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PETROGRAPHIC, GEOCHEMICAL AND RADIOMETRIC DATA ON TERTIARY VOLCANO-ARENITIC BEDS FROM THE SICILIAN MAGHREBIAN CHAIN: VOLCANIC SOURCES AND GEODYNAMIC IMPLICATIONS

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Abstract: The volcanic fraction of impure volcano-arenitic beds of the Reitano Flysch (Early Oligocene, Sicilian Maghrebian Chain) was investigated by petrographic, geochemical and radiometric techniques. Two distinct volcanic grain populations were recognized: (1) paleovolcanic clasts, Late-Permian in age and calc-alkaline in character, probably linked to late-Hercynian magmatism and (2) alkaline (potassic) neovolcanic clasts. As regards the alkaline fraction, it is difficult to link its provenance with the Oligocene-Miocene Sardinia volcanism. Indeed, this latter volcanism shows a distinct calc-alkaline character typical of subduction and/or collision-related magmas. We suggest that the volcanic sources of this alkaline fraction could be related to magmatic events close to the sedimentary basin and associated with extensional processes preluding the opening of new oceanic areas (i.e. Algero-Provençal Basin and Sardinia Rift).

Key words: Sicilian Maghrebian Chain, Reitano Flysch, Oligocene, volcanogenic sediments, petrography, geochemistry, K/Ar dating.

Introduction and objectives

The Alpine orogenic system that borders the western Mediterranean area includes Tertiary sedimentary rock piles with very widespread, and locally thick, volcanogenic sediments interbedded with Tertiary marine formations (Fig. 1).

Volcanogenic levels have been found within many Oligocene-Miocene successions of the Betic Cordillera (Martin-Algarra 1987; Puglisi & Carmisciano 1992), of the Rifian sector of Morocco (Feinberg et al. 1990; Chiocchini et al. 1980) and of the Algerian-Tunisian sector (Bellon 1976; Rivière 1988). As regards the northern Apennines, volcanogenic sediments have been studied in the internal sector (Amorosi et al. 1994, 1995; Mattioli 1997) as well as in the external sector (Papini & Vannucci 1993; Delle Rose et al. 1994) and in the Piemonte Tertiary Basin (Tateo 1993; Bonci et al. 1994; Ruffini & Cadoppi 1994).

The southern Apennines and the Calabria-Peloritani Arc also show excellent examples of Oligocene-Miocene flysch deposits affected by volcanic supply (Critelli & Monaco 1993; Critelli 1991; Critelli & Le Pera 1990; Crisci et al. 1988; Cavazza 1989). The calc-alkaline Oligocene-Miocene Sardinia volcanism has often been invoked to have fed these volcanoclastic deposits. The origin of these deposits, in fact, has been traditionally referred to Early Tertiary magmatic events of western Sardinia, linked to subduction of the African lithosphere beneath Europe, considering the counterclockwise rotation of the Corsica-Sardinia microplate (Scandone 1980; Patacca & Scandone 1989).

Volcanic detritus is also present in the Oligocene-Miocene turbiditic sedimentary rocks of the outermost sectors of the Sicilian Maghrebian Chain. The Reitano Flysch, a thick turbiditic succession of Early Oligocene age overlying the Africa-verging tectonic units in the easternmost segment of the Sicilian Maghrebian Chain (Nebrodi Mountains sector, Fig. 2), and the well known Tusa Tuffites are characterized by abundant neovolcanic detritus (sensu Zuffa 1987), thus providing evidence of a volcanism coeval with sedimentation.

In this study we focus our attention on the petrographic, geochemical and textural characters of the volcanic fraction of the Reitano Flysch in order (i) to identify the volcanic source areas and the mechanisms of sedimentary transport and (ii) to constrain an Oligocene-Miocene geodynamic reconstruction.

In particular, the Reitano Flysch can be correlated with other turbiditic sequences cropping out in the Betic Cordillera (Algeciras Flysch) and along the Maghrebian Chain in northern Africa (Beni Ider Flysch and Flysch marno-gréso-micacé, in Morocco and Algeria, respectively). As indicated by the occurrence of volcanic clasts and of clinopyroxenes characterizing the heavy mineral assemblages, the composition of these turbiditic successions is similar (Puglisi & Carmisciano 1992). Thus, if the above assumed correlation is valid, the results of this study could provide useful information about the Early Tertiary kinematic evolution of the western Mediterranean

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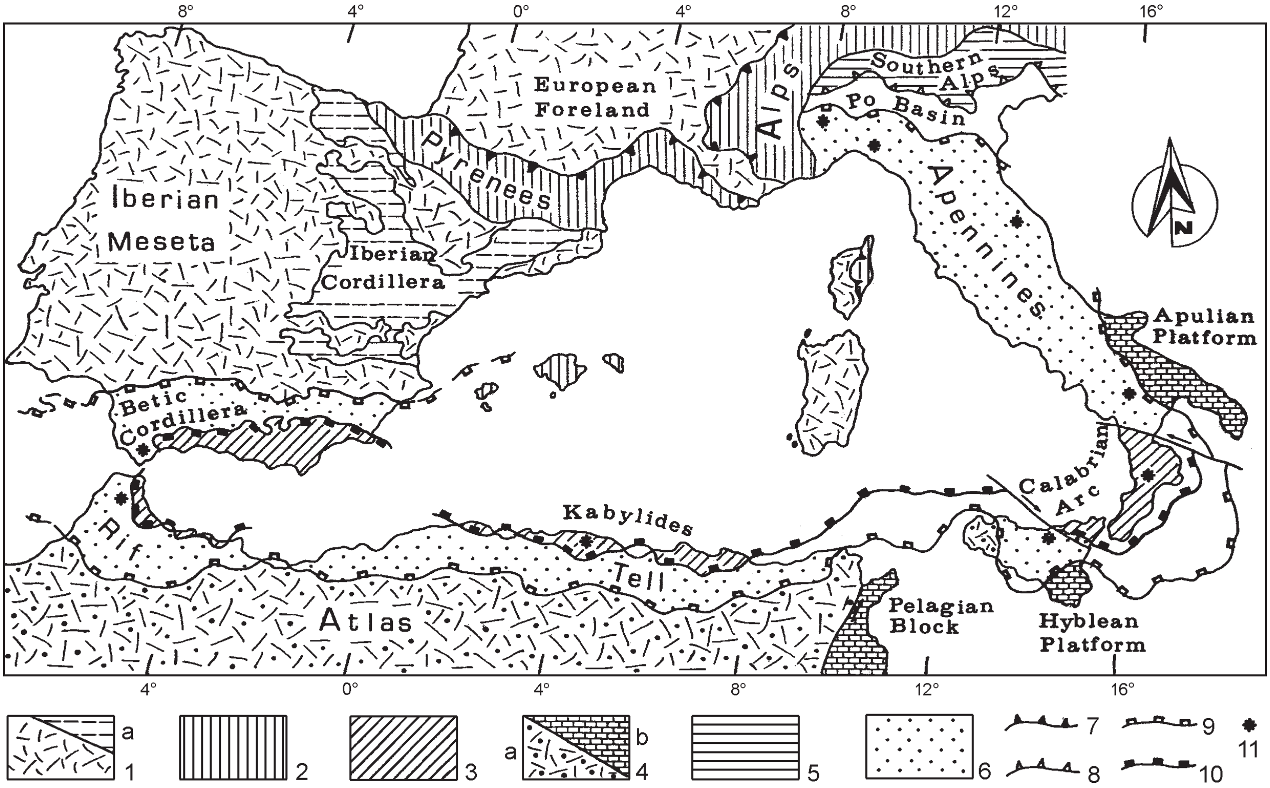

Fig. 1. Tectonic scheme of the western Mediterranean area. **European Units: 1** = Spanish and European Foreland (including "a" Iberian Cordillera), **2** = Units of the Spanish–European palaeomargin deformed during the Alpine orogeny (Pyrenees, Provençal Chain and Alps), **3** = Kabylo-Calabride Chain (including the internal units of the Betic Cordillera). **African Units: 4** = African Forelands (**a** = gently deformed: Atlas and Trapanese area; **b** = undeformed: Pelagian Block, Hyblean Plateau and Apulian Platform), **5** = Units of the African paleomargin deformed during the Alpine orogeny (Southalpine), **6** = African Units deformed during the Apenninic-Maghrebian orogeny (Apennines, Sicilian Maghrebian Chain, Rif, Tell and Betic Cordillera). **7–10** = Pennidic, South-Alpine, Kabylo-Calabride Chain and Apenninic-Maghrebian Chain fronts; **11** = main outcrops of Tertiary volcanogenic sediments along the Betic Cordillera and the Apenninic-Maghrebian Chain.

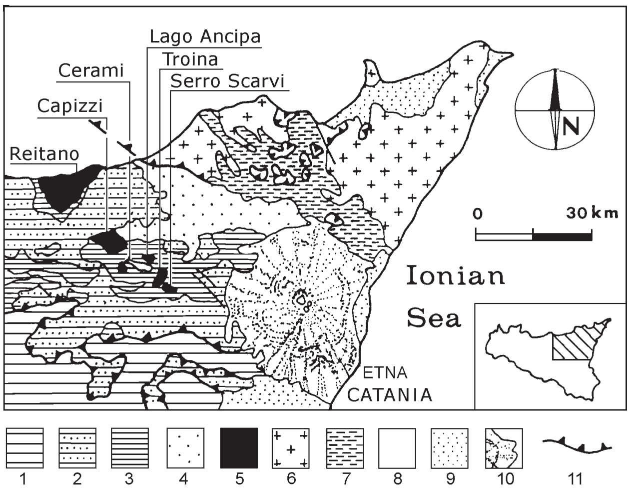

Fig. 2. Geological sketch map of North-Eastern Sicily with Reitano Flysch outcrops (taken from Puglisi 1992). **1** = External Units; **2** = Numidian Flysch; **3** = Sicilide Units s.s. and Tusa Tuffites; **4** = Monte Soro Flysch; **5** = Reitano Flysch; **6** = Calabride Units; **7** = Stilo-Capo d'Orlando Formation; **8** = Antisicilide units; **9** = Quaternary deposits; **10** = Monte Etna volcanites.

area by studying the relationships between volcanism and sedimentation.

Petrographic and geochemical characters of the volcanic detritus

The basal and middle levels of the southern outcrops of the Reitano Flysch (Puglisi 1979; Loiacono & Puglisi 1983) are made up of impure volcano-arenitic beds (sensu Zuffa 1987), where a locally abundant volcanic fraction (max 30–35 %) is mixed with quartzose-feldspathic detritus. This quartzose-feldspathic detritus, which is predominant at the top of the succession, is related to a provenance from the Hercynian crystalline rocks now deformed into the Peloritani Mountains tectonic edifice (Cassola et al. 1992, 1995; Costa et al. 1992; Puglisi 1992).

Petrographic and geochemical characters of the Reitano Flysch sandstones (henceforth RF), taken from the literature, are shown in Table 1. The Table also includes the discriminating parameters [(Fe_2O_{3tot}+MgO), TiO_2, (Al_2O_3/SiO_2), (K_2O/Na_2O) and Al_2O_3/(CaO+Na_2O)] suggested by Bathia (1983) for interpreting the provenance and tectonic setting of the sedimen-

Table 1: Petrographic and chemical characters of the Reitano Flysch sandstones.

Gross Composition (n = 41) [1]			**Chemical Composition (n = 21)** [2]		
	x	σ		x	σ
Qm	22.1	5.95	**SiO_2**	69.58	4.15
Qp	5.3	1.61	**TiO_2**	0.39	0.07
Qr	3.8	2.59	**Al_2O_3**	13.18	0.85
Ch	0.4	0.73	**Fe_2O_3**	2.42	0.72
			FeO	0.89	0.32
Ps	18.7	2.46	**MnO**	0.09	0.05
Pr	3.9	2.46	**MgO**	2.08	0.44
Ks	5.1	3.02	**CaO**	5.33	4.19
Kr	1.3	1.26	**Na_2O**	2.92	0.40
			K_2O	2.95	0.25
Lv	9.2	7.46	**P_2O_5**	0.11	0.03
Lc	0.3	0.75			
Lf	0.6	1.00	**Fe_2O_{3tot}+MgO**	5.51	1.29
			Al_2O_3/SiO_2	0.19	0.02
Ms	5.6	3.12	**K_2O/Na_2O**	1.03	0.15
Mr	0.7	0.76	**$Al_2O_3/(Na_2O+CaO)$**	2.03	0.97
Al	1.1	1.20			
			lg (Fe_2O_{3tot}/K_2O)	0.05	0.15
Mt	4.6	3.28	**lg (SiO_2/Al_2O_3)**	0.72	0.04
Cm	17.3	10.24	**lg (Na_2O/K_2O)**	-0.01	0.04
	100.0				
Q	44.7	6.76			
F	41.0	6.98			
L	14.3	10.11			
	100.0				
Qm	36.6	6.30			
F	41.0	6.98			
Lt	22.4	9.15			
	100.0				

[1] after Puglisi (1979), Loiacono & Puglisi (1982), Cassola et al. (1992; 1995)

[2] oxide compositions re-calculated on the volatile-free basis (after Puglisi, 1994); x e σ = average and standard deviation, n = number of analyzed samples.

Gross compositions: symbols of the parameters adopted for modal analysis

Q = $Q_m + Q_p$, where: **Q** = total quartzose grains, Q_m = monocrystalline quartzose grains (including Q_r = quartz in coarse-grained rock fragments, i.e. >0.06 mm), Q_p = polycrystalline quartzose grains (including **Ch** = chert);
F = **P** + **K**, where: **F** = total feldspar grains, **P** and **K** = plagioclase and potassium feldspar single grains (**Ps** and **Ks**) or in coarse-grained rock fragments (**Pr** and **Kr**);
L = **Lv** + **Lc** + **Lf**, where: **L** = unstable fine-grained rock fragments (< 0.06 mm, i.e.: **Lv** = volcanic, **Lc** = carbonate and **Lf** = epimetamorphic lithic fragments);
Lt = **L** + Q_p, where: **Lt** = total lithic fragments (both unstable and quartzose);
M = micas and chlorites in single grains or in coarse-grained rock fragments (**Ms** and **Mr**, respectively);
Al = other mineral grains, **Mt** = siliciclastic matrix, **Cm** = carbonate cement.

tary basins. By using both Bathia's model (1983) and Roser & Korsch's (1986) simple bivariate plot [(K_2O/Na_2O) vs. SiO_2], the Reitano Flysch succession seems to have been deposited inside a sedimentary basin connected with active continental margins (Puglisi 1994).

In order to define the petrographic and geochemical characteristics of the volcanic detritus, samples of RF sandstones were collected from several channeled conglomerate and coarse-grained sandstone basal levels in the outcrops of Troina and Lago d'Ancipa (southern slope of the Nebrodi Mountains) and of Cefalù (Tyrrhenian coast of Sicily, Fig. 2). The petrographic analysis indicates the presence of two distinct volcanic grain populations with different sizes and features:

A — well-rounded volcanic pebbles (about 1–2 cm in size) characterized by oligo-porphyritic texture with a low number of phenocrysts (not more than 7–9 %), ranging in size from 0.3 to 0.6 mm and mainly represented by sanidine, plagioclase and quartz, set in a holocrystalline fine-grained groundmass forming a felt of feldspar and quartz microlites;

B — medium sand-sized (25–50 mm) grains made of angular and subangular volcanic clasts, scattered in the sandstones, always associated with quartz and feldspars derived from plutonic and/or middle-high grade metamorphic sources. These volcanic lithic fragments contain phenocrysts of (i) remarkably fresh augitic clinopyroxenes (ii) plagioclase, (iii) rare K-feldspar and subordinate biotite and amphibole, all of them set in a micro- to cryptocrystalline groundmass. Clinopyroxenes are also present as monocrystalline detrital grains.

The chemical compositions of the mineral phases (phenocrysts and microlites, about 245 as total number of analyses for both the A and B volcanic grain populations) and of the groundmass of the volcanic fraction (84 analyses, 28 and 56 for the A and B populations respectively) have been determined by SEM–EDS methods. Analyses have been performed at the Institute Internazionale di Vulcanologia of Catania (C.N.R.).

Plagioclase phenocrysts and microlites of both A and B volcanic grain populations always show an albite composition (average composition measured on 140 plagioclase crystals is, by weight: SiO_2 = 68.27 %, Al_2O_3 = 19.96 %, FeO_{tot} = 0.15 %, CaO = 0.33 %, Na_2O = 11.03 %, K_2O = 0.26 %). B-population volcanic clasts shows an abundance of sanidine, mainly as microlites rather than phenocrysts (average composition on 70 sanidine crystals is, by weight: SiO_2 = 64.86 %, Al_2O_3 = 18.29 %, Na_2O = 0.45 %, K_2O = 16.30 %, SrO = 0.22 %, BaO = 0.14 %), and of clinopyroxenes. Very few amphiboles were also found and analyzed (SiO_2 = 43.92 %, TiO_2 = 2.39 %, Al_2O_3 = 10.69 %, FeO_{tot} = 14.11 %, MnO = 0.43 %, MgO = 13.48 %, CaO = 11.56 %, Na_2O = 2.33 %, K_2O = 1.10 %).

Because of the low number of phenocrysts within the A-population of volcanics, we assume the groundmass composition as representative of the affinity of the whole rock. Thus, the two different volcanic grain populations can also be discriminated by the simple Total Alkali-Silica diagram (Fig. 3, after Le Maitre 1989), where the average groundmass compositions (see Tables 2 and 3) have been plotted. The groundmass of the two volcanic fractions shows a strongly variable alkali content, with K_2O/Na_2O ratio <1 and >4 in the pebbles and in the fine-grained detritus, respectively. The groundmass of the fine-grained fraction, in fact, shows a well marked alkaline (potassic) character with trachytic composition, whereas the groundmass of the volcanic pebbles shows a subalkaline character with rhyolitic composition. In addition, the [SiO_2 vs. (FeO_{tot}/MgO)] diagram clearly shows the calc-alkaline affinity of this subalkaline fraction (Fig. 4).

Clinopyroxenes are only present within the fine-grained volcanic fraction. Their chemical composition (see Tables 4 and 5) ranges from augite to diopside. As the composition of the clinopyroxenes vary according to the chemistry of the

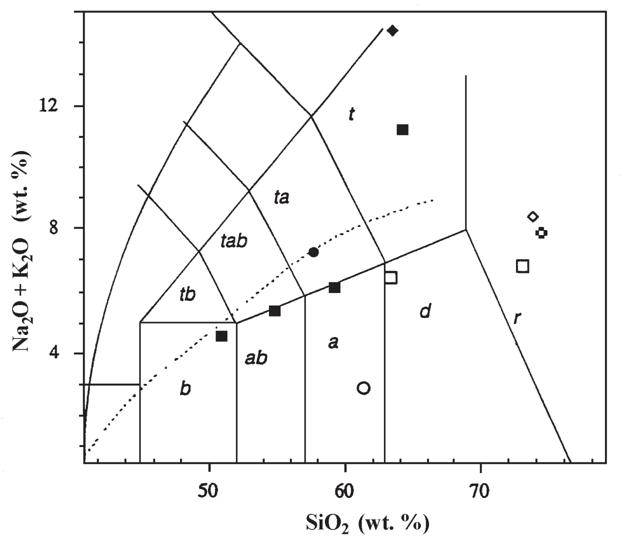

Fig. 3. TAS (after Le Maitre 1989, with the Irvine and Baragar's curve 1971) showing the average groundmass composition of the study volcanic fraction. **Reitano Flysch**: ◇ A-population volcanic grains (i.e. volcanic pebbles, average of 28 analyses), ◆ B-population volcanic grains (i.e. fine-grained volcanic fraction scattered in the sandstones, average of 56 analyses); **Tusa Tuffites**: ● Sicily (after Ogniben 1964), ○ southern Apennines (after Ardito et al. 1985); **S. Mauro Fm.** (southern Apennines, after Crisci et al. 1988): ✚; **Val d'Aveto Sandstones** and **Petrignacola Fm.** (northern Apennines, after Mattioli 1997): ■ lavas, □ ignimbrites.

Table 2: Groundmass composition of the A-population volcanic grains (i.e. volcanic pebbles).

Samples		SiO_2	Al_2O_3	FeO_{tot}	MgO	CaO	Na_2O	K_2O	
A (5)	x	68.83	19.47	0.05	0.04	0.50	10.00	1.11	**100.00**
	σ	1.95	1.39	0.12	0.09	0.16	0.92	1.02	
B (3)	x	69.24	19.07	-	0.07	0.78	10.14	0.70	**100.00**
	σ	2.91	2.02	-	0.12	0.14	1.02	1.01	
C (2)	x	74.53	12.26	4.36	1.80	2.31	3.44	1.30	**100.00**
	σ	1.75	1.63	0.60	0.35	0.57	0.64	0.08	
D (7)	x	80.83	11.28	0.18	0.03	0.22	4.63	2.83	**100.00**
	σ	1.95	1.14	0.23	0.09	0.20	1.43	1.52	
E (6)	x	79.93	14.90	1.05	0.32	0.75	7.20	1.85	**100.00**
	σ	8.96	4.74	1.46	0.58	0.77	2.64	0.88	
F (5)	x	76.83	14.88	0.25	-	0.62	6.26	1.16	**100.00**
	σ	5.65	3.20	0.42	-	0.22	2.61	0.54	

Number of analyzed groundmass within the brackets; x = average; σ = standard deviation.

host magma, it can be used to identify the original magmatic affinity. Thus, the chemical composition of the analyzed clinopyroxenes (about 30 analyses of single detrital grains and of phenocrysts) are plotted in the diagram suggested by Leterrier et al. (1982), discriminating the alkaline/subalkaline affinities of volcanic rocks (Fig. 5). The alkaline character of the fine-grained volcanic fraction is also supported by means of this diagram.

Table 3: Groundmass composition of the B-population volcanic grains (i.e. fine-grained volcanic clasts scattered in the sandstones).

Samples		SiO_2	Al_2O_3	FeO_{tot}	MgO	CaO	Na_2O	K_2O	BaO	P_2O_5	
1 (6)	x	62.53	21.77	0.99	0.31	0.10	3.45	10.49	-	0.35	**100.00**
	σ	1.50	0.90	0.77	0.25	0.11	0.85	0.88	-	0.18	
2 (7)	x	60.91	21.65	0.99	0.57	0.42	1.12	13.79	0.30	0.25	**100.00**
	σ	4.42	3.31	1.30	0.50	0.64	0.84	2.93	0.40	0.31	
3 (4)	x	63.91	19.93	0.41	0.17	0.04	2.43	12.53	0.51	0.07	**100.00**
	σ	2.01	2.22	0.42	0.23	0.08	1.40	3.23	0.59	0.14	
4 (12)	x	63.98	20.49	0.51	0.18	0.07	2.70	11.81	0.21	0.05	**100.00**
	σ	2.15	2.37	0.58	0.22	0.18	1.77	2.25	0.28	0.11	
5 (24)	x	64.55	20.23	0.57	0.16	0.11	2.44	11.58	0.34	0.02	**100.00**
	σ	4.28	3.60	0.61	0.20	0.25	1.23	2.48	0.33	0.08	
6 (3)	x	64.96	20.10	0.55	0.21	0.72	4.27	9.27	0.12	-	**100.00**
	σ	0.47	0.56	0.11	0.20	0.43	0.70	1.32	0.21	-	

Number of analyzed groundmass within the brackets; x = average; σ = standard deviation.

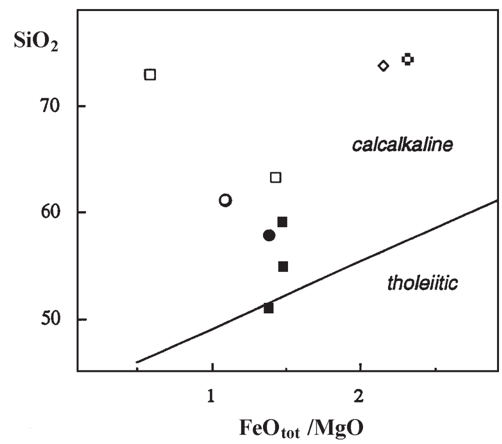

Fig. 4. SiO_2-FeO_{tot}/MgO diagram (after Miyashiro 1974) discriminating between the calc-alkaline and tholeiitic products. Only the subalkaline volcanic fraction of the Reitano Flysch is plotted in this diagram. For explanation of symbols see Fig. 3.

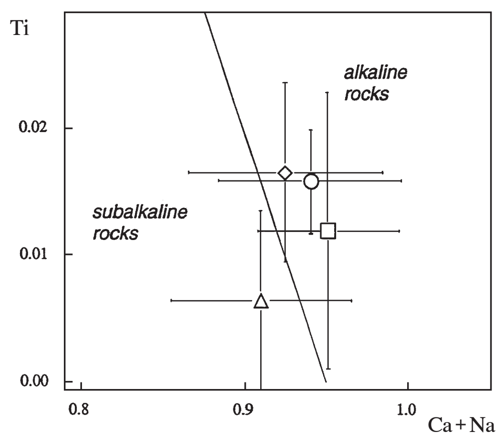

Fig. 5. Average and standard deviation of clinopyroxene compositions of phenocrysts (□, n = 6) and detrital single grains (◇, n = 9; ○, n = 7; △, n = 9); n = number of clinopyroxene grains analyzed in the different samples.

Table 4: Chemical composition of clinopyroxene detrital grains and phenocrysts (B-population volcanic grains).

Samples		SiO_2	TiO_2	Al_2O_3	FeO_{tot}	MnO	MgO	CaO	Na_2O	
2 (9)	x	52.39	0.23	1.57	9.54	0.67	13.41	21.60	0.59	**100.00**
	σ	0.24	0.25	0.23	0.68	0.13	1.03	0.99	0.23	
3 (9)	x	51.19	0.58	2.48	9.77	0.51	13.08	21.67	0.72	**100.000**
	σ	1.26	0.25	1.15	1.34	0.13	1.51	1.07	0.28	
5 (7)	x	51.35	0.56	2.36	9.14	0.50	13.20	22.26	0.63	**100.00**
	σ	0.60	0.15	0.94	1.04	0.28	1.34	1.01	0.26	
5 (6)*	x	51.49	0.42	2.56	8.17	0.39	13.62	22.84	0.51	**100.00**
	σ	1.60	0.35	1.27	1.50	0.25	1.35	0.82	0.20	

Number of analyzed clinopyroxenes within the brackets; x = average; σ = standard deviation; asterisk marks the analyzed clinopyroxenes representing the phenocrysts of volcanic clasts.

Table 5: Selected analyses of clinopyroxenes (detrital and phenocrysts*) from the B-population volcanic grains.

Chemical composition					N° of ions on the basis of 6 oxygens				
Samples	**2**	**3**	**5**	**5***	**Samples**	**2**	**3**	**5**	**5***
SiO_2	52.46	52.04	51.68	48.66	**Si**	1.944	1.950	1.940	1.819
TiO_2	0.40	0.23	0.47	0.91	**Al^{IV}**	0.056	0.050	0.060	0.181
Al_2O_3	1.75	1.50	1.80	5.08	**Σ T Site**	**2.000**	**2.000**	**2.000**	**2.000**
FeO_{tot}	9.84	7.68	9.40	8.85	**Al^{VI}**	0.020	0.016	0.020	0.043
MnO	0.55	0.56	0.71	0.28	**Fe^{3+}**	0.036	0.072	0.061	0.119
MgO	14.99	13.71	12.33	11.97	**Ti**	0.011	0.006	0.013	0.026
CaO	20.06	22.47	22.67	23.61	**Mg**	0.828	0.766	0.690	0.667
Na_2O	0.31	0.70	0.65	0.45	**Fe^{2+}**	0.269	0.169	0.234	0.158
Total	**100.36**	**98.89**	**99.72**	**99.81**	**Mn**	0.017	0.018	0.023	0.009
					Σ M_1 Site	**1.181**	**1.047**	**1.041**	**1.022**
					Ca	0.796	0.902	0.912	0.946
					Na	0.022	0.051	0.047	0.033
					Σ M_2 Site	**0.818**	**0.953**	**0.959**	**0.979**
					Ca %	40.91	46.83	47.50	49.82
					Mg %	42.54	39.76	35.95	35.14
					Fe %	16.55	13.41	16.55	15.04

K/Ar dating

Radiometric investigation was only possible for the porphyritic pebbles belonging to the A-population of volcanic fragments. Two pebbles were submitted to analysis in order to obtain the K/Ar ages measured for the whole rocks.

Measurement of K/Ar age was performed in the Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), Debrecen, using the conventional method. The interlaboratory standards Asia 1/65, HD-B1, LP-6 and GL-O as well as atmospheric Ar were also used for the calibration. Details about instruments, applied methods and results of calibration have been described elsewhere (Balogh 1985; Odin et al. 1982). Age was calculated with the constants suggested by Steiger & Jaeger (1977).

Table 6: K/Ar ages of two volcanic pebbles from the A-population volcanic grains.

Samples (whole rock)	K %	40 Ar (rad) 10^{-5} cc STP/g	40 Ar (rad) %	Age (My ± σ)
A	3.68	3.241	93.1	213 ± 8
B	2.85	2.959	94.5	249 ± 10

The obtained results are summarized in Table 6. The younger age of 213 ± 8 My (sample A) can be explained by admitting a loss of radiogenic Ar which frequently occurs in altered whole rock samples. The measured age of 249 ± 10 My (sample B) agrees with the Permian/Triassic boundary (245 My, Harland et al. 1990). Since some Ar loss may be assumed even for the sample B, related to the transportation of the pebble, its real geological age either coincides with the measured value or it is older.

Discussion and conclusive remarks

The above results show that two distinct volcanic sources fed the Reitano Flysch.

A calc-alkaline source, Late Permian in age, originates paleovolcanic clasts (i.e. non-coeval to the sedimentation, sensu Zuffa 1987), derived by the erosion of ancient volcanics probably linked to a late-Hercynian magmatism. The other source displays a well marked alkaline (potassic) affinity and originates products having textural and petrographic characters (angular shaped volcanic clasts, presence of well preserved augites and amphiboles) of a volcanism penecontemporaneous with the sedimentation and of a rapid burial after short-lived transports (i.e. coeval volcanic grains, B-population volcanic grains).

Our results have been compared with the geochemical data of several turbiditic successions cropping out in the southern and northern Apennines, showing a similar volcanism-induced sedimentation coeval to the deposition of the Reitano Flysch (Fig. 3). The volcanic fraction of these latter deposits always shows a calc-alkaline affinity, commonly interpreted as derived from the Oligocene-Miocene, subduction-related, magmatic arc of the Sardinia-Corsica microplate (Crisci et al. 1988; Critelli et al. 1990a,b). Nevertheless, this hypothesis of provenance can undoubtedly be excluded for the calc-alkaline volcanic pebbles of the Reitano Flysch (A-population), because of their older K/Ar age (minimum age is about 249 ± 10 My, i.e. Late Permian).

At first sight, the fine-grained alkaline volcanic clasts of the Reitano Flysch (B-population volcanic grains) could be related to the Late Paleocene-Early Eocene volcanic activity, responsible for the alkaline products of South-Western Sardinia (about 62–60 My, Assorgia et al. 1992). These last products, in fact, are the only Early Tertiary volcanics of Sardinia showing an alkaline character. Nevertheless, the petrographic and geochemical features of these Early Tertiary volcanics of Sardinia (SiO_2 ~ 39 %, MgO ~ 12 % and K_2O ~ 1.52 %, Maccioni et al. 1990) are very different from those of the analyzed clasts. Moreover, this hypothetical correlation is also in contrast with the textural characters recognized in the alkaline fraction of the Reitano Flysch which testify for volcanic events coeval with deposition.

Alkaline volcanism in Sardinia also occurred during Pliocene Tyrrhenian spreading (Beccaluva et al. 1977), but it cannot be compared with the alkaline volcanic B-population of the Reitano Flysch sandstones, whose age has recently been referred to the Early Oligocene (Cassola et al. 1992).

In conclusion, it seems difficult to relate the provenance of this alkaline volcanic fraction of the Reitano Flysch to the Oligocene-Miocene Sardinia-Corsica magmatic arcs. The source of the alkaline volcanism, in fact, may fairly be interpreted as the result of magmatic events located closely to the sedimentary basin during extensional processes. Tentatively, the Reitano Flysch could have a provenance similar to that already suggested for the Early Oligocene volcano-sedimentary beds from the Tertiary Piedmont Basin (D'Atri & Tateo 1994). In this way we would consider the deposition of the Reitano Flysch as coeval to the incipient break-up of the southern paleomargin of the European plate, which at that time included the Hercynian basement of the presently deformed Calabria-Peloritani Arc. This rifting phase widely affected the western Mediterranean region from the Rupelian-Chattian boundary (Cherchi & Montadert 1982a,b; Fanucci & Morelli 1995, 1997), preluding the opening of new oceanic areas (i.e. Algero-Provençal Basin and Sardinian Rift, Kezirian et al. 1994; Carmignani et al. 1995) and the translation and counterclockwise rotation movements of the Sardinia-Corsica microplate during Oligocene–Miocene times (Beccaluva 1989; Patacca & Scandone 1989). Therefore, the geodynamic significance of the alkaline neovolcanic fraction of the Reitano Flysch may be linked to these processes of tearing and thinning of the European continental crust occurred during Oligocene times. Successively to this process of early continental rifting and together with the drifting of the Sardinia-Corsica microplate, other volcanic events, calc-alkaline in nature, are commonly recorded within the Late Oligocene-Miocene successions widespread along the southern and northern Apennines as well as in the Sicilian Maghrebian Chain (i.e. Tusa Tuffites of Early Miocene age).

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