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Extreme variability of iron bioavailability in the Southern Ocean

MARION ANNE FOURQUEZ[1,2], DAVID J JANSSEN[3], TIM M. CONWAY[4], DAMIEN CABANES[5], MICHAEL J ELLWOOD[6], MATTHIAS SIEBER[4], SCARLETT TRIMBORN[7] AND CHRISTEL HASSLER[5,8]

[1]Mediterranean Institute of Oceanography
[2]Mediterranean Insitute of Oceanography
[3]Eawag: Swiss Federal Institute of Aquatic Science and Technology
[4]University of South Florida
[5]University of Geneva
[6]Australian National University
[7]Alfred Wegener Institut
[8]University of Lausanne

Presenting Author: marion.fourquez@gmail.com

While global programs such as GEOTRACES have illuminated the distribution of dissolved Fe (dFe) in the surface Southern Ocean (SO), one concept which continues to elude the field is the degree of the dFe that is actually available for uptake by phytoplankton. This concept is complicated by the operational size definition of dFe in marine chemistry, a very small free inorganic Fe pool, and ~95% of dFe thought bound to organic ligands. In fact, the question of Fe bioavailability cannot be simply addressed directly in the field because Fe uptake rates measured in situ reflect a multitude of factors (e.g. composition of the microbial community and/or different physiological states for cells) that hinder straightforward comparisons between water types. To overcome this, we used the model organism *Phaeocystis antarctica* in a series of ^{55}Fe uptake experiments performed on real SO seawater samples collected during the 2016-2017 Antarctic Circumnavigation Expedition (Figure 1). This unique approach revealed show that Fe bioavailability to phytoplankton varies widely across the SO (<1% to ~200% compared to free inorganic Fe), regardless of *in situ* dFe concentration and depth (Figure 2), with the most bioavailable Fe near to proximal Fe sources (glaciers, sediments). The results of this study also challenge the consensus that dFe concentrations can be used to predict Fe uptake in modeling studies. Further, our data suggest a disproportionately important role of biologically-mediated ligands, and encourage revisiting the role of humic substances in influencing marine Fe biogeochemical cycling. Lastly, we describe a novel linkage between in situ Fe bioavailability and dFe isotopic signatures that we anticipate will stimulate future research.

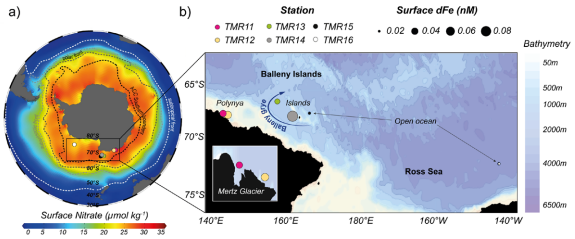

Figure 1 Station sampling locations from the Antarctic Circumnavigation Expedition (GEOTRACES Compliant Cruise GSc01) Leg 2 in Austral Summer Dec. 2016– Mar. 2017.

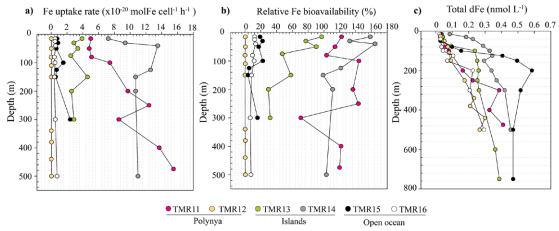

Figure 2 Profiles of Fe uptake rates by *P. antarctica* (**a**) compared to estimated uptake of inorganic Fe (Fe', **b**) as a proxy of Fe bioavailability and to total dFe concentration (**c**).