Stratigraphical Studies of The Area Located Between Nallihan and Bozyaka Villages Along The Sorgun River

by

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Vedia TOKER

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ABSTRACT

Detailed stratigraphic studies have been carried out along the Sorgun River in an area which is located between Nallihan and Bozyaka villages. In the nineteen stratigraphic measured sections examined, a characteristic uniform deposition of strata, dating back from Jurassic to Paleocene, was observed.

In order to clarify the Lithostratigraphy and Biostratigraphy, which represent the first and second parts of our study, respectively, paleontological determinations were carried out by the author of the macro – and microfauna collected in this area. The oldest unit of the investigated area is the “Nallihan Formation”. From the exposures observed here it was not possible to determine how this formation was deposited over the underlying older formations; however, in the eastern part of our area, a discordancy with the Paleozoic formations was observed. Although the base of this formation consist of bimicrites and micrites, the middle and upper levels are composed of depositions of bimicrite, dolomitic limestones, intrabiosparites and partly dolomitized micrites and bimicrites. All these rocks contain very small amounts of sand and have been formed in littoral and submeritic environment.

Representatives of the classes Tintinninna and Coccolithophoridae, identified in these rocks, have constituted biozones.

* This paper is a doctoral thesis written under the supervision of associate Prof. Dr. S. Erk in the Department of Geology, Faculty of Science, University of Ankara, in June, 1973.
These biozones determine the following stages: Tithonian-Berriasian-Barremian and Aptian-Albian.

The second unit is the “Bozyaka Formation” which overlie on the “Nallhan Formation”, showing and vertical transitions, it has a thickness of 1,300 meters.

It was observed that in the gray to green - colored marls, starting from the base of the formation, the ratio of carbonates, clays and sands is consistently uniform; however towards the upper levels this ratio shows fluctuations. In these marls we have encountered large sandstone lenses. According to the microfauna studied, four biozones can be distinguished here, which determines the following stages; Turonian-Santonian - Campanian - Maestrichtian.Overlaying concordantly this formation, comes Paleocene, which consist of red sandstones and conglomerates.

INTRODUCTION

Our area of study is situated 165 Km. northwest of Ankara, around Nallhan village. This location can be found in the topographical maps of Adapazarı (numbers H 26 c₁ and H 26 b₂) on a scale of 1: 25,000. From the studied area 775 samples were taken. 601 of these samples were hard rocks from which 1,500 thin sections were prepared; the remaining 174 soft samples were washed and determined. For all these rocks sedimentological studies were carried out together with the macro - and microfauna determinations. The results obtained were used in establishing the Lithostratigraphic, Biostratigraphic and Chronostratigraphic units which represent the three main and most important parts of our work.

Previous studies carried out on this subject were performed by V. Stechepinsky (1940) who gave rather a generalized description. Following V. Stechepinsky’s work Dr. Abdüsselâmoğlu (1959) has performed intensive studies in the vicinity of our area and discovered Upper and Lower Cretaceous and Paleocene series. At the end of our studies we have come to a conclusion that formations observed in our area are a continuation of the above mentioned formations discovered by Dr. Abdüsselâmoğlu. Later, Dr. S. Türküinal, A. Kalafatçioğlu and H. Uysallı (1964) have studied Cretaceous series around the Nallhan area.
MATERIAL AND METHODS

As material for study we have collected rocks samples along measured stratigraphic sections. In order to be more clear and specific we have also collected some random samples to perform a spot check. We shall divide the description of the work carried out into two parts: (1) Field work methods and (2) Laboratory work methods.

1. Field work methods

Since the greatest part of my field work was assigned to the stratigraphical measured section, a planetable method was used that yields better results graphically. Main points of stratigraphical units were measured with a planetable and the details were completed by utilizing a tape meter.

Compass and altimeter were the other auxiliary devices used in finishing the work.

2. Laboratory work methods

a) For soft samples, hot-water and perhydrol ($H_2O_2$) methods were applied.

b) For the hard samples, thin sections were prepared and and determined (Kimmel 1965).

c) The soft samples which disintegrated were subjected to sieve analysis. (Tyler sieve series, fractions 28, 48, 65, 150 and below 150 mesh).

Microfauna in these fractions were separated, using a binocular microscope.

d) Residual analysis

To find the main components ratio of rocks which consist of two or more components and also to determine the other constituents we have applied residual analysis. Results were evaluated in the lithological triangle diagrams.

e) In determining of minerals in the rock samples although we have used devices as various microscopes and in some minerals staining methods (silver chromate, crystal violet etc. methods) were also used.
f) Spectrum analysis: Spectral analysis was applied to some of the residue which could not be completely determined by utilizing other methods.

g) In naming and titling of calcareous rockes L. Folk (1962), J. Pettijohn (1957) and seldom L. Cayeux (1916, 1936) classifications were used.

ACKNOWLEDGEMENT

I hereby express my gratitude to Associate Prof. Suat Erk for giving me the guidance in preparation of this thesis.

I also give my hearty thanks to the Scientific and Technical Research Council of Turkey and my husband M. Toker, my brother S. Uncular, my sister I. Uncular and my colleagues A. Güven, İ. Dökmeci and R. Dincer who prepared the thin sections and to all who gave me assistance and their utmost support during my field work and helped me to finish this thesis, for without their help and encouragement this thesis could not achieve its purpose.

STRATIGRAPHY

The studied area is located northwest of Ankara, around Nalhahan and on both sides of the Sorgun valley (Figure 1.).

![Figure 1 Geographic location Map of the Investigated area.](image)
The area shows a difference in altitude varying between 600 – 1,400 meters from the sea level and is mostly mountainous and rocky. Going from south to north the topography changes and the terrain becomes more level.

It was impossible to determine the stratigraphic sections of the studied area along a single section due to the area's tectonics and surface characteristics. Therefore, nineteen stratigraphic measured sections were taken. In our area Paleozoic sediments were not encountered, but stratigraphical units of Mesozoic and Cenozoic were identified. The following sequence of deposits starting from the oldest strata towards younger levels was observed.

1. Nalhhan Formation

In this formation the following measured sections were taken and studied:

**KARABELENTEPE MEASURED STRATIGRAPHIC SECTION**

This section was measured on the Karabelen Hill, located 1.5 Km. north of Nalhhan; it strikes N 353° and is 203 m. thick (Figure 2.). Nineteen samples were taken from this section (from the base upwards) within cream-colored, hard, compact limestones of various thickness, which cutted by calcite veins intersecting each other in different directions. Residual analysis of these limes gave the following results: 66–90 % CaCO₃, 4.2–24 % sand and 3–14.1 % clay.

The measured stratigraphic section of Karabelentepe-as seen in the lithologic triangle diagram (Figure 3.)–starts with biomericite (Folk 1959, 1962) and micrite limestones with a very high carbonate content; it continues with an intercalation of intrabiosparite and limestones containing clay and sand and, then, it continues towards the peak of the hill again with biomericite limestones. Since this lithology does not show any important changes in its composition, we come to the conclusion that during the sedimentation period of these deposits the sea level had remained the same.
As microfauna, abundant *Calpionella alpina* Lorenz, *Calpionella elliptica* Cadisch, *Tintinnopsella carpathica* (Murgeanu and Philipescu) (Plate, II, III) are the main *Tintinnellidae*, which are encountered here. There are also spicules of Spongiata, section of Ostracoda shells, as well as fragments of shells spines of very small Echinoidea. *Tintinnellidae* are represented in three biozones. These are:
3. Tintinnopsella biozone
2. Calpionella-Tintinnopsella biozone
1. Calpionella biozone

The chronostratigraphical sequence determined with the help of characteristic microfauna is as follows:

— Tintinnopsella biozone: Berriasian – Barremian
— Calpionella – Tintinnopsella biozone: Berriasian- Valanginian
— Calpionella biozone: Tithonian

ÇİLLERGÖBEDI MEASURED STRATIGRAPHIC SECTION

This section was measured on the Çillergöbedi Hill (height 1,082 m. from sea level) starting from the base of the hill the top, in a N 300° direction. The bedding of this section has a N 70° W strike and a 25° E dip (Figure 4.).

From the base of the hill to the top, all our samples were biomicrites which contained 73-95 % carbonate. This continuity, which has little variations, shows that during the sedimentation period sea level had unchanged. In the residual analysis, it was observed that these samples contained some small amounts
of sand deposits. The thin sections obtained from the samples contained of pyrite, limonitized hematite and angular or subangular quartis. The texture of rock is heterogenous.

Biomicritez contain abundant *Nannoconus colom"i* (De Lapparent) and *Nannoconus globulus* Bronnimann (Plate I) Furt-

<table>
<thead>
<tr>
<th>Epoch</th>
<th>System</th>
<th>Subsystem</th>
<th>Stage</th>
<th>Lithology</th>
<th>Fauna</th>
</tr>
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<tbody>
<tr>
<td>Early</td>
<td>Cretaceous</td>
<td>Lower Cretaceous</td>
<td>Neocomian-Berriasian</td>
<td>Beige colored biomicrite</td>
<td><em>Radiolaria</em>, <em>Spongialta</em> spicules, <em>Ostracoda</em> shell fragments</td>
</tr>
<tr>
<td>Early</td>
<td>Cretaceous</td>
<td>Lower Cretaceous</td>
<td>Neocomian-Berriasian</td>
<td>Beige colored biomicrite</td>
<td><em>Nannoconus colomii</em>, <em>N. globulus</em>, <em>Cornuspira</em>, <em>Ostracoda</em> shell fragments</td>
</tr>
<tr>
<td>Early</td>
<td>Cretaceous</td>
<td>Lower Cretaceous</td>
<td>Neocomian-Berriasian</td>
<td>Beige colored biomicrite</td>
<td><em>Nannoconus colomii</em>, <em>N. globulus</em>, <em>Radiolaria</em>, <em>Spongialta</em> spicules, <em>Ostracoda</em> shell fragments</td>
</tr>
<tr>
<td>Early</td>
<td>Cretaceous</td>
<td>Lower Cretaceous</td>
<td>Neocomian-Berriasian</td>
<td>Beige colored biomicrite</td>
<td><em>Nannoconus colomii</em>, <em>N. globulus</em></td>
</tr>
</tbody>
</table>

Figure 4: Çillegöbedi Measured Stratigraphic Section
hermore we have observed Spongiata spicules, Ostracoda shell sections and Radiolariae.

No characteristic fauna besides *Nannoconus* was encountered here to indicate the chronologic sequence in this area. The biozone established by the presence of *Nannoconus* proved the existence of Neocomian-Barremian.

**AKDERE MEASURED STRATIGRAPHIC SECTION**

This section was measured in the vicinity of the Akdere village situated 1 Km. northwest of Nallihan, starting from the nearly Eskiköy stream trending in a N 252° direction. Total thickness of the section is 376 meters (Figure 5.).

For the first 210 meters samples were taken from the layers striking E–W with a northern dip. In the upper layers the strike changed to N 105° W with 45° N dip. Lithologically these beds do not show any characteristics they are parallel to each other and are intersected by calcite veins of different thicknesses. These limestone layers, with a very high content in carbonates (Figure 6.), consist of biomicrites in the first seven samples taken at the base; however, towards the upper levels the biomicrites alternate with pseudo - oolitic limestones. The monotonous continuity observed at the base demonstrates that a sedimentation process took place within a long period of time, while in the upper levels materials coming from the nearly reef have produced certain changes in the environment. Study of the section showed that microfauna within the biomicrites, from base to top, did not display any changes and representatives of *Tintinnellidea*—such as *Calpionella alpina* Lorenz, *Calpionella elliptica* Cadisch, *Tintinnopsis carpathica* (Murgeanu and Filpescu), *Tintinnopsis cadischiana* Colom (Plate I, II) — were widespread. The fauna encountered in the pseudooolitic limestones, on the other hand, is entirely different. We have observed such fossils as *Trocholina sp.*, *Lituola sp.*, *Cyclamina sp.*, *Quinqueloculina sp.*, *Pyrgo sp.*, *Textularia sp.*, as well as shell fragments of Echinoida and Ostracoda and Spongiata spicules.
<table>
<thead>
<tr>
<th>Era</th>
<th>System</th>
<th>Sub-System</th>
<th>Stage</th>
<th>Formation</th>
<th>Reflections</th>
</tr>
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<tbody>
<tr>
<td>Cretaceous</td>
<td>Lower</td>
<td>Berriasian</td>
<td></td>
<td>Valanginian</td>
<td></td>
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</table>

Figure 5: Akkere Measured Stratiographic Section

- Light beige colored
- Dark gray colored
- Orange colored
Relying on the presence of Tintinnellidae which created a Calpionella-Tintinnopsis biozone, we have attributed a Berriasian-Valanginian age to this unit.

**YAZILIKAYA MEASURED STRATIGRAPHIC SECTION**

This section was measured on the Yazılıkaya Hill; it is 275 m. thick and trends in a N 335° direction (Figure 7.).

The base of the section consist of biomicrites and limestones with dolomites and intrabiosparites; further up it is followed by a layer of biomicrites while the uppermost levels contain dolomitie limestones.

The residual analysis performed on the samples showed the following results: 75.2 – 85.6 % CaCO₃, 3 – 4.2 % sand and 11–21.8 % clay.

The difference in the rock content observed in this area is due to the fact that after the sedimentation period of these biomicrites, a subsequent intrusion of MgCO₃ altered this environment. In this way biopelsparites were formed. Since this rock is the derivative of a bioherm, and , furthermore, its cementing material being sparite, it is assumed that the bioherm in question was formed in an area further away from our locality. Following
Figure 7: Yazılıkaya Measured Stratigraphic Section

this stage comes a formation sequence containing biomierites which reverts to its initial lowermost stage observed at the base of the section. In these rocks, at two levels, we have encountered
a characteristic microfauna consisting of a *Calpionella - Tintinnopsis* biozone, that indicates Berriasian and Valanginian stages.

**YAZILIKAYA (A) MEASURED STRATIGRAPHIC SECTION**

This section was measured starting from the base of the Yazihkaya – which consist of massive basal limestones-towards the top, going in a N 270°, direction. The thickness was estimated as 200 meters (Figure 8.). However the upper part of the section being entirely covered with detritus, it was impossible to measure

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
<th>Fauna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcs. Clay sand</td>
<td>Lime - colored microcrystalline limestone</td>
<td>Spengiata spicules, Ostracoda shell fragments</td>
</tr>
<tr>
<td>Marl</td>
<td>Lime - colored microcrystalline limestone</td>
<td>Radiclaria, Ostracoda shell fragments</td>
</tr>
</tbody>
</table>

![Figure 8: Yazihkaya (A) Measured Stratigraphic Section](image)
its exact thickness. Moreover, numerous fractures and fissures which resulted from strong Alpine movements occur in this area. The carbonate ratio in the microcrystalline limestones, which continue without interruption from base to the top of this section, is very high (90–98.9 %).

Since the limestones observed here are in microcrystalline form, we conclude that they were formed in a lithozone which although distant from the shore was shallow in character, abundant Spongiata spicules encountered in these limestones indicate to a warm marine climate that prevailed in this area. We have also encountered here fragments of Ostracoda shells, but no characteristic micro or macrofauna was found which could help in age determination of this unit.

**Norgöbedí Measured Stratigraphic Section**

This section was measured as having a thickness of 200 meters in the N 251° direction, at Norgöbedí Hill (altitude 930 m) which is located on the right slope of the Küçüköz stream 2.5 km northwest of Nallihan. The beds were measured in E – W direction and a dip of 20° – 24° S (Figure 9).

Samples taken from the base showed a biointrasparite character and were mostly heterogeneous. They contained very little amounts of pyrite (2 – 3 %), limonitized hematite and sharp-edged (angular) quartz. Above this level biomicrites were deposited. Further up, again biointrasparites and, at the summit, biomicrites were observed.

The environmental conditions, which contributed to the sedimentation processes of biomicrites, continued unchanged for a long period. Subsequently, due to changes in the environment and fragmentation of material, biomicrites have been formed. Later on, when climatic conditions underwent another change, fragments of a bioherm form another locality, were carried here and again biointrasparites were formed. Overlying this layer biomicrite sedimentation took place.

In the biomicrites large amounts of the following characteristic fossils were observed: *Calpionella alpina* Lorenz, *Calpionella*
eliptica Cadisch, Tintinnopsella carpathica (Murgeanu and Filipescu), Tintinnopsella longa Colom (5-7 ea per sq mm). On the other hand, in the biointrarparites we found some broken shells of Textularia sp., Robulus sp., Lituola sp., Quinqueloculina sp. Spirolina sp., Alge and Echinoidea.

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Fauna</th>
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<tbody>
<tr>
<td>Gray - colored</td>
<td>Calpionella alpina, C.elliptica, Tintinnopsella carpathica, T. longa</td>
</tr>
<tr>
<td>biomicrite</td>
<td></td>
</tr>
<tr>
<td>Beige - colored</td>
<td>Alge, Verriassella, Echinoidea shell fragments</td>
</tr>
<tr>
<td>bioelastarite</td>
<td></td>
</tr>
<tr>
<td>Beige - colored</td>
<td>Calpionella alpina, C.elliptica, Tintinnopsella carpathica, T. longa</td>
</tr>
<tr>
<td>biomicrite</td>
<td></td>
</tr>
<tr>
<td>Beige - colored</td>
<td>Textularia, Alge, Echinoidea shell fragments</td>
</tr>
<tr>
<td>bioelastarite</td>
<td></td>
</tr>
<tr>
<td>Orange - white - colored bioelastarite</td>
<td>Textularia, Spirolina, Robulus, Lituola, Megasphaera, Alge, Echinoidea shell fragments</td>
</tr>
<tr>
<td>Bioelastarite</td>
<td>Robulus, Lituola, Textularia, adenoculina, acrocora</td>
</tr>
</tbody>
</table>

Figure 9: Norgôbedi Measured Stratigraphic Section

In this section, Tintinnopsella longa Colom which was first encountered by us, showed a narrower biostratigraphic distribution
when compared with other Tintinnellidae. Therefore we have assigned a Berriasian age to this section.

**NORGÖBEDİ (NOR) MESAURED STRATIGRAPHIC SECTION**

This section was measured on the slope of the Norgöbedi Hill, approximately 2.5 km to the northwest of Nalihan, along the left bank of the Küçüközdere Stream. It is 113 meters in thickness (Figure 10). The beds are 20–25 cm thick, trending in a N 80° W direction and a dip of 20° – 25° N. The samples taken from the base towards the top consist of sandy-clayey limestones, sandy limestones, intrabiosparites and cryptocrystalline limestones. Numerous calcite veins intersecting each other are present here. In thin sections, pyrite, limonitized hematite and angular quartz were observed.

At the base of the section occur intercalations of sandy-clayey limestones and sandy limestones. The residual analysis of these rocks gave the following results: 51.5 – 68.7 % CaCO₃, 7.3 – 10.9 % clay and 20 – 43.8 % sand (Figure 11). This intermittent pattern shows that during the formation of this sequence, the sea level as well as the depth of the sea and the currents underwent considerable changes. The fact that our samples contained angular and rounded quartz grains, which were carried by currents, indicates that the deposition of this material took place several hundred meters away from the shore in sub-littoral and sub-meritic environments. Overlying these beds, intercalations of sandy-clayey limestones and intrabiosparites were formed. Analysis of these rocks showed the following: 58.1 – 70.5 % CaCO₃, 10.5 – 14.1 % clay, 18.1 – 28.4 % sand. At this phase, fragments of a bioherm, the location of which is not certain, were transported here to form an intercalation of intrabiosparite limestones. Overlying this layer come interbeds of microcrystalline limestone and intrabiosparite limestone. At this stage the sea depth increased, while intrusions of bioherms appeared again. The sandy clayey limestone as well as the sandy limestone samples, collected at the base of the section, contained shell fragments of Robulus, Textularia sp., Radiolaria, Echinoidea, Ostracoda
<table>
<thead>
<tr>
<th>Era</th>
<th>System</th>
<th>Sub-system</th>
<th>Stage</th>
<th>Formation (200 meters)</th>
<th>Lithology</th>
<th>Description</th>
<th>Fauna</th>
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<tr>
<td>Mesozoic</td>
<td>Cretaceous</td>
<td>Lower</td>
<td>Berriasian</td>
<td>Nalibian</td>
<td>Beige colored</td>
<td>Calciumite alpina, C.elliptica, Tintinnopsisella carpatica</td>
<td>Trocholina sp., Ostracoda, Echinoida shell fragments, C.alpina, C.elliptica</td>
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<td>micritic lime</td>
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Figure 10: Norgöbedi Measured Stratigraphic Section
and Ammonidea. However, no characteristic fossils were encountered in this faunal complex that might have helped with the age determination of this unit. In the layer overlying this unit such fossils as *Trocholina alpina* (Leupold), *Textularia*, *Radiolaria*, *Echioidea*, and *Ammonoidea*, as well as *Carpionella alpina* Lorenz, *Calpionella elliptica* Cadisch, *Tintinnopsis carpatica* (Murgeanu and Filpescu), *Trocholina sp.*, *Textularia*, *Alge* and *Ostracoda* were found. Among these fossils Tintinninas have created a *Calpionella - Tintinnopsis bicozone*.

From the base upwards no characteristic biostratigraphic elements were observed in the first unit. In the second unit, on the other hand in the beds that were formed in a shallow marine environment, a rather poorly represented microfauna contained some *Trocholina alpina* (Leupold) fossils. This species is found in Turkey mostly within the Upper Jurassic-Lower Cretaceous limestones. The *Calpionella - Tintinnopsis bicozone*, on the other hand, points to a Berriasian-Valangian age. On the basis of the above evidence, the author attributes this section to Tithonian-Valanginian.

**FATMAKUZ MEASURED STRATIGRAPHIC SECTION**

This section has a thickness of 450 meters (Figure 12) and was measured in the N-S direction on the Fatmakuz Hill.
<table>
<thead>
<tr>
<th>Lithology</th>
<th>Fauna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray colored clayey sandy limestone</td>
<td>Textularia, Reticulites</td>
</tr>
<tr>
<td>Beige colored dolomite</td>
<td>Reticulites</td>
</tr>
<tr>
<td>Beige colored biomicrite</td>
<td>Calpionella alpina, Tintinnopsis carnea, Cornuspira, Radiolaria</td>
</tr>
<tr>
<td>White-beige colored biomicrite</td>
<td>Trocholina sp., Bobulus sp., Echinoderm's shell fragments</td>
</tr>
<tr>
<td>White-beige colored biomicrite</td>
<td>Calpionella alpina, Celliptica, Cornuspira, Bobulus, Reticulites, Spongiata spicules, Sowerby's shrimp fragments</td>
</tr>
<tr>
<td>Yellow-gray colored biomicrite</td>
<td>Tintinnopsis carnea, Cornuspira, Bobulus, Spongiata spicules, Lasiella branchiata's shell fragments</td>
</tr>
<tr>
<td>Yellow-gray colored dolomite</td>
<td>Radiolaria</td>
</tr>
<tr>
<td>Beige colored biomicrite</td>
<td>Spongiata spicules, Echinoderm's shell fragments</td>
</tr>
</tbody>
</table>
The directions and dips of the beds here change very frequently at very short distances (E–W 10° S, N 85° W, 90° S, etc.). All the samples taken were calcareous; their residual analysis yielded the following results (Figure 13); 61.8 - 93.7 % CaCO₃, 8.2 - 24.7 % clay, 2.5 - 20.8 % sand. The sand consist of pyrite, limonitized hematite, angular quartz and altered green – colored minerals. Lithological sequence from the base upwards is as follows:

Figure 13 Lithological triangle diagram of the Fatmakuz Hill Section

a. Clayey - sandy limestones,
b. Dolomites,
c. Biomicrites,
d. Intrabiosparites,
e. Dolomites,
f. Clayey - sandy limestones.

The environmental conditions at the base, which produced the clayey - sandy limestones; show a stable character which lasted for a long time, as is evidenced by the great thickness of this formation (152.8 m.), later on chemical alterations due to penetration of this layer by large amounts of magnesium, have caused formation of dolomites. Subsequently, magnesium is replaced by fragments of bioherms introduced into this environment. Overlying this layer deposition of dolomites is again observed. The uppermost layers of this sequence does not show any foreign
material and reverts entirely to its initial deposition of clayey-sandy limestones.

In the samples taken from this unit such characteristic microfauna as *Tintinnellidae* as well as fragments of *Radiolaria* and *Ostracoda shells* were identified. As macrofauna sections of *Echinoidea shells* were also encountered. Our samples showed a regular distribution of Calpionella and Tintinnopsisella species. Among these, *Calpionella alpina* Lorenz, *Calpionella elliptica* Cadisch were observed, sometimes in association with Tintinnopsisella species and sometimes isolated. Because of this irregular distribution we were unable to establish a biozone for this section; however, it is assumed that these layers (horizons) are Berriasian-Valanginian in age.

**FATMAKUZ (F) MEASURED STRATIGRAPHIC SECTION**

This section was measured on the slope of the Fatmakuz Hill, 3 km north of Nalghan. It is 65 meters thick (Figure 14) and lies in an E–W direction. The direction of the beds is N–S with a dip of 25° E. The limestones are cream-colored to yellowish, sometimes light-gray hard and compact.

Residual analysis performed by applying acetic acid gave the following results (Figure 15); 44.9 - 73.2 % CaCO₃, 5.4 - 25.3 % clay, 21.1 - 39.7 % sand. Although the samples taken from the base seem to be sandy and clayey limestones, in the upper levels the clay content decreases to below 10 % and it becomes a sandy limestone. The clay content of more than 5 % is the evidence of an inadequate washing of rocks. In the thin section of our samples *Radiolaria* (*Spgharellaria*), *Spongiata spicules*, and section of *Echinoidea* were observed. Although these organic components indicate an infrarneritic environment, a part of the fauna could have been transported here as thanatosocnose material. Since no characteristic fauna was encountered, we could not reach to any definite conclusion as far as the Chronostratigraphy is concerned.
<table>
<thead>
<tr>
<th>Era</th>
<th>System</th>
<th>Sub-system</th>
<th>Stage</th>
<th>Lithology Description</th>
<th>Fauna</th>
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<tr>
<td>Mesozoic</td>
<td>Cretaceous</td>
<td>Lower</td>
<td>Nallihan</td>
<td>Gray-colored sandy limestone</td>
<td>Radiolaria, Spongiata spicules, Ostracoda shell fragments</td>
</tr>
</tbody>
</table>

Figure 14: Fatmaku (F) Measured Stratigraphic Section
SİVRİTEPE MEASURED STRATIGRAPHIC SECTION

The thickness of the section measured in the Sivritepe area is 665 meters and a total of 59 samples collected from this area were analyzed. The section, striking N 25°, was taken on the right bank of the Demirkapı Dere and it starts at the margins of a SE-NW striking fault, located along the Demirkapı Dere. Samples collected from this area are mainly composed of limestones and were taken from parallele beds striking N 55° S and dipping 25°–35°. Deposition is characteristically uniform and macroscopic feature are essentially similar within the entire sequence (Figure 16). Gray to beige-colored, compact and closely packed samples are mostly composed of biomicrite; some, however, are represented by pelsparite. Results obtained from the residual analysis carried out on the samples are shown below (Figure 17): 72.3–99 % CaCO₃, 1.4 – 15.7 % clay and 1.1–25.2 % sand. Uniformity observed within the entire sequence—which is 665 meters thick—indicates a continuous and characteristically regular sedimentation process, as evidenced by the fact that the organic remnants observed here, such as shell fragments of Echinoidea, Lamellibranchiata and Ostracoda stayed for a long time without undergoing any changes.

Thin section are characterized by heterogenous gel texture and contain pyrite, hematite, quartz as well as subordinate glauconite.
<table>
<thead>
<tr>
<th>System</th>
<th>Sub-system</th>
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<th>Lithology</th>
<th>Description</th>
<th>Fauna</th>
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<td>Lower Cretaceous</td>
<td>Nelliber Formation</td>
<td>Beige-colored biomicrite</td>
<td>Textularia, Robulus, Spongiata spicules, Ostracoda and Echinoidea shell fragments</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beige-colored biopelmatite</td>
<td>Textularia, Robulus, Dilimina</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beige-colored biomicrite</td>
<td>Cornuspira, Textularia, Robulus, Spongiata spicules</td>
<td></td>
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<tr>
<td></td>
<td></td>
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<td>Beige-colored biopelsparite</td>
<td>Robulus, Dilimina, Ostracoda and Echinoidea shell fragments</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gray-beige-colored biomicrite</td>
<td>Textularia, Nodosaria, Robulus, Dantaliina</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beige-colored dolomitic limestone</td>
<td>Bulimina, Echinoidea shell fragments</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Calpionella alpina C. elliptica</td>
<td></td>
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</tr>
</tbody>
</table>

Figure 16: Sivriitepe Measured Stratigraphic Section
Calpionella-Calpionellites are found within the basement of the present sequence where environmental features were stable and continuous. In the upper parts of the sequence Robulus, Bulimina, Textularia as well as Radiolaria were discovered.

![Lithologic triangle diagram of the Sivriytepe Section](image)

Figure 17: Lithologic triangle diagram of the Sivriytepe Section

A part from the Calpionella-Calpionellites suite found in the basement, no characteristic microfauna were discovered here, and based on these fossils a Berriasian age is assigned to this series.

Although Calpionellites darderi (Colom) (Plate II) were discovered even in the Hauterivian beds, their association with the Calpionella alpina Lorenz suggest the Berriasian age.

DEĞIRMENKIZI MEASURED STRATIGRAPHIC SECTION

The section starts at the foothills of Değirmenkızı Hill, NW of Nalhhan, and strikes N 250° having a total thickness of 426 meters (Figure 18); it consists of beds striking N 50° W and dipping 40° SW. Samples collected from these beds are beige-to-white colored and are composed of 72.2 – 83.3 % Ca CO₃, 7.6 22.1 % clay and 5.8 – 9.1 % sand (Figure 19): Sands consist of angular quartz grains. Pyrite, limonitized hematite, quartz and subordinate green minerals were found in this section. Alternating biopelsparites and clayey limestones rest upon the
<table>
<thead>
<tr>
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<th>Lithology</th>
<th>Fauna</th>
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<td>Cenomanian</td>
<td>Beige - colored clayey limestone</td>
<td>Calpionella alina, c. elliptica, Tintinnopsis sello carpathica, Bulimina, B. spongiate, spicules, Ostracoda's and Echinoderm's shell fragments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gray-beige - colored clayey limestone</td>
<td>Echinoderm's, Ostracoda's shell fragments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beige - colored biomicrite</td>
<td>Echinoderm's, Ostracoda's shell fragments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beige - colored biopelletarite</td>
<td>Echinoderm's, Ostracoda's shell fragments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gray - colored clayey limestone</td>
<td>Echinoderm's, Ostracoda's shell fragments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gray - colored clayey limestone</td>
<td>Cernusia, Echinoderm's, Bulimina, Radiolaria, Echinoderm's and Ostracoda's shell fragments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gray - colored pelletarite</td>
<td>Echinoderm's shell fragments</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Beige - colored biomicrite</td>
<td>Echinoderm's shell fragments</td>
</tr>
</tbody>
</table>

Figure 18: Değirmenköy Hill Measured Stratigraphic Section
underlying Echinoidea-bearing limestones. Upper beds are entirely composed of clayey limestones.

![Lithological triangle diagram of the Değirmenkızı Hill Section](image)

Figure 19: Lithological triangle diagram of the Değirmenkızı Hill Section

The assumption that these rocks were formed in a shallow sea environment and that the Echinoidea-bearing limestones were formed on a submarine platform, suggests the presence of a shallow as well as laterally extending sea-bottom. This shallowness is even more marked and obvious in other sections. Limestone alternations observed here are not in contrast with this view. Although the *Calpionella-Tintinnopsella* fauna assemblage should indicate the presence of a deep sea, the limited number of species, in fact, lead us to assume that these were transported to the area. Fauna thus transported laterally, do not cause any difference in the stratigraphical horizon. On the basis of the biozone, which contains the above-mentioned fauna a Berriasian-Valanginian age is assigned to these horizons.

**ALACATEPE MEASURED STRATIGRAPHIC SECTION**

This section was measured to the north of Nallihan on the Alaca Hill; its total thickness is 720 meters (Figure 20), with thicknesses of beds varying between 2 cm to 75 cm, the trend of the section is N 288°. From the base up, for 373 meters, the beds strike and dip N 50° E and 30° NW, respectively, while in the upper parts of the section the strike of these beds is N 50° W and
<table>
<thead>
<tr>
<th>System</th>
<th>Subsystem</th>
<th>Stage</th>
<th>Lithology</th>
<th>Description</th>
<th>Fauna</th>
</tr>
</thead>
</table>
| CRETACEOUS | LOWER CRETACEOUS | Thanetian Formation (720 meters) | Beige colored, clayey limestone | Nannocoma columni, N. globulus, Radiolaria, Spongiata spicules | Fauna
| | | | Beige colored, biomicrite | Nannocoma columni, N. globulus, Radiolaria, Spongiata spicules, Ostracoda's shell fragments | |

Figure 20: Alacatepe Measured Stratigraphic Section
the dip 50° NE. No distinct macrolithological differences can be seen in these beds due to intensive fracturing and cracking. The entire section consists of beige-colored, closely packed, compact biomicritic limestones containing numerous calcite veinlets intersecting each other in various directions.

Thin section consist of heterogenous and gel textured biomicrites composed of pyrite, limonitized hematite, angular quartz grains and subordinate chlorite and glauconite.

Uniformity observed in sedimentation shows that the level of sea bottom did not change during the sedimentation process and that the ratio between the materials transported to the area and the subsidence is roughly equal. The beds from which samples were taken, were deposited in a sublittoral–neritic environment, only a few hundreds of meters off the coastline. Spongiota spicules frequently observed in thin sections, indicate the presence of a nearby bionome where Spongiota lived; thus showing the domination of warmsea environment. In the basement, various examples of Miliolidae and Buliminidae families, as well as shell fragments of Textularia, Radiolaria, Ostracoda and Echinoidea were found. In the upper parts; Nannoconus colomi (De Lapparent), Nannoconus globulus Bronnimann associations were found. These species, found very abundant in the upper parts, constitute the Nannoconus biozone, and based on it, Neocomian-Barremian age is assigned to this horizon.

SİVRİTEPE (SV) MEASURED STRATIGRAPHIC SECTION

In this section, striking N 50°, 4.5 km North of Nallihan, beige colored, compact, closely packed biomicritic limestones, containing calcite veinlets intersect each other (Figure 21). Thin sections are represented by biomicritic limestones having a heterogenous gelly texture and containing pyrite, limonitized hematite and subordinate quartz. Limestones contain abundant Spongiota spicules and Ostracoda shell fragments.

Results obtained from the residual analysis are as follows: 75.1–86.8 % CaCO₃, 9.4 – 14.7 % clay and 3.8 – 10.3 % sand (Figure 22). Microfauna such as Bulimina, Robulus, Nodosaria and Cor-
<table>
<thead>
<tr>
<th>Era</th>
<th>System</th>
<th>Sub-system</th>
<th>Stage</th>
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<td>CRETACEOUS</td>
<td>Lower</td>
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<td>Nalihan Formation</td>
<td>Calcareous Clay</td>
<td>Beige - colored biomicrite</td>
<td>Cornuspira, Spongiata spicules, Ostracoda shell fragments</td>
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<td></td>
<td></td>
<td>Cretaceous</td>
<td></td>
<td></td>
<td></td>
<td>Beige - colored biomicrite</td>
<td>Robulus, Nodosaria, Duliminidae, Spongiata spicules, Ostracoda shell fragments</td>
</tr>
</tbody>
</table>

Figure 21 Sivritepe (Sv) Measured Stratigraphic Section
*nuspira*, having no biostratigraphical importance, were discovered in these beds.

![Diagram](image)

Figure 22: Lithological (triangle) diagram of the Sivritepe (Sv) Section

The so-called Bozyaka Formation can be seen the end of this profile. Bozyaka Formation, which is conformable with the Nallihan Formation, differs from it in view of the lithological, chronostratigraphical features and the fossil fauna contained. The following profiles are taken in this formation:

**MAHMUTGÖBEDİ TEPE (Mg,) MEASURED STRATIGRAPHIC SECTION**

This section measured on the flanks of the Yenibozyaka village is 360 meters thick and strikes N 325 ° (Figure 23). Samples collected are characteristically gray, gray - to - beige- colored and are represented by closely consolidated, compact sandy calcareous clays, calcareous clays, calcareous sandstones and fine-grained sandstones (Pettijohn 1949, 1957). Clayey sands, and fine grained sandstones occur in the basal part.

Results obtained from the residual analysis are as follows: 36.8–72.8 % sand, 22.1–29.5 % CaCO₃, 5–15.1 % clay (Figure 24). Sands are composed of angular quartz grains (0.05 × 0.09 – 0.18 × 0.29 mm), subordinate feldspar, mica scales and altered green minerals. Calcareous clay and sandy-calcareous clays over-
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<td>calcareous clayey sand</td>
<td>Globotruncana arca,</td>
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<td></td>
<td></td>
<td>Pseudotruncana, Nodosaria,</td>
</tr>
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<td></td>
<td></td>
<td>Nodosaria</td>
</tr>
<tr>
<td></td>
<td>Gray-beige colored</td>
<td>fine-grained sandstone</td>
<td>Ostracod's shell fragments</td>
</tr>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Gray colored</td>
<td>calcareous clayey sand</td>
<td>Haedergerella planispira,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Marcosella, Bullina,</td>
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<td></td>
<td></td>
<td></td>
<td>Anomalina, Chitinoidea</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Gray colored</td>
<td>calcareous clay</td>
<td>Haedergerella planispira,</td>
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<td>Marcusella, Bullina,</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Gray colored</td>
<td>fine-grained sandstone</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Gray, gray green</td>
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<td>Globotruncana lapparantii,</td>
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<td></td>
<td></td>
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<td>G. arca, Haedergerella</td>
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<td></td>
<td>planispira, Pseudotruncana,</td>
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<td>Bullina, Chitinoidea,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Anomalina</td>
</tr>
</tbody>
</table>

Figure 23: Mahmutgöbedi (Mg,) Measured Stratigraphic Section
lie this series. Results of the residual analysis are as follows: 30.6 – 61 % clay, 32.4 – 35.2 % CaCO₃, 5–34.2 % sand. Sands are composed of angular quartz grains (0.01 × 0.015 – 0.12 × 0.09 mm), subordinate tourmaline and kaolinized feldspar. The variations in the ratio of arenite contained within the sequence, as much as 360 meters thick, shows that the transportation from the continents continued throughout the sedimentation process.

Figure 24: Lithological triangle diagram of the Mahmutgöbedi (Mg.) Section

Thus it is assumed that the distance to the continent did not change and that the bottom of the sedimentation basin subsided uniformly. It is further assumed that the ratio between the subsidence and the transportation from the nearby continent was equal. In this basin, where, as we have already pointed out, the shallowness was maintained, no important environmental changes can be observed apart from the variations in the ratio of the limestones, clays and sands. This assumption is further supported by the distribution of bentonic and pelagic foraminifera discovered in this unit; these are:

Globotruncana arca (Cushman)
Globotruncana lapparenti Brotzen
Globotruncana bulloides Vogler
Hedbergella planispira (Tappan)
Allomorphina trigona Reuss
Bathysiphon sp.
Spiroplectammina sp.
Clavulinoides sp.
Marssonella sp.
Robulus sp.
Bulimina sp.
Bolivina sn.
Nodosaria sp.
Anomalina sp.
Lagenia sp.
Cibicides sp.
Lenticulana sp.
Stensiöina sp.
Heterohelix sp.
Ostracoda sp.

On the basis of the above-mentioned Foraminifera, which compose Globotruncanana lapparenti biozone in the lower part and Globotruncanana lapparenti-Hedbergella biozone in the upper part, a Turonian-Santonian-Campanian age is assigned to this section. It was, however, impossible to determine the stage of Turonian where this section began due to the lack of Rotalipora which otherwise should be present.

MAH MUTGÖBEDI (Mg.) MEASURED STRATIGRAPHIC SECTION

This section, measured from Mahmutgöbedi Hill towards north, has a total thickness of 950 meters (Figure 25), and (from bottom to top) consists of grayish-green and gray-colored, compact, clayey-sandy limestones, calcareous clays, sandy calcareous clays and calcareous clayey sands.

The first 60 meters from the bottom upwards consist of clayey-sandy limestones. The residual analysis gave the following results: 30-32.5 % clay, 40-51.4 % CaCO₃ and 15-17.8 % sand (Figure 26).
<table>
<thead>
<tr>
<th>System</th>
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<th>Lithology</th>
<th>Description</th>
<th>Fauna</th>
</tr>
</thead>
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<td>Meso C</td>
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<td>Kephalus</td>
<td>Dark - grey-colored sandy calcareous clay</td>
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<td>Bathysiphon, Bullina, Ostracoda, Lamellibranchiata, Gastropoda, Micraster</td>
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<td></td>
<td></td>
<td>Gray - colored calcareous clayey sand</td>
<td></td>
<td>Bathysiphon, Clavulinoides, Nodosaria, Bullina, Sponges, Quinqueloculina</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gray-colored calcareous sandy clay</td>
<td></td>
<td>Bathysiphon, Prionia, Bullina, Globotruncana sp., Lamellibranchiata, Ostracoda</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Gray-colored sandy calcareous clay</td>
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<td>Globotruncana constricta, Bathysiphon, Clavulinoides</td>
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<td>Gray-colored sandy calcareous clay</td>
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<td>Globotruncana stuartii, G. gesseri, Bolivinidae, B. decoratus, Spiroplectammina, Bullina, Heterorbis, Cibicides</td>
</tr>
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<td>Gray-green colored calcareous clay</td>
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<td>G. stuartii, G. stuartiformis, G. arca</td>
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<td></td>
<td>Green-gray colored calcareous clay</td>
<td></td>
<td>Hedbergella planispi, clayey sandy limestone, ra, G. apparenti</td>
</tr>
</tbody>
</table>

Figure 25: Mahmutgöbedi (Mg) Measured Stratigraphic Section

![Lithologidal triangle diagram of the Mahmutgöbedi (Mg) Section](image)

Figure 26: Lithologidal triangle diagram of the Mahmutgöbedi (Mg) Section
Pelagic fauna as well as abundant bentonic Foraminifera, as listed below, were discovered in these limestone beds:

**Globotruncana lapparenti** Brotzen  
**Globotruncana arca** (Cushman)  
**Hedbergella planispira** (Tappan)  
**Marssonella oxytana** (Reuss)  
**Bolivinoides decoratus** (Jones)  
**Bathysiphon** sp.  
**Clavulinoides** sp.  
**Spiroplectammina** sp.  
**Lenticulina** sp.  
**Nodosaria** sp.  
**Lagenia** sp.  
**Bulimina** sp.  
**Cibicides** sp.  
**Anomalina** sp.  
**Heterohelix** sp.

This horizon is overlain by calcereous clays, which characteristicly are gray and grayish-green-colored, compact and fragmental. Residual analysis gave the following average values 66.2 % clay, 21.4 CaCO$_3$ and 12.4 % sand.

Calcereous clays contain also the following bentonic and pelagic fauna:

**Globotruncana arca** (Cushman)  
**Globotruncana stuartii** (De Lapparent)  
**Globotruncana stuartiformis** (Dalbiez)  
**Globotruncana gansseri** Bolli  
**Rotundina ordinaria** Subbotina  
**Marssonella oxytana** (Reuss)  
**Bolivinoides decoratus** (Jones)  
**Bathysiphon** sp.  
**Spiroplectammina** sp.
Clavulinoides sp.
Robulus sp.
Nodosaria sp.
Quinqueloculina sp.
Heterohelix sp.

Sands are continuously transported to the overlying calcareous clays and sedimentation is represented by gray-colored, closely packed and compact angular as well as fragmental sandy-calcareous clays. The following fossils were discovered in these beds:

Globotruncana arca (Cushman)
Globotruncana contusa (Cushman)
Globotruncana gansseri Bolli
Globotruncana stuarti (De Lapparent)
Globotruncana stuartiformis Dalbiez
Rotundina ordinaria Sobbotina
Marssonella oxygana (Reuss)
Bolivinoides decoratus (Jones)
Bathysiphon sp.
Spiroplectammina sp.
Clavulinoides sp.
Robulus sp.
Neoflabellina sp.
Cibicides sp.
Anomalina sp.
Heterohelix sp.

Marked increases recorded in the amount of sands transported to the upper part of the series, caused the subsidence of calcareous and clayey sands. The rocks are gray-colored, compact, closely packed and heterogenous: they show no sorting or orientation. The residual analysis indicated that these rocks are composed of 30.4 – 32.4 % CaCO₃, 47–48.2 % sand and 19.6–20.9 % clay. Sands consist of angular quartz, green minerals, altered felds-
pars and limestone fragments. Although Foraminifera are relatively scarce, some

Marsonella sp.
Lagena sp.
Quinqueloculina sp.
Racemiguembelina su.
Nodosaria sp.
Bulimina sp.

were discovered.

Calcareous and clayey limestones occurring in the uppermost part are in turn overlain by the sandy and calcereous clays, which contain macrofauna such as Lamellibranchiate, Gastropoda, Echinoidea and Ostracoda. Golobotruncana are very widespread within the upper horizons, along with an abundant bentonic foraminifera. Analysis carried out to determine the microfaunal content of the samples collected from the Dereköy area, also supports this viewpoint.

An Orbitoides biozone as well as the underlying Globotruncana stuarti biozone were distinguished in the present profile. Upper Maestrichtian is represented by Orbitoides fauna assemblage due to facies changes taking place in relatively upper parts.

BOZYAKA MEASURED STRATIGRAPHIC SECTION

The present profile was measured between Bozyaka Dere and Dorukkayasi sirti, north of the Bozyaka village (Eski Bozyaka), situated NNE of Nalihan. Profile was taken 650 meters east of İncekez Tepe and has a total thickness of 261 meters (Figure 27).

 Beds at the basal part have characteristically high clay contents; towards upper parts limestone and then sand contents increase, while the uppermost part is generally marked by iron oxide staining. Sediments having relatively high clay contents, are the continuation of the marls which are not included in this profile. Going upward, the limestone and then the sand contents increase. This
<table>
<thead>
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<th>Epoch</th>
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<th>Lithology</th>
<th>Description</th>
<th>Fauna</th>
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<tr>
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<td>Oligocene</td>
<td>Upper</td>
<td>Bozyaka</td>
<td>Gray - colored calcareous clayey sand</td>
<td>Orbitoides sp., Lenticulina, Ostracoda, Gastropoda, Lamellibranchiata</td>
<td></td>
</tr>
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<td></td>
<td>Gray - colored sandy clayey limestone</td>
<td>Orbitoides sp., Lenticulina, Ostracoda, Gastropoda, Lamellibranchiata</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dark gray - colored sandy calcareous clay</td>
<td>Nathyshphon, Ostracoda, Gastropoda</td>
<td></td>
</tr>
<tr>
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<td></td>
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<td></td>
<td>Gray - colored sandstone</td>
<td>Orbitoides sp., Pararotalia, Lathyshphon, Ostracoda, Gastropoda, Lamellibranchiata</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gray - colored sandy calcareous clay</td>
<td>Nariesonella oxyrana, Nathyshphon, Spiroplectamina, Nodosaria, Inoculina, Orbitoides sp.,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gray - colored sandstone</td>
<td>Orbitoides sp.</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Gray - colored sandy calcareous clay</td>
<td>Nariesonella oxyrana, Clavulinoides, Nathyshphon, Spiroplectamina, Lenticulina, Nodosaria, Pentalina, Buliminina, Anomalinia, Lepidines, Cibicides, Bebulina, Ostracoda, shell fragments</td>
<td></td>
</tr>
</tbody>
</table>

Figure 27: Bozyaka Measured Stratigraphic Section

sedimentation sequence indicates a gradual decrease in depth followed by transition to a littoral environment. Indeed the high
content of Fe – oxides in the uppermost part of the sequence, clearly indicate the presence of a littoral lithosome. The distance between the said horizons occurring within the section, when compared with the estimated period of sedimentation process, will show that transition was relatively gradual. The beds occurring in the uppermost part of the profile, measured to the NNE of Nallihan, are distinguished from the underlying beds on the basis of their lithofacies. Thick, gray-colored marls grade into sandy facies at the base of Bozyaka Dere. This sandy unit, in fact, causes some changes in the general lithological classification already made.

Beds contain abundant macro and microfauna, as listed below:

*Marssonella oxygana* (Reuss)
*Bathyysiphon* sp.
*Clavulinoides* sp.
*Spiroplectammina* sp.
*Lenticulina* sp.
*Nodosaria* sp.
*Dentalina* sp.
*Frondicularia* sp.
*Bulimina* sp.
*Eponides* sp.
*Anomalina* sp.
*Cibicides* sp.
*Robulus* sp.
*Orbitoides* sp.
*Inoceramus* sp.
*Lamellibranchiata*
*Gastropoda*

The majority of fauna contained in these beds are represented by bentonic fauna. These are mostly arenaceous shell forms. This discovery further supports the conclusion reached on the basis of the lithological evidence mentioned above. Based on the *Orbitoides gensacicus* Leymerie and *Orbitoides apiculatus* Schlum-
berger a Maestrictian age was assigned to this stratigraphic profile.

**YATAKKEZİ TEPE MEASURED STRATIGRAPHIC SECTION**

This section, measured N 345° at the foothills of Yatakkezi Tepe, 1.5 km north of the Yeni Bozyaka village, has a thickness of 60 meters (Figure 28). Samples were collected from beds striking N 50° E and dipping 30° NW. The sequence consist of conglomerate and sandstone beds, 15–1.20 m thick, composed of quartz, mica, igneous rock fragments, and limestones. Gray-colored, compact, closely consolidated and fine-grained quartzitic sandstones occur in the basement. Neither orientation, nor sorting can be seen in thin sections. Abundant macro- and microfauna were discovered within the quartz-rich beds containing green minerals, iron oxides, and limestone fragments. The following fossils were identified:

- *Orbitoides apiculatus* Schlumberger
- *Orbitoides erdagi* Meriç
- *Chlamys sparsinodosus* Zittel
- *Cardium (Granocardium) productum* (Sowerby)
- *Exogyra* sp.
- *Pachydiscus* sp.
- *Turritella* sp.
- *Panopea* sp.
- *Actoenella* su.
- *Inoceramus* sp.
- *Rudist* sp.
- *Hemiaster* sp.

This horizon is overlain by fine-grained sandstones. The analysis of samples collected from this bed showed that their quartz content is relatively lower compared to the underlying beds; this bed contained the following fauna:

- *Orbitoides apiculatus* Schlumberger
- *Cardium (Granocardium) productum* (Sowerby)
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<th>Sub-system</th>
<th>Stage</th>
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<td>Mesozoic</td>
<td>Cretaceous</td>
<td>Upper Cretaceous</td>
<td>Maestrichtian</td>
<td>Dozyaka Formation</td>
<td>CaCO₃ Clay Sand</td>
<td>Gray-colored sandstone, conglomerate</td>
<td>Cardium, Exogyra</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gray-colored conglomerate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gray-colored sandstone</td>
<td>Orbitoides apiculatus, Turritella, Exogyra, Cardium productum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gray-colored sandstone</td>
<td>EDT, O. erdagi, Hallenocyclina</td>
</tr>
</tbody>
</table>

Figure 28: Yatakkezi Measured Stratigraphic Section
Turritella sp.

Exogyra sp.

Coarse-grained conglomerates, gray-colored, compact, closely consolidated limestone pebbles showing neither sorting nor orientation, sandstone pebbles, and igneous pebbles overlie this sandstone unit. No fossils were discovered in these beds. Compact, closely consolidated and coarse-grained sandstones occur in the uppermost part of this section. Only Cardium and Exogyra were discovered here.

In the previously studied sections, unit which were deposited in a shallow sea environment and displayed a continental character of long duration were is established. Here, however, these units are completely converted to sediments of a littoral facies. This is due to a gradual subsidence of the sea bottom which resulted in a quieter environment.

From a biostratigraphical viewpoint, microfauna discovered in these beds are normally characteristic of sublittoral and neritic bionomies, and their transportation to littoral sediments is natural. Thus the presence of very thick-shelled Lamellibranchiata is normal for this environment. On the basis of the forms described above a Maestrichtian age is assigned to this horizon.

YUMRUKAYA MEASURED STRATIGRAPHIC SECTION

Yumrukaya section measured at Yumrukaya Hill, NW of Bozkaya village, strikes in a N – S direction and has a thickness of 78 meters (Figure 29). Samples were collected from alternating sandstone and conglomerate beds striking N 85° W and dipping 23° N.

Quartzitic sandstones, predominantly red-to-buff-colored, compact and showing neither orientation nor sorting, occur in the basal part. Abundant angular quartz grains, subordinate feldspars, limestone fragments, pyrites, as well as opaque and green minerals, cemented by limestone are observed in thin sections. Residual analysis of the samples collected from these beds gave the following results: 49.7 % CaCO₃, 13.8 % clay and 37.5 %
<table>
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<td>Sandy clay</td>
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<td>Red-colored</td>
<td>Sandstone</td>
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<td>Red-colored</td>
<td>Sandstone</td>
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</tr>
</tbody>
</table>

Figure 29: Yumrukaya Measured Stratigraphic Section
sand. Overlying this horizon, red - colored, compact, and closely consolidated conglomerate pebbles, containing Lamellibranchiata, were observed.

Overlying these conglomerates occur loosely-consolidated sandstones where, again, no sorting or orientation can be noted. Residual analysis gave the following results: 28.1 % CaCO₃, 7.7 % clay and 64.2 % sand. Sands are mainly composed of angular quartz grains and subordinate green minerals and feldspars, cemented by a clayey and calcareous matrix. These sandstones are overlain again by another red-colored conglomerate bed, which has identical characteristics with those of the basal conglomerates. The remaining part of the sequence consists of coarse-grained quarzitic sandstones.

Red color observed in this series is due to iron oxides. The following microfauna was identified in the samples collected here:

- Orbitoides apiculatus (Schlumberger)
- Hellenocyclina beotica Reichel
- Siderolites sp.

On the basis of these fossils a Maestrichtian age is assigned to this series.

**ORUÇTEPE MEASURED STRATIGRAPHIC SECTION**

The Oruçtepe section was measured 2 km to the east of Dereköy, on the left bank of Sorgun River, in a N 15° direction; the thickness of this section is 93 meters (Figure 30). It consists of alternations of red and gray-colored sandstones, conglomerates and breccia. These loosely consolidated samples were collected from beds striking N 70° E and dipping 25° NW. Red colored and sandy-calcareous clays occur in the basal part; their residual analysis gave the following results: 49.1 % clay, 18.2 % CaCO₃ and 37.2 % sand (quartz, feldspar and mica). This layer is overlain by a sterile breccia horizon mainly consisting of red-colored angular quartz, feldspar, limestone, biotite and muscovite grains. The upper part of the series, of terminates with alternations of
<table>
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<td></td>
<td></td>
<td>Red - colored sandstone</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Red - colored sandy calcareous clay</td>
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</table>

Figure 30: Oruçtepe Measured Stratigraphic Section
sandstones and conglomerates. These detrital rocks, consisting of various components, overlie the two sections described above. No organic remnants were found within these rocks. Sedimentary rocks, which differ from the underlying Maestrichtian detrital rocks only on the basis of their color, can either be considered as a product of the Cretaceous regression, or assuming a change of facies, interpreted as Paleocene in age.

**NALLIHAN FORMATION**

The present formation is called after Nallhan district located south of the region under investigation. It starts 3 km beyond Nallhan and extends as far as the vicinity of Bozyaka village, situated 10 km further the Nallhan formation covers the area situated within Sheet H26 c1 and extends laterally in the NE-SW direction.

The type section extends from the foothills of Karabelen Tepe to Çırçırpmarı and some sections can be best seen on the right of Sorgun River.

Such characteristic fossil associations as Calpionelle, Tintinnopsella and Nannoconus were found in this formation. These fossils are embedded in the microcrystalline, pseudo-colithic and dolomitic limestones. Limestones described above were deposited in a sublittoral-subneritic environment. Angular quartz grains, contained in these limestones in subordinate amounts, indicate that the sediments are of continental origin and were transported here from a short distance pseudo-oolithic limestones, frequently observed in these beds, indicate the presence of bioherms and the domination of a warm shallow-sea environment. The basement of the Nalhan limestone formation can not be seen in the area under investigation; its upper part, on the other hand, grades conformably into the overlying Bozyaka formation. This formation occupies extensive areas. Limestones overlying the Kadiköy Paleozoic formation are best exposed along the road between Duvutoğlan-Duduş villages, located further to the NE. The formation, characterized by a steep topography, is Titonian-Albian in age. The name assigned to this formation is proposed by the writer of the present paper.
BOZYAKA FORMATION

This formation is called after the Bozyaka village located to the north of the area under investigation. This village is situated 11 km north of Nalhhan, on the Nalhhan-Mudurnu road. The Bozyaka formation begins where the Nalhhan formation terminates; it extends for 1400 meters to the north. Its lateral extension is in the NE-SW direction.

The type section was measured from Mahmutgöbedi Tepe towards the north. Good sections can also be taken in the vicinity of Dereköy.

Pelagic and bentonic foraminifera, as well as Lamellibranchiata, Gastropoda and Ammonoidea forms are contained in the Bozyaka formation, which mainly consists of marls and sandstones, deposited in a littoral-sublittoral-subneritic environment.

The basement of the Bozyaka formation overlies concordantly the Nalhhan formation, while the upper part is bordered by Paleocene sandstones and conglomerates, showing a continuous deposition. Bozyaka formation, which occupies extensive areas in the region under investigation, is assigned a Turonian-Maestrichtian age.

CONCLUSION

Conclusions drawn from the “Stratigraphic studies of the area located between Nalhhan and Bozyaka villages along the sorgun River” dealt in detail in the present paper, can be summarized as follows:

Stratigraphical features of the area, as a whole could not be studied in one section due to difficulties arising from tectonics and surface cover. Thus, a total of 19 stratigraphic profiles were taken on both banks of the Sorgun River. As a result of these studies, the following geological sequence (from older to younger formations) was determined:

“NALLIHA FORMATION”

The relationship between the Nalhhan Formation, the oldest unit within the area under investigation, and the underlying formations could not be proved. It was, however, established
that the present formation is unconformable with Paleozoic formation further to the east, outside our area.

The basement of Nallihan formation consists of biomicrite and micritic limestones, overlain by littoral-subneritic sediments composed of biomicrite, dolomitic limestone, intrabiosparite and sandy micrites, which were considered to be pelagic limestones during previous investigations. The uniformity observed in their lithological characteristics prevented the writer to group them into members.

The fault zone observed along Demirkapi Dere bisects the Nallihan formation. Lithological as well as faunal features of the sediments also contribute to the understanding of the geological setting of this fault.

Biozone described below and determined for the first time within the limestones, were taken as a basis in the chronostratigraphical evaluations:

- 5 — 11. Nannoconus biozone
- 4 — 1. Nannoconus biozone
- 3 — Tintinnopsis biozone
- 2 — Calpionella—Tintinnopsis biozone
- 1 — Calpionella biozone


titonian

“Bozyaka Formation”

The overlying Bozyaka formation, grading both laterally and vertically into the Nallihan formation has a total thickness of 1300 meters and consists of marls. Carbonate, clay and sand amounts, although stable within the gray-green-colored marls occupying lower parts, shows a wide range of variation in relatively upper parts. The varying content of arenite within the whole sequence, also indicates that a continuous transportation from the continents took place during the sedimentation process. Marls contain limestone lenses characterized by the Orbitoides media biozone, in contrast to the Globotruncanua stuarti biozone observed in the marls. Benthonic and pelagic foraminifera as well as other macrofauna, are discovered in these beds. Detailed investi-
gations carried out on the pelagic foraminifera resulted in the
determination of the following three biozones, namely:

Globotruncana stuarti biozone
Hedbergella — Globotruncana lappa-renti biozone
Globotruncana lappanrenti biozone

Maestrichtian Turonian-Campanian

Maestrichtian formations are directly overlain by the red-co-
red sandstones without any indication to a stratigraphical gap or
discontinuity of deposition, These beds are considered to be Pa-
leocene and no fossils were found in them.

ÖZET

“Sorgun Çayı boyunca Nalhhan-Bozyaka köyü arasındaki sahanın stratigrafi
etüdü” adlı bu çalışmada bölenin tektoniği ve yüzey örtüsü dolayısıyla stratigrafisini
bir tek kesit boyunca inceleme mümkün olmamıştır. Bu nedenle Sorgun çayının sağ
ve sol yanınaclarında 19 stratigrafi kesiti ölçülmü yapılmıştır. Bu çalışmalar sonucu ist-
tifin yazılıdan gence doğru sıralanmış şöyledir:

“Nalhhan Formasyonu”

Bölgenizde en yaşı birim olan “Nalhhan Formasyonunun” daha eski formasyonlar
üzerine nasıl geldiği görülmemektedir. Fakat inceleme sahasının dışında doğuda, Paleo-
zok ile uyumuz olduğu saştanmıştır.

Bu formasyonun tabanı mikrit ve biomikritli kalkerlerle başlar. Üst seviyelerde
biomikrit, dolomitinli kalker, intrabiosparit, kumlu mikrit istifi görülür. Bu tortullar
litoral ve suberitik ortam tortullandır.

Bu kalkerler içinde etüd sahamesiz ilk defa tesbit ettigimiz aşağıdaki biozonlar
kronostratigrafik değerlendirmelerimizde esas teşkil etmişlerdir.

5—11. Nannoconus biyozonu
4—1. Nannoconus biyozonu
3— Tintinnopsis biyozonu
2— Calpionella - Tintinnopsis biyozonu
1— Calpionella biyozonu

Apsien - Albien
Berriasien - Barremien
Titonien

“Bozyaka Formasyonu”

Nalhhan formasyonu üzerine yanal ve dikey geçişlerle 1300 m. kalınlkta marnlar
gelir. Gri yeşil renkl里的 marnlarda tabandan itibaren karbonat, kil ve kum oranları belirli
isede üst seviyelerde dalgalanmalar gösterir. Bu istif içerişinde değişim arenit mikta-
rada tortulasma boyunca sürekli karasal gelentiyi belirtil. Marn tortulları içinde kum
taşı mekekleri mevcut olup, bu mekeklerde, marnlardaki Globotruncana stuarti bi-
yozonuna karşı Orbitoides media biyozonu yer almaktadır. Bu tortullar içindeki Pelajık foraminiferalar aşağıdaki üç biyozonu oluşturur.

\[
\begin{align*}
\text{Globotruncana stuarti biyozonu} & \quad \text{Maestrichten} \\
\text{Hedbergella-Globotruncana lapparenti biyozonu} & \quad \text{Turonien - Kampanien} \\
\text{Globotruncana lapparenti biyozonu} & \quad \text{Turonien - Kampanien}
\end{align*}
\]

Mestrihtien tortullar üzerinde herhangi bir tortullama kesintisi olmaksızın kırmızı renkli kum taşları gelir. Paleosen yaşlı olarak kabul edilen bu seviyelerde herhangi bir fosil izine rastlanmamıştır.
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Barr, F. T. 1972: Cretaceous biostratigraphy and planktonic Foraminifera of Libya. Micropal. vol. 18, n. 1, p. 1–46


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Plate I

Figure 1 — 2 Equatorial and Axial sections of Nannoconus forms, X 600

3 — 6 Nannoconus colomi (DE’LAPPARENT) × 2400
    Nannoconus globulus BRONNIMANN × 2400
Plate II

Figure 1 — 9 Calpionella alpina LORENZ × 250
Figure 10 — 11 Tintinopsella cadischiana COLOM × 250
Figure 12 Calpionellites darderi (COLOM) × 250
Plate II
Plate III

Figure 1 — 2 Culpionella elliptica CADISCH × 250

Figure 3 — 12 Tintinnopsella carpathica (MURGEANU And FILIPESCU) × 250
Plate IV

Figure 1 — 12 Tintinnopsis carpathica (MURGEANU and FILIPESCU) × 250
Plate V

Figure 1 — 12 Axial and tangential sections of Hedbergella trochoidea (GANDOLFI)
\times 150
Plate V
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<th>Mesozoik</th>
<th>Lithology</th>
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</tr>
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<td>Limestone</td>
<td>Hynerella - Globotruncanum laparenti biozone</td>
</tr>
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<td>Marl</td>
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<td></td>
<td>Limestone</td>
<td>Neomicrocystites - Globotruncanum laparenti biozone</td>
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</tbody>
</table>

Composite column section of the area between Nallihan and Bozvaka.
COMPOSITE CROSS SECTION OF THE AREA BETWEEN YATAKKEZI AND KARABELEN
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