

ENGINEERING GEOLOGICAL PROBLEMS OF YENİCEKÖY SETTLEMENT AREA (BURSA-TURKEY)

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ABSTRACT:Yeniceköy town is located 45 km southwest of Bursa province at the foothill of the Uludağ mountain. The area is included within the first-degree earthquake zone of Turkey. The seismicity of the region is controlled by Bursa Fault, Geyve-İzmit Fault Zone, and İnönü-Eskişehir Fault Zone. Yeniceköy and its close vicinity are traversed by a number of parallel fault segments of İnönü-Eskişehir Fault Zone.

The area is underlain by conglomerate, sandstone, shale, and marl alternation (Middle-Late Miocene), semi-consolidated sandstone, mudstone and lacustrine limestone (Pliocene), gravelly sandy silty clays and clayey sands (Early Quaternary), and alluvial fan deposits (Quaternary). The cohesive soils generally have stiff to hard consistency and low swelling potential. The noncohesive soils are medium dense to dense and show no liquefaction potential. In the area the groundwater occurs under confined aquifer conditions. No water is encountered during trial pitting and shallow geotechnical drilling. In the study area no flood and landslide hazards are anticipated. However, the the seismicity of the region must be taken into consideration during planning studies.

1 INTRODUCTION

Yeniceköy town is located 45 km southwest of Bursa province at the foothill of the Uludağ mountain (Figure 1). The town is located within the first-degree earthquake zone of Turkey. The seismicity of the region is controlled by active fault systems (Doyuran et al., 2000). After the August 17, 1999 ($M_s=7.4$) and the December 12, 1999 ($M_s=7.2$) earthquakes, which produced excessive damage and loss of lives in the Marmara region, detailed morphological, geological, hydrogeological and engineering geological studies were performed to revise existing urban plans of the Yeniceköy town.

2 MORPHOLOGICAL SETTING

The Yeniceköy town is located in the northwest of İnegöl plain at the foothill of the Uludağ mountain. The average altitude of the town is 460 m at the western margin of the settlement area. It gradually increases towards east. Drainage pattern is dendritic, suggesting no structural and lithological control. A northeast flowing stream divides the settlement area into two segments. The average slope of the study area is generally less than 10° . Locally 10° - 20° slopes are noted at the west and the north. The land slope reflects the control of various lithological units. Thus, $<5^\circ$ slopes correspond to the Quaternary alluvial fan deposits, 5° - 10° slopes to Early Quaternary and Middle-Late Miocene sediments, and 10° - 20° slopes are observed in areas underlain by Miocene deposits.

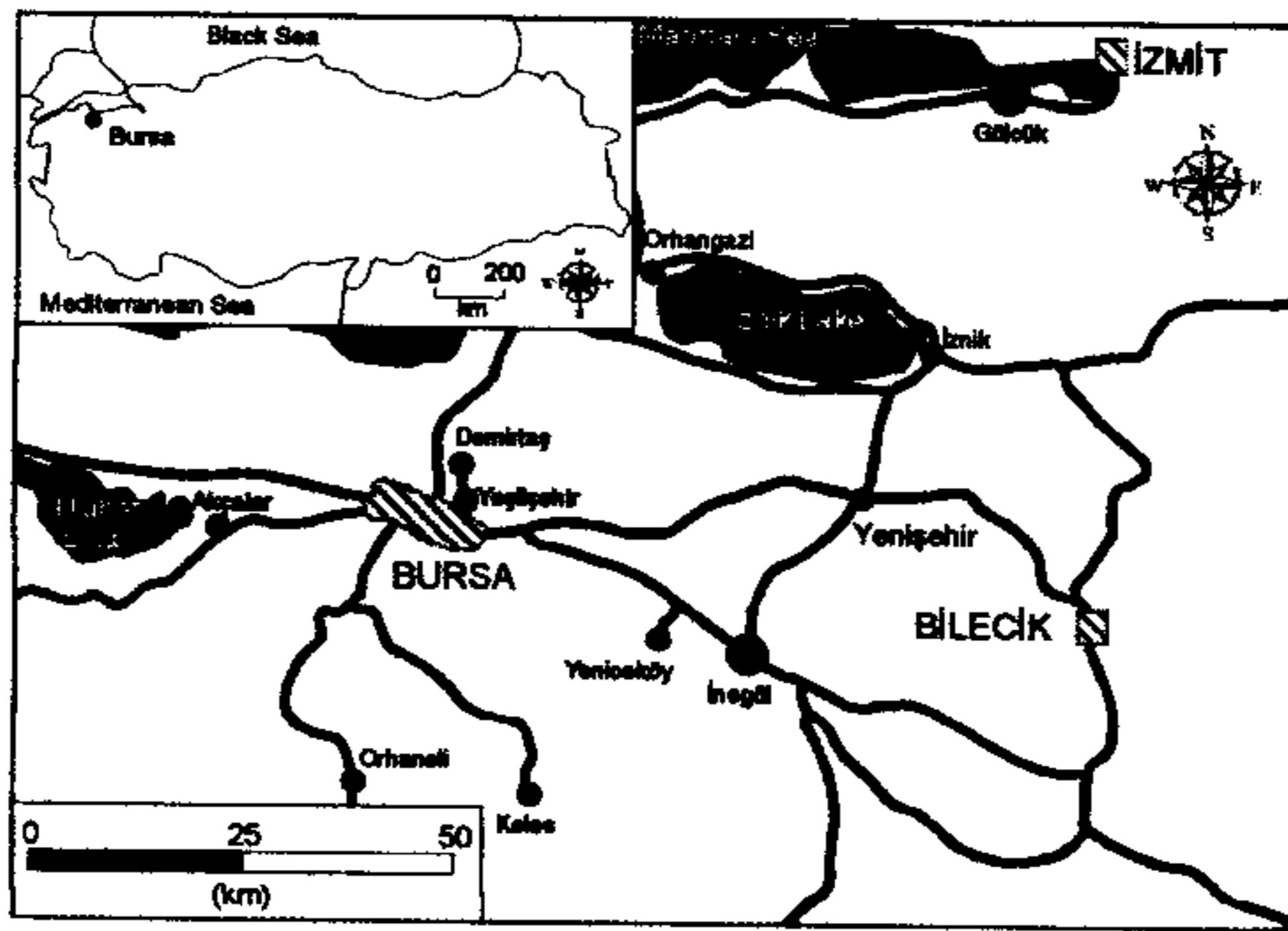


Figure 1. Location map of the study area.

3 SEISMOTECTONICS

The seismicity of Yeniceköy town and its vicinity is controlled by Geyve-İznik Fault Zone in the north, Bursa Fault in the northwest, and İnönü-Eskişehir Fault Zone in the southwest (Doyuran et al., 2000) (Figure 2).

Geyve-İznik Fault Zone: The Geyve-İznik Fault Zone belongs to the southern branch of the North Anatolian Fault Zone, a major right lateral strike slip fault which extends all the way from the Northern Aegean Sea towards Eastern Anatolia for a distance of approximately 1200 km. The zone includes parallel and subparallel active right lateral strike slip faults. The Geyve-İznik fault zone is located 40 km north of Yeniceköy town.

Bursa Fault: The Bursa fault extends in the west-east direction for a distance of 45 km between Ulubat Lake and Bursa municipality. It is essentially a right-lateral strike-slip fault with an appreciable normal component. The latest earthquake (Intensity:IX) had occurred in February 28, 1855 which caused extensive structural damage and loss of life in Bursa and its vicinity. The Bursa fault is about 20 km away from Yeniceköy.

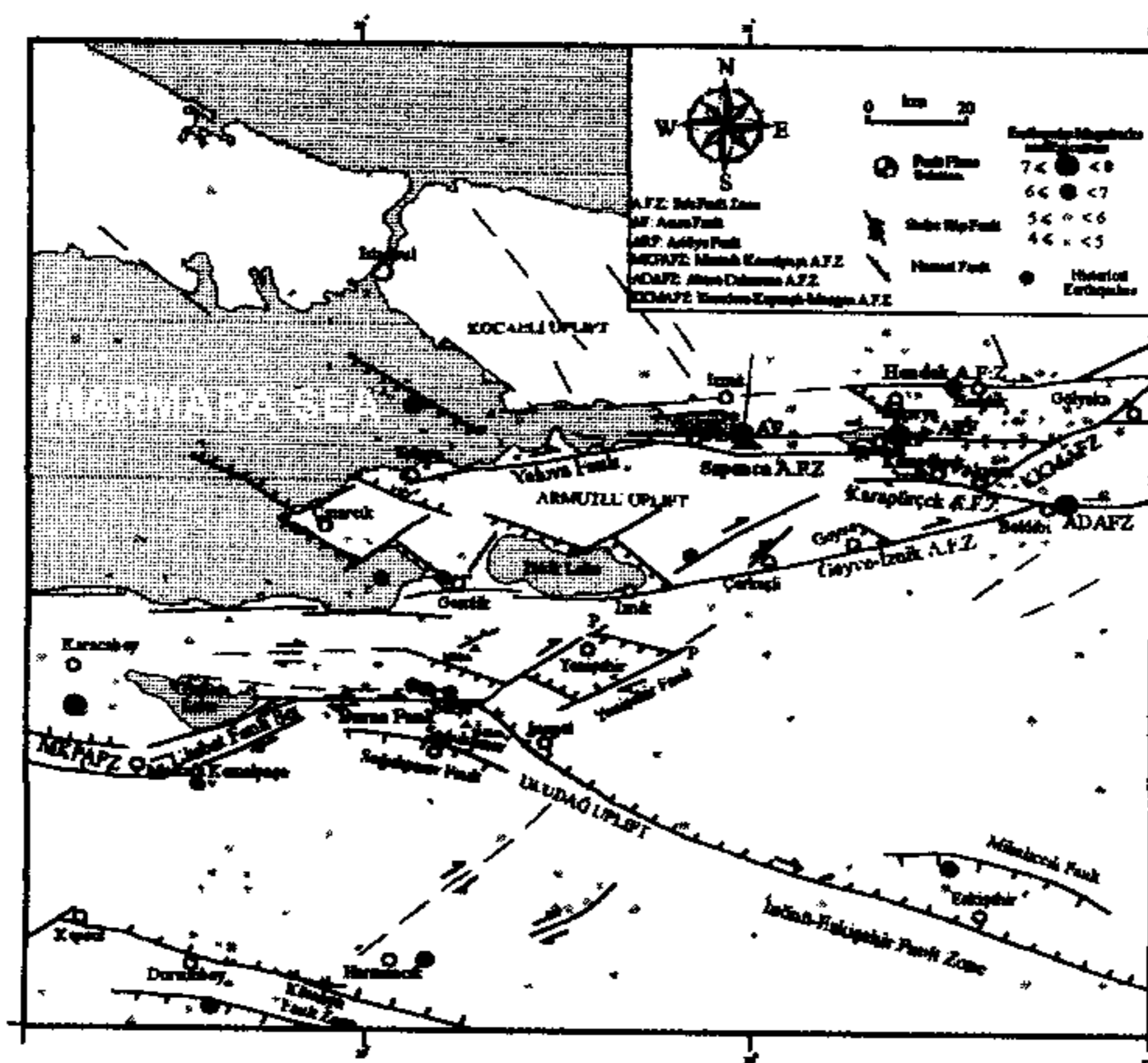


Figure 2. Seismotectonic map of Yeniceköy and its vicinity.

İnönü-Eskişehir Fault Zone: The fault zone extends in the northwest-southeast direction for a distance of 380 km between Salt Lake and Bursa. The zone includes several discontinuous faults with lengths ranging between 1 km and 50 km. Small to medium earthquakes have occurred at different segments of the fault zone. Northwestern segment of the İnönü-Eskişehir Fault Zone is observed at the Yeniceköy settlement area. Based on the distance to the fault zone, their characteristics and observed activity the İnönü-Eskişehir Fault Zone is expected to control the seismicity of Yeniceköy.

4 GEOLOGICAL SETTING

Middle-Late Miocene deposits, Pliocene deposits, Early Quaternary deposits, Quaternary fan deposits and alluvium are the main lithological units exposed at Yeniceköy and its vicinity (Figures 3 and 4).

Miocene deposits consist of conglomerate, sandstone, shale and marl. They are mainly observed in the west and southwest of the study area. The lithological units dip by an amount of 35° - 65° in the northwest direction. The deposits are unconformably overlain by Pliocene deposits.

Pliocene deposits are weakly-cemented lacustrine-river deposits consisting mainly of cross-bedded sandstone with conglomerate lenses, clayey sandstone, and lacustrine limestone alternations. They are mainly observed within the valleys. The Pliocene deposits are unconformably overlain by Early Quaternary and Quaternary deposits.

Early Quaternary deposits consist of a chaotic mixture of loosely-cemented, poorly sorted boulder, gravel, sand, and clay. The deposits show debris flow character. They are exposed in the north and northwest of the study area. Early Quaternary deposits are overlain by Quaternary fan deposits and alluviums.

Quaternary fan deposits are observed on both sides of the stream running through the town. They consist of a mixture of gravel, sand, silt and clay. Quaternary alluvium is only observed along the stream channel (Doyuran et al., 2000)

5 ENGINEERING GEOLOGICAL EVALUATION

Large-scale (1:1000) geological mapping, trial pitting, geotechnical drilling, in-situ and laboratory testing were performed in order to evaluate the engineering geological properties of foundation materials of Yeniceköy settlement area.

A total of 14 boreholes with a total depth of 135 m were drilled. The maximum depth of boreholes is 10 m. Standard Penetration Tests (SPT) were conducted at every 1.5 m intervals within the boreholes. The SPT samples were used to determine the index properties of the soils. Laboratory testing includes determination of water content, specific gravity, unit weight, sieve analyses, and atterberg limits of soils obtained from the boreholes. Twenty-three trial pits were opened. The maximum depth of the pits was 4.8 m. During drilling and trial pitting no groundwater was observed. However, the depth of groundwater table ranges between 0.20 m and 12.5 m at deeper (35 m-40 m) water wells drilled by local people for irrigation purpose. This suggests that the groundwater occurs under confined conditions. The saturated zone is well below the foundation level of the buildings. Thus, during foundation excavation no water inflow problems will be expected within the study area.

Distribution of various lithological units is determined through field observations, trial pits, and drilling (Figures 3 and 4). The Miocene deposits consisting of conglomerate, sandstone, shale and marl are very stiff to hard for cohesive levels and very dense for granular levels.

Pliocene deposits are loosely-cemented lacustrine-river deposits consisting mainly of cross-bedded sandstone with gravel lenses, clayey sandstone, and lacustrine limestone alternations. Based on the SPT results, they are very stiff to hard for cohesive levels and very dense for granular levels.

Early Quaternary deposits consist of chaotic mixture of loosely-cemented, poorly sorted boulder, gravel, sand, and clay. Based on the SPT results, they are stiff to very stiff for upper cohesive levels and hard for lower cohesive levels. However, they are medium dense for upper granular levels and very dense for lower granular levels.

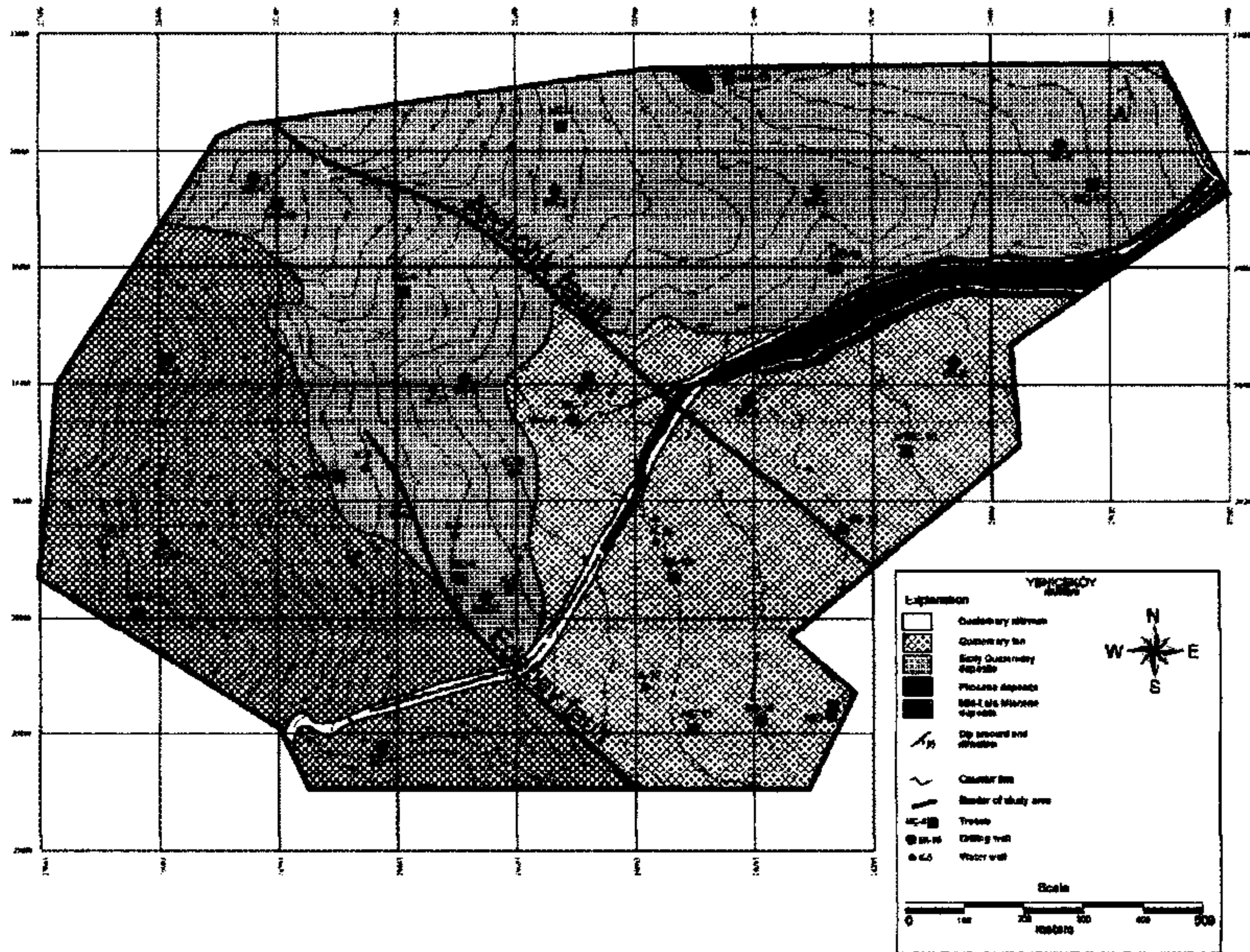


Figure 3. Geological map of Yeniceköy.

Quaternary fan deposits consist of a mixture of gravel, sand, silt and clay. They are very stiff to hard for cohesive levels and dense to very dense for granular levels.

Laboratory tests carried out on SPT samples reveal that clayey soils are both CH and CL type. However, low plasticity and/or clay content of the soil indicate low to medium swelling potential. Therefore, no significant swelling problem is expected for the settlement area.

Although no groundwater exists at the foundation level of the study area, liquefaction analyses are carried out considering the highest groundwater table. Seed and Idriss (1971) and NCEER (1996) procedures are used for 5%, 15%, and 35% fine fractions in the liquefaction analyses. Expected maximum horizontal ground acceleration of an earthquake with magnitude of 7.5 is taken as 0.4g for the settlement area. The analyses show that no liquefaction potential exists in the study area.

Field studies reveal that no flood and landslide hazards are expected in the settlement area. However, two active faults traverse the Quaternary deposits. The first one belongs to the Ardıçlık Fault Set. This normal fault trends in the NW-SE direction and cuts across all the units exposed in the study area. The fault plane dips by an amount of 70°-80° towards NE. Outside the study area a few landslides are noted along the fault set. The second fault belongs to the Edebey fault zone, a

normal fault with minor lateral displacement. It is observed in the south-southwest part of the study area with a limited extension. It trends in the NW-SE direction. The fault displaces the Quaternary deposits.

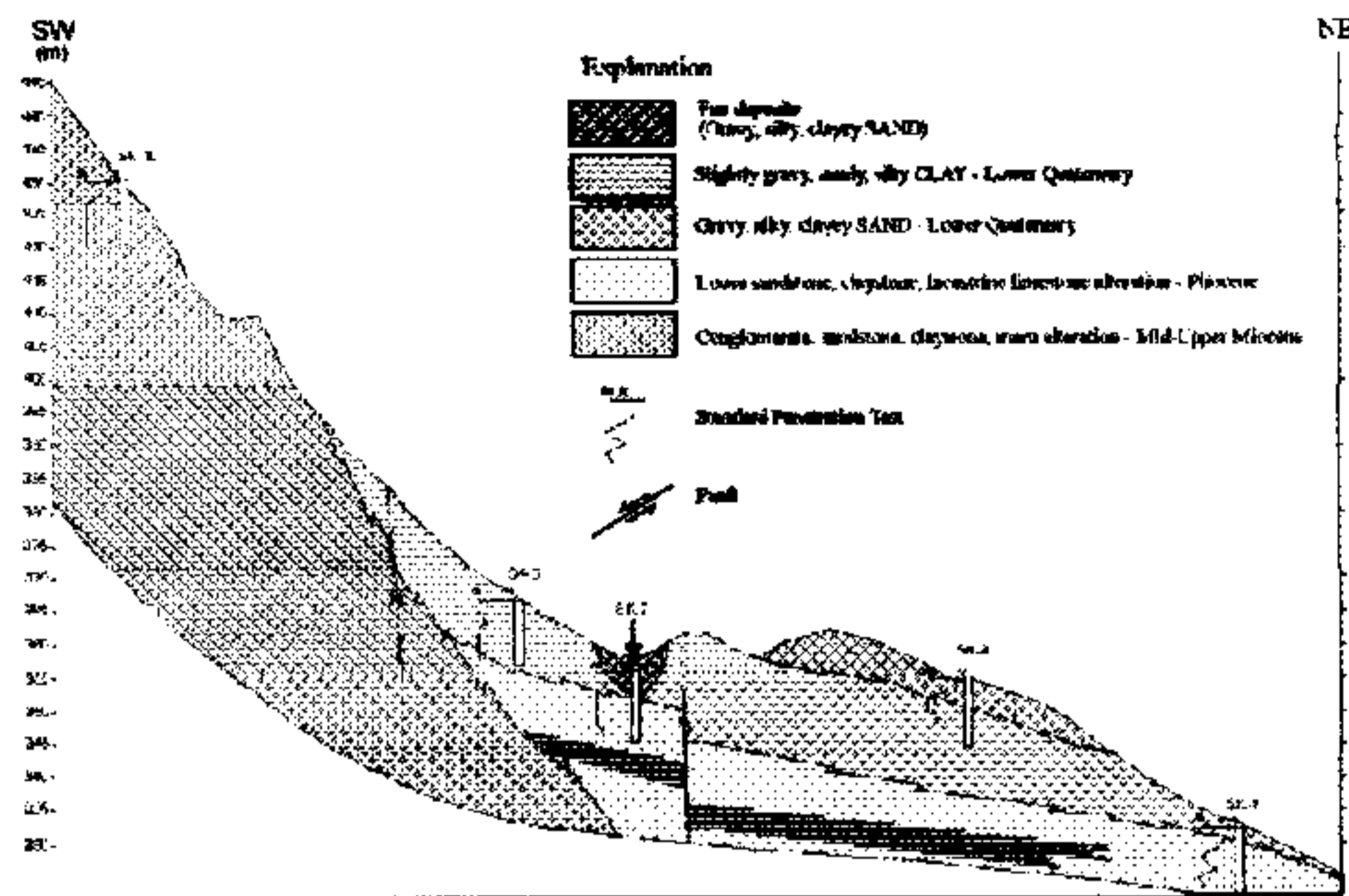


Figure 4. Geological cross-section

Although both faults are considered to be active, due to their limited lengths and small to medium magnitude earthquakes (<5) recorded during the last century they do not seem to produce a significant risk at the urban area. However, considering the Bursa fault and Iznik-Geyve Fault Zone the foundation and the structural design must be based on the procedure recommended in the “Code of Earthquake Resistant Design of Turkey”.

6 MICROZONATION

Based on the geological, geotechnical, hydrogeological, and seismotectonic characteristics of the Yeniceköy town and its close vicinity, the foundation materials may be grouped under single zone. The General Directorate of Disaster Affairs of Turkey (2000) recommends the following subdivisions.

Zone I: Areas suitable for settlement

Zone II: Provisional settlement areas

Zone III: Areas requiring detailed geotechnical investigations

Zone IV: Areas not suitable for settlement

During microzonation studies special emphasis is given to the natural hazard (earthquake, landslide, and flood) susceptibility of the study as well as the response of the foundation materials to the static and dynamic loading conditions. Due to earthquake risks and geological/geotechnical characteristics of the foundation material, only “Zone II” is identified for the Yeniceköy settlement area. The buildings should not be constructed across the active faults. In addition, the buildings should not exceed four stories, and for the foundation and structural design “Code of Earthquake Resistant Design” should strictly be applied.

7 CONCLUSIONS AND RECOMMENDATIONS

The Yeniceköy settlement area is located generally over gently sloping topography ($<10^\circ$) and locally on steep topography (10° - 20°). Miocene deposits, Pliocene deposits, Early Quaternary deposits, Quaternary fan deposits and alluviums are the main units exposed at Yeniceköy and its vicinity. Semi-consolidated conglomerate, sandstone, shale and marl, and gravel, sand, silt and clay are the dominant lithologies. At the foundation level, the granular soils are medium dense to dense; the cohesive soils are very stiff to hard. Based on the field studies no flood, landslide, and liquefaction hazards exist in the study area. Zone II-Provisional settlement is identified for the Yeniceköy settlement area. Considering the earthquake potential of the region associated with active faults, the buildings should not exceed four stories, and for the foundation and structural design "Code of Earthquake Design" should strictly be applied.

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