Benthic Iron flux in the Arctic Ocean

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Between 1990 and 2007, sediments box cores were recovered within the Arctic Ocean at locations spanning shallow to deep water (40-4200 m), and analyzed for total Fe and S, operationally-defined fractions of Fe and S, other inorganic components and organic C. Cores from the basins (defined as depth > 1000 m) are characterized by the lowest concentrations of organic C, undetectable levels of pyrite, and high concentrations and inventories of Fe oxihydroxides (Fe soluble in a dithionite solution at pH 4.8). In contrast, cores from the arctic continental shelves and slopes exhibit relatively higher levels of organic C, detectable concentration of pyrite, and significantly lower levels and inventories of Fe oxyhydroxides. Using these data to determine the sediment sink and relying on literature values for physical transport of material in and out of the polar ocean, we have constructed a budget for highly reactive Fe (FeHR), defined as Fe oxihydroxides plus pyrite-Fe, for the whole Arctic Ocean. This budget reveals that most FeHR comes from rivers and coastal erosion and that almost all of it is trapped within the Arctic Ocean. The amounts of FeHR accumulating in shelf, slope and basin sediments represents 36%, 22% and 33% of its total input, respectively, with pyrite-Fe representing less than 20% of total burial of FeHR in shelf and slope sediments. This budget, combined with the fact that the proportion of FeHR relative to total Fe (FeT) is significantly higher in basin sediments (FeHR/FeT = 0.30±0.03) than in shelf sediments (FeHR/FeT = 0.19±0.07), implies that authigenic pyrite is not a substantial sink for Fe in the Arctic Ocean and that a significant fraction of the Fe recycled as a consequence of Fe oxyhydroxides reduction during the anaerobic metabolism of organic matter in shelf sediments is eventually exported towards the Arctic Ocean interior. Considering that the large-scale distribution of FeHR in the arctic marine sediments is strongly dependent of organic matter metabolism in shelves and that the Arctic Ocean presently contains as much as 50% shelf area, but loses most of that when global sea level falls by ~120 m during glacial maxima, we argue that sea-level fluctuation is a major factor influencing the biogeochemical cycle of Fe in the Arctic Ocean.

Climate change: the future of continental weathering

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Continental weathering has been considered for long as a key process in the global carbon cycle at the geological timescale. Conversely, the evolution of the CO_2 sink by weathering is neglected in all studies dealing with the future of our climate, because weathering is considered as a slow process, almost inert at the secular time scale. However, recent data surveys have demonstrated the potential high sensitivity of weathering to the ongoing climate and land use changes[1,2].

According to future anthropogenic emission scenarios, the atmospheric CO_2 concentration may double before the end of 21st century, resulting in a global warming more than 6°C in the worse case. The global temperature increase will promote changes in the hydrologic cycle through redistributions of rainfall patterns and continental vegetation cover[1,2]. All these changes will impact the chemical weathering of the continental rocks. To evaluate these impacts, we use a process-based model of the chemical weathering of the continental surfaces (B-WITCH[3], spatial resolution 1°x1°) forced by models describing the atmospheric general circulation and the dynamic of the vegetation under increased atmospheric CO_2. We focus on the arctic environment where land use changes can be neglected while the climate change is expected to be important (the Mackenzie watershed)[4]. We calculate that the CO_2 consumption flux related to weathering processes (including carbonate and silicate dissolution) may increase by more than 50% for an atmospheric CO_2 doubling for one of the most important arctic watershed: the Mackenzie River basin. 40% of this increase is directly related to the warming (1.4 to 3°C warming over the watershed) and to the rainfall increase (averaged increase of 7%). But the remaining 60% are due to the direct CO_2 impact on the vegetation. Indeed, under higher CO_2 pressure, plants close their stomata, limiting the evapotranspiration and the fertilization effect promotes below ground CO_2 respiration[4]. Our study stresses the potential role that weathering may play in the evolution of the global carbon cycle over the next centuries.

[1] Raymond et al. (2008) *Nature* **451**, 449-452 [2] Gislason et al. (2009) *Earth Planet. Sci. Lett.* **277**, 213-222 [3] Roelandt et al. (2010) Glob. Biogeochem. Cycles 24, doi:10.1029/2008GB003420 [4] Beaulieu et al. (2012) *Nature Climate Change* **in press**.