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Tectonic Implications of the Combined Use of Tectonomagmatic Geochemical Discrimination Diagrams and Indicators of Magma Flow Sense in Mafic Dykes

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Geochemistry is a powerful tool to help characterize the tectonic setting of igneous rocks associations. However, when continental mafic dykes and flood basalts are the target most of the proposed geochemical discrimination diagrams fail to correctly classify them, i.e. many mafic dykes and flood basalt data fall in the geochemical fields of ocean ridge and/or destructive plate margin settings. There are several petrological explanations for this paradox, the most common of which are crustal contamination, degree of mantle melting, and mantle source characteristics. The former is quite easy to understand because during its ascent from the mantle to the crust the hot basic magma is prone to contamination with pre-existing rocks. The second, i.e., low amount of mantle partial melting will produce magmas more alkaline and enriched in incompatible elements, chemically similar to ocean island basalts (some mafic dykes are like that). Conversely, a high proportion of mantle partial melting will produce a sub-alkaline and incompatible element depleted magma similar to mid ocean-ridge (MORB). Third, Mantle source characteristic is very complex and includes processes such as mantle enrichment by fluids and melts, and mixing of mantle and sedimentary rocks in subduction zones all of which eventually giving rise to a heterogeneous sub-continental lithospheric mantle.

We have plotted geochemical data for key continental mafic dyke swarms in new multi-dimensional discrimination diagrams to assess how the tectonic setting varies along the strike. We have noticed that the farther away the sample is located from the proposed magma plumbing system (e.g. at a rifted continental margin) the tectonic setting is correctly indicated from the data as within-plate [either as ocean island (OIB) or continental rift (CRB) basalts], or is very close to that tectonic field. Dyke samples closer to the proposed magma sources may erroneously be classified as originated in island arc or ocean floor settings. In these cases, and like many other diagrams (e.g. the Ti-Y-Zr and Th-Hf-Ta diagrams), the new multi-dimensional discrimination diagrams fail to infer the tectonic setting of mafic dykes. The main outcome of this finding is that if one wants to use mafic dyke swarms for tectonic reconstruction of orogenic belts and cratons with mafic dykes-hosting exotic terranes it is interesting to have geochemical data along the dykes' strike to infer where the magma plumbing system was located. When field features of magma flow direction, such as branching, rotate xenoliths, crystal tiling, and sigma- and delta-shape crystals, is combined with geochemistry the final interpretation from the use of discrimination diagrams might be even more robust.

In summary, the combination of along dyke swarm tectonic setting geochemical variation with field indicators of magma flow sense can more confidently help locate where the magma plumbing system was, and eventually reconstruct the rifted margin of continents or their exotic fragments. This approach may be more useful in areas of complex geological evolution such as ancient orogenic belts and cratonic areas.

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