Potential role of particulate forms of Fe in island fertilisation in the Southern Ocean

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Talk Overview

- Vertical particle flux studies around the Crozet Islands

- Implications of biogenic Fe fluxes for conversion of lithogenic to biologically available Fe- how important are particle sources of Fe to micro-organisms in this environment?

- Mechanisms by which organisms access lithogenic Fe- ideas from the geomicrobiology community

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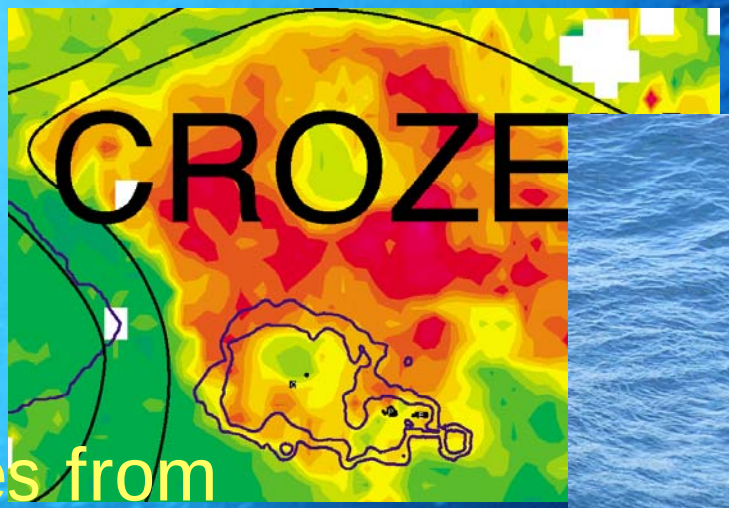

- Vertical Fe fluxes from combination of analysis of in situ pump collected samples and Th -234 fluxes
- “labile” (acetic acid leach) total and biogenic (=total – lithogenic) Fe fluxes estimated
- Details in Planquette et al. GBC 2011

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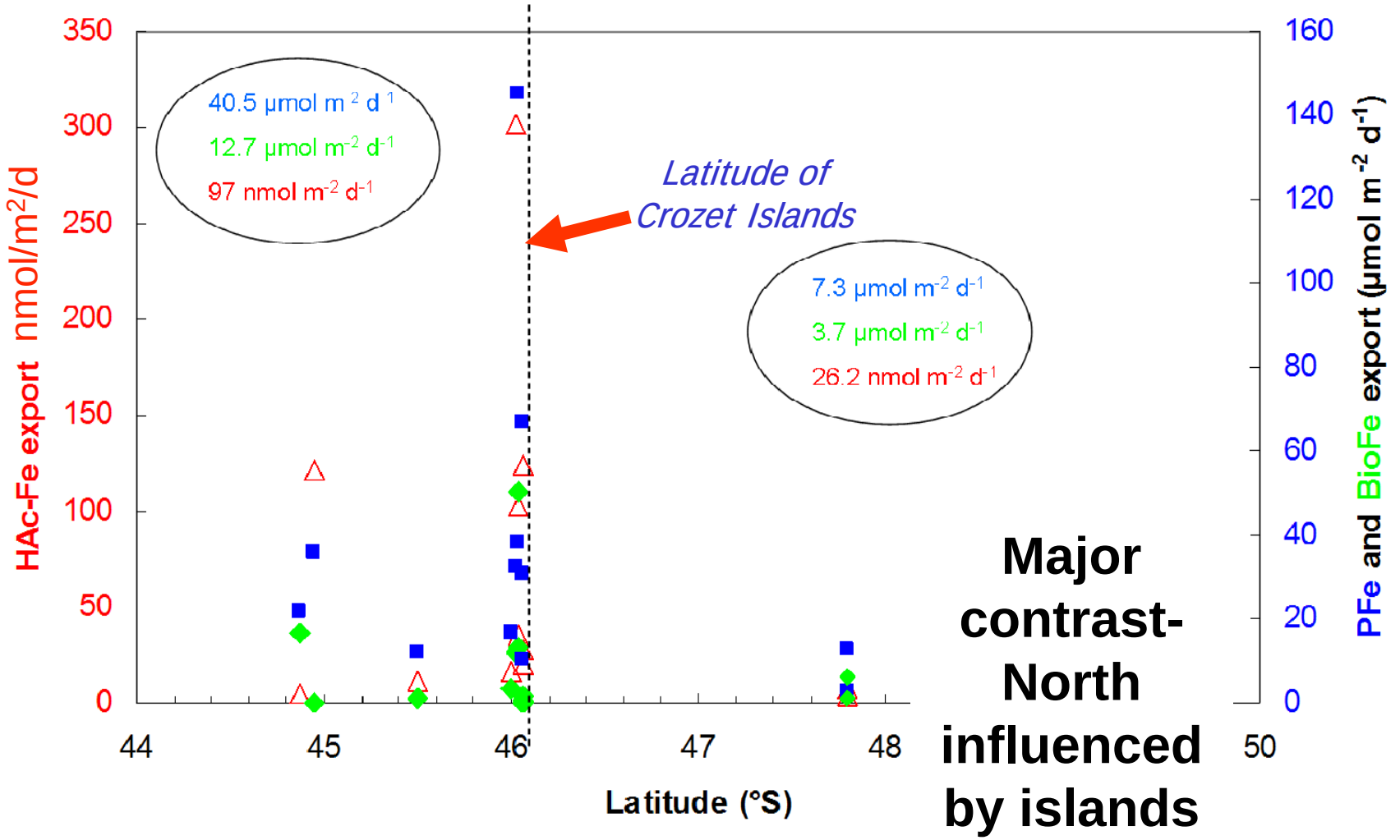

Major contrast- North influenced by islands and south true HNLC

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Origin of Fe in particles?

- Possible to estimate Fe budget in this system for area N of the islands
- Dissolved lateral and vertical upward Fe fluxes estimated with use of Ra isotopes (Charette et al DSR (2007) 54, (18-20), 1989.
- Atmospheric input estimate from samples collected on cruise
- Can compare fluxes of labile, biogenic and total particulate Fe

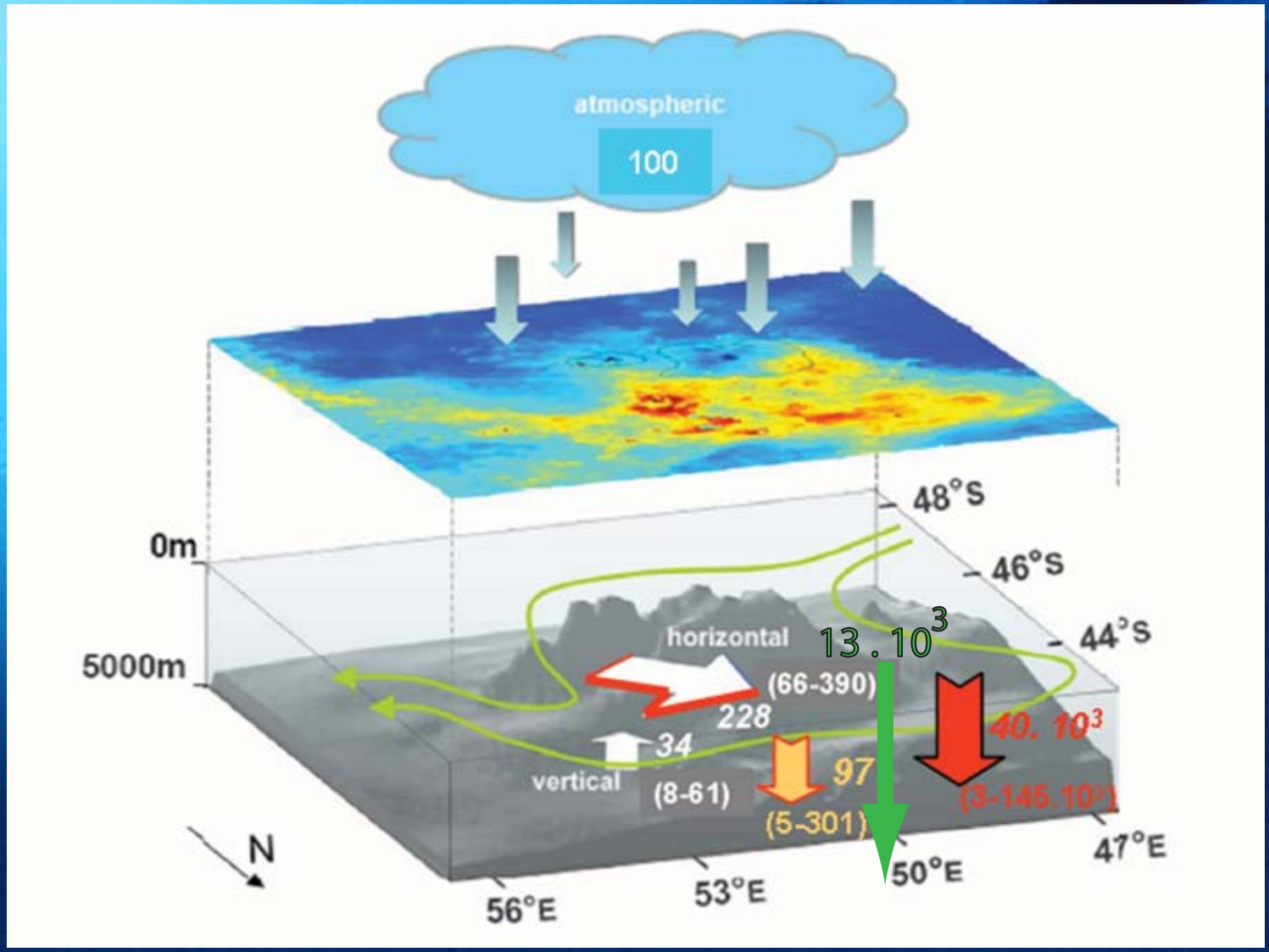
white = dissolved

orange = labile

Green = biogenic

red= total

Biogenic ~third of total



Units are nmol/m²/day see Planquette et al. GBC doi:10.1029/2010GB003789 (2011) for details

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Key points from the Crozet particle flux study:

- Lithogenic "refractory" Fe particles dominate vertical flux downstream of islands. Leachable flux does not = biogenic flux
- **biogenic flux component, (total - lithogenic) greater than other combined dissolved inputs to system**
- **Infers biota have accessed a fraction of the "lithogenic" Fe present. In agreement with ideas in Frew, Lam and others, but over larger scale**

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Recycling of Fe in the water column

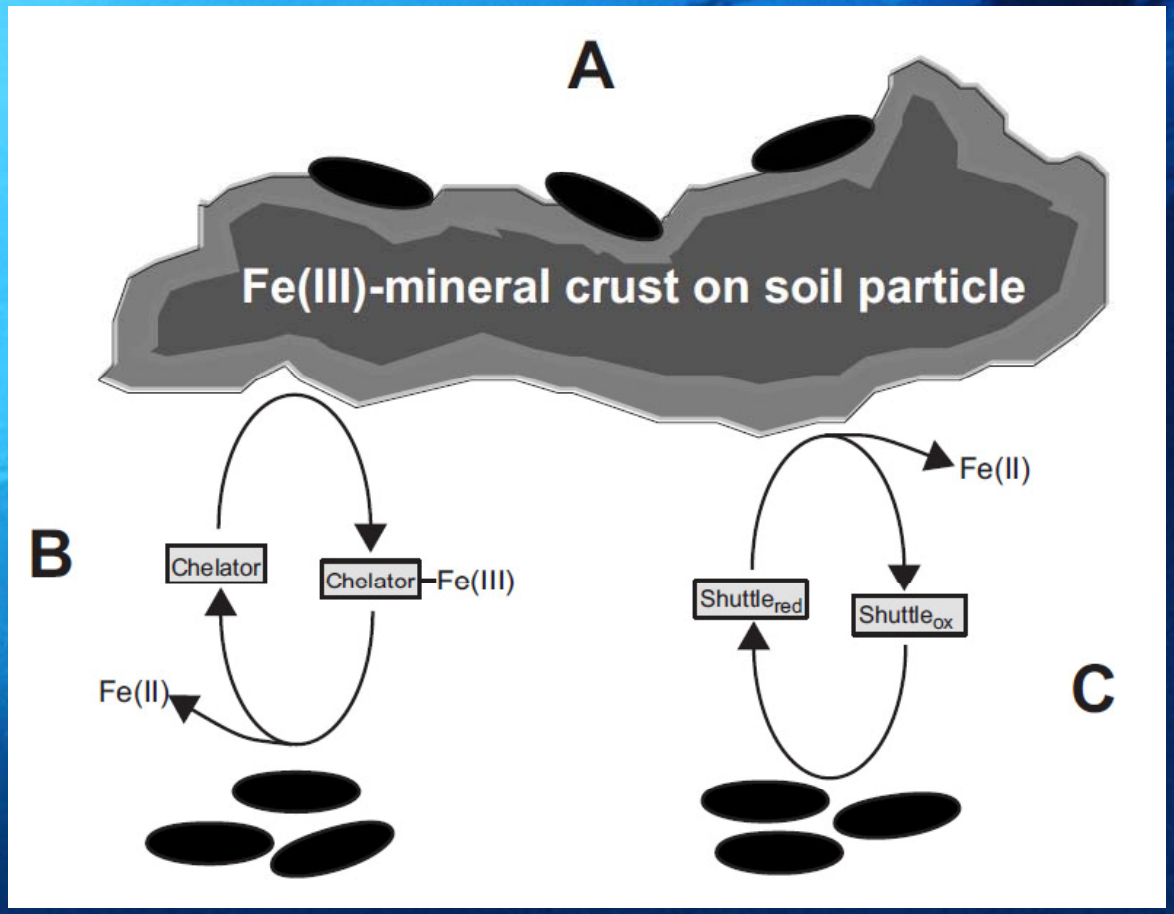
- Boyd et al. (L&O 2010 **55**(3)) showed rapid release of DFe and ligands by heterotrophic bacteria in presence of natural particles (near SO)
- Argue release of biogenic Fe important for fuelling algal growth and lithogenic material more relevant to ballast and adsorption site for Fe
- Does not really address potential for lithogenic phases to be source of Fe to micro organisms
- How can organisms access lithogenic Fe??

Microbial access to mineral forms of Fe

- Interactions take two general forms: a) Fe metabolically limiting and mechanism to obtain Fe needed b) Fe redox processes used for microbial energy
- The ocean water column is generally oxic and so Fe II not *expected* form, thus Fe III reduction most likely redox mechanism for energy
- Ocean prokaryotes use predominantly siderophores to access Fe (recycled or mineral)

Dissimilatory Electron transfer mechanisms

Figure from Kappler and Straub, Reviews Min. Geochem (2005) **59**, 85



- **A. Bacteria on mineral surface (or nanoparticles on surface of bacterium)- direct electron transfer**
- **B. Chelated Fe transferred, reduced Fe released**
- **C. Organic compounds used to transfer electrons (e.g.phenazine-1-carboxamide)**

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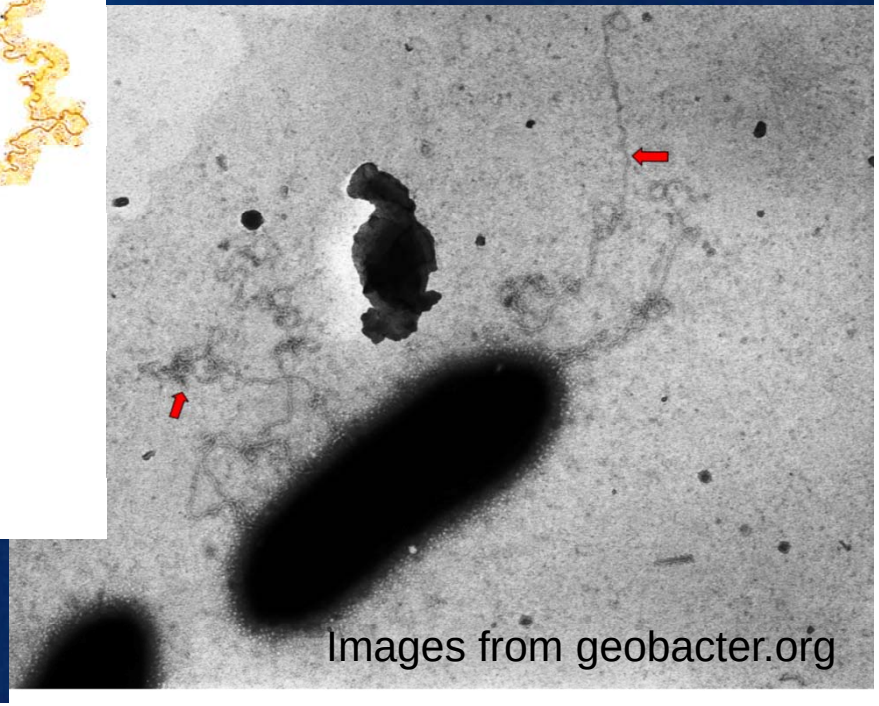
Bacterial reduction processes using nanowires

- Recent evidence for electron transfer via external cytochrome "wires" in *geobacter*-pili (Reguera et al., Nature 2005)



Images from geobacter.org

Geobacter sulfurreducens cells expressing pili (arrows). Photo credit: Gemma Reguera

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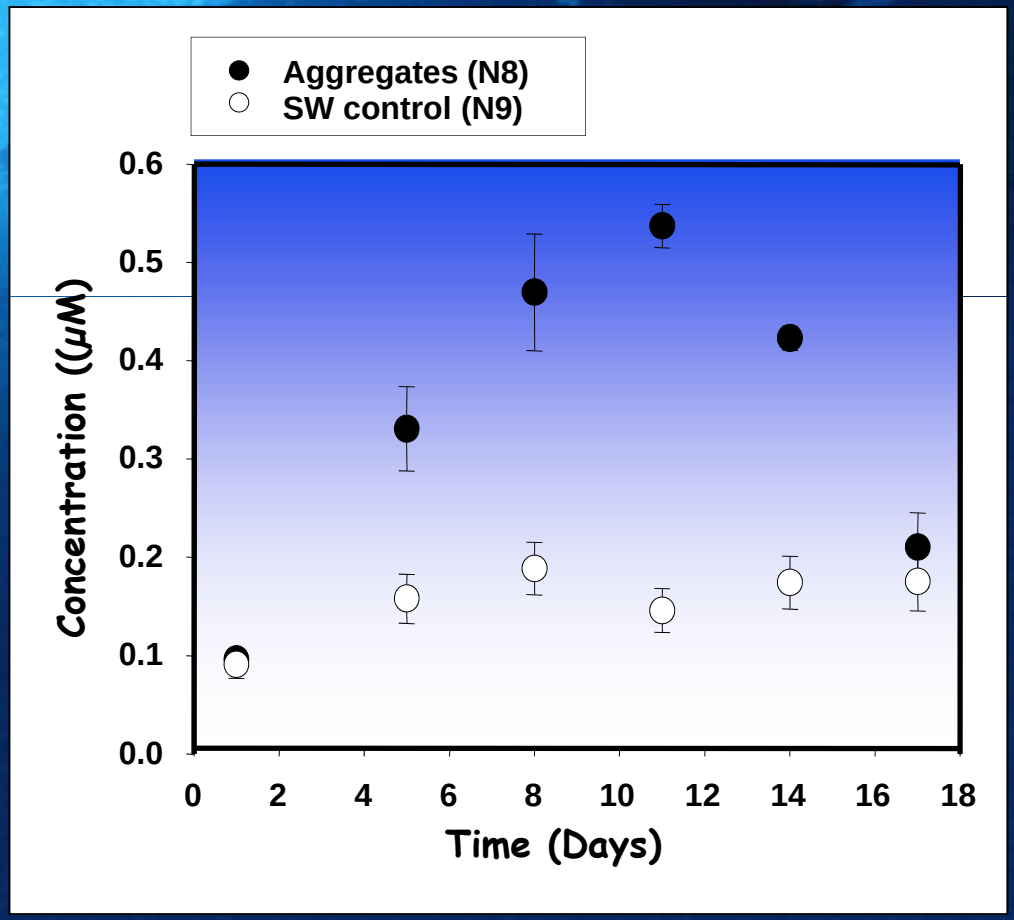
Release of Fe II

- Evidence for release of reduced Fe II?
- Not a fully oceanic environment but Balzano [AME (2009) **54**(3)] has shown aggregates containing environmental particles can release Fe II. *Desulfovibrio sp.* and *Marinobacter sp.* most likely reducers of bacteria identified
- Forms of FeII may be more bioavailable than FeIII



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Summary on microbial access to Fe in minerals

- Fe could be released from minerals by siderophores or though reductive bacterial action. In latter case Fe release is a side issue for bacteria; Fe not limiting for them
- Rates, availability of different substrate, and many other aspects need further study
- Much useful information in geo-microbiology literature

Thanks to :

- *Helene Planquette for most of the Crozet work (do look at her poster!!)*
- *Captain and crew of RRS Discovery*
- *Colleagues and support staff in lab and at sea*
- *Natural Environment Research Council for support*

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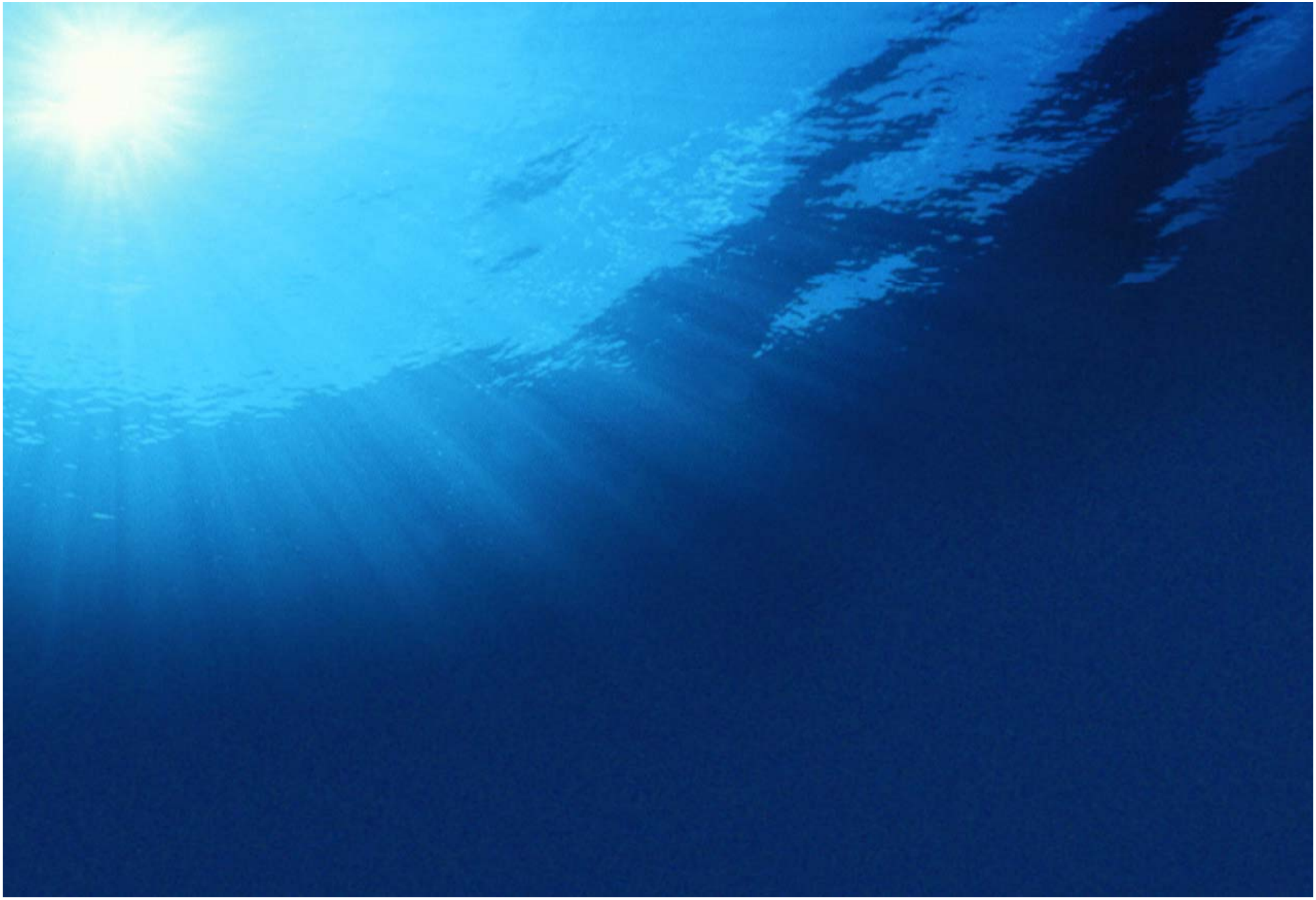

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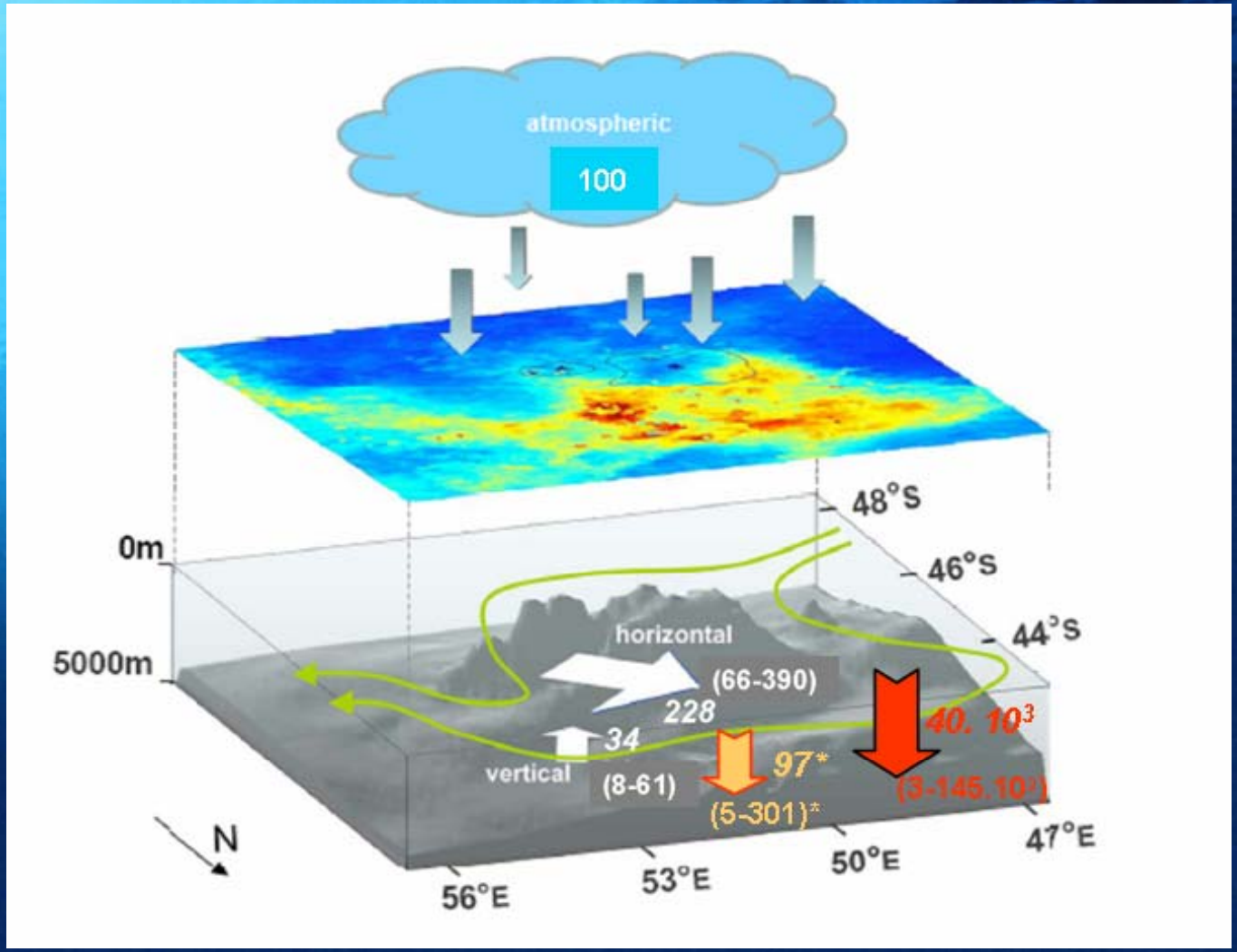
Red= total particulate Fe

Inferred horizontal flux from islands to balance vertical flux off shore



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