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Refining SEDEX for optimal separation of authigenic and detrital apatite in sedimentary rocks

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SEDEX is a sequential extraction method used to separate and quantify different phases of phosphorus (P) in sediments, soils, and rocks [1]. It was originally developed for marine sediments and optimized to separate authigenic apatite (primarily as carbonate fluorapatite or CFA, commonly referred to as P-auth) that precipitates in marine sediments during early diagenesis, from non-reactive detrital apatite (P-det) of igneous or metamorphic origin. Application of the SEDEX method to sedimentary rocks is a powerful technique to reconstruct ancient P and redox cycling [2]. However, sedimentary rocks have commonly undergone burial and heating, which may lead to recrystallization of CFA. In SEDEX extractions, this is a known issue that can cause CFA to become more resistant to dissolution and instead be extracted in the P-det step [3]. To determine the extent of this issue, and to develop a methodological framework for alleviating it, we performed multiple P-auth extractions on early mature Silurian–Devonian deep-water shales and siltstones. We found that we were able to extract substantially more CFA (up to a tenfold increase) with multiple (≥3) extractions relative to the standard one-step extraction. In addition, we find that this revised methodology can result in notable changes in stratigraphic trends in both P-auth and P-det. These results also indicate that the effects of CFA recrystallization may not impact all samples in a stratigraphic section equally (even under relatively uniform thermal maturity), with a more pronounced effect for samples with higher total P and carbonate content. Studies that rely on accurate quantitative estimates of P-auth, for example geochemical modeling of carbon cycle feedbacks, should consider modifying the original SEDEX method to include multiple sequential P-auth extractions to ensure adequate separation of P-auth from P-det.

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