Critical Review of the Article: "Evidence of Dark Oxygen Production at the Abyssal Seafloor" by Sweetman et al. in Nat. Geosci. 1–3 (2024)

Authors ordered alphabetically as first co-authors:
Alden Denny* (Chief Geoscientist), Werner Svellingen* (CTO), Lars-Kristian Trellevik* (CSOO)
*Adepth Minerals, Bergen, Norway

Contact: post@adepth.no

Abstract

This review examines the findings and methodologies presented in Sweetman et al. (2024) (hereafter referred to as 'the paper'). The paper presents findings contrasting those of all previous comparable work and has stirred international debate pertaining to deep-sea minerals. We identify significant issues in data collection, validation, and interpretation including unvalidated data collection methods, the omission of crucial observations relevant for electrolysis processes, and unsupported voltage measurements which undermine the study's conclusions. These issues, coupled with unfounded hypotheses about early Earth oxygen production, call into question the authors' interpretation of the observations and warrant re-examining the validity of this work. Our analysis is driven by scientific curiosity of mineral related processes, as our company has no vested interests in nodule production.

Introduction

The paper describes the observation of abiotic oxygen production allegedly via electrolysis induced by nodules located within the Clarion-Clipperton Zone. The authors then tie this observation both to implications for potential mining activities and understanding of early Earth oxygen production. However, our review identifies several critical omissions and methodological flaws that call into question the study's reliability.

Methodological Review

Oxygen Production and Hydrogen Observations

- The oxygen optode observations appear to be robust and supported by Winkler titration measurements. However, the oxygen production trends fit best to a model comprised of an initial oxygen production (24 hours or less) followed by an oxygen consumption typical of deep-sea sediment processes. The papers steady state oxygen production values (given in paragraph two) are directly contradicted by this data trend.
- The paper lacks data or discussion on hydrogen observations, which from our understanding, are critical for validating the proposed electrochemical process. The omission of such data is a significant procedural shortcoming, and we therefore question the thoroughness of the research.

Electrolysis Observations

- The reported nodule-surface voltage value (0.95V) is insufficient to initiate seawater electrolysis and an outlier not supported by the data graph (Fig 2 and associated tables) where the highest given value is 0.24V. This discrepancy suggests either an error or selective data reporting, both of which are problematic.

- Excluding anomalous data from the figures but discussing it in the text without context can mislead readers and misrepresent the findings.
- Even if the 0.95V value was seen, the lack of reported current and the fact that this value is significantly below the voltage required for electrolysis eliminate electrolysis as an observed mechanism for oxygen production. While the authors of the paper admit the voltage is insufficient for electrolysis, their insistence on dark oxygen production from electrolysis is not in line with their evidence.

Lack of Validation for the Lander System

- The paper fails to validate the lander device used for data collection, either via presentation of baseline deployments of the system, or with bench-top experiments run on the benthic chamber system. Validation is crucial for ensuring the accuracy and reliability of the measurements.
- Potential issues such as stirring pumps introducing external energy inputs (e.g., ground faults, voltage leaking) are not addressed.
- The lander in question is designed in a way that increases the risk of energy transfer from the lander to the benthic chambers; particularly as stirring motors are mounted directly through sample chamber via a penetrator, which differs from other landers with an isolated motor design.
- The absence of data from other sensors, with only O_2 sensor readings and samples discussed, raises concerns about the comprehensiveness of the observations.
- No 'background' deployments of the lander in non-nodule areas are mentioned, without any rationale, potentially skewing the results and certainly prohibiting critical analysis of the results through use of reference samples.

Data Interpretation and Conclusions

- The final statement regarding early Earth oxygen production is fundamentally flawed. The formation of oxides (seafloor nodules) in anoxic water is chemically implausible, indicating either a profound misunderstanding or intentional misrepresentation of the geological and chemical context. Such a conclusion requires either significant revision or retraction due to its inaccuracy.
- The title of the article is misleading, suggesting broader and more definitive findings than the data supports. Accurate representation of the study's scope and limitations is essential for scientific transparency and credibility. To argue that this study presents "evidence", considering the questionable data, methodology and analysis presented, is an overreach.

Environmental Impact Comparison

The maximum oxygen production proposed in this paper still represents *magnitudes less* oxygen production than occurs over a similar area of forest. Should this phenomenon indeed occur naturally at the seafloor (something the paper fails to support), it is still a negligible factor in modern planetary oxygen production compared to terrestrial systems. This comparison further undermines the paper's implied significance of the findings.

Conclusion

Sweetman et al.'s observation of oxygen production in seafloor nodule environments presents is of significant scientific interest but is marred by critical methodological flaws, data omissions, and misinterpretations. This work reports unique observations bereft of a plausible formation mechanism. The lack of lander validation, inconsistent nodule voltage data, omission of crucial hydrogen observations, and erroneous conclusions about early Earth oxygen production necessitate a thorough revision or potential retraction of the paper. The level of care necessary to justify extraordinary claims with such broad implications is absent from the paper. The sensational claims within the paper are in direct opposition to all other published works. Rigorous validation, comprehensive data reporting, and accurate interpretation are imperative for advancing our understanding of seafloor nodule environments and their broader implications.

Recommendations

Given the outlined issues, we recommend the title of the article be more accurately renamed to "Observations of Possible Dark Oxygen Production at the Abyssal Seafloor" to reflect the tentative nature of the findings.

To uphold scientific integrity, it would be beneficial for the feedback provided during the peer review process to be published alongside the paper. This transparency would enhance understanding and trust in the scientific community.