IODP New Ventures in Exploring Scientific Targets (INVEST)
White Paper

Title :

New World of Technology developed with “Chikyu”

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Abstract :

The Center for Deep Earth Exploration (CEDX) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is an implementing organization of IODP and operate D/V “Chikyu”, a state-of-the-art scientific drilling vessel. Since delivery in July 2005, “Chikyu” has been drilling riser and riserless wells off Japan (Shimokita and Nankai) and Overseas (Kenya and Australia) for the last 4 years. The deepest water was 2,200m and the deepest well was 3,700m below sea floor by riser drilling operation. Recently, “Chikyu” has completed the world’s first riser drilling operation for the scientific purpose off Kumano. These wells have demonstrated the high performance of “Chikyu” drilling capabilities.

JAMSTEC/CDEX has been developing the enhanced systems for “Chikyu” to meet future scientific requirements, especially to reach the mantle where human being have never reached, on the ultra-deep water drilling (beyond 4,000m water depth) & deep drilling (total depth of 12,000m) technology, the improved coring technology and the long-term borehole monitoring technology.

In this paper, we will introduce briefly what systems are being developed.

By the middle of the IODP Phase 2, i.e. 2018, the development of all the systems will be completed, then “Chikyu” will be ready for approaching the unexplored deep interior of the earth. It could be the opening day of a new world of science and technology.

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New World of Technology developed with “Chikyu”

Yoshio Isozaki, Wataru Azuma, Eigo Miyazaki & Yuichi Shinmoto
(CDEX, JAMSTEC)

The Center for Deep Earth Exploration (CEDX) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is an implementing organization of IODP and operate D/V “Chikyu” (Fig. 1), a state-of-the-art scientific drilling vessel. Since delivery in July 2005, “Chikyu” has been drilling riser and riserless wells off Japan (Shimokita and Nankai) and Overseas (Kenya and Australia) for the last 4 years. The deepest water was 2,200m and the deepest well was 3,700m below sea floor by riser drilling operation. Recently, “Chikyu” has completed the world’s first riser drilling operation for the scientific purpose off Kumano. These wells have demonstrated the high performance of “Chikyu” drilling capabilities together with its massive and stable hull structure and the extensive four-storied laboratory area of 2,300 m^2 in total, equipped with a high-resolution X-ray CT scanner, an XRF core logger, a non-magnetic room, a microbiology laboratory, etc.

JAMSTEC/CDEX has been developing the following systems for “Chikyu” to meet future scientific requirements, especially to reach the deep earth’s interior where mankind has never reached, as shown on the attached Fig. 2 briefly.

1. Deep Drilling Technology / Ultra-Deep Water Technology

The deep drilling & ultra-deep water technology is a key issue to develop a new science frontier. Especially, in order to reach the mantle, we have to drill more deeply than 7,000 m under the sea floor in the ultra-deep water beyond 4,000 m. Therefore we are developing the deep drilling technology and the ultra-deep water technology.

(1) Deep Drilling Technology

To extend the current capability of drilling depth of 10,000m to 12,000m and to drill as vertical as possible notwithstanding the high temperature upto 300 °C and the sophisticated soil conditions in the deep layers, the following technologies are being developed.

- Ultra-deep pipes using super-high tensile steel
- Turbine motor to rotate the bit by mud stream
- High temperature core barrel
- High temperature drilling fluid
- Ultra-deep casing pipes such as expandable casing

The turbine motor driven by mud stream is necessary to drill the deep holes, because the rotating whole drill pipes causes the large friction forces between drill pipes and hole wall.

(2) Ultra-Deep Water Technology

To extend the current capability of water depth of 2,500m to beyond 4,000m, which is an average depth of the ocean, the following technologies are being investigated considering the technology under development in the oil industry.

Also, to withstand the strong current, we have developed the anti-VIV (Vortex Induced Vibration) riser fairing system which were installed on the riser pipes during the Exp. 319, and the phenomena of risers during the drilling operation were measured using six sets of riser angle logging system of six-degree of freedom. We are analyzing such data to improve the deep riser analysis technology to evaluate the fatigue life of the riser pipes more accurately, which contribute the safe riser operation in the deeper water.

- Buoyant riser constructed of lightweight material (High strength steel, Aluminum alloy, Titanium alloy, CFRP (Carbon Fiber Reinforced Plastics), etc.)
- Low density buoyant material
- New riser/BOP system (RMR (Riserless Mud Recovery) system, Surface BOP system, Free standing riser system, etc.)
- BOP control system (Electric-hydraulic system, etc.)

To apply the above developed technology to the actual operation, “Chikyu” has many advantages, because it has a large variable load capacity of 23,500 tons, a high dual derrick with total hanging capacity of 1,900 tons, a wide utility/pipe rack area onboard, huge tank capacities to enable the long stay at one drilling location, etc.

2. Improved Coring Technology

Along with the development of the deep drilling technology, cores can be recovered from the various deeper layers on the way to the mantle, which can be supplied to the various scientific fields.

As a common issue in the scientific drilling, it is one of the most important things to recover the cores continuously with higher quality, better recovery rate and less break, and also keeping biosphere live in the cores preventing from being contaminated by drilling fluid under the its original conditions.

(1) Coring Technology for Higher Quality and Better Recovery Rate

The good quality cores were recovered at the Exp. 319 riser drilling with a recovery rate of approx. 85% on the average. It owes to riser operation and improved coring equipment. In order to improve further the core quality to be recovered from the deep layer regardless the soil conditions, the following technologies are being developed.

- Mud driven core barrel
- Measurement while coring tool
- Improved core bit (PDC or Implemented diamond bit)

- Improvement of function of the existing active heave compensator (AHC) onboard “Chikyu”

Among them, the mud driven core barrel will enable to recover the high quality cores from the complicated layer such as combination of hard layer and soft soil, which recover the core with low weight on bit and high revolution.

(2) Deep Biosphere Cultivation Technology

It is one of the new challenges of IODP to explore sub-surface biosphere. To carry out exploratory research into deep-sea microorganisms collected live from the earth’s oceanic crust, the following technologies are being developed in order to enable their cultivation by creating the same extreme deep-sea environment, like high temperature, high pressure, hazardous gases, where they thrive even on land.

We will utilize our previous research on the gel-coring system, the existing Deep Bath in JAMSTEC, the current pressure corer technology, etc. for the development.

- Anti-contamination technology
- Extreme environment sustaining technology
- Environment monitoring system and simulation technology
- Continuous cultivation system based on the existing Deep Bath

After completion of such technology development, we will provide the deep biosphere cultivation system onboard “Chikyu”, which contribute a germination of new science.

3. Long-Term Borehole Monitoring Technology

Boreholes remained after drilled are not mere relics after recovering core samples from the sea floor, but are scientifically very important “window” for monitoring the earth’s interior. For example, NanTroSEIZE (Nankai Trough Seismogenic Zone Experiment) not only proposes drilling, coring and geological analysis, and geophysical logging, but also mandates that a long-term borehole monitoring system be installed into two deep riser holes at about 3,500m and about 6,000m below the sea floor, where we expect to encounter the mega-splay and the locked region of mega thrust fault, respectively.

The major technological challenges for developing the deep ocean borehole monitoring system are mainly as follows;

- High temperature, long life monitoring system
- Deployment technology (15,000 psi wellhead system, deep well, retrieval, perforation, packer, mechanical shock)
- Reliable monitoring system (multi layer, multi purpose, low power consumption, real time, accurate synchronization, wide frequency range)

These developments could lead to the future LTBMS technologies to contribute

the deeper borehole science.

"Chikyu" will install and maintain the system, and such technology is applicable to other purposes to monitor the inside of the earth.

After completion of development of the above-mentioned technology, we are planning to test it during the actual operation by "Chikyu" combined with the existing systems, so-called "Engineering Leg", and it will be thrown into the actual field of operation one by one prior to completion of the whole systems.

It is scheduled that the development of the whole systems listed above are completed by the middle of IODP Phase 2, i.e. around 2018, then "Chikyu" will be ready for approaching the deep earth's interior like a mantle where human being never reached. It could be the opening day of new world of science and technology.

Apart from such technology development, the accommodation capacity of "Chikyu" will be increased to 200 persons having single cabins and double cabins, from the current 150 within the next year to welcome more scientists onboard.

Fig. 1 D/V "Chikyu"

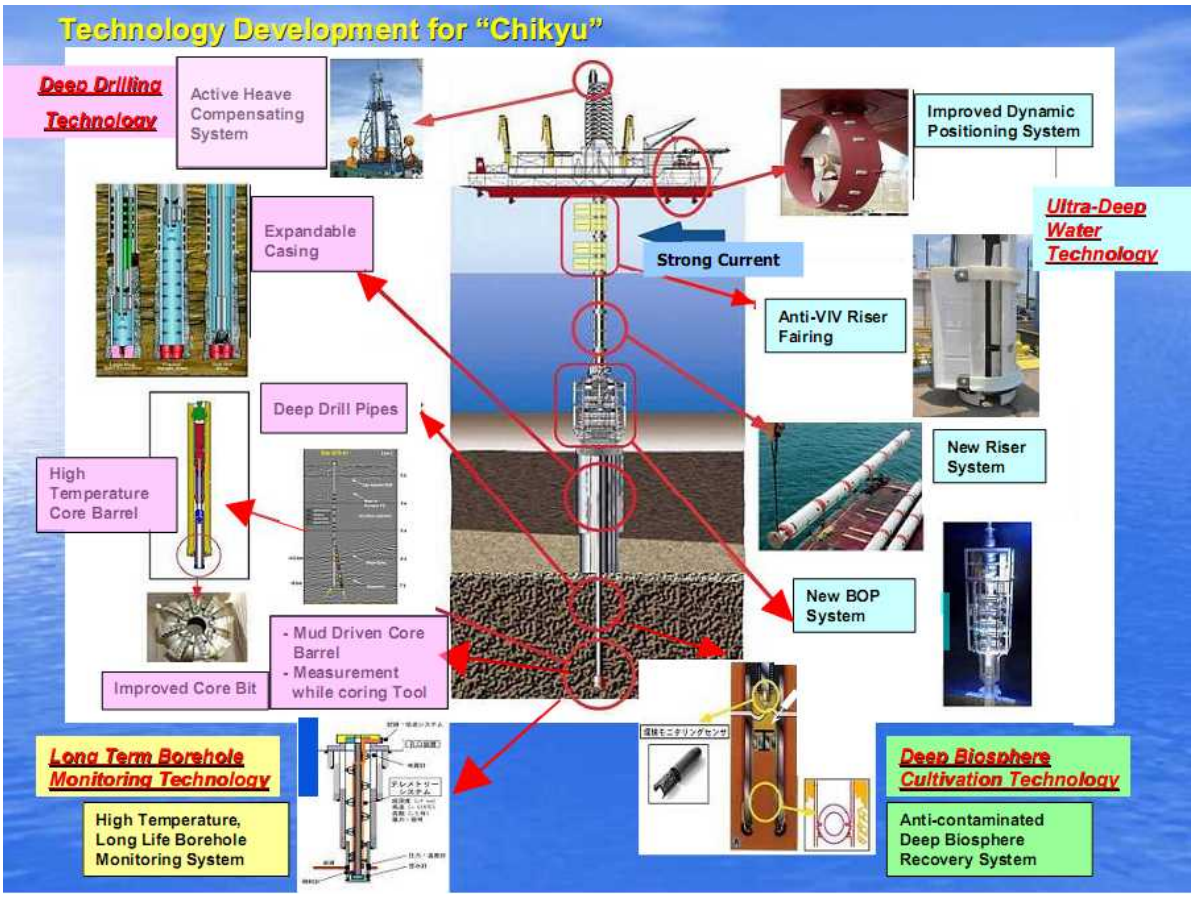

Fig. 2 Technology Development for "Chikyu"