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Detection of subsurface layers by Sub Bottom Profiling (SBP) of cross section of Shatt Al-Arab River at Al-Rebat branch, Basrah, southern Iraq

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Abstract - Two types of the subsurface layers were investigated by two Boreholes on the two banks of the Shatt Al Arab River near the old Al-Rebat port at Basrah city. Sub Bottom Profiling along the River section has also been investigated. The boring was carried out in two sides of Shatt Al-Arab at Al-Ashar and Al-Tanuma sides at Al-Rebat square. Marine geophysical investigations were made including Sub Bottom profile technique (SBP) using the Strata Box instrument. Besides, Acoustic Doppler Current Profiler (ADCP) technique was used along a 400 m section for determining the cross section of the River. the Boring Log Data of two Boreholes have been represented depending on SPT Values as the bearing Strength of subsoil layers profiles, which is matching with the sedimentary layers resulting from the seismic profiles for obtaining the geotechnical model of subsurface layers along cross section of the River. High bearing capacity layer is very dense sandy layer which appears at -22m of the elevation on sea level and extends to -29 m in left bank of the River. This layer is old deposits belonging to Dibdiba deposits (upper Miocene-Pleistocene).

Introduction

Much of the information on deep sediment layers has been gained from drilling and seismic echo profiling. This latter technique is similar to echo sounding of ocean depth in that it involves producing a loud sound and analyzing the echoes from subsurface sediment layers (Stowe, 1996).

A subsurface mapping system is used to obtain information about the sediments beneath the surface of the coastal bottom. High resolution mapping of seabed morphology is now essential for geophysical investigations, especially since the emphasis in recent years has shifted from broad reconnaissance exploration to intensive studies of local areas (Jones, 1999).

The investigated area represents the project of a bridge construction on the Shatt Al-Arab River at Basrah city, southern Iraq, which links two sides of the Shatt Al-Arab (Ashar and Tanuma sides) (Fig. 1). The River is considered deltaic river influenced by the tidal effects of the Gulf. Several constructions have been built on it, and others will be performed in future. These types of engineering constructions involve estimating depths of high bearing capacity stratum along the section of the River which will be the deep stratum of Bridge Piles foundations. For detecting of the bearing stratum, geotechnical Investigations by two Boreholes on the two sides, in addition to Sub Bottom Profile (SBP) along the River section have been performed. Using geophysical methods in issues of geotechnical investigations are integration process of acquisition data of subsurface layers. Marine geophysical equipments are mostly used for getting on sub bottom profiling properties. These methods became very vital role to perform the subsurface layers investigations and their integration with the drilling works.

A long cross section in Shatt Al-Arab River at Al-Ashar Square in Basra city are taken to carry out the geotechnical investigations, where the investigated area is referred to right and left banks of the river, and the cross section locating between those two banks. Figure (1) Shows the location of study area and also positions of the drilling points on the two banks and lines of marine geophysical survey.

This study is aim to detect depths of subsurface layers and high bearing capacity by integration between the drilling works on two banks and using marine geophysical methods along line between two banks at the River section for plotting geotechnical section model of the investigated in area.

Materials and Methods:

1. Drilling work:

This work has been conducted with the assistance of the National Construction Centre at Basra. Two boreholes were drilled on the Banks of the Shatt Al-Arab River (Al-Ashar and Al-Tanuma sides) (Fig. 1), using Auger type drilling machine with detailed logging. In-situ tests such as the Standard Penetration Test (SPT) according to (ASTM Standard) were made. The data has been analyzed to assess different material properties. Representative soil samples were taken at appropriate intervals ranged between 0.5 to 2.0 meters depth generally or where the stratum has been changed. Table (1) shows the Coordinates and elevations of Boreholes above sea level, in addition to depth of drilling.

2. Marine Geophysical Survey:

The geophysical investigations included carrying out a Seismic Sub Bottom technique using the Strata Box geophysical instrument, and Acoustic Doppler Current Profiler (ADCP) technique along a 400 m cross section of the river. ADCP was used to detect the cross section and depth of riverbed which were corrected to sea level. Three lines of longitudinal sections at (Right, Mid and Left) sides of the river and fourth width line along 400 m cross section have been carried out using StrataBox device (Fig. 2). StrataBox instrument is a sub bottom profiling system of sedimentary layers, where the transducer has been mounted at the side of the vessel at 0.3 m below water surface. 10 Mhz of frequency has been chosen to investigate. It is based on the reflected pulse waves from the beds of River or sea. These reflected waves have been recorded as seismic section,

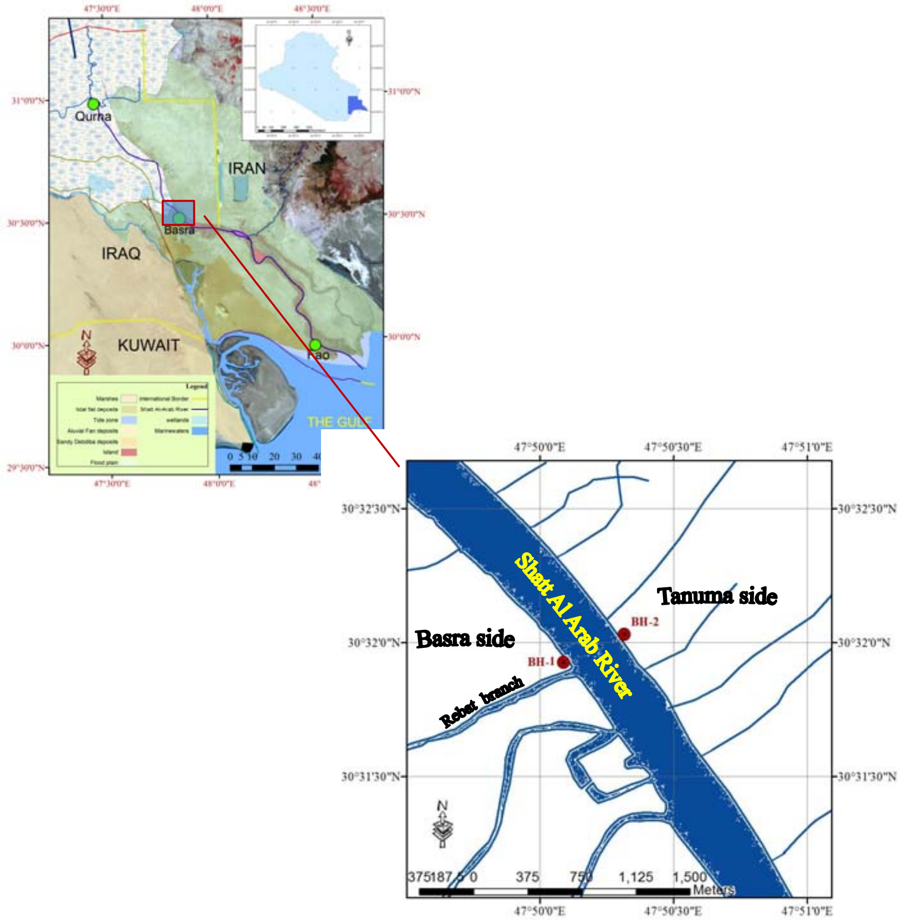

Figure 1. Shows the investigated area and two Boreholes relative to Shatt Al-Arab River.

Table 1. Shows the GPS and elevations of the Boreholes.

Borings	Longitude	Latitude	Elevations (m)	Depth of Drilling (m)
BH-1 (Al-Ashar Side)	470 50- 5.6=	300 31- 55.8=	2.65	30
BH-2 (Al-Tanuma side)	470 50- 17.9=	300 32- 3.6=	3.06	35

Figure 2. Photos of StrataBox equipment and installation during the field work, the condenser was kept at 0.3 m under the surface of water.

where consists of horizontal distance scale (m) and veritcal time Scale (msec) (Yaacob and Mustapa, 2010). The vertical Time Scale has been converted to depth scale (m) during the interpretation of seismic sections. The SBP uses acoustic waves that are sent into the sub-bottom by means of a transducer. The acoustic signal reflects upon material transition in the ground that is registered by a receiver. These profilers are dragged along by a boot on which positioning equipment is present. By carrying out a sequence of measurements a long a measuring line, detailed information concerning the composition of the sub bottom and the internally present disturbances can be obtained (Lafferty *et al.*, 2006).

While ADCP transducer is based on Doppler Phenomenon to get data. It has the same mounted method in stratabox transducer. ADCP technique has been depended on determination of cross section of the river (Fig. 3).

Figure 3. Shows ADCP equipment and its installation during the field work. The equipment was kept at 0.45 m under the surface of water.

Chart Datum:

Auto level instrument has been used to detect the elevations of two boreholes and elevation of seabed of the river.

Elevations and coordinates of two boreholes were detected by a process of transferring and fixing the elevations of two boreholes using the B.M. The elevations are referenced to sea level as chart datum.

Results and Discussion

Boring log data:

Figures 4 and 5 show the Boring Log Data of two boreholes which describe subsoil profiles and SPT Chart as indicator to the bearing Strength of layers.

The subsoil profile can be summarized as the following:

1. Right Bank Site (BH-1) Boring:
   - The top layer is a fill sand soil from ground surface to (1) meter of the depth.
   - The first layer consists of medium. Stiff brown Silty clay, this layer extends from 1 to 11 m depth.
   - The second soil layer consists of medium stiff to stiff lean clay, or sandy clayey silt, this layer extends from the above layer down to about 20.5 m depth.
   - The third soil layer consists of v.stiff to hard brown lean clay (CL), elastic Silt (MH) extending between 20.5 and 26.5 m.
   - The four soil layer consists of very dense gray silty sand (SM), this layer extends to the end of boring (E.O.B) at 30.0 m depth.

2. Left Bank Site (BH-2) Boring:
   - The top layer is compacted brown silty clay extending from ground surface to 2.5 meter of the depth.
   - The first layer consists of soft to medium. Stiff brown and gray Silty clay, this layer extends from 2.5 to 11 m depth.
   - The second soil layer consists of soft gray lean clay, this layer extends from the above layer down to about 16 m depth.
   - The third soil layer consists of stiff gray lean clay (CL), elastic Silt (MH) ranging between 16 and 22 m.
   - The fourth soil layer consists of very. Stiff to hard gray marly clayey sandy lean clay (CL), extending between 22 to 32.5 m.
   - The fourth soil layer consists of very dense gray silty sand (SM), this layer extends to the end of boring (E.O.B) at 35 m depth.

3. The Sub Bottom profiling (SBP) is used to determine thicknesses and lateral continuity of the bottom and Sub Bottom strata (Yaacob and Mustapa, 2010) (Fig. 6).

Sediments and sedimentation conditions:

The investigated area represents a part of lower Mesopotamian basin deposits, where there are two types of deposits locating within the influence of the constructions foundations, (Muttashar, 2002), as following: (1) Recent deposits consist of fine grained

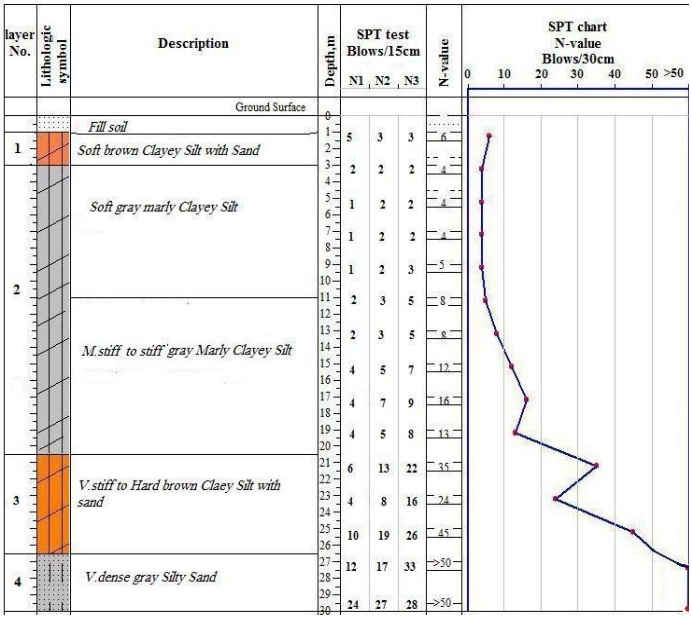

Figure 4. Boring Log Data (BH-1) at Al-Ashar Side (Right Bank) at elevation of 2.65 m on S.L.

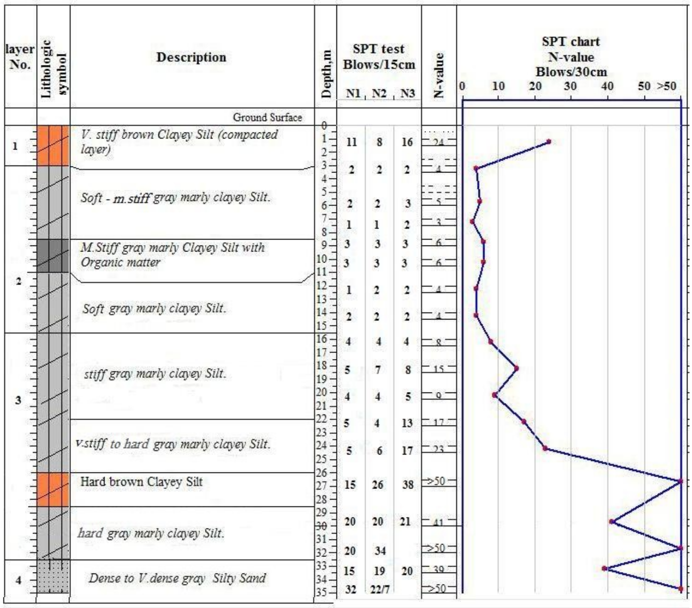

Figure 5. Log Data of BH-2 on the Tanuma Side (Left Bank) at elevation of 3.06 m on sea level.

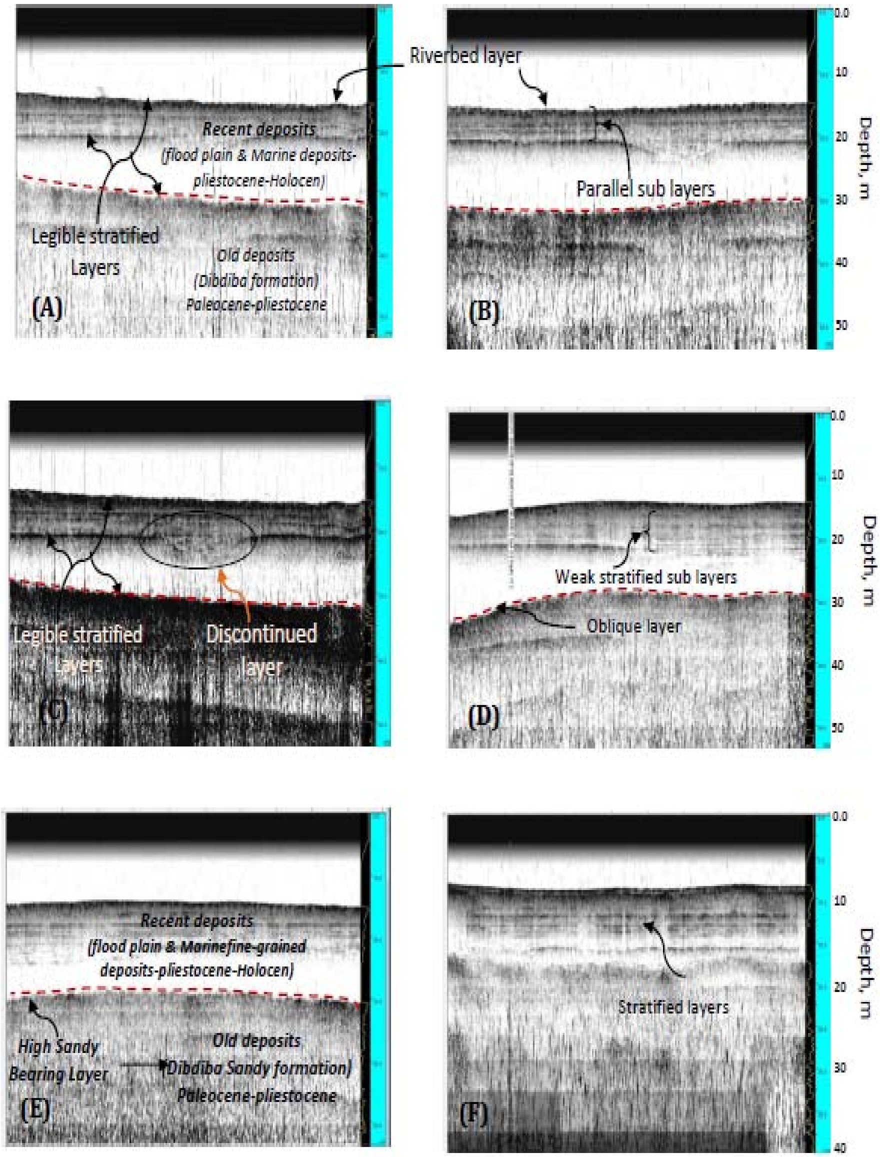

Figure 6. Sub bottom profiles of strataBox survey indicating the sedimentary layers, these are: Stratified layers with obvious main layers, and sub layers detected with weak stratified thin layers. The sedimentary layer-dash red line-with high bearing capacity layer, which highlights at 30 m. of the depth under the water surface after matching with data log of boreholes.

deposits sility clay and clayey Silt with a little of sand grains. It is belong to Late Pleistocene – Holocene age deposits resulting from flood plain, marshes and marine deposits. (2) Old deposits consist mostly of very dense coarse deposits and hard deposits belonging to late Pliocene-Pleistocene (Jassim, Goff, 2006), (Muttashar, 2010). The Sub Bottom Profilers (SBF) (Fig. 7) have been interpreted by identifying the types of layers and diagnoses their boundaries, where appeared two types of layers Recent and Old deposits, and also estimation the high bearing stratum with matching to Log Data of Borings.

The model of geotechnical section:

Figure (8) shows in detail methodology of data acquisition at the section of the river within two banks, where the Figure (7) reviews the final geotechnical model explaining layers depths along the cross section to sea level datum. The high bearing capacity layer is very dense Silty Sand. It was elevated from -22 m on the sea level in the right bank of the river and extended to -29 m at the Left bank. The layer extended from -22 to -27 m across the river section. Subsequently, there is a difference 7 m in the depth between two sides of the River. While very stiff to hard silty clay layer has 4 m. A difference of the depth. And elevated at -15m in right bank and extended to -19 m at another side.

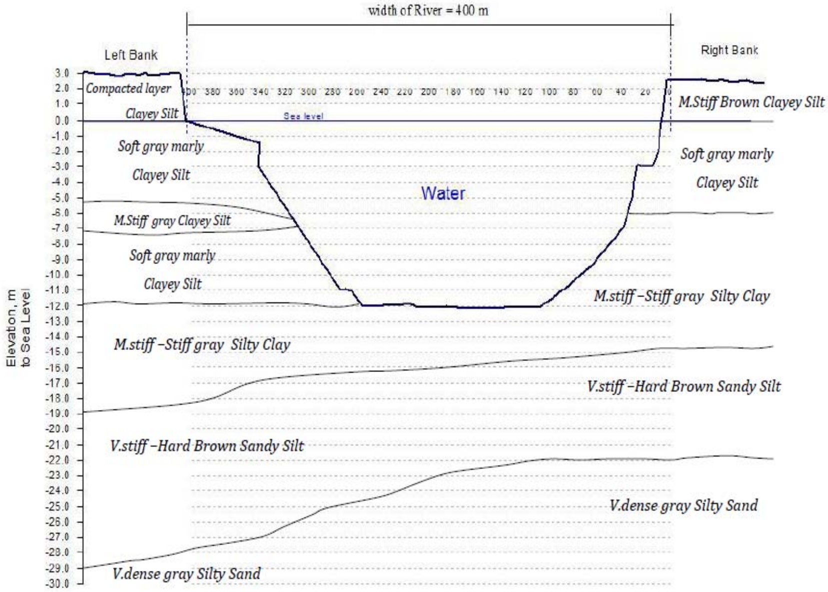

Figure 7. The final section of geotechnical model of the investigated site.

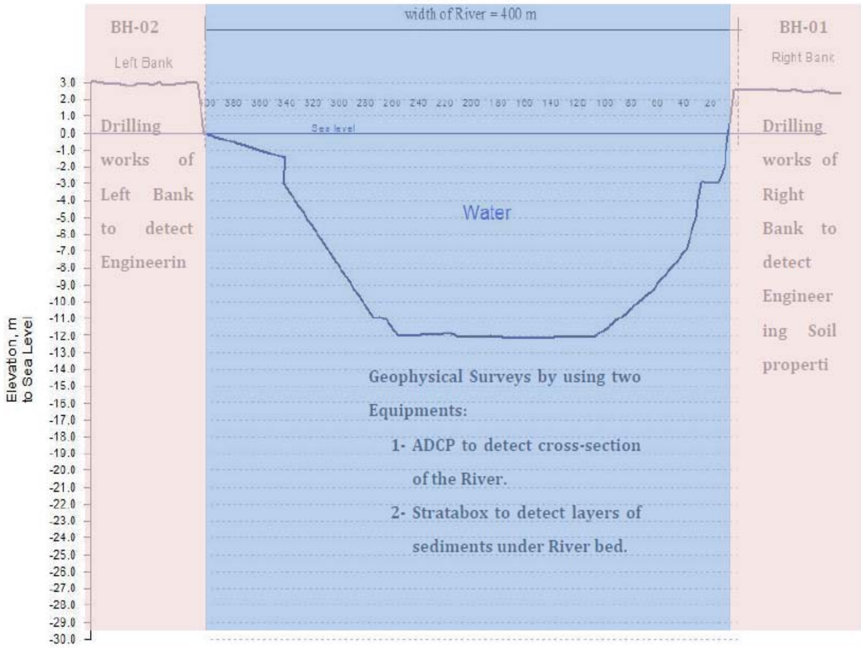

Figure 8. The locations of the drilling works (pink color), and the marine Geophysics survey (Blue color).

Conclusion

1. High bearing capacity extends from -22 m at basrah side to -29m at Tanumma side.
2. Integration process between the drilling and marine geophysics data has made the stratabox equipment instrumental tool to characterize the sub bottom of the Riverbed sequence and prediction of high bearing capacity at the river sections.
3. This investigation detect two main types from sediments layers, first is fine-grained soil which be classified into three subclass relying on the SPT measurements; v.soft- soft gray silty clay layer, m.stiff-stiff silty clay layer and v.stiff-hard layer. While the second type is V.dense Silty Sand layer which represents the high bearing capacity requiring to piles foundations of the construction.
4. Regarding to the sedimentary layers appearing in sub bottom profiles of StrataBox, the sedimentary layers were divided into two types; the first type represents main stratified layers with strong boundaries; the second is thin weak sub layers.

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تحديد الطبقات التحتسطحية بمساعدة تقنية المقاطع تحت السطحية الجيوفيزيائية البحرية على طول مقطع عرضي لنهر شط العرب قرب تفرع الرباط في منطقة البصرة، جنوب العراق

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المستخلص - اجريت تحريات التربة من اجل تحديد الطبقات التحتسطحية بأستخدام اعمال حفر جستين اختباريتين على ضفتي نهر شط العرب قرب ميناء الرباط القديم في مدينة البصرة، فضلا عن المسح الجيوفيزيائي على طول مقطع النهر العرضي بين الضفتين. تعد منطقة التحري موقع لانشاء جسر الرباط في المستقبل القريب. نفذت اعمال حفر الحفرتين في جانبي النهر عند الضفة في جانب العشار والاخرى في جانب التنومة، واما التحريات الجيوفيزيائية فتضمنت استخدام تقنيتي المقاطع الزلزالية باستخدام جهاز الستراتابوكس StrataBox لتحديد مقاطع اعماق الطبقات القاعية ، وكذلك استخدام جهاز ADCP لتحديد اعماق طبقة قاع النهر على طول مقطع عرضي للنهر والذي بلغ 400 متر عرض تقريبا. اعتمادا على قيم مقاومة الاختراق القياسي SPT تم تمثيل بيانات الجس البئري للحفرتين من اجل تحديد الطبقات التحتسطحية، هذه الطبقات تمت مقارنتها ومطابقتها مع الطبقات المشخصة من خلال المقاطع الزلزالية، وبالتالي رسم الموديل الجيوتكنيكي النهائي لموقع التحري. الطبقة ذات السعة التحملية العالية هي الطبقة الرملية الكثيفة جدا والتي تظهر عند (22-) متر عن مستوى سطح البحر وتمتد الى (29-) متر في الضفة اليسرى الاخرى. تعد هذه الطبقة الرواسب القديمة التي تقع اسفل الرواسب الحديثة والتي تعود الى ترسبات تكوين الدبدبة (مايوسين اعلى-بلايستوسين). وهي الطبقة التي تكون القاعدة الاساس التي تصل اليها الاسس العميقة للمنشآت الضخمة المراد انشائها كالجسور.