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THE STRATIGRAPHIC RECORD OF NEOGENE EVENTS IN THE TIRANA DEPRESSION

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Riassunto. La Depressione di Tirana é situata nella parte orientale e interna della Depressione Periadriatica. Essa forma un elemento strutturale allungato per circa 60 km in direzione NW-SE, tra il fronte delle strutture dinariche ovest-vergenti e l'allineamento costituito dall'anticlinale di Paper Rova e dalla monoclinale di Preze, sviluppato con vergenza opposta ed agente come retroscorrimento fino ad un'età post-pliocenica.

Sono state studiate alcune significative sezioni stratigrafiche, soprattutto nel settore a sud di Tirana, sui fianchi orientale ed occidentale di un'ampia sinclinale. Le sezioni sono state correlate con elementi fisici e micropaleontologici, dati in particolare da livelli-guida, superfici di discontinuità e contenuto in foraminiferi planctonici.

Come livelli-guida sono stati presi in particolare considerazione due orizzonti calcarei a Lithothamni datati rispettivamente alla parte superiore del Langhiano e al Serravalliano. Si é rivelata particolarmente utile la presenza di peliti a Foraminiferi planctonici di età Serravalliano superiore - Tortoniano. Superfici di discontinuità collocate alla base dei due orizzonti calcarei a Lithothamni e datate al Langhiano ed al Serravalliano sono state ritenute di importanza regionale.

La successione della Depressione di Tirana mostra sedimenti di mare profondo limitatamente agli intervalli Oligocene-Miocene inferiore e Serravalliano superiore-Tortoniano p.p., presenti soprattutto al margine occidentale della stessa; per il resto sedimenti continentali e di acque basse sono largamente prevalenti. Essa é stata confrontata con la successione langhiano-tortoniana della omoclinale di Preze, ritenuta riferibile alla Depressione Periadriatica rispetto alla quale la Depressione di Tirana mostrerebbe una differente evoluzione. Infatti: durante il tardo Oligocene-Aquitaniano essa può essere considerata una piattaforma stretta e instabile sviluppata al margine orientale dell'avanfossa periadriatica; nel Burdigaliano-Serravalliano inferiore é ritenuta una depressione sviluppata alla sommità del settore frontale dei thrusts dinarici; successivamente, sino al Tortoniano, potrebbe aver rappresentato la zona di avanpaese al fronte dei retroscorrimenti la cui enucleazione si protrae anche in età post-pliocenica.

Abstract. The Tirana Depression is located in the eastern and inner part of the Periadriatic Depression. It forms an elongated NW-SE oriented structural element, 60 km in length, located between the front of west-verging Dinaric structures and the east-verging Paper Rova anticline-Preze homocline alignment, which acted as a back-thrust till post-Pliocene age. Some significant stratigraphic sections were examined mainly south of Tirana on the eastern and western limbs of a wide syncline. Physical and micropaleontological data, including marker levels, unconformities and planktonic foraminifera content were used to correlate the sections.

Two Lithothamnium levels, uppermost Langhian and Serravallian, were used as markers. The generalized occurrence of planktonic Foraminifera-bearing mudstones,uppermost Serravallian-Tortonian in age, is interpreted as significant. The Langhian and Serravallian unconformities, recognizable at the base of the Lithothamnium limestone levels, are thought to be of regional importance.

Continental and shallow marine sediments are largely prevailing.Deep-marine sediments are limited to the Oligocene-earliest Miocene and Serravallian-Tortonian p.p., and crop out only along the western margin of the Tirana Depression. The sequence was compared with the Langhian-Tortonian foredeep succession of the Preze homocline, which belongs to the Periadriatic Depression. The Tirana Depression differs from the Periadriatic Depression in the following developmental steps:
- during the late Oligocene-Aquitanian it can be considered as a narrow unstable shelf, probably forming the eastern margin of the foredeep;
- during Burdigalian-early Serravallian time, it behaved as a "thrust sheet top basin", related to the front of west-verging Dinaric thrusts;
- during the Serravallian-Tortonian it played the role of foreland zone of the backthrust, whose ultimate enucleation is post-Pliocene in age.

Introduction.

The Neogene succession of the Tirana Depression was studied as a collaborative project between Fakulteti Gjeologji-Miniera (Universiteti Politeknik, Tirana, Albania) and the Earth Sciences Department of the University of Milano. Research focused on the stratigraphy and structural evolution of sequences in the Tirana Depression, located at the front of the west-verging Dinaric thrust belt (Fig. 1).

The Tirana Depression is situated at the north-eastern side of the wider Periadriatic Depression which, according to Shehu et al. (1981), is made up of a Miocene and Pliocene "Molasse" succession, unconformably overlying Ionic zone deposits and, in the Tirana area, Kruja zone deposits.The succession of the Tirana Depression is reported as Aquitanian - Burdigalian - Helvetian - Tortonian in age on the western side of the De-

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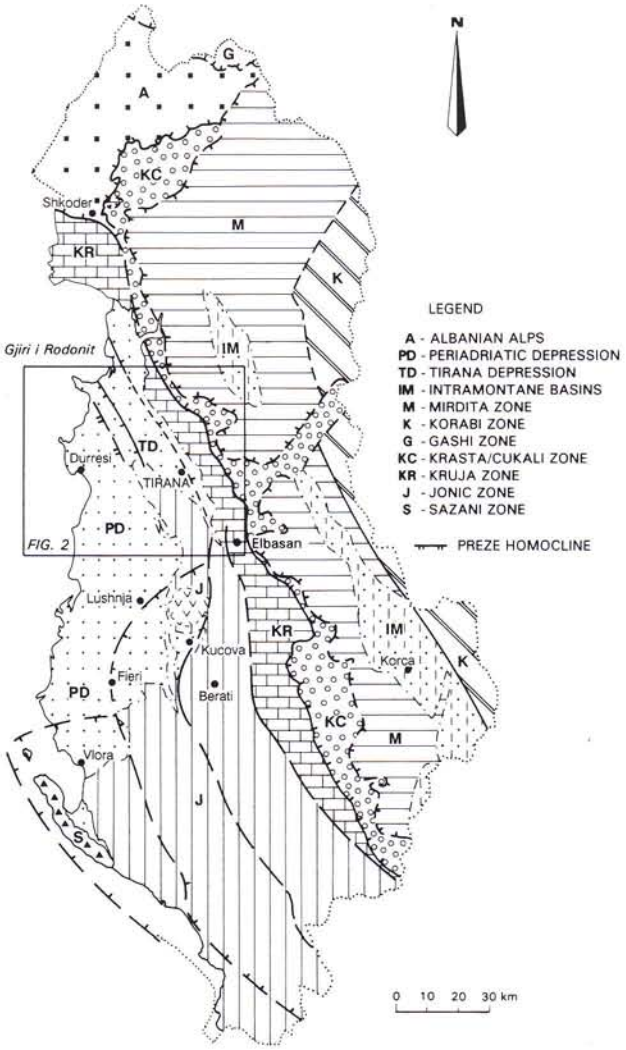


Fig. 1 - Schematic structural sketch map of Albania (drafted in the Faculty of Geology and Mining - Tirana).

pression, while Tortonian only on the eastern side (1:200,000 Geological Map of Albania; Harta Gjelogjike e RPS të Shqipërisë-H.G.RPS S., 1983). On the western side the succession lies in continuity over Oligocene deposits and shows unconformities between Aquitanian and Burdigalian deposits and at the base of the Tortonian. On the eastern side Tortonian sediments unconformably overlie Oligocene and Cretaceous deposits. This chronostratigraphic distinction is based on unpublished data or local reviews by Albanian researchers from several institutions (Faculty of Geology, Academy of Science, Petroleum Institute of Fier), using both field and subsurface data.

In the early nineties Albanian researchers began, along with foreign colleagues, a detailed review, introducing new stratigraphic analytical methods. Two papers, by Sorel et al. (1992) and Guri et al. (1995), are of particular importance. Sorel et al. (1992) proposed a chronostratigraphic subdvision, based on planktonic Foraminifera, of the whole Neogene succession of the External

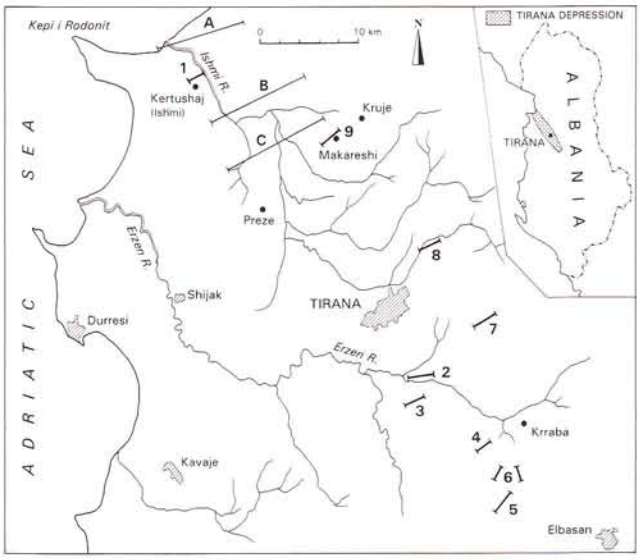


Fig. 2 - Location of the stratigraphic sections: 1, Kertushai; 2, Mulleti; 3, K. Varoshit-Petrela, K. Petreles; 4, Mihajas-Cirma; 5, Pajenga; 6, Mamli-Gracenit; 7, Priska; 8, Brari; 9, Makareshi. A, B, C: location of seismic sections. (see H.G.RPS S., 1983).

Hellenides. As far as Albanian territory is concerned, they take into account some sections in the southern part of the Periadriatic Depression, showing a Serravallian-Messinian Molasse succession unconformably overlying the deformed "Langhian" (*bisphericus* zone) Flysch. Guri et al. (1995) gave a complete geological outline of the Periadriatic Foredeep on the basis of subsurface data mainly from the offshore zone. They first subdivided the Neogene succession in depositional sequences and discussed the post-Serravallian facies in detail. A prevailing turbidite sedimentation in a basin floor fan and slope fan setting was outlined during the Serravallian and Tortonian.

The initial results of the Italo-Albanian collaboration (Diamanti et al., 1994) pointed out the need for a better understanding of the lateral and vertical relations between the depositional systems recognized in different parts of the Tirana Depression. For this purpose further stratigraphic sections were studied and sampled for micropaleontological analysis based on planktonic Foraminifera. This work, while not exhaustive, provides the groundwork for further research in other districts of the Periadriatic Depression.

The stratigraphic succession

The stratigraphic succession of the Tirana Depression was studied mainly south of Tirana toward Elbasan, where the best exposures are available (Fig. 2). As detailed later, this succession forms a wide syncline on whose limbs the most significant sections are exposed.

Fig. 3 - Correlation scheme.

On the eastern limb a mostly continental to shallow marine succession crops out. This succession was studied in the Brari valley, in the Priska zone east of Tirana and in the Makareshi (Kruja) area about 20 km to the north. On the western limb a prevailing marine succession crops out. The best exposures may be seen between Pajenga and Mulleti. At the southeastern closure of the syncline, in the Mamli-Gracenit area, a reddish fluvio-deltaic conglomeratic body, presumably Serravallian in age, attains maximum thickness.

The successions were correlated through physical and micropaleontological data, using specific marker levels, unconformities and planktonic Foraminifera content. Two Lithothamnium limestone levels, dated to uppermost Langhian and Serravallian respectively, were used as marker levels. The widespread occurrence of planktonic Foraminifera-bearing mudstones, uppermost Serravallian - Tortonian in age, is considered significant. The Langhian and Serravallian unconformities, recognizable at the base of the Lithothamnium limestone levels, are thought to be of regional importance.

The features discussed above allow recognition of the following stratigraphic units in the Neogene succession of the Tirana Depression (Fig. 3):

- Aquitanian-Langhian terrigenous succession
- "Lithothamnium limestone 1"
- Serravallian terrigenous succession
- "Lithothamnium limestone 2"
- Serravallian-Tortonian mudstone succession
- Tortonian sandstone unit.

The succession of the Tirana Depression was compared with the deep marine succession of the Preze homocline, a structural feature at the eastern margin of the Tirana Depression, in the direction of Kepi i Rodonit. The comparison was based on a good resolution of the planktonic Foraminifera and on interpretation of the conspicuous mass-resedimented levels.

The Aquitanian-Langhian terrigenous succession.

The Aquitanian-Langhian succession shows a different evolution at the opposite margins of the Depression: at the western margin it appears to overlie the Oligocene turbidites (Pg 2-3, H.G.RPS S., 1983) in stratigraphical continuity, while at the eastern margin it unconformably overlies the deformed Cretaceous-Paleogene substratum. The top of the Aquitanian-Langhian succession is marked by an unconformity.

a) The Aquitanian-Langhian succession at the western margin.

Between Pajenga and Petrele (14 km distance) three stratigraphic sections were analyzed.

Pajenga section. The Pajenga section is exposed at the Pajenga village in a SW-NE orientation between a height of 558 m and the Tirana-Elbasan road. The basal deposits (Oligocene Flysch) consist of lenticular-bedded turbidite sandstones, in beds 5-30 cm thick with a 1:5 sand to mud ratio. Fining upward conglomerates in metric lenticular bodies with an erosional base are intercalated. Three lithozones may be recognized above the Oligocene deposits. The lower and the middle zones display a regressive trend, while the upper zone records a transgressive trend.

Lithozone 1:

1) Locally burrowed gray silty mudstone with intercalated rippled sandstone beds 5-6 cm thick (30 m);

2) Thin-bedded turbiditic sandstones with hemipelagic mudstones (50 m);

3) Homogeneous grey mudstones with marl-silt intraformational hard blocks. Locally narrow scars are recognizable (50 m);

4) Thin-bedded mud/sandstone turbidites forming plurimetric levels, intercalated to mudstones and homogeneous silty mudstones, with pebbly mudstones in the upper part (140 m).

Lithozone 2:

5) Bioclastic sandstones and siltstones forming thickening and coarsening-upward cycles, 1-2 m thick (23 m);

6) Massive bioclastic sandstones forming amalgamated beds 60-70 cm thick (35 m).

Lithozone 3:

7) Fossiliferous and burrowed silty mudstones, grading upward to bioclastic sandstones in thickening upward beds (Fig. 4). They form plurimetric cycles with the mud percentage increasing upward (120 m).

At the top of the section, the unconformable boundary with the overlying Lithothamnium Limestone 1 is exposed.

Significant micropaleontological data were collected in lithozone 1 and in the upper part of lithozone 3.

- Lithozone 1 (sample PA9): *Globigerinoides immaturus, Globigerinoides primordius, Globoquadrina praedehiscens, Globoquadrina dehiscens, Globoquadrina venezuelana, Globigerina tripartita tripartita, Globoquadrina rohri, Globorotalia opima nana.* This assemblage may be ascribed to the *Globoquadrina dehiscens dehiscens* Subzone (Iaccarino, 1985), hence to the upper Aquitanian.

- The upper part of lithozone 1 may be dated as Burdigalian starting at sample PA10, which records the first occurrence of *Globigerinoides altiaperturus.* In more detail (sample PA14) the assemblage of *Globigerinoides trilobus, Globigerinoides bisphericus, Globigerinoides sacculifer, Globorotalia* gr. *mayeri, Globoquadrina dehiscens* may be ascribed to the *Globigerinoides trilobus* Zone (Iaccarino, 1985).

- The upper part of lithozone 3 is Langhian in age, due to the occurence of *Orbulina suturalis, Praeorbulina glomerosa* s.l., *Globigerinoides bisphericus, Globigerinoides quadrilobatus, Globigerinoides trilobus, Globorotalia scitula* (*Orbulina suturalis* Subzone, Iaccarino 1985) in sample MAM5.

Mihajas-Cirma section. This section is exposed at Mihajas-Cirma, southwest of Krraba, between K. Qorraj (height 617.0 m) and m. Qelit (height 722.6 m). The examined exposures form the NW-SE oriented cliff along the mule track to Mihajas-Cirma (Qorraj). This section extends over 90 m under "Lithothamnium limestone 1" and may be compared to the upper part of the Pajenga section, located 7 km southeast of Mihajas-Cirma.

The Mihajas-Cirma section is made up of fossiliferous sandy marls and massive bioclastic sandstones, forming plurimetric bed packages and locally coarsening

Fig. 4 - Pajenga section: mudstone-sandstone cycles of the lithozone 3.

and thickening upward cycles. Along the mule track a scar 8 m deep may be observed for a distance of about 35 m, although the true extent is at least twice this value. The scar is filled with burrowed sandstones in beds 10-50 cm thick. Slumped beds 1 m in total thickness and a 0.50 m thick coral-bearing reworked level containing a sand matrix, may be recognized in the deepest part of the scar (Fig. 5).

Petrela sections. Two different sections, believed tectonically detached, were studied in the Petrela zone: the Kodra Varoshit-Petrela and K. Petreles sections, 7 km northwest of Mihajas-Cirma (Fig. 6).

The Kodra Varoshit-Petrela section is exposed from the southeastern slope of Varoshit to the Petrela castle, along the ravine near Zaranides. This section is about 400 m thick. The Aquitanian-Burdigalian succession overlies the Oligocene Flysch (Pg 2-3) in stratigraphical continuity. The topmost unit of the section is the conglomeratic body outcropping below the castle (Fig. 7).

Grey homogeneous mudstones and thin-bedded turbidite sandstones prevail. Disorganized conglomerates in lenticular beds up to 6 m thick, pebbly mudstones and breccias with biocalcarenitic intrabasinal clasts are intercalated. A sandstone and conglomerate body at least 15 m thick, with an erosional base, crops out at the bottom of the valley, near some houses. At least 5 levels may be recognized within this body. They are made up of coarse-medium sandstones, locally normally graded, forming amalgamated beds more than 1 m thick, and disorganized conglomerates with mudstone blocks and an erosional base, up to 4 m in thickness.

The whole Kodra Varoshit-Petrela succession shows slope facies, similar to lithozone 1 of the Pajenga

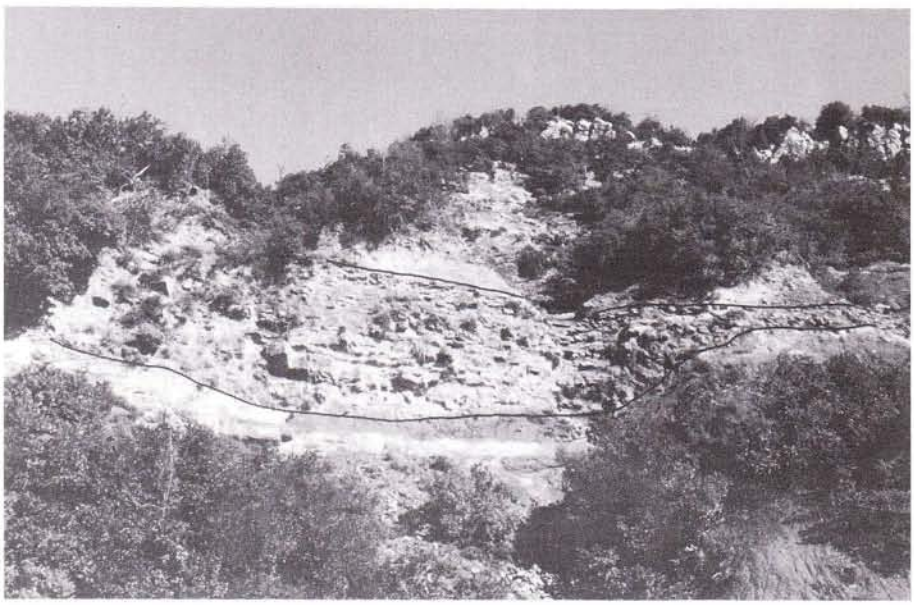


Fig. 5 - Mihajas-Cirma section: burrowed sandstones filling a scar at least 8 m deep.

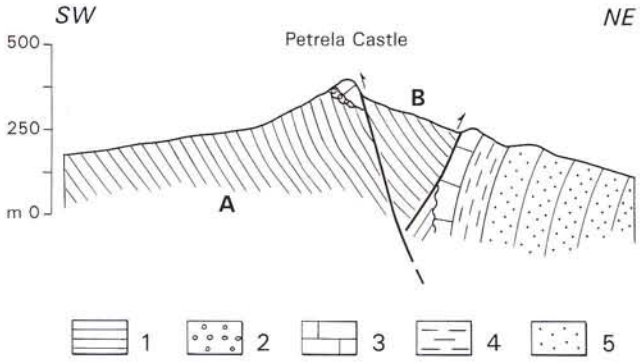


Fig. 6 - Assumed structural relationships between K.Varoshit-Petrela section (A) and K.Petreles section (B). 1, lower Miocene mudstones and thin bedded turbidites; 2, conglomerate body of the Petrela castle; 3, "Lithothamnium limestone 2"; 4, Serravallian-Tortonian mudstone succession; 5, Tortonian sandstone unit.

section. At the top the succession is unconformably overlain by the conglomeratic body outcropping below the castle. The boundary, which is presumably erosional, is hidden by detrital cover.

The K. Petreles section is exposed upstream of Petrela, on the southwestern slope of K. Petreles. This succession seems tectonically bounded with respect to the castle body and to "Lithothamnium limestone 2", which forms the top of the K. Petreles cliff. The K. Petreles section is at least 150 m thick and shows the alternations of plurimetric packages of:

- mudstones and thin-bedded turbidite sandstones, faintly graded and mostly cross-laminated;
- pebbly mudstones with subrounded intraformational clasts of silty marls, up to 1 m in size, and locally slumped thin-bedded silty marls (Fig. 8).

Both Petrela sections are thought to be made up of slope sediments, with frequent and conspicuous reworked levels. The sections provide good planktonic Foraminifera data.

The lower part of the Kodra Varoshit-Petrela section (samples VAR1 and VAR2) is considered Aquitanian in age, due to the presence of *Globorotalia kugleri, Globorotalia opima nana, Globoquadrina dehiscens, Globoquadrina praedehiscens, Globigerinoides primordius, Catapsydrax dissimilis, Globigerina ciperoensis* (*Globoquadrina dehiscens dehiscens* Subzone, Iaccarino 1985).

The upper part of the Kodra Varoshit-Petrela section (sample VAR6) is upper Burdigalian in age, because it contains *Globoquadrina dehiscens, Globigerinoides bisphericus, Globigerinoides trilobus, Globigerinoides immaturus* (*Globigerinoides trilobus* Zone, Iaccarino 1985).

Samples CAS1-CAS7 from the K.Petreles section contain basically similar assemblages. They are characterized by *Globigerinoides trilobus, Globigerinoides altiaperturus, Globigerinoides sacculifer*, and frequently *Globigerinoides bisphericus, Globoquadrina dehiscens, Paragloborotalia mayeri, Paragloborotalia siakensis* while *Catapsydrax is* lacking. Similar assemblages are recorded in three samples from isolated outcrops, which seem to overlie the Lithothamnium limestone northeast of the castle. These assemblages may be ascribed to the *Globigerinoides trilobus* Zone (Iaccarino 1985), hence to upper Burdigalian.

a) The Aquitanian-Langhian succession at the eastern margin.

The Aquitanian-Langhian succession was studied in the Priska and Brari areas at the eastern margin of the Tirana Depression where it overlies the Dinaric Cretaceous-Paleogene substratum of the Kruja Zone. In this region the Aquitanian-Langhian succession is basically made up of coastal sediments with frequent fluvio-del-

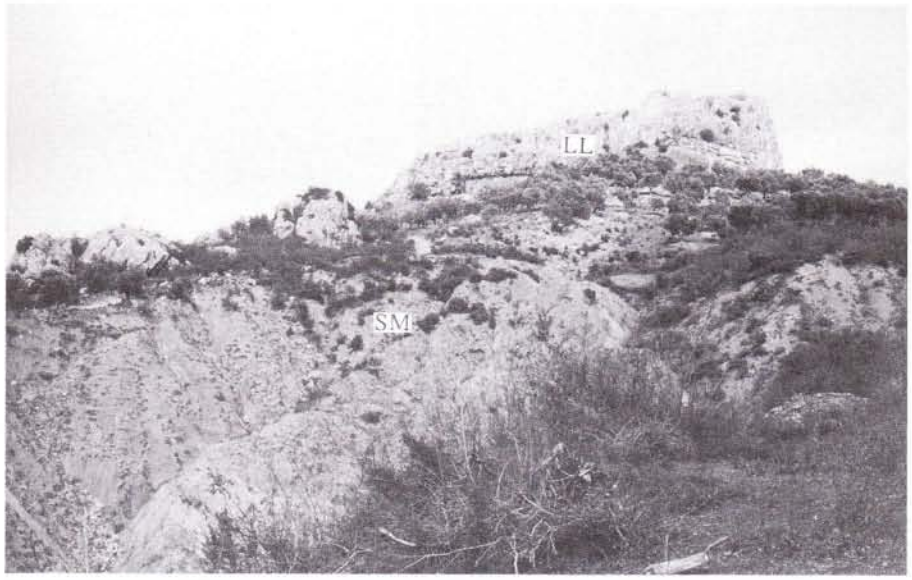


Fig. 7 - Slope mudstone (SM) of Petrela section unconformably underlying the Lithothamnium limestone (LL) of Petrela castle.

Fig. 8 - K.Petreles section: a pebbly mudstone level (PM) alternating to hemipelagic mudstones (HM).

taic deposition. The only data available as chronostratigraphic reference come from the basal part of the Brari section (sample BRA0), where a thin and discontinuous grey mudstone level records the occurrence of *Globigerinoides trilobus* and *Catapsydrax dissimilis*, indicating a late Aquitanian - early Burdigalian age (*Globoquadrina dehiscens - Catapsydrax dissimilis* Zone, Iaccarino 1985). "Lithothamnium limestone 1", bounding the top of the Aquitanian-Langhian succession, is considered a good lithostratigraphic marker.

Fluvio-deltaic facies are clearly exposed at the Priska section, where they are about 40 m thick. These sediments are conglomerates and sandy conglomerates, faintly bedded, with an erosional base and normal or inverse rough grading, locally forming festoon-bedded lenses. Reddish burrowed mudstones are intercalated.

The overlying coastal facies at Priska are massive burrowed and fossiliferous sandstones (Ostreidae, Pectinidae, balanids, *Turritella*, Echinoida, corals in living position), with a maximum thickness of 10 m. At Brari these deposits form the whole succession, about 30 m thick, as follows:

- basal sandy conglomerate bed, with *Turritella* and concretions (1 m);
- burrowed sandstone beds with irregular base, locally cross-bedded conglomerates and silty mudstones in decimetric beds (10 m);
- plane and parallel bedded conglomerates with well-sorted and subrounded pebbles, up to 5 cm in size (3 m);
- conglomeratic sandstones with frequent bivalves, Echinoida (*Scutella*) in living position (3 m);
- massive fossiliferous sandstones (mainly Ostreidae), with minor lenticular intercalations of conglomerates in the lower part (12 m).

"Lithothamnium limestone 1".

Lithothamnium Limestone 1 crops out in the eastern and southwestern parts of the Tirana Depression, displaying a maximum thickness of 30 m in the Brari valley. "Lithothamnium limestone 1" is made up of *Lithothamnium- Lithophyllum*-bearing rudstone/boundstone with bivalves (Pectinidae, Ostreidae), bryozoans and benthonic Foraminifera. A decrease in thickness, mainly by erosion, is frequently associated with an increase of the rudite fraction, with well-rounded extraclasts. Conglomerates prevail in the upper part, frequently forming the whole level.

The base of "Lithothamnium limestone 1" is marked by an unconformity, which is a mild angular unconformity in the southwestern areas.

"Lithothamnium limestone 1" is overlain by Serravallian deposits at Brari (BRA3,4,5) and overlays Langhian sediments at Pajenga (MAM5), thus indicating an upper Langhian - lower Serravallian age.

In our opinion "Lithothamnium limestone 1" may be interpreted as foramol-type carbonate platform sediments, typical of temperate areas and similar to the middle Miocene carbonate platforms of the Southern Apennines (Simone & Carannante, 1988).

The conglomerate body of the Petrela castle.

The conglomerates cropping out at the Petrela castle form a lenticular body, showing maximum thickness at the base of the western slope of the cliff on which the castle stands.

The conglomerate body unconformably overlies the Burdigalian succession of Kodra Varoshit-Petrela and is overlain by a lenticular level of Lithothamnium limestone (Fig. 9). This level, which may be ascribed to "Lithothamnium limestone 2", is 20 m thick and 400 m wide with a NW-SE orientation.

The following succession may be recognized (bottom to top) within the conglomerate body of the Petrela castle (Fig. 10):

a) massive and roughly graded polygenic conglomerates, with oversize blocks at the base and pebbles/cobbles (maximally 10 cm in

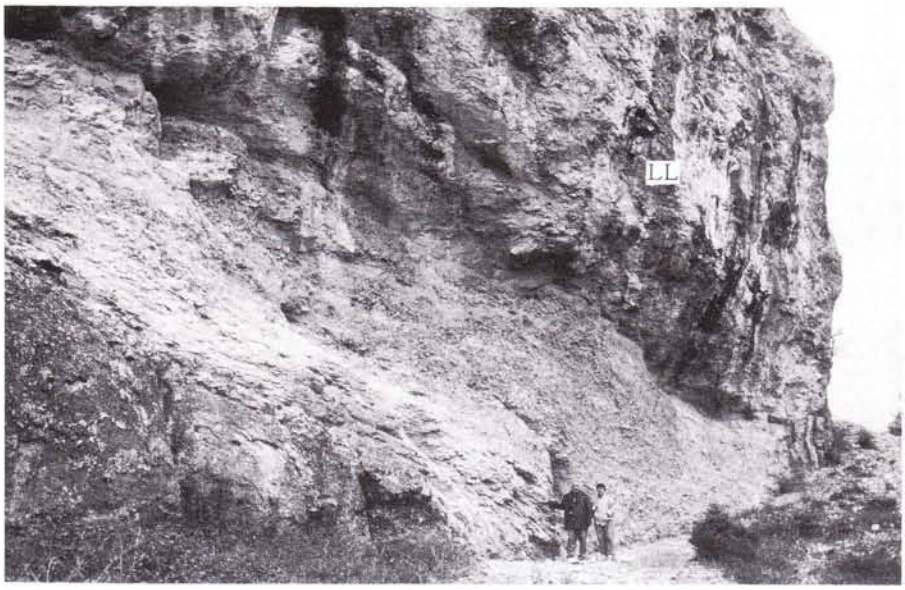


Fig. 9 - Conglomeratic body of Petrela castle underlying the Lithothamnium limestones (LL).

size), showing lithofagous borings locally, in a sand matrix (12 m);

b) biocalcarenites with heterogeneous well-rounded clasts, of Lithothamnium limestone as well (1.8 m);

c) matrix-supported conglomerates (4 m) with flat pebbles frequently made of Lithothamnium limestone, with imbrications indicating paleocurrents from 120°, capped by a single biocalcarenite bed 0.3 m thick;

d) conglomerates, with a biocalcarenite matrix (0.3 m).

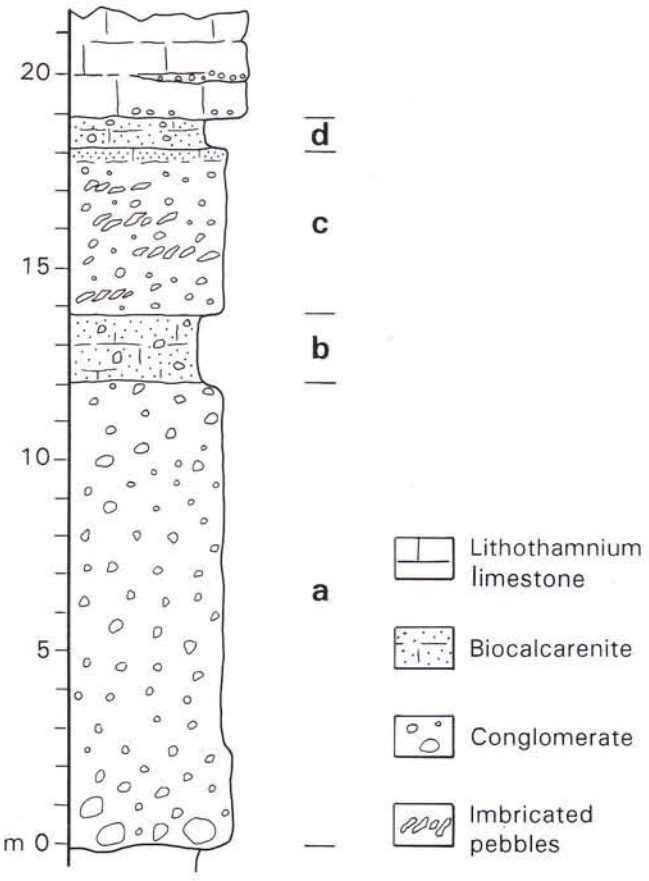


Fig. 10 - Stratigraphic succession of the conglomeratic body of Petrela castle.

The Serravallian terrigenous succession.

The Serravallian terrigenous succession is exposed in the eastern and southwestern sectors of the Tirana Depression where it is clearly defined (except at Mamli), and is bounded by "Lithothamnium limestone 1 and 2". The Serravallian terrigenous succession shows mainly shallow-marine and fluvio-deltaic facies. From Pajenga to the northwest, on the eastern side of the basin, its thickness progressively decreases so that the unit is not present in the Petrela area.

The Serravallian terrigenous succession was studied at Brari, Priska, Mamli and Mihajas-Cirma.

Brari section. The Brari section may be split into two parts.

The lower part, 21 m thick, is made up of fossiliferous (Pectinidae mainly) and strongly burrowed sandstones, alternated with fossiliferous grey silty marls, displaying three different levels increasing in thickness upward.

The upper part, 50 m thick, is made up of fossiliferous rippled sandstones with roundish concretions, in beds up to 30-40 cm thick, cyclically alternated with sandstones in a mud matrix.

This lithofacies organization suggests that sedimentation started in a coastal environment which evolved to deeper-water conditions and eventually returned to a shallow-water facies.

The micropaleontological content of samples from the marl levels in the lower part of the succession (BRA3, BRA4, BRA5) indicate at least a middle Serravallian age. The assemblage contains *Orbulina universa, Orbulina suturalis, Orbulina bilobata, Praeorbulina glomerosa, Globigerinoides trilobus, Globigerinoides sacculifer, Globigerinoides subquadratus, Dentoglobigerina altispi-*

Fig. 11 - Mamli section: the Serravallian fluvio-deltaic succession (FD) overlying "Lithothamnium limestone 1" (LL) and uppermost Burdigalian-Langhian shelf mudstone (SH).

ra, Globorotalia gr. *menardii*, and may be ascribed to the *Globorotalia siakensis* Zone (Iaccarino, 1985).

Priska section. This part of the Priska section is exposed at 500 m altitude, on the western slope of M. Daiti, between the bauxite and Sorel mines. The section, bounded by "Lithothamnium limestone 1 and 2" shows a reduced thickness (7.5 m) and is made up of massive sandstones with roundish and layered concretions, lacking significant sedimentary structures.

The underlying "Lithothamnium limestone 1" is intensively reworked, with frequent extrabasinal clasts.

Two parts also may be distinguished in the Mamli and Mihajas-Cirma sections: a lower conglomerate-sandstone unit, interpreted as fluvio-deltaic facies, and a prevailing brackish-water mudstone upper unit.

Mihajas-Cirma section. The Mihajas-Cirma section is well defined, being bounded by "Lithothamnium limestone 1" at the bottom and "Lithothamnium limestone 2" at the top. This section is exposed along the Tirana-Elbasan road from the Mihajas-Cirma junction toward m. Qetit (722.6 m). From the bottom the following units may be recognized:

- red polygenic, fining upward conglomerates, , forming lenticular bodies with an erosional base, amalgamated in the lower part and better defined upward, where red mudstones showing evidence of paleosol are intercalated; red sands at the top (80 m);
- fossiliferous sand and sandy conglomerate beds; fossiliferous sandstone beds are intercalated (8 m);
- grey and locally red mudstones; in the upper part a coal layer (0.5 m) and at least two Oyster-bearing levels are intercalated (15 m).

Mamli section. The Mamli section crops out between the village and the m.Kulla - Gracenit ridge (Fig. 11). At Mamli the lower part of the section shows reddish conglomerates and sandstones forming lenticular and channeled plurimetric bodies, in a fining-upward trend, with red mudstones showing evidence of paleosol at the top (over 150 m).

On the western slope of m. Kulla and Gracenit the upper mudstone part, 28 m-thick, is exposed. Mudstones are grey and locally reddish. Coal lenses, frequently reworked, and a basal Oyster-bearing bed 0.4 m-thick are present.

A planktonic Foraminifera assemblage (*Globoquadrina dehiscens, Globigerinoides bollii, Paragloborotalia continuosa)* was observed at the base of the mudstones (MAM8):. The occurrence of *Globigerinoides bollii* suggests a middle Serravalian age (sensu Iaccarino 1985).

Discussion.

The continuity of "Lithothamnium limestone 1" is broken by lenticular conglomerate bodies with extrabasinal clasts. Conglomerate facies are very frequent at the top of "Lithothamnium limestone 1".

The conglomerate body of the Petrela castle seems to be strictly limited to an erosional depression and may be subdivided into two parts: a roughly graded lower part (a) and a predominantly matrix-supported biocalcarenite upper part (b, c, d). Its texture suggests the occurrence of debris flow processes. Reworking from coastal areas may be indicated by the abundance of Lithothamnium limestone pebbles, a biocalcarenite matrix, and occurrence of lithofagous borings in the pebbles. Hence the conglomerate body is supposed to have been formed by reworking of "Lithothamnium limestone 1" and of the associated extrabasinal conglomerates.

At Mamli and Mihajas-Cirma the fluvio-deltaic conglomerates underlie shallow-marine fossiliferous

sandstones. This boundary may be interpreted as a transgressive surface, which is correlated to the base of the sandstone level overlying "Lithothamnium limestone 1" at Brari and Priska.

The mudstone upper lithozones of the Mamli and Mihajas-Cirma sections are correlated and show a lagoonal setting upon the previous fluvio-deltaic depositional system. They also may be correlated to the mudstones observed in the Brari section in the upper part of the lower lithozone, marking a transgressive trend from the local shelf conditions.

The top of the Serravallian terrigenous succession is clearly bounded by "Lithothamnium limestone 2" at Brari and Priska. Evident in more detail at Priska, the considerable decrease in thickness of the underlying sandstone succession suggests that the base of "Lithothamnium limestone 2" is an erosional surface. The same interpretation is possible at Mihajas-Cirma, at the boundary with fossiliferous conglomerates including Lithothamnium limestone clasts.

"Lithothamnium limestone 2".

"Lithothamnium limestone 2" is widely exposed in the Tirana Depression and is mainly made up by *Lithothamnium- Lithophyllum*-bearing rudstone/boundstone, with abundant bivalves.

In the eastern areas "Lithothamnium limestone 2" is up to 90-100 m thick between Priska and Brari, while in the west between Petrela and Mulleti, a 7-40 m thickness may be estimated, not excluding tectonic elisions.

At the southeastern margin of the studied area "Lithothamnium limestone 2" is progressively less identifiable. At Mihajas-Cirma only a 5.5 m thick level may be observed, made up of (bottom to top):

- Ostreidae-bearing conglomerates and sandy conglomerates (1 m);
- Gastropoda- and Ostreidae-bearing reddish sandstones (2 m);
- *Lithothamnium*- and Ostreidae-bearing conglomerates (1 m);
- fossiliferous reddish sandstones (1.50 m).

In the Mamli section the Oyster-bearing sandstones overlying brackish-water mudstones (m. Kulla-Gracenit) occur in the same stratigraphic position of "Lithothamnium limestone 2".

The Serravallian age of "Lithothamnium limestone 2" is suggested by the planktonic Foraminifera assemblages observed in fine-grained deposits at the bottom (Brari) and at the top (Mamli, Mihajas-Cirma).

Like "Lithothamnium limestone 1", "Lithothamnium limestone 2" is intrepreted as a foramol-type carbonate platform.

The Serravallian-Tortonian mudstone succession.

The Serravallian-Tortonian mudstone succession overlies Lithothamnium Limestone 2 and is overlain by a thick sandstone unit (N2-1t,H.G.RPS S., 1983). The Serravallian-Tortonian mudstone succession is exposed at the eastern and western margins of the studied area, where it shows different features.

The Serravallian-Tortonian mudstone succession at the western margin

The studied sections are exposed in the Mulleti-Petrela and Mihajas-Cirma areas (Fig. 12).

a) Between Mulleti and Stermasi, in a abandoned quarry on the right bank of the Erzen river, the following levels may be observed, from bottom to top:

1) grey-green fossiliferous marls, containing a Lithothamnium limestone pebble-bearing pebbly-mudstone lens up to 30 cm thick and at least 4 m wide (10 m);

2) thin-bedded cross-laminated sandstones, alternating with mudstones (sand to mud ratio 1:1 - 1:3), presumably turbidites (10 m);

3) grey-green marls, with sandstone beds intercalated in the upper part, at the boundary with the overlying sandstone unit (40 m).

This succession, over 60 m thick, may be interpreted as slope facies with mud-dominated sediments, channeled bodies and thin-bedded overbank turbidites.

The micropaleontological assemblage in samples MU2 and MU3 from the basal (10 m) part of the succession is characterized by *Orbulina universa, Orbulina suturalis, Globigerinoides trilobus, Globigerinoides sacculifer, Globigerinoides bisphericus, Dentoglobigerina altispira*. Samples MU4-MU6, from the upper 40 m of marls, contain *Orbulina universa, Orbulina suturalis, Globigerina nepenthes, Globigerinoides obliquus, Paragloborotalia siakensis*. Both assemblages indicate a Serravallian age (*sensu* Iaccarino, 1985). The latter assemblage may be ascribed to the *Globorotalia siakensis/Globigerinoides obliquus obliquus* subzone (upper Serravallian). The uppermost part of the described succession may be Tortonian in age.

The transition to the overlying sandstone unit, sampled (PETR3) along the road to Petrela, shows an oligotypical fauna with *Ammonia beccarii*.

b) At Mihajas-Cirma, at the top of the *Lithothamnium*-bearing conglomerate level, between the heights of 722.6 and 676 m, fossiliferous and burrowed silty marls 90 m thick crop out. *Turritella*- and bivalve-bearing beds (10-20 cm), two beds of fossiliferous sandstones and, in the upper part, a coal layer 0.3 m thick are intercalated.

An open-marine depositional environment (at least upper bathyal) is suggested based on both lithofacies and the occurrence of *Lenticulina*, which forms 80% of the benthonic faunas. On the other hand, the frequency of *Turritella*-bearing beds and strongly burrowed coarse beds suggests cyclic variations of depth, indicating prevailing outer shelf conditions. *Ammonia beccarii*, observed in the middle-upper part (sample K7), infers anomalous salinity values.

The most significant micropaleontological assemblage, in the middle to upper part of the succession (sample K7), contains *Orbulina universa, Orbulina suturalis, Praeorbulina glomerosa, Dentoglobigerina altispira, Globigerinoides trilobus, Globigerinoides sacculifer, Globigerinoides bisphericus* and is at least Serravallian in age.

The Serravallian-Tortonian mudstone succession at the eastern margin.

The eastern margin Serravallian-Tortonian mudstone succession is reduced in thickness and is made up of

grey-brownish clay and marl, bounded at the base by "Lithothamnium limestone 2" and at the top by the "Tortonian" sandstone unit (N2-1t). The Serravallian-Tortonian mudstone succession was measured and sampled in the Priska and Brari sections, where it is 2.50 m and 0.50 m thick, respectively.

At Priska (PR1), a monotypical fauna with *Ammonia beccarii* was observed, along with a planktonic Foraminifera assemblage formed by *Dentoglobigerina altispira, Globigerinoides trilobus, Globigerina falconensis, Neogloboquadrina acostaensis*, Tortonian in age (*sensu* Iaccarino, 1985).

At Brari (BR6) *Ammonia beccarii* still prevails, with *Orbulina universa, Orbulina suturalis, Globigerinoides quadrilobatus, Globigerinoides trilobus, Globigerinoides bollii, Globigerina falconensis, Neogloboquadrina acostaensis*. This assemblage is considered lowermost Tortonian in age.

The Serravallian-Tortonian mudstone succession at the southern margin.

At m. Kulla-Gracenit (Mamli), the mudstone level overlies Oyster-bearing fossiliferous sandstones (9 m) which show the same stratigraphic position as "Lithothamnium limestone 2".

The Serravallian-Tortonian mudstone succession is made up of grey fossiliferous mudstones, red at the top, with (MAM6, MAM7) *Ammonia beccarii*, ostracods and rare planktonic Foraminifera (*Globigerinoides trilobus, Globigerinoides quadrilobatus*).

Discussion.

In spite of difficulties in sampling, enough data were collected to infer an upper Serravallian - lowermost Tortonian age for the mudstone succession. Different facies were observed, but the occurrence of *Ammonia beccarii* indicates a common evolution to anomalous salinity conditions.

A transition from slope to outer shelf (Mihajas-Cirma) to marginal-marine environment (m. Kulla Gracenit - Mamli) is exposed from Mulleti to the southeast.

At the eastern margin of the studied area (Priska, Brari) the mudstone succession is Tortonian in age and, in a few meters, it records a swift drowning of the "Lithothamnium limestone 2" platform.

The Tortonian sandstone unit (N1-2t).

The Tortonian sandstone unit overlies the previously described mudstone successions and is widely exposed in the entire Tirana Depression, forming a wide asymmetrical syncline.

Fig. 12 - Mulleti section on the right bank of the Erzen river. LL, 'Lithothamnium limestone 2"; M, Serravallian-Tortonian mudstone succession; Tortonian sandstone unit: lS, lower part; uS, upper part.

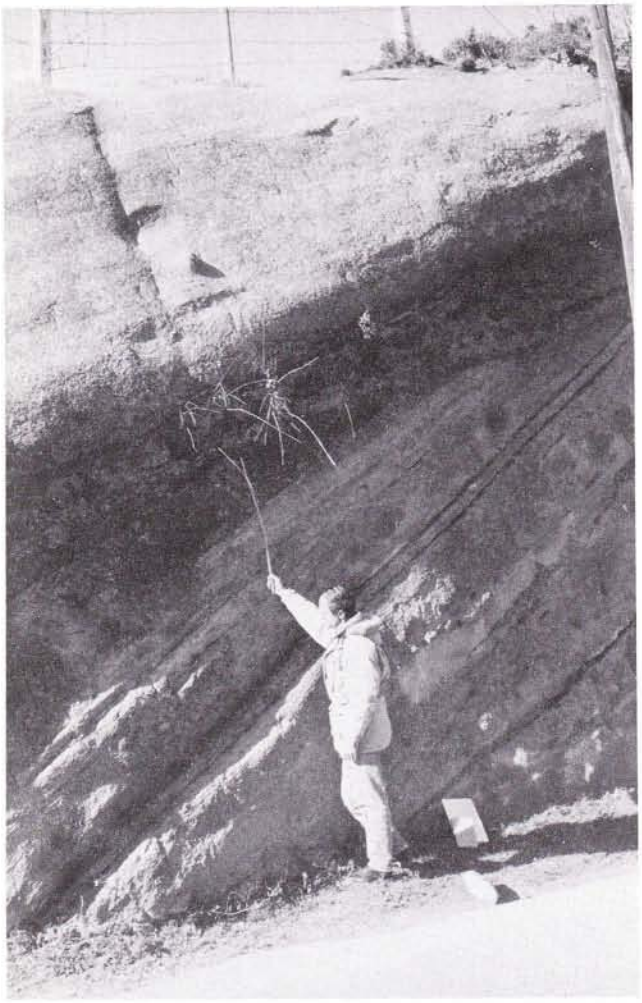


Fig. 13 - Intraformational angular unconformity in the Tortonian sandstone unit near Surel (Priska).

a) At Mulleti, on the right bank of the Erzen river, the Tortonian sandstone unit, about 1400 m thick, forms the western limb of the syncline. There the Tortonian sandstone unit may be subdivided into two parts (Fig. 12).

- The lower part, overlying the mudstones outcropping in an abandoned quarry, is over 400 m thick and is exposed as far as the military installation of Mali i Mykalive. It is a homogeneous succession of coarse and medium fossiliferous and burrowed sandstones, in amalgamated beds with frequent Ostreidae-bearing levels, also containing *Turritella* locally.

- The upper part, between the military installation and the village of Mulleti, shows sandstone-conglomerate bodies 20-25 m thick, cyclically alternating with sandstone-mudstone packages up to 50 m thick. Amalgamated beds 1 m or more thick may be recognized within the sandstone-conglomerate bodies.They have an erosional base and form thickening-upward cycles. These bodies are made up of fine conglomerates, in general normally graded with well-rounded pebbles, and festoon- and cross-laminated coarse sandstones. In the sandstone-mudstone packages fine sandstones and thin-bedded or laminated mudstones prevail. In the upper part of the succession grey and hazel-brown chipped mudstones occur.

b) On the eastern limb of the syncline the Tortonian sandstone unit is made up of prevailing sandstones. Near Surel, along the road, sandstones and conglomeratic sandstones form lenticular bodies with a concave or even base, showing cross-lamination and festoons, including mud and sand intraformational clasts locally. Hazel-brown and reddish mudstone beds up to 30-40 cm in thickness are sporadically intercalated and cut by erosion laterally (Fig. 13).

In the basal part of the succession reworked Ostreidae form a 1 m wide and 40 cm thick lens.

c) At the northern end of the study area near Makareshi (Fig. 14), a considerable decrease in thickness of the Tortonian sandstone unit may be recognized, despite the extensive alluvial cover. This unit shows no more than 25 m of exposure and is made up of cross-laminated sandstones forming metric lenses, overlying a Lithothamnium Limestone bed 1.50 m thick.

Samples from the mudstone levels are barren. Only samples MU7 and MU8 from the upper part of the Mulleti succession contain a scanty and possibly reworked benthonic and planktonic Foraminifera fauna. In MU7 badly preserved *Uvigerina, Globigerina, Globoquadrina* occur. MU8, from a chipped clay level outcropping in the upper part of Mulleti village, shows small planktonic Foraminifera: *Globigerina bulloides, Paragloborotalia mayeri/acostaensis, P. partimlabiata, Paragloborotalia siakensis, Cassigerinella chipolensis.*

General discussion.

The stratigraphic evolution of the Neogene succession of the Tirana Depression may be outlined as follows.

- At the eastern margin of the Depression the Neogene deposition starts in the late Aquitanian-early Burdigalian. The Neogene sediments overlie unconformably the Cretaceous-Paleogene Dinaric substratum (Priska, Brari). At the western margin, Oligocene turbidites and hemipelagites occur and continue to deposit at least until the earliest Miocene (Kodra Varoshit, Pajenga).

At the beginning of the Miocene the inner margin of the depression was probably emerged, representing the front zone of the west-verging Dinaric thrust-belt, while the western margin belonged to the foredeep area.

- The most complete lower Miocene succession was observed at Pajenga and shows first a regressive trend, from slope to shelf facies, followed by a transgressive trend with a deepening shelf. This transgression, is

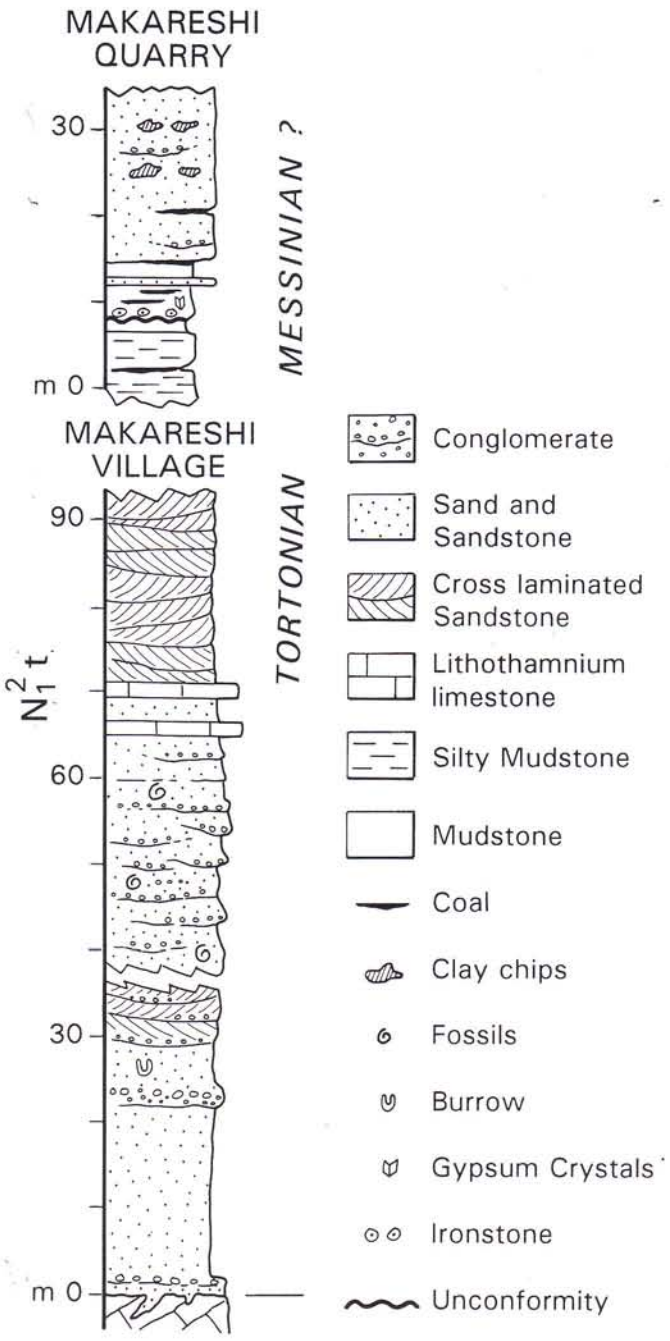


Fig. 14 - Tortonian-Messinian stratigraphic succession at Makareshi.

thought to have been progressing eastward to the front area of the Dinaric thrusts (Brari, Priska) at least up to early Langhian.

- In the entire Tirana Depression a marked erosional surface cuts the Burdigalian-Langhian succession with angular unconformity in the western areas (Petrela). This unconformity is sealed by "Lithothamnium limestone 1" or by correlative conglomerate facies.

- "Lithothamnium limestone 1" represents a carbonate platform of upper Langhian - lower Serravallian age, at present cropping out in the eastern and southwestern areas of the Tirana Depression. The evolution of this platform was frequently hampered by terrigenous supply from the margins of the Depression. Subsequent continental conditions may have caused the partial or complete erosion of the platform sediments, and the conglomerates at the Petrela castle may be the product of mass redeposition processes.

Continental and marginal marine conditions continue to prevail until the Serravallian giving rise to a considerable fluvio-deltaic depositional system in the southern part of the Tirana Depression (Mamli, Mihajas-Cirma).

- The following setting of transitional and shallow-marine conditions, is documented in eastern and southern portions of the study area. At Brari, a transgressive-regressive cycle may be recognized whose maximum deepening is shown in the other sections by mudstone facies.

- "Lithothamnium limestone 2" marks the return of shelf conditions in the Serravallian. This shelf advanced toward the western areas of the Tirana Depression (Petrela, Mulleti) as well. These areas are interpreted as a structural high for most of the Langhian and Serravallian. At Mulleti "Lithothamnium limestone 2" unconformably overlies Burdigalian slope sediments.

- "Lithothamnium limestone 2" underlies a mudstone level, indicating slope to marginal marine deposition and a widespread deepening of the platform during the upper Serravallian - Tortonian. This deepening is thought to have advanced progressively eastwards, arriving at the eastern margin of the depression (Priska and Brari) only in the Tortonian.

- The Tortonian sandstone unit (N1-2t) displays a widespread and likely heterochronous regression, recorded in the Preze homocline as well as in the Tirana Depression.

The Langhian-Tortonian deep marine succession of the Preze homocline.

A Neogene succession exposed north of Tirana differs considerably from the Neogene succession of the Tirana Depression and forms the Preze homocline, a NW-SE oriented structural element, tectonically bounding the Tirana Depression in the direction of Cape Rodonit (Kape i Rodonit).

A significant section was studied in the Kertushaj zone. The lower part is exposed along a valley northeast of Ishmit Castle and the upper part from Ishmit Castle along the road to Lalezi. This section is covered at the base by alluvial deposits of the Ishmit River while the top underlies the Tortonian sandstone unit (N1-2t). Two lithozones may be recognized: a lower zone made up of turbidite mud-sandstone beds and an upper zone made of hemipelagic mudstone.

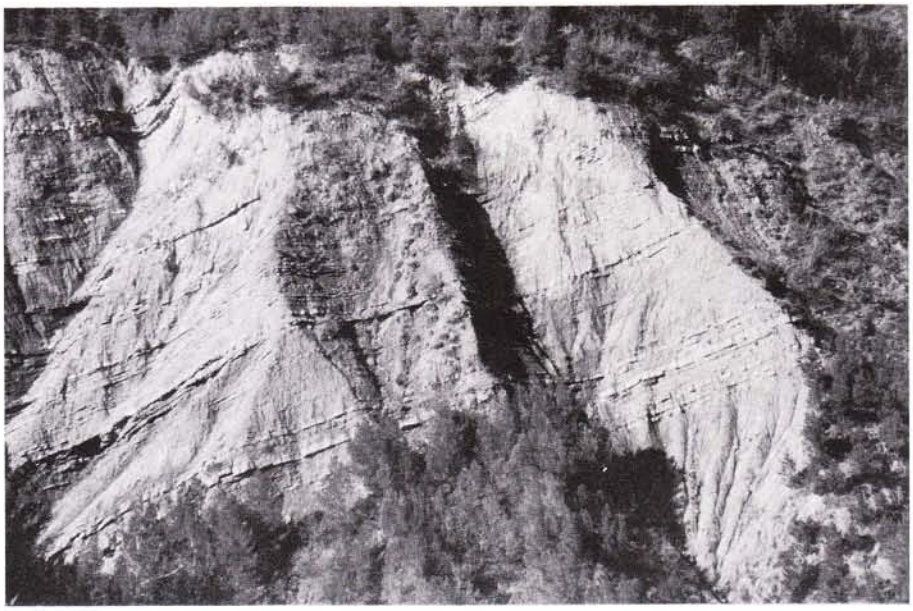


Fig. 15 - Turbiditic sandstones and hemipelagic mudstones of the lower lithozone of the Preze homocline succession (Ishmi).

Lower lithozone.

The lower lithozone (Fig. 15) is at least 800 m thick and is made of thin bedded turbidites with a very low sand to mud ratio. Sandstone beds are commonly thin (max. 15 cm thick), faintly graded and parallel- and cross-laminated. Thicker sandstone beds with an erosional base are cyclically intercalated, into thinning upward sequences up to 5-6 m thick. In the lower part of the section conspicuous reworked levels are exposed. At 20 m height a pebbly mudstone level, including a conglomerate block of 1 m in diameter, may be observed.

The following succession is exposed between 40 m and 70 m heights (Fig. 16):

1) pebbly mudstone with centimetric extrabasinal clasts, grading to pebbly sandstone with Lithothamnium limestone clasts, laminated at the top, forming a lenticular level 0.3 m thick;

2) thin-bedded and cross-laminated sandstones, frequently graded, alternating with mudstones in a ratio of 1:5 (7.4 m);

3) conglomerate with clasts of Mesozoic carbonate rocks and Lithothamnium limestone (Fig. 17), in a level with an irregular base and flat top, formed by two amalgamated, roughly graded beds (0.3 m);

4) pebbly mudstone with extrabasinal and Lithothamnium limestone clasts up to 30 cm in size and Oyster fragments (0.9 m);

5) thin-bedded sandstones with alternated mudstones (20 m);

6) a slumped mudstone-sandstone bed package (Fig. 18), overfolded presumably to the west (4-5 m).

Upper lithozone.

The upper lithozone is exposed between Kertushaj and Lalezi and is over 1500 m thick. This lithozone is made up of commonly laminated mudstones. Thin-bedded fine sandstones are sporadically intercalated. The top is abruptly overlain by massive sandstones (N2-1t), which are very thick in the Preze homocline as well.

The samples collected (10) show significant and diversified planktonic Foraminifera assemblages.

IS1, at the base of the succession, contains *Orbulina suturalis, Praeorbulina glomerosa curva, Globigerinoides bisphericus, Globigerinoi-*

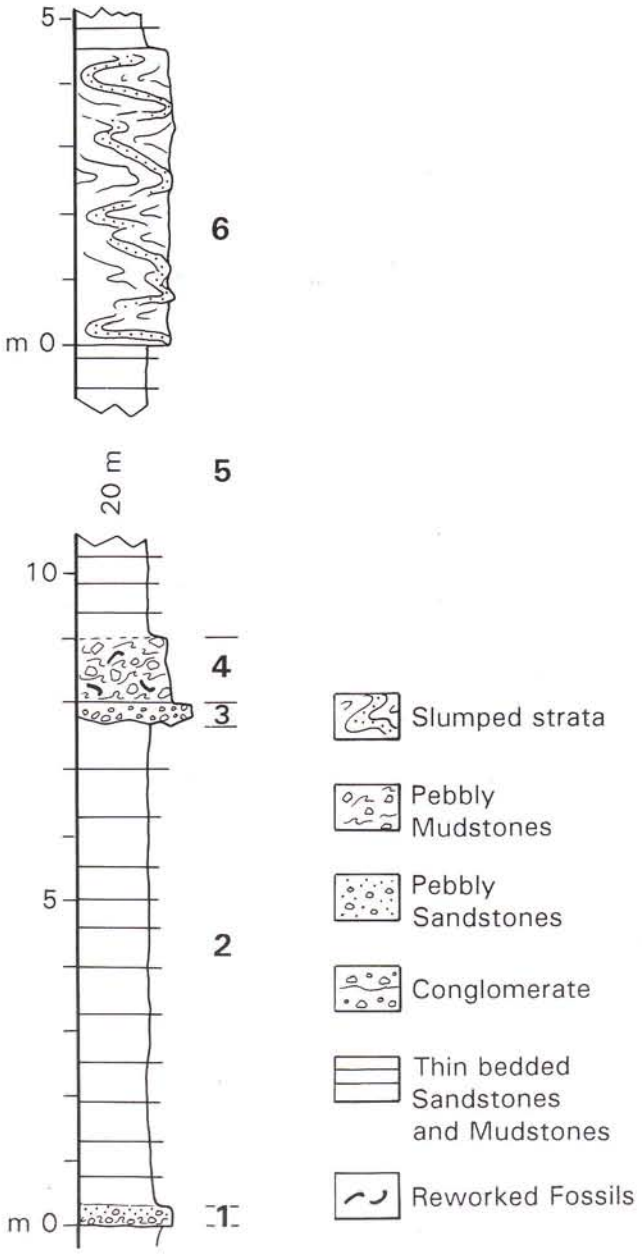


Fig. 16 - Deep-marine succession of the Preze homocline: the lower lithozone between the heights 40 and 70 m.

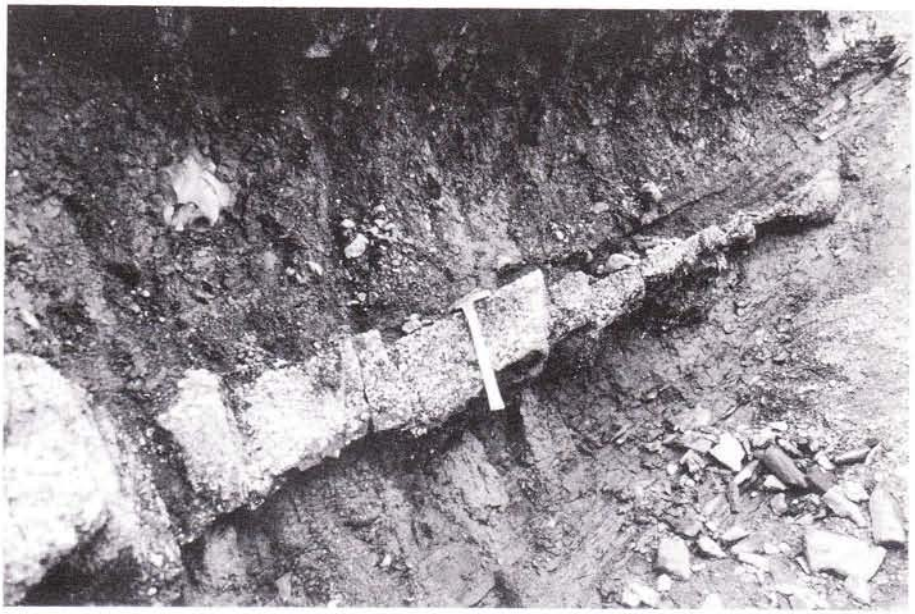


Fig. 17 - A discontinuous conglomeratic level with clasts of Lithothamnium limestone in the lower lithozone of the Preze homocline succession.

des immaturus, Globigerinoides trilobus, Globorotalia fohsi peripheroronda and may be ascribed to the *Orbulina suturalis* Zone (Iaccarino, 1985) of upper Langhian age.

Samples IS3 and IS5 allow dating of the reworked levels (Fig. 17). IS3, from the base of the levels, contains *Orbulina universa, Orbulina suturalis, Globorotalia praemenardii, Dentoglobigerina altispira, Globigerinoides trilobus, Globigerina falconensis, Globigerina druryi.* IS5, from the top of the levels, contains the previous forms together with *Paragloborotalia siakensis*. Both assemblages are middle Serravallian in age (*Orbulina suturalis-Globorotalia peripheroronda* Zone and *Globorotalia siakensis* Zone, Iaccarino 1985).

The lower part of the upper lithozone is upper Serravallian in age, since sample IS7 contains *Globorotalia* gr. *menardii, Globigerina nepenthes, Orbulina universa* (upper part of the *Globorotalia siakensis* Zone, Iaccarino 1985).

Samples IS8 and IS9, from the middle-upper part of the upper lithozone, are Tortonian in age, since they contain *Orbulina universa, Globigerinoides bollii, Globigerinoides obliquus, Globigerinoides subquadratus, Globigerina nepenthes* (*Globorotalia acostaensis* Zone, Iaccarino 1985).

Discussion.

The mud-sandstone succession of the Preze homocline, formed by planktonic Foraminifera-bearing hemipelagic mudstones and thin-bedded turbidites, may be interpreted as deep-marine sediments of a basin area west of the Tirana Depression. Overbank deposits prevail, with limited intercalations of sandstone bodies, slumps and chaotic deposits. The successions of the Preze homocline and of the Tirana Depression may be correlated through planktonic Foraminifera assemblages and the following lithofacies characters.

- The chaotic level present at 20 m height from the bottom includes a conglomerate block, perhaps arising from reworking of the fluvio-deltaic conglomerates exposed at Mamli and Mihajas-Cirma.

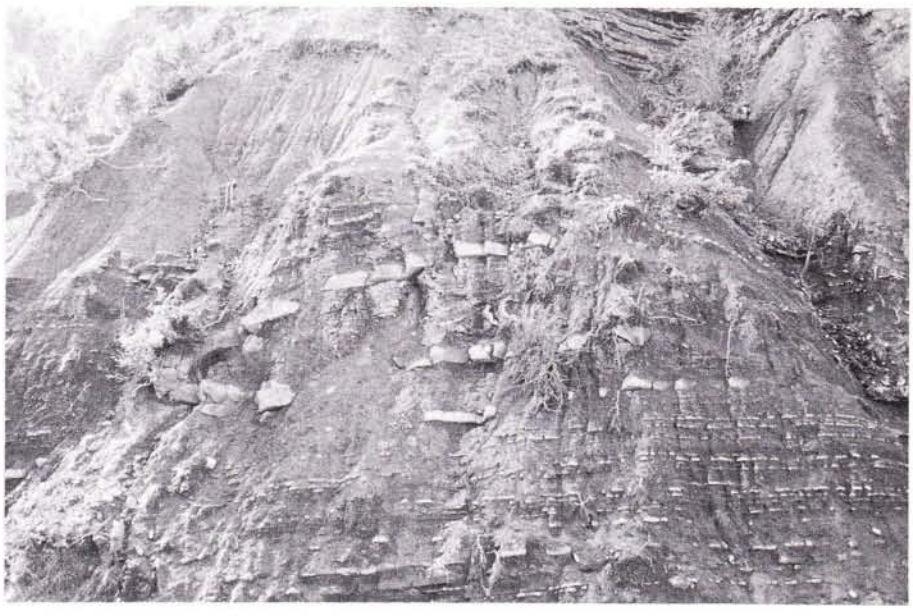


Fig. 18 - Slumped mudstone-sandstone beds in the lower lithozone of the Preze homocline succession.

- The conglomerate levels between 40 m and 70 m height with Lithothamnium limestone clasts originate from erosion of the *Lithothamnium*-bearing carbonate platforms of the Tirana Depression. The base of these levels might be correlated to the erosional surface at the top of "Lithothamnium limestone 1", which is entirely cut off to the northwest of Mihajas-Cirma in the direction of Petrela-Mulleti, and therefore appears to be the most likely source of the reworked conglomerate levels.

- The mudstone upper lithozone section may be related to the coheval mudstone succession of the Tirana Depression, which is normally underlain by "Lithothamnium limestone 2" and overlain by the Tortonian sandstone unit (N1-2t). In spite of different sedimentary features, both of these units indicate a widespread maximum flooding, upper Serravallian-Tortonian in age. Furthermore, both units grade upward to shallow-marine sandstones, in a regressive trend.

Structural features

The Tirana Depression is included in a regional structural framework of post-Pliocene inverse faults and thrusts, that is the tectonic style of external Albanides (Shehu et al., 1981; Papa et al., 1991; Hyseni et al., 1995). The Tirana Depression forms a NW-SE oriented elongated structural element, which may be recognized from a 60 km distance between Elbasan and the Gulf of Rodonit (Gjiri i Rodonit), and it shows different features north and south of Tirana.

To the north of Tirana the available subsurface data show a wide syncline with mild internal undulations, formed by a thick "Tortonian-Pliocene" succession, mostly covered by the alluvial deposits of the Ishmi River (Fig. 19).

A west-dipping buried thrust plane of regional importance cuts the western limb of the syncline and bounds it from an east-verging structure, shaped as an anticline to the north of Gjiri i Rodonit and as the Preze homocline farther south.

The eastern limb of the syncline is exposed with a 50° dip at the base and a progressively lower dip upwards. The succession forming this limb was observed in the Makhareshit area, where it is at least 200 m thick, and is likely to be Tortonian in age, although barren of fossils. It is worth noting that the sandstone-conglomerate lower part of this succession underlies the Lithothamnium limestone levels and may be pre-Tortonian, while the mud-sandstone upper part, with gypsum levels, may be up to Messinian in age.

To the south of Tirana the Tirana Depression also may be outlined by field data and is a wide northeast-verging asymmetrical syncline.

The high dipping (locally 80°) western limb is bounded by the NW-SE oriented Paper-Rova anticline with Oligocene rocks at the hinge zone (Pg 2-3, H.G.RPS S., 1983). This anticline stretches on the Preze homocline alignment and is formed by the Neogene succession up to the Tortonian.

The eastern limb of the syncline is made up of moderately dipping Burdigalian-Tortonian beds, locally anchored by the overthrusting external front of the Kruja Unit.

A comparison between field structures and subsurface data indicates the opposite verging of the structures of the Mesozoic-Paleogene substratum and the Tirana Depression.

The Mesozoic-Paleogene substratum, ascribed to the Ionic Zone, forms a sequence of west-verging slices at the front of the Kruja Zone, sealed by the Neogene succession of the Tirana Depression. On the contrary, the Tirana Depression structures are connected to the east-verging thrusting of the Paper-Rova anticline - Preze Homocline alignment. These structures may be interpreted as backthrusts if compared to the main vergency of the Dinaric structures.

Conclusions

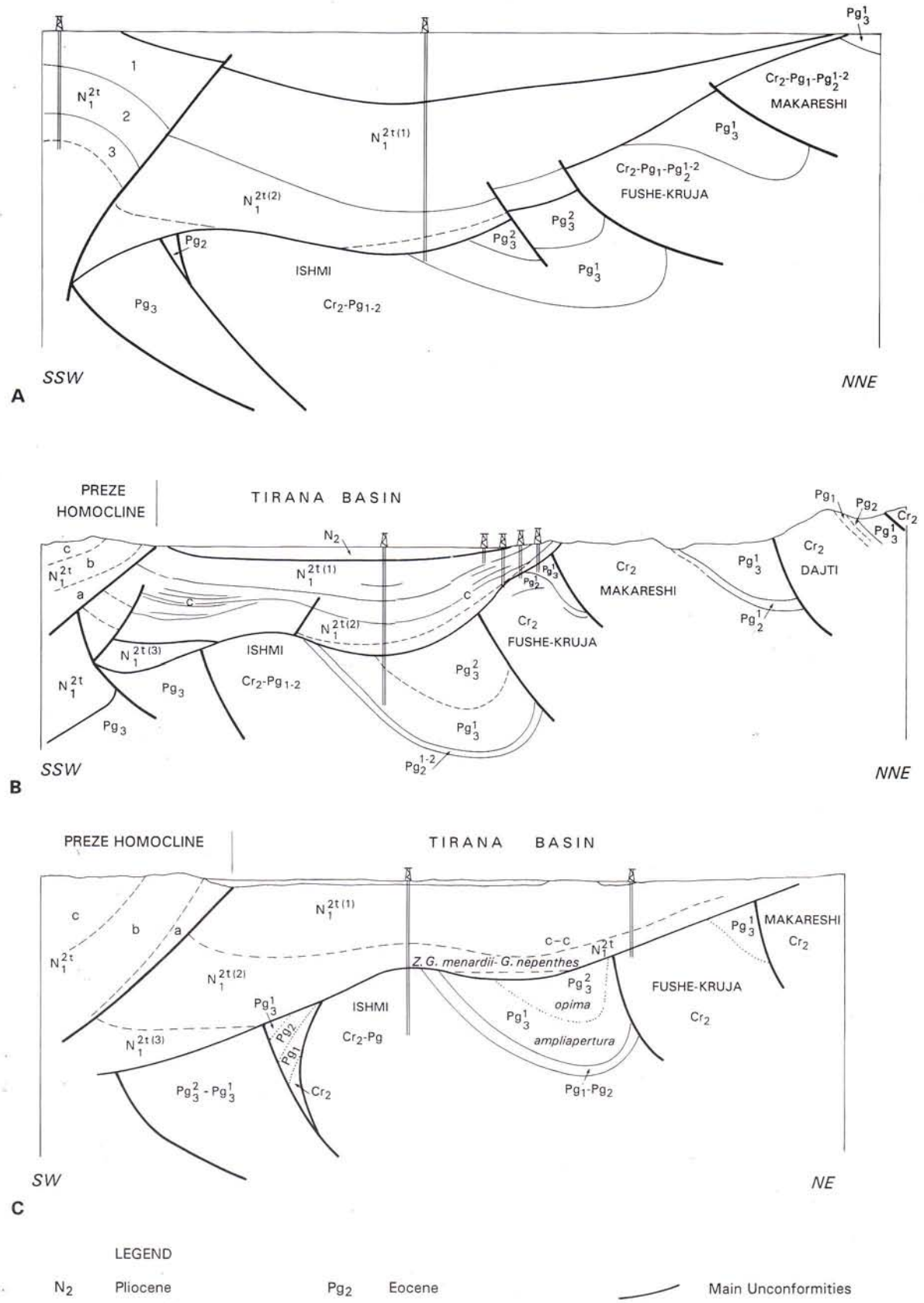
The Tirana Depression is located in the eastern and inner part of the Periadriatic Depression. The Periadriatic Depression is regarded as a foredeep filled by a mainly deep-marine succession, described by Guri et al. (1995) in the Albanian offshore. On the Albanian mainland the succession of the Periadriatic Depression is represented, at least in the Langhian-Tortonian time span, by the succession of the Preze homocline.

The present day Tirana Depression area is characterized by prevailing continental and shallow marine sediments. Deep marine sediments are restricted to Oligocene-earliest Miocene and Serravallian-Tortonian p.p. and crop out only along the western margin of the Depression. Hence the relations to the Periadriatic foredeep stand out as a key point to understand the evolution of the Tirana Depression.

The structural features allow localization of the Tirana Depression between the front of west-verging Dinaric structures and the opposite verging Paper-Rova anticline - Preze homocline alignment. Within this regional structural framework the evolution of the Tirana Depression may be outlined as follows (Fig. 20).

Fig. 19 - Seismic cross sections through the Tirana Depression (courtesy of the Instituti Gjeologjik i Naftès nè Fier).

CROSS SECTION THROUGH THE TIRANA BASIN



LEGEND

N_2	Pliocene	Pg_2	Eocene		Main Unconformities
N_1^{2t}	Tortonian	Pg_1	Paleocene		Thrust, Reverse Fault
Pg_3^2-Pg_3^1	Oligocene	Cr_2	Upper Cretaceous		

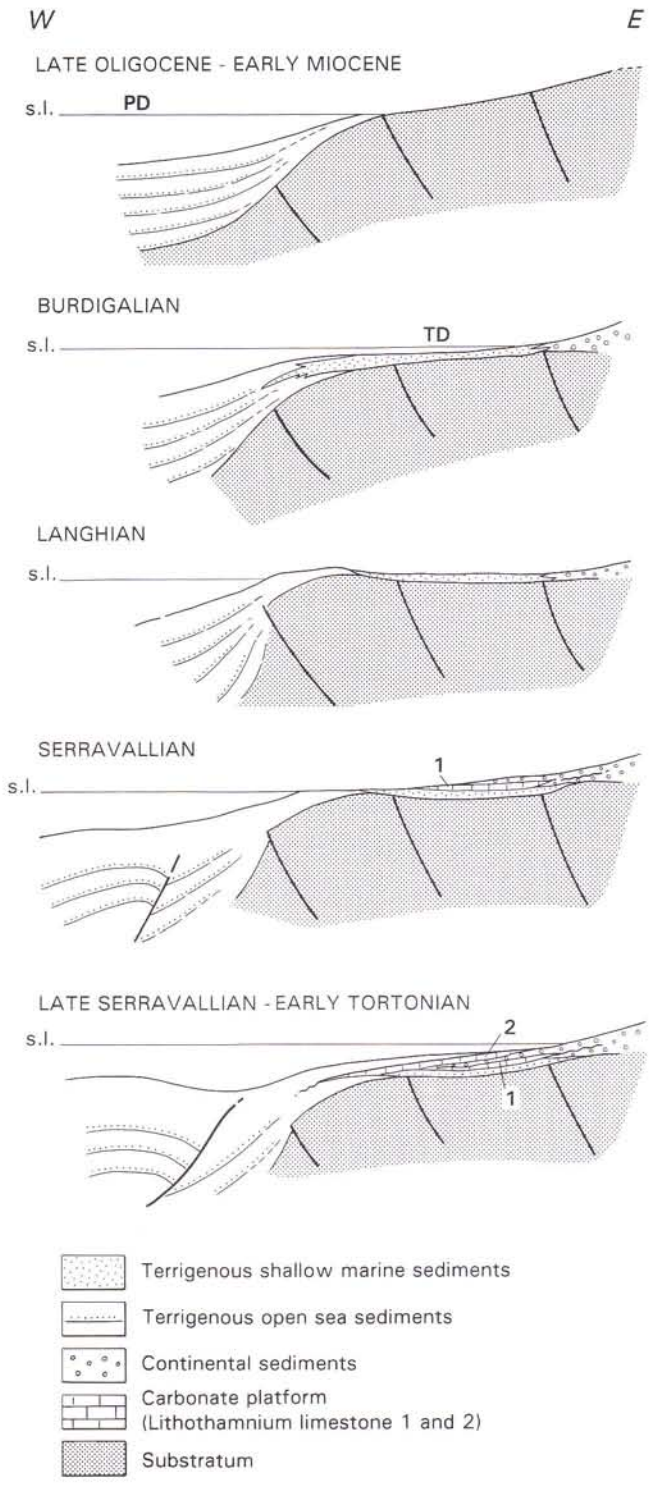


Fig. 20 - Assumed late Oligocene-late Miocene evolution of the Tirana Depression.

At the Oligocene-Miocene boundary the Tirana Depression had not yet identified itself and was likely to be a narrow elongated area, not recorded in outcrops, at the inner margin of the Periadriatic foredeep. It may be assumed though, that no wide shelves and large delta complexes developed due to the likely steep gradients and large amount of extratopography. Thick and highly unstable small deltas on a narrow shelf seem to be more probable. Sediments would have been carried down into a deep sea environment, almost completely bypassing the narrow or nonexistent neritic area.

The Tirana Depression becomes a depositional area in the early Miocene, presumably in late Aquitanian-early Burdigalian. This basin may be interpreted as a "thrust sheet top basin" *sensu* Nichols & Ori (1983), whose evolution is controlled, at least up to the Serravallian, by the Dinaric thrusts. The Langhian-Serravallian widespread continental conditions are thought to be connected to subsequent pulses of tectonic activity.

The Langhian tectonic activity, before the deposition of "Lithothamnium limestone 1", takes place at the external front of the Dinaric thrusts and gives rise to a conspicuous uplift of the western margin of the Tirana Depression.

After deposition of "Lithothamnium limestone 1", the Serravallian continental conditions lead to the removal, completely in some sections, of the previous carbonate platform and to development of a conglomerate fluvio-deltaic complex, especially prominent in the southern area of the Tirana Depression. This event also influences the Periadriatic foredeep, where considerable reworking of conglomerate and calcareous sediments is recorded, as shown in the succession of the Preze homocline.

A significant Late Serravallian - Tortonian event in the evolution of the Tirana Depression is the drowning of the "Lithothamnium limestone 2" carbonate platforms. This may be compared to the evolution of the Serravallian carbonate platforms of the Southern Apennines, the drowning of which, according to Simone & Carannante (1988), is bound to their low rate of growth influenced by their biogenic constitution (Foramol s.l.). In the Tirana Depression the Serravallian platform is abruptly overlain by hemipelagic marls, indicating a swift rise in sea level, in opposition to the general trend of the eustatic curve by Haq et al. (1988). Moreover, this drowning progressively advances eastwards. Thus the drowning of the "Lithothamnium limestone 2" carbonate platforms is thought to be related mainly to tectonic processes. Backthrusting is supposed to have generated the flexure of the platform and consequently its progressively eastwardly extending subsidence. Associated bulging of peripheral areas may have caused the local emersion of the platform, as recorded by erosional truncations and pebbly mudstones, occurring on the slope at the western margin of the Tirana depression (Mulleti disused quarry).

The Late Serravallian - Tortonian slope stretched in the direction of the inner margin of the Periadriatic foredeep, as the mudstone facies (upper lithozone) of the

Preze homocline show. This large depositional slope connected the Periadriatic foredeep to the Tirana Depression and shows a widespread regressive trend, evolving to shallow-marine conditions. This regressive phase may be related to the increased uplift resulting from the prograding east-verging backthrusting.

In conclusion, the late Oligocene-Tortonian evolution of the Tirana Depression, which has frequently been reported simply as "Molasse" basin, appears to be considerably different from the adjoining Periadriatic foredeep and may be summarized as follows.

- Late Oligocene - Aquitanian: narrow and unstable shelf, probably forming the high-gradient eastern margin of the foredeep.

- Burdigalian - early Serravallian: "thrust sheet top basin", related to the front of the west-verging Dinaric thrusts.

- Serravallian-Tortonian: "foreland zone" of the backthrusts, the ultimate development of which is post-Pliocene in age.

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