

Short Cluster Airgun Array for Shallow to Deep Crustal Survey

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ABSTRACT

Seismic airgun source should be designed under several conditions which depend on geological targets. For shallow-targeted survey like usual oil gas exploration, we should take broadband frequency spectrum and high primary-bubble ratio (P/B) into the consideration. As target is deeper or long-offset acquisition, we need large amplitude in much lower frequency range. In addition, the primary peak amplitude should be raised up. The P/B is still important in deep-penetration survey for accurate imaging and inversion tomography. However, it is usually difficult to obtain such features simultaneously with a practical airgun array, we are proposing a new short airgun array that can achieve these demands using closely-spaced linear cluster technique.

KEY WORDS:

Seismic, Airgun, Source, Cluster, Low-frequency, Long-offset, OBS.

INTRODUCTION

Recently, as offshore oil and gas exploration goes deepwater and more complex geological region such as sub-salt or sub-basalt layer, low frequency content of seismic exploration become much more important. The feature of seismic source, mostly airgun array, is quite essential for imaging deep or complex geological targets. Especially low-frequency ingredient from few Hz to 25 Hz in source energy is crucial for deep penetration of its energy.

With respect to scientific experiment, there are geological interests in much deeper region: plate boundaries, Moho, and igneous regions. Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been conducting seismic survey for deep crustal studies with low-frequency-rich source in recent 10 years. The basic approaches for understanding the whole crustal structure are followings:

- (1) Seismic reflection survey with long streamer aiming structural understanding down to the Moho and constructing shallow layer's velocity model.
- (2) Seismic refraction survey with more than 100 Ocean Bottom seismometers (OBS) to built entire crustal velocity model.

Both of the approaches much rely on the high-output and low-

frequency-rich source in order to make the source energy penetrate far down through the ocean bottom. These studies always need more excellent source and sensors to detect seismic wave more clearly from deeper of the earth. In addition, for further integrated understanding of the earth's crust from shallow to deep with highly resolved imaging and accurate velocity model, we should have broadband and higher amplitude source which accommodates various features of geological targets, such as depth, structural complexity, rock property and so on.

However, such seismic instrument is so expensive for an academic institute, unlike oil and gas exploration industry, that very difficult to maintain huge airgun array and multi-streamer system. Usually, academic research vessel is not dedicated for seismic exploration but also multi-purpose scientific experiments. Such limitations motive us to obtain single excellent source suitable for the various scientific interests by small configuration to be installed on limited deck space.

We designed a new short airgun array to meet shallow to deep targeted survey.

LOW FREQUENCY OF SOURCE

Airgun is the most reliable source that emanates low-frequency-rich and high-energy elastic wave for marine seismic exploration. Several studies for effective use of airgun to generate low-frequency output for deeper penetration have been reported from 1970's. Basically the frequency of the airgun signature depends on two factors. First, chamber volume of airgun makes some difference on low-frequency side of the spectrum. Large chamber's airgun can produces much low-frequency energy than smaller chamber's one. Second is depth of the airgun. Reflection from the water surface causes cancellation around specific frequency. This affects the frequency curve of lower end of the spectrum (ghost notch). In addition to this sea-surface ghost effect, releasing airgun energy itself is affected by its depth (hydrostatic pressure).

In order to concentrate the low-frequency energy, as special technique, bubble tuning method was introduced by Avedik et al. (1993), which is the tuning method centering the output on first bubble pulse. This is also reported by Lau, et al. (2007) as a source of long-offset acquisition using OBS, and they also described that useful frequency band is as low as ~ 25 Hz if major requirement is long offset, sub-basalt, deep crustal penetration.