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Dissolution methods for strontium isotope stratigraphy: Guidelines for the use of muddy, dolomitic limestone

XI CHEN, YING ZHOU AND GRAHAM A. SHIELDS

University College London

Presenting Author: helen.xi.chen.19@ucl.ac.uk

In recent years, various sample preparation methods have been developed to extract a primary Sr isotope signal from carbonate rocks. However, there has been little consensus on the best method due to natural variability in sample purity and mineralogy. For this study, we conducted systematic leaching experiments, focussing mainly on generally less favoured argillaceous and dolomitic limestone, using samples from the Mesoproterozoic Gaoyuzhuang Formation. A multistep leaching approach was applied to explore strontium isotope leaching patterns for each type of rock and extract the nearest-to-primary chemical composition. For muddy and dolomitic limestone, after ammonium acetate (NH_4Ac) prewash, the first 20%-30% weak acid leach shows the lowest, most primary seawater $^{87}Sr/^{86}Sr$ ratios. The corresponding lowest Rb/Sr and Mg/Ca ratios suggest that this leach corresponds to a relatively pure, “clay-free” calcite component. Further dissolution significantly increased the measured $^{87}Sr/^{86}Sr$, Rb/Sr, Al/Ca, and Mg/Ca ratios, which might indicate dissolution of both detrital aluminosilicate and dolomite. The REY pattern of each leaching step was also examined. In most cases, seawater-like REY patterns with highest Y/Ho ratios (mostly>36) occur in the first leaching step after ammonium acetate prewash, which is consistent with the Sr isotope study. One exception lies in an organic-rich sample (TOC_{total} ~1.3%) with a near-seawater Sr isotope value but a non-seawater-like REY pattern, indicating that organic matter remineralization during early diagenesis may alter the REY pattern of carbonate rocks but not necessarily Sr isotopes. We also applied a previously proposed leaching method [1] (acid pre-leach for 30% followed by further 40% dissolution) for the same muddy, dolomitic carbonate rocks, leading to $^{87}Sr/^{86}Sr$ values up to 0.001 higher than targeting the first 20-30% directly after NH_4Ac prewash. However, no significant differences were evident for high purity, low Mg/Ca limestones. This observation emphasizes the importance of matching different sample types to the most appropriate dissolution method. Muddy, dolomitic limestones could potentially help fill gaps in the Precambrian seawater Sr isotope curve, especially when high purity limestone successions are not readily available.

[1] Bailey, T.R., McArthur, J.M., Prince, H., Thirlwall, M.F., 2000. Dissolution methods for strontium isotope stratigraphy: Whole rock analysis. Chem. Geol. 167, 313–319.