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A tentative pre-Variscan geodynamic model for the Palaeozoic basement of the Peloritani mountains (Sicily): evidence from meta-igneous products

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ABSTRACT. — Although the metavolcanics interbedded in the Palaeozoic basement of the tectonic units constituting the Peloritani belt show various and contrasting geodynamic affinities,. these rocks are the only record allowing us to establish the chronology of the extensive and compressive events which developed prior to the Hercynian orogenesis. For this reason, their study becomes very important in reconstructing a pre-Hercynian geodynamic model for the Peloritani area. This paper examines two of the most important metavolcanic successions, outcropping in the southern sector of the Peloritani belt. Geochemical analyses, carried out on these two metavolcanic successions, reveal different magmatic affinities: the first succession, Early Ordovician in age, has an alkaline basaltic composition and within-plate affinity; the second, Late Ordovician in age, consists of metavolcanics with orogenic affinity. Taking into account these different geochemical features, the present paper proposes a preliminary geodynamic model for the Palaeozoic basement of the Peloritani plate, spanning an interval from Late Cambrian- Early Ordovician to Late Ordovician.

RIASSUNTO. — Le metavulcaniti intercalate nel basamento Paleozoico delle unità tettoniche costituenti i Monti Peloritani mostrano varie e contrastanti affinità geodinamiche. Queste rocce sono l'unica testimonianza che permette di stabilire la cronologia degli eventi distensivi e compressivi sviluppatisi prima dell'orogenesi Ercinica. Per questo motivo, il loro studio diventa molto importante nella elaborazione di un modello geodinamico pre-Ercinico per l'area Peloritana. In questo lavoro sono state studiate due successioni metavulcaniche affioranti nel settore meridionale dei Monti Peloritani. Le analisi geochimiche hanno evidenziato una differente affinità magmatica: la prima successione, di età Ordoviciano inferiore, ha una composizione alcalina basaltica ed una affinità intra-placca; la seconda, di età Ordoviciano superiore, è costituita da metavulcaniti con affinità orogenica. Tenendo conto di queste differenti caratteristiche geochimiche, in questo lavoro proponiamo un modello geodinamico preliminare per il basamento Paleozoico della placca Peloritana per un intervallo di tempo compreso tra il Cambriano superiore - Ordoviciano inferiore fino all'Ordoviciano superiore.

KEY WORDS: *Pre-Variscan magmatism, Palaeozoic basement, paleo-geography, Peloritani Mountains*

INTRODUCTION

Preparing and presenting a geodynamic model for the pre-Hercynian history of the

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Calabrian-Peloritan Arc basements is hard, for the following reasons:

1) it is not easy to correlate different sectors of the chain because of the development of the Hercynian orogenesis (Bodinier *et al.*, 1986; Paris and Robardet, 1990; Pin, 1990).

2) the Alpine orogenesis caused considerable fragmentation and translation of the early Palaeozoic successions.

The first step in preparing a pre-Variscan model for the Peloritani sector is reconstruction of the original stratigraphic succession, which records the chronology of extensional and compressive events developing prior to the Hercynian orogenesis. These events are recorded by pre-Hercynian metavolcanics interbedded at various levels within the metamorphic suites which represent the basement of the lower tectonic unit of the Peloritani Mountains. Systematic study was therefore undertaken of the metavolcanics outcropping in the southern sector (Peloritani lower domain: Pld), where low-grade metamorphism has maintained the geochemical and textural features of the original magmatic rocks.

The study area is situated between the towns of Taormina and Mongiuffi-Melia where metavolcanics of different geodynamic settings outcrop, interbedded with metapelites of very low metamorphic grade.

The various chemical and petrographic features of these rocks make them helpful as stratigraphic markers.

The present paper describes a possible geodynamic scenario related to a time interval spanning from Late Cambrian to Late Ordovician.

GEOLOGICAL SETTING

During the last decade, renewed research has produced a number of data on the Variscan Fold Belt in Europe.

The Peloritani Chain is located in north-eastern Sicily and represents the southern part of the Calabrian-Peloritan Arc, a segment of the Variscan Belt linking the Southern Apenninic Range with the Apenninic-Maghrebid Chain (fig. 1).

The most important hypotheses regarding the evolution and geodynamic significance of the Calabrian-Peloritan Arc are the following:

a) according to Ogniben (1970) and Boullin *et al.* (1986), this domain is a fragment of the Europe paleo-margin;

b) according to Alvarez (1976) and Bonardi *et al.* (1976) it is a fragment of the Alpine orogenic belt, originated from the African domain and emplaced on the Apenninic-Maghrebian domains during Neogene times.

The Peloritani belt is an Alpine collisional chain consisting of a pile of nappes composed by a Palaeozoic basement metamorphosed during the Hercynian orogenic cycle and Meso-Caenozoic covers. According to tectono-metamorphic histories, these nappes can be grouped into two domains (Atzori et al, 1994; Cirrincione and Pezzino, 1994).

The upper domain, in the north-eastern part of the belt, consists of two tectonic units (Mandanici and Aspromonte) showing Hercynian metamorphism ranging from low to high grade, with an Alpine greenschist metamorphic overprint.

The lower domain outcrops in the southern part of the Peloritani belt in three tectonic thrust sheets having a Hercynian metamorphic basement composed mainly of metapelite and quartz schist with some marble and minor metabasite, showing very low to low-grade metamorphism, overlain by Mesozoic-Caenozoic sedimentary rocks without an Alpine metamorphic overprint. The metamorphic features of the basement have been described previously by Atzori and Ferla (1979), Pezzino (1982) and Cirrincione *et al.* (1999).

The metavolcanic rocks examined in this paper come from two areas within the lower domain:

1) Mongiuffi-Melia (MM samples)

2) Taormina-Castelmola (TC samples).

The Mongiuffi-Melia metavolcanics may represent the oldest magmatic event in the Peloritani mountains (Acquafredda *et al.*,

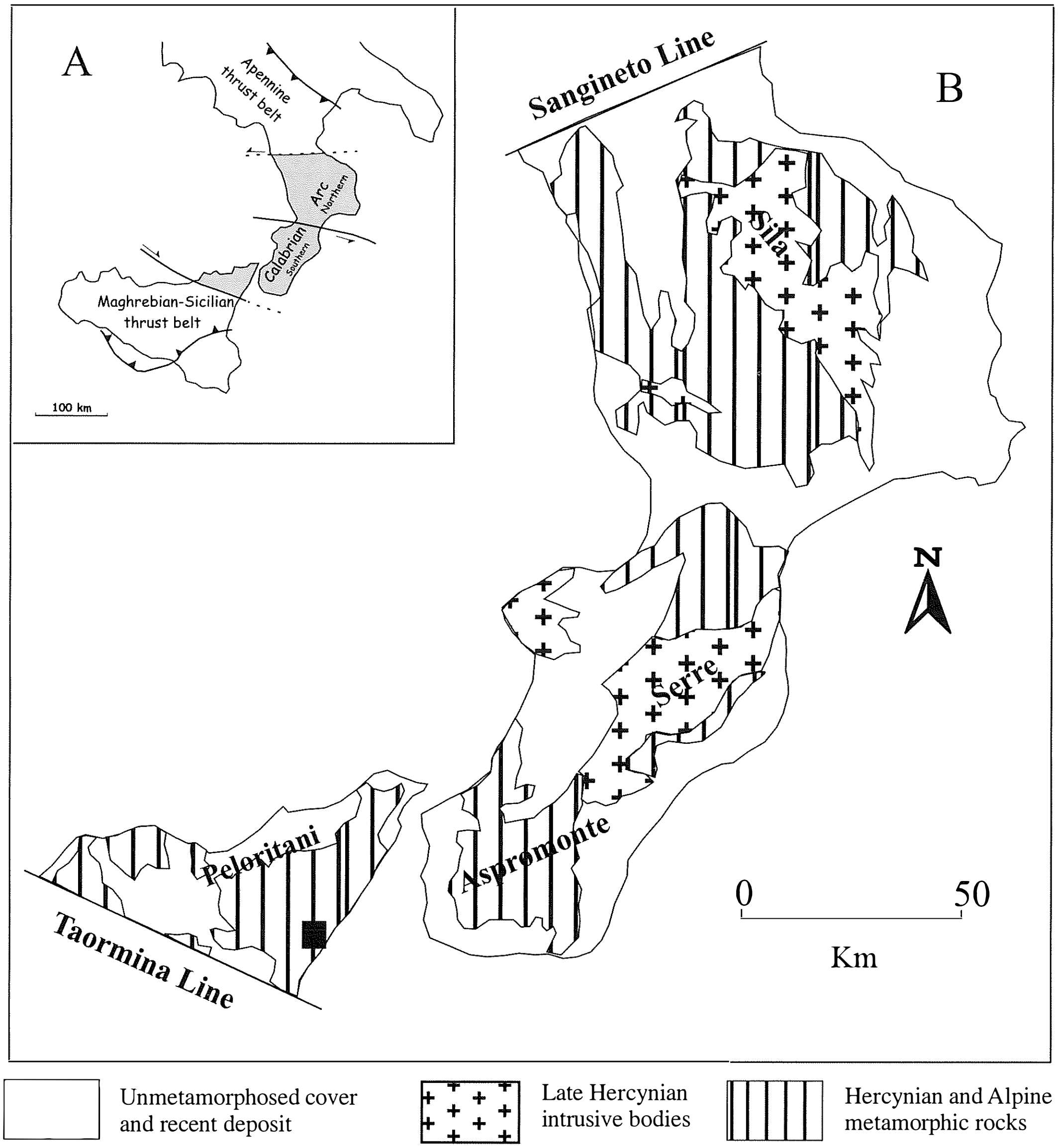

Fig. 1 – **A)** Location of Calabrian-Peloritan Arc (grey); **B)** Geological map of Calabrian-Peloritan Arc (from Atzori *et al.*, 1981, modified). Full square: location of area shown in fig. 2.

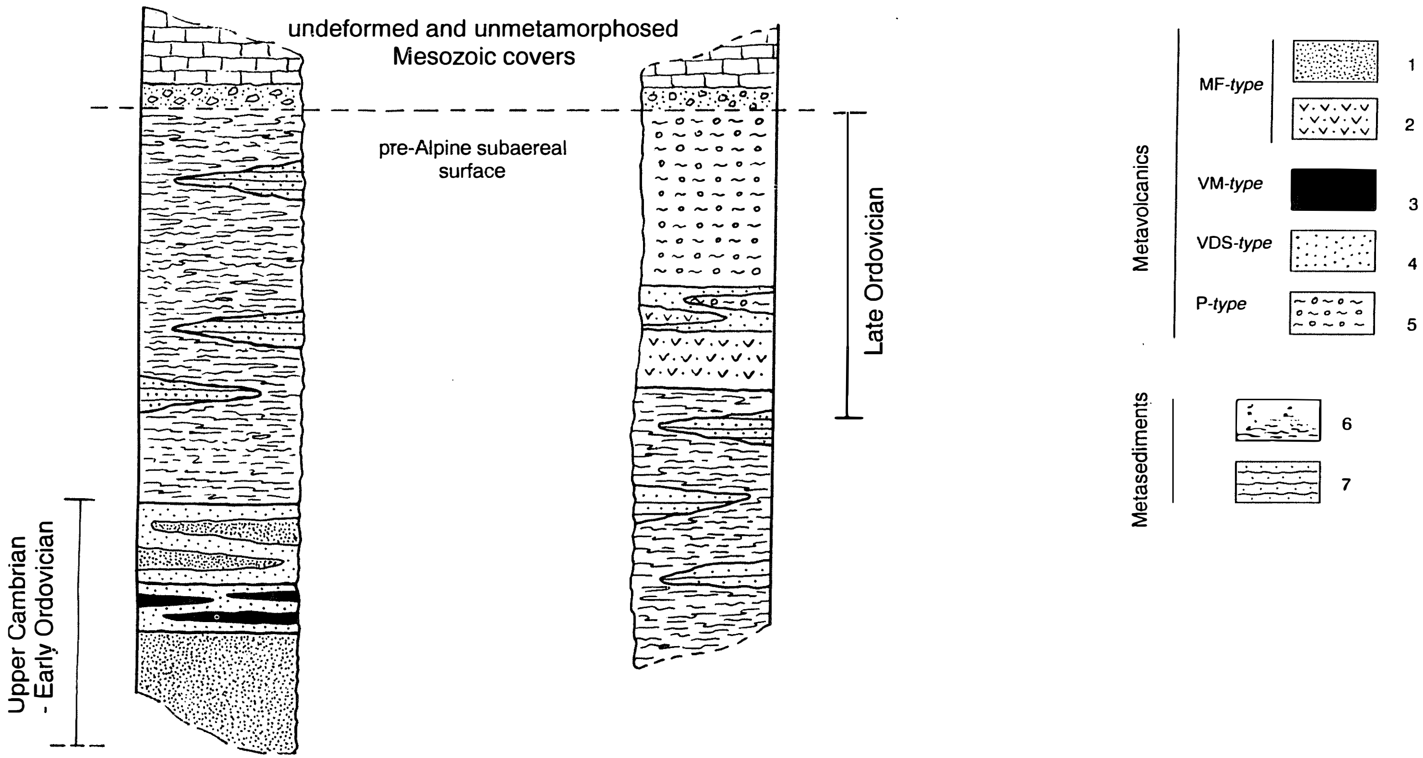

Fig. 2 – Stratigraphic successions of Mongiuffi-Melia and Taormina sequences. 1: Metabasite with alkaline affinity; 2: Meta-volcanics with andesitic to dacitic composition of orogenic affinity; 3: Metabasite with alkaline affinity; 4: Volcanic-derived sediments; 5: Porphyroids; 6: Metapelites; 7: Metapsammites.

1994). Owing to the occurrence of fossils in the underlying metapelitic layers (Majesté-Menjoulas *et al.*, 1986; Boullin *et al.*, 1987), the MM event is dated Late Cambrian-Early Ordovician. The succession is composed of metabasalt and metavolcanoclastic rocks with alkaline affinity (Ferla, 1978; Ferla and Azzaro, 1978).

The Taormina-Castelmola succession displays a Late Ordovician age (Acquafredda *et al.*, 1994). It is composed of metavolcanics varying in composition from andesitic to rhyolitic (Atzori el al., 1983; Atzori and Ferla, 1992), of orogenic affinity, interbedded with thick layers of metavolcanoclastic rocks.

Sections studied and field observations

On the basis of field and structural observations, the metavolcanics may be subdivided into four different rock types:

1) green metabasite (MF), with massive structure and minor metamorphic foliation, constituting the entire lower portion of the Mongiuffi-Melia and Taormina-Castelmola successions, and are found in layers 0.5 to 3-4 m thick, interbedded with other rocks from both units. They represent the metamorphic product of an early massive lava flow.

2) metavolcanoclastic rock types (VDS), characterised by marked foliation and colours varying from grey-green to violet. They represent the metamorphic product of volcanoclastic layers, thicknesses varying from a few centimetres to 4-5 m.

3) vesicular metabasite (VM) with massive structure; the metamorphic foliation is less evident. This only outcrops in the Mongiuffi-Melia unit in layers 1-2 m thick interbedded in the MF and VDS rock types. Empty vesicles suggest that this rock type represents the metamorphic product of vesicular lava flows.

4) porphyroid (P) with massive to foliate structure, from grey to green in colour. The original porphyric structure is also visible on a macroscopic scale. This rock type outcrops only in the Taormina unit. The lower part of the succession contains layers with thicknesses varying from 1 to 10 cm of P interbedded in VDS rock type; in the upper part they give rise to a single body.

The Mongiuffi-Melia succession (80 m thick) contains three sub-units:

a) lower, represented by MF-type metabasites;

b) intermediate, 15 m thick, of VDS alternating with VM rock type;

c) upper, 45 m thick, consisting mainly of VDS rock type and 0.5-3 m thick layers of MF type metabasite (fig. 2).

The Taormina succession (170 m thick) represents a quite dominant volcanic succession, which may be divided into three sub-units:

a) lower, 30 m thick, consisting of MF type rocks;

b) intermediate, about 70 m thick, of VDS rock type and occasional intercalations of MF and P types;

c) upper, 70 m thick in Castelmola and 120-130 m thick in Monte Puretta, consisting entirely of P rock types (fig. 2).

Petrography

MF Type

The MF rock type is characterised by massive structure and poorly defined metamorphic foliation. The groundmass is quartz-feldspathic with various amounts of chlorite. Apatite and Fe-Ti oxides are common accessory minerals. Under the microscope, the porphyric texture is well recognisable, with phenocrysts of plagioclase and femic minerals, now transformed into amygdaloid associations of *Chl+Cal+Qz+Ep* or *Chl+Cal*. The metamorphic paragenesis is represented by the association «*Chl+Cal*», called «Transitional Facies» by Liou *et al.* (1985, 1987) not diagnostic to establish the P-T conditions of metamorphism. However, in both successions (Mongiuffi-Melia and Taormina), rocks with pumpellyite and prehnite relicts confirm that sub-greenschist facies metamorphism (prehnite-pumpellyite zone) was reached (Cirrincione *et al.*, 1999).

VM Type

Vesicular metavolcanic rocks with massive structure and poorly defined foliation. Igneous textures, intersertal and intergranular, are well preserved; the grain size is finer compared with the MF type. The matrix presents plagioclase needles, oxides, calcite and minor chlorite, epidote, titanite, +/- prehnite; rutilo and white mica are present as accessory minerals. Amygdales of calcite, and calcite+white mica are peculiar to the rock. They are 0.5 cm in size and may represent up to 30% of the rock.

P Type

Porphyroids are characterised by massive to foliate structure, depending on the amount of mica (sericite). The poorly foliated type still contains relicts of the original porphyric texture, with idiomorphic phenocrysts of quartz, K-feldspar and minor albite; these phenocrysts often show corrosion loops. Mesostasis shows several different levels of recrystallization and consists of quartz, K-feldspar, epidote and sericite. Spherulitic and vesicular texture, elongated patches of white mica and Fe-oxide, and flux structure are very frequent. The structural and petrographic evidence of P type rocks suggests that their protolith was an original succession of acid effusive products, such as lava flows and ignimbrites.

VDS Type

The VDS type shows marked schistosity, with alternating granoblastic and lepidoblastic beds. The granoblastic ones consist mainly of quartz and calcite, with lesser quantities of albitic plagioclase; the lepidoblastic layers are defined by chlorite, with minor white mica and quartz in minute grains.

GEOCHEMICAL DATA

The geochemical data of a selection of samples were compared with those known in the literature (Ferla, 1978; Ferla and Azzaro, 1978; Atzori *et al.*, 1983), confirming the affinities of the two successions.

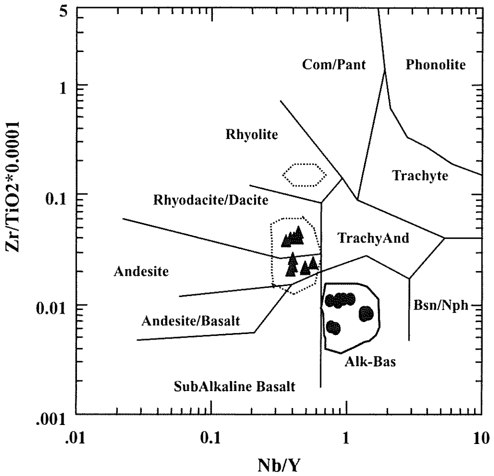

Fig. 3 – Classification of metavolcanics using immobile element ratios (Winchester and Floyd, 1977). Dashed line: field of meta-alkali basalts (from Ferla, 1978; Ferla and Azzaro, 1978b); Dotted line: field of orogenic meta-volcanics ranging from basalt to rhyolite (from Atzori *et al.*, 1983); full circles: MM samples; triangles: TC samples.

The chemical analyses of selected metabasites for both areas are listed in Tab.1. Major elements were determined by XRF; H_2O was calculated by weight analysis and MgO by atomic absorption. Trace elements and REE

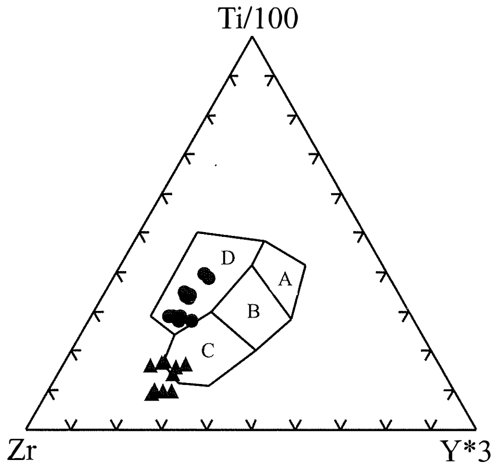

Fig. 4 – Discriminant Ti-Zr-Y diagram (from Pearce and Cann, 1973). A: island-arc tholeiites; B: MORB, island-arc tholeiites and calc-alkali basalts; C: calc-alkali basalts; D: within-plate basalts. Symbols as in fig. 3.

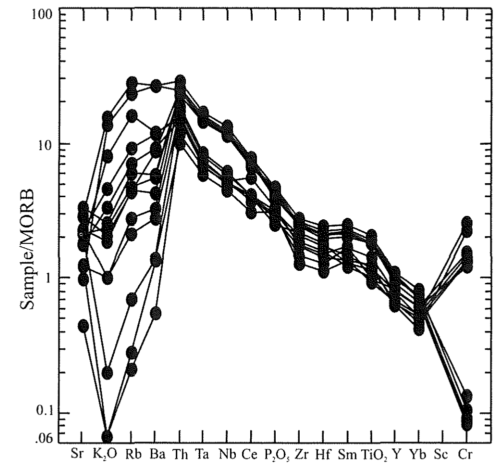

Fig. 5 – Spider-diagram for MM metavolcanics. Values normalized to MORB (after Pearce, 1982)

were measured by ICP-MS at the Nancy laboratory (CNRS).

Taking into account that the metavolcanics underwent alteration and metamorphism, some elements may have been mobile. For this reason, emphasis was placed on high field strength elements (HFSE: Th, Nb, Zr, Hf, Ti, Y) which are considered to be relatively immobile.

MM succession

All samples have basaltic composition. Trace element analysis indicates the alkaline affinity of the MM samples (Ferla, 1978; Ferla and Azzaro, 1978).

Using the less mobile element plot, the Nb/Y vs Zr/TiO_2 classification diagram of Winchester and Floyd (1977), all the samples fall exclusively within the field of alkaline basalts (fig. 3). The Zr-Ti-Y discrimination diagram (Pearce and Cann, 1973) was used to define the geochemical nature of the basaltic metavolcanics. The samples fall in the field of within-plate basalts (fig. 4).

The development of the metavolcanics in a within-plate environment is also suggested by analysis of their trends in the spider-diagram normalised to MORB (Pearce, 1982) (fig. 5).

TC Succession

The samples show a wide range of SiO_2. Intermediate-acidic products prevail in the lower sub-unit; the massive layers of the intermediate sub-unit have compositions ranging from intermediate to acidic; the products of the upper sub-unit are mainly acidic.

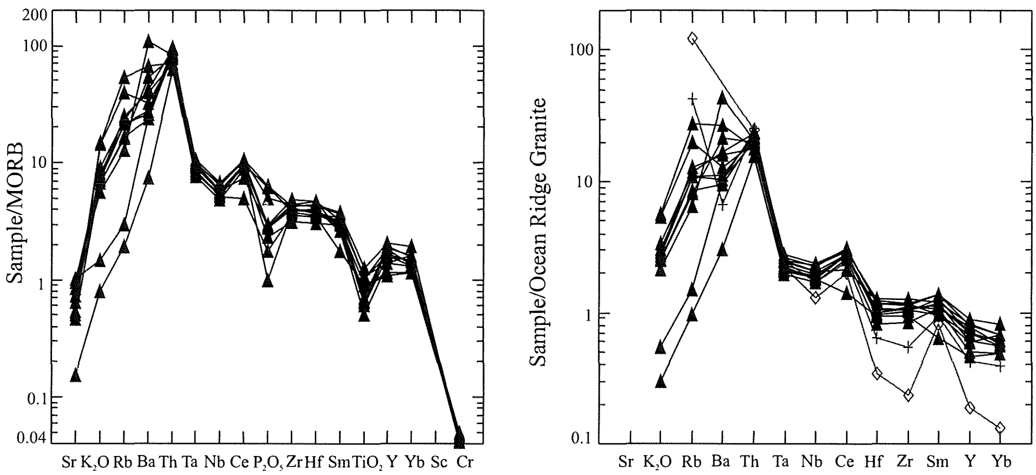

Fig. 6 – Spider-diagram for TC metavolcanics: a) values normalized to MORB; b) values normalized to ORG (Ocean Ridge Granite). Triangles: TC samples; crosses: Chile VAG; diamonds: S.W. England COLG (from Pearce *et al.*, 1984).

TABLE 1

Chemical analysis of selected metavolcanics from Mongiuffi-

	TC 8	TC 9	TC 11	TC 17	TC 21	TC 25	TC 30	TC 33	TC 34	TC 35	TC 37	MM 1	MM 2
SiO_2	56.58	63.49	66.05	64.14	68.41	52.58	59.42	63.09	60.11	44.18	52.2	41.79	40.53
TiO_2	1.06	0.97	0.9	0.99	0.77	1.52	1.61	1.34	1.53	1.36	1.87	2.69	2.72
Al_2O_3	17.24	14.65	14.11	15.56	13.45	17.38	17.32	15.85	16.96	16.68	20.03	16.89	16.82
Fe_2O_3	11.58	9.82	9.18	8.99	8.35	15.87	11.82	10.5	9.43	23.93	11.87	12.53	12.95
MnO	0.1	0.1	0.08	0.08	0.05	0.14	0.16	0.05	0.06	0.15	0.12	0.18	0.12
MgO	1.29	0.88	1.16	0.8	1.4	2.78	1.23	1.16	1.47	5.12	2.84	6.45	4.21
CaO	1.4	1.09	0.61	0.62	0.23	1.08	1.09	0.34	1.23	0.87	1.25	6.64	8.29
Na_2O	7.27	4.85	4.46	5.03	4.37	3.9	3.3	2.89	5.38	1.43	4.25	4.83	3.81
K_2O	0.22	0.85	1.01	1.36	1.09	1.02	2.14	2.26	1.15	0.12	1.2	0.35	2.32
P_2O_5	0.36	0.34	0.33	0.35	0.12	0.59	0.74	0.21	0.77	0.28	0.76	0.52	0.5
Ba	510	2154	1079	833	510	472	638	1322	788	150	552	109	531
Be	2.17	3.59	3.06	2.55	2.15	1.62	1.77	2.89	1.48	0.65	2.03	1.77	2.55
Cd	0.13	0.3	0.04	0.13	0.13	0.11	0.13	0.07	0.07	0.05	0.14	0.13	0.17
Ce	104	94.8	98.8	74.6	96.5	108	97.5	49.3	95.2	89.2	106	74.5	71.03
Co	12.1	10.6	10.4	13.2	8.48	17.4	22.9	6.13	7.96	14.1	36.6	38.4	42.7
Cr	11.3	10.4	12	10.6	10.4	10.8	12.6	12.3	11.8	11.5	10.6	21.6	23
Cs	0.61	2.24	4.37	4.63	2.94	2.6	4.42	6.93	3.64	0.57	4.27	0.51	2.74
Cu	37.1	32.6	30.5	31.3	16.8	21.6	26.4	14	19.8	8.3	23.7	41.7	46.3
Dy	9.11	9.26	8.19	7.47	7.49	9.87	7.64	5.91	8.63	7.37	10.8	5.61	5.79
Er	5.23	4.56	4.51	4.24	4.46	5.7	4	3.57	4.92	3.54	6.48	2.65	2.73
Eu	2.11	2.11	1.94	1.48	1.69	2.39	2.25	1.41	2.35	2.04	2.63	2.37	2.39
Ga	31.5	27.1	22.1	25.1	23.1	29.8	26.5	26.1	24.3	38.1	32.5	24.3	23.4
Gd	10.2	9.67	9.64	7.83	8.1	11.7	9.66	5.69	10.7	8.92	11.8	6.71	6.8
Hf	11.3	8.88	8.99	11.1	9.69	10.4	9.28	8.39	8.64	7.26	10.5	4.97	5.04
La	50.3	44.5	47.5	34.6	43	47.7	45.5	22.9	38.4	41.7	46.8	38.13	35.41
Lu	0.873	0.694	0.72	0.79	0.918	0.848	0.67	0.577	0.786	0.589	0.984	0.36	0.36
Nb	23.2	19.1	18.7	20.6	17.9	22.2	20.5	18.2	19.7	17	23.6	41.16	42.31
Nd	50.7	46	49	40.2	42	56.6	48.2	27	54	44.3	58.3	34.51	32.69
Ni	7.8	7.3	10.9	11	7.1	5.8	9	7.6	5.8	9.1	12.1	33.2	41.4
Pb	32.6	34.6	19.5	12	8.83	24.1	14.8	13.7	13.3	7.97	16.2	4.29	6.11
Pr	12.4	11.6	12	9.44	10.4	13.5	12.1	6.51	12.4	10.9	13.7	8.21	8.04
Rb	5.93	25.6	32.4	47.6	42.9	34.1	79.7	108	50.5	3.89	42.9	9.4	55.87
Sm	10.7	9.77	10.1	8.56	8.75	12.3	10.4	5.78	11.4	9.72	12.5	7.12	7.07
Sr	124	121	103	87	55.4	76.6	60.4	64.2	115	18.6	115	257	351
Ta	1.75	1.48	1.45	1.71	1.53	1.83	1.73	1.56	1.63	1.38	1.94	2.63	2.7
Tb	1.51	1.54	1.42	1.15	1.28	1.64	1.38	0.942	1.47	1.28	1.88	0.97	1.03
Th	19	16.3	15.8	18.5	16.3	17	15.7	14.2	14.2	12.4	17.7	4.88	4.86
Tm	0.864	0.817	0.718	0.796	0.778	0.849	0.625	0.585	0.716	0.578	0.979	0.4	0.4
U	4.6	4.09	3.71	4.3	3.12	4.33	3.56	2.24	3.61	2.37	5.8	1.04	0.98
V	36	32.6	29.9	30.5	22.6	39.4	57.3	56.7	50	62.6	61.6	236	246
Y	57.3	54	48.4	46.7	40.9	55.9	42	32.1	49.2	34.7	61.5	30.1	31.3
Yb	5.36	4.63	4.49	4.95	5.47	5.43	4.48	3.89	4.81	3.86	6.62	2.4	2.42
Zn	168	152	140	139	109	178	178	85	148	266	223	131	129
Zr	431	373	367	393	355	396	354	320	341	288	385	224	230

Melia (MM) and Taormina- Castelmola (TC) successions.

MM 3	MM 4	MM 5	MM 6	MM 9	MM 20	MM 21	MM 23	MM 24	MM 29	MM 46	MM 47
39.41	39.5	42.88	43.08	44.28	41.98	37.07	40.82	45.79	40.23	42.91	43.15
2.68	3.07	2.73	2.87	2.7	1.51	1.38	1.47	1.76	1.73	2.14	1.89
17.14	18.24	17.4	17.08	16.4	14.16	12.49	13.79	15.03	13.64	14.54	13.27
15.42	14.78	11.72	12.83	12.35	9.71	9.82	9.39	9.31	11.12	14.2	12.32
0.16	0.12	0.19	0.14	0.15	0.06	0.07	0.05	0.12	0.15	0.09	0.11
7.19	6.77	6.33	6.48	6.29	2.48	2.71	2.82	8.59	10.42	12.03	10.38
5.33	4.29	6.1	5.55	5.54	12.77	16.39	13.21	6.31	9.17	3.71	6.89
4.25	3.11	4.97	4.98	5.07	6.23	5.65	5.63	4.91	2.23	2.07	2.26
0.31	2.04	0.38	0.28	0.15	0.69	0.5	1.21	0.15	0.03	0.01	0.01
0.47	0.57	0.56	0.51	0.53	0.37	0.33	0.4	0.38	0.3	0.35	0.37
171	529	116	85	64	231	183	240	56	28	11	27
1.83	3.91	1.09	2.07	1.89	1.58	1.28	1.51	1.73	1.45	1.2	1
0.12	0.13	0.19	0.24	0.19	0.12	0.07	0.08	0.15	0.1	0.04	0.07
71.12	77.08	68.7	76.79	66.58	37.1	40.51	54.9	41.64	40.18	41.44	31.15
41.4	40.5	37.6	35.5	34.2	26.5	29.2	29.4	42.2	42.2	53	48
33.6	26.3	22.2	23.3	21	335	331	302	381	364	633	561
1.18	2.53	1	0.503	0.475	0.855	0.68	1.01	0.166	0.205	0.079	0.115
38.6	38.4	37.7	34.9	33.6	23.5	26.6	22.6	36.7	59.6	45.4	62.7
5.64	6.15	5.67	6	5.07	3.65	3.6	4.62	4.31	3.82	4.46	3.68
2.8	3.07	2.69	2.8	2.4	1.81	1.85	2.29	2.07	1.93	2.01	1.76
2.37	2.69	2.22	2.48	2.14	1.39	1.35	1.76	1.57	1.57	2.02	1.67
26.3	27.5	24.3	22.9	21.6	17.8	15.7	20.1	22.4	22	20.6	19.6
6.83	7.84	6.95	7.61	6.2	4.16	4.32	5.6	4.77	4.34	5.38	4.49
5.05	5.82	5.15	5.37	4.71	3.78	3.46	3.61	4.13	4.37	3.11	2.72
36.03	37.24	33.55	39.1	33.68	17.93	20.57	26.59	19.29	19.85	18.34	13.52
0.35	0.41	0.36	0.36	0.35	0.251	0.27	0.32	0.29	0.245	0.237	0.209
40.93	46.44	40.62	42.81	39.78	18.29	17.53	18.36	20.59	21.74	17.77	15.69
33.14	37.23	30.61	34.93	30.52	17.24	20.06	25.98	20.41	19.62	23	18.04
43.2	33.5	28.4	30.3	26.8	84.2	95	114	133	125	246	226
7.98	7.13	4.71	5.36	5.3	5.37	5.95	5.5	3.68	4.61	5.53	4.54
7.88	8.76	7.56	8.44	7.47	4.24	4.56	6.19	4.77	4.48	5.08	3.9
8.73	46.49	11.96	9.02	5.54	18.46	13.87	32.14	4.22	1.4	0.421	0.56
7.3	8.18	7.15	7.58	6.57	3.96	4.45	5.66	4.81	4.21	5.58	4.44
342	117	401	276	267	265	212	216	146	254	53.3	148
2.66	3.06	2.64	2.84	2.55	1.33	1.23	1.31	1.44	1.53	1.19	1.04
1	1.09	0.95	1.07	0.91	0.63	0.62	0.81	0.77	0.63	0.8	0.65
5.07	5.7	4.84	5.1	4.53	3.22	2.94	3.05	3.47	3.72	2.29	1.99
0.4	0.46	0.4	0.41	0.36	0.29	0.27	0.35	0.32	0.28	0.29	0.26
1.3	1.3	0.99	1.05	0.96	0.54	0.57	0.51	0.81	0.87	0.52	0.51
228	304	228	239	231	204	182	166	216	228	244	226
28.7	32.4	30.3	31.5	27.5	19.3	19.9	24.4	24.1	20.5	23.2	19.9
2.54	2.77	2.52	2.42	2.26	1.71	1.587	2.05	2.05	1.82	1.77	1.443
138	136	124	118	112	73.4	78.1	88	93.1	101	117	102
225	250	221	238	220	167	155	158	187	194	133	116

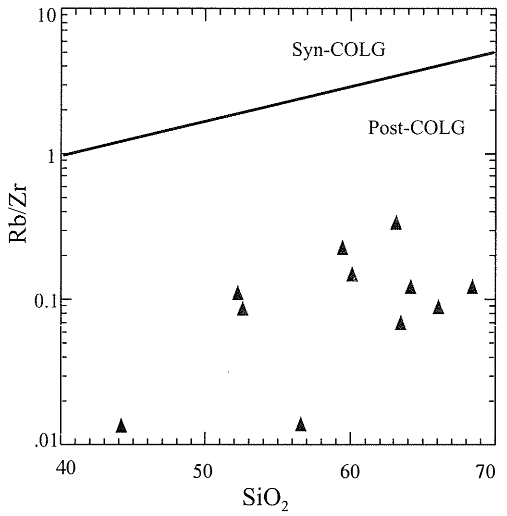

Fig. 7 – Rb/Zr *vs* SiO2 discriminant diagram (from Harris *et al.*, 1986). Symbols as in fig. 3.

The prevailing acidic character of the metavolcanics of the Taormina area, with SiO_2>65%, must be emphasized.

The Harker diagrams reveal the negative relations of TiO_2, MgO, Fe_2O_{3tot}, P_2O_5 and Al_2O_3, and the positive ones of the alkalis. CaO and alkali dispersions are probably linked to selective mobilisation, which took place during deuteric alteration of lava flows.

Trace element analysis reveals the subalkaline affinity of these metavolcanics (fig. 3); their protoliths may be classified as andesite to rhyolite (Atzori *et al.*, 1982).

Although the tectonic discriminant diagrams do not give straightforward indications, some discriminations may be made with Zr-Ti-Y (Pearce and Cann, 1973) (fig. 4). The data-points of the Taormina samples, intermediate in composition, fall mainly in the calc-alkaline field.

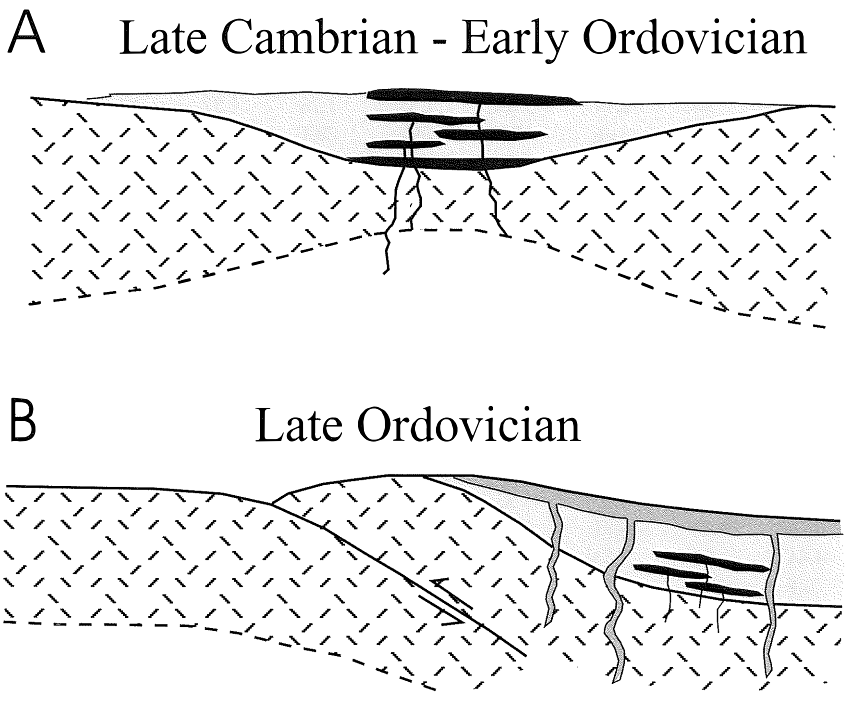

Fig. 8 – Sketch of geodynamic evolution of Hercynian basement of Peloritan microplate. Line: continental crust; light grey: metavolcanoclastic layer; black: metavolcanics of alkaline affinity; dark grey: metavolcanic products of andesitic-rhyolitic composition.

The spider-diagram normalised to MORB (Pearce, 1982) (fig. 6a) shows enrichment of mobile elements and negative anomalies for Nb, P_2O_5 and TiO_2, characteristic of the subduction zone.

The Ocean Ridge Granite normalised pattern of the Taormina samples (fig. 6b) has a shape which fits well with collisional (S.W. England) and volcanic-arc (Chile-like) patterns, even considering that the plot of the elements on the left side may have been distorted by their mobility.

In the Rb/Zr *vs* SiO_2 diagram (Harris *et al.*, 1986), the position of the samples suggests a post-collisional environment (fig. 7).

Discussion

Late Cambrian-Upper Ordovician plate-tectonics scenario in Europe

Two major domains, Gondwana and Baltica, which were temporally separated by a mid-European Rheic Ocean, played a prominent role in the palaeogeographical evolution of Europe. One open question is how and when the closure of the ocean occurred (Bodinier *et al.*, 1986; Matte, 1986; Paquette *et al.*, 1987; Pin, 1990). In the early Palaeozoic, some palaeogeographic reconstructions (e.g., Bodinier *et al.*, 1986; Paris and Robardet, 1990) locate the South Armorican Ocean, which appears as a branch of the Rheic Ocean, between the Armorica and Gondwana plates.. The suture zone of this ocean is now located in the Massif Central, the external Crystalline Massifs of the Eastern Alps, and along the «Posada-Asinara Line» in northern Sardinia (Paris and Robardet, 1990; Carmignani *et al.*, 1992).

In the Late Cambrian-Early Ordovician, the sedimentary and magmatic record suggests that most of the sedimentary basin within the future Variscan Belt originated during a large-scale rifting episode, which led to the splitting up of Gondwana (Paris and Robardet, 1990).

During the Middle Ordovician, several pieces of evidence support the hypothesis of

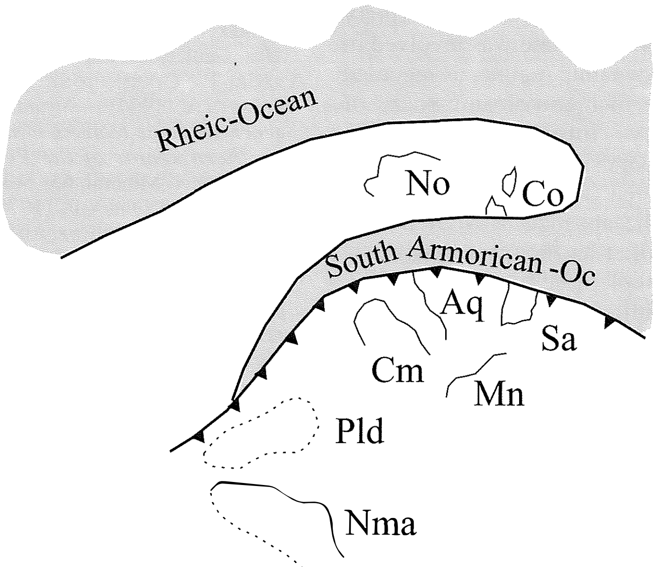

Fig. 9 – Late Ordovician paleogeography (from Paris and Robardet, 1990, modified). Grey: oceanic crust; White: continental crust; Sa: central and southern Sardinia; Co: northern Sardinia and Corsica; No: Normandy; Cm: Cantabrian Mountains; Aq: Aquitania; Mn: Montagne Noire; Nma: Northern Maghrebid; Pld: Peloritan lower domain.

subduction under the Gondwana continental crust, causing an Andean-type volcanic arc. This is well recognised in southern and central Sardinia, where the subalkaline character of the magmatic activity, combined with the prevalence of acidic effusives, is characteristic of an orogenic suite involving continental crust (Carmignani *et al.*, 1992). These products are similar to other Lower Palaeozoic igneous rocks occurring everywhere in the Hercynian massifs of the Mediterranean area (Sardinia, Spain, Massif Central, etc.).

Taking into account the petrographic and geochemical features discussed above, we propose here a preliminary geodynamic model for the *Pld* (Peloritani Lower Domain) microplate, spanning a time interval from Late Cambrian-Early Ordovician to Late Ordovician.

Comparing the studied area with other sectors of the Variscan Chain, the succession of events occurred at different times and different rates, probably as a result of the original position of the Pld microplate.

The two most important stages of the model are as follows:

– during the Late Cambrian-Early Ordovician, the Pld microplate was involved in an extensional geodynamic regime, as recorded by the occurrence of metavolcanic rocks of alkaline affinity interlayered within metasedimentary deposits, outcropping in the Mongiuffi-Melia area (Ferla, 1978; Ferla and Azzaro, 1978). The absence of MORB-type products suggests that an incipient episode of continental rifting took place (fig. 8a).

– during the Middle-Late Ordovician, the Pld microplate was involved in subduction, as were other sectors of the Variscan Chain (Paris and Robardet, 1990; Pin, 1990). The occurrence of metavolcanic products of late-orogenic affinity (andesite, dacite and rhyolite in the Taormina succession) indicates emplacement in an environment close to an active margin (fig. 8b). Underthrusting of continental crust is suggested, because the absence of oceanic crust is presumed. In view of the projections of the metavolcanics in some discriminant diagrams, their most probable tectonic setting is a late orogenic environment.

The geochemical features of the Palaeozoic metavolcanic rocks, together with stratigraphic data, indicate that the Pld microplate may probably be located within a pre-Variscan geodynamic model. During the Late Cambrian-Early Ordovician, the Pld may have been positioned in a marginal zone of the South Armorican Ocean (e.g., its south-western termination) (fig. 9), thus clearly explaining the diachronism existing between the rifting episode in Pld, dated to the Cambro-Ordovician and ending early with an intracontinental stage, and other sectors of the Hercynian Chain, such as Sardinia, where an oceanic setting with MORB-type rocks was present at the same time (Carmignani *et al.*, 1992).

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