

I/ Outcrops location of the studied eruptive units

The names of the eruptions and eruptive units are based on de Vita et al. (2010). For Bosco dei Conti and Cretaio eruptions, the sampling was done at the type section outcrops detailed in de Vita et al. (2010).

Montagnone-Maschiata lava (MM) – main lava dome

Sample ISH 24-14 - **40°44'05.8"N 13°55'40.1"E**

Bosco dei Conti tephra (BdC) – Eruptive Unit A (EUA)

Sample ISC BdCA - **40°43'54.2"N 13°55'42.9"E**

Cretaio tephra (CT) – Eruptive Unit C (EUC)

Sample ISH 24-12 - **40°44'04.6"N 13°55'22.3"E**

II/ Texture of the volcanic rocks

For BdC tephra and CT tephra pumices, in a section of a centimetric grain, phenocrysts and glomerocrysts number is typically less than 10 and they account for ~3% of the total area (pixel counting). Those characteristics make unreliable attempts to have a quantitative estimate of the mineral assemblage. However, the mineral assemblage can be defined qualitatively by alkali-feldspar >> plagioclase + clinopyroxene + biotite + titanomagnetite. The surface of vesicles has been estimated to be 70-80% of the total area (visual estimation), which aligns well with vesicularity values calculated by density measurements on CT tephra pumices that showed a unimodal vesicularity distribution with a peak between 75 and 85% vesicularity (Balcone-Boissard, unpublished data). Considering a vesicularity surface of 70 to 80% and a phenocrysts surface of 3%, the vesicle-free crystal content of the CT and BdC pumices is 10-15%. This estimation is confirmed by the results of image analysis on two thin sections of pumices having a density representative of the studied deposit (Table 1).

For MM lava, the lower number of vesicles and higher number of phenocrysts in a single section allows a better estimation of the mineral assemblage based on image analysis. Pixel-counting image analysis were performed using the ImageJ software on three different lava sections scans where the different mineral species were previously outlined in different shades of grey. The results are shown in the Table 1 and confirm the observations on the pumices. The vesicle-free phenocryst content range between 13 and 15%, a similar value to what was calculated for the pumices.

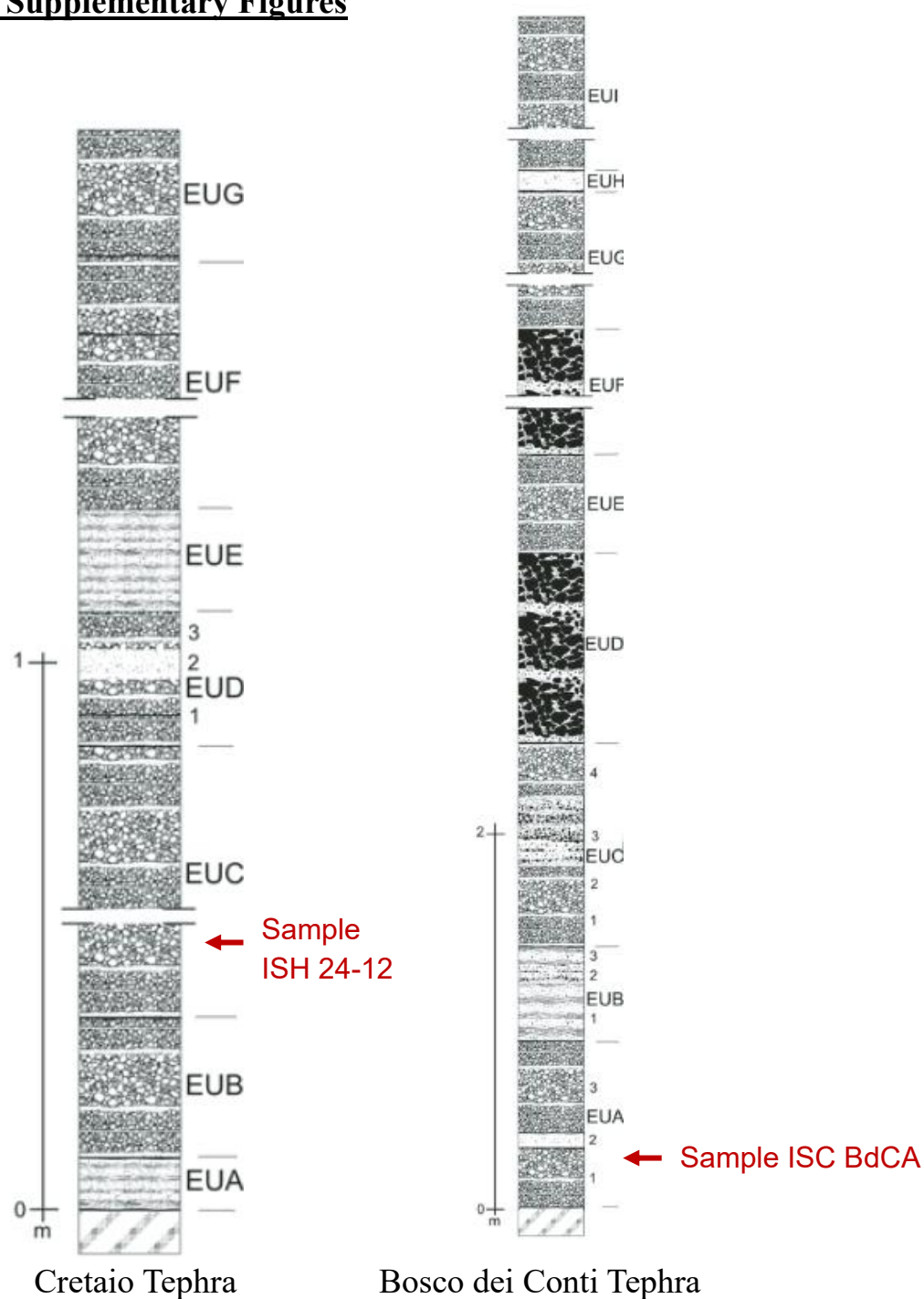
Table S1 vesicle and phenocrysts fraction obtained from image analyses

		phenocrysts fraction (calculated on vesicle-free basis)						
ID sample	vesicle fraction	All minerals	Feldspars			Bt	Cpx	Mt
			Afsp+Pl	Afsp	Pl			
MM lava								
ISH_24-13B-L	0.40	0.13	0.124			0.004	0.002	0.001
ISH_24-13B-R	0.29	0.15	0.130			0.006	0.009	0.004
ISH_24-14-L ⁽¹⁾	0.29	0.14	0.130	0.120	0.010	0.001	0.004	0.001
BdC tephra (pumice)								
ISH_24-05 ⁽¹⁾	0.77	0.12	0.096	0.092	0.003	0.007	0.016	0.000
CT tephra (pumice)								
ISH_24-12 ⁽¹⁾	0.75	0.12	0.100	0.090	0.010	0.011	0.008	0.001

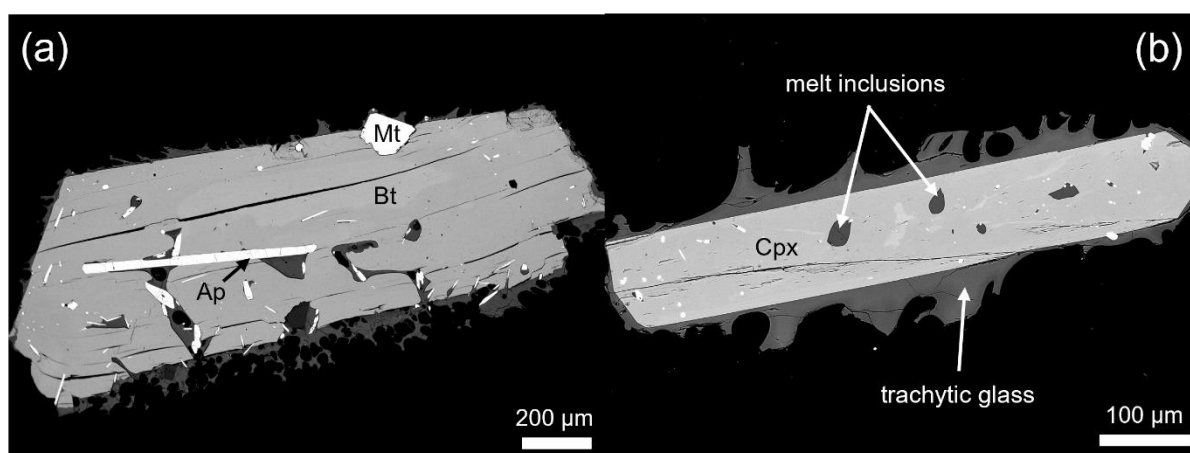
Afsp: alkali-feldspar; Pl: plagioclase; Bt: biotite; Cpx: clinopyroxene; Mt: titano-magnetite

⁽¹⁾ image analyses performed on a BSE scan, allowing a precise distinction between plagioclases and alkali-feldspars

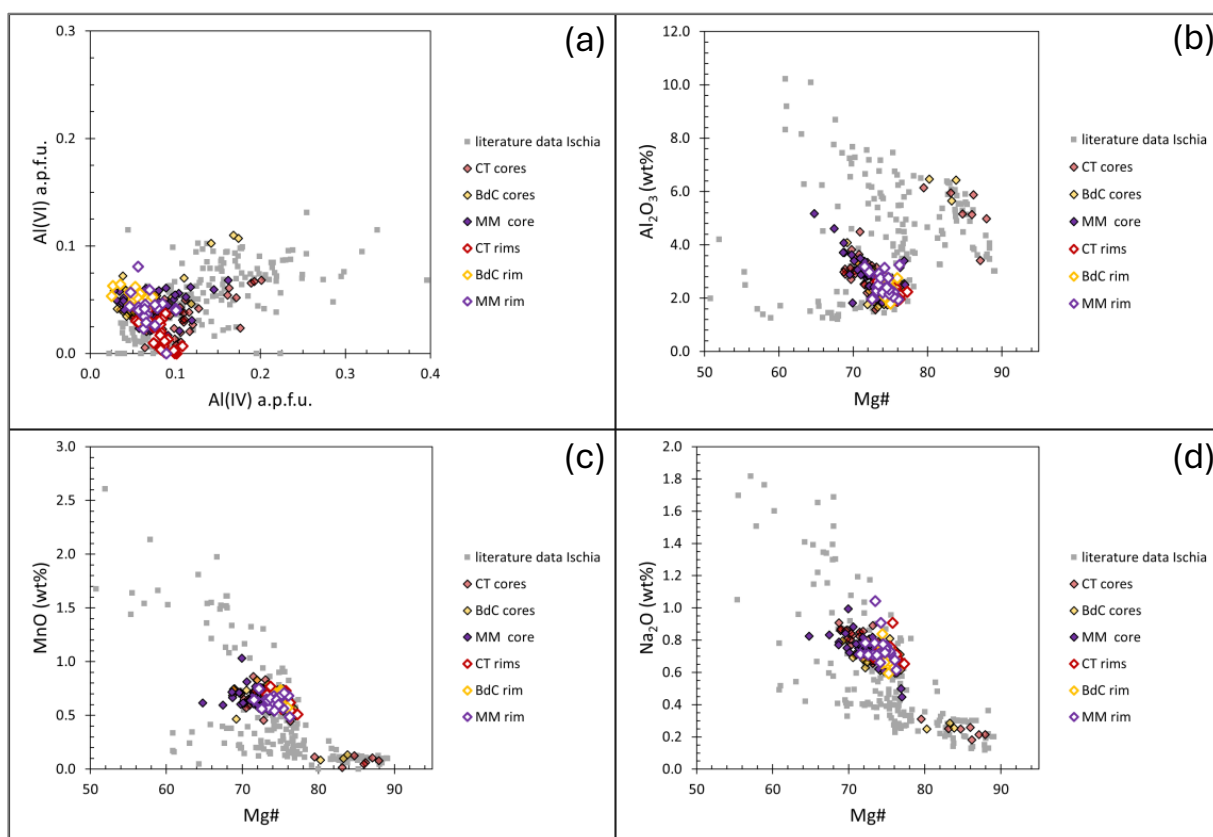
III/ Supplementary Figures



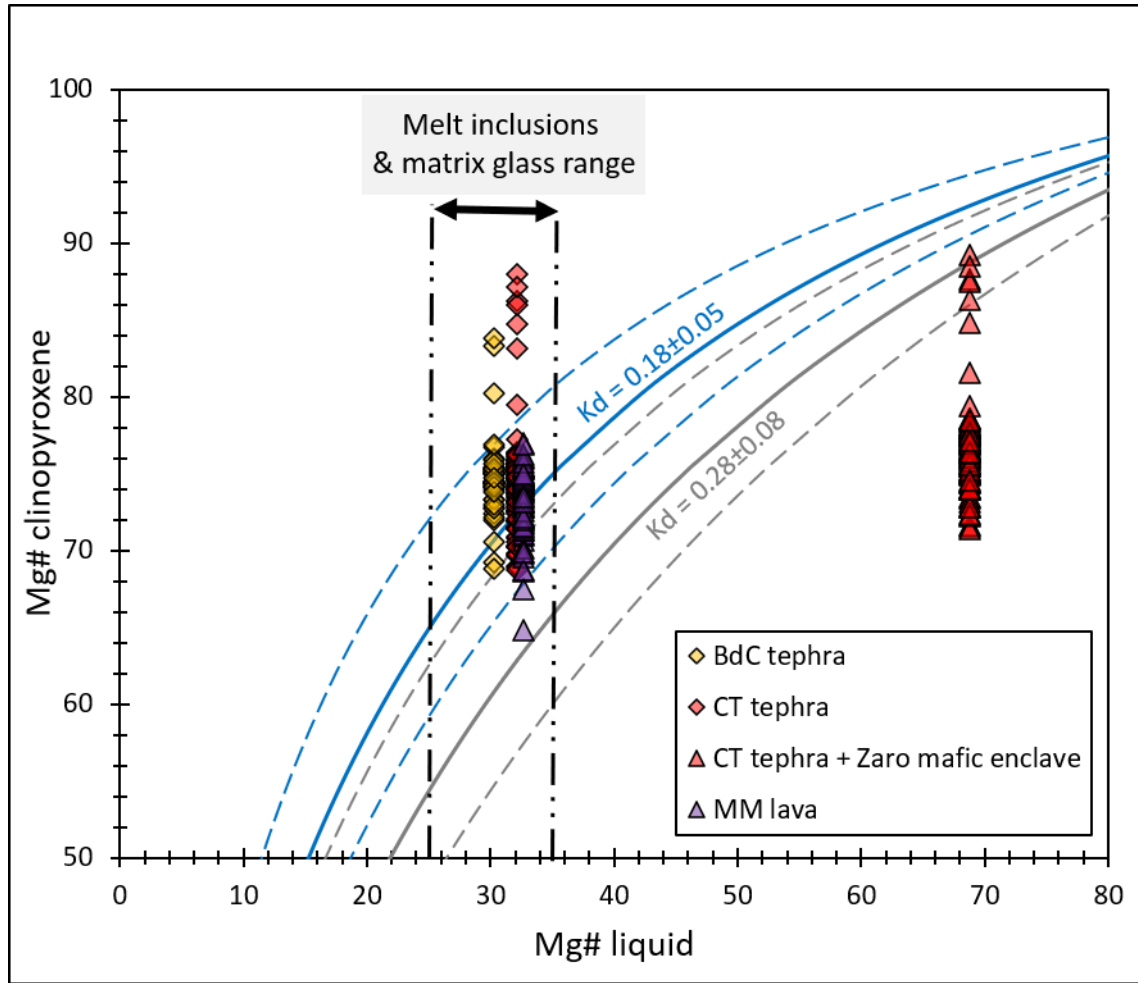
Supplementary Fig. S1 proximal stratigraphic logs of the Cretaio Tephra and Bosco dei Conti Tephra deposits (from De Vita et al. 2010), showing the units sampled for each eruption (red arrows). For both eruptions, the chemical composition of the erupted products remained homogeneous through the entire eruptive sequence (Electronic Supplementary Material 2; Andria 2008)



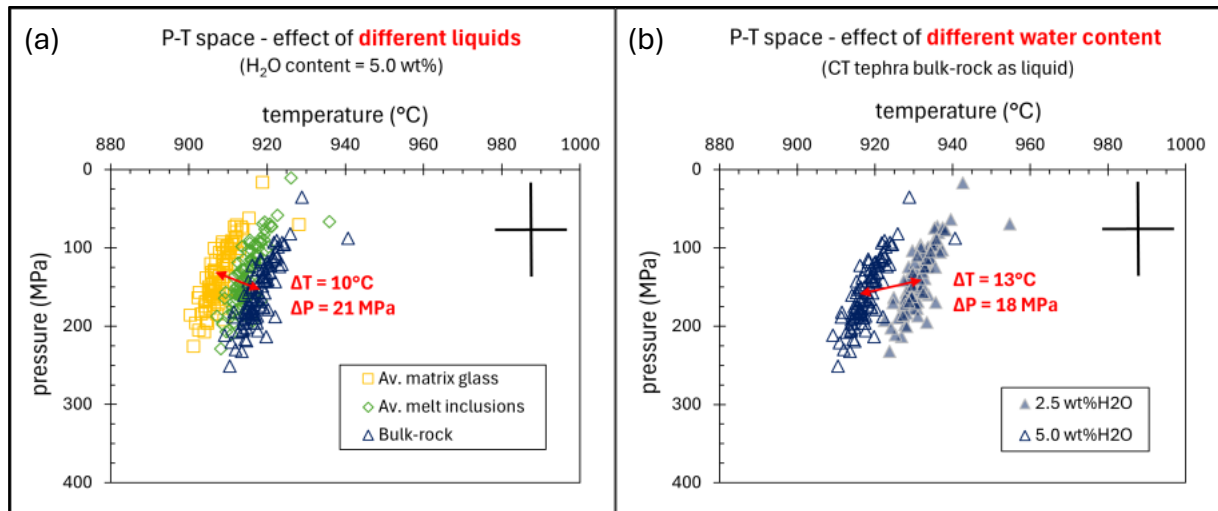
Supplementary Fig. S2 (a) biotite phenocryst from CT tephra, with apatite inclusions and melt embayments. (b) melt inclusions hosted by clinopyroxene phenocrysts from CT tephra and BdC tephra, respectively. Mt: Ti-Magnetite, Cpx: clinopyroxene, Ap: apatite, Bt: biotite



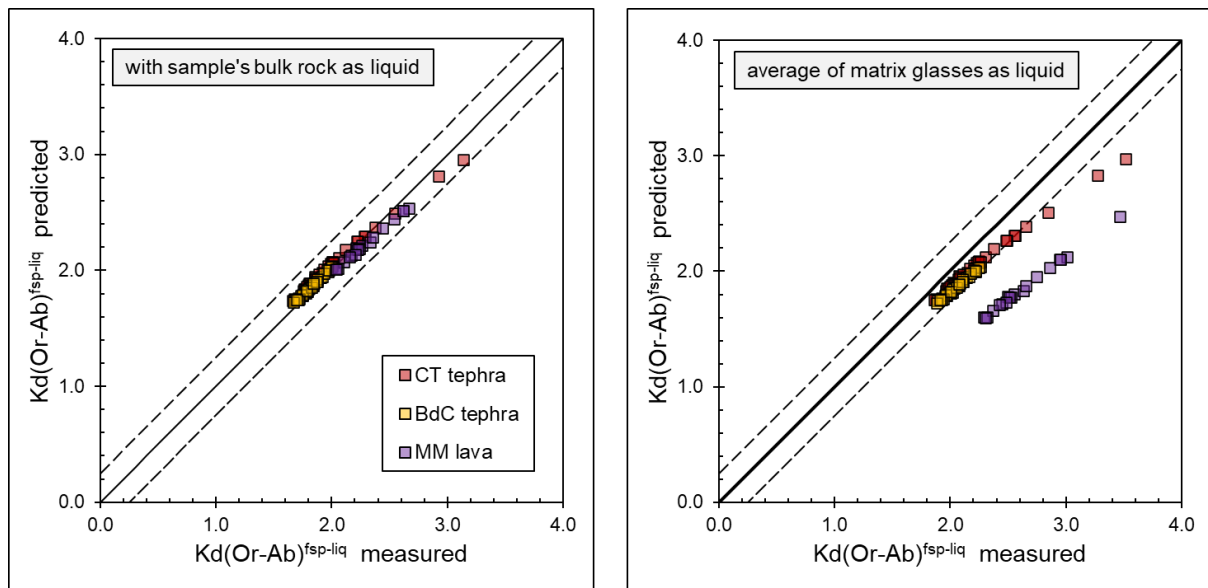
Supplementary Fig. S3 Clinopyroxene composition of the Montagnone eruptions (CT tephra, BdC tephra, MM lava). (a) Al(VI) vs Al(IV) calculated by stoichiometry, (b)–(d) Na_2O , MnO, and Al_2O_3 content of clinopyroxenes as a function of their mg-number (Mg#). Literature data of Ischia’s clinopyroxenes come from D’Antonio et al. (2013), Melluso et al. (2014), Iovine et al. (2017), Pelullo et al. (2020).



Supplementary Fig. S4 Clinopyroxene-liquid equilibrium test using a $K_d(\text{Fe-Mg})^{\text{cpx-liq}} = 0.18$ (solid blue curve) and 0.28 (solid black curve). The dashed blue and black curves correspond to ± 0.05 and ± 0.08 of deviation from the equilibrium value (Masotta et al. 2013, Putirka 2008). Coloured diamonds correspond to clinopyroxene crystals from the studied samples, tested with the samples bulk-rock compositions. Red triangles are an example of test using the ZR1C mafic enclave from the Zaro lava (Pelullo et al. 2020), in this case with CT tephra's clinopyroxene phenocrysts. The black arrow shows the Mg# range of melt inclusions and microlite-free matrix glass from the CT and BdC tephra. The Fe^{2+} content for the Mg# calculation of the liquids was estimated using a ratio $\text{Fe}^{2+}/\text{Fe}^{\text{total}}$ of 0.66 ($f\text{O}_2$ conditions of QFM+1 for Ischia trachytes chosen after Brown et al. 2014, obtained using the rhyolite_melts_ver.1.2.0 software, Gualda et al. 2012). For clinopyroxenes, Fe^{2+} was approximated as equal to Fe^{total} as stoichiometry calculations showed that $\text{Fe}^{2+}/\text{Fe}^{\text{total}}$ was systematically higher than 0.88 , resulting in Mg# differences lower than the error of the equilibrium test itself.



Supplementary Fig. S5 Differences in results of clinopyroxene-liquid thermobarometer calculations (Masotta et al. 2013) due to different input parameters (in this case, on CT tephra clinopyroxenes). (a) effect of using different liquid composition from the studied sample: average of matrix glass, average of melt inclusions, and bulk-rock compositions. (b) effect of using different water content, with the maximum (5.0 wt%) and minimum (2.5 wt%) water content obtained by melt inclusions analyses. Red arrows and adjacent text show the difference in pressure and temperature from those different input parameters.



Supplementary Fig. S6 Alkali-feldspar – liquid equilibrium test based on the comparison between observed and predicted $Kd(Or-Ab)^{fsp-liq}$ following the calculation scheme of Mollo et al. (2015). Equilibrium range is defined by the 1:1 line (solid line) ± 0.25 (dashed lines). Equilibrium between matrix glass and phenocrysts is never achieved in the MM lava due to microlite crystallisation, therefore those crystal-liquid pairs were not used for hygrometer calculations.

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