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CHAPTER 3
Monte Amiata volcanic products and their inclusions

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3.1 HISTORICAL PERSPECTIVES

Monte Amiata is the highest mountain of Tuscany (1750 m.a.s.l.). This solitary mountain lies in the very heart of the region, and rises between the valleys of Orcia, Fiora, and Paglia rivers. It is well known for its mercury sulphide (cinnabar) mines; some of the deposits were discovered by the Etruscans and, until recently, they formed a substantial component of the local economy. There was human settlement on the mountain in prehistoric times, as testified by the Pittura dell'Arciere on the top of the mountain. This was also due to the abundance of water springs at the contact between the volcanic products and Oligocene flysh. The Etruscans dominated from 900 BC up to 300 BC. In the river Fiora valley there are lots of signs of prehistoric and Etruscan settlement.

Then Romans conquered this area and at the falling of the Roman empire the area was godforsaken for long time until the Low Middle Age. At Abbadia San Salvatore there is an abbey founded in 743 by the Longobard King Rachis and rebuilt in a Romanesque style in 1036. Piancastagnaio was originally the property of the abbey, but then it changed hands and came under the control of the Visconti, then the Aldobrandeschi family, and finally, in 1416, it was taken over by Siena. Entrance to the town is through a battlemented gateway; inside are the remains of a castle erected by the Aldobrandeschi, and in the central Piazza Matteotti there is the ancient Palazzo Pretorio.

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3.2 GENERAL REMARKS

The Mount Amiata is the youngest and the southernmost volcanic complex belonging to the Tuscan magmatic province, excluding the Tolfa complex. It is located about 30 Km North of Vulsini volcanoes, the northernmost Roman volcanic complex. The M. Amiata volcanic massif, consists essentially of felsic effusive products covering an area of about 85 km^2 and resting on rocks of different age: Tuscan series (Palaeozoic basement, Triassic limestones, Cretaceous-Oligocene terrigenous formations), the Ligurid sequence (mainly ophiolites) and Neogene sediments (Fig. 1). The eruptive activity of M. Amiata volcano occurred in an area (comprising also the Radicofani volcano) uplifted during Quaternary time, most probably due to the emplacement of a magma body at 5-6 km of depth (Barberi *et al.*, 1994). The volcanic activity developed in four phases mainly along a fault system with ENE-WSW direction (normal to the Apennine trend; Fig. 1; Mazzuoli and Pratesi, 1963; Barberi *et al.*, 1971; Van Bergen, 1985; Ferrari *et al.*, 1996). The emplacement of these products occurred in a relatively narrow span of time ranging from 303 to 209 Ka (Ferrari *et al.*, 1996).

3.3 FIELD CHARACTERISTICS AND VOLCANOLOGY

The first phase of volcanic activity gave rise to trachydacite lavas (BT: basal tracydacites) outpoured from the ENE-WSW trending fault system (Fig. 1). These lavas, although viscous, flowed in narrow valleys far from the vents for deep morphology and assumed the typical structures of viscous lavas. These features are well visible in all marginal sectors of the basal volcanic complex. The structural elements of these lavas, recognizable on the field (i.e in southern sector at Marroneto and in the North Eastern sector at Castel Del Piano cimitery) are: a) massive lava usually laminated for the flowing b) tongues usually laminated (ramps) uprising among c) brecciated lava very common at the base of the flow and among the ramps. The complex is still object of different interpretations. Old studies (Rittmann, 1958; Marinelli, 1961) referred to BT as rheoignimbrite, which is an ignimbrite that

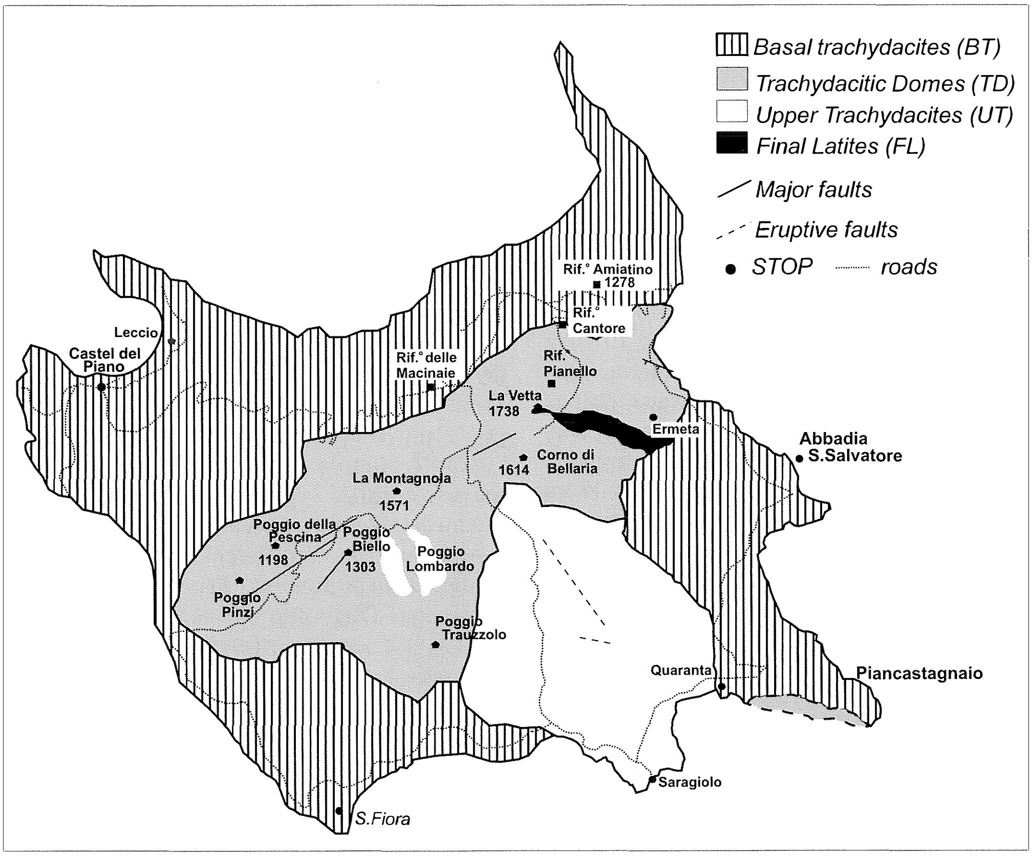

Fig. 1 – Geological sketch map of Mt. Amiata (modified from Mazzuoli and Pratesi, 1963 and Ferrari *et al.*, 1996).

developed secondary flowage after the depostion, due to high temperature. More recent studies (Ferrari *et al.*, 1996) propose that BT was initially characterized by an explosive activity that progressively decreased its energy, with final emission of blocky lava flows. The described field characters, as well as the relevant thickness in respect to the extension of BT volcanics, however, led to exclude that these products can be considered ignimbrites. Furthermore in the M. Amiata area no pyroclastic products associated with BT lavas has been recognised in the field.

The second period of activity is characterised by the emplacement of trachydacite lava domes (TD: Trachydacitic Domes) and minor lava flows usually outpoured by the margins of the domes (Fig. 1). These products were mainly erupted along the same ENE-WSW fault and along a fault with conjugate direction. The tree cover on the majority of the volcanites, makes difficult to recognise domes and lava flows structures. An attempt to distinguish them on the basis of photogeologic studies can be found in Ferrari *et al.* (1996). However the few outcrops on the border of the volcanic complex show structures characteristic of exogenous domes. The most common superficial aspect of these volcanic units is constituted by blocks somewhere sheeted, which represent the autobrecciated margins of the domes.

The third period of activity produced trachydacitic lava flows (UT: Upper Trachydacites) outpoured from the southern flank of two lava domes: Poggio Biello and Corno di Bellaria. The easternmost of these flows, even if trachydacitic in composition and similar to the previous products, extends quite far from the vent southward (Fig. 1).

The M. Amiata volcanism ends with the eruption of two small latitic lava flows (FL: Final Latites) from the same eruptive fracture (Fig. 1). It is noteworthy that although the Mt. Amiata magmas are felsic they did not give explosive products as, on the other hand, all the others Tuscan anatectic magmas (e.g. S. Vincenzo and Roccastrada).

In figure 2 published ages with relative errors are reported for the four Amiata complexes (Ferrara and Tonarini, 1985; Laurenzi and Villa, 1991; Barberi *et al.*, 1994). It is shown that Amiata volcano has been emplaced into two main phases: 290 ± 18 Ka and 202 ± 8 Ka. In the first period were emplaced the basal Trachydacites and the domes and lavas, whereas in the second period were emplaced the Upper Trachydacites and the final Latites.

The Mt. Amiata volcanites contain metamorphic xenolith and/or magmatic inclusions. The latter are very scanty or lacking in the basal trachydacites and abundant in the other samples rock types, whereas the metamorphic xenoliths are particularly abundant in the basal products.

3.4 Petrography and geochemistry of lavas

In Table 1 modal analyses of Amiata rocks are reported. The basal trachydacites (BT) have medium grained porphyritic texture with phenocrysts of plagioclase, sanidine, biotite, orthopyroxene and scarce clinopyroxene set in a generally glassy and perlitic groundmass. Apatite, zircon and ilmenite are the common accessory phases. Resorbed xenocrysts of quartz may somewhere occur. The trachydacitic domes (TD) contain large and abundant phenocrysts of sanidine reaching up 5 cm in length, plagioclase, orthopyroxene somewhere rimmed by clinopyroxene, clinopyroxene, biotite and sporadic olivine. Microcrystals of clinopyroxene, biotite and rarely of orthopyroxene are found in a generally glassy groundmass. The accessory minerals are apatite, zircon and ilmenite. Under microscope the upper trachydacite lava flows (UT) are similar to the basal trachyidacites whereas the final latites (FL) contain phenocrysts of plagioclase, sanidine, ortho- and clinopyroxene, biotite, olivine and sporadic xenocrysts of quartz. In the glassy groundmass microcrystals of plagioclase, sanidine,

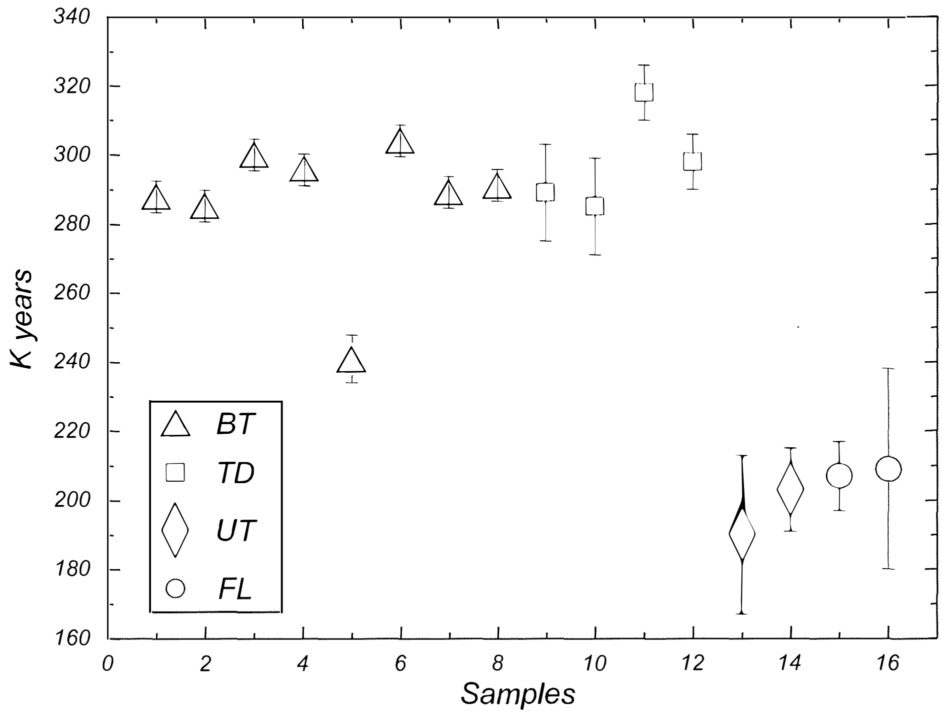

Fig. 2 – Published age data of M. Amiata volcanics. Triangles: Basal trachydacite (BT); squares: Trachy-dacitic domes (TD); rhombs: Upper trachydacites (UT); circles: Final latites (FL). Data sources: Ferrara and Tonarini, 1985; Laurenzi and Villa, 1991; Barberi *et al.*, 1994.

TABLE 1

Modal analyses of selected samples from Mt. Amiata volcanic units. BT: Basal Trachydacites, TD:trachydacitic Domes, UT:Upper Trachydacites, FL: Final Latites

	BT	TD	UT	FL
N° samples	20	21	12	12
Plg	17.4	14.5	18.2	10.1
San	15.1	10.9	15.7	4.2
Opx+Cpx	3.3	3.9	4.3	8.65
Bio	2.3	3.3	3.1	2.4
Acc *	0.5	1	0.7	0.95
Gnd	61.4	66.4	58	73.7
Total	100	100	100	100

* Ap, Zr, Mgt.

clinopyroxene and minor magnetite are usually found.

In Table 2a are reported selected chemical analyses of M. Amiata volcanites. On TAS diagram (Fig. 3) the products belonging to the first three periods of activity (BT, TD and UT, respectively) fall in calc-alkaline field of Irvine and Baragar (1971) and show a relatively narrow cluster in the trachydacitic field, whereas the final lava flows have a latitic composition and more alkaline character. On the K_2O-SiO_2 diagram (Fig. 4A; Peccerillo and Taylor, 1976) all the rocks belong to the shoshonitic series.

In figure 4 B-D Harker's diagrams of selected elements are reported. TiO_2, CaO and FeO_{tot}, MgO, Na_2O, P_2O_5 (not shown) decrease

TABLE 2A

Representative chemical whole rock compositions of selected samples from Mt. Amiata volcanic units. BT: Basal Trachydacites, TD:trachydacitic Domes, UT:Upper Trachydacites, FL: Final Latites.

Samples	*Unit*	*SiO_2*	*TiO_2*	*Al_2O_3*	*Fe_2O_3*	*FeO*	*MnO*	*MgO*	*CaO*	*Na_2O*	*K_2O*	*P_2O_5*	*LOI*	*Total*	*K_2O/Na_2O*
AM 129	BT*	64.53	0.58	16.62	3.30	0.78	0.07	1.80	3.50	2.27	5.18	0.24	1.13	100.00	2.28
AM 132	BT*	66.30	0.60	15.85	2.20	1.38	0.06	1.53	3.12	2.16	5.60	0.22	0.98	100.00	2.59
AM 1	BT*	67.22	0.52	15.78	2.15	0.86	0.05	1.20	2.64	2.29	5.93	0.18	1.20	100.02	2.59
AM 37	BT*	68.27	0.48	15.26	2.14	0.64	0.05	1.11	2.56	2.20	6.14	0.15	1.01	100.01	2.79
AM 16	BT*	68.34	0.48	15.19	2.41	0.36	0.05	1.13	2.30	2.15	6.25	0.15	1.20	100.01	2.91
AM 104	TD*	63.58	0.57	16.96	1.64	2.31	0.07	2.05	3.33	2.08	5.74	0.23	1.44	100.00	2.76
AM 79	TD*	64.94	0.60	16.60	3.05	0.25	0.05	1.52	2.99	2.27	5.77	0.22	1.74	100.00	2.54
AM 147	TD*	66.69	0.47	16.75	1.59	1.63	0.05	1.35	2.02	1.97	5.98	0.17	1.33	100.00	3.04
AM 29	TD*	66.87	0.50	15.97	2.10	1.07	0.05	1.58	2.69	2.21	5.82	0.18	0.96	100.00	2.63
AM 174	TD*	67.55	0.51	16.04	1.79	1.52	0.05	1.35	2.28	2.21	5.64	0.19	0.87	100.00	2.55
AM 74	UT*	64.88	0.53	17.83	2.53	0.79	0.05	1.40	2.65	2.24	5.78	0.20	2.37	101.25	2.58
AM 120	UT*	66.54	0.52	15.97	2.30	0.84	0.05	1.35	2.79	2.20	5.86	0.18	1.39	99.99	2.66
AM 71	UT*	66.87	0.51	15.95	2.18	0.97	0.05	1.29	2.72	2.40	5.63	0.18	1.25	100.00	2.35
AM 184	FL*	57.37	0.74	18.48	1.64	3.61	0.08	3.65	5.15	1.79	5.44	0.27	1.77	99.99	3.04
AM 27	FL*	59.63	0.66	15.70	3.56	1.40	0.09	4.08	6.15	1.91	5.55	0.27	1.01	100.01	2.91
AM 138	FL*	61.42	0.64	16.70	3.69	0.78	0.08	3.02	4.73	1.96	5.63	0.24	1.13	100.02	2.87
AM 87	FL*	61.16	0.64	17.20	2.00	2.68	0.08	2.99	4.19	1.84	5.79	0.26	1.19	100.02	3.15
AMT 78	BT#	64.00	0.57	17.80	0.54	2.70	0.05	1.51	2.75	2.20	5.82	0.16	1.87	99.97	2.65
AMT 95	BT#	64.80	0.55	17.50	0.19	2.84	0.05	1.44	2.54	2.16	5.90	0.19	1.86	100.02	2.73
AMT 60	BT#	65.40	0.63	16.40	0.53	2.76	0.06	1.34	2.87	2.29	6.22	0.17	1.41	100.08	2.72
AMT 54	BT#	65.90	0.54	16.80	0.21	2.80	0.05	1.23	2.75	2.13	6.09	0.16	1.32	99.98	2.86
AMT 04	BT#	66.00	0.56	15.90	0.77	2.68	0.06	1.28	3.08	2.18	6.11	0.16	1.25	100.03	2.80
AMT 01	BT#	66.90	0.58	15.50	0.50	2.56	0.05	1.19	3.00	2.25	6.24	0.16	1.05	99.98	2.77
AMT 52	BT#	67.10	0.50	15.90	0.23	2.72	0.05	1.19	2.79	2.17	6.15	0.15	1.07	100.02	2.83
AMT 34	BT#	67.70	0.60	15.80	0.05	2.60	0.05	1.26	2.91	2.19	6.21	0.17	0.46	100.00	2.84
AMT 44	TD#	58.40	0.67	18.60	1.15	3.40	0.08	3.05	4.21	1.80	5.46	0.22	2.91	99.95	3.03
AMT 104	TD#	62.80	0.60	16.90	1.18	2.88	0.07	2.08	3.68	1.96	5.94	0.18	1.78	100.05	3.03
AMT 21	TD#	64.60	0.57	16.90	0.69	2.68	0.06	1.43	2.98	2.25	5.99	0.16	1.66	99.97	2.66
AMT 65	TD#	66.10	0.45	17.00	1.77	1.28	0.05	1.51	2.25	2.18	5.85	0.18	1.37	99.99	2.68
AMT 89	TD#	66.50	0.50	16.30	1.80	1.66	0.06	1.56	2.18	2.06	5.94	0.16	1.28	100.00	2.88
AMT 82	FL#	58.80	0.65	16.50	1.01	3.98	0.08	4.43	5.91	1.82	5.89	0.21	0.74	100.02	3.24
AMT103	FL#	59.30	0.66	15.80	1.80	3.28	0.09	3.92	6.47	1.72	5.68	0.21	1.09	100.02	3.30
AMT 28	FL#	60.50	0.66	16.50	2.15	2.80	0.08	3.08	5.17	1.93	5.76	0.21	1.09	99.93	2.98

* Rombai *et al.*, 1995; # Ferrari *et al.*, 1996.

TABLE 2B

Representative chemical whole rock compositions of magmatic inclusions (MI) hosted in Mt. Amiata volcanic products. Data source: Rombai et al., 1995.

Samples	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	*FeO*	*MnO*	*MgO*	*CaO*	Na_2O	K_2O	P_2O_5	*LOI*	*Total*	K_2O/Na_2O
AM 170	48.28	0.88	17.25	4.08	3.15	0.14	8.26	9.88	0.75	5.25	0.34	1.77	100.03	7.00
AM 144	51.02	0.80	16.24	3.49	3.70	0.12	7.61	8.67	1.19	5.18	0.42	1.56	100.00	4.35
AM 179	51.45	0.88	17.14	4.02	2.95	0.12	6.63	8.25	1.31	5.44	0.38	1.45	100.02	4.15
AM 180	51.98	0.84	18.89	4.99	1.64	0.11	5.26	6.33	1.74	5.95	0.43	1.84	100.00	3.42
AM 175	54.34	0.83	18.73	3.29	2.88	0.10	4.66	6.36	1.62	5.51	0.35	1.33	100.00	3.40
AM 45	55.35	0.81	18.51	2.97	3.40	0.11	4.33	4.80	1.52	5.78	0.32	2.10	100.00	3.80
AM 101	50.72	0.91	17.39	4.21	2.69	0.12	6.72	7.95	1.43	5.75	0.50	1.61	100.00	4.02
AM 176	50.74	0.87	18.51	3.22	3.94	0.12	6.22	7.27	1.32	5.89	0.42	1.49	100.01	4.46
AM 103	51.05	0.92	16.81	4.62	2.51	0.12	6.62	8.53	1.51	5.23	0.48	1.59	99.99	3.46
AM 189	51.41	0.84	17.47	4.06	3.10	0.11	6.62	7.99	1.50	5.20	0.46	1.24	100.00	3.47
AM 181	51.64	0.88	19.05	3.28	3.65	0.11	5.08	6.08	1.64	6.18	0.43	1.97	99.99	3.77
AM 100	51.77	0.89	18.43	3.07	3.51	0.11	5.54	7.06	1.59	5.99	0.44	1.59	99.99	3.77
AM 89	51.80	0.91	18.22	2.00	4.97	0.11	4.65	7.28	2.02	5.73	0.52	1.78	99.99	2.84
AM 187	52.90	0.98	18.69	4.33	2.36	0.11	4.01	6.88	1.71	5.92	0.47	1.64	100.00	3.46
AM 143	53.01	0.91	17.84	4.49	2.71	0.12	5.55	8.16	1.42	4.01	0.49	1.30	100.01	2.82
AM 52	53.54	0.82	17.99	3.78	2.80	0.11	4.84	6.68	1.74	6.03	0.41	1.27	100.01	3.47
AM 107	54.43	0.77	17.76	2.21	4.23	0.11	5.44	6.25	1.25	5.45	0.37	1.74	100.01	4.36
AM 140	55.08	0.79	17.55	3.60	2.64	0.11	4.97	6.43	1.60	5.15	0.38	1.71	100.01	3.22
AM 99	55.32	0.91	17.66	4.18	1.98	0.10	4.82	5.94	1.51	6.18	0.35	1.06	100.01	4.09
AM 96	58.28	0.76	17.63	3.45	1.92	0.09	3.83	4.69	1.85	5.93	0.29	1.27	99.99	3.21
AM 85	59.03	0.77	17.24	3.89	1.68	0.09	3.16	5.39	1.96	5.56	0.31	0.91	99.99	2.84

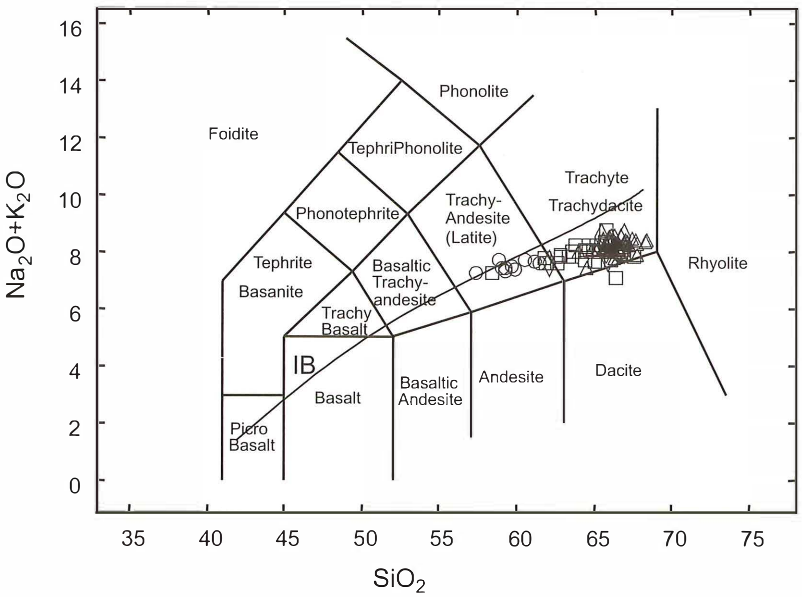

Fig. 3 – TAS classification diagram (Le Bas *et al.*, 1986) of Monte Amiata volcanic rocks and magmatic inclusions. The IB line divides alkaline and subalkaline fields, according Irvine and Baragar (1971). Symbols as in figure 2 but grey field: Magmatic inclusions (MI). Data sources: Rombai *et al.*, 1995; Ferrari *et al.*, 1996.

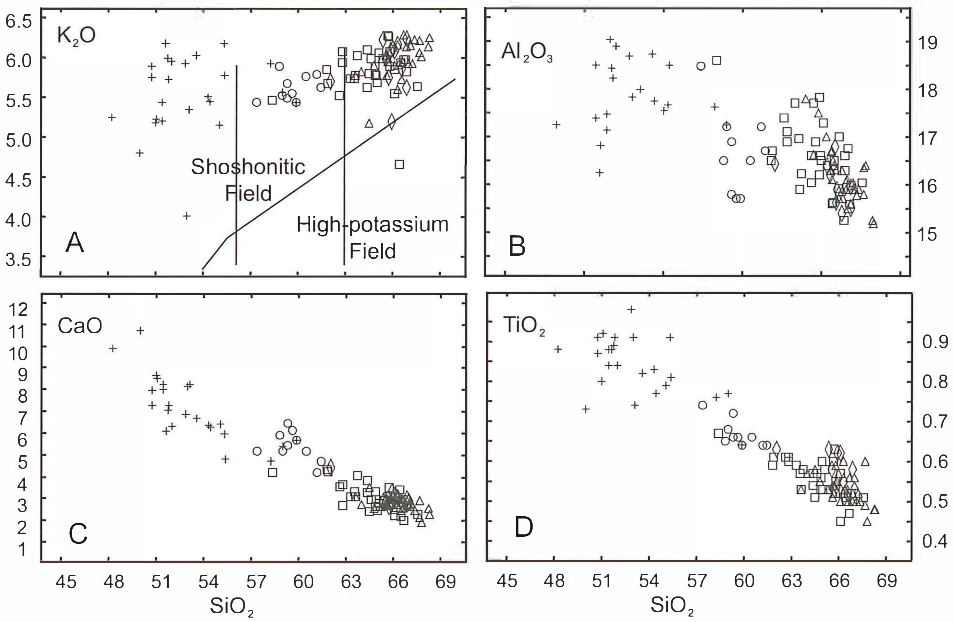

Fig. 4 – K_2O vs. SiO_2 diagram (Peccerillo and Taylor, 1976) (A) and selected major element Harker diagrams for M.Amiata volcanites (B-D). Symbols as in figure 2 but plus cross: magmatic inclusions. Data sources: Rombai *et al.*, 1995; Ferrari *et al.*, 1996.

regularly with increasing silica content from the mafic enclaves to the trachydacites, whereas Al_2O_3 is quite scattered. Sr and Ba show a quite regular decrease with increasing silica (Fig. 5), whereas Y and Rb increase even if MME have a very large scattering. Zr and La (not shown) are quite scattered. In figure 6 average of available trace elements for the rock units of M.Amiata are reported in the primordial mantle normalized spider diagram (Wood, 1979). The samples are relatively enriched in Rb, Ba, K, La and Ce and depleted in Nb, Ti, P and Zr indicating a typical calc-alkaline affinity.

The isotopic compositions are quite high suggesting a crustal origin for lavas from M. Amiata as for many rocks of Tuscan Magmatic Province (Table 3). In figure 7 $^{87}Sr/^{86}Sr$ against 1/Sr is reported. Two groups of samples at different $^{87}Sr/^{86}Sr$ can be recognized: groups at higher and lower isotopic ratios correspond to volcanites, basal Trachydacites and the domes and lavas, emplaced during the first period of activity (290 Ka), and to volcanites, Upper Trachydacites and the final Latites, emplaced during the second period of activity (202 Ka), respectively. Enclaves plot on the lower $^{87}Sr/^{86}Sr$ ratio group.

3.5 METAMORPHIC XENOLITHS AND MAGMATIC INCLUSIONS

Metamorphic xenoliths, generally less than 15 cm in size, show angular shape and are dark in colour. Detailed macroscopic and petrographic description of the M. Amiata metamorphic xenoliths has been given by Van Bergen (1983) and by Van Bergen and Barton (1984). These authors defined these xenoliths as a fine-grained hornefels like rocks representing the fragments of the contact aureole set in the

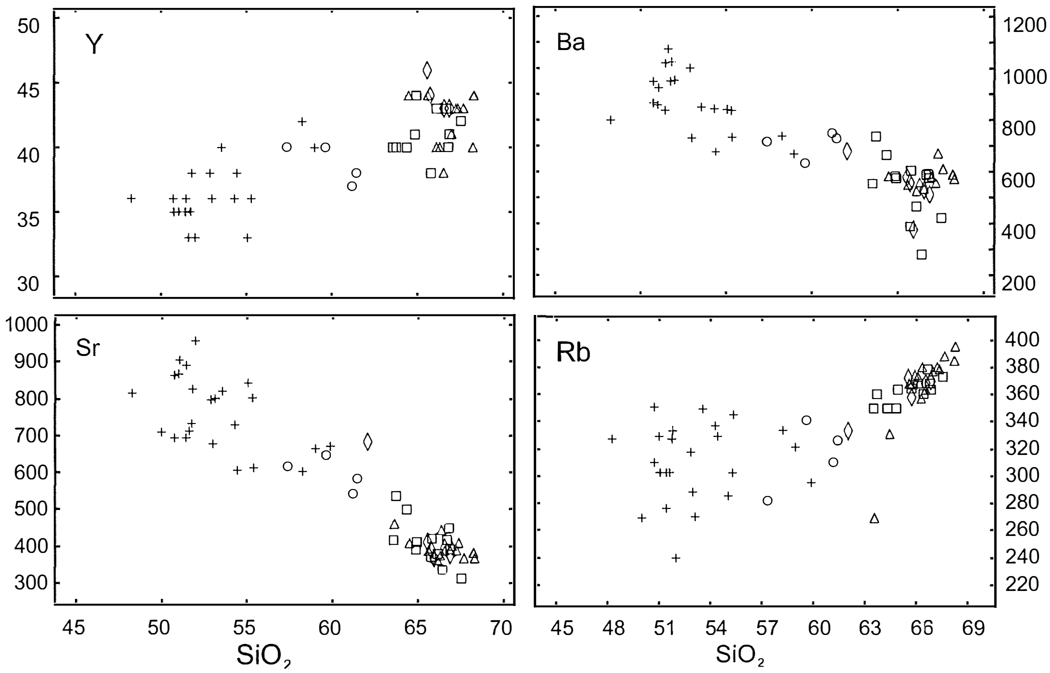

Fig. 5 – Selected inter-elemental diagrams for M.Amiata volcanites showing the variation of some elements against SiO_2. Symbols and data source as in Figure 4.

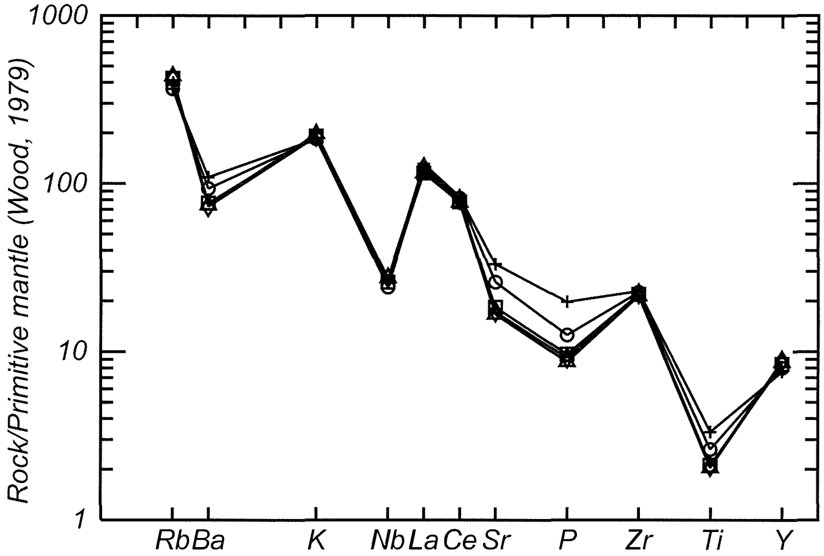

Fig. 6 – Average trace elements of the rocks units and magmatic inclusions of Mt. Amiata. Symbols and data source as in Figure 4.

TABLE 3

Sr concentration and Sr, Nd and Pb isotopic composition for Mt. Amiata volcanic rocks. Data source: Vollmer, 1977 (#); Hawkesworth and Vollmer, 1979 (#); Poli et al., 1984 (*);Conticelli et al., 2002 (&).

samples	rock type	Sr ppm	$^{87}Sr/^{86}Sr$	$^{143}Nd/^{144}Nd$	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
TR 82*	latite	593	0.7121±2				
MA 77-14*	latite	581	0.7119±3				
QLB 86*	trachydacite	391	0.7126±2				
MA 77-24*	trachydacite	334	0.7129±5				
MA 77-1*	trachydacite	370	0.7130±3				
MA 77-19*	trachydacite	356	0.7131±3				
MA3V#	trachydacite	340	0.71300±3	0.51214±2	18.720	15.678	39.007
MA4V#	latite	626	0.71184±5	0.51216±2	18.706	15.661	38.937
MA5V#	trachydacite	374	0.71293±5		18.688	15.65	38.918
Amt 10&	trachydacite	444	0.71298±1	0.51211±1			
Amt 21&	trachydacite	461	0.71120±1	0.51207±1			
Amt 26&	Enclaves	671	0.71195±1	0.51204±1			
Amt20&	Enclaves	708	0.71088±1	0.51216±1			
Amt41&	Enclaves	798	0.7115±2	0.51228±1			

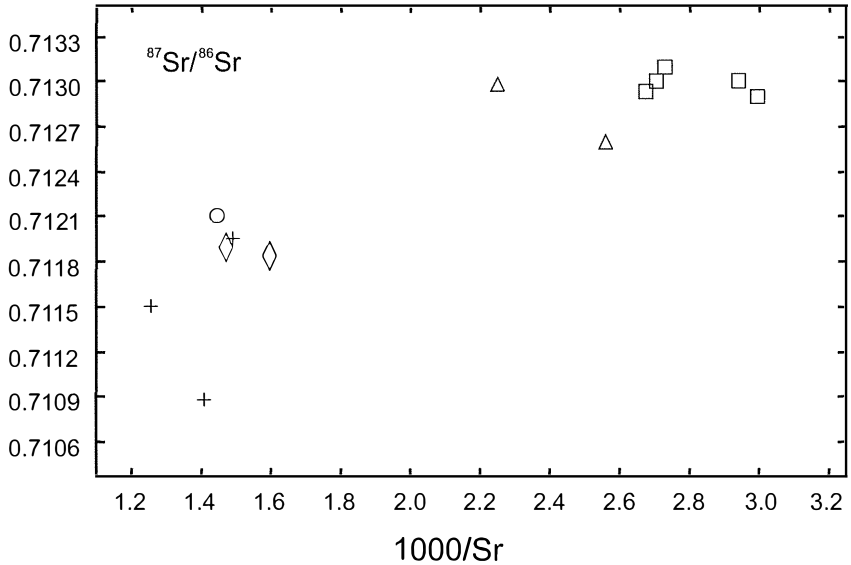

Fig. 7 – $^{87}Sr/^{86}Sr$ vs. 1/Sr*1000 for Mt. Amiata volcanic rocks. Symbols as in figure 4. Data sources: Vollmer, 1977; Hawkesworth and Vollmer, 1979; Poli *et al.*, 1984; Conticelli *et al.*, 2002.

pre-Mesozoic sediments of the Tuscan crystalline basement and entrained to the surface by the uprising magma. In table 4 is reported the summary of the mineralogy of representative samples. Three types of metamorphic xenoliths with distinct mineral assemblage have been distinguished (Rombai *et al.* 1995): a) quartz-plagioclase-sanidine-biotite-graphite and orthopyiroxene; b) sillimanite-plagioclase-sanidine-biotite-spinel-corundum-cordierite and garnet; c) sanidineplagioclase- biotite and orthopyroxene. Rombai *et al.* (1995) on the base of Ga-Si-Sp-Cd and Sp-Si-Cd-C mineral assemblage from metapelites, suggest that the contact metamorphic process occurred under conditions of 4 Kb and a temperature of about 700° C.

The magmatic inclusions (MI) are particularly widespread close to the emission fracture in the products of the second and third period of activity where they can reach even 70/80 cm in size. They are characterised by rounded or lobate shape, and are dark in colour, usually fine grained, aphyric somewhere porphyritic for sanidine. Under the microscope the porphyritic magmatic inclusions show phenocrysts of ortho and clinopyroxene, biotite, sanidine and somewhere olivine. Sanidine crystals are usually corroded and somewhere they show large size reaching 2/3 cm. For these characteristics this mineral has been considered as xenocryst (Balducci and Leoni, 1981) entrained from the host magma. Cloudy aggregates of pyroxene, plagioclase and biotite are also found.

Selected chemical analyses of magmatic inclusions are reported in table 2b. The majority of these rocks fall in the alkaline field as defined by Irvine and Baragar (1971) (Fig. 3) due to the high K_2O content (K_2O/Na_2O 4-4.5). For the relatively high Mg content (always more than 3%) and high K_2O/Na_2O ratio, the magmatic inclusions can be defined as shoshonitic rocks (Fig. 4A).

3.6 Petrogenetic model

Van Bergen (1983) observed that the straight-line correlation between M. Amiata

TABLE 4
Index of mineral assemblages for metamorphic xenoliths (Rombai et al., 1995). BT: Basal; Trachydacites; TD: trachydacitic Domes, UT: Upper Trachydacites, FL: Final Latites.

	Samples	M.Amiata volcanic Units	K-Feldspar	Plagioclase	Quartz	Sillimanite	Cordierite	Spinel	Biotite	Garnet	Orthopyroxene	Clinopyroxene	Graphite	Other
Assemblage «a»	AM 63	UT	X		X				X	X	X			
	AM 83	TD	X	X	X				X	X	X			
Assemblage «b»	AM 38	BT	X	X		X	X	X	X	X			X	corundum
	AM 66	UT	X	X		X		X	X	X				corundum
	AM 171	TD	X	X		X		X	X		X			oxides
Assemblage «c»	AM 7	BT	X	X				X	X		X		X	
	AM 18	BT	X	X				X	X		X		X	
	AM 67	UT	X	X				X	X		X			glass
	AM 88	FL	X	X			X	X	X		X		X	
	AM 142	FL	X	X				X	X		X	X	X	
	AM 151	TD	X	X				X	X		X		X	

magmatic inclusions and the whole rock chemistry of different rock units, could not be explained by any classic differentiation mechanism and a magma mixing process between mafic and felsic end members had to be invoked. This author estimated the composition of mafic end member solving best fit correlation lines in SiO_2-oxide/elements of the magmatic inclusions. This composition resulted similar to the composition of potassic magma of Roman magmatic province. The felsic end member is represented by the trachydacitic magma. Also Poli *et al.* (1984) asses that the M.Amiata magma is the product of mixing process between potassic magma of Roman magmatic province and a crustal magma, accompanied by crystal-liquid fractionation.

Further constraints can be placed with the new data. Figure 8 reports K_2O vs. SiO_2 diagram in which compositions of rocks belonging to the Tuscan Magmatic Province (both intrusives and effusives) and Roman Magmatic Province are plotted. It is shown that rocks from the M. Amiata area define a pattern that straddle the fields comprised between melts similar to the acid rocks of the Tuscan Magmatic Province and melts belonging to the HKS of Roman Province. In the light of this evidence the pattern defined by the Mt. Amiata rocks can be explained considering a geochemical evolution starting from a potassic magma generated by partial

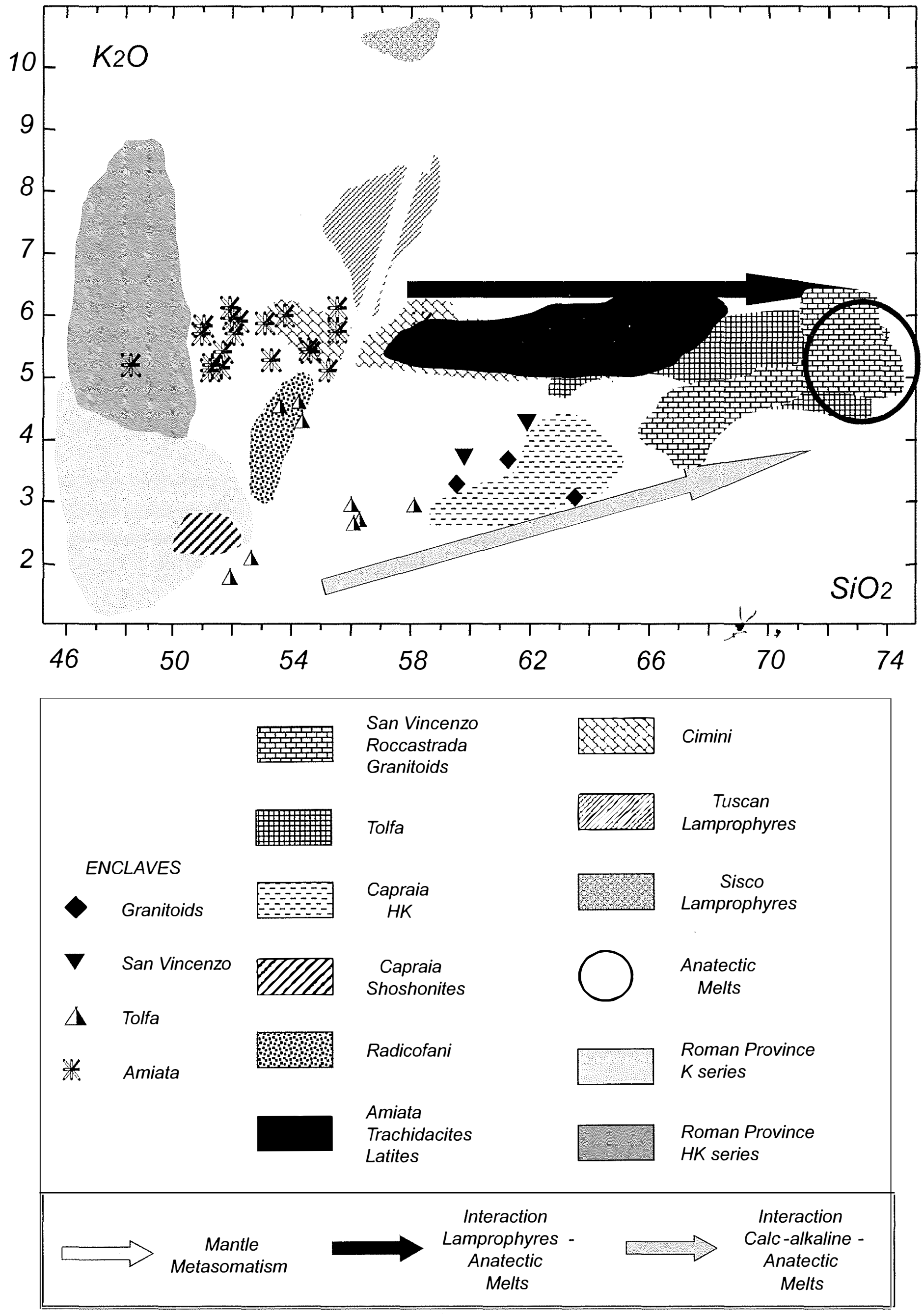

Fig. 8 – K_2O vs. SiO_2 diagram showing the pattern exhibited by M. Amiata rocks in comparison with intrusive and effusive rocks of the Tuscan and Roman Magmatic Province.

melting of a metasomatised mantle source (Peccerillo, 1999) that, successively, interacted with crustal components having compositional characters similar to the Tolfa more evolved rocks or the acid facies found in granitoid and volcanic rocks from the Tuscan Magmatic Province. Involvement of magmas belonging to the Roman Province is confirmed also by ratios of LILE/HFSE even if data on enclaves are lacking of peculiar elements like Ta and Hf useful to decipher their geochemical affinity. It is to note, in addition, that Mt.Amiata has an age very young and similar to that of Roman Province.