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Using machine learning to better quantify the frequency and distribution of explosive volcanism in the Alaska-Aleutian arc

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Alaska contains over 130 volcanoes and volcanic fields that have been active within the last two million years. Of these, roughly 90 have erupted during the Holocene, with many characterized by at least one large, explosive eruption. These large tephra-producing eruptions (LTPEs) generate orders of magnitude more erupted material than a “typical” arc explosive eruption and distribute ash thousands of kilometers from their source. Because of this, they pose significant threats to both people and infrastructure. Quantifying LTPE frequencies, then, is paramount in developing accurate hazard assessments for Alaska volcanoes. Because LTPEs occur infrequently, however, and the proximal explosive deposit record in Alaska in generally limited to the Holocene, we require a method that links distal deposits to their source where correlative proximal deposits are no longer preserved.

Here we present a new model that accurately links distal tephra deposits from ocean drill cores in the Gulf of Alaska to their most probable source volcano by using a combination of *in situ* major and trace element geochemistry, machine learning, and some basic logic constraints (e.g., prevailing wind directions and Ash3D tephra dispersal model results). To illustrate the effectiveness of our model, we generate probabilistic maps of potential source volcanoes for late Pleistocene and younger tephra layers found in IODP cores U1417 and U1418. These maps help us to better identify LTPE event sources and their ash distribution throughout the Alaska-Aleutian arc during that time period. We also show that proximal LTPE tephra samples across the arc that have been positively linked to their source through field mapping or radiometric dating can reliably be used as training data for a family of robust machine learning classifier algorithms (e.g., Random Forest, Extremely Random Trees, etc.). Ultimately, this permits establishment of a model that has the capability to evolve and become more accurate as new data become available. Our findings increase understanding of spatial and temporal distribution of explosive volcanism in the Alaska-Aleutian arc and provide a methodology that may be applied to other volcanic arcs around the world.