Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31715

Facies-Driven Shifts in Mo and U Sequestration during a Transgressive Event: Evidence from Northeastern Estonia

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We report new isotopic and geochemical evidence from the Aseri PH012B drillcore in northeastern Estonia that provides fresh insights into the controls on redox−sensitive metal enrichment in Tremadocian black shales. High-resolution analyses using multi-collector ICP-MS on a suite of twenty samples reveal a counterclockwise paired δ98Mo–δ238U trend, with δ98Mo values spanning from −0.89‰ to +2.03‰ and δ238U values ranging from −0.27‰ to +0.52‰. The basal section, characterized by extreme Mo hyper-enrichment, exhibits the lightest δ98Mo and heaviest δ238U signatures, whereas an upward transition to a U-dominated enrichment regime is marked by a pronounced lightening of δ238U. We interpret these shifts as evidence for a change in the dominant mechanisms of Mo and U sequestration in response to facies changes during a transgressive event. Ultra-slow sedimentation rates (0.6–1.0 mm/kyr) and rising sea levels in a shallow epicontinental setting under super greenhouse conditions prolonged seawater–sediment interaction, thereby promoting diffusion-controlled uptake of Mo and U under euxinic conditions. Moreover, recycling of Fe–Mn oxides near the redoxcline likely enhanced Mo sequestration. This study underscores the importance of local depositional dynamics in modulating metallogeny and provides new constraints on the interplay between redox processes and trace metal cycling in Early Ordovician marine environments.