**References cited**

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**Captions to supplementary material**

Electronic supplement 1: Single points chemical data recalculated to 100% water free and reference chemical composition of explosive eruptions products used for correlation.

Electronic supplement 2: Summary of assigned ages and analytical methods.

Electronic Supplement 3: Geophysical and well data from the Piani di Buccino and Pantano di San Gregorio Magno basins (Celico, 1983).

Electronic supplement 4: Total Alkali – Silica classification plot (TAS; Le Bas et al., 1986) of the glasses of investigated tephra layers. For single points chemical analyses see Electronic supplement 1.

Electronic supplement 5: Laser fusion $^{40}Ar/^{39}Ar$ data for sanidine sample S10. Data shown with solid symbol represent juvenile crystals, whereas open symbol data are contaminated with xenocrystic K-feldspar.

Electronic supplement 6: Laser fusion $^{40}Ar/^{39}Ar$ data for sanidine sample S6. Data shown with solid symbol represent juvenile crystals, whereas open symbol data are contaminated with xenocrystic K-feldspar.

| electronic suppl_1 | | | | | | | | | | | | | | | **Chemical data for reference pyroclastic products** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **sample** | **AT2a** | **AT2a** | **AT2a** | **AT2a** | **AT2a** | **AT2a** | **AT2a** | **AT2a** | **AT2a** | **AT2a** | **AT2a** | | | | **2$^{nd}$ prototohist. eruption [1]** | **AP2[2]** |
| **$SiO_2$** | 56.12 | 55.87 | 56.48 | 56.02 | 56.10 | 55.91 | 56.26 | 55.11 | 54.55 | 54.62 | 54.57 | | | | 56.65 | 55.73 |
| **$TiO_2$** | 0.57 | 0.31 | 0.37 | 0.66 | 0.91 | 0.59 | 0.60 | 0.85 | 0.87 | 0.67 | 0.55 | | | | 0.47 | 0.57 |
| **$Al_2O_3$** | 20.17 | 19.95 | 20.55 | 20.46 | 20.45 | 19.67 | 19.92 | 19.90 | 19.84 | 20.43 | 19.63 | | | | 20.65 | 21.07 |
| **FeO** | 4.59 | 3.85 | 3.96 | 3.94 | 3.12 | 4.50 | 4.02 | 4.94 | 5.72 | 5.78 | 5.73 | | | | 3.75 | 3.91 |
| **MnO** | 0.08 | 0.29 | 0.14 | 0.01 | 0.21 | 0.25 | 0.08 | 0.00 | 0.14 | 0.06 | 0.20 | | | | 0.17 | 0.12 |
| **MgO** | 0.64 | 0.55 | 0.53 | 0.48 | 0.52 | 0.48 | 0.54 | 0.90 | 0.80 | 0.89 | 1.01 | | | | 0.72 | 0.84 |
| **CaO** | 3.81 | 4.02 | 3.76 | 3.53 | 3.56 | 3.02 | 3.99 | 5.16 | 5.45 | 4.82 | 5.09 | | | | 3.84 | 3.91 |
| **$Na_2O$** | 4.94 | 5.35 | 5.10 | 5.35 | 7.93 | 6.95 | 5.53 | 5.37 | 5.13 | 5.71 | 6.24 | | | | 5.95 | 5.69 |
| **$K_2O$** | 8.66 | 9.15 | 8.90 | 9.22 | 6.90 | 8.33 | 8.82 | 7.36 | 7.47 | 6.72 | 6.95 | | | | 7.80 | 8.17 |
| **Cl** | 0.42 | 0.66 | 0.23 | 0.31 | 0.30 | 0.30 | 0.23 | 0.40 | 0.10 | 0.25 | 0.01 | | | | _ | _ |
| **real sum** | 95.60 | 96.25 | 97.46 | 97.86 | 96.51 | 96.94 | 95.12 | 96.84 | 96.19 | 95.82 | 97.30 | | | | | |
| | | | | | | | | | | | | | | | | |
| **sample** | **AT4a** | **AT4a** | **AT4a** | **AT4a** | **AT4a** | **AT4a** | **AT4a** | **AT4a** | **AT4a** | **AT4a** | | | | | | **Agnano Monte Spina eruption[3]** |
| **$SiO_2$** | 60.45 | 60.19 | 60.89 | 60.48 | 60.11 | 60.48 | 60.91 | 60.29 | 59.94 | 60.52 | | | | | | 59.82 |
| **$TiO_2$** | 0.39 | 0.53 | 0.37 | 0.25 | 0.40 | 0.31 | 0.31 | 0.33 | 0.40 | 0.29 | | | | | | 0.45 |
| **$Al_2O_3$** | 18.68 | 19.27 | 18.61 | 18.82 | 19.10 | 19.25 | 19.49 | 19.33 | 19.30 | 18.65 | | | | | | 19.26 |
| **FeO** | 3.31 | 3.26 | 3.39 | 3.53 | 3.27 | 3.25 | 3.07 | 3.74 | 2.91 | 3.01 | | | | | | 3.40 |
| **MnO** | 0.31 | 0.31 | 0.16 | 0.16 | 0.25 | 0.03 | 0.20 | 0.02 | 0.06 | 0.18 | | | | | | 0.14 |
| **MgO** | 0.49 | 0.47 | 0.58 | 0.44 | 0.50 | 0.53 | 0.63 | 0.72 | 0.32 | 0.60 | | | | | | 0.57 |
| **CaO** | 2.53 | 2.84 | 2.36 | 2.67 | 2.54 | 2.42 | 2.41 | 3.17 | 2.97 | 2.76 | | | | | | 2.54 |
| **$Na_2O$** | 4.22 | 4.16 | 4.09 | 4.44 | 4.34 | 3.96 | 3.89 | 3.39 | 4.55 | 4.48 | | | | | | 4.72 |
| **$K_2O$** | 9.12 | 8.29 | 9.02 | 8.52 | 8.96 | 9.18 | 8.48 | 8.71 | 8.81 | 8.76 | | | | | | 9.09 |
| **Cl** | 0.50 | 0.69 | 0.55 | 0.69 | 0.54 | 0.65 | 0.62 | 0.31 | 0.74 | 0.74 | | | | | | _ |
| **real sum** | 97.42 | 98.91 | 97.16 | 96.23 | 97.23 | 98.03 | 97.84 | 97.20 | 97.43 | 97.13 | | | | | | |
| | | | | | | | | | | | | | | | | |
| sample | **AT24a** | **AT24a** | **AT24a** | **AT24a** | **AT24a** | **AT24a** | **AT24a** | **AT24a** | **AT24a** | **AT24a** | | | | | | **Agnano Pomici Principali eruption[4]** |
| **$SiO_2$** | 57.82 | 57.89 | 58.03 | 58.09 | 58.04 | 58.10 | 58.27 | 57.95 | 57.45 | 57.59 | | | | | | 58.06 |
| **$TiO_2$** | 0.39 | 0.36 | 0.56 | 0.20 | 0.41 | 0.34 | 0.44 | 0.59 | 0.59 | 0.60 | | | | | | 0.52 |
| **$Al_2O_3$** | 19.14 | 19.17 | 18.85 | 19.14 | 19.04 | 19.21 | 19.27 | 18.88 | 19.29 | 18.82 | | | | | | 18.99 |
| **FeO** | 4.26 | 4.30 | 4.22 | 4.26 | 4.22 | 4.16 | 4.47 | 4.24 | 4.08 | 4.37 | | | | | | 4.57 |
| **MnO** | 0.24 | 0.15 | 0.09 | 0.25 | 0.19 | 0.17 | 0.30 | 0.16 | 0.23 | 0.10 | | | | | | 0.14 |
| **MgO** | 0.89 | 0.95 | 0.96 | 0.97 | 1.02 | 0.85 | 0.82 | 1.00 | 0.91 | 0.82 | | | | | | 1.20 |
| **CaO** | 3.77 | 3.99 | 4.08 | 3.97 | 4.00 | 4.00 | 3.85 | 4.15 | 4.47 | 4.42 | | | | | | 3.99 |
| **$Na_2O$** | 4.08 | 3.67 | 3.60 | 3.72 | 3.77 | 3.58 | 3.46 | 3.73 | 3.77 | 3.83 | | | | | | 3.60 |
| **$K_2O$** | 8.80 | 8.86 | 8.72 | 8.81 | 8.76 | 8.88 | 8.68 | 8.65 | 8.53 | 8.81 | | | | | | 8.94 |
| **Cl** | 0.61 | 0.67 | 0.78 | 0.61 | 0.64 | 0.71 | 0.51 | 0.65 | 0.76 | 0.62 | | | | | | 0.62 |
| **real sum** | 97.87 | 98.03 | 98.16 | 97.10 | 96.19 | 98.57 | 97.65 | 98.21 | 96.84 | 97.95 | | | | | | |
| | | | | | | | | | | | | | | | | |

**[1] averaged composition data from Rolandi et al., 1998**

**[2]averaged composition - data from Santacroce et al., 2008**

**[3] from Lirer et al., 2012**

**[7] from Smith et al., 2011**

**Summary**

| Sample | L# | Irrad | analysis | n | MSWD | K/Ca | ±1σ | Age | ±1σ |
|---|---|---|---|---|---|---|---|---|---|
| S10 Sanidine | 56036 | NM-193 | Laser fusion | 10 of15 | 1.67 | 17.0 | 4.3 | 0.113 | 0.004 |
| | | | | | | | | | |
| S4 Sanidine | 56038 | NM-193 | Laser fusion | 8 of 26 | 1.59 | 26.0 | 56.0 | 0.239 | 0.008 |

L#= Lab number
Irrad = Irradiation number
n = used for age calculation of those analyzed
K/Ca = Mean and standard deviation of grains defining age population

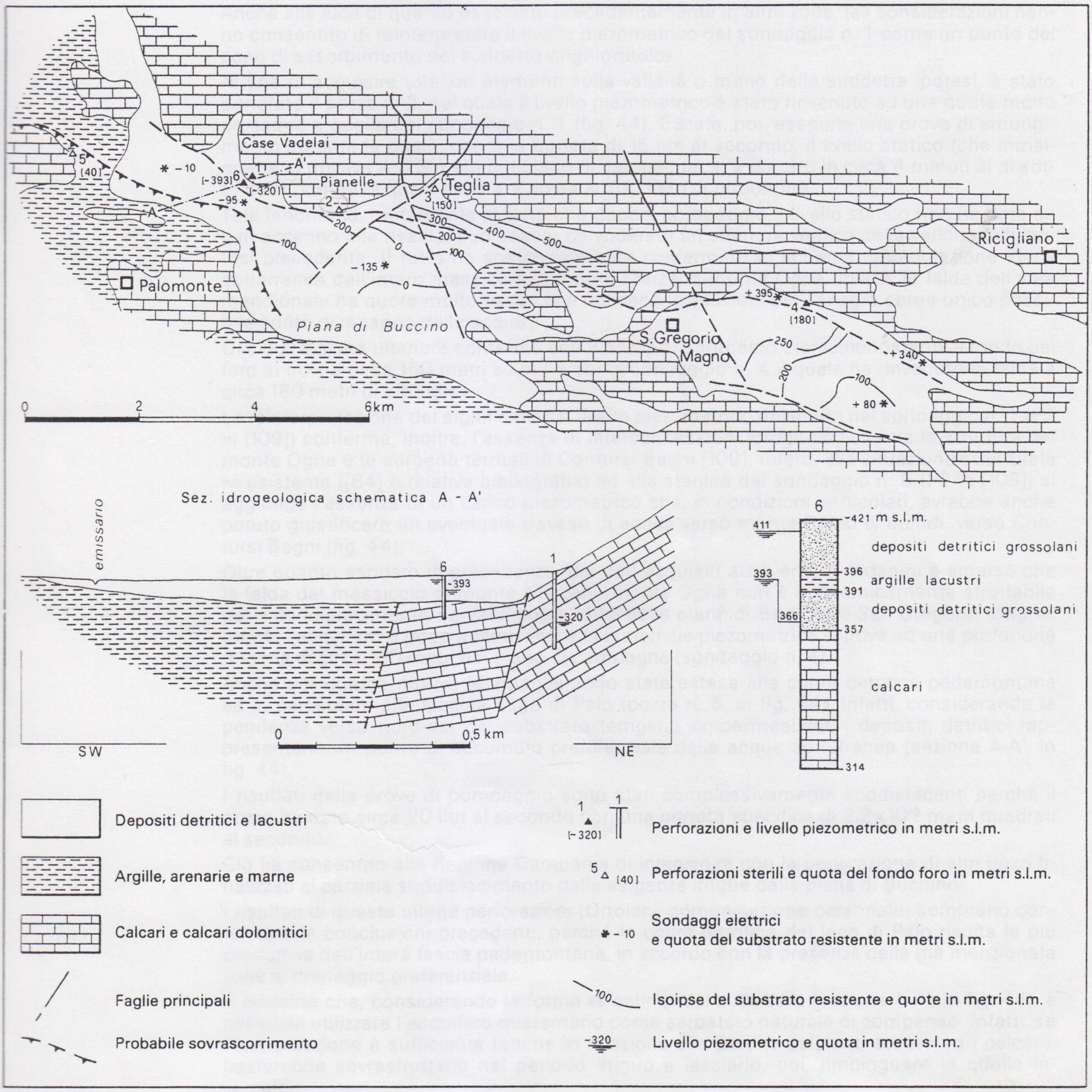
## Methods

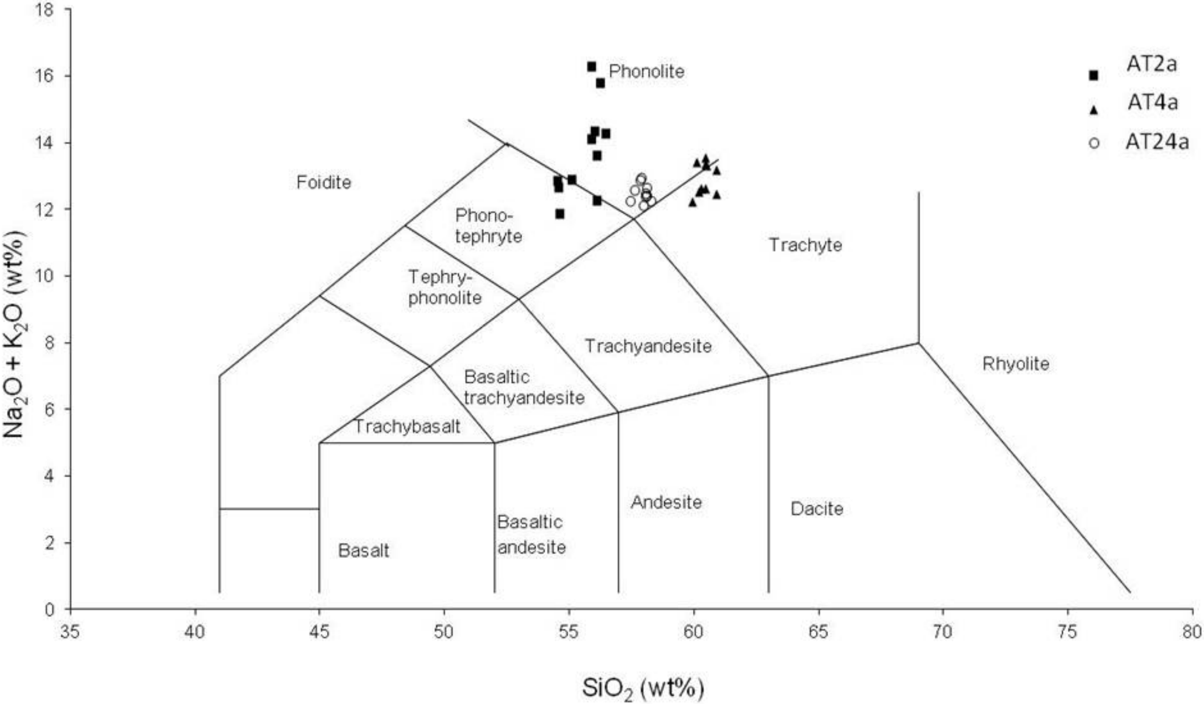
**Sample preparation and irradiation:**
Sanidine separated using standard heavy liquid and hand-picking tecniques.
Separates were loaded into machined Al discs and irradiated for 1.5 hours in D-3 position, Nuclear Science Center, College Station, TX
Neutron flux monitor Fish Canyon Tuff sanidine (FC-2). Assigned age = 28.02 Ma (Renne et al., 1998)

**Instrumentation:**
Mass Analyzer Products 215-50 mass spectrometer on line with automated all-metal extraction system.
Sanidine crystals fused with a 50 watt Synrad $CO_2$ laser.
Reactive gases removed during a 2 minute reaction with 2 SAES GP-50 getters,
1 operated at ~450°C and 1 at 20°C. Gas also exposed to a W filament operated at ~2000°C and a cold finger operated at -140°C.

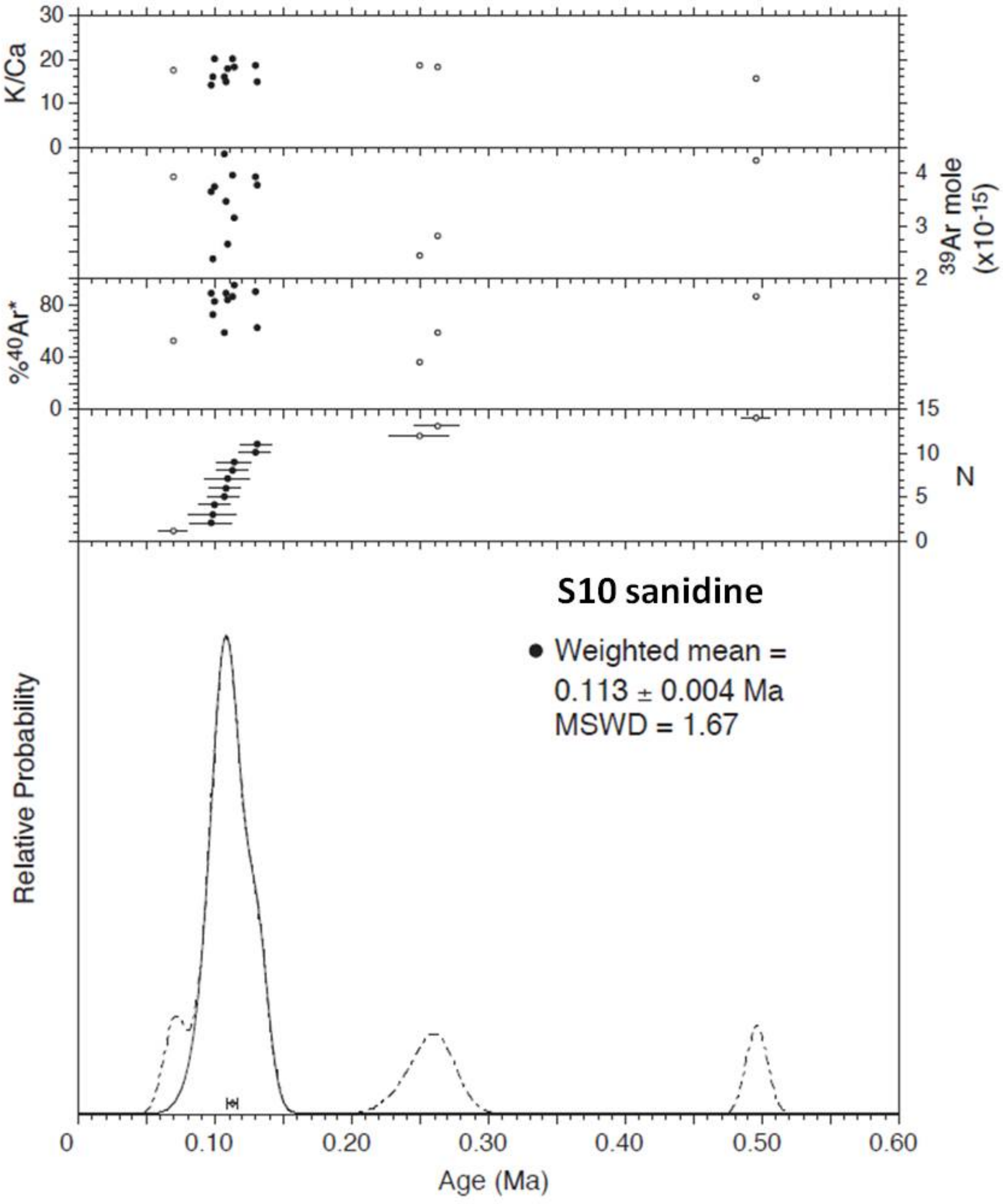
**Analytical parameters:**
Electron multiplier sensitivity ranged between 5&9x10$^{-16}$ moles/pA.
Total system blank and background = 70, 1.7, 0.4, 1.2, 0.7 x 10$^{-17}$ moles for masses 40, 39, 38, 37, 36, respectively.
J-factors determined to a precision of ± 0.11% by $CO_2$ laser-fusion of 6 single crystals from
each of 6 radial positions around the irradiation tray.
Correction factors for interfering nuclear reactions were determined using K-glass and $CaF_2$ and are as follows:
($^{40}$Ar/$^{39}$Ar)K = 0±0.0004; ($^{36}$Ar/$^{37}$Ar)Ca = 0.00028±0.00001; and ($^{39}$Ar/$^{37}$Ar)Ca = 0.00070±0.00005.

**Figura 44** - **Principali risultati delle indagini eseguite nelle piane di Buccino e San Gregorio Magno.**

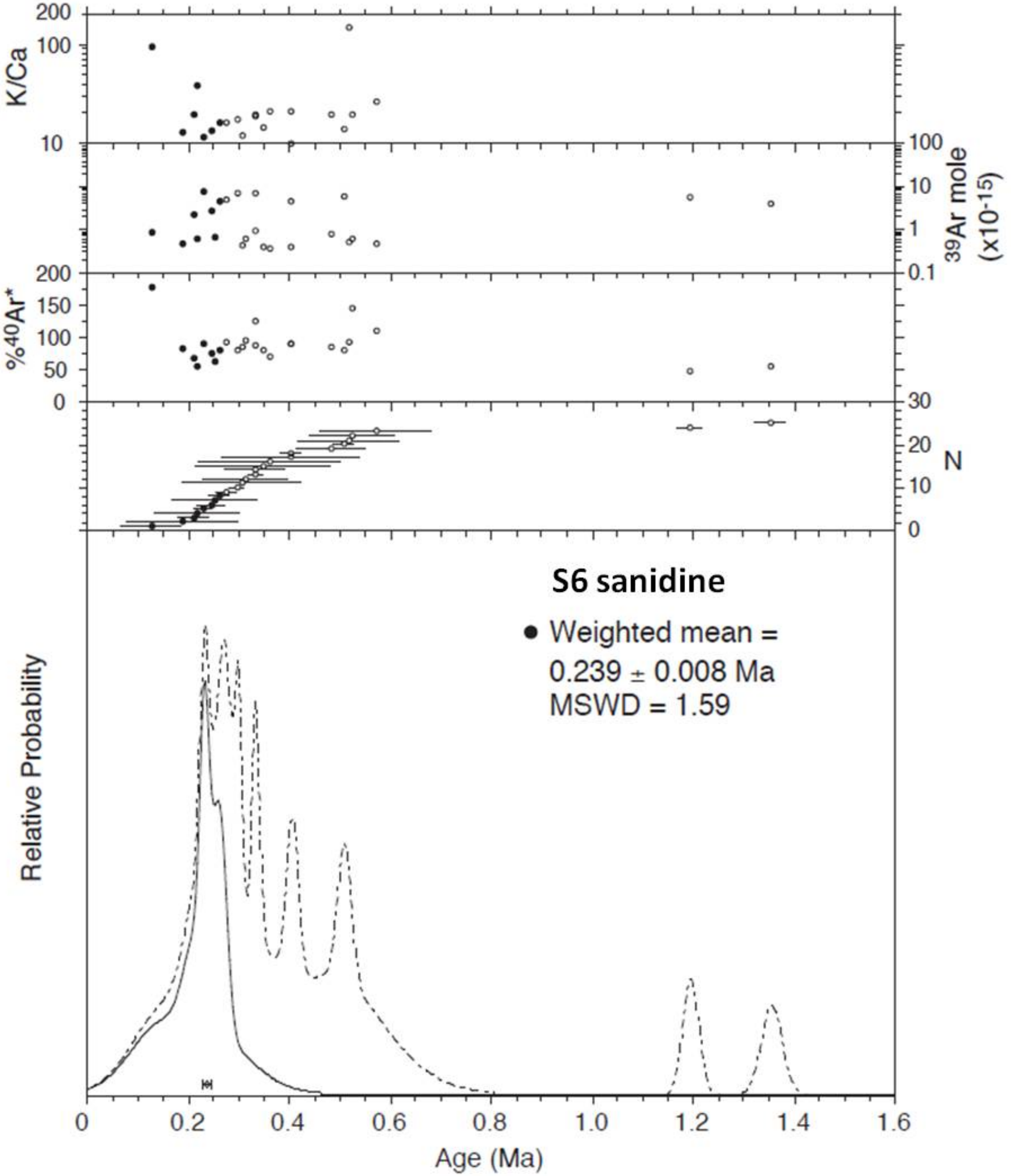




Phonolite
AT2a
AT4a
AT24a
Foidite
Phono-
tephryte
Tephry-
phonolite
Trachyte
Trachyandesite
Rhyolite
Basaltic
trachyandesite
Trachybasalt
Basalt
Basaltic
andesite
Andesite
Dacite
$Na_2O + K_2O$ (wt%)
$SiO_2$ (wt%)



K/Ca
30
20
10
0
$^{39}$Ar mole (x10$^{-15}$)
4
3
2
%$^{40}$Ar*
80
40
0
N
15
10
5
0
S10 sanidine
● Weighted mean =
0.113 ± 0.004 Ma
MSWD = 1.67
Relative Probability
0
0.10
0.20
0.30
0.40
0.50
0.60
Age (Ma)


K/Ca
39Ar mole (x10-15)
%40Ar*
N
S6 sanidine
Weighted mean =
0.239 ± 0.008 Ma
MSWD = 1.59
Relative Probability
Age (Ma)
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6