Geophysical Surveys in West Africa

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, seismic data constitute an essential part as they 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.<P>

West Africa is rich inmineral resources, often in land-based areas. In order to transport these minerals, offloading facilities are required. These do not normally 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 requirements, often combined with metocean, geotechnical or onshore survey requirements.

There are two main categories of application for shallow-water seismic surveys:
1. to map the shallow sub-seabed geology
2. to locate buried or submerged objects.
For new developments, it is the first application that is of primary interest. A typical survey setup 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 multi-beam), a side-scan sonar and a sub-bottom profiler completed with differential GPS (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 multi-beam is often cost-based, the choice of profiling system is a technological choice.

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 sea floor. 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:
1. systems where the source and receiver are combined in a single transducer array; examples of such systems include pingers, high-frequency chirps and parametric echosounders
2. 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
• 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. 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, equipment has become 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 are 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 being towed. Whereas a dedicated survey vessel is often equipped with hull-mounted transducers, the vessels that are available in these areas have, in general, 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/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 high-frequency signals generally give better resolution, and different systems give varying results subject to seabed composition (which is typically unknown), it is often very difficult 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 top-side unit. The pinger system typically operates in the 2- to 7kHz frequency range to acquire high-resolution data for the uppermost sub-seabed layers. Depth of penetration is highly dependent on sediment type/consolidation and typically ranges between 5 and 15m.

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

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.

The Significance of Detailed Geological Data for New Near-shore 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 near-shore West African environment, acquiring shallow-water seismic data has proven instrumental in the planning and design for near-shore developments.