

## **Characteristics of sub-bottom profile acquired in Shatt Al-Arab River, Basrah-Iraq**

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**Abstract-** A single sub bottom profile, nearly 1.0 km long, was acquired in Shatt Al-Arab River, at the river's portion next to the downtown of Basrah city, 2010. The profile characterized by predominant ripple-marked features. Beneath the bottom, signal penetration was relatively low attributed to the existence of thick layer identified in the sub-bottom and interpreted as the main load bearing layer in the area. Riverbed multiple showed a strong presence and occupied the profile's bottom. Interpretation beyond the riverbed multiple was not possible. Water bottom was flat, except for a buried object of undetermined type lying within the sediments of the bottom.

**Keywords:** Sub bottom profile, Shatt Al-Arab, Interpretation, Heave, Seismic, Buried object.

### **Introduction**

During March 2010, a joint team from Marine Science center and Earth Science Department acquired a sub-bottom profile in Shatt Al-Arab River, near the anchorage of Marine Science Center (Fig. 1). Basrah City has a complex infrastructure of canals and streams that were once used to transport both people and cargo. For some time, Basrah was known as "the Venice of the Middle East". However, in the last two decades, pollution and low water levels have rendered the canals unfit for transportation. They still remain an essential system of irrigation (NCCI, 2010). Iraq's two largest rivers, the Tigris and the Euphrates eventually meet to form the Shatt Al-Arab in south-eastern Basrah, approximately 60 miles (95 km) downstream from the Arab Gulf (NCCI, 2010).

The Shatt Al-Arab River has a variety of basin patterns, including straight, meandering, and braided. Meandering and braided patterns specifically appear at the southern part (Al-Mayahi, 2011). The objectives of this study were to investigate patterns of reflection associated with buried objects beneath and within the river's bottom, and to determine the acoustic signature of the strata in the sub-bottom with focus on the stratum offering support to foundations of buildings, especially heavy constructions.

### **Theory:**

Single-channel reflection profiling is a simple but highly effective method of seismic surveying at sea, common in many of offshore applications.

The recording system used in single-channel profiling was inexpensive because of no processing costs and because seismic records were produced in real time by continuous chart recording. Good basic reflection records

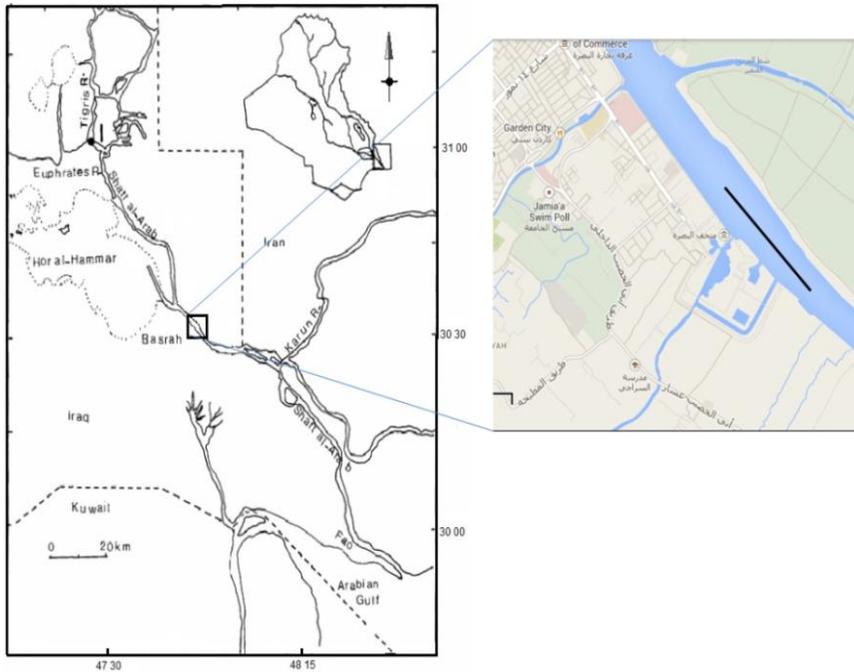


Figure 1. Map and location of the profile.

may be obtained from a single-channel system, but are still inferior to the more expensive the type of seismic record produced by computer processing of multichannel data. Moreover, single-channel recordings cannot provide velocity information so that conversion of reflection times into reflector depths has to utilize independent estimates of seismic velocity (Keary *et al.*, 2002). The acoustic impedance method may be exploited with other form of equations 1-1 and 1-2 to determine parameters of the soft aqueous materials. The acoustic impedance “ $z$ ” for a unit is the product of its density “ $\rho_b$ ” and velocity “ $V_p$ ”. The reflection coefficient “ $R$ ” from a particular horizon is given by equation 1-3 (Corps of Engineers & ASCE, 1997):

$$E = \rho_b V_p^2 (1 - 2\nu)(1 + \nu)/(1 - \nu) \dots\dots\dots (1-1)$$

$$R = \frac{(\rho_{b2} V_2 - \rho_{b1} V_1)}{(\rho_{b2} V_2 + \rho_{b1} V_1)} \dots\dots\dots (1-2)$$

$$R = \left( \frac{E_{refl}}{E_{inc}} \right)^{1/2} = \left[ \frac{(z_i - z_j)}{(z_i + z_j)} \right] \dots\dots\dots (1-3)$$

Where “ $E$ ” is shear modulus, “ $\nu$ ” Poisson ratio, “ $E_{refl}$ .” is the Energy reflected at  $i^{th}$ - $j^{th}$  unit boundary, “ $E_{inc}$ .” is the incident energy at  $i^{th}$ - $j^{th}$  unit boundary, “ $z_i$ ” is the acoustic impedance of  $i^{th}$  (lower) material and “ $z_j$ ” the acoustic impedance of  $j^{th}$  (upper) material.

*Acquisition:*

Data acquisition was performed under stable weather condition. Using Stratabox developed by SYQWEST, the acquisition was divided into two stages: the trial-run and the return-run. The trial-run was for parameters testing of the main acquisition software, as well as the device. The profile characterization was obtained from the return-run. The profile was acquired far from the neighboring area and traffic of highly populated downtown (Havskov and Alguacil, 2006). For most pingers (sub-bottom profilers) the depth of penetration is limited to a few tens of meters in muddy sediments or several meters in coarse sediments (Keary *et al.*, 2002). Following Alsadi *et al.* (2006), we expected an increase in the suspended particles in the water column which may cause additional loss to the energy (SYQWEST, 2008). Therefore, we intentionally used an iron rod, about 1.5 meters long, to place the transducer as close as possible to the riverbed in an effort to deliver maximum energy without significant loss along the water column.

We conducted testing and acquisition on board a vessel cruising at a speed of about 1.5 knots. For testing and with aim to investigate further details, we set DC gain to 75 dB, bottom trigger gain to 2dB/meter and water velocity to 1450 m/sec. We used 10 kHz for acquisition, as we did not expect external signals to interfere with our recording (SYQWEST, 2008 ; Sheriff and Geldart, 1995).

*Interpretation:*

In the profile, the first signal observed was for the riverbed, and marked "A" in Figure (2). It was less affected by the vessel's roll and highly apparent due to the large difference in the impedance across the interface. Depth from this site was between 13.8 and 15.6 meters (9.0 to 11 msec. TWT). We did not take into account tide effects, as the return-run lasted just one hour. The second event below the riverbed was event "B", (Fig. 2), and somewhat affected by the vessel's roll. Acoustic wave propagation after event "B" suffered considerable attenuation, to the extent that no apparent single reflection could be detected after 25 meter depth, for example below 25 meters in Figure (3) to the left of event "D".

The third event, which is different from the others, was a buried object within the sediment of the water bottom. It had two distinct characters that differentiated it from the other events. The first was the shape of the object, "D" in Figure (3). It was a bulge-like shape rising from the water bottom with relief of 0.8 msec. TWT (c. 1.3 meters) measured from the top of the object to the adjacent readings of both depth and time on its sides. The second observable object was the free acoustic blanking zone in the underlying sediments (Plets *et al.*, 2009). The event marked with "D" in Figure (3) was a mask to the acoustic waves propagating downwards.

It is further supported by the fact that the continuity of event "B" in Figure (3) just beneath event "D" endured complete obliteration, even though the coherence of event "B" was relatively low (Fig. 4). This is an indication that the composite material consisting of event "D" is different from the surroundings. The fourth event was the riverbed multiple on the bottom of the profile, obscuring any apparent reflection beyond 30 meters depth (Figs. 3 and 4).

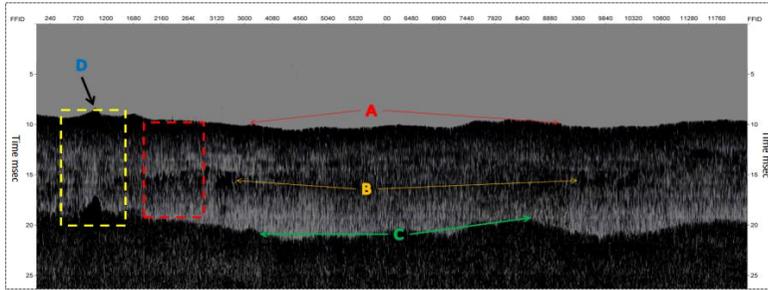


Figure 2. Sub bottom profile in Shatt Al-Arab River; letters A, B, C and D represent interpreted events; dashed colored rectangles indicate locations of the figures mentioned in the text.

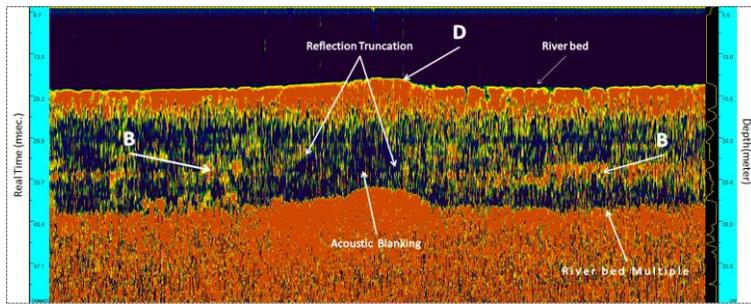


Figure 3. Enlarged view of event D in the sub bottom profile, location of the view is the yellow dashed rectangle in Figure (2). Notice the acoustic blanking below event “D” with abrupt truncation in event “B”.

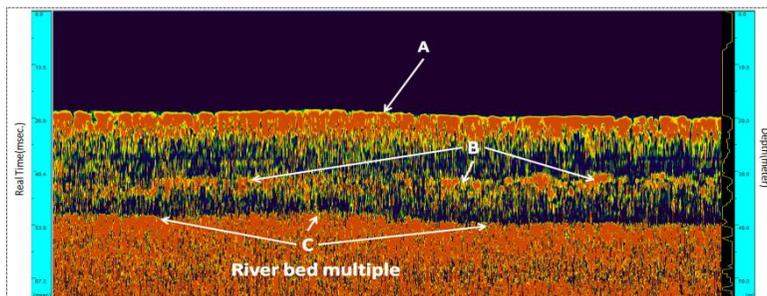


Figure 4. Portion of sub bottom profile showing the effects of the vessel's roll on event B, location is the red dashed rectangle in Figure (1), note the misalignment in the middle of the figure and the discontinuity to the right.

## Results

With reference to Albadran and Mahmood (2006), the proposed lithology for the recorded events, except for “C” and “D”, at the profile site are illustrated in Figure (5). Red lines in Figure (5) are upper and lower lithology shown in Figures 2 through 4. As mentioned below, we cannot see any feature to interpret below 25 meters depth. Vertical columns in Figure (5) represent locations of geotechnical boreholes drilled at sites in the vicinity of Shatt Al Arab River, where the lithology from drilling is comparable to the sub-bottom of the river basin.

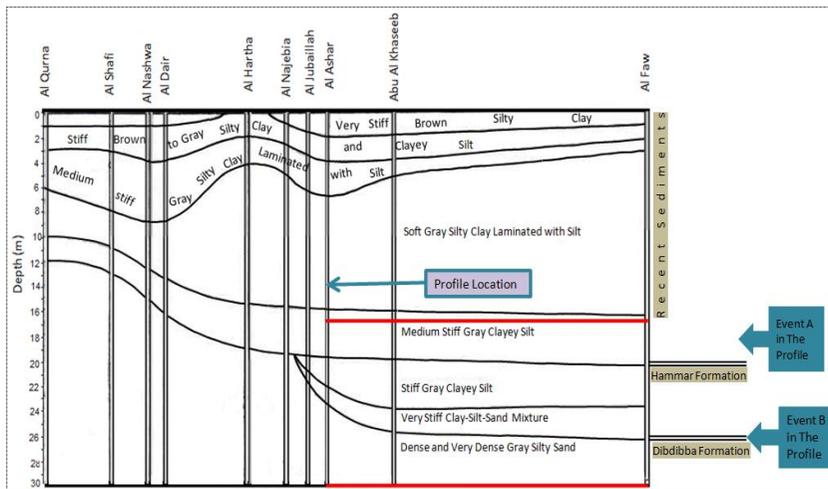


Figure 5. Proposed lithology of the sub-bottom profile, red lines are lithology shown in Figure (2) through (4). The figure is reproduced and modified after Albadran and Mahmood (2006).

## Discussion

Vertical resolution of pingers, in this work sub bottom profiler, can be as good as a 10-20 cm, but depth of penetration is limited to a few tens of meters in muddy sediments or several meters in coarse sediments (Keary *et al.*, 2002). Inspecting acoustic wave propagation after event “B” showed that is almost no single reflection could be picked below 25 meter (Figs. 2 and 4). Hence, it might be indicative of compacted sand. Interpretation of event “B” as compacted sand layer is consistent with depth and areal distribution of load bearing stratum at the profile location Albadran and Mahmood (2002; 2006).

According to Figure (4), the coherence of event “B” along the profile exhibits out-of-alignment. The coherence measures the similarity among more than two functions, for example, seismic reflection events are coherent in a linear way with respect to dip (Sheriff, 2006), which refers to swell filtering (Van-lancker *et al.*, 2009). In other words, it resulted from the ship roll (Innomar, 2009). It has the following relation to a static correction (Van-lancker, *et al.*, 2009).

Ozdogan (2001) provided a full description about the effect of the static on the quality of the seismic data. Vessel motion affects the coherence of events in manner that response from flat events appears like ripple-mark (Innomar, 2009). Figure (4) represent a portion of the profile where event "B" is partially lost due to that effect. The correction of it lies in procedure of bringing about the transducer and the receiver as they were on the same datum. And because they are on the same device, so the correction must be directed towards compensation of the motion. The suggestion is to use motion compensator simultaneously with acquisition, then incorporates the information from the compensator into removal of that effect (SYQWEST, 2010).

Most multiple reflection rose from an interface with a strong impedance contrast, such as the free surface and water bottom (Ozdogan, 2001). With reference to Muttashar *et al.* (2012), misidentification of long-path multiple as a primary event, for example, would lead to serious interpretation error (Keary *et al.*, 2002).

The arrival times of the multiple are predictable, however, from the corresponding primary reflection times (Keary *et al.*, 2002). By definition, event "C" was the riverbed multiple, which appeared at double the time of the riverbed from which it originated, and double the depth in our software display (Fig. 4). Moreover, event "C" follows the shape of the riverbed, which has been frequently observed (Fig. 3).

It is worthy to mention that the Basrah area was a battle field from 1980 to 1988. Because of war, destruction included ships in the water way, as those anchored at Shatt Al-Arab River (UNEP, 2003). While the most likely interpretation for event "D" is a buried object, interpretation of event "D" as being a boat or ship wreckage is possible. Further investigation is necessary to resolve this, especially because the lateral extent and lower boundary of event "D" were not clear from our profile. Side scan sonar or cross-sectional sub-bottom profiles, over the study site, or even magnetic surveying, will better resolve this issue.

## **Conclusion and Recommendation**

- 1- Vessel motion caused loss of information regarding the strata below the riverbed. Only a thick layer with high acoustic impedance, for instance event "B", could be detected. Owing to motion, deterioration resulted in misalignment of strata in the transition sequence between the riverbed and event B. In addition, the deterioration has turned most parts of this transition throughout the whole profile into a fuzzy image that was difficult to interpret and trace.
- 2- The riverbed multiple was unmistakable, as it stood out clearly in the profile and, masked any reflection below event "B". Processing could only be proved practical, if the acquisition was corrected for vessel motion. On the other hand, acquisition at different timing, with optimal weather conditions, would diminish the need for correction.
- 3- One major benefit from this work was the successful identification of a buried object within the riverbed sediments. Further work should be conducted to inspect the nature of the object detected and examine surrounding areas for additional buried items.

## Acknowledgement

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## الصفات المميزة لمقطع تحت - قاعي في شط العرب, البصرة - العراق

حازم عباس ناصر

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**المستخلص -** تم اقتناء 1 كم تقريباً من مقطع طولي تحت - قاعي في نهر شط العرب عند الجزء المجاور لمركز مدينة البصرة عام 2010. تميز المقطع بطغيان اشكال متعرجة ناتجة من تأثير حركة الزورق خلال عملية اقتناء المقطع. عمق الاختراق للموجات الصوتية ما بعد قاع النهر ضعيف نسبياً بسبب وجود طبقة سميكة ومتراصة تم تفسيرها على انها طبقة رملية وهي تمثل الطبقة التجميعية في منطقة البصرة. تميز المقطع ايضا بوجود ملحوظ للانعكاس المضاعف والناشئ من قعر النهر وقد احتل الجزء الاسفل من المقطع تحت - قاعي. في هذا المقطع, التفسير الزلزالي ما بعد الانعكاس المضاعف غير ممكن. بشكل عام, يظهر قاع النهر منبسطاً ما عدا مرتفع يقع عند الطرف الجنوبي من المقطع فسر على انه جسم مطمور ضمن رواسب قاع النهر.