FINAL REPORT PROGRAM LEFE

Program LEFE/ CHAT-CYBER	Project Title : Biodisponibility and solubility of iron in dust particles and volcanic ashes (BISOU)	Years 2017 - 2018

PI: Emilie Journet; LISA, UMR7583 CNRS
E-mail : emilie.journet@lisa.u-pec.fr;

Partners:

- **LOCEAN**, UMR 7159
- **ELI**, université Catholique de Louvain, Louvain-la-Neuve, Belgique

Other funding sources :
UPEC; Campus France

Context:

Atmospheric deposition of mineral dust and volcanic ash supplies new iron to high nutrient low chlorophyll (HNLC) waters of open ocean, where phytoplankton activities, that controls the biologic pump of carbon are iron-limited. A key question in the context of the ocean iron fertilization hypothesis is how much of the total Fe in dust/ash is bioavailable.

Objectives:

The research aims to investigate if iron solubility in mineral dust and volcanic ash, can be considered as an accurate proxy to predict iron bioavailability to marine phytoplankton. This work plan to establish, for the first time, the link between iron solubility in Fe-bearing materials and their actual induced biological response on starved cultures under conditions representative of HNLC waters.

Main results:

First of all, experiments carried out on mineral dust models (pure minerals) confirm the hypothesis that well-crystallized iron oxides, very poorly soluble, such as goethite, do not constitute a supply of bioavailable iron contrary to the iron contained in clays (like illite/smectite) or in amorphous iron oxides (ferrihydrite).

For model or natural materials that release soluble iron, there is always a biological answer of the starved cultures, whether the supply is made by dry or wet way (simulated rain). In our experimental conditions, the addition of these materials reduces the stress of Fe in 24 hours and induces cell growth up to 7 days.

A comparison of natural volcanic ash with natural mineral dust shows that ashes are richer in structural iron (iron trapped in the crystal lattices of aluminosilicates) and releases more dissolved iron than dust, but that it does not induce better cell growth. Iron solubility variability between materials of different nature therefore might not reflect the variability of its bioavailability.

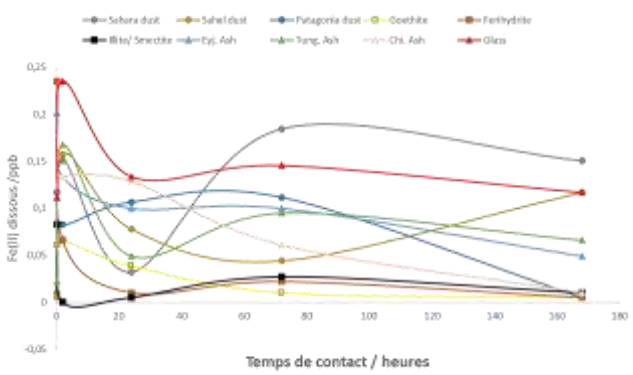

Figure 1 : Measurement (in ppb) of soluble iron II over a period of 7 days in synthetic seawater for the different materials studied.

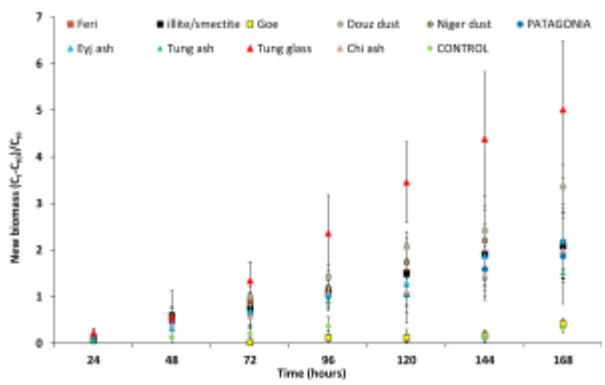

Figure 2 : Measurement of cell growth after deposition of different materials over a 7 days period (*Dunaliella tertiolecta culture).*

Figure 1 : Iron solubility varies almost an order of magnitude between the less soluble materials (goethite in yellow) and the more soluble materials (synthetic glass ash in red). For mineral dust, model materials (square symbol) are less soluble than natural materials (round symbol) while for ash, it is the opposite. Synthetic glass ash (red triangle) is more soluble than natural ash (other triangle symbol). In order to be able to interpret these variabilities, the next step will be to pay particular attention to the amorphous phases contained in these materials.

Figure 2 : Goethite is the only mineral that does not induce cell growth (identical to control). Apart from synthetic glass, which stands out with strong cell growth, all of the other materials do not show any significant difference. Iron solubility variability observed between the different natural materials does not seem sufficient to induce significant differences on iron bioavailability.

Future of the project:

In order to fully exploit all the results obtained during this project, a fine characterization of the amorphous phases of natural materials is necessary. Indeed, the analyses by XRD carried out during the BISOU project have highlighted that a significant part of amorphous materials or in the form of smectite was present in the studied samples (> 80% for ash; between 30 and 50% for dust). We therefore plan to study more specifically these amorphous phases in a future project.

Publications related to the project

Oral communications in international conferences :

- Ammar, R., Delmelle, P., Journet, E., Effect of dust mineralogy on Fe solubility and Fe bioavailability to marine phytoplankton, Goldschmidt Conference, Paris, August, 2017.

- Ammar, R., Delmelle, P., Journet, E., Solubility of Iron in Mineral Dust and Volcanic Ash and its bioavailability to marine phytoplankton, EGU General Assembly, Vienna (Austria), April, 2017.

Poster presentation :

- Colloque de Bilan et de Prospective du programme LEFE, 20-30 mars 2018, Clermont-Ferrand.