International Journal of Geography and Geology
2018 Vol. 7, No. 1, pp. 1-13
ISSN(e): 2305-7041
ISSN(p): 2306-9872
DOI: 10.18488/journal.10.2018.71.1.13

EROSION SURFACES OF THE LAND BETWEEN IZNIK-MEKECE (TURKEY)

Oznur YAZICI[1]

[1]*Karabuk University, Faculty of Letters, Department of Geography, Turkey*
Email: oznuryazici@karabuk.edu.tr

Article History
Received: 26 December 2017
Revised: 18 January 2018
Accepted: 30 January 2018
Published: 8 February 2018

Keywords
Geomorphology
Erosion surfaces
Turkey
North Anatolian Fault Zone.
Iznik-Mekece.

ABSTRACT

The study area begins from the eastern part of the Lake Iznik which is in the southeast of Marmara Region in Northwest Turkey, and extends to Mekece. The area is part of the North Anatolian Fault Line, which has been operating since Miocene. Gemlik Gulf-Iznik Depression-Karadin Trough, and Pamuk Plain are the depression series from west to the east which developed due to the fault. During the cool and rainy periods of the Pleistocene, a part of the depression filled with water and became the Lake Iznik. In this period, there have been level changes on the lake due to the climate oscillations and some lacustrine terraces formed. Main geomorphological units in the study area are; high mountain ranges, high and low plateaus, plains and flat fields. Erosion surfaces, which spread widely in the study area, have been handled and evaluated according to Prof. Dr. Oğuz Erol's method. Erosion surfaces were dated as Lower-Middle Miocene surfaces, Upper Miocene surfaces and Pliocene surfaces by applying Erol's 'Relation Method Between Slopes and Contour Lines'. Some of these surfaces are valuable for the settlement and agriculture because of the small amount of the slopes. It can be said that the research area has a polycyclic feature, and it is in the late youth stage of geomorphologic development.

Contribution/Originality: This paper which is based on the author's PhD thesis titled "The geomorphology of the land between Iznik-Mekece" describes erosion surfaces of the region according to Prof. Dr. Oğuz Erol's 'Relation Method between Slopes and Contour Lines'.

1. INTRODUCTION

The study area in the south-east of the Marmara Region extends from the eastern part of the Lake Iznik to Mekece (Figure 1). The area is part of the North Anatolian Fault Line, which has been operating since Miocene. Gemlik Gulf-Iznik Depression-Karadin Trough, and Pamuk Plain are the depression series from west to the east which developed due to the fault. Lake Iznik, settled in the Iznik Depression, is 85 m above sea level. The lake, which forms the local base level for rivers around it, is about 65 m deep. The Iznik Plain, located to the east of the lake, is an accumulation area of sediment deposited by the streams. From the Iznik Plain to the northeast, it is passed to the low and high plateaus (Figure 2).

The fault that passes through the south of the lake extends to the Mekece in the east. Therefore, it is called as Iznik-Mekece Fault. Barka and Kadinsky-Cade (1988) in the study about strike-slip fault geometries in Turkey, they divided the western section of the North Anatolian Fault Zone into three branches. Also in this study,

according to historical records, it is stated that a great earthquake did not happen on the middle branch of the NAFZ (North Anatolian Fault Zone) for at least 200 years.

Between Mekece and Çerkeşli Pond, the Northern Anatolian Fault's middle branch made a slip of 150 to 200 meters, and was opened towards the Lake Iznik via Karadin Trough (Ak, 2017).

It is suggested that the faulted structures encountered along the middle branch of the North Anatolian Fault Zone (about 150 km from the east of Geyve to the Gemlik Gulf) is formed by check-break basins (Barka and Kuşçu, 1996; Emre *et al*., 1998). In 1999, within the scope of the Iznik Earthquake Mitigation Center connected to Boğaziçi University Kandilli Observatory and Earthquake Research Institute, a geomagnetic field observatory was established within the borders of the Inikli Village of Elbeyli District of Iznik and the activity was carried out in August 2005 in order to increase the sensitivity of geomagnetic studies (Boğaziçi University Kandilli Observatory and Earthquake Research Institute, 2015).

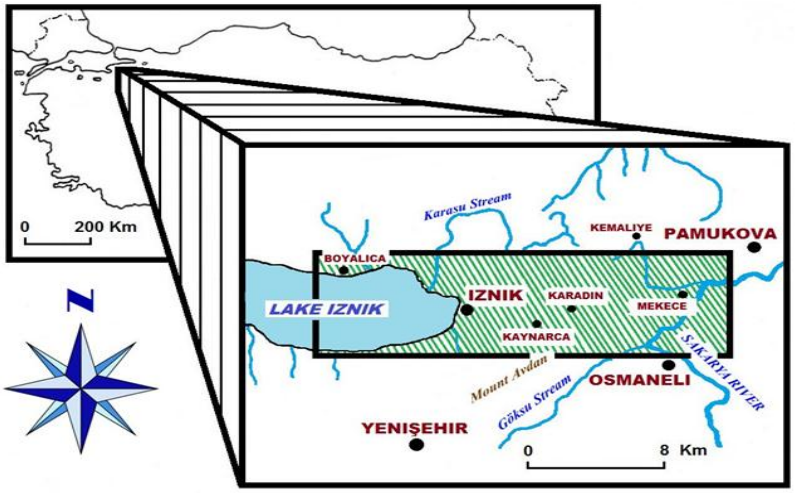


Figure-1. Location map of the study area
Source: General Command of Mapping (Turkey)

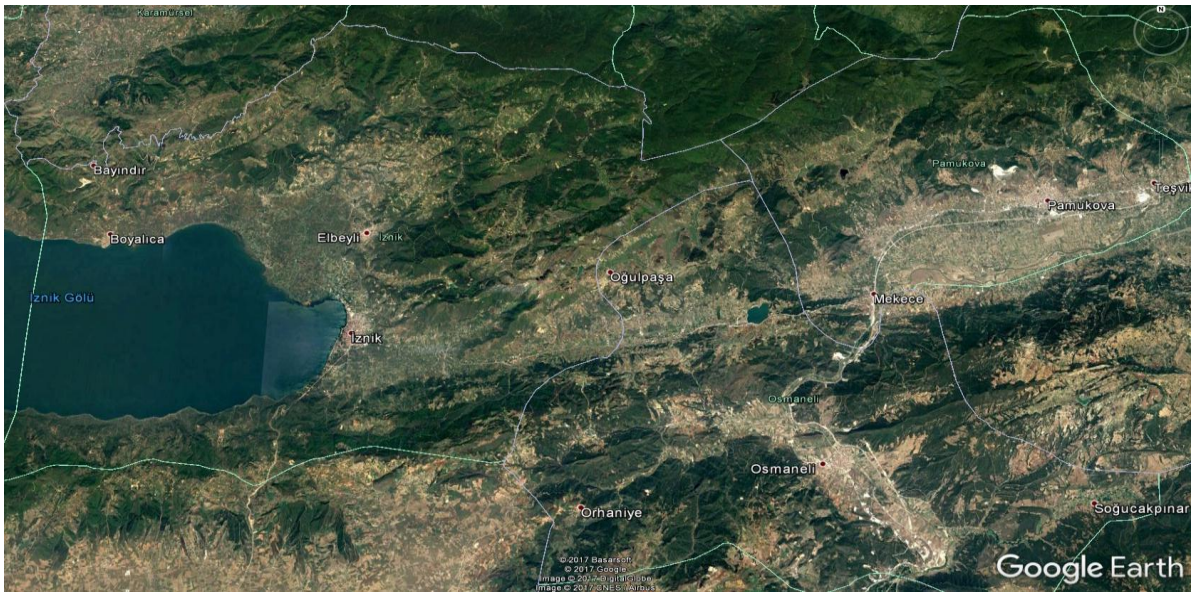


Figure-2. Aerial view of the study area (Google Earth)
Source: Google Earth

The general slope direction of the landscape is to the Lake Iznik in the west and the Sakarya River in the east. Accordingly, the flow direction of the rivers located in the western part of the study area is to the Iznik Plain and to the lake as parallel to the slope of the topography. The narrow trough in the middle section is the water collecting

basin of the rivers in the vicinity. The drainage pattern on the field is generally dandritic and somewhat parallel. Apart from this, samples of centripetal, radial and caged drainage are also observed. The most important stream is the Sakarya River in the east. Other important streams are from west to east; Karasu Stream, Kıran Stream, Ana Stream, Papaz Stream, Göksu Stream and Kızılöz Stream. The highest peak of the study area is Pilâv Hill, which has an elevation of 1261 meters (Yazıcı, 1999).

Climate characteristics include some differences in the north and the south. The Mediterranean climate is seen in southern and southeast of the Lake Iznik. In the north-east of the lake, the climate becomes more terrestrial. The most common type of soil in the region is brown forest soils. These soils extend from the north of Orhaniye to the east, and are located on the high section. In addition, they continue along the southern and southeastern parts of the lake, and they nearly reach the Sakarya River. The eastern part of the Sakarya River is also covered by brown forest soils. There are lime-free brown forest soils in the northwestern part of Mahmudiye, in the south of Dırazali, on the high section in the north, in the east of Adliye. Iznik and Pamuk plains, and the vicinity of the Sakarya River is covered by young alluvial soils carried and stored by the streams. Along the north coast of the lake up to Orhaniye, there are red brown Mediterranean soils. Also, colluvial soils are seen around the plains. These are the soils that are deposited on the skirts of the steep slopes, by transporting from short distances because of gravity, surface flow, tributaries, and where the slope decreases.

In terms of natural vegetation, it is seen that the Mediterranean plant community is dominant in general. Vegetation types are depend on climate, altitude and lithology. There are maquis about 500 m from this level the forest area begins. Among the broad-leaved trees, the oaks are prevalent. Different types of pine are visible. While a vegetation distruction is seen in oneside, the otherside Iznik and Adapazarı Forest District Conservancy work out afforestation.

Iznik is the largest settlement place in the study area. The district, which is bound to the province of Bursa, carries traces of various old civilizations established on it. Other places are rural settlements. Some of them are Mekece, Boyalıca, Elbeyli, Dereköy, Karadin, and Ciciler.

The main geomorphological units in the study area can be divided into three groups. These are the 'High Mountainous Sections', which are composed of resistant rocks relative to their environment and show large elevation values. The second geomorphological unit consists of plateau areas. Plateaus are classified as 'High Plateau Areas' and 'Low Plateau Areas'. 'Plains and Valley Floors' are the third geomorphological unit. The rivers show various drainage patterns. Generally, the rivers which have consequent establishment in young valleys conform to tectonic structure lines in some parts.

The Iznik-Mekece Fault on the North Anatolian Fault Zone (NAFZ) separates the northern plains from the low plateau area in the west and the high plateau area from the east of Kaynarca. It has a major role in present morphological view.

Between 1939-1999, a total of 1100 km of surface faulting occurred between Erzincan and the Sea of Marmara depending on nine major earthquakes that occurred on the NAFZ. Within this series of earthquakes, each seismic segment is the next trigger of the earthquake by transferring stress to the adjacent segment in the west (Ambraseys, 1970; Toksöz *et al.*, 1979; Barka and Kadinsky-Cade, 1988; Stein *et al.*, 1996). During this earthquake migration, right-lateral displacements varying between 1.5-7.5 m have been observed along the fault (Ketin, 1969; Öztürk *et al.*, 1985; Koçyiğit, 1989; Barka, 1993). Ketin (1976) determined that the beginning of the rightward slip along the North Anatolian Fault (age of fault) most likely came to the Upper Miocene (8-10 million years ago), but certainly to the Early Pliocene (5-10 million years ago). Behavior and fault geometry of the North Anatolian Fault in the Marmara Sea, earthquake occurrence characteristics differ from the observed pure characteristics of the North Anatolian Fault on overland (Kalafat, 2009). The length of the Iznik-Mekece Fault, which caused the formation of the Iznik Depression, is about 50 km.

2. MATERIAL AND METHOD

In this study, the site, which contains old and new landforms together, has been dealt with in order to identify and date the erosion surfaces. For this aim, it was carried out of literature review, office work, mapping, and field studies.

In the research area, the erosion surfaces has developed in stages. These are slightly sloped towards the low floors and plains. Bare steep slopes have gully erosion showing current shaping.

'Relation Method Between Slopes and Contour Lines' developed by Prof. Dr. Erol (1993) was used in the determination and aging of the erosion surfaces. This method is based on the principle of showing flats and slopes on morphometry map prepared by using topography maps. Correlations were made between the extracted profiles of the study area; the ones that match each other are grouped among themselves and dated from the old to the young (Figures 3 and 4). Each elevation stage is symbolized with a different color and the morphometry map is aged with overlapping profiles. When this aging is carried out, the types, characteristics and ages of the geological formations consisting of the surface are taken into consideration. Finally, the map prepared for called as 'Map of Erosion Surfaces' (Figure 5).

3. EROSION SURFACES IN THE RESEARCH AREA

The erosion surfaces identified in the research area will be described below from old to young.

3.1. Lower-Middle Miocene Erosion Surfaces

The Lower-Middle Miocene surfaces forming the uppermost stage of the erosion surfaces in the study area are located in mountainous areas that make high relief. These are surfaces separated from each other by the river valleys, usually with steep slopes. Elevations of the Lower-Middle Miocene surfaces carrying the erosional surface character due to the cuts of the Cretaceous, Jurassic and Paleozoic formations vary between 700-1261 m.

The Lower-Middle Miocene surfaces, which constitute the high section of the area that is under the influence of a hot-marine climate in the Miocene, continued to form due to the effects of mild tectonic movements till the middle of this period and they have a wavy surface appearance.

In the east of Sansarak, which is located on the Kiremitlik Stream basin flatness and has a height of 750 m, erosion surfaces with steep slopes are observed. In this section, an erosion surface has developed including Çukureyrek Hill that has 1129 m height, which is composed of Jurassic sediments resistant to erosion.

The surface, starting from 1000 m in the south and reaching 1100 m in the central part, descends again to the tributaries of the Yongalık Ridge, and goes down to 1030 m. On the south-west edge of the same surface approaching to the Kısıklar Stream is 1050 m. The Yongalık Ridge descending from 1050 m to 800 m is connected to this surface. The elevation of the ridge decreases to the northwest. In the west of Yongalık Ridge, there is a second ridge on which Devyatağı Hill (1100 m) is located.

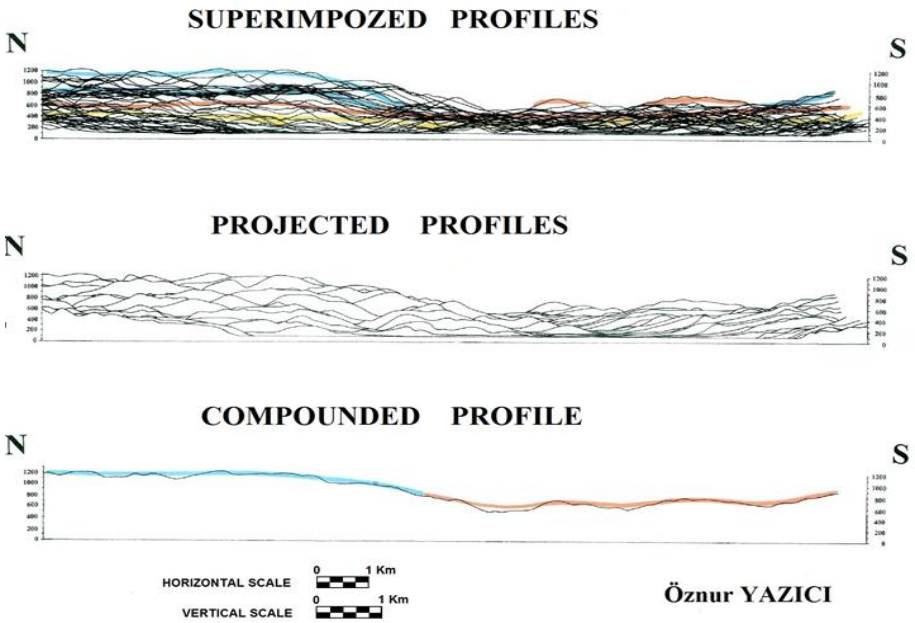


Figure-3. Superimposed, projected, and compounded topographic profiles in the North-South direction between Iznik and Mekece
Source: General Command of Mapping (Turkey)

The stage which is included in Gâvuralan Hill (1200 m) among the surface pieces in the south of the Elmalı show a wavy feature between levels of 950-1200 m. On the east of this surface consisting of limestone and dolomite, there is a small erosion surface with a level difference of 50 m between 1110 and 1160 m. Further, a very steep slope descends to the plain. The rocks which generates to the ridge's structure are ophiolitic schists that resist erosion.

In the east of Elmalı, there is a high erosion surface which involve in Aluç Hill (1210 m), and Karakaya Hill (1222 m). The southern part of this wavy surface is bifurcated at elevation levels of 1160 and 1200 m, and extends towards to the southern plain as three ridges. In the south of Kürdüngöbet Ridge, there is a surface piece which descending from 1000 m to 900 m and rising Ayıini Hill (1243 m) on have steep slopes and the level difference is 90 m. On the north-western side of Ayıini Hill, which is formed by the Jurassic sediments, there is a small erosion surface fragment at 950-1030 m.

Further south, the section that is formed by the limestones and dolomites that has 1261 m high Pilâv Hill, which is the highest peak of this study area is located. On this high relief, which is quite steep slope, there is a broad erosion surface.

This flatness takes place on 1150 m to the north of Pilâv Hill, 1200 m to the north of Kocapınar Hill, 1100 m to the west of the Kayapınar Stream, 1000 m to the north of the Söğütalan Stream, 1190 m to the south of Tekke Hill, 1100 m to the south of the Karkuyuları Stream, and 1150 m to the north of the Karkuyuları Stream. This wavy erosion surface which covers a wide area is the place where most of the streams surrounding it are born.

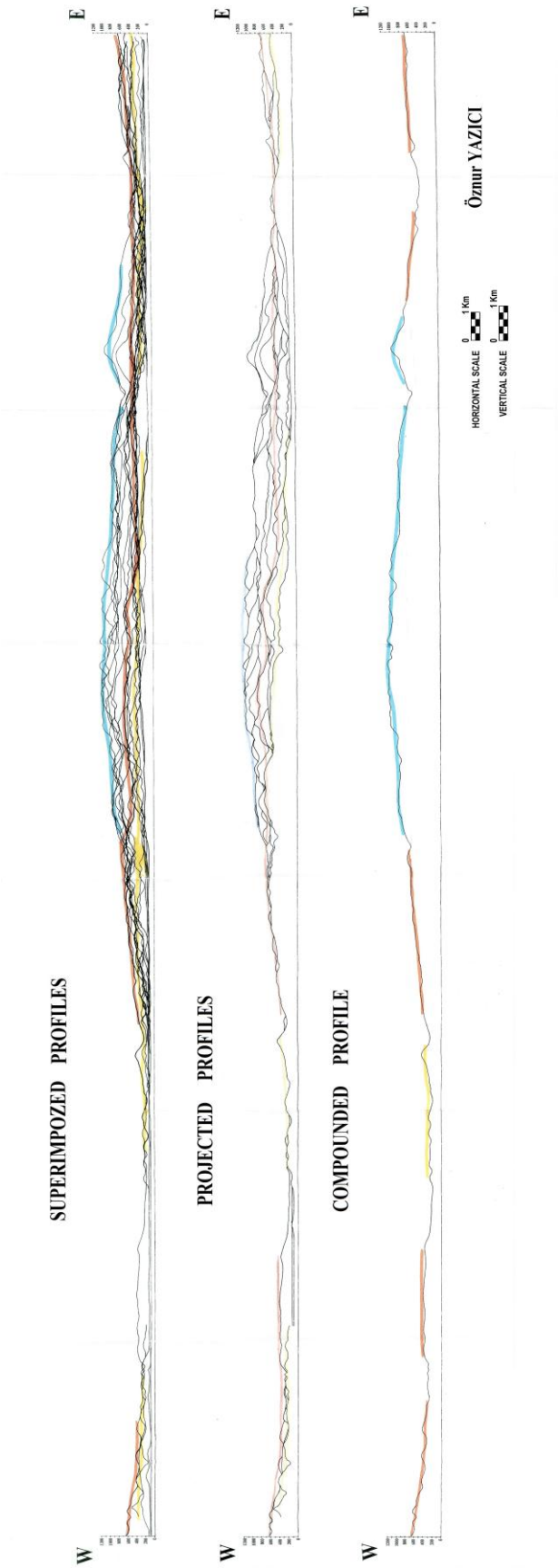


Figure-4. Superimposed, projected, and compounded topographic profiles in the West-East direction between Iznik and Mekece

Source: General Command of Mapping (Turkey)

The surface located at 1100 m where Ihsaniye is founded is steeper in the south and southeast parts. Asymmetry caused by lithological differences can be attributed to the fact that the metamorphic rocks in the south are more resistant than the sandstones in the north.

On the sandstones around this village, it is observed that plenty of cliffs which are residuals of differential erosion and young gullies which are evidences of current morphodinamism. Hillsides were exposed to erosion by carving due to the sudden precipitations that caused sheetfloods. This area is a very bare in terms of vegetation.

In the west of Oğulpaşa, there is an erosion surface decreasing to the northeast between 830-860 m. Doruk Hill at 841 m is on this surface. If it is continue from this Upper Cretaceous flysch formations to towards the northeast direction, it is reached the Adliye Plain. Another surface which includes Hisarcık Village on extends between 870-910 m. In this area, there is one more surface segment which Koca Hill (943 m) is risen on. This surface is at 900 m to the north of Koca Hill, at 900 m near the Kovancı Stream, and at 780 m to the Benli District. Kovancı Stream that flows towards the north takes its source from here.

The high section to the south of Yenişerefiye has been formed by Jurassic limestones. Avdan Hill on the relief where the metamorphic rocks of Permian are exposed is located at altitude of 926 m. The presence of a fault line extending in the southwest-northeast direction may have played a role in this distinct relief height. The surface that descends from 926 m to 740 m within the study area is aged as Lower-Middle Miocene. The surface segment has a mild incline towards to north-northeast.

3.2. Upper Miocene Erosion Surfaces

Upper Miocene erosion surfaces have been formed under semi-moist conditions in the Tortonian period, and have gained their final form in Messiniyen in the late Upper Miocene under increasingly became drought climatic conditions (Erol, 1983). With the effect of tectonic movements exacerbated in the Upper Miocene, the first major faults occurred and towards the end of the period, the flat relief of the Lower-Middle Miocene was replaced by the sloping skirts which were affected by the arid-semi-arid climate of the Upper Miocene. Their altitudes range from 400 to 700 m.

The surface at the westernmost point of the study area starts from 730 m and descends to 600 m. This surface predominantly consist of Upper Cretaceous flysch and marls. At the east of its, the Ortaburun Ridge that is formed a narrow ridge extends towards southeastward to approximately 500 m.

Lower-Middle Miocene surfaces in the north of the study field are surrounded by the Upper Miocene surfaces. In the north of Gürmüzlü Village, the surface part of Mantarlık Hill (625 m) descends to 600 m. The erosion surface in the east of the Beypınarı Stream rises out of the study area by starting 630 m altitude. The small surface west of Mantarlık Hill, which is formed by recrystallized limestones, is located at 520-530 m.

On the southwest of Alakaya Village, two surface parts of northeast-southwest direction composed of metavolcanic rocks which emerges by metamorphosing of volcanic rocks descend towards Iznik Plain. While the north surface forms an inclined ridge descending from 650 m to 450 m, the south surface is a wider surface which spreads between 400-450 m.

On the northwestern side of Dereköy, a wavy Upper Miocene surface, which contains Aygıran Hill, Dede Hill, and Kel Hill, has developed (Photograph 2, Figure 6).

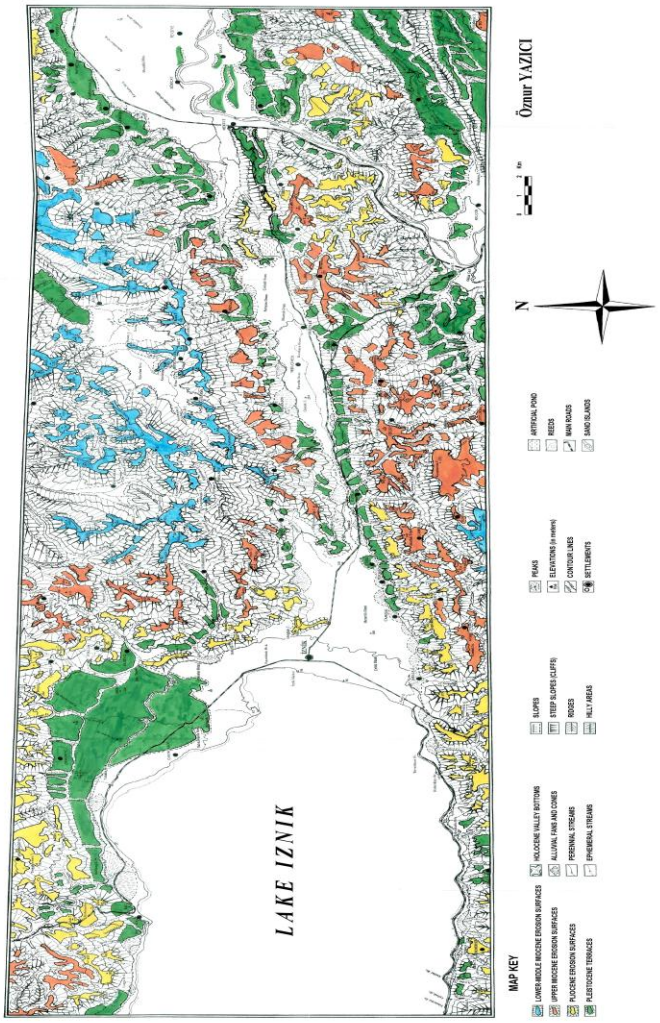
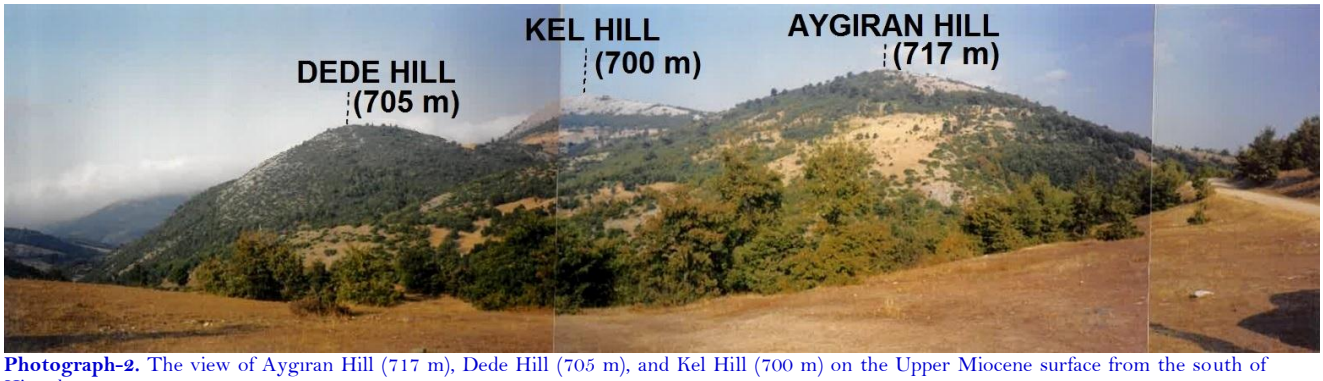


Figure-5. Map of erosion surfaces between Iznik-Mekece
Source: General Command of Mapping (Turkey)

Photograph-1. Differential erosion forms on the surface of the Lower-Middle Miocene east of Ihsaniye



Photograph-2. The view of Aygıran Hill (717 m), Dede Hill (705 m), and Kel Hill (700 m) on the Upper Miocene surface from the south of Hisardere.

Karadin Ridge lies between 450-550 m in the north of Karadin. In the east of this ridge, there is a small surface part which forms from Upper Cretaceous flysch at 470-500 m. In the north of the Karadin Plain, there is a small erosion surface extending elevations of 470-490 m, and a large surface extending elevations of 550 m-650 m. In the vicinity of Karadin, there are many side-by-side alluvial fans that develop due to the decrease of incline.

When it is looked at the southeast part of the Karadin Trough; it is seen that Kumluk Ridge (in approximately 8.4 km southeast of Iznik), which consists of Upper Cretaceous flysch, creates a quite wide and long erosion surface. Nüshetiyeköy is established here. The surface which has a peak of 507 m on starts from 510 m altitude and decreases to 450 m.

The erosion surface which includes in Şerefiye is between 450-470 m. In the south of this village there is a narrow and long flatness. On this surface of 550-620 m levels, there is Yardankaya Hill at 733 m elevation. The hill, composed of recrystallized limestones, retained its elevation. In the south of the Sarısu Stream, there are two ridges extending to the northwest.

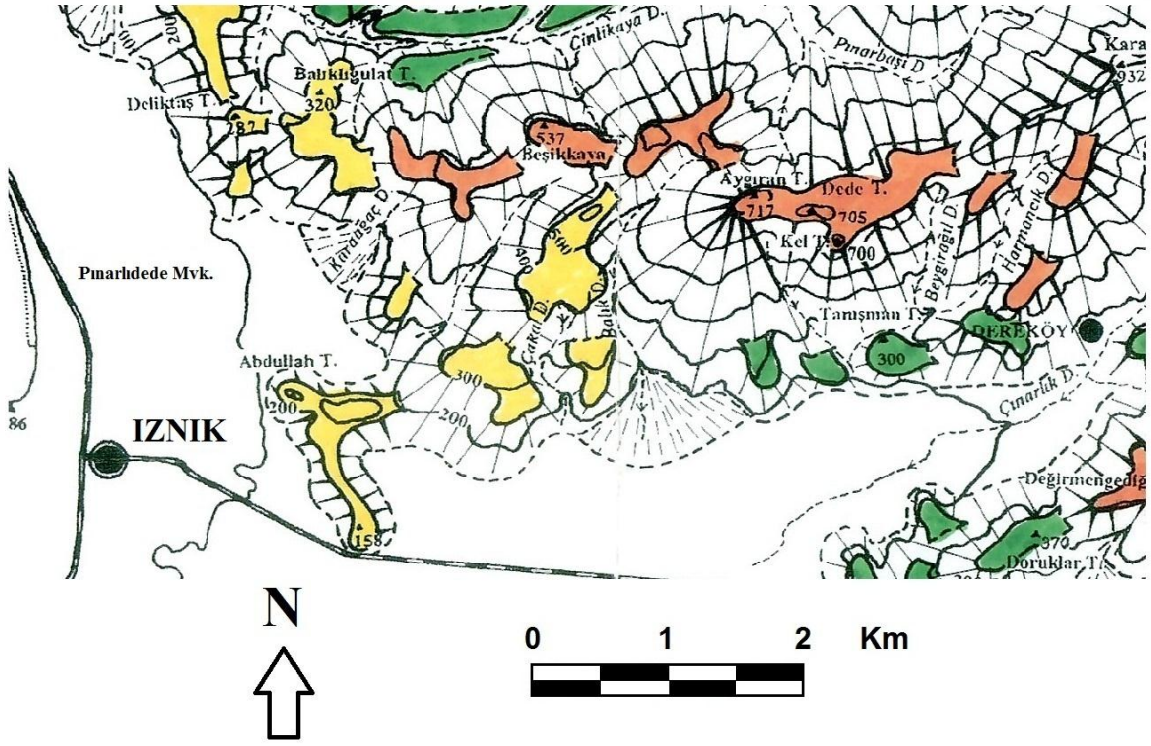


Figure-6. Location of Aygıran Hill (717 m), Dede Hill (705 m), and Kel Hill (700 m).
Source: General Command of Mapping (Turkey) Prepared by Ö. YAZICI

Hacıdağ Hill (821 m) and its surroundings which consist of limestones create a remarkable relief in the study

area. There are various peaks on this wide erosion surface surrounded by 700 m contour line. In addition, Çerkeşli settlement and Günkaya Hill are on the Upper Miocene erosion surfaces. The erosion surface on which Günkaya Hill (506 m) is located extends between 380-400 m, while the elevation in the central part of the surface exceeds 500 m. The surface consisting of Jura formations contains scarped cliffs due to the differential erosion. As to the area in the south of the Içmeler anticlinal axis was affected by tectonic ascending.

There are four surface fragments to the north-west of the Sırakaya Ridge which has various lithologies. The northernmost of these is the largest and the lowest one extending between 400-500 m. The level difference is approximately 100 m. The surface in the south is taken place between 500-600 m, and Bayatgediği Hill (600 m) is located at this surface. Other two small erosion surface parts are observed at 600-620, and at 550-560 m. The Sırakaya Ridge, which is quite long, lie down to the Pamuk Plain as three separate ridges by dividing in the north with the streams of Gök and Kamışlı.

3.3. Pliocene Erosion Surfaces

In Pliocene, on the study area which is a part of the North Anatolian Fault Zone, some depressions developed under the influence of the Iznik-Mekece Fault. A more humid and rainy climate in the Middle Pliocene replaced to the semi-arid and steppe climate of the Lower Pliocene. Consequently, Pliocene erosion surfaces were formed as a result of the accelerated erosion and transport of the rivers. The outlines of the river system in the region were set in this period.

The Pliocene surfaces, which have a chance of spreading in the low plateau areas which provide transition to the plain areas, constitute the third stage (level) on this system. These surfaces, which are located at 130-400 m, show various slope values towards to the plains.

The average elevation of the low plateau area (from north of the Lake Iznik to the east of Iznik) is around 250-300 m altitudes (Photograph 3). The inclined surface, which Conga Hill is located on, is made up of marbles.

There is an alluvial fan with 15-degree where the Karaağaç Stream opens to the plain in the north of Abdullah Hill. If it is continued to the east direction from Abdullah Hill, it is seen that Balık Stream's alluvial fan with 10-degree slope.

Photograph-3. Southwest view of the Iznik Plain from the northeast of Elbeyli. Behind the village, there is a low plateau field where the Pliocene erosion surfaces are found.

The volcanic rocks of Eocene are widespread throughout the southern part of the Iznik-Mekece Fault beginning from the east of Göllüce. Elsewhere, there are sediments of the Jurassic and Upper Cretaceous ages in general. Other than these, there are some Pliocene erosion surfaces in vicinity of Dırazali and Nüshetiyeköy. Horasan Hill is formed of volcanic origined formations.

The average elevation of the low plateau area surrounding the Sakarya River basin and the Pamuk Plain varies between 250-300 m. The highest point of this section with different lithologies is Samanlık Hill which has an elevation of 456 m at east of the river. A wavy erosion flatness lies at 390-430 m north of Çerkeşli Pond. The surface that Göl Hill is on at 427 m is surrounded by 400 m contour line.

The ridge, which has an opportunity of broadening to the west of Şahvarmazköy, which is one of the villages established in the north of the Pamuk Plain, is divided into four sections. All of them has narrow and long appearance, and Duman Hill is located here at 434 m.

It goes out of the study area by starting 280 m in the east and at 300 m in the middle of the erosion surfaces in the north of the Pamuk Plain and Hayrettinköy. Zeytinkaya Hill, which is located on the eastern surface at 345 meters above the sea level, is composed of recrystallized limestones. The small plain in the northeast of the Bacı Stream, which is located at contact of the flysch-metamorphic schist in the western, ranges from 300 to 350 m altitudes, and the level difference is approximately 50 m.

3.4. Pleistocene Terrace Systems

In the study area, the river terraces around the rivers has been formed due to the change of the base level depending on the tectonic uplifts. After the Pleistocene, the Lake Iznik was withdrawn due to the increasingly becoming drought climate. As a result, while lacustrine terraces have been formed in various altitudes, some river valleys are suffered from alluvial drowning. Alluvial fans and cones are one of the Quaternary deposits which consist of the elements of clay, sand and gravel size due to decreasing terrain slope in the regions where the rivers reach the plains from the high places.

The village of Ciciler which is located on the east of the Sakarya River was settled down on a very wide river terrace at 20 m. On the south, Değirmenuçtu Stream, Kayalı Stream, and Büyük Stream which present a dandritic drainage pattern together with their tributaries empty into the Sakarya River.

In the northeast of the Lake Iznik, there are three different terrace levels tilted towards the lake, and showing the previous high levels of the lake. The uppermost level of those is 60 m, the middle one is 15-20 m, and the lowest level is 5 m. According to this, level of the Lake Iznik rose to about 145 m in humid periods due to pluvial oscillations of the Pleistocene. Currently, the Lake Iznik is at 85 m level.

On this lacustrine terrace system, the alluvial fans formed by deposits of the Karasu Stream took a shape of a terrace of alluvial fan by splitting the alluviums that it brought itself. The mutual influence of lacustrine and fluvial processes is dominant on the Iznik Plain. The Pamuk Plain, located in the northeast, is the second largest flatness on the study area after the Iznik Plain.

The Pamuk Plain, narrowing down towards the Papaz Stream valley in the southwest, ends with a narrow valley bottom near the Ahiler. The Sakarya River, which flows to the northeast and afterwards to the east, passes the plain by drawing the meanders. The river that flows by turning to the right sharply in the section where it is merged with the Göksu Stream, continues from the southwest to the northeast into its wide valley. The length of the Sakarya River within the boundaries of the study area is about 18 km, the width varies between 5 m and 30 m.

The Sakarya River, which is surrounded by steep slopes up to Mekece along its valley, heads to the east by drawing wide meanders from the section between Mekece and Ciciler. The old meander scars (oxbow) on the northeast of Bayat and on the southwest of the Fevziye Village show that this large river changed its bed frequently. The Ciciler Dam, built on the Sakarya River in 1976 west of the Ciciler, meets the irrigation needs of the agricultural areas of the surrounding settlements, and controls the river floods even partially.

Trough shaped wide plain in the central part of the study area consists of many small plains. These are; Karadin Plain, Kocakuyu Plain, Hisarcık Plain, Sarıyazı Plain and Çerkeşli Plain.

In the western part, Kıran Stream reaches to the Iznik Plain by flowing from the east to the west as a continuation of the Karanlık Stream which comes from the plateau in the south. Ana Stream shows light meanderings at the bottom of the plain. Its length in the southwest-northeast direction is 7.5 km. The narrowest part of the flatness in the northwestern-southeast direction is about 500 m, and the widest part is about 3 km.

4. GEOMORPHOLOGICAL EVOLUTION AND CONCLUSIONS

Role of tectonism is the dominant effect in landform formation of the study area which locates between Iznik-Mekece. Probably in the Eocene, the study area went up to the sea level and turned into the land. Iznik Depression and Karadin Trough formed due to the influence of Iznik-Mekece Fault as a result of transverse (or diagonal) fracture in the late Pliocene.

Iznik Depression, separated from Gemlik Gulf via Garsak Threshold in the west, and separated from the Pamuk Plain via Karadin Threshold in the east, continued its development during the Quaternary period. In the Pleistocene, tectonic events on a large scale occurred especially along fault lines.

The Iznik-Mekece Fault, which has a pull-apart basin character, caused the formation of fault scarps beginning from the south of Lake Iznik, and was covered by alluvial cones and fans along the route that it follows.

The depression filled with water during cool and rainy periods of the Pleistocene became the Lake Iznik. The lake, which was under the influence of climate fluctuations during this period, was withdrawn three times by pausing due to the drought as a result of negative level changes. Three levels of lacustrine terraces in northeastern of the Lake Iznik proves this withdrawal. Besides, the current level changes in the Holocene provides the formation of beachrocks on the southeast coast of the lake. The Çerkeşli Pond at the west of Mekece is an artificial pond basin formed depending on the Iznik-Mekece Fault.

In the study field, there is three main geomorphologic units which are mountainous high sections, high and low plateaus, and plains. Regions that are composed of more resistant rocks relatively to the surrounding area, and show higher altitudes emerge a significant relief in the study area.

Pilâv Hill and its surrounding high mountainous area, north extensions of Mount Avdan, Hacıdağ Hill and its surroundings; are significant landforms in the field. Plateaus are also included in various altitudes. Generally, the high plateaus are between 400-700, the low plateaus are between 130-400 m.

The most widespread group of landform in the study area is erosion surfaces. Erosion surfaces have been aged as Lower-Medium Miocene surfaces, Upper Miocene surfaces and Pliocene surfaces. Some of them are important in terms of settlement and agriculture because of the low slope values.

River system started establishing in the Pliocene. When it is passed that from the cool-rainy climatic conditions of the Pleistocene to the warmer and drier climatic conditions of Holocene, alluvial drowning has been observed showing last base level changes on the valleys depending on changed alluvion-volume-slope balances and relations.

Parallel to the formation of the graben, a tectonic collapse occured on the Pamuk Plain, and river terraces lined up on the edge of the Sakarya River as a result of base level changes. By the effect of the tectonic movements in the Pleistocene, consequent valleys were set up on the streams that deepened their beds according to the new base level. Afterwards, the rivers showed conformity to the structure by following weak zones and the fault lines in some places. Lateral erosion and the meandering activities started in the rivers flowing on the plains such as Sakarya River and Karasu Stream.

With these characteristics, it can be said that the research area has a polycyclic feature, and it is in the late youth stage of geomorphologic development.

Funding: This study received no specific financial support.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

REFERENCES

Ak, S., 2017. North Anatolian Fault and Iznik. Iznik Newspaper. Retrieved from http://iznikgazetesi.com/yazar-kuzey-anadolu-fayI-ve-iznik-257.html [Accessed 01.12.2017].

Ambraseys, N.N., 1970. Some characteristic features of the North Anatolian fault. Tectonophysics, 9(2-3): 143-165. *View at Google Scholar* | *View at Publisher*

Barka, A.A., 1993. Paleoseismic investigations on the Sapanca-Izmit and Geyve-Iznik branches of the North Anatolian Fault.Project No: TBAG 1013/YBAG 0021, Istanbul.

Barka, A.A. and K. Kadinsky-Cade, 1988. Strike-slip fault geometry in Turkey and its influence on earthquake activity. Tectonics, 7(3): 663-684. *View at Google Scholar* | *View at Publisher*

Barka, A.A. and İ. Kuşçu, 1996. Extents of the NAF in the Izmit, Gemlik ve Bandırma Bays. Turkish Journal of Marine Sciences, 2: 93-106.

Boğaziçi University Kandilli Observatory and Earthquake Research Institute, 2015. İznik Deprem Zararlarının Azaltılması Merkezi. Retrieved from http://www.koeri.boun.edu.tr/iznik/?page_id=136&lang=tr [Accessed 04.11.2017].

Emre, Ö., T. Erkal, A. Tchepalyga, N. Kazancı, M. Keçer and E. Ünay, 1998. Neogene–Quaternary evolution of the Eastern Marmara region, Northwest Turkey. Bulletin of the Mineral Research and Exploration Institute of Turkey, 120: 119-145. *View at Google Scholar*

Erol, O., 1983. Neotectonics and geomorphological development of Turkey. Geomorphology Journal, 11: 1-22.

Erol, O., 1993. A method of drawing of the detailed geomorphological maps. I.U. Marine Science and Geography Institute Bulletin, 10: 19-37.

Kalafat, D., 2009. The seismicity of Marmara region and the importance of the earthquake network. Turkish Earthquake Engineering and Seismology Conference (October 11-14 , 2011), METU – Ankara.

Ketin, İ., 1969. About North Anatolian fault. MTA Journal, 72: 1-27.

Ketin, İ., 1976. A comparison between the San Andreas and the North Anatolian Faults. Bulletin of the Geological Society of Turkey, 19(2): 149-154. *View at Google Scholar*

Koçyiğit, A., 1989. Suşehri basin: An active fault-wedge basin on the North Anatolian Fault Zone, Turkey. Tectonophysics, 167(1): 13-29. *View at Google Scholar* | *View at Publisher*

Öztürk, A., S. İnan and Z. Tutkun, 1985. Tectonics of Abant-Yeniçağa Region. Journal of Engineering Faculty, 2: 35-52. *View at Google Scholar*

Stein, R.S., J.H. Dieterich and A.A. Barka, 1996. Role of stress triggering in earthquake migration on the North Anatolian fault. Physics and Chemistry of the Earth, 21(4): 225-230. *View at Google Scholar* | *View at Publisher*

Toksöz, M.N., A.F. Shakal and A.J. Michael, 1979. Space-time migration of earthquakes along the North anatolian fault zone and seismic gaps. Pure and Applied Geophysics, 117(6): 1258-1270. *View at Google Scholar* | *View at Publisher*

Yazıcı, Ö., 1999. The geomorphology of the land between Iznik-Mekece. Istanbul University Institute of Social Sciences, Division of Physical Geography Doctorate Thesis. pp: 182.