University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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MSc (Dalhousie University, 2003)

"An Investigation into the Sources of Iron and Iron(II) in HNLC High-Latitude Oceans"

School of Earth and Ocean Sciences

Tuesday, May 26, 2015
11:00 A.M.
David Turpin Building
Room A144

Supervisory Committee:
Dr. Jay T. Cullen, School of Earth and Ocean Sciences, University of Victoria (Supervisor)
Dr. Roberta Hamme, School of Earth and Ocean Sciences, UVic (Member)
Dr. James Christian, School of Earth and Ocean Sciences, UVic (Member)
Dr. David Harrington, Department of Chemistry, UVic (Outside Member)
Dr. Philippe Tortell, Department of Earth, Ocean and Atmospheric Sciences, UBC, (Additional Member)

External Examiner:
Dr. Katherine Barbeau, Scripps Institution of Oceanography, University of California

Chair of Oral Examination:
Dr. Bradley Buckham, Department of Mechanical Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

High nutrient, low chlorophyll (HNLC) regions, where the availability of iron (Fe) limits primary production, comprise approximately 40% of the global ocean. Variability in Fe supply to these regions modulates Earth's climate by affecting the efficiency of the biological carbon pump, and thereby carbon dioxide uptake by the oceans. Characterizing Fe sources to HNLC regions is thus crucial for a better understanding of the connections and feedbacks between the ocean and climate change.

This work addresses the question of Fe supply to two HNLC regions: the Southern Ocean and the subarctic northeast (NE) Pacific Ocean. In both regions, dissolved Fe (dFe) and the reduced form of iron, Fe(II), were measured in the water column. In the Southern Ocean, measurements were undertaken under the seasonal pack ice in the East Antarctic south of Australia. The results indicate that the sea ice represents a significant dFe source for the under-ice water column in spring, and that the Fe delivered from brine drainage and sea ice-melt likely contributes to the formation of the spring bloom at the ice edge. Shelf sediments were also found to supply dFe to the water column. Their effect was most pronounced near the shelf break and at depth, but offshore transport of Fe-enriched waters was also implicated. Fe(II) concentrations in spring were very low, most likely due to a lack of electron donors in the water column and limited solar radiation underneath the sea ice.

Repeat measurements along a transect in the subarctic NE Pacific indicate that shelf sediments supply dFe and Fe(II) at depth, but their influence does not appear to extend offshore beyond several hundred kilometres. Episodic events such as the passage of sub-mesoscale eddies may transport subsurface waters a limited distance from the shelf break, supplying Fe(II) in a depth range where upwelling and deep mixing could bring it to the surface. Offshore, dFe shows little variability except in June 2012, where an aerosol deposition event is suspected to have increased dFe concentrations at depth. Fe(II) concentrations offshore are generally low, but show transient maxima at depth that likely result from remineralization processes in the oxygen deficient zone that stretches from _600 to 1400 m depth in the subarctic NE Pacific. Elevated Fe(II) concentrations at depth were also observed in conjunction with the aerosol deposition event, which might indicate Fe(II) production associated with settling particles. However, the aerosol deposition event, which most likely stemmed from forest _res in Siberia, did not appear to trigger a phytoplankton bloom in surface waters, possibly due to a lack of Fe fertilization from the deposited material, or due to toxic effects on the resident phytoplankton community.

Dust deposition from the atmosphere is considered a major Fe supply mechanism to remote HNLC regions, but the factors affecting Fe solubility of dust are poorly constrained. A laboratory experiment was conducted to test whether the presence of superoxide, a reactive oxygen species, enhances the dissolution of dust from different geographic source regions. The results indicate that superoxide may promote Fe solubilisation from the dust sources tested, and that the effect of exposure to superoxide is on par with the Fe solubilizing effect of photochemical reactions. Given the possibility of widespread superoxide production by heterotrophic bacteria at all depths of
the ocean, this finding suggests that significant Fe dissolution of dust particles could occur throughout the water column, not only in the well-lit surface layer.