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Characterization of Offshore Freshened Groundwater systems on the Ross sea shelf

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Offshore Freshened Groundwater (OFG) is increasingly recognized as an important component of continental shelf hydrogeology, yet its physical structure, geochemical evolution, and preservation mechanisms remain poorly documented in polar settings. This study characterizes OFG systems on the Ross Sea shelf using borehole porewater data from IODP (Integrated Ocean Drilling Program) Sites U1522 and U1524, with the aim of resolving their vertical structure, origin, and diagenetic state.

Depth-resolved porewater samples were analyzed for chloride, stable water isotopes ($\delta^{18}O$, $\delta^{2}H$), major cations and anions, and redox-sensitive species. Lithological information was used to assess stratigraphic controls on fluid distribution. A groundwater transport model was applied to evaluate the relative roles of diffusive and advective processes in shaping present-day porewater profiles.

Both sites host vertically stratified OFG systems comprising a saline, marine-influenced upper unit, an intermediate transition zone, and a deeper freshened interval preserved beneath finer-grained sediments. Downcore decreases in chloride and progressive depletion of $\delta^{18}O$ and $\delta^{2}H$ indicate dilution by a non-marine water source, while elevated Br/Cl ratios and smooth concentration gradients support long residence times and limited modern exchange. Redox profiles show sulfate depletion, ammonium enrichment, and methane production at depth, indicating active diagenetic alteration of the fluids. The transport model demonstrates that diffusion is the dominant control on present-day tracer distributions, with only minor or negligible vertical flow patterns.

The Ross Sea OFG systems at Sites U1522 and U1524 are therefore laterally extensive, vertically stratified, and geochemically evolved bodies, preserved through stratigraphic confinement and diffusion-dominated transport. Their characteristics reflect long-term isolation and water-rock interaction rather than active recharge phenomena, highlighting OFG as a stable subsurface reservoir and an archive of past hydrogeological conditions on polar continental shelves.