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STRUCTURAL-STRATIGRAPHIC UNITS AND TECTONIC FRAMEWORK OF SOUTHERN APENNINES

by

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INTRODUCTION

The aim of the present work is to synthesize our present points of view on the tectonic framework and on the paleogeographic history of southern Apennines.

This work is based on research carried out both by us and our collegues of the Naples University. Research carried out by geologists from other universities have also been taken into account.

The discussion will follow the scheme of the lecture made by B. D'Argenio at the "Symposium on Modern Views on the Apenninic Geology" held by the Accademia Nazionale dei Lincei on February 1972. This means that we will describe the structural framework of southern Apennines as it appears from field work carried out in Campania, Lucania, Puglia and northern Calabria: that is, between the Garigliano and Sangro valleys to the north and the Sangineto, Esaro, and Crati valleys to the south. It must be noted that the palinspastic models presented in this work are limited to the Apenninic *outer zones* only, as we do not have information enough to do the same thing for the *inner zones*.

HISTORICAL REMARKS

Not much was known of the geological structure of southern Apennines until the end of last century if we except a few brillant observations made by L. Pilla (1847).

Systematic observations started in 1880, thanks to geologists of the Geological Survey, to consultant geologists working for the railways and to A. Scacchi and F. Bossani of the Neapolitan geological school.

The most representative man of the Neapolitan school was G. De Lorenzo, who between 1896 and 1904, published a series of papers illustrating his ideas on the geology of southern Apennines. De Lorenzo, following the geological ideas of his times, believed in the total autochtony of southern Apennines, but he also admitted "tectonic denudation" of wide areas caused by the gravitative sliding of the "Eomiocenic flysch".

The ideas of De Lorenzo formed the basic background of the geological school of Naples until the first half of the present century.

Foreign workers were the first to doubt the total autochthony of southern Apennines. Among them we may recall M. Lugeon and E. Argand (1906) who recognized the allochthonous nature of the trust sheets of Calabria; N. Tilmann (1912), M. Limanowski (1913) who recognized the Calabrian granites to be the highest tectonic unit of the Apennine, J. Gryzobwski (1921) and others that were later joined by some Italian workers as S. Franchi (1923), M. Anelli (1939) and R. Signorini (1939).

Of particular interest are the works by H.W. Quitzow (1935) and R.B. Behrmann (1936) of the Berlin geological school directed by H. Stille.

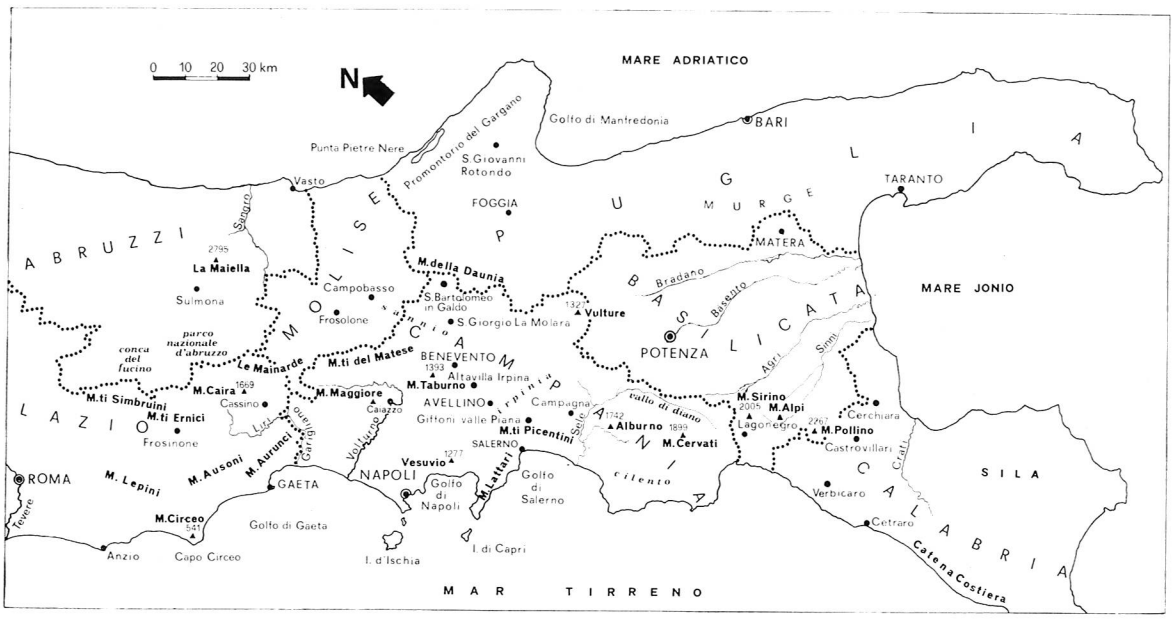

Fig. 1. *Map of the locations mentioned in the text.*

Quitzow centered his attention on Calabria that he thought to be a typical example of the behaviour of a relatively stable massif as opposed to his more mobile marginal belt. In other words he saw the central part of the Calabrian massif (Serre) as essentially autochthonous while his edges were thrusted over the marginal basins. As far as the areas north of the Sangineto line are concerned, Quitzow thought the Basilicata's carbonatic series to be autochthonous and overthrusted by metamorphic Triassic thrust sheets, which, in turn, are owerthrusted by the edges of the Calabrian granites.

R.B. Behrmann agrees with Quitzow as far as the geology of Calabria is concerned, while for the remaining areas he agrees more with De Lorenzo, even if he expresses some doubts on his previous ideas in a short paper published in 1958. In the last century the consultants of the railways recognized the analogy existing between the ophiolitic "argille scagliose" of northern Apennines and certain shales of southern Apennines such as some sequences of the Cilento's flysch, the Frido formation and some outcrops of varicolored shales affected by large size landslides. Beneo (1950) accepted such analogy and grouped the above mentioned formations along with others to form the group of the Argille Scagliose (AS), virtually identifying them with the Ligurides of Steinmann (1926).

Between 1956 and 1957 F. Ippolito and P. Lucini published their paper on the flysch and R. Selli published his paper on the Miocenic transgression.

The former paper, beside attempting to group and classify the known flyschs, recognizes for the first time the existence of a gradual passage between the "Triassic" *cherty shales* of Lagonegro and the "Cretaceous" *Galestri* formation.

The latter paper recognizes and describes on regional scale the Mocenic transgression; besides we find in it some ideas on the structure of southern Apennines that will be expressed more completely in a successive work.

Also in the late fifties we have the confirmation of the stratigraphic continuity between the cherty limestones and the "galestri" (F. Scarsella, 1957) the differentiation between ophiolites and limburgitic cycle (P. Lucini, 1959), the discovery of Cretaceous fossils in the Cilento's flysch (P. Lucini, L.

Masperoni, A. Spada, 1957), and the recognition of the thrusting of metamorphic rocks ("ophiolitic flysch") over unmetamorphosed sediments in the Frido Valley.

The second monograph of R. Selli is published in 1962 and represents the first important attempt, after De Lorenzo's synthesis, to give an integrated view of the geology of southern Apennines.

The monograph reaffirms the autochthony of the carbonatic series which is seen as backbone of the Apenninic chain but it recognizes the existence of thrust sheets in the Sannio, Cilento, Lagonegro and northern Calabria areas.

Furthermore this work attempts as first coherent paleogeographic reconstruction of the Langhian and post-Langhian basins and recognizes the existence of several tectonic phases during the Miocene and the Pliocene.

In the early sixties the geologists of the Laboratory of Dynamic Geology of the Sorbonne and of the Institute of structural geology of Montpellier, began to study the southern Apennines. Using their knowledge of the western Alps, Glangeaud and Grandjacquet (1961) focus their interest on one of the most important geological problems of the central Mediterranean area: the tectonic boundary between Africa and Europe. The authors hypothetically localize this boundary in Calabria along the "Sanguineto line". To the South of this structural element the authors recognize the prolongation of the tectonic units of northern Africa and Sicily and generally recognize a tectonic style made of thrust sheets; to the North of the "Sangineto line" the tectonic style is completely different and is characterized by the presence of the autochthonous, calcareous Apennines. The "Sangineto line" would then represent the scar of an oceanic hiatus between the "Mesogeide" sialic plate which represents the basement of the autochthonous, calcareous Apennine, and the Sila's plate. The Sila has been thrusted over the Apennines and would then represent the forefront of the African domain.

As the geological information on hand for the southern Apennines increased the previous scheme has been successively modified up to the latest synthesis of Grandjacquet, Haccard and Lorenz (1972) where the authors recognize a total allochthony of the pre-Upper Pliocene rocks of southern Apennines.

The authors, moreover, attempt a correlation between Alpine, Apenninic and Calabrian tectonic movements recognizing a series of older tectonic phases with a "Tyrrhenian" vergence which starting from the Aquitanian and Langhian, are followed by tectonic phases with an "Adriatic" vergence. In 1969 Ogniben published a synthesis discussing the "Calabrian-Lucanian" border. Ogniben separates the rocks of southern Apennines in several "complexes" which are, in a downward, sequence, as follows:

H) Post-orogenic complex (Upper Pliocene-Lower Pliocene cycle and later deposits);

G) Ex post-orogenic complex (Tortonian-mid-Pliocene deposits);

F) Sicilide complex (Nocara flysch, varicolored shales and Gorgoglione flysch of the Rosito's thrust sheet, varicolored shales of the Rocca Imperiales thrust sheet);

E) Calabride complex (crystalline rocks of the dioritic-kinzigitic formation etc.);

D) Liguride complex (Albidona flysch, Saraceno formation, Frido-"Cretenere" formation and associated ophiolites, Calpionella limestone formation);

C) Panormide complex (Mesozoic calcareous-dolomitic series and sediments of the Miocenic transgression);

B) Former basal complex (Masseria Luci flysch, Serra Palazzo and Masseria Palazzo formation, Serra Cortina marls and Numidian flysch);

A) Basal complex (sediments of Lagonegro Basin).

The paleogeography, following Auboin's scheme (1963), would be as follows from east to west:

1) Apulian foreland;

2) Miogeosyncline (basal and ex-basal complexes);

3) Tectonic borderland (Panormide complex);

4) Eugeosyncline (inner area: Liguride complex; outer area: Sicilide complex);

5) Island arc group (Calabride complex).

The author recognizes five periods of orogenesis:

1st period: (Eocene-Oligocene) the Calabride complex is thrusted over the Liguride complex;

2nd period: (lower Miocenic) the Sicilide complex is thrusted over the Calabride and Liguride complexes.

3rd period: (mid-Serravallian) the Sicilide, Calabride and Liguride complexes are thrusted over the Panormide complex.

4th period: (Serravallian-Tortonian) the previous complexes are thrusted over the Basal complex.

5th period: (following immediately in time) with further outer thrusting of the Sicilide complex.

A strong uplift of the chain in upper Pliocene, along with strong subsidence, in the fore trough, caused a resurgence of the thrusting movements with the emplacement of the Metaponto thrust sheet.

Ogniben's monograph, after the Selli's one, is a notable offort to organically represent within a theoretical scheme the complex structure of southern Apennines in its entirety.

In this short review we purposely did not mention the papers published by workers of the University of Naples in recent years as their most valid parts will be used in the following pages. A complete list of authors will be found in the bibliography published by F. Ippolito in 1972.

DESCRIPTION OF THE STRUCTURAL-STRATIGRAPHIC UNITS

Before briefly discussing the geometric disposition of the various structural-stratigraphic units and before talking of the most meaningful aspects of the paleogeographic evolution of the southern Apenninc area, it is a must to give a brief description of the units themselves.

North of Sangineto line we may distinguish between: a) foreland and foretrough units; d)inner units.

For what concerns units a), b), and c) it is presently possible to recognize the relationships between the stratigraphic-structural units and the original paleogeographic units. The same thing is not possible for the inner units due to our scarce information about them.

FORELAND AND FORE-TROUGH UNITS

Apulo-Garganic unit.

This unit, which represented the foreland in Pliocene time, outcrops in the area between the Gargano and the Murge.

The outcropping area is tectonically stable, with a gently rolling surface, and is affected by subvertical faults only, often with strong relative displacements.

The sequence, which does not outcrop in its full thickness but is well known because it has been crossed by drilling, begins with evaporites of upper Triassic age (Carnian) followed by shelf carbonate platform deposits of Jurassic, Cretaceous and lower Tertiary age. Reefoidal and basinal facies (eastern Gargano) are known to occur from the upper Jurassic.

The unit's thickness ranges from about 4000 meters (Gargano) to over 6000 meters (Salento).

Units of the Bradanic through

This unit crops out in the Bradanic trough. The unit ranges in age from Pliocene to Calabrian and is made of ruditic, arenitic and pelitic sediments with facies varying from littoral to bathyal.

Allochthonous sediments of Apenninic origin are intercalated in the normal sequence in the inner part of the trough.

The total thickness may sometimes exceed 3000 meters.

LATE TECTOGENESIS UNITS

We group here the units deposited after the main tectonic periods took place. This means, as we will see, that these units were deposited after the Tortonian tectonic movements.

Ariano Unit

This unit consists of Plio-Pleistocenic sequences which were deposited within intra-Apenninc basins formed after the middle Pliocene tectonic movements.

Mostly the unit consists of neritic clastics.

Altavilla Unit

This unit outcrops discontinously along the Apenninc front and in more internal areas such as that of Altavilla (Avellino) after which the unit has been named.

At the base we often find evaporitic sediments (*"gessoso-solfifera"* formation) followed upwards by clastics.

The age ranges from upper Tortonian to middle Pliocene. The facies range from littoral to bathyal.

The thickness varies strongly from place to place with a maximum of a few hundred meters. The Altavilla unit has been affected by the last thrusting movements of middle Pliocene as we can see along the Apenninic front where sediments of the Bradanic unit overlie unconformably the Altavilla unit.

External units

Frosolone unit

The upper part (Upper Cretaceous-Miocene) of this unit outcrops north of the Matese area. The lower part of the unit is known because it his been crossed by the Frosolone 1 well, drilled by AGIP (Pieri, 1966).

From down up unit is made of cherty dolomites (Triassic-Liassic?), shale and radiolarites with volcanic intercalations (Jurassic), graded calcareous sandstones, calcilutites, and marlstones (Cretaceous-lower Tertiary), calcarenites, siltstones and sandstone (lower and middle Pliocene); terrigenous clastics start to be deposited between upper Serravalian and Tortonian.

The facies are basinal, and the pertaining sediments are correlable with these outcropping near the northern limits of the Matese area.

The paleogeographic area where this unit was deposited is the Molisen Basin and it was localed between the Apulian and the Abruzzi Campania carbonate platforms.

Matese - Mt. Maggiore unit (Abruzzi-Campania Carbonate Platform)

This unit outcrops in the Matese area at the following localities: Mt. Maggiore, Mt. Camposauro, Mt. Massico, Suio Mtns. and in parts of the Lepini Mtns.

In Lucania the unit outcrops in the tectonic window of Mt. Alpi.

Lithologically the sequence is made of carbonates. In the lower part (Upper Triassic-lower Liassic) dolomites are predominant, while limestones are predominant in the middle and upper parts (Middle Liassic-Upper Cretaceous). Middle Cretaceous deposits are absent and the disconformity is frequently marked by a bauxitic horizon.

Rocks of lower Tertiary are generally absent and the Miocene sediments which are transgressive on top of the Cretaceous rocks usually, consist of limestones, marlstones and secondarily,of terrigenous clastics.

The base of the Miocene sediments ranges in age between upper Serravallian and lower Tortonian The unit may be thicker then 3000 meters.

The facies of the carbonates is mostly backreef; locally (western Matese) the facies may be typical of a proximal basin so that it is possible to make correlations with similar facies of the Frosoline unit.

The Miocenic terrigenous clastics are mostly turbidites and their facies is bathyal.

Monte Croce unit

This unit outcrops in the Picentini Mountains and represent the lowest known unit outcropping, in the tectonic window of Campagna.

The outcrops are several hundred meters thick and the sequence, from down up, consits of: white, sometimes cherty dolomites; grey limestones and shales; cherty, white dolomites (Carnian-Norian); massive limestones and breccias with corals (Upper Jurassic) overlie unconformably the Triassic rocks and are overlain unconformably by Eocenic sediments (calcirudites and calcarenites with nummulites and alveolinas) and Miocenic sediments (calcarenites, passing to marlstones and sandstones of Servallian-Tortonian age).

This sequence appears to have been deposited on the inner edge of the Abruzzi-Campania carbonate platform.

Irpinian Units

Under this name we group several units generally made by terrigenous deposits, very variable in facies; some of these units have wildflysch characters.

These units outcrop along a belt, about 50 kilometers wide, extending across Campania, Lucania and Daunia.

From northwest to southeast we may recognize three types of sequences:

— a sequence of marls and calcarenites (Fateo or Daunia flysch), about 500 meters thick and ranging in age from Langhian to lower Tortonian.

— a sequence of Langhian quartzose sandstones (Stigliano sandstones or Numidian flysch) overlain by calcarenites and then by arkose (Serrapalazzo fm.) of Serravallian age; these sediments are topped by Tortonian marls. Total thickness is over 1500 meters.

— a mostly arenaceous sequence consisting of conglomerates and arkosic sandstones (Castelvetere flysch, Caiazzo sandstones, San Giorgio fm., Gorgoglione flysch, etc.). The age ranges from Langhian to lower Tortonian and the thickness in the order of 1500 meters.

The lower part of the Castelvetere fm. has wildflysch characters and encloses calcareous blocks of varying volumes (from a few cubic meters to many thousands) which have been broken off from the front of the Campania-Lucania carbonate platform.

The sedimentation of these various units began during Langhian time in an area (*Irpinian basin*) which is roughly equivalent to that occupied by the basin of Lagonegro during Mesozoic and lower Tertiary.

In Langhian time of Campania-Lucanian carbonate platform and the allochthonous sheets, originated further inward (*Sicilides and Ligurides*), had already begun to invade the Lagonegro Basin so that the Abruzzo Campania carbonate platform formed the outer margin of the Irpinian Basin, while the calcareous units, resulting from the breaking down of both the inner platform and the more internal allochthonous sheets, formed the inner margin. This is demonstrated by the wildflysch of the Castelvetere fm. and by the fact that the sediments of Lagonegro (in some places the Numidian Flysch acts as a gradual passage between the Irpinian units and the units of Lagonegro) sometimes overlie the carbonates of the Apulia-Campania platform, and, in some other instances, may also overlie the *Ligurides* and *Sicilides* thrust sheets.

Lagonegro units

The units of Lagonegro outcrop widely in western Basilicata and in Campania (tectonic windows of the Picentini Mts., Giffoni Vallepiana, Campagna). The Lagonegro Basin was formed in upper Triassic (Carnian) and was located between the Lucanian-Campania and the Abruzzi-Campania carbonate platforms.

In Langhian time it was affected by tectonic movements and replaced by the Irpinian Basin.

We may recognize two units in tectonic contact:

Lower Lagonegro unit.

From down up we may distinguish the following levels:

a) *Calcari con Selce.* Limestones with cherty interbeds and nodules, cherty calcilutites (500 meters).

b) *Scisti silicei* radiolarites and siliceous shales (70 meter).

c) *Galestri* shales and cherty limestones in "black shales" facies; 400 meters.

d) Scisti di *Pecorone* green and red shales and calcarenites, 70-80 meters.

The age of the sequence ranges between Carnian and upper Cretaceous-Eocene.

Upper Lagonegro unit.

From down up we may recognize:

a) *Mt. Facito formation* shales, siltstone, sandstones, and conglomerates with some reefoidal limestones and probably, diabases and pillow breccias; 200 meters.

b) *Calcari con liste e noduli di selce.* Cherty calcilutites and dolorudites 250 meters).

c) *Scisti silicei* (radiolarites and cherty shales with interbeds of calcirudites and graded calcarenites; about 250 meters).

d) *Galestri* shales and cherty limestones with interbeds of calcirudites and graded calcarenites; several hundred meters.

e) *Flysch rosso* (red and green shales, calcarenites, calcirudites and sandstones; about 200 meters).

The age of the sequence ranges between Anisian and lower Miocene.

Unit of Mt. Foraporta-Maddalena Mtns.

This unit outcrops in the Lagonegro area, in the Maddalena Mtns and in the Lauria-Castellucio Mtns. In the Lagonegro area the unit consists of three thrust-sheets. From down up these thrust sheets are made of upper Triassic white dolomites (80-100 meters), lower Liassic, fish bearing, grey and black dolomites (70-80 meters), lower to middle Jurassic, marly, green and black limestones (about 300 meters).

In the Maddalena Mtns. and in the Lauria-Castellucio Mtns. we find that the Jurassic and younger limestones are transgressive over the upper Triassic white dolomites. The Jurassic and younger limestones are, in turn, transgressed by Aquitanian calcarenites which are vertically replaced by flyschs during Langhian time.

The sediments of this unit are part of the outer margin of the Campania-Lucania carbonate platform.

Alburno-Cervati unit

(Campania-Lucania Carbonate platform)

This unit outcrops in Campania (Lattari and Picentini Mnts., Alburno-Cervati group, Mt. Marzano in western Calabria (Pollino group and Coastal Range, north of the Sangineto line). The lower part of the sequence outcrops in Calabria and it is made of phyllades with interbeds of slightly metamorphosed, *Diplopora* limestones of Anisian to Ladinian age. These phyllades are overlain by over 1500 meters of upper Triassic dolomites (slightly metamorphosed in the Coastal Range). Between Liassic and Paleocene the sediments are mostly calcareous and may be thicker than 2500 meters. The facies is neritic during middle Triassic and changes to a backreef during the upper Triassic.

Aquitanian calcarenites transgress on top of the older sediments (Cretaceous or Paleocene) and pass rapidly upward into flyschs (Langhian) no more than 200 meters thick.

Bulgheria - Verbicaro unit.

This unit outcrops in Campania (Mt. Bulgheria and Capri island) and in northern Calabria along the Coastal Range, north of the Sangineto line.

Lithologically the lower part of the unit (upper Triassic - lower Liassic) is mostly dolomitic, while the upper part (Liassic to Aquitanian) is mostly calcareous.

There are some intercalations of lavas, sometimes pillow-lavas (Upper Senonian).

The facies are from forereef to basinal. Flyschs are present in the lower Miocene part of the sequence. The total thickness ranges from a few hundred meters to over 2000 meters.

The sediments of this unit belong to the inner margin of the Campania-Lucania carbonate platform.

Internal units.

Some of the internal stratigraphic-structural units are involved in the southern Apennines orogenesis north of the Calabrian crystalline terranes.

We may group these units as follows:

Sicilides units.

Rocks belonging to these units outcrop largely in Campania and Basilicata.

Often these sediments are chaotic and are similar to the "argille scagliose" of northern Apennines. Sediments of these units may sometimes be found as olistostromes within the Irpinian units, the Altavilla unit and the Bradanic unit.

Ogniben (1969) recognizes in the *Sicilides* sequence from down up - about 500 meters of sandstones and conglomerates (Aptian-Cenomanian);

— 500-1000 meters of lower, varicolored shales (Upper Cretaceous);

— 500-1500 meters of turbidites (Upper Cretaceous-Paleocene);

— 400-600 meters of upper varicolored shales (Eocene);

— 250-300 meters of andesitic tuffs: "Tusa tuffs"; (Upper Eocene-Oligocene).

The facies is generally bathyal.

Cilento unit.

This unit outcrops widely in western Cilento, in southern Basilicata and in northern Calabria.

The sequence may be subdivided as follows from down up:

— Creta Nere formation: blacks shales and siltstones with interbeds of fine grained sandstones.

The thickness is around 400 meters; the age ranges between Aptian and Albian.

— Pollica (or Saraceno) formation: this formation is represented by an arenaceous flysch in the Cilento area, more calcerous in the Lucania and Calabria areas.

Thickness: between 500 and 1000 meters.

Age: Albian-Paleocene.

— St. Mauro and Albidona formation: very thick (over 2000 meters) marly and sandy flysch with some conglomeratic interbeds.

Age: Eocene to upper Oligocene.

Generally speaking: the flysch facies is proximal in the upper part, more distal in the lower part.

Olistostromes and olistoliths are found within the unit.

Frido unit.

This unit outcrops in southern Cilento, southern Lucania and in northern Calabria. and is overlain by the Cilento unit.

In the northern part of the Calabrian Coastal Range the unit is overlain by the ophiolitic units and by the metamorphic rocks of the *Dioritic Kinzigitic* formation.

The sequence, slightly metamorphosed, is made of shales, limestones and calcarenites. The unconformity between this unit and the Cilento unit may be due to the sedimentation of the Cilento Unit after the metamorphism of the Frido rocks or even may be due to thrusting. Olistostromes made by ophiolites and rocks of the dioritic-kinzigitic fm. are found within this unit in the Frido Valley.

Other internal units.

Other units have been recognized immediately outside the area of our present concern and precisely in Northern Calabria and in the Coastal Range. We will mention these units for completeness' sake. They are:

— *Ophiolitic units*: two units: the lower unit is made of serpentine, green shales and glaucophanitic rocks in association with phyllites and calcareous schists; the upper unit is made of diabases overlain by radiolarites and limestones with Calpionellas.

The lower unit is similar to the ophiolites of the Piemonte region, while the upper unit is more similar to the ophiolites of the Ligurian region.

— Dioritic - Kinzigitic unit: it outcrops in the Sile area and along the Calabrian Coastal Range. It consists of biotitic and sillimanitic gneisses, associated with granites.

This unit overlies all the other units.

— Other Calabrian units:

In the Calabrian Coastal Range, which has not been completely studied as yet, it is possible to recognize some more units such as: the *Paola schists* the slightly metamorphosed Basal Carbonatic Unit.

TECTONICS AND PALEOGEOGRAPHY

The structural map of Table I and the two cross-sections of Table II (in pocket), give a synthetic view of the tectonics of southern Apennines.

There we will discuss the tectonic evolution of the *external zones* only as we do not have enough data to discuss the *internal zones.*

The paleogeography of the *external zones* of southern Apennines is controlled by epeirogenetic movements from the middle Triassic up to the Aquitainian. Between Langhian and middle Pliocene time the Mesozoic-lower Tertiary paleogeographic units are deformed and thrusted progressively one onto another originating the external structural stratigraphic units.

By middle-upper Pliocene we have the beginning of the final orogenetic, mainly vertical movements that brought to the present structure of the southern Apennines.

These three different moments of the Apennines tectonic evolution appear to have developed along with complex and, as yet,

not completely understood regional rotations and thrust movements linked to the evolution of the Tethys.

PALEOTECTONICS

Sedimentation began in Anisian time when the sea transgressed over the peneplained Hercynian basement. Shales, marls, sandstones and conglomerates represent the bulk of these sediments.

Small size *Diplopora* reefs developed locally. Basic lavas and pillow-breccias are also present.

These sediments form the basal part of the Lagonegro unit II and of the Alburno-Cervati unit.

The basin of Lagonegro did develop in Carnian time and separated the Campania-Lucania Carbonate Platform from the Abruzzo-Campania Carbonate Platform. During the remaining part of upper Triassic this basin received siliceous and calcareous muds.

We do not know for certain whether the Molise Basin and the Apulia Carbonate Platform were already developed by upper Triassic or not. Upper Triassic sedimentation was prevalently calcareous and early dolomitization took place in the shelf areas.

Evaporites do not appear to be as wide - spread as in the coeval deposits of northern Apennines and we find them in a few places only (near Lesina, Gargano at the Punta delle Pietre Nere) in northern Calabria (Scalone pass, Coastal Range), and in a few deep tests in Puglia and Lazio (Gargano and Abruzzo-Campanian Carbonate Platform).

Between Triassic and Jurassic we have a marked differentiation in carbonate platforms and basins separating the shelves due to the Phaetian-Liassic tectonic phase.

After the tectonism we may recognize a certain number of paleogeographic units, both basins and platforms, which will maintain their individuality up to lower Miocene.

They are:

a) *Campania-Lucania Carbonate Platform*: very wide shelf area, covered by very shallow water, characterized by carbonates of biologic origin since upper Trias.

This area, along with the others, is very similar, under all point of views, to the present day Bahamian carbonate platforms.

The Campania-Lucania platform was often limited by scarps due to synsedimentary faults. Locally reefs did develop along the edges. The shelf carbonates are not older than Anisian.

b) *Lagonegro Basin* - The sediments of this basin are cherty limestones passing to cherty shales which presumably have been deposited below the compensation depth of the carbonates.

The lateral transition between the basin and the adjacent carbonate platforms is characterized by calcareous turbidites. The oldest outcropping sediments are Anisian in age.

c) *Abruzzi-Campania Carbonate Platform.* This platform presents the same characteristics as the Campania-Lucania Platform. The oldest sediments are of Norian age.

d) *Molise Basin.* We find evidence of this basin in the northern part of the studied area only. The sediments indicate shallower waters than in the Lagonegro basin.

The oldest sediments known to us are of probable upper Triassic age.

e) *Apulian Carbonate Platform.* This platform does not differ from the previous ones with the only exception of having thicker sediments. The oldest beds are upper Triassic in age.

f) *Eastern Gargano basin.* Sediments belonging to this basin outcrop on the eastern side of the Gargano area. These sediments represent the marginal part of the basin and do not appear to be older than upper Jurassic.

The lower Cretaceous tectonic movements affect the margins of the shelves, mostly, and this is shown by repeated shifts of the transitional areas. Between Albian and Cenomanian we have a general regression of the sea and most parts of the shelf areas undergo continental conditions as is witnessed by the presence of paleokarstism and of a widespread bauxitic horizon.

By Maestrichtian time we have a very strong tectonic phase that reduces the platform areas widening, at the same time, the

basinal or transitional areas. Contemporaneously volcanic episodes are documented along the internal margin of the Campania-Lucania Platform.

During Eocene time we have the last tectonic phase of regional importance which, once again, brought wide portions of the platforms to emerge.

The continental conditions lasted up to lower Miocene.

TECTOGENESIS.

Between Oligocene and Miocene, strong orogenetic movements hit for the first time the outer Apenninic areas. These orogenetic movements had already affected the internal areas of the Apennines but as we said before, was do not know enough about these areas to discuss them.

At present it is possible to subdivide these movements into three phases.

Langhian phase.

In Aquitanian time the sea transgresses widely over the Campania-Lucania platform. As a result of this transgression we have calcarenites overlying paraconformably Cretaceous and early Tertiary limestones. The carbonate platform subsides rapidly so that the neritic sediments are generally replaced upward by flysch. In Langhian time this flysch is over-thrusted by a series of thrust sheets which originated in the internal areas (Sicilides units, Cilento unit, Frido unit). The Campania-Lucania Carbonate Platform slides on the facing slope of the Lagonegro Basin. These sediments of this basin are in turn thrusted over the sediments of the axial zone of the same basin. The platform itself is broken down, giving rise to the Foraporta - Monti della Maddalena structural-stratigraphic unit and to the Alburno Cervati unit.

At the same time the internal thrust sheets which glided over the Campania-Lucania carbonate platform are thrusted further eastward and, in places, are even overriding the *external* edge of the platform itself. The result of these events is the development of the Irpinian Basin which is underlain partly by the thrust-sheet, and partly by the most external areas of the Lagonegro Basin. The outer margin of this Basin is represented by the Abruzzi-Campania Carbonate Platform.

Sedimentation in the newly formed Irpinian Basin will be active up to Tortonian, at the same time the basin's axis keeps "shifting" eastward.

Serravallian phase.

During Serravallian time both the Sicilides and the Alburno-Cervati units are thrusted further eastward.

In the meantime, between upper Langhian and lower Serravallian, the Abruzzi-Campania Carbonate Platform starts to subside.

Sedimentation begins with carbonates which are soon replaced by marls with a rapidly increasing rate of subsidence. The marls are, in turn, replaced by turbidites.

The subsidence of this platform brings to an eastward widening of the Irpinian Basin which, by Tortonian, will join with the Molise Basin.

Tortonian phase.

Further thrusting takes place in Tortonian time affecting the sediments of the Langhian - Serravallian units and those of the Irpinian Basin.

These sediments are thrusted over the area of flysch sedimentation (Abruzzi-Campania platform). At the same time the Abruzzi-Campania Carbonate Platform is thrusted over the area of the Molise Basin.

LATE TECTOGENESIS.

Between upper Tortonian and lower Pliocene several small basins did develop in the area affected by the thrusting (Altavilla unit). During the same period the intensity of the thrust movements decreased.

Finally, by middle Pliocene, we have a resurgence of intense orogenetic activity with the thrusting of all the previously mentioned thrust sheets over the Apulian Platform. The western side of the Apulian Platform is faulted down, so that we have the forming of the Bradanic Trough.

At this stage the Apulian Platform acts as Apenninic foreland.

The *Bradanic Trough* itself is not affected by thrusting and there the sedimentation

is continuous from lower-middle Pliocene to Calabrian time. Olistostromes of Apenninic origin are sometimes intercalated within these sediments.

NEOTECTONICS.

By the end of middle Pliocene the Apenninic orogenesis was practically over. The movements that followed tended to adjust the already existing situation more than anything else: the chain tends to be uplifted while the Bradanic Trough is still subsiding. The active role in this kind of tectonics is played by the faults which may be subdivided into two groups: faults with *Apenninic trend* (NW-SE) and faults with anti-Apenninic trend (NE-SW).

During these movements gravitative slides may take place in the Bradanic foretrough from time to time. Some of these slides might be going on at present north of the Gargano area or in the Ionian Sea.

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