Mineralogy as a critical factor of dust iron solubility and bioavailability

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introduction

To estimate impact of atmospheric iron on ocean primary productivity, it is necessary to understand how iron deposited on ocean is soluble. Various previous studies have shown an extremely variable solubility (0,01-80%) and a number of factors influencing this solubility.
Previous laboratory experiments suggest that iron solubility increases during long range transport. What are the factors influencing this increase of solubility?

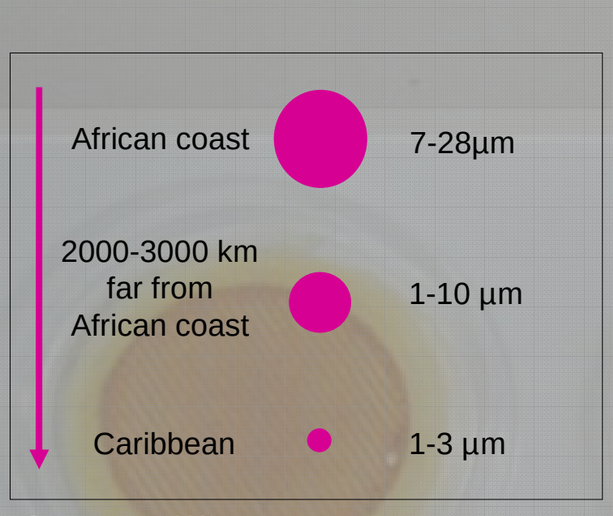
conclusion

Long range atmospheric transport of dust induces a mineralogical splitting up by a preferential sedimentation of the coarse mode.
The i**ncrease of clay content in aerosol during atmospheric transport** impacts on the **iron solubility that becomes greater.**
Furthermore, results suggests that **redox state of iron released in drop water is firstly controlled by dust mineralogy.**

Impact of sedimentation during mineral dust long range transport over tropical Atlantic ocean

1- Size modification

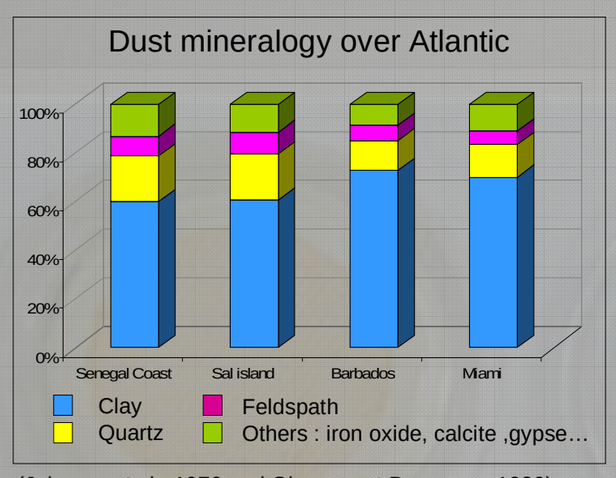
Average size of mineral dust decreases with distances from dust desert source



(Schütz et al, 1980)

2- Mineralogical splitting up

Dust clay content increases while dust moving away from the source



(Johnson et al., 1976 and Glaccum et Prospero , 1980)

Effect on iron solubility

Backer et al, 2006 suggest that the smaller dust particles are the greater proportion of their volume is exposed and therefore avaible for iron dissolution

What is the effect of a greater proportion of clay in dust particles on iron solubility?

African dust mineralogy and iron

Total Iron content in African dust : about 9% (Lafon et al, 2004)

Two iron categories :

✓ 44-65% of iron is "**free-iron"** under the form of oxide or hydroxide

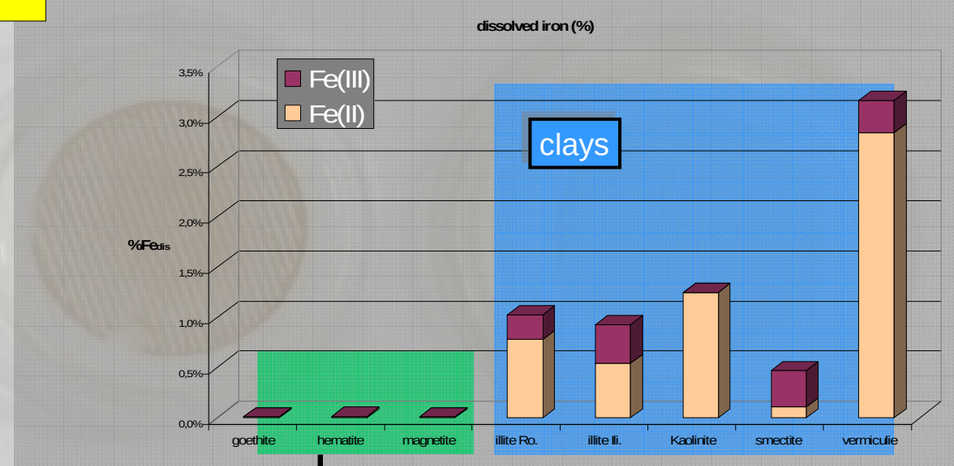
iron oxide :
hematite, goethite

✓ 35-56% of iron is **"Structural iron"** trapped in the crystal lattice of alumino-silicate

***Clays** :*
Illite, Kaolinite, smectite

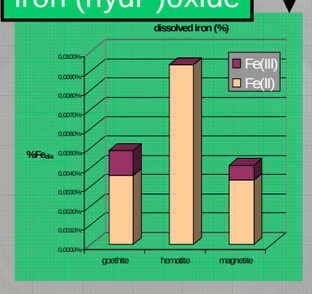
The aim of this work is to determinate iron solubility in usual minerals which composed dust aerosol

Results and discussion



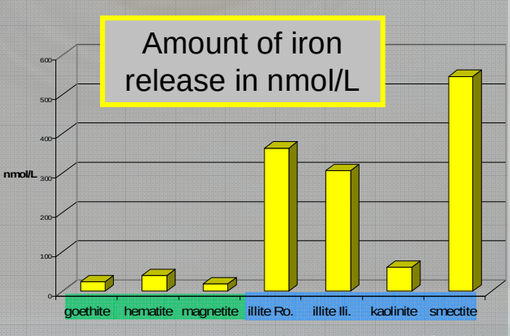
Results show a greater solubility of iron resulting from clays (between 0,1-4%) compare to iron coming from oxide (< 0,001 %). Iron(II) represents a major part of release iron for a majority of minerals

Iron (hydr-)oxide



Iron solubility is closely linked with the mineralogical composition of aerosol

In spite of their low solubility and because of their large iron content, iron released by iron oxide is not negligible.



(particulate charge :40mg/L)

These results suggest that amount of dissolved iron in drop water and so its redox state mainly depend on clay content in dust particles

Experimental section

Lab simulations of the dissolution of atmospheric particles which contains iron

Studied minerals:

iron oxide	formula	origin	%Fe (%w)
goethite	Fe_2O_3	Minnesota[1]	63
hematite	FeOOH		60
magnetite	Fe_3O_4	Michigan[1]	65

Clay	*origin*	%Fe (%w)
Illite	Rochester [1]	5
	Illinois [1]	4,65
kaolinite	Georgia	0,7
smectite	Pennsylvania	16,4
vermiculite	Libby [1]	7,68

[1] ward's natural sciences products

Materials and method:

About 10mg of pure phase are added to 250ml of acidified MQ water (pH=2, acid= HNO3). After one hour the dissolved fraction is filtered through a 0,2µm nuclepore filter during less than 3min.

30 ml of the filtrate are acidified to pH=1 to be analyze by ICP-AES to quantified total dissolved iron and dissolved cations.
60ml are used to complete iron redox speciation with the FZ modified method coupled with GFAAS (Journet et al., 2007)

IRON REDOX SPECTIATION
Open column filled with ferrozine (FZ)