Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31096

REE and U enrichment in the early Cambrian phosphate deposits or nodules, South China

HONGJIE ZHANG[1,2] AND HAIFENG FAN[1]

[1]Institute of Geochemistry, Chinese Academy of Sciences
[2]Centre de Recherches Pétrographiques et Géochimiques

During the Ediacaran-Cambrian transition, marine sedimentary phosphorites were extensively developed worldwide. Phosphorites are not only an important resource for phosphorus (P) itself, they also contain significant associated resources of rare earth elements (REEs) and uranium (U). However, only a few phosphate deposits or nodules show exceptional REE (>1000 ppm) and U (>100–200 ppm) enrichment, and the mechanisms behind this enrichment remain unclear. To better understand the processes governing REE and U enrichment, we investigated three early Cambrian phosphatic sedimentary units in South China: the low-REE (~200–400 ppm) and low-U (~10–20 ppm) Meishucun phosphorites (inner-shelf phase), the high-REE (~1000–2000 ppm) and low-U (~8–15 ppm) Zhijin phosphorites (outer-shelf phase), and the high-REE (~1000–3000 ppm) and high-U (~100–200 ppm) P-nodules (slope phase) from the Nanhua Basin, South China. Mineralogical data and in-situ REE mapping suggest that the Meishucun phosphorites underwent more intensive diagenetic alteration than the Zhijin phosphorites. Consequently, the extraordinary REE enrichment in the Zhijin phosphorites cannot be ascribed to diagenetic alteration, but diagenetic alteration may explain the slightly elevated U content in the Meishucun phosphorites. Notably, the δ^{56}Fe values near 0.0‰ in the Meishucun phosphorites indicate a fully oxic depositional environment, while the ~0.2–0.4‰ δ^{56}Fe values in the Zhijin phosphorites suggest suboxic conditions. In contrast, the ~0.4–2.0‰ δ^{56}Fe values in the P-nodules point to a completely anoxic environment. These δ^{56}Fe variations likely reflect redox-stratified water columns in the early Cambrian Nanhua Basin, which align with earlier redox studies. Importantly, the positive δ^{56}Fe values in the outer-shelf Zhijin phosphorites and slope P-nodules may record frequent iron redox cycling under suboxic conditions, which could significantly enrich REEs in porewater. These REEs were subsequently incorporated into apatite during early diagenesis inducing exceptional REE enrichment in the Zhijin phosphorites and slope P-nodules. Additionally, U^{6+} reduction and deposition under strongly anoxic conditions could explain independent enrichment of U in the slope P-nodules. Therefore, the redox gradients within the early Cambrian Nanhua Basin could have determined the REE and U enrichment as well as their differentiation among the phosphatic sedimentary units.