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LAVA: A machine learning method for predicting absolute paleointensities from pseudo-Thellier data

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Reliable paleointensity estimates are crucial for understanding past behavior of the Earth's magnetic field but remain difficult to obtain using traditional methods. Conventional thermal Thellier paleointensity experiments often have low success rates for volcanic samples, as repeated heating can induce alteration. Heating can be avoided by using the pseudo-Thellier method, in which samples are magnetized using alternating fields. However, pseudo-Thellier experiments intrinsically yield only relative paleointensities.

Over the past years, several attempts have been made to calibrate pseudo-Thellier results to absolute paleointensities for lavas by relating laboratory-induced anhysteretic remanent magnetizations (ARMs) to the thermally acquired natural remanent magnetizations (NRMs). Because magnetization depends on factors such as magnetic grain size, shape, and minerology, simple linear models struggle to consistently predict paleointensities across varied datasets.

Here, we present LAVA (Learning Absolute paleointensities from Volcanic ARMs), a machine learning approach that predicts absolute paleointensities from pseudo-Thellier data. Machine learning methods are well suited to model highly non-linear and complex relationships between ARM and NRM. LAVA was calibrated and tested using two datasets: a synthetic laboratory-induced datasets and a dataset of recently cooled volcanic products from diverse volcanic settings and geographic locations whose natural remanent magnetizations span the full range of observed geomagnetic field strengths. LAVA outperforms existing pseudo-Thellier interpretation techniques, by predicting the paleointensity for every volcanic site in the natural dataset within 5.6 μT and with an average error of 1.3 μT. These results demonstrate that LAVA provides a robust new tool for recovering absolute paleointensities from volcanic rocks.