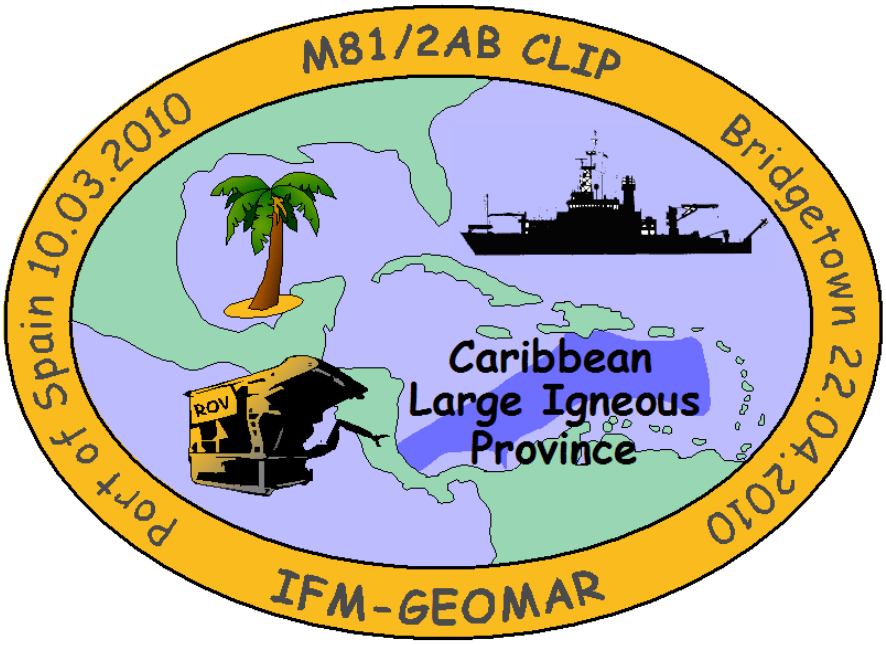
METEOR-Berichte 11-8

CLIP – Origin of the Caribbean Large Igneous Province (CLIP) in connection with the geodynamic evolution of the Central Caribbean

Cruise No. 81, Leg 2A/B

March 11 – April 21, 2010
Port of Spain (Trinidad and Tobago) – Willemstad (Netherlands Antilles) – Bridgetown (Barbados)



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2011

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1 Summary

The main purpose of R/V METEOR cruise M81/2AB was to obtain new insights into the controversially discussed origin and geodynamic evolution of the Caribbean Large Igneous Province (CLIP) and the Caribbean Plate using an interdisciplinary approach combining structural geology, geodynamics, magnetics, volcanology, sedimentology, petrology, magmatic geochemistry and geochronology. The rock sampling on M81/2AB achieved its major objectives through successful 1) stratigrafically-controlled sampling of a complete basement section of the northern Beata Rise with Kiel 6000 ROV (remote operated vehicle), 2) extensive dredge sampling of the southern Beata Rise, and 3) the first representative hard rock sampling of the Hess-Escarpment region. The wide range of intrusive, volcanic and sedimentary rocks recovered on M81/2AB represents the most detailed marine sampling of the CLIP and associated features to date. SIMRAD EM120 and PARASOUND were used to select sampling stations and to assess the structural geology of the region. Multi-beam seafloor mapping and preliminary analyses of the recovered samples suggest large-scale tectonic movements of the Beata Rise and the area north of the Hess-Escarpment and a volcanic rather than continental origin for the Nicaragua Rise north of the Hess-Escarpment. The magnetic studies were also highly successful with more than 7,300 km of magnetic profiles being acquired. Magnetic anomalies measured on four parallel profiles in the Colombia Basin suggest that the crust is oceanic, but seafloor spreading anomalies could not be correlated. Along the Hess Escarpment high amplitude magnetic anomalies associated with morphological features indicate a volcanic origin and basaltic composition of the crust, consistent with the seafloor morphology and recovered samples.

Zusammenfassung

Basierend auf der FS METEOR-Reise M81/2AB sollen mit einem interdisziplinären Ansatz (Strukturgeologie, Geodynamik, Magnetik, Vulkanologie, Petrologie, magmatische Geochemie, Geochronologie, Sedimentologie) neue Erkenntnisse über den bisher kontrovers diskutierten Ursprung und die geodynamische Entwicklung der karibischen Flutbasaltprovinz (CLIP) und –Platte gewonnen werden. Die Gesteinsbeprobung während M81/2AB verlief mit der stratigraphisch kontrollierten Beprobung einer vollständigen Basementabfolge des nördlichen Beatarückens mittles des Tauchroboters (ROV) Kiel 6000, der umfassenden Dredge-Beprobung des südlichen Beatarückens und der ersten representativen Beprobung von Gebieten nördlich des Hess-Escarpments äußerst erfolgreich. Das dabei gewonnene weite Spektrum an Gesteinen repräsentiert höchstwahrscheinlich die bis heute detaillierteste marine Beprobung der CLIP. SIMRAD EM120 and PARASOUND wurden für die Auswahl der Beprobungsstationen und strukturgeologische Untersuchungen genutzt. Beobachtungen an Bord und erste vorläufige Daten deuten u.a. auf großräumige tektonische Bewegungen am Beatarücken und im Norden des Hess-Escarpment sowie auf einen vulkanischen Ursprung der von den meisten Geowissenschaftlern bisher als kontinental angesehen Strukturen am Hess-Escarpment hin. Weiterhin wurden mehr als 7.300 km Magnetikprofile akquiriert. Magnetische Anomalien, die entlang von 4 parallelen Profilen über das Columbia-Becken aufgezeichnet wurden, deuten auf ozeanische Kruste in diesem Gebiet hin, können aber nicht als Ozeanbodenspreizungsanomalien korreliert werden. Entlang des Hess-Escarpment stützen magnetische Anomalien mit hohen Amplituden, die mit morphologischen Strukturen assoziiert sind, die Hypothese eines vulkanischen Urpsrungs dieser Strukturen und einer basaltischen Zusammensetzung der Kruste in diesem Bereich.

2 Participants M81 Leg 2A

2.1 M81/2A (Port of Spain – Willemstad)

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3 Research Program

The main goals of cruise M81/2AB were to combine geological and geophysical research methods in order to gain new insights into 1) the origin, evolution and composition of the Caribbean Large Igneous Province (CLIP), a giant submarine lava plateau, and 2) the geodynamic evolution of the Central Caribbean. Cruise M81/2AB is part of an international strategy to improve our understanding of submarine large igneous provinces (LIPs).

Combined use of multi-beam mapping (SIMRAD EM120), sediment echo-sounding (ATLAS PARASOUND), hard rock sampling of uplifted basement complexes using a remotely operated vehicle (ROV) and dredges, and magnetic surveying using a modern magnetometer array with subsequent shore-based sample analyses and data processing will allow us to reconstruct the geodynamic evolution of the CLIP, including determination of (1) the age and chemical composition (and thus sources) of magmatism; (2) location where the Caribbean Plate formed (ie. Pacific or between the Americans); (3) the causes of long-lived volcanism within a LIP which is commonly thought to have formed over a relatively short time scale and to (4) gather information on the internal structure and succession of magmatic events in the CLIP and (5) characterize internal deformation processes that took place after flood basalt formation. Through integration of these results we will not only provide new information on the geodynamic evolution of the Caribbean, but will also significantly contribute to improving our understanding of LIPs and the causes of intraplate volcanism („Great Plume Debate").

Two issues out of our control required considerable rescheduling of the original working plan and time schedule for M81/2AB:

(1) After 5 successful dives, all further ROV dives were canceled because of problems with the bow thruster of R/V METEOR. In order to unload the ROV so that dredging could take place via the rear A-frame, it was decided to terminate Leg 2A as early as possible in order to gain more time for dredging during Leg 2B to compensate for the lost ROV dives (see also chapter 4). The remaining time on Leg 2A was used for magnetic profiling and extensive mapping to prepare the dredge sampling on Leg 2B.

(2) We did not receive a research permit for Colombian waters in due time for Leg 2A because of an unacceptable high claim of money for a Colombian observer (500,- USD/day). This problem could be solved during Leg 2A thanks to the support of the German Foreign Office, the German Embassy in Bogota, and the Leitstelle Meteor/Merian, so that we were able to conduct our planned research in Colombian waters during Leg 2B. The permit was granted, however, on condition to embark and disembark a military observer at the Colombian port Santa Marta (see chapter 4), resulting in approximately two days loss of working time.

Consequently Leg 2A focused on the Central Caribbean in the exclusive economic zones (EEZ) of the Dominican Republic, Haiti, and Jamaica (Fig. 3.1). EM120 and PARASOUND surveys were used to select appropriate sites for ROV dives and later sampling by dredging as well as to assess the structural geology of the region. The ROV sampling was conducted on uplifted sequences of basement rock in the northern and central part of the Beata Rise and

yielded in situ samples from stratigraphic sequences of the upper 2,000 m of the CLIP. Magnetic surveys were carried out in the Haiti Basin and adjacent areas (Fig. 3.1).

During Leg 2B, hard rock sampling by dredging focused on scarps, ridges and seamounts along and north of the Hess Escarpment. The extensive profiling on Leg 2A enabled very target-oriented sampling, compensating the time loss due to the Santa Marta port calls and allowing additional dredge sites at the southern Beata Rise to complement the ROV-sampling. Magnetic surveys and EM120- and PARASOUND profiling focused on the Colombia Basin and the area east of the Beata Rise (Fig. 3.1).

Despite the difficulties mentioned above, M81/2AB has achieved its major goals, i.e. stratigrafically-controlled ROV-sampling of the CLIP basement, the first representative sampling along and to the north of the Hess Escarpment, and extensive magnetic profiling in the Colombia and Haiti basins. In addition to 5,984 nm of EM120 and PARASOUND profiling and 5,440 nm of magnetic profiling, 5 ROV profiles and 28 dredges were carried out. None of the scientific equipment was lost or seriously damaged.

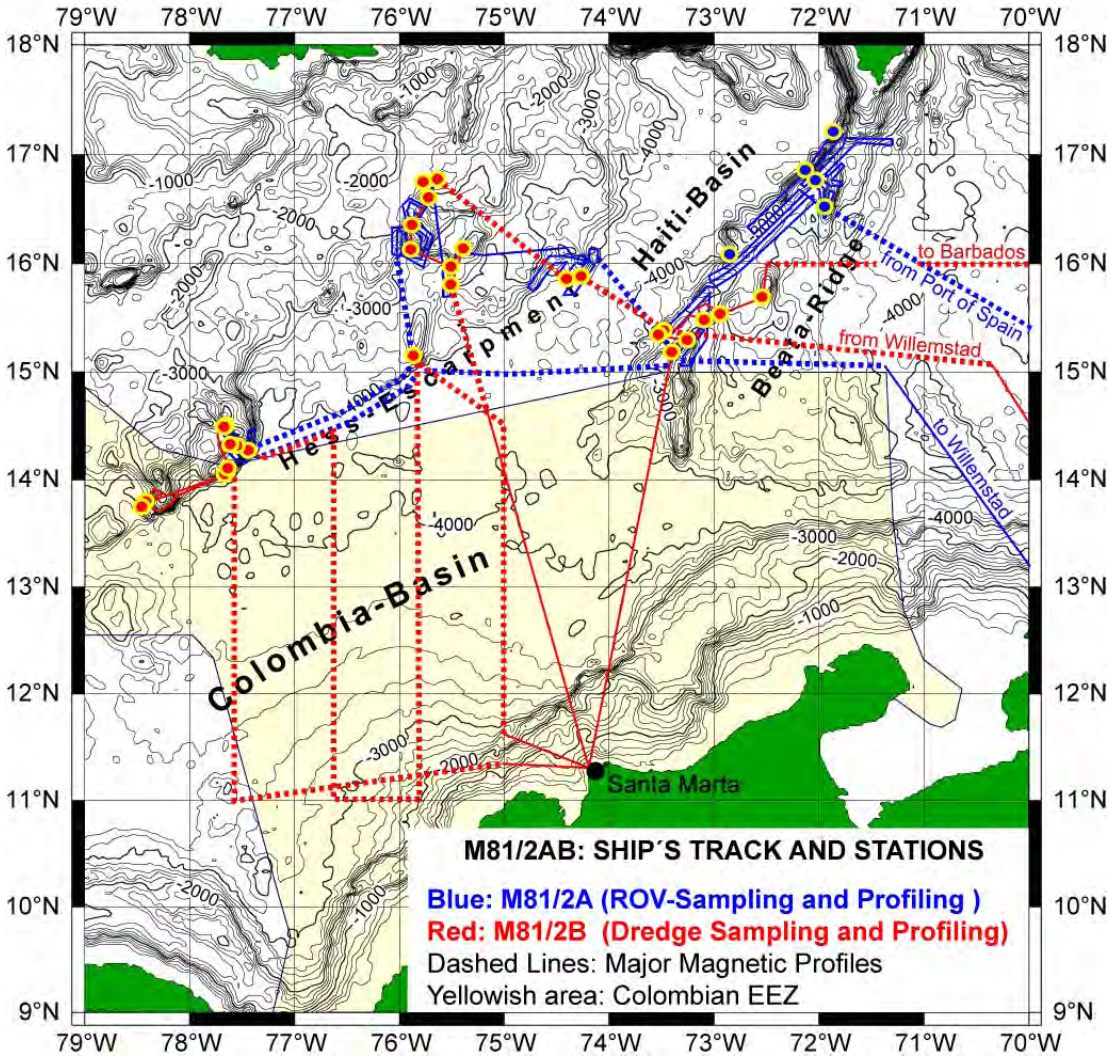

Fig. 3.1 Track chart of R/V METEOR Cruise M81/2AB (bathymetry based on 'The GEBCO_08 Grid, version 20091120, http://www.gebco.net'; blue dots = ROV dives, red dots = dredge sites). Note that we were not allowed to conduct any scientific work in Colombian waters without a Colombian observer on board (i.e. on Leg 2A and on the transits to and from Santa Marta).

4 Narrative of the Cruise

On March 8 preparations for R/V METEOR cruise M81/2AB began with the loading and unpacking of containers, setting up of laboratories and servicing of the ROV Kiel 6000. On March 10 we conducted a successful ROV test in the harbor. On the morning of March 11, members of the German embassy in Port of Spain toured the ship before R/V METEOR departed from Port of Spain at 10:30. After a two-day transit during which preparations for the cruise continued, we reached the EEZ of the Dominican Republic on Saturday evening of March 13, where we began magnetic, EM120 and PARASOUND surveys. On the morning of Sunday March 14, we reached the Beata Rise, a submarine ridge located south of Haiti and the Dominican Republic. EM120 data collected on the Beata Rise were used to produce high-resolution bathymetric maps of the seafloor in order to determine a track for the first ROV dive.

From Monday March 15 through Friday March 19, five dives with the ROV Kiel 6000 were carried out on the western slopes of the Beata Rise. The ROV dives took place during the day with time on the seafloor averaging about 8 hours per dive. Magnetic, EM120 and PARASOUND profiles were conducted between dives. The extensive multi-beam mapping of the seafloor was used to select the steepest areas away from seafloor canyons, which proved to have the most continuous sequences of outcropping rocks for stratigraphic sampling. In situ sampling of volcanic, plutonic and sedimentary sequences was carried out on the first, third, fourth and fifth dives. Although no hard rock sequences were found on the second dive, we did find many young faults cutting the soft sediments. Mud mounds located on the fault traces were sampled at several locations.

On March 16 magnetic, EM120 and PARASOUND surveys continued on the Beata Rise, while maintenance was carried out on the ROV. On Sunday March 17, magnetic and mapping of the Haiti Basin and the central Hess Escarpment was carried out, crossing through the EEZ of Haiti and into the EEZ of Jamaica. On Monday March 18, due to a technical problem with the bow thruster that could not be resolved at sea, all future ROV dives were cancelled. It was decided to terminate Leg 2A as early as possible in order to gain more time for dredging during Leg 2B (see chapter 3). The master, Laeisz shipping company, Control Station Meteor/Merian and the leading scientists agreed to call at Willemstad already on the early morning of March 29 instead of on April 02 as originally planned.

From Monday March 18 through Friday March 26, magnetic and EM120 surveys continued along the central Hess Escarpment and on seamounts north of the Hess Escarpment within the Jamaican EEZ, providing valuable data for selecting dredge sites for Leg 2B. During the later half of Friday March 26, we again crossed the Haiti Graben in the Haitian EEZ. Late Friday night, the Beata Rise was reached again in the EEZ of the Dominican Republic. On Saturday March 27, the EM120 system was calibrated in preparation for Leg 2B. On Sunday morning March 28, we ended our magnetic and EM120 surveys shortly before leaving the EEZ of the Dominican Republic and began our transit to Willemstad, Curacao. On Monday morning March 29, we reached Willemstad, successfully ending Leg 2A despite the technical difficulties.

On March 31 at 02:00 pm, R/V METEOR sailed from Willemstad with course towards the Beata Rise. Directly after reaching the EEZ of the Dominican Republic in the late morning of April 01, the scientific investigations of Leg 2B started with magnetic, EM120 and PARASOUND surveys. On April 02 at 01:00, we arrived at the Beata Rise, where the first

dredge track of this cruise recovered lavas, intrusive rocks (gabbros), volcanic breccias, Mn-oxides, carbonates and shales.

At noon of April 02, we reached the main target area of Leg 2B for hard rock sampling, the Hess Escarpment, after a profile track (magnetic sensors, EM120, PARASOUND) crossing the Haiti basin. Two dredge tracks at the eastern termination of the escarpment yielded nearly exclusively lavas. However, a limestone fragment with Late Cretaceous microfossils was also found. In the morning of the April 03, the next magnetic profile led to an area characterized by seamounts and NNE-SSW or NNW-SSE trending ridge structures north of the Hess Escarpment that were already mapped during Leg 2A. Sedimentary rocks, soft sediments, and thick Mn-oxides, and in particular basaltic lavas were recovered in this area at several dredge tracks.

During the night from April 04 to 05, we left the Hess Escarpment with course to the Colombian port Santa Marta. There, a Columbian observer embarked who accompanied us during our work in the Columbian EEZ. Subsequently we started a magnetic profile of 1,000 nm, which covered four N-S profiles crossing the Columbia Basin. This profile was interrupted on April 07 in the afternoon to sample a seamount at the Hess Escarpment when the first N-S profile was completed. A dredge haul at the seamount recovered mainly pillow lava and some breccias.

In the evening of April 07, the magnetic sensors were again deployed and we started the next N-S profiles crossing the Colombia Basin. On April 11 at noon we arrived again at the Hess Escarpment. Our EM120 surveys performed during Leg 2A and sea floor maps based on satellite altimetry revealed an area of by ~100 x 70 km extent with a notably rough morphology. Our main target in that area, to sample the magmatic basement of two large seamounts, was difficult to reach because the seamounts are largely covered with carbonate rocks. Nevertheless, we were successful in dredging mostly aphyric lavas and volcanic breccias from both seamounts. Most dredges, however, recovered exclusively carbonate rocks, among them massive blocks with corals, spherules and crusts of red algae and a large number of nummulites, discocyclines and large foraminifera.

In the afternoon of April 13, we left the Hess Escarpment to complete the magnetic survey in the Colombia Basin. On April 14 we arrived again at Santa Marta, where our Colombian observer was picked up by a pilot boat. After only a one hour stop (!), R/V METEOR sailed again towards the Beata Rise. In addition to the dredge track at the beginning of the cruise and to the ROV dives of Leg 2A, four ridge-like structures were sampled and mapped that where not covered by Leg 2A. Several dredge tracks resulted in a great variety and amount of mostly aphyric fine to coarse-grained basalts as well as mafic and more evolved gabbros and dolerites. In the early morning of April 18, the sampling work of Leg 2B was terminated at a long stretched, N-S trending seamount in the eastern part of the Beata Rise with the 28th dredge track of this cruise. This dredge haul again yielded aphyric basalts and microgabbros, as well as soft, nearly white shales. Directly after the end of dredging, we sailed toward east to measure an about 250 nm long magnetic profile from the Beata Rise to the EEZ of Puerto Rico/U.S.A.

On April 19 at noon, the scientific work of cruise M81/2AB was finished and we started the about 550 nm long transit to Bridgetown/Barbados. The last days at sea were filled with a first evaluation of the data, cleaning and wrapping the equipment and, finally, the obligatory cleaning of the laboratories. In the afternoon of April 20, R/V METEOR passed the Antilles arc between the islands St. Lucia and St. Vincent. In the morning of April 21 we reached Bridgetown.

5 Preliminary Results

5.1 ROV KIEL 6000 Deployment

5.1.1 Methods, Technical Information, and Station Overview

(M. Pieper, P. Cuno, A. Foster, H. Huusmann, A. Meier, I. Suck, A. Petersen)

The ROV (remotely operated vehicle) KIEL 6000 (Fig. 5.1) is a 6000 m rated deep diving platform manufactured by Schilling Robotics LLC. As an electric work class ROV of the type QUEST, this is build No. 7., and is based at the Leibniz Institute for Marine Sciences IFM-GEOMAR in Kiel, Germany.

The vehicle is equipped with 7 brushless thrusters. Power is supplied through the 19 mm diameter steel armed umbilical with up to 4160VAC/460 Hz. The data transfer between the vehicle and the topside control van is managed by the digital telemetry system (DTS^{TM}) which consists of two surface and four sub-sea nodes, each representing a 16-port module. Each port may be individually configured for serial, video or ethernet purposes.

To unlink the vehicle from ship's movements, floats are attached to the umbilical. For more details please visit www.ifm-geomar/kiel6000.

Tools standardly installed on the vehicle include an HDTV camera, two high-resolution colour zoom cameras and one digital still camera as well as three black and white observation cameras. Two manipulator arms, a seven-function position controlled manipulator of the type ORION and a five-function rate controlled manipulator, type RIGMASTER. are the major tools used on this platform. Further sensors include a depth gauge, a sonar system, a compass, a motion reference unit (MRU) containing a gyro compass, and an RDI Doppler velocity log (DVL). For navigation, a USBL-based IXSEA POSIDONIA^{TM} system is employed.

Fig. 5.1: View of ROV KIEL 6000 just before diving.

Fig. 5.2: Front view of the ROV with sample containers on drawers for M81-2A.

A tool sled in the lower-most part of the vehicle is especially dedicated to take up the scientific payload. A SBE 49 FastCAT CTD is permanently mounted. Located on portside front of the tool sled is a sample tray which can be opened hydraulically. On starboard front there is a

drawer likewise hydraulically driven, which can take up sample containers, probes or other scientific tools continuously mounted or used by the manipulator. Port aft and starboard aft are reserved for additional scientific payload which differ from mission to mission.

During expedition M81 Leg 2A, both drawers were rigged with different boxes, split into compartments of varying size for taking up rock samples (Fig. 5.2).

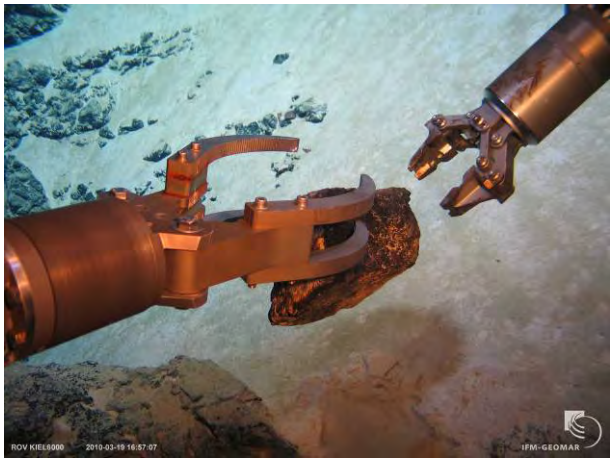

Fig. 5.3: Rigmaster and Orion "co-operating" during rock-sampling.

Fig. 5.4: Orion claw with chisel.

In total, 5 scientific dives (Tab. 5.1) were conducted at the Beata Rise, all of which consisted of up-slope transects. The main task was to collect rocks (Fig. 5.3), carbonates and other consolidated sediments. These were taken in situ where possible, using a very simple, but effective chisel (Fig. 5.4). In total more than 50 samples were retrieved. The maximum water depth during dives was 4,200 m, bottom time accumulated to a total of 40 hours.

On March, 22nd, wind and waves had picked up so much that it was decided to abandon the already planned day's dive. Shortly later, due to a failure of the ships bow thruster, all further dives had to be abandoned.

Tab. 5.1: Summary of dives during the M81-2A Expedition.

Station No. M81-2	Dive No.	Date (2010)	Time Start (UTC)	At Bottom (UTC)	Off Bottom (UTC)	Time End (surface) (UTC)	ROV Bottom Time	% Bottom Time	Location	Depth (m)	Sample Summary
		11.03.	Harbour test Trinidad								
217ROV	100	15.03.	12:15	13:55	21:45	22:18	07:50	77.94	Northern Beata Rise	1300 - 900	lava, gabbroic rocks (13 samples)
220ROV	101	16.03.	12:12	14:25	20:50	22:10	06:25	64.38	Northern Beata Rise	4200 - 3450	sedimentary rocks (4)
223ROV	102	17.03.	12:14	14:00	22:22	23:00	08:22	77.71	Northern Beata Rise	3500 - 2400	lava, gabbroic rocks, volcaniclastics (13)
226ROV	103	18.03.	14:54	16:08	22:00	22:39	05:52	75.70	Northern Beata Rise	2400 - 1640	volcaniclastics, sedimentary rocks (4)
229ROV	104	19.03.	12:03	13:56	01:27	02:33	11:31	79.43	Central Beata Rise	4200 - 2500	lava, gabbroic rocks, volcaniclastics (21)
total: 5 scientific dives							**40:00**	75.42			total: 55 samples

5.1.2 Observations and Sampling Along the ROV Profiles

(K. Hoernle, F. Hauff, D. Maicher, R. Werner, C. Conrad, E. Seidel, U. Krüger)

Refer to Appendix I for latitude and longitude of the ROV profiles and a detailed summary of rock descriptions.

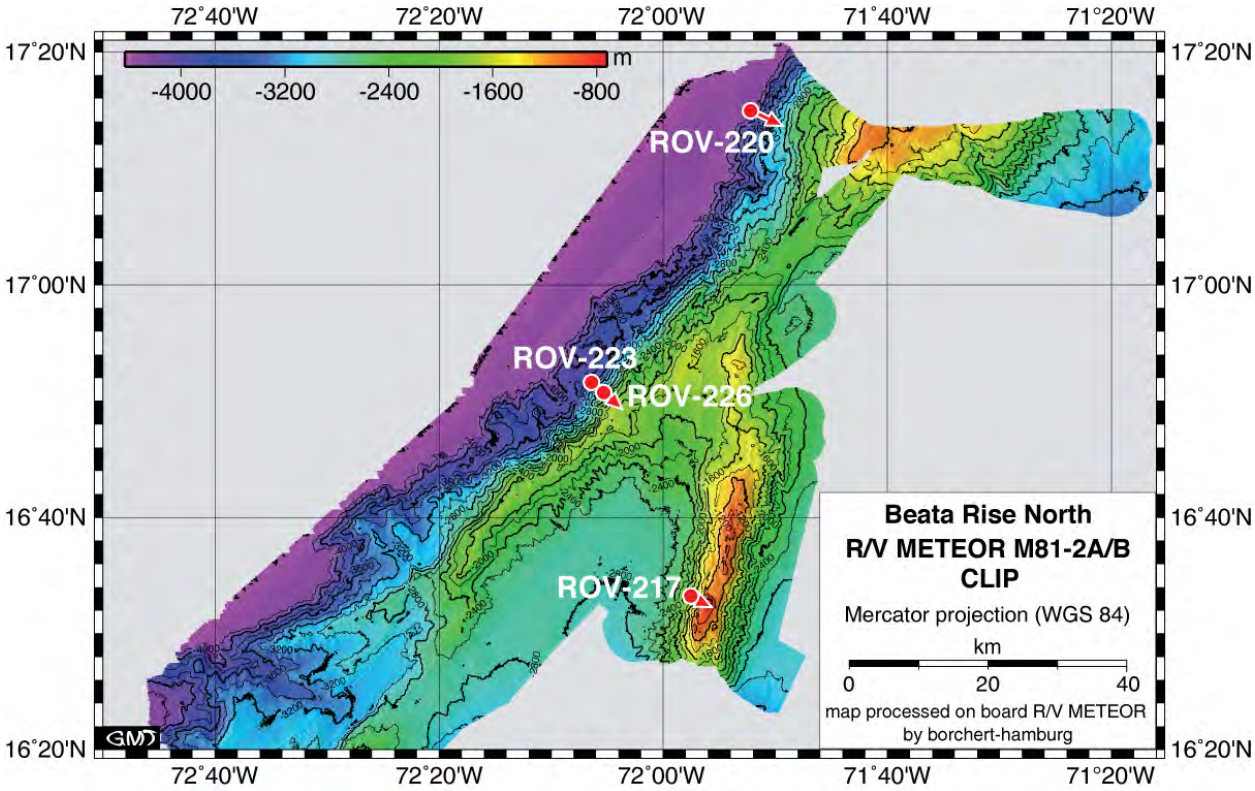

Fig. 5.5: Bathymetric map of the northern Beata Rise baased on mutli-beam data recorded on Leg 2A. Red dots (starting points) and arrows mark the location of the ROV dives 1 – 4 (M81-217, -220, -223, 226).

5.1.2.1 M81-217 ROV Dive 1

The first ROV profile of cruise M81/2AB was conducted at the upper western slope of a ~N-S striking ridge on top of the Beata Rise (Fig. 5.5). The profile began in 1,305 m water depth by first going through a pillow breccia and then primarily a pillow lava sequence. Six basaltic samples were taken from this sequence with decreasing water depth: In situ (? – believed to be in situ but not certain) sample #1 from pillow breccia, in situ samples #2 – 4 (pillow lavas), sample #5 from basaltic lava debris, and in situ (?) sample #6 (pillow breccia). From 1,078 - 882 m below sea level (b.s.l.), the steep flank of the ridge was covered by plain, featureless soft sediments which are interrupted by isolated outcrops consisting of massive, roughly jointed lava (sample #7, in situ? basalt, Fig. 5.6). Directly adjacent to one of these outcrops, the ROV cameras showed abundant subangular cobbles and boulders, which were most likely derived from this outcrop (sample #8, basalt). After crossing a slope covered with subangluar rock debris and soft sediments, a very steep protrusion of massive rock formed a distinct cliff, which extended for tens of meters. Sample #9 (in situ? basalt) was taken near the top of the cliff. Further uphill, the slope was covered with a solid, knobbly sheet-like crust, possibly lava rubble and sediment/manganese crusts. Sample #10 (basalt) was a loose piece of debris, sample #11

(basalt) was possibly a piece out of the crust. Subsequently the ROV crossed firmly attached scree, possibly cemented by manganese crusts. The last part of this dive (from 882 – 843 m b.s.l.) was dominated by a pillow sequence (debris sample #12, coarse-grained basalt) followed by massive outcrop (in situ sample #13, basalt).

Taken together, ROV profile M81-217 yielded 13 volcanic rock samples from a 450 m thick basement sequence. Interestingly, the volcanic sequences observed on this dive look like a typical CLIP section outcropping on the Nicoya Peninsula (Costa Rica), which are dominated by pillows and pillow breccias.

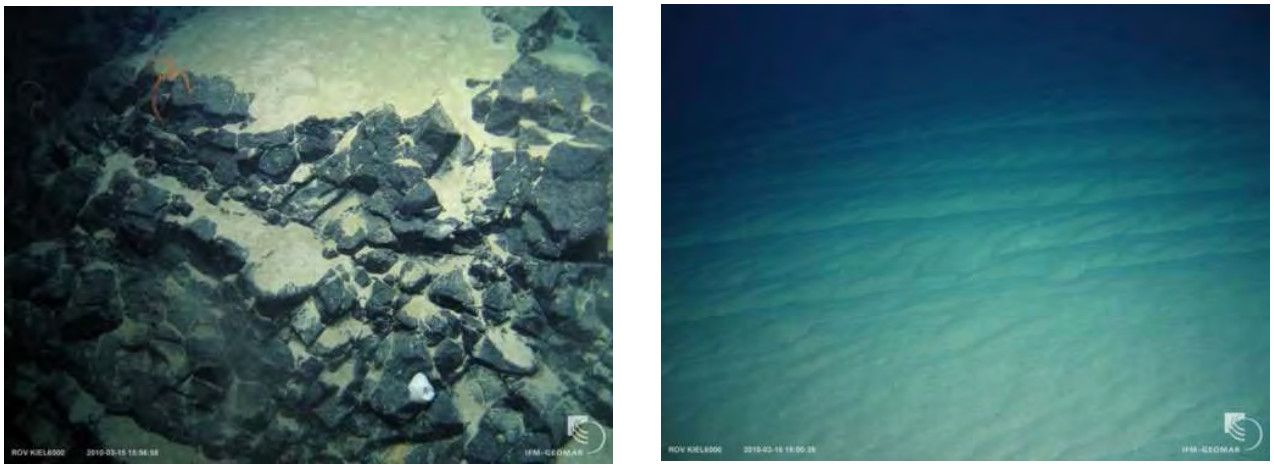

Fig. 5.6: Left: ROV dive 217: Classic columnar joints in basalt lava, formed by contraction during cooling. Right: ROV dive M81-220: Faults on the seafloor, cutting ripple marks and forming steps going up towards the Beata Rise (view towards the Beata Rise).

5.1.2.2 M81-220 ROV Dive 2

The second ROV dive was carried out ~50 km south of the southern tip of Hispaniola at the base of the northwestern slope of the Beata Rise (Fig. 5.5). The dive began in 4,180 m water depth and aimed to sample magmatic rocks from the deepest parts of the northern Beata Rise basement. The ROV cameras revealed, however, primarily sediments during this dive, which revealed some remarkable features. The first section of the dive was characterized by long linear, parallel, NNE-SSW-striking grooves in the sediment, extending more than 50 m (Fig. 5.6). These structures were subparallel to the Beata Rise and are interpreted to be very recent faults, since they cut the ripple marks in the sediments and therefore movement on the faults must be younger than the ripple marks. A mud mound measuring ~2 m in diameter in one groove was sampled (sample #1). Fluids could be seen emanating from the sample location, supporting the hypothesis that these linear features are active faults. Larger mounds (bioherms) and mud flows, tens of meters across, were found emanating from the faults. Some showed spectacular layering (in situ sample #2, layered mud stone). Dozens of faults were observed during the course of the dive. From 3,878 – 3,750 m b.s.l., the slope was dominated by smooth, soft sediment plains. Above 3,750 m b.s.l., chunks and boulders of carbonate, large carbonate mounds (up to some tens of meters in diameter) and outcrops of consolidated sediment were observed. Sample #3 (in situ solidified carbonate mud) was broken off from a large chunk at a mound. Above ~3,640 m b.s.l., huge cliffs and canyon-like structures form a surprisingly steep morphology. The manipulator of the ROV revealed that these cliffs and canyons consist of poorly consolidated

sediments (!). At ~3,500 m b.s.l., sample #4 (in situ solid carbonate with tubes, maybe a fossil fluid venting site) was taken. The dive ended at 2,987 m b.s.l. after passing extensive soft sediment plains.

Active faulting, fluid venting, and rough morphology of the (soft) sediments indicate that the Beata Rise (horst) and related graben structure are still active with activity being possibly related to the Haiti earthquake on January 12, 2010. The orientation of the faults sub-parallel to the strike of the Beata Rise and Haiti Basin and the apparent down-dropping towards the Haiti Basin suggest that subsidence of the Haiti Basin is still taking place and thus could represent another potential location for earthquakes and tsunamies in this area.

5.1.2.3 M81-223 and -226 ROV Dives 3 and 4

ROV dives 3 and 4 were conducted ~50 km SSW of profile 2 at the northwestern flank of the Beata Rise (Fig. 5.5). Dive 3 started in 3,421 m water depth and covered the lower section of the slope. Dive 4 continued where dive 3 left off and covered the upper part of the slope.

The basal section of this profile was covered with massive boulder-sized debris (sample #1 and #2, gabbroic rocks). The dive track followed a fairly steep slope uphill. Here soft sediment plains alternated with isolated outcrops of massive and randomly jointed rocks. Samples #3 (in situ basalt), #4 (in situ volcaniclastic breccia), and #5 (in situ gabbro) have been taken from these outcrops. At ~2,920 m b.s.l., the morphology becomes very steep. Huge, partly overhanging rock cliffs were interpreted as successions of pillow and massive sheet lavas. However, sampling of these cliffs also yielded grabbroic rocks (in situ sample # 6). Approximately 30 m above sample site #6, sample #7 (in situ fine-grained lava) was taken. Above sample site #7, the morphology became more and more gentle and soft sediments and debris covered the slope. Strange lobe-like outcrops were present perpendicular to the slope. At 2,846 m sample #8 (fine-grained graded tuff) was taken from the debris right in front of such a lobe-like outcrop. Further upslope a canyon began to develop perpendicular to the slope. Further on the canyon had steep flanks and its base appeared to be formed by pillow lavas. Sampling of these lavas, however, failed since the canyon proved to be too narrow for ROV operations. At 2,760 m b.s.l., debris (sample #9, tuff) dominated near vertical sediment layers, which appeared to be overlain by a folded sediment layer forming an anticline, probably reflecting soft sediment slumping. Sample #10 (tuff) was taken from what seemed to be an in situ part of the vertical layers. Samples #11 and #12 (solidified turbidites) were taken from the debris. At ~2,640 m b.s.l., the ROV sampled a pillow outcrop (in situ sample #13, aphyric lava). Above the pillows, the slope was covered with soft sediments until the end of dive 3 at 2,383 m b.s.l.

On the next day, this profile was continued on the same track in 2,369 m water depth. Dive 4 began with a fairly gentle slope covered with soft sediments. Isolated outcrops of rocks were protruding through the sediment, often forming horizontally elongated, several m-sized ledges. The rock surface was knobbly (probably Mn-crusts) and often sheet-like, orientated roughly parallel to the slope. Below the sheet-like surface, the rock was homogeneous, poorly jointed and appeared to be massive. Several tries to sample these deposits failed. At 1,910 m b.s.l., sampling was finally successful at the base of a ~20 m high cliff (in situ sample #1, solidified mudstone). Sample #2 (massive carbonate) was taken from debris at the base of the cliff. Above the cliff, soft sediments covered the seafloor. Some outcrops were present in the sediment plain (in situ sample #3, massive carbonate). Sample #4 (in situ carbonate) was taken from the debris of a

outcrop further upslope. Soft sediments covered the uppermost part of the slope, until the top of the flank of Beata Rise at 1,870 m b.s.l.

Together, both dives 3 and 4 covered a profile of the entire, at this location ~1,550 m high flank of the Beata Rise. A wide array of basement outcrops were observed and sampled at the lower, ~800 m high section of this sequence. Soft sediments and carbonates appeared to cover the upper ~750 m of the basement.

5.1.2.4 M81-229 ROV Dive 5

The fifth ROV dive started at 4,201 m water depth at the base of the central Beata Rise and aimed to sample a complete sequence from the base to the top of its northwestern flank (Fig. 5.7). At 4,150 m b.s.l., the ROV cameras showed the first outcrop consisting of massive and heavily jointed rocks (in situ sample #1, gabbroic rock). Up to 3,910 m b.s.l., outcrops of volcanic and intusive rocks continued, sometimes interrupted by soft sediment plains with fault traces. Seven further samples were taken from this sequence with decreasing water depth: Sample #2 (basaltic lava debris), in situ sample #3 (altered picritic rock with ~30% iddingsitized ol) from a massive outcrop, in situ sample #4 (picritic rock with ~20% altered ol and ~20% altered pyx) from the same outcrop, in situ sample #5 (vesicular basalt) from a massive outcrop with jointing, debris sample #6 (heterogeneous tuff), and in situ samples #7 and #8 (lapilli tuffs) from another massive outcrop further uphill at 3,920 m b.s.l. The remaining part of this section of the dive crossed only soft sediments and debris.

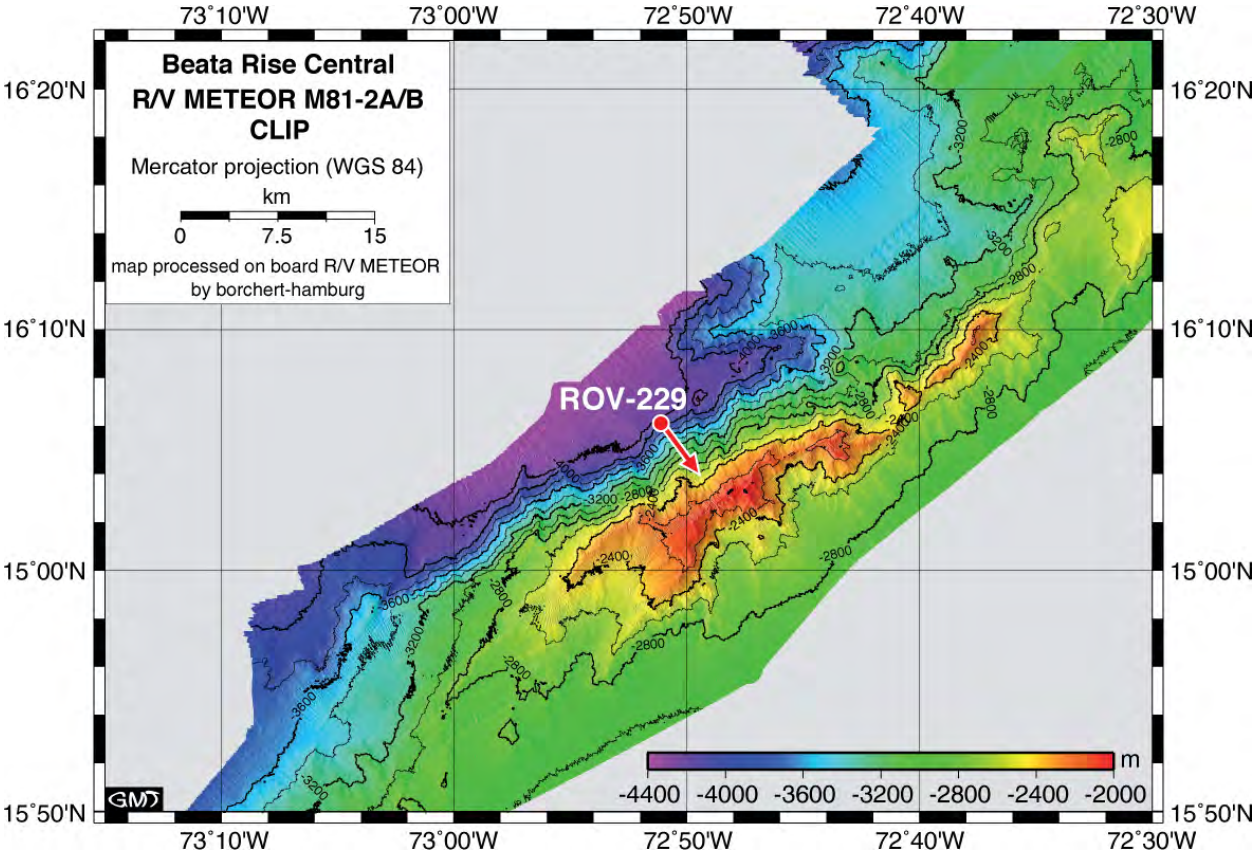

Fig. 5.7: Bathymetric map of the central western Beata Rise based on mutli-beam data recorded on Leg 2A. The red dot (starting point) and arrow marks ROV dive 5 (M81-229).

At ~3,770 m b.s.l. an outcrop of Mn-encrusted pillow-like lava yielded in situ sample #9 (Mn-encrusted pyx-phyric lava clast). A second sample was taken from the debris of this outcrop (sample #10, heterogeneous lapilli tuff). At ~3,700 m b.s.l., steep cliffs of lava (?) appeared. Sampling of the debris at the base of these cliffs, however, yielded volcaniclastic rocks (sample #11, heterogeneous tuff). After passing a sediment plain, another outcrop of lavas was sampled (in situ sample #12, ol-pyx-basalt). From ~3,600 – 3,250 m b.s.l., soft sediment plains, debris and outcrops of massive or pillow-like hard rocks (partly huge cliffs) alternated. Sample #13 (in situ vesicular lava, possibly picritic) was taken from such a cliff at ~3,400 m b.s.l.

The beginning of the next section of the dive was characterized by alternating soft sediment plains, cobble to bolder-sized debris, slabs of possibly sediment and/or manganese crusts, and outcrops with an irregular knobbly surface, which seem to be a manganese/sediment crust with embedded large solid rocks, perhaps a lava flow breccia or pillow breccia. Sampling, however, was abandoned after several attempts because the rocks were too friable. At 3,250 m b.s.l., the ROV passed an outcrop of massive rock with a sheet-like surface (debris sample #14, gabbroic rock). An outcrop a bit further uphill yielded in situ (?) sample #15 (porphyric ol-pyx-lava, may be picritic). Subsequently the ROV crossed soft sediments and knobbly, sheet-like surfaces oriented parallel to the slope. Slope failure scarps were common. Sample #16 (porphyric ol-pyx-basalt) and #17 (Mn-encrusted basalt?) were in situ pieces broken off these sheets taken at ~3,050 m b.s.l. Further uphill the ROV passed a steep, soft-sediment covered slope, a broad canyon-like valley, and an extensive rubble field. At ~2,830 m b.s.l., outcrops of magmatic rocks appeared again. Sample #18 (Mn-encrusted lava clast) was taken from a large, massive outcrop, sample #19 (fsp-phyric lava) further uphill from another massive outcrop with planar jointing. At 2,571 m b.s.l. (after passing a beer bottle), sample #20 (pillow breccia) was taken from the debris. The profile ended at 2,504 m b.s.l. Onboard sample #21 (ol-pyx-phyric lava) was found on the porch of the ROV. It must have fallen on the porch during sampling.

Taken together, ROV profile 5 sampled a broad variety of magmatic rocks from a ~1,700 thick basement succession of the Beata Rise and therefore fullfilled one of the major objectives of M81 Leg 2A.

5. 2 Dredging

5.2.1 Methods, Shipboard Procedure, and Station Overview

(R. Werner, F. Hauff, D. Maicher, K. Hoernle, C. Conrad, E. Seidel, U. Krüger, P. Loose, E. Seidel, D. Sperl)

Rock sampling on Leg 2B of cruise M81 was carried out using heavy chain bag dredges. Chain bag dredges are similar to large buckets with a chain bag attached to their bottom and steel teeth at their openings, which are dragged along the ocean floor by the ship's winch.

The pre-selection of the sampling areas was mainly made based on predicted bathymetry, derived from gravity data and ship depth soundings (e.g. Etopo [Smith and Sandwell, 1997] and GEBCO [The GEBCO_08 Grid, version 20091120, http://www.gebco.net]) and on published monographs, maps and papers. The individual dredge tracks were chosen based on the mutli-beam bathymetry recorded on Leg 2A and 2B of R/V METEOR cruise M81.

A total of 28 dredges were carried out in an average water depth of 2,400 m during 17 working days on M81 Leg 2B. Of these deployments, 15 recovered magmatic rocks, 4 volcaniclastics, 17 sedimentary rock, and 3 Mn-Fe oxides (Tab. 5.2).

Tab. 5.2: Summary of dredge tracks conducted on M81 Leg 2B.

Stat.	Location	total volume	Rock summary	on bottom		off bottom		depth (m)	
				lat °N	long °W	lat °N	Long°W	max	min
M81-234	Southern Beata Rise	1/6 full	lava, volcaniclastics, sedimentary rocks, Mn	15,397	73,485	15,402	73,478	2866	2457
M81-237	Hess Escarpment East	1/6 full	lava	15,901	74,268	15,909	74,266	4166	3808
M81-238	Hess Escarpment East	few rocks	lava, sedimentary rocks	15,877	74,411	15,873	74,404	3998	3665
M81-241	Hess Escarpment North	2/3 full	lava, volcaniclastics, sedimentary rocks	16,805	75,642	16,802	75,635	1705	1111
M81-242	Hess Escarpment North	1/4 full	lava, volcaniclastics, sedimentary rocks	16,779	75,779	16,772	75,657	1692	1351
M81-243	Hess Escarpment North	1/4 full	Mn	16,636	75,727	16,645	75,726	1408	1000
M81-245	Hess Escarpment North	1/4 full	sedimentary rocks, Mn	16,379	75,886	16,381	75,881	927	632
M81-247	Hess Escarpment North	1/4 full	lava, sedimentary rocks	16,151	75,897	16,157	75,891	2402	1840
M81-249	Hess Escarpment North	1/4 full	sedimentary rocks	15,990	75,514	15,997	75,506	3159	2645
M81-251	Hess Escarpment North	few rocks	lava, sedimentary rocks	16,159	75,395	16,152	75,392	1998	1724
M81-253	Hess Escarpment North	one pebble	sedimentary rocks	15,825	75,512	15,828	75,506	2101	1676
M81-258	Hess Escarp. Middle	few rocks	lava	15,161	75,872	15,158	75,869	2499	2245
M81-261	Hess Escarpment SW	1/6 full	lava, volcaniclastics, sedimentary rocks	14,279	77,444	14,287	77,443	4146	2987
M81-262	Hess Escarpment SW	empty		14,322	77,555	14,326	77,554	1124	954
M81-263	Hess Escarpment SW	few rocks	sedimentary rocks	14,336	77,616	14,336	77,615	1196	1025
M81-265	Hess Escarpment SW	few rocks	sedimentary rocks	14,505	77,665	14,505	77,652	1125	699
M81-266	Hess Escarpment SW	few rocks	sedimentary rocks	14,515	77,656	14,516	77,653	1143	629
M81-267	Hess Escarpment SW	empty		14,497	77,676	14,494	77,673	1800	1439
M81-269	Hess Escarpment SW	1/4 full	lava, sedimentary rocks	13,804	78,422	13,801	78,415	1981	1573
M81-270	Hess Escarpment SW	one pebble	sedimentary rocks	13,796	78,440	13,792	78,434	2115	1869
M81-272	Hess Escarpment SW	empty	(rock pebbles in sediment traps)	14,057	77,670	14,064	77,667	3467	3171
M81-273	Hess Escarpment SW	empty		14,112	77,640	14,121	77,639	2856	2490
M81-276	Southern Beata Rise	1/2 full	lava, gabbroic rocks, volcaniclastics	15,196	73,406	15,193	73,397	3074	2397
M81-277	Southern Beata Rise	1/5 full	lava	15,305	73,262	15,300	73,258	2687	2235
M81-278	Southern Beata Rise	empty		15,399	73,511	15,395	73,508	3648	3279
M81-279	Southern Beata Rise	one pebble	lava	15,494	73,098	15,390	73,091	2876	2549
M81-281	Southern Beata Rise	1/5 full	lava, gabbroic rocks	15,548	72,946	15,554	72,940	2580	2207
M81-283	Southern Beata Rise	few rocks	lava, gabbroic rocks, sedimentary rocks	15,706	72,545	15,707	72,538	1943	1641

Once onboard, a selection of the rocks were cleaned and cut using a rock saw. The magmatic rocks were then examined with a hand lens and microscope, and grouped according to their lithologies and degree of submarine weathering. The immediate aim was to determine whether material suitable for geochemistry and radiometric age dating had been recovered. Suitable samples have an unweathered and unaltered groundmass, empty vesicles, glassy rims (ideally), and/or phenocrysts that are fresh. Sedimentary rocks were examined with a hand lenses and microscope to identify their composition, texture, and content of (micro-) fossils.

Fresh blocks of representative samples were then cut for thin section and microprobe preparation, geochemistry and further processes to remove manganese and alteration products and/or to extract volcanic glass and fossils (if applicable). Each of these sub-samples, together

with any remaining bulk sample, was described, labeled, and finally sealed in either plastic bags or bubble wrap for transportation to IFM-GEOMAR or cooperating institutions.

5.2.2 Dredge Sampling

(R. Werner, K. Hoernle, F. Hauff, D. Maicher, C. Conrad, E. Seidel, U. Krüger, P. Loose, E. Seidel, D. Sperl)

Refer to Appendix I for a detailed summary of the dredge tracks and rock descriptions. Distances, dimensions and heights given in this chapter are approximate only and are included only to give a rough idea of dimensions of morphological features.

5.2.2.1 Southern Beata Rise

At the southern Beata Rise, four ridge-like structures were sampled and the areas were mapped that were not already mapped during M81 Leg 2A (Fig. 5.8). This dredge sampling was included in the research program of M81 Leg 2B to compensate for the cancelled ROV profiles in this area (see chapter 3).

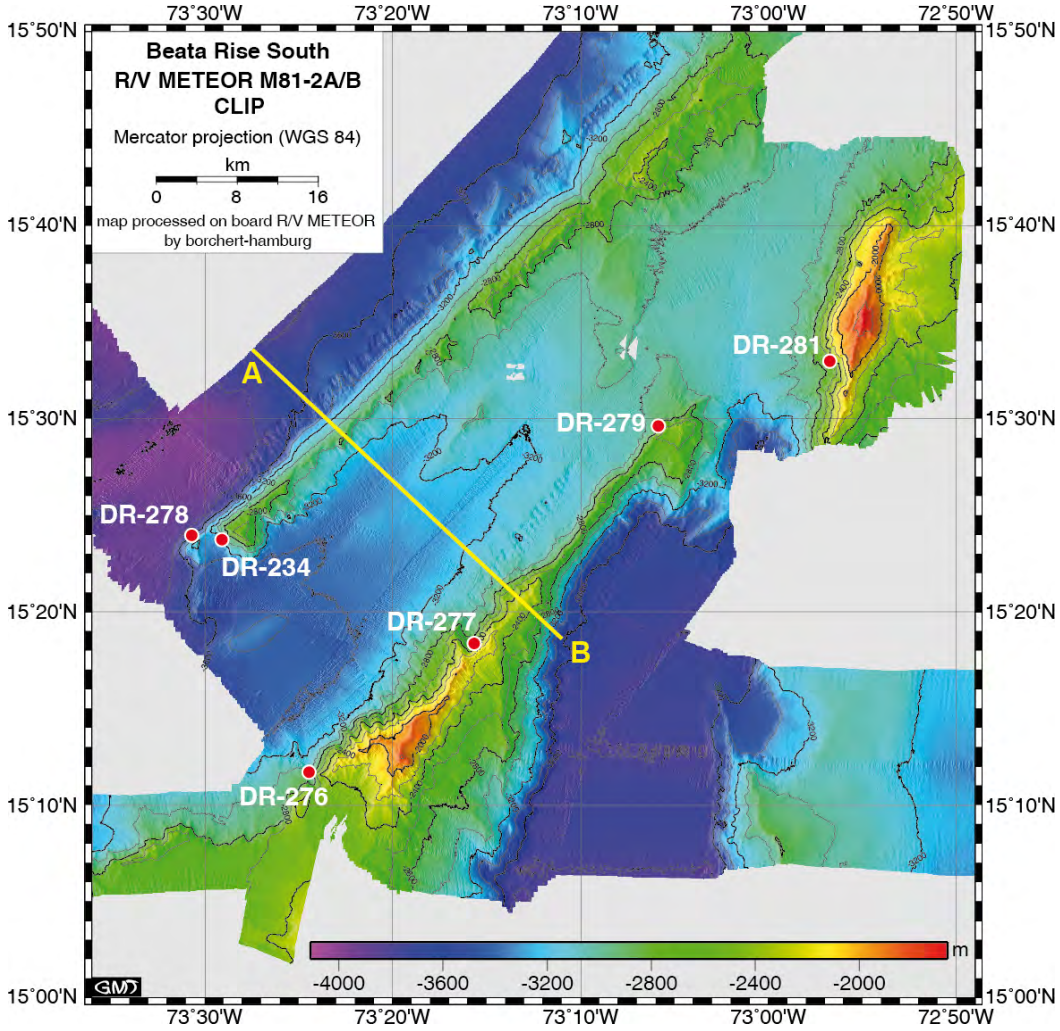

Fig. 5.8: Dredge sites at the southern Beata Rise (note that DR-283 is located outside of the map c. 60 km east of DR-281). The yellow line (A-B) marks the location of the profile shown in Figure 5.23. The bathymetric map is based on mutli-beam data recorded on Leg 2A and 2B.

Five dredge tracks were conducted at two parallel, NW-SE trending ridges (Fig. 5.8), which we interpreted as step faults based on the SIMRAD mapping. Dredge DR-234 recovered lavas, gabbroic rocks, volcanic breccias, Mn-oxides, carbonates and shales from the upper slope of the southern tip of the western ridge. Fsp-pyx-phyric basalts (up to 25% fsp and 10% pyx) dominate among the magmatic rock. Some of the shales indicate intense tectonic deformation providing further support that the ridge structures and the Beata Rise were formed through faulting and extensional tectonic processes. DR-278 was carried out just beneath DR-234 but failed to return samples. DR-276 was conducted at the lower slope of the central part of the eastern ridge. The dredge yielded mainly mafic and more evolved gabbroic rocks and aphyric, dense lava, and some vesicular lava fragments (up to ~20% vesicularity). Some of these samples show sharp contacts between a fine-grained basaltic melt and coarse-grained gabbro. These contacts indicate that magma penetrated already crystallized plutonic rocks. Vertical tectonic movements then brought these deeper parts of the crust up to the surface. DR-276 also recovered some breccias with sedimentary matrixes. At least part of these breccias with partly matching angular components are of tectonic origin. Approximately 22 km further northeast, DR-277 yielded abundant fine crystalline, dense to poorly vesicular lava fragments from the upper slope of the eastern ridge. DR-279 was conducted at the northern tip of the western ridge and returned a crystalline lava fragment (~20-30% fsp, ~5% pyx) being very similar to rocks from DR-277.

Directly to the northeast of the step faults, dredge haul DR-281 recovered mainly aphyric, dense (pillow) lava fragments and medium to altered doleritic rocks (up to ~40% fsp and ~60% pyx) from the lower southern slope of a N-S trending ridge-like seamount (Fig. 5.8). Approximately 60 km further east, DR-283 was carried out at a similar N-S elongated seamount and yielded aphyric to fine-crystalline lavas, microgabbros, and soft, white shales with almost no fossils, probably representing fossil submarine ashes (cinerites).

In summary, dredging at the southern Beata Rise recovered a large variety and amount of lavas, mafic and more evolved gabbros, and dolerites. Even if dredging does not allow detailed stratigraphically-controlled sampling, this sample set represents a cross-section through the basement of the southern Beata Rise and therefore ideally complements the successful ROV profiles on the central and northern Beata Rise.

5.2.2.2 Hess-Escarpment

The Hess-Escarpment represents a NNE-SSW trending fault zone in the northwestern part of the Caribbean Plate. The area north of the Hess-Escarpment is in part more than 2,000 m shallower compared to the abyssal plain of the Colombia Basin which is bounded to the northwest by this structure (e.g., Fig. 3.1). The nature of the crust of the area north of the escarpment, however, is unclear. Some geoscientists assume that it is part of the continental Chortis Block. On the other hand, basaltic lava with geochemical characteristics of the CLIP were drilled by the Deep Sea Drilling Program (DSDP) at Site 152 in the northeastern part of the Hess-Escarpment. Dredging and mapping during M81 Leg A and B aimed to decipher the nature of the area north of the Hess-Escarpment and to test the hypothesis that at least parts of this region belong to the CLIP.

Eastern Hess-Escarpment: Two dredge hauls were carried out in the neighborhood of DSDP Site 152 at a triangle-shaped seamount located at the transition of the Hess-Escarpment to the Haiti Basin (Fig. 5.9). DR-237 yielded mainly fsp-phyric lavas (up to 15% fsp-phenocrysts, up to 20 mm in size) and a few aphyric lava fragments from the lower southeastern flank of this

seamount, i.e. the Hess-Escarpment *sensu stricto*. DR-238 recovered a slightly fsp-phyric lava clast and a limestone fragment with Late Cretaceous (pre-Campanian) microfossils.

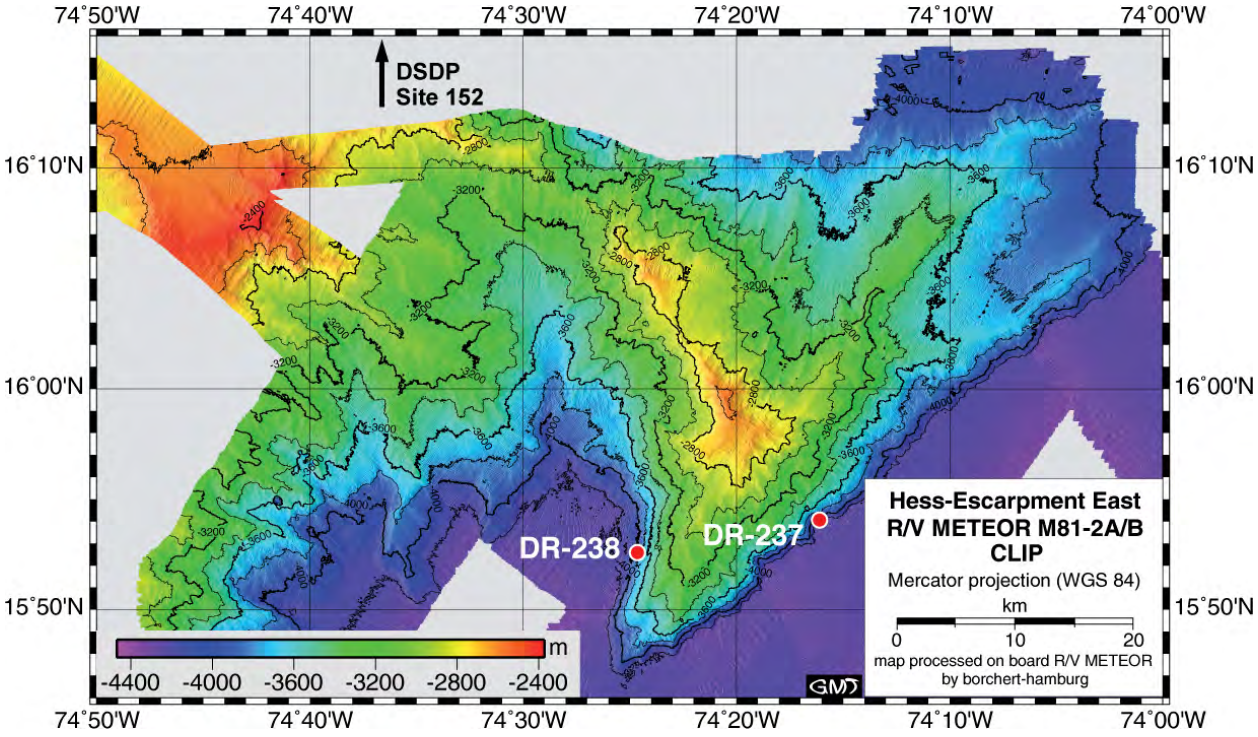

Fig. 5.9: Dredge sites DR-237 and –238 at the eastern Hess-Escarpment. DSDP Site 152 is located outside of the map at 15°52,72´N and 74°36,47´W (i.e. ~20 km to the north).

Central Hess-Escarpment: Multi-beam mapping during M81 Leg 2A revealed c. 100 km north of the central Hess Escarpment an area characterized by seamounts and NNE-SSW or NNW-SSE trending ridge structures (Fig. 5.10). Most of the seamounts and ridges are characterized by distinctive plateaus and are located on a large erosional (?) plateau of a deeper level. We proposed as a working hypothesis that these seamounts and ridges once were volcanic islands, which subsided and were eroded to sea level (cf. chapters 5.5. to 5.7). Five dredge hauls were conducted at the seamounts on the plateau. DR-241 and –242 were conducted at the northwestern flank of a small ridge representing the northernmost seamount of the mapped area. The dredges recovered a large amount of homogeneous fine-crystalline (fsp, pyx), variably vesicular pillow and sheet lava fragments, volcanic and sedimentary breccias, and a great variety of shallow water carbonates. Notably, DR-242 also contained strongly tectonically sheared and brecciated lava fragments. Further to the south, the small ridge develops to a broader, NNE-SSW-trending structure. DR-243 only yielded up to 30 cm (!) thick manganese crusts from the southeastern slope of this feature. DR-245 was carried out c. 30 km further south in the top area of a NNW-SSE-elongated seamount but also returned only manganese. Finally an oval shaped seamount, being located c. 60 km further east, was sampled by dredge haul DR 251. The dredge contained a massive, almost aphyric lava fragment, sandstones and pelagic limestones.

Two further dredge tracks aimed to sample the basement of the large plateau at its southern flank (Fig. 5.10). DR-247 yielded a large amount of mainly dense, aphyric to slightly porphyric pillow fragments (up to 3-4% fsp, 2% pyx, 1% ol), reddish oxidized sedimentary breccias, and pelagic carbonate. DR-249 returned exclusively pelagic limestones. An oval-shaped seamount

situated ~15 km south of DR-249 off the plateau flank was sampled by DR-259. The dredge, however, only contained one pebble of coarse-grained sandstone.

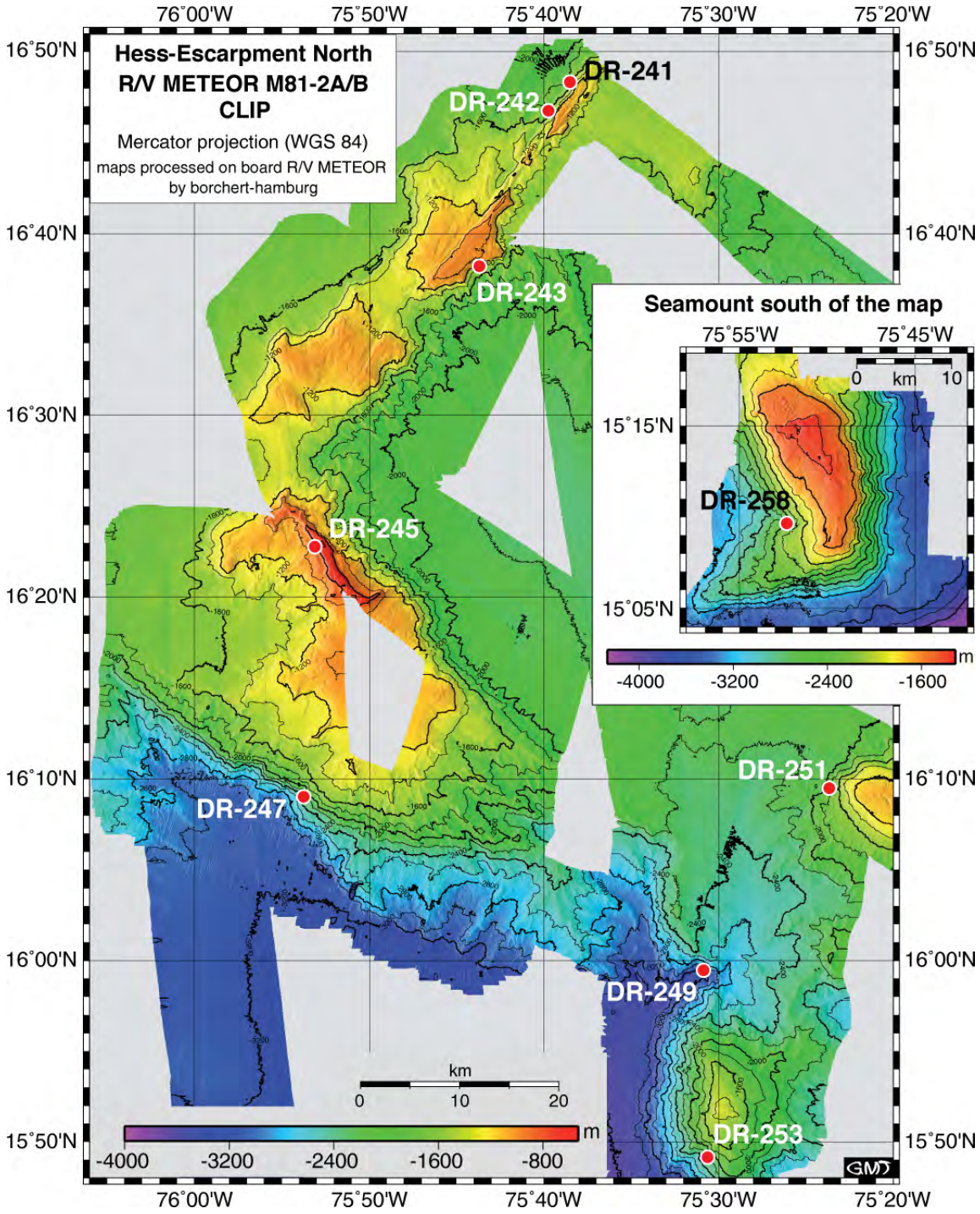

Fig. 5.10: Dredge sites c. 100 km north of the central Hess-Escarpment in an area characterized by seamounts and ridges being located on a large plateau-like structure. The insert shows a seamount situated c. 100 km further south directly at the escarpment.

Approximately 100 km further south, a large, N-S-trending guyot-like seamount exists directly at the Hess-Escarpment (insert in Fig. 5.10). Dredge track DR-258 was conducted at the upper western slope of this seamount and yielded dense to moderate vesicular pillow fragments, some of them embedded in pelagic sediments. The lavas vary in texture from pyx-phyric (up to

10% pyx) and fsp-phyric (up to 15% fsp, < 15 mm in size) to almost aphyric, one of the pillow fragments even contained fresh volcanic glass.

Taken together, dredging at and north of the central Hess Escarpment reached its main target to get magmatic rocks of the plateau (shield phase?), from the structures on top (post-erosinal phase?), and from the escarpment as well. The lavas yielded by dredging confirm the volcanic origin of these structures. Tectonic movements in this area are proved by distinctive tectonization of the lavas. Sediments recovered demonstrate that the highest peaks in this area were covered by carbonate reef platforms of Tertiary age. Their present bathymetric location indicates a subsidence of about 1,000 m. Pelagic limestone of Late Tertiary age was discovered as sedimentary infilling proving for a rapid subsidence of the structures.

South-western Hess-Escarpment: Multi-beam mapping performed during M81 and sea floor maps based on satellite altimetry reveal at the south-western Hess-Escarpment an area of about 100 x 70 km extent with a notably rough morphology. Two major features dominate this region: (1) A huge seamount (at least 80 x 40 km at its base) characterized by large flat plateau which is topped by smaller plateau-like structures and ridges (Fig. 5.11) and (2) a large guyot-type seamount (c. 35 km Ø at its base) being located c. 60 km further southwest (insert in Fig. 5.11). Our main target in that area was to sample the magmatic basement of these two features.

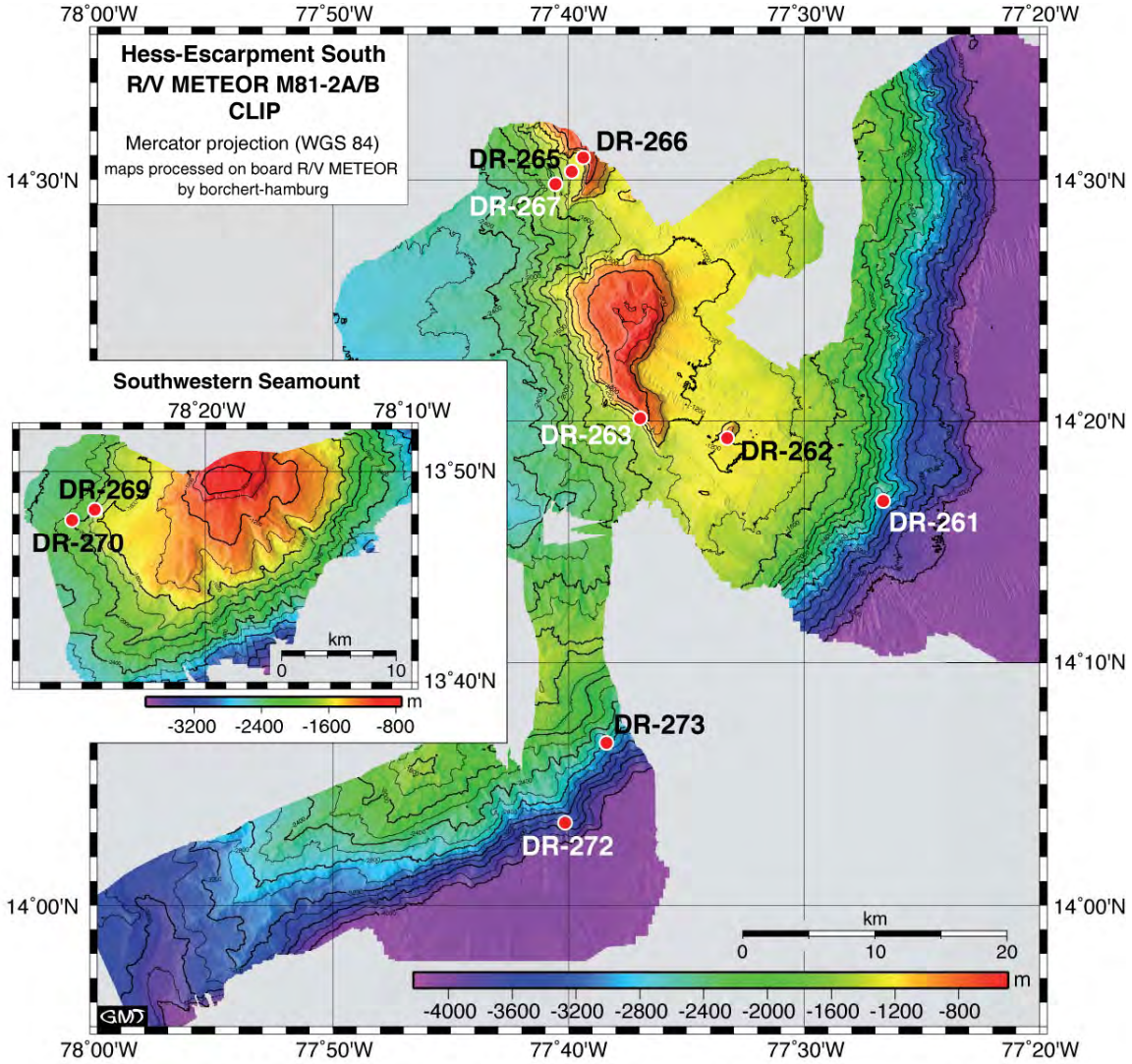

Fig. 5.11: Dredge sites at the south-western Hess-Escarpment.

Dredge haul DR-261 at the western flank of the huge seamount yielded a broad variety of volcanic rocks and a piece of upper Late Cretaceous pelagic limestone. Major lithologies are aphyric fine- to coarse grained, variable vesicular lavas and brecciated fsp-phyric lava fragments (up to 10% fsp), the latter clearly indicating tectonic deformation. The dredge also contained various volcaniclastic rocks as, for example, monomict lapillistones as well as heterogeneous and monomict basaltic breccias, some of them have been interpreted as *in situ* flow top breccias. Two further attempts to sample the flank of this seamount (DR-272 and –273) failed. Several dredge tracks at the smaller structures on top of the large plateau either also failed (DR-262 and –267) or resulted exclusively in carbonate rocks (DR-263, -265, - 266), amongst them large blocks of shallow water limestone very similar to those which have been dredged c. 350 km to the northwest (see above) and also of Early Tertiary age. Most likely these seamounts represent fossil reefs, which, like those in the northwest, have subsided by about 1,000 m.

Two dredge hauls were carried out at the western flank of the guyot-type seamount further southwest. DR-269 recovered a large amount of aphanitic to porphyric crystalline lava fragments with up to 30% fsp-phenocrysts and some pieces of pelagic limestone. Many of the lava fragments are highly tectonized as indicated, for example, by brecciated zones, abundant joints and cracks. DR-270 only yielded one piece of soft marly chalk.

In summary, dredging of the seamounts along the southeastern Hess-Escarpment proved to be difficult because they are largely covered with carbonate rocks and encrustations. Nevertheless, we were successful in sampling magmatic rocks from the basement of both seamounts.

5.3 Volcaniclastic Rocks

(D. Maicher)

In addition to magmatic hard rocks and sediments, the ROV dives carried out on Leg M81/2A yielded a remarkable broad variety of volcaniclastic rocks. This chapter summarizes descriptions and preliminary interpretations of some examples of volcaniclastic outcrops and samples, respectively, found at the Beata Rise.

5.3.1 Tuff

On ROV dive 3, strange lobe-like outcrops, which resemble crusts, occured from time to time in ~2,800 - 2,900 m b.s.l. (Fig. 5.12). The lobes extend perpendicular to the slope and the dive tried to follow the outcrops up to the top of the slope. At 2,850 m b.s.l., a dark red, wedge-shaped sample of ***lapilli tuff*** (223-8) has been taken from the debris right in front of such a crust-like outcrop. Internally it is a faintly graded, diffusely bedded sequence of accretionary lapilli set in a very fine-grained matrix of probably co-genetic ashy material (Fig. 5.12). The lapilli are 3 – 6 mm in diameter and consist of a core surrounded by a <1 mm thick rim of darker red, very fine-grained ash. In the majority of the lapilli the cores are composed of a lump of aggregated coarse ash. Only in the tip of the wedge-shape sample (most likely the basal part of the sequence) some coarser grained lapilli have cores of mineral grains (pyroxene, olivine?), sandstone fragments, and vesicular basaltic clasts up to 8 mm in size. In the centre of the sequence, some lapilli are plastically deformed, which indicates a relatively wet environment during formation in the eruption cloud. Accretionary lapilli form subaerially from fine-grained tephra ejected during explosive volcanic eruptions, either in pyroclastic surges and flows or in eruption clouds.

Deposition occurs relatively close to source, and can be either subaerially or subaqueously. In this specific case, the presence of accretionary lapilli together with a very fine-grained matrix is thought to indicate a subaerial deposition – subaqueous settling of lapilli would have separated them from the finest material. Subsequently the subaerial terrain either subsided almost 3,000 m below sea level, or the bulk deposit was displaced into the deep marine environment by gravity processes (which however is in contrast to the observation of sheet-like morphologies of the deposits, Fig. 5.12).

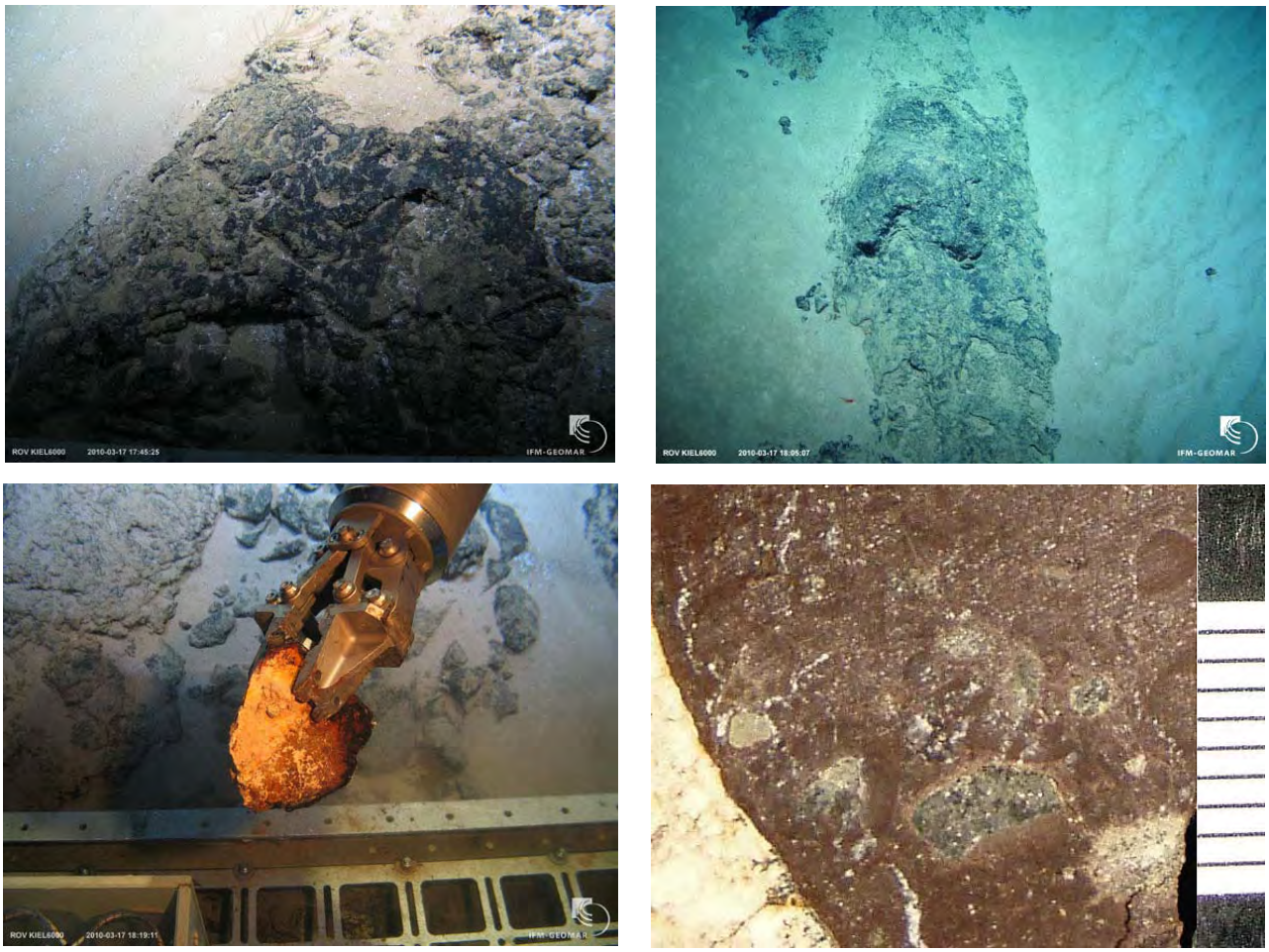

Fig. 5.12: Top left: Shortly before arriving at sampling site #223-8; note sheet-like nature of rock. Top right: Rocky outcrop ridge protruding out of the sediment. Down left: Sample #8 is loose debris from the side of the outcrop. Down right: Faintly graded sequence of accretionray lapillis (white scale: 1 cm).

Two samples of ***inhomogeneous bioclastic tuff*** (223-9 and -10) have been taken on the same dive ~100 m upslope in c. 2,700 m water depth. Sample #9 was recovered from debris near an outcrop of near-vertical sediment layers (Fig. 5.13), which appears to be overlain by a folded sediment layer forming an anticline, or (as an alternative interpretation) which appears to be covered by a sediment layer blanketing the underlying material. Sample #10 was taken from what appears to be an in situ part of the vertical layers. Both samples are very similar in texture and componentry. They are composed of subangular to subrounded , dark red ash particles up to about 0.5 mm size. Rarely 2-4 mm sized microvesicular clasts, single bottle-green crystals of up to 4 mm size (olivine, pyroxene?) and bioclasts of gastropods up to 10 mm occur (Fig. 5.13). Texturally, the rocks show diffuse irregular cm-sized domains of darker and lighter colour. This

is derived from variations in abundance of ashy matrix and/or white calcite cementation. In addition, the packing of the particles ranges widely from closely packed to matrix-supported to floating in a white sparitic calcite cement. Occasionally, a preferred orientation of clasts is seen. The overall impression is that of a tephra deposit which has undergone large-scale deformation in a soft, only partly consolidated state, perhaps related to slumping. Noticeable is the red colour of the particles, which is due to oxidation. This suggests either a subaerial origin of the tephra or hydrothermal oxidation of a submarine deposit.

Fig. 5.13: Left: Site of samples #223-9 and -10 before sampling. Right: Sample #223-9. Note large oval white clasts which are gastropods (scale in cm).

Several samples of ***heterogenous tuff*** (229-6 to -8, -10, -11) have been recovered on ROV dive 5. Sample #6 was taken from a massive outcrop at 3,980 m b.s.l. The tuff is grey greenish, massive, moderately well sorted and matrix-supported. Two types of clasts occur, both are aphanitic and have vesicles filled with secondary mineral phases. Dark clasts, which are non-vesicular to very poorly vesicular (about 2% vesicles), appear glassy and mafic in composition. Cream coloured clasts are more vesicular (up to 10%) and are possibly of more evolved composition. The matrix is very fine grained, non-carbonaceous and greenish coloured. Samples #7 and #8 are both in situ from 3,920 m b.s.l. Both samples are massive and have brown-grey to grey greenish cut surfaces. The deposits are massive, moderately to poorly sorted, and consist of a matrix-supported coarse tuff with 5% fine lapilli. Both show a very fine-grained matrix and translucent cement are present. Two types of clasts occur: dark and cream coloured clasts. The dark clasts have 0-2% vesicles, which are empty. The cream coloured clasts, which are micro-vesicular and have up to about 20% vesicles, are possibly more evolved composition. Both types of clasts are mostly glassy and generally rounded, angular and irregularly shaped clasts occur rarely.

Sample #10 has been taken in 3,650 m from debris in front of an pillow lava outcrop (Fig. 5.14) and turned out to be lapilli tuff. This medium grey to creamy yellowish deposit is massive with a very faint, diffuse clast size and component variation. Generally the deposit is poorly sorted, with clasts set in a fine matrix and translucent to white calcite cement. Three types of clasts occur: (a) highly altered yellow, roundish clasts, which are mainly micro-vesicular, possible of more evolved composition; (b) less common dark grey, irregular shaped to subangular clasts of 1-2 mm, non vesicular, possibly mafic clasts; (c) rare (2-5%) accretionary

lapilli, roundish up to 8 mm sized with a core of coarser grained ash and a rim of the same but very fine grained ashy material (Fig. 5.14). The accretionary lapilli are seen only in a diffusely defined layer in this sample, and their occurrence indicates again the presence of a near-by subaerial volcanic source. Clasts of type (a) are probably co-genetic to the accretionary lapilli. The deposit is interpreted as a debris flow deposit mixing different types of components together, and transporting the accretionary lapilli into the deep sea. At ~3,600 m b.s.l., sampling of the debris at the base of steep cliffs yielded roundish, brownish-yellow tuffs similar to sample #10. Differerences include (a) a faint alignment of fine particles, (b) secondary Fe-Mn mineralisation "pretending" layering/bedding of the otherwise massive deposit, (c) an absence of accretionary lapilli, and (d) presence of some clasts with highly elongate vesicles "tubes" and many splinter shaped clasts.

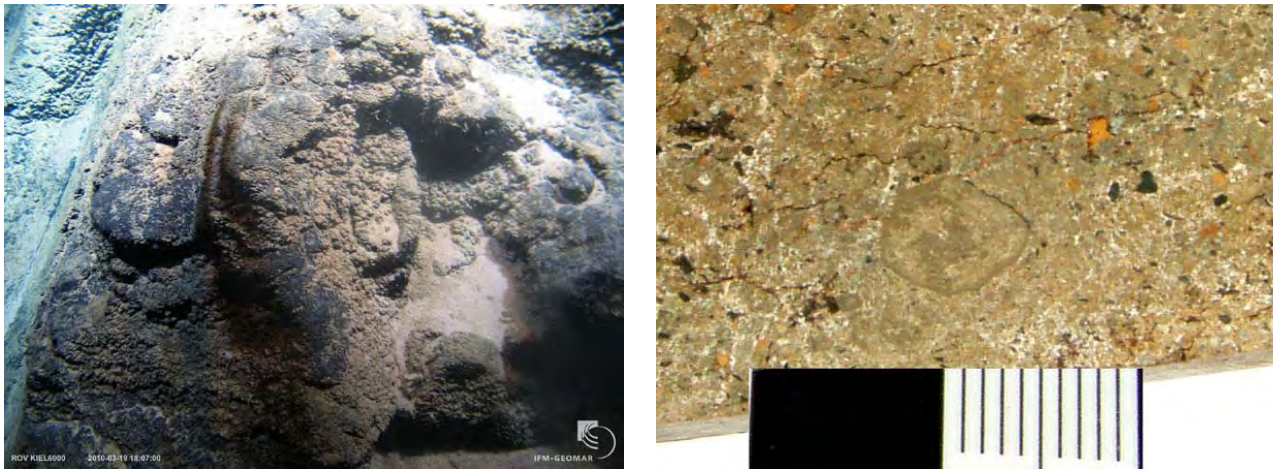

Fig. 5.14: Left: Outcrop of pillow lava in the near vicinity of sampling site #229-10. Right: Detail of sample #229-10 showing an accretionary lapillus (white scale = 1cm).

5.3.2 Turbiditic Volcaniclastic Sandstones

Two samples of dark olive green to dark grey turbiditic volcaniclastic sandstones (223-11 and -12) have been recovered on ROV dive 3 in c. 2,650 m water depth. The deposits are moderately to well sorted, with a calcite cement in coarser horizons. Sample #11 shows a well developed turbidite sequence of Bouma Ta, b, c, with the grain size ranging from 3-4 mm to very fine grained material (Fig. 5.15). Sample #12 consists of three individual horizons. The middle horizon is clast-supported and consists of 1-2 mm sized particles that are elongated parallel to bedding. The upper and lower horizon are moderately closely packed coarser grained particles. The clasts are angular to subangular, and in the coarse grained horizons highly irregularly shaped. Greenish particles are non- to poorly microvesicular altered glassy fragments, some with very rugged and whispy shapes. The red particles are microvesicular (possibly oxidized basaltic) particles of equant dimensions. A very minor component are altered feldspar crystals. The particles are interpreted to be derived directly from magma fragmentation during eruption (rather than erosion-derived sedimentary material). Glassy material generally indicates rapid cooling of melt, e.g. during quenching by water, whereas the red particles are possibly formed by magmatic fragmentation during a subaerial explosive eruption. To explain the formation of two types of clasts together (separate formation and a long transport is excluded since none the clast types are

rounded), a possible scenario is a shallow marine eruption of Surtseyan-style. During such an eruption, alternations between phreatic (and phreatomagmatic) and magmatic fragmentation occur, more or less simultaneously producing these two particle types. Their similar size could be an expression of the efficiency of sorting, either from settling out of the eruption column or during settling in the water column. The poor rounding (Fig. 5.15), together with the sedimentary features indicates a short distance redeposition of the volcanic material down the slope of the Beata Rise by sediment gravity flow processes. Bedding irregularities as seen in sample #12 suggest some soft sediment deformation.

Fig. 5.15: Left: Site of both samples #223-11 and -12; note angular nature of slope debris. Right: Graded deposit (sample #223-11) with Bouma Ta, b and c- sequences (scale is in cm).

5.3.2 Volcanic Breccias

On ROV dive 3, an in situ sample of ***monomict volcanic breccia*** (223-4) has been taken from a solid, massive and randomly jointed outcrop at 3,250 m b.s.l. The breccia appears to be intercalated in a succession of lavas and gabbros and has a yellowish colour (matrix) with dark grey clasts. The clasts are 2 – 6 cm sized, non-vesicular, subangular shaped and fairly coarse crystalline (Fig. 5.16). Their lithology is similar to the micro-gabbroic rocks retrieved up- and downslope during this dive (see chapter 5.1.2.3). The matrix consists of feldspar fragments and of fine-grained (but more altered) material as the clasts. The sample is poorly sorted, closely packed and with a faint alignment of finer grained clasts. This breccia is most likely deposited from a locally sourced debris flow. A debris flow is in good agreement with the observed morphology of the outcrop, i.e. sheet-like deposits, which are approximately parallel to the slope and blanket underlying boulders (Fig. 5.16).

ROV dive 5 yielded a sample of a ***monomict lava flow top breccia*** (229-20) from hill-slope debris at 2,570 m b.s.l. The sample is irregular shaped, subangular and has a yellowish-grey rock colour. The texture of the deposit is massive, very poorly sorted with clast-supported components set in a fine grained matrix and bound by white calcite cement and a translucent cement phase (zeolites?). Some of the calcite cements are hanging cements, thus indicating original pore space and allowing a sample orientation. The clasts range from altered glassy to microcrystalline, the latter containing very fine feldspar needles and rarely 3 mm dark mica crystals.

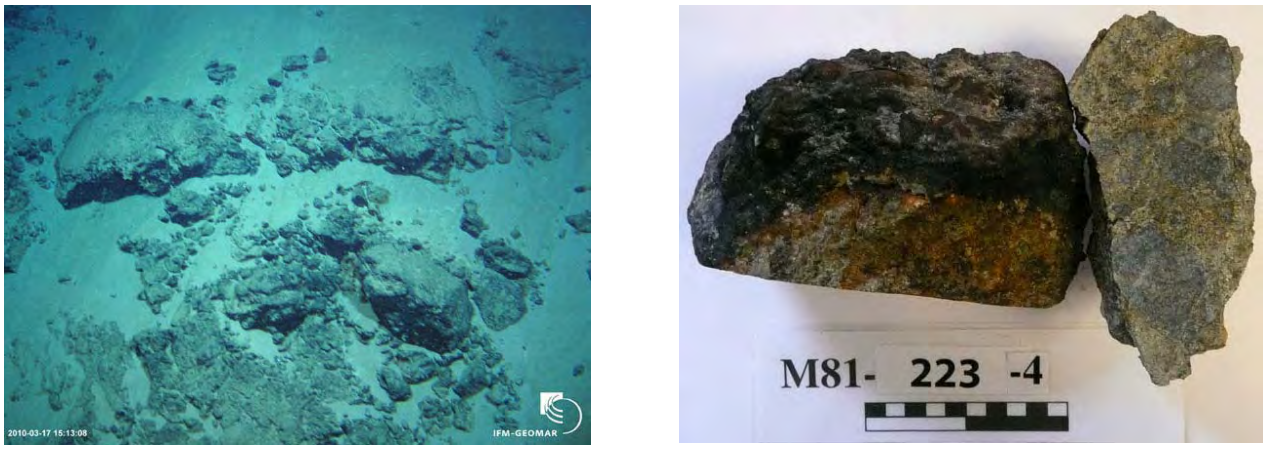

Fig. 5.16: Left: Sampling site of breccia #223-4; note sheet-like material emerging upslope from underneath loose sediment, covering cobbles and boulders. Right: In situ sample of monomict breccia #223-4 (scale = 10 cm).

5.4 Magmatic Rock Sampling Summary

(R. Werner, K. Hoernle, F. Hauff, D. Maicher, C. Conrad, E. Seidel, U. Krüger, P. Loose, E. Seidel, D. Sperl)

Rock sampling on R/V METEOR cruise M81/2AB achieved its major objectives by successful stratigrafically-controlled ROV-sampling of a complete basement section of the northern Beata Rise, extensive dredge sampling of the southern Beata Rise, and the first representative hard rock sampling along the Hess-Escarpment and in the area to the north of the escarpment. The wide range of intrusives, subvolcanic rocks, lavas and volcaniclastic rocks yielded on M81/2AB represents the most detailed marine sampling of the CLIP basement and associated features to date. Extensive volcanological, petrological and geochemical analyses, and radiometric age dating of these rocks will provide a comprehensive data set of the CLIP rocks. Combined with the results of the morphological, geophysical, and sedimentary studies (see chapters 5.5 - 5.8), our data will enable us to successfully accomplish the research project M81/2AB CLIP and to achieve the goals listed in chapter 3. Most hard-rock analytical results, however, require complex and long-lasting preparation and analytical facilities not available onboard a research vessel. In addition, many of the analytical methods cannot be carried out at the same time but have to be conducted one after the other. For example, thin sections of the samples need to be made and evaluated to select samples that are appropriate major element analyses and age dating. The major element analyses are used to evaluate alteration of the samples further and to select representative samples for trace element analyses and age dating. Trace element data is then used to select samples for isotope analyses. The samples selected for age dating need to be irradiated in a reactor and then analyzed after short-lived isotopes have had a chance to decay. Based on the trace element and isotope data, additional samples are selected for age dating and so forth. This procedure will last at least two years and, therefore, results of hard rock analyses and radiometric age dating cannot be presented at this stage. A few preliminary conclusions, however, can already be drawn from visual observations during the cruise and microscopic studies of the magmatic rocks:

- The structure and texture of several magmatic rocks sampled at the Beata Rise show clear evidence of intense tectonism as, for example, intense fracturing, matching angular

components of breccias, or chilled marigins at contacts of fine-grained basaltic lava with coarse-grained gabbro. We interpret these features with intense, large-scale vertical tectonic movements, being consistent with ROV observations (cf. chapter 5.1.2) and the preliminary results of the sedimentary and morphological studies conducted on M81/2AB (cf. chapters 5.5.1 and 5.6). Moreover, ROV dives provided evidence for active faulting and fluid venting at the Beata Rise, indicating still active tectonism (see chapter 5.1.2.2).

- The presence of accretionary lapilli, being formed subaerially from fine-grained tephra ejected during explosive volcanic eruptions, in volcaniclastic deposits and volcanological evidence for shallow marine Surtseyan-style eruptions on the Beata Rise (see chapter 5.3) indicates that at least some parts of the Beata Rise were subaerial during its formation. Combined with the bathymetric data and sedimentary studies (see chapters 5.5 - 5.7), it appears that islands may have been abundant during the earlier history of the CLIP.
- Notably none of the 16 successful dredge hauls conducted in the area of the Hess-Escarpment yielded rocks of continental origin. Therefore, we suggest that our area of investigation is not a part of the continental Chortis Block, as assumed by some geoscientists, but rather a part of the CLIP. The age and geochemistry of the rocks will allow us to determine if the volcanic rocks indeed belong to the CLIP.

5.5 Sedimentary Rocks

(P. Baumgartner, C. Baumgartner-Mora)

The description of sediment types is based on shipboard examination of cut and etched slabs of all sampled rocks. Laboratory work includes the initial examination of about 100 thin sections for microfacies, and micropaleontology. Further thin sections are in preparation. Sr^{87}/Sr^{86} – ratios will be measured on selected bioclasts in order to confirm and/or better constrain the ages obtained form microfossil zonations.

5.5.1 Beata Rise

Most of the recovered material at the Beata Rise is magmatic. However, some rare pelagic sediments may indicate Early Late Cretaceous ages. However, more thin sections are needed to confirm these ages.

At station 234 we recovered a big block (40x30x20 cm, sample #234-8s) that is made of fractured 3-5 cm thick indurated orange-brown claystone beds, set in a less indurated microbreccia containing basaltic granules and pebbles set in a lighter colored claystone matrix. No microfossIls could be clearly identified in the claystones, but they must contain nannofossils (under study). Numerous mm- to cm thick “neptunian dykes” cut through the fractured claystone beds and testify for multiple fracturing and injection of soft sediment (Fig. 5.17). This block clearly is derived from a once tectonically active, sediment-starved environment, such as the top of a fault scarp in an extensional setting (it reminds of the Jurassic Arzo limestone in southern Switzerland). The sedimentary infill in these samples may turn out to be the oldest sediments recovered during the M81/2B cruise. In sample 234-8 we found poorly preserved monokeeled and round planispiral planktonic Foraminifera that could indicate a **Turonian - Coniacian** (90-85 m.y.) age. However, more thin sections are needed to confirm this age.

We recovered one cobble of a coarser basalt breccia including very angular relatively fresh, few cm-sized dolerite clasts set in a pink indurated clay-rich matrix. This sample again indicates tectonic fracturing and local reworking of basalts. One pebble of a pelagic stromatilite, represents probably a slowly accumulated deep water microbialite (234-11). In thin section, the fine lamination confirms the microbial origin and planktonic foraminifers trapped in the laminae include *Heterohelix* sp. and small monokeeled (*Rotalipora*-tpe) or round planispiral (*Ticinella*-type) forms suggesting an **early Late Cretacous** (>85 m.y. ?) age.

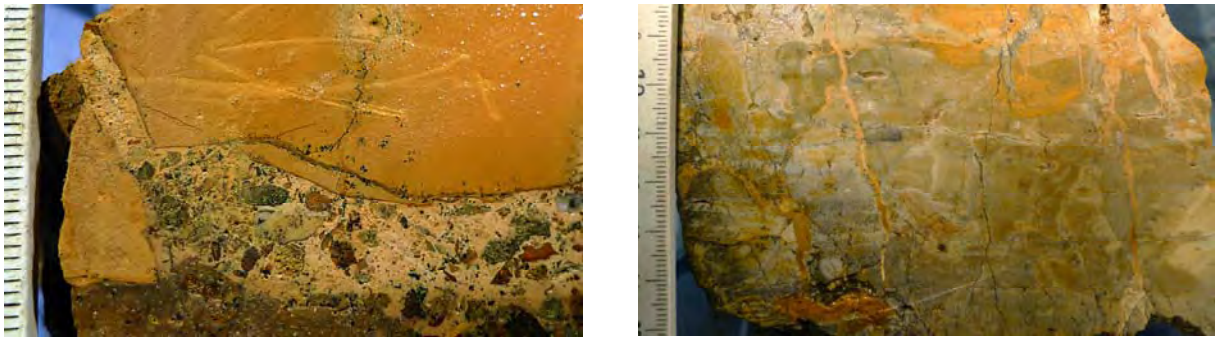

Fig. 5.17: Left: Basalt breccia and claystone #234-8Sc; note filled fractures in claystone (scale in mm). Right: Siliceous claystone #234-8Sb with "neptunian dykes".

5.5.2 Northern Hess-Escarpment/Lower Hess Rise

This area is characterized by the presence of late Campanian pelagic sediments dredged from the deeper localities, that seem to encroach on a slightly older basaltic basement. Shallow water carbonates were recovered at the edges of flat ridge-tops that are fault-bounded. These carbonates range in age from a probable Late Paleocene-early Eocene to a well documented **Late Eocene** (Priabonian) (59-34 m.y.).

Station DR-238 yielded one sediment pebble that is a light yellow pelagic limestone with abundant planktonic foraminifera. The examination of thin sections reveals poorly preserved taxa: *Globotruncanita calcarata*, *Globotruncana ventricosa*, *Globotuncanita stuarti*, indicating a **latest Campanian** age (70 m.y.).

At station DR-241 we recovered about 40 kg of massive carbonates as blocks up to 40x30x30 cm in size. To our surprise many of them are reefal and peri-reefal facies. The following groups of sediments can be distinguished:

- *fractured altered basalts* with carbonate veins “Neptunian dykes” that are either cements or some fine grained sediment that filled the fractures.
- *basalt breccias* with carbonate matrix. Variably angular to subrounded fractured basalt clasts are embedded in a pink to red carbonate matrix that sometimes contains small bioclasts.
- *Basalt conglomerate*. One piece of basaltic conglomerate (214-25S) was recovered that shows rounded 1-5 cm pebbles set originally in a red matrix. The rock became lithified, then fractured across the clasts and filled in by a younger matrix for at least two times. The rounding is very suggestive of littoral, high-energy conditions. A round alteration halo inside the pebbles underlines their prolonged (subaerial ?) exposure.
- *Cross-stratified washed carbonate sands*. One block (241-15S) of massive, yellowish limestone (Fig. 5.18) showed alternations of winnowed coarse carbonate sands, made of Melobesian (“red algal”) and mollusk fragments, and packstones. There are 2 sets of

laminations at an angle of about 30° suggesting cross-bedding. This sample again indicates shallow, above wave-base, high energy conditions, such as an fore-reef carbonate bank environment. Abraded and coated fragments of Discocyclididae and Miscellaneidae suggest a Paleogene age.

- *Reefal limestones*. We recovered several big chunks (e.g. 241-19S) of reefal limestones containing several cm-sized fragments of coral (Fig. 5.18),
- Gasteropods and tube-shaped red algal structures that are determined as *Polystrata alba*. Coral colonies are finger-shaped, branching and are likely to bélong to the genus *Porites* (looks like *Porites porites* of the Caribbean). These limestones look very much like peri-reefal, coarse bioclastic, coral rubble deposits filled in with carbonate mud. This facies also suggests a **Paleocene-Eocene** age.
- *Lagoonal carbonate mud-wakestones*. Several samples (e.g. 241-27S) are rather rich in carbonate mud and contain abundant Gasteropods, such as a 2 cm long mold of *Turritella* sp. The basalt surface was never very far as shown by occasional basalt clasts.
  Aragonitic shells have largely been dissolved leaving an important secondary porosity. The Mn-encrusted surfaces of the blocks are often cavernous. Miscellaneidea and Discocyclinid fragments suggest a **Paleocene-Eocene** age.
  Sediments at station DR-241 document a shallow, above wave-base depositional environment by physical sedimentary textures and structures, as well as by macro- and microfossils known from the photic zone. While it is difficult for now to establish the precise age of this reefal facies, it is clearly Early Paleogene (perhaps late Paleocene- early Eocene).
- Pelagic limestones with angular basalt clasts (241-24S). Several small pieces of pelagic limestone including cm-sized altered basalt clasts were recovered at stations DR-241 and -242. They contain Mn-impregnated planktonic Foraminifera in which cross-sections of *Orbulina universa* can be seen. This indicates a **Middle Miocene** or younger age for this lithology.

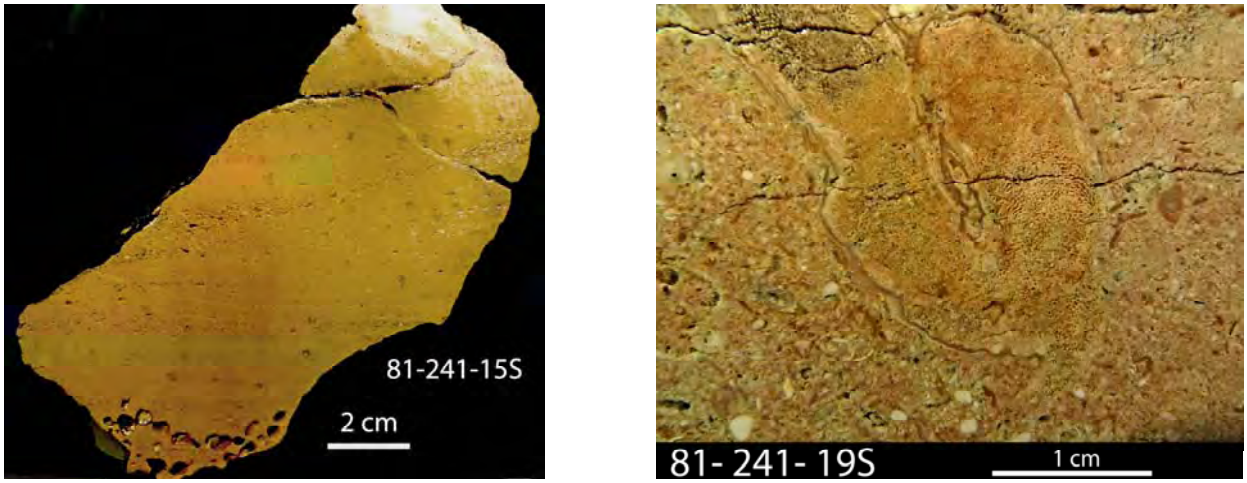

Fig. 5.18: Right: Cross-bedded mssive shallow water limestone #241-15S. Right: Finger-shaped (*Porites porites*–like) coral branches in coarse bioclastic grainstone.

At station DR-242 we recovered 3 small pieces of carbonate sediment:

- A fossil "coquina" made of Bivalves and Melobesian ("red algal") bioclasts, containing Dasyclad Algae, small Alveolinids, Miscellaneidae . None of these bioclasts is really age-diagnostic but they suggest an **early Paleogene** age.

- A pelagic limestone with sparse basalt clasts like in DR-241.
- A "*Stronatactis*"-type cement structure embedded in a matrix containing small Bachiopods, one Miliolid and abundant planktonic Foraminifera (242-18S). Incomplete geopetal infills of shells indicate the top direction in the sample by original porosity. The panktonic Foraminifera include cross-sections of Globigerinids, Globorotalids and *Orbulina universa* (**middle Miocene** or younger). Again, shallow water material, though scarse, is definitely present and seems to be displaced into a pelagic environment of Late Tertiary age.

At station DR-245 we recovered a big chunk of a Mn-encrusted and bored limestone that has a definite shallow water origin (245-3S) It is composed of cm-sized rhodoliths enclosing coral fragments and abundant larger benthic Foraminifera. These include ; *Lepidocyclina chaperi, Lepidocyclina pustulosa Lepidocyclina tournori, Lepidocyclina gubernacula* and *Homotrema* sp. Indicating a **late Eocene** (37-34 m.y.) age.

As usual, numerous cavities are filled in by pink pelagic limestone containing younger Tertiary planktonic Foraminifera. Finally, the whole rock was pervasively impregnated by Mn-oxides.

At station DR-249 the whole approximate 40 kg load of the dredge was of one lithology: 5-10 cm bedded light yellowish gray clayey pelagic limestone. Bedding is shown by varying clay content, subhorizontal burrow mottling is common (Fig. 5.19). Beautiful *Zoophycus* trace fossils were found in several samples, indicating an *bathyal* environment of deposition. Examination of many thin sections of this lithology resulted in the following list of planktonic Foraminifera: *Globotruncanita calcarata, Globotruncana bulloides, Golotruncana ventricosa, Globotruncana arca,* indicating a **late Campaian** (75-70 m.y.) age.

Fig. 5.19: Left: Pelagic limestone block #249-3S with well visible bedding. Right: Burrow mottled pelagic limestone M81-249-8S with Zoophycus, a bathyal trace-fossil.

While many pieces are totally unfractured, an important portion of pieces (small and big ones up to 30x30x20 cm) are characterized by pervasive, brittle (post lithification) fracturing of the limestone. Fractures are cemented by calcite and sometimes re-fractured.

5.5.3 South-Western Hess-Escarpment

This area is characterized by the presence of early to middle Campanian pelagic sediments dredged from the deeper localities, that seem to encroach on a slightly older basaltic basement.

Again, shallow water carbonates of very similar facies and ages as those of the NW lower Hess Rise were recovered at the ridge-tops. These carbonates range are dated as **middle to late Eocene** (Priabonian) (40-34 m.y.).

At station DR-261 one pebble of pelagic limestone was recovered. It contains abundant planktonic Foraminifera: *Globotruncana elevata, Golobotruncanita startiformis, Rosita fornicata* indicating an **early to middle Campanian** (84-76 m.y.) age.

The abundant sediments at station DR-263 belong to 3 facies types: (1) Shallow water carbonates similar to those found at stations DR-241 to -245, (2) platy pelagic limestones, and (3) a new lithology consisting of pelagic wakestones containing probable deep water corals (Fig. 5.20).

The first group document, again for this region, a shallow photic depositional environment by the presence of abundant larger Foraminifera and rhodliths. The age of this facies is middle to late Eocene. The lithofacies include:

- Bioclastic limestones made principally of rhodoliths and larger Foraminifera, namely abundant Discocyclinids and rather rare Nummulitids. The same *Porites* sp. corals as at station DR-241 are present. In fact, the genus *Porites* ranges from the Eocene to the Recent. Some of the limestone blocks have preserved a fresh reducing environment in the core of the sample. Sample 263-2 contains: *Lepidocyclina pustulosa*, *Nummulites macquaveri*, *Operculina dia*, *Fabiania cassis*, *Fabiania ssp.*, *Homotrema* sp. *Sporadotrema sp.* and planktic Foraminifera from the *Globigerinateka ssp.* level. Age : **Late middle Eocene to Priabonian**.
- Rhodolith boundstones. Big blocks (44x28x17 cm) of bioconstructed rhodolith limestone. This facies contains sporadically infills with larger Foraminifera. Sample 263-9 contains: *Lepidocyclina pustulosa*, *Lepidocyclina macdonaldi*, *Asterocyclina asterisca*, *Asterocyclina sp.*, and planktonic foaminifera such as *Orbulinoides* sp. and *Globigerinateka* sp. Age: **Late middle Eocene or Priabonian**

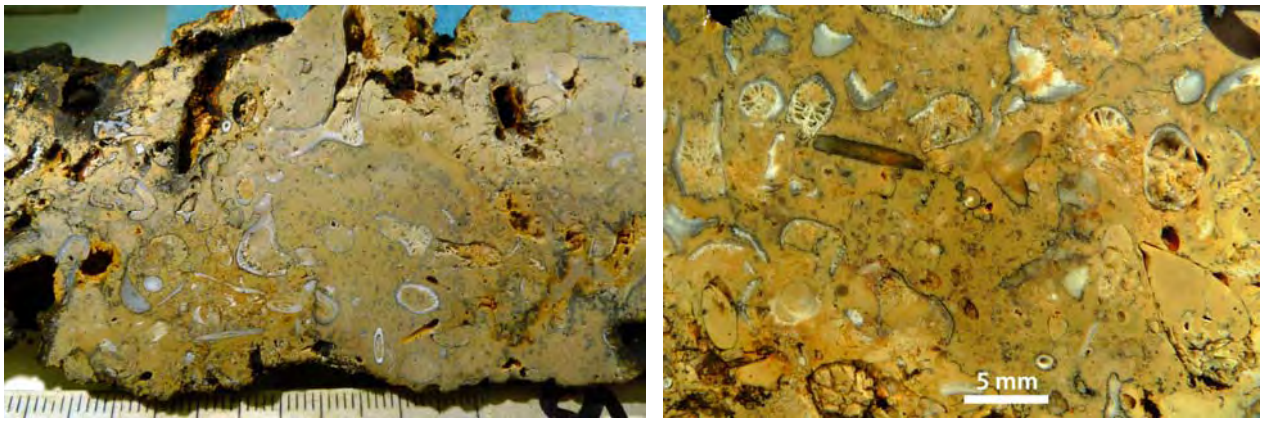

Fig. 5.20: Left: Highly bored and corroded pelagic wakestone #263-4S containing delicate branching corals, brachiopods, echinoids, worm tubes reflecting a deep dwelling community. Right: Detail of sample #263-4S showing echinoid spine, encrusted coral and brachiopods sections.

The second group includes thin bedded, platy pelagic limestones. One slab (35x27x5 cm) and several pieces were recovered. All these samples are micrites, show fine lamination, no visible microfossil content and are heavily encrusted with Mn. In one sample contorted beds suggest slump structures. In another sample cm-sized clasts of a pink microbreccia are embedded in

fluidally deformed laminae of the same facies. In two other samples pelagic laminae fill in and are interlayered with Mn-crusts. The age of this facies is unknown but it is clearly not related with the shallow water environment. It could document later stages of condensed sedimentation when the seamount subsided to deep marine depths.

The third group consists of highly bored slabs of pelagic wakestones containing a probably deep dwelling community of brachiopods, echinoids and delicate branching deep water corals (Fig. 5.20). Again, the planktonic Foraminifera in the matrix **(≤ Middle Miocene**) seem to reflect the post-drowning colonization of the seamount area. This facies may correlate with 242-16S described earlier.

Station DR-265 yielded three pebbles of highly bored foraminifer-rhodolith bioclastic limestone. Sample 265-2 contains *Amphistegina* ssp, *Lepidocyclina chaperi*, *Operculinoides ocalanus*, *Nummulites* ssp. Sample 265-3 contains *Lepidocyclina pustulosa*. Both samples indicate a **middle to late Eocen**e age.

Station 269 had some big basalt blocks with fine fractures filled with reddish matrix and abundant abraded pebbles to cobbles of a soft pelagic chalk, undoubtedly of young **(≤ Middle Miocene**) age, recognizable at the large spherical planktonic Foraminifera (*Orbulina universa*).

5.5.4 Sedimentary Rock Summary

The discovery of Eocene shallow water reefal sediments encroaching on basaltic basement exposed on structural highs along the Hess Escarpment are fundamental for the understanding of the tectonic (and/or magmatic ?) history of the Hess Rise. The sediment facies and ages imply that the basement of the lower Hess rise originated at bathyal depths prior to the Campanian, became uplifted to sea level in Eocene times and reached again pelagic depths at latest in the middle Miocene.

5.6 Geomorphological Observations (Hydroacustics)

(M. Meschede, H. Hueneke, C. Bartsch, D. Sperl, K. Hoernle, R. Werner)

ROV dives, dredge hauls, and magnetic profiling were always accompanied by multi-beam mapping (SIMRAD EM120) and sediment echosounding (ATLAS PARASOUND) to get information about the morphological structure of the sea floor and the sedimentary layering in flat areas. The two sampling areas of investigation revealed different features (e.g., more longitudinal structures at the Beata Rise vs. more circular structures at the Hess-Escarpment) as well as similar structures and material detecting a common origin.

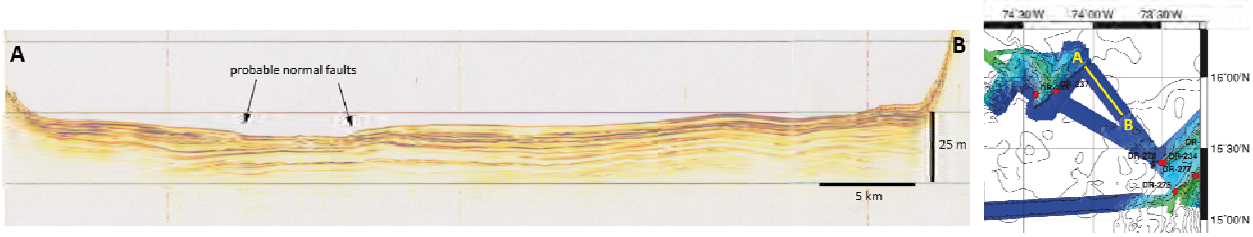

Fig. 5.21: PARASOUND Profile between the Hess-Escarpment (A) and the Beata Rise (B) in the central Northern Caribbean. Location of the profile is indicated in the map (A-B). Note the strong vertical exaggeration.

Numerous seamounts can be observed northwest of the Hess-Escarpment and in the area of the Beata Rise. The area in between those two major structures and south of the Hess Escarpment is a more or less flat deep sea plain with an average depth around 4,000 m. It seems likely that the Hess-Escarpement and the Beata Rise reflect transtensive structures which evolved as a result of the E-W extension of the Caribbean Plate during the Cenozoic. The flat area in between those two morphologically higher areas may be thus interpreted as a transtensive graben structure filled by younger sediments. This is supported by PARASOUND profile data of the sediments which revealed a few structures that may be interpreted as extensional faults running parallel to the graben margin (Fig. 5.21). A more detailed analysis of these structures is currently being prepared.

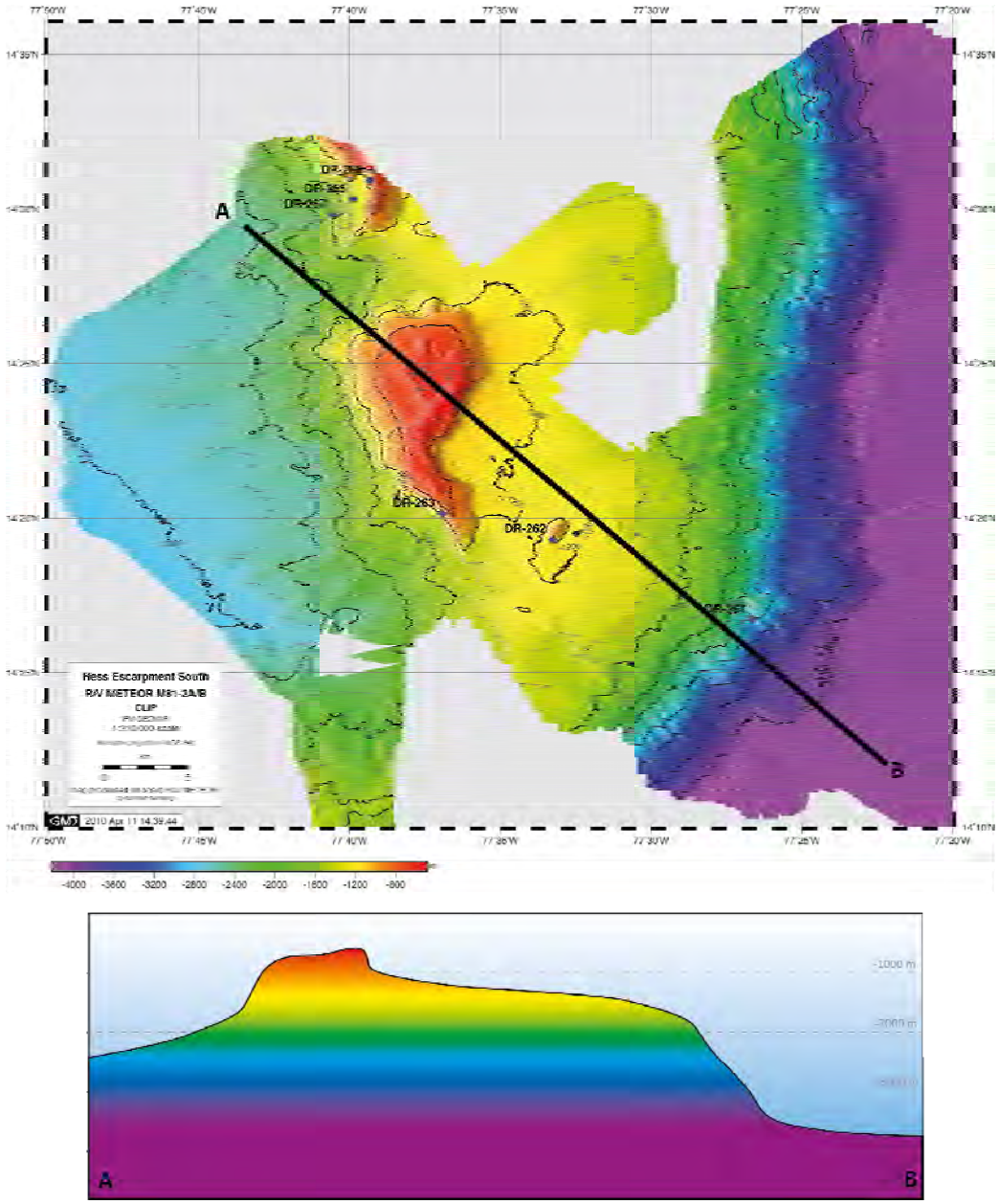

Fig. 5.22: Guyot-like structure north of the Hess-Escarpment in the southwestern part of the area of investigation. The topographic profile indicates two more or less plain levels, a deeper one at about 1,400 m depth and a second smaller one at about 700 m depth. Location of the profile is indicated in the map (A-B).

The abundant seamounts northwest of the Hess-Escarpment and at the Beata Rise are likely to have a volcanic origin (cf. chapters 5.2 and 5.4). Mapping of the Hess-Escarpment and some particular groups of seamounts to the northwest of the escarpment showed a series of guyot-type structures (i.e. seamounts with steep sides and gentle dome-like tops; Fig. 5.22). On several of these structures, the transition from steep to gentle slope occurred at depths of 1,600-1,800 m. Our working hypothesis is that at this level of the seamounts once ocean island volcanoes formed, related to either the main Caribbean Flood basalt event at c. 90 Ma or a probable second phase at c. 77 Ma. The islands were eroded to sea-level as they subsided, forming the gentle dome-like tops. Subsidence of 1,600-1,800 m of a large part of the area north of the Hess-Escarpment extending westward to the Nicaragua Rise and covering a triangular area of 500 by 300 km must have resulted in response to the extension of the central Caribbean. This is a result of large-scale tectonic forces possibly related to north-south compression of the Caribbean Large Igneous Province (CLIP) between the Americas.

On the tops of several of the guyots with their flat top in depths of 1,600-1,800 m, there are significantly smaller structures, some also forming guyot-like structures with flat tops at depths of less than 1,000 m (see Fig. 5.22). Based on morphology and their magnetic intensities these structures are interpreted to reflect later (post-erosional) volcanism, either belonging to the second main phase of volcanism on the CLIP (c. 77 Ma) or representing even younger volcanism. Preliminary results from dredged samples of these structures, however, mainly revealed sedimentary rocks indicating shallow water conditions. This is represented by corals, large foraminifera, rodoliths (see chapters 5.5 and 5.7) and probably subaerial ejected volcanic material (see chapter 5.3). Some of the post-erosional volcanism may have occurred along NNE-SSW and NNW-SSE oriented structures appearing to form along conjugate fractures which may be related to the left lateral motion between the North American and Caribbean Plates.

Bathymetric mapping of the Beata Rise, as well as ROV observations along the Beata Rise flanks (see chapter 5.1.2.2.,), showed a series of en echelon step faults, consistent with the Beata Rise being an extensional horst-and-graben structure. In the southern part of the Beata Rise a NE-SW trending graben-like structure was mapped with a difference in depth of more than 1,200 m from the shoulder to the deepest point of the graben (Fig. 5.23). The width of the graben is about 25 km and its trend is parallel to the northwestern margin of the Beata Rise as well as to the general trend of the Hess-Escarpment. The southeastern flank of the Beata Rise is dominated by N-S trending faults which also form horst and graben structures. They are directly connected to the NE-SW trending graben structure.

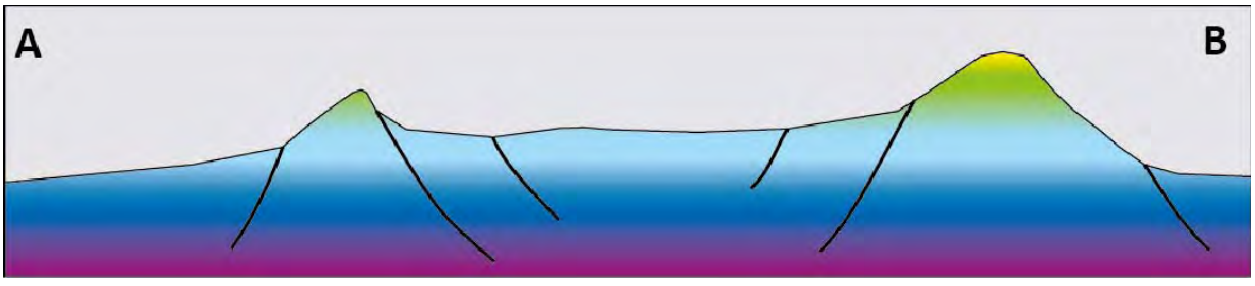

Fig. 5.23: Topographic profile of a graben-like structure at the southern part of the Beata Rise. Location of the profile A-B is shown in Figure 5.8.

It is assumed that the Beata Rise structure once has been connected to the area north of the Hess-Escarpment. The separation from this region is a result of the E-W extension of the Caribbean Plate during the Cenozoic. Figure 5.24 shows an attempt to restore the area north of the Hess-Escarpment and to fit it together with the Beata Rise. The distance between two points marked by A (Nicaragua Rise) and B (southern shoreline of Hispaniola) has been stretched by about 50%. The result is a remarkable well fit of the blocks which have been outlined using the sea floor bathymetry map based on the etopo 1 data set (Amante and Eakins, 2009). The insets show a simplified schematic profile through the stretched oceanic crust of the CLIP. The blocks are intensely disrupted and rotated due to tilting by the extensional movement. This is supported by observations of tilted and partly folded sedimentary strata during the ROV dives (cf. chapter 5.2).

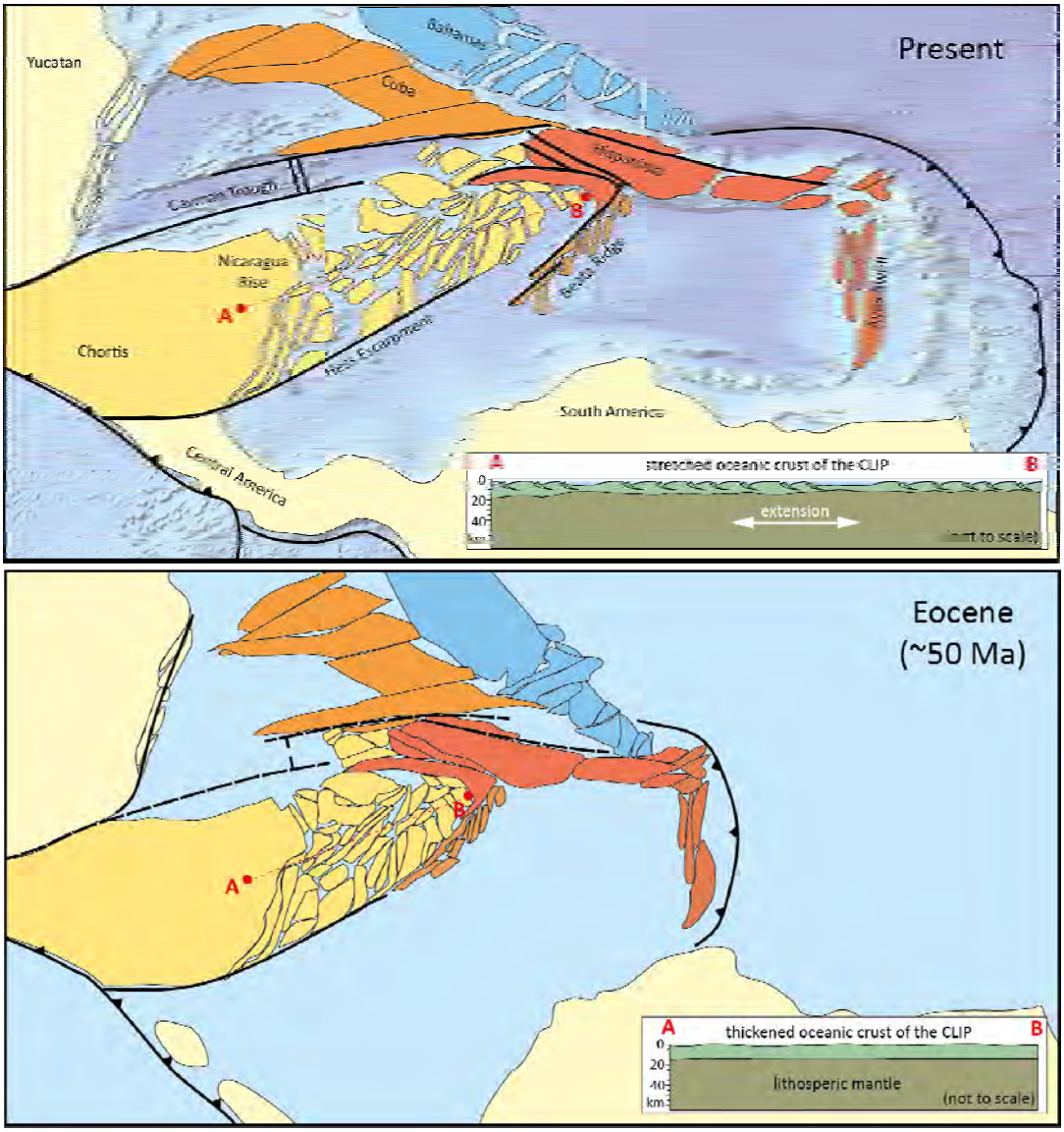

Fig. 5.24: Preliminary paleogeographic restoration of the area north of the Hess-Escarpment and the Beata Rise at Eocene times. The sea floor bathymetry map based on the etopo 1 data set (Amante and Eakins, 2009) was used to define the blocks according to their present situation. The insets show a schematic view of extensional tectonics acting in the Central and Northern Caribbean during the Cenozoic.

5.7 Morphology of the Seamounts from a Sedimentological Perspective

(H. Hueneke)

Naturally, lithified and unlithified pelagic sediments of different ages (Cretaceous to Neogene) occur widespread on many slopes of the seamounts (see chapter 5.5). An unexpected result of the dredge sampling was the recovery of abundant shallow-water carbonates at some of the dredge sites from the seamounts along the Hess-Escarpment (Figs. 5.10 and 5.11). For detailed description, composition, and ages of these sediments see chapters 5.5.2 and 5.5.3.

Shallow-water carbonates have been recovered from both, the deeper-sited slopes of the large seamount-plateaus (e.g. station DR-241) and from the slopes of the (superimposed) smaller seamount-caps (e.g. stations DR-245 and -263). The sampled shallow-water carbonates may certainly include (par-) autochthons material as well as allochthonous material, which has been redeposited by sedimentary gravity flows. Its occurrence allows an alternative working hypothesis to explain the characteristic plateau-like morphology (see chapter 5.6) and the formation of the seamounts studied.

The various seamounts that are part of the Hess-Escarpment reveal a striking morphology (see chapter 5.6). Their lower part is characterized by steep slopes and a (more or less) flat-topped plateau situated at a water depth between 1.200 and 900 m. On top of these plateaus, there are distinctly smaller seamount caps, which have a crest-like shape rather than a circular form. These seamount caps rise into water depths of less than 800 m.

Although there is general agreement that the seamounts were formed by extensive volcanism, we can only speculate – as a working hypothesis – that the seamounts once have been volcanic islands which subsided and were eroded down to the sea level (more exactly: to the wave base). The recovery of shallow-water carbonates confirms this hypothesis and indicates that shallow-water carbonate platforms began to grow at the margins of these levelled volcanic seamounts and contributed to the formation of the distinct plateaus. Tropical carbonate platforms, generally, form flat tops because (1) the euphotic high-production zone is abruptly limited by sea level, (2) waves and currents efficiently redistribute sediment from high-production areas to fill up depressions, and (3) the platform margin tends to develop a wave-resistant rim that protects the sediment of the platform interior (e.g. Schlager 2005).

With increasing subsidence of the seamounts (probably reinforced by rising sea level), the carbonate platform were subjected to flooding or incipient drowning (Fig. 5.25); i.e. demise photo-autotrophic marine communities (e.g. reef corals, larger foraminifera, rodoliths) by submergence below the photic zone. The basic pattern is a deepening of the carbonate depositional environment to below the photic zone and thus below the zone of maximum carbonate production of the warm-water carbonate factory. Incipient drowning lead to less-than-optimal but still photic conditions; the carbonate platform tries to keep-up with the rising sea level. Such flooding events often lead to backstepping and reorientation of the platform margins, which are the areas of a carbonate platform the growth potential (Fig. 5.25). Such backstepping pattern and raised-rim topographies are common features of drowning unconformities and provide good criteria for their recognition. Thus, the smaller seamount caps sitting on top of the plateaus may represent back-stepped platform margins that document the incipient drowning of the carbonate platforms (as an alternative interpretation to a late volcanic phase). This hypothesis is consistent with the lack of volcanic rocks in most dredges carried out at the seamount caps.

Above the flat-topped seamount plateau the build-up backsteps and changes the topography from a flat-topped plateau to a mounded plateau – indicating gradual submergence below the zone of wave action and – finally – complete drowning.

The sedimentary record of drowning may show a gradual transition from shoal-water to deep-water deposition but major gaps and abrupt changes are common. A common reason for the punctuated record is current amplification by sharp seamount topography. The results are major hiatuses or condensed sequences between the drowned platform and its (hemi-)pelagic cover or within this cover. Based on the (preliminary) stratigraphic ages of the sampled material, the drowning may have occurred during Palaeogene-Neogene transition. Shallow-water carbonates of the drowning succession are probably of Eocene (station DR-263) age or are younger (station DR-241). Pelagic limestones of the post-drowning succession are of Miocene age or are younger (stations DR-241, DR-242) (cf. chapter 5.5.4) .

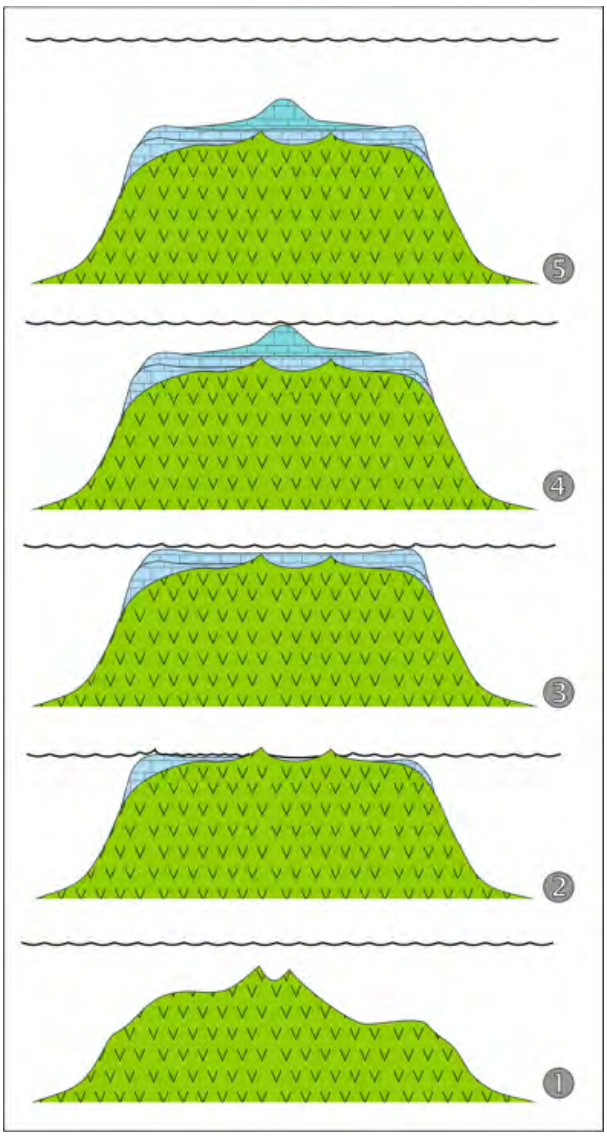

Fig. 5.25: Working hypothesis explaining seamount morphology based on the sampled shallow-water carbonates. 1 – Volcanic seamount stage (pre-Campanian); 2 – early plateau stage (Eocene); 3 – late plateau stage (Eocene); 4 – cap stage with incipient drowning (Eocene?); 5 – final drowning (Miocene). For explanation of the highly simplified sketch see text.

5.8 Magnetic Profiling

(U. Barckhausen)

During cruise M81/2AB, more than 7,300 km of magnetic profiles were acquired with modern towed sensors (Fig. 5.26). Different magnetometer array configurations were applied depending on sensor availability, time constraints, and purpose of the respective magnetic profiles. Because the majority of BGR's magnetometer equipment had been in use on a cruise with R/V MERIAN which ended only a few days before the start of M81/2AB, during Leg M81/2A only two total field magnetic sensors (Marine Magnetics SeaSpy™) were available which were deployed in gradiometer mode on seven profiles totalling 4,273 km.

During the port call in Curacao, two more total field sensors, two vector sensors (Magson Vector), and additional tow cables were taken on board which had been shipped there via airfreight from the MERIAN cruise. With the vector sensors available, the standard configuration used was a combination of two total field sensors working in gradiometer mode and a vector sensor mounted on the same tow cable between them. On the four magnetic profiles in the Colombia Basin, a second vector sensor was deployed in order to get magnetic gradients in the total field as well as in the components of the magnetic field. The distance between the ship and the first towed sensor was 600 m throughout the cruise. The distance between sensors operating in Gradiometer mode was 150 m. During Leg M81/2B a total of 3,074 km of magnetic profiles was acquired.

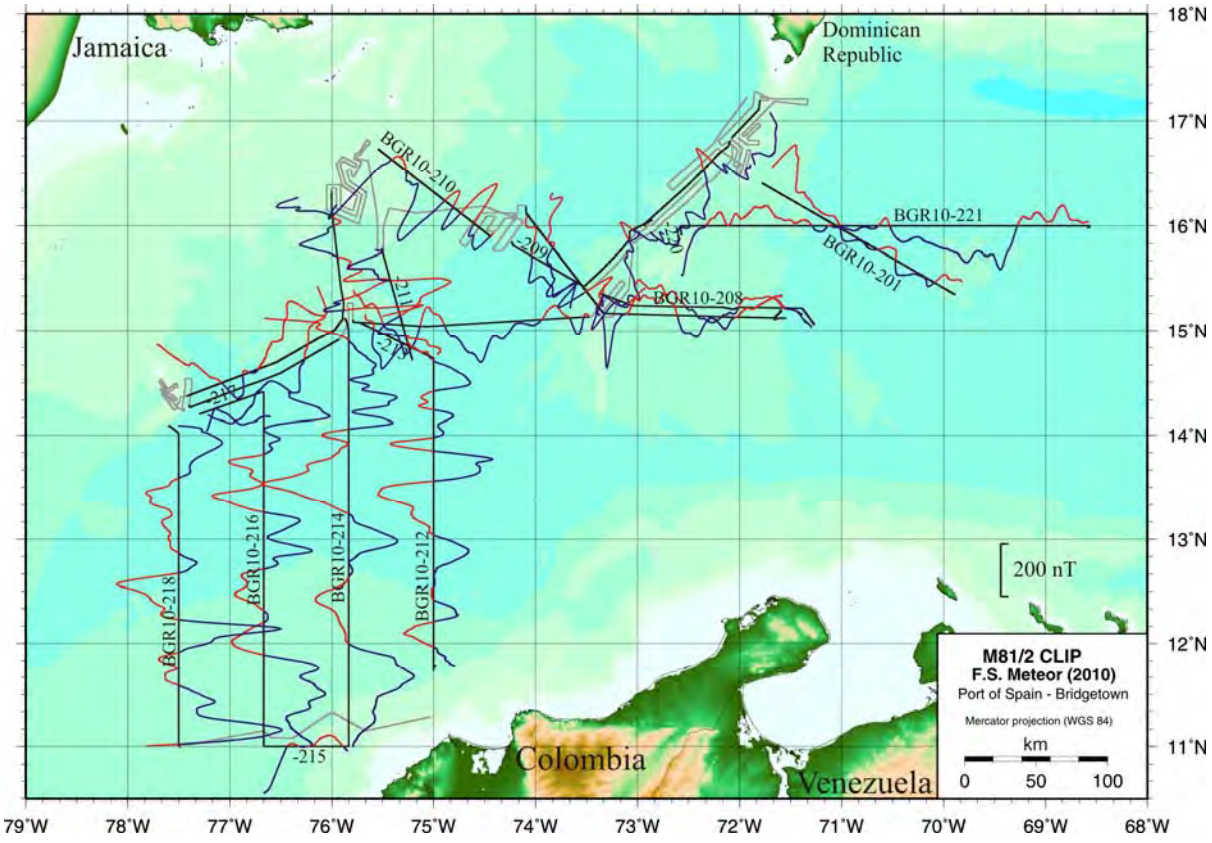

Fig. 5.26: Magnetic profiles of cruise M81/2AB shown as wiggles along ship tracks. Positive anomalies are shown in red, negative anomalies in blue. Only data acquired on the black tracks are shown, but magnetic data also exist on the grey tracks. Numbers are profile names.

In addition to the towed magnetometers, a new shipboard magnetometer system built by the Magson Company (Berlin) consisting of two fluxgate sensors, a power supply/data acquisition unit, and a GPS receiver was used during cruise M81/2AB permanently except in waters where we had no research permission. The sensors were mounted to the handrails of the 6th superstructure deck while the power supply/data acquisition unit was located right underneath in the Luftchemielabor.

On all magnetic profiles anomalies with amplitudes of several hundred Nanoteslas (nT) were recorded. The amplitudes and the wavelengths of the anomalies are typical for basaltic crust throughout the study area. No significant changes in the characteristics of the magnetic anomalies were observed across the Hess Escarpment so that in a first analysis of the data we see no indication for a change in the type of underlying crust across this boundary. The same is true for the Beata Rise.

On the four long magnetic profiles acquired in the Colombia Basin the anomalies recorded seem to indicate an E-W striking structure. However, a simple correlation of seafloor spreading anomalies is not possible between the profiles (Fig. 5.27). Since the sedimentary cover in the turbidite-filled Colombia Basin is very thick, no morphologic features of the underlying crust are visible in the multi-beam bathymetry data except for the northernmost part of the basin where a few structures can be seen. The thickness of the sediments in the Colombia Basin is unknown. ODP Site 999 on the Kogi Rise west of the area investigated here did not reach the presumably volcanic basement at 1,066 m b.s.f. A depth of the basement of ~1450 m b.s.f. at this site is inferred from a reflection seismic line (Abrams and Hu, 2000). The sediments at the base of Site 999 were of Upper Cretaceous age and the predicted age right above the basement is Middle Cretaceous (Abrams and Hu, 2000). If these results can be transferred to the Colombia Basin farther east, then the presumed underlying oceanic crust would have formed during the Cretaceous Normal Superchron (C34). This might explain why no correlation of the magnetic anomalies between the profiles is possible. The water depth, however, seems to be too shallow for normal oceanic crust of Middle Cretaceous age even with a sedimentary cover of 1,500 m taken into consideration (Hillier and Watts, 2005). Therefore it seems plausible that the crust underlying the Colombia Basin is thicker than normal. The question is whether this is the result of a later volcanic episode or if the crust already formed anomalously thick near a hotspot. These questions need to be addressed with a detailed analysis of the vector data from the magnetic profiles in the Colombia Basin which will begin in mid 2011. After a thorough processing these data will show if there are any coherent 2D-strike directions of the magnetic anomalies along the individual profiles. If such strike directions exist they will help distinguishing between a possible Pacific and an inter-American origin of this part of the Caribbean Plate. Another question is whether the Colombia Basin is underlain by one single piece of crust. The small morphological structures which show up in the bathymetric data in the northern part of the basin might indicate an E-W striking tectonic boundary (Fig 5.27). Also, there could be a N-S offset between the westernmost of the four profiles and the others. All these questions require the processing and interpretation of the vector data.

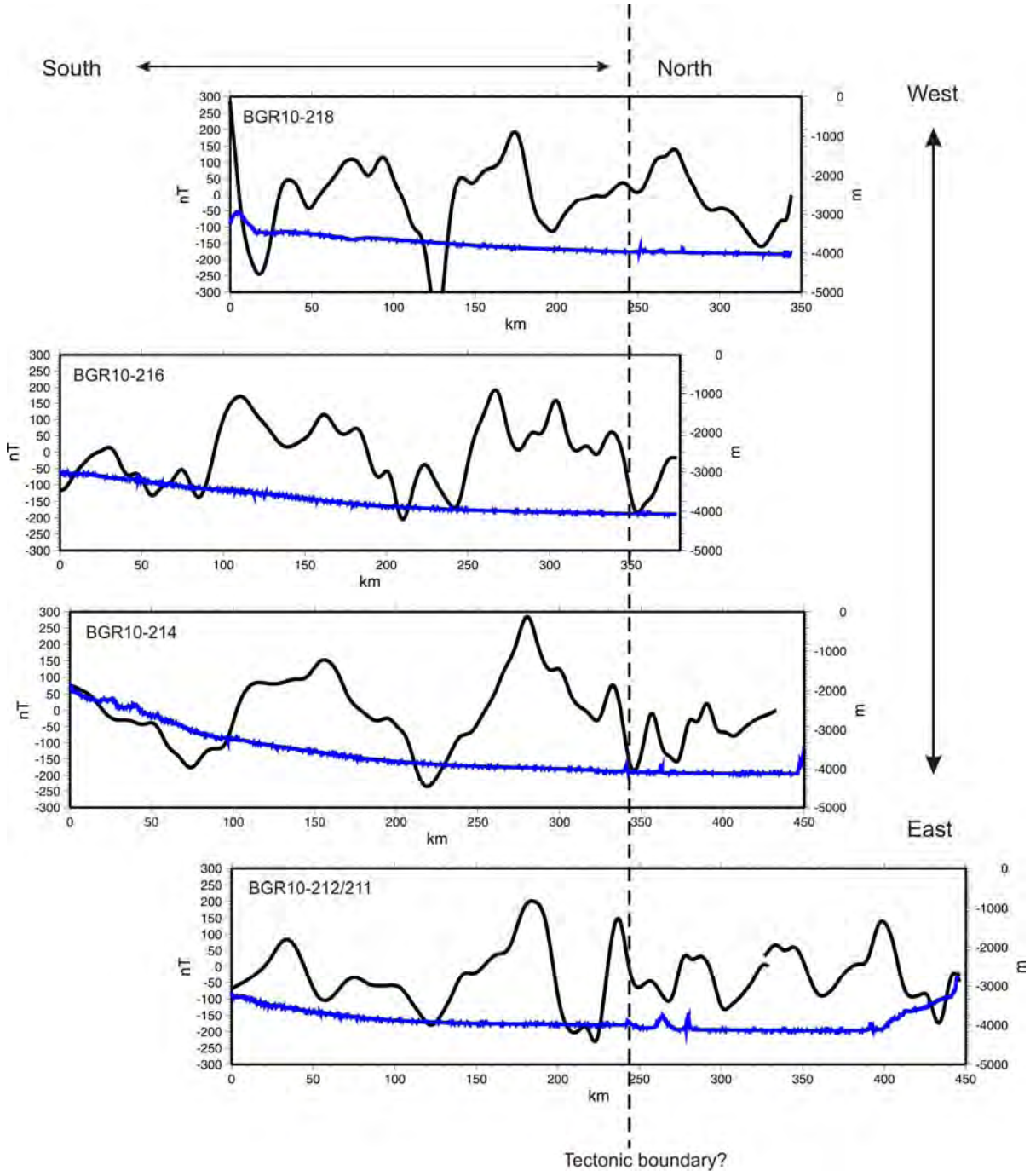

Fig. 5.27: Magnetic profiles (total field) of the Colombia Basin. The blue curves show the depth of the seafloor along the profiles. No correlation as seafloor spreading anomalies seems possible, but distinct anomalies as well as a morphological structure may indicate a tectonic boundary in the northern part of the basin.

During the mapping of dredge targets on the Beata Rise and Hess Escarpment, small-scale magnetic anomalies with high amplitudes were regularly recorded. The strongest anomalies, however, did not always correspond with the largest morphological structures. A volcanic origin for the abundant seamounts that were mapped is likely. Two phases of volcanism were identified based on the morphology of the seamounts. It appears that the younger morphological structures are also the source of the stronger anomalies, although they are significantly smaller than the older structures. An example is shown in Fig. 5.28.

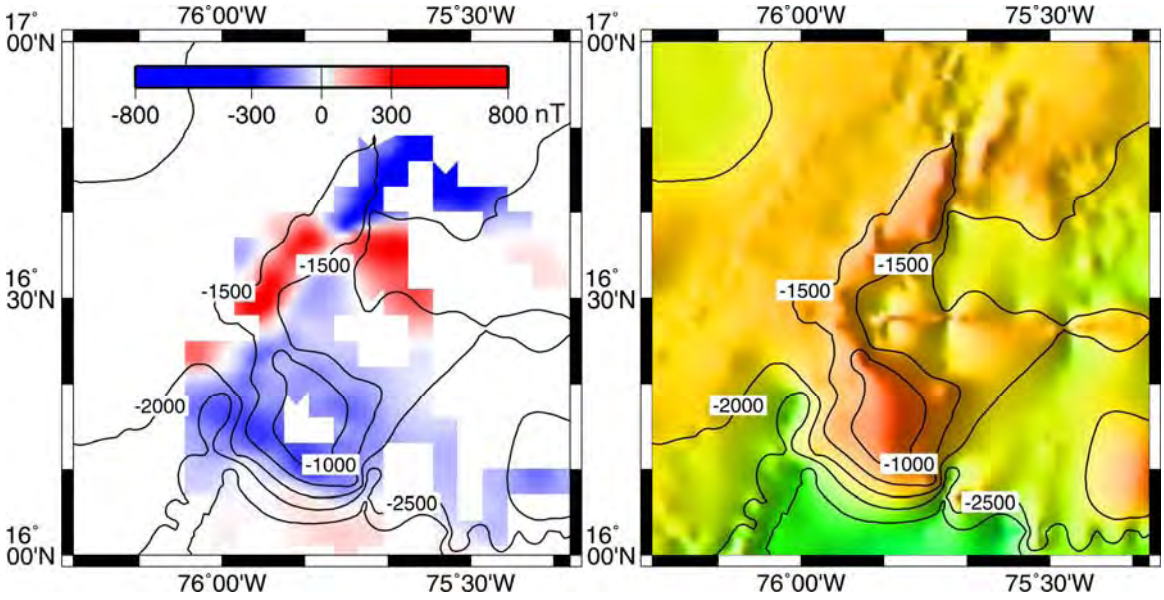

Fig. 5.28: Seamounts north of the Hess Escarpment: a) magnetic anomalies and b) bathymetry.

The planned magnetic profiles west of the Beata Rise could only partly be measured due to time constraints and the limits of the area where we had research permissions (Fig 5.26). Of these, only profile BGR10-221 was acquired with a vector magnetometer during M81/2B. Therefore, a simple correlation with magnetic anomalies from the Venezuela Basin was not possible. However, the vector magnetometer profile can be analysed for possible local 2D-strike directions after processing which can confirm a connection with the Venezuela Basin anomalies.

6 Ship's Meteorological Station

(H. Rentsch)

On 10th of March, when we left the port of Port of Spain, the typical trade weather had established that Meteor could expect all the year as averaged values during the cruise: characterized by steadily winds of Beaufort (Bft) 4 to 5 from easterly directions. The main reasons for the existence and strength of the trade winds are the position of the subtropical high's between 23° N and 45° N and the position of the ITCZ (Intertropical Convergence Zone), which is moving with the annual changing position of the sun. From the beginning of the cruise, a subtropical high existed at 35° N, otherwise the ITCZ stayed between the equator and 5° N. A wedge of this high reached the Southern Antilles and brought us mostly sunny and dry weather with temperatures up to 28°C. Lows and fronts which developed at the same time in the east of USA passed the northern part of the Caribbean and moved then south-eastward. So the weather on cruise track of the ship was always touched in a weakening way.

A change of the wind regime took place mostly during passing of narrow straits, for instance between Trinidad and Venezuela. Here a jet affect caused gusts up to 26 knots (average of wind speed of nearly Bft 6) and produced wave heights up to 2 m.

On the following days of the cruise the wind decreased more and more during the transit to the first working area to 3 to 4 wind forces from south-east on the arrival day. The sunny and front free-weather remained until the middle of following week.

Close to the border of Dominican Republic and some land masses, lower water depths caused weaker winds and a shallow swell up to 1 m, mostly from south-easterly directions.

After the 17th of March in connection with a weak front a cloud belt reached the Greater Antilles.

The whole day was characterized by huge cumulus clouds and isolated rain showers were observed. Unusual weak trade-winds and a calm sea were the dominant features until the 19th of March. Wave-heights didn't reach hardly 1.5 m.

Afterwards the wind speed increased together with a strengthened pressure gradient in the whole Caribbean. In the period March 22 to 25, an average-wind of 6 wind forces and a swell of up to 2.5 m brought the work with the ROV (Remotely Operated Vehicle) to its meteorological limits. Heavy seas up to 3.5 m and additional generated gusts of Bft 7 to 8 were observed in the afternoon.

In the last week of Leg 2A, when we were already on our course to the port of Curacao, the wind speed was weakening very slowly. The average of wind speed reached first up to Bft 6, and the sea state didn't exceed more than 3 m. Later, on the last two days along our cruise track we got a friendly, partly sunny weather with nearly calm seas and still fresh winds of Bft 5.

On 29th of March 2010 Leg 2A ended with a light swell and moderate north-easterly winds when R/V METEOR entered the port of Willemstad/Curacao.

On 31st of March, steadily trade winds of Bft 4 to 5 from easterly directions and wave heights which didn't exceed 2 m have been established, when R/V METEOR left the port of Willemstad. Exactly those winds and sea states can be expected when we look on the climatologically mean values for the whole Caribbean. The main reasons for the formation and strength of the trade winds are the position of the subtropical high's between the range of 23° and 45° N and the position of the ITCZ (Intertropical Convergence Zone) which is moving with the annual changing position of the sun.

From the beginning of Leg 2B high pressure systems retained west and east of Florida /USA, otherwise the ITCZ would have established along the equator and 5° N. A wedge of this high pressure centres extended to the Lesser Antilles and brought us a calm sea (significant wave heights lower than 1.5 m) and easterly winds around Bft 4 during the first week of Leg 2B. A weak cold front passed the ship's course to the South of the Caribbean Sea and produced some strong isolated showers which occurred for the first time of Leg 2B. Along the coastal areas of Colombia and towards the port of Santa Marta, which we reached on April 6th, fine and dry weather with temperatures around 28°C dominated. Near the port of Santa Marta strong north-easterly winds began to blow and reached Bft 6 to 7 caused by topographical effects and by strengthening of the ridge of high pressure. At the same time the sea swelled up to 3.5 m. The ship also reached parts of the ITCZ which existed over northern Colombia without producing showers. At the start of magnetic profiles the windy weather and bumpy sea state were preserved westerly of the 74th meridian. Steadily winds of Bft 6 and wave heights up to 3 m were observed.

During the following days, the wind decreased and therefore the sea state was slightly reduced on the ship's track directly towards the North.

For the period of April 8 to 11, significant wave heights of 2.5 to 3 m and north-easterly winds of Bft 6 to 7 were observed for areas between 15°N, 75°W and 12°N, 78°W. At our second approach to the port of Santa Marta the same strengthened effects on winds and swell like occurred as during the first call at Santa Marta. But this time winds and swell didn't exceed

Bft 5 and 2 m, respectively. When the ship left of the coastal areas the sea-meteorological conditions improved more and more. On our track to the Beata Rise wind blew with Bft 4 against heading. On the 15th of April wind raised up to Bft 6c causing significant wave heights of c. 3 m at our last dredge stations. This fact, however, didn't disturb the work on board.

Most of the remaining time of the Leg 2B was characterised at first by moderate winds (Bft 5), later mostly by Bft 4 and a moderate sea state. The fine sea-weather was only interrupted when we reached the eastern site of the Windward Islands. There, we observed wave heights up to 2.5 m and also some unexpected directions of currents and swell for a short time.

R/V METEOR reached the port of Bridgetown/Barbados at a calm sea and weak easterly winds in time in the morning of April 21.

7 Station List M81/2AB

7.1. Station List Leg 2A

Station No.	Date	Gear	Time [UTC]	Lat. [°N]	Lon. [°W]	Depth [m]	Remarks/Recovery
M812/214	10.03.14	Magnetometer array, EM120, PARASOUND	1:15	15° 21.36'	69° 54.15'	3723.4	begin of profile
M812/214	10.03.14	Magnetometer array, EM120, PARASOUND	14:12	16° 24.89'	71° 47.48'	2987.8	end of profile
M812/215	10.03.14	EM120. PARASOUND	15:12	16° 28.67'	71° 53.27'	2526.9	begin of profile
M812/216	10.03.14	Magnetometer array	17:40	16° 37.68'	71° 53.34'	1356.8	begin of profile
M812/216	10.03.14	Magnetometer array	17:46	16° 36.73'	71° 53.60'	1227.5	end of profile
M812/216	10.03.14	Magnetometer array	18:45	16° 29.70'	71° 55.55'	1274.6	begin of profile
M812/216	10.03.15	Magnetometer array	10:46	16° 33.42'	71° 58.93'	2333	end of profile
M812/215	10.03.15	EM120. PARASOUND	11:00	16° 33.09'	71° 57.60'	1789.6	end of profile
M812/217	10.03.15	ROV	13:55	16° 32.98'	71° 56.78'	1303.5	begin of profile 1
M812/217	10.03.15	ROV	21:44	16° 32.95'	71° 56.28'	839.9	end of profile 1 13 samples (lava. gabbroic rocks)
M812/218	10.03.15	EM120. PARASOUND	22:36	16° 33.44'	71° 56.31'	1265.3	begin of profile
M812/219	10.03.15	Magnetometer array	23:00	16° 34.66'	71° 58.19'	2305.6	begin of profile
M812/219	10.03.16	Magnetometer array	10:48	17° 14.04'	71° 54.86'	4277.4	end of profile
M812/218	10.03.16	EM120. PARASOUND	11:14	17° 14.73'	71° 52.58'	4265.8	end of profile
M812/220	10.03.16	ROV	14:25	17° 14.88'	71° 51.96'	4146.7	begin of profile 2
M812/220	10.03.16	ROV	20:50	17° 14.24'	71° 50.62'	2987.4	end of profile 2 4 samples (sedimentary rocks)
M812/221	10.03.16	EM120. PARASOUND	22:24	17° 13.83'	71° 49.86'	3091.8	begin of profile
M812/222	10.03.16	Magnetometer array	22:42	17° 13.55'	71° 47.90'	2359	begin of profile
M812/222	10.03.17	Magnetometer array	10:30	16° 50.35'	72° 1.18'	1850.2	end of profile
M812/221	10.03.17	EM120. PARASOUND	11:20	16° 51.50'	72° 6.20'	3396.7	end of profile
M812/223	10.03.17	ROV	14:03	16° 51.61'	72° 6.12'	3442.5	begin of profile 3
M812/223	10.03.17	ROV	22:20	16° 50.67'	72° 5.15'	2393.8	end of profile 3 13 samples (lava. gabbroic rocks. volcaniclastics)
M812/224	10.03.17	EM120. PARASOUND	23:28	16° 50.64'	72° 5.05'	2363.4	begin of profile
M812/225	10.03.17	Magnetometer array	23:56	16° 48.22'	72° 5.72'	1979.8	begin of profile
M812/225	10.03.18	Magnetometer array	11:00	16° 26.81'	72° 22.68'	2955.4	end of profile
M812/224	10.03.18	EM120. PARASOUND	14:18	16° 50.30'	72° 5.16'	2249.4	end of profile
M812/226	10.03.18	ROV	15:59	16° 50.61'	72° 5.10'	2332.3	begin of profile 4
M812/226	10.03.18	ROV	21:54	16° 50.03'	72° 4.71'	1875	end of profile 4 4 samples (volcniclastics. sedimentary rocks)
M812/227	10.03.18	EM120. PARASOUND	22:46	16° 49.89'	72° 4.60'	1828.9	begin of profile
M812/228	10.03.18	Magnetometer array	23:26	16° 44.97'	72° 4.34'	2216.7	begin of profile

Station No.	Date	Gear	Time [UTC]	Lat. [°N]	Lon. [°W]	Depth [m]	Remarks/Recovery
M812/228	10.03.19	Magnetometer array	9:50	16° 3.97'	72° 52.40'	3278.9	end of profile
M812/227	10.03.19	EM120. PARASOUND	10:24	16° 6.52'	72° 51.37'	4213	end of profile
M812/229	10.03.19	ROV	13:56	16° 6.29'	72° 51.21'	4201.7	begin of profile 5
M812/229	10.03.20	ROV	1:24	16° 4.12'	72° 50.42'	2533.3	end of profile 5 21 samples (lava. gabbroic rocks. volcaniclastics)
M812/230	10.03.20	EM120. PARASOUND	2:49	16° 3.82'	72° 50.45'	2378.3	begin of profile
M812/231	10.03.20	Magnetometer array	3:12	16° 2.51'	72° 53.30'	2753.8	begin of profile
M812/231	10.03.27	Magnetometer array	16:56	15° 7.19'	71° 30.32'	4024.2	end of profile
M812/230	10.03.27	EM120. PARASOUND	16:56	15° 7.19'	71° 30.32'	4024.2	end of profile. begin of calibration
	10.03.27	EM120. PARASOUND	19:42	15° 0.22'	71° 17.84'	4093.8	end of calibration

7.2. Station List Leg 2B

Station No.	Date	Gear	Time [UTC]	Lat. [°N]	Lon. [°W]	Depth [m]	Remarks/Recovery (for recovery of dredges see chapter 5)
M813/232	10.04.01	EM120, PARASOUND	16:00	15° 0.40'	71° 13.67'	4144.4	begin of profile
M813/233	10.04.01	Magnetometer array	16:48	15° 4.39'	71° 16.63'	4140.1	begin of profile
M813/233	10.04.02	Magnetometer array	4:24	15° 21.87'	73° 22.95'	3368.4	end of profile
M813/232	10.04.02	EM120, PARASOUND	5:40	15° 23.68'	73° 29.43'	3290.4	end of profile
M813/234	10.04.02	Chain bag dredge	5:44	15° 23.68'	73° 29.43'	3290.9	
M813/235	10.04.02	EM120, PARASOUND	9:40	15° 24.03'	73° 28.94'	2948.7	begin of profile
M813/236	10.04.02	Magnetometer array	10:18	15° 25.99'	73° 32.54'	3927.9	begin of profile
M813/236	10.04.02	Magnetometer array	14:21	15° 50.03'	74° 13.77'	4228	end of profile
M813/235	10.04.02	EM120, PARASOUND	15:01	15° 53.57'	74° 15.87'	4218	end of profile
M813/237	10.04.02	Chain bag dredge	15:10	15° 54.06'	74° 16.15'	4185.5	
M813/238	10.04.02	Chain bag dredge	20:34	15° 52.75'	74° 24.89'	4073.7	
M813/239	10.04.03	EM120, PARASOUND	0:15	15° 52.39'	74° 24.24'	3647.4	begin of profile
M813/240	10.04.03	Magnetometer array	0:55	15° 54.41'	74° 26.97'	4193.2	begin of profile
M813/240	10.04.03	Magnetometer array	8:20	16° 43.63'	75° 32.14'	1449	end of profile
M813/239	10.04.03	EM120, PARASOUND	9:18	16° 47.77'	75° 37.91'	1185.1	end of profile
M813/241	10.04.03	Chain bag dredge	9:31	16° 48.28'	75° 38.47'	1646.8	
M813/242	10.04.03	Chain bag dredge	12:51	16° 46.65'	75° 39.64'	1653.2	
M813/243	10.04.03	Chain bag dredge	18:00	16° 38.20'	75° 43.66'	1381.6	
M813/244	10.04.03	EM120, PARASOUND	21:06	16° 38.66'	75° 43.55'	1005.4	begin of profile
M813/244	10.04.03	EM120, PARASOUND	22:41	16° 30.29'	75° 51.50'	1326.7	end of profile
M813/245	10.04.03	Chain bag dredge	23:36	16° 22.70'	75° 53.21'	932.1	
M813/246	10.04.04	EM120, PARASOUND	1:46	16° 22.36'	75° 52.76'	793	begin of profile
M813/246	10.04.04	EM120, PARASOUND	3:04	16° 9.86'	75° 52.80'	1515	end of profile
M813/247	10.04.04	Chain bag dredge	3:21	16° 9.07'	75° 53.88'	2462.2	
M813/248	10.04.04	EM120, PARASOUND	6:32	16° 9.41'	75° 53.44'	1853.3	Begin Profile
M813/248	10.04.04	EM120, PARASOUND	9:30	15° 59.50'	75° 31.37'	3103.2	end of profile
M813/249	10.04.04	Chain bag dredge	9:40	15° 59.48'	75° 30.83'	3148.2	
M813/250	10.04.04	EM120, PARASOUND	13:00	15° 59.99'	75° 30.38'	2615.2	begin of profile
M813/250	10.04.04	EM120, PARASOUND	17:28	16° 9.61'	75° 23.83'	2042.2	end of profile
M813/251	10.04.04	Chain bag dredge	17:38	16° 9.69'	75° 23.68'	1926.6	
M813/252	10.04.04	EM120, PARASOUND	20:24	16° 9.05'	75° 23.48'	1716.2	begin of profile
M813/252	10.04.04	EM120, PARASOUND	22:43	15° 51.15'	75° 26.59'	2054.6	end of profile
M813/253	10.04.04	Chain bag dredge	23:14	15° 49.58'	75° 30.68'	2030.2	
M813/254	10.04.05	EM120, PARASOUND	2:08	15° 49.65'	75° 30.44'	1785.4	begin of profile
M813/255	10.04.05	Magnetometer array	2:40	15° 46.76'	75° 30.13'	2758.4	begin of profile
M813/255	10.04.05	Magnetometer array	10:32	14° 42.62'	75° 12.43'	4131	end of profile
M813/254	10.04.05	EM120, PARASOUND	11:16	14° 38.81'	75° 11.35'	4127.8	end of profile
M813/256	10.04.06	EM120, PARASOUND	16:00	11° 26.21'	74° 34.96'	1043.4	begin of profile

Station No.	Date	Gear	Time [UTC]	Lat. [°N]	Lon. [°W]	Depth [m]	Remarks/Recovery (for recovery of dredges see chapter 5)
M813/257	10.04.06	Magnetometer array	19:43	11° 44.56'	75° 0.00'	3188	begin of profile
M813/257	10.04.07	Magnetometer array	20:54	15° 4.30'	75° 42.51'	4122.7	end of profile
M813/256	10.04.07	EM120, PARASOUND	21:50	15° 8.24'	75° 49.69'	1640.4	end of profile
M813/258	10.04.07	Chain bag dredge	22:09	15° 9.74'	75° 52.48'	2537	
M813/259	10.04.08	EM120, PARASOUND	1:04	15° 9.38'	75° 52.55'	2400.6	begin of profile
M813/260	10.04.08	Magnetometer array	1:40	15° 7.26'	75° 52.12'	2263.7	begin of profile
M813/260	10.04.10	Magnetometer array	14:59	14° 12.29'	77° 18.53'	4041.3	end of profile
M813/259	10.04.10	EM120, PARASOUND	16:28	14° 16.62'	77° 26.74'	2889.1	end of profile
M813/261	10.04.10	Chain bag dredge	16:30	14° 16.62'	77° 26.75'	2866.5	
M813/262	10.04.10	Chain bag dredge	21:10	14° 19.25'	77° 33.45'	1147.7	
M813/263	10.04.10	Chain bag dredge	23:30	14° 20.06'	77° 37.11'	1373.4	
M813/264	10.04.11	EM120. PARASOUND	2:38	14° 19.25'	77° 37.18'	1573.5	begin of profile
M813/264	10.04.11	EM120. PARASOUND	4:54	14° 30.26'	77° 39.35'	1217.6	end of profile
M813/265	10.04.11	Chain bag dredge	4:58	14° 30.27'	77° 39.34'	1213.9	
M813/266	10.04.11	Chain bag dredge	7:16	14° 30.88'	77° 39.37'	1175.2	
M813/267	10.04.11	Chain bag dredge	9:35	14° 29.69'	77° 40.65'	1745.3	
M813/268	10.04.11	EM120. PARASOUND	11:54	14° 29.46'	77° 40.42'	1491.6	begin of profile
M813/268	10.04.11	EM120. PARASOUND	22:50	13° 47.89'	78° 23.25'	1482.7	end of profile
M813/269	10.04.11	Chain bag dredge	23:10	13° 48.16'	78° 25.39'	1953.2	
M813/270	10.04.12	Chain bag dredge	2:38	13° 47.70'	78° 26.45'	2139.1	
M813/271	10.04.12	EM120. PARASOUND	5:16	13° 47.53'	78° 26.06'	1868.1	begin of profile
M813/271	10.04.12	EM120. PARASOUND	11:16	14° 3.11'	77° 40.89'	3629.8	end of profile
M813/272	10.04.12	Chain bag dredge	11:25	14° 3.32'	77° 40.33'	3496.8	
M813/273	10.04.12	Chain bag dredge	15:28	14° 6.66'	77° 38.49'	2834.2	
M813/274	10.04.12	EM120. PARASOUND	18:30	14° 7.30'	77° 38.18'	2819.8	begin of profile
M813/275	10.04.12	Magnetometer array	19:06	14° 5.46'	77° 35.71'	4030	begin of profile
M813/275	10.04.14	Magnetometer array	7:22	11° 16.88'	75° 2.87'	1384.8	end of profile
M813/274	10.04.14	EM120. PARASOUND	8:00	11° 17.53'	74° 59.80'	1357	end of profile
M813/276	10.04.15	Chain bag dredge	14:06	15° 11.75'	73° 24.38'	3066.2	
M813/277	10.04.15	Chain bag dredge	19:30	15° 18.35'	73° 15.78'	2691.7	
M813/278	10.04.16	Chain bag dredge	0:15	15° 23.95'	73° 30.76'	3694.8	
M813/279	10.04.16	Chain bag dredge	7:17	15° 29.59'	73° 6.02'	2889.8	
M813/280	10.04.16	EM120. PARASOUND	10:34	15° 29.25'	73° 5.85'	2750.9	begin of profile
M813/280	10.04.16	EM120. PARASOUND	18:32	15° 32.86'	72° 56.81'	2649.3	end of profile
M813/281	10.04.16	Chain bag dredge	18:36	15° 32.87'	72° 56.82'	2691	
M813/282	10.04.17	EM120	1:39	15° 40.45'	72° 35.01'	2446.4	begin of profile
M813/282	10.04.17	EM120	5:20	15° 42.31'	72° 32.87'	1897.8	End profile
M813/283	10.04.17	Chain bag dredge	5:22	15° 42.31'	72° 32.86'	1892.5	
M813/284	10.04.17	EM120. PARASOUND	8:16	15° 42.61'	72° 32.14'	1607.7	begin of profile
M813/285	10.04.17	Magnetometer array	9:00	15° 47.29'	72° 32.77'	2153.3	begin of profile
M813/285	10.04.18	Magnetometer array	15:13	15° 59.81'	68° 33.83'	4165.8	end of profile
M813/284	10.04.18	EM120. PARASOUND	15:24	15° 59.60'	68° 33.20'	4167.8	end of profile

8 Data and Sample Storage and Availability

The bathymetric data recorded on cruise M81/2AB have been handed over to the Federal Maritime and Hydrographic Agency (BSH). Bathymetric and sediment echosounding data are stored and are being processed at IFM-GEOMAR, the Ernst-Moritz-Arndt Universität Greifswald, and the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR). The magnetic data acquired during cruise M81/2AB are being processed at BGR in Hannover. The magnetic data are held in the marine geophysical database which is being maintained in the sub-

department Marine Resource Exploration at BGR. Upon request, copies of the original data are made available to third parties after a two year moratorium. Metadata will be submitted to the PANGAEA database.

The rocks recovered by ROV dives and dredging are stored and are being analysed and dated at IFM-GEOMAR and co-operating institutions (e.g. Ernst-Moritz-Arndt Universität Greifswald, Université de Lausanne). The data yielded from the analyses and dating of rock samples will be published and thus made available to third parties. Upon request, reference samples are made available to third parties after analyses, data interpretation and publication.

Copies of the original magnetic, bathymetric, and sediment echosounding data as well as reference samples have been handed over to observers from Haiti and Colombia, respectively, during the cruise. The bathymetric data recorded within the EEZ of Jamaica were sent to the National Environment and Planning Agency of Jamaica (NEPA). In general, data and results yielded from the M81/2AB CLIP research project will be made available to the abutting nations upon request.

9 Acknowledgements

We would especially like to thank Captain Wunderlich and Captain Baschek and the crew of R/V METEOR. Their hard work, professionalism, high level of experience, and willingness to help, as well as the pleasant working atmosphere on board, contributed directly to the success of the M81/2B CLIP expedition.

We are grateful to Wolfgang Borchert for processing of EM120 data and most of the maps shown in this report. We thank the Governments of Haiti, Jamaica, Colombia, Panamá, and of the Dominican Republic for granting permission to work within their territorial waters. We also gratefully acknowledge the support of the German Foreign Office, the German Embassy, and the Control Station Deutsche Forschungsschiffe in this matter.

We are also grateful to the German Science Foundation (DFG) for funding this cruise and the German Federal Ministry of Education and Research (BMBF) for their continuing support of the marine research. We would also like to thank the research institutes and universities involved in this project for additional support.

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Appendix 1: Sampling Locations and Rock Descriptions

Appendix I (Rock Description)

M81-217

Description of Location and Structure: Western Slope of the Southern End of a N-S striking Ridge in the Center of the Beata Ridge. Profile from 1500-800 mbsl

ROV on bottom UTC 15/03/10 13:55hrs, lat 16°32,98'N, long 71°56,78'W, depth 1411m

ROV off bottom UTC 15/03/10 21:44hrs, lat 16°32,95'N, long 71°56,28'W, depth 839m

total volume: 13 samples; basaltic and gabbroic

Comments: steep slope which is mostly pure outcrop with little stretches of sediment. Lava flows, pillows and cliffs

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-217-1	1. Rock Type: medium altered basaltic volcanic rock 2. Size: not recorded 3. Shape / Angularity: subangular 4. Color of cut surface: medium brownish grey with cream colored freckles of up to 1mm 5. Texture / Vesicularity: massive, very poorly vesicular <1%, filled with calcite 6. Phenocrysts: Fsp needles <1mm, clear to whitish altered, 1.2mm dark crystals, equant, probably pyroxene, no large pheoncrysts 7. Matrix: microcrystalline, intersatal 8. Secondary Minerals: brownish-yellow overgrowth on matrix along cracks 9. Encrustations: ca 1mm Mn crust 10. Comment: Classified as Insitu? Light colored freckles are probably related to groundmass alteration. This is a medium grained basalt	1	x	4	no			x		N3		
M81-217-2	1. Rock Type: Basaltic volcanic rock, slightly altered 2. Size: not recorded 3. Shape / Angularity: subangular 4. Color of cut surface: medium grey to brownish grey 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: aphyric, Fsp needles 1mm, clear to whitish altered, dark grey equant crystals possibly pyroxene 7. Matrix: microcrystalline 8. Secondary Minerals: pyrite overgrowth in patches, brown-reddish minerals along cracks 9. Encrustations: <1mm Mn crust 10. Comment: Classified as Insitu, medium grained basalt	1	x	3	no		x			X1	Sample was located in front part of ROV in the front right corner	
M81-217-3	1. Rock Type: basaltic volcanic rock similar to sample -2 2. Size: not recorded 6. Phenocrysts: slightly more dark minerals 8. Secondary Minerals: reddish brown mineral overgrowth 10. Comment: Insitu sample, medium grained basalt	2	x	3	no		x			N1		

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-217-4	1. Rock Type: basaltic volcanic rock, strongly altered 2. Size: 18x13cm 3. Shape / Angularity: subangular 4. Color of cut surface: leight brown to cram colored on dry surface 5. Texture / Vesicularity: massive, non vesicular 6. Phenocrysts: no large phenocrysts, fsp needles up to 2mm, whitish altered, few dark grey Px? 7. Matrix: microcrystalline 8. Secondary Minerals: abundant brown opaque waxy patches, homogeneously distributed; probably Mn 9. Encrustations: 1-3mm thick Mn crust 10. Comment: Insitu sample, medium grained basalt	1	x	5	no		x			X2	Sample was taken with chisel and fell underneath H1 container; initially misslabled as sample -3 in ROV protocol	
M81-217-5	1. Rock Type: basaltic volcanic rock similar to sample -4, strongly altered 2. Size: 27x14cm 3. Shape / Angularity: subangular 4. Color of cut surface: cream-brown greyish on dry surface 8. Secondary Minerals: homogeneously distributed brown seconday minerals (Fe-OH) 9. Encrustations: <1mm Mn crust 10. Comment: Debris, medium grained basalt	1	x	5	no				x	H1	originally labelled as sample 4 in ROV protocol	
M81-217-6	1. Rock Type: basaltic volcanic rock similar to sample -4 2. Size: 10x15cm 4. Color of cut surface: medium greyish-brown when dry 8. Secondary Minerals: ~1mm dark concentric alteration rings, waxy brown patches <1mm 9. Encrustations: 1mm Mn crust 10. Comment: Insitu ?, medium grained basalt	1	x	5	no			x		M3		
M81-217-7	1. Rock Type: basaltic volcanic rock similar to -4, strongly altered 2. Size: 15x18cm 6. Phenocrysts: Fsp needles <1mm, clear and altered; few Px? crystlas 8. Secondary Minerals: waxy clear brown patches 9. Encrustations: 1mm Mn crust 10. Comment: Insitu?, medium grained basalt	1	x	5	no			x		M1		
M81-217-8	1. Rock Type: basaltic volcanic rock similar to -2, altered 2. Size: 14x12cm 4. Color of cut surface: cream brown to greyish 8. Secondary Minerals: brown opaque patches, cracks filled with Fe-Oxides 10. Comment: Debris, , medium grained basalt	1	x	~4	no				x	M2		
M81-217-9	1. Rock Type: basaltic volcanic rock similar to 4 but coarser, medium altered 2. Size: 18x16cm 4. Color of cut surface: brown-cream greyish 6. Phenocrysts: Fsp needles up to 3mm, altered, Px? often with brown opaque patches 7. Matrix: crystalline 9. Encrustations: 1-3 mm Mn crust 10. Comment: Insitu?, medium to coarse grained basalt	1	x	4-5	no			x		H5		

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-217-10	1. Rock Type: basaltic volcanic rock, strongly altered 2. Size: 9x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: cream when dry 5. Texture / Vesicularity: massive, non vesicular 6. Phenocrysts: Fsp needles 1-2mm, altered often in radial aggregates 7. Matrix: microcrystalline 8. Secondary Minerals: pervasive oxidation to brown Fe-oxides, crack fillings consist of carbonate 9. Encrustations: 1-3mm Mn crust 10. Comment: Debris, medium grained basalt	1	x	5	no				x	F2		
M81-217-11	1. Rock Type: basaltic volcanic rock similar to -10, altered 2. Size: 12x15cm 4. Color of cut surface: brown greyish 6. Phenocrysts: Px? More abundant than in previous samples, Fsp similar to sample -4 8. Secondary Minerals: Fe-oxides and bright red oxide overgrowth, cracks filled with carbonate 10. Comment: Debris, medium grained basalt	1	x	4	no				x	F4		
M81-217-12	1. Rock Type: coarse grained basaltic? volcanic rock similar to sample -4 and -9, relatively fresh, overall fine-grained micro-gabbroic appearance 2. Size: 32x18cm 3. Shape / Angularity: 4. Color of cut surface: grey to slightly brownish 5. Texture / Vesicularity: dense 6. Phenocrysts: Fsp up to 3mm, white clear fresh and altererd yellowish needles; Px? 1mm 7. Matrix: crystalline 8. Secondary Minerals: bright red to cream Fe-oxides, crack fillings are made of carbonate 9. Encrustations: 1-2mm Mn crust 10. Comment: Debris, crystallinity resembles an intrusive rock (dike, gabbro?), fine-grained micro-gabbro	1	x	3	no				x	L1		
M81-217-13	1. Rock Type: basaltic volcanic rock similar to sample -10, medium altered 2. Size: 6x8cm 4. Color of cut surface: cream grey 8. Secondary Minerals: Bright red Fe-oxide patches 9. Encrustations: 2mm Mn crust 10. Comment: Insitu, medium grained basalt	1	-	4-5	no		x			H5		

Appendix I (Rock Description)

M81-220
Description of Location and Structure: Northern Part of Beata Ridge; base of the main scrap into the Haiti basin starting at 4200mbsl. Profile 3 on Map.
ROV on bottom UTC 16/03/10 14:25hrs, lat 17°14,88'N, long 71°51,96'W, depth 4146m
ROV off bottom UTC 16/03/10 20:50hrs, lat 17°14,24'N, long 71°50,62'W, depth 2987m
total volume: 4 sediment samples; no basement outcrops
Comments: sediment covered slope, ruptured sediment surface in places by NNW-SSW striking faults with fossil fluid venting sites.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-220-1	1. Rock Type: soft sediment, clay rich mud, partially solidified 2. Size: 40cm3 4. Color of cut surface: brown 10. Comment: Insitu sample taken from first patchy, fossil fluid venting site along one of the presumed fault zones					x	x					
M81-220-2	1. Rock Type: solidified mudstone 2. Size: 50cm3 4. Color of cut surface: light brown 10. Comment: Insitu from layered mud-mound? deposit or bioherm at the very beginning of the profile					x	x					
M81-220-3	1. Rock Type: solidified carbonate mud 2. Size: ca 50cm3 4. Color of cut surface: white with brown patches 10. Comment: Insitu					x	x					
M81-220-4	1. Rock Type: solid carbonate, appears of biological origin with tubes and small 0.5mm sized holes that somehow resemble a coral 2. Size: 150cm3 4. Color of cut surface: brown with white patches 10. Comment: Insitu, this sample is closest to a biological origin. Maybe a fossil fluid venting site.					x	x					

Appendix I (Rock Description)

M81-223

Description of Location and Structure: Beata Ridge Western slope. Main scrap W of Dive 217. Longest profile between 3600 and 1800 mbsl. Profil 2 on map

ROV on bottom UTC 17/03/10 14:03hrs, lat 16°51,61'N, long 72°06,12'W, depth 3442m

ROV off bottom UTC 17/03/10 22:20hrs, lat 16°50,67'N, long 72°05,15'W, depth 2393m

total volume: 13 samples, plutonics, volcanics, lots of volcaniclastic sediment

Comments: Lower part of profile consists of magmatic rocks (gabbros, dikes?, basalts) followed by volcaniclastic sediments with a basalt sample at the end of the profile

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-223-1	1. Rock Type: coarse grained plutonic rock, Fsp rich gabbro, medium altered 2. Size: 16x13x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey-white with orange patches of altered olivine? 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 60% Fsp up to 8mm, a single Fsp megacryst measures 3x2cm; 30% altered olivine or Px, 2-6mm; 10% fresh Px, 2-4mm 8. Secondary Minerals: Fe-Oxyhydroxides replacing Ol-Px; small <1mm spots of Pyrite 9. Encrustations: 1mm Mn crust 10. Comment: Insitu?, coarse grained gabbro occured at the bottom of the profile, however with questionable insitu origin. Has good potential for Fsp age dating	2	x	2	Fsp			x		N2		
M81-223-2	1. Rock Type: coarse grained plutonic rock, medium altered 2. Size: 17x12x11cm 3. Shape / Angularity: subangular 4. Color of cut surface: medium grey with red-black dots of altered Ol-Px 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 50% Px, 5-10mm, difficult to identify on cut surface; 30% Fsp, 3-8mm, brighter than dark Px; 20% altered Ol or Px up to 1cm 8. Secondary Minerals: Fe-Oxyhydroxides replacing Ol or Px. Diseminated mm sized spots of pyrite 9. Encrustations: < 0.5mm Mn crust 10. Comment: Debris, another coarse grained at bottom of slope. Fsp should have good Ar-Ar age dating potential.	1	x	2	Fsp				x	N1		
M81-223-3	1. Rock Type: aphyric to slightly phyric basalt, altered 2. Size: 18x14x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish-brown 5. Texture / Vesicularity: dense, fine crystalline 6. Phenocrysts: 1% Px, 1-2mm, fresh 7. Matrix: fine grained groundmass of Fsp and Px 8. Secondary Minerals: Fe-Oxyhydroxide replacing groundmass, 0.5mm wide cracks dissecting the sample are filled with Mn 9. Encrustations: 1-2mm Mn crust 10. Comment: Insitu, first basalt in section, only groundmass Fsp may have potential for Ar-Ar dating, fine grained basalt	1	x	3			x			N3		

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-223-4	1. Rock Type: monomict breccia 2. Size: 20x18x12cm 3. Shape / Angularity: subangular 4. Color of cut surface: yellow with dark grey clasts 5. Texture / Vesicularity: coarse grained, non-vesicular 6. Clasts: 2-6cm, subangular, plutonics, probably gabbros 7. Matrix: feldspar fragments and fine grained matrix of the same material as the clasts 8. Secondary Minerals: 9. Encrustations: 1mm Mn crust 10. Comment: Insitu, this is the first sediment of the profile upsection, deposit poorly sorted, closely packed, possibly a debris flow deposit	1	x			x	x			M2		
M81-223-5	1. Rock Type: medium grained plutonic, Px-Fsp gabbro, strongly altered 2. Size: 43x17x12cm 3. Shape / Angularity: subangular 4. Color of cut surface: greenish brown 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 70% Px, 5-10mm, extremely mixed with Fsp, diffcult to identify individual crystals, some are gold-bronze reflecting and could be Opx 8. Secondary Minerals: abundant veins cutting the rock are filled with calcite. Overall the rock is strongly altered 9. Encrustations: thin Mn coating 10. Comment: Insitu, Fsp need to be checked by thin section for their dating potential, medium grained gabbro	1	x	3	fsp, px		x			K2		
M81-223-6	1. Rock Type: medium to fine grained plutonic rock, Fsp rich gabbro, strongly altered 2. Size: 19x14x9cm 3. Shape / Angularity: subangular 4. Color of cut surface: greenish 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 50% Fsp, 3-10mm, forms rounded grains but mostly occurs as elongated laths; 50%Px, 3-6mm, intergrown with Fsp, often altered to redish-orange Fe-Oxyhydroxide 7. Matrix: holocrystalline, medium grained 8. Secondary Minerals: pervasively altered 9. Encrustations: 2-3mm Mn crust 10. Comment: Insitu, maybe Fsp ok for dating. The medium grain size indicates shorter cooling times; possibly part of a dike, massive lava flow or subvolcanic intrusion	1	x	3	fsp		x			X1	lying on porch	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-223-7	1. Rock Type: volcanic, fine grained basalt, medium altered 2. Size: 20x12x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish-yellow 5. Texture / Vesicularity: aphyric, dense 7. Matrix: fine grained groundmass consisting of Fsp & Px 8. Secondary Minerals: numereous veins dissect the rock, at vein intersections large areas 1-3cm of groundmass replacement by Fe-Oxhydroxide and Mn form. Veins are filled with calcite and and Mn 9. Encrustations: thin Mn coating 10. Comment: Insitu likely; second basalt in profile, groundmass Fsp may have potential for dating, fine grained basalt	1	x	3	gm-fsp		x			D2		
M81-223-8	1. Rock Type: tuff with accretionary lapilli 2. Size: 16x13x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark red 5. Texture / Vesicularity: fine grained, graded sequence 6. Phenocrysts: <1% rounded black minerals Px?, and shiny metallic crystals of oxides? 7. Matrix: very fine grained ash, individual particles not visible 9. Encrustations: 8mm calcite vein attched on one side of the sample 10. Comment:: Debris. Rock colour and presence of accretionary lapilli suggest subaerial origin of the tuff. Chemistry slab taken for reconaissance	1	x			x			x	F2	1xTS: EMAU	
M81-223-9	1. Rock Type: inhomogeneous tuff with gastropods 2. Size: 17x11x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark red with white cement 5. Texture / Vesicularity: ~0.5mm, subangular dark red particles, distributed in cm-sized domains variably closely packed and matrix-rich to floating in cement. 6. Phenocrysts: occasional Px?-crystals, 3-4mm, fresh 7. Matrix: very fine dark red ash, calcite cement 9. Encrustations: thin Mn coating 10. Comment: Debris. Possibly a debris flow reworking partly consolidated deposits; rock containing fresh Px crystals, no phase for Ar-Ar dating detected. Oxidized red particles suggest subaerial origin	1				x			x	F4	1xTS: EMAU	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-223-10	1. Rock Type: tuff very similar to sample 223-9 except for the fossils 2. Size: 44x30x23cm 3. Shape / Angularity: rounded, originally described as pillow in ROV protocol 4. Color of cut surface: dark red with white cement 5. Texture / Vesicularity: variably grain- to matrix-supported 6. Phenocrysts: 5% Px phenocrysts, fresh, 5-10mm 7. Matrix: very fine dark red ash, calcite cement 9. Encrustations: thin Mn coating 10. Comment: Insitu?, Px may be used for geochemistry, saved 3 large chunks. No useful Ar-Ar phases detected	4				x		x		H5	Observer 1 Piece 1xTS: EMAU	
M81-223-11	1. Rock Type: turbidite with nice grain size gradation 2. Size: 21x13x14cm 3. Shape / Angularity: subrounded 4. Color of cut surface: olive green to dark grey 5. Texture / Vesicularity: very good grainsize gradation from mm sized to fine grained material with internal layering, turbidite sequences Ta, b, c. Clasts: angular to subangular, highly irregularly shaped in the coarse grained part , greenish particles are non- to poorly vesicular altered glassy fragments, red particles are oxidized microvesicular ?basaltic particles 6. Phenocrysts: very minor Fsp crystals, altered, 5-10mm 7. Matrix: mostly grain supported with some white calcite inbetween 9. Encrustations: 2-3mm Mn crust 10. Comment: Debris. Turbidite sequence indicates reworking processes of volcanic material along the Western slope of the Beata Ridge. Was the Beata ridge once subaerial?	1				x			x	M1	Observer 1 Piece 1xTS: EMAU	
M81-223-12	1. Rock Type: turbidite similar to sample -11 2. Size: 15x10x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark red to brownish green 5. Texture / Vesicularity: three individual grain horizons, the upper and lower are moderately closely packed particles with a calcite cement. The middle horizon is clast supported and consists of green and red grains (1-2mm) that are elongated parallel to bedding. Bedding irregularities suggest soft sediment deformation. 7. Matrix: calcite cement in some horizons 9. Encrustations: 1-2mm Mn crust 10. Comment: Debris. Turbidite deposit similar to sample -10 with more coarse grained layers					x			x	B4	1xTS: EMAU	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-223-13	1. Rock Type: aphyric basalt, strongly altered 2. Size: 24x12x1cm Piece1; 8x6x5cm Piece2 3. Shape / Angularity: subrounded to pillow shaped 4. Color of cut surface: grey to orange oxidized 5. Texture / Vesicularity: aphyric, dense 7. Matrix: Fsp-Px groundmass, fine grained 8. Secondary Minerals: strongly altered groundmass by Fe-Oxyhydroxide replacement 9. Encrustations: 3mm Mn crust 10. Comment: Insitu; first volcanic rock after sequence of sediments lower in the section. Fairly altered, requires careful thin section inspection, Ar-Ar dating if at all possible only on groundmass Fsp, fine grained basalt	1	x	4	Fsp gm		x			L2		

M81-226

Description of Location and Structure: Beata Ridge; Continuation of Profile M81-220; Western slope of main Beata Ridge, upper section 2500 - 1875 mbsl

ROV on bottom UTC 18/03/10 14:53hrs, lat 16°50,72'N, long 71°05,28'W, depth 2875m

ROV off bottom UTC 18/03/10 21:54hrs, lat 16°50,03'N, long 71°04,71'W, depth 2472m

total volume: 4 samples

Comments: sediment; mostly carbonate, sample 1 could be volcaniclastic

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-226-1	1. Rock Type: solidified mudstone with mm to sub mm sized clasts / grains 2. Size: 19x20x11cm 3. Shape / Angularity: angular with fresh broken surfaces 4. Color of cut surface: medium brown when dry 5. Texture / Vesicularity: dense 6. Grains / Clasts: 5-10%, 0.2-1mm rounded to angular mineral? grains. Grains are white to light brown and could be Fsp or Qz 7. Matrix: very fine grained mud-like material 9. Encrustations: thin <0.2mm Mn coating 10. Comment: Insitu, clastic sediment, volcaniclastic origin appears unlikely	2				x	x			N2	Observer 1 Piece	
M81-226-2	1. Rock Type: altered massive carbonate 2. Size: 25x15x15cm 3. Shape / Angularity: subrounded 4. Color of cut surface: white where unaltered, grey where altered by dendritic Mn, yellow where alteration halo develops along the outer rims 5. Texture / Vesicularity: dense, looks like smaller, cm sized carbonate junks were put together to form this rock 8. Secondary Minerals: abundant dentritic Mn 9. Encrustations: thin Mn coating 10. Comment: Debris, first carbonate within profile	1				x			x	M2	Observer 1 Piece	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-226-3	1. Rock Type: similar to sample -2 but less altered 2. Size: 38x17x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: white in core, grey at the edges 8. Secondary Minerals: Mn dendrites along outer 1cm wide rim 9. Encrustations: 5cm Mn crust on one side of sample with holes 10. Comment: Insitu	1				x	x			K2		
M81-226-4	1. Rock Type: similar to sample -2 & -3 2. Size: 14x8x3cm 10. Comment: Debris?, contains tubes from biological activities	1				x			x	F2		

M81-229

Description of Location and Structure: Beata Ridge, West facing slope South of prev. Profile; 4200-2500mbsl

ROV on bottom UTC 19/03/10 13:56hrs, lat 16°06,88'N, long 72°51,21'W, depth 4201m

ROV off bottom UTC 20/03/10 01:24hrs, lat 16°04,12'N, long 72°50,42'W, depth 2533m

total volume: 20 samples plus 1 sample (X4) fell on portside porch at unknown location

Comments: Dive collected gabbros, aphyric basalt, Ol-Px phyric basalts, some appear picritic, along with volcaniclastics and tuffs in the lower section

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-229-1	1. Rock Type: coarse grained plutonic, Px-Fsp gabbro, strongly altered 2. Size: 36x14x15cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish-brown 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 60% Fsp, 5-20mm, medium altered; 25% Px, 5-15mm, altered; 15% Ol, 5-10mm, altered 8. Secondary Minerals: occasional spots of pyrite 9. Encrustations: 1cm Mn crust 10. Comment: Insitu, coarse grained gabbro, Fsp may work for age dating	2	x	3	Fsp		x			X1	1x TS: Observer	
M81-229-2	1. Rock Type: volcanic rock, dense aphyric basalt, fairly fresh 2. Size: 23x13x16cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey 5. Texture / Vesicularity: aphyric, dense 7. Matrix: fine grained; Fsp-Px 9. Encrustations: 3mm Mn crust 10. Comment: Debris; fine grained basalt, freshest sample in section, check TS to confirm igneous origin	1	x	2	Fsp gm				x	N1	1x TS: Observer	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-229-3	1. Rock Type: volcanic rock, strongly altered, possibly a picrite ?! 2. Size: 12x8x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: redish-brown 5. Texture / Vesicularity: porphyric, dense 6. Phenocrysts: 30% altered Ol, 2-6mm 7. Matrix: fine grained intersertial mixture of Px and Fsp 8. Secondary Minerals: Iddingsite replacing Ol, 5% Calcite fillings of vesicles? 9. Encrustations: 1-2mm Mn crust 10. Comment: Insitu?, Ol-phyric lava, possibly a picrite	2	x	5				x		N3	1x TS: Observer	
M81-229-4	1. Rock Type: volcanic rock, extremely altered, possibly a picrite? 2. Size: 31x11x20cm 3. Shape / Angularity: rounded 4. Color of cut surface: dark grey to brown 5. Texture / Vesicularity: porphyric, 5% vesicles, filled 6. Phenocrysts: 20% altered Ol, 5mm; 20% altered Px, 5mm 7. Matrix: pervasively altered groundmass, impossible to identify minerals 8. Secondary Minerals: Calcite, Mn and Zeolite fillings of vesicles and replacement of phenocrysts and groundmass 9. Encrustations: 3-4cm thick Mn crust 10. Comment: Insitu, not clear whether this is really a volcanic rock, check TS; porphyric lava with high Ol content; possibly a picrite	1	x	6			x			H5	1x TS: Observer	
M81-229-5	1. Rock Type: volcanic rock, vesicular lava, strongly altered 2. Size: 13x12x9cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey to dark brown 5. Texture / Vesicularity: aphyric, 10% vesicles, 5-10mm mostly filled with Mn and minor calcite 6. Phenocrysts: 7. Matrix: fine grained, Fsp-Px 8. Secondary Minerals: Mn, Calcite filling vesicles 9. Encrustations: 3mm Mn crust 10. Comment: Insitu?, fine grained vesicular basalt	2	x	5				x		F2	1x TS: Observer	

Appendix I (Rock Description)

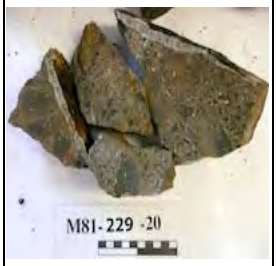
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-229-6	1. Rock Type: heterogeneous tuff 2. Size: 22x21x15cm 3. Shape / Angularity: roundish 4. Color of cut surface: grey-greenish 5. Texture / Vesicularity: homogeneous, massive, clast vesicularity ranges from dark clasts = non-vesicular to 2%; to light-cream clasts ~10%, filled with secondary minerals 6. Phenocrysts: dark clasts aphanitic & glassy (altered); cream clasts aphanitic 7. Matrix: very fine grained, non-carbonaceous, greenish colored 8. Secondary Minerals: Fe-Mn mineral overgrowth 9. Encrustations: < 1mm Mn crust 10. Comment: Debris; moderately well sorted, matrix supported tuff, dark clasts possibly basaltic, cream colored clasts possibly of more evolved composition. Chemistry slab taken for reconaissance	1	x			x			x	L2	1x TS: Observer 1x TS: EMAU	
M81-229-7	1. Rock Type: heterogeneous fine lapilli tuff 2. Size: 25x17x16cm 3. Shape / Angularity: roundish boulder 4. Color of cut surface: brown-grey 5. Texture / Vesicularity: massive, clast vesicularity 0-2% (dark clasts), vesicles lumpy, rarely ~20% 6. Phenocrysts: 7. Matrix: very fine grained matrix and translucent cement 8. Secondary Minerals: dark Fe-Mn minerals along cracks 9. Encrustations: <1mm Mn crust 10. Comment: Insitu; moderately to poorly sorted, matrix supported coarse tuff with 5% fine lapilli. Cream clasts micro-vesicular, possibly more evolved composition, rounded dark clasts very angular & irregular shapes, mostly glassy. Chemistry slab taken for reconaissance	1	x			x	x			N2	1x TS: Observer 1x TS: EMAU	
M81-229-8	1. Rock Type: similar to sample -7 2. Size: 35x21x14cm 10. Comment: Insitu	1				x	x			M2	1x TS: Observer 1x TS: EMAU	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-229-9	1. Rock Type: volcanic rock, Px phyric lava clast within Mn crust, medium altered 2. Size: 10x11x10cm original size, basalt clast is 4x4x3cm 3. Shape / Angularity: rounded clast 4. Color of cut surface: greenish-grey 5. Texture / Vesicularity: porphyric, dense 6. Phenocrysts: 5% Px, 1-3mm 7. Matrix: fine grained 8. Secondary Minerals: Mn in small cracks 9. Encrustations: 4cm thick Mn crust 10. Comment: Insitu, fine grained Px phyric lava clast within Mn crust	1	x	3			x			M1		
M81-229-10	1. Rock Type: heterogeneous fine lapilli tuff, very altered 2. Size: 39x26x13cm 3. Shape / Angularity: subangular 4. Color of cut surface: medium grey - creamy yellowish 5. Texture / Vesicularity: massive 7. Matrix: fine matrix & translucent to white cement crust made of calcite 8. Secondary Minerals: Fe-Mn minerals as patchy overgrowth and in crack fillings 9. Encrustations: <1mm Mn crust 10. Comment: Debris, clast description: (a) mainly micro-vesicular clasts of possible more evolved composition, highly altered yellow, roundish. (b) less common dark grey, non vesicular, possibly mafic clasts, irregular shaped - subangular, 1-2mm. (c) several roundish up to 4mm sized clasts with core in center and a very fine rim - accretionary lapilli? subaerial formation!! Chemistry slab taken for reconaissance	1	x			x			x	X2	1x TS: Observer 1x TS: EMAU	
M81-229-11	1. Rock Type: heterogeneous tuff, similar to sample -10 2. Size: 19x12x7cm 3. Shape / Angularity: roundish 4. Color of cut surface: brownish-yellow 5. Texture / Vesicularity: massive, fine particles faintly aligend 8. Secondary Minerals: Extensive Fe-Mn minaralisation "pretending" layering 10. Comment: Debris; clast decription: (a) same as in sample -10. (b) same as in sample -10, some clasts with highly elongate vesicles "tubes", many splinter shaped	1				x			x	F4	1x TS: Observer 1x TS: EMAU	
M81-229-12	1. Rock Type: volcanic, Ol-Px basalt, altered 2. Size: 18x7x11cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish-brown 5. Texture / Vesicularity: porphyric, dense 6. Phenocrysts: 5% Ol, 1-3mm, altered; 3%Px, 1mm, partially altered 7. Matrix: fine grained, Fsp-Px 8. Secondary Minerals: Iddinsite replacing Ol, few cracks filled with Mn 9. Encrustations: thin Mn coating 10. Comment: Insitu, porphyric Ol-Px basalt	2	x	4			x			F6	1x TS: Observer	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-229-13	1. Rock Type: volcanic, vesicular lava, strongly altered, possibly a picrite 2. Size: 14x12x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: red-brown 5. Texture / Vesicularity: porphyric, 15% vesiclesup to 1cm, filled with calcite and Mn 6. Phenocrysts: 15% Ol, 0.5-3mm, altered 7. Matrix: fine grained, strongly oxidized 8. Secondary Minerals: Calcite and Mn fillings of vugs, groundmass alteration by Fe-Oxyhydroxides 9. Encrustations: 2cm thick Mn crust 10. Comment: Insitu, vesicular lava	2	x	5			x			D6	1x TS: Observer	
M81-229-14	1. Rock Type: plutonic, medium grained gabbro or subvolcanic rock, strongly altered 2. Size: 13x11x9cm 3. Shape / Angularity: rounded 4. Color of cut surface: brownish-grey 5. Texture / Vesicularity: crystalline, dense 6. Phenocrysts: 60% Fsp, 2-6mm, fresh to altered; 30% Px, 1-4mm, altered, 10% Ol, 1-2mm, altered 8. Secondary Minerals: 5-10 mm lithic fragments 9. Encrustations: thin Mn coating 10. Comment: Debris, medium grained intrusive rock with rounded lithic fragments, strongly altered, possibly a picrite	2	x	3					x	B2	1x TS: Observer	
M81-229-15	1. Rock Type: volcanic rock, porphyric Ol-Px lava, medium altered, picrite? 2. Size: 12x10x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: brownish-red 5. Texture / Vesicularity: porphyric, dense 6. Phenocrysts: 25% altered Ol, 0.5-3mm; 5% Px, 1-4mm, partially fresh 7. Matrix: fine grained, intergrowth of Fsp & Px 8. Secondary Minerals: Iddingsite replacing Ol 9. Encrustations: Thin Mn coating	2	x	4					x	B4	1x TS: Observer	
M81-229-16	1. Rock Type: volcanic rock, porphyric Ol-Px lava, medium altered 2. Size: 30x12x18cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish-red 5. Texture / Vesicularity: Ol-Px phyric, 5-10% vesicles, 3-20mm filled with calcite and Mn 6. Phenocrysts: 15% Ol-Px phenocrysts that often occur as intergrown clusters, 0.5-3mm, Ol altered, Px partially fresh 7. Matrix: fine grained, Fsp-Px intergrown 8. Secondary Minerals: iddinsite replacing Ol, vesicle fillings see 5. 9. Encrustations: 3-5cm thick Mn crust 10. Comment: Insitu?, similar to sample -13 & -14	1	x	4				x		L1	1x TS: Observer	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-229-17	1. Rock Type: Mn encrusted basalt? clast, strongly to medium altered 2. Size: 9x6x8cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish brown 5. Texture / Vesicularity: aphyric, dense 7. Matrix: fine grained 8. Secondary Minerals: groundmass oxidation; abundant Mn spots 9. Encrustations: 1-2cm Mn crust 10. Comment: Insitu, not clear whether this is really lava	x	x	4			x			D4		
M81-229-18	1. Rock Type: volcanic, very strongly altered lava clast 2. Size: 8x4x5cm 3. Shape / Angularity: subrounded 4. Color of cut surface: greyish-green 5. Texture / Vesicularity: aphyric 7. Matrix: coarse grained, totally altered to green-brown 9. Encrustations: 1cm Mn crust 10. Comment: Insitu, coarse grained lava, extremely altered, Mn encrusted clast most likely comes from a tallus deposit and is not from a lava flow within the stratigraphy	2	x	6			x			H4	1x TS: Observer	
M81-229-19	1. Rock Type: volcanic, Fsp-phyric lava, medium altered 2. Size: 17x12x10cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey to brown 5. Texture / Vesicularity: slightly phyric, dense 6. Phenocrysts: 2% Fsp clusters, 1-3mm, appear altered 7. Matrix: medium grained with abundant altered Ol microphenocrsts and Px-Fsp 8. Secondary Minerals: Iddingsite replacing Ol 9. Encrustations: thin Mn coating 10. Comment: Insitu, medium grained, slightly Fsp phyric, dense lava	2	x	3	Fsp		x			K1	1x TS: Observer	
M81-229-20	1. Rock Type: basaltic lapilli breccia 2. Size: 42x26x24cm 3. Shape / Angularity: irregular, subangular 4. Color of cut surface: yellowish-grey 5. Texture / Vesicularity massive: 6. Phenocrysts: very fine Fsp needles, altered; rare 3mm dark mica 7. Matrix: cement, translucent clear, zeolites? 9. Encrustations: <1mm Mn crust 10. Comment: Debris, monomict lava (top?) breccia, poorly sorted, clast supported, clasts ranging from altered to microcrystalline	1		2	Bi				x	X3	1x TS: Observer 1x TS: EMAU	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	INSITU	INSITU?	DEBRIS	ROV Box No	NOTES	PICTURE
M81-229-21	1. Rock Type: volcanic, Ol-Px phyric lava, strongly altered 2. Size: 14x12x8cm 3. Shape / Angularity: angular 4. Color of cut surface: dark grey to slightly orange 5. Texture / Vesicularity: Ol-Px phyric, dense 6. Phenocrysts: 10%Px, 3-10mm, mostly fresh; 5-8% Ol, altered, <2mm 7. Matrix: medium grained, Fsp-Px 8. Secondary Minerals: Iddingsite replacing Ol, Fe-Oxyhydroxides along cracks 9. Encrustations: thin Mn coating 10. Comment: Debris; Sample was lying on porch and probably fell into it during sampling at an unknown location, check dive video	1	x	4					x	X4	1x TS: Observer	

M81-234
Description of Location and Structure: Beata Ridge southern section, westernmost ridge
Dredge on bottom UTC 10/04/10 16:30hrs, lat 14°16,71'N, long 77°26,65'W, depth 2866m
Dredge off bottom UTC 10/04/10 19:11hrs, lat 14°17,22'N, long 77°26,58'W, depth 2457m
total volume: 1/6 full
Comments: rounded to subangular basalt clasts and basaltic breccias, one piece of carbonate

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-234-1	1. Rock Type: microgabbro 2. Size: 21x15x4cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: holocrystalline, non vesicular, equigranular 6. Phenocrysts: 20% Fsp up to 4mm, translucent fresh and only marginally altered 7. Matrix: very little, light grey interstitial substance 9. Encrustations: Mn crust 10. Comment: subvolcanic or intrusive mafic rock, possibly good for geochemistry and dating	1	x	2								
M81-234-2	1. Rock Type: well crystallized basaltic rock 2. Size: 20x12x7cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey to slightly brownish 5. Texture / Vesicularity: crystalline, non-vesicular 6. Phenocrysts: 10% Fsp needles, fresh to reddish altered up to 2mm length, Px equant crstals <1mm, ~5% second generation Fsp equant <1mm, altered cream 7. Matrix: translucent patches 8. Secondary Minerals: Fe-OH minerals along cracks 9. Encrustations: 1mm Mn crust 10. Comment: Massive mafic lava or perhaps subvolcanic rock (dike). Alteration of Fsp irregularly distributed, careful search shows fresh material.	1	x	3								
M81-234-3	1. Rock Type: basaltic rock very similar to sample -2 2. Size: 13x11x8cm 6. Phenocrysts:10% Fsp needles fresh to altered reddish, up to 2mm; 10% Px equant, <1mm, ~5% rectangular Fsp, fresh to altered cream, <1mm 8. Secondary Minerals: uneven Mn crust of 1mm to 1cm thickness 10. Comment: see sample -2	1	x	3								
M81-234-4	1. Rock Type: massive crystalline basaltic rock similarto sample -2 & -3 2. Size: 18x10x5cm 4. Color of cut surface: brownish-grey 6. Phenocrysts: ~20% Fsp, short needles, 1mm and rectangular crystals, fresh and altered brown-reddish; 5% equant Px 9. Encrustations: 1-2mm Mn crust 10. Comment: more altered rock with few fresh Fsp for dating, lava or dike/subvolcanic	1	x	4								

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-234-5	1. Rock Type: slightly fine crystalline basaltic rock, similar to sample -4 2. Size: 8x8x6cm 3. Shape / Angularity: subangular, irregular sample 4. Color of cut surface: brown-greyish 5. Texture / Vesicularity: crystallin, massive, non-vesicular 6. Phenocrysts: 20-25 Fsp needles <1mm, fresh and altered cream ; ~10% Px <1mm irregularly distributed 7. Matrix: translucent patches 8. Secondary Minerals: Fe-OH minerals along cracks 9. Encrustations: Mn crust 1-2mm 10. Comment: pervasively altered basaltic lava	1	x	4-5								
M81-234-6	1. Rock Type: fine crystalline basalt similar to sample -5 2. Size: 16x8x7cm 10. Comment: alteration irregularly distributed, some areas with partly fresh Fsp with potential for dating	1		4-5								
M81-234-7	1. Rock Type: similar to samples -5 & -6 2. Size: 16x9x5cm 7. Matrix: 20-25% Fsp altered, Px marginally altered to a reddish phase, centers fresh 8. Secondary Minerals: abundant Fe-OH minerals 9. Encrustations: Mn cfrust <1mm 10. Comment: worst sample of the igneous suite	1		5								
M81-234-8S	1. Rock Type: sediment, bedded, silicified claystone, notice HCl reaction 2. Size: 40x30x20cm 3. Shape / Angularity: angular piece of beds 4. Color of cut surface: yellowish brownish red 5. Texture / Vesicularity: 4cm thick beddings. Broken beds with younger sedimentary infills, neptunian dikes cm thick, cm thick volcanic mircobreccia beds 10. Comment: condensed section including early lithification, fraturing (tectonics?) and infill, several phases, last sediment poorly cemented.											
M81-234-8Sa	1. Rock Type: block from sample 8S for sedimentology 2. Size: 22x20x30cm						x					

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-234-8Sb	1. Rock Type: block with Neptunian dikes	x					x				2TS: POB	
M81-234-8Sc	1. Rock Type: orange brown bed with microbreccia	x					x				1TS: POB 1TS: EMAU 1HS: EMAU	
M81-234-9S	1. Rock Type: sediment, hard limestone 2. Size: 30x30x30cm 3. Shape / Angularity: angular 4. Color of cut surface: white, with dark brown Mn dendrites from surface inwards 10. Comment: pelagic limestone with microfossils?	x					x				1TS: EMAU 1TS: POB	
M81-234-10S	1. Rock Type: sediment, soft, silicic claystone 2. Size: 5x5x5cm 3. Shape / Angularity: rounded by dredging 4. Color of cut surface: brownish-orange, with microfossils?	x									1TS: EMAU 1TS: POB	
M81-234-11S	1. Rock Type: pelagic stromatolite limestone 2. Size: 7x5x4cm 3. Shape / Angularity: rounded, abraded by dredging 4. Color of cut surface: brownish-pink, microfossils 10. Comment: probably microbially induced pelagic stromatolites, rich in nannofossils?	x									2TS: EMAU 2TS: POB	
M81-234-12S	1. Rock Type: sediment, siliceous claystone, no HCl reaction 2. Size: 5x5x5cm 3. Shape / Angularity: angular 4. Color of cut surface: orange-brown 10. Comment: pelagic sediment, microfossils?	x									1TS: EMAU 1TS: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-234-13S	1. Rock Type: sediment, siliceous claystone with Mn crust 2. Size: 5x5x4cm 3. Shape / Angularity: rounded 4. Color of cut surface: orange brown 10. Comment: lithified sediment pebble encrusted with Mn on seafloor	x									1TS: POB	
M81-234-14S	1. Rock Type: sediment, siliceous claystone 2. Size: 4x4x4cm 3. Shape / Angularity: rounded 4. Color of cut surface: orange brown 10. Comment: like sample -13S	x									1TS: EMAU 1TS: POB	
M81-234-15S M81-234-16S M81-234-17S M81-234-18S M81-234-19S	1. Rock Type: sediment, siliceous claystone 2. Size: 5x5x5cm 3. Shape / Angularity: angular 4. Color of cut surface: orange-brown to greenish: 10. Comment: silicic pelagic sediment, often encrusted	x									15S: 1TS to EMAU & POB 17S: 1TS_POB 18S: 1TS_POB	
M81-234-20S	1. Rock Type: sediment, siliceous claystone 2. Size: 4x5x5cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish-brown	x									1TS: POB	
M81-234-21S	1. Rock Type: sediment, siliceous claystone with Mn crust 2. Size: 6x6x4cm 3. Shape / Angularity: angular 4. Color of cut surface: yellow-grey	x									1TS: POB	
M81-234-22S	1. Rock Type: similar to sample -21S	x									1TS: POB	
M81-234-23S	1. Rock Type: sediment, basalt breccia with pink matrix 2. Size: 5x7x7cm 3. Shape / Angularity: angular 4. Color of cut surface: reddish-pink matrix, dark green basalt / gabbroic clasts, angular. Igneous rocks are similar to igneous samples -1 to -7 10. Comment: age of sediment matrix could provide info on age of erosion	x									1TS: EMAU 1TS: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-234-24S M81-234-25S	1. Rock Type: sediment, Mn nodules 2. Size: 10x10x5cm 3. Shape / Angularity: round, grown as such 4. Color of cut surface: dark brown to black	x									25S: TS_EMAU	

M81-237

Description of Location and Structure: Hess Escarpment East; Dredge Detail 2.2; SE facing slope, deepest section along slope with a little nose-like protruison

Dredge on bottom UTC 02/04/10 16:26hrs, lat 15°54,04'N, long 74°16,10'W, depth 4166m

Dredge off bottom UTC 02/04/10 18:10hrs, lat 15°54,51'N, long 74°15,95'W, depth 3808m

total volume: 14 samples

Comments: basaltic igneous rock

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-237-1	1. Rock Type: volcanic rock, weakly to medium altered 2. Size: 27x24x19cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: dark grey 5. Texture / Vesicularity: coarse grained, dense 6. Phenocrysts: porphyric, 5-10% Fsp, 2-8mm, fairly fresh, 3% Px, 5-10mm, <1% fresh? Ol, <3mm 7. Matrix: coarse grained groundmass, Px-Fsp 8. Secondary Minerals: slight groundmass oxidation 9. Encrustations: very thin Mn coating 10. Comment: coarse grained basalt with Fsp-Px phenocrysts, Fsp phenos and from groundmass should be for Ar-Ar dating	2	x	2	Fsp Px							
M81-237-2	1. Rock Type: volcanic rock, similar to sample -1 with alteration halo 2. Size: 17x10x8cm	2	x	3	Fsp							

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-237-3	1. Rock Type: similar to sample -1 with alteration halo 2. Size: 9x8x6cm	1		3							WL: 1TS	
M81-237-4	1. Rock Type: volcanic rock, medium grained, aphyric basalt 2. Size: 21x8x9cm 3. Shape / Angularity: rounded 4. Color of cut surface: leight greyish-brown 5. Texture / Vesicularity: aphyric, dense 7. Matrix: medium grained groundmass of Fsp and Px 8. Secondary Minerals: grondmass oxidized, Mn filling of vein 9. Encrustations: none 10. Comment: medium to fine grained basalt, groundmass Fsp may have dating potential	1	x	3								
M81-237-5	1. Rock Type: similar to sample -1 2. Size: 9x7x5cm	1		3								
M81-237-6	1. Rock Type: volcanic rock, medium altered, Fsp porphyric, similar to sample -1 2. Size: 30x26x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: light grey to orange red where oxidized 5. Texture / Vesicularity: porphyric; <1% vesicles, filled with Mn 6. Phenocrysts: 10% Fsp, 5-10mm, fresh 7. Matrix: fine grained matrix, Fsp-Px, partially oxidized to red 8. Secondary Minerals: Fe-OH minerals replacing groundmass 10. Comment: Fsp porphyric lava with good Ar-Ar dating potential	2	x	2	Fsp						WL: 1TS	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-237-7	1. Rock Type: slightly phyric volcanic rock, medium altered 2. Size: 21x19x25cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish-brown 5. Texture / Vesicularity: slightly phyric, dense 6. Phenocrysts: 1-2% Px?, 3-4mm, fresh 7. Matrix: fine to medium grained Fsp-Px 8. Secondary Minerals: minor Mn filling of vugs 10. Comment: fine to medium grained basalt, groundmass Fsp for dating	2	x	2-3							WL: 1TS	
M81-237-8	1. Rock Type: Fsp phyric basalt, fairly fresh 2. Size: 27x17x14cm 3. Shape / Angularity: subangular 4. Color of cut surface: light grey 5. Texture / Vesicularity: porphyric, dense 6. Phenocrysts: 5-10% Fsp, 5-20mm, mostly fresh 7. Matrix: fine grained 8. Secondary Minerals: Mn filling along cracks 10. Comment: Fsp phyric basalt with fine grained groundmass. Fsp phenos have good age dating potential	2	x	2	Fsp							
M81-237-9	1. Rock Type: similar to sample -8, medium to strongly altered 2. Size: 19x12x9cm 3. Shape / Angularity: subangular 6. Phenocrysts: 10-15% Fsp, 5-10mm, altered 10. Comment: similar to sample -8 but Fsp phenocrysts are more altered, 3x4 cm sized red xenolith	2	x	3-4	Fsp							
M81-237-10	1. Rock Type: volcanic rock similar to sample -9 2. Size: 17x9x6cm 3. Shape / Angularity: rounded	2		4							WL: 1TS	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-237-11	1. Rock Type: Fsp phyric volcanic, similar to sample -9 2. Size: 17x10x6cm 3. Shape / Angularity: rounded	2		4								
M81-237-12	1. Rock Type: Fsp phyric volcanic rock, medium altered 2. Size: 15x9x7cm 3. Shape / Angularity: rounded 6. Phenocrysts: 3-4% elongated & angular Fsp, 5-10mm 10. Comment: similar to sample -6, but less Fsp phyric	2		2	Fsp							
M81-237-13	1. Rock Type: aphyric basalt, fairly fresh 2. Size: 25x19x12cm 3. Shape / Angularity: rounded 4. Color of cut surface: dark grey 5. Texture / Vesicularity: aphyric dense 7. Matrix: fine grained 8. Secondary Minerals: Mn filled veins 9. Encrustations: slight Mn coating 10. Comment: very fine grained aphyric basalt, only sample of that kind in this dredge	2	x	2	Fsp gm						WL: 1TS	
M81-237-14	1. Rock Type: porphyric volcanic, medium altered 2. Size: 8x7x7cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: light grey 5. Texture / Vesicularity: porphyric, 5% vesicles <2mm often filled with Mn 6. Phenocrysts: 5-10% Fsp, 5-10mm, fresh; 5% Px, 5-10mm, fresh 7. Matrix: very fine grained 8. Secondary Minerals: Mn fillings, some oxidation of groundmass 10. Comment: only somewhat vesicular basalt in this dredge, otherwise similar to other Fsp phyric basalts	1		3							WL: 1TS	

M81-Station
238
Description of Location and Structure: Hess Escarpment, Dredge Detail 1.1; NNW facing slope of large structure, deep section of slope
Dredge on bottom UTC 02/04/10 21:43hrs, lat 15°52,60'N, long 74°24,65'W, depth 3998m
Dredge off bottom UTC 03/04/10 00:06hrs, lat 15°52,40'N, long 74°24,26'W, depth 3665m
total volume: 2 small rock pebbles
Comments: 1xbasalt, 1x carbonate

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-238-1	1. Rock Type: volcanic rock medium altered 2. Size: 4x3x2cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark grey 5. Texture / Vesicularity: slightly phyric, dense 6. Phenocrysts: 1-2%Fsp, 1-3mm, medium fresh 7. Matrix: fine grained needle shape Fsp intergrown with Px 8. Secondary Minerals: Mn filled veins < 1mm 9. Encrustations: thin Mn coating 10. Comment: slightly Fsp phyric basalt, fine to medium grained	1	1	3								NO PICTURE
M81-238-2S	1. Rock Type: sediment, pelagic limestone 2. Size: 5x4x4cm 3. Shape / Angularity: subangular 4. Color of cut surface: light cream 5. Texture / Vesicularity: fine grained, no bedding visible, some irregular contacts resemble compaction structures 6. Fossils: may contain lower Upper Cretaceous Globutruncanides 10. Comment: check sediment facies and biostratigraphic age	1					x		POB		1TS: EMAU	NO PICTURE

M81-241
Description of Location and Structure: Hess Escarpment North, Map 1. NW facing slope at NE tip of NE-SW elongated ridge
Dredge on bottom UTC 03/04/10 10:08hrs, lat 16°48,32'N, long 75°38,50'W, depth 1705m
Dredge off bottom UTC 03/04/10 11:28hrs, lat 16°48,10'N, long 75°38,08'W, depth 1111m
total volume: 2/3 full; mostly basaltic pillow and lava fragments, several carbonate sediments
Comments: igneous rocks; very homogeneous selection of fine-crystalline basalt, variably vesicular, pervasive jointing of all samples

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-241-1	1. Rock Type: aphanitic basaltic pillow lava, poorly vesicular 2. Size: 35x20x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, finecrystalline, intersertal; 2% vesicularity, few large vesicles filled with carbonate 6. Phenocrysts: 5% fresh Fsp needles up to 2mm, rectangular stubby Fsp crystals, variably fresh to cream altered, 10-20% Px, 0.5 equant 8. Secondary Minerals: Fe-OH minerals along cracks and calcite veins 9. Encrustations: <1mm Mn crust 10. Comment: alteration ingressing along cracks, requires careful selection of material for geochemistry and Ar-Ar dating	1	x	1-2						A2: several pieces similar to sample -1		

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-241-2	1. Rock Type: basaltic rock similar to sample -1 but more vesicular 2. Size: 28x14x12cm 4. Color of cut surface: grey with white dots 5. Texture / Vesicularity: massive fine crystalline, 5% vesicles filled with cc 10. Comment: alteration features see sample -1. Rock intensely cracked into chunks of ~2cm size	1	x	1-2						A1: several pieces similar to sample -2		
M81-241-3	1. Rock Type: fine crystalline basalt similar to -2 2. Size: 20x18x9cm 4. Color of cut surface: light grey with cream diffuse areas 5. Texture / Vesicularity: massive, micro-vesicular ~5%, vesicles filled with dark brown amorph substance Mn? 6. Phenocrysts: ~5% Fsp needles 1-2mm, fresh; 10-20% Fsp rectangular crystals up to 1mm, translucent to opaque white (altered), very small sized mafic min phase with possibly Px 8. Secondary Minerals: calcite as vein fillings, Fe-OH minerals on Fsp along cracks 9. Encrustations: <1mm Mn crust 10. Comment: alteration see sample 1, pervasive cracking	1	x	2								
M81-241-4	1. Rock Type: very similar to sample -2 but with two different vesicle fillings 2. Size: 19x12x11cm 4. Color of cut surface: grey and light brown cream areas 5. Texture / Vesicularity: micro vesicles with dark amorph filling, larger vesicles filled calcite, overall 5-10% vesicles 8. Secondary Minerals: calcite veins and cracks with Fe-OH minerals 10. Comment: proportion of altered rock exceeds proportion of fresh material	1	1	2-3								
M81-241-5	1. Rock Type: very similar to -2 with two types of vesicle fillings 2. Size: 19x12x11cm 4. Color of cut surface: mostly cream, few areas grey 5. Texture / Vesicularity: see -4 6. Phenocrysts: 10% Fsp rectangular fresh to altered <1mm; Fsp needles, fresh, rare, ~1-2% 8. Secondary Minerals: calcite and Fe-OH minerals in veins and cracks and in vesicles 9. Encrustations: <1mm Mn crust 10. Comment: thoroughly jointed rock, pieces 1-2cm with fresh interiors and altered along margins; very careful sample preparation required	1		2-3								

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-241-6	1. Rock Type: altered basalt 2. Size: 17x13x11cm 4. Color of cut surface: cream very little grey domains 5. Texture / Vesicularity: massive, 5% vesicles filled with calcite 6. Phenocrysts: Fsp needles & rectangular crystals, mostly altered 20%, Px? 8. Secondary Minerals: Calcite and FeOH minerals along veins and cracks 9. Encrustations: <1mm Mn crust											
M81-241-7	1. Rock Type: similar to sample -6 2. Size: 23x12x11cm 4. Color of cut surface: cream and grey areas 10. Comment: very intensely veined and cracked	1		3-4								no picture
M81-241-8	1. Rock Type: micro-vesicular basalt aphanitic 2. Size: 25x12x10cm 4. Color of cut surface: grey and cream domains 5. Texture / Vesicularity: 2% vesicles filled with dark amorphous substance 6. Phenocrysts: see -3 8. Secondary Minerals: Calcite and Fe-OH minerals infilling veins and cracks 9. Encrustations: <1mm Mn crust 10. Comment: very irregular jointed rock, some fresh parts available for geochemistry and dating											
M81-241-9	1. Rock Type: vesicular basalt with Fsp crystals 2. Size: 10x10x9cm 4. Color of cut surface: mostly grey, little cream 5. Texture / Vesicularity: massive, ~2% vesicles filled with calcite = resemble Fsp at first glance 6. Phenocrysts: ~5% Fsp lath clusters of 1-2mm size, crystals clear white, probably fresha and 10% <1mm Fsp 8. Secondary Minerals: Fe-OH vein fillings 9. Encrustations: <1mm Mn crust 10. Comment: very similar rock to all others from this dredge, except for those Fsp clusters	1	x	2-3								
M81-241-10	1. Rock Type: similar to -8 2. Size: 24x11x8cm	1										

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-241-11	1. Rock Type: similar to -8 and -10 2. Size: 12x8x6cm 5. Texture / Vesicularity: vesicle filled with calcite and dark substance											
M81-241-12	1. Rock Type: same as -11 2. Size: 13x11x7cm											
M81-241-13	1. Rock Type: very altered magmatic rock 2. Size: 22x14x13cm 3. Shape / Angularity: subrounded 4. Color of cut surface: cream-brown 5. Texture / Vesicularity: massive, fine-crystalline, non-vesicular 6. Phenocrysts: Fsp rectangular up to 1mm, altered, 20-30% (no needles visible), cream; Px <1mm equant patches, 10%; clear translucent equant patches ~10% rembling Quarz 9. Encrustations: <1mm Mn crust 10. Comment: slightly coarser crystallin than all previous samples, tool altered for geochemistry and Ar-Ar dating, most likely a more evolved rock	1		5								
M81-241-14	1. Rock Type: same as -13 2. Size: 24x12x10cm			5								
M81-241-15S	1. Rock Type: redeposited shallow water calcarenite 2. Size: 15x15x10cm 3. Shape / Angularity: angular, Mn crust 4. Color of cut surface: orange-yellowish brown 10. Comment: shows cm layering, mm sized bioclasts, peloids, red algae, small numulitids	x							IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-241-16S	1. Rock Type: shallow water limestone, micrite 2. Size: 30x20x20cm 3. Shape / Angularity: angular, Mn crust 4. Color of cut surface: yellowish-brown light 10. Comment: dense micrite, small bentic foraminifera	x							IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-17S	1. Rock Type: shallow water limestone 2. Size: 20x20x10cm 3. Shape / Angularity: angular, clean 4. Color of cut surface: light reddish brown 10. Comment: mosuse-red algal packstone, many bivalves dissolved, secondary porosity	x							IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-18S	1. Rock Type: shallow water limestone 2. Size: 30x20x10cm 3. Shape / Angularity: angular, thin Mn crust 4. Color of cut surface: light yellow brown 10. Comment: gastropod-rich packstone, secondary porosity due to dissolution of aragonite, small forams	x							IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-19S	1. Rock Type: shallow water limestone 2. Size: 20x20x10cm 3. Shape / Angularity: angular, flat Mn crust 4. Color of cut surface: light yellowish-red 10. Comment: red algae, poritid corals, cm sized tubiform shells - rudictids? small forams, packstone	x							IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-20S	1. Rock Type: shallow water limestone 2. Size: 8x4x4cm 3. Shape / Angularity: rounded 4. Color of cut surface: light orange - red 10. Comment: cm sized poritid corals, mostly in micrite; fore reef or back reef facies	x							IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-241-21S, -22S	1. Rock Type: limestone micrite 2. Size: 3x4x4cm, two pieces 3. Shape / Angularity: round 4. Color of cut surface: reddish-pink 10. Comment: backreef lagoon facies	x									2xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-23S	1. Rock Type: angular basalt breccia in pink carbonate matrix 2. Size: 15x10x5cm 3. Shape / Angularity: angular clast 4. Color of cut surface: dark green, light pink to red matrix 10. Comment: slope breccia in fossiliferous limestone matrix, looks like shallow water deposit	x							IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-24S	1. Rock Type: sparse basalt breccia in limestone 2. Size: 15x5x5cm 3. Shape / Angularity: angular to subrounded 4. Color of cut surface: light pink, Mn dendrites 10. Comment: Mn impregnated fossils in matrix; deeper water	x							IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-25S	1. Rock Type: basalt-conglomerate, pink limestone matrix 2. Size: 10x5x5cm 3. Shape / Angularity: angular 4. Color of cut surface: dark green, pink matrix 10. Comment: clearly rounded pebbles of β, probably coastal deposit	x							IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-26S	1. Rock Type: basalt-breccia in reddish matrix 2. Size: 4x4x4cm 3. Shape / Angularity: angular 4. Color of cut surface: dark green -reddish matrix 10. Comment: variable degree of rounding and intensive slope, some coastal matrial	x							IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-27S	1. Rock Type: sparse shallow water breccia 2. Size: 10x6x6cm 3. Shape / Angularity: rounded, Mn crust, dissolution of aragonite 4. Color of cut surface: light yellowish brown 10. Comment: shallow water moluscs, partly dissolved (below CCD?); offshore slope breccia	x							IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-241-28S	1. Rock Type: β-breccia in Mn stained limestone 2. Size: 10x8x4cm 3. Shape / Angularity: angular 4. Color of cut surface: dark green & light pink limestone, Mn impregnated	x									1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-29S	1. Rock Type: pelagic limestone microbreccia 2. Size: 5x4x2cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey 10. Comment: small angular volcanic clasts in limestone matrix	x							IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-30S	1. Rock Type: limestone micrite 2. Size: 10x10x5cm 3. Shape / Angularity: angular, Mn coating 4. Color of cut surface: light yellowish brown 10. Comment: micrite with sparse bioclasts								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-31S	1. Rock Type: fine grained shallow water calcarenite 2. Size: 10x6x6cm 3. Shape / Angularity: rounded, etched, dissolution macroporisity 4. Color of cut surface: light yellow brown 10. Comment: cm sized vugs - dissolution of aragonite filled with pelagic sediment										1xTS: POB 1xPC: POB	
M81-241-32S	1. Rock Type: sahllow water calcarenite 2. Size: 4x4x5cm 3. Shape / Angularity: rounded 4. Color of cut surface: light brownish grey 10. Comment: shallow bioclasts, some pelagics								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-33S	1. Rock Type: limestone micrite 2. Size: 10x6x6cm 3. Shape / Angularity: angular clast 4. Color of cut surface: light yellowish brown 10. Comment: micrite with few bioclasts could be a lagoon								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-241-34S	1. Rock Type: calcarenite 2. Size: 5x4x4cm 3. Shape / Angularity: rounded, abraded 4. Color of cut surface: light orange 10. Comment: apparently off-shore, pelagic organisms! reworked β and shallow clasts								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-35S	1. Rock Type: calcarenite 2. Size: 5x4x3cm 3. Shape / Angularity: rounded 4. Color of cut surface: light greenish grey 10. Comment: offshore redeposited, fine grained								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-36S	1. Rock Type: shallow water limestone 2. Size: 4x3x2cm 3. Shape / Angularity: angular clast, Mn coated 4. Color of cut surface: yellow white 10. Comment: fine grained pelletal (fore reef?) limestone								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-37S	1. Rock Type: shallow water limestone 2. Size: 30x20x15cm 3. Shape / Angularity: angular with Mn crust 4. Color of cut surface: yellow-brownish 10. Comment: interlayered brown lithology								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-241-38S	1. Rock Type: altered basalt with sediomentary dikes 2. Size: 12x4x5cm 3. Shape / Angularity: angular 4. Color of cut surface: dark-green brown, dikes pinkish-white 10. Comment: fractured basalt got filled in with red pelagic? sediment								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	

M81-242

Description of Location and Structure: Hess North (Dredge Detail 1); NW slope of northern ridge -"post erosional phase"

Dredge on bottom UTC 03/04/10 13:43hrs, lat 16°46,75'N, long 75°39,75'W, depth 1692m

Dredge off bottom UTC 03/04/10 15:05hrs, lat 16°46,30'N, long 75°39,44'W, depth 1351m

total volume: 1/4 full

Comments: fine crystalline basaltic rocks strongly tectonically sheared and brecciated, mostly altered; few carbonate rocks; fault zone

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-242-1	1. Rock Type: basaltic, tectonically sheared rock, aphanitic, non-vesicular 2. Size: 25x21x9cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey and brownish streaks 5. Texture / Vesicularity: massive non-vesicular, microcrystalline 6. Phenocrysts: Fsp < 1mm, fresh to altered, Px? tiny black specks 8. Secondary Minerals: Fe-OH minerals in veins and streaks 9. Encrustations: 1mm Mn crust 10. Comment: domains of 1-2cm size which appear fresh, most part of rock diffuse irregularly sheared and altered, required careful picking to obtain good material for geochemistry and dating. Tectonic influence of fault zone? Tectonic shearing very diffuse domains to clear cut wispy areas. Generally highly altered but well cemented with calcite. Described rock is interstitial original rock as are all samples	1	x	2-3								
M81-242-2	1. Rock Type: poorly vesicular aphanitic basalt 2. Size: 25x16x11cm 4. Color of cut surface: grey-greenish and reddish 5. Texture / Vesicularity: massive, 2-5% vesicles filled with calcite 6. Phenocrysts: 5% Fsp needles up to 1mm, fresh to altered; 10% Fsp rectangular crystals <1mm, generally fresh; Px? tiny black specks, ubiquitous 8. Secondary Minerals: Fe-OH minerals and calcite 9. Encrustations: 1mm Mn crust 10. Comment: very diffuse shear zones	1	x	2-3								
M81-242-3	1. Rock Type: basaltic micro-breccia, rock similar to -1 2. Size: 23x19x8cm 4. Color of cut surface: grey to cream-beige 5. Texture / Vesicularity: massive, 2% vesicles filled with calcite 10. Comment: monomict, insitu breccia, cataclastic?	1		3								

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-242-4	1. Rock Type: similar to -2 2. Size: 30x13x3cm 3. Shape / Angularity: 4. Color of cut surface: light grey to greenish cream 8. Secondary Minerals: veins up to 1cm of calcite and Fe-OH minerals	1		3							1TS: EMAU	
M81-242-5	1. Rock Type:cataclastic basaltic breccia 2. Size: 26x14x12cm 4. Color of cut surface: dark grey to beige brown 5. Texture / Vesicularity: whole rock <1-5mm basaltic sandgrains, very closely packed in matrix of same material, crudely aligned; 1-2% vesicles filled with calcite 8. Secondary Minerals: calcite filled veins 9. Encrustations: 1mm Mn crust 10. Comment: amazing!	1	x	4								
M81-242-6	1. Rock Type: poorly vesicular basaltic rock similar to -2 2. Size: 12x11x7cm 4. Color of cut surface: grey 5. Texture / Vesicularity: ~2% vesicles <1mm filled with dark substance 8. Secondary Minerals: few calcite filled veins 10. Comment: possibly good for geochemistry and Ar-Ar, but fairly small sample	1		2								
M81-242-7	1. Rock Type: same as -6 2. Size: 10x8x7cm			2								
M81-242-8	1. Rock Type: same as -5 2. Size: 20x15x10cm	1		4								

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-242-9	1. Rock Type: same as -2 2. Size: 20x16x9cm	1		3							1TS: EMAU	
M81-242-10	1. Rock Type: same as -2 2. Size: 25x20x8cm			3								
M81-242-11	1. Rock Type: similar to -5 2. Size: 23x15x9cm 10. Comment: cataclastic areas ~1cm wide very fine shear zones			4							1TS: EMAU	
M81-242-12	1. Rock Type: coarse grained cataclasite similar to -5 2. Size: 22x10x8cm	1		4							1TS: EMAU	
M81-242-13	1. Rock Type: similar to -12 2. Size: 16x10x6cm			4								
M81-242-14	1. Rock Type: basaltic breccia cemented with dark red matrix 2. Size: 21x16x12cm 10. Comment: basalt same as -1, clasts 1-3cm angular closely packed			4								

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-242-15	1. Rock Type: strongly jointed 2cm sheet lava flow with top and bottom of former glass 2. Size: 17x12x8cm 3. Shape / Angularity: grey interior, black margin 5. Texture / Vesicularity: massive, glassy to very fine crystalline, non vesicular 6. Phenocrysts: aphanitic 8. Secondary Minerals: calcite filled cracks, carbonate mud filled vein 10. Comment: glassy crust crumbles off, perhaps fresh glass. No TS for that reason											
M81-242-16S	1. Rock Type: sparse pelagic limestone breccia 2. Size: 10x73cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey 10. Comment: Mn impregnated planktonic foraminifera same lithology as M81-241-24S								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-242-17S	1. Rock Type: shallow water limestone coquina 2. Size: 11x8x4cm 3. Shape / Angularity: angular, Mn crust bored? 4. Color of cut surface: light orange brown 10. Comment: breccia of fossils								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	
M81-242-18S	1. Rock Type: deep water mound structure covered with pelagic sediment 2. Size: 8x7x6cm 3. Shape / Angularity: angular to rounded 4. Color of cut surface: light brown-yellow-white 10. Comment: cemented structure filled and covered with pelagic & benthic foram limestone								IFM-GEOMAR		2xTS: POB 1xTS: EMAU 1xPC: POB	
M81-242-19S	1. Rock Type: volcanic sedimentary breccia 2. Size: 12x7x8cm 3. Shape / Angularity: angular 4. Color of cut surface: dark-greenish brown 10. Comment: angular volcanic breccia with white calcite, fragements - broken veins								IFM-GEOMAR		1xTS: POB 1xTS: EMAU 1xPC: POB	

M81-243

Description of Location and Structure: Hess North; Upper SE slope (up to top) of flat topped structure (post erosional phase), Dredge Detail 2, track 2.3

Dredge on bottom UTC 03/04/10 18:30hrs, lat 16°38,14'N, long 75°43,64'W, depth 1408m

Dredge off bottom UTC 03/04/10 20:17hrs, lat 16°38,72'N, long 75°43,55'W, depth 1000m

1/4 full + big block

Comments: massive manganese only

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-243-1Mn	1. Rock Type: Mn crust 2. Size: 55x45x30cm 3. Shape / Angularity: knobbly surface, sheet-like with large central "bloulder", massive Mn 4. Color of cut surface: black shiny 5. Texture / Vesicularity: layered sheet like to concentric hemispheres 8. Secondary Minerals: white calcite veins and Fe-OH minerals lining cracks 10. Comment: 4 large pieces											

M81-245

Description of Location and Structure: Hess Escarpment North, Dredge Detail 3

Dredge on bottom UTC 03/04/10 23:57hrs, lat 16°22,74'N, long 75°53,14'W, depth 927m

Dredge off bottom UTC 04/04/10 01:04hrs, lat 16°22,84'N, long 75°52,87'W, depth 632m

total volume: 1/4 full

Comments: Mn crusts only

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-245-1	1. Rock Type: Mn crust 4-5cm thick, polished surface											
M81-245-2	1. Rock Type: Mn crust on limestone, 2-3 cm thick											
M81-245-3	1. Rock Type: limestone with onkoides and large foraminifera 10. Comment: boreholes and neptunian dikes filled with pelagic carbonate and forams	x									1xTS: POB 3xTS: EMAU	

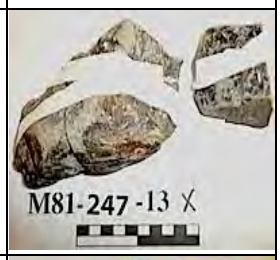
M81-247
Description of Location and Structure: Hess Escarpment North, Dredge Detail 4, Track 4.3
Dredge on bottom UTC 04/04/10 04:06hrs, lat 16°09,06'N, long 75°53,80'W, depth 2402m
Dredge off bottom UTC 04/04/10 05:42hrs, lat 16°09,43'N, long 75°53,47'W, depth 1840m
total volume: 1/4 full
Comments: pillow fragments, 1x intra pillow sediment, 1x small breccia, 4 large pillow fragments

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-247-1	1. Rock Type: volcanic rock, aphyric basalt, fairly fresh 2. Size: 14x10x9 3. Shape / Angularity: subangular 4. Color of cut surface: medium grey 5. Texture / Vesicularity: aphyric, dense 7. Matrix: very fine grained groundmass of Fsp and Px 8. Secondary Minerals: abundant veins disecting the sample with cm wide alteration halos along the cracks. Some veins are filled withe calcite 9. Encrustations: 2-3mm Mn crust in places 10. Comment: aphyric, dense basalt, fresh when veins are avoided	3	x	2	Fsp gm						TS: WL	
M81-247-2	1. Rock Type: volcanic rock similar to -1, but more veins leading stronger overall degree og alteration 2. Size: 24x20x12cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark grey 5. Texture / Vesicularity: aphyric, dense 8. Secondary Minerals: more abundant veins with calcite and Mn fillings og mm sized vugs cause alteration halos 9. Encrustations: thin Mn coating 10. Comment: similar to sample -1	4	x	3							1xTS: WL 1xTS: POB 1xTS: EMAU	
M81-247-3	1. Rock Type: volcanic rock, slightly phyric, medium altered due to cracks 2. Size: 18x12x6cm 3. Shape / Angularity: subangular 4. Color of cut surface: light grey 5. Texture / Vesicularity: slightly phyric, dense 6. Phenocrysts: 2% Fsp roundish, <1mm, vesicle filling; 1% altered Ol microphenocrysts, 1% Px, 1-2mm, fresh 7. Matrix: fine grained Fsp-Px 8. Secondary Minerals: iddingsite replacing Ol, calcite & Mn fillings along veisn 9. Encrustations: thin Mn coating 10. Comment: slightly phyric Px-Ol-Fsp basalt with fine groundmass	3	x	3							1xTS: WL	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-247-4	1. Rock Type: volcanic rock, coarse grained basalt, medium altered 2. Size: 27x25x12cm; three pieces from a larger block 3. Shape / Angularity: subangular 4. Color of cut surface: greenish brown 5. Texture / Vesicularity: coarse grained aphyric, dense 7. Matrix: coarse grained matrix, very dark groundmass, abundant Px? 8. Secondary Minerals: several calcite veins disecting sample 9. Encrustations: thin Mn coating 10. Comment: coarse grained basalt or subvolcanic rock, may contain fresh groundmass Fsp										1xTS: WL	
M81-247-5	1. Rock Type: volcanic rock, massive basalt, medium altered, similar to -4 2. Size: 13x12x8cm 3. Shape / Angularity: subrounded 4. Color of cut surface: light brown 5. Texture / Vesicularity: aphyric dense 7. Matrix: coarse grained Fsp-Px 8. Secondary Minerals: slight groundmass oxidation 9. Encrustations: thin Mn coating in places 10. Comment: similar to sample -4	3	x	2-3	Fsp gm						1xTS: WL	
M81-247-6	1. Rock Type: volcanic rock similar to -4 & -5 2. Size: 15x12x5cm 3. Shape / Angularity: subrounded 4. Color of cut surface: brownish grey	x									1xTS: WL	
M81-247-7	1. Rock Type: volcanic rock, strongly altered 2. Size: 50x40x34cm, two pieces from large single block 3. Shape / Angularity: angular 4. Color of cut surface: brownish 5. Texture / Vesicularity: slightly phyric, 5% vesicles filled with Mn 6. Phenocrysts: 2% Px, 2-3mm, partially fresh, 1% Fsp, 1-2mm altered 7. Matrix: fine grained 8. Secondary Minerals: abundant veins filled with calcite and sediment 9. Encrustations: thin Mn crust 10. Comment: Initially thought that this rock is similar to porphyric sample -8, however this sample has less phenocrysts	4	x	4							1xTS: WL	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-247-8	1. Rock Type: volcanic rock, medium to strongly altered 2. Size: 10x8x7cm 3. Shape / Angularity: subangular 4. Color of cut surface: light brown 5. Texture / Vesicularity: porphyric, 2-3% vesicles filled with Mn 6. Phenocrysts: 3-4% Fsp, 1-3mm altered and partially fresh; 1-2% Px, 1-2mm fresh; <1% Ol altered <0.5mm 7. Matrix: fine grained 8. Secondary Minerals: Mn filling of vesicles, calcite filled veins, groundmass oxidation 9. Encrustations: thin Mn coating 10. Comment: Fsp porphyric rock; appears more evolved than previous basalts	3	x	2	Fsp						1xTS: WL	
M81-247-9	1. Rock Type: porphyric volcanic rock, similar to -8, strongly altered 2. Size: 10x7x6cm 3. Shape / Angularity: subrounded 4. Color of cut surface: reddish brown 5. Texture / Vesicularity: porphyric, 3-5% vesicles filled with Mn 6. Phenocrysts: 3-4% Fsp or Px, 2-5mm, medium altered 7. Matrix: fines grained 8. Secondary Minerals: strong groundmass oxidation 9. Encrustations: thin Mn coating 10. Comment: porphyric basalt, more altered than -8										1xTS: WL	
M81-247-10S	1. Rock Type: fine grained pelagic carbonate 2. Size: 8x8x4cm 3. Shape / Angularity: looks like intrapillow sediment 10. Comment: microfossils may give age of basalts	x									1xTS: POB 1xTS: EMAU	
M81-247-11VC	1. Rock Type: reddish oxidized breccia with subangular clasts <1cm, matrix supported											
M81-247-12X	1. Rock Type: 3 pieces similar to -1 2. Size: 7x7x5cm; 17x10x16cm; 20x12x10cm									x		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-247-13X	1. Rock Type: 2 pieces similar to -2 2. Size: 15x10x5cm; 6x5x3cm									x		
M81-247-14X	1. Rock Type: 1 piece similar to -4 & -5, coarse grained basalt 2. Size: 18x12x12cm									x		
M81-247-15X	1. Rock Type: 2 pieces similar to -8 2. Size: 12x10x9cm; 12x8x6cm									x		

M81-249

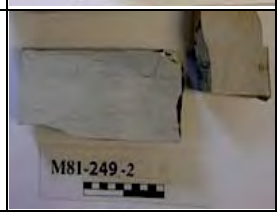
Description of Location and Structure: Hess Escarpment North; Dredge Detail 5, Track 5.1, N of large Smnt; SW facing slope plateau like structure to the North

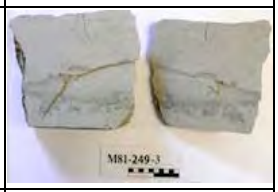
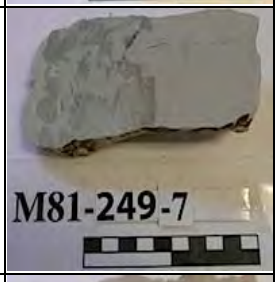
Dredge on bottom UTC 04/04/10 10:38hrs, lat 15°59,42'N, long 75°30,82'W, depth 3159m

Dredge off bottom UTC 04/04/10 11:55hrs, lat 15°59,79'N, long 75°30,38'W, depth 2645m

total volume: 1/4 full

Comments: carbonate rocks exclusively

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-249-1S	1. Rock Type: pelagic clayey limestone 2. Size: 14x12x8cm 3. Shape / Angularity: angular 4. Color of cut surface: light yellowish grey 10. Comment: strongly fractured, fractures cemented	x							IFM-GEOMAR		3xTS: POB 1xTS: EMAU 1xPC: POB	
M81-249-2S	1. Rock Type: similar to -1 2. Size: 48x12x8cm 10. Comment: laminated, mottled, burrowing	x							IFM-GEOMAR		4xTS: POB 2xTS: EMAU 1xPC: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-249-3S	1. Rock Type:similar to -1 2. Size: 23x19x14cm 3. Shape / Angularity: dark grey mottles 10. Comment: bedded, mottled, burrows, nice zoophycus burrows → deep water								IFM-GEOMAR		4xPC: POB	
M81-249-4S	1. Rock Type: idem, strongly fractured 2. Size: 18x8x7cm 3. Shape / Angularity: idem, dark grey mottles 4. Color of cut surface: idem 10. Comment: strong fracturing								IFM-GEOMAR		1xPC: POB	
M81-249-5S	1. Rock Type: idem, strongly fractured 2. Size: 7x9x9cm 3. Shape / Angularity: idem, dark grey mottles 4. Color of cut surface: idem 10. Comment: strong fracturing								IFM-GEOMAR		1xPC: POB	
M81-249-6S	1. Rock Type: identicle to -4 & -5 2. Size: 20x11x9cm								IFM-GEOMAR		1xPC: POB	
M81-249-7S	1. Rock Type: identical nor tectonized 2. Size: 15x7x9cm 3. Shape / Angularity: strong color mottles, dark brown grey								IFM-GEOMAR		4xTS: POB 2xTS: EMAU 1xPC: POB	
M81-249-8S	1. Rock Type: idem 2. Size: 18x24x17cm 10. Comment: burrow mottling, zoophycus								IFM-GEOMAR		6xTS: POB 6xTS: EMAU 2xPC: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-249-9S	1. Rock Type: idem 2. Size: 20x10x8cm								IFM-GEOMAR		1xPC: POB	
M81-249-10S	1. Rock Type: idem 2. Size: 19x9x10cm								IFM-GEOMAR		1xPC: POB	
M81-249-11S	1. Rock Type: idem 2. Size: 13x10x10cm								IFM-GEOMAR		2xTS: POB 1xPC: POB	
M81-249-12S	1. Rock Type: idem 2. Size: 16x7x9cm 10. Comment: strongly fractured								IFM-GEOMAR		1xPC: POB	

M81-251
Description of Location and Structure: Hess North, Eastern Seamount, western flank, SW slope of a small canyon, Track 7.1
Dredge on bottom UTC 04/04/10 18:15hrs, lat 16°09,53'N, long 75°23,67'W, depth 1998m
Dredge off bottom UTC 04/04/10 19:37hrs, lat 16°09,11'N, long 75°23,49'W, depth 1724m
total volume: few rocks
Comments: 1x small basalt, 2 sandstones, 4 carbonates

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-251-1	1. Rock Type: basaltic aphanitic rock 2. Size: 5x6x7cm 3. Shape / Angularity: round 4. Color of cut surface: greyish-cream 5. Texture / Vesicularity: massive, 1-2% micro-vesicles filled with dark substance 6. Phenocrysts: 1-2mm clusters of Fsp crystals, ~5%, appear fresh, up ti 1.5mm long, few black specks possibly Px, ubiquitous 7. Matrix: 8. Secondary Minerals: along rim of sample. Fe-OH min form ~5mm overgrowth 9. Encrustations: irregular ????, up to 5mm Mn crust & carbonate coat 10. Comment: sample to small for geochemistry bloc; dating might be possible	1		3-4								
M81-251-2S	1. Rock Type: pelagic limestone 2. Size: 39x22xcm 3. Shape / Angularity: angular, Mn coating 4. Color of cut surface:light brownish grey 10. Comment: burrow mottled hard limestone; same facies as M81-249 but less clay. Small planctonic foraminifera	x							IFM-GEOMAR		5xTS: POB 5xTS: EMAU 1xPC: POB	
M81-251-3S	1. Rock Type: pelagic limestone 2. Size: 12x6x5cm 3. Shape / Angularity: subrounded 4. Color of cut surface: very light yellow brown 10. Comment: rich in planctonic formaminifera	x							IFM-GEOMAR		2xTS: POB 1xPC: POB	
M81-251-4S	1. Rock Type: pelagic limestone 2. Size: 9x8x7cm 3. Shape / Angularity: rounded, abraded 4. Color of cut surface: light brownish red 5. Texture / Vesicularity: slightly siliceous pelagic limestone with radiolarians? very small forams	x							IFM-GEOMAR		2xTS: POB 1xPC: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-251-5S	1. Rock Type: wellsorted sandstone 2. Size: 10x9x6cm 3. Shape / Angularity: round 4. Color of cut surface: cream-beige 5. Texture / Vesicularity: massive 6. Phenocrysts: clasts possibly basaltic material, small gastropods, calcareous particles of different color, well sorted, rounded, closely packed, rarely outsized limestone clasts 10. Comment: sortimg & rounding indicates possible beach origin	1										
M81-251-6S	1. Rock Type: 2 layers of two types of sandstone 2. Size: 4x6x9cm 3. Shape / Angularity: subrounded 4. Color of cut surface: a) cream light, b) dark brownish grey 5. Texture / Vesicularity: internally massive, two layers with irregular diffuse boundary and a) as 5-10mm clasts within b). 6. Phenocrysts: a) fine grained mostly calcareous material and few black grains. b) slightly coarser grained sand, poss. basalt derived clasts and rare calcareous clasts with fossils (gastropods) 10. Comment: in addition a few 8-10mm serpentine clasts in both layers. soft sediment deformation, remobilisation of partly consolidated sediment	1										
M81-251-7S	1. Rock Type: pelagic limestone 2. Size: 7x5x5cmcm 3. Shape / Angularity: subrounded 4. Color of cut surface: light brownish grey 10. Comment: seem also radiolarian bearing								IFM-GEOMAR		1xTS: POB 1xPC: POB	

M81-253

Description of Location and Structure: Hess North, Dredge Detail 6, Southern Seamount, western slope, small ridge like structure with dredge track directly upslope

Dredge on bottom UTC 04/04/10 23:54hrs, lat 15°49,47'N, long 75°30,71'W, depth 2101m

Dredge off bottom UTC 05/04/10 01:15hrs, lat 15°49,68'N, long 75°30,34'W, depth 1676m

total volume: 1 small pebble

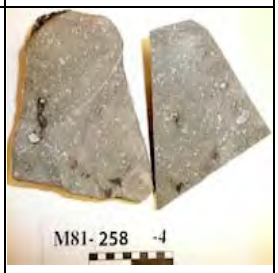
Comments: coarse grained sandstone

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-253-1	1. Rock Type: coarse grained sandstone 2. Size: 12x10x4cm 3. Shape / Angularity: rounded 4. Color of cut surface: dark green 5. Texture / Vesicularity:coarse grained, 0.1-2mm particle size, often quite angular 9. Encrustations: thin Mn coating 10. Comment: semi solidified, could break it manually, check for volcaniclastic origin	3									1xTS: WL	

M81-258
Description of Location and Structure: Hess Escarpment Middle, Dredge Detail 1; Track 1.5; SW flank of large seamount, north facing steep slope of small canyon
Dredge on bottom UTC 07/04/10 22:56hrs, lat 15°09,64'N, long 75°52,29'W, depth 2499m
Dredge off bottom UTC 07/04/10 23:49hrs, lat 15°09,45'N, long 75°52,16'W, depth 2245m
total volume: few rocks
Comments: pillow lava fragments, some embedded in sediment

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-258-1	1. Rock Type: volcanic rock, Px phyric basalt, slightly to medium altered, probably a pillow 2. Size: 19x15x11cm 3. Shape / Angularity: angular 4. Color of cut surface: dark grey, light brown where altered along margins 5. Texture / Vesicularity: porphyric, 3% vesicles, 0.5-1mm filled calcite 6. Phenocrysts: 10% Px, 2-4mm, fresh 7. Matrix: very fine grained, no groundmass minerals visible 8. Secondary Minerals: slight groundmass oxidation 9. Encrustations: 1-2cm light brown sediment attached on one side, could be a fracture fill or intrapillow space. Within this sediment a 2cm chunk of fresh glass visible. Saved togehter with TS 10. Comment: Px phyric basalt with fine grained fresh groundmass. After sawing of multiple cuts the interior looked more complex with a large sediment (clay?) filled fracture between two basalt domains. The second basalt domain is also Px phyric but groundmass is oxidized red	3	x	2	Gl Px						1xTS: WL	
M81-258-2	1. Rock Type: volcanic rock similar to -1, slightly altered 2. Size: 18x12x13 3. Shape / Angularity: angular 4. Color of cut surface: dark to medium grey 5. Texture / Vesicularity: porphyric, dense; 1-2% vesicles <0.5mm filled with calcite 6. Phenocrysts: 5-10% Px, 2-4mm, mostly fresh 7. Matrix: very fine grained 8. Secondary Minerals: Fe-OH minerals along cracks and veins, calcite as well 9. Encrustations: 0.2-0.3mm Mn coating 10. Comment: Px phyric basalt similar to -1	3	x	2-3							1xTS: WL	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-258-3	1. Rock Type: volcanic rock, medium to strongly altered 2. Size: 19x11x9 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey, reddish where oxidized 5. Texture / Vesicularity: porphyric, 2-3% vesicles filled calcite 6. Phenocrysts: 5-10% Px, 2-3mm mosly fresh, 1-2% Ol?, 1-2mm, appear fresh 7. Matrix: very fine grained 8. Secondary Minerals: reddish oxidation halos around sub mm wide cracks. Calcite filling of veins and vesicles, along edge sediment filled veins 9. Encrustations: altered glass margin dissected by small sediment veins 10. Comment: mm-cm wide veins (fractures) filled withe several generations of light grey cements (calcite?), red sediment (oxides) and finally pink pelagic sediment with rare planktonic foraminifera	2	x				x				4x Slab: POB 1x Slab: EMAU 1xTS: WL	
M81-258-4	1. Rock Type: volcanic rock, Fsp phyric vesicular basalt, strongly altered 2. Size: 23x17x16cm 3. Shape / Angularity: angular 4. Color of cut surface: light brown 5. Texture / Vesicularity: porphyric, 5-7% vesicles, 0.5-2mm filled with Mn 6. Phenocrysts: 5-10% Fsp, 1-10mm, fresh and altered 7. Matrix: medium grained Fsp-Px groundmass 8. Secondary Minerals: Mn filling of vesicles, pervasive groundmass oxidation 9. Encrustations: Mn coating 10. Comment: Fsp phyric basalt, this is the second type of basalt in this dredge, appears more evolved than sample -1 to -3	3	x	3	Fsp						1xTS: WL	
M81-258-5	1. Rock Type: volcanic rock similar to -4, very strongly altered, largest piece in dredge 2. Size: 40x30x30cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish-green 5. Texture / Vesicularity: slightly phyric, 15% vesicles, 1-2mm, mostly filled calcite, some with Mn 6. Phenocrysts: 15% Fsp up to 15mm, fresh and altered, somewhat difficult to distinguish from vesicle fillings 7. Matrix: medium to fine grained groundmass 8. Secondary Minerals: Calcite & Mn filling of vesicles 9. Encrustations: thin Mn coating 10. Comment: similar to sample -4											

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-258-6	1. Rock Type: see description #10 of: M81-258-3						x		IFM-GEOMAR		2x Slab: POB 1x Slab: EMAU 1xTS: WL	
M81-258-7	1. Rock Type: see description #10 of: M81-258-3						x		IFM-GEOMAR		4x Slab: POB	
M81-258-8X	1. Rock Type: two pieces similar to sample -4 2. Size: 14x13x11cm; 9x6x6cm									x		
M81-258-9X	1. Rock Type: 1piece similar to sample -1 2. Size: 12x9x6cm									x		
M81-258-10X	1. Rock Type: oxidized chilled pillow margin 2. Size: 8x5x5cm									x		

M81-261

Description of Location and Structure: Hess Escarpment SW, Dredge Detail 3, Track 3.2. East facing slope of main plateau structure. Track is along the southern slope of an E-W striking ridge / nose.

Dredge on bottom UTC 16/03/10 14:25hrs, lat 17°14,88'N, long 71°51,96'W, depth 4146m

Dredge off bottom UTC 16/03/10 20:50hrs, lat 17°14,24'N, long 71°50,62'W, depth 2987m

total volume: few rocks

Comments: rounded to subangular basalt clasts and basalt breccias, one piece of carbonate

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-261-1	1. Rock Type: brecciated basalt, strongly altered, largest intact piece of basalt in dredge 2. Size: 19x16x16cm 3. Shape / Angularity: rounded 4. Color of cut surface: light grey to brownish green 5. Texture / Vesicularity: appears porphyric (Fsp?), but could also be filled / deformed versicles, dense 6. Phenocrysts: Fsp?, 5-10%, 2-20mm, altered 7. Matrix: fine grained 8. Secondary Minerals: abundant sub mm sized veins filled with calcite, pervasive groundmass oxidation 9. Encrustations: Mn coating in places 10. Comment: very strongly altered and deformed piece of basalt.Taken as sample -1 because largest piece in dredge	x	x	4	Fsp ?						1xTS: WL	
M81-262-2	1. Rock Type: Fsp-Px phyric basalt, strongly altered 2. Size: 13x9x10cm 3. Shape / Angularity: subrounded 4. Color of cut surface: brownish-grey to dark green 5. Texture / Vesicularity: porphyric, dense 6. Phenocrysts: 5% Fsp, 2-10mm, partially fresh; 5% Px, 1-3mm, fresh? 7. Matrix: fine grained 8. Secondary Minerals: calcite along veins and cracks, pervasive groundmass oxidation 9. Encrustations: thin Mn crust 10. Comment: somewhat similar to sample -1, except for Px phenocrysts; on one side strongly brecciated	3	x	4	Fsp						1xTS: WL	
M81-261-3	1. Rock Type: medium grained vesicular basalt, strongly altered 2. Size: 11x10x9cm 3. Shape / Angularity: subrounded 4. Color of cut surface: brownish green, 5%, 1-3mm vesicles partiallay open, otherwise filled with black substance, Mn? 5. Texture / Vesicularity: aphyric 7. Matrix: medium grained Fsp-Px 8. Secondary Minerals: pervasive groundmass alteration 9. Encrustations: thin Mn coating 10. Comment: aphyric vesicular basalt, medium grained	4	x	4	Fsp Gm						1xTS: WL	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-261-4	1. Rock Type: aphyric medium grained basalt, stongly altered 2. Size: 17x14x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: greenish-brown 5. Texture / Vesicularity: aphyric, dense with few angular vugs 6. Phenocrysts: 7. Matrix: medium grained 8. Secondary Minerals: 9. Encrustations: thin Mn crust 10. Comment: similar to sample -3 except for absence of vesicles	2	x	4	Fsp Gm						1xTS: WL	
M81-261-5	1. Rock Type: aphyric basalt, fairly fresh 2. Size: 15x7x6cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey 5. Texture / Vesicularity: aphyric, dense 7. Matrix: fine grained 8. Secondary Minerals: Mn filled cracks 9. Encrustations: thin Mn crust 10. Comment: aphyric dense basalt, appears to be the freshest sample of the dredge	1	x	2							1xTS: WL	
M81-261-6	1. Rock Type: coarse grained aphyric basalt, strongly altered due to Mn filling and groundmass replacement 2. Size: 14x10x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: light brown 5. Texture / Vesicularity: aphyric, dense 7. Matrix: coarse grained Fsp-Px 8. Secondary Minerals: pervasive Mn? infiltration and fillings along cracks and vesicles 9. Encrustations: thin Mn coating 10. Comment: coarse grained basalt with suspicious layering, not clear whether primary or secondary by Mn infiltration	3	x	5	Fsp Gm						1xTS: WL	
M81-261-7	1. Rock Type: aphyric vesicular basalt, medium altered, vesicles are unfilled 2. Size: 9x7x6cm 3. Shape / Angularity: rounded 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: aphyric, 5% vesicles, 0.5-1mm unfilled 7. Matrix: fine grained 8. Secondary Minerals: groundmass oxidation along edge of sample 9. Encrustations: Mn patches 10. Comment: aphyric vesicular basalt, fairly fresh sample, good for chemistry but too small to cut slab	3		3							1xTS: WL	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-261-8	1. Rock Type: aphyric vesicular basalt similar to sample -7, medium to strongly altered 2. Size: 8x7x6cm 3. Shape / Angularity: subrounded 4. Color of cut surface: greenish grey 5. Texture / Vesicularity: aphyric, 5-10% vesicles 0.2-2mm, mostly unfilled even when small 7. Matrix: fine grained 8. Secondary Minerals: lining of vesicles with zeolithes 9. Encrustations: Mn patches 10. Comment: similar to sample -7	3		3-4							1xTS: WL	
M81-261-9	1. Rock Type: vesicular basalt, very strongly altered 2. Size: 9x9x5cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey where fresh, green brown where altered 5. Texture / Vesicularity: vesicular, 5%, 0.2-1mm filled with calcite 7. Matrix: very fine grained 8. Secondary Minerals: calcite filling of vesicles and cracks 9. Encrustations: Mn patches 10. Comment: unaltered zones posess fresh groundmass; will require extremely careful picking	2		5							1xTS: WL	
M81-261-10	1. Rock Type: coarse grained basalt similar to sample -3 & -6, strongly altered 2. Size: 8x7x5cm 3. Shape / Angularity: subangular 4. Color of cut surface: light brown to beige 5. Texture / Vesicularity: aphyric , dense 7. Matrix: coarse grained, intersertial groundmass 8. Secondary Minerals: pervasive groundmass alteration 9. Encrustations: Mn patches 10. Comment: coarse grained basalt, groundmass Fsp may work for age dating	1		4	Fsp Gm							
M81-261-11VC	1. Rock Type: monomict basaltic lapillistone 2. Size: 15x12x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey-brownish clasts with reddish matrix 5. Texture / Vesicularity: poorly sorted clasts, ~2% vesicles filled with calcite, closely packed, clasts massive microcrystalline 6. Phenocrysts: aphanitic 7. Matrix: calcareous sediment with cacite cement 8. Secondary Minerals: cracks filled calcite 10. Comment: clasts randomly oriented to slightly aligned, debris flow deposit	1		5		x					EMAU POB	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-261-12VC	1. Rock Type: heterogeneous volcaniclastiv breccia 2. Size: 23x13x11cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark green with brown clasts inside, scarce red matrix 5. Texture / Vesicularity: poorly vesicular clasts ~2% filled with dark substance or calcite, massive aphanitic 7. Matrix: of breccia; dark grey very fine muddy matrix 9. Encrustations: <1mm Mn crust 10. Comment: volcanic clasts subrounded to highly irregular shaped, heterogeneous sub-mm to 5cm sized, few angular sub-mm to 1cm sized reddish-pink chert? clasts in clusters scatterd in VC. Faint layering, poss. debris flow.			6		x					TS: EMAU TS: POB	
M81-261-14VC	1. Rock Type: monomict basaltic breccia (boulder size) 2. Size: 19x18x12cm 3. Shape / Angularity: one rounded, Mn coated side, rest angular 4. Color of cut surface: dark brown-green 5. Texture / Vesicularity: volcanic clasts massive, apganitic, poorly vesicular ~5% filled with calcite 7. Matrix: reddish and drak brown very fine muddy matrix 8. Secondary Minerals: Fe-OH minerals on matrix and possible carbonate rims around basalt clasts 9. Encrustations: 1-2mm Mn crust 10. Comment: insitu breccia partly with jigsaw fit texture , crack infill of sediment. Apparently rounded cobbles-boulders of basalt breccia with red veins and diffuse matrix	1		5							TS: WL TS: POB	
M81-261-15VC	1. Rock Type: factured basaltic (pillow?) rind with Mn crust- Irregular clasts; possible sheet flow tops with insitu VC as reworked clasts. 2. Size: 17x13x6cm 3. Shape / Angularity: angular 4. Color of cut surface: drak brownish green altered basalt, black Mn crust 5. Texture / Vesicularity: aphanitic massive, non-vesicular 7. Matrix: brown? alteration / palagonite or muddy sediment 8. Secondary Minerals: Fe-OH minerals 9. Encrustations: one side Mn crust 1cm 10. Comment: some small zones of pelagic? sediment trapped below Mn-crust. Or Fe-OH min. alteration. Insitu flow top breccia with cracks infilled with muddy sediment possibly alteration crap	1		5							TS: WL TS: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-261-16VC	1. Rock Type:monomict volcaniclastic lapillistone 2. Size: 13x10x7cm 3. Shape / Angularity: angular 4. Color of cut surface: dark green cm sized clasts, dark pink matrix 5. Texture / Vesicularity: aphanitic massive clasts, poorly vesicular 7. Matrix: dark muddy matrix and sparitic cement 8. Secondary Minerals: Fe-OH min on matrix 9. Encrustations: <1mm Mn-crust 10. Comment: poorly sorted, moderately closely packed, highly irregular shaped coarse ash & fine lapilli, sined??? clasts. Clasts quite angular with concave sides			6							TS: POB	
M81-261-17VC	1. Rock Type: monomict volcaniclastic breccia 2. Size: 13x11x10cm 3. Shape / Angularity: angular 4. Color of cut surface: dark brownish green, 5x7cm clasts with scarce matrix; dark reddish brown 5. Texture / Vesicularity: basalt similar to sample -1 & -2 10. Comment: insitu brecciated & possibly re-welded lava flow breccia with abundant co-genetic clasts surrounding sediment			4							TS: POB	
M81-261-18VC	1. Rock Type: basalt breccia similar to sample -17 2. Size: 13x8x6cm 3. Shape / Angularity: angular 4. Color of cut surface: dark green clasts, dark brown-red matrix, silicic, Fe-oxide rich matrix			5							TS: POB	
M81-261-19VC	1. Rock Type: highly altered basaltic VC 2. Size: 11x7x5cm 3. Shape / Angularity: angular 4. Color of cut surface: dark brown with greenish cm sized clasts 5. Texture / Vesicularity: massive, poorly vesicular 7. Matrix: muddy dark brown matrix 8. Secondary Minerals: Fe-OH min on matrix 9. Encrustations: <1mm Mn crust 10. Comment: very altered aphanitic volc. clast in brown matrix, may be silicified pelagic sediment			6							TS: POB	
M81-261-20	1. Rock Type: basalt breccia, similar to sample -17 2. Size: 17x10x7cm 3. Shape / Angularity: angular 4. Color of cut surface: basalt clasts dark green, matric dark brownish red 10. Comment: angular valcaniclastic breccia, very fine grained			6							TS: POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-261-21S	1. Rock Type: pelagic limestone (siliceous) 2. Size: 6x6x6cm 3. Shape / Angularity: angular 4. Color of cut surface: pale pink 10. Comment: siliceous pelagic limestone rich in radiolarians and planktonic. Recognized on sawn and acid etched surface: Globotruncana elevata group (age Santonian-Campanian)										TS: POB TS: EMAU	
M81-261-22VC	1. Rock Type: heterogeneous basaltic VC 2. Size: 7x5x4cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey brown 5. Texture / Vesicularity: variable massive, 0-10% vesicles, generally filled with calcite 6. Phenocrysts: some clasts with 10% Fsp of up to 5mm, altered 7. Matrix: dark brown muddy matrix with reddish staining of Fe-OH min 10. Comment: closely packed, variably subrounded to highly irregular shaped clasts of <1mm to 2mm size, variably altered, random clast orientation											
M81-261-23X	1. Rock Type: 13 cm sized basalt pebbles similar to sample -1 to -11											no picture

M81-262

Description of Location and Structure: Hess Escarpment SW, Map Detail 2; Track 2.3. Oval shaped seamount structure 1.5x1km, 200m high; on erosional? Plain of platform; SW facing flank

Dredge on bottom UTC 10/04/10 21:36hrs, lat 14°19,30'N, long 71°33,28'W, depth 1124m

Dredge off bottom UTC 10/04/10 22:35hrs, lat 14°19,54'N, long 71°33,21'W, depth 954m

total volume: empty

Comments:

M81-263

Description of Location and Structure: Hess Escarpment SW, Map Detail 1; Track 1.2. SW slope of plateau like structure on top of large plateau

Dredge on bottom UTC 10/04/10 23:56hrs, lat 14°20,14'N, long 77°36,96'W, depth 1196m

Dredge off bottom UTC 11/04/10 01:45hrs, lat 14°20,18'N, long 77°36,91'W, depth 1025m

total volume: few rocks

Comments: dredge got stuck at the beginning. Various carbonates

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-263-1S	1. Rock Type: shallow water limestone 2. Size: 40x27x11cm 3. Shape / Angularity: subangular 4. Color of cut surface: center grey, wide rim altered cream brown 5. Texture / Vesicularity: massive 9. Encrustations: 5mm Mn-crust 10. Comment: 3cm sized Rodoliths, Nummulites, Discocyclina, cavernous with pelagic infill										POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-263-2S	1. Rock Type: algae reef limestone 2. Size: 44x28x17cm 3. Shape / Angularity: subrounded 4. Color of cut surface: light cream 9. Encrustations: mm thick variable Mn crust 10. Comment: rhodolithic boundstones with occasional larger forams										POB	
M81-263-3S	1. Rock Type: Mn encrusted pelagic deep water limestone 2. Size: 35x27x5cm 3. Shape / Angularity: slab 4. Color of cut surface: cream - black 8. Secondary Minerals: Mn encrusting growing into limestonenup to 15mm thick 10. Comment: finely laminated pelagic limestone, no microfossils visible										POB	
M81-263-4S	1. Rock Type: shallow water limestone 2. Size: 30x23x7cm 3. Shape / Angularity: slab with irregular surfaces 4. Color of cut surface: dark cream 9. Encrustations: mm thick Mn crust 10. Comment: packstone with corals, large foraminifera, brachiopods. Cavernous slab of mictritic shallow limestone with many gastropods, corals, some disocylinae; lagoonal facies!										POB	
M81-263-5S	1. Rock Type: similar to sample -3 2. Size: 16x12x4cm 10. Comment: pelagic finely laminated limestone with slump structure; soft sediment derformation on a slope										POB	
M81-263-6S	1. Rock Type: pelagic limestone 2. Size: 25x20x8cm 3. Shape / Angularity: subrounded 4. Color of cut surface: cream with black (mm) 10. Comment: several generations of pelagic condensated limestone with Mn crusts and infills, no microfossils										POB	
M81-263-7S	1. Rock Type: pelagic limestone 2. Size: 26x13x11cm 3. Shape / Angularity: subround 4. Color of cut surface: mostly black with cream 10. Comment: a 3-4cm thick Mn crust around pink pelagic limestone. The whole is embedded in soft (young) pelagic chalk. Probably late Miocene!										POB	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-263-8S	1. Rock Type: shallow water limestone 2. Size: 30x25x13cm 3. Shape / Angularity: subround 4. Color of cut surface: dark cream 10. Comment: coquina of rhodolithic material and larger forams										POB	
M81-263-9S	1. Rock Type: shallow water limestone 2. Size: 25x20x14cm 3. Shape / Angularity: subround 4. Color of cut surface: cream brown mottled 10. Comment: rhodolithic crusts and larger forams, same corals as in sample -4										POB	
M81-263-10S	1. Rock Type: pelagic limestone 2. Size: 11x10x7cm 3. Shape / Angularity: subangular 4. Color of cut surface: cream black 10. Comment: contoured finely laminated										POB	
M81-263-11S	1. Rock Type: limestone 2. Size: 13x9x11cm 3. Shape / Angularity: subrounded 4. Color of cut surface: light grey 10. Comment: coquina mainly of larger forams										POB	

M81-265

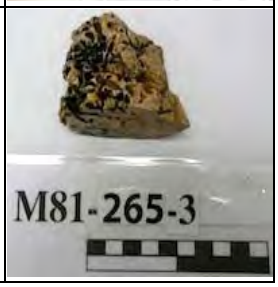
Description of Location and Structure: Hess Escarpment SW, Dredge Detail 6, Track 6.1. Northern section of Hess Escarpment SW, N-S striking ridge like structure, W facing very steep slope

Dredge on bottom UTC 11/04/10 05:26hrs, lat 14°30,30'N, long 77°39,30'W, depth 1125m

Dredge off bottom UTC 11/04/10 06:21hrs, lat 14°30,27'N, long 77°39,11'W, depth 699m

total volume: 3 small rocks

Comments: carbonates

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-265-1S	1. Rock Type: shallow water limestone 2. Size: 18x12x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: cream 9. Encrustations: ~1-5mm Mn-crust & pervasive Mn infiltration into carbonate 10. Comment: large foraminifera, porous cavities										EMAU POB	
M81-265-2S	1. Rock Type: similar to sample -1 2. Size: 14x9x4cm 3. Shape / Angularity: subangular 4. Color of cut surface: cream 5. Texture / Vesicularity: 1-2mm Mn crust and into the burrow channels 10. Comment: extensively bioturbated, large foraminifera										EMAU POB	
M81-265-3S	1. Rock Type: similar to sample -1 2. Size: 11x8x5cm 3. Shape / Angularity: subangular 10. Comment: extensively bioturbated, large foraminifera, a ~2cm oval shell, possibly mollusk										EMAU POB	

M81-266

Description of Location and Structure: Hess Escarpment SW, Dredge Detail 6, Track 6.2. W facing slope of northernmost elevation in Hess SW, ca 0.7nm north of previous dredge

Dredge on bottom UTC 11/04/10 07:43hrs, lat 14°30,90'N, long 77°39,36'W, depth 1143m

Dredge off bottom UTC 11/04/10 08:44hrs, lat 14°30,95'N, long 77°39,15'W, depth 629m

total volume: very few rocks

Comments: carbonates

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-266-1S	1. Rock Type: shallow water coralline limestone 2. Size: 20x17x14cm 3. Shape / Angularity: irregular 9. Encrustations: <1mm Mn crust 10. Comment: several cm long, branching corals and tube like bryozoans?, interstitial amtrix in soft cream colored fine calcareous ooze; too friable to saw											

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-266-2X	1. Rock Type: same as sample -1, 6 small pieces for archive									x	additional pieces for EMAU, POB	

M81-267
Description of Location and Structure: Hess Escarpment SW, Track 6.4: Northern part of Hess SW, W facing slope, site is W of station #266, deeper steep slope
Dredge on bottom UTC 11/04/10 10:13hrs, lat 14°29,80'N, long 77°40,56'W, depth 1800m
Dredge off bottom UTC 11/04/10 10:13hrs, lat 14°29,62'N, long 77°40,35'W, depth 1439m
total volume: emty
Comments:

M81-269
Description of Location and Structure: Hess Escarpment, southwesternmost Seamount, SW facing slope beneath plateau edge along valley flank
Dredge on bottom UTC 11/04/10 23:49hrs, lat 13°48,22'N, long 78°25,30'W, depth 1981m
Dredge off bottom UTC 12/04/10 01:19hrs, lat 13°48,06'N, long 78°24,88'W, depth 1573m
total volume: 1/4 full
Comments: basaltic tectonized rocks, 1 type of carbonate

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-269-1	1. Rock Type: aphanitic crystalline basaltic rock 2. Size: 18x17x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey areas and brown beige 5. Texture / Vesicularity: massive , non-vesicular, fairly coarse crystalline 6. Phenocrysts: Fsp equant, up to 0.5mm, 30%, mostly altered beige-cream, few areas with white freshish Fsp. Fsp needles up to 1.5mm, ~5%. Px? dark patches ~10% 7. Matrix: clear translucent interstitial fillings 8. Secondary Minerals: Fe-OH minerals along cracks and increasing into the rocks 9. Encrustations: 1mm Mn crust 10. Comment: dating potential but careful picking required. Subvolcanic or massive thick lava. Cracks and joints in rock possibly tectonic origin (regular pattern)	1	x	2-3							1TS: WL 1Pcs: Diego	
M81-269-2	1. Rock Type:similar to sample -1 2. Size: 10x9x8cm 6. Phenocrysts: Fsp equant same as in sample -1, needle shapes Fsp thicker and more abundant, often radially / star shaped. Px? same as #1 7. Matrix: interstitial translucent filling less than in #1 10. Comment: see #1	1	x	2-3							1TS: WL	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-269-3	1. Rock Type: similar to sample -1 but vesicular and finer crystalline 2. Size: 16x14x8cm 3. Shape / Angularity: subangular, irregular 4. Color of cut surface: grey and beige areas 5. Texture / Vesicularity: massive 6. Phenocrysts: Fsp ~0.3mm, 20-30%, altered cream, fresh whitish. Fsp needles very thin, ~2mm, appear fresh but rare dark patches of ? Px, generally sub-mm, rarely up to 2mm. <1% phenocrysts of 2mm size, white yellowish altered and <1% parallel laminated black & white rectangular crystals, plag twins? 7. Matrix: very little translucent matrix / groundmass 8. Secondary Minerals: cracks filled with Fe-OH minerals, calcite and possibly muddy sediment 9. Encrustations: Mn crust variable up to 1cm thick 10. Comment: age dating requires careful separation of fresher areas. Abundant cracks and joints create pieces of <2cm size, probably of tectonic origin	1	1	2-3								
M81-269-4	1. Rock Type: same as sample -2 2. Size: 12x9x6cm 6. Phenocrysts: Px more abundant 10. Comment: sample too small for geochemistry slab but possibly better quality than -1 & -2	1		2-3							1TS: WL	
M81-269-5	1. Rock Type: vesicular basaltic rock, aphanitic 2. Size: 9x9x6cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey-brownish 5. Texture / Vesicularity: massive, 5% vesicles up to 2mm, filled with calcite and Mn 6. Phenocrysts: Fsp laths up to 3mm, altered cream-brownish, intersertal arranged, 10-20%. Fsp equant crystals sub-mm, 5% altered cream brownish. Px? dark patches; sub-mm clear Fsp needles? 5% 7. Matrix: translucent interstitial filling 9. Encrustations: < 1mm Mn crust 10. Comment: except for Fsp needles very little dating potential due to small sample size. Subvolcanic rock or massive thick lava flow. No tectonic jointing visible	1	x	3								

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-269-6	1. Rock Type: fine crystalline vesicular aphanitic basalt 2. Size: 24x13x7cm 3. Shape / Angularity: subangular 4. Color of cut surface: mostly grey 5. Texture / Vesicularity: massive, 5% vesicles up to 2mm, filled with calcite 6. Phenocrysts: Fsp laths altered cream & rectangular crystals more yellowish, both ~1mm needles fresh(?), shiny, rare. Dark Px patches 8. Secondary Minerals: cracks with calcite and muddy sediment 9. Encrustations: up to 1cm Mn-crust 10. Comment: lava flow, tectonic deformation, dating potential difficult to judge	1	x	3							1Pcs: Diego	
M81-269-7	1. Rock Type: similar to sample -6 with larger vesicles 2. Size: 13x11x8cm 5. Texture / Vesicularity: 5-10% vesicles up to 3mm, calcite filled 8. Secondary Minerals: cracks filled with Fe-OH minerals and calcite	1		3							1TS: EMAU 1TS: WL	
M81-269-8	1. Rock Type: porphyritic fine crystalline basalt 2. Size: 8x8x4cm 3. Shape / Angularity: subangular 4. Color of cut surface: mottled beige to grey 5. Texture / Vesicularity: massive, ~2% vesicles, calcite filled, ~1mm 6. Phenocrysts: Fsp phenocrysts 3-4mm, mostly whitish appear altered, 3-5% 7. Matrix: fine crystalline Fsp-Px mix 8. Secondary Minerals: along margin, 5mm wide totally altered rock 9. Encrustations: <1mm Mn crust 10. Comment: similar to sample -6	1		5								
M81-269-9	1. Rock Type: fine crystalline basalt with Fsp phenocrsyts 2. Size: 40x30x20cm 6. Phenocrysts: no Fsp needles, otherwise similar to sample -6 9. Encrustations: up to 1.5cm Mn crust 10. Comment: very abundant cracks and joints; very small pieces with fresh quality available	?		3-5						2Pcs	1TS: WL 1Pcs: Diego	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-269-10	1. Rock Type: similar to sample -6, but highly tectonized & altered 2. Size: 30x25x14cm 3. Shape / Angularity: irregular 4. Color of cut surface: brown 5. Texture / Vesicularity: massive, 1-2% vesicles 6. Phenocrysts: no fresh Fsp needles, otherwise similar to -6 9. Encrustations: 1mm Mn crust 10. Comment: highly jointed & cracked rock, pieces often less than 1cm, pervasively altered			6							1Pcs: Diego	
M81-269-11	1. Rock Type: tectonized basalt 2. Size: 18x9x6cm 10. Comment: fine crystalline, aphanitic, non vesicular, highly altered basalt. Extensively cracked & jointed. Joints with Fe-OH minerals and calcite										1TS: EMAU 1TS: WL	
M81-269-12	1. Rock Type: tectonized basalt with brecciated zone 2. Size: 11x10x17cm 10. Comment: basalt, fine crystalline, aphanitic, non-vesicular, highly altered zone cream to pink. Jig-saw fit breccia of <1mm to 1cm pieces with ? basalt in interstitial spaces (odd!). No idea what this zone consistst of, TS of both	1		6							EMAU POB	
M81-269-13S	1. Rock Type: pelagic semi consolidated limestone with large foraminifera 2. Size: 20x13x6cm 3. Shape / Angularity: subround slabs 4. Color of cut surface: light cream - whitish 5. Texture / Vesicularity: massive 8. Secondary Minerals: dentritic Mn growth into sediment 10. Comment: large round forams, young age, possibly younger than Miocene								IFM-GEOMAR		EMAU POB Diego	
M81-269-14S	1. Rock Type: same as sample -14 2. Size: 20x16x6cm 10. Comment: bioturbation, worm burrows								IFM-GEOMAR		EMAU POB Diego	

M81-270
Description of Location and Structure: Hess Escarpment SW, Track 1.2, western flank of seamount, along NW facing slope of W trending ridge like structure; SW of station 269
Dredge on bottom UTC 12/04/10 03:17hrs, lat 13°47,75'N, long 78°26,39'W, depth 2115m
Dredge off bottom UTC 12/04/10 04:32hrs, lat 13°47,53'N, long 78°26,04'W, depth 1869m
total volume: 1 small "rock"
Comments: soft marly chalk

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-270-1	1. Rock Type: soft marly chalk 2. Size: 13x13x8cm 3. Shape / Angularity: round 4. Color of cut surface: white-cream 10. Comment: soft friable, partly consolidated material										POB Diego	no picture

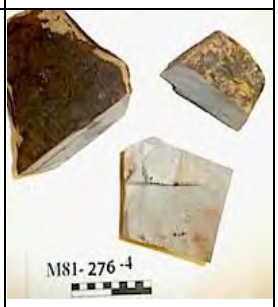
M81-272
Description of Location and Structure: Hess Escarpment SW, Track 7.1. Ridge-like extension out of Hess Escarpment, dredge track goes across SW-facing slope
Dredge on bottom UTC 12/04/10 12:27hrs, lat 14°03,40'N, long 77°40,19'W, depth 3467m
Dredge off bottom UTC 12/04/10 13:38hrs, lat 14°03,84'N, long 77°40,02'W, depth 3171m
total volume: empty
Comments: small greenish pebbles in sediment trap; serpentinite? POB prepares TS

M81-273
Description of Location and Structure: Hess Escarpment SW, Map 7, Track 7.2. 3.3nm N of station 272, SE facing main slope of plateau, dredging across nose
Dredge on bottom UTC 12/04/10 16:19hrs, lat 14°06,72'N, long 77°38,38'W, depth 2856m
Dredge on bottom UTC 12/04/10 17:30hrs, lat 14°07,23'N, long 77°38,31'W, depth 2859*m
total volume: empty
*Comments: *wrong water depth at end point of track due to false EM120 signals. According to map should have been at 2490mbsl*

M81-276
Description of Location and Structure: Beata Ridge South, Map 2, Track 2.3. WNW facing nose along southern end of Eastern Beata Ridge. Large scarp / indent in slope south of this station
Dredge on bottom UTC 15/04/10 14:06hrs, lat 15°11,75'N, long 73°24,36'W, depth 3074m
Dredge on bottom UTC 15/04/10 16:50hrs, lat 15°11,58'N, long 73°23,80'W, depth 2397m
total volume: half full
Comments: plutonics, mafic and more ecolved gabbros; volcanics mostly aphyric, some fresh, some vesicular, most dense

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-276-1	1. Rock Type: volcanic rock, Ol?-phyric basalt, medium altered 2. Size: 28x24x11cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey to greenish red 5. Texture / Vesicularity: aphyric, corarse grained texture gives phyric impression, dense 7. Matrix: corarse grained, Ol 0.2-0.5mm altered, 20-30% Px, 0.1-0.5mm fresh, 30.40% Fsp? 8. Secondary Minerals: Ol altrered to iddingsite 9. Encrustations: thin Mn patches 10. Comment: coarse grained dense basalt, very angular piese; could be also part of a dike. Seems to be the freshest basalt in dredge judging from freshly broken surface by sledge hammer	3	x	2-3	Fsp GM						1xTS: WL	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-276-2	1. Rock Type: volcanic rock, aphyric, fairly fresh groundmass 2. Size: 24x20x10cm 3. Shape / Angularity: angular 4. Color of cut surface: dark grey 5. Texture / Vesicularity: aphyric, dense, vesicle fillings along cracks 7. Matrix: very fine grained to glassy 8. Secondary Minerals: minor Mn fillings along cracks 9. Encrustations: sub mm thick Mn crust 10. Comment: aphyric very fine grained basalt with fairly fresh dark grey groundmass	4	x	3-4	Fsp GM						1xTS: WL	
M81-276-3	1. Rock Type: volcanic rock, aphyric, medium to strongly altered 2. Size: 30x13x8cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: light brown 5. Texture / Vesicularity: aphyric, 2-4%, 1-4mm vesicles filled with calcite & Mn 7. Matrix: fine grained 8. Secondary Minerals: pervasive groundmass alteration 9. Encrustations: Mn-patches 10. Comment: a more fine grained and vesicular variety of the aphyric basalts of this dredge	4	x	3-4							1xTS: WL	
M81-276-4	1. Rock Type: aphyric volcanic rock, medium altered with a few fresh areas 2. Size: 34x16x8cm 3. Shape / Angularity: angular 4. Color of cut surface: dark grey to orange oxidized 5. Texture / Vesicularity: aphyric, dense 7. Matrix: medium grained Fsp-Px groundmass 8. Secondary Minerals: pervasive groundmass oxidation 9. Encrustations: 1mm Mn crust 10. Comment: not clear if this is really lava part of a dike, shape is quite platy	5	x	4							1xTS: WL	
M81-276-5	1. Rock Type: vesicular lava, strongly altered due to calcite filled vesicles 2. Size: 28x14x12cm 3. Shape / Angularity: subangular 4. Color of cut surface: light grey where fresh groundmass 5. Texture / Vesicularity: aphyric, 20% vesicles, 1-10mm, filled with calcite 7. Matrix: very fine grained to glassy 8. Secondary Minerals: calcite filling of vesicles 9. Encrustations: 1-3mm thick Mn crust 10. Comment: Highly versicular lava, strongly altered, groundmass similar to sample -2	2	x	4-5							1xTS: WL	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-276-6	1. Rock Type: aphyric lava, slightly vesicular, strongly altered 2. Size: 17x14x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: light brown 5. Texture / Vesicularity: aphyric, 2% vesicles, 2-5mm filled with Mn 7. Matrix: fine grained 8. Secondary Minerals: pervasive groundmass oxidation 9. Encrustations: Mn patches 10. Comment: somewhat similar to sample -3	2	x	5							1xTS: WL	
M81-276-7	1. Rock Type: coarse grained crystalline plutonic rock, gabbroic, strongly altered 2. Size: 23x17x12cm 3. Shape / Angularity: rounded 4. Color of cut surface: light brown to beige 5. Texture / Vesicularity: holocrystalline, coarsest sample in dredge 6. Phenocrysts: 40-50% Fsp altered, 3-4mm; 30% Px, 1-2mm, fresh?; 10-20% Ol, 1-3mm, altered 8. Secondary Minerals: iddinsite replacing Ol, pyrite spots 9. Encrustations: Mn patches 10. Comment: Coarsest plutonic rock in dredge, intermediate gabbroic composition. Fsp may work for dating	2	x	3							1xTS: WL	
M81-276-8	1. Rock Type: mafic plutonic rock, very strongly altered 2. Size: 22x14x10cm 3. Shape / Angularity: rounded 4. Color of cut surface: dark grey to black 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 40-60% Px, 2-5mm, altered to partially fresh; 20-30% Ol?, 2-3mm, altered; 10-20% Fsp, 2-3mm, altered 8. Secondary Minerals: pervasive alteration with ring like alteration halos 9. Encrustations: thin Mn-crust and patches 10. Comment: appears to be the most mafic plutonic rock of the dredge based on dark color; otherwise very strongly altered	2	x								1xTS: WL	
M81-276-9	1. Rock Type: plutonic rock, gabbro, medium grained 2. Size: 18x17x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish pink 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 30-40% pinkish Fsp, 0.2-1mm, altered; 40% Px, fresh? 1-2mm; 10% Ol?, altered, <1mm 8. Secondary Minerals: pervasive oxidation of minerals 9. Encrustations: Mn patches 10. Comment: medium grained gabbro, more evolved (leucocratic) than sample -8	x	x	3-4							1xTS: WL	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-276-10	1. Rock Type: similar to sample -9 2. Size: 22x16x10cm 3. Shape / Angularity: angular 9. Encrustations: Mn-patches	x	x	3-4							1xTS: WL	
M81-276-11	1. Rock Type: plutonic rock, similar to sample -8 2. Size: 13x10x19cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey to black 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: Ol-Px-Fsp; extremely difficult to identify species on cut surface 8. Secondary Minerals: greenish smectite 9. Encrustations: thin Mn-crust 10. Comment: mafic gabbro coarse grained	x	x	4-5							1xTS: WL	
M81-276-12	1. Rock Type: mafic plutonic rock, similar to 1; strongly altered 2. Size: 18x12x9cm 9. Encrustations: Mn-patches	x	x	4-5							1xTS: WL 1xTS: EMAU	
M81-276-13	1. Rock Type: mafic gabbro, medium to coarse grained, medium altered 2. Size: 18x12x9cm 3. Shape / Angularity: subangular 4. Color of cut surface: black to slight dark red 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 40-60% Px, 1-5mm patches, fesh to altered; 20-30% Fsp 0.2-1mm, pinkish altered 8. Secondary Minerals: oxidized Fsp; Fe-OH minerals 9. Encrustations: 1mm Mn-crust in places 10. Comment: appears to be the freshest gabbro so far	x	x	4							1xTS: WL 1xTS: EMAU	
M81-276-14	1. Rock Type: aphyric basalt, fine grained, strongly altered 2. Size: 33x17x16cm 3. Shape / Angularity: angular 4. Color of cut surface: mostly brown; fresh grey in places 5. Texture / Vesicularity: aphyric, dense 7. Matrix: fine grained 8. Secondary Minerals: pervasive groundmass oxidation 9. Encrustations: very thin Mn coating 10. Comment: aphyric. dense basalt, similar to sample -4	x	x	5							1xTS: WL	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-276-15	1. Rock Type: aphyric basalt, similar to sample -14, but fresher 2. Size: 42x20x12cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey to brownish 5. Texture / Vesicularity: aphyric, vugs along cracks filled with calcite 6. Phenocrysts: 7. Matrix: fine grained 8. Secondary Minerals: slight groundmass oxidation 9. Encrustations: thin Mn coating 10. Comment: similar to sample -14 & -4; taken as one of the largest aphyric basalt pieces. After cutting the sample: two lithologies with irregular intrusive contact (a) vuggy basaltic lithology, darker, (b) fine light lithology, described already in protocol	x	x	3-4							1xTS: WL	
M81-276-16	1. Rock Type: mafic plutonic rock, medium to coarse grained with sharp intrusive contact to fine grained basalt (see 10 for details) 2. Size: 12x13x5cm 3. Shape / Angularity: angular 4. Color of cut surface: black to reddish 5. Texture / Vesicularity: holocrystalline 6. Phenocrysts: 40% Ol, 1-3mm, altered; 40-50%Px, 1-5mm fresh to altered; 10% Fsp unrecognizable 8. Secondary Minerals: Ol replaced by iddingsite 9. Encrustations: thin Mn coating 10. Comment: somewhat similar to other mafic gabbros of this dredge. Chilled margin of intrusive contact with aphyric basalt displays alignment of tiny crystals in the fine grained basalt along the margin. This suggest intrusion of melt into gabbro.	x	x	4							1xTS: WL	
M81-276-17	1. Rock Type: volcanic rock? Looks like mixing of two "flows" and reworking material; very strongly altered 2. Size: 25x21x13cm 3. Shape / Angularity: rounded 4. Color of cut surface: greenish-grey 5. Texture / Vesicularity: aphyric, slightly vesicular, 2-5% filled with greenih smectite materia; could be reworked glassy material 7. Matrix: very fine grained 8. Secondary Minerals: Mn along cracks and infills 9. Encrustations: Mn-patches 10. Comment: There seems to be a boundary of two different types of materials / flows? (a) light grey against (b) greenish grey. Could be a contact of different flows that are maybe of more intermediate composition	x	slab	6							1xTS: WL 1xTS: EMAU	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-276-18	1. Rock Type: red oxidized vesicular lava, intermediate composition 2. Size: 18x16x11cm 3. Shape / Angularity: subangular 4. Color of cut surface: reddish-brown 5. Texture / Vesicularity: aphyric, lithic fragments, 3-5% ocal shaped vesicles, filled with Mn 7. Matrix: very fine grained 8. Secondary Minerals: oxidized groundmass 9. Encrustations: Mn-patches 10. Comment: appears more evolved in composition; too altered for geochemistry	x		6								
M81-276-19S	1. Rock Type: basalt breccia with limestone matrix 2. Size: 14x11x9cm 3. Shape / Angularity: angular 4. Color of cut surface: dark green basalt; pale pink limestone 10. Comment: abundant pelagic limestone with planctonic formaminifera. Jigsaw-fit texture of basaltic clasts. Clasts are highly angular, splinter and elongate & equant shapes. Similar to sample -4 & -14.	x							IFM-GEOMAR		1xTS: WL 3xTS: EMAU 3xTS: POB	
M81-276-20S	1. Rock Type: basalt breccia limestone matrix 2. Size: 8x7x3cm 3. Shape / Angularity: thin slab 4. Color of cut surface: pale-pink, dark-green clasts, black coating on up side 10. Comment: pelagic sediment with visible laminated and cm sized basalt clasts										POB	
M81-276-21S	1. Rock Type: basalt with breccia rim 2. Size: 17x14x8cm 3. Shape / Angularity: angular 4. Color of cut surface: mainly dark green, pale pink rim 10. Comment: pelagic limestone rim								IFM-GEOMAR		POB	
M81-276-22X	1. Rock Type: 7x representative boulders of plutonic rocks									x		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-276-23X	1. Rock Type: 7x representative boulders of volcanic rocks									x		

M81-277

Description of Location and Structure: Beata Ridge South, southern part of eastern ridge. NW facing slope in the middle part of NE-SW elongated seamount.

Dredge on bottom UTC 15/04/10 20:18hrs, lat 15°18,37'N, long 73°15,69'W, depth 2687m

Dredge off bottom UTC 15/04/10 21:39hrs, lat 15°18,01'N, long 73°15,49'W, depth 2235m

total volume: 1/5 full

Comments: basaltic lava flows, aphanitic fine, crystalline lithologies

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-277-1	1. Rock Type: vesicular fine crytalline basalt 2. Size: 34x20x16cm 3. Shape / Angularity: subangular 4. Color of cut surface: mottled cream & grey brown 5. Texture / Vesicularity: massive, poorly vesicular, ~2-5% vesicles round, filled with black substance (Mn?), up to 2mm, irregularly distributed 6. Phenocrysts: Fsp rectangular crystals, cream - reddish or yellowish altered, max 1mm, 20-30% 8. Secondary Minerals: Fe-OH minerals ubiquitous and especially along cracks, cracks also filled with calcite 9. Encrustations: Mn crust up to 1cm and marine organisms encrusting surface 10. Comment: dating potential fairly low, alteration pervasive with little fresh rock remaining. Massive lava, jointing possibly of tectonic origin	x	x	4							1xTS: WL	
M81-277-2	1. Rock Type: very similar to sample -1 2. Size: 30x25x15cm 6. Phenocrysts: more abundant Fsp laths, mostly altered, Fsp needles appear fresh, up to 2mm, 5%, otherwise same as sample -1 8. Secondary Minerals: cracks filled with muddy sunstance / clay minerals 9. Encrustations: <1mm Mn-crust 10. Comment: in grey = little altered domains potential for dating Fsp and geochemistry; otherwise rock cracked and jointed (tectonic origin?) from where the alteration fronts are ingressing	x	x	3							1xTS: WL	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-277-3	1. Rock Type: same as sample -2 2. Size: 20x18x16cm 9. Encrustations: Mn-crust up to 1cm thick 10. Comment: less fresh than sample -2	x	x	3-4							1xTS: WL	
M81-277-4	1. Rock Type: texturally same as sample -2 2. Size: 21x15x10cm 3. Shape / Angularity: 4. Color of cut surface: more uniform grey-brownish color 5. Texture / Vesicularity: vesicles ~1mm, 2% filled with black substance?, Mn	x	x	3-4							1xTS: WL	
M81-277-5	1. Rock Type: same as sample -2 2. Size: 14xx10x10cm 3. Shape / Angularity: 4. Color of cut surface: distinct grey and brownish-yellow domains of <1cm size (fresh and altered) (too small for separartion?) 10. Comment: abundant hair fine cracks	x	x	4							1xTS: WL	
M81-277-6	1. Rock Type: same as sample -5 2. Size: 4x9x6cm	x		4							1xTS: WL	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-277-7	1. Rock Type: microcrystalline, non-vesicular basaltic rock 2. Size: 19x13x9cm 3. Shape / Angularity: brownish-grey 4. Color of cut surface: subangular 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: ~2mm clusters of Fsp (altered brown yellowish), 30-40%, surrounded by dark areas, which consist of chocolate brown amorph. patches (= vesicles fills in other sample) and tiny black crystals, poss. Px 8. Secondary Minerals: Fe-OH minerals 9. Encrustations: <1mm Mn-crust and encrustations by marine organisms 10. Comment: this lithology is probably a more well crystallized version of sample -1 to -6	x	x	4							1xTS: WL	
M81-277-8	1. Rock Type: well crystallized, very poorly vesicular basaltic rock 2. Size: 21x16x12cm 3. Shape / Angularity: subangular 4. Color of cut surface: umbra 5. Texture / Vesicularity: massive, 1-2% vesicles, <1mm, filled with Mn? 6. Phenocrysts: 40% Fsp laths ~1mm, intersertal, tiny shiny specks, oxides?, <1mm black patches Px? 8. Secondary Minerals: along cracks ingrowing Fe-OH minerals, cracks filles with clay 9. Encrustations: Mn-crust up to 15mm 10. Comment: this and sample -9 through -10 have a noticable different color as compared to sample -1 to -7. Abundant joints are poss. of tectonic origin causing pervasive alteration throughout the specimen.	x	x	4-5								
M81-277-9	1. Rock Type: lava flow top with former glassy surface grading downwards into well crystallized rock; same as sample -8 2. Size: 17x12x10cm 3. Shape / Angularity: subangular 4. Color of cut surface: umbra 5. Texture / Vesicularity: massive and whirly texture poss. related to flow. Tube vesicles up to 12mm long, filled with black substance (Mn?), ~5% 6. Phenocrysts: see sample -8, grading upwards into glassy margin 8. Secondary Minerals: cracks filled with clay and Mn 9. Encrustations: Mn-crust up to 20mm 10. Comment: pillow or sheet lava flow top with 4mm palagonized glass crust grading into a tachylitic zone and eventually into micro and fine crystalline rock, same as sample -8. No fresh glass found	x	x	5	altered glass						1xTS: WL	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-277-10	1. Rock Type: same as sample -9, except for glassy crust 2. Size: 10x9x9cm 10. Comment: sample falls apart into 2-4cm sized angular pieces ----> result of tectonism											

M81-278
Description of Location and Structure: Beata Ridge South, Track 1.1. Western Ridge near southernmost tip, deep section along NW facing flank.
Dredge on bottom UTC 16/04/10 01:25hrs, lat 15°23,96'N, long 73°30,66'W, depth 3648m
Dredge off bottom UTC 16/04/10 02:38hrs, lat 15°23,70'N, long 73°30,47'W, depth 3279m
total volume: empty
Comments:

M81-279
Description of Location and Structure: Beata Ridge South, Track 4.1. Eastern segment, northern part, NW-facing slope
Dredge on bottom UTC 16/04/10 08:08hrs, lat 15°29,62'N, long 73°05,85'W, depth 2876m
Dredge off bottom UTC 16/04/10 09:29hrs, lat 15°29,39'N, long 73°05,47'W, depth 2549m
total volume: 1 small rock
Comments: basaltic

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-279-1	1. Rock Type: well crystallized, non-vesicular basaltic rock 2. Size: 7x7x4cm 3. Shape / Angularity: subangular 4. Color of cut surface: brownish 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: Fsp laths, rectangular crystals, altered brownish yellowish, 20-30%, max 1mm. Fsp needles, whitish-yellow ~5%, max 1.5mm. Px equant crystals <1mm. 7. Matrix: clear-whitish substance or is it Fsp phase? 8. Secondary Minerals: Fe-OH minerals 9. Encrustations: <1mm Mn-crust and biological encrustations 10. Comment: very similar to samples from last sucessful dredge 277. Potential for dating very low due to small size											

M81-281

Description of Location and Structure: Beata Ridge East, Track 1.1. N-S elongated ridge-like seamount without plateau; East of main Beata structure. Dredge track lies in southern half along SW facing nose

Dredge on bottom UTC 16/04/10 19:25hrs, lat 15°32,91'N, long 72°56,74'W, depth 2580m

Dredge off bottom UTC 16/04/10 21:01hrs, lat 15°33,24'N, long 72°56,38'W, depth 2207m

total volume: 1/5 full

Comments:

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-281-1	1. Rock Type: microgabbro or massive lava (dolerite), medium altered 2. Size: 20x12x10cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: dark grey to black with reddish oxidized zones 5. Texture / Vesicularity: microcrystalline, equigranular groundmass, dense 7. Matrix: medium grained; Fsp 30-40%, 0.1-0.4mm, fresh; Px, 50-60%, 0.1-0.4mm, fresh; Ol? 8. Secondary Minerals: Fe-OH minerals in places, mainly around fractures 9. Encrustations: Mn patches 10. Comment: medium grained gabbro - subvolcanic rock. Most representative, abundant rock type of dredge. Groundmass Fsp should be good for dating	2	x	2-3	Fsp Gm						1xTS: WL	
M81-281-2	1. Rock Type: micro gabbro identicle top sample -1 2. Size: 12x10x8cm 10. Comment: possibly slightly less altered than sample -1 due to less fractures	4	x	2-3	Fsp Gm						1xTS: WL	
M81-281-3	1. Rock Type: micro gabbro, dolerite similar to sample -1 2. Size: 10x10x4cm 10. Comment: slightly coarser than sample -1	x		2-3	Fsp Gm							
M81-281-4	1. Rock Type: see sample -1 2. Size: 11x8x8cm 10. Comment: check TS for Fsp freshness	x										

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-281-5	1. Rock Type: see sample -1 2. Size: 6x6x5cm 10. Comment: check TS for Fsp freshness	x										
M81-281-6	1. Rock Type: pillow margin with chilled, no glass, interior aphyric, fine grained similar to other samples, strongly altered 2. Size: 24x13x11cm 3. Shape / Angularity: angular 4. Color of cut surface: yellowish brown 5. Texture / Vesicularity: aphyric dense 7. Matrix: Fsp-Px fine grained groundmass, altered 8. Secondary Minerals: intense groundmass oxidation, abundant cracks filled with Mn 9. Encrustations: thin Mn crust 10. Comment: only rock in dredge that could identified as lava, otherwise verx strongly altered	2	x	4-5							1xTS: WL	
M81-281-7	1. Rock Type: basalt breccia 2. Size: 15x8x6cm 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: clast supported, 0.5-2cm, angular clasts 7. Matrix: pelagic sediment attached on one side and infill along 0.8mm wide crack 9. Encrustations: thin Mn-crust											
M81-281-8	1. Rock Type: rounded pebble of fractured aphyric basalt. Filled by calcite along cracks 2. Size: 7x5x4cm 4. Color of cut surface: light grey											
M81-281-9	1. Rock Type: aphyric volcanic rock with red oxidized mm sized patches 2. Size: 11x6x4cm 3. Shape / Angularity: angular 4. Color of cut surface: black to red dotted 5. Texture / Vesicularity: aphyric, dense, appears glassy 7. Matrix: fine grained, no minerals visible 8. Secondary Minerals: FeOH minerals as round patches 9. Encrustations: thin Mn coating 10. Comment: Apart from Fe-OH patches the groundmass appears quite fresh	1		3								

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-281-10	1. Rock Type: alteration or hydrothrmal crust 2. Size: 4x3x2cm 3. Shape / Angularity: rounded 4. Color of cut surface: greenish brown 10. Comment: TS just to check what it is	2									1xTS: POB	
M81-281-11X	1. Rock Type: 7x representative micro gabbros - dolerites 2. Size: 20x11x10, 10x5x4, 10x5x4, 6x6x5, 11x8x5, 9x6x6, 12x8x5, 12x10x7cm									x		

M81-283

Description of Location and Structure: Beata Ridge Seamount 2. Nose like protrusion of W facing upper flank

Dredge on bottom UTC 17/04/10 05:59hrs, lat 15°42,34'N, long 72°32,72'W, depth 1943m

Dredge off bottom UTC 17/04/10 07:17hrs, lat 15°42,43'N, long 72°32,29'W, depth 1649m

total volume: few

Comments: basaltic and mircogabbroic rocks without tectonic jointing; semi consolidated pelagic sediments

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-283-1	1. Rock Type: aphanitic basaltic rock 2. Size: 28x18x13cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, vesicles filled with calcite or light green amorphous substance, <1mm, 2%, round 6. Phenocrysts: Fsp clear to whitish, mostly fresh, lath shaped, rarely needles, sub-mm 30-40%. Tiny black specks ? Px or oxides. 8. Secondary Minerals: along margin & cracks Fe-OH min alteration, ~5mm wide zone 9. Encrustations: ~1mm Mn crust 10. Comment: nice fresh basalt; appears very suitable for dating and geochemistry, large specimen	x	x	2	Fsp						1xTS: WL	

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-283-2	1. Rock Type: aphanitic, basaltic rock with tiny vesicles 2. Size: 22x20x16cm 3. Shape / Angularity: subangular 4. Color of cut surface: mostly grey 5. Texture / Vesicularity: massive, vesicles <<1mm, irregular shaped, filled with green amorphous substance ~5% (or is this altered matrix) 6. Phenocrysts: Fsp clear to whitish lath often in clusters, <1mm, appear fresh, less common Fsp needles, shiny especially on broken surfaces, 30-40%. 2% white-cream Fsp laths up to 1mm "big". Tiny black specks, ? Px or oxides 8. Secondary Minerals: along margins cracks 5-10mm wide FeOH min zones 9. Encrustations: <1mm Mn-crust 10. Comment: similar to sample -1; but pay attention to these patches which are either vesicles or matrix(?)	x	x	2	Fsp						1xTS: WL	
M81-283-3	1. Rock Type: fine crystalline microporphyritic, poorly vesicular basaltic rock 2. Size: 12x11x6cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, vesicles irregular shaped, filled with brownish light amorphous substance ~2-5%, sub-mm sized (or are these altered matrix) 6. Phenocrysts: Fsp lath & rectangular crystals up to 2mm, white & appear fresh, 15 %. Fsp in groundmass sub-mm sized, equant white, ~30%, tiny black specks. 8. Secondary Minerals: along margin of sample, 5mm wide zone with pervasive alteration & FeOH min 9. Encrustations: 1mm Mn crust 10. Comment: appears relatively fresh and good potential for geochemistry and dating	x	x	2	Fsp						1xTS: WL	
M81-283-4	1. Rock Type: fine crystalline poorly vesicular basaltic rock 2. Size: 16x12x10cm 3. Shape / Angularity: 4. Color of cut surface: grey-brown irregular diffuse 5. Texture / Vesicularity: massive, vesicles ~1mm, round, filled with brown amorphous substance ~2% 6. Phenocrysts: Fsp laths up to 1mm either clear to whitish or altered cream-brown 30-40%. Tiny black specks, 1%, 1x1mm zebra striped crystals 8. Secondary Minerals: pervasive irregular alteration with only small domains of fresh rock 9. Encrustations: 1mm Mn crust 10. Comment: careful separation of altered versus fresh domains necessary	x		3							1xTS: WL	

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-283-5	1. Rock Type: similar to sample -4 2. Size: 14x10x7cm 4. Color of cut surface: mostly brownish cream 5. Texture / Vesicularity: massive, Fsp laths form a whirly pattern, shiny needles of Fsp <5% 10. Comment: more altered than sample -4, but fresh needles of Fsp are present ----> potential for dating	x		3-4							1xTS: WL	
M81-283-6	1. Rock Type: fine crystalline basaltic rock with few vesicles & few Ol ? phenocrysts 2. Size: 9x9x7cm 3. Shape / Angularity: subangular 4. Color of cut surface: cream-brownish 5. Texture / Vesicularity: massive to whirly pattern around Ol?; vesicles highly irregular shaped ~5% filled calcite ± brownish substance 6. Phenocrysts: Fsp lath ~1mm brown, altered, angular patches, poss. Ol or Px?, pseudomorphs ~5% 8. Secondary Minerals: 9. Encrustations: 1mm Mn crust 10. Comment: very rarely small domains with grey-fresh color and shiny Fsp-crystals	x		4								
M81-283-7	1. Rock Type: micro gabbroic, poorly vesicular rock 2. Size: 16x14x8cm 3. Shape / Angularity: 4. Color of cut surface: mottled cream-brown & grey 5. Texture / Vesicularity: massive, vesicles up to 2mm, round, filled with dark brown amorphous substance 6. Phenocrysts: Fsp clusters cream brownish up to 1.5mm, 30-40%, Fsp needles clear to whitish 10%, tiny black & shining specks (oxides?); brown <1mm angular patches similar to sample -6 (Ol, Px??) 10. Comment: perhaps Fsp needles good for dating	x	x	4							1xTS: WL	
M81-283-8	1. Rock Type: very similar to sample -7 2. Size: 13x10x7cm 10. Comment: slightly less altered than sample -7 and slightly coarser crystalline	x		3-4								

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-283-9	1. Rock Type: very similar to sample -7 2. Size: 19x15x7cm 10. Comment: odd-shaped sample, consists of mostly thoroughly altered & FeOH min overgrowth											
M81-283-10	1. Rock Type: very similar to sample -7 6. Phenocrysts: Fsp needles up to 2.5mm 10. Comment: only very small portion in center of sample with partly fresh minerals											
M81-283-11S	1. Rock Type: semi consolidated micritic (clayey chalk-lime-claystone) limestone with some volcanic clasts 2. Size: 12x11x7cm 3. Shape / Angularity: irregular, falling apart 4. Color of cut surface: light yellow 5. Texture / Vesicularity: 6. Phenocrysts: 7. Matrix: 8. Secondary Minerals: 9. Encrustations: pervasive Mn-growth along cracks & dentritic growth into limestone. Variable with and without Mn-crust 10. Comment: no fossils visible, chalk claystone, volcanic clasts 1-10mm, highly altered, ~5% of rock volume. Cinerite?											
M81-283-12S	1. Rock Type: similar to sample -11 2. Size: 10x8x5cm											
M81-283-13S	1. Rock Type: similar to sample -11 2. Size: 10x7x5cm											

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	VULC	SED	MN	Rest	ARCH	NOTES	PICTURE
M81-283-14S	1. Rock Type: similar to sample -11 2. Size: 11x7x6cm 10. Comment: for samples 11S to 14S; soft claystone-chalk, almost no reaction to acid. No microfossils seem present. Cinerite?											
M81-283-15S	1. Rock Type: similar to sample -11 2. Size: 13x10x4cm											
M81-283-16S	1. Rock Type: similar to sample -11 2. Size: 7x5x5cm											
M81-283-17S	1. Rock Type: similar to sample -11 2. Size: 8x7x4cm											
M81-283-18S	1. Rock Type: similar to sample -11 2. Size: 12x7x4cm 10. Comment: almost no reaction to acid. No microfossils seem present. Cinerite?