



Can discriminant diagrams tell us something about Archaean geodynamics?

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Discriminant (or geotectonic) diagrams are a popular way to interpret geochemical (mostly trace elements) data. In essence, these diagrams attempt at linking a specific geochemical signature with a geodynamical environment. Most diagrams differentiate an enriched vs. depleted mantle source (OIBs vs. MORBs), and try to evidence a fluid component (arc signature).

Using such diagrams for Archaean rocks implicitly makes extremely strong assumptions – namely, that during this period of Earth's history, geodynamical sites similar to the one present on modern Earth existed. However, even if one takes this for granted, the use of these diagrams during Archaean times is seriously limited by effects related to secular changes of Earth's composition:

1) The continental crust has essentially an “arc” signature (whether or not it formed in such settings). It has been extracted from the mantle, presumably some times during the Archaean. Therefore, prior to the extraction of the continental crust, Earth's mantle had a geochemical signature intermediate between arc and “normal” mantle; discriminant diagrams consequently assigns, by construction, an arc affinity to far too many Archaean mantle-derived rocks, whether they are or not related to subduction (or similar processes).

2) Archaean mafic rocks, collectively, lack the evidence for very depleted or very enriched signatures, suggesting a mantle far more homogeneous and less stratified than the modern mantle. The geochemical distinction between MORBs and OIBs is therefore less appropriate during Archaean times, and in any case can not be used as a tectonic indicator. Even if a distinct oceanic crust existed during the Archaean, it is unlikely it had a MORB signature.

As a result, even if one assumes similar geodynamic sites in the Archaean, their geochemical signature can be predicted to be different from the modern situation.

On the other hand, petrogenetic scenarios such as melting of amphibolites, that were probably common in the Archaean, are now rare, and are therefore ignored by geotectonic diagrams: rocks formed by such processes will be misclassified randomly.

The use of discriminant diagrams in the Archaean is therefore dangerous, and leads to circular reasoning in the best case; by construction such diagrams can only predict petrogenetic and geodynamic scenarios matching the ones existing in the modern Earth.