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Compositional evolution of the upper continental crust: Perspectives from Machine Learning

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The composition of the Archean upper continental crust (UCC)—whether mafic or felsic—remains debated due to tectonic uncertainties and proxy limitations [1-6]. Here, we employ machine learning (Random Forest Regression) to analyze multi-element geochemical data from terrigenous sedimentary rocks and reconstruct the chemical evolution of the UCC over Earth's history. By training the model with geochemical data from Archean and post-Archean igneous rocks, we are able to precisely predict the bulk MgO content of the igneous source rocks of terrigenous sedimentary rocks. We also demonstrate that the accuracy of the predictions is not sensitive to tectonic settings. Our results reveal a systematic decline in MgO content (8–10 wt.% to ~4 wt.%, Figure 1) and a shift from mafic (70–90% komatiite-basalt) to felsic dominance (~60–80% granite) by ~2.5 Ga (Figure 2), mirroring the composition of the modern UCC. This rapid transition may have promoted the elevation of continents and potentially exposed them above sea level, initiating element cycling between continents and oceans.

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