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Arsenic-sulfide mineralization as a key mechanism for biomass preservation in seafloor massive sulfide hydrothermal diffuser chimneys

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The mineralization and preservation of biomass in diverse environments offer a critical window into the evolution and diversification of life over geological time, as well as the composition and structure of ancient ecosystems [1]. This process replaces organic material with minerals, ensuring long-term preservation[1]. The type and efficiency of mineralization depend on the chemical and elemental composition of the fossilization fluid, which determines the fossilization processes and minerals formed. Even though minerals are often associated with biological activity, such as pyrite formation driven by microbial sulfate reduction [2], the specific mechanisms of mineralization in hydrothermal environments remain poorly understood. We show that arsenic (As) sulfides play a key role in fossilizing diverse biological specimens within modern actively boiling, CO_2-degassing, Seafloor Massive Sulfide (SMS) diffuser chimneys from the Kolumbo submarine volcano, Hellenic volcanic arc [3]. These include exquisitely preserved diatoms from the open ocean, whose siliceous frustules are replaced by As-sulfides, microbial filaments—including twisted stalks resembling members of the *Zetaproteobacteria* iron-oxidizing bacteria and globules of unknown biological origin. Combining morphological features, spectroscopic data, geochemical composition, and metagenomic analysis, we demonstrate that As mineralization coincides with microbial activity. Our findings reveal that As-sulfide formation near hydrothermal chimneys acts as a critical agent for preserving whole biological specimens from both the water column and indigenous microbial communities. This suggests that hydrothermal chimneys, with their extensive As-sulfide mineralization, provide a unique medium for fossil preservation. These structures not only serve as sites of mineral formation but also as archives of ancient life, offering new insights into the interplay of geology, chemistry and biology in shaping the fossil record.

References

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