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Application of machine learning techniques, microanalyses and large geochemical datasets for tephra studies in complex volcanic areas: new age constraints for the Pleistocene magmatism of Central Italy

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Characterization, correlation, and provenance determination of tephra samples in sedimentary sections (tephra studies) are powerful tools for establishing ages of depositional events, volcanic eruptions, and tephra dispersion. Despite the extensive literature and the advancements in this research field, the univocal attribution of tephra deposits to specific volcanic sources remains too often elusive. In this contributions, we test the application of a machine learning technique to attempt shedding new light upon tephra deposits related to one of the most complex and debated volcanic regions on Earth: the Pliocene-Pleistocene magmatism in Italy. The machine learning algorithm was trained using one of the most comprehensive global petrological databases (GEOROC). A total of 16 chemical elements including major (SiO2, TiO2, Al2O3, Fe2O3T, CaO, MgO, MnO, Na2O, K2O, P2O5) and selected trace (Sr, Ba, Rb, Zr, Nb, La) elements were chosen as input parameters. We first show the ability of support vector machines in discriminating among different Pliocene-Pleistocene volcanic provinces in Italy and then apply the same methodology to determine the volcanic source of tephra samples occurring in the Caio outcrop, an Early Pleistocene sedimentary section located in Central Italy. Our results show that: 1) support vector machines can successfully resolve high-dimensional tephrochronological problems overcoming the intrinsic limitation of two- and three-dimensional discrimination diagrams; 2) support vector machines can discriminate among different volcanic provinces in complex magmatic regions; 3) in the specific case study, support vector machines indicate that the most probable source for the investigated tephra samples is the so-called Roman Magmatic Province. These results have substantial geochronological and geodynamical implications

suggesting new age constraints (1.4 Ma instead of 0.8 Ma) for the starting of the volcanic activity in the Roman Magmatic Province.