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THE GEOARCHEOLOGY OF THE YENİKAPI EXCAVATION SITE IN THE LAST 8000 YEARS AND GEOLOGICAL TRACES OF NATURAL DISASTERS (İSTANBUL - TURKEY)

Doğan PERİNÇEK*

ABSTRACT.- During the excavations of the Istanbul Archaeological Museum for the Marmaray Project, which will connect two sides of the Bosphorus by rail tube tunnel, an ancient Byzantine Port (Port of Theodosius)** was explored around Yenikapı, district of Istanbul. The aim of the study is to understand the stratigraphical sequence observed in the excavation site, to recognize the traces of natural events observed within the sequence and to reach the geoarcheological data that will provide contribution to the archeological studies by geological findings. The sequence studied in the Yenikapı Excavation site was divided into 9 different units. The sequence is transgressive from 1st to 7th unit and regressive from 7th unit, to upper part of the 8th unit. These investigated sequences have been deposited during the last 8000 years. 32 ancient shipwrecks were detected in three different geological layers of nine units which were dated to the 6th century, 7th, 8th, 9th centuries and 10th, 11th centuries respectively. The 4th unit was formed under the effect of an earthquake and following tsunami waves occurred in A.D. 557. It is considered that some of the districts of Istanbul which are very close to shore have submerged by the effect of tsunami waves during the earthquakes in A.D. 553 and 557. It was also considened that the reason of the sinlang of the was 25 Byzantine vessels a very strong storm that affected the coasts of Istanbul city. The traces of this storm are detected in 5th and 6th units.

Key words: Yenikapı, geoarcheology, tsunami, ancient shipwreck, amphora, Byzantine.

INTRODUCTION

The Port of Theodosius belonging to Byzantine era has been unearthed in ongoing excavations in Yenikapı district of Istanbul under the administration of Istanbul Archeological Museums for the Marmaray project which will connect both sides of Istanbul strait by rail tube passage (Figure 1).

By the directorate of Istanbul Archeological Museums, in Yenikapı district, 1.5 km inward from the shoreline, to the north of the railway, nearly 30 shipwrecks were encountered during excavations in the area where Metro and Marmaray stations will be constructed formerly named as "Langa Orchard" (Pulak, 2007; Asal, 2007; Başaran et al, 2007; Kocabaş and Kocabaş, 2007; Gülbahar, 2007). The "Port of Theodosius" (Kocabaş and Kocabaş, 2006) belonging to Byzantine Era is also called as the "Port of Eleutherios" in some published papers (Müller-Wiener, 2001). The Port of Theodosius was probably founded by Theodosius I (379-395) in a naturally occurred bay in Yenikapı (Asal, 2007). According to archeological evidences the port mentioned has intensively been used after A.D. 4th century (Gökçay, 2007). A marble stele of 4 B.C. gives some clues about the construction date of the Port (Gökçay, 2007).

The author visited the Yenikapı excavation site in April, 2005 to get an information about the reason of the sinking of the vessels and started to collect geological data in order to answer to the questions relevant to subject. Within the following months of his first visit, he has been invited by the Directorate of Istanbul Archeological Museum. The geological investigations have been formalized with this invitation. The

* Çanakkale 18 Mart University, Faculty of Engineering and Architecture, Terzioğlu Campus, 17020, Çanakkale

** Among historical places mentioned in the article, the “Theodosius Port” of Byantian era is called as the “Yenikapı Port” with its present name and “Lycos River” is called the “Bayrampaşa River”.

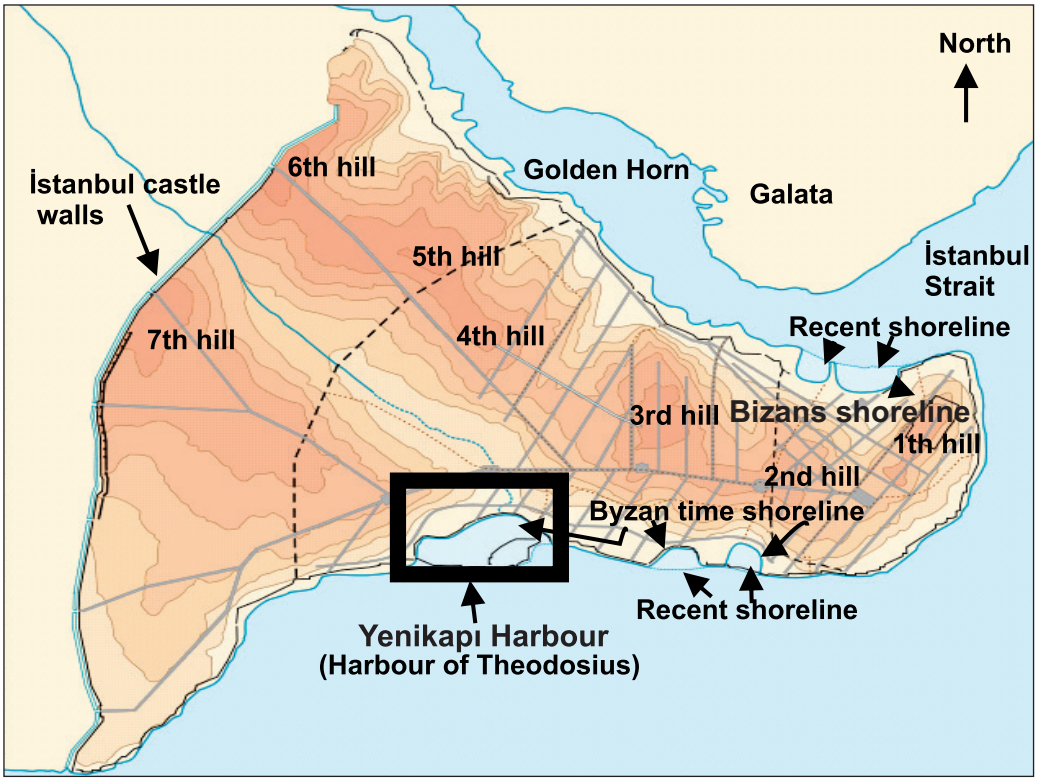

Figure 1- Topography of Istanbul in Byzantine era and port of Theodosius (Janin, 1964). The location of the Port was marked as rectangle.

purpose of this study is to collect geological data related with the site of excavation, to understand their relations with archeological evidences, to transfer geological information to archeologists working in the area and to provide a support, to find out the reason of the sinking of the vessels and to reveal the geological history of the site of excavation. Geological investigations have been intensified after necessary permissions had been taken from the Ministry. Thus the author has been the first authorized geologist who worked on the site of the excavation. In 2007, a student from the Geological Engineering Department of 18 Mart University carried out a graduation thesis on the site of the excavation with the permission of the Ministry. The interest of earth scientists into excavations in Yenikapı district has increased a lot in the following years, then a group of scientists from Istanbul University proposed a profect and started to work here with the presentcauthor in 2007 by basing on his permission.

In studies carried out in Yenikapı area, the distinguishing features of units were determined and lithological differences were revealed. Based on these, 9 different units were detected on the site of excavation. Sedimentological data were compiled based on field observations and the relations of units were studied in detail. Mainly data collected in the field, related results and interpretations since 2005 will be presented in this article.

The Marmara region has been shaken by earthquakes several times throughout the history. The first known earthquake occured in A.D. 29, and the first earthquake which its details

have been registered, had experienced the region in 1st of February 363. Byzantine sources state that Istanbul thoroughly has been collapsed in 10 quakes until the earthquake in 1265, and some of tsunamis affected the shores of Istanbul during these earthquakes (Altınok, 2005; Yalçıner et al., 2002). Tsunami waves which were formed by earthquakes mentioned in historical documents should have remained traces on land. Sediments which it was brought by tsunami waves from the sea should have been preserved in some areas of Istanbul. It will be possible to reach many unknowns when these traces are found (Perinçek et al., 2007).

STRATIGRAPHIC SUCCESSION

Sections in six stations were measured in the Yenikapı excavation site and generalized stratigraphic section was obtained making numerous point observations (Figures 2, 3). 9 different units were distinguished from bottom to top on the site of excavation in terms of lithological features. Late Miocene - Holocene units form the Pre Quaternary basement of the excavation site. All units forming the site of excavation will be introduced in detail starting from the 1st unit at the bottom.

1st Unit

The 1st unit is represented by dark gray to black colored sandy mud in patches (Figures 2, 4). Crushed, dark brown rush stalks are observed in mud indicating to a swamp environment. After the unit had been deposited in lagoonal environment, the study area has been submerged under water as a result of a transgression. It was observed that living beings in marine environment had previously burrowed in mud of the lagoonal environment, and these burrows had been filled by the sands of the 2nd unit. In these burrows, abundant shell fragments and small gastropods with sand are recognized (Figure 4). The unit starts with pebble, coarse pebble and sand (sand ratio is small) at least in two places at the site of excavation. Regularly arranged pebbles are observed in mud which is too rare to form a layer in patches. Surface of pebbles are in white color and are composed of crystallized limestone and Miocene limestone. Their fracture surface is gray to whitish gray in color. The contact between the 1st unit and the 2nd unit is clear. Beneath this unit Late Miocene deposits are seen. These are represented by claystone and siltstones. There is also a possibility about the unit that may be the equivalent of the Kuşdili formation of Holocene age (Meriç et al., 1991).

Swamp deposit is represented by mud silty mud, sandy mud, muddy sand and sand bands are observed in patches. Besides, channels are observed within the deposit. The filling material of these channels is silt, sand and pebble with muddy matrix and has a direction of N-S. These data indicate that the center of the lagoon is to the south of the study area. The pebble in channels, mostly are less rounded and poorly sorted. In some channel fills, some angular coarse pebbles also exist. Angular grains have been transported from close areas or thrown into channel by people. Over the surfaces of the pebbles in channel fills, carbonate accumulation/coating is observed. The lime carried in channel by water has been accumulated on pebbles which have fresh gray surface and turned their colors into white. The surface of pebbles is irregular and no any reworking are seen after transportation into the channel and coating by lime. The channels are not deep. These are flat laying channels having 3-15 cm depths. Channels filled by gravel laterally grades into pebbly sand and sand. The granular size decreases from bottom to top of the channel. Sand layers which are laterally lensoidal in marsh form wide shallow channels as well. The sand in question is usually represented by quartz grains and well sorted. Abrasion marks in mud layers at channel bottoms are distinctive but the boundary here is irregular. However, the upper boundary was detected as regular. Besides, there are silty, less

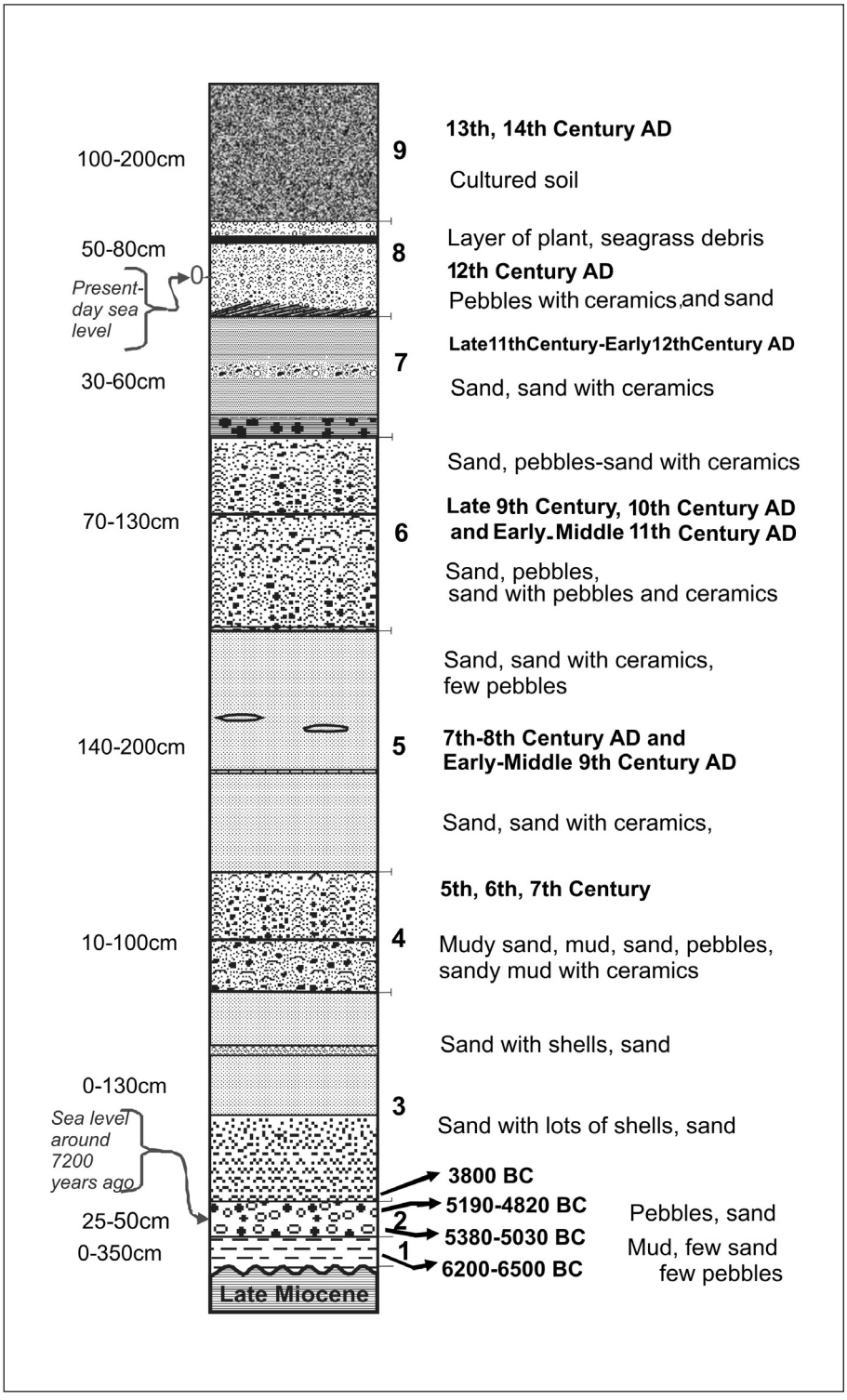

Figure 2- Generalized stratigraphical section of the Yenikapı Excavation site.

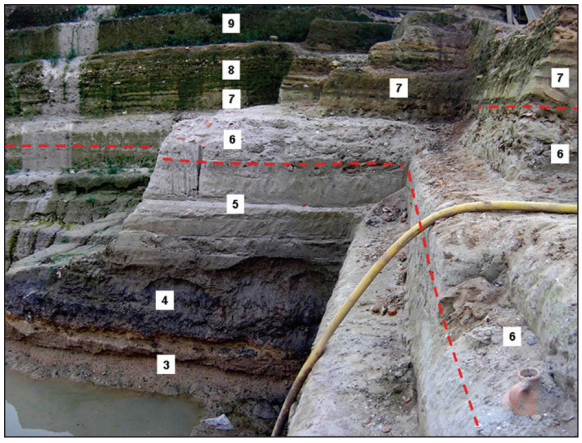

Figure 3- Close up view of succession from 3rd to 9th units.

Figure 4- Relation of the 1st Unit (dark gray colored marsh) and pebbly, sandy unit denoted as number 2. Nests of living organisms (burrows) are observed while the 2nd unit deposits in the upper parts of the marsh. These burrows were filled by sand and fragmented shells.

muddy sands with regular lower and upper boundaries in marsh deposit. These were interpreted as sheet sands that had been deposited during flood.

The thickness of the 1st unit varies between 0 to 3.5 m. Regions where the thickness reaches 3.5 meters are observed to the east of the excavation site. The 2nd unit directly overlies the Late Miocene deposits in areas where the 1st unit does not exist. Marsh deposits are observed at eastern parts of the Yenikapı excavation site. Coastal marshes can easily be traced at this location. The settlement area which can be observed along the coastal marshes falls into the eastern-northeastern part of the marsh (Çelik, 2007; Prof. M. Özdoğan, 2007, oral interview). Usually, Late Miocene deposits crop out at the bottom of the settlement area.

At the bottom of the marsh, 6 tree roots and part of trunks close to root section were found. However, the upper sections of trunks did not exist. As a result of the increase in water level, the contact of the lagoon along the coast has been cut off due to the development of spit and the mud began to deposit in the area. After the formation of lagoon environment, trees remained in the marsh land decayed as these were subjected to excess submersion in water. That is why only roots and trunks close to roots have been preserved. Tree branches were also recognized in some locations in the marsh land other than roots. In some places shells of bivalves were recognized in the marsh land. The shells in question are observed both as dispersed and also in the form of aggregation. It is considered that strong waves in stormy times have transported material into the marsh land from sea and shells have also been transported into the lagoon within materials.

2nd Unit

Flat and sub rounded pebbles and coarse pebbles of the 2nd unit overlie the unit deposited in lagoon environment (Figures 4, 5, 8). Pebbles are mostly composed of formed of recrystallized limestones and sometimes reach to a small block dimensions. The matrix among pebbles is sandy. The burrows are observed on pebbles and coarse pebbles. This case shows that pebbles have remained in marine environment for a long time. Fossils have been preserved in many burrows (mollusc Teredo navalis, Prof. C.

Morhange, March, 2008, oral interview). It is observed that both ends of pebbles are usually equally sized and disc shaped. This indicates the bidirectional wave action but not the unidirectional erosion of river flow. Although pebbles mentioned have been transported to the area by a river, there are distinct features showing that these pebbles have been eroded by wave actions and flattened. The total thickness of pebble layer is around 25 - 50 cm.

Figure 5- The 2nd unit can be divided into three sub units as there is sand among gravel layers in some parts of the excavation site. Therefore the unit has been denoted as 2a, 2b, 2c.

The unit can be divided into three sub units (2a, 2b, 2c) in some sections of the excavation site due to the presence of sand. There was observed pebble at the bottom (2a) then sand in the middle (2b) and again pebble at top (2c). The pebble sizes at the bottom reach 30 x 20 x 7 cm. However, pebble sizes located at top of the sand layer in the middle are mostly 10 x 5 x 2 cm. The ratio of both pebble layers decreases as going to the south in seaward direction. Whereas on land, pebble at the bottom and sand layer located in the middle are pinched out and fine grained pebbly layer at the top directly overlies the 1st Unit at the bottom. The reason for pinching out of pebble at the bottom and the decrease in pebble ratio towards sea is due to the regression. The pebbly layer named as 2c disappears before 2a pebble layer on seaward and laterally grades into sand. This lateral change has developed as a result of transgression. Pebbles show a transition into sand towards open sea but overlaps with each other in landward. The shore line of the sea which caused the precipitation of the pebble layer at top might be located very near or inside the site of excavation. Since the excavation has not yet reached the area in question the accurate information will be obtained in further stages of the excavation. Mollusc burrows are observed in both pebble layers (mollusc Teredo navalis). Some of the smaller granules of the pebble layer at top have probably been formed by the transportation, abrasion and re-deposition of pebbles at the bottom.

It is considered that the 2nd Unit was deposited in beach environment. After the transgression that had caused the deposition of this unit the environmental conditions were deepened and the 3rd unit on top was deposited. The upper boundary of the 2nd unit is as distinct as the lower boundary.

C14 analysis was performed in samples taken from shells of mollusc (*Teredo navalis*) which were observed in burrows over pebbles in the unit. After the calibration of C14 dating, the layer 2c was dated as 5190 B.C. - 4820 B.C. with 94.5 % probability (Sample no: Yenikapı U2 798; Petricola). However the sample taken from the layer 2a of the 2nd unit was dated as 5380 B.C. - 5030 B.C. (sample no: Yenikapı U2A 801; Ostrea) with 95.4% probability (Prof. C. Morhange, July, 2008, written communication). Ceramics found at different levels of the 2nd unit and at levels closer to the bottom of the 3rd unit were ages as 5200 B.C. - 3800 B.C. (Prof. M. Özdoğan, 2008, oral communication). These are important data indicating that the transgression started at least 7200 years ago. The reason for the transgression is because the rise of water level in the Sea of Marmara started to rise 11000

- 8000 years ago (Stanley and Blanpied, 1980; Ryan et al, 1997, 2003; Çağatay et al., 2000). The reaching of the seawaters to the coasts of the Theodosius port happened 7200 years ago.

3rd Unit

There is the sandy level of the 3rd unit containing abundant sea shells with a thickness of 60 cm over the 2nd unit (Figures 2, 3, 6, 7, 8). The thickness of the 3rd unit varies between 0 - 130 cm It is observed that the 3rd unit pinches out and the 4th unit directly lies on the 2nd unit to the northeast of the site of excavation. The unit begins with a layer formed by complete shell and fragments of shell with 80% at the bottom having a thickness of 10 - 50 cm. The amount of sand in the fragmented shell layer increases upward. It is also observed that the shelly level becomes thinner and disappears in some places. There is a sand layer over it with a total thickness of 60 -70 cm. Shell layers and lenses were observed in variable thicknesses within the sandy level. The 3rd unit generally shows a fining upward sequence. Very little amount of amphora fragments were recognized within this unit. An oxidation level was observed in the upper part of the 3rd level. It might be considered that the reason of this oxidation of ferrous material in the 4th unit and stained the 3rd unit in its below.

Figure 6- The relation of the mud bearing dark gray 4th unit with lower and upper units is observed.

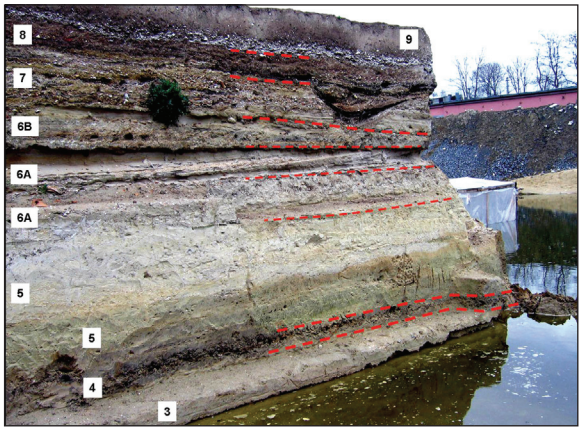

Figure 7- Vessels which are considered as has submerged by the storm are observed in the 6th unit. In photo succession from 3rd unit to 9th unit is observed. At upper right corner a channel excavated during the deposition of eight units and its filling is viewed.

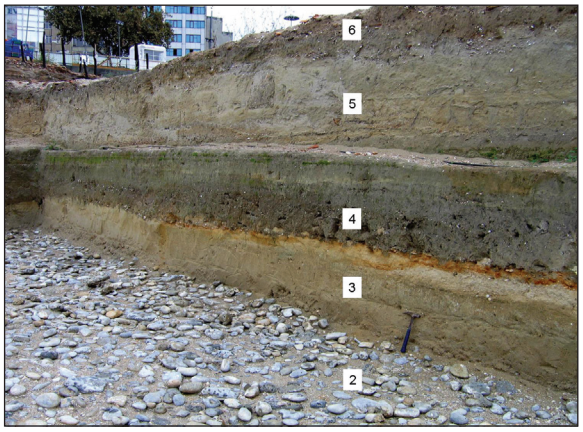

Figure 8- The relation of pebbly unit denoted as the Unit number 2, the 3rd Unit represented by sand and the 4th Unit which was deposited with a distinct contact is seen in photo. Oxidation around the bottom of the dark colored muddy 4th unit is noticed. The 4th unit is overlain by light colored 5th Unit. The 6th Unit is observed at the topmost.

4th Unit

Gray colored, muddy sand and sand belonging to the 4th unit exits over the 3rd unit (Figures 2, 3, 6, 7, 8, 9, 11). Dark gray to black colored level rich in black colored organic material takes place

Figure 9- The camel skeleton at the 4th Unit (Gökçay 2007, R11) is observed in dark colored mud. The bones of the camel skeleton are not in messy form.

at the base of this layer. The matrix of this coarse grained layer is made up of mud, silt, sand and less pebble. This unit is very poorly sorted. The unit is represented by the coarse sand and muddy sand in some places. There are also detritic particules in pebble and block size. The size of some particules may even reach 1 m. An angular ceramic fragment, a tree with length of 150 cm. and a spetia type amphora in 40-50 cm in size may possibly be observed next to a marble block 1 m in length (Katalog, 2007). In addition to things mentioned above, there are also abundant shells, sometimes complete amphora and fragments of amphora, coins, metal pots, ceramic pots and fragments, fragments of kerosene lamp, rounded marbles, piece of decayed wood, fragments of glassy pots, hawser and stone anchors of ships found at this level (Pulak, 2007; Asar, 2007), pine cones, marine and terrigenous fossils, animal bones, plant pieces and leaves transported from land and kernels of different fruits (Figure 11). There was found 4 horses as completely preserved and a skeleton of camel in muddy layers of the unit (Figure 9) (Çelik, 2007; Gökçay, 2007; Perinçek et al., 2007; Perinçek, 2008). The bones of skeletons found in the site are not dispersed. The leash of one of the horses was found next to them and the feed basket of the other horse was detected next to it as transported as the horse was drifted towards sea.

The lower boundary of the unit is distinct and irregular (Figure 6, 8). There are some evidences showing that previously deposited 3rd unit has been eroded by submarine currents. Channels which were formed after being scraped by current activity were filled by the material of the 4th unit following the erosion. The depth of these channels varies in between 10 - 30 cm. These channels might have been engraved by sea base currents formed after the tsunami. Although the lower boundary of the 4th unit is distinct (Figure 8), the upper boundary usually gradually passes into 5th unit (Figure 6, 7, 8). Along the gradual transition zone, laminating sand and muddy sand layers between 4th and 5th units are observed. Sometimes this transition is observed without lamination.

The thickness of the 4th unit varies in between 10 cm to 1 m. The mud present within the unit has changed the color of all ceramics observed in one portion of the site brown to dark gray in color. Besides, the mud in the unit has also colorized the 3rd unit at the bottom into dark gray infiltrating through pores of the sand. Metals parts in the 4th unit has decayed and penetrated through 3rd unit at the bottom. Thus, the oxidized surfaces were formed parallel to the contact between the two Units. The 4th unit is divided into 2 sub units to the southwest of the study area. The lower one of these sub units 30 cm and the upper one is 40 cm in thickness. Muddy sand and less archeological findings (ceramic etc.) and blocks of stone unfamiliar to the environment also exist at the lower level. The upper layer is more pervasive and distinguishable at the site of excavation. The information given in previous paragraphs are mostly related with this upper layer and there are many materials in it. Many dock piles were found in different units within the marine sand at the Yenikapı excavation site. Many of piles in the 4th unit disappear at the

boundary of the overlying 5th unit (Figure 10). Tsunami might be the natural event which has deteriorated the piles at the same height.

Figure 10- The 4th Unit is considerably thin in some places. Docks constructed at the Port in the 6th century and earlier have been destructed by tsunami and piles of the dock were later covered by the deposits of the 5th Unit. The relation of the 4th, 5th and 6th Units are observed in photo. Piles marked by "X" have been destructed by tsunami and next piles marked by "Y" have been constructed.

C14 analysis was performed in one of the samples taken from woods in the 4th unit (Yenikapı U4 795). After the calibration the sample was dated as A.D. 420 - A.D. 570 with 95.4 % probability. Another sample taken from the same unit was dated in an interval of A.D. 400 - A.D. 450 with 68.2% probability (Prof. C. Morhange, July 2008, in written communication). The first sample had been taken into account since the probability was high. The 4th unit was dated as A.D. 5 - 7 centuries according to the ceramic, coin and similar archeological materials in it (Katalog, 2007). When historical earthquakes and tsunamis were studied (Altınok, 2005; Yalçıner et al. 2002), records of strong earthquake and tsunami were encountered as 543, 545, 549, 553, 555 and as 557 B.C. There was not recorded any important tsunami happened in A.D. 5 - 7 centuries. The 4th unit

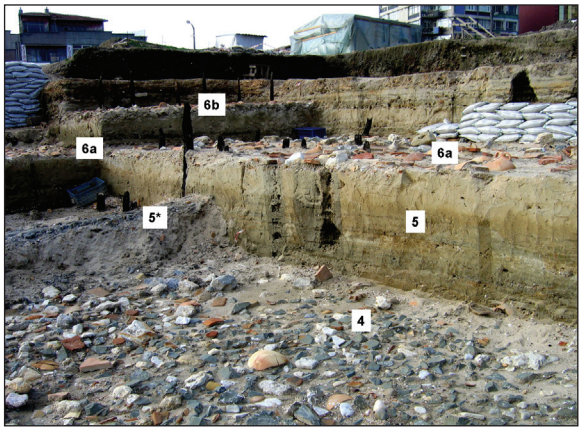

Figure 11- The photo shows the relation of 4th, 5th and 6th Units. The section marked by 5* indicates the wooden part belonging to 7th and 8th centuries in the 5th Unit. At the bottom of 4th Unit, there is observed ceramic, various furniture, coins, processed angled marble, pebble and unprocessed wooden parts transported from land and processed wooden material belonging to destroyed ships in the sea and piles.

most probably was formed due to the earthquake which occurred in A.D. 557 and following tsunami waves. The dome of Ayasofya (Hagia Sophia) Museum was weakened by the earthquake in December 557 then collapsed in May 558 (Wikimedia, 2008). Therefore, although many earthquakes and tsunamis happened in 6th Century, the earthquake in A.D. 557 have been brought foreground in this article. Taking records of historical earthquake, tsunami and C14 dating into account, it was brought into foreground that the important part of the 4th unit was formed in A.D. 6th Century.

5th Unit

Sand belonging to the 5th unit overlies the 4th unit (Figures 2, 3, 6, 7, 8, 10, 11). Minor cross bedded sand was observed in the unit. Lens shaped levels composed of shells exist toward upper layers. Besides; pieces of ceramic were also observed. The 5th unit is composed of well sorted fresh sand and its thickness changes in between 140 - 200 cm The archeological findings

are not much in this unit when compared with the 4th unit at the bottom. It usually has a gradual transition with the 4th unit at the bottom but mostly has a distinct contact with the 6th unit above it. The distinct boundary indicates an important event. The 5th unit contains intercalations of sand with thin muds and lensoidal gastropod accumulations 5 mm in length. Besides, there are many shells as dispersed in the sequence. It is observed that fresh sand and very little muddy sand intercalate with each other and the bedding is markedly visible in some part of the excavation site. The transgression in the Yenikapı excavation site has begun with the 2nd unit and has continued during depositional periods of 3rd, 4th and 5th units.

Relics of 5 shipwrecks were encountered at 4 different places within the 5th unit. One of the ships which it has recently been studied within this unit by archeologists was dated as 7th century (Pulak, 2007; Asal, 2007). While some of the remnants are in the form of whole vessel, some are the parts of the ship. Laminated layers have been formed just above the shipwreck by the abrasion of wood and the aggregation of the abraded material. When these dark brown surfaces were investigated it is observed that granules were originated from abraded wood. Other than the shipwreck within the unit, the wooden materials have been detected mostly parallel but sometimes with an angle to the bedding plane. It is commonly considered that wooden parts are dock piles. The reason for sinking of ships has been noted that there has been a storm affecting the shores of Istanbul (Perinçek, 2008). The 4th unit underlying the 5th unit was most probably deposited in A.D. 6th century. As for the ships found in the 6th unit that was deposited above the 5th unit were dated as 10 - 11th centuries by archeologists (Pulak, 2007; Asal, 2007; Kocabaş and Kocabaş, 2007; Gülbahar, 2007). Thus, it is possible to date the 5th unit between A.D. 7 - 9 centuries. There are rare findings in ships which have been unearthed in this unit. Only in one location, many well preserved amphorae have been found close to the wrecked dock (Figure 12).

Figure 12- During the excavation, well preserved several amphorae were found in the 5th Unit near dock that was destructed.

6th Unit

This unit takes place above the 5th unit and contains many pieces of amphorae (Figure 2, 3, 7, 11, 13, 14, 15). The thickness of the 6th unit varies in between 70 - 130 cm. The sequence is generally represented by sand. Besides; it contains intercalations of clayey sand and silty sand and has a plenty of shells. Levels full of shell are laterally discontinuous. Plenty of angular ceramic pieces are observed in the 6th Unit. Sporadically rounded pebble and granules, angular to sub-rounded rock fragments, bones and ceramic levels are present in the unit. Considerably intense pieces of ceramic, almost complete amphorae are observed in three different levels in the unit. Sporadically, angular rock fragments that have been transported from shore and structures on the coast into the sea by stormy waves also exist (Figure 11, 13). Pieces of ceramic have usually been accumulated in a way that convex sides would look upward. Cross bedded sands in the form of ripple mark were observed in ceramic levels. The thickness of this sand layer varies in between 20 - 35 cm. The

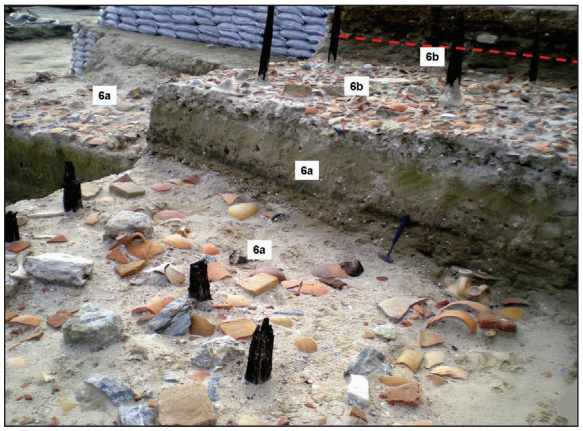

Figure 13- The 6th Unit can easily be divided into 2 sub units (as 6a and 6b) to the north of the study area. The division can be made by layers which masses of ceramic, pieces of amphora and angular stones are dense. Levels in which there are several coarse materials were deposited as a result of storm. The sand however has been deposited in normal sea conditions after the storm. Ceramic (6a and 6b) and sand layers (6a and 6b) of both sub units were marked by the same symbol in figure.

Figure 14- A view from shipwreck existing in fine to medium grained sand within the 6th Unit. There were found pieces of ceramic, walnut shells, cherry kernels and pieces of alga (posidonia) in the sand which precipitated after the storm in the vessel

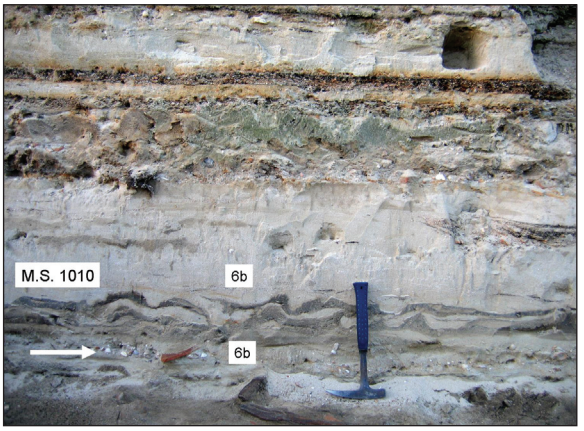

Figure 15- Seismite sedimentary structures are observed in the 6a sub unit. This data indicate that Istanbul surround has been influenced by earthquake during the precipitation of this unit. When historical records are taken into account, it can be considered that the earthquake which formed the seismites seen in the photo occurred in A.D. 1010. The section marked by white arrow indicates the level of ceramics dispersed at the sea bottom after the storm. These data show that first the storm then the earthquake occurred.

sand layer in some places intercalates with muddy sand and shows lamination. It is observed that the cross bedded sand sometimes contains black to dark gray colored lenses. These lenses include decayed, carbonized and disintegrated sea weed and other pieces of plant. Besides; 25 shipwrecks were found in the unit. Shipwrecks were determined as these belong to 10th century (Pulak, 2007). The macro cross bedded sand was also observed other than the micro cross bedded sand in the sequence of the 6th unit. The presence of macro cross bedding and non-mudy sand precipitated in shipwrecks were interpreted as indicators for the occurrence of storm.

The unit in some parts of the excavation site is represented by 70 cm. thick intensive pieces of ceramic levels. In these parts, it has not been possible to differentiate the unit into subunits. In places where the unit was divided into 2

subunits, it was seen that two ceramic levels overlapped each other and were difficult to separate them laterally. The unit can be divided into two subunits in many places (Figures 7, 11, 13). In areas where the separation was made it was observed that there had been no ceramics following the pieces of ceramic levels (6a) but very less amount of sand (6a). The ceramic level at the bottom and the sand on it was separated as "6a". The "6b" level containing plenty of ceramic pieces exists after "6a" sand level and is covered by sand (6b). On the other hand, sand layers which cover ceramic levels have been deposited at a longer period of time under conditions of marine environment. Two big storms that affected the shores of Istanbul in 10th or in mid 11th centuries might be the reason of formation of "6a" and "6b" ceramic levels (Perinçek, 2008). Following storms "6a" and "6b" sand accumulations occurred under normal coastal-marine conditions.

"Seismite" sedimentary structures observed at lower layers which were separated as 6a and 6b indicate that Istanbul and its surrounding area was subjected to two important earthquakes during the deposition of this unit. Uncemented sediments having too much water in the pores had lost their primary sedimentary structures and the sequence was subjected to deformation. Thus, seismites was formed before compaction and cementation (Figure 15). It is thought that seismites observed at 6a and 6b levels seperataly are related with the earthquakes in 989 and in 1010 (Yalçıner et al., 2002 and Altınok, 2005). Many seismites were found over the ceramic level located at the bottom of "6b" and at the bottom of "6b" sand layer (Figure 15). This data indicate that the earthquake happened after the storm.

Ballast stones were detected around the shipwreck. Ballast stones are usually rounded to subrounded as these are collected in sea or river beds. However, angular bile stones were found in some vessels. Some of the ballast stones dispersed from the ships are made up of serpentinite. As it is known, serpentinite and basic rocks do not crop out around Istanbul. Therefore, it is certain that those ballast stones had been transported by ships taking the goods from the harbours, out of the city.

More than two ceramic levels were observed within the 6th unit. There are 3 ceramic levels at the bottom, in the middle and at the uppermost part of the 6th unit. The 7th unit begins after the ceramic level at the uppermost layer. It is difficult to distinguish the boundary between the 6th and 7th units where the mentioned ceramic level does not exist.

7th Unit

In some of the observation stations, ripple marks are observed at section where it coincides with the boundary between 6th and 7th units and in the 7th unit. The boundary of 6th and 7th units can not be detected easily. The transition of the boundary is gradational.

The 7th unit is represented by sand and sporadically laminated sand (Figure 2, 3, 7, 16). Dispersed fragments of ceramic and ceramic levels, rounded pebbles and dark gray layers rich in organic material are observed sporadically. The thickness of the unit varies between 30 - 60 cm. Ceramic fragments are both angular and of some were rounded as being eroded by the wave action. It is considered that the 7th unit was deposited at the end of 11th century - beginning of 12th centuries and shows a gradational transition with the 8th unit over it in some places.

The ballast stones are also present in this unit and this is another important thing that had been noticed. Rocks which were transported to the port by vessels had been dropped on port while ships were being loaded. Lithologies of some rocks show that some of these ballast stones do not belong to Istanbul district.

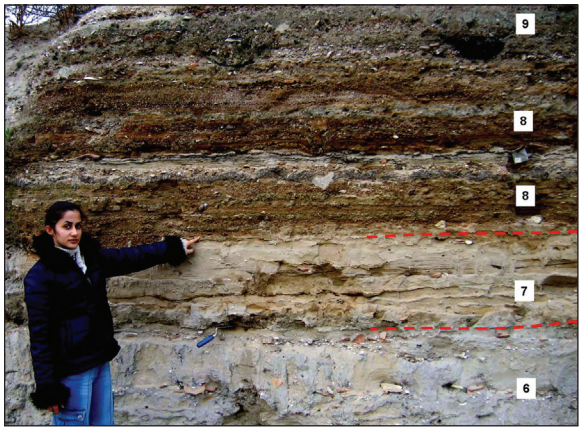

Figure 16- 7th and 8th Units have both lateral and vertical transitions. 8th Unit is pebbly and majority of pebbles are represented by pieces of ceramic. Ceramics dispersed into the sea with various reasons have then been rounded by waves in time. The 7th Unit in the photo can easily be differentiated from the 6th Unit at the bottom and 8th Unit at top in terms of color and texture. The 9th Unit exists at the topmost level.

8th Unit

The 7th unit traverses into 8th unit which is 50-80 m thick. The unit is mostly made up of pebble, rounded pebble, granule and lesser amount of sand. There are black colored intercalations and lenses composed of decayed and carbonized sea weeds and plant residuals. Plenty of glassy spines (sponge spicule) were encountered in these intercalations (Prof. E. Meriç, 2007, written communication; Perinçek et al., 2007). The characteristic of the 8th level (Figure 2, 3, 7, 16) is that it consists of sand and pebbles formed generally by rounded ceramic pieces. 80 to 90 % of most pebbles which were made up of ceramics have been processed by wave actions and corners are rounded. The color of the unit is red, dark gray and black; the red color originates from abraded and rounded ceramics. The said distinct key horizon is over the vessels in the 6th Unit which was dated as 10th and 11th centuries. Rounding and flattening of pebbles made up of ceramic occurred after the processes of wave erosion that had lasted for a long time following the sinking of vessels. Besides, it is considered that pieces of ceramic pots which have accidentally fallen at the port were passed through the same process in the first half of the 12th century. Most of ceramic pieces belong to the Port and can be considered that one portion of these have been carried to the Port along river.

Channels which have been formed during the deposition of the 8th unit have sporadically eroded the 7th unit and sediments that belong to 8th unit have been accumulated in these channels. The channel fill contains intercalations of sand, gravel and decayed sea weeds. The depositional environment of the 8th Unit might be the coastal - beach environment which was developed under the effect of stream action. According to Algan et al. (2009), the 8th unit reflects the conditions of fluvial environment and had been formed by the deposition of materials which was transported by Bayrampaşa river (Lykos river) flowing along the Vatan Street until the beginning of 1950s. The thickness of this fluvial deposit that underlies the 9th unit (molasse fill at the top) is 1 to 3 meters (Algan et al., 2007; Algan et al., 2009). At the lower part of the sequence, Meriç et al. (2007), determined the presence of less amount of *Chara* sp. which was a plant organism. The most important characteristic of *Chara* sp. is that it has lived and still lives around the mouth of streams at coastal zones. Besides, the observation of ostracods living both in fresh and brackish waters in upper levels supports this idea. Consequently, the presence of the stream mouth in the Yenikapı excavation site and around is strongly considered.

9th Unit

9th Unit made up of terrigenous soil is recognized after the 8th unit (Figure 2, 3, 7, 16). The 9th unit is represented by 1-2 meters thick cultivation soil. In the cultivated soil around the study area many architectural structures and archeological findings belonging to Late Middle Age and later

have been investigated (Çelik, 2007; Gökçay, 2007).

DISCUSSION

At the northeastern part of the Yenikapı excavation site, it is observed that the 3rd unit is pinched out to north and east and 4th unit directly lies on the 2nd unit. The 2nd unit has been deposited B.C. whereas the 4th unit was deposited A.D. 6th - 7th centuries. Accordingly; there is a time gap of at least 1500 years between the 2nd and the 4th units. Since, in the studied area, the 4th unit directly overlies the 2nd unit the archeological evidences give quite different ages (Archeologists working at excavation, 2008, 2009, oral communication). It is observed that a vessel belonging to 6th or 7th centuries has been settled directly on the 2nd unit in the same area. It was also investigated that the 5th unit becomes thinner from west to east. Generally all units become thinner from south to north in a way that it reflects the topography of the sea bottom. Other than these, the 5th unit also becomes thinner in east-west directions.

The settlement area of people who lived on the edge of marsh land falls into the eastern and northeastern parts of the marsh area. Usually Late Miocene sequence crops out at the bottom of the settlement area. Depending on the water level changes in summer times, northern edges of the marshland as well have seasonally been used as settlement area on swamp mud. The boundary of marsh land importantly changes in summer and winter times depending on the season and the rate of precipitation. When the water level decreased in summer, people on the edge of marsh would approach the area submerged under water to benefit from the area. There are evidences which support this observation in the study area. One of them is the arrangement of stones within the marsh deposits towards the center of the marsh. People living in the region have usually collected angular stones and put them on the edges of muddy marsh land although its water had receded. Thus, they approached the edge of the lake stepping on these stones. The reason of doing so is most probably to hunt for fish, bird and other living animals. The reason of stones to be mostly angular is an important indicator that these have been placed by people. The other indicator showing that the boundary of marsh has changed in summer is the presence of cemetery, granary and cremations in the area where water receded. The marsh land that had dried up in the summer has been used by people. Swamp mud was observed both below and above the cemetery. It is not possible that the cemetery has been buried in the mud. The corpse which has been placed on wooden grid in the form of litter had been buried there digging swamp mud when the water has receded in the summer. This litter is considered to have been attached on the ground by nailing small piles as shown in Figure 17. Any other aim of the piles is not known at present. People who lived in the region followed by the retreating of water in the summer have created seasonal storage areas for themselves. Wheat and similar materials were stored in these storages. The swamp mud exists below and above these storages which the archeologists unearthed in Yenikapı district. It is not possible to

Figure 17- A human skeleton is seen within the 1st Unit belonging to Neolithic era as placed on wooden grid. Wooden grid may have been stitched up by piles "K" into mud ground. Both the top and bottom of the skeleton and wooden grid is covered by marsh.

store grains in humid conditions. Therefore, it has been considered that these storages were temporal storage used in the summer.

There are some uncertainties about the origin of crystallized lime pebbles in the 2nd unit. There is not any data showing that the crystallized limestone crops out in and around the excavation site in geological maps. Lack of information about the origin of pebbles at this stage might have originated from the deficiency in available geological maps. It is considered that one portion of stones on beach might have been arranged and used by people although there is not any possibility for people to carry pebbles available in the 2nd unit to nearby the site of excavation. The presence of a river which has enough flow rate to carry the flattened limestone blocks of pebbly, blocky levels in the study area is out of question. The traces of the river are observed in the site of excavation and its presence is mentioned in historical records. However it does not have enough flow rate to carry limestone blocks to its recent place. There has not been collected enough data so far about their origins and on how flattened coarse pebble and blocks had been transported to their recent places. Exposures of the crystallized limestone could not be observed that might be the source to pebbles along the shore near the Port and around the tributary area of the river mentioned above. For the source of pebbles, it can be interpreted that the exposure of it might be in the sea to the south. During marine transgression that caused the precipitation of the 2nd Unit, particles detached from the exposures of crystallized limestone located under the sea at south by wave action have formed marine sediments which advanced landward without being transported much.

Archeological evidences which have been found in the 2nd unit belong to Neolithic Era Fikirtepe culture which was 8000-600 years ago than today (Algan et al., 2009). The architectural ruin with its pebbly foundations which has lasted so far possesses a rectangular plan in patches and sometimes rounded plan at a level where two units exist (approximately 6.3 m). Its bearing system was formed by wooden pillars which have been supported by stones. However, walls have been made by masonry branches plastered with mud originating from burnt bricks obtained during excavation (Çelik, 2007; Prof. M. Özdoğan, 2007, oral communication). Architectural ruin shows a similarity with the architecture of Aşağı Pınar Neolithic era found in Kırklareli (Çelik, 2007).

The oldest ceramic pot fragment found in the Yenikapı Prehistoric settlement area shows a similarity with pot samples in Fikirtepe settlement area (Prof. M. Özdoğan, 2007, oral communication). Late Miocene claystone in and below the 2nd unit and skeletons found in 4 cemeteries (2 of them are small) which were dug into the mud of the 1st unit most probably belong to 6200 - 6400 B.C. according to Prof. Özdoğan (Hürriyet, 2008). In 2009, there was found an 8500 years old cemetery at the level of 1st unit in the excavations carried out at the construction area of the Yenikapı Marmaray Station as well. The executive person of the excavation Mr. Yaşar Anılır claimed that this cemetery which was very important for the archeological history of Istanbul was much older than Yarımburgaz, Fikirtepe Neolithic Excavation site and was the oldest cemetery found in Istanbul. According to Mr. Anılır the skeleton which has been placed on the Neolithic wooden grid has not any other example (Hürriyet, 2008). As a summary, people lived on a topographic plain at 6.5 meters below the recent sea level, 7200-8500 years ago in the site of excavation. As a result, the transgression that had started within the 2nd unit and the following submersion of the land has mostly occurred mostly 7200 years ago.

In the muddy layers of the 4th unit the skeleton of 4 horses and one camel has been found as one piece (Çelik, 2007; Gökçay, 2007; Perinçek et al., 2007; Perinçek, 2008). It was also noticeable that feeding basket of one horse and the

halter made up of rope of the other horse had remained next to horses. These animals have been brought to marine environment with muddy, sandy, pebbly coagulated materials and have rapidly been buried by unprocessed trees and leafs transported from land. The neck of the camel might give some information about how it has died (Figure 9). The neck was found in a position that it had turned toward its body in the direction of tail. The animal should have taken this position before he had died and his body had been cooled. It is deliberated that both camel and horses had been into the sea in excess mud then have rapidly died under the water. Different interpretations are made for each skeletons found in the study area. According to one of them, the animals belonging to skeleton have been thrown away here. If it had been so, then the feeding basket and the halter would not have existed there. Besides; according to another interpretation, if animals mistakenly had fallen into the sea then these should have bulged and remained on the water. Animals that had died in this way would decay in time and bones would break away by wave actions. However, the skeletons of animals are as one piece.

Although some ceramic fragments were covered by shells in the 4th unit some of them are not. It is considered that ceramics not covered with shells have not remained on water for a long time but have been buried into sand and gravel as soon as they have been transported there after the tsunami in the region. On the other hand, shelly ceramic fragments have most probably been transported to marine environment previously, stayed in contact with water for long time then mollusks have hung on these ceramics. Ceramics covered with shells are considered to be older than the others. Most probably; shelly ceramic pieces in sand at the sea bottom belonging to 4th and 5th centuries have been scraped off the sea bottom at tsunami which has occurred after the earthquake in 6th century. These pieces have then mixed with ceramics of the 6th century and re-deposited at the sea bottom and have finally formed marine and terrigenous deposits of the 4th unit with abundant ceramics and pebbles. When the surface of processed marble fragments have carefully been studied within the unit, it was observed that upper faces of these fragments had been hung by seashells but had no shells on lower faces when these were lifted up. Pieces of amphora found in the 4th unit have behaved mostly like shells settling in the sea during the precipitation of the unit and these have been deposited at the sea bottom in a way that convex sides would look upward. One portion of these pieces has been lifted up and the material below has been investigated. The abundant plant pieces were observed under some fragments which were transported from land. Plant pieces in syrupy mud which have been transported into the sea had been trapped under amphora fragments before they got a chance to float on the water. Since some amphora pieces have not totally contacted with the sea bottom one or two types of the living marine organisms have invaded and colonized there. Colonization of only one species was observed at the lower part of some fragments.

The 4th unit to contain mud in significant amounts, to have a poor sorting and full skeletons indicate the presence of a low energy environment that occurred in a short time and the event related with it. It does not seem possible this event to be highly energetic storm. All other possibilities are tsunamis and floodings. Based on data given above, it is considered that the 4th unit was deposited under the control of tsunami which occurred after the earthquake. Tsunami waves coming from open and deep sea have carried sea shell, mud and sand towards land scraping the bottom of the sea. When tsunami waves which carry these materials had reached the Port they have destructed some vessels and docks there and have carried them to shore and landward. Tsunami waves reaching the land have lost its force after it had advanced a bit more and had receded back to sea. Waves which

have returned to sea have also carried living creatures on land, goods such as amphorae and oil lamps on shore for commercial purposes, trees and other terrestrial materials. Syrupy mud returning to sea has carried the accompanied material to open shallow sea and on the depressions of the sea bottom on port. Materials which may float such as tree and animal did not have any chance to do so thus, have rapidly been buried - precipitated together with mud and all materials within mud. The probability of rapid burial of animals into mud which were carried into sea by tsunami is much higher than by floodings. However, if these had been carried into the sea by floodings then the animals would have died, expanded and floated over the water. Thus, there would have been less chance for skeletons to be as one piece. On the depressions of the sea bottom first coarse material then fine grained sand and mud were accumulated. At the strike of strong tsunami wave, the sections of dock piles at the port which have remained under water were broken by the effect of tsunami wave. Thus, the broken part has been mixed with the material which the tsunami had brought and removed away. However the portion in the sand had been buried under tsunami deposits after the tsunami has ended. Later on, portions of these wooden piles which were close to the sea bottom and in contact with water have partly been deteriorated by the living marine organisms. Then, these piles were completely covered by deposits of the 5th unit (Figure 10). It was observed that some piles have completely been detached off the sea bottom where these were placed and pile slots had been filled by deposits of tsunami level.

Significantly deteriorated shipwreck and processed wooden materials (dock piles) were found in the 4th unit. Shipwrecks observed in two locations were probably carried towards land by tsunami then brought back to port by the receding waters. Ships have significantly been crashed during this process. Therefore, ships in the 4th unit have been damaged more than the ships settled at upper level which belong to B.C. 7, 8, 9, 10 and 11. There are very less findings close to shipwreck which belongs to 4th unit. Findings are observed everywhere without directly related with shipwreck. In one section of the excavation site nearly 100 baked soil gas lamps were found although there was not any wreckage. It is considered that these lamps have been drifted into the sea by the tsunami wave from a table of lamp seller near the coast but not related with the ship.

The 4th unit at Yenikapı excavation site the exposure is divided into 2 sub units. There are many entries of earthquake and tsunami at 6th century in historical records. Since two different layers are distinctly separated at some exposures, it is considered that there has been more than one tsunami that affected the port at 6th century. There is a need for additional data to be gathered to reach the final decision about this event. Observations will continue to demystify this issue in further stages of the study.

It is claimed that one portion of the 4th unit was deposited after the tsunami (Perinçek et al., 2007; Perinçek, 2008). However it is necessary to make detailed study on it. The event that caused the formation of the unit might be the flooding that occurred just after a heavy rain. The presence of excess mud in the unit and materials carried from land (branches of tree, leaf, angular rock fragments, ceramic pots and etc.) might reinforce the idea of flooding. If there is such a possibility then there should be a section where there is only terrigenous material at any location of the port within the marine deposit in the study area. Whereas; the layer distinguished as the 4th unit was formed by the complex mixture of marine and terrigenous material. The 4th unit can be divided into two sub units to the southwest of the study area. The sequence below the unit is made up of mud and sandy mud and there is little angular rock and ceramic fragments. The sequence which is in the same unit is observed throughout the study area and the thickness varies in between 10 - 80 cm. Marine and

terrigenous material is mixed in the upper part of the sequence and composed of muddy sand, sandy mud and sand. It contains sediments varying from pebble to large cobbles and many archeological findings. It is considered that this unit was deposited followed by a significant geological event. Perinçek mentions that this important event could be tsunami after earthquake (National Geographic, Turkey, 2007; Hürriyet, 2007).

The Lycos River is the reason of occurrence of mud in the 4th unit. The Theodosius Port was constructed at the 4th century (Asal, 2007; Gökçay, 2007). After the Port had been constructed, significant amount of mud might have been accumulated on the western part of the Port possibly because of breakwater located at the southwest. This muddy layer corresponds to the lower half of the 4th unit. The mud accumulation at the eastern part of the port might have occurred due to the breakwater located at the southwestern part of the port to stop the wave energy entering to the port. However, at the eastern part of the port the wave energy is higher relative to western part since it is the entrance of the port. There fore, this case caused the sequence at east to be less muddy. Let us once assume that Lycos River located at east of the port might have been effective in filling up the port with muddy sand at the 5th and 6th centuries. According to this; ones who have used the port after the 6th century might have changed the direction of the river setting a wall in order to overcome negative effects of Lycos River to the port at location where the river reaches the sea between the port and the mouth of the river. Thus, they have tried to remove the material which the river transported from the port. After this probable structuring the mud accumulation at the port has rapidly decreased and the 5th unit composed of fresh marine sand might have been deposited. After discussing this possibility, the possibility of muddy sand in the 4th unit to be tsunami becomes stronger when data in hand are reevaluated.

Shipwreck and the material being thrown away from these ships are encountered at sequence belonging to 5th unit. Storm is the reason for ships to sink down (Perinçek, 2008). Macro cross bedded sand at the deposit and the sand precipitated in sunken ships indicate the presence of storm. There is less findings in the unit. Many well preserved amphorae were found near the destroyed dock which occurs at only one location (Figure 12). There has not yet been found any shipwrecks near amphorae but since these were found at the foot of docks it was considered that amphorae had been brought to dock to be loaded on to ships. The dock has been destroyed after the storm and amphorae which were ready to be loaded to ships have been as dispersed over the sea bottom.

Shipwrecks were encountered in areas where ceramic fragments and amphorae are intensely present in the 6th unit. Frame timbers of these ships has mostly been preserved. There was observed nutshells, cherry kernels and carbonized sea weeds (Posidonia) with sea shells in the sand which filled up the vessel. There was also found laminated sand, amphora, ceramic fragments and various goods other than sand in vessel. As a result of two storms occurred in 10th century and in the mid of 11th century ceramic fragments dispersed after the sinking of 25 vessels and these fragments had been buried in the sand of the 6th unit and had well been preserved (Perinçek et al., 2007, Perinçek, 2008). The sand is usually available in undamaged sections of ships and mud is quite less. These sand layers have been deposited at high energy zone which the storm had made. It was understood that the sand which the storm had lifted up at sea bottom has generally covered the bottom of vessels and therefore, these parts have been well preserved from the effect of waves and living organisms and not decayed. However sections of vessels which are covered with sand and directly in contact with water were broken apart by wave and water actions. It was also observed that organisms living in the sea

and fed on woods have destroyed these parts by boring. The traces of borrow are very distinctive. The wooden material shivered by wave action has formed laterally discontinuous laminae by being deposited within sand at top. Amphorae that had fallen into the sea from ships and not buried into the sand have been fragmented more by the wave action thus, the edges of ceramics have been rounded. Big ones of complete amphorae and fragments of amphorae exist in and near the sunken ships. Generally, getting away from the sunken area the size of amphora and other ceramic pieces gets smaller and their density decrease. This observation shows that ceramic pieces found in the 6th unit at the excavation site were dispersed from sunken ships over the port base by the effect of storm. Consequently; it is observed that there is less possibility that these pieces have been thrown away at port by hand. In deeper parts of the port and towards open sea there are many ceramic pieces. However, there are less or almost no angular blocks and coarse angular pebbles. Approaching the shore, there is observed a significant increase in numbers of angular blocks and coarse angular pebbles. The storm which sank ships has made significant damage at coast and has drifted rock pieces which had been detached from structures at coasts. These pieces could not be carried into deeper parts but were deposited near the coast as these were big in size. However, in the 4th unit there is not such an arrangement. Angular blocks and coarse pebbles have been dispersed as disordered and disproportionally is near or away from the coast. There are 3 ceramic levels in the 6th unit. Vessels that exist with ceramic layers at the lowermost layer were dated as B.C. 10th century by Pulak (2007). The relation of the ceramic level at the uppermost part of the 6th unit which also forms the bottom of the 7th unit does not have a definite relation with the storm. The formation of this layer might be due to the deposition of ceramics by wave actions which were spilled off the sea because of storms in previous times.

Prof. A. Ergin, from the Institute of Marine Sciences of the Middle East Technical University, has contributed to the idea of the author from a different perspective saying that the storm was the reason for vessels to sink at 7th and 11th centuries at Port of Theodosius assessing data of coastal engineering (NTV, 2009). Prof. Ergin has also determined the dominant wind direction in the area as south-southwest in his assessments. According to wave data, he estimated that the storm wave heights towards port had changed between 3-4 meters outside the port within the periods of 100, 500 and 1000 years. Prof. Ergin has detected that the height of waves in harbor had decreased to 1.5 m. by means of breakwater and concluded that waves at such a height could sink vessels at the port. He said that the harbor had been overwhelmed by strong waves in harbor as resonance waves and waves reflected from the walls of the port were combined with storm waves from the sea (NTV, 2009).

Following the 7th unit, data indicating the regression was encountered in the 8th unit too. The most significant of these data indicate that the sea has receded back. The 8th unit down laps the boundary of the 7th unit and partly along the upper boundary of the 6th unit. The 8th unit has been deposited in coastal environment under river action near the study area. The material which has been transported to the shore by Lykos River and shore currents has been flattened by being processed and formed beach deposits. This level is very poorly sorted. The 8th unit which contains seashells, ceramic fragments and partly sand intercalations was truncated by minor channels in upward direction. Intercalation of pebble layers with ceramic pieces, carbonized marine alga and terrestrial plant residuals intercalate with sand layers. Carbonized layers also form intercalations at 7th and 8th units. The ratio of these intercalations is much more in the 8th unit. Sponge spicules are encountered in sand which contains decayed dark brown and black colored layers.

It is known that Lycos River has discharged near the harbor at Yenikapı but, the trace of materials transported by the Lycos River near the excavation site was not observed very much in deposits. Shores of Istanbul extend in W-SW and E-NE directions. Dominant wind directions in the Sea of Marmara are northward based on long term averages. Ostro and Tramontane winds reach the shores of Istanbul with an angle and form shore currents. These northeastern currents sweep the material away which the Lycos River had transported, carry them in north-east direction and spread it out. According to data available, the Port of Theodosius is at the western part where the Lycos River has reached the shore. Therefore; the material which the river had carried has been distributed by shore currents in the opposite direction of the port. That is why alluvial deposits in the 8th unit are less recognized in the study area. Algan et al. (2007) mentioned about the Lycos River deposits in the 8th unit. Perinçek et al. (2007) and Perinçek (2008) claimed that the material observed in the 8th unit had been deposited at coast by the river action.

It is observed that the 8th unit in total and the 7th unit in partial did not exist under the basement of light house which was unearthed during excavations in Yenikapı. However the 6th unit remains under the basement of the light house. The 8th unit and one portion of the 7th unit were deposited after the light house had been constructed. The age of deposits of the 6th unit belongs to 10th and to the first half of the 11th century. Accordingly; the construction of the light house had been made before the first half of the 11th century. Data regarding the level of the sea at time of construction has been collected during investigations around the light house. There are traces of wave erosion on the walls of the light house. Besides; the traces of marine organisms which have lived by attaching themselves on the wall of the light house were found over the basement of it which was submerged in water. The attachment levels of sea shells on the wall are compatible with levels of wave erosion. The highest level which these organisms were attached shows the sea level at that time. It is seen that the sea level has not changed since the 11th century when the level of the sea at time of construction of lighthouse with the recent sea level was compared.

There exists a church at the excavation site which dates back to the end of 12th century (Archeologist M. Gökçay, 2008, oral communication) and beginning of 13th century (Gökçay, 2007). It was seen that this church had been constructed over the 8th unit when the basement of this church was investigated. The construction of the church has been after the deposition of 8th unit or towards last stages of the deposition. The 8th unit is younger than the lighthouse but older than the church. Therefore, it is considered that the age of the 8th unit would be the beginning, second quarter or mid of the 12th century. According to Erel et al. (2009), the Port of Theodosius was fully filled by natural deposits carried by river, sea and anthropogenic wastes from the northern settlement area due to the increase in population in B.C. 1200. Algan et al. (2009) stated that after the 11th century the Port has started to fill up fully with alluvials which the Lycos River has carried and the coast line has again receded seaward.

Traces of Lycos River are not encountered in the 9th unit. The unit is composed of cultivated soil and molasses which were carried by humans to Langa Orchards. If the Lycos River had continued its activity in 13th and 14th centuries then the traces of alluvial deposits should have been in this unit. But it is not so, then two possibilities may be in question. First, the river bed of Lycos has been changed under human control. Second, material which was carried by river is mostly fine grained and has easily been distributed by sea waves.

The 2nd unit deposited in coastal environment is the production of transgression. The sea level

has increased as waters of Black Sea or Mediterranean Sea entered the Marmara Basin 11.000-8.000 years ago (Stanley and Blanpied, 1980; Ryan et al., 1997, 2003; Çağatay et al., 2000). Increasing sea level reached the shores of the Port of Theodosius approximately 7200 years ago. As a result of transgression people who lived on a topographic plane 6.5 m. below the recent sea level had to leave their living areas. As a result of continuing sea level increase the 3rd, 4th, 5th and 6th units have been deposited under shallow marine conditions. After the 6th unit, the material carried by rivers that reached the shore has been carried away being reworked by wave and shore currents and accumulated on coastal plain. Thus, the coast line has receded back to sea. Since the sea level was constant in this period, the material accumulated along shore has caused regression. The structures of down lap encountered in layers of the 8th unit are data which show the coast line change and regression.

CONCLUSIONS

9 units which were differentiated in the study area are represented by different lithological groups. It is considered that the 1st unit at the bottom is older than 6200 B.C. in age. However, the cultivated soil at top represents the sequence that has been deposited so far since 13th century.

The 1st Unit represented by the marsh sequence was deposited in lagoon - lake environment. People lived around the shore of the mentioned lagoon at a topographical plain 6.5 m. lower than the present sea level at least 7200 years ago than today. The people used coastal zones and it was also detected that they had also used lagoon lakes due to the retreat of sea water in summer times detecting traces of life. The 1st unit lies on the deposit represented by Late Miocene aged clay, silt sequence. However, the 2nd unit directly lies on that clay-silt deposit in areas where marsh deposits do not exist. Marsh deposits are encountered to the east of the site of excavation, whereas; 1st unit is not observed to the west of the site.

The 2nd unit started to deposit by the transgression which developed due to increase of sea levels in the Sea of Marmara which began 7200 years ago than today. The sequence investigated in Yenikapı excavation site is transgressive from 1st to 7th unit. However, a regressive sequence is observed starting from the 7th unit to the upper part of the 8th unit. The regression is not due to change in the sea level but the existence of abundant material that have been transported and deposited. This material was accumulated along the beach and caused the coast line to be seen as if it had receded seaward.

Archeologists working at the excavation site have detected ceramics for the 4th unit indicating A.D. 5-7th centuries (Katalog, 2007). Afterwards; archeological data obtained in the 4th unit have been correlated with geological data. It was found that a significant portion of this unit belongs to A.D. 6th century due to C14 dating results from samples taken. Archeologists aged vessel and plenty of ceramic materials as A.D. 10th century and as the beginning of 11th century from the 6th unit which is located at upper levels of the deposit (Pulak, 2007; Asal, 2007; Gülbahar, 2007). To date all units, the dating results of 4th and 6th units have been used to date all other units. Thus, the depositional age of the 5th unit was determined as A.D. 7th and 8th centuries and in the first half of the 9th century although the unit has not enough ceramic to perform radiometric dating. The wooden materials and vessels detected in the 5th unit were determined as A.D. 7th century and this age was proposed for all other vessels (Asal, 2007).

The 4th unit was investigated and it was obtained that data indicating deposits at this level were related with the tsunami. Fragments of ceramic, pebbles, wooden materials and pieces of bones are present chaotically and indicate a rapid sedimentation. The sediments in which a

skeleton of camel and 5 horses exist in the excavation site belong to the 4th unit. Tsunami waves which had reached the coast after the earthquake have then carried camel and horses towards sea when these were still alive as it recedes and caused these animals to be buried mixing with suspended marine and terrigenous materials in water. Pieces of skeleton and woods mixed with water have been deposited in the matrix without having an opportunity to float on the sea. The earthquake and the following tsunami waves that occurred in A.D. 557 are probably responsible for the formation of one portion of the 4th unit. After the earthquakes that occurred in A.D. 553 and 557, some districts of Istanbul which are very close to seaside were affected by the tsunami waves (Perinçek et al., 2007).

Shipwrecks and their loads which had been dropped off ships were encountered in the deposits of 5th and 6th units. Existence of macro cross bedded sand layers in the sequence and the deposited sand in shipwrecks to be free of mud are two important evidences indicating the occurrence of storm. Due to decrease in energy the sand which was lifted up by waves during storm has been accumulated in vessels with no mud after the storm. Amphorae in the 6th unit to be either in one piece or as less damaged, the decrease in sizes of ceramic as moving away the wrack and this distribution to occur independently from the distance to the shore indicate the presence of storm.

The sinking of Byzantine vessels detected in the 6th unit in Yenikapı excavations is due to the presence of severe storm. Data obtained from the 6th unit so far indicate that vessels have sunk due to storm (Perinçek et al., 2007). Two different storms that happened in mid 10th and 11th centuries damaged approximately 25 vessels. The sinking of vessels found in deposits of the 7th unit is also due to swashes and waves that had occurred in the port.

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