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Supersaturated N₂O in a perennially ice-covered Antarctic lake: Molecular and stable isotopic evidence for a biogeochemical relict

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ABSTRACT: The east lobe of Lake Bonney, a permanently ice-covered lake in the McMurdo Dry Valleys, Antarctica, has a mid-depth maximum N₂O concentration of 43.3 μmol N L⁻¹ (>700,000% saturation with respect to air), representing one of the highest concentrations reported for a natural aquatic system. δ¹⁵N and δ¹⁸O measurements indicate that this is the most isotopically depleted N₂O yet observed in a natural environment (minimum δ¹⁵N-N₂O of -79.6‰ vs. air-N₂; minimum δ¹⁸O-N₂O of -4.7‰ vs. Vienna standard mean ocean water), providing new end points for these parameters in natural systems. The extremely depleted nitrogen and oxygen isotopes, together with nitrogen isotopic isomer data for N₂O, imply that most of the N₂O was produced via incomplete nitrification and has undergone virtually no subsequent consumption. However, molecular evidence provides little support for metabolically active nitrifying populations at depth where the maximal N₂O concentrations occur and contemporary biogeochemical reactions cannot explain the extreme excesses of N₂O in Lake Bonney. The gas appears to be a legacy of past biogeochemical conditions within the lake, and in the absence of a significant sink and the presence of a highly stable water column, gradients in N₂O produced by past microbial activity could persist in the cold saline waters of Lake Bonney for >10⁴ years.

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