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Authigenic and early diagenetic minerals as indicators of geomicrobiological processes in shelly fossil preservation and their significance for late Neoproterozoic-early Palaeozoic near-surface environments

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Secular changes in near-surface environments during the late Neoproterozoic-early Palaeozoic critical transition significantly influenced geomicrobiological processes involved in fossil preservation. Although numerous investigations have examined the effects of these changes on the exceptional preservation of soft tissues, the vast majority of studies on shelly fossils have been focused on physical phenomena rather than geomicrobiological processes that affect biomineralized skeletal elements. To explore possible effects of the late Neoproterozoic-early Palaeozoic transition on shelly fossil preservation, we studied authigenic and early diagenetic minerals associated with phosphatic linguliformean brachiopods from the lower Cambrian Shuijingtuo Formation of Hubei, South China, and lower Cambrian Nolichucky Formation of Virginia, USA. These minerals—which include pyrite, barite, and silica—most likely formed within anoxic sediments in response to focused degradation of the shells' organic matrixes via microbial sulphate reduction. Organic matrixes, nonetheless, are preserved within some brachiopods in the Shuijingtuo Formation, suggesting that they survived the focused geomicrobiological processes. Overall, when considered in the context of the late Neoproterozoic-early Palaeozoic critical transition, the authigenic and early diagenetic minerals suggest oxygenation of near-surface environments may have profoundly impacted shell preservation by deepening the aerobic zone of microbial activity in which shells' organic matrixes are most aggressively degraded, and thereby, promoting development of environments favouring complete organic matrix degradation. As a result, the frequency of organic matrix preservation within shells likely declined, and shells' biominerals may have become more susceptible to dissolution (as organics counterbalance the effects of undersaturated water and high biomineral surface areas). Thus, our observations suggest that the critical transition may have influenced the preservational potentials of both skeletal elements and soft tissues.