

Intrinsic Iron May Have Promoted Ancient Nervous Tissue Fossilization

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Remarkably, over the last decade, nervous tissues have been reported from fossils over 500 million years old.^[1] Such evidence is providing unique insights into the nascent evolution of animal nervous systems during the Cambrian Explosion, as well as helping to resolve phylogenetic ambiguities between basal animals. Yet these discoveries, from geological deposits like the renowned Burgess Shale, are not without controversy. Decay experiments on modern organisms have cast doubt on whether nervous tissues can even be fossilized at all. They show that nervous tissues from a variety of modern animals decay rapidly, and at a faster rate than other tissues that are not apparent in the new fossils.^[2] How are nervous tissues preserved in fossils in preference to other tissues that show greater resistance to decay?

In this issue, Saleh et al. propose a novel solution to this fossilization conundrum—a way to explain why nervous tissues are preserved in some fossils, not despite their propensity to decay but in part because of it.^[3] Inspiration for their hypothesis comes from the observation that some fossilized nervous tissues are mineralized in pyrite (FeS₂), replicating them in a long-lived mineral. Pyritization necessitates sources of iron, sulfate, and organic carbon—a lack of any can limit its formation. Organic carbon is a nutrient source for sulfate-reducing bacteria, which produce hydrogen sulfide necessary for pyrite formation. Limiting organic carbon reduces the amount of hydrogen sulfide that can be produced, and thus pyrite. However, Saleh et al. note that patterns of pyritization in these fossils suggest that it proceeded from the interior of decaying carcasses where the internal tissues themselves would have provided ample carbon. Instead, they propose that iron limitation governed selective pyritization. This is where the chemical composition of nervous systems may

have been critical. Saleh et al. hypothesize that ferritin, a metal-loprotein common to nervous systems, could have provided the necessary iron for pyritization. Ferritin stores iron in a mineral similar in structure to ferrihydrite, a mineral known to release large quantities of iron quickly. Fast-decaying nervous tissues would have released iron for pyritization. In contrast, other tissues with lower iron content would not have pyritized, eluding fossilization.

There are, however, reasons to be cautious about this hypothesized mode of fossilization. Far from being iron-limited, there is geochemical/mineralogical evidence that Cambrian seawater was enriched in iron, and that the iron-bearing mineral berthierine is unusually abundant in strata that preserve these exceptional fossils.^[4] Berthierine formation requires a concentration of iron within sediment pore waters—pore-water iron that would also have been available for fossil pyritization. Further, it needs to be understood whether other tissues that contain iron are also preferentially pyritized. What is the pattern of pyritization in fossils from Burgess Shale-type deposits? And it is notable that nervous tissues are known to be preserved as carbonaceous material in some Cambrian fossils, in the absence of pyrite.^[5]

Regardless of the specifics of nervous tissue fossilization, Saleh et al. highlight the importance of understanding the effects of original tissue composition on post-mortem mineralization and fossilization. Such effects have hitherto received less attention than the geochemistry of the sedimentary environment.


Conflict of Interest

The author declares no conflict of interest.

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