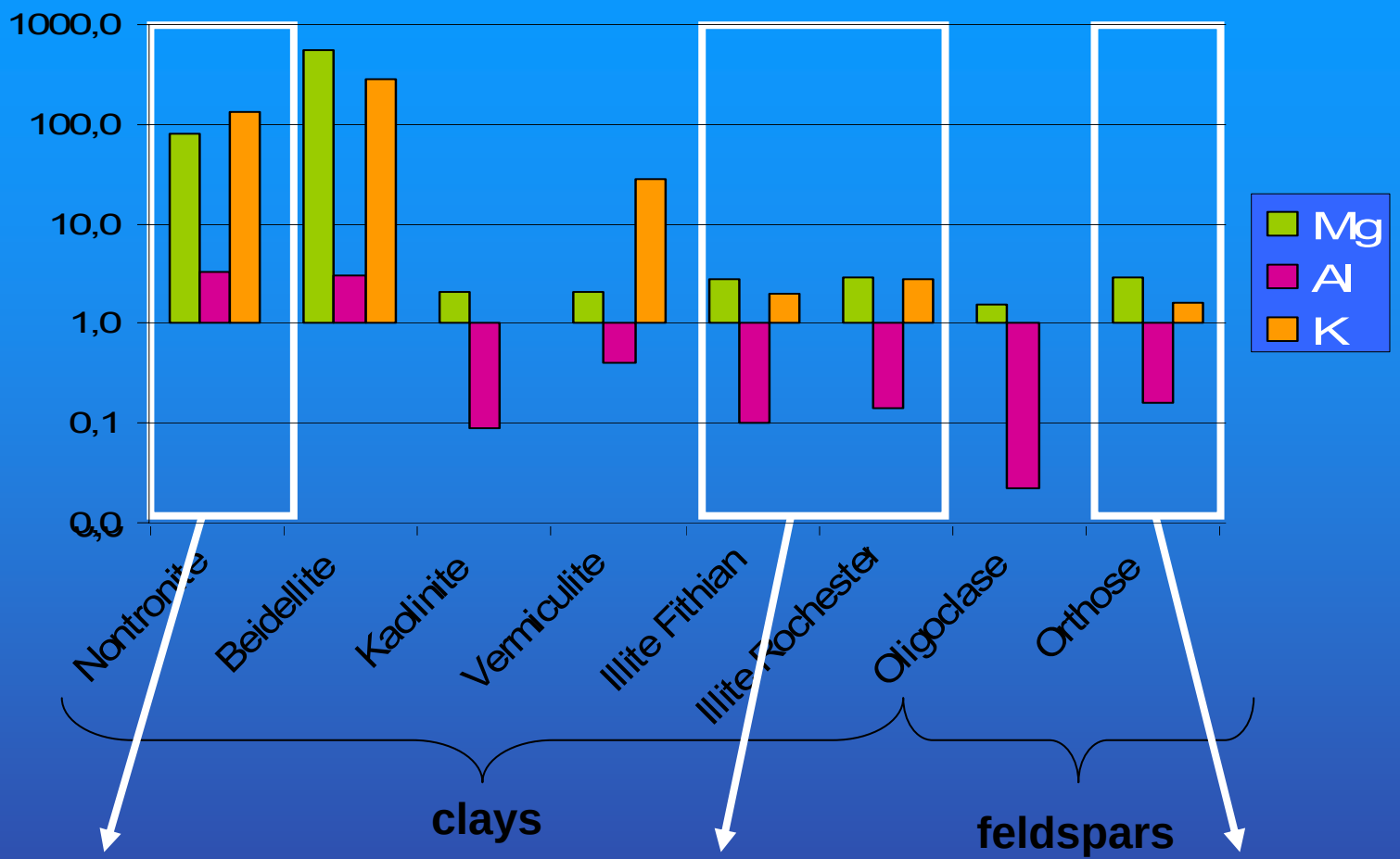
Fe = interlayer ion



Fe in sheet structure

What is the Iron location effect on its solubility?

Mg, Al and K solubilty compare to iron solubitity



Smectite (nontronite)

Fe Solubility

≈ Al solubility < K solubility

Illite

Fe Solubility

> Al solubility ≈ K solubility

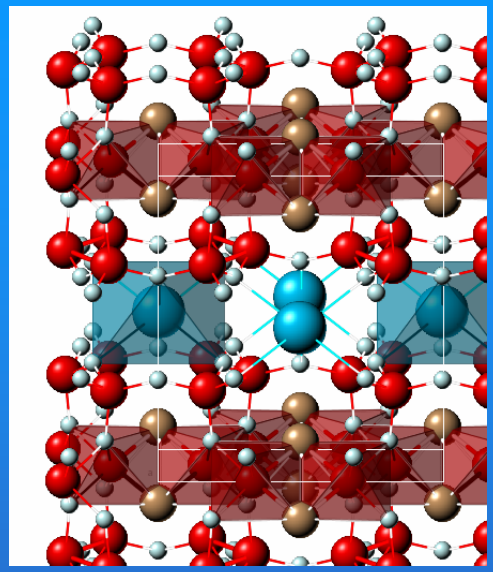
Orthoclase

Fe Solubility

> Al solubility

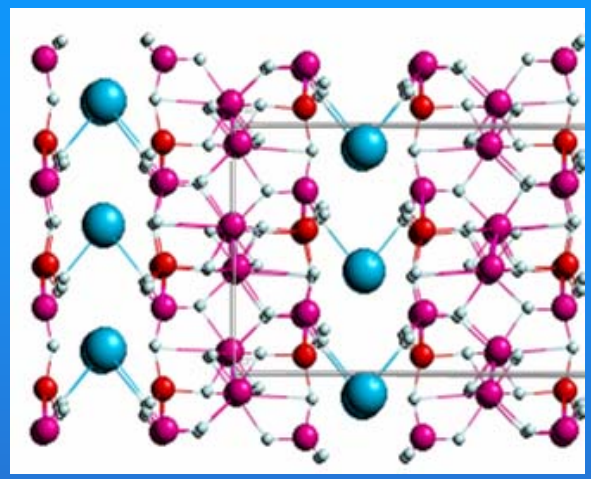
Iron location

Na Al Si



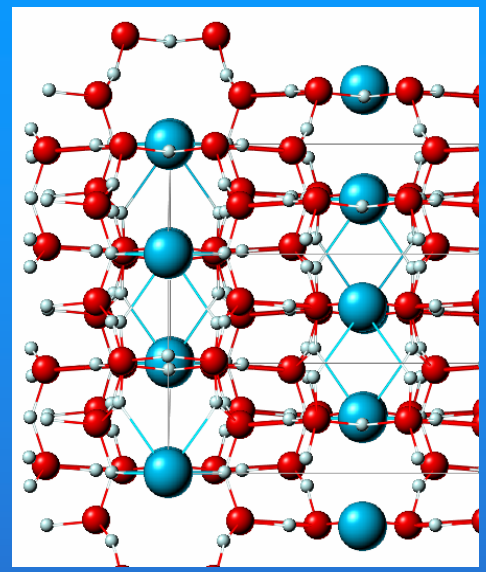
$Na_{0.3}Fe_2(Si,Al)_4O_{10}(OH)_2$

K Al Si



$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2$

K Al Si



$KAlSi_3O_8$

Fe substitutes Al or/and Si

Fe substitutes Interlayer ions (K)

Fe = impurities

Nontronite

Fe Solubility

≈ Al solubility < K solubility

Illite

Fe Solubility

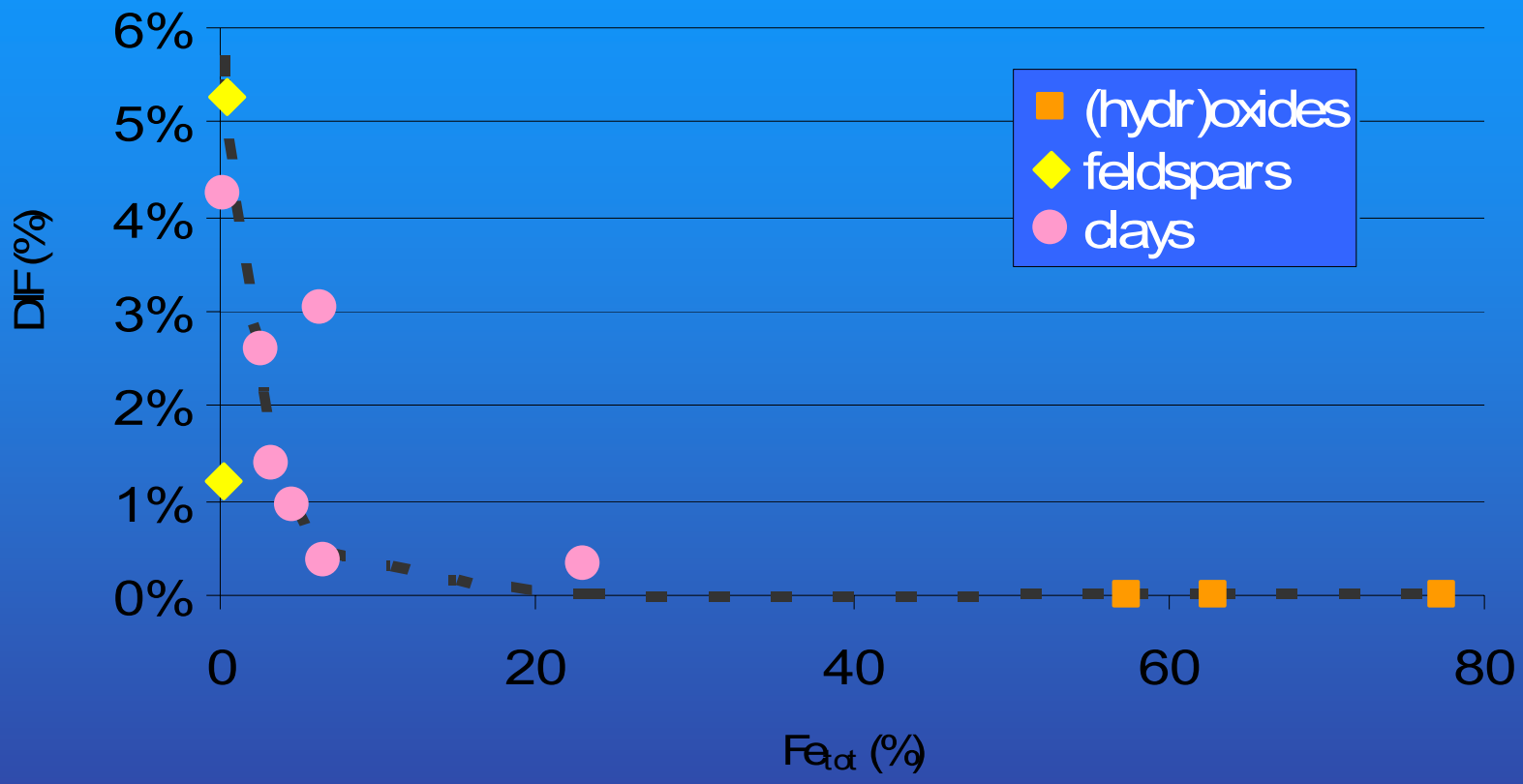
> Al solubility ≈ K solubility

Orthoclase

Fe Solubility

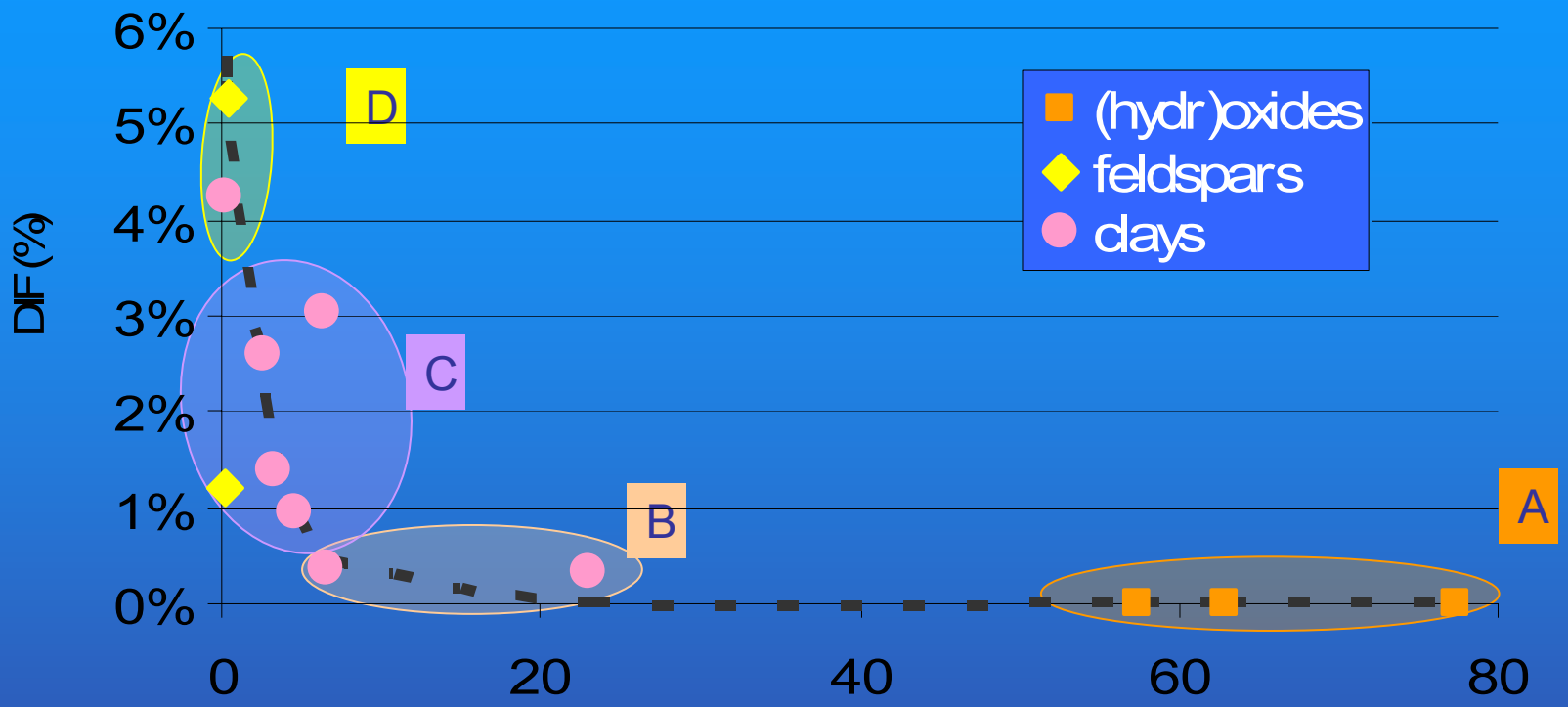
> Al solubility

DIF as a function of total iron content in %



Exponential decrease of DIF

% of dissolved Fe as a function of total iron content in %



A — (Hydr-)oxides :
Covalent bonds Fe-O or Fe-OH

B — clays :
Fe substitutes Al & Si

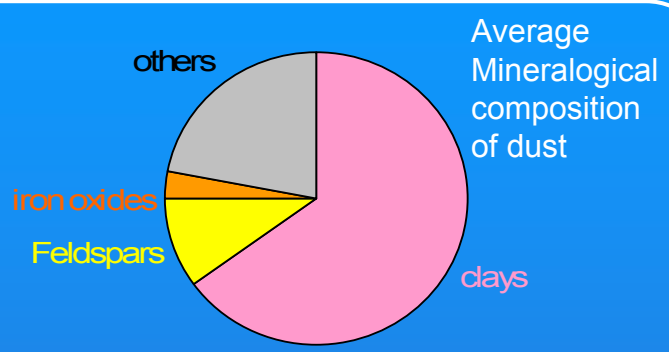
C — Clays and feldspars:
Fe substitutes interlayer ions

D — Claiys & Feldspars:
Fe = impurities

dissolution efficiency depends on iron location in minerals

IMPACT – biogeochemical context

By considering the relative proportion of minerals in dust



Contribution of each mineral group to the total dissolved iron

DIF :

Clay has to be considered like the dominant dissolved iron supplier

Conclusion…

The results of this study suggest that dissolved Fe from dust mainly comes from clay

Relative clay content increases with distance from the source,

that can explain partly, the enhancement of iron solubility during atmospheric transport

Iron dust solubility model which assumes that Fe is produced primarily through the dissolution of hematite should be reconsidered

… and outlook

To estimate available iron input from dust by atmospheric deposition

Similar dissolution experiments of pure minerals and dust have to be conducted in rainwater and seawater

Thank you