Study highlights importance of mineral iron in ocean ecosystems

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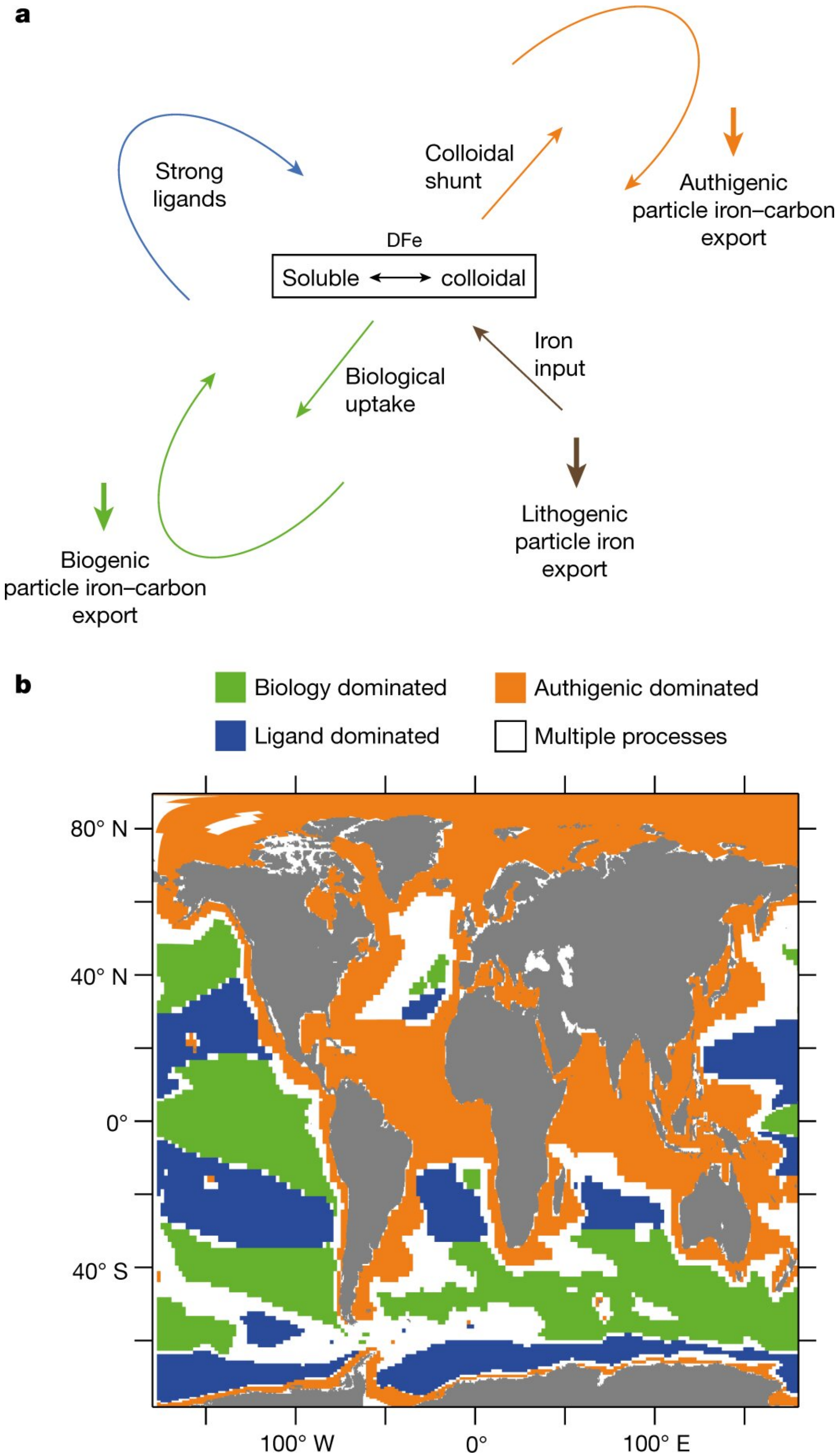

a
Strong
ligands
Colloidal
shunt
Authigenic
particle iron–carbon
export
DFe
Soluble
colloidal
Iron
input
Biological
uptake
Biogenic
particle iron–carbon
export
Lithogenic
particle iron
export
b
Biology dominated
Authigenic dominated
Ligand dominated
Multiple processes
80° N
40° N
0°
40° S
100° W
0°
100° E

An integrated view of the ocean iron cycle. **a**, A schematic illustrating how the biological uptake (green: sum of diatom, picophytoplankton, nanophytoplankton, microzooplankton, mesozooplankton and organic PFe), ligand stabilization (blue: sum of organically complexed and free DFe) and the colloidal shunt (orange: sum of colloidal iron (oxyhydr)oxides and small and large authigenic particle Fe) maintain surface ocean Fe levels. **b**, Model quantifications of the dominant term at each location in the upper 100 m using the new PISCES-Quota-Fe model in the same colors, with white areas denoting regions in which more than one process dominates. Credit: *Nature* (2023). DOI: 10.1038/s41586-023-06210-5

New research published today in *Nature* has revealed the importance of mineral forms of iron in regulating the cycling of this bio-essential nutrient in the ocean.

The findings pave the way for new work on the relationship between the iron and carbon cycles and how changing ocean oxygen levels may interact.

The study, led by the University of Liverpool and involving collaborators in the United States, Australia and France, addresses a knowledge gap in ocean research.

Principal Investigator Professor Alessandro Tagliabue said, "To date we have not fully appreciated the role that mineral forms of iron have played in driving the distributions and temporal dynamics of iron in the ocean."

The ocean of the early earth was low in oxygen and rich in iron, which was incorporated as a catalyst in many biological reactions. These include photosynthesis, which via its proliferation oxygenated the earth system. As iron is less soluble in well oxygenated seawater, precipitation and sinking of iron oxides led to iron levels declining. Consequently, iron now plays a critical role in regulating ocean productivity and hence ecosystems across the contemporary ocean.

It is thought that iron levels are largely regulated above their soluble thresholds by organic molecules called ligands, which bind iron. This view has underpinned the representation of the marine iron cycle in global models used to explore how changes in climate affect levels of biological productivity in the future.

However, oceanographers have been puzzled as to why there seemed to be a much larger loss of iron due to insolubility from the ocean than expected from the measured high levels of ligands. The ocean models built according to the expected pattern have generally performed poorly in reproducing observations.

Peter Sedwick (Old Dominion University) deploys the clean rosette system to collect water samples during project fieldwork

This project examined the processes driving the cycling of iron over an annual cycle for the first time. It revealed that iron was largely cycling independently of ligands in the upper ocean and instead controlled by the clustering of iron oxide colloids to form so-called 'authigenic' particles that are lost from the upper ocean.

The authors developed a new numerical model to both explain their results and extrapolate their findings across the ocean. The new model performed markedly better in reproducing other independent observations and highlighted that this new process was important in around 40% of upper ocean waters.

A key implication is that this process occurs via the co-aggregation of iron oxides and carbon, which has implications for the global carbon cycle and may be sensitive to future trends of ocean oxygen loss.

"These findings will cause us to reassess our understanding of the iron cycle and its sensitivity to changing environmental conditions," said Professor Tagliabue.

Professor Tagliabue said, "Our work was only possible thanks to the efforts to measure multiple different forms of iron in seawater over the annual cycle at the Bermuda Atlantic Time Series site."

More information: Alessandro Tagliabue, Authigenic mineral phases as a driver of the upper-ocean iron cycle, *Nature* (2023). DOI: 10.1038/s41586-023-06210-5.
www.nature.com/articles/s41586-023-06210-5

Provided by University of Liverpool

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