U054-011 **Room: 302** **Time: May 18 15:30-15:52**

Ocean circulation changes in the North Pacific after the Last Glacial Maximum

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We present thermohaline circulation and water mass structure changes in the North Pacific after the Last Glacial Maximum (LGM) by reviewing available proxy records from marine sediments. To discuss past ocean circulation, we can reconstruct (1) ater mass properties by using based on carbon isotope ratios and cadmium concentrations in benthic foraminifer shells and (2) ventilation based on ^{14}C age differences between co-existing planktonic and benthic foraminifers.

Carbon isotope ratios and cadmium concentrations in benthic foraminifer shells suggested glacial water mass structures were more stratified due to intensified halocline than the present in the both Atlantic and Pacific Oceans. Unlike today, deep water produced in the North Atlantic (corresponding to the present North Atlantic Deep Water; NADW) did not penetrate below 2.5 km and formed the Glacial North Atlantic Intermediate Water (GNAIW). The meridional overturning circulation (MOC) remained active during LGM inferred from ^{231}Pa/^{230}Th in sediments from the Atlantic Ocean. Significant change in MOC was suggested during the Heinrich Event 1 (H1) period (17.5 ka to 14.5 ka). H1 is known as a time when stagnant North Atlantic Deep Water (NADW) formation due to a large amount of freshwater supply by massive ice-berg collapse from the Laurentide Ice Sheet. This period corresponds to the Mystery Interval because of unsolved problem for a 190 per mil drop in atmospheric Delta ^{14}C. To explain such large drop, carbon dioxide release from isolated glacial abyssal reservoir must have been contributed. However, reconstructed ventilation based on ^{14}C age differences between co-existing planktonic and benthic foraminifers did not show significant changes during H1 in the deep Equatorial Pacific. On the other hand, significantly large ^{14}C age differences between co-existing planktonic and benthic foraminifers were observed in the subarctic Pacific. This discrepancy is a major topic among paleoceanographers. Most of these ^{14}C records in the subarctic Pacific contain considerable uncertainty due to age model difficulties (reservoir effect and poor $CaCO_3$ preservation) and low sedimentation rates (bioturbation).

In the Bering Sea, carbon isotope ratios in benthic foraminifer shells (*Uvigerina* spp.), possible proxy for phosphate content in bottom water, showed heavy (phosphate depleted) values during H1 and the Younger Dryas (YD) cold events and light (phosphate enriched) values during the deglacial warming periods. These events may be responding to NADW formation with fresh water discharge in the North Atlantic. Diatom production (biogenic opal) in the Bering Sea increased during the Bolling-Allerod period, suggesting nutrient supply to the euphotic layer from deep water.