Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24487

A Machine Learning and Statistical View of Oceanic Island Basalts

PROF. WILLIAM M. WHITE, PHD[1], MATTHEW G. JACKSON[2] AND SUNNA HARDARDOTTIR[2]

[1]Cornell University
[2]University of California, Santa Barbara
Presenting Author: wmw4@cornell.edu

Most oceanic island basalts (OIB) are products of mantle plumes rising from regions of slow s-wave velocities in the deep mantle known as Large Low S-wave Velocity Provinces (LlSVPs). Mantle plumes contain both materials subducted from the Earth's surface as well as noble gas and tungsten from a source that has been sequestered from the rest of the mantle for most of Earth's history. In this study, we use statistical and unsupervised machine learning techniques of agglomerative and hierarchical clustering analysis based on T-distributed Stochastic Neighbor Embedding (T-SNE) of isotope ratios to identify compositional relationships among mantle plumes. Results reveal the following (Figure 1): 1. Clustering analysis of isotope ratios robustly identifies a unique HIMU composition that is restricted to the Macdonald and St. Helena hotspots and is absent from others. 2. Clustering analysis also consistently identifies an EM I cluster consisting of Tristan, Gough, Kerguelen, Heard, and Pitcairn ± Loa, an EM II cluster consisting of Samoa, Society, and Marquesas, and somewhat less consistently a 'LOND' cluster consisting of Reunion, Comoros, Crozet, Juan Fernandez, and Desventurados hotspots. A "depleted" cluster consisting of Iceland ± Galapagos, Kea, and Caroline is also identifiable. Clustering of the remaining 'so-called' PREMA hotspots tends to be inconsistent. 3. There is no identifiable 'PREMA', 'C', or 'PHEM' mantle component with high $^{3}He/^{4}He$ or low μ_{182W} signal that contributes to Sr, Nd, or Hf isotope compositions. However, T-SNE and agglomerative clustering hint at a relationship between high $^{3}He/^{4}He$ and Pb isotope ratios similar to that noted by [1] and not apparent in two-dimensional plots. The correlation between high $^{3}He/^{4}He$ and low μ_{182W} along with the moderately siderophile behavior of W, the likely enrichment of the core in Pb, and the association of high $^{3}He/^{4}He$ with high plume buoyancy flux, suggests that the 'primordial' $^{3}He/^{4}He$ is derived from the Earth's core. While machine learning identifies distinct clusters of isotopic compositions, they provide no evidence that these clusters result from mixing of unique "components."

[1] Hanan, B. B.; Graham, D. W. *Science* 1996, *272*, 991-995.