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Iron-Rich Microbial Mats in the Lucky Strike Hydrothermal Field: Diversity, Adaptation, and Biogeochemical Dynamics

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In hydrothermal environments, diffuse fluid emanations create favorable conditions for the formation and expansion of iron-rich microbial mats. These ecosystems, characterized by steep physicochemical gradients, serve as critical interfaces between geothermal activity and microbial life. The Lucky Strike Hydrothermal Field (LSHF), situated approximately 400 kilometers southwest of the Azores archipelago along an active 65-kilometer segment of the Mid-Atlantic Ridge (MAR), represents a prime example of such environments. Since the establishment of the EMSO-Azores deep-sea observatory in 2010, continuous geophysical, geochemical, and biological monitoring has been conducted, enabling an in-depth exploration of vent ecosystem dynamics in response to environmental fluctuations.

This long-term observational framework has facilitated the systematic sampling of iron-rich microbial mats and black smoker hydrothermal fluids, providing invaluable insights into the interplay between microbial communities and their abiotic surroundings. For this study, iron-rich microbial mats were collected from diverse sites within the LSHF, including Lava Lake, West Sintra, Capelinhos, Y3, North Tour Eiffel, and South Isabel. These sites exhibit significant variability in mineral substratum composition and hydrothermal influence, offering a robust comparative basis for investigating microbial adaptation strategies.

To elucidate the mechanisms by which substratum and hydrothermal fluid compositions shape the taxonomic and functional diversity of iron-rich microbial mats, advanced molecular techniques—specifically 16S metabarcoding and metagenomic analyses—were employed. The results revealed a remarkable stability in microbial diversity over extended time scales, with notable deviations occurring primarily during geological events [1]. This underscores the potential of microbial diversity as a proxy for tracking such events. Furthermore, the study highlighted the profound influence of substratum and hydrothermal activity on both taxonomic and functional microbial diversity [2, 3], particularly in relation to the carbon cycle.

A focused analysis on iron-oxidizing Zetaproteobacteria uncovered a core microbiome shared across all sites, alongside site-specific operational taxonomic units (ZetaOTUs) [2]. These findings not only enhance our understanding of microbial adaptation in hydrothermal ecosystems but also emphasize the role of iron-oxidizing bacteria in shaping biogeochemical cycles in these extreme environments.

[1] Astorch-Cardona et al. (2023), *Front. Mar. Sci,* 10, 1038192.

[2] Astorch-Cardona et al (2024), *Appl. Env. Microb.*, e02041-23.

[3] Mendes et al (2026) (submitted).