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Research paper

Data report: Hybrid Pressure Coring System tool review and summary of recovery result from gas-hydrate related coring in the Nankai Project

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ABSTRACT

In the exploration phase for development of methane hydrate as an energy resource, pressure coring that maintains the in-situ hydrostatic pressure is a critically important technical issue. Such pressure core-sampling tools have been used since the 1990's; however, during core analyses, the samples were typically exposed to atmospheric conditions. The Pressure Core Analysis and Transfer System (PCATS) of Geotek, Ltd. was developed to enable pressure core samples to be analyzed at the in situ hydrostatic pressure at which they were recovered. Subsequently, a new pressure core-sampling tool, the Hybrid Pressure Coring System (Hybrid PCS), was developed in which an autoclave section connects to PCATS without releasing the in situ hydrostatic pressure. In 2012, JOGMEC successfully conducted a pressure-coring operation in the Nankai Trough offshore Japan. The basic design and features of the Hybrid PCS are described here, along with pressure-coring operations, the workflow for core analysis shipboard, pressure core sample recovery results, and technical issues. Representative examples are presented for pressure–temperature relations in the autoclave core-sampling tool during core analysis.

1. Introduction to pressure coring and the Hybrid PCS

On the basis of seismic analysis, Japan Oil, Gas and Metals National Corporation (JOGMEC) had the technology to estimate the volume and distribution of methane-hydrate-bearing formations, and found huge reserves in the offshore Japan. To develop these resources we needed to evaluate the business economics as is done for conventional oil and gas resources. The requirements included the distribution and volume of gas hydrate deposits, and the source rock and mechanisms of source gas move and accumulations of, methods for producing the deposits safely and efficiently, and for highly accurate evaluations of productivity.

To develop methods for evaluating the volume of the methane-hydrate reservoir, the first step is sampling and analysing methane-hydrate bearing cores under in-situ conditions. Then, a production system can be developed and the potential productivity of the gas hydrates evaluated.

In this article, we describe the recovery of cores from the methane hydrate reservoir under in-situ conditions and present some related results.

2. Description of the Hybrid PCS

A) Comparison with PTCS

The Hybrid PCS was developed from the pressure–temperature core sampler (PTCS) by the Japanese Agency for Marine-earth Science and Technology (JAMSTEC) (Kubo et al., 2014). The PTCS, in turn, was invented in 1998 by Aumann & Associates Inc. (AAI) and the Japan National Oil Corporation (JNOC: now the Japan Oil, Gas and Metals National Corporation, JOGMEC). The PTCS was upgraded in 2004. Relative to PTCS, the Hybrid PCS offers: (a) continued compatibility with the JAMSTEC coring system and (b) compatibility with Geotek, Ltd.'s Pressure Core Analysis and Transfer System (PCATS), which includes core handling and an analysis system. These compatibility features are required because JAMSTEC needs to use the same outer barrel in all their several coring systems, including the Hybrid PCS. JAMSTEC also requires that their hydrate-bearing cores be analyzed at nearly in-situ hydrostatic pressure.

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Table 1
Comparison of basic features in PTCS and Hybrid PCS.

	PTCS	Hybrid PCS
Core recovery method	Wire-line	Wire-line
Maximum working pressure (bar)	241.3	344.8
Sample core ID (mm)	73.0	51.0
Maximum core length (m)	3.5	3.5
Outer barrel OD (mm)	203.2	212.7
Coring Bit OD (mm)	269.9	269.9
Drill pipe diameter (mm)	168.3	127.0 or 139.7

However, as the PTCS inner barrel does not adapt to PCATS, PTCS core samples could not be analyzed without depressurizing them, thereby altering their mechanical properties because methane hydrates dissociate at atmospheric pressure (Takahashi and Tsuji, 2005). By designing the Hybrid PCS to connect to PCATS, JAMSTEC can analyze core samples at nearly in-situ hydrostatic pressures.

The basic design features of PTCS and the Hybrid PCS are compared in Table 1 and Figure 1. Both core samplers have an inner barrel and an outer barrel. The inner barrel consists of a latch section, a pressure accumulator section, and an autoclave section. The autoclave section includes the core liner, which contains the core sample, and core catcher. The autoclave section has two pressure and temperature gauges: a plug gauge, and a rabbit gauge. The plug gauge is set on top of the core liner, and the rabbit gauge is set on the rabbit, which is placed on the core catcher. As a core sample is being cut, the rabbit travels inside of the core liner with the core sample.

B) Highlight of critical upgrades

The ball-valve seal on the Hybrid PCS is placed on the topside of the ball valve because the inner barrel OD is smaller than that of PTCS. The cutting shoe is attached to the bottom of the inner barrel because the coring bit is compatible with the JAMSTEC coring bit, which has a larger ID than PTCS.

Because of these modifications, the new core sampler, Hybrid PCS, required (a) matching tests with PCATS to confirm coring performance with the cutting shoe on the core bit and (b) onshore field coring tests before offshore coring operations to confirm the ability to maintain pressure with the new position for the ball-valve seal. The PTCS coring in the Nankai Trough in 2004 had on overall recovery rate of 79.3% for 203.5 m of attempted coring.

3. Hybrid PCS testing

A) Matching test with PCATS

For the matching test, the Hybrid PCS inner barrel and PCATS transfer tools were sent to the Geotek workshop. The test was successfully completed in spite of several instances of difficulty in

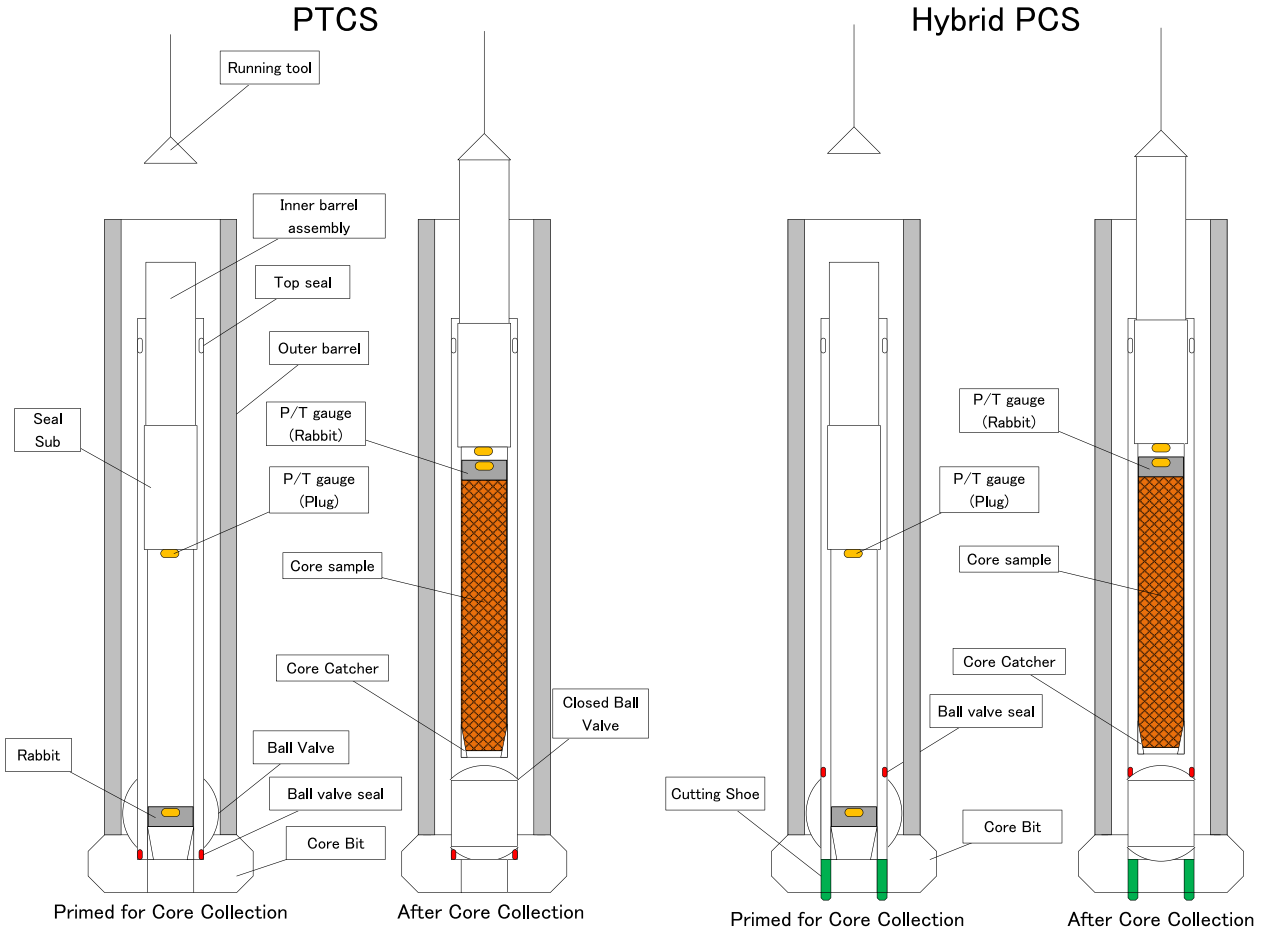

Figure 1. Design Comparison between PTCS and Hybrid PCS. Pressure/Temperature (P/T) gauges are self-contained data logging devices set to record P/T data near the core top every 10 s.