Text S1 –Results of paleosol analysis (San Potito site)

The paleosol sampled in the San Potito Sannitico area consists, from top to bottom, of the dark brown (10YR 3/3) AB_b and the dark yellowish brown (10YR 4/6) $2Bw_b$ horizons (Sample S228_3 in Fig. 9 of the main text). The pedogenetic structure changes from crumby granular in the AB_b horizon to sub-angular blocky in the Bw_b horizons, with a weak to moderate consistence, and slight field appearance of volcanic soil with andic properties, such as fluffy consistence, powdery aspect when dried, slight stickiness, no plasticity, low bulk density, high porosity, water retention and weak thixotropy (e.g. IUSS Working Group, 2014). From top to bottom, the particle size changes from loam to silty loam (Tab. S2). The occurrence of calcareous clasts mainly in the AB_b horizon is in agreement with the strong reaction showed with the 10% HCl solution field test, suggesting at least a partial colluvial origin of the paleosol. The main chemical analysis indicates an organic matter content of about 1.33% in the AB_b horizon. The occurrence of calcareous fragment is also consistent with the slightly alkaline pH values of about 7.8 (Tab. S2). Cation exchange capacity (CEC) shows high values in both horizons.

In thin section, the skeletal grains of all soil horizons are made up of volcanic and carbonate rock fragments, as well as of single pyroxene, olivine, and mica grains. Moreover, the soil horizons include unaltered to moderately altered vegetal roots, and occasional black charcoal fragments with a typical cellular structure. Abundant faunal passages and occasional planar pores represent the main porosity. Rounded to irregular Fe/Mn segregation and nodules around the grains are also present.

The ABb horizon shows an anisotropic pedogenetic matrix, with some isotropic domains when viewed in cross-polarized light, without the presence of illuvial clay coatings. Moreover, it includes carbonate coatings/infilling within pores. The presence of calcite within pores of spiritic grains indicates alternation of dissolution and re-precipitation of carbonate due to changes of the humidity regime (Zamanian et al., 2016).

The Bw horizon shows a weakly isotropic pedogenetic matrix, in cross-polarized light, with a change of colour from dark brown to yellowish brown. It includes poor illuvial clay coatings within the pores. These clay coatings are papules, i.e isolated fragments of clay coatings or weathered mica mineral. The pedogenetic matrix has in some areas a more developed pedogenetic aggregation.

Selective extraction and related geochemical indexes are listed in Tab. S2. The Alo+ 0.5 Feo ICOMAND index (ICOMAND,1988), which ranges between 0.89 and 1.13 %, is lower than the minimum required to define an andosol (2%), in according with the WRB criteria for the andic properties (IUSS Working Group WRB, 2014). Nonetheless, this index is ≥ 0.4%, which is a low-level proxy for andic properties according to the USDA Soil Taxonomy, along with a volcanic glass content ≥ 5% (Soil Survey Staff, 2014). In the whole, low (Alo−Alp)/Sio ratio, together with Alp/Alo values close to 0.7 and low value of Sio (< 0.6) indicates Alu-andic properties of the paleosol (IUSS, Working Group,WRB 2014). This means that Al complexed by the organic matter prevails over the Al that entered in the crystal lattice of short-order range minerals (e.g., García-Rodeja et al., 2007; Tangari et al., 2018). Therefore, this paleosol shows a weak andic properties. These ratios are consistent with the pedogenetic indices Feo/Fed (0.17-0.18), suggesting a low amount of non-crystalline iron (Parfitt and Child, 1988), comparable with other soils located in the Matese Mt.s (Campitello Matese and Cole Santa Croce sites; Colombo et al., 2014). Fed values are greater than Feo, suggesting that high amount of iron are released from weathering of Fe-bearing minerals and transformed in crystalline Fe-oxides. Nevertheless, the low values of pedogenic iron indices Fed/Fet (between 0.25 and 0.17) and (Fed-Feo)/Fet (between 0.21 and 0.14) indicate mainly a low degree of pedogenetic development. In fact, these ratios increase with increasing degree of pedogenic maturity, because free Fe (released from weathering of primary minerals) and crystalline Fe (fixed mainly in Fe-oxides) increase with pedogenesis (e.g. Torrent et al., 1980; Scarciglia et al., 2018).

Furthermore, high values of Fed-Fet indices (between 6.69 and 8.21) indicate that iron is still present in the crystal lattices of Fe-bearing primary minerals (e.g. Scarciglia et al.,2018).

In summary, the soil shows a poor pedogenetic evolution as confirmed by the medium-to-coarse grain-size, the presence of abundant skeletal fraction, the pedogenetic indices, and the poor clay illuviation. These features confirm a young soil age, in line with the clay illuviation found more frequently in Holocene soils (e.g., Xiubin et al., 2008; Bronger et al., 2019).

Some uneven patterns of the above ratios and the micromorphology of the soil, with strong colour changes in the pedogenetic matrix within soil horizons, can indicate some disturbance of the pedogenic processes. This disturbance can be related to erosion and colluviation. All these features indicate the coexistence of young and old pedogenetic features of late Pleistocene to Holocene age, in substantial agreement with radiocarbon dating (Tab. 1).

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