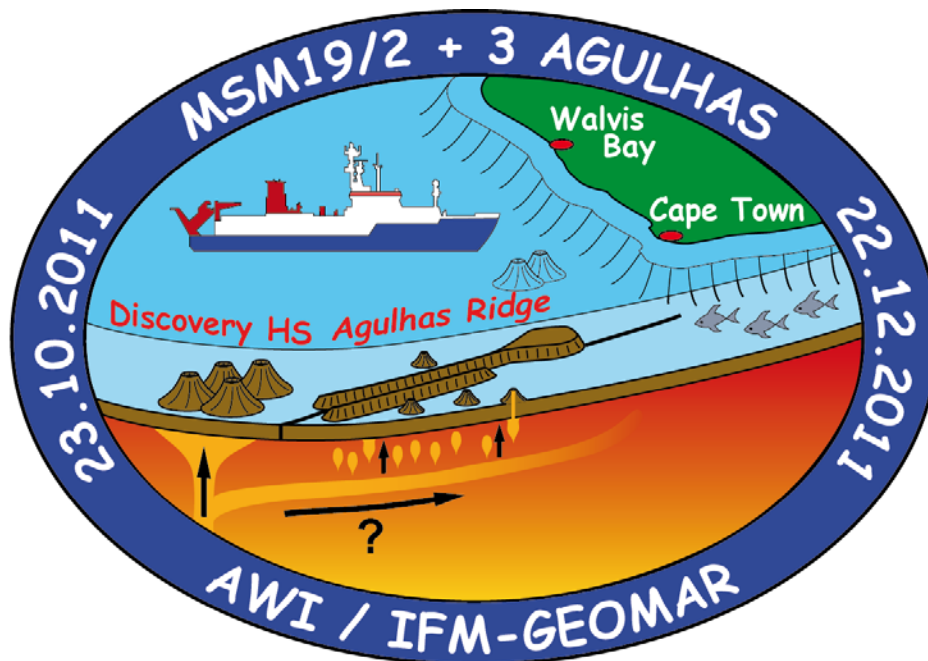


MARIA S. MERIAN-Berichte

The Agulhas Ridge: Connections between changing patterns of deep sea currents and volcanic-tectonic activity as well as origin of the "Dupal Anomaly" and intraplate volcanism

Cruise No. MSM19/3

December 1st - December 23rd, 2011
Cape Town (South Africa) – Cape Town (South Africa)



R. Werner, F. Hauff

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Table of Contents

	Page
1 Summary	3
2 Participants	4
3 Research Program	4
4 Narrative of the Cruise	7
5 Preliminary Results	10
5.1 Dredging and Hydroacoustics	10
5.1.1 Methods, Shipboard Procedure, and Station Overview	10
5.1.2 Dredge Sampling	12
5.1.2.1 Richardson Seamount (DR 1 - 13)	12
5.1.2.2 Agulhas Ridge und Associated Structures (DR 14 - 38)	15
5.1.2.3 Meteor Rise (DR 39 - 43)	18
5.1.2.4 Discovery Rise (DR 44 - 57)	20
5.2 Magmatic Rock Sampling Summary and First Results	24
5.3. Biology	27
5.3.1. Methods	27
5.3.2. Preliminary Results and Discussion	28
6 Station List MSM19/3	28
7 Data and Sample Storage and Availability	30
8 Acknowledgements	30
9 References	31

Appendices:

Appendix 1: Sampling Locations and Rock Descriptions

Appendix 2: Biological Samples

1 Summary

The main purpose of R/V MARIA S. MERIAN cruise MSM19/3 was to obtain new insights into the origin and evolution of tectonic and volcanic structures in the South Atlantic (Agulhas Ridge and associated structures, Discovery Rise) using morphological, volcanological, geochemical and geochronological methods in combination with the geophysical data yielded on the previous AWI-cruise MSM19/2. The rock sampling on MSM19/3 achieved its major objectives through successful extensive dredge sampling of Richardson Seamount, the Agulhas Ridges and adjacent features, the northern Meteor Rise, and of 11 Discovery seamounts. Of the 57 dredges carried out on MSM19/3 in only 15 working days, 31 recovered magmatic rocks, 16 volcanoclastics, 7 sedimentary rock, and 23 Mn-Fe oxides. The wide range of volcanic, metamorphic, intrusive, and sedimentary rocks recovered on MSM19/3 represents the most detailed marine sampling of this area to date. SIMRAD EM120 data recorded on MSM19/2 and /3 (and previous R/V POLARSTERN cruises) were used to select sampling stations and to assess the morphology of the region. Multi-beam seafloor mapping and preliminary analyses of the recovered samples suggest among others reactivation of the Agulhas Fracture Zone, a volcanic rather than continental nature of Richardson Seamount, and a mantle plume origin of the Discovery Seamounts. Furthermore biological material was obtained successfully as macrofauna and as sediment samples containing meiofaunal organisms. Macrofaunal organisms were recovered from the rocks at 26 out of 57 stations, 43 stations yielded sediment samples in the built-in sediment traps of the dredges. Meiofauna was extracted after the cruise from sediment samples. Preliminary sorting of 1/3 of all samples reveals a total of 1,671 meiofaunal organisms.

Zusammenfassung

Mit der FS MARIA S. MERIAN-Reise MSM19/3 sollen in Kombination mit der vorherigen AWI-Reise MSM19/2 durch einem interdisziplinären Ansatz (Vulkanologie, Petrologie, magmatische Geochemie, Geochronologie, Bathymetrie und Geophysik) neue Erkenntnisse über Ursprung und Entwicklung tektonischer und vulkanischer Strukturen im Südatlantik (Agulhas-Rücken und assoziierte Strukturen, Discovery Rise) gewonnen werden. Die Gesteinsbeprobung während MSM19/3 verlief mit der ersten repräsentativen Beprobung des Richardson Seamounts, des gesamten Agulhas-Rückens, des nördlichen Meteor Rise sowie von 11 Discovery Seamounts sehr erfolgreich. Von 57 Dredgezügen, die während MSM19/3 in nur 15 Arbeitstagen durchgeführt wurden, erbrachten 31 magmatische Gesteine, 16 Vulkaniklastika, 7 sedimentäre Gesteine und 23 Mn-Fe-Oxide. Das dabei gewonnene weite Spektrum an Gesteinen repräsentiert die bis heute detaillierteste Beprobung dieses Seegebietes. SIMRAD EM120 wurde für die Auswahl der Beprobungsstationen und morphologische Untersuchungen genutzt. Beobachtungen an Bord und erste vorläufige Daten deuten u.a. auf eine Reaktivierung der Agulhas Fracture Zone, eine eher vulkanische als kontinentale Natur des Richardson Seamounts und auf einen Mantleplume für die Herkunft der Discovery Seamounts hin. Zusätzlich wurde biologisches Material (Makrofauna und Meiofauna aus Sedimentproben) von den gewonnenen Gesteinsproben und mit Hilfe der in den Dredgen eingebauten Sedimentfallen gesammelt. Von den 57 Dredgen erbrachten 26 Makrofauna-Organismen und 43 Sedimentproben. Bisher wurde 1/3 der Sedimentproben auszentrifugiert und die Meiofauna (1.671 Organismen) vorläufig nach Tiergruppen sortiert.

2 Participants

Name	Discipline	Institution
Werner, Reinhard, Dr.	Volcanology / Chief Scientist	GEOMAR
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3 Research Program

The complementary R/V MARIA S. MERIAN legs MSM19/2 and 3 (and subsequent onshore laboratory studies) combine geophysical (19/2) and geological (19/3) methods to conduct bathymetric, geophysical, volcanological, petrological, geochemical, and geochronological studies at the Agulhas Ridge and associated features and at the Discovery Rise (South Atlantic). The ~1,100 km long and more than 2,000 m high Agulhas Ridge is part of the Agulhas Falkland Fracture Zone (AFFZ), that initially formed during the Gondwana break-up in the early Cretaceous by the separation of South America and Africa. The Discovery Rise, located to the northwest of the Agulhas Ridge, extends over an area of ~250 x 350 km and consists of several huge seamounts, which elevate up to > 4,000 m above the surrounding abyssal plain. Up till now too little is known about the ages and the geochemical composition of the magmatic rocks forming the Agulhas Ridge and the Discovery Rise to understand their nature and formation. Leg MSM19/3 was mainly dedicated to comprehensive bathymetric mapping (SIMRAD EM120) and representative hard rock sampling by dredging of all geomorphological units of these features.

Combined with the results of the geophysical studies conducted by the Alfred Wegener Institute for Polar and Marine Research (AWI) on the previous leg MSM19/2, MSM19/3 and the subsequent laboratory studies on land aim to reconstruct the age, origin, composition, and evolution of the Agulhas Ridge and the Discovery Rise. This approach addresses the following major questions:

(1) Has the Agulhas Ridge been reactivated tectono-magmatically in Cenozoic and is there a relation between the tectonic-magmatic activity of the ridge and the active hotspots in the South Atlantic?

Seismic profiles yielded on MSM19/2 (Uenzelmann-Neben, 2012) and a previous cruise (Uenzelmann-Neben and Gohl 2005) show basement highs adjacent to the Agulhas Ridge, which penetrate the sediment layers and may indicate a reactivation of the AFFZ in the Cenozoic (Middle Oligocene?). Hard rock sampling at these features combined with bathymetric and seismic data should provide new information on the age and origin of this volcanism. Furthermore we will verify if the rocks forming these features (A) show an ocean island basalt (OIB) component and if this component can be attributed to the Discovery Rise (Hotspot?) or (B) if their formation can be explained by other processes (as, for example, upwelling of upper mantle) related to a reactivation of the AFFZ and/or (C) if their magmas are contaminated by continental crust or continental lithospheric mantle. Furthermore we will assess by morphological and volcanological methods and $^{40}\text{Ar}/^{39}\text{Ar}$ age dating in combination with seismic reflexion data (yielded on MSM19/2) if the two parallel striking steep ridges of the Agulhas Ridge have similar ages as the adjacent oceanic crust or if younger volcanic rocks exist also directly on the Agulhas Ridge (magmatic reactivation?).

(2) What is the origin of the "Dupal Anomaly" and the enriched mantle components EM-I and EM-II?

The Dupal Anomaly (named after the french geochemists Dupré and Allègre) extends primarily in the southern hemisphere around the entire globe as an up to 60° broad belt and is characterized by anomalous, enriched Sr-, Nd- und Pb isotope signatures of oceanic magmatic rocks. The area of the Agulhas Ridge is predestinated for studies of the Dupal Anomaly and of the EM components since the maximum of this anomaly in the South Atlantic lies here. We will particularly test the hypothesis, that the Dupal Anomaly can be attributed to fragments of continental crust, which were separated during the break-up of the super continent Gondwana in the Cretaceous and are now incorporated into the oceanic lithosphere for example along transform faults and fracture zones. One target of MSM19/2 and -3 was to verify, if a small plateau (Richardson Seamount), located at the north-eastern tip of the Agulhas Ridge, represents such a fragment of continental crust.

(3) What is the origin of intraplate volcanism and which role do mantle plumes play ("Great Plume Debate")?

Seismic tomography records do not provide any clear evidence for plume structures beneath most hotspots in the South Atlantic (e.g. Discovery, Shona, Tristan de Cunha, Gough). This poses the question, if these hotspots with enriched Dupal signatures can really be attributed to deep roots (i.e. plumes) or if this volcanism is caused by shallow processes. We will contribute to the clarification of this question by petrological methods and major-, trace element- and Sr-Nd-Pb-Hf-isotope analyses, we will reconstruct melting depths, -temperatures, -degrees, and

magma sources involved in the melt generation (e.g. mid-ocean-ridge basalt [MORB], OIB, continental material) of the volcanism forming the Agulhas Ridge and the Discovery Seamounts.

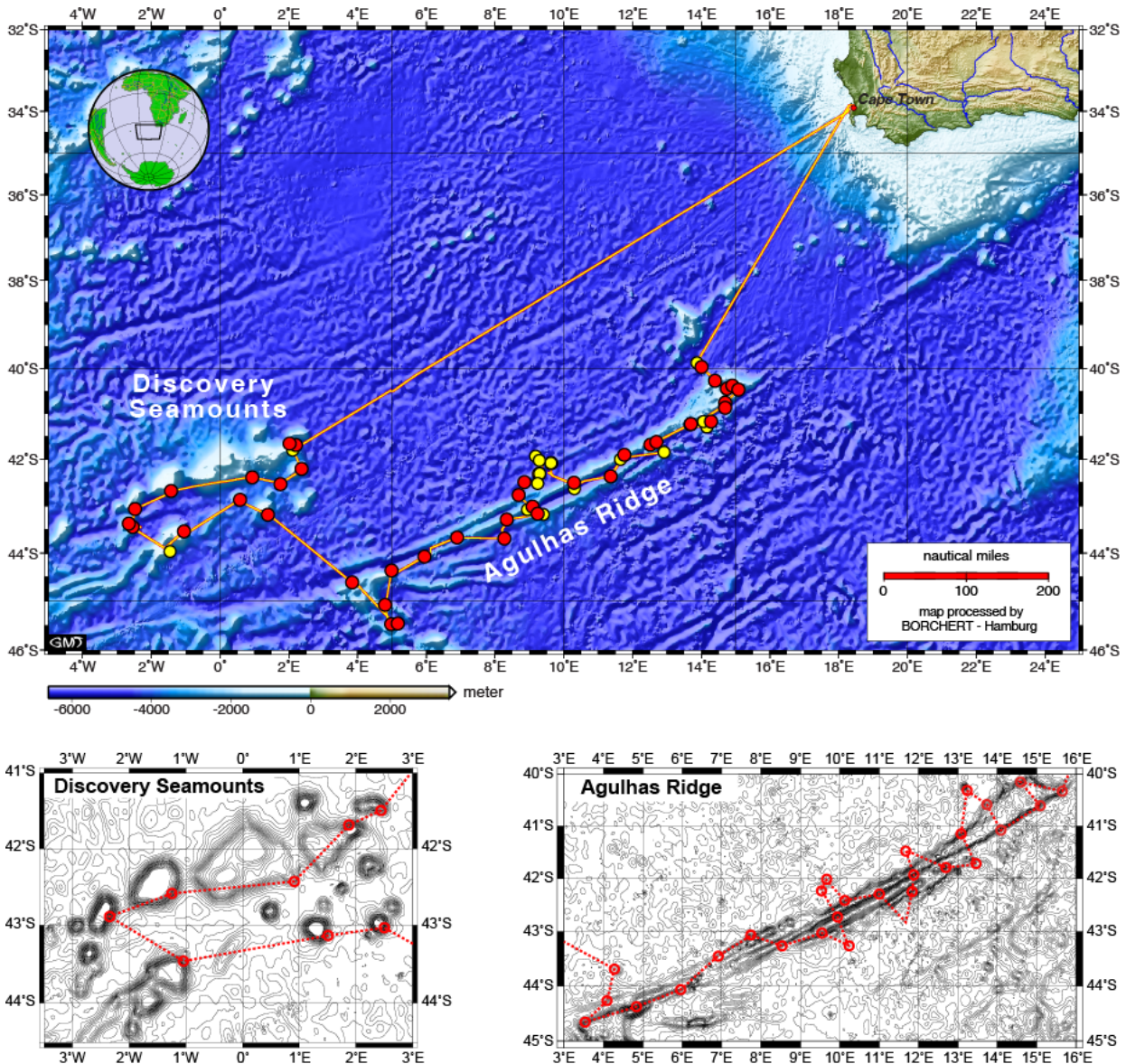


Fig. 3.1 **Top:** Track chart of R/V MARIA S. MERIAN Cruise MSM19/3. Bathymetry based on the GEBCO_08 Grid (version 20091120, <http://www.gebco.net>). Dredge hauls which yielded in situ magmatic rocks are marked by red dots, those which recovered only sediments, manganese, dropstones etc. are marked by yellow dots. SIMRAD EM120 and PARASOUND surveys were carried out on all ship tracks outside of the EEZ of the South Africa. **Bottom:** Planned MSM19/3 cruise track (red dashed lines) and planned major sampling stations (red circles) for comparison.

During leg MSM19/2 extensive multi-beam mapping has been already conducted to prepare the dredge sampling of leg MSM19/3. The maps generated on MSM19/2 enabled focused target selection on MSM19/3, compensating the time loss due to the closure of the port of Cape Town at the beginning of our cruise (see chapter 4). Despite occasionally typical weather conditions for the "roaring 40s", mapping and rock sampling of MSM19/3 could be conducted as originally

planned (Fig. 3.1.). The excellent support of the crew of R/V MARIA S. MERIAN, smooth progress of sampling, and the MSM19/2 maps allowed even some additional dredge tracks at the northern and southern tip of the Agulhas Ridge (i.e. Richardson Seamount and Meteor Rise, respectively). In addition, the research program of MSM19/3 included sediment echosounder profiling (PARASOUND) to complement the PARASOUND surveys of MSM19/2 and a minor biological program to investigate benthic animals found on the dredged rocks and meiofauna recovered by sediment traps in our dredges. The biological studies focus on the biodiversity and biogeography of benthic meio- and macrofaunal key groups such as Kinorhyncha, Loricifera, Porifera, Brachiopoda, and Bryozoa. These investigations complement results of the previous expedition M48-3 to the Angola Basin and a planned expedition S-501 WALVIS II to Walvis Ridge. It is expected that benthic species from the circumantarctic marine areas may be transported far north by benthic currents such as the North Atlantic Deep Water Current via the Antarctic Circumpolar Current and from there via its northern extensions into the southern Agulhas Basin and further into the Kap Basin (Schmitz, 1976a, 1976b; Reid, 1989).

4 Narrative of the Cruise

The starting point of the R/V MARIA S. MERIAN expedition MSM19/3 was the port of Cape Town in South Africa (Fig. 4.1.). By coincidence the German research icebreaker R/V POLARSTERN called in Cape Town at the same time on its way from Bremerhaven (Germany) to Antarctica. Although it was a busy day in port, the MARIA S. MERIAN crew hosted a tour of the ship for crew members and scientists of POLARSTERN, which elicited great interest. On the morning of December 1st, the sixteen MSM19/3 scientists from Germany and Chile came on board. Originally it was planned to leave the port immediately after boarding of the scientists. Strong gusty winds from the Table Mountain, however, turned out to be a disadvantage of our scenic berth directly at the busy "Water Front", as these winds caused a closure of this part of the port due to its narrow entrance. Therefore, MARIA S. MERIAN could not leave the port before the next morning. From Cape Town we sailed southwest approximately 400 nautical miles (nm) to arrive at the northeastern tip of the Agulhas Ridge in the evening of December 3rd. Despite little time we managed to prepare all laboratories and devices punctually thanks to the excellent support from the MARIA S. MERIAN crew.

The northeastern tip of the Agulhas Ridge is formed by a huge plateau (Richardson Seamount). Multi-beam mapping carried out on leg MSM19/2 revealed abundant small volcanic cones on the eastern part of the plateau and on the seafloor directly south of Richardson Seamount. Sampling of Richardson Seamount and both cone fields, however, proved difficult due to thick manganese crusts and solidified sediments which cover the magmatic rocks. Nevertheless we managed to get magmatic rocks from most sampled features. While occasionally the southern summer provided perfect conditions with nearly calm seas and sunny weather in the "roaring 40's", on other days wind up to 8 Beaufort made the acclimatization more difficult for us during the first week of the cruise. In general, however, the working conditions were good and our work on board MARIA S. MERIAN proceeded smooth so that we already could compensate almost half of the time lost in Cape Town.



Fig. 4.1 View on Cape Town, the table mountain, and R/V POLARSTERN (to the left) upon departure.

On December 6th MARIA S. MERIAN arrived at the Agulhas Ridge itself. At noon we started with systematic sampling along the ridge which took us approximately 600 nm further west within the second week of the cruise. We aimed to sample the steep flanks of the ridges in more or less regular intervals of approximately 100 km in order to identify temporal geochemical variations (i.e. with increasing distance from the Mid Atlantic Ridge). Overall we sampled 10 sites at the flanks. At eight of these sites the dredge hauls recovered volcanic rocks which mainly comprise fragments of aphyric pillow lava (Fig 4.2, 4.3). Additional sampling has been conducted at seamounts and small ridges situated directly on the Agulhas Ridge, which may be related to a reactivation of the fracture zone. The dredge hauls at these structures yielded moderate to highly vesicular pillow and sheet lava fragments, which resemble the vesicular lavas dredged at the flanks of the Agulhas Ridges.

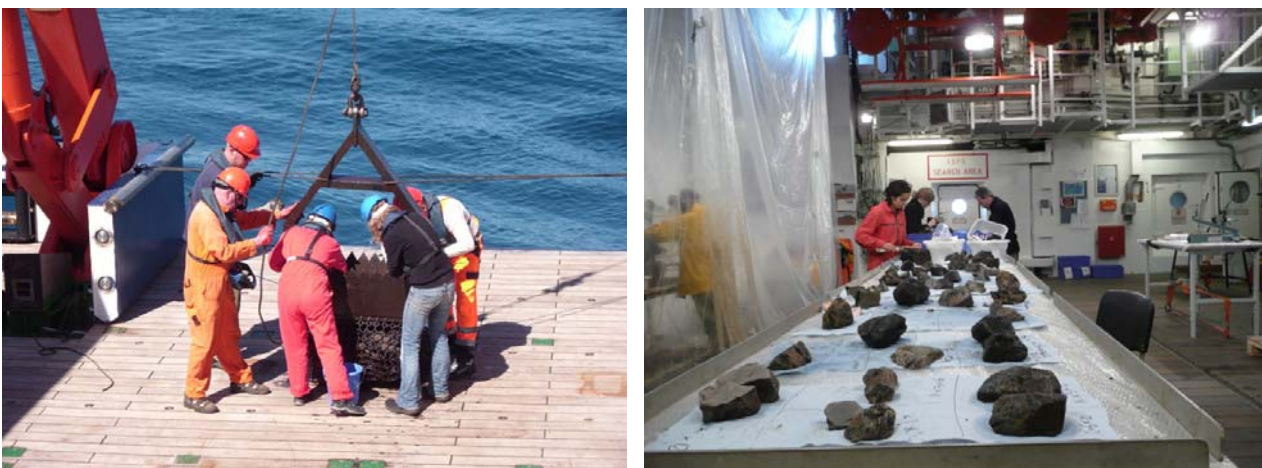


Fig. 4.2 **Left:** Dredge on deck... **Right:** The rock laboratory onboard MARIA S. MERIAN after a successful dredge haul.

Leg MSM19/2 and a previous AWI cruise also revealed, that the ocean floor to the north and the south of the Agulhas Ridge is characterized by unusual rough morphology which clearly

differs from normal deep sea plain. We made the attempt to sample some of the seamounts north of the ridge. Dredging at these features, however, proved to be a very difficult task most likely due to thick manganese crusts covering the magmatic rocks and most dredges returned empty or contained only manganese. Finally we managed to sample successfully one of the seamounts.

After finishing our work at the Agulhas Ridge on December 12th, R/V MARIA S. MERIAN sailed to the northern end of the Meteor Rise, adjacent to the southwestern tip of the Agulhas Ridge. Bathymetric maps based on satellite altimetry (“predicted bathymetry”) reveal some large, up to 3,000 m high seamounts in this area which are situated on a huge ridge-like structure. Our bathymetric mapping, however, showed, that these seamounts are large plateaus with steep flanks. Several dredge hauls at the flanks of these plateaus yielded magmatic rocks, sediments and manganese. In the early morning of December 14th, we finished our work at the Meteor Rise and R/V MARIA S. MERIAN headed 140 nm in northern direction towards the final working area of leg MSM19/3, the Discovery Rise. On the way we could frequently observe albatrosses and a particular highlight was the appearance of ~15 pilot whales which followed the vessel for almost one hour (Fig. 4.3). During the second week of MSM19/3, the weather was on our side for most of the time. Apart from two deeps which caused wind up to 9 Beaufort and high swell for a short time, the sea was relatively calm and did not hinder our studies.



Fig. 4.3 Left: A rock sample prepared for further analyses on land. Right: Pilot whales visiting MARIA S. MERIAN.

During the third and last week of cruise MSM19/3 we focused on mapping and sampling of the Discovery Rise. This area extends over ca. 250 x 350 km and consists of several, often very large seamounts that rise up to 4.000m above the surrounding seafloor. In order to reconstruct the origin of the Discovery Rise and to evaluate its role for geodynamic processes in the South Atlantic it was the ultimate goal of MSM19/3 to sample this region with near complete aerial coverage for the first time. From almost the entire Discovery Rise, a total of 11 seamounts were partially mapped and 10 successfully sampled by dredging which mostly delivered porphyric lava along with volcanic breccias and conglomerates.

In the evening of December 18th our station work ended with a last dredge haul in the northeastern area of the Discovery Rise under stormy weather conditions. Thereafter MARIA S. MERIAN began the 900 nm transit to Cape Town (South Africa). The transit was used to

continue multi-beam mapping and running the sediment echosounder but also to celebrate the success of the expedition with a BBQ in the evening of December 20th Dec. The scientific work ended Wednesday morning 21st Dec by turning off the multi-beam echosounder shortly before entering the South African Exclusive Economic Zone. In the morning of December 22nd MARIA S. MERIAN arrived in Cape Town where the majority of MSM19/3 scientists spent Christmas and New Year's Eve.

Taken together, leg MSM19/3 has reached its main scientific goals. Complementing ~2,500 nm multi-beam mapping and ~1,500 nm PARASOUND profiling, a total of 57 dredge hauls were carried out in an average water depth of 3,300 m during only 15 working days at sea. Furthermore 31 dredges delivered magmatic rocks for petrological and age dating studies and 45 dredges provided sediment samples for the biologists.

5 Preliminary Results

5.1 Dredging and Hydroacoustics

(R. Werner, F. Hauff, A. Herbrich, M. Wanke, and Shipboard Scientific Party)

5.1.1 Methods, Shipboard Procedure, and Station Overview

Rock sampling on cruise MSM19/3 was carried out using heavy chain bag dredges (manufactured by KUM Kiel), which were dragged along the ocean floor by the ship's winch. The pre-selection of the sampling areas at Richardson Seamount and Agulhas Ridge was already made on cruise MSM19/2 based on multi-beam mapping and seismic surveys carried out on that cruise. For Meteor Rise and the Discovery Seamounts, the sampling areas were first chosen based on predicted bathymetry, derived from gravity data and ship depth soundings (e.g., GEBCO [The GEBCO_08 Grid, version 20091120, <http://www.gebco.net>]) and on published monographs, maps and papers. The individual dredge tracks were set based on multi-beam data recorded on cruises MSM19/2, MSM19/3 and previous R/V POLARSTERN cruises (see chapter 5.1.2.) using CARIS and FLEDERMAUS software.

Of the 57 dredges carried out during MSM19/3, 31 recovered magmatic rocks, 16 volcanoclastics, 7 sedimentary rock, and 23 Mn-Fe oxides (Tab. 5.1). At all dredge sites, the angular shape of the rocks, freshly broken surfaces and homogeneity of rock types within a single dredge were taken as evidence for an *in situ* (non-ice rafted) origin of the rocks. Dropstones and rock of unclear origin have not been sampled and thus do not appear in the statistics and descriptions presented here.

Once onboard, a selection of the rocks were cleaned and cut using a rock saw. The magmatic rocks were then examined with a hand lens and microscope, and grouped according to their lithologies and degree of submarine weathering. The immediate aim was to determine whether material suitable for geochemistry and radiometric age dating had been recovered. Suitable samples have an unweathered and unaltered groundmass, empty vesicles, glassy rims (ideally), and/or phenocrysts that are fresh. Based on the results of these studies an appropriate sample set has been selected, prepared, and archived for the volcanological, petrological, geochemical and geochronological analyses planned onshore. Fresh blocks of representative samples were then cut for thin section and microprobe preparation, geochemistry and further processed to remove manganese and alteration products and/or to extract volcanic glass (if applicable). Each of these

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

Tab. 5.2: Summary of dredge tracks conducted on MSM19/3.

Stat.	Location	Recovery	Rock summary	on bottom		off bottom		depth (m)	
				lat °S	long°E	lat °S	long°E	max	min
DR 1	Richardson Smt, NW-Rift	empty		39.868	13.879	39.872	13.871	4697	4376
DR 2	Richardson Smt, NW-Rift	few rocks	Mn	39.893	13.891	39.897	13.885	4233	3894
DR 3	Richardson Smt, N-flank	few rocks	pillow fragments	40.263	14.402	40.268	14.394	2778	2357
DR 4	Richardson Smt, cone on plat.	3/4 full	volcaniclastics, Mn	40.457	14.749	40.459	14.741	1776	1513
DR 5	Richardson Smt, cone on plat.	3/4 full	volcaniclastics, Mn	40.372	14.904	40.374	14.896	1606	1440
DR 6	Richardson Smt, cone on plat.	1/5 full	lava fragm., volcaniclastics, Mn	40.468	15.089	40.472	15.078	2323	1990
DR 7	Richardson Smt, SE-flank	1/2 full	lava., volcaniclastics, sed. rocks	40.757	14.704	40.751	14.695	3083	2443
DR 8	Richardson Smt, SE-flank	few rocks	lava fragments, Mn	40.809	14.705	40.806	14.698	4198	3910
DR 9	Cones S of Richardson Smt	few rocks	lava fragments, sedimentary rocks	41.206	14.201	41.206	14.202	4100	4100*
DR 10	Cones S of Richardson Smt	few rocks	dropstones	41.261	14.169	41.260	14.160	4016	3706
DR 11	Cones S of Richardson Smt	empty		41.205	14.113	41.205	14.104	4245	3974
DR 12	Agulhas Ridge E, N-ridge	few rocks	pillow fragments	41.232	13.690	41.233	13.690	3120	3121*
DR 13	Agulhas Ridge E, N-ridge	few rocks	pillow fragments	41.231	13.699	41.229	13.694	3333	2923
DR 14	Agulhas Ridge central, N-ridge	few rocks	pillow fragments, volcaniclastics	41.678	12.529	41.679	13.520	4183	3667
DR 15	Agulhas Ridge central, N-ridge	empty		41.652	12.582	41.652	12.571	3870	3555
DR 16	Agulhas Ridge central, S-ridge	few rocks	plutonic/pegmatitic rocks, Mn	41.837	12.930	41.843	12.921	3692	3130
DR 17	Agulhas Ridge central, N-ridge	empty		41.968	11.735	41.970	11.728	3521	3137
DR 18	Agulhas Ridge central, N-ridge	1/2 full	pillow fragments	41.958	11.726	41.962	11.718	2795	2270
DR 19	Agulhas Ridge central, S-ridge	few rocks	pillow fragments, dropstones	42.356	11.367	42.363	11.361	4134	3680
DR 20	Agulhas Ridge W, N-ridge	empty		42.564	10.310	42.569	10.304	4190	3864
DR 21	Agulhas Ridge W, N-ridge	few rocks	volcaniclastics (dropstones?)	42.535	10.308	42.538	10.299	3611	3273
DR 22	Smt N of Agulhas Ridge	few rocks	Mn-knolls	42.300	9.645	42.307	9.638	4764	4435
DR 23	Smt N of Agulhas Ridge	empty		42.078	9.618	42.080	9.625	4410	4095
DR 24	Smt N of Agulhas Ridge	1 rock	dropstone	41.959	9.231	41.962	9.219	4872	4521
DR 25	Smt N of Agulhas Ridge		not on bottom -> tech. problem	41.823	9.243				
DR 26	Smt N of Agulhas Ridge	empty		42.319	9.292	42.317	9.282	4788	4534
DR 27	Smt N of Agulhas Ridge	empty		42.306	9.304	42.308	9.295	4817	4597
DR 28	Smt N of Agulhas Ridge	empty		42.510	9.237	42.517	9.233	4610	4280
DR 29	Smt N of Agulhas Ridge	1/5 full	lava, metamorphic rocks, dropst.	42.492	8.863	42.491	9.851	4311	3938
DR 30	Smt. on (N-) Agulhas Ridge	few rocks	pillow fragments, Mn, dropstones	42.765	8.688	42.770	9.140	3650	3225
DR 31	Agulhas Ridge W, N-ridge	empty		43.077	8.940	43.077	8.941	2993	3100*
DR 32	Agulhas Ridge W, N-ridge	1/2 full	pillows, volcanicl., Mn, dropst.	43.016	9.099	43.013	9.089	3404	3041
DR 33	Smt. on (S-) Agulhas Ridge	1/5 full	lava fragments, dropstones, Mn	43.172	9.244	43.166	9.237	3015	2497
DR 34	Agulhas Ridge W, S-ridge	empty		43.187	9.326	43.182	9.317	3796	3330
DR 35	Agulhas Ridge W, N-ridge	1/2 full	pillow fragments, Mn, dropstones	43.292	8.347	43.288	8.338	2940	2345
DR 36	Smt S of Agulhas Ridge	few rocks	Intrusiva (gabbro?), Mn-knolls	43.698	8.277	43.691	8.273	4465	4110
DR 37	Agulhas-Meteor, N-ridge	few rocks	lava fragment, dropstones	43.675	6.902	43.670	6.895	3953	3579
DR 38	Agulhas -Meteor, S-ridge	1/2 full	lava, metam. rock, volcaniclastics	44.062	5.950	44.070	5.950	3926	3495
DR 39	Meteor Rise, N-E smt	few rocks	lava fragments, sedimentary rocks	44.360	4.987	44.367	4.989	2461	1943
DR 40	Meteor Rise, central smt	1/3 full	pillows, volcanicl., metam., Mn	45.065	4.799	45.073	4.800	3253	2717
DR 41	Meteor Rise, S-smt	few rocks	metamorphic rocks, Mn	45.469	4.977	45.478	4.978	2559	2244
DR 42	Meteor Rise, S-smt	1/4 full	lava, volcanicl., sed. rocks, Mn	45.451	5.082	45.460	5.085	3276	2920
DR 43	Meteor Rise, N-flank	1/4 full	sedimentary rocks, dropstones	44.605	3.848	45.612	3.841	3222	2874
DR 44	Discovery Smts SE	few rocks	lava fragments, sed. rocks, Mn	43.192	1.396	43.186	1.391	2616	2178
DR 45	Discovery Smts SE	few rocks	lava fragm., volcaniclastics, Mn	42.862	0.582	42.867	0.574	2349	1889
DR 46	Discovery Smts SW	few rocks	lava fragments, volcaniclastics	43.540	-1.047	43.541	-1.056	1460	1057*
DR 47	Discovery Smts SW		dredge lost -> broken bolt	43.971	-1.454	43.966	-1.459	1479	1100*
DR 48	Discovery Smts S-most NW	1 rock	Mn-crust	43.452	-2.540	43.448	-2.550	3370	2939
DR 49	Discovery Smts NW	few rocks	lava fragm., volcaniclastics, Mn	43.370	-2.575	43.375	-2.583	2517	2160
DR 50	Discovery Smts NW	few rocks	volcaniclastics	43.071	-2.469	43.068	-2.478	2263	1834
DR 51	Discovery Smts NW	1/6 full	pillow fragments, volcaniclastics	42.678	-1.426	43.679	-1.433	1441	1100
DR 52	Discovery Smts NE	few rocks	pillow fragments, Mn	42.385	0.943	42.387	0.935	2907	2514
DR 53	Discovery Smts NE	1/5 full	lava fragments, Mn	42.529	1.766	42.533	1.756	2343	1947
DR 54	Discovery Smts NE	1/5 full	lava fragments	42.205	2.369	42.207	2.369	1705	1454*
DR 55	Discovery Smts NE	empty		41.721	2.091	41.721	2.042	2177	2188*
DR 56	Discovery Smts NE	1/4 full	lava fragments, volcaniclastics	41.713	2.084	41.714	2.075	1947	1539
DR 57	Discovery Smts NE	few rocks	sedimentary rocks, Mn	41.799	2.124	41.798	2.114	2513	2152

5.1.2 Dredge Sampling

Refer to Appendix II for a detailed summary of the dredge tracks and rock descriptions. Distances, dimensions and heights given in this chapter are approximate and are only included to give a rough idea of dimensions of morphological features. Distances between seamounts are given between the seamount tops. The maps shown in this chapter are mainly based on multi-beam data recorded on MSM19/2 and /3, but may also contain multi-beam data from RV POLARSTERN cruise ANTXXIII/5 (Jokat 2008) and previous R/V POLARSTERN transits (e.g. ANTXXV/4, ANTXXVI/2+3, ANTXXVII/3, ANTXXVIII/4, ANTXXIX/2+3, ANTXXIII/7+8+9), kindly provided by the Alfred Wegener Institute for Polar and Marine Research (AWI).

In this chapter we use the abbreviations ol for olivine, fsp for feldspar and cpx for clinopyroxene.

5.1.2.1 Richardson Seamount (DR 1 - 13)

Richardson Seamount is a huge plateau at the northeastern tip of the Agulhas Ridge. It extends over ~180 x 80 km and elevates more than 2,000 m above the surrounding abyssal plain. The flat top plateau (~2,300 m b.s.l. at the edges and less than 2,000 m b.s.l. in the center) is interpreted to be most likely an erosional platform formed by wave activity at sea level. The inward shoaling of the platform is consistent with subsidence occurring contemporaneously with erosion at sea level to shape the platform. Previously, three dredge hauls have been conducted on R/V POLARSTERN cruise ANTXXIII/5 in a restricted area at the southeastern flank of Richardson Seamount. These dredges yielded basalts, basanites, and hawaiites being geochemically enriched relative to mid-ocean ridge basalt (LeRoex et al. 2010). Ar/Ar age dating of these samples yielded a wide range of ages varying between 26 and 81 Ma (O'Connor et al. 2012). Multi-beam mapping carried out on leg MSM19/2 revealed abundant small volcanic cones on the eastern part of the plateau and on the seafloor directly south of Richardson Seamount. Most of these cones have a circular base up to 2 km in diameter and are up to 400 m high. They are well preserved and at least those located on the top platform must have formed after the erosional platforms subsided below wave base. We presume that they represent a late phase of volcanic activity in the area of the Agulhas Falkland Fracture Zone which may be related to reactivation of the fracture zone.

Altogether 13 dredge hauls have been carried out at Richards Seamount and both cone fields on MSM19/3. Sampling, however, proved difficult due to thick manganese crusts and solidified sediments which cover the magmatic rocks. Moreover the magmatic basement often appeared heavily altered and probably reflects long-term interaction with sea water. Nevertheless we managed to get magmatic rocks from most sampled features.

Dredges DR 1 and 2 were made at the northwestern tip of a ridge emanating ~50 km from the northern flank of Richardson Seamount in northwestern direction (Fig. 5.1). That ridge is interpreted as volcanic rift. DR 1 returned empty from the northeast facing lower slope near the northwestern termination of the ridge. DR 2 was made 3.5 km south of DR 1 right below the rift axis and yielded only manganese crusts and knolls. The next dredge haul DR 3 was conducted at the upper northeastern flank beneath the plateau edge and yielded very homogeneous, Mn-encrusted pillow fragments. The pillow lavas are altered and have less than 2% vesicles and up to 5% altered ol phenocrysts.

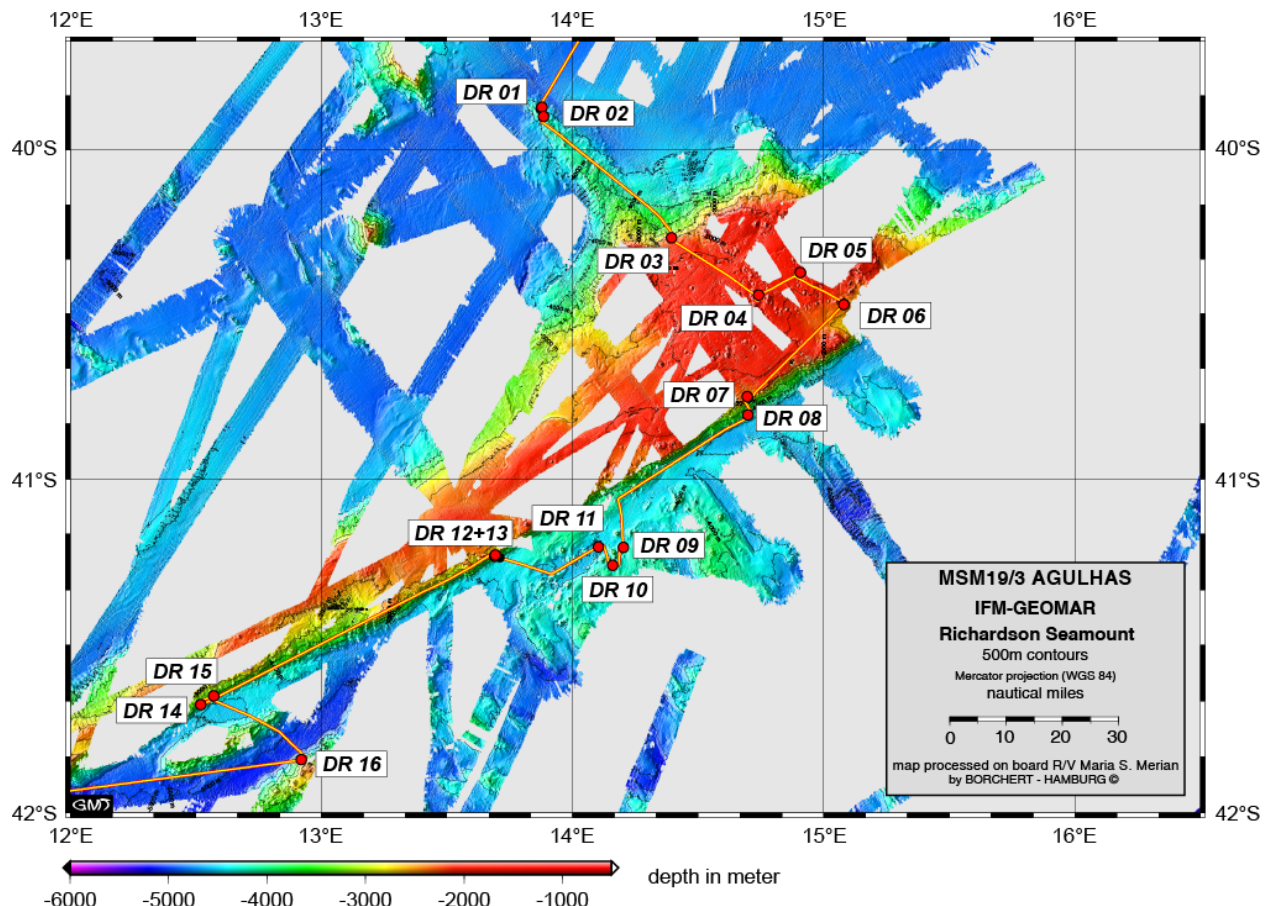


Fig. 5.1 Multi-beam map of Richardson Seamount incl. MSM19/3 dredge stations. For data sources see chapter 5.1.2 (first paragraph).

From the northwestern flank R/V MARIA S. MERIAN headed to the cone field on the plateau where dredge hauls DR 4 - 6 have been carried out at three different cones (Fig. 5.2). DR 4 returned heavily altered volcanic breccias and manganese crusts from a ~250 m high cone. DR 5 also yielded altered breccias, which partly consist of highly vesicular lava fragments, from a only ~150 m high cone. The last dredge DR 6 in this cone field has been conducted at an almost 400 m high volcano located directly on the southeastern edge of the plateau. The rocks found in DR 6 are more usable and comprise only moderately altered, aphyric lava fragments with up to 30% vesicles and volcanic breccias. The breccias are made up of aphyric, highly vesicular cm-sized lava clasts embedded in a white, fine-grained sediment matrix which shows no or only weak reaction with HCL and may possibly consist of completely altered volcanic ash particles.

The next two dredge hauls aimed to sample the "shield stage" of Richardson Seamount and therefore are set up in an area at its southeastern flank where no cones are present on the overlying plateaus (Fig. 5.1). DR 7 was made directly beneath the plateau edge and yielded a large amount of pillow fragments, various volcanoclastic and sedimentary rocks. The lavas are moderately altered, aphyric, dense, and display limited vesicularity (up to 5%). The breccias have completely undergone alteration and in some cases it is even difficult to decide by visual observation if the rocks are highly altered porphyric rocks or highly altered breccias. Among the sedimentary rocks dominate coarse grained, layered sediment with different sized clasts and sorted bedding with a finer layer on top of coarse grained material. Some of the clasts may be of

volcanic origin. A preliminary working hypothesis is that these sediments represent volcanoclastic material reworked in shallow coastal water. DR 8 returned besides manganese crusts just one piece of altered, aphyric lava with 20% vesicularity.

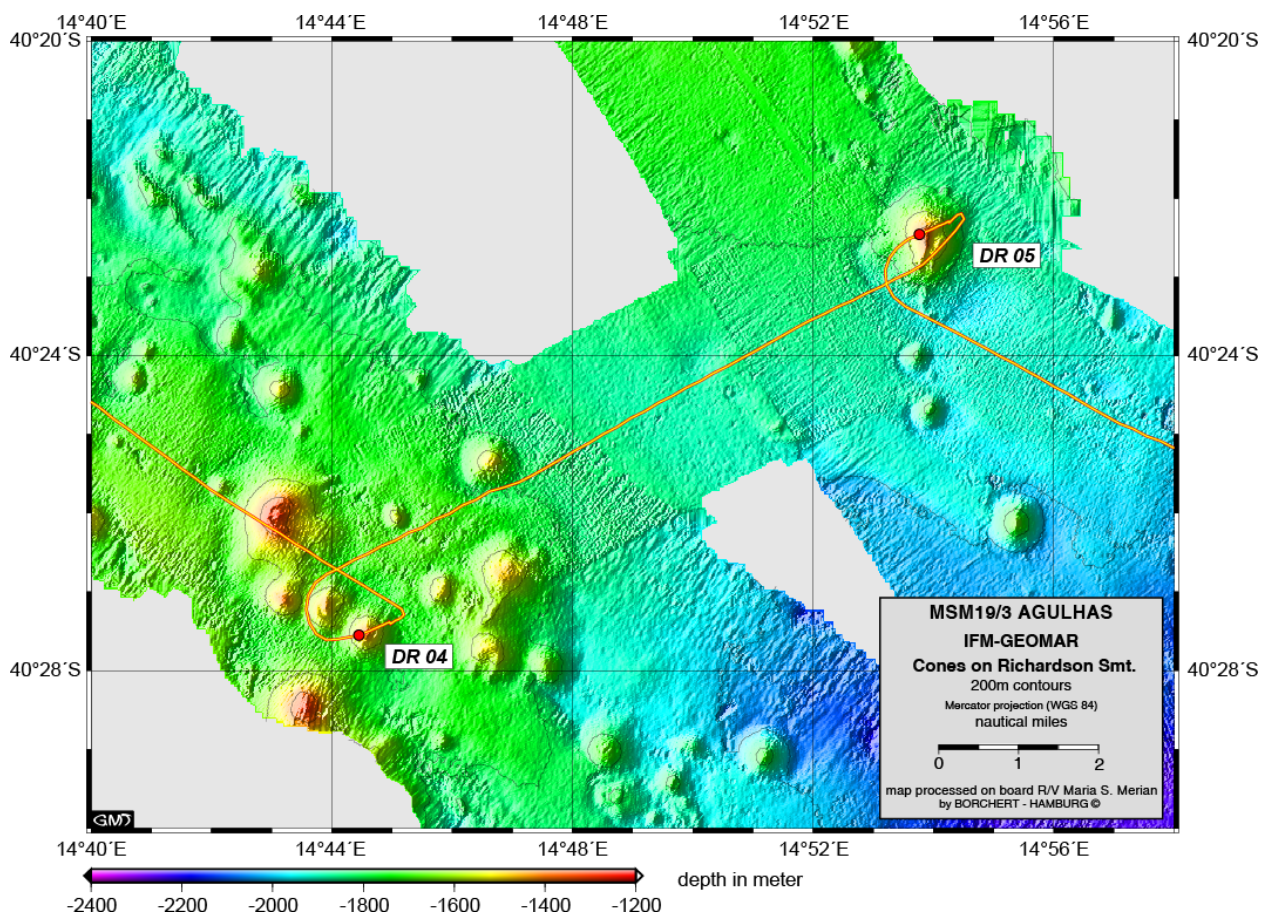


Fig. 5.2 Small volcanic cones on the top plateau of Richardson Seamount incl. MSM19/3 dredge stations. For data sources see chapter 5.1.2 (first paragraph).

The following target of MSM19/3 was the cone field on the deep sea plain off the base of the southeastern flank of Richardson Seamount. Three dredge hauls (DR 9 - 11) have been carried out at three different, medium-sized, ~300 m high cones with approximately 1.5 km diameter at their base. Sampling of these cones, however, failed. DR 9 and 10 recovered only sediments and rocks of unclear origin (dropstones?) and DR 11 returned empty.

Two dredges hauls (DR 12 and 13) at the southeastern tip of Richardson Seamount took a more successful course. Both dredge tracks were set up at the upper southeastern flank (Fig. 5.1) and yielded mainly moderately to highly altered pillow fragments. DR12 contained porphyric, non to moderate vesicular (0 - 15%) lavas with up to 3% cpx in a microcrystalline matrix with cpx- and fsp- needles. Similar, but aphyric pillow fragments represent a second lithology in this dredge. By contrast, the rocks found in DR 13 are very homogeneous, moderately altered porphyric pillow fragments with <5% vesicles and ~2% up to 4 mm sized fsp phenocrysts.

Taken together, the dredge hauls conducted at the flanks of Richardson Seamount yielded mainly dense to moderately vesicular pillow fragments, whereas highly vesicular volcanoclastic rocks and lava fragments dominate at the small cones on the top plateau. The high vesicularity and strong fragmentation of the cone lavas could point to explosive volcanic activity during their

formation. Notably the cone field on the deep sea plain lies more than 2,000 m beneath the erosional platform of Richardson Seamount and the other one on the plateau must have been formed after erosion and subsidence of the seamount, implying deep submarine formation of both cone fields. The occurrence of heavily fragmented and highly vesicular volcanics formed in deep water conditions may contribute to the ongoing discussion if - in contradiction to the traditional opinion - explosive volcanic eruptions occur in deep water conditions and, if so, which processes may cause that explosivity.

5.1.2.2 Agulhas Ridge and Associated Structures (DR 14 - 38)

The Agulhas Ridge is formed by two prominent, parallel striking ridge structures (here called northern and southern ridge). In between these ridges narrow troughs are up to 6,000 m deep, whereas the abyssal plain north and south of the Agulhas Ridge is situated in "only" 4,000 to 5,000 m water depth. The foremost feature of the ridges are their steep flanks towards the troughs and more gentle slopes facing away from the troughs (Fig. 5.3). This morphology indicates that the ridges represent fractured and tilted ocean crust; a perfect setup to systematically sample the ocean crust in this area. Therefore we aimed to sample the steep flanks of the ridges in more or less regular intervals of ~100 km in order to identify temporal geochemical variations (i.e. with increasing distance from the Mid Atlantic Ridge). In previous studies, the Agulhas Ridge is considered as part of the Shona hotspot track (Le Roex et al. 2010), whereas Douglass et al. (1999) postulate migration of material from the Discovery plume into the Agulhas Falkland Fracture Zone.

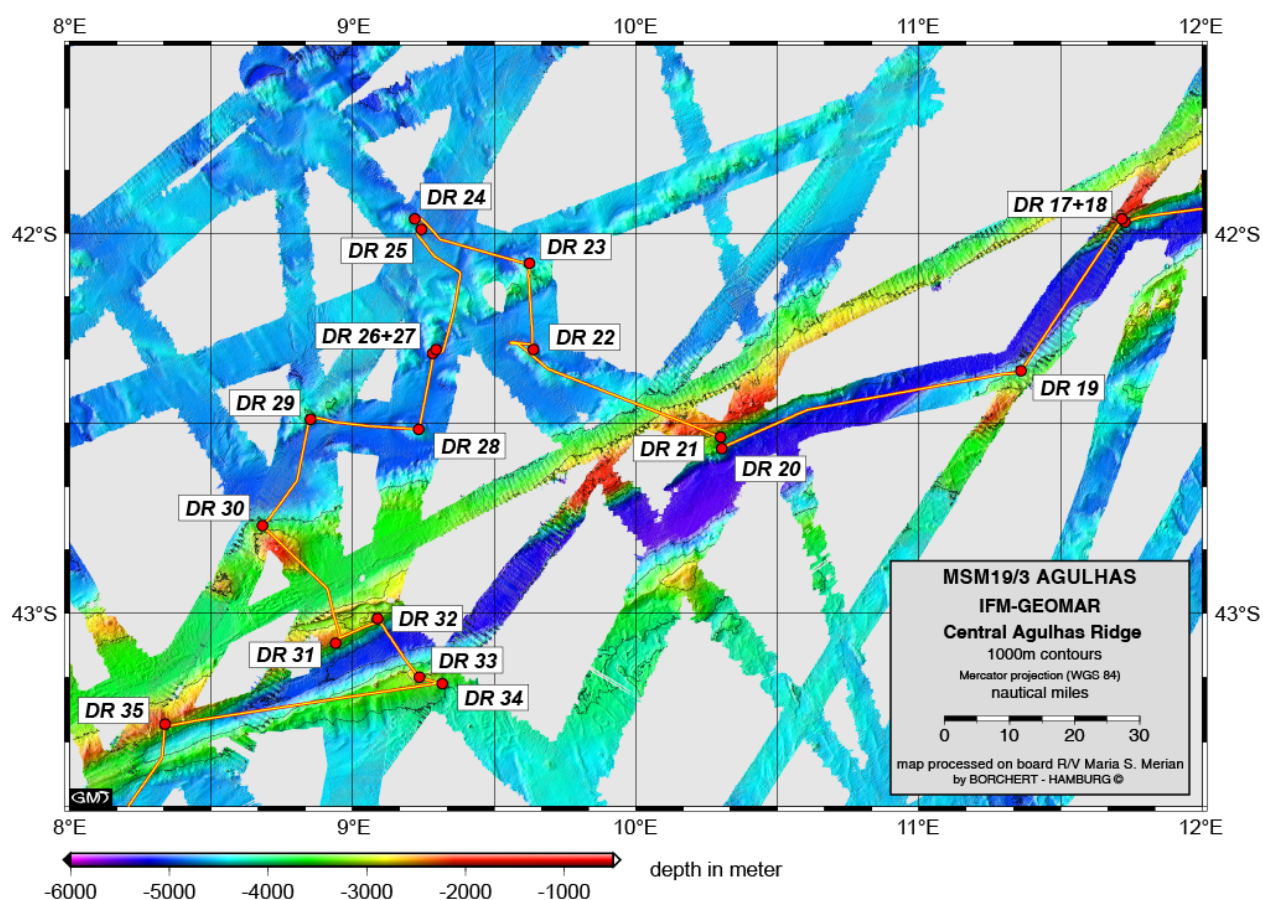


Fig. 5.3 Multi-beam map of the central part of the Agulhas Ridge and associated structures incl. MSM19/3 dredge stations. For data sources see chapter 5.1.2 (first paragraph).

Another feature of the Agulhas Ridge has been revealed by bathymetric mapping and geophysical studies conducted on the previous leg MSM19/2. Seamounts and small ridges are situated directly on the northern and southern ridge and appear of volcanic origin. These structures may have formed after the formation of the Agulhas Falkland fracture zones and may be related to reactivation of this fracture zone. To test this hypothesis, MSM19/3 aimed to sample some of these volcanoes.

Altogether 16 dredge hauls have been conducted at the flanks of the two parallel striking ridges and on seamount-like structures on top of them. The north-easternmost dredge hauls of the Agulhas-transect (DR 14 and 15) have been carried out at the southern flank of northern ridge in the transition zone between Richardson Seamount and the real Agulhas Ridge (Fig. 5.1). While DR 15 returned empty, DR 14 recovered homogeneous, heavily altered pillow fragments with 15 - 30% mostly filled vesicles and a fine-grained matrix. The matrix contains partly fresh fsp needles which may be suitable for Ar/Ar-dating. Dredge haul DR 16 aimed to sample a NW-SE-striking, oval shaped seamounts-like structure at the northeastern tip the southern ridge. The dredge returned mostly quartz, fsp and mica-bearing plutonic rocks with a pegmatitic matrix. Several cm-thick manganese crusts on the top and fresh broken surfaces on the downside of the rocks indicate that they are broken off from the ground. Minor lithologies are gabbroic rocks and crystalline rocks with fsp and quartz between layered mica (most likely biotite) and ~3% garnet. The latter appear to be plutonic rocks which has been metamorphically overprinted. This rock assemblage suggests that this seamount is an uplifted tectonic complex with continental crust affinities. Dredge tracks DR 17 and DR 18 have again been set up at the southern flank of northern ridge ~80 km southwest of DR 14 and 15. DR 17 failed to return rocks from the central part of the slope while DR 18 recovered a large amount of pillow fragments. The lavas are slightly to moderately altered, vary in vesicularity from 18% to almost dense, and range in texture from aphyric to porphyric with up to 8% fsp (< 8 mm), up to 8% cpx (< 8 mm) and up to 3% mostly iddingsitized ol.

Afterwards R/V MARIA S. MERIAN sailed ~50 km southwest to the southern ridge where DR 19 yielded homogeneous, aphyric and almost dense pillow fragments from the flank of a canyon-like structure which most likely was formed by a slope failure. Some of the pillow fragments are relatively fresh and chilled margins of some pieces contain even fresh volcanic glass. The next sampling station was again at the southern flank of the northern ridge ~120 km southwest of the last dredges there (Fig. 5.1). Unfortunately dredge DR 20 returned empty and a second attempt (DR 21) yielded only highly altered volcanoclastic rocks from a nose-like feature at the central slope. DR 31 was made again ~120 km southwest of DR 21 and 22 beneath the upper edge of the southern flank of the northern ridge and aimed to sample a prominent elevation on the ridge crest in order to test if this feature is volcanic or tectonic in origin. The dredge, however, failed to return rocks. The systematic sampling of the northern ridge was continued with dredge DR 32 being located ~10 km northeast of DR 31 at its upper southern slope. This dredge yielded different lithologies comprising pillow fragments, volcanoclastic rocks and gabbro-like material. The lavas are porphyric, have 3-20% vesicles and contain up to 7% fsp (< 3 mm) and up to 8% cpx (< 2.5 mm) as major mineral phases. Altered ol (< 2 mm) occurs minor. The rocks showing a gabbro-like fabric contain idio- to xenomorph ol, cpx and fsp phenocrysts. The volcanoclastic breccias consist of partly highly vesicular lava fragments embedded in a fine-grained sedimentary matrix. Just opposite of DR 32 (Fig. 5.1), dredge hauls DR 33 and DR 34

have been carried out on top of the southern ridge. DR 33 recovered a broad spectrum of rocks from a cone-like feature on top of the ridge crest. Apart from some highly altered, aphyric, and almost dense lava fragments, we consider the plutonic and volcanic rocks of this dredge haul as dropstones. Another attempt (DR 34) was made ~6 km east of DR 33 at the flank of a depression, which may have formed by a landslide, but failed to return any rocks. Back at the southern flank of the northern ridge, dredge haul DR 35 yielded a huge amount of pillow fragments, lava blocks, and some manganese crusts. The major lithologies are slightly to strongly altered porphyric lavas with up to 10% fsp (< 15 mm), 8% cpx (< 10 mm), and 5% ol (< 5 mm) and varying vesicularity (~25 - 2%) as well as aphyric, almost dense lavas (< 3%) being slightly to moderately altered. Approximately 130 km further southwest, dredge haul DR 37 yielded only intrusive rocks of unclear origin and manganese crusts from the upper southern flank of the northern ridge (Fig. 5.4). The southwestern-most sampling station at the real Agulhas Ridge (DR 38) has been conducted 90 km southwest of DR 37 at the upper northern slope of the southern ridge. The dredge returned lots of homogeneous, aphyric, and only slightly vesicular (< 5%) lava fragments and volcanic breccias. The majority of the lava fragments show a slight to moderate reddish alteration, slightly to strongly altered lavas without reddish discoloration are minor. The breccias consists of up to ~2.5 cm-sized fragments of the lavas in a clayey matrix and may represent the top breccia of the dredged lava flow.

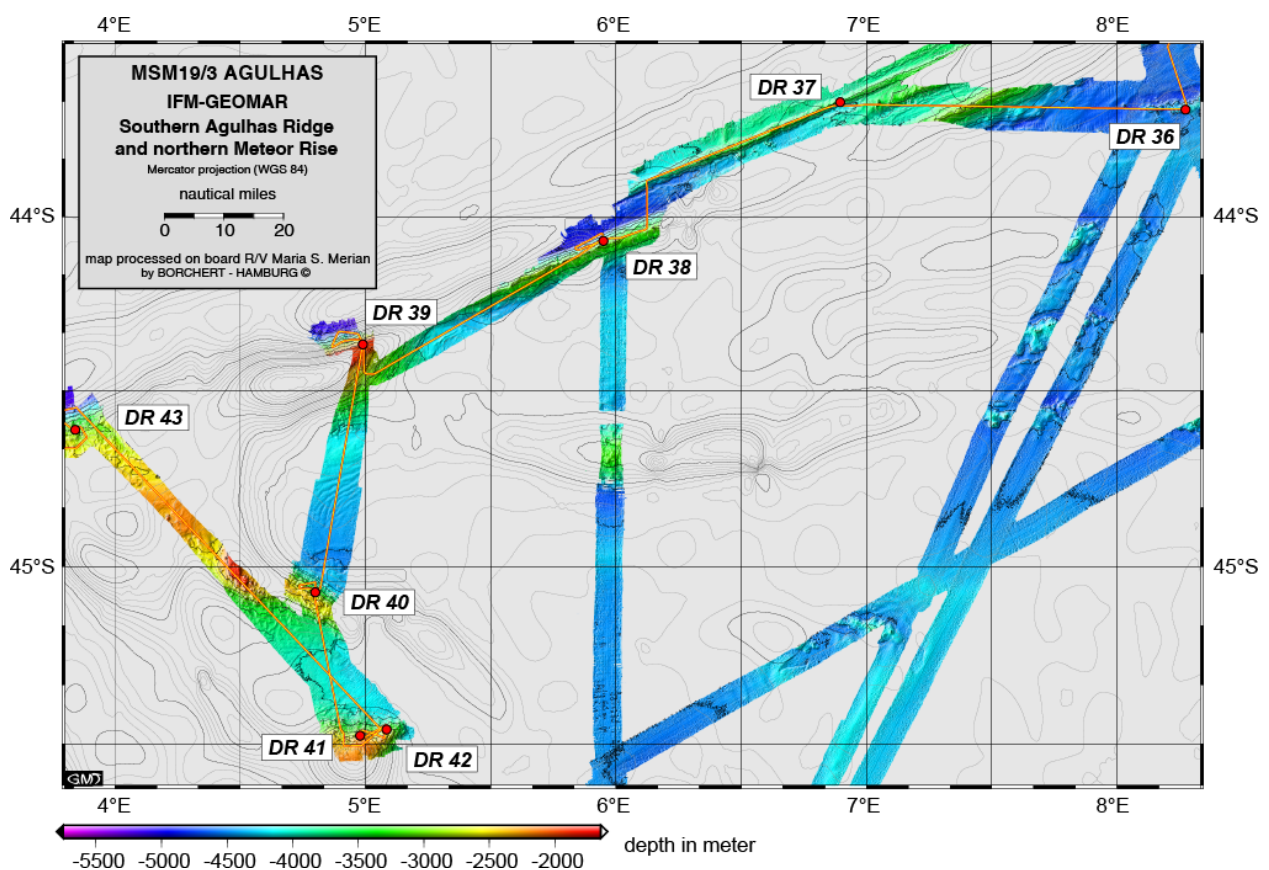


Fig. 5.4 Bathymetry of the southern part of the Agulhas Ridge and the northern Meteor Rise incl. MSM19/3 dredge stations. For multi-beam data sources see chapter 5.1.2 (first paragraph), background is based on GEBCO_08 (The GEBCO_08 Grid, version 20091120, <http://www.gebco.net>).

Taken together, 7 of 9 sampling sites at the ridge flanks yielded volcanic rocks, only DR 20/21 and DR 37 failed. The average distance between the successful sampling stations is ~140 km (i.e. 40 km more than originally planned), the largest sampling gap amounts to ~200 km at the southwestern Agulhas Ridge. Both stations at the northeastern and southwestern tip of the real Agulhas Ridge have been successful. Some of the recovered lavas and volcanoclastics are surprisingly fresh, other are moderately or heavily altered. We are, however, quite sure that rocks from all stations are suitable for further analyses if carefully prepared. Sampling of the (younger?) seamount- and ridge-like structures on the ridge crest was not as successful as dredging at the ridge flanks and yielded only highly altered volcanics at one station.

Leg MSM19/3 and a previous AWI cruise (project SETARAP, e.g. Uenzelmann-Neben and Gohl, 2005) also revealed, that the ocean floor to the north and the south of the Agulhas Ridge is characterized by a unusual rough morphology which clearly differs from normal deep sea plain. Among others, seismic profiles show that the magmatic basement frequently penetrates the sediments in this area and forms basement highs which rise up to ~1,000 m above the ocean floor (Uenzelmann-Neben and Gohl, 2005; Uenzelmann-Neben, 2012). That also points to a younger (Cenozoic?) phase of volcanic activity in the area of the Agulhas Ridge and therefore may indicate reactivation of the fracture zone. To verify this observation, we made the attempt to sample some of the seamounts north of the ridge (DR 22 - 29, Fig. 5.3). Dredging at these features, however, proved to be an extremely difficult task most likely due to thick manganese crusts covering the magmatic rocks and most dredges returned empty (DR 23 and 25 - 28) or contained only manganese knolls (DR 22) or dropstones (DR 24). Finally DR 29 sampled successfully one of the seamounts. Dredge haul DR 29 was made at the steep southeastern slope of seamount-like feature being part of a larger, probably tectonic NE-SW striking lineament. The dredge yielded four major lithologies. (1) moderately altered, dense lavas with up to 20% altered ol and up to 3% fresh fsp, (2) moderately altered, dense and aphyric lavas with up to 3% fresh fsp and 1% fresh cpx in a microcrystalline matrix, (3) relatively fresh dense volcanic rocks being very rich in fsp and cpx (both ~30%), and (4) dense metamorphic rock showing S-textures with flow structures which contain up to 1 mm sized fsp and may represent basaltic lava that has been metamorphically overprinted by fluids. Minor lithologies are gabbro-like plutonics and dense, aphyric volcanic rocks with several veins and cracks and partly metamorphized edges which appear to represent some kind of transitional stage between the lavas and the metamorphic rocks out of this dredge. Notably, the wide variety of lithologies and the presence of metamorphic rocks suggest intense tectonic movements in this area, being consistent with our morphological observations. An attempt to sample a seamount-like structure ~25 km south of the Agulhas Ridge (DR 36, Fig. 5.4) failed again to recover *in situ* magmatic rocks and yielded only manganese knolls and plutonic rocks of unclear origin.

5.1.2.3 Meteor Rise (DR 39 - 43)

The Meteor Rise forms a bathymetric anomaly which extends from the southwestern tip of the Agulhas Ridge ~600 km in southeastern direction until ~48°S. Four previous dredge hauls, carried out at its southeastern end during R/V POLARSTERN cruise ANTXXIII/5, recovered primarily geochemically enriched alkali basalts, trachybasalts and basaltic trachyandesites (LeRoex et al. 2010) which yielded Ar/Ar ages of 44 - 31 Ma (O'Connor et al. 2012). Based on trace element data, LeRoex et al. consider the Meteor Rise as part of the "Shona Ridges"

(includes Shona Ridge, Meteor Rise, Agulhas Ridge, and Cape Rise Seamounts), representing the surface expression of a Shona plume. Prior to MSM19/3, however, no samples or multi-beam data exist from the northern part of the Meteor Rise. Bathymetric maps based on satellite altimetry (“predicted bathymetry”) show some large, up to 3,000 m high seamounts in its northern part which are situated on a huge ridge-like structure. Our bathymetric mapping, however, revealed that these seamounts are large guyot-like features with steep flanks and flat topped plateaus. Some of them are obviously situated on a huge plateau morphologically resembling in part Richardson Seamount (in-between DR 40 and 43 on Fig. 5.4). Mapping and sampling of the northern part of Meteor Rise on cruise MSM19/3 aimed to get a more representative sample set of this structure in order to reconstruct its origin and relation to the Agulhas Ridge and Fracture Zone.

The first dredge haul (DR 39) at Meteor Rise was made directly beneath the plateau edge at the northern flank of a huge, NE-SW elongated seamount where the Agulhas Ridge passes over into the Meteor Rise (Fig. 5.4). DR 39 recovered mainly slightly to highly altered, dense to relatively vesicular (20 - 25%) ol-fsp-phyric lava fragments (ol up to 1 cm, but mostly altered) and a variety of yellowish to brownish sedimentary rocks. Approximately 75 km further south, multi-beam mapping revealed a NW-SE-trending ridge-like feature striking perpendicular to the Agulhas Ridge and associated structures. From a noose-like structure at the upper northeastern flank of this ridge DR 40 returned mainly moderate to strongly altered, aphyric, highly vesicular (up to 50%) pillow fragments with up to 5 mm-sized, mostly altered ol phenocrysts. Additionally DR 40 contained some highly altered volcanoclastic rocks, manganese crusts, and metamorphic rocks with shist-like layering which may be metamorphic overprinted fragments of the lava described above. Approximately 50 km south of DR 40 the predicted bathymetry shows a large circular seamount which turned out to be a ~2,500 m high guyot-like feature. Dredge haul DR 41 has been carried out at the upper northern flank of this seamount and yielded manganese crusts containing fragments of highly altered volcanic rocks and slightly altered, migmatitic metamorphic rocks with up to 20% garnet, 10-15% quartz, 20 - 30% fsp, and 5 - 10% mica (biotite). A second attempt to sample this structure was made by dredge haul DR 42 at a small, ridge like structure at its northeastern foothills. Dredge DR 42 yielded a highly heterogeneous mixture of volcanic, volcanoclastic, metamorphic, intrusive, and sedimentary rocks. Most of these rocks are most likely dropstones. Some volcanic rocks, however, show evidence for *in situ* origin. They comprise moderately altered, highly vesicular (up to 50%) porphyric lavas with altered ol (~1%), cpx, and fsp (both up to 10% and up to 15 mm), relatively fresh, almost dense, and aphyric lavas, and strongly altered volcanic breccias consisting of clasts that appear to be the same lithology as the highly vesicular, porphyric lavas of this dredge. A final dredge station (DR 43) in the Meteor Rise region has been selected ~130 km northwest of DR 41/42 at the northern flank of the huge plateau (Fig. 5.4). This dredge, however, contained only a large amount of solidified sediments (mudstones) and some intrusive rocks considered as dropstones.

Taken together, dredging at the northern Meteor Rise yielded again metamorphic rocks besides lavas, volcanoclastics, sediments and manganese. Furthermore the dredges contained a broad variety of plutonic, metamorphic, and sedimentary rocks which we consider as dropstones. Two varieties dominate among the *in situ* lavas recovered at Meteor Rise: a vesicular, ol-fsp-phyric lava and a dense, almost aphyric lava.

5.1.2.4 Discovery Rise (DR 44 - 57)

The Discovery Rise comprises 12 large, ~3,500 - 4,000 m high seamounts and some smaller bathymetric highs which appear to be roughly aligned in two ENE-WSW trending sub-parallel seamount chains (Fig. 5.5). Although most of these seamounts are enormous structures and sometimes reach only a few 100 m below sea-level, it took until 1936 before they were discovered. So far only a few rock samples were recovered from five localities along the easternmost seamounts of the Discovery Rise (Kempe and Schilling 1974, LeRoex et al. 2010 and references therein). Most of these samples are 41 - 35 m.y. old trachybasalts, trachyandesites, and trachytes which have been dredged on R/V POLARSTERN cruise ANTXXIII/5 (LeRoex et al. 2010, O'Connor et al. 2012). The only sample dredged previously is from the northernmost seamount of the Discovery Rise (BMI954) and has been described as ~25 m.y. old basalt by Kempe and Schilling (1974). Based on the enriched geochemical composition of the available samples and/or plate kinematic plume track reconstructions, some authors postulate a deep mantle origin (plume) for the Discovery Rise (e.g. Douglass et al. 1995, LeRoex et al. 2010, O'Connor et al. 2012). Seismic mantle tomography, however, does not provide any evidence for an active plume structures (e.g. Montelli et al. 2004). Their absence rather may indicate that the Discovery Rise is a remnant of a fossil intraplate volcanic event or hotspot track. MSM19/3 aimed for a representative dredge sampling of the entire Discovery Rise complementing the previous sampling in order to verify the models of its origin and possible relations to magmatism along the Agulhas Ridge. Accordingly ten of the 12 large Discovery seamounts and one smaller feature were partially mapped and sampled. In the following paragraphs, the seamounts studied on MSM19/3 are named "Seamount 1" through "Seamount 12" (Fig. 5.5). All studied Discovery seamounts possess a guyot-type morphology with steep flanks and an erosional plateau on top. Guyots are former ocean island volcanoes that were eroded to sea-level and submerged to the deep sea as a result of lithospheric cooling.

MSM19/3 dredge sampling of the Discovery Rise started in its southeastern region at the southern flank of "Seamount 1", a circular guyot measuring ~50 km in diameter at its base (Fig. 5.5). The edge of its erosional platform lies at ~770 m and its base at ~4,000 - 3,800 m water depth. Dredge DR 44 recovered mainly relatively fresh, slightly to moderately vesicular (up to ~25%) aphyric and porphyric lava fragments and manganese crusts from the central part of the slope. The porphyric lavas contain up to 20% cpx, up to 12% fsp and sometimes strongly altered ol phenocrysts (up to 12%). "Seamount 2", located ~70 km northwest of "Seamount 1", is one of the few seamounts situated in between the two Discovery seamount chains. This seamount is also a typical circular guyot but measures only ~30 km at its base in 3,800 m water. The erosional platform lies in 1,300 m water depth at the edges and in 950 m in the center. The inward shoaling of the platform is consistent with subsidence occurring contemporaneously with erosion at sea level to form the platform. Notably the platform edges of "Seamount 2" lie 530 m deeper than those of "Seamount 1", implying different ages and/or subsidence rates for these nearby volcanoes. Short ridges emanate from the main edifice of "Seamount 2" mainly in south and southeast direction, which reach lengths of a few km. These ridges are interpreted as volcanic rift zones. Dredge haul DR 45 has been carried out at the upper eastern flank of such a rift and yielded mainly slightly altered porphyric lava fragments. The lavas are moderately vesicular (15 - 20%) up to 7% fsp phenocrysts and minor amounts of cpx. An altered

volcaniclastic rock found in that dredge appears to consist of clasts of the porphyric lava described above embedded in fine-grained yellowish lava.

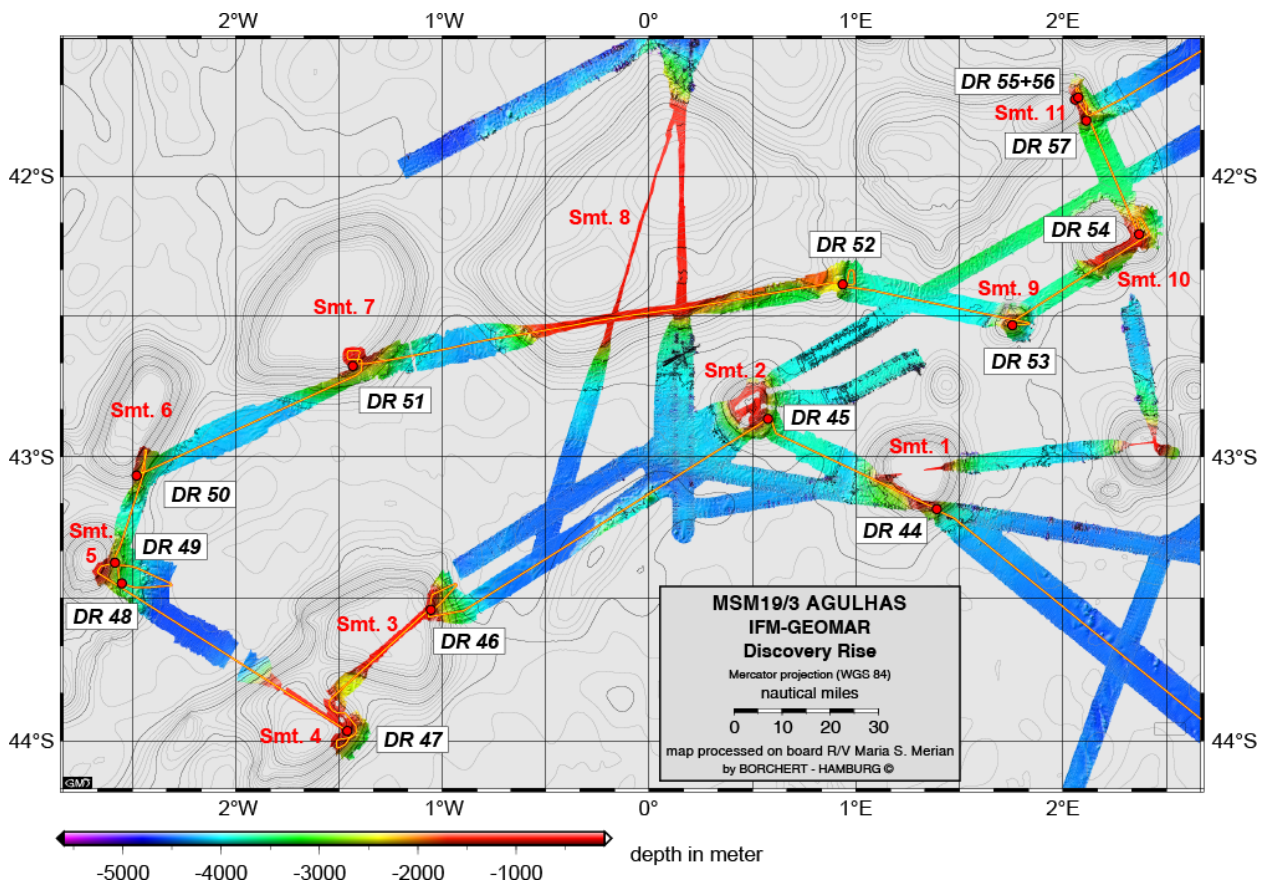


Fig. 5.5 Bathymetry of the Discovery Rise incl. MSM19/3 dredge stations and seamount numbers (red) used in this chapter. For multi-beam data sources see chapter 5.1.2 (first paragraph), background is based on GEBCO_08 (The GEBCO_08 Grid, version 20091120, <http://www.gebco.net>).

The next target of RV MARIA S. MERIAN was a large NE-SW trending seamount/ridge complex marking the southwestern end of the southern Discovery seamount chain (Fig. 5.5). The complex comprises a chain of two major and one smaller, partly merged seamounts and a curvilinear ridge-like extension emanating from the seamounts more than 200 km in WSW direction. The northeasternmost seamount of this complex, "Seamount 3", is a large guyot being ~70 km at its base at ~4,300 m water depth. The outer part of the plateau occurs at depths of 1,100 m and the interior at depths of 550 m. Dredge haul DR 46 was made at the upper northeastern flank of "Seamount 3" directly beneath the plateau edge. The dredge mainly returned altered porphyric lava fragments which are probably clasts out of a breccia. The lava fragments have 3 - 15% vesicularity, 5 - 10% fsp phenocrysts up to 2 cm in size and varying amounts of cpx and ol. Some of the fragments show differently colored parts, others elongated, unequally distributed flowing structures or highly vesicular "areas" in their matrix. These fragments either consists of two different types of lava and were formed by lava mingling or represent pieces of an igminbrite. A minor lithology of DR 46 are aphyric, highly vesicular (~40%) lava fragments. "Seamount 4" is again a roughly circular guyot and located directly southwest of "Seamount 3". According to the predicted bathymetry both volcanoes seem to be

partly merged. "Seamount 4" measures ~60 km in diameter at its base (4,300 m water depth) and rises to 1,200 m b.s.l. at its plateau edges and less than 650 m in its center. An attempt to sample the upper southeastern flank of this seamount failed because the dredge was lost due to a technical failure. Afterwards RV MARIA S. MERIAN headed to the westernmost Discovery Seamounts due to time constraints.

"Seamount 5" is a circular guyot at the western tip of the northern Discovery seamount chain (Fig. 5.5). This guyot is the central seamount of NNE-SSW-trending complex which consists of 4 partly merged seamounts. The base of this complex lies at ~4,500 m water depth. "Seamount 5" measures ~35 km in diameter and rises up to 950 m at its plateau edge. Only a small section of its eastern flank has been mapped on MSM19/3. In this area several extension (volcanic rifts) emanate from its main edifice up to ~20 km in eastern directions. Dredge haul DR 48 recovered only one piece of manganese crust from the lower eastern flank of "Seamount 5". A second sampling attempt (DR 49) was made ~9 km further north at the northern slope of one of the volcanic rifts. This dredge yielded relatively homogeneous, porphyric lava clasts out of a breccia and manganese crusts. The lava clasts are only slightly to moderately altered and show little vesicularity (<5%). They consist of ol (~10%) and fsp (~5%) phenocrysts up to 6 mm in size in a fsp-ol-cpx-phyric groundmass and may represent picritic rocks. "Seamount 6" is located directly north of "Seamounts 5" and has a 65 x 45 km oval shaped base, elongated NNE-SSW. Its plateau edge lies in ~1,000 m water depth. Due to time constraints, again only a very small part of its southeastern flank has been mapped. The map reveals some kind of volcanic rift at its southeastern corner which is marked by ridge- and cone-like structures. Dredge haul DR 50 was made at the upper northern flank of this feature and yielded two pieces of volcanoclastic rocks consisting of altered, aphyric, and moderately vesicular lava fragments and palagonite clasts which sometimes contain relatively fresh glass cores.

"Seamount 7" appears to be the second largest guyot of the Discovery Rise and is located in the center of the northern seamount chain. Its oval shaped base amounts to ~100 x 75 km at ~4,200 m water depth and its partly mapped southeastern flank rises to ~1,100 m (plateau edge). The flank is marked by depressions, which most likely have formed by slumps, and small ridge-like structures. Dredge haul DR 51 recovered abundant homogeneous pillow fragments from the upper flank directly beneath the plateau edge. The rocks are moderately altered, aphyric and only slightly vesicular (< 3%). Palagonite breccia containing sometimes low amounts of relatively fresh glass is attached to some of the pillow fragments. "Seamount 8" is located directly east of "Seamount 7" and represents by far the largest Discovery seamount. It roughly triangle-shaped base measures ~150 x 120 km and lies in 4,500 - 3,800 m water depth. According to the few multi-beam tracks crossing "Seamount 8" (recorded on MSM19/3 and previous R/V POLARSTERN transits) its eastern and northern plateau edges lie in 1,400 m water depth and the western plateau edges in ~1,900 m, implying non-uniform subsidence of this seamount. A multi-beam track crossing its plateau reveals shallow water depths of less than 420 m in its center. The predicted bathymetry may suggest that "Seamount 8" consists of two or three merged seamounts (Fig. 5.5). Dredge haul DR 52 has been conducted at the central flank of the southeastern corner of "Seamount 8" just beneath a small sub-plateau located in ~2,400 m water depth. Apart from manganese crusts and a dropstone, DR 52 yielded a large pillow. The lava is altered, ol-phyric and almost dense. Ol (up to 7%, < 5 mm, highly altered), fresh cpx (< 3%), and fsp (< 1%) occur as phenocrysts.

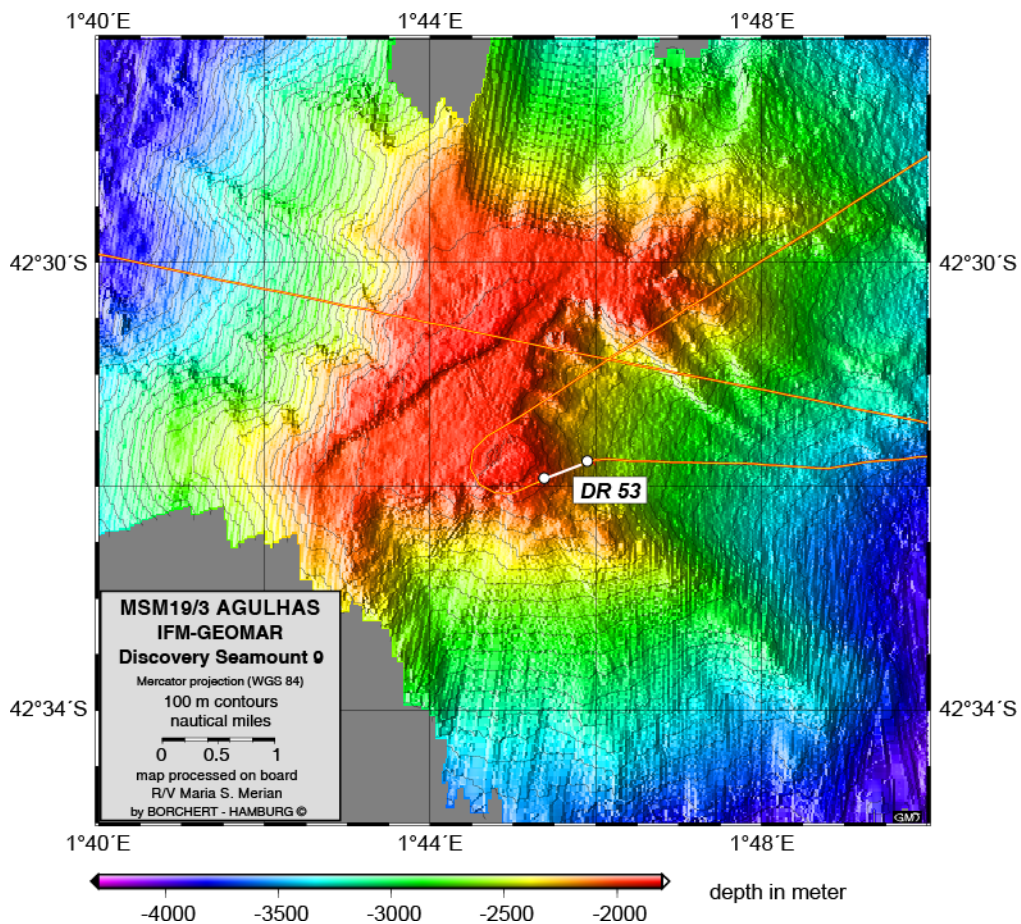


Fig. 5.4 Multi-beam bathymetry of "Seamount 9" incl. MSM19/3 dredge track. Multi-beam data are recorded on MSM19/3.

From "Seamount 8" RV MARIA S. MERIAN sailed to the northeastern part of the Discovery Rise. "Seamount 9" differs in many aspects from the other Discovery seamounts studied on MSM19/3. This volcano is located in-between the two seamount chains and is significantly smaller and lower than most other Discovery seamounts (Fig. 5.5). Its roughly oval, irregular shaped base measures $\sim 20 \times 15$ km and it rises from 3,900 m to 1,850 m water depth. A small, irregular shaped top plateau with a maximum extend of 6 km indicates that this seamount is most likely also a guyot. The plateau edges are located in 2,100 - 2,000 m water depth. The flanks of "Seamount 9" are marked by numerous ridges and depressions formed by slumps (Fig. 5.6). Obviously this seamount underwent significant erosion not only during formation of the top plateau but also at its flanks. Dredge haul DR 53 was made directly beneath the top plateau at the northeastern flank of a ridge-like structure. The dredge returned pillow fragments, volcanic breccias, and manganese crusts. The lava fragments are moderately altered, slightly vesicular (<1 - 7%), and porphyric. Based on their phenocryst content, two lithologies can be distinguished: one with 3% ol, 2% cpx, and 3% fsp and the other with significantly more cpx (12 - 15%) and fsp (7% - 10%). "Seamount 10", a roughly circular guyot, is located ~ 50 km northeast of "Seamount 9" and belongs to the easternmost Discovery seamounts. Its base measures ~ 45 km in diameter at 3,500 m water depth. Similar as observed at the huge "Seamount 8", its plateaus edges lie at 1,350 m water depth in the east and at 1,900 m in the west. Its flanks are marked by numerous depressions and ridge-like structures (but less distinct as at "Seamount 9"). Dredge DR

54 has been carried out at its upper eastern flank again directly beneath the plateau edge and returned strongly altered volcanic rocks and some deep sea corals. The major lithology in this dredge are slightly vesicular (3 - 15%), porphyric lava fragments with ~10% ol (< 2.5 mm), < 3% cpx, and ~5% fsp phenocrysts. Vesicular (20 - 35%) lavas with less ol and cpx are minor. All phenocrysts except of some fsp are altered. Approximately 50 km further NNW, the final dredge hauls of MSM19/3 have been conducted at "Seamount 11". According to the predicted bathymetry, this guyot is the eastern of two merged seamounts (Fig. 5.5). It has an oval shaped base measuring 40 x 30 km in 3,500 m water depth. Only a part of the eastern flank has been mapped on MSM19/3. The new multi-beam data reveal a steep slope with a plateau edge at 1,100 m water depth. A ~11 km long ridge representing a volcanic rift emanates from the slope in eastern direction. Dredge haul DR 55 has been carried out at the upper slope and returned empty. Some hundred meters further north, another attempt was more successful. DR 56 returned lots of only slightly to moderately altered, porphyric lava fragments with varying vesicularity (< 3 - 30%) and volcanic breccias. The lavas contain up to 20% ol, 5 - 10% cpx and minor amounts of fsp phenocrysts. The breccias are highly altered and consist of dense, aphyric to slightly ol-phyric lava clasts. After this successful dredge there was still time for one more dredge in this area before RV MARIA S. MERIAN had to start to transit to Cape Town. The final dredge (DR 57) of the cruise was made at a ridge-like structure at the southeastern corner of "Seamount 11" but yielded only a big bloc of solidified sediment, some manganese crusts and one fossil coral.

MSM19/3 dredge sampling at the Discovery Rise provided by far the most representative sample set of these seamounts to date. Ol-cpx-fsp-phyric lavas with varying vesicularity dominate among the dredged volcanics, aphyric lavas and volcanoclastic rocks are minor. Today's water depth of the plateau edges at 9 from 11 seamounts of our survey shows that they sunk 950 - 1,400 m below sea-level since their erosion. This relative uniform submergence level most likely implies that these seamounts are similar in age and have analogous submergence rates. This hypothesis is consistent with the available Ar/Ar data (41 - 35 Ma, O'Connor et al. 2012). The plateau edge of "Seamount 1", however, is higher (770 m water depth) and that of the small "Seamount 9" significantly deeper (1,850 m) as those of the majority of the Discovery seamounts. Moreover the huge "Seamount 8" and "Seamount 10" appear to be tilted during subsidence as indicated by deeper plateau edges in the west (1,900 - 1,800 m) as in the east (1,400 - 1,350 m). This observation may point to intense tectonic processes and, in case of "Seamount 1" and "Seamount 9", possibly to differing ages, implying long-lasting or repeated volcanic activity in the area of the Discovery Rise. On the other hand, neither the new bathymetric data nor the previous R/V POLARSTERN tracks provide any evidence for post-erosional or late stage volcanism (e.g. cones on the erosional plateaus) as it has been observed at Richardson Seamount and many other guyot-type seamounts worldwide. Ar/Ar dating of the new samples will allow us to constrain the volcanic history of the Discovery Rise.

5.2 Magmatic Rock Sampling Summary and First Analytical Results

(R. Werner, F. Hauff, P. Hoffmann)

Rock sampling on R/V MARIA S. MERIAN cruise MSM19/3 achieved its major objectives by extensive dredge sampling of the Discovery Rise and at Richardson Seamount, and the first representative hard rock sampling along the Agulhas Ridge and the northern Meteor Rise. The

wide range of intrusives, subvolcanic rocks, lavas and volcanoclastic rocks obtained on MSM19/3 represents by far the most detailed sampling of these structures and associated features to date. Detailed volcanological, petrological and geochemical analyses, and radiometric age dating of these rocks will provide a comprehensive data set of the Agulhas- and Discovery rocks. Combined with the results of the geophysical investigations of MSM19/2, our data will enable us to successfully accomplish the research project AGULHAS and to achieve the goals listed in chapter 3. Most hard-rock analytical results, however, require complex and long-lasting preparation and analytical facilities not available onboard a research vessel. In addition, many of the analytical methods cannot be carried out at the same time but have to be conducted one after the other. For example, thin sections of the samples need to be made and evaluated to select samples that are appropriate for major element analyses and age dating. The major element analyses are used to evaluate alteration of the samples further and to select representative samples for trace element analyses and age dating. Trace element data are then used to select samples for isotope analyses. The samples selected for age dating need to be irradiated in a reactor and then analyzed after short-lived isotopes have had a chance to decay. Based on the trace element and isotope data, additional samples are selected for age dating and so forth. This procedure will last at least 2 - 3 years and, therefore, comprehensive results of hard rock analyses and radiometric age dating cannot be presented at this stage.

A few preliminary conclusions, however, can already be drawn from visual observations during the cruise and a first evaluation of the rock samples onboard:

- Bathymetric mapping on MSM19/2 and MSM19/3 provides strong evidence for a tectono-magmatically reactivation of the Agulhas Ridge and in adjacent areas as, for example, small, well preserved volcanic cones on the erosional plateau of Richardson Seamount and nearby on the ocean floor; seamount- and ridge-like structures on the ridge crest of Agulhas Ridge; or the rough morphology of the ocean floor to the north and south of the Agulhas Ridge which is certainly caused by tectonic and volcanic events. Furthermore, the occurrence of metamorphic and intrusive rocks as well as of tectonic breccias at the Agulhas Ridge, Meteor Rise, and associated features indicates intense, probably large-scale vertical tectonic movements. These observations are consistent with first results of the seismic studies carried out on MSM19/2 (e.g. Uenzelmann-Neben 2012) and a previous cruise (Uenzelmann-Neben and Gohl 2005) and certainly proves reactivation of the Agulhas Fracture Zone. Age dating of MSM19/3 rock samples will constrain the time period(s) of that reactivation.
- Notably none of the 8 successful dredge hauls conducted at Richardson Seamount yielded *in situ* rocks of continental origin. Therefore, dredge sampling on MSM19/3 does not support the hypothesis, that the northern Agulhas Ridge (i.e. Richardson Seamount) might represent a sliver of continental lithosphere (Uenzelmann-Neben and Gohl 2005). Even if we cannot completely exclude the occurrence of continental rock in non-surveyed areas of the huge Richardson Seamount, MSM19/3 shows that at least significant parts of this structure are volcanic in origin.
- Rock sampling of MSM19/3 yielded heavily fragmented and highly vesicular volcanic rocks which have been erupted in water depth $\gg 2,000$ m and thus provides further evidence for explosive volcanic processes in deep water conditions. Therefore MSM19/3 may also contribute to the ongoing discussion to what extent and how explosive volcanic eruptions can occur in deep water conditions.

- All surveyed seamounts of the Discovery Rise are guyots (i.e. former island volcanoes). Our new bathymetric data reveal that most but not all of these seamounts are most likely similar in age and have analogous submergence rates. MSM19/3, however, also yielded some evidence for differing periods of volcanic activity and / or intense tectonic processes in the area of the Discovery Rise. Detailed analyses and age dating of the Discovery rocks will help to verify this observation.

So far more than 100 thin sections of the almost 400 MSM19/3 rock samples have been microscopically evaluated. Based on the results of microcopy, a first set of 43 samples (mainly from the Discovery Rise, see below) has been prepared for geochemistry by means of crushing, sieving, cleaning in deionized water, picking of the freshest rock chips under a binocular microscope and finally preparation of powders in an agate mortar and agate ball mill. Major elements by XRF and loss on ignition (LOI) were determined for all of these samples at the University Hamburg in the lab of Prof. Jung at the Institute of Mineralogy and Petrography. Trace elements were determined for a subset of 23 samples by solution ICP-MS in the lab of Dr. Garbe-Schönberg at the Institute of Geosciences at Kiel University. As expected from field observations during the cruise and thin section petrography many samples, in particular those from the Discovery Seamounts, are indeed altered and show elevated LOI values of up to ~ 6 wt % and up to ~ 4 wt% P₂O₅. These values are in places higher than those reported for 13 samples of four previous dredges along the eastern Discovery Rise (Le Roex et al. 2010).

A preliminary petrological-geochemical study on 25 samples recovered from the Discovery Rise was carried out in the framework of a master thesis by Ms. Paulina Hoffmann between April and September 2012 (Hoffmann 2012). This work included screening of all Discovery Rise samples by thin section petrography to obtain the freshest samples from all 11 Discovery seamounts sampled during MSM19/3. On this subset, a more detailed petrographic description has been worked out showing the presence of altered ol, ± fresh plagioclase and subordinate pyroxene phenocrysts in variable altered groundmass in the majority of samples. In some samples biotite (DR 44) and kalifeldspar (DR 46) have been observed and will serve, besides plagioclase, as prime K-bearing minerals for ³⁹Ar/⁴⁰Ar age dating. According to the newly obtained geochemical data, the MSM19/3 Discovery samples are also alkaline in character as reported by Le Roex et al. (2010) for the eastern Discovery Seamounts and show a progression in differentiation from basanites/tephrites over basalts, trachybasalts, basaltic trachyandesites and trachyandesites to trachytes. The trachyandesites and trachytes contain biotite in their mineral assemblage, whereas more mafic minerals (ol, cpx) and plagioclase are restricted to the less evolved samples. Chemical discrimination diagrams suggest formation in an intraplate setting away from mid-ocean ridges. Mantle normalized incompatible element values display a highly enriched ocean island basalt (OIB) pattern and the depletion of the heavy rare earth elements (HREE's) relative to the light and middle REE's indicate deep average melting depths in the presence of garnet. Some trace elements, e.g. Ba, La, Th and Nb are more enriched than in common OIB or other South Atlantic OIB. Examination of the elevated Ba/Nb, Ce/Nb, La/Nb, Nb/Yb and Th/Yb ratios in the MSM19/3 Discovery samples suggests the presence of the enriched mantle one (EM1) end member in the magma source of the Discovery Rise. Available data for terrigenous and pelagic sediment and subcontinental lithospheric mantle (SCLM) along with model estimates indicate that pelagic sediment and small amounts of recycled SCLM are likely to be the major constituents of the EM1-component in the source of the Discovery

seamounts. This source is thought to have formed via subduction of ocean crust along with SCLM erosion during the subduction process, followed by storage at a boundary layer within the mantle and later ascend in a mantle plume or blob to form the Discovery Seamounts. Thus far the elevated EM1 like trace element ratios along with published ages for seamounts from this area (O'Connor et al. 2012) in conjunction with plate kinematics favor a plume origin for the Discovery seamounts. Although the absence of negative P-wave anomalies beneath the Discovery seamounts argues against the presence of a mantle plume today, it may well indicate that intraplate volcanism in this area operates in pulses that might be related to small upwelling blobs originating from the African superswell (Rhode et al. 2013).

Apart from this master thesis, an ongoing bachelor thesis deals with a comparison of small data sets from the Agulhas Ridge incl. Richardson Seamount, Meteor Rise, and Discovery Rise. For a more detailed understanding on the origin of the features sampled during MSM19/3, major and trace element analyses of more comprehensive sample set mainly from Richardson Seamount, Agulhas Ridge and associated features, and Meteor Rise as well as further investigations in terms of age determinations and radiogenic isotopes will be conducted among others in the framework of a PhD-thesis which started in September 2012.

5.3 Biology

(C. Lüter, B. Neuhaus, N. Furchheim, A. Roth)

The biological studies conducted in the framework of MSM19/3 are not integral part of the MSM19/2 and /3 research project and did not require any additional ship's time. The biological studies just aim to preserve and study marine organism found on the dredged rocks and in the sediment traps installed in our dredges.

5.3.1. Methods

Biological material was collected during the cruise by deployment of a geological chain bag dredge. All boulders and rocks collected with the dredge were scanned for encrusting benthic invertebrates. Additionally, four sediment trap tubes (length: 21 cm, diameter: 4 cm) were fixed in the dredge to collect a disturbed sediment sample from each dredging site.

For studies of the meiofauna, sediment sampled by four sediment trap tubes (length: 21 cm, diameter: 4 cm) inside the geological chain bag dredges was fixed immediately in cold 6% formaldehyde buffered with buffer tablets for haematology (Merck # 1.09468.10100, pH 7.2) and stored on board the ship at 4-8°C. After the cruise, the sediment was washed carefully with plenty of tap water on a 40 µm-sieve and centrifuged (THERMO Heraeus Multifuge 3s) three times for 5 minutes with three to four times the amount of Levasil 200A/40% at 4,000 rpm in order to quantitatively extract the meiofauna. After rinsing with tap water on a 40 µm-sieve, specimens were stored in 75% ethanol.

Macrofaunal organisms were picked from the collected rock and immediately fixed in cold, 100% ethanol for future histological and/or molecular investigations. Selected specimens were also fixed in formalin for preservation and long term storage in the marine invertebrate collection of the Museum für Naturkunde, Berlin. Small pieces of these specimens were additionally fixed in ethanol to facilitate DNA extraction. All specimens were kept in the fixative until further processing.

5.3.2. Preliminary Results and Discussion

Macrofaunal organisms were recovered at 26 out of 57 collecting stations; 42 stations revealed sediment samples. Preliminary sorting of one third of the samples (= 14 samples) after the cruise reveals a total of 1,671 meiofaunal organisms from about 8 kg of sediment (Tab. 1). For a detailed list of the collected macrofaunal taxa and the number of specimens per taxon see Appendix II.

The sediment samples from the dredge revealed meiofauna species from many marine invertebrate groups of the animal kingdom, and demonstrated the diversity of animal life on the seamounts. Nematoda and Copepoda outnumbered by far all other meiofaunal groups followed by the Polychaeta and Plathelminthes. Specimens of several other taxa have been recovered at far lower densities from the pre-sorted samples. Kinorhyncha (probably species of the genus *Echinoderes*) were found only occasionally. It must be kept in mind that just 1/3 of the samples have been sorted yet and that the amount of sediment captured by the sediment traps in the geological chain bag dredges was quite small and variable. After sorting of all samples it will most certainly turn out that a considerable amount of biological specimens has been collected with only slightly modified geological dredges during the cruise of MSM19/3.

The dominating macrofaunal groups were cnidarians and sponges, but we also found polychaetes, bryozoans, echinoderms, molluscs, and at 3 stations (DR4, 5 and 46) the target group Brachiopoda. These brachiopods mainly comprise cancellothyridid species of the genus *Eucalathis*, which has a worldwide distribution along the oceanic ridges and can be found in depths down to about 5000 m. Previous expeditions to the SW-Pacific (SO168) and SE-Pacific (SO144-3, SO158, SO208-1, SO208-2) revealed many specimens of this genus and the closely related genera *Bathynanus*, *Nanacalathis*, and *Notozyga*, which can now be used for comparison. Morphologically, all *Eucalathis* species are very similar and difficult to distinguish by shell characters alone. Since we have found *Eucalathis* specimens in the MSM19/3 samples which seem to be identical to the Pacific ones, we have now started molecular analyses of standard markers, such as the nuclear 18S gene, and the mitochondrial 16S and 12S genes to look for differences on the DNA level. If these specimens happen to be identical on the molecular level, too, we can hypothesize a worldwide distribution not only of the genus *Eucalathis*, but also of certain species within the genus. This would be even more astonishing, since these deep sea brachiopods have non-feeding larvae, which have to settle after a short period of time and can therefore only bridge short distances per generation. Taking into account the cold water temperatures in the deep, physiological processes of the swimming larvae may be slower than in warmer conditions to the effect that the non-feeding larvae of *Eucalathis* have a much slower development and hence may be long-distance travellers. A similar situation has been described for the Antarctic terebratulid brachiopod *Liothyrella uva* (Peck and Robinson 1994).

6 Station List MSM19/3

Station No.		Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
Event label	Dredge	2011		[UTC]	[°S]	[°E]	[m]	
MSM19/1072-1	DR 1	3.12	DR	22:58	39° 52.31'	13° 52.25'	4741.1	empty
MSM19/1073-1	DR 2	4.12	DR	02:39	39° 53.81'	13° 53.11'	4244.5	few rocks
MSM19/1074-1	DR 3	4.12	DR	08:32	40° 16.09'	14° 23.66'	2786.7	few rocks
MSM19/1075-1	DR 4	4.12	DR	12:56	40° 27.56'	14° 44.45'	1690.1	3/4 full
MSM19/1076-1	DR 5	4.12	DR	15:14	40° 22.29'	14° 54.26'	1649.0	3/4 full

Station No.		Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
Event label	Dredge	2011		[UTC]	[°S]	[°E]	[m]	
MSM19/1077-1	DR 6	4.12	DR	18:26	40° 28.08'	15° 5.31'	2363.7	1/5 full
MSM19/1078-1	DR 7	4.12	DR	23:13	40° 45.47'	14° 42.49'	3214.9	1/2 full
MSM19/1079-1	DR 8	5.12	DR	03:01	40° 48.51'	14° 42.32'	4203.3	few rocks
MSM19/1080-1	DR 9	5.12	DR	10:10	41° 12.36'	14° 12.07'	4056.3	few rocks
MSM19/1081-1	DR 10	5.12	DR	15:18	41° 15.67'	14° 10.16'	4010.5	few rocks
MSM19/1082-1	DR 11	5.12	DR	19:11	41° 12.29'	14° 6.78'	4253.6	empty
MSM19/1083-1	DR 12	6.12	DR	00:13	41° 13.99'	13° 41.44'	3205.4	few rocks
MSM19/1084-1	DR 13	6.12	DR	03:51	41° 13.87'	13° 41.92'	3316.5	few rocks
MSM19/1085-1	DR 14	6.12	DR	12:23	41° 40.71'	12° 31.81'	4194.3	few rocks
MSM19/1086-1	DR 15	6.12	DR	16:46	41° 39.11'	12° 34.90'	3975.9	empty
MSM19/1087-1	DR 16	6.12	DR	21:41	41° 50.19'	12° 55.79'	3717.8	few rocks
MSM19/1088-1	DR 17	7.12	DR	06:42	41° 58.08'	11° 44.15'	3527.7	empty
MSM19/1089-1	DR 18	7.12	DR	10:01	41° 57.57'	11° 43.58'	2708.3	1/2 full
MSM19/1090-1	DR 19	7.12	DR	17:17	42° 21.37'	11° 22.03'	4137.9	few rocks
MSM19/1091-1	DR 20	8.12	DR	02:00	42° 33.81'	10° 18.60'	4228.1	empty
MSM19/1092-1	DR 21	8.12	DR	05:34	42° 32.09'	10° 18.50'	3625.4	few rocks
MSM19/1093-1	DR 22	8.12	DR	12:39	42° 18.01'	9° 38.71'	4712.7	few rocks
MSM19/1094-1	DR 23	8.12	DR	17:28	42° 4.69'	9° 37.09'	4403.7	empty
MSM19/1095-1	DR 24	8.12	DR	22:25	41° 57.55'	9° 13.84'	4873.5	1 rock
MSM19/1096-1	DR 25	9.12	DR	03:43	41° 59.36'	9° 14.59'	4870.5	not on bottom due to tech. problem
MSM19/1097-1	DR 26	9.12	DR	08:59	42° 19.15'	9° 17.51'	4796.2	empty
MSM19/1098-1	DR 27	9.12	DR	12:41	42° 18.38'	9° 18.22'	4796.8	empty
MSM19/1099-1	DR 28	9.12	DR	17:11	42° 30.62'	9° 14.22'	4588.4	empty
MSM19/1100-1	DR 29	9.12	DR	21:56	42° 29.51'	8° 51.76'	4304.3	1/5 full
MSM19/1101-1	DR 30	10.12	DR	03:05	42° 45.87'	8° 41.30'	3644.7	few rocks
MSM19/1102-1	DR 31	10.12	DR	08:12	43° 4.61'	8° 56.41'	3085.6	empty
MSM19/1103-1	DR 32	10.12	DR	12:40	43° 0.93'	9° 5.94'	3412.0	1/2 full
MSM19/1104-1	DR 33	10.12	DR	17:00	43° 10.31'	9° 14.62'	3001.9	1/5 full
MSM19/1105-1	DR 34	10.12	DR	20:22	43° 11.19'	9° 19.56'	3797.1	empty
MSM19/1106-1	DR 35	11.12	DR	03:23	43° 17.53'	8° 20.81'	2931.8	1/2 full
MSM19/1107-1	DR 36	11.12	DR	08:46	43° 41.87'	8° 16.64'	4443.8	few rocks
MSM19/1108-1	DR 37	11.12	DR	18:18	43° 40.51'	6° 54.14'	4000.7	few rocks
MSM19/1109-1	DR 38	12.12	DR	05:08	44° 3.69'	5° 57.00'	3922.7	1/2 full
MSM19/1110-1	DR 39	12.12	DR	16:54	44° 21.62'	4° 59.23'	2453.1	few rocks
MSM19/1111-1	DR 40	13.12	DR	00:53	45° 3.84'	4° 47.97'	3289.5	1/3 full
MSM19/1112-1	DR 41	13.12	DR	08:19	45° 28.16'	4° 58.64'	2559.0	few rocks
MSM19/1113-1	DR 42	13.12	DR	11:38	45° 27.06'	5° 4.94'	3284.7	1/4 full
MSM19/1114-1	DR 43	13.12	DR	23:12	44° 36.32'	3° 50.90'	3224.5	1/4 full
MSM19/1115-1	DR 44	14.12	DR	15:22	43° 11.51'	1° 23.77'	2625.1	few rocks
MSM19/1116-1	DR 45	14.12	DR	22:49	42° 51.73'	0° 34.91'	2360.5	few rocks
MSM19/1117-1	DR 46	15.12	DR	12:15	43° 32.41'	1° 2.79' W	1431.7	few rocks
MSM19/1118-1	DR 47	15.12	DR	20:15	43° 58.24'	1° 27.23' W	1472.1	dredge lost because of broken bolt
MSM19/1119-1	DR 48	16.12	DR	09:48	43° 27.10'	2° 32.41' W	3396.5	1 rock
MSM19/1120-1	DR 49	16.12	DR	13:28	43° 22.20'	2° 34.49' W	2493.1	few rocks
MSM19/1121-1	DR 50	16.12	DR	19:11	43° 4.29'	2° 28.13' W	2265.9	few rocks
MSM19/1122-1	DR 51	17.12	DR	03:19	42° 40.66'	1° 25.54' W	1456.0	1/6 full
MSM19/1123-1	DR 52	17.12	DR	15:18	42° 23.11'	0° 56.60'	2915.0	few rocks
MSM19/1124-1	DR 53	17.12	DR	22:08	42° 31.77'	1° 45.98'	2355.0	1/5 full
MSM19/1125-1	DR 54	18.12	DR	04:37	42° 12.31'	2° 22.16'	1711.1	1/5 full
MSM19/1126-1	DR 55	18.12	DR	10:59	41° 43.25'	2° 5.46'	2192.3	empty
MSM19/1127-1	DR 56	18.12	DR	14:09	41° 42.79'	2° 5.05'	2012.3	1/4 full
MSM19/1128-1	DR 57	18.12	DR	17:13	41° 47.94'	2° 7.45'	2509.9	few rocks

DR - Chain bag dredge

Note: On all routes/transits in international waters (e.g. Cape Town - working area and back and between sampling stations and working areas) multi-beam and sediment echo-sounding data have continuously been recorded (without specific station number).

7 Data and Sample Storage and Availability

The bathymetric data recorded on cruise MSM19/3 have been handed over to the Federal Maritime and Hydrographic Agency (BSH). Bathymetric and sediment echo-sounding data are stored and are being processed at GEOMAR (see below) and the Alfred Wegener Institute for Polar and Marine Research (AWI). Metadata have been submitted to the PANGAEA database.

The rocks recovered by dredging are stored and are geochemically analyzed and age dated by GEOMAR. The compositional and age data obtained through these analyses will be published and thus made available to third parties. These data will also be stored at GEOMAR and will be accessible online (see below) and via Prof. Kaj Hoernle and Dr. Reinhard Werner (GEOMAR) as soon as cruise-related PhD-projects are finished (expected in 2016). Upon request, reference samples are made available to third parties after analyses, data interpretation and publication. In general, data and results yielded from the MSM19/3 AGULHAS research project will be made available to the abutting nations upon request.

The Kiel Data Management Team (KDMT) provides an information and data archival system where metadata of the onboard DSHIP-System is collected and made publicly available. This Ocean Science Information System (OSIS-Kiel) is accessible for all project participants and can be used to share and edit field information and to provide scientific data, as they become available. The central system OSIS is providing information on granted ship time with information on the scientific program and the general details down to the availability of data files from already concluded cruises. The transparency of the research activities is regarded as an invitation to external scientists to start communication on collaboration on behalf of the newly available samples and data. The KDMT, as data curators, will see to it that the generated data are published in a World Data Center (e.g. PANGAEA), which will then assure long-term archival of and access to the data. The data publication process will be based on the available files in OSIS and is therefore transparent to all reviewers and scientists. This cooperation with a world data center will make the data globally searchable, and links to the data owners will provide points of contact to project-external scientists. The bathymetric and hydroacoustic raw and processed data will be archived on a dedicated server at GEOMAR, which is backed up daily and which holds all data since the founding days of GEOMAR. OSIS provides contact information for these large data files. Samples, such as hard rocks and sediment cores, will be stored in the GEOMAR Lithothek and core repository and OSIS serves as a catalogue for the defined storage locations. Other data generated in laboratory work, e.g. from sedimentological, petrological, and geochemical analyses, will be stored in OSIS-Kiel until publication.

8 Acknowledgements

We would especially like to thank Captain von Staa and the crew of MARIA S. MERIAN. Their hard work, high level of experience, and willingness to help, as well as the pleasant working atmosphere on board, contributed directly to the success of the MSM19/3 expedition.

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9 References

- Douglass, J., Schilling, J.-G., Kingsley, R.H., Small, C., 1995, Influence of the Discovery and Shona mantle plumes on the southern Mid-Atlantic Ridge: rare earth evidence. *Geophysical Research Letters* 22, 2893-2896.
- Douglass, J., Schilling, J.-G., Fontignie, D., 1999, Plume-ridge interactions of the Discovery and Shona mantle plumes with the southern Mid-Atlantic Ridge (40°-55°S), *Journal Geophysical Research* 104 no. B2, 2941-2962.
- Hoffmann, P., 2012 Petrography, Major and Trace Element Geochemistry of the Discovery Seamounts. Unpublished Master Thesis University Kiel: pp. 66.
- Jokat, W., 2008, The south Atlantic expedition ANT-XXIII/5 of the research vessel "Polarstern" in 2006, *Berichte zur Polar- und Meeresforschung (Reports on Polar and Marine Research)*, Bremerhaven, Alfred Wegener Institute for Polar and Marine Research, 574, 110 p. hdl:10013/epic.30252.
- Kempe, D. R. C. and Schilling, J.-G., 1974, Discovery tablemount basalt: petrology and geochemistry. *Contributions to Mineralogy and Petrology* 44, 101-115.
- Le Roex, A., Class, C., O'Connor, J., Jokat, W., 2010, Shona and Discovery Aseismic Ridge Systems, South Atlantic: Trace Element Evidence for Enriched Mantle Sources. *Journal of Petrology* 51 no. 10, 2089-2120.
- Montelli, R., Nolet, G., Dahlen, F.A., Masters, G., Engdahl, E.R., Hung, S.-H., 2004, Finite-frequency tomography reveals a variety of plumes in the mantle. *Science* 303, 338 - 343.
- O'Connor, J.M., Jokat, W., Le Roex, A.P., Class, C., Wijbrans, J.R., Keßling, S., Kuiper, K.F., Nebel, O., 2012 Hotspot trails in the South Atlantic controlled by plume and plate tectonic processes. *Nature Geoscience* 5, 735-738.
- Peck, L.S., Robinson, K., 1994, Pelagic larval development in the brooding Antarctic brachiopod *Liothyrella uva*. *Marine Biology* 120, 279-286.
- Reid, J.L., 1989, On the total geostrophic circulation of the South Atlantic Ocean: Flow patterns, tracers, and transports. *Prog Oceanography* 23, 149-244.
- Rohde, J.K., Hoernle, K., Hauff, F., Werner, R., O'Connor, J., Class, C., Garbe-Schönberg, D., Jokat, W., 2013, 70 Ma chemical zonation of the Tristan-Gough hotspot track. *Geology* doi:10.1130/G33790.33791.
- Schmitz, W.J., 1996a, On the world ocean circulation: Volume I. Some global features, North Atlantic circulation. Woods Hole Oceanographic Institution Technical Report WHOI-96-03, 140 pp.
- Schmitz, W.J., 1996b, On the world ocean circulation: Volume II. The Pacific and Indian Oceans, a global update. Woods Hole Oceanographic Institution Technical Report WHOI-96-08, 237 pp.
- Uenzelmann-Neben, G., Gohl, K., 2005, The Agulhas Ridge, South Atlantic: the peculiar structure of a fracture zone. *Marine Geophysical Research* 25, 305-319.
- Uenzelmann-Neben, G., 2012, Cruise report MSM19/2 - The Agulhas Ridge, Walvis Bay - Cape Town, Oct. 23 - Nov. 30, 2011. *Meteor/Merian Berichte*, pp. 37.

Zhao, D., 2007. Seismic images under 60 hotspots: Search for mantle plumes. *Gondwana Research* 12, 335–355.


Appendix 1: Sampling Locations and Rock Descriptions

Appendix 2: Biological Samples


Appendix I (Rock Description)

MSM19-3 DR1	
Description of Location and Structure: NW striking ridge connecting with Richardson Smt. NE facing lower slope near NW termination of the ridge.	
Dredge on bottom	UTC 03/12/11 22:26hrs, lat 39°52.08'S, long 13°52.72'E, depth 4697m
Dredge off bottom	UTC 03/12/11 23:44hrs, lat 39°52.31'S, long 13°52.24'E, depth 4376m
total volume:	empty
Comments:	MSM staion no: 1072

MSM19-3 DR2	
Description of Location and Structure: NW termination of rift structure. NE facing slope right below riftaxis.	
Dredge on bottom	UTC 04/12/11 2:13hrs, lat 39°53.59'S, long 13°53.48'E, depth 4233m
Dredge off bottom	UTC 04/12/11 3:20hrs, lat 39°53.80'S, long 13°53.11'E, depth 3894m
total volume:	4 pieces
Comments:	Mn-crust, MSM staion no: 1073

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM 19-3 DR2-1-M	1. Rock Type: Mn-crust 2. Size: 40x30x15 7. Matrix: black to dark brown matrix, sub mm-wide layering visible							
MSM 19-3 DR2-2-M	1. Rock Type: Mn-knoll 2. Size: 11x8x6							
MSM19-3 DR2-3-M	1. Rock Type: Mn-knoll 2. Size: 14x14x7							
MSM19-3 DR2-4-M	1. Rock Type: Mn-plate 2. Size: 8x7x3							







MSM19-3 DR3	
Description of Location and Structure: Richardson Seamount. Northern flank, upper slope, plateau edge.	
Dredge on bottom	UTC 04/12/11 8:00hrs, lat 40°15.79'S, long 14°24.10'E, depth 2778m
Dredge off bottom	UTC 04/12/11 9:15hrs, lat 40°16.09'S, long 14°23.66'E, depth 2357m
total volume:	few rocks
Comments:	pillow lava, heavily altered, manganese crusts; in-situ (for sure), MSM staion no: 1074

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR3-1	1. Rock Type: pillow lava, strongly altered 2. Size: 33x32x18 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: 2% vesicles; small (mm) ones open; some (1cm) filled with calcite 6. Phenocrysts: <5% olivine, completely altered, <1mm 7. Matrix: fine grained 8. secondary Minerals: Mn-Fe-minerals along fissures, calcite in larger vesicles 9. Encrustations: Mn-crust <3cm 10. Comment: all samples are relatively similar, and strongly altered, no fresh minerals preserved	2	x	5				

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR3-2	1. Rock Type: pillow lava, strongly altered, similar to #1 2. Size: 18x10x7 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: <1% vesicles not filled 6. Phenocrysts: <5% olivine, completely altered, <1mm 7. Matrix: fine grained 8. secondary Minerals: Mn-Fe-minerals along fissures 9. Encrustations: Mn-crust <0.5cm	2	x	5				
MSM19-3 DR3-3	1. Rock Type: pillow lava, strongly altered, similar to #1 2. Size: 16x14x13 3. Shape / Angularity: angular 4. Color of cut surface: brown, greyish in some parts (mainly along fissures) 5. Texture / Vesicularity: 2% vesicles not filled in some parts filled with calcite 7. Matrix: fine grained 8. secondary Minerals: Mn-Fe-minerals along fissures, Calcite in some vesicles 9. Encrustations: Mn-crust 1cm 10. Comment: requires picking for geochemistry! some less altered parts	2	x	5				
MSM19-3 DR3-4	1. Rock Type: pillow lava, strongly altered, similar to #1 2. Size: 9x7x6 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: <1% vesicles not filled 6. Phenocrysts: <5% Ol, completely altered 7. Matrix: fine grained 8. secondary Minerals: Mn-Fe-minerals along fissures, Calcite in some vesicles 9. Encrustations: Mn-crust <3cm	2	x	5				
MSM19-3 DR3-5	1. Rock Type: pillow lava, strongly altered, similar to #1 2. Size: 13x11x8 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: <1% vesicles not filled 7. Matrix: fine grained 8. secondary Minerals: Mn-Fe-minerals along fissures, Calcite in some vesicles 9. Encrustations: Mn-crust <1cm	2	x	5				
MSM19-3 DR3-6	1. Rock Type: pillow lava, strongly altered, similar to #1 2. Size: 17x14x14 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: <1% vesicles not filled 6. Phenocrysts: <5% Ol, completely altered, <1mm 7. Matrix: fine grained 8. secondary Minerals: Mn-Fe-minerals along fissures 9. Encrustations: Mn-crust <2cm	2	x	5				
MSM19-3 DR3-7	1. Rock Type: pillow lava, strongly altered, similar to #1 2. Size: 11x7.5x6 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: <1% vesicles not filled 6. Phenocrysts: <1% Ol, completely altered, <1mm 7. Matrix: fine grained 8. secondary Minerals: Mn-Fe-minerals along fissures 9. Encrustations: Mn-crust <1mm	2	x	5				
MSM19-3 DR3-8	1. Rock Type: pillow lava, strongly altered, similar to #1 2. Size: 10x5x4 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: <1% vesicles 7. Matrix: fine grained 8. secondary Minerals: Mn-Fe-minerals along fissures 9. Encrustations: Mn-crust <1mm			5				




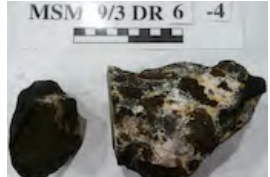



Appendix I (Rock Description)

MSM19-3 DR4								
Description of Location and Structure: Richardson Seamount. Small cone on top of the plateau								
Dredge on bottom		UTC 04/12/11 12:00hrs, lat 40°27.39'S, long 14°44.95'E, depth 1776m						
Dredge off bottom		UTC 04/12/11 13:28hrs, lat 40°27.55'S, long 14°44.45'E, depth 1513m						
total volume:		3/4 full						
Comments:		crusts, breccias, volcanoclastics, pssbl lava, MSM staion no: 1075						
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SEDS	NOTES	PICTURE
MSM19-3 DR4-1	1. Rock Type: volcanic breccia, completely altered 2. Size: 23x16x9 3. Shape / Angularity: angular 9. Encrustations: Mn-crust up to 3cm 10. Comment: clasts <1.5cm, light colored; mainly already soft from alteration, geochemistry not recommended	2						
MSM19-3 DR4-2	1. Rock Type: piece of volcanic breccia 2. Size: 14x11x9 3. Shape / Angularity: angular 9. Encrustations: Mn-crust 2cm 10. Comment: clasts: brownish <2cm clasts, mainly already soft from alteration, geochemistry not recommended	2						
MSM19-3 DR4-3 M	1. Rock Type: Mn-crust on a piece of strongly altered volcanic breccia 3.5cm black							
MSM19-3 DR4-4 M	1. Rock Type: Mn-crust on a piece of strongly altered volcanic breccia 3.5cm black							
MSM19-3 DR4-5 M	1. Rock Type: Mn-crust on a piece of strongly altered volcanic breccia up to 5cm black, sub-mm layering visible							
MSM19-3 DR4-6 M	1. Rock Type: Mn-crust on a piece of strongly altered volcanic breccia 5cm black 2. 16x11x6							

Appendix I (Rock Description)

MSM19-3 DR5								
Description of Location and Structure: Richardson Seamount. Small cone on top of the plateau, 9nm east of DR4 cone								
Dredge on bottom UTC 04/12/11 15:38hrs, lat 40°22.31'S, long 14°54.21'E, depth 1606m								
Dredge off bottom UTC 04/12/11 16:30hrs, lat 40°22.46'S, long 14°53.77'E, depth 1481m								
total volume: 3/4 full								
Comments: Mn-crusts, highly vesicular basalt fragments, (volcanic)clastites, heavily altered, MSM staion no: 1076								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR5-1 VC	1. Rock Type: volcanoclastic/Breccia, highly altered 2. Size: 41x38x23 3. Shape / Angularity: angular 4. Color of cut surface: greyish/red (dry) 5. Texture / Vesicularity: high vesicularity, filled with sediment 9. Encrustations: Mn-crust <3cm 10. Comment: huge block with thick Mn-crust, representative amount of material was collected	x	x					
MSM19-3 DR5-2a-VC	1. Rock Type: volcanoclastic/Breccia, highly altered 2. Size: 71x55x30 3. Shape / Angularity: angular 4. Color of cut surface: greyish/orange (dry) 5. Texture / Vesicularity: high vesicularity, vugs, partly filled with sediment 9. Encrustations: Mn-crust 0.5cm 10. Comment: huge block with thick Mn-crust, representative amount of material was collected	x	x					
MSM19-3 DR5-2b-VC	1. Rock Type: Breccia, highly altered 2. Size: 71x55x30 3. Shape / Angularity: angular 4. Color of cut surface: brownish/white with clasts (dry) 5. Texture / Vesicularity: no vesicles, clasts have some vesicles 9. Encrustations: Mn-crust 0.5cm 10. Comment: huge block with thick Mn-crust, representative amount of material was collected, material is highly altered, contains clasts that seem to be altered lava fragments	x						
MSM19-3 DR5-3 VC	1. Rock Type: volcanoclastic/Breccia, highly altered 2. Size: 50x40x25 3. Shape / Angularity: round - angular 4. Color of cut surface: black/greyish (dry) 5. Texture / Vesicularity: vesicles filled with sediment and 2nd material 9. Encrustations: Mn-crust 1cm 10. Comment: huge block with thick Mn-crust, representative amount of material was collected	x						
MSM19-3 DR5-4 VC	1. Rock Type: volcanoclastic/Breccia, highly altered 2. Size: 11x8x8 3. Shape / Angularity: round 4. Color of cut surface: black/brown (dry) 5. Texture / Vesicularity: no vesicles 9. Encrustations: thin Mn coating 10. Comment: little piece of highly altered VC, thick vein of sec. material, maybe some sediment or dolomite -> no or weak reaction with 3N HCl	x						
MSM19-3 DR5-5 VC	1. Rock Type: volcanoclastic/Breccia, highly altered 2. Size: 20x18x11 3. Shape / Angularity: round 4. Color of cut surface: black/greyish (dry) 5. Texture / Vesicularity: no vesicles 9. Encrustations: Mn-crust 0.5cm 10. Comment: similar to #4	x						
MSM19-3 DR5-6 M	1. Rock Type: Mn crust 2. Size: 10x10x8 3. Shape / Angularity: rounded 4. Color of cut surface: black with white veins of sec. material 5. Texture / Vesicularity: sub-mm layering visible 9. Encrustations: thick Mn-crust 5cm 10. Comment: piece of thick Mn crust with small part of vc oder breccia - difficult to distinguish	x						








Appendix I (Rock Description)

MSM19-3 DR6								
Description of Location and Structure: Richardson Seamount plateau, small cone near SE edge of plateau								
Dredge on bottom UTC 04/12/11 18:58hrs, lat 40°28.10'S, long 15°05.25'E, depth 2323m								
Dredge off bottom UTC 04/12/11 20:01hrs, lat 40°28.32'S, long 15°04.78'E, depth 1990m								
total volume: 1/5 full								
Comments: Mn-crusts, volcanoclastics covered with Mn, possibly contains lava fragments, MSM staion no: 1077								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SEDS	NOTES	PICTURE
MSM19-3 DR6-1	1. Rock Type: volcanic, moderately altered basalt 2. Size: 14x7x7 3. Shape / Angularity: round 4. Color of cut surface: black/red (dry) 5. Texture / Vesicularity: aphyric with vesicles ca 30%, partly filled with sec. minerals/sediments, vugs 7. Matrix: very dense, microcrystalline, no minerals 8. secondary Minerals: fillings in vesicles 9. Encrustations: Mn crust 10. Comment:relatively small piece of basalt with high vesicularity, vesicles partly filled with sec. minerals, probably Fe-oxides (orange color) or sediments, geochemistry requires carefully picking	x	x					
MSM19-3 DR6-2	1. Rock Type: volcanic, moderately - highly altered basal, similar to DR6-1 2. Size: 30x28x20 3. - 9. same as DR6-1 10. Comment: similar to DR6-1 but more altered and higher amount of filled vesicles, huge block -> representative amount of material was collected	x	x					
MSM19-3 DR6-3	1. Rock Type: volcanic, highly altered basalt 2. Size: 14x10x10 3. - 9. same as DR6-1 10. Comment: similar to DR6-1 but more altered, Mn encrustation about 0.5cm	x						
MSM19-3 DR6-4 X	1. Rock Type: similar to DR6-1 2. Size: 16x9x8 10. Comment: sample for archive							
MSM19-3 DR6-5 X	1. Rock Type: similar to DR6-1 2. Size: 10x7x5 10. Comment: sample for archive							
MSM19-3 DR6-6 X	1. Rock Type: similar to DR6-1 2. Size: 8x6x5 10. Comment: sample for archive							
MSM19-3 DR6-7	1. Rock Type: Breccia -> basaltic clasts embedded in sediment matrix 2. Size: 19x16x3 3. Shape / Angularity: rounded 4. Color of cut surface: sediment: white; clasts: brown/black (wet) 5. Texture / Vesicularity: clasts: aphyric with vesicles, vesicularity 30%; sediment: fine grained 6. Phenocrysts: clasts: prob. Cpx and Ol (very altered, difficult to determine) 7. Matrix: fine grained, no bedding visible 8. secondary Minerals: fillings in vesicles partly due to formation of sec. mineral (Fe-oxides) 9. Encrustations: Mn-crust 0.5 - 1.0 cm 10. Comment: Breccia with basaltic clasts embedded in sediment, clasts are highly altered with macroscopic visible phenocrysts of Cpx (?)	x						

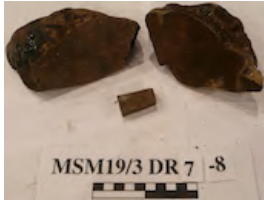






Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR6-8	1. Rock Type: Breccia -> basaltic clasts in sediment 2. Size: 19x14x9 3. 10. Comment: same as DR6-7							
MSM19-3 DR6-9X	1. Rock Type: similar to DR6-7 2. Size: 15x12x10 10. Comment: sample for archive							
MSM19-3 DR6-10-X	1. Rock Type: similar to DR6-7 2. Size: 17x16x10 10. Comment: sample for archive							
MSM19-3 DR6-11-X	1. Rock Type: some volcanic (?) material, highly altered 2. Size: 16x10x9 3. Shape / Angularity: angular 4. Color of cut surface: high vesicularity, vugs unfilled 9. Encrustations: thick Mn-crust of 2.5cm 10. Comment: numerous fissures and cracks							
MSM19-3 DR6-12-X	1. Rock Type: similar to DR6-11 2. Size: 25x12x7 10. Comment: sample for archive							


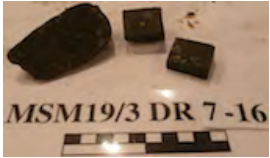





Appendix I (Rock Description)

MSM19-3 DR7								
Description of Location and Structure: Richardson Seamount. SE-plateau edge, no volcanic cones present on plateau flat, track immediately below plateau edge.								
Dredge on bottom UTC 04/12/11 23:51hrs, lat 40°45.39'S, long 14°42.25'E, depth 3083m								
Dredge off bottom UTC 05/12/11 01:28hrs, lat 40°45.07'S, long 14°41.72'E, depth 2443m								
total volume: 1/2 full								
Comments: rounded to subrounded boulder, sediments, clastics, possible a few igneous rocks, overall very heterolithological, MSM station no: 1078								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR7-1	1. Rock Type: volcanic, pillow fragment, fresh 2. Size: 17x14x12 3. Shape / Angularity: subrounded - angular 4. Color of cut surface: light grey (dry) 5. Texture / Vesicularity: aphyric, dense, vesicularity 30% 7. Matrix: microcrystalline with gm, fsp and cpx 8. secondary Minerals: marginal vesicles filled with sec. minerals (prob. Fe-oxides) 9. Encrustations: thin Mn-coating 10. Comment: fresh basalt might not be in-situ because of freshness an thin Mn cover -> appears younger than other material	x	x	2 gm-fsp				
MSM19-3 DR7-2	1. Rock Type: volcanic, pillow fragment, slight - moderately altered 2. Size: 14x12x10 3. Shape / Angularity: round - angular 4. Color of cut surface: light grey with orange (dry) 5. Texture / Vesicularity: aphyric, dense, vesicularity 5%, partly filled 7. Matrix: microcrystalline with gm, fsp and cpx 8. secondary Minerals: fresh part in center (no infillings), alteratin halo 3-5cm -> vesicles filled with sec. min, prob. Fe-oxide 9. Encrustations: thin Mn coating 10. Comment: similar to DR 7-1 but more altered and higher vesicularity, age dating might be possible	x	x	3 gm-fsp				
MSM19-3 DR7-3	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 13x10x8 3. Shape / Angularity: angular 4. Color of cut surface: light grey o black/brown (dry) 5. - 9. same as DR7-1 10. Comment: similar to DR7-1 but more altered	x						
MSM19-3 DR7-4 X	1. Rock Type: similar to DR7-1 2. Size: 16x14x8 10. Comment: sample for archive							
MSM19-3 DR7-5 X	1. Rock Type: similar to DR7-1 2. Size: 16x11x9 10. Comment: sample for archive							
MSM19-3 DR7-6 X	1. Rock Type: similar to DR7-1 2. Size: 8x7x3 10. Comment: sample for archive							
MSM19-3 DR7-7	1. Rock Type: volcanic, pillow fragment, highly altered 2. Size: 22x19x10 3. Shape / Angularity: angular 4. Color of cut surface: brownish/orange (dry) 5. Texture / Vesicularity: vesicularity 0%, porphyric 6. Phenocrysts: cpx, maybe fsp needles, very altered 7. Matrix: porphyric, dense, microcrystalline 8. secondary Minerals: almost all phenocrysts altered to sec. mineral 9. Encrustations: thin Mn coating 10. Comment: seems to be very altered volcanic rock -> maybe more evolved material, similar to melaphyr (?)	x						



Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR7-8	1. Rock Type: volcanic material, highly altered 2. Size: 18x14x7 3. Shape / Angularity: angular 4. - 9. similar to DR7-7	x						
MSM19-3 DR7-9 X	1. Rock Type: similar to DR7-7 2. Size: 14x13x10 10. Comment: sample for archive							
MSM19-3 DR7-10	1. Rock Type: volcanic material, highly altered breccia (?) 2. Size: 15x15x10 3. Shape / Angularity: angular - rounded 4. Color of cut surface: yellowish/brown with black infillings 5. Texture / Vesicularity: porphyric, vesicularity 5% 6. Phenocrysts: seems to have pieces of glass (?) incorporated 7. Matrix: microcrystalline 8. secondary Minerals: palagonite (?) 9. Encrustations: thin Mn coating 10. Comment: prob. dropstone	x						
MSM19-3 DR7-11-X	1. Rock Type: similar to DR7-10 2. Size: 13x11x10 10. Comment: sample for archive							
MSM19-3 DR7-12	1. Rock Type: Breccia 2. Size: 23x15x9 3. Shape / Angularity: rounded 4. Color of cut surface: greyish/brown (dry) 5. Texture / Vesicularity: porphyric 6. Phenocrysts: clasts and grains appear to be welded together, veins of lighter material included, occasionally cpx, strong signs of alteration 9. Encrustations: thin Mn coating 10. Comment: seems to be dropstone	x						
MSM19-3 DR7-13	1. Rock Type: Breccia 2. Size: 12x9x6 3. Shape / Angularity: rounded 4. Color of cut surface: blackish/brown (dry) 5. Texture / Vesicularity: porphyric 10. Comment: porphyric texture with several altered phenocrysts fsp needles, might be dropstone	x						
MSM19-3 DR7-14	1. Rock Type: Breccia 2. Size: 12x9x9 3. Shape / Angularity: rounded 4. Color of cut surface: brown/orange/yellow (dry) 5. Texture / Vesicularity: porphyric 10. Comment: seems to be very altered porphyric rock, maybe highly altered Breccia, clasts have completely undergone alteration -> maybe some palaeobasalt/melaphyr	x						

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR7-15-X	1. Rock Type: similar to DR7-14 2. Size: 19x10x7 10. Comment: sample for archive							
MSM19-3 DR7-16	1. Rock Type: sediment/conglomerate/breccia (?) 2. Size: 7x6x4 3. Shape / Angularity: rounded 4. Color of cut surface: dark grey with brown clasts 5. Texture / Vesicularity: porphyric 10. Comment: seems to be sediment that has been solidified with high variety of clasts which are in some parts highly altered	x						
MSM19-3 DR7-17-X	1. Rock Type: similar to DR7-16 2. Size: 10x8x5 10. Comment: sample for archive							
MSM19-3 DR7-18	1. Rock Type: sedimentary rock 2. Size: 22x19x11 3. Shape / Angularity: angular 4. Color of cut surface: white/greenish 10. Comment: white layered sediment, coarse grained, containing clasts, sorted bedding	x						
MSM19-3 DR7-19	1. Rock Type: sedimentary rock 2. Size: 20x14x10 3. Shape / Angularity: angular 4. Color of cut surface: brown/orange 10. Comment: layered sediment with different sized clasts, coarse grained, sorted bedding, finer layer on top of coarse grained material -> reworking signs, some clasts might be volcanic, prob. basalt	x						
MSM19-3 DR7-20-X	1. Rock Type: similar to DR7-19 2. Size: 20x15x11 10. Comment: sample for archive							
MSM19-3 DR7-21-X	1. Rock Type: similar to DR7-19 2. Size: 17x11x10 10. Comment: sample for archive							

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR7-22-X	1. Rock Type: similar to DR7-19 2. Size: 12x10x5 10. Comment: sample for archive							
MSM19-3 DR7-23-X	1. Rock Type: similar to DR7-19 2. Size: 16x13x10 10. Comment: sample for archive							

MSM19-3 DR8





Description of Location and Structure: Richardson Seamount. SE-plateau edge, lower part of NE-SW striking plateau edge, 3nm south of DR7

Dredge on bottom UTC 05/12/11 03:56hrs, lat 40°48.51'S, long 14°42.32'E, depth 4198m



Dredge off bottom UTC 05/12/11 04:56hrs, lat 40°48.38'S, long 14°41.88'E, depth 3910m



total volume: very few rocks

Comments: Mn crusts and one piece of brownish basalt, MSM station no: 1079







SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR8-1	1. Rock Type: lava, very altered 2. Size: 12x9x8 3. Shape / Angularity: subangular 4. Color of cut surface: very altered parts -> brown/orange, less altered parts -> grey/brownish 5. Texture / Vesicularity: aphyric, dense, vesicularity 20%, rounded vesicles filled with sec. minerals 7. Matrix: microcrystalline, fine grained 8. secondary Minerals: clay minerals and zeolites 9. Encrustations: thin Mn-coating 10. Comment: very altered basalt. there are some less altered parts, requires picking for geochemistry	2	x	6				
MSM19-3 DR8-2-M	1. Rock Type: Mn crust 2. Size: 10x7x4 3. Shape / Angularity: subangular 4. Color of cut surface: black 10. Comment: 1-3cm thick on sedimentary rock							
MSM19-3 DR8-3-M	1. Rock Type: Mn crust 2. Size: 8x5x4 10. Comment: similar to DR8-2-M							
MSM19-3 DR8-4-M	1. Rock Type: Mn crust 2. Size: 5x4x3 10. Comment: similar to DR8-2-M							

Appendix I (Rock Description)








MSM19-3 DR9								
Description of Location and Structure: deep sea plain S of Richardson seamount. Small cone ± in the center of the southern cone field								
Dredge on bottom		UTC 05/12/11 11:06hrs, lat 41°12.36'S, long 14°12.07'E, depth 4100m						
Dredge off bottom		UTC 05/12/11 13:30hrs, lat 41°12.37'S, long 14°12.12'E, depth 4100m						
total volume:		2 rocks						
Comments:		sediment and volcanic rock, MSM station no: 1080, EM120 problems -> no determination of water depth						
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTE S	PICTURE
MSM19-3 DR9-1	1. Rock Type: most likely volcanic rock, fresh 2. Size: 14x10x7 3. Shape / Angularity: subrounded 4. Color of cut surface: we -> black, dry -> dark grey 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: fsp <5% 3mm 7. Matrix: microcrystalline 9. Encrustations: Mn crust 2mm 10. Comment: fresh fsp -> dropstone (?)	x	x	2	fsp			
MSM19-3 DR9-2	1. Rock Type: piece of sediment 2. Size: 7x6x5 3. Shape / Angularity: angular 4. Color of cut surface: white, grey and black layers 5. Texture / Vesicularity: slightly deformed layers, no vesicles 7. Matrix: layers of claystone and calcite (?) 8. secondary Minerals: few brownish clayminerals							

MSM19-3 DR10								
Description of Location and Structure: deep sea plain S of Richardson seamount. Small cone 3.5nm from DR9, southern direction, dredge track along E-flank								
Dredge on bottom		UTC 05/12/11 16:11hrs, lat 41°15.67'S, long 14°10.16'E, depth 4016m						
Dredge off bottom		UTC 05/12/11 17:36hrs, lat 41°15.62'S, long 14°09.58'E, depth 3706m						
total volume:		2 rocks						
Comments:		subrounded plutonic rock and small angular volcanic rock, MSM station no: 1081						
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTE S	PICTURE
MSM19-3 DR10-1	1. Rock Type: plutonic, fresh - slightly altered 2. Size: 11x10x8 3. Shape / Angularity: rounded 4. Color of cut surface: grey reddish with black (dry) 5. Texture / Vesicularity: dense, crystalline 6. Phenocrysts: fsp kfsp + plag -> xenomorph 7. Matrix: fine, dense 9. Encrustations: thin Mn coating 10. Comment: gabbroic texture, seems to be more crystalline, xenomorph phenocrysts	x		2	fsp			
MSM19-3 DR9-2	1. Rock Type: volcanic, slightly - moderately altered 2. Size: 7x6.5x5 3. Shape / Angularity: angular 4. Color of cut surface: grey matrix with phenos (dry) 5. Texture / Vesicularity: porphyric 6. Phenocrysts: fsp + cpx -> 15% 7. Matrix: fine, dense, microcrystalline 8. secondary Minerals: few brownish clayminerals -> alteration of fsp 9. Encrustations: thin Mn coating 10. Comment: seems non in-situ material, matrix appears to be basaltic but very rich in phenos	x						







Appendix I (Rock Description)

MSM19-3 DR11								
Description of Location and Structure: deep sea plain S of Richardson seamount. Small cone 4nm NNW of DR10, dredge track along E-flank								
Dredge on bottom		UTC 05/12/11 20:03hrs, lat 41°12.28'S, long 14°06.78'E, depth 4245m						
Dredge off bottom		UTC 05/12/11 21:08hrs, lat 41°12.29'S, long 14°06.26'E, depth 3974m						
total volume:		empty						
Comments:		MSM station no: 1082						
MSM19-3 DR12								
Description of Location and Structure: Agulass FZ at SW tip of Richardson Smnt. Small valley in NE-SW striking slope								
Dredge on bottom		UTC 06/12/11 00:53hrs, lat 41°13.99'S, long 13°41.41'E, depth 3120m						
Dredge off bottom		UTC 06/12/11 02:46hrs, lat 41°13.99'S, long 13°41.39'E, depth 3121m						
total volume:		few rocks						
Comments:		angular basalt fragments, partially covered with Mn, MSM station no: 1083						
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR12-1	1. Rock Type: pillow fragment, highly altered 2. Size: 18x18x15 3. Shape / Angularity: angular 4. Color of cut surface: brown/orange/grey (dry) 5. Texture / Vesicularity: microcrystalline, porphyric, no vesicles 6. Phenocrysts: cpx 3%, xenomorph, fresh - altered 7. Matrix: microcrystalline with cpx and fsp needles, submm - mm, fresh - altered 8. secondary Minerals: matrix seems to be already altered (Fe-oxides), infilling in cracks 9. Encrustations: thin ca 1cm thick Mn crust 10. Comment: huge block of pillow fragment, representative for this dredge, majority appears to be same lithology but varying amount of phenocrysts, some parts are less altered than others, geochemistry requires picking	x	x					
MSM19-3 DR12-1-X	1. Rock Type: pillow fragments same as DR12-1 2. Size: 18x18x15 10. Comment: sample for archive, rest of sample DR12-1							
MSM19-3 DR12-2	1. Rock Type: pillow fragment, highly altered 2. Size: 24x15x11 3. Shape / Angularity: subangular 4. - 9. similar to DR12-2 10. Comment: overall very similar to 1 but seems to have more cracks, cracks filled with sec. minerals or clay	x	x					
MSM19-3 DR12-3-X	1. Rock Type: pillow fragments, similar to DR12-2 2. Size: 16x11x7 10. Comment: sample for archive							
MSM19-3 DR12-4-X	1. Rock Type: pillow fragments, similar to DR12-2 2. Size: 12x10x8 10. Comment: sample for archive							
MSM19-3 DR12-5-X	1. Rock Type: pillow fragments, similar to DR12-2 2. Size: 14x8x6 10. Comment: sample for archive							






Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTE S	PICTURE
MSM19-3 DR12-6	1. Rock Type: pillow fragment, highly altered 2. Size: 19x14x7 3. Shape / Angularity: rounded - angular 4. Color of cut surface: greyish/orange/brown (dry) 5. Texture / Vesicularity: porphyric, high vesicularity 15%, mainly filled with Mn or sec. mineral 6. Phenocrysts: Cpx <1%, 0.5mm, xenomorph, fresh - altered 7. Matrix: microcrystalline with fsp + cx needles, submm-mm, altered 8. secondary Minerals: matrix seems to be already altered -> Fe-oxide and or some clay mineras 9. Encrustations: thin Mn coating 10. Comment: vesicles seem to be filled in two different events, geochemistry requires picking due to infillings (attention: contamination due to Mn infilling)	x	x					
MSM19-3 DR12-7-X	1. Rock Type: pillow fragments, similar to DR12-6 2. Size: 11x9x7 10. Comment: sample for archive							
MSM19-3 DR12-8-X	1. Rock Type: pillow fragments, similar to DR12-6 2. Size: 8x5x5 10. Comment: sample for archive							
MSM19-3 DR12-9	1. Rock Type: piece of pillow fragment, highly altered 2. Size: 17x8x5 3. Shape / Angularity: round - angular 4. Color of cut surface: grey/brown/orange (dry) 5. Texture / Vesicularity: aphyric, no vesicles 6. Matrix: microcrystalline with cpx needles, submm - mm, fresh to altered 8. secondary Minerals: partly altered, some parts are replaced by sec. minerals, maybe Fe-oxide 9. Encrustations: thin Mn coating 10. Comment: very dense fine grained pillow with signs of alteration, matrix mainly needles of cpx/fsp	x	x	2 gm fsp				
MSM19-3 DR12-10-X	1. Rock Type: pillow fragments, similar to DR12-9 2. Size: 12x8x3 10. Comment: sample for archive							
MSM19-3 DR12-11	1. Rock Type: pillow fragment, highly altered 2. Size: 19x18x15 3. Shape / Angularity: angular 4. Color of cut surface: reddish/orange/brown (dry) 5. Texture / Vesicularity: aphyric, vesicularity 15%, filled with Mn 6. Phenocrysts: cpx <1%, fresh altered, submm 7. Matrix: fine grained with cracks and fissures, strong signs of alteration, seems to have hostet microliths -> due to high alteration difficult to determine 8. secondary Minerals: fissures/cracks and vesicles filled with Mn 9. Encrustations: thick Mn crust 3cm, partly incorporated in rock, submm layering 10. Comment: highly altered pillow fragment hat has been partly reworked by Mn -> precipitated or squeezed in fissures/cracks, little pieces of rock in Mn layer	x	x					
MSM19-3 DR12-11-X	1. Rock Type: pillow fragments, same as DR12-11 2. Size: 19x18x15 10. Comment: sample for archive, rest of sample DR12-11							

Appendix I (Rock Description)






MSM19-3 DR13								
Description of Location and Structure: SW end of Richardso Smnt. NE-SW striking slope, 0.5nm E of DR12, beneath plateau edge								
Dredge on bottom UTC 06/12/11 04:34hrs, lat 41°13.86'S, long 13°41.92'E, depth 3333m								
Dredge off bottom UTC 06/12/11 05:31hrs, lat 41°13.75'S, long 13°41.61'E, depth 2923m								
total volume: 3 rocks								
Comments: strongly altered fragments of pillow lavas, MSM station no: 1084								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Ar Grade	GL/MIN	SEDS	NOTES	PICTURE
MSM19-3 DR13-1	1. Rock Type: pillow fragment, moderately altered 2. Size: 14x9x6 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, <5% vesicles, most filled with sec. mineral 6. Phenocrysts: fsp 2%, up to 4mm 7. Matrix: fine grained, felty matrix, mainly altered 8. secondary Minerals: vesicles filling -> Mn, CC(?), clay minerals in matrix 9. Encrustations: thin Mn coating	x	x	3				
MSM19-3 DR13-2	1. Rock Type: pillow fragment, moderately altered 2. Size: 9x7x6 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, <5% vesicles, most filled with sec. mineral 6. Phenocrysts: fsp 1%, up to 3mm 7. Matrix: fine grained, felty matrix, mainly altered 8. secondary Minerals: vesicles filling -> Mn, CC(?), clay minerals in matrix 9. Encrustations: thin Mn coating 10. similar to DR13-1	x	x	3				
MSM19-3 DR13-3	1. Rock Type: pillow fragment, moderately altered 2. Size: 13x10x6 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, <5% vesicles, most filled with sec. mineral 6. Phenocrysts: fsp 1%, up to 3mm 7. Matrix: fine grained, felty matrix, mainly altered 8. secondary Minerals: vesicles filling -> Mn, CC(?), clay minerals in matrix 9. Encrustations: Mn crust up to 1.5cm 10. Comment: similar to DR13-1							
MSM19-3 DR14								
Description of Location and Structure: Agulhas Ridge, central part, southern flank of the northern ridge								
Dredge on bottom UTC 06/12/11 13:23hrs, lat 41°40.70'S, long 12°31.76'E, depth 4183m								
Dredge off bottom UTC 06/12/11 15:00hrs, lat 41°40.71'S, long 12°31.17'E, depth 3663m								
total volume: few rocks								
Comments: pillow fragments and volcanoclastica, highly altered, MSM station no: 1085								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Ar Grade	GL/MIN	SEDS	NOTES	PICTURE
MSM19-3 DR14-1	1. Rock Type: badly altered fragment of pillow lava 2. Size: 13x7x7 3. Shape / Angularity: angular 4. Color of cut surface: dark brown 5. Texture / Vesicularity: 20% vesicles, mostly filled with sec. minerals 7. Matrix: fine grained, mostly altered, some microphenocrysts of fsp 8. secondary Minerals: clay minerals, Mn 9. Encrustations: thin Mn coating 10. Comment: badly altered, requires picking for geochemistry, plagioclase needles in matrix might be fresh enough for dating, all samples show same lithology varying only in degree of alteration	x	x	3-4 gm-fsp				
MSM19-3 DR14-2	1. Rock Type: badly altered fragment of pillow lava 2. Size: 11x7x6 3. Shape / Angularity: angular 4. Color of cut surface: dark brown 5. Texture / Vesicularity: 15% vesicles, mostly filled with sec. minerals 7. Matrix: fine grained, mostly altered, some microphenocrysts of fsp 8. secondary Minerals: clay minerals, Mn 9. Encrustations: thin Mn coating 10. Comment: badly altered, some parts brecciated by fluids, requires careful picking for geochemistry, plagioclase needles in matrix might be fresh enough for dating, all samples show same lithology varying only in degree of alteration, similar to DR14-1	x	x	3-4 gm-fsp				
MSM19-3 DR14-3	1. Rock Type: badly altered fragment of pillow lava 2. Size: 15x10x6 3. Shape / Angularity: subangular 4. Color of cut surface: reddish brown, few less altered parts are less reddish 5. Texture / Vesicularity: 20% vesicles, mostly filled with sec. minerals, rock is fragmented by veins 7. Matrix: fine grained, mostly altered, some microphenocrysts of fsp 8. secondary Minerals: clay minerals, Mn 9. Encrustations: thin Mn coating 10. Comment: badly altered, some parts brecciated by fluids, requires careful picking for geochemistry, plagioclase needles in matrix might be fresh enough for dating, all samples show same lithology varying only in degree of alteration, similar to DR14-1	x	x					

Appendix I (Rock Description)



SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR14-4	1. Rock Type: badly altered fragment of pillow lava 2. Size: 15x11x11 3. Shape / Angularity: nice pillow shape 4. Color of cut surface: orange/reddish/brown 5. Texture / Vesicularity: 30% vesicles, mainly filled with sec. minerals, filled veins 7. Matrix: fine grained, mainly replaced by sec. minerals 8. secondary Minerals: clay minerals, Mn, cc in veins 9. Encrustations: thin Mn coating 10. Comment: badly altered, requires picking for geochemistry, similar to DR14-1	x						
MSM19-3 DR14-5	1. Rock Type: badly altered fragment of pillow lava 2. Size: 7x6x4 3. Shape / Angularity: angular 4. Color of cut surface: dark brown 5. Texture / Vesicularity: 15% vesicles, mostly filled with sec. minerals 7. Matrix: fine grained, mainly replaced by sec. minerals 8. secondary Minerals: clay minerals, Mn 9. Encrustations: thin Mn coating 10. Comment: no fresh minerals preserved, similar to DR14-1	x						
MSM19-3 DR14-6	1. Rock Type: badly altered fragment of pillow lava, brecciated in some parts 2. Size: 11x10x6 3. Shape / Angularity: angular 4. - 9. similar to DR14-1 10. Comment: no fresh minerals preserved, similar to DR14-1	x						
MSM19-3 DR14-7	1. Rock Type: badly altered fragment of pillow lava, brecciated in some parts 2. Size: 8x6x4 3. Shape / Angularity: angular 4. - 9. similar to DR14-1 10. Comment: no fresh minerals preserved, similar to DR14-1	x						
MSM19-3 DR14-8	1. Rock Type: badly altered fragment of pillow lava 2. Size: 16x11x7 3. Shape / Angularity: subangular 4. Color of cut surface: yellowish with sme black parts 5. Texture / Vesicularity: 30% vesicles, all filled with sec. minerals (Mn?) 6. Phenocrysts: maybe altered cpx 7. Matrix: fine grained, mainly replaced by sec. minerals 8. secondary Minerals: clay minerals, Mn 9. Encrustations: Mn crust up to 1 cm 10. Comment: probably same lithology as DR14-1 - DR14-7	x	x					

MSM19-3 DR15	
Description of Location and Structure: Agulhas Ridge, central part. Southern flank of the northern ridge, NE of DR14 3nm away	
Dredge on bottom	UTC 06/12/11 17:35hrs, lat 41°39.11'S, long 12°34.88'E, depth 3870m
Dredge off bottom	UTC 06/12/11 18:47hrs, lat 41°39.11'S, long 12°34.28'E, depth 3555m
total volume:	empty
Comments:	MSM station no: 1086

Appendix I (Rock Description)





MSM19-3 DR16								
Description of Location and Structure: Smnt structure, SE of Agulhas FZ, NE-NW striking oval shaped smnt, NW-slope along nose								
Dredge on bottom UTC 06/12/11 22:27hrs, lat 41°50.19'S, long 12°55.79'E, depth 3692m								
Dredge off bottom UTC 07/12/11 00:07hrs, lat 41°50.55'S, long 12°55.23'E, depth 3130m								
total volume: very few rocks								
Comments: mostly plutonic rocks, look very similar, some with cm thick Mn crust and fresh broken surface on the downside -> broken off from ground? Unlikely along dropstone, maybe this structure is an uplifted plutonic complex. Is it oceanic or continental? MSM station no: 1087								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR16-1	1. Rock Type: metamorphic rock, fresh 2. Size: 28x20x14 3. Shape / Angularity: angular - subrounded 4. Color of cut surface: light grey/whitish (dry) 5. Texture / Vesicularity: no vesicles, gneissic texture -> thin layers of glimmer (prob. biotite) enclosing qrz eyes 7. Matrix: crystalline, xenomorph crystals 9. Encrustations: thin Mn coating 10. Comment: appears to be plutonic rock that has been metamorphic overprinted, kfsp, plag, qrz are present between layered glimmer, garnet is present (3%)	x		1				no picture
MSM19-3 DR16-2	1. Rock Type: volcanic material 2. Size: 20x13x7 3. Shape / Angularity: angular 4. Color of cut surface: dark grey 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: fsp (xenomorph), 10%, fresh 7. Matrix: crystalline 10. Comment: difficult to determine, unusual crystalline, might be something between basalt and gabbro	x		2				
MSM19-3 DR16-3	1. Rock Type: plutonic, pegmatite 2. Size: 14.5x12x4.5 3. Shape / Angularity: angular 4. Color of cut surface: dark grey/brown/black 5. Texture / Vesicularity: granitic 6. Phenocrysts: qrz, fsp, glimmer -> xenomorph 7. Matrix: pegmatitic 8. secondary Minerals: clay minerals 9. Encrustations: thin Mn coating 10. Comment: appears pegmatitic with some glimmer that might be altered to sec. minerals (red colored clay), fsp shines like glimmer	x		2				
MSM19-3 DR16-4	1. Rock Type: plutonic pegmatite 2. Size: 13x8x4.5 3. Shape / Angularity: subangular - rounded 4. - 8. similar to DR16-3 9. Encrustations: 1-1.5cm thick Mn crust							
MSM19-3 DR16-5	1. Rock Type: plutonic pegmatite 2. Size: 8x5x5 3. - 8. similar to DR16-3 9. Encrustations: 2cm thick Mn crust							
MSM19-3 DR16-6	1. Rock Type: plutonic pegmatite 2. Size: 8.5x7x3 3. - 8. similar to DR16-3 9. Encrustations: 1.5 - 2cm thick Mn crust							

Appendix I (Rock Description)







SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR16-7-M	1. Rock Type: Mn crust 2. Size: 11.5x8.5x5							
MSM19-3 DR16-8-M	1. Rock Type: Mn crust 2. Size: 13.5x8.5x4.5							

MSM19-3 DR17	
Description of Location and Structure: Agulhas Ridge, central part. Steep southern flank of the northern ridge	
Dredge on bottom	UTC 07/12/11 07:32hrs, lat 41°58.08'S, long 11°44.09'E, depth 3521m
Dredge off bottom	UTC 07/12/11 08:40hrs, lat 41°58.19'S, long 11°43.69'E, depth 3137m
total volume:	empty
Comments:	MSM station no: 1088




MSM19-3 DR18	
Description of Location and Structure: Agulhas Ridge, central part, southern flank of northern ridge ~0.7nm N of DR17	
Dredge on bottom	UTC 07/12/11 10:41hrs, lat 41°57.57'S, long 11°43.58'E, depth 2795m
Dredge off bottom	UTC 07/12/11 12:07hrs, lat 41°57.69'S, long 11°43.04'E, depth 2270m
total volume:	half full
Comments:	pillow lava, moderately altered, MSM station no: 1089

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR18-1	1. Rock Type: pillow fragment, moderately altered 2. Size: 25x12x11 3. Shape / Angularity: angular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: porphyric, ~6% vesicles, filled with sec. minerals 6. Phenocrysts: ~5% cpx up to 5mm, ~5% fsp up to 2mm, ~3% Ol (mainly altered) 7. Matrix: microcrystalline with gm fsp and cpx 8. secondary Minerals: clay minerals, Iddingsite (?), Mn filling vesicles 9. Encrustations: thin Mn coating (<2mm) 10. Comment: requires picking, ± fresh cpx	x	x	2-3 gm-fsp	cpx, fsp			
MSM19-3 DR18-2	1. Rock Type: pillow fragment, moderately altered 2. Size: 50x43x24 3. Shape / Angularity: pillow shaped 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: porphyric, ~18% vesicles, filled with Mn, CC 6. Phenocrysts: ~5% cpx up to 6mm, ~8% fsp, altered, up to 1cm, partly rounded 7. Matrix: microcrystalline with gm fsp and cpx 8. secondary Minerals: palagonized rim, Mn, CC 10. Comment: fsp might be xenoliths, smaller fsp are idiomorph, many small vesicles -> requires carefully picking for geochemistry similar to DR18-1	x	x	3-4	cpx, fsp			
MSM19-3 DR18-3	1. Rock Type: pillow lava, moderately altered 2. Size: 45x28x20 3. Shape / Angularity: pillow shaped 4. Color of cut surface: brownish grey to orange 5. Texture / Vesicularity: slightly porphyric, ~3% vesicles, filled with sec. minerals 6. Phenocrysts: <2% fsp up to 2mm 7. Matrix: fine grained with fsp, partly altered 8. secondary Minerals: cc, clay minerals 9. Encrustations: <5mm Mn crust 10. Comment: fresh fsp in matrix	x	x	2 gm-fsp				
MSM19-3 DR18-4	1. Rock Type: Pillow lava, moderately altered 2. Size: 39x18x13 3. Shape / Angularity: pillow shaped 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: aphyric, ~5% vesicles <1mm, filled with Mn 7. Matrix: fine grained, fsp, cpx, altered parts 8. secondary Minerals: Mn filling in vesicles, clay minerals in matrix 10. Comment: more coarse grained than previous rocks	x	x	3 gm-fsp				



Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR18-5	1. Rock Type: pillow fragment, moderately altered 2. Size: 15x10x8 3. Shape / Angularity: subangular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: aphyric, ~6% vesicles up to 2mm, filled with Mn or cc 6. - 9. similar to DR18-4 10. Comment: Similar to DR18-4 but varies in amount and size of vesicles	x	x	3				
MSM19-3 DR18-6	1. Rock Type: pillow fragment, moderately altered 2. Size: 13x8x7 3. - 10. similar to DR18-4	x	x	3				
MSM19-3 DR18-7	1. Rock Type: pillow fragment, moderately - highly altered 2. Size: 32x22x14 3. Shape / Angularity: pillow shaped 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: subaphyric, ~3% vesicles filled with sec. minerals 6. Phenocrysts: 2% fsp <7mm 7. Matrix: fsp <3mm, cpx up to 1mm, altered 8. secondary Minerals: clay minerals 9. Encrustations: Mn crust up to 2mm 10. Comment: high amount of Plag, but altered	x	x	4				
MSM19-3 DR18-8	1. Rock Type: pillow fragment 2. Size: 37x24x18 3. - 9. similar to DR18-4 10. Comment: similar to DR18-4, but more altered and higher amount of vesicles. All vesicles filled with sec. Minerals	x		4				
MSM19-3 DR18-9	1. Rock Type: pillow fragment, moderately altered 2. Size: 11x9x8 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: 5-10% vesicles, filled with sec. material 6. Phenocrysts: fsp, <3%, 4mm; cpx, <5%, <8mm 7. Matrix: fine grained, fsp, cpx 8. secondary Minerals: clay minerals, Mn 9. Encrustations: Mn coating 10. Comment: fsp might be sufficient for age dating	x		3-4				
MSM19-3 DR18-10	1. Rock Type: pillow fragment 2. Size: 15x10x6 3. Shape / Angularity: subangular 4. Color of cut surface: 5. - 9. similar to DR18-4 10. Comment: gm-dating might be possible	x		3-4				
MSM19-3 DR18-11	1. Rock Type: pillow fragment 2. Size: 26x14x13 3. Shape / Angularity: subangular 4. - 9. similar to DR18-4 10. Comment: more altered than DR18-4	x		3-4				








Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR18-12	1. Rock Type: pillow fragment 2. Size: 18x9x7 3. Shape / Angularity: subrounded 4. - 10. similar to DR18-4	x						
MSM19-3 DR18-13	1. Rock Type: pillow fragment 2. Size: 26x14x13 3. Shape / Angularity: angular 4. - 10. similar to DR18-4 but highly altered	x						
MSM19-3 DR18-14	1. Rock Type: pillow fragment 2. Size: 11x10x7 3. Shape / Angularity: angular 4. - 10. similar to DR18-4 but finer matrix. Chilled margin with glass, most likely altered, but check	x						
MSM19-3 DR18-15-X	1. Rock Type: pillow fragments 10. Comment: additional material of sample DR DR18-1 for archive							no picture
MSM19-3 DR18-16-X	1. Rock Type: pillow fragments 10. Comment: additional material of sample DR DR18-2 for archive							no picture
MSM19-3 DR18-17-X	1. Rock Type: pillow fragments 10. Comment: additional material of sample DR DR18-3 for archive							no picture
MSM19-3 DR18-18-X	1. Rock Type: pillow fragments 10. Comment: additional material of sample DR DR18-4 for archive							no picture


MSM19-3 DR19
Description of Location and Structure: Agulhas Ridge, central part, southern ridge
Dredge on bottom UTC 07/12/11 18:14hrs, lat 42°21.37'S, long 11°22.03'E, depth 4134m
Dredge off bottom UTC 07/12/11 19:35hrs, lat 42°21.77'S, long 11°21.66'E, depth 3727m
total volume: few rocks
Comments: lava fragments, appear fresh, contain glass

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR19-1	1. Rock Type: pillow fragment, slight - moderately altered 2. Size: 9x6.5x4 3. Shape / Angularity: angular 4. Color of cut surface: grey (dry) 5. Texture / Vesicularity: aphyric, vesicularity <1%, mostly filled with sec. minerals 6. Phenocrysts: cpx, <1%, altered, submm - mm 7. Matrix: dense, microcrystalline with gm-fsp 8. secondary Minerals: mainly Fe-oxides in vesicles but also Mn and cc (?) 10. Comment: freshest piece of this dredge, representative lithology for all samples, carefully picking for geochemistry required	x	x	2 gm-fsp				
MSM19-3 DR19-2	1. Rock Type: pillow fragment 2. Size: 10x8x7 3. Shape / Angularity: angular 4. Color of cut surface: grey brown to orange (dry) 5. Texture / Vesicularity: aphyric, 3% vesicles mostly unfilled 7. Matrix: dense, microcrystalline 8. secondary Minerals: phenos replaced by sec. minerals, mainly cpx replaced by Fe-oxide 9. Encrustations: partly thin Mn coating 10. Comment: similar to DR19-1 but varies in vesicularity (higher) and alteration grade. small area with glass that is mostly altered -> palagonite but might contain some fresh glass	x	x		x			

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR19-3	1. Rock Type: pillow fragment, med-highly altered 2. Size: 6x6x4 3. - 9. similar to DR19-1 + DR19-2 10. Comment: small piece of pillow fragment with glass crust and chilled margin, glass has been separated, otherwise rock is very altered, no GC was cut	x			x			
MSM19-3 DR19-4	1. Rock Type: pillow fragment, highly altered 2. Size: 6x4x4 3. - 9. similar to DR19-3 10. Comment: glass has been separated, otherwise rock is very altered, no GC was cut	x			x			
MSM19-3 DR19-5	1. Rock Type: pillow fragment, highly altered 2. Size: 7x6x5 3. - 9. similar to DR19-3 10. Comment: glass has been separated, otherwise rock is very altered, no GC was cut	x			x			
MSM19-3 DR19-6	1. Rock Type: pillow fragment, highly altered 2. Size: 4x4x2 3. - 9. similar to DR19-3 10. Comment: really small piece of pillow - > only glass has been separated				x			
MSM19-3 DR19-7	1. Rock Type: pillow fragment, highly altered 2. Size: 10x10x9 3. - 9. similar to DR19-3 10. Comment: whole rock very altered - > GC not possible, glass crust has been cut off, but might be already completely palagonized. TS includes glass crust, chilled margin and whole rock	x			x (?)			
MSM19-3 DR19-8	1. Rock Type: pillow fragment, highly altered 2. Size: 8x7x6 3. - 9. similar to DR19-1 10. Comment: completely altered	x						
MSM19-3 DR19-9	1. Rock Type: pillow fragment, highly altered 2. Size: 8x7x5 3. - 9. similar to DR19-1 10. Comment: completely altered	x						

Appendix I (Rock Description)





SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR19-9	1. Rock Type: plutonic, fresh 2. Size: 14x13x10 3. Shape / Angularity: subrounded 4. Color of cut surface: grey - white 5. Texture / Vesicularity: granitic texture 7. Matrix: crystalline 9. Encrustations: thin Mn Coating 10. Comment: gabbro, appears like dropstone -> might not be in-situ sampling	x						

MSM19-3 DR20	
Description of Location and Structure: Agulhas Ridge, western part. Area where AR is split into two parallel ridges. Northern ridge along SE facing slope, across nose	
Dredge on bottom	UTC 08/12/11 02:52hrs, lat 42°33.81'S, long 10°18.60'E, depth 4190m
Dredge off bottom	UTC 08/12/11 04:06hrs, lat 42°34.11'S, long 10°18.24'E, depth 3864m
total volume:	empty
Comments:	MSM station no: 1091


MSM19-3 DR21	
Description of Location and Structure: Agulhas FZ, western part. 2nm N of DR20, NNE facing slope, along nose	
Dredge on bottom	UTC 08/12/11 06:23hrs, lat 42°32.09'S, long 10°18.49'E, depth 3611m
Dredge off bottom	UTC 08/12/11 07:40hrs, lat 42°32.25'S, long 10°17.96'E, depth 3273m
total volume:	3 rocks
Comments:	volcaniclastica, heavily altered, probably dropstones, MSM station no: 1092

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR21-1	1. Rock Type: strongly altered volcaniclastic rock 2. Size: 14x10x5 3. Shape / Angularity: subangular 4. Color of cut surface: green 5. Texture / Vesicularity: 50% vesicles, partly filled 6. Phenocrysts: ~5% different clasts (phenocrysts?), fsp, qrz (?), rock fragments 7. Matrix: fine grained, completely altered 8. secondary Minerals: greenish sec. minerals 9. Encrustations: Mn coating 10. Comment: might contain fresh crystals, possibly xenocrystals (?), DROPSTONE (?)							
MSM19-3 DR21-2	1. Rock Type: strongly altered volcaniclastic rock 2. Size: 15x15x15 3. Shape / Angularity: subrounded 4. Color of cut surface: red, orange & white parts 5. Texture / Vesicularity: < 5% vesicles, not filled, s-texture, flowing structure 7. Matrix: fine grained, layers of kfsp, plag, qrz (?) 8. secondary Minerals: brown orange sec. minerals 9. Encrustations: Mn coating 10. Comment: ignimbrite (maybe metamorphic), DROPSTONE (?)							
MSM19-3 DR21-3	1. Rock Type: strongly altered volcaniclastic rock 2. Size: 13x9x7 3. Shape / Angularity: subrounded 4. Color of cut surface: green & red, most altered parts orange 5. Texture / Vesicularity: <3% vesicles, not filled, layering, flowing structure (?) 7. Matrix: fine grained, layers of kfsp, plag, qrz (?) 8. secondary Minerals: orange sec. minerals 10. Comment: most likely a DROPSTONE							

Appendix I (Rock Description)

MSM19-3 DR22								
Description of Location and Structure: Agulhas ridge								
Dredge on bottom		UTC 08/12/11 13:41hrs, lat 42°18.01'S, long 09°38.70'E, depth 4764m						
Dredge off bottom		UTC 08/12/11 14:59hrs, lat 42°18.42'S, long 09°38.30'E, depth 4433m						
total volume:		6 rocks						
Comments:		6 manganese knolls, MSM station no: 1093						
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Ar Grade	GL/MIN	SEDS	NOTES	PICTURE
MSM19-3 DR22-1-M	1. Rock Type: manganese knoll 2. Size: 8x7x6 3. Shape / Angularity: rounded 4. Color of cut surface: black 7. Matrix: mm-thick layering visible 10. Comment: small orange core (~8x2mm), probably altered basalt							
MSM19-3 DR22-2-M	1. Rock Type: manganese knoll 2. Size: 10x7x5 3. -10. Comment: similar to DR22-1-M							
MSM19-3 DR22-3-M	1. Rock Type: manganese knoll 2. Size: 7x6x5 3. -10. Comment: similar to DR22-1-M							
MSM19-3 DR22-4-M	1. Rock Type: manganese knoll 2. Size: 9x8x7 3. -10. Comment: similar to DR22-1-M							








MSM19-3 DR23	
Description of Location and Structure: Agulhas ridge (west) smnt lower part of most eastern part	
Dredge on bottom	UTC 08/12/11 18:21hrs, lat 42°04.69'S, long 09°37.09'E, depth 4410m
Dredge off bottom	UTC 08/12/11 19:23hrs, lat 42°04.78'S, long 09°37.47'E, depth 4095m
total volume:	empty
Comments:	MSM station no: 1094

MSM19-3 DR24								
Description of Location and Structure: Agulhas FZ, western part, 2nm N of DR20, NNE facing slope, along nose								
Dredge on bottom		UTC 08/12/11 23:24hrs, lat 42°57.55'S, long 09°13.83'E, depth 4868m						
Dredge off bottom		UTC 09/12/11 00:52hrs, lat 42°57.73'S, long 09°13.16'E, depth 4521m						
total volume:		1 rock						
Comments:		plutonic, MSM station no: 1095						
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Ar Grade	GL/MIN	SEDS	NOTES	PICTURE
MSM19-3 DR24-1	1. Rock Type: plutonic, fresh 2. Size: 9x6x5 3. Shape / Angularity: angular 4. Color of cut surface: reddish grey 5. Texture / Vesicularity: granitic, xenomorph crystals 6. Phenocrysts: qrz fsp (kfsp & plag), biotite, epidot 7. Matrix: crystalline 10. Comment: plutonic rock of granitic texture that is divided into two parts -> one part more kfsp rich, appears more red, other part more qrz rich, appears more grey. two parts divided by vein filled with epidot, whereas part that is more qrz enriched contains also epidot, part with more kfsp does not contain epidot	x						








Appendix I (Rock Description)

MSM19-3 DR25								
Description of Location and Structure: ocean floor NW of Agulhas FZ, 2.5 nm from DR24								
Dredge on bottom UTC 09/12/11 00:00hrs, lat 00°00.00'S, long 00°00.00'E, depth 0000m								
Dredge off bottom UTC 09/12/11 00:00hrs, lat 00°00.00'S, long 00°00.00'E, depth 0000m								
total volume: aborted								
Comments: when dredge was @ 3600m it was aborted due to some major technical problems, MSM station no: 1096								
MSM19-3 DR26								
Description of Location and Structure: Agulhas ridge, central part, steep "steps"/scarps at ocean floor, N of Agulhas Ridge, southern tip of one "step"								
Dredge on bottom UTC 09/12/11 10:00hrs, lat 42°19.15'S, long 09°17.51'E, depth 4733m								
Dredge off bottom UTC 09/12/11 11:08hrs, lat 42°19.03'S, long 09°16.94'E, depth 4534m								
total volume: empty								
Comments: MSM station no: 1097								
MSM19-3 DR27								
Description of Location and Structure: Agulhas ridge, central part, steep "steps"/scarps at ocean floor, N of Agulhas Ridge, 1nm N of DR26								
Dredge on bottom UTC 09/12/11 13:46hrs, lat 42°18.38'S, long 09°18.21'E, depth 4817m								
Dredge off bottom UTC 09/12/11 14:42hrs, lat 42°18.47'S, long 09°17.72'E, depth 4597m								
total volume: empty								
Comments: MSM station no: 1098								
MSM19-3 DR28								
Description of Location and Structure: ocean floor N of Agulhas ridge oval shaped smnt, E-W axis, N facing slope								
Dredge on bottom UTC 09/12/11 18:07hrs, lat 42°30.62'S, long 09°14.22'E, depth 4610m								
Dredge off bottom UTC 09/12/11 19:19hrs, lat 42°31.03'S, long 09°13.98'E, depth 4280m								
total volume: empty								
Comments: MSM station no: 1099								
MSM19-3 DR29								
Description of Location and Structure: Seafloor north of Agulhas FZ, Seamount part of larger NE -SW striking lineament SE - Flank below top								
Dredge on bottom UTC 09/12/11 22:52 hrs, lat 42°29.51'S, long 08°51.75'E, depth 4311m								
Dredge off bottom UTC 10/12/11 00:15 hrs, lat 42°29.48'S, long 08°51.07'E, depth 3938m								
total volume: 1/5 full								
Comments: angular fragments of volcanic rocks with thin Mn-coating. A few can be readily identified as plutonics -> dropstones, MSM station no: 1100								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR29-1	1. Rock Type: volcanic, fairly fresh 2. Size: 22x15x15 3. Shape / Angularity: angular 4. Color of cut surface: grey / greenish with orange 5. Texture / Vesicularity: aphyric, dense, vesicles <1% 6. Phenocrysts: Ol 20%, mm, completely altered -> Iddingsite, Cpx 1%, sub mm, fresh, platy; Fsp 3%, sub mm - mm, fresh, needles 7. Matrix: microcrystalline with gm fsp + cpx 8. secondary Minerals: Ol replaced by Iddingsite 9. Encrustations: thin Mn coating 10. Comment: relatively big piece of lava with altered ol. Biggest piece of this lithology. -> representative sample	x	x	Fsp 1	Ol, Fsp, Cpx			
MSM19-3 DR29-2	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 9x7x5.5 3. Shape / Angularity: angular 4. Color of cut surface: grey / greenish with orange 5. Texture / Vesicularity: aphyric, dense, vesicles <1% 6. Phenocrysts: Ol 20%, mm, completely altered -> Iddingsite, Cpx 1%, sub mm, fresh, platy; Fsp 3%, sub mm - mm, fresh, needles 7. Matrix: microcrystalline with gm fsp + cpx 8. secondary Minerals: Ol replaced by Iddingsite 9. Encrustations: thin Mn coating 10. Comment: small piece of same lithology as DR29-1. Alteration grade is high + veins with sec. Minerals and/or Zeolite.	x		Fsp 2				
MSM19-3 DR29-3	1. Rock Type: volcanic, lava fragment, highly altered 2. Size: 14.5x9x2 3. Shape / Angularity: angular 4. Color of cut surface: grey / greenish with orange 5. Texture / Vesicularity: aphyric, dense, vesicles <1% 6. Phenocrysts: Ol 20%, mm, completely altered -> Iddingsite, Cpx 1%, sub mm, fresh, platy; Fsp 3%, sub mm - mm, fresh, needles 7. Matrix: microcrystalline with gm fsp + cpx 8. secondary Minerals: Ol replaced by Iddingsite 9. Encrustations: thin Mn coating 10. Comment: small piece of same lithology as DR29-1. But more altered.	x		Fsp 2				
MSM19-3 DR29-4	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 10x7x4 3.-9. similar to DR29-1 10. Comment: similar to DR29-1, but higher vesicularity (3%), and cracks filled with Fe-oxides	x		Fsp 3				


Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR29-5	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 14x10x7 3.-9. similar to DR29-1 10. Comment: same as DR29-4, but Ol even more altered, some vesicles filled with Mn or Fe-oxides	x		Fsp 3				
MSM19-3 DR29-6	1. Rock Type: volcanic, slightly altered 2. Size: 34x27x7 3. Shape / Angularity: angular 4. Color of cut surface: light grey to yellowish / orange 5. Texture / Vesicularity: aphyric, dense, no vesicles 6. Phenocrysts: Cpx, mm, 5%, fresh 7. Matrix: microcrystalline with sub-mm fsp + cpx 8. secondary Minerals: matrix slightly altered, some of the Cpx is altered 9. Encrustations: Mn coating 10. Comment: biggest piece of this lithology, representative amount of material was fresh, big min. Collected archive sample (-6X). Really high amount of Cpx.	x	x	2 gm - Fsp				
MSM19-3 DR29-7	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 8x7x6 3. Shape / Angularity: angular 4. Color of cut surface: light grey with orange 5. Texture / Vesicularity: aphyric, dense, 5% vesicles, partly filled 6. Phenocrysts: Cpx 1%, fresh - altered, submm - mm, platty 7. Matrix: microcrystalline, fine grained, with submm fsp+cpx 8. secondary Minerals: Fe-oxides in vesicles and cracks, iddingsite 9. Encrustations: thin Mn coating 10. Comment: similar to DR29-6, but more altered	x		Fsp 3				
MSM19-3 DR29-8	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 8x6x6 3. Shape / Angularity: angular 4. Color of cut surface: light grey with orange/red 5. Texture / Vesicularity: aphyric, 15% vesicles, partly filled 6. Phenocrysts: Fsp 3%, blocky needles, sub mm - 0.5 cm, fairly fresh; Cpx <1%, platty, fresh 7. Matrix: microcrystalline with sub-mm fsp + cpx 8. secondary Minerals: Fe-oxides as vesicle filling 9. Encrustations: thin Mn coating 10. Comment: small piece of same lithology as DR29-6, but more altered, and higher vesicularity. Contains veins filled with green minerals (chloride?).	x		Fsp 3				
MSM19-3 DR29-9	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 10x9x5 3.-10. similar to DR29-6, see also description of DR29-7 and DR29-8	x						
MSM19-3 DR29-10	1. Rock Type: volcanic 2. Size: 10x7x5.5 3.-10. similar o DR29-66, see also description of DR29-7 and DR29-8							
MSM19-3 DR29-11	1. Rock Type: volcanic (?), lava fragment, fresh 2. Size: 36x32x16 3. Shape / Angularity: angular 4. Color of cut surface: grey-green with black (dry) 5. Texture / Vesicularity: aphyric, dense, vesicles <1%, partly filled 6. Phenocrysts: Fsp 30%, fresh, mm - 0.5 cm, platty, needles; Cpx 30%, fresh, mm, blocky; zeolite mm - cm, fresh, in veins 7. Matrix: microcrystalline, with fsp + cpx in gm 8. secondary Minerals: sec. minerals in vesicles; and calcite in veins and cracks 9. Encrustations: thin Mn coating 10. Comment: material very rich in Fsp + Cpx; biggest piece of this lithology; additional material as -11X in archive	x	x	Fsp 1	Fsp, Cpx			

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR29-12	1. Rock Type: volcanic, lava fragment 2. Size: 9x6x4 3.-9. similar to DR29-11 10. Comment: small piece of same lithology as DR29-11	x		Fsp 1-2				
MSM19-3 DR29-13	1. Rock Type: volcanic, lava fragment, slightly altered 2. Size: 11x7x3 3.-9. similar to DR29-11 10. Comment: small piece of same lithology as DR29-11, but more altered Fsp	x		Fsp 2-3				
MSM19-3 DR29-14	1. Rock Type: volcanic, lava fragment, slightly altered 2. Size: 11x8.5x1 3.-10. similar to DR29-11	x						
MSM19-3 DR29-15	1. Rock Type: metamorphic 2. Size: 10x7x5 3. Shape / Angularity: subrounded - subangular 4. Color of cut surface: grey with green and orange 5. Texture / Vesicularity: dense, S-texture with flow structure 7. Matrix: basaltic clasts with Fsp-phenocrysts <1%, mm, subrounded, flow structure 10. Comment: metamorphic material, maybe basalt that has been metamorphic overprinted by fluids	x						
MSM19-3 DR29-16	1. Rock Type: metamorphic 2. Size: 9.5x8.5x7.5 3. Shape / Angularity: subangular 4.-10. similar to DR29-15	x						
MSM19-3 DR29-17	1. Rock Type: volcanic 2. Size: 13x9.5x4 3. Shape / Angularity: subrounded 4. Color of cut surface: grey, with white veins 5. Texture / Vesicularity: aphyric, dense, no vesicles 6. Phenocrysts: Fsp, platty, fresh, mm, <1% 7. Matrix: microcrystalline 8. secondary Minerals: sec. minerals, maybe calcite or zeolite in veins 9. Encrustations: thin Mn coating 10. Comment: transitional sample between volcanic and metamorphic; several veins, cracks go through sample, partly already metamorphized edge	x						
MSM19-3 DR29-18	1. Rock Type: metamorphic, fresh 2. Size: 11.5x6x6 3.-10. very similar to DR29-15	x						

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR29-19	1. Rock Type: plutonic 2. Size: 10.5x9x4 3. Shape / Angularity: subangular 4. Color of cut surface: black, with orange 5. Texture / Vesicularity: aphyric, dense, no vesicles 6. Phenocrysts: Fsp, cm, 15%, xenomorph; Cpx, mm-cm, 3%, idio-xenomorph 7. Matrix: coarse grained, gabbroid 8. secondary Minerals: slightly altered fsp 10. Comment: gabbro-like plutonite	x						
MSM19-3 DR29-20	1. Rock Type: plutonic 2. Size: 9.5x6x5 3. Shape / Angularity: subrounded - subangular 4. Color of cut surface: orange with black 5. Texture / Vesicularity: granitic with idiomorphic and xenomorphic phenocrysts 6. Phenocrysts: Cpx 30%, partly idiomorphic, blocky, fresh, mm - 0.5 cm; Fsp 30%, needle-like, fresh - altered, mm - 0.5 cm 7. Matrix: coarse grained 8. secondary Minerals: partly altered 9. Encrustations: thin Mn coating 10. Comment: small piece of plutonic material; relatively light colored; appears to be transitional between granitic texture, but contains idiomorphic Cpx	x						
MSM19-3 DR29-6-X	1. Rock Type: pillow fragments 10. Comment: additional material of sample DR29-6 for archive							
MSM19-3 DR29-11-X	1. Rock Type: pillow fragments 10. Comment: additional material of sample DR29-11 for archive							

MSM19-3 DR30



Description of Location and Structure: Agulhas FZ, Western section, large smnt on top of Northern Ridge Morth facing slope along flank of a ridge

Dredge on bottom UTC 10/12/11 03:52 hrs, lat 42°45.87'S, long 08°41.29'E, depth 3650m

Dredge off bottom UTC 10/12/11 05:15 hrs, lat 42°46.20'S, long 08°40.90'E, depth 3225m

total volume: few rocks


Comments: pillow lava, Mn-crust and dropstones, MSM station no: 1101

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR30-1	1. Rock Type: pillow tube, strong altered 2. Size: 20x18x14 3. Shape / Angularity: tube shaped 4. Color of cut surface: ark brown 5. Texture / Vesicularity: 25% up to 4mm, open vesicles 6. Phenocrysts: Ol <2%, mm, completely altered, fsp <5%, two kinds - large, >1cm, rounded and xenomorph, -small, 3mm, idiomorph 7. Matrix: fine grained, altered 8. secondary Minerals: cc, Mn, clay in vesicles 9. Encrustations: Mn crust 0.5cm 10. Comment: very altered rock, but fsp might be okay for dating	x	x	2-3				
MSM19-3 DR30-2	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 13x8x6 3. Shape / Angularity: pillow shaped, subangular 4. Color of cut surface: brownish grey (center), orange (rim) 5. Texture / Vesicularity: open vesicles 10-15% 6. Phenocrysts: Ol <3%, mm, completely altered, 0.5mm, fsp submm - mm, fresh, needles 7. Matrix: fine grained 8. secondary Minerals: palagonized rim, clay & cc 10. Comment: inner part relatively fresh matrix might be sufficient enough for dating, some fresh glass preserved	x	x					

Appendix I (Rock Description)




SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR30-3	1. Rock Type: volcanic, pillow fragment, highly altered 2. Size: 14x11x8 3. Shape / Angularity: pillow shaped 4. Color of cut surface: orange - brown 5. Texture / Vesicularity: well rounded vesicles, 35%, up to 2mm, partly filled with cc 6. Phenocrysts: fsp 0.2 - 1.5cm 7. Matrix: fine grained, completely altered 8. secondary Minerals: cc, Mn-fe minerals along fissures, clay minerals 9. Encrustations: Mn coating 10. Comment: fsp relatively dark, if phenocrysts maybe good for dating	x	x	3				
MSM19-3 DR30-4	1. Rock Type: volcanic clasts in Mn crust 2. Size: 4x3x2 (biggest clasts) 3. Shape / Angularity: subangular 4. Color of cut surface: dark brown 5. Texture / Vesicularity: 5% vesicles, partly filled with cc 6. Phenocrysts: fsp 10%, up to 8mm 7. Matrix: fine grained, altered 8. secondary Minerals: cc, clay minerals 9. Encrustations: thick Mn crust 10. Comment: plag not fresh; Mn as separate sample (MSM19-3 DR30-4-M)	x		4				
MSM19-3 DR30-4-M	1. Rock Type: Mn crust, 9cm thick 2. Size: 16x14x9 3. Shape / Angularity: subangular 4. Color of surface: black							
MSM19-3 DR30-5-M	1. Rock Type: Mn crust, 6cm thick 2. Size: 18x14x6 3. Shape / Angularity: subangular 4. Color of surface: black - dark brown							
MSM19-3 DR30-6-M	1. Rock Type: Mn crust, 6cm thick 2. Size: 16x10x6 3. Shape / Angularity: subangular 4. Color of surface: black							
MSM19-3 DR30-7-M	1. Rock Type: Mn crust, 6cm thick 2. Size: 14x9x6 3. Shape / Angularity: subangular 4. Color of surface: black							
MSM19-3 DR30-8-M	1. Rock Type: Mn crust, 6cm thick 2. Size: 17x9x6 3. Shape / Angularity: subangular 4. Color of surface: black							

Appendix I (Rock Description)








SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Air Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR30-9-M	1. Rock Type: Mn crust, 5cm thick 2. Size: 7x5x5 3. Shape / Angularity: subangular 4. Color of surface: black							
MSM19-3 DR30-1-X	1. Rock Type: pillow fragments 10. Comment: additional material of sample DR30-1 for archive							no picture

MSM19-3 DR31	
Description of Location and Structure: Area Agulhas central, southern flank of northern ridge, upper part beneath flat (younger???) structure	
Dredge on bottom	UTC 10/12/11 08:54hrs, lat 43°04.61'S, long 08°56.41'E, depth 2993m
Dredge off bottom	UTC 10/12/11 11:00hrs, lat 43°04.63'S, long 08°56.44'E, depth 3100m
total volume:	empty
Comments:	MSM station no: 1102








MSM19-3 DR32	
Description of Location and Structure: Area Agulhas central	
Dredge on bottom	UTC 10/12/11 13:26hrs, lat 43°00.93'S, long 09°05.93'E, depth 3404m
Dredge off bottom	UTC 10/12/11 14:50 hrs, lat 43°00.76'S, long 09°05.32'E, depth 3041m
total volume:	few rocks
Comments:	MSM station no: 1103

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Air Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR32-1	1. Rock Type: pillow fragment, moderately altered 2. Size: 18x17x13 3. Shape / Angularity: subangular 4. Color of cut surface: dark brown 5. Texture / Vesicularity: porphyric, 10-15% vesicles, partly filled 6. Phenocrysts: fsp 3% 1mm, strongly altered, cpx ~3% up to 2.5mm, strongly altered 7. Matrix: very fine grained 8. secondary Minerals: Mn, clay in vesicles, clay in matrix, palagonite rim 9. Encrustations: Mn crust 1cm 10. Comment: most representative sample of this lithology	x	x	4				
MSM19-3 DR32-2	1. Rock Type: volcanic, pillow lava fragment, moderately altered 2. Size: 16x13x13 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey 5. Texture / Vesicularity: porphyric, ~10% vesicles, up to 1cm, partly filled, 3% vugs partly filled 6. Phenocrysts: fsp <5% up to 3mm, strongly altered, cpx (?) 7. Matrix: very fine grained, gm fsp and cpx (?) 8. secondary Minerals: Zeolithes, clay minerals and foraminifera ooze filling vesicles 9. Encrustations: Mn crust <3mm 10. Comment: requires carefully picking for geochemistry	x	x	4				
MSM19-3 DR32-3	1. Rock Type: volcanic, pillow lava fragment, moderately altered 2. Size: 14x8x9 3. Shape / Angularity: subangular (heart-shaped) 4. Color of cut surface: dark brown 5. Texture / Vesicularity: porphyric, ~14% vesicles, partly filled 6. Phenocrysts: fsp <3%, needles, ~1mm, altered, cpx <8%, strongly altered, <3mm, OI <5%, completely altered, <2mm 7. Matrix: fine grained 8. secondary Minerals: Zeolithes, clay minerals and cc 9. Encrustations: Mn crust up to 5mm	x	x	4				







Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR32-4	1. Rock Type: volcanic, pillow lava fragment, moderately altered 2. Size: 11x11x7 3. Shape / Angularity: subangular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: porphyric, 3-5% vesicles, partly filled 6. Phenocrysts: fsp <7%, <1mm, very altered, cpx <5%, <3mm 7. Matrix: very fine grained 8. secondary Minerals: clay minerals and Mn 10. Comment: similar to DR32-1	x	x	4				
MSM19-3 DR32-5	1. Rock Type: volcanic, pillow lava fragment, moderately altered 2. Size: 9x8x6 3. Shape / Angularity: subangular - rounded 4. Color of cut surface: brown with grey 5. Texture / Vesicularity: porphyric, 20% vesicles, partly filled, vugs partly filled 6. Phenocrysts: fsp 3%, needles, mm, fresh - altered, cpx 5%, blocky, fresh - altered, mm - 0.5cm, OI 1%, altered -> Iddingsite 7. Matrix: microcrystalline with submm fsp and cpx 8. secondary Minerals: Iddingsite and cc, altered matrix, vesicles filling clay, zeolithes, Mn, cc 9. Encrustations: Mn coating 10. Comment: matrix appears similar to DR32-1 but higher vesicularity	x		3 gm-fsp				
MSM19-3 DR32-6	1. Rock Type: lava fragment, strongly altered 2. Size: 13x7x7 3. - 9. similar to DR32-1 10. Comment: less vesicularity -> 5%	x		3 gm-fsp				
MSM19-3 DR32-7	1. Rock Type: lava fragment, moderately altered 2. Size: 7x7x6 3. - 9. similar to DR32-1 10. Comment: vesicularity 30%	x		2 gm-fsp				
MSM19-3 DR32-8	1. Rock Type: lava fragment, strongly altered 2. Size: 8x8x6 3. - 9. similar to DR32-1 10. Comment: vesicularity 5%, Phenocrysts: cpx 0.5 - 1cm, 5%	x		4				
MSM19-3 DR32-9	1. Rock Type: lava fragment, highly altered 2. Size: 12x8x8 3. - 9. similar to DR32-1 10. Comment: vesicularity 30%, OI very altered -> Iddingsite	x						
MSM19-3 DR32-10	1. Rock Type: volcanic, pillow lava fragment, slight - moderately altered 2. Size: 10x10x9 3. Shape / Angularity: angular 4. Color of cut surface: grey - brownish 5. Texture / Vesicularity: porphyric, <1% vesicles, filled 6. Phenocrysts: fsp 3%, needles, submm - mm, fresh - altered, cpx 7%, blocky, fresh - altered, mm - 0.5cm, OI 3%, altered -> Iddingsite 7. Matrix: microcrystalline dense, partly altered, submm fsp and cpx 8. secondary Minerals: Iddingsite and cc, altered matrix 9. Encrustations: thin Mn coating 10. Comment: matrix appears similar to DR32-1 but is more dense and contains OI	x		3-4 gm-fsp				


Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR32-11	1. Rock Type: plutonic 2. Size: 23x20x11 3. Shape / Angularity: angular 4. Color of cut surface: grey / black with orange 5. Texture / Vesicularity: granitic, no vesicles 6. Phenocrysts: cpx, Ol, fsp -> idio - xenomorph, partly altered, mm 8. secondary Minerals: sec. Minerals (e.g. Fe-oxides) 10. Comment: bigger block of Gabbro(?) -like material, representative amount as sample material, rest as DR32-18-X in archive	x	x					
MSM19-3 DR32-12	1. Rock Type: Breccia, strongly altered 2. Size: 16x13x9 3. Shape / Angularity: rounded 4. Color of cut surface: orange brown with red 10. Comment: vesicular lava fragment clasts embedded in finer matrix, partly high vesicularity, appears to be highly altered	x						
MSM19-3 DR32-13	1. Rock Type: Breccia, strongly altered 2. Size: 25x13x8 3. Shape / Angularity: rounded 4. Color of cut surface: orange brown with red 10. Comment: similar to DR 32-12 but with white vesicles filling, maybe zeolithe	x						
MSM19-3 DR32-14	1. Rock Type: Breccia, strongly altered 2. Size: 9x9x4 3. Shape / Angularity: rounded 4. Color of cut surface: orange brown with red 10. Comment: similar to DR 32-12	x						
MSM19-3 DR32-15-VC	1. Rock Type: volcanoclastica, highly altered 2. Size: not determined approx. 32x20x13 10. Comment: pieces of vesicular basalt embedded in fine sediment, thick Mn crust ca 3cm	x						
MSM19-3 DR32-16-M	1. Rock Type: Mn knoll 2. Size: 18x15x12 3. Shape / Angularity: rounded 4. Color of surface: black							
MSM19-3 DR32-17-M	1. Rock Type: Mn crust 2. Size: 25x17x8 3. Shape / Angularity: subangular 4. Color of surface: black	x						

Appendix I (Rock Description)


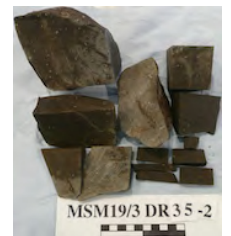

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR32-11-X	1. Rock Type: plutonic (?) 10. Comment: additional material of sample DR32-11 for archive							
MSM19-3 DR33								
Description of Location and Structure: Area Agulhas west								
Dredge on bottom		UTC 10/12/11 17:41hrs, lat 43°10.31'S, long 09°14.62'E, depth 3015m						
Dredge off bottom		UTC 10/12/11 19:07hrs, lat 43°09.94'S, long 09°14.19'E, depth 2497m						
total volume:		1/5 full						
Comments:		Mn encrusted magmatic rocks, single large angular block, MSM station no: 1104						
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR33-1	1. Rock Type: plutonic (?), altered 2. Size: 36x27x23 3. Shape / Angularity: angular 4. Color of cut surface: light grey to orange 5. Texture / Vesicularity: porphyric - granitic 10. Comment: difficult to determine, seems porphyric texture with high amount of phenos, contains red/brown mineral ca 7% maybe garnet or titanite, big block representative amount of material was collected, rest as DR33-1-X in archive	x	x					
MSM19-3 DR33-2	1. Rock Type: volcanic, highly altered 2. Size: 15x11.5x8 3. Shape / Angularity: rounded 4. Color of cut surface: orange 5. Texture / Vesicularity: aphyric, 3% vesicles 6. Phenocrysts: completely altered, replaced by sec. minerals, not possible to determine 7. Matrix: dense, crystalline 8. secondary Minerals: sec. minerals as alteration product of matrix and phenos 9. Encrustations: Mn crust 1.5 - 1cm 10. Comment: completely altered basalt -> Mn crust chipped of on bord	x						
MSM19-3 DR33-3	1. Rock Type: volcanic, fairly fresh 2. Size: 10x6x5 3. Shape / Angularity: angular 4. Color of cut surface: light grey 5. Texture / Vesicularity: porphyric, vesicles 3% + vugs 6. Phenocrysts: cpx 5%, blocky, mm-cm, fresh-altered, fsp 3% needles, platy, mm - cm, fresh - altered 7. Matrix: microcrystalline, dense, gm fsp and cpx (submm) 8. secondary Minerals: Mn in vesicles and vugs 9. Encrustations: Mn coating	x		2-3 gm-fsp				
MSM19-3 DR33-4	1. Rock Type: plutonic, fresh 2. Size: 9.5x9x5 3. Shape / Angularity: angular 4. Color of cut surface: light grey with black and orange 5. Texture / Vesicularity: granitic, xenomorph crystals 10. Comment: pegmatite with kfsp and qrz and px small area with PbS (?)	x		1 fsp				
MSM19-3 DR33-5-M	1. Rock Type: Mn crust 2. Size: 10x8x5							

Appendix I (Rock Description)








SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Air Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR33-6-M	1. Rock Type: Mn crust 2. Size: 27x22x13.5 10. Comment: huge block of Mn crust with "face" block introduced himself as Igor-Agate							
MSM19-3 DR33-1-X	1. Rock Type: plutonic (?) 10. Comment: additional material of sample DR33-1 for archive							no picture

MSM19-3 DR34	
Description of Location and Structure: Agulhas Fracture Zone, western section, southern ridge, SE facing slope at base of southern ridge	
Dredge on bottom	UTC 10/12/11 21:09hrs, lat 43°11.19'S, long 09°19.56'E, depth 3796m
Dredge off bottom	UTC 10/12/11 22:35hrs, lat 43°10.92'S, long 09°19.02'E, depth 3330m
total volume:	empty
Comments:	MSM station no: 1105








MSM19-3 DR35	
Description of Location and Structure: Agulhas Fracture Zone, western section, northern ridge, southern slope, SE facing slope at a ridge	
Dredge on bottom	UTC 11/12/11 04:00hrs, lat 43°17.53'S, long 08°20.80'E, depth 2940m
Dredge off bottom	UTC 11/12/11 05:24hrs, lat 43°17.26'S, long 08°20.29'E, depth 2345m
total volume:	half full
Comments:	lava fragments, Mn crusts, dropstones, MSM station no: 1106

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Air Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR35-1	1. Rock Type: pillow fragment, slightly altered 2. Size: 14x13x11 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey 5. Texture / Vesicularity: porphyric, <5% partly filled vesicles 6. Phenocrysts: fsp ~10%, <4mm, fresh; cpx <5%, moderately altered, <2mm 7. Matrix: very fine grained 8. secondary Minerals: fractures filled with clay and Mn 9. Encrustations: up to 5mm Mn crust 10. Comment: most representative and freshest sample, big and fresh fsp	x	x	1-2 fsp				
MSM19-3 DR35-2	1. Rock Type: pillow fragment, slightly altered 2. Size: 15x15x9 3. Shape / Angularity: subrounded 4. Color of cut surface: dark grey 5. Texture / Vesicularity: porphyric, ~20-30% vesicles, mostly open, very few filled with clay minerals 6. Phenocrysts: fsp <5%, fresh, up to 2mm; cpx <3%, strongly altered, up to 2mm; Ol <4% completely altered, up to 2mm 7. Matrix: very fine grained 8. secondary Minerals: veins filled with clay minerals or cc, some vesicles filled with the same sec. minerals 9. Encrustations: up to 3mm Mn crust	x	x	1-2 fsp				
MSM19-3 DR35-3	1. Rock Type: pillow fragment, moderately altered 2. Size: 11x8x8 3. Shape / Angularity: subangular 4. Color of cut surface: brownish (wet), grey (dry) 5. Texture / Vesicularity: porphyric, <2% partly filled vesicles 6. Phenocrysts: fsp ~5%, moderately altered, up to 5mm; cpx <3%, completely altered, up to 2mm; cpx <3%, moderately altered, up to 5mm 7. Matrix: fine grained 8. secondary Minerals: some vesicles filled with orange-brownish minerals (clay?) 9. Encrustations: up to 3mm Mn crust 10. Comment: ~5mm palagonite rim	x	x	2-3 fsp				






Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR35-4	1. Rock Type: pillow fragment slightly altered 2. Size: 14x10x9 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: slightly porphyric, ~5-10% vesicles, mostly filled with secondary minerals, up to 1mm 6. Phenocrysts: fsp <2%, needles, up to 1mm; cpx <2%, <1mm 7. Matrix: fine grained 8. secondary Minerals: cc filling vesicles, clay minerals in matrix 9. Encrustations: up to 5mm Mn crust	x	x	4-5 gm-fsp				
MSM19-3 DR35-5	1. Rock Type: piece of lava (block), moderately altered 2. Size: 30x26x21 3. Shape / Angularity: subangular 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, ~5% vesicles partly altered, up to 1cm 6. Phenocrysts: fsp <5%, moderately altered, up to 1.5cm; cpx <5%, strong to moderately altered, up to 7mm; Ol <3%, completely altered, up to 2mm 7. Matrix: fine grained 8. secondary Minerals: Mn, clay minerals, and cc filling some vesicles and veins 9. Encrustations: up to 3cm Mn crust	x	x	3-4 fsp				
MSM19-3 DR35-6	1. Rock Type: lava, moderate - strongly altered 2. Size: 20x15x11 3. Shape / Angularity: subangular 4. Color of cut surface: brown 5. Texture / Vesicularity: aphyric, ~5-10% vesicles, mostly filled with sec. minerals 7. Matrix: fsp needles, <1%, Ol (?) very altered 8. secondary Minerals: Mn and clay minerals 9. Encrustations: up to 1cm Mn crust 10. Comment: similar to DR35-4	x	x	5 gm-fsp				
MSM19-3 DR35-7	1. Rock Type: lava, strog altered 2. Size: 15x8x8 3. Shape / Angularity: subangular 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, <5% vesicles, up to 8mm, partly filled with sec. minerals 6. Phenocrysts: fsp ~5%, moderately altered, <7mm; cpx <5%, moderately altered, <3mm; <1% Ol (?) 7. Matrix: fine grained 9. Encrustations: up to 1cm Mn crust 10. Comment: fluids altered most of the rock	x	x	5 fsp				
MSM19-3 DR35-8	1. Rock Type: pillow lava, block, slightly altered 2. Size: 47x23x18 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, <5% vesicles mostly filled with sec. minerals 6. Phenocrysts: cpx <4%, slightly altered, up to 2mm; fsp 2%, up to 1mm; Ol <1%, strongly altered 7. Matrix: fine grained 8. secondary Minerals: clay minerals and cc 9. Encrustations: <1mm Mn crust 10. Comment: similar to DR 35-4	x	x	4-5 gm-fsp				
MSM19-3 DR35-9	1. Rock Type: lava, moderately altered 2. Size: 15x9x8 3. Shape / Angularity: subangular 4. Color of cut surface: bwonish - grey 5. Texture / Vesicularity: aphyric, ~5% vesicles, mostly filled with sec. mineral 7. Matrix: fsp needles 8. secondary Minerals: cc, clay minerals filling vesicles 9. Encrustations: up to 5mm Mn crust 10. Comment: similar to DR35-4	x	x	5 gm-fsp				
MSM19-3 DR35-10	1. Rock Type: lava, slightly altered 2. Size: 13x13x8 3. Shape / Angularity: angular 4. Color of cut surface: grey (dry), dark grey (wet) 5. Texture / Vesicularity: aphyric, <3% vesicles, partly filled 7. Matrix: fsp needles 8. secondary Minerals: clay minerals 9. Encrustations: ~1mm Mn crust 10. Comment: similar to DR35-8	x		5 gm-fsp				

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR35-11	1. Rock Type: lava, slight o moderately altered 2. Size: 17x9x6 10. Comment: similar to DR35-8, DR35-9, DR35-10 but bigger vesicles (up to 3mm)	x		5 gm fsp				
MSM19-3 DR35-12	1. Rock Type: lava, moderatley altered 2. Size: 32x23x13 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, ~5-10% vesicles, mostly open, up to 2mm 6. Phenocrysts: fsp ~5-10%, moderately altered, <1cm; OI <5%, completely altered, <2mm 7. Matrix: fine grained with cpx (?) 8. secondary Minerals: veins filled with cc and clay minerals 9. Encrustations: <2mm Mn crust 10. Comment: many veins filled filled with cc	x	x	3-4 fsp				
MSM19-3 DR35-13	1. Rock Type: lava, moderately altered 2. Size: 20x15x11 10. Comment: similar to DR35-12 but less big fsp	x	x	3-4 fsp				
MSM19-3 DR35-14	1. Rock Type: lava, moderately altered 2. Size: 11x11x7 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, <5% vesicles, 1mm, mostly filled with sec. minerals 6. Phenocrysts: fsp ~3-5%, up to 8mm, moderately altered; OI ~3%, completely altered, <2mm; cpx (?) <3% up to 5mm, moderately altered 7. Matrix: fine grained 8. secondary Minerals: cc filling in most vesicles 10. Comment: similar to DR35-12	x	x	3-4 fsp				
MSM19-3 DR35-15	1. Rock Type: lava, moderately altered 2. Size: 18x10x8 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, ~5-10% vesicles mostly open, up to 3mm 6. Phenocrysts: fsp 5-10%, strongy altered, up to 3mm; OI ~5%, completely altered, up to 5mm; cpx (?) ~5%, up to 8mm 7. Matrix: fine grained 8. secondary Minerals: clay minerals filling in some vesicles 9. Encrustations: <1mm Mn crust	x		5 fsp				
MSM19-3 DR35-16	1. Rock Type: lava, moderately altered 2. Size: 13x10x6 10. Comment: similar to DR35-15 but more fsp	x		5				
MSM19-3 DR35-17	1. Rock Type: lava, strongly altered 2. Size: 14x9x9 10. Comment: similar to DR35-15 but with thick veins filled with cc and 2cm Mn crust	x	x	5-6				

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR35-18	1. Rock Type: lava, moderately altered 2. Size: 11x8x7 3. Shape / Angularity: subangular 4. Color of cut surface: brownish - grey 5. Texture / Vesicularity: porphyric, ~25% vesicles, mostly open, up to 6mm 6. Phenocrysts: fsp <5%, moderate to strongly altered, up to 2mm 7. Matrix: fine grained 8. secondary Minerals: cc and clay minerals filling vesicles 9. Encrustations: <1mm Mn crust 10. Comment: requires carefully picking for gc	x	x	5-6				
MSM19-3 DR35-19	1. Rock Type: lava, moderately altered 2. Size: 11x8x8 10. Comment: similar to DR35-18 but less fsp, and with veins (up to 3mm wide) filled with clay, Mn crust ~1.5mm	x	x	5-6				
MSM19-3 DR35-20	1. Rock Type: lava, moderately altered 2. Size: 12x10x5 3. Shape / Angularity: subangular 4. Color of cut surface: grey - light grey 5. Texture / Vesicularity: porphyric, <2% vesicles filled with sec. minerals 6. Phenocrysts: fsp 5-10%, moderately altered, up to 8mm; Ol(?) <1% 7. Matrix: fine grained 8. secondary Minerals: clay minerals (?) 9. Encrustations: <1mm Mn crust 10. Comment: single sample with this lithology, might be fsp or sec. minerals filling vesicles	x	x	3				
MSM19-3 DR35-21-M	1. Rock Type: Mn crust 2. Size: 21x15x10 3. Shape / Angularity: angular 4. Color of cut surface: black							
MSM19-3 DR35-22-M	1. Rock Type: Mn crust 2. Size: 24x19x7 10. Comment: similar to DR35-21-M							

MSM19-3 DR36


Description of Location and Structure: Area Agulhas Ridge, west, smnt S of Agulhas ridge, southern flank from base to top area

Dredge on bottom UTC 11/12/11 09:42hrs, lat 43°41.87'S, long 08°16.64'E, depth 4465m



Dredge off bottom UTC 11/12/11 10:53hrs, lat 43°41.47'S, long 08°16.40'E, depth 4110m

total volume: 1 big and 3 small rocks




Comments: lgabbro, Mn crust & dropstone, MSM station no: 1107

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR36-1	1. Rock Type: intrusive, slightly altered 2. Size: 9x8x5 3. Shape / Angularity: subangular 4. Color of cut surface: blueish-grey 5. Texture / Vesicularity: phaneritic, middle to coarse grained 6. Phenocrysts: fsp ~60%; px ~40%; purple mineral (?) <3% 8. secondary Minerals: small brownish clay minerals 9. Encrustations: <2mm Mn crust 10. Comment: dropstone ?	x	x	2 fsp				

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR36-2	1. Rock Type: intrusive, pegmatite, relatively fresh 2. Size: 6x6x6 3. Shape / Angularity: subrounded 4. Color of cut surface: white and grey 5. Texture / Vesicularity: pegmatitic 6. Phenocrysts: fsp 75%, cpx ~25% 8. secondary Minerals: very few clay minerals 9. Encrustations: <1mm Mn crust 10. Comment: dropstone ?	x		2 fsp				
MSM19-3 DR36-3	1. Rock Type: Mn knoll 2. Size: 13x8x7 3. Shape / Angularity: subangular 4. Color of cut surface: black 10. Comment: ~8mm pieces of completely altered rock fragments							







MSM19-3 DR37
Description of Location and Structure: Agulhas FZ, western section, SE facing slope of central ridge
Dredge on bottom UTC 11/12/11 19:07hrs, lat 43°40.51'S, long 06°54.14'E, depth 3953m
Dredge off bottom UTC 11/12/11 20:24hrs, lat 43°40.17'S, long 06°53.71'E, depth 3578m
total volume: a few rocks
Comments: two large boulder 1xgranite, 1x amphibolite, single piece of fsp-phyric basalt ???, MSM station no: 1108

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR37-1	1. Rock Type: volcanic, lava fragment, fresh - slightly altered 2. Size: 8x8x8 3. Shape / Angularity: angular 4. Color of cut surface: dark grey (dry) 5. Texture / Vesicularity: pophyric 6. Phenocrysts: fsp 5%, 1-3mm; cpx 5%, <1mm 7. Matrix: microcrystalline, fsp submm 9. Encrustations: Mn coating	x		2				
MSM19-3 DR37-2	1. Rock Type: intrusive, plutonic, fresh 2. Size: 47x39x26 3. Shape / Angularity: rounded 4. Color of cut surface: white and grey and red (dry) 5. Texture / Vesicularity: granitic 6. Phenocrysts: qrz, fsp, bt, hbl/px (?) -> idio - xenomorph 9. Encrustations: 2cm Mn crust 10. Comment: dropstone ? huge -> representative amount was collected	x		1				
MSM19-3 DR37-3	1. Rock Type: metamorphic 2. Size: 38x20x15 3. Shape / Angularity: subrounded 4. Color of cut surface: grey to black (dry) 5. Texture / Vesicularity: granitic 6. Phenocrysts: difficult to determine qrz, fsp, bt, amph/px (?), mm, fresh 9. Encrustations: Mn coating 10. Comment: single crystal structure, planar texture possible, white (fsp?), thin needle-like crystals (up to 1cm), slightly altered	x		2				








Appendix I (Rock Description)

MSM19-3 DR38								
Description of Location and Structure: Agulhas FZ, western section, southernmost ridge, NW facing slope								
Dredge on bottom UTC 12/12/11 06:00hrs, lat 44°03.70'S, long 05°57.00'E, depth 3926m								
Dredge off bottom UTC 12/12/11 07:31hrs, lat 44°04.18'S, long 05°56.98'E, depth 3495m								
total volume: half full								
Comments: "reddish" lava fragments, volcanoclastic rocks, few metamorphic, MSM station no: 1109								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SEDS	NOTES	PICTURE
MSM19-3 DR38-1	1. Rock Type: lava fragment, slightly altered 2. Size: 13x12x8 3. Shape / Angularity: subangular 4. Color of cut surface: grey with reddish rim 5. Texture / Vesicularity: aphyric, ~5% vesicles, 1mm, filled with Mn 7. Matrix: microcrystalline, fsp 8. secondary Minerals: red Fe-oxides (?), Mn, clay minerals 10. Comment: major lithology in this dredge; most like in-situ rocks, typical for this lithology; reddish alteration; this sample is relatively fresh, but requires careful picking for Gc	x	x	3-4 gm-fsp				
MSM19-3 DR38-2	1. Rock Type: lava fragment, slightly altered 2. Size: 21x15x13 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1	x	x	3-4 gm-fsp				
MSM19-3 DR38-3	1. Rock Type: lava fragment, slightly altered 2. Size: 11x9x6 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1	x	x	3-4 gm-fsp				
MSM19-3 DR38-4	1. Rock Type: lava fragment, slightly altered 2. Size: 12x8x7 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1	x	x	3-4 gm-fsp				
MSM19-3 DR38-5	1. Rock Type: lava fragment, slightly altered 2. Size: 20x13x9 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1	x	x	3-4 gm-fsp				
MSM19-3 DR38-6	1. Rock Type: lava fragment, moderately altered 2. Size: 21x15x13 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1, but slightly more altered	x	x	3-4 gm-fsp				
MSM19-3 DR38-7	1. Rock Type: lava fragment, slightly altered 2. Size: 9x7x6 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1, but more cracks and vesicles filled with sec. Minerals	x						


Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR38-8	1. Rock Type: lava fragment, moderately altered 2. Size: 12x8x6 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1, but slightly more altered	x						
MSM19-3 DR38-9	1. Rock Type: lava fragment, moderately altered 2. Size: 12x8x6 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1, but slightly more altered	x						
MSM19-3 DR38-10	1. Rock Type: lava fragment, moderately altered 2. Size: 18x8x6 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1, but slightly more altered	x						
MSM19-3 DR38-11	1. Rock Type: lava fragment, moderately altered 2. Size: 16x8x8 3. Shape / Angularity: angular 4. - 10. Comment: similar to DR38-1, but slightly more altered	x						
MSM19-3 DR38-12	1. Rock Type: lava fragment, moderately altered 2. Size: 17x12x9 3. Shape / Angularity: subangular 4. - 10. Comment: similar to DR38-1, but slightly more altered and with palagonite rim	x						
MSM19-3 DR38-13	1. Rock Type: lava fragment, slightly altered 2. Size: 8x8x8 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: aphyric, ~5% vesicles, mostly filled with sec. minerals 7. Matrix: microcrystalline with fsp (?) 8. secondary Minerals: clay minerals and Mn filling in vesicles 9. Encrustations: <2mm mn crust 10. Comment: similar to DR38-1, but without reddish alteration	x	x					
MSM19-3 DR38-14	1. Rock Type: lava fragment, relatively fresh 2. Size: 8x6x4 3. - 10. Comment: similar to DR38-13	x						



Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR38-15	1. Rock Type: lava fragment, moderately altered 2. Size: 12x7x6 3. - 10. Comment: similar to DR38-13, but more fractionated and veins filled with clay minerals	x						
MSM19-3 DR38-16	1. Rock Type: lava fragment, moderately altered 2. Size: 12x7x6 3. - 10. Comment: similar to DR38-15, but even more fractionated	x						
MSM19-3 DR38-17	1. Rock Type: lava fragment, moderately altered 2. Size: 7x7x7 3. - 10. Comment: similar to DR38-13, but with more vesicles (5-10%), all filled with clay minerals, or Mn and slightly more altered	x						
MSM19-3 DR38-18	1. Rock Type: lava fragment, moderate to strongly altered 2. Size: 10x9x7 3. - 10. Comment: similar to DR38-13, but with more veins filled with clay minerals	x						
MSM19-3 DR38-19	1. Rock Type: lava fragment, moderately altered 2. Size: 13x13x12 3. - 10. Comment: similar to DR38-13, but more fractionated, with veins up to 1mm thick, filled with cc and clay minerals, More vesicles (10-15%), all filled with Mn, cc and clay minerals	x						
MSM19-3 DR38-20	1. Rock Type: block of lava, moderately altered 2. Size: 25x20x18 3. Shape / Angularity: angular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: ~15% vesicularity, filled with Mn 6. Phenocrysts: fsp, <1cm, white yellowish, completely altered 7. Matrix: fine grained, mainly altered 8. secondary Minerals: cc in veins, Mn 9. Encrustations: Mn crust <5mm 10. Comment: only rock of this lithology, in-situ ?	x						
MSM19-3 DR38-21	1. Rock Type: breccia fragment with basalt clasts, moderately altered 2. Size: 11x11x15 3. Shape / Angularity: rounded with subrounded clasts 4. Color of cut surface: grey and brown 5. Texture / Vesicularity: clasts up to 2.5cm, no vesicles 8. secondary Minerals: veins filled with cc, Mn, and clay minerals 9. Encrustations: ~1mm Mn crust 10. Comment: clasts are similar to DR38-1, freshest and biggest breccia of this dredge	x						






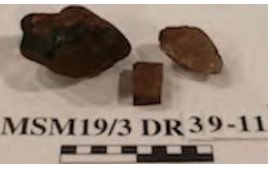

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR38-22	1. Rock Type: metamorphic (gneiss) 2. Size: 13x8x8 3. Shape / Angularity: angular 4. Color of cut surface: white and grey 5. Texture / Vesicularity: s-texture, layering of dark and light minerals 6. Phenocrysts: qrz, fsp, biotite, muscovite (?) 10. Comment: dropstone ?							



MSM19-3 DR39
Description of Location and Structure: smnt at the NE end of Meteor Rise, upper flank at the northern side of smnt
Dredge on bottom UTC 12/12/11 17:26hrs, lat 44°21.62'S, long 04°59.23'E, depth 2461m
Dredge off bottom UTC 12/12/11 18:47hrs, lat 44°22.01'S, long 04°59.34'E, depth 1943m
total volume: few rocks
Comments: 3 pieces of ol-phyric basalt, yellowish rounded clasts of clastic rock sediment?, Mn crust, MSM station no: 1110

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR39-1	1. Rock Type: volcanic, slightly altered 2. Size: 22x17x10 3. Shape / Angularity: angular 4. Color of cut surface: grey-black (dry) 5. Texture / Vesicularity: porphyric, <1% vesicles (mostly unfilled) 6. Phenocrysts: ol, mostly altered, ~7%, submm - mm 7. Matrix: microcrystalline, fsp, cpx 8. secondary Minerals: iddingsite 9. Encrustations: Mn coating 10. Comment: ol in nearly all sampls, freshes and biggest piece of this dredge	x	x	2 gm-fsp				
MSM19-3 DR39-2	1. Rock Type: volcanic, slightly altered 2. Size: 19x5x4 3. - 10. Comment: similar to DR39-1, but ol-phenos smaller (<1mm) no gc cut because of shape of sample	x		2 gm-fsp				
MSM19-3 DR39-3	1. Rock Type: volcanic, slightly altered 2. Size: 9x6x4 3. - 10. Comment: similar to DR39-1, but more cracks	x		2 gm-fsp				
MSM19-3 DR39-4	1. Rock Type: volcanic, slightly medium altered 2. Size: 28x23x15 3. Shape / Angularity: angular 4. Color of cut surface: grey (dark - dry) 5. Texture / Vesicularity: porphyric, vesicles 7-15%, mostly filled (0.1 -1 cm) 6. Phenocrysts: ol and fsp, altered -> mostly accumulated in center of sample, cpx, submm - mm 7. Matrix: microcrystalline, gm-fsp & cpx 8. secondary Minerals: iddingsite, vesicles filled with cc, clay minerals, zeolithes,... 9. Encrustations: Mn coating 10. Comment: bigger block, rest as backup in archive, carefully picking for gc required	x	x	1				
MSM19-3 DR39-5	1. Rock Type: volcanic, altered 2. Size: 10x8x6 3. Shape / Angularity: subrounded 4. Color of cut surface: light grey - light brown (dry) 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: Iddingsite ~15%, mm; cpx 5%, mm (biggest pieces 5mm), altered 7. Matrix: microcrystalline, gm-fsp & cpx 8. secondary Minerals: Iddingsite and altered cpx 9. Encrustations: partly Mn coating 10. Comment: matrix similar to DR13-1 - 3, but more altered, plus phenos are bigger and more altered	x		3 gm-fsp				




Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR39-6	1. Rock Type: volcanic, altered 2. Size: 15x14x4 3. Shape / Angularity: subrounded - rounded 4. Color of cut surface: light grey - light brown (dry) 5. Texture / Vesicularity: porphyric, 5-7% vesicles mostly unfilled, submm - mm 6. Phenocrysts: fsp ~5mm, very altered 7. Matrix: microcrystalline, gm-fsp & cpx 8. secondary Minerals: altered fsp 9. Encrustations: partly mm-thick Mn crust 10. Comment: similar to DR39-1, but bigger fsp and more altered, age dating possible ?	x		5				
MSM19-3 DR39-7	1. Rock Type: sedimentary, slightly altered 2. Size: 14x13x12 3. Shape / Angularity: rounded 4. Color of cut surface: brown-yellow (dry) 10. Comment: components submm-mm, qrz, filled cracks (Mn), dropstone (?)	x						
MSM19-3 DR39-8	1. Rock Type: sedimentary, altered 2. Size: 13x8x7 3. Shape / Angularity: rounded 4. Color of cut surface: light - dark brown 10. Comment: similar to DR39-7, but with layering, stronger alteration and more cracks	x						
MSM19-3 DR39-9	1. Rock Type: sedimentary, altered 2. Size: 13x9x7 10. Comment: similar to DR39-8							
MSM19-3 DR39-10	1. Rock Type: sedimentary, altered 2. Size: 12x8x3 10. Comment: similar to DR39-8							
MSM19-3 DR39-11	1. Rock Type: volcanic, very altered 2. Size: 9x7x3 3. Shape / Angularity: rounded 4. Color of cut surface: grey (light) to light brown (dry) 5. Texture / Vesicularity: porphyric, vesicles 20 - 25%, partly filled, mm 6. Phenocrysts: cpx 5-7%, submm; fsp 5-7%, submm 7. Matrix: microcrystalline 8. secondary Minerals: altered fsp, Fe-oxides 9. Encrustations: mm-thick Mn crust 10. Comment: red alteration around minerals and vesicles, looks like network -> fluids ?	x		5				
MSM19-3 DR39-12	1. Rock Type: volcanic, very altered 2. Size: 15x13x7 3. Shape / Angularity: angular - subrounded 4. Color of cut surface: red-brown (wet) 5. Texture / Vesicularity: porphyric, vesicles 10-15%, mm-cm 6. Phenocrysts: fsp, submm, needles; cpx >25%, slightly altered 7. Matrix: microcrystalline with fsp & cpx 8. secondary Minerals: sec. minerals in vesicles 9. Encrustations: partly Mn crust mm - 1.5cm							

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR39-13-M	1. Rock Type: volcanic, altered 2. Size: 19x15x9 3. - 10. Comment: similar to DR39-12 but covered with thick Mn crust -> 5-8cm							
MSM19-3 DR39-14-M	1. Rock Type: volcanic, altered 2. Size: 12x10x4 3. - 10. Comment: similar to DR39-12 but covered with thick Mn crust -> 1-3cm (more crust than rock)							
MSM19-3 DR39-15-X	1. Rock Type: volcanic, altered							




MSM19-3 DR40
Description of Location and Structure: Meteor Rise, NW-SE striking plateau edge, N-facing slope, middle section
Dredge on bottom UTC 13/12/11 01:35hrs, lat 45°03.87'S, long 04°47.96'E, depth 3253m
Dredge off bottom UTC 13/12/11 03:10hrs, lat 45°04.39'S, long 04°47.99'E, depth 2717m
total volume: 1/3 full
Comments: MSM station no: 1111

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR40-1	1. Rock Type: volcanic, pillow fragment, medium to strongly altered 2. Size: 17x9x8 3. Shape / Angularity: angular 4. Color of cut surface: light grey with green (dry) 5. Texture / Vesicularity: aphyric, 30% vesicles partly filled 6. Phenocrysts: ol, altered, 7%, mm - 0.5cm 7. Matrix: microcrystalline with submm fsp 8. secondary Minerals: cc, clay and other sec. minerals in vesicles 9. Encrustations: thin Mn coating 10. Comment: high vesicular pillow fragment, main lithology of this dredge, this sample appears as the freshest	x	x	2-3 gm-fsp				
MSM19-3 DR40-2	1. Rock Type: volcanic, pillow fragment, medium to strongly altered 2. Size: 14x8x6 3. Shape / Angularity: angular 4. Color of cut surface: light grey with brown (dry) 5. 9. similar to DR40-1 10. Comment: more altered and more vesicles are filled	x		2-3 gm-fsp				
MSM19-3 DR40-3	1. Rock Type: volcanic, pillow fragment, medium to strongly altered 2. Size: 23x18x17 3. Shape / Angularity: angular 4. Color of cut surface: red brown(dry) 5. Texture / Vesicularity: aphyric, 50% vesicles 7. Matrix: microcrystalline, very altered 9. Encrustations: Mn coating partly thick Mn crust of 0.5cm 10. Comment: bigger block of pillow fragment similar to DR40-1 but highly altered and higher vesicularity	x	x					

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR40-4	1. Rock Type: volcanic, pillow fragment, strongly altered 2. Size: 17x13x10 3. - 10. Comment: similar to DR40-1 but more altered	x						
MSM19-3 DR40-5	1. Rock Type: volcanic, pillow fragment, strongly altered 2. Size: 23x21x20 3. - 10. Comment: similar to DR40-1 but more altered	x						
MSM19-3 DR40-6	1. Rock Type: volcanic, pillow fragment, fresh 2. Size: 14x8x8 3. Shape / Angularity: angular 4. Color of cut surface: light - dark grey (dry) 5. Texture / Vesicularity: aphyric 6. Phenocrysts: fsp ~5mm, very altered 7. Matrix: micro- cryptocrystalline, gm-fsp & cpx 9. Encrustations: Mn coating 10. Comment: very fresh pillow -> unusual compared to other samples -> might be dropstone	x						
MSM19-3 DR40-7-M	1. Rock Type: Mn crust with very altered breccia 2. Size: 14x10x7 3. Shape / Angularity: rounded 4. Color of cut surface: greenish-yellow (breccia) black (Mn) 10. Comment: very altered breccia, green mineral very present, might be sec. Mineral -> partly as vesical filling in highly altered clasts							
MSM19-3 DR40-8-M	1. Rock Type: Mn crust 2. Size: 19x10x9 3. Shape / Angularity: rounded 4. Color of cut surface: black							
MSM19-3 DR40-9-M	1. Rock Type: Mn crust 2. Size: 30x24x20 3. Shape / Angularity: rounded 4. Color of cut surface: black 10. Comment: huge block -> representative amount of material was collected							
MSM19-3 DR40-10-VC	1. Rock Type: volcanoclastica, highly altered 2. Size: 23x16x15 3. Shape / Angularity: rounded 10. Comment: clasts seem to be same lithology and alteration grade as DR40-1, clay mineras as alteration product already inside of rock, matrix between clasts highly altered, Mn inside and outside of rock							

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR40-11	1. Rock Type: volcanic <-> metamorphic, fairly fresh 2. Size: 21x20x7 3. Shape / Angularity: angular - platy 4. Color of cut surface: light grey with black (dry) 5. Texture / Vesicularity: porphyric 6. Phenocrysts: cpx 3%, fresh, mm - 0.5cm 7. Matrix: crypto - microcrystalline 9. Encrustations: thin Mn coating 10. Comment: similar to DR40-6 but looks like shist. contains fissures that are filled with sec. minerals (reddish-orange and whitish)	x						
MSM19-3 DR40-12	1. Rock Type: metamorphic, fresh 2. Size: 45x25x16 3. Shape / Angularity: angular - platy 4. Color of cut surface: dark grey with white 10. Comment: metamorphic overprinted basalt (?), shist-like layering	x						
MSM19-3 DR40-13-X	1. Rock Type: volcanic, pillow fragments, altered 10. Comment: archive samples, 4 small pieces of high vesicular pillow fragment, similar to DR40-1							

MSM19-3 DR41




Description of Location and Structure: Meteor Rise, southernmost smnt of the cruise, upper flank at northern side of smnt

Dredge on bottom UTC 13/12/11 08:56hrs, lat 45°28.16'S, long 04°58.64'E, depth 2559m


Dredge off bottom UTC 13/12/11 10:11hrs, lat 45°28.63'S, long 04°58.70'E, depth 2244m

total volume: few rocks






Comments: metamorphic rocks and Mn crusts, MSM station no: 1112

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR41-1	1. Rock Type: metamorphic rock, slightly altered 2. Size: 22x15x13 3. Shape / Angularity: angular 4. Color of cut surface: greyish red, white, partly striped 5. Texture / Vesicularity: non vesicular, migmatitic 6. Phenocrysts: porphyroblasten: garnet 20%, >5mm, qz 15-20%, fsp (?) 20-30% micas (biotite) 5-10% 8. secondary Minerals: clay minerals in fractures 10. Comment: most representative sample of this dredge	x		2				
MSM19-3 DR41-2	1. Rock Type: metamorphic rock, moderately altered 2. Size: 42x18x17 3. Shape / Angularity: subangular to angular 4. Color of cut surface: grey 5. Texture / Vesicularity: fine grained, micas are orientated, especially in some parts 6. Phenocrysts: biotite + muscovite 60%, garnet <5%, fsp 20%, qz <10%, amph or px (?) 8. secondary Minerals: clay minerals in fractures, altered rim with clay minerals 9. Encrustations: <2mm Mn crust 10. Comment: metapelite -> dropstone ?	x		2-3				
MSM19-3 DR41-3-M	1. Rock Type: Mn crust plus pieces of volcanic rocks -> breccia like 2. Size: 19x18x11 4. Color of cut surface: black							








Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR41-4-M	1. Rock Type: Mn crust 2. Size: 29x23x12 4. Color of cut surface: black							




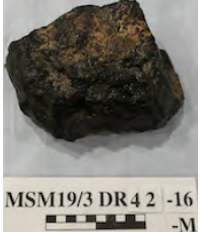
MSM19-3 DR42
Description of Location and Structure: Meteor Rise, southernmost smnt of the cruise, NE flank of smnt, NE of DR41
Dredge on bottom UTC 13/12/11 12:21hrs, lat 45°27.06'S, long 05°04.94'E, depth 3276m
Dredge off bottom UTC 13/12/11 13:43hrs, lat 45°27.59'S, long 05°05.07'E, depth 2920m
total volume: 1/4 full
Comments: volcanic rocks, volcanoclastica, metamorphic rocks, sedimentary rocks, Mn crusts, intrusive rocks, highly heterogenic lithologies, no major lithology; MSM station no: 1113

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR42-1	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 20x19x10 3. Shape / Angularity: subangular 4. Color of cut surface: dark brown - dark grey 5. Texture / Vesicularity: porphyric, 50% vesicles, partly filled, 1-10mm 6. Phenocrysts: ol, strongly altered, ~1%, cpx 5-10%, 3-10mm, altered; fsp 5-10%, 3-10mm, altered 7. Matrix: microcrystalline 8. secondary Minerals: zeolithes in vesicles, iddingsite, clay minerals 9. Encrustations: in some parts rest of volcanoclastic breccia 10. Comment: in-situ ?	x	x	4				
MSM19-3 DR42-2	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 34x23x20 3. Shape / Angularity: subangular 4. Color of cut surface: dark brown - dark grey, white in some parts with filled vesicles 5. Texture / Vesicularity: porphyric, 50% vesicles, partly filled, 0.5-2mm 6. Phenocrysts: cpx 5-10%, 3-10mm, altered; fsp 5-10%, 0.5-1.5cm, tablet, relatively dark, altered 7. Matrix: microcrystalline 8. secondary Minerals: cc in vesicles, clay minerals 9. Encrustations: Mn crust <3mm 10. Comment: similar to DR42-1, but vesicles are much smaller, requires carefully nicking for cc. additional material as DR42-2-X in archive	x	x	4				
MSM19-3 DR42-3	1. Rock Type: most likely volcanic rock, relatively fresh 2. Size: 20x12x12 3. Shape / Angularity: very angular 4. Color of cut surface: dark grey 5. Texture / Vesicularity: aphyric, <3% vesicles, unfilled, <0.5mm 7. Matrix: microcrystalline, dense, fsp in gm 9. Encrustations: Mn crust <1mm	x	x	3-4 gm-fsp				
MSM19-3 DR42-4	1. Rock Type: volcanoclastic breccia, strongly altered 2. Size: 11x9x8, clasts up to 3cm 3. Shape / Angularity: subangular, angular clasts 4. Color of cut surface: brownish grey - orange clasts 5. Texture / Vesicularity: up to 40% vesicles, partly filled 6. Phenocrysts: some clasts contain fsp <0.8cm, altered 7. Matrix: fine grained 8. secondary Minerals: zeolithes, clay minerals 9. Encrustations: Mn crust <2mm 10. Comment: clasts seem to be of same lithology as DR42-1, most of them are completely altered, but some fresher ones could be worth picking			3-4				
MSM19-3 DR42-5	1. Rock Type: intrusive rock, moderately altered 2. Size: 16x11x7 3. Shape / Angularity: angular 4. Color of cut surface: greenish-grey with many pink minerals 5. Texture / Vesicularity: crystalline, coarse grained 6. Phenocrysts: px <1.2cm, 10-20%; fsp 20-35%, <3mm; qrz 5-10%, <2mm; amph 5-10%, <6mm 8. secondary Minerals: cc and clay minerals in veins 10. Comment: dropstone ?	x						

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR42-6	1. Rock Type: intrusive rock, moderately altered 2. Size: 23x19x18 3. Shape / Angularity: rounded 4. Color of cut surface: green-light grey 5. Texture / Vesicularity: crystalline, coarse grained 6. Phenocrysts: fsp 40-50%; qrz 40%; micas 10-15%, greenish 8. secondary Minerals: greenish mica might be altered biotite -> clay minerals around mica 9. Encrustations: <1mm Mn crust 10. Comment: dropstone ?							
MSM19-3 DR42-7	1. Rock Type: intrusive rock, slightly altered 2. Size: 54x23x19 3. Shape / Angularity: subrounded 4. Color of cut surface: reddish, dark brown 5. Texture / Vesicularity: crystalline, medium grained 6. Phenocrysts: fsp 20-40%; micas 5-10%; px 30-35% (?) 10. Comment: dropstone ?							
MSM19-3 DR42-8	1. Rock Type: intrusive rock with low degree of metamorphic overprinting, slightly altered 2. Size: 12x8x4 3. Shape / Angularity: subangular 4. Color of cut surface: red and grey 5. Texture / Vesicularity: crystalline, coarse grained with oriented micas 6. Phenocrysts: fsp 20-35%, <1cm; qrz 40%, <1cm; micas 5%, <3mm 8. secondary Minerals: some fsp altered to clay minerals 10. Comment: dropstone ?	x						
MSM19-3 DR42-9	1. Rock Type: metamorphic rock, slightly altered 2. Size: 21x15x10 3. Shape / Angularity: rounded 4. Color of cut surface: white and dark grey 5. Texture / Vesicularity: s-texture, migmatitic gneis 6. Phenocrysts: porphyroblasten: px 20-30%, >5mm, qz 15-20%, fsp 15-20%; micas (biotite) 10-15% 10. Comment: dropstone	x						
MSM19-3 DR42-10	1. Rock Type: metamorphic rock, moderately altered 2. Size: 11x8x5 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: s-texture, migmatitic gneis 6. Phenocrysts: biotite <5%, garnet <5%, fsp 15-30%, qrz 30%, px ~5% 8. secondary Minerals: some fsp altered to clay minerals 10. Comment: dropstone ?	x						
MSM19-3 DR42-11	1. Rock Type: metamorphic rock, moderately altered 2. Size: 16x14x6 3. Shape / Angularity: very rounded 4. - 10. similar to DR42-10, but strongly layered and coarse grained -> migmatitic gneis, dropstone ?							
MSM19-3 DR42-12	1. Rock Type: most likely sedimentary rock 2. Size: 41x21x18 3. Shape / Angularity: subrounded, elongated 4. Color of cut surface: dark grey 5. Texture / Vesicularity: dense, very massive 7. Matrix: very fine grained 10. Comment: claystone? dropstone ?	x						

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR42-13	1. Rock Type: sedimentary rock 2. Size: 13x9x6 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: dense, very massive 7. Matrix: >70% qrz, fsp <20%, biotite <5% 10. Comment: dropstone or in-situ?	x						
MSM19-3 DR42-14	1. Rock Type: sedimentary rock 2. Size: 15x11x6 3. Shape / Angularity: rounded 4. Color of cut surface: light yellowish - greenish grey 5. Texture / Vesicularity: dense, mm-cm-thick layering of lighter and darker parts 7. Matrix: medium grained; qrz >90%, well rounded, ~1mm; some fsp 9. Encrustations: Mn crust <1mm 10. Comment: dropstone? sandstone	x						
MSM19-3 DR42-15-M	1. Rock Type: Mn crust 2. Size: 18x14x7 4. Color of cut surface: black							
MSM19-3 DR42-16-M	1. Rock Type: Mn crust 2. Size: 28x21x9 4. Color of cut surface: black							
MSM19-3 DR42-2-X	1. Rock Type: volcanic, pillow fragment 10. Comment: additional material from DR42-2 fro archive							no picture

MSM19-3 DR43


Description of Location and Structure: Meteor Rise, Northern en of Meteor Rise at intersection with Agulhas FZ, NE-facing slope above small valley cutting into plateau edge

Dredge on bottom UTC 13/12/11 23:53hrs, lat 44°36.32'S, long 03°50.89'E, depth 3222m

Dredge off bottom UTC 14/12/11 01:08hrs, lat 44°36.70'S, long 03°50.48'E, depth 2874m

total volume: 1/4 full




Comments: solidified sediments (mudstones) and plutonic dropstones; MSM station no: 1114

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR43-1-S	1. Rock Type: sediment, slightly altered 2. Size: 21x10x8 3. Shape / Angularity: angular 4. Color of cut surface: light grey 10. Comment: fine grained, sandy solidified mudstone with veins filled with cc, main lithology of this dredge	x						

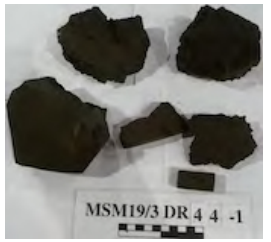


Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR43-2-S	1. Rock Type: sediment, slightly altered 2. Size: 20x11x9 3. Shape / Angularity: angular 4. Color of cut surface: light grey to brownish 10. Comment: similar to DR43-1-S, but more coarse grained and no veins	x						
MSM19-3 DR43-3-S	1. Rock Type: sediment, fairly fresh 2. Size: 20x16x9 3. Shape / Angularity: angular, platy 4. Color of cut surface: greenish grey 10. Comment: clayey mudstone with horizontally aligned clasts, clasts are <3mm reddish orange, needles to rounded	x						
MSM19-3 DR43-4-S	1. Rock Type: sediment, fairly fresh 2. Size: 20x15x8 3. Shape / Angularity: subangular 4. Color of cut surface: greenish orange 10. Comment: clayey mudstone similar to DR43-3, but contains green layers and individual crystals of green minerals, maybe glauconite and thin veins filled with cc	x						
MSM19-3 DR43-5-S	1. Rock Type: sediment, fairly fresh 2. Size: 13x8x8 3. Shape / Angularity: angular 4. Color of cut surface: greenish orange 10. Comment: clayey mudstone similar to DR43-4, but higher amount of green mineral	x						
MSM19-3 DR43-6-S	1. Rock Type: sediment, fairly fresh 2. Size: 10x10x6 3. Shape / Angularity: subangular 10. Comment: clayey mudstone similar to DR43-4, but higher amount of green mineral	x						
MSM19-3 DR43-7	1. Rock Type: intrusive rock, highly altered 2. Size: 12x9x8 3. Shape / Angularity: rounded 4. Color of cut surface: brownish orange 5. Texture / Vesicularity: phaneritic 10. Comment: highly altered plutonic rock, most likely a dropstone	x						
MSM19-3 DR43-8	1. Rock Type: breccia, moderately altered 2. Size: 8x6x5 3. Shape / Angularity: subrounded 4. Color of cut surface: brown with white and orange 10. Comment: clasts embedded in fine grained matrix, clasts mostly cc	x						



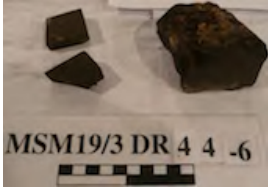


Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR43-9	1. Rock Type: breccia 2. Size: 10x8x5 3. - 10. similar to DR43-8							
MSM19-3 DR43-10	1. Rock Type: intrusive, fresh 2. Size: 25x22x10 3. Shape / Angularity: angular 4. Color of cut surface: dark grey with black 5. Texture / Vesicularity: phaneritic 6. Phenocrysts: fsp 20%, px ~7%, fresh, blocky 7. Matrix: gabbroic, coarse grained 10. Comment: very mafic plutonic rock with pegmatitic vein	x						
MSM19-3 DR43-11-S	1. Rock Type: sediment 2. Size: 13x12x10 4. - 10. similar to DR43-1, but has very nice hornish structures on one side							








MSM19-3 DR44
Description of Location and Structure: Discovery smnt chain, south, second eastern smnt, center of flank
Dredge on bottom UTC 14/12/11 16:01hrs, lat 43°11.51'S, long 01°23.77'E, depth 2616m
Dredge off bottom UTC 14/12/11 17:24hrs, lat 43°11.18'S, long 01°23.44'E, depth 2164m
total volume: few rocks
Comments: lava fragments and Mn crusts; MSM station no. 1115

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR44-1	1. Rock Type: volcanic, pillow fragment, fresh 2. Size: 36x27x22 3. Shape / Angularity: pillow shaped, angular 4. Color of cut surface: brownish 5. Texture / Vesicularity: aphyric, 10% vesicles, unfilled 6. Phenocrysts: cpx, ~2%, submm 7. Matrix: fine grained 9. Encrustations: Mn crust <2mm 10. Comment: huge block, representative amount of material was collected, rest as DR44-1-X in archive, pillow with breccia on top (clasts same material as pillow).	x	x					
MSM19-3 DR44-2	1. Rock Type: volcanic, lava fragment, fresh 2. Size: 12x10x8 3. Shape / Angularity: subangular 4. - 10. similar to DR44-1, but about 12% vesicularity, about 1% of cpx and Fe-oxides in some vesicles	x	x					
MSM19-3 DR44-3	1. Rock Type: volcanic, lava fragment, fresh 2. Size: 15x12x5 3. Shape / Angularity: angular 4. - 10. similar to DR44-1, but also zeolithes as sec. minerals	x						

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR44-4	1. Rock Type: volcanic, slightly altered 2. Size: 14x7x7 3. Shape / Angularity: subrounded 4. Color of cut surface: light grey to brownish 5. Texture / Vesicularity: porphyric, 1% vesicularity, partly filled 6. Phenocrysts: cpx ~20%, <1mm, fairly fresh 7. Matrix: fine grained, partly altered 8. secondary Minerals: zeolithes in vesicles 9. Encrustations: Mn coating 10. Comment: clasts (xenolithes) are incorporated	x	x					
MSM19-3 DR44-5	1. Rock Type: volcanic, slightly altered 2. Size: 14x11x7 3. Shape / Angularity: rounded 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: pophyric, 10% vesicularity 6. Phenocrysts: ol (?) ~2mm, cpx, submm 7. Matrix: fine grained 9. Encrustations: Mn crust <2mm 10. Comment: contains also clasts/xenolithes (~1cm ø), breccia-like structures on top of sample	x						
MSM19-3 DR44-6	1. Rock Type: volcanic, slightly altered 2. Size: 11x7x6 3. Shape / Angularity: subrounded 4. Color of cut surface: dark brow (wet) 5. Texture / Vesicularity: porphyric, 1% vesicularity, partly filled 6. Phenocrysts: cpx ~12%, submm, fairly fresh 7. Matrix: fine grained 8. secondary Minerals: sec. minerals along fissures 9. Encrustations: Mn coating 10. Comment: clasts (xenolithes) are incorporated, 0.5-1cm thick "contact zone" difficult to determine	x						
MSM19-3 DR44-7	1. Rock Type: volcanic, slightly altered 2. Size: 12x8x4 3. Shape / Angularity: subrounded 4. Color of cut surface: dark grey with brownish parts (wet) 5. Texture / Vesicularity: porphyric, 20% vesicularity in incorporated clasts 6. Phenocrysts: cpx ~10%, submm-mm, fairly fresh 7. Matrix: fine grained 8. secondary Minerals: sec. minerals along fissures 9. Encrustations: Mn coating 10. Comment: clasts (xenolithes) similar to those in sample DR44-5, but bigger in ø (~4cm)	x	x					
MSM19-3 DR44-8	1. Rock Type: volcanic, slightly altered 2. Size: 8x7x3 3. Shape / Angularity: angular 4. Color of cut surface: grey (wet) 5. Texture / Vesicularity: porphyric, 20% vesicularity 6. Phenocrysts: cpx 12%, submm 7. Matrix: fine grained 8. secondary Minerals: sec. minerals along fissures 9. Encrustations: Mn coating 10. Comment: contains xenolithes clasts up to 1cm. fissures outline shape of clasts and are filled with sec. minerals	x						
MSM19-3 DR44-9	1. Rock Type: volcanic, slightly altered 2. Size: 7x7x6 3. Shape / Angularity: angular 4. Color of cut surface: dark grey (wet) 5. Texture / Vesicularity: porphyric, 15% vesicularity 6. Phenocrysts: cpx 10%, submm - mm 7. Matrix: fine grained 8. secondary Minerals: sec. minerals along fissures, could be zeolithes 9. Encrustations: 1-2mm Mn crust 10. Comment: xenolith clasts of altered minerals	x						
MSM19-3 DR44-10	1. Rock Type: volcanic, moderately altered 2. Size: 22x18x8 3. Shape / Angularity: subrounded 4. Color of cut surface: light grey (dry) 5. Texture / Vesicularity: porphyric, 20% vesicularity 6. Phenocrysts: fsp 3%, altered, mm; cpx 2%, submm - mm 7. Matrix: fine grained 8. secondary Minerals: sec. minerals along fissures and cracks 9. Encrustations: Mn coating 10. Comment: xenolith clasts up to 1cm, ~1cm thick "contact zone" on one side of the rock	x	x					

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR44-11	1. Rock Type: volcanic, moderately altered 2. Size: 12x10x5 3. Shape / Angularity: subrounded 4. Color of cut surface: light grey (dry) 5. - 10. Comment: similar to DR44-10, but more altered and Fe-oxides and Mn crust as encrustations	x						
MSM19-3 DR44-12	1. Rock Type: volcanic, moderately altered 2. Size: 24x14x7 3. Shape / Angularity: angular 4. Color of cut surface: dark brown (wet) 5. Texture / Vesicularity: porphyric, 20% vesicularity 6. Phenocrysts: fsp 5%, altered, mm; ol 7%, strongly altered; cpx in clasts 7. Matrix: fine grained 9. Encrustations: Mn coating 10. Comment: large xenolith clasts 1-2cm, reddish	x	x					
MSM19-3 DR44-13	1. Rock Type: volcanic, moderately altered 2. Size: 16x9x3 3. Shape / Angularity: angular 4. Color of cut surface: brownish (wet) 5. Texture / Vesicularity: porphyric, 5% vesicularity, 1-10mm 6. Phenocrysts: fsp 3%, strongly altered; ol 12%, strongly altered; cpx 5%, strongly altered 7. Matrix: fine grained, altered 8. secondary Minerals: sec. minerals along fissures (no cc) 9. Encrustations: Mn coating	x						
MSM19-3 DR44-14	1. Rock Type: volcanic, altered 2. Size: 12x10x6 3. Shape / Angularity: subrounded 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, 15% vesicularity, <5mm 6. Phenocrysts: fsp 7%, strongly altered; cpx 5%, up to 5mm, elongated 7. Matrix: fine grained, altered 8. secondary Minerals: sec. minerals along fissures (no cc), fsp partly completely replaced by clay minerals 9. Encrustations: Mn coating and Fe-oxides	x	x					
MSM19-3 DR44-15	1. Rock Type: volcanic, altered 2. Size: 11x7x7 3. Shape / Angularity: subrounded 4. Color of cut surface: brownish grey 5. - 10. similar to DR44-14, but vesicularity 20%, larger vesicles, higher amount of clay minerals (10%), and Fe-oxides along fissures	x						
MSM19-3 DR44-16	1. Rock Type: volcanic, altered 2. Size: 8x7x5 3. Shape / Angularity: subrounded 4. Color of cut surface: brown (wet) 5. Texture / Vesicularity: porphyric, 20% vesicularity 6. Phenocrysts: fsp 2%, altered; cpx 5%, altered 7. Matrix: fine grained 8. secondary Minerals: cc in vesicles 9. Encrustations: 1-3mm Mn crust and Fe-oxides	x						
MSM19-3 DR44-17	1. Rock Type: volcanic, altered 2. Size: 11x7x7 3. Shape / Angularity: subangular 4. Color of cut surface: brownish olive (wet) 5. Texture / Vesicularity: porphyric, 20% vesicularity, partly filled 6. Phenocrysts: fsp 7%, strongly altered; cpx 5%, altered 7. Matrix: fine grained 8. secondary Minerals: sec. minerals (maybe zeolithe) in vesicles 9. Encrustations: 1-2cm Mn crust and Fe-oxides 10. Comment: thick Mn crust and "contact zone" of 2-4cm	x						

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR44-18-M	1. Rock Type: Mn crust, 3 pieces 2. Size: 13x9x5; 10x7x5; 6x6x6 3. Shape / Angularity: subrounded to rounded 4. Color of cut surface: black							
MSM19-3 DR44-19	1. Rock Type: solidified sediment (?) difficult to determine 2. Size: 9x7x3 3. Shape / Angularity: subangular 4. Color of cut surface: greenish 5. Texture / Vesicularity: up to 40% vesicles, partly filled 10. Comment: contains clasts embedded in matrix that is difficult to determine, maybe solidified mud	x						
MSM19-3 DR44-20	1. Rock Type: volcanic, palagonized glass crust with lava fragments 2. Size: 18x14x12 3. Shape / Angularity: angular 4. Color of cut surface: reddish brown with blocky parts 5. Texture / Vesicularity: porphyric, 25% vesicularity 6. Phenocrysts: ol 15-20%, strongly altered; cpx 7%, altered 7. Matrix: fine grained 8. secondary Minerals: iddingsite, palagonite, sec. minerals in veins 9. Encrustations: Mn crust with Fe-oxides 10. Comment: palagonitic parts need to be crushed might contain fresh glass	x						
MSM19-3 DR44-1-X	1. Rock Type: volcanic, pillow fragment 10. Comment: additional material from sample DR44-1							

MSM19-3 DR45

Description of Location and Structure: Discovery Smnts, smnt in-between northern and southern smnt chain, E-flank along NE-facing ridge

Dredge on bottom UTC 14/12/11 23:21hrs, lat 42°51.73'S, long 00°34.91'E, depth 2350m




Dredge off bottom UTC 15/12/11 00:40hrs, lat 42°51.99'S, long 00°34.41'E, depth 1889m

total volume: few rocks




Comments: Mn encrusted basalt fragments, volcanoclastites and Mn crust; one coral; MSM station no: 1116

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR45-1	1. Rock Type: volcanic, lava fragment, slightly altered 2. Size: 20x17x8 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey brownish (wet) 5. Texture / Vesicularity: porphyric, 15% vesicles, partly filled 6. Phenocrysts: fsp 7%, mm-cm, cpx, 1%, submm-mm, blocky, fresh 7. Matrix: microcrystalline, partly altered 8. secondary Minerals: cc in some vesicles and veins + clay minerals as vesical filling 9. Encrustations: Mn crust 3cm 10. Comment: freshest piece of this dredge, contains minerals that might be fsp but appear pretty dark and show dissolution features (hopper crystals)	x	x					
MSM19-3 DR45-2	1. Rock Type: volcanic, lava fragment, fresh - slightly altered 2. Size: 6x6x3 3. Shape / Angularity: angular 4. Color of cut surface: dark grey black (wet) 5. Texture / Vesicularity: porphyric, 20% vesicles, mostly unfilled 6. Phenocrysts: fsp 3%, mm-cm; cpx, 2 generations -> smaller ones: 1%, bigger ones: 3% 7. Matrix: microcrystalline, dense, gm-fsp 9. Encrustations: Mn coating 10. Comment: similar to DR45-1, because of size no gc was cut	x						

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTE S	PICTURE
MSM19-3 DR45-3	1. Rock Type: volcanic, pillow fragment, moderate to strongly altered 2. Size: 37x24x15 3. Shape / Angularity: subangular 4. Color of cut surface: brown orange - grey 5. Texture / Vesicularity: porphyric, 20% vesicles, mostly filled 6. Phenocrysts: fsp <1%, submm -mm, cpx, 3%, mm-0.5cm, blocky, fresh 7. Matrix: microcrystalline, partly altered 8. secondary Minerals: Fe-oxides, veins filled with sec. minerals, Mn 9. Encrustations: Mn crust 4cm 10. Comment: pillow with thick Mn crust - representative amount of material was collected, size with Mn crust determined and then chipped of	x						
MSM19-3 DR45-4-VC	1. Rock Type: volcanoclastic, altered 2. Size: 20x28x20 3. Shape / Angularity: rounded 4. Color of cut surface: grey orange yellow 9. Encrustations: Mn crust 6-8cm 10. Comment: basaltic clasts embedded in finegrained matrix, clasts: 0.5-3cm, grey-greenish orange, fresh-altered, appear similar to DR45-1, DR45-2, DR45-3	x						
MSM19-3 DR45-5-M	1. Rock Type: Mn crust 2. Size: 21x11x10 3. Shape / Angularity: rounded 4. Color of cut surface: black 10. Comment: submm layering visible							





MSM19-3 DR46
Description of Location and Structure: Discovery Smnts south, 2nd smnt from SW-direction, upper part of eastern flank
Dredge on bottom UTC 15/12/11 12:40hrs, lat 43°32.41'S, long 01°02.81'W, depth 1460m
Dredge off bottom UTC 15/12/11 14:30hrs, lat 43°32.47'S, long 01°03.33'W, depth 1057m
total volume: few rocks
Comments: lava fragments and volcanoclastica; MSM station no: 1117

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTE S	PICTURE
MSM19-3 DR46-1	1. Rock Type: volcanic but contains some highly vesicular clasts, slightly altered 2. Size: 28x17x16 3. Shape / Angularity: angular 4. Color of cut surface: grey brownish 5. Texture / Vesicularity: porphyric, <3% vesicles 6. Phenocrysts: fsp 5%, 1-5mm, idiomorphic, laths and tabular, altered, ol, <3%, 1-5mm, completely altered 7. Matrix: irregular texture, fine grained, fsp, ol and cpx in gm 8. secondary Minerals: iddingsite, clay minerals 9. Encrustations: ~5cm rim of breccia on one side, covered by ~1.5cm thick Mn crust 10. Comment: most likely lava, but contains xenolithic clasts (brown + highly vesicular), similar to DR46-12; requires carefully separation for geochemical analyses	x	x	3-4 gm-fsp				
MSM19-3 DR46-2	1. Rock Type: volcanic, slightly altered 2. Size: 9x7x5 3. Shape / Angularity: rounded 4. - 10. similar to DR46-1, but ~1cm of breccia-like rim covered by 1cm Mn	x		3-4 gm-fsp				
MSM19-3 DR46-3	1. Rock Type: volcanic, strongly altered 2. Size: 22x21x10 3. Shape / Angularity: subrounded 4. Color of cut surface: brown black 5. Texture / Vesicularity: porphyric, 15% vesicles, 0.1-3mm, partly rounded, partly elongated, unequally distributed, flowing structure 6. Phenocrysts: fsp <5%, 1mm-2cm, strongly altered; ol <3%, 1-5mm, completely altered 7. Matrix: microcrystalline, in some parts black and fresher in other parts brown and strongly altered, gm-fsp 8. secondary Minerals: iddingsite and Fe-oxides 9. Encrustations: Mn crust <1cm 10. Comment: lava or ignimbrite. In case of lava -> big evidence for magmamixing and mingling	x	x	4-5 gm-fsp				

Appendix I (Rock Description)


SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR46-4	1. Rock Type: volcanic, moderately altered 2. Size: 13x8x7 3. Shape / Angularity: subangular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: porphyric, <5% vesicles, <5mm, filled 6. Phenocrysts: fsp <5%, <7mm, altered; ol 1%, completely altered 7. Matrix: fine grained, gm-fsp, cpx and ol 8. secondary Minerals: sec. minerals in vesicles, iddingsite, small veins filled with cc and clay minerals 9. Encrustations: Mn crust ~3mm 10. Comment: lava or ignimbrite	x	x	3 gm-fsp				
MSM19-3 DR46-5	1. Rock Type: volcanic, moderately altered 2. Size: 8x7x4 3. Shape / Angularity: subangular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: porphyric, ~5% vesicles, up to 3mm, mostly unfilled 6. Phenocrysts: fsp <5%, <7mm, strongly altered; ol ~1%, completely altered, <1mm; cpx <5%, strongly altered, <5mm 7. Matrix: fine grained, gm-fsp, cpx and ol 8. secondary Minerals: iddingsite, small veins filled with cc and clay minerals 10. Comment: possibly lava fragment, similar to DR46-3	x	x	3 gm-fsp				
MSM19-3 DR46-6	1. Rock Type: volcanic, moderately altered 2. Size: 13x8x7 3. Shape / Angularity: subangular 4. Color of cut surface: brown and grey 5. Texture / Vesicularity: porphyric, <5% vesicles, <5mm 6. Phenocrysts: fsp <5%, <3mm, strongly altered; ol 1%, completely altered, <1.5mm; cpx <5%, strongly altered, <4mm 7. Matrix: fine grained, gm-fsp 8. secondary Minerals: iddingsite, small veins filled with cc and clay minerals 9. Encrustations: Mn crust <1mm 10. Comment: grey and brown parts in matrix may indicate magma mingling, or could be just alteration	x	x	3-4 gm-fsp				
MSM19-3 DR46-7	1. Rock Type: volcanic, moderately altered 2. Size: 14x13x6 3. Shape / Angularity: angular 4. Color of cut surface: brown and grey 5. Texture / Vesicularity: porphyric, <5% vesicles, <2mm, mostly unfilled 6. Phenocrysts: fsp ~5%, <12mm, very altered; ol ~1%, completely altered, <2mm 7. Matrix: fine grained, gm-fsp 8. secondary Minerals: iddingsite, small veins filled with cc and clay minerals 9. Encrustations: Mn crust <3mm 10. Comment: might represent lava mingling or different alteration grades in different parts of rock	x	x					
MSM19-3 DR46-8	1. Rock Type: volcanic, moderately altered 2. Size: 9x6x3 3. Shape / Angularity: angular 4. Color of cut surface: brown and grey 5. Texture / Vesicularity: porphyric, 5% vesicles, <2mm, mostly unfilled 6. Phenocrysts: fsp <5%, <2mm, very altered 7. Matrix: fine grained, gm-fsp and ol, completely altered 8. secondary Minerals: clay minerals 10. Comment: there are two clasts in matrix, grey part is more abundant, brownish part most likely more altered, TS broken because of fractures	x	x					
MSM19-3 DR46-9	1. Rock Type: volcanic, big clasts from Breccia, strongly altered 2. Size: Breccia - 18x20x14; clast - 8x6x5 3. Shape / Angularity: rounded 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, <5% vesicles, <1mm 6. Phenocrysts: fsp ~5-10%, <15mm, very altered; ol 1-2%, completely altered, <2mm 7. Matrix: fine grained, gm-fsp + ol 8. secondary Minerals: iddingsite, vesicles filled with clay minerals 9. Encrustations: Breccia with Mn crust ~3cm 10. Comment: there are some parts in the texture with fluid texture, dark grey with higher vesicularity -> might represent two different magmas => magma mingling	x	x					
MSM19-3 DR46-10	1. Rock Type: volcanic, clast from Breccia, strongly altered 2. Size: Breccia - 7x5x5; clast - 5x5x2 3. Shape / Angularity: subangular 4. - 10. similar to DR46-9							

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR46-11	1. Rock Type: volcanic, strongly altered 2. Size: 31x22x11 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, flowing texture, <5% vesicles, <2mm, mostly unfilled 6. Phenocrysts: fsp ~5%, <10mm, very altered; ol ~1%, completely altered, <3mm 7. Matrix: fine grained, gm-fsp, partly altered 8. secondary Minerals: small veins filled with cc and clay minerals 9. Encrustations: Mn crust <15mm 10. Comment: similar to DR46-6, might represent lava mingling or different alteration grades in different parts of rock	x		4-5 gm-fsp				
MSM19-3 DR46-12	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 11x8x6 3. Shape / Angularity: subrounded 4. Color of cut surface: brown 5. Texture / Vesicularity: aphyric, 40% vesicles, up to 5mm, some are rounded, some elongated, unequal distributed, mostly unfilled 7. Matrix: microcrystalline, completely altered 8. secondary Minerals: cc and clay minerals 9. Encrustations: Mn crust <5mm 10. Comment: similar to DR46-6, might represent lava mingling or different alteration grades in different parts of rock	x	x					
MSM19-3 DR46-13	1. Rock Type: volcanic, fragments of breccia with clasts of same lithology as DR46-12 2. Size: breccia - 9x6x5; clast - 5.5x3x2 3. Shape / Angularity: subangular 4. - 10. similar to DR46-12	x						
MSM19-3 DR46-14	1. Rock Type: volcanoclastic breccia with strongly altered volcanic clasts 2. Size: 13x8x8 3. Shape / Angularity: angular 4. - 10. similar to DR46-12, but Mn crust <1cm	x						

MSM19-3 DR47
Description of Location and Structure: Discovery Smnts @ SW end of southern chain beneath plateau edge at SE corner of smnt
Dredge on bottom UTC 15/12/11 20:37hrs, lat 43°58.24'S, long 01°27.23'W, depth 1479m
Dredge off bottom UTC 15/12/11 21:52hrs, lat 43°57.93'S, long 01°27.59'W, depth 1100m
total volume:
Comments: lost dredge; MSM station no: 1118








MSM19-3 DR48
Description of Location and Structure: Discovery Smnts north, southern most of the western seamounts, south-western flank
Dredge on bottom UTC 16/12/11 10:35hrs, lat 43°27.10'S, long 02°32.42'W, depth 3371m
Dredge off bottom UTC 16/12/11 11:59hrs, lat 43°26.88'S, long 02°32.97'W, depth 2939m
total volume: 1 piece
Comments: Mn crust; MSM station no: 1119

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR48-1-M	1. Rock Type: Mn crust 2. Size: 9x9x4 3. Shape / Angularity: subrounded 4. Color of cut surface: black							



Appendix I (Rock Description)

MSM19-3 DR49								
Description of Location and Structure: Discovery Smnts north, southern most of the western seamounts, south-western flank, ~5nm of DR48								
Dredge on bottom UTC 16/12/11 14:03hrs, lat 43°22.20'S, long 02°34.52'W, depth 2517m								
Dredge off bottom UTC 16/12/11 15:29hrs, lat 43°22.52'S, long 02°34.95'W, depth 2160m								
total volume: few rocks								
Comments: lava fragments and Mn crust; MSM station no: 1120								
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Ar Grade	GL/MIN	SEDS	NOTES	PICTURE
MSM19-3 DR49-1	1. Rock Type: volcanic, slightly altered 2. Size: 21x18x13 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, <5% vesicles, <1mm, mostly unfilled 6. Phenocrysts: fsp ~5%, <6mm, very altered, ol, ~10%, <5mm, completely altered 7. Matrix: fine grained, fsp, ol and cpx (?) in gm 8. secondary Minerals: iddingsite, clay minerals 9. Encrustations: encrustation of breccia, ~3cm covered by Mn crust, ~2mm 10. Comment: most representative sample of this dredge. probably picrite -> breaks like pillow lava	x	x	3 gm fsp				
MSM19-3 DR49-2	1. Rock Type: volcanic, slightly altered 2. Size: 14x9x7 3. Shape / Angularity: subangular, columns like pillow lava 4. - 10. similar to DR49-1, but slightly more ol (15-20%)	x	x	3 gm fsp				
MSM19-3 DR49-3	1. Rock Type: volcanic, clasts of breccia, slightly altered 2. Size: breccia - 18x14x13; clast - 11x9x9 3. Shape / Angularity: angular 4. - 10. similar to DR49-1, other clasts of breccia as DR49-4 and DR49-3-X	x	x	3 gm fsp				
MSM19-3 DR49-4	1. Rock Type: volcanic, clasts of breccia, slightly altered 2. Size: breccia - 18x14x13; clast - 10x7x4 3. Shape / Angularity: angular 4. - 10. similar to DR49-1, other clasts of breccia as DR49-3 and DR49-3-X	x	x	3 gm fsp				
MSM19-3 DR49-5	1. Rock Type: volcanic, moderately altered 2. Size: 8x6x5 3. Shape / Angularity: angular 4. - 10. similar to DR49-1, but less ol (<3%)	x	x	3 gm fsp				
MSM19-3 DR49-6	1. Rock Type: volcanic, clasts of breccia, slightly altered 2. Size: breccia - 20x15x12; clast - 8x7x7 3. Shape / Angularity: angular 4. - 10. similar to DR49-1, other clasts of breccia as DR49-7 and DR49-6-X	x	x	3 gm fsp				
MSM19-3 DR49-7	1. Rock Type: volcanic, clasts of breccia, slightly altered 2. Size: breccia - 20x15x12; clast - 9x8x6 3. Shape / Angularity: subrounded 4. - 10. similar to DR49-1, other clasts of breccia as DR49-6 and DR49-6-X	x						



Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR49-8	1. Rock Type: volcanic, moderately altered 2. Size: 7x6x5 3. Shape / Angularity: angular 4. - 10. similar to DR49-1, but more altered	x						
MSM19-3 DR49-9	1. Rock Type: volcanic, fragment von volcanic breccia, clasts similar to DR49-1, slight to moderately altered 2. Size: Breccia - 12x10x6; clast <4cm 3. Shape / Angularity: angular 10. Comment: clasts seem to be same lithology as DR49-1, requires separation of individual clasts for geochemical analyses	x						
MSM19-3 DR49-10	1. Rock Type: volcanic, strongly altered 2. Size: 7x6x5 3. Shape / Angularity: rounded 4. - 10. similar to DR46-1, but contains more fsp (~10%), might be sufficient for age dating even though matrix is strongly altered	x		3 gm fsp				
MSM19-3 DR49-11	1. Rock Type: volcanic, strongly altered 2. Size: 9x7x7 3. Shape / Angularity: subangular 4. - 10. similar to DR46-1, but more altered, clasts up to 3cm							
MSM19-3 DR49-12-M	1. Rock Type: Mn crust 2. Size: 12x9x5 3. Shape / Angularity: subangular 4. Color of cut surface: black							
MSM19-3 DR49-13-M	1. Rock Type: Mn crust 2. Size: 13x10x4 3. Shape / Angularity: subangular 4. Color of cut surface: black							
MSM19-3 DR49-14-M	1. Rock Type: Mn crust 2. Size: 10x7x4 3. Shape / Angularity: subangular 4. Color of cut surface: black							


Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Ar Grade	GL/MIN	SED	NOTE S	PICTURE
MSM19-3 DR49-3-X	1. Rock Type: volcanic, fragments of breccia with clasts of same lithology as DR49-3 10. additional material for archive							
MSM19-3 DR49-6-X	1. Rock Type: volcanic, fragments of breccia with clasts of same lithology as DR49-6 10. additional material for archive							








MSM19-3 DR50
Description of Location and Structure: Discovery Smnts north, western end, E-facing slope beneath ridge
Dredge on bottom UTC 16/12/11 19:43hrs, lat 43°04.29'S, long 02°28.13'W, depth 2264m
Dredge off bottom UTC 16/12/11 21:02hrs, lat 43°04.08'S, long 02°28.69'W, depth 1834m
total volume: two small rocks
Comments: volcaniclastic and Mn crust, one coral (alive); MSM station no: 1121

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Ar Grade	GL/MIN	SED	NOTE S	PICTURE
MSM19-3 DR50-1-VC	1. Rock Type: volcaniclastite, altered 2. Size: 8.5x8x4.5 3. Shape / Angularity: subangular - rounded 4. Color of cut surface: clasts - grey, brown (dry); matrix - black, light brown 5. Texture / Vesicularity: clasts - aphyric, 20% vesicles, mostly filled 6. Phenocrysts: clasts - fsp <1%, fresh, needles; cpxl <1%, fresh, blocky 7. Matrix: clasts - microcrystalline, altered 8. secondary Minerals: clay minerals as vesicles filling and matrix, Mn 9. Encrustations: Mn crust 1cm 10. Comment: two generations of clasts 1) basalt/laval fragments 2) palagonite clasts, palagonite clasts contain sometimes relatively fresh glass cores -> polished thin sections of these parts recommended => might be sufficient for maior and trace elementanalyses with EPMA and LA-ICPMS	x						
MSM19-3 DR50-2-VC	1. Rock Type: volcaniclastite, highly altered 2. Size: 9x7x3 3. Shape / Angularity: subangular - rounded 4. Color of cut surface: matrix - grey with black; clasts - brown orange yellow 10. similar to DR50-1-VC, but more altered and thicker Mn crust, clasts are highly altered and palagonite mostly doesn't contain fresh glass, block for TS was cut, but might qualitatively not sufficient enough	x						






MSM19-3 DR51
Description of Location and Structure: Discovery Smnts north, central area, smnt E of big one, SE-facing slope beneath plateau edge, along ridge
Dredge on bottom UTC 17/12/11 03:41hrs, lat 42°40.66'S, long 01°25.55'W, depth 1441m
Dredge off bottom UTC 17/12/11 04:39hrs, lat 42°40.73'S, long 01°25.95'W, depth 1100m
total volume: 1/6 full, 1 large block
Comments: rounded basalt cobbles cemented with Mn, pillow fragments; MSM station no: 1122

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Air/Ar Grade	GL/MIN	SED	NOTE S	PICTURE
MSM19-3 DR51-1	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 49x43x30 3. Shape / Angularity: angular 4. Color of cut surface: brownish-grey 5. Texture / Vesicularity: aphyric, <3% vesicles, <0.5mm 7. Matrix: fine grained, fsp and ol in gm 8. secondary Minerals: palagonite, iddingsite, cc, zeolithes and clay minerals in veins 9. Encrustations: Mn crust, <2cm, encrusted by thick palagonite breccia 10. Comment: block of pillow inside of breccia, additional material as DR51-1-X in archive, palagonite breccia was also collected, might contain fresh glass -> as DR51-1-GL	x	x	3 gm fsp				

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR51-2	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 17x15x9 3. Shape / Angularity: subangular 4. - 10. similar to DR51-1, but slightly more unfilled vesicles (5%)	x	x	3 gm-fsp				
MSM19-3 DR51-3	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 14x11x6 3. Shape / Angularity: subangular 4. - 10. similar to DR51-1, but slightly more unfilled vesicles (5%)	x	x	3 gm-fsp				
MSM19-3 DR51-4	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 14x9x8 3. Shape / Angularity: subangular 4. - 10. similar to DR51-1	x	x	3 gm-fsp				
MSM19-3 DR51-5	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 11x11x8 3. Shape / Angularity: subangular 4. - 10. similar to DR51-1, but up to 2.5cm Mn crust	x	x	3 gm-fsp				
MSM19-3 DR51-6	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 13x10x5 3. Shape / Angularity: subangular 4. - 10. similar to DR51-1, but more altered and higher vesicularity (up to 1mm, partly filled with zeolithes and clay minerals)	x		3-4 gm-fsp				
MSM19-3 DR51-7	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 9x6x5 3. Shape / Angularity: subrounded 4. - 10. similar to DR51-1, but fine grained matrix	x		3-4 gm-fsp				
MSM19-3 DR51-8	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 11x6x5 3. Shape / Angularity: subrounded 4. - 10. similar to DR51-1	x		3 gm-fsp				

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR51-9	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 7x7x4 3. Shape / Angularity: subrounded 4. - 10. similar to DR51-1	x		3 gm-fsp				
MSM19-3 DR51-10	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 12x11x5 3. Shape / Angularity: subrounded 4. - 10. similar to DR51-1, but more altered	x		3-4 gm-fsp				
MSM19-3 DR51-11	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 9x8x5 3. Shape / Angularity: subrounded 4. - 10. similar to DR51-1, but more altered	x		3-4 gm-fsp				
MSM19-3 DR51-12	1. Rock Type: volcanic, fragment of volcanoclastic breccia 2. Size: 16x11x7 3. Shape / Angularity: subangular 4. Color of cut surface: brown 10. Comment: clasts are similar to DR51-1 plus palagonite							
MSM19-3 DR51-1-X	1. Rock Type: volcanic, lava fragments plus brecciated rim 10. Comment: additional material for archive from sample DR51-1							

MSM19-3 DR52


Description of Location and Structure: Discovery Smnts north, 2nd big smnt from E to W, SE flank, lower part

Dredge on bottom UTC 17/12/11 15:56hrs, lat 42°23.11'S, long 00°56.60'E, depth 2908m


Dredge off bottom UTC 17/12/11 17:10hrs, lat 42°23.22'S, long 00°56.10'E, depth 2514m

total volume: 2 big rocks


Comments: large pillow, Mn crust; MSM station no: 1123

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR52-1	1. Rock Type: volcanic, pillow fragment, moderate - strongly altered 2. Size: 43x24x19 3. Shape / Angularity: angular 4. Color of cut surface: brownish-grey 5. Texture / Vesicularity: porphyric, <1% vesicles, mostly unfilled 6. Phenocrysts: Ol 7%, highly altered, mm-0.5cm; cpx 3%, blocky, fresh, partly replaces Ol(?),mm; fsp <1%, fresh, submm-mm 7. Matrix: microcrystalline - fine grained, dense with fsp and cpx in gm 8. secondary Minerals: iddingsite replacing Ol, Mn along fissures and cracks 9. Encrustations: Mn crust <0.5cm 10. Comment: pillow fragment with high amount of altered Ol, huge block -> representative amount of material was collected. contains big fsp-xenos => more pieces (1-B, 1-C, 1-D) were cut for later fsp preparation for age dating piece 1-A - cut for TS and GC piece 1-B - cut for fsp preparation piece 1-c - cut for fsp preparation piece 1-D - cut for fsp preparation additional material as DR52-1-X in archive	x	x	1				








Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR52-2	1. Rock Type: intrusive, fresh 2. Size: 52x46x32 3. Shape / Angularity: subangular - rounded 4. Color of cut surface: light grey with black 5. Texture / Vesicularity: phaneritic 6. Phenocrysts: fsp and cpx 7. Matrix: crystalline, coarse grained 10. Comment: microgabbro -> most likely dropstone	x						
MSM19-3 DR52-3-M	1. Rock Type: Mn crust 2. Size: 16x10x6.5 3. Shape / Angularity: subrounded 4. Color of cut surface: black							
MSM19-3 DR52-4-M	1. Rock Type: Mn crust 2. Size: 13x12x7 3. Shape / Angularity: subrounded 4. Color of cut surface: black							
MSM19-3 DR52-5-M	1. Rock Type: Mn crust 2. Size: 14x12x8 3. Shape / Angularity: subrounded 4. Color of cut surface: black							
MSM19-3 DR52-1-X	1. Rock Type: volcanic, pillow fragments 10. Comment: additional material for archive from sample DR52-1							


MSM19-3 DR53
Description of Location and Structure: Discovery Smnts, small smnt in-between southern and northern smnt chain, E-facing slope
Dredge on bottom UTC 17/12/11 22:40hrs, lat 42°31.76'S, long 01°45.96'E, depth 2343m
Dredge off bottom UTC 18/12/11 00:03hrs, lat 42°31.95'S, long 01°45.34'E, depth 1947m
total volume: 1/5 full
Comments: pillow fragments and conglomeres with lava fragments, some Mn crusts; MSM station no: 1124

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR53-1-A	1. Rock Type: volcanic, pillow fragment from conglomerate, moderately altered 2. Size: not exactly determined, estimated values: 15x12x10 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, 5% vesicles, mostly unfilled 6. Phenocrysts: Ol 3%, moderate - highly altered, 2-5mm; cpx 2%, moderately altered, ~3mm; fsp 3%, moderately altered, ~2mm, elongated 7. Matrix: microcrystalline with fsp and cpx in gm 8. secondary Minerals: iddingsite replacing Ol, sec. minerals as coating in vesicles 9. Encrustations: Mn crust 3-4cm thick 10. Comment: pillow fragment from conglomerate, lithologies appear in all clasts similar, size of conglomerate block: 32x28x16, representative amount of material was collected => more pieces (1-B) as sample, additional material as DR53-1-X in archive	x	x	2 gm fsp				






Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR53-1-B	1. Rock Type: volcanic, pillow fragment from conglomerate, moderate - strongly altered 2. Size: 13x12x8 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, 7% vesicles, mostly unfilled 6. 10. similar to DR53-1-A, but OI up to 8mm; second piece of conglomerate block	x	x	2 gm-fsp				
MSM19-3 DR53-2	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 10x10x4 3. Shape / Angularity: subrounded 4. Color of cut surface: greenish-grey 5. 10. similar to DR53-1, but only Mn coating	x						
MSM19-3 DR53-3	1. Rock Type: volcanic, moderately altered 2. Size: 22x12x9 3. Shape / Angularity: angular 4. Color of cut surface: greenish-brown 5. Texture / Vesicularity: porphyric, 2% vesicles, mostly unfilled 6. Phenocrysts: OI completely altered, up to 3mm; cpx 12-15%, moderately to strongly altered, up to 5mm; fsp 10%, moderately to strongly altered, mm 7. Matrix: fine grained 8. secondary Minerals: iddingsite replacing OI, sec. minerals in cracks and fissures 9. Encrustations: Mn crust 3-4cm thick 10. Comment: very suitable for age dating	x	x	2				
MSM19-3 DR53-4	1. Rock Type: volcanic, moderately altered 2. Size: 13x10x7 3. Shape / Angularity: angular 4. Color of cut surface: olive-brown 5. Texture / Vesicularity: porphyric, <1% vesicles, mostly unfilled 6. Phenocrysts: OI completely altered, up to 3mm; cpx 12%, moderately altered, up to 7mm; fsp 7%, moderately altered, up to 5mm 7. Matrix: fine grained 8. secondary Minerals: iddingsite replacing OI 9. Encrustations: Mn crust 2cm 10. Comment: Mn crust chipped of on bord, suitable for age dating	x	x	2				
MSM19-3 DR53-5	1. Rock Type: volcanic, moderately altered 2. Size: 12x7x6 3. Shape / Angularity: angular 4. Color of cut surface: olive to grey 10. Comment: similar to DR53-4, but 2% vesicularity, 5% iddingsite, 3-5% cpx and 5-7% fsp, suitable for age dating	x	x	2				
MSM19-3 DR53-6-M	1. Rock Type: Mn crust 2. Size: 18x14x9 3. Shape / Angularity: subrounded 4. Color of cut surface: black 10. Comment: Mn crust with sediment core (clay)							
MSM19-3 DR53-7-M	1. Rock Type: Mn crust 2. Size: 16x13x5 3. Shape / Angularity: subrounded 4. Color of cut surface: black 10. Comment: nice submm-mm layering visible							








Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR53-1-X	1. Rock Type: volcanic, pillow fragments from conglomerat 2. Size: DR53-1-X_1 - 14x7x2 DR53-1-X_2 - 10x9x6 DR53-1-X_3 - 10x7x4 DR53-1-X_4 - 10x6x6 10. additional material for archive from sample DR53-1-A and DR53-1-B							




MSM19-3 DR54
Description of Location and Structure: Discovery Smnts, NE most smnt in-between southern and northern smnt chain, NE-facing slope
Dredge on bottom UTC 18/12/11 05:04hrs, lat 42°12.31'S, long 02°22.16'E, depth 1705m
Dredge off bottom UTC 18/12/11 06:46hrs, lat 42°12.41'S, long 02°22.12'E, depth 1454m
total volume: 1/5 full
Comments: strongly altered volcanic rocks plus corals; MSM station no: 1125

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR54-1	1. Rock Type: volcanic, strongly altered 2. Size: 24x19x17 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, <3% vesicles, mostly unfilled, <1mm 6. Phenocrysts: Ol ~10%, completely altered, <2.5mm; cpx <3%, altered, 1-2mm; fsp ~5%, slightly altered, 1-5mm 7. Matrix: microcrystalline with fsp and ol in gm 8. secondary Minerals: iddingsite replacing Ol, Mn and clay minerals 9. Encrustations: Mn crust ~1cm 10. Comment: representative sample for this dredge, strongly altered basalt, fsp could be fresh enough for age dating, additional material as DR54-1-X in archive	x	x	3-4 gm-fsp				
MSM19-3 DR54-2	1. Rock Type: volcanic, strongly altered 2. Size: 28x15x10 3. Shape / Angularity: angular 4. - 10. similar to DR54-1, but Mn crust <3mm, additional material as DR54-2-X in archive	x	x	3-4 gm-fsp				
MSM19-3 DR54-3	1. Rock Type: volcanic, strongly altered 2. Size: 33x20x15 3. Shape / Angularity: angular 4. - 10. similar to DR54-1, but Mn crust <2cm, additional material as DR54-3-X in archive	x	x	3-4 gm-fsp				
MSM19-3 DR54-4	1. Rock Type: volcanic, strongly altered 2. Size: 20x18x16 3. Shape / Angularity: angular 4. - 10. similar to DR54-1, but Mn crust <2cm, additional material as DR54-4-X in archive	x	x	3-4 gm-fsp				
MSM19-3 DR54-5	1. Rock Type: volcanic, strongly altered 2. Size: 15x11x11 3. Shape / Angularity: angular 4. - 10. similar to DR54-1, but Mn crust <3mm	x	x	3-4 gm-fsp				

Appendix I (Rock Description)


SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR54-6	1. Rock Type: volcanic, strongly altered 2. Size: 18x15x13 3. Shape / Angularity: rounded 4. - 10. similar to DR54-1, but Mn crust <1cm	x		3-4 gm-fsp				
MSM19-3 DR54-7	1. Rock Type: volcanic, strongly altered 2. Size: 26x17x16 3. Shape / Angularity: subangular 4. - 10. similar to DR54-1, but Mn crust <0.5cm	x	x	3-4 gm-fsp				
MSM19-3 DR54-8	1. Rock Type: volcanic, strongly altered 2. Size: 21x18x17 3. Shape / Angularity: subangular 4. - 10. similar to DR54-1, but Mn crust <3mm and higher vesicularity (10-15%, unfilled, ~1mm)	x		3-4 gm-fsp				
MSM19-3 DR54-9	1. Rock Type: volcanic, strongly altered 2. Size: 12x9x6 3. Shape / Angularity: subrounded 4. - 10. similar to DR54-1, but Mn crust <1cm	x		3-4 gm-fsp				
MSM19-3 DR54-10	1. Rock Type: volcanic, strongly altered 2. Size: 27x17x10 3. Shape / Angularity: subangular 4. - 10. similar to DR54-1, but Mn crust <1cm							
MSM19-3 DR54-11	1. Rock Type: volcanic, strongly altered 2. Size: 16x11x10 3. Shape / Angularity: rounded 4. - 10. similar to DR54-1, but Mn crust <3cm	x						
MSM19-3 DR54-12	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 14x12x10 3. - 10. Comment: similar to DR54-13, but contains less OI and more fsp (~5%, up to 6mm, moderately altered). Is on one side attached to breccia with clasts of same lithology	x	x	4				

Appendix I (Rock Description)








SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR54-13	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 14x7x7 3. Shape / Angularity: subrounded 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, <20-25% vesicles, mostly unfilled, <8mm 6. Phenocrysts: Ol ~6%, completely altered, <2mm; fsp <3%, strongly altered, <2mm 7. Matrix: fine grained with fsp and ol in gm 8. secondary Minerals: iddingsite replacing Ol, Mn and clay minerals and cc in veins, vesicles 9. Encrustations: Mn crust <1cm	x	x					
MSM19-3 DR54-14	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 11x9x4 3. Shape / Angularity: rounded 4. Color of cut surface: dark brown 5. Texture / Vesicularity: porphyric, <30-35% vesicles, mostly unfilled, <1.5cm 6. Phenocrysts: Ol ~6%, completely altered, <4mm; fsp <3%, strongly altered, <2mm 7. Matrix: cryptocrystalline (?) completely altered 8. secondary Minerals: Zeolithes, clay minerals and Mn in vesicles 9. Encrustations: Mn crust <1cm 10. Comment: similar to DR54-13	x						
MSM19-3 DR54-15	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 9x8x5 3. - 10. Comment: similar to DR54-13, but fsp is more altered	x		6				
MSM19-3 DR54-1-X	1. Rock Type: volcanic, pillow fragments from conglomerat 10. Comment: additional material for archive from sample DR54-1							no picture
MSM19-3 DR54-2-X	1. Rock Type: volcanic, pillow fragments from conglomerat 10. Comment: additional material for archive from sample DR54-2							no picture
MSM19-3 DR54-3-X	1. Rock Type: volcanic, pillow fragments from conglomerat 10. Comment: additional material for archive from sample DR54-3							no picture
MSM19-3 DR54-4-X	1. Rock Type: volcanic, pillow fragments from conglomerat 10. Comment: additional material for archive from sample DR54-4							no picture

MSM19-3 DR55	
Description of Location and Structure: Discovery Smnts, NE most smnt in-between southern and northern smnt chain, NE-facing slope	
Dredge on bottom	UTC 18/12/11 11:32hrs, lat 41°43.25'S, long 02°05.46'E, depth 2177m
Dredge off bottom	UTC 18/12/11 13:13hrs, lat 41°43.241'S, long 02°05.48'E, depth 2188m
total volume:	empty
Comments:	MSM station no: 1126





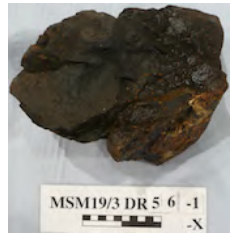
MSM19-3 DR56	
Description of Location and Structure: Discovery Smnts, NE most smnt in-between southern and northern smnt chain, NE-facing slope	
Dredge on bottom	UTC 18/12/11 14:38hrs, lat 41°42.76'S, long 02°05.02'E, depth 1947m
Dredge off bottom	UTC 18/12/11 15:53hrs, lat 41°42.85'S, long 02°04.50'E, depth 1539m
total volume:	1/4 full
Comments:	volcanic rocks -> basalts and volcanoclastica; MSM station no: 1127

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR56-1	1. Rock Type: volcanic, pillow fragment, slightly altered 2. Size: 43x24x34 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: porphyric, <3% vesicles, mostly unfilled, <0.5mm 6. Phenocrysts: Ol 5-10%, moderately altered, <1cm; cpx 5-10%, relatively fresh, <1.2cm 7. Matrix: fine frained with fsp and ol in gm, relatively fresh 8. secondary Minerals: iddingsite replacing Ol and some clay minerals 10. Comment: representative sample for this dredge, additional material as DR56-1-X in archive	x	x	2 gm fsp				

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ai/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR56-2	1. Rock Type: volcanic, lava fragment, slightly altered 2. Size: 18x13x5 3. Shape / Angularity: subrounded 4. - 10. similar to DR56-1, but larger fsp (<2mm), and higher vesicularity with overall larger vesicles (~5%, <4mm, mostly unfilled)	x	x	2 gm fsp				
MSM19-3 DR56-3	1. Rock Type: volcanic, lava fragment, slightly altered 2. Size: 13x9x5 3. Shape / Angularity: angular 4. - 10. similar to DR56-1, but some vesicles are filled with cc	x	x	2 gm fsp				
MSM19-3 DR56-4	1. Rock Type: volcanic, lava fragment, slightly to moderately altered 2. Size: 21x17x10 3. - 10. similar to DR56-1, but only the core is relatively fresh, rest is moderately altered, flowing texture and <2.5 Mn crust, requires picking of inner core for geochemistry	x	x	2-3 gm fsp				
MSM19-3 DR56-5	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 25x19x12 3. Shape / Angularity: angular 4. - 10. similar to DR56-1, but encrusted by breccia fragments and Mn crust of 3cm thickness, more altered but fresh parts in core	x	x					
MSM19-3 DR56-6	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 12x8x7 3. Shape / Angularity: rounded 4. Color of cut surface: dark olive brown 5. - 10. similar to DR56-1, but relatively altered matrix with flowing texture	x						
MSM19-3 DR56-7	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 16x14x6 3. Shape / Angularity: subangular 4. Color of cut surface: greyish brown 5. - 10. similar to DR56-1	x						
MSM19-3 DR56-8	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 20x14x10 3. Shape / Angularity: subangular 4. - 10. similar to DR56-1, but Mn crust <5mm	x						

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR56-9	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 27x14x8 3. Shape / Angularity: subangular 4. - 10. similar to DR56-1, but Mn crust <8mm	x						
MSM19-3 DR56-10	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 13x7x6 3. Shape / Angularity: angular 4. Color of cut surface: dark grey with white and orange points 5. Texture / Vesicularity: porphyric, ~30% vesicles, mostly filled, up to 1cm 6. Phenocrysts: Ol 15-20%, completely altered, <7mm; cpx 5%, slightly altered, <4mm 7. Matrix: microcrystalline with fsp and ol in gm, relatively fresh 8. secondary Minerals: iddingsite replacing Ol and zeolithe and cc in vesicles 9. Encrustations: Mn coating 10. Comment: similar to DR56-1, but higher vesicularity, gm might be sufficient for age dating	x	x	3 gm fsp				
MSM19-3 DR56-11	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 12x10x8 3. Shape / Angularity: subrounded 5. - 10. similar to DR56-10, but more altered, vesicles in core are elongated and parallel oriented	x						
MSM19-3 DR56-12	1. Rock Type: volcanoclastic, breccia, strongly altered 10. Comment: clasts are aphyric, slightly ol-phyric and without vesicles							
MSM19-3 DR56-1-X	1. Rock Type: volcanic, pillow fragment, slightly altered 10. Comment: additional material for archive from sample DR56-1							

MSM19-3 DR57


Description of Location and Structure: Discovery Smnts, NE most smnt in-between southern and northern smnt chain, SE-facing slope

Dredge on bottom UTC 18/12/11 17:49hrs, lat 41°47.94'S, long 02°07.45'E, depth 2513m




Dredge off bottom UTC 18/12/11 19:05hrs, lat 41°47.87'S, long 02°06.84'E, depth 2152m

total volume: few rocks

Comments: Mn and sediment, one fossil coral; MSM station no: 1128

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR57-1-S	1. Rock Type: sediment 2. Size: 37x27x11 10. Comment: big block of solidified sediment with worm tubes on one side, clayey grain size							

Appendix I (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	SED	NOTES	PICTURE
MSM19-3 DR57-2-M	1. Rock Type: Mn crust 2. Size: 25x17x10 3. Shape / Angularity: subrounded 4. Color of cut surface: black 10. Comment: solidified sediment on downside							
MSM19-3 DR57-3-M	1. Rock Type: Mn crust 2. Size: 16x11x9 3. Shape / Angularity: subrounded 4. Color of cut surface: black 10. Comment: solidified sediment on downside							
MSM19-3 DR57-4	1. Rock Type: coral 2. Size: 10x9x4 10. Comment: fossil coral with Mn crust <2mm							

Appendix II (Biological Samples)

MSM19/3 Biological Samples

Abbreviations: n = number of collected specimens, FIX = fixative, F = Formalin, EtOH = 100% pure Ethanol.
The numbers 2, 5, 50, 100, 200, 500 and 1000 give the size of the vials in ml, OT=Orange Tube.
Fixation of meiofauna from sediment traps as 1 volume sediment : 1 volume 6% formalin.

MSM19/3 - DR3 (MSM-NAME: 1074) Richardson Seamount, northern flank, upper slope, plateau edge.

Date: 04.12.2011

Coordinates On Bottom: Latitude: 40°15,79'S
Longitude: 14°24,10'E
Depth: 2778 m

Coordinates Off Bottom: Latitude: 40°16.09'S
Longitude: 14°23.66'E
Depth: 2357 m

total volume: few rocks

Comments: pillow /mn-crusts heavily altered

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	>5		x						EtOH

MSM19/3 - DR4 (MSM-NAME: 1075) Richardson Seamount, small cone on top of the plateau.

Date: 04.12.2011

Coordinates On Bottom: Latitude: 40°27,39'S
Longitude: 14°44,95'E
Depth: 1676 m

Coordinates Off Bottom: Latitude: 40°27.55'S
Longitude: 14°44.45'E
Depth: 1513 m

total volume: 3/4 full

Comments: crusts, breccias/volcanoclastics possibly lavas

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	>5		x						EtOH
Porifera	>5		x						EtOH
Ophiuridae	1	x							EtOH
Bryozoa	>5	x							EtOH
Polychaeta	5		x						EtOH
Brachiopoda / Crania	1	x							EtOH
Brachiopoda	2	x							EtOH
Brachiopoda	1	x							EtOH
Brachiopoda	1	x							EtOH
Brachiopoda	1	x							EtOH
Brachiopoda	5	x							EtOH
Brachiopoda	5	x							EtOH
Brachiopoda	1	x							EtOH
Brachiopoda	1	x							EtOH
Brachiopoda	3	x							EtOH
Brachiopoda	7	x							EtOH
Brachiopoda	5	x							EtOH
Brachiopoda / Eucalathis?	5	x							EtOH
Brachiopoda / Eucalathis?	5	x							EtOH
Brachiopoda /Novocrania	3	x							EtOH
Brachiopoda	>5				x				EtOH
Bivalvia	>5							OT50	EtOH

Appendix II (Biological Samples)

MSM19/3 - DR5 (MSM-NAME: 1076) Richardson Seamount, small cone on top of the plateau, 9 nm east of DR4 cone.

Date: 04.12.2011

Coordinates On Bottom: Latitude: 40°22,31'S
Longitude: 14°54,21'E
Depth: 1606 m

Coordinates Off Bottom: Latitude: 40°22.46'S
Longitude: 14°53.77'E
Depth: 1481 m

Sediment: yes

Macrofauna: yes

	TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna	Diverses	>5		x						EtOH
	Porifera	>5		x						EtOH
	Porifera	1			x					EtOH
	Cnidaria	2	x							EtOH
	Coronata	4	x							EtOH
	Tunicata	5		x						EtOH
	Bivalvia	4							50 OT	EtOH
	Brachiopoda	1	x							EtOH
	Brachiopoda	1	x							EtOH
	Brachiopoda	1	x							EtOH
	Brachiopoda	1								EtOH
	Brachiopoda (Rhynchonellid)	1							50OT	EtOH
	Brachiopoda	2	x							EtOH
	Brachiopoda	1	x							EtOH
	Brachiopoda (Eucalathis?)	>5	x							EtOH
	Brachiopoda	1	x							EtOH
	Polychaeta	>3	x							EtOH
	Bivalvia	1	x							EtOH
	Bryozoa	>5	x							EtOH

MSM19/3 - DR6 (MSM-NAME: 1077) Richardson Seamount plateau, small cone near SE edge of plateau.

Date: 04.12.2011

Coordinates On Bottom: Latitude: 40°28,10'S
Longitude: 15°05,25'E
Depth: 2323 m

Coordinates Off Bottom: Latitude: 40°28.32'S
Longitude: 15°04.78'E
Depth: 1990 m

Sediment: no

Macrofauna: yes

	TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna	Diverses	2	x							EtOH
	Porifera	>3	x							EtOH
	Polychaeta	1	x							EtOH
	Bivalvia	2	x							EtOH
	Bryozoa	>5	x							EtOH

Appendix II (Biological Samples)

MSM19/3 - DR7 (MSM-NAME: 1078) Richardson Seamount, SE-plateau edge, no volcanic cones present on plateau flat, track immediately below plateau edge.

Date: 05.12.2011

Coordinates On Bottom: Latitude: 40°45,39'S
Longitude: 14°42,25'E
Depth: 3083 m

Coordinates Off Bottom: Latitude: 40°45.07'S
Longitude: 14°41.72'E
Depth: 2443 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Porifera	1	x							EtOH
Porifera	2	x							EtOH
Bryozoa	1	x							EtOH

MSM19/3 - DR8 (MSM-NAME: 1079) Richardson Seamount, SE-plateau edge, lower part of NE-SW striking plateau edge, 3 nm S of DR7.

Date: 05.12.2011

Coordinates On Bottom: Latitude: 40°48,51'S
Longitude: 14°42,32'E
Depth: 4198 m

Coordinates Off Bottom: Latitude: 40°48.38'S
Longitude: 14°41.88'E
Depth: 3910 m

total volume:

Comments:

Sediment: yes 2

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	3				x				EtOH

MSM19/3 - DR10 (MSM-NAME: 1081) deep sea plain S of Richardson Seamount, small cone 3.5 nm from DR9, southern direction, dredge track along E flank.

Date: 05.12.2011

Coordinates On Bottom: Latitude: 41°15,66'S
Longitude: 14°10,16'E
Depth: 4016 m

Coordinates Off Bottom: Latitude: 41°15.62'S
Longitude: 14°09.58'E
Depth: 3706 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR12 (MSM-NAME: 1083) Agulhas FZ at SW tip of Richardson Smt., small valley in NE-SW striking slope.

Date: 06.12.2011

Coordinates On Bottom: Latitude: 41°13,99'S
Longitude: 13°41,41'E
Depth: 3120 m

Coordinates Off bottom: Latitude: 41°13.99'S
Longitude: 13°41.39'E
Depth: 3121 m

Sediment: no

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	1	x							EtOH

Appendix II (Biological Samples)

MSM19/3 - DR13 (MSM-NAME: 1084) SW end of Richardson seamount, NE-SW striking slope, 0.5 nm E of DR12, beneath plateau edge.

Date: 06.12.2011

Coordinates On Bottom: Latitude: 41°13,06'S
Longitude: 13°41,92'E
Depth: 3333 m

Coordinates Off Bottom: Longitude: 13°41.61'E
Latitude: 41°13.75'S
Depth: 2923 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR14 (MSM-NAME: 1085) Agulhas Ridge, central part, southern flank of the northern ridge.

Date: 06.12.2011

Coordinates On Bottom: Latitude: 41°40,70'S
Longitude: 12°31'76"E
Depth: 4183 m

Coordinates Off Bottom: Longitude: 12°31.17'E
Latitude: 41°40.71'S
Depth: 3663 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR15 (MSM-NAME: 1086) Agulhas Ridge, central part, southern flank of the northern ridge, NE of DR14, 3 nm away.

Date: 06.12.2011

Coordinates On Bottom: Latitude: 41°39,11'S
Longitude: 12°34,89'E
Depth: 3870 m

Coordinates Off Bottom: Longitude: 12°34.28'E
Latitude: 41°39.11'S
Depth: 3555 m

Sediment: yes 2

Macrofauna: no

MSM19/3 - DR16 (MSM-NAME: 1087) Seamount structure, SE of Agulhas FZ, NE-NW striking oval shaped seamount, NW-slope along nose.

Date: 07.12.2011

Coordinates On Bottom: Latitude: 41°50,19'S
Longitude: 12°55,79'E
Depth: 3692 m

Coordinates Off Bottom: Longitude: 12°55.23'E
Latitude: 41°50.55'S
Depth: 3130 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR17 (MSM-NAME: 1088) Agulhas Ridge, central part, steep southern flank of the northern ridge.

Date: 07.12.2011

Coordinates On Bottom: Latitude: 41°58,08'S
Longitude: 11°44,09'E
Depth: 3521 m

Coordinates Off Bottom: Longitude: 11°43.69'E
Latitude: 41°58.19'S
Depth: 3137 m

Sediment: yes

Macrofauna: no

Appendix II (Biological Samples)

MSM19/3 - DR18 (MSM-NAME: 1089) Agulhas Ridge, central part, southern flank of northern ride ~0.7 nm N of DR17.

Date: 07.12.2011

Coordinates On Bottom: Latitude: 41°57,5'S
Longitude: 11°43,58'E
Depth: 2795 m

Coordinates Off Bottom: Longitude: 11°43.04'E
Latitude: 41°57.69'S
Depth: 2270 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR19 (MSM-NAME: 1090) Agulhas Ridge, central part, southern ridge.

Date: 07.12.2011

Coordinates On Bottom: Longitude: 11°22.03'E
Latitude: 42°21.37'S
Depth: 4134 m

Coordinates Off Bottom: Longitude: 11°21.66'E
Latitude: 42°21.77'S
Depth: 3727 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR20 (MSM-NAME: 1091) Agulhas Ridge, western part, area where AR is split into two parallel ridges, northern ride along SE facing slope, across nose.

Date: 08.12.2011

Coordinates On Bottom: Latitude: 42°33,81'S
Longitude: 10°18,60'E
Depth: 4190 m

Coordinates Off Bottom: Longitude: 10°18.24'E
Latitude: 42°34.11'S
Depth: 3863 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR21 (MSM-NAME: 1092) Agulhas FZ, western part, 2 nm N of DR20, NNE facing slope, along nose.

Date: 08.12.2011

Coordinates On Bottom: Latitude: 42°32,09'S
Longitude: 10°13,49'E
Depth: 3611

Coordinates Off Bottom: Longitude: 10°17.96'E
Latitude: 42°32.25'S
Depth: 3273 m

Sediment: yes

Macrofauna: yes

	TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna	Diverses	2	x							EtOH

MSM19/3 - DR22 (MSM-NAME: 1093) Agulhas Ridge.

Date: 08.12.2011

Coordinates On Bottom: Latitude: 42°18,01'S
Longitude: 9°38,70'E
Depth: 4764 m

Coordinates Off Bottom: Longitude: 09°38.30' E
Latitude: 42°18.42'S
Depth: 4435 m

Sediment: yes

Macrofauna: no

Appendix II (Biological Samples)

MSM19/3 - DR23 (MSM-NAME: 1094) Agulhas Ridge (west) seamount, lower part of most eastern part.

Date: 08.12.2011

Coordinates On Bottom: Latitude: 42°04,69'S
Longitude: 9°37,09'E
Depth: 4410 m

Coordinates Off Bottom: Longitude: 09°37.47'E
Latitude: 42°04.78'S
Depth: 4095 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR24 (MSM-NAME: 1095) Agulhas FZ, western part, 2 nm N of DR20, NNE facing slope, along nose.

Date: 09.12.2011

Coordinates On Bottom: Latitude: 41°57,55'S
Longitude: 9°13,83'E
Depth: 4868 m

Coordinates: Longitude: 09°13.16' E
Latitude: 41°57.73'S
Depth: 4521 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR26 (MSM-NAME: 1097) Agulhas Ridge, central part, steep "steps"/scarps at ocean floor, N of Agulhas Ridge, southern tip of one "step".

Date: 09.12.2011

Coordinates On Bottom: Latitude: 42°19,15'S
Longitude: 9°17,51'E
Depth: 4733 m

Coordinates Off Bottom: Longitude: 09°16.94'E
Latitude: 42°19.03'S
Depth: 4534 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR27 (MSM-NAME: 1098) Agulhas Ridge, central part, steep "steps"/scarps at ocean floor, N of Agulhas Ridge, 1 nm N of DR26.

Date: 09.12.2011

Coordinates On Bottom: Latitude: 42°18,38'S
Longitude: 9°18,21'E
Depth: 4817 m

Coordinates Off Bottom: Longitude: 09°17.72'E
Latitude: 42°18.47'S
Depth: 4597 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR28 (MSM-NAME: 1099) Ocean floor N of Agulhas Ridge, oval shaped seamount, E-W axis, N facing slope.

Date: 09.12.2011

Coordinates On Bottom: Latitude: 42°30,62'S
Longitude: 9°14,22'E
Depth: 4610 m

Coordinates Off Bottom: Longitude: 09°13.98'E
Latitude: 42°31.03'S
Depth: 4280 m

Sediment: yes

Macrofauna: no

Appendix II (Biological Samples)

MSM19/3 - DR29 (MSM-NAME: 1100) Seamount north of Agulhas Ridge.

Date: 10.12.2011

Coordinates On Bottom: Latitude: 42°29,51'S
Longitude: 8°51,75'E
Depth: 4311 m

Coordinates Off Bottom: Longitude: 08°51,07'E
Latitude: 42°29,48'S
Depth: 3938 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR30 (MSM-NAME: 1101) Agulhas Ridge West, seamount on top of Northern ridge.

Date: 10.12.2011

Coordinates On Bottom: Latitude: 42°45,87'S
Longitude: 8°41,29'E
Depth: 3650 m

Coordinates Off Bottom: Longitude: 08°40,90E
Latitude: 42°46,20S'
Depth: 3225 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR31 (MSM-NAME: 1102) Agulhas Ridge west, northern ridge.

Date: 10.12.2011

Coordinates On Bottom: Latitude: 43°04,61'S
Longitude: 8°56,41'E
Depth: 2993 m

Coordinates Off Bottom: Longitude: 08°56,44'E
Latitude: 43°04,63'S
Depth: 3100 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR32 (MSM-NAME: 1103) Agulhas Ridge west, northern ridge.

Date: 10.12.2011

Coordinates On Bottom: Latitude: 43°0,93'S
Longitude: 9°5,93'E
Depth: 3404 m

Coordinates Off Bottom: Longitude: 09°05,32'E
Latitude: 43°00,76'S
Depth: 3041 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR33 (MSM-NAME: 1104) Agulhas Ridge west, younger (?) feature on top of the southern ridge.

Date: 10.12.2011

Coordinates On Bottom: Latitude: 43°10,31'S
Longitude: 9°14,62'E
Depth: 3015 m

Coordinates Off Bottom: Longitude: 09°14,19'E
Latitude: 43°09,94'S
Depth: 2497 m

Sediment: yes

Macrofauna: yes

Macrofauna	TAXA	n	2	50	100	200	500	1000	other	FIX
Bryozoa		3	x							EtOH

Appendix II (Biological Samples)

MSM19/3 - DR34 (MSM-NAME: 1105) Agulhas Ridge west, southern ridge.

Date: 10.12.2011

Coordinates On Bottom: Latitude: 43°11,19'S
Longitude: 9°19,56'E
Depth: 3796 m

Coordinates Off Bottom: Longitude: 09°19,02'E
Latitude: 43°10,92'S
Depth: 3330 m

Sediment: yes 2

Macrofauna: no

MSM19/3 - DR35 (MSM-NAME: 1106) Agulhas Ridge West, Northern ridge.

Date: 11.12.2011

Coordinates On Bottom: Latitude: 43°17,53'S
Longitude: 8°20,80'E
Depth: 2940 m

Coordinates Off Bottom: Longitude: 08°20,29'E
Latitude: 43°17,26'S
Depth: 2345 m

Sediment: no

Macrofauna: yes

Macrofauna	TAXA	n	2	50	100	200	500	1000	other	FIX
	Porifera	2		x						EtOH
	Bryozoa	1		x						EtOH

MSM19/3 - DR36 (MSM-NAME: 1107) Seamount south of Agulhas Ridge west.

Date: 11.12.2011

Coordinates On Bottom: Latitude: 43°41,87'S
Longitude: 8°16,64'E
Depth: 4465 m

Coordinates Off Bottom: Longitude: 08°16,40'E
Latitude: 43°41,47'S
Depth: 4110 m

Sediment: yes

Macrofauna: no

MSM19/3 - DR38 (MSM-NAME: 1109) Agulhas FZ western section.

Date: 11.12.2011

Coordinates On Bottom: Latitude: 43°3,70'S
Longitude: 5°57,00'E
Depth: 3926 m

Coordinates Off Bottom: Longitude: 05°56,98'E
Latitude: 44°4,18'S
Depth: 3495 m

Sediment: yes

Macrofauna: no

Appendix II (Biological Samples)

MSM19/3 - DR39 (MSM-NAME: 1110) Seamount on the NE end of Meteor Rise.

Date: 12.12.2011

Coordinates On Bottom: Latitude: 44°21,62'S
Longitude: 4°59,23'E
Depth: 2461 m

Coordinates Off Bottom: Longitude: 4°59,34'E
Latitude: 44°22,01'S
Depth: 1915 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	1	x							EtOH
Porifera	>3	x							EtOH

MSM19/3 - DR40 (MSM-NAME: 1111) Meteor Rise.

Date: 13.12.2011

Coordinates On Bottom: Latitude: 45°03,87'S
Longitude: 4°47,96'E
Depth: 3253 m

Coordinates Off Bottom: Longitude: 4°47,99'E
Latitude: 45°4,39' S
Depth: 2717 m

total volume:

1/3 full

Sediment: yes 2

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	>5		x						EtOH
Coronata	1	x							EtOH
Bryozoa	>5	x							EtOH
Bryozoa	>5	x							EtOH

MSM19/3 - DR41 (MSM-NAME: 1112) Seamount of the Meteor Rise, southern-most seamount of the cruise.

Date: 13.12.2011

Coordinates On Bottom: Latitude: 45°28,16'S
Longitude: 4°58,64'E
Depth: 2559 m

Coordinates Off Bottom: Longitude: 4°58,70'E
Latitude: 45°28,63'S
Depth: 2244 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Porifera	2	x							EtOH
Bryozoa	1	x							EtOH

Appendix II (Biological Samples)

MSM19/3 - DR42 (MSM-NAME: 1113) Seamount of the Meteor Rise, southern-most seamount of the cruise.

Date: 13.12.2011

Coordinates On Bottom: Latitude: 45°27,06'S
Longitude: 5°04,94'E
Depth: 3276 m

Coordinates Off Bottom: Longitude: 5°05,07'E
Latitude: 45°27,59'S
Depth: 2920 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	1	x							EtOH
Coronata	1	x							EtOH

MSM19/3 - DR43 (MSM-NAME: 1114) Meteor Rise.

Date: 14.12.2011

Coordinates On Bottom: Latitude: 44°36,32'S
Longitude: 3°50,89'E
Depth: 3222 m

Coordinates Off Bottom: Longitude: 3°50,48'E
Latitude: 44°36,70'S
Depth: 2874 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	1	x							EtOH
Bryozoa	5	x							EtOH
Polychaeta	1	x							EtOH

MSM19/3 - DR44 (MSM-NAME: 1115) Discovery Seamounts.

Date: 14.12.2011

Coordinates On Bottom: Latitude: 43°11,508'S
Longitude: 1°23,767'E
Depth: 2616 m

Coordinates Off Bottom: Longitude: 1°23,44'E
Latitude: 43°11,18'S
Depth: 2178 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	>3	x							EtOH
Cnidaria	>3	x							EtOH
Annelida	1	x							EtOH
Bryozoa	3	x							EtOH
Crustacea	1	x							EtOH

Appendix II (Biological Samples)

MSM19/3 - DR45 (MSM-NAME: 1116) Discovery Seamounts.

Date: 14.12.2011

Coordinates On Bottom: Latitude: 42°51,73'S
Longitude: 0°34,91'E
Depth: 2350 m

Coordinates-off bottom: Longitude: 0°34,41'E
Latitude: 42°51,99'S
Depth: 1889 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	>5	x							EtOH
Porifera	3	x							EtOH
Cnidaria/Bryozoa	1		x						EtOH
Cnidaria/Bryozoa	1							5l Weithal s	F

MSM19/3 - DR46 (MSM-NAME: 1117) Discovery Seamounts.

Date: 14.12.2011

Coordinates On Bottom: Latitude: 43°32,41'S
Longitude: 1°02,8191'W
Depth: 1460 m

Coordinates Off Bottom: Longitude: 01°3,331'W
Latitude: 43°32,472'S
Depth: 1057 m

Sediment: no

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	>5		x						EtOH
Porifera	>5		x						EtOH
Polychaeta	1	x							EtOH
Bivalvia	1	x							EtOH
Brachiopoda	2	x							EtOH
Echinodermata	1	x							EtOH

MSM19/3 - DR48 (MSM-NAME: 1119) Discovery Seamounts.

Date: 15.12.2011

Coordinates On Bottom: Latitude: 43°27,097'S
Longitude: 2°32,415'W
Depth: 3441 m

Coordinates Off Bottom: Longitude: 2°32,97'W
Latitude: 43°26,88'S
Depth: 2939 m

Sediment: yes

Macrofauna: no

Appendix II (Biological Samples)

MSM19/3 - DR49 (MSM-NAME: 1120) Discovery Seamounts.
Date: 15.12.2011

Coordinates On Bottom: Latitude: 43°22,20'S
Longitude: 2°34,52'W
Depth: 2517 m

Coordinates Off Bottom: Longitude: 2°34,95'W
Latitude: 43°22,52'S
Depth: 2164 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	2	x							EtOH

MSM19/3 - DR50 (MSM-NAME: 1121) Discovery Seamounts.
Date: 16.12.2011

Coordinates On Bottom: Latitude: 43°4,286'S
Longitude: 2°28,134'W
Depth: 2264 m

Coordinates Off Bottom: Longitude: 2°28,69'W
Latitude: 43°4,075'S
Depth: 1834 m

Sediment: no

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Cnidaria	####				x			5l	EtOH/F

MSM19/3 - DR51 (MSM-NAME: 1122) Discovery Seamounts.
Date: 17.12.2011

Coordinates On Bottom: Latitude: 42°40,657'S
Longitude: 1°25,542'W
Depth: 1441 m

Coordinates Off Bottom: Longitude: 1°25,95'W
Latitude: 42°40,73'S
Depth: 1100 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	>5	x							EtOH
Diverses	>5		X						EtOH
Porifera	>5	x							EtOH
Porifera	>5		x						EtOH
Cnidaria	3	x	x						EtOH
Cnidaria	>5								EtOH
Bivalvia	4		x						EtOH
Bivalvia	1	x							EtOH
Bryozoa	>3	x							EtOH
Bryozoa	3	x							EtOH

Appendix II (Biological Samples)

MSM19/3 - DR52 (MSM-NAME: 1123) Discovery Seamounts.

Date: 17.12.2011

Coordinates On Bottom: Latitude: 42°23,11'S
Longitude: 0°56,595'E
Depth: 2908 m

Coordinates Off Bottom: Longitude: 0°56,103'E
Latitude: 42°23,218'S
Depth: 2514 m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Coronata	2	x							EtOH
Porifera	1	x							EtOH

MSM19/3 - DR53 (MSM-NAME: 1124) Discovery Seamounts.

Date: 18.12.2011

Coordinates On Bottom: Latitude: 42°31,76'S
Longitude: 01°45,96'E
Depth: 2343 m

Coordinates Off Bottom: Longitude: 01°45,32'E
Latitude: 42°31,95'S
Depth: 1947 m

Sediment: no

Macrofauna: yes 3

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Porifera	1	x							EtOH
Bryozoa	1	x							EtOH
Porifera?	1	x							EtOH
Cnidaria	1							5l	F

MSM19/3 - DR54 (MSM-NAME: 1125) Discovery Seamounts.

Date: 18.12.2011

Coordinates On Bottom: Latitude: 42°12,63 S
Longitude: 2°22,06 'E
Depth: 1337 m, dredge
stuck

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	3	x							EtOH
Porifera	>5	x							EtOH
Bryozoa	>3	x							EtOH
Echinodermata	1		x						EtOH

MSM19/3 - DR55 (MSM-NAME: 1126) Discovery Seamounts.

Date: 18.12.2011

Coordinates On Bottom: Latitude: 41°43,26 S 'S
Longitude: 2°02,52 'E
Depth: 1613 m, dredge
stuck

Sediment: yes

Macrofauna: no

Appendix II (Biological Samples)

MSM19/3 - DR56 (MSM-NAME: 1127) Discovery Seamounts.

Date: 18.12.2011

Coordinates On Bottom: Latitude: 41°42,84'S
Longitude: 2°04,50'E
Depth: 1544m

Coordinates Off Bottom: Longitude:'E
Latitude: 'S
Depth: 1547m

Sediment: yes

Macrofauna: yes

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Porifera	3	x							EtOH
Cnidaria	1	x							EtOH
Cnidaria	1	x							EtOH
Bryozoa	1	x							EtOH
Bivalvia	2		x						EtOH

MSM19/3 - DR57 (MSM-NAME: 1128) Discovery Seamounts.

Date: 18.12.2011

Coordinates On Bottom: Latitude: 41°47,94'S
Longitude: 02°07,45'E
Depth: 2513 m

Coordinates Off Bottom: Longitude: 02°06,84'E
Latitude: 41°47,87'S
Depth: 2152 m

Sediment: yes

Macrofauna: yes 1

TAXA	n	2	50	100	200	500	1000	other	FIX
Macrofauna									
Diverses	3		x						EtOH
Porifera	1	x							