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# GEOLOGICAL CONSTITUTION AND EVOLUTION OF THE CALABRO-PELORITAN HERCYNIAN RANGE

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RIASSUNTO. — Viene presa in esame la costituzione della Catena Ercinica calabro-peloritana e la sua evoluzione a partire da tempi pre-ercinici.

La Catena è formata da un basamento « cristallino » pre-mesozoico e da una copertura mesozoico-cenozoica. Nel basamento si distingue:

- la *parte superiore,* costituita da un frammento di un orogene pre-ercinico (caledoniano?) in posizione complessivamente rovesciata e suddiviso in numerose unità tettoniche erciniche;
- la *parte inferiore,* costituita da metasedimenti prevalentemente devoniani depositatisi in un bacino prospicente all'orogene « caledoniano ».

L'edificio ercinico è intruso da magmatiti tardo-erciniche.

Le principali interpretazioni relative all'evoluzione geologica della Catena sono le seguenti:

nella Catena vi sono testimonianze di un'orogenesi caledoniana (?), che è stata accompagnata da fenomeni metamorfici, magmatici, sedimentari ancor oggi in parte riconoscibili;

l'orogenesi ercinica, assai complessa, è caratterizzata da due eventi metamorfici principali, il primo dinamico ed il secondo termico; da un vulcanesimo iniziale con prodotti dapprima basaltico-alcalini, poi calc-alcalini e riolitici; da un magmatismo intrusivo tardivo con magmi dapprima di anatessi profonda, poi di anatessi superficiale e iperalluminosi. Si ritiene che l'orogene ercinico si sia formato al margine meridionale del continente paleoeuropeo; l'orogenesi viene inquadrata in un modello con subduzione di litosfera a crosta almeno in parte oceanica.

L'orogenesi alpina — considerata soltanto per gli effetti che ha prodotto all'interno della Catena Ercinica — è responsabile essenzialmente di scagliamenti e frantumazioni con traslazioni relative rigide. Di particolare rilievo è la discontinuità determinatasi all'altezza dello stretto di Messina: i Peloritani, originariamente a SE dell'Aspromonte, hanno subito in tempi post-eocenici una traslazione con rotazione di 90° circa in senso orario che li ha portati nella posizione attuale.

ABSTRACT. — An examination is made of the constitution of the Calabro-Peloritan Range and its evolution starting from pre-Hercynian times.

The Range is formed by a pre-Mesozoic « crystalline » basement and a Mesozoic-Cenozoic cover. In the basement it is possible to distinguish:

- an *upper part,* consisting of a fragment of a pre-Hercynian orogene (Caledonian?) which has been completely overturned and broken down into numerous Hercynian tectonic units;
- a *lower part,* consisting of mainly Devonian metasediments deposited originally in a basin looking on to the Caledonian orogene.

The Hercynian structure is intruded by late-Hercynian magmatites.

The main interpretations regarding the geological evolution of the Range are as follows:

in the Range there is evidence of Caledonian (?) orogeny, which was accompanied by metamorphic, magmatic and sedimentary phenomena still partly recognisable even today;

the very complex Hercynian orogeny is characterized by two principal metamorphic events, the first dynamic, the second thermal; by volcanism with alkali-basalt, calc-alkalic and rhyolitic products, in that order; and by late intrusive magmatism, first involving deep-seated anatectic magmas, then moderate-depth anatectic and peraluminous types. It is considered that the Hercynian orogene was formed on the southern edge of the paleo-European continent; the orogeny is viewed in a model that involves subduction of lithosphere with a crust that is at least partly oceanic.

Considering only the effects produced within the Hercynian Range, the Alpine orogeny was responsible for imbrication and crushing with relatively rigid translatory movements. Of particular interest is the discontinuity at the Strait of Messina: the Peloritan Mountains, which were originally to the SE of the Aspromonte, were brought to their present position by clockwise rotation through 90° in post-Hercynian times.

## Foreword

Right from the time of the earliest investigations most authors have explicitly or implicitly considered the « Calabro-Peloritan Arc » — understood as a fragment formed of crystalline rocks in a setting that is basically sedimentary — as a unitary geological object. However, the geological correlations made between Calabria and the Peloritani area until quite recently (QUITZOW, 1935; GRANDJAQUET et alii, 1961; TRUILLET, 1968; OGNIBEN, 1973; AMODIO MORELLI et alii, 1976; DUBOIS, 1976) (¹) do not entirely stand up to critical scrutiny. One objective difficulty has been the very scant knowledge of the Aspromonte (considered by all as the Calabro-Peloritan link) and even today this is the part of the Arc that has been least well studied. Furthermore, most of the correlations have been based on extension to the whole Arc of knowledge or interpretations concerning one or other parts of it. In addition to the unity of the Calabro-Peloritan Arc as a geological object, few workers, especially in the last decade, have even questioned the Alpine age of its constitution (at least the essential part of it); consequently their attention has been concentrated on the tectonic structures revealed by the Mesozoic cover, while the structures revealed only in the pre-alpine basement have either been ignored or under-valued.

Investigations performed recently by the authors (LORENZONI and ZANETTIN LORENZONI, 1978, 1978 a; FERLA et alii, in prep.) tend to suggest, however, that basically Calabria and the Peloritans only have a first-order structural element in common, namely a Hercynian Range involved in the Alpine orogeny. According to this idea, the pre-Alpine geological-tectonic history of this structural element is decidedly fundamental as regards a Calabro-Peloritan correlation: far more so than the Alpine history.

The essential characters of the *Calabro-Peloritan Range* are detailed here, along with an evolutionary model thereof, the general lines of which are complete from pre-Hercynian times.

## Introduction

The Hercynian Calabro-Peloritan Range outcrops discontinously from the Sybaris Plain to the western extremity of the Peloritan Mountains (fig. 1). In Calabria it is the lowest tectonic element (ZANETTIN LORENZONI, 1982) and so no possible allochtony can be established directly (²). In the Peloritans, the Hercynian Range rests on the Sicilian Maghrebids along a subvertical surface (« Taormina line » auct.). In Calabria, three first order tectonic elements come in contact with the Hercynian Range, namely:

- the Stilo Unit, which was overthrust on the Hercynian Range in the Oligocene (LORENZONI et alii, 1980);
- the « Alpine Range » (after AMODIO MORELLI et al., 1976), which came alongside the Hercynian Range and was partly overthrust thereon in the Middle Miocene (ZANETTIN LORENZONI, 1982);
- the Monte Gariglione Unit, which was overthrust on the Hercynian Range in Middle-Upper Miocene times (ZANETTIN LORENZONI, 1982).

There are also another two structural elements that do not come directly into contact with the Hercynian Range, namely:
- the Apennine Range, on which the « Alpine Range » was overthrust in the Lower Miocene and, together with this, was juxtaposed with the Hercynian Range in the Middle Miocene;
- the Tiriolo Unit, a fragment of the Stilo Unit and of the upper part of the Hercynian Range which broke away and became wedged in the « Alpine Range » during the compressive phases of the Middle Miocene.

Here we shall merely mention that many authors consider the Sicilian Maghrebids to be the southern continuation of the Apennine Range.

In the Peloritans there is no trace of any of the tectonic elements overthrust on the Hercynian Range, except perhaps for a few isolated Klippen of the Stilo Unit.

## The Hercynian Calabro-Peloritan Range

This Range (fig. 2) is formed of a « crystalline » basement — composed of numerous Hercynian tectonic units consisting of metamorphites and intruded by late-Hercynian

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(¹) Owing to the great number of articles about the « Calabro-Peloritan Arc », references are usually made only to the work which first deals with the subject.

(²) Not even seismic data (SCHÜTTE, 1978) concerning the Hercynian Range provide any evidence of the « crystalline » overlying sedimentary terranes, as would be the case, instead, if it is assumed that the Hercynian Range was overthrust on the « foreland » during the Alpine orogeny.

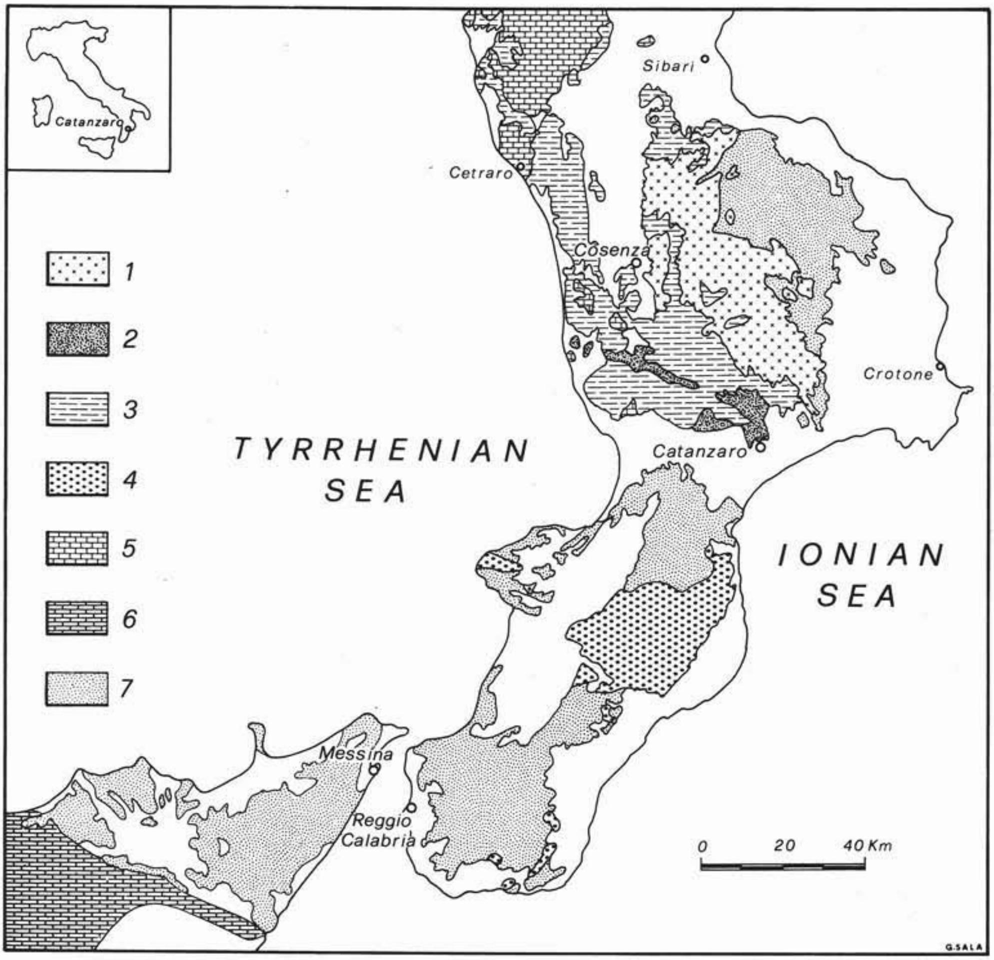

Fig. 1. — Tectonic sketch-map of Calabria (from Zanettin Lorenzoni, 1982, modified) and north-eastern Sicily. - 1. Monte Gariglione Unit; 2. Tiriolo Unit; 3. « Alpine Range »; 4. Stilo Unit; 5. Apennine Range; 6. Sicilian Maghrebids; 7. Hercynian Range.

sialic magmatites — on which rests a Mesozoic-Cenozoic cover.

The cover (Magri et al., 1964) is well represented in the Sila and in the Peloritans, but there is little of it in the Aspromonte. It consists of « Verrucano » conglomerates, limestones, marls, ± sandy clays (Lias-Cretaceous), breccias, sandstones and marls (Eocene). There are marked lithological variations even laterally, while outcrops are discontinuous as a result of intense Alpine imbrication, basically of Eocene-Oligocene age (3). The vergence of the imbrication is eastwards in Calabria, and southwards in the Peloritans, where the translatory movements of the basement on its own cover are the most marked. In the deeper tectonic positions the cover is slightly metamorphosed (Ferla and Azzaro, 1978 c).

Late-Hercynian sialic magmatites (Borsi and Dubois, 1968; Ferrara et alii, 1959) intrude the Hercynian Range, forming batholits and minor bodies. They belong to two magmatic cycles (Lorenzoni et alii, 1978) the first of which — represented basically in the Sila — consists of essentially granodioritic magmas; these are of deep-seated

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(3) These facts explain why many authors, when dealing with the Peloritans, wrongly — in our opinion — attribute various outcrops of sedimentary rocks to different covers and consequently ascribe the underlying basement rocks to different Alpine tectonic units.

origin and rose to moderate depths during times of crustal tension. They have given rise to biotite and amphibole-biotite granodiorites and to differentiated dyke rocks of various types. The second cycle, represented throughout the whole Range, albeit with different frequencies, includes peraluminous granite-granodiorite crustal-melt magmas which rose to moderate depth in the crust during times of great tension. These have given rise to muscovite granodiorite-granites with fibrolite and/or andalusite and a few differentiated dyke rocks.

From the attitude of the magmatic bodies, which cut the tectonic contacts of the crystalline basement or are actually intruded along these, a pre-Alpine age for the contacts can be deduced.

The various tectonic units of the Hercynian Range are all formed of metamorphites. The tectonic contact surfaces are generally subhorizontal or only slightly inclined (where the original attitude has not been too greatly disturbed by Alpine dynamism) and are discordant with the schistosity (the attitude of which varies in the different units); confining pressures are not usually very high or such as to have caused marked diaphtoresis.

Regarding the number and characteristics of the individual units of the Range, we are still not able to provide a complete picture of the whole outcrop area. However, it is certain that the Range has two basic parts:

- a *lower part,* formed of a single tectonic unit, consisting of rocks metamorphosed only in the Hercynian, and containing Devonian fossils;
- an *upper part,* formed of several tectonic units (six have been recognised in the Aspromonte), consisting of pre-Devonian rocks mostly already metamorphosed before the Hercynian orogeny.

The *lower part* of the Range outcrops only in the Sila (where DE VIVO et alii, 1978, named it the «Hercynian Bocchigliero Unit») and in the Peloritans (where FERLA, 1974 a, named it the «South-Peloritan Complex»). It consists mainly of ± quartzose phyllites, which are accompanied by alkali metabasalts, metalimestones and metaconglomerates in what is geometrically (and in our opinion stratigraphically) the lowest part. The following facts are of special interest:

- Devonian *Tentaculites* occur in the metalimestones (TRUILLET, 1968);
- the metaconglomerates have phyllite, gneiss, marble, porphyry, pegmatite, sandstone and chert pebbles.

The Hercynian metamorphism of the unit has produced a single schistosity with blastesis. It is of the low-pressure type (as indicated by the $b_0$ values of 9.005 of the K-white micas) and is also low-grade. As a result, sedimentary pebbles or pebbles with original metamorphic characters have been conserved in the metaconglomerates. The phyllite pebbles in particular, where the $b_0$ value of the K-white micas is 9.025 (indicating intermediate pressure metamorphism) have the composition and structural characters of the low-grade metamorphites of the upper part of the Range (FERLA, 1974 b). The gneisses, marble, porphyries and pegmatites can also be tied in with the lithological associations that today form the upper part of the Range. It can thus be deduced that the rocks of the lower Hercynian Unit were laid down in a post-Caledonian basin fed by an emergent zone consisting, at least to some extent, of rocks that subsequently came to form the upper part of the Range.

The *upper part* of the Range, outcropping from the Sila to the Peloritans, is well represented, especially in southern Calabria and in the Peloritans. Taking an overall look at this part, it appears to consist of moderate crustal depth metamorphites (phyllites and mica schists with porphyroids, metabasites and metalimestones) towards the bottom, and of medium and deep crust metamorphites (fine-grained gneisses ± sillimanite, andalusite, kyanite, and garnet; amphibolites; « kinzigites » and metabasites in granulite facies) towards the top. In the metamorphites, especially the moderate-depth variety, two schistosities accompanied by blastesis are quite evident. In the rocks that nowdays form the *upper part* of the Hercynian Range, the last occurrence of the dynamic metamorphism was followed by regional thermal metamorphism (the effects of which are especially marked in the metapelites that were originally in a deeper position); this caused the crystallization of minerals such as biotite, muscovite, staurolite, andalusite, cordierite and fibrolite.

In the Peloritans, the quite evidently overturned sequence ranging from moderate-depth metasediments to medium-high grade gneisses (there are no real « kinzigites ») is generally affected by both Hercynian and Alpine dynamic effects. However, there are some long, particularly favourable sections where the gradual increase in metamorphic grade and intensity from the bottom upwards can be observed (Giampilieri - Capo d'Orlando Series according to FERLA, 1982). In Calabria, instead, lithological associations corresponding to different crustal levels alternate in the different Hercynian tectonic units like cards in a not-too-well-shuffled pack, so that the overturned position of the whole is still evident. In the Aspromonte, for example, the orogenetic movements produced the following type of lithological successions in diverse tectonic units, from the bottom upwards (LORENZONI et alii, 1980): phyllites (Pentidattilo Unit) - micaschists with thermal metamorphism (Mandatoriccio Unit) - medium grade gneisses (Capo San Giovanni Unit) - mica-schistose phyllites (Montebello Jonico Unit) - intermediate to high grade gneisses with thermal metamorphism (Monte Lesti Unit) - « kinzigites » (Polia-Copanello Unit).

Since tectonic contacts separate lithological associations that differ as regards intensity and type of metamorphism, it is evident that the piling up of the tectonic units occurred after even the very latest metamorphic phases (which we ascribe to the Hercynian, as indicated ahead) and so they cannot be pre-Hercynian. The attitudes vis-à-vis the « granites » and the cover sediments (already mentioned) thus fix the age as Hercynian, without any shadow of doubt.

The upper part of the Range can therefore be considered as a fragment of crust which was overturned during the Hercynian orogeny and split up into numerous tectonic units owing to Hercynian dynamism.

To summarize, according to our interpretation, the basement of the Hercynian Range is formed of an old polymetamorphic « crystalline basement », fragmented into numerous tectonic units, that was overthrust and overturned on Hercynian metamorphites deriving from rocks of a basin where materials coming from the same « basement » had been deposited. Intrusion of sialic magmas occurred subsequently.

### Geological history of the Calabro-Peloritan Hercynian Range

The salient points in the reconstruction of the older geological events are:

- the existence of a single schistosity with metamorphism in the Devonian phyllites and of at least two schistosities with metamorphism in the rocks of the upper units of the Hercynian Range;
- the existence in the Devonian metaconglomerates of metamorphite clasts some of which are lithotypes from the upper units of the Hercynian Range (including phyllites with only one schistosity), as well as sedimentary and volcanic clasts.

From these facts it can be deduced that, in the Devonian, there existed a sedimentation basin fed from emergent areas in some parts of which there were outcrops of rocks that subsequently came to form the upper tectonic elements of the Hercynian Range.

The presence of metamorphic rocks togheter with sedimentary rocks and volcanic rocks and of phyllitic rocks togheter with gneissic rocks, points to the existence of situations closely resembling those of the present orogenes; we interpret the co-existence of all these lithological types in the same area as being the consequence of tectonic juxtapositioning or evolutions of the basement - cover type. In both cases the characters of the « emergent area » are those of an orogenetic zone, evidently pre-Hercynian. According to FERLA (1974) the metamorphism of the pre-Hercynian phyllites is Barrowian type, which is similar to the classical Caledonian metamorphism. From what has been said, therefore, we hold that the rocks of the upper units of the Hercynian Range could well belong to an orogene that is probably Caledonian.

The pre-Hercynian — or Caledonian — orogeny was accompanied by metamorphic phenomena, as already observed; there is also evidence of magmatic events. In this respect we should note that the pegmatite clasts in the Devonian conglomerates is in good accord with the existence of single schistosity pegmatites intruded in the polymetamorphic gneisses that are very common

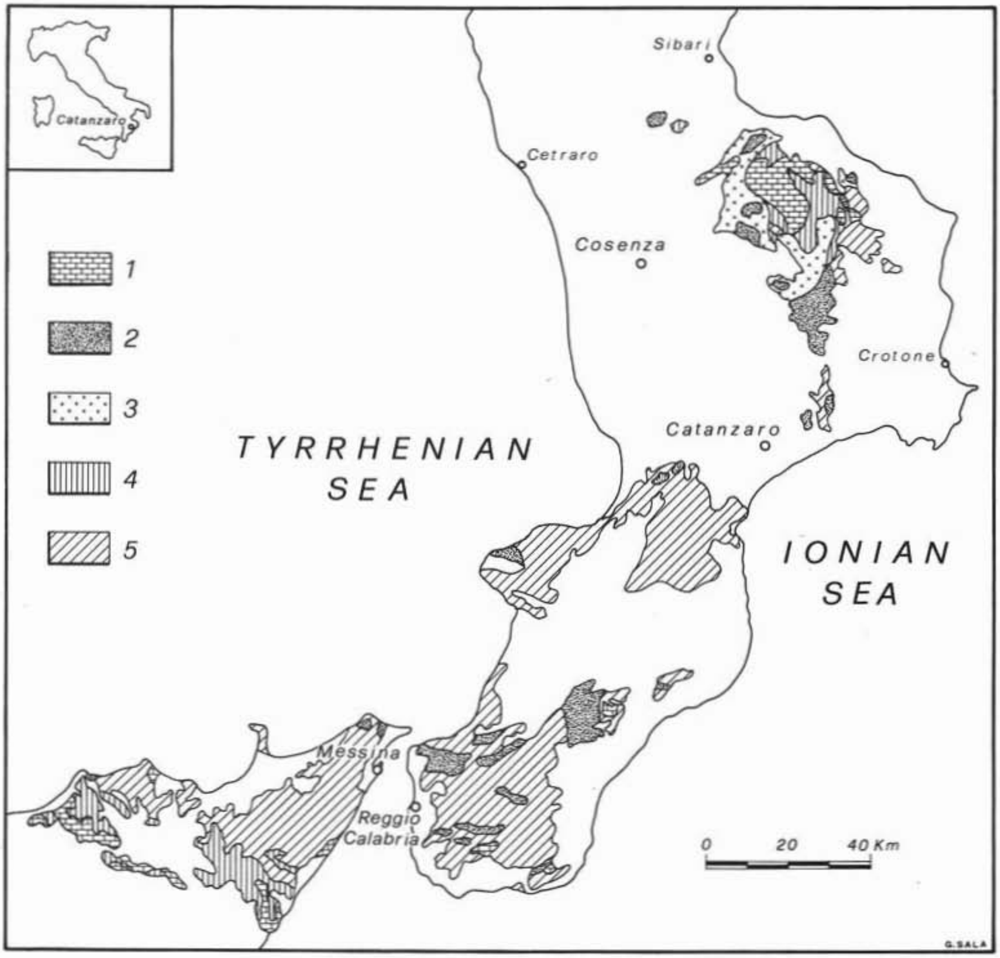

Fig. 2. — Calabro-Peloritan Hercynian Range. - 1. Mesozoic-Cenozoic sedimentary cover (conglomerates, breccias, sandstones, limestones, marls); 2. Late-Hercynian magmatites: 2nd cycle (two-mica $Al_2SiO_5$ granites and granodiorites); 3. Late-Hercynian magmatites: 1st cycle (biotite ± amphibole granodiorites); 4. Hercynian Range: lower part (metasediments and metavolcanites p.p. Devonian, metamorphosed only in Hercynian times); 5. Hercynian Range: upper part (high-to-medium grade gneisses, micaschists, phyllites pre-Devonian, metamorphosed in Hercynian and generally in pre-Hercynian (Caledonian?) times too).

in the tectonically higher parts of the Hercynian Range. Instead, we have not found any late-post-Caledonian (?) porphyries metamorphosed in the Hercynian, to explain the porphyric clasts of the Devonian metaconglomerates.

To a somewhat limited extent it is also possible to theorise on the original nature of the rocks that formed the « Caledonian » orogene. Indeed, a good part of the metamorphites derive from sedimentary sequences in which it is possible to observe the evolution from graywackes to pelites, from the bottom upwards (FERLA, 1974). At various levels in the sequence there are also products of synsedimentary volcanism, the most basic of which (now amphibolites) can be tied in with arc tholeiites (FERLA and AZZARO, 1978). There are also very frequent traces of synsedimentary volcanism (present porphyroids) in the micaschistose phyllite units of the upper part of the Hercynian Range (and also in the gneissic units, according to ATZORI and LO GIUDICE, 1982). Finally the existence of intrusive sialic magmatites is also probable: it is likely that these were the origin of the augen gneisses, widespread in the upper part of the Hercynian

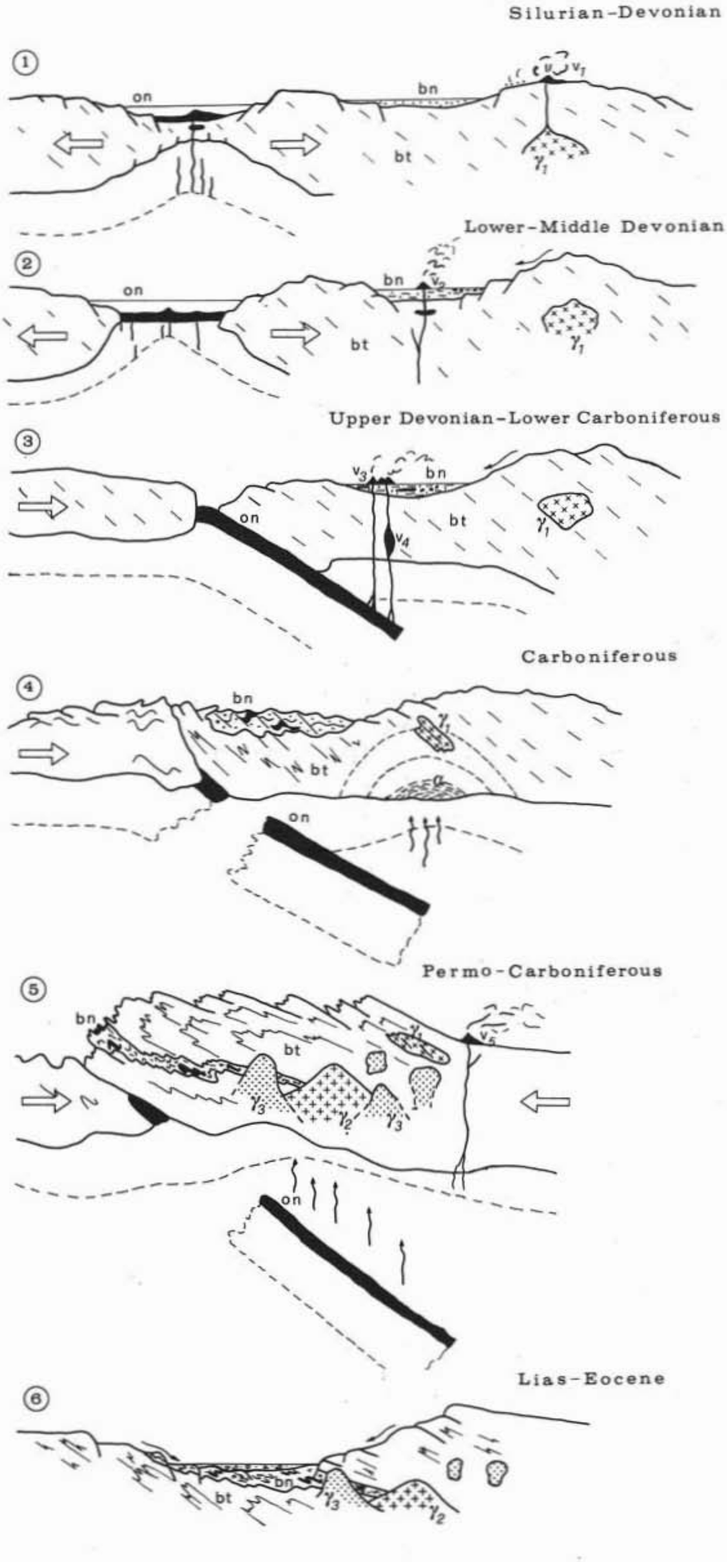

Fig. 3. — 1 - *Silurian-Devonian.* First spreading in a continental crust (*bt*) plate and incipient formation of the future oceanic basin (*on*). Basins with prevailing terrigenous sedimentation develop in the future paleo-Europe continent where magmatic phenomena occur (granites = $\gamma_1$; rhyolites = $v_1$). 2 - *Lower-Middle Devonian.* Spreading of the oceanic basin and separation of the paleo-Europe from the paleo-Africa plate. Alkali-basalt volcanism ($v_2$) occurs in the continental basin, at the same time of sedimentation of *Tentaculites* limestones and clastic deposits. 3 - *Upper Devonian-Lower Carboniferous.* Subduction of the oceanic crust plate under the paleo-Europe plate and consequent volcanism with calc-alkalic products ($v_3$ = basalts, andesites, dacites) and local melting in the basement ($v_4$ = rhyolites). 4 - *Carboniferous.* Closure of the oceanic basin and shortening of the continental crust; development of the dynamic metamorphism which get at completation. A thermal increasing affects the basement relatively far from the trench zone and determines anatexis ($\alpha$) in the deeper crustal levels, thermal metamorphism in the higher ones. 5 - *Permo-Carboniferous.* Main compressive phases and building of the Hercynian Range. At the frontal part of the chain the basement is overturned on its own cover. The late-orogenic anatectic magmas ($\gamma_2$) of the first cycle rise to moderate-depth levels; melting of the second cycle magmas occurs; the late-post-orogenic volcanism ($v_5$) is due to K-andesitic magmas. 6 - *Lias-Eocene.* Dismantling of the Hercynian Range and formation of basins with prevailing terrigenous sedimentation. The Alpine compressive phases begin in Eocene times.

Range, that were already metamorphosed at the end of the Caledonian.

In the Devonian (fig. 3) the Caledonian orogene, with the lithological and geological characters envisaged by us, fronted on a sedimentation basin the formation of which may even pre-date the Devonian. The lithological associations of the basin and their sequence (ATZORI and FERLA, 1979; GURRIERI et alii, 1978) indicate intracontinental characters for the basin and sedimentation conditions in the upper part similar to those for Flysch. The basin was probably formed by a rifting process: in the lower part of the sedimentary sequence, in fact, there are metabasites that derive from effusive volcanites of the alkali basalt type (FERLA, 1978). In the Peloritans, the metabasites are associated in part with the fossiliferous Devonian limestones. Probably in the Devonian and almost certainly in eo-Carboniferous times, environmental conditions changed, with the onset of a compressive regime that caused volcanic activity with the outflow of calc-alkalic magmas (locally associated with anatectic rhyolitic magmas, bound up with the rise of the calc-alkalic magmas themselves). Volcanic activity is proved by the metavolcanites, which are quite widespread in the upper part of the sequence at the close of the sedimentary cycle.

The compressive cycle of the Hercynian orogeny had thus already started. Pressures increased causing deformations in the whole of the crustal sector considered. From what can be seen today, these were plastic deformations, being accompanied by metamorphism. The rocks of the Devonian basin were finely refolded and metamorphosed with the formation of axial plane schistosity; the metamorphism was that of an anchimetamorphic environment. The rocks of the Caledonian orogene were also subject to dynamic metamorphism, with the formation of refolded folds and a new schistosity superimposed on the old. This is visible especially in the pre-Hercynian phyllite associations. Metamorphism here occurred at overally low *P* and *T*, but increasing from the moderate-depth zones (which are now in lower position and where the metamorphism is of greenschist facies), to the deeper ones (which are now in a higher position and where the metamorphism is of intermediate to high grade). The grade of Hercynian metamorphism thus varies, within the Range, from anchimetamorphism to greenschists facies, to amphibolite facies, to anatexis.

Dynamic metamorphism, which certainly involved marked deformation and shortening of the crust, was followed by a considerable rise in temperature which caused thermal metamorphism (as demonstrated by the structural characteristics of the blastic associations). From what can be observed nowdays, this occurred in the area where there were rocks of the old Caledonian orogene, not where there were rocks derived from the sediments of the Devonian basin; the metamorphism thus affected the relatively more internal parts of the continent. The thermal metamorphism also affected the moderately deep part of the crust (where there are polymetamorphic ± micaschistose phyllites) with quite considerable intensity and with temperatures that gave rise to minerals such as biotite, andalusite, staurolite, cordierite and locally even ± orthoclase and fibrolite. In the deeper zones, at the « kinzigites » which now outcrop in the highest part of the Hercynian Range, it is very likely that thermal metamorphism was responsible for the production of the anatectic-metamorphic «diorites» associated with the «kinzigites».

As far as can be seen, there were no magmatic intrusion associated with the phases in which thermal metamorphism developed. It is evident, of course, that the rise in temperature must have caused melting in the deeper parts of the crust. The lack of intrusions means, therefore, that the magmas had little or no possibility of rising, owing to the existence of general compression conditions. This is anyway in accordance with the « autochthonous » nature of the anatectic « diorites » associated with the kinzigites that we link genetically with the thermal metamorphism.

Thermal metamorphism was followed by new compressive phases, after a sufficient lenght of time for the head to disperse. The rocks behaved rigidly, in fact, to this renewal of pressure, the crustal sector involved not being metamorphosed but fragmented and moved. The movement involved the general overturning of that part of the crust corresponding to the « Caledonian » orogene onto the rocks originally belonging to the Devonian basin; thus there was further marked crustal shortening.

Only with the onset of late-orogenic tensions could the magmas start to rise. The magmas of the first cycle seem to be the product of crustal melts that occurred in previous phases. The peraluminous magmas of the second cycle — too cold even at the origin and formed at moderate depths (LORENZONI et alii, 1979) — instead, probably rose immediately after their formation. The magmas may have been formed in a variety of ways, namely: flows of heat from deep levels arriving relatively not far from the surface; re-equilibrium of isotherms deformed by crustal thickening; or yet again induction of heat from the deeper magmas and from evolution of the metamorphic process itself in the orogene zone. It is likely, however, that all these processes played a role in the genesis of particular magmas such as those of the second cycle.

Our interpretation of the Hercynian evolution involves an orogenetic model with subduction. Owing to the characters of the metamorphism and the tectonics, we ascribe the rocks of the Hercynian Range now outcropping to the plate being overthrust. The « African » vergence of the Range indicates that the descending plate dipped towards paleo-Europe. The conditions under which metamorphism occurred and the tectonic, sedimentary and magmatic evolution lead us to think that the trench zone lay even farther south than the Devonian basin (4). The first Hercynian compressive cycle — with initial calc-alkalic magmatism and subsequent low-pressure, low-temperature metamorphism without any important relative translatory movements of the rock masses is explained by assuming subduction of a plate, at least part of which was of the oceanic crust type. The subsequent temperature rise is explained by assuming an evolution similar to that which brought about Abukuma-type metamorphism. The second Hercynian compressive cycle, with rigid-type dynamic movement involving the complete overturning of the more rigid formations, in our opinion, indicates collision conditions, with the definitive closure of the oceanic basin (5). The post-orogenic K-andesitic volcanism recorded in Cenozoic conglomerates and probably Permian in age, is refered to the senile stage of the extreme post-collisional subduction (FERLA and ALAIMO, 1976; FERLA, 1978).

The whole of our reconstruction cannot but be hypothetical, of course: the Hercynian Range, as it outcrops today, consists of formations that originally belonged to a single continental block. Indeed, only a more thorough understanding of Alpine dynamism in the Mediterranean basin would permit reconstruction of paleogeographic conditions existing at the end of the Hercynian orogeny. With these limitations, the Hercynian evolution envisaged by us is in good accord with the assumed palaeogeographic and paleotectonic situations that — in what is now Calabria — involve the existence of a limited Paleothetys and also of continental crust microplates between the European and African continents (RIDING, 1974; LORENZ, 1976; SCOTESE et alii, 1979).

At the end of the Hercynian orogeny, the Range was not much different from what it is today. The Alpine orogeny, in fact, was destined to produce imbrication, crushing and relative translatory movements of the various fragments. These phenomena are certainly important in the framework of Alpine dynamism in the Mediterranean basin, but they do not form the subject of this paper, so only those Alpine phenomena that most directly affect the Hercynian Range are treated here, albeit briefly.

Postorogenic sedimentation on the Range started with a Verrucan-type conglomerate and evolved towards basin conditions with sedimentary formations (Lias-Eocene); these indicate marked discontinuity of environment laterally, and tectonically unstable con-

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(4) In a classical model with the subduction plane dipping at 45° and the zone of formation of calc-alkalic magmas at a depth of about 250 km, the distance of the Devonian basin from the trench should not be less than 200 km.

(5) The size of the ocean basin, calculated on the basis of the depth reached by the descending plate when the calc-alkalic magma was formed should not be less than 400 km. This is in line with the paleogeographic reconstruction proposed by SCOTESE et alii (1979).

ditions vertically owing to the existence of compressive phases especially in the Eocene. Indeed, sedimentation ceased in the Upper Eocene, owing to an intensification of pressures, with the formation of very marked imbrication and with some considerable translatory movements (in the Peloritans) of the basement on its own cover. The vergence of the slices is eastwards in Calabria and southwards in Sicily. Locally (in the tectonic windows of Alì and Gioiosa Vecchia - see FERLA, 1982) in the tectonically deeper zonas the movement caused some slight metamorphism in the sedimentary cover rocks.

Compression occurred again in the Oligocene, the Stilo Unit, formed by pre-Alpine continental crust rocks (metamorphites and late-Hercynian magmatites) with Mesozoic sedimentary cover, being overthrust on the Hercynian Range. The Oligocene compression did not produce metamorphic effects; it is thus evident that bodies with rigid behaviour were being moved within the continental plate itself. In our reconstruction, the Stilo Unit domain must belong to parts of the paleo-European continent that are farther inland than the Hercynian Range.

Sedimentation of the essentially conglomeratic-arenaceous « Stilo-Capo d'Orlando formation » on the Hercynian Range + Stilo Unit ensamble started in the Oligo-Miocene; this sedimentation is extremely uniform from the Peloritans to Calabria.

Dynamic conditions occurred in the Miocene, bringing the Hercynian Range in contact with the Sicilian Maghrebids units on the southern edge of the Peloritans, along the « Taormina line ». The significance of this line is not altogether clear, as yet, though various theories have been advanced. Again in the Miocene, in north-central Calabria, the « Alpine Range » + Apennine Range ensamble was juxtaposed with the Hercynian Range on which the Monte Gariglione Unit was overthrust.

The most pronounced of the numerous discontinuities the Alpine orogeny caused in the Hercynian Range is that between the Peloritans and the Aspromonte, namely along the Strait of Messina. The existence of this discontinuity is indicated by the following facts:

- the vergence of the Eocene slices, which is southwards in the Peloritans and eastwards throughout Calabria;
- the paucity of late-Hercynian magmatites in the Peloritans, even though these lie on the prolongation of the Cittanova-Villa San Giovanni granite lineament (fig. 2);
- the absence, in the Aspromonte, of formation belonging to the lower part of the Hercynian Range, though these are very well represented in the Peloritans;
- the extreme scarcity, in the Aspromonte, of the sedimentary cover which lacks the Mesozoic formations that are relatively common, instead, in the Peloritans.

It ensues from all these elements that the original position of the Peloritans must have been different from what it is now. We consider that the Peloritans lay on the south-eastern or eastern coast of the Aspromonte and that the Alpine structures would have had similar vergence in the two sectors. In post-Eocene times (we are unable to be more precise) the Peloritans must thus have moved some 90° clockwise around the Aspromonte. This interpretation is in line with reasoning based on paleomagnetic data (GREGOR et alii, 1975; CATALANO et alii, 1976; SCHULT, 1976, 1979; SCHAREL et alii, 1980) and confirmed by SCHUTTE (1978) and GHISETTI and VEZZANI (1982) on the ground of structural data.

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