IFM-GEOMAR REPORT

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

FS POSEIDON
Fahrtbericht / Cruise Report P379/2
Mid-Atlantic-Researcher Ridge Volcanism (MARRVi)

Mindelo - Fort-de-France
15.02.-08.03.2009

Berichte aus dem Leibniz-Institut
für Meereswissenschaften an der
Christian-Albrechts-Universität zu Kiel

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Table of Contents

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Front page photos: POS 379/2 scientific party.

1. Scientific Party & Crew

Scientific Party

Svend Duggen	IFM-GEOMAR[1]	Chief Scientist
Romina Gehrmann	IFM-GEOMAR[1]	Magnetotellurics
Sandra Meissl	IFM-GEOMAR[1]	Petrology / Bathymetry
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Claudia Teschner	IFM-GEOMAR[1]	Petrology / Volcanology

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Proponents of the proposal for ship time for the R.V. Poseidon from the Steuergruppe Mittelgroße Forschungsschiffe were: Colin Devey, Svend Duggen, Ingo Grevemeyer, Thor Hansteen, Kaj Hoernle and Thomas Kokfelt (alphabetical order).

Crew

Michael Schneider	Captain
Theo Griese	First mate
Bernhard Windscheid	Second mate
Kurre-Klaas Kröger	First engineer
Günther Hagedorn	Second engineer
Hendrik Schmidt	Electrician
Rüdiger Engel	Motorman
Joachim Mischker	Bosun
Ronald Kuhn	Ship mechanic
Kai Riedel	Ship mechanic
Bernd Rauh	Ship mechanic
Jürgen Sauer	Ship mechanic
Pedro Barbosa	Seaman
Volkhardt Falk	Cook
Bernd Gerischewski	Steward

2. Introduction and Scientific Background

by Thomas Kokfelt and Svend Duggen

The oceanic crust develops a geochemical heterogeneity already by the time of its formation at mid-ocean ridges. This is reflected by lavas showing a considerable range in composition, ranging from normal- to enriched MORB (N-MORB to E-MORB), and the occurrence of E-MORB is often associated with increased crustal thickness. A heterogenous mantle source and variable melting processes appear to be what control the geochemical composition of relatively young oceanic crust. It is, however, poorly understood why and at what scale the mantle source in the vicinity of mid-ocean ridges is heterogenous, as to how it melts, and the relative importance of source variation and melting processes in producing the different types of MORB.

The proposed research project MARRVi (**M**id-**A**tlantic and **R**esearcher **R**idge **V**olcan**i**sm), will focus on the role of mantle processes responsible for the formation of different MORB types in the Central Atlantic Ocean. The POSEIDON will be used to obtain lava samples from the Mid-Atlantic Ridge (MAR) around the 15º 20´ N Fracture Zone and the associated off-axis Researcher Ridge (RR), a unique ca. 400 km chain of seamounts perpendicular to the MAR (Fig. 1). Although situated on 20-40 Ma old oceanic crust, seismic events along the RR point to recent volcanic activity. A combination of systematic sampling on the MAR and RR and state-of-the-art geochemical analysis and age dating of the recovered samples can be advanced to reconstruct the temporal and spatial geochemical evolution of the magmatism in the MAR-RR igneous system. Such data will provide new constraints on how lava geochemistry and crustal thicknesses at mid-ocean ridges is controlled by heterogeneities and melting processes in the oceanic upper mantle.

Upper mantle heterogeneity and origin of the oceanic lithosphere

Traditionally oceanic crust/lithosphere is thought being derived from depleted MORB type mantle. Increasing evidence, however, suggests that the oceanic lithosphere in the North Atlantic is highly heterogeneous in composition, showing a range equal to or even greater than normal mid-ocean ridge basalt (N-MORB) and ocean island basalt combined. This is the case even when the effects of recent hotspot volcanism (e.g. Canary, Madeira or Cape Verde Islands) are considered. Heterogeneity in the oceanic lithospheric composition occurs on crust of all ages and does not appear to correlate with crustal age. In part, the observed heterogeneity may reflect later incorporation of fertile, enriched subcontinental mantle or lower crustal material during a process of underplating and entrapment during or shortly after crustal ridge formation. However, it remains that a significant contribution to the overall range in compositions observed within the oceanic plate originates at the spreading ridge, as witnessed by the geochemical variation seen in zero-aged Mid Atlantic Ridge (MAR) basalts (HÉMOND et al., 2006).

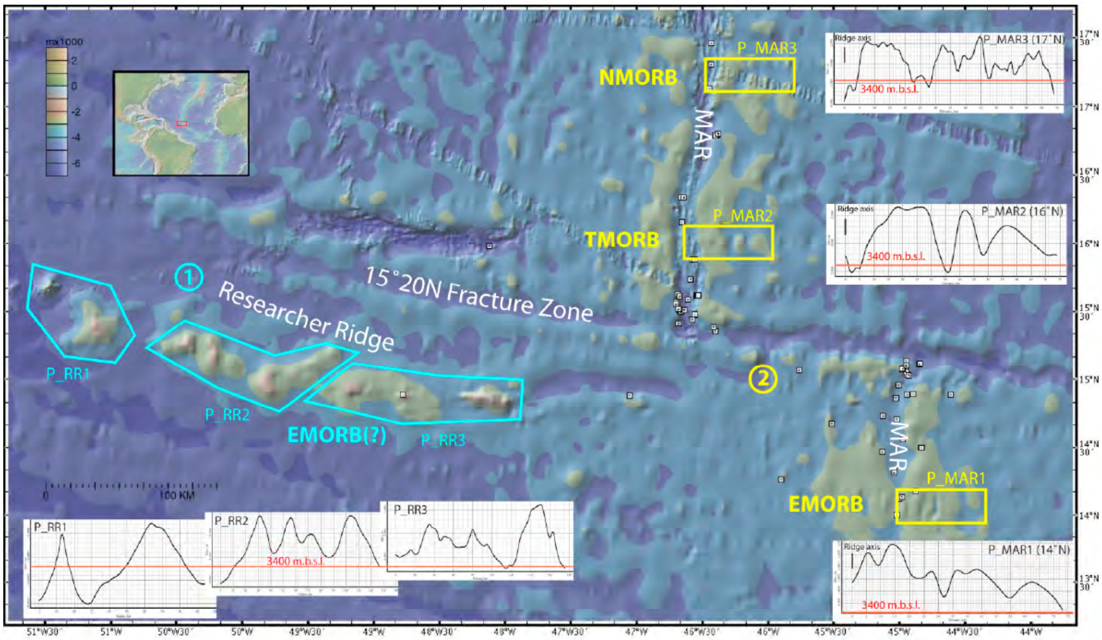


Figure 1*: Map showing the northern Central Atlantic region around 14-17° N. The two main working areas are: 1) Researcher Ridge (RR) (light blue boxes), a ca. 400 km long WNW-ESE oriented ridge situated about 200 km west of the active spreading axis, and 2) the Mid-Atlantic Ridge (MAR) at 14° N, 16° N and 17° N, where three profiles perpendicular to the MAR are shown (yellow boxes). The MAR lavas show a compositional gradation, going from E-MORB at ~14° N, over T-MORB at ~16° N, to N-MORB at ~17° N. Bathymetry along the three MAR profiles show short wave-length variations, or 'camel-back' patterns. Previous sampling in the area (white boxes) is almost entirely focussed on the ridge axis (HÉMOND et al., 2006). Source: GeoMapApp.*

Scales of upper mantle heterogeneity revealed by E-MORB

Short-medium wavelength geochemical anomalies along the MAR have for some time been well documented (DOSSO et al., 1999; SCHILLING et al., 1983; YU et al., 1997). Examples of such anomalies are the occurrence of enriched Mid Ocean Ridge Basalt (E-MORB) at latitudes around 9° S, 14° N, 23° N, 35° N, 39° N, 43° N and 46° N. Some of these enriched anomalies reflect the geochemical influence of nearby mantle plumes interacting with the ridge, such as the Azores hotspots influencing the MAR at 39° N (BOURDON et al., 1996). In a number of cases, however, E-MORB lavas were argued to occur isolated from any known mantle plumes. Examples of the latter include E-MORB at 14° N (DOSSO et al., 1993; DOSSO et al., 1991), and arguably at 43° N and 9° S MAR. Also in the MARK area (i.e., ~23° N MAR near the Kane Fracture Zone), which previously was thought to be homogeneously depleted, more recent high density sampling has revealed that a small proportion of basalt are enriched in incompatible elements (DONNELLY et al., 2004). Often these postulated non-plume influenced anomalies also represent positive bathymetric anomalies, as in case of 9° S and 14° N. The correlation between bathymetry and composition is consistent with E-MORB being derived from enriched and relatively fertile mantle material, as such material should melt to a higher extent than normal depleted upper mantle and therefore provide higher lava volumes to build up oceanic crust. Recent results from seismic tomography, however, point to the existence of an Atlantic Ridge mantle plume, at 300 km depth extending from 0° N to almost 40° N (MONTELLI et al., 2006), thus being located beneath the E-MORB domains at 9° N, 14° N and 35 ° N. Why such a mantle plume should contribute material to some areas of the MAR sub-ridge partial melting region and not in others remains unclear.

Three overall explanations have been offered to account for these intermediate-scaled enrichments of E-MORB: 1) recycled oceanic crust (with or without minor amounts of continental input) (HÉMOND et al., 2006; HOFMANN and WHITE, 1982), 2) recycled subcrustal (usually also oceanic) lithosphere that has been enriched 'metasomatically', that is, by infiltration of low-degree melts at some point during its way from the ridge through the subduction zone (DONNELLY et al., 2004; WORKMAN et al., 2004), or 3) shallowly recycled subcontinental lithosphere or lower continental crust in the upper mantle (RODEN et al., 1984; WIDOM et al., 1997). By constraining the likely origin of E-MORB, this ultimately may provide a key to understanding the organisation and scales of heterogeneity in the upper mantle. Central for distinguishing between the various models is to evaluate and quantify the relative roles on E-MORB generation of: 1) variable mantle temperatures, 2) variable melting processes (e.g., depths of melting, velocities of solid mantle upwelling and melt extraction), and 3) variable source composition. The existence of an Atlantic Ridge mantle plume, as recently evidenced by seismic tomography (MONTELLI et al., 2006), argue that any geodynamic model proposed for the origin of E-MORB in the northern central Atlantic should invoke larger-scale mantle upwelling.

The 14-17° N Mid Atlantic Ridge (MAR)

The proposed work area at 14-17° N MAR is situated in a transition zone on the spreading system that, to the south, shows a strong segmentation due to the oblique direction of spreading compared to the plate motion, and, to the north, is only moderately segmented (Fig. 1). In the proposed work area, the 15° 20´ N fracture zone offsets the two segments (100 km sinistral offset). Previous work in the area is almost entirely restricted to the rift valley and the study of zero-aged basalts (sample locations given as white boxes in Fig. 1). Based on geochemical and isotopic data it was shown that 14° N is characterised by E-MORB, and that compositions become progressively more depleted to the north and south of this latitude (DOSSO et al., 1993; DOSSO et al., 1991; HÉMOND et al., 2006). Thus, transitional MORB (T-MORB) occurs at 16° N and normal MORB (N-MORB) at 17° N. The chemical transitions are observed for trace element and isotope ratios (La/Yb_{Cho} = 2-5, $^{87}Sr/^{86}Sr$ = 0.7027-0.7028, $^{206}Pb/^{204}Pb$ = 18.5-19.2), indicating significant mantle source variations beneath this part of the MAR. The 14° N domain also represents a positive melt anomaly, as the axial depth here is at ~3,000 m, compared to ~3,500 m at 16° N and ~4,000 m at 17° N (Fig. 1).

We aim to sample along a transect perpendicular to the MAR. The obvious advantage of this sampling strategy is to obtain information about the temporal lava chemistry at the ridge axis. The proposed location for our three profiles (P_MAR1-3) are at 14° N, 16° N and 17° N (Fig. 1), i.e., at latitudes of contrasting enrichment in the axial lavas (i.e., E-MORB, T-MORB, N-MORB). One of the intriguing features of the local MAR region, apart from the contrasting chemistry, are the short wavelength (~10-20 km) variations in bathymetry observed as series of ridges and structures aligned sub-parallel to the spreading axis (Fig. 1). These undulations in water depths produce a 'camel-back' pattern, which is particularly pronounced at 14° N, 16° N and 17° N, where we placed three profiles (Fig. 1). Each of the profiles starts at the spreading axis and ends at about 80-100 km off-axis (ca. 6-7 Myr old crust) to the east, where the relief flattens out and the sediment cover increases. Over lateral distances of 10-20 km, the relative topography varies by up to ~1,000 m. Sampling the topographically high and low areas along the profiles will be equally important, this will provide a test of whether the crustal thickness variations are reflected in the rock chemistry. For time reasons, the three profiles are placed on only one side (east) of the MAR, a decision that is justified by the expected symmetry around the spreading axis (e.g., (STURM et al., 2000)). The profiles have been placed on to the east of the MAR, as this side appears to have a slightly more distinct off-axis relief, compared to the western side (Fig. 1).

Whereas the progressive smoothening of the relief further off-axis could reflect degradation of the structures due to subsurface weathering and alteration, the origin of these fluctuations are most likely to reflect temporal changes in melt production at the MAR. Thus, one thing to investigate is how long back in time the enriched anomaly at 14° N has existed, and if enriched lavas possibly occur along the other two profiles. If any changes in chemistry can be detected along any of the profiles, this will constrain the likely scales of mantle source heterogeneity beneath the MAR today.

The Researcher Ridge

The Researcher Ridge is about 400 km long and consists of single volcanic structures (seamounts) that are aligned to form a WNW-ESE oriented chain (Fig. 1). The crust underlying the entire RR ranges in age between ca. 20 Myr in the east to ca. 40 Myr in the west, corresponding to Chron 6 and 18, respectively (MÜLLER et al., 1997). Two recorded events of seismic activity along the RR have been reported (ENGDAHL et al., 1998), indicating that volcanic activity may still be ongoing. The minimum water depths increase from ca. 800 m in the east to ca. 1,300 m in the west, which reflects the deepening of the seafloor level with increasing age, rather than a change in the relative topography along the ridge structure (Fig. 1). Considering the likely amount of subsidence of the plate following isostatic compensation due to the effect of cooling and contraction, it is not impossible that the easternmost seamount could have been above the water surface, assuming that it formed at the MAR. If so, it would be expected to find evidence for wave activity (coarse grained sediments and boulders) and fossils of photic fauna (e.g. mollusks). Dredging has to be done on the top and at the basal parts of the individual structures (seamounts) to ensure representative sampling of oldest and youngest material. For example, in order to detect any transgression in magmatic activity along the RR with time, lavas belonging to the shield building phase (base of the structures) should be collected.

The chemical data available from the RR is restricted to two samples from the eastern part of the ridge. These data show an enriched geochemical and isotopic signature, similar to the E-MORB at 14° N MAR (see below), but with even higher $^{87}Sr/^{86}Sr$ (0.7032 and 0.7034), and similar $^{206}Pb/^{204}Pb$ (18.9 and 19.1) and La/Yb_{Cho} (5.6 and 10.9). The geochemical and isotopic similarity with the presently erupted MAR basalts at similar latitude, could indicate a genetic relationship between these two areas. One possibility could be derivation from a common mantle plume (DOSSO et al., 1991), in particular because recent results from seismic tomography point to the existence of an Atlantic Ridge mantle plume (MONTELLI et al., 2006). An alternative origin is by melting of a heterogenous mantle source, containing more enriched domains that are passively embedded in a depleted mantle matrix. One model is that the RR formed as the result of the migration of the triple junction between North and South America and Africa (ROEST and COLLETTE, 1986). New chemical and isotopic data from along the RR should provide new insights into its temporal and chemical evolution, which will help to clarify its origin, and in turn, shed new light on the processes responsible for oceanic crust formation and the scales of upper mantle heterogeneity.

3. Methods

3.1. ELAC multi-beam echosounder

ELAC multi-beam echosounder

Bathymetric information was generated by means of a mobile Seabeam 1000 system (ELAC Nautic GmbH). The ELAC system is build up by two transmitter/receiver units, motion sensor and CTD, which were installed in the moonpool (Hydrographenschacht) of the vessel Poseidon. GPS data stems from the vessel's DataVis-system. A first calibration was carried out in shallow water and a flat sea bottom to correct the bias between the ships vertical reference and the sonar. Supplementary a CTD was performed to obtain a sound velocity profile, determined by measuring the temperature, pressure and salinity.

The multi-beam-system was set at 50 kHz and to a 120° cover sector. Due to relatively great depth, the swath width was set between 60° and 80°. Data acquisition was done with the Hydrostar 3.4 software. The data were processed with the Mbsystem software package whereas MBedit was used for data editing and MBgrid for bathymetric grid calculation. Final bathymetric maps were realised in GMT. The 3D-Visualisation was done at IFM-GEOMAR with Fledermaus software. The ELAC multi-beam system is capable of giving trustful data down to a depth of around 2,000 m. Some of the areas of interest, however, were situated close to or below the recordable depth. We recognized a strong influence of weather conditions on the quality of the ELAC data. Under rough sea conditions it was only possible to record proper data if waves and swell came from astern. Together, ca. 15 profiles at Rocket Seamount and the Researcher Ridge were conducted during the cruise POS 379/2. Aim of the surveys was to provide bathymetric information of the summit region of selected seamounts and to determine areas of interest for dredging (preferentially relatively steep slopes). For water depths greater than 2,000 m we used bathymetric data from previous cruises with research vessels permanently equipped with deep-sea multi-beam systems, if available.

3.2. The chain sack dredge

A fairly simple but effective way to obtain rock samples from seamounts is by dredging. Figure 2 shows a chain sack dredge used on POS 379/1 that weighs almost 500 kg. The bottom is open with a chain sack attached. Samples hauled into the dredge during the dredging process will usually fall into the chain sack and effectively be trapped there. During the POS 379/1 the dredge was mounted to a ca. 4,100 m long wire on the W3 heavy weight winch. With the given configuration sampling down to ca. 3,500 was possible, with several hundred metres in addition laid out on ground. The dredge can be used to sample the plateau region and flanks of seamounts and cone and ridge structures as well as the MOR axial valley and MOR shoulders. Inside the dredge four tubes are mounted in each corner, in which sediments can be trapped. Dredging and hauling is generally done with the winch rather than the ship.

Figure 2. *A chain sack dredge of the Department of Magmatic and Hydrothermal Systems at IFM-GEOMAR on the port side deck of the German research vessel Poseidon. Photo: POS 379/1 Scientific Party.*

3.3. Magnetotellurics

The magnetotelluric experiment was part of the geophysical study of the Logatchev HYDROthermal vent field and its magmatic PLUMBing system and was previously scheduled on the Maria S. Merian cruise MSM 10/2. Due to technical problems of MS Merian, however, it was moved to the Poseidon cruise POS-379/2. The passive magnetotelluric method is applied to reveal the electrical conductivity distribution below the sea floor and complements other geophysical studies in the area such as active seismic and long-term seismic measurements. The geophysical experiments can provide new constraints on the relationship between the crustal structure on the surface, the magmatic plumbing system and its pathways, the heat transport, the micro-seismicity and the hydrothermal vent activity in the Logatchev field at the slow-spreading Mid-Atlantic Ridge.

The sources of the signal are low frequency electromagnetic waves (< 1 Hz), produced naturally by currents in the ionosphere. The receivers (Ocean Bottom Magnetometers, OBMT) measure the induced electric and magnetic fields at the seafloor. Electric field measurements are performed through two orthogonal 10 m long electric dipole antennas, kept in place by polyethylene (PE) tubes mounted on a frame of titanium and PE. Magnetic field measurements occur through fluxgate magnetometers, placed inside titanium cylinders mounted on the OBMT frame. The cylinders also contain a data logger and control unit recording three components of the magnetic field, the horizontal electric fields and the horizontal tilt variations at a sampling rate of 1 Hz.

Figure 3. *A MT-Lobster station (designed at the IFM-GEOMAR in Kiel) is deployed on Poseidon cruise POS-379/2.*

The MT instruments (Fig. 3) were deployed along a 2-D profile perpendicular to the strike direction of the spreading center as outlined in the MT station protocol below. The orientation of the profile can be further used for 1-D and 2-D inversions of the apparent resistivity data resulting in a conductivity-depth distribution of the subsurface. The instruments are attached to concrete anchors using releasers and deployed at the sea floor in free fall in the water column. The releasers open upon receive of an acoustic signal (12 kHz) transmitted with a specified code from the recovering vessel, causing the instruments to rise to the sea level surface due to the buoyancy of syntactic floats. On this deployment, the instruments are planned to remain on the seafloor for at least several weeks. Magnetotelluric response, consisting of the ratio of electric and magnetic field variations, may be recorded in a frequency range of 0.1 Hz to 10-5 Hz, where high frequencies yield information about the shallow structure and low frequencies about the deeper structure of the subsurface. From the expected frequency range of the data we estimate that the method is sensitive to resistivity variations on a few kilometre scale, down to a depth of 50 km based on a typical resistivity model of a mid-ocean ridge.

Table 1. Magnetotelluric (MT) station protocol.

MT station	Date (UTC)	Time	Latitude	Longitude	Depth (mbsl)
MT001	25/02/09	12:15	14°48.65' N	45°09.19' W	3,500 ± 300
MT002	25/02/09	14:10	14°47.75' N	45°14.58' W	3,000 ± 300
MT003	25/02/09	16:36	14°46.91' N	45°10.06' W	3,200 ± 300
MT004	25/02/09	18:11	14°46.16' N	45°06.02' W	3,200 ± 300
MT005	25/02/09	19:35	14°45.62' N	45°02.99' W	4,070 ± 50
MT006	25/02/09	21:02	14°45.17' N	45°00.49' W	3,600 ± 50
MT007	26/02/09	11:13	14°44.57' N	44°57.47' W	2,900 ± 50
MT008	26/02/09	12:27	14°44.15' N	44°54.98' W	2,500 ± 300
MT009	26/02/09	13:31	14°43.70' N	44°52.49' W	2,200 ± 300
MT010	26/02/09	14:31	14°43.12' N	44°49.47' W	2,500 ± 300
MT011	26/02/09	16:05	14°42.52' N	44°46.23' W	2,800 ± 300
MT012	26/02/09	17:01	14°41.76' N	44°42.06' W	2,600 ± 300

4. Regional Geology and Preliminary Results

4.1. Isolated seamounts

The eastern central Atlantic basin hosts several isolated seamounts or clusters of few seamounts, rising up to 3 km above the deep sea floor. Some are only indicated from satellite altimetry (SMITH and SANDWELL, 1997) but others were reported to exist from former cruises (e.g. Mt. Dementskoy, Kane seamount and Krylov seamount) as described in more detail in the report of the previous cruise POS 379/1 (ViKKi) (DUGGEN et al., 2009). Rocket Seamount, a large seamount about 600 nautic miles west of the Cape Verde Islands, was originally planned to be a working area during the cruise POS 379/1 but was chosen to be investigated during the POS 379/2 cruise for logistic reasons. The scientific background for the possible origin of isolated seamounts and possibly associated hydrothermal activity for the chemical evolution of the oceanic crust are outlined in the report of the cruise POS 379/1 (ViKKi) (DUGGEN et al., 2009).

Rocket Seamount

Based on satellite altimetry the seamount is approximately 40 km wide at its base and rises about 3,000 m above the surrounding deep sea floor, with the summit area found around 1,100 mbsl (SMITH and SANDWELL, 1997). In official printed and electronic sea charts, however, the summit region is displayed with 640 mbsl. To our knowledge, so far no sampling of the seamount has been performed.

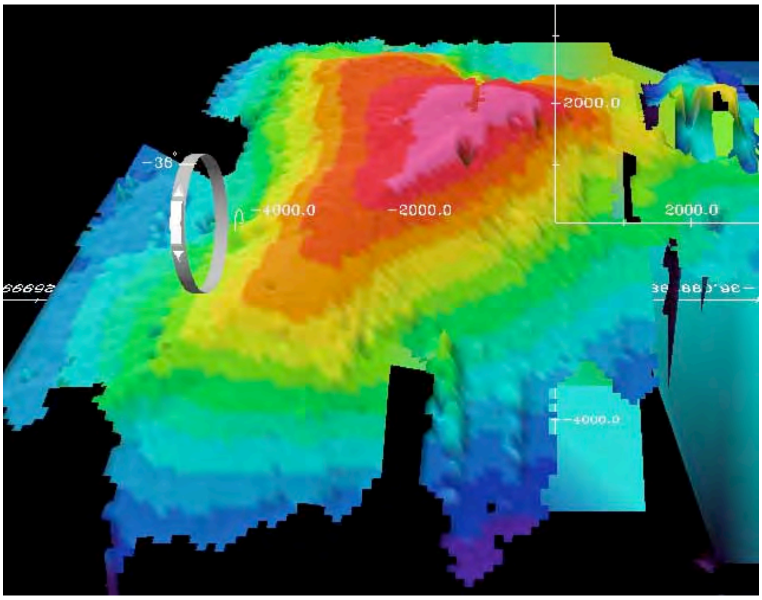


Figure 4. *Bathymetric data of the summit area of the Rocket Seamount, generated during cruise POS 379/2 by means of the ELAC multi-beam system and data displayed by Fledermaus software. The summit area lies at ca. 600 mbsl. Not exaggerated.*

Our multi-beam bathymetric data confirms the shallower depth of the summit at 600 mbsl and reveals new insights to the geometry of the summit area (Fig. 4). Instead of a highly symmetric, cone-like (or rocket-like) feature as inferred from satellite data, the multi-beam mapping results display a north-south-trending, slightly elongated summit area apparently branching out in three directions. The summit area appears to extend from the peak at about 600 mbsl down to ca. 2,100 mbsl, where the slope decreases. Several dredge hauls (DR1 to DR5) between 2,700 to 790 mbsl recovered well-lithified micritic and bioclastic limestones, the origin of which are most likely associated with a former reef. Despite two strong bites during dredging, a relatively deep dredge haul at 3,300 mbsl at the west flank of Rocket Seamount recovered only deep-sea mud. The material obtained suggests that the summit region of Rocket Seamount is covered by limestone, probably linked to a former and now drowned reef. Volcanic rocks were not found but a volcanic origin of the mountain is likely. Another dredge haul recovered up to 1 cm thick dense and well-layered manganese crusts from ca. 1,000 to 800 mbsl. Successful sampling of igneous rocks from Rocket Seamount requires a larger research vessel, detailed bathymetric mapping and sampling of the deeper flank regions of the seamount eventually using heavier dredges, or drliing.

4.2. Mid-Atlantic Ridge (MAR)

Part of the mid-Atlantic Ridge area around the 15° 20´ N fracture zone are the Logatchev Field and, on the shoulders of the MAR, camel-back-like bathymetric highs found in east-west profiles (Fig. 1). The bathymetric highs are sections of north-south trending ridges oriented parallel to the axial valley. Twelve magnetotelluric devices were successfully deployed along a west-east profile crossing the Logatchev field (Table 1). Recovery was scheduled for a later cruise, resulting in standing times of at least several weeks.

Based on satellite altimetry and printed bathymetric maps, dredge points were chosen on slopes of the near-axis north-south trending ridges (Table 3). Due to very rough sea and loss of three working days in the MAR area, dredging focused on the E-MORB domain south of the Logatchev Field and, unfortunately, had to be cancelled in the T-MORB and N-MORB domains due north of the 15° 20´ fracture zone due to unfavourable weather conditions.

The first dredge haul (DR 6) recovered a relatively wide range of igneous rock, including fresh to slightly altered pillow lavas containing some olivine and plagioclase that therefore most likely are tholeiites. The dredge also contained slightly to moderately altered igneous rocks with plutonic texture containing plagioclase, pyroxene and presumably altered olivine, so these rocks are most likely gabbros. The samples, especially the gabbros, showed signs of moderate to strong tectonic deformation such as harnisch, open fractures or fractures healed with secondary minerals. So obviously, the dredge haul was performed very close to and eventually across a fracture zone that probably is north-south trending and seems to be associated with the ridges parallel to the MAR axial valley.

Two off-axis dredge hauls (DR7 and DR8) at the western slopes of bathymetric highs (dredging had to be conducted towards the east due to the trade winds) recovered only deep-sea muddy sediments but no igneous rocks, probably due to considerable sediment cover. Another dredge haul was performed at the western flank of the Menner Seamount (see Seamount Catalog, http://earthref.org) also found within the E-MORB domain. The haul recovered a remarkable range of igneous rocks, including: 1) pebbles and cobbles of fairly fresh dark grey lava (with former olivine phenocrysts oxidised and possibly alkali basaltic lava) found in highly (hydrothermally?) altered igneous, partly clastic material, 2) slightly altered, pale grey, slightly olivine- and plagioclase-phyric (probably tholeiitic) lavas that were tectonically affected, showing cross-cutting multiple fractures healed with secondary minerals, brecciation and cataclastite, 3) moderately to strongly altered equigranular igneous rocks (with coarser grain size than the grey lavas), containing altered olivine?, pyroxene and plagioclase, so apparently hypo-volcanic, and 4) plutonic rocks with most likely plagioclase and possibly alkali feldspar (with interference colors, labradorite?) and/or hornblende?, with fresh interior but 1-2 cm rim of alteration. The plutonic rocks are grey-blueish on freshly broken surfaces and wet cut surfaces. The tectonic characteristics of the samples, however, indicate that the origin of the ca. 1 km high Menner Seamount is associated with a deep-going fault and probably alkaline magmatism.

4.3. Researcher Ridge

The Researcher Ridge is a ca. 400 kilometre long, east-west-trending chain of seamounts due south and parallel to the 15° 20´ N fracture zone (Fig. 5). Two of the seamounts were already listed named in the Seamount Catalogue (http://earthref.org): Vayda Seamount and Molodezhnaya Seamount. Satellite altimetry data suggests that the summit areas of the Researcher Ridge seamounts range from ca. 800 mbsl to 1,300 mbsl, largely progressively deepening to the west.

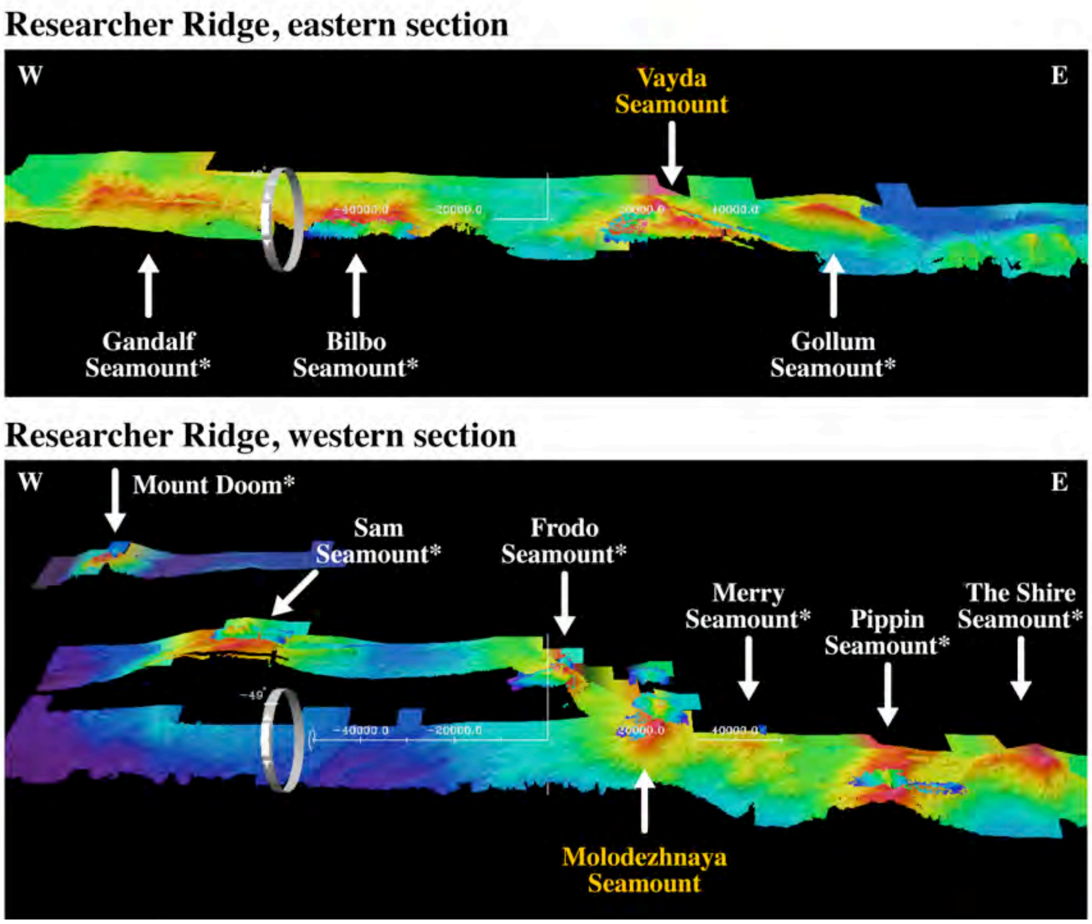


Figure 5. *Bathymetric data of the western and eastern section of the Researcher Ridge as outlined in the main text. Names shown are those of previously named seamounts (Vayda and Molodezhnaya Seamounts) and working names of the remaining seamounts (Gollum, Bilbo, Gandalf, Pippin, Merry, Frodo, Sam Seamounts and Mount Doom, indicated with asterisk).*

New bathymetric data were generated with the German R.V. Maria S. Merian during the cruise MSM 10/2 in 2008 and on request during another cruise in January/February 2009 that took place at the same time as our POS 379/1 cruise (ViKKi). The data was transferred in the beginning of cruise POS 379/2 (MARRVi) via the IFM-GEOMAR server and, after processing, further on board the R.V. Poseidon. Significant amounts of additional bathymetric data were generated during POS 379/2 using the ELAC multi-beam. Several so far unnamed seamounts were assigned working names as outlined in Figure 5: “Gollum Seamount” due east of Vayda Seamount (summit at ca. 1,450 mbsl), two east-west trending seamounts “Bilbo Seamount” and “Gandalf Seamount” (from east to west) due west of Vayda Seamount with summit areas at ca. 950 mbsl ca. 1,400 mbsl, respectively; “The Shire Seamount” ca. 80 nautic miles west of Vayda Seamount and summit area at ca. 1,200 mbsl; “Pippin Seamount” and “Merry Seamount” due west of “The Shire Seamount” and summit depths at ca. 1,120 mbsl and <1,950 mbsl; “Frodo Seamount” due northwest of Molodezhnaya Seamount and summit at ca. 960 mbsl, “Sam Seamount” ca. 40 nautic miles northwest of Molodzhnaya Seamount and summit at ca. 800 mbsl; and finally “Mount Doom”, the westernmost seamount of the Researcher Ridge system with summit at ca. 2,050 mbsl.

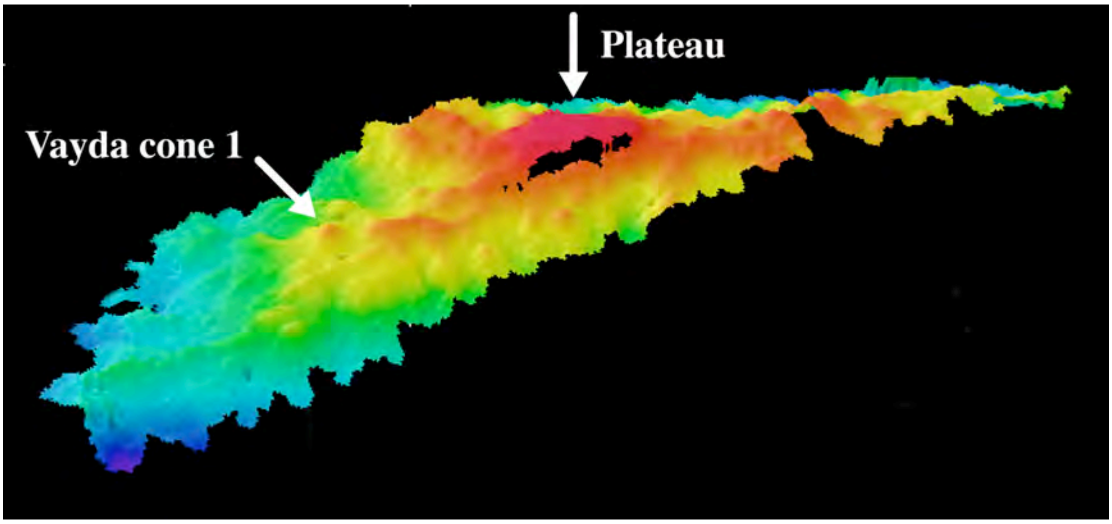


Figure 6. *ELAC multi-beam bathymetric data of the summit region of Vayda Seamount, generated during the POS 379/2 cruise. The summit area hosts a small central plateau at ca. 400 mbsl, which is surrounded by numerous cone-like structures. One of these, Vayda cone 1, with the summit at 830 mbsl has the size and geometry typical of a scoria cone. The cone was sampled successfully recovering rounded cobbles of lava, most likely affected by wave action after eruption.*

During the cruise POS 379/2 (MARRVi) samples were recovered from Vayda Seamount, The Shire Seamount, Molodezhnaya Seamount, Frodo Seamount and Mount Doom (DR11 to DR21). In the summit area of Vayda Seamount numerous cone-like structures were discovered by means of the ELAC multi-beam system. One of the cones (Vayda Cone 1) was successfully sampled (Fig. 6). Samples found at the Researcher Ridge are rounded basaltic lava cobbles with thin manganese crust from Vayda Seamount. Thick manganese crusts with some lava were found at the western flank of The Shire Seamount. Reef-facies limestone with thin manganese crust and single lava pebbles were recovered from the summit area of Molodezhnaya Seamount but hyaloclastites, columnar lava flow fragments and partly fresh and glass-rich lava (probably scoria) were obtained from an asymmetric cone-like structure at the western flank of Molodezhnaya Seamount. At Frodo Seamount bioclastic limestone with manganese crusts was recovered from the summit area but numerous clasts of different lavas and manganese crusts were obtained from a N-S-trending ridge structure at the northern flank. Samples dredged in the summit area of Mount Doom were bioclastic limestone and manganese crusts.

The samples indicate that the seamounts of the Researcher Ridge are old structures of which the summit areas were situated close to the sea level in an earlier stage of their evolution, at this time probably located much closer to the Mid-Atlantic Ridge. Although many of the seamounts seem to be guyots and are possibly almost as old as the underlying oceanic crust, the presence of cones on these seamounts and recovery of relatively fresh (glassy) lavas from one of these cones (at Molodezhnaya Seamount), indicates fairly recent re-activation of the igneous activity in some areas.

5. Cruise Narrative

Pre-cruise preparation

As part of the pre-cruise preparation we responded to an enquiry of the U.S. Navy on January 8 asking for the coordinates of the working areas and a timetable in order to route submarines around safely as needed. The enquiry was responded to immediately as outlined in Table 2.

February 15th, 2009 – Sunday

The R.V. Poseidon left the harbour of Mindelo and headed for Rocket Seamount about 600 nautic miles west of the Cape Verde Islands. During the transit the scientific party proceeded with the cruise report.

February 16th, 2009 – Monday

Transit to Rocket Seamount. The scientific party worked on the cruise report and prepared the laboratories and scientific equipment for the next working area.

February 17th, 2009 – Tuesday

Transit to Rocket Seamount. The scientific party worked on the cruise report and prepared the laboratories and scientific equipment for the next working area.

February 18th, 2009 – Wednesday

Arrival at Rocket Seamount. The ELAC multi-beam was started and a track of the summit area of the seamount was mapped. Close to noon the first dredge haul (DR1) was performed at the southwestern flank at 2,750 mbsl while the multi-beam data was processed. Based on the first bathymetric data a second dredge station (DR2) was selected at 1,200 mbsl at the western flank of the seamount. Samples obtained were processed immediately. Mapping of the summit region of Rocket Seamount using the multi-beam was finalised overnight.

February 19th, 2009 – Thursday

Based on the new bathymetric data three dredge stations were assigned at the western flank of the seamounts: One at intermediate depth at 1,800 mbsl (DR3), one at shallow depth eat 970 mbsl (DR4) and one deep dredge haul at ca. 3,300 mbsl (DR5). For the last dredge haul, due to the depth, no multi-beam data was available so that station selection was based on the on-board single beam signal that, unfortunately, temporarily was out of order. After the last station at Rocket Seamount the ELAC multi-beam was taken up inside the moonpool and the R.V. Poseidon headed for the next working area at the mid-Atlantic ridge (MAR).

Table 2:

Coordinates of the working areas and timetable sent to the US Navy Jan. 2009

	Start (earliest)	End (latest)	Longi-tude	Latitude	Longi-tude	Latitude	Planned work
Working area 1 With unnamed seamount	28. Jan. 6 am		26.9°W	26.4°N	25.6°W	26.4°N	Bathymetric mapping using multi-beam-echosounder. Sampling of geological material by dredging (to max. 3500 mbsl).
in box defined by:		05. Feb. 6 pm	26.9°W	25.3°N	25.6°W	25.3°N	
Working area 2 With unnamed and Kane seamount(s)	30. Jan. 6 am		30.5°W	21.5°N	27.5°W	21.5°N	Bathymetric mapping using multi-beam-echosounder. Sampling of geological material by dredging (to max. 3500 mbsl).
in box defined by:		08. Feb. 6 pm	30.5°W	20.0°N	27.5°W	20.0°N	
Working area 3 With unnamed and Krylov seamount(s)	01. Feb. 6 am		30.8°W	18.0°N	28.8°W	18.0°N	Bathymetric mapping using multi-beam-echosounder. Sampling of geological material by dredging (to max. 3500 mbsl)
in box defined by:		12. Feb. 6 pm	30.8°W	16.8°N	28.8°W	16.8°N	
Working area 4 With unnamed and Rocket seamount(s)	02. Feb. 6 am		38.0°W	17.0°N	34.0°W	17.0°N	Bathymetric mapping using multi-beam-echosounder. Sampling of geological material by dredging (to max. 3500 mbsl).
in box defined by: Incl. harbour stay in Mindelo, Cabo Verde		23. Feb. 6 pm	38.0°W	14.5°N	34.0°W	14.5°N	
Working area 5 With Mid-Atlantic Ridge and seamounts	21. Feb. 6 am		47.2°W	18.0°N	44.0°W	18.0°N	Bathymetric mapping using multi-beam-echosounder. Sampling of geological material by dredging (to max. 3500 mbsl).
in box defined by:			47.2°W	12.5°N	44.0°W	12.5°N	
			46.0°W	15.5°N	44.0°W	15.5°N	Deploying magnetotelluric equipment at the seafloor for magnetic field measurements.
			46.0°W	12.5°N	44.0°W	12.5°N	Ca. 12 devices each of ca. 20 m x 20 m x 20 m size. Standing time ca. 5 weeks.
		04. March 6 pm					
Working area 6 With Researcher Ridge seamounts	22. Feb. 6 am		52.0°W	16.0°N	46.5°W	16.0°N	Bathymetric mapping using multi-beam-echosounder. Sampling of geological material by dredging (to max. 3500 mbsl).
in box defined by:		07. March 6 pm	52.0°W	14.0°N	46.5°W	14.0°N	
							No dredging during transits between the working areas.

February 20th, 2009 – Friday

On transit to working area 5, MAR. The scientific party processed the samples obtained from Rocket Seamount, prepared the scientific equipment such as the dredge (the used was replaced with a new one due to damage of the chain sack) and the 12 magnetotelluric (MT) devices, and worked out a more detailed working plan/timetable for the next working area.

February 21st, 2009 – Saturday

On transit to working area 5, MAR. The scientific party finalised processing the samples obtained from Rocket Seamount, continued to prepare the 12 magnetotelluric (MT) devices for operation and worked on the cruise report.

February 22nd, 2009 – Sunday

It was scheduled to release 12 magnetotelluric (MT) devices along a W-E-trending profile in the Logatchev Field at the mid-Atlantic Ridge (MAR) at ca. 14° 30´ N as outlined in Table 1. Due to bad weather conditions (very rough sea) and for safety reasons the work had to be postponed. Dredging was not possible either.

February 23rd, 2009 – Monday

Due to bad weather conditions (very rough sea) and for safety reasons the deployment of the MT-devices had to be postponed again. The longer-term weather forecast, however, predicted more favourable conditions from Tuesday/Wednesday on. Since deployment of the MT-devices is possible at slightly rougher sea than dredging it was decided to stay and wait near the working area until being able to conduct the deployment.

February 24th, 2009 – Tuesday

Weather conditions and safety issues did neither allow deployment of the MT-equipment nor dredging. The short-term weather forecast predicted more favourable conditions for Wednesday.

February 25th, 2009 – Wednesday

Weather conditions had improved finally allowing bringing out the first six MT-devices across the Logatchev Field. A MT-device was mounted and made ready while the vessel moved between the station points about 4-5 nautic miles apart.

February 26th, 2009 – Thursday

Weather conditions had further improved. The remaining six MT-devices were successfully deployed across the Logatchev Field. Since weather conditions had improved further during the day, dredging became possible too. Therefore a dredge point was chosen ca. 30 nautic miles southeast of the Logatchev Field and east of the MAR, in order to use properly the remaining time of the day. The dredge haul (DR6) was performed at about 3.300 mbsl. Processing of the samples obtained started as soon as the dredge was back on board. Over night the vessel headed for the next working area at the MAR further south.

February 27th, 2009 – Friday

Three dredge hauls were done in the MAR E-MORB domain: two at ca. 3,000 mbsl on the western slopes of two north-south-trending ridge structures parallel to the MAR (DR7 and DR8) and one at about 3,000 mbsl at the Menner Seamount (DR 9).

The scientific party finalised processing the samples obtained the day before and started to process the new samples. At the end of the day the vessel headed for the first seamount at the eastern end of the Researcher Ridge, 200 nautic miles further east.

February 28th, 2009 – Saturday

During the day the vessel was still on transit to the Researcher Ridge. The scientific party proceeded with processing the samples obtained the day before. The vessel arrived to the first seamount of the Researcher Ridge in the evening. Since there was not sufficient time for a dredge haul, the ELAC multi-beam system was started for over night bathymetric mapping of the Vayda Seamount, filling in gaps in the bathymetric data available (Figs. 5 and 6).

March 01st, 2009 – Sunday

The first dredge haul (DR10) was performed at the western flank of Vayda Ridge at ca. 2,000 mbsl. During the dredge haul the main wire unexpectedly broke (at 15 Mp, corresponding to 7.5 tons) despite a successful force test of up to 18 Mp (ca. 9 tons) the day before. The wire broke about 80 m above the dredge, which therefore was lost. The wire was cut several metres above the broken end by the ship crew and another force test was performed. During the test the main wire broke again at a force of about 8 tons. Then the ship crew decided to cut the lower 200 metre of cable that already showed numerous kinks. The wire withstood a new force test of up to 19 Mp (9.5 tons). Another chain sack dredge was made ready and connected to the main wire. Two following dredge hauls (DR11 and DR12) at the west flank of Vayda Seamount at ca. 1,600 mbsl and a cone in the central part of Vayda Seamount at ca. 1,000 mbsl (Fig. 6) recovered new samples that were processed immediately. For the night the vessel headed for "The Shire Seamount", located in the central part of the Researcher Ridge. During the night two profiles were bathymetrically mapped across "Bilbo Seamount" and "Gandalf Seamount" using the ELAC multi-beam to fill up gaps in the bathymetric data set (Fig. 5).

March 02nd, 2009 – Monday

Three dredge hauls were performed due southwest of the summit area of "The Shire Seamount" at ca. 2,500 mbsl and 1,900 mbsl and one at the westernmost end of the seamount at 2,500 mbsl (DR13 to DR15) (Fig. 5). In the evening the vessel headed for Molodezhnaya Seamount in the Researcher Ridge ca. 80 nautic miles further east. Overnight bathymetric mapping was performed to extend the bathymetric data of Pippin Seamount and Merry Seamount (Fig. 5). Further bathymetric data of the summit area of Molodezhnaya Seamount were also generated.

March 03rd, 2009 – Tuesday

Two dredge hauls were performed at Molodezhnaya Seamount at about 1,300 mbsl (DR16), one at the southern end of the summit area and another at ca. 3,000 mbsl at the southern flank (DR17). During the two east-west dredge hauls the dredge got stuck but by significantly changing the ship position to the south of the presumed location of the dredge and repeated heaving and slacking the dredge was released and brought on deck safely. Samples, however, were only recovered from the summit area. In the evening the vessel started with an overnight mapping program, producing more bathymetric data of Molodezhnaya Seamount and Frodo Seamount.

March 04th, 2009 – Wednesday

In the very early morning the vessel had returned to a dredge location at the western flank of Molodezhnaya Seamount and recovered a large amount of samples from ca. 2,300 mbsl (DR18) while the bathymetric data of Frodo Seamount was processed. Then the vessel headed for two dredge locations at Frodo Seamount, one at the summit area at ca. 1,000 mbsl (DR19) and one at a north-south trending ridge at the northern flank at ca. 2,100 mbsl (DR20). Over night new bathymetric data was added to Sam Seamount and the westernmost seamount of the Researcher Ridge, Mount Doom (Fig. 5).

March 05th, 2009 – Thursday

Time for a final dredge haul (DR21) at Mount Doom was available that recovered samples from ca. 2,400 mbsl. Hereafter the R.V. Poseidon had to head for the port of call, Fort de France on Martinique. While on transit, the scientific party processed the samples in the laboratory and dismounted and packed the mobile ELAC multi-beam system.

March 06th, 2009 – Friday

The vessel was on transit to Fort de France. The scientific party finalised processing the samples, started with cleaning the laboratories and packing the container.

March 07th, 2009 – Saturday

The vessel was on transit to Fort de France. The scientific party finalised cleaning the laboratories and packing the container.

March 08th, 2009 – Sunday

The R.V. Poseidon arrived to Fort de France of Martinique in the Antilles early in the morning as scheduled.

March 09th, 2009 – Monday

The scientific party left the cabins clean and got prepared for the journey home to Germany late in the evening.

6. Station Summary

Table 3: Summary of dredge locations during the POS 379/2 cruise.

Date/Time (UTC)	Station No.	Lat./Long. (start) Depth (mbsl)	Lat./Long. (on bottom) Depth (mbsl)	Lat./Long. (off bottom) Depth (mbsl)	Lat./Long. (End) Depth (mbsl)	Comment
18.02.2009 13:24 – 16:57	DR1	15°47,03'N 36°13,61'W 2,763 m	15°47,17'N 36°13,34'W 2,754 m	15°47,72'N 36°12,39'W 2,211 m	15°47,60'N 36°12,23'W 2,217 m	Dredging Rocket seamount SW- flank
18.02.2009 17:31 – 19:40	DR2	15°48,98'N 36°11,25'W 1,283 m	15°49,05'N 36°10,98'W 1,205 m	15°49,10'N 36°12,73'W 1,023 m	15°49,10'N 36°12,73'W 995m	Dredging Rocket Seamount W- flank of the cone
19.02.2009 10:05 – 12:56	DR3	15°49,83'N 36°11,59'W 1,799 m	15°49,91'N 36°11,25'W 1,800 m	15°50,02'N 36°10,77'W 1,039 m	15°50,00'N 36°10,75'W 1,110 m	Dredging Rocket Seamount Ridge structure, W- flank
19.02.2009 14:13 – 15:57	DR4	15°51,14'N 36°10,71'W 1,091 m	15°51,11'N 36°10,61'W 969 m	15°51,20'N 36°10,20'W 792 m	15°51,20'N 36°10,20'W 792 m	Dredging Rocket Seamount W- flank
19.02.2009 18:22 – 22:10	DR5	15°51,42'N 36°14,33'W 3,300 m	15°51,36'N 36°14,33'W 3,300 m	15°51,55'N 36°14,07'W 3,000 m	15°51,70'N 36°14,07'W 3,000 m	Dredging Rocket Seamount W- flank
26.02.2009 19:12 – 22:38	DR6	14°31,00'N 44°51,65'W 3,350 m	14°31,00'N 44°51,57'W 3,326 m	14°30,90'N 44°50,85'W 2,957 m	14°30,73'N 44°50,52'W 2,957 m	Dredging E-MORB domain Western slope of N-S trending ridge
27.02.2009 09:0 2 – 12:29	DR7	14°04,03'N 44°28,59'W 3,079 m	14°03,99'N 44°28,61'W 3,065 m	14°04,03'N 44°28,24'N 2,920 m	14°03,91'N 44°28,20'W 2,917	Dredging E-MORB domain-profile, eastern end Western slope of N-S trending ridge
27.02.2009 14:27 – 17:25	DR8	14°04,01'N 44°42,14'W 3,153 m	14°04,00'N 44°42,12'W 3,054 m	14°03,96'N 44°41,69'W 2,800 m	14°03,97'N 44°41,59'W 2,786 m	Dredging E-MORB domain-profile, centre Western slope of N-S trending ridge
27.02.2009 19:19 – 23:00	DR9	13°52,58'N 44°38,30'W 3,079 m	13°52,58'N 44°38,28'W 3,079 m	13°52,44'N 44°37,15'W 2,184 m	13°52,41'N 44°37,05'W 2,184 m	Dredging Menner Seamount Western flank
01.03.2009 11:02 – 15:00	DR10	14°55,58'N 48°11,92'W 1,824 m	14°55,60'N 48°11,95'W 1,833 m	14°55,39'N 48°11,37'W 1,420 m	14°55,39'N 48°11,37'W 1,420 m	Dredging Researcher Ridge Vayda Seamount N-flank, dredging in E-direction along the W-flank of a small "ridge-like" structure
01.03.2009 16:25 – 18:59	DR11	14°56,22'N 48°11,24'W 1,642 m	14°56,22'N 48°11,23'W 1,688 m	14°56,12'N 48°10,79'W 1,180 m	14°56,11'N 48°10,86'W 1,221 m	Dredging Researcher Ridge Vayda Seamount

Date/Time (UTC)	**Station No.**	**Lat./Long. (start) Depth (mbsl)**	**Lat./Long. (on bottom) Depth (mbsl)**	**Lat./Long. (off bottom) Depth (mbsl)**	**Lat./Long. (End) Depth (mbsl)**	**Comment**
01.03.2009 19:45 – 21:50	DR12	14°52,69'N 48°12,89'W 1,120 m	14°52,67'N 48°12,88'W 1,168 m	14°52,60'N 48°12,47'W 850 m	14°52,60'N 48°12,42'W 799 m	Dredging Researcher Ridge, Vayda Seamount Flank of Vayda Cone 1
02.03.2009 11:03 – 14:25	DR13	15°00,30'N 49°35,06'W 2,540 m	15°00,28'N 49°34,93'W 2,490 m	15°00,28'N 49°34,40'W 2,150 m	15°00,26'N 49°34,44'W 2,215 m	Dredging Researcher Ridge, The Shire Smt. Hill at the southwestern flank
02.03.2009 15:15 – 19:00	DR14	15°02,00'N 49°34,64'W 2,021 m	15°02,00'N 49°34,41'W 1,912 m	15°01,93'N 49°34,00'W 1,630 m	15°01,93'N 49°34,00'W 1,630 m	Dredging Researcher Ridge The Shire Smt. SW- flank
02.03.2009 19:14 – 22:17	DR15	15°01,92'N 49°39,74'W 2,481 m	15°01,88'N 49°39,71'W 2,489 m	15°01,65'N 49°39,24'W 1,966 m	15°01,62'N 49°39,16'W 1,971 m	Dredging Researcher Ridge The Shire Smt. Western flank
03.03.2009 11:05 – 13:49	DR16	15°06,79'N 50°14,03'W 1,346 m	15°06,83'N 50°13,87'W 1,350 m	15°06,67'N 50°13,76'W 1,315 m	15°06,51'N 50°13,74'W 1,202 m	Dredging Researcher Ridge Molodezhnaya Seamount Western flank of the summite region
03.03.2009 15:19 – 19:47	DR17	15°01,56'N 50°15,60'W 3,000 m	15°01,53'N 50°15,61'W 2,980 m	15°01,43'N 50°15,63'W 3,000 m	15°01,28'N 50°15,59'W 3,000 m	Dredging Researcher Ridge Molodezhnaya Seamount SW-flank
04.03.2009 11:04 – 14:31	DR18	15°05,30'N 50°17,25'W 2,317 m	15°05,30'N 50°17,22'W 2,413 m	15°05,22'N 50°16,82'W 2,030 m	15°05,22'N 50°16,88'W 2,030 m	Dredging Researcher Ridge Molodezhnaya Seamount NW-flank
04.03.2009 16:20 – 18:54	DR19	15°15,22'N 50°25,02'W 1,097 m	15°15,23'N 50°25,21'W 1,154 m	15°15,24'N 50°24,98'W 1,000 m	15°15,28'N 50°24,95'W 909 m	Dredging Researcher Ridge Frodo Seamount
04.03.2009 19:48 – 22:45	DR20	15°18,29'N 50°24,44'W 2,169 m	15°18,28'N 50°24,42'W 2,140 m	15°18,10'N 50°23,85'W 1,636 m	15°18,09'N 50°23,72'W 1,636 m	Dredging Researcher Ridge, Frodo Seamount N-E trending ridge at the northern flank
05.03.2009 11:04 – 13:34	DR21	15°40,47'N 51°29,47'W 2,463 m	15°40,50'N 51°29,48'W 2,490 m	15°40,38'N 51°29,21'W 2,246 m	15°40,21'N 51°29,25'W 2,246 m	Dredging Researcher Ridge, Mount Doom Smt. Western slope of the NE-SW trending ridge–like summit area

7. Sample Description

As soon as brought on deck new samples were sorted and washed. The first lava samples were immediately cut with the rock saw for an initial petrographic description, based on which the scientific party could decide to perform another dredge haul at the same location or to move on to the next dredge station. Other types of samples were eventually cut with the rock saw as part of the sample preparation procedure too. In general, volcanic rock samples were cut before manganese crusts in order to minimize the risk of cross-contamination (e.g. trace element concentrations can be orders of magnitude higher in manganese crusts than associated volcanic rocks).

The sample numbers include the cruise number (here POS 379/2), followed by the dredge number (DR1 to DR21) as outlined in the aforementioned station list (Table 3). The subsequent numbers and letters refer to the number and type of sample:

A – Archive sample (either the whole sample or a part of it is stored in the archive)

B – Biology sample (e.g. living organisms sampled and dried such as soft corals, sea stars, crabs etc.)

C – Corals and sponges (mostly skeletal and other hard material)

GC – Geochemistry part (most altered parts and surfaces and manganese crusts were removed from the volcanic rocks by means of the rock saw).

M – Mangenese crust

S – Sediment

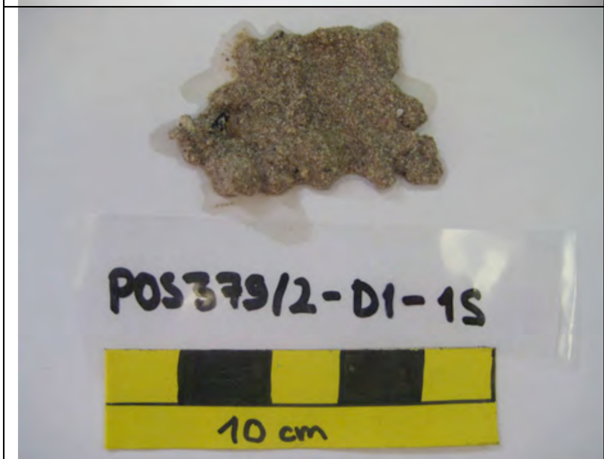
TS – A ca. 3 cm by 1.5 cm, thin (3-5 mm) slice cut from the GC for thin section petrography.

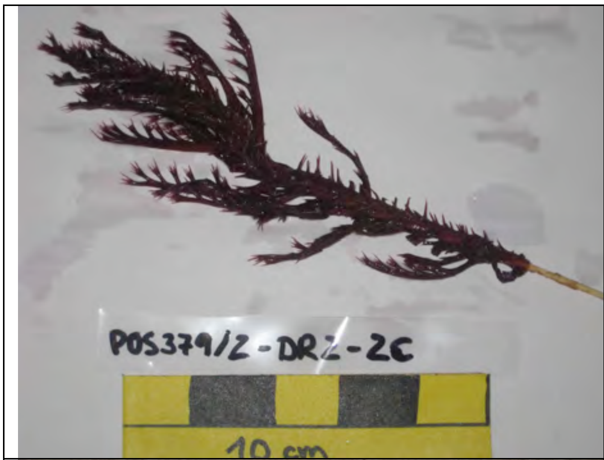
V – Volcanic material

W – Working half for further laboratory procedures, if a sub-sample was stored in the archive.

Letters may be combined, indicating that a sample contains two types of material, e.g. SM or VM for a sediment or volcanic rock having a relatively thick manganese crust. Thin sections and geochemistry pieces were transported back to the institute in the personal luggage, whereas all remaining samples and the equipment was shipped back with the container.

7.1. Samples recovered from Rocket Seamount

	**POS379/2-DR1-1B** *Southwestern flank of Rocket Seamount at ca. 2,700 mbsl.* 10 cm by 5 cm sponge (discarded).
	**POS379/2-DR1-1S** *Southwestern flank of Rocket Seamount at ca. 2,700 mbsl.* Foraminifera sand with fragments of fossils from the sediment traps.
	**POS379/2-DR2-1C** *Western flank of Rocket Seamount at ca. 1,200 mbsl.* Several pieces (13 cm - 3 cm) white coral.



POS379/2-DR2-2C
Western flank of Rocket Seamount at ca. 1,200 mbsl.

18 cm sea pen coral (dark red).

POS379/2-DR2-1S
Western flank of Rocket Seamount at ca. 1,200 mbsl.

Foraminifera sand with fragments of fossils from the sediment traps.

POS379/2-DR2-2S
Western flank of Rocket Seamount at ca. 1,200 mbsl.

14 cm by 11 cm pale orange, fine grained, very dense limestone with Fe-Mn-oxide impregnation thin manganese crust. Stored in the archive.

POS379/2-DR3-1C
Western flank of the ridge structure of Rocket Seamount at ca. 1,800 mbsl.

10 cm stony coral with thin manganese crust.

POS379/2-DR3-1S
Western flank of the ridge structure of Rocket Seamount at ca. 1,800 mbsl.

Foraminifera sand with fragments of fossils from the sediment traps.

POS379/2-DR3-2S
Western flank of the ridge structure of Rocket Seamount at ca. 1,800 mbsl.

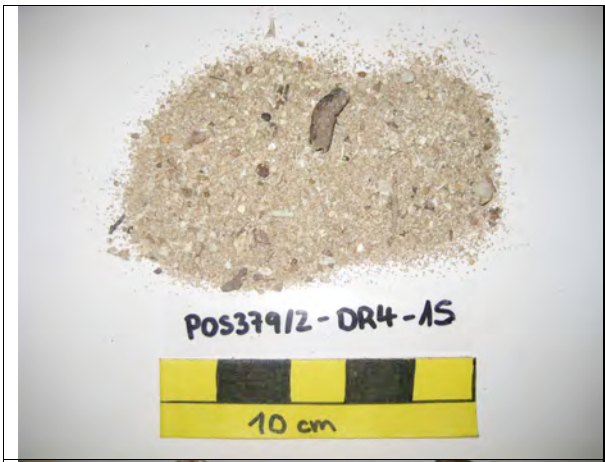
Several 8 to 30 cm pieces of limestone with fossils. Stored in the archive.

POS379/2-DR3-3S
Western flank of the ridge structure of Rocket Seamount at ca. 1,800 mbsl.

7 x 4 cm light grey bioclastic limestone covered by thin Mn-crust. Stored in the archive.

POS379/2-DR4-1C
Western flank of Rocket Seamount at ca. 1,000 mbsl.

3 pieces of 12 to 20 cm long corals.

	**POS379/2-DR4-1S** *Western flank of Rocket Seamount at ca. 1,000 mbsl.* Foraminifera sand with fossils from the sediment traps.
	**POS379/2-DR4-2S** *Western flank of Rocket Seamount at ca. 1,000 mbsl.* Several, 5 to 20 cm pieces of bioclastic, partly laminated limestone. The sample is covered by thin manganese crust and has dendrites of Fe-Mn-oxides.
	**POS379/2-DR4-1M** *Western flank of Rocket Seamount at ca. 1,000 mbsl.* 10 cm by 6 cm limestone covered by very dense, black manganese crust, varying from <1 mm to 1 cm thickness.
	**POS379/2-DR4-2M** *Western flank of Rocket Seamount at ca. 1,000 mbsl.* 22 cm by 9 cm limestone covered by very dense, black manganese crust, varying from <1 mm to 1 cm thickness. The sample is similar to **DR4-1M**.

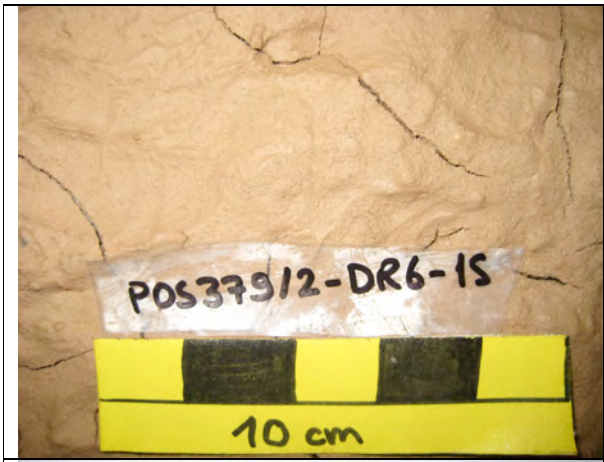
<table>
<tr><td>
</td><td>POS379/2-DR4-3M
Western flank of Rocket Seamount at ca. 1,000 mbsl.

12 cm by 6 cm limestone covered by very dense, black manganese crust, varying from <1 mm to 1 cm thickness. The sample is similar to DR4-1M.</td></tr>
<tr><td>
</td><td>POS379/2-DR4-4M
Western flank of Rocket Seamount at ca. 1,000 mbsl.

7 cm by 3 cm limestone covered by very dense, black manganese crust, varying from <1 mm to 0.5 cm thickness. The sample is similar to DR4-1M.</td></tr>
<tr><td>
</td><td>POS379/2-DR5-1S
Western flank of Rocket Seamount at ca. 3,300 mbsl.

Red-brownish deep-sea mud.</td></tr>
</table>

7.2. Samples recovered from the Mid-Atlantic Ridge



POS379/2-DR6-1S
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

Silty red-brownish mud with some foraminifera sand.

POS379/2-DR6-1V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

Several cm-sized pieces of hyaloclastite still containing black, shiny and relatively fresh glass shards. The sample was selected for geochemistry and thin section.

POS379/2-DR6-2V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

13 cm x 20 cm fragment of dark grey-blueish pillow lava with some hyaloclastite attached. Alteration is slight at the rim and largely absent in the centre. The lava is slightly vesicular (2-3 %, <1 mm) and contains fresh olivine + plagioclase (ca. 5%, up to 3 mm). The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

	**POS379/2-DR6-3V** *E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.* 20 cm x 16 cm fragment of dark grey-blueish pillow lava similar to **DR6-2V**. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.
	**POS379/2-DR6-4V** *E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.* 16 cm x 8 cm fragment of dark grey-blueish pillow lava similar to **DR6-2V**. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.
	**POS379/2-DR6-5V** *E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.* 13 cm x 8 cm fragment of dark grey-blueish pillow lava similar to **DR6-2V**. A sub-sample is stored in the box with working halfs and the other part is stored in the archive.
	**POS379/2-DR6-6V** *E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.* 11 cm x 6 cm fragment of dark grey-blueish pillow lava similar to **DR6-2V**. A sub-sample is stored in the box with working halfs and the other part is stored in the archive.

POS379/2-DR6-7V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

12 cm x 14 cm fragment of dark grey-blueish pillow lava similar to **DR6-2V**. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR6-8V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

15 cm x 14 cm aphyric, slightly vesicular pale grey lava. Vesicles (2 %, < 2 mm) are filled with dark gray-blueish secondary minerals. Sample seems to contain one single larger phenocryts (olivine ?). A sub-sample is stored in the box with working halfs section and the other half is stored in the archive.

POS379/2-DR6-9V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

10 cm x 4 cm igneous rock with plagioclase + pyroxene in the groundmass. Texture is between lava and gabbro with micro-phenocrysts of plagioclase, pyroxene + olivine. Former vesicles (2 %, <2 mm) are filled with red-brown secondary minerals. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR6-10V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

12 cm x 5 cm igneous rock similar to **DR6-9V**. The sample was selected for geochemistry and thin section. A sub-sample was stored in the archive.

POS379/2-DR6-11V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

6 cm x 5 cm cobble of igneous rock similar to **DR6-9V** but much more altered to red-brown with dark grey dots. The sample is stored in the archive.

POS379/2-DR6-12V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

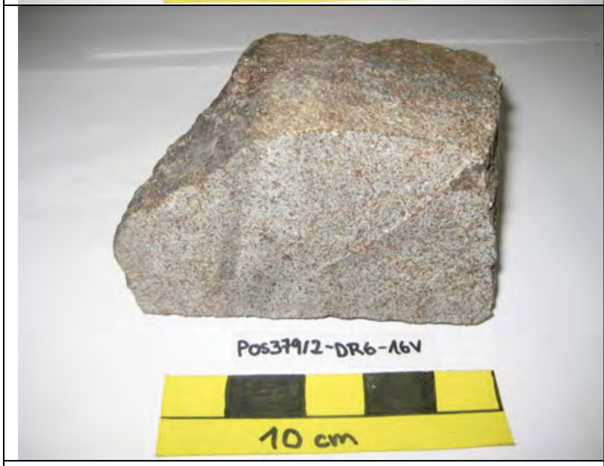
9 cm x 11 cm aphyric lava with several cross-cutting veins filled with secondary minerals (healed cracks). Red-brown near-spherical secondary minerals may either have been former vesicles or olivine (2 %, <2 mm). The sample is stored in the archive.

POS379/2-DR6-13V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

21 cm x 13 cm cobble of igneous rocks with gabbroic texture. The sample contains plagioclase and pyroxene. A central greenish-blue domain (possibly greenschist-facies ?) is surrounded by a several centimetre wide brownish rim (most likely due to seawater alteration). Sub-samples of the fresh and altered parts, **DR6-13V-f** and **DR6-13V-a**, respectively, were selected for geochemistry and thin sections. A sub-sample is stored in the archive.

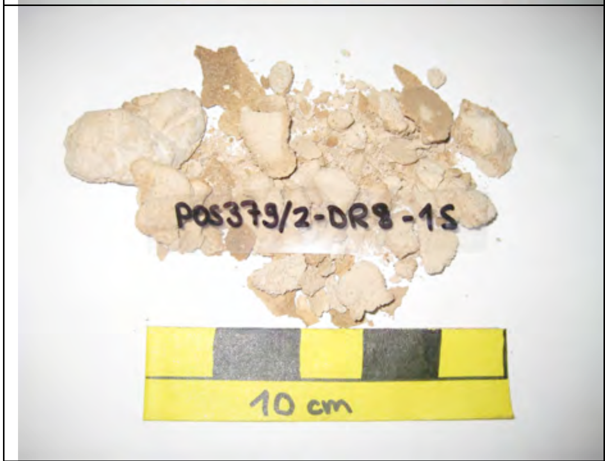
POS379/2-DR6-14V
E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.

25 cm x 14 cm gabbroic igneous rock similar to **DR6-13V**. Sub-samples of fresh and altered parts, **DR6-14V-f** and **DR6-14V-a**, respectively, were selected for geochemistry and thin sections. A sub-sample is stored in the archive.

	**POS379/2-DR6-15V** *E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.* 22 cm x 12 cm gabbroic igneous rock similar to **DR6-13V** but without green-blue centre. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.
	**POS379/2-DR6-16V** *E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.* 15 cm x 11 cm gabbroic igneous rock similar to **DR6-13V** but without green-blue core and a little more altered (reddish parts). The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.
No photo available.	**POS379/2-DR6-17VA** *E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.* Several centimetre-sized pebbles and cobbles of lava similar to **DR6-1V** & **DR6-8V**. A sample is stored in the archive.
No photo available.	**POS379/2-DR6-18VA** *E-MORB domain at 14°30'N, 44°51'W, western slope of a N-S-trending ridge structure at ca. 3,300 mbsl.* Several centimetre- to decimetre-size cobbles and boulders of gabbroic igneous rocks, similar to **DR6-13V**, partly with tectonic fractures. A sample is stored in the archive.

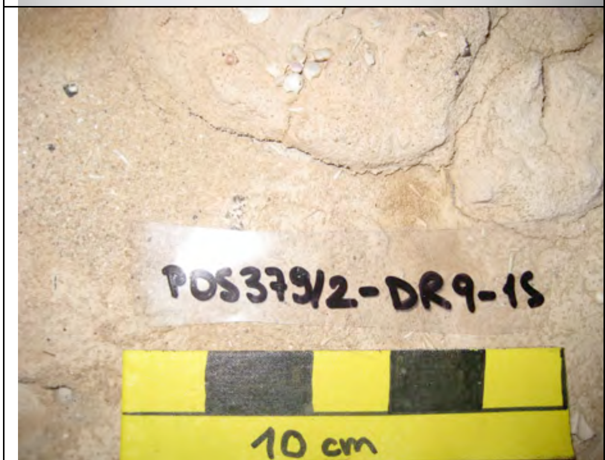
POS379/2-DR7-1S
Eastern end of E-MORB domain-profile at 14°04'N, 44°28'W, western flank of a N-S trending ridge at ca. 3,000 mbsl.

Pale brown mud.



POS379/2-DR8-1S
Centre of E-MORB domain-profile at 14°04'N, 44°42'W, western flank of a N-S trending ridge at ca. 3,000 mbsl.

Pale brown mud mixed with foraminifera sand.



POS379/2-DR9-1S
Western flank of Menner Seamount at 3,000 mbsl.

Silty brownish beige mud with some foraminifera sand.

POS379/2-DR9-1M
Western flank of Menner Seamount at 3,000 mbsl.

Ca. 1 cm black and partly dense and shiny manganese crust with cauliflower-like structure. The sample was selected for geochemistry and thin section.

POS379/2-DR9-2M
Western flank of Menner Seamount at 3,000 mbsl.

Ca. 0.5 cm black and dense manganese crust on moderately altered igneous rock. The sample is stored in the archive.

POS379/2-DR9-1V
Western flank of Menner Seamount at 3,000 mbsl.

21 cm x 22 cm boulder of pale grey, probably basaltic lava showing tectonic brecciation and signs of shearing. The boulder has attached a moderately lithified, mainly matrix supported breccia of the same material (angular fragments) as in the boulder and is more likely to be a tectonic breccia than volcanic. Another 3-5 cm wide zone at the rim of the boulder is apparently formed by shearing of the lava, generating a cataclastite that is crosscut by the breccia. The sample has a ca. 3 mm layer of dense black manganese crust underlying a ca. 5 mm layer of manganese crust with cauli-flower texture.
The lava is slightly vesicular (1-3 %, <1 mm) and nearly aphyric and slightly altered with altered relicts of ferromagnesian minerals (olivine ?, ca. 3 %, up to 3 mm) and rare plagioclase phenocryts (1 %, up to 3 mm). Plagioclase needles are frequent in the groundmass. Numerous cross-cutting cracks are filled with white secondary minerals. Vesicles are partly filled with white secondary minerals. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR9-2V
Western flank of Menner Seamount at 3,000 mbsl.

15 cm x 13 cm boulder of pale grey, probably basaltic lava with breccia attached and a 3-10 mm layer of black, dense cauli-flower-like manganese crust. The igneous rock is quite equigranular, mineralogically similar to **DR9-1V** but coarser grained and non-vesicular. Black 1 mm dots are probably phenocrysts (pyroxene ?, 1-2 %,<2 mm). Alteration is slight but cracks are filled with white secondary minerals. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR9-3V
Western flank of Menner Seamount at 3,000 mbsl.

10 cm x 7 cm cobble of tectonically affected, probably basaltic lava similar to **DR9-1V**. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR9-4V
Western flank of Menner Seamount at 3,000 mbsl.

5 cm x 7 cm cobble of tectonically affected, probably basaltic lava similar to **DR9-2V**. The sample is stored in the archive.

POS379/2-DR9-5V
Western flank of Menner Seamount at 3,000 mbsl.

8 cm x 7 cm cobble of cobble of pale grey, sightly altered igneous rock with black dots and numerous micro-fractures. The black dots are most likely phenocrysts of a ferromagnesian phase (pyroxene ?, ca. 15 %, <3 mm). The groundmass contains plagioclase needles and black and shiny pyroxene/hornblende?. The black and dense manganese crust is 2-3 mm thin. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR9-6V
Western flank of Menner Seamount at 3,000 mbsl.

8 cm x 6 cm cobble of cobble of igneous rock similar to **DR9-5V**. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR9-7V
Western flank of Menner Seamount at 3,000 mbsl.

7 cm x 5 cm cobble of igneous rock similar to **DR9-4V**, but sheared, cracked and somewhat more altered. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR9-8V
Western flank of Menner Seamount at 3,000 mbsl.

5 cm x 7 cm cobble of cobble of lava similar to **DR9-1V**. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR9-9VA
Western flank of Menner Seamount at 3,000 mbsl.

Several 5-10 cm cobbles of brecciated lava similar to **DR9-1V** and **DR9-2V**. The sample is stored in the archive.

POS379/2-DR9-10V
Western flank of Menner Seamount at 3,000 mbsl.

7 cm x 6 cm rounded clast from highly altered igneous material **DR9-30V**. The clast is slightly altered, non-vesicular basaltic lava with former olivine phenocrysts, now completely altered (ca. 5 %, <3 mm) but with a relatively fresh dark grey groundmass containing plagioclase. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR9-11V
Western flank of Menner Seamount at 3,000 mbsl.

5 cm x 3 cm rounded pebble from **DR9-30V**, The sample is similar to **DR9-10V**. The sample was selected for geochemistry and thin section.

POS379/2-DR9-12V
Western flank of Menner Seamount at 3,000 mbsl.

2.5 cm x 2.0 cm pebble from **DR9-30V**, similar to **DR9-10V**. The sample was selected for geochemistry and thin section.

POS379/2-DR9-13V
Western flank of Menner Seamount at 3,000 mbsl.

3 cm x 4 cm pebble from **DR9-30V**, similar to **DR9-10V**, but contains much less former (altered) olivine and some feldspars. The sample is stored in the archive.

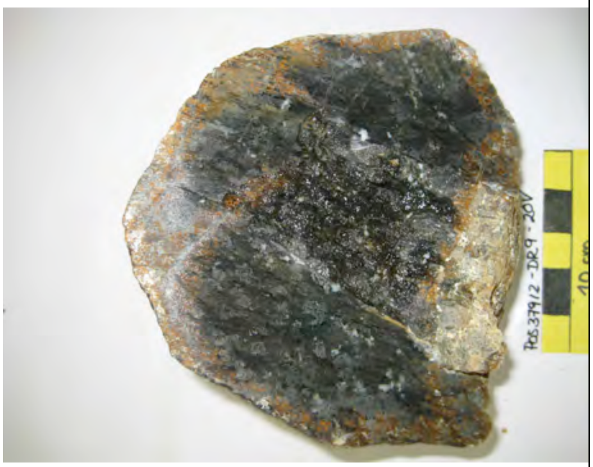
POS379/2-DR9-14V
Western flank of Menner Seamount at 3,000 mbsl.

2 cm x 1 cm pebble from **DR9-30V**, similar to **DR9-13V**. The sample is stored in the archive.

	**POS379/2-DR9-15V** *Western flank of Menner Seamount at 3,000 mbsl.* 13 cm x 7 cm brown, strongly altered equigranular igneous rocks, containing feldspar (apparently both plagioclase and alkali feldspar) and probably pyroxene and former oxidised olivine?. Cracks are filled with white-yellowish secondary minerals. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.
	**POS379/2-DR9-16V** *Western flank of Menner Seamount at 3,000 mbsl.* 11 cm x 10 cm of equigranular igneous rock similar to **DR9-15V** but less (only moderately) altered. The texture is almost gabbroic with probably olivine (15-20 %, now completely oxidised), possibly pyroxene and feldspar (plagioclase and eventually some alkali feldspar, 50-60 %). The sample was selected for geochemistry and thin section. A subsample is stored in the archive.
	**POS379/2-DR9-17V** *Western flank of Menner Seamount at 3,000 mbsl.* 3 cm x 4 cm pebble from **DR9-30V** similar to **DR9-16V**. The sample is stored in the archive.
	**POS379/2-DR9-18VA** *Western flank of Menner Seamount at 3,000 mbsl.* Several pebbles and cobbles and fragments of igneous rock similar to **DR9-16V** and **DR9-1V**. The sample is stored in the archive.

POS379/2-DR9-19V
Western flank of Menner Seamount at 3,000 mbsl.

5 cm x 6 cm fragment from **DR9-30V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.



POS379/2-DR9-20V
Western flank of Menner Seamount at 3,000 mbsl.

50 cm x 20 cm subangular igneous rock boulder. The interior is fresh and surrounded by a 1-3 cm rim of alteration with oxidised minerals. The sample has a plutonic texture with minerals up to 1 cm across and is similar to larvikite with grey-blueish minerals showing interface colours. Mineral phases are apparently plagioclase, alkali feldspar, hornblende? that tends to be oxidised first in the alteration rim. The sample also rarely contains sheet silicates such as biotite and muscovite, the latter on altered surfaces that therefore may be secondary. Based on the Steckeisen diagram the sample may be monzonitic to syenitic, either quartz or foid-bearing. The manganese crust is thinner (1 mm) than that of the associated lavas. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR9-21V
Western flank of Menner Seamount at 3,000 mbsl.

23 cm x 19 cm subangular cobble of plutonic igneous rock similar to **DR9-20V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

	**POS379/2-DR9-22V** *Western flank of Menner Seamount at 3,000 mbsl.* 30 cm x 12 cm cobble of plutonic igneous rock similar to **DR9-20V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.
	**POS379/2-DR9-23V** *Western flank of Menner Seamount at 3,000 mbsl.* 20 cm x 11 cm cobble of plutonic igneous rock similar to **DR9-20V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.
	**POS379/2-DR9-24V** *Western flank of Menner Seamount at 3,000 mbsl.* 16 cm x 10 cm cobble of plutonic igneous rock similar to **DR9-20V**. The sample is selected for geochemistry and thin section. One sub-sample is stored in the archive.
	**POS379/2-DR9-25V** *Western flank of Menner Seamount at 3,000 mbsl.* 20 cm x 14 cm subangular cobble of plutonic igneous rock similar to **DR9-20V** but with larger minerals (up to) 2.5 cm). The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

	**POS379/2-DR9-26V** *Western flank of Menner Seamount at 3,000 mbsl.* 13 cm x 10 cm subangular cobble of plutonic igneous rock similar to **DR9-20V** but with ca. 3 cm wide, more plagioclase-rich zone. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.
	**POS379/2-DR9-27VA** *Western flank of Menner Seamount at 3,000 mbsl.* 10 cm x 7 cm subrounded cobble of plutonic igneous rock similar to **DR9-25V**, but with ca. 3 cm wide, more plagioclase-rich zone. The sample is stored in the archive.
	**POS379/2-DR9-28VA** *Western flank of Menner Seamount at 3,000 mbsl.* 16 cm x 14 cm subrounded platy fragment of plutonic igneous rock similar to **DR9-25V** but seems to have been sheared and more fractured. The sample is stored in the archive.
No photo available.	**POS379/2-DR9-29VA** *Western flank of Menner Seamount at 3,000 mbsl.* Several decimetre-size cobbles and boulders of plutonic rock similar to **DR9-20V** and **DR9-25V**. The sample is stored in the archive.

No photo available.	**POS379/2-DR9-30VA** *Western flank of Menner Seamount at 3,000 mbsl.* Several centimetre- to decimetre-size fragments of highly (hydrothermally altered) igneous rock. Precursor material may have been a rock like **DR9-16V**. The manganese crust is ca. 1-1.5 cm and cauli-flower-like. The sample is stored in the archive.

7.3. Samples recovered from the Researcher Ridge

<table>
<tr><td>
</td><td>POS379/2-DR11-1S
Vayda Seamount, northern flank at ca. 1,700 mbsl.

Red-brownish foraminifera sand.</td></tr>
<tr><td>
</td><td>POS379/2-DR11-1V
Vayda Seamount, northern flank at ca. 1,700 mbsl.

8 cm to 5 cm rounded cobble of highly vesicular, strongly altered lava. Vesicles and cracks are filled with yellow-brown and black secondary minerals (partly Fe-Mn-oxides). The sample contains black to brown phenocrysts (2 %, up to 2 mm) that may be amphibole. The sample was selected for geochemistry.</td></tr>
<tr><td>
</td><td>POS379/2-DR12-1B
Vayda Seamount, cone at the eastern end of the summit region at ca. 1,200 mbsl.

Several 4 cm - 20 cm pieces of silica sponges.</td></tr>
</table>

	**POS379/2-DR12-2B** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* Several 5 cm - 8 cm pieces of sponges with seastars.
	**POS379/2-DR12-1C** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 15 cm piece of coral.
	**POS379/2-DR12-2C** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* Several pieces of golden corals with seastar.
	**POS379/2-DR12-1S** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* Foraminifera sand with pieces of sponges and crustacea.

POS379/2-DR12-1V
Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.
16 cm - 13 cm rounded cobble of vesicular, brown, moderately altered, probably tholeiitic lava. Former most likely ferromagnesian phenocrysts and plagioclase are completely oxidised (5 - 10 %, up to 3 mm). Few layers with transparent phenocrysts (probably feldspar, 1 %, up to 7 mm) seem to be quite unaltered. Alteration is more intense at the rim (brownish) and less so in the centre, leaving a 3 cm wide dark grey core. The manganese crust is thin (1 mm). The sample was selected for geochemistry and thin section.

POS379/2-DR12-2V
Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.

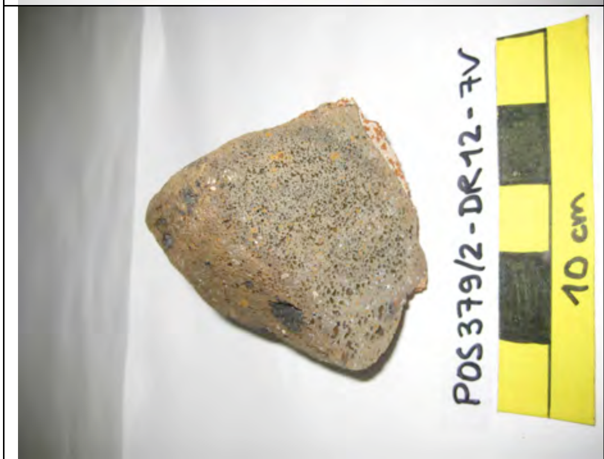
14 cm to 11 cm rounded cobble of lava similar to **DR12-1V** but vesicles are smaller and there is some altered hyaloclastite with palagonite attached. No fresh centre remained. The sample was selected for geochemistry and thin section.

POS379/2-DR12-3V
Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.

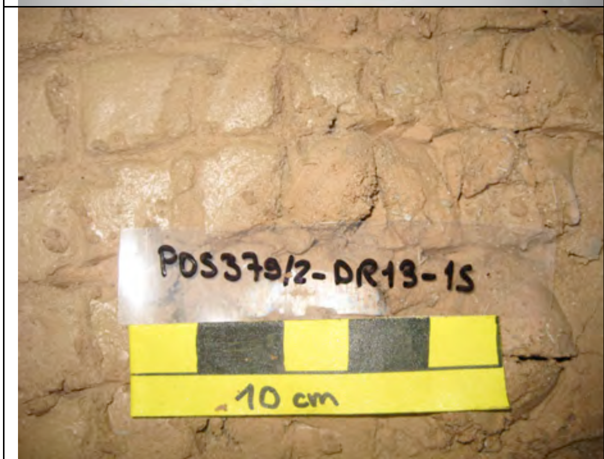
20 cm to 14 cm subrounded cobble of lava similar to **DR12-1V** but more vesicular. The groundmass in the centre is a little less altered with vesicles only partly filled, whereas the vesicles at the rim are entirely filled. The sample was selected for geochemistry and thin section.

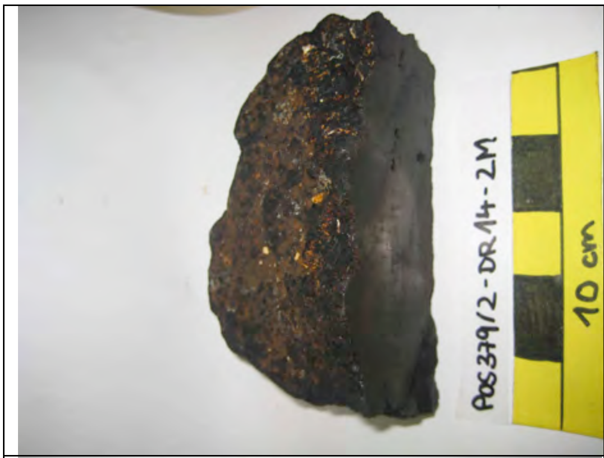
POS379/2-DR12-4V
Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.

8 cm to 9 cm rounded cobble of lava similar to **DR12-1V** but with variable vesicularity and altered hyaloclastite attached. A 2 cm to 3 cm grey domain in the interior is less altered. Larger phenocrysts are oxidised and vesicles are partly filled with white secondary minerals. The sample was selected for geochemistry and thin section.

	**POS379/2-DR12-5V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 10 cm to 5 cm rounded cobble of lava similar to **DR12-4V** but phenocrysts tend to be less altered. The sample shows a grey less altered interior. The sample was selected for geochemistry and thin section.
	**POS379/2-DR12-6V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 7 cm to 4 cm rounded pebble of lava similar to **DR12-4V**, with grey fresher domains. The sample was selected for geochemistry and thin section.
	**POS379/2-DR12-7V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 16 cm to 5 cm rounded cobble of lava similar to **DR12-2V** but with hyaloclastite more altered attached. The sample was selected for geochemistry and thin section.
	**POS379/2-DR12-8V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 10 cm to 6 cm rounded cobble of lava similar to **DR12-2V**. The sample was selected for geochemistry and thin section.

	**POS379/2-DR12-9V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 13 cm to 9 cm rounded cobble of lava similar to **DR12-2V**. Vesicles are concentrated in parallel zones. The sample was selected for geochemistry and thin section.
	**POS379/2-DR12-10V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 15 cm to 8 cm rounded cobble of lava similar to **DR12-9V**, but with hyaloclastite more altered attached. The sample was selected for geochemistry and thin section.
	**POS379/2-DR12-11V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 23 cm to 24 cm platy, edge-rounded fragment of altered and cemented hyaloclastite with a single pebble of lava similar to **DR12-2V**. The sample was selected for geochemistry and thin section.
	**POS379/2-DR12-12V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 7 cm to 6 cm rounded cobble of hyaloclastite similar to **DR12-11V**. The sample was selected for geochemistry and thin section.

	**POS379/2-DR12-13V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* 8 cm to 5 cm rounded cobble of hyaloclastite similar to **DR12-11V**. The sample is selected for geochemistry and thin section.
	**POS379/2-DR12-14V** *Vayda Seamount, Vayda Cone 1 at the eastern end of the summit region at ca. 1,200 mbsl.* Several centrimetre- to decimetre-size pieces of hyaloclastite similar to **DR12-11V**.
	**POS379/2-DR13-1S** *The Shire Seamount, SW flank at ca. 2,500 mbsl.* Silty red-brownish muddy foraminifera sand.
	**POS379/2-DR14-1M** *The Shire Seamount, SW flank at ca. 1,900 mbsl.* 12 cm x 8 cm, 3 cm thick, very dense and black manganese crust, without any obvious lamination. Some altered lava is attached underneath.

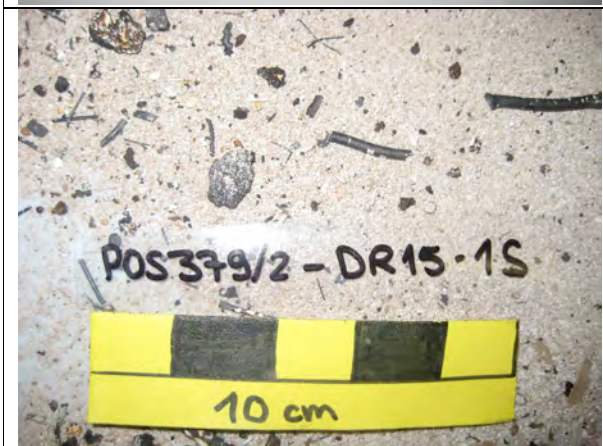


POS379/2-DR14-2M
The Shire Seamount, SW flank at ca. 1,900 mbsl.

15 cm x 12 cm, 4 cm thick, very dense and black manganese crust, without any obvious lamination.

POS379/2-DR15-1C
The Shire Seamount, western flank at ca. 2,400 mbsl.

3 pieces of coral (8 cm to 5 cm) covered with thin black manganese crust.



POS379/2-DR15-1S
The Shire Seamount, western flank at ca. 2,400 mbsl.

Foraminifera sand with manganese crust covered fragments of coral.

POS379/2-DR15-1M
The Shire Seamount, western flank at ca. 2,400 mbsl.

21 cm x 9 cm, 6 cm thick black manganese crust with some of hyaloclastite underneath. The crust is moderately laminated and contains a 1 cm thick layer of brown iron-oxide.

POS379/2-DR15-2M
The Shire Seamount, western flank at ca. 2,400 mbsl.

15 cm x 8 cm, 5 cm thick black dense manganese crust with few millimetre-size brown iron-oxide layers.

POS379/2-DR15-3M
The Shire Seamount, western flank at ca. 2,400 mbsl.

3 pieces of 2 cm – 4 cm thick, black manganese crust with 0.5 mm – 1 mm, brown iron-oxide layers.

POS379/2-DR15-4M
The Shire Seamount, western flank at ca. 2,400 mbsl.

20 cm x 14 cm, 6 cm thick, black manganese crust on hyaloclastite. The sample contains a ca. 1 cm brown iron-oxide layer.

POS379/2-DR15-1V
The Shire Seamount, western flank at ca. 2,400 mbsl.
6 cm x 5 cm x 3 cm angular cobble of altered volcanic breccia that was attached to manganese crust sample **DR15-4M**. The breccia contains angular clasts of strongly to very strongly altered lava, presumably of basaltic composition. The lava is highly vesicular and vesicles are partly to completely filled with secondary minerals. The sample contains altered plagioclase phenocrysts (ca. 3 %, up to 3 mm) and eventually relicts of pyroxene (ca. 2 %, up to 3 mm). Single phenocrysts appear to be still fresh and feldspar dateable. The sample was selected for geochemistry and thin section.

POS379/2-DR16-1B
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

Silica sponges.

POS379/2-DR16-2B
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

Seastars.

POS379/2-DR16-1C
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

Several 10 to 20 cm pieces of golden corals.

POS379/2-DR16-2C
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

Ca. 5 cm fragment of coral with manganese crust.

POS379/2-DR16-3C
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

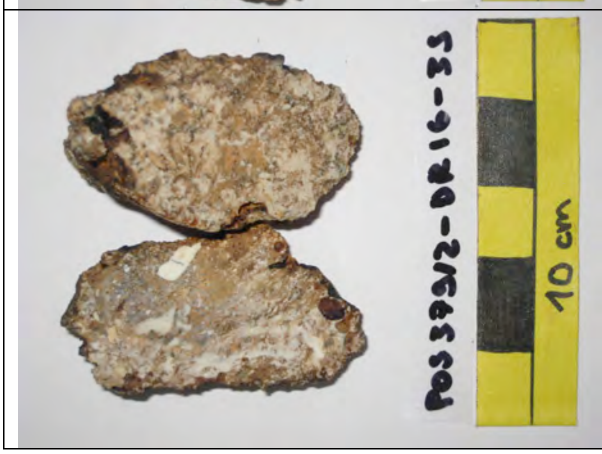
Ca. 10 cm fragment of coral.

POS379/2-DR16-1S
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

Foraminifera sand.

POS379/2-DR16-2S
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

Ca. 8 cm piece of sub-rounded bioclastic limestone. The sample was selected for geochemistry and thin section. One sub-sample is stored in the archive.



POS379/2-DR16-3S
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

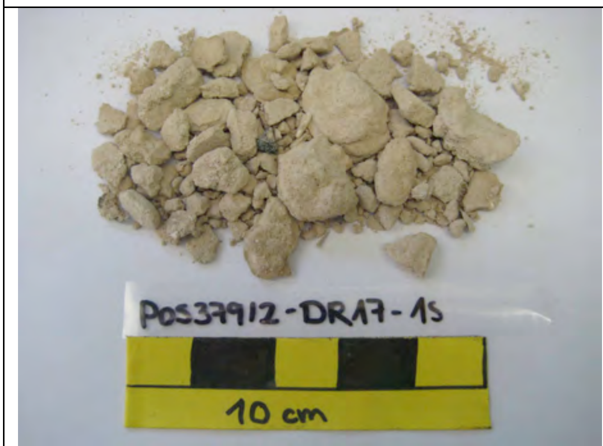
Ca. 5 cm piece of sub-rounded bioclastic limestone, similar to **DR16-2S**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR16-4S
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

Several 3 to 10 cm pieces of subrounded bioclastic limestone, similar to **DR16-2S**. The sample is stored in the archive.

POS379/2-DR16-1VS
Molodezhnaya Seamount, summit region at ca. 1,350 mbsl.

8 cm x 5 cm rounded cobble of dense limestone containing remnants of three rounded pebbles of strongly altered and palagonitised vesicular lava. Vesicles are mostly filled with secondary minerals. The lava contains plagioclase? phenocrysts (2 %, 1 mm) that are only slightly to moderately altered, eventually allowing dating. The sample was selected for geochemistry and thin section.



POS379/2-DR17-1S
Molodezhnaya Seamount, southern flank ca. 3,000 mbsl.

Pale brown foraminifera sand.

POS379/2-DR18-1S
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

Foraminifera sand.

POS379/2-DR18-2S
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

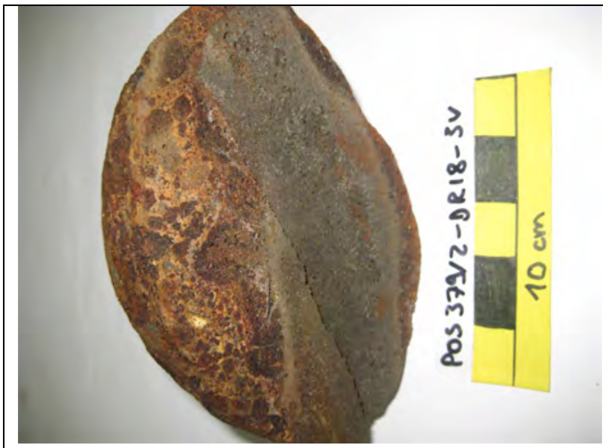
Several centimetre- to decimetre-size cobbles and boulders of moderately lithified bioclastic limestone. Mangenese crust is absent. The sample was selected for geochemistry and thin section. Sub-samples are stored in the archive.

POS379/2-DR18-3S
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

12 cm x 7 cm subangular cobble of well-lithified breccia containing small angular and subrounded clasts of lava and limestone. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-1V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.
48 cm x 20 cm columnar basaltic lava with 3 cm chilled margin at one end, including a former, now palagonised glass rind. The grey lava is vesicular (30 %, up to 3 mm). Vesicles only to a minor extent contain secondary minerals (oxides and sulphides). The sample is slightly to moderately altered although with former phenocrysts (olivine? + plagioclase ?, 10 %, <1mm) are completely oxidised. The manganese crust is very thin (<1mm). The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-2V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.
18 cm x 11 cm subrounded cobble of vesicular basaltic lava with 1 cm chilled margin containing a palagonitised glass rind. Alteration ranges from barely any to slightly with the freshest part found in the centre. The rind still contains quite fresh glass. The dark grey lava contains fresh pyroxene (5 %, <2 mm) and some plagioclase (1 %, <1 mm). In the slightly altered rim the phenocrysts are almost completely oxidised. Vesicles contain some secondary minerals (15 %, <2mm). The sample was selected for geochemistry and thin section. A subsample is stored in the archive.



POS379/2-DR18-3V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

15 cm x 14 cm rounded cobble of moderately to strongly altered lava with cm-wide rims of hyaloclastite and palagonitised glass rind. Parts of the glass seem to be still fresh. Mangenese crust is absent. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-4V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

6 cm x 7 cm cobble of highly vesicular black lava. The sample is barely altered and apparently mostly consists of fresh, glass-rich material. Vesicles do not contain any visible secondary minerals. The sample is almost aphyric but seems to have some rare olivine phenocrysts. Manganese crust is absent. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-5V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

6 cm x 4 cm cobble of highly vesicular glass-rich lava, similar to **DR18-4V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-6V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

11 cm x 7 cm rounded cobble of lava, similar to **DR18-3V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-7V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

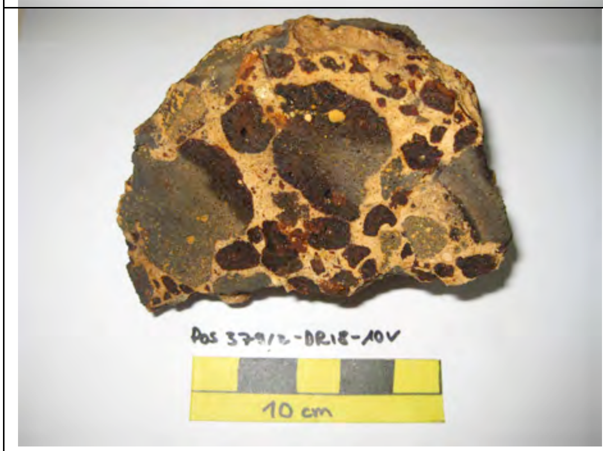
7 cm x 8 cm rounded cobble of lava, similar to **DR18-3V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-8V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

7 cm x 5 cm rounded cobble of lava, similar to **DR18-3V** but somewhat less altered and with thinner glass-palagonite rind. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

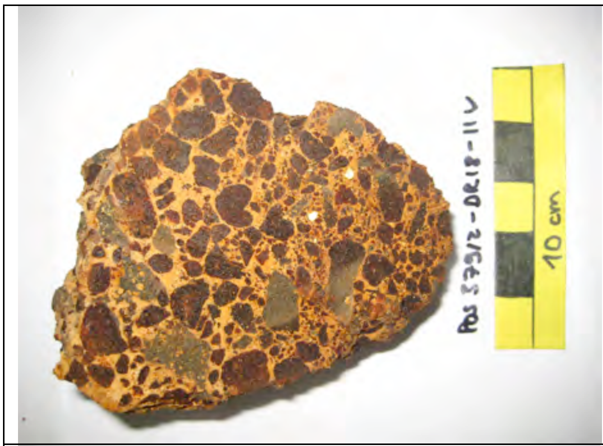
POS379/2-DR18-9V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

Several centimetre-size rounded cobbles of lava similar to **DR18-3V**. The sample is stored in the archive.



POS379/2-DR18-10V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

18 cm x 15 cm rounded boulder of altered hyaloclastite with fragments of vesicular lava and palagonitised glass rinds, similar to **DR18-3V**. The clasts are angular to subrounded and mostly supported by a pale-yellowish matrix. Some clasts still seem to contain some fresh glass. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.



POS379/2-DR18-11V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

13 cm x 11 cm cobble of hyaloclastite similar to **DR18-10V** but with smaller clasts and a matrix more orange. A mangenese crust is absent. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-12V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

13 cm x 9 cm rounded cobble of hyaloclastite similar to **DR18-10V** but with smaller clasts and a matrix that is orange-brown. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR18-13V
Molodezhnaya Seamount, western flank at ca. 2,400 mbsl.

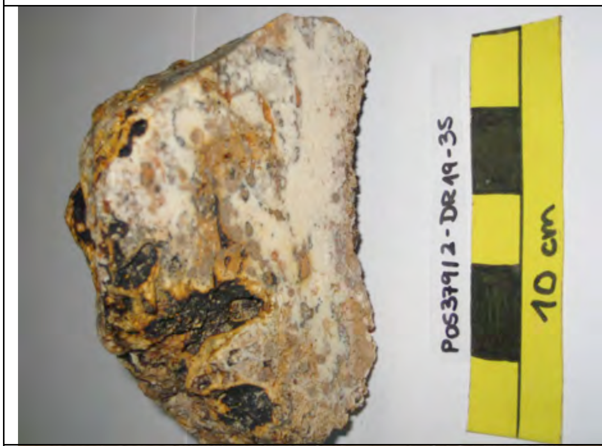
Several centimetre- to decimetre- size cobbles of hyaloclastite simial to **DR18-10V**, stored in the archive.

POS379/2-DR19-1S
Frodo Seamount, summit region at ca. 1,150 mbsl.

Foraminifera sand.

POS379/2-DR19-2S
Frodo Seamount, summit region at ca. 1,150 mbsl.

30 cm x 17 cm subangular boulder of well lithified bioclastic limestone with thin (1 mm) manganese crust. The sample is stored in the archive.

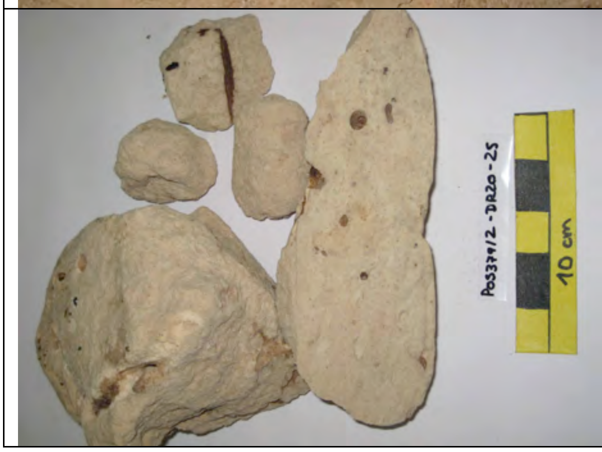


POS379/2-DR19-3S
Frodo Seamount, summit region at ca. 1,150 mbsl.

Several centimetre- to decimetre-size subangular cobbles of bioclastic limestone similar to **DR 19-2S**. The sample is stored in the archive.

POS379/2-DR20-1S
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

Foraminifera sand containing some pieces of corals.



POS379/2-DR20-2S
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

Several 3 to 20 cm pieces of limestone, eventually the lithified foraminifera sand. The samples are stored in the archive.

No photo available.	**POS379/2-DR20-3S** *Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.* 4 pieces of ca. 15 cm fine-grained, matrix supported bioclastic limestone, including pieces of fossils and layers of altered hyaloclastite. The samples are covered by thin manganese crust. Stored in the archive.
No photo available.	**POS379/2-DR20-1SM** *Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.* Several pieces of bioclastic limestone ranging from 5 to 50 cm, similar to **DR20-3S** but covered with thicker, ca. 3 cm manganese crust. The sample is stored in the archive. No photo available.
 	**POS379/2-DR20-1V** *Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.* 13 cm x 9 cm angular cobble of lava, presumably of basaltic composition. Several cracks are filled with brown and black secondary minerals. The sample is nearly aphyric and nonvesicular. Rare phenocysts are plagioclase, clinopyroxene (2 %, <1 mm) and are mostly altered. Rare vesicles have only to some extent been filled with secondary minerals. The groundmass seems to be only slightly altered. The manganese crust is very thin (< 1 mm). The sample was selected for geochemistry and thin section. A subsample is stored in the archive.
 	**POS379/2-DR20-2V** *Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.* 8 cm x 6 cm angular cobble of lava similar to **DR20-1V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR20-3V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

12 cm x 8 cm angular cobble of lava similar to **DR20-1V** but more vesicular and more altered (to brown at one rim that appears to be a former chilled margin). The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR20-4V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.
8 cm x 6 cm angular cobble of yellowish lava with pale grey dots, apparently resulting from slight to moderate alteration. The sample is non-vesicular and seems to contain phenocrysts or remnants of these such as a ferromagnesian phase and magnetite. The composition may be more evolved than basaltic. The manganese crust is black and thin and 2 mm thick. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR20-5V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.
5 cm x 4.5 cm rounded pebble of lava similar to **DR20-1V** but with more phenocrysts such as plagioclase (5 %, <3 mm) and probably black clinopyroxene (5 %, <3 mm). Attached to the pebble is breccia containing small altered (sub-)angular fragments of lava. The breccia is impregnated with Fe-Mn-oxides and red-brown secondary minerals and is only slightly altered. The manganese crust is black, dense and 3-4 mm thick. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR20-6V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

7 cm x 8 cm cobble of breccia with centimetre-size rounded pebbles of lava similar to **DR20-5V** and **DR20-2V** and minor lava fragments as in the breccia of **DR20-5V**. The sample contained two major clasts prepared as subsamples **DR20-6V-a** (similar to **DR20-2V**) and **DR20-6V-b** (similar to **DR20-5V**). The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR20-7V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

5 cm x 3 cm rounded pebble of grey non-vesicular lava. A former ferromagnesian phase (3 %, <1 mm, possibly originally olivine) is now entirely oxidised. The sample also contains some plagioclase (1 %, up to 3 mm) and micro-phenocrysts of presumably clinopyroxene. Attached is a breccia as in the sample **DR20-5V**. The sample was selected for geochemistry and thin section. A subsample is stored in the archive.

POS379/2-DR20-8V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

3 cm x 2 cm rounded pebble of lava similar to **DR20-2V** with some volcanic breccia attached as found in **DR20-5V**. The sample was selected for geochemistry and thin section.

POS379/2-DR20-9V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

2 cm x 2.5 cm rounded pebble of lava similar to **DR20-2V** with some volcanic breccia attached as found in **DR20-5V**. The sample was selected for geochemistry and thin section.

POS379/2-DR20-10V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

1 cm x 1 cm rounded pebble of lava, similar to **DR20-7V**. The sample was selected for geochemistry and thin section.

POS379/2-DR20-11V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

1 x 1 cm rounded pebble of lava, similar to the pebble in **DR20-7V**. The sample was selected for geochemistry and thin section.

POS379/2-DR20-12V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

1 cm x 1 cm rounded pebble of lava, similar to the pebble in **DR20-7V**. Manganese crust is black and dense and 1 mm thick. The sample was selected for geochemistry and thin section.

POS379/2-DR20-13V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

7 cm x 3 cm rounded pebble of moderately altered lava. Alteration is stronger toward one side. Vesicles (<3 %, <2 mm) have been filled with secondary minerals. The sample contains plagioclase (5 %, <2 mm) and most likely pyroxene (5 %, < 1 mm) and was selected for geochemistry and thin section.

POS379/2-DR20-14V
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

5 cm x 3 cm pebble of pale brown, strongly altered aphyric and non-vesicular lava. Attached are remnants of conglomerate with small rounded pebbles of lava (<5 mm) and a carbonate-rich, micro-fossil-bearing matrix. Manganese crust found on one side is 2 mm thick. The sample was selected for geochemistry and thin section.

	**POS379/2-DR20-15V** *Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.* 4 cm x 3 cm rounded pebble of pale grey aphyric and non-vesicular lava with slight alteration and remnants of conglomerate as found in **DR20-14V**. The sample was selected for geochemistry and thin section.
	**POS379/2-DR20-16V** *Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.* 2 cm x 1.5 cm subangular pebble of lava similar to **DR20-15V**. The sample was selected for geochemistry and thin section.
	**POS379/2-DR20-17V** *Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.* Several centimetre- to decimetre-size pieces of breccia containing fragments of lava similar to **DR20-15V**. The sample was selected for geochemistry and thin section.
	**POS379/2-DR20-18V** *Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.* 20 cm x 15 cm cobble of green-yellowish, strongly altered volcanic breccia, probably former hyaloclastite. The sample was selected for geochemistry and thin section.

POS379/2-DR20-1M
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

21 cm x 15 cm and 2 cm thick, dense, black, moderately laminated manganese crust on carbonate breccia. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR20-2M
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

17 cm x 9 cm and 1.5 cm thick, dense, black manganese crust on carbonate breccia. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR20-3M
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

9 cm x 8 cm and 3.5 cm thick, dense, black manganese crust with cauli-flower texture on hyolaclastite. The sample was selected for geochemistry and thin section. A sub-sample is stored in the archive.

POS379/2-DR20-4M
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

7 cm x 6 cm and 3 cm thick dense, black manganese crust. The sample is stored in the archive.

POS379/2-DR20-5M
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

11 cm x 7 cm and 1.5 cm thick, dense, black manganese crust with cauli-flower texture grown on hyaloclastite.

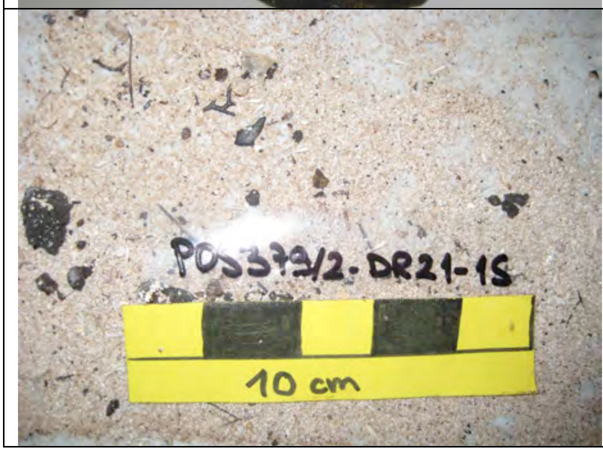
The sample is stored in the archive.

POS379/2-DR20-6M
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

8 cm x 8 and 1.5 cm thick, dense, black manganese crust with cauli-flower texture. The sample is stored in the archive.

POS379/2-DR20-7M
Frodo Seamount, N-S trending ridge at the N-flank at ca. 2,140 mbsl.

Three cobbles of manganese crust similar to **DR20-6M**. The sample is stored in the archive.



POS379/2-DR21-1S
Mount Doom, western end of NE-SW trending ridge of the summit area at ca. 2,400 mbsl.

Foraminifera sand with some fragments of fossils and manganese crust.

POS379/2-DR21-1M
Mount Doom, western end of NE-SW trending ridge of the summit area at ca. 2,400 mbsl.

22 cm by 14 cm and 7 cm thick, dense and black manganese crust on carbonate breccia.

POS379/2-DR21-2M
Mount Doom, western end of NE-SW trending ridge of the summit area at ca. 2,400 mbsl.

24 cm by 16 cm and 7 cm thick, dense, black and moderately laminated manganese crust with intercalated 1 cm brown iron-oxide layer about 1 cm below the top.

POS379/2-DR21-3M
Mount Doom, western end of NE-SW trending ridge of the summit area at ca. 2,400 mbsl.

20 cm by 16 cm and 7 cm thick manganese crust similar to **DR21-2M**.

POS379/2-DR21-4M
Mount Doom, western end of NE-SW trending ridge of the summit area at ca. 2,400 mbsl.

Several pieces of manganese crust similar to **DR21-2M**.

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9. Literature

Bourdon B., Langmuir C. H., and Zindler A. (1996) Ridge-hotspot interaction along the Mid-Atlantic Ridge between 37°30 and 40°30N: the U-Th disequilibrium evidence. *Earth and Planetary Science Letters* **142**(1-2), 175-189.

Donnelly K. E., Goldstein S. L., Langmuir C. H., and Spiegelman M. (2004) Origin of enriched ocean ridge basalts and implications for mantle dynamics. *Earth and Planetary Science Letters* **226**, 347-366.

Dosso A., Bougault H., Langmuir C., Bollinger C., Bonnier O., and Etoubleau J. (1999) The age and distribution of mantle heterogeneity along the Mid-Atlantic Ridge (31-41ºN). *Earth and Planetary Science Letters* **170**, 269-286.

Dosso L., Bougault H., and Joron J.-L. (1993) Geochemical morphology of the North Mid-Atlantic Ridge, 10°-24°N: Trace element-isotope complementarity. *Earth and Planetary Science Letters* **120**, 443-462.

Dosso L., Hanan B. B., Bougault H., Schilling J.-G., and Joron J.-L. (1991) Sr-Nd-Pb geochemical morphology between 10° and 17° N on the Mid-Atlantic Ridge: a new MORB isotope signature. *Earth and Planetary Science Letters* **106**, 29-43.

Duggen S., Olgun N., Teschner C., Schmidt A., and Meissl S. (2009) Cruise Report: Vulkanismus im Karibik-Kanaren-Korridor (ViKKi). In *IFM-GEOMAR Reports*, pp. 65. Leibniz Institute of Marine Sciences, IFM-GEOMAR.

Engdahl E. R., van der Hilst R. D., and Buland R. (1998) Global teleseismic earthquake relocation with improved travel times and procedures for depth relocation. *Bull. Seismol. Soc. Am.* **88**, 722-734.

Hémond C., Hofmann A. W., Vlastélie I., and Nauret F. (2006) Origin of MORB enrichment and relative trace element compatibilities along the Mid-Atlantic Ridge between 10º and 24ºN. *Geochemistry Geophysics Geosystems* **7**(12), 1-22.

Hofmann A. W. and White W. M. (1982) Mantle plumes from ancient oceanic crust. *Earth and Planetary Science Letters* **57**(2), 421-436.

Montelli R., Nolet G., Dahlen F. A., and Masters G. (2006) A catalogue of deep mantle plumes: new results from finite-frequency tomography. *Geochemistry Geophysics Geosystems* **7**(11), Q11007.

Müller R. D., Roest W. R., Royer J.-Y., Gahagan L. M., and Sclater J. G. (1997) Digital isochrons of the World´s ocean floor. *Journal of Geophysical Research* **102**(B2), 3211-3214.

Roden M. K., Hart S. R., Frey F. A., and Melson W. G. (1984) Sr, Nd and Pb isotopic and REE geochemistry of St. Paul´s Rocks: the metamorphic and metasomatic development of an alkali basalt mantle source. *Contribution to Mineralogy and Petrology* **85**, 376-390.

Roest W. R. and Collette B. J. (1986) The 15°22'N fracture zone and the north American/south American plate boundary. *Journal of the Geological Society of London* **143**, 833-843.

Schilling J.-G., Zajac M., Evans R., Johnston T., White W., Devine J. D., and R. K. (1983) Petrologic and geochemical variations along the Mid-Atlantic Ridge from 29°N to 73°N. *American Journal of Science* **283**, 510-586.

Smith W. H. F. and Sandwell D. T. (1997) Global seafloor topography from satellite altimetry and ship depth soundings. *Science* **277**, 1956-1962.

Sturm M. E., Goldstein S. J., Klein E. M., Karson J. A., and Murrell M. T. (2000) Uranium-series age constraints on lavas from the axial valley of the Mid-Atlantic ridge, MARK area. *Earth and Planetary Science Letters* **181**, 61-70.

Widom E., Carlson R. W., Gill J. B., and Schmincke H.-U. (1997) Th-Sr-Nd-Pb isotopes and trace element evidence for the origin of the Sao Miguel, Azores, enriched mantle source. *Chemical Geology* **140**, 49-68.

Workman R. K., Hart S. R., Jackson M., Regelous M., Farley K. A., Blusztain J., Kurz M., and Staudigel H. (2004) Recycled metasomatized lithosphere as the origin of the Enriched Mantle II (EM2) end-member: Evidence from the Samoan Volcanic Chain. *Geochemistry Geophysics Geosystems* **5**(4), Q04008.

Yu D., Fontignie D., and Schilling J.-G. (1997) Mantle plume-ridge interactions in the Central North Atlantic: a Nd isotope study of Mid-Atlantic Ridge basalts from 30°N to 50°N. *Earth and Planetary Science Letters* **146**, 259-272.

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28	FS POSEIDON Fahrtbericht / Cruise Report P379/1: Vulkanismus im Karibik-Kanaren-Korridor (ViKKi), Las Palmas – Mindelo, 25.01.-12.02.2009, Ed.: Svend Duggen, 74 pp. In English

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