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Identifying the tectonic settings of Archean greenstone belt-basalts: A Machine Learning approach

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The debate on the probable tectonic setting for the emplacement of basaltic and related rocks of Archean greenstone belts is yet to be settled. Given that exposures of Archean greenstone belts are limited, and that the complexities in their chemical signatures do not permit an unambiguous classification of the rocks of the belts based on their tectonic setting, a machine learning approach is expected to give better insights into the geochemical data for the tectonic classification of Archean basalts.

Random Forest and K-Nearest Neighbour algorithms were utilized for training a model using 80% of the trace element data from the voluminous GEOROC database for basalts from diverse geological settings. The models were tested on rest of the GEOROC database for basalts. The test result returned an average accuracy of about 80% considering all the geological settings, namely Continental Flood Basalts, Convergent Margins, Intraplate Volcanic rocks, Ocean Islands, Seamounts, Ocean Basin Flood Basalts, Oceanic Plateaus, Rift Volcanic rocks and Submarine Ridges. The variables that were assigned as features in the machine learning model were trace element concentrations and trace element ratios that are normally considered to be discriminatory for tectonic settings, such as REEs, Nb/Nb*, Th/Yb to name a few.

The advantage of using the machine learning model in identifying basalts of unknown tectonic settings is two-pronged: 1. Simultaneously multiple variables can be considered for determining the probability of a tectonic setting; 2. The probabilities obtained using machine learning models will come handy in supporting or opposing the interpretation based on traditional methods of arriving at the tectonic setting using multiple bivariate and ternary plots. Defining the basalts from the greenstone belts of Dharwar craton as unknown, which are generally interpreted to be of convergent margin-origin, the machine learning model also suggested the same tectonic setting for a majority of the basalt samples. In terms of probabilities obtained from the machine learning model, a convergent margin-setting is favoured over an intraplate-setting for the Dharwar basalts. Therefore, in addition to conventional interpretation, a data-driven machine learning approach could assist in unravelling hidden information from large geochemical data.