Post-depositional manganese mobilization during the last glacial period in sediments of the eastern Pacific Ocean

Session: 08h
Flash Talk Theatre 2,
Wednesday @ 14:35 – 14:40

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Motivation

The Pacific Ocean has experienced substantial glacial/interglacial changes in bottom-water oxygenation associated with enhanced CO_2 storage in the glacial ocean[1,2]. While the deep Pacific Ocean is currently well oxygenated, bottom-water oxygen concentrations (O_2^{bw}) were most likely lower during the last glacial period (LGP)[3,4] between 15-28 kyr ago, which must have caused a much more compressed redox zonation in the sediments than at present[5,6,7].

We have extracted mobilizable MnO_2 (Mn_{mobil}) from surface sediments and used transport-reaction modelling in order to reconstruct past redox changes in the NE Pacific.

Material and Methods

- R/V SONNE cruise SO239[8] in 2015 to four European areas for the exploration of polymetallic nodules in the CCZ and one of the Areas of Particular Environmental Interest (APEI)
- Leaching of Mn_{mobil} from MUC sediment cores[9]
- Transport-reaction modelling

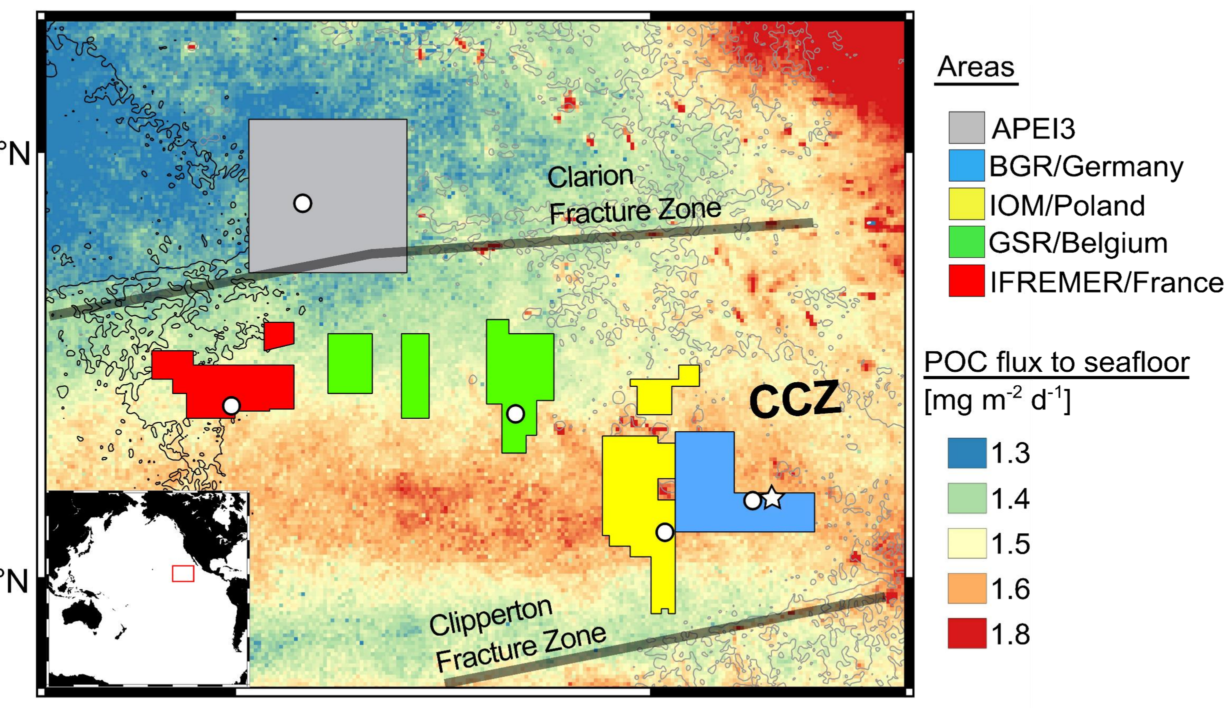


Fig. 1: Study areas in the CCZ. Two sites were studied in the BGR area: Prospective area (BGR-PA; star) and Reference area (BGR-RA; circle).

Results and Discussion

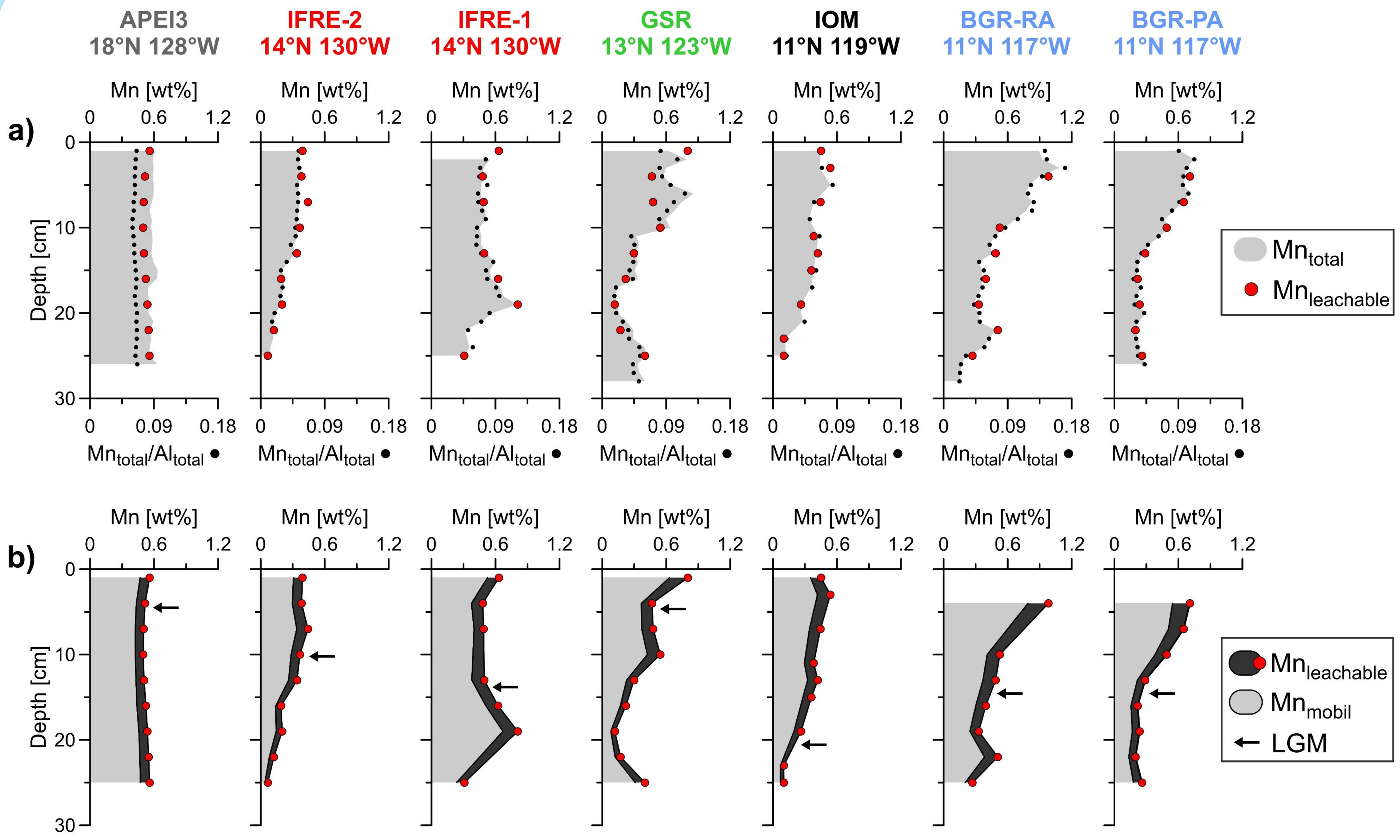


Fig. 2: a) Bulk sediment Mn (Mn_{total}), leachable Mn ($Mn_{leachable}$) and b) mobilizable Mn (Mn_{mobil}) contents with the location of the LGM sediment surface.

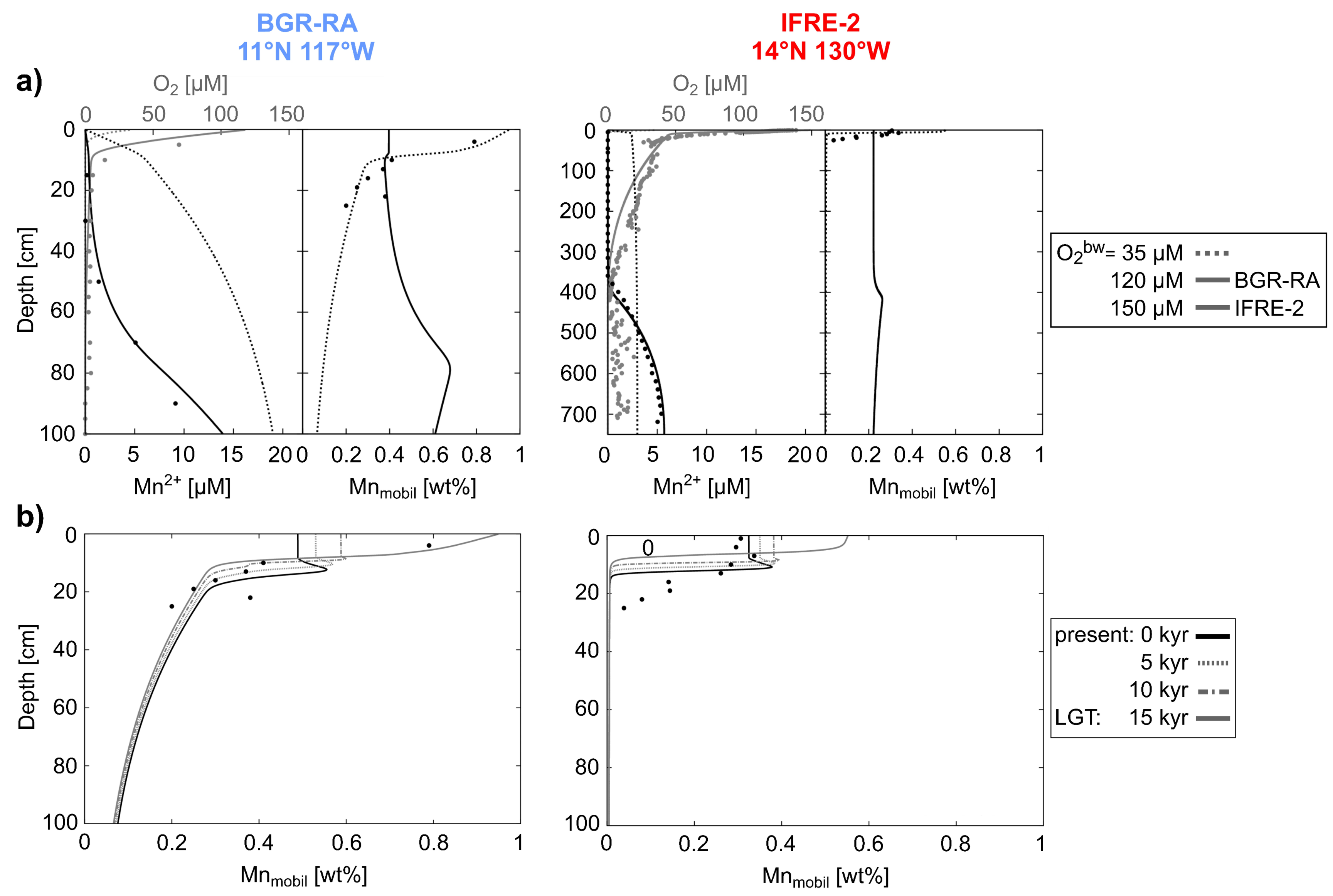


Fig. 3: a) Oxygen and pore-water Mn^{2+} data[10], steady-state model results for current O_2^{bw} (~150 µM) and glacial O_2^{bw} (35 µM). b) Transient model results for the depth distribution of solid-phase Mn_{mobil} during linearly increasing O_2^{bw} at the LGT between 14-15 kyr from glacial O_2^{bw} to current O_2^{bw}.

- Mn_{total} maxima of up to 1 wt% in upper 10 cm of oxic sediments
- Constant Mn_{total} contents over depth at site APEI3
- More than 85% of Mn_{total} is extracted as $Mn_{leachable}$
- $Mn_{leachable}$ is dominated by Mn_{mobil}

Current location of oxic-suboxic redox boundary in >0.5 m ⟷ Mn_{mobil} enrichment not formed under modern redox conditions

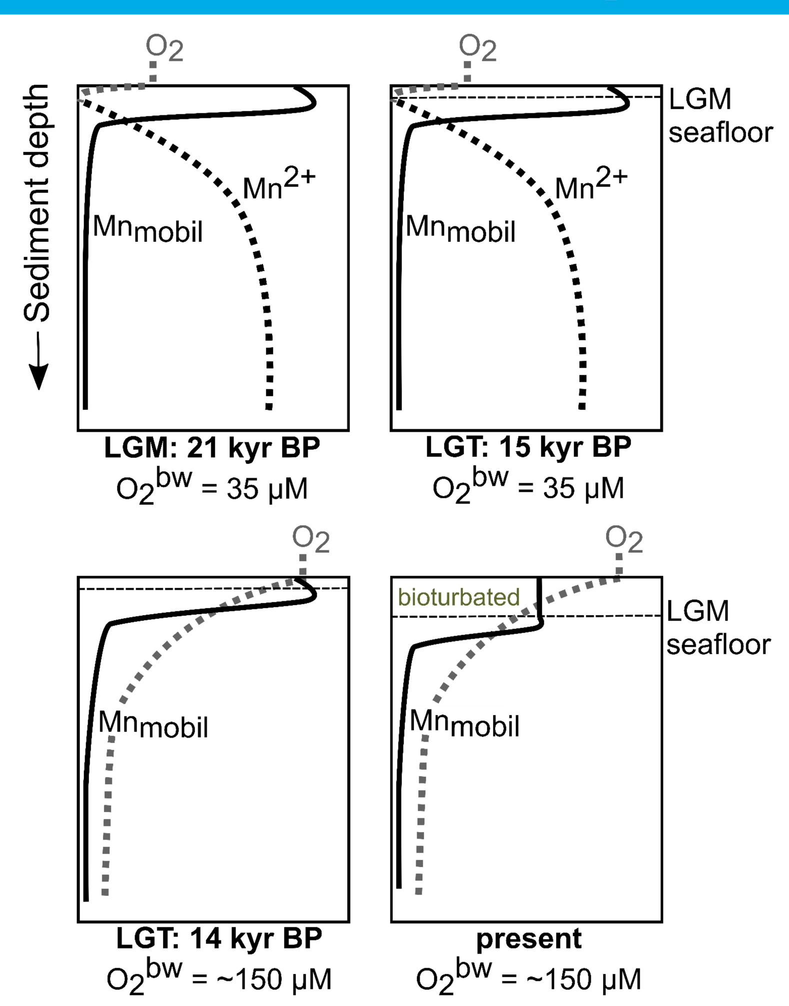
Glacial O_2^{bw} of 35 µM → oxic-suboxic boundary located in the upper 5 cm of the sediments → Near-surface authigenic Mn_{mobil} precipitation during the LGP → Downward migration of the oxic-suboxic boundary due to O_2^{bw} increase during the last glacial termination (LGT) → Continuous mixing of Mn_{mobil} into subsequently deposited oxic sediments due to bioturbation

Conclusions and Implications

- Lower O_2^{bw} during glacial periods caused more condensed redox zonation in Pacific sediments

➡ Authigenic Mn_{mobil} precipitation at shallow oxic-suboxic boundary in the upper 5 cm

- Ocean ventilation onset after glacial periods caused downward extension of the oxic zone
- Lower carbon burial rates at site APEI3 did not allow for a more condensed redox zonation during the last glacial period



- Deep basin-wide de-oxygenation in the glacial NE Pacific Ocean
- Polymetallic nodules in the European areas of the CCZ have experienced suboxic-diagenetic growth „pulses" during glacial periods
- Development of shallow oxic-suboxic redox boundary during lower glacial O_2^{bw} at carbon burial rates >1.5 mg m^{-2} d^{-1}

➡ Site APEI3 is not representative for the sites in the European exploration areas

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