Geophysical surveys in West Africa

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A behind the scences look at a typical shallow water seismic survey for new developments.

Detailed marine geophysical surveys are considered a key element in the process of development and construction of new offshore ports and load out facilities. Specifically the seismic data constitutes an essential part as it can reveal many unknown factors. Due to the challenging environment in West Africa and the often very shallow water depths, it requires a flexible and versatile approach from a survey company.

This article gives an overview of how this type of project is approached and some of the lessons we have learnt when performing marine geophysical surveys in shallow water in West Africa.

Background

West Africa is rich in mineral resources, often in land based areas. In order to transport these minerals, offloading facilities are required. These normally do not exist in underdeveloped West African regions. In addition, with developing economies, ports require additional development to allow more import and export.

Often the client is a construction company, a power company or port authority, requiring expert help for such a new development. The information they have available at the early stages is limited and they are looking for recommendations on the scope of work for a seismic survey based on their anticipations and the expert's experience. It is a joint operation and in co-operation we determine the best approach for their survey requirement, often combined with metocean, geotechnical or onshore survey requirements.

There are two main categories of application for shallow water

Fig. 1: A variety of survey platforms including dinghies, patrol-boats and luxurious catamarans have been used for the surveys.

Fig. 2: A typical survey vessel.

Fig. 3: Echosounder pole and SSS tow cable.

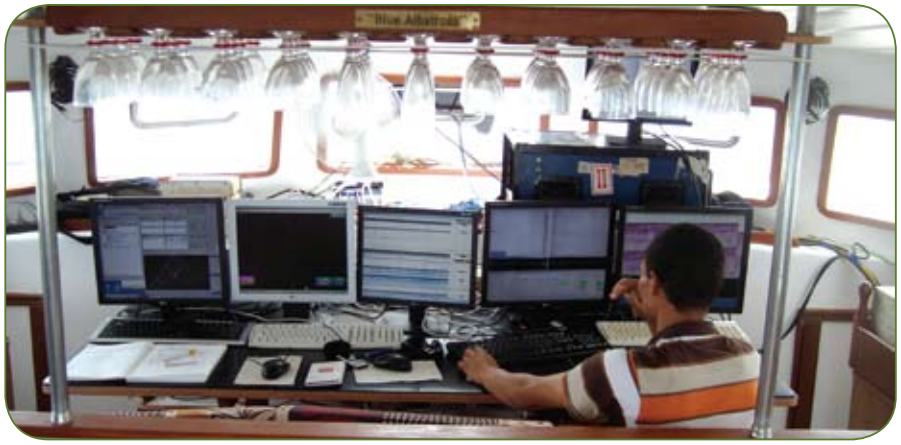

Fig. 4: Unconventional survey room on a vessel of opportunity.

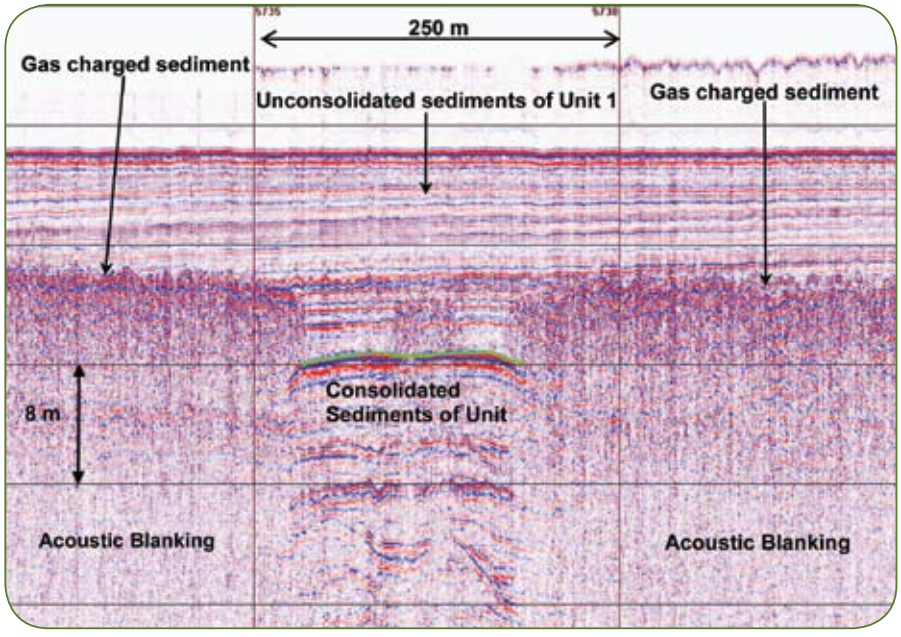

Fig. 5: Boomer data showing gas charged sediments causing acoustic blanking.

seismic surveys: to map the shallow sub-seabed geology or to locate buried or submerged objects.

For new developments, it is the first application that is of primary interest. A typical survey set-up for a new development will consist of bathymetry, seabed imaging and sub-seabed geophysical survey. The equipment spread will therefore typically consist of an echosounder (single or multibeam), a side scan sonar and a sub-bottom profiler completed with DGPS positioning and navigation sensors.

Choosing the right equipment

The ever-returning issue when performing shallow water seismic surveys is the source of equipment, primarily the sub-bottom profiling system. Whereas the choice for single or multibeam often is cost-based, the choice of profiling system is a technological choice.

The sub-bottom profiling technique is based on using a sound source to generate an acoustic pulse. The pulse is transmitted through the water column and penetrates the seafloor. The acoustic signals are reflected by layers/objects with different acoustic impedance and the returning signal is received by a transceiver or hydrophone, depending on the type of system used. The received acoustic signals are then resolved by an appropriate seismic processing unit providing a real-time "sub-bottom" profile, which is used to map geological boundaries or sub-seabed objects.

The two distinct types of sub-bottom profiling equipment, which are typically proposed for shallow water seismic surveys, are:

- Systems where the source and receiver are combined in a single transducer array; examples of such systems include pingers, high frequency chirps and parametric echo sounders.
- Systems using a seismic source, such as a sparker or boomer and a separate single channel hydrophone, also referred to as a mini-streamer.

The major factors that are considered when selecting the most suitable system include:

- Objective/purpose of the investigation

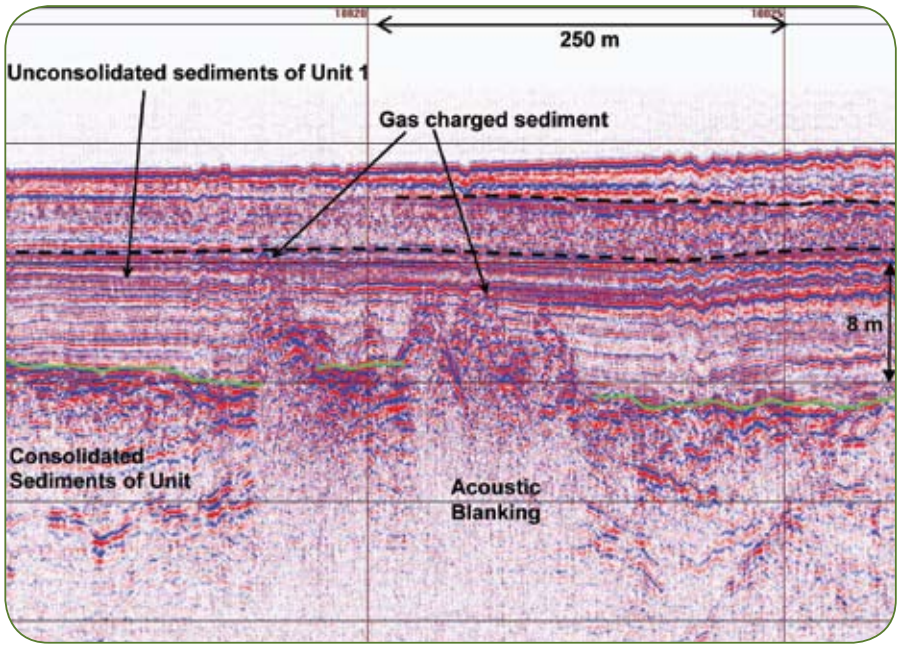

Fig. 6: Boomer data showing gas charged sediments.

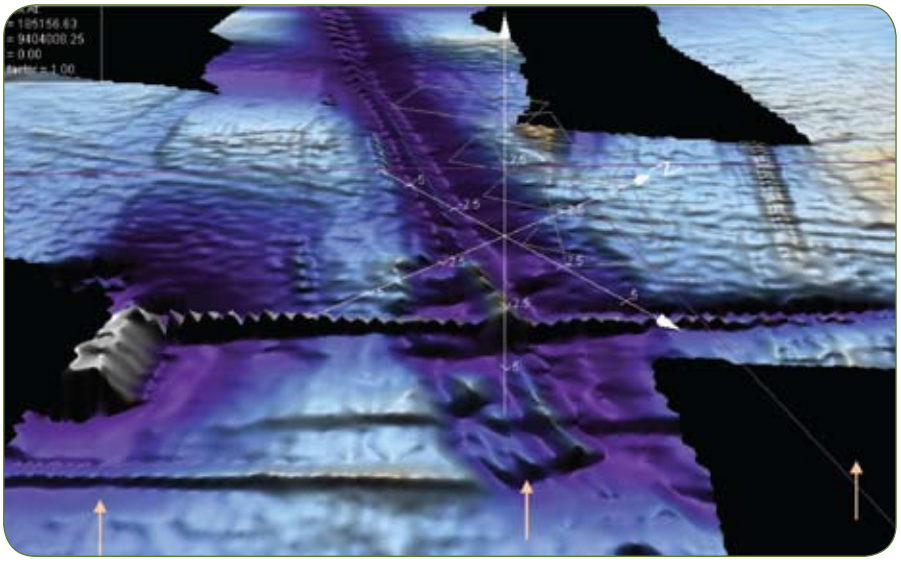

Fig. 7: Centre of the picture is a 24" pipeline. Left pipeline support, middle: 24" crossing, right pipeline into burial.

- Expected depth of sub-seabed penetration
- Seabed/sediment type
- Water depths
- Size of survey vessel

Past experience

As many of the places chosen for new developments are frontier areas in West Africa, these projects are often very challenging logistically, environmentally as well as geologically.

Logistically, the areas have poor communication facilities, limited accommodation and very little infrastructure available. Finding a suitable survey vessel is often the major challenge, and over the years, we have used a variety of survey platforms including dinghies, patrol-boats and luxurious catamarans for the surveys (see Fig. 1 and 2). Most often it is not a question of which option to choose but a question of what is available.

Environmentally, local fishing activity is a major hazard to the sub-surface towed survey equipment resulting in survey lines frequently being aborted and re-started as the survey vessel has to come off-line to avoid nets and lines. On several occasions the equipment becomes snagged on fishing apparatus or in nets and has to be cut free. For obvious reasons, fishermen are not always too pleased with the survey activities.

Geologically, more often than not survey data is unavailable for the locations, as no survey work has previously been carried out. We therefore rely on generally available regional geological information, but more importantly on our experience from similar projects in similar areas when deciding on what equipment to propose for the project. In this process, we typically look at the potential sediment types and the depth of penetration that will be required for our client's project.

In order to overcome these difficulties, we have prepared a complete geophysical spread, readily available for rapid deployment. Operational versatility and flexibility are the keywords as most of these projects are characterised by the small survey platforms that are available in these regions and thereby limited options for deployment.

Deployment

Sub-bottom profilers can be deployed in a number of different ways, including fixed mounting on the vessel or towed. Whereas a dedicated survey vessel is often equipped with hull-mounted transducers, the vessels that are available in these areas have most of the time never been used for similar operations and need adjustments in order to become suitable for deployment of our equipment. This requires the manufacturing of custom designed brackets for deployment.

For very shallow water or small boat survey operations transducers can be deployed over-the-side using suitable mounting brackets, whereas the Boomer and Sparker sources are deployed in a catamaran, surface-towed behind the vessel.

As the challenge with sub-bottom profilers is that low frequency signals will penetrate further/deeper, while a high frequency signal generally gives better resolution, and different systems give varying results subject to seabed composition (which is

typically unknown) it is often very hard to choose the right tool. Given the mostly unknown geology, we normally recommend using two different systems to ensure maximum data quality in all sediment types. Although this results in a higher mobilisation cost due to extra weight, it greatly reduces the risk to the client. We have even experienced varying sediment types in very small survey areas, where only one system would not have obtained the required results.

Therefore, the preferred approach is a sub-towed Pinger or Chirp towfish for recording high resolution shallow geological profile images beneath the seabed controlled by a topside unit. The Pinger system typically operates in the 2 – 7 kHz frequency range to acquire high-resolution data for the uppermost sub-seabed layers. Depth of penetration is highly dependant on sediment type/consolidation and typically ranges between 5 and 15 m.

In addition a surface-towed boomer system is used for recording geological profiles down to a maximum of approximately 50 m beneath the seabed. The boomer system typically operates in a lower frequency from 300 Hz – 3 kHz. Modern boomer systems are lightweight, making them ideal for small boat operations. They are much safer to operate than older systems due to their low voltage requirement enabling them to be powered by a small generator.

The images are recorded digitally using Fugro's GLog/GPlot acquisition system and accurate offsets from the DGPS antenna are applied to give the towfish position during data acquisition.

By utilising two different systems complementing each other, we ensure that nothing is left unmapped and where one system may be limited in its capability to penetrate layers, the other system will simply overlap showing a clearly defined geological structure.

Significance of detailed geological data for new nearshore developments

On some occasions, unexpected online findings such as shallow gas pockets have resulted in a complete re-design of the entire development. Having different seismic systems available on a project can greatly assist the client in taking the right engineering decisions.

With flexibility and experience as requirements to overcome the challenges posed in the nearshore West African environment, acquiring shallow water seismic data has proven instrumental in the planning and design for nearshore developments.

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