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Spatial variability in Karoo dolerites

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The Karoo Large Igneous Province (KLIP) in South Africa consists of both a spatially limited extrusive basalt suite (Drakensberg Group) and a spatially extensive dolerite suite, both generally considered to be remarkable homogenous and of a “low-Ti” character (Luttinen, 2018). The homogeneity of the rocks requires that statistical analysis is necessary to look for spatial and geochemical trends in the data, which may yield clues to the mantle processes producing the 60 000 km^2 expanse of basaltic magma. In this project, data derived from several locations are used as proxies to check for lateral variability in the Karoo dolerites. A principal component analysis (PCA) on trace element data using a covariance matrix was performed, and comparisons based on variables that are 1) common to the Karoo dolerites and Lesotho basalts and, 2) responsible for the most amount of variation to the data set are made. Trace element modelling is then used to test different mantle melting scenarios possibly responsible for the variation seen in the dolerites.

Principal component analyses revealed several trace elements are responsible for most of the variability in the dolerites. Cr and Ni has the strongest positive loading on Component 1 whereas Cr and Ba has the strongest positive loading on Component 2. Ba has a strong negative loading on Component 1. Cu, Sr, V and Zr do impart an appreciable amount of variation to the data, but all four variables have weak negative loadings on both components. Interestingly, the activity of Cu and V seems to be the inverse of that of Cr and Ni.

Due to the nature of a PCA, this work is afforded an opportunity to place the geochemistry of the Karoo dolerites within a larger geodynamic context without bias. From the observed variation, the activity of Ba and Cr is interpreted as an assimilation-oxidation process, whereas the Ni signature reflects the mantle origin of the magmas. Further modelling of these processes will allow the testing of suggested mechanisms for the formation of the KLIP, especially whether the magmatism is plume-related or related to the foundering of crustal blocks.

Luttinen, A., 2018. Bilateral geochemical asymmetry in the Karoo large igneous province. Scientific Reports, 8(5223).