Elemental abundance distributions in suboceanic basalt glass: Evidence of biogenic alteration

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Abstract: The alteration of subseafloor volcanic glass from three locations is qualitatively attributed to biological (biotic) or chemical (abiotic) reactions on the basis of microscopic morphology of the boundary between the unaltered and altered glass. Eleven-element composition of fresh basalt glass (sideromelane) and its alteration products were determined by electron microprobe. Principal component analysis (PCA) using these eleven elements as input (Na^{11}, Mg^{12}, Al^{13}, Si^{14}, P^{15}, Cl^{17}, K^{19}, Ca^{20}, Ti^{22}, Mn^{25}, and Fe^{26}) extracts three factors accounting for 80.5% of the variance in the data. These three factors can serve as inputs to a hierarchical cluster analysis (HCA) algorithm for data-driven discovery of three sample classes. This autonomous classification agrees with the petrographic microscopic classification in 14 of 15 biotic clay analyses. From a set of 34 analyses identified microscopically as abiotic clay the autonomous system identifies 4 with elemental abundance characteristics similar to the biotic clay and 4 similar to unaltered glass. PCA factors are then used as inputs to train an artificial neural network to produce a Bayesian probability of correct classification using the classes discovered by HCA. Mean Bayesian probabilities of correct classification for abiotic clays, biotic clays, and glass were 76.1 ± 8.5%, 64.9 ± 9.0%, and 77.0 ± 7.2%, respectively. Interestingly, in the 9 of 74 cases where visual and elemental analysis disagree, the Bayesian probability estimate of correct classification using only elemental abundance data is low (60.0 ± 11.7%) compared to analyses where visual and elemental data agree (75.5 ± 7.8%). To our knowledge, this is the first demonstration of a quantitative method for discrimination of biotic and abiotic alteration of subocean basalt glass. As such, the techniques make possible the systematic assessment of the impact of microbial life on subsurface basalts.

Keywords: Ocean Drilling Program; basalt; microorganisms; elemental abundances; artificial neural networks; Bayesian probabilities.
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