

Radiometric geochronology in the Calabrian Arc: a review

ANTONIO PAGLIONICO

Dipartimento Geomineralogico dell'Università, Piazza Umberto I 1, 70121 Bari

ABSTRACT. — This work is a review of otherwise dispersed geochronological data relative to the metamorphics and plutonics cropping out along the Calabrian Arc. The most significant geochronological events are evidenced.

Key words: geochronology, prealpine, alpine, metamorphics, plutonics.

RIASSUNTO. — Viene presentata un'analisi critica delle datazioni radiometriche effettuate sino ad oggi su rocce affioranti nell'Arco calabro-peloritano e vengono messi in evidenza i principali eventi geocronologici registrati.

Parole chiave: geocronologia, prealpino, alpino, metamorfiti, plutoniti.

Introduction

The Calabrian arc is a complex structure made up of Palaeozoic, Mesozoic and Recent terrains. Geochronological data are relatively scarce; only in the last years they have been obtained to highlight geological problems and they concentrate essentially on palaeozoic metamorphics and plutonics.

Geological picture

The Calabrian arc is a « foreign » element connecting the Apenninic and Maghrebic chains which are formed essentially of nappes of Mesozoic and Tertiary sedimentary rocks. Two basic current opinions concern the formation of the belt: 1) it represents an Alpine s.l. structure (AMODIO MORELLI et al., 1976; BONARDI et al., 1980; HACCARD et

al., 1972; SCANDONE, 1983) and 2) it results from the juxtaposition of Alpine and Hercynian ranges (LORENZONI et al., 1983; ZANETTIN LORENZONI, 1982) (fig. 1). According to the former, there are two sectors present in the Calabrian Arc, which behaved differently during the Alpine tectonism.

The first one (Northern sector) represented by 1) the calcareous apennines, 2) the eo-Alpine chain (ophiolitiferous and australpine units) and 3) the Longobucco Unit; the second one (Southern sector) is formed of 1) the crystalline nappes of the Southern Serre, Aspromonte and Mt. Peloritani, 2) the calcareous Maghrebic units and 3) the Longi-Taormina unit.

According to the latter hypothesis it is possible in the Calabrian Arc to distinguish an « Alpine chain » lying upon the Apennines cropping in central and northern Calabria, and a Hercynian chain cropping out on the Ionian side of Central Calabria and forming essentially the Serre, Aspromonte and Peloritani ranges.

Diversities relative to the significance and composition of some lower rank structural units, such as Mt. Gariglione Unit, Stilo Unit, ... exist too.

On the basis of both available and unpublished data, the present author thinks that a totally Alpine history of the Calabrian Arc also involving a pre-alpine basement, is more realistic.

Thus the geochronological data, which play a fundamental role in the restoration of the evolution of the Calabrian arc, will be arranged accordingly (fig. 2).

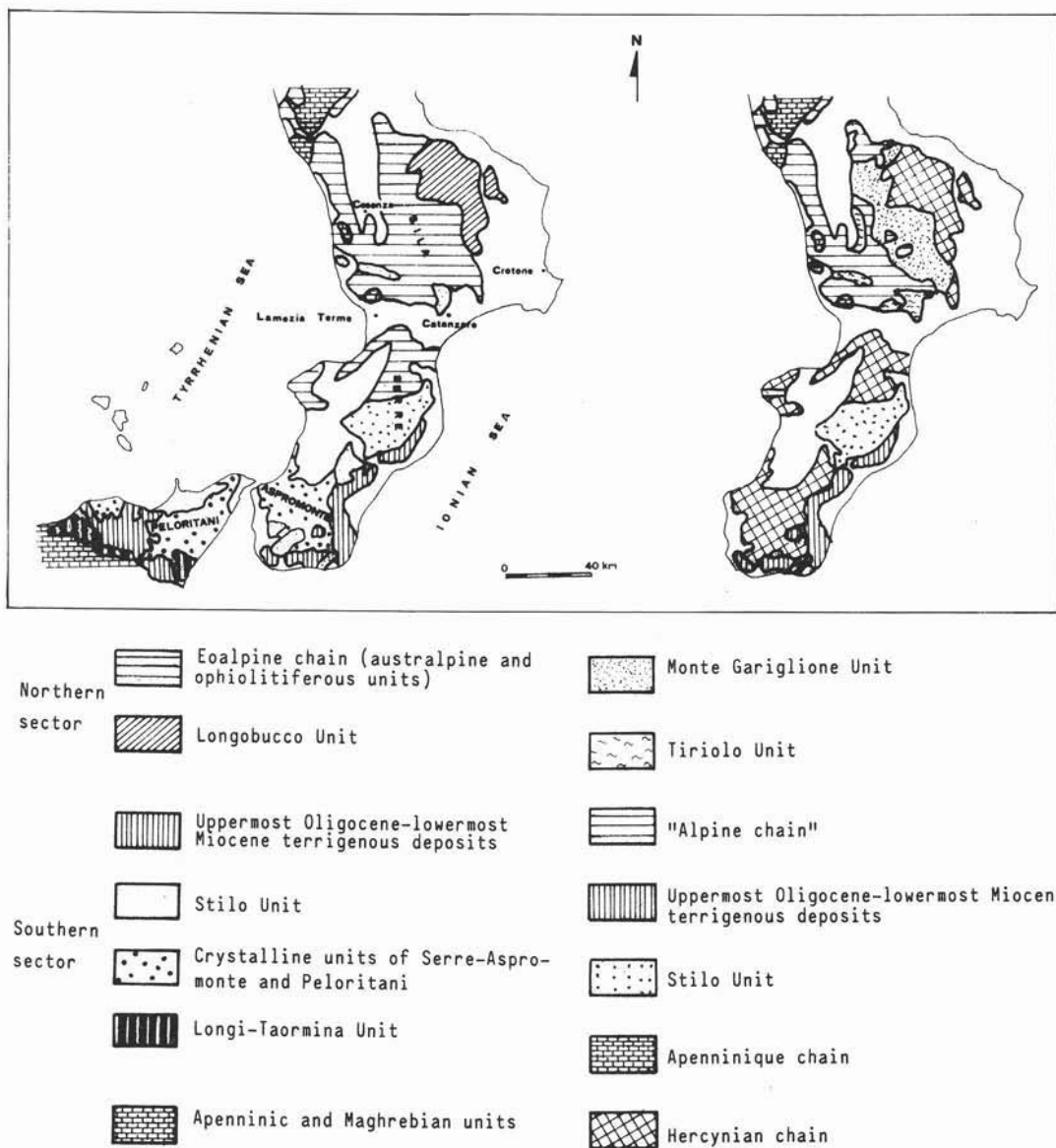


Fig. 1. — Structural sketch of the Calabrian Arc according to current opinions. *Left*: the Calabrian arc is a composite belt of Alpine I.S. age. *Right*: the Calabrian arc is due to juxtaposition of Alpine I.S. and Hercynian ranges.

Geochronological data

Most of the radiometric data concern Palaeozoic rocks. The earliest, scarce data were determined without a well-established geological frame. They are mineral ages (biotite and uraninite) from intrusives cropping out in Serre and Aspromonte (FERRARA et al., 1959; FERRARA & LONGINELLI, 1960).

These data point to a palaeozoic magmatic activity.

A more comprehensive geochronological study was performed by BORSI & DUBOIS (1968) which investigated minerals from plutonics and metamorphics of Central and Northern Calabria. This study was based on a framework developed from geological

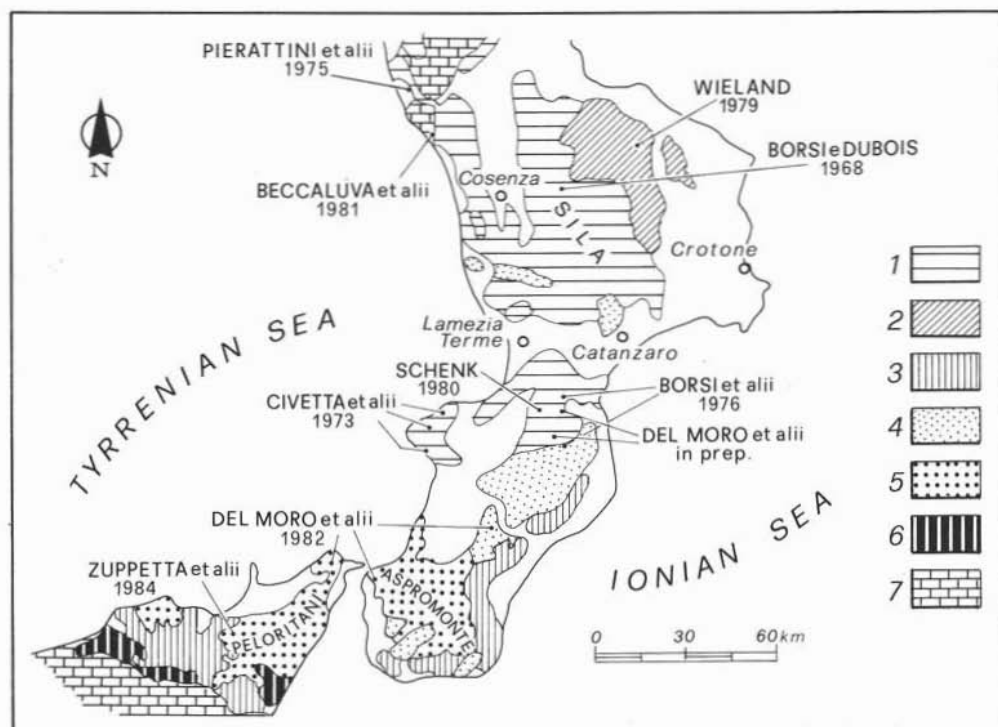


Fig. 2. — Structural sketch map of the Calabrian arc and location of geochronologically investigated areas. Symbols as in fig. 1 (left).

and structural studies carried out by the Laboratoire de Géologie Dynamique de la Sorbonne. The major results were: 1) the confirmation of the Hercynian intrusion of huge masses of granitoides; 2) the occurrence of mesozoic and tertiary rejuvenation of minerals of crystalline palaeozoic basement; 3) the Eocene age for the alpine metamorphism.

An extensive study on whole rocks and minerals was carried out by CIVETTA et alii (1973) on tonalites and pegmatites from the Capo Vaticano area. These data show that the intrusions are Hercynian, and that there was a later rejuvenation of both biotite and muscovite. In particular the authors have pointed out two post-hercynian geochronological events dated at 181 ma and 116 ma respectively.

In 1975, Maastrichtian-Paleocene volcanics crosscutting a dolomitic sequence of the Apennines (Verbicario Unit) affected by metamorphism were investigated.

The whole rock K/Ar isochron reveals

an upper Aquitanian age metamorphism (18 ma).

A comprehensive geochronological survey concerning metamorphics (fig. 3) and plutonics (fig. 4) of the Serre (Southern Calabria) appeared in 1976 (BORSI et alii). This was helpful in the restoration of the evolution of the Calabrian arc. The most important results were:

1) the occurrence of Hercynian and Mesozoic ages for biotites (from both plutonics and very high grade rocks), preferentially distributed, which have been related-taking into account also the geological data — to a first order tectonic contact between two different structural units (Stilo and Polia-Copanello Units);

2) the proto-Alpine uplift of the former section of the Palaeozoic lower continental crust (i.e. the very high grade rocks cropping out in the northern Serre);

3) the composite nature of the pluton of the Serre displaying Sr isotopic ratios which do not plot along an isochrone.

NORTHERN SECTOR OF THE CALABRIAN ARC
cretaceous paleogenic alpine chain

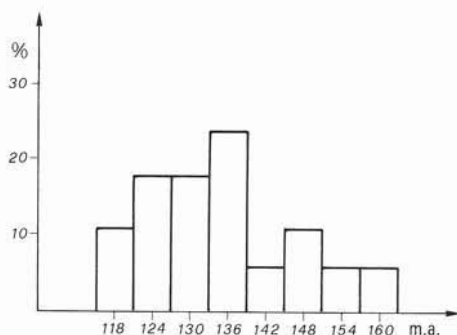


Fig. 3. — Distribution of biotite ages (Rb/Sr) of metasediments of the former lower crust section of Northern Serre ($\bar{x}$ = 136 ma; σ = 12 ma; n = 17) (BORSI et al., 1976).

In 1979 Wieland reported the results of radiometric data on muscovite and biotite of plutonics and metamorphics, as well as on whole rock of granites cropping out in the Sila.

Whole rock data give an age of 284 ± 14 ma for the granitic intrusions. The values obtained for minerals, notwithstanding the scattering, confirm also in Sila the effects of a Mesozoic rejuvenation at around 170-180 ma ago, as found in Southern Calabria.

SCHENK (1980) presents U/Pb and Rb/Sr radiometric data through a former section of lower crustal continuous sequence about 7 Km thick (Polia-Copanella auct).

On the basis of the radiometric ages of

various minerals and of the PT path — deduced petrologically — the author hypothesized that: 1) the primary crystallization of a metabasic rock happened 450 ma ago; 2) the granulite facies metamorphism ended at 295 ma and was followed by an uplift of the lower crustal rocks into intermediate crustal levels, and by synchronous plutonic intrusions.

Accordingly this restoration appears to the author to be very similar to that inferred for the Ivrea zone.

A contribution on the late alpine and apennine orogenic phases recorded in the Calabrian arc has been supplied by BECCALUVA et alii (1981).

On the basis of two K/Ar determinations on metabasites belonging to the ophiolitic units outcropping in Northern Calabria the authors postulated an isotopic re-equilibration event in the Oligocene-Miocene.

A Rb/Sr radiometric study (DEL MORO et al., 1982) was carried on three peraluminous granitoid masses outcropping in the Southern sector of the Calabrian Arc (fig. 4).

An age of 293 ± 9 ma was calculated by means of a whole rock isochron on samples of Capo Rasocolmo mass (Southern sector of the Calabrian Arc). Strontium isotopic data [$(^{87}\text{Sr}/^{86}\text{Sr})_i \approx 0.708$] suggest a crustal origin for all the studied granitoids originating from an heterogeneous metasedimentary source with a high pelitic content. The ages of micas ranging from 282-291 ma are consistent with the calculated isochrone.

SOUTHERN SECTOR OF THE CALABRIAN ARC

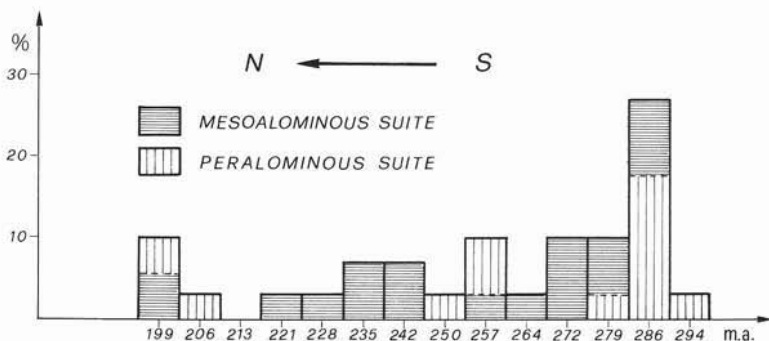


Fig. 4. — Distribution of biotite ages (Rb/Sr) of plutonites outcropping in Southern Serre, Aspromonte and Mt. Peloritani (σ = 29 ma; n = 30) (BORSI et al., 1976; DEL MORO et al., 1982).

GEOCHRONOLOGICAL EVENTS RECORDED IN THE CALABRIAN ARC

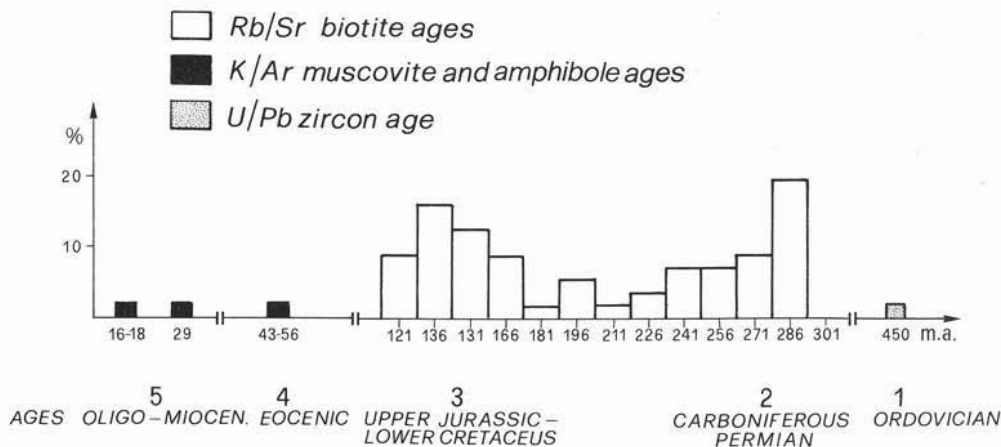


Fig. 5. — Geochronological events recorded in the Calabrian arc (references in the text).

Few data are available relating to metamorphic and plutonics dredged in the Tyrrhenian sea (SARTORI, 1982). The plutonics give an isochron (Rb/Sr whole-rock-mineral) of 302 ma; whereas metamorphics give an isochron (Rb/Sr whole rock-mineral) of 69 ma. K/Ar (whole rock) of 47 ma and 97 ma have also been determined on metamorphics.

In 1983 the results of 40 K/Ar determinations on ophiolites and associated lower continental crust rocks outcropping at boundary between Calabria and Lucania were published (DELALOYE et al., 1983) in a summary. The main results are as follows: metabasalts with monophase orogenic metamorphism give total rock ages of 50 ma; metabasalts and metagabbros showing a multistage metamorphism give total rock ages from 26 to 57 ma; recrystallized amphibolites give ages of 55-90 ma and poorly recrystallized amphibolites give ages of 81-223 ma. Interestingly, an isochron of 210 ma has been calculated for amphiboles from amphibolites, and isochrons of 27-28 ma have been calculated for blue amphiboles, and chlorites from blue schist ophiolites.

Recently (1984) a geochronological study (ZUPPETTA et alii, 1984) on the metabasalts occurring in the Borghi Unit of the M. Peloritani area has been published. By

means of K/Ar methods on seven samples an isochron of 217 ± 3 ma was obtained. This age, according to the authors, points to a middle Triassic tectonic phase in the Peloritani range.

Concluding remarks

From the geochronological review, it appears that the data available relating to the Calabrian Arc are still very ambiguous. Palaeozoic, Mesozoic and Tertiary geochronological events are recorded (fig. 5).

Palaeozoic ages seem to indicate: 1) the existence of an Ordovician magmatic activity or of a pre- or eo-Hercynian metamorphism; 2) the end of Hercynian metamorphism at about 295 ma followed by intrusion of huge masses of granodiorite-granite-tonalite mostly between 295 and 275 ma. Some problems arise when we consider some mineral ages ranging from 238-250 ma, whose significance is still obscure.

A lot of Jurassic-Cretaceous Rb-Sr mineral ages have been determined both in plutonics and in metamorphics cropping out north of Capo Vaticano-Soverato line. Interestingly similar ages have been determined on rocks dredged on the floor of the Tyrrhenian sea. The significance of these

ages is still in debate. They might be due to the cooling subsequent to the Hercynian uplift, otherwise they may reflect phenomena connected to Tethy's evolution.

Tertiary mineral ages have been determined in the Australpine nappes and in the ophiolitic units; the events recorded in the former are older than in the latter. Probably they reflect, on the whole, isotopic resetting consequent to the Alpine and Apennine orogeneses.

It is worthy of note that Triassic ages have been also determined. Whether or not these are connected with Triassic continental thinning and/or rifting needs deeper analysis.

On the other hand, the mesozoic and tertiary geochronological events need to be better fitted into the geodynamic evolution of the Calabrian arc.

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TABLE 1
U/Pb radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	CONCENTRATIONS		OBSERVED ATOMIC RATIOS			AGE MA			BIBLIOGRAPHIC SOURCES
			U (PPM)	Pb RAD (PPM)	$\frac{206}{204}Pb$	$\frac{207}{206}Pb$	$\frac{208}{206}Pb$	$\frac{206}{238}U$	$\frac{207}{235}U$	$\frac{207}{206}Pb$	
AUSTRALPINE UNITS											
GRANULITE **	K AL-808*	ZIRCONS	428	23.8	17100	0.06375	0.09937	349	400	706	22
"	K AL-808	"	425	23.8	16300	0.06494	0.09845	353	409	744	"
"	K AL-808	"	761	42.6	38250	0.06513	0.10323	350	410	766	"
"	K AL-808	"	463	25.6	4004	0.06598	0.12115	289	392	687	"
GRANOBLASTITE	K AL-170	"	439	19.7	6030	0.05651	0.03986	302	311	376	"
META-MONZOGABBRO	K AL-420	"	220	12.4	632	0.75344	0.24380	303	302	294	"
NORITE	K AL-420	"	211	11.1	1055	0.06630	0.19944	298	298	304	"
GRANULITE	K AL-145	"	446	24.1	2490	0.05907	0.15113	324	326	337	"
TONALITIC GNEISS	K AL-730	"	410	20.7	3670	0.05631	0.19483	293	294	299	"
"	K AL-730	"	448	21.9	3600	0.05623	0.14855	295	295	293	"
QUARTZODIORITIC GNEISS	K AL-887	"	1255	38.2	10410	0.05374	0.17441	183	192	300	"
"	K AL-887	"	852	41.6	9960	0.05347	0.30051	264	266	286	"
GRANULITE	K AL-147	MONAZITES	2266	885.6	6950	0.05441	8.5353	296	296	298	"
"	K AL-85	"	906	443.1	4870	0.05509	11.0450	292	292	290	"
GNEISSIC	K AL-90	"	2204	578.8	5310	0.05475	5.6870	283	283	286	"
GRANOBLASTITES	K AL-170	"	2140	639.5	12620	0.05321	6.4646	289	289	290	"
"	K AL-168	"	2555	717.6	11770	0.05363	5.8627	295	296	302	"
"	K AL-489	"	2136	587.7	8910	0.05362	5.8476	290	290	285	"
"	K AL-879	"	739	596.1	2240	0.05870	18.9018	291	291	293	"

* Sieve fraction of the same sample. ** According to the nomenclature proposed by WINKLER & SEN (1973). *** According the order of the references.

TABLE 2
K/Ar radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	K%	$^{40}\text{Ar}/^{39}\text{Ar}$ RD ML/G	$^{40}\text{Ar}/^{39}\text{Ar}$ RD%	K-Ar AGE MA	BIBLIOGRAPHIC SOURCES
AUSTROALPINE UNITS	QUARZODIORITE CV1	WR	1.48±0.05	0.0452	65.6	164±7	6
		Bi	5.97±0.12	0.150±0.007	65.5	136±5	
	QUARZODIORITE CV2	FELD-QZ	0.409	0.0385	57.6	238±8	6
		WR	1.34	0.0493	76.6	196±6	
	QUARZODIORITE CV3	Bi	5.48	0.136	62.6	134±4	6
		FELD-QZ	0.145	0.0237	72.5	749±33	
	QUARZODIORITE CV6	WR	2.22	0.0637	69.2	155±6	6
		Bi	6.10	0.150	66.0	133±4	
	QUARZODIORITE CV9	FELD-QZ	0.198	0.212	69.2	520±45	6
		Mu	10.0	0.279	73.0	151±4	
NORTHERN SECTOR - CRETACEOUS PALEOGENIC ALPINE CHAIN	QUARZODIORITE CV10	Mu	8.67	0.252	73.1	157±5	6
		Bi	9.42	0.293	63.8	167±5	
	QUARZODIORITE CV11	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV13	FELD-QZ	0.0854	0.0682	61.2	2403±40	6
		WR	2.02	0.0619	65.2	164±5	
	QUARZODIORITE CV15	Bi	6.22	0.150	71.6	131±4	6
		Bi	6.57	0.174	77.6	143±5	
	QUARZODIORITE CV16	Bi	6.57	0.172	90.9	142±4	6
		Mu	9.01	0.252	89.4	151±5	
SOUTHERN SECTOR	QUARZODIORITE CV17	Bi	7.42	0.171	96.4	125±4	6
		Mu	7.65	0.208	75.3	147±4	
	QUARZODIORITE CV18	Bi	8.04	0.272	90.0	181±6	6
		Ca10	0.73	0.019	87.4	145±3	
	QUARZODIORITE CV19	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV20	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV21	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
APENNINIC CHAIN	QUARZODIORITE CV22	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV23	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV24	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV25	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV26	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
LIGURIAN CHAIN	QUARZODIORITE CV27	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV28	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV29	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV30	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	
	QUARZODIORITE CV31	WR	2.77	0.0661	71.6	130±5	6
		Bi	6.58	0.152	86.9	128±5	

TABLE 3
K/Ar radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	K%	$^{40}\text{Ar}/^{39}\text{Ar}$ RD ML/G	$^{40}\text{Ar}/^{39}\text{Ar}$ RD%	K-Ar AGE MA	BIBLIOGRAPHIC SOURCES
M. GARIJOLONE UNIT	GRANOBLASTITES KAM1765	Bi	7.95			188±6	25
		Bi	7.79			161±5	
	GRANOBLASTITES KAM1766	Bi	7.76			161±5	25
		Bi	6.21			231±7	
	GRANOBLASTITES KAM1767	Bi	5.98			167±5	25
		Bi	5.98			167±5	
	GRANOBLASTITES KAM1768	Bi	5.98			167±5	25
		Bi	5.98			167±5	
	GRANOBLASTITES KAM1769	Bi	5.98			167±5	25
		Bi	5.98			167±5	
BORGHET UNIT	METABASALT PI-085	WR	0.258	0.012	78.6	204±9	28
		WR	0.289	0.014	83.1	256±9	
	METABASALT PI-086	WR	0.289	0.014	83.1	256±9	28
		WR	0.289	0.014	83.1	256±9	
	METABASALT PI-087	WR	0.289	0.014	83.1	256±9	28
		WR	0.289	0.014	83.1	256±9	
	METABASALT PI-088	WR	0.289	0.014	83.1	256±9	28
		WR	0.289	0.014	83.1	256±9	
	METABASALT PI-089	WR	0.289	0.014	83.1	256±9	28
		WR	0.289	0.014	83.1	256±9	
VERBICARO UNIT	METABASALT PI-091	WR	0.237	0.012	75.6	279±9	28
		WR	0.237	0.012	75.6	279±9	
	METABASALT PI-216	WR	0.837	0.035	77.4	224±7	28
		WR	0.837	0.035	77.4	224±7	
	METABASALT 0636	WR	2.05	0.0069		1950.7	18
		WR	0.16	0.00056		2070.8	
	METABASALT 0634-1	WR	0.16	0.00056		2070.8	18
		WR	0.15	0.00054		2070.6	
	METABASALT 0634-2	WR	0.15	0.00054		2070.6	18
		WR	0.15	0.00054		2070.6	

TABLE 4
Rb/Sr radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Sr (PPM)	$\frac{87\text{Rb}}{86\text{Sr}}$	$\frac{87\text{Sr}}{86\text{Sr}}$	AGE MA	BIBLIOGRAPHIC SOURCES
GRANITE	1A	Bi					286±10	4
		Bi						
	1B	Bi					288±9	4
		Bi						
	1C	Bi					282±8	4
		Bi						
	1D	Bi					251±8	4
		Bi						
	2A	Bi					280±9	4
		Bi						
GNEISSIC GRANOBLASTITE	2B	Bi					287±10	4
		Bi						
	2C	Bi					283±8	4
		Bi						
	3A	Bi					167±6	4
		Bi						
	3B	Bi					177±6	4
		Bi						
	3C	Bi					205±7	4
		Bi						
ORTOGNEISS	3D	Bi					103±3	4
		Bi						
	3E	Bi					181±6	4
		Bi						
	3F	Mu					210±6	4
		Mu						
	3G	Bi					122±4	4
		Bi						
	3H	Mu					253±8	4
		Mu						
ORTOGNEISS	3I	Bi					114±4	4
		Bi						
	4A	Mu					229±7	4
		Mu						
	4B	Mu					246±8	4
		Mu						
	4C	Mu					250±8	4
		WR						
	4D	Mu					245±8	4
		WR						
ORTOGNEISS	4E	Bi					271±9	4
		Bi						
	4F	Bi					183±6	4
		Bi						
	4G	Bi					56±2	4
		Bi						
	4H	Bi					183±6	4
		Bi						
	4I	Bi					56±2	4
		Bi						

TABLE 5
Rb/Sr radiometric data

NORTHERN SECTOR	GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Sr (PPM)	$\frac{87}{86}\frac{Rb}{Sr}$	$\frac{87}{86}\frac{Sr}{Sr}$ M	$\frac{87}{86}\frac{Sr}{Sr}$ I	AGE MA	BIBLIOGRAPHIC SOURCES
	LONGORBUCCO UNIT									
	GRANITE	KAW 1770	Mu Bi	137 151	16 7				285±14 424±17	25
	GRANITE	KAW 1856	Mu Bi	149 79	17 11				264±14 142±15	25
	GRANITE	KAW 1771	Mu Bi	127 181	13 7				284±13 302±12	25
	GRANITE	KAW 1852	Mu Bi	180 265	4 4				275±11 285±11	25
	GRANITE	KAW 1857	Bi	174	7				270±11	25
	GRANITE	KAW 1772	Bi	12	97				800±750	25
	GRANITE	KAW 1860	Bi	116	4				221± 9	25
	GRANITE	KAW 1861	Bi	112	3				223± 9	25

TABLE 6
Rb/Sr radiometric data

NORTHERN SECTOR - CRETACEOUS PALEOGENIC ALPINE CHAIN	GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Sr (PPM)	$\frac{87}{86}\frac{Rb}{Sr}$	$\frac{87}{86}\frac{Sr}{Sr}$ M	$\frac{87}{86}\frac{Sr}{Sr}$ I	AGE MA	BIBLIOGRAPHIC SOURCES
	AUSTROALPINE UNITS (POLIA COPANELLO UNIT)									
	GNEISSIC GRANOBLASTITE	Ccz III 119	Bi	231	7.5				139±13	5
	GNEISSIC GRANOBLASTITE	Ccz III 350	Bi	561	6.5				147± 6	5
	QUARZODIORITIC GNEISS	Ccz III 236	Bi	304	12.6				131±16	5
	QUARZODIORITIC GNEISS	Ccz III 237	Bi	299	4.1				152± 7	5
	TONALITIC GNEISS	Ccz III 238	Bi	355	1.6				142± 4	5
	TONALITIC GNEISS	Ccz III 245	Bi	395	3.1				134± 4	5
	TONALITIC GNEISS	Ccz III 247	Bi	425	3.2				137± 4	5
	TONALITIC GNEISS	Lcit 21	Bi	312	8.2				139±11	5
	GRANITOID BIOTITIC GNEISS	Ccar 23	Bi	391	5.4				137± 6	5
	GRANITOID BIOTITIC GNEISS	Ccz III 54	Bi	300	11.0				137±14	5
	GRANITOID BIOTITIC GNEISS	Lcit 18	Bi	365	3.7				140± 5	5
	TONALITE	Lcit 22	Bi	318	5.1				149± 7	5
	TONALITE	Ccz III 217	Bi	431	9.5				149± 9	5

TABLE 7
Rb/Sr radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Sr (PPM)	$\frac{87}{86} \frac{Rb}{Sr}$	$\frac{87}{86} \frac{Sr}{Sr}$ M	$\frac{87}{86} \frac{Sr}{Sr}$ I	AGE MA	BIBLIOGRAPHIC SOURCES
SOUTHERN SECTOR									
<u>STILO UNIT</u>									
GRANODIORITE	Ccz III 251	B ₁	378	1.9				289±5	5
GRANODIORITE	Ccz III X	B ₁	465	8.4				268±9	5
GRANODIORITE	Ccz III 252	B ₁	330	4.5				278±8	5
GRANODIORITE	Bd II 121	B ₁	390	1.1				281±5	5
GRANODIORITE	Bd II 111	B ₁	363	2.5				270±5	5
GRANODIORITE	Ccit III 313	B ₁	374	4.3				244±7	5
TONALITE	Ccit III 312	B ₁	348	4.3				238±7	5
TONALITE	Ccz III 248	B ₁	695	2.6				271±4	5
TONALITE	Ccz III 249	B ₁	697	1.6				276±4	5
BIOTITIC PORPHYRITE	Ccz III 306	B ₁	563	6.9				236±7	5
K-FELDSPAR-MEGACRYST GRANITE	Ccz III 240	B ₁	524	2.6				203±4	5
K-FELDSPAR-MEGACRYST GRANITE	Ccz III 241	B ₁	507	3.5				200±6	5
K-FELDSPAR-MEGACRYST GRANITE	Ccz III 258	B ₁	434	6.3				230±8	5
K-FELDSPAR-MEGACRYST GRANITE	Ccit I 512	B ₁	667	3.8				261±5	5
K-FELDSPAR-MEGACRYST GRANITE	Ccit I 574	B ₁	680	6.8				243±6	5

TABLE 8
Rb/Sr radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Sr (PPM)	$\frac{87}{86} \frac{Rb}{Sr}$	$\frac{87}{86} \frac{Sr}{Sr}$ M	$\frac{87}{86} \frac{Sr}{Sr}$ I	AGE MA	BIBLIOGRAPHIC SOURCES
NORTHERN SECTOR - CRETACEOUS PALEOGENIC ALPINE CHAIN									
<u>AUSTROALPINE UNITS</u>									
GRANOLITE	KAL-147	WR	97.6	167.5	1.69	0.72349	0.702107	108±1	22
		B ₁	585.7	5.0	356	1.26887			
		PL	19.1	176.9	0.313	0.72091	0.72026	147±7	22
		K-FELD	230.4	366.7	1.82	0.72405			
GRANOLITE	KAL-808	WR	89.6	154.6	1.68	0.72140	0.71867	114±1	22
		B ₁	647.1	9.7	199	1.04110			
		PL	34.6	141.9	0.708	0.71980	0.7183	144±9	22
		K-FELD	265.0	309.2	2.47	0.72341			
GRANOLITE	KAL-85	WR	72.1	167.9	1.25	0.71967	0.71769	112±1	22
		B ₁	580.7	8.8	198	1.03171			
		PL	22.1	180.9	0.354	0.71815	0.71744	141±9	22
		K-FELD	210.4	453.6	1.35	0.72014			
GNEISSIC GRANOBLASTITE	KAL-370	WR	87.0	110.6	2.28	0.73078	0.7279	88±1	22
		B ₁	731.7	8.6	254	1.04567			
GNEISSIC GRANOBLASTITE	KAL-657	WR	79.4	314.4	0.732	0.71645	0.7154	101±1	22
		B ₁	325.3	8.4	115	0.88049			
META-MONZOGABBRO NORITE	KAL-94	WR	77.6	199.0	1.13	0.71507	0.71290	135±1	22
		B ₁	588.1	5.0	367	1.41704			
		PL	4.6	299.4	0.0446	0.71239	0.71227	176±5	22
		K-FELD	273.8	393.7	2.02	0.71734			

TABLE 9
Rb/Sr radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Sr (PPM)	$\frac{87}{86}\frac{Rb}{Sr}$	$\frac{87}{86}\frac{Sr}{Sr_M}$	$\frac{87}{86}\frac{Sr}{Sr_I}$	AGE MA	BIBLIOGRAPHIC SOURCES
NORTHERN SECTOR - CRETACEOUS PALEOGENIC ALPINE CHAIN									
AUSTROALPINE UNITS									
GNEISSIC GRANOBLASTITE	KAL-170	WR Bi	127.0 503.7	126.3 4.6	2.92 325	0.73046 1.35316	0.7250	132±1	22
GNEISSIC GRANOBLASTITE	KAL-168	WR Bi	61.0 496.4	211.1 6.3	0.839 238	0.72261 1.17526	0.72101	134±1	22
APLITE	KAL-491	Mu PL Bi	154.3 8.3 371.4	140.4 648.6 5.5	3.18 0.03690 203	0.71298 0.70390 1.03193	0.7038 0.7039	203±4 114±1	22 22
GNEISSIC GRANOBLASTITE	KAL-879	PL Bi	1.3 309.4	613.5 8.2	0.00610 112	0.71274 0.92657	0.71273	134±1	22
QUARZODIORITIC GNEISS	KAL-887	PL Bi	0.8 272.3	239.3 18.1	0.0095 43.9	0.71136 0.76403	0.71135	85±1	22
TONALITE	KAL-730	WR Bi	81.9 321.7	285.1 1.3	0.832 803	0.71346 2.22801	0.7119	133±1	22
MICASCHIST	KAL-42	Mu WR Bi	532.0 623.3 1667.7	75.2 184.4 17.7	20.7 9.83 279	0.79609 0.75457 0.91987	0.7170 0.7485	268±4 43±1	22 22
GNEISS	KAL-51	WR Mu	194.5 604.6	69.9 26.8	8.09 66.7	0.75183 0.93003	0.7272	214±2	22

TABLE 10
Rb/Sr radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Sr (PPM)	$\frac{87}{86}\frac{Rb}{Sr}$	$\frac{87}{86}\frac{Sr}{Sr_M}$	$\frac{87}{86}\frac{Sr}{Sr_I}$	AGE MA	BIBLIOGRAPHIC SOURCES
SOUTHERN SECTOR									
CAPO RASOCOLMO MASS									
LEUCOMONZO-GRANITE	P 80-1	WR	109	277	1.14	0.7154			8
"	P 80-2	WR	131	224	1.70	0.7174			8
"	P 80-2	Bi	829	5.6	504.18	2.5457		256±4	8
"	P 80-2	Kf	262	367	2.07	0.7190			8
"	P 80-2	PL	10	165	0.18	0.7113			8
LEUCOTONALITE	P 80-3	WR	56	616	0.26	0.7111			8
"	P 80-3	Bi	374	5.0	232.98	1.5648		258±4	8
"	P 80-3	Mu	160	55.7	8.35	0.7441		287±6	8
LEUCOTONALITE	P 80-4	WR	66	528	0.36	0.7113			8
LEUCOMONZO-GRANITE	P 80-5	WR	167	62	7.84	0.7420			8
"	P 80-5	Bi	1011	2.7	1761.00	7.0209		252±4	8
"	P 80-5	Mu	398	7.8	156.57	1.3498		287±5	8
GRANODIORITE	P 80-6	WR	99	426	0.67	0.7124			8
"	P 80-8	WR	110	327	0.97	0.7141			8
"	P 80-8	Bi	697	3.5	736.98	3.7186		287±5	8
LEUCOGRANODIORITE	P 9	WR	98	361	0.78	0.7125			8
"	P 84	WR	115	151	2.22	0.7198			8
"	P185	WR	50	471	0.31	0.7116			8
"	P194	WR	113	194	1.68	0.7169			8

TABLE 11
Rb/Sr radiometric data

SOUTHERN SECTOR

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Sr (PPM)	$\frac{87}{86}\frac{Rb}{Sr}$	$\frac{87}{86}\frac{Sr}{Sr\ M}$	$\frac{87}{86}\frac{Sr}{Sr\ I}$	AGE MA	BIBLIOGRAPHIC SOURCES
CITTANOVA									
HASS									
GRANODIORITE	C 80-10	WR	95	379	0.73	0.7112			8
LEUCOGRANO- DIORITE	C 80-11	WR	161	349	1.34	0.7133			8
		Bi	956	5.9	574.46	3.0896	0.7077	291±4	
		Mu	484	22.5	63.70	0.9697	0.7078	289±5	
MONZONITIC APLITE	C 80-12	WR	147	261	1.63	0.7164			8
GRANODIORITE	C 80-14	WR	140	311	1.30	0.7149			8
		Bi	933	3.9	945.11	4.5319	0.7096	284±5	
		KF	313	496	1.83	0.7169			
		PL	9.2	303	0.09	0.7100			
MONZONITIC APLITE	C 80-15	WR	180	66	7.90	0.7418			8
		Mu	724	4.5	569.53	3.0463	0.7094	288±4	
MONZOGRANITE	C 80-16	WR	151	215	2.03	0.7203			8
GRANODIORITE	C 80-17	WR	126	437	0.83	0.7116			8
LEUCOMONZO- GRANITE	C 80-18	WR	162	208	2.36	0.7214			8
MONZOGRANITE	C 80-19	WR	162	338	1.39	0.7138			8
GRANODIORITE	C 80-20	WR	75	381	0.57	0.7103			8
		Bi	483	4.0	403.82	2.3687	0.7080	289±5	
LEUCOGRANO- DIORITE	C 80-21	WR	183	249	2.13	0.7202			8
LEUCOGRANO- DIORITE	CN 4	WR	210	138	4.43	0.7312			8
"	GE 72	WR	209	50	12.22	0.7609			8
"	CN120	WR	107	361	0.86	0.7115			8
"	CN176	WR	213	96	6.46	0.7439			8

TABLE 12
Rb/Sr radiometric data

GEOLOGICAL REFERENCES	SAMPLES	ANALYZED PHASE	Rb (PPM)	Rb (PPM)	$\frac{87}{86}\frac{Rb}{Sr}$	$\frac{87}{86}\frac{Sr}{Sr\ M}$	$\frac{87}{86}\frac{Sr}{Sr\ I}$	AGE MA	BIBLIOGRAPHIC SOURCES
VILLA SAI GIOVANNI MASS									
LEUCOGRANODIO- RITE	C 80-1	WR Bi	108 714	328 6.9	0.95 337.87	0.7142 2.0835	0.7103	286±4	8
MONZOGRANITIC APLITE	C 80-2	WR Bi Mu	145 866 421	55 7.2 7.1	7.63 381.60 184.46	0.7429 1.7774 1.4621	0.7119	195±3 286±6	8
LEUCOGRANODIO- RITE	C 80-3	WR	122	325	1.08	0.7148			8
	C 80-4	WR Bi Mu KF PL	100 682 225 272 32	237 2.4 157 435 255	1.23 1240.56 4.15 1.81 0.36	0.7158 5.7064 0.7281 0.7282 0.7124	0.7108 0.7106	283±4 296±7	8
	C 80-5	WR	74	439	0.49	0.7118			8
	C 80-6	WR	119	319	1.08	0.7149			8
GRANODIORITE	C 80-7	WR	106	383	0.80	0.7138			8
	C 80-8	WR	99	349	0.82	0.7132			8
MUSCOVITIC PEGMATITE	C 80-9	Bi Mu KF	794 456 350	5.9 17.3 743	458.28 78.70 1.36	2.5783 1.0350 0.7249	0.7193 0.7194	285±4 282±4	8
LEUCOGRANODIO- RITE	CAT 43	WR	127	169	2.18	0.7205			8
"	CAT 64	WR	156	171	2.65	0.7223			8
"	CAT131	WR	65	484	0.39	0.7119			8
"	CAT261	WR	102	295	1.00	0.7143			8

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