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CRUISE REPORT
JAPAN MARINE SCIENCE AND TECHNOLOGY CENTER
R/V Natsushima
Cruise NT0517

Studies of submarine arc volcanism in the southern Mariana Arc

October 8, 2005 to October 20, 2005

(Guam to Saipan)

TABLE OF CONTENTS:

List of cruise personnel ii

Acknowledgements iv

Summary v

1. Introduction 1

2. Scientific Objectives 4

3. Cruise narrative and schedule of operations... 7

4. Operations and data processing information 7

5. Scientific Results 8

5.1 Bathymetric surveys 8

5.2 MAPR Measurements... 9

5.3 Water and temperature sampling.. 9

5.4 Hyper-dolphin Studies and Sample Descriptions.......................... 9

5.4.1 Dive 480 10

5.4.2 Dive 481 17

5.4.3 Dive 482 23

5.4.4 Dive 483 29

5.4.5 Dive 484 37

5.4.6 Dive 485 45

5.4.7 Dive 486 50

5.4.8 Dive 487 56

5.4.9 Dive 488 61

5.4.10 Dive 489 67

6. Future studies 74

7. References... 75

Appendices:

Appendix A: Descriptions of samples 76

Appendix B: Sample distribution list 85

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SUMMARY OF PRINCIPAL CRUISE RESULTS

During this cruise, JAMSTEC's R/V Natsushima and ROV Hyper-Dolphin and a Japan-US team of scientists studied volcanism and sedimentation near the southern end of the active Izu-Bonin-Mariana arc (Stern et al., 2003). We focused on the Southern Seamount Province of the active Mariana Arc between 14°10'N and 15°20'N (Fig. 1, 2, 3) . The targets lie just west of the Mariana frontal arc islands, especially Rota, Tinian, and Saipan. The cruise completed additional multibeam maps of the seafloor, completed ten dives of Hyper-Dolphin, and recovered more than 130 samples of rocks, water, and sediment.

The cruise provided important insights to active venting of sulphur, hyaloclastite formation, vent biology, and water chemistry at the summit of NW Rota-1 volcano; the structure and evolution of a silicic caldera at West Rota Seamount; the origin of primitive lavas at Chaife Seamount, the development of giant sediment waves west of Esmeralda Bank; the evolution of arc seamounts at parasitic cones on NW Rota-1 and West Rota; and the nature of volcanism on parasitic cones on NW Rota-1 and W. Rota volcanoes. The following paragraphs summarize our findings; more detailed discussions are found in individual dive summaries that follow the introduction.

<u>NW Rota-1 volcano</u>: Dives 480 and 481 (Oct. 9 & 10) revisited the summit region of this young submarine volcano. Activity near the summit region of NW Rota-1 was discovered by CTD casts in 2003 (Embley et al., 2004) and observed with ROV ROPOS during TT-167 in Spring of 2004 (Embley et al., submitted). These studies discovered a deep pit (Brimstone Pit) just south of the summit that was throwing out sulphur globules and basaltic lapilli. Acidic vent fluids stimulated a biological community, dominated by shrimp. NW-Rota-1 Brimstone Pit represents an extremely early stage in the evolution of a submarine arc hydrothermal field. The associated biota also seems to be in the earliest stages, with a low diversity community that consists of only the most mobile invertebrate species, especially shrimp. Studies during NT05-17 indicate that vigorous activity around the pit continues and is at an increased level of intensity relative to observations in 2004.

Dive 488 (Oct. 18) examined and sampled two small parasitic cones on the southeastern flanks of NW Rota-1. The pillow lavas, sampled at deeper depths and that run down from the ridge trending east-southeastwardly are primitive cpx-ol basalt lavas. The two parasitic knolls themselves consist of pl-phyric ol-cpx basalts. These may represent two types of basalt lavas derived from a wet and dry mantle source beneath a single volcano, as suggested in the Sumisu caldera volcano, Izu-Bonin arc (Tamura et al., 2005), or these may be primitive and evolved lavas derived from the same primary basalt magma.

<u>W. Rota Volcano</u>: Dives 482, 483, and 484 studied the steep eastern wall of West Rota caldera. Dive 489 (Oct. 19th) traversed two parasitic cones on the southeastern flanks of West Rota. W. Rota is an extinct submarine volcano with a caldera that is similar in size to Crater Lake, Oregon. This is by far the largest caldera in the Mariana arc but was unknown until 2001. The four Hyper Dolphin dives were very successful, identifying the location of hydrothermally altered lavas and stockwork sulfide mineralization towards the bottom of the caldera walls in Dives 482 and 484. This marks the exhumed roots of an arc hydrothermal system. Dive 483 found a weak but active low-T hydrothermal vent at the bottom of the SE caldera wall. Chemosynthetic macrofauna was not present, but

tan to orange microbial mat was actively forming. Abundant dacitic dikes were observed during dive 483 which could be traced upwards into coarse pyroclastic flows, and the abundance of basaltic material erupted simultaneously with rhyodacitic pyroclastics suggests that the final, caldera-forming eruptions were triggered by injection of basaltic melt into a felsic magmatic body. The abundance of dikes observed during HD 483 suggests that the SE portion of the volcano was its magmatic apex.

Dive 489 (October 19th) traversed two small cones on the southeast flank of West Rota and recovered a number of lava types.

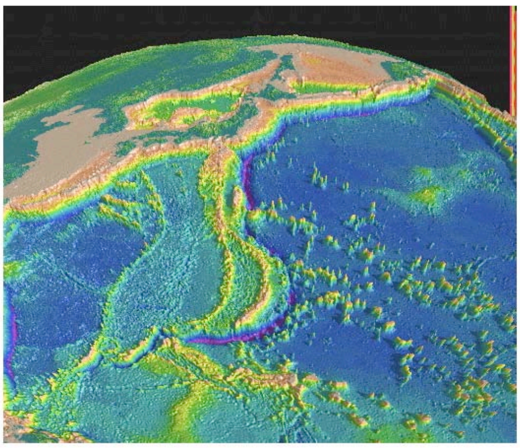
Chaife and Mt. Manganese: Dives 485 and 486 examined smaller volcanoes in the eastern part of the 14°40'N cross-chain. One of these seamounts – Chaife - has erupted the most primitive lavas (picrite and ankaramite) reported from the Neogene IBM arc (Kohut et al., submitted). These samples were recovered in a single dredge (D14) during the Cook 7 expedition. Whole rock samples have Mg# = 76-77 and olivines are as Mg-rich as FO 93. Chaife lavas have estimated (OL-SP geothermometry) magmatic equilibration temperatures of up to 1478°C and magmagenesis was largely anhydrous (Kohut et al., submitted)

Dives 485 and 486 provided important new data on the nature and composition of Chaife Seamount and Mt. Manganese. Although locally faulted, Chaife appears to be built on top of a NNE striking fissure. Lavas recovered from blocky flows were CPX-PLAG phyric basalts on the lower slopes (2300-2050 meters depth), ankaramitic and picritic on the mid- slopes (2055-1896 m) (similar to those sampled in 2001 by Cook 7), and aphyric basalts on the upper flanks (1875-1686 m). These lavas occurred in steep ridges, separated by flatter sediment covered slopes. Mt. Manganese is bisected by the fracture zone on its northern side. The bottom of the rift valley contains NNW-ESE trending flow channels in pumiceous sediment and small cones of tephra, lava and breccias. The cones are eroded and Mn-encrusted. Some lavas in the may have be primitive. The western fault scarp of the fracture zone exposes the flows on Mt. Manganese. These were basaltic in composition and Mn-coated. No intermediate or felsic lavas were observed.

Giant sediment waves around Esmeralda (Dive HD-487): On the aprons of many volcanic islands and larger submarine volcanoes, sediment waves with wavelengths of up to 2.0 km and amplitudes up to 100 m commonly occur (Embley et al. 2003). Giant sediment waves (GSW) of similar scale commonly occur in fine-grained sediments associated with turbidite channel levees and bottom current depostional areas Stow and Wynn, 2002). GSW in the Marianas appear to be limited to submarine slopes around active volcanoes and probably formed by major eruptions which discharged great volumes of sediment. HD 487 examined 2 lee slopes and one intervening upcurrent slope of GSW on the SW flanks of Esmeralda bank volcano, an active submarine volcano west of Tinian. The deeper of the two lee slopes appeared to be a depositional feature (perhaps draped over thinly-bedded volcaniclastics) whereas the shallower lee slope clearly revealed a cut bank of well-bedded volcaniclastics, which we infer were exposed by currents that deposited GSW farther downslope.

1. INTRODUCTION AND BACKGROUND

The Izu-Bonin-Mariana arc system (IBM) extends over 2800 km south from near Tokyo, Japan, to beyond Guam, U.S.A. (Fig. 1.1), and is an excellent example of an intra-oceanic convergent margin (IOCM). The IBM arc presents an outstanding opportunity to study the operation of the Subduction Factory at an IOCM, for several reasons: 1) the history of IBM evolution is one of the best known of any convergent margin; 2) there are four opportunities across the arc to sample products being produced by the Subduction Factory – the forearc, the active magmatic arc, arc cross-chains, and back-arc basins - more than any other convergent margin; 3) Subducted sediments are simple, diagnostic, and completely subducted; 4) IBM is a type example of convergent margins undergoing extension; and 5) IBM is large and diverse. Furthermore, a collision zone in the north provides an unparalleled opportunity to study the composition of middle IBM crust and so better infer products and processes leading to the formation of this crust. Because the islands and EEZ's of IBM are governed by the US in the south and Japan in the north, IBM provides special opportunities for teambuilding between US and Japanese scientists to collaborate and learn from each other, to involve young scientists in this process, and to work together to develop research proposals. The suitability of IBM for studies that promise to lead to fundamental understanding of Earth processes has made it a focus of international research efforts, including the US NSF-MARGINS 'Subduction Factory' experiment. It is likely to be an important focus of IODP drilling. In spite of its importance, we have much to learn about it in order to allow the best proposals to be written.



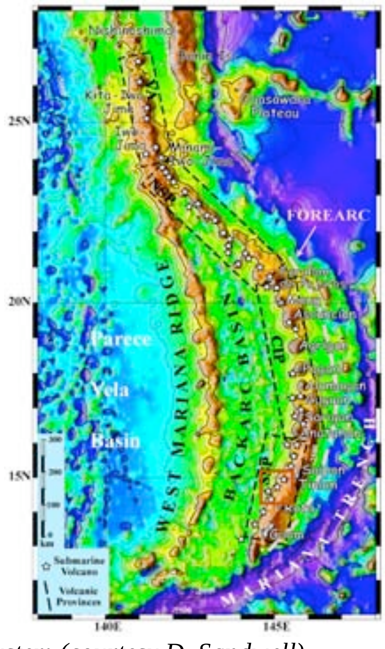


Figure 1.1 (left): Perspective view of the IBM subduction system (courtesy D. Sandwell)

Fig. 1.2 (right): IBM arc system locality map, modified after NOAA map of R. W. Embley. Red box shows location of Fig. 3.

(Stern et al. 2003) provide an up-to-date overview of the IBM arc system, noting that the arc system shows important variations in tectonic and magmatic expression along its strike. They divide the arc into three segments. The two best studied segments are the Izu segment in the north (north of 30°N) and the Mariana segment in the south (south of 24°N). These two segments provide natural focii for US and Japanese investigators to study arc systems, and the along-strike variations provide opportunities for scientists from these two nations to compare and contrast the different perspectives that these provide. The Mariana arc is further divided into the Northern Seamount Province, Central Island Province, and Southern Seamount Province (SSP) (Bloomer et al. 1989). The Mariana SSP lies close to populated islands of Guam, Rota, Tinian, and Saipan and SSP volcanoes are within the US EEZ. In spite of this, there have been relatively few studies of these volcanoes, although this is changing. In 2001 this region was surveyed with HAWAII MR-1 and extensively dredge-sampled during the COOK 7 cruise (R/V Melville; Bloomer and Stern, co-chief scientists). In 2003 a NOAA cruise (R/V Thompson, Bob Embley, chief scientist) surveyed the region and identified likely sites of hydrothermal activity with CTD casts. In 2004 this team returned for interdisciplinary studies of vent geology, biology, and chemistry using ROV ROPOS. Guam and Saipan have good ports and international airports.

The volcanoes of interest to this study occupy a small segment (about one degree latitude) of the Southern Seamount Province of the Mariana Arc, between 14°10'N and 15°20'N (Fig. 1.3).   Although these volcanoes lie in a geographically restricted region, they illuminate important petrologic, geochemical, sedimentological, and

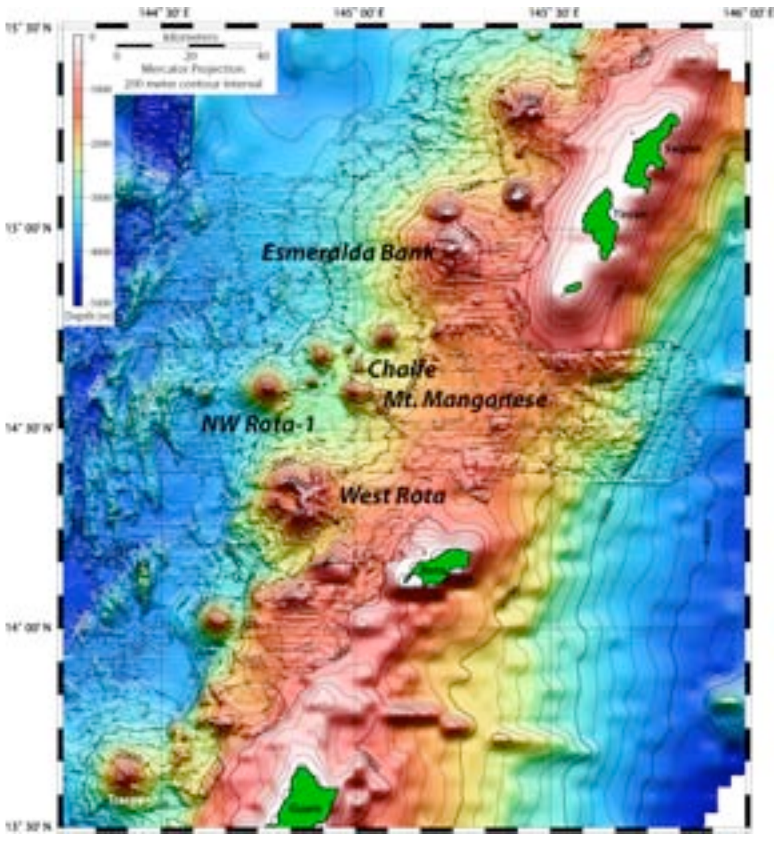


Figure 1.3: Bathymetric map of the southern Mariana arc. Four data sets are used, with gridcell size in parentheses: Satellite data (3500m), Hawaii MR1 (300m), Seabeam (150m), EM300 (50m). Figure by Susan Merle (NOAA). Features studied during NT0517 and HD 480-489 are shown in boldface italics.

hydrothermal aspects of arc evolution. The volcanoes are submarine but vary in volume by more than three orders of magnitude, from tiny Chaife ($1.2x10^9$ m^3)

through medium-sized), and NW Rota-1 (1.2×10^{11} m^3), to the largest volcanoes in the SSP, West Rota (5.2×10^{11} m^3) and Esmeralda Bank (6.5×10^{11} m^3). NW Rota and West Rota were the principal targets of our dive program.

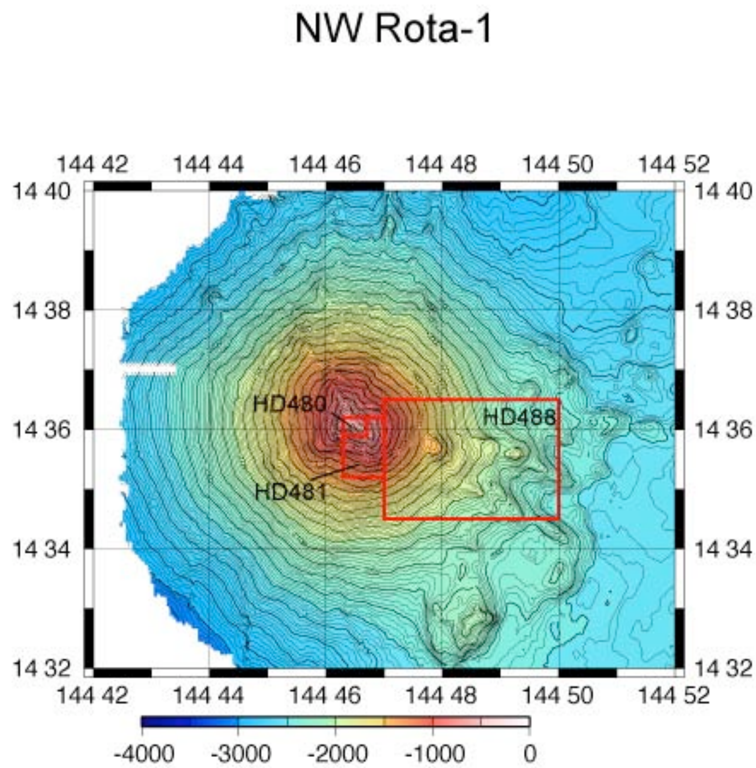


Figure 1.4 Area of operations for Dives 480, 481 and 488

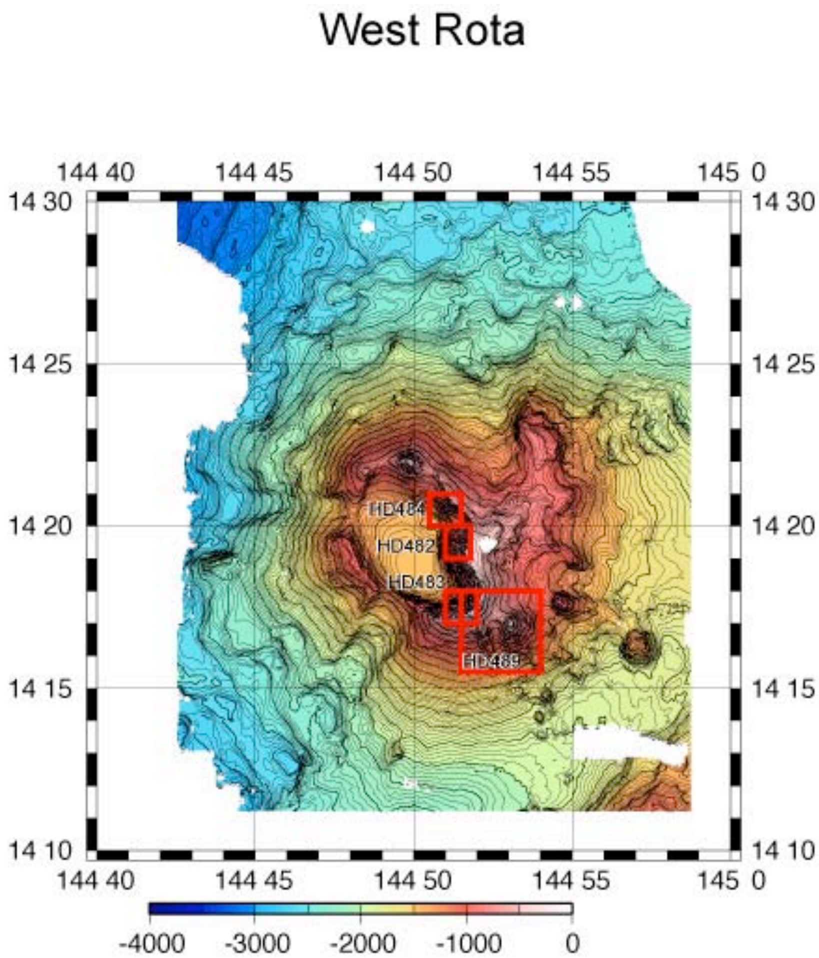
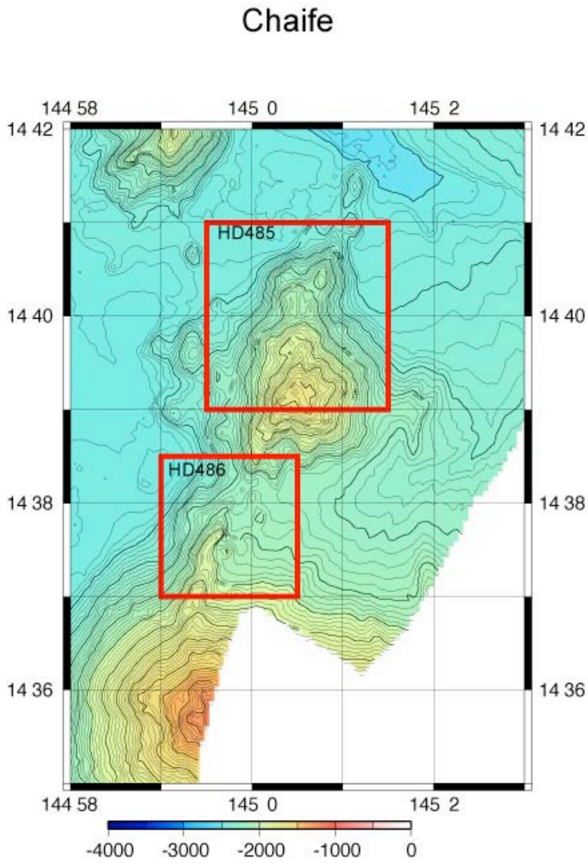


Figure 1.5 Area of operations for Dives 482, 483, 483, and 489



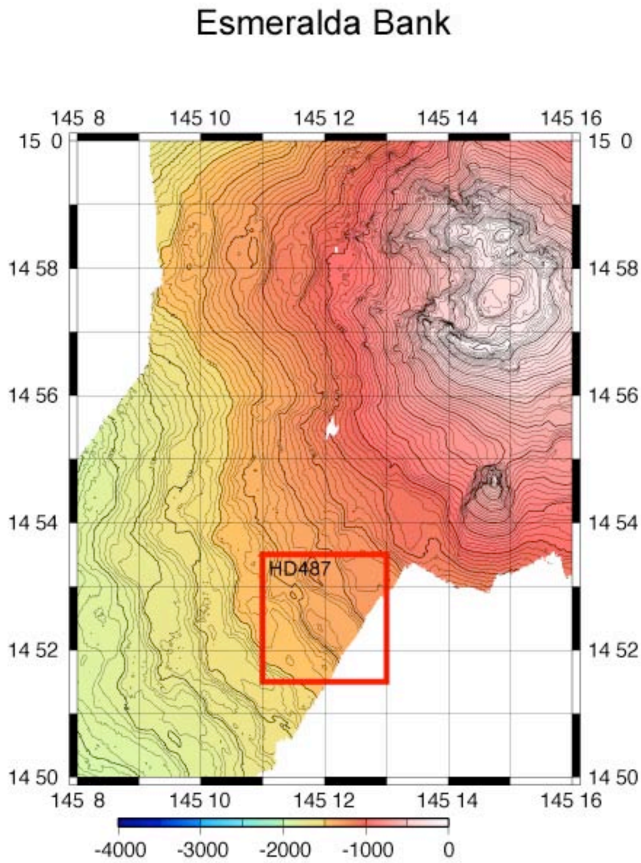


Figure 1.6 Area of operations for Dives 485 and 486

Figure 1.7 Area of operations for Dive 487

2. Scientific Objectives:

Our scientific objectives included aspects of the geochemical, hydrothermal, and sedimentologic processes in the southern Mariana Arc. Our original dive plan included work on high reflectivity features at the base of West Tinian Guyot and pits on the lower slopes of West Saipan Guyot, both of which addressed problems of volcano evolutioin and morphology. However, those sites were within the 12-mile territorial limit of the Commonwealth of the Northern Marianas, so had to be removed from the schedule. Our modified objectives included:

2.1. Examination of the stratigraphy and composition of West Rota Caldera to understand felsic volcanism in the IBM Arc System and the growth of continental crust.

West Rota caldera, is important because it is more like the large Izu felsic calderas than any other IBM volcano. This volcano has a Crater Lake (OR) size caldera that was likely the site of large-volume eruptions of silicic pumice. The caldera floor is 6 to 10 km from wall to wall and 1300 m deep (Fig. 4). The northern and eastern scarps rise to 400 m while the western scarp has a minimum depth of 1000 m. Near-vertical walls preserve a remarkable volcanic stratigraphy that we were able to examine with one ROPOS dive in March 2004 (Fig. 5). Previous dredging (Cook 7 D 63 in 2001) and ROPOS diving (R785 during TT-167 in 2004) indicate that it consists of lower andesite flows, upper dacite-rhyolite pyroclastics and volcaniclastics, and hydrothermally altered rocks. Two 40Ar/39Ar ages on andesites yield good plateau ages of 347±14 Ka and 572±117 Ka (Basu and Stern, unpublished data). We don't know (yet) when felsic volcanism and caldera collapse occurred, but it must have happened in the last 350,000 years.

Major goals of our work included the identification of the roots of an extinct hydrothermal system, description of the volcanic stratigraphy of West Rota, and collection of samples for petrologic, geochemical, isotopic, and geochronologic studies.

2.2. Early stage hydrothermal activity in the IBM arc system at NW Rota-1

NW-Rota-1 is nearly perfect cone that rises about 2,500 m above the surrounding sea floor (Fig. 6A). It was first surveyed and sampled during Cook 7, where D9 recovered fresh dacite ~65% SiO_2). In 2003, CTD casts by a NOAA-funded research team led by Bob Embley found a 200-m-thick layer of intense hydrothermal plumes above the volcano summit, indicating that a vigorous hydrothermal vent system was active.

The 2004 T167 cruise using ROPOS dived four times (Dives 782, 783, 784, and 786; note that these dives were typically 18 hours in duration) on this site, and quickly found that activity was concentrated near the summit. The first site we found (above the pit) was a large area of sand with shimmering (100°C) water percolating through it. Further exploration revealed the main hydrothermal vent, located about 30m below the summit and which was called 'Brimstone Pit" (Fig. 6B).We believe that NW-Rota-1 Brimstone Pit represents and extremely early stage in the evolution of a submarine arc hydrothermal field. The associated vent community also seems to be in the earliest stages, with a low diversity community that consists of only the most mobile invertebrate species, especially shrimp. In contrast to other hydrothermal sites surveyed during TT167, NW-Rota-1 showed little bacterial mat growth.

To test the hypothesis that this vent is in the earliest stages of formation, we need to revisit the area for the purpose of establishing a time series of how this system is evolving and to set the stage for future research on this fascinating and important geobiological system.

2. 3 Eruption of young 'komatiite-like' lavas at Chaife Seamount

Very primitive lavas from Chaife seamount were recovered in a single dredge (D14) during the Cook 7 expedition (Fig. 7A). Primitive lavas such as boninites are common for Paleogene lavas of the infant IBM arc, but Neogene IBM arc lavas are quite fractionated, with Mg# <60. Ar-Ar dating of the D14 samples yield plateau ages of 2.49±0.18 Ma for the picrite and 1.73±0.06 Ma for the ankeramite, so these lavas are part of the Mariana magmatic arc that formed after the Mariana Trough opened.

Understanding these primitive lavas is important for understanding temperatures in the sub-arc mantle wedge, for understanding the composition of primitive melts in arcs, and for testing the 'hot fingers' hypothesis of (Tamura et al. 2002). Chaife lavas also are important for addressing an important controversy about the tectonic setting of Archean komatiites. Most scientists prefer the interpretation that komatiites formed in Archaen mantle plumes (Arndt 2003), but some scientists argue that they may have formed in subduction zone environments (Grove and Parman 2004). Further study of Chaife and its lavas is expected to contribute to this important geoscientific controversy.

2.4. Giant sediment waves at Esmeralda Bank

The submarine flanks of the submarine volcanoes and islands of the central and northern Mariana Arc consist largely of low relief aprons, presumably made up of volcaniclastic sediments and minor lava flows. On the aprons of many volcanic islands and larger submarine volcanoes, sediment waves with wavelengths of up to 1.0 km and amplitudes up to 50 m commonly occur (Embley et al. 2003). We can recognize at least 8 sites on the flanks of the larger Mariana islands and seamounts with GSW fields. For these fields, sediment wave crests parallel regional contours, indicating a formation mechanism that is related to down-slope flow, probably initially as a result of flank failure. Recognizing and understanding of the distribution of GSW in the IBM arc is likely to be important for IODP drilling in the IBM arc.

Giant sediment waves in volcanic arc environments were previously largely unknown because few volcaniclastic aprons have been imaged in sufficient detail to recognize them; we suspect that they also exist on the flanks of other arc volcanoes, including northern IBM, but have not yet been recognized. HMR-1 and EM300 backscatter imagery show distinct alternating high and low reflectivity wave-parallel bands associated with these features. We interpret this as that could be grain-size sorting and further evidence that at least some of GSW are related to fluidized flow. For these fields, sediment wave crests parallel regional contours, indicating a formation mechanism that is related to down-slope flow, probably initially as a result of flank failure. In some places we have observed relationships between mass wasting on the volcanoes' steep, upper flanks and sediment waves on the gentler, lower slopes. In other places, it appears that GSW formed during the transition from channelized to unconstrained flows. Typical Mariana giant sediment waves appear to be among the largest amplitude and wavelength coarse-grained sediment waves known. Recognizing and understanding of the distribution of GSW in the IBM arc is likely to be important for IODP drilling in the IBM arc. These deposits consist of very unconsolidated pumice-rich sands and gravels, and drilling through them will require different approaches than drilling through more consolidated units.

Our objectives were to study the giant sediment waves west of Esmeralda Bank, which is a very active submarine volcano (Stern and Bibee, 1984).. In this part of the cruise we hope to examine how two waves in the field vary as a function of depth and distance from the volcano summit.

2.5. Structure and composition of parasitic volcanic cones at NE Rota-1 and West Rota

Small, parasitic volcanic cones are common features of large arc volcanoes. These can have highly variable compositions, but may be sites of unusually primitive magma compositions. They also represent an important evolutionary feature of arc volcanoes and provide a site where small volume lavas with key characteristics may be sampled. Our plan was to map and obtain representative samples for two such cones.

3. Cruise narrative and schedule of operations

R/V Natsushima departed Apra Harbor, Guam at 1100 on October 8th, 2005. The ship arrived at NW Rota-1 that evening and completed Seabat multibeam sonar surveys of the volcano until dive operations commenced at 0900 on October 9th. Dive 480 was completed that day at NW Rota-1, Dive 481 was at the same site on October 10th. Upon recovery of Hyper Dolphin on Oct 10th Natsushima proceeded to West Rota Seamount, where dives 482, 483, and 484 were completed on October 11, 12, and 13. Surveys around the seamount were completed during the evenings. The ship transited to Chaife Seamount the evening of October 13th, and upon completion of bathymetric surveys did dives 485 and 486 at Chaife and Mt. Manganese on Oct. 14th and 15th. Sunday October 16th was used as a day to do maintenance and catch up on archiving and describing the results from the first 7 dives. Preliminary sampling of the recovered materials was completed. Operations began again with Dive 487 on giant sand waves west of Esmeralda Bank, and concluded with Dives 488 and 489 on parasitic cones of NW Rota-1 and West Rota on October 18th and 19th. Natsushima entered port at Saipan early on October 20th where the scientific party disembarked.

4. Operations and data processing information

The only underway data collection was by the hull-mounted multibeam system Seabat. Data from the Seabat surveys will be merged with existing Seabeam, Seabat, and EM-300 data at the NOAA research labs in Oregon.

Hyper Dolphin dove with payloads that included the rock sampling basket and two sample canisters with swivel lids for dives 482, 483, 484, 485, 486, 488, and 489. Dives 480 and 481 mounted two push or M-type cores and one lidded box in the sample basket, as well as a temperature probe and water sampler mounted on the starboard arm and the body of HyperDolphin. Dive 487 used two lidded boxes, the two lidded canisters, and two M-type cores. Dives 480 through 488 mounted a small nephelometer provided by the NOAA participant R. Embley.

Data and samples from the dives were archived as customary. Half of all samples will be archived at JAMSTEC. Samples distributed to the scientific party are listed in Appendix B. Standard data products were provided to the shipboard scientific party.

5. Scientific Results

5.1 Bathymetric surveys .

R/V Natsushima completed additional Seabat surveys in several areas around the dive sites (Figure 5.1.1) . These data will be merged with existing multibeam data to produce final maps of each study area.

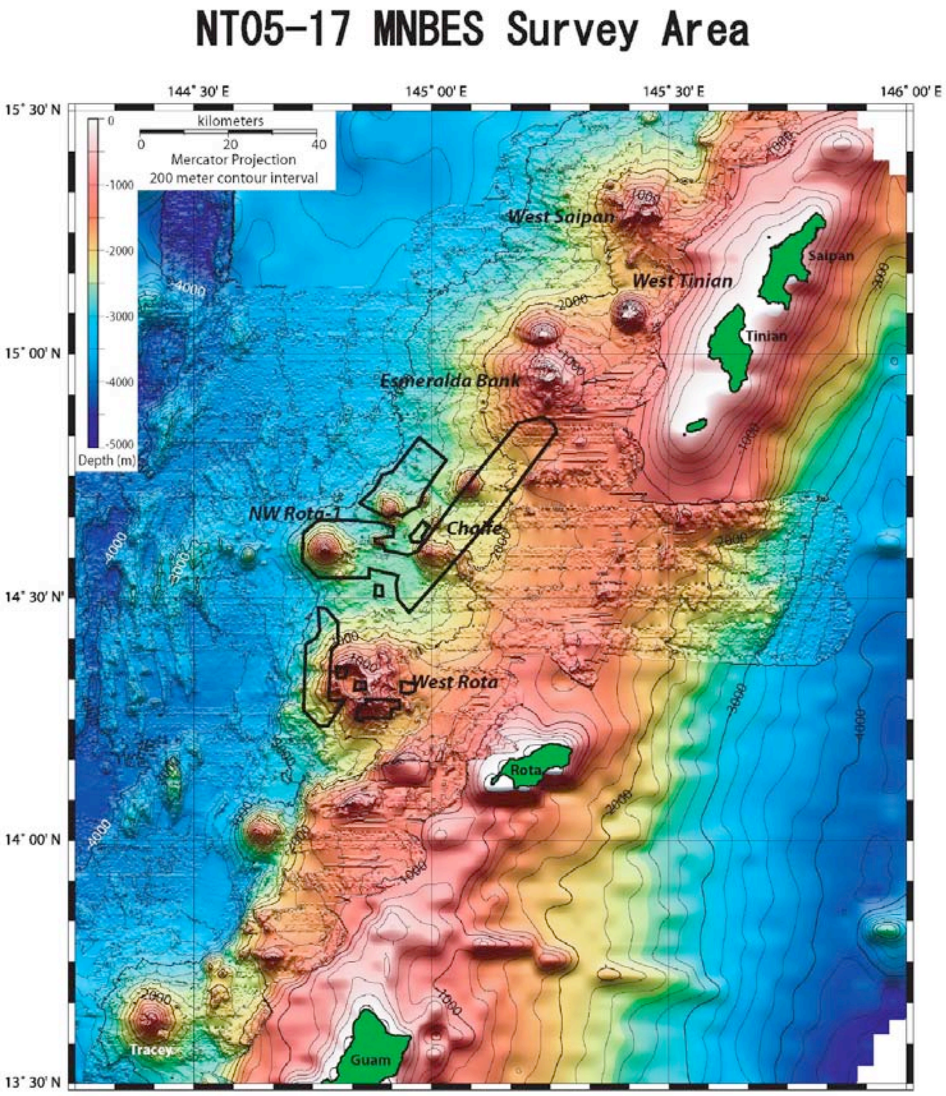


Figure 5.1. Bathymetric map of study area with Seabat survey fields shown by heavy dark lines.

5.2 MAPR Measurements

The MAPR is a self-contained (battery powered) unit capable of recording pressure, temperature and water turbidity at pre-set time intervals (but no less than 5 sec). The unit was mounted on the front upper bar of the Hyper-Dolphin on all dives except for Dive 487 and 489. Data were collected by the MAPR on dives HD-480, 481, 482, 483, 486 and 488. It failed to collect data on HD-484 because of low voltage on the batteries and on HD-485 because the delay time was set incorrectly. It was not deployed on HD-487 and 488.

The primary objective of the MAPR unit during NT-05-17 was to collect data on the plumes over NWRota-1. The unit was deployed and collected data on all three dives at that site (HD-480, 481 and 488). Only the nephelometer data were looked at during the cruise. Although data appeared to be somewhat noisy it clearly showed the turbid clouds around the Brimstone Pit and it is hoped useful information about the water column turbidity will be derived by post-processing and filtering the data.

5.3 Water and temperature sampling

Water samples and temperature measurements were collected using instrumentation from the Extremobiosphere Research Center (XBR), Japan Agency for Marine-Earth Science and Technology during Dives 480 and 481. Water samples from the plume had pH less than 2.0 and temperatures in excess of 120^{o}C were measured within the eruptive plume.

5.4 Hyper-dolphin Studies and Sample Descriptions

Summaries of the results of each dive with representative pictures, start and finish locations, track maps, and dive logs are included in the sections below. A comprehensive list of samples with brief descriptions is included in Appendix A.

5.4.1 Dive 480

Technical information:

Location:	NW Rota-1 Seamount, summit ridge
Objective:	survey rim of Brimstone Pit, assess activity, sample, examine hydrothermal activity

DIVE 480	On bottom:		Off bottom:	
Time (local)	09:21		16:11	
Latitude:	14^o	35.989'N	14^o	36.008'N
Longitude:	144^o	46.515'E	144^o	46.476'E
Depth (m):	600		496	

Samples returned: 10 rocks (one lost on ascent), 1 scoop, 2 cores, 1 water sample

Representative images:

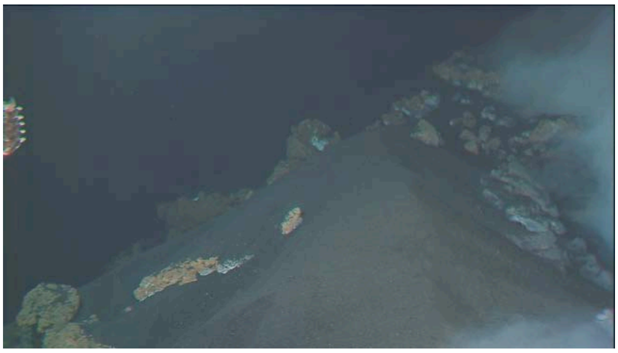


Figure 480A: Cinder pile with altered rocks or hydrothermal precipitate, with warm fluids venting from summit and sides. (image hdc20051009110941

Figure 480B: Bacterial (?) mats or fibers growing on rocks in low-temperature field (image hdc20051009110941)

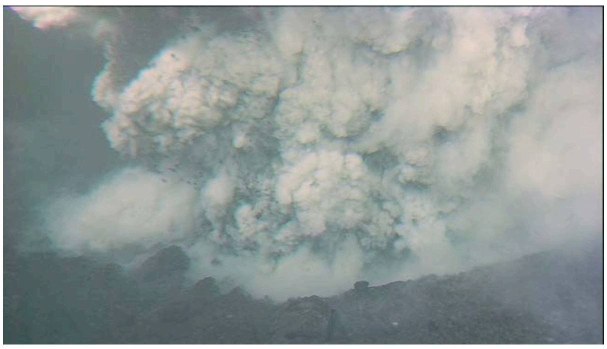


Figure 480C: Plume emerging from active vent at Brimstone Pit. Plume periodically emitted bursts dense in rock fragments (image hdc20051009120057_1)

Scientific summary:

NWRota-1 Dives – Background and Purpose

An active volcanic crater was discovered on NW Rota-1 Seamount during a NOAA expedition on the T. G. Thompson. The site was originally identified from water column measurements in 2003. In April 2004 deposits of volcaniclastic sand with occasional outcrops of basalt were mapped along the summit ridge.

The objectives of the Hyper-Dolphin dives included: (1) relocate and determine the level of hydrothermal and volcanic activity on the summit, (2) sample fluids from these systems for microbiological and chemical studies, (3) obtain samples of the juvenile volcanic ejecta from the Brimstone Pit, and (4) obtain samples of older lavas for a general study of the volcano, and (5) obtain samples of the shrimp species that are the dominant megafaunal component of the site.

Dive HD-480

Dive 480 landed about 100 m south of the Brimstone Pit at a depth of 600 m (S01). After ascending to the approximate depth of Brimstone Pit the visibility became very poor, with a “fog” enveloping much of the area. The summit above the Brimstone Pit site (S02) also had poor visibility (520 m minimum depth on log), so it was decided to traverse east to the “Fault Shrimp” site to look for a site for sampling water and biology. This site had very low level diffuse venting and white microbial mats covering much of the outcrop (S03). There was no visible diffuse flow, but the site was not fully explored. After obtaining a rock sample (S03), Hyper Dolphin returned to the Brimstone area, traversing south-southwest along the contours and approaching the Pit from the east. The Brimstone Pit, an active volcanic vent, was finally sighted at 11:57 at a depth of 527 m (S04, 05). Several water, rock and sediment samples were taken at the Brimstone Pit (S04, S05) along with video documentation of the activity, including many volcanic “bursts” occurring slightly above the rim of the pit. A high temperature of 130° C was recorded during the sampling. This was quite extraordinary given that the highest temperature recorded in 2004 was approximately 30° C.

After leaving the Brimstone Pit, Hyper-Dolphin traversed east to relocate the “Iceberg” vent discovered in 2004. Clear shimmering water and abundant shrimp were present at this site. A marker was placed about 50 m southeast of the Iceberg site (S06) to relocate the area for Dive HD-481. Hyper-Dolphin made a mid-water traverse to the southwest and landed on the slope approximately 200 southwest of Brimstone Pit at a depth of 639 m. A traverse was then made to the north up the steep southern slope of the summit ridge to a depth of 561. Several rocks (S07-S11) were taken on this traverse. After a brief return to the Brimstone Pit (approached from the east this time), Dive HD-480 ended at 16:11.

Some general summary of critical observations at NWRota-1 appear after the Dive HD-481 summary.

NT0517HD480

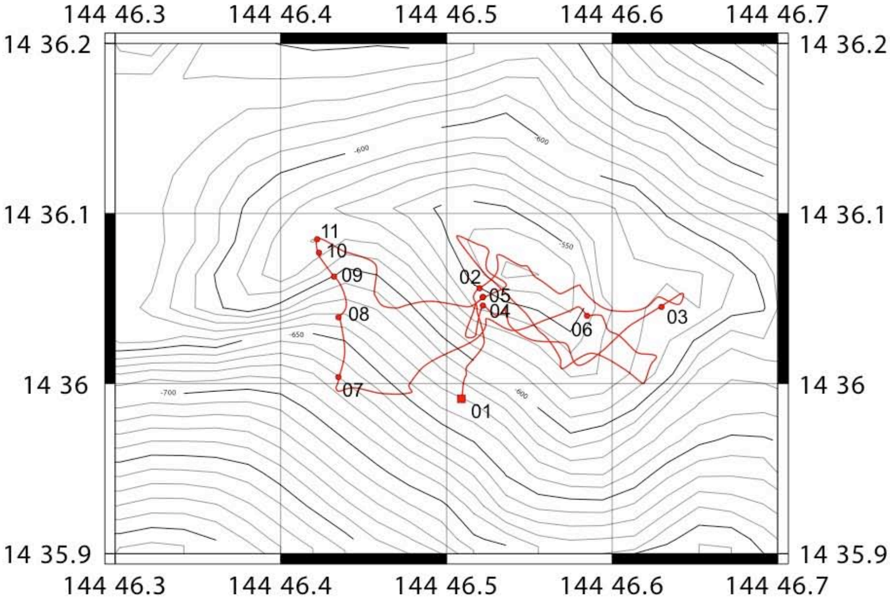


Figure 480D: Bathymetry and station locations for HD 480

Table 480A: Dive Log NT0517HD480

Time (Local)	Depth (m)	Vehicle Hdg	Notes	Sample #
8:35			In water	
9:21	600	359	On bottom. Loose scoria or bombs perhaps. Looks volcaniclastic. Variety of colors, reds to grays and blacks with speckled whites. Majority of clasts 5-20 cm diameter?	
9:26	606	15	Sampling glassy (?) vesicular basalt (?). ~20-30 cm placed in front of box.	NT0517HD-480-1-R-01
9:30	601	8	Moving up slope, encountering blocky flow or outcrop or bombs, up to ~1m diameter sub-rounded blocks. Not the freshest looking rocks. Some coated with orange crust (manganese?). Whitish to yellowish coating on others. Perhaps sulfur. Moving closer to Brimstone pit perhaps.	
9:40	560	359	Still moving up slope. Much more suspended particulate matter, mostly white in color. The surrounding loose bombs are mostly all covered in white material now. A few more fish present than at the beginning of dive. Clearly more turbid than at 600 meters.	
9:45	541	359	Very fine white to grey particulate venting. Very turbid, not great visibility. Quite "smokey".	
9:48	536	359	Very heavy venting. Smoke resuspension perhaps due to vehicle, but mostly encountering active venting. Looks like it has been continuous since at least April 2004.	
9:52	531	359	Audio finally turns on!! Heading up a ridge composed of very fine sand sized ejecta. Large blocks protruding from fine grained material and covered with white to yellow sulfur. First encounter with shimmering water. Small venting area. Appears that we've gone passed where the pit is supposed to be.	
9:57	526	359	Temperature probe but I didn't hear an official temperature.	
10:06	527	48	Scoop sample of the basaltic sand comprising the ridge that is resting at the angle of repose. NW trending ridge.	NT0517HD-480-2-S-01
10:15	526	53	This fog seems to be coming directly out of the sand. Really no obvious source yet for this material. Going to go see if we can find the pit. This is certainly a different style of venting than 2004. The 'smoke' is just diffusing out of the very permeable slope. Plumbing system has gone to hell. Temperature and chemistry has probably changed over the last 18 months.	
10:17	525	53	Appears to be a finely layered rock amidst the small vent area.	
10:22	525	55	Taking temperature directly from where the smoke is diffusing from. The discolored rocks may be due to some type of acid leaching.	
10:25	525	48	Observing a rock exhibiting ash water fall layering. Probably pseudo-cemented and then slightly deformed.	
10:28	525	46	The lack of shrimp is odd. The temperature has probably dropped since 2004 because the smoke is much more milky than before. The pit may have collapsed and what we see venting is just seeping	

			through the sand.	
10:31	525	45	Temperature reading from a small vent is 9°C.	
10:38	520	26	Appears to be the summit. A little more current up here results in ripples along the top.	
10:43	522	30	Observing some bacterial mat. Fe staining?	
10:47	520	100	Changing course. Absencs of hydrogen sulfide results in no biology. Coming over to the north side. Very sharp ridge. Shrimp!! Not sure if this is the same species that was observed last year. The north slope is gentle and everything comes over the top and falls down the south side resulting in a steeper slope on the south.	
11:00			Flying over to "Fault Shrimp" on the eastern edge. Hopefully find some better sites for water sampling with some more focused flow.	
11:08	570	270	Fault-Shrimp. Appears to be some venting. Microbial mat! But where are the shrimp?	
11:13	574	234	Sampling rock with microbial mat on it. Placed in the box with the scoop sample.	NT0517HD-480-3-R-02
11:22	564	239	Cruising over a fairly gentle slope covered in fine grained light colored rippled ash. Looking for a place to take water samples.	
11:28	551	308	On the south side of the Fault Shrimp area. Some 'snow' suspended in the water. Shrimp and a crab observed. Small community grazing on the bacterial mat.	
11:35	559	308	Maybe some pillow lavas observed in passing. But mainly similar to the first blocky slope we observed at the beginning of the dive.	
11:38	550	309	Found some more milky smoke. Fairly dense.	
11:42	539	309	Similar venting as earlier venting through the sand. Probably getting closer to the source of sediment falling through the water column. Lapilli sized fragments suspended as well.	
11:52	527	322	Searching for the source of all of this suspended matter. Hard to find though if we're down current. It is coming out from many different areas so may be difficult to pinpoint a single venting site. The concentrated haze is hugging the floor.	
11:55	527	311	Very dense 'cumulus' like cloud. Probably too dense to be diffusing through the sand.	
11:57	534	311	Found the rim of the pit! Bellowing broccoli-like dense clouds almost the same as last year. It was a pit but certainly has built up since last year. Perhaps more active than last year? The colulmn of smoke has a vortex to it, perhaps from some interaction with the water current. The billowing plumes are white and yellow. Big fist sized pieces of rock in there! Much longer and stronger bursts than last year. Certainly more active than last year. The bursts also seem to be more violent and powerful.	
12:04	533	21	Push-core sample next to the pit. I think I heard the temperature is 120 or 130 C. Empty, returned to aft holder	NT0517HD-480-4-C-01

12:14	533	21	Water sampling into bag.	NT0517HD-480-4-W-01
12:21	533	22	Push-core sample? Used corer in aft holder again, this is C-01	NT0517HD-480-4-C-01
12:22	533	22	Rock sample of bomb. I assume it is spatter.	NT0517HD-480-4-R-03
12:27	507	3	64 m off sea floor; moving to next goal; discussing plan	
12:31	522	340	back near bottom; 4 meters off;	
12:32	531	268	over small bench, c/c tohead due west; can see edge of plume	
12:35	532	29	highly turbid water; fragments of rocks in plume; lens of camera has spots on it; probably sulfur drops/	
12:36	527	30	can see edge of plume, looks like a seep out of the cinder pile; cinders covering yeloowish-orange coated blocks; sit down on bottom, sampling	
12:38:45	527	26	attempting a push core sample; very resistant and hard to push in; multiple attempts;mostly seems to wash out on pull out; may have collected a little; goes in forward core holder	NT0517HD-480-5-C-02
12:42	526	30	underway heading NNE	
12:43	519	316	came along and off a fairly sharp ridge'; 4.5 meters off bottom	
12:45	536	340	heading NNW along a sloping surface; looks like significant sulfur on surfaces	
12:47	521	339	looks like came over summit of ridge…	
1251	533	318	not active out here; considering moving towards the other end of the ridge	
13:15	580	24	Heading back towards Snow Cone. Many fish all aligned in the same direction.	
13:20	565	311	Small colony of red shrimp grazing on some loose material. Seems to be a small amount of bacterial mat.	
13:26	561	309	Left a marker	
13:32	546	311	Encounter another colony of shrimp and crab on an outcrop. Sampling rock from colony. Pie-shaped piece.	NT0517HD-480-6-R-04
13:36	545	314	Sampling another rock.	NT0517HD-480-6-R-05
13:39	538	314	Shimmering water at another shrimp colony. Broad extent area with very large amounts of shimmering sands.	
13:54	533	18	Temperature probe at a shrimp-infested vent.	
14:00			In transit	
14:15	543	300	Back into the cloud. Dense but not as many fragments.	
14:23	543	357	Cruising around some clouds.	
14:33	516	250	The clouds seem stationary. Striking, really.	
14:48	639	0.8	Sampling a rock at a blocky pile with a few shrimp but basically barren. Sample is fist sized, probably basalt.	NT0517HD-480-7-R-06
15:01	624	16	Rock sample. Looks like a dogs head. Vesicular basalt?	NT0517HD-480-8-R-07
15:06	596	351	Large blocky flow with some sulfur staining.	
15:09	589	339	Viewing very large and striking shrimp.	
15:10	589	339	Rock sample with some slight sulfur crust or staining.	NT0517HD-480-9-R-08
15:15	582	343	Large flow, or maybe a dike.	
15:21	570	296	Rock sample with some type of Fe crust. Fresh basalt?	NT0517HD-480-10-R-

				09
15:28	561	358	Rock sample from Fe crusted pillow outcrop. Seems pretty fresh from the fresh surfaces.	NT0517HD-480-10-R-10
15:45	547	83	Back into the cloud. Lots of fine material.	
15:56	532	335	Looking into the pit from the rim. Just as violent as it was this morning.	
16:11	496	227	Ascending	

5.4.2 Dive 481

Technical information:

Location: NW Rota-1 Seamount, summit ridge
Objective: water samples from eruptive column, sampling of summit region rocks and hydrothermal materials, rock sampling of lower fault flank fault scarp

DIVE 481	On bottom:		Off bottom:	
Time (local)	09:23		15:08	
Latitude:	14°	36.037'N	14°	36.820'N
Longitude:	144°	46.436'E	144°	46.780'E
Depth (m):	623		709	

Samples returned: 14 rocks, 2 cores, 1 water sample, miscellaneous pieces in basket a and box

Representative images:

Figure 481A: Active venting from edge of Brimstone Pit. Note small density flows down the right side of the cinder crater (image hdc20051010095743_1)

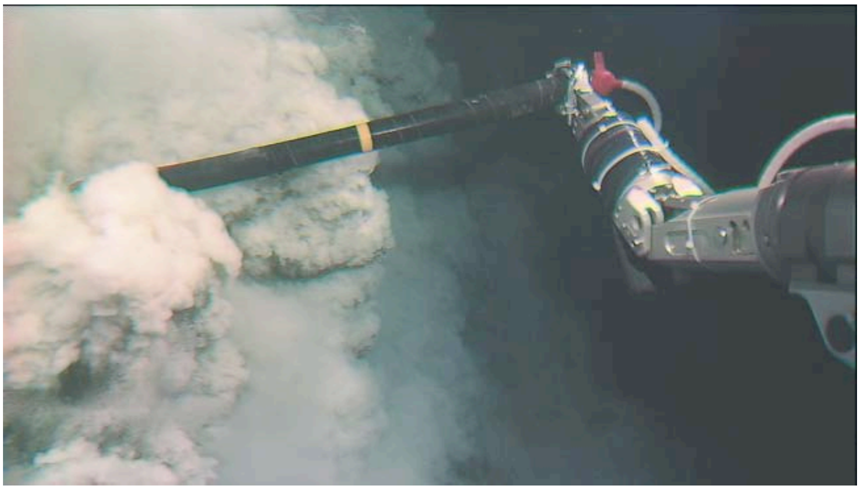


Figure 481B: Inserting the temperature and water sampling probe in the edge of the plume (image hdc20051010095910_1)

Scientific summary:

Also see background section in front of Dive HD-480

The objectives of Dive HD-481 were to revisit the Brimstone Pit to take additional water samples and obtain rock samples of other locations on the summit area.
The Hyper-Dolphin landed about 150 m west of the Brimstone pit at 623 m and headed east obliquely upslope. The Brimstone Pit was found at 09:47. The activity was somewhat more subdued than observed on dive HD-480, although there were still frequent bursts and the Hyper-Dolphin was frequently showered with volcanic ejecta while sampling at the rim of the crater. Several scoop and rock samples were taken of the pit's ejecta (S1), including some large pieces that landed in the basket. A water sample was taken, but its temperature probe was not giving reliable data. At 10:35, Hyper-Dolphin made a traverse to the marker left on Dive HD-480. A sediment scoop was made of the volcaniclastic sand (S02) which also captured four of the smaller shrimp. A short traverse upslope to the Iceberg site was then made and a water sample (S03) was taken at the base of one of the white-coated outcrops. Several rocks were also taken in the vicinity (S03). Hyper-Dolphin then drove south through mid-water to set up for an upslope traverse to collect rock samples. It landed at a depth of 1080 m. It then traversed upslope to 728 m taking a series of rock samples (S04-S13) before terminating the dive at ~730 m at 15:08.

Summary of NWRota-1 Dives

The very active volcanic plume at Brimstone Pit showed that the volcano continued to be active after almost 18 months since its discovery in March 2004. The higher plume temperature (up to 100 C higher than measured in April 2004) and the expulsion of significantly larger volcanic ejecta compared to 2004 indicates that the October 2005 volcanic episode was more intense than the activity observed in April 2004. The bursts of the ejecta were observed to collapse into small volcaniclastic flows that formed density currents. The position of the Brimstone Pit appears unchanged, although the upper rim may be shallower compared to 2004. However, this will have to be confirmed by careful comparison with the 2004 dive data.

The lower turbidity plume below 700 m that was observed both visually and by a nephelometer (instrument that measures light scattering) mounted on a CTD in 2004 did not appear to be as intense this year, which is somewhat surprising given the increased intensity of the Brimstone Pit. Post-cruise laboratory analysis of data taken with a nephelometer on the NOAA/PMEL MAPR instrument mounted on Hyper-Dolphin should resolve this issue.

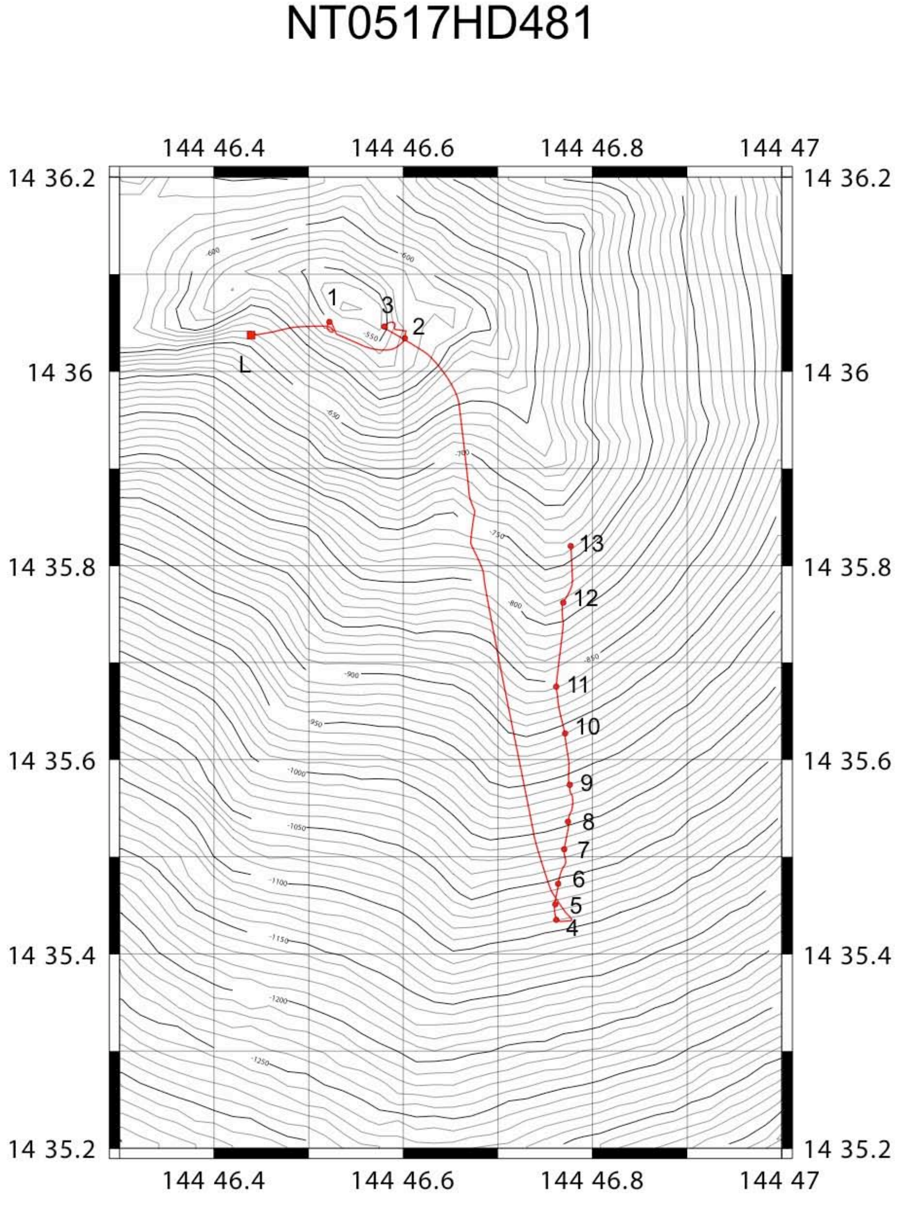


Figure 481C: Dive track and station locations for Dive 481

Table 481A: Dive Log NT0517HD481

Time (local)	Depth (m)	Vehicle Hdg	Notes	Sample #
8:48			In water	
8:59			Began descent	
9:17	485	unk~90.5	Passed through a zone of cloudy water,~20 m thick, possibly from the plume?	
9:23	623	78.3	Just above bottom, 1.6 m above. Area is covered by loose, angular rocks with brown-yellow coatings with bright spots of white. Arrived at dive point 1.	
9:25	617.7	79.2	Small shrimp.	
9:28	610.6	78.1	Continuing to cruise along the bottom, still angular basalt clasts with brown coating.	
9:37	581.9	78.4	Continuing to cruise along the bottom, still angular basalt clasts with brown coating, occasional shrimp	
9:38	575.2	78.2	Ratfish	
9:39	570.8	89.1	Landscape has changed, we appear to be heading up the spine of a small ridge	
9:41	552.7	89.4	Very angular rocks	
9:43	544	88	Moving upslope with alternating areas of angular blocks with slopes that are fine grained, lying at the angle of repose? with some white material on the top. More particulates in the water	
9:46	538.3	56.5	Particulates in the water, possibly from the lower plume	
9:47	533.8	354.8	Rim of the pit, plumes from the rim, with flows down the slope as well.	
9:48	533		moving clockwise around the rim, with breakouts, very high contrast between the water and the cloud.	
9:50	532.2	38.8	plume enveloping the hyperdolphin	
9:51	527.1	41	HD camera in a plume of particulates, possibly some bubbles	
9:53	516.7	30.3	Rock landed in the sample basket, possibly on the water sampler?	
9:55	0:00	13.2	Approaching the plume site again, rotating around in a counterclockwise direction. The rim is dominated by fine material, with coarser (bombs?) pushed back. Possibly evidence of more explosive eruptions in the past?	
9:59	533.2	1.6	Possible spatter from the vent, on the basket	
10:01	533.2	1.7	Manipulator knocked the rock that landed on basket rim into the basket.	NT0517HD-481-1-R-01
10:03	532.4	3.5	Attempted water sampling	
10:07	541	4.3	Backed away from the vent site, preparing bottle sample, Slide in the background, grain flow. There is a layered rock that was unearthed by the flow.	
10:13	532.6	50.1	Scooping up rim material using water sampling bottle?	NT0517HD-481-1-S-01
10:14	532.5	50.9	Filling water bag sampler, from active plume, temperature 60-70 degrees	NT0517HD-481-1-W-01
10:23	532.6	49.5	Continuing pumping bag samples, activity seems less vigorous than yesterday, lower temperatures noted.	
10:26:43	532.6	50.6	Bottle holding NTO517HD-481-2-W-01 returns to container	
10:29	532.6	48.5	Continue pumping water sample, opening box to collect falling debris	

10:31	526.4	98.8	Turned off the water sampling pump	
10:37	558	88.4	Jellyfish!	
10:39	546	94.8	proceeding along a steep slope of fine material, with a white coating	
10:40	545.1	91.8	Bottom flattened out with dunes	
10:44	563.8	24.3	Returned to marker HD480-2, for sample, scooped up scoria,water, and maybe some shrimp, definitely at least one.	NT0517HD-481-2-S-02
10:55	564.8	262.7	Completed scoop sampling	
10:58	549.5	294.7	Position 12 on the map, outcrop is coated with white material, possibly sulfur or possibly bacteria, and reddish areas. Scattered shrimp around.	
11:04	534	291.7	Outcrop is a series of lava flows, are layer boundaries acting as conduits for hydrothermal fluids?	
11:06	532.4	322.8	Warm water diffusely venting from white-coated hillside	
11:12	531	325.3	At base of an outcrop with hydrothermal fluid venting, granular material resting on the slopes, fallout from the vent ~ 100 m distant around the base of the outcrop.	
11:13	531.1	323.7	Water sampling at the boundary bretween the granular material and the white coated material, sampling probe was pressed close to the white coated rock	NT0517HD-481-3-W-02
11:30	531.2	319	Continuing to collect water samples, Texture of rocks is like the bark of a tree, it is ropy.	
11:40	532.2	317.6	Continuing to sample water	
11:41	531.3	317	Finished water sampling	
11:43	531.4	317.3	Opened box	
11:44	531.4	320.5	Collected rock sample from wall where water sample was taken. The sample has a white coating on the outside. Rock put into closed-lid box.	NT0517HD-481-3-R-02
11:47	531.1	320.3	Trying to collect another sample, the manipulator arm is breaking off the coating, the rock beneath is black.	
11:51	531.1	319.7	Sample from wall where rock sample was collected, dark with white coating on the outside. Also placed in closed-lid box.	NT0517HD-481-3-R-03
11:54	531.1	319	Sample from wall where rock sample was collected, dark with white coating on the outside. Also placed in closed-lid box.	NT0517HD-481-3-R-04
12:03	526	162.4	departing stn 3 and heading downslope to site -500, +300 in grid	
12.08	540.2	180	small jellyfish floated by	
12:17	550.2	195.8	transiting to site for rock sampling	
12:23	560.1	189.9	Jellyfish on CCD camera	
12:52	560.1	169.8	Continuing transit to rock sampling site	
12:55	58	169.5	Started descent at rock sampling side	
13:04	165.9	809.2	Water is turbid	
13:14	1079	1.1	Sandy looking bottom, with broken blocks, probably basalts	
13:16	1080.2	352.3	Rock sample picked up from rubble, sample has oxide sltaining on the outside, possibly filling vesicles	NT0517HD-481-4-R-05
13:18	1079.7	355	Shrimp? With very long legs, walking in side steps across the bottom. This is a diferent one from those	

			we have seen before	
13:23	1068.3	3.9	Rock sample from the bottom, basalt	NT0517HD-481-5-R-06
13:29	1047.4	5.9	Heading up slope, large blocks or possible outcrop, sampled block, white spots on the outside.	NT0517HD-481-6-R-07
13:35	1041.2	6.4	Outcrop with small white balls attached to the side	
13:43	1019.2	0.8	Traversed along slope to a field of angular clasts, pyramidal shaped sample	NT0517HD-481-7-R-08
13:46	1009	0.2	Continuing upslope, many shrimp, both with long legs and antennae and ones similar to those we have seen before. The two types of shrimp are comparable in size, the long legged ones have a more delicate body than the regular ones and are a much darker red.	
13:50	1002	0.3	Vesicular rock, red material filling in the vesicles.	
13:54	992.4	354.5	Large rock sample picked from amongst block on the floor.	NT0517HD-481-8-R-09
14:01	976.7	348.6	A long unidentified creature swims by on the CCD	
14:04	970.3	347.5	A fish, unidentified, has large eyes, translucent body, that swam with a waddling strokes, with fluttering fins	
14:09	951.9	344.1	Large rock sample, rounded, placed in basket between the scoop samples and the marker flag	NT0517HD-481-9-R-10
14:11	951.7	342.7	Outcrop made of vesicular rocks, closeup images taken	
14:27	901.1	346.6	Rock sample, looks fresh, basalt? Shaped like a piece of pie with a bite taken out.	NT0517HD-481-10-R-11
14:29	899.2	345.6	Outcrop with iron staining	
14:30	896	346	Sea anenome	
14:32	884	346	branching structures off of rocks, sessile organisms of some kind, possibly coral	
14:36	856	354	Stalk attached to the rock, possibly coral, indicating that the surface has been stable for some time.	
14:38	848	353	Rock sample, float taken from an area with large weathered blocks. Sample looks somewhat altered	NT0517HD-481-11-R-12
14:42	827.5	354	Continuing upslope, turbidity increasing	
14:50	771.4	346	Rock sample, one very flat edge, oblong in shape, I think it was placed on top of sample 10 in the basket	NT0517HD-481-12-R-13
15:00	728	291.8	Rock sample, minimum dimension is the max grasp of the manipulator Dark,fine grained, front of the box, a little bit on the lid	NT0517HD-481-13-R-14
15:08	709	302.5	Began ascent	

5.4.3 Dive 482

Technical information:

Location: West Rota Seamount

Objective: map and sample stratigraphy inside caldera, eastern slope

DIVE 482	On bottom:		Off bottom:	
Time (local)	09:39		15:06	
Latitude:	14°	19.661'N	14°	19.433'N
Longitude:	144°	51.098'E	144°	51.669'E
Depth (m):	1012		414	

Samples returned: 12 rocks, 1 scoop

Representative images:

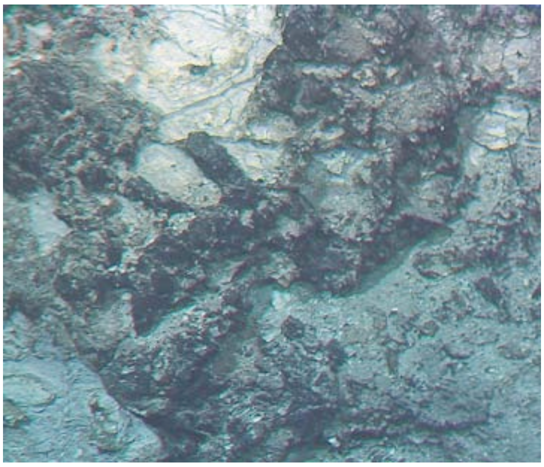



Fig. 482A (Left) Hydrothermally altered and silicified (white) lavas at about 980m depth. Note dark resistant ribs anastamatosing through outcrop. These ribs are likely mineralized. Fig. 482B (Right) Breccia consisting of easily eroded altered volcanics (white) set in a matrix of dark, resistant, mineralized rocks, observed at ~750m depth. Sample 482-R10 was collected from the dark matrix.

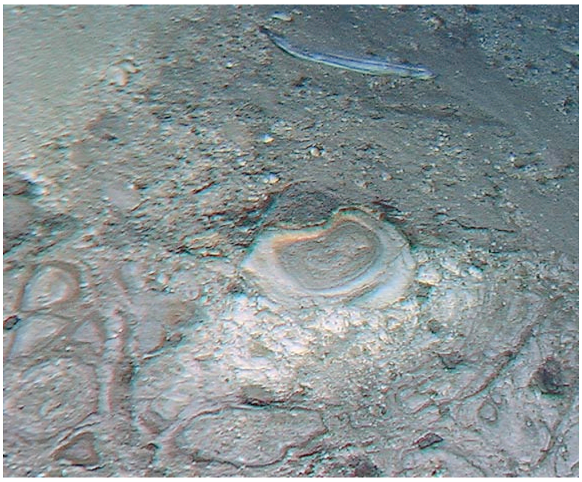



Fig. 482C (Left) Outcrop of altered pillows at 753m. Note large sample at top with brown center. This was collected as sample R9. Fig. 482D (Right) Photo of sample collected at this site. Note many concentric layers, with bleached outer rind and inner, darker interior.


Fig. 482E (Left) Felsic pyroclastic flow overlying heterolithologic breccia with abundant mafic and intermediate clasts at ~600m depth. Fig. 482F (Right) Coarse felsic pyroclastic flow overlain by weakly layered pumice-rich tuff at ~550m.

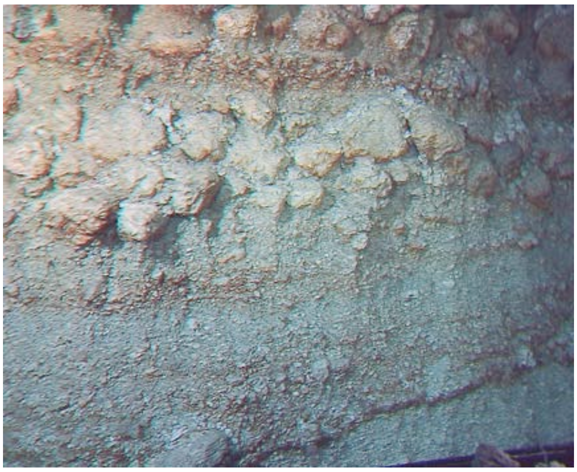
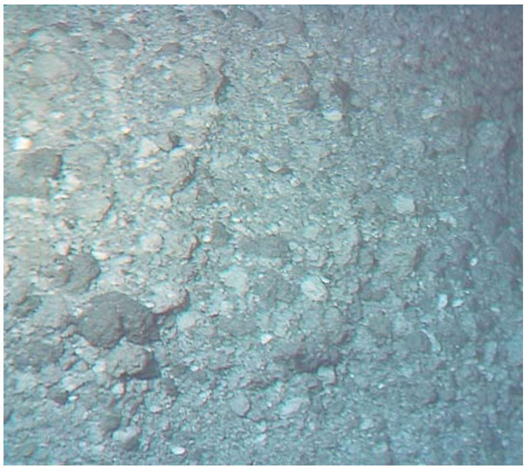



Fig. 482G (Right) Reversely graded, weakly layered tuff at ~570m, probably formed by fragments settling out of water, with ash and smaller pumice clasts becoming saturated with water and sinking sooner than larger pumice clasts. Note Fe-stained horizons.
Fig. 482H. Pyroclastic flow with dark grey and light grey clasts.

<u>Scientific summary:</u>

This dive ascended through an exposed section of about 600m of West Rota volcano. The observed section can be about equally divided into lower altered lavas and upper pyroclastics. The lower, altered section consists of about 250m of variably – and sometimes intensely – altered andesite and dacitic tuff, overlain. Eight of the nine samples collected at depths greater than ~760m appear in hand specimen to be hydrothermally altered. Altered rocks were inferred to exist as shallow as 640m, the depth at which the pyroclastic section begins. Altered rocks are bleached very white and very friable, although more silicified and mineralized veins sand out as irregular ribs (Fig 482A,B). Some of the altered lavas contain disseminated sulfide mineralization. Some of the altered rocks are breccias, although it is not clear whether brecciation occurred before alteration (volcanic breccia) or was associated with mineralization. A very distinctive zone in the altered rocks may have originally been pillowed lavas which have been silicified and show concentric metasomatic zonation (Fig. 482 C, D). Similar sorts of alteration have been observed near the Galapagos in the eastern Pacific.

A diverse sequence of pyroclastic rocks was observed at depths shallower than about 750m. This sequence consisted of about 13 distinctive units of heterolithologic breccia (Fig. 482E), felsic pyroclastic flows (Fig. 482F), and fine-grained tuffs. These units ranged in thickness from a few meters up to 80 meters. Some clearly reflect debris flow deposits, such as the heterolithologic and homolithologic breccias. Abundance of dark, mafic and andesitic clasts in heterolithologic breccias (Fig. 482E) may mark when a new eruptive vent was established or may indicate contemporaneous mafic and felsic igneous activity. The pyroclastic section observed during HD 482 appears to have been deposited close to the vents that produced this ejecta, and the generally upward-coarsening nature of the deposits suggests that explosive volcanism became increasingly violent with time. The friable and unwelded nature of the deposits suggest that these were deposited in a submarine environment, with eruption mechanisms varying from units deposited by pyroclastic flows (Fig. 482G, H).

NT0517HD482

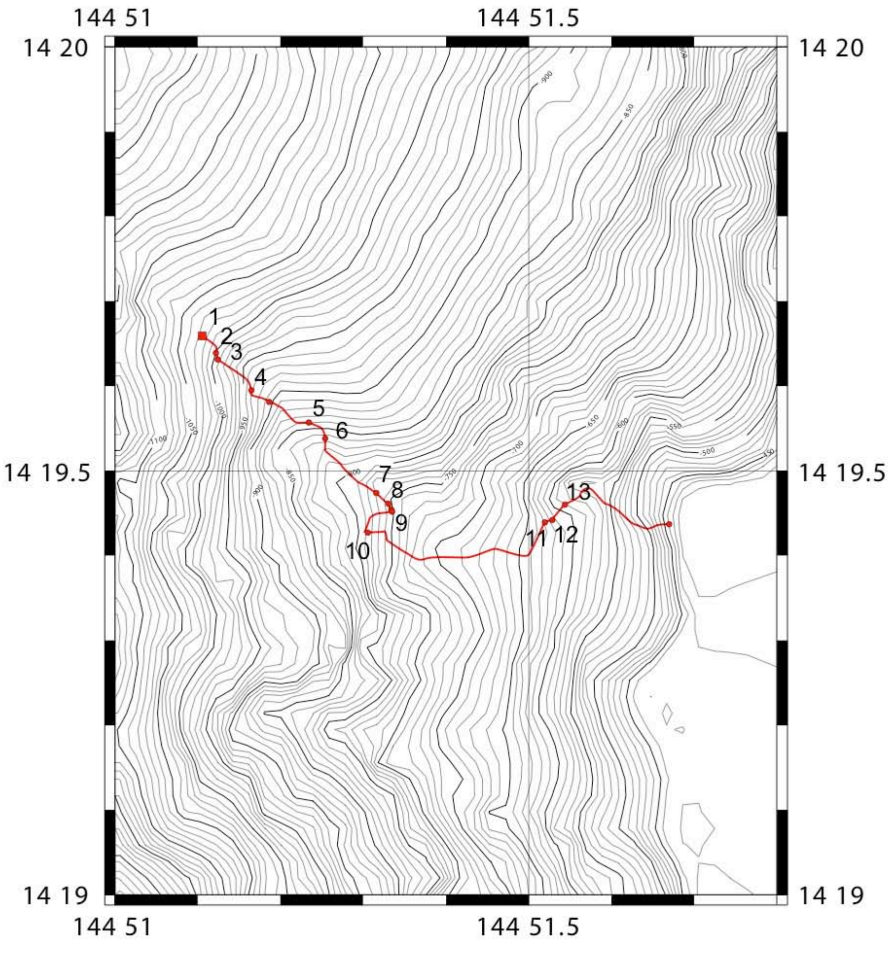


Figure 482I: Dive track and stations for HD 482

Table 482A: Dive log for NT0517HD482

Time (Local)	Depth (m)	Vehicle Hdg	Notes	Sample #
9:03	279.2	86.4	vehicle is descending to site #1	
9:39	1012	129.7	vehicle at bottom on talus slope - variable sized fragments with some alteration. Both lighter coloured pumice and basalt (andesites) fragments are observed. Small coral branches are protruding from large rock fragments	
9:45	1015	129.9	rock sample - possibly andesitic, covered with some algae.	NT0517HD-482-1-R-01
9:47	1007	135	star fish or anemone? on CCD	
9:50	992	163	Rhyolite or altered material is seen as we transit up talus slope	
9:53	992.1	164.6	Stn 2 (252.13, -494) altered rock? Rhyolite or andesite ~ 50cm	NT0517HD-482-2-R-02
10:00	985	165.8	Stn 3 silicic rock, covered in moss, with white ruffles on outcrop and possibly a Mn coating - 'pie shaped with a nose' in yellow box	NT0517HD-482-3-R-03
10:09	942	129	pink crinoid	
10:20	925.1	41.3	stn 4 dark wall of rock which seems to be in place, dark rock (andesite?) with orange/black coating - into yellow box	NT0517HD-482-4-R-04
10:33	886.7	130.2	rhyolitic crumbly material, coated with Mn to deceive the average geologist into thinking it is andesite - no sample taken	
10:45	860	192	Stn 5 Altered scallopy rock outcrop, pale rock with black coating - sample looks like a small slab of andesite, but unsure whether it is related to the outcrop. The claw is unable to break off a sample from the outcrop	NT0517HD-482-5-R-05
10:55	851	139.4	continuing upslope, passing andesite/rhyolite rubble slopes	
11:01	821.5	199.2	sharp boundary between altered rock and andesite? Perhaps rubble simply fallen from above	
11:10	821.3	196	dike, which has been somewhat altered	
11:12	820.6	204.8	stn 6 sample of dike, andesitic, flying saucer shaped, ~50cm, into the yellow box	NT0517HD-482-6-R-06
11:16	817	140.5	continuing up massive rubble slope	
11:31	778.3	131	columnar jointed rhyolite showing lots of texture - lots of little flakey white rock fragments lying around	
11:37	775.8	112	stn 7 sample of outcrop which shows Mn coating everywhere except at the base where it has been covered with debris. Sample is gray with red coating, possibly dacite? ~ 30 cm	NT0517HD-482-7-R-07
11:44	749.6	129.6	Stn 8 altered pillows with dark and light veins, roots of a hydrothermal system? A broken up sample of the altered rock is dropped into the blue box.	NT0517HD-482-8-R-08
11:51	753.2	125.2	first layered rock, very crumbly pyroclastic material	
12:00	752.9	94.3	more altered pillows	
12:02	753	98	At beautiful altered pillow zone, very similar to shallow stockwork at Galapagos site. Excellent sample.	NT0517HD-482-9-R-09
12:15	770	345	Moving northwest along slope.	
12:16	770	143	Looking SE along slope	
12:19	786	142	Seeing another altered outcrop, looking closer	
12:21	789	132	At this other outcrop trying to sample black material (it probably manganese coated.	
12:22	789		Sample of black material	NT0517HD-482-10-R-10
12:34	760.6	161	very sharp contact between lower andesite (?) and concentric altered rocks	

12:43	758.4	153.9	large phenocrysts are visible within concentric zones	
12:51	739	153.3	still in the alteration zone - therefore at least 20m thick	
12:53	721.6	153.1	transiting to way point 2	
12:54	714	150	more altered rocks	
13:12	681.3	90.2	piles of fist sized pumice covering a fairly large area	
13:16	666.9	89.5	outcrop encountered (-660, -110) - very altered breccia with possible black dikes	
13:24	644.5	88.9	traveling across the pumice rubble pile	
13:25	639.7	40.6	reached way pt 3 and heading to way pt 4	
13:35	636.7	344.6	stn 11 sample of altered material in hopes of finding hornblende or biotite to date the eruption	NT0517HD-482-11-S-01
13:44	638.2	41.7	very faint layering, but mostly very massive	
13:47	621.9	38.4	continuing through the pyroclastic unit, some darker clasts can be seen; everything looks quite altered	
13:49	613	40.1	unit looks much darker and poorly sorted, possibly a boundary with lower unit	
13:57	611.7	38.6	possible contact between unit with larger more defined clasts and lower more massive unit; large clasts seen at boundary	
14:02	610.9	15.7	sampling of an andesitic block from the contact layer - possibly signifying the eruption of a new vent?	NT0517HD-482-12-R-11
14:07	602	40.6	possible contact between unit containing andesite blocks and a more altered pumice rich unit above	
14:15	588.6	3.8	sharp boundary	
14:16	589	2.5	contacts between pumiceous deposits, some red banding, oxidation, capped by breccia with rounded cobbles? Blocks appear to be largely rhyolitic? Not mixed lithologies	basket filled with pumice when ran into slope.
14:29	579.8	27.5	airfall pumice?	
14:32	580.6	28.3	sample of pumice deposited into rear tube (2) - we may be able to find some biotites to date the material	NT0517HD-482-13-R-12
14:42	572	39.6	travelling upslope - difficult to see any structure - may not be subaerial since there is no welding	
14:44	558	40.7	layering of flows - may be fall deposit - alternating light and and dark horizons	
14:47	550.2	3.4	distinctive unit with orange layer on top of darker material (looks like a paleosoil, but this is submarine)	
14:50	547	122	transit to next way pt looking at pyroclastic flow	
14:51	563	120.2	coming up to a wall with normal faults all through it - cross bedding is visible	
14:53	549	123.6	pyroclastic flow units with layers	
14:54	522.8	144.7	thick dark bands within pyroclastic layers	
14:57	506	117	still within the flow unit, which is capped by a bright orange layer (possibly a paleosoil)	
15:00	480	89.3	vertical pyroclastic flow with lots of lithic (< fist sized)	
15:06	413.7	88.6	travelling up to surface, end of dive - pumice from dive is seen floating out of basket	

5.4.4 Dive 483

Technical information:

Location: West Rota Seamount, southeast wall of caldera
Objective: Map and sample stratigraphy exposed in SE wall of W. Rota caldera.

DIVE 483	On bottom:		Off bottom:	
Time (local)	09:23		16:15	
Latitude:	14^{o}	17.739'N	14^{o}	17.644'N
Longitude:	144^{o}	51.130'E	144^{o}	51.694'E
Depth (m):	1150		662	

Samples returned: 20 rocks (one lost on ascent), 2 scoops

Representative images:

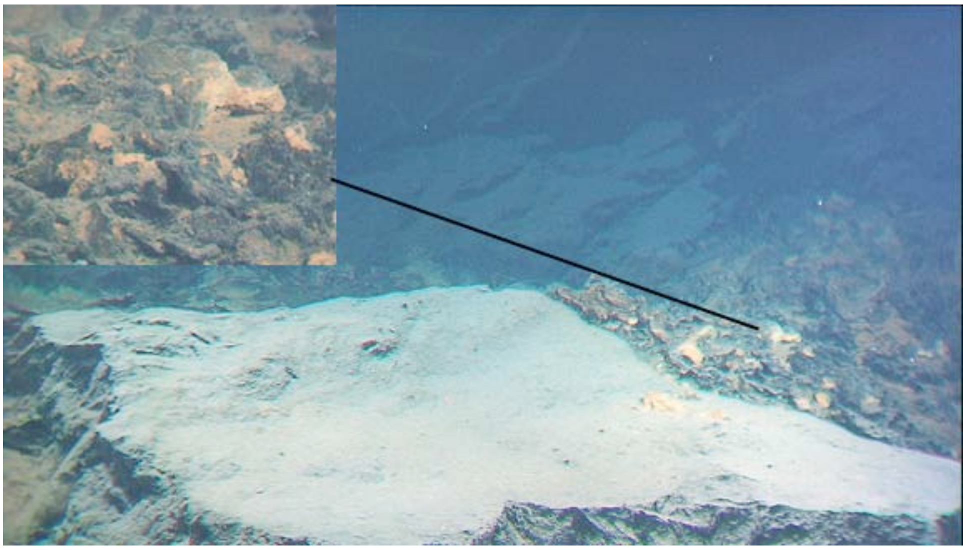


Fig. 483A. Weak hydrothermal vent near the base of the SE wall of West Rota caldera (hdc20051012092341_1). Note grey mound of fine sediments flanked by hydrothermal crusts on right. Inset shows detail of this crust (hdc20051012092500_1).

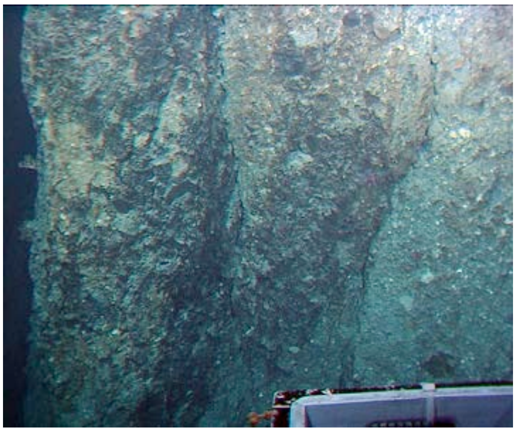
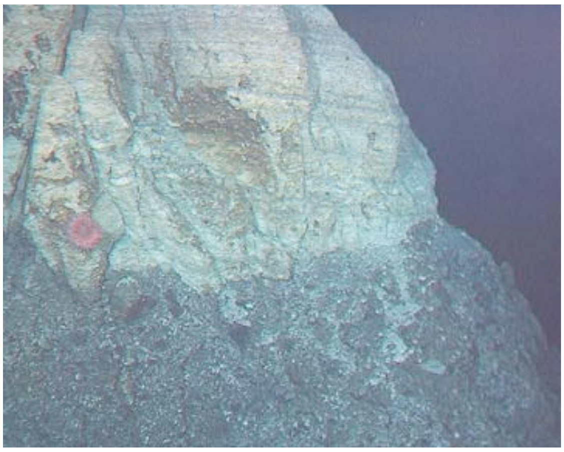


Fig. 483B: Dacitic dikes ~1050m. Sample 483-R3 is from one of these dikes (HDTV grab hdc20051012101913_1). Fig. 483C: Basaltic dike (left) intruding massive breccia (right) at about 770m depth. Sample 483-R7 was taken from this dike (hdc20051012113249_1).



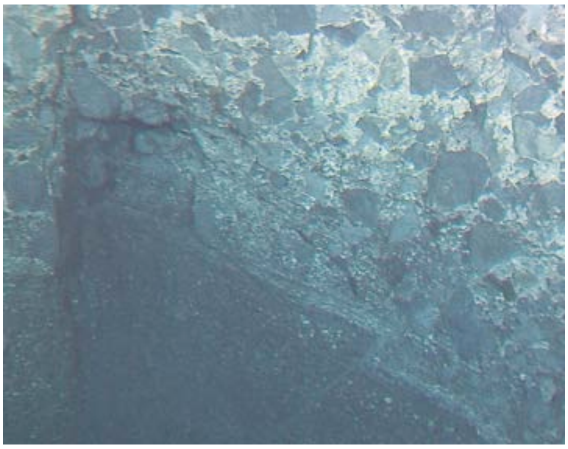
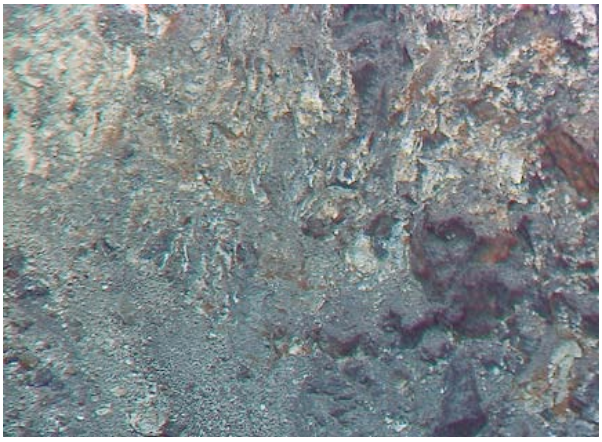


Fig. 483D: Laminated felsic tuff overlying massive breccia at about 750m depth (hdc20051012114457_1). Fig. 483E: Clast-supported breccia with abundant mafic clasts overlying thin laminated tuff at about 700m. Note small fault (hdc20051012120207_1).



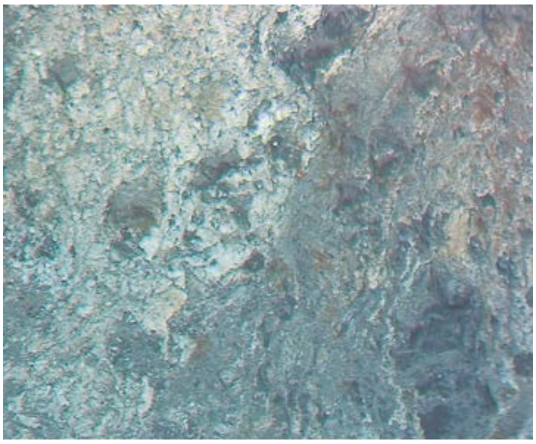


Fig. 483F: Termination of dike in pyroclastic breccias at about 720m (hdc20051012115714_1). Fig. 483G: Close-up of left contact between dike and pyroclastics. Dike is brecciated and appears to have produced pyroclastic deposits (hdc20051012115810_1).

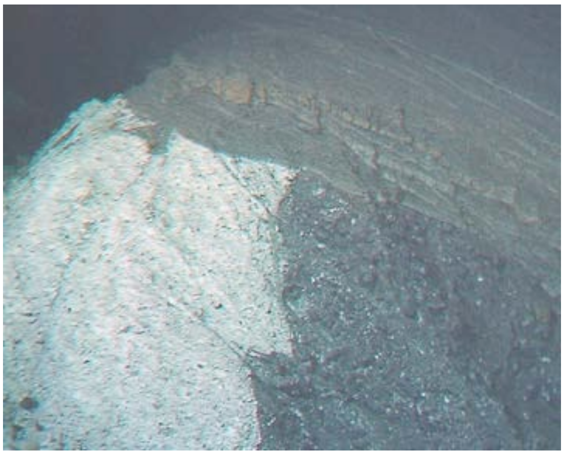


Fig. 483H: Basaltic dike (sampled by 483-R9) intruding felsic tuff and overlain by mafic hyaloclastics at about 675m (hdc20051012120920_1). Fig. 483I: Olivine Basalt with weak columnar jointing and pillow structure at 400m depth. Sample 483-R16 was taken at this outcrop (hdc20051012133022_1).

Scientific summary:

Principal results: This dive ascended through an exposed section of about 800m of West Rota volcano and then moved east to continue the dive at 790-660 m water depth. At the bottom of the dive we observed a weak hydrothermal vent with a weak flow of shimmering water and possible bacterial mat (Fig. 483A). We suspect that other, perhaps more vigorous vents may exist near the base of the caldera wall.

The caldera wall up to 850m is dominated by dikes. We sampled three of these: two from the lower section are dacites and one from ~890m is andesite. Moving up-section through this interval dike density was observed to decrease such that dikes at the bottom had a sheeted (dike-on-dike) appearance, with increasing proportions of volcanic screens as we rose through the section. These dikes indicate that the SE part of the caldera wall was an important magmatic conduit for West Rota Volcano. Hydrothermally altered and mineralized rocks like those encountered during HD 482 and 484 do not appear to be an important component in the lower wall of the SE caldera. We speculate that this region was to hot to allow seawater to penetrate, circulate, and alter the rocks in the immediate region of the volcanic conduit.

At about 750m laminated felsic tuffs were found to overly the massive volcanic brccia, and from this depth upward the proportion of dikes decreases. The pyroclasitc succession is bimodal in composition, dominated by dacite and basalt as shown by the abundance of mafic clasts in some breccias (Fig. 483E), mafic dikes and tuffs (Fig. 483H) and basalt flows (Fig. 483I). One dike was observed to terminate within the pyroclastic. The dike itself was brecciated and appears to have provided material for the breccias that it intrudes (Fig. 483F&G).

Many of the dark clasts found in heterolithologic breccias observed during HD482-484 came may have come from contemporaneous basalt flows or dikes such as those observed in the upper part of HD483. Samples 483-R9 to 17 all are basalts and about half of these contain visible olivine, suggesting that these were primitive magmas. Felsic samples are under-represented because these are very friable and break apart during sampling, in contrast to fresh basalts that were easily collected with ROV manipulators. The abundance of basalts near at least one volcanic center suggests that dacitic eruptions may have been triggered by an influx of mafic melt into a felsic magma chamber.

NT0517HD483

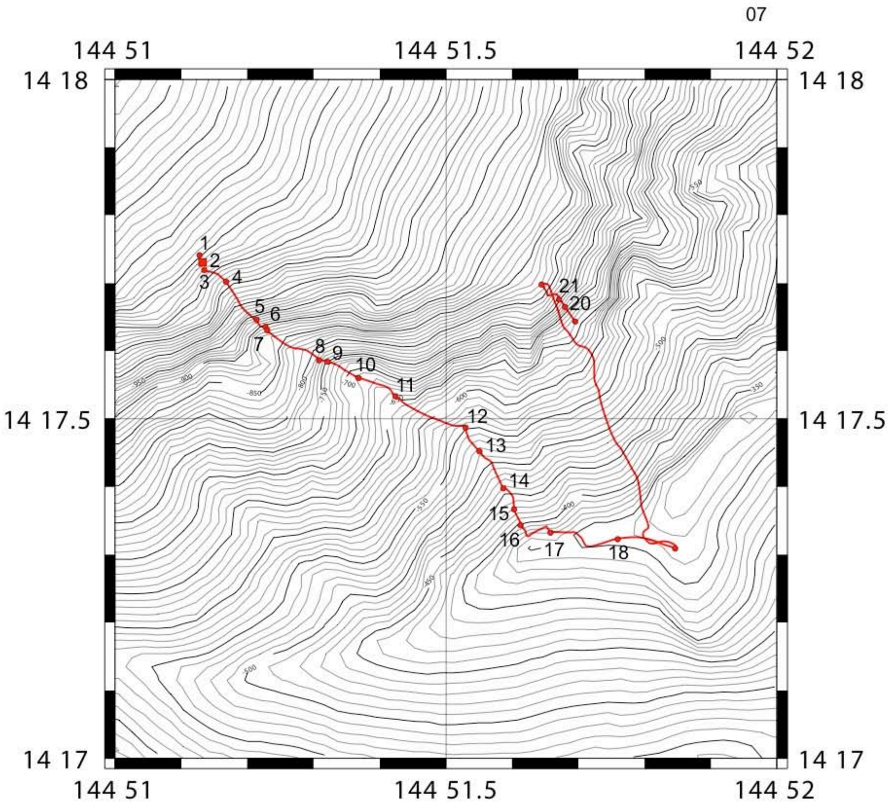


Figure 483H: Dive track and station locations for HD 483

Table 483A: Dive Log NT0517HD483

Time (local)	Depth (m)	Vehicle Hdg	Notes	Sample #
820	0		in water; start a bit earlier because of weather	
8:37	98	79	on descent	
9:19	1122.8	141.8	Can see an outcrop that appears to be a vertical wall, possibly the crater wall?	
9:23	1149.8	139.5	Completed descent, travelled down a vertical wall. The block in front looks like andesite? The floor is covered in rusty red alteration.	
9:26	1150.7	139.7	Attempted to sample a flat rock, the claw is able to crush an edge, material seems friable.	
9:29	1150.7	138.8	Spotted a hydrothermal seep, there is yellow alteration around the rim. Possibly associated bacterial mats.	
9:33	1149.6	158.2	Ground material and rock coatings are very easy to stir up.	
9:36	1149.6	157.9	Sampling a white and gray surface that looks like it is a bacterial mat, scoop consistest of red material and white + gray material, sample went into front closed container	NT0517HD-483-1-S-01
9:49	1149.2	157.8	Discussion of what the seeping water may mean, including possibilities of enhanced mineralization and remaining magma acting as a heat source.	
9:53	1140.7	158.9	Dikes in the wall we are ascending, attempting to sample what may be a dike or may be andesite. Sample fell into the blue box	NT0517HD-483-2-R-01
10:00	1146.9	158.7	Dike with columnar jointing	
10:03	1123		continuing up a wall of massive andesites	
10:10	1104.9	138.4	407, -472, station 3, sampling an in situ andesite, though it shatters easily. Sample looks very glassy, possibly a dacite vitrophyre. Sample is placed in a blue box	NT0517HD-483-3-R-02
10:15	1101.8	138.5	Continuing upslope, more possible dikes, dacitic composition?	
10:17	1081	138.6	Very different from similar depths along other traverses, arrived at point 1 on the dive plan	
10:19	1068.6	140	dike, dipping off the the right, still no breccias	
10:21	1057.1	139	Another massive wall, with pronounced planer features, dips to the left	
10:25	1055.8	145.8	Sample directly off what looked like a planaqr dike, the broken surface looks like a rhyolite, these may be all rhyolite dikes, sample went into the blue box, a pretty rectangular piece.	NT0517HD-483-4-R-03
10:31	1032.2	164.2	Continuing upslope, increased amount of loose cover over outcrops	
10:35	1025.2	164.2	stopping to sample massive outcrop of dark rock	
10:42	987.7	158.4	Texture of outcrop has changed, looks almost like pillows, but is most likely a fracture pattern.	
10:48	950.6	174.5	Trying to sample from the side of the wall. Unable to get a piece the rock wall appears quite solid	
10:54	935.7	186.9	Found a good place to set down the ROV and sample pieces from the wall. Sample has a rust coating, shaped lke a potato, ~20x40 cm. Sample placed behind blue basket, x=259m, -y = 331m	NT0517HD-483-5-R-04
10:58	926	178.9	Rocks in outcrop are shattered, with lots of sediment on top	
11:01	901	129.8	Way point 2, columnar jointed dikes	
11:07	888.2	187.3	Sampling the wall.	NT0517HD-483-6-R-05

11:09	179	886.2	Texture of outcrop has changed, looks almost like pillows, but is most likely a fracture pattern.	
11:10	867	148.8	Rhyolitic appearance, with some alteration showing on broken surfaces. Weathered surfaces are black, fresher surfaces are grey with some rust staining.	
11:13	862.20	173.5	Collected a 20cm long sample of very soft, black stained, rock with a light colored interior, sample went into blue box,	NT0517HD-483-7-R-06
11.19	822.6	111	More dikes, at least two	
11:26	789	111.2	Tuff? There is some layering	
11:27	788	150.6	Attempting to scratch the surface of the outcrop, too hard for tuff, but it is very broken up and lithology is difficult to infer. X= -180 y = -188	
11:31	753	124.6	Brecciated tuff, clast sizes are difficult to see estimated largest ones are 5 cm There is some kind of layering, clast vary from dark to light, red to green, mostly angular, some sub-rounded to rounded. Heterolithic, dikes are intruding into breccia but do not seem to progress very far.	
11:37	752.5	82.9	Sampling the dike to try to get a piece of obsidian? This location is between the contact of the dike and the dacite, rock was placed in the blue box.	NT0517HD-483-8-R-07
1143	745	82.9	Layered series, lying right on top of the breccia, contact is sharp, laminated white tuff, very friable	
11:48	740.1	82.1	Breccia and layered series are next to each other, possibly juxtaposed by a faults.	
11:48	736	112.9	Back into breccia from thin wite laminated area	
11:49	732	112	Layered series	
11:49	730		Back into breccia	
11:50	730.7	124.2	Collecting a small sample, a clast from breccia, with d=10cm, covered with slime, into blue box	NT0517HD-483-9-R-08
11:53	726.4	113.5	In the background you get the sense that there are alternating layers of tuff and breccia	
11:54	719	113	Dark clasts are gone, there is prominent lamination, we will be going up v-shaped notch.	
11:55	711	114	another breccia unit, lots of faulting.	
11:57	711	111	Vertical structure, possibly a dike that is at its maximum elevation, like it reached the surface.	
12:01	702	113	Stopping to look at a breccia zone	
12:06	690	108	Climbing up talus covered slope; lot of light colored gravel and cobbles mixed with darker pieces	
12:08	675	108	Beautiful outcrop of dark rock intruding white rock with layered stuff above. Sampling dark intrusion rock	NT0517HD-483-10-R-09
12:14	677	67	R-9 placed in basket; Start upslope again.	
12:15	672	108	Continuing upslope on dipslope	
12:17	667	109	Crest of local ridge, going along it now	
12:18	666	119	came over a lava flow and now going off ridge off bottom	
12:19	658	115	Seeing bottom again, in rough terrain of ridge after ridge; looks like mafic dikes, then looks like truncated pillows	
12:20	645	181	sampling looks like breccia deposits? Into blue bucket	NT0517HD-483-11-R10
12:26	645	188	looked like another rock may have gotten into bucket; probably in top of blue box?; nope, didn't get in, keep trying to get another piece; got one put behind blue box	NT0517HD-483-11-R11
12:28	637	142	underway upslope; irregular knobbly outcrop; breccias?	

12:31	639.9	123.5	Shark!	
12:32	638.6	140	traversing through very coarse breccia, maybe close to the volcanic eruption site, due to observations of today, very coarse breccias, feeder dikes.	
12:34	624	unk	orange crust in fractures and on surfaces of the breccia.	
12.36	614	119	x = 20.4,y = 112	
12:39	597	113	continuing through a covered interval.	
12:42	566	118	massive breccia, exposed by mass wasting	
12:43	562	119	crude layering in the breccia	
12:46	556.9	118.9	Sampling breccia, angular block, 20cm, placed behind blue basket	NT0517HD-483-12-R12
12:49	554.6	118	waypoint 4	
12:53	533.7	147	Layering is more aparent, note the absence of an rhyolite balloons	
12:56	518	140	Looks like lava flows, took a sample, very fractures, maybe 40 cm. Chevrons in one surface, in yellow basket	NT0517HD-483-13-R13
13:01	508	150	In a covered interval	
13:03	500.8	150.1	Fractured rock, still mostly covered, but with visible fractures filled with something, breccia is massive.	
13:06	473	155	bigger blocks	
13:08	461	153	bigger blocks of breccia	
13:09	456	153	Blocky lava flow or a dike, sample is round, with some iron staining on the outside, sample in front of the yellow box,	NT0517HD-483-14-R14
13:15	447.6	153	Way point 5	
13:19	433	153	More vent breccia	
13:30	429	153.1	Sample of blocky from bottom, has a starfish attached to the bottom, placed behind the blue box	NT0517HD-483-15-R15
13:26	414	156	Massive outcrop	
13:29	396	162	Massive outcrop, looks like there is some columnar jointing, and some spherical, placed in front of the yellow basket	NT0517HD-483-16-R16
13:32	393.7	153.1	chaotic large blocks	
13:34	389	151.3	Looks like a lava dome, large chaotic blocks with nearly black to rusty brown coating. The wall in this area was overhanging	
13:41	370	92.1	Completed planned dive, so now we turn east up ridge	
13:42	377	90	Encountered big blocks of rhyolite?	
13:47	378	167	Took a sample of large blocky rhyolite outcrop, has a couple of small sponges attached, placed behind the blue box.	NT0517HD-483-17-R17
13:57	361.4	129.4	Continuing up the ridge, seeing cooling joints, maybe a massive, welded tuff, with some volcanoclastic breccia	
13:59	365	131	Alternating layers of breccia and welded tuff	
14:00	354	130	Nice black sand with layering	
14:05	344.5	60.3	traversing across a big pumice covered slope	
14:07	343	61.7	traversing across a big pumice covered slope	
14:11	341	89.3	Still on the pumice plain, took a scoop sample of the pumice at location x=-327 y = -47, tube in the back was filled	NT0517HD-483-18-S2
14:35	334.2	73.7	still travelling on pumice slope, the grade is very gentle	
14:38	331	78	Completed the dive plan, now go east to look for dikes within the volcano. X=250, y = 250	
14:42	331	78	Shark!	
unk			reached new dive site	
1535	788	148	Nice looking dike with columnar jointing	

15:39	784	117	Used claw on wall of dacitic or rhylitic dikes, the claw ripped right through the material	
15:43	780	130	Very nice columnar jointing in a dacitic dike	
15:46	778	131	Attempting to sample dike, unable to get sample	
15:47	773	131	dikes intruding tuff? Breccia present at 800 m. Layers of tuff with some dikes.	
15:48	760	132	Clast increased in size during ascent	
15:49	740	150	Between this entry and the last there appears to be either a fault or a dike alongside breccia	
15:52	726	150	x =350, attempting to sample a columnarly jointed dike, placed in front of yellow basket. Large, flat sample	NT0517HD-483-19-R18
16:00	701	149.2	massive rocks	
16:03	678	150	Picked up loose rocks from a pile of rocks presumably from the steep wall, two samples were picked up in one grab, rocks 19 and 20. Both rocks are oblong. One rock is 2-3 times the size of the other.	NT0517HD-483-20-R19
16:03	678	150	Same as previous entry	NT0517HD-483-20-R20
16:13	664	129	Dropped a sample trying to get the scoop back in the box	
16:15	662.3	129.2	Began ascent	

5.4.5 Dive 484

Technical information:

Location: West Rota Seamount, inside caldera, northeastern slopes
Objective: map and sample stratigraphy of caldera slopes

DIVE 484	On bottom:		Off bottom:	
Time (local)	09:30		16:05	
Latitude:	14°	20.079'N	14°	20.747'N
Longitude:	144°	50.666'E	144°	51.400'E
Depth (m):	1391		642	

Samples returned: 17 rocks (one lost on ascent)

Representative images:

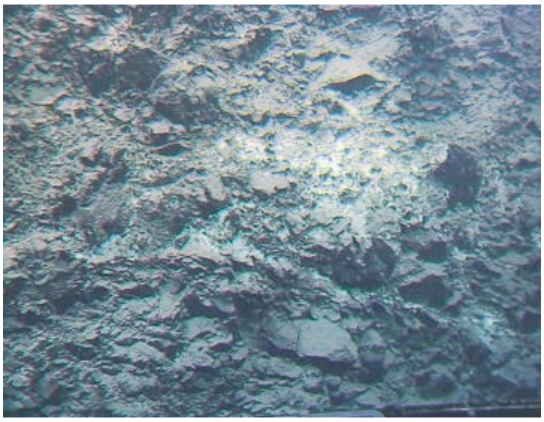
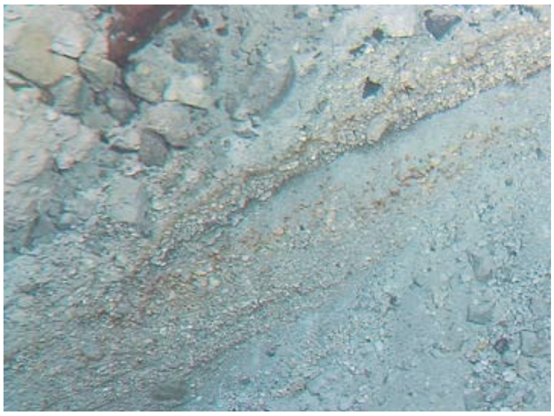



Fig. 484A(left): Contact between andesitic flow below andesitic breccia about 1350m depth. Sample 484-R1, a slightly altered pyroxene andesite, was collected here (hdc20051013095944_1). Fig. 484B(right): Poorly bedded felsic (pumiceous) ash at about 1300m depth. This may be an airfall deposit that settled through water (hdc20051013100939_1).

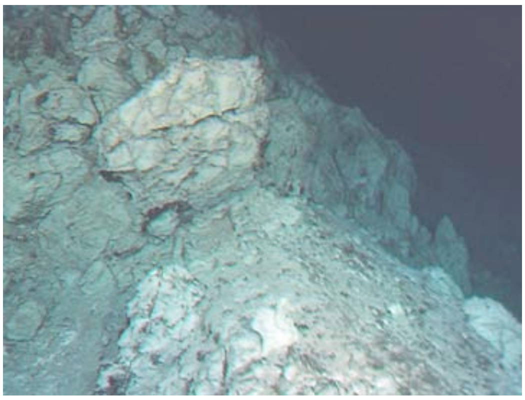
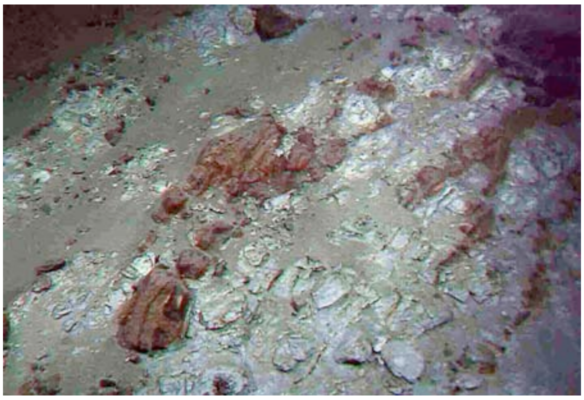



Fig. 484C (left): Hydrothermally altered igneous rocks, probably originally andesites, at about 1230m depth. These rocks have been bleached, indicating that nearly all of the Fe has been leached by hydrothermal solutions (hdc20051013110341_1). Fig. 484D (right). Resistant rib of red-brown, sulfide-rich stockwork at about 1260m depth (hdc20051013105447_1). HD484-R6 (Fig. 484F) was collected here.

Fig. 484E (upper left): Sampling at 484 Station 6, 1260m depth (red-brown sulfide vein shown in Fig. 484D; hdc20051013105706_1). Fig. 484F (right) cut surface of sulfide-rich altered andesite (484-R6). Note vein lining of chalcopyrite and abundant disseminated sulfides. Fig. 484G (lower left): close-up of chalcopyrite lining cavity in 484-R6.

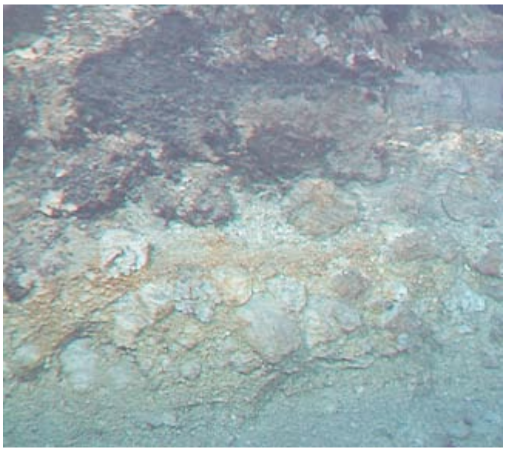


Fig. 484H (left): Weakly layered dacitic pyroclastics at about 740m depth. Probably deposited by settling of pumice and ash through the water column (hdc20051013135508_1). Fig. 484I (right): dacitic pyroclastic flow deposit overlain by breccia with large proportion of mafic clasts (hdc20051013135834_1).

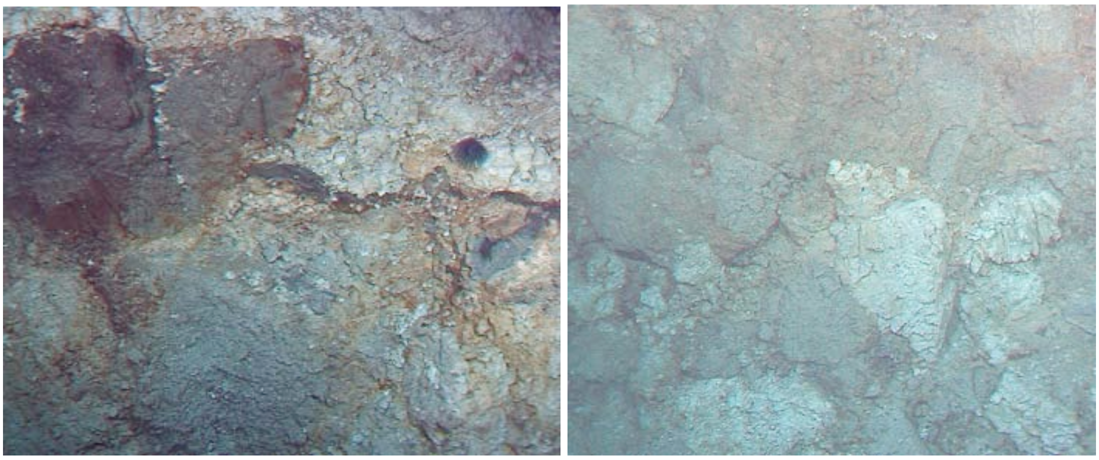


Fig. 484J (left): Basaltic lava flow (left; ~50cm thick) and basaltic hyaloclastite (right; a few centimeters thick) between dacitic pyroclastic flow deposits at about 705m depth (hdc20051013140811_1). Dark feature above hyaloclastite is a sessile animal. Fig. 484K (right): Detail of dacite pumice pyroclastic flow at about 690m (hdc20051013141005_1).

Fig. 484L (left): Rhyolite balloon", about 1 m across, at about 630m depth. Note crude columnar jointing developed perpendicular to cooling surface and individual columns that have spalled off (hdc20051013152510_1). Fig. 484M: Detail showing the vesicular interior of rhyolite balloons at about 630m depth. For scale, manipulator claw is about 10cm long (hdc20051013141005_1).

<u>Scientific summary:</u>

The lower part of the dive (deeper than 1250m) examined two faults inferred from MR-1 sonar backscatter images, which trend ~NNW-SSE. The lower part of the investigated section (up to 780m) is dominated by 2-pyroxene andesite (Fig. 484A) and minor basalt; at least these were most amenable to sampling with the ROV manipulators. Pyroclastic rocks become increasingly important upwards in the section, first appearing at depths of about 1300m (Fig. 484B). This is the deepest that we found felsic pyroclastics and this appearance may mark the early stages in the evolution of a felsic magmatic system, which becomes increasingly impressive up-section in the volcano.   An important zone of alteration and pervasive sulfide mineralization was encountered between 1250 and 1100m depth, similar to that observed during HD482 but at greater depth. The section about 1250m depth exposed very bleached igneous rocks (presumably andesites originally; Fig. 484C) and resistant ribs of reddish-brown material (Fig. 484D). The reddish-brown ribs mostly are oriented sub-vertically and were only observed in the bleached rocks. One of these was sampled (Fig. 484E) which proved to be very rich in sulfides, especially chalcopyrite (Fig. 484F,G), set in a fine grained grey matrix that is probably silicified. The red-brown, resistant ribs in the bleached zone represent stockwork mineralization associated with a vigorous hydrothermal system. We are not sure what is the significance of our observation that relatively fresh andesites occur at depths below the 1250-1100m zone of intense hydrothermal alteration and stockwork mineralization. It may be that this reflects downfaulting of the section west of the two NNW-trending faults or may indicate stratigraphic control of the alteration zone.

Andesites flows were encountered as shallow as 775m but pyroclastics become increasingly dominant at depths shallower than 850m. These units are poorly indurated and individual clasts disintegrate when grabbed by the manipulator. This suggests eruption and rapid quench-hydration in seawater. The interpretation of submarine eruption is consistent with the fact that none of the pyroclastic units are welded (ignimbrites), in spite of the fact that the thickness of units and the large size of some pumice clasts indicates proximity to the vent. These include weakly layered units of ash and pumice, which we interpret as due to settling of pyroclastics out of the water column (Fig. 484H). Thick dacitic pyroclastic flow deposits are also common (Figs. 484I, K). We also noted basaltic volcanism interlayered with the dacitic pyroclastics, although basalts are less common on the NE caldrea wall than found during HD 482, closer to the inferred eruptive vent. Fig. 484J shows a basalt flow on the left and an associated layer of basaltic hyaloclastites on the right.

The uppermost unit is dominated by large (up to 1m or so) irregularly rounded bodies of rhyolite (Fig. 484L). When their interiors are exposed, radial columnar jointing is seen and a close look revels abundant large vesicles (Fig. 484M). We interpret these as rhyolite “balloons”, which formed by eruption of viscous, volatile-rich magma at ~500m depth in the ocean. The process may have been similar to the formation of pillow basalt, with the exception that the low-density pumice balloons rose away from the vent. Continued exsolution of magmatic volatiles and perhaps trapped seawater may have caused the hot rhyolite magma blobs to expand beneath quenched rinds. Moderate hydrostatic pressure may have impeded explosive vesiculation and fragmentation, allowing the balloons to be preserved rather than completely fragment. These blobs would likely have cooled quickly, allowing seawater to be absorb into the vesicles and increasing the density of cooling balloons so that they quickly sank back to the seafloor. Similar balloons with radial columnar jointing have been observed north of Hachijojima at water depths of ~600m (O. Ishizuka, personal communication 2005)

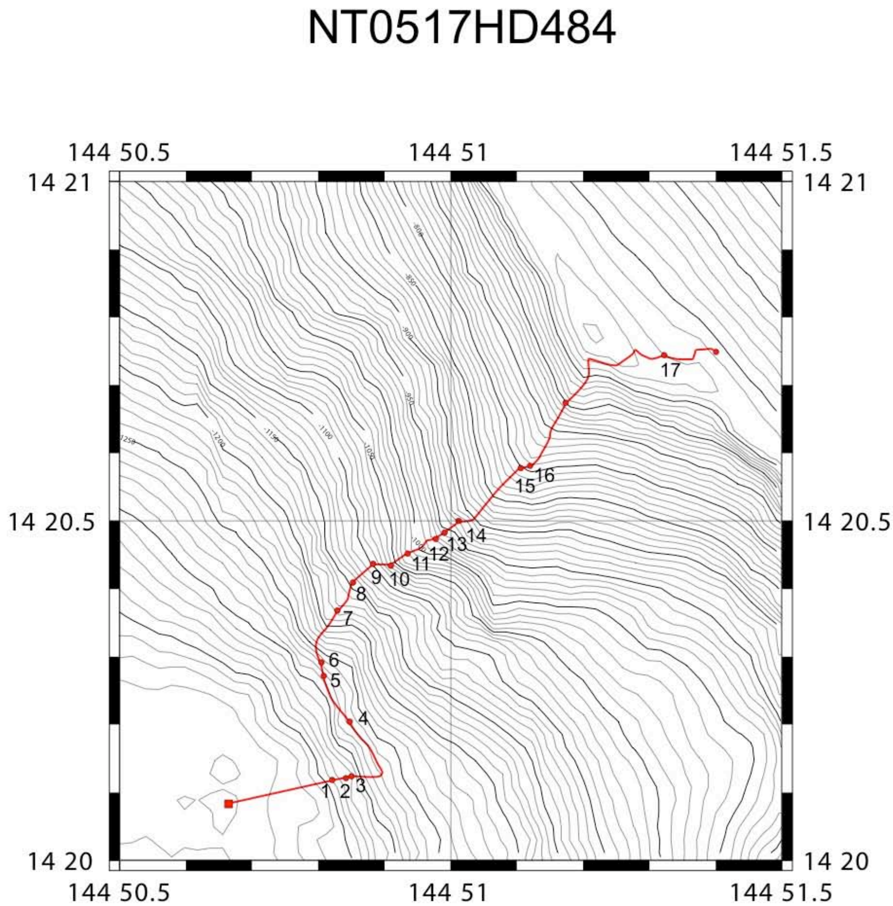


Figure 484N: Dive track and stations for HD 484

Table 484A: Dive Log NT0517HD484

Time (local)	Depth (m)	Vehicle Hdg	Notes	Sample #
8:39	42.5	89.3	Vehicle on descent	
9:30	1391.3	87.5	Reached floor, floor is lightly colored with scattered large, angular clasts. There are depressions around the stones.	
9:38	1377	83.1	Pumice, with ripples	
9:39	1376.4	484	Possible hydrothermal seep, does not look like it is still active.	
9:44	1364.3	84.4	Slope is increasing, with a greater proportion of the surface covered by large rocks.	
9:46	1353	94.1	Talus slope consisting of many different lithologies	
9:47	1349	87	Massive, broken up, outcrop, with some staning in a horzontal line of white. The rock type is probably andesite	
9:49	1350	64	Trying to scratch the outcrop with the manipulator, waiting for the ship to catch up to the ROV. Manipulator is able to break of a very small piece. It appears this is not a vein. No sample collected	
9:56	1348	54	Collected sample 1 from below the white horizon in outcrop of andesite	NT0517HD-484-1-R-01
9:58	1344	70	Continuing up-wall, possible pillows, with pervasive fracturing. With at least 2 white layers, maybe dipping to the right	
10:01	1332	69	Maybe a scarp, with a talus slope of fresh, poorly sorted clasts of rhyodacites, andesites, possibly some hydrothermally altered rocks.	
10:03	1315	84	In the distance we can see a second scarp, with high relief, heading east to check it out.	
10:05	1314	85	Sampling the talus slope, photo at 100534, big sample, photo at 100605, going behind the blue basket.	NT0517HD-484-2-R-02
10:09:00	1303	76	A landslide deposit with exposed layering in tuff. Photo taken of landslide deposit	
10:09:40	1300	74	Close ups of landslide (4 photos)	
10:12	1297	74	Hydrothermally altered andesite or dacite in place	
10:14:20	1294	73	Close up of diamictite, collecting a sample. Dark angular clast from the landslide deposit. There is white alteration on one edge and rust staining around the middle. Sample is behind the blue basket. -x = 568, y = -354	NT0517HD-484-3-R-03
10:25	1259	327	Slope appears to be 10°	
10:33	1258	318	Possible layering within pumice	
10:37	1258	50	Sampling out of a talus slope, going for a clast of what looks like a piece of pie. There is an interesting texture on the back, very orange. Placed behind the blue box	NT0517HD-484-4-R-04
10:40:32	1257.1	322	Very steep talus slope	
10:43	1269	357	Very steep wall, appears to be some outcrop, rock surface looks like there was alteration	
10:48	1276	359	Zooming in for a close look at talus blocks	
10:50	1277.5	358	Collecting a sample of talus, trying to determine whether it is pumice or andesite. Crinoid walking around!	
10:51:48	1277.4	369.7	~20 cm rock, that the claw was unable to scratch, into the yellow basket	NT0517HD-484-5-R-05

10:54:39	1266.9	329	Large outcrop of hydrothermally altered pillows, with very dark brown staining or veins through the outcrop. Black veins that are sulfide rich, took a sample of dark material.	NT0517HD-484-6-R-06
11:00	1249	329	Continuing through large outcrop of massive andesite, seems to have more of the sulfide rich veining. Similar to the altered rocks we saw on 482, but different. Brown areas may be sulfide dominated ones.	
11:00	1247	329	Big wall of chaotically altered rocks with some layering, and some vertically oriented veins.	
11:02	1229	359	Continuing through hydrothermally altered rocks	
11:05	1210.7	29	On top of a flat plain with ripple marks, we turned right a bit before reaching point 3.	
11:06	1203	29.3	Still going through outcrops of very altered rocks	
11:11	1178	353	Collecting sample of ?andesite? Overlying the altered rocks. Dark colored, small sample with some red staining on the outside. Placed in the yellow box	NT0517HD-484-7-R-07
11:13	1174	29	brecciated top rock, looks in place above alteration zone	
11:15	1164	28	travelling across a smooth plain with ripples in the sand, saw two jellies and a ray	
11:17	1148.1	30.9	Occasional outcrops of dark materials, but mostly talus	
11:18	1133.3	38.1	Breccia outcrop of andesite, outcrop is highly fractured, sample volunteered, fell in the box, was placed in the front of the yellow basket	NT0517HD-484-8-R-08
11:23	1131	39.9	continuing upslope on the brecciated andesite	
11:27	1103	41.1	approaching point 4, continuing up through blocky andesites with some covered intervals. There may be some dikes	
11:31	1093	10	Sampling andesite from an outcrop. First attempted sample rolled downhill. Second sample that is shaped like africa. Placed in front of the yellow box.	NT0517HD-484-9-R-09
11.39	1083	70.8	reached point 4, headed for point 5	
11:40	1078.4	68.9	Hot pink, bioluminescent creature, with very long tentacles, totally amazing little thing, cilia moving luminecsed (cydippid ctenophore)	
11:42	1063.4	57.5	More massive andesite	
11:44	1047	40	Sponges attached to a big boulder	
11:46	1041	67	dikes? In massive andesite	
11:49	1043.7	50.7	Outcrop of massive andesite or maybe dike. Sample is large with iron staining on largest side, and what look like biological material on the top. Placed in blue box.	NT0517HD-484-10-R-10
11:54	1044	51	closeup of the adesite wall	
11:59	1023	60	Contact? A breccia overlain by a massive flow	
12:03	1004	58	More andesite	
12:04	1001	56.4	blocky outcrops in the midst of a covered interval, stopped at one that looked like it might be dike, due to the prescence of jointing and a horizontal layering pattern. Took sample of 'dike material', in a piece shaped like california. Picture taken at 12:08:06, placed in the box in front of the yellow box.	NT0517HD-484-11-R-11
12:13	991	54.3	reached a flat, covered interval between two layers of blocky outcrops of fresh looking andesite	
12:17	963	58.1	brecciated andesite	
12:21	960	25	sampling andesite blocks; 12:22.56, put in blue container; iron staining on some blocks, looks like a bit of jointing on some?	NT0517HD-484-12-R12

12:27:19	936	51	some veining, fractured volcanic or volcanic breccia;may be a dike, lot of orange coatings on surfaces	
12:29:45	936	57	positioning to sample what may be a dike; looks massive, extensive orange coating on fractures; piece taken at 12:33:57; dacite?	NT0517HD-484-13-R13
12:42	913.2	73.5	sampling dacite material - triangle shaped	NT0517HD-484-14-R14
12:54	892	47.9	dike cutting through massive breccia and then a sharp contact between coarse and finer breccia	
12:56	881	45.2	still in coarse breccia	
12:59	861	40.2	dike on right	
13:00	857.7	43.1	back into breccia	
13:12	795.2	27.4	still in breccia	
13:13	796.7	51.3	Stn 15 sampling vertical dike - mercedes symbol on one face	NT0517HD-484-15-R15
13:20	788.6	24.2	talus slope with block of dacite	
13:21	782.6	19.7	massive breccia (or flow?) with many corals on surface	
13:27	776.1	19.4	attempt to break off sample from massive dark unit with orange alteration and tubular organisms	
13:33	776.5	354.7	Stn 16 sampling rock from massive breccia unit	NT0517HD-484-16-R16
13:37	776	358.4	We are out of the breccia and into a dike unit. We can see the domed surface of dike, covered with corals and sponges	
13:40	773	32	we are at way pt 6 heading to 7	
13:43	769.7	20.3	ascending talus slope	
13:49	748	14.4	slope becomes more shallow and we are traversing breccia debris	
13:53	740.3	29.5	vertical wall with layers of pumice	
13:58	732.1	66.9	coarse breccia	
14:01	728.1	36.1	wall of layered material	
14:03	724.8	35.9	moving up through the breccia wall	
14:04	719.2	19.1	pumice layer - very extensive	
14:06	709.6	20.2	into breccia or tuff unit	
14:08	704.6	20.2	dark layer within unit - seems to be orginating from a large mafic block - possibly an intrusion	
14:14	694	30.7	traveling upslope and another dark layer is encountered - possibly a sill	
14:17	678	30.8	pumice layer	
14:27	634	8	pumice rubble - no layer cake stratigraphy	
14:32	618	30	On slope looking at rhyolite and pumice, near rim of caldera	
14:39	618.7	49.4	end of official dredge track and we will head SE to study the rhyolite balloons	
14:50	621	4.9	heading to top of the ridge, then following it to the SE	
15:11	623	49.8	rhyolite balloons are getting bigger so perhaps we are getting closer to the source	
15:15	627	80.7	broken off columns from rhyolitic boulder	
15:28	628.1	49.4	sample of rhyolitic column - sample broke up into several pieces	NT0517HD-484-17-R17
15:33	628.1	49.4	column rubble is also put into front scoop container	
15:48	631	315.8	close up view of the rhyolitic boulder	
15:55	641	130	another close up view of the rhyolitic boulder	
16:05	642	150.4	end of dive - heading up to surface	

5.4.6 Dive 485

Technical information:

Location: Chaife Seamount, northern flanks
Objective: map and sample lava distribution on Chaife Seamount, examine exposures on fault cutting volcano, recover primitive lava compositions

DIVE 485	On bottom:		Off bottom:	
Time (local)	09:40		15:41	
Latitude:	14^{o}	40.600'N	14^{o}	39.312'N
Longitude:	145^{o}	00.526'E	145^{o}	00.454'E
Depth (m):	2308		1684	

Samples returned: 20 rocks

Representative images:

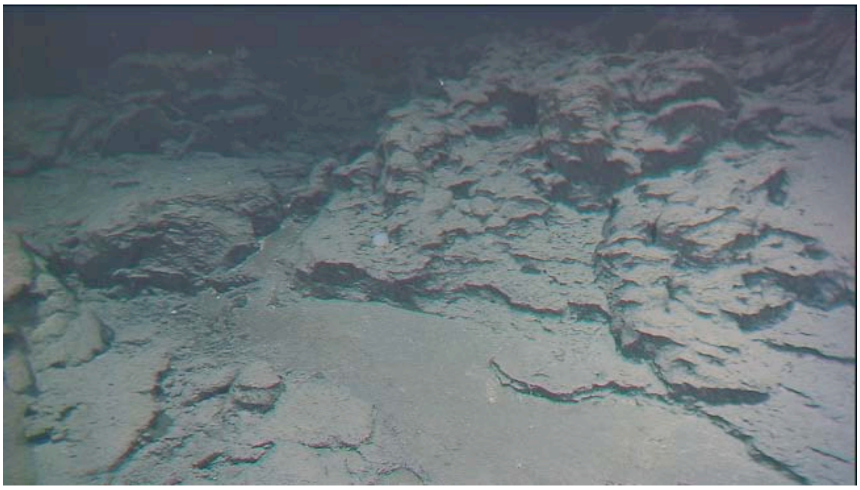


Figure 485A: lower slopes of the northern end of Chaife Seamount (image hdc20051014094216_1)

Figure 485B: mid-slopes of the northern end of Chaife Seamount (image hdc20051014142357_1)

Scientific summary:

Chaife Seamount is a small volcano located on the Mariana magmatic front. It is located at the arc end of a cross-chain of seamounts that extend roughly along 14° 35' N latitude. Unlike the Guguan cross-chain there is no large arc volcano associated with the 14° 35' cross-chain. Adjacent to Chaife (~1 km to the south) is a larger volcano labeled "Mt. Manganese" by the Cook 7 science party in 2001.

Recent EM3 side-scan data show that Chaife appears to be built on top of a large NNE striking fracture. This fracture may also cut into Chaife, indicating rifting and magmatism occurred over the same time interval. The fracture also bisects the northern flank of "Mt. Manganese". Side-scan imagery also shows a smaller cone, "Little Chaife" on Chaife's eastern flank.

In 2001, the Cook 7 cruise aboard R/V *Melville* dredged Chaife (D14) and recovered samples of picritic and ankaramitic lavas. Analyses of these lavas indicated they were primitive, with Mg#s >70 and MgO contents of ~15 wt%. These lavas also had Indian Ocean-type mantle isotopic signature and subdued arc-like trace-element signatures. These lavas erupted 2.18 and 1.79 Ma. based on Ar^{39}/Ar^{40} dating. Melt inclusion analyses indicated that the lavas' parental melts had ~17-18% MgO and were relatively anhydrous with 0.3-0.5 wt% water.

Hyper Dolphin Dive 488 landed on the northern flank of Chaife and traversed upslope SSW along the western side of the fracture zone and intersected the track of Cook 7 Dredge 14 along the western flank. *Hyper Dolphin* then continued along the D14 track SE towards the summit.

Hyper Dolphin encountered steep slopes of blocky lava flows alternating with gentler slopes covered with sediment. The blocky flows in many locations had ~0.5 to 1 meter rounded protuberances suggestive of pillows. The lava flows were very competent and difficult to sample directly, probably in part due to significant growth of manganiferous crusts. Many separated clasts were cemented to the flows by manganese. Several outcrops with a "lumpy" surface were likely breccias. At 2124 and 1940 meters depth steeply dipping, NNE striking fracture surfaces (likely fault scarps) were observed.

Twenty rock samples were recovered. Samples R1-R4 collected on the lowest slopes were plagioclase-CPX phyric basalts. Most of these lavas displayed alteration rinds of 1 to 4 cm and several had interior alteration zones. The next lava flow contained largely olivine and CPX phyric basalt with little to no plagioclase phenocrysts. Manganese crust was thickest here. Further upslope (~2050-1876 meters) the next flow contained picritic and ankaramitic lavas (R11-R16) similar to those sampled by the Cook 7 cruise. This flow was part of a ridge that extends into the region dredged by Cook 7. Flow morphology was similar to that on the lower slopes, but also contained vesiculated sheet flows. The lavas on the upper slopes of Chaife (1896-1686 meters) were largely aphyric and altered.

NT0517HD486

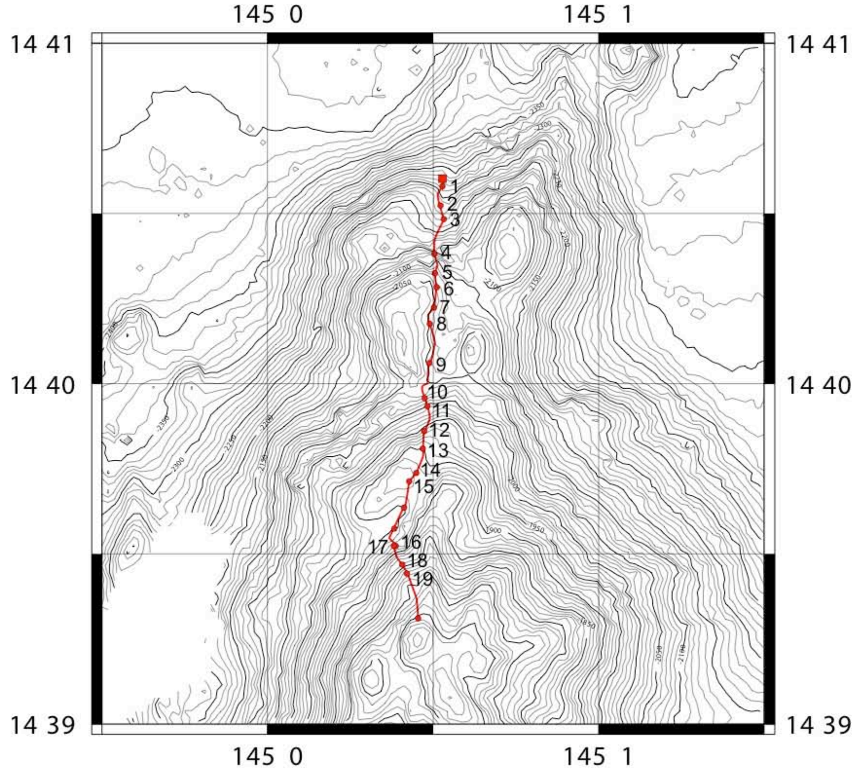


Figure 485C: Dive track and station locations for Dive 485

Table 485A: Dive Log NT0517HD485

Time (local)	Depth (m)	Vehicle Hdg	Notes	Sample #
8:15			in water & begin descent	
9:40	2308	178	Bottom. Sheet or pillow flows? Clearly flows. Not really any Mn.	
9:47	2310	150	Sampling the sheety flow. Having trouble finding a rock that can be pulled from the flow. No sample taken. Moving on to find a looser rock to take.	
9:56	2305	178	Attempting a sample. Again, nothing loose enough.	
10:07	2296	181	Moving up the slope. Relatively gentle grade. Still trying to get a sample every once in a while. Looks like Pahoehoe. Clearly not a lot of explosive eruptions, lack of hyaloclastics.	
10:09	2296	187	Sample taken from sediment. Essentially in place though.	NT0517HD485-1-R01
10:14	2275	180	Moving up slope, calling them sheet flows but also plenty of pillow-like structures.	
10:22	2256	173	Sampling from a pillow outcrop. Seem to be fairly small pillows (~ 20cm diameter). No luck getting a sample.	
10:30	2249	200	Small sample (~10cm). Maybe with some Mn?	NT0517HD485-2-R02
10:31	2249		Sample from same location.	NT0517HD485-2-R03
10:42	2241	196	Sample from pillowy/sheety flow	NT0517HD485-3-R04
10:55	2196	181	Looking over sheet flows for more sampling possibilities	
11:04	2180	164	Sample from pillow. Lots of Mn.	NT0517HD485-4-R05
11:15	2124	246	Another sample from pillow-like feature	NT0517HD485-5-R06
11:18	2104	175	Coming across a wall that may be a fracture surface.	
11:24	2073	174	Sample with Mn coating, but nice igneous center.	NT0517HD485-6-R07
11:32	2047	235	some sort of orientation to the blocks, so perhaps it is a flow. It looks to be loose, but it is not.	NT0517HD485-7-R08
11:40	2050	199	Transit to north slope. Smooth slope, not much outcrop. Sparse with lots of sediment. Moving up central cone of "Chaife proper".	
11:46	2049	212	Sampling from pillow flow along the slope. Proving to be difficult. Mn crust on this one as well.	NT0517HD485-8-R09
12:01	2066	179	Transit to another slope. More outcrop on this slope. Sample from blocky flow.	NT0517HD485-9-R10
12:12	2052	221	Transit. Now on an east-facing slope. Covered in pillows or loose blocks.	
12:25	2055	170	Sampling from what may be pillow flow, but it is fairly loose. Talus slope?	NT0517HD485-10-R11
12:29	2039	172	Large outcrop of blocky flow. May be very different from what has already been seen today. This region seems to be more pillow-like than the other outcrops. Perhaps more basaltic.	
12:38	2016	169.4	stn 11 small sample from flow	NT0517HD485-11-R12
12:42	1985	154.7	traveling upslope through sheet flows	
12:50	1971	175.5	sample attempt in blocky lava section	

12:57	1964	170	moving up an essentially vertical wall of blocky lava - small pillows? Very difficult to sample	
13:08	1940	160.8	stn 12 sample of blocky lava with orange coating dropped into blue box	NT0517HD485-12-R13
13:12	1926	163	brecciated material - possible fault zone?	
13:15	1917	204	way pt 2 - interesting sponge	
13:22	1903	212	Sample of pillow. St. 13	NT0517HD485-13-R14
13:33	1893	198	Sample with fair amount of Mn crust.	NT0517HD485-14-R15
13:41	1879	188	Sample of flow fragments. A lot of sediment. Vesicular with lots of Mn.	NT0517HD485-15-R16
13:46	1890	183	Transit	
14:02	1903	156	Heading towards WayPoint 4	
14:07	1896	160	Looks like very small pillows. Attempting to sample.	NT0517HD485-16-R17
14:17	1877	148	Trying to sample a grapefruit sized pillow. Difficult to pull from flow.	NT0517HD485-17-R18
14:25	1850	115	Very large outcrops of the small pillow lavas.	
14:45	1800	141	Sampling mini-pillow. They are very well attached to each other.	NT0517HD485-18-R19
14:56	1769	159	stn 19 rounded lava block sampled from flow	NT0517HD485-19-R20
15:00	1751	159.1	traversing a fairly extensive sedimented region	
15:12	1740	138.1	back into outcrop	
15:31	1709	172.2	ascending slope	
15:39	1684	170	ridge of lava	
15:41	1684	170	Off Bottom	

5.4.7 Dive 486

Technical information:

Location: south of Chaife Seamount, north slopes of Mt. Manganese
Objective: traverse fault cutting southern Chaife and northern Mt. Manganese to sample volcanic sequence

DIVE 486	On bottom:		Off bottom:	
Time (local)	10:38		16:02	
Latitude:	14^{o}	38.252’N	14^{o}	37.393’N
Longitude:	144^{o}	59.974’E	144^{o}	59.404’E
Depth (m):	2184		1940	

Samples returned: 12 rocks, 1 scoop

Representative images:

Figure 486A: Rippled ridge at beginning of Dive 485 (image DSC00005)

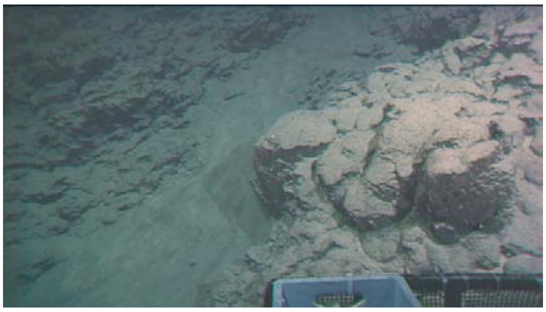


Figure 486B: Outcrops and a sediment chute on the steep west-facing scarp cutting the northern slopes of Mt. Manganese (image hdc20051015141539_1)

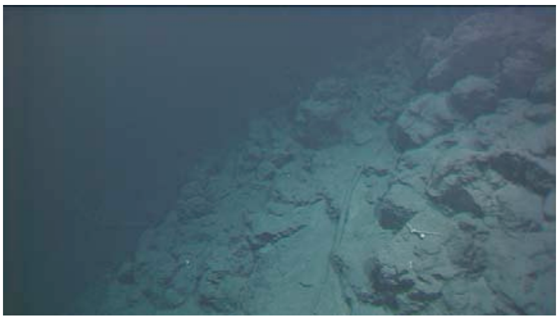


Figure 486C: Steep fault scarp cutting the northern slopes of Mt. Manganese, looking roughly south (image hdc20051015151200_1)

Scientific summary:

Mt. Manganese is the name given by the 2001 Cook 7 science party to a magmatic front seamount due to heavy Mn crust that prevented sampling of rock via dredging. More recent EM3 side-scan bathymetry shows the existence of a NNE striking fracture or rift zone that bisects the northern flank of Mt. Manganese. The side-scan imagery also shows several cone-like features in the “rift valley”.

Hyper Dolphin Dive 486 landed on the flat, sedimented valley floor at 2184 meters. Observed on the flat valley floor were darker, slightly raised surfaces trending NNW-ESE. These 1-3 meter wide strips, parallel to one another, contained darker sediment than the valley floor base and contained small-type dunes. Dune shapes indicated that flow was to the NNW. Interestingly, sediment disturbed during sampling was observed becoming entrained in a strong SE flowing current. It is possible there are strong tidally controlled currents flowing over the bathymetric sill in the area.

Hyper Dolphin then climbed the first of two cones along the planned dive track. This cone consisted of talus, sediment and Mn-encrusted lava flows. The lowest slopes were covered by what appeared to be a debris flow deposit. The sediment had been strongly eroded into shapes reminiscent of continental “badlands” topography, although it was suggested that the rounded depressions and pinnacles surrounded by “moats” could be drain-out pits like those observed on mid-ocean ridges. Also observed were finely layered dark sediments, possibly indicating that the cone is in part composed of tephra. The second cone was of similar composition, but significantly less eroded. Lavas sampled from these cones were basaltic with heavy alteration and most were (R3-R6) were clasts in breccia. The matrix of the breccia appeared to be Mn crust and mixed lithology sediments, which indicates that the breccias themselves are epiclastic and not volcanic in origin. One sample from the second cone (R8) could be ankaramitic; exact determination awaits further analysis.

After sampling the second cone, *Hyper Dolphin* flew over to the western scarp of the rift valley and began traversing to the south (along-strike) and up the east-facing surface. The scarp was very steep and consisted largely of blocky lava flows, although breccias were present. Some jointing, including poorly formed columnar joints and radial joints indicative of pillows, were observed. The outcrop rock was competent and Mn-coated and thus difficult to sample *in situ*. Samples successfully recovered were breccias fragments found loose in sediment. The basaltic clasts in the breccias had varying amounts of alteration and most were pyroxene-plagioclase phyric basalts. Although abundant lava flows were observed at the top of the scarp and the upper slopes of the seamount, direct sampling of these was unsuccessful. Samples that were recovered were found to be slabs of Mn-cemented sediment. No intermediate or felsic rocks were observed and it may be concluded that Mt. Manganese is comprised of mafic lavas. The cones on the rift valley floor appear to be volcanic in origin and some lavas erupted from these may be primitive.

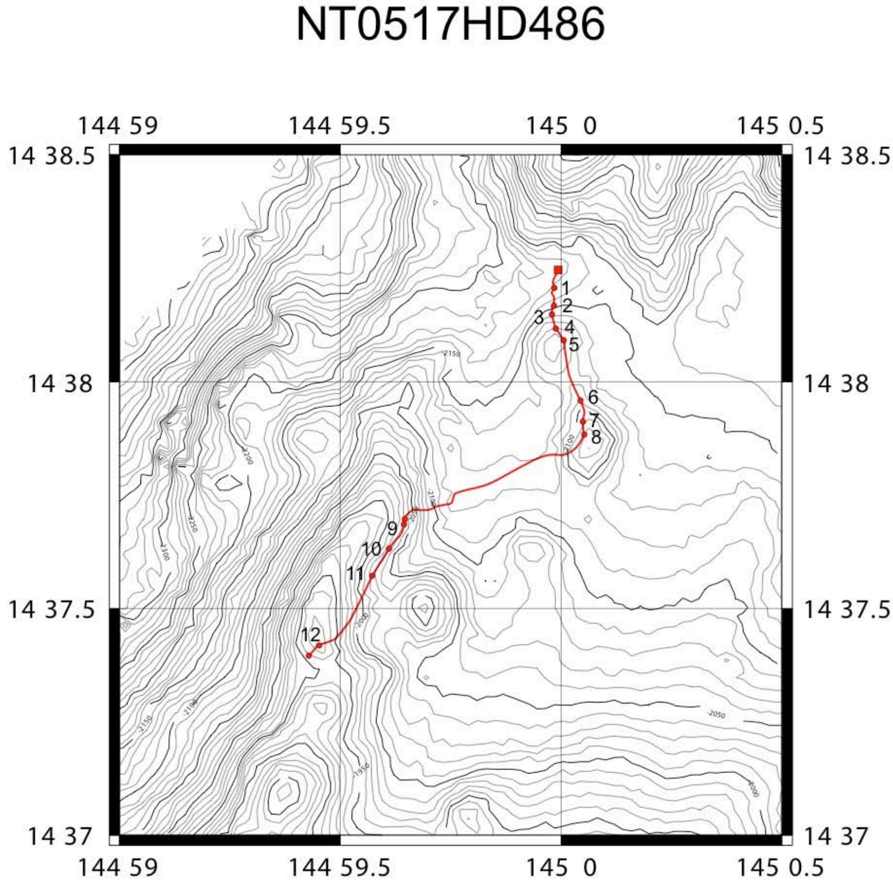


Figure 486C: Dive track and station locations for Dive 486

Table 486A: Dive Log NT0517HD486

Time (local)	Depth (m)	Vehicle Hdg	Notes	Sample #
8:20	1.7		Vehicle in the water	
8:39			Lost video, switched to bootup screen	
9:11			Vehicle back in the water	
9:15	5.3		I think they are checking the camera	
9:28	64.6	236	On descent	
10:38	2184	198	Looking at ripples in a a flat lying area,current ripples	
10:40	2183	184	Sediment flows a few meters across, with small dune features defined by altering dark and light sediments. Rippled areas are oriented E-W, manipulator tested, the sediment is very loose. There is a small dark clast in the sediment. Dune look generally symmetric	
10:45	2188	192	alternating between undisturbed, flat sediment, and rippled material, looking more like it is coming from the east.	
10:49	2180	213	Close up view of dunes, there are larger clasts(about two to three teeth on the scoop wide) of variable lithologies, dark brown, black, light grey, light brown, mostly angular that are visible on the surface.	
10:55	2179	212	Scoop sample, while scooping disturbed sediment reveals there is a SE flowing current. The scoop sample was placed in the front scoop box.	NT0517HD-486-1-S-01
10:58	2173	181	Continuing across rippled area, all ripples now with no flat areas	
11:00	2169	180	Reached the edge of a cone or block, with a debris flow at the bottom. There are much coarser fragments, some question as to whether this is outcrop or eroded debris, armored with manganese.	
11:03	2169	200	Small sample of debris flow, likely Mn armored, placed in yellow basket	NT0517HD-486-2-R-01
11:04	2168	199	Continuing upslope, looks like a deposit that has been eroded away	
11:05	2161	200	alternating between undisturbed, flat sediment, and rippled material, looking more like it is coming from the east.	
11:11	2154	171	Sampled debris flow beneath sheet flow.	NT0517HD-486-3-R02
11:14	2142	179	Moving along a large pile of Mn encrusted sediment.	
11:23	2131	238	Large sample of Mn coated lava. Placed behind blue box.	NT0517HD-486-4-R03
11:24	2122	180	The surface is more rugged still looks like Mn-armored material, increased number of corals, usually two to three in each frame	
11:29	2116	180	Unable to sample due to strong Mn armoring on a steep slope of reddish-brown material	
11:32	2114	194	There is a depression ahead to the right, possibly a drain-out pit similar to those found in Mid-ocean ridges?	
11:36	2114	213	Possible dike on the left side of the screen	
11:36	2115	212	attempting to sample, most possibilities are too strongly attached or are crushed in the manipulators grasp, abandoned attempt	

11:47	2115	208	Sample taken from beneath a horizontal ledge, one side is lumpy, with reddish brown colored placed behind the blue basket. Sample is a large, flat, oval.	NT0517HD-486-5-R04
11:48	2115	207	Zoomed in on layers beneath ledge, alternating dark and light layers, of unknown scale but small.	
11:48	2021	215	We reached the top of the mound, the ground is falling away from the ROV.	
11:52	2121	221	Possible outcrop of dark brown material partially draped by white sediments	
11:58	2124	324	Attempting to sample from a nearly vertical wall of rounded brown rocks, partially draped by sediments, unable to get anything.	
11:59	2121	210	Alternating between undisturbed, flat sediment, and rippled material. Similar to what was seen on the north slope	
12:05	2132	177	Boundary between rippled material and rounded brown rocks	
12:17	2127	181	Flying through rounded blocky material that looks armored with Mn.	
12:25	2125	353	Trying to sample from a partially sediment covered outcrop, very difficult to get a piece. Abandoned attempt	
12:30	2121	171	Still in the soft sediment draping outcrops of dark rocks	
12:32	2119	189	Little to no sediment cover, outcrop has many small pieces	
12:38	2120	215	A rounded sample of Mn coated lava. Dark brown, taken from a nearly vertical wall of rounded, blocky material. There is some red staining on one side. Placed in the yellow basket.	NT0517HD-486-6-R05
12:42	2120	215	Sample of Mn-coated lava, with one side shaped like a chair, much larger than the previous sample, placed in the yellow basket.	NT0517HD-486-6-R06
12:44	2115	180	Passed over a small rippled plain, to another blocky looking outcrop	
12:50	2099	182	Out onto a rippled plane	
12:52	2102	86	Approaching an outcrop of a flow the has a knobby appearance.	
12:55	2102	86	Pulled a sample out of the sediment at the base of the outcop noted in previous entry, small sample, has a dark brown crust, lots of biological material on the outside. Placed in the yellow basket.	NT0517HD-486-7-R07
13:03	2087	169	Continuing up the flow slope	
13:07	2084	145	Sample with crust. Placed in blue box (?)	NT0517HD-486-8-R08
13:11	2079	240	transit	
13:55	2034	197	End transit	
13:57	2040	252	Appears to be a scarp, on the side of the rift	
14:04	2042	265	Attempting to sample, picked up a small sample at the base of an outcrop, sample is black, placed in the blue basket.	NT0517HD-486-9-R09
14:07	2037	211	Continuing on our way, the surface is similar to what we have seen earlier in the day.	
14:19	2026	264	A rounded outcrop of Mn-covered lava? Broke off a rounded piece, the sample is ovoid shaped, dark brown.	NT0517HD-486-10-R10
14:23	2030	209	Looks very steep	
14:24	2033	192	Steep outcrops of rounded flows	

14:40	2033	261	We have continued up slope along a series of rounded flows, attempting to sample. Have been trying for the past twenty minutes to obtain a sample.	
14:43	2034	257	Scarp face, Mn crust into the blue basket	NT0517HD-486-11-R11
14:45	2030	228	Passing over a sediment covered area, there are alternating areas of outcrop and sediment covered areas along this traverse.	
14:56	2017	214	sediments lowing between two flows. Nice pictures here	
14:58	2007	209	Traversing sediment covered basalts	
15:01	2005	250	Pried off a piece, exposed the crust and a core of deeply altered rock. There has been no obvious change in rock type as we have proceeded up the fissure. On some outcrops were there is a vertical exposure with some evidence of columnar jointing.	
15:21	1963	222	Continuing upslope, slope is a bit shallower, outcrop similar to all those we have seen today.	
15:22	1957	221	Pillows? Some radial faces	
15:27	1956	277	Pried a crust off of the outcrop, exposing what looks like more manganese	
15:35	1948	236	Tried pushing against the sediment to break a rock free, did not work.	
15:38	1932	235	Very steep outcrop	
15:45	1931	182	Sample pried loose from outcrop, possibly a dike, placed in the blue basket.	NT0517HD-486-12-R12
15:47	1933	219	Look like pillows	
15:56	1943	198	Attempting to sample, picked up a large crust of Mn	
16:02	1940	263	On ascent	

5.4.8 Dive 487

Technical information:

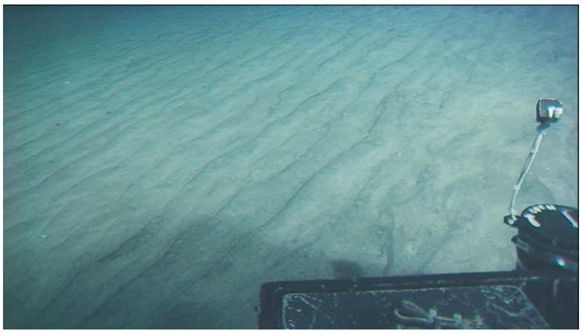
Location:	Giant sediment waves southwest of Esmeralda Bank
Objective:	examine characteristics of giant sediment waves, sample for grain size and compositional analysis

DIVE 480	On bottom:		Off bottom:	
Time (local)	09:22		15:52	
Latitude:	14^{o}	52.137'N	14^{o}	52.637'N
Longitude:	145^{o}	11.591'E	145^{o}	12.632'E
Depth (m):	1485		1269	

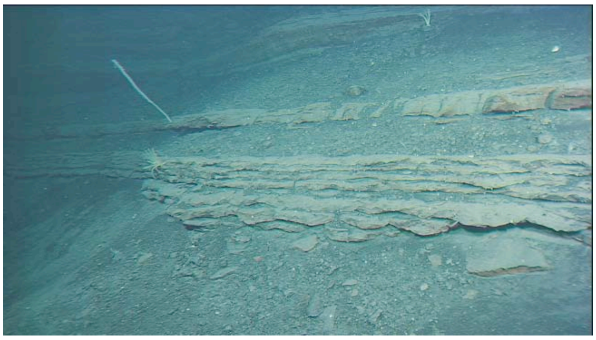
Samples returned: 4 scoops, 2 cores, 5 rocks (one lost on ascent)

Representative images:

Picture 1: Ledge-like outcrops in lower slopes of western dune form (image hdc20051017100930_1)



Picture 2: ripples near crest of western dune form (image hdc20051017113000_1



Picture 3: Outcrop of thin-bedded material in lower slopes of eastern dune from (image hdc20051017144154_1)

Scientific Summary

The primary goal of HD-487 was to obtain seafloor data on a set of giant sediment waves (GSWs) on the SE flank of Esmeralda volcano. These GSWs are among the longest wavelength and highest amplitude of those mapped to date on Mariana volcanoes. The traverse began at the base of the downslope facing steeper face of one waveform and ended at the rim of a second wave. The seafloor at the landing site (1484 m) consisted of volcaniclastic sand with a crust that was often partly or mostly eroded away. Some sessile organisms (sponges, etc.) colonized the scattered remnants of the crust. Samples of the crust, rocks and sediment (S01, S02, S03) were taken at intervals on the slope of the first wave and at its top (S04). The seafloor within the flatter trough of the GSW was primarily rippled volcaniclastic sand. A sample of this material was taken at S05. The downslope-facing face of the second wave had several bands of outcrops of what visually appeared to be semi-lithified turbidites of ~10-50 cm thickness. They were too friable to be sampled with the Hyper-Dolphin's manipulator. The fine-grained sections of these beds had horizontal round holes which were probably burrows of contemporary animals. A final sample of the sand was taken at the crest of the second wave (S11). The dive was terminated at 1552 at 1269 m.

The exposures of semi-lithified sediments on the upper waveform face (it is also likely that the "crust" on the lower, western, bedform face was the same substrata) indicate that the unique "angular" character of the waveforms as revealed on the EM300 multibeam data can be explained by erosion of underlying lithified material with a penetrative structural fabric. Whether the latest episode of waveform evolution was purely erosional or had a depositional component will await analyses of the sediment samples collected during Dive HD-487.

NT0517HD487

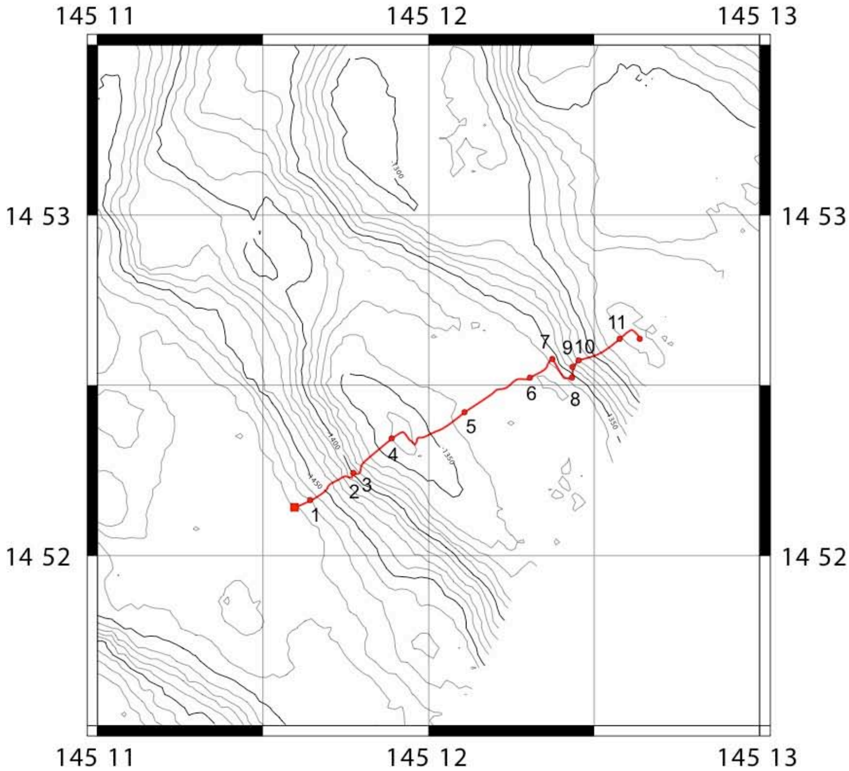


Figure 847D: Dive track and station locations for HD 487

Table A: Dive Log NT0517HD487

Time (local)	Depth (m)	Vehicle Hdg	Notes	Sample #
8:35	0		launch	
9:00	750.9	263.6	descending	
9:22	1484.9	55	sandy bottom is reached; ripples trend at 053	
9:27	1483	304	sand is very easily thrown into suspension; we can see pieces of the original crust that become more prevalent as we travel upslope	
9:51	1473.1	21.9	stn 1 crust material is scooped up into black box; material is a lot harder than it looks (likely a Mn crust), orange and black; nice footage of a swimming eel	NT0517HD-487-01-S01
9:59	1473.5	303.8	close up look at stratigraphy of stn 1 site, looks like there is devitrified scoreacous material overlain by finer volcaniclastics	
10:10	1458.2	19.8	larger blocks of broken up crust can be seen; slope is steepening as we travel up	
10:19	1443	12.6	stop to examine the crust/sediment; manipulator arm is used to drill into sediment	
10:30	1433.9	29.3	linear features trend at 030 (younger) and ~045	
10:41	1419.1	28.4	material is slightly darker, softer and coarser	
10:50	1409.9	31.7	stn 2 darker, coarser material is scooped into core box 2; fines are beeing taken away by current before making it into the core box thus grain size analysis may be skewed	NT0517HD-487-02-S02
11:06	1403	31	stn 3 close up look at sediments - some larger rock fragments can be seen; bacterial mat (?) on surface; small rock fragment is dropped into basket on right side	NT0517HD-487-03-R01
11:14	1397	356	slope is steepening	
11:19	1390	73.1	attempt to sample rock (?) or crust with manipulator - some small bits were dropped into core box 2	
11:29	1355	19.7	pronounced linear ridges (ripples) trending at ~060; scratch test reveals that there is no crust here and that the sand is soft and dark; continuing upslope	
11:44	1343.6	23.3	stn 4 core sample of sandy material from rippled surface	NT0517HD-487-04-C01
11:48	1338	20.2	way pt 2 and we will now turn off to the SE	
11:56	1345.2	333	possible location where fluids may have been expelled or where something has been excavating sand; ripples have formed around it; nice stratigraphy	
12:09	1356	59.2	passing point 3 and now travelling downslope	
12:24	1362	155	stn 5 4 scoops of rippled sand put into aft box	NT0517HD-487-05-S03
12:51	1370.7	17.2	close up view of dark ripples; small white grains are visible - saltation of grains	
12:58	1370.4	50	dark lineations (ripples) trending at 065; current is perpendicular to ripple trend, as expected	
13:03	1371	57.5	darker, coarser, more mafic sand	
13:21	1371	77.2	stn 6 sample of altered rock/crust sitting in sand	NT0517HD-487-06-R02
13:31	1372	29.9	beer bottle and a mafic rock - possibly a vesicular basalt	
13:35	1370	13.9	more rocks on sand surface	
13:44	1363.7	12	stn 7 sample of volcaniclastics - black sand scooped into scoop box 3 - front to the far right	NT0517HD-487-07-S04
14:03	1365	49	sand no longer has visible ripples or structure	
14:07	1363.2	31.6	stn 8 black rock sitting in sand - mafic lava	NT0517HD-487-08-R03

14:15	1358	29.4	coarser grained volcaniclastic material with no visible layering	
14:20	1351.9	29.6	layered deposits; detailed photographs -well indurated ash layers (surge deposits? slumped subaerial ash deposits)	
14:37	1350	10.6	travelling up the layers - soft sediment deformation vs. dunes or ripples	
14:44	1345	24.5	these may be turbidite units - with coarser material, grading up into laminated clay rich sediments with dunes	
14:50	1344.5	25	large holes in fine grained unit - tube worm burrows?	
14:51	1344.5	25	stn 9 basalt from breccia unit from burrowed/vesicular unit	NT0517HD-487-09-R04
14:55	1343	25.1	close up of burrows - and you can see a crab on ledge	
15:01	1340.7	25.2	travelling upslope you can see another unit of layers - soft sediment deformation is apparent	
15:08	1324.4	51.9	Stn 10, basaltic clast	NT0517HD-487-10-R05
15:13	1316	52.9	bright red crab as we traverse the brecciated unit	
15:19	1284	50	back into sand with very subtle ripples becoming more defined	
15:20	1282	50.8	a small sequence of fine altered ash layers	
15:25	1270	52.2	stn 11 rippled sand near top of crest	NT0517HD-487-11-C02
15:36	1268	51.6	ripples become increasingly chaotic - much less linear	
15:39	1268.5	143	way pt 6 - now heading SE to way pt 7	
15:52	1269	126.2	off the bottom and ascending to surface	

5.4.9 Dive 488

Technical information:

Location: Parasitic volcanic cones on the southeast slopes of NW Rota-1 Seamount
Objective: sample and describe principal volcanic units on parasitic cones

DIVE 488	On bottom:		Off bottom:	
Time (local)	10:56		16:15	
Latitude:	14^{o}	35.280’N	14^{o}	35.708’N
Longitude:	144^{o}	49.619’E	144^{o}	47.912’E
Depth (m):	2261		1468 m	

Samples returned: 24 rocks, 1 scoop

Representative images:

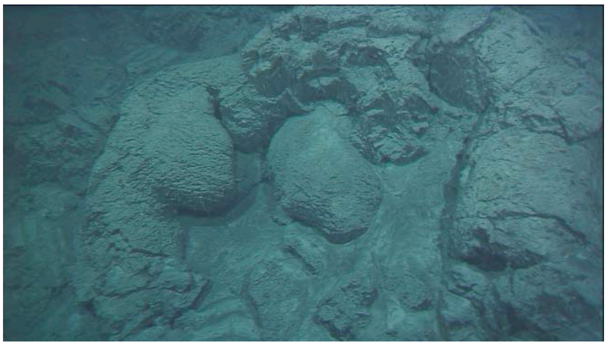
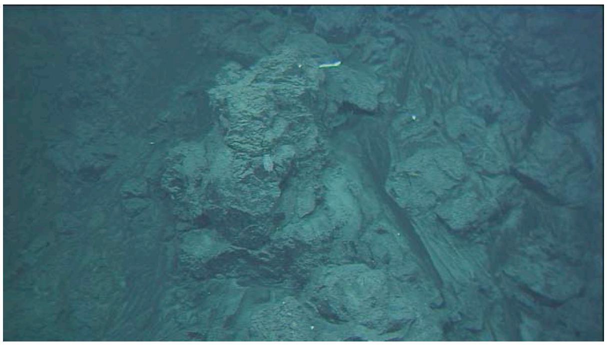


Figure 488A: Pillow basalts on lower slopes of deeper parasitic cones (Image hdc20051018113745_1


Picture 488B: Volcanic outcrops on the lower slopes of the shallower parasitic cone (Image hdc20051018153102_1

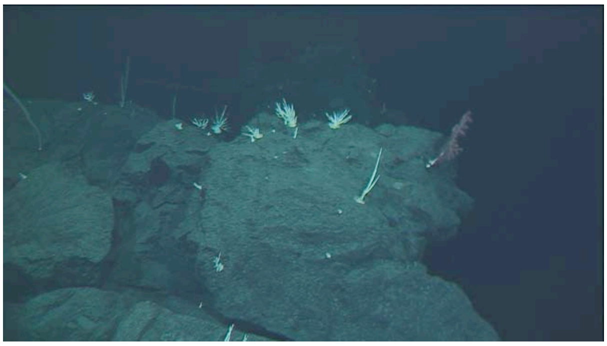


Figure 488C: Volcanic outcrops on the upper slopes of the shallower parasitic cone (Image hdc20051018154748_1small)

Scientific summary:

NW Rota-1 has many parasitic volcanic cones or knolls on its eastern slopes. These knolls seem to be distributed radially from the center of the body. The objectives of Dive 488 were to collect samples from the eastern part of the volcano, which includes two of the eastern parasitic knolls and the deeper part of the volcano southeast of a knoll. The dive started from outcrops of pillow lavas at the depth of 2260 m, which seem to run down from the ridge trending east-southeastwardly from the knoll. These pillow lavas gradually changed into more blocky lavas upward. We collected a fragment of block lava flow at the flank of the first knoll and then moved quickly to the second knoll without observation because of time restrictions. The second knoll we visited in this dive consists mostly of piles of block lava and lava breccias. At the end of steep slope, we found a small crater, whose walls consist of massive blocky lavas.

The rocks sampled are classified into two types. One type is primitive cpx-ol basalts, which are free of plagioclase phenocrysts and another type is pl-phyric ol-cpx basalts, which contain more than 20 vol. % of plagioclase. Although both types of lava are fairly vesiculated the former are more vesiculated than the latter. R01 to R13 are cpx-ol basalts and R14 to R24 are pl-phyric ol-cpx basalts, thus the rock types are closely related to the occurrence of the lavas as observed during the dive. The pillow lavas, sampled at deeper depths and that run down from the ridge trending east-southeastwardly are primitive cpx-ol basalt lavas. The two parasitic knolls themselves consist of pl-phyric ol-cpx basalts. These may represent two types of basalt lavas derived from a wet and dry mantle source beneath a single volcano, as suggested in the Sumisu caldera volcano, Izu-Bonin arc (Tamura et al., 2005), or these may be primitive and evolved lavas derived from the same primary basalt magma. The origin of basalt magmas of NW Rota-1 will be of much interest in the future study.

NT0517HD488

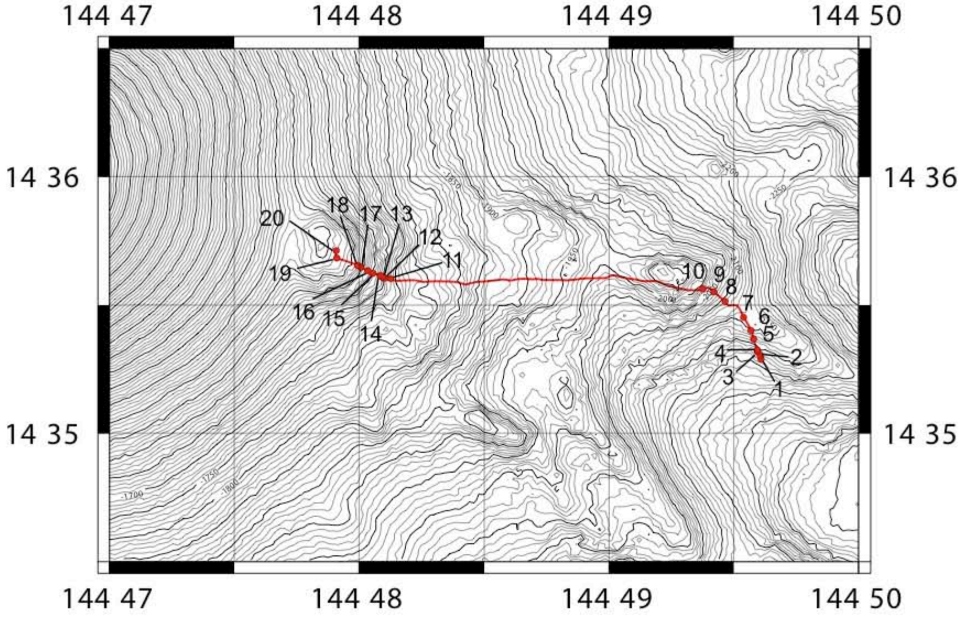


Figure 488D: Dive track and station locations for HD 488

Table 488A: Dive Log NT0517HD488

Time (local)	Depth (m)	Vehicle Hdg	Notes	Sample #
10:56	2261	311	Bottom. Ripples and some rocks. Sampled a loose rock from rippled seds.	NT0517HD488-1-R01
11:05	2257	334	Moving up gentle slope. Approaching blocky flows. Sample.	NT0517HD488-2-R2
11:07	2247	328	Rippled sediment drapes amongst pillow flows. The best pillow structures we've seen thus far. Probably farily old and altered though. All of the sediment and cover is streaky black and white but mostly white.	
11:13	2237	488	Sample from pillow.	NT0517HD488-3-R03
11:15	2237	488	Another sample from the weathered pillow.	NT0517HD488-3-R04
11:22	2229	333	Trying to sample glassy material. But it looks pretty weathered to me. Some Mn crust as well.	NT0517HD488-4-R05
11:27	2229	332	Sample from base of heavily fractured pillow. Very small piece (10 cm?)	NT0517HD488-4-R06
11:32	2228	332	Hypnotic ripples. Sample of weathered vesicular pillow. Perhaps phenocryst rich?	NT0517HD488-4-R07
11:37	2221	333	The pillow outcrop is becoming steeper and the pillows seem to be rounder and perhaps less weathered toward the top. Actually blockier.	
11:39	2217	327	Moving across a small flat of well developed ripples before heading up another pillow flow.	
11:42	2202	327	Flows seem to be getting blockier and more fractured.	
11:52	2200	1.6	Spent the last 10 minutes cruising around attempting samples.	
11:55	2197	359	Sample small rock from base of pillow outcrop. Vesicular piece of pillow.	NT0517HD488-5-R08
11:56	2194	342	Moving up the flank of the volcanic region to the east. A steep sediment rippled slope. The blocky outcrop is much more sparse and consists of much smaller pieces. Patches of unknown white material.	
12:00	2179	328	The water is surprisingly non-murky.	
12:03	2180	329	Sample from outcrop of small pillows and blocks. Again, quite fractured. Into blue box.	NT0517HD488-6-R09
12:05	2179	326	Traveling along a submarine skree slope. More disseminated patches of white material.	
12:07	2167	322	Seem to have left the pillows behind and among lower profile blocky flows.	
12:09	2164	328	Large flow, blocky, but almost pahoehoe 'ooze' features.	
12:14	2153	328	Moving over a humocky section of flow.	
12:16	2151	330	Large sample with light brown discoloration.	NT0517HD488-7-R10
12:19	2151	329	rock sample, rough terrane	NT0517HD488-7-R11
12:21	2148	328	mixed rock outcrops and rippled sediment patches	
12:22	2145	328	near WP2, in uniformly sedimented area; some ripplling; quite linear in places	
12:25	2135	293	at WP2, c/c to the NW; uniformly sedimented and rippled; slope drops away a little bit	

12:31	2117	324	outcrop rising out of sediment; somewhat pillowed,white "litter" on sediment and rock; sampling attempt; a lot of heave today; successful;	NT0517HD488-8-R12
12:34	2114	320	mixed outcrop and sediment; then long section of linear ripples;	
12:36	2107	319	uniofrmly sediment now, an occational block of rock on surface; does look like a fair amount of cobble or coarse sandy debris on bottom too	
12:38	2086	322	still visible ripples, though we are about 4 m off bottom, a little dark to see; some places with concentrations of debris; also may be rubbly outcrops sticking out of slope	
12:39	2082	316	now into more otucrop sticking our of sediment; rough,angular blocks and outcrop, doesn't seem particularly pillowed	
12:40	2079	302	landing to sample a piece; angular piece, bit of brown on bottom, loose in sediment; into blue basket	NT0517HD488-9-R13
12:42	2076	298	mixed rubble and sediment; linear ripples or troughs downslope in sediment; piece and occasional outcrop still angular and broken, not really pillowed	
12:46	2053	299	similar, with occasionally larger blocks, then into largely sediment at 12:47	
12:49	2038	303	into area with blocks of rubble sticking out from sediment; head in to sample; angular blocks, not pillowed; large angular block recovered, ibehind blue basket (it is very large, having some problems fitting it in	NT0517HD488-10-R14
12:57	2029	294	Moving off bottom to WP 4	
14:34	1675	277	Back on bottom, mixed outcrop and sediment, angular irregular blocks of rock; setting down for sampling; took piece loose in pile;	NT0517HD488-11-R15
14:34	1675	277	Second sample from same station.	NT0517HD488-11-R16
14:39	1666	279	Complex sandy ripples. Broken, humocky blocky…blocks. Hard to tell if they are outcrop or just blocks that have fallen from above.	
14:43	1654	279	Reaching WP 4. Continuing up slope of mossy-like covering on the rocks and vast sediment ripples.	
14:48	1649	279	Sample of loose rock from silt pile. Sharp edged lava. May be the surface of a flow…pillow-like textures on the top.	NT0517HD488-12-R17
14:50	1645	290	Cruising over incredible sediment ripples. Seems to be quite a bit of algae or some growth on the surface of almost every exposed rock.	
14:57	1641	290	Small sample of dark blocky lava.	NT0517HD488-13-R18
15:00	1633	290	Rounded blocky outcrop with bright white clasts of something. Hard to tell if it is a sponge, bivalve or not biology at all. Steep blocky flows.	
15:05	1628	280	Lava from blocky flow	NT0517HD488-14-R19
15:07	1629	280	Trying to figure out what the small white pieces are. Found a white anemone, but the majority seem to be	

			hard.	
15:10	1624	289	Continuing up the steep slope. White flecks still on surface of sediment and outcrop. Probably broken pieces of the white branched corals.	
15:14	1606	288	Moving up, the flows seem to be much more blocky than the lower areas of the slope.	
15:18	1593	288	Dark, somewhat vesiculated lava into the yellow box.	NT0517HD488-15-R20
15:20	1583	287	The grade of the slope seems to be steeping somewhat. Back into the pillow structuresl although still some blockier flows. The ripples are less orderly and neat relative to down slope. Consistent with a steepening grade.	
15:23	1566	288	Higher concentration of large, blocky flows with steeper slope.	
15:26	1565	285	Sample easily taken from fractured sediment covered flow.	NT0517HD488-16-R21
15:29	1556	290	Perhaps some jointing in a very large rock with coral growing on it.	
15:31	1546	290	Larger blocks in general. Quite a bit of jointing within these flows.	
15:36	1526	291	Sample taken from very loose sediment at base of flow. This whole area is very different. Looks like some of this has been reworked.	NT0517HD488-17-R22
15:38	1515	289	Very unstable-looking large fresh talus blocks.	
15:41	1505	273	Freshesh block taken from massive block pile. Perhaps andesite.	NT0517HD488-18-R23
15:44	1496	265	Clearly out of the sediment/lava flow area and now only very large loose blocks. Enormous amount of various corals growing on the rough surfaces. Truly a lot of life here. Spectacular!	
15:47	1492	263	Zoomed in on one coral. The structure of it is remarkable. This particular coral was built just like a phalenopsis orchid.	
15:50	1490	265	The top of the slope has flattened out. Extremely well-defined black and light ripples aligned parallel to slope. The edge of the ridge is defined by very blocky flow. Perhaps some cooling fractures were observed in this flow. Unbelievable. A submarine zen garden. Multiple perpendicular sets of ripples.	
15:55	1474	292	Some layering in the upper few meters of the flow.	
16:00	1473	332	Fresh sample taken from vertical wall. Impressive.	NT0517HD488-19-R24
16:02	1470	330	Back into rippled area of fine grained ash. These ripples are composed of three hues:black, white and gray. Some areas of ripples are covered by a darker band of non-rippled newer fallout.	
16:09	1468	338	Scoop sampling from very fine-grained ash ripple layer. Hopefully find some olivine grains. Seems to be a very thick unit (thickness of scooper) of unconsolidated ash that was scoop sampled.	NT0517HD488-20-S01
16:15			Fin	

5.2.10 Dive 489

Technical information:

Location: Parasitic volcanic cones on the slopes of West Rota Seamount
Objective: sample and describe principal volcanic units on parasitic cones

DIVE 489	On bottom:		Off bottom:	
Time (local)	09:12		16:10	
Latitude:	14^{o}	16.214'N	14^{o}	16.887'N
Longitude:	144^{o}	53.741'E	144^{o}	52.035'E
Depth (m):	1229		491	

Samples returned: 21 rock samples, 1 scoop sample

Representative images:

Figure 489A: Outcrops of silicic? Volcanics on slopes of deeper parasitic cone (Image hdc20051019104642_1)

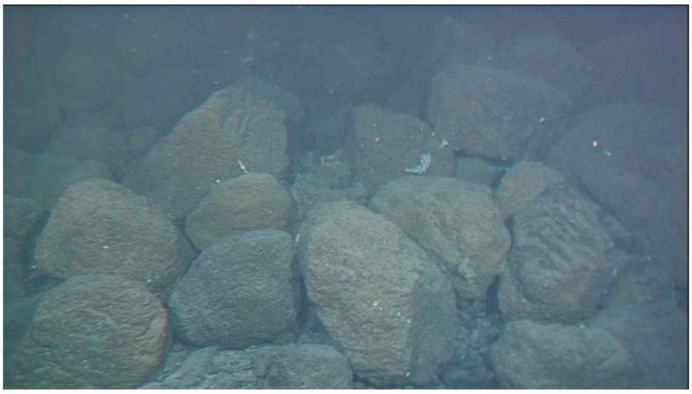


Figure 489B: Large pumice boulders or "balloons" on seafloor, typical of many parts of the dive track (Image hdc20051019130919_1)

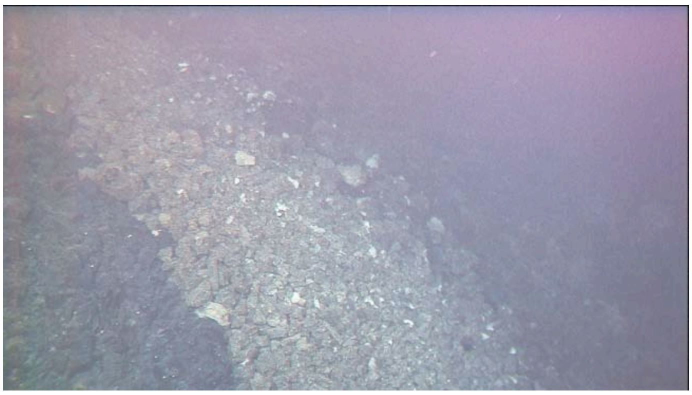


Figure 489C: A chute of pumice running between two outcrops of darker volcanic rock, in the upper portions of the dive traverse (Image hdc20051019153018_1)

Scientific summary:

The objective of this dive is to investigate three small cones on the SW flank of W Rota seamount. Basaltic lavas observed in the three knolls are all plagioclase-phyric (~20 vol. %) basalts, which contain rare olivine and/or augite. Thus, all rocks are fairly evolved compared to the last dive on NW Rota-1. In the Izu-Bonin arc, we generally have plagioclase-enriched and mafic-poor lavas. When magma is dry, plagioclase floats and mafic minerals sink in magma chambers. Thus, these plagioclase-enriched basalts may suggest low water contents in the source of W Rota basalts. Although olivines are rare in these basalts, melt inclusion study should reveal water content of these magmas.

Interestingly, we observed a dacite dike intrude a basaltic lava at a depth of 1150 m. This is a beautiful hornblende dacite and we found similar dacite at the depth of 820m as talus blocks of the third knoll. One possibility is that the three basalt knolls appeared comtemporaneously and then at a later point were intruded by dacite. The caldera-forming eruption produced rhyolite balloons, which cover most of this area. Thus, the eruption order is from pl-phyric basalt through dacite to rhyolite pumice eruptions. However, the first knoll was not covered by large pumices very much, which is fairly strange given the short distance between the first knoll and the second and third knolls. Another possibility is that the third knoll appeared after the caldera-forming rhyolite eruption. The detailed chemical and petrographical studies of these basalts and dacites may show differences among knolls and should help us distinguish between these scenarios.

Dive 489 landed approximately 200m southeast of the small knoll on the southeast flank of W Rota (SO1). The area of the landing site was dominated by brecciated basaltic lava flows. From the site where the Hyper Dolphin began ascending the cone, we bagan collecting samples of basaltic lavas. Along the side of the first ridge, blocks of pumice were encountered ~1/5 of the way up the side and were observed with increasing frequency during ascent. Upon arriving at a depth of 1030 m, large, rounded boulders of rhyolite were found. These boulders, described as rhyolite ‘balloons’, are similar to those found on the eastern margin of W Rota during the 2004 TT167 expedition. As Hyper Dolphin continued to ascend pumice, became the dominant rock type observed with a field of rhyolite boulders of ~.5m in diameter.

At a depth of 1015m Hyper Dolphin transited across a depression to a depth of 787m (SO3) and traversed to the summit of the hill over a field of pumice (sizes ranged from < 10 cm to > 1 m in diameter). We observed ‘black pumice’ beneath rhyolite boulders and we thought this could be a dacite lava dome. However, these ‘black pumices’ are found to be pl-phyric basalts, which are similar to those we found in the first knoll.

From the top of the first hill (SO4), Hyper Dolphin transited to another ridge on the SE flank of W Rota Caldera where a steep talus slope of rhyolite balloons and angular, black blocks of lava was found, several rock samples were collected. These black blocks (R19 and R20) are dacite and basalt, respectively, which are similar to those we found in the first knoll. At this point Hyper Dolphin encountered a strong current that made sampling and ascending the slope extremely difficult. The choice was made to ascend a short distance and then try to approach the slope at a shallower depth. At 706 m, we found a steep wall of basalt. After this point, there were alternating areas of basaltic lava flows and field of pumice with rhyolite balloons. In this area several of the rhyolite balloons show columnar fractures producing rectangular fragments of the boulders. Hyper Dolphin ascended to a depth just below the summit of this ridge (508 m), where basaltic lavas had given way to fields of pumice. Dive HD-489 ended at the summit of the second ridge (SO6) at 16:10.

NT0517HD489

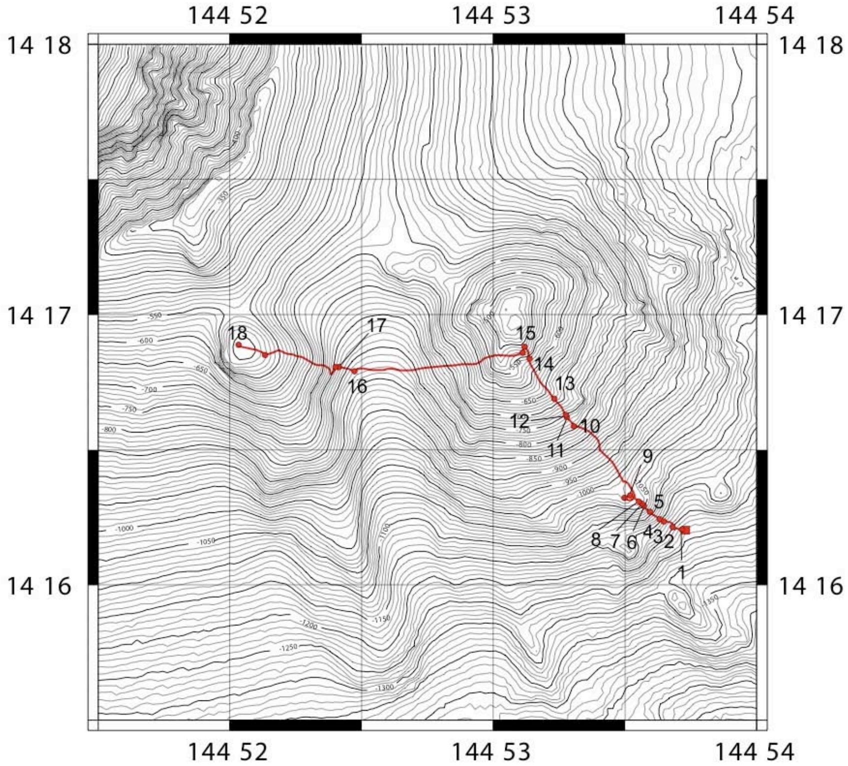


Figure 489D: Dive track and station locations for HD 489 (being prepared)

Table 489A: Dive Log NT0517HD489

Time (local)	Depth (m)	Vehicle Hdg	Notes	Sample #
9:12	1229	269	Arrived at the bottom, fish swimming backwards, bottom appears to be pumice	
9:16	1226	279	Bombs, with little ripples	
9:19	1224	279	Collected a lava sample, that was loose on the side, with some iron oxide alteration on the surface. Into the yellow box.	NT0517HD-489-1-R-01
9:20	1222	280	Continueing upslope over a brecciated lava flow. Flow appears extensive.	
9:23	1199	294	Lava flow, appears to be outcrop, there is a sedimented area off to the left	
9:29	1201	293	Sampling lava flow, sample is medium sized, with some Fe staining. Placed in yellow basket	NT0517HD-489-2-R-02
9:31	1194	291	Pretty crinoid, with a beautiful arms	
9:36	1169	292	Lava less blocky, more continuous	
9:42	1170	288	Rhyolite block, blocks around the	
9:46	1170	297	Rhyolite block, sample is a diamond shaped piece that seems to be staying together fairly well. Tried to put into fore scoop bin, broke into ~3 pieces in front of the yellow box. There is at least one piece in the scoop box two.	NT0517HD-489-3-R-03
10:00	1171	297	Sample of blocky lava flow from right next to the rhyolite sample. Huge sample, placed in front of the yellow box.	NT0517HD-489-3-R-04
10:01	1167	297	Continueing upslope over a brecciated lava flow. Flow appears extensive. Possible dike on the right.	
10:04	1151	298	Large boulders on a talus slope, with a dike trending NW-SE similar to those observed within West Rota Caldera	
10:04	1148	296	Radial cracks in the rock, supporting dike	
10:11	1148	338	Sampling dike, long, rectangular samples with an unfortunate starfish. Basaltic lava with iron stainig on the outside of the sample. Placed behind the blue basket.	NT0517HD-489-4-R-05
10:14	1138	304	Continuing upslope with two different flow styles, large blocks to the N and S, with finer, brecciated lava straight ahead.	
10:17	1115	297	Flow banding in lava flows, zoomed in for some close up views	
10:19	1110	297	Unusual animal, sessile organism with three crinoids on top of a sponge.	
10:21	1106	297	Blocks of rhyolite	
10:23	1090	297	Sampled a large piece of lava, possibly scoria? Sitting in a bed of pumice, placed in yellow box	NT0517HD-489-5-R-06
10:28	1091	295	Took a sample of pumice, small, strong enough not to crush in claws, placed in yellow box	NT0517HD-489-5-R-07
10:30	1091	295	Another piece of possible pumice **(Rocks 8 and 9 were caught together in one grab by manipulator)**	NT0517HD-489-5-R-08
10:30	1091	295	Another piece of possible pumice	NT0517HD-489-5-R-09
10:35	1063	294	Smaller rock fragments	
10:45	1047	296	Sampling a massive flow, blocks appear strong. Rounded piece of basalt, dark in color. Placed in the corner behind the blue basket.	NT0517HD-489-6-R-10

10:50	1037	289	Increasing amounts of pumice blocks, breaks apart very easily. There are also small fragments of vesiculated lava, though sampled piece appears to be tuff as well. Sample taken crumbled into several pieces. Placed behind blue basket.	NT0517HD-489-7-R-11
10:53	1037	282	Tested several pieces looking for lavas, most squeezed are pumice. There is a dark coating over many of the pumice blocks.	
11:00	1030	281	Rhyolite baloons!	
11:03	1031	286	Approached a rhyolite, the claw can move an enitre ball (~.3-.5 m d) without trouble.	
11:05	1032	286	Sampling pumice fragmant, collumn shaped, with a dark coating. Sample placed behind the blue basket.	NT0517HD-489-8-R-12
11:08	1033	277	Bottom has changed, there are fine grained bed of clasts with very large balls of rhyolite	
11:10	1022	282	Pretty radially fractured rhyolite.	
11:11	1022	280	Lava flow off to the right	
11:16	1022	282	Sampling lava flow, broke off a small piece, placed in blue basket	NT0517HD-489-9-R-13
11:21	1023	248	We have come to a massive block that is composed of pumice.	
11:24	1015	243	Conitnuing upslope over a field of pumice blocks with sand around them.	
12:00			Transited to next point	
12:05	787	288	Waypoint 3, took a small sample of basalt, placed in the blue basket	NT0517HD-489-10-R-14
12:06	781	299	Took a picture of a collumnar jointed rhyolite block	
12:07	776	302	Travelling over a talus slope of lava breccia	
12:11	751	315	Sample of lava from the slope of talus, sample is dark.	NT0517HD-489-11-R-15
12:13	749	315	Possibly scoriaceous material, that appears up close to be small lava clasts.	
12:22	743	324	Scoop sample of the possibly scoria, there are several different colors of material, with red, black, and pink pumice.	NT0517HD-489-12-S-01
12:32	743	324	Finished collecting scoop sample, cannister very full, some pieces of pumice have fallen into the basket.	
12:36	720	325	Large rhyolite balls with some radially jointed.	
12:39	712	333	Pulled up to a huge rhyolite ball, measuring the size against the basket, diameter is at least as big as the basket, this is not the biggest one observed.	
12:41	713	325	Come to an outcrop of basalt,	
12:42	713	325	Pretty little anenome	
12:50	688	324	Over small blocks of lava and pumice	
12:51	687	323	Monster shrimp or small lobster	
12:54	677	351	Striking landscpae of dark material, with some light coloured broken open pumice clasts. There are sponges, with and without crinoids, scattered about.	
12:59	675	22	Approached a flow, that is dark in color but seems to either be very low density or highly altered.	
13:07	673	328	Sample of a baked potato shaped sample, pumice, with black coating outside.	NT0517HD-489-13-R-16
13:09	885	333	Rhyolite baloons, jointed into rectangular collumns.	
13:12	651	330	Floater with biolumencense swam by very quickly	

13:15	635	336	Traversing (still) an area of pumice boulders, though they are small before.	
13:18	624	338	Now over an area with few ballons and a possibly pumaceous bottom, though it is dark in color like lava.	
13:31	576	324	Structures have changed, looks like there may be some lava flows with layering or may be hydrothermal crust, or may be manganese.	
13:32	571	326	Flow sheets with nice coral, and snges	
13:34	549	344	Pumice clasts look more blocky	
13:35	550	345	Sample, small ball of what I assume is pumice. Sample is covered in a dark coating. Sample was placed in the blue basket.	NT0517HD-489-14-R-17
13:37	522	330	crab	
13:39	513	327	Rhyolite baloons, an entire field of them.	
13:39	508	506	Out of Rhyolite baloon field, into manganese crusted autobreccia?	
13:43	495	329	Sampled a black pumice rock, with some biological material on the side, maybe a clam? Placed in the blue basket	NT0517HD-489-15-R-18
			In transit	
14:40	810	281	On bottom	
14:41	810		Pumice- and black-rock covered slope at point 5; Sampling big black rock; behind blue basket	NT0517HD-489-16-R-19
14:46	808	281	white pumice, tan pumice, and angular back rocks, probabley basalt	
14:50	772	274	Large pumice balloons	
14:55	769	272	Large tan or black rock, behing blue basket	NT0517HD-489-17-R-20
14:57	760	272	Broken open rhyolite baloon with manganese coating	
15:03	756	291	Talus slope of pumice	
15:09	752	281	Encountering a very strong current. There are large black blocks with the appearance of layering or flow banding	
15:18	741	283	Transiting up and over to try to avoid strong currents **(in water column from 1517 to 1518).**	
15:18	739	280	Similar scene, with dark small rocks and light colored boulders of rhyolite.	
15:24	713	713	Dark, angular material.	
15:26	706	318	Dark, blocky wall of basalt.	
15:27	703	316	Near top of ridge, with both pumice and dark material, there is another flow unit up to the right of the field of view.	
15:30	691	205	View of a talus of pumice overlying lava flows, that are outcropping on either side.	
15:33	682	291	Outcrop of lava	
15:36	684	297	Unable to proceed upslope due to current, will be pulled up and then moved over (**in water 1538 to 1552**)	
15:52	508	287	Arrived at 3/4 way between point 5 and point 6, there are pumice boulders, with less of the black material than before. There are collumns of material broken off and scattered about the boulders.	
15:56	499	279	Plain of pumice with scattered large boulders of ryolite, rocks crumble beneath manipulator.	
15:58	496	281	Shark	
15:59	492	280	Giant pumice baloon	
16:00	494	279	Nice starfish	

16:00	494	279	Crab	
16:03	489	280	Biolumunescent floater flashed by	
16:08	492	274	Large piece of pumice, fragmented when we put it in the basket, 4-5 pieces? In the blue basket?	NT0517HD-489-**18-R-21**
16:10	491	273	On ascent, end of dive	

(bold notes by S. Bloomer after review of video tape)l

6. Future studies

A comprehensive work plan for the rock and sediment samples was developed by the shipboard scientific party. This work will include major element analyses, trace element analyses, geochronologic studies, mineral analyses, fluid inclusion studies, petrographic characterization, and stable and radiogenic isotope characterization. The work will be completed at the various labs of the shipboard scientific party.

Bathymetric data will be merged with existing databases at the NOAA labs in Newport, Oregon and will be provided to all participants.

Oxygen isotope analyses of minerals separates will be carried out on primitive basalts collected from NW Rota 1, and Chaife to relate oxygen isotope variations in Marianas Arc lavas to the addition of altered oceanic crust materials. Studies of materials collected during NT-0517 will complement previous studies of the oxygen chemistry of the Marianas Arc system.

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APPENDIX A: Samples and preliminary sample descriptions for NT0517

HD#480 Oct. 9 2005 NW Rota-1

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD480-1-R01	14_35.991	144_46.509	606	pl-px phyric basalt	subrounded	14	8	7	0.8kg	dark grey	fresh	0	ol5%, px40%,Pl35%	10%	
HD480-3-R02	14_36.045	144_46.630	575	pl-px phyric basalt	angular	8	6	5	0.15kg	dark grey	fresh	0	Pl20%	30%	bacterial mat on surface (white furry mat)
HD480-4-R03	14_36.046	144_46.522	534												
HD480-6-R04	14_36.040	144_46.585	546	pl-px phyric basalt	subrounded	8	4	3	0.09kg	grey	fresh	0	px10%,Pl10%	10-25%	
HD480-6-R05	14_36.040	144_46.585	546	ol-bearing pl-px-phyric basalt	angular	7	4	3	0.05kg	dark grey	fresh	0	ol1%, px10%,Pl10%	10%	glassy rind, very large plagiclase 5mmx5mm
HD480-7-R06	14_36.004	144_46.435	645	pl-px phyric basalt	subangular	16.5	12	12	1.9kg	black	fresh	0	px15%,Pl25%	20%	dark glassy rind
HD480-8-R07	14_36.039	144_46.435	624	pl-px phyric basalt	subangular	20	16	11	3.0kg	black	fresh	0	px10%,Pl20%	15%	glassy rind
HD480-9-R08	14_36.063	144_46.432	589	pl-px phyric basalt	subangular	25	18	16.5	5.5kg	black	fresh	0	px5%,Pl15%	25%	glassy rind
HD480-10-R09	14_36.077	144_46.423	570	ol-bearing pl-px-phyric basalt	subangular	17	11	9	1.9kg	black	fresh	0	ol1%, px3%,Pl12%	20%	Surface is copvered with orange bacterial mat . Vesicules range in size from 2-10mm. Glassy groundmass 2cm in from edge.
HD480-11-R10	14_36.085	144_46.422	561	pl-px phyric basalt	subangular	33	21	16	6.2kg	black	fresh	0	px3%,Pl20%	30%	surface coated with orange bacterial mat. glassy rind.
HD480-2-S1	14_36.056	144_46.520	527	scoriaceous sand						black	fresh	0	plagioclase and glass-rich		1-2mm-sized grains
HD480-4-C1	14_36.046	144_46.522	534	scoriaceous sand						black	fresh	0	plagioclase and glass-rich		1-2mm-sized grains
HD480-5-C2	14_36.051	144_46.522	527	scoriaceous sand						black	fresh	0	plagioclase and glass-rich		1-2mm-sized grains
HD480-4-W-01	14_36.046	144_46.522	534												Total 700 ml of water was sampled. The pH was 1.8.

HD#481 Oct. 10 2005 NW Rota-1

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD481-1-R01	14_36.051	144_46.522	532	scoria	angular	12	7	6	0.4kg	dark brown	fresh	0	pl7%	>30%	lithic fragment
HD481-3-R02	14_36.046	144_46.580	531	basalt	angular	11	8	6	0.4kg	dark gray					
HD481-3-R03	14_36.046	144_46.580	531	basalt	angular	6	6	5	0.15kg	dark gray					
HD481-3-R04	14_36.046	144_46.580	531	basalt	angular	5.5	4.5	3.5	0.1kg	dark gray					
HD481-4-R05	14_35.435	144_46.762	1080	ol-bearing pl-px-phyric basalt	subangular	14	10	8	0.85kg	black	fresh	0	px15%,Pl25%,ol1 %	<10%	
HD481-5-R06	14_35.451	144_46.761	1068	pl-px phyric basalt	angular	19	11	10	1.3kg	black	fresh	0	px15%,Pl20%	15%	
HD481-6-R07	14_35.472	144_46.764	1047	pl-px phyric basalt	subangular	10	10	6	0.55kg	black	fresh	0	px10%,Pl15%	15%	
HD481-7-R08	14_35.508	144_46.770	1019	pl-px phyric basalt	subangular	16	12	10	1.7kg	black	fresh	0	px15%,Pl20%	15%	
HD481-8-R09	14_35.536	144_46.774	992	pl-px phyric basalt	subangular	22	16	15	5.5kg	black	fresh	0	px15%,Pl20%	20%	glassy rind
HD481-9-R10	14_35.574	144_46.776	952	pl-px phyric basalt	subrounded	18	18	15	6.2kg	black	fresh	0	px15%,Pl25%	15%	
HD481-10-R11	14_35.627	144_46.771	901	pl-px phyric basalt	subangular	13	11	8	1.1kg	black	fresh	0	px10%,Pl20%	10%	
HD481-11-R12	14_35.675	144_46.762	848	pl-px phyric basalt	subrounded	9	6	5	0.4kg	black	fresh	0	px15%,Pl25%	8%	
HD481-12-R13	14_35.762	144_46.769	771	pl-px phyric basalt	subangular	24	15	14	5.5kg	black	fresh	0	px15%,Pl25%	15%	thin glassy rind
HD481-13-R14	14_35.820	144_46.777	728	pl-px phyric basalt	angular	33	33	21	21.5kg	black	fresh	0	px16%,Pl20%	5%	glassy rind

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD481-1-c1	14_36.051	144_46.522	532	fragments of scoria and pl-px-phyric basalt											M-type core. Scooped.
HD481-2-c2	14_36.034	144_46.602	564	fragments of pl-px-phyric basalt											M-type core.Scooped
HD481-1-W01	14_36.051	144_46.522	532												Total 550 ml of water was sampled. The pH was 2.3.
basket box				cinders	angular	0.5-5mm			0.4kg	black	fresh			>50%	scoria collected from the bottom of the sample box after passage through vent plume.
basket				vesicular basalt		0.5-15cm			1.5kg					~10%	Rocks and cinders from the bottom and the backet, after passage through plume.

HD#482 Oct. 11 2005 West Rota

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD482-1-R01	14_19.659	144_51.105	1015	rhyodacitic pumice	subrounded	17	16	11	2kg	gray	weak	film	opx,cpx,pl (3%)	70%	
HD482-2-R02	14_19.639	144_51.122	992	hydrothermally altered lava	subangular	23	16	12	3.6kg	gray	extensive	no		-	calcite, amorphous silica?
HD482-3-R03	14_19.631	144_51.124	964	hydrothermally altered lava(andesite or dacite)	subangular	14	11	10	1.0kg	dark gray	extensive	film			pyritization and silicification
HD482-4-R04	14_19.595	144_51.165	921	hydrothermally altered lava(andesite or dacite)	angular	25	20	15	6.5kg	gray	extensive	film			
HD482-5-R05	14_19.557	144_51.234	860	hydrothermally altered lava(andesite or dacite)	subangular	20	7	5	0.6kg	gray	extensive	film			pyritization and silicification
HD482-6-R06	14_19.538	144_51.254	821	hydrothermally altered lava(andesite or dacite)	angular	30	16	13	5.7kg	gray	extensive	film			
HD482-7-R07	14_19.474	144_51.316	776	hydrothermally altered lava(andesite or dacite)	angular	40	27	12	9.0kg	gray	extensive	film			pyritization and silicification
HD482-8-R08	14_19.461	144_51.331	751	hydrothermally altered lava(andesite or dacite)	subangular	6	6	65	0.25kg	gray,white	extensive	no		weak	pyritization and silicification
HD482-9-R09	14_19.452	144_51.335	754	hydrothermally altered lava(andesite or dacite)	rounded	38	36	30	28.6kg	dark to light gray	extensive	no			silicification, concentric hydrothermal alteration halo
HD482-10-R10	14_19.427	144_51.306	785	hydrothermally altered lava(andesite or dacite)	angular	8	6.5	4	0.25kg	gray	extensive	film			pyritization and silicification
HD482-12-R11	14_19.442	144_51.529	610	px-pl-phyric andesite	subangular	16	13	10	2kg	dark gray	fresh	no	px8%,pl 12%	15	
HD482-13-R12	14_19.460	144_51.544	581	rhyolitic pumice	angular	10	6	5	0.5kg	pale gray	fresh	no	px2-3%,bt>1%, pl	>50%	
HD482-11-S01	14_19.439	144_51.520	637	rhyolitic pumice	angular	max4	av2-3		0.4kg	pale gray	weakly altered	no	px2-3%,pl<1%	>50%	

HD#483 Oct. 12 2005 West Rota

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD483-2-R01	14_17.730	144_51.132	1140	altered tuff breccia	angular	28	14	13	5.4kg	dark brown	extensive	film			
HD483-3-R02	14_17.719	144_51.135	1105	dacite (dyke)	angular	27	17	11	4.5kg	dark brown	weak	film	px trace,pl8%,hb3%	weakly	

HD483-4-R03	14_17.702	144_51.168	1055	dacite (dyke)	angular	11	9	6	0.75kg	dark gray	weak	<1mm	pl10%,hb5%	weakly	
HD483-5-R04	14_17.646	144_51.214	935	layered scoriaceous tuff	subangular	32	21	14	8kg	dark brown	weak	film			
HD483-6-R05	14_17.636	144_51.227	891	andesite (dyke)	angular	17	17	11	1.5kg	black	extensive	1mm	pl30%	moderately	
HD483-7-R06	14_17.630	144_51.230	861	dacitic tuff	angular	14	9	6	0.6kg	gray	weak	film	aphyric	weakly	
HD483-8-R07	14_17.586	144_51.308	752	basalt(dyke)	subangular	12	11	9	1.4kg	black	fresh	<1mm	pl20%	moderately	
HD483-9-R08	14_17.584	144_51.321	731	aphyric dacite breccia	angular	10	8	6	0.7kg	dark brown	-	film	aphyric	weakly	
HD483-10-R09	14_17.560	144_51.368	677	basalt breccia dyke	subrounded	11	10	8	1kg	gray	weak	film	pl9%	strongly	
HD483-11-R10				lost											
HD483-11-R11	14_17.533	144_51.424	645	ol-cpx basalt lava	angular	17	14	10	2.3kg	dark gray	fresh	film	ol2%, px10%	moderately	
HD483-12-R12	14_17.487	144_51.530	557	ol-cpx-pl basalt	angular	19	15	11	2.3kg	black	fresh	film	ol1%, px2%,pl10%	strongly	
HD483-13-R13	14_17.452	144_51.551	516	ol-cpx-pl basalt	angular	33	30	18	18.7kg	dark gray	fresh	film	ol1%, px5%,pl20%	moderately	
HD483-14-R14	14_17.398	144_51.587	457	cpx-pl basaltic dyke	subangular	22	18	15	8kg	black	weak	film	px3%,pl20%	weakly	
HD483-15-R15	14_17.367	144_51.603	428	cpx-pl basalt	angular	19	17	14	4kg	black	fresh	film	px5%,pl20%	strongly	
HD483-16-R16	14_17.343	144_51.613	395	ol-cpx-pl basalt	angular	32	22	22	24.4kg	black	fresh	film	ol2%, px2%,pl20%	weakly	
HD483-17-R17	14_17.332	144_51.658	378	ol-cpx-pl basaltic spatter	angular	15	15	11	2.75kg	black	fresh	film	o12%, px2%,pl30%	weakly	
HD483-19-R18	14_17.676	144_51.671	722	andesitic volcanic breccia	angular	40	33	16	19.8kg	black	weak	film	px trace,pl30%	weakly	
HD483-20-R19				lost											
HD483-20-R20	14_17.665	144_51.680	679	hb-px dacite	subangular	23	17	16	5.5kg	black	weak	film	px 5%,pl30%,hb5%	weakly	
HD483-1-S01	14_17.730	144_51.132	1149	pumice clast with hydrothermal precipitate or microbial mat	angular	2-3mm			2.75kg						Sample consist of a scoop of pumiceous material.
HD483-18-S02	14_17.323	144_51.760	341	pumice clast		max size 3	3	2.5	0.3kg						Size listing is for the largest clast in the bag. There are many more clats that vary down to 1mm or less.

HD#484 Oct. 13 2005 West Rota

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD484-1-R01	14_20.118	144_50.821	1348	andesite	angular	30	21	12	6.3kg	black	weakly	film	px 5%,pl15%	weakly	
HD484-2-R02	14_20.121	144_50.842	1314	two-px andesite	subangular	27	16	13	7.3kg	black	weakly	0	px 5%,pl20%	weakly	
HD484-3-R03	14_20.124	144_50.851	1293	andesite	angular	26	22	13	6.35kg	gray	extensive	film	px 5%,pl~10%		
HD484-4-R04	14_20.204	144_50.848	1258	two-px andesite	angular	27	16	15	6.6kg	black	weakly	0	px 5%,pl20%	weakly	
HD484-5-R05	14_20.272	144_50.808	1277	cpx basalt (andesite)?	angular	18	13	12	3.5kg	black	fresh	film	px 5%,pl30%	moderately	
HD484-6-R06	14_20.292	144_50.805	1266	hydrothermally-alteredand jointed lava	subangular	27	17	15	7.0kg	gray	extensive	0		moderately	sulfide veins (pyrite) and silicification observed.
HD484-7-R07	14_20.368	144_50.829	1178	strongly altered andesite	angular	24	18	16	6.5kg	black&dark gray	extensive	film		weakly	
HD484-8-R08	14_20.409	144_50.853	1135	lost											
HD484-9-R09	14_20.437	144_50.883	1091	tuff	angular	34	41	18	10kg	black&pale gray	weakly	film		weakly	
HD484-10-R10	14_20.434	144_50.910	1044	altered tuff breccia	subangular	35	26	11	12.5kg	black&pale gray	extensive	film			
HD484-11-R11	14_20.452	144_50.935	1002	altered andesite	angular	36	21	13	6.5kg	black	extensive	film		weakly	
HD484-12-R12	14_20.473	144_50.978	960	two-px andesite	angular	18	13	12	3.0kg	black	weakly	film	px 5%,pl20%	weakly	
HD484-13-R13	14_20.483	144_50.991	936	two-px andesite	angular	18	13	11	2.0kg	black	fresh	film	px 5%,pl20%		
HD484-14-R14	14_20.500	144_51.012	912	two-px andesite	subangular	16	15	13	4.2kg	black	fresh	film			
HD484-15-R15	14_20.578	144_51.106	798	two-px andesite	subrounded	12	12	11	2.5kg	black	fresh	film	px 5%,pl20%	weakly	
HD484-16-R16	14_20.581	144_51.120	776	two-px andesite	subangular	11	8	7	0.75kg	black	fresh	film	px 5%,pl10%	weakly	

HD484-17-R17	14_20.744	144_51.323	628	rhyolite	angular	11	7	5	0.75kg	pale green	fresh	0	px 2%,pl4%,hb trace	extensively	Samples is in many pieces, dimensions are for the largest pieces. This samples were shed off a rhyolite ball with columnar joint.

HD#485 Oct. 14 2005 Chalfe

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD485-1-R01	14_40.580	145_00.528	2297	basaltic lava	subrounded	19	16	14	3.0kg	black	fresh	~10mm	ol3%,px 6%,pl1%	35%	Thick alteration zone on one side. Alteration in areas in interior.
HD485-2-R02	14_40.523	145_00.523	2249	basaltic lava	subangular	11	10	8	0.9kg	black	altered	2-10mm	px 1%,pl4%	10%	Appears a phyric, not many phenocrysts observed. Brown Mn in zones in interior.
HD485-2-R03	14_40.523	145_00.523	2249	basaltic lava	subangular	24	17	12	3.6kg	black	altered	1-10mm	px 3% (total <10%)	15-20%	Similar to R02. Alteration in interior. Few phenocrysts only -3%cpx in total volume.
HD485-3-R04	14_40.484	145_00.533	2241	basaltic lava	subrounded	13	12	10	1.3kg	black	weakly	0-5mm	ol15%,px 5%	20%	Does contain 0.5-3mm olivine phenocrysts and minor pyroxene. No internal alteration.
HD485-4-R05	14_40.382	145_00.505	2181	ol basalt	subrounded	27	27	20	11.8kg	black	weakly	4mm	ol10%	35%	20mm alteration rind.
HD485-5-R06	14_40.324	145_00.506	2124	basaltic lava	angular	24	16	12	3.8kg	black	weakly	5mm	ol10%,px10%	10%	weakly vesiculated basalt, 20% total volume is phenocrysts. Some vesicules are filled.
HD485-6-R07	14_40.283	145_00.512	2073	basaltic lava	subrounded	25	16	14	4.8kg	black	altered	1mm	ol12%,px7%,pl1%	20%	10mm alteration rind. Olivine, cpx, minor cpx.
HD485-7-R08	14_40.224	145_00.504	2048	ol basalt	subrounded	27	17	17	7.2kg	black	weakly	0-6mm	ol15%,px 2%	35%	30mm alteration rind. Vesicules range in size from 1-10mm.
HD485-8-R09	14_40.176	145_00.490	2050	manganese crust	subrounded	11	9	8	0.3kg	black	-	all			manganese crust in odd hollow cone.
HD485-9-R10	14_40.061	145_00.489	2066	basaltic lava	subangular	28	20	18	9.3kg	black	altered	2mm	ol3%,px 2%	60%	Interior alteration. Bimodal vesicle size distribution 3-5mm vesicles and many small 1mm vesicles phenocrysts <5% total volume.
HD485-10-R11	14_39.957	145_00.475	2056	sheet flow of picritic lava	subrounded	22	16	15	4.6kg	black	weakly	2mm	ol25%,px 10%,pl1%	50%	Top of flow, highly vesiculated on outer surface. Many olivine and cpx phenocrysts. Ol 2-4mm in size. Some ol glomerocrysts.
HD485-11-R12	14_39.934	145_00.483	2016	basaltic lava(altered)	subrounded	14	9	8	0.6kg	black	altered	1mm		30%	Small "pillow" piece. Altered throughout. Cannot see phenocrysts, difficult to determine % vesiculation.

HD485-12-R13	14_39.861	145_00.474	1938	picrite/ankaramite lava	subangular	19	12	12	2.1kg	black	weakly	2mm	ol15%,px 25%	30-60%	% vesiculation varies. Cpx>Ol may have minor plagioclase. Cpx phenocrysts up to 2mm in size.
HD485-13-R14	14_39.809	145_00.470	1902	basaltic lava (maybe picritic/ankaramitic)	subrounded	25	20	16	5.6kg	black	altered	3mm	ol15%,px 15%	25%	Some interior alteration. 7-10mm alteration rind. Olivine and cpx phenocrysts.
HD485-14-R15	14_39.738	145_00.449	1892	vesiculated flow top. Ankaramite.	subangular	30	22	15	7.8kg	black	fresh	2-4mm	ol10%,px 20%	50-70%	3-5mm phenocrysts of cpx and ol. Cpx>ol.
HD485-15-R16	14_39.713	145_00.429	1879	vesiculated flow top. Picrite/ankaramite.	angular	15	14	12	1.8kg	black	fresh	2mm	ol15%,px 10%	60%	Highly vesiculated flow top. Olivine and cpx phenocrysts. Fairly fresh looking sample.
HD485-16-R17	14_39.524	145_00.388	1896	flow fragment, basaltic	angular	9	6	5	0.3kg	black	fresh		ol1%,px 5%	40%	Small fragment. Small (0.5-1.5mm) vesicules. Almost aphyric, few phenocrysts visible.
HD485-17-R18	14_39.523	145_00.382	1877	altered fragment	angular	10	6	4	0.25kg	black	altered	2mm			Hihghly altered fragment, maybe manganese crust.
HD485-18-R19	14_39.468	145_00.408	1801	massive flow	subrounded	15	13	12	1.8kg	black and light brown	altered	2-9mm	non observed.	30%	1cm alteration rind. Very small vesicles (amm). Appears aphyric.
HD485-19-R20	14_39.443	145_00.421	1769	basaltic flow	angular	24	21	20	4.2kg	black and light brown	weakly		ol 2%	35%	Vesicles range in size from 2-5mm. Appears aphyric. Very small olivines (1mm and smaller) are 2% of total volume.

HD#486	Oct. 15 2005	Mt. Mn (south of Chaife)													
sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD486-2-R01	14_38.168	144_59.984	2169	basaltic lava	angular	5	4	3	0.09kg	black	altered	2	pl1%	60	heavily altered breccia clast and breccia matrix
HD486-3-R2	14_38.148	144_59.980	2154	altered lava	subrounded	10	5	4	0.3kg	gray	altered	1	-	-	Heavily altered vesiculated lava. Phenocrysts not visible. Another fragment is 9x7x3 in size.
HD486-4-R3	14_38.117	144_59.988	2132	breccia	subangular	29	27	15	9.8kg	black and brown	altered	1	px2%	30%	Manganese cemented breccia. Some clasts heavily altered. Minor cpx in clasts.
HD486-5-R4	14_38.091	145_00.007	2115	breccia	subangular	45	33	15	17kg	black and brown	altered	1	aphyric	40%	Small breccia fragment, not cut. Heavy alteration and manganese cement.
HD486-6-R5	14_37.958	145_00.045	2120	brecciated lava	subangular	22	13	11	3.4kg	black	altered	10	px10%,pl2%	15%	Basaltic clasts cemented with volcanic sand and manganese. Alteration in interior of clasts. Small cpx and plagioclase phenocrysts visible in clast.

HD486-6-R6	14_37.958	145_00.045	2120	basaltic lava	subangular	27	26	22	12.3kg	black	altered	2	px10%	10%	Weakly vesiculated lava. Some cpx, possible plagioclase. Most vesicles <1mm in size. Some of the largest ones (3-5mm) are amygdules filled with calcite or zeolite.
HD486-7-R7	14_37.912	145_00.050	2103	basaltic breccia clast	subangular	12	9	7	0.6kg	black	altered	3	px 5%,pl1%	20%	Basaltic clast with breccia cement of sand and manganese. Clast is altered, not heavily. Plagioclase and cpx visible.
HD486-8-R8	14_37.883	145_00.053	2084	basaltic lava(ankaramitic?)	subangular	15	11	10	2.0kg	black and brown	altered	1	ol5%,px 25%	25%	Vesiculated basalt. Some alteration near flow edge (8mm). 30% small (1-3mm) phenocrysts, mostly cpx.
HD486-9-R9	14_37.685	144_59.644	2042	basaltic breccia clast	rounded	11	8	6	0.5kg	black	altered	1	aphyric	20%	Clast from a breccia. Breccia matrix on some surface. Alteration rind of 4mm thick around clast.
HD486-10-R10	14_37.632	144_59.611	2026	breccia	subrounded	17	13	11	1.6kg	black	altered	1	aphyric	35%	Breccia clast with a 4cm rind of alteration.
HD486-11-R11	14_37.572	144_59.573	2034	breccia clast and matrix	subrounded	11	10	8	0.6kg	brown with black crust	altered	2	?	?	heavily altered breccia clast and breccia matrix
HD486-12-R12	14_37.418	144_59.452	1931	breccia clast	subrounded	16	14	11	2.7kg	brown with black crust	altered	1	ol10%,px 5%,pl5%	35	Vesiculated basaltic clast with breccia matrix and oxidized. Sediment cemented to one surface. Clast has a 2cm alteration rind in some locations. Some oxidation in interior. Olivine, cpx and plagioclase phenocrysts.
HD486-1-S01	14_38.207	144_59.985	2180	pumiceous sand					2.2kg						

HD#487 Oct. 16 2005 Esmeralda bank sediment wave

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD487-1-S01	14_52.164	145_11.642	1474	volcanic sand					4.9kg	black to dark brown					very coarse volcanic sand, with minor mud, angulat to subangular pieces, fine sand to pebbles (2 cm) in size; pebbles are pieces of moderately indurated and burrowed formation; can be broken by hand; may be pieces of ashy outcrop?

HD487-2-S02	14_52.243	145_11.775	1410	volcanic sand					2.3kg	black to dark brown					very coarse volcanic sand, basaltic to andesitic fragments?, very coarse (2 mm) to fine, poorly sorted, significant mud fraction
HD487-3-R01	14_52.241	145_11.776	1404	very small irregular black fragment: lost on ascent					x						lost on ascent
HD487-4-C01	14_52.344	145_11.892	1343	dark brown silty mud					0.35kg	dark brown					dark brown silty mud, some very fine sand grains
HD487-5-S03	14_52.414	145_12.107	1362	silty mud					5.8kg	dark brown					silty mud with fine (gritty feel) sand in it, rare medium-sized sand grains
HD487-6-R02	14_52.522	145_12.307	1371	sandstone	subangular	34	32	10	7400	light and dark brown	-	-	-	-	with many burrows. Upper layer: light-brown colored
HD487-7-S04	14_52.574	145_12.376	1364	volcanic sand					5.3kg	black to dark brown					black to dark brown volcanic sand, poorly sorted with rare white grains (forams?), very coarse (6mm) to very fine, small clay fraction
HD487-8-R03	14_52.523	145_12.433	1363	ol-bearing pl-phyric basalt	subrounded	19	17	14	3500	black	fresh	film	ol2-3%,pl10%	5%	
HD487-9-R04	14_52.554	145_12.435	1344	aphyric basalt	angular	12	6	5	450	black	altered	film	none	20%	altered basalt with strongly altered rind. Secondary minerals (zeolite) in vesicles.
HD487-10-R05	14_52.573	145_12.453	1326	sparsely plagioclase-phyric basalt	angular	16	8	7	750	black	fresh	film	pl2%	<5%	dense nearly aphyric basalt fragment
HD487-11-C02	14_52.640	145_12.577	1269	silty mud					0.9kg	dark brown					dark brown silty mud, some very fine sand grains, rare sand-sized grains

HD#488 Oct. 17 2005 NW Rota-1 satellite cones

sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD488-1-R01	14_35.290	144_49.609	2260	cpx-ol basalt	angular	28	18	14	5kg	black	fresh	film	ol5%,px1%	moderate	
HD488-2-R02	14_35.306	144_49.606	2255	cpx-ol basalt	angular	13	10	8	1kg	dark brown	fresh	film	ol5%,px1%	moderate	
HD488-3-R03	14_35.318	144_49.595	2238	cpx-ol basalt	angular	7	6	4	0.15kg	black	fresh	-	ol3%,px1%	moderate	
HD488-3-R04	14_35.318	144_49.595	2238	cpx-ol basalt	angular	12	11	6	0.75kg	black	fresh	-	ol3%,px1%	moderate	
HD488-4-R05	14_35.325	144_49.596	2229	cpx-ol basalt	angular	16	12	12	2.05kg	black	fresh	-	ol5%	moderate	
HD488-4-R06	14_35.325	144_49.596	2229	cpx-ol basalt	angular	17	13	9	1.6kg	black	fresh	-	ol5%,px<1%	moderate	
HD488-4-R07	14_35.325	144_49.596	2229	ol basalt	angular	20	12	10	3.4kg	black	fresh	-	ol4%	moderate	
HD488-5-R08	14_35.367	144_49.581	2196	cpx-ol basalt	angular	15	13	11	1.8kg	black	fresh	-	ol3%,px3%	moderate	
HD488-6-R09	14_35.400	144_49.569	2180	cpx-ol basalt	angular	12	11	11	0.7kg	black	fresh	-	ol3%,px1%	strongly	
HD488-7-R10	14_35.453	144_49.541	2151	cpx-ol basalt	angular	38	28	25	23.4kg	dark brown to black	fresh	-	ol5%,px<1%,pl<1%	strongly	
HD488-7-R11	14_35.453	144_49.541	2151	cpx-ol basalt	angular	13	11	10	1.1kg	dark brown to black	fresh	-	ol5%,px<1%	strongly	
HD488-8-R12	14_35.514	144_49.466	2117	ol basalt	angular	22	15	14	3.6kg	black	fresh	-	ol5%	strongly	
HD488-9-R13	14_35.551	144_49.422	2079	cpx-ol basalt	angular	21	12	12	2.9kg	black	fresh	-	ol<1%,px<1%	moderate	
HD488-10-R14	14_35.563	144_49.378	2039	ol-bearing cpx-pl phyric basalt	angular	20	18	12	3.0kg	dark gray	fresh	-	ol<1%,px5%,pl30%	moderate	

HD488-11-R15	14_35.603	144_48.126	1675	ol-bearing cpx-pl phyric basalt	angular	16	10	10	1.4kg	black	fresh	-	ol<1%,px5%,pl30 %	moderate	
HD488-11-R16	14_35.603	144_48.126	1675	ol-bearing cpx-pl phyric basalt	subangular	10	10	6	0.4kg	black	fresh	-	ol<1%,px5%,pl30 %	moderate	
HD488-12-R17	14_35.604	144_48.102	1649	px andesite (basalt?)	angular	37	22	21	14.5kg	light brown to black	fresh	-	px<2%,pl<5%	moderate	
HD488-13-R18	14_35.609	144_48.095	1641	ol-bearing cpx-pl phyric basalt	angular	10	7	7	0.45kg	black	fresh	-	ol<1%,px15%,pl3 0%	moderate	
HD488-14-R19	14_35.615	144_48.085	1629	ol-bearing cpx-pl phyric basalt	angular	12	10	10	1.3kg	black	fresh	-	ol2%,px5%,pl20%	moderate	
HD488-15-R20	14_35.623	144_48.056	1593	ol-bearing cpx-pl phyric basalt	angular	14	10	10	1.3kg	black	fresh	-	ol1%,px5%,pl20%	moderate	
HD488-16-R21	14_35.634	144_48.034	1585	ol-bearing cpx-pl phyric basalt	angular	21	14	12	2.4kg	black	fresh	-	ol1%,px5%,pl20%	moderate	
HD488-17-R22	14_35.649	144_48.008	1527	ol-bearing cpx-pl phyric basalt	angular	18	15	15	2.7kg	black	fresh	-	ol1%,px5%,pl20%	moderate	
HD488-18-R23	14_35.654	144_47.994	1505	ol-bearing cpx-pl phyric basalt	angular	27	20	18	7.8kg	black and pale gray	fresh	-	ol1%,px5%,pl20%	moderate	
HD488-19-R24	14_35.684	144_47.911	1474	ol-bearing cpx-pl phyric basalt	angular	30	23	20	9.3kg	black	fresh	-	ol1%,px5%,pl20%	moderate	
HD488-20-S1	14_35.712	144_47.907	1468	fresh volcanic sand					1.3kg						volcanic sand (<1mm grain size) mainly composed of dark brown-colored glass and crystals (mainly pl, px)

HD#489	Oct. 19 2005	West Rota satellite cones													
sample No.	latitude(N)	longitude(E)	depth (m)	rock type	shape	size X (cm)	size Y (cm)	size Z (cm)	weight	colour	alteration	Mn coating	phenocrysts	vesiculation	Memo
HD489-1-R01				pl-phyric basalt	subangular	21	16	13	6kg	black	fresh	film	pl30%	moderate	
HD489-2-R02				pl-phyric cpx basalt	subangular	18	13	12	3.5kg	black	fresh	film	pl30%,px rare	moderate	
HD489-3-R03				pumice	angular	24	20	13	2.2kg	white	fresh	film	px2-3%,bt?	strongly	broken into pieces when sampled
HD489-3-R04				pl-phyric basalt	angular	42	30	22	29kg	black	fresh	film	pl30%	moderately	
HD489-4-R05				hb dacite	subangular	25	19	16	6.8kg	gray	fresh	film	pl30%,hb5%,qz	weakly	
HD489-5-R06				pl phyric ol basalt	angular	34	24	24	14.8kg	black	fresh	film	pl30%,ol<1%	moderately	
HD489-5-R07				hb dacite	subangular	10	8	7	0.02kg	white	fresh	film	pl20%,hb<1%,qz	strongly	
HD489-5-R08				pumice	angular	11	8	7	0.03kg	white	fresh	film	pl10%,hb<1%,qtz	strongly	
HD489-5-R09				pumice	angular	10	7	6	0.015kg	white	fresh	film	pl20%,hb<1%,qz	strongly	
HD489-6-R10				pl-phyric cpx-ol basalt	angular	39	23	14	11.4kg	black	fresh	film	pl20%,ol<1%,px<1%	moderately	
HD489-7-R11				pumice	angular	12	9	7	0.03kg	white	fresh	film	pl<10%,hb<1%,qtz	strongly	
HD489-8-R12				pumice	subangular	18	8	6	0.06kg	white	fresh	film	px<3%	strongly	columnar jointed
HD489-9-R13				pl-phyric basalt lava	angular	5	4	3	0.01kg	black	fresh	film	pl20%	moderately	
HD489-10-R14				pl-phyric basalt	subangular	14	9	8	1.5kg	black ~ dark brown	fresh	-	pl20%,ol +	moderately	
HD489-11-R15				pl-phyric basalt	angular	15	9	9	1.5kg	black	fresh	-	pl20%,ol?	moderately	
HD489-13-R16				pl-phyric basalt	subrounded	32	21	17	11.5kg	black & brown	fresh	-	pl20%,ol +	moderately	

HD489-14-R17	pl-phyric basalt	subangular	14	11	9	1.7kg	black	fresh	film	pl20%,ol?	moderately
HD489-15-R18	pl-phyric basalt	subangular	18	15	11	3.6kg	black	fresh	film	pl20%	moderately
HD489-16-R19	hb dacite	angular	23	18	11	3.2kg	gray	fresh	film	pl10%,hb3%	moderately
HD489-17-R20	pl-phyric basalt	subangular	16	13	12	2.8kg	black	fresh	film	pl20%	moderately
HD489-18-R21	lost										
HD489-12-S01	coarse volcanic sand					1.5kg					

APPENDIX B: Initial Distribution of samples to the shipboard scientific party

HD#480 Oct. 9 2005 NW Rota-1

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD480-1-R01	14_35.991	144_46.509	pl-px phyric basalt	O	O						
HD480-3-R02	14_36.045	144_46.630	pl-px phyric basalt	O						O	
HD480-4-R03	14_36.046	144_46.522		O		O					
HD480-6-R04	14_36.040	144_46.585	pl-px phyric basalt	O	O						
HD480-6-R05	14_36.040	144_46.585	ol-bearing pl-px-phyric basalt	O	O						
HD480-7-R06	14_36.004	144_46.435	pl-px phyric basalt	O	O					O	O
HD480-8-R07	14_36.039	144_46.435	pl-px phyric basalt	O	O						
HD480-9-R08	14_36.063	144_46.432	pl-px phyric basalt	O	O						
HD480-10-R09	14_36.077	144_46.423	ol-bearing pl-px-phyric basalt	O	O						
HD480-11-R10	14_36.085	144_46.422	pl-px phyric basalt	O	O					O	O
HD480-2-S1	14_36.056	144_46.520	scoriaceous sand	O		O				O	O
HD480-4-C1	14_36.046	144_46.522	scoriaceous sand	O		O				O	
HD480-5-C2	14_36.051	144_46.522	scoriaceous sand	O		O				O	
HD480-4-W-01	14_36.046	144_46.522		O							

NOTE:small piece of filamentous material from R02 scraped off for microbiologists at Oregon State

sulfur sample

HD#481 Oct. 10 2005 NW Rota-1

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD481-1-R01	14_36.051	144_46.522	scoria	O	O	O				O	
HD481-3-R02	14_36.046	144_46.580	basalt	O							
HD481-3-R03	14_36.046	144_46.580	basalt	O							
HD481-3-R04	14_36.046	144_46.580	basalt	O							

HD481-4-R05	14_35.435	144_46.762	ol-bearing pl-px-phyric basalt	O	O						O
HD481-5-R06	14_35.451	144_46.761	pl-px phyric basalt	O	O						
HD481-6-R07	14_35.472	144_46.764	pl-px phyric basalt	O	O						
HD481-7-R08	14_35.508	144_46.770	pl-px phyric basalt	O	O						
HD481-8-R09	14_35.536	144_46.774	pl-px phyric basalt	O	O						
HD481-9-R10	14_35.574	144_46.776	pl-px phyric basalt	O	O						
HD481-10-R11	14_35.627	144_46.771	pl-px phyric basalt	O	O						
HD481-11-R12	14_35.675	144_46.762	pl-px phyric basalt	O	O						
HD481-12-R13	14_35.762	144_46.769	pl-px phyric basalt	O	O						
HD481-13-R14	14_35.820	144_46.777	pl-px phyric basalt	O	O						
HD481-1-c1	14_36.051	144_46.522	fragments of scoria and pl-px-phyric basalt	O		O				O	O
HD481-2-c2	14_36.034	144_46.602	fragments of pl-px-phyric basalt	O	O	O					
HD481-1-W01	14_36.051	144_46.522		O							
basket box			cinders	O	O						O
basket			vesicular basalt	O				O			O

HD#482 Oct. 11 2005 West Rota

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD482-1-R01	14_19.659	144_51.105	rhyodacitic pumice	O	O	O	O				
HD482-2-R02	14_19.639	144_51.122	hydrothermally altered lava	O	O	O	O	O			
HD482-3-R03	14_19.631	144_51.124	hydrothermally altered lava(andesite or dacite)	O	O	O	O				
HD482-4-R04	14_19.595	144_51.165	hydrothermally altered lava(andesite or dacite)	O	O	O	O	O			
HD482-5-R05	14_19.557	144_51.234	hydrothermally altered lava(andesite or dacite)	O	O	O	O				
HD482-6-R06	14_19.538	144_51.254	hydrothermally altered lava(andesite or dacite)	O	O	O	O	O			
HD482-7-R07	14_19.474	144_51.316	hydrothermally altered lava(andesite or dacite)	O	O	O	O				
HD482-8-R08	14_19.461	144_51.331	hydrothermally altered lava(andesite or dacite)	O	O	O	O				
HD482-9-R09	14_19.452	144_51.335	hydrothermally altered lava(andesite or dacite)	O	O	O	O				
HD482-10-R10	14_19.427	144_51.306	hydrothermally altered lava(andesite or dacite)	O	O	O	O				
HD482-12-R11	14_19.442	144_51.529	px-pl-phyric andesite	O	O	O	O				

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD482-13-R12	14_19.460	144_51.544	rhyolitic pumice	O	O	O	O	O			
HD482-11-S01	14_19.439	144_51.520	rhyolitic pumice	O		O	O				

HD#483 Oct. 12 2005 West Rota

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD483-2-R01	14_17.730	144_51.132	altered tuff breccia	O		O	O				
HD483-3-R02	14_17.719	144_51.135	dacite (dyke)	O	O	O	O				
HD483-4-R03	14_17.702	144_51.168	dacite (dyke)	O	O		O				
HD483-5-R04	14_17.646	144_51.214	layered scoriaceous tuff	O			O				
HD483-6-R05	14_17.636	144_51.227	andesite (dyke)	O	O	O	O				O
HD483-7-R06	14_17.630	144_51.230	dacitic tuff	O			O				
HD483-8-R07	14_17.586	144_51.308	basalt(dyke)	O	O	O	O				
HD483-9-R08	14_17.584	144_51.321	aphyric dacite breccia	O	O		O				
HD483-10-R09	14_17.560	144_51.368	basalt breccia dyke	O	O	O	O				
HD483-11-R10			lost	O			O				
HD483-11-R11	14_17.533	144_51.424	ol-cpx basalt lava	O	O	O	O				
HD483-12-R12	14_17.487	144_51.530	ol-cpx-pl basalt	O	O		O				O
HD483-13-R13	14_17.452	144_51.551	ol-cpx-pl basalt	O	O	O	O				
HD483-14-R14	14_17.398	144_51.587	cpx-pl basaltic dyke	O	O		O				
HD483-15-R15	14_17.367	144_51.603	cpx-pl basalt	O	O		O				
HD483-16-R16	14_17.343	144_51.613	ol-cpx-pl basalt	O	O		O				
HD483-17-R17	14_17.332	144_51.658	ol-cpx-pl basaltic spatter	O	O		O				O
HD483-19-R18	14_17.676	144_51.671	andesitic volcanic breccia	O	O		O				
HD483-20-R19			lost	O			O				
HD483-20-R20	14_17.665	144_51.680	hb-px dacite	O	O		O				
HD483-1-S01	14_17.730	144_51.132	pumice clast with hydrothermal precipitate or microbial mat	O		O	O				
HD483-18-S02	14_17.323	144_51.760	pumice clast	O			O				

HD#484 Oct. 13 2005 West Rota

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern &	Bloomer	Kohut	Shaw	O'Leary

							Basu				
HD484-1-R01	14_20.118	144_50.821	andesite	O	O	O	O				
HD484-2-R02	14_20.121	144_50.842	two-px andesite	O	O	O	O				
HD484-3-R03	14_20.124	144_50.851	andesite	O			O				
HD484-4-R04	14_20.204	144_50.848	two-px andesite	O	O		O				
HD484-5-R05	14_20.272	144_50.808	cpx basalt (andesite)?	O	O	O	O				
HD484-6-R06	14_20.292	144_50.805	hydrothermally-alteredand jointed lava	O	O	O	O	O			
HD484-7-R07	14_20.368	144_50.829	strongly altered andesite	O		O	O				
HD484-8-R08	14_20.409	144_50.853	lost	O			O				
HD484-9-R09	14_20.437	144_50.883	tuff	O			O				
HD484-10-R10	14_20.434	144_50.910	altered tuff breccia	O		O	O	O			
HD484-11-R11	14_20.452	144_50.935	altered andesite	O		O	O				
HD484-12-R12	14_20.473	144_50.978	two-px andesite	O	O		O				
HD484-13-R13	14_20.483	144_50.991	two-px andesite	O	O	O	O				
HD484-14-R14	14_20.500	144_51.012	two-px andesite	O	O		O				
HD484-15-R15	14_20.578	144_51.106	two-px andesite	O	O		O				
HD484-16-R16	14_20.581	144_51.120	two-px andesite	O	O		O				
HD484-17-R17	14_20.744	144_51.323	rhyolite	O	O	O	O				

HD#485 Oct. 14 2005 Chaife

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD485-1-R01	14_40.580	145_00.528	basaltic lava	O	O				O		
HD485-2-R02	14_40.523	145_00.523	basaltic lava	O	O				O		
HD485-2-R03	14_40.523	145_00.523	basaltic lava	O	O						
HD485-3-R04	14_40.484	145_00.533	basaltic lava	O	O				O		
HD485-4-R05	14_40.382	145_00.505	ol basalt	O	O				O		O
HD485-5-R06	14_40.324	145_00.506	basaltic lava	O	O				O		
HD485-6-R07	14_40.283	145_00.512	basaltic lava	O	O				O		
HD485-7-R08	14_40.224	145_00.504	ol basalt	O	O				O		
HD485-8-R09	14_40.176	145_00.490	manganese crust	O							
HD485-9-R10	14_40.061	145_00.489	basaltic lava	O	O				O		
HD485-10-R11	14_39.957	145_00.475	sheet flow of picritic lava	O	O				O		O

HD485-11-R12	14_39.934	145_00.483	basaltic lava(altered)	O							
HD485-12-R13	14_39.861	145_00.474	picrite/ankaramite lava	O	O				O	O	O
HD485-13-R14	14_39.809	145_00.470	basaltic lava (maybe picritic/ankaramitic)	O	O				O		
HD485-14-R15	14_39.738	145_00.449	vesiculated flow top. Ankaramite.	O	O			O	O		
HD485-15-R16	14_39.713	145_00.429	vesiculated flow top. Picrite/ankaramite.	O	O				O		O
HD485-16-R17	14_39.524	145_00.388	flow fragment, basaltic	O	O				O		
HD485-17-R18	14_39.523	145_00.382	altered fragment	O							
HD485-18-R19	14_39.468	145_00.408	massive flow	O	O						
HD485-19-R20	14_39.443	145_00.421	basaltic flow	O	O				O		

HD#486 Oct. 15 2005 Mt. Mn (south of Chaife)

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD486-2-R01	14_38.168	144_59.984	basaltic lava	O							
HD486-3-R2	14_38.148	144_59.980	altered lava	O							
HD486-4-R3	14_38.117	144_59.988	breccia	O	O						
HD486-5-R4	14_38.091	145_00.007	breccia	O	O						
HD486-6-R5	14_37.958	145_00.045	brecciated lava	O	O				O		
HD486-6-R6	14_37.958	145_00.045	basaltic lava	O	O				O		
HD486-7-R7	14_37.912	145_00.050	basaltic breccia clast	O							
HD486-8-R8	14_37.883	145_00.053	basaltic lava(ankaramitic?)	O	O				O		
HD486-9-R9	14_37.685	144_59.644	basaltic breccia clast	O	O						
HD486-10-R10	14_37.632	144_59.611	breccia	O	O						
HD486-11-R11	14_37.572	144_59.573	breccia clast and matrix	O							
HD486-12-R12	14_37.418	144_59.452	breccia clast	O	O				O		O
HD486-1-S01	14_38.207	144_59.985	pumiceous sand	O		O					

HD#487 Oct. 16 2005 Esmeralda bank sediment wave

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD487-1-S01	14_52.164	145_11.642	volcanic sand	O							

HD487-2-S02	14_52.243	145_11.775	volcanic sand	O							
HD487-3-R01	14_52.241	145_11.776	very small irregular black fragment; lost on ascent	O							
HD487-4-C01	14_52.344	145_11.892	dark brown silty mud	O							
HD487-5-S03	14_52.414	145_12.107	silty mud	O							
HD487-6-R02	14_52.522	145_12.307	sandstone	O	O						
HD487-7-S04	14_52.574	145_12.376	volcanic sand	O							
HD487-8-R03	14_52.523	145_12.433	ol-bearing pl-phyric basalt	O	O						
HD487-9-R04	14_52.554	145_12.435	aphyric basalt	O	O						
HD487-10-R05	14_52.573	145_12.453	sparsely plagioclase-phyric basalt	O	O						
HD487-11-C02	14_52.640	145_12.577	silty mud	O							

HD#488 Oct. 17 2005 NW Rota-1 satellite cones

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary
HD488-1-R01	14_35.290	144_49.609	cpx-ol basalt	O	O						
HD488-2-R02	14_35.306	144_49.606	cpx-ol basalt	O	O						
HD488-3-R03	14_35.318	144_49.595	cpx-ol basalt	O	O						
HD488-3-R04	14_35.318	144_49.595	cpx-ol basalt	O	O						
HD488-4-R05	14_35.325	144_49.596	cpx-ol basalt	O	O				O		
HD488-4-R06	14_35.325	144_49.596	cpx-ol basalt	O	O						
HD488-4-R07	14_35.325	144_49.596	ol basalt	O	O				O		
HD488-5-R08	14_35.367	144_49.581	cpx-ol basalt	O	O				O		
HD488-6-R09	14_35.400	144_49.569	cpx-ol basalt	O	O						
HD488-7-R10	14_35.453	144_49.541	cpx-ol basalt	O	O						
HD488-7-R11	14_35.453	144_49.541	cpx-ol basalt	O	O				O		
HD488-8-R12	14_35.514	144_49.466	ol basalt	O	O						
HD488-9-R13	14_35.551	144_49.422	cpx-ol basalt	O	O						
HD488-10-R14	14_35.563	144_49.378	ol-bearing cpx-pl phyric basalt	O	O						
HD488-11-R15	14_35.603	144_48.126	ol-bearing cpx-pl phyric basalt	O	O				O		
HD488-11-R16	14_35.603	144_48.126	ol-bearing cpx-pl phyric basalt	O	O						
HD488-12-R17	14_35.604	144_48.102	px andesite (basalt?)	O	O						
HD488-13-R18	14_35.609	144_48.095	ol-bearing cpx-pl phyric basalt	O	O						

HD488-14-R19	14_35.615	144_48.085	ol-bearing cpx-pl phyric basalt	O	O						
HD488-15-R20	14_35.623	144_48.056	ol-bearing cpx-pl phyric basalt	O	O						
HD488-16-R21	14_35.634	144_48.034	ol-bearing cpx-pl phyric basalt	O	O				O		
HD488-17-R22	14_35.649	144_48.008	ol-bearing cpx-pl phyric basalt	O	O						
HD488-18-R23	14_35.654	144_47.994	ol-bearing cpx-pl phyric basalt	O	O						
HD488-19-R24	14_35.684	144_47.911	ol-bearing cpx-pl phyric basalt	O	O						
HD488-20-S1	14_35.712	144_47.907	fresh volcanic sand	O							

HD#489 Oct. 19 2005 West Rota satellite cones

sample No.	latitude(N)	longitude(E)	rock type	IFREE	Ishizuka	Embly	Stern & Basu	Bloomer	Kohut	Shaw	O'Leary

not completed at time of cruise report printing