Mount Vesuvius and Mount Etna

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NDSU Petrology: GEOL 422

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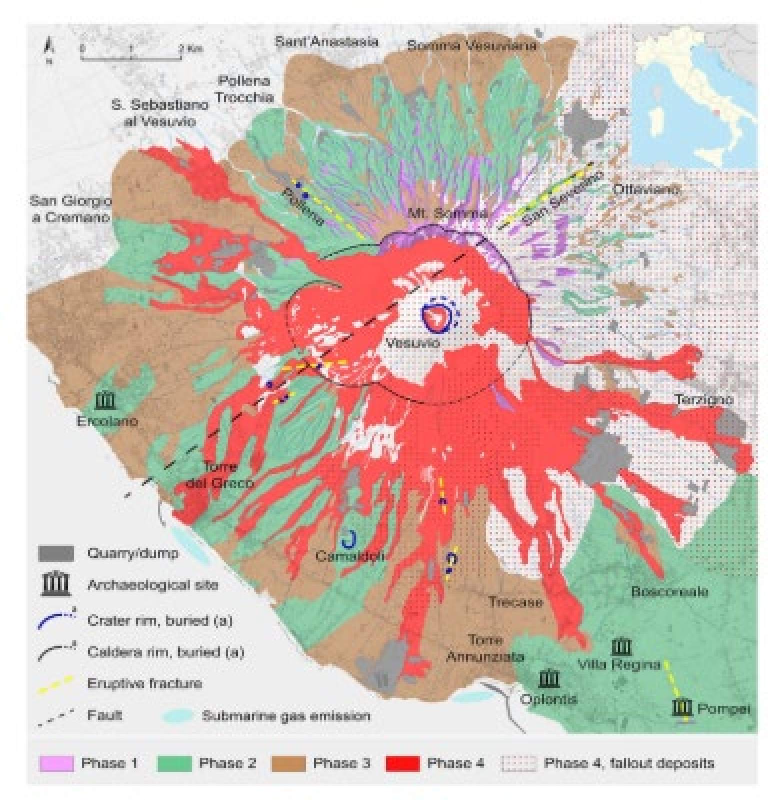
Background

Geography, Geology, Volcanism, Mineral Chemistry

Vesuvius Photography



Last eruption, 1944

(Sbrana et al., 2020)

Etna Photography

- ★ The largest subaerial volcano in Europe (Mollo et. al, 2011)
- ★ 1200 km^2 wide and 3.3 km high

Paroxysms (October 2013)

Low output rate effusive eruption

Eastern Aerial View - Gas plume emitted through summit craters

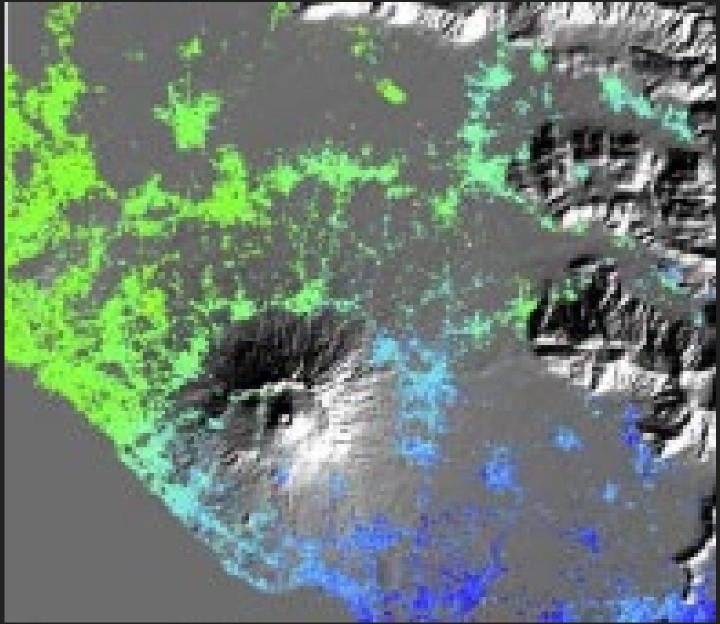
Rim of Summit Crater - Emitted by fractures on crater's surface

(Ferlito et. al, 2017)

Vesuvius and Etna Geographic Locations

Geological Setting & Tectonic Regime

Vesuvius



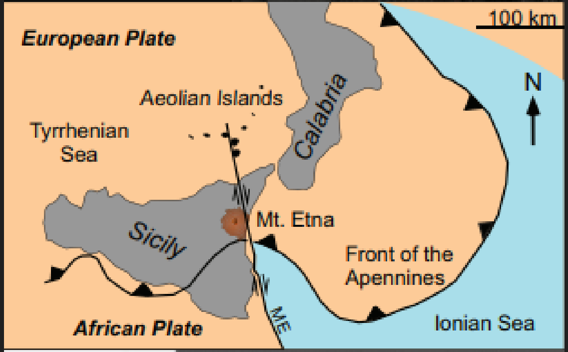
(Borgia et al.,2005)

Vesuvius (Sbrana et al., 2019)

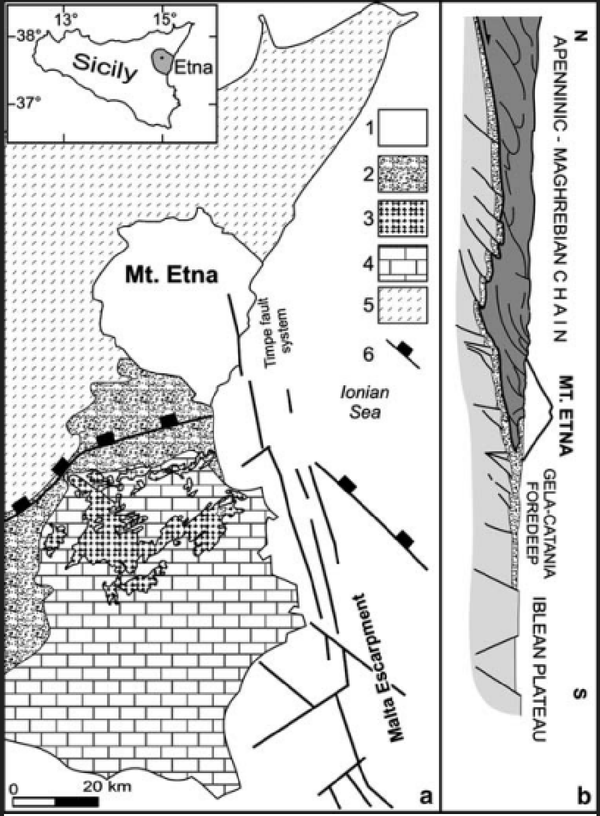
- stands about 7.5 miles southeast of Naples, Italy.
- coordinated around 40.8224 N, 14.4289 E.
- Intersection of two main fault systems (NE-SW and NW-SE)
- Inside the southeast portion of the Campanian plain half graben.

Etna

- East: Bounded by Malta Escarpment
    - Affected by E-W extensional tectonic activity
- North: subduction-related Aeolian Arc
- West: compressive regime of continental collision between Eurasian and African plates (Kahl et al., 2015)



(Kahl et al., 2015)



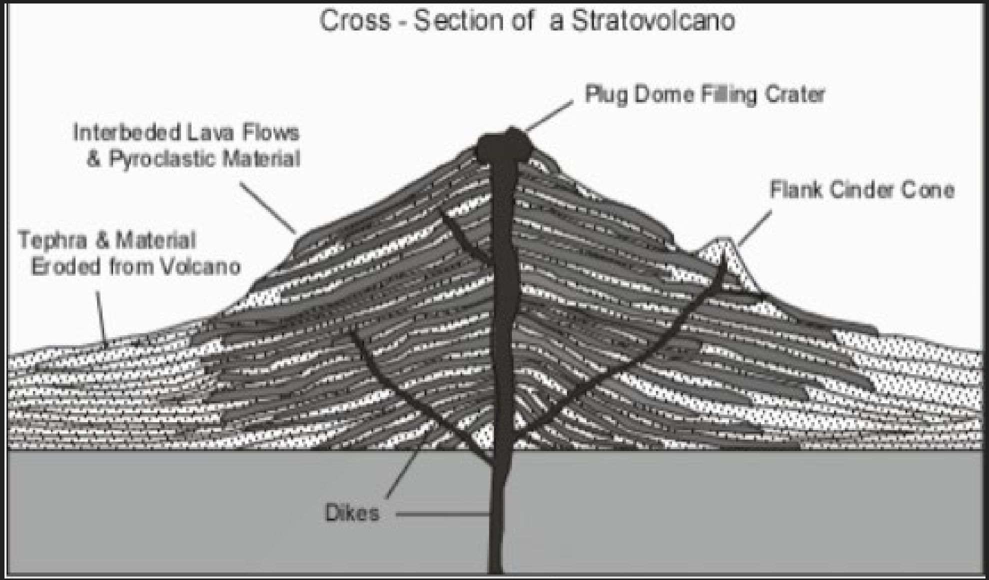
(Branca et al., 2006)

Stratovolcano

Formations & Discussion

Stratovolcano (Composite Volcano)

- Built up by layers of ash, pumice, scoria, and hardened lava
- Steep profile (30°-35°)
  - conical or cylindrical shape
- Periodic explosive eruptions (Doronzo et. al, 2012)
- Typical lava flows
  - Andesitic to rhyolitic



(Nelson, 2017)

Somma-Vesuvius Stratovolcano & Eruptions

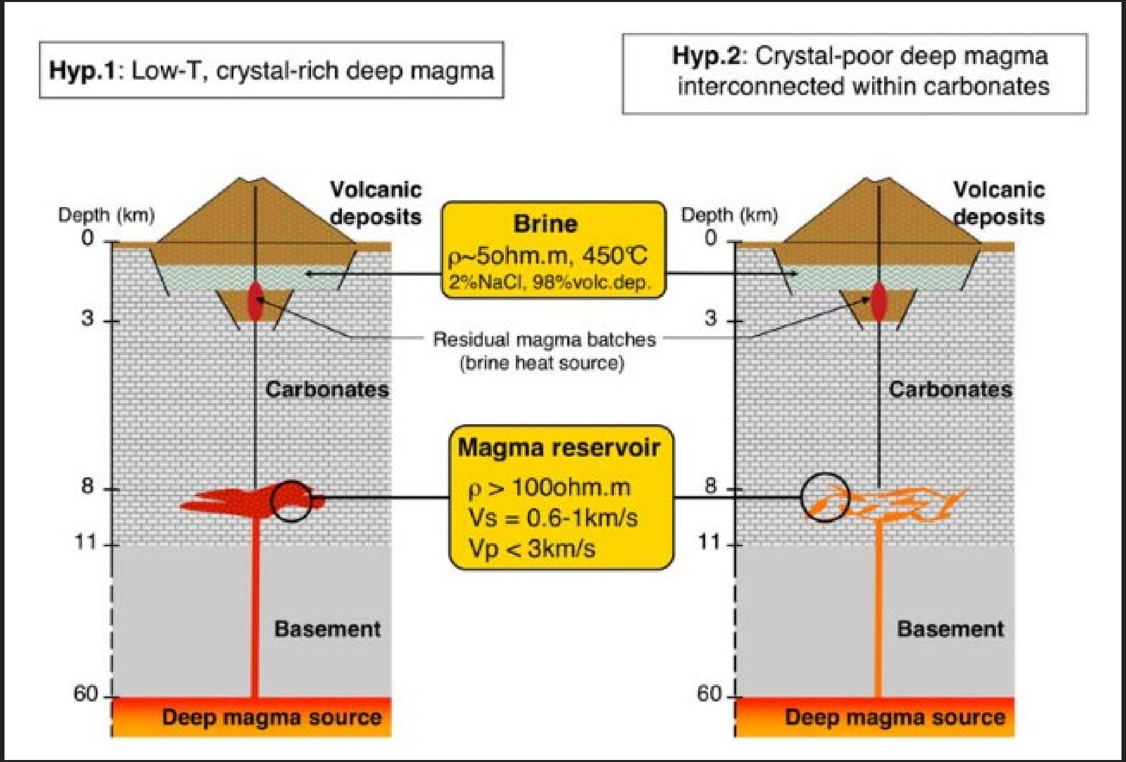
Vesuvius (Sbrana et al., 2020)

- Formed by an older stratovolcano, Mt Somma, that is cut by a polyphasic caldera, and by the stratovolcano Vesuvius which grew inside the caldera.
- The stratovolcano of Mt Somma grew up mainly through the piling up of lava flows and spatter and loose scoria deposits
- Has deposits from a large number of eruptions of different intensity that had occurred in the last 22,000 years.
    - Well known in terms of stratigraphy, dispersal and main physical parameters.
- Vesuvius cone possibly began to form after 79 AD inside the Somma caldera.
    - Coincidence with minor explosive activity
    - Growth occurred discontinuously during periods of open conduit activity
- After an eruption is 1631 the last period of activity formed its present geomorphology

Eruption types (Vogel et al., 2015)

- Plinian,
- Sub-Plinian,
- Strombolian to Vulcanian,
- effusive Volcanic events

Magma Chamber Hypothesis



(Pommier et al., 2010)

Two possible scenarios concerning the presence of a deep magma chamber below Mt. Vesuvius. Hyp 1, considers a low-temp and crystal-rich magma. Hyp 2, explains the deep geophysical anomaly by the presence of a hot magma interconnected within the surrounding carbonates.

Etna Stratovolcano & Eruptions

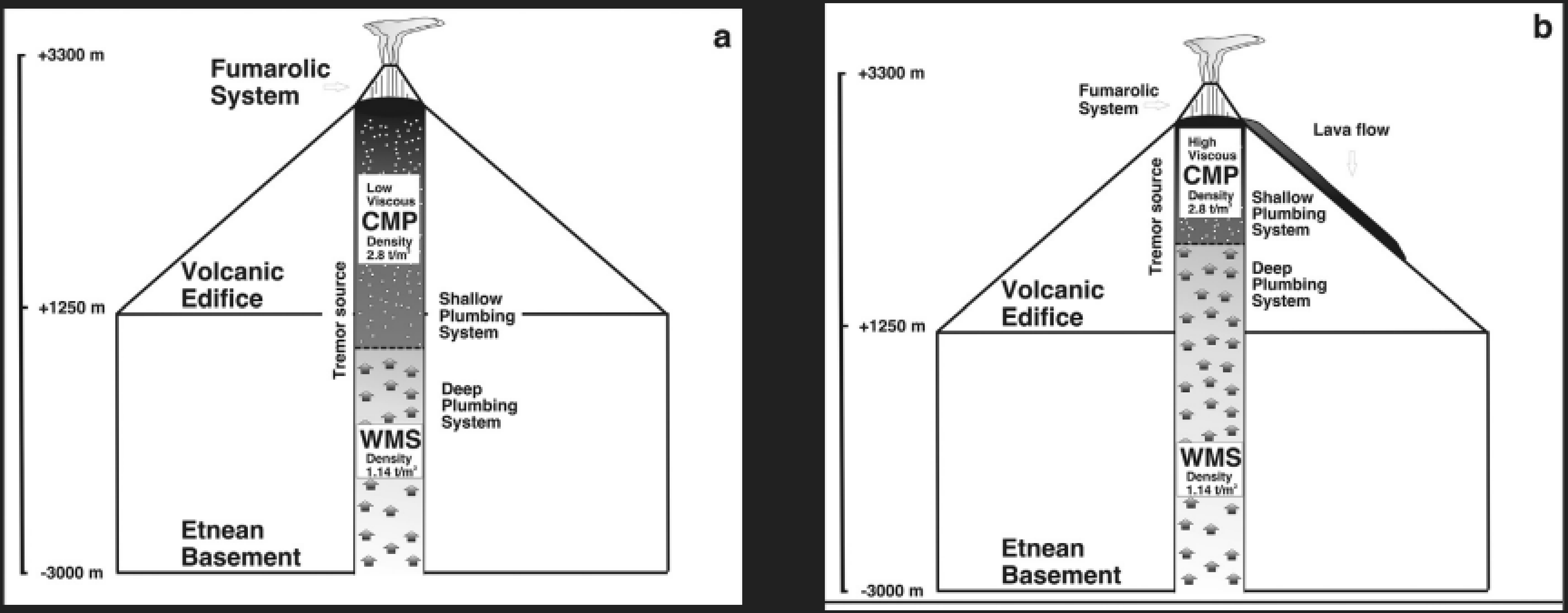
- The convection and Mixing of volatile-rich and volatile-poor melts within a single plumbing system is thought to play a critical role in sustaining long-lasting volcanic activity in Mt. Etna (Kahl et al., 2015)
    - Hot water flux transports molten basalt that accumulates in the shallow plumbing system to be erupted discontinuously (Ferlito, 2018)
- Basaltic volcanism developed on the structural domain of the Gela-Catania Foredeep
- Characterized by persistent and long standing Strombolian Activity
- Vigorous short-lived periods of high explosivity (paroxysmal) eruptions
    - High eruption columns and widespread ash fall
- Irregular intervals of years to decades
    - Hazardous eruptions from flanks
- Currently in a high active state started 63 years ago (Branca et. al, 2006)

Open-conduit system with four active craters

Eruption Types

1. Non-Eruptive
2. Effusive
3. Explosive

Etna Plumbing System



(Ferlito, 2018)

Past Eruptions / Geologic History

Etna - (Branca et. al, 2007)

- ★ Beginning of Eruptive Volcanism
  - Middle Pleistocene
- ★ 500 ka:
  - Submarine eruptions - thoeleiitic pillow lavas
  - Gela-Catania Foredeep basin seafloor
- ★ 300 ka:
  - Fissure-type eruptions
  - Lava plateau formed on alluvial plain
- ★ 220 ka:
  - Localized eruptive activity along Ionian Coast
  - Fissure-type eruptions
- ★ 129-126 ka:
  - Central volcanism

Somma-Vesuvius (Sbrana et al., 2020)

- 22,000 The trachytic Pomici di Base Plinian eruption marks the shift to a more explosive activity fed by generally evolved magmas.
- 79 AD, which caused the destruction of Roman cities: Pompeii, Herceulaneum, Oplontis, Stabiae and several other smaller settlements. (first eruption of vesuvius)
- 1631 the last explosive even occurred
- Last eruption occurred in 1944
  - The rise of volatile-rich mafic magma triggered a mix effusive-explosive eruption
- Vesuvius is quiescent since March 1944

In short
39ka-22ka: building of Somma
22ka-79AD: Caldera formation
472AD-1631: Post-caldera activity
1631-1944: Vesuvius cone

Mineral Chemistry

Etna (Ferlito, 2018)

- Volcano composed of Na-rich hawaiites (olivine basalt)
- Erupted trachybasalt
  - (plagioclase, pyroxene, alkali feldspar)
- Extreme dispersion of basaltic components
  - Various generations of olivine
  - Plagioclases

Vesuvius:

- ClinoPyroxene and olivine are ubiquitous phases in Somma-Vesuvius. (Redi et al., 2016)
- Composition of vesuvius is related to the effect of carbonate assimilation in the Mesozoic basement of the volcano. (Dallai et al., 2011)
  - A massive exchange of heat and mass produces large amounts of CO_2
  - this has the potential to change the composition and solubility of volatile components that are dissolved in the melt.
  - This prompts an increase of magma explosivity.

Guiding Questions + Divided Work

- ★ *How do our collected samples from Mount Vesuvius and Mount Etna compare to literature compositions?*
- ★ *How do Mount Vesuvius and Mount Etna compare to each other?*

Payton-Jean

- Vesuvius
  - XRF powder pellets
    - Powderizing, pellet making
- Etna
  - Thin sections
    - Grinding

Zoe

- Etna
  - XRF powder pellets
    - Powderizing, pellet making
  - Thin sections
    - Impregnation, cutting, grinding

★ Helped each other on these processes

Hand Samples & Descriptions

Vesuvius 1

Light tan/ white in color with dark crystals imbedded.

★ Porphyritic

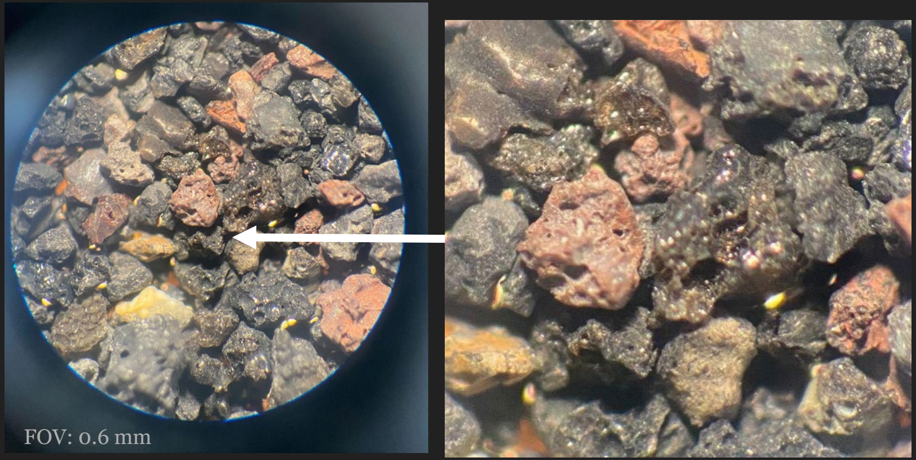
Vesuvius 2

Dark gray/ light gray in color, with lighter/white crystals imbedded.

Etna-98-Rock

★ Basaltic volcanic rock with vesicular texture

Etna-98-Ash

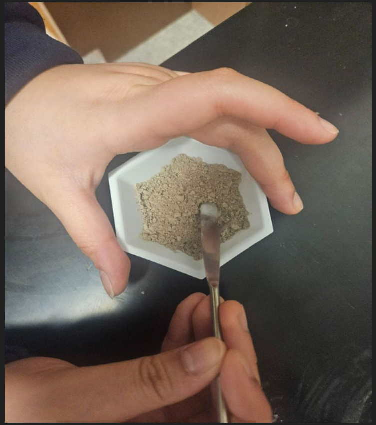


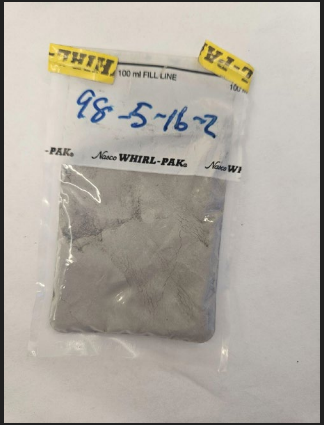
★ Coarse ash with black, red, and yellow fragments, some crystalline

Methods

Thin Section & XRF

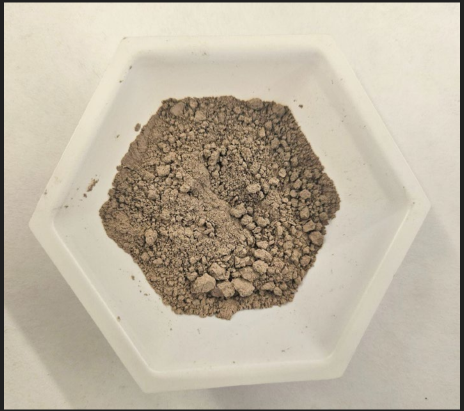
Methods for XRF





Vesuvius 2 - powderized rock

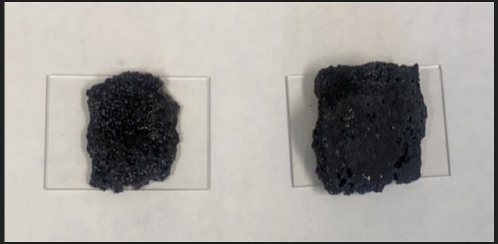
Etna-98-Rock (Broken & Powderized)

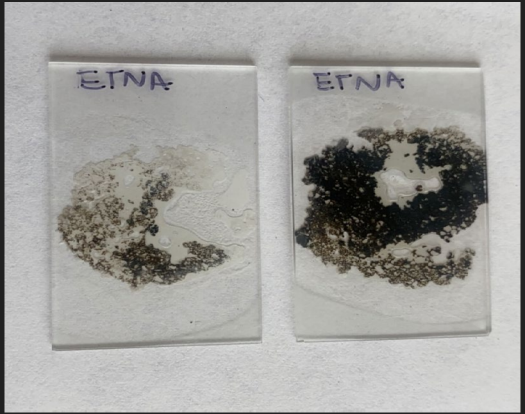


Vesuvius 1 - powderized rock

Etna-98-Ash (Powderized)

Thin Section Preparation



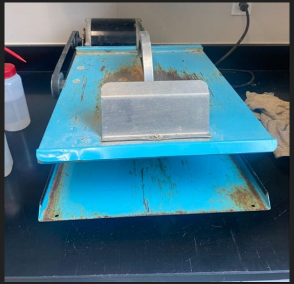


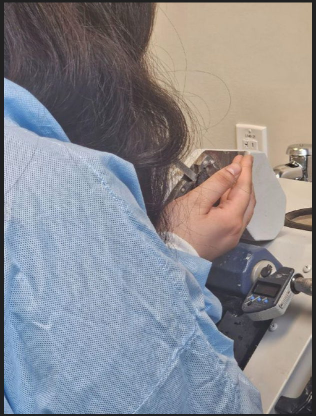
Impregnation
section to 30μm

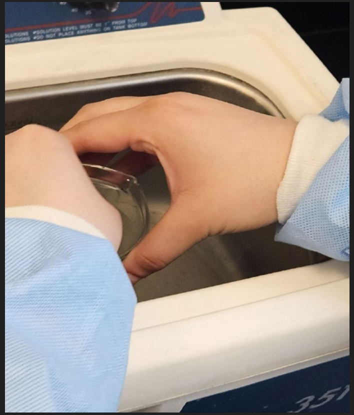
Cutting billets
Clean & ready

Attaching billets to glass slide

Grinding thin

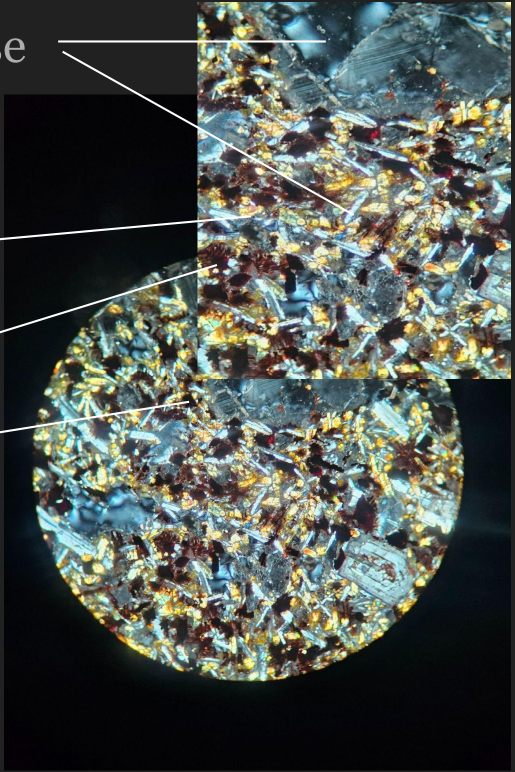






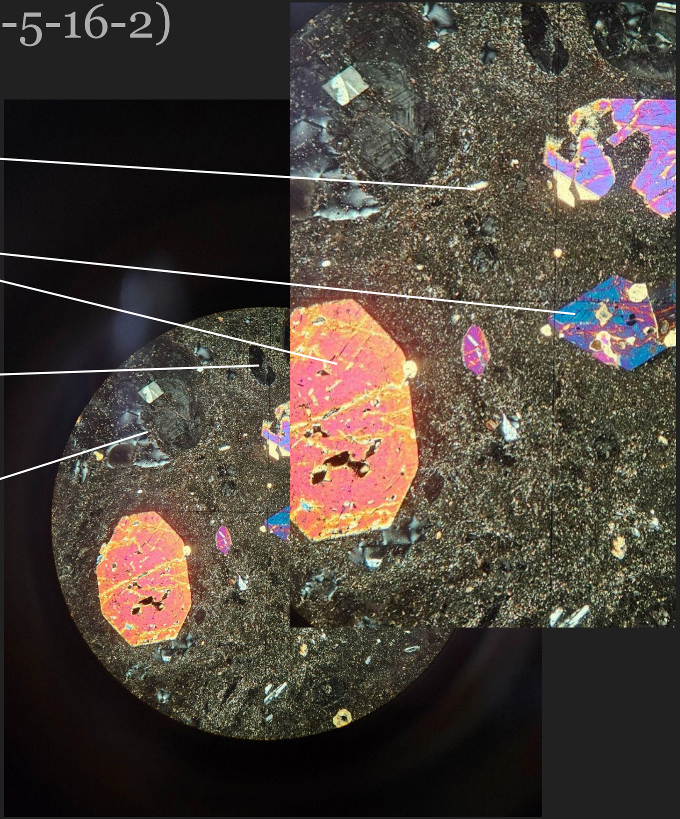
Petrographic Analysis

Vesuvius (98-5-16-1)



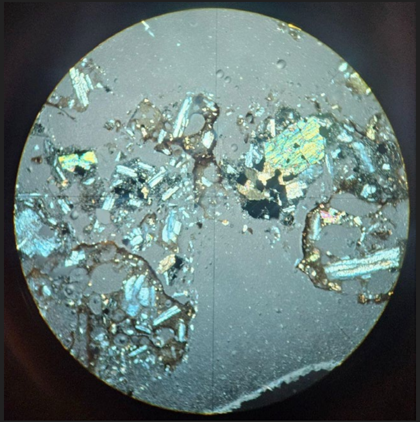
FOV: 2mm

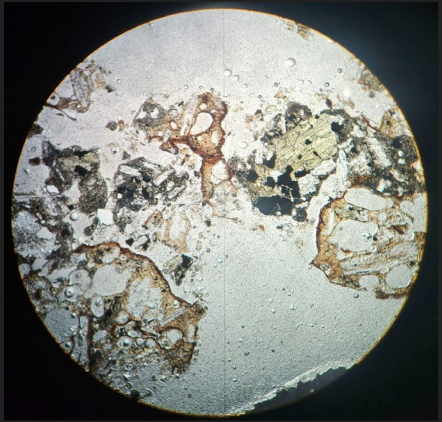
Vesuvius (98-5-16-2)



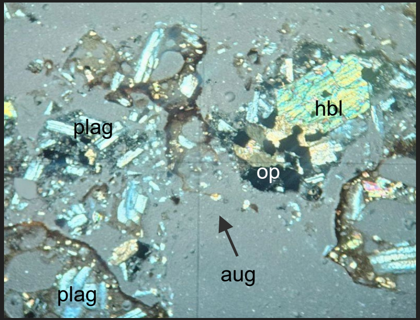
FOV: 4mm

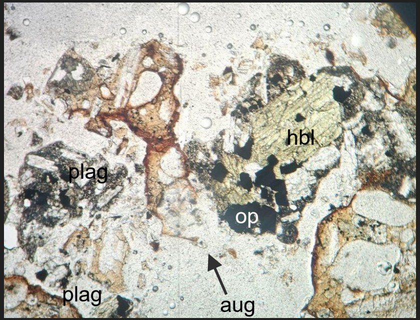
Etna-98-Rock

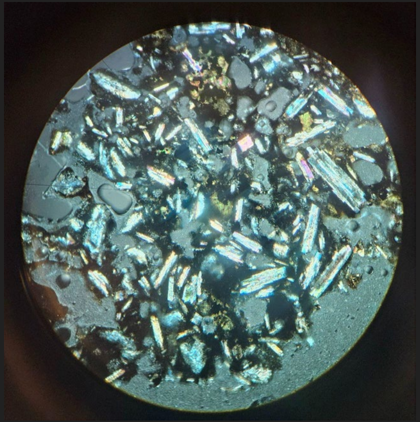


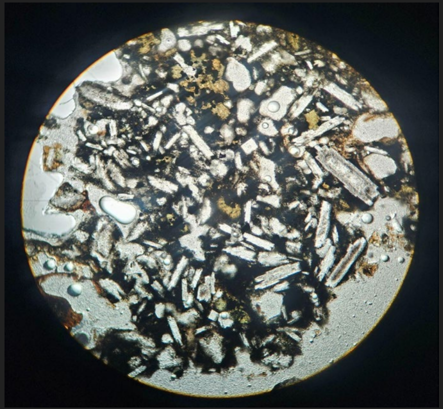


FOV: 3.2 mm

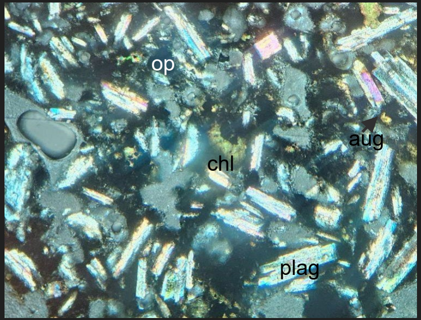


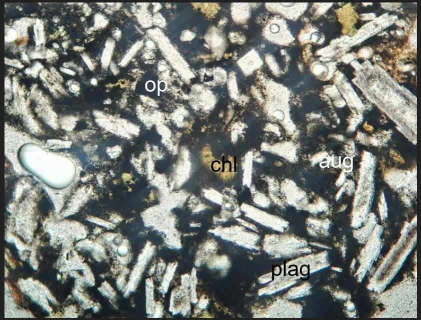






FOV: 3.2 mm





XRF Results

Our Vesuvius Analysis

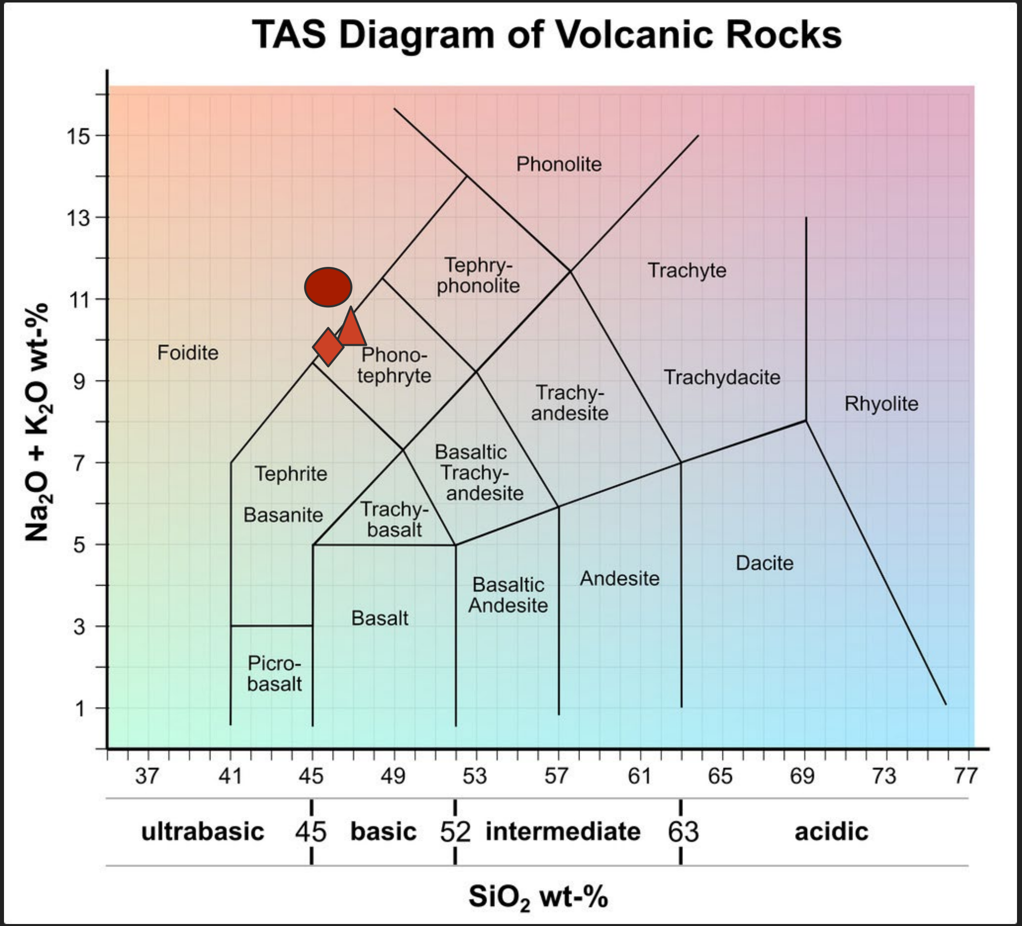
- High in SiO_2 and Al_2O_3
- Low in MnO and P_2O_5

Mass%	98-5-16-1	98-5-16-1 (2)	98-5-16-2
SiO2	46.4	47.9	46.9
TiO2	0.992	0.946	1.02
Al2O3	17.9	18.4	17.4
Fe2O3	8.99	8.24	8.68
MnO	0.153	0.141	0.15
MgO	3.11	3.42	4.38
CaO	9.56	10.05	10.1
Na2O	2.95	2.75	2.8
K2O	8.58	7.9	7.39
P2O5	0.74	0.756	0.645
Total	99.375	100.503	99.465

Vesuvius TAS diagram

	98-1	98-1 (2)	98-2
SiO2	46.4	47.9	46.9
Na2O+ K2O	11.53	10.65	10.19

	98-1	98-1 (2)	98-2
SiO2	46.7%	47.7%	47.2%
Na20+K 2O	11.6%	10.6%	10.24%



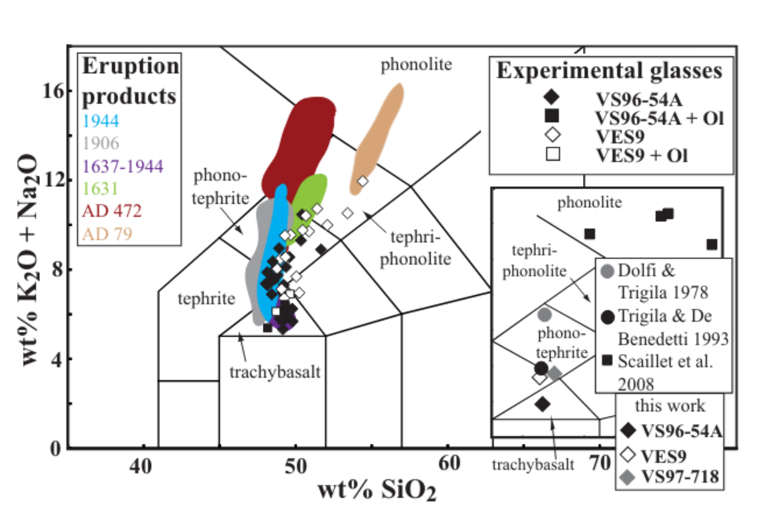
Vesuvius - Mineralogy Literature

Bull Volcanol (2011) 73:789–810 803

Table 2 Whole rock (XRF) and glass (SEM-EDS) composition of samples from the different stratigraphic units. In brackets is the number of the averaged analyses for the glass matrix

Sample	AS 94 50	AS 94 51	AS 94 52	AS 94 55	AS 94 56	AS 94 58	AS 94 59	AS 94 60	Matrix glass		
Unit	U3base	U3interm	U3top	U5interm	U5top	U6	U7base	U7top	U3 (4)	U3 (6)	U7 (6)
wt %											
SiO_2	49.08	48.78	48.76	48.86	48.01	48.67	48.13	47.77	48.70	48.37	46.66
TiO_2	0.86	0.91	0.94	0.98	1.03	0.98	1.00	1.02	0.93	0.93	1.24
Al_2O_3	17.94	17.46	17.16	16.41	15.70	14.88	15.65	15.79	20.28	19.32	18.89
Fe_2O_3	3.18	3.42	3.47	3.28	3.59	3.41	3.49	3.79	7.79	7.52	8.54
FeO	4.17	4.27	4.20	4.31	4.41	4.19	4.20	4.25			
MnO	0.16	0.16	0.16	0.15	0.16	0.15	0.15	0.16	0.34	0.15	0.16
MgO	3.09	3.60	3.90	5.04	5.29	6.13	5.94	6.00	1.83	2.91	3.79
CaO	8.09	8.72	8.97	9.83	10.85	11.18	10.82	10.99	7.54	9.15	10.11
Na_2O	3.63	3.46	3.56	2.99	2.85	2.68	2.78	2.73	5.45	4.33	4.30
K_2O	6.95	6.77	6.49	5.91	5.82	5.39	5.55	5.55	6.05	6.36	5.20
P_2O_5	0.51	0.55	0.57	0.68	0.69	0.68	0.72	0.67			
LOI	2.35	1.89	1.83	1.57	1.61	1.67	1.57	1.29			
Total	100.01	99.99	100.01	100.01	100.01	100.01	100	100.01			

(Cioni et al., 2011)



(Pichavant et al., 2014)

Our Etna XRF Results

- High in SiO_2 & Al_2O_3
- Low in MnO
- Ash and rock samples similar
  - MgO most variable

Mass %	98-Etna-Ash	98-Etna-Rock
SiO_2	46.3	47.7
Al_2O_3	16.4	17.3
Fe_2O_3	11.8	10.9
CaO	10.6	9.9
MgO	7.59	5.2
Na_2O	2.76	3.77
TiO_2	1.91	1.84
K_2O	1.72	2.27
P_2O_5	0.346	0.422
MnO	0.18	0.19
Total	99.606	99.492

Etna TAS Diagram

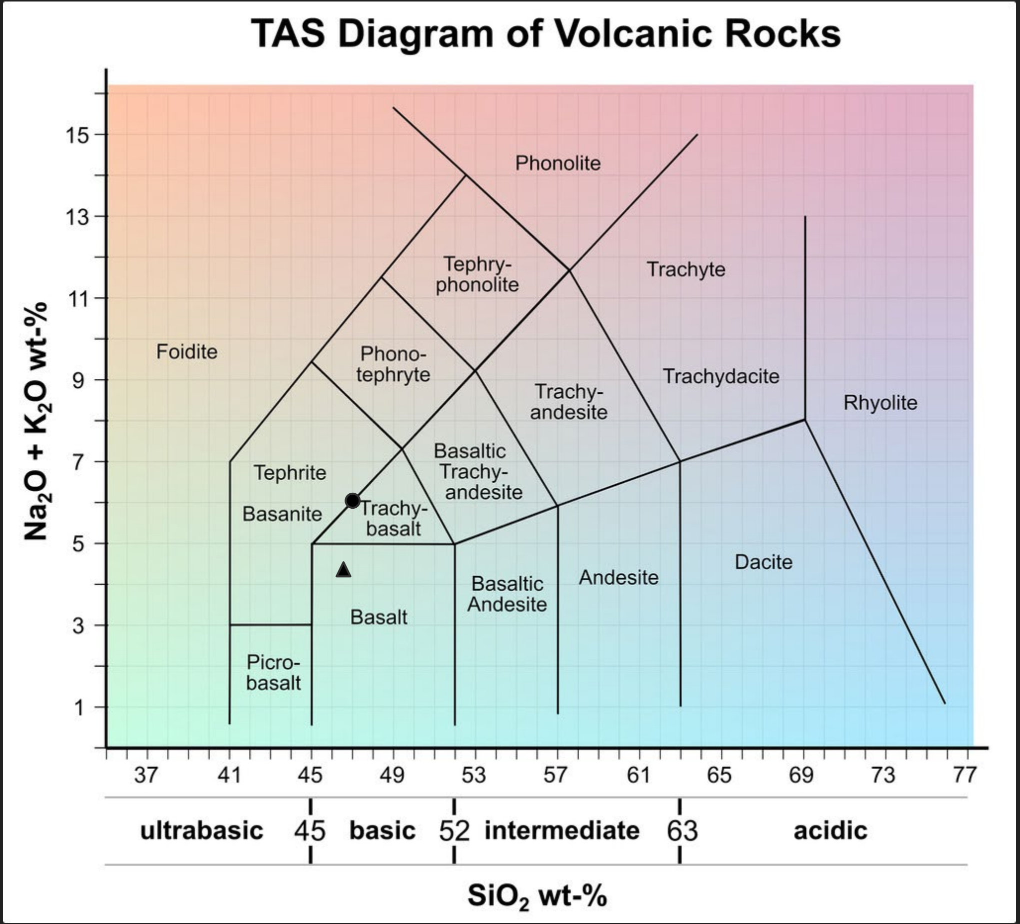
Mass %	98-Etna-Ash	98-Etna-Rock
Na_2O+K_2O	4.48	6.04
SiO_2	46.3	47.7

Mass %	98-Etna-Ash	98-Etna-Rock
Na_2O+K_2O	4.50%	6.07%
SiO_2	46.48%	47.94%

Legend

98-Etna-Ash: ▲

98-Etna-Rock: ●



Horwell et. al (2015) XRF & TAS Diagram

Table 3 Whole-rock XRF data for Etna ash samples (oxide weight %)

Sample #	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	LOI	Total
INGV_1	48.82	1.61	17.72	10.30	0.171	4.66	9.43	4.16	2.049	0.599	0.045	−0.09	99.48
INGV_2	46.74	1.79	16.96	11.59	0.177	5.16	10.50	3.45	2.039	0.558	0.047	0.03	99.05
INGV_3	47.73	1.78	17.20	11.51	0.169	5.67	10.38	3.28	1.866	0.536	0.080	−0.19	100.00
INGV_4	47.37	1.72	16.84	11.44	0.177	5.68	10.16	3.41	1.928	0.560	0.020	0.09	99.40
INGV_5	46.76	1.81	16.63	11.79	0.181	5.64	10.50	3.52	1.925	0.557	0.123	−0.10	99.34
INGV_6	46.69	1.82	16.72	11.87	0.177	5.41	10.64	3.41	1.931	0.542	0.061	−0.23	99.04
INGV_7	46.59	1.78	16.93	11.86	0.177	5.77	10.48	3.39	1.915	0.527	0.067	−0.24	99.26
INGV_8	47.91	1.69	17.61	10.86	0.172	4.80	10.10	3.71	2.142	0.577	0.060	0.00	99.62
CdF_1	49.28	1.44	19.84	9.10	0.151	3.12	8.98	4.14	1.593	0.620	0.017	0.95	99.22
CdF_2	49.01	1.41	19.52	9.19	0.150	3.43	9.09	4.09	1.540	0.602	0.023	0.70	98.74
CdF_3	48.41	1.46	19.96	9.41	0.154	3.33	8.84	3.83	1.465	0.624	0.038	1.71	99.23
CdF_4	45.21	1.69	19.48	10.56	0.199	3.35	7.66	3.09	1.246	0.711	0.026	5.92	99.15
CdF_5	47.81	1.51	19.80	9.61	0.161	3.39	8.35	3.74	1.441	0.621	0.035	3.13	99.60
CdF_6	48.09	1.59	18.77	8.95	0.122	2.64	6.96	3.74	1.796	0.746	0.240	5.71	99.36
CdF_7	48.57	1.58	18.77	8.64	0.134	2.74	7.37	3.79	1.720	0.715	0.220	4.94	99.19
CdF_8	49.04	1.48	19.67	9.34	0.155	3.41	9.79	4.09	1.545	0.553	0.036	0.24	99.36
ETNA4/11/02	47.46	1.73	16.72	11.56	0.17	5.72	10.10	3.84	2.10	0.61	-	−0.18	99.84

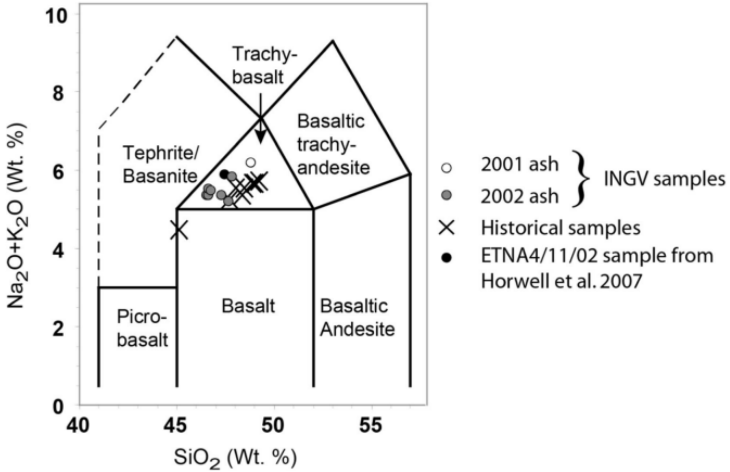


Fig. 3 Total alkali silica plot from XRF data, showing the magmatic composition of samples

(Horwell et. al, 2015)

Mollo et. al (2011) TAS Diagram

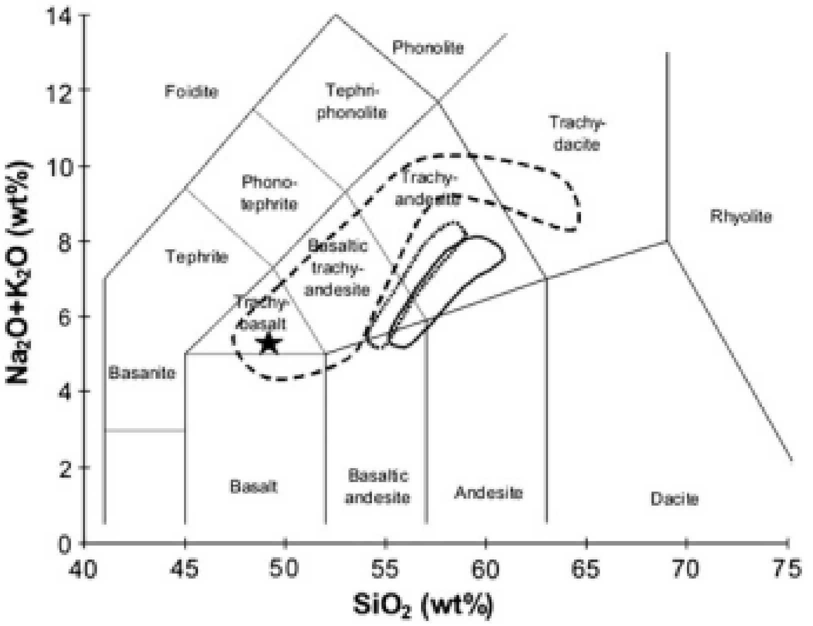


Fig. 2. Compositions of products erupted at Mt. Etna volcano. In the Na_2O+K_2O versus SiO_2 diagram the bulk rock analysis of the dike (closed star) and deposits of Trifogletto II (solid line), Vavalaci (dotted line), and Ellittico (dashed line) eruptive centers are plotted.

(Mollo et. al, 2011)

Discussion

Etna - Our Results vs. Literature

Similar Results to Horwell et. al (2015) & Mollo et. al (2011)

- Basalt, Trachybasalt
  - Etna-98-Rock plotted closer to the line of tephrite basanite & trachybasalt than Horwell et. al (2015) & Mollo et. al (2011)
    - Horwell et. al (2015) –Trachybasalt ash
    - Mollo et. al (2011) – Trachybasalt dike, deposits from basalt to trachydacite
- Near exact mass % for all components
  - High SiO_2 (46-48% range)
    - Horwell et. al (2015): SiO_2 most variable (45-49%)

Vesuvius - Our Results vs. Literature

Slightly off from Pichavant et al., 2014

- Our 1998 samples plotted closer to that of the Foidite line.
  - Our two most recent XRF analysis are still in the Phono-tephrite range, which is were the majority of the Pichavant sample sit.
  - The Pichavant Samples ranged from Trachybasalt to Phonotlite
- Silica mass in ours were 46.7 - 47.7%
  - Cioni: 46-49%
  - Pichavant: 46-57%

Conclusions

Vesuvius vs. Etna

★ Phonotephrite (Vesuvius), Trachybasalt (Vesuvius & Etna)
- Vesuvius has higher K_2O and higher Na_2O than Etna, but they have similar SiO_2 content

1. Etna-98-Rock & Etna-98-Ash had similar chemical composition to literature published on studies indicating magma flow/ash creation likely occurred at similar periods of basaltic volcanic activity
    - However, there is high variability

2. Vesuvius 98-1, 98-2 Had similar but not exact composition to the literature published. If I was to place a phase in which our rock sames were from based on the Pichavant TAS diagram I would say they are from the last phase so the 1631-1944 vesuvius cone.

This is just my thought

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