

The origin of the Columbretes Islands' basanitic and phonolitic magmas (Western Mediterranean)

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Introduction

The Columbretes island (Fig. 1) are only recent (Quaternary) volcanic action in the Western Mediterranean and represent the superficial representation of a large submerged volcanic field; measuring more than 90 km by 40 km (Maillard and Mauffet, 1993). They are located on a thin crust, with a thickness of 15 km (Martin and Surifiach, 1988) of which the first 5 km are sedimentary evaporitic rocks from the upper Tertiary.

The largest of the islands (Grossa I.) is made up one volcanic edifice. This is composed of basic rocks and was formed by 4 volcanic episodes; three hydromagmatic (I, II, IV) with a development of surges and an episode of pyroclastic fall (III). The age of this volcanism varies between 0.3 and 1 m.a. (Aparicio *et al.*, 1991). The smaller islands and eyots are comprised of massive salic rocks (flows), the age of which is not determined, although judging from its morphology it is probably similar to that of the Grossa island.

Mineralogy and Geochemistry

The basic materials of Grossa Island are alkaline basanites with normative nepheline, including olivine (crysholite), augite, plagioclase and amphibole (kaersutite) phenocrystals. Also quartz and plagioclase (oligoclase-andesine) as xenocrystals of metamorphic origin (corroded crystals with undulatory extinction) are present. The groundmass varies between microcrystalline and glassy with secondary zeolites and carbonates.

In all the pyroclastic surges, sedimentary rock xenoliths (limestones) and lithics from other substratum basalts are common.

The salic rocks from the eyots are phonolites and tephritic phonoites with sanidine, nepheline, amphibol (kaersutite) and opaques. Enclaves of sedimentary rocks, gabbros, and nephelinitic syenites (all of a small size; $\phi < 10$ cms) are present.

The basic rocks, when plotted on different structural diagrams, are placed in the within plate field and are related with the rifting zone which comprises the western Mediterranean (Araña *et al.*, 1983, Martí *et al.*, 1992) and also with the recent basaltic volcanism in the eastern Iberian peninsula.

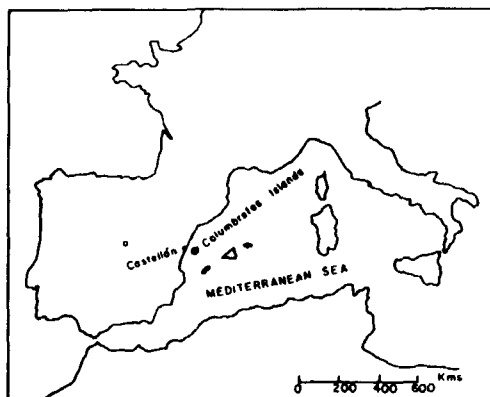


FIG. 1. Situation of Columbretes Islands in the Mediterranean Sea.

The temperatures obtained with an olivine-clinopyroxene geothermometer (Powell and Powell, 1974) in basanites of different episodes, show constant values of about 1018–1021°C at a pressure of 5 kbar which corresponds to a crustal thickness of approximately 15 km; similar to that in the Columbretes area.

Conclusions

The mineralogy and also the Sr^{87}/Sr^{86} isotopic values (Table 1) shows the possible genetic links between the basic and salic rocks of Columbretes

TABLE 1. Major elements of different rock types in Columbretes Islands

	Grossa I. Basanite 1	Bergantin I. Phonolite 2	Foradada I. Phonolite 3	Foradada I. Phonolite 4	Ferrera I. Phonolite 5	Ferrera I. Syenite 6	Ferrera I. Gabbro 7
SiO ₂	46.40	55.80	56.20	57.00	54.73	56.27	52.00
TiO ₂	2.36	0.78	0.55	0.81	1.05	0.81	2.52
Al ₂ O ₃	15.25	20.21	20.24	20.31	20.14	21.32	16.12
Fe ₂ O ₃	4.65	3.96	2.85	2.25	5.14	3.80	8.14
FeO	5.27	0.39	1.02	2.54	0.08	0.67	1.36
MnO	0.15	0.13	0.11	0.12	0.14	0.20	0.21
MgO	7.51	1.02	1.66	0.92	1.54	0.63	4.15
CaO	9.66	3.49	2.97	3.20	3.90	3.57	7.26
Na ₂ O	4.11	8.03	7.44	7.61	7.94	6.32	4.72
K ₂ O	2.30	4.69	4.82	4.58	3.73	5.43	1.52
P ₂ O ₅	0.74	0.22	0.17	0.25	0.33	0.36	1.11
H ₂ O	1.25	0.69	1.95	0.26	1.13	0.47	0.55
Total	99.65	99.41	99.98	99.85	99.85	99.85	99.66
Rb	53	152	108	122	44	104	30
Sr	824	579	486	431	450	628	792
Sr ⁸⁷ /Sr ⁸⁶	0.702940 ± 12	0.703084 ± 14	0.703087 ± 14	0.702963 ± 13	0.703019 ± 21	0.703022 ± 21	0.703267 ± 14

islands, considering the salic rocks as a differentiated magma from basic magma. The Columbretes islands are the only recent volcanism in the western Mediterranean. In submarine drillings near the Columbretes islands (Hsu, 1973; Pautot *et al.*, 1973) volcanic rock sequences have been found. The age and calcalkaline composition (andesitic) of these rocks show them to be of different origins from those studied at the Columbretes island. The ages of these andesitic rocks are > 16 m.a. (Ferrara *et al.*, 1973; Hsu and Ryan, 1973), similar to andesitic series from S.E. Spain (Bellon *et al.*, 1983) and from Alboran island (Western Mediterranean) Aparicio *et al.*, 1991. The genesis of these rocks is also related to shallow crustal anatectic processes (Munskgaard, 1984).

A genetic link can be established between the alkaline volcanism of the Columbretes Islands and that which exists in nearby areas as Cataluña (Araña *et al.*, 1983) and even in Central Europe (Wedepohl *et al.*, 1994) where rifting processes produce generation and upwelling of alkaline magmas from different levels of the mantle. The crustal thickness of these continental areas has been measured as more than 30 km, being characteristic the existence of ultramafic enclaves, whereas the crust at the Columbretes Islands measures less than 15 km and the absence

of ultramafic enclaves would indicate that the alkaline magma was generated in a relatively shallow mantle.

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