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JURASSIC FACIES PATTERN IN THE SOUTHERN APENNINES (CAMPANIA - LUCANIA)

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JURASSIC FACIES PATTERN IN SOUTHERN APENNINES (CAMPANIA - LUCANIA)

by
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ABSTRACT

In the discussed area of the Apenninic geosyncline, the available data and the related palinspastic restoration given in the present paper allow to distinguish two parts:

(a) an internal part formed by the *Mt. Foraporta* and *Lagonegro belts* and, after the Jurassic, also by *Cilento belt*;

(b) an external part formed by the *Campania-Lucania, Abruzzi-Campania* and *Apulia platforms*, with intermediate basins.

The individuation of the internal part begins during the upper Triassic time, whereas the external part individuates itself during the Liassic time.

After the Jurassic the internal part attains a new configuration: on the external side of the Lagonegro belt the Cilento flysch basin develops because of the eastward migration of the geosyncline axis; on the contrary, in the external part the general pattern remains unchanged and only the boundaries among the isopic zones become sharper.

INTRODUCTION.

The present paper is a contribution to an understanding of the Southern Apennines paleogeography. In the above area Jurassic sediments had not been recognized, but in a few places, up to ten

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years ago. They had been mapped mostly as Cretaceous, sometimes as upper Triassic in age. A large amount of geological work has allowed the mapping of many Jurassic outcrops which have been analyzed also in relation to their facies distribution.

A new general scheme of the geologic development of the Southern Apennines has been reached and several structural units, which have their own peculiar pre-orogenetic history, have been recognized. At this stage of the geological research, the geometrical analysis of the tectonic units and the facies analysis of the constituting rocks give the possibility to attempt a palinspastic reconstruction of the Campania, Lucania and northern Calabria area during the middle Jurassic time.

The authors wish to point out that this paper is mainly a summary of numerous scientific contributions which have been presented by several students of the geologic problems of the Southern Apennines. Therefore no specific reference is given in the text and the interested reader is kindly invited to refer to the bibliography presented at the end of this paper.

D'Argenio has carried on research mainly to the West of the Salerno-Benevento line, while Scandone has dealt mainly with the area East of the above line.

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PART 1

TECTONIC UNITS AND PRIMARY PALEOGEOGRAPHIC BELTS OF CAMPANIA-LUCANIA APENNINES

1. TECTONIC PATTERN.

Four main tectonic elements can be traced in the Southern Apennines: Tyrrhenian hinterland, Apenninic chain, foretrough and foreland.

The Tyrrhenian hinterland is now occupied by the Tyrrhenian sea and no direct observations of its geologic nature have been possible up to this moment.

The Apenninic chain is constituted by several stratigraphic-structural units which are in complex tectonic relationships due to large overthrusts and/or overridings which took place mainly during the Miocene time.

The Southern Apennine foretrough develops during the Miocene time on the external side of the chain. This trough is filled by more or less large masses tectonically derived by the Apenninic chain and by autochthonous and parautochthonous clastic sediments, ranging in age mainly from the middle Miocene to the lower Pleistocene.

The Apenninic foreland is given by a very thick shallow water Mesozoic carbonate sequence, covered by a thin veneer of Tertiary clastics and calcareous sediments. This area has been subjected only to minor tectonic deformations mainly through a system of normal faults.

1.1. Southern Apenninic chain.

In the Southern Apenninic chain several stratigraphic-structural units (1) can be distinguished:

1.1.1. *Monte Foraporta unit.* It consists of white dolomites of Triassic age; grey dolomites, black bituminous calcilutites and

(1) Large geological bodies, corresponding to portions, more or less developed, of the paleogeographic belts, tectonically deformed and/or removed from their original positions, characterized by traceable boundaries and by large scale homogeneous lithology and mechanic behaviour.

calcarenites with thin calcareous claystones of lower-middle Jurassic age, tectonically resting on the former Triassic dolomites.

Triassic beds reach up to 150 meters in total thickness, while Jurassic beds are up to 300 meters.

This unit is a thrust sheet resting upon the Lagonegro and Alburno-Cervati units.

1.1.2. *Lagonegro units.* Two units may be recognized.

a. Lower unit. Upper Triassic cherty calcilutites, Jurassic radiolarites and Lower Cretaceous claystones, highly siliceous claystones and siliceous limestones form the lower Lagonegro unit.

Its total thickness is about 1000 meters.

b. Upper unit. Middle Triassic calcareous claystones, claystones, siltstones and sandstones with interbedded reefs form the lower part of the upper Lagonegro unit. This section grades upward into a sequence of upper Triassic cherty limestones and dolomites and then of Jurassic radiolarites interbedded with calcareous microbreccias. The upper portion of this unit consists of siliceous and calcareous claystones, siliceous limestones and calcareous microbreccias of lower Cretaceous.

Its total thickness reaches up to 1000 meters.

Both Lagonegro units form a composite thrust sheet which is generally tectonically covered by the Alburno-Cervati and Foraporta units, while, in some instances, rest upon the Alburno-Cervati unit.

1.1.3. *Cilento unit.* This unit consists of flysch sediments completely. Siltstones, claystones, siliceous claystones and limestones of Cretaceous age occur together with ophiolites translated from their original unknown position in northern Calabria and Lucania. In Cilento and central Lucania Cretaceous-Paleocene graded sandstones and claystones are predominant while in southern Lucania and in Calabria graded sandstones, calcareous microbreccias, red and green calcareous shales and claystones are more frequent. The above sequences pass upward into lower Eocene to probable lower Miocene section consisting mostly of graded sandstones, calcareous claystones and polygenic conglomerates with local sills and submarine flows in primary position.

The total thickness of the Cilento unit is at least 3500 meters.

This unit forms a thrust sheet resting upon all the previously described units and upon the Alburno-Cervati unit.

1.1.4. *Alburno-Cervati unit.* In this unit upper Triassic withe massive dolomites, blackish limestones and calcareous shales, grading upward into grey and white dolomites, Jurassic and Cretaceous dolomitic limestones and limestones are locally covered by disconformable Paleocene and Eocene limestones. Aquitanian to Burdigalian glauconitic calcarenites, graded sandstones, calcareous shales and microbreccias lie with a small unconformity or disconformably upon the previously mentionned section.

The total thickness of the Mesozoic and lower Tertiary beds reaches up to 4500 meters, while Miocene beds are about 200 meters thick.

Along the Tyrrhenian and Adriatic rims frequently occur Jurassic reefs with reef breccias, cherty limestones and calcareous shales and Cretaceous and lower Tertiary calcareous breccias, graded calcarenites and pelagic limestones.

The Alburno-Cervati unit is a thrust sheet resting upon the Lagonegro thrust sheet and is tectonically covered by the Monte Foraporta, Cilento and locally also by the Lagonegro units.

1.1.5. *Matese - Mt. Maggiore unit.* In this unit the sequence is formed by upper Triassic white dolomites, Jurassic and lower Cretaceous limestones and dolomitic limestones covered by disconformable upper Cretaceous limestones. The stratigraphic breack is marked by bauxitic deposits. Locally Paleocene and Eocene limestones lie disconformably upon the above section, while Burdigalian disconformable limestones, Helvetian clayey limestones and Helvetian to Tortonian graded sandstones and calcareous claystones are generally present over the whole area.

The total thickness of the Mesozoic and lower Tertiary beds reaches 2500 meters, while the Miocene thickness ranges between 500 and 800 meters.

Along the Tyrrhenian and Adriatic rims of this unit there are transitional facies to basinal facies, as it has been observed in the Alburno-Cervati unit.

The Matese - Mt. Maggiore unit probably is not a thrust sheet, though it can not be considered strictly autochthonous (probably parautochthonous). Its southern rim is partially tectonically covered by the Alburno-Cervati thrust sheet.

1.1.6. *Frosolone unit.* In this unit are cropping out cherts and cherty limestones, calcarenites, calcirudites and calcilutites of Cretaceous to lower Tertiary age. Calcarenites and calcareous shales interbedded with calcareous graded sandstones and graded sandstones overly the above section, being Aquitanian to Tortonian in age.

The total thickness of this unit is about 600 meters.

The Frosolone unit is parautochthonous and is tectonically covered by allochthonous sheets yet undistinguished of the following complexes.

1.1.7. *Undistinguished Southern Apenninic complexes.* Three types of rock sequences which, according to the stratigraphic nomenclature rules, can be named complexes, are present throughout the studied area. These complexes are: (a) « Argille Varicolori » Complex, consisting of variegated, thin bedded, generally highly deformed claystones and siltstones; (b) « Corleto Petricara » Complex, consisting of whitish calcilutites and calcarenites, grey and reddish calcareous shales interbedded with graded sandstones; (c) the provisionally named « Red Flysch » Complex, consisting of sequences similar to those of the Frosolone unit previously described; however the sediments of this complex were very probably in stratigraphic relation with the Lagonegro units.

Geological work about these complexes is being carried on presently. No information can be given about their thickness while it can be stated that these complexes are allochthonous sheets resting upon all the previously described units.

1.1.8. *Mt. Alpi unit.* In this unit, the position of which in relation to the main tectonic elements of the Southern Apennines is still controversal, the rock sequence consists of middle Jurassic to lower-most Cretaceous limestones. « Helvetian » calcarenites, calcilutites and calcareous shales overlie disconformably the above section. Probably Tortonian conglomerates and calcareous shales rest unconformably upon either Jurassic or Cretaceous or Helvetian beds.

The total thickness of the section reaches 1200 meters.

The Mt. Alpi unit is tectonically overlain by the Lagonegro and Cilento thrust sheets.

1.2. Foretrough.

It is possible to divide the foretrough in two parts: the foretrough *sensu stricto* and the Bradano trough.

In the foretrough fragments of several units of the Apenninic chain and Burdigalian and post-Burdigalian flysch and molasse are cropping out. The basement is unknown.

In the Bradano trough essentially Pliocene and Pleistocene clastic sediments are cropping out. The basement for this trough, when reached, is given by the western edge of the Apulian foreland.

1.3. Apulian foreland.

In the Apulian foreland the sequence, known partially through wells drilled for oil exploration, consists of upper Triassic evaporites, black bituminous limestones and dolomites, of Jurassic and Cretaceous dolomites and limestones, and locally disconformable Eocene, Oligocene and Miocene calcarenites. The whole sequence reaches a total thickness ranging from less than 4000 meters in the northern part up to more than 6000 meters in the southern part. No cristalline basement has been reached.

2. PALEOGEOGRAPHIC UNITS.

Several paleogeographic units have been recognized through the analysis of the rock sequences which form the previously described stratigraphic-structural units. Therefore, when possible, the same names have been applied to those paleogeographic domains where the corresponding units were originally located previous to their orogenetic displacement. Naming these paleogeographic units, the term belt has been applied in a descriptive way, since the above units generally were elongated areas more or less parallel to the alignment of the Apenninic chain as far as it is possible to recognize at the present time.

The analysis of the paleogeographic units has allowed to reconstruct a series of parallel belts which are located one after another, from the internal to the external domains of the Apenninic geosyncline, and in this order are described. At times it has been possible to estabilish the relationships between adjacent belts, at other times these relationships are inferred only.

2.1. Mt. Foraporta belt.

The presence of Mt. Foraporta belt is evidenced by the rock sequence of the Mt. Foraporta stratigraphic-structural unit. This belt represents the innermost known paleogeographic realm since the rock sequence deposited in this area is carried « piggy back » on the Lagonegro thrust sheet. The Mt. Foraporta belt possibly corresponds to an open and partly landlocked shallow water area.

a. Liassic. Thin bedded gray dolomites (80-100 meters), blackisch calcilutites and calcarenites (about 100 meters).

Fossils: rare and small gastropods molds, arenaceous forams.

b. Dogger. Well bedded, blackish, bituminous calcilutites and calcarenites with thin yellowish marly beds (about 150 meters).

Fossils: brachiopods and rare ammonites, arenaceous foraminifera and rare algae.

2.2. Lagonegro belt.

The rock sequence forming the Lagonegro composite thrust sheet belongs to the internal domains of the Apenninic geosyncline. Distal facies of this basin (Lagonegro zone) are represented in the lower thrust sheet; the western proximal facies (Pignola-Abriola zone) are represented in the upper sheet; the eastern proximal facies of the Lagonegro basin are unknown. The sequences show the evolution of an open instable shelf area, with patch reefs of middle Triassic age, to a more and more deepening basin during the upper Triassic and Jurassic time in which the starvation and the beginning of the filling stage (« pre-flysch » facies during lower Cretaceous) are evident.

Among the distinguished facies, a typical proximal one is present in the S. Fele section; a typical distal facies is that of the Lagonegro section; intermediate facies characters are shown by the Pignola-Abriola section.

2.2.1. *S. Fele section.*

a. Liassic. Graded polygenic breccias and microbreccias (granules provenance from a shallow water carbonate sequence; bed thickness 0.6 - 4 meters) with cherty lenses and nodules and thin beds of claystones and radiolarites.

Fossils: echinoid, pelecypod, brachiopod, coral and algae fragments; radiolaria and foraminifera (in the upper part *Dictyoconus* (?) *cajeuxi* LUCAS).

Thickness: 30 meters.

b. Dogger-Malm. Graded microbreccias and oolithic calcarenites, claystones and radiolarites; red and green radiolarites with thin graded, often silicified, microbreccias intercalations. Slumps in the upper part of the radiolaritic sequence.

Fossils: *Protopeneroplis striata* WEINSCHENK, *Nautiloculina oolitica* MOHLER, *Trocholina* spp., radiolaria, etc.

Thickness about 200 meters.

c. Lower Cretaceous. Claystones, siliceous claystones, calcareous shales, siliceous limestones and graded calcareous microbreccias.

Fossils: radiolaria and in the lower part *Protopeneroplis* sp., *Nautiloculina* sp., *Trocholina* spp., etc.

Thickness: few hundreds meters (outcropping part of the section).

2.2.2. *Pignola-Abriola section.*

a. Liassic. Gray, red and green marls and claystones, fine grained graded calcarenites and subordinately jaspers.

Fossils: radiolaria, rare foraminifera.

Thickness: about 70 meters.

b. Dogger-Malm. Radiolarites and claystones; red and green radiolarites with some graded calcarenites intercalations. Frequent slumps in the upper part of the section.

Fossils: radiolaria, *Protopeneroplis striata* WEINSCHENK, *Nautiloculina oolitica* MOHLER, *Trocholina* spp., etc.

Thickness: about 170 meters.

c. Lower Cretaceous. Claystones, siliceous and calcareous claystones, siliceous limestones and graded calcareous microbreccias.

Fossils: radiolaria and in the lower part *Protopeneroplis* sp., *Nautiloculina* sp., *Trocholina* spp.

Thickness: few hundreds meters (outcropping part of the section).

2.2.3. *Lagonegro section.*

a. Liassic, Dogger-Malm. Red, green and dark gray siliceous claystones and radiolarites; green radiolarites.

Fossils: radiolaria.

Thickness: 60-65 meters.

b. Lower Cretaceous. Claystones, siliceous claystones and limestones, manganesiferous in the lower part of the section; in the upper part rare, fine grained, graded calcarenites.

Fossils: radiolaria only.

Thickness: more than 400 meters.

2.3. CILENTO BELT.

It is a basin which belongs to a paleogeographic realm between the Lagonegro and Campania-Lucania belts.

Possibly the Cilento belt was located on the external zone of the Lagonegro basin, the axis of which migrated eastward during its development.

The sequences show the evolution of a geosynclinal basin in the filling stage from a «pre-flysch» facies (Cretaceous) to a typical flysch facies (upper Cretaceous - upper Oligocene).

2.4. CAMPANIA-LUCANIA BELT.

It is a platform, evidenced by the carbonate sequence forming the Alburno-Cervati thrust-sheet and belongs to the external domain of the Apenninic geosyncline. During the upper Triassic, the whole Jurassic and the Cretaceous p.p., its position is between the external side of the Lagonegro basin and the Lucania-Molise basin (2). As it was pointed out previously, during the Cretaceous the Cilento basin was established on the eastern side of the Lagonegro basin, so that the Campania-Lucania platform was located

(2) See over, discussion on Lucania-Molise paleogeographic domains.

between the Lucania-Molise and Cilento basins during. Cretaceous and lower Tertiary times.

The Campania-Lucania belt is a large carbonate platform across which it is possible to distinguish:

— an internal zone (Mt. Bulgheria zone), with reefs and transitional facies to pelagic sedimentary environments;
— a central part (Cervati-Alburno zone), with back-reef facies;
— an external zone (Monti della Maddalena zone), having an analogous paleotectonic role of the Mt. Bulgheria zone, on the eastern side.

The areal diversification begins during the uppermost Triassic - lower Liassic and the paleogeographic pattern then established continues up to the lower Miocene (Aquitanian-Burdigalian) when the whole belt is disconformably overlapped by calcarenites which are passing upward (Burdigalian) to flysch sediments.

2.4.1. *Mt. Bulgheria zone.*

a. Lower Liassic. Dolomitic limestones, gray calcarenites and calcilutites, reef limestones and breccias, calcarenites. Fossils: algae, corals, gastropods and pelecypods. Thickness: about 300 meters.

b. Middle Liassic. Gray calcarenites and calcilutites with chert nodules. Graded calcarenites and calcilutites near the Palinuro village. Fossils: foraminifers, rare ammonites, echinoid fragments. Thickness: about 500 meters.

c. Upper Liassic. Yellow calcareous shales and clays, calcarenites, microbreccias and intraformational conglomerates. Fossils: brachiopods, echinoid fragments, *Posidonomya* sp. Thickness: about 180 meters.

d. Dogger - lower Malm. Gray cherty calcarenites. Fossils: foraminifers, echinoid fragments. Thickness: about 200 meters.

e. Upper Malm - lower Cretaceous. Massive and/or bedded *Ellipsactinia* limestones; calcilutites, calcarenites and calcirudites with tintinnids. Thickness: ranging from few tens of meters to more than 180.

In the studied region this internal zone extends from Capri Island to northern coastal Calabria. Outcrops are present also near Maiori in the Sorrento peninsula and at the Mai Mt. (Picentini Mountains). In Capri the liassic facies are neritic, similar to

those of the next central zone; the Dogger and the lower Malm facies are represented by cherty limestones and the upper Malm facies by *Ellipsactinia* limestones. In northern Calabria there is a wide facies variability. Cherty limestones are prevailing and evidence of *Ellipsactinia* limestones is given by the large amount of their fragments in some upper Cretaceous-Paleocene breccias.

2.4.2. *Alburno-Cervati zone.*

a. Lower Liassic. Dolomitic limestones, often stromatolitic or oncolitic, calcarenites and intraformational conglomerates. Fossils: gastropods, pelecypods *Palaeodasycladus mediterraneus* (PIA), in the upper part. Thickness: about 450 meters.

b. Middle - upper Liassic. Gray and light brown, sometimes oncolitic calcarenites; calcarenites and calcilutites with yellowish calcareous shales, calcarenites and white oolitic limestones. Fossils: algae (*Palaeodasycladus mediterraneus* (PIA), etc.), foraminifers (*Orbitopsella praecursor* GÜMBEL, etc.), gastropods, pelecypods (*Lithyotis* guide-level). Thickness: 250-300 meters.

c. Dogger-Malm. Calcarenites and calcilutites, often oncolitic, oolitic limestones. Fossils: algae (Dogger: *Selliporella donzellii* SARTONI and CRESCENTI; Malm: *Clypeina jurassica* FAVRE), foraminifers (Dogger: *Pfenderina salernitan* SARTONI and CRESCENTI; Malm: *Kurnubia* spp.), nerineids and other gastropods, *incertae sedis* (*Cladocoropsis mirabilis* FELIX). Thickness: about 700 meters.

In the studied region this central zone has a wide uniformity. The only difference is in the color of the rocks, darker and darker toward the internal (southwestern) part of this zone.

2.4.3. *Monti della Maddalena zone.*

a. Lower Liassic. A section very similar to that of the Alburno-Cervati zone is cropping out.

b. Middle - upper Liassic. Generally absent. When observed the section is similar to that of the Alburno-Cervati zone, although with minor thickness.

c. Dogger - lower Malm. Generally absent. When observed the section consists of calcirudites and oolitic limestones, disconformably transgressing on the upper Triassic and Liassic part of the section. Thickness ranging from a few to 250 meters.

d. Upper Malm - lower Cretaceous. Ellipsactinia limestones and breccias (only locally). Thickness ranging from a few to about 100 meters.

In the studied region the Jurassic rocks belonging to this external zone are outcropping only locally along the external rim of the Campania-Lucania carbonate platform (Avella-Partenio Mts, Marzano Mt., Mountains of Muro Lucano and Vietri di Potenza, Monti della Maddalena and Campagna tectonic window).

2.5. Abruzzi-Campania belt.

The evidence of this belt is given by the carbonate rocks forming the Matese - Mt. Maggiore tectonic unit. The Abruzzi-Campania belt is a carbonate platform, the boundaries of which are the Lucania-Molise basin on the eastern and southeastern sides, and a probable tongue of this basin between the Campania-Lucania and the Abruzzi-Campania platforms on the southwestern side ([3]).

Across the Abruzzi-Campania carbonate platform it is possible to distinguish: (a) an internal, not yet well known, zone with reefoid and proximal forereef facies, mainly developped during Cretaceous time; (b) a central part (Mt. Maggiore zone) with back reef facies and (c) an external zone (western Matese zone) with transitional facies to pelagic sedimentary environments.

The areal diversification begins during the Liassic time and the paleogeographic pattern then established continues up to the middle Miocene (uppermost Burdigalian-Helvetian) when the whole belt is conformably overlapped by reefoid limestones and calcarenites which are grading upward into a flysch sequence during the Helvetian-Tortonian time.

2.5.1. *Internal zone.*

Jurassic outcrops of the internal zone of the Abruzzi-Campania platform are unknown, unless the sections present at the Maiulo and Taburno Mountains (considered as parts of the western Matese external zone, cropping out in tectonic windows) belong to this zone.

([3]) See over, discussion on Lucania-Molise paleogeographic domains.

2.5.2. *Mt. Maggiore zone.*

The Jurassic section of this zone is similar to that of the homologous central zone of the previously described Campania-Lucania platform. The main differences between the sections present in the two platforms are: lighter colors of the rocks, more diffused dolomitization in the lower part, lower thickness (about 1000 meters in the Mt. Maggiore zone against 1500 meters in the Alburno-Cervati zone of the Campania-Lucania belt).

2.5.3. *Western Matese zone.*

a. Lower Liassic. White dolomites and dolomitic limestones, often stromatolitic, intraformational conglomerates. Fossils: gastropods and pelecypods (Megalodontidae), algae. Thickness is about 450 meters.

b. Middle - upper Liassic. Red and green intraformational conglomerates, calcarenites. Fossils: *Palaeodasycladus mediterraneous* (Pia), *Orbitopsella praecursor* Gümbel, etc. Thickness is over 200 meters.

c. Dogger-Malm. Calcarenites and intraformational conglomerates. Fossils: *Pfenderina salernitana* Sartoni and Crescenti in the lower part, *Cladocoropsis mirabilis* Felix etc. in the upper part. The thickness is variable, possibly reaches more then 400 meters.

In this external zone the Jurassic sediments are partly or completly lacking and, moreover, when they are present, the lateral variations are very frequent.

2.6. Lucania-Molise belt.

This unit is evident by the rocks of upper Cretaceous and Tertiary age outcropping in the Frosolone window. Its existence in Lucania is inferred by the transitional facies of the eastern rim of the Campania-Lucania carbonate platform. In this region the sediments of the Lucania-Molise basin are supposed to be buried under the Lagonegro, Cilento, Alburno-Cervati and undistinguished Southern Apenninic thrust sheets. In Molise the Jurassic sediments belonging to this unit are known in the subsurface (Frosolone 2 well, drilled by AGIP), where pelagic cherty limestones, clayey limestones, breccias and interbedded volcanic tuffs have been reached.

2.7. Mt. Alpi.

The positione of Mt. Alpi is still uncertain and represents a focal point in the paleogeographic and palinspastic restoration of the Southern Apennine geosyncline.

Dogger-Malm. Gray calcarenites and calcilutites. Fossils: foraminifera (Dogger: *Pfenderina salernitana* Sartoni and Crescenti, etc.; Malm: *Kurnubia* spp., etc.), algae (*Selliporella donzellii* Sartoni and Crescenti; *Clypeina jurassica* Favre), nerineids and other gastropods, *incertae sedis* (*Cladocoropsis mirabilis* Felix). Thickness: more then 800 meters.

On the ground of the available data three hypotheses may be presented about the original position of Mt. Alpi:

— Mt. Alpi belongs to the foreland and therefore is a part of the Apulian carbonate platform, or it belongs to the Apenninic chain and therefore:

— it is a smaller platform forming a local morphologic high in the Lucania-Molise basin or

— it is, somehow, a southward continuation of the Abruzzi-Campania platform (4).

In the last case it is clear that there would be two basins: the internal Lucania basin between the Campania-Lucania and Abruzzi-Campania (including Mt. Alpi) carbonate platforms, and the external Molise basin between the Abruzzi-Campania and Apulian platforms.

2.8. Apulia belt.

It is evidenced by the carbonate rocks present in the Apulia region. This belt is a platform linking the Apenninic and the Helleno-Dinaric chains and, since the upper Triassic, it has been strongly subsiding during the Mesozoic.

The only Jurassic rocks in this area are outcropping in the western Gargano Peninsula. They are upper Malm calcarenites, calcirudites and oolitic limestones.

On its eastern side the Apulian carbonate platform passes to a basin facies (here named Gargano zone) through an *Ellipsactinia* and coral reef band. The Jurassic sediments of basinal facies are pelagic cherty limestones with tintinnids.

(4) This last possibility has been suggested by dr. I. Sgrosso, Institute of Geology, Naples University.

MAIN TECTONIC ELEMENTS	STRATIGRAPHIC-STRUCTURAL UNITS AND CORRESPONDING PALEOGEOGRAPHY		
	STRUCTURAL UNITS	PALEOGEOGRAPHIC UNITS	
	STRATIGRAPHIC-STRUCTURAL UNITS	BELTS	ZONES
SOUTHERN APENNINIC CHAIN	Monte Foraporta Unit	Monte Foraporta Belt	
	Lagonegro Units	Lagonegro Belt	Lagonegro Zone Pignola-Abriola Zone
	Cilento Unit	Cilento Belt	
	Alburno-Cervati Unit	Campania-Lucania Belt	Monte Bulgheria Zone Alburno-Cervati Zone Monti d. Maddalena Zone
		Lucania (Molise-Lucania) Belt	
	Monte Maggiore Unit Monte Alpi Unit	Abruzzi-Campania Belt (+Monte Alpi)	Internal Zone (unnamed) Monte Maggiore Zone Western Matese Zone
	Frosolone Unit	Molise (Molise-Lucania) Belt	
FORETROUGH	Foretrough Units	Apulia Belt	Murge Zone Gargano Zone
FORELAND	Murge-Gargano Unit		

TABLE 1

PART 2

PALEOGEOGRAPHIC EVOLUTION

3. GENERAL REMARKS.

A single cross-section in the studied area does not pass through all the distinguished paleogeographic units. So, two main sections will be used in the following discussion.

A first section goes across Lucania, from Mt. Bulgheria (Palinuro Cape) to the Adriatic Sea (Bari); a second one goes across Campania, from Capri Island to the Gargano Peninsula.

4. UPPER TRIASSIC PALEOGEOGRAPHY.

The upper Triassic sediments outcropping in the studied region allow to recognize three original belts:

a. an internal southwestern carbonate platform, corresponding to the Mt. Foraporta belt;

b. a central basin with pelagic calcareous sediments corresponding to the Lagonegro belt;

c. an external (north-eastern) broad platform corresponding to an area which, after the lower Liassic time, will be the location of the Campania-Lucania and Abruzzi-Campania platforms, of the Lucania-Molise basin and of the Apulia platform.

This Triassic external area can be divided in two parts: a southwestern part with shallow water dolomites and a northeastern part, corresponding to the Apulian belt (Gargano peninsula) with evaporitic sediments (mainly anhydrites) arching northwesterly around the dolomite area into the Central Apennines.

At the end of the Triassic time in the outer platform belt conglomeratic levels show the beginning of a tectonic phase which developed mainly at the end of the lower Liassic time.

5. JURASSIC PALEOGEOGRAPHY.

5.1. Lower Liassic paleogeography.

The broad Triassic platform begins to subdivide itself into smaller platforms separated by depressions, which later evolve into

basins, during the lower Liassic time. Widespread conglomeratic facies are present along those alignements which well mark the northeastern margins of the post-Triassic Campania-Lucania and Abruzzi-Campania platforms.

Along the Tyrrhenian margin of the Campania-Lucania platform the Palinuro reef complex is the only outcropping part of the platform western limit.

The sedimentary sequence present in the Lagonegro basin indicates a progressive deepening of the sea during the lower Liassic time.

At the end of the lower Liassic a strong tensional tectonic phase interests the whole external area of the Apenninic geosyncline, impressing the gross features which persist during the whole pre-orogenetic history of the studied region.

5.2. Middle - upper Liassic paleogeography.

During the middle and upper Liassic time a sharper differentiation into platforms and basins is reached in the studied area. At this point it is possible to recognize the belts described in the first part of this paper. A restored section, from the internal known belts, through Lucania shows:

a. a *carbonate platform* with bituminous dolomites and limestones (Mt. Foraporta belt) where starvation conditions of sedimentation were probably present over a large area;

b. a *basin* with clay and radiolarite sediments, interfingering with calcareous turbidites in the proximal part of the basin (Lagonegro belt);

c. a *carbonate platform* with a large back-reef area and margins characterized by reef complexes, emerging narrow lowlands and submerged thresholds bounded by faults in motion and, in the more external parts, by interfingering fore-reef and basinal sediments (Campania-Lucania platform belt);

d. a *basin* (Lucania or (?) Lucania-Molise basin) whose sediments not outcropping are inferred by the transitional facies along the external rim of the Campania-Lucania platform.

e. a *carbonate platform* (Mt. Alpi) the original position of which has been already discussed. If it corresponds to a southward extension of the Abruzzi-Campania platform it divides a western

Lucania basin from an eastern Molise basin; if Mt. Alpi is part of the Apulian platform it constitutes the innermost part of the foreland;

f. a *carbonate platform* highly subsident (Apulia platform).

A restored section through Campania shows:

— the Campania-Lucania and Abruzzi-Campania platforms. It is not yet ascertained when the Abruzzi-Campania and the Campania-Lucania platforms differentiate as distincted units;
— a basin (Molise or (?) Lucania-Molise basin), the Jurassic sediments of which are unknown but inferred by the transitional facies along the external rim of the Abruzzi-Campania platform;
— the Apulia platform which passes eastward to a basin (eastern Gargano Peninsula).

5.3. Dogger - Malm paleogeography.

During the Dogger and Malm time the paleogeographic pattern of the studied region is similar to that of the upper Liassic time.

A section through Lucania shows practically unchanged conditions in the Mt. Foraporta belt. On the contrary the Lagonegro basin subsides strongly and reaches bathyal deepts in its central part at this time.

At the end of the Jurassic time « pre-flysch » sediments begin to fill the Lagonegro basin.

The Campania-Lucania platform mantains its general configuration, although minor horizontal facies migrations occur as a consequence of vertical oscillations. During the upper Malm *Ellipsactinia* limestones mark the rims of the Campania-Lucania platform.

A section through Campania shows at this time evidences of the separation of the Campania-Lucania and Abruzzi-Campania platforms.

The breack between the two platforms corresponds to a northwestern extension of the Lucania basin. A further northward extension of this tongue is assumable, although not yet recognized. The connection of Mt. Massico with the Campania-Lucania platform is hypothetical.

On the contrary the Abruzzi-Campania platform surely extends northward up to the Velino Mountains, south of L'Aquila.

Along its external rim there is clear evidence of transition to the Molise basin; viceversa the inner rim is not well evident, possibly because it is partially covered by the overthrusting of the Campania-Lucania platform.

The Molise basin Jurassic sediments are not outcropping and are known only in the Frosolone 2 well, drilled by A.G.I.P.

In the Apulia carbonate platform the transitional facies to the Molise basin are not known, whereas an eastward transition to the Gargano basin, marked by a reef complex, is outcropping.

6. CONCLUSIVE REMARKS.

The available data and the related palinspastic restoration given in the present paper allow to distinguish, in the discussed area of the Apenninic geosyncline, two parts:

a. an internal part formed by the Mt. Foraporta and Lagonegro belts and, after the Jurassic, also by the Cilento belt;

b. an external part formed by the Campania-Lucania, Abruzzi-Campania and Apulian platforms, with intermediate basins.

The individuation of the internal part begins during the upper Triassic time, whereas the external part individuates itself during the Liassic time.

After the Jurassic the internal part attains a new configuration: on the external side of the Lagonegro belt the Cilento flysch basin develops because of the eastward migration of the geosyncline axis; on the contrary, in the external part the general pattern remains unchanged and only the boundaries among the isopic zones become sharper.

The main open problems relative to the area of the internal belts concern the relationships between the Lagonegro and Cilento belts and the emplacement area of the lower Cretaceous ophyolites.

In the external belts the main open problems concern the original extension and relationships of the Campania-Lucania and Abruzzi-Campania platforms and the meaning of Mt. Alpi. The latter is a first order problem since, until now, it is not clear whether Mt. Alpi belongs to the Apenninic chain or to the Apulian foreland.

Along these lines future geological research will be directed.

University of Naples, Geology Institute, August 1969.

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CONTENTS

Part 2

PALEOGEOGRAPHIC EVOLUTION

FORAPORTA MT.

L A G O N E G R O

CAMPANIA – LUCANIA

MONTE ALPI

S. FELE

PIGNOLA–ABRIOLA

LAGONEGRO

BULGHERIA MT.

ALBURNO–CERVATI MT.

MONTI DELLA MADDALENA

DOGGER

LIAS

LOW CRET

DOGGER – MALM

LIAS

TRIAS

LIAS DOGGER – MALM

U. LIAS

M. LIAS

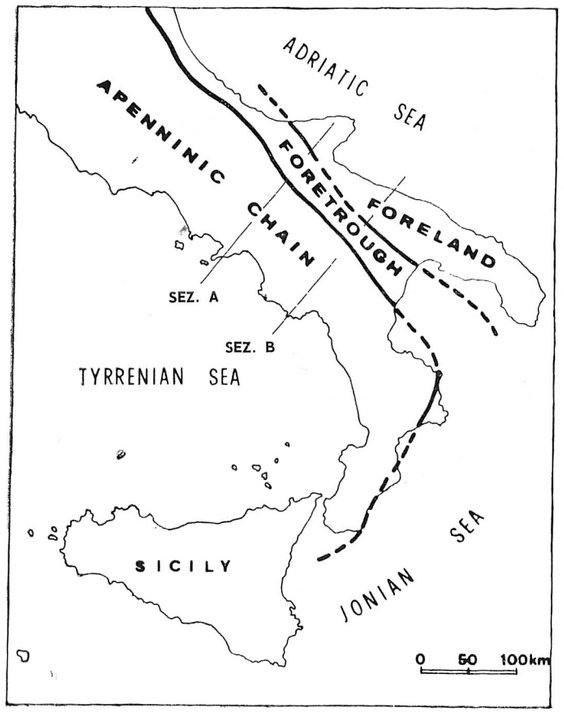
L. LIAS

M. and U. LIAS

MALM

L. LIAS

TRIAS



m
400
300
200
100
0

0 25 50 km

LEGEND

- Radiolarites
- Claystones
- Marls
- Breccias and microbreccias
- Massive limestones
- Limestones
- Dolomites
- Disconformity

SEZ. A

CAMPANIA – LUCANIA B. LUCANIA B. ABRUZZI-CAMPANIA B. MOLISE B. APULIA B.

?

SEZ. B

MT. FORAPORTA B. LAGONEGRO B. CAMPANIA – LUCANIA B. LUCANIA B. MT. ALPI MOLISE B. APULIA B.

?