An algorithmic intercomparison of geochemical proxies for reconstructing the nature of Earth's emerged continents

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In order to understand when plate tectonics started and how the fluxes of biochemically important elements varied with time, it is necessary to first accurately reconstruct how the composition of the Earth's emerged continental crust has changed through its history. Several recently-published studies, based on analyses of shale geochemistry, suggest the Earth's continents were predominantly mafic during the Archaean. However, these studies are based on elements such as Zn, U, Cr, and others which are likely prone to post-depositional remobilisation during weathering. Other proxies can be affected by the presence of komatiites, which would also confound geochemical reconstructions. A recent study using Ti isotopes, which should be resistant to weathering, indicates a predominantly felsic crust even 3.5 billion years ago. It is important to understand why the results of these studies diverge, and which of the available proxies accurately reconstruct the actual nature of the Earth's continents.

In this study, we conduct a systematic intercomparison of many geochemical systems to understand their relative strengths and weaknesses. We employed a grid search algorithm to find those most robust to measurement error. We then conducted a literature study to assemble a database of geochemical measurements of shales, distributed throughout the Earth's geological record. To further improve our analysis we also employed a hyperdimensional filtering process, based on local data density, to strip our database of extensively weathered samples.

After selecting our geochemical systems and filtering our data, we employed a mixing model to determine the relative contributions of komatiitic, mafic, and felsic material to the emerged continental crust over the last 3.5 billion years. We also identified which systems could accurately estimate the modern-day composition of the continents. We found that for all such systems a large continuous felsic input is required, starting from at least 3.5 billion years ago, to explain the shale compositions observed in the geologic record.