NT08-07 Cruise

Dynamics of submarine eruption of felsic magmas at Myojinsho caldera

Natsushima

Cruise Report

April 3 to April 11, 2008

NT08-07 Leg 1

Research Leader

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

- **Cruise number:** NT-08-07
- **Ship name:** Natsushima
- **Title:** Dynamics of submarine eruption of felsic magmas at Myojinsho caldera
- **Proposal number:** S08-56
- **Title:** Dynamics of submarine eruption of felsic magmas at Myojinsho caldera
- **Period:** April 3 to April 10, 2008
- **Port:** Yokosuka (JAMSTEC: April 3, 2008) – Yokosuka (April 10, 2008)
- **Area:** Myojinsho Caldera (Bayonnaise rocks): 31-53N, 139-57E
- **Dive list:** see Chapter 3 for detail
- **Track line chart:** see Chapter 4 for detail
SUMMARY

Submarine volcanic eruption can be highly destructive generating characteristic jets (called “cock’s tail jets”) and base surges in addition to pyroclastic gravity currents. Although some models have been proposed for these phenomena (ex. FCI theory for water-magma interaction), the mechanisms of magma-water interaction and mode of pyroclast deposition on the sea floor are still unclear. We surveyed Myojinsho caldera, 32° N, 140° E, for the second time after the cruise we made in December 2006. The caldera is one of the calderas along Izu-Bonin island arc with an active post-caldera volcano called Myojinsho reef.

We confirmed similar facts as NT06-21 cruise; (1) Myojinsho is a conical edifice whose surface of the slope consists of deposits by gravity currents of pumices at distant farther than 500 m from the vent, and dense angular lava blocks probably as a consequence by cock’s tail jets that accompanied with phreatomagmatic eruptions. (2) The edifice of Myojinsho caldera consists of the alternation of altered lava and pyroclastic layers at deeper part than ca. 500 m bsl, and thick pumice fall and flow deposit that would have been generated by caldera eruption. We also obtained new observation; (1) Deposits outside the caldera also consist of pumiceous materials. (2) The N-S aligned ridge is a chain of pyroclastic cones consisting of scoria, spatter and possibly lavas with some morphological variety.

Samples for petrological and geochemical analyses in the laboratory are obtained, more than 50 rock samples and some sediment samples. Most samples are relatively fresh for whole rock measurement.

要旨

海底火山における噴火活動については、その実態、メカニズムともまだ不明な点が多い。特に海底噴火活動ではマグマと海水との接触によって爆発が起こり、きわめて破壊的な現象が発生することが危惧されるが、この爆発メカニズムや噴出物の堆積過程などについてはあまり調べられていな。本調査航海では、明神礁カルデラにおける2度目の潜航調査である。明神礁カルデラは伊豆小笠原弧にいくつか存在する海底カルデラの一つであり、現在もきわめて活発な活発な活動を続ける後カルデラ火山である明神礁を有する。

本調査の結果、我々は次の点について、前回調査（NT06-21航海）を裏付ける証拠を得た。（1）明神礁の山体斜面は山頂火口から500m以内の地域では角張った溶岩片からなる堆積物、500m以遠では軽石からなる重力流堆積物からなり、それぞれ1952－53年噴火で確認されたマグマ水蒸気爆発によるcock’s tail jetおよびベースサーブの到達範囲に対応する。（2）明神礁カルデラを有する火山体は水深約500m以深が変質した溶岩・火砕物の互層、これ以浅がカルデラ噴火によって堆積したと考えられる軽石堆積物からなる。また、次の新たな事実を確認した。（1）カルデラ外側にも軽石からなる堆積物が存在する。（2）カルデラの西方に存在する南北に連なる凸状地形は、数多くの火砕丘ないし割れ目火口列である。

本調査では、本火山のマグマ進化過程を考察するため、岩石学的、地球化学的分析に用いる試料を各潜航地点において採取した（岩石試料50試料以上、堆積物試料数試料）。これらは分析に十分な新鮮さであると考えられる。
1. INTRODUCTION

Understanding the mechanism of explosive eruption has been one of the major subjects in volcanology. This topic is now fairly understood for those that occurred on land; for example, degassing of magma during ascent in a conduit controls the eruption style. However, the fundamental processes that control degassing and how deep they work during the course of an eruption is still not clear. In addition, how effusive eruptions and explosive eruptions could result from similar magma is not well understood. Explosive eruptions have also resulted from the sudden large volume expansion of seawater due to magma-water interactions. These processes can be highly destructive and can generate jets (called “cock’s tail jets”) and base surges. Some models have been proposed for these phenomena (ex. FCI theory for water-magma interaction). However, the mechanisms of magma-water interaction and mode of pyroclast deposition on the sea floor are still not well understood.

In addition, the mechanisms associated with caldera-forming eruption in the sea are much less understood. These types of eruptions occur rarely (There have been almost no direct observations), but they are known as some of the most violent and destructive and can generate large scale pumice falls, pyroclastic flows and surges, and tsunamis. Although the deposits on land associated with caldera-forming eruptions (including subaqueous) are documented in detail due to their well-preserved and accessible exposures, the counterparts in the deep sea have not been well investigated.

The evolution of the edifices and magmatic systems for these caldera forming-volcanoes is one of the topics that should be investigated to better understand how magma ascends from depth and resides at shallow level in the crust. Recent topographical mapping by Sea beam scanning in the Izu-Bonin arc revealed many submarine calderas which consist of several topographical peaks around each caldera in this area. So the investigation of stratigraphy with its petrological evolution and the correlation among these calderas should give constraints on the evolution of submarine calderas in this island arc.

In this research project of Myojinsho caldera and related volcanic features, three main subjects to be investigated; (1) the dynamics of recent eruptions, (2) the dynamics of its caldera forming eruption, and (3) the evolution of both the Myojinsho volcanic edifice and the magma whose eruption caused the caldera to form. In the following sections, the objectives of each of these topics are described.

Fig. 1-1 Locality map of the Izu-Bonin arc front showing islands and submarine calderas near Myojinsho caldera (after Fiske et al., 1998)
Myojinsho, or Myojin reef, is situated ca. 600 km south of Tokyo (Fig. 1-1), and is one of the several submarine peaks surrounding Myojinsho caldera. Myojinsho is at the eastern rim of the caldera. The topography of Myojinsho edifice is highly symmetrical cone whose slope angle is almost identical for all directions (Fiske et al., 1998). The shape of the caldera is elongated to E-W direction with diameter of ca. 12 km and ca. 8 km, for longitudinal and latitudinal direction, respectively (Fig. 1-2). Another famous peak, Beyonnaise rocks, is above sea level and located at the western rim of the caldera. At the center of the caldera, there is a hill or central edifice on the flat caldera floor at depth of ca. 1100 m bsl (below sea level). The central hill has a flat top surface which declines eastwards.

![Fig. 1-2](image-url) **Fig. 1-2** Topographical map near Myojinsho caldera (Tamaki et al., unpublished data). Myojinsho caldera is at 31-53N, 139-57E (WGS84). The 10-km diameter submarine caldera at Myojin Knoll at 32-07N, 139-52E.
The Myojinsho volcano is one of the most active submarine volcanoes in Japan. Some eruptions had been witnessed by fishermen since 19th century, and it became famous when many crews of a ship of Japan Coast Guard were killed by explosions during the 1952-53 eruption. The eruption is characterized by the alternation of dome formation and its collapse accompanied by energetic phreatomagmatic eruptions. The lava dome morphology changed from rubbly lava in early 1952 to spine-like features from October 1952 to October 1953. Some explosion events are investigated during eruption and the pressure sources of the explosions were estimated by using this information. Fiske et al. (1998), using bathymetric data, proposed a model of the mode of emplacement for the products of the eruption; Large dense blocks and pumices ejected into water traveled down the slope in density currents. In contrast, pumices ejected in the air floated and were dispersed widely, or descended as vertical density currents as a consequence of hyperconcentrations when large volumes of tephra fell to the sea surface. There are some reports on discolored seawater and floating pumices in 1970-80’s. As the locality of this area is far from the mainland of Japan, however, many small-scale eruptions might have occurred more recently.

In this cruise, we are planning to study the slopes of Myojinsho. In addition, detailed bathymetric data have been obtained recently around this area (Fig. 1-1). From direct observation of the topography and internal structures of the deposits, we will discuss the mode of emplacement of pyroclastics on the slopes of submarine volcano, accessing the model of Fiske et al. (1998). We are also planning to survey the summit area and to investigate present-day activity that might be taking place.

We will also collect samples from recent eruptions. Shimano and Nakada (2006) investigated vesicular texture of submarine scoria from the submarine fissure formed during the 2000 eruption at Miyakejima volcano in Izu-Bonin arc. These scorias have identical composition (basalt), but have different densities

Table 1-1 Representative recent eruptions at Myojinsho volcano (after Fiske et al., 1998)

<table>
<thead>
<tr>
<th>Year</th>
<th>Reported location</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1860</td>
<td>?</td>
<td>Submarine eruption</td>
</tr>
<tr>
<td>1870</td>
<td>?</td>
<td>Submarine eruption, new island</td>
</tr>
<tr>
<td>1871</td>
<td>?</td>
<td>Submarine eruption</td>
</tr>
<tr>
<td>1896</td>
<td>Approximately 8 nautical miles north of Bayonnaise Rocks</td>
<td>New island forms and then disappears</td>
</tr>
<tr>
<td>1906</td>
<td>9 nautical miles northeast of Bayonnaise Rocks</td>
<td>Eruption columns, floating pumice</td>
</tr>
<tr>
<td>1915</td>
<td>Approximately 6 nautical miles east of Bayonnaise Rocks</td>
<td>Submarine eruption, eruption columns, discolored water</td>
</tr>
<tr>
<td>1934</td>
<td>Approximately 5.5 nautical miles east of Bayonnaise Rocks</td>
<td>Submarine eruption, discolored water, smell of sulfur</td>
</tr>
<tr>
<td>1946</td>
<td>31°57’N, 140°01’E</td>
<td>Dome eruption builds new island, which then disappears</td>
</tr>
<tr>
<td>1952-1953</td>
<td>Myojinsho</td>
<td>Many explosive eruptions; three cycles of island growth and destruction</td>
</tr>
<tr>
<td>1954</td>
<td>Myojinsho</td>
<td>Submarine eruption</td>
</tr>
<tr>
<td>1955</td>
<td>Myojinsho</td>
<td>Submarine eruption</td>
</tr>
<tr>
<td>1957</td>
<td>Myojinsho</td>
<td>No known eruption, but dead fish found floating nearby</td>
</tr>
<tr>
<td>1960</td>
<td>Myojinsho</td>
<td>Submarine eruption; sub-aerial eruption column rises to 2000–3000 m</td>
</tr>
<tr>
<td>1970</td>
<td>Myojinsho</td>
<td>Submarine eruption, discolored water, floating pumice</td>
</tr>
<tr>
<td>1971</td>
<td>Myojinsho</td>
<td>Discolored water</td>
</tr>
<tr>
<td>1979</td>
<td>Myojinsho</td>
<td>Discolored water</td>
</tr>
<tr>
<td>1980</td>
<td>Myojinsho</td>
<td>Discolored water</td>
</tr>
<tr>
<td>1982</td>
<td>Myojinsho</td>
<td>Discolored water</td>
</tr>
<tr>
<td>1986</td>
<td>Myojinsho</td>
<td>Discolored water</td>
</tr>
<tr>
<td>1987</td>
<td>Myojinsho</td>
<td>Discolored water</td>
</tr>
<tr>
<td>1988</td>
<td>Myojinsho</td>
<td>Discolored water</td>
</tr>
</tbody>
</table>
Stage I (most observations made during this stage)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 Sept 1952</td>
<td>Eruption (and explosions) begin; tsunamis recorded at Hachijo Island (130 km away); SOFAR signals received in California</td>
</tr>
<tr>
<td>17 Sept</td>
<td>Eruption first observed by crew of fishing boat “No. 11 Myojin-maru,” whose name was given to the volcano. Numerous small explosions; island emerges from sea</td>
</tr>
<tr>
<td>18–23 Sept</td>
<td>Numerous explosions, island persists</td>
</tr>
<tr>
<td>24 Sept</td>
<td>Large explosion at 0540 JST; island destroyed. Survey ship No. 5 Kaiyo-maru cruises above submerged volcano summit and is destroyed by large explosion at approximately 12:20 JST</td>
</tr>
</tbody>
</table>

Stage II (intermittent observations only)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 Sept–10 Oct</td>
<td>Numerous explosions from submerged volcano summit: eruption columns repeatedly rise into the air</td>
</tr>
<tr>
<td>11 Oct</td>
<td>New dome growth builds island</td>
</tr>
<tr>
<td>12 Oct–10 March 1953</td>
<td>Numerous explosions; island persists</td>
</tr>
<tr>
<td>11 March</td>
<td>Perhaps the largest explosion of the eruption; island is destroyed</td>
</tr>
</tbody>
</table>

Stage III (intermittent observations only)

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 March–3 April</td>
<td>Numerous submarine eruptions; many subaerial eruption columns noticed</td>
</tr>
<tr>
<td>5 April</td>
<td>New island observed</td>
</tr>
<tr>
<td>14 April–17 Aug</td>
<td>No explosions observed; island persists</td>
</tr>
<tr>
<td>18 Aug–1 Sept</td>
<td>Numerous large explosions; subaerial eruption columns noted; island persists</td>
</tr>
<tr>
<td>3 Sept</td>
<td>Continuing explosions; island destroyed; breakers on sea surface mark position of former island</td>
</tr>
<tr>
<td>16 Sept–5 Oct</td>
<td>No island visible; minor steaming and discolored water</td>
</tr>
</tbody>
</table>

Table 1-2  The sequence of the 1952-53 eruption (after Fiske et al., 1998).

1-2. Dynamics of caldera forming eruption at Myojinsho Caldera

There are many submarine calderas in the Izu-Bonin island arc. Among them, Fiske et al. (2000) proposed, for Myojin Knoll caldera, that most pumices ejected from the caldera sank and formed caldera-fill deposit because the volcano is deep in the sea and large volumes of pumices ingested seawater rather than air as magmatic steam condensed. Manned submersible observations showed that much pumice was deposited along the caldera rim.

In contrast, Tani et al. (2007) investigated the deposits of Sumisu Caldera. There, the eruption column rose high into the air. Magmatic steam filling the vesicles thus quenched in the air, causing air (rather than seawater) to be ingested; these pumices floated when they fell back to the sea surface. These workers interpreted that much pumice floated for long periods of time and was deposited far from the volcano. They also showed that only minor amounts were deposited along the caldera rim. They concluded that this is because the caldera rim was near sea level and this had an important influence on pumice dispersal patterns.
Myojinsho Caldera is at relatively shallow depth (<1000 m) but it is deeper than Sumisu calderas. Thus, some of the pumices produced during the Myojinsho’s caldera forming eruption may have floated but probably not as extensively as those of Sumisu caldera. In this research cruise, we will search for the essential pumices of Myojinsho’s caldera-forming eruption. We will then correlate the pumices at several localities and attempt to define their areal distribution.

Fig. 1-3 The phreatomagmatic explosion on September 23, 1952 (after Ossaka, 1991).

1-3. Evolution of volcanic edifice and magma at Myojinsho Caldera

Myojinsho caldera volcano consists of several older edifices whose summits lie below sea level; one of these, however, is above sea level and is called Beyonnaise rocks. There are many caldera volcanoes in Izu-Bonin island arc, and they have some similarity in topography. They consist of several edifices with topographical peaks around the main caldera. The chemistry of the rocks Making up these caldera-forming volcanoes seem to have similar variation, although additional data are needed. As one of the examples, Tani et al. (2007) showed the stratigraphical relationship of the edifices of Sumisu caldera and defined three stages of its evolution history; (1) stratovolcano stage, (2) caldera forming stage, and (3) post-caldera stage. They also suggested systematic change in chemistry with the edifice evolution. At the stratovolcano stage, basaltic and dacitic magmas were dominant. At the caldera forming stage, large amount of rhyolitic magma was ejected as pumices. Then, during the post-caldera stage, lava domes grew around the caldera.

Regarding the evolution of the Myojinsho volcano, we observed three major facts during the first cruise, NT06-21-leg2-2. (A) The lower part of the caldera wall (ca. 500-1100 mbsl) consists of stratified successions of altered lava and volcaniclastic deposits. (B) The upper part of the wall consists of pumice fall and flow deposits (ca. 500-200 mbsl). (C) At least lower part of the edifice at the center of the caldera consists of very similar sequence to that of caldera wall. (A) and (B) show that the upper pumice deposits are the essential materials produced during the caldera-forming eruption, and that the lower altered rocks make up part of the pre-caldera edifice of the volcano. (C) is inconsistent with the idea that the central edifice is a post-caldera cone, and indicates that the edifice may be a criptdome formed after the caldera-forming eruption.

In addition, we found a very unique chain of conical seamounts during the cruise NT06-21 that has a trend of N-S direction to the west of the caldera, and the formation of such kind of structure may have some relation with the evolution of Myojinsho caldera.

In this cruise, we are planning to survey the caldera wall at some localities, especially northern and outer part of the caldera, to confirm the evolution history of Myojinsho caldera. We will also have dives into the
topographic chain with N-S trend to investigate its mode of formation. The SCS survey will also provide constraints on the structure of the deposit near the seafloor. We will collect rock samples to investigate chemical evolution of the magmatic system at Myojinsho caldera.

Fig. 1-4  Topographic map of Myojinsho caldera (Japan Coast Guard, 2000).
2. PAYLOADS AND OPERATIONS

2-1. Scoop

Samples of loose pyroclastic materials are collected by manipulator using a steel scoop in Fig. 2-1. To collect a sample, the scoop is held by its handle (yellow), and dragged along the sea floor rotating the wrist of the manipulator. Scooped samples are poured into box or cylinder with cap to prevent lost during ascent to the sea surface.

![Fig. 2-1 Scoop](image)

2-2. Stand-Alone Heat Flow meter (SAHF) measurements

The Stand-Alone Heat Flow meter (SAHF; Fig. 2-2) is designed to measure heat flow from manned submersibles or ROVs. Five thermistors are situated within the probe at 11 cm intervals. Since SAHF takes measurements as an “OFF LINE” system, heat flow can be measured while the observer is conducting other tasks at that position or elsewhere. While Hyper-Dolphin (HD) is descending or ascending, SAHF is inserted into a case beside the sample basket. After HD lands on the seafloor, SAHF is grasped by the HD’s left manipulator and takes a reference water temperature for 5 minutes. SAHF is then pushed vertically into the sediment and the temperature gradient is measured for 20 minutes. Thermal conductivity data is necessary to obtain a heat flow value, which is not available on current SAHF. We measured thermal conductivities after the cruise from the sediments sampled simultaneously using push-cores and MBARI-type cores from nearby (<1 m) sites. The following are descriptions of SAHF.

<table>
<thead>
<tr>
<th>Material</th>
<th>Titanium alloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>4.0 kg in air, 2.6 kg in seawater</td>
</tr>
<tr>
<td>Length of pressure case</td>
<td>294 mm</td>
</tr>
<tr>
<td>Diameter of pressure case</td>
<td>85 mm</td>
</tr>
<tr>
<td>Length of probe</td>
<td>600 mm</td>
</tr>
<tr>
<td>Diameter of probe</td>
<td>13.8 mm (filled by silicon oil inside)</td>
</tr>
<tr>
<td>Number of thermistors</td>
<td>5</td>
</tr>
<tr>
<td>Intervals of thermistors</td>
<td>110 mm</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.01 °C</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.001 °C</td>
</tr>
<tr>
<td>External Interface</td>
<td>RS232C (9600bps, 8bit, Non-parity, 2 stop-bit)</td>
</tr>
</tbody>
</table>
During the NT08-07 Leg 1 cruise, two heat flow measurements were conducted using the SAHF probe. One measurement was made during Dive HD815 on the floor of Myojinsho caldera, and the other during Dive HD817 at the western foot of the N-S seamount chains.

2-3. SEABAT bathymetric survey

Bathymetric data were obtained by a hull-mounted multi-narrow beam mapping system SEABAT 8160 aboard R/V Natsushima. The SEABAT system has hydrophone arrays that synthesize narrow, fan-shaped beams. The width of the sea floor mapping in a single swath is generally ca.0.7 times the local water depth, and the resolution of the depth measurement is generally within 0.25 % of the water depth. The SEABAT system can collect up to 126 soundings on each ping cycle over depths varying from 10 to 3,000 meters, providing swath width coverage up to 150°. The ship speed was kept below 8 knots (against water) during the SEABAT survey. In measurement of bathymetry, one of the important parameters is the sound velocity profile of the local water column. We calculated the sound velocity profile onboard, using a temperature profile based on in-situ XBT (Expendable Bathythermograph) measurements.

2-4. Single-Channel Seismic (SCS) survey

The single channel seismic (SCS) system is comprised of a generator-injector (G.I.) air gun as a seismic source, a streamer cable as a receiver, controllers for firing and data processors. The seismic source consists of two parts, pressurized air supplied from two air compressors (total 1785 psi); the 45 / 105 cu in. generator (G) creates the primary seismic pulse, and the 105 cu in. injector (I) controls bubble oscillation. The GI gun was towed ~30 m aft, port side, at a depth of 2 m. Seismic waves were received by an analog streamer filled with mineral oil. The streamer has a 47 m active section with 48 hydrophones and was towed 135m aft, starboard side, at a depth of 3 m (Fig. 2-3). Received seismic data are monitored with an on-line processing system and recorded digitally in SEG-Y format. The system was operated at a ship speed of 3.2-3.5 knots (against ground), with shot intervals of 10-14 seconds.

Fig. 2-3 Processing flow of SCS survey
The single channel seismic survey equipment and specification is as follows.

**Streamer**
- Manufacturer: S.I.G
- Active section length: 47m
- Hydrophone Interval: 1m
- Type of Hydrophone: S.I.G.16
- Hydrophone output: -90 dB, re 1V/μbar, ±1dB
- Frequency flat from 10Hz to 1000Hz
- Depth sensor: Yes
- Preamplifier gain: 39
- Lead in cable: 135m
- Receiver depth: 4.0m[scs-a-1], 3m[scs-b-1], 3.5m[scs-b-2]

**Source**
- Manufacturer: Sercel
- Type of airgun: GI-Gun
- Volume: 45(G)+105(I)cu.in
- Air pressure: 14MPa
- Source depth: 2m
- Depth sensor: None
- Gun Controller: GI-01

**Air Compressor**
- Manufacturer: Service Eng.Ltd.
- Type of machine: 4S30A-150K
- Air supply capacity: 2m³/min.

**Recording System**
- Manufacturer: TRITON ELICS
- Type of system: Delph Seismic
- Monitor: EPC The model GSP-1086 Printer
- Recording format: SEG-Y Int.
- Recording length: 7.0sec
- Single Channel Seismic Equipment and Survey Specification

**GPS System**
- Manufacturer: Fugro
- Type of system: SkyFix
- DGPS Reference Station: Okinawa

**GPS System**
- Manufacturer: MARIMEX JAPAN
- Type of system: NAVLOG

**Shot Point Geometry**
- Time mode shooting: 10.0sec

**Geodetic Parameter**
- Spheroid: WGS84
- Semi-major Axis: 6,378,137m
- Inverse Flattening: 298.26
- Projection: U.T.M
- Zone: 54

Table 2-1 Line list of single-channel seismic survey
Fig. 2-4 Offset diagrams of SCS survey (JAMSTEC) for lines A, B-1, and B-2.
### 3. DIVE LOGS

#### 3-1. Ship log: Natsushima (NT08-07 leg 1)

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Description</th>
<th>Position/Weather/Wind/Sea condition (Noon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>03,Apr,08</td>
<td>9:00</td>
<td>embarkation science group</td>
<td>4/3 12:00</td>
</tr>
<tr>
<td></td>
<td>10:00</td>
<td>departure from JAMSTEC</td>
<td>35-00.8N, 139-41.5E</td>
</tr>
<tr>
<td></td>
<td>11:00</td>
<td>on board seminar for safety NATSUSHIMA life</td>
<td>fine but cloudy</td>
</tr>
<tr>
<td></td>
<td>13:00</td>
<td>on board education &amp; training for emergency operation</td>
<td>N-3(Gentle breeze)</td>
</tr>
<tr>
<td></td>
<td>19:00</td>
<td>scientific meeting</td>
<td></td>
</tr>
<tr>
<td>04,Apr,08</td>
<td>5:30</td>
<td>arrived at Dive point</td>
<td>4/4 12:00</td>
</tr>
<tr>
<td></td>
<td>5:49</td>
<td>released XBT</td>
<td>31-55.0N, 140-02.5E</td>
</tr>
<tr>
<td></td>
<td>6:08 ~ 6:49</td>
<td>carried out MBES survey</td>
<td>fine but cloudy</td>
</tr>
<tr>
<td></td>
<td>8:09</td>
<td>launched HPD</td>
<td>NW-4(Moderate breeze)</td>
</tr>
<tr>
<td></td>
<td>8:25</td>
<td>started HPD Dive#812</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8:57</td>
<td>arrived at bottom D=753m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11:58</td>
<td>leave the bottom D=60m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12:04</td>
<td>surfaced HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12:20</td>
<td>recovered HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13:33</td>
<td>launched HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13:49</td>
<td>started HPD Dive#813</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:28</td>
<td>arrived at bottom D=1113m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16:41</td>
<td>leave the bottom D=725m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:03</td>
<td>surfaced HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:16</td>
<td>recovered HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:28</td>
<td>commenced proceeding to MBES area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19:43</td>
<td>commenced MBESS mapping survey</td>
<td></td>
</tr>
<tr>
<td>05,Apr,08</td>
<td>3:49</td>
<td>finished MBESS mapping survey</td>
<td>4/5 12:00</td>
</tr>
<tr>
<td></td>
<td>6:00</td>
<td>arrived at Dive point</td>
<td>31-46.9N, 140-00.0E</td>
</tr>
<tr>
<td></td>
<td>8:02</td>
<td>launched HPD</td>
<td>fine but cloudy</td>
</tr>
<tr>
<td></td>
<td>8:20</td>
<td>started HPD Dive#814</td>
<td>NNW-4(Moderate breeze)</td>
</tr>
<tr>
<td></td>
<td>9:13</td>
<td>arrived at bottom D=1287m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11:47</td>
<td>leave the bottom D=709m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12:09</td>
<td>surfaced HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12:25</td>
<td>recovered HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:03</td>
<td>launched HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14:21</td>
<td>started HPD Dive#815</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15:03</td>
<td>arrived at bottom D=1107m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:22</td>
<td>leave the bottom D=822m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:49</td>
<td>surfaced HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18:04</td>
<td>recovered HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18:25 ~ 19:03</td>
<td>set GI Gun &amp; SCS Streamer cable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21:22</td>
<td>commenced SCS survey</td>
<td></td>
</tr>
<tr>
<td>06,Apr,08</td>
<td>4:21</td>
<td>finished SCS survey</td>
<td>4/6 12:00</td>
</tr>
<tr>
<td></td>
<td>7:00</td>
<td>arrived at Dive point</td>
<td>31-51.7N, 139-47.9E</td>
</tr>
<tr>
<td></td>
<td>8:02</td>
<td>launched HPD</td>
<td>cloudy</td>
</tr>
<tr>
<td></td>
<td>8:18</td>
<td>started HPD Dive#816</td>
<td>SE-3(Gentle breeze)</td>
</tr>
<tr>
<td></td>
<td>8:59</td>
<td>arrived at bottom D=1004m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10:47</td>
<td>leave the bottom D=822m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11:11</td>
<td>surfaced HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11:24</td>
<td>recovered HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13:01</td>
<td>launched HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13:16</td>
<td>started HPD Dive#817</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13:45</td>
<td>arrived at bottom D=614m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:00</td>
<td>leave the bottom D=424m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:15</td>
<td>surfaced HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17:28</td>
<td>recovered HPD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18:00 ~ 18:12</td>
<td>set GI Gun &amp; SCS Streamer cable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18:28</td>
<td>commenced SCS survey</td>
<td></td>
</tr>
<tr>
<td>07,Apr,08</td>
<td>8:04</td>
<td>finished SCS survey</td>
<td>4/7 12:00</td>
</tr>
<tr>
<td></td>
<td>8:25</td>
<td>commenced proceeding to HACHIJO SHIMA</td>
<td>32-48.8N, 139-43.4E</td>
</tr>
</tbody>
</table>
Table 3-1 Shipboard log of Natsushima (NT08-07 Leg 1)

3-2. Hyper Dolphin Dive # 812: Log

Date: 2008/04/04

Objective

Dive to the eastern slope of the conical-shaped Myojinsho seamount. We will traverse its eastern slope from a depth of ca. 750 m to its summit at ca. 50 m. This is a revisit to the Myojinsho summit; we surveyed the western slope to its summit during Hyper-Dolphin Dive #620 in December, 2006. This time we will observe and sample pyroclastic deposits from a different side of the cone.

Dive Summary

Start: 31° 54.996’ N, 140° 02.408’ E (depth = 753 m)

Finish: 31° 55.087’ N, 140° 01.297’ E (depth = 60 m)

Hyper Dolphin Dive #812 Log (HD and CCD Camera)

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:13</td>
<td>0</td>
<td>266</td>
<td>Enter water</td>
<td></td>
</tr>
<tr>
<td>8:56</td>
<td>752</td>
<td>278</td>
<td>Observe seafloor. Landed on pumiceous gravel. Coarse buff pumice fragments are scattered. Lobes consisting of small pumice fragments are observed every several meters.</td>
<td></td>
</tr>
<tr>
<td>9:01</td>
<td>753</td>
<td>276</td>
<td>Trying to sample small pumice fragments using MBARI core.</td>
<td></td>
</tr>
<tr>
<td>9:02</td>
<td></td>
<td></td>
<td>Cancel sampling with MBARI core. Change to M-type</td>
<td></td>
</tr>
<tr>
<td>9:11</td>
<td>754</td>
<td>277</td>
<td>Successful in sampling fine pumice fragments from the lobe using M-type core.</td>
<td>HD812-S01</td>
</tr>
<tr>
<td>9:14</td>
<td>742</td>
<td>270</td>
<td>Scattered subrounded pumice blocks.</td>
<td></td>
</tr>
<tr>
<td>9:16</td>
<td>730</td>
<td>270</td>
<td>Landed to sample pumice blocks. Columnar jointed angular pumice blocks.</td>
<td></td>
</tr>
<tr>
<td>9:18</td>
<td>730</td>
<td>270</td>
<td>Sampled two large pumice blocks. One jointed pumice block, another one was a dense, less-vesiculated rock.</td>
<td>HD812-R01, R02</td>
</tr>
<tr>
<td>9:24</td>
<td>712</td>
<td>270</td>
<td>Continuous slope of fine light-colored pumice fragments. Occasionally, dark pumice blocks are scattered.</td>
<td></td>
</tr>
<tr>
<td>9:28</td>
<td>688</td>
<td>270</td>
<td>Slope begins to cover with dark blocks. Less amount of fine material.</td>
<td></td>
</tr>
<tr>
<td>9:34</td>
<td>650</td>
<td>280</td>
<td>Landed to sample. Collected three dark dense subrounded blocks from the cover. Blocks from fragmented lava dome?</td>
<td>HD812-R03, R04, R05</td>
</tr>
<tr>
<td>9:40</td>
<td>650</td>
<td>280</td>
<td>Start to traverse.</td>
<td></td>
</tr>
<tr>
<td>9:44</td>
<td>640</td>
<td>270</td>
<td>Again, slope begins to be covered with light-colored pumiceous gravel. Fewer amounts of dark blocks.</td>
<td></td>
</tr>
<tr>
<td>9:53</td>
<td>564</td>
<td>280</td>
<td>Still going up a slope. Fewer amount of dark blocks. In contrast, increasing amount of whitish block, pumice?</td>
<td></td>
</tr>
<tr>
<td>9:56</td>
<td>552</td>
<td>275</td>
<td>Landed to sample. Trying to sample whitish block.</td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Depth</td>
<td>Heading</td>
<td>Descriptions</td>
<td>Samples</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>---------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>9:58</td>
<td>552</td>
<td>275</td>
<td>Fragmented when grabbed with a manipulator. Pumice.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Collected two rounded white pumice.</td>
<td>HD812-R0 6, R07</td>
</tr>
<tr>
<td>10:03</td>
<td>526</td>
<td>276</td>
<td>Dominated by fine pumiceous gravel. Ripple marks.</td>
<td></td>
</tr>
<tr>
<td>10:08</td>
<td>477</td>
<td>276</td>
<td>Slope covered with white subrounded pumice blocks.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Landed to sample.</td>
<td></td>
</tr>
<tr>
<td>10:11</td>
<td>474</td>
<td>272</td>
<td>Collected two fresh subangular pumice blocks.</td>
<td></td>
</tr>
<tr>
<td>10:18</td>
<td>452</td>
<td>275</td>
<td>Landed to sample. Collected one dark subrounded block.</td>
<td></td>
</tr>
<tr>
<td>10:21</td>
<td>452</td>
<td>274</td>
<td>Moved a short distance. Collected one large pumice blocks.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Broken into pieces.</td>
<td>HD812-R1 1</td>
</tr>
<tr>
<td>10:29</td>
<td>434</td>
<td>269</td>
<td>Observed a large pumice block. Ascending a slope of pumiceous gravel with pumice rubbles.</td>
<td></td>
</tr>
<tr>
<td>10:37</td>
<td>366</td>
<td>270</td>
<td>Continuous slope of pumiceous gravel. Zzzzz…</td>
<td></td>
</tr>
<tr>
<td>10:39</td>
<td>350</td>
<td>270</td>
<td>Landed to sample gravel using MBARI core.</td>
<td></td>
</tr>
<tr>
<td>10:48</td>
<td>350</td>
<td>270</td>
<td>Finished sampling gravel.</td>
<td>HD812-S0 2</td>
</tr>
<tr>
<td>10:50</td>
<td>348</td>
<td>271</td>
<td>Start to traverse again.</td>
<td></td>
</tr>
<tr>
<td>10:56</td>
<td>295</td>
<td>270</td>
<td>Slope covered with dark and white subangular rubbles.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Smaller amount of fine materials.</td>
<td></td>
</tr>
<tr>
<td>11:02</td>
<td>228</td>
<td>268</td>
<td>Amount of large blocks increased. Angular to subangular pumice blocks.</td>
<td></td>
</tr>
<tr>
<td>11:08</td>
<td>201</td>
<td>268</td>
<td>Landed to sample rubbles. Collected two (lava?) blocks.</td>
<td>HD812-R1 2, R13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Put into black box.</td>
<td></td>
</tr>
<tr>
<td>11:23</td>
<td>149</td>
<td>263</td>
<td>The bottom is now completely covered with dark angular blocks. It seems that all the blocks are monolithic. Fragmented lava dome?</td>
<td></td>
</tr>
<tr>
<td>11:27</td>
<td>125</td>
<td>270</td>
<td>Huge pumice block ~size of the Hyper-Dolphin is observed.</td>
<td></td>
</tr>
<tr>
<td>11:30</td>
<td>105</td>
<td>266</td>
<td>Approaching the summit; Slope becomes more gentle. The surface is covered with monolithic dark blocks.</td>
<td></td>
</tr>
<tr>
<td>11:35</td>
<td>80</td>
<td>268</td>
<td>Landed on a summit surface. Reddened dense lava blocks. Collected two blocks.</td>
<td>HD812-R1 4, R15</td>
</tr>
<tr>
<td>11:48</td>
<td>48</td>
<td>268</td>
<td>Arrive at the crater rim. Surface is partly covered with whitish unidentified material.</td>
<td></td>
</tr>
<tr>
<td>11:58</td>
<td>60</td>
<td>255.4</td>
<td>End of dive; leave the bottom.</td>
<td></td>
</tr>
</tbody>
</table>

3-3. **Hyper Dolphin Dive # 813: Log**

**Date: 2008/04/04**

**Objective**

Dive to the western wall of Myojinsho caldera. We will traverse from the caldera floor at 1100 m to the caldera rim at 250 m below sea level. This is a revisit to the Myojinsho caldera wall following our survey of the SW and SE walls during Hyper-Dolphin Dives #618 and #621 in December, 2006. This time we will observe and sample the pyroclastic deposits from a different side of the caldera.

**Dive Summary**

Start: 31° 53.797′ N, 139° 57.301′ E (depth = 1113 m)

Finish: 31° 53.899′ N, 139° 56.926′ E (depth = 725 m)

**Hyper Dolphin Dive #813 Log (HD and CCD Camera)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:38</td>
<td>0</td>
<td>266</td>
<td>Enter water</td>
<td></td>
</tr>
<tr>
<td>14:28</td>
<td>1114</td>
<td>289</td>
<td>Observe seafloor. Landed on flat surface of fine</td>
<td></td>
</tr>
</tbody>
</table>
20

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:31</td>
<td></td>
<td></td>
<td>white sand. Very few coarse pumice or rock fragments are found.</td>
<td></td>
</tr>
<tr>
<td>14:35</td>
<td>1112</td>
<td>279.6</td>
<td>Flat caldera floor covered with fine white material</td>
<td></td>
</tr>
<tr>
<td>14:35</td>
<td>1108</td>
<td>277</td>
<td>Caldera wall lava-like rock covered thickly with fine pelagic snow. The rock (light color inside with black cover; Mn) was sampled but may be altered.</td>
<td>HD813-R01(attached backside basket)</td>
</tr>
<tr>
<td>14:42</td>
<td></td>
<td></td>
<td>Altered rock with white to light yellow color and brown stains.</td>
<td>HD813-R02(attached backside basket)</td>
</tr>
<tr>
<td>14:45</td>
<td>1105</td>
<td>269</td>
<td>Thick snowy deposit on the wall.</td>
<td></td>
</tr>
<tr>
<td>14:48</td>
<td>1080</td>
<td>266</td>
<td>Alternation of nearly vertical walls and talus slopes covered with fine pelagic snow.</td>
<td></td>
</tr>
<tr>
<td>14:50</td>
<td>1079</td>
<td>226</td>
<td>Altered lava-like rock from near the talus on the caldera wall.</td>
<td>HD813-R03(backside space)</td>
</tr>
<tr>
<td>14:54</td>
<td>1075</td>
<td>244</td>
<td>Ascending the wall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Big rock several meters high</td>
<td></td>
</tr>
<tr>
<td>15:00</td>
<td>1038</td>
<td>243</td>
<td>Talus consists of slightly coarser sand.</td>
<td></td>
</tr>
<tr>
<td>15:01</td>
<td>1039</td>
<td>245</td>
<td>Sampled; huge altered rock gradually broken to pieces</td>
<td>HD813-R04(backside space)</td>
</tr>
<tr>
<td>15:05</td>
<td>1036</td>
<td>280</td>
<td>Take off</td>
<td></td>
</tr>
<tr>
<td>15:06</td>
<td>1025</td>
<td>287</td>
<td>Landing and sampling &gt;&gt;&gt;&gt;abandoned</td>
<td></td>
</tr>
<tr>
<td>15:11</td>
<td>1012</td>
<td>234</td>
<td>Sampled an altered block with red surface.</td>
<td>HD813-R05(right basket)</td>
</tr>
<tr>
<td>15:16</td>
<td>1005</td>
<td>289</td>
<td>Take off</td>
<td></td>
</tr>
<tr>
<td>15:18</td>
<td>990</td>
<td>297</td>
<td>Wall rock with rough surface; breccia?</td>
<td>HD813-R06(right basket)</td>
</tr>
<tr>
<td>15:22</td>
<td>960</td>
<td>290</td>
<td>Sampled altered rock with black surface</td>
<td></td>
</tr>
<tr>
<td>15:30</td>
<td></td>
<td></td>
<td>Continued</td>
<td></td>
</tr>
<tr>
<td>15:38</td>
<td>920</td>
<td>300</td>
<td>Talus of fine material covers almost entire the wall</td>
<td></td>
</tr>
<tr>
<td>15:40</td>
<td>900</td>
<td>300</td>
<td>Vertical wall with horizontal laminae</td>
<td></td>
</tr>
<tr>
<td>15:44</td>
<td>867</td>
<td>300</td>
<td>Stratified wall with alternation of cm scale layers</td>
<td></td>
</tr>
<tr>
<td>15:46</td>
<td>848</td>
<td>323</td>
<td>Breccia with round blocks</td>
<td></td>
</tr>
<tr>
<td>15:56</td>
<td></td>
<td></td>
<td>Tried sampling….and at last obtained black dense block</td>
<td>HD813-R07(front space)</td>
</tr>
<tr>
<td>15:58</td>
<td>845</td>
<td>329</td>
<td>Take off</td>
<td></td>
</tr>
<tr>
<td>16:02</td>
<td>833</td>
<td>310</td>
<td>Thick snow-like talus deposit</td>
<td></td>
</tr>
<tr>
<td>16:05</td>
<td>830</td>
<td>378</td>
<td>A block with some creatures sampled</td>
<td>HD813-R08(front space)</td>
</tr>
<tr>
<td>16:07</td>
<td></td>
<td></td>
<td>Take off</td>
<td></td>
</tr>
<tr>
<td>16:08</td>
<td>821</td>
<td>293</td>
<td>Massive breccia, but flat blocks are near-horizontal. The deposit looks unconsolidated and has loose matrix. Sampled black subrounded block (inside not known)</td>
<td>HD813-R09(left basket)</td>
</tr>
<tr>
<td>16:17</td>
<td>808</td>
<td>315</td>
<td>Alternation of breccia and laminated layers; faults?</td>
<td></td>
</tr>
<tr>
<td>16:20</td>
<td>795</td>
<td>315</td>
<td>Tried sampling but gave up.</td>
<td></td>
</tr>
<tr>
<td>16:22</td>
<td>779</td>
<td>320</td>
<td>Stratified dense rock covered by white pelagic snow.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Less steeper talus and some meters high slightly stratified ~ massive breccia (consisting of white sand)</td>
<td></td>
</tr>
</tbody>
</table>
### 3-4. Hyper Dolphin Dive # 814: Log

**Date:** 2008/04/05

**Objective**

Dive up the west wall of a large bathymetric re-entrant on the south side of the edifice of Myojinsho caldera. We will traverse from a depth at 1280 m to the caldera rim at 450 m bsl. This is the first visit to the outer edifice of the Myojinsho caldera. This time we will try to investigate the evolution of the volcano in the steep cliffs where outcrops of the pre-caldera rocks are expected.

**Dive Summary**

Start: 31° 46.899’ N, 140° 00.010’ E (depth = 1287 m)  
Finish: 31° 47.485’ N, 139° 58.941’ E (depth = 709 m)

Hyper Dolphin Dive #814 Log (HD and CCD Camera)

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:28</td>
<td>745</td>
<td>337</td>
<td>Wall of breccia with rugged surface</td>
<td>HD813-R10 (left basket)</td>
</tr>
<tr>
<td>16:33</td>
<td>727</td>
<td>338</td>
<td>Rounded large blocks (pumice or altered rock) sampled.</td>
<td>HD813-R11 (left basket)</td>
</tr>
<tr>
<td></td>
<td>725</td>
<td></td>
<td>Black block ca. 10cm sampled</td>
<td>HD813-R12 (left basket)</td>
</tr>
<tr>
<td>16:39</td>
<td>725</td>
<td>337</td>
<td>Black block</td>
<td></td>
</tr>
<tr>
<td>16:40</td>
<td></td>
<td></td>
<td>End of dive; Leave bottom</td>
<td></td>
</tr>
</tbody>
</table>
3-5. Hyper Dolphin Dive #815: Log

Date: 2008/04/05

Objective

Investigate the north wall of Myojinsho caldera. We will traverse from the caldera floor at 1100 m to the caldera rim of 820 m bsl. This is the first visit to the north wall of the caldera. This time we will observe pyroclastic deposits from a different side of the caldera wall.

Dive Summary

Start: 31° 54.598’ N, 139° 58.502’ E (depth = 1107 m)

Finish: 31° 54.953’ N, 139° 58.597’ E (depth = 822 m)

Hyper Dolphin Dive #815 Log (HD and CCD Camera)

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:44</td>
<td>709</td>
<td>281</td>
<td>Collected one pumice block using MBARI core.</td>
<td>HD814-S01, M01</td>
</tr>
<tr>
<td>11:45</td>
<td>710</td>
<td>282</td>
<td>End of dive; Leave bottom.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:08</td>
<td>0</td>
<td>XX</td>
<td>Enter water</td>
<td></td>
</tr>
<tr>
<td>15:03</td>
<td>1108</td>
<td>360</td>
<td>Observe seafloor. Landed on sand. Mainly fines, and lava blocks are sometimes scattered.</td>
<td></td>
</tr>
<tr>
<td>15:06</td>
<td>1108</td>
<td>360</td>
<td>Try to set SAHF.</td>
<td>HD815-S01</td>
</tr>
<tr>
<td>15:12</td>
<td>1108</td>
<td>358</td>
<td>Successful in setting SAHF on seafloor, and start of heat-flow measurement.</td>
<td>HD815-R01</td>
</tr>
<tr>
<td>15:13</td>
<td>1108</td>
<td>357</td>
<td>Sampled sandy materials composed of seafloor, using a 2K-type sampler.</td>
<td>HD815-R02</td>
</tr>
<tr>
<td>15:20</td>
<td>1108</td>
<td>348</td>
<td>Sampled a subrounded rock (lava?).</td>
<td></td>
</tr>
<tr>
<td>15:24</td>
<td>1108</td>
<td>357</td>
<td>Sampled a subangular pumice block (whitish-colored).</td>
<td></td>
</tr>
<tr>
<td>15:33</td>
<td>1108</td>
<td>357</td>
<td>Finish of heat-flow measurement with SAHF, and leaving the first event mark.</td>
<td></td>
</tr>
</tbody>
</table>

Flat sandy seafloor continuing…

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:51</td>
<td>1098</td>
<td>4.5</td>
<td>Coarse blocks appeared on sandy seafloor.</td>
<td>HD815-R03</td>
</tr>
<tr>
<td>15:53</td>
<td>1100</td>
<td>1.7</td>
<td>Trying to sample a part of a large block.</td>
<td></td>
</tr>
<tr>
<td>15:57</td>
<td>1100</td>
<td>4.0</td>
<td>Successful in sampling the large rock fragment.</td>
<td></td>
</tr>
<tr>
<td>15:58</td>
<td>1100</td>
<td>4.0</td>
<td>Leaving the sampling point.</td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>1090</td>
<td>4.0</td>
<td>Massive lava appeared.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continuing the massive-lava and coarse lava blocks, which are partially covered by sand.</td>
<td></td>
</tr>
<tr>
<td>16:04</td>
<td>1080</td>
<td>25.0</td>
<td>Lobes of small submarine debris flows or talus (?), composed of coarse rounded to subrounded clasts (lava or pumice).</td>
<td></td>
</tr>
<tr>
<td>16:05</td>
<td>1080</td>
<td>26.1</td>
<td>Sampling a subrounded rock.</td>
<td>HD815-R04</td>
</tr>
<tr>
<td>16:10</td>
<td>1080</td>
<td>26</td>
<td>Trying to sample another one, but end to be fault.</td>
<td></td>
</tr>
<tr>
<td>16:18</td>
<td>1057</td>
<td>31.7</td>
<td>Again, sandy seafloor, and large blocks.</td>
<td></td>
</tr>
<tr>
<td>16:20</td>
<td>1057</td>
<td>32.2</td>
<td>Landing to sample.</td>
<td></td>
</tr>
<tr>
<td>16:23</td>
<td>1037</td>
<td>10.3</td>
<td>Successful in sampling angular-shaped rock block.</td>
<td>HD815-R05</td>
</tr>
<tr>
<td>16:30</td>
<td>1005</td>
<td>6.4</td>
<td>Set a chain marker.</td>
<td></td>
</tr>
<tr>
<td>16:37</td>
<td>960</td>
<td>18.3</td>
<td>Observe massive dark-colored rock (near-vertical wall) with fractures.</td>
<td></td>
</tr>
<tr>
<td>16:40</td>
<td>940</td>
<td>10.9</td>
<td>Massive rock continuing.</td>
<td></td>
</tr>
</tbody>
</table>

Massive rock and its fragments continuing.

Decrease of massive rock with increase sandy
3-6. Hyper Dolphin Dive # 816: Log

Date: 2008/04/06

Objective

Dive to the ridge ca. 20 km to the west of Myojinsho caldera where a chain of small cones is aligned N-S. We will traverse deepest part of the ridge from its bottom ca. 1000 m bsl to its top at ca. 800 m bsl. This is the first-time visit to this ridge. We will attempt to survey the structure and deposits of the cones.

Dive Summary

Start: 31° 51.708’ N, 139° 47.902’ E (depth = 1004 m)

Finish: 31° 51.768’ N, 139° 48.164’ E (depth = 822 m)

Hyper Dolphin Dive #816 Log (HD and CCD Camera)

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:07</td>
<td>0</td>
<td>250</td>
<td>Enter water</td>
<td></td>
</tr>
<tr>
<td>8:59</td>
<td>1005.1</td>
<td>70</td>
<td>Landed on breccia composed of grayish coarse (a few to 10 cm size) grains. Unknown species.</td>
<td></td>
</tr>
<tr>
<td>9:02</td>
<td>1004.8</td>
<td>69.3</td>
<td>Try to set SAHF, but ended up to fault. It is difficult to put SAHF on hard seafloor.</td>
<td>HD816-R01</td>
</tr>
<tr>
<td>9:09</td>
<td>1005.2</td>
<td>68.7</td>
<td>Retry to set SAHF several times, but again ended up to fault.</td>
<td></td>
</tr>
<tr>
<td>9:16</td>
<td>1005.4</td>
<td>67.4</td>
<td>Try to sample a platy subrounded block (&gt; 30 cm in diameter).</td>
<td></td>
</tr>
<tr>
<td>9:18</td>
<td>1005.4</td>
<td>68.4</td>
<td>Successful in sampling the platy block, but it broke into pieces when placed into the box.</td>
<td></td>
</tr>
<tr>
<td>9:24</td>
<td>1005.3</td>
<td>69.3</td>
<td>Collected relatively coarse (lapilli size) grains using M-type sampler.</td>
<td>HD816-M01</td>
</tr>
<tr>
<td>9:27</td>
<td>1002.4</td>
<td>69.2</td>
<td>Leaving the first sampling point.</td>
<td></td>
</tr>
<tr>
<td>9:30</td>
<td>991.3</td>
<td>68.9</td>
<td>Seafloor is mainly composed of lapilli or block sized grains. Fines-poor.</td>
<td></td>
</tr>
<tr>
<td>9:32</td>
<td>990.4</td>
<td>68.9</td>
<td>SAHF was moved to a cylinder in right-hand side.</td>
<td></td>
</tr>
<tr>
<td>9:33</td>
<td>990.4</td>
<td>69.5</td>
<td>Try to sample a subangular block (&gt; 30 cm in diameter).</td>
<td></td>
</tr>
<tr>
<td>9:34</td>
<td>990.2</td>
<td>69.1</td>
<td>Successful in sampling it, and departed this site.</td>
<td>HD816-R02</td>
</tr>
<tr>
<td>9:38</td>
<td>966.0</td>
<td>74.0</td>
<td>Grain size increased with distance.</td>
<td></td>
</tr>
</tbody>
</table>
Observe and landed on breccia. Sampled a subrounded black clast composed of breccia. Sampled another subrounded black clast (> 30 cm size in diameter) at the same point. Leaving the sampling point. Breccia continuing. Sand to lapilli-sized grains increased. Not large blocks. Landing on sandy seafloor. Sampled a grayish subangular block (> 30 cm in diameter). It was broken during setting in the box. Try to collect sand to lapilli-sized clasts using 2K-type core. After a few times challenges, it ended up being successful. Leave the sampling point. A lot of strange corals… Narrow flat and breccia. Observation of the breccia Almost the top of slope? Landing on brecciated seafloor. Loose and looks like a basalt fragments (clinker-like?). Sampled a subrounded block. Sampled another subangular block (> 30 cm in long axis) at the same point. Leave the sampling point. Still gentle slope. Landing on brecciated seafloor, and sampled a subangular block with some leaves. End of dive; Leave bottom.

3-7. Hyper Dolphin Dive # 817: Log

Objective
Dive again to the ridge ca. 20 km to the west of Myojinsho caldera where a chain of small cones is aligned along an N-S direction. We will traverse along the axis of the ridge from the foot of the cone ca. 600 m bsl to the top of ca. 500 m bsl. We will survey the structure and deposits of the cones, and compare with the results of Dive HD816.

Dive Summary

Start: 31° 48.790’ N, 139° 47.591’ E (depth = 614 m)
Finish: 31° 48.172’ N, 139° 48.016’ E (depth = 424 m)

Hyper Dolphin Dive #817 Log (HD and CCD Camera)

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:05</td>
<td>0</td>
<td>137</td>
<td>Enter water</td>
<td></td>
</tr>
<tr>
<td>13:45</td>
<td>614</td>
<td>79.4</td>
<td>Landed on seafloor. Sand to gravel-sized clasts are dominant; some scattered angular blocks are present.</td>
<td></td>
</tr>
<tr>
<td>13:47</td>
<td>614.1</td>
<td>78.2</td>
<td>Try to set SAHF, but failed to do so. It is difficult to push the SAHF into the hard seafloor.</td>
<td></td>
</tr>
<tr>
<td>13:55</td>
<td>614.7</td>
<td>79.7</td>
<td>Sampled an angular-shaped lava block.</td>
<td>HD817-R01</td>
</tr>
<tr>
<td>13:57</td>
<td>614.7</td>
<td>79.2</td>
<td>Retry to set SAHF. Incompletely set.</td>
<td></td>
</tr>
<tr>
<td>14:00</td>
<td>615</td>
<td>78.7</td>
<td>Start to measure heat flow, using only a lower half of the sensor.</td>
<td></td>
</tr>
<tr>
<td>14:05</td>
<td>615.2</td>
<td>79.4</td>
<td>Try to sample sand to gravel-sized materials on</td>
<td>HD817-M01</td>
</tr>
</tbody>
</table>
14:10 615.1 48.4 seawater using M-type core sampler. Successful.
14:13
14:20
14:21
14:26 614.1 68.5 Seafloor is flat, and covered by sand to gravel-sized materials. Some subangular blocks are scattered.
14:30 602.3 57.4 Continuation of sand to gravel-sized materials.
14:35 575.0 65.1 Still continuing of sand to gravel-sized materials, but grain-size seems to increase.
14:37 566.5 69.6 Breccia is dominant around here. Landing on the breccia, and try to sample an angular lava block. Successful.
14:42 566.5 67.4 Try to sample another angular lava block at the same point as R03, but fail to do so.
14:43 566.5 108.5 Again try to sample a fragment composed of breccia (probably basaltic lava). Leave the point.
14:47 547.4 73.2 Still continuing of sand to gravel-sized materials with breccia.
14:53 497.5 74.4 Try to sample a platy angular-shaped lava fragment. Successful.
14:54 497.5 74.4 Try to sample another angular-shaped lava fragment. Successful. Leaving the sampling point.
14:58 467.0 79.6 Again, sand to gravel-sized materials.
15:00 459.2 78.2 Landing on seafloor to sample a lava block. Successful in sampling a platy subangular lava block. It was broken to some pieces in a box.
15:04 459.2 78 Leaving the sampling point.
15:07 440 179 Change vehicle direction from east to south. (event mark 3)
15:10 426.7 163.6 Basically, gravel to block-sized lava is dominant. Large irregular-shaped lava blocks sometimes appear.
15:13 425.7 168.4 Flat bottom continues.
15:17 467.1 147.0 Landing on seafloor to observe and sample. Successful in sampling angular-shaped lava clast. Leave the seafloor.
15:19 467 173.2 Almost flat and continues of small to medium-sized lava fragments (the surface of lava flow?).
15:28 491.3 154.6 Landing on seafloor to sample.
15:31 491.3 154.2 Successful in sampling of a subangular lava block. HD817-R09
15:35 482.5 179.2 Almost flat, and continues of small to medium-sized lava fragments or lava surface.
15:43 479.6 168.9 Seafloor is covered with fragments of lava, but large blocks cannot be observed.
15:46 479.6 197.3 Massive lava appeared (Main body?). Try to sample a fragment of massive lava. Successful in sampling a subangular block.
15:51 479.3 195.9 Successful in sampling another subangular block. Leave this point.
15:56 506.7 168.3 Continue of irregular-shaped small to medium-sized lava blocks or lava surface.
16:00 517.6 174.2 Massive lava field, covered with irregular-shaped lava fragments.
16:03 509.2 148.1 Landing on seafloor, composed of massive and
<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Heading</th>
<th>Descriptions</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:10</td>
<td>500.2</td>
<td>169.2</td>
<td>fragmented lava. Try to sample, but resulted in fault.</td>
<td></td>
</tr>
<tr>
<td>16:16</td>
<td></td>
<td></td>
<td>Landing on seafloor. Retry to sample, and successful</td>
<td>HD817-R12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>in sampling a subangular lava block (&gt; 30cm).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Leave the point.</td>
<td></td>
</tr>
<tr>
<td>16:21</td>
<td>477.7</td>
<td>179.5</td>
<td>Continue of irregular-shaped small to medium-sized</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>lava blocks or lava surface.</td>
<td></td>
</tr>
<tr>
<td>16:22</td>
<td>470</td>
<td>179.7</td>
<td>Fissure-like structure. (Vent?)</td>
<td></td>
</tr>
<tr>
<td>16:24</td>
<td>468.8</td>
<td>179.2</td>
<td>Landing on seafloor, and try to sample.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Successful in sampling a subrounded lava block.</td>
<td>HD817-R13</td>
</tr>
<tr>
<td>16:27</td>
<td>469.2</td>
<td>179.3</td>
<td>Successful in sampling another angular-shaped lava block.</td>
<td>HD817-R14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Leave the point.</td>
<td></td>
</tr>
<tr>
<td>16:36</td>
<td>439.6</td>
<td>179.4</td>
<td>Almost flat, and continues of small to medium-sized</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>lava fragments or lava surface, but sometimes,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>fissures are developed and welded spatter deposits (? are recognized.</td>
<td></td>
</tr>
<tr>
<td>16:42</td>
<td>422.2</td>
<td>252.5</td>
<td>Try to sample a fragment of the spatter.</td>
<td>HD817-R15</td>
</tr>
<tr>
<td>16:46</td>
<td>422.2</td>
<td>251.3</td>
<td>Successful in sampling a block of it.</td>
<td></td>
</tr>
<tr>
<td>16:50</td>
<td>416</td>
<td>189.9</td>
<td>Large fragments (&gt; m size) of agglutinate (?).</td>
<td></td>
</tr>
<tr>
<td>16:56</td>
<td>424.8</td>
<td>208.8</td>
<td>Try to sample a massive lava-like rock.</td>
<td></td>
</tr>
<tr>
<td>16:58</td>
<td>424.9</td>
<td>213.4</td>
<td>Successful in sampling a fragment of the rock.</td>
<td>HD817-R16</td>
</tr>
<tr>
<td>17:00</td>
<td>424.4</td>
<td>216</td>
<td>End of dive; leave bottom.</td>
<td></td>
</tr>
</tbody>
</table>
4. RESULTS

4-1. Track lines of Natsushima

Fig. 4-1 Track line of Ship Natsushima (left) and index map of the dive tracks of Hyper-Dolphin of the NT08-07 leg 1 cruise.

Dive schedule

Dive 1 (#812) Apr. 4, 2008
Eastern slope of Myojinsho
7:45 to 12:00
From (31°54.996' N, 140°02.408' E; depth = 753 m) to (31°55.087' N, 140°01.297' E; depth = 60 m)
Payloads: Scoop, square box, M-type sampler, MBARI core (2), baskets

Dive 2 (#813) Apr. 4, 2008
Western wall of Myojinsho caldera
13:00 to 17:00
From (31°53.797' N, 139°57.301' E; depth = 1113 m) to (31°53.899' N, 139°56.926' E; depth = 725 m)
Payloads: Scoop, square box, M-type sampler, MBARI core (2), baskets

Dive 3 (#814) Apr. 5, 2008
Southern edifice of Myojinsho caldera
7:45 to 12:00
From (31°46.899' N, 140°00.010' E; depth = 1287 m) to (31°47.485' N, 139°58.941' E; depth = 709 m)
Payloads: Scoop, square box, M-type sampler, MBARI core (2), baskets
Dive 4 (#815) Apr. 5, 2008
Northern wall of Myojinsho caldera
13:00 to 17:00
From (31° 54.598'N, 139° 58.502'E; depth = 1107 m) to (31°54.953'N, 139° 58.597'E; depth = 822 m)
Payloads: Scoop, square box, M-type sampler, MBARI core (2), baskets, SAHF

Dive 5 (#816) Apr. 6, 2008
Deeper part of the N-S ridge, west of Myojinsho caldera
7:45 to 12:00
From (31°51.708'N, 139°47.902'E; depth = 1004 m) to (31°51.768'N, 139°48.164'E; depth = 822 m)
Payloads: Scoop, square box, M-type sampler, MBARI core (2), baskets, SAHF

Dive 6 (#817) Apr. 6, 2008
Deeper part of the N-S ridge, west of Myojinsho caldera
13:00 to 17:00
From (31°48.790'N, 139°47.591'E; depth = 614 m) to (31°48.172'N, 139°48.016'E; depth = 424 m)
Payloads: Scoop, square box, M-type sampler, MBARI core (2), baskets, SAHF

4-3. Dive tracks
Dive 1 (#812)
From (31°46.899'N, 140°00.010'E; depth = 1287 m) to (31°47.485'N, 139°58.941'E; depth = 709 m)
Samples: HD812-R01-R15, M01, S01
1: 08:57 on floor
   09:11 D = 754 m, sediment (M-type) sampled
2: 09:20 D = 731 m, 2 rocks sampled
3: 09:42 D = 650 m, 3 rocks sampled
4: 10:00 D = 552 m, 2 rocks sampled
5: 10:15 D = 475 m, 2 rocks sampled
6: 10:27 D = 454 m, rocks sampled
7: 10:47 D = 350 m, pumice (MBARI) sampled
8: 11:12 D = 202 m, 2 rocks sampled
9: 11:40 D = 80 m, 2 rocks sampled
10: 11:58 D = 60 m, off the floor

Fig. 4-2 Dive track of HD#812

Dive 2 (#813)
From (31°53.797'N, 139°57.301'E; depth = 1113 m) to (31°53.899'N, 139°56.926'E; depth = 725 m)
Samples: HD813-R01-R12
1: 14:28 D = 1113 m, on floor
2: 14:43 D = 1109 m, 2 rocks sampled
3: 14:54 D = 1079 m, rock sampled
4: 15:04 D = 1039 m, rock sampled
5: 15:15 D = 1012 m, rock sampled
6: 15:31 D = 961 m, rock sampled
7: 15:56 D = 850 m, rock sampled
8: 16:06 D = 831 m, rock sampled
9: 16:15 D = 819 m, rock sampled
10: 16:39 D = 726 m, 3 rocks sampled
16:41 D = 725 m, off the floor

Fig. 4-3 Dive track of HD#813

Dive 3 (#814)
From (31°46.899’N, 140°00.010’E; depth = 1287 m) to (31°47.485’N, 139°58.941’E; depth = 709 m)
Samples: HD814-R01-R03, M01, S01
1: 09:13 D = 1287 m, on floor
2: 09:48 D = 1222 m, observation
3: 10:14 D = 1122 m, observation
4: 10:32 D = 1101 m, rocks sampled
5: 10:57 D = 925 m, observation
6: 11:10 D = 888 m, rocks sampled
7: 11:35 D = 709 m, rock sampled
11:41 sediments sampled (MBARI)
11:44 sediments sampled (M-type)
11:47 off the floor

Fig. 4-4 Dive track of HD#814

Dive 4 (#815)
From (31° 54.598’N, 139° 58.502’E; depth = 1107 m) to (31° 54.953’N, 139° 58.597’E; depth = 822 m)
Samples: HD815-R01-R07, M01, S01
1: 15:03 D = 1107 m, on floor
15:12 D = 1108 m, SAHF measurement started
15:15 sediment sampled (MBARI)
15:20 rock sampled
15:24 rock sampled
15:32 SAHF measurement ended
2: 15:57 D = 1100 m, rock sampled
3: 16:08 D = 1081 m, rock sampled
4: 16:19 D = 1058 m, rock sampled
5: 16:53 D = 918 m, rocks sampled
6: 17:17 D = 823 m, rock sampled
7: 17:21 sediment sampled (M-type)
    17:22 D = 822 m

Fig. 4-5 Dive track of HD#815

Dive 5 (#816)
From (31°51.708’N, 139°47.902’E; depth = 1004 m) to (31° 51.768’N, 139°48.164’E; depth = 822 m)
Samples: HD816-R01-R09, M01, S01
1: 8:59 D = 1004 m, on floor
    9:20 D = 1005 m, rocks sampled
    9:25 sediment sampled (M-type)
2: 9:34 D = 990 m, rock sampled
3: 9:44 D = 964 m, 2 rocks sampled
4: 9:58 D = 909 m, rock sampled
    10:09 sediment (MBARI) sampled
5: 10:18 D = 879 m, rock sampled
6: 10:34 D = 844 m, 2 rocks sampled
7: 10:44 D = 823 m, rocks sampled
    10:47 D = 822 m, off the floor

Fig. 4-6 Dive track of HD#816

Dive 6 (#817)
From (31°48.790’N, 139°47.591’E; depth = 614 m) to (31°48.172’N, 139°48.016’E; depth = 424 m)
Samples: HD817-R01-R16, M01
1: 13:45 D = 614 m, on floor
    13:56 rock sampled
    13:59 SAHF measurement started
    14:05 sediment (M-type) sampled
14:11 rock sampled
14:20 SAHF measurement finished
2: 14:38 D = 567 m, rock sampled
14:43 rock sampled
3: 14:54 D = 498 m, 2 rocks sampled
4: 15:03 D = 459 m, rock sampled
5: 15:19 D = 468 m, rock sampled
6: 15:30 D = 491 m, rocks sampled
7: 15:47 D = 479 m, rock sampled
15:51 rock sampled
8: 16:15 D = 502 m, rock sampled
9: 16:28 D = 469 m, 2 rocks sampled
10: 16:46 D = 422 m, rock sampled
11: 16:58 D = 425 m, rock sampled
17:00 D = 424 m, off the floor

Fig. 4-7 Dive track of HD#817
4-4. Dive points

Dive 1 (#812): Dive at the E slope of Myojinsho (Apr. 4, 2008)
Objective: Comparison of surface deposit and geomorphology of the E slope of Myojinsho with N side (Dive HD 620, December 2006).

<table>
<thead>
<tr>
<th>Time</th>
<th>HD812-1 (754 m bsl)</th>
<th>HD812-2 (730 m bsl)</th>
<th>HD812-3 (650 m bsl)</th>
<th>HD812-4 (552 m bsl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:11</td>
<td>Coarse buff pumice fragments are scattered. Lobes consist of small pumice fragments are observed every several meters. Pumice fragments were sampled with M-type sampler (S01).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:16</td>
<td>Coarse buff pumice fragments are scattered. Lobes consist of small pumice fragments are observed every several meters. Two large pumice blocks are sampled. One jointed pumice block and the other is a dense less vesicular rock (R01 and R02).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:34</td>
<td>Slope completely covered with equally sized blocks. Sampled three dark dense subrounded blocks from the cover. Blocks from fragmented lava dome (R03-05)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:56</td>
<td>Fewer amount of dark blocks. In contrast, increasing amount of whitish block or pumice. Collected two rounded white pumice (R06, R07).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10:08 HD812-5 (477 m bsl)
Slope covered with white subrounded pumice blocks.
Collected two fresh subangular pumice blocks (R08 and R09).

10:18 HD812-6 (452 m bsl)
Collected one dark subrounded block (R10) and one large pumice block (R11) which was broken to pieces.

10:39 HD812-7 (350 m bsl)
Continuous slope of pumiceous gravel.
Sampling the gravel with MBARI core (S01).

11:08 HD812-8 (201 m bsl)
Amount of large blocks increased. Angular to subangular pumice blocks. Collected two (lava?) blocks (R12, R13).

11:35 HD812-9 (80 m bsl)
Mostly on the summit of Myojinsho. Slope became gentle. The surface is covered with monolithologic dark blocks.
Two reddened dense lava blocks were sampled (R14, R15).
Dive 2 (#813): Dive on the W wall of Myojinsho caldera (Apr. 4, 2008)
Objective: Comparison of stratigraphical sequence with other sides of the caldera wall

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth (m bsl)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:35</td>
<td>1108</td>
<td>Alternation of nearly vertical wall and talus of fine sand. Caldera wall lava-like rock covered thickly with fine white sand material. An altered lava-like rock on the wall was sampled (R01). Another altered rock with white to light yellow color and brown stains was also sampled (R02).</td>
</tr>
<tr>
<td>14:48</td>
<td>1079</td>
<td>The alternation of nearly vertical wall and talus of fine sand. An altered lava-like rock on the wall was sampled (R03).</td>
</tr>
<tr>
<td>15:01</td>
<td>1039</td>
<td>A huge altered rock gradually broken to pieces was sampled (R04).</td>
</tr>
<tr>
<td>15:11</td>
<td>1012</td>
<td>An altered block with red surface sampled (R05).</td>
</tr>
<tr>
<td>Time</td>
<td>Depth (m bsl)</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>15:22</td>
<td>960</td>
<td>Wall rock has characteristic rough surface feature of the outcrop (breccia?). An altered rock with black surface was sampled (R06).</td>
</tr>
<tr>
<td>15:56</td>
<td>848</td>
<td>Breccia with rounded blocks which overlies stratified layers of cm scale thick for each. Collected black dense block (R07).</td>
</tr>
<tr>
<td>16:05</td>
<td>830</td>
<td>The alternation of lava-like rocks and talus continues. A block with some creatures was sampled (R08).</td>
</tr>
<tr>
<td>16:08</td>
<td>821</td>
<td>Massive breccia, but flat blocks are oriented horizontally. The deposit looks unconsolidated and has loose matrix. Sampled black subrounded block (R09).</td>
</tr>
<tr>
<td>16:33</td>
<td>727</td>
<td>Wall of breccia with rugged surface. Rounded large blocks (pumice or altered rock) were sampled (R10-R12).</td>
</tr>
</tbody>
</table>
Dive 3 (#814): Dive on the SSE slope of Myojinsho caldera edifice up to the summit (Apr. 5, 2008)  
Objectives: Understanding the evolution of pre-caldera volcanic edifice. Sampling rocks of the old edifice from the bottom to the top of the cliff is also one of the objectives.

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth (m bsl)</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:23</td>
<td>1101</td>
<td>HD814-1: Rippled sand floor continues from depth of 1283 m bsl. Small debris of subangular dark blocks. Three dark blocks were sampled (R01-R03). They were turned out to be fragments of a large pumice block.</td>
</tr>
<tr>
<td>11:01</td>
<td>891</td>
<td>HD814-2: Surface becomes rough with thin sediment cover. The blocks on the surface consist of pumice. Tried to sample a piece of white pumice block but cancelled.</td>
</tr>
<tr>
<td>11:32</td>
<td>709</td>
<td>HD814-3: Still continues slope of fine pumice. One pumice block was sampled using MBARI (S01). Collected pumiceous sand using M-type core (M01)</td>
</tr>
</tbody>
</table>
Dive 4 (#815): Dive on the N caldera wall from 1100 m bsl up to ca. 500 m bsl (Apr. 5, 2008)

Objectives: Collecting sequential samples, reconstructing the evolution history of the edifice and correlating the deposit with those at other locality, looking for syn-eruptive products of caldera formation.

15:03 HD815-1 (1108 m bsl)
Flat sandy seafloor with some lava blocks scattering sometimes.
Heat flow measurement was carried out (SAHF). Sandy materials were sampled (MBARI; S01). Also sampled subrounded rock (lava?; R01) and subangular whitish pumice block. (R02).

15:51 HD815-2 (1100 m bsl)
Flat sandy seafloor continued, and coarse blocks appeared on the floor. Massive lava appeared soon after the ROV left here.
A part of a large block was sampled (R03).

16:04 HD815-3 (1080 m bsl)
Lobes of small submarine debris flows or talus (?) with finger-like morphology appeared. The lobes consist of coarse rounded to subrounded grains.
A subrounded rock was sampled (R04). Tried to sample another one but in vain.

16:20 HD815-4 (1057 m bsl)
Massive lava-like rock crops out on the sub-vertical wall with “snow-like” sediments.
An angular dense lava was sampled directly from the outcrop (R05). ROV climbed up nearly vertical wall of dark-colored rock (with many cracks or faults).
At depth of ca. 1000 m bsl stratified facies appeared with many fractures and joints.
<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:52</td>
<td>HD815-5 (918 m bsl)</td>
<td>Massive lava-like rock crops out on the sub-vertical wall with “snow-like” sediments. A fragment of massive rock was sampled from near the outcrop (R06) after some unsuccessful tries.</td>
</tr>
<tr>
<td>17:17</td>
<td>HD815-6 (823 m bsl)</td>
<td>Alternation of massive lava-like rocks and fine whitish sandy materials continued. Sampled one of the fragments of fragile rock (pumice?; R07) and whitish sandy material (M01).</td>
</tr>
</tbody>
</table>

Dive 5 (#816): Dive on the N-S aligned ridge to the west of Myojinsho caldera from the foot up to the summit of the ridge (Apr. 6, 2008)

Objectives: Understanding the evolution of the ridge. This topography is thought to be volcanic origin which is related with rifting of oceanic plate. Sampling rocks of the edifice is also one of the objectives.

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>HD816-1 (1005 m bsl)</td>
<td>Breccia composed of grayish coarse (a few to 10 cm size) grains. Unknown species. Try to set SAHF, but ended up to fault. Sampled a platy subrounded block, but broken to some pieces in a box (R01). Collected relatively coarse (lapilli size) grains using M-type sampler (M01).</td>
</tr>
<tr>
<td>9:33</td>
<td>HD816-2 (990 m bsl)</td>
<td>The surface is covered with lapilli size pyroclastic grains. Fine materials seems to be poor. A subangular block was sampled (R02).</td>
</tr>
</tbody>
</table>
9:40 HD816-3 (964 m bsl)
Grain size increases with distance from the start point.
A subrounded block was sampled from breccia (R03). Another one of >30 cm in size was sampled (R04).

9:54 HD816-4 (909 m bsl)
The seafloor consists of sand to lapilli size grains which increased in amount. Some larger bombs or blocks are scattered every several meters.
Sampled a grayish subangular block (>30 cm in diameter), broken to pieces during sampling into the box (R05). Lapilli-size grains are also sampled (MBARI; S01).

10:16 HD816-5 (879 m bsl)
A lot of strange leaves on the floor consisting of breccia.
A subangular block was sampled (R06) from the surface of lava(?) or breccia.
Around here a lot of leaves settled.

10:27 HD816-6 (843 m bsl)
On the top of the hill, but there may be some peaks. The floor seems to consist of loose basaltic fragments.
A subrounded block (R07) and a subangular block (>30 cm in diameter; R08) were sampled.

10:42 HD816-7 (822 m bsl)
The seafloor composed of breccia with gentle slope.
A subangular block with some leaves was sampled (R09).
**Dive 6 (#817):** Dive on the N-S aligned ridge to the west of Myojinsho caldera from the foot up to the summit of the ridge. The point of this dive is shallower than that of Dive HD816, and thus the thickness of the crust would be thicker (Apr. 6, 2008).

**Objectives:** Understanding the evolution of the ridge. This topography is thought to be volcanic origin which is related with rifting of oceanic plate. Sampling rocks of the edifice is also one of the objectives.

<table>
<thead>
<tr>
<th>Time</th>
<th>Depth (m bsl)</th>
<th>Description</th>
</tr>
</thead>
</table>
| 13:45 | 614 | HD817-1 (614 m bsl)  
Sand to gravel size grain is dominant with some scattering angular blocks. SAHF measurement was also executed.  
Two angular lava fragments were sampled (R01-R02). Sand to gravel size materials are sampled (M01). |
| 14:37 | 566 | HD817-2 (566 m bsl)  
Although sand to gravel size materials still scatter around, breccia is dominant here.  
An angular lava block was sampled (R03). After some tries, another sample, a fragment of a breccia, was sampled (R04). |
| 14:53 | 497.5 | HD817-3 (497.5 m bsl)  
Sand to gravel size materials cover the surface with breccia.  
Two angular lava fragments were sampled (R05, R06). |
| 15:00 | 460 | HD817-4 (460 m bsl)  
Almost at the top of the hill or cone. Many cracks, gullies and depressions appeared. They seem to be aligned N-S direction.  
A platy subangular lava block was sampled, but broken to pieces in the box (R07). |
<table>
<thead>
<tr>
<th>Time</th>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:17</td>
<td>HD817-5 (468 m bsl)</td>
<td>Along the top of the ridge. Gravel to block size lava is dominant. Large irregular shape lava blocks sometimes appear. An angular lava was sampled (R08).</td>
</tr>
<tr>
<td>15:28</td>
<td>HD817-6 (491 m bsl)</td>
<td>Going down the slope then climb another peak again. Small to medium size lava fragments scatter on the flat surface (surface of a lava flow?) with many corals. A subangular lava block was sampled (R09).</td>
</tr>
<tr>
<td>15:46</td>
<td>HD817-7 (479 m bsl)</td>
<td>Seafloor is covered with fragments of lava, but large blocks are few. Then, reached another peak or lava flow. The number of coral decreased. Massive subangular lava blocks were sampled (R10, R11).</td>
</tr>
<tr>
<td>16:10</td>
<td>HD817-8 (500 m bsl)</td>
<td>Massive lava field covered with irregular shape small to medium size lava blocks (Row of agglutinate blocks?). Tried sampling some times, but one subangular lava block was sampled (R12; &gt;30 cm).</td>
</tr>
<tr>
<td>16:24</td>
<td>HD817-9 (469 m bsl)</td>
<td>Still irregular shape small to medium size lava blocks cover the surface. Fissure-like structure appears. A subrounded lava block and a subangular block of lava were sampled (R13, R14).</td>
</tr>
<tr>
<td>Time</td>
<td>Location</td>
<td>Observation</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>16:46</td>
<td>HD817-10 (422 m bsl)</td>
<td>Section of agglutinate appears in between segmented agglutinate blocks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:58</td>
<td>HD817-11 (425 m bsl)</td>
<td>Massive agglutinate blocks scattered (&gt;m size).</td>
</tr>
</tbody>
</table>
4-5. Representative columnar sections

Dive 1 (#812): E slope of Myojinsho

Fig. 4-8 Representative columnar section of HD#812
Dive 2 (#813): W wall of Myojinsho caldera

Fig. 4-9 Representative columnar section of HD#813
Dive 3 (#814): W cliff of the re-entrant on the south side of the edifice of Myojinsho caldera

Fig. 4-10 Representative columnar section of HD#814
Dive 4 (#815): N wall of Myojinsho caldera

Fig. 4-11 Representative columner section of HD#815
Dive 5 (#816): N-S ridge to the west of Myojinsho caldera (across the ridge)

Fig. 4-12  Representative columner section of HD#816
Dive 6 (#817): N-S ridge to the west of Myojinsho caldera (along the axis)

Fig. 4-13  Representative columner section of HD#817
4-6. New topographic map
West of Myojinsho Caldera
Most of the survey area had been covered by recent Seabat operation. In this cruise, only a small portion of the scheduled area was surveyed.

4-7. Heat flow measurements by SAHF
Northern part of the Myojinsho caldera floor (HD815)

<table>
<thead>
<tr>
<th>Date</th>
<th>2008/4/5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Myojinsho caldera floor</td>
</tr>
<tr>
<td>Lat.(N)</td>
<td>31° 54.598'</td>
</tr>
<tr>
<td>Lon.(E)</td>
<td>139° 58.502'</td>
</tr>
<tr>
<td>Depth (m)</td>
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<td>M.S.</td>
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<tr>
<td>Geotherm (mK/m)</td>
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Water temperature measurement  Core sampling and HF measurement
N-S ridge to the west of Myojinsho caldera (HD817)

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<td>Area</td>
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<td>Lon.(E)</td>
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<td>C.S.</td>
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<td>Geotherm (mK/m)</td>
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Core sampling and HF measurement

Preliminary interpretation of the results

The two heat flow measurements conducted at Myojinsho caldera floor and at the ridge to the west of Myojinsho volcano both showed negative geotherms. The negative geotherm observed in heat flow measurement at a shallow seafloor is generally attributed to a fluctuation of the water temperature. The
temperature gradients in two sites were too small to overcome the effect from the water temperature fluctuation.

4-8. **SCS survey**

We conducted three lines of SCS surveys (Fig. 4-13). Results are as follows.

**Line A**

The survey traverses from WNW to ESE of Myojinsho cutting across North Beyonnaise caldera and Myojinsho caldera.

**Line B-1**

The survey traverses from W to E, crossing across the southern part of the N-S ridge and Myojinsho caldera.

**Line B-2**

The survey traverses from SSE to NNW, crossing across the center of Myojinsho caldera to the center of Myojin knoll from S to N.

![Fig. 4-14 The index map of the SCS sections of Myojinsho caldera area.](image)
Line A The section from NW (left) to SE (right). Right hand side half of the figure is the section of Myojinsho caldera crossing the central edifice.

Line B-1 The section from W (left) to E (right) crossing southern part of the surveyed area. The shallowest peak among the three peaks in the left hand side is the pyroclastic cone along the N-S trending ridge.

Line B-2 The section from SSE (left) to NNW (right) crossing Myojinsho caldera on the left hand and Myojin knoll caldera on the right side.

Fig. 4-15 Results of SCS surveys.
5. FUTURE SCHEDULE

5-1. Recent eruptions of Myojinsho

This is the second submersible operation of Myojinsho volcano. First of all, we had few signs of activity probably because we could not reach active vent at the summit. However, the present state of activity seems not so quiet, although discolored seawater has not been witnessed for years. This is because the echo gram showed some signs of abnormality above the summit during Dive HD620 in December, 2006 (Fig. 5-1) when the ship crossed above the summit of Myojinsho, which we interpret as rising bubbles. We should be watching for the activity in the future.

![Echogram of the ship Natsushima which shows anomaly above the summit of Myojinsho during the cruise NT06-21 (top left).](image)

As for the topography and the deposit on the eastern slope of Myojinsho, there have been similar characteristic features to those on the northern slope where we observed two years ago. On the slope (farther than ca. 500 m from the summit), there were some lobate topographic structures with a lot of decimeter size pumices covering the surface. They may be a kind of deposits by gravity currents. In addition, the pumices in these deposits changed from white pumice at depth to banded pumice at shallower level. Then near the summit (closer than ca. 500 m to the summit), most lobate deposits consist of angular lava blocks, and some of the blocks are red implying oxidation in the air. These observations may indicate that there are two different modes of deposition, and the travel distance possible for each mode is different. The two depositional facies can be also correlated with two types of phenomena with eye-witness accounts during the 1952-53 eruption; Cock’s tail jets and base surges. All the trajectories of the cock’s tail jets are confined to within ca. 500 m from the center of the explosion. In contrast, base surges travel farther than 500 m. To constrain more strictly the depositional mechanism that worked, we are going to investigate physical characteristics of pumice samples we collected in this cruise.

We are also planning to carry out chemical analysis to identify the essential products of the recent eruption (ex. the 1952-53 and the 1970 eruption), and textural analysis to investigate vesiculation processes of these eruptions. We are successful in sampling fresh pumice blocks during this cruise for these analyses.
5-2. Caldera forming eruption of Myojinsho caldera

Through the last cruise (NT06-21) we had two dives for caldera wall survey; at SW wall and at SE wall. As a result we have found some candidate pyroclastic fall units at these two sites that might have erupted during caldera formation. In this cruise we observed similar pumice deposits on the top of caldera wall (W and N wall). We correlate them in terms of sequential relation and they all seem to deposit at depth around 500 m to 300 m bsl. To confirm this, we will execute chemical composition analysis, and petrological and morphological characterization of the pyroclasts that we sampled in this cruise.

On the other hand, the mechanism by which central edifice was generated is one of the topics to understand dynamics of caldera formation. In this cruise, we could not have dives for the central edifice. What we found on the western cliff of the edifice in the last cruise was very similar to those found on the caldera wall. The deposit was almost totally altered and stratified from the caldera floor up to ca. 300 m below the top. Some altered rocks have pyrite. This means that this edifice is not a lava dome or post-caldera cone itself, but stratified structure similar to the caldera wall and flat-topped morphology of the edifice indicate that the central edifice is a criptdome or a remnant of pre-caldera edifice of Myojinsho caldera. The alteration of lavas may imply the heat source below the bottom of the caldera, and the existence of criptdome beneath the caldera floor. We have not yet found any essential materials of the lava dome, but the SCS survey crossing the edifice shows stratified reflecting layers only in the very shallow part of the edifice, and this is in favor for the existence of the criptdome. We are now investigating the samples obtained in the last cruise to check if the sequence of the central edifice and the caldera wall can be really correlated in terms of chemical analysis and stratigraphy.

5-3. Evolution of Myojinsho caldera

We had two dives for the walls of Myojinsho caldera and one for the outer side of the edifice during this cruise. At the W wall, vertical section of the edifice of Beyonnaise rocks is expected. At the N wall, vertical section of the edifice without any peak is expected. These two sections on the caldera wall showed similar lithology and sequence as well as those of the SE and NW wall surveyed in the last cruise (NT06-21); alternation of altered lava and pyroclastic rocks. We will correlate the deposits on these walls by chemical and stratigraphical analyses. In addition, the chemical and petrological relationship among the rock samples collected in this cruise will be carried out to reconstruct chemical evolution of magma system in the whole history of Myojinsho caldera in conjunction with caldera formation.
### SAMPLE LIST

#### 6-1. Rock sample list

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6-2. Sample photo

HD812 Sample Photos (1/4)

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HD812-R02 cut

HD812-R03
HD812-R03 cut

HD812-R04
HD812-R04 cut
HD812 Sample Photos (3/4)

HD812-R09

HD812-R09 cut

HD812-R10

HD812-R10 cut

HD812-R11

HD812-R11 cut

HD812-R12

HD812-R12 cut
Acknowledgements

We all thank the crew of Ship Natsushima and the operation team of ROV Hyper-Dolphin for their sophisticated and helpful support during the cruise. We especially thank Captain Hitoshi Tanaka, Chief Officer Shinichi Kusaka, Operation manager Kazuya Mitsufuji for their profound advice and kindness during the survey. We also thank Kazuki Iijima of JAMSTEC, Satoshi Okada, Maiko Kimino and other members of NME for their support about everything!

Crew and Operation Team
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Chief Officer          Shinichi Kusaka
2nd Officer            Isao Maeda
3rd Officer            Makoto Ohkubo
Chief Engineer         Kazuya Mitsufuji
1st Engineer           Masahiro Kajiwara
2nd Engineer           Yoshinobu Hiratsuka
 Junior 2nd Engineer    Kazunori Noguchi
3rd Engineer           Takahiro Mori
Chief Radio Operator   Satoshi Watase
2nd Radio Operator     Hidehiro Itoh
3rd Radio Operator     Yosuke Komaki
Boat Swain             Kazuo Abe
Able Seamen            Tugimi Sasaki
Able Seamen            Kozo Yatogo
Able Seamen            Shuji Takuno
Able Seamen            Kazushiro Ohsako
Sailer                 Hiroaki Murase
Sailer                 Tomohiro Kimura
No.1 Oiler             Kouzou Miura
Oiler                  Takaatsu Inomoto
Oiler                  Shinya Maruyama
Oiler                  Tatsuo Chino
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Chief Steward          Teruyuki Yoshikawa
Steward                Yukio Tatsuki
Steward                Toshiharu Kishita
Steward                Shinzuke Tanaka
Steward                Yoshio Okada

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2nd Submersible Staff  Shigeru Kikuya
3rd Submersible Staff  Tetsuya Ishizuka
3rd Submersible Staff  Katsushi Chiba
3rd Submersible Staff  Tepppei Kido
3rd Submersible Staff  Yuta Sakakibara

Information for secondary use

This cruise report is a preliminary documentation as of the end of the cruise. It may not be corrected even if changes on content (i.e. taxonomic classifications) are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the PI for the latest information before using.

Users of data or results of this cruise are requested to submit their results to Data Integration and Analysis Groupe (DIAG), JAMSTEC.

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Abbreviation

HD: Hyper-Dolphin
JAMSTEC: Japan Agency for Marine-Earth Science and Technology
NT: Natsushima
ROV: Remotely Operated Vehicle
SAHF: Stand-Alone Heat Flow meter
SCS: Single Channel Seismic