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Geochronology in Sardinia: results and problems

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ABSTRACT. — Geological and geochronological data indicate that in Sardinia three main periods of tectonism, metamorphism and/or igneous activities can be recognized: Ordovician-Silurian, Carboniferous-Permian and Tertiary-Quaternary.

The older radiometric datings are around 460-430 Ma and refer to medium-grade igneous derived products (acid volcanics and plutonics), which can be connected with the widespread pre-Caradocian low-grade calcalkaline metavolcanics of central Sardinia.

The fairly chronological coincidence between this igneous activity and the Sardic tectonic phase is considered good evidence of a Caledonian orogenetic event, even if no radiometric data of lower Paleozoic metamorphism has been obtained.

The second period of tectono-metamorphic and magmatic activities was the Hercynian orogenesis which determined the main features of the basement. Radiometricc datings support that it developed during a time span of about 40 Ma from 344 Ma (corresponding to the isotopic closure of a banded migmatite) to 310-300 Ma (as indicated by the isotopic synchronous closure of different metamorphic minerals and by the whole-rock isochron and mineral ages of the main syn- to late-tectonic granitoids).

The intrusions of the post-tectonic leucogranites (∼ 290 Ma) possibly accompanied the uplift and denudation of the basement, which were almost completed at Upper Carboniferous-Permian time, when the post-orogenetic calcalcaline volcanites emplaced.

During the Tertiary, a widespread volcanic activity took place in Sardinia in two main periods. The older cycle had a general calcalkaline character, and developed from about 32 to 11 Ma, producing ignimbrites and lavas, mainly along a NS trending complex graben structure. This volcanism may be related to a NW or NNW dipping subduction zone along the paleo-European continental margin. The younger volcanism took place starting in the Uppermost Miocene and lasted until the Upper Pleistocene. Volcanic products outpoured initially in the Capo Ferrato area (5,3 Ma) afterwards extending to various sectors of the Island (Monte Arci 3.8-2.8 Ma; Montiferro 3.9-1.6 Ma; Orosei-Dorgali 3.9-2.1 Ma; central-southern plateaux 3.8-1.7 Ma). The most recent activity is present only in the Logudoro region (NW Sardinia, 0.9 - <0.15 Ma).

Key words: Geochronology, Sardinia, Caledonian, Hercynian, Alpine.

RIASSUNTO. — Dati geologici e geocronologici consentono di individuare in Sardegna tre principali periodi di attività tettonica, metamorfica e/o magmatica: Ordoviciano-Siluriano, Carbonifero-Permiano e Terziario-Quaternario.

Le più antiche età radiometriche cadono intorno a 460-430 Ma e si riferiscono a prodotti di medio grado derivati da rocce ignee (vulcaniti e plutoniti acide) i quali possono essere correlati con le diffuse metavulcaniti calcalcaline di età pre-Caradociana che affiorano nella Sardegna centrale.

La buona coincidenza cronologica tra questa attività magmatica e la ben nota fase tettonica Sarda è considerata una evidenza di un evento orogenetico caledoniano, anche se nessun dato radiometrico che supporti un metamorfismo Paleozoico inferiore è stato a tutt'oggi ottenuto.

Il secondo periodo di intensa attività tettono-metamorfica e magmatica è stato quello dell'orogenesi ercinica, la quale ha impartito i lineamenti fondamentali del basamento cristallino. I dati radiometrici indicano che detta orogenesi si sviluppò in un arco di tempo di circa 40 Ma, tra 344 Ma (corrispondenti alla chiusura isotopica di una migmatite a bande) e 310-300 Ma (come indicato dalla chiusura isotopica sincrona di minerali metamorfici differenti e dalle età ottenute mediante isocrona di roccia totale e su minerali dei principali granitoidi sin- e tardo-tettonici).

L'intrusione di leucograniti post-tettonici (~ 290 Ma) fu verosimilmente contemporanea all'uplift e al denudamento del basamento, che si era praticamente già completato quando nel tardo-Carbonifero-Permiano si misero in posto le vulcaniti post-orogenetiche di affinità calcalcalina.

Durante il Terziario, nel corso di due periodi, si verificò una diffusa attività vulcanica. Il primo ciclo a carattere calcalcalino si sviluppò tra 32 e 11 Ma, con produzione di ignimbriti e lave, all'incirca lungo una complessa struttura a graben con direzione NS. Questo vulcanismo può essere correlato con una zona di subduzione immergente verso NW o NNW lungo il margine continentale della paleo-Europa.

Il vulcanismo più recente iniziò nel Miocene superiore e proseguì sino al Pleistocene superiore. I primi prodotti dell'attività vulcanica furono emessi nell'area di Capo Ferrato (5,3 Ma) per poi estendersi ad altri settori dell'isola (Monte Arci 3,8-2,8 Ma; Montiferro 3,9-1,6 Ma; Orosei-Dorgali 3,9-2,1 Ma; plateaux centro-mereidionali 3,8-1,7 Ma). L'attività più recente è presente solo nel Logudoro (Sardegna nord-occidentale, 0,9 - <0,15 Ma).

Parole chiave: Geocronologia, Sardegna, Caledoniano, Ercinico, Alpino.

Introduction

Geochronological research started in 1962 in Sardinia with pioneering work by FERRARA, SEGRE & TONGIORGI who dated some rocks of the crystalline basement, and had its maximum developement during the seventies.

The radiometric ages cover a time span from Lower Paleozoic to Quaternary: but most of the results fall in the Paleozoic (crystalline basement + Post-Hercynian volcanites) and in the Tertiary-Quaternary (volcanic covers); no convincing Mesozoic age has been reported up to now.

Most of the geochronological data are of great importance in defining the geological evolution of the island, even if the meaning of some of them (especially K/Ar data relative to pre-Alpine rocks) are not clear at the moment, as these results are sometimes in contradiction to stratigraphic evidence.

On geological and radiometric grounds three main periods of tectonism, metamorphism and/or igneous activities, can be recognized: Ordovician-Silurian (the so-called «Caledonian event»), Carboniferous-Permian (the Hercynian orogeny), Tertiary-Quaternary (the Alpine volcanism).

This paper reports the content of an invited lecture given at the Meeting of the Italian Society of Mineralogy and Petrology (S.I.M.P.) in Milan, on the 26^{th} May 1984. All the available geochronological data are reported in the Appendix as follows: tables 1 *a*, 1 *b* - those relative to the « Caledonian event »; tables 2 *a*, 2 *b*, 2 *c*, 2 *d*, 2 *e* - those relative to Hercynian orogeny; and 3 *a*, 3 *b* - those relative to the Alpine volcanism.

The same chronological three-partition system has been adopted in the presentation of the main geochronological results and problems.

Decay constants used in all tables were: for $Rb = 1.42 \cdot 10^{-11}\ \gamma^{-1}$ and for K/Ar ages $\lambda_\varepsilon = 0.581 \cdot 10^{-10}$ per year; $\lambda_\beta = 4.962 \cdot 10^{-10}$ per year; $^{40}K/K_{tot}$ (weight ratio) $= 1.194 \cdot 10^{-4}$; $^{40}Ar/^{36}Ar$ (atm) $= 295.5$.

1) « Caledonian » event

1.1. GRANITIC AND GRANODIORITIC ORTOGNEISS (table 1 *a*)

The oldest ages recorded in the crystalline basement have been obtained on granitic and granodioritic gneiss derived from igneous rocks.

The Rb/Sr whole-rock isochron performed by DI SIMPLICIO et al. (1974) on the granodioritic orthogneiss of NE Sardinia yields an age of 458 ± 31 Ma, the isochron by COCOZZA et al. (1977) on the orthogneiss of Capo Spartivento (southern Sardinia) yields an age of 427 ± 33 Ma and the one by FERRARA et al. (1978) on the augen gneiss (meta-rhyolites) on NE Sardinia yields age of 441 ± 33 Ma.

The initial $^{87}Sr/^{86}Sr$ ratios, respectively, are 0.7081 ± 0.0012, 0.7122 ± 0.0058 and 0.7113 ± 0.0034.

These values have been considered as the ages of the plutonic or volcanic emplacement of magmas produced by anatexis of crustal material.

No radiometric data supporting a « Caledonian » metamorphism have been obtained up to now.

According to COCOZZA (in COCOZZA et al., 1977) the radiometric age of the orthogneiss of Capo Spartivento, should be questioned because of the geometrical position of the orthogneiss, which lies below the Cambrian sequence.

1.2. Acid metavolcanics (Porfiroidi auct.) (table 1 *b*)

K/Ar ages of 25 whole-rock samples of Porfiroidi (rhyolitic and rhyodacitic metavolcanics from central Sardinia have been determined by Calderoni et al. (1984).

The radiometric ages range from 363 to 243 Ma.

These ages are less than that which can be inferred by their stratigraphic position (pre-Caradocian according to Carmignani et al., 1982) and are interpreted by the Authors as the results of modifications of the K/Ar ratios during post-magmatic event(s) like the Hercynian metamorphism or weathering processes.

No radiometric age exists for the Upper Ordovician-Silurian alkalic metabasites, relatively widespread in several places on the Island (Beccaluva et al., 1981; Memmi et al., 1982, 1983 and references).

2) Hercynian orogeny

In this section we consider all those geological events and radiometric ages falling within the Carboniferous-Permian periods. Essentially they refer to the crystalline basement, constituted of approximately half metamorphic and half plutonic rocks, but also include the post-orogenetic volcanites which started to emplace in Upper Carboniferous-Permian time.

In the metamorphic basement three main structural zones, trending NW-SE have been distinguished: an External zone (SW Sardinia), a Nappe zone and an Axial zone (NE Sardinia). From the External to the Axial zone tectonism and metamorphism increase fairly regularly (Carmignani et al., 1982, 1984) from low greenschist facies to upper amphibolite facies.

The batholith is a composite one and consists of scanty mafic precursors and syntectonic tonalites and granodiorites, about 75 % of late tectonic intrusions ($\sim$ 10 % tonalites and tonalitic granodiorites; $\sim$65 % monzogranitic granodiorites to leucomonzogranites) and $\sim$ 25 % of post-tectonic leucogranites (Ghezzo and Orsini, 1982; Carmignani et al., 1984).

2.1. Metamorphic rocks (table 2*a* and 2*b*)

On the metamorphic rocks two different approaches have been used: Rb/Sr isochron on a banded migmatite and Rb/Sr and K/Ar measurements of separated minerals (Di Simplicio et al., 1974; Ferrara et al., 1978).

Rb/Sr age of a Banded Migmatite

Six layers of a sample of a stromatic migmatite from north-east Sardinia fit a Rb/Sr isochron of 344 ± 7 Ma with an initial $^{87}Sr/^{86}Sr$ of 0.7136 ± 0.0001.

Taking this age indicating the age of the isotopic closure of the bands it has been assumed as marking... « something like the Hercynian metamorphic climax » (Ferrara et al., 1978).

Rb/Sr and K/Ar age of minerals

Four mineral isochrons have been constructed on two samples of granodioritic orthogneiss, one sample of augen gneiss and one layer of banded migmatite.

The ages obtained are in every case very similar: 304 ± 1 and 308 ± 24 Ma for the granodioritic orthogneiss, 306 ± 10 Ma for the augen gneiss, and 298 ± 2 for the two-point isochron of the banded migmatite (Di Simplicio et al., 1974; Ferrara et al., 1978). Rb/Sr and K/Ar ages have been determined by Di Simplicio et al. (1974) and Ferrara et al. (1978) on separated metamorphic minerals like hornblende, muscovite, biotite. The ages range from 319 to 284 Ma, with an average of 297 Ma.

Comparing the results obtained on different mineral types and/or with analytical methodologies no systematic difference appear, suggesting a simultaneous and rapid closure of various isotopic systems.

* * *

As can be seen, the geochronological data on the Hercynian metamorphism are few and limited to the north-eastern zone of the Island, where the medium to high grade rocks outcrop.

It would be desirable for other data to be collected in the central and southern zones, in order to verify the synchronous or diachronous tectonometamorphic evolution of the different structural zones of the chain.

2.2. PLUTONIC ROCKS (table *2c* and *2d*)

All classical methodologies, including Rb/Sr whole-rock isochrons and Rb/Sr and K/Ar measurements on minerals have been adopted to date these rocks.

Rb/Sr isochron ages

DEL MORO et al. (1973, 1975), were the first to date these rocks by Rb/Sr whole-rock isochrons. These isochrons were constructed using samples collected all over the Sardinian batholiths, from different plutons of similar composition.

The tonalitic to granodioritic rocks define an isochron of 307 ± 6 Ma with an initial $^{87}Sr/^{86}Sr$ of 0.7099 ± 0.0006.

Monzogranites and monzogranitic granodiorites fit an isochron of 302 ± 5 Ma with an initial $^{87}Sr/^{86}Sr = 0.7107 \pm 0.0008$.

Leucogranites yield an isochron of 289 ± 1 Ma with a $(^{87}Sr/^{86}Sr)_i = 0.7085 \pm 0.0005$.

More recently several dates have been obtained on single plutons or plutonic bodies.

SCHARBERT (1978) reports a Rb/Sr isochron of 299 ± 21 Ma and $(^{87}Sr/^{86}Sr)_i$ of 0.7091 ± 0.0099 on the granodiorite of Capo Spartivento (southern Sardinia).

BARBIERI (in NICOLETTI et al., 1982) using three mineral phases and the whole rock obtained a Rb/Sr age of 301 ± 3 Ma on the granodiorite of Capo Carbonara (S-SE Sardinia).

COCHERIE (1978, 1984) performed a Rb/Sr isochron on the monzogranitic plutons of Buddusò and Concas (northern central Sardinia), obtaining an age of 281 ± 5 Ma with Sr initial isotopic ratio of 0.70962 ± 0.00038.

FERRARA et al. (1980), studying the mafic mass of Punta Falcone (north Sardinia) found an age of about 280 Ma and $(^{87}Sr/^{86}Sr)_i$ $\sim$ 0.708. They consider these values as the result of chronological readjustment due to isotopic interaction between mafic and acid magmas.

Rb/Sr ages on biotites

Eleven biotites of the different groups of plutonic rocks from NE Sardinia have been analyzed by DEL MORO et al. (1975).

Ages of biotites from tonalites and granodiorites are between 305 and 279 Ma, those of monzogranites and monzogranitic granodiorites are between 297 and 275 Ma; two biotites from leucogranites give a ages of 298 and 295.

One biotite from the granodiorite of Capo Carbonara (S-SE Sardinia) gives an age of 289 ± 1 Ma (BARBIERI, in NICOLETTI et al., 1982).

Two biotites from the granodiorite of Capo Spartivento (S-SW Sardinia) give ages of 293 and 284 Ma (SCHARBERT, 1978).

Therefore ages of all the biotites, except those from leucogranites, are slightly less old than those of the respective isochrons (cfr. table 2 *c*).

K/Ar ages

K/Ar ages of biotites from plutonites of NE Sardinia are more or less in agreement with those obtained with the Rb/Sr method (DEL MORO et al., 1975). The K/Ar ages of minerals and the Harper and isotope isochrons determined by NICOLETTI et al. (1982) on the granodiorite of Capo Carbonara are all consistently around 285 Ma (281-287 Ma).

Other K/Ar measurements on different minerals of plutonites from central-eastern Sardinia have been performed by COZZUPOLI et al. (1971, 1972). The results, ranging from 232 to 275 Ma, are considered by the same Authors to be strongly influenced by alteration processes.

* * *

It is quite clear that the Rb/Sr whole-rock isochron results are the more reliable for dating the Hercynian plutonism. However, it must be noted that the single pluton isochrons are too scanty, and the isochrons of DEL MORO et al. (1975), should be criticized, principally, because of their, *a priori,* assumption that plutons of the same composition are coeval and with the same initial isotopic ratio.

The age of the mafic precursor as well as that of the syntectonic intrusions still remain open to conjecture. The only (and still unpublished) result is that by CARMIGNANI, DEL MORO, FRANCESCHELLI, PERTUSATI (personal communication) on the schistose granite of Mount Grighini (central Sardinia): age 340 ± 8 Ma; $(^{87}Sr/^{86}Sr)_i = 0.7080 \pm 0.0003$.

2.3. POST-OROGENETIC VOLCANITES (table 2 *e*)

Upper Paleozoic volcanics outcrop in the north (Gallura), the north-west (Nurra), the south-east (Barbagia, Ogliastra, Gerrei) and the south-west of the Island. They range in composition from andesite to rhyolite and, at present, cover about 300 Km^2 (FONTANA et al., 1982).

K/Ar measurements both on whole rocks and minerals, spread over a period ranging between 315 and 140 Ma (COZZUPOLI et al., 1971; LOMBARDI et al., 1974; EDEL et al., 1981) even though a critical analysis of these results leads the various Authors to rejecting the ages lower than 210 Ma.

COZZUPOLI et al. (1984) carried out whole-rock K/Ar analyses on various samples of ignimbrite from Galtellì (eastern Sardinia), collected according to the « Mellor-Musset » criterion. Hunziker's total isochron yields an age of 284 ± 15 Ma.

The radiometric data, and in particular their spread over a time span of more than 100 Ma are interpreted in different ways by different Authors. According to EDEL et al. (1981) the post-orogenetic volcanics belong to a single cycle of Upper Carboniferous-Permian age and the lower age-values are considered the result of alteration and/or of overprinting of the Alpine tectonics; whereas according to FONTANA et al. (1982) some stratigraphical evidence supports the hypotesis that the volcanic activity developed during two cycles: the first of the Upper Carboniferous-Permian age, and the second of the Permian-Triassic age.

3) The Alpine ages

About 200 K/Ar datings of Alpine age are reported in table 3 *a*. Some other fission track ages are reported in table 3 *b*. Results in disagreement with the stratigraphy have not been considered. The datings are referred to the widespread volcanic activity which took place in Sardinia during Oligocene-Miocene and Pliocene-Pleistocene times.

3.1. OLIGOCENE-MIOCENE VOLCANICS (table 3 *a*)

The older volcanism had a general calc-alkaline character and may be related to a NW or NNW dipping subduction zone along the paleo-European continental margin which ultimately resulted in the formation of the Balearic backarc Basin and the counter-clockwise drift of the Sardinia-Corsica microplate (ALVAREZ, 1972; COULON and DUPUY, 1975; SAVELLI et al., 1979).

The beginning of rifting between Sardinia and Provence is tentatively placed in the Early Oligocene (CHERCHI and MONTADERT, 1982; BURRUS, 1984), while the volcanic activity on the Island started from about 32 Ma (fig. 1). In the time span 32-26 Ma calc-alkaline lavas (also with some tholeiitic tendency in south Sardinia) outpoured sporadically along the western graben structure both in the southern and the northern areas.

Such effusive calcalkaline activity shows a significant spatial zonation in the period between 23 and 17 Ma, with tholeiitic and high-K_2O calcalkaline lavas in the southern and northern areas respectively.

Starting from about 23 Ma, highly explosive ignimbritic products, probably originated by anatexis of the granitic continental crust (COULON, 1977; SAVELLI et al., 1979), outpoured over large sectors of the western graben structure, alternated with, and were partly contemporary to, the effusive products.

Both the effusive and explosive activities lasted until 13-11 Ma when the drift movements were already accomplished and the Sardinia volcanic arc became inactive.

3.2. PLIOCENE-PLEISTOCENE VOLCANICS (table 3 *a* and 3 *b*)

A new volcanic cycle resumed in Sardinia around 5 Ma after a period of relative tectonic stability.

This new volcanism continued, with varying intensity until the Upper Pleistocene ($\sim$ 0.1-0.2 Ma) and had a within-plate character connected to widespread extensional tectonics which affected the Sardo-Tyrrhenian area during Pliocene and Quaternary times (BECCALUVA et al., 1983).

It consisted principally of alkaline to subalkaline basic lavas, and their differentiated products, which outpoured initially in the Capo Ferrato area (5.0-5.3 Ma). Afterwards they extended to various sectors of

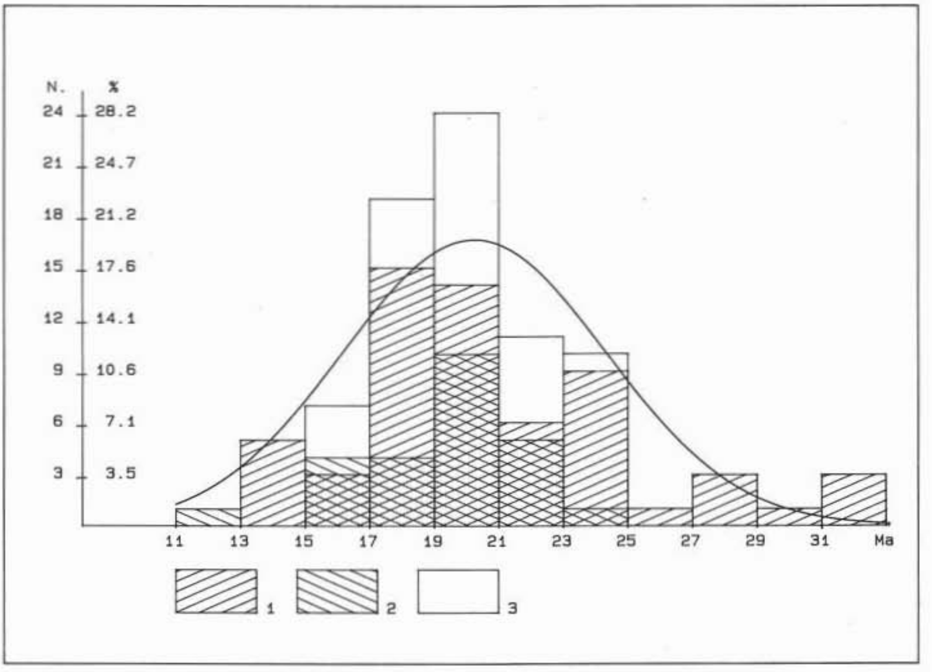

Fig. 1. — Age histogram for Oligocene-Miocene volcanics from Sardinia. - N = number of data; 1 = basaltic and andesitic lavas; 2 = rhyodacitic ignimbrites; 3 = all data. Data after Table 3 *a*.

the Island: Montiferro 3.9-1.6 Ma; Monte Arci 3.8-2.8 Ma; Orosei-Dorgali 3.9-2.1 Ma and central-southern plateaux 3.8-1.7 Ma. The most recent activity, aged 0.9-0.1 Ma is present only in northern Sardinia (Logudoro) where older volcanic products also occur.

In the frequency histogram of fig. 2 it can be observed that maximum activity took place in the interval between 4 and 2 Ma and two periods of quiescence, respectively at 5-4 and 2-1 Ma occurred.

Capo Ferrato

Capo Ferrato volcanic rocks are of great interest being the oldest dated products of the second cycle of activity in Sardinia. The chemical compositions of these rocks range from mildly alkalic trachybasalts to trachyte (BROTZU et al., 1975). K/Ar determinations (table 3 *a*) range from 5.9 to 5.0 Ma; three of the four determinations cluster around 5.0-5.3 Ma. This suggests that the most reliable age for Capo Ferrato volcanism is Uppermost Miocene.

Monte Arci volcanic complex

Monte Arci is a volcanic complex located in west-central Sardinia, along the east Campidano graben faults. Fissural volcanic activity characterized the Monte Arci complex, with outpouring of lava flows mainly along NNW-SSE and N-S trending fractures. The general Pliocene stratigraphy, from the base upwards, of the area can be summarized as follows, from BECCALUVA et al. (1977).

3) Rhyolitic lava flows.

4) Dacitic and alkalitrachytic lava flows.

5) Basaltic lava flows.

Submarine pillow lavas, hyaloclastites and volcanic breccias are interbedded with Miocene marine sediments.

The last unit represents different episodes of Miocene submarine activity.

The available radiometric data relative to Pliocene-Pleistocene activity of the Monte Arci complex are reported in table 3 *a*. The K-Ar data range from 3.7 to 2.8 Ma, most of these data do not correspond perfectly with the field stratigraphy observed probably due to Ar loss in the glassy rhyolitic samples.

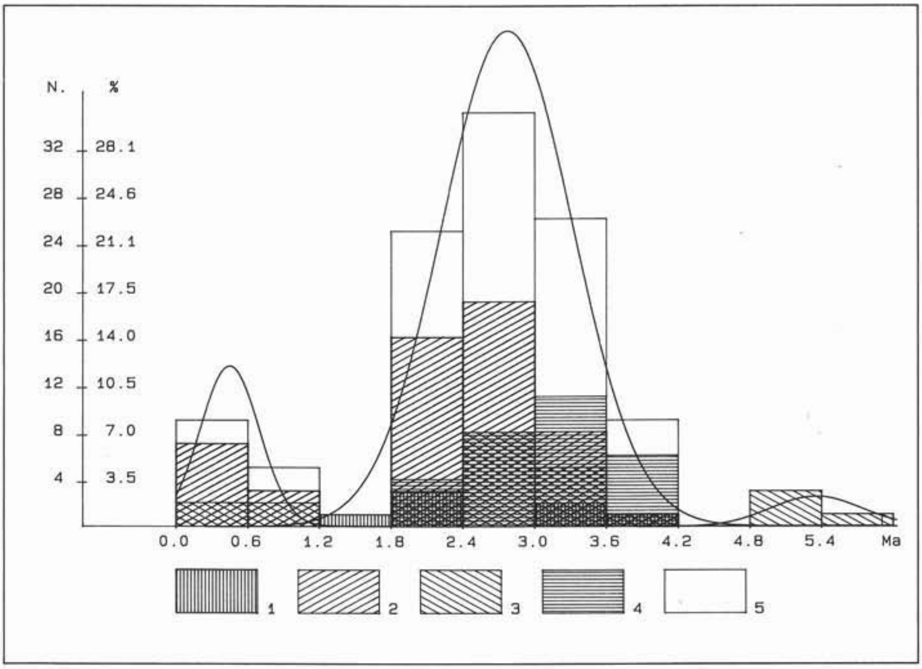

Fig. 2. — Age histogram for Pliocene-Quaternary volcanics from Sardinia (after MACCIOTTA and SAVELLI, 1984, modified). - N = number of data; 1 = strongly alkaline lavas; 2 = alkaline lavas; 3 = middly alkalic and transitional lavas; subalkalic lavas; 5 = all data.

The fission tracks dates for the Monte Arci obsidians are reported in table 3 *b*. Two sets of data are considered, the conventional fission tracks determinations (around 3 Ma) and the ages corrected for fading (around 5 Ma).

The fission track corrected ages fit into the stratigraphic succession but, firstly, they strongly disagree with the K/Ar data, and secondly, they give an excessive age for the beginning of the volcanism, not easily accounted for by field observations.

The data indicate only that the subaerial activity must have occurred in a relatively short time interval comprised between 3.7 and 2.8 Ma.

Montiferro volcanic complex

Montiferro is a volcanic complex of about 400 Km^2 located in central-western Sardinia on the northeast part of the Campidano graben at the intersection with the NE-SW Marghine fault.

The stratigraphy of the complex is detailed in BECCALUVA et al. (1977).

The Authors have made the following distinctions from the basis upwards:

1) An early magmatic activity, represented by analcite basanites lava flows, mainly in the central-western side of the complex.

2) Analcite phonolitic tephrite and tephritic phonolite lava flows outcropping in the western and in the central parts.

3) Lava flows and domes of phonolite trachyte and phonolitic compositions.

4) Basaltic lava flows.

5) Recent trachybasaltic and basanitic lava flows.

K/Ar datings are reported in table 3 *a* and range from 3.9 to 1.6 Ma for the whole sequence in agreement with the stratigraphy.

Basaltic plains

Besides more complex volcanic structures of the Montiferro and the Monte Arci, Pliocene-Pleistocene volcanic activity also built extensive basic lava plains in central-western Sardinia (Planargia, Campeda-Pranu Mannu, Abbasanta-Paulilatino) and in central- southern Sardinia (Nurri, Orroli, Gesturi). Lava plains cover an area of about 1000 Km^2. The basaltic rocks cover a wide petrographic and chemical range: trachybasalts, alkalic and transitional basalts are the most abundant products.

Radiometric ages range, on the whole, from 3.8 to 1.7 Ma.

Orosei-Dorgali volcanic rocks

In central-eastern Sardinia several basaltic lava flows outcrop along a trend approximately following the Orosei Gulf coast. Basaltic rocks, either with alkalic and subalkalic affinity rest on Paleozoic rocks.

Radiometric data for basalts range from 3.9 to 2.1 Ma.

Logudoro eruptive centres

In the Logudoro region (north-west Sardinia) an important Pliocene-Pleistocene volcanic activity took place with products spread widely over an area of about 300 Km^2.

The volcanics rest on Miocene sediments or calcalkaline rocks of the Oligocene-Miocene magmatic cycle. The volcanic vents are mainly aligned along N-S and NE-SW trending faults.

The rocks are mostly alkalic in character, but some transitional and subalkalic ones also exist.

Geochronological data (table 3 *a*) show that the volcanic activity occurred during two distinct phases: the older dated between 2.4 and 1.8 Ma and the younger between 0.9 - <0.15 Ma.

4) Conclusions

On the basis of the geochronological results previously reported, several points appear to be well-established, even if many problems are still unsolved.

1) The older radiometric ages fall in the Ordovician and are relative to acid igneous-derived products (plutonic and volcanic) that can be connected both on stratigraphic age and on petrologic affinity, with the widespread pre-Caradocian calcalkaline metavolcanics of central Sardinia (MEMMI et al., 1983).

The igneous activity coupled with the fairly coeval tectonic activity of the well-known Sardic phase is considered good evidence of a « Caledonian » orogenetic event (BARCA et al., 1983).

2) The main features of the Sardinian crystalline basement were determined by the Hercynian orogeny. It developed during a time span of 30-40 Ma; from about 344 Ma (isotopic closure of banded migmatite, possibly corresponding to the peak of metamorphism) to 310-300 Ma (synchronous closure of different metamorphic minerals together with whole-rock isochron and mineral ages of the main-granitoids). This leads us to assume that the main granitoids emplacement was contemporaneous with the cooling of the metamorphic basement (FERRARA et al., 1978).

3) The uplift and denudation of the basement, which were possibly accompanied by the intrusion of post-tectonic leucogranites, were almost completed at the moment of the emplacement (Upper Carboniferous-Permian) of the post-orogenetic volcanites (FERRARA et al., 1978).

4) During the Tertiary widespread volcanic occurred in two main periods, at 32-11 Ma and 5.3 - <0.15 Ma respectively.

The older volcanism firstly developed between 32 and 26 Ma, and had is climax in the period 23-17 Ma. From about 23-22 Ma the volcanism was characterized by highly explosive ignimbritic products which accompanied the outpouring of calcalkaline lavas until the end of the volcanic cycle (13-11 Ma).

The most recent volcanic cycle took place from the Uppermost Miocene (5.3 Ma) and had its peak activity in the time span 4-2 Ma. After a period of quiescence volcanism resumed in north-western Sardinia at about 0.9 Ma and lasted until <0.15 Ma.

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CALEDONIAN AGES

TABLE 1 *a*
Rb/Sr data on granitic and granodioritic orthogneiss

Rock type	Sample		Rb_{ppm}	Sr_{ppm}	$^{87}Rb/^{86}Sr$	$(^{87}Sr/^{86}Sr)_m$	$(^{87}Sr/^{86}Sr)_i$	Age ± ε	Locality	Ref.
Granod. orthogneiss	101A	WR	156	150	3.00	0.7290			NE Sardinia	1
Granod. orthogneiss	101B	WR	151	201	2.17	0.7241			NE Sardinia	1
Granod. orthogneiss	163	WR	131	177	2.13	0.7214			NE Sardinia	1
Granod. orthogneiss	287	WR	153	154	2.87	0.7284			NE Sardinia	1
Granod. orthogneiss	288	WR	165	139	3.44	0.7301			NE Sardinia	1
Granod. orthogneiss	296	WR	221	148	4.32	0.7363	0.7081 ±0.0012	458 ±31	NE Sardinia	1
Granod. orthogneiss	616	WR	164	204	2.32	0.7233			NE Sardinia	1
Granod. orthogneiss	619	WR	161	135	3.45	0.7288			NE Sardinia	1
Granod. orthogneiss	701	WR	130	179	2.10	0.7201			NE Sardinia	1
Granod. orthogneiss	904	WR	91	212	1.24	0.7163			NE Sardinia	1
Granod. orthogneiss	1075	WR	119	223	1.55	0.7175			NE Sardinia	1
Augen gneiss	285	WR	242	28	25.25	0.8717			NE Sardinia	2
Augen gneiss	286	WR	232	30	22.76	0.8541			NE Sardinia	2
Augen gneiss	289	WR	266	44	17.71	0.8256			NE Sardinia	2
Augen gneiss	290	WR	275	42	19.26	0.8290			NE Sardinia	2
Augen gneiss	294	WR	219	58	10.93	0.7831	0.7113 ±0.0034	441 ±33	NE Sardinia	2
Augen gneiss	295	WR	226	55	12.06	0.7812			NE Sardinia	2
Augen gneiss	319	WR	183	72	7.36	0.7594			NE Sardinia	2
Augen gneiss	331	WR	228	55	12.10	0.7840			NE Sardinia	2
Augen gneiss	615	WR	280	45	18.14	0.8721			NE Sardinia	2
Cataclastic gneiss	KAW1042	WR	257	29.3	24.92	0.8650			Capo Spartivento	3
Cataclastic gneiss	KAW1050	WR	233	52.0	12.73	0.7873			Capo Spartivento	3
Cataclastic gneiss	KAW1051	WR	234	63.1	10.55	0.7755			Capo Spartivento	3
Cataclastic gneiss	KAW1052	WR	215	68.1	8.97	0.7679	0.7122 ±0.0058	427 ±33	Capo Spartivento	3
Cataclastic gneiss	KAW1053	WR	226	55.4	11.58	0.7841			Capo Spartivento	3
Cataclastic gneiss	KAW1054	WR	233	54.8	12.11	0.7864			Capo Spartivento	3
Cataclastic gneiss	KAW1055	WR	245	59.5	11.73	0.7838			Capo Spartivento	3

1 = Di Simplicio et al., 1974; 2 = Ferrara et al., 1978; 3 = Scharbert, 1978. *WR* = Whole rock.

TABLE 1 *b*
K/Ar data on acid metavolcanics

Rock type	Sample		%K	$^{40}Ar_{rad}$ (nl/g)	%$^{40}Ar_{rad}/^{40}Ar_{tot}$	Age ± ε	Locality	Ref.
Porphyroid	S_3C	WR	6.16	62.32	95.21	243 ± 7	Gerrei-Sarcidano	1
Porphyroid	S_2B	WR	5.89	68.12	93.87	275 ± 8	Gerrei-Sarcidano	1
Porphyroid	S_2A	WR	5.62	64.76	87.54	278 ± 8	Gerrei-Sarcidano	1
Porphyroid	S_1B	WR	5.15	62.03	85.22	286 ± 9	Gerrei-Sarcidano	1
Porphyroid	S_6B	WR	6.91	83.47	92.64	287 ± 9	Gerrei-Sarcidano	1
Porphyroid	S_1C	WR	4.92	61.47	90.38	296 ± 9	Gerrei-Sarcidano	1
Porphyroid	S_1A	WR	6.24	78.52	78.52	298 ± 9	Gerrei-Sarcidano	1
Porphyroid	S_2C	WR	6.17	77.68	88.96	298 ± 9	Gerrei-Sarcidano	1
Porphyroid	S_3B	WR	5.35	70.60	95.25	311 ±10	Gerrei-Sarcidano	1
Porphyroid	S_5B	WR	2.95	39.79	85.87	317 ±10	Gerrei-Sarcidano	1
Porphyroid	S_8C	WR	4.24	57.06	86.60	317 ±10	Gerrei-Sarcidano	1
Porphyroid	S_8A	WR	4.52	62.70	81.25	327 ±10	Gerrei-Sarcidano	1
Porphyroid	S_7C	WR	4.65	64.11	89.26	328 ±10	Gerrei-Sarcidano	1
Porphyroid	S_3A	WR	5.57	76.96	95.14	325 ±10	Gerrei-Sarcidano	1
Porphyroid	S_1D	WR	5.68	78.76	95.27	326 ±10	Gerrei-Sarcidano	1
Porphyroid	S_6C	WR	2.50	35.09	71.99	329 ±10	Gerrei-Sarcidano	1
Porphyroid	S_7A	WR	3.74	54.55	88.72	341 ±10	Gerrei-Sarcidano	1
Porphyroid	S_5A	WR	2.66	38.94	88.73	342 ±10	Gerrei-Sarcidano	1
Porphyroid	S_4C	WR	5.79	85.23	93.17	344 ±10	Gerrei-Sarcidano	1
Porphyroid	S_8B	WR	4.27	62.99	80.22	345 ±10	Gerrei-Sarcidano	1
Porphyroid	S_6A	WR	3.64	54.42	88.41	346 ±10	Gerrei-Sarcidano	1
Porphyroid	S_4B	WR	4.66	69.39	84.94	347 ±10	Gerrei-Sarcidano	1
Porphyroid	S_7B	WR	5.29	78.88	93.65	348 ±10	Gerrei-Sarcidano	1
Porphyroid	S_4A	WR	4.59	71.55	93.10	362 ±10	Gerrei-Sarcidano	1
Porphyroid	S_5C	WR	2.11	32.92	73.37	363 ±11	Gerrei-Sarcidano	1

1 = Calderoni et al., 1984. *WR* = Whole rock. (*nl/g*) = nanolitres/gram (0° C - 740 torr).

HERCYNIAN AGES

TABLE 2 *a*
Rb/Sr data on metamorphic rocks

Rock type	Sample		Rb_{ppm}	Sr_{ppm}	$^{87}Rb/^{86}Sr$	$(^{87}Sr/^{86}Sr)_m$	$(^{87}Sr/^{86}Sr)_i$	Age ± ε	Locality	Ref.
Banded migmatite	248A	WR	8.36	423	0.06	0.7139			NE Sardinia	1
Banded migmatite	248B	WR	41	349	0.34	0.7154			NE Sardinia	1
Banded migmatite	248C	WR	142	257	1.60	0.7215			NE Sardinia	1
Banded migmatite	248D	WR	52	356	0.42	0.7156	0.7136 ±0.0001	344 ± 7	NE Sardinia	1
Banded migmatite	248E	WR	115	236	1.41	0.7205			NE Sardinia	1
Banded migmatite	248F	WR	78	289	0.78	0.7174			NE Sardinia	1
Banded migmatite	248E	Pl	3.4	261	0.04	0.7145			NE Sardinia	1
Banded migmatite	248E	Bt	444	5.7	247	1.7608	0.7144 ±0.0001	298 ± 2	NE Sardinia	1
Banded migmatite	248E	WR	115	236	1.41	0.7205			NE Sardinia	1
Granod. orthogneiss	163	Pl	53	229	0.67	0.7152			NE Sardinia	2
Granod. orthogneiss	163	Kf	184	315	1.69	0.7194	0.7122	304	NE Sardinia	2
Granod. orthogneiss	163	Bt	536	2.8	548.69	3.0942			NE Sardinia	2
Granod. orthogneiss	163	WR	131	177	2.13	0.7214			NE Sardinia	2
Granod. orthogneiss	296	Pl	12	57	0.61	0.7223			NE Sardinia	2
Granod. orthogneiss	296	Kf	286	211	3.93	0.7388	0.7195	308	NE Sardinia	2
Granod. orthogneiss	296	Bt	809	10.2	242.30	1.7844			NE Sardinia	2
Granod. orthogneiss	296	WR	221	148	4.32	0.7363			NE Sardinia	2
Augen gneiss	290	Kf	376	71	15.28	0.8158			NE Sardinia	1
Augen gneiss	290	Ms	790	3.96	577	3.2787	0.7473 ±0.0019	306 ± 10	NE Sardinia	1
Augen gneiss	290	Bt	1545	1.13	3962	18.0363			NE Sardinia	1
Augen gneiss	290	WR	275	42	19.26	0.8290			NE Sardinia	1
Cataclastic gneiss	KAW1042	Bt	1373	3.99	977	4.705		284 ± 3.5	Capo Spartivento	3
Cataclastic gneiss	KAW1054	Bt	1010	5.97	482	2.725		290 ± 4	Capo Spartivento	3

1 = Ferrara et al., 1978; 2 = Di Simplicio et al., 1974; 3 = Scharbert, 1978. *Bt* = Biotite; *Kf* = Alkali feldspar; *Ms* = Muscovite; *Pl* = Plagioclase, *WR* = Whole rock.

TABLE 2 *b*
K/Ar data on metamorphic rocks

Rock type	Sample		%K	$^{40}Ar_{rad}$ (nl/g)	$\%^{40}Ar_{rad}/^{40}Ar_{tot}$	Age ± ε	Locality	Ref.
Amphibolite	279	Hb	0.30	3.63	71	287	Golfo Aranci	1
Amphibolite	273	Hb	0.12	1.46	54	289	Golfo Aranci	1
Amphibolite	1236	Hb	0.15	1.64	30	295	Golfo Aranci	1
Amphibolite	275	Hb	0.19	2.47	57	307	Golfo Aranci	1
Amphibolite	278	Hb	0.16	2.10	57	309	Golfo Aranci	1
Amphibolite	281	Hb	0.11	1.33	27	287	Torpè	1
Amphibolite	867	Hb	0.27?	3.29?	69	289?	Torpè	1
Amphibolite	282	Hb	0.21	2.58	66	292	Torpè	1
Amphibolite	280	Hb	0.43	5.29	87	292	Torpè	1
Amphibolite	283	Hb	0.50	6.45	66	305	Torpè	1
Granod. orthogneiss	296	Bt	7.78	94.9	94	289 ± 9	NE Sardinia	2
Granod. orthogneiss	101A	Bt	7.80	95.2	84	289 ± 9	NE Sardinia	2
Granod. orthogneiss	304	Bt	7.90	96.4	93	289 ± 9	NE Sardinia	2
Granod. orthogneiss	163	Bt	7.87	107.	71	319 ±10	NE Sardinia	2
Augen gneiss	294	Bt	4.37	52.4	76	284 ± 9	NE Sardinia	2
Augen gneiss	289	Bt	7.05	90.9	83	304 ± 9	NE Sardinia	2
Augen gneiss	294	Ms	8.83	115.	91	306 ± 9	NE Sardinia	2
Augen gneiss	285	Ms	8.84	118	88	315 ±10	NE Sardinia	2

1 = DI SIMPLICIO et al., 1974; 2 = FERRARA et al., 1978. *Bt* = Biotite; *Hb* = Horneblenda; *Ms* = Muscovite; (*nl/g*) = nanolitres/gram (0° C - 760 torr).

TABLE 2 *c*
Rb/Sr data on plutonic rocks

Rock type	Sample		Rb_{ppm}	Sr_{ppm}	$^{87}Rb/^{86}Sr$	$(^{87}Sr/^{86}Sr)_m$	$(^{87}Sr/^{86}Sr)_i$	Age ± ε	Locality	Ref.
Qzdiorite+granod.	G293	WR	124	201	1.79	0.7174			Ogliastra-Gallura	1
Qzdiorite+granod.	G338	WR	121	220	1.58	0.7165			Ogliastra-Gallura	1
Qzdiorite+granod.	G110	WR	116	231	1.45	0.7161			Ogliastra-Gallura	1
Qzdiorite+granod.	G482	WR	148	49	8.72	0.7478	0.7099 ±0.0006	307 ± 6	Ogliastra-Gallura	1
Qzdiorite+granod.	G485	WR	145	87	4.80	0.7308			Ogliastra-Gallura	1
Qzdiorite+granod.	G486	WR	185	36	14.50	0.7728			Ogliastra-Gallura	1
Qzdiorite+granod.	G484	WR	167	94	5.13	0.7314			Ogliastra-Gallura	1
Qzdiorite+granod.	G483	WR	195	88	6.43	0.7404			Ogliastra-Gallura	1
Monzogranite+granod.	G279	WR	153	91	4.87	0.7296			Ogliastra-Gallura	1
Monzogranite+granod.	G33	WR	198	101	5.65	0.7344			Ogliastra-Gallura	1
Monzogranite+granod.	G23	WR	113	142	2.31	0.7208			Ogliastra-Gallura	1
Monzogranite+granod.	G411	WR	136	131	3.02	0.7231			Ogliastra-Gallura	1
Monzogranite+granod.	G602	WR	192	100	5.57	0.7344			Ogliastra-Gallura	1
Monzogranite+granod.	G452	WR	110	170	1.87	0.7181			Ogliastra-Gallura	1
Monzogranite+granod.	G91	WR	148	186	2.31	0.7200	0.7107 ±0.0008	302 ± 5	Ogliastra-Gallura	1
Monzogranite+granod.	G204	WR	134	264	1.47	0.7169			Ogliastra-Gallura	1
Monzogranite+granod.	G268	WR	110	209	1.52	0.7181			Ogliastra-Gallura	1
Monzogranite+granod.	G495	WR	154	194	2.30	0.7188			Ogliastra-Gallura	1
Monzogranite+granod.	G481	WR	179	31	16.70	0.7870			Ogliastra-Gallura	1
Monzogranite+granod.	G493	WR	229	22	30.59	0.8397			Ogliastra-Gallura	1
Monzogranite+granod.	G492	WR	195	66	8.55	0.7518			Ogliastra-Gallura	1
Leucogranite	G606	WR	158	51	9.01	0.7449			Ogliastra-Gallura	1
Leucogranite	G205	WR	218	49	12.79	0.7611			Ogliastra-Gallura	1
Leucogranite	G270	WR	157	71	6.37	0.7365	0.7085 ±0.0005	289 ± 1	Ogliastra-Gallura	1
Leucogranite	G349	WR	226	45	14.65	0.7683			Ogliastra-Gallura	1
Leucogranite	G2	WR	281	23	34.54	0.8506			Ogliastra-Gallura	1
Leucogranite	G466	WR	578	3	536.60	2.9194			Ogliastra-Gallura	1
Granite	KWA1045	WR	244	20.7	33.43	0.8519			Bivio di Chia	2
Granite	KWA1046	WR	254	19.9	36.24	0.8624			Bivio di Chia	2
Granite	KWA1047	WR	234	27.8	23.95	0.8102			Bivio di Chia	2
Granite	KWA1048	WR	249	21.9	32.21	0.8477	0.7091 ±0.0099	299 ±21	Bivio di Chia	2
Granite	KWA1049	WR	238	27.4	24.70	0.8148			Bivio di Chia	2
Granite	KWA1058	WR	244	23.1	30.00	0.8365			Bivio di Chia	2
Granite	KWA1059	WR	244	11.5	60.11	0.9644			Bivio di Chia	2
Granite	KWA1056	WR	253	51.1	14.1	0.7655			Punta Pineddu	2
Granite	KWA1057	WR	220	84.7	7.41	0.7396			Punta Pineddu	2
Granodiorite	KWA1043	WR	166	117	4.06	0.7289			Capo Spartivento	2
Granodiorite	KWA1044	WR	184	115	4.56	0.7314			Capo Spartivento	2
Granitoid	T156	WR	93.5	216.9	1.247	0.71437			Buddusò	3
Granitoid	T68	WR	126.2	136.2	2.683	0.72072			Buddusò	3
Granitoid	T124	WR	131.7	99.0	3.770	0.72491			Buddusò	3
Granitoid	T273	WR	110.6	67.0	4.790	0.72878			Buddusò	3
Granitoid	T153	WR	172.9	40.3	12.16	0.75798	0.70962±0.00038	281 ± 5	Buddusò	3
Granitoid	T1308	WR	187.9	66.8	7.98	0.74132			Concas	3
Granitoid	T1252	WR	207.5	45.2	13.35	0.76230			Concas	3
Granitoid	T1305	WR	263.0	19.6	38.01	0.86389			Concas	3
Granodiorite	----	WR	92	320	0.81	0.7125			Capo Carbonara	4
Granodiorite	----	Kf	220	322	1.92	0.7174	0.7089	301 ± 3	Capo Carbonara	4
Granodiorite	----	Pl	10	356	0.35	0.7095			Capo Carbonara	4
Qzdiorite+granod.	G122	Bt	424	2.6				305 ± 5	Ogliastra-Gallura	1
Qzdiorite+granod.	G186	Bt	629	2.8				293 ± 5	Ogliastra-Gallura	1
Qzdiorite+granod.	G338	Bt	541	12.5				302 ±11	Ogliastra-Gallura	1
Qzdiorite+granod.	G132	Bt	474	4.6				279 ± 6	Ogliastra-Gallura	1
Monzogranite+granod.	G23	Bt	602	2.2				283 ± 4	Ogliastra-Gallura	1
Monzogranite+granod.	G274	Bt	631	2.2				297 ± 4	Ogliastra-Gallura	1
Monzogranite+granod.	G204	Bt	529	13.9				275 ±12	Ogliastra-Gallura	1
Monzogranite+granod.	G129	Bt	729	5.7				289 ± 6	Ogliastra-Gallura	1
Monzogranite+granod.	G495	Bt	769	3.3				275 ± 4	Ogliastra-Gallura	1
Leucogranite	G205	Bt	890	6.0				295 ± 5	Ogliastra-Gallura	1
Leucogranite	G349	Bt	1247	5.5				298 ± 4	Ogliastra-Gallura	1
Granite	KAW1047	Bt	1082	3.23	951	4.689		293 ± 3.6	Bivio di Chia	2
Granite	KAW1057	Bt	1197	2.60	1309	6.020		284 ± 3	Punta Pineddu	2
Granodiorite	----	Bt	529	6.20				289 ± 7	Capo Carbonara	4

1 = DEL MORO et al., 1975; 2 = SCHARBERT, 1978; 3 = COCHERIE, 1984; 4 = NICOLETTI et al., 1982. *Bt* = Biotite; *Kf* = Alkali feldspar; *Pl* = Plagioclase; *WR* = Whole rock.

TABLE 2 *d*

K/Ar data on plutonic rocks

Rock type	Sample		%K	$^{40}Ar_{rad}$ (nl/g)	%$^{40}Ar_{rad}$/$^{40}Ar_{tot}$	Age ± ε	Locality	Ref.
Diorite	D[illegible]	WR	1.41	16.3	92	275 ± 5	Barbagia	1
Diorite	D[illegible]	WR	1.16	12.0	79	248 ± 6	Barbagia	1
Granitoid	F1	WR	3.94	33.8	92.0	208 ± 6	Ogliastra Barbagia	2
Granitoid	F2	WR	3.95	35.6	91.3	218 ± 7	Ogliastra Barbagia	2
Granitoid	G3	WR	4.00	37.4	88.0	226 ± 7	Ogliastra Barbagia	2
Granitoid	B8	WR	2.97	26.1	87.0	213 ± 6	Ogliastra Barbagia	2
Granitoid	F1	Ms	6.51	75.0	92.0	274 ± 9	Ogliastra Barbagia	2
Granitoid	F2	Ms	6.61	52.1	50.1	192 ± 8	Ogliastra Barbagia	2
Granitoid	G3	Ms	7.26	78.9	92.4	260 ± 8	Ogliastra Barbagia	2
Granitoid	F1	Bt	2.82	26.9	99.6	230 ± 6	Ogliastra Barbagia	2
Granitoid	F2	Bt	3.49	38.5	82.3	264 ± 8	Ogliastra Barbagia	2
Granitoid	G3	Bt	1.70	97.6	55.0	142 ± 8	Ogliastra Barbagia	2
Granitoid	B8	Bt	4.49	44.3	92.0	238 ± 7	Ogliastra Barbagia	2
Granitoid	F1	Kf	10.33	100.0	97.9	233 ± 7	Ogliastra Barbagia	2
Granitoid	F2	Kf	8.46	83.2	94.0	237 ± 7	Ogliastra Barbagia	2
Granitoid	B8	Kf	9.15	88.1	95.2	232 ± 7	Ogliastra Barbagia	2
Qz diorite	g132	Bt	7.85	91.1	91	276 ± 8	Ogliastra Gallura	3
Qz diorite	g122	Bt	7.24	92.0	93	300 ± 9	Ogliastra Gallura	3
Monzogranite	g204	Bt	7.66	85.8	87	267 ± 8	Ogliastra Gallura	3
Leucogranite	g349	Bt	7.31	87.7	83	285 ± 8	Ogliastra Gallura	3
Granodiorite	-----	Kf	11.10	131.4	74.89	281 ± 8	Capo Carbonara	4
Granodiorite	-----	WR	4.38	52.35	77.21	284 ± 8	Capo Carbonara	4
Granodiorite	-----	Bt	7.54	91.30	83.15	287 ± 7	Capo Carbonara	4

1 = COZZUPOLI et al., 1971; 2 = COXZUPOLI et al., 1972; 3 = DEL MORO et al., 1975; 4 = NICOLETTI et al., 1982. *Bt* = Biotite; *Kf* = Alkali feldspar; *Ms* = Muscovite; *WR* = Whole rock; (*nl/g*) = nanolitres/gram (0° C - 760 torr).

TABLE 2 *e*

K/Ar data of post-orogenic volcanites

Rock type	Sample		%K	$^{40}Ar_{rad}$ (nl/g)	%$^{40}Ar_{rad}$/$^{40}Ar_{tot}$	Age ± ε	Locality	Ref.
Subvolcanic qzlatite	Q[illegible]	WR	2.32	25.0	85	258 ± 5	Barbagia	1
Subvolcanic qzlatite	Q[illegible]	WR	2.08	18.2	76	213 ± 5	Barbagia	1
Rhyolitic ignimbrite	15[illegible]	WR	3.57	40.8	99	273 ± 5	Barbagia	1
Rhyolitic ignimbrite	7[illegible]	WR	4.07	42.3	99	250 ± 5	Barbagia	1
Rhyolitic ignimbrite	A[illegible]	WR	3.74	39.8	99	255 ± 5	Barbagia	1
Rhyolitic lava	C[illegible]	WR	3.40	37.0	64	260 ± 8	Barbagia	1
Rhyolitic lava	M[illegible]	WR	3.40	35.5	81	250 ± 6	Barbagia	1
Rhyolitic lava	M[illegible]	WR	4.48	42.7	99	230 ± 5	Barbagia	1
Rhyolitic lava	T[illegible]	WR	3.47	32.2	94	223 ± 4	Barbagia	1
Alkalirhyolite	S[illegible]	WR	6.10	50.6	97	202 ± 6	Nurra	2
Alkalirhyolite	S[illegible]	WR	8.57	71.0	98	201 ± 6	Nurra	2
Alkalirhyolite	S[illegible]	WR	6.57	56.7	97	209 ± 6	Nurra	2
Pyroclastics	B5	WR	3.96	39.5	88.9	240 ± 7	Barbagia	2
Rhyolitc ignimbrite	B6	WR	4.10	39.0	98.0	230 ± 5	Barbagia	2
Rhyolitic ignimbrite	OR16	WR	4.53	48.1	97.1	254 ± 5	Baunei	2
Rhyolitic ignimbrite	T15	WR	3.72	35.1	91.5	228 ± 7	Tertenia	2
Quartz-latitic lava	A1	WR	3.12	29.0	92.9	225 ± 5	Perdasdefogu	2
Quartz-latitic lava	A3	WR	3.02	27.9	90.5	223 ± 6	Perdasdefogu	2
Latitic lava	E1	WR	3.25	27.0	85.0	202 ± 7	Gerrei	2
Latitic lava	E[illegible]190	WR	2.33	23.1	98.0	239 ± 5	Gerrei	2
Rhyodacitic lava	P20	WR	3.10	36.3	84.0	279 ± 5	Sulcis	2
Rhyodacitic lava	P46	WR	3.31	30.3	82.0	221 ± 6	Sulcis	2
Ignimbrite	104	Bt	5.02	64.35	93	303 ± 9	Nurra	3
Ignimbrite	149	Fs	5.53	57.58	95	249 ± 9	Nurra	3
Ignimbrite	149	Bt	6.90	88.20	95	302 ± 8	Nurra	3
Ignimbrite	1	WR	4.07	41.87	97	247 ± 7	Gallura	3
Ignimbrite	2	Fs	4.03	35.15	96	211 ± 6	Gallura	3
Ignimbrite	2	Fs	5.40	50.39	87	226 ± 6	Gallura	3
Ignimbrite	3	Fs+Q	3.18	34.32	97	258 ± 7	Gallura	3
Ignimbrite	4	Fs+Q	4.65	52.07	95	267 ± 7	Gallura	3
Ignimbrite	4	Q+Fs	0.17	1.819	76	262 ± 9	Gallura	3
Ignimbrite	5	FsQz	3.82	39.72	90	249 ± 7	Gallura	3
"	5	FsQz	3.64	39.61	96	260 ± 9	"	"
Andesite	76	Pl	0.465	5.169	89	266 ± 8	Escalaplano	3
Andesite	76	Bt	6.13	78.25	87	301 ± 8	Escalaplano	3
Ignimbrite	88	Pl	0.880	9.755	83	265 ± 7	Seui-Seulo	3
Ignimbrite	164	Fs	2.04	22.82	91	267 ± 8	Seui-Seulo	3
Ignimbrite	151	Pl	0.722	8.746	86	287 ±10	Baunei	3
Ignimbrite	153	Pl	0.498	6.256	69	297 ±11	Baunei	3
Ignimbrite	153	ClBt	1.71	9.692	47	140 ± 5	Baunei	3
Ignimbrite	154	FsQz	2.09	26.16	90	296 ± 9	Baunei	3
Ignimbrite	155nm	FsQz	1.19	13.32	87	268 ± 8	Talana	3
Ignimbrite	155m	FsQz	1.50	16.59	93	264 ± 8	Talana	3
Ignimbrite	155	BtCl	2.15	28.0	84	307 ± 8	Talana	3
Ignimbrite	158	Pl	0.311	3.770	61	287 ±10	Talana	3
Ignimbrite	159	Pl	0.336	4.496	61	315 ±11	Talana	3
Ignimbrite	160	Pl	1.85	16.46	86	215 ± 8	Monte Ferru	3
Ignimbrite	161	FsQz	2.46	26.49	92	258 ± 8	Monte Ferru	3
Ignimbrite	2/1	WR	4.33	47.02	88.5	260 ± 8	Galtelli	4
Ignimbrite	2/2	WR	4.26	50.56	92.6	282 ± 9	Galtelli	4
Ignimbrite	2/3	WR	4.47	46.57	95.4	250 ± 8	Galtelli	4
Ignimbrite	3/1	WR	4.21	46.14	93.1	262 ± 8	Galtelli	4
Ignimbrite	3/2	WR	4.45	44.49	81.1	240 ± 8	Galtelli	4
Ignimbrite	3/3	WR	4.13?	42.67?	91.8	248?± 8	Galtelli	4
Ignimbrite	7/1	WR	3.69	38.76	80.3	252 ± 8	Galtelli	4
Ignimbrite	7/2	WR	3.49	42.63	94.5	290 ± 9	Galtelli	4
Ignimbrite	7/3	WR	3.51	40.02	89.7	272 ± 8	Galtelli	4
Ignimbrite	10/1	WR	3.88	35.39	84.2	221 ± 7	Galtelli	4

TABLE 2e(continued)

Rock type	Sample		%K	$^{40}Ar_{rad}$ (nl/g)	%$^{40}Ar_{rad}$/$^{40}Ar_{tot}$	Age ± ε	Locality	Ref.
Ignimbrite	10/2	WR	4.08	43.50	86.8	255 ± 8	Galtelli	4
Ignimbrite	10/3	WR	3.79	35.77	88.8	228 ± 7	Galtelli	4
Ignimbrite	11/1	WR	3.69	45.03	90.8	290 ± 9	Galtelli	4
Ignimbrite	11/2	WR	4.09	45.80	91.6	267 ± 8	Galtelli	4
Ignimbrite	11/3	WR	3.64	42.02	91.3	275 ± 8	Galtelli	4

1 = COZZUPOLI et al., 1971; 2 = LOMBARDI et al., 1974; 3 = EDEL et al., 1981; 4 = COZZUPOLI et al., 1984. *Bt* = Biotite; *Cl* = Chlorite; *Fs* = Feldspars; *Ms* = Muscovite; *Pl* = Plagioclase; *Qz* = Quartz; *WR* = Whole rock; *(nl/g)* = nanolitres/gram (0° C - 760 torr).

ALPINE AGES

TABLE 3 *a*

K/Ar data on Cainozoic volcanics

PLIOCENE-PLEISTOCENE VOLCANISM

Rock type	Sample		%K	$^{40}Ar_{rad}$ (nl/g)	%$^{40}Ar_{rad}$/$^{40}Ar_{tot}$	Age ± ε	Locality	Ref.
Strongly alkaline lavas								
Basanite	LL10	WR	1.29	0.103	61.6	2.08 ± 0.08	Logudoro	8
Basanite	LL74	WR	1.28	0.118	64.5	2.31 ± 0.09	Logudoro	8
Basanite	371	WR	0.58	0.0488	22.9	2.16 ± 0.2	Logudoro	5
"	"	"	"	0.0535	26.8	2.37 ± 0.2	"	"
"	"	"	"	0.0555	21.9	2.45 ± 0.2	"	"
Basanite	A196	WR	1.57	0.165	39.3	2.7 ± 0.2	Montiferro	2
Basanite	LL56B	Bt	5.40	0.660	21.0	3.06 ± 0.19	Logudoro	8
Analc. teph. phonolite	BL3	WR	4.48	0.567	79.0	3.3 ± 0.2	Montiferro	2
Alkaline lavas								
Trachybasalt	A456	WR	2.22	0.010	13.8	0.11 ± 0.02	Logudoro	8
Trachybasalt	LL85	WR	2.16	<0.011	--	<0.12	Logudoro	8
Trachybasalt	SB1	WR	2.35	0.013	1.8	0.14 ± 0.10	Logudoro	2
Trachybasalt	LL78	WR	2.44	0.037	44.6	0.38 ± 0.04	Logudoro	8
Trachybasalt	A430	WR	2.08	0.031	12.9	0.4 ± 0.2	Logudoro	2
Trachybasalt	A400	WR	2.34	0.045	14.6	0.45 ± 0.09	Logudoro	8
Trachybasalt	A404	WR	2.29	0.052	25.5	0.55 ± 0.06	Logudoro	8
Alk. basalt	SB2	WR	1.81	0.045	6.1	0.6 ± 0.1	Logudoro	2
Trachybasalt	A460	WR	2.27	0.055	3.7	0.6 ± 0.3	Logudoro	8
Trachybasalt	LL92	WR	2.42	0.066	16.9	0.68 ± 0.07	Logudoro	8
Hawaiite	A459	WR	1.68	0.121	61.3	1.9 ± 0.1	Logudoro	2
Hawaiite	LL60	WR	1.50	0.116	53.0	1.93 ± 0.08	Logudoro	8
Hawaiite	A1117	WR	1.29	0.105	44.0	2.01 ± 0.08	Logudoro	8
Trachybasalt	A441	WR	2.61	0.213	75.2	2.02 ± 0.08	Campeda	8
Alk. basalt	----	WR	1.39	0.110	19.0	2.04 ± 0.08	Orosei-Dorgali	12
Alk. basalt	----	WR	1.46	0.123	9.2	2.16 ± 0.15	Orosei-Dorgali	12
Hawaiite	A412	WR	0.82	0.073	48.9	2.3 ± 0.1	Logudoro	2
Trachybasalt	V91	WR	3.00	0.272	24.3	2.3 ± 0.2	Montiferro	2
Alk. basalt	----	WR	1.71	0.153	18.9	2.30 ± 0.08	Orosei-Dorgali	12
" "	"	WR	"	0.154	22.1	2.31 ± 0.08	" "	"
Trachybasalt	SB5	WR	2.59	0.243	41.0	2.4 ± 0.2	Logudoro	2
Trachybasalt	LL66	WR	2.54	0.244	25.0	2.41 ± 0.12	Logudoro	8
Alk. basalt	LL117	WR	1.67	0.166	27.0	2.49 ± 0.12	Campeda	8
Trachybasalt	MOT4	WR	2.10	0.21	73.9	2.5 ± 0.1	Montiferro	1
Alk. basalt	----	WR	1.62	0.165	9.4	2.61 ± 0.17	Baunei	12
Alk. basalt	----	WR	1.53	0.155	17.5	2.61 ± 0.11	Orosei-Dorgali	12
Trachybasalt	LL98	WR	3.32	0.348	75.0	2.63 ± 0.11	Campeda	8
Phonolite	100	WR	6.16	0.6728	22.00	2.81 ± 0.1	Montiferro	5
"	"	"	"	0.6826	42.80	2.85 ± 0.1	"	"
Trachybasalt	LL99	WR	2.48	0.283	64.9	2.85 ± 0.11	Campeda	8
Alk. basalt	----	WR	1.73	0.195	17.4	2.90 ± 0.12	Orosei-Dorgali	12
Trachybasalt	LL36	WR	2.34	0.272	37.5	2.91 ± 0.12	Logudoro	8
Trachybasalt	LUG6	WR	2.43	0.28	68.7	2.98 ± 0.10	Logudoro	1
Trachybasalt	20F	WR	2.63	0.302	76.8	3.0 ± 0.1	Montiferro	2
Trachybasalt	MOT1	WR	2.57	0.30	57.6	3.01 ± 0.09	Montiferro	1
Alk. basalt	MOT5	WR	1.43	0.17	82.2	3.1 ± 0.2	Montiferro	1
Basalt	----	WR	1.44	0.173	10.4	3.10 ± 0.19	Canyon Orosei	12
Basalt	16	Pl	0.344	0.0418	20.2	3.12 ± 0.19	Sinis	9
Trachybasalt	LUG7	WR	2.73	0.34	34.2	3.18 ± 0.06	Logudoro	1
Basalt	----	WR	1.98	0.268	6.9	3.48 ± 0.32	Canyon Orosei	12
"	"	"	"	0.272	8.6	3.52 ± 0.28	" "	"
Alk. basalt	A244	WR	3.04	0.450	72.0	3.8 ±, 0.2	Montiferro	2
Mildly alkaline & transitional lavas								
Mildly alk. basalt	A1114	WR	1.93	<0.026	--	<0.29	Logudoro	8
Mildly alk. basalt	LL17	WR	0.81	<0.011	--	<0.31	Logudoro	8
Mildly alk. basalt	A1113	WR	1.49	0.051	40.7	0.78 ± 0.04	Logudoro	8
Mildly alk. basalt	A408	WR	1.54	0.056	3.1	0.9 ± 0.4	Logudoro	8
Tristanite	LUG3	WR	3.86	0.28	77.3	1.85 ± 0.08	Logudoro	1
Trans. basalt	A240	WR	0.77	0.082	25.9	2.7 ± 0.2	Montiferro	2
Alkalitrachyte	MMR119	Kf	6.42	0.668	37	2.7 ± 0.15	Monte Arci	6
Mildly alk. basalt	----	WR	1.67	0.184	5.7	2.84 ± 0.3	Orosei-Dorgali	12
Mildly alk. basalt	B403	WR	1.98	0.225	29.3	2.9 ± 0.2	Montiferro	2
Trachybasalt	SS-15	WR	1.55	0.178	34.9	2.95 ± 0.10	Dualchi	**
Mildly alk. basalt	LL102	WR	1.57	0.180	84.0	3.00 ± 0.12	Campeda	8
Trans. basalt	----	WR	1.41	0.168	17.0	3.06 ± 0.14	Orosei-Dorgali	12
" "	"	"	"	0.171	16.6	3.12 ± 0.14	" "	"
Trans. basalt	AR3	WR	1.15	0.15	59.6	3.30 ± 0.09	Monte Arci	1
Trans. basalt	AR1	WR	1.00	0.13	48.0	3.39 ± 0.08	Monte Arci	1
Trans. basalt	----	WR	1.81	0.257	9.6	3.66 ± 0.23	Orosei-Dorgali	12
" "	"	"	"	0.257	11.2	3.66 ± 0.21	" "	"
Trachybasalt	CF2	WR	2.45	0.478	27.3	5.0 ± 0.2	Capo Ferrato	2
Trachyte	CF10	WR	4.13	0.840	75.8	5.2 ± 0.2	Capo Ferrato	2
Trachybasalt	SS-260	Fs	0.467	0.0967	21.5	5.32 ± 0.18	Capo Ferrato	**
Latite	SS-259	Fs	3.44	0.785	65.4	5.87 ± 0.17	Monte Ferru	**
"	"	"	"	0.790	76.7	5.90 ± 0.17	"	"
Subalkaline lavas								
Sub. basalt	1524	WR	0.83	0.0802	12.16	2.48 ± 0.2	Campeda	5
Sub. Basalt	SS-246	WR	0.860	0.0866	12.3	2.59 ± 0.11	Giara di Gesturi	**
" "	"	"	"	0.0862	7.92	2.67 ± 0.2	"	"
Sub. Basalt	SS-213	WR	1.06	0.100	12.4	2.67 ± 0.12	Bosco di Burgos	**
Sub. bas. andesite	LL119	WR	0.67	0.077	18.9	2.85 ± 0.20	Campeda	8
Sub. bas. andesite	A439	WR	0.95	0.110	28.0	2.86 ± 0.14	Campeda	8
Dacite	MC4	WR	3.43	0.381	40.2	2.9 ± 0.2	Conca de Mesu	2
Sub. bas. andesite	A466	WR	0.89	0.108	8.4	3.1 ± 0.5	Campeda	8
Sub. basalt	39F	WR	1.02	0.123	13.8	3.1 ± 0.2	Montiferro	2
Dacite	MMR68	WR	3.02	0.374	16	3.2 ± 0.15	Monte Arci	6
Sub. basalt	AR4	WR	0.93	0.12	60.3	3.29 ± 0.09	Monte Arci	1
Sub. basalt	MMR130	WR	0.75	0.098	27	3.3 ± 0.2	Monte Arci	6
Rhyolite	MMR53	WR	4.49	0.584	66	3.34 ± 0.2	Monte Arci	6

TABLE 3 *a* (*continued*)

Rock type	Sample		%K	$^{40}Ar_{rad}$ (nl/g)	$\%^{40}Ar_{rad}/^{40}Ar_{tot}$	Age ± σ	Locality	Ref.
PLIOCENE-PLEISTOCENE VOLCANISM								
Sub. basalt	AR5	WR	0.76	0.10	76.8	3.36 ± 0.15	Monte Arci	1
Rhyolite	MMR61	WR	4.65	0.618	69	3.4 ± 0.2	Monte Arci	6
Sub. basalt	SB3	WR	1.14	0.151	9.0	3.4 ± 0.3	Montiferro	2
Sub. basalt	SB4	WR	0.71	0.095	9.2	3.4 ± 0.3	Montiferro	2
Sub. basalt	MMR26	WR	0.85	0.122	9	3.7 ± 0.3	Montiferro	6
Sub. basalt	MMR31	WR	1.06	0.154	31	3.7 ± 0.2	Monte Arci	6
Sub. basalt	MMR34	WR	0.44	0.065	6.5	3.8 ± 0.4	Marmilla	6
Sub. basalt	SE11	WR	0.95	0.140	10.8	3.8 ± 0.24	Marmilla	10
" "	"	"	"	0.145	10.4	3.9 ± 0.24	"	"
OLIGOCENE-MIOCENE VOLCANISM								
Calcalkaline ignimbrites								
Ignimbrite	SS-256	Fs	6.89	3.119	83.8	11.6 ± 0.3	Monte Narcao	**
"	"	"	"	3.202	91.0	11.9 ± 0.3	" "	"
Rhyolite	2	WR	4.13	2.4419	43.68	15.1 ± 0.5	Gallura	4
Rhyodacitic ignimbrite	1473	WR	3.32	2.1014	65.26	16.21 ± 1.0	Monte Ruzzunis	5
Rhyolitc pumice	B6	WR	3.46	2.2489	47.23	16.64 ± 0.2	Monte Traessu	5
" "	"	"	"	2.2707	49.91	16.80 ± 0.2	"	"
Rhyolite	12	WR	3.66	2.4090	66.63	16.9 ± 0.5	Gallura	4
Rhyod. ignimbrite	1450	WR	3.28	2.2159	81.47	17.31 ± 0.4	Punta Tribides	5
" "	"	"	"	2.2617	81.53	17.66 ± 0.4	" "	"
Rhyolite	19	WR	4.11	2.8031	60.23	17.5 ± 0.5	Gallura	4
Rhyolitic ignimbrite	G4635	WR	4.01	2.89	66.9	18.5 ± 0.7	Montiferro	11
Rhyolitic ignimbrite	CB133	WR	3.27	2.39	46.6	18.7 ± 0.7	Logudoro	11
Upper ignimbrite	133	Bt	6.525	4.88	46.0	19.1 ± 0.5	Banari	9
Upper ignimbrite	145	Bt	1.004	0.743	70.5	18.9 ± 0.5	Castelsardo	9
" "	"	"	1.004	0.755	67.5	19.2 ± 0.5	"	"
" "	"	"	1.014	0.781	62.6	19.7 ± 0.5	"	"
Upper ignimbrite	143	Pl	1.038	0.782	40.1	19.3 ± 0.5	Castelsardo	9
Upper ignimbrite	146	Pl	1.004	0.754	69.9	19.2 ± 0.5	Castelsardo	9
" "	"	Pl	1.021	0.776	70.6	19.5 ± 0.5	"	"
Upper ignimbrite	97	Pl	0.971	0.745	75.5	19.6 ± 0.5	Banari	9
Upper ignimbrite	148	Pl	0.508	0.391	53.4	19.7 ± 0.5	Banari	9
Tuffs	134	Bt	6.71	5.20	83.0	19.9 ± 0.5	Romana	9
Dacitic ignimbrite	MC36	WR	3.71	2.9	70.3	20.0 ± 0.8	Marghine	11
Hi-K dacitic ignimbrite	SS-200	Gs	3.69	2.942	61.7	20.3 ± 0.6	Castelsardo	**
Ignimbrite	2	Pl	0.490	0.399	57.0	20.9 ± 0.7	Castelsardo	9
Lower ignimbrite	103	Bt	6.516	5.39	80.0	21.2 ± 0.5	Ittiri	9
Ignimbrite	1	Pl	0.506	0.419	50.0	21.2 ± 0.7	Castelsardo	9
Hi-K Dacitic ignimbrite	SS-204	Gs	4.01	3.351	85.9	21.4 ± 0.6	Castelsardo	**
" " "	"	WR	3.64	3.072	65.2	21.6 ± 0.6	"	"
Ignimbrite	8	Pl	0.481	0.410	21.4	21.7 ± 0.9	Castelsardo	9
Hi-K dacitic ignimbrite	SS-206	Gs	3.24	2.850	38.4	22.5 ± 0.7	Capo Marargiu	**
Lower ignimbrite	112	Pl	0.351	0.318	47.0	23.2 ± 0.8	Capo Maragiu	9
Calcalkaline lavas								
Andesite	11	WR	1.48	0.7572	34.74	13.14 ± 0.2	Monte Larenta	5
"	"	"	"	0.7764	32.11	13.47 ± 0.2	" "	"
Dacite	920	WR	2.71	1.3789	25.09	13.06 ± 0.8	Monte Maggiore	5
"	"	"	"	1.5117	24.77	14.32 ± 0.8	" "	"
Andesite	GG2	WR	1.10	0.60	32.8	14.0 ± 0.6	Cixerri	11
Dacite	30	WR	2.39	1.3204	84.36	14.15 ± 0.2	Monte Mundigu	5
"	"	"	"	1.3542	84.11	14.52 ± 0.2	"	"
Andesite	AS137	WR	1.5	0.85	40.4	14.5 ± 0.6	Paulilatino	11
Basalt	MMR114	WR	1.447	0.9687	23	15.17 ± 0.7	Monte Arci	6
Basalt	MMR108	WR	1.02	0.646	25	16.2 ± 0.8	Monte Arci	6
Dacite	940	WR	2.11	1.3965	51.76	16.96 ± 0.2	Monte Tilomoro	5
"	"	"	"	1.4392	39.48	17.48 ± 0.2	" "	5
Dacite	795	WR	3.07	2.0787	62.94	17.33 ± 0.2	Monte Frusciu	5
"	"	"	"	2.1074	60.65	17.57 ± 0.2	" "	"
Andesite	1129	WR	1.59	1.0544	29.14	17.03 ± 0.5	Monte Pedru	5
"	"	"	"	1.1193	29.84	18.07 ± 0.5	" "	"
Terminal andesite	132	Pl	0.268	0.1787	21.6	17.1 ± 0.8	Romana	9
" "	"	"	0.303	0.2145	4.6	18.1 ± 1.1	"	"
Andesite	AS138	WR	1.22	0.84	61.0	17.6 ± 0.7	Paulilatino	11
Andesite	38	WR	2.34	----	79.6	17.7 ± 0.8	Sorso	3
Andesitic flow	SS-226	WR	0.946	0.6553	14.5	17.7 ± 0.8	Monte Arcuentu	**
Upper andesite	26	Pl	0.291	0.2045	35.3	18.0 ± 0.8	Padria	9
Andesite	SS-217	WR	1.16	0.862	39.4	18.0 ± 0.5	Monte Funesu	**
Andesitic flow	SS242	Pl	0.275	0.182	15.1	17.0 ± 0.7	Monte Perdoso	**
" "	"	Gn	1.320	0.985	34.2	19.1 ± 0.6	" "	"
Andesitic dome	SS-257	WR	1.69	1.17	36.6	17.8 ± 0.5	Siba	**
" "	"	Fs	0.351	0.258	27.5	18.8 ± 0.9	"	"
Andesite	AL1	WR	3.11	1.89	53.6	18.4 ± 0.7	Anglona	11
Lower andesite	23	WR	1.079	0.763	72.1	18.1 ± 0.5	Montresta	9
" "	"	Pl	0.293	0.2182	27.4	19.1 ± 0.9	"	"
Andesitic flow	SS-229	Fs	2.03	1.43	12.4	10.0 ± 0.8	Nurecci	**
" "	"	WR	0.943	0.702	35.9	19.1 ± 0.6	"	"
Basalt	A714	WR	0.81	0.59	34.1	18.6 ± 0.7	Marmilla	11
Upper andesite	27	Pl	0.299	0.2187	40.9	18.7 ± 0.7	Padria	9
Andesite	69	Pl	0.210	0.1563	30.0	19.0 ± 0.7	Perdaxius	9
Andesite	41	WR	1.47	----	28.3	19.3 ± 1.0	Chiaramonti	3
Andesitic flow	SS-230	WR	1.220	0.918	50.5	19.3 ± 0.6	Padru Atzei	**
Upper andesite	30	Pl	0.245	0.1853	30.4	19.4 ± 0.7	Bosa	9
Basalt	AR2b	WR	1.00	0.76	47.3	19.4 ± 0.8	Arcuentu	11
Andesite	39	WR	1.88	----	61.1	19.4 ± 1.0	Sorso	3
Andesite	GG1	WR	0.95	0.72	44.6	19.5 ± 0.8	Cixerri	11
Andesite	1444	WR	0.75	0.5698	68.24	19.52 ± 0.2	Punta Tribides	5
"	"	"	"	0.5707	97.80	19.55 ± 0.2	" "	"
Andesite	SE10	WR	0.27	0.202	11.5	19.2 ± 1.3	Marmilla	10
"	"	"	"	0.210	15.2	19.9 ± 1.1	"	"
Andesite	GG3	WR	1.32	1.01	32.8	19.6 ± 0.8	Cixerri	11
Andesitic flow	SS-243	WR	1.07	0.824	15.2	19.7 ± 0.8	Monte Pedroso	**
Lower andesite	24	Pl	0.191	0.1397	32.3	18.7 ± 0.7	Montresta	9
" "	"	Pl	0.056	0.0460	5.9	21.2 ± 1.6	"	"
Andesite	116'	Pl	0.730	0.593	67.5	20.8 ± 0.7	Osilo	9
Andesite	1862	WR	1.19	1.0168	53.30	21.91 ± 1.0	Capo Marargiu	5
"	"	"	"	0.9596	75.24	20.68 ± 1.0	" "	"
Andesite	1453	WR	1.16	0.9588	69.49	21.10 ± 0.6	Capo Marargiu	5
"	"	"	"	0.9967	67.81	21.93 ± 0.6	" "	"
Andesite	5	Pl	0.531	0.449	60.2	21.6 ± 0.8	Castelsardo	9
Andesite	SE8	WR	0.69	0.584	34.9	21.6 ± 0.9	Marmilla	10
"	"	"	0.70	0.613	39.1	22.4 ± 1	"	"
Andesite	7h	WR	2.01	1.74	42.4	22.2 ± 0.9	Sarroch	11
Andesite	GG4	WR	0.84	0.73	42.5	22.3 ± 0.9	Cixerri	11
Andesite	MOS7	WR	1.02	0.93	72.0	23.3 ± 0.9	Monastir	11
Andesite	11	Pl	0.299	0.275	18.5	23.5 ± 0.9	Castelsardo	9
Andesite	SM4	WR	0.46	0.42	44.3	23.5 ± 0.9	Luri	11
Andesite	75	Hb	0.359	0.329	50.8	23.4 ± 0.8	Perdaxius	9
"	"	"	0.359	0.335	36.3	23.8 ± 0.9	"	"
Basalt	1864	WR	0.65	0.5994	50.25	23.66 ± 1.0	Capo Marargiu	5
Lower andesite	98	Pl	0.021	0.0208	5.36	25.6 ± 4.1	Banari	9
" "	"	Pl	0.830	0.0712	10.54	21.9 ± 1.7	"	"
Andesite	2g	WR	0.67	0.65	22.2	24.7 ± 1.0	Sarroch	11
Lower andesite	29	WR	0.65	----	50.2	24.4 ± 1.2	Capo Marargiu	3
Lower andesite	131	Pl	0.064	0.0624	15.4	24.9 ± 2.0	Banari	9
Andesite	MOS5	WR	0.92	0.92	55.7	25.5 ± 1.0	Monastir	11

TABLE 3 a (continued)

Rock type	Sample		%K	$^{40}Ar_{rad}$ (nl/g)	$\%^{40}Ar_{rad}/^{40}Ar_{tot}$	Age ± σ	Locality	Ref.
OLIGOCENE-MIOCENE VOLCANISM								
Microdiorite	3	WR	1.18	1.320	54.5	28.6 ± 1.5	Alghero	7
"	"	"	1.18	1.273	77.1	27.6 ± 1.5	"	"
Andesite	SE1	WR	1.71	1.893	54.9	28.3 ± 1	Cixerri	10
Andesite	SE5	Fm	2.43	2.710	38.4	28.4 ± 1	Cixerri	10
Dacitic dome	02215	Fs	0.561	0.664	41.7	30.2 ± 0.9	Acquafredda	**
Andesite	147	Pl	0.274	0.335	55.2	31.2 ± 1.1	Osilo	9
Andesite	71	Hb	0.511	0.643	63.0	32.1 ± 0.9	Siliqua	9
Porphyrite	106	Pl	0.179	0.227	20.0	32.3 ± 1.5	Valverde	9

1 = BECCALUVA et al., 1983; 2 = BECCALUVA et al., 1976-77; 3 = BELLON, 1976; 4 = BROTZU et al., 1975; 5 = COULON et al., 1971; 6 = DI PAOLA et al., 1975; 7 = GIRAUD et al., 1979; 8 = MACCIOTTA and SAVELLI, 1984; 9 = MONTIGNY et al., 1981; 10 = SAVELLI, 1975; 11 = SAVELLI et al., 1979; 12 = SAVELLI and PASINI, 1973; ** = CIVETTA, Unpublished data; *Bt* = Biotite; *Fm* = Femic fraction; *Fs* = Feldspars; *Gn* = Groundmass; *Gs* = Glass; *Hb* = Hornblende, *Kf* = Alkali feldspar; *Pl* = Plagioclase; *WR* = Whole rock; (*nl/g*) = nanolitres/gram (0° C - 760 torr).

TABLE 3 *b*

Fission track data on Monte Arci volcanics

Rock type		$T_A \pm \varepsilon$	$T_R \pm \varepsilon$	$T_P \pm \varepsilon$	Locality	Ref.
Obsidian	4A$_I$	2.93 ± 0.17	5.14 ± 0.51	---	Uras quarry	1
Obsidian	4A$_{II}$	2.88 ± 0.13	5.05 ± 0.50	4.59 ± 0.28	Uras quarry	1
Obsidian	5B$_I$	3.19 ± 0.16	5.15 ± 0.52	5.14 ± 0.38	Uras quarry	1
Obsidian	5B$_{II}$	3.11 ± 0.14	4.44 ± 0.38	4.77 ± 0.34	Uras quarry	1
Obsidian	8B	3.61 ± 0.15	5.92 ± 0.53	5.27 ± 0.27	Uras quarry	1
Perlite	9	2.73 ± 0.29	4.96 ± 0.69	5.30 ± 0.90	Uras quarry	1
Obsidian	13A	3.51 ± 0.22	5.57 ± 0.53	5.29 ± 0.35	Pira inferta	1
Obsidian	14A	3.16 ± 0.21	5.18 ± 0.88	---	Pira inferta	1
Obsidian	16A	3.38 ± 0.22	5.37 ± 0.59	---	Perdas Urias quarry	1
Obsidian	16B	3.22 ± 0.20	5.15 ± 0.40	---	Perdas Urias quarry	1

1 = BIGAZZI et al., 1976. T_A = Apparent age; T_R = True age (size method); T_P = True age (plateau method).

REFERENCES

ALVAREZ W. (1972) - *Rotation of the Corsica-Sardinia microplate.* Nature, 235, 103-105.

ASSORGIA A., BECCALUVA L., DERIU M., DI BATTISTINI G., GALLO F., MACCIOTTA G., PINGANI L., VENTURELLI G., VERNIA L., ZERBI M. (1981) - *Carta geopetrografica del complesso vulcanico del Montiferro (Sardegna centro-occidentale).* Grafiche STEP, Parma.

ASSORGIA A., BECCALUVA L., DI PAOLA G.M., MACCIONI L., MACCIOTTA G., PUXEDDU M., SANTACROCE R., VENTURELLI G. (1976) - *Il complesso vulcanico di Monte Arci (Sardegna centro-occidentale). Nota illustrativa alla carta geopetrografica 1:50.000.* Boll. Soc. Geol. It., 95, 371-401.

ASSORGIA A., MACCIONI L., MACCIOTTA G., SAVELLI C. (1983) - *Geopetrographic map of the Pliocene volcanism of Central-Southern Sardinia.* S.EL.CA., Firenze.

BARCA S., CARMIGNANI L., FRANCESCHELLI M., GHEZZO C., MEMMI I., MINZONI N., PERTUSATI P.C., RICCI C.A. (1984) - *The Caledonian events in Sardinia.* In: « The Caledonian orogen ». Gee and Sturt ed., Wiley and Sons Ltd.

BECCALUVA L., CAMPREDON R., FERAUD G., MACCIOTTA G. (1983) - *Etude des relations entre volcanisme plio-quaternaire et tectonique en Sardaigne à l'aide de l'analyse structurale des dykes.* Bull. Volcanol., 46, 365-379.

BECCALUVA L., DERIU M., MACCIOTTA G. (1980) - *Riflessioni sul significato del vulcanismo oligo-miocenico della Sardegna nell'ambito dell'evoluzione geodinamica del Mediterraneo occidentale.* Volume dedicato a Sergio Venzo, Grafiche STEP, Parma.

BECCALUVA L., DERIU M., MACCIOTTA G., SAVELLI C., CANTONI M. (1981) - *Geopetrographic map of the Pliocene-Pleistocene volcanism from North-Western Sardinia.* L.A.C., Firenze.

BECCALUVA L., DERIU M., MACCIOTTA B., SAVELLI C., VENTURELLI G. (1976-77) - *Geochronology and magmatic character of the Pliocene-Pleistocene volcanism in Sardinia (Italy).* Bull. Volcanol., 40, 1-16.

BECCALUVA L., LEONE F., MACCIONI L., MACCIOTTA G. (1981) - *Petrology and tectonic setting of the Paleozoic basic rocks from Iglesiente-Sulcis (Sardinia, Italy).* N. Jb. Miner. Abh., 140, 184-201.

BELLUOMINI G., DISCENDENTI A., MALIPIERI L., NICOLETTI M. (1970) - *Studi sulle ossidiane italiane. II. Contenuto in ^{40}Ar radiogenico e possibilità di datazione.* Per. Min., 34, 469-479.

BELLON H. (1976) - *Séries magmatiques néogènes* *et quaternaires du pourtour de la Méditerranée occidentale, comparées dans leur cadre géochronométrique - Implications géodynamiques.* Thesis, Université de Paris Sud.

BIGAZZI G., BONADONNA F.P., BELLUOMINI G., MALIPIERI L. (1971) - *Studi sulle ossidiane italiane. IV. Datazione con il metodo delle tracce di fissione.* Boll. Soc. Geol. It., 90, 469-480.

BROTZU P., MORBIDELLI L., NICOLETTI M., PETRUCCIANI C., TRAVERSA G. (1975) - *Vulcanismo miocenico in Gallura (Sardegna sett.). Datazioni K/Ar.* Rend. Soc. It. Min. Petr., 31, 409-414.

BROTZU P., FERRINI V., MORBIDELLI L., TRAVERSA G. (1975) - *Il distretto vulcanico di Capo Ferrato.* Rend. Sem. Fac. Sci. Univ. Cagliari, 45, 1-26.

BURRUS J. (1984) - *Contribution to a geodynamic synthesis of the Provençal Basin (North-Western Mediterranean).* Marine Geology, 55, 247-269.

CALDERONI G., MASI U., MACCIONI L., NICOLETTI M., PETRUCCIANI C., PADALINO XX. (1984) - *Geochemistry and geochronology of the Caledonian « Porphyroids » from central Sardinia (Italy).* Rend. Soc. It. Min. Petr., 39, 261-274.

CARMIGNANI L., COCOZZA T., GHEZZO C., PERTUSATI P.C., RICCI C.A. (1982) - *Lineamenti del basamento sardo.* In: Guida alla Geologia del Paleozoico sardo. Guide Geologiche Regionali. Soc. Geol. It., 11-23.

CARMIGNANI L., COCOZZA T., GHEZZO C., PERTUSATI P.C., RICCI C.A. (Editors) (1984) - *Structural model of Hercynian basement of Sardinia.* C.N.R. Progetto Finalizzato Geodinamica, Sottoprogetto Modello Strutturale.

CHERCHI A., MONTADERT L. (1982) - *Oligo-Miocene rift of Sardinia and the early history of the Western Mediterranean Basin.* Nature, 298, 736-739.

COCHERIE A. (1978) - *Géochimie des terres rares dans les granodiorites.* Thèse, 3ème cycle, Univ. Rennes.

COCHERIE A. (1984) - *Interaction manteau-croûte: son rôle dans la genèse d'associations plutoniques calco-alcalines, contraintes geochimiques (élément en traces et isotopes du strontium et de l'oxygen).* Thèse, Doct. des Sciences, Univ. Rennes.

COCOZZA T., CONTI L., COZZUPOLI D., LOMBARDI G., SCHARBERT S., TRAVERSA G. (1977) - *Rb/Sr age and geopetrologic evolution of crystalline rocks in southern Sulcis (Sardinia).* N. Jb. Geol. Paläont. Mh., 1977, H2, 95-102.

COULON C., DEMANT A., BELLON A. (1971) - *Premières datations par la méthode K/Ar de quelques laves cénozoïques et quaternaires de la Sardaigne Nord-Occidentale.* Tectonophysics, 22, 41-57.

COULON C., DUPUY C. (1975) - *Evolution spatiale des caractères chimiques du volcanisme andésitique de la Sardaigne (Italie).* Earth Planet. Sci. Lett., 25, 170-176.

COULON C., DEMANT A., BOBIER C. (1974) - *Contribution du paléomagnétisme à l'étude des séries volcaniques cénozoïques et quaternaires de Sardaigne nord-occidentale.* Tectonophysics, 22, 59-82.

COZZUPOLI D., DISCENDENTI A., LOMBARDI G., NICOLETTI M. (1971) - *Cronologia K-Ar delle manifestazioni eruttive del settore di Seui-Seulo (Barbagia - Sardegna).* Period. Mineral., 40, 113-124.

COZZUPOLI D., DISCENDENTI A., LOMBARDI G., NICOLETTI M. (1972) - *Datazione K-Ar di rocce granitoidi della Barbagia e dell'Ogliastra (Sardegna centro-orientale).* Period. Mineral., 41, 113-124.

COZZUPOLI D., GERBASI G., NICOLETTI M., PETRUCCIANI C. (1984) - *Età K-Ar delle ignimbriti permiane di Galtellì (Orosei - Sardegna orientale).* Rend. Soc. It. Min. Petr., 39, 471-476.

DEL MORO A., DI SIMPLICIO P., RITA F. (1972) - *Lineamenti geopetrologici del cristallino sardo. Età radiometrica delle plutoniti del settore Ogliastra-Gallura.* Miner. Petr. Acta, 18, 245-254.

DEL MORO A., DI SIMPLICIO P., GHEZZO C., GUASPARRI G., RITA F., SABATINI G. (1975) - *Radiometric data and intrusive sequence in the Sardinian Batholith.* N. Jb. Miner. Abh., 126 (1), 28-44.

DI PAOLA G.M., PUXEDDU M., SANTACROCE R. (1975) - *K-Ar ages of Monte Arci volcanic complex (central-western Sardinia).* Rend. Soc. It. Min. Petr., 31, 181-190.

DI SIMPLICIO P., FERRARA G., GHEZZO C., GUASPARRI G., PELLIZER R., RICCI C.A., RITA F., SABATINI G. (1974) - *Il metamorfismo e il magmatismo paleozoico della Sardegna.* Rend. Soc. It. Min. Petr., 30, 979-1068.

EDEL J.B., MONTIGNY R., THUIZAT R. (1981) - *Late Paleozoic rotations of Corsica and Sardinia: New evidence from paleomagnetic and K-Ar studies.* Tectonophysics, 79, 210-223.

FERRARA G., SEGRE A.G., TONGIORGI E. (1962) - *Datazione assoluta con il metodo Rb/Sr di alcune rocce della Sardegna settentrionale.* Atti Soc. Tosc. Sc. Nat., A, 69, 469-475.

FERRARA G., RICCI C.A., RITA F. (1978) - *Isotopic ages and tectonometamorphic history of the metamorphic basement of north-eastern Sardinia.* Contrib. Mineral. Petrol., 68, 99-106.

FERRARA G., GHEZZO C., GUASPARRI G., RITA F., SABATINI G. (1980) - *Evidenze radiometrico-isotopiche di processi di interazione con magmi granitici nella massa basica di Punta Falcone (Sardegna Settentrionale).* Rend. Soc. It. Min. Petr., 36 (riassunto).

FONTANA D., GELMINI R., LOMBARDI G. (1982) - *Le successioni sedimentarie e vulcaniche Carbonifere e Permo-Triassiche della Sardegna.* In: Guida alla Geologia del Paleozoico sardo. Guide Geologiche Regionali, Soc. Geol. It., 183-192.

GHEZZO C., ORSINI J.B. (1982) - *Lineamenti strutturali e composizionali del batolite ercinico sardo-corso in Sardegna.* In: Guida alla Geologia del Paleozoico sardo. Guide Geologiche Regionali, Soc. Geol. It., 165-181.

GIRAUD J., BELLON H., TURCO G. (1979) - *L'intrusion microdioritique tertiaire d'Alghero (Sardaigne). Age K/Ar et relation avec le migmatisme calco-alcalin sarde. Analogies avec les estérellites de l'Estérel (Var).* C.R. Acad. Sc. Paris, 288, 9-12.

LOMBARDI G., COZZUPOLI D., NICOLETTI M. (1974) - *Notizie geopetrografiche e dati sulla cronologia K-Ar del vulcanesimo tardopaleozoico sardo.* Period. Mineral., 43, 221-312.

MACCIOTTA G., SAVELLI C. (1984) - *Petrology and K/Ar ages of Pliocene-Quaternary volcanics from*

North-Western Sardinia. Grafiche STEP, Parma, 1-45.

MACCIOTTA G., VENTURELLI G., BECCALUVA L. (1978) - *Geochemistry of mafic Cainazoic volcanic rocks from Sardinia (Western Mediterranean).* Bull. Volcanol., 41, 56-78.

MASSARI F., DIENI I. (1973) - *La formazione fluviolacustre di Nuraghe Casteddu ed i suoi rapporti con i basalti di Orosei-Dorgali (Sardegna).* Mem. Soc. Geol. It., 12, 377-410.

MEMMI I., BARCA S., CARMIGNANI L., COCOZZA T., FRANCESCHELLI M., GATTIGLIO M., GHEZZO C., MINZONI N., NAUD G., PERTUSATI P.C., RICCI C.A. (1982) - *Il magmatismo pre-ercinico della Sardegna.* In: Guida alla Geologia del Paleozoico sardo. Guide Geologiche Regionali, Soc. Geol. It., 157-164.

MEMMI I., BARCA S., CARMIGNANI L., COCOZZA T., ELTER F., FRANCESCHELLI M., GATTIGLIO M., GHEZZO C., MINZONI N., NAUD G., PERTUSATI P.C., RICCI C.A. (1983) - *Further geochemical data on the pre-hercynian igneous activity of Sardinia and on their geodynamic significance.* I.G.C.P. N. 5, Newsletter, 5, 87-93.

MONTIGNY R., EDEL J.B., THUIZAT R. (1981) - *Oligo-Miocene rotation of Sardinia: K-Ar ages and paleomagnetic data of Tertiary volcanics.* Earth Planet. Sci. Lett., 54, 261-271.

MORELLI C., GIESE P., HIRN A., COLOMBI B., EVA C., GUERRA I., LETZ H., NICOLIC R., REICHERT C., SCARASCIA S., WIGGER P. (1976) - *Seismic investigation of crustal and upper mantle structure of the northern Apennines and Corsica.* (Int. Symp. Structural History Mediterr. Basins). Technip, Paris, 281-286.

NICOLETTI M., ARDANESE L.R., COLASANTI S. (1982) *La granodiorite di Capo Carbonara (Sardegna - Italy). Età K/Ar di fasi minerali in paragneiss.* Rend. Soc. It. Min. Petr., 38, 765-769.

SAVELLI C. (1975) - *Datazioni preliminari col metodo K-Ar di vulcaniti della Sardegna sud-occidentale.* Rend. Soc. It. Min. Petr., 31, 191-198.

SAVELLI C., BECCALUVA L., DERIU N., MACCIOTTA G., MACCIONI L. (1979) - *K/Ar geochronology and evolution of the Tertiary « calc-alkalic » volcanism of Sardinia (Italy).* Journ. Volc. Geoth. Res., 5, 257-269.

SAVELLI C., PASINI G. (1973) - *Preliminary results of K-Ar dating of basalts from eastern Sardinia and the gulf of Orosei (Tyrrenian sea).* Giornale di Geologia, 39, 303-312.

SCHARBERT S. (1978) - *Supplementary remarks on "Rb/Sr age and geopetrologic evolution of crystalline rocks in southern Sulcis (Sardinia)" by Cocozza et al. (1977).* N. Jb. Geol. Paläont. Mh., 1978, h, 1, 59-64.