Appendix S1. Cryptotephra extraction methods

Due to the extremely low abundance of cryptotephra in our samples (3 shards/gram), we modified the methods following procedures successfully employed in Smith et al. (2018). Samples were air-dried, weighed, and placed in 10 mL of 10% HCL to remove any carbonates. The material was then rinsed with distilled water and wet-sieved into a 20-80 μm grain size fraction. Lithium metatungstate (LMT) heavy liquid at densities of 2.2 g/cm^3 and 2.5 g/cm^3 was used to separate the vitric component from minerals such as quartz and feldspar. LMT was added to each sample and centrifuged twice for 15 minutes at 2500 rpm to expedite the separation process. The separate was further cleaned with distilled water and then mounted on a one-inch diameter epoxy round. Rounds sat for 24 hours before being hand polished with four different clothes (6, 3, 1, and 0.25 μm). Samples were then scanned using a petrographic microscope to identify isotropic grains (potential glass shards).

Major elements of individual tephra grains were determined using a JEOL JSX8900 SuperProbe EPMA, equipped with four wavelength dispersive spectrometers (WDS), at the Electron Microanalysis and Imaging Laboratory at University of Nevada Las Vegas, following methodologies published in Smith et al. (2018). We used a 15kV accelerating voltage, 10nA beam current and beam size of 10 μm for operating conditions of the EPMA. We set peak and background counting times to 30 and 10 s for all elements except Na (Na was set to 10 and 5 s). To prevent element migration from beam damage, elements Na and K were counted on the first WDS cycle. The rhyolite glass standard ATHO-G, a part of the MPI-DING international standard set, was analyzed alongside glass shards on the electron microprobe to monitor instrument accuracy and precision (Jochum *et al.*, 2006). Analytical error was minimal for most elements (< ±0.2 wt. %) except for SiO_2 (±0.83 wt. %), Al_2O_3 (±0.25 wt. %), and Na_2O (±0.57 wt. %).

Conducting trace element analyses is critical to correlating tephra to its proper source. Since tephra from the same region can produce volcanic rocks with similar major elements signatures (Vinkler *et al.*, 2007; Lowe, 2011), trace elements are needed to properly identify the source. Therefore, we performed trace element analyses on the glass shards that had been analyzed for major elements. These analyses were completed at Michigan State University using a Thermo Scientific ICAP Q Quadrupole Inductively Coupled Plasma Mass Spectrometer (ICP-MS) integrated with a Photon Machines Analyte G2 193 nm excimer laser ablation system. This laser ablation system is equipped with a 15 x 15 cm HelEx sample cell for solid sample microanalyses. For our samples, we used a laser fluence of 4.1 J/cm^2 at a repetition rate of 10 Hz (10 laser hits per second). We adjusted beam diameters based on sample size and calibrated concentrations at a 110 μm pit diameter on surface scans of NIST 612, USGS basalt glass standards, and rock powder standards from the Geological Survey of Japan and the U.S. Geological Survey. The ICP-MS was tuned using surface scans of NIST 612 and the oxide production rate was kept at (ThO/Th) < 0.7% and double charged cations was ($^{137}Ba^{++}/^{137}Ba$) < 3% while performing surface scans. We subtracted backgrounds from each analysis and collected gas blanks after each standard and sample.

Jochum, K. P. *et al.* (2006) 'MPI-DING reference glasses for in situ microanalysis: New reference values for element concentrations and isotope ratios', *Geochem. Geophys. Geosyst*, 7, p. 2008. doi: 10.1029/2005GC001060.
Lowe, D. J. (2011) 'Tephrochronology and its application: A review', *Quaternary Geochronology*. Elsevier B.V, 6(2), pp. 107–153. doi: 10.1016/j.quageo.2010.08.003.
Smith, E. I. *et al.* (2018) 'Humans thrived in South Africa through the Toba eruption about 74,000 years ago', *Nature*, 555(7697), pp. 511–515. doi: 10.1038/nature25967.

Vinkler, A. P. *et al.* (2007) ‘Petrology and geochemistry of pumices from the Ciomadul volcano (Eastern Carpathians) -implication for petrogenetic processes’, *Földtani Közlöny*, 137(1), pp. 103–128.

Figure S1. Location of total cryptotephra sample columns at Arma Veirana.

Table S1. Geochemical data of P1, P2, and P3.

Table S2. List of reference tephra.

Table S3. Compiled data used for sourcing tephra.

Table S4. Bayesian model posterior results.