

Machine learning-based geochemical discrimination of magmatic tectonic settings

*Kenta Ueki¹, Hideitsu Hino², Tatsu Kuwatani^{1,3}

1. Japan Agency for Marine-Earth Science and Technology, 2. Graduate School of Systems and Information Engineering, University of Tsukuba, 3. PRESTO, Japan Science and Technology Agency (JST)

Geochemically discriminating between magmatism in different tectonic settings is a fundamental part of understanding the processes of magma generation within the Earth's mantle. Here, we present an approach where machine-learning (ML) methods are used for quantitative tectonic discrimination and feature selection using global geochemical datasets containing data for volcanic rocks generated in eight different tectonic settings (Back-arc basin, Continental arc, Continental flood, Island arc, Intra-oceanic arc, Mid-ocean ridge, Oceanic island and Oceanic plateau).

This study uses three ML methods; support vector machine (SVM), random forest (RF), and sparse multinomial regression (SMR). We found that SMR is a particularly powerful and interpretable method because it quantitatively identifies geochemical signatures that characterize the tectonic settings of interest and the characteristics of each sample.

All Three ML methods with data for 20 elements and 5 isotopic ratios allowed the successful geochemical discrimination between igneous rocks formed in eight different tectonic settings. The results show that magmas formed in different tectonic settings have unique geochemical signatures, indicating that magma generation processes are closely connected to the tectonic setting. Our results indicate that ML is a highly effective tool in geochemical research that it is particularly useful for the analysis of high-dimensional and huge geochemical datasets.

Keywords: Machine learning, magma process, Tectonic setting