PROCESSI PALEOCARSICI E NEOCARSICI E LORO IMPORTANZA ECONOMICA NELL'ITALIA MERIDIONALE

guida alle escursioni

1-5 aprile 1978

ISTITUTO DI GEOLOGIA E GEOFISICA DELL'UNIVERSITA DI NAPOLI
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guide
to
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1-3 april, 1978

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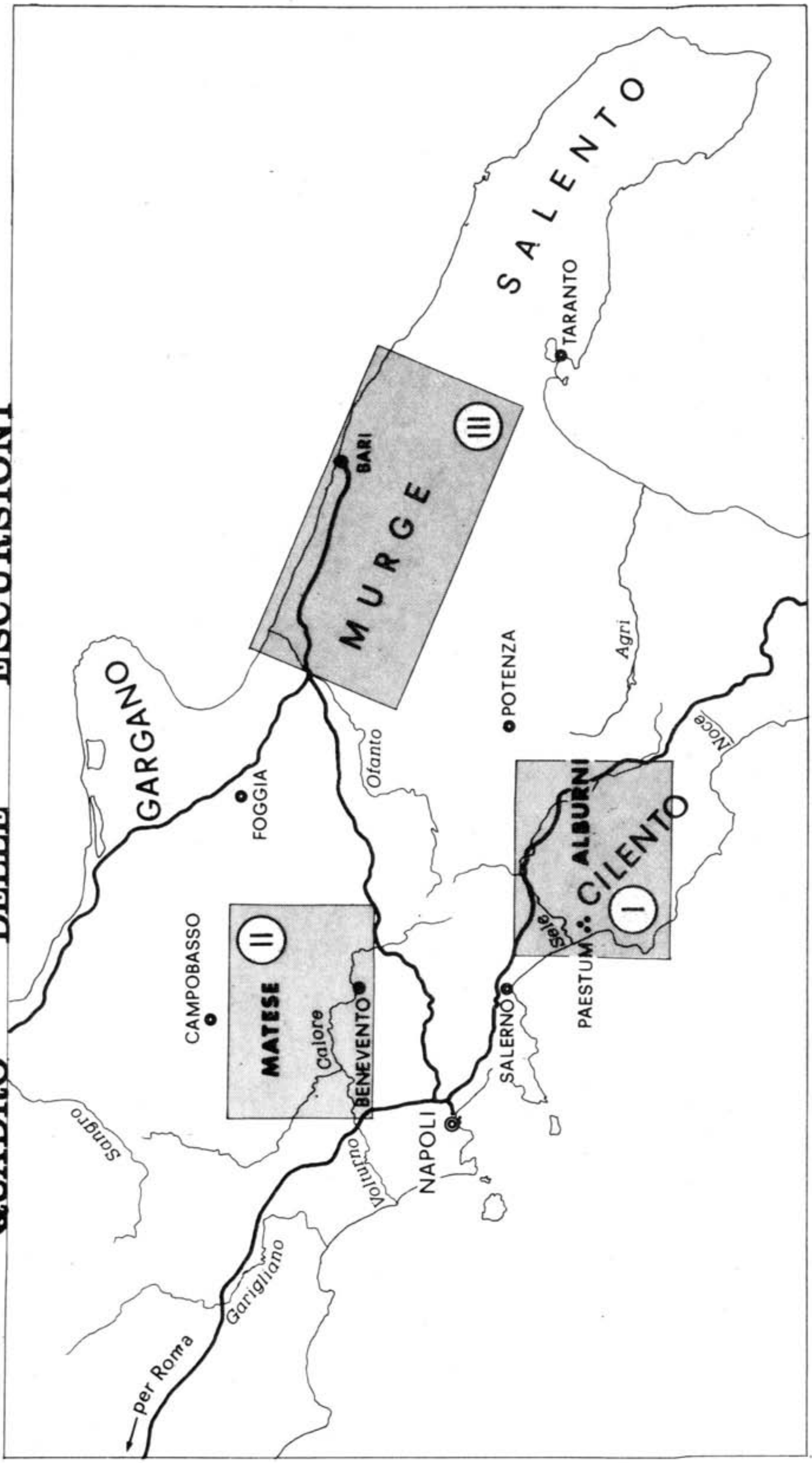

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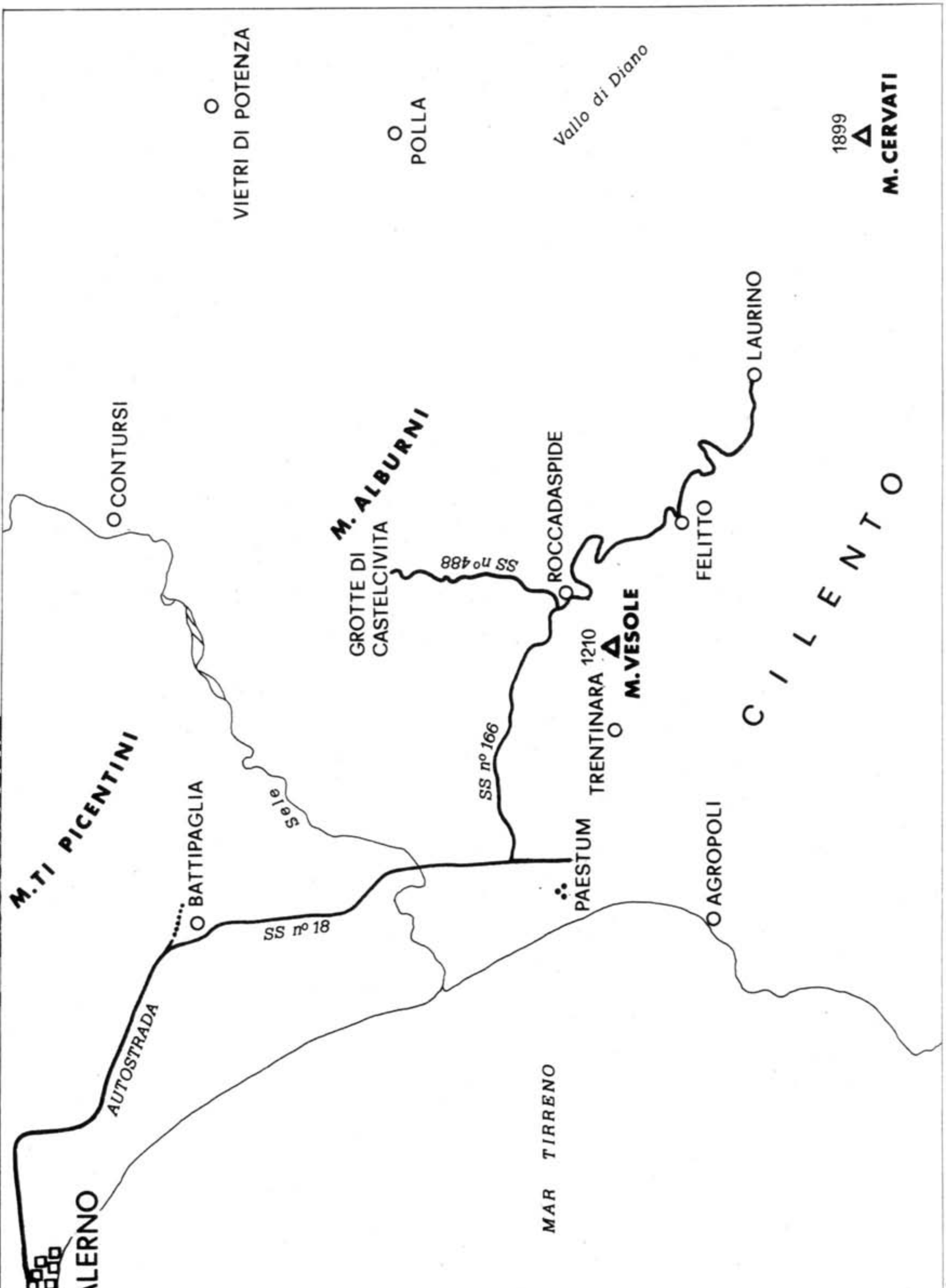

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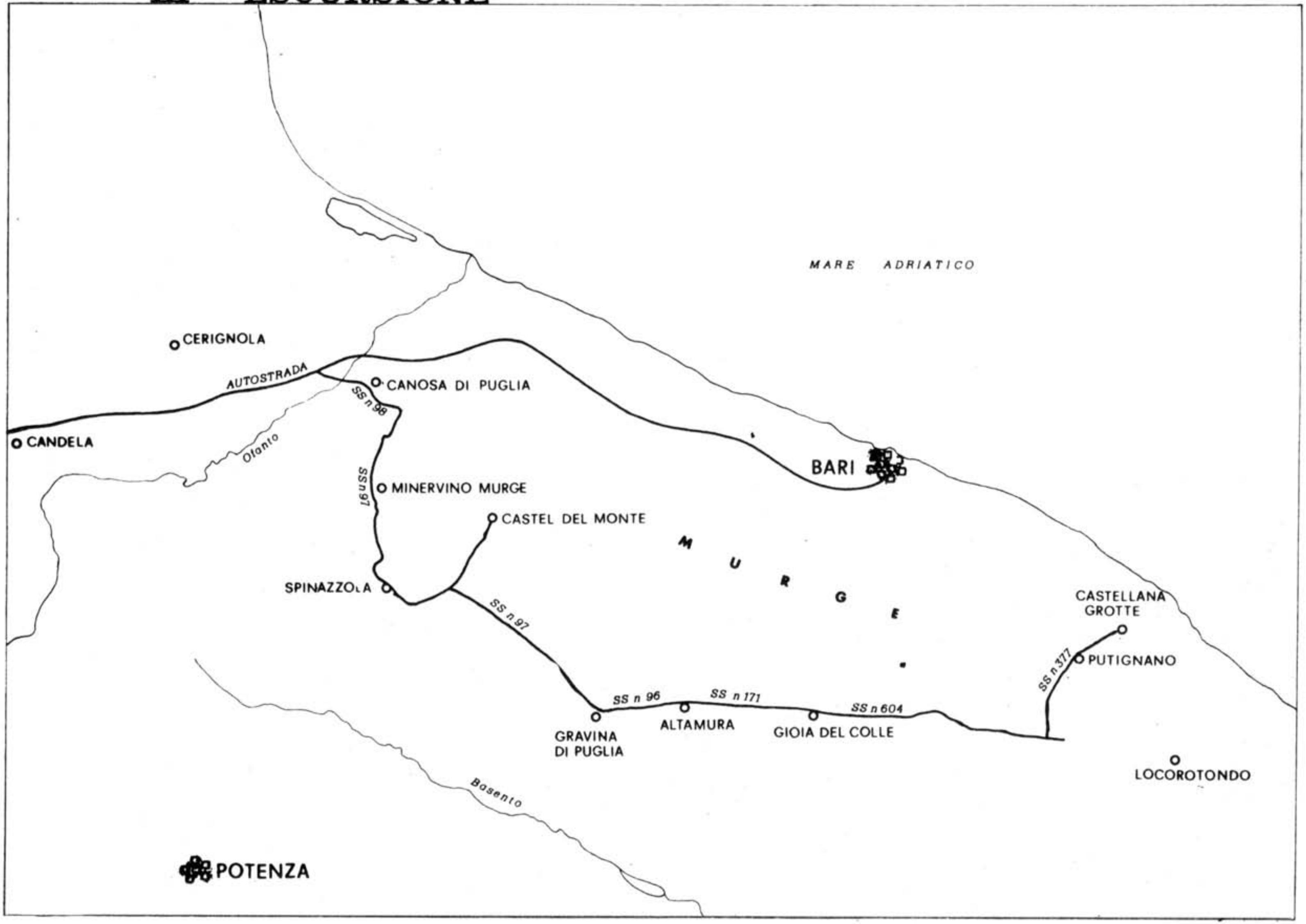

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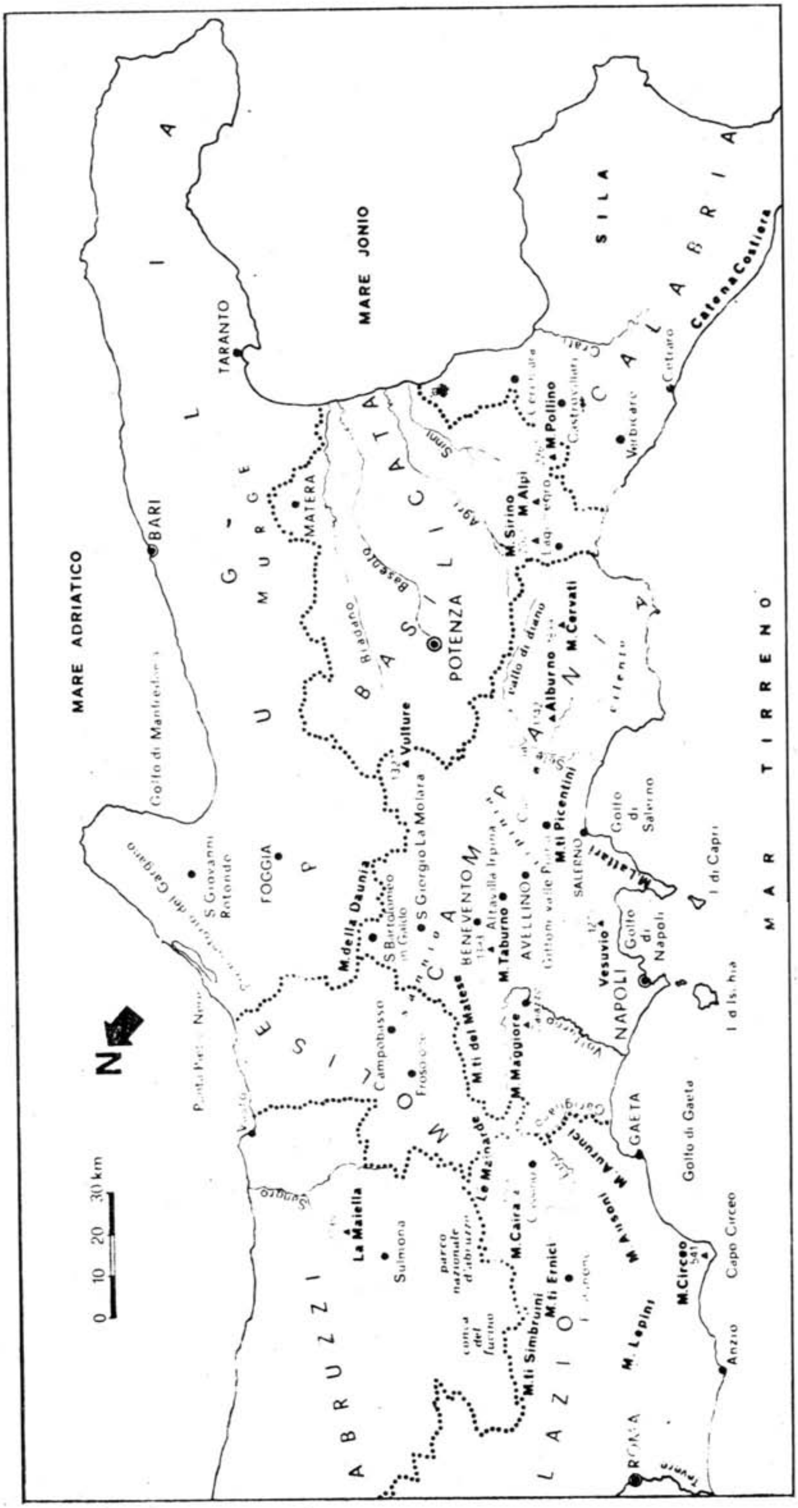

Fig. 1 - Index map

the authors

This guidebook to the excursions is the fruit of the joint collaboration of a number of colleagues. In particular, the Introduction has been written by Bruno D'Argenio, while Geology and Geomorphology notes have been compiled by Ludovico Brancaccio, Bruno D'Argenio and Tullio Pescatore.

The description of the Carbonatic Structural-Stratigraphic Units which open chapters 3 and 4 has been edited by Bruno D'Argenio and Tullio Pescatore and the Murge - Gargano unit edited by Bruno D'Argenio, Antonia Iannone, Piero Pieri and Giustino Ricchetti.

The first excursion (Window geology) has been outlined by Ludovico Brancaccio (paragraph 3.2 a and b), Vittoria Ferreri and Lamberto Laureti (paragraph 3.2 c) and Silvio Di Nocera together with Antonio Rodriquez (paragraph 3.2 d).

The Paleokarstic phenomena of the lower Tertiary in the Trentinara mountains have been detailed by Maria Boni, the Grotte of Castelcivita have been described by Silvio Di Nocera and Antonio Rodriquez while the Greek City of Paestum has been described by Alfonso Piciocchi.

The second excursion (Window geology), has been outlined by Gabriele Carannante and Bruno D'Argenio (paragraph 4.2 a), Ludovico Brancaccio (paragraph 4.2 b) and Lamberto Laureti (paragraph 4.2 c and d).

The Paleokarstic hypogean phenomena in Cretaceous rocks of Mount Camposauro have been detailed by Gabriele Carannante, Vittoria Ferreri and Lucia Simone; the springs of Torano and of Maretto have been described by Pietro Celico and the bauxites of the Matese area by Maria Boni and Bruno D'Argenio.

The third excursion (Window geology) has been outlined by Franco Ortolani (paragraph 5.2 a), Antonia Iannone, Piero Pieri and Giustino Ricchetti (paragraph 5.2 b, c and d).

The Paleokarstic phenomena and the Spinazzola bauxites have been described by Maria Boni and Bruno D'Argenio, Castel del Monte by Consiglia De Venere and the "Grotte di Castellana" by Michele Stigliano.

Aldo Cinque sketched the landscapes and Michele Stigliano translated a large part of the guidebook. Anna Terracciano has patiently typed the text.

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foreword

Excursions following the Seminar on Paleo- and Neokarstic Processes in Southern Italy had the aim to complete in the field the matter debated in Naples.

As the geological and geomorphological problems concerned by the debate are often beyond the different scientific interests and regional knowledges of the excursionists, we try here to provide a simple picture of them.

The guidebook comprises three sections:
- a brief description of the geological and geomorphological distinctive features of the Apennines between Liri and Sangro valleys in the north and Noce and Agri valleys in the south;
- a geomorphological picture of the region covered by the trip ("window geology");
- an introduction to the problems to be debated during the stops - few but of a some length.

Such a book naturally can only give an outline which - we hope - will be accepted as an opportunity for debating. In the same time it is useful for seeking the elements of unity of the karstic phenomena - even if they are so different and often seemingly contradictory - and to obtain an answer to the dynamic ineraction between tectonics and climate.

By such a way we can try to draw the pattern of the evolution of the evenements.

introduction

We wish to emphasize that we do not intend either to propose a new approach to the study of the karstic phenomena, or to urge for new formal nomenclature of the various and complex morphogenetic processes generally covered by the item "Karst".

Both excursion and previous seminar offer the opportunity to debate ideas on geological features and objects. In such a way we may order the succession of processes before interpretate them, analysing connection between processes happened under different tectonic and climatic conditions, as well as in different times.

Accordingly we shall try, as much as possible, to avoid discussion on nomenclature, only clarifying the reasons of the choice of terms as "paleokarstic" and "neokarstic" used in titling the seminar. The choice is based on the analysis of the paleogeographic evolution of Southern Italy.

This section of the alpidic orogene formed during the Neogene shows the marks of many, variously widespread, geomorphic cycles, which had unlike length, intensity and development; and where all characterized by the weathering of carbonate rocks submitted to the karstic process.

The above cycles present a various evolution according to their development before or after deformation of the ancient continental margin of Apennines from which the main part of Southern Italy derives.

Genesis, of cavities, their form and reletionship with the topographic surface, the way of fossilization are often different. Therefore, the first distinction concerns the age when karst developed: the mophogenesis related to paleotectonic processes are scheduled as paleokarst. whatever is the way and degree of fossilization. Subsequent morphogenesis, related to uplift of the chain (neotectonics) are scheduled as neokarst.

Consequently, paleo- and neokarst represent two moments in the general evolution of sedimentary carbonate bodies since their sedimentation, passing by the stages of early (synsedimentary) and late diagenesis - with all the related modifications (even chemical and mineralogical) - until the more or less marked deformation and epigenesis.

On this ground, paleo- and neokarst do not involve the effects of different processes, but rather some prevailing phenomena in the various moments above mentioned. They are then processes which operated almost continously during the last 200 m.y., when the great carbonate bodies of Sourhern Italy (carbonate platforms and partly internal basins) formed and were deformed and eroded.

2. geology and geomorphology

2.1 Structural framework of Southern Apennines

Southern Apennines represent a section of the Neogene orogenic belt normally considered as the result of deformation of the southern "African" margin of the Tethys.

The genaral structure of this chain is that of a pile of nappes, whose tectonic transport decreases from the geometrically higher to the lower ones, reaching the autoctony in the foredeep and foreland (Apulia).

Different lithological nature, influence of paleotectonic, tectogenetic and neotectonic phases and differential behaviour of the rocks during the deformation are the characters and processes whose interaction - together with climatic conditions and related variations - allow to determine the main morphological units.

Barring Calabria Arc, where plutonites and metamotphites with related sedimentary cover autcrop, Southern Apennines east of the tectonic line Anzio-Ancona consist of:

- carbonate neritic sediments;
- calcareous-siliceous and marly basinal sediments;
- arenaceous-clayey sediments with flysch facies.

The age of these sediments ranges from middle Triassic to middle-upper Tertiary. Individual thickness of the sequences can be over 5 Km, that of the whole chain reaches about 10-15 Km.

2.2 Structural-Stratigraphic Units

Southern Apennines are therefore a nappes pile, whose sediments can be grouped in structural-stratigraphic units. This term inidicates (D'Argenio and Scandone, 1969) great geological bodies, continuous or broken, deriving from preexisting paleogeographic units. Their lithological distinctive features, mechanical homogeneous behaviour at large scale and geometrical relationships with the adjacent units, allow to trace their boundaries.

These structural-stratigraphic units may have preserved the stratigraphic connection with their basement (i.e. Apulia) or have been displaced (i.e. Apennines); in some cases, they may also be undeformed.

The structural-stratigraphic units of the Southern Apennines, north of Calabrian crystalline rocks, can be divided as follows (D'Argenio, Pescatore, Scandone, 1973; Ippolito, D'Argenio, Pescatore and Scandone, 1975):

- Foreland and foretrough unit;
- External units of the chain;
- Internal units of the chain.

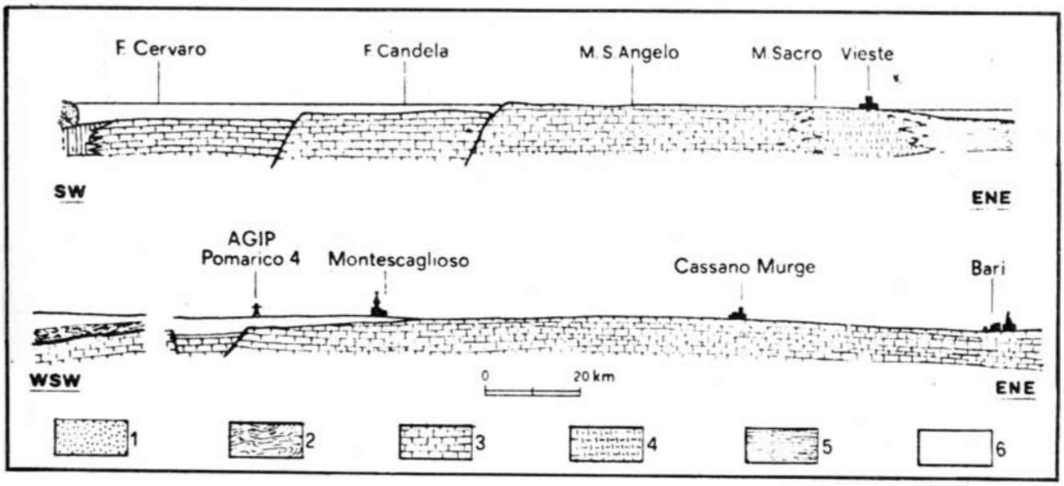

Fig. 2 - Stratigraphic and tectonic relationships among structural-stratigraphic units (see also Tab.III) 1. Irpinian Units; Frido Flysch and Cilento Units; 3.5 Murge-Gargano Unit: 3. back-reef lagoon facies, 4. reef-complex facies, 5. reef-scarp and basin facies; 6. Bradano Unit and sediments of intra-apenninic troughs. (Da D'Argenio et al., 1973).

Foreland and Foretrough Units.

a) Murge-Gargano Unit. This unit outcrops in the area between Gargano and Murge. The sequence begins with evaporites (Carnian) crossed by drilling at Foresta Umbra and outcropping at Punta delle Pietre Nere, to which follow shelf carbonate platform deposits of Jurassic Cretaceous and Tertiary age. Reefoidal and basinal facies of the upper Jurassic are known to occur in eastern Gargano.

Thickness of this unit ranges from about 4.000 meters in Gargano area to over 6.000 meters in Salento area. The cretaceous system itself reaches over 3.000 meters in the Murge area (Ricchetti, 1975).

b) Bradanic Unit and Deposits of intrapenninic basins. This unit consists of the sediments of Bradanic Foretrough and intrapenninic basins and its sequence, which ranges from Pliocene to Calabrian, is formed of terrigenous deposits with facies varying from littoral to bathyal.

Allochthonous sediments coming from the Apennines are intercalated in the normal sequence in the inner part of the trough. Thickness is over 3.000 meters.

External Units of the Chain

a) Altavilla Unit. This unit outcrops either along the apenninic front or in the inner areas (Altavilla, Irpinia). At its base we often find evaporitic sediments ("gessoso-solfifera" formation), followed upwards by clastic. The age renges from upper Tortonian to middle Pliocene. Thickness varies strongly from place to place, with a maximum of a few hundred meters, and the facies vary from littoral to bathyal.

The Altavilla Unit (which is formed of sediments settled in a series of basins fitted on nappes) has been affected by the last thrusting movements of middle Pliocene.

b) Frosolone Unit. The upper part (upper Cretaceous-Miocene) of this unit outcrops north of the Matese area. The lower part, on the contrary, is known because it has been crossed by the "Frosolone I" well, drilled by AGIP (Pieri, 1966).

From down up the unit is made of cherty dolomites (Triassic-Liassic?), shales and radiolarites with volcanic intercalations (Jurassic), graded calcareous sandstones, calcilutites and marlstones (Cretaceous-lower Tertiary), calcarenites, siltstones and sandstones (lower and middle Miocene). The paleogeographic area in which this unit was formed is the Molise Basin, which was located between Apulian and Abruzzi-Campania carbonate platform.

c) - Matese-Mt. Maggiore Unit. This unit outcrops in the following localities: Mt. Maggiore. Mt. Camposauro. In Lucania it outcrops in the tectonic window of Mt. Alpi.

The sequence consists of dolomites (upper Triassic-lower Liassic) and limestones (middle Liassic-upper Cretaceous). Sediments of the lower Tertiary are generally absent and the Miocenic sediments, which are usually transgressive on the top of the Cretaceous, consist of limestones, marls and terrigenous clastics (Catenacci, De Castro, Sgrosso, 1963; Selli, 1957).

Thickness is over 3.000 meters. The carbonates show mainly a backreef facies. In the western Matese we also find parts of the outer margin of the former paleogeographic body (Abruzzi-Campania carbonate platform), whose facies are in correlation with those of the Frosolone Unit.

The Miocenic terrigenous clastics consist mainly of turbidites and the facies is bathyal.

d) - Mt. Croce Unit. - The unit outcrops in the Picentini Mts. and represents the lowest known unit of the tectonic window of Campagna (Scandone and Sgrosso, 1974; Turco. 1976).

The sequence, whose thickness is of several hundred meters, consists of: white, some times cherty. dolomites; gray limestones and shales; cherty white dolomites (Carnian-Norian). Follow massive limestones and breccias (upper Jurassic) that overlie unconformably Triassic sediments and in turn are overlain, unconformably again, by the Eocenic sediments. The latter consists of calcirudites and calcarenites of Aquitanian age, passing to marls and sandstones of Serravallian-Tortonian age. This sequence, whose charaters are those of a margin of platform can be interpretated as derived from the inner edge of the Abruzzi-Campania carbonate platform.

e) - Irpinian Units. - The sequence of these units is made of terrigenous and deep sea deposits: it outcrops along a belt, about 50 Km wide, ranging from southern Lucania to the Daunia (Pescatore, 1976).

From the east to the west we can distinguish three types of sequences:

- a sequence of marls and calcarenites (Mt. Faeto flysch). some of which are 500 meters thick and range from the lower Serravallian to the lower Tortonian.
- a mainly marly-calcareous sequence (Langhian) overlain by an arkosic formation of Serravallian age (Serra Palazzo formation); the top of the sequence consists of Tortonian marls. The thickness of the whole sequence is over 1.500 meters.
- a terrigenous sequence consisting of conglomerates, arkosic sandstones and graywackes. which ranges from Langhian to lower Tortonian age (Castelvetere flysch, Caiazzo sandstones, Gorgoglione flysch). Thickness is over 1.500 meters.

The Castelvetere formation presents wildflysch characters and encloses calcareous blocks of various size (from a few cubic meters to many thousands) carried out from the front of the Campano-Lucanian carbonate platform.

In the Langhian time, therefore, the area of sedimentation of Irpinian Units (Irpinian Basin) was partly coinciding with the Lagonegro Basin of Mesozoic and lower Tertiary ages.

The outer margin of the Irpinian Basin consisted of the Abruzzi-Campania carbonate platform not yet translated. The inner margin, on the contrary, consisted of stratigraphic-structural units resulting both from the breaking down of the Campano-Lucanian carbonate platform and the more internal allochtonous sheets.

f) - Lagonegro Units - In these units, widely outcropping in western Lucania and in the tectonic window of Campagna (Giffoni Vallepiana, Campagna), we may recognize two units in tectonic contact. The paleogeographic unit from which they derive is the Lagonegro Basin, that was located between the Abruzzi-Campania - Mt. Alpi carbonate platform and the Campano-Lucania carbonate platform (Scandone, 1972). The Basin was formed in the upper Triassic and reached the maximum depth in Jurassic age.

Lower Lagonegro Unit; from down up we may distinguish:

Limestones with cherty interbeds and nodules (calcari con liste e noduli di selce), cherty calcilutites (500 meters);

"Scisti silicei", radiolarites and siliceous shales (70 meters);

"Galestri", shales and cherty limestones (400 meters);

Pecorone schists, green and red shales and calcarenites (70 to 80 m.).

The age of the sequence ranges from Carnian to upper Cretaceous.

Upper Lagonegro Unit; from down up we find:

Mt. Facito formation consisting of shales, siltstones, sandstones and conglomerates with some reefoidal limestones, probably diabases and pillow breccias too (200 meters);

Limestones with cherty interbeds and nodules (calcari con liste e noduli di selce), cherty calcilutites and dolomites with interbedded dolorudites (an average of 250 meters):

"Scisti silicei", radiolarites and siliceous shales with graded calcarenites and calcirudites interbeds (an average of 250 meters);

"Galestri", shales and more or less siliceous limestones with calcirudites and graded calcarenites interbeds (several hundred mts.);

"Flysch rosso" (red flysch) consisting of red and green shales, calcarenites and sandstones (about 200 meters);

"Flysch Numidico" (Numidico flysch), given by turbiditic quartz-sandstones (about 200 meters).
The age of the sequence ranges from Anisian to Aquitanian.

g) - <u>Mt. Foraporta and Maddalena Mts. Unit</u> - The unit outcrops in the Lagonegro area along the Noce River valley. At the Mt. Foraporta we can see three thrust-sheets, whose sequence from down up is made of white and gray fish bearing dolomites (upper Triassic-lower Liassic), followed by black marly limestones (lower to middle Jurassic). Thickness is of about 450 meters; facies are neritic in dolomites and pelagic in black limestones (Scandone, 1972). The sediments of the Mt. Foraporta were derived from the outer margin of the Campano-Lucania carbonate platform.

In the Maddalena Mts. the sequence shows Norian dolomites overlain by reefoidal or perireefoidal limestones (Jurassic), calcirudites and calcarenites with fossil fragments and macroforaminiphera (upper Cretaceous-Eocene and lower Miocene)

h) - <u>Alburno-Cervati Unit.</u> - It outcrops in Campania (Avella-Partenio Mts., Lattari Mts., Picentini Mts., Alburno-Cervati Mts., Marzano Mt.), in western Lucania (Mt. Coccovello, Lauria Mts.) and in northern Calabria (Mt. Pollino and Coastal Chain north of Sangineto Line).

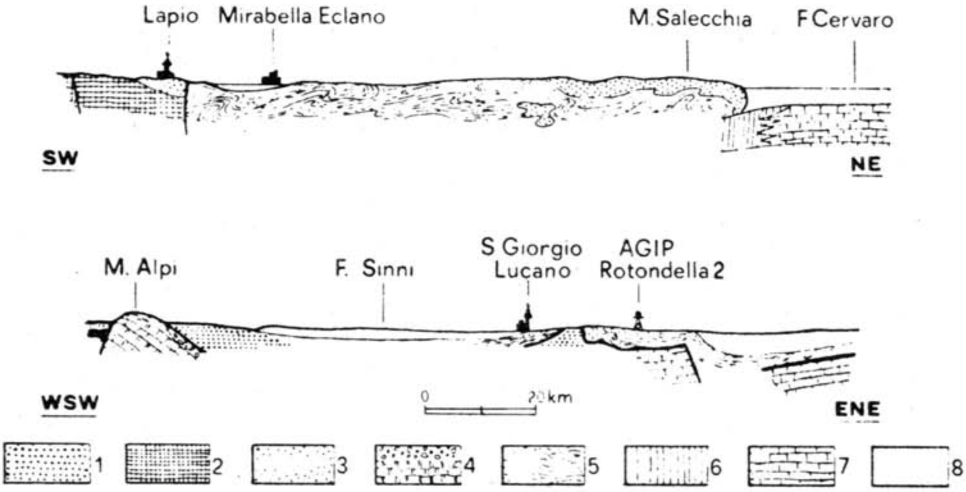

Fig. 3 - Stratigraphic and tectonic relationships among structural-stratigraphic units (see also Tab. III).
1. Sicilidi Units ("argille varicolori"); 2. Foraporta-Monti della Maddalena Unit; 3. Irpinian Units; 4. Matese-Monte Maggiore Unit; 5. Frido Flysch, Cilento Units; 6-7 Murge-Gargano Unit: 6. internal margin of the original Apulia Carbonate Platform (interpolated), 7. back reef lagoon facies; 8. Bradano Unit and sediments of intra-apenninic troughs. (Da D'Argenio et al. 1973).

The sequence consists of:

— Dolomites of upper Triassic, weackly metamorphic in the Coastal Chain (about 1.500 meters);

— Mainly calcareous sediments (Triassic to Paleogene) reaching a thickness of over 2.500 meters;

— Calcarenites of Aquitanian age rapidly passing to clastic sediments with flysch facies (maximum thickness of 20 meters).

— Mesozoic facies are neritic and reefoidal from upper Triassic on. In the coastal Chain of Calabria. north of Sangineto Line, this sequence is underlain by schists several hundred meters thick, with interbeds of fossiliferous - sometimes metamorphosed - limestones and of prasinites.

i) - Mt. Bulgheria-Verbicaro Unit. - This unit outcrops in Campania at Mt. Bulgheria and at the Island of Capri) and in Calabria (Coastal Chain north of the Sangineto Line).

Lithologically the lower part of the unit (upper Triassic to lower Liassic) is mainly dolomitic, while the upper part (Liassic to Aquitanian) is mainly calcareous. Locally we find some intercalations of lava. Generally facies are neritic and show to belong to the margin of a carbonate platform; sometimes we can have intercalations of pelagic facies. In the Aquitanian-Langhian age facies become terrigenous (flysch). The whole thickness ranges from a few hundred meters to over 2.000 meters. The sediments of this unit belong to the inner margin of the Campano-Lucania carbonate platform.

The top is an arenaceous-marly flysch with some conglomeratic levels of Eocene-upper Oligocene age and has a thickness of over 2.000 meters (S. Mauro and Albidona formation).

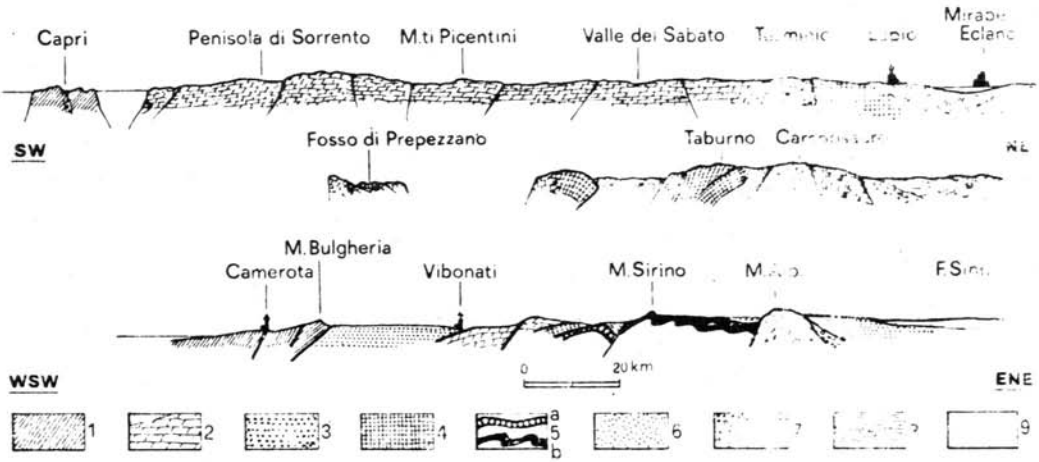

Fig. 4 - Stratigraphic and tectonic relationships among structural-stratigraphic units (see also Tab. III).
1. Bulgheria-Verbicaro Unit; 2. Alburno-Cervati Unit; 3. Sicilidi Units ("argille varicolori"); 4. Foraporta Monti della Maddalena Unit; 5. Lagonegro Units, a. upper unit, b. lower unit; 6. Irpinian Unit; 7. Matese-Monte Maggiore Unit; 8. Frido Flysch, Cilento Units; 9. Bradano Unit and sediments of intra-apenninic troughs. (Da D'Argenio et al., 1973).

Internal Units of the Chain.

Some of the internal stratigraphic-structural units are involved in the Southern Apennines orogenesis north of calabrian crystalline body. When we use the term "internal", we want to say that these units are derived from paleogeographic areas originally oceanic or in any case located between ocean floors and the areas of neritic carbonate sedimentation of the apenninic continental margin.

The sequence, from up down, is as follows:

a) - Silicidi Units. Sediments of these units widely outcrop in Campania and in northern and eastern Lucania, The sequence (Ogniben, 1969) from down up shows:

- about 500 meters of sandstones and conglomerates (Aptian to Cenomanian);
- 500 to 1.000 meters of "argille varicolori" (varicoloured shales) (upper Cretaceous);
- 500 to 1.500 meters of calcareous-arenaceous flysch (upper Cretaceous to Paleocene);
- 400 to 600 meters of "argille varicolori" (Eocene);
- 250 to 300 meters of andesitic tuffs (Tusa tuffs) (upper Eocene to Oligocene).

b) - Cilento Unit. This unit outcrops widely in western Cilento, in southern Lucania and in northern Calabria east of the Mt. Pollino. The sequence, which has a flysch facies, consists of deposits mainly pelitic at the base (Crete Nere formation) of Aptian-Albian age, 350 to 400 meters thick, arenaceous (Pollica formation) or calcareous-arenaceous (Saraceno formation) of the Albian to Paleocene age, with a variable thickness of 500 to 1.000 meters.

c) - Frido Unit. It outcrops in the Cilento area. in southern Lucania and in northern Calabria, east of Mt. Pollino. This unit underlies tectonically the Cilento unit in the Cilento area, whereas in Calabria is overlain by the ophiolitic units and the crystalline dioritic-kinzigitic formation.

Sequence, slightly metamorphosed, is made of shales, limestones and quartz-arenites. Ophiolitic olistostromes of different size, more or less metamorphosed, are found within this unit in the Frido Valley. east of the Mt. Pollino.

2.3 Pre-Pliocenic Paleogeography

It is of a great interst to give a palinspastic picture of the whole, by taking again towards the inner areas (i. e. towards the ancient oceanic areas) the structural-stratigraphic units, after the interpretation of their original sedimentary environment.

The original paleogeography may be represented as paleogeography a belt several hundred Km. wide within which carbonate platforms (shallow sea sedimentation) alternate with basins (carbonate-marly-siliceous sedimentation of open and deep sea).

These areas were connected by more or less steep talus. where a synsedimentary tectonics was active. During the Mesozoic great sedimentary bodies, elongated (even several hundred Km.) and with single volume of some hundred thousand of cubic Km (paleogeographic units). were formed. From the Triassic to Paleogene this picture does not change characters. From Triassic, until Pliocene, we can find two periods of palogeographic evolution:

- a paleotectonic period during which we assist to an active sedimentation and to a series of moviments of distention, so that an oceanic area develops as the result of processes of continental drift. The paleogeographic areas therefore become sedimentary sheets of continental margin.

- a shorter tectogenetic period still corresponding to sedimentation, accompanied by deformation of the continental margin and their sedimentary sheets. Indeed, the oceanic area was already contracting at the end of the former period, so that continental margins begin to close again (collisio orogenesis).

Paleotectonics: this interval essentially cover those stages allowed the evolution both of the southern continental margin of Thethys and of the facing oceanic area. The lenght of the priod covers about 200 m.y., from Triassic lower Tertiary. Major tectonic episodes nappened during middle Triassic, Norian-lower Liassic. upper Malm, middle Cretaceous and finally upper Cretaceous and Paleocene.

a) - Ancient physiographic features. The picture is that of an alternation of sedimentary belts with basins and shallow water characters with a carbonate sedimentation, gradually prograding towards the foreland and developing parallely to the above continental margin. The wideness of single belt may range from some dozens to few hundred Km. A number of synsedimentary faults and a prononced subsidence characterize. the sedimentary belts. The subsidence is gradually decreasing from about 150 to about 10 m/MY.

b) - Features of the emerged areas. During the emersion phases which affected only the carbonate platforms, the relief never was over a few meters above the sea level; the emerged areas where widely affected by karst with inter and intrastratal and/or superficial cavities with bauxitic (middle Cretaceous) or clayey (Paleocene) deposits.

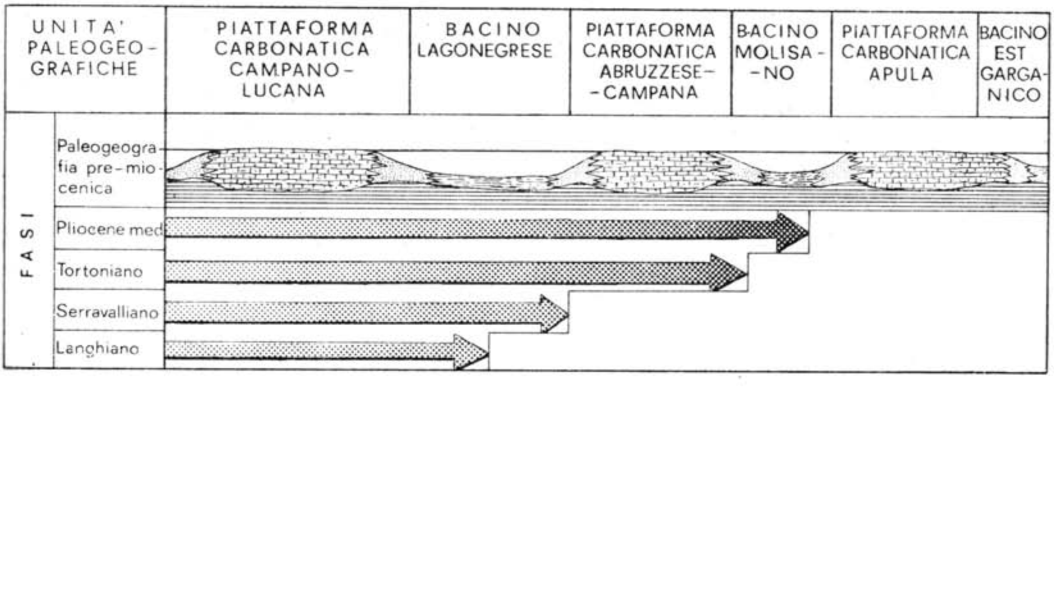

Fig. 5 - Tectogenetic phases and paleogeographic units in the Campania-Lucania Apennines. (Da D'Argenio et al., 1973).

Petrological, geochemical and paleontological evidences show warm-dry paleoclimates (from Triassic to Liassic) gradually evolving to warm-wet paleoclimates (from Jurassic to Paleocene).

c) - Influence on the present morphology. Relationships among different original facies belts often correspond to ancient synsedimentary fault lines.

These faults during tectogenetic and neotectonic periods, were rejuvenated. By this rejuvenation the location of the structural-stratigraphic unit, margins often depend on these ancient fault lines, which had afterawrds a morphological importance during the neotectonic uplift.

Tectogenesis: this interval includes compression stages during which the structural-stratigraphic units were detached from their basement and thrusted. The continental margin above mentioned, and the facing oceanic area were therefore deformed. The process covered a priod of less than 100 m.y. (from middle-upper Cretaceous to lower-middle Pliocene), of which 30 m.y. (from Miocene to lower-middle Pliocene) needed for the tectonization of the Apenninic continental margin ("external zones").

a) - Ancient physiographic features. These are similar to those above delineated for the paleotectonic interval except for the more internal areas gradually deforming and tectonically migrating towards the foreland (paleochain).

b) - Features of emerged areas. We have no fossil evidences of such features. Sedimentological study of deposits (for instance, the Cretaceous-Tertiary flysch) shows in any case a more marked morphology, with an evident hydrographic pattern. From the Tertiary on the paleoclimates are gradually wetter.

c) - Influences on present day morphology. All we said about paleotectonic interval is valid here. Present day morphology inherited features from this period. These features are related either to the regional arrangement of different rocks forming the structural-stratigraphic units or to their superposition.

2.4 Neotectonics.

Geomorphological features of the Southern Apennines, as already mentioned, have been and still are controlled by lithology, tectonics and climate.

Especially to the small scale is evident the influence of different morphoclimatic systems occurred during the Pleistocene. Nevertheless, when we cosider great morphological units (or groups of units) we find that tectonics is a controlling factor.

Indeed, actual geometric relationship between lithologically distinct geological bodies (i.e. mainly arenaceous or, mainly argillous-calcareous bodies as well as mainly carbonate bodies) were produced by the overthrusting of the structural-stratigraphic units during the tectogenesis.

By this way the main groups of morpho-structural units (i.e. carbonate massifs, arenaceous-flysch reliefs) took place.

Uplift of the following neotectonic period gave to the single sectors a different role, in connection either with direction (tectonic valleys and surrected blocks) or with intensity of the movement.

We have often, for instance, that a fast uplift favoured a likewise fast denudation of the terrigenous cover revealing underlying carbonate rocks. In both cases morphoclimatic systems only shaped substratum already differentiated as regards height and/or lithology.

The main movement is therefore uplift, to which followed gravitational glidings towards the foredeep (glidings of the Bradano Foretrough in Plio-Quaternary age), as well as towards the Tyrrenian Sea (gliding of the Paola Basin). Both these depressions were gradually thorowing of even 1 mm p.y.

The uplift begins in the Pliocene, after the last great tectonic translation, and two periods can be recognized corresponding to as many morphological cycles:

- a period covering upper Pliocene to lower Pleistocene;
- a period covering middle to upper Pleistocene.

Uplift is gradually more marked during these periods and so wideness of the morphological units decreases. This is confirmed by the records of these processes in the calcareous blocks (i.e. tectonically truncated valleys).

Present geomorphological cycle is still young and affected by the uplift, as the seismic activity proves.

This activity is evident along the great cross lines (i.e. Naples-Bari) and longitudinal lines of the chain. and goes together with geochemical and/or thermal anomaly of many springs whose circulation is, almost partly, very deep, even far away from the volcanic areas.

2.5 Plio-Pleistocene Geomorphological Cycles.

a) - Villafranchian morphogenetic cycle.

The uplift in this period is not well recognized, and we can only say that present boundaries with the facing seas are determined as well as the main morphological structural units are definite.

From a more strictly morphological point of view, at the end of the period the mature topographic surface (after the erosion of the upper terrigenous sheets) has reached the carbonate sediments and there geomorphic cycle is often superimposed.

b) - Late Villafranchian morphogenetic cycle.

During this period ($\simeq$ 0,8 m. y.) the former topographic surface (of which in present times only some residual strips remain) was broken out by a stronger uplift of varying intensity along the chain. This led to the formation of internal grabens often occupied by lakes and now filled (Diano Valley, Latina Valley).

In the same time calcareous areas were affected rapidly by the karstic processes, whose activity is favoured by the Pleistocene cold climate. By this way a complex system of cavities at various levels took place.

Records of ancient erosional surfaces in non-calcareous areas are indeed very rare.

At this time the discordance between orography and hydrography in Southern Apennines occurs. It consists of a displacement to the east of the watershed, leaving to the west the main reliefs and producing the actual pattern of the hydrographic network, chiefly subsequent and rarely obsequent (f.i.: Bianco river, Mingardo river etc.).

At the end of the Riss age ($\simeq$ 0,2 m.y.) probably the chain is completely uplifted.

2.6 Coast Morphology.

Features of the coasts of the inner part of the chain are chiefly controlled by the great perithyrrenian faults, whereas a longitudinal subsidence and some less important faults are the controlling factors respectively of the ionian and adriatic coasts.

Eustatic movements of the Pleistocene are also important in featuring coasts, and their records widely occur in Southern Italy. Consequently a number of marine-cut terraces were formed, which can be divided as follows:

- eustatic terraces, ranging between 2 and 10 meters a.s.l. (normally they correspond to 2,4 and 8-10 meters a.s.l.), whose age belongs to the last 1,5 m.y. (f.i.: the Salento Peninsula).
- tectonically dislocated terraces, corresponding to sec-

tions of the coast prior to or rarely contemporary with eustatic terraces (f.i.: the shores with Strombus of southern Calabria uplifted to over 100 meters, while normally they are at about 8 meters a.s.l.).

The greatest uplift of the coast is found in Calabria (terraces of the Calabrian age of Mt. Aspromonte, 1.400 meters high); generally, on the thyrrenian side the uplift decreases northward; in the ionian and adriatic side it is of a few meters.

High Coasts.

In calcareous dolomitic sediments high coasts are evidently controlled by the structure. The cliffs move back slowly, as shown by the well preserved pleistocenic waterline marks.

These parts of the coast are therefore controlled by fault systems striking NW (apenninic direction) and NE, sometimes EW. Naturally the cliffs move back more rapidly when formed of softer rocks as sandstones, marlstones and volcanic tuffs.

Coastal Plains.

On the thyrrenian side there are some plains corresponding to transverse tectonic troughs in which to a marked subsidence counterparts a great sedimentation at the mouth of main rivers (Garigliano, Volturno, Sele, Lao rivers). Thickness of the sediments may be over 3.000 meters (Volturno and Sele River Plains), displaying a rate of sedimentation of even 1 meter p.y.

On the contrary, the coastal plains of the ionian side are the result of coalescing deltas.

All things considered, the present time shoreline tend to move back thanks either to eustatism or to anthropic activity along the rivers, whose solid charge notably decreased in the last years.

3 - first excursion: paleo-and neokarstic processes in the alburno-cervati structural-stratigraphic unit

3.1 The Alburno-Cervati structural-stratigraphic unit.

The karstic phenomena to be observed in this first excursion are all located in the Alburno-Cervati structural-stratigraphic unit.

This unit derives, as already mentioned, by the deformation of the original Campania-Lucania Carbonate Platform, a large Mesozoic-Tertiary paleogeographic unit.

The Alburno-Cervati unit largely outcrops in Campania (Avella-Partenio Mountains, Picentini and Lattari Mountains, Alburno-Cervati Mountains, Mount Marzano); in western Lucania.

The original carbonate platform was a large carbonate body mainly formed during the Mesozoic in shallow and very shallow waters, with widespread generally early dolomitization processes (Trias-Lower Lias) and rare clayey intercalations (lower Cretaceous-Paleocene).

The mesozoic sediments of the back reef lagoons were mostly micritic muds; their organogenic contentis given mainly by algae,forams and molluscs. The mesozoic sediments of the tidal flats were generally stromatolitc, often cyclically alternating with the former (cyclothems).

In the original rim belts true reef complex are very rare (frequently the platform margins were dissected, downfaulted and/or dismantled before the Miocene).

The platform scarp sediments are clastic and bioclastic calcarenites and calcirudites, sometimes very coarse grained, up to megabreccias. The latter evidence moments of particular activity of the synsedimentary tectonics.

The sequence is carbonatic from Triassic to Miocene and terrigenous (flysch deposits) during the Miocene. The total thickness may exceed 4.500 m.

In Campania the sequence is the following (De Castro, 1962, 1968; Scandone and Sgrosso, 1963; Selli, 1957):

- Massive white dolomites with rare clayey intercalations and cherty lenses, thickness 350 m;
- Myophoria marls; limestones, marls, shales with black cherts and which Myophoria, Avicula, Esteria, (Carnian), thickness 150 m;
- Bedded whithe and gray dolomites with marly intercalations, thickness 600 m;
- "Scisti Ittiolitici", thin bedded bituminous carbonates with brown coal lenses, thickness 30 m;
- Gervilleia dolomites, whitish, poorly bedded sucrosic dolomites, with Gervilleia, Megalodon, pleuotomarids, thickness 300 m (Norian);
- Dolomites and dolomitic limestones, with Megalodon and pleurotomarids, alternating with stromatolitic dolomites, thickness 200 m (Norian-lower Lias);
- Calcilutites and calcarenites with Palaeodasycladus Mediterraneous, Orbitopsella praecursor, Lithiotis problematica, thickness about 800 m (Liassic);
- Calcilutites, oolitic and onkolitic limestones with Clypeina, Pfenderina, Cladocoropsis, thickness 800 m (Dogger-Malm);
- Calcilutites and calcarenites, sometimes dolomitic limestones, with diceratids; in the upper part a clayey Orbitolina bearing level is known; thickness 700-800 m (lower Cretaceous);
- Rudistid bearing limestones, thickness 500-600 m (upper Cretaceous);
- Calcilutites and calcarenites with Alveolina and Spirolina, thickness few dozens of m (Paleocene-Lower Eocene).

Upon a disconformity surface which cuts upper Cretaceous and Paleocene limestones follow:

- greenesh calcarenites and calcirudites with Miogypsina upward grading to turbiditic sandstones and siltstones (Aquitanian-Langhian).

Some hundred meters of slightly metamorphosed phyllites with diploporid limestone intercalations (Middle Triassic) and prasinites outcrop at the base of the above sequence in the Catena Costiera (Western Calabria) north of the so-called Sanqineto Line.

3.2

a. The Vesuvius (from Naples to Pompei)

The High way between Naples and Salerno in its first part, crosses an area where morphology and human geography are very interesting. Before the raising of the Somma-Vesuvius volcanic edifice (about 25.000 years ago) there was here a wide plain, stretching until the first calcareous reliefs. Thanks to the great fertility of the land (soils derived from potassic pyroclastites), until some years ago the area was still supporting the richest italian production of vegetables. Nowaday a great conurbation has taken the place of this farming.

Approaching Vesuvius we can see some of its morphological characters, like the ancient caldera ring of the trachytic Mt. Somma and the thephrytic cone of Vesuvius: between them the Antro del Cavallo, from where came down the dark lava flow of 1944 last eruption.

The roadcut allow to see the older flows which sometimes are utilized as quarries for paving roads material. At the 14 th Km are also visible some eccentric cones, the most evident of which is that of Camaldoli.

b - From Pompei to Salerno and Battipaglia: the Cava Furrow, and Picentini Mountains

On the right hand stands out the Sorrento Peninsula. which is the Campania physiographic unit where mainly the structures control the landscape.

The Peninsula is a calcareous block belonging to the Campano-Lucanian carbonate platform and it is nearest one to the volcanic area. It appears to have been dislocated in a great homoclinal structure dipping to the Gulf of Naples. At its foot, near Castellammare di Stabia sprays a series of springs variously mineralized. Approaching the massif we can recognize the stages of its uplift, which are marked by two series of suspended morphologies. One of these is visible at the 37 th Km., on the right hand.

Between Nocera and Cava the road crosses a wide structural depression corresponding to a fault set; some of the faults, which can be seen on the right hand, developed into triangular facettes as the Mt. Finestra. This fault set separates the base of the Peninsula from the Picentini Mts.

After passed the watershad between Naples and Salerno Gulfs, the road crosses first a wide, strongly dissected pleistocenic fan coming from the Lattari Mts., then a valley whose right slope clearly shows the scars made by the landslide of 1955.

The sliding body was the pyroclastic cover of the dolomite limestone, highly affected by the pedogenesis and so easily mobilized by the over 500 mm. (about 20 inches) of rain fallen in less than 24 hours. During this disaster the talwegs of the streams received detritic masses several meters thick. The solid charge of the Bonea stream, in one night only, raised of 150 meters the beach of Vietri, that we can now see on the right side of the village (Ilario, 1976).

The base of this landscape is made of the oldest rocks of the structure (upper Triassic).

The last view of the Sorrento Peninsula shows the niches of the Amalfi coast, which correspond to the faults of the Quaternary uplift.

After the viaduct on the Irno stream, we can see on the right the characteristic gray columnar tuffs. The columnar shape of these campanian ignimbrites, produced by a Flegrean explosion of some 30.000 years ago, is due to the cooling joints. We may note that the tuffs filled the pre-existing valleys with a flat terraced surface.

On the left hand the marginal relief of the Picentini Mts. is visible. Here outcrops a part of the carbonate sequence, well stratified and ranging from the Aptian-Albian (green marlstones with Orbitolina) to the upper Cretaceous.

Fig. 6 - Somma-Vesuvio.

Very interesting is the morphology of the slope, controlled by a fault that dislocated this margin, following the Lehman law of parallel rectilinear recession with total ablation of the wastes at its foot (Richter's denudation slope), (Bakker, Le Heux, 1950), where the present day linear erosion is very active. Indeed, a great part of the slopes controlled by marginal faults is seemingly shaped.

At the 8 th Km outcrops the Eboli formation (Baggioni 1973) consisting of lower-middle Pleistocene conglomerates deposited by the streams flowing from the Picentini Mts. These sediments were faulted in the Quaternary.

Near the Battipaglia road station, on the left hand we can see some remnants of the old morphological surface shaped on limestones. These remnants stand out of the actual plain and are bounded by fault-linescarps.

The hills in the foreground are also formed by the conglomerates of Eboli formation, and they connect each other thank to fault steps which lowered these conglomerates in relation to the plain.

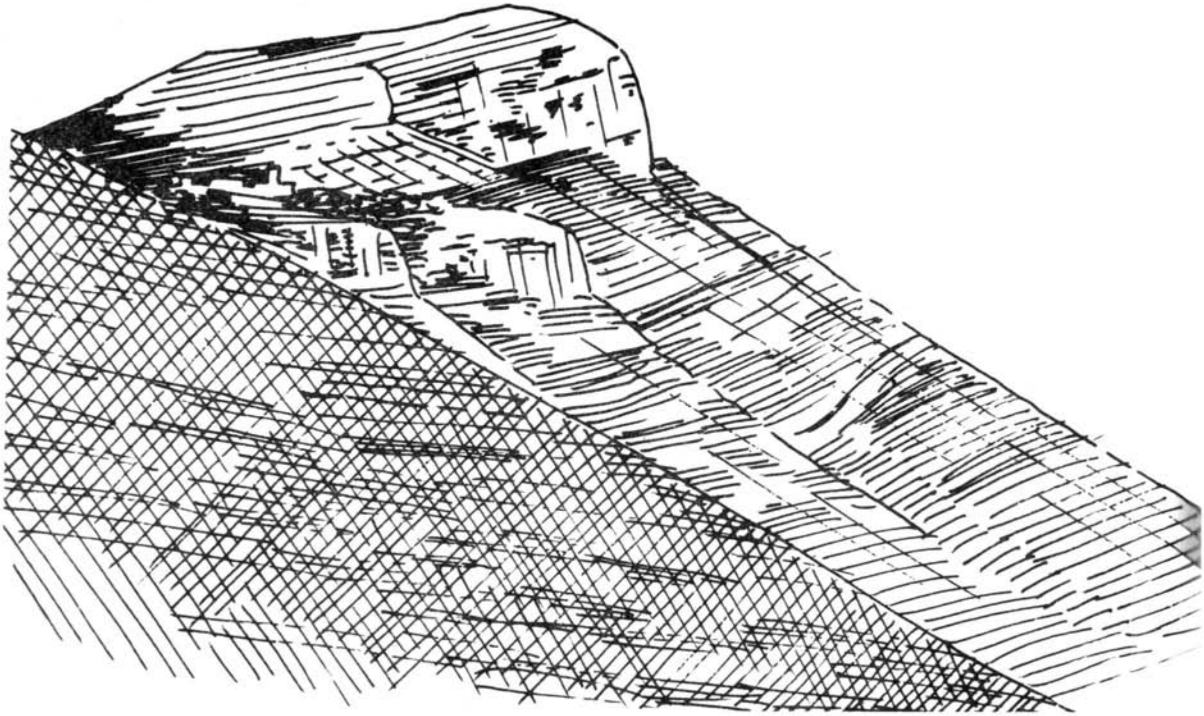

Fig. 7 - Monte Tobenna. Richter's denudational slope.

c - From Battipaglia to Campagna and Capaccio crossroads: the Sele River Plain

After Battipaglia we find the hills of Eboli (407 meters a.s.l.), formed of loose, more or less stratified sediments of mainly dolomitic pebbles. This is the Eboli formation, probably originated in a cold morphoclimatic system , which shows almost two stages coinciding with the plio-quaternary tectonics (Baggioni. 1973), that raised the relief surrounding the plain.

Between the two cold stages (Günz and Mindel ?) probably a period of intense alternation with formation of paleosoils tooks place.

Leaving the highway at Battipaglia we drive to the Nr. 18 road until the Capaccio crossroads, and we are in the Sele River alluvial plain.

Here the sediments have a fluvio-lacustrine and lagoon-cycle facies with an alternation of sand and gravels, sometimes volcanic materials.

The regular structure of the agricultural landscape is the product of the human presence. The territory, once swampy and unhealthy, was completely drained and a new regulation of waters, land and cultivations tooks place.

In the eastern part of the plain the Sele and Calore rivers eroded more ancient and dislocated conglomerates. which dip under the alluvial sediments for some 1.000 meters (Ippolito, Ortolani, Russo, 1973).

Morphologically these conglomerates are shaped on a series of glacis delimited by two orders of terraces evident in the area between Eboli and Altavilla Silentina.

The lagoon-cycle and fluvio- lacustrine facies are distinct in two units, each delimited downstream by a dune ridge. The inner unit shows recasted Volcanic heavy minerals, which are also found in the Würmian dune delimiting the unit (west of the Capaccio station). The inner lagoon-cycle deposits, containing heavy volcanic minerals from the Vesuvius eruptions, are in turn delimited by a flandrian dune which is imminent on coast (Baggioni,1975).

In the lower part of the plain two large plates of travertine outcrop. This formation, which supports the old greek town of Paestum, spreads beyond the enclosure walls and is partly covered by the quaternary and present day alluvial sediments, never reaching a great height. Vertically we find an alternation of compact and porous travertine, with some interbeds of sands, clay and peat.

On the northern and eastern sides of the enclosure walls, a few meters below the ground, between two layers of travertine we can see a level of soil bearing volcanic minerals, whose thickness increases eastawards.

More eastwards, at a deeper level, interbeds of white-yellow, calcareous, fine-graned sands, often cemented showing Helix, other similar terrestrial gastropods and calcareous fragments are known. Some levels of travertine are rich of leaves and/or lacustrine plants patterns.

The plates of travertine are located (turning back on the sea) on the right hand of the remnants of the Gromola dune (some 80.000 years, Würm I - Würm II).

If we lengthen the dune, we separate two coastal plains. the older one in the back, which were filled essentially by the travertine deposits. Therefore, the travertine plate more distant from the sea was deposed before the nearest one. The dune itself was probably eroded by running waters.

Some wells, drilled for water supply near Capodifiume (about 2 kM. downstreams from the spring), found at 25 meters and 12 meters beneath the surface two fossil shores intercalated in travertine layers. They represent two standstills of the sea level during the flandrian transgression. We can therefore state that the Paestum travertine is surely younger than the Gromola dune (i.e. younger of Würm I - Würm II).
The water is cold, with a carbonate and alkaline chloryde content varying from a spring to another. Where the southern plate of travertine outcrops other springs of mineralized water pour out.

At the Capaccio station we take the Nr. 166 road for the Alburni Mts. Opposite stand out two calcareous homoclines: that of Mt. Soprano (1083 meters a.s.l.) on the

A most important factor in the genesis of travertine is the underground water circulation, probably the same feeding the springs of Capodifiume river pouring at the foot of the nort-western part of Mt. Soprano (3.000 l/sec.). left, and that of mt. Sottano (632 meters a.s.l.) on the right, dipping north-westward. Where the layers dip against the slope, there is a thick cover of debris cones and detritic breccias probably of rissian and würmian age.

d - From Capaccio crossroads to Castelcivita: the Calore Graben

Coming back on the Nr. 166 road, we go round of Mt. Soprano, leaving on the left the last edges of the travertine originated by the springs of Capaccio.

On the northern slope of Mt. Soprano homocline are visible thick layers of green calcarenites of lower Miocene (Roccadaspide formation) starting from 15 th Km. of the road.

This formation, of Aquitanian age, is transgressive on limestones of Paleocene age, with a gap recording the emersion stage during which karst processes started. Calcarenites are used from ancient times as building and decorative material (see, for instance, freizes, capitals and metopes of the most part of the temples of Paestum).

Upward sedimentation passes to argillaceous-arenaceous terms with calcareous-marly interbeds with flysch facies.

Here we can have a complete view of the Alburno Mts.. which form an homocline gently dipping to the south and delimited by fault line scarps. The top is shaped by the karst processes and costitutes a surface suspended on the present day valleys.

From Roccadaspide we take the Nr. 488 road and, after the crossroads of Laurino (some 58 Km. far). we can observe several pockets of kaolinic red clay overlaying paleocene - partly pseudoconglomerate - limestones.

The pockets underlay organogenous calcirudites of Miocene that are not visible here but outcrop distinctly near Felitto village. We can also see disconformity between Paleocene and Miocene without any bauxitic pocket. From Felitto we come back to Roccadaspide.

Leaving Roccadaspide the road penetrates in the lucanian Calore valley, having here a NW-SE direction which correspond to a structural low (graben) actually occupied by the terrigenous Cilento flysch.

Morphology shows gentle features due to the softer lithology. Very important in the landscape are the landslides, whose scars are visible, mainly where the "argille varicolori" (Sicilides units) outcrop.

The hydrographic pattern of Calore, according to the main fault lines, consists of talwegs where the streams cannot remove the weastes of the slopes. The last section of the road custs a fluvial terrace at the same height of the opening of the Castelcivita Caves (about 90 meters a.s.l.).

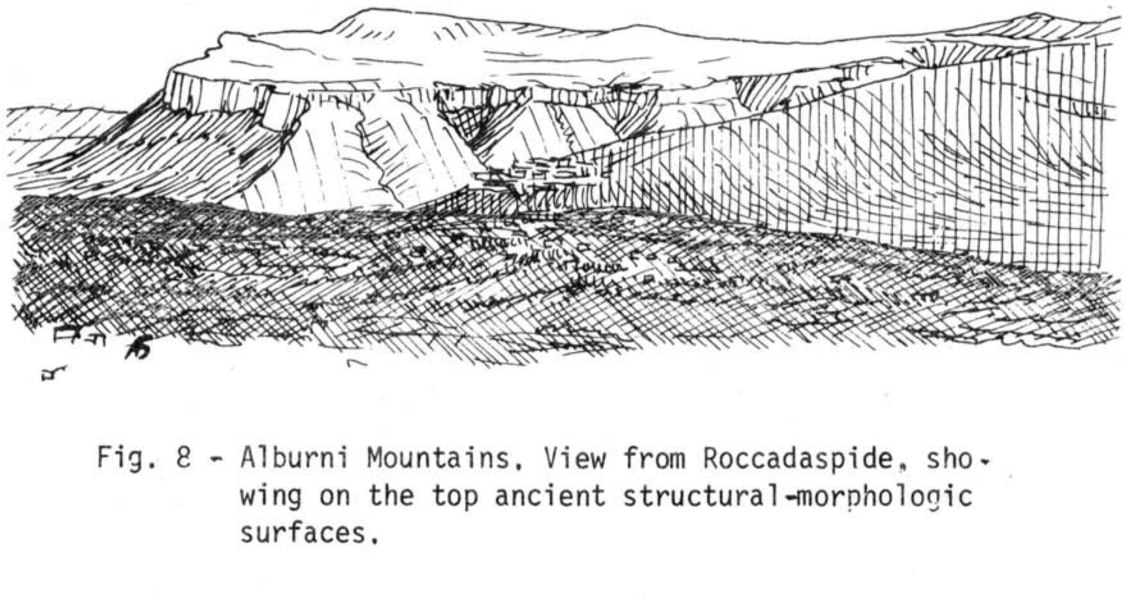

Fig. 8 - Alburni Mountains. View from Roccadaspide, showing on the top ancient structural-morphologic surfaces.

3.3 Paleokarstic features of the lower Tertiary in the Trentinara Mountains.

The carbonates of Mt. Soprano, Mt. Sottano-Trentinara and Mt. Vesole belong to the structural-stratigraphic unit of Alburno-Cervati, deriving from deformation of the

Campania-Lucania carbonate platform (D'Argenio et al., 1973; Ippolito et al., 1975).

They are essentially formed by Cretaceous to upper Paleocene-Eocene (?) backreef carbonates (Trentinara formation, Selli, 1962), as well as by lower Miocene calcarenites (Roccadaspide and Capaccio formation, Selli, 1957).

The biostratigraphical analysis (Sgrosso, 1968) shows that in the Mt. Vesole sequence there are sediments of upper Cretaceous (Cenomanian-Senonian) to upper Paleocene (Eocene?) and Miocene. Between Senonian and Paleocene two regressive episodes are supposed, probably connected with short gaps allowing the formation of very hard (flint clay) kaolinic clays (T politype, (Boni, Stanzione and Zenone, 1978).

From a lithological point of view, the overlying Trentinara formation (Paleocene- lower Eocene ?) is formed by compact limestones, calcarenites and calcirudites, sometimes breccias, with frequent intebeds of shales and marls; the environment changes from brackish-marine to lagoonal.

The upper part of the paleocenic sequence shows some reddish levels with a poorly developed karst consisting of superficial pockets of 5 meters maximum thickness. Such features are related to an emersion preceding the miocenic transgression, which is also responsable of the local thick deposits of red "bauxitic" clays, very rich indeed of allochtonous materials.

The outcrops of these clays, which are not really bauxitic because they contain very small amount of alumina hydroxide, constitute a discontinuous level even if relatively frequent, that marks everywhere in the Campania-Lucania carbonate platform the period of continentality preceeding the transgression of the miocenic calcarenites (Boni, 1974).

The thickness of the pockets is various, as well as the arrangement and percent of minerals. either authigenous or allocthonous.

In this case, we could refer to the rearrangement of the mainly illitic clays present in the marly layers and in the breccias of the Trentinara formation. This rearrangement colud have caused the loose of cations and consequent change into kaolinite with a low crystallinity index.

The texture of red clays is quite similar to that of typical bauxite, with oolithic structures in a argillaceous-ferrigenous finegrained matrix. It is supposed to have had a sequence of almost two successive cycles during the recasting of continental sediments.

In this time the environmental factors (continental waters like those of coastal swamps or swampy lagoons) remained relatively unchanged (Boni, 1974).

The forming minerals, of a supposed authigenous origin, are: kaolinite (40-50%), hematite-goethite (20-25%), argillaceous minerals, mixed-layer-illite (10-20%), anatase (1-3%), gibbsite (1-2%) and calcite (1-10%).

We are not sure of the authigenous origin of illites. mixed-layer and maybe also of kaolinite whose crystallinity is lower than that of the clays present in the Senonian limestones.

In all the outcrops allochtonous detritic minerals in a variable percent, as quartz (15-30%) with included rutile, feldspar (1-3%), tourmaline and zircon are also found. Also silt size particles of metamorphics (essentially of quartz-muscovite association, sometimes quartz only) have been noticed.

In the genesis of the outcrops we cannot avoid the hypothesis of an authoctonous origin for the red clays, which could represent the insoluble residue of a partial solution of the underlaying carbonates: in other words, the same process that develops in many deposits of "terra rossa" and bauxite.

We must in any case note that in the shales of the Trentinara formation detritic elements as quartz. feldspar zircon and tourmaline, are absent, whereas they are abo-undant in the red clays. This lead us to infer that the red clays are of different origin.

On this ground, we can imagine, during the period between upper Pleocene and lower Miocene, a terrigenous detritic contribution (of unknown origin, maybe from the already impinging allochtonous nappes), related to weathering of silicate rocks.

3.4 Karstic features of the Alburni Mts. (Castelcivita Caves).

The Castelcivita caves are situaded near the village bearing the same name at the foot of the southern side of Alburno Mts. The square of entry, derived from the excavation of a detritical fan, corresponds to a terrace 91 meters a.s.l.

Looking at left side of the entry, we note in the upper part a pyroclastic body of unknown origin, in the lower part the detritical fan formerly hiding the entry itself. In the fan can also be found some paleolithic artifacts recording the presence of man in the open-air stations.

Description of the caves

I) From the entry to the section Nr. 4.
Evident is an old graviclastic morphology with a strong chemioclastic evolution. The relative thinness of the cover demostrates the marked influence of the external environment. Due to collapses of the floor, the siphon of the last part of the section is now at the same height of the N branch.

Many branches are visible, penetrated by some interstrata passages and frequently characterized by ortovacua and presence of water (northern branch, CAI I and CAI II passages).

II) From section Nr. 4 to section Nr. 17.

An interstrata situation prevails here as well, while the diaclasic morphology of E-W direction is secondary. Two levels of interstrata character are always: an upper one morphologically old, with large sized stalactites and stalagmites; a lower one morphologically younger and sometimes hydromorphic, with well-developed isolated concretions, mostly located on the southern wall.

From the Bertarelli cavity on, we can find external material formed by calcareous and marl-calcareous rounded pabbles, fine to medium grained sands and pyroclastites. Their sequence is characteristic, with disappearence of pebbles but never of sands and pyroclastites, always to be found either in the upper or in the lower level.

Corresponding to section Nr. 15 the vault shows a bell-shaped formation due to the crossing of two tectonic directions (NW-SE and NE-SW). At the point where fractures become plentiful, the vault shows a vast ortovacuum once communicating with the outside, representing in the past a

a path for alimentation of the cave by external material.

Branches

The P branch is the tallest of the caves and shows an interstrato morphology with some old collapses. It ends in a well, deriving from an ortovacuum.

The A branch is tectonically disturbed along the E-W direction. The M branch after a very steep first part, presents a typical hydromorphic section with some collapses. The morphology of the CAI III passage is perfectly correspondent.

The E branch presents columnar concretions in the walls. On the floor are some concretions "a vaschetta" where water coming from interstrata persists. In the upper part the morphology is very old and shows great flows and columnshaped stalactites and stalagmites.

In the middle part there is a chaotic mass of rocky blocks, while the lower part finally shows large blocks of rock with concretions. The two levels previously mentioned and corresponding to the Nr. 15 section, are also evident.

"Il Deserto", at a higher level, shows a characteristic interstrata section with few isolated concretions. In its last part, the control of tectonics, truncating the interstrata section itself, is evident.

III) From section Nr 17 to section 29.
Apart from the "Principe di Piemonte" cavity the entire strike shows a typical diaclasic morphology. The "Boegan" cavity, which is at a higher level that the former, shows a very old morphology with large concretions.

The "Principe di Piemonte" cavity corresponds to a fracture stretching E-W, successively widened by chemioclastic and graviclastic action. The only branch is here, "Il Tempio", corresponding to the upper level above mentioned. In the first part an hydromorphic section is evident, then the passage widens and a great stalactitic flow appears, recording an important water flow from the north through interstrata.

The strong erosion of the water flow is recorded by a 20 cm thick calcareous blade, in the central part of the cavity, eroded on both sides.

After its broadening the branch shows the diaclasic section connected with the main cavity near the "Grande cascata", a white flow of concretions "a vaschetta".

IV) From section Nr 29 to the end.
This area is the most difficult strike. The sections are always of graviclastic type in the upper part, while in the lower part they are hydromorphic, either on limestone, or on the filling material.

The only branch is the "Orrido", with an upper gravi-clastic and a lower hydromorphic section. The passage ends with a large well containing water, derived from the lateral association of two ortovacua. The "Orrido" constitutes the principal entrance for water penetrating the main cavity.

A series of great stalactites forms the "Anelli terrace" which continues until the "Salto dei Titani". The small passage north of "Salto dei Titani" shows a characteristic dome-shaped formation, filled by pebbles, sands, clay and tuffs.

The last strike has interstrata and collapse characters along the E-W tectonic direction. The northern part of "Redivo" cavity shows interstrata characters corresponding to the upper level, the southern part, on the contrary, has hydromorphic characters.

Genesis and evolution of the cavities.

The evolution is connected with fluctuation of the water table, as we noted for the Ausini caves, and we can state that the development of both caves was contemporary. Such a conclusion is based, on the morphology, trend of layers and position of sediments exsting in the caves, and as well on the possibility of correlation of the evolution stages of the two caves.

The sequence of the evolution of Castelcivita caves results as follows:
- development of the upper level as an interstrata or diaclasic cavity;
- formation of the lower level also as an interstrata cavity;
- formation of ortovacua out doors passage ways and partial filling;
- collapse of central part of the vault with partial filling.

An additional evidence of the common genesis of the Ausino and Castelcivita caves is the analytical determination of the supplementary calcium dissolved by corrosion in the water.

The ratio between the $\Delta(Ca^{++})$ of the caves is constant.

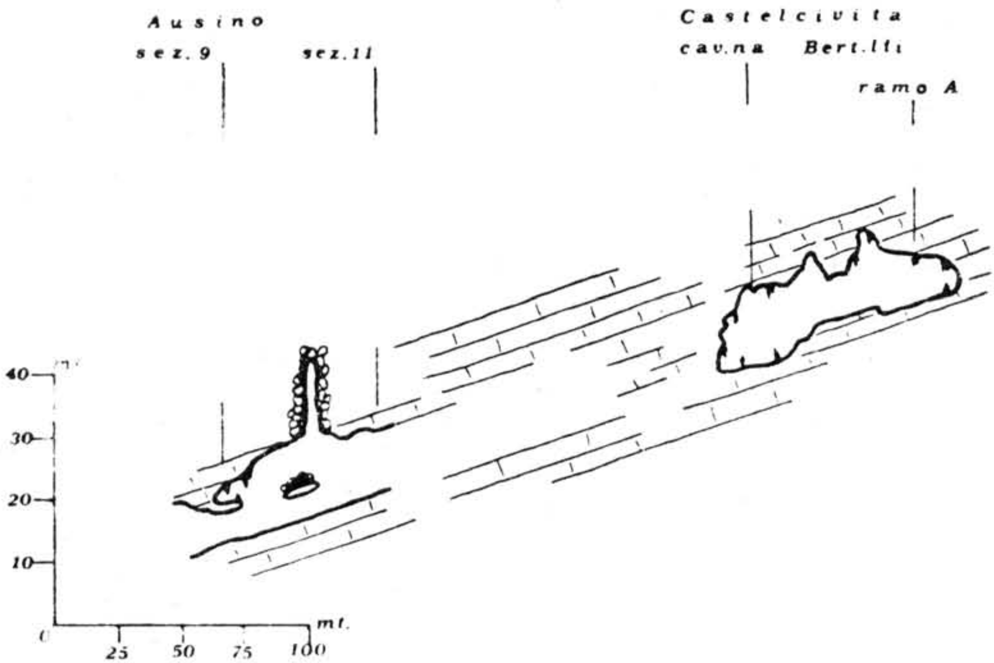

Fig. 9 - Schematic section trough the Ausino and Castelcivita Caves. The section shows the location of the cavities in the same group of beds.

3.5 Paestum: the ancient Greek town

First named Poseidonia by the Greeks and later called Paîstum and Paistas by the Italic populations and Paestum by the Romans, this ancient city, collocated in the most eastern area of the Golf of Salerno about 9 to 10 kilometers from the mouth of the Sele River, of the northern border of the region called Magna Grecia in the Fourth Century a.C., was one of the richiest and most flourishing Greek colonies in Southern Italy.

The essential reason for its foundation was the primary need of the Greeks of Sibari to open a path for commerce between the Ionic and Tirrenian Seas across the Apennine Mountains, thus avoiding the necessity of circumnavigation of the Calabrian coast and passage via the Strait of Messina of maritime commerce.

The only surviving evidence of the Greek period consists in monuments such as walls and temples, the rests of the Herion uncovered in 1934, and selections of coins. When, in the later part of the Fifth Century a.C., the vast movement of the Italic races broke out against the Greek colonies of Campania and Lucania, Poseidonia as well as other cities fell under Lucanian hands. More than a century later (273 a.C.), Rome rushed in establishing her own colony at Paestum.

<u>The City Walls</u>: The surrounding wall, circa 4.700 meters in circumference, is considered one of the greatest and best preserved defensive works of the Greek cities in Magna Grecia, including Sicily. The fortification is in the shape of a pentagon having its smallest side toward the coast line. Turrets are inserted onto the wall, which is crossed by numerous small gates ("postierle") of the Greek and Lucanian eras.

<u>Temples</u>: Paestum is still alive in the spheres of art and culture above all for its marvelous three temples, which represent the most organic architectural complex

left of cities in Magna Grecia. The three temples have come to portray three periods in the evolution of Doric architecture in Italy, from the fully-developed Archaic era (the so-called Basilica) to the full maturity of the Doric style (the temple of Poseidon) and the intermediate stage between them (the temple of Ceres).

The Basilica: Was mistakenly given its name by designers and men of letters of the Eightenth Century due to the almost total disappearance of the walls of the cella, of the upper façade, and of the trabeation, as well as for the low and uniform aspect of its colonnade. Nine columns characterize the front façade while 18 columns enclose each side. The chief archaic element lies in the building measures, the lenght of which scarcely prevails upon its width.

The Temple of Poseidon: Is considered the best example of Doric temple architecture in both Italy and Greece. The cella, composed of pronaos and opistodom, has a naos divided into three naves by two double ordered colonnades, upon which the beams of the roof rest.

The Italic Forum: With its covered colonnades, public buildings and countless taverns arrayed under its porticos, the Italic Forum clearly mirrors the divergent character of the Italic and Roman city, which began its formation from the time of the Lucanian conquist and particularly after settlement of the Latin colony.

Among other civic and sacred buildings at the center of the greater sides of the Forum, the Temple of Peace was a religious area resting on a high podium, with Corinthian columns having figured, composite capitels. The Italic and Roman Curium buildings were outside the Forum area, where the perimeter of the Roman amphitheater can still be distinguished.

Archaeological findings from the entire area of Paestum are contained in a rich museum, presently being re-

stored group of Italic tombs, including that of the Diver, which have been recently discovered, offer an important series of beautiful frescos.

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4 second excursion: paleo -and neokarstic processes in the matese -monte maggiore structural-stratigraphic unit

4.1 The Matese-Monte Maggiore structural-stratigraphic Unit.

The Matese-Monte Maggiore S.S.U. shows sedimentary characters very close to those of the Alburno-Cervati Unit. Infact the sediments consist of upper Triassic (Norian) to lower Miocene carbonates which since the Serravallian become terrigenous (marls and sandstones).

The afarementioned unit, which derives from the deformation of the Mesozoic-Tertiary Abruzzese-Campania carbonate platform, widely outcrops in the Matese area, at Monte Maggiore, at Monte Camposauro and Monte Massico: in Lucania appears, in a tectonic window, at Monte Alpi.

The depositional environments are thought to be tidal flats and large back-reef lagoons (since the Cretaceous not always restricted). The reefoidal deposits are almost wholly missed because of the synsedimentary tectonics; on the contrary the marginal ones, clastic and bioclastic, largely outcrop (mainly since the Cretaceous).

The whole succession is thick about 3.000 meters and according to Catenacci, De Castro, Sgrosso. (1963); D'Argenio, (1963, 1967); Pescatore and Vallario (1963) is given by:

- Well stratified bituminous, white to grey. dolomites, in place silicified, 200 m. thick (Norian).
- Microcrystalline, white to grey dolomites and Gervilleia and Megalodus searing marls cyclically alternated with stromatolitic dolomites and limestones, 350 m. thick (Norian-Infralias);
- Algal and foraminiferal calcilutites with oolitic limestones intercalations, topwards carbonatic levels bearing large pelecy pods (Lithiotis facies), 300 m. thick (Lias);

- oolitic and oncolitic limestones, dolomitic limestones with Pfenderina salernitana, Cladocoropsis mirabilis and Clypeina jurassica, 350 m. thick, (Dogger-Malm):
- Diceratid bearing limestones and dolomitic limestones 200-250 m. thick (lower Cretaceous-Cenomanian p.p.): these are often covered by a bauxitic horizon laterally passing to breccias with a reddish cement (the corresponding lacuna includes a part of Cenomanian):
- Rudistid bearing limestones and dolomitic limestones (Turonian p.p., Senonian).

Miocenic transgressive deposits concordantly follow:
- calcarenites and calcilutites with red algae. pelecypods, bryozoans, 1 to 40 in thick (upper middle Langhian);
- Orbulina bearing marls and marly limestones, 20-40 thick, (Serravallian);
- terrigenous deposits, pelites and turbidites mainly more than 300 m. thick, (Serravallian-Tortonian).

Dolomitization is diffused in the lower part of the sequence, where the littoral-supralittoral facies alternated with the sublittoral ones (cyclothems). In relation with the supralittoral episodes, ephemeral emersions with solution processes evidences may be noted.

Other emersion short episodes are found at the Jurassic-Cretaceous boundary. Finally emersion interrupted the sedimentation between the Cenomanian and the lower Senonian.

4.2 Window Geology

a. The Monte Camposauro (Benevento-Montesarchio-Cautano Vitulano, Solopaca).

Leaving Benevento, built up mainly on fluvial lacustrine deposits (Riss and partly Würm age), where the Sabato and Calore rivers converge we continue along the Torrente Corvo valley towards Montesarchio.

The road moves accross Miocenic sandstones, upper Pliocene silty clays and sandstones and welded tuffites (near Tufara), then goes up towards the Valle Caudina.

This tectonic depression, between the Taburno to the North and the Avella group to the South, is a typical intermontane basin, individuated probably since the end of the Pliocene and filled by lacustrine; fluvio-lacustrine and pyroclastic terrains deposited during the Pleistocene (Bergomi, Manfredini, Martelli, 1975; D'Argenio, 1967).

Leaving Montesarchio, the road climbs the eastern slopes of the Taburno showing a panoramic view of the Valle Caudina and of the southern side of the Taburno Mts.

The southern Taburno side appears largely shaped according to the mechanism of the parallel rectilinear recession slope typical of the geomorphic cryonival systems (quaternary glaciations); the flat large surface of the slope, appears dissected by torrential furrows produced from the linear erosion of the present day geomorphic system.

Eastwards the hills are made up by miocenic wildflysch (Formazione di Castelvetere) with their large carbonatic blocks (Cesco di Luccaro, Pietra di Tocco).

The morphology of the transverse valleys which cross the Taburno from West to East clearly shows these valleys were set up on tectonic lines. The Piana di Prata between Taburno and Camposauro Mountains is filled up by very thick, sometimes coarse, breccia deposits with reddish paleosoils (lower Würm, Bergomi et al., 1975).

Further on the road crosses the Torrente Ienga and goes up towards Cautano where it is possible to see the southern slopes of Monte Camposauro (Colle della Noce and Vallone Guria) characterized by the reddish coloration from the quarries of the polychrome "Marmi di Vitulano" cretaceous limestones with widespread paleokarst features.

Along this tract and in the next one (covered by tru· cks accross the Colle della Noce, the eastern side of Pizzo Cupone and Monte Cappello till Vitulano) remnants of ancient morphologies are preserved at different eleva· tions.

Some of these traces, now at an elevation of 1.000 m. (between Pizzo del Piano and Monte Rosa) will be seen white rising the Matese. They are part of ancient surfa- ces karstified and displaced during the late post-Villa- franchian uplifting phases.

Leaving Vitulano the road gets down Solopaca around the Monte Pentime at the basis of its northern side. Thick detrital fans of Würmian age leaning on well welded brec· cias of (?) prerissian age, outcropping toward the top.

Before Solopaca a one Km wide belt with dolineform de- pressions is present. They have been interpreted as col- lapse subdetrital dolines (D'Argenio 1959, 1967) or as dolines formed in the slope conglomerates and breccias of the Camposauro (Bergomi, Manfredini, Martelli, 1975).

Fig. 10 - Monte Taburno: Rectilinear fault slope grading to the basal breccia talus.

4.2

c. The south-eastern Matese (Piedimonte Matese- Lago- Regia Piana).

Approaching Piedimonte it is possible to discern afar the east-west calcareous dolomitic massif of the Matese. Its slope appears incised by deep furrows bearing large fans walded each with the other to form a unique detrital belt where several towns were built up.

To the left of Piedimonte triassic dolomitic terranes representing the outcropping lowermost levels of the massif outcrop, while Jurassic-Createaceous calcareous terranes are visible on the right. This area is particularly tectonically disturbed. The abrupt changes in slope are related with faults, while the gently steep areas correspond to the argillaceous miocenic flysch.

Between Castello di Alife and M. Raspato, aboundant calcareous breccias more or less stratified and welded, possibly originated during some pleistocenic cold phases (Mindel or Günz).

After S. Gregorio Matese, towards Passo di Miralago (1120 m.) the road runs on karstfied cretaceous limestones, with large dolines and lapiez.

Just at the Passo di Miralago we enter the tectonic valley of the Lago Matese (trending from WNW to ESE far some 30 Km at an elevation of 1.000 m). The waters cover cretaceous limestones whose general dipping is towards NE. So the northern side of the trench appear less steep than the southern one. On the former appear a typical Richter's slope, dissected by thin furrows. At their base lie beatiful and flat fans, mostly welded among them and with the alluvial deposits of the lake floor.

Leaving the lake towards E we pass again the Passo Miralago along the Matese graben. Still crossing the karstic environment of the cretaceous limestones (peculiar the superficial production of "Terra rossa") we go up respect to the chain. As for other apenninic rivers, this valley runs along a "graben" with an apenninic trend marginal to the Matese.

The faults which formed the trench indicate a certain maturity degree as it is possible to see, in a closer view, in an area where the scarp, produced by faulting, appear dissected from torrential incisions with interposed residual triangular facettes.

Finally we get Piedimonte Matese at the basis of the homonimous massif where in the deep canyon of the Vallone dell'Inferno the Torano and Maretto springs come out.

Fig. 11 - The Southern Matese side. A fault slope dissected by linear erosion

b. The Calore and Volturno valleys. West of Ponte (Solopaca, Telese, Piedimonte).

Getting down towards the Calore valley, enormous alluvial deposits, occupying its rigth side, are visible from the top of the road. These deposits are forming wide climatic terraces of Riss age (Malatesta, 1968) whose surface appear dipping toward the valley axis.

The corresponding deposits are lacking on the other side covered by the road we are just running, and are replaced by different age slope breccias, derived by the cryoclastic denudation developed during the quaternary glaciations. This asymmetry is derived from the different physiographic evolution of the erosional basins (Matese to the orographic right and Camposauro to the left).

After crossing the Calore-Ponte Santa Cristina, small terraces set on grey tuffites (ignimbrite campana) appear. They derived from the peneplanation of preexisting valley morphologies and later underwent a newly the incision by the same rivers.

Taking the superway Telese-Caianello, we cross the small Colle di Pugliano and the town of Telese very important thermal station known for its sulphur waters. These waters are alimented by the karstic basins of the Matese. The origin of their mineralization is not jet clear: it may be related to the Messinian evaporites or to the Triassic evaporites of the Matese-Monte Maggiore structural-stratigraphic unit.

On the Colle di Pugliano, above the Terme. an assemblage of collapse dolines among the most characteristic in the Southern Apennines tooks place. A certain role in their morphogenesis may have been played by the aggressive, sulphureous waters of Telese.

Since now we are rising the Volturno valley in a sector where the idrographic axes develops longitudinally with toward the Sella del Perrone (1250 m.) dominated Southeastward by the M. Mutria (1823 m.) (Cretaceous limestones).

From here, across the Cusanara valley carved along a fault line with apenninic direction, we mount towards Bocca della Selva (1393 m.) where the first bauxitic levels appear. These bauxites correspond to an emersional phase followed by a karstic cycle during the middle Cretaceous (well exposed outcrops at Regia Piana).

Fig. 12 - Civita di Pietraroia (on the left) and the South western margin of Regia Piana (on the rigth) with the Titerno furrow inbetween.

4.2

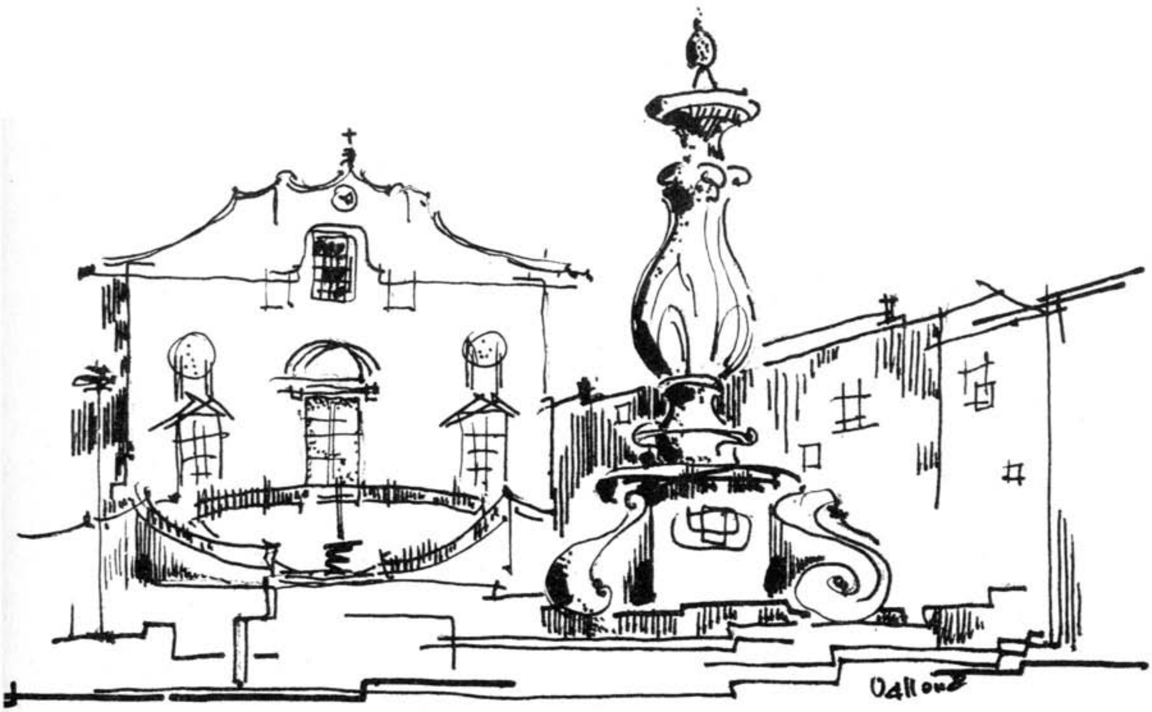
d. The Titerno Valley

From the Regia Piana the road runs along the gently inclined area at the basis of M. Mutria, consisting of Miocenic limestones marls and sandstones; transgressive on cretaceous limestones.

Going down towards Pietraroia the Titerno deep gorge between the Civita di Pietraroia and the Civita di Cusano-Regia Piana appears. From Pietraroia to Cusano Mutri it is possible to see, to the North, an impressive sequence of fans welded to the deep furrows coming down from the Regia Piana.

The gently morphology of the upper basin of the Titerno (with intensive coltures) is given by the marly-arenaceous terranes which strongly contrast with the roughness of the encircling calcareous massifs.

After Civitella Licinio, the Titerno flows fully in the cretaceous limestones of the M. Cigno (675 m.) where near Cerreto Sannita, has again hollowed an impressive gorge.



Cerreto Sannita

4.3 Hypogean paleokarstic phenomena in the Cretaceous limestones of Matese-Monte Maggiore Unit.

In the Matese-Monte Maggiore structural-stratigraphic Unit a stratigraphic gap close to the middle Cretaceous has been identified (Bàrdossy, Boni, D'Argenio, Dall'Aglio, Pantò, 1977; Bergomi, Manfredini, Martelli, 1975; Catenacci, De Castro e Sgrosso, 1963; Crescenti e Vighi, 1970; D'Argenio, 1963, 1967, 1969; Sartoni e Colalongo, 1963).

The amount of the gap is variable: it may be limited only to a part of Cenomanian (Monte Maggiore) or may include the entire interval between Albian and lower Senonian.

In the southern part of Monte Maggiore two shorts stratigraphic gaps, between uppermost Albian-lowermost Cenomanian and uppermost Cenomanian-lowermost Turonian have also been pointed out (Sartoni e Colalongo, 1963; Carannante, Ferreri, Simone, 1974).

At the level of the lower gap we can find an outcropping bauxite horizon (which will be discussed later); the main evidence of the upper gap is above all the widespread karstic cess, causing an anastomized network formed by small cavities completely filled by polychrome calcilutites.

The eastern side of M. Camposauro is very similar to the southern one of M. Maggiore, despite the absence of any bauxitic horizon.

Here in fact we can find lenticular levels of poorly-sorted poligenic breccias, with bauxitic fragments and polychrome limestone elements, sometimes even of a great bulk and thin and scattered green clayey intercalations.

They are thirty or forthy meters thick at all, and of an age between Albian and lower Cenomanian (D'Argenio, 1967; Bergomi, Manfredini, Martelli, 1975) and presumibly represent one or more short stratigraphic gaps.

Towards the top gray limestones very rich in gastropods (acteonids, nerineids) follows. At Colle della Noce they change into withish limestones rudistids (caprinids and radiolithids). The transition is marked by a slightly wavy clear cut surface.

Also in this case the scarcity of significant forms does not allow to appreciate the entity of a presumable stratigraphic gap.

These levels are Cenomanian in age. Both in the gastropods and in rudistids levels we may fing large karstic lenticular cavities, completely fetted by chemical and detritic polychrome sediments ("Marmi di Vitulano").

The cavities have a prevailingly horizontal development. It is possible to distinguish 4 groups: a) interstratal cavities; b) intrastratal cavities; c) transverse fracture cavities (preceeding the complete fitting) and d) subvertical fracture cavities (i.e. subperpendicular to the bedding).

Evolution of the cavities

The sedimentologic and diagenetic characteristics of the limestones in which these cavities were formed indicate shallow water environments, typical of the large epioceanic carbonate platforms that flourished during the Mesozoic along the southern margin of the Tethys (D'Argenio, 1974).

The gray limestones with gastropods have characters of back reef lagoon sediments, with ostracods and benthic forams and are almost algaeless.

In some levels the microfaunas are essentially made by miliolids, arenaceous forams (verneulinids, valvulinids, textularids), sometimes by orbitolinids and with very abundant pellets; in other micritic levels, very abundant ostracods are often associated with scarce and small miliolids.

Many levels contain a large amount of gastropods (among which acteonids and nerineids) and pelecipods (mainly diceradits), they often form biostromal banks (Nelson, Brown, Brineman, 1962; D'Argenio 1967). Early diagenetic features commonly are:birdseyes, intense microboring with frequent micritic envelops, weak early cementation.

The whitish limestones with rudistids that follow upward mark a sharp lithological change: they are micrites and calcarenites with shells of rudistids (caprinids and radiolitids). Sometimes small rudistid biolithites are also recognizable.

The transition to a "continental" environment is indicated by the increase of the vadose diagenesis, characterized by pervasive solution within the sediments which caused redistribution of newly loosed sedimentary particles that "percolated" downward (Carannante, Ferreri, Simone, 1974).

Moreover, hypogeal, mostly lenticular cavities and cavity networks developed by subsequently circulating phreatic waters that enlarged the preexsisting early diagenetic and vadose voids which coalesced in larger cavity systems.

Interstratal cavities of larger dimensions are often localized at the transition between the gastropod bearing gray limestones and the overlying caprinid and radiolitid bearing limestones.

Filling of cavities by alternating episodes of chemical and mechanical deposits appears quite complex.

Among the chemical deposits a first generation of radiaxial cements remarcably impure, followed by further generations of cements intercalated with "mechanical" sediments is often recognizable.

Gray and reddish to yellowish siltites and arenites with coarser, bauxite derived materials, burrows, can be distinguished in the internal detrital sediments. In the gray calcisiltites sometimes ostracods and small burrows may also be observed.

Little variations of the base level may cause repeated oscillations from phreatic to vadose environment, with superposition of dissolution upon deposition (chemical and/or "mechanical") effects.

Besides final processes (small scale faulting and partial downfall of the roof in some cavities), in some large cavities there are also evidences by bioclastic calcarenites ("calcari cristallini"). These calcarenites presumably derive from the synsedimentary dismantling of the Senonian, ippuritid bearing limestones that disconformably overlap the white limestones with caprinids and radiolitids.

A mineralogical and geochemical preliminary study of the Vitulano paleokarstic cavities fillings is at present in press (Pozzuoli et al., in press). This study evidences a derivation of the mechanical fillings from the already existing bauxite deposits as already supposed (D'Argenio, 1967).

Pozzuoli et al., (in press) infer that bauxite derived materials mostly underwent crystallochemical and geochemical changes during several stages of their transport, dispersion and diagenesis. The above authors support the partial origin of the detritic fraction of the fillings from the bauxites on these grounds:

- "mixed layers" minerals are very frequent in the bed rock (in whose pores they penetrated during the early phases of vadose diagenesis that have preceeded the karstification); moreover they decrease in those fillings with coarse bauxitic fragments; this may indicate a differential evolution during transport and reworking if the "mixed layers" come from the degradation of the illites of the bauxites;

- chlorites and kaolinites decrease from the bauxitiferous fillings to the bedrock; the same may be said for the crystallinity of kaolinite which is higher in the bauxitiferous fillings.

From a geochemical point of view, the connections with bauxites of the cavity fillings is suggested by several elements found in them. These elements indicate percentage variations that may be related to the alteration processes of the materials during their transport. This is the case of iron and manganese whose content increase with the insoluble residue increasing.

The paleokarstic cavities may be seen at Cava Turaldo and at the old quarries "Uria".

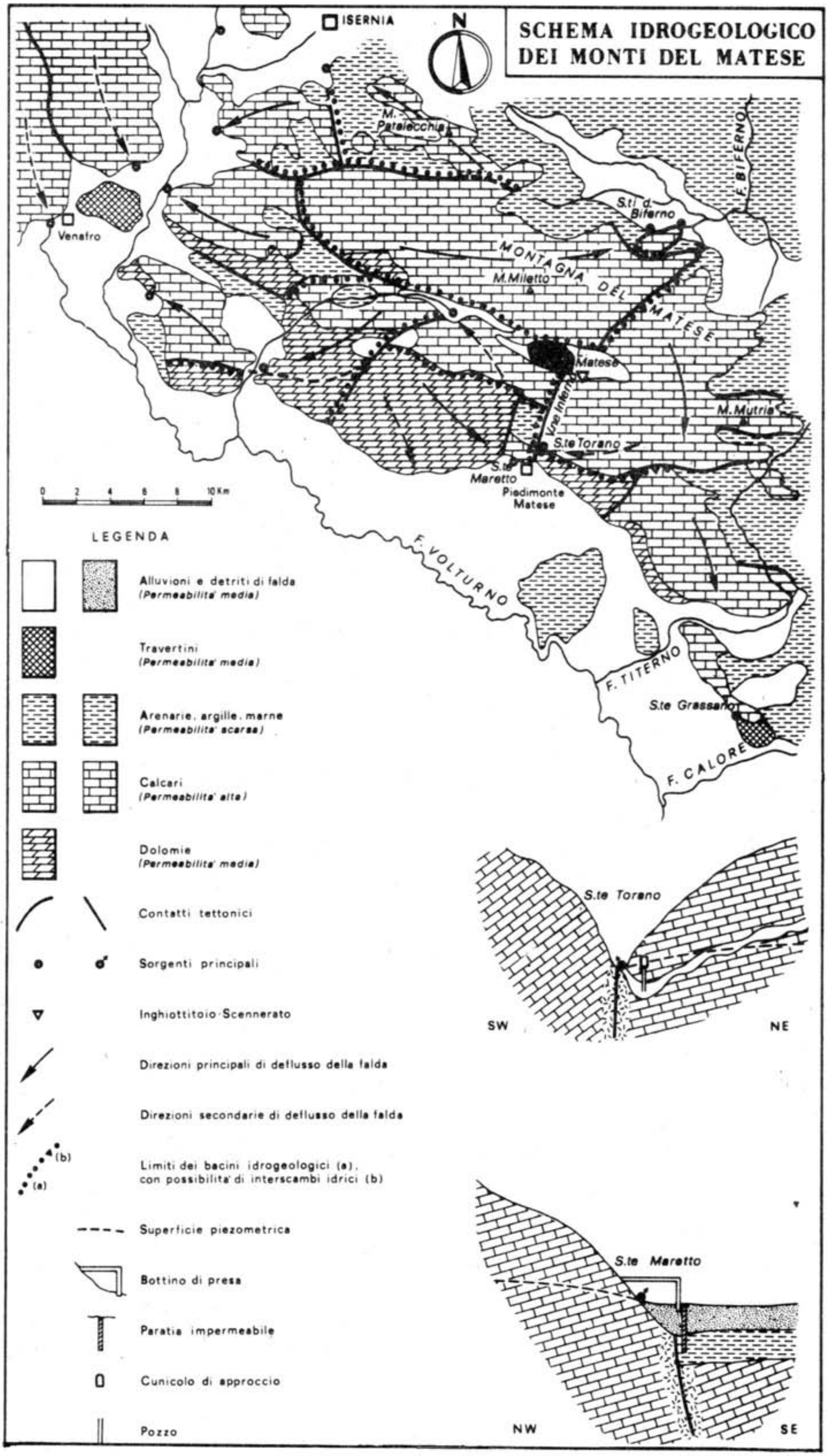


Fig.13 - Hydrogeologic scheme of Matese Mountains.

4.4 The Torano and Maretto springs

Torano and Maretto springs are feeded by the hydrogeological unit of Matese Mountains, one of most important of southern Apennines.

This unit has an areal extent of more than 540 square Km and is characterized by an average annual rainfall of about 1.490 millimeters. The total pluviometric contribution exceed 800 x 10^6 cubic m/y. This means that the aquiferous yieldy (about 32 l/p x sq. km) is higher than the statistic FAO average for the mediterranean karst (about 25 l/p x sq. Km).

Torano and Maretto springs among the most important of the Matese Mountains are feeded by distinct, although contigous, basins, separated perhaps by a fault-zone corresponding to the Vallone dell'Inferno gorge. This fault zone probably, acts as an underground watershade.

The distinct feeding is evident by comparing the flow hydrograms. The Torano spring diagram, related to the heaviest rainfalls, shows sharp peaks corresponding to short waters circuits, particularly connected with Matese lake through the "Scennerato" sinkhole.

On the contrary the hydrograms of the Maretto spring show that the feeding is given by a different type of aquifer formed by dolomites, with less pronounced karstification and a better regulation of the underground water flux.

Therefore the Torano (average flow: 2,3 cubic m/y; height 202 m a.s.l.) and Maretto springs (average flow: 1,2 cubic m/y; height 500 m a.s.l.), are genetically connected to the overflowing of the aforesaid water table, intercepted by important structural and stratigraphic discontinuities.

The water table of the Torano spring is "suspended" on the dolomitic rocks on the south-east of Piedimonte Matese, while those of the Maretto spring are controlled in their out flowing by the "Vallone dell'Inferno" fault zone.

The waters of the Maretto spring outflows in a low of the "permeability treshold", given by detritic alluvial materials and by deeper clayey-arenaceous deposits overlapping the carbonatic aquifer.

The figure shows the technical devices used for educting waters.

4.5 The epigeal paleokarstic features of the Regia Piana Cretaceous carbonates and their bauxite deposits.

Widespread bauxite horizons of Cretaceous age are interbedded in the shallow water carbonate sediments of Southern Italy. These bauxites, though mined till few years ago, have never had a relevant economic importance (a large bibliography was recently commented by Boni, 1972).

A comprehensive study was finally carried on by Bàrdossy, Boni, Dall'Aglio, D'Argenio and Pantò (1977). The following notes have been mostly derived from the above paper.

The bauxites are embedded in the sequences of two already mentioned paleogeographic units: the Abruzzi-Campania Carbonate Platform and the Apulia Carbonate Platform. These platforms were formerly separated by an intermediate basin (Molise-Marsica Basin).

The bauxites mark a widespread stratigraphic gap originated by an emersion and are disconformably overlapped by Cretaceous rudistid limestones; they may also pass laterally to bauxitic breccias or even to clayey deposits. (Catenacci, De Castro & Sgrosso, 1962; Crescenti e Vighi, 1964, 1970; D'Argenio, 1963, 1969; Sartoni & Crescenti, 1962; Sartoni & Colalongo, 1964).

Moreover, in the Abruzzi-Campania Carbonate Platform deposits, two almost parallel bands with bauxite intercalations are known. In these bands, roughly running along the Apenninic strike, the width of the stratigraphic gap increases eastward. To the west, two bauxitic horinzons have been recognized, each of them representing a shorter emersion episode, whereas to the east only one horizon is known and it is characterized by a larger lacune (D'Argenio 1963, 1969).

The bauxite horizon is never continous, but rather made of many small concentrations of different type, grouped in several outcrop areas; the thickness is generally variable from few cm to more than 10 meters. Like in the most deposits of karstic bauxites, the cavities filled with bauxite are generated by solution processes. The forms of the bauxite bodies essentially are/

a) flat contiguous lenses, whose thickness is ranging from 50 to 200 cm;
b) thick scattered lenses, never thicker than 10 meters;
c) vertically developed bodies, filling canyon-like cavities, with steep walls and thickness higher than 40 meters.

Although the different types of occurrences are not characteristic of a single district, each of them, however, is diffused prevailing in a single district more than in the others. On this ground it is possible to distinguish:

1) prevalence of type (a) forms (Campania District; type area: Monte Maggiore);
2) prevalence of type (b) forms (Abruzzi District; type area: Monti d'Ocre);
3) prevalence of type (c) forms (Apulia District; type area: Northern Murge);
4) occurrence of type (a+b) forms (Apulia District: Gargano Peninsula; Campania District: Monti del Matese; Abruzzi District: Monti della Marsica).

In the Campania District mainly little deposits occur as flat lenses and pockets with diameters of 10 to 100 meters. Their thickness varies from 0,5 to 3 meters with rare maxima of 6 meters. The basal surface is slightly karstified. The bauxites graded laterally into calcareous breccias and conglomerates, cemented by reddish calcite and/or bauxitic clays. The total amount of bauxitic rocks forming the deposits is about 5 million tons, but only a small portion is commercial grade bauxite. Some of the deposits were mined in small open pits.

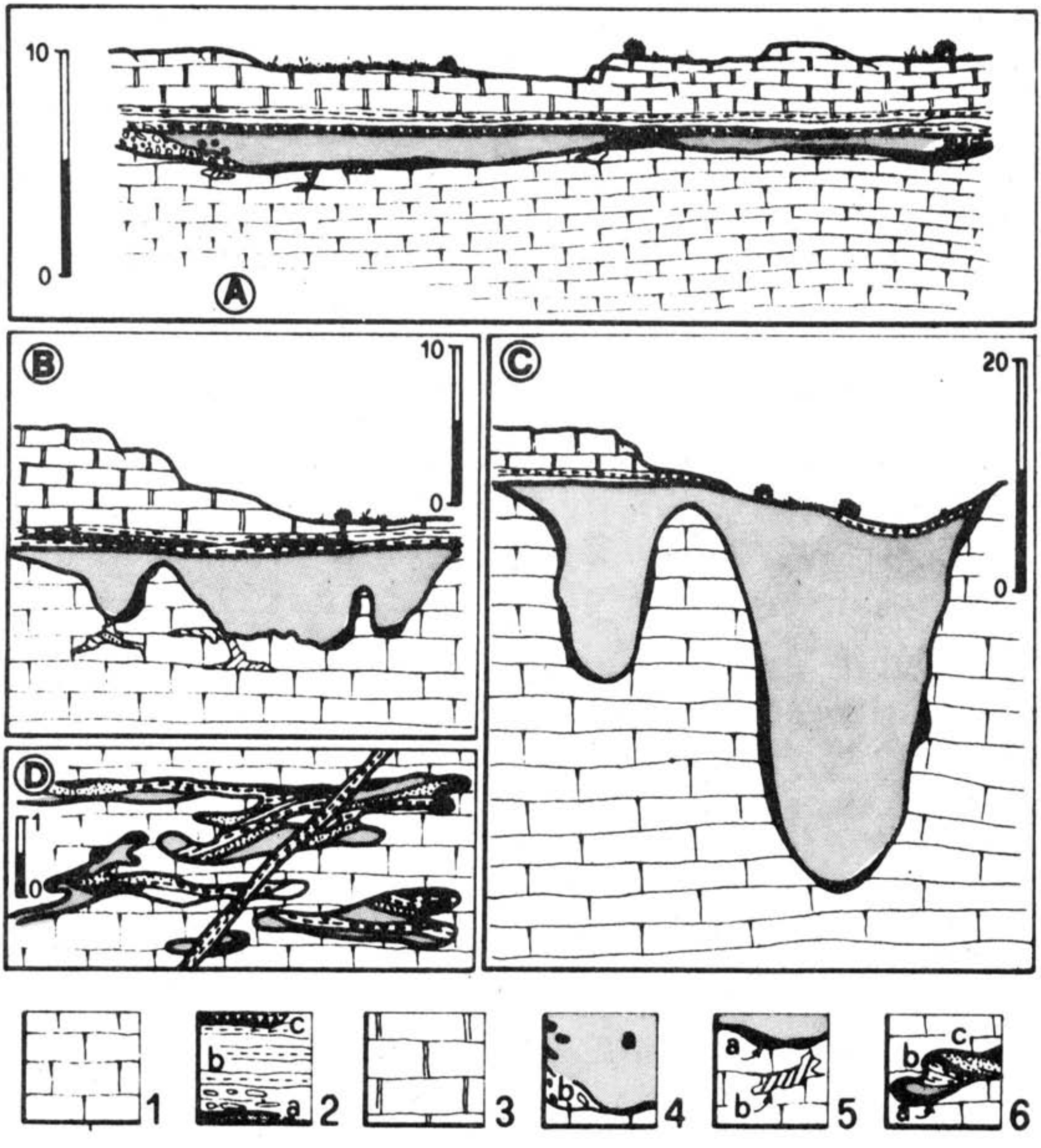

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Fig.14 - Forms of bauxite bodies. A. Flat, contigous lenses; B. Thicker, scattered lenses: C. Vertically developed bodies, filling sinkhole or canyon like cavities; D. Network of underground karstic cavities, filled, mostly only in part, by bauxite or reworked bauxitic materials. 1. Footwall limestones (generally white or pink micrites and biomicrites); 2a. Calcareous conglomerates with clayey matrix; 2b. Green or red clays; 2c. Thin levels of brown coal; 3. Hanging wall limestones (withe intra-and biomicrites, sometimes stromatolites and tidal channel breccias); 4a. Bauxites; 4b. Calcareous breccia embedded in bauxitic groundmass; 5a. Calcitic crusts at the bauxite-footwall contact; 5b. Karstic cavities in the uppermost footwall; 6. Paleokarstic networks of cavities rimmed by calcite crusts and filled by laminae of reworked bauxites (6a), varicoloured micrites and calcisiltite (6b) and bioclastic calcarenites (6c).

Petrography

The central part of most deposits consist of pure bauxite accompanied in some deposits by a lesser amount of iron-rich bauxite. Iron-poor bauxites are abundant only at the Regia Piana deposits, in the other deposits they form only small patches in the normal ore. The bauxite grades downward into clayey bauxite and bauxitic clay. They become dominant in the upper and marginal parts of the deposits too.

Most bauxite deposits have a massive, non stratified structure. A very faint stratification could be observed in some parts of the Regia Piana deposits (Matese). Detrital bauxite grains are arrenged parallel to the stratification.

Italian bauxites are composed by the following textural elements: pelitomorphic groundmass (syngenetic); detrital bauxite grains and bauxite pebbles; detrital mineral grains; ooides, pisoides, spastoides (early diagenetic); coatings around older textural elements (late diagenetic and epigenetic); pore and fissure fillings (epigenetic); individual macrocristal (epigenetic); crusts and rhytmic segregations (epigenetic).

In the Abruzzi District the detrital elements are more frequent than the others; in Campania those diagenetic and in Apulia the diagenetic and syngenetic ones. The aforesaid differences are due to local variability in duration and/or importance of depositional (detrital grains), as well as syngenetic, early and late diagenetic processes within the three bauxite districts.

Mineralogy.

Boehmite is the main alumina mineral; gibbsite and diaspore are less common. Almost all silica is present in the form of clay minerals, the most important one being kaolinite.

It is accompanied by less dioctahedral Al-chlorite by illite and hydromuscovite. A green clay occurring at the bottom of the Campo Felice deposits contains up to 68% hydromica minerals, mainly glauconite- Hematite is the principal iron mineral. Alumogoethite is almost as widespread as hematite, but its quantity is generally less. Rarely small quantities of magnetite, maghemite and pyrite also occur. The main titanium minerals are anatase and rutile.

The detrital bauxite grains contains more Hematite and less boehmite, kaolinite, anatase, rutile than the groundmass.

Geochemistry

We can see that the italian bauxites have a very similar chemical composition. There are only slight differences in the most frequently occurring Al_2O_3 and SiO_2 values. In the same time there is a wide range for the maximum and minimum contents of both components. The Fe_2O_3 content is low in the Matese region and highest in the Castello Dragoni deposit.

The average TiO_2 content increases from west to east: it is lowest in the Campania bauxites, a little higher in the Abruzzi ones and highest in the Apulian bauxites. The latter ones are higher than those of most karstic bauxites in the Mediterranean belt.

The most frequent CaO values are below 1%, but in the limy bauxites they may reach 10 to 20%. The maximum MgO values are much lower, below 1,4%. Accordingly the most frequently occurring MgO content is 0,1 to 0,2%. The potassium content is generally very low (0,1 to 0,2%), but in the Campo Felice bauxites it may reach 1,2%. This is in good correspondance with the illite and hydromuscovite detected by us in these bauxites. Sodium is generally even less than the potassium content, except in the Monte Turchio Bauxites, where the analyses of Fabbri & Rabbi (1973) show a surprisigly high average value: 1,05%.

Italian bauxites have a very low MnO content (0,05 to 0,2%). Local manganese enrichments occur in the black crusts of the footwall contact, mentioned in the mineralogical section.

The average P_2O_5 content is even lower (0,05 to 0,1%) being less than the average of karstic bauxites. The ignition loss consist mainly of the $+H_2O$ content plus the CO_2 and the organic material. It is generally II to 13% attaining 16 to 22% in the limy bauxites.

Origin of the bauxites

As the Cretaceous sediments of the carbonate platforms consisted mainly of limestones, one would be tempted to conclude that the bauxites were derived from their insoluble residues. Indeed a strong chemical weathering of the limestones occurred and their isoluble residues contributed certainly to the material of the bauxites, but this was not enough to form the bauxite deposits. This opinion is supported by the very low insoluble residue content of the near footwall limestones.

Furthermore the big differences in the Cu, Li and Pb content of the footwall limestones and the bauxites cannot be explained by taking into account only a limestone origin. The same is for the monazite, xenotime, cheralite and baddeleyite detritic grains found in these bauxites.

Bàrdossy et al. (1977) suppose that wind-blown, mainly pyroclastic material contributed to the formation of the bauxites (D'Argenio, 1969). Similar ideas were developed by Comer (1974) for the formation of Jamaican bauxites and by Taylor & Hughes (1975) for the bauxites found on Rennel Island.

The texture and the meneralogical composition of the green clay found at the bottom of the Campo Felice deposit indicates its pyroclastic origin. The boehmite pseudomorphose formed after a pyroxene crystal at the Cusano Mutri deposit can be also interpreted as a pyroclastic mineral. The arrival of this material is also supperted by the Frosolone borehole, drilled near Isernia, that encountered pyroclastic intercalations within the Cretaceous limestones and marls. The glauconitic-montmorillonitic composition of the green clay indicates that volcanic ash (eventually fallen into the shallow sea covering the carbonate platforms shortly before their emersion), altered into clay minerals, and the weathered into bauxite.
The ilmenite, zircon, monazite, xenotime and cheralite grains support also of pyroclastic origin;
Moreover, the position of the carbonate platforms, bordering the "southern margins" of the Thetys, was also suitable to receive wind blown powders from the weathering of the southern cratonic areas: from these low latitude, high atmospheric pressure lands, (trade?) winds may have blown toward the carbonate platforms, characterized by a more oceanic climate. This could explain the presence of quartz and detritic chlorite. As matter of fact, no plutonic or metamorphic or other alumosilicate rocks has been found so far in the ouctrops. Consequently there is a very low probability that such outcrops were attached to the platform that were surrounded by steep scarps and during their emersion behaved as islands.

Finally it has to be noticed that during the middle Cretaceous emersion, the wind blown material, whatever was its provenance, accumulated upon the platforms without mixing with marine sediments, hence giving rise to a veneer that could reach a thickness of many centimeters. only considering an half of the 5-8 MY lasting time of emersion.

An easy calculation shows that only few centimeters distributed over all the 5.10^3 Km2 of the Abruzzi-Campania and Apulia Carbonate Platforms could account for the $4.5.10^7$ tons of bauxites evaluated for the peninsular Italy.

As a conclusion Bàrdossy et al. (1977) assume that the bauxites originated essentially from wind blown materials (mainly pyroclastic with a minor amount of mainland derived dusts), with an eventual small contribution of the insoluble residues of the footwall carbonates.

5. third excursion: paleokarstic and neokarstic processes in the murge-gargano structural-stratigraphic unit

5.1 The Murge-Gargano structural-stratigraphic unit.

The Murge-Gargano structural-stratigraphic unit individuated during the Pliocene, when the Apenninic chain underwent the last phases of the tectogenesis and the Bradano forethrough reached its present characters.

This unit differentiates from the large Apenninic carbonate structural-stratigraphic units already described because it is still rooted on its basement.

The central part of the original carbonate platform is well preserved (back reef lagoon deposits, often dolomitized). The western margin of the platform does not outcrop, because it is downfaulted below the Bradano Foretrough sediments. The eastern margin is known in the Gargano peninsula, where a large reef complex passes to scarp and basin deposits.

According to Ricchetti (1975) the sedimentologic characters of the eastern Murge carbonates inidicates a gently eastward batimetry increase during the Cretaceous, without evidences of scarp facies.

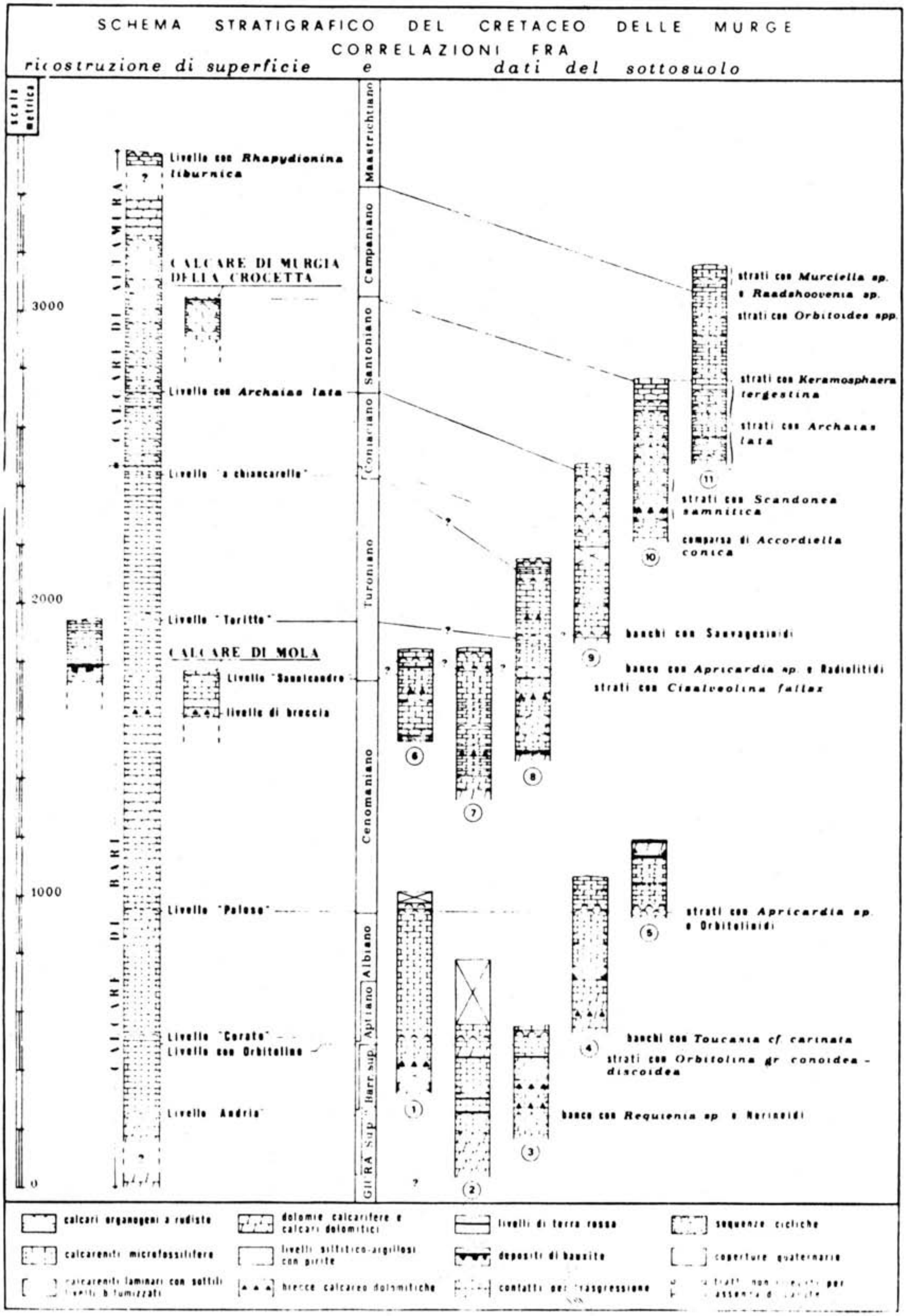
In the Gargano area almost the entire sequence (Triassic evaporites and Jurassic - Cretaceous carbonates) outcrops, whereas in the Murge only Cretaceous carbonates more than 3.000 meters thick are known (Ricchetti, 1975).

The lithostratigraphic units individuated in the latter sequence (Azzaroli & Valduga, 1967; Azzaroli, Perno & Radina, 1968; Ricchetti, 1975) are from below:

- Calcare di Bari, thickness over 2.000 m (upper Jurassic ? - Turonian). It widely outcrops in the northwestern Murge; in its upper part a bauxitic horizon sometimes occurs (Spinazzola and Gravina Murge). Back-reef and tidal facies.

- Calcare di Mola, few meters thick (upper Cenomanian-lower Turonian ?) crops out in the central part of Murge. Back-reef facies.
- Calcare di Altamura, 1.000 m thick (Coniacian - Maastrichtian). Crops out mainly in the south eastern Murge. Rudistid banks are largely diffused in this formation. In the Spinazzola and Gravina areas disconformably overlap the Calcare di Bari and its bauxites.
- Calcare di Murgia della Crocetta, few meters thick (Maastrichtian), possibly transgressing over the Calcare di Altamura (Murge di Gravina).

The Tertiary and Pleistocenic marine sediments are given by coarse to fine grained calcarenites, repeteadly overlapping the Mesozoic carbonate platform top. The depositional environment was generally a shallow open sea. Other Tertiary carbonates are of minor or local importance.


SCHEMA STRATIGRAFICO DEL CRETACEO DELLE MURGE
CORRELAZIONI FRA
ricostruzione di superficie e dati del sottosuolo
scala metrica
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2000
1000
0
CALCARE DI BARI
CALCARE DI ALTAMURA
CALCARE DI MURGIA DELLA CROCETTA
CALCARE DI MOLA
Livello con Rhapydionina liburnica
Livello con Archaias lata
Livello "a chiancarelle"
Livello "Toritto"
Livello "Sannicandro"
livello di breccia
Livello "Palese"
Livello "Corato"
Livello con Orbitolina
Livello "Andria"
Maastrichtiano
Campaniano
Santoniano
Coniaciano
Turoniano
Cenomaniano
Albiano
Aptiano
Barr sup
Sup
GIURA
strati con Murciella sp. e Raadshoovenia sp.
strati con Orbitoides spp.
strati con Keramosphaera tergestina
strati con Archaias lata
strati con Scandonea samnitica
comparsa di Accordiella conica
banchi con Sauvagesinidi
banco con Apricardia sp. e Radiolitidi
strati con Cisalveolina fallax
strati con Apricardia sp. e Orbitolinidi
banchi con Toucasia cf carinata
strati con Orbitolina gr conoidea - discoidea
banco con Requienia sp e Nerineidi
calcari organogeni a rudiste
calcareniti microfossilifere
calcareniti laminari con sottili livelli bitumizzati
dolomie calcarifere e calcari dolomitici
livelli siltitico-argillosi con pirite
brecce calcareo dolomitiche
livelli di terra rossa
depositi di bauxite
contatti per trasgressione
sequenze cicliche
coperture quaternarie

5.2 Window Geology

a. The outer Apenninic margin.

From Benevento we take the link for Napoli-Bari motor-road. Along the road, until we reach the Apulia Plain, several morphologic features of the Apenninic chain may be observed. From a morphologic standpoint we can distinguish 4main parts.

From Benevento to the Calore River bridge

Along the way towards the link for Napoli-Bari motor-road we can observe large flat areas, between Sabato and Calore rivers valleys, from 200 to 350 m. u.s.l., these areas, now very dismembered, are remanents of a large pleistocenic peneplaned surface parallel to the eastern chain margin. We can see at different elevations more or less extensive terraced areas which are tectonically displaced also many hundreds meters, and are characterized by a flat top with very old morphologic features.

Their margins correspond usually to recent faults and are deeply eroded by linear erosion and landslides. Main outcropping terranes are conglomerates, sands and marine clays of lower-middle Pliocene age and continental quaternary sediments which were deposited in a tectonic depression bounded by SW-NE faults (Benevento-Buonalbergo on the North and Parolise - Grottaminarda on the South).

The lower-Middle Pliocene cycle sediments represent the marine youngest terrains outcropping in this interior area of the chain.

The Matese carbonatic Units lie at a depth from 1.500 to 2.500 m. below siliceous, marly and clayey terrains related to the Lagonegro, and Pliocene Units.

From the Calore River bridge to the Ufita River Valley

After the Calore River bridge, we enter in the large Ufita River Valley, near Grottaminarda. This valley is upflooded filled by continental quaternary deposits and filled between Frigento structural high and Baronia syncline (respectively on the left and on the right orographic sides).

The Ufita valley is among the few flat areas of the internal southern Apennines, and is utilized for an intensive agriculture.

Here we have an important axial depression which causes the structures on the right (Frigento anticline, made of siliceous and marly Mesozoic terranes of Lagonegro Units; Baronia anticline made of lower-middle Pliocene clays sands and conglomerates) to disappear on the left of the motor-road. This, is to be related with the Parolise-Grottaminarda notable regional fault.

This recent fault, trending SN-NE, has determined a barrage and the follouring upfloouring of the Ufita Valley near Grottaminarda.

From the Ufita Valley to the Apenninic watershed Gallery

After the Ufita river valley the motor-road runs along the Fiumarella Valley, deeply boxed between clayey and sandy miocenic and pliocenic terranes on the orographic left and oligocenic and miocenic terranes of the Lagonegro Units on the orographic right.

The slopes of the valley are interested by intensive and localized superficial erosion phenomena and by diffused landslides that are very active expecially near the headland.

At the end of the valley, inside the tunnel. the motor-road crosses the superficial watershed which disjoins the Tirrhenian sea tributary basins (Sabato. Calore and Ufita rivers) from the Adriatic sea tributary ones, (Fiumarella and Calaggio streams, Ofanto river).

The Ufita river and Fiumarella stream valleys correspond to recent structures oriented NW-SE.

From the Apenninic watershed to the Apulia Plane

After the tunnel, we enter the Fiumarella valley. This valley correspond to recent oriented SW-NE structures, and is boxed among clayey terranes characterized by intensively eroded areas with widespread landslides.

On the foreground we can see the top of the upsaid peneplaned areas; those on the orographic left are at an elevation of 600 m., while those on the right are displaced at 850 m., by the recent tectogenesis.

Going on along the way, we arrive at the eastern boundary of the chain, where the morphology becomes smoother and smoother when leaving the alloctonous terranes and entering in the autoctonous Pliocene and Quaternary deposits which fill the Bradano Foretrough with a thickness of some thousands m.

Near Candela we can observe afar some surfaces gently inclined towards NE which represent the top of the Pleistocene terranes.

The Calaggio stream valley is carved along the Bagnoli Irpino-torrente Calaggio fault, oriented SW-NE, which has caused a left lateral displacement of more or less 10 Km of the orographic right towards the Bradano Foretrough.

The alloctonous Units of the chain underwent the last important translation towards the Bradano fore through during the middle Pliocene and here they have a complexive thickness of about 4.000 m. They are superimposed to the lower and middle Pliocene Bradano Forethrough terranes.

Near Candela the Apenninic tectonic Units end in the subsurface.

5.2

b. The Lacone and Ofanto Valleys
(from Candela to Spinazzola).

After leaving the eastern Apenninic margin, we enter the "Tavoliere delle Puglie" which is on the Ofanto river orographic left.

At the motor-road sides and nearby the plio-pleistocenic sequence outcrops. Here the section is formed by argillaceous silts and fine-grained sandstones. The rocks constitute a NE dipping monocline. Often the marine deposits are covered by coarse deposits of alluvial facies.

After passing the Ofanto river near Canosa di Puglia, we approch the north-western side of the Murge relief, along which the Cretaceous limestones have been by faults directed NE-SW (antiapenninic) determining a graben structure towards the Ofanto itself valley.

Leaving the motor-road at the Canosa exit, we cross Gravina Calcarenites and "Subapennine Clays", which constitute the part of the marine Bradano forethrough filling (lower Pleistocene).

Along the way to Minervino Murge and afterwards we cross cretaceous outcrops of Bari Limestones Formation (Barremian-Turonian). This formation is made by micritic limestones with an homoclinal structure dipping mainly to S-SW. At 20 th Km. of the 97 Statal Highway we enter again the Bradano Forethrough quaternary terranes, along the Locone stream headland, where a large part of the sequence outcrops (M. Marano Sands, Irsina Conglomerate, Gravina Calcarenite).

The area is characterized by flat reliefs, that are the remnants of the old quaternary cycle regressive surface.

We now go up again the calcareous slope along the narrow Cavone Valley to reach the Spinazzola bauxite mining area. The bauxitic mineralizations of Spinazzola are located near Murgetta Rossa and about 20 main pockets are known. Some of them are very deep and outcrop at both sides of Cavone Valley.

From the bauxite mines area crossing the high part of the Murge platean we go to Castel del Monte, which rises on the adriatic edge of the Murge relief.

From the castle it is possible to have a panoramic view of the wide plateaus parallel to the coast and degrading towards the Adriatic sea, gently dipping to NE.

Somewhere on these planes marine transgressive deposits of the lower Quaternary lay. They are calcareous bioclastic sediments locally called "tufo calcareo", which sometimes have fossilized carsified surfaces which residual "terre rosse" deposits in the cretaceous limestones.

5.2

c. The Murge (from Spinazzola to Locorotondo).

From Castel del Monte we take again the 97 Statal Highway towards Itria Valley and Castellana Caves, through Gravina di Puglia, Altamura, Gioia del Colle, Alberobello, Locorotondo.

Along the way we cross the Altamura limestone (Senonian age) somewhere covered by the ancient Quaternary deposits (Bradano forethrough series).

Near Gravina the first part of the road runs on the regression surface of the Bradano Forethrough sequence and flanks the high Murge cliff, which is controlled by an important NW-SE (Bradano Valley) Fault, Martinis, (1962).

Near Gravina it is possible to see some quarries in the Gravina calcarenite. Here also the deep erosional features interesting the quaternary calcarenites and the underlaing cretaceous substrate ("gravina") is also visible.

Going on to Altamura and Locorotondo we cross the Altamura

Limestone, a bioclastic, more or less coarsely grained limestone with abundant Ippuritides and Radiolitides.

Fig. 16 - View of Murge relief from Spinazzola

5.2

d. Itria Valley and Pirro's Canal

Locorotondo, as well as the other abovementioned villages (Castellana, Noce, Alberobello, Martina Franca) rests on a large NW gently inclined surface which is limited at SW by Fasano-Ostuni coastal cliff.

This area, with flat bottomed incisions ("lame"), shows a clearly karstic morphology with many dolines and poljes that are often filled by earthy deposits. There are also some deep holes, (locally "grave").

Some faults and fractures have controlled this morphologic features (i.e. the Itria Valley and Pirro's Canal).

From Locorotondo we can see a large and very singular landscape: the Murgia dei Trulli. It includes the large karstic depression of the Itria Valley, with NW-SE direction, a diameter of some Km and a depth of about 100 m. below the large plane.

The Valley bottom is rich of vineyards (this is the production area of very good wines(!) i.e. Verdeca) and of the famous Trulli: conical houses.

The other large karstic depression, Pirro's Canal striking EW, extends for 12 Km. On the polje bottom there are many sinkholes which are often masked by eluvial deposits. From Monte Laureto the whole extension of the Pirro's Canal is well observable.

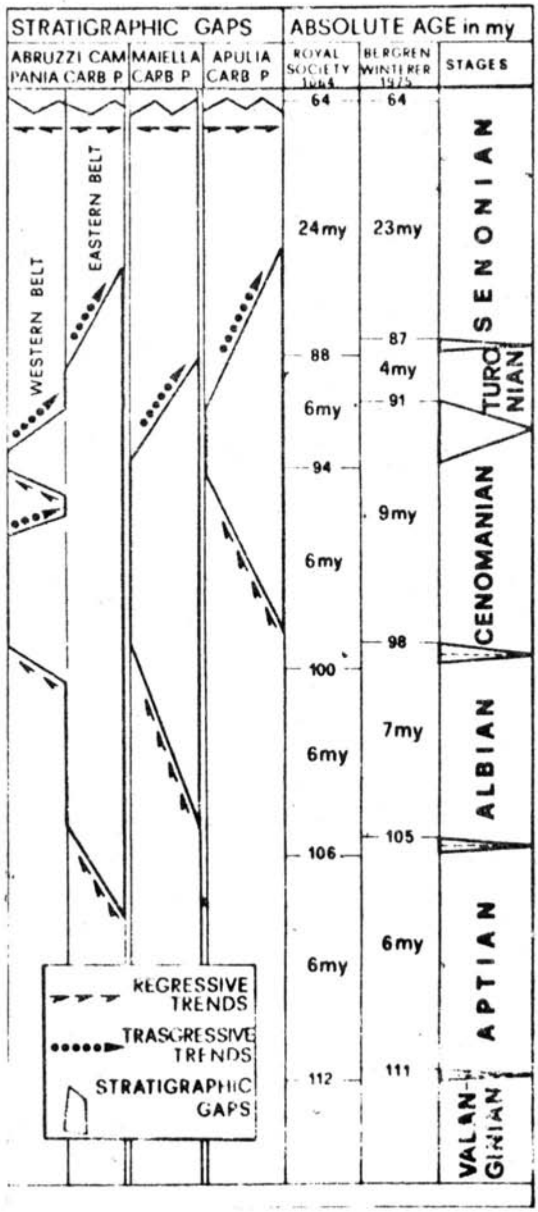


Fig. 17 - Stratigraphic faps in the Southern Italy Cretaceous sequences

5.3 Epigenic Paleokarst in the Murge Cretaceous terrains of Spinazzola.

Paleokarstic phenomena in the createaceous terrains of the Murge have been described by several A.A. (Anelli. 1964: Crescenti e Vighi, 1964; D'Argenio, 1969: Bārdossy et al., 1977; Iannone e Pieri, pre stampa in questo seminario).

These phenomena were developed at the time of the emersion that interested, large ereas of the carbonate platforms during the Cenomanian and part of the Turonian in the Spinazzola's Murge we may observe narrow and deep cavities filled up by bauxites and covered, gently disconformably by the "Calcare di Altamura" (lower Senonian).

These cavities are connected by narrow ducts Locally canyon like depressions have been found; during the bauxite exploitation. The walls of the cavities and of the "canyons" are very steep. The bauxite deposits are 100 to 400 m long, 20 to 80 m wide and 10 to 15 m. thick.

Some cavities are almost 40 m. deep. The karstfication of the bottom is here the most intense among the several deposits of the peninsular Italy. Laterally the bauwites abruptly end.

For the Spinazzola bauxites may be made the same considerations that for those of the Matese Mountains (for informations related to their textural mineralogical and geochimical characters and to their genesis see what has been said before).

The total amount of the bauxites in the Spinazzola area and in northernward area of the Gargano (S. Giovanni Rotondo) is of about 20 millions of tons (Bàrdossy et al.. 1977). Only a part has economic value.

5.4) Castel del Monte

On one of the highest hills of the western Murge chain at 540 meters above sea level and located south of Andria and southwest of Corato, Castel del Monte is considered the masterpiece of Swabian architecture in Southern Italy and an outstanding example of civil construction in the Middle Ages notable for both perfection and originality.

No precise documentation or citations exist which establish an exact date in which the castle was built. In a letter from Gubbio dated the 28 th of february 1240. Frederick II gave Riccardo di Montefuscolo (Giustiziere di Capitanata) the task of providing for the castle's pavement. From this we can deduce the year either that the construction had been completed or that the restauration of the pavingstones was in act.

Surely, Castel del Monte was at the beginning a residence only and not a fortress because there are no remnants of ditchs, draw-bridges or underground constructions, but only a sequence of large and sumptuous rooms. This is confirmed by the document dated 5 th of October. 1240, from Milan, upon which Castel del Monte is not listed among the Bari "Giustizierato" castles acting as fortresses.

Many are the cultural components in the castle's architecture. Structural elements take up technical solutions used for cirsteciense churchs and echos the roman tradition tipical of classicism in Frederick's era are evident in the sculptural decoration. On the other hand. on the origin of the iconography, different hypothesis have been formulated. For example, that the castle was first a roman imperial villa, later used for its elevated location by Longobards and Normans and finally restored by Federico II.

The name of the architect of the castle, called the greatest Swabian civil construction, is unknown even if traditionally the designor is considered to be Federico II himself.

Upon the basis of either historic data or stylistic components, German and French scholars to attribute their fellows with the construction of Castel del Monte, but there is no real proof for their suppositions. On the contrary, it has been ascertained that every measurement of the castle is a multiple or a submultiple of the Napoletan "hands", used in Puglia for a long period, and not at all corresponding to either the German or French foot, which might demostrate that the building was locally designed. Local and foreign workmen seemingly partecipated in the actual construction and decoration of the building, together with Arabian workers, whose possible presence can be deducted from the complexity of the hydraulic system.

The first name of the castle was Castello di Santa Maria del Monte, after a benedectine abbey, famous in the XII century and no longer in existence. The present-day name can be found for the first time in a law of Ferdinando d'Aragona proclamed in 1463 at Altamura.

Federico II lived, perhaps for short periods in the castle, built not for defence but for recreation and hunting meets. In 1249, the marriage of Federico's natural daughter Violanta with Count of Caserta Riccardo, was celebrated. When the Swabian dinasty ended Carlo D'Angiò imprisoned Manfredi's children: Enrico, Federico and Azzolino, here, together with some exponents of the philo-Swabian party.

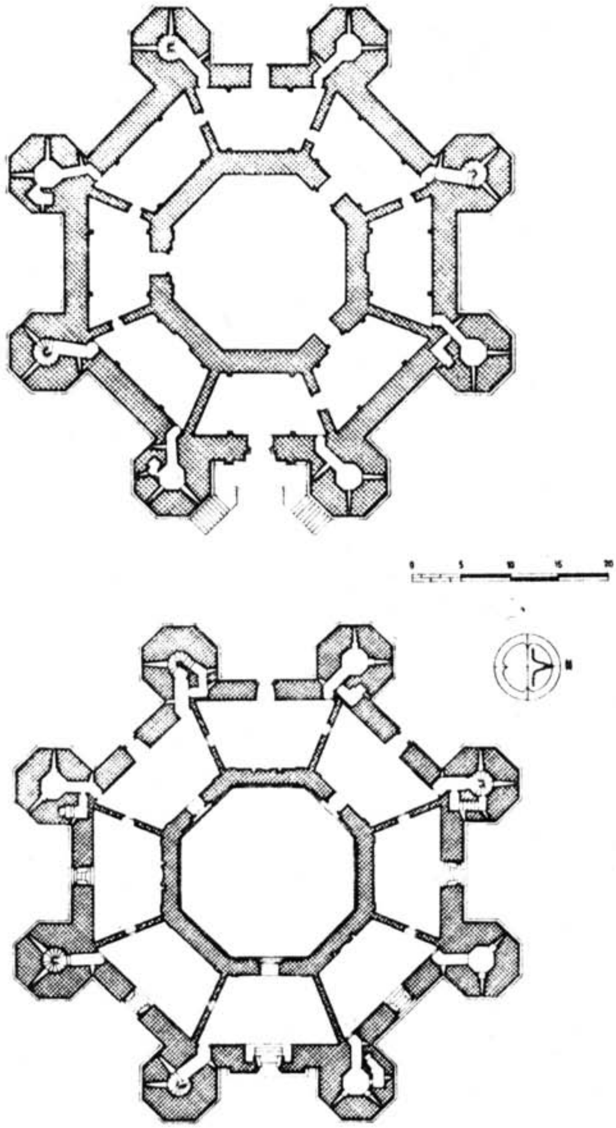
From excavations in the neighbouring area, the castle appears to have been protected by a surrounding wall which was, according to some, threefold and octagonal and according to others, with sixteen sides at 12 meters distance. The form of the castle is a regular octagon to which the internal octagonal yard corresponds. On the external corners there are eight octagonal towers. At half height the deeply broad founded building is surrounded by a frame showing the internal has eight identical rooms, one at each octagonal side.

There are two portals, one at E and there other at W. The main one shows classic and gothic influences but also romanic echoes. On the other six sides at the first floor there are six windows "monofore".

At the second floor there are eight windows (seven "bifore" and one "trifora" in front of Andria). The towers are crossed only by narrow slits ("feritoie") three of them have spiral staircases and the rest contain bothrooms o maintenance with ribbing resting on sculptured mantlepieces and toilets provided with an inventive system of airing and cleaning.

The castle rooms are designed on the basis of isosceles triangles, with cross vaults bordering a center square space. Two pieces of ogival vaults cover the side triangle. The capitels of the piers have been finely sculptured and sculptures with masks or vegetable and animal themes adorn the boss of each cross vault. The internal walls of the rooms were once covered with marble or limestone breccias.

The courtyard repeats the octagonal plan of the building and has eight walls and pointed arches. Doors and windows have been situated without any exact symmetrical order. Three portals open onto the ground floor. Initially there was a marble vat in the courtyard, which today is a cistern collecting the rain waters of the middle drains of the terrace. Outer drains, on the other hand, lead rain waters to the toilets in the turrets.



Castel del Monte - Pianta del Castello

(da De Vita, 1974).

5.5 The Castellana Caves

The Castellana Caves are situated in the upper Cretaceous limestones (Altamura limestone) and show a NW - SE general trend corresponding to the main and more recent tectonic direction.

We can separate three distinct stretches: 1) the first from the entry (la Grave) to "Il Precipizio"; 2) the second from "Il Precipizio" to the "Duomo di Milano" and 3) the third from this last point to the end.

1st strike:
"La Grave", at the entry, is a great cavity aligned along the main tectonic direction. It has been widened by marked gravi-chemioclastic processes accompanied by collapses (chiefly in the north-eastern wall). Due to these processes the vault has cut the external surface. From here on, the cavity has an interstrate section with records of chemioclastic action.

The west branch shows, on the contrary, a typical diaclasic section along which a number of vertical ortovacua formed. Successively these were unified by a collateral parabasal association. The north-east branch has a more marked diaclasic section, with two contrasting walls: the upstream one very rich in stalactites, the downstream one very poor and marked more by faults.

Quite interesting is "Il Precipizio", a cavity with marks of collapse. The lower level derive from a series of passages successively widened due to many wells caused by ortovacua strongly developed in a downward direction.

2nd strike:
Typical here are diaclasic sections while concretions are poor, and from place to place some marks of collapse can be found. Frequent are also the composite sections with interstrate characters in the lower part and diaclasic characters in the upper one.

The last part shows more or less the same characters of the entry. Here the chemioclastic and collapse featuring vere favoured by a pattern of diaclases according to two systems. The younger, which is the principal system, has already been described while the older one is aligned along a NS-EW direction.

3nd strike:
The pattern of diaclases controls also this 3nd strike, particularly at the end (between "La Cupola" and "La Grotta Bianca") where there are many concretions. In the west branch ("La Voragine") a series of vertical orto-vacua gave origin to the lower level.

From the point of view of the genesis, the cave seem the result of the influence of the tectonic system already mentioned. Probably the great interstrate cavities began to form on both two levels during the first tectonic stage when the water table was very near.

In a later period, its deepening caused either the vertical development of ortovacua, or the fusion of the formed cavities in a complex.

The persisting situation of the water table favoured the chemioclastic morphology and formation of the great concretions wherever it was possible.

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