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Sub-bottom Profiling Acquisition Techniques in HYPACK®

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INTRODUCTION

In general, sub-bottom profiling (SBP) systems are single-channel systems used for shallow reflection seismic profiling. These sub-bottom profilers operate at different transmit frequencies and this has an effect on the depth of acoustic penetration into the seabed and the resultant resolution. Lower frequency sound sources produce more acoustic penetration into the seabed, but at a lower resolution; and conversely, higher frequency systems attain less penetration but produce higher resolution data. Signal penetration is further limited in coarse sediment or highly compacted sands, due to scattering. Most sub-bottom profiling systems can be considered as “uncalibrated systems” which makes statistical sediment classification and other quantitative measurements difficult to calculate. There are however certain SBP systems, making use of Chirp Technology, which can be considered “calibrated systems” and these could be used for quantitative seabed assessments.

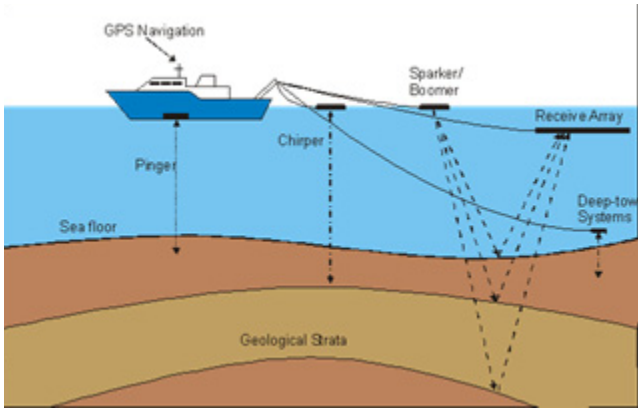
Sub-bottom profilers are used extensively in offshore, coastal and port engineering and geotechnical site surveys, renewable energy surveys, dredging studies, mineral exploration and habitat mapping projects. The interpreted data from these systems includes the thickness and qualitative sediment characteristics of the different sediment layers that comprise the sub-bottom strata.

PRINCIPLES OF SUB-BOTTOM PROFILING

Depending on the type of sub-bottom profiling system, the energy source and the receiver can be combined, as in a transducer, or separated, as a sound source (i.e. boomer plate) and a receiver (hydrophone array) – see Figure 1. It is important that the number of hydrophone elements and the spacing between the elements is matched to the acoustic characteristics of the sound source.

Sub-bottom profilers work by transmitting sound energy in the form of a short pulse towards the seabed. This sound energy is reflected from the seabed and the sub-surface sediment layers. The reflected energy intensity depends on the different densities of the sediments, the denser (harder) the sediments, the stronger the reflected signal. The reflected signal then travels back through the water to the receiver (either a towed hydrophone or transducer). The received signals are then amplified, processed and displayed in the acquisition system.

FIGURE 1. *Deployment of Various Shallow-Water Sub-bottom Profiling Systems. After Stoker et al. (1997).*



TYPES OF SUB-BOTTOM PROFILING SYSTEMS

Typically sub-bottom profiling surveys are undertaken using a variety of systems: Chirp, Pinger, Parametric, Bubble Pulser, Boomer, Sparker or mini-Airgun systems. These systems are listed in Table 1 according to their increasing typical depth of acoustic penetration into the seabed/lake/river substrate. Generally, sub-bottom profilers transmit acoustic energy around a central frequency, but the band width varies from system to system. The exceptions to this are Chirp and Parametric sub-bottom profilers. Chirp sub-bottom profiling systems operate around a central frequency that is swept electronically across a range of frequencies between 2 kHz to 16 kHz, which can improve resolution in shallow seabed sediments. Parametric sub-bottom profilers are non-linear systems that transmit two different higher frequencies that interact during sound propagation to generate a resultant lower frequency (i.e. 4 kHz). This lower frequency can penetrate the seabed more effectively.

TABLE 1. *Acoustic characteristics of commonly used sub-bottom profiling systems. The depth of penetration is related to the frequency, source energy & nature of the seabed geology.*

System	Operating Frequency	Source & Receive Array	Typical Resolution	Typical Depth of Penetration	Mount Configuration
Chirp	2 - 16 kHz	Swept frequency transducer	0.05 – 0.1 m	5 – 50 m	Vessel mounted or sub-towed
Parametric SBP	2 - 22 kHz	Parametric transducer	0.05 – 0.1 m	5 – 30 m	Vessel mounted or sub-towed
Pinger	2 - 12 kHz	Combined piezo-transducer/ transceiver	0.2 m	10 – 50 m	Vessel mounted or sub-towed
Bubble Pulser	0.4 kHz	Plate & towed array	0.3 - .0.5 m	20 – 100 m	Surface catamaran

System	Operating Frequency	Source & Receive Array	Typical Resolution	Typical Depth of Penetration	Mount Configuration
Boomer	0.3 - 6 kHz	Plate & towed array	0.2 - 0.5 m	20 – 150 m	Surface catamaran
Sparker	0.2 – 3 kHz	Spark electrodes & towed array	0.3 – 1 m	30 – 750 m	Surface catamaran or sub-towed
Mini-Airgun	0.1 – 3 kHz	Airgun & towed array	0.5 – 1 m	30 – 200 m	Towed

Installation & Towing Configuration Recommendations

Mounting a sub-bottom profiler on a vessel and towing the source/hydrophone array correctly are critical to acquiring a noise-free dataset. In vessel hull mounted or over-the-side systems, it is important that the transducers are mounted away from areas of potential noise or turbulence, which can have a considerable effect on the quality of the data acquired. With a surface towed source and receive array configuration, it is a good idea to have the source and the receive array separated by the aerated propeller wash as this significantly reduces the amplitude of the direct/first arrival signal (Figure 2). It is, however, important that the source and receive array do not get towed into the aerated propeller wash as this causes acoustic blanking and poor data quality. The data position origin when using a surface towed source and separated receive array is mid-point between the source and receive array and this is termed the SBP Common Midpoint (Figure 2).

FIGURE 2. *Various towed and vessel mounted sub-bottom profiling system installations.*