

Geochronology of volcanic rocks from Latium (Italy)

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ABSTRACT. — The age determination data for volcanic rocks from Latium (Italy) are reviewed. This paper reports the geochronological data obtained chiefly by the Ar-K technique, but also by Rb-Sr, ^{230}Th , ^{14}C and fission tracks methods.

The Latium region comprises rocks belonging to the acidic volcanic groups of Tolfa, Ceriti and Manziana districts and to Mt. Cimino group, having strong magmatic affinity with the Tuscan magmatic province and the rocks of the Roman Comagmatic Region. The last one encompasses the Vulsinian, Vicoan, Sabatinian volcanoes, the Alban Hills and the volcanoes of the Valle del Sacco, often referred to as Mts. Ernici volcanoes, all distinguished by a pronounced alkaline-potassic character.

To the Latium region belong also the volcanic islands of Ponza, Palmarola, Zannone, Ventotene, and S. Stefano (the Ponza archipelago), located at the margin of the Tyrrhenian trench, the magmatic activity of which evolved from an acidic to an alkaline-potassic character.

More than 180 age determinations are available at present and the general framework of the geochronology of the volcanic activity in Latium is fairly well established, even if contradictory results are still present.

The volcanic activity in the Tolfa, Ceriti and Manziana districts covered a time span from 4.2 to 1.8 Ma and the present data allow to assign their magmatic activity to the upper Pliocene rather to the lower Pliocene as stated before. Wide range variations are shown by the ages of ignimbrites and lavas belonging to the same sector and the age measurements are not always in agreement with the field evidence. Problems connected with inheritance and loss of radiogenic argon make it difficult to enter in chronological detail.

The activity of Mt. Cimino volcano can be located precisely enough from 1.27 to 0.94 Ma.

The oldest known products of Vulsinian activity appear fairly old, reaching 860 ka, but the most frequently dated samples cluster in the range from 130 to 500 ka. The lower limit of 55 ka needs further confirmation.

The dating of rocks from Vico volcano indicate age values ranging from 820 to 95 ka. To the ignimbrite C, often referred to as «tufo rosso a scorie nere», one of the typical products of the vicoan activity, an age of 420 ka may be reasonably assigned.

A few reliable age measurements are available for the Sabatini volcanoes, rather uniformly scattered between 607 and 85 ka. The «tufo rosso a scorie nere» from the sabatian region, which is the analogue of the ignimbrite C from Vico has a firmly established age of 442 ± 7 ka. This formation can be considered an important marker not only for the tephrochronology but also, more generally, for the Quaternary deposits in Latium.

Taking into account all data in the literature the oldest known product of the Alban Hills show an age of 706 ka, but more recent measurements indicate for these products a more recent age (400 ka). One of the pyroclastic units of the Alban Hills, the «Tufo di Villa Senni» has been dated with extremely good accuracy at 338 ± 8 ka and it is to be considered as the best reference term for the Alban Hills chronology. A lower age limit for the activity of the Alban Hills volcano is not yet precisely established, even there are clear signs of a recent age (40-50,000 years B.P.) for the last phreato-magmatic explosions.

The whole chronology of the Alban Hills needs further consideration owing the many inconsistencies in the published data.

The K-Ar ages obtained for the Hercinian district range from 700 ± 20 to 80 ± 40 ka and do not pose particular problems.

Contradictory results are also present regarding the activity in the Ponza Archipelago, which developed from 4.7 to less than 0.15 Ma. On the whole to the acidic volcanism in this group a Pliocene age can be assigned. During the lower Pleistocene, starting from 1.75 Ma a pronounced break in the volcanic activity occurred, which started again at about 1.1-1.2 Ma with the emplacement of products of alkaline-potassic affinity.

The data reported represent the results of almost 20 years of study in dating the young volcanics of Latium. Starting from the first measurements many improvements have been achieved but at the same time it turned out that the general situation is far to be satisfactory due to the persistent difficulties in dating young volcanic rocks.

The causes of the discrepancies are discussed and the need of further work is stressed.

Key words: Italy, Latium, volcanic rocks, geochronology, radiometric age.

RIASSUNTO. — Vengono passate in rassegna le datazioni delle rocce vulcaniche del Lazio. Questo lavoro riporta i dati ottenuti prevalentemente con il metodo potassio-argon, ma anche con i metodi del rubidio-stronzio, del carbonio-14 e delle tracce di fissione.

La regione laziale comprende le rocce appartenenti ai gruppi vulcanici acidi dei complessi Tolfa-tano, Cerite e Manziate ed al gruppo del M. Cimino, aventi una pronunciata affinità magmatica con la provincia Toscana e le rocce della Provincia Comagmatica Romana. Quest'ultima comprende i vulcani Vulsini, il vulcano di Vico, i vulcani Sabatini, i Colli Albani ed i vulcani della Valle del Sacco (o Valle Latina), spesso denominati anche vulcani degli Ernici, tutti caratterizzati da uno spiccato carattere alcalino-potassico.

Alla regione laziale appartengono anche le isole dell'arcipelago Pontino: Ponza, Palmarola, Zannone, Ventotene, Santo Stefano, situate al margine della fossa tirrenica, la cui attività si è andata evolvendo da un carattere acido a tipi alcalino-potassici.

Più di 180 determinazioni di età sono oggi disponibili e si può ritenere che il quadro generale della geocronologia dell'attività vulcanica nel Lazio sia abbastanza bene stabilito anche se sussistono ancora dati contraddittori e molti punti oscuri.

L'attività vulcanica nei complessi Tolfa-tano, Cerite e Manziate copre un intervallo di tempo da 4,2 a 1,8 Ma ed in base ai dati attuali è possibile attribuire questa attività al Pliocene superiore piuttosto che al Pliocene inferiore come ritenuto in precedenza. Notevoli variazioni si osservano fra le età delle lave e delle ignimbriti anche appartenenti allo stesso settore e le misure di età non sono sempre in accordo con le osservazioni di campagna. Diversi problemi connessi con eccessi di argon radiogenico o a successive perdite rendono difficile se non impossibile una ricostruzione cronologica di dettaglio.

L'attività vulcanica nel gruppo del M. Cimino può essere localizzata abbastanza bene fra 1,27 e 0,94 Ma.

I prodotti più vecchi dell'attività dei vulcani vulsini sembrano piuttosto antichi, essendo state registrate età fino a 860 ka, ma i campioni più frequentemente datati si addensano fra i 500 ed i 130 ka. Il limite inferiore di 55 ka necessita di ulteriore conferma.

Le datazioni dei prodotti del vulcano di Vico indicano valori di età compresi fra 820 e 95 ka. Alla ignimbrite C, nota anche come «tufo rosso a scorie nere», uno dei prodotti tipici dell'attività di Vico, si può ragionevolmente assegnare un'età di 420 ka.

Poche determinazioni attendibili di età si hanno per i vulcani Sabatini: le età sono distribuite piuttosto uniformemente fra 607 e 85 ka. Il «tufo rosso a scorie nere» della regione sabazia, che è l'analogo della ignimbrite C di Vico, ha un'età, molto ben definita, di 442 ± 7 ka. Questa formazione può essere considerata un importante livello guida non solo per la tefrocronologia ma, più generalmente, per la cronologia dei depositi quaternari del Lazio.

Se si prendono in considerazione tutti i dati esistenti in letteratura per la regione vulcanica

dei Colli Albani, le prime grandi effusioni laviche dovrebbero avere un'età di 706 ka, ma misure più recenti indicano per questi prodotti un'età più giovane (400 ka). Una delle formazioni piroclastiche dei Colli Albani, il «tufo di Villa Senni» è stata dataata con grande accuratezza e la sua età di 338 ± 8 ka costituisce un importantissimo termine di riferimento per la cronologia di questo vulcano. Un limite inferiore per l'attività vulcanica nei Colli Albani non si è ancora potuto stabilire con precisione. Vi sono però chiari indizi di un'età abbastanza recente (40-50.000 anni B.P.) per le ultime eruzioni freatomagmatiche. Tutta la cronologia dell'attività nei Colli Albani deve essere revisionata a causa della scarsa attendibilità di molti dati sinora pubblicati.

Le età K-Ar ottenute per i vulcani degli Ernici sono comprese fra 700 ± 20 e 80 ± 40 ka e non pongono problemi di interpretazione.

Qualche disaccordo si può osservare anche per quanto riguarda le datazioni delle rocce dell'arcipelago Pontino. Nell'insieme si può concludere che il vulcanismo acido in questo gruppo sia di età pliocenica, con inizio intorno a 4,7 Ma. Durante il Pleistocene inferiore, a partire da 1,75 Ma si è verificata una netta interruzione nell'attività vulcanica, che ha ripreso a circa 1,1-1,2 Ma con la messa in posto di prodotti ad affinità alcalino-potassica.

I dati sinora discussi rappresentano il risultato di circa 20 anni di ricerche intese allo studio cronologico delle rocce vulcaniche del Lazio. A partire dalle prime misure molti progressi sono stati realizzati ma allo stesso tempo molte discrepanze sono emerse così che la situazione generale è lungi dall'essere soddisfacente a causa delle persistenti difficoltà inerenti alla datazione di rocce vulcaniche giovani.

Vengono discusse alcune delle cause di tali discrepanze e viene sottolineata la necessità di ulteriori ricerche.

Parole chiave: Italia, Lazio, rocce vulcaniche, geocronologia, età radiometrica.

Introduction

Volcanic rocks play a considerable role in the geology of Latium. Of the 17184 Km² of his area 4922 Km² are i.e. 28.6 % are covered by volcanic products.

The volcanic activity developed from the late Pliocene up to some 50,000 years ago and is related to the Quaternary tensive tectonics which followed the plicative tectonics of the early Neogene, leading to the well known complex series of Apennine overthrusts. For an exhaustive discussion concerning the structural evolution and the petrogenesis reference should be made to the work of LOCARDI et al. (1976).

Two distinct series can be recognized among the Latium volcanites. The first one

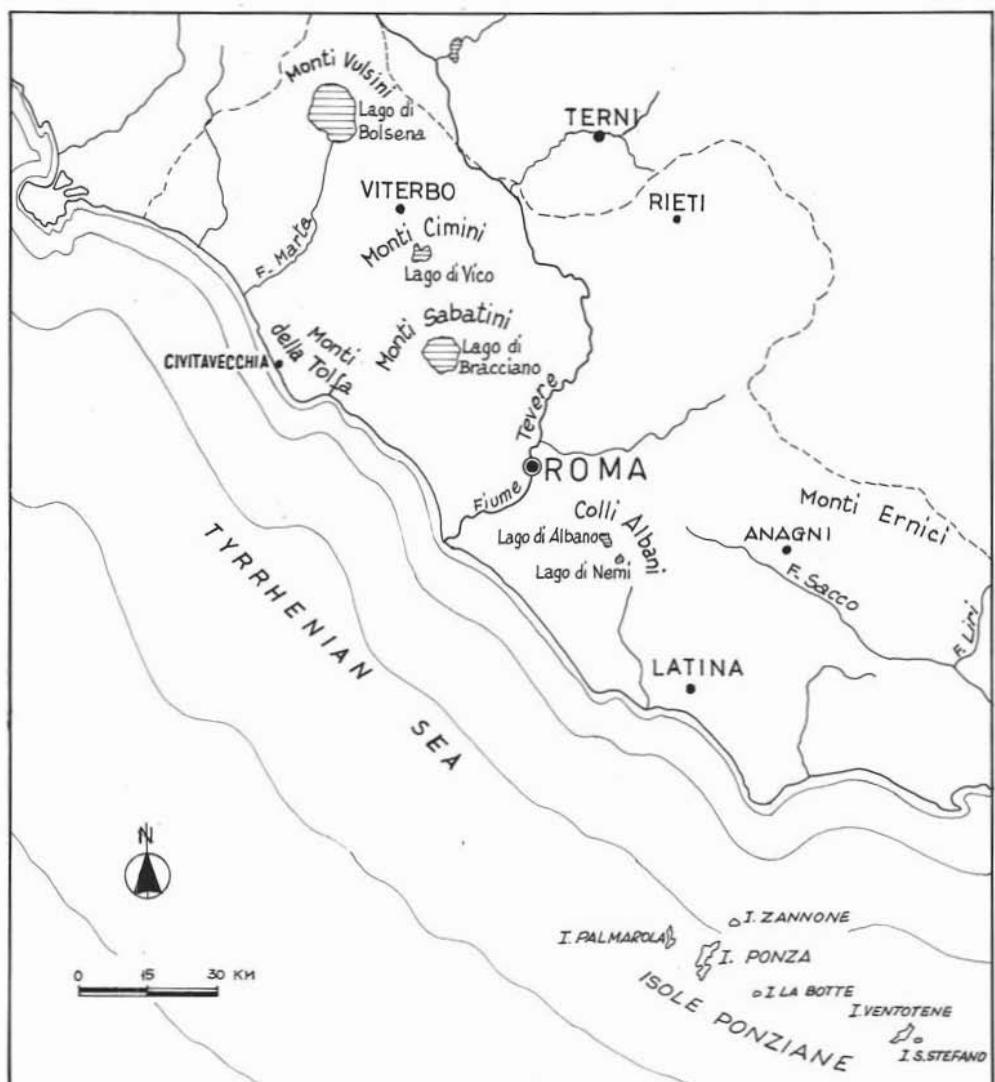


Fig. 1. — The volcanic groups of Latium.

encompasses the acidic volcanoes of Tolfa, Ceriti and Manziate districts and of Mt. Cimino; the second the Vulsinian, Vicoan, Sabatinian volcanoes, the volcanic region of the Alban Hills (often referred to as « Latian Volcano ») and the volcanoes of the Valle del Sacco (also called Vulcani della Valle Latina or Mts Ernici volcanoes).

The first series has a strong petrographic affinity with the Tuscan magmatic province, the anatetic nature of which has been widely recognized. The second is characterized by a pronounced alkaline-potassic character and is linked to the Campania alkaline magmatic

activity (Roccamonfina, Phlegraean Fields, and Vesuvius).

Also the islands of the « Arcipelago Pontino »: Palmarola, Ponza, Ventotene, Santo Stefano, belong to the Latium region. These islands are located at the margins of the Tyrrhenian trench and their magmatic activity, developing from the Pliocene up to late Quaternary, evolved from an acidic to an alkaline potassic character.

BARBERI et al. (1967) pointed out that the $^{87}\text{Sr}/^{86}\text{Sr}$ ratios measured in the products of the Pontine islands fall in a very narrow range and cluster around an average value

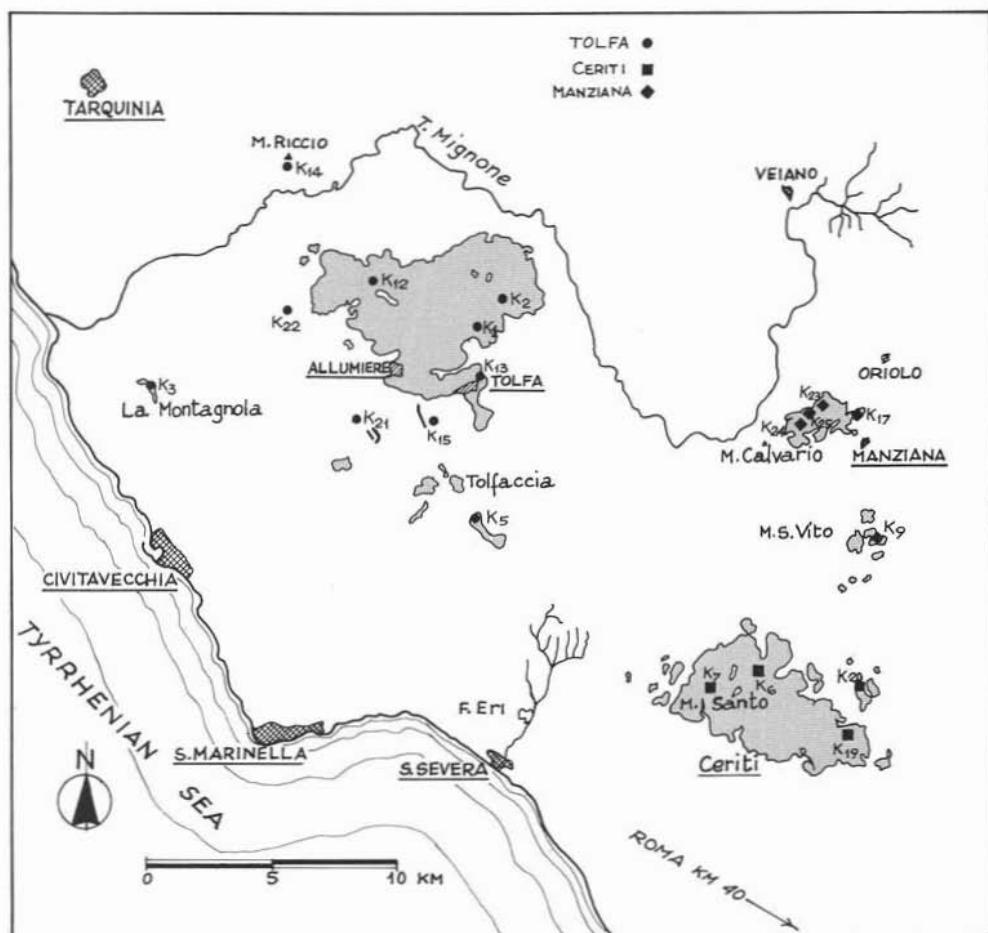


Fig. 2. — Tolfa, Ceriti and Manziana districts. Samples location and locality map.

of 0.7073, thus suggesting a single magmatic source. On the other hand, the above ratio is significantly lower than the value normally observed in materials of crustal origin, but higher as compared with typical values of uncontaminated basalts.

Two possible models are then considered for the origin of the rocks of the Pontine islands: either they derive from a contaminated basaltic magma or from partial melting of deep crust layers in which the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio is lower in comparison with the uppermost surficial zones.

Some 180 age measurements are available for the different volcanic districts and we can say that none of the most important volcanic units was overlooked and that the framework of the geochronology of the volcanic activity in Latium is fairly well established even if

some contradictory results are present, some points are still open to discussion and sometimes a more detailed work is needed.

The acidic volcanic group

Tolfa, Ceriti and Manziana districts

This district comprises the Tolfa and the Cerite massifs and the minor volcanic nuclei of the Manziana sector such as Mt. Calvario, Mt. San Vito and others, and together with some of the products of Ponza, represents the most ancient occurrence of volcanic activity in Latium.

The rocks of these massifs, although showing topographically separated identities are linked by similar structural and petrographical features and are therefore referable to a single genetic model.

Detailed research work by NEGRETTI (1963, 1965 a, 1965 b), LAURO et al. (1965), NEGRETTI et al. (1966), LAURO and NEGRETTI (1969), FERRINI et al. (1970) build up an exhaustive geological and petrographical image of this volcanic complex.

As for the geochronology, after a first K-Ar dating by EVERNDEN and CURTIS (1965) on a sanidine from the Tolfa massif and a second one by BIGAZZI et al. (1979) on biotite crystals from the lava of Mt. Cucco dome (Cerveteri, Cerite district) a group of 20 K-Ar datings were obtained by LOMBARDI et al. (1974) of which eleven concern the Tolfa sector, four the Cerite and five the Manziana sector.

The results concerning lavas, ignimbrites and hypoabyssalites are presented in table 1. From the relevant data the following conclusions may be drawn.

a) Wide range variations are shown by the ages of the ignimbrites and lavas belonging to the same sector. In the Tolfa massif, including some minor outcrops, the age of the lavas ranges from 2.4 to 3.7 Ma and the age of the ignimbrites from 2.1 to 2.7 Ma. The age of 2.3 Ma determined by EVERNDEN and CURTIS (1965) approaches the lower limit found for the lavas and falls within the general age limits of the Tolfa products.

For the Cerite massif the age limits are 2.4 and 4.1 Ma for the lavas and 2.4-4.0 Ma for the ignimbrites. Such variations are interpreted by the authors as due to inheritance or to loss of radiogenic argon and possibly to the so called «phenocryst effect».

b) The hypoabyssalites appear to have been emplaced during the first period of activity of the Tolfa volcanism, even if they fit within the general variation limits of age.

c) While field evidence shows that the lavas are older than the ignimbrites, K-Ar dating do not allow to recognize a chronological order. At any rate these events must have occurred in a narrow interval of time.

d) The magmatic activity in the Tolfa, Cerite and Manziana sectors may be regarded as contemporary, belonging to the upper Pliocene and not to the lower Pliocene as stated by FAZZINI et al. (1972). Only a

biotite from a subvolcanite inclusion found in the chaotic tuffs of the Tolfa area (Mt. Sassetto) showed an age of 6.4 ± 1 Ma.

On the whole the present data do not give a clear image of the chronology of the volcanic activity of the Tolfa, Cerite and Manziana districts. Problems connected with inheritance and loss of radiogenic argon make it difficult to enter in chronological detail and need to be faced with adequate techniques.

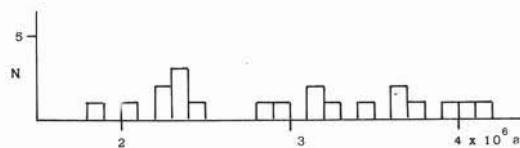


Fig. 3. — Tolfa, Ceriti and Manziana districts: frequency distribution of measured ages.

The Cimino volcano

The geology and petrology of Mt. Cimino volcano are well known after the works of SABATINI (1912), MATTIAS and VENTRIGLIA (1970), PUXEDDU (1971), MICHELUCCHINI et al. (1971) including an up to date bibliography.

The geologic units forming the Cimino volcano are fairly simple and may be summarized as follows (PUXEDDU, 1971):

a) plateau ignimbrite of quartzlatitic composition, often referred to as « peperino tipico » auct.;

b) lava domes of quartzlatitic composition, often referred to as « peperino delle alteure » auct.;

c) lava flows of latitic composition;

d) lava flow of olivinlatitic composition, often referred to as « radial lava flows » or « ciminites » (WASHINGTON, 1906).

For the above-mentioned products a group of ten age estimations is available, enough for locating the activity of the Cimino volcano chronologically, even if some problems are still open (table 6).

As for the quartz-latitic ignimbrite (peperino tipico auct.) the four measurements available indicate ages varying from 1.19 ± 0.05 Ma to 1.31 ± 0.008 Ma with an average

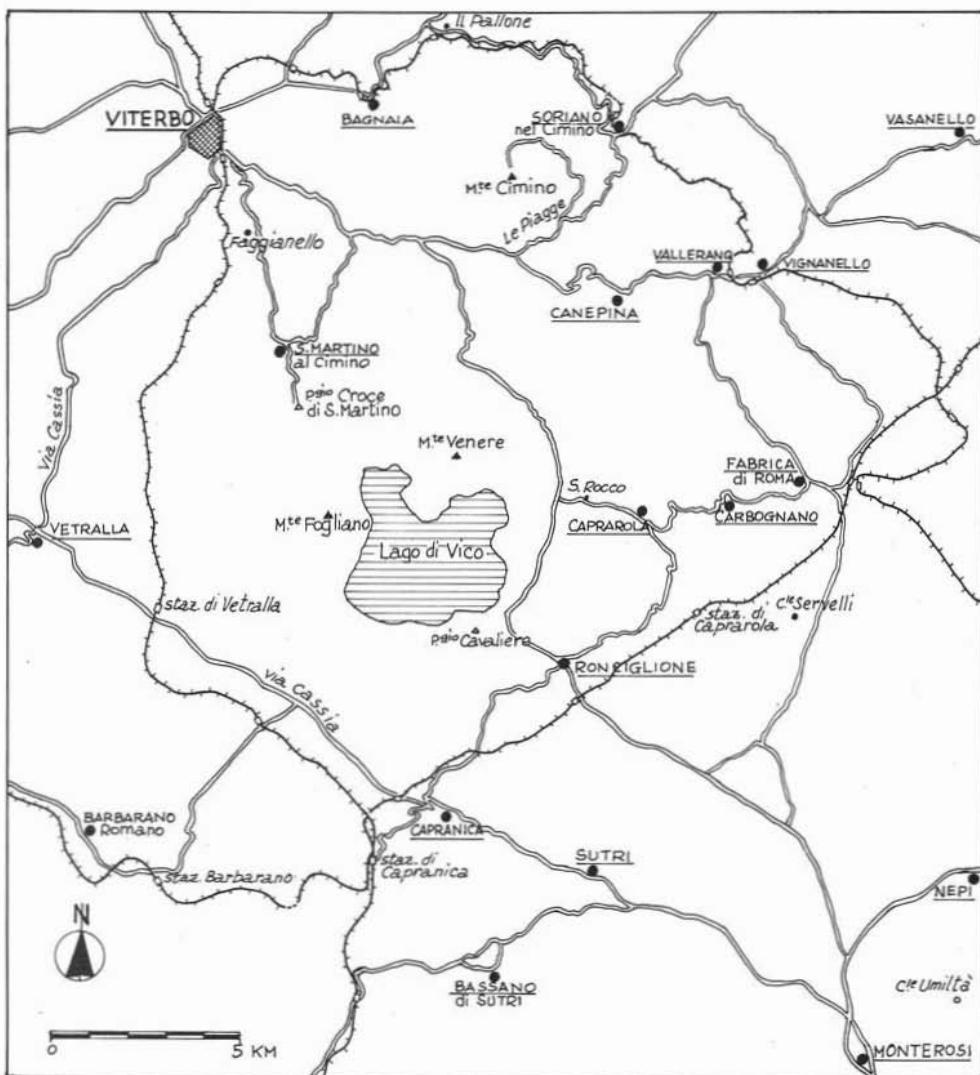


Fig. 4. — Cimino and Vico volcanic groups: localities map.

value of 1.27 Ma. Five measurements on lava domes from Mt. Cimino range from 0.975 ± 0.05 to 1.18 Ma with an average value of 1.066 Ma.

The only dating existing in the literature for the olivinlatitic lava flows (radial lavas, ciminites auct.), of 0.94 ± 0.2 Ma, although affected by a too large error, is consistent with the geological setting of these rocks.

The latitic ignimbrite (peperino tipico auct.) thus appears somewhat older ($1.27 \pm$

0.08 Ma) than the age of the lava domes (1.066 ± 0.08 Ma). It is worth noting, however, that at the time of the measurements the « resolution » of these datings was probably not sharp enough to settle the controversy about the priority of both formations (MITTEMPERGHER, TEDESCO, 1963; VENTRIGLIA, 1963; PUXEDDU, 1971); as a result more detailed measurements are required, taking also in account that, in most cases, tongues of dome lavas are seen to flow

over the already consolidates ignimbrite (PUXEDDU, 1971) but in other cases the ignimbrite covers are likely to be younger than some domes (PUXEDDU, 1971).

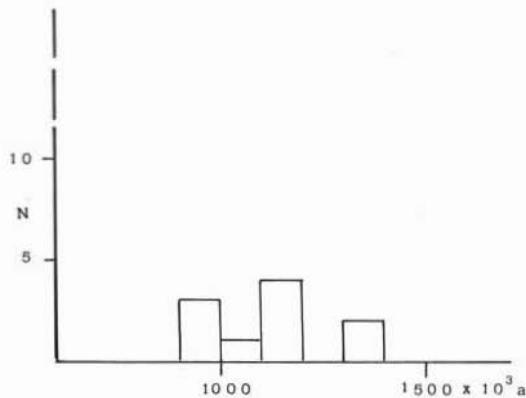


Fig. 5. — Cimino volcanic group: frequency distribution of measured ages.

The alkaline potassic volcanic group

The Vulsinian volcanoes

Along with the most recent geological and petrographical works on the vulsinian area (SCHNEIDER, 1965; MARINELLI and MITTEMPERGH, 1966; NAPPI, 1969; TRIGILA, 1966, 1969; TRIGILA et al., 1971; VAREKAMP, 1980; METZELTIN and VEZZOLI, 1983) over 50 radiometric datings on lavas and pyroclastic products have been performed in the last few years.

To frame the results of these datings into a definite and comprehensive pattern for the evolution of the volcanism in the Vulsinian area is not an easy task, since most of the published data are affected by major errors and because some of the recently proposed evolutionary patterns are based on radiometric data, which in turn call for further verification.

We can assume as ascertained that the volcanoes of Bolsena and Latera developed independently (METZELTIN and VEZZOLI, 1983) and that the activity of the Bolsena cycle started before the beginning of the activity of Latera (NAPPI, 1969; METZELTIN and VEZZOLI, 1983). That being stated the radiometric data concerning the products of

the Bolsena activity (or at least not referable to the activity of Latera) are presented separately in tables 2, 3 in which they are simply displayed in chronological order, distinguishing between the lavas (table 2) and the ignimbrites (table 3). Comments will follow concerning their consistency with the geological situation. Table 4 contains the data for the activity of Latera broken down according to the respective volcanic phases following the evolutionary models proposed by NAPPI (1969), SPARKS (1975), and METZELTIN and VEZZOLI (1983).

As regards the activity of Bolsena volcano a few comments may be appropriate.

a) The first products of the activity of Bolsena are fairly old. The dating obtained by NICOLETTI et al. (1969) on the lava flow of Torre Alfina (820 ± 40 ka) matches well with a dating recently performed by VILLA (1984) on a phlogopite of a sample from a deep well drilled at Latera (862 ± 20 ka). The Torre Alfina lava flow was already considered coeval with the Radicofani rock dated by EVERNDEN and CURTIS (1965) at 880 ka (VAREKAMP, 1980).

b) The youngest lava flow of the Bolsena volcano was dated at 40 ka. However, the latter figure, calculated by NICOLETTI et al. (1979) proved to be unacceptable as pointed out by METZELTIN and VEZZOLI (1983) because it is inconsistent with the geological record and not in agreement with the data first obtained by EVERNDEN and CURTIS (1965) of 328 ka, further confirmed at 333 ± 8 ka by METZELTIN and VEZZOLI (1983). The activity of Bolsena volcano is thus likely to cover a time extent between 860 and 150 ka.

c) As to the Vulci lava flow there is disagreement between the value obtained by NICOLETTI et al. (1981) of 180 ± 40 ka and that estimated by METZELTIN and VEZZOLI (loc. cit.) of 322 ± 6 ka. The same holds for the Monte Calvo flow, dated at 410 ± 150 ka (with large error) by NICOLETTI et al. (1981) and at 316 ± 8 ka by METZELTIN and VEZZOLI. It should be noted that the values determined by the latter authors with refined techniques, affected by a minor error, are highly reproducible and are thus at present the best available data.

There is also disagreement between the value obtained by NICOLETTI et al. (1969) for a lava flow of Buonviaggio, near Porano (660 ± 30 ka) and the measurement of EVERNDEN and CURTIS (431 ka).

(31 A, 31 and 30 A) yielded isochrone (fig. 7) ages of 550 ka and this is the value recommended by the authors for the ignimbrite complex outcropping near La Rocca along the Traponzo stream.

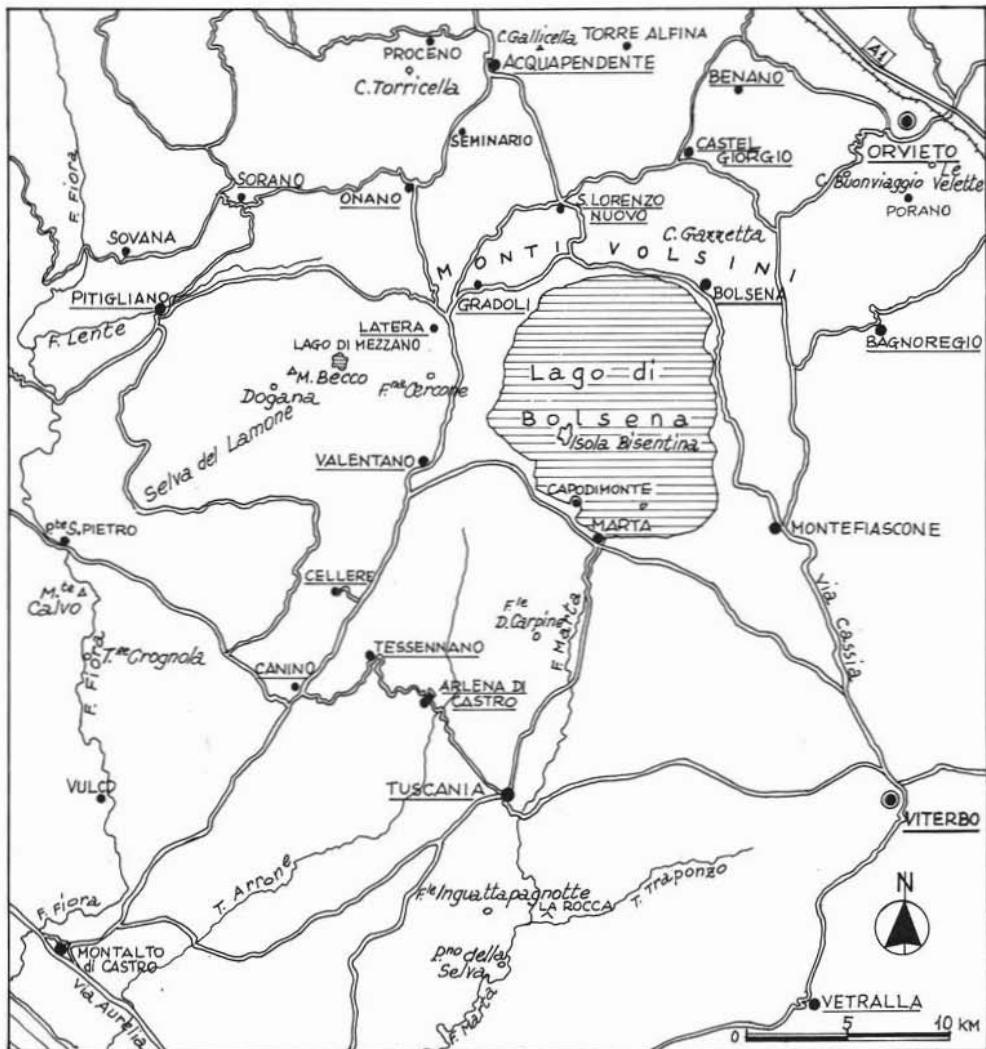


Fig. 6. — The vulsinian volcanoes: localities map.

The basal ignimbrites show ages ranging from 880 ± 40 ka to 400 ± 20 ka (NICOLETTI et al., 1981). In the opinion of these authors, the youngest ages determined (400–450 ka) are less reliable. Three samples

The ignimbrite outcropping along the Arnone River dated at 880 ± 40 ka may well be the product of an older activity.

As for the Latera activity the available datings suggest ages ranging from 310 ± 10

to 55 ± 22 ka (NICOLETTI et al., 1979) with two highly accurate values estimated by METZELTIN and VEZZOLI (278 ± 8 ; 261 ± 6.5 ka) for the lower trachytic ignimbrite (G-unit); an age of 190 ± 20 ka for the upper trachytic ignimbrite (E-unit) and a group of dating obtained by different authors and with different methods, ranging from 183 ± 4 to 117 ± 28 ka for the « complex Pitigliano volcanite ». The value determined by NICOLETTI et al. (1970) of 55 ± 20 ka for a member of this complex needs further validation representing one of the youngest ages recorded for the Latena activity and for the overall Vulsinian activity.

The Vico volcano

Geology and petrology of the Vico volcano were thoroughly investigated and reference should be made to the works of WASHINGTON (1906), SABATINI (1912), LOCARDI (1965), MATTIAS and VENTRIGLIA (1970) in which a complete bibliography is reported.

For the Vico volcano the geochronological data are frankly scarce and need more detailed work and refinement. Only seven age measurements have been performed on lavas and pyroclastic rocks.

One of the most important pyroclastic formations in the Vico district is the « tufo rosso a scorie nere » auct. (red tuff with black scoriae), which was interpreted by LOCARDI (1965) as an ignimbrite sheet (ignimbrite C) extending to a maximum distance of 25 km from its emission center and covering an area of about 1250 km^2 .

South east and south west the ignimbrite C is in contact with the analogous formation from the Sabatini district. For this reason the ignimbrite C from Vico and its analogue belonging to the Sabatini district were often considered as one single pyroclastic unit attributed to the Vico volcano. According to LOCARDI (1965) however the ignimbrite C occurs always as a filling in the erosion valleys cut in the Sabatini formation. The question however is far to be settled, as ALVAREZ et al. (1975) by determining the elevation of the upper surface of the Tufo Rosso concluded that all this unit is of Vico origin.

To avoid misunderstandings in table 7 only the age data for the ignimbrite C from Vico

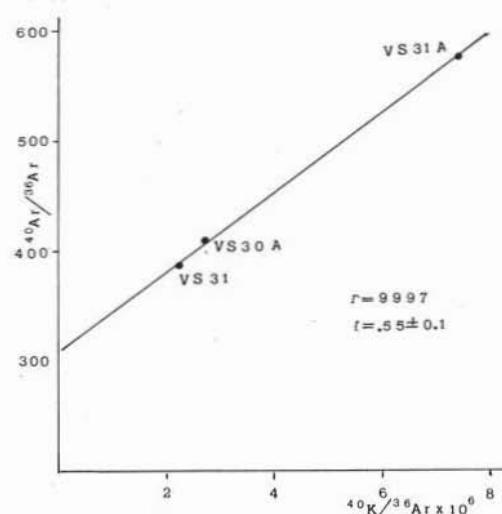


Fig. 7. — The vulsinian volcanoes. Isochrone from samples VS 31 A, VS 30 A and VS 31.

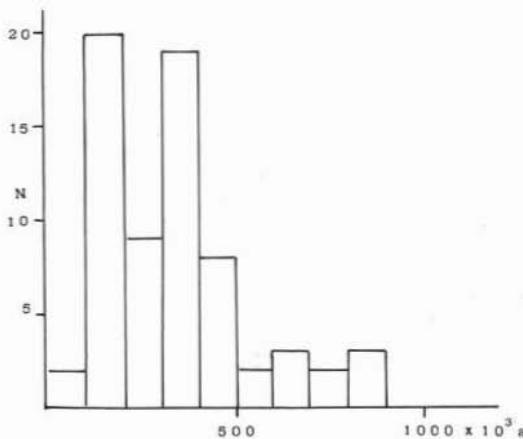


Fig. 8. — The vulsinian volcanoes: frequency distribution of measured ages.

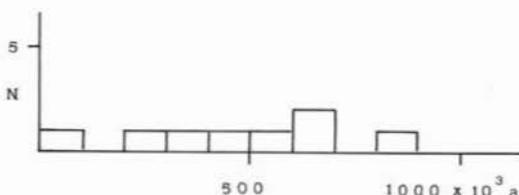
are reported and the data for the similar « tufo rosso a scorie nere » belonging to the Sabatini district are reported in tab. 8 and discussed in the next chapter.

In spite of its importance only two K-Ar measurements are available for the vicoan ignimbrite. One of them (table 7, sample no. 9) is affected by a large error (520 ± 120 ka); the second shows a more reliable age of 420 ± 40 ka. This is clearly not enough to assess precisely the age of the ignimbrite C.

Among the others pyroclastic units from Vico only a «black pozzolan» was considered.

Its age of 620 ± 220 ka, although affected by such a large error is not in conflict with the age obtained for the ignimbrite C since the pozzolan underlies the ignimbrite C and may well represent one of the terms of the ignimbrite B of LOCARDI (1965).

The remaining datings available indicate an activity of the Vico volcano ranging from 820 to 95 ka. It is worth noting that the upper limit is affected by a very large error and needs further verification although it is consistent with the stratigraphic position of the lava considered (NICOLETTI, 1969). The lower limit (95 ka) results from a measurement of EVERNDEN and CURTIS (1965) performed on a leucite-rich lava from Ve-tralla.



so» underlies the «tufi stratificati varicolori de La Storta» (La Storta stratified manycolored tuffs). The later ones show a wide spectrum of ages not very significant owing the large associated errors and often inconsistent with their stratigraphic position. When considering its heterogeneous nature and its complex depositional mechanism (MATTIAS and VENTRIGLIA, 1970) it is conceivable that this unit may reasonably represent the product of the deposition of older, reworked material.

DONNA and BIGAZZI, 1969) may well represent one of the final events of the deposition of the complex unit of the «tufi de La Storta» the age of which may be comprised between 442 ± 7 (age of the «tufo rosso a scorie nere») and 225 ± 60 ka. Obviously, further study is needed to remove any residual uncertainty.

The ages established with different methods by ALVAREZ et al. (1976) and by CONFORTO et al. (1977) for the «tufo giallo di Sacrofano» (370 ± 70 and 200 ± 100 ka

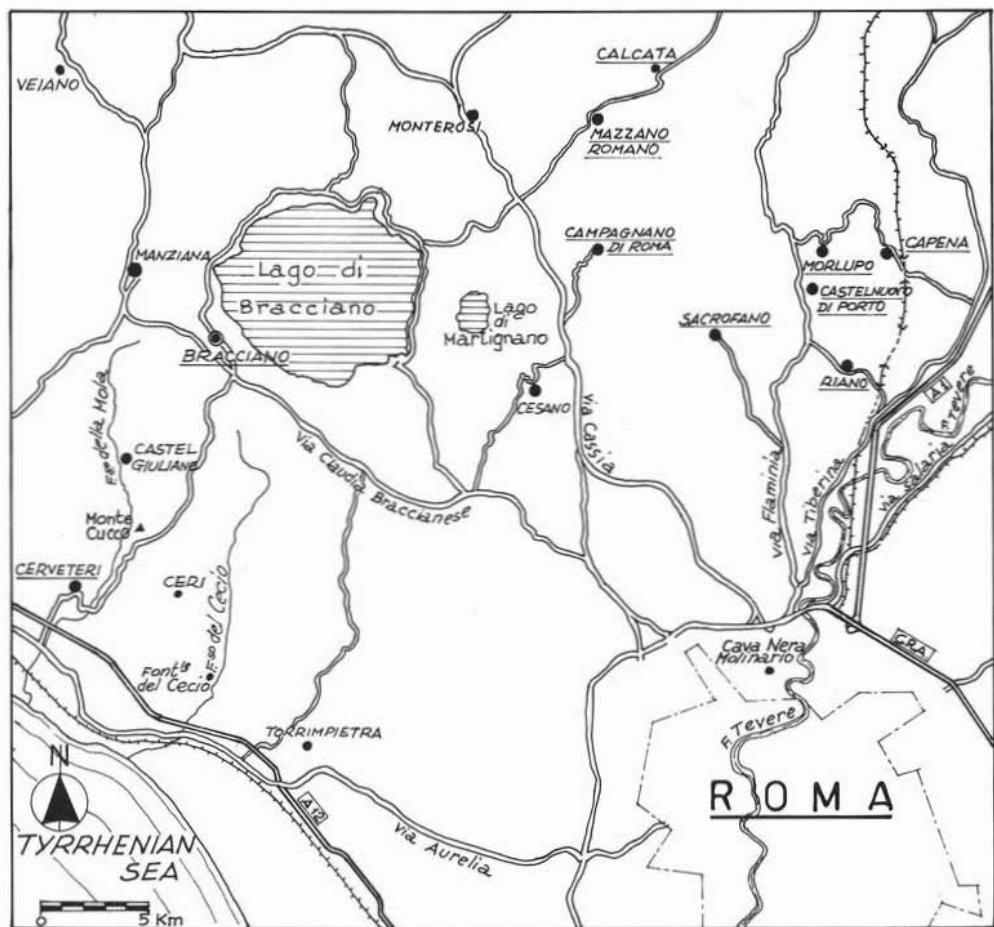


Fig. 10. — Sabatini volcanic district: localities map.

The volcanic level interbedded in the diatomitic deposit of Riano, for which two quite concordant ages are reported, obtained by different authors and with different methods (AMBROSETTI et al., 1969; BONA-

resp.) are affected with large errors. For the same unit VILLA (1984 b) determined an age of 288 ± 6 ka, which can be considered the best value available, owing to the small associated error. In any case the time interval

between the deposition of the upper levels of the « tufi stratificati varicolori de La Storta » and of the « tufo giallo di Sacrofano » appears to be rather small.

It turns out again that increasingly precise measurements are needed to better establish the chronological relationship between the two above-mentioned units.

As for the « tufo di Bracciano » which, in series, like the « tufo giallo di Sacrofano », overlies the « tufi de La Storta », research work by BONADONNA and BIGAZZI (1970) in the area of Monte Cucco (Cerveteri) showed the existence of four levels; three of them were dated with the fission track technique on biotite crystals, yielding ages of 177 ± 30 ; 127 ± 13 and 90 ± 18 ka, respectively. These data were used by the authors to establish the correlation between erosive phases and intratyrrenian regressions of the Quaternary in the surroundings of Rome.

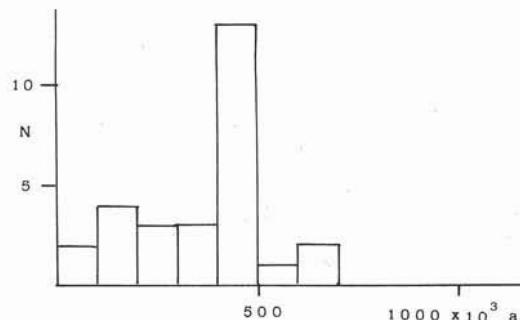


Fig. 11. — Sabatini volcanic district: frequency distribution of measured ages.

An ejected block from the « tufo di Bracciano », considered as a fragment of a skarn connected with an underlying plutonic body, was dated by VILLA (private communication) with the potassium-argon method at 334 ± 48 ka, a value which is obviously in line with the data previously reported.

For the « tufo di Bracciano » which in the stratigraphic sequence established by MATTIAS and VENTRIGLIA (1970) appears to overlap the above described « tufo di Bracciano », VILLA (1984b) obtained a consistent age of 85 ± 9 ka.

Summing up, for the Sabatini volcanoes few reliable datings are available and more work has to be carried out to improve previous data and to examine the pyroclastic

units not yet studied from the chronological viewpoint, such as the « tufo giallo della Via Tiberina », which represents also an important unit, and others.

The Alban Hills

Even if the existing literature contains a considerable amount of data, the present state of the Alban Hills geochronology is far to be satisfactory.

To frame the existing data into a single evolutionary pattern reference will be made to the chronostratigraphic sequence proposed by FORNASERI, SCHERILLO and VENTRIGLIA (1963) of which use was made in drawing up table 10.

For the lower terms of the series, the « first outcropping effusions » two datings are available, substantially concordant, by EVERNDEN and CURTIS (1965), at 706 ka and by GASPARINI and ADAMS (1969) at 680 ± 50 ka, and two obtained more recently by VILLA (1984). The last ones, of 400 ± 10 and 460 ± 6 ka, with which a very small error is associated would rejuvenate the age of those which were considered so far as the oldest lava flows of the Alban Hills, by almost 300 ka.

In the central area of this district, superimposed on the above mentioned first large lava effusions there is a significant pyroclastic complex referred to as the « complex of the lower tuffs » (complesso dei tufi inferiori). This complex includes the following terms, from top to bottom, and omitting details, for which reference should be made to the previously mentioned work by FORNASERI et al. (1963),

- a) Tufo di Villa Senni
- b) Upper pozzolanas (grey pozzolanas)
- c) Tufo litoide della Campagna Romana, often referred to as « tufo lionato da costruzione »
- d) Middle pozzolanas or pozzolane nere
- e) Yellow conglomerate
- f) Lower pozzolanas often referred to as « red pozzolanas » or « pozzolanas of San Paolo ».

According the most recent papers (BERNARDI et al., 1982; PECCERILLO et al., 1984) the first activity phase of the Alban Hills

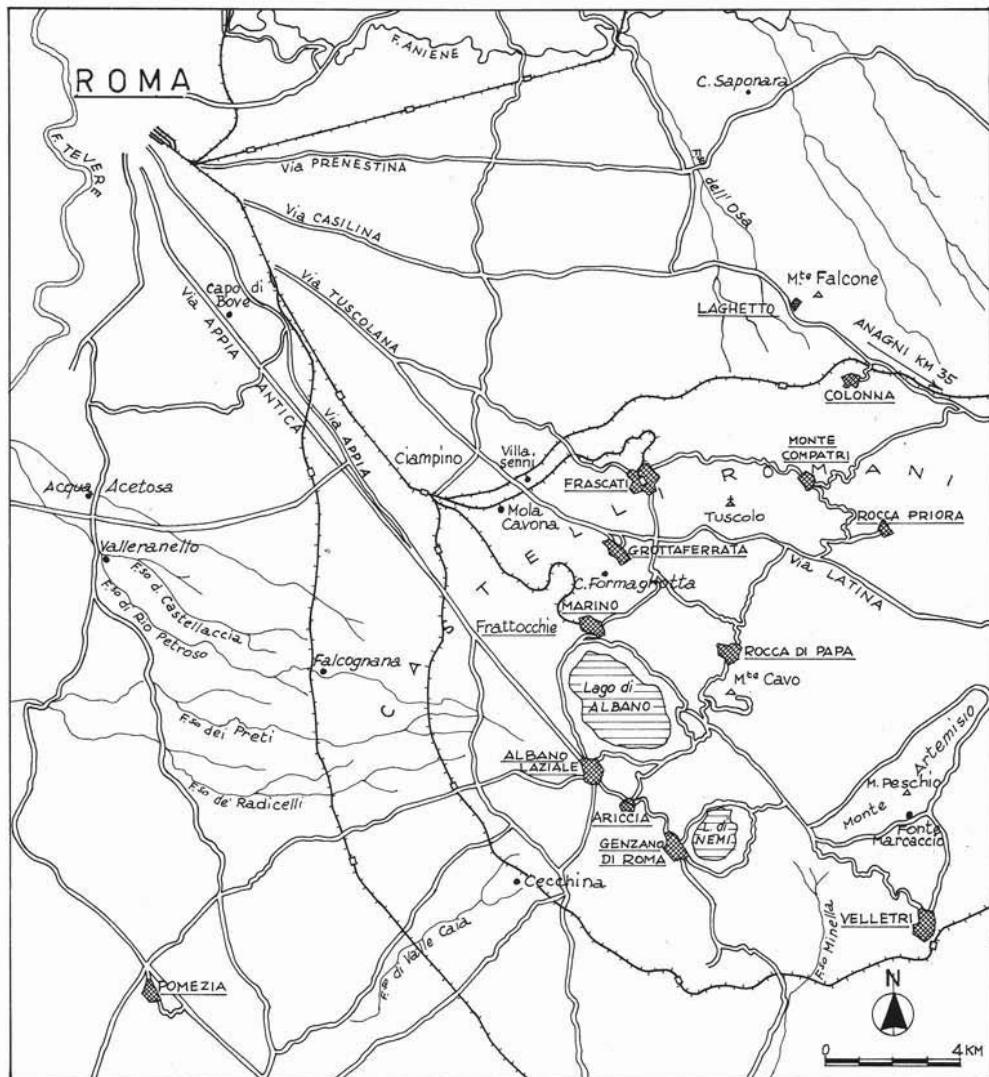


Fig. 12. — Alban Hills: localities map.

was terminated by a big explosive episode, giving rise to the deposition of the Villa Senni tuff, which is interpreted as due to emptying of the magma chamber and subsequent collapse of the caldera. Following this model the products of the activity of the Alban Hills are often referred to as «pre-caldera» and «post-caldera» depending on their location with respect to the «Villa Senni» tuff.

The «Villa Senni» tuff is also the best known formation from the geochronological

standpoint. For this formation, a wide age spectrum, extending from 620 ± 200 to 160 ± 30 ka can be inferred from the literature (MASI et al., 1976; TADDEUCCI, 1969; BIGAZZI et al., 1977; RADICATI DI BROZOLO et al., 1981; VILLA, 1984). Fortunately to make order in such a dispute an extremely accurate methodological study by RADICATI DI BROZOLO et al., carried out with ^{40}Ar - ^{39}Ar and with Rb-Sr methods was published in 1981, whose results may be summarized as follows:

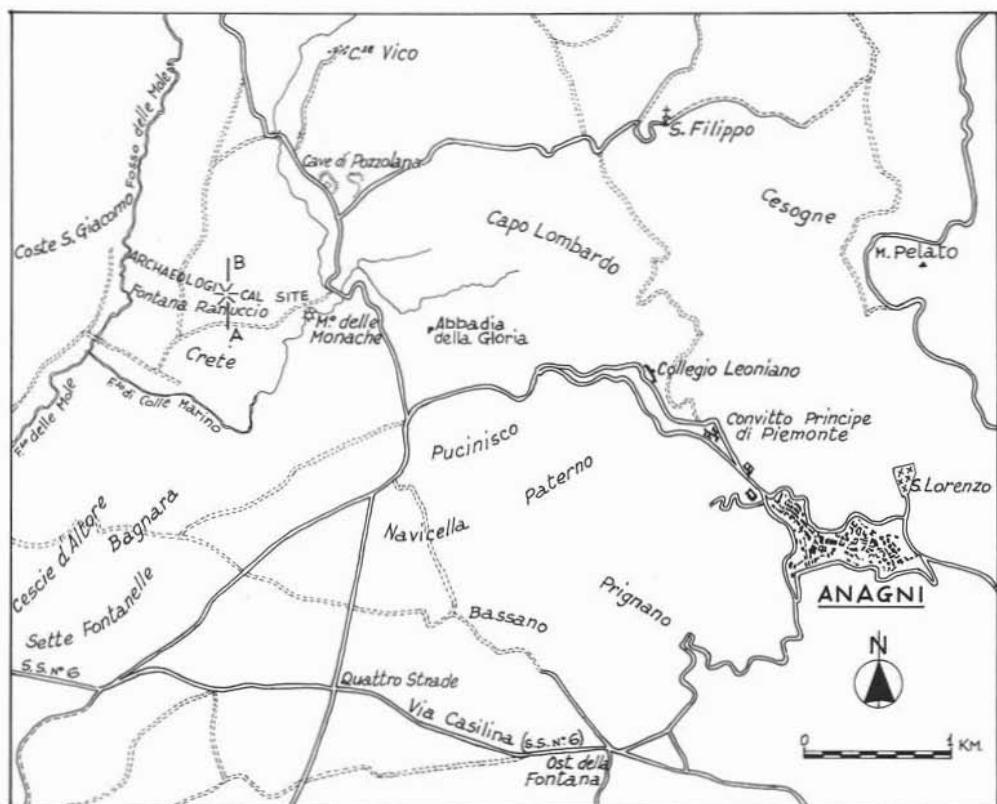


Fig. 13. — Anagni and Fontana Ranuccio archaeological site: locality map.

a) six leucite samples yielded defined ^{40}Ar - ^{39}Ar ages with an average value of 338 ± 8 ka (see table 11).

b) Rb-Sr measurements on leucite, biotite and pyroxene allowed the determination of internal isochrone ages ranging from 380 ± 20 to 330 ± 20 ka, in good agreement with the previous ones.

c) The biotite ^{40}Ar - ^{39}Ar ages are in three cases in agreement with the cogenetic leucites, although less precise, but in the remaining cases two discordant ages were obtained, suggesting that the biotites must be considered with caution for ^{40}Ar - ^{39}Ar and K-Ar dating of Quaternary rocks.

Nonetheless the study by RADICATI et al. allows to establish with certainty the age of the « Tufo di Villa Senni » at 338 ± 8 ka; given its extension over an area of about 1500 Km² this tuff represents one of the

major markers of the Alban Hills volcanic district.

Out the previous datings of the same formation, only two of the four obtained with the fission track technique are in agreement with the above value. Other values are to be considered as aberrant (too young or too old) and are to be rejected.

The situation for the lower terms in the complex of the « lower tuffs » is far from being satisfactory. The only chronological information we have comes from a study on the archaeological site of Fontana Ranuccio, Anagni basin, conducted with the K/Ar method by RADICATI DI BROZOLO and VILLA (in BIDDITTO et al., 1979). The stratigraphic profile of this site (fig. 14) includes different pyroclastic units, among them the « tufo litoide della Campagna Romana » (3) is the upper limit of the Ranuccio site series, which includes, proceeding downwards, the archaeological layer (6), a thin layer of leucite

crystals (12), a thick layer of pozzolana (13), and a tuffitic limnosol (14).

The « tufo litoide » (3) was estimated to be slightly younger than 366 ± 0.4 ka, this being the age of a lapilli tephra layer (4) found immediately below it.

The age of the thick pozzolana layer (13) should be comprised between 528 ± 6 ka, which is the age of 14 and 487 ± 7.5 ka, the age of 12. Incidentally, the age of the palaeosol archaeological layer (6) with industry of the lower Palaeolithic was measured at 458 ± 5.7 ka.

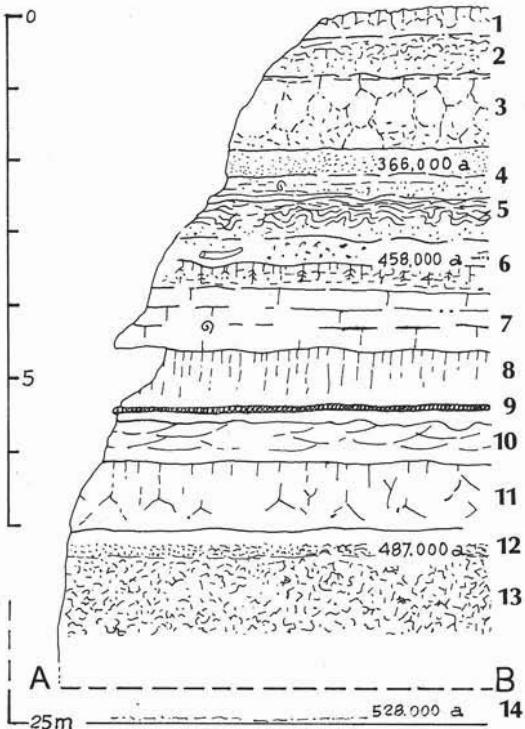


Fig. 14. — Fontana Ranuccio site section.
Fig. 14. — 1: « Terra rossa » paleosol - 2: Pedogenized layer - 3: « Tufo litoide » - 4: Lapilli tephra - 5: Solifluction and cryoturbated horizon - 6: Palaeosol archaeological layer - 7: Tephra from Ernici Volcanoes with *Buxus* and *Zelkova* flora and *Cyclostoma elegans* - 8: Clayey limnosol - 9: Iron duricrust - 10: Tufitic current bedded sands - 11: Palaeosol - 12: Thin layer of leucite crystals - 13: « Pozzolana » - 14: Tuffitic limnosol.

(From SEGRE and ASCENZI, 1984).

Now, while the age of the « tufo litoide » is consistent with the expected age of this formation, which in the central area of the Alban Hills underlies the « tufo di Villa

Senni », some problems arise as regards the thick pozzolana layer (13) which is, like the « tufo litoide » (3) a product of the Alban Hills (BIDDITTO et al., 1979). The age estimated for this pozzolana layer (between 428 and 487 ka) is consistent with the expected age if one admits the value of 706 ± 680 ka for the oldest lava flows (EVERNDEN and CURTIS, 1965; GASPARINI and ADAMS, 1969) on which the pozzolana is superimposed in the Rome area (Acquacetosa, Vallerano etc). However this estimate is no longer in agreement with the expected age if one accepts for these lavas the new values of VILLA (1984) (400 ± 10 ka) and BERNARDI et al. (1982) (460 ± 6 ka). Whether the pozzolana layer of Fonte Ranuccio is to be considered as the same overlying the lava flows of Acquacetosa and Vallerano or represents an older pyroclastic unit is still an open issue, taking into account that the Fonte Ranuccio series lies some 30 km away, eastward and on the opposite side of the volcanic complex.

From the Tuscolano-Artemisio period, different lava flows were dated. One of them is the well known lava flow of Capo di Bove (WASHINGTON, 1925; FORNASERI et al., 1963) for which GASPARINI and ADAMS obtained 520 ± 40 ka on leucite separates and 500 ± 50 ka on the whole rock. Nevertheless these discordant values are inconsistent with the stratigraphic position of the lava flow which overlaps the Villa Senni tuff of 338 ± 8 ka. For the same lava flow the dating of NICOLETTI (360 ± 40 ka) is more acceptable, but the best available value was obtained by BERNARDI et al. (1982) at 292 ± 6 ka.

For the Divino Amore lava flow EVERNDEN and CURTIS (1965) calculated 268 ka and more recently BERNARDI et al. (1982) 175 ± 2 ka. For the Saponara lava flow, BERNARDI et al. give a consistent age of 260 ± 5 ka. The age obtained by the same authors for a small lava outcrop east of Saponara poses some problems since this small lava flow underlies the « tufo litoide » and, according to its stratigraphic position it should be « pre-caldera ».

The large lava effusion of Laghetto (Al-12) which represents a « post caldera » eruption, shows an age (365 ± 5 ka) slightly older than the expected one.

Even more serious problems are raised by the two lava flows which belong to the Tuscolano-Artemisio rim and which, according to FORNASERI et al. (1963) are to be considered « post caldera ». One of these lavas (Al-9) was dated by BERNARDI et al. (1982) at 477 ± 6 ka; the other (Al-38) at 524 ± 9 ka. Both ages are older than those obtained by the same authors and by VILLA (1984) for the lava flows of Valleranello (460 ± 6 ka) and Acquacetosa (400 ± 10 ka) underlying not only the « tufo di Villa Senni » but also the lower pozzolana formation, and consequently being « pre caldera » products.

If one considers the ages of Valleranello and of Acquacetosa lava flows and of « tufo di Villa Senni » as well established, the ages of Al-9 and of Al-38 samples are difficult to explain because they would represent the oldest lava products of the Alban Hills. Further field work is needed to verify the stratigraphic position of both Al-9 and Al-38 lavas and to give a satisfactory interpretation to such unexpected old ages (2).

Among the products of the last period of the central activity the ages measured range from 331 ± 7 (the lowest of the 7 lava flow outcropping at the north-east wall of the crater of Nemi) to 240 ± 3 ka for the lava flow of Arcioni (Rocca di Papa) (BERNARDI et al., 1982) which is the youngest of the products from the last period of the central activity.

Coming back to the lava flow of Divino Amore, until yet considered as a product of the Tuscolano-Artemisio period (FORNASERI et al., 1983), its younger age (175 ka) rises the question whether this flow belongs to the Tuscolano-Artemisio activity or represents rather the products of a more recent eccentric vent. It is worth underlining that the Divino Amore flow represents the youngest lava products known far for the Alban Hills.

The last activity in this volcanic region had a strong explosive phreato-magmatic character, giving rise to the well known craters of Albano, Nemi and others, sur-

rounded by typical explosion products. One of them is the well known « peperino » of Albano.

Many attempts were made to estimate the age of this eruption.

a) The zircon found in the sands from the Nettuno littoral with the fission track technique revealed an age of 59 ± 9 ka (BIGAZZI and FERRARA, 1971); such sands are reasonably believed to have been fed by the « peperino » of Albano (BIGAZZI and FERRARA, 1971). The same zircons (CERRAI et al., 1965) gave 43 ± 5 ka with the ^{230}Th method while TADDEUCCI (1969) obtained an age of 67.5 ka, still working with disequilibrium methods on minerals of the « peperino » groundmass. These reported data are to be considered as an upper limit, since the afore mentioned minerals can be older and not necessarily coeval with the explosion.

b) Unburned wood samples, embedded in the « peperino's » layers were dated at 29.7 ± 0.4 ka with the ^{14}C method by DE VRIES (1958). Prof. DE VRIES (private communication) pointed out that this date had to be verified but this did not unfortunately happen owing his untimely death. Further unburned wood samples collected in the following years were repeatedly dated in Rome (ALESSIO et al., 1966; CORTESI, 1984) but the obtained ages turned out always higher than the local limit of the method (37-40 ka).

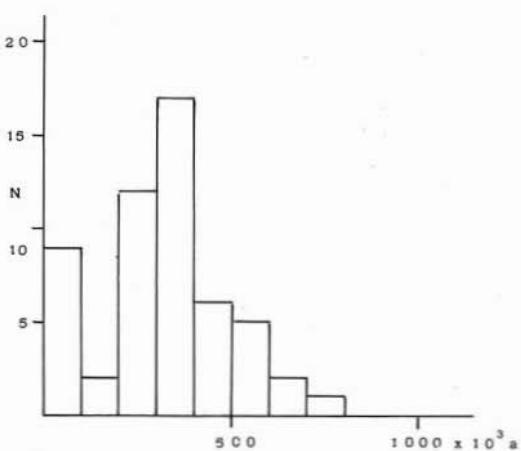


Fig. 15. — Alban Hills: frequency distribution of measured ages.

(2) According FUNICIELLO (private communication) the Al-9 lava flow appears underlying the « tufo di Villa Senni ». This could explain its unexpected old age.

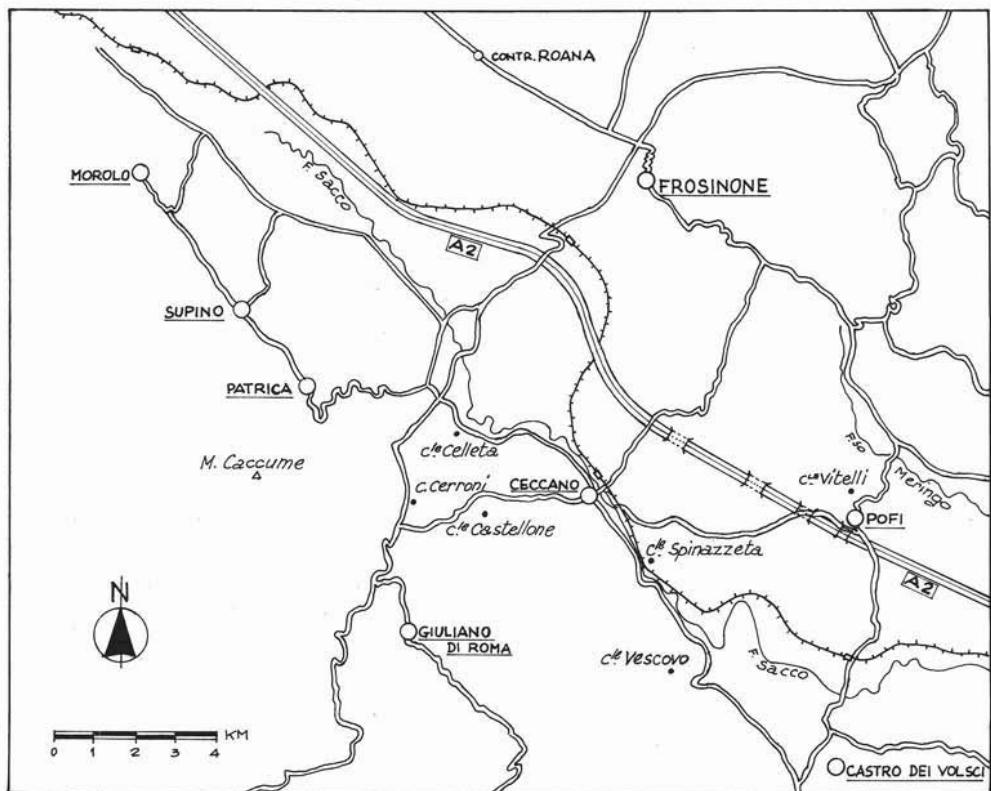


Fig. 16. — The Hernican district: localities map.

It is apparent that there are clear signs of a recent age for this eruption and further attempt are being made to obtain new information. At present it may be reasonably assumed that the eruption of Albano took place about 40-50,000 years B.P.

The Hernican district

The volcanoes of the valley of Sacco or Valle Latina, often referred to as Hernican volcanoes, are located about 50 Km east-southeast of the Alban Hills and 70 Km northeast of the Auruncan district (Roccamonfina), the latter one belonging to the Neapolitan area.

This district, well known after the studies by VIOLA (1896, 1889), WASHINGTON (1906), SCHERILLO (1937), ACCORDI et al. (1967), FRANCO and DE GENNARO (1971), ANGELUCCI et al. (1974) was recently studied by BASILONI and CIVETTA (1975), CIVETTA (1974) as regards the geochronology and by

CIVETTA et al. (1981) in its geochemical aspects.

The district involves different eruptive centers, located near Patrica, Giuliano di Roma, Colle Castellone, Pofi, Roana and others; their products may be considered as leucite tephrites and leucitites.

The K/Ar ages obtained, shown in table 14, range between 700 ± 20 and 80 ± 40 ka and do not pose particular problems at present.

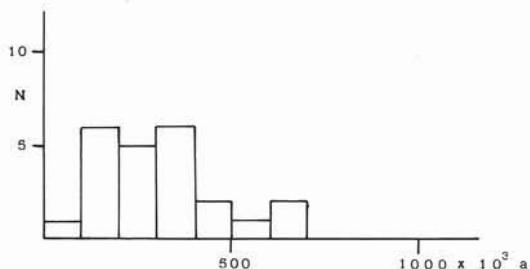


Fig. 17. — The Hernican district: frequency distribution of measured ages.

A discussion concerning the chronological relation between the volcanic activity of the Hernican district and of the Alban Hills is hard to undertake at present, owing the big problems still open concerning the chrono-logy of the Alban Hills.

It may be considered as ascertained that both volcanic complexes were contemporaneously active for a long period of time.

The Ponza archipelago

The Ponza archipelago consists of two different groups of islands: the eastern group includes the islands of Ventotene and Santo Stefano; the western group the islands of Ponza, Palmarola and Zannone.

The geology of the Pontine islands was outlined in different works by DOELTER (1876), SABATINI (1893, 1896, 1898), SEGRE (1954, 1956, 1960) and in a more recent paper by CARMASSI et al. (in press). Volcanology and petrology were studied in detail by BARBERI et al. (1967), METRICH and SANTACROCE (in press).

Age determinations have been performed by BARBERI et al. (1967) and more recently

by SANTACROCE et al. (1983) and SAVELLI (1984).

The results obtained for the eastern group (Ventotene and Santo Stefano) are displayed in table 15. According to BARBERI et al. (1967) a quaternary volcanic activity produced trachybasaltic lava flows at Ventotene and phonolithic ones at Santo Stefano. The ages measured range from 1.2 Ma for Santo Stefano to 1.7 Ma for Ventotene. New datings by SANTACROCE et al. (in press) for the Punta dell'Arco lava flows (Ventotene) covering the entire pre-caldera sequence gave ages ranging from 0.81 to 0.48 Ma, in poor agreement with the previous value of 1.7 Ma obtained for the base of the same sequence. K/Ar measurements on the Romanello lava flow and on pumices from different pyroclastic units representing the products of a post-caldera activity indicate 0.2 Ma as the lower age limit.

Table 15 also displays the age determinations for the volcanites of the western islands (Ponza, Palmarola). According to BARBERI et al. (1967), the volcanic activity in the western group started during the Pliocene (5 Ma) with the emplacement of



Fig. 18. — The Ponza archipelago: localities map.

rhyolitic volcanites. Approximately at the Quaternary-Pliocene boundary (1.9 Ma) several dykes intruded the brecciated lavas. A little later (1.7-1.6 Ma), an intrusion of a sodalite lava dome took place at Palmarola. The volcanic products, although of different age and composition have a common magmatic origin as shown by the concordant $^{87}\text{Sr}/^{86}\text{Sr}$ initial ratio of 0.7073 (mean value).

On the basis of the new datings by SAVELLI (1984) however, the above model was somehow modified in that the « rhyolitic dikes » display a K/Ar age substantially similar to that of the other acidic rocks and therefore they are not to be considered as being separated by a significant interval of time.

This result is in agreement with the model proposed by CARMASSI et al. for the volcanic evolution of the island of Ponza in a shallow submarine environment.

The acidic volcanism of the Ponza archipelago is thus of pliocenic age. According to SAVELLI (1984) during the lower Pleistocene, starting from 1.75 Ma, a pronounced break in the volcanic activity occurred, not only in the Ponza archipelago but also in the emerged volcanic areas surrounding the Thyrrenian Sea. The volcanic activity started again at about 1.1-1.2 Ma with the emplacement of products of alkaline potassic affinity (Monte La Guardia trachytic lava flow, having an age of 1.1-1.2 Ma, according to BARBERI et al., 1967).

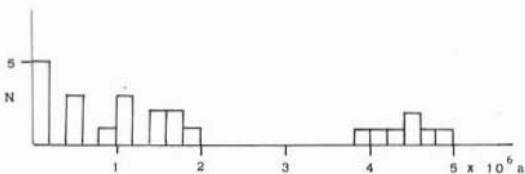


Fig. 19. — The Ponza archipelago: frequency distribution of measured ages.

Dating volcanic material interbedded in sedimentary formations

A number of age measurements have been performed on volcanic levels interbedded in Neogene and Quaternary sediments, mostly aimed to define a chronostratigraphic scale.

These data, together with the already reported and discussed age measurements on

volcanic rocks of Latiuum, have been widely used in discussing the Pliocene-Pleistocene limit in Latiuum. This problem however is out of the scope of this work and will not be discussed here.

In table 17 the K/Ar and fission track results obtained up today are reported.

The provenance of the above mentioned volcanic materials remains still an open question which deserves further attention in the future.

Concluding remarks

The data here reported represent the result of almost twenty years of activity in dating the young volcanic rocks of Latiuum with various techniques, among them the most widely used was the K-Ar method. From the first age measurements a significant improvement has been achieved due also to the availability of more sophisticated instruments and techniques, resulting in more precise data, as shown by their small associated error.

Nevertheless the general situation concerning the geochronology of volcanics of Latiuum is still far to be satisfactory, due to the persistent difficulties in dating very young volcanic rocks.

Many points are still open to discussion. Among them there are analytical problems connected with measurements near the limits of the method. Moreover an accurate sampling, i.e. an accurate selection of samples with a precise location of the sampling point is of fundamental importance, and sometimes the significance of an age measurement is hard to evaluate and to be compared with the results obtained in different laboratories owing to the lack of information on sampling localities and location. This remark is not so obvious because we have to take into account the variability which is likely to occur even in the same formation.

As a matter of fact one of the possible perturbing factor in dating young volcanics is the often invoked presence of excess argon. Such presence is now to be considered more than a suspect after the $^{40}\text{Ar}/^{39}\text{Ar}$ stepwise heating experiments carried out by VILLA (1985) on two leucites from the Alban Hills (VS 3 and AL 43), revealing their contrasting behaviour with respect to Ar geochemistry.

AL 43 is the first documented case of ^{40}Ar

excess in a leucite. VILLA (1985) considers as an attractive hypothesis the derivation of the excess argon from the mantle.

The experiment of VILLA indicates also that such excess argon is not homogeneously distributed in the Alban Hills products and, indirectly, that the results of the conventional K-Ar dating should be considered with caution. In this respect the accuracy in the description of the sample location seems to be appropriate and it is worth noting that an high analytical precision, even if desirable, is not necessarily a warranty that the apparent K-Ar age be a real age.

Taking this into account it seems advisable to recommend whenever possible, the use of the ^{39}Ar - ^{40}Ar dating technique this one being the specific method by which the eventual presence of excess argon can be directly revealed.

At present, to keep under control the conventional K-Ar dates, a comparison with different methods is advisable. RADICATI et al. (1981) showed that the Rb-Sr method can be used as a cross check criterion for rocks as young as 350 ka. An attempt to revive the K-Ca technique for high potassium minerals (leucite, kaliophilite, kalsilite) should also be taken into consideration.

Similarly fission track dating technique and also the use of the ^{230}Th disequilibrium method deserve particular attention as possible alternative methods in estimating the age of the very young volcanic rocks.

Acknowledgments. — This work was carried out in the frame of the research programme of the Centro di Studio per la Geocronologia e la Geo-chimica delle Formazioni Recenti of the C.N.R.

The author thanks prof. S. METZELTIN, prof. L. VEZZOLI and Dr. I. VILLA who kindly allowed to make use of their unpublished data and prof. R. FUNICIELLO for helpful discussion.

Constants used by the K-Ar dating

ALVAREZ et al., 1976; BARBERI et al., 1967; BASILONE and CIVETTA, 1975; BIGAZZI et al., 1979; CIVETTA, 1984 and private comm.; DESCENDENTI et al., 1978; GASPARINI and ADAMS, 1969; LOMBARDI et al., 1974; MASI et al., 1976; NICOLETTI, 1965:

$$\lambda_e = 0.585 \times 10^{-10} \text{ a}^{-1}$$

$$\lambda_\beta = 4.72 \times 10^{-10} \text{ a}^{-1}$$

$$\lambda_e + \lambda_\beta = 5.305 \times 10^{-10} \text{ a}^{-1}$$

$$^{40}\text{K} = 0.0119 \text{ atom\%}$$

SCHNEIDER, 1965:

$$\lambda_e = 0.583 \times 10^{-10} \text{ a}^{-1}$$

$$\lambda_\beta = 4.737 \times 10^{-10} \text{ a}^{-1}$$

$$\lambda_e + \lambda_\beta = 5.32 \times 10^{-10} \text{ a}^{-1}$$

EVERNDEN and CURTIS, 1965:

$$\lambda_e = 0.584 \times 10^{-10} \text{ a}^{-1}$$

$$\lambda_\beta = 4.72 \times 10^{-10} \text{ a}^{-1}$$

$$\lambda_e + \lambda_\beta = 5.304 \times 10^{-10} \text{ a}^{-1}$$

BERNARDI et al., 1982; BIDDITTU et al., 1981; METZELTIN and VEZZOLI, 1983; NICOLETTI et al., 1979, 1981; RADICATI et al., 1981; VILLA, 1984 and private comm.; VAREKAMP, 1979, 1980:

$$\lambda_e = 0.581 \times 10^{-10} \text{ a}^{-1}$$

$$\lambda_\beta = 4.962 \times 10^{-10} \text{ a}^{-1}$$

$$\lambda_e + \lambda_\beta = 5.543 \times 10^{-10} \text{ a}^{-1}$$

$$^{40}\text{K} = 0.0167 \text{ atom\%}$$

Constants used by Rb-Sr dating

RADICATI et al., 1981:

$$\lambda = 1.42 \times 10^{-11} \text{ a}^{-1}$$

Abbreviations used in the Tables

<i>Anc</i>	Analcime
<i>Ap</i>	Apatite
<i>Aug</i>	Augite
<i>Bi</i>	Biotite
<i>FT</i>	Fission tracks
<i>FS</i>	Feldspar separate
<i>GM</i>	Groundmass
<i>Lc</i>	Leucite
<i>Ol</i>	Olivine
<i>Pbl</i>	Phlogopite
<i>Px</i>	Pyroxene
<i>Sa</i>	Sanidine
<i>Tit</i>	Titanite
<i>WR</i>	Whole rock
<i>Zir</i>	Zircon

TABLE 1
Tolfa, Cerite, Manziate acidic volcanic group

K-Ar dating

SECTOR	LOCALITY	ROCK TYPE	SAMPLE No	MAT.	% K	$^{40}\text{Ar}_{\text{rad}} \text{ ml/g} \times 10^{-6}$	$^{40}\text{Ar}_{\text{rad}} \text{ %}$	AGE $\times 10^6$ a	REF.
TOLFA	p ^{gio} Casalavio	Quartz latite	K 1	FS	7.18	0.6677	24.3	2.4 ± 0.2	52
	1 km east of Tolfa		KA302.	Sa	10.57		13	2.3	39
	Rocca di Tolfa	Liparite	K 13	FS	6.43	1.0717	69.3	4.2 ± 0.1	52
	S ⁸⁰ della Strega	Quartz latite (1)	K 2	Bi	5.03	0.5969	13.0	3.0 ± 0.4	52
	" "	" (1)	K 2	FS	7.76	0.9097	26.4	2.9 ± 0.2	52
	F ⁸⁰ d. Melledra	Liparite (1)	K 12	FS	8.44	1.2359	69.0	3.7 ± 0.1	52
	La Tolfaccia	Quartz latite (1)	K 5	FS	7.98	0.7410	20.0	2.4 ± 0.2	52
	La Montagnola	Liparite (1)	K 3	FS	9.98	0.8237	32.3	2.1 ± 0.1	52
	p ^{gio} della Stella	Monzonitic porphyry (2)	K 15	FS	7.46	1.0238	43.4	3.5 ± 0.1	52
	La Roccaccia	Monzonitic porphyry (2)	K 21	Sa	8.74	1.1177	26.0	3.2 ± 0.2	52
CERITE	M ^t Riccio	Lipar.qz lat. (1)	K 14	Sa	10.47	1.3843	44.1	3.3 ± 0.1	52
	M ^t Sassetto	Bi-Melalatite (3)	K 22	Bi	5.46	1.3896	18.7	6.4 ± 1.0	52
	Monte Cucco	Trachyte		Bi	3.93	0.582	21	3.7 ± 0.12	5,22
	Monte Santo	Trachytic liparite	K 7	FS	7.71	0.7179	15.3	2.4 ± 0.2	52
	M ^t La Guardia	Quartz latite	K 20	FS	9.78	1.5890	47.5	4.1 ± 0.2	52
MANZIALE	Le Galeracce	Liparite (1)	K 6	FS	5.25	0.5250	25.1	2.5 ± 0.2	52
	M ^t Ercole	Liparite (1)	K 19	FS	8.54	1.3512	41.0	4.0 ± 0.2	52
	Mad. d. Salette	Rhyolite	K 23	FS	6.17	0.7819	16.4	3.2 ± 0.5	52
MANZIALE	Canale Monterano	Rhyolite	K 24	FS	8.81	0.8125	50.5	2.3 ± 0.1	52
	M ^t Arsiccio	Quartz latite	K 9	FS	8.84	1.3286	72.0	3.8 ± 0.1	52
	M. Calvario	Latite (3)	K 17	Sa	9.48	0.8285	62.9	(2.2 ± 0.1)	52
	M. Calvario	Latite (3)	K 25	Sa	9.51	0.6884	49.1	(1.8 ± 0.1)	52

(1) ignimbrites; (2) hypoabyssalites; (3) inclusions.

TABLE 2
Vulsinian District - Bolsena activity: lava flows

K-Ar dating

LOCALITY	ROCK TYPE	SAMPLE No.	MATERIAL	% K	$^{40}\text{Ar}_{\text{rad}}/\text{g}$ $\times 10^{-7}$	$^{40}\text{Ar}_{\text{rad}}\%$	Age $\times 10^3$ a	REF.
San Lorenzo Nuovo	Trachyte	TSL	Sa	9.16	0.154	8.32	40 ± 10	66
Bagnoregio	Trachyte	VF4	Sa	13.45	0.6890	6.96	130 ± 10	67
Proceno	Tephritic phonolite	BS26	Lc	14.45	0.870	7.86	150 ± 30	66
Vulci	Latite	VS36	WR	5.62	0.385	6.96	180 ± 40	67
T ^{re} Crognola	Latite	VS38	WR	5.94	0.5150	4.81	220 ± 90	67
Latera	Phonolitic tephrite	P164	Lc	15.13	1.6310	10.15	280 ± 30	67
F. Cercone	Py-trachyite	S	Sa	10.38	-	220 ± 20	78	
Seminario	Leucite tephrite	L	Lc	15.85	-	20-40	277 ± 30	78
Acquapendente	Leucite basalt	X4457	Lc	15.85	-	22	270	39
C. Gallicella	Leucite trachyte	BS31	Lc	14.36	1.72	12.80	310 ± 30	66
F. le Carpine	Phonolitic tephrite	VF8	Lc	15.31	1.86	27.36	310 ± 60	66
M. Calvo	Latite	PSQ ₁	GM	5.90	0.7245	18.70	316 ± 8	56
Vulci	Latite	PSQ ₂	Bi	7.74	0.9403	6.67	316 ± 9.5	56
San Lorenzo Nuovo	Trachyte	KA406	Sa	9.83	0.704	26.03	325 ± 6	56
San Lorenzo Nuovo	Trachyte	KA406	GM	5.56	0.691	24.71	319 ± 6	56
San Lorenzo Nuovo	Trachyte	35A	Sa	10.20	1.3049	41.79	329 ± 8	56
C. S. Gazzetta	Leucitite (dyke)	35A	Bi	7.00	0.9146	8.76	332 ± 8	56
Bertino	Leucite tephrite	768.1 (T12)	Lc	16.35	2.073	41	336 ± 8	56
Bolsena	Vulsinite	768.2 (T13)	Lc	16.20	2.213	33	340 ± 30	89.90
Monte Calvo	Latite	1020(T10)	Lc	16.78	2.286	80	350 ± 40	89.90
Acquapendente	Tephritic phonolite	BS7	WR	16.68	2.308	81	350 ± 40	89.90
T. Lente	Tephrite	VUL2	GM	15.14	2.43	44.0	410 ± 20	66
C. Buonviaggio	Leucitic lava	KAB54	Lc	4.74	0.7602	26.10	413 ± 10	56
Le Velette	Leucite tephrite	1018(19)	Lc	15.98	0.7885	20.83	429 ± 10	56
C. Torricella	Tephritic phonolite	BS21	Lc	15.96	3.65	64	431	39
Acquapendente	"	BS14	Lc	15.02	3.74	3.2	410 ± 150	67
C. Buonviaggio	"	VF5	Lc	15.35	3.98	44.0	410 ± 20	66
Torre Alfina	OI-trachybasalt	TA7	WR	6.20	1.941	23.23	660 ± 30	66
Latera	"	Li 1870	Phl	8.26	2.77	26.86	820 ± 40	67
						11.70	862 ± 20	13,92,93

TABLE 3
Vulsinian District - Bolsena activity: basal ignimbrites

K-Ar dating

LOCALITY	ROCK TYPE	SAMPLE No	MAT.	% K	$^{40}\text{Ar}_{\text{rad}}$ $\times 10^{-7}$ ml/g	$^{40}\text{Ar}_{\text{rad}}$ %	AGE $\times 10^3$ a	REF.
La Rocca	Trachyte	VS 44	Sa	12.37	1.8990	30.23	400 ± 20	67
La Rocca	Tephrite pho- nolite	VS 47C	"	12.14	2.0120	12.88	420 ± 40	67
		VS 30	"	10.86	1.8850	34.81	450 ± 20	67
Fontanile		VS 33	"	9.81	2.0546	35.85	550 ± 20	67
Inguatta- pagnotte	Trachyte	VS 31A	"	7.35	1.7200	46.00	610 ± 20	67
		VS 31	"	11.26	3.1200	23.31	720 ± 40	67
		VS 30A	"	10.82	3.0101	26.68	720 ± 40	67
T. Arrone		VS 50	"	10.04	3.3901	33.68	880 ± 40	67

TABLE 4
Vulsinian District - Latera activity

K-Ar dating

TABLE 5
Vulsinian District - Latera activity

²³⁰Th dating

PHASE	UNIT	LOCALITY	SAMPLE NO	MATERIAL	AGE $\times 10^3$ a	REF.
II Post- Caldera	A Pitigliano complex volcanite	Case Collina	-	px, glass ap, px, bi	146 \pm 30 190 \pm 30	38 38

TABLE 6
M^t Cimino acidic volcanic group

K-Ar dating

LOCALITY	ROCK TYPE	SAMPLE No	MAT.	% K	$^{40}\text{Ar}_{\text{rad}}$ ml/g $\times 10^{-7}$	$^{40}\text{Ar}_{\text{rad}}$ %	AGE $\times 10^3$ a	REF.
Quarry 1 km east of Viterbo	quartz latitic ignimbrite (peperino tipico auct.)	1	Sa	10.04	5.17	34	1310 \pm 80	65
		3	Sa	9.86	5.51	37.4	1390 \pm 70	65
		2	Bi	6.18	4.64	29	1190 \pm 50	65
Fagianello M. Cimino (north slope)	quartz latitic lava domes (peperino delle alteure auct.)	KA1162	Sa	10.97	4.32	87	1140	39
		KA1181	Sa	10.59		95	1181	39
		4	Sa	10.44	4.02	28.4	1048 \pm 50	65
						67	975 \pm 25	
							990 \pm 50	40
Le Piagge	Olivine latite radial lava flows (Ciminite auct.)	5	WR	5.42	2.05	8.2	940 \pm 200	65

TABLE 7
Vico volcanic District

K-Ar dating

LOCALITY	ROCK TYPE	SAMPLE No	MATERIAL	% K	$^{40}\text{Ar}_{\text{rad}}$ ml/g $\times 10^{-7}$	$^{40}\text{Ar}_{\text{rad}}$ %	AGE $\times 10^3$ a	REF.
Vetralla	Leucitic lava	KA853	Lc	15.62		3	95	39
P. gio Cavaliere	Trachyte	10	Sa	10.75	1.10	11.8	264 \pm 28	65
La Rocca	IGNIMBRITE C OF LOCARDI	VS47C	Sa	12.14	1.47	8.09	347 \pm 76	67
C. Umiltà	(Tufo rosso a sco- rie nere auct.)	9	Sa	10.90	2.012	12.88	420 \pm 40	65
C. Servelli	Black pozzolana (IGNIMBRITE B?)	8	Sa	10.07	2.26	7.1	520 \pm 120	65
San Rocco	Lc-Phonolite	7	Sa	10.15	2.55	3.6	640 \pm 220	65
San Martino	Tephritic Lc- phonol.	6	Sa	10.50	2.81	3.64	700 \pm 210	65
					3.42	8	820 \pm 180	65

TABLE 8
Mts Sabatini volcanic District

K-Ar dating

LOCALITY	FORMATION	SAMPLE NO	MATERIAL	% K	$^{40}\text{Ar}_{\text{rad}}$ ml/g $\times 10^{-7}$	$^{40}\text{Ar}_{\text{rad}}$ %	AGE $\times 10^3$ a	REF.
Baccano	TUFO DI BACCANO (1)	VSA 13	Sa	11.5	0.38	26.0	85 \pm 9	93
Baccano	INCLUSION IN TUFO DI BRACCIANO (1)	SH2 - 2550	Phl	8.43	1.09	17.3	334 \pm 48	93
Quarry above Mazzano - Calcata rd	TUFO GIALLO DI SACROFANO (1)	SAB 7	Sa	10.34	1.529	10.12	370 \pm 70	3
V. Inferno (Riano)	Volcanic level in diatomites(1)(2)	1 2	Bi	7.3	0.766 0.591	5.2 3.0	250 \pm 80 200 \pm 80	8
Casale del Bottegone	TUFI STRATIFICATI VARICOLORI DE LA STORTA	SAB 10	Lc Bi	15.75 6.00	3.789 0.952	13.99 3.88	610 \pm 100 400 \pm 200	3
Capo Magliano	(BASE)	SAB 15	Bi Lc	8.06 16.7	1.593 1.556 3.025	7.82 1.86 23.64	500 \pm 100 490 \pm 200 470 \pm 50	3
Torre in Pietra	TUFO ROSSO	KA334	Sa			34	434	39
" "	A SCORIE NERE	KA345	Sa	12.16		12	438	39
" "	AUCT.	KA1185	Sa	12.07		83	431	39
Cava Nera Molin.	(Analogue of the Ignimbrite C of Locardi)	KA408	Sa	11.53		53	432	39
Cava del Cecco		KA1175	Sa	11.45		81	422	39
Rome area	See table 7	KA407	Sa	11.9		44	417	39
Sabatian area		KA304	Sa	12.06		68	431	39
		VSA3	Sa	11.4	1.97	58.8	446 \pm 8	93
F. della Mola	Leucite		Lc	14.89	2.62	26.0	440 \pm 20	22
Morlupo	Trachyte	VSA 2	Sa	11.5	2.29	68.7	514 \pm 9	93
	Trachyte	VSAC31a	Sa	11.1	2.61	29.8	607 \pm 15	93

(1) See also dating with Fission Tracks and ^{230}Th , Table 9. (2) Average value $225 \pm 60 \times 10^3$ a.

TABLE 9
Mts Sabatini volcanic District

FT and ^{230}Th dating

LOCALITY	FORMATION LEVEL	SAMPLE No	MATERIAL	METHOD	AGE $\times 10^3$ a	REF
MONTE CUCCO (Cerveteri)	TUFO 1	1	Bi		177 \pm 30	
	DI 2	2	Bi	FT	127 \pm 13	26
	BACCANO 3	3	Bi		90 \pm 18	
MONTE GELATO (Mazzano)	TUFO GIALLO	SAB 7	Sa, Aug		200 \pm 100	
	DI SACROFANO	SAB 9	Sa, Anc, Aug, Ti	^{230}Th	> 300	32
VALLE DELL'INFERNO (Riano)	VOLCANIC LEVEL IN DIATOMITES	-	Bi (as detector)	FT	280 \pm 30	25

TABLE 10
Alban Hills

K-Ar dating

PHASE	LOCALITY	ROCK TYPE	SAMPLE	MAT.	% K	$^{40}\text{Ar}_{\text{rad}}$ ml/g $\times 10^{-7}$	$^{40}\text{Ar}_{\text{rad}}$ %	AGE $\times 10^3$ y	REF.
FINAL		Products of phreatic explosions	(1)						
CENTRAL POST-CALDERA ACTIVITY	M. Cavo	scoriaceous agglomerate	KA409	Lc	16.38		28	277	39
	M. Cavo	leucite tephrite	Al 5	Lc	17.0	1.81	36.3	268 ± 4	16
	Arcioni	phonolitic tephrite	Al 6	Lc	15.3	1.46 1.47	17.8 7.0	240 ± 13 242 ± 9	16
	Albano lake	tephritic leucitite	Al 28	Lc	15.9	1.64	20.2	260 ± 5	16
	Nemi lake, flow lowest lava	tephritic leucitite	Al 3	Lc	16.7	2.20	19.7	331 ± 7	16
LATERAL POST-CALDERA ACTIVITY	P ^{te} Divino Amore	tephritic leucitite	KA 855	Lc	16.07		12	268	39
	P ^{te} Divino Amore	tephritic leucitite	AL 23	Lc	16.2	1.13	32.4	175 ± 2	16
	Capo di Bove	tephritic leucitite		Lc	16.10 (2)	3.25 3.49	14.5 15.6	520 ± 40	44
	Capo di Bove	tephritic leucitite		WR	7.05 (3)	1.44 1.46	9.1 6.4	500 ± 50	44
	Capo di Bove	tephritic leucitite		Lc	16.90	2.40	20.11	360 ± 40	53
	Capo di Bove	tephritic leucitite	Al 20	Lc	17.3	2.01	7.6	292 ± 6	16
	Laghetto	tephritic leucitite	Al 12	Lc	17.2	2.46	50.3	360 ± 5	16
	Saponara	tephritic leucitite	Al 30	Lc	17.1	1.80	27.5	264 ± 6	16
	East of Saponara	tephritic leucitite	Al 33	Lc	15.4	1.67	37.3	273 ± 8	16
	Mola Cavona ta			Lc	15.7	3.20	24.4	520 ± 40	53
COMPLEX OF LOWER PYROCLASTICS	T Falcognana	Tufo di		Lc	16.9	3.55	42.7	590 ± 40	53
	Mola Cavona le	Villa		Bi	8.38	2.05	5.97	620 ± 200	53
	C Formagrotta	Senni		FG	17.2	2.34	44	352 ± 8	93
	from 10 outcrops	formation		VS3-VS7	Lc	By ^{39}Ar - ^{40}Ar method	(4)	338 ± .8	70
	Fontana Ranuccio (Anagni)	Tufo litoide	LS 4	Lc	17.2	2.42	86.3	366 ± 4.5	17
PRE CALDERA ACTIVITY FISSURAL LAVA FLOWS	Archaeol. layer	LS 3	Lc	17.1	3.12	72.9	458 ± 5.7	17	
	cinerite (5)	LS 2	Lc	16.4	3.07	57.6	487 ± 7.5	17	
	limnosol (6)	LS 1	Lc	16.5	3.45	87.2	528 ± 6	17	
	Acqua Acetosa	tephritic leucitite	KA 348	Lc	16.92		47	706	39
	Acqua Acetosa			WR	7.45	2.08 2.05	18.9 17.5	680 ± 50	44
EAST OF TUSCOLO	Acqua Acetosa	tephritic leucitite	Al 17	Lc	15.6	2.42	25.1	400 ± 10	93
	Valleranello	tephritic leucitite	Al 18	Lc	15.6	2.85	44.6	460 ± 6	16
	East of Tuscolo	leucitite	Al 9	Lc	17.0	3.29	38.0	487 ± 6	16
	F ^{te} Marcaccio (M. Artemisio)		Al 38	Lc	16.6	3.47	42.3	524 ± 9	16

(1) See Table 13. (2) Average of two values: γ -spectr. 18.10%; at. abs. 16.03%. (3) Average of two values: γ -spectr. 7.18%; at. abs. 6.29%. (4) See Table 11. (5) Probably from Ernici volcanoes, but overlying a «pozzolana» layer from the Alban Hills. (6) Tuffitic limnosol underlying the «pozzolana» layer.

TABLE 11
Alban Hills - Tufo di Villa Senni (1)

³⁹Ar-⁴⁰Ar dating

SAMPLE No	MATERIAL	AGE x 10 ³ a	REF.	SAMPLE No	MATERIAL	AGE x 10 ³ a	REF.			
VS 3	Lc	342 ± 16	70	VS 6	Lc	336 ± 20	70			
	Bi	348 ± 15			Bi	278 ± 15				
VS 4A	Lc	343 ± 16	70	VS 7	Lc	333 ± 22	70			
	Bi	341 ± 17			Bi	344 ± 25				
VS 4B	Lc	329 ± 32	70	VS 8	Lc	332 ± 17	70			
	Lc	335 ± 19			Lc	309 ± 17				
VS 5	Bi	380 ± 22	70	VS 10	Lc	344 ± 19	70			
					Lc	315 ± 19				
Average value from leucite samples										
VS3, VS4A, VS4B, VS5, VS6, VS7										
338 ± 8 ± 10 ³ a										

(1) Samples from different outcrops.

TABLE 12
Alban Hills - Tufo di Villa Senni (1)

Rb-Sr dating

FORMATION	SAMPLE	MAT.	Rb ppm	Sr ppm	⁸⁷ Rb/ ⁸⁶ Sr	(⁸⁷ Sr/ ⁸⁶ Sr) _i	(⁸⁷ Sr/ ⁸⁶ Sr) _m	AGE x 10 ³ a	REF.
TUFO	VS 3	Lc 1	1177	12.89	218.2	0.71026 ± 3	0.71141 ± 3	372 ± 20	70
		Lc 2	1186	13.00	216.6		0.71137 ± 4		
		Bi	737	297.4	5.94		0.71029 ± 4		
		WR	404	177	0.54		0.71026 ± 4		
	VS 58	Lc	1347	30.1	107.0	0.71031 ± 3	0.71082 ± 6	337 ± 50	70
		Bi	628	350.5	5.04		0.71078 ± 6		
DI	VILLA	Px	22.7	482.8	0.112	0.71032 ± 3	0.71032 ± 7	337 ± 50	70
SENNI		Lc	946	18.4	122.6		0.71095 ± 3		
		Bi	537	278.9	4.60		0.71100 ± 12		
	VS 10	Px	14.1	585.3	0.05	0.71037 ± 3	0.71041 ± 3	334 ± 20	70
							0.71038 ± 4		
							0.71035 ± 3		

(1) Samples from different outcrops.

TABLE 13
Alban Hills

¹⁴C, Fission Trac and ²³⁰Th dating

LOCALITY	FORMATION	SAMPLE No	MAT.	METHOD	AGE $\times 10^3$ a	REF.
Albano	Final activity	GRO-1496	Wood fragments embedded in the "peperino"	¹⁴ C	29.7 \pm 0.4	37
	Products of phreatic explosions	R-135			37	2
	(peperino di Albano Auct.)	R-135			37	2
	(peperino di Albano Auct.)	R-135A			37	2
	(peperino di Albano Auct.)	R-135B			37	2
	(peperino di Albano Auct.)	R-135C			37	2
Nettuno	littoral sand	-	Ap, Bi	²³⁰ Th	67 \pm 5	84
		-	Zr	²³⁰ Th	43 \pm 5	28
		-	Zr	FT	56 \pm 9	24
	Tufo di Villa Senni	1	Bi	FT	340 \pm 70	20
		2	Bi	FT	160 \pm 30	
		3	Bi	FT	300 \pm 60	
		4	Bi	FT	520 \pm 10	

TABLE 14
Hernican District (Mt^{ts} Ernici)

K-Ar dating

LOCALITY	ROCK TYPE	SAMPLE No	MATERIAL	%K	$^{40}\text{Ar}_{\text{rad}}$ ml/g $\times 10^{-7}$	$^{40}\text{Ar}_{\text{rad}}$ %	AGE $\times 10^3$ a	REF.
Contr. Roana		Er-4	Lc	13.40	2.9581	35	540 \pm 20	14
Patrica		S 10	Bi	7.95	1.2729	4.4	400 \pm 80	31
Giuliano Romano	Tephritic leucitite	Er-1	Lc WR	14.37 5.03	2.2858 0.8381	19 8	400 \pm 20 420 \pm 40	14
C ^{le} Cerroni	Tephritic leucitite	M 5	WR	6.55	0.7687	8.5	290 \pm 20	31
C ^{le} Celleta	Tephritic leucitite	M 2	WR	6.71	0.6790 0.5692	8.6 6.6	250 \pm 20 220 \pm 20	31
C ^{le} Castellone	Phonolitic leucitite	Er-2	Lc WR	15.13 6.65	4.2803 1.7793	19.5 32	700 \pm 20 680 \pm 20	14
C ^{le} Spinazzetta	Lc-alkalibasalt	S 1	WR	2.24	0.2151	3.1	240 \pm 100	31
C ^{le} Spinazzetta (dyke)	Lc-alkalibasalt block embedded in-	S 9 S 9	WR WR	2.16 2.16	0.1916 0.1553	1.9 2.3	230 \pm 110 180 \pm 90	31
C ^{le} Spinazzetta	Lc-alkalibasalt	ERN 3	WR	2.20	0.1699	3.5	200 \pm 40	31
Pofi, highway	Tephritic leucitite	Er-5	Lc WR	15.61 5.38	2.5523 0.7687	33 15	400 \pm 10 370 \pm 20	14
Pofi	Leucitite	S 14	WR	5.69	0.9838	10.2	430 \pm 20	31
C ^{le} Vitelli (Pofi)	Leucitite	S 22	WR	5.41	0.2734 0.2510	3.9 3.6	130 \pm 30 110 \pm 30	31
P. ^{zo} Colonnello (Pofi)	Lc-alkalibasalt	S 18	WR	6.09	0.1990 0.3093	2.5 1.5	80 \pm 40 120 \pm 60	31
F ^{zo} Meringo (Pofi)	Tephritic leucitite	Er-3	Lc	14.86	2.3306	24.16	390 \pm 20	14
C ^{le} del Vescovo	Lc-trachybasalt	ERN 7 S 4	WR WR	2.81 2.89	0.4168 0.1844	5.4 2.7	370 \pm 40 170 \pm 80	31 31

TABLE 15
Ponza Archipelago

ISLAND	LOCALITY	ROCK TYPE	SAMPLE No.	MAT.	% K	$^{40}\text{Ar}_{\text{rad}} \text{ml/g}$	$^{40}\text{Ar}_{\text{rad}} \%$	AGE $\times 10^6$ a	REF.
VENTOTENNE	Parata Grande	Trachybasalt	V58	WR	1.90	1.28	23	1.7 ± 0.06	12
	Parata Grande	Anc-trachybasalt	V83	WR	1.43	0.33	15.5	<2	12
	Capo Arcos	Basalt	1/155	WR	1.28	0.32	8.2	0.81 ± 0.08	75
	Semaforo	Basalt	4/572	WR	1.54	0.32	18.1	0.53 ± 0.08	75
	Parata Grande	Basalt	5/564	WR	2.42	0.45	18.1	0.48 ± 0.04	75
	S. of Montagnozzo	Pumice	25/599	B1	7.78	< 0.46	-	<0.15	75
	Montagnozzo	Pumice	26/600	B1	7.86	< 0.45	-	<0.15	75
	Parata Grande	Scoriae	24/598	B1	8.04	< 0.6	-	<0.19	75
	Parata Grande	Scoriae	24/604	WR	5.12	< 0.55	-	<0.27	75
	Romanello d.B.	Basalt	6/603	WR	0.99	< 0.05	-	<0.13	75
SANTEANO	LA BOTTE	Trachyte	8/491	WR	5.72	2.74	54.5	1.23 ± 0.04	75
	Phonolite		63	WR	5.51	2.48	30	1.2 ± 0.04	12
	Phonolite		65	WR	5.53	-	-	2	12
	Phonolite		7/606	Sa	8.05	2.49	33.5	0.80 ± 0.03	75
	Phonolite		7/597	WR	6.28	1.36	51.5	0.56 ± 0.02	75
PONZA	Punta Nera (base of series)	Rhyolite, glassy	P13	Bi	6.74	12.6	26	4.7 ± 0.16	12
		Rhyolite, compact	P105	WR	3.06	6.41	22	5.0 ± 0.17	12
		Rhyolite, dyke	P107	WR	4.10	6.58	32	4.06 ± 0.14	12
		P44	P44	WR	3.95	3.04	29	1.9 ± 0.07	12
		Retinite of P44	P43	WR	3.21	-	-	<2.5	12
			102	WR	4.96	2.16	35	1.1 ± 0.04	12
			102	FS	3.63	1.71	17	1.2 ± 0.05	12
		Perlite	PN246b	WR	3.74	6.36	40.8	4.36 ± 0.16	76
		Rhyolite	PN220	WR	4.51	7.78	28	4.43 ± 0.19	76
		Rhyolite	PN24	WR	4.62	7.13	11.6	3.96 ± 0.49	76
PALMAROLA	S. Maria	Rhyolite	PN23	WR	4.60	7.98	47.8	4.45 ± 0.16	76
	Punta Nera	Obsidian, rhyolite	PN223	WR	3.98	-	-	-	76
	M. La Guardia	Nephryolite dome	156	WR	4.44	2.90	23	1.6 ± 0.06	12
	Cala d. Acqua	Obsidian	156A	WR	3.59	2.46	50	1.7 ± 0.06	12
	M. Tramontana (see also table 16)	Obsidian	B	WR	-	-	14	1.6 ± 0.2	15

TABLE 16
Ponza Archipelago

ISLAND	LOCALITY	ROCK TYPE	SAMPLE No.	AGE $\times 10^6$ a	REF.
PALMAROLA	Monte Tramontana-Porto	Obsidian	PAL 13	1.7 ± 0.3	19
	Monte Tramontana	PAL 3	-	1.3 ± 0.3	19
		-	-	1.58 ± 0.23	10

TABLE 17
Volcanic level interbedded in sedimentary units

K-Ar and FT dating

LOCALITY	STRATIGRAPHIC POSITION	MATERIAL	METHOD	AGE ₆ $\times 10^6$ a	REF.
Marco Simone Quarry	Volcanic level interbedded	Pl	K-Ar	4.20 ± 0.2	7
Via Palombarrese	in blue marine Pliocene	Ho	K-Ar	4.34 ± 0.8	7
Mentana, Rome	clays	glass	FT	4.03 ± 0.93	10
		glass	FT	3.32 ± 0.30	10
		glass	FT	3.18 ± 0.31	10
Valle Ricca	Volcanic ashes level	glass	FT	2.13 ± 0.27	10
Monterotondo	interbedded in marine	glass	FT	2.03 ± 0.26	10
Rome	sandy clays				
Corchiano	Volcanic level overlying	glass	FT	3.85 ± 0.5	4,23
Viterbo	Middle Pliocene clays				

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