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Paleoclimate and weathering on volcanic islands: insights from well-dated paleosols spanning the last Myr in the Central Azores

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Paleosols (PSs) contain valuable information about the climatic conditions under which they formed and constitute an outstanding archive of past weathering processes. Nevertheless, paleosol dating over most of the Quaternary remains challenging. Volcanic environments are unique sites for such purposes, as precise radiometric age determination can be achieved on volcanic units 'bracketing' PSs. Here, we present a combined geochemical and geochronological study of PSs spanning the last Myr in the Central Azores archipelago (Pico, Faial and São Jorge Islands; central North Atlantic). Precise K-Ar dating of lava flows on groundmass separates (unspiked Cassinot-Gillot technique) yield ages with a typical uncertainty of a few kyr, allowing us to tightly constrain PS ages and weathering rates near key paleoclimatic transitions. PS geochemistry further allowed us to reconstruct weathering conditions and estimate Mean Annual Precipitation and Temperature (MAP & MAT) by two proxies previously validated for other volcanic terranes (CIA-K and Clayeyness).

Four periods of PSs formation are constrained at 870-845 ka, ~725 ka, 320-280 ka and 130-45 ka. Most PSs formed just after interglacial peaks, with a few exceptions. Our MAP reconstructions are variable (600-1,500 mm/yr), but generally lower than current annual precipitations (~1,000 mm/yr). MAT estimates (14-28°C) are higher than present-day annual temperatures (~17.5°C). MAP & MAT variations are in general agreement with global climatic curves; the highest values (28°C, 1,500 mm/yr) are reached at ~855 ka, coinciding with an interglacial peak. The younger PSs (130-45 ka) indicate more stable MAP & MAT in the ranges 650-1,000 mm/yr and 15-20°C, respectively and seem to show a temperature decrease after the MIS5e interglacial stage.

Most paleosols were formed in a few kyr under high MAT (>17°C) and moderate to high MAP (>700 mm/yr), supporting a major influence of temperature on weathering kinetics. Parental material texture also had an important role, as several PSs formed upon pyroclastic deposits over most of their depth, whereas those developed on lava flows were generally restricted to the highly fragmented upper brecciated parts. Minimum vertical soil formation rates are in the range of

~0.3-4.5 cm/kyr, with a mean of ~1.7 cm/kyr and an outlier around ~10 cm/kyr. Those generally high values can be explained by the highly vesicular parental material, and by an exceptionally feldspar-rich (easily weathered) parental rock for the outlier.

As current precipitation and temperatures are higher than the threshold values of ~700 mm/yr and ~17°C under which most PSs formed, enhanced soil formation is expected for the near future, especially in the context of global warming and particularly in volcanic contexts. This may have important and fast impacts on local human activities, but also regarding CO₂ consumption by rock weathering and geological hazards.