DEVELOPMENT OF OCEAN BOTTOM MULTI-COMPONENT SEISMIC SYSTEM

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Abstract: In this paper we introduce the development of 4-components monitoring system called 'DSS' (Deep-sea Seismic System) using multi-component seismic sensors aim to delineate the methane hydrate dissociation zone for the offshore methane hydrate production trial scheduled in FY2012. We have successfully carried out experimental off-shore performance trials in November 2011 and the obtained data was of very high quality. The newly developed DSS, comprising 36 receivers, was deployed and buried on the seabed off the Atsumi Peninsula in August 2012 to conduct a pre-test baseline survey at 1,000m water depths. Some results of this survey are presented.

1. Introduction

MH21 (Research Consortium for Methane Hydrate Resources in Japan) is planning to carry out the off-shore methane hydrate production trial during the FY2012. In this production trial, it is very important to know and understand how the methane hydrate dissociation progresses. The dissociation process progress and changes can be captured only by long-term reflection seismic monitoring which is conducted in intervals as a pre-test survey and a post-test survey, before and after the production trial. The RSCS (Real-time Seismic Cable System), developed as a dedicated reflection seismic survey system, was available and its capabilities have been confirmed when we successfully obtained clear BSR (Bottom Simulating Reflector) records during survey trials conducted off Shima coast in 2006. But RSCS's receiver size and weight make it very difficult to achieve the requirements for methane hydrate dissociation process monitoring, which requires a receiver interval of 25m at water depths of 1,000m. The estimated cable load was very high and its precise deployment to deep water was too difficult due to the hydrodynamics of the receiver stream.

Based on the RSCS design concept, we have developed the "DSS" with a more compact and lighter receiver. We have successfully carried out experimental performance trials off-shore in November 2011, and carried out pre-test survey in August 2012.

This paper describes about the DSS development and the result of performance trials.

2. Development of DSS

(1) Receiver miniaturization

The base concept was developed as a refraction seismic survey system (RSCS) in the year 2004, comprising receivers equipped with 3-components geophone and electro-optical telemetry circuitry serially connected using optical submarine cable for real-time data retrieval and recording. Refraction seismic surveys were conducted off the Miyagi Prefecture coast at a depth of 1,000m, obtaining excellent results. Then the RSCS design was improved to realize its application also as a reflection seismic survey system. 2 field surveys in 1,000m water depth sea area, deploying the upgraded RSCS were conducted with the support of JOGMEC in 2005 and 2006. These surveys produced excellent quality records, successfully detecting BSR, indicating the methane hydrate lower stability limit.

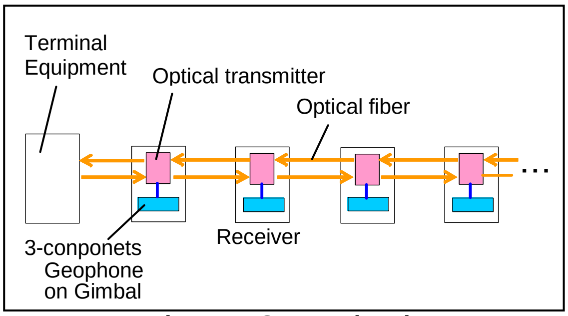

Figure 1: Conventional RSCS data transmission schema

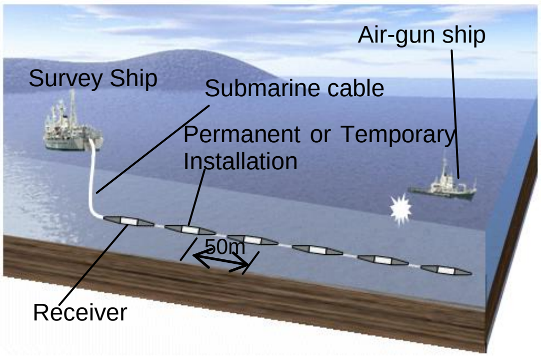

Figure 2: Reflection Seismic Survey Schema.

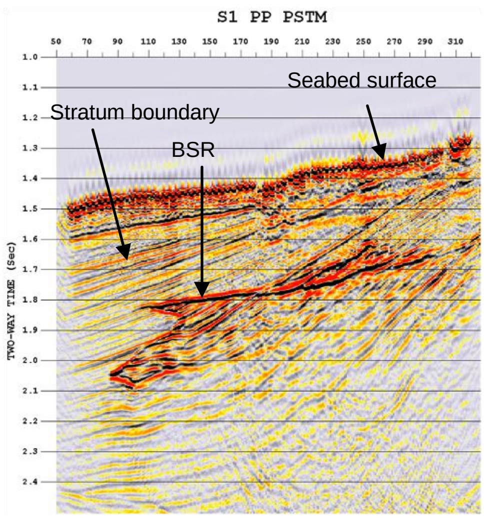

Figure 3: BSR reflection record obtained by RSCS in 2006

RSCS thus demonstrated its functions and capabilities as reflection seismic system. Additionally in this experiment, we retrieved data from a receiver equipped with accelerometer sensors to confirm its suitability for a reflection seismic system, which may allow receiver miniaturization. If an accelerometer can be used, then receiver housing miniaturization is possible, since the gimballed mechanism for maintaining geophone axial alignment becomes unnecessary. The obtained reflection records of both receiver types, equipped with accelerometer and with geophone, deployed with 50m spacing at a seabed depth of 1000m showed that the accelerometer records have the same quality as that of the geophone, confirming the feasibility for miniaturizing the receiver. Referring to the results obtained in this survey [1], we improved RSCS receiver by reducing its size to 2/3, adopting accelerometers and hydrophone.

The system equipped with the new compact size receivers was named 'DSS'. The receiver casing has a protective metallic exterior and the optical submarine cable is protected with steel-screened armouring, allowing its deployment up to 2,000m water depths and burial usage by ROV for sub-seabed deployment. The specification of DSS and RSCS are shown in Table 1. The DSS and RSCS receiver are shown in Figure 4. Optical submarine cable specification is shown in Figure 5. DSS data transmission schema is shown in Figure 6.

Item	DSS	RSCS
Sensors	3-Acerelometers 1-Hydrophone	3-Geophones
A/D	24 bit	24 bit
Sampling rate	1 kHz	1 kHz
Receiver Interval	25m	50m
Receiver Size	Length: 1.6m Dia.: 136mm	Length: 2.3m Dia.: 230mm
Weight in water	50kg	100kg

Table 1: Specification of DSS & RSCS

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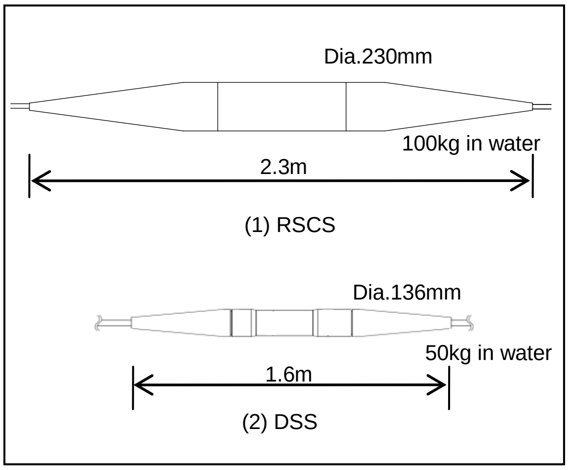
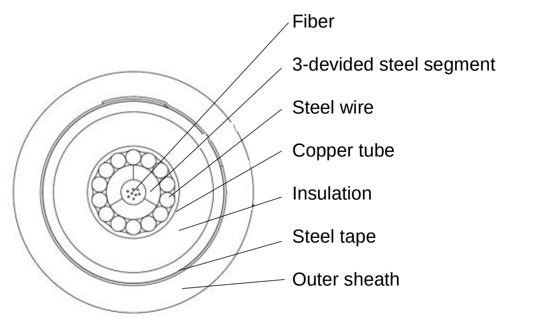


Figure 4: Comparison of RSCS and DSS receiver size



Cable nominal diameter	27 mm
Cable weight in air	11.0 kN/km
Cable weight in water	5.4 kN/km
Cable breaking load	≥98 kN
Hydrodynamic constant	40 deg-knots
Minimum bending radius (without tension)	900 mm

Figure 5: Optical submarine cable (OCC-SC300-LWS)

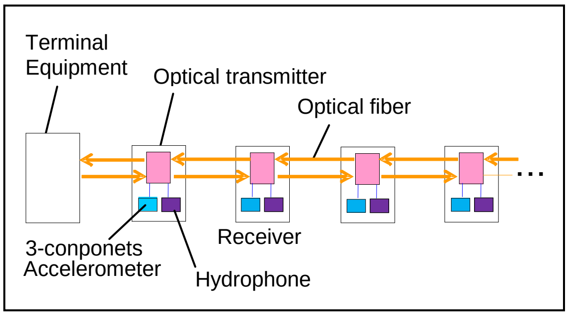


Figure 6: DSS data transmission schema

(2) Performance trials

a) Performance confirmation

To confirm the functions of the compact sized receivers of DSS, trial system, equipped with 12 receivers at 25m spacing, was deployed at off Amami Island 1,000m sea area in November 2011. We use cable laying ship (KDDI Pacific Link) for system deployment. The DSS receiver being launched to the sea during the trial is shown in Figure 7.

Figure 7: DSS receiver deployment

The obtained records show quite low noise and high contrast, reflected S-wave can be recognized in horizontal (X and Y axis) accelerometer records and reflected P-wave record is almost the same with vertical accelerometer (Z axis) and hydrophone. These results confirmed the high quality record that can be obtained with this system. A caption of the obtained records is shown in Figure 8.

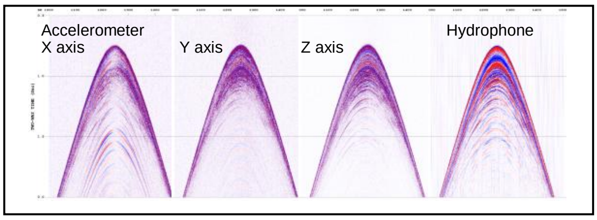
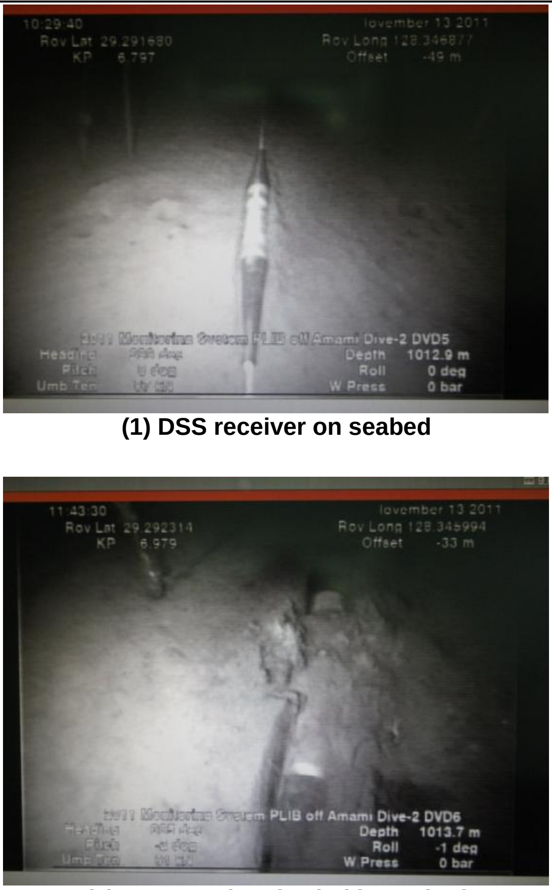


Figure 8: Record obtained at performance trials

b) Receiver burial effect confirmation

We are planning that the DSS receivers would be buried in seabed to improve its coupling with seabed, reduce sea current induced noise and fix its position.

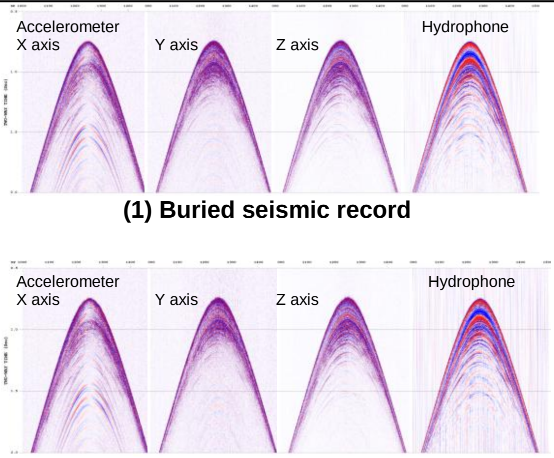
We carried out the burial of the receivers in to the seabed to a depth of about 50cm using ROV. The obtained survey record is compared with not-buried record. The DSS receiver on seabed and buried seabed is shown in Figure 9. The comparison of seismic records for DSS receiver buried and not-buried is shown in Figure 10.



(1) DSS receiver on seabed

(2) DSS receiver buried in seabed

Figure 9: DSS receiver on seabed and buried



(1) Buried seismic record

(2) Not-buried seismic record

Figure 10: Seismic records comparison of DSS receiver buried and not-buried

The buried receiver's records have low noise compared with the not buried one. These results confirmed the effect of receiver burial in the quality of records.

3. Conclusion

We developed and manufactured DSS that improve the receiver size to 2/3 of previously developed RSCS and confirmed its performance by sea trials.

The burial of receiver proved its effectiveness to obtain seismic records with lower sea current noise in comparison with not-buried one, and improving the data quality.

4. Acknowledgement

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5. Reference

[1] Hiroo Takahashi, Eiichi Asakawa, The development of reflection seismic survey system ~ Receiver miniaturizing, Sub-Optic (2010)

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