Laboratory Experiment for Sustainable Pressure Observation at the Seafloor

Hiroyuki Matsumoto, Aki Ito, Keisuke Ariyoshi, Yuya Machida, Satoru Tanaka & Eiichiro Araki

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

INTRODUCTION AND MAIN RESULTS

Pressurization to pressure gauges using a pressure balance is conducted before deployment at the seafloor to evaluate sensors' stability.

In-situ pressure recordings of the long-term borehole observatory system (LTBMS) are examined and compared with the experiment.

The experiment has reproduced the sensor drift over time, and therefore it can contribute to screening better sensors to perform sustainable seafloor pressure observation.

Laboratory Experiment for Sustainable Pressure Observation at the Seafloor

Hiroyuki Matsumoto, Aki Ito, Keisuke Ariyoshi, Yuya Machida, Satoru Tanaka & Eiichiro Araki

P3.1-311

Introduction

A pressure gauge at the seafloor is key sensing instrument for geophysics and oceanography. Pressure change over time can be consent to the seafloor deformation associated with plate convergence in the plate subduction zone or the magma injection near the submarine volcanoes etc. It is also suggested that pressure change at the seafloor can be partly reflected by the ocean current variations, e.g., the Kuroshio merenda in Japan. On the other hand, sensor drift, i.e., offset from the standard pressure is observed in pressure gauge, whose rate is sometimes larger than the in-situ true pressure change. Therefore, a stable pressure gauge should be selected for long-term continuous observation to perform quantitative pressure measurement. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has developed the seafloor observatories network known as DONET, long-term borehole observatory system (LTBMS), or campaign-typed pressure sensing system in the past, which are composed of pressure gauges. All pressure gauges were pressurized by a pressure balance with equivalent static pressure to an installed water depth before deployment. This experimental procedure allowed us to determine which pressure gauge was best suited for in-situ measurement. Screening of the better sensors can reflect to the more sustainable *in-situ* observation.

Pressure Gauges for LTMBS

The pore fluid pressure measurement at the site of the borehole observatory consists of three pressure gauges; two of them measure in-situ pressure at the borehole and one of them measures *in-situ* pressure at the seafloor. Therefore, three pressure gauges were evaluated before assembling the pressure sensor system of the LTMBS. We compared three quartz pressure gauges (Model: 410K-184) manufactured by Paroscientific, Inc., USA (**Figure 1**). In the present pressurization experiment, we characterize three pressure from the viewpoint of the sensor drift.

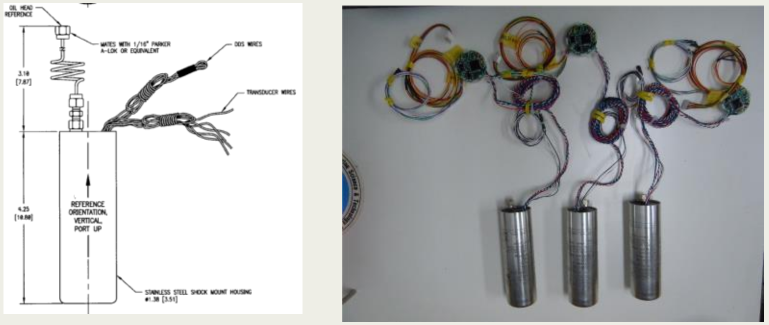

Figure 1. Drawing of the pressure gauge of Paroscintrific, Inc., '410K-184' (*Left*), and three pressure gauges tested in the pressurization experiment (*Right*).

Experimental Setup

The JAMSTEC operates the pressure balance 'PG7302' of DH Instruments, Inc. The combination of the pressure controller system 'PPCH' and 'PG7302' can continue to generate the standard pressure for long-term. Three pressure gauges set with the manifold are connected with the pressure balance with high-pressure tubes (**Figure 2**). This setup makes it possible to provide the standard pressure to the pressure gauges simultaneously.

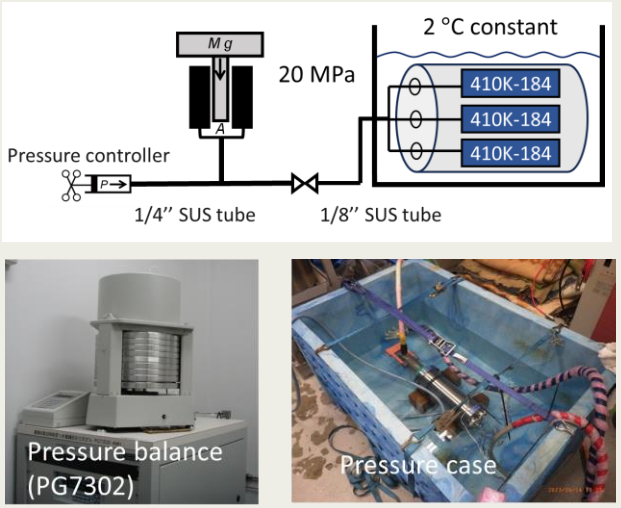

Figure 2. Block diagram of the long-term pressurization experiment (Top), and the photos of the pressure balance 'PG7302' (Left Bottom) and of the pressure sensor unit in the water bath (Right Bottom).

Laboratory Experiment for Sustainable Pressure Observation at the Seafloor

Hiroyuki Matsumoto, Aki Ito, Keisuke Ariyoshi, Yuya Machida, Satoru Tanaka & Eiichiro Araki

Pressurization Experiment

The sensor drift of pressure gauges were characterized by applying a constant pressure for a period of 36 – 54 days. The purple lines in the shaded domain represent the pressure calibration results at 20 MPa pressurization during the vent period (**Figure 3**). The sensor drift can be modelled by a fitting function with an exponential component followed by a liner component over time (e.g., Polster *et al.*, 2009). We used the time-depending function (1) given by Kajikawa & Kobata (2019) to model the sensor drift. Two important coefficients K_2 and K_3 represent the elapsed time to dominate linear component and the slope of the sensor drift, respectively (**Table 1**).

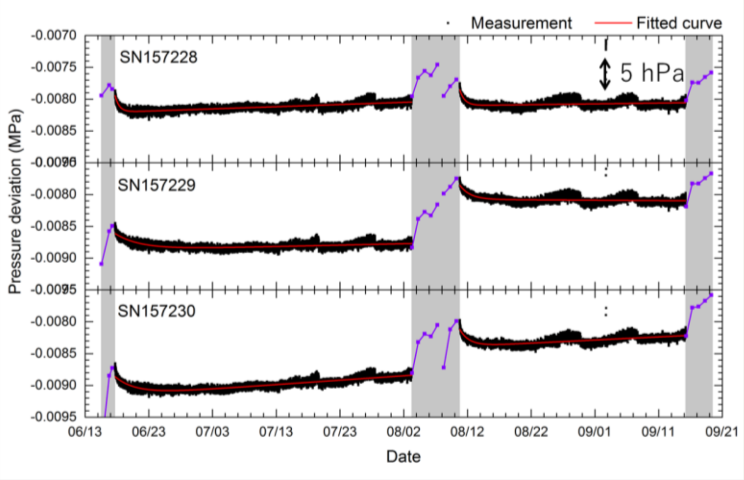

Figure 3. Time-line of long-term pressurization.

Our pressurization results suggest that one pressure gauge of SN157230 can show a relatively large sensor drift rate compared to the other two pressure gauges.

$$\Delta DI(t) = K_1 \times \{1 - \exp(-t/K_2)\} + K_3 \times t + K_4 \quad \cdots\cdots (1)$$

Relaxation coeff. (K_2) Linear coeff. (K_3)

Table 1. Relaxation coefficient K_2 and linear coefficient K_3.

Serial number (SN)	Relax. coeff. K_2 (day)	Linear coeff. K_3 (Pa/day)
SN157228	+0.678	+3.434
SN157229	+3.916	+2.220
SN157230	+3.274	+6.915

Serial number (SN)	Relax. coeff. K_2 (day)	Linear coeff. K_3 (Pa/day)
SN157228	+0.784	+1.255
SN157229	+1.647	-0.578
SN157230	+1.524	+4.918

In-Situ Pressure Observation

The borehole observatory, C9038B was installed in 2023 (**Figure 4**). The pressure gauges showing the first and the second smallest sensor drift based on the experiment were used for seafloor and the borehole pressure measurements, respectively.

The Baytap-G program (Tamura *et al.*, 1991) is applied to the pressure dataset (**Figure 5**). Comparing the sensor drift of the experiment with that of the in-situ measurement for the initial one month, our laboratory evaluation could support the in-situ observation. The recent pressure measurement suggests that the pore fluid pressure is rising up at a rate of 0.3 hPa (cm) per day in the borehole over time. Although the permeability of the pore fluid pressure section in the borehole can be changing, further discussions may be needed to clarify the reason.

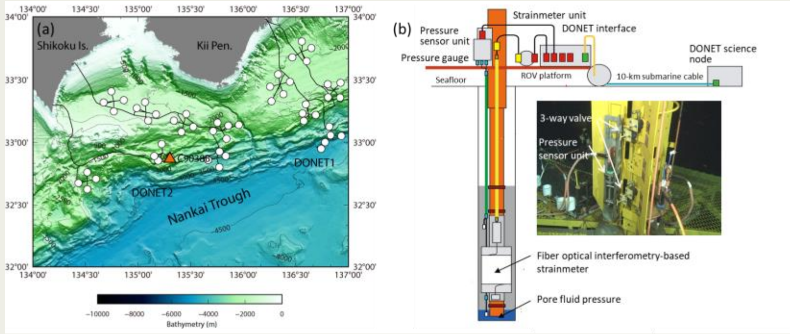

Figure 4. Map showing the location of the borehole observatory (C9038B) in the Nankai Trough (*Left*). Schematic drawing of the C9038B borehole observatory (*Right*).

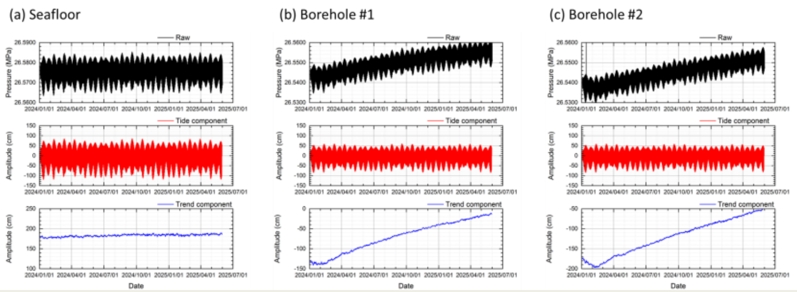

Figure 5. Pressure waveforms by three pressure gauges and their processed waveforms. (a) Seafloor, (b) borehole #1, and (c) borehole #2. Black, red, and blue lines represent the raw, the tide, and the trend components, respectively.