

Water enrichment in plume-derived magmas revealed by machine learning

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Many hotspots and large igneous provinces (LIPs) are thought to incorporate recycled subducted materials. Studies of submarine basalt glasses from some hotspots, particularly those from EM localities, proposed that they are depleted in water by low H_2O/Ce . However, recent analyses of melt inclusions and clinopyroxene from the Samoan and Cook-Austral Islands indicate wetter mantle sources [1,2], implying the previous low H_2O/Ce of glasses may result from degassing. Besides, subaerial magmas also record valuable information about reflecting the recycled materials, while the ubiquitous degassing has hindered detailed investigations. Machine learning provides a powerful tool for analyzing high-dimensional datasets, identifying underlying patterns and predicting unknown outcomes based on learned relationships. This method offers an opportunity to reconstruct the original water concentrations of both submarine and subaerial magma, enabling a better understanding of degassing and mantle heterogeneity. We compiled and selected melt inclusion data, whose water contents and essential major and trace elements have been determined, from oceanic island basalts (e.g. Hawaii, Iceland, Galapagos, and Samoan) and LIPs (e.g. Siberian Trap, and Yellowstone-Snake River province), from the GEOROC database. Then we developed machine learning regression models to predicted water contents of melt inclusions based on their major and trace elements. The best-performed CatBoost model shows R^2 of 0.903 and a RMSE of 0.169 wt% for the test set, indicating a robust capability. The model was applied to the basalts from global other well-studied OIBs and LIPs. The results show the H_2O/Ce ratios of these plume-derived magma are mainly equal to or higher than the mid-ocean ridge basalts (~150-280), challenging the notion that subducted slabs are entirely dehydrated. These findings highlight the necessity of reevaluating the dehydration mechanisms of subducting slabs and the water abundance as well as distribution in the deep mantle.

[1] Anderson, Jackson, Pamukçu, Rose-Koga, Le Roux, Klein et al. (2024), *Chemical Geology* 651, 121979.

[2] Bruce-Etzel, Marshall & Lassiter (2024), *Contributions to Mineralogy and Petrology* 179(9), 83.