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

by

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Introduction

The present paper is a contribution to an understanding of the Southern Apennines paleogeography. In the area Jurassic sediments had not been recognized, but in a few places, up to ten years ago. They had been mapped mostly as Cretaceous, sometimes as Upper Triassic in age. A mighty 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 geologic development of the Southern Apennines has been worked up 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 areas 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 investigators of the geologic problems of the Southern Apennines.

D'ARGENIO has carried out his research mainly west of the Salerno–Benevento line, while SCANDONE has dealt mainly with the area situated east of the above mentioned line.

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I. Tectonic units and primary paleogeographic Belts of the 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 therefore 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* has developed during the Miocene time on the external side of the chain. This trough is filled by sediments tectonically derived by the Apenninic chain and by autochthonous and parautochthonous clastics, 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 section, covered by a thin veneer of Tertiary clastics and calcareous sediments. This area has been subjected only to minor tectonic deformation through a system of normal faults.

Southern Apenninic chain

In the *Southern Apenninic chain* several stratigraphic-structural units can be distinguished*.

1. Monte Foraporta unit

It consists of white dolomites of Triassic age; grey dolomites, black bituminous calcilutites and calcarenites with thin calcareous claystones of Middle Jurassic age, tectonically resting on the former Triassic dolomites.

Triassic beds reach up to 150 metres in total thickness, while Jurassic beds are up to 250 metres.

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

2. Lagonegro units

a) *Lower unit.* Upper Triassic cherty calcilutites, Jurassic radiolarites, Upper Jurassic and Lower Cretaceous claystones, highly siliceous claystones and siliceous limestones form the lower Lagonegro unit. Its total thickness is about 1000 metres.

b) *Upper unit.* Middle Triassic calcareous claystones; claystones, siltstones and sandstones with interbedded reefs form the lower part of the upper Lagonegro unit.

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

This section grades upward into a sequence of radiolarites interbedded with calcareous microbreccias of Jurassic age. The upper portion of this unit consists of siliceous and calcareous claystones, siliceous limestones and calcareous microbreccias ranging in age from the Upper Jurassic to the Lower Cretaceous. Its total thickness reaches up to 1000 metres.

Both Lagonegro units form a composite thrust sheet which rests upon the Alburno–Cervati unit some instances, while it is generally covered by the same unit and by the Monte Foraporta and Cilento units.

3. Cilento unit

This unit consists of flysh 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. This rock sequence passes 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 upward of 3,500 metres.

This unit forms a thrust sheet resting up on all the previously described units and up on the Alburno–Cervati unit.

4. Alburno–Cervati unit

Int this unit Carnian with massive dolomites, blackish limestones and calcareous shales, grade upward into Upper Triassic grey and white dolomites, Jurassic and Cretaceous dolomitic limestones and limestones which are locally covered by disconformable Eocene and Paleocene limestones. Aquitanian to Burdigalian glauconitic calcarenites, graded sandstones, calcareous shales and microbreccias lie with a small uncorformity or disconformably upon the previously mentioned section.

The total thickness of the Mesozoic and Lower Tertiary beds reaches up to 4 500 metres, while Miocene beds are about 200 metres thick.

Along the Tyrrhenian and Adriatic rims frequently disconformable reefs with reef breccias, cherty limestones and calcareous shales were deposited during Jurassic time while calcareous breccias, graded calcarenites and pelagic limestones developed during the Cretaceous and Lower Tertiary.

This unit is a thrust sheet resting upon the Lagonegro Thrust sheet and is tectonically covered by the Monte Foraporta, Cilento and locally by the Lagonegro units.

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 disconformably by Upper Cretaceous limestones. The stratigraphic break is marked by bauxitic deposits. Locally Paleocene and Eocene limestones lie

disconformably upon the above section while Burdigalian 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 25 000 metres, while the Miocene thickness ranges between 500 and 800 metres.

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.

6. Frosolone unit

In this unit cherts and cherty limestones, calcarenites, calcirudites and calcilutites are Cretaceous to Lower Tertiary in age. Calcarenites and calcareous shales interbedded with calcareous graded sandstones and graded sandstones overlie the above section, being Aquitanian to Tortonian in age.

The total thickness of this unit is about 600 metres.

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

7. Undistinguished Southern Apenninic complexes

Three types of rock sequences which, according to the Code of Stratigraphic Nomenclature, can be named complexes, are present throughout the studied area. These complexes are: *a)* "*argille varicolori*" = variegated, thin bedded, generally highly deformed claystones and siltstones, *b)* the *Corleto Perticara complex* consists of whitish calcilutites and calcarenites, grey and reddish calcareous shales interbedded with graded sandstones, *c)* the provisionally named "*red flysch*" consists 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.

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 1 200 metres.

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

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 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 is given by the western edge of the Apulian foreland.

Apulian foreland

In the Apulian foreland the sequence, known partially through wells rilled 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 4 000 metres in the northern part up to more than 6 000 metres in the southern part.

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 time it has been possible to establish the relationships between adjacent belts, at other times these relationships are inferred only.

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 St. Foraporta belt possibly corresponds to an open and partly landlocked shallow water area.

Jurassic stratigraphy:

a) *Upper Lias* (?). Thin bedded grey dolomites (80–100 metres).
Fossils: rare and small gastropods moulds.

b) *Dogger*. Well bedded, blackish, bituminous calcilutites and calcarenites with thin yellowish marly beds (around 150 metres).
Fossils: brachiopods and rare ammonites, arenaceous foraminifera and rare algae.

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) arerepresented 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 are evident.

Jurassic stratigraphy:

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.

1. S. Fele section

a) *Lias*. Graded polygenic breccias and microbreccias (granules provenance from a shallow water carbonate sequence; bed thickness 0.6–4 metres) with cherty lenses and nodules and thin beds of claystone and radiolarites.
Fossils: echinoid, pelecypod, brachiopod, coral and algae fragments; radiolaria and foraminifera [in the upper part *Dictyoconus* (?) *cayeuxi* LUCAS].
Thickness: 40 metres.

b) *Dogger—Malm*. Graded microbreccias and oölithic calcarenites, claystones and radiolarites; red and green radilolarites with thin graded, often silicified, microbreccia intercalations. Slumps in the upper part of the radiolaritic sequence.
Fossils: *Protopeneroplis striata* WEINSCHENK, *Nautiloculina oolitica* KOHLER, *Trocholina* spp., radiolaria etc.
Thickness about 190 metres.

c) *Upper Malm—Lower Cretaceous*. Claystones, siliceous claystones, calcareous shales, siliceous limestones and graded calcareous microbreccias.
Fossils: radiolaria and in the lower part *Protopeneroplis striata* WEINSCHENK, *Nautiloculina* cfr. *oolitica* KOHLER, *Trocholina* spp. etc.
Thickness: a few hundred metres (outcropping part of the section).

2. Pignola-Abriola section

a) *Lias*. Grey, red and green marls and claystones, fine grained graded calcarenites and subordinately jaspers.
Fossils: radiolaria, rare foraminifera.
Thickness: about 70 metres.

b) *Dogger—Malm*. Radiolarites and claystones; red and green radiolarites with some graded calcarenite intercalations. Frequent slumps in the upper part of the section.

Fossils: radiolaria, *Protopeneroplis striata* WEINSCHENK, *Nautiloculina oolitica* KOHLER, *Trocholina* spp. etc.
Thickness: about 170 metres.

c) *Upper Malm—Lower Cretaceous.* Claystones, siliceous and calcareous claystones, siliceous limestones and graded calcareous microbreccias.
Fossils: radiolaria and in the lower part *Protopeneroplis striata* WEINSCHENK, *Nautiloculina oolitica* KOHLER, *Trocholina* spp.
Thickness: a few hundred metres (outcropping part of the section).

3. Lagonegro section

a) *Lias, Dogger—Malm.* Red, green and dark grey siliceous claystones and radiolarites; green radiolarites.
Fossils: radiolaria.
Thickness: 60–65 metres.

b) *Upper Malm—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: only radiolaria.
Thickness: more than 400 metres.

Cilento belt

It is a basin and its characters are shown by the rocks forming the Cilento thrust sheet. This basin 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 "preflysch" facies (Cretaceous) to a typical flysch facies (Upper Cretaceous—Upper Oligocene).

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

* See over discussion on Lucania—Molise paleogeographic domains.

The areal diversification begins during the uppermost Triassic – Lower Lias 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.

Jurassic stratigraphy:

1. Mt. Bulgheria zone

a) *Lower Lias*. Dolomitic limestones, grey calcarenites and calcilutites, reeflimestones and breccias, calcarenites.
Fossils: algae, corals, gastropods and pelecypods.
Thickness: about 300 metres.

b) *Middle Lias*. Grey calcarenites and calcilutites with chert nodules. Graded calcarenite and calcilutites near the Palinuro village.
Fossils: foraminifers, rare ammonites, echinoid fragments.
Thickness: about 500 metres.

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

d) *Dogger – Lower Malm*. Grey cherty calcarenites.
Fossils: foraminifers, echinoi fragments.
Thickness: about 200 metres.

e) *Upper Malm – Lower Cretaceous*. Massive and or bedded *Ellipsactinia* limestones; calcilutites, calcarenites and calcirudites with tintinnids.
Thickness: ranging from few tens of metres 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. Alburno – Cervati zone

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

b) *Middle – Upper Lias*. Grey and light brown, sometimes oncolitic calcarenites; calcarenites and calcilutites with yellowish calcareous shales, calcarenites and white oölitic limestones.
Fossils: algae [*P. mediterraneus* (PIA) etc.], foraminifers (*Orbitopsella praecursor* GÜMBEL etc.), gastropods, pelecypods (*Lithiotis* guide-level).
Thickness: 250–300 metres.

c) *Dogger – Malm*. Calcarenites and calcilutites, often oncolitic, oölitic limestones.

Fossils: algae (Dogger: *Selliporella donzellii* SARTONI and CRESCENTI; Malm: *Clypeina jurassica* FAVRE), foraminifers (Dogger: *Pfenderina salernitana* SARTONI and CRESCENTI; Malm: *Kurnubia* sp.), nerineids and other gastropods, incertae sedis (*Cladocoropsis mirabilis* FELIX).

Thickness: about 700 metres.

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.

3. Monti della Maddalena zone

a) *Lower Lias*. A section very similar to that of the Alburno–Cervati zone is outcropped.

b) *Middle–Upper Lias*. 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 oölitic limestones, disconformably transgressing on the upper Triassic and Lias, part of the section.

Thickness ranging from a few to 250 metres.

d) *Upper Malm–Lower Cretaceous*. *Ellipsactinia* limestones and breccias (only locally).

Thickness ranging from a few to about 100 metres.

In the studied region the jurassic rocks belongig to this external zone are outcropping only locally along the external rim of the Campania–Lucania carbonate platform (Avella–Partenio Mt., Campagna tectonic window in the Picentini Mt., Arzano Mt. and the Mountains of Muro Lucano and Vietri di Potenza.

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*.

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 developed during the 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.

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* See over, discussion on Lucania–Molise paleogeographic domains.

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, outcropping in tectonic windows) belong to this zone.

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 metres in the Mt. Maggiore zone against 1500 metres in the Alburno – Cervati zone of the Campania – Lucania belt.).

3. Western Matese zone

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

b) *Middle – Upper Lias*. Red and green intraformational conglomerates, calcarenites.
Fossils: *Palaeodasycladus mediterraneus* (PIA), *Orbitopsella praecursor* GÜMBEL, etc.
Thickness is over 200 metres.

c) *Dogger – Malm*. Calcarenites and intraformational conglomerates.
Fossils: *Pfenderina salernitana* SARTONI and CRESCENTI in the lower part, *Clypeina mirabilis* FELIX etc. in the upper part. The thickness is variable, possibly reaches more then 400 metres.

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

At the Taburno and Maiulo Mountains the sequence from the Middle Lias up to the Malm is entirely formed by calcarenites and intraformational conglomerates.

Lucania – Molise belt

This unit is evident by the rocks of upper Cretaceous and Tertiary age outcropping in the Frosolone tectonic unit. 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.

Mt. Alpi

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

Jurassic stratigraphy:

Dogger—Malm. Gray calcarenites and calcilutites.
Fossils: foraminifera (Dogger: *Pfenderina salernitana* SARTONI and CRESCENTI etc.) Malm: *Kurnubia* sp. etc.); algae (*Selliporella donzellii* SARTONI and CRESCENTI; *Clypeina jurassica* FAVRE), nerineids and other gastropods, incertae sedis (*Cladocoropsis mirabilis* FELIX).
Thickness: more than 800 metres.

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

1. 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:
2. it is a smaller platform forming a local morphologic high in the Lucania – Molise basin or
3. it is, somehow, a southward continuation of the Abruzzi – Campania platform*.

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.

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 oölitic 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 basin facies are pelagic cherty limestones with tintinnids.

II. Paleogeographic Evolution

1. 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 Capr Island to the Gargano Peninsula.

* This last possibility has been suggested by DR. SGROSSO, Institute of Geology, Naples University.

2. 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 correspondig to the Lagonegro belt;

c) an easternal (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 other platform belt conglomeratic levels show the beginning of a tectonic phase which developed mainly at the end of the Lower Liassic time.

3. JURASSIC PALEOGEOGRAPHY

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 Lias 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.

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 (St. 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 margine 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—Molise basin or (?) Lucania 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 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 platform with its inner rim outcropping. It is not yet ascertained if the Abruzzi—Campania and the Campania—Lucania platforms are already differentiated 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;
- a carbonate platform (Apulia platform) which passes eastward to a basin (eastern Gargano Peninsula).

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 deeps 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 maintains 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 the first evidence of the separation of the Campania–Lucania and Abruzzi–Campania platforms.

The break between the two platforms corresponds to a northwestern extension of the Lucania basin. A further northward extension of this tongue is 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 AGIP.

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.

Conclusive remarks

The available data and the related palinspastic restoration given in the present paper allow to distinguish, in the discussed area of the Appenninic geosyncline, 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 Apulian platforms, with intermediate basin. 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 ophiolites.

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.

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NOTICE

The authors beg excuse because for unexpected technic reasons the reference list does not follow the text.

The authors will send the above list to any interested student who should request it in about two weeks.