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Foraminiferal U/Ca Constraints on Glacial–Interglacial Pacific Oxygenation and Carbon Storage

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Dissolved oxygen regulates marine biogeochemical cycles and is tightly coupled to ocean carbon storage and atmospheric CO_2 on glacial–interglacial timescales. To better constrain Pacific oxygenation changes, we follow a framework of proxy development, glacial comparison, and downcore application. We first calibrate authigenic U/Ca in mixed planktonic foraminiferal coatings as a bottom water oxygen proxy using 54 Pacific surface sediment sites spanning modern BWO of 8–210 μmol/kg. A robust correlation with ambient oxygen demonstrates that foraminiferal U/Ca reliably records bottom water oxygen concentration and has not been obscured by factors such as sedimentation rates or organic carbon fluxes. Applying this proxy to Holocene and Last Glacial Maximum sediments reveals a "sandwich-like" vertical structure in the glacial South Pacific, with better oxygenation in upper and abyssal waters but pronounced mid-depth deoxygenation. This pattern contrasts with the deep Atlantic and Indian Oceans, indicating basin-specific ventilation and enhanced carbon storage in Pacific intermediate waters during glacials. We further extend the approach downcore by generating a continuous 200 kyr redox record from intermediate depths on the Campbell Plateau, southeast of New Zealand. Multi-proxy data (U/Ca, Mn/Ca, Ce anomalies) show strongly suboxic conditions during MIS 2 and MIS 6 coinciding with AAIW shoaling and increased export production, and weaker depletion during MIS 4 when productivity remained low. Together, these results provides critical new insights into the mechanisms controlling intermediate-depth carbon storage across glacial cycles, with important implications for understanding the Pacific Ocean's role in atmospheric CO_2 variations.