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Helmholtz-Zentrum für Ozeanforschung Kiel

RV SONNE
Fahrtbericht / Cruise Report
SO225

MANIHIKI II Leg 2
The Manihiki Plateau - Origin, Structure and Effects of Oceanic Plateaus and Pleistocene Dynamic of the West Pacific Warm Water Pool

19.11.2012 - 06.01.2013
Suva / Fiji – Auckland / New Zealand

Berichte aus dem Helmholtz-Zentrum
für Ozeanforschung Kiel (GEOMAR)

Nr. 6 (N. Ser.)

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SUMMARY

R/V SONNE cruises SO-224 and SO-225 are part of the cooperative project MANIHIKI II between GEOMAR Helmholtz Centre for Ocean Research Kiel and the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), funded by the German Ministry of Education and Research (BMBF). This multidisciplinary project continues previous research at the Manihiki Plateau conducted since 2007 (SO-193) on morphological, volcanological, geochemical, and geochronological studies and is now broadened by geophysical and paleoceanographic research foci.

SO-225 focused on stratigraphically controlled sampling of the igneous successions of the Manihiki Plateau. This has been accomplished by using the remotely operated vehicle ROV Kiel 6000 and chain bag dredges. Coring of deep sea sediments and sampling of the overlying water column has been added to the program. SO-225 and subsequent shore-based research in the home institutes mainly address (1) the temporal, spatial, and compositional evolution of the igneous basement of Manihiki Plateau, (2) the environmental impact of the large volcanic eruptions, which formed the Manihiki Plateau, (3) the Plio-Pleistocene dynamics and evolution of the West Pacific Warm Pool during the last ~3 million years, and (4) the potential oceanographic interaction between the equatorial Pacific and the Southern Ocean ("ocean tunnel hypothesis") and its climatic responses. The integration of scientific results from SO-224 and SO-225 with existing data from the West Pacific large igneous provinces Manihiki, Hikurangi, and Ontong Java will contribute towards a better understanding of the origin and effects of volcanic mega events, the formation of large igneous provinces, and the paleoceanography and paleoclimate of the equatorial West Pacific.

R/V SONNE cruise SO-225 started in Suva/Fiji on November 21st, 2012, and ended in Auckland/New Zealand on Januar 5th, 2013. Complementing 2,940 nm multi-beam mapping and 2,250 nm sediment echo-sounding, a total of 62 deployments of various devices have been carried out during SO-225. Ten of 11 multi corers yielded sediment samples, 16 piston corer and 3 gravity corer deployments recovered altogether 131.6 m sediment cores. The sampling of the water column by CTD and multi net was successful. Foraminiferal sand and ooze dominate among the sediment samples, some cores also contained sandy clayey silt rich in foraminifers and nanno ooze. The sediment cores cover a more than 1,100 km core transect extending from the ocean floor to the north of the Manihiki Plateau to the southern foothills of the High Plateau. Preliminary studies on board showed that the SO-225 sediment sampling yielded excellent paleoceanographic archives which can be correlated along the entire core transect and dated back to Pliocene. Further preliminary results include that past climate changes significantly affected the West Pacific Warm Pool. The sediment samples also will allow to reconstruct the Plio/Pleistocene variability of equatorial currents and the Antarctic intermediate water. Four ROV dives yielded 32 rock samples from two profiles across the slopes in the northern and central part of the Manihiki Plateau (North Plateau and Danger Island Troughs). Stratigraphically controlled sampling along c. 3 km long profile reaching from 4,600 m up to 3,260 m water depth across the flank of the south-eastern foothills of the North Plateau was particularly successful. Due to a series of unfortunate circumstances beyond our control, further ROV sampling on SO-225 had to be cancelled. Instead we decided to run dredges to considerably broaden the range of samples from the Manihiki Plateau basement by dredging. Twenty-three dredge hauls have been conducted in an average water depth of 4,380 m. Of these, 20 delivered magmatic rocks, 12 volcaniclastics, 8 sedimentary rocks, and 13 Mn-Fe-Oxide crusts. Notably, some of the dredged rocks show spinifex textures indicating unusual high eruption temperatures and several dredges contained fresh volcanic glass. The recovery of fresh glass from a presumably c. 120 million years old flood basalt province is a great achievement which will enable detailed petrological and geochemical studies of the plateau forming melts. Finally, mapping of submarine volcano Monowai en route on the transit to Auckland SO-225 should contribute to a time series of maps which continuously document the evolution of the volcano. During profiling, however, a sudden and significant increase in volcanic activity hindered us in mapping the top area of Monowai.

ZUSAMMENFASSUNG

Die FS SONNE-Reisen SO-224 und SO-225 in den äquatorialen Westpazifik sind Teil des BMBF-Verbundprojektes MANIHIKI II, das vom GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel und dem Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) gemeinsam durchgeführt wird. Mit diesem multidisziplinären Projekt werden bereits im Jahr 2007 mit SO-193 begonnene morphologische, vulkanologische, geochemische und geochronologische Untersuchungen am Manihiki-Plateau, einer Flutbasaltprovinz im äquatorialen Westpazifik, fortgeführt und um neue geophysikalische und paläozeanographische Forschungsansätze erweitert.

Der Schwerpunkt von SO-225 lag auf der stratigraphisch kontrollierten Beprobung der Lavaabfolgen des Plateaubasements mit dem Tiefseeroboter ROV Kiel 6000 und Kettensackdredgen sowie auf umfangreichen Beprobungen von Tiefseesedimenten und der darüberliegenden Wassermassen. Mit SO-225 und den nachfolgenden Forschungsarbeiten an Land sollen neue Erkenntnisse gewonnen werden über (1) die zeitliche, räumliche und kompositionelle Entwicklung des magmatischen Basements des Manihiki-Plateaus, (2) die Umweltfolgen der großen Vulkanausbrüche, die zur Bildung des Plateaus führten, (3) die Dynamik und Entwicklung des Westpazifischen Warmwasserpools während der letzten ca. 3 Millionen Jahre und (4) die möglichen ozeanographischen Wechselwirkungen zwischen dem Pazifik und dem Südozean ("Ozeantunnel-Hypothese") und deren klimatische Folgeerscheinungen. Das Zusammenbringen der wissenschaftlichen Ergebnisse von SO-224 und SO-225 mit bereits vorhandenen Daten von den westpazifischen Flutbasaltprovinzen Manihiki, Hikurangi und Ontong Java wird zu besseren Verständnis der Ursachen und Auswirkungen von vulkanischen Großereignissen, der Bildung von Flutbasaltprovinzen und der Paläozeanographie und des Paläoklimas des äquatorialen Westpazifik beitragen.

Die FS SONNE-Reise SO-225 begann am 21.11.2012 in Suva/Fidschi und endete am 5.01.2013 in Auckland/Neuseeland. Insgesamt wurden 62 Geräteeinsätze sowie 2.940 nm Fächerecholot- und 2.250 nm Sedimentecholotvermessungen durchgeführt. Zehn von 11 Multicorern erbrachten Sedimentproben, 16 Kolben- und 3 Schwereloteeinsätze insgesamt 131,6 m Kerngewinn. Die Beprobung der Wassersäule mit CTD und Multinetz verlief erfolgreich. Unter den Sedimentproben dominieren Foraminiferensande und - schlämme, in einigen Kernen wurde auch foraminiferenreicher sandiger toniger Silt und Coccolithen-schlamm gefunden. Die Sedimentkerne decken ein 1.100 km langes N-S-Profil ab, dass sich vom Ozeanboden nördlich des Manihiki-Plateaus bis zu dessen südlichen Ausläufern erstreckt. Die Sedimentbeprobung erbrachte exzellente paläoozeanographische Archive, die über das gesamte N-S-Profil korreliert werden können und bis in das Pliozän zurückreichen. Vorläufige Ergebnisse sind u.a., dass Klimaänderungen in der Vergangenheit dem Westpazifischen Warmwasserpool erheblich affektiert haben und dass die Sedimentproben es erlauben werden, die Plio/Pleistozäne Variabilität der äquatorialen Strömungen und des antarktischen Zwischenwassers zu rekonstruieren. Bei 4 ROV-Tauchgängen wurden 32 Gesteinsproben von 2 Profilen im Norden und im Zentrum des Manihiki-Plateaus (North Plateau und Danger Island Troughs) gewonnen. Besonders erfolgreich verlief die stratigraphisch kontrollierte Beprobung entlang eines etwa 3 km langen Profils, das sich von 4.600 m bis in 3.260 m Wassertiefe an einem südöstlichen Ausläufer des North Plateaus erstreckt. Aufgrund einer Reihe unglücklicher Umstände außerhalb unserer Kontrolle musste die ROV-Beprobung anschließend abgebrochen werden. Stattdessen wurde das Basement des Manihiki-Plateaus mit Dredgen beprobt, um den vorhandenen Probensatz zu erweitern. Von 23 Dredgezügen förderten 20 magmatische Gesteine, 12 Vulkaniklastika, 8 Sedimentgesteine und 13 Fe-Mn-Oxide aus durchschnittlich 4.380 m Wassertiefe zu Tage. Bemerkenswerterweise erbrachten einige Dredgezüge Gesteine mit Spinifex-Texturen, die auf außergewöhnlich hohe Eruptionstemperaturen hinweisen. Weiterhin fand sich in einigen Dredgen frisches vulkanisches Glas, was detaillierte petrologische und geochemische Untersuchungen der plateaubildenden Schmelzen erlauben wird. Auf dem Rückweg nach Auckland sollte auf Bitten von Kollegen hin noch der aktive submarine Vulkan Monowai kartiert werden, um die Entwicklung dieses Vulkans kontinuierlich zu dokumentieren. Während der Profilfahrten am Monowai nahm die vulkanische Aktivität jedoch plötzlich so stark zu, dass die Kartierung des Gipfelbereichs aus Sicherheitsgründen abgebrochen werden musste.

1. ACKNOWLEDGEMENTS

We would especially like to thank Captain Mallon and the crew of the R/V SONNE. Their hard work, high level of experience, willingness to help, and the pleasant working atmosphere on board contributed significantly to the success of SO-225. In particular we acknowledge their heroic efforts and their highly professional support carrying out an alternative dredging program on very short notice that assured that hard rock sampling was successful, despite the failure to deploy the ROV Kiel 6000 after only 4 dives and having lost working days by various unfortunate circumstances.

We are very grateful to G. Uenzelmann-Neben, K. Gohl, and D. Damaske for providing bathymetric and sediment echo-sounding data, maps, seismic data and profiles, and many other valuable information for SO-225 cruise, all of which contributed to the achievement of the cruise objectives.

We thank the Government of Cook Islands for granting permission to work within their territorial waters. We also gratefully acknowledge the support he German Foreign Office and the German Embassy in Wellington in this matter.

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Lastly the chief scientist would like to thank the scientific shipboard party for their excellent work and their high level of motivation that significantly contributed to the good atmosphere on board throughout this expedition.

2. PARTICIPANTS

2.1. Ship's Crew

Mallon, Lutz	Master	Rex, Andreas	Chief Engin.
Korte, Detlef	Chief Mate	Klinder, Klaus	2nd Engineer
Büchele, Heinz Ulrich	2nd Mate	Pieper, Carsten	2nd Engineer
Hoffsommer, Lars	2nd Mate	Krawczak, Ryszard	Motorman
Großmann, Matthias	Chief Electronican	Bolik, Torsten	Motorman
Meinecke, Stefan	Systems Manager	Rosemeyer, Rainer	Fitter
Borchert, Wolfgang	Systems Manager	Rieper, Uwe	Electrician
Heuser, Sabine	Surgeon	Schmandke, Harry	Chief Steward
Wieden, Wilhelm	Chief Cook	Royo, Luis	2nd Steward
Garnitz, Andre	2nd Cook	Kallenbach, Christian	Apprentice
Bierstedt, Torsten	Boatswain	Schröder, Andreas	Apprentice
Stengl, Günther	A.B.	Schernick, Robert	Apprentice
Eidam, Oliver	A.B.	Ernst, Arnold	A.B.
Heibeck, Frank	A.B.	Mohrdiek, Finn	A.B.
Grave, Manuel	A.B.		

2.2. Principal Investigators for MANIHIKI II *(in alphabetical order)*

Gohl, Karsten	AWI
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Hoernle, Kaj	GEOMAR (Project Coordinator)
Portnyagin, Maxim	GEOMAR
Nürnberg, Dirk	GEOMAR
Tiedemann, Ralf	AWI
Uenzelmann-Neben, Gabriele	AWI
Werner, Reinhard	GEOMAR

2.3. Shipboard Scientific Party *(in alphabetical order)*

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Bodendorfer, Matthias	ROV-Team	GEOMAR
Cuno, Patrick	ROV-Team	GEOMAR
Furchheim, Nina	Scientist	Museum für Naturkunde
Glückselig, Birgit	Technician	AWI
Golowin, Roman	Scientist	GEOMAR
Hauff, Silke	Technician	GEOMAR
Hauff, Folkmar	Senior Scientist	GEOMAR
Hennke, Jan	ROV-Team	GEOMAR
Huusmann, Hannes	ROV-Team	GEOMAR
Kawohl, Helmut	Technician	Marinetechnik Kawohl
Max, Lars	Scientist	AWI
Meier, Arne	ROV-Team	GEOMAR
Nürnberg, Dirk (Co-Chief Scientist)	Head Paleoceanography	GEOMAR
Osborne, Anne	Scientist	GEOMAR
Peukert, Anne	Student	GEOMAR
Pieper, Martin	ROV-Team	GEOMAR
Poggemann, David-Willem	Scientist	GEOMAR
Portnyagin, Maxim	Senior Scientist	GEOMAR
Raddatz, Jacek	Scientist	GEOMAR
Schilling, Nadine	Scientist	AWI
Suck, Inken	ROV-Team	GEOMAR
Werner, Reinhard (Chief Scientist)	Geologist	GEOMAR

The SO-225 Shipboard Scientific Party (photo Stefan Meinecke).

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Museum für Naturkunde	Museum für Naturkunde an der Humboldt-Universität zu Berlin, Invalidenstr. 43, 10115 Berlin, Germany (http://www.museum.hu-berlin.de)

3. MAJOR OBJECTIVES AND BACKGROUND OF SO-225 MANIHIKI II

(R. Werner, N. Nürnberg, F. Hauff, M. Portnyagin, K. Hoernle, R. Tiedemann)

R/V SONNE cruises SO-224 and SO-225 are part of the cooperative project MANIHIKI II between the GEOMAR Helmholtz Centre for Ocean Research Kiel and the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (AWI), funded by the German Ministry of Education and Research (BMBF). This multidisciplinary project continues previous research at the Manihiki Plateau conducted since 2007 (SO-193) on morphological, volcanological, geochemical, and geochronological studies and is now broadened by geophysical and paleoceanographic research foci. While the preceding RV SONNE SO-224 expedition by the AWI has conducted an extensive geophysical program (Uenzelmann-Neben 2012) of which preliminary results have been used in the follow up cruise, SO-225 focused on the stratigraphically controlled sampling of the igneous successions of the Manihiki Plateau. Coring of deep sea sediments and sampling of the overlying water column has been added to the program.

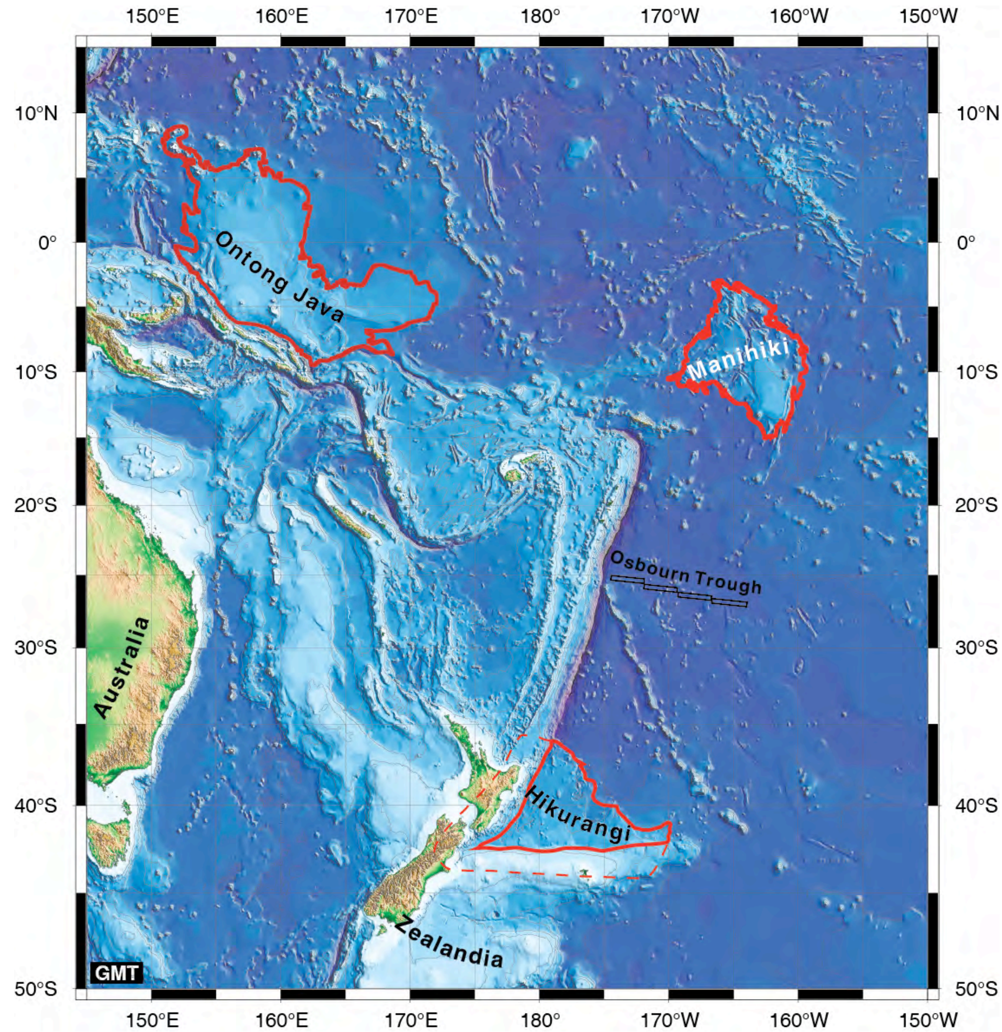

Fig. 3.1: *Overview bathymetric map of the Southwest Pacific showing the three major oceanic plateaus or Large Igneous Provinces (LIPs) Manihiki, Ontong Java, and Hikurangi. Hikurangi has partly been subducted beneath Zealandia (shown by dashed red line). Data base: The GEBCO_08 Grid, version 20091120, http://www.gebco.net.*

3.1. LARGE IGENOUS PROVINCES AND OCEANIC PLATEAUS IN THE SW-PACIFIC

The Manihiki Plateau is a huge submarine lava plateau (c. 0,8 Mill km^2), approximately equal in size to France. Besides the significantly larger Ontong Java Plateau (> 1,5 Mill km^2) and the somewhat smaller Hikurangi Plateau (c. 0,35 Mill km^2) it is one of the three "Large

Igneous Provinces" (LIPs) in the Southwest-Pacific (Fig. 3.1). Continental and oceanic LIPs belong to the most extreme volcanic events on earth and have major implications for the short-term mass transfer between mantle and lithosphere and consequently for the heat budget and heat flux in the Earth´s interior. During LIP formation up to several 10 km^3 of volcanic rocks may be produced within a short time period (e.g. Hooper 2000, Self et al. 2008). The presence of a paleo-spreading center, the Osbourn Trough, midway between the Manihiki and Hikurangi plateaus (Fig. 3.1) and evidence that the northern margin of the Hikurangi Plateau is a rifted margin, has led to the proposal that the Hikurangi and Manihiki plateaus might have once been connected (Billen and Stock 2000, Hoernle et al. 2004b, 2010, Downey et al. 2007). It has also been proposed that the Ontong Java, Hikurangi, and Manihiki plateaus formed synchronously at the same time (Greater Ontong Java Plateau Event; e.g. Coffin und Eldholm 1993, Ingle und Coffin 2004, Taylor 2006, Hoernle et al. 2010). If this was the case almost one percent of the Earth´s surface would have been covered by lava within a few million years only. Such extensive volcanism not only contributes significantly to the growth of the earth's crust but also influences the entire Earth system inclusively the evolution of life. Besides the release of huge amounts of climate influencing gases (e.g., CO_2), large LIPs may cause changes of oceanic current systems and of the chemical composition of the sea water. Therefore LIPs could by responsible for changes of the global environment and mass extinctions (e.g. Tarduno et al. 1998, Courtillot et al. 1999, Larson und Erba 1999, Coffin et al. 2006).

The „classic“ model to explain the formation of LIPs is based on the hotspot or mantle plume head hypothesis (e.g. Campbell et al. 1989, Campbell 1998, 2003, Courtillot et al. 2003, Fitton and Godard 2004, Hauff et al. 2000, Hoernle et al. 2010, Ingle et al. 2007, Larson 1991a,b, 1997, Mahoney 1987, Mahoney and Spencer 1991, Mahoney et al. 1993, Tejada et al. 1996, 2002, 2004). Mantle plumes are considered to be cylindrical or pipe-like regions of rising mantle rock several hundred kilometers in diameter. These regions of upwelling mantle, which rise at rates of tens of centimeters per year, extend from a thermal boundary layer within the Earth, such as the core/mantle boundary, to the base of a lithospheric plate. As a result of dynamic uplift of the rising plume material and thinning and heating of the lithospheric plate, a swell or upward bulge is formed in the lithosphere above the plume and melts from the plume ascend to the surface forming volcanoes. It has been postulated that the ascending mantle material forms mushroom-like plume head which may broaden laterally up to 2,500 km when it hits the base of the lithosphere (Griffits and Campbell 1991, Richards et al. 1989). In this initial stage melt production rates above a mantle plume are especially high and many million cubic kilometers of volcanic rocks may form over large areas within a few million years. This process may lead to the formation of LIPs. $^{40}Ar/^{39}Ar$ age dating confirms the geologically extreme short duration of LIP formation for some continental LIPs (e.g., Duncan and Pyle 1988, Peate 1997, Renne et al. 1995). By contrast to the well exposed continental LIPs, however, not much is known about the significantly larger oceanic LIPs. Open questions concern, among others, their internal structure, geochemical heterogeneities, their relationship to local tectonism and, above all, the duration of their formation. Recent studies suggest that some oceanic plateaus being considered as LIPs have not formed within a few million years but over much longer time scales (e.g., over some 10 mill. years). For example, new age data from the Caribbean LIP (Hoernle et al. 2004a), Hikurangi (e.g. Hoernle et al. 2005, 2010), and Manihiki (Ingle et al. 2007, Hoernle et al. 2010, Timm et al. 2011) indicate formation of these LIP over longer time periods or several phases of volcanic activity. In response to increasing problems in explaining LIP formation solely with the plume head model a global debate has developed on the origin of these dramatic volcanic events (e.g., O´Connor et al. 2000, Fitton et al. 2003, Anderson 2003, Coffin 2003, Hoernle et al. 2004a). Alternative models for the formation of oceanic LIP´s propose, for example, (1) plateau formation through increased melt production by plume-ridge interaction (e.g., Mahoney and Spencer 1991; Mahoney et al. 1993), (2) upwelling and subsequent extensive melting induced by the impact of meteorites (e.g., Rogers 1982, Jones et al. 2002, Ingle und Coffin 2004), (3) accumulation of several smaller terranes, formed at different times by intraplate volcanism, to a large plateau by, for example, subduction processes (e.g., Hoernle et al. 2004a) (4) extension and decompression melting (plate separation model; Anderson 1996, 2000, Hames et al. 2000, King and Anderson, 1998), (5) enhanced partial melting due to the presence of eclogite (Cordery et al. 1997, Korenaga 2005, Yasuda et al. 1997), and (6) delamination of subcontinental lithospheric mantle followed by upwelling and decompression melting (e.g. Anderson 2005, Hales et al. 2005).

3.2. THE MANIHIKI PLATEAU

The Manihiki Plateau is located between ~ 3°S and ~ 16°S and ~ 159°W and ~ 169°W (Figs. 3.1 and 3.2). The plateau elevates ~2,000 - ~4,000 m above the Cretaceous Pacific sea floor at a depth of 4,000 - 5,500 m. Numerous seamounts and a couple of small islands and atolls, belonging to the Cook Islands, are situated on the plateau. Its volume is estimated of 8.8 - 13.6 Million cubic kilometers.

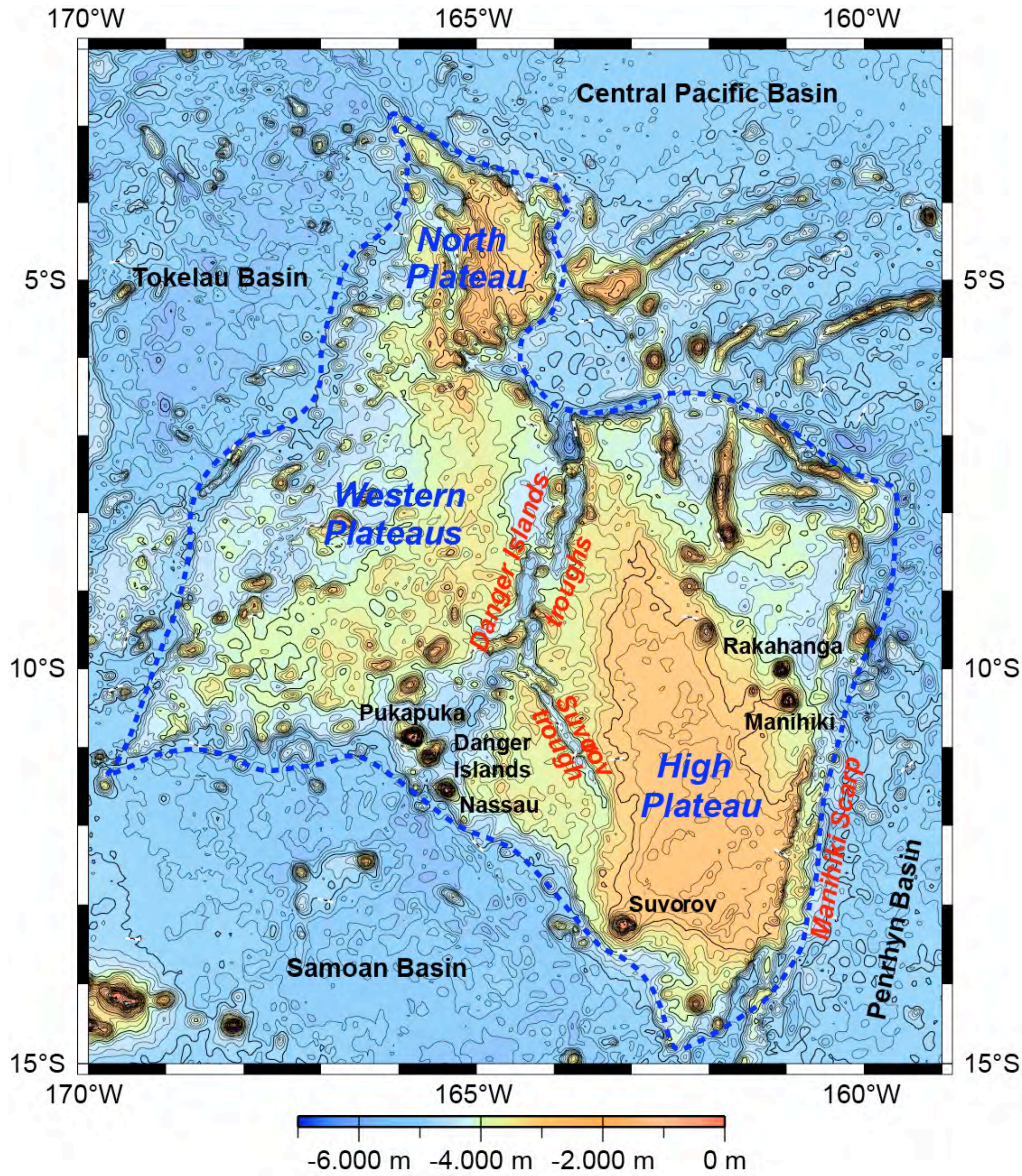

Fig. 3.2: *Predicted bathymetry of the Manihiki Plateau (after Smith and Sandwell 1997). The dashed blue line shows the approximate extend of the plateau, blue labeling its major geomorphological units, and red labeling its major troughs and scarps.*

Prior to SO-224 and SO-225, several cruises in the 1960´s and 70´s, the Deep Sea Drilling Project (DSDP) site 317 and, more recently, the Japanese RV HAKUHO MARU cruise KH03-01 (e.g. Ingle et al. 2007), and the R/V SONNE cruise SO-193 (Werner and Hauff 2007, Hoernle et al. 2010, Timm et al. 2011) investigated the Manihiki Plateau. Winterer et al. (1974) subdivided the Manihiki Plateau into three major geomorphological units: (1) „High Plateau“ in the east, (2) „North Plateau“, and (3) „Western Plateaus“(Fig. 3.2). These units are separated by deep fault systems which are considered to be rift structures (Mahoney and Spencer 1991). Winterer et al. (1974) postulate that the Manihiki Plateau has been formed during active rifting in Barremium when it was at or near the middle Cretaceous triple junction between the Pacific, Antarctic, and Farallon plate. Other authors attributed the formation of the Manihiki Plateau to arrival of a plume head (e.g., Mahoney and Spencer 1991) or to a combination of plume activity and rifting (e.g., Larson 1997). The most prominent fault system are the Danger Islands Troughs which are a large fault-bounded series of en echelon, up to ~6,200 m deep bathymetric depressions, named after the atolls at its southern end. The en echelon basins strike north-south, bifurcate the Manihiki Plateau into the High Plateau to the east and the Western Plateaus to the west, and diverge into the Suvorov Trough and the southern Danger Islands Troughs south of 10°S (Fig. 3.2). SO-193 revealed, that up to 2,000 m thick basement sequences are exposed at the flanks of these faults systems, allowing unique insights into the plateau´s interior (e.g. Werner and Hauff 2007). The igneous basement of the Manihiki Plateau is covered by up to 1 km thick sediments (e.g., Winterer et al. 1974). At DSDP Site 317, being located approximately in the center of the High Plateau, 910 m of sediments and 34 m of the underlying basaltic basement have been cored. Paleontological and volcanological data suggest a formation of the Manihiki Plateau in shallow water depths of possibly less than 400 m (Kauffman 1976, Jackson et al. 1976, Mahoney and Spencer 1991), indicating at least 3,000 m subsidence since its formation.

Prior to the SO-193 cruise, only few samples had been recovered from the Manihiki Plateau. Analyzed and/or dated igneous rock samples only existed from (1) DSDP Site 317 (Hoernle et al. 2010, Jackson et al. 1976, Mahoney and Spencer 1991), (2) a few dredge locations from the 1900 m high Mt. Eddie seamount and from the base of the Manihiki Atoll (Beiersdorf et al. 1995a) and (3) from four locations along the flanks of the Danger Island Troughs (Clague et al. 1976, Ingle et al. 2007). Early age and geochemical data show a wide range in ages from 122 Ma (Mahoney et al. 1993) to 81,6 - 49,5 Ma (Beiersdorf et al. 1995a, b) and a broad variety of compositions, suggesting different or heterogeneous mantle sources and a complex history of the sampled features. The most recent data obtained from the old samples indicate a tholeiitic plateau stage and an alkalic late stage for the Manihiki Plateau (Ingle et al. 2007, Hoernle et al. 2010), as it has also been postulated for the Hikurangi Plateau by Hoernle et al. (2010). SO-193 conducted the first representative hard rock sampling of all major geomorphological units of the plateau as well as of seamounts on adjacent oceanic crust and recovered a broad variety of magmatic rocks (e.g. Werner and Hauff 2007, Werner et al. 2007, Coffin et al. 2007, Hoernle et al. 2010, Timm et al. 2011). Olivine bearing sheet and pillow lavas dominate among these rocks, but various types of volcaniclastic rocks are also common, some of them indicate subaerial or shallow water volcanic activity and/or deposition. The analyses of the rocks obtained during SO-193 indicates formation of the tholeiitic plateau basement between c. 125 and 117 Ma (Fig. 3.3) and a common magma source for the Manihiki, Hikurangi and Ontong Java plateau basements, supporting the model of a "Greater Ontong Java Event" (Hoernle et al. 2010, Timm et al. 2011). Hoernle et al. (2010) postulate that the alkalic late stage volcanism on the plateaus may have been caused by a second large-scale event, which may have been related to the final phase of the Gondwana break-up.

Taken together, previous studies of the Manihiki Plateau and first preliminary results of SO-224 showed that the Manihiki Plateau formed through multiple episodes of magmatic activity (e.g. Ingle et al 2007, Hoernle et al 2010, Timm et al. 2011, Beiersdorf et al 1995a, b, Hoernle et al 2009, Uenzelmann-Neben 2012, Werner et al. 2013). In principle an early tholeiitic, oceanic plateau forming stage between c. 117 and c.125 Ma was followed by probably several late stage magmatic events between 110 and 46 Ma of mainly alkalic composition and presumably low volume. The origin, temporal and spatial evolution of widespread, high volume volcanism during the main plateau forming stage is, however, still unclear and cannot be reconstructed with the available sample set.

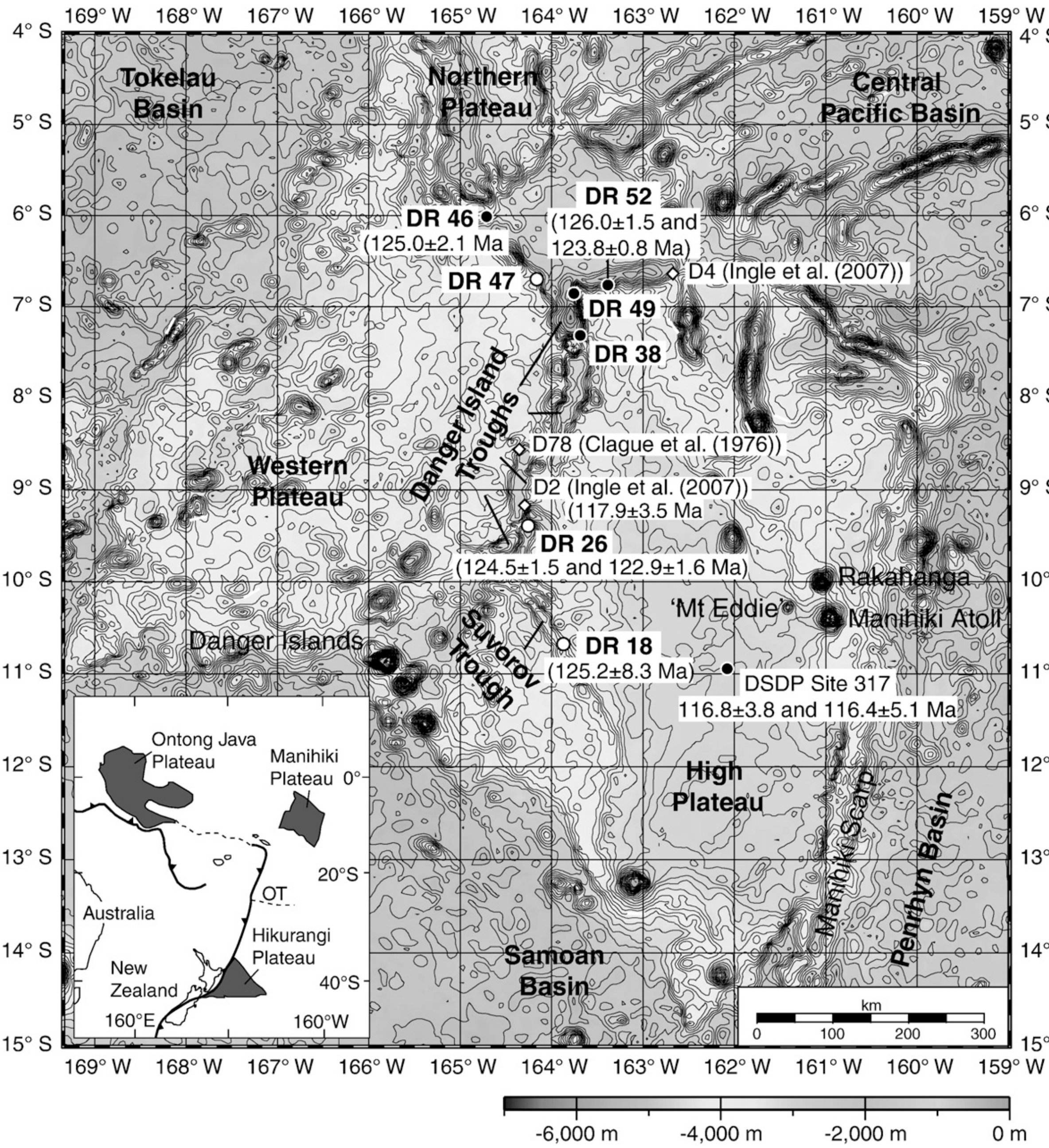

Fig. 3.3: *Overview map of published $^{40}Ar/^{39}Ar$ ages from the oceanic plateau forming tholeiitic stage of the Manihiki Plateau. Also shown are locations of undated tholeiitic rocks which presumably belong to the main plateau building phase based on their chemistry. Figure from Timm et al. (2011) including ages of DSDP Site 317 from Hoernle et al (2011) and D2 from Ingle et al (2007).*

3.3. OBJECTIVES OF HARD ROCK SAMPLING

Why do we study the Manihiki Plateau located far away in the Pacific Ocean? As pointed out above, LIPs represent the largest volcanic events on Earth which may had major implications for the evolution of the Earth but also may have lead to the formation of polymetallic deposits. In general, a better knowledge of LIPs and the processes triggering their formation are essential for a better understanding of the Earth system. To date, however, little is actually known about these huge magmatic events and their origin, evolution, and internal structure as well as their causes and effects on the environment are controversially discussed. In summary, there are still many open questions concerning LIPs which are addressed by the research project MANIHIKI II, in particular since the investigation of LIPs through a combination of age dating, volcanological, petrological, geochemical, and geophysical methods has major implications for the evaluation of plume models and the understanding of mantle dynamics. The Manihiki Plateau is predestinated to shed some light into these questions because SO-193 revealed up to 2,000 m thick lava sequences exposed along fault zones at the Suvorov Trough and Danger Island Troughs, the southern margin of the Northern Plateau and the northern margin of the High Plateau, allowing unique insights into the plateaus interior. Therefore the hardrock sampling strategy of SO-225 concentrated on these areas in order to deliver an extended suite of basement rocks from the plateau forming stage by stratigraphically controlled sampling which should enable a detailed work out of the magmatic and chemical stratigraphy for selected areas by means of geochronology, petrology and geochemistry.

Major questions to be addressed by the SO-225 hard rock sampling and subsequent shorebased research in the home institutes include:

(1) How was the detailed temporal course of the formation of the Manihiki Plateau basement? Comparison and extrapolation of the sampled stratigraphic sequences and their geochronology with the seismic profiles yielded on SO-224 should contribute to a better understanding of the large-scale evolution of the plateau forming stage. With this approach it should be possible to clarify, if the plateau basement has been formed by a single large event (corresponding to the classic model) or over a longer time interval and by multiple magmatic events, respectively (as it seems to be the case for the Hikurangi and Caribbean LIP basement, see above). Furthermore it should be determined, if temporal differences exist in the basement evolution of the major geomorphological units of the plateau.

(2) Are there compositional variations during the formation of the plateau basement and how homogeneous or heterogeneous are oceanic LIPs? Available data from the Hikurangi, Manihiki and Ontong Java LIPs reveal striking similarities in the composition of their plateau phases, even though Manihiki shows so far the largest compositional range. The Manihiki II project aims to determine spatial and temporal compositional variations within the plateau basement and to evaluate their correlation with the temporal evolution of the plateau formation. In addition possible rifting events should be identified and dated.

(3) In which paleo-environment has the Manihiki Plateau basement been formed? Did the volcanic activity take place in shallow water conditions as suggested by prior studies for some areas of the plateau (see above)? The paleo-environment and possible changes of the environment during the plateau formation should be reconstructed based on structure, texture, and volatile content of volcanic rocks. This approach also aims to complement the geophysical studies of SO-224.

(4) What was the environmental impact of the large volcanic eruptions which formed the Manihiki Plateau? A better knowledge of the temporal evolution, rates of magma production, composition of the erupted magmas, and paleo-environment of the (mega-) eruptions is essential to evaluate the effects of the plateau formation on the hydrosphere and atmosphere and therefore of the evolution of the Earth. On the other hand these information is crucial to better estimate what is the resource potential of these huge magmatic events.

(5) How is the internal structure and stratigraphy of the Manihiki plateau basement? The scarps of the Manihiki Plateau provide a perfect opportunity to characterize the internal structure of an oceanic LIP by modern observation and sampling devices (i.e. ROV).

The integration of the scientific results from SO-224 and SO-225 with existing data from the West Pacific large igneous provinces Manihiki, Hikurangi, and Ontong Java will contribute towards a better understanding of the origin and effects of volcanic mega events and the formation of large igneous provinces.

3.4. PALEOCEANOGRAPHIC OBJECTIVES

The paleoceanographic studies intend to reconstruct the dynamics and development of the West Pacific Warmpool (WPWP, Fig. 3.4) in the Pleistocene / Pliocene, in particular the changes of the thermocline due to intermediate water masses entering from the south via „ocean tunneling". In addition, the joint research project Manihiki II contributes to the „Pre Site Survey" for IODP Drilling Proposal 620 „Cretaceous igneous and paleoceanographic events recorded at Magellan, Manihiki, and Hikurangi Plateaus, central Pacific Ocean".

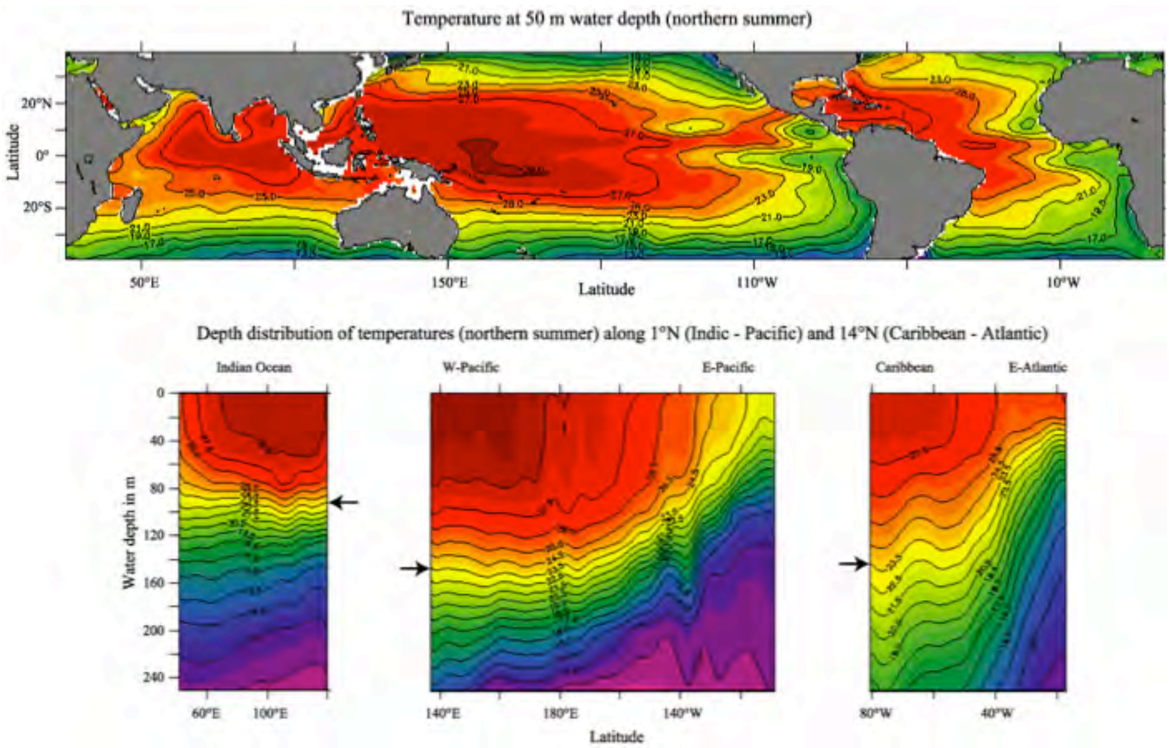

Fig. 3.4: *Above: Mean annual temperatures of the world ocean at 50 m water depth (World Ocean Atlas, www.nodc.noaa.gov). The West Pacific Warmpool is clearly visible. Below: Thermocline structure of the Indian, Pacific, and Atlantic Ocean.*

Pleistocene evolution of the W Pacific Warmpool

The Manihiki Plateau is located at the southeastern margin of the WPWP and hence, is a key area to address questions concerning the Plio/Pleistocene dynamics of the warmpool, its climatic relevance, and the existence of ocean tunnels (Fig. 3.5). Paleoclimatic models and some studies on sediment cores from the equatorial E-Pacific highlight the “ocean tunnel” as a key mechanism to explain Pleistocene changes in the biological pump and thermocline depth (Gu und Phillander, 1997; Barnett et al., 1999; Liu and Yang 2002). A direct link between the tropical climate system and the high southern latitudes, and hence evidence for extratropical climate forcing, however, is still missing. The following topics will be addressed in MANIHIKI II, for which an ambitious water and sediment sampling program was pursued during SO-225:

WPWP dynamics:

- How did the WPWP climatically and oceanographically develop throughout the Pleistocene?
- Did oceanographic gradients exist, crossing the WPWP in lateral (N-S) direction?
- Were sea-level induced changes in the Indonesian Throughflow responsible for a warming or cooling of the WPWP?
- Did changes in the Indonesian Throughflow influence the WPWP thermocline structure sustainably?
- Did the surface ocean circulation in the W-Pacific (e.g EAC, Kuroshio) and E-Indian ocean change synchronously to the Pleistocene evolution of the WPWP?
- How did the temperature gradient between the WPWP and West-Atlantic-Warm-Pool change on orbital timescales? Did the gradient change have provable influence on the formation of tropical storms in the equatorial N Atlantic?

We intend to yield new and improved insight by comparing our SO-225-records from Manihiki-Plateau to paleoceanographic records from Manihiki Plateau (DSDP Site 317), Ontong-Java-Plateau (ODP Site 806, Lea et al., 2000), the Tasman See (ODP Site 1172, DFG Project Nu60/7-3), Indian ocean northwest off Australia (IMAGES-Core MD01-2378, DFG-Project KU649/25-1) and from the Gulf of Mexico (IMAGES-Core MD02-2575, DFG-Project Nu60/8-1).

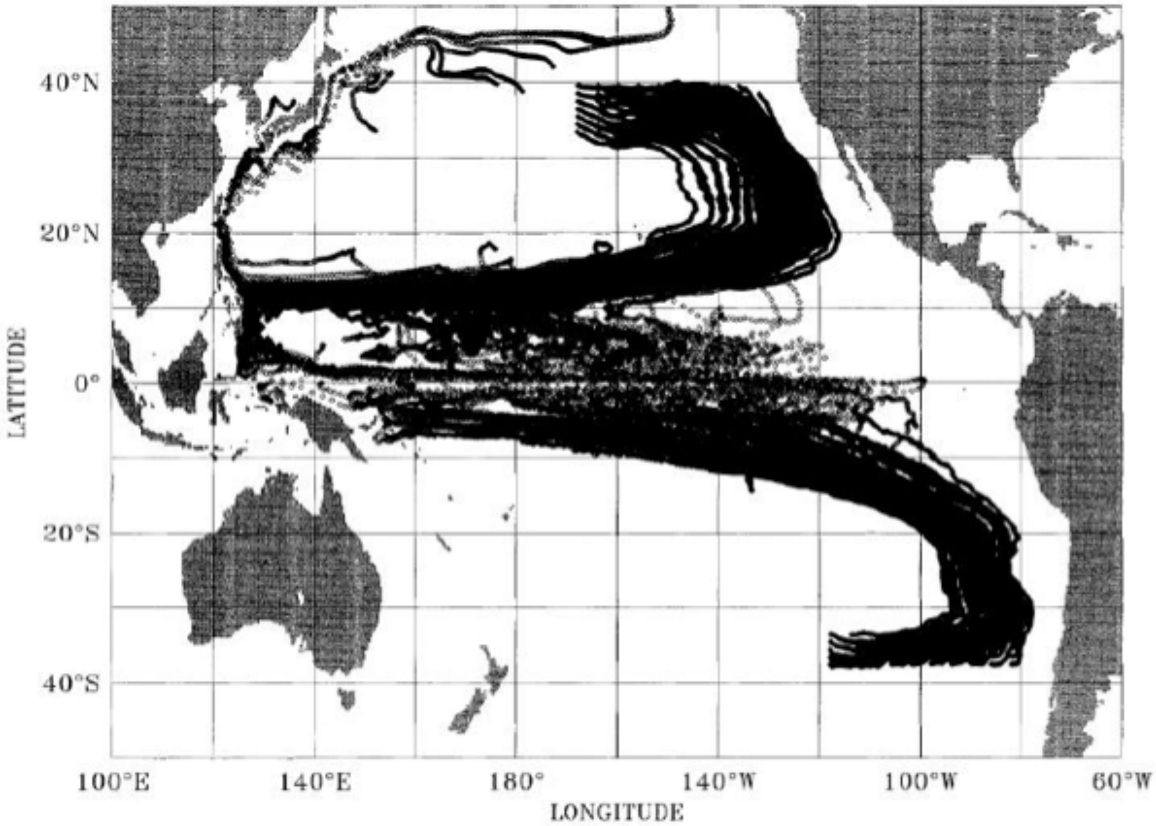

Fig. 3.5: *Ocean tunnel: Modeled particle transport from mid northern and southern latitudes of the Pacific towards the equatorial area (Harper 2000). These „ocean tunnel“ pathways significantly affect the thermocline structure of the West Pacific Warmpool.*

"Ocean tunnel"

- Was the tropical climate during the Pleistocene controlled by extra-tropical climate forcing mechanisms?
- Are the postulated "ocean tunnels" traceable with paleoceanographic methods?
- Did the inflow of extra-tropical intermediate water masses via "ocean tunnels" into the Equatorial Undercurrent (EUC) influence the thermocline structure and the paleoproductivity in the equatorial Pacific?
- May the cooling of the sub-tropics via ocean tunnels, accompanied by changes in the thermocline temperature, have caused a change in the temperature gradient between the E Pacific and the W Pacific and hence, may haved affected the "El-Niño – Southern Oscillation" (ENSO)?
- Did advances of subantarctic water masses influence the nutrient budget and hence, the biological pump in the area of the Equatorial Divergence?

We will receive new insight by comparing our sediment records from Manihiki Plateau, where it is suspected that large advances of southern component water masses contributed to the EUC, with records from the Southern Ocean and the eastern flank of the Subtropical Gyre (ODP Site 1236).

3.5. PALEOCEANOGRAPHIC BACKGROUND

A Pleistocene dynamics of the West Pacific Warmpool

The evolution of the WPWP, the largest oceanic warm-pool on earth (Fig.1), is of key importance for both the meridional ocean-atmosphere heat-transport and global climate. The WPWP formed already in the middle Miocene accompanied by the progressive closing of the Indonesian gateway. It plays an important role for the temperature gradient between the eastern and western equatorial Pacific and hence, for the dynamics of the El Niño Southern Oscillation (ENSO). Its long-term and short-term variability is related to the throughflow of water masses from the Pacific into the Indian Ocean (Australian Mediterrane Water, AAMW). These changes on millennial to orbital time-scales are mainly caused by changes in the thermohaline circulation, global ice volume (sea-level change), and trade winds. Hence, the thermal development of the tropical ocean is regulating global climate change (Bacastov, 1996), mainly via atmospheric teleconnections (e.g., Lau, 1997). Whether the tropic climate system is controlled by extra-tropical climate forcing, either by the Hadley-circulation (Lau, 1997) or by "ocean-tunnels"(Toggweiler et al., 1991; Liu and Yang, 2002) is widely discussed and has only been studied by oceanic/atmospheric climate models (Barnett et al., 1999; Gu and Phillander, 1997; Liu and Yang 2002). The models suggest that both high latitudes and the tropics have rather similar climate controlling effects on each other (e.g., Alexander et al., 2002; Lee and Poulsen, 2005; Chiang and Bitz, 2005).

Ocean tunnels – the impact of the Southern Ocean on equatorial ocean temperatures

Liu and Yang (2002) suggested first that the ocean temperature of the tropical thermocline is controlled mainly by water mass exchange via "ocean tunnel" between the Southern Ocean and the equatorial ocean regions. Notably, Southern Ocean surface water masses are subducted ("thermocline ventilation") and transported northwestward as Subantarctic Mode Water (SAMW) on defined pathways ("ocean tunnels") along the Subtropical Gyre, across Manihiki Plateau and subsequently into tropical regions (Fig. 3.5). These intermediate water masses feed the eastward directed Equatorial Undercurrent (EUC), the upper boundary of which aligns with the thermocline. The EUC, subsequently, builds the source of upwelled water masses in the E-Pacific. According to Sun et al. (2004), both the subtropical cooling caused by the "tunnel-effect" and the change in thermocline temperature may affect the "El Niño–Southern Oscillation" (ENSO) phenomenon. In fact, a cooler EUC causes upwelling of cooler water masses in the equatorial E Pacific. The lowered E-Pacific sea-surface temperatures, in turn, amplify the ocean surface temperature gradient between the E and W Pacific and hence, affects ENSO. It is further suggested that the supply of nutrients via "ocean tunnels" change the nutrient budget of the upwelled equatorial water masses and hence, the biological pump. The "ocean tunnel" apparently affects the global carbon cycle by connecting the Southern Ocean, which is a sink for atmospheric CO_2, and the equatorial Pacific representing an important source for atmospheric CO_2. Changes in the Southern Ocean marine productivity and nutrient utilization in consequence, should be closely related to changes in productivity in the equatorial upwelling regions.

The influence of the WPWP on surface circulation patterns

Ocean models (Ocean General Circulation Model, OGCM) indicate that a reduced water mass throughflow from the Pacific into the Indian Ocean cause sea-surface cooling in the Indian Ocean and warming in the W-Pacific, with most pronounced changes in the thermocline. The warming of the WPWP may then cause the intensification of the Kuroshio and the East Australian Current (EAC). Whether sea-level induced variations of the Indonesian throughflow cause a significant and sustainable warming or cooling of the WPWP and hence, a change of the thermocline structure especially in the northern WPWP needs to be investigated.

It is also still unknown whether lateral oceanographic gradients within the WPWP were existent during the Pliocene and Pleistocene. We here intend to study the poorly studied southern margin of the WPWP. This region, in particular, is sensitive to sea-surface temperature fluctuations being related to either the retraction or expansion of the southern margin of the WPWP. Since past studies focused mainly on the central WPWP and its temperature gradient towards the equatorial upwelling region in the E Pacific (e.g., de Garidel-Thoron et al., 2005; McClymont and Rosell-Melé, 2005), it still remains unclear whether the Plio/Pleistocene variations of the WPWP sea-surface signature developed symmetrically and synchronously on both hemispheres. Furthermore, our studies will provide insight into the long-term development of the temperature gradient between the WPWP and the West Atlantic Warmpool (WAWP) on orbital time scales. According to Latif et al. (2007), the modern temperature gradient between the Indopacific and the tropical Atlantic is responsible for the vertical wind shear and hence, causes tropical storms in the tropical N Atlantic (Latif et al., 2007).

4. CRUISE NARRATIVE

(R. Werner, D. Nürnberg, F. Hauff)

The starting point of R/V SONNE expedition SO-225 was the port of Suva on Viti Levu island (Fiji). After 48 hours of travel the first group of scientists, engineers, and technicians from Germany arrived safe but somewhat tiered in Suva in the late evening of Saturday the 19th of November. There, the unloading of nine containers with scientific equipment for SO-225 and the mobilization of the remotely operated vehicle ROV Kiel 6000 kept us busy during the following days. In the evening of November 19th, the remaining scientists arrived in Suva, finally completing the scientific party of the SO-225 expedition. In tropical heat and occasionally heavy rain showers we managed to finish all port related cruise preparations on time thanks to the excellent support from the SONNE crew. Approximately one hour after a test program of the ROV was successfully completed, R/V SONNE left Suva on November 21st and headed towards the Manihiki Plateau, located ~1,000 nm to the northeast of Fiji in the area of the northern Cook Islands (Fig. 4.1).

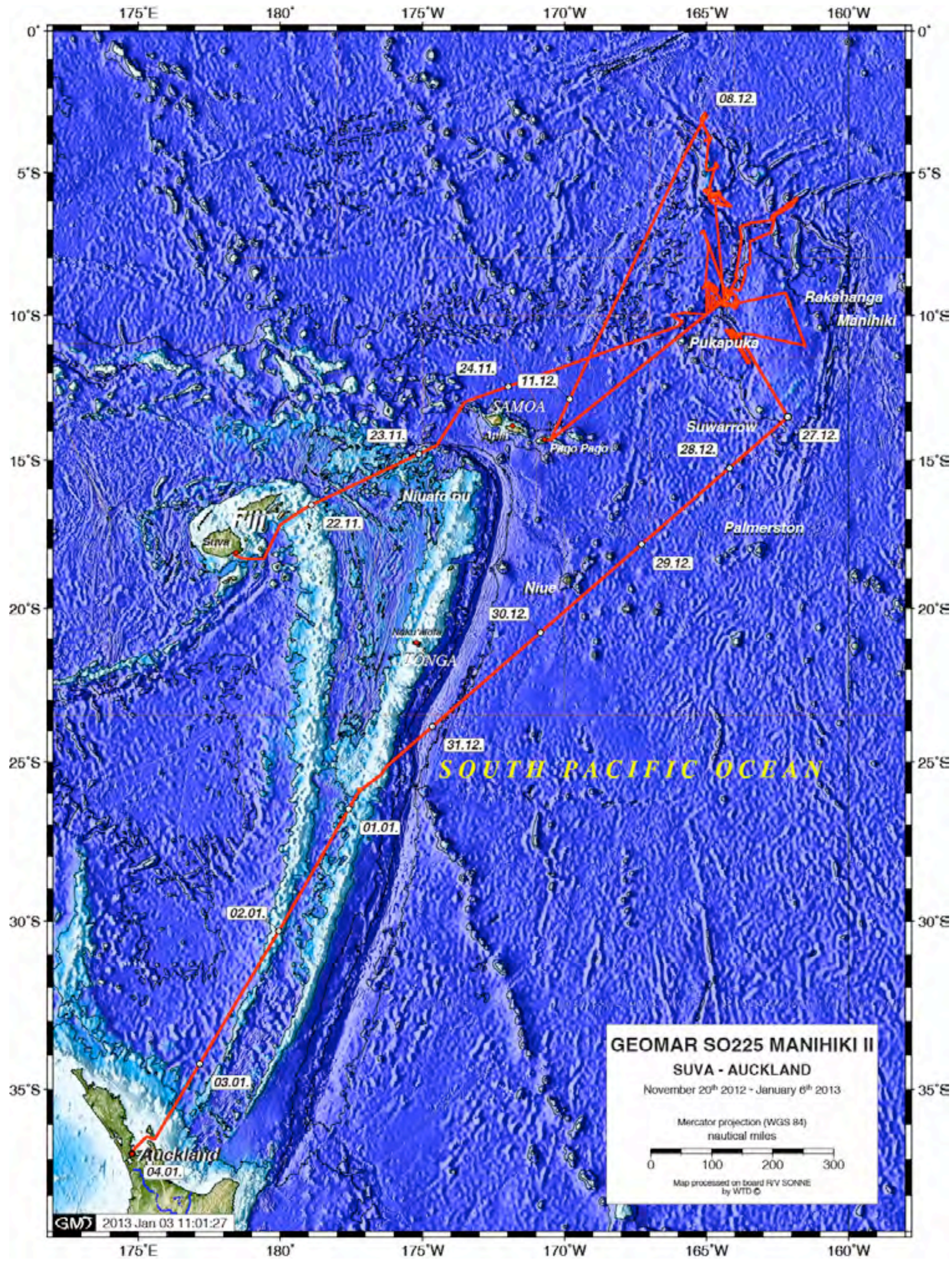

Fig. 4.1: *Cruise track of SO-225.*

The four days of transit to the Manihiki Plateau were used by the scientists to accommodate on board, to unpack the equipment, and to setup the labs and the ROV. In the night from November 25th to 26th, R/V SONNE arrived at the Western Plateaus of the Manihiki Plateau and headed for a seamount, which has already been investigated on cruise SO-193 in 2007. The data compiled on that cruise show that the top region of this seamount is a large plateau covered by thick sediment layers. Here, we conducted the first coring station of our cruise in 1,500 m water depth. At each coring station, we commonly deployed one to two piston corers to recover sediment cores as long as possible. Additionally, the multi-corer was run to sample bottom water and the sediment surface (Fig. 4.2), which is usually destroyed in the cores recovered by piston corer. At the first station, unfortunately, the foraminiferal sand turned out to be difficult to sample as it was easily washed out during heaving of the sampling tools. Finally, we managed to obtain a core as well as samples form the sediment surface (Figs. 4.2 and 4.3). Furthermore, we sampled and analyzed the water column in various depths from the ocean floor up to the water surface using a CTD (Conductivity, Temperature, Density) and a rosette water sampler.

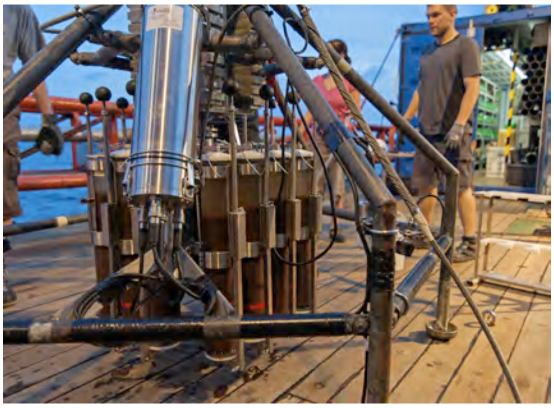

Fig. 4.2: *Samples of the sediment surface yielded with a multi-corer (photo: Torsten Bierstedt).*

Fig. 4.3: *Scientists investigate sediment cores in the geology lab on board R/V SONNE and prepare them for subsequent shore based research in the home institutes (photo: GEOMAR).*

During the following days, we gave priority to further coring stations located on a N-S-profile across the Western Plateaus, since a dive with the ROV Kiel 6000 had to be cancelled due to unforeseeable technical problems. Sediment sampling at these stations was very successful and yielded up to 16 m long sediment cores. On Friday, November 30th, R/V SONNE sailed back to the Danger Island Troughs, where several ROV dives were scheduled. In the morning of December 1st, we were able to conduct the first ROV dive of the cruise thanks to the tireless commitment of the GEOMAR ROV team. The dive covered a depth profile extending from 3,500 to 3,000 m water depth across the steep upper slope of the central basin of the Danger Island Troughs. The images taken by the ROV from the sea floor reveal a spectacular rough landscape and *in situ* rock successions were just right for the planned systematic sampling, but turned out to be extremely solid and robust (Fig. 4.4). Nevertheless, we were able to recover rock samples thanks to the skillful handling of the manipulator by the ROV pilots.

The first two weeks of SO-225 also let us recognize that the sun does not always shine in the equatorial Pacific. Quite often short, but very intense rain showers surprised us. This and the burning heat made work on the aft deck somewhat unpleasant. Overall, we enjoyed the warm tropical evenings with now and then spectacular sun sets.

In the 3rd week SO-225 focused on the northernmost part of the Manihiki Plateau, the North Plateau, and the ocean floor between Manihiki and the equator. On Monday and Tuesday, two dives with the ROV Kiel 6000 have been conducted in order to sample a c. 3 km long profile reaching from 4,600 m up to 3,260 m water depth across the flank of the south-eastern foothills of the North Plateau. The pictures from these slope provided by the ROV show a rough, chaotic landscape dominated by steep slopes, small sediment-covered terraces, canyons, and ridge-like structures. Large parts of the slope are covered with rock debris including up to several meter-sized blocs. In between the debris bizarre rock formations are frequently exposed and consist of pillow lava, breccias, and massive rocks. Altogether 28 rock samples have been taken by the ROV during the two dives (Figs. 4.5).

Fig. 4.4: *Rock sampling in 3,500 m water depth using ROV Kiel 6000. A conventional chisel hold by the manipulator of the ROV turned out to be a useful tool for rock sampling (photo: GEOMAR).*

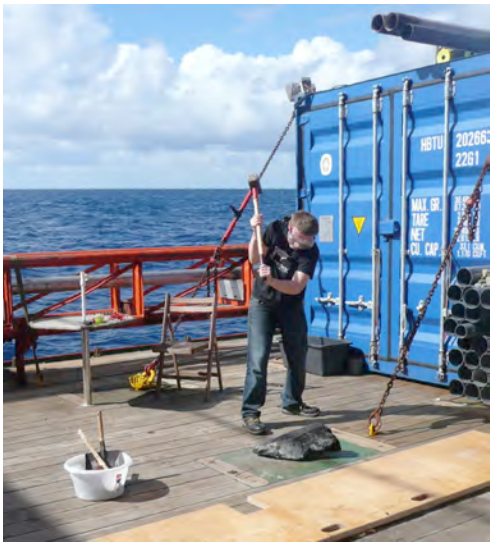

Fig. 4.5: *Some ROV samples are too big and must be crushed with a sledge-hammer prior to further processing (photo N. Furchheim).*

The remaining week was under the lead of the paleoceanography working group. A coring station on the southeastern part of the North Plateau was the beginning of a series of 4 coring sites along a N-S-trending transect, which ended ca. 330 km south of the equator. In the night from Saturday to Sunday we deployed the multi net which can sample plankton from varying water depths and should serve for proxy calibration studies. The multi net has been lowered 7 times up to 500 m water depth and sampled, besides larger organisms like Copepoda, large amounts of plankton from the water column of the nutritious, equatorial water masses. In the early afternoon of Sunday, December 9th, the studies in the north of the Manihiki Plateaus were completed with a final piston corer deployment.

In the 4th week, SO-225 did not remain on „the sunny side of the street" as before. After an unexpected stop-over at Pago Pago on American Samoa at the beginning of the week, we experienced the effects of the tropical cyclone „Evan", which caused large damage in Apia, the capitol of the Republic of Samoa. Luckily, we were not close enough that „Evan" could threaten us heavily, but station work was hampered and delayed. During the second half of the week we concentrated on mapping the ocean floor in the central and northern parts of Manihiki Plateau using multi-beam and sediment echosounding techniques. Unfortunately, we remained unlucky during the course of the week. After having left the influence of „Evan", we realized that the POSIDONIA antenna mounted below the ship was severely damaged, possibly by floating refuse. POSIDONIA is necessary for operating and navigating our ROV. As we were not able to repair the antenna aboard R/V SONNE, we could no longer operate the ROV, but instead we decided to run dredges to recover hard rock from the seafloor. Thanks to the crew of R/V SONNE, we managed to change equipment during calm weather conditions on Sunday, December 16th. Nevertheless we were very positive that the combined use of both ROV and dredges will allow us to fulfill the petrologicial part of MANIHIKI II. Since SO-225 focuses on the temporal evolution of the basement at Manihiki Plateau, we intended to considerably broaden the range of samples by dredging. Late Sunday afternoon, the first dredge haul was successfully accomplished at the northern margin of Manihiki Plateau. Meanwhile the paleoceanographic working group concentrated entirely on laboratory work. That included cutting of the cores (Fig. 4.6) and documentation by photography, visual core description, sampling of sediment records, and continuous core-logging techniques which included measurements of magnetic susceptibility and color and lightness of the sediment.

Fig. 4.6: *Cutting sediment cores during SO-225. The light sediments consisting primarily of calcitic microfossils, are cut into cm-slices (photo: GEOMAR).*

Fig. 4.7: *Scientists study rock samples yielded by dredging (photo: GEOMAR).*

At the beginning of the 5th week of SO-225 we finished rock sampling along the northern margin of the High Plateau. Afterwards R/V SONNE sailed to the northern end of the Danger Island Troughs. On Tuesday, December 18th, the deepest dredge haul of this cruise has been carried out at a small ridge located in the center of the northernmost basin in more than 5.800 m water depth. The dredge, however. returned only a few heavily altered lava fragments and lithified sediments. Two dredges conducted in an adjacent trough yielded similar results. Therefore we decided to continue further south, where a SO-193 dredge haul yielded particularly interesting, c. 120 m.y. old rocks of the plateau basement and where a seismic profile conducted on the previous cruise SO-224 showed exposed plateau basement. Here, we carried out 11 dredge hauls in 4,800 to 3,000 m water depth between the early morning of Wednesday, December 19th, an Friday evening (Fig. 4.7). A structure of most likely tectonic origin, characterized by several terraces along its southwestern slope, has been studied particularly intense, through systematic sampling of the cliffs below each terrace. Some 15 nm further north, two dredge tracks not only recovered lava and sediments, but also metamorphically overprinted rocks. Finally, we dredged samples from the western and eastern flanks of Danger Island Troughs, at the intersection with detailed seismic profiles of SO-224. Complementing mapping of the ocean floor and sediment echo sounding, a total of 17 dredges have been carried out during the first five days of this week. On December 21st, we celebrated that earth did not tumble down as predicted by the Mayan calendar, together with the birthday of a colleague in the seismic laboratory.

At the very end of the 5th week, the paleoceanography group started again, carrying out 2 coring stations on the High Plateau. Site selection was based on seismic profiles from SO-224. Unfortunately, sediment recovery was not as easy as thought, with some coring failures and loss of equipment probably due to the hard and lithified sediment even at very shallow core depths. After many attempts at extremely hot conditions on the working deck, we were finally paid off with a high quality sediment record.

In the 6th week, the station work was continued by several dredge hauls at the Suvorov Trough. The unusual, for this region, Russian name of the trough derives from a nearby atoll that was discovered in 1814 by the crew of the Russian ship „Suvorov“. The major target of dredging at the Suvorov Trough was to recover an as wide as possible spectrum of rocks from a presumably tectonically formed, east-west striking ridge. In total, we carried out five dredge hauls at this ridge which yielded a broad variety of magmatic rocks. Besides dredging, we closed some gaps in the available multi-beam map of the Suvorov Trough. By this, we hoped to identify further (tectonic?) structures to be sampled, but unfortunately did not make a strike.

And then of course there was Christmas. As still parts of the Suvorov Trough had to be mapped with our echo-sounding devices, station work was interrupted and we took the chance during profiling to celebrate Christmas jointly. On Christmas Eve, sausages with potato salad and mulled wine, a traditional German meal, was served, followed by the opening of Christmas presents. Afterwards we spent a pleasant evening on deck in the balmy tropical night. On Christmas Day we had a banquet with the traditional roasted goose with that our cook has again surpassed himself. After a short lunch break, the Christmas celebration was over and we continued dredging.

After the final, full dredge (Fig. 4.8) at Suvorov Trough on December 26th, which was the last dredge of the cruise, R/V SONNE sailed southeast for the final coring site on High Plateau. This station was quite important as it represents the southernmost location of our N-S-striking coring transect across Manihiki Plateau. We hoped to be more successful than on the previous coring stations further north on High Plateau. At the beginning, however, coring did not look promising. Both, multi-corer and gravity corer certainly gained sediments but overall sediment recovery was rather disappointing. Apparently, sampling of sediments in this area is as difficult as further to the north. Nonetheless, the paleoceanography group made a final attempt with a 15 m long piston corer - and had success! A more than 12 m long undisturbed sediment core returned, a great achievement in this rather un-sampled ocean area and hence, the culmination of SO-225 sediment sampling.

Fig. 4.8: *A dredge full to the top was the culmination of rock sampling on SO-225 (photo: GEOMAR).*

After a final CTD deployment in the evening of December 27th, R/V SONNE started the almost 2,000 nm long transit to our final destination Auckland, located on the northern island of New Zealand (Fig. 4.1). Among others, the transit was used for preliminary studies of the samples and their preparation for the analyses in the home labs. Furthermore writing of reports, the big cleaning, and packing was on the agenda during the transit. In the evening of December 31st of course we have celebrated New Year on the colorful decorated working deck with a BBQ and thereupon a party at New Year Eve.

The scientific work of SO-225, however, was not completely finished yet. On request of colleagues from Kiel we intended to map the submarine volcano Monowai en route. Monowai is located in the Kermadec-Tonga Arc, which extends from south of Samoa to New Zealand. The Kermadec-Tonga subduction zone is marked by powerful and quite explosive volcanism. R/V SONNE already passed large amounts of floating pumice on its way to the arc. We could manage it to collect some pumice out of the water (Fig. 4.9). With that we will try to reconstruct the origin of this pumice in our home lab. In the early morning of New Year´s Day R/V SONNE arrived at Monowai, which already has been mapped and investigated on several earlier expeditions. According to the newest data compiled in 2011, its top rises already 60 m beneath the water surface. Our renewed mapping should contribute to a time series of maps which continuously document the evolution of the volcano. A light discoloration of the water and faint rumble indicated slight activity of Monowai when we were approaching its top (Fig. 4.10). During profiling close to the top area, however, a sudden and significant increase in volcanic activity with explosive hydroclastic eruptions was accompanied by thunder and shock waves rapidly spreading out on the water surface. That hindered us in mapping the top area but was a very impressive experience for all of us.

Fig. 4.9: *Pumice of unkown origin, sampled at the Kermadec-Tonga Arc from the water surface of the Pacific (photo: GEOMAR).*

Fig. 4.10: *Yellowish colored water by volcanic activity above the top of Monowai volcano (photo: Torsten Bierstedt).*

In order to preempt an upcoming cyclone, R/V SONNE entered the port of Auckland already in the afternoon of January 4th and so a bit earlier than originally planned. After packing of several containers, the SO-225 scientists disembarked on Sunday, January 5th and looked back on a long, memorable cruise which was characterized by several problems but also by great success and surprising events.

Complementing 2,930 nm multi-beam mapping and 2,250 nm sediment echo-sounding, a total of 62 deployments of various devices have been carried out during R/V SONNE cruise SO-225. Ten of 11 multi corers yielded sediment samples, 16 piston corer and 3 gravity corer deployments recovered altogether 131.6 m sediment cores. Foraminiferal sand and ooze dominate among the sediment samples, some cores also contained nanno ooze. The sampling of the water column by CTD and multi net was successful. Four ROV dives yielded 32 rock samples and 23 dredge hauls have been conducted in an average water depth of 4,380 m. Of these, 20 delivered magmatic rocks, 12 volcaniclastics, 8 sedimentary rocks, and 13 Mn-Fe-Oxide crusts.

5. BATHYMETRY AND ROCK SAMPLING

(F. Hauff, M. Portnyagin, R. Werner, R. Golowin, S. Hauff, N. Furchheim, M. Anders, A. Peukert, F. Abegg and ROV-Team)

5.1. METHODS

5.1.1. Bathymetry (Kongsberg EM120)

Data acquisition

Since June 2001 the R/V SONNE has been equipped with a Kongsberg EM120 multi-beam echo sounder system (Kongsberg) for continuous mapping of the seafloor. The Kongsberg EM120 system consists of several units. A transmitter/receiver transducer array is fixed in a mills cross below the keel of the vessel. A preamplifier unit contains the preamplifiers for the received signals. The transceiver unit contains the transmitter and receiver electronics and processors for beam-forming and control of all parameters with respect to gain, ping rate and transmit angles. The system has serial interfaces for vessel motion sensors, such as roll, pitch and heave, external clock and vessel position. The system also includes a Intel based (Windows XP) operator station. The operator station processes the collected data, applying all corrections, displays the results and logs the data to internal or external disks. The EM120 system has an interface to a sound speed sensor, which is installed near by the transducers.

The Kongsberg EM120 system uses a frequency of about 12 KHz with a whole angular coverage sector of up to 150° (75° per port-/starboard side). When one ping is sent, the transmitting signal is formed into 191 beams by the transducer unit through the hydrophones. The beam spacing can be defined in equidistant or equiangular modes or in a mix of both. The ping-rate depends on the water depth and the runtime of the signal through the water column. The variation of angular coverage sector and beam pointing angles was set automatically. This optimized the number of usable beams.

During a survey the transmitter fan is split into individual sectors with independent active steering according to vessel roll, pitch and yaw. This forces all soundings on a line perpendicular to the survey line and enables a continuous sampling with a complete coverage. Pitch and roll movements within ±10 degrees are automatically compensated by the software. Thus, the Kongsberg EM120 system can map the seafloor with a swath width about up to six times the water depth. The geometric resolution depends on the water depth and the used angular coverage sector and is less than 10 m at depths of 2,000 - 3,000 m.

The accuracy of the depth data obtained from the system is usually critically dependent upon weather conditions and the use of a correct sound speed profile. During SO-225 sound profiles have been used recorded on SO-224 and SO-225 in the working area, ensuring the use of the correct sound velocity on this cruise.

Data processing

The collected data were processed onboard with the EM120 coverage software. The post-processing was done on two other workstations by the accessory Neptune software. The Neptune software converted the raw data in 9 different files which contains information about position, status, depth, sound velocity and other parameters and are stored in a SIMRAD binary format.

The data cleaning procedure was accomplished by the Neptune software. The first step was to assign the correct navigational positions to the data without map projections. The second step was the depth corrections, for which a depth threshold was defined to eliminate erratic data points. In the third part of post-processing statistical corrections were applied. Therefore, a multitude of statistical functions are available in a so called BinStat window where the data are treated by calculating grid cells with an operator-chosen range in x and y direction. Each kind of treatment is stored as rule and has an undo option. For the calculation the three outermost beams (1 - 3 and 188 - 191) were not considered. Also a noise factor, filtering and a standard deviation were applied to the calculated grid. All this work was done by the system operators of RV SONNE. After the post-processing the data have been exported in an ASCII x,y,z file format with header information and it was transferred to other workstations where assembling, girding and contouring with the GMT software (Wessel and Smith 1995) and/or Fledermaus version 7 by Interactive Visualization Systems Inc. were done.

5.1.2. Deployment of ROV (Remotely Operated Vehicle) KIEL 6000

(F. Abegg, M. Bodendorfer, P. Cuno, J. Hennke, H. Huusmann, A. Meier, M. Pieper, I. Suck)

ROV KIEL 6000 is a 6000 m rated deep diving platform manufactured by Schilling Robotics LLC, Davis, USA. It is based on commercially available ROVs, but customized to research demands, e.g. being truly mobile. *KIEL 6000* has been operated from a variety of different national and international research vessels (R/V SONNE, N/O L'ATALANTE, R/V MARIA S. MERIAN, R/V METEOR, R/V CELTIC EXPLORER, RRS JAMES COOK, and R/V POLARSTERN) until today as an electric work class ROV of the type QUEST, this is build No. 7. *ROV KIEL 6000* is based at the Helmholtz Centre for Marine Sciences GEOMAR in Kiel, Germany.

ROV KIEL 6000 is equipped with a tool skid containing 2 drawers onto which a variety of tools to customers demand can be mounted.

Including this cruise, ROV KIEL 6000 has accomplished 169 dives during 15 missions. During SO-225 4 scientific dives (Tab. 5-1) were completed. Maximum diving depth was 4,800 m and maximum bottom time was 6:07 hours. In total, bottom time accumulated to approx. 17 hours (total dive time approx. 31 hours). This very low number of dives is related to several reasons which are explained in the cruise narrative. Major reason was a failure of the ships POSIDONIA underwater navigation system, most probably due to damage of the plug by floating particles.

Fig. 5.1: *Drawer setup of ROV KIEL 6000 during SO 225 (photo: GEOMAR)*

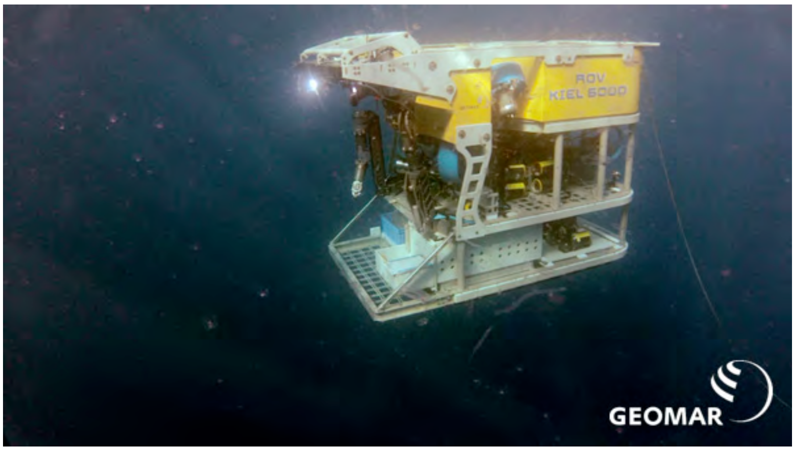

Fig. 5.2: *Underwater impression of ROV KIEL 6000. (photo: GEOMAR)*

ROV Tasks during SO-225

The major task of *ROV KIEL 6000* during SO-225 was to stratigraphically sample hard rocks at the Manihiki Plateau. The sampling setup (Fig. 5.1) was chosen to create as many separate boxes for samples as possible in both drawers, allowing to sample rocks of various sizes. Besides the two manipulators, a chisel was used to loosen parts of the rocks. The samples were collected using the ORION manipulator, photo-documented and stored in a box compartment (for more details see chapter 5.2.1).

Additionally, underwater video footage of the ROV in action were taken during one short surface dive (Fig. 5.2).

Table 5-1: ROV station list SO-225.

Station Number SO225	Dive No.	Date	Time Start (UTC)	At Bottom (UTC)	Off Bottom (UTC)	Time End (surface) (UTC)	Location	Depth (m)	ROV Bottom Time
	165	22.11.2012	Harbour Test Suva, Fiji						
1	166	27.11.2012	19:49	21:53	22:27	00:15	Manihiki: Danger Island Trough	4800	00:34
2	167	30.11./1.12.12	23:35	00:59	05:19	06:33	Manihiki: Danger Island Trough	3500	04:20
3	168	2./3.12.2012	21:00	23:15	04:10	05:58	Manihiki: North Plateau	4600	04:55
4	169	3./4.12.2012	21:15	23:09	06:07	07:37	Manihiki: North Plateau	4100	06:58
									16:47:00

5.1.3. Dredging, Site Selection, and Laboratory Work

Since planned ROV deployment had to be cancelled after 4 dives (see chapters 4 and 5.1.2), rock sampling on SO-225 was continued using chain bag dredges. Chain bag dredges are similar to large buckets with a chain bag attached to their bottom and steel teeth at their openings (c.f. Fig. 4.8), which are dragged along the ocean floor by the ship or the ship's winch.

Selection of sampling sites

Sites for detailed Kongsberg EM120 mapping and sampling were chosen on the basis of a number of existing datasets. These include:

1. Swath bathymetry data, maps as well as age and geochemical data yielded on SO-193 MANIHIKI I (e.g. Werner and Hauff 2007, Werner et al. 2007, Coffin et al. 2007, Hoernle et al. 2009, Timm et al. 2011, unpubl. data by Hoernle, Hauff et al., see also chapter 3).
2. Swath bathymetry and geophysical data recorded on SO-224 (e.g. Uenzelmann-Neben 2012, unpubl. data by Uenzelmann-Neben, Gohl et al.).
3. Swath bathymetry data, provided by Mike Coffin (cruise R/V HAKUHO MARU KH03-01), Joann Stock (cruise R/V ROGER REVELLE KIWI Leg 12), and the Marine Geoscience Data System (http://www.marine-geo.org) (R/V N.B. PALMER cruises 9806A, 0207, 0304, 0304A, B, C).
4. Predicted bathymetry, derived from gravity data and ship depth soundings (Smith and Sandwell 1997), as well as the GEBCO data set (The GEBCO_08 Grid, version 20091120, http://www.gebco.net).
5. Published monographs, maps and papers (see, for example, chapter 3).

As pointed out in chapters 3.3, 4, and 5.2 of this report, SO-225 aimed to sample rock sequences of the main plateau forming phase of the Manihiki Plateau. Therefore hard rock sampling focused on areas where Early Cretaceous (c. 120 ± 5 Ma) rocks with tholeiitic composition have been sampled on previous cruises (e.g. Ingle et al. 2007, Timm et al. 2011).

Shipboard procedure

Once onboard, a selection of the rocks were cleaned and cut using a rock saw. They 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 any phenocrysts that are fresh. If suitable samples were present, the ship moved to the next station. If they were not, then the importance of obtaining samples from the station was weighted against the available time.

Fresh blocks of representative samples were then cut for thin section and microprobe preparation, geochemistry and further processes to remove manganese and alteration products and/or to extract glass (if applicable). Each of these sub-samples, together with any remaining bulk sample, was documented by photography, described, labeled, and finally sealed in either plastic bags or bubble wrap for transportation to GEOMAR or cooperating institutions.

Shore based analyses

Magmatic rocks sampled by the R/V SONNE from the ocean floor will be analyzed using a variety of different geochemical methods. The ages of whole rocks and minerals will be determined by $^{40}Ar/^{39}Ar$ laser dating. Major element geochemistry by X-ray fluorescence (XRF) and electron microprobe (EMP) will constrain magma chamber processes within the crust, and also yield information on the average depth of melting, temperature and source composition to a first approximation. Phenocryst assemblages and compositions will be used to quantify magma evolution, e.g. differentiation, accumulation and wall rock assimilation. Petrologic studies of the volcanic rocks will also help to constrain the conditions under which the melts formed (e.g., melting depths and temperatures). Further analytical effort will concentrate on methods that constrain deep seated mantle processes. For example, trace element data by inductively coupled plasma mass spectrometry (ICP-MS) will help to define the degree of mantle melting and help to characterize the chemical composition of the source. Long-lived radiogenic isotopic ratios by Thermal Ionization Mass Spectrometry (TIMS) and Multi-collector ICP-MS such as $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$, $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$, and $^{176}Hf/^{177}Hf$ are independent of the melting process and reflect the long term evolution of a source region and thus serve as tracers to identify mantle and recycled crust sources. Additionally, morphological studies and volcanological analyses of the sampled rocks will be used to constrain eruption processes, eruption environment and evolution of the volcanoes. Through integration of the various geochemical parameters, the morphological and volcanological data, and the age data the origin and evolution of the sampled structures can be reconstructed.

Non-magmatic rocks (e.g., solidified or lithified sediments) and Mn-Fe oxides yielded by dredging will be transferred to co-operating specialists for further shore based analyses.

5.2. ROCK SAMPLING REPORT AND PRELIMINARY RESULTS

This section gives background information and short summaries of the features sampled and/or mapped on SO-225 and on the rocks obtained by ROV sampling and dredging. Refer to Appendix I and II for exact latitude, longitude, and depth of dredge sites and more detailed rock descriptions. Appendix VI shows an overview map with all SO-225 sampling sites. Distances between locations are approximate only; dimensions and heights are preliminary and are included only to give a rough idea of dimensions of morphological features. All photos shown in this chapter are taken by GEOMAR.

5.2.1. SO-225 ROV Sampling

A total of four ROV dives have been carried out during SO-225. The first two dives took place in the southern Danger Island Troughs (Fig. 5.3) at the intersection with SO-224 seismic line AWI20120100 (ROV-01, aborted at profile start due to technical problems) and along the upper part of a presumably tectonic basement bloc (ROV-02) between locations DR26 of Timm et al. (2011) and D2 of Ingle et al (2007) for which $^{40}Ar/^{39}Ar$ ages of 122.9±1.6, 124.5±1.5 and 117.9±3.5 Ma are reported. Dives ROV-03 and ROV-04 were carried out along a basement high between the northeastern margin of the Western Plateaus and the Northern Plateau (Fig. 5.6). From the top of this structure, Timm et al. (2011) report an $^{40}Ar/^{39}Ar$ age of 125±2.1 Ma for a basalt dredged at site DR46 of SO-193 (Fig. 3.3). Although the solitary location of this basement high is most likely related to extensional or transtensional tectonics after plateau formation, the c. 1.5 km depth interval along its flanks potentially exposes deeper and thus lower(?) stratigraphic units of the Manihiki Plateau. A summary of the ROV dives along with a description of the recovered rocks follows.

Dive Summary of SO225-009ROV02

Area: Danger Island Troughs, central trough, upper part of NW-SE striking ridge, steep W facing slope, close to SO-193 DR27 (Fig. 5.3).

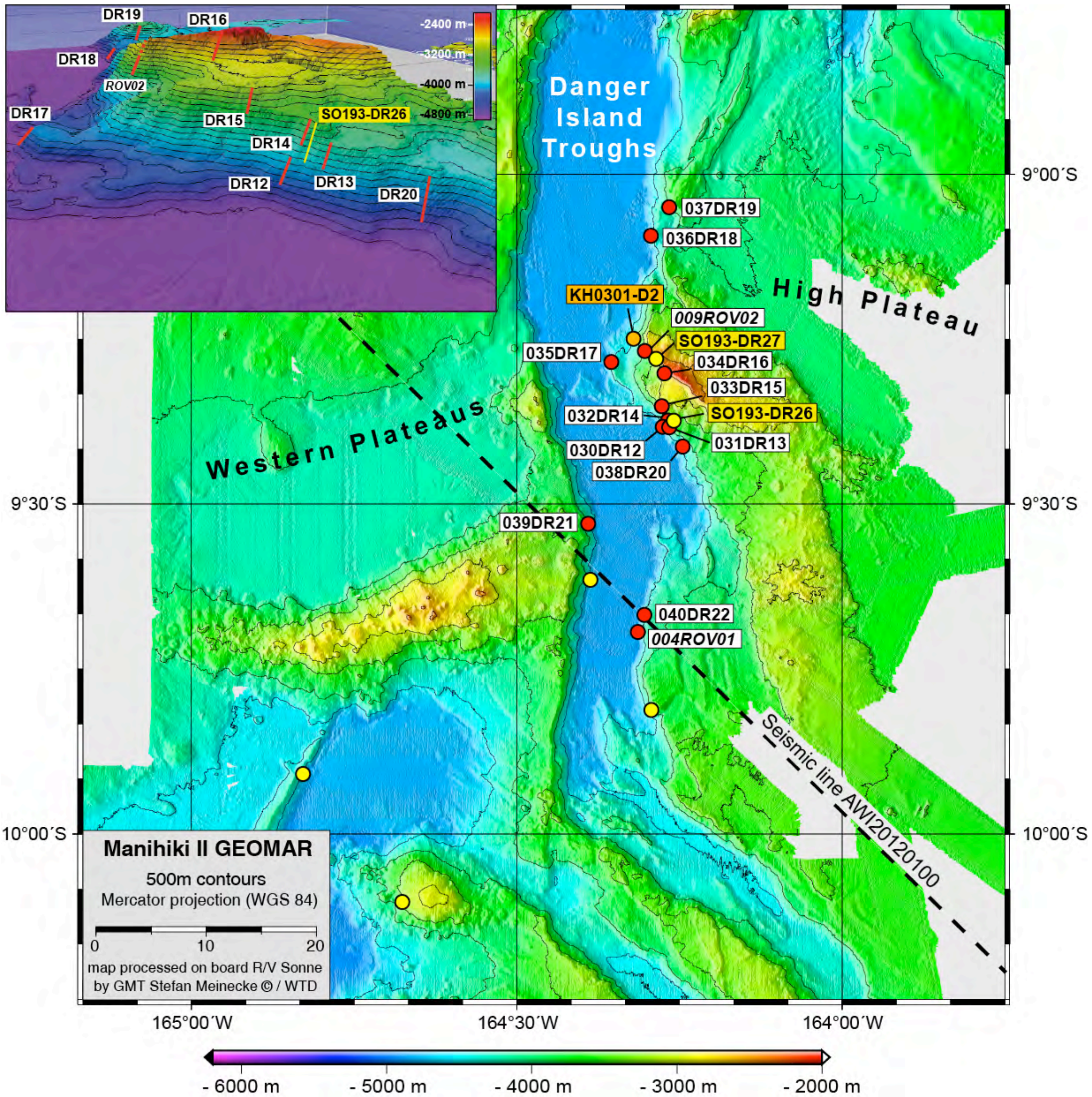

Fig. 5.3: *Locations of ROV-profiles and dredge sites conducted in the southern Danger Island Troughs. Red dots mark sites sampled on SO-225, yellow and brown dots sites sampled on SO-193 and R/V HAKUHO MARU cruise KH03-01. Labeled sites are mentioned in the text. Multi-beam data are recorded on RV SONNE cruises SO-193, SO-224, SO-225, and R/V HAKUHO MARU cruise KH03-01.*

<u>Responsible Scientists and Protocol Scientists:</u>
01:00-03:00 UTC (R. Werner, S. Hauff); 3,514 – 3,446 m b.s.l.
03:00-05:00 UTC (F. Hauff, R. Golowin); 3,446 – 3,174 m b.s.l.
05:00-05:30 UTC (M. Portnyagin, N. Furchheim); 3,174 – 3,088 m b.s.l.

The ROV dive began by first going through sediments covered with debris. After a few tens of meters a massive, several meters thick rock outcrop appeared. The rocks mostly showed smooth, roundish surfaces and were obviously encrusted with manganese crusts. They proved very solid with rare cracks so that sampling, even using the chisel, of *in situ* rocks from this outcrop failed. At the same depths interval the ROV cameras revealed a dike (?) with column like structures (Fig. 5.4). Despite the jointing it was impossible to break off rock pieces with the chisel. The area adjacent to the dike is apparently covered by slightly rounded rock debris and light soft sediments. An attempt to sample this "debris", however, also failed because the rocks proved to be solid *in situ* rocks surrounded by sediments. Finally we sampled an angular rock fragment which most likely belongs to the rock unit described above (sample #1). Then the dive track followed a steep slope uphill with alternating outcrops of pillows, pillow breccias, massive rocks, and dikes, interrupted by soft sediments covered by mostly angular rock debris. Further upslope outcrops of brecciated material, probably pillows, occurred. Attempts were made to break off material but failed. Further up smaller blocs beneath a cliff were tried to sample but turned out to be crusts that crushed when the claws of the ROV squeezed. The cliffs were made of pillows and abundant pillow breccias but overall were only vaguely indentified.

Fig. 5.4: *Columnar dike (?) cutting an outcrop with pillow-like structures in 3,510 m water depth.*

Fig. 5.5: *Sample #2 taken from debris at the base of an outcrop in 3,302 m water depth.*

At 3,302 m b.s.l. a Mn-encrusted pillow fragment was taken (sample #2, Fig. 5.5). At one place we had the impression to see a dike cutting through the breccias. An attempt was made to sample an exposed area of the dike but was too tightly attached to the ground. Following were several cliffs made of pillows and pillow breccias separated by sediment covered slopes / terraces. None of the cliffs looked promising for *in situ* sampling. At 3,276 m b.s.l. another loose Mn-encrusted, roundish pillow fragment (sample #3) was taken along with a more angular sample #4 to check for lithological heterogeneities within the debris. The source of the debris was assumed to be the cliffs. At this point it became clear that the dive will have to aborted due to a drop of the oil compensator level below 10%, so it was decided to exchange the science team at 3,145 m b.s.l. Still a few more outcrops/cliffs made of homogeneous pillow breccias, perhaps, partly pillow-lavas covered by thick Mn-crusts were covered. Short cliffs are separated by sediment covered 20-30 m slopes with numerous loose rock fragments, all subrounded and seem to be covered with Mn-crusts. At c. 3,080 m b.s.l. two large perfectly rounded ca. 2 m in diameter boulders of possibly pillows, were observed next to a cliff composed of a lava breccia. None of the cliffs/large blocks looked promising for *in situ* sampling. The dive was aborted due to technical problems at 3,046 m b.s.l.

ROV-02 Rock Samples: A total of 4 rock samples were collected between 3,512 and 3,278 m b.s.l. They are of volcanic origin and represent aphyric, strongly altered pieces of lava. In hand specimen no unique criteria could be found that indentifies them as pillows lava as inferred during the dive for samples ROV-02-2, -3 and -4 or as part of a dike (ROV-02-1). The most significant differences is vesicularity ranging from up to 25% to dense and being variable within single specimens (20 to 5%). This and the irregular shape of the vesicles and their variable size from a few mm up to 1 cm suggests that all 4 samples are pillow fragments coming from the dense inner and more vesicular outer parts. The groundmass is thoroughly oxidized to light brown in all samples, but groundmass plagioclase is still present in places and may be suitable for age dating. Special care has to be taken to avoid secondary fillings of voids and cracks with manganese, light green smecite (?) and calcedone (amorphous quartz) when preparing the samples for geochemistry. Still the prime magmatic information based on bulk rock chemistry is probably limited in these samples.

Dive Summary of SO225-011ROV03

Area: Ridge between Western and Northern Plateau (Fig. 5.6). The top of this structure has been dredged during SO193 DR46 and recovered basalt gave 125±2.1 Ma (Timm et al. 2011). Dive ROV03 was carried out along the SW facing slope near the SE tip of the ridge. The planned track starts at the base in c. 4,600 m b.s.l. and ends at a small plateau on the crest of the ridge in 3,050 m b.s.l.

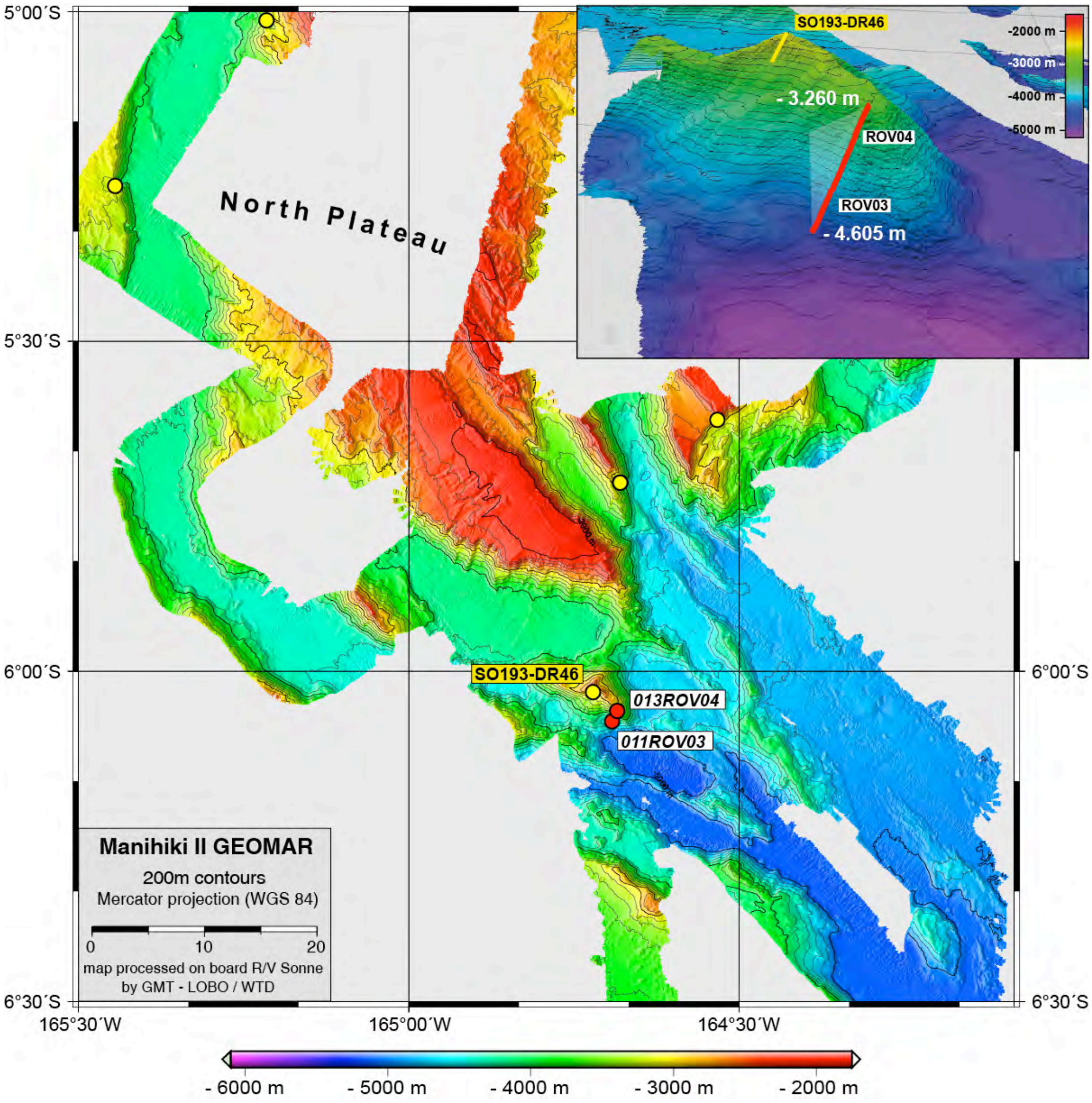

Fig. 5.6: *Locations of ROV-profiles and dredge sites conducted in the south-western area of the North Plateau. ROV-dives conducted on SO-225 are marked in red, dredge sites of SO-193 in yellow. Labeled sites are mentioned in the text. Multi-beam data are recorded on RV SONNE cruises SO-193 and SO-225.*

Responsible Scientists and Protocol Scientists:
23:21-01:22 UTC (M. Portnyagin, N. Furchheim); 4,602 – 4,425 m b.s.l.
01:22-03:22 UTC (R. Werner, M. Anders); 4,425 – 4,141 m b.s.l.
03:22-04:11 UTC (F. Hauff, A. Peukert); 4,141 – 4,073 m b.s.l.

The dive started at 4,605 m b.s.l. on a gentle slope covered with soft sediments with rare traces of life (worm traces). First small rocks fragments, few cm in size appeared at depth of 4,597 m b.s.l. Further along the profile several spots of relatively abundant detritus were observed. Amount of rounded rock fragments and boulders and their maximal size increased gradually up to c. 3 m at depth of 4,576 m b.s.l. Abundant rock debris was observed at c. 4,550 m b.s.l. All rocks have sub-rounded surface and covered with Fe-Mn crusts. Next tens of meters were again soft sediments with few random large to smaller boulders forming protrusions in the sediment blanket. The first attempt to sample rocks was made at 4,550 m b.s.l. at one of the exposures of consolidated rock boulders. An attempt to take a sample directly from the outcrop was not successful as the rocks were strongly cemented with Fe-Mn-crusts. Sample #1 was a loose small angular rock fragment picked up from the soft sediment. Next exposures of crust-cemented outcrops appeared at c. 4,520 m b.s.l. A short try of rock stability confirmed that the rocks are firmly attached to the ground. During the next tens of meters the seafloor was still the same: cemented rocks sticking through soft sediments. Up the slope, the protrusions became larger and in some parts dominated spatially over soft sediments.

A new attempt to sample was done at 4,520 m b.s.l. After several tries to collect rock from outcrop, a loose fragment was taken from sediments. Sample #2 was a small rounded rock fragment. Next hundred meters of outcrop looks similar and became semi-continuous in character. Sample #3 was a loose well rounded large rock covered with Fe-Mn crust taken from near outcrop at 4,430 m b.s.l. (Fig. 5.7).

Fig. 5.7: *Sample #3 from 4,430 m b.s.l.*

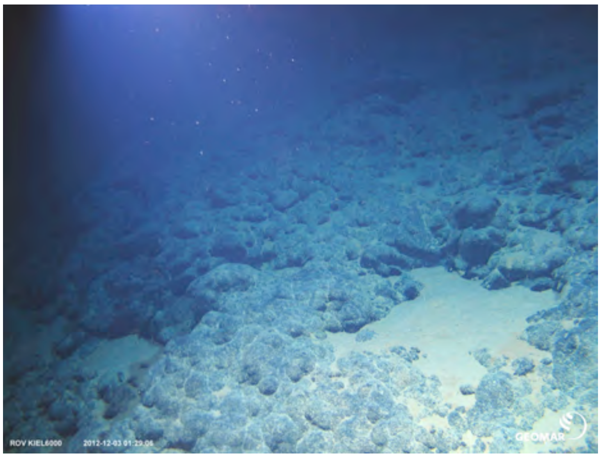

Fig. 5.8: *Pillow-like structures in 4,386 m water depth.*

Then a rock outcrop with pillow-like structures was passed (Fig. 5.8). Subsequently the ROV crossed an area of alternating rock outcrops and small sediment plains. The outcrops have relatively flat surfaces and resemble sheet lava which cover the slope. This is, however, unlikely because this seamount is most likely a tectonic feature. Sample #4 has been taken out of the rock debris lying on soft sediments in between the lava "sheets". The next part of this dive section is dominated by soft sediments and rock debris partly consisting of large blocks. At c. 4,300 m b.s.l. an attempt was made to sample an outcrop of pillow lavas but the exposed rocks turned out to be too solid and robust for sampling. Alternatively a rock fragment found in an sediment-filled fracture (?) cutting the outcrop has been sampled. The size and shape of the rock fragment made sampling rather difficult but finally the sample grabbed with the rigmaster (sample #5, close to *in situ*...). The pillow outcrop continues along the profile until a relatively large soft sediment plain appears at 4,270 m b.s.l. The sediments seem to cover some kind of terrace. Approximately 20 m further uphill the sediments are covered with rock debris increasing uphill in size and amount. At 4,246 m b.s.l. the next rock outcrop with pillow-like structures appeared. An attempt to sample a rock fragment lying at the base of the outcrop resulted in sample #6. The last part of this dive section crossed alternating sediment plains, debris, and rock outcrops (mainly pillows).

Several attempts to sample *in situ* rocks at one of the pillow outcrops and even something what appeared to be debris failed again because of the resistance of the rocks. Sampling of these outcrop in 4,148 m water depth could not successfully completed. Several additional sampling tries were made at different locations but proved to be too tightly attached to the ground. Going upwards the strata resembled a pillow sequence but was difficult to identify with certainty due to the structureless appearance and smoothness of rock surfaces. Cliffs of pillow seem separated by sediment covered planes that dip at a lower angle.

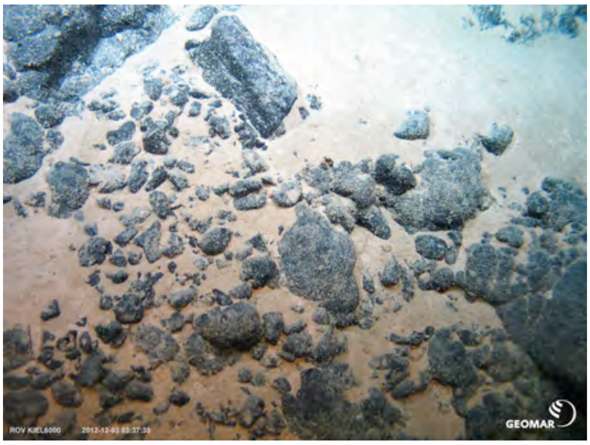

Fig. 5.9: *Sediment plane with rock debris from pillow cliff above. Sampling site of sample #7 & 8 in 4,127 m b.s.l.*

Fig. 5.10: *Blocs in sediment covered slope. Sampling site of sample #11 in 4,084 m b.s.l.*

Sample #7 and #8 were loose rocks lying in the sediment beneath a pillow cliff and it was assumed that they broke off from there (Fig. 5.9). Two samples were taken to check for lithological heterogeneity of the debris. Further up the next pillow cliff showed no areas where a sample could be broken off, instead two loose blocs lying on the edge of the cliff were sampled (#9 and #10). Thereafter there was another pillow outcrop but during the last stretch of the dive the slope became a bit shallower and sediment coverage increased. It was then difficult to judge whether rocks sticking out of the sediment was debris or partially covered outcrop. When it became clear that the dive will end soon a final sample was taken from loose blocs lying in the sediment (sample #11, Fig. 5.10). In summary the section from 4,149 to 4,078 m b.s.l. contains outcrops / cliffs of pillow lava until ~4,100 m b.s.l. of which #7 and #8 are closest to be *in situ*. Dive ended at 4,078 m b.s.l. due to oil compensator reaching a critical level.

ROV-03 Rock Samples: A total of 11 rock samples in the depth interval from 4,552 to 4,085 m b.s.l. were collected. They comprise six, fairly fresh, dense, volcanic rocks from throughout the profile (Fig. 5.11). All of them are characterized by a light grey groundmass with a slight metamorphic overprint expressed by whitish to greenish veins. Petrographically an aphyric suite is distinguished from a pyroxene phyric (1-2mm,10-30%) variety. Feldspar appears macroscopically absent. No clear evidence could be found to determine whether these volcanics are lavas or dikes. A unique finding of this dive is a plutonic rock represented by sample ROV-03-4 (Fig. 5.12). The rock is mainly composed of pyroxene (35%) and feldspar (40%) and altered olivine (10-20%). On broken surfaces small greenish-yellow titanite crystals can be observed. The texture of the rock is quite variable ranging from coarse grained to medium grained. Some areas contain abundant feldspar and resemble plagiogranitic patches. The rock probably represents a shallow level intrusion with late stage plagiogranitic melt pockets. This is the first plutonic rock reported from the Manihiki Plateau. While $^{40}Ar/^{39}Ar$ ages of the feldspar will deliver a cooling age, accessory minerals, if present, will provide intrusion ages by U-Pb dating of zircon. Together with the volcanic rocks of this profile unique insights into the temporal and compositional relationships are envisioned. The remainder of the samples are two Mn-nodules, a Mn encrusted breccia with volcanic clasts similar to those described above and a piece of Mn encrusted sediment. The latter four samples testify for the difficulties to clearly distinguish between Mn encrusted material from igneous rocks in particular when *in situ* sampling proves difficult. Under such circumstances angularity of rock fragments and stability when squeezed with the ROV claws appear to be good indicators for igneous rocks.

Fig. 5.11: *Fresh, aphyric volcanic rock prepared for shore based analytical work.*

Fig. 5.12: *Fresh plutonic sample of presumably leuco-gabbroic composition.*

Dive Summary of SO225-013ROV04

Area: Ridge between Western and Northern Plateau (Fig. 5.6). The top of this structure has been dredged during SO193 DR46 and recovered basalt gave 125±2.1 Ma (Timm et al. 2011). Dive ROV04 was carried out along the upper SW facing slope near the SE tip of the ridge and is the continuation of 011ROV03.

Responsible Scientists and Protocol Scientist:
23:14-01:20 (M. Portnyagin, S. Hauff); 4,067 – 3,855 m b.s.l.
01:20-03:24 (R. Werner, R. Golowin); 3,855 – 5,592 m b.s.l.
03:24-05:22 (F. Hauff, N. Furchheim); 3,592 – 3,363 m b.s.l.
05:22-06:06 (M. Portnyagin, M. Anders); 3,363 - 3,260 m b.s.l.

The goal of this section was to collect many rock samples from the potential transitional zone from intrusive and dyke complex to lava complex along the profile as was suggested from the preliminary on-board interpretation of the petrographic rock varieties obtained during the ROV03 dive.

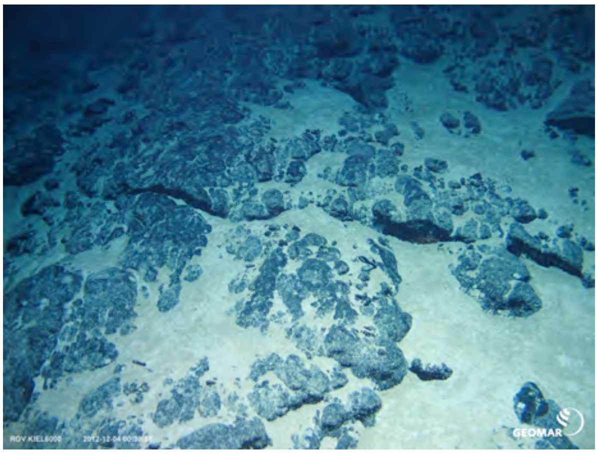

Fig. 5.13: *Fault in consolidated by Fe-Mn crusts debris deposits 3,960 m b.s.l.*

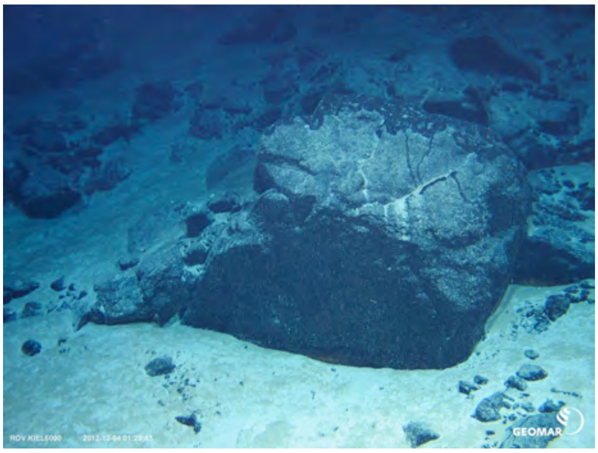

Fig. 5.14: *The section from 3,855 – 3,592 m b.s.l. is characterized by rock debris (incl. large boulders).*

The dive started at 4,067 m b.s.l. on a small soft sediment plain with evenly exposed rock debris. The entire section appeared quite uniform, characterized by an alternation of steeper slopes with more exposed rocks and gentle slopes with accumulations of soft sediments, spots of rock debris and sporadic large blocks up to 5 m across. In the lower part of the section the seabed appeared as a relatively steep slope obliquely armored with thick Mn-crusts and rock debris. A sub-horizontal fault or crack in consolidated by Fe-Mn crusts debris with pillowed appearance was observed in 3,960 m b.s.l. (Fig. 5.13). This fault is likely a relatively recent feature suggesting slope instability and recent movement material along the slope in conjunction with disintegration of previously formed thick Mn-crusts. In the upper part the seabed relief appeared more dissected with small canyons and ridges. More massive outcrops with smooth pillowed surface formed by Mn-crusts became predominant. Nine samples were collected in this section of the dive at an approximately 20-30 m depths interval. Samples #1 and #2 are loose rocks fragments from debris covered with soft sediments and were taken in 4,046 m b.s.l. Sample #3 is an angular ca. 15 cm rock fragment taken near the outcrop of disintegrated Mn-crusts and rock debris. Samples #4 to #9 were taken in depths interval from 4,005 to 3,855 m b.s.l. from debris next to outcrops and represent loose angular to sub-rounded rock fragments ranging in size from 10 to 50 cm.

Further up-section a steep slope characterized by rough morphology followed. The slope is dominated by rock debris lying on and sticking out of soft sediments, respectively. The rock fragments are angular or sub-rounded and include boulders up to several meters in size (Fig. 5.14). Parts of the slope resemble debris flow deposits. Relatively small rock outcrops, partly showing pillow-like structures, appear from time to time. In some cases, however, it was difficult to decide whether massive rocks sticking out of the sediment are *in situ* or large boulders. In general, the rock outcrops are very tight and even many rock fragments are firmly attached to the ground as it has been observed during 011ROV03 the day before. Since sampling of *in situ* rocks from these outcrops turned out to be impossible, we continued with the sampling strategy to sample rock fragments lying directly at the base of outcrops in regular depth intervals (approximately every 100 m). Sample #10 is an angular rock fragment resembling a piece of a pillow. It was taken in 3,801 m water depth from the debris in the vicinity of an rock outcrop with pillow-like structures and probably broke off from that outcrop. Samples #11 and #12 both were taken in 3,693 m water depth at the base of an outcrop consisting of massive rocks intercalated with rough rock units resembling pillow (?) breccias. Another angular rock fragment has been sampled at the base of a pillow outcrop in 3,592 m water depth (sample #13).

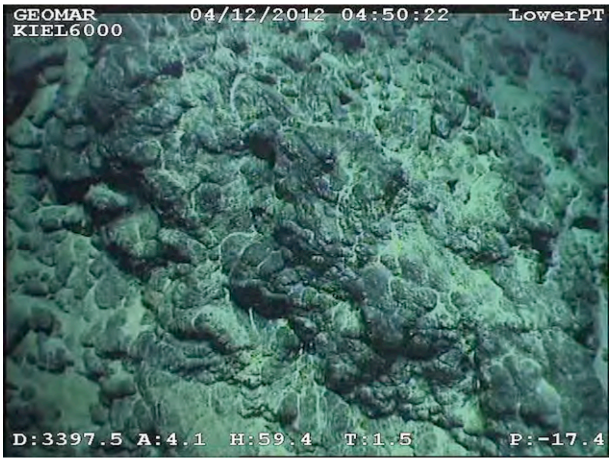

Fig. 5.15: *Outcrop of pillow lava in 3,397 m b.s.l.*

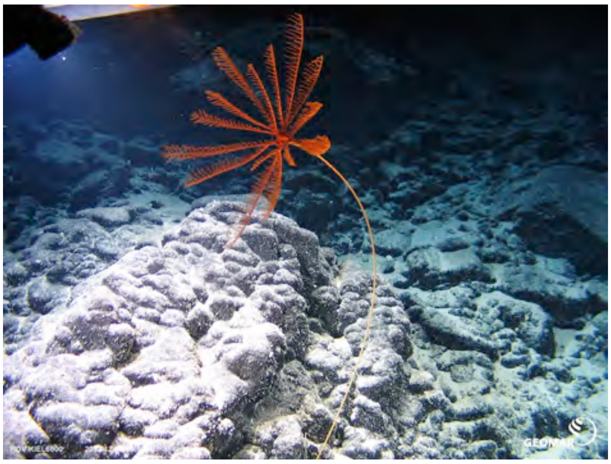

Fig. 5.16: *Crinoidae below pillow like cliff in 3,376 m b.s.l.*

Outcrops continued with pillow breccias and possibly intact pillows. They were interrupted by short sediment covered stretches. Then the frequency of large sub-rounded boulders (pillows?) lying on the sediment covered slope increased. An Ophiuridae growing on one of these blocs was observed in 3,562 m. b.s.l. Until 3,522 m. b.s.l. the slope was covered by large, several meter sized angular blocs, lying on their cleavage planes parallel to the slope. These blocs could have been fragments of sheet flow lava or dikes. At 3,532 m. b.s.l. an angular rock fragment was picked up from the sediment (sample #14). A few meters further up an outcrop of massive rock without distinctive structures was discovered. Sample #15 was taken from a corner within this cliff and is assumed to represent local debris of this massive rock. The next c. 120 m further upslope are characterized by rock debris, often in a chaotic assemblage interrupted by sections completely covered with sediment. At c. 3,400 m. b.s.l. a cliff of massive pillow lava and pillow breccia occurred (Fig. 5.15).

Due to the roundish, smoothed surface a loose fragment was picked up at 3,401 m. b.s.l. (sample #16). A pillow breccia was attempted to sample directly beneath the cliff in a sediment pocket. The rocks sticking out of the sediment, however, turned out to be firmly attached to the ground (*in situ?*) so that *in situ* sampling of this pillow cliff failed. A Crinoidae rising from the base of this outcrop (Fig. 5.16) was out of reach for the “Orion” manipulator at the time the biology sampling box was open for loading. After the pillow breccia cliff a slope followed with numerous unsorted blocs of rocks up to several meters across with soft sediments between. The slope ended at a c. 8 m high near vertical cliff with the surface covered by Mn-crust of globular surface. In the middle part of the cliff a 3 m angular rock fragment was observed. Then the ROV passed a short terrace with numerous sub-rounded to angular boulders up to 5 m across (Fig. 5.17) and followed over gentler slope completely covered with sediments. This slope was found to end with a c. 20 m deep ditch in 3,330 m b.s.l. The dive followed the rim of a terrace which turned to be a small ridge (Fig. 5.18) striking ca. 350^{o}, parallel to the slope for about 70 m and then the dive returned along the planned profile direction. After crossing a sedimentary plain, the dive continued above debris deposits composed by middle-sized boulders. Sample #17, a loose well rounded rock fragment covered with Fe-Mn crust was taken from soft sediment at 3,306 m b.s.l. The ocean floor continued to change from sedimentary terraces to areas with abundant rocks debris and outcrops with no sediments until the end of the dive. Some very large rock blocs could be fragments of lava flows. The dive has been aborted at 3,260 m water depth due to time constraints.

Fig. 5.17: *Terrace with large blocks all covered in sediments ahead in 3,340 m b.s.l.*

Fig. 5.18: *A wall composed by debris deposits along the slope in 3,330 m b.s.l. View to the west, orthogonally to the profile.*

<u>ROV-04 Rock Samples:</u> Along the upward extension of the ROV-03 profile another 17 rock samples were collected between 4,046 and 3,306 m b.s.l.. Again fine grained, relatively fresh and dense volcanic rocks dominate (12 samples) with subordinate occurrences of coarse grained intrusive rocks (ROV-04-1), a single greenshist (ROV-04-14) and two matrix supported, polymict breccias (ROV-04-5, -6) containing mainly angular aphyric volcanic clasts (Fig. 5.19). Small (1-3 mm) plagioclase phenocrysts are described in sample ROV-04-3 and -13 (Fig. 5.20). Otherwise the volcanic rocks are for the most part aphyric (Fig. 5.21), some contain minor pyroxene and altered olivine phenocrysts (2-5%) (Fig. 5.22). A slight metamorphic overprint is manifested by a light greenish appearance of the grayish groundmass and abundant veins filled with white material. Dating attempts will have to concentrate on the slightly plagioclase phyric samples or groundmass if freshness permits. The possibility of dating groundmass feldspar requires thin section inspection beforehand. The presence of foliated greenshists testifies for crustal deformation under ductile conditions most likely related to the separation of this basement high from the Western Plateaus. The polymict breccias are probably related to mass wasting along the steep southwest facing slope of the structure.

Fig. 5.19: *Breccia with fresh lava clasts.*

Fig. 5.20: *Fresh, slightly plagioclase phyric lava sample.*

Fig. 5.21: *Fairly fresh aphyric lava sample with abundant filled veins / cracks.*

Fig. 5.22: *Olivine phyric lava sample. Olivine is altered but groundmass still fresh.*

5.2.2. SO-225 Dredging

Due to a severe technical problem with the ship based deep water positioning POSIDONIA antenna further ROV dives were not possible after the 4th dive. Instead the ship was reconfigured for dredge operations to save large parts of the scientific hard rock program. Although this meant giving up the stratigraphically controlled sampling aspect, we still wanted to concentrate sampling efforts to the above mentioned strategic areas with known plateau basement exposures and eventually expand aerial sampling where appropriate. The prime dredging strategy was then to simulate the planned ROV profiles by overlapping dredge tracks along specific sections (cf. Fig 5.3, insert). Through this it was hoped to obtain an integrated, representative rock record which would still allows a further, more detailed look into the compositional and possibly age variations of the plateau basement despite the lack of stratigraphically controlled sampling.

Northern Margin of the High Plateau and northernmost Danger Island Trough (DR5 through DR9)

The northwestern corner of the High Plateau is bounded by two, more than 6,000 m deep, orthogonally aligned basins (Fig. 5.23). While the smaller north-south trending basin belongs to the northernmost Danger Island Trough with an aerial extend of 40 x 10 km; the east-west striking basin bounding the northern margin of the High Plateau stretches over 60 km along axis at similar widths. Previous dredge sampling recovered tholeiitic basement at DR38, -52, -53 and -54 during SO-193 and site D4 of Ingle et al (2007) in the vicinity of SO193-DR54 (Fig. 5.23). Weighted mean ages of 126.0±1.5 Ma and 123.8±0.8 Ma have been determined for fresh glass from DR52 at the GEOMAR and Oregon State University geochronology facilities (Timm et al. 2011). Chemically, low Ti group lavas are identified at DR54 and D4, while the remainder belongs to the high Ti group lavas of the Manihiki Plateau. For a definition of low and high Ti lavas see Timm et al. (2011).

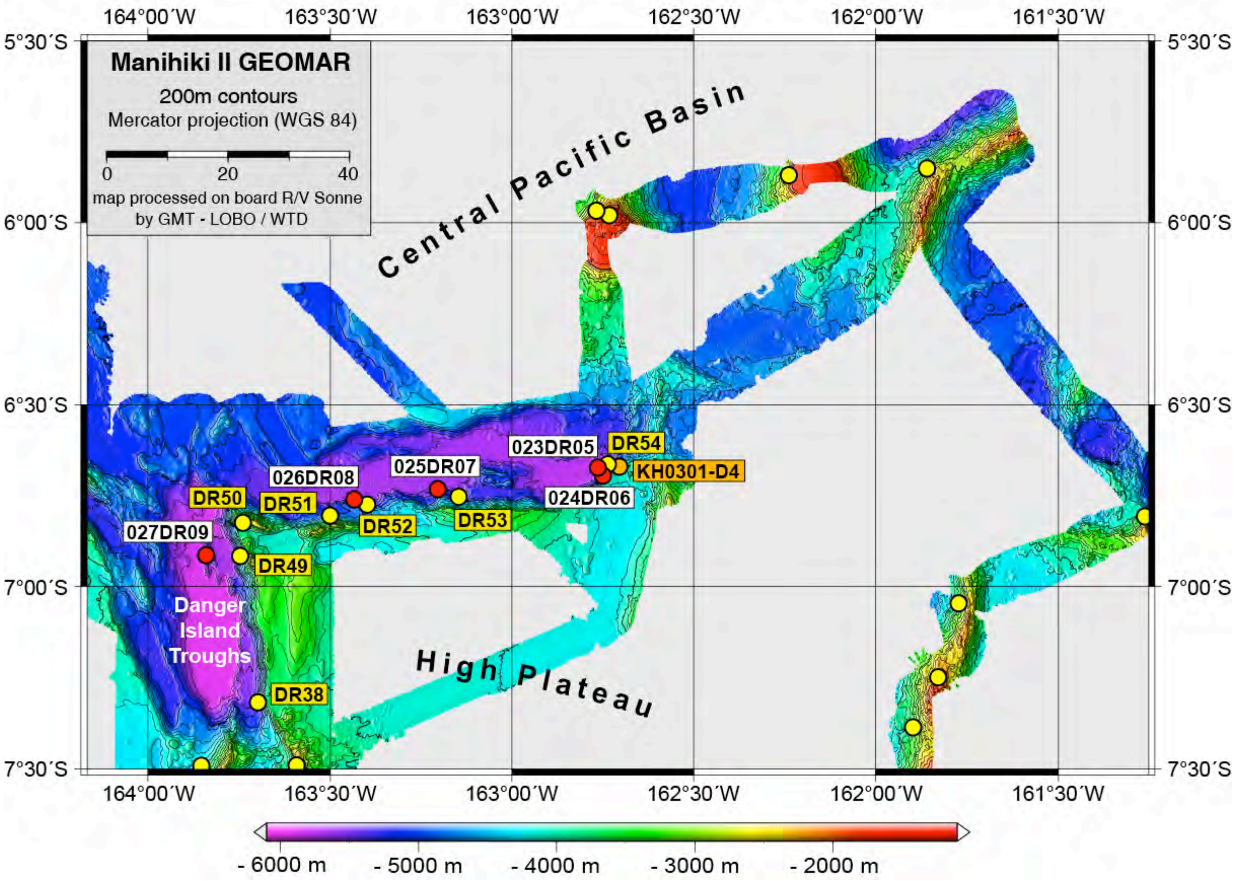

Fig. 5.23: *Locations of dredge sites conducted at the northern margin of the High Plateau and in the northernmost Danger Island Trough. Red dots mark sites dredged on SO-225, yellow and brown dots sites sampled on SO-193 and R/V HAKUHO MARU cruise KH03-01, respectively. Labeled sites are mentioned in the text. Multi-beam data are recorded on RV SONNE cruises SO-193, SO-225, and R/V HAKUHO MARU cruise KH03-01.*

The first two dredge hauls of SO-225 (023DR05 & 024DR06) were carried out along the northwest facing slopes of the High Plateau at the eastern termination of the northern basin near station DR54 of SO-193 (Fig. 5.23). They were designed to cover the entire slope from bottom to top with c. 100 m elevation overlap. Besides the known occurrence of basalt this site was also chosen because there are no volcanic structures on the plateau nearby which may be younger and a potential source of debris. Dredge 023DR05 from the base of the slope (5,600 - 5,100 m b.s.l.) recovered mainly solidified, dark to light brown clay stone. Still two pieces of moderately altered, fine grained, dense, angular volcanic rock clasts were found. Sample DR5-1 appeared aphyric and DR5-3 contained small (<1mm) pyroxene needles and c. 10% plagioclase microphenocrysts in the groundmass. Sample DR5-3 is an *in situ* brecciated (jigsaw puzzle like) clay stone with several cm wide infill of grayish, most likely silicic material (no reaction with diluted HCl). In places, the infill displays a symmetric zonation suggesting changing fluid conditions during sealing of the cracks. The rock may have formed when the clay stone compacted and fluids escaped in larger quantities. Dregde 024DR06 covered the upper parts of the slope beneath the plateau edge (5,200 - 4,650 m.b.s.l). Despite several strong bites the dredge delivered only two pieces of solidified clay stone, similar to that recovered in the previous dredge. From this it was concluded that the slope mainly consists of solidified clay stone with occasional, angular volcanic clasts. We note that at the nearby SO193-DR54 site angular volcanic clasts and Mn crust were recovered but no solidified clay stone. Since the northern slope of the High Plateau seems to largely consist of solidified sediment (see also SO193-DR50 and -51, Werner and Hauff 2007) and igneous basement seems restricted to the very base of the plateau margin the next dredge was chosen slightly east of SO193-DR53. Here several east-west striking ridges cover the southern basin floor and were assumed to have formed as remnant basement highs during the opening of the northern basin. Indeed a total of 5 pillow fragments were recovered in dredge 025DR07 from 5,550 to 5,120 m b.s.l. The freshest sample (DR7-1) is a dense, aphyric lava fragment with a well crystallized groundmass containing fresh plagioclase and occasional clusters (up to 1cm) of xenocrystic plagioclase (Fig. 5.24). The remaining 4 samples appear geochemically more primitive due to the presence of a few percent altered olivine along with fresh plagioclase phenocrysts. Overall this group of lavas is significantly more altered as is evident from the light to dark brown color of the groundmass and abundant Fe-hydroxide replacement. Still age dating seems feasible on the plagioclase phenocrysts in both lava types good chemical data can be obtained on the first sample. The next dredge track (026DR08) was chosen slightly east of SO193-DR52 at the very base of the north facing slope (5,400 - 5,150 m b.s.l) and recovered a single large piece of a lava flow top breccia. It consists of variably sized angular clasts of dense, plagioclase phyric lava (1-2mm, up to 10%) (Fig. 5.25). The groundmass is in most cases moderately altered with a few grayish areas left. Plagioclase appears datable and bulk chemistry will at least deliver basic information using immobile elements. The next dredge was located in the northernmost Danger Island Trough east of the High Plateau (Fig. 5.23). From SO-193 it was known that the northwest corner of the High Plateau consists of solidified sediment (SO193-DR49, -50 and 51, Werner and Hauff 2007). Therefore we choose to sample a north-south trending ridge near the center of the basin as it appeared to be of tectonic origin and may have potentially exposed igneous basement below the sediment pile. Dredge 027DR09 was the deepest haul of SO-225 from 5,800 to 5,150 m b.s.l. and returned only a few rocks. These were mainly solidified, light brown clay rich sediments and three Mn encrusted angular clasts of volcanic origin and identical petrography. They possess a strongly altered, dense brownish groundmass with a few percent of 1 mm sized pyroxene phenocrysts. Due to the increasing evidence that igneous basement along the northern and northwestern margin of the High Plateau is at best exposed over only short distances at the base of the plateau margins we decided to continue further south where larger basement section are exposed.

Fig. 5.24: *Moderately to slightly altered lava fragment.*

Fig. 5.25: *Porphyric lava with strongly altered groundmass but fresh, datable plagioclase.*

Central and southern Danger Island Troughs (DR10 through DR22)

Previous work in the second northernmost Danger Island Trough extending from c. 7°30'S to c 8°50'S has shown that its margins in the northern half consist of huge north-south elongated ridges that are aligned in an oval pattern on both sides. Some of them appear clearly truncated by the basin margins. Previous dredges were carried out at SO193 DR33, -34, -35, -36 and 37, and D3 of Ingle et al. (2007) which lies south of SO193-DR33 (Fig. 5.26). Recovered basalts from these locations have alkalic compositions and an age of 99.5±0.7 Ma has been published for D3 (Ingle et al. 2007), similar to our unpublished ages for the SO-193 locations in this trough (Hoernle et al. 2009). Based on this background information it is concluded that the margins of this trough are affected by younger, akaline volcanism and thus sampling of the older, tholeiitic plateau basement along the margins of the trough is challenging. Therefore our strategy was to still try our luck as we had to cross the area anyway, but to choose structures / slopes that do not lie at or near a seamount structure further up. The first target was a north-south trending ridge of probably tectonic origin on the western margin of the trough near its southern termination. Dredge 028DR10, however, returned empty. At the opposite basin margin dredge 029DR11 recovered solidified, in places foliated brown to slightly greenish clay stones. We therefore conclude that the margins of the trough are either covered by solidified sediment or younger volcanics and that igneous basement of the plateau phase is unlikely to be exposed here.

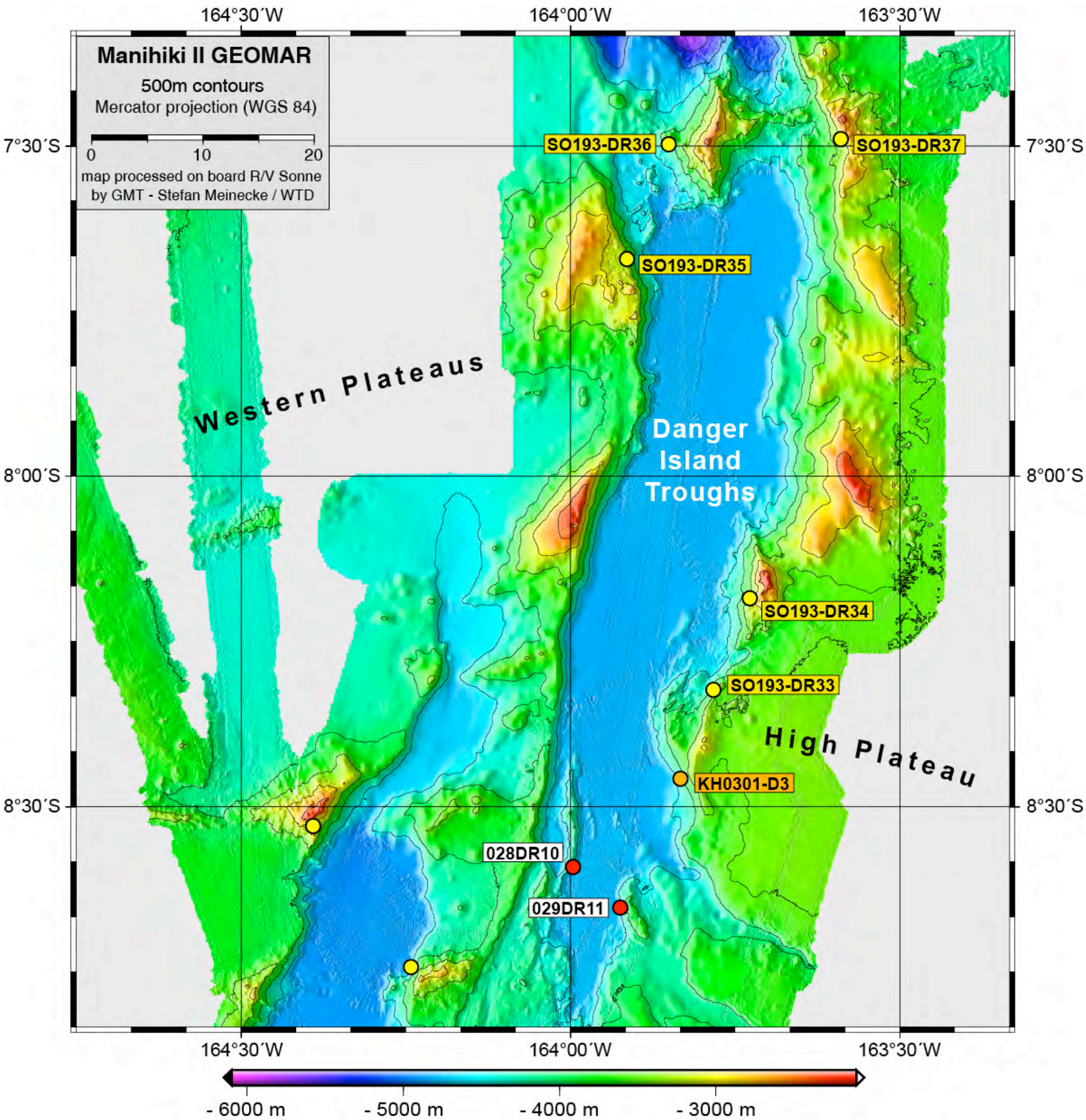

Fig. 5.26: *Locations of dredge sites conducted in the central Danger Island Trough. Red dots mark sites dredged on SO-225, yellow and brown dots sites sampled on SO-193 and R/V HAKUHO MARU cruise KH03-01, respectively. Labeled sites are mentioned in the text. Multi-beam data are recorded on RV SONNE cruises SO-193, SO-225, and R/V HAKUHO MARU cruise KH03-01.*

The prime target for plateau basement sampling was the third northernmost Danger Island Trough extending from c. 8°30'S to c. 10°S (Fig. 5.3). Here, at c. 9°20'S a large seamount structure rises at the eastern flank of the trough from c. 4,800 to 2,000 m b.s.l. The seamount has a steep, southwest facing flank with several step like terraces along the slope (Fig. 5.3, insert). The shape of the structure is oval in map view with its long axis striking northwest-southeast. Similarly the contour lines along the southwestern flank also strike northwest-southeast. A prominent lineament with the same strike cuts through the upper half of the structure, separating the uppermost terrace from the steep cliff that makes up the top the seamount. The strike of the seamount and lineaments is similar to those of the Suvorov Trough and a small sub basin where the Suvorov Trough connects with the north-south striking Danger Island Troughs. Based on these morphological observations it is concluded that this seamount represents a tectonic structure related to the formation of the Danger Island and Suvorov Troughs and the interaction of different principle directions of extensions (east-west vs. southwest-northeast). Previous sampling has been carried out at SO193 DR26 along the base of the southwestern slope where large amounts of pillow lava and hyaloclastites with abundant fresh glass were recovered and at D2 along the base of the west facing slope (Ingle et al 2007). Ages of 124.5±1.5 and 122.9±1.6 Ma are reported from SO193-DR26 (Timm et al. 2011) and 117.9±3.5 Ma for D2 (Ingle et al. 2007). Lavas from both sites belong to the low Ti group of Manihiki Plateau lavas (Timm et al 2011, Ingle et al 2007).

Fig. 5.27: *Large volcanic glass fragment with green palagonite on the outside and fresh black glass in the interior.*

Fig. 5.28: *Olivine phyric lava fragment with fresh groundmass and altered olivine.*

Dredge 030DR12 was carried out immediately below SO193-DR26 at the base of the northwest-southeast striking, cliff forming scrap from 4,440 to 4,000 m b.s.l. (Fig. 5.3). It returned mainly slightly vesicular, aphyric lava fragments with fresh to variably altered groundmass. The groundmass contains sometimes visible plagioclase and altered olivine. Most importantly two large pieces of pillow glass rinds (DR12-2) and intrapillow(?) hyaloclastites (DR12-3) containing abundant fresh glass were also obtained (Fig. 5.27). The black glass is embedded in yellowish-greenish palagonite and the zones of fresh glass are up to several cm thick. Care needs to be taken when preparing the glass from the hyaloclastite to keep individual glass shards separate and to check for compositional variations before glass is eventually merged. The associated palagonite could be used to quantify element changes during glass alteration. Notably an altered ultramafic plutonic rock (wherlite) has also been recovered. It is composed of ~60% altered olivine, ~20% fresh, bottle green clinopyroxene and amorphous material (possibly plagioclase?) filling space between olivine and cpx. The clinopyroxene can be used for chemistry. A large piece of a volcanic breccia (56x32x26 cm) contains angular lava clasts that are quite homogeneous, aphyric in texture and contain up to 50% filled vesicles. Finally a thick piece of laminated hyaloclastite altered to palagonite has been also sampled. The following dredge 032DR13 was carried out slightly southeast of SO193 DR26 at similar depth (4,068 to 3,655 m b.s.l.). It contained mainly olivine phyric lava fragments ranging from weakly to altered groundmass (Fig. 5.28). Olivine is up to 3 mm in size and ranges from 5 to 15% but is altered throughout. Vesicles are small and less abundant. They are increasingly filled with secondary minerals the higher the degree of overall alteration.

Fig. 5.29: *Strongly oxidized lava fragments. Red groundmass suggests subaerial eruption / weathering.*

Fig. 5.30: *Altered volcanic rock with spinifex textured pyroxene. Spinifex only visible with hand lense.*

Some pieces (DR13-8) possess chilled pillow margins which may still contain fresh glass. Others are greenish palagonite fragments (DR13-9, -10, 12) that should be checked for fresh glass. The last dredge below the 2nd terrace (032DR14) was located slightly north of SO193-DR26 and covered the depth from 3,800 to 3,400 m b.s.l. Although the dredge was well filled it mainly returned fist sized basaltic debris that was for the most part medium to strongly altered as expressed by a brownish to reddish groundmass color. The freshest pieces (DR14-1, -2, -3) possess a dense microcrystalline groundmass with occasional (1%) altered olivine phenocrysts (1 mm) but for the most part they are aphyric. Dredge 033DR15 covered the slope immediately below the 1st terrace from 3,400 to 2,950 m.b.s.l (Fig. 5.3) and returned only two pieces of manganese encrusted palagonite and breccia. The top region of the seamount was sampled at 034DR16 (2,858 - 2,172 m b.s.l.) along the steep southwest facing cliff below the summit. A half full dredge returned variable altered, fragments of olivine basalt. In many pieces the groundmass is oxidized to dark red implying subaerial conditions of eruption and weathering (Fig. 5.29). Fresh groundmass plagioclase is observed in some samples. Two pieces of matrix supported basalt breccias (DR16-14 and -15) have been also included as some clasts appear relatively fresh with a coarse grained groundmass that may be suitable for dating. Dredge 035DR17 (4,700 - 4,300 m b.s.l.) was an attempt to possibly sample the lowermost units along a small cliff that lies halfway into the Danger Island Trough where the contour lines change from a southeast-northwest strike into northern directions (Fig. 5.3). Still this cliff could also represent the deposit of a slope failure as the slope to the east has characteristic inward bending contour lines. The dredge returned strongly oxidized, olivine phyric lava fragments similar to those of the previous dredge at the top, indicating that they could be indeed debris from the top region. One piece (DR17-5) may contain plagioclase in the groundmass. Two volcaniclastic rocks, a breccia and a greenish hyaloclastite along with a Mn-crust were also sampled. Chemistry and age dating will be difficult for this dredge. The final dredge along this seamount (038DR20) was carried out at he southeastern termination of the main southwest facing cliff from 4,600 to 4,000 m b.s.l. Here variably oxidized, olivine phyric lava fragments were obtained. Some samples (DR20-3, -4, -5) contain needle like groundmass pyroxene resembling spinifex textures. These are probably primitive basalts and resemble those found at SO225-DR18 and DR19 (see below).

Two additional locations were dredged c. 15nm north of the tectonic seamount structure on the east side of the Trough (036DR18 and 037DR19, Fig. 5.3). This is area is in the vicinity of the SOTW 78D location of Claque (1976) on the western side of the trough from where unusual fresh olivine phyric, high magnesium lavas are reported. They also belong to the low Ti group of Manihiki basalts. DR18 of SO-225 is located at the base of a gentle westward dipping slope at the eastern side of the trough and covers the depth range from 4770 to 4310 m b.s.l. The haul recovered several up to 0.5 m large blocs and medium to small fragments of pillow lava, greenshist and sediment. The lava, although medium to strongly altered in most pieces, revealed spectacular spinifex textured 1-2 mm sized, light brown pyroxene needles (Fig. 5.30). The groundmass is mircocrystalline and dense with a few percent vesicles and microspinifex of pyroxene. The spinifex textured pyroxene may indicate elevated eruption temperatures along with an unusual chemistry (low aluminum?) that prevented plagioclase being on the liquidus as well.

The second unusual rock type were large, massive fragments of greenshist with a coarse grained, diabase like groundmass and large up to 1 cm long chlorite laths that are aligned parallel to a weakly developed schistosity (Fig. 5.31). The origin of this metamorphic rock is, however, unclear. The third rock type is fine grained, solidified claystone with a light grey to light brown color. The next dredge target (037DR19) was located c. 2.5 nm northeast of the previous site and ranged from 4,200 to 3,600 m b.s.l. Here a gentle southwest facing slope connects to the top region of a regional bathymetric high. The dredge returned only a few rocks. These were strongly altered, subrounded clasts of spinifex textured pyroxene lavas, quite similar to the previous dredge but more altered. The other rocks were massive Mn-crusts. The last two dredges within the Danger Island Troughs were carried at along the western (9°32'S) and eastern (9°40'S) sides of the trough where seismic line AWI20120100 of SO-224 (Uenzelmann-Neben 2012) intersects (Fig. 5.3). Dredge 039DR21 was carried out along the southeast facing flank of a steep nose that forms an irregularity within the east facing slope. A full dredge with pillow and sheet lava was obtained from 4,430 to 3,770 m b.s.l. The lavas are quite variable and range from aphyric with mircocrystalline groundmass (DR21-1 and -2, Fig. 5.32) to plagioclase phyric varieties (DR21-7 to -12) and spinifex textured groundmass (DR21-4 to -6).

Fig. 5.31: *Coarse grained greenshist with up to 1 cm long chlorite crystals.*

Fig. 5.32: *Medium crystallized aphyric lava fragment from western side of the Danger Island Troughs.*

The degree of groundmass alteration ranges from moderately to strong. Fresh glass for spot analysis could still be preserved in the some of the pillow margins (DR21-20). A single piece of light brown solidified, layered sediment was also sampled. The final dredge in the Danger Island Trough was 040DR22 along the eastern slope, southeast of DR21. Although carried in greater depth (4,600 - 4,200 m b.s.l.) only a single piece of Mn encrusted solidified, light brown, layered clay stone was recovered.

Suvorov Trough (DR23 through DR27)

The Suvurov Trough is a prominent northwest-southeast striking graben structure that dissects the southern part of the High Plateau and connects with the Danger Island Troughs at c. 10°S. Dredge sampling of SO-193 revealed indurate sediment along most parts of its flanks. Only at SO193-DR18 *in situ* magmatic basement was found. This location is part of a prominent east-west striking, c. 20 km long ridge at c. 10°40'S (Fig. 5.33) which appears related to the opening of the Suvorov Trough and may have formed through transpressional forces. Additional mapping during SO-225, however, shows that the ridge has no continuation on the western side nor do conjugate northeast-southwest striking faults occur in the area. Rocks obtained at SO193-DR18 are olivine rich and most notably olivine appeared unusually fresh in some samples. According to their bulk chemistry they belong to the low Ti group of Manihiki lavas which is characterized by complex trace element depletion patterns. A $^{40}Ar/^{39}Ar$ step heating age on feldspar from one of the SO193-DR18 samples gave 125.2±8.3 Ma (Timm et al. 2011). The relatively high analytical error reflects low ion beam intensities due to ultra low K contents in these depleted high magnesium rocks. Dredge sampling of the structure during SO-225 was designed to cover its western termination at the Suvorov Trough (with the presumably best basement exposures) at variable depth intervals but also locations along the ridge (Fig. 5.33).

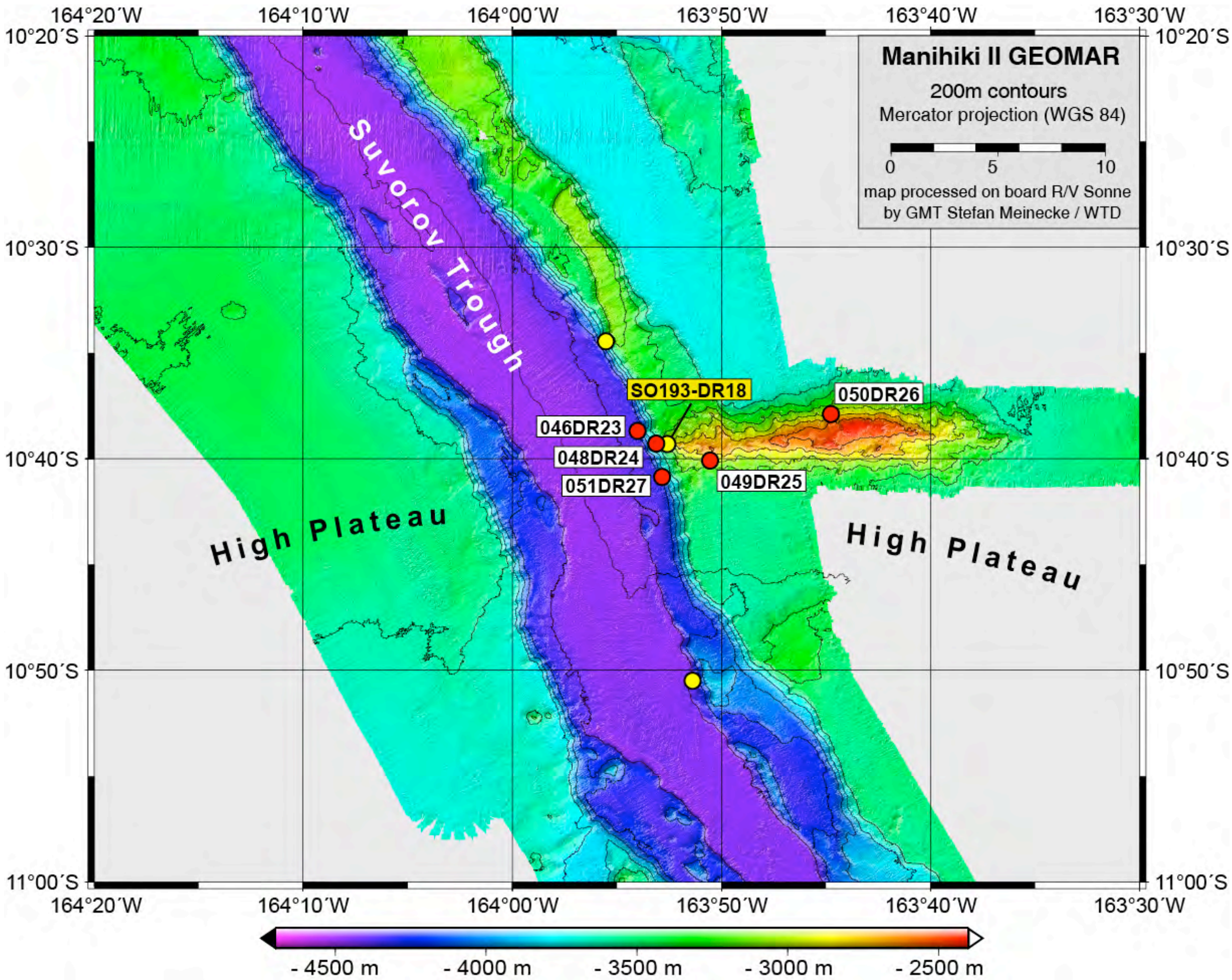

Fig. 5.33: *Locations of dredge sites conducted at the Suvorov Trough. Red dots mark sites dredged on SO-225, yellow dots sites sampled on SO-193. Labeled sites are mentioned in the text. Multi-beam data are recorded on RV SONNE cruises SO-193 and SO-225.*

Dredge 046DR23 was carried out at the base of the southwest dipping slope into the Suvurov Trough from 4,300 to 3,800 m b.s.l. It returned a variety of lava fragments that differ by phenocryst content. Sample DR23-1 is a rounded piece of moderately altered, vesicular (10-15% filled with amorphous quartz) basalt that in places has fresh groundmass patches preserved (Fig. 5.34). Notably it contains fresh plagioclase (<1 mm) phenocrysts making it the most suitable rock of the dredge for age dating. Other lava fragments comprise aphyric (DR23-2 and -3) or clinopyroxene phyric (5-7%, fresh) varieties.

Fig. 5.34: *Slightly to moderately altered, plagioclase phyric lava. Vesicles are filled with amorphous quartz (white dots).*

Fig. 5.35: *Smashed piece of hyaloclastite bloc. Green palagonite dominates but black areas contain fresh glass.*

Station 048DR24 is located immediately below DR18 of SO-193 and covers 3,600 to 3,000 m b.s.l. Most notably a large bloc (25x23x16 cm) of greenish palagonite with abundant fresh glass clasts was recovered (DR24-1 and -1X). Several cm sized shards of fresh glass were prepared on board and one original piece of the bloc saved as archive sample (Fig. 5.35). The glass requires additional careful preparation and must be checked for chemical heterogeneities before individual splits are eventually merged. In addition to insights into the pristine magmatic composition of lavas (major and trace elements, radiogenic isotopes, volatiles and rare gas) and age using the fresh glass; the palagonite could be used to quantify element changes during glass alteration. Furthermore two relatively fresh, fairly dense, angular pieces of olivine basalt were collected (DR24-2, -3). The remainder of the samples consist of strongly altered lava fragments with yellowish-brown, oxidized groundmass and possible relicts of altered pyroxene needles. DR24-10 is another piece of lava that still contains fresh spots of grayish groundmass that may be useful for chemistry.

Fig. 5.36: *Coarse grained pyroxene-olivine phyric lava from the last dredge of SO-225.*

Fig. 5.37: *SO-225 scientists handling the content of a successful dredge in the geology lab of R/V SONNE.*

The top of the ridge was sampled at two locations, south and north of the crest (Fig. 5.33). Only 049DR25 returned rocks; station 050DR26 was empty. DR25 collected fairly altered, vesicular (20-25%), olivine basalt fragments from 2,975 to 2,550 m b.s.l. Care needs to be taken to avoid maganese fillings of the vesicles and along veins. The last dredge of SO-225 aimed once again for the east dipping slope of the ridge slightly south of DR23 and DR24 from

4,600 to 4,200 m b.s.l. A full dredge returned with mainly fine grained, purple to red colored sandstones but also contained a few olivine-pyroxene basalts. DR27-1 is a coarse grained, massive basalt with 40% well crystallized clinopyroxene (<2 mm), 15% <1 mm sized olivine phenocrysts and small, datable plagioclase microphenocrysts (Fig. 5.36). An aphyric variety with moderately to slightly altered groundmass is represented by sample DR27-2 and -6 whereas sample DR27-3 to 5 contain minor amounts (5%) of pyroxene phenocrysts. The most primitive sample is probably represented by DR27-7, a moderately altered olivine basalt with c. 20% altered olivine.

SO-225 Rock Sampling Summary

Two ROV profiles along a 1.5 km section of tectonically formed seamount collected very fresh aphyric basalt and a fairly fresh gabbro with plagiogranitic patches. The northern margin of the High Plateau exposed only limited stretches of igneous basement at the very base of the slope. A few datable pieces of lava were obtained from here. The vast part of the northern margin of the High Plateau, however, is covered with solidified sediment. The second northernmost Danger Island Trough is made up of younger alkaline volcanic structures. Away from these solidified sediment was sampled. The largest plateaus basement exposure suitable for surface sample is a tectonic bloc at 9°20'S on the High Plateau side. Large amounts of fresh glass along with variably altered lavas were obtained here. The groundmass of the lava becomes more reddish oxidized when going up-section, indication subaerial conditions of eruption and / or weathering. Pyroxene spinifex textured lava has been obtained slightly north of the tectonic bloc and may provide new insights into eruption temperatures of the plateau forming lavas and their unusual chemistry. A final highlight was the recovery of large amounts of fresh glass from the Suvurov Trough. Taken together the recovery of large quantities of fresh glass from localities with known occurrences of low Ti group lavas will allow a more detailed work out of the geochemistry and source parameters of these unique chemical group but will also permit exploration of volatile and rare gas systematics (Fig. 5.37). Age dating by Ar-Ar is possible in many of the sampled locations and will (1) expand the aerial coverage of dated plateau basement and (2) will provide an age range of plateau formation for a least 3 areas that were sampled in more detail.

5.2.3. Volcanic Particles and Lithics from Sediment Cores *(M. Portnyagin)*

Particle of Volcanic Material from SO225-MUC-8-1

The particle was found in pilot core SO225-MUC-8-1 at 7-8 cm. The particle was nearly isometric, well rounded, dark gray in color and c.1 cm in size. For the investigation, the particle was split by hand into several pieces (Fig. 5.38a). It appeared to be a dark fine material with few crystals of plagioclase when observed under small magnification binocular microscope. For closer look, one of small fragments was crushed by hammer in PVC film down to <200 µm powder, which was used to prepare a thin section on Canadian balsam. Investigation under optical microscope on board of R/V SONNE revealed that the fine matrix material is represented by well-preserved color-less vesicular glass shards placed in smectite matrix(Fig. 5.38b). The glasses have typical appearance for felsic (dacite and rhyolite) volcanic glasses produced by explosive eruptions on-land. Phenocryst minerals are honey brown orthopyroxene, dark green clinopyroxene (Fig. 5.38c and d) and color-less plagioclase (Fig. 5.38c). The latter is often with tiny melt inclusions.

The particle can be preliminary interpreted as a single pumice lapilli or tuff (or accretionary lapilli). To distinguish between these two possibilities an investigation of large fragment is required. Judging from the high vesicularity, the magma was apparently rich in volatiles and probably erupted on land or under shallow water conditions allowing expansion of fluid phase to form abundant vesicles during eruption.

a. b. c. d.

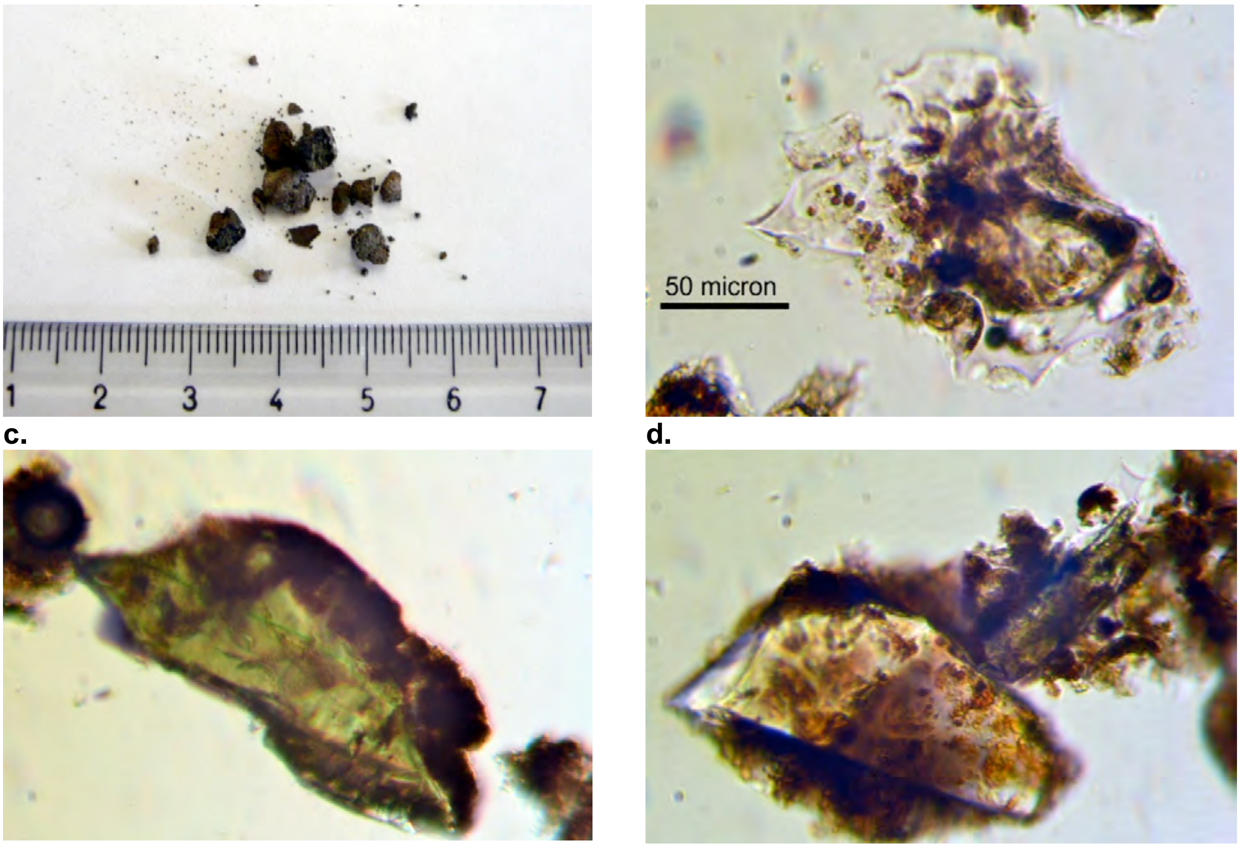

Fig. 5.38: *Accretionary lappilli/tuff particle from SO225-MUC-8-1 (7-8 cm).* ***a.*** *Sample after breaking apart.* ***b.*** *Typical glass shard. Dark fine material is smectite from the rock matrix.* ***c.*** *Clinopyroxene crystal.* ***d.*** *Plagioclase and pyroxene with glass coatings. Photos b, c, and d are taken under optical microscope in transmitted polarized light and have the same scale as in b.*

Lithics from pilot core SO225-MUC-21-2

<u>Sample SO225-MUC-21-2 Nd GEOMAR 0-1 cm:</u> Strongly altered volcanic rock (olivine-plagioclase-phyric basalt). Flattened angular rock fragment of 6.5x3x1.5 cm in size (Fig. 5.39). Brown outer surface with incrustation of Fe-Mn hydroxides. The rock has porphyric texture with c. 5-8% of plagioclase and 3-5% olivine phenocrysts, both up to 1.5 mm in size. Intergrowths of plagioclase are common. Brown matrix is finely recrystallized with well describable plagioclase microliths. The matrix is strongly altered with smectites and Fe-oxides replacing glass.

a. b.

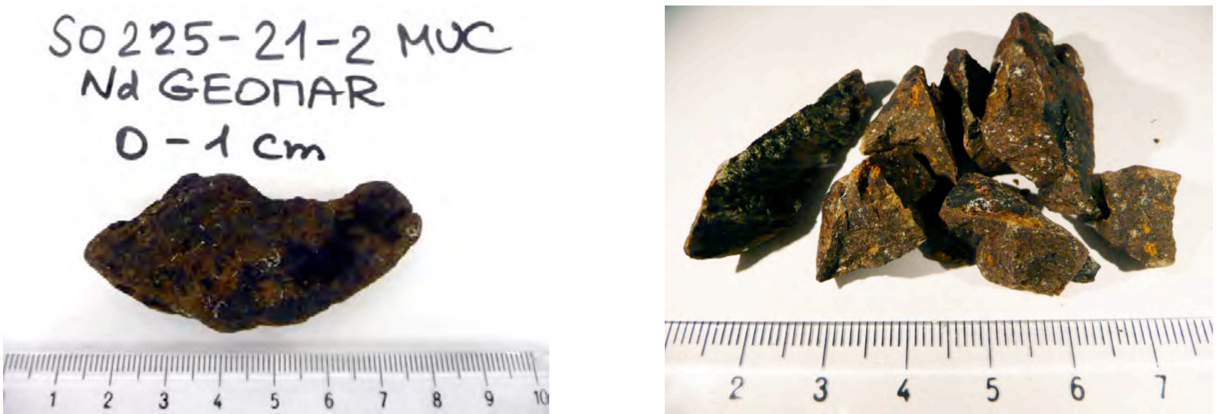

Fig. 5.39: *SO225-MUC-21-2 (0-1 cm).* ***a.*** *General view of the sample;* ***b.*** *Broken sample. White dots on broken surface are plagioclase phenocrysts, dark yellow dots are olivine phocrysts replaced with limonite.*

<u>Sample SO225-MUC-21-2 AWI-I 2-3 cm:</u> Sedimentary rock (Fig. 5.40), a fragment of silicate part of Fe-Mn-hydroxide crust. Flattened angular rock fragment, 4x2.3x1.5 cm in size, reddish brown with black incrustations on outer surface. Inner parts are somewhat yellowing cream-white, in some parts greenish with black incrustations and spots of Fe-Mn oxides. Microcrystalline/amorphous texture. No reaction with HCl. The sample can be interpreted as silicate (zeolite group?) aggregate usually associated with Fe-Mn hydroxide crusts.

a. **b.**

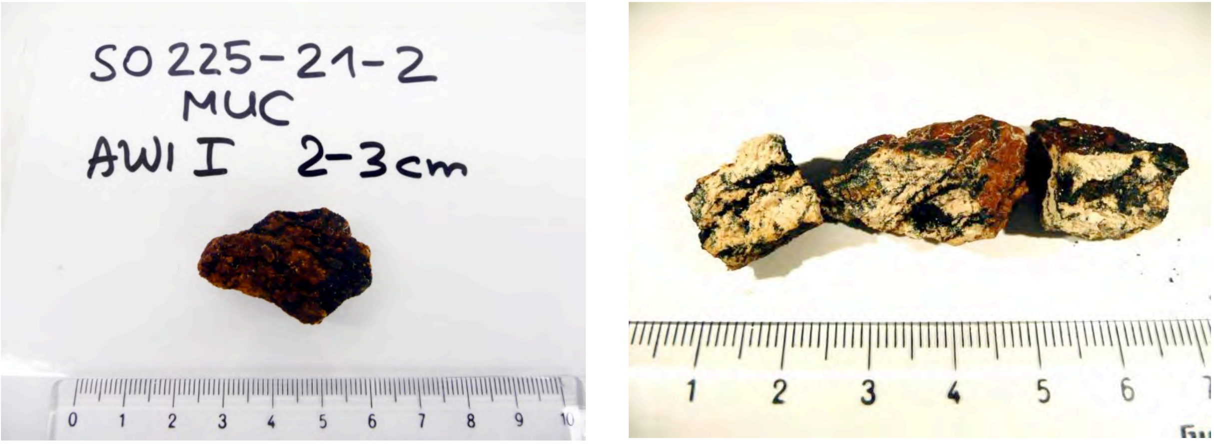

Fig. 5.40: *SO225-MUC-21-2 AWI-I (2-3 cm).* ***a.*** *General view of the sample.* ***b.*** *Broken sample with inner parts exposed.*

6. PALEOCEANOGRAPHIC OPERATIONS AND PRELIMINARY RESULTS

(N. Nürnberg, J. Raddatz, N. Schilling, A. Osborne, L. Max, D. Poggemann, B. Glückselig, N. Furchheim)

6.1. CTD-PROFILING AND ROSETTE

Water column profiles of salinity, oxygen, and temperature were measured with a Seabird 911 CTD profiler at four locations: Station SO225-02-02 at the southwest of the Western Plateaus, station SO225-15-01 at the north of the Western Plateaus, station SO225-21-01 in deep water north of the North Plateau, and station SO225-53-04 an the south-eastern rim of the High Plateau. The locations were chosen to encompass the entire study area. The CTD was deployed in conjunction with a rosette consisting of 24 x 10 L Niskin bottles (Fig. 6.1), with which water samples from depths of interest were retrieved. The CTD temperature, salinity and oxygen data were plotted in real time and were used to identify pertinent sampling depths for the various water-based investigations (see chapter 6.1.2).

Fig. 6.1: *Water sampler device (Rosette) equipped with Seabird 911 CTD.*

6.1.1. Preliminary Results of Hydrographic Measurements

There are striking differences between the CTD water column profiles from the four stations, particularly in salinity and dissolved oxygen content (Fig. 6.2). The presence of Antarctic Intermediate Water (AAIW) is suggested by a salinity minimum between 400 and 1,000 m water depth, decreasing in amplitude to the north.

The two southerly stations, SO225-02-02 and SO225-53-04, have strong salinity maxima at 130 m of 36.35 and 36.29 (psu), respectively. Station SO225-02-02, at a latitude of 9°59.77'S, is expected to sample the South Equatorial Counter Current (SECC) in the upper 200 m. By comparison, the subsurface salinity maximum at the north of the Western Plateaus, station SO225-15-01, is less pronounced (35.93) and deeper (170 m). The T-S diagram (Fig. 6.3) shows that station SO225-15-01 subsurface properties lie between those measured at the southern and northern stations. These findings are consistent with plots of World Ocean Atlas data (WOA09, Fig. 6.4), which show high salinity in the subsurface between c. 5 and 15°S.

The northernmost station, SO225-21-01, at 3°2.99'S, has no subsurface salinity maximum and instead, has a well mixed layer extending to 180 m (Fig. 6.5). This well mixed surface layer is consistent with the southern edge of the Equatorial Undercurrent (EUC). Normally present between 2°N and 2°S, the EUC originates at a depth of 200 m north of Papua New Guinea and rises during eastward flow across the Pacific (Wyrtki and Kilonsky 1984, Lukas and Firing 1989). A strong pycnocline has been observed within the EUC, separating it into two main layers above and below 150 m. The density profile of station SO225-21-01 shows a very rapid change between 150 and 200 m. However, a similar feature is observed in the more southerly station SO225-15-01, located at 5°47'S, so that the strong pynocline alone cannot be taken to indicate the presence of the EUC. The pycnocline at stations SO225-02-02 and SO225-53-04 have, by contrast, a lower rate of change.

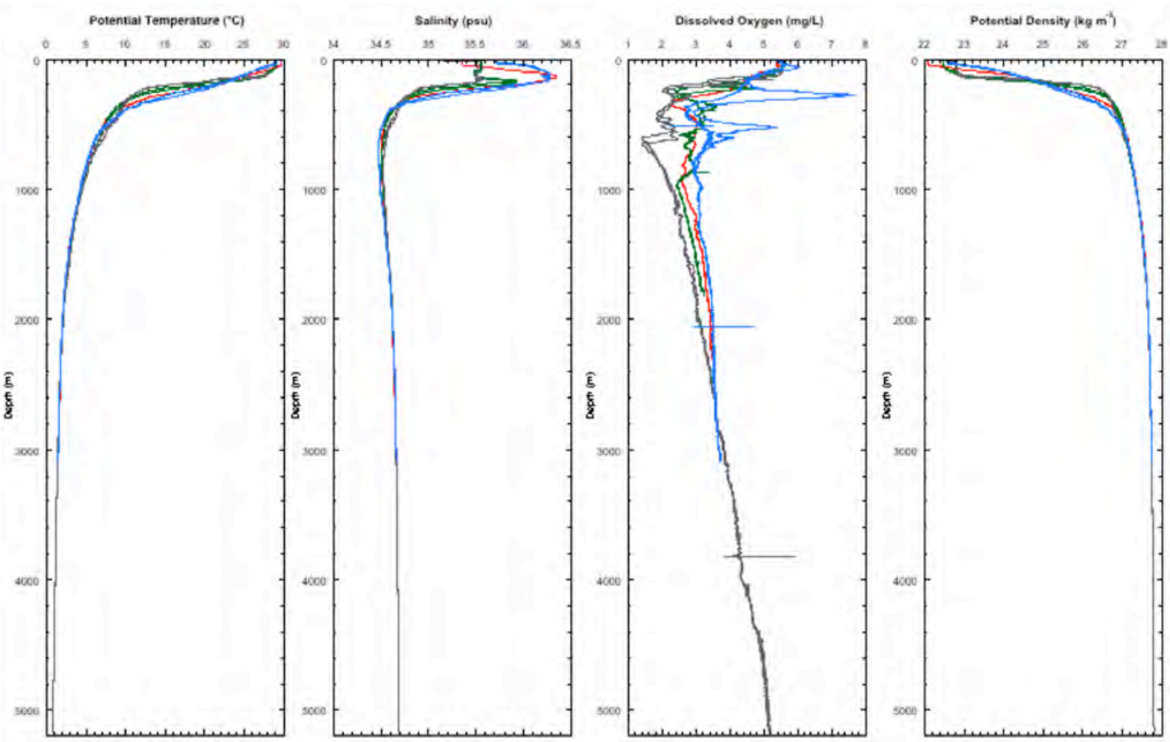

Fig. 6.2: *Water column profiles of potential temperature, salinity, dissolved oxygen and potential density for CTD stations SO225-02-02 (Western Plateaus, red), SO225-15-01 (North Plateau, green), SO225-21-01 (North Plateau, grey) and SO225-53-04 (High Plateau, blue).*

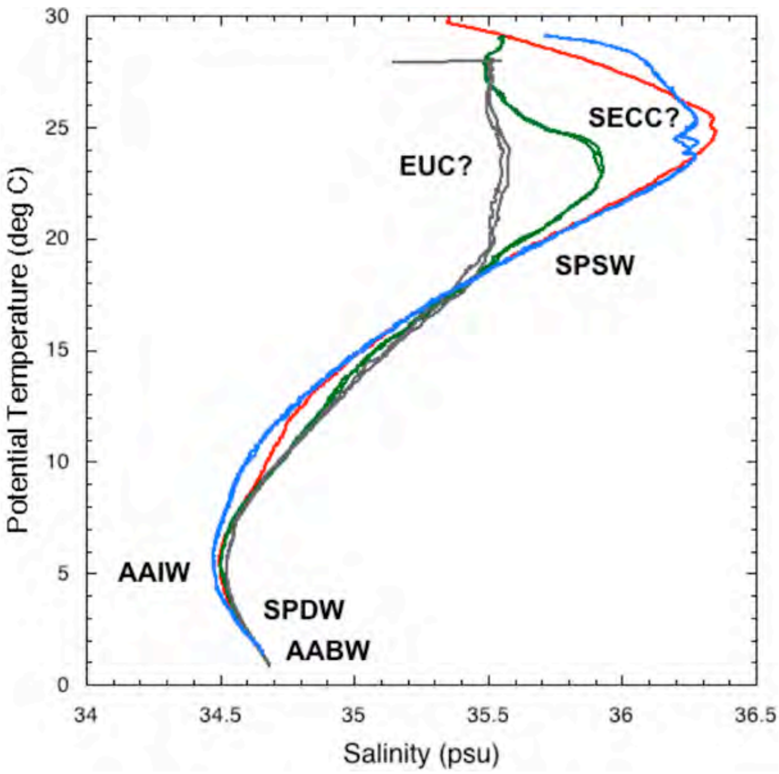

Fig. 6.3: *Temperature-salinity diagram for CTD stations SO225-02-02 (red), SO225-15-01 (green), SO225-21-01 (grey) and SO225-53-04 (blue). EUC = Equatorial Under Current; AABW = Antarctic Bottom Water; SPDW = South Pacific Deep Water; AAIW = Antarctic Intermediate Water; SPSW = South Pacific Subtropical Water, after Zhang and Nozaki (1996).*

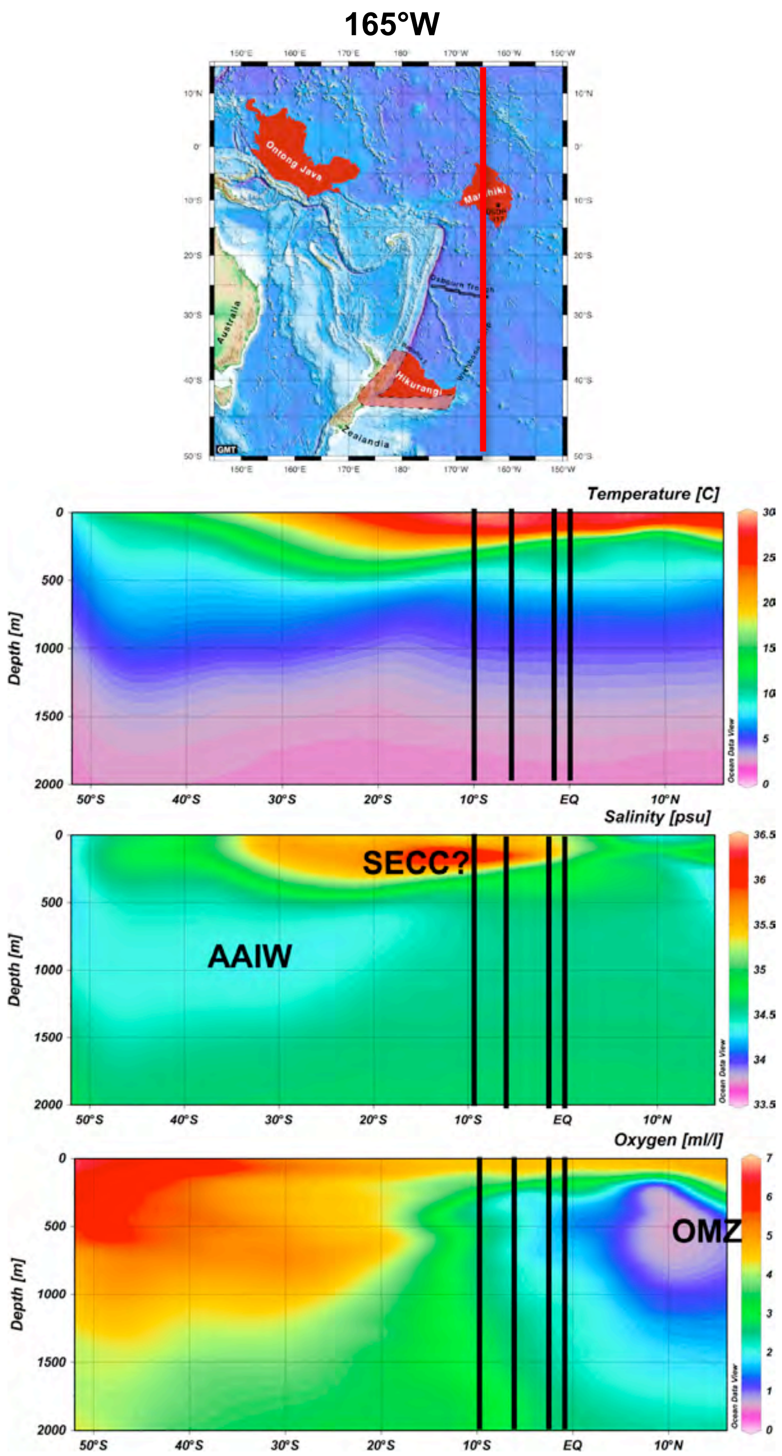

Fig. 6.4: *Ocean Data View (ODV) plots of WOA 09 temperature, salinity and oxygen at 165°W, showing the low salinity tongue of Antarctic Intermediate Water (AAIW), the high salinity South Equatorial Counter Current (SECC) and the strongly developed oxygen minimum zone (OMZ) associated with equatorial divergence. The black vertical lines indicate the latitudes of the CTD stations.*

Below the thermocline the T-S profiles of all sites (Fig. 6.3) follow a mixing line between South Pacific Subtropical Water (SPSW) (T = 18-20°C, S = 35.7) and Southern Pacific Deep Water (SPDW), which itself is a mixture of Antarctic Bottom Water (AABW) (T < 2°C, S =34.69-34.70) and Antarctic Intermediate Water (AAIW) (T = 5-6°C, S = ~ 34.4). The inflection point of minimum salinity associated with AAIW is only weakly expressed in the Manihiki Plateau region; however it does decreases with distance from the south.

Another major difference between the four stations is the extent and intensity of the oxygen minimum zone (OMZ). Surface concentrations of dissolved O_2 are 5.5 - 5.6 mg l^{-1} for all stations. The minimum for station SO225-02-02 is 2.2 mgl^{-1} at 350 m. For station SO225-15-01, a minimum of 2.3 mgl^{-1} occurs at 280 m. For station SO225-53-04, the minimum is 2.7 mgl^{-1} at 400 m. There are further, less developed local minima extending to 1,000 m water depth in these three profiles. During the down-cast, very high O_2 concentrations of up to 7.7 mg l^{-1} (280 m) were recorded in the upper 600 m. These high concentrations were absent in the up-cast, some 2-3 hours later in the evening. According to WOA09 such high O_2 concentrations of the downcast are obvious outlier and therefore, we only consider up-cast O_2 concentrations. However, a weak positive anomaly in dissolved oxygen concentrations characterized by an increase of 0.6 mg l^{-1} at 600 m water depth might be associated with advances of AAIW.

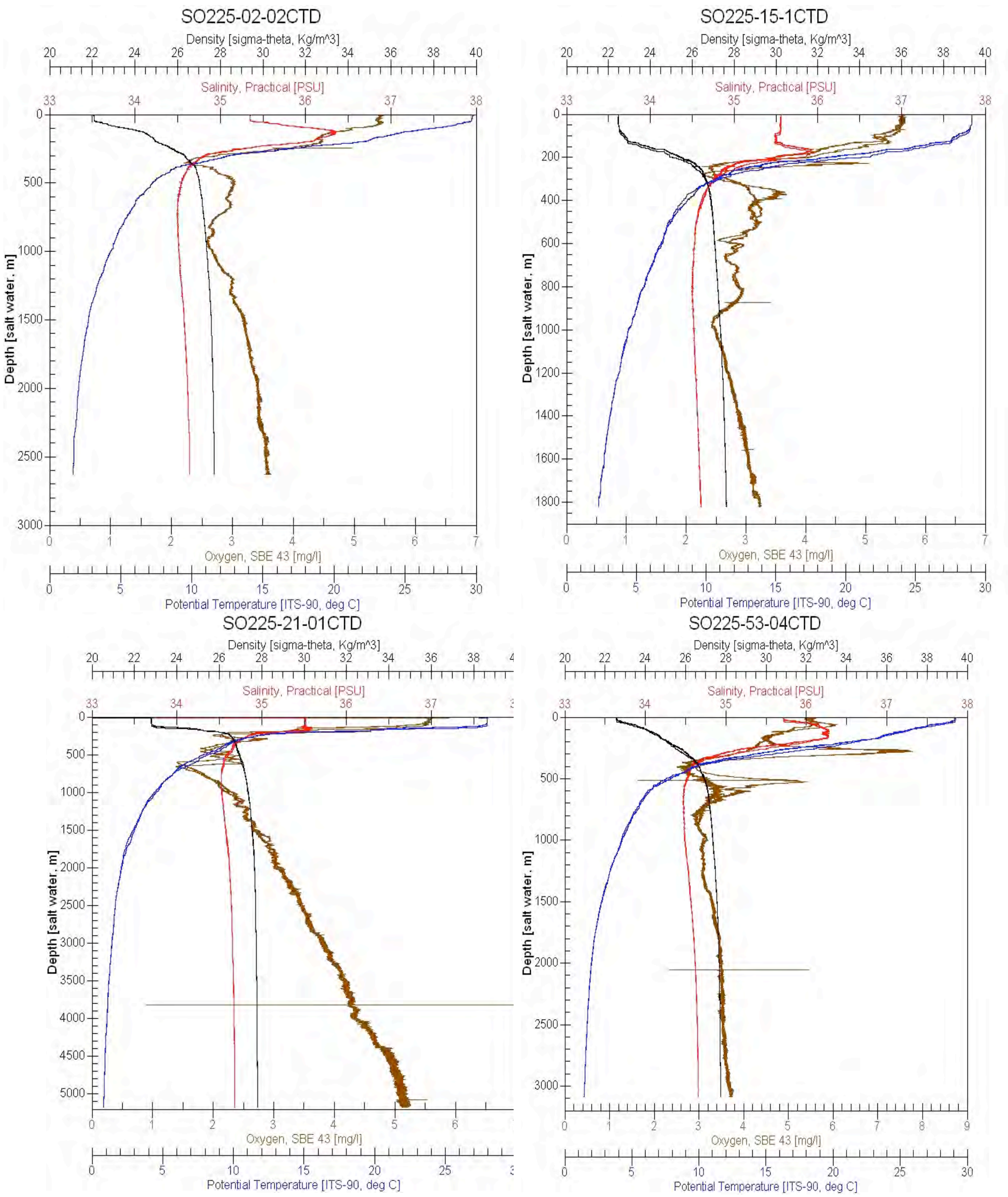

Fig. 6.5: *Temperature (blue), oxygen (brown), salinity (red) and potential density (black) profiles of the water column at stations SO225-02, -15, -21 and -53.*

Station SO225-21-01 has a very strongly developed OMZ, with three minima, located at 250 m, 460 m, and 660 m, the deepest of which is the most depleted in oxygen, with concentrations of 1.4 mgl^{-1}. This strong OMZ is a feature of equatorial divergence and again indicates that the northern edge of the Manihiki Plateau is under the influence of equatorial water masses, consistent with WOA09 dissolved oxygen data (Fig. 6.4).

Equatorial Pacific Intermediate Waters (EqPIW) as described by Bostock et al. (2010), differ from AAIW, having a slightly higher salinity (34.5 - 34.6) and a lower oxygen content. Bostock et al. (2010) concluded that EqPIW is a mixture of AAIW and upwelling Pacific Deep Water. The CTD results for Station SO225-21-01 are consistent with the presence of EqPIW.

6.1.2. Water Column Sampling

The 24 x 10 L Niskin bottles of the rosette were opened prior to deployment and the closing mechanism was sequentially fired at the desired depths during the up-cast. On deck, tubing was attached to the bottom vents of each bottle and water samples were collected for dissolved nutrient concentrations (nitrate, phosphate, silicon), stable isotopes ($\delta^{13}C$, $\delta^{18}O$), silicon isotopes, rare earth element (REE) concentrations and neodymium isotopes (Table 6-1).

Table 6-1: Water column sampling at CTD stations: Type and water depth [m], A: Nutrients, B: $\delta^{18}O$; C: $\delta^{13}C$; D: Silicon isotopes, E: REE; F: Neodymium.

Station SO225-02-02 CTD

Bottle	Depth (m)	Potential T (deg C)	Salinity (psu)	O2 (mg l^{-1})	sigma-theta (kg/m^3)	Samples
1	2627	1.66	34.64	3.58	27.71	A,B,C,D,E,F
2	2022	2.02	34.62	3.42	27.67	A,B,C,D,E,F
3	1525	2.69	34.58	3.21	27.58	A,B,C,D,E,F
4	1028	4.15	34.52	2.70	27.39	A,B,C,D,E,F
5	730	5.54	34.50	2.81	27.21	A,B,C,D,E,F
6	531	7.06	34.54	2.99	27.05	A,B,C,D
7	491	7.31	34.55	3.02	27.02	E,F
8	491	7.31	34.55	3.02	27.02	A,B,C
9	462	7.66	34.57	2.93	26.98	A,B,C
10	382	9.19	34.64	2.53	26.81	E,F
11	381	9.17	34.64	2.56	26.81	A,B,C,D
12	283	13.88	34.92	3.12	26.15	E,F
13	282	13.99	34.94	3.13	26.14	A,B,C
14	243	17.70	35.37	4.01	25.63	E,F
15	243	17.70	35.37	4.01	25.63	A,B,C,D
16	134	24.75	36.35	4.62	24.44	E,F
17	134	24.75	36.35	4.62	24.44	A,B,C,D
18	51	29.62	35.37	5.42	22.14	E,F
19	51	29.62	35.37	5.42	22.14	A,B,C,D
20	10	29.75	35.35	5.44	22.07	E,F
21	10	29.75	35.35	5.44	22.07	A,B,C

Station SO225-15-01 CTD

Bottle	Depth (m)	Potential T (deg C)	Salinity (psu)	O2 (mg l^{-1})	sigma-theta (kg/m^3)	Samples
1	1817	2.28	34.60	3.23	27.63	A,B,C,D
2	1489	2.90	34.57	2.98	27.55	A,B,C,D
3	993	4.45	34.52	2.49	27.36	A,B,C,D
4	893	5.03	34.51	2.70	27.28	A,B,C

Station SO225-15-01 CTD (continued)

Bottle	Depth (m)	Potential T (deg C)	Salinity (psu)	O2 (mg l^{-1})	sigma-theta (kg/m^3)	Samples
5	795	5.58	34.50	2.88	27.21	A,B,C
6	695	6.18	34.51	2.80	27.14	A,B,C,D
7	576	6.96	34.53	2.94	27.06	A,B,C
8	496	7.51	34.55	3.19	27.00	A,B,C,D
9	347	9.45	34.68	3.04	26.80	A,B,C
10	280	11.66	34.83	2.47	26.52	A,B,C,D
11	230	14.30	35.01	2.58	26.13	A,B,C
12	210	17.89	35.40	3.36	25.60	A,B,C,D
13	170	22.52	35.91	4.21	24.76	A,B,C
14	130	27.05	35.50	5.04	23.07	A,B,C
15	109	27.67	35.50	5.29	22.88	A,B,C
16	90	28.20	35.50	5.28	22.70	A,B,C
17	70	28.90	35.56	5.52	22.52	A,B,C
18	49	29.03	35.56	5.61	22.47	A,B,C
19	49	29.03	35.56	5.61	22.47	D
20	31	29.04	35.56	5.59	22.47	A,B,C
21	11	29.04	35.56	5.60	22.47	A,B,C

Station SO225-21-01 CTD

Bottle	Depth (m)	Potential T (deg C)	Salinity (psu)	O2 (mg l^{-1})	sigma-theta (kg/m^3)	Samples
1	5172	0.82	34.68	5.16	27.80	A,B,C,D,E,F
2	3992	1.08	34.67	4.34	27.78	A,B,C,D,E,F
3	3005	1.41	34.66	3.80	27.74	A,B,C,D,E,F
4	2009	2.09	34.62	3.04	27.66	E,F
5	2009	2.09	34.62	3.04	27.66	A,B,C,D
6	1493	3.01	34.57	2.66	27.54	E,F
7	1493	3.01	34.57	2.66	27.54	A,B,C,D
8	997	4.42	34.53	2.30	27.37	E,F
9	997	4.42	34.53	2.30	27.37	A,B,C,D
10	649	6.38	34.54	1.54	27.14	E,F
11	649	6.38	34.54	1.54	27.14	A,B,C,D
12	450	8.77	34.64	1.95	26.87	E,F
13	450	8.77	34.64	1.95	26.87	A,B,C,D
14	281	10.73	34.78	2.26	26.65	A,B,C,D
15	241	11.86	34.86	2.14	26.51	A,B,C
16	202	15.31	35.15	2.58	26.02	E,F
17	202	15.31	35.15	2.58	26.02	A,B,C,D
18	182	19.56	35.51	3.34	25.26	A,B,C
19	153	21.58	35.52	3.54	24.73	E,F
20	153	21.58	35.52	3.54	24.73	A,B,C,D
21	54	27.94	35.52	5.55	22.80	E,F
22	54	27.94	35.52	5.55	22.80	A,B,C,D
23	14	27.96	35.52	5.58	22.80	E,F
24	14	27.96	35.52	5.58	22.80	A,B,C

Station SO225-53-04 CTD

Bottle	Depth (m)	Potential T (deg C)	Salinity (psu)	O_2 (mg l^{-1})	sigma-theta (kg/m^3)	Samples
1	3088	1.43	34.66	3.72	27.74	A,B,C,D,E,F
2	2006	1.97	34.62	3.50	27.67	A,B,C,D,E,F
3	1499	2.76	34.57	3.28	27.56	A,B,C,D,E,F
4	1001	4.27	34.49	3.17	27.35	A,B,C,D,E,F
5	802	5.11	34.48	3.04	27.25	A,B,C,D
6	703	5.64	34.47	3.22	27.18	E,F
7	703	5.64	34.47	3.22	27.18	A,B,C,D
8	506	7.86	34.52	3.02	26.92	E,F
9	505	7.87	34.52	3.04	26.92	A,B,C,D
10	396	9.82	34.59	2.81	26.66	E,F
11	396	9.82	34.59	2.81	26.66	A,B,C,D
12	278	15.55	35.09	4.05	25.92	E,F
13	277	15.57	35.09	4.06	25.91	A,B,C,D
14	198	21.38	35.96	4.45	25.12	A,B,C,D
15	168	23.54	36.27	4.59	24.74	E,F
16	168	23.54	36.27	4.59	24.74	A,B,C,D
17	99	25.85	36.24	5.10	24.02	E,F
18	98	25.88	36.24	5.10	24.01	A,B,C,D
19	50	28.10	36.07	5.66	23.17	E,F
20	50	28.10	36.07	5.66	23.17	A,B,C,D
21	11	29.05	35.72	5.40	22.58	E,F
22	10	29.05	35.72	5.41	22.58	A,B,C,D

Water sampling for nutrient concentrations

Samples for measuring nutrient concentrations were taken at all four CTD stations. 100 ml of seawater was decanted into a plastic bottle for each nutrient sample. The samples were poisoned with 100 µl of saturated $HgCl_2$ solution (7.5 g/100 ml) and stored at 4ºC.

Stable oxygen and carbon isotopes ($\delta^{13}C$, $\delta^{18}O$)

Stable isotope samples were taken at all four CTD stations. Slow and careful filling of 50 ml and 100 ml glass bottles for $\delta^{13}C$ and $\delta^{18}O$ respectively, avoided the inclusion of air bubbles, which would have an adverse effect on the sample quality. Samples were taken from depths capturing the major water masses and also depths of interest, as indicated by the CTD profiles of temperature, salinity and oxygen (Table 6-1). Prior to storage, the $\delta^{13}C$ samples were poisoned with 100 µl of saturated $HgCl_2$ solution (7.5 g/100 ml). All stable isotope sample bottles were sealed with bees wax to prevent interaction with the air and placed in the cool room at 4ºC.

Silicon isotopes

Samples for silicon isotopes were taken at all four CTD stations. Silicon concentrations are expected to be very low in surface waters and the upper parts of the water column, as is typical for nutrients. The volume of water required for silicon isotope analysis is, therefore, greater at shallower depths. Above 100 m depth, 4 L were taken for silicon isotope samples; between 100 m and 700 m, 3 L; between 700 m and 1500 m, 2 L and; below 1500 m, 1 L. All samples were decanted from the Niskin bottles using silicon-free tubing. The seawater was then filtered through 0.45 µm polycarbonate membrane filter and stored in a new set of 1 L plastic bottles at 4ºC.

Rare-Earth-Elements (REE)

Samples for REE concentration analyses were taken at three stations, SO225-02-02, SO225-21-01 and SO225-53-04. 0.2 µm AcroPak 500 continuous flow filters were attached with tubing to the Niskin Bottles. 125 ml of filtered seawater was collected in acid-cleaned Teflon bottles, avoiding air bubbles. 125 µl of twice-distilled, concentrated HCl was added to each sample to acidifidy to pH 2. Subsequently, samples were stored at 4ºC.

Neodymium (Nd)

Samples for Nd isotope measurements were taken at the same stations as for REE and were filtered in the same manner. Approximately 15 minutes was required to filter 10 L of seawater. As for silicate, Nd concentrations are expected to be very low in surface and upper water column seawater. For depths shallower than 500 m, an entire Niskin Bottle of 10 L was required for Nd. For greater depths, only 5 L was required and the Niskin Bottle could be shared with the other water samples when necessary. Samples were collected in acid-cleaned 10 L collapsible PE containers and acidified with 10 ml of 6 N distilled HCL per 5 L seawater, resulting in a pH of 2. These samples were stored at room temperature.

The objectives of the Nd isotopes and REE sampling are to extend the Pacific data set and to examine the propagation of signals associated with Antarctic Intermediate Water and the Equatorial Under Current.

6.2. MULTINET

The multinet (Fig. 6.6) was deployed at the northernmost station SO225-21 to collect plankton samples from different water depths between 500 m and the sea surface. Different depth intervals were selected to sample the uppermost water column: 500-300 m, 300-200 m, 200-100 m, 100-50 m and 50-0 m (Table 6-2).

Table 6-2: Multinet hauls at SO-225 stations.

Number of usage	Time of start	Latitude ‘S	Longitude ‘W
1	8:13	3°3.062	165°3.342
2	9:42	3°2.617	165°2.390
3	11:09	3°2.116	165°1.493
4	12:46	3°1.615	165°0.634
5	14:12	3°1.120	164°59.785
6	15:35	3°0.613	164°58.895
7	17:05	3°0.118	164°58.076

Fig. 6.6: *The AWI multinet deployed during SO-225.*

The multinet consists of a steel box with 5 net hoses, each with a mesh size of 55 µm. On the lower end of the multinet, a frame with 5 net beakers (1 liter each) was attached. In order to collect larger plankton fractions such as zooplankton (radiolarians, foraminifera, dinoflagellates), the net beakers were equipped with 41 µm mesh size gaze.

The multinet was lowered with closed nets down to 500 m water depth at a maximum speed of 0.5 m/s. A board unit allowed for the opening and closing of the nets at selected water depth intervals, according to a pressure sensor installed on the device. The heaving speed was 0.3 m/s. Since this area is known for its low marine primary productivity, the multinet was heaved 7 times. With each multinet application the ship was shifted by one nautical mile in order to always obtain a stratified upper ocean water column.

Back on board, the remaining plankton in the net hoses was washed into beakers. The plankton and remaining seawater were transferred into 1-liter bottles and stained with Bengal rosa.

6.3. SEDIMENT ACOUSTICS

6.3.1. ATLAS PARASOUND

The ATLAS PARASOUND sub-bottom profiler acts as a low-frequency sediment echo sounder and as high-frequency narrow-beam sounder to determine the water depth. The sub-bottom profiler is based on the parametric effect, which is produced by additional frequencies through nonlinear acoustic interaction of finite amplitude waves. In principle, if two sound waves of similar frequencies (18 kHz and e.g. 22 kHz) are emitted simultaneously, a signal of the difference frequency (e.g. Secondary Low Frequency of 4 kHz) is generated for sufficiently high primary amplitudes. This new component is traveling within the emission cone of the original high frequency waves, which are limited to an angle of only 4.5° for the equipment used. The resulting footprint size of only 7 % of the water depth is much smaller than for conventional systems and both vertical and lateral resolution is significantly improved (Fig. 6.7).

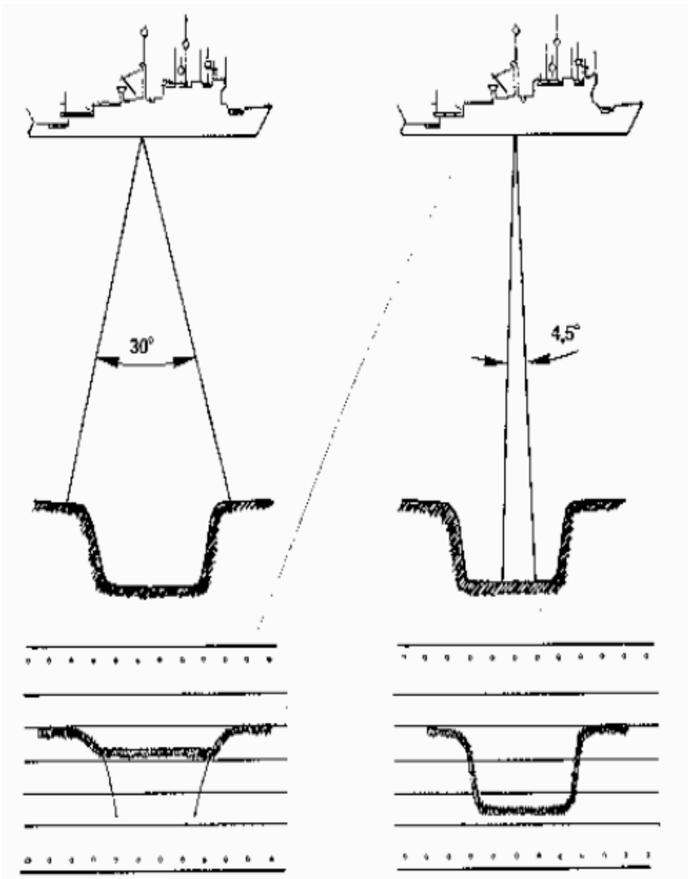

Fig. 6.7: *The extremely narrowed beam of the ATLAS PARASOUND of 4.5° compared to a conventional echosounder system and a beam angle of 30°. The ATLAS PARASOUND even resolves small-scale bottom structures and offers a deeper penetration of up to ~150 m into the seafloor (ATLAS Hydrographic).*

The ATLAS PARASOUND system is permanently installed on R/V SONNE. The hull-mounted transducer array has 128 elements within an area of 1 m^2. It requires up to 70 kW of electric power due to the low degree of efficiency of the parametric effect.

The PARASOUND sub-bottom profiler on R/V SONNE is equipped with the digital data acquisition software from ATLAS Hydrographic, which is subdivided in ATLAS Parastore and ATLAS Hydromap Control. ATLAS Parastore allows the buffering, transfer and storage as well as the visualization of the digital echograms at very high repetition rates. ATLAS Hydromap Control is responsible for user defined modifications of the system (e.g. pulse rate or mode) and supports the operator in running the system properly.

6.3.2. Preliminary Results

The PARASOUND system was the major tool to recover suitable sediment core sites during R/V SONNE cruise SO-225 MANIHIKI II. Altogether, more than 2,245 nautical miles were profiled during this expedition. Figures 6.8 - 6.10 provide a summary of backscatter profiles with selected core locations representing different working areas (Western Plateaus / North Plateau / High Plateau) within the Manihiki Plateau.

Western Plateaus (06° - 10°S; 165 °- 166°30'W)

Figure 6.8 sums up the core locations within the Western Plateaus area of the Manihiki Plateau. Sediment deposits were detected mostly on top of seamounts (Fig. 6.8a - b) but also covers parts of the Western Plateaus area (Fig. 6.8c - d). In particular, shallow seamounts (< 2,500 m water depth) of the Western Plateaus provide huge sediment packages of coarse-grained foraminiferal ooze and sand of up to 50 m in thickness.

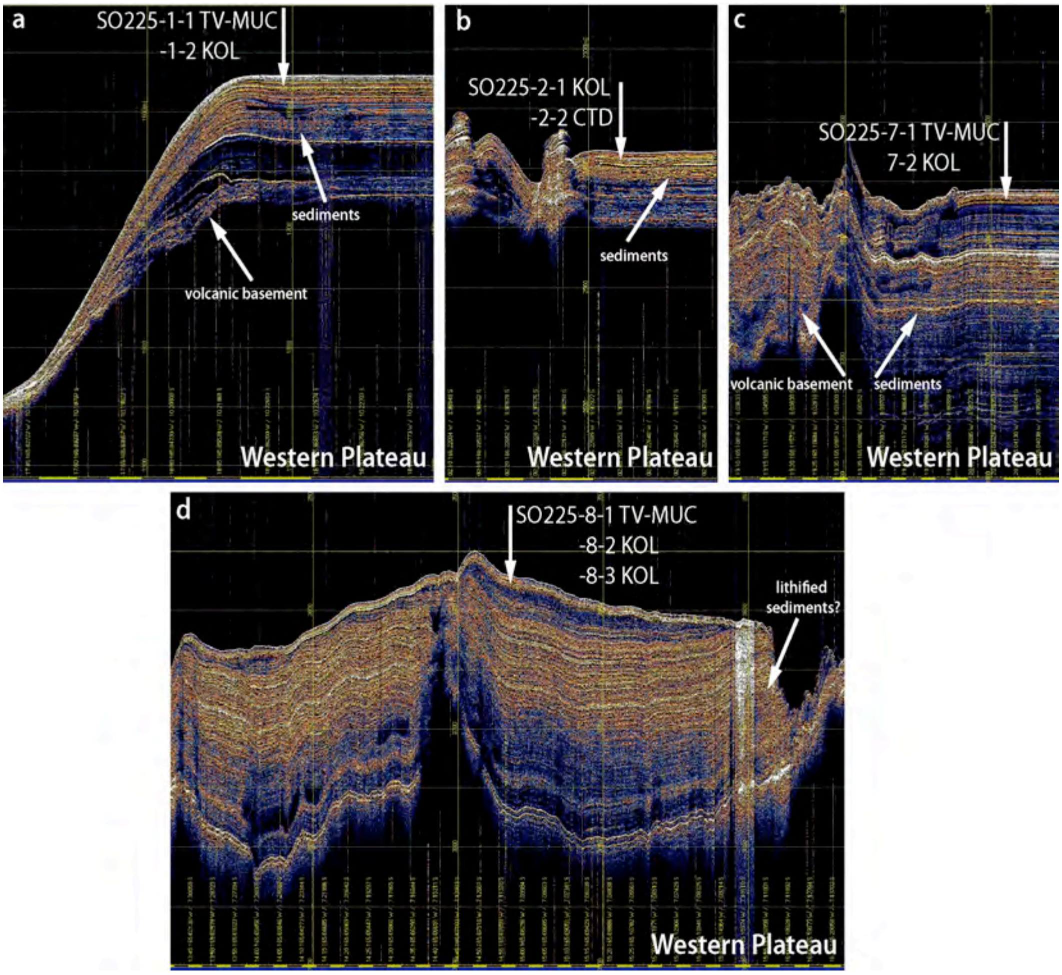

Fig. 6.8a - d: *Western Plateaus. Summary of PARASOUND profiles at the Western Plateaus together with associated coring sites and preliminary sedimentological interpretation (white arrows). Well-stratified sediments were often located on top of seamounts but also cover some deeper parts of the Western Plateaus.*

North Plateau (03° - 06°30'S; 163°30' - 165°W)

The PARASOUND backscatter profiles of the North Plateau together with selected core sites are given in Figures 6.9a-d. In general, the PARASOUND profiles of the North Plateau indicate a rougher and more complex seafloor bathymetry compared to the Western Plateau, associated with volcanic outcrops and ridge-like structures recorded in the PARASOUND profiles (e.g., Fig. 6.9d). Rough bathymetry and too steep flanks for PARASOUND profiling were common on the North Plateau. Often, the ATLAS PARASOUND sediment echosounder was simply not able to detect sediment deposits due to its physical limitations. However, suitable core sites were found on top of ridges, in small-scale depressions or proximal to or on top of seamounts (e.g., Fig. 6.9a). Here, North Plateau sediment deposits varied between several meters (Fig. 6.9b - d) to up to >100 m (Fig. 6.9a) in sediment thickness.

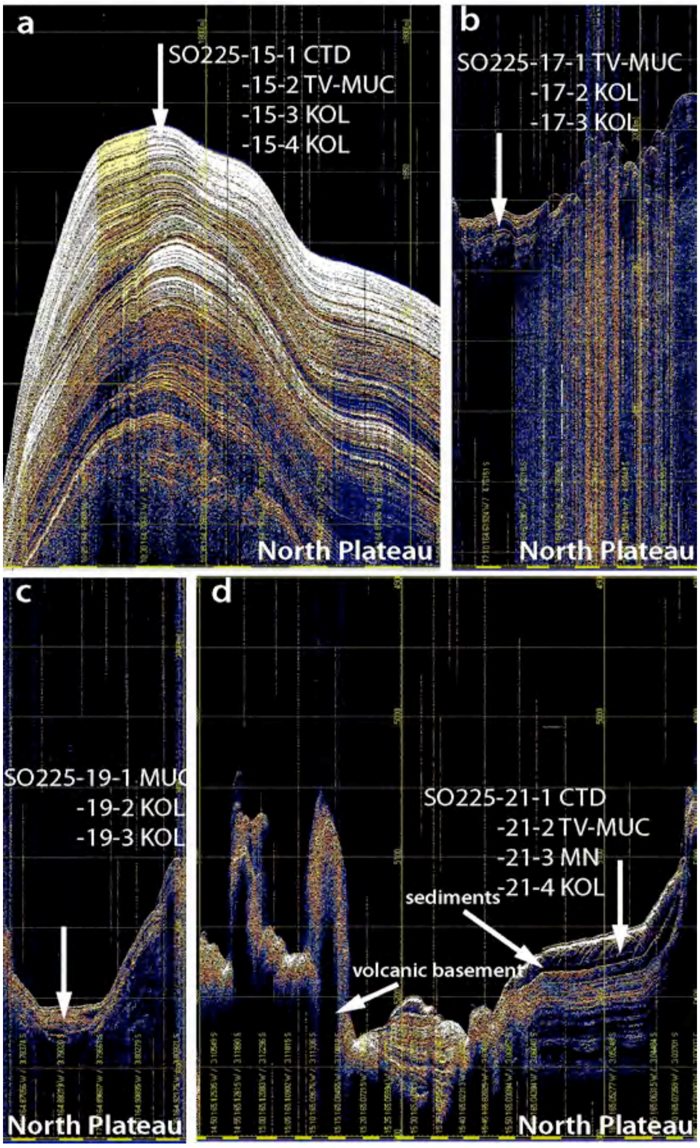

Fig 6.9a - d: *North Plateau. Summary of selected PARASOUND profiles with coring sites and preliminary sedimentological interpretation (white arrows) from the North Plateau. As indicated by Figure 6.9a huge sediment deposits (>100m) were found on top of a seamount within the North Plateau.*

High Plateau (09° - 15°30'°S; 161°30' - 163°W)

The largest part of the Manihiki Plateau is represented by the High Plateau, a huge and relatively flat Plateau area. In general, the PARASOUND backscatter profiles of the High Plateau indicate a much smoother seafloor bathymetry compared to the Western- or North Plateaus. Here, vast areas are covered with well-stratified sediments as indicated by the backscatter profiles (Fig. 6.10a - c). Due to technical problems with the piston corer device, no sediment core was recovered from the northern part of the High Plateau (Fig. 6.10a). In Figure 6.12b, a backscatter profile across the proposed IODP drilling site at the Manihiki Plateau is given, together with a coring site of the SO-225 MANIHIKI II expedition. Unfortunately, only a short gravity core (SO225-44-4 SL) was recovered at the proposed drilling site.

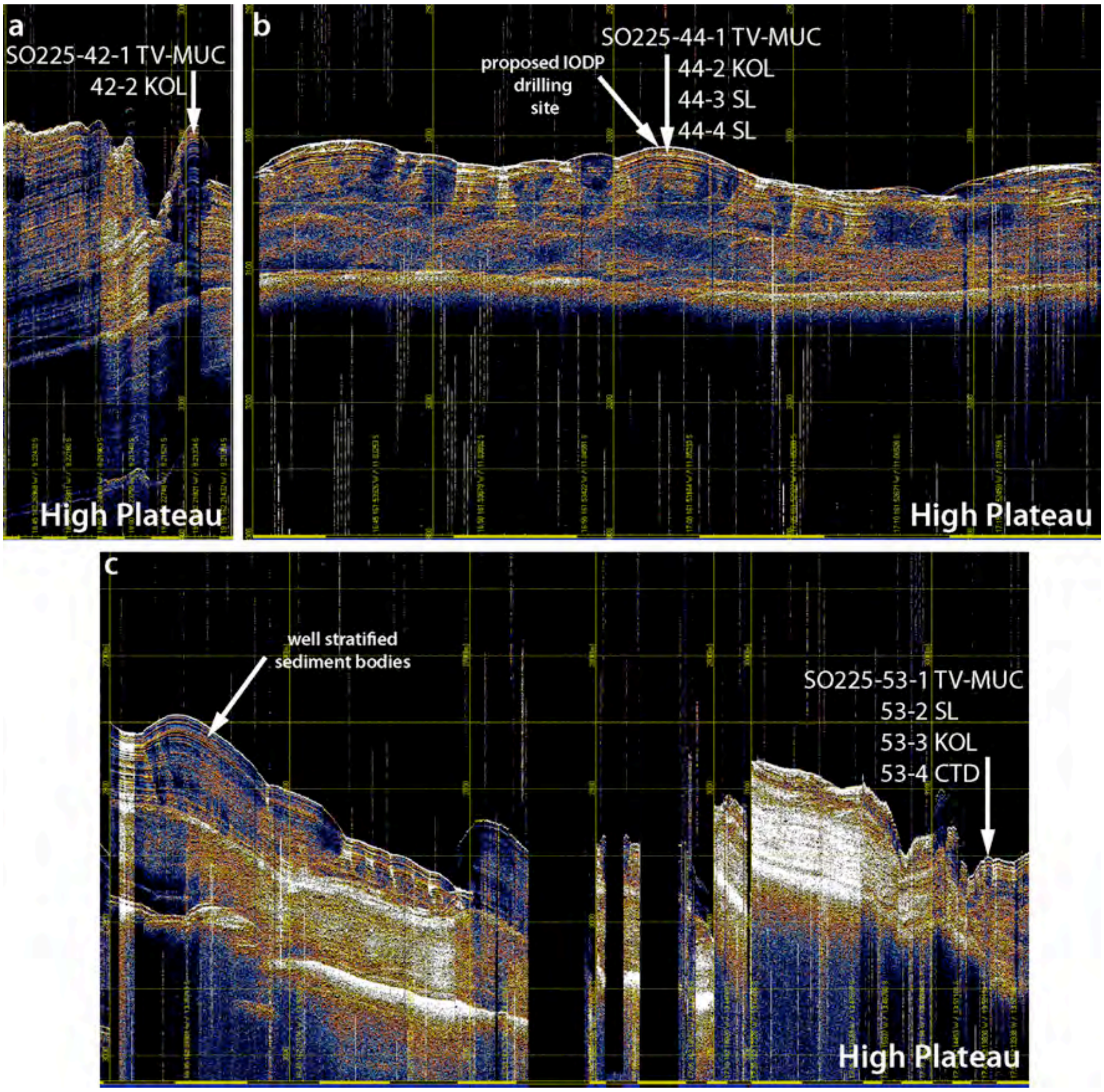

Fig. 6.10a-c: *High Plateau. Summary of selected PARASOUND profiles with coring sites and preliminary sedimentological interpretation (white arrows) from the High Plateau. In Figure 6.10b the proposed IODP drilling site is shown together with the coring site SO225-44. Note the thick and layered sediment sequences (> 50 m), which cover large parts of the High Plateau (Fig. 6.10a – c).*

6.4. SEDIMENTS: SAMPLING, LOGGING, FACIES

We retrieved sediment cores and surface sediment samples from Manihiki Plateau in the equatorial W Pacific from three working areas (Fig. 6.11):

- ***Working area 1*** west of the Danger Island Through. (~7-11-°S; ~165°-167°W). It comprises a latitudinal coring transect across the Western Plateaus.
- ***Working area 2*** includes sediment cores of the North Plateau (~3-6°S).
- ***Working area 3*** was located on the eastern side of the Danger Island through. Sediment cores were recovered between ~11-14°S. At the High Plateau we were able to obtain sediment cores from the proposed IODP Proposal MAN-2A.

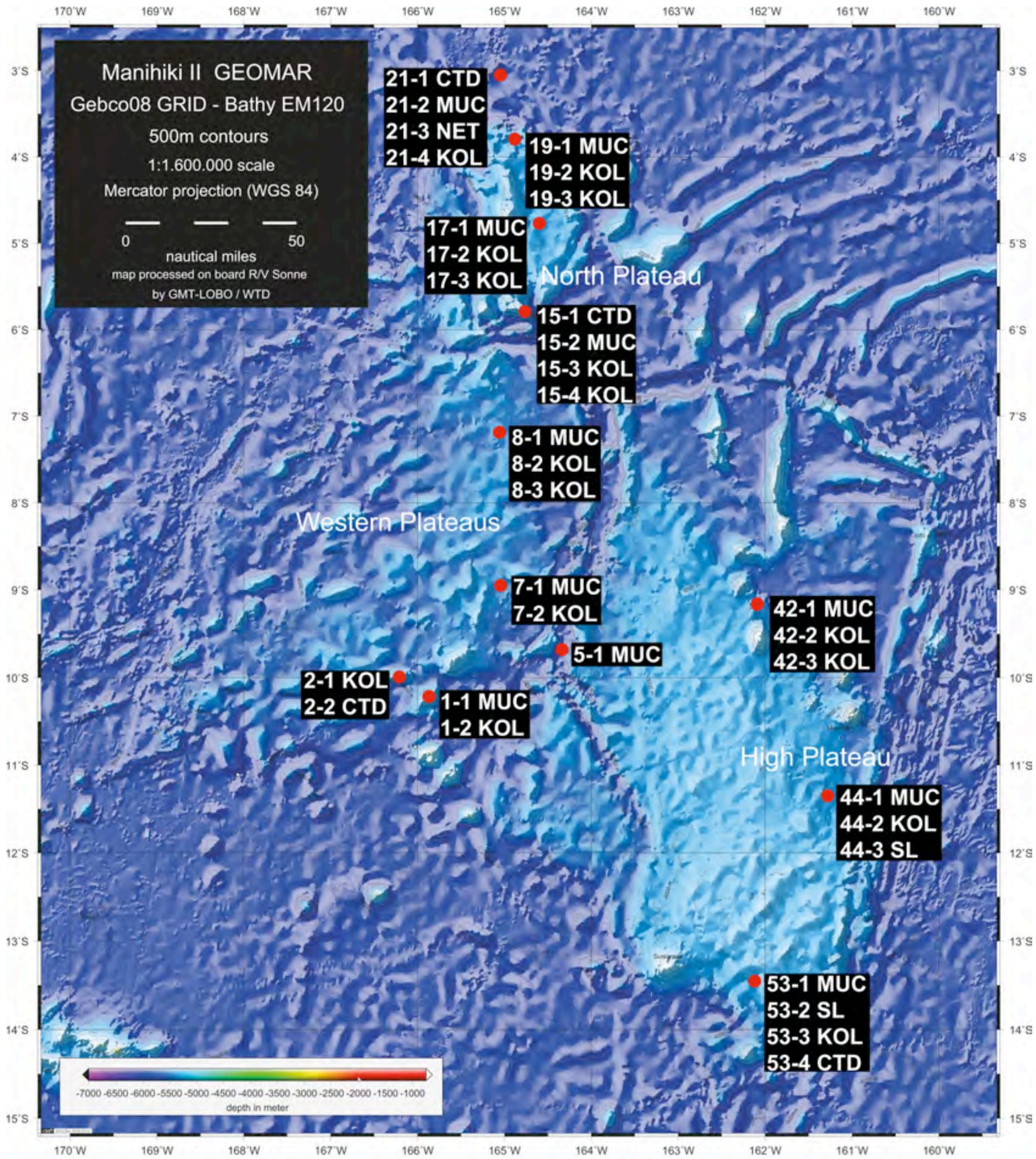

Fig. 6.11: *Overview map of all paleoceanographic relevant stations during Sonne expedition SO225 MANIHIKI 2 (red dots) covering the Western Plateaus, the North Plateau and the High Plateau.*

6.4.1. TV-Multicorer

Deployment

The multicorer (MUC) was deployed 11 times in total during SO-225. After several improvements to the device, a successful series of core recovery yielded almost 12 full tubes of sediment. On cruise SO-225, the MUC was equipped with a TV telemetry camera system developed by Fa. Marinetechnik Kawohl (marinetech.-kawohl@tonline.de) (Fig. 6.12). This telemetry system was used to monitor the seafloor and to provide information about sediment structures.

The MUC was lowered with an average speed of 0.7 m/s to a depth of about ~100 m above seafloor, where it was stopped for c. 2-3 minutes, and the winch personnel changed over to the Geo-laboratory. The MUC was then lowered with a speed of ~0.5 m/s until seafloor came into sight. Contact with the seafloor was monitored visually and through cable tension. The multicorer was left on the seafloor for about 1 minute, until MUC tubes did no longer penetrate, and then pulled out with a speed of 0.5 m/s to guarantee rapid closure of the tubes. Finally, the MUC was heaved with a speed of 1 m/s to deck.

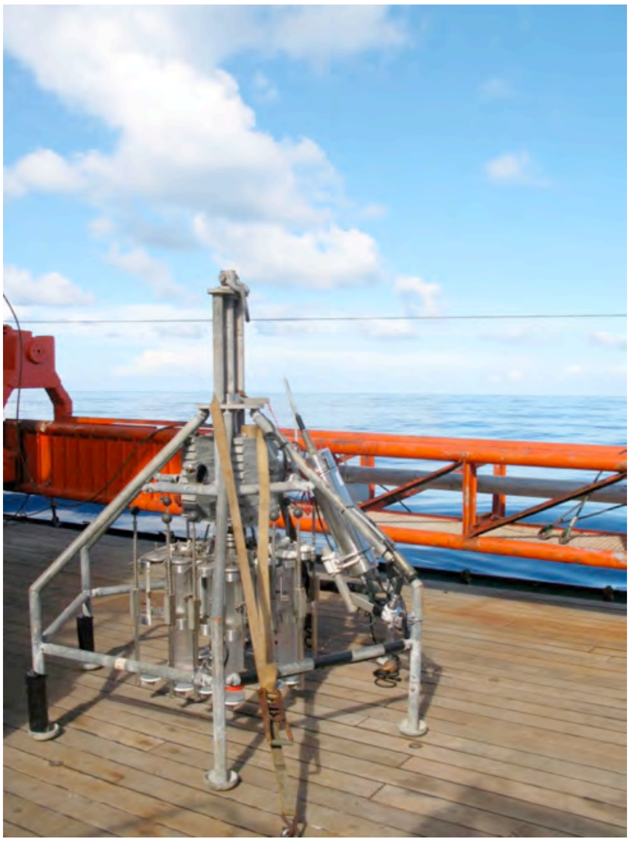

Fig. 6.12: *GEOMAR multicorer with Kawohl-Marinetechnik Deep Sea TV-Camera system. Technical specifications*: Height: c. 2,250 mm, diameter: c. 1,900 mm, weight of head: c. 180 kg, weight of framework: c. 465 kg, number of tubes: 12, diameter of tubes: 100 mm.

Sampling Multicorer

Sediment recovery of each of the 12 tubes was recorded, seawater was siphoned off (for bottom water analyses) and the sediment was briefly described. The tubes were divided among working groups at the Alfred-Wegener-Institute (AWI, Bremerhaven) and the GEOMAR (Kiel) (Table 6-3, Fig. 6.13). Three cores for each institute were completely cut into 1 cm thick slices and put into plastic bags (Whirl-Pak). Additionally, the first 3 cm of two tubes were sampled (in 1 cm resolution) and preserved in Bengal Rose. For Neodymium analyses, the uppermost 3 cm were taken of another core. The sediment surface (uppermost 1 cm) of the remaining tubes were stored in a Kautex bottle.

Table 6-3: Multicorer recoveries during SO-225.

	Tube	1	2	3	4	5	6	7	8	9	10	11	12	
		Recovery [cm]												Total Recovery [cm]
Station														
SO225-1-1		18	15	18	17	16	18	14	-	-	-	-	-	116
SO225-5-1		41	43	44	44	3	3	45	45	1	1	1	1	272
SO225-7-1		28	27	28	27	26	3	3	26	1	1	-	-	170
SO225-8-1		28	29	27	29	27	28	3	3	3	26	4	4	211
SO225-15-2		10	11	12	12	11	11	3	3	-	-	-	-	73
SO225-17-1		23	26	26	28	26	27	23	3	3	4	-	-	189
SO225-19-1		27	28	29	29	28	27	3	3	18	5	1	-	198
SO225-21-2		44	44	44	3	42	45	3	3	1	44	1	-	274
SO225-42-1		1	-	-	-	-	-	-	-	-	-	-	-	1
SO225-44-1		1	1	1	3	5	2	1	7	5	6	1	-	33
SO225-53-1		1	1	1	1	1	1	6	4	5	6	3	-	30
SO225 Total														1567

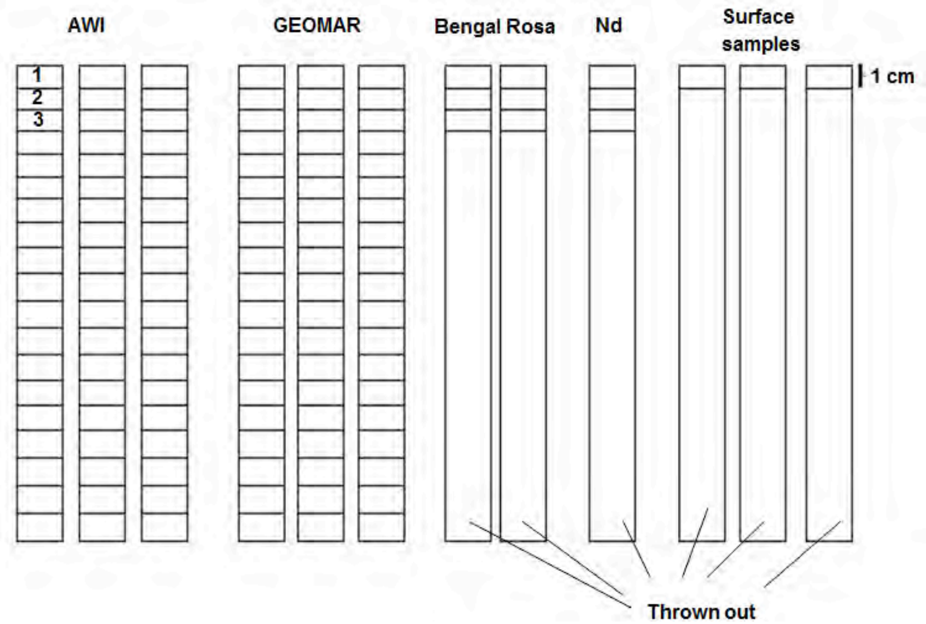

Fig 6.13: *Sampling scheme applied for multicorer tubes recovered during SO-225.*

6.4.2. Piston Corer and Gravity Corer

Deployment

During research cruise SO-225 with R/V SONNE, 16 piston corers with core barrel lengths between 10 and 20 m (KOL) and 3 gravity corers with length between 5 and 10 m (SL) were run. 13 successful deployments resulted in a total core recovery of 131.63 m, including 7.31 m core length recovered by the pilot corer (TC) triggering the KOL (Fig. 6.14). Six deployments were not successful.

The gear types and length of the coring devices were chosen based on detailed acoustic sediment mapping performed with the ATLAS PARASOUND echosounding system prior to coring. Acoustic patterns such as the strength of characteristic reflectors, their spacing, and the total sub-bottom penetration were taken into account (see chapter 6.3). Core recoveries and barrel lengths in the individual working areas (Fig. 6.15) were as follows:

- ***Working area 1 (Western Plateaus):*** 5 KOL deployments (barrel lengths 15 - 20 m) recovered sediment cores ranging from 0 m to 16.18 m.
- ***Working area 2 (North Plateau):*** 7 KOL (barrel lengths 10 - 20 m) recovered core lengths of 0 m to 16.15 m.
- ***Working area 3 (High Plateau):*** 4 KOL deployments (barrel lengths 10 - 15 m) recovered 0 m to 12.38 m long sediment records. In addition, we deployed 3 SL (barrel lengths 5 - 10 m) and retrieved 3 sediment cores ranging from 0.39 m to 4.70 m.

The GEOMAR piston corer with split piston developed by Fa. Marinetechnik Kawohl (marinetech.-kawohl@tonline.de) can be fitted with a core barrel up to 30 m in length (in 5 m increments). The core diameter is 12.5 cm. On R/V SONNE, the piston corer was deployed with an 18 mm steel cable attached to the ship´s deep-sea winch (max. speed: 2 m/s for up to 70 kN or max. speed: 1 m/s for up to 140 kN). The piston corer was lowered with an average speed of 1.0 m/s to c. 50 m above seafloor, where it was stopped for c. 3 minutes. Subsequently, it was lowered with a speed of 0.3 m/s until the pilot trigger core hit the seafloor. Contact with the seafloor was monitored through cable tension. When the pilot core reached the seafloor, the piston corer was released, free falling by c. 5 m before reaching the seafloor, and penetrating into the sediments. The device remained at the seafloor for about 30 seconds after piston release in order to allow for deep penetration, then pulled out with a speed of 0.1 m/s. Once out of the sediment, it was heaved up with a speed of 1.0 m/s.

The gravity corer applied has a core diameter of 12.5 cm and a barrel of ~3.0 tons. It was lowered with 1 m/s to the seafloor. The device remained on the seafloor for about 30 seconds in order to allow for deep penetration, and was then pulled out with a speed of 0.1 m/s. Heave velocity was 1.0 m/s.

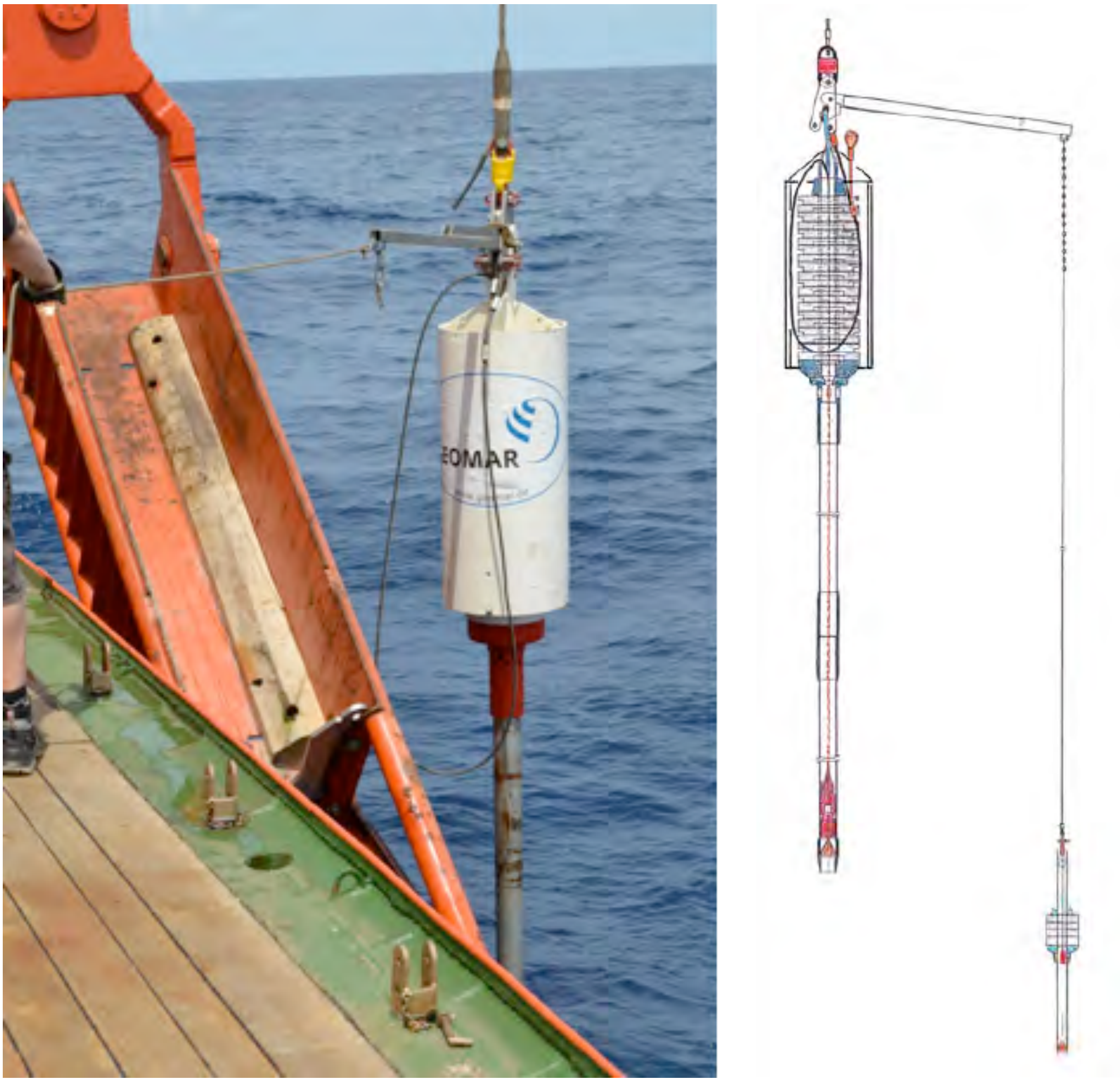

Fig. 6.14: *Operation of the GEOMAR piston corer during SO-225 (right) and schematic diagram of the split-piston corer from Fa. Marinetechnik Kawohl.*

Core handling

The PVC-core liners of the piston and gravity cores were oriented, then labeled, and commonly cut into 1 m sections. After the measurement of physical properties with the multi-sensor core logger (see chapter 6.4.3), cores were selected for opening and on-board sampling (Table 6-4). Each section was split into working and archive halves. The sediment surface was cleaned and smoothed before core photos were taken, and lithological description started. Color reflectance measurements were taken from the archive half. The archive halves were usually packed into plastic D-tubes and stored at ~4°C in the R/V SONNE cooling store, and later into the reefer for home transport. The working halves were completely used up, providing sample material for the various working groups (Fig. 6.15).

Labeling of core liners and D-tubes

Liners and D-Tube caps contain the following information:

- Core number (e.g., SO225-02-1 KOL)
- "A" for archive half, "W" for working half
- Arrow pointing to base with depths of section top and base
- Top and base of each section is marked with "Top" and "Base/Bottom", respectively, and the continuous depth alongside the core.

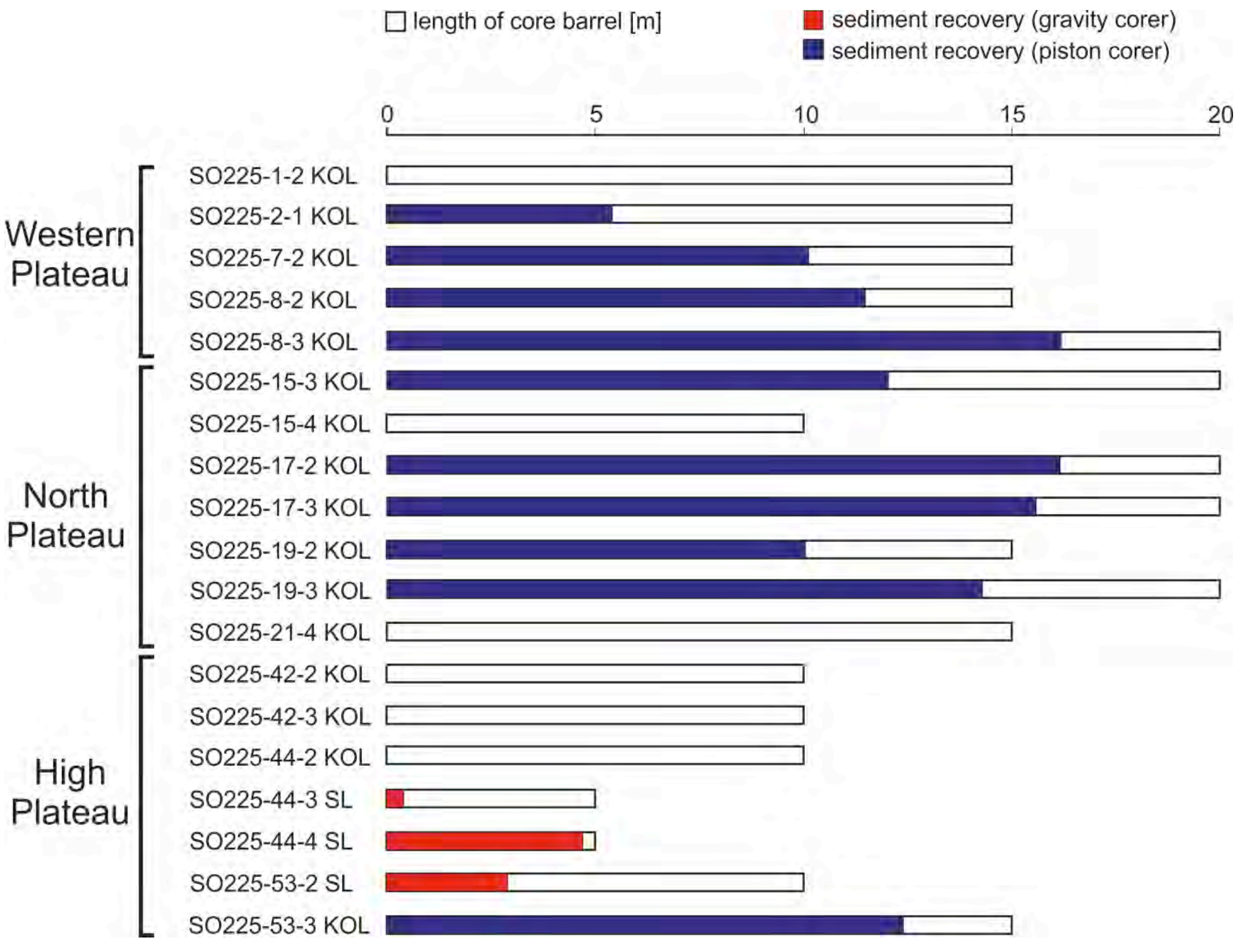

Fig. 6.15: *Length of core barrel and core recovery of piston and gravity corers.*

Table 6-4: Sediment recovery of piston and gravity cores.

Station	Recovery [cm]	Pilot [cm]	PVC-Liner opened [x]	Color Scan [x]	Magnetic Susceptibility [x]	Samples taken [x]
SO225-1-2 KOL	-	-	-	-	-	-
SO225-2-1 KOL	541	-	x	x	x	-
SO225-7-2 KOL	1012	86	x	x	x	x
SO225-8-2 KOL	1148	90	x	x	x	x
SO225-8-3 KOL	1618	overfull	x	x	x	x
SO225-15-3 KOL	1203	-	x	x	x	-
SO225-15-4 KOL	-	-	-	-	-	-
SO225-17-2 KOL	1615	90	x	x	x	x
SO225-17-3 KOL	1558	94	x	x	x	x
SO225-19-2 KOL	1004	30	-	-	-	-
SO225-19-3 KOL	1429	41	x	x	x	x
SO225-21-4 KOL	-	-	-	-	-	-
SO225-42-2 KOL	-	76	-	-	-	-
SO225-42-3 KOL	-	-	-	-	-	-
SO225-44-2 KOL	-	24	-	-	-	-
SO225-44-3 SL	39	-	x	x	x	x
SO225-44-4 SL	470	-	x	x	x	x
SO225-53-2 SL	288	-	x	x	x	-
SO225-53-3 KOL	1238	overfull	x	x	x	x

Visual core description and core photography

The sediment core descriptions (Appendix IV) are presented as lithology logs and summarize logging data and onboard visual observations of each core. All descriptions were documented with the software package APPLECORE, using a lithology custom file containing patterns following the standard IODP/ODP sediment classification scheme, a modified version of the lithologic classification of Mazzullo et al. (1988). Sediments were named on the basis of composition and texture, using a principal name together with major and minor modifiers. Sediment core descriptions were performed on the working half, if present, and were complemented by binocular analyses of the sieved coarse fraction of selected samples. According to the classification of Mazzullo et al. (1988), sediments encountered during SO-225 are mostly coarse grained, granular sediments consisting predominantly of biogenic particles.

Sediment names consist of a principal name related to the major biogenic component and the degree of compaction. During expedition SO-225, we only recovered unconsolidated calcareous biogenic sediments (generally “ooze”, and if dominated by foraminifera, “sand”). For biogenic sediments with a larger silty/clayey component, we here used the principal name describing the texture (silt+clay).

Further information in the lithology logs includes the location and nature of sedimentary structures, the occurrence of fossils, ichnofossils, the degree of bioturbation, and accessories (such as burrows, laminae, shell fragments, manganese mottles, volcanic fragments, etc.), and artificial core disturbance.

As the color measurements taken with the Minolta spectrophotometer are reliable, we included the Y (D65)-records into the lithology logs. Furthermore, the core description logs also include the magnetic susceptibility data of each core. Core sections were photographed using a digital camera (Nikon D3100). The single images were added to the lithology logs, and also arranged for each core and presented in the Appendix III.

Sampling scheme of sediment cores

The 1 m-long half segments of selected sediment cores were sampled according to the following scheme (Fig. 6.16). Due to disturbance during coring operations, some segments were not completely filled with sediment. These segments were not sampled, as XRF-scanning will be performed first in the home lab. Sampling of sediment cores was done cm-wise. The samples were taken in whole slices and were placed in plastic bags (Whirl-Pak), jointly for GEOMAR and AWI. Samples were stored at 4°C. Only the upper two meters of selected cores were additionally sampled for organic geochemistry in Teflon beakers (Fig. 6.16). These samples were immediately stored at 4°C and shipped home by air-freight. Additionally, every c. 50 cm samples were taken for physical property analyses and biostratigraphy in syringes.

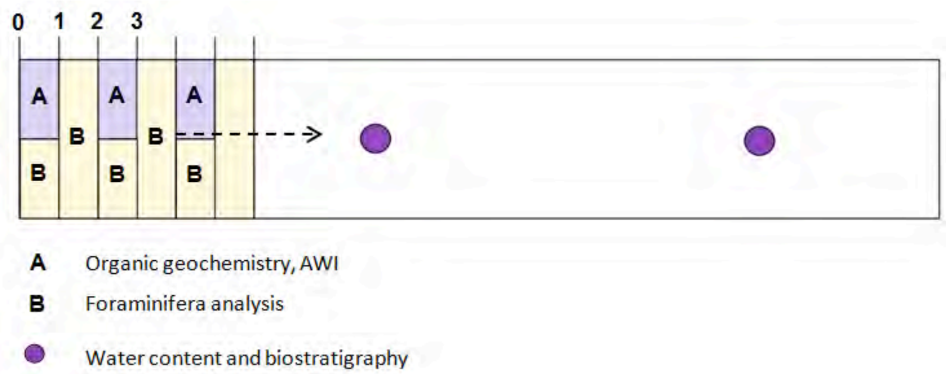

Fig. 6.16: *Sampling scheme applied for SO225 sediment cores. The displayed sampling pattern is repeated every 2 cm:* 0-1 cm org. geochemistry (AWI) / foraminifera geochemistry (GEOMAR/AWI), 1-2 cm foraminiferal (GEOMAR/AWI).

4.4.3. Shipboard Core Logging

Magnetic susceptibility

Measurement of the magnetic susceptibility of the sediments was done aboard R/V SONNE on unsplit sediment cores using the GEOTEK Multi Sensor Core Logger (MSCL). In order to obtain a constant temperature of the sediments, core segments were stored in the air-conditioned Magnetics and Gravimetry Laboratory for at least 12 hours after core retrieval. For determination of the magnetic susceptibility, the sediment core sections were placed on the rails of a conveyor system and aligned to the start position. A core pusher moved the section in increments of 1 cm through a BARTINGTON loop sensor (MS2C) with a diameter of 140 mm. An oscillator circuit in the sensor produces a low-intensity (80 A/m RMS), non-saturating alternating magnetic field (0.565 kHz). Changes in magnetic susceptibility of the sediments causes differences in the oscillator frequency that is electronically converted into (artificial) magnetic susceptibility values (SI-Units). The sampling time was set to 10 s. The GEOTEK MSCL 6.2 and GEOTEK Utilities 6.1 software were used for measurements and data processing. The raw data were initially collected on a PC and edited with EXCEL and KALEIDAGRAPH software. Artificial susceptibility minima near the end of core sections were eliminated.

Preliminary results: In particular, the magnetic susceptibility data were useful to distinguish major lithologies and for core-to-core correlation. Sediments recovered during SO-225 were primarily composed of calcareous microfossils and generally minor amounts of siliciclastic material, expressed by low magnetic susceptibilities of <20 SI-Units (Figs. 6.17 and 6.18). A few cores recovered on top of shallow seamounts on the Western Plateaus contained almost pure foraminifera sand (e.g. SO225-2-1 KOL or SO225-15-3 KOL) and no significant amount of lithogenic material (not shown). The variability of magnetic susceptibility from Western- and High Plateau sediments are between 0–15 SI-Units and thus, are slightly higher compared to the sediment cores of the North Plateau (0–5 SI-Units).

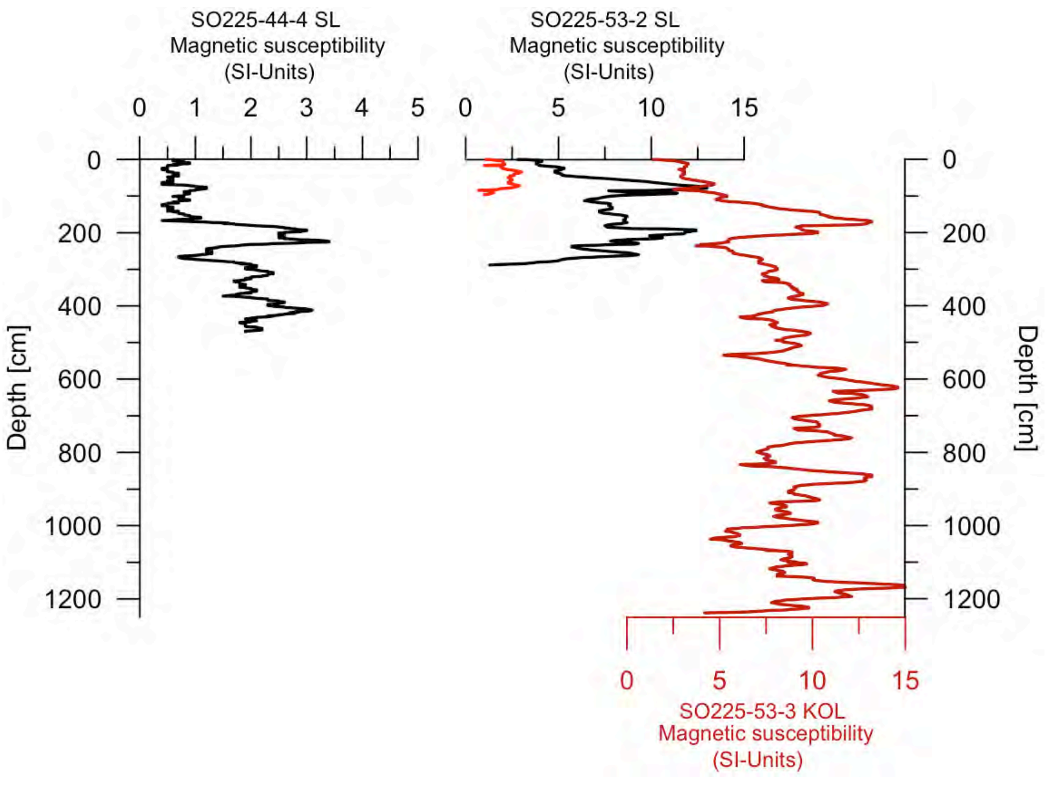

Fig. 6.17: *Magnetic susceptibility data of sediment cores SO225-44-4 and SO225-53-2 and -3, together with pilot core records, from High Plateau.*

The variability in magnetic susceptibility is generally linked to changes in the content of Fe-bearing minerals. For example, some sediment cores contain large volcanic rocks (up to a few centimetre in diameter) and are expressed as positive peaks in the magnetic susceptibility (e.g. SO225-19-3 KOL; Fig. 6.18b). At the Manihiki Plateau, potential sources of such particles are either wind-delivered dust local (sub)marine volcanism or re-deposition of such material. Most sediment records from Manihiki Plateau show low magnetic susceptibilities. Nonetheless, the pronounced variability of the high-resolution magnetic susceptibility records were successfully used for the initial stratigraphy by matching prominent and similar structures preserved in the magnetic susceptibility records. Magnetic susceptibility logs of the sediment cores for the different working areas of the Manihiki Plateau are given in Figures 6.17 and 6.18 (Western Plateaus, North Plateau, and High Plateau) and are also shown in the core description sheets (Appendix III).

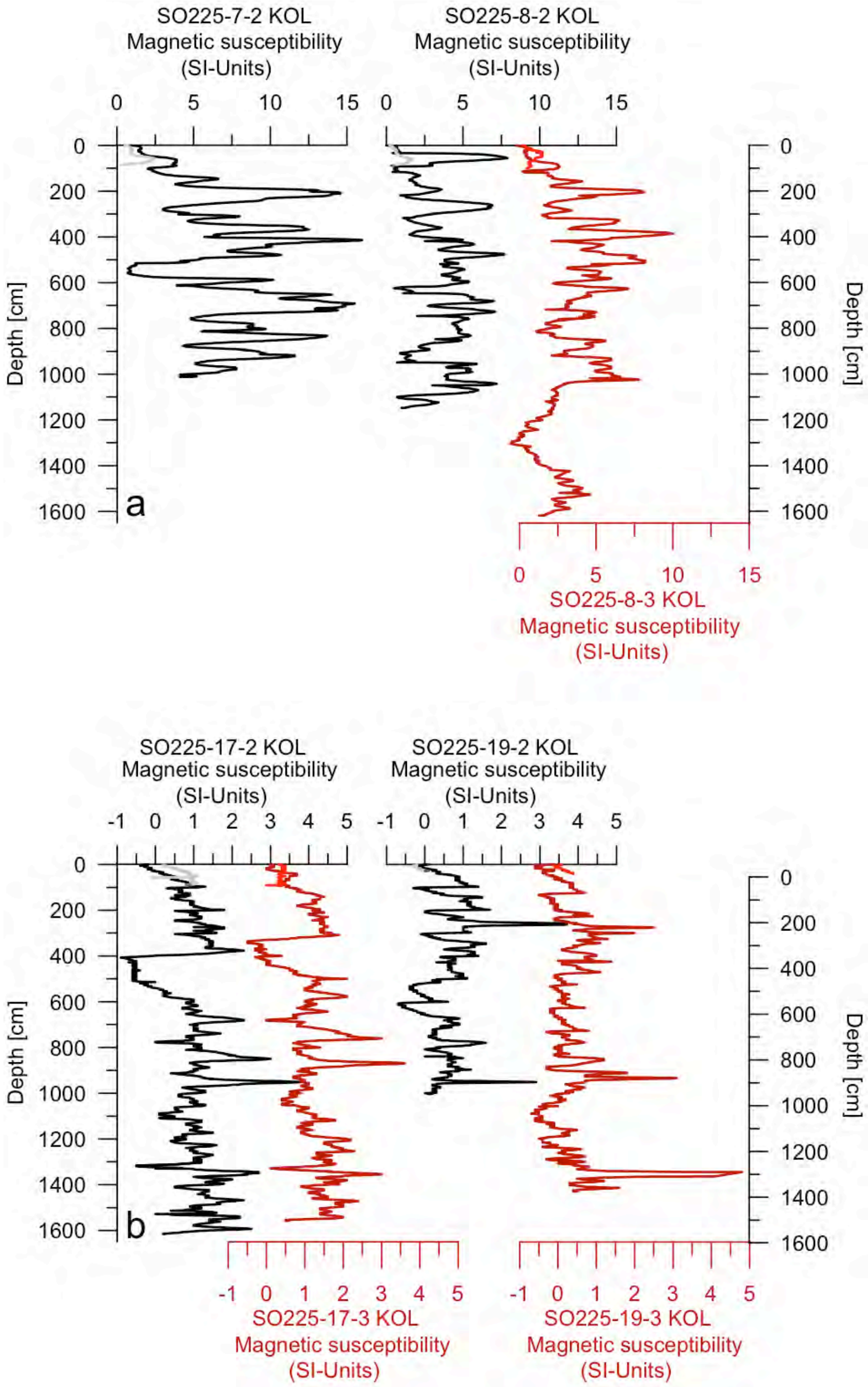

Fig. 6.18: a. *Magnetic susceptibility data of sediment cores SO225-7-2 and SO225-8-2 and -3, from the Western Plateaus.* **b.** *Magnetic susceptibility data of sediment cores SO225-17-2 and -3, as well as SO225-19-2 and -3, from the North Plateau.*

Minolta Color-Scan

The hand-held Konica Minolta spectrophotometer type CM-600d was used to color scan sediment surfaces from open core segments by measuring the light reflectance (Fig. 6.19). For the measurements, the device was directly placed on the sediment surface that was covered by clean and clear plastic wrap. Measurements were taken at intervals of 1 cm. The spectrum of the reflected light was measured by a multi-segment light sensor, and the spectral reflection was measured at a 20 nm pitch for wavelengths of 400 to 700 nm. The variation in the illumination from the CM-600d pulsed xenon arc lamp was automatically compensated by a double-beam feedback system. At the beginning of the measurement of each core-segment, a color calibration was performed to avoid any variation in color measurements due to the environmental (temperature, humidity, background light) and instrumental variations. The spectrophotometer was calibrated for black colors using "zero-calibration" as well as for white color reflections. The data were processed by the program Minolta SpectaMagic v.2.3.

Interpretation

The reflection data and the standard color-values X, Y, Z are automatically calculated by SpectraMagic, and are displayed in the Y, L*, a* and b* CIELAB color coordinates. The Y and L*-value represents brightness and can be directly correlated to grey value measurements, whereas Y represents the lightness on a linear scale and L* on a non-linear scale. The a*-values indicate the relationship between green and magenta and the b*-value reflects blue/yellow colors. The color scans of each core are displayed in Appendix V, whereas the Y-records are also shown in the lithology logs (Appendix IV).

Fig. 6.19: *Color scanning the SO-225 sediment cores.*

6.4.4. Sediment Facies and Results

Preliminary interpretations of the sediment facies are based on sedimentological and physical properties, as well as color-scan data and visual inspection of the cores. The graphical core descriptions (lithology strip logs performed with AppleCORE version 10.1t by Mike Ranger 2011) and photographs (Nikon D3100) can be found in Appendix III and IV.

Sediment Facies

We basically differentiated between four major lithologies present in our SO-225 sediment cores: Foraminiferal sand, foraminiferal ooze, sandy clayey silt rich in foraminifers, and nanno ooze. The formation of these sediment types is either in dependence of bottom currents and/or climatic changes. Apparently, past climate change significantly even affected the West Pacific Warmpool area.

Foraminiferal sand: Most prominent and very difficult to recover with our sampling devices is the pure foraminiferal sand, which is particularly found at the shallow sites on the Western Plateaus between c. 1,500 and 2,350 m water depths (cores SO225-1-1 MUC and SO225-2-1 KOL), but also at deeper locations. At station SO225-2-1, the foraminiferal sand reaches a sediment thickness of more than 5 m. Commonly, the foraminiferal sand entirely consists of well-preserved calcitic tests of predominantly planktonic foraminifera (marine protozoa), lacking any fine fraction. The sediment is coarse, homogenous, whitish-gray, and very soupy, loosing its porewater easily during core retrieval. Lightness Y(D65) data reach very high values, while the magnetic susceptibility is very low. When without porewater, it is a stiff, hard, and dry sand. By now we could not decipher whether the foraminiferal sand was deposited as it is implying that the foraminiferal productivity was extremely high or whether it is a residual sediment with the fine fraction transported away by bottom currents. As foraminiferal sands were recovered with the MUC from water depths between 1.5 km to larger than 3 km, bottom currents may have developed in response to bottom topographic conditions even in large water depths, e.g. in the vicinity of seamounts or canyons.

Foraminiferal ooze: According to our interpretation, the typically interglacial sediment consists of foraminiferal ooze. This silty clayey sediment type is build up mainly by foraminiferal shells (>30%), but has a high portion of nanno ooze keeping the porewater much better than the foraminiferal sand. It is mostly a light yellowish brown to light brownish gray, homogenous sediment, which is moderately bioturbated. Large burrows (centimeter in diameter) filled with white foram to nanno ooze are common. The lightness Y(D65) have commonly medium values, as the magnetic susceptibility have.

Sandy clayey silt: The most presumably glacial sediment found in our cores is sandy clayey silt, still rich in foraminifera with colors from dark to light yellowish/grayish brown. It is relatively stiff and clearly darker and less soft than the foraminiferal ooze. Bioturbation is mostly strong, with large burrows (centimeter in diameter) filled with sediment from above leading to a patchy appearance of the sediment. The upper contact of the glacial section is typically sharp and mostly even. The lower contact is commonly gradational, changing to a „transitional“ foraminiferal ooze, which becomes less dark and less bioturbated down-core and changing into the typical interglacial foraminiferal ooze. The magnetic susceptibility values are typically high, while lightness Y-data are low.

Nanno ooze*:* At site locations SO225-19 and -8 from the North Plateau, as well as at site location SO225-53 on High Plateau, we observed a typical bright white nanno ooze at deeper core depths, and hence of considerably older age. This very fine-grained ooze consisting predominantly from calcitic coccolithophorid platelets (= coccoliths, marine phytoplankton) of <2 µm in size appears clayey and homogenous, and is in parts strongly bioturbated with large burrows/patches (centimeter in diameter) filled with white sediment. Foraminiferal tests are still abundant. On North Plateau, the nanno ooze is rather pure, while at our southernmost site location (SO225-53), the nanno ooze has a considerable admixture of coarse foraminiferal ooze. Lightness Y (D65) data reach maximum values, while the magnetic susceptibility is close to zero.

Double coring

At most stations, we performed double coring for two reasons: First, we intended to recover enough sediment material for the planned analyses. Second, the time intensive double coring allowed to cross-check for the quality of the recovered sediment records. In case of coring disturbance in one core, the disturbed sediment sections can be replaced by sections from the neighboring core.

Core disturbance, indeed, was a common feature during SO-225. In particular, the pure and soupy foraminiferal sands easily lost the porewater when being recovered, and the porewater flowed freely through the core pipe and partly washed out the sediment.

The comparison of Minolta Y (D65) data of both sediment records from one station fortunately showed that neither core disturbance and washout nor stretching of sediments is problematic. The according Minolta Y (D65) data records from adjacent cores were remarkably similar, and could be matched mostly peak by peak (Figs. 6.20 - 6.24), suggesting that the sediment lightness records provide robust signals of lithological change and that sediment records are of high value for paleoceanographic studies.

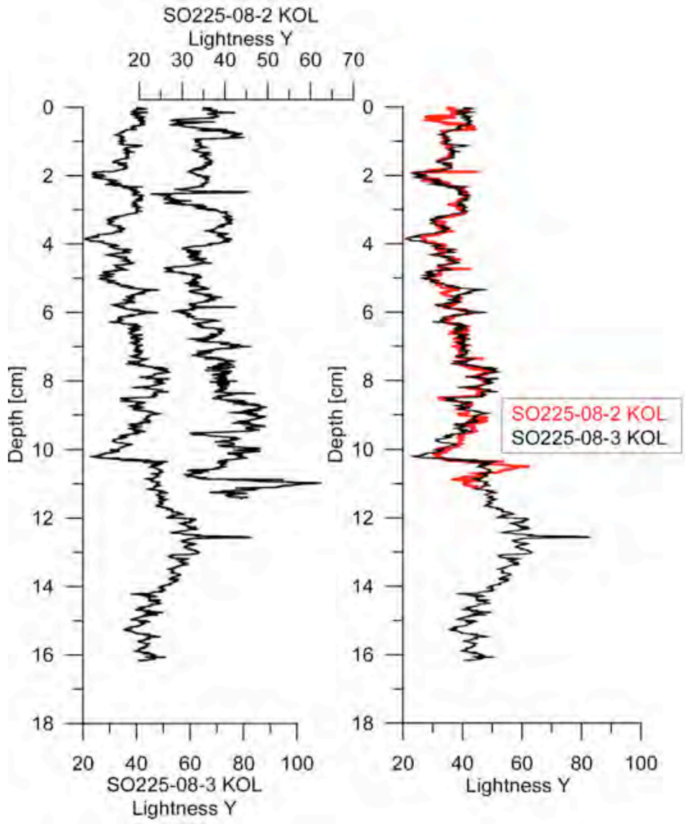

Fig. 6.20: *Left: Minolta lightness Y (D65) data records of adjacent sediment cores from Manihiki Western Plateaus, location SO225-08 KOL, versus core depth. Right: Matched records, tuned to each other by AnalySeries 2.0.3 (Paillard et al. 1996-2005).*

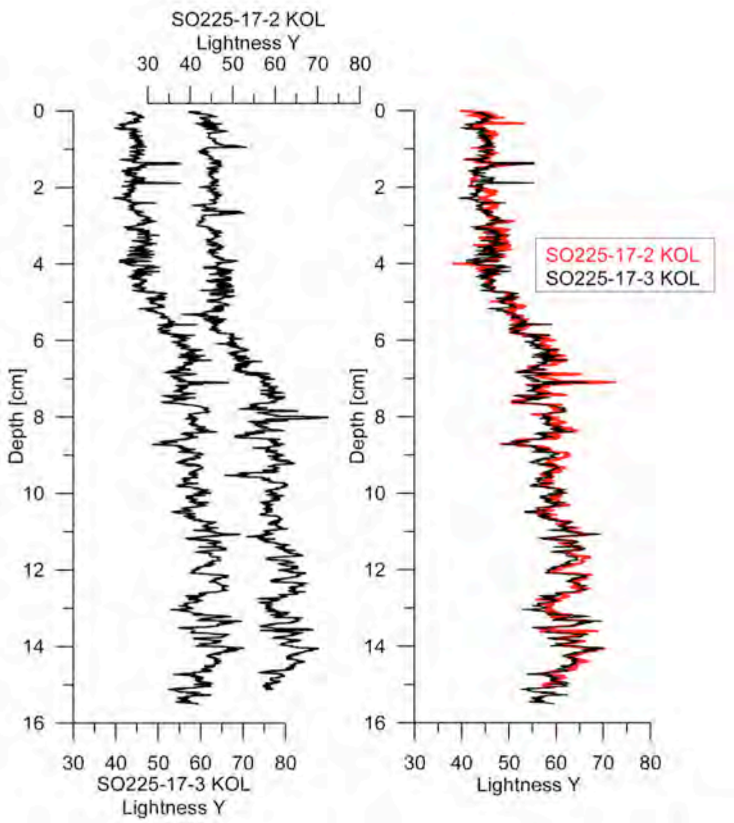

Fig. 6.21: *Left: Minolta lightness Y (D65) data records of adjacent sediment cores from Manihiki North Plateau, location SO225-17 KOL, versus core depth. Right: Matched records, tuned to each other by AnalySeries 2.0.3 (Paillard et al. 1996-2005).*

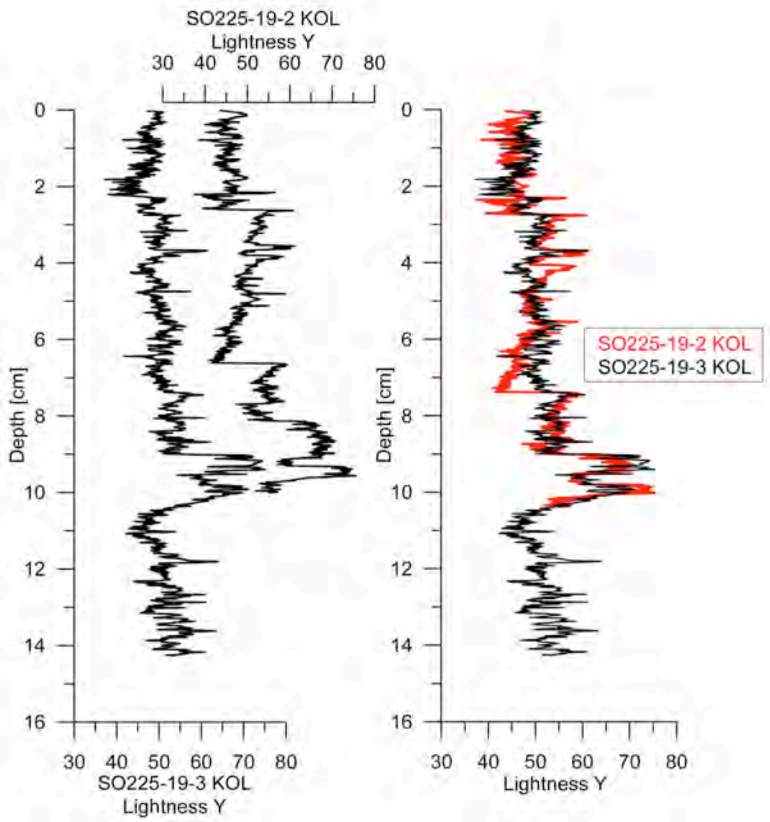

Fig. 6.22: *Left: Minolta lightness Y (D65) data records of adjacent sediment cores from Manihiki North Plateau, location SO225-19 KOL, versus core depth. Right: Matched records, tuned to each other by AnalySeries 2.0.3 (Paillard et al. 1996-2005).*

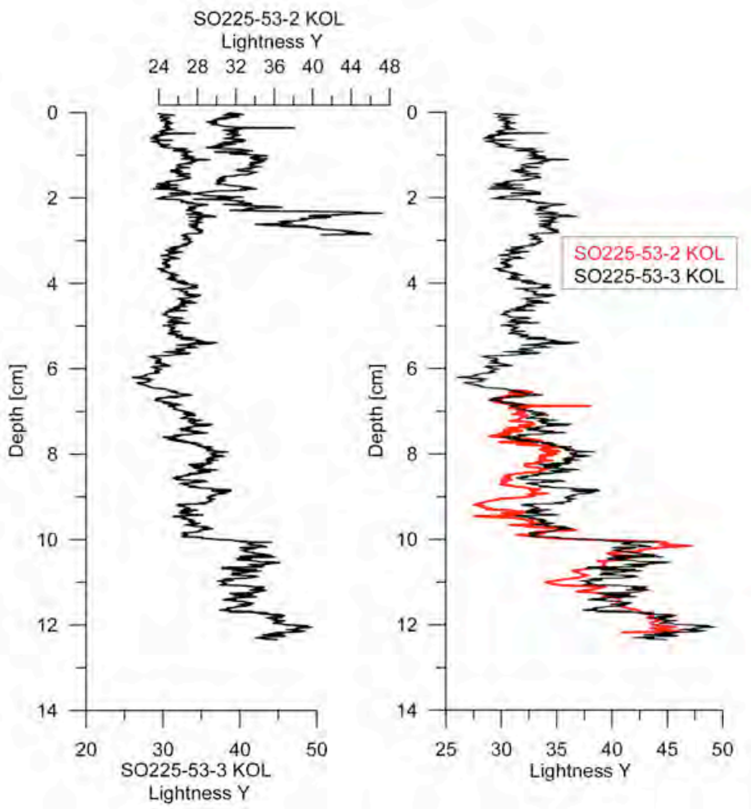

Fig. 6.23: *Alternative 1. Left: Minolta lightness Y (D65) data records of adjacent sediment cores from Manihiki High Plateau, location SO225-53 KOL/SL, versus core depth. Right: Matched records, tuned to each other by AnalySeries 2.0.3 (Paillard et al., 1996-2005).*

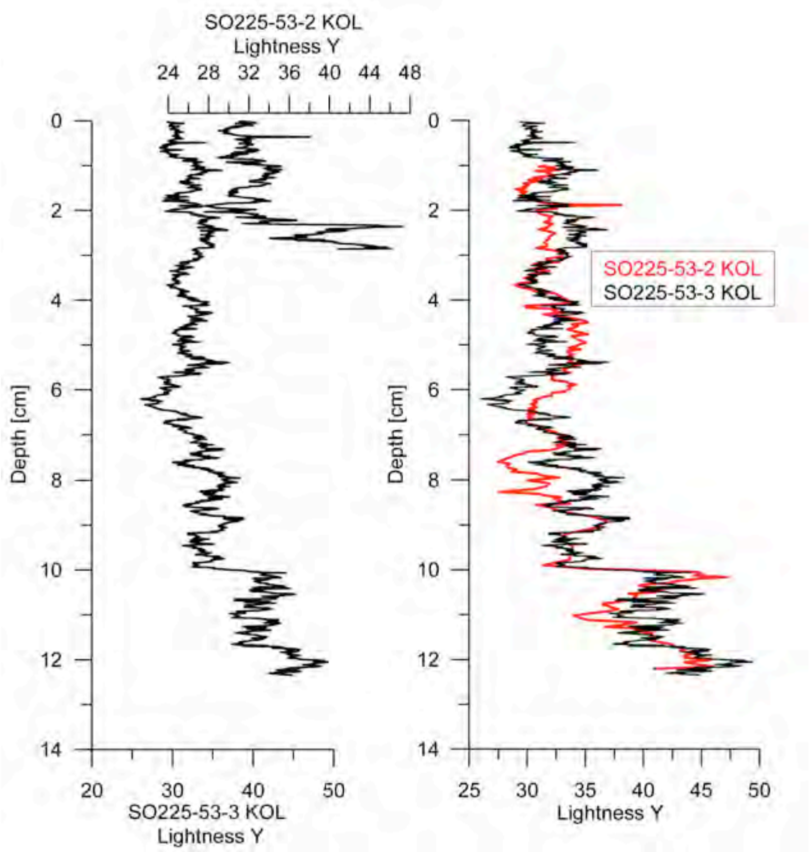

Fig. 6.24: *Alternative 2. Left: Minolta lightness Y (D65) data records of adjacent sediment cores from Manihiki High Plateau, location SO225-53 KOL/SL, versus core depth. Right: Matched records, tuned to each other by AnalySeries 2.0.3 (Paillard et al. 1996-2005).*

Correlation of Lightness Records across the Manihiki Plateau

For paleoceanographic purposes, sediment cores from below ~3 km water depths appeared to be most valuable. Calcite preservation, inferred from the visual inspection of the foraminiferal tests, seemed to be excellent down to even larger water depths. Instead, the shallow core locations above c. 2.5 km water depths seem to be affected by strong currents, as foraminiferal sands dominate.

The physical property records, in particular the Minolta Y (D65) data but also the magnetic susceptibility data (Fig. 6.18 and 6.25) allow for the detailed correlation of selected sediment cores across Manihiki Plateau. We tentatively assigned Y (D65) maxima (i.e., more biogenic calcite) to warm (interglacial) marine isotope stages as suggested by previous studies in the area. Conversely, low Y (D65) intervals indicate the carbonate-low, most likely cool climatic phases.

Core correlation is an important step towards the establishment of a reliable core chronostratigraphy in the Manihiki area. Figure 6.25 demonstrates our tentative attempt to correlate selected sedimentary records across Manihiki Plateau from ca. 3°S to 14°S. Initially, the correlation of cores is based on the assumption that the nanno oozes found in cores SO225-19-3, 8-3, and 53-3 formed synchronously, an assumption that needs to be verified later. The pronounced shift in Y (D65) to low values indicating the termination of nanno ooze deposition was taken as a first tie line. Subsequently, prominent peaks and lows in the remaining data records could be easily matched. As we still have no age control on our records, cores SO225-8-3, 7-3, and 19-3 were related to the depth scale of core SO225-53-3.

The comparison of Y (D65) data from the different working areas imply that lightest sediments occur at North Plateau (SO225-17 and -19), most likely due to the highest amounts of coccoliths in the sediments. The enhanced primary productivity of calcitic marine phytoplankton (and of biogenic silica, as revealed by binocular examination) might be explained by the vicinity of the equatorial divergence and related nutrient supply by upwelling processes. Our southernmost core SO225-53-3, for comparison, shows lowest Y (D65) values. Primary productivity was generally lower, also supported by the lack of biogenic silica. The variability in Y (D65), in general, supports the assumption that the West Pacific Warmpool reacted sensitively on global climatic changes, with pronounced laterally (N-S) oriented gradients in surface oceanography.

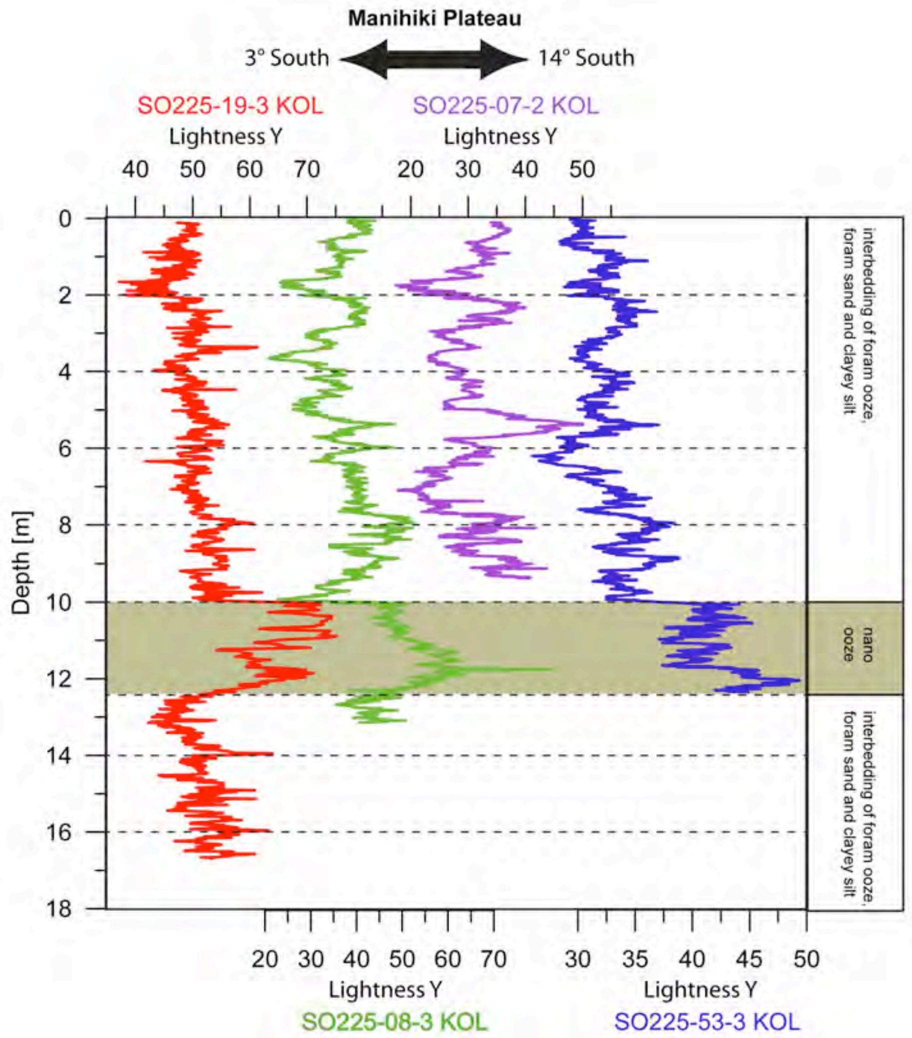

Fig. 6.25: *Preliminary core correlation across Manihiki Plateau from north (~3°S, left) to south (~14°S, right). The Minolta lightness Y (D65) data, which reflect the varying carbonate concentration of the sediments, appeared valuable for correlation purposes, as downcore patterns were rather similar at core locations SO225-19-3 (North Plateau), -8-3, 7-3 (Western Plateaus), and 53-3 (High Plateau). All record were tuned to sediment core 53-3, whereas the lower part was tuned to 19-3 as it provides the longest record. The shaded area marks the prominent nanno ooze present in the core and used for initial core correlation.*

7. BIOLOGY

(N. Furchheim)

The biological studies conducted in the framework of SO-225 are not integral part of the MANIHIKI II research project and did not require any additional ship´s time. The biological studies just aim to preserve and study marine organism found on rocks, in sediments, and in water samples collected during SO-225 for petrological and paleoceanographic investigations.

Biological samples were collected deploying the ROV Kiel 6000 and a geological chain bag dredge. With both devices boulders and rocks were collected and carefully checked for benthic invertebrates. Additionally we were able to collect some surface samples at one station with a plankton multinet and by fishing pelagic pumice stones with epifauna and -flora near an active underwater volcano.

The collected animals were directly fixed in 100% pure ethanol or 4% formaldehyde (buffered with buffer tablets for haematology (Merck # 1.09468.10100, pH 7.2)). The specimens are voucher specimens for the Museum of Natural History in Berlin and can be used for morphological and histological investigations. The samples fixed in ethanol can be also used for molecular research. The video- and photodata of the ROV furthermore allowed us to observe the seafloor and analyse the benthic communities occurring at the Manihiki Plateau.

The video observation with the ROV Kiel 6000 shows, that the Manihiki Plateau is sparsely populated by invertebrates. Sporadically, large sea lilies (Crinoida), octocorals (Cnidaria) and sponges (Porifera) were attached to the seafloor. Not only the sessile fauna but also errant invertebrates were very rare. Amongst the latter were shrimps and mainly echinoderms such as (Holothuroidea, Ophiuroidea).

The low diversity and number of animals was not surprising, reflecting previous experiences during an earlier expedition in this region (SO-193 MANIHIKI-I).

CTD-data collected during this cruise show, that the surface water is very warm (~ 29°C in 10 m depth) and even in a depth of about 213 m the temperature is still ~ 18°C (average of CTD-stations). Warm and probably nutrient-depleted water implicates a low number of plankton organisms in the water column. That would be in accordance with the observed absence of fish and marine mammals during the whole cruise. Although a low concentration of marine snow resulting from the small number of plankton organisms may explain the small number of animals seen in the videos, this is contrasted by the relative large size of the filter feeders like the crinoids seen during the ROV-dives.

Unfortunately we were not able to collect some of the large but very fragile specimens but in three out of six ROV-dives small encrusting invertebrates of different taxa were found on the collected rocks even if the number of collected specimens was extremely low (ten specimens belonging to seven different taxa).

Only two geological dredges contained biological material; with all specimens found (Bivalvia and coronate Cnidaria) very small in size.

Luckily, the previously defined station of the plankton multinet turned out to be the only location where we observed a huge amount of jellyfish and especially tunicates in the water column. Voucher specimens of these animals were collected and fixed in ethanol and 4% formaldehyde.

Near the submarine volcano Monowai which was mapped during the cruise we were able to collect pumice stones from the water surface. Although the pieces of pumice were relatively small they were populated with different animals and plants. None of the groups found on these pumice stones live in the deep sea, but form an interesting community comprising goose barnacles (Pedunculata) and carnivorous non-sessile crustaceans.

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APPENDICES:

I. Sampling Summary/Station List

II. Rock Description

III. Core Photos

IV. Core Description

V. Core Logging

VI. Overview Map: SO-225 Sampling Sites

Appendix I (Station list)

Station no.	Device	Location	Recovery	Sample summary	on bottom		off bottom		depth (m)	
					lat °S	long °E	lat °S	long °E	max	min
001POZ01	TV-MUC	Western Plateaus, southern part	14-18 cm	white foraminiferal sand (7 tubes)	-10,227	-165,868	- -	- -	-1567	- -
001POZ02	KL 15 m	Western Plateaus, southern part	empty	foramimiferal sand washed out	-10,233	-165,868	- -	- -	-1566	- -
002POZ01	KL 15 m	Western Plateaus, southern part	541 cm	pure white foraminiferal sand	-9,979	-166,226	- -	- -	-2358	- -
002POZ02	CTD	Western Plateaus, southern part	water	- -	-9,996	-166,199	- -	- -	-2610	- -
003VER01	MB+PS	Western Plateaus to southern DIT	173 nm	- -	- -	- -	- -	- -	- -	- -
004ROV01	ROV	southern DIT, E-flank	- -	dive aborted after 20 Min. due to technical problems	-9,694	-164,314	-9,694	-164,308	-4829	-4750
005POZ01	TV-MUC	southern DIT, center of basin	41-45 cm	dark brown homogeneous clay (12 tubes)	-9,694	-164,338	- -	- -	-4855	- -
006VER02	MB+PS	southern DIT to central western plateaus	135 nm	- -	- -	- -	- -	- -	- -	- -
007POZ01	TV-MUC	central Western Plateaus	26-28 cm	light yelloy foraminiferal sand with clayey silty portion (10 tubes)	-8,951	-165,041	- -	- -	-3552	- -
007POZ02	KL 15 m	central Western Plateaus	1012 cm	foraminiferal ooze with with clayey silty portion	-8,951	-165,041	- -	- -	-3554	- -
008POZ01	TV-MUC	northern Western Plateaus	26-29 cm	foram. sand with clayey silty portion, tephra particles (12 tubes)	-7,198	-165,053	- -	- -	-3589	- -
008POZ02	KL 15 m	northern Western Plateaus	1148 cm	foraminiferal ooze with clayey silty portion	-7,199	-165,053	- -	- -	-3565	- -
008POZ03	KL 20 m	northern Western Plateaus	1618 cm	foraminiferal sand and ooze, sandy silt, nanno ooze	-7,199	-165,053	- -	- -	-3589	- -
009ROV02	ROV	southern DIT, upper E- flank	4 samples	lava fragments, dive aborted after 4.5 hours due to tech. problems	-9,268	-164,303	-9,268	-164,298	-3497	-3046
010VER03	MB+PS	western High Plateau	121 nm	- -	- -	- -	- -	- -	- -	- -
011ROV03	ROV	south-western foothills of North Plateau	11 samples	lava fragments, volcaniclastics, intrusive rocks, Mn-crusts	-6,078	-164,675	-6,063	-164,673	-4602	-4073
012VER04	MB+PS	south-western foothills of North Plateau	135 nm	- -	- -	- -	- -	- -	- -	- -
013ROV04	ROV	south-western foothills of North Plateau	17 samples	lava fragments, volcaniclastics, metamorphic rocks, Mn-crusts	-6,071	-164,689	-6,06	-164,684	-4062	-3413
014VER05	MB+PS	North Plateau	80 nm	- -	- -	- -	- -	- -	- -	- -
015POZ01	CTD	North Plateau, southern part	water	- -	-5,797	-164,769	- -	- -	-1831	- -
015POZ02	TV-MUC	North Plateau, southern part	10-12 cm	light yelloy foraminiferal sand (8 tubes)	-5,798	-164,767	- -	- -	-1828	- -
015POZ03	KL 20 m	North Plateau, southern part	1203 cm	foranimiferal sand and ooze (corer brocken)	-5,798	-164,767	- -	- -	-1802	- -
015POZ04	KL 10 m	North Plateau, southern part	empty	foramimiferal sand washed out	-5,798	-164,767	- -	- -	-1810	- -
016VER06	MB+PS	North Plateau	160 nm	- -	- -	- -	- -	- -	- -	- -
017POZ01	TV-MUC	North Plateau, central part	23-28 cm	foraminiferal sand	-4,766	-164,617	- -	- -	-3246	- -
017POZ02	KL 20 m	North Plateau, central part	1615 cm	foraminiferal sand and ooze, clayey sand silt	-4,77	-164,621	- -	- -	-3248	- -
017POZ03	KL 20 m	North Plateau, central part	1558 cm	foraminiferal sand and ooze	-4,766	-164,618	- -	- -	-3247	- -
018VER07	MB+PS	North Plateau	146 nm	- -	- -	- -	- -	- -		- -
019POZ01	TV-MUC	northern foothills of North Plateau	27-29 cm	foraminifera in silty clayey matrix	-3,792	-164,887	- -	- -	-3558	- -
019POZ02	KL 15 m	northern foothills of North Plateau	1004 cm	foraminiferal sand and ooze, nanno ooze	-3,792	-164,887	- -	- -	-3558	- -
019POZ03	KL 20 m	northern foothills of North Plateau	1429 cm	foraminiferal sand and ooze, sandy silty clay	-3,792	-164,887	- -	- -	-3558	- -
020VER08	MB+PS	ocean floor north of North Plateau	75 nm	75 nm surveyed	- -	- -	- -	- -		- -
021POZ01	CTD	ocean floor north of North Plateau	water	- -	-3,05	-165,056	- -	- -	-5185	- -
021POZ02	TV-MUC	ocean floor north of North Plateau	42-45 cm	dark brown deep sea clay (11 tubes)	-3,05	-165,055	- -	- -	-5186	- -
021POZ03	MN St1	ocean floor north of North Plateau	plankton	500 m water depth	-3,051	-165,056	- -	- -	-500	- -
021POZ03	MN St2	ocean floor north of North Plateau	plankton	500 m water depth	-3,044	-165,04	- -	- -	-500	- -
021POZ03	MN St3	ocean floor north of North Plateau	plankton	500 m water depth	-3,035	-165,025	- -	- -	-500	- -
021POZ03	MN St4	ocean floor north of North Plateau	plankton	500 m water depth	-3,027	-165,011	- -	- -	-500	- -

Appendix I (Station list)

Station no.	Device	Location	Recovery	Sample summary	on bottom		off bottom		depth (m)	
					lat °S	long °E	lat °S	long °E	max	min
021POZ03	MN St5	ocean floor north of North Plateau	plankton	500 m water depth	-3,019	-164,996	- -	- -	-500	- -
021POZ03	MN St6	ocean floor north of North Plateau	plankton	500 m water depth	-3,01	-164,982	- -	- -	-500	- -
021POZ03	MN St7	ocean floor north of North Plateau	plankton	500 m water depth	-3,002	-164,968	- -	- -	-500	- -
021POZ04	KL 15 m	ocean floor north of North Plateau	empty	core catcher teared off	-3,055	-165,056	- -	- -	-5182	- -
022VER09	MB+PS	southern High Plateau to northern margin	420 nm	- -	- -	- -	- -	- -	- -	- -
023DR05	DR	High Plateau, N-margin	1/5 full	lava fragments, sedimentary rocks, Mn crusts	-6,673	-162,748	-6,676	-162,743	-5590	-5099
024DR06	DR	High Plateau, N-margin	few rocks	sedimentary rocks	-6,679	-162,745	-6,686	-162,739	-5213	-4647
025DR07	DR	High Plateau, N-margin	few rocks	lava fragments	-6,732	-163,204	-6,737	-163,199	-5562	-5120
026DR08	DR	High Plateau, N-margin	large bloc	lava fragments (in situ pillow breccia)	-6,762	-163,43	-6,766	-163,424	-5396	-5143
027DR09	DR	DIT, northernmost trough	1/6 full	lava fragments, sedimentary rocks	-6,914	-163,841	-6,911	-163,833	-5801	-5142
028DR10	DR	DIT, second trough from north	empty	- -	-8,592	-163,996	-8,582	-163,996	-4730	-4290
029DR11	DR	DIT, second trough from north	1/5 full	sedimentary rocks	-8,653	-163,925	-8,653	-163,917	-4580	-4123
030DR12	DR	southern DIT, tectonic (?) smt. at E-flank	1/3 full	lava fragments, volcaniclastics, intrusive rocks	-9,383	-164,276	-9,379	-164,269	-4440	-4004
031DR13	DR	southern DIT, tectonic (?) smt. at E-flank	1/5 full	lava fragments, volcaniclastics, Mn crusts	-9,384	-164,266	-9,382	-164,26	-4068	-3655
032DR14	DR	southern DIT, tectonic (?) smt. at E-flank	3/4 full	lava fragments, volcaniclastics, Mn crusts	-9,374	-164,267	-9,372	-164,26	-3793	-3370
033DR15	DR	southern DIT, tectonic (?) smt. at E-flank	2 rocks	volcaniclastics, Mn crusts	-9,352	-164,277	-9,348	-164,273	-3397	-2947
034DR16	DR	southern DIT, tectonic (?) smt. at E-flank	1/2 full	lava fragments, volcaniclastics, Mn crusts	-9,302	-164,273	-9,299	-164,265	-2858	-2172
035DR17	DR	southern DIT, tectonic (?) smt. at E-flank	1/4 full	lava fragments, volcaniclastics, Mn crusts	-9,285	-164,355	-9,286	-164,347	-4700	-4288
036DR18	DR	southern DIT, E-flank north of smt.	1/4 full	lava fragments, metamorphic rocks, sedimentary rocks	-9,093	-164,294	-9,091	-164,286	-4768	-4314
037DR19	DR	southern DIT, E-flank north of smt.	few rocks	lava fragments, volcaniclastics	-9,05	-164,266	-9,048	-164,259	-4192	-3583
038DR20	DR	southern DIT, tectonic (?) smt. at E-flank	1/4 full	lava fragments, volcaniclastics, Mn crusts	-9,413	-164,245	-9,406	-164,239	-4582	-3980
039DR21	DR	southern DIT, W-flank (SO224 seismic line)	full	lava fragments, sedimentary rocks	-9,53	-164,39	-9,524	-164,396	-4433	-3773
040DR22	DR	southern DIT, E-flank (SO224 seismic line)	1 rock	sedimentary rock with thick Mn crust	-9,668	-164,304	-9,668	-164,297	-4601	-4200
041VER10	MB+PS	southern DIT to central High Plateau	130 nm	- -	- -	- -	- -	- -	- -	- -
042POZ01	TV-MUC	High Plateau, northern part	~1 cm	foraniniferal sand to ooze (1 tube)	-9,214	-162,22	- -	- -	-3086	- -
042POZ02	KL 10 m	High Plateau, northern part	empty	5 m segment teared off	-9,213	-162,22	- -	- -	-3089	- -
042POZ03	KL 10 m	High Plateau, northern part	empty	core catcher teared off	-9,214	-162,22	- -	- -	-3075	- -
043VER11	MB+PS	northern to central High Plateau	110 nm	- -	- -	- -	- -	- -	- -	- -
044POZ01	TV-MUC	High Plateau, central part	1 - 6 cm	light yelloy foraminiferal sand (10 tubes)	-11,052	-161,532	- -	- -	-3005	- -
044POZ02	KL 10 m	High Plateau, central part	empty	core catcher teared off	-11,051	-161,065	- -	- -	-2990	- -
044POZ03	SL 5 m	High Plateau, central part	39 cm	Foraminiferal sand and foramininferal ooze	-11,051	-161,532	- -	- -	-3012	- -
044POZ04	SL 5 m	High Plateau, central part	470 cm	Foraminiferal sand and foramininferal ooze	-11,051	-161,532	- -	- -	-3011	- -
045VER12	MB+PS	044POZ to Suvorov Trough	142 nm	- -	- -	- -	- -	- -	- -	- -
046DR23	DR	Suvorov Trough	1/5 full	lava fragments, Mn crusts	-10,645	-163,9	-10,643	-163,894	-4309	-3822
047VER13	MB	Suvorov Trough	246 nm	246 nm survey	- -	- -	- -	- -	- -	- -
048DR24	DR	Suvorov Trough	1/8 full	lava fragments, volcaniclastics	-10,654	-163,883	-10,652	-163,876	-3601	-3014
049DR25	DR	Suvorov Trough	1/4 full	lava fragments, volcaniclastics, Mn crusts	-10,668	-163,842	-10,659	-163,841	-2975	-2556
050DR26	DR	Suvorov Trough	empty	- -	-10,631	-163,747	-10,638	-163,746	-2999	-2540
051DR27	DR	Suvorov Trough	full	lava fragments, sedimentary rocks, Mn crusts	-10,681	-163,88	-10,68	-163,87	-4060	-3508

Appendix I (Station list)

Station no.	Device	Location	Recovery	Sample summary	on bottom		off bottom		depth (m)	
					lat °S	long °E	lat °S	long °E	max	min
052VER14	MB+PS	High Plateau, southern margin	196 nm	- -	- -	- -	- -	- -	- -	- -
053POZ01	TV-MUC	High Plateau, southern margin	0,5 - 6 cm	light yelloy foraminiferal ooze (11 tubes)	-13,521	-162,140	- -	- -	-3154	- -
053POZ02	SL 10m	High Plateau, southern margin	288 cm	Foraminiferal ooze and nanno ooze	-13,520	-162,138	- -	- -	-3153	- -
053POZ03	KL 15m	High Plateau, southern margin	1238 cm	Foraminiferal ooze and nanno ooze	-13,521	-162,140	- -	- -	-3150	- -
053POZ04	CTD	High Plateau, southern margin	water	- -	-13,510	-162,126	- -	- -	-3090	- -
054VER15	MB+PS	Monowai	c. 50	- -	- -	- -	- -	- -	- -	- -

SO-225 deployments:

4	ROV-dives
23	Dredge hauls
11	TV-MUC
3	Gravity corer
16	Pistion corer
4	CTD
1	Multi net (jojo -> 7x to 500 m water depth)
2943	nm SIMRAD EM120 survey
2245	nm ATLAS PARASOUND survey

Abbreviations:

ROV
DR
TV-MUC
KL
SL
CTD
MN
MB
PS

Appendix II (Rock Description)

SO225- **004ROV01** **Description of Location and Structure: Central Danger Islands Trough, steep W facing slope into DIT's** ROV on bottom UTC 27/11/12 21:35hrs, lat 9°41.35'S, long 164°18.80'W, depth 4829m ROV off bottom UTC 27/11/12 22:27hrs, lat 9°41.64'S, long 164°18.50'W, depth 4750m *total volume: none* *Comments: Dive aborted due to technical problems. Oil compensator <5%*	

SO225-
009ROV02
Description of Location and Structure: Eastern flank of DIT, upper part of NW-SE striking ridge, steep W facing slope
ROV on bottom UTC 01/12/12 00:59hrs, lat 9°16.09'S, long 164°18.18'W, depth 3497m
ROV off bottom UTC 01/12/12 05:19hrs, lat 9°16.05'S, long 164°17.89'W, depth 3088m
total volume: 4 pieces of massive lava and highly vesicular lava
Comments: Dive aborted after c. 4 hrs due to technical problems. Oil compensator <10%

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	ROV Box No	NOTES	PICTURE
SO225-ROV-2-1	Sampling Depth: 3512m Coordinates: lat 9°16,09'S, long 164°18,17'W 1. Rock Type: aphyric, volcanic rock, slightly altered 2. Size: 30x15x12 3. Shape / Angularity: angular 4. Color of cut surface: medium brown (dry) 5. Texture / Vesicularity: fairly dense, 1-3% original vesicles, mostly filled with Mn, some with light green smectite 6. Phenocrysts: green smectite, one single xenocrystic px (about 2mm) 7. Matrix: fine grained groundmass with small fsp needles and px 8. Secondary Minerals: Mn filling of vesicles and smectite? 9. Encrustations: <1mm Mn coating on outer surface of rock 10. Comment: strongly altered, dense basalt? check groundmass fsp for dating!	2	6	6 with possibly gm, fsp	ground mass, fsp	N2	from dertis	
SO225-ROV-2-2	Sampling Depth: 3302m Coordinates: lat 9°16,08'S, long 164°18,03'W 1. Rock Type: badly altered, vesicular lava 2. Size: 30x15x13 cm 3. Shape / Angularity: rounded 4. Color of cut surface: medium brown with light green spots 5. Texture / Vesicularity: 25% rounded to oval, but often irregular shaped, 1-3mm sized vesicles. On broken surface vesicles often open with Mn lining. On cut surface vesicles filled with greenish material 6. Phenocrysts: not visible 7. Matrix: fine grained, highly altered 8. Secondary Minerals: epidote (yellowish green) replacing olivine? 9. Encrustations: 2-3 mm Mn encrustation 10. Comment: very badly altered lava, use for chemistry and dating questionable	3	1			M2		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	ROV Box No	NOTES	PICTURE
SO225-ROV-2-3	Sampling Depth: 3278m Coordinates: lat 9°16,08'S, long 164°18,01'W 1. Rock Type: volcanic, strongly altered rock, probably lava 2. Size: 27x20x16 cm 3. Shape / Angularity: rounded 4. Color of cut surface: light brown with yellowish and black spots (dry surface) 5. Texture / Vesicularity: vesicular, voids up to 1cm in size of irregular shape, distributed unequally and vary from about 20% to about 5%. Voids are filled with yellow greenish material (microcrystalline), some voids with small colorless crystals. Black dots in gm. are likely Fe-Mn oxides ≤1mm. They are globules or elipses in shape in parts where voids are large. Small, irregular Mn oxides occur where voids are less abundant. Gm. of the rock is composed predominantly by plag elongate xls, perhaps cpx, altered glass. Gm. texture is intersertal to doleritic. 6. Phenocrysts: phenocrysts are hardly recognisable and probably not present 7. Matrix: matrix has intersertal texture and mainly composed by elongate plag xlg. Relatively well crystallized 8. Secondary Minerals: smectites, possibly calcedone (amorphous quartz) in voids and in matrix 9. Encrustations: tiny cracks filled with Fe-Mn oxides, Fe-Mn crust up to ~0.5cm thick 10. Comment: -	2				L1	from dertis	
SO225-ROV-2-4	Sampling Depth: 3278m Coordinates: lat 9°16,08'S, long 164°18,01'W 1. Rock Type: aphiric, finely crystallized, volcanic rock, altered 2. Size: 12x6x4cm 3. Shape / Angularity: angular 4. Color of cut surface: dark, dirty yellow with small black dots 5. Texture / Vesicularity: massive, not vesicular (rare voids up to 1mm filled with Fe-Mn oxides) 6. Phenocrysts: very rare intergrowths of plag phenocrysts up to 1.5mm along the longest dimension 7. Matrix: matrix is very finely recrystallized and composed by chaotically oriented plag xls + texture is massive 8. Secondary Minerals: matrix glass is completely replaced with Fe-oxides and likely smectites 9. Encrustations: thin Fe-Mn crust on outer surface (~0.5mm), cracks are filled with Fe-Mn oxides 10. Comment: -	2				M1	from dertis	

SO225-
011ROV03
Description of Location and Structure: Ridge between Western and Northern Plateau, top sampled at SO193-DR46; SW-facing slope of NW-SE striking ridge. Ridge SE at top
ROV on bottom UTC 02/12/12 23:15hrs, lat 6°04.73'S, long 164°41.55'W, depth 4605m
ROV off bottom UTC 03/12/12 04:11hrs, lat 6°04.27'S, long 164°41.36'W, depth 4079m
total volume: 11 samples; aphyric, microcrystalline volcanics, some resembling diabase-dolerite, 1 piece of pegmatoid gabbro

Comments: -

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	ROV Box No	NOTES	PICTURE
SO225-ROV-3-1	Sampling Depth: 4552m Coordinates: lat 6°04,65'S, long 164°41,52'W 1. Rock Type: volcanic, slightly altered 2. Size: 7x5.5x5.5cm 3. Shape / Angularity: angular clast 4. Color of cut surface: light grey on dry, cut surface 5. Texture / Vesicularity: dense, microcrystalline texture, no vesicles 6. Phenocrysts: black mineral, pyroxene? (~10%) 7. Matrix: light grey ground mass 8. Secondary Minerals: <<1% red dots of Fe-hydroxide, minor filling of white & red material along cracks 9. Encrustations: 2-3 mm Mn crust 10. Comment: dense, volcanic rock with slight metamorphic overprint	1	1	2		C1		
SO225-ROV-3-2	Sampling Depth: 4509m Coordinates: lat 6°04,61'S, long 164°41,50'W 1. Rock Type: sediment? 2. Size: 14.5x11x4cm 3. Shape / Angularity: platy, rounded at edges 4. Color of cut surface: white, brown (black) on dry surface 5. Texture / Vesicularity: breccia? 6. Phenocrysts: ~0.5cm clasts (partly rounded) 7. Matrix: layered matrix with clasts 8. Secondary Minerals: - 9. Encrustations: 2-3 mm Mn-crust 10. Comment: breccia with ~0.5cm clasts with a layered structure					B1		
SO225-ROV-3-3	Sampling Depth: 4430m Coordinates: lat 6°04,54'S, long 164°41,48'W 1. Rock Type: fine grained, volcanic rock 2. Size: 28x26x22cm 3. Shape / Angularity: angular shape (partly rounded) 4. Color of cut surface: dark grey color on dry surface 5. Texture / Vesicularity: fine grained texture without vesicles 6. Phenocrysts: no phenocrysts 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: ~1mm brown Fe-oxides? in white veins 9. Encrustations: 0.5-1cm Mn-crust 10. Comment: dense, fine grained, volcanic rock with alteration veins (diabase?)	3	2	2		E2		
SO225-ROV-3-3Mn	Sampling Depth: 4430m Coordinates: lat 6°04,54'S, long 164°41,48'W 1. Rock Type: massive Mn crusts 2. Size: 1-3cm thickness 3. Shape / Angularity: partly angular, partly rounded shape 4. Color of cut surface: black 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -					E2		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	ROV Box No	NOTES	PICTURE
SO225-ROV-3-4	Sampling Depth: 4364m Coordinates: lat 6°04,51'S, long 164°41,46'W 1. Rock Type: intrusive rock 2. Size: 20x14.5x12cm 3. Shape / Angularity: angular 4. Color of cut surface: grey-black 5. Texture / Vesicularity: coarse grained texture, no vesicles (melanocratic) 6. Phenocrysts: elongated, black, ~0.5cm pyroxene phenocrysts (~35%) 7. Matrix: light grey matrix (ophitic?) 8. Secondary Minerals: 2-3mm Fe-hydroxides, on broken surfaces: small, green-yellow grains of titanite?! 9. Encrustations: 1-3mm Mn crust 10. Comment: dense, coarse grained, plutonic rock with an ophitic? structure	3	6	1 (U/Pb?; zircon?)	mineral separation for pyroxene and plag	N2		
SO225-ROV-3-5	Sampling Depth: 4296m Coordinates: lat 6°04,45'S, long 164°41,44'W 1. Rock Type: Mn-encrusted breccia 2. Size: 18x14x10cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: igneous clasts, several cm in diameter, subangular, are matrix supported by light brown, beige, fine grained material with Mn-particles, igneous rocks range from ophyric basalt to monocrystalline dolerite. Igneous rocks are similar to those, collected in this dive							
SO225-ROV-3-6	Sampling Depth: 4235m Coordinates: lat 6°04,40'S, long 164°41,40'W 1. Rock Type: fine grained, volcanic rock, slightly altered (green veins) 2. Size: 26x12.5x20cm 3. Shape / Angularity: angular shape 4. Color of cut surface: dark green to grey color on broken surface 5. Texture / Vesicularity: fine grained texture, no vesicles 6. Phenocrysts: 1-2mm dark pyroxene phenocrysts (~10%) 7. Matrix: light grey, fine grained matrix 8. Secondary Minerals: small grained, red brown Fe-oxides? 9. Encrustations: 1-2mm Mn-crust 10. Comment: dense, fine grained, volcanic rock with slight metamorphic overprint (white-green veins)	2	5	2		C2		
SO225-ROV-3-7	Sampling Depth: 4127m Coordinates: lat 6°04,31'S, long 164°41,37'W 1. Rock Type: Mn-nodule with light brown core 2. Size: 5x8x6.5cm 3. Shape / Angularity: round ball 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: 2-3mm black Mn-crust 10. Comment: core consists of light brown chert-like material					N3		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	ROV Box No	NOTES	PICTURE
SO225-ROV-3-8	Sampling Depth: 4127m Coordinates: lat 6°04,31'S, long 164°41,37'W 1. Rock Type: Mn-nodule similar to sample 7 2. Size: 8x6x6cm 3. Shape / Angularity: rounded to circular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: up to 7mm curtains, angular 10. Comment: 5cm sized clast of aphyric, greenish basalt, similar to volcanics of this dive							
SO225-ROV-3-9	Sampling Depth: 4112m Coordinates: lat 6°04,30'S, long 164°41,37'W 1. Rock Type: fine grained, volcanic rock (altered-> white veins) 2. Size: 27x18x14cm 3. Shape / Angularity: angular shape 4. Color of cut surface: dark-green to grey color on dry surface 5. Texture / Vesicularity: fine grained texture without vesicles 6. Phenocrysts: no phenocrysts 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: small grained, brown Fe-oxides? in white veins 9. Encrustations: 1-5mm Mn crust 10. Comment: dense, volcanic rock with metamorphic overprint (veins)	3		2-3		L1		
SO225-ROV-3-10	Sampling Depth: 4112m Coordinates: lat 6°04,30'S, long 164°41,37'W 1. Rock Type: volcanic, slightly altered 2. Size: 23x13x13cm 3. Shape / Angularity: angular 4. Color of cut surface: dark grey color on dry surface 5. Texture / Vesicularity: dense, microcrystalline texture, no vesicles 6. Phenocrysts: 1mm, dark, pyroxene phenocrysts (~30%) 7. Matrix: grey, fine grained matrix 8. Secondary Minerals: no visible, secondary minerals 9. Encrustations: 1-5mm Mn crust 10. Comment: dense, volcanic rock, only slightly altered	1		2		L2		
SO225-ROV-3-11	Sampling Depth: 4085m Coordinates: lat 6°04,27'S, long 164°41,36'W 1. Rock Type: volcanic, altered 2. Size: 24x9.5x12.5cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey on dry surface 5. Texture / Vesicularity: dense, microcrystalline texture 6. Phenocrysts: fine pyroxene grains? 7. Matrix: light grey, fine grained matrix with alteration veins 8. Secondary Minerals: red dots of Fe-hydroxides near the veins 9. Encrustations: 1-2mm Mn crust 10. Comment: dense, volcanic rock with metamorphic overprint (veins)	1	2	2		B2		

SO225-013ROV04

Description of Location and Structure: Continuation of Profile ROV03; Ridge between Western & Northern Plateau; SW facing slope near SE tip of ridge; Dive will start at ~4050m and end at 3000 mbsl

ROV on bottom UTC 03/12/12 21:10hrs, lat 6°04.25'S, long 164°41.35'W, depth 4065m
ROV off bottom UTC 04/12/12 06:07hrs, lat 6°03.57'S, long 164°41.10'W, depth 3261m
total volume: 17 samples
Comments: -

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	ROV Box No	NOTES	PICTURE
SO225-ROV-4-1	Sampling Depth: 4046m Coordinates: lat 6°04,22'S, long 164°41,33'W 1. Rock Type: dense, intrusive? rock with a tectonic+metamorphic overprint (altered) 2. Size: 28x16x13cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey-red to green color on dry, broken surface 5. Texture / Vesicularity: coarse grains (phenocrysts) in a coarse grained matrix (no vesicles) 6. Phenocrysts: 0.5-1cm olivines?, strongly altered 7. Matrix: coarse grained, grey matrix 8. Secondary Minerals: rock is strongly altered, Fe-oxides? in cracks 9. Encrustations: 1-3mm Mn crust 10. Comment: dense, coarse grained, intrusive rock with strongly altered phenocrysts, need to check thin section for datable mineral phases!	2	1+2 backups for minerals	3-4		L1		
SO225-ROV-4-2	Sampling Depth: 4046m Coordinates: lat 6°04,22'S, long 164°41,34'W 1. Rock Type: volcanic rock, slightly altered 2. Size: 22x16x12cm 3. Shape / Angularity: angular shape 4. Color of cut surface: dark-green to grey color on dry surface 5. Texture / Vesicularity: medium to fine grained matrix (no vesicles) 6. Phenocrysts: ~1mm pyroxene? phenocrysts (black) + 1-3mm brown Fe-oxides? -> altered olivine? 7. Matrix: grey, fine grained matrix 8. Secondary Minerals: Fe-oxides (red brown) 9. Encrustations: 1-3mm Mn crust 10. Comment: dense, fine grained, volcanic rock with slight metamorphic overprint (olivine replaced by Fe-oxides)	1	3	2		M1		
SO225-ROV-4-3	Sampling Depth: 4034m Coordinates: lat 6°04,22'S, long 164°41,33'W 1. Rock Type: volcanic rock, altered (veins) 2. Size: 12x7x6cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color on dry, broken surface 5. Texture / Vesicularity: dense, fine grained structure (no vesicles) 6. Phenocrysts: 1-2mm transparent feldspar phenocrysts 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: recrystallized alteration veins 9. Encrustations: 1-2mm Mn crust 10. Comment: dense, volcanic rock with fine grained matrix, plag phenocrysts and alteration veins	2	2; mineral separation: plag!	2-3		A1		
SO225-ROV-4-4	Sampling Depth: 4005m Coordinates: lat 6°04,19'S, long 164°41,31'W 1. Rock Type: volcanic (intrusive?) rock 2. Size: 16x14x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color on broken, dry surface 5. Texture / Vesicularity: fine grained, vesicles filled with Mn or minerals (~0.5mm size) 6. Phenocrysts: 0.5-0.8mm olivine phenocrysts replaced by Fe-oxides 7. Matrix: fine grained matrix (grey color) 8. Secondary Minerals: Fe-oxides replacing olivine 9. Encrustations: 2-5mm Mn crust 10. Comment: fine grained, volcanic rock with metamorphic overprint	3	2	3-4		M2		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	ROV Box No	NOTES	PICTURE
SO225-ROV-4-5	Sampling Depth: 3973m Coordinates: lat 6°04,17'S, long 164°41,30'W 1. Rock Type: matrix supported by polymict breccia 2. Size: 10x6x7cm 3. Shape / Angularity: angular, parly circular shape 4. Color of cut surface: brown, fine grained matrix, different colors (black-grey) depending on the type of clast within the breccia 5. Texture / Vesicularity: angular clasts (basalt?) in a small grained matrix 6. Phenocrysts: no phenocrysts 7. Matrix: brown-grey matrix of small clasts 8. Secondary Minerals: no visible, secondary minerals 9. Encrustations: 1-2mm Mn crust 10. Comment: tectonic breccia containing different magmatic clasts	2		6		N1		
SO225-ROV-4-6	Sampling Depth: 3973m Coordinates: lat 6°04,24'S, long 164°39,71'W 1. Rock Type: polymict breccia 2. Size: 16x10x8cm 3. Shape / Angularity: rounded, partly angular shape 4. Color of cut surface: different colors due to different clasts 5. Texture / Vesicularity: fine grained matrix containing different clast sizes (0.1-1.5cm clasts) 6. Phenocrysts: no visible phenocrysts 7. Matrix: fine grained matrix with weak schistosity 8. Secondary Minerals: - 9. Encrustations: 1-2mm Mn crust 10. Comment: breccia containing different types of clasts with foliation			6		N1		
SO225-ROV-4-7	Sampling Depth: 3944m Coordinates: lat 6°04,15'S, long 164°41,28'W 1. Rock Type: volcanic rock, strongly altered (small veins and cracks (~0.5-0.8cm) filled with secondary minerals) 2. Size: 15x8x14cm 3. Shape / Angularity: angular, partly rounded shape 4. Color of cut surface: dark green to grey color on broken surface 5. Texture / Vesicularity: dense, fine grained texture with veins and cracks 6. Phenocrysts: - 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: 1-2mm Fe-oxides 9. Encrustations: 1-5mm Mn crust 10. Comment: dense, volcanic rock with strong metamorphic overprint (veins and cracks), note: ~0.5cm thick crack filled with calcite?-> could be useful for analysis of fluid cracks (Sr-isotopes)	1	1	5		B1		
SO225-ROV-4-8Mn	Sampling Depth: 3905m Coordinates: lat 6°04,11'S, long 164°41,25'W 1. Rock Type: Mn crust 2. Size: 26x16x7.5cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: grey-black 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: fine grained 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: "massive Mn crust"					N2		
SO225-ROV-4-9	Sampling Depth: 3855m Coordinates: lat 6°04,07'S, long 164°41,22'W 1. Rock Type: volcanic rock, slightly altered 2. Size: 54x20x20cm 3. Shape / Angularity: angular shape 4. Color of cut surface: dark green-black color on dry surface 5. Texture / Vesicularity: dense, fine grained rock (no vesicles) 6. Phenocrysts: no visible phenocrysts 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: secondary minerals only in fluid veins (calcite?) 9. Encrustations: 0.1-2cm Mn crust 10. Comment: dense, volcanic rock with metamorphic overprint (small veins)	1	1 for GC +2-3 for mineral separation	2		E2		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	ROV Box No	NOTES	PICTURE
SO225-ROV-4-10	Sampling Depth: 3801m Coordinates: lat 6°04,02'S, long 164°41,22'W 1. Rock Type: volcanic rock, strongly altered 2. Size: 25x11x9cm 3. Shape / Angularity: rounded, partly angular shape 4. Color of cut surface: dark green-grey color on broken surface 5. Texture / Vesicularity: massive, fine grained with cracks/veins, vesicles filled with secondary minerals 6. Phenocrysts: 1-2mm olivines? replaced by Fe-oxides 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: Fe-oxides 1-2mm (~2-3%) 9. Encrustations: 1-2cm Mn crust 10. Comment: dense, volcanic rock with cracks filled with secondary minerals (alteration), Note: Mn crust is relatively thick	1	2	4-5		B2		
SO225-ROV-4-10Mn	Sampling Depth: 3801m Coordinates: lat 6°04,02'S, long 164°41,22'W 1. Rock Type: Mn crust 2. Size: relatively thick (2-2.5cm) 3. Shape / Angularity: rounded shape 4. Color of cut surface: black color 5. Texture / Vesicularity:- 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: massive (solid) Mn crust on basaltic rock?					B2		
SO225-ROV-4-11	Sampling Depth: 3698m Coordinates: lat 6°03,93'S, long 164°41,17'W 1. Rock Type: volcanic rock, altered 2. Size: 12x6x6cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: fine grained groundmass with cracks and veins, filled with secondary minerals (calcite?) 6. Phenocrysts: no visible phenocrysts 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: Fe-oxides replacing olivine? (1-2mm size) 9. Encrustations: 1-2mm Mn crust 10. Comment: dense, volcanic rock with cracks, filled with secondary minerals (diabase?)	1	1	3		N3		
SO225-ROV-4-12	Sampling Depth: 3698m Coordinates: lat 6°03,93'S, long 164°41,17'W 1. Rock Type: volcanic rock, slightly altered 2. Size: 7.5x6.5x4cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: fine grained groundmass with veins filled with secondary phases (silicates?) 6. Phenocrysts: no visible phenocrysts 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: thin veins filled with non-carbonate, secondary minerals, slight chloritisation on plag 9. Encrustations: 1-4mm Mn crust 10. Comment: dense, volcanic rock with veins, filled with secondary minerals, some spots more white --> more plag	1	1	2-3		N3		
SO225-ROV-4-13	Sampling Depth: 3593m Coordinates: lat 6°03,86'S, long 164°41,14'W 1. Rock Type: volcanic rock, slightly altered 2. Size: 30x15x12.5cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: fine grained groundmass with phenocrysts 6. Phenocrysts: phenocrysts (plag, pyroxene) ~3-5%, size 1-3mm 7. Matrix: fine grained, grey matrix with phenocrysts, microcrystalline, slight chloritisation in matrix 8. Secondary Minerals: less than 1% Fe-oxides replacing olivine? 9. Encrustations: Mn crust (<1mm) 10. Comment: good rock, good for geochemistry and dating (rare plag-clinopyroxene phyric basalt)!	1	2	2	plag (up to 1mm); cpx (up to 3mm)	L2		

<table>
<tr><th>SAMPLE #</th><th>SAMPLE DESCRIPTION</th><th>TS</th><th>CHEM</th><th>Ar/Ar Grade</th><th>GL/MIN</th><th>ROV Box No</th><th>NOTES</th><th>PICTURE</th></tr>
<tr><td>SO225-ROV-4-14</td><td>Sampling Depth: 3533m
Coordinates: lat 6°03,80'S, long 164°41,12'W
1. Rock Type: metamorphic rock (greenschist)
2. Size: 29x14x7cm
3. Shape / Angularity: angular shape
4. Color of cut surface: grey to green
5. Texture / Vesicularity: strong foliation (schist)
6. Phenocrysts: 1-2mm phenocrysts (brown), magnetite? ~5%
7. Matrix: fine grained, greenish matrix with 1-2mm clasts (matrix is foliated)
8. Secondary Minerals: difficult to estimate secondary minerals due to strong metamorphism
9. Encrustations: 1-2cm Mn crust
10. Comment: metamorphic rock with foliation (greenschist)</td><td>2 (1perpendicular to foliation)</td><td></td><td></td><td></td><td>C2</td><td></td><td></td></tr>
<tr><td>SO225-ROV-4-15</td><td>Sampling Depth: 3522m
Coordinates: lat 6°03,78'S, long 164°41,13'W
1. Rock Type: dense, volcanic rock (intrusive?), altered (cracks and veins)
2. Size: 31x26x12cm
3. Shape / Angularity: angular shape
4. Color of cut surface: green-grey color on broken surface
5. Texture / Vesicularity: no vesicles, fine grained matrix with phenocrysts
6. Phenocrysts: 1-3mm, dark phenocrysts (pyroxene?)--> max. 5%
7. Matrix: fine grained, green-grey matrix (microcrystalline) with dark phenocrysts
8. Secondary Minerals: small Fe-oxide grains (~1mm)
9. Encrustations: 1-2mm Mn crust
10. Comment: dense (intrusive?) rock with slight metamorphic overprint with big pyroxene? phenocrysts</td><td>2</td><td>3</td><td>2-3</td><td></td><td>K2</td><td></td><td></td></tr>
<tr><td>SO225-ROV-4-16</td><td>Sampling Depth: 3401m
Coordinates: lat 6°04,48'S, long 164°42,59'W
1. Rock Type: volcanic rock, altered
2. Size: 13x13x10cm
3. Shape / Angularity: circular, partly angular shape
4. Color of cut surface: grey color on broken surface
5. Texture / Vesicularity: dense matrix with cracks (no vesicles)
6. Phenocrysts: no visible phenocrysts
7. Matrix: fine grained, grey matrix with a reaction rim between the rock and the Mn crust
8. Secondary Minerals: cracks filled with calcite? and Fe-oxides
9. Encrustations: 1-4cm Mn crust
10. Comment: dense, volcanic rock with a fine grained matrix, metamorphically overprinted + very thick, dense Mn crust (clast transported from far away?, thick Mn crust--> very long residence time on the sediment!)</td><td>1</td><td>2</td><td>2-3</td><td></td><td>B3</td><td></td><td></td></tr>
<tr><td>SO225-ROV-4-17</td><td>Sampling Depth: 3306m
Coordinates: lat 6°03,61'S, long 164°41,11'W
1. Rock Type: volcanic, altered
2. Size: 17x14x8cm
3. Shape / Angularity: circular, partly angular shape (Mn crust), rock has very angular shape!
4. Color of cut surface: grey-brown color on broken surface
5. Texture / Vesicularity: dense matrix with cracks and veins (microcrystalline)
6. Phenocrysts: no visible phenocrysts
7. Matrix: fine grained, grey matrix (microcrystalline)
8. Secondary Minerals: <1mm brown dots (Fe-oxide?)
9. Encrustations: 1-4cm Mn crust
10. Comment: dense, volcanic rock with metamorphic overprint, clast covered with thick Mn crust (transported from somewhere else and covered by Mn crust for a long time!)</td><td>1</td><td>2</td><td>2-3</td><td></td><td>X1</td><td></td><td></td></tr>
</table>

SO225-023DR05
Description of Location and Structure: Flank of NE-striking basin; Eastern part close to SO193-DR54; lower slope
Dredge on bottom UTC 16/12/12 07:53hrs, lat 6°40.42'S, long 162°44.89'W, depth 5590m
Dredge off bottom UTC 16/12/12 09:31hrs, lat 6°40.85'S, long 162°44.57'W, depth 5118m
total volume: 1/5 full
Comments: Several medium sized bites (6-7tons); 1 large bite (8.8t); Mn-encrusted pebbles; solidified sediment

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-5-1	1. Rock Type: volcanic? rock, very altered 2. Size: 7x5x3cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: grey-brown 5. Texture / Vesicularity: fine grained, no vesicles 6. Phenocrysts: no phenocrysts 7. Matrix: fine grained, grey matrix (brown near alteration cracks/veins) 8. Secondary Minerals: Fe-oxides in veins/cracks 9. Encrustations: 0.5-1cm Mn crust 10. Comment: dense, volcanic rock?, strongly altered with cracks and veins (rounded clast covered by Mn crust)	1	1+ small pieces	4-5			
SO225-DR-5-2	1. Rock Type: sediment with magmatic veins? 2. Size: 16x11x8cm 3. Shape / Angularity: rounded, partly angular shape 4. Color of cut surface: brown (sediment), black (veins) on broken surface 5. Texture / Vesicularity: fine-grained sediment, zoned veins 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix (sediment) 8. Secondary Minerals: reddish and green minerals in veins (~1mm size) 9. Encrustations: 0.1-1cm Mn crust 10. Comment: angular clast, sediment (claystone) with magmatic veins?	4					
SO225-DR-5-3	1. Rock Type: volcanic rock?, altered (veins) 2. Size: 5x5x3cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: grey-brownish color on broken surface 5. Texture / Vesicularity: fine grained, no vesicles 6. Phenocrysts: <1mm black needles (pyroxene?) 7. Matrix: brown, fine grained matrix with ~10% white grains 8. Secondary Minerals: Fe-oxides in alteration veins 9. Encrustations: 0.1-1cm Mn crust 10. Comment: rounded clast (volcanic, altered), covered by Mn crust	1	1				
SO225-DR-5-4	1. Rock Type: sediment (claystone) 2. Size: 5x9x8cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: grey-brown 5. Texture / Vesicularity: fine grained 6. Phenocrysts: - 7. Matrix: fine grained matrix with alteration veins 8. Secondary Minerals: - 9. Encrustations: 1-2mm Mn crust 10. Comment: claystone clast covered by Mn	1					
SO225-DR-5-5	1. Rock Type: sediment (claystone) 2. Size: 5.5x3x7cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: grey brown 5. Texture / Vesicularity: grey brown, fine grained 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: 1-5mm Mn crust 10. Comment: sediment clast (claystone) covered by Mn	1					

Appendix II (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-5-6	1. Rock Type: sediment (claystone) 2. Size: 8x8x4cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: brown on broken surface 5. Texture / Vesicularity: fine grained, brown matrix with black alteration veins 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: <1-5mm Mn crust 10. Comment: sediment clast (claystone) covered by slight Mn crust	2					
SO225-DR-5-7	1. Rock Type: sediment 2. Size: 5x4x3cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: greenish-white-brown color on broken surface 5. Texture / Vesicularity: fine grained green-white-brownish color with brownish cracks, with green <1mm rounded grains 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: 1-5mm Mn crust 10. Comment: sediment clast with green veins, covered by Mn	1					
SO225-DR-5-8	1. Rock Type: volcanic/metamorphic? rock 2. Size: 6x7x4cm 3. Shape / Angularity: rounded, partly angular shape 4. Color of cut surface: grey-green-brownish 5. Texture / Vesicularity: fine- to mid-grained matrix, possible ~1mm vesicles filled with minerals 6. Phenocrysts: - 7. Matrix: fine- to mid-grained, brown, partly green matrix 8. Secondary Minerals: Fe-oxides? 9. Encrustations: <1-10mm Mn crust 10. Comment: magmatic/metamorphic? clast covered by Mn crust						
SO225-DR-5-9Mn	1. Rock Type: Mn crust 2. Size: 20x10x7cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: black color 5. Texture / Vesicularity: Mn layers (different layers--> massive to coarse grained), with sediment clasts (1-2mm); changing layers (sediment/Mn) 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: Mn layers 1-3cm thick 10. Comment: massive Mn layers with sediment (sample stored in Mn box!)						
SO225-DR-5-10X	1. Rock Type: massive, fine grained sediment clast (with internal layers) 2. Size: 20x13x11cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-5-11X	1. Rock Type: 2 pieces of Mn encrusted sediment clasts (brown), Mn crust partly massive (sediment clasts up to 8x4cm size, not rounded) 2. Size: 1. piece: 16x12x10cm, 2. piece: 15x12x9cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-
024DR06
Description of Location and Structure: Continuation of DR-05. Middle section; NW facing slope at eastern end of the northern High-Plateau margin
Dredge on bottom UTC 16/12/12 14:18hrs, lat 6°40.75'S, long 162°44.67'W, depth 5213m
Dredge off bottom UTC 16/12/12 15:48hrs, lat 6°41.17'S, long 162°44.31'W, depth 4647m
total volume: two rocks
Comments: a few 5-7tons bites in first third of the track; sediments

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-6-1	1. Rock Type: sediment 2. Size: 20x9x4cm 3. Shape / Angularity: angular, partly rounded shape 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: fine grained, layered clay (brown color) 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: 0.1-1cm Mn crust 10. Comment: claystone clast with clay layers with different sizes	1					
SO225-DR-6-2	1. Rock Type: sediment 2. Size: 9x11x6cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: fine grained, layered clay (brown color) 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: 1-3mm Mn crust 10. Comment: claystone with clay layers with different clay sizes	2					

SO225-
025DR07
Description of Location and Structure: Small E-W-trending ridge-like structure in the E-W-Basin off its central southern flank
Dredge on bottom UTC 16/12/12 22:40hrs, lat 6°43.92'S, long 163°12.21'W, depth 5562m
Dredge off bottom UTC 17/12/12 00:05hrs, lat 6°44.23'S, long 163°11.92'W, depth 5120m
total volume: few rocks
Comments: Dredge stopped at 5168m rope length (>9tons); 1 fragment of relatively fresh aphyric basalt. Pillow lava; 5 pieces of more altered rare Ol.-phyric pillow lavas (size up to 30cm); At least 2 samples look promising for

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-7-1	1. Rock Type: volcanic rock, moderately to slightly altered 2. Size: 21x15x14cm 3. Shape / Angularity: angular black with rounded surface suggesting pillow rim 4. Color of cut surface: dark grey, sometimes greenish yellow in altered parts 5. Texture / Vesicularity: fine grained texture, no vesicles 6. Phenocrysts: no clear phenocrysts, but some plag xls are up to 1mm along long side 7. Matrix: matrix well crystallized, intersertal with fresh plag! 8. Secondary Minerals: rare Mn spots in g.m., alteration from the outer surface and along fractures, the inner parts are mostly fresh 9. Encrustations: Mn crusts up to 1.5cm 10. Comment: good for chemistry and Ar-Ar dating, the rock is likely relatively evolved basalt, pillow lava	2	1	2	plag		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-7-2	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 32x17x10cm 3. Shape / Angularity: angular block 4. Color of cut surface: brown to reddish or yellowish (dry) 5. Texture / Vesicularity: medium grained, recrystallized, no vesicles 6. Phenocrysts: 2-3% altered olivine up to 2mm; plag well preserved, up to 1mm long 7. Matrix: matrix medium to coarse grained, relatively well crystallized intersertal, the matrix alteration is homogeneous (picking fresh parts is impossible, but separation of plag possible) 8. Secondary Minerals: Fe-hydroxide after olivine and a lot in matrix 9. Encrustations: Mn crust up to 1.5cm thick 10. Comment: the rock is likely fragment of inner part of pillow, plag is likely good for Ar-Ar. Thin section inspection is required. Geochemically should be primitive basalt (different from sample 1)!	1	2	2-3	plag		
SO225-DR-7-3	1. Rock Type: volcanic rock, strongly altered 2. Size: 24x17x13cm 3. Shape / Angularity: angular, with rounded pillow surface 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: the rock is overall similar to sample 2, but has more finely crystallized outer parts adjacent to pillow surface and less olivine. Like sample 2 this rock is relatively primitive basalt with olivine. Pillow lava, plag must be fresh in inner parts. The alteration grade is stronger, compared to sample 2	4					
SO225-DR-7-4	1. Rock Type: volcanic rock, strongly altered 2. Size:11x9x7cm 3. Shape / Angularity: angular to subrounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: the rock represents outer part of pillow incl. former glass rims, nearly aphiric, amount of olivine <<1%, strongly altered and has no visible xls, suitable for Ar-Ar	2					
SO225-DR-7-5	1. Rock Type: volcanic rock, strongly altered 2. Size: 10x7x6cm 3. Shape / Angularity: subrounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: analogous to sample 2,3 with some more olivine (up to 5%). Not good for chemistry but may be considered for plag separation from matrix. The alteration grade is stronger compared to sample 2	2					

SO225-026DR08
Description of Location and Structure: Southern flank of NE-W-Basin; lower slope close to SO193-DR52

Dredge on bottom UTC 17/12/12 05:44hrs, lat 6°45.71'S, long 163°25.78'W, depth 5396m
Dredge off bottom UTC 17/12/12 06:55hrs, lat 6°45.99'S, long 163°25.42'W, depth 5143m
total volume: 1 piece (large)
Comments: First looked like Mn encrusted clasts, later due to homogeneity and angularity of clasts interpreted as lava top or pillow breccia

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-8-1	1. Rock Type: dense, volcanic rock, altered (Mn veins) 2. Size: 16x15x12cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: fine grained matrix, no vesicles 6. Phenocrysts: ~10% white plag? phenocrysts (~1-3mm) 7. Matrix: brown, fine grained matrix (porphyric) with plag? phenocrysts 8. Secondary Minerals: Mn veins, brown Fe-oxides 9. Encrustations: 1-3mm Mn crust 10. Comment: dense, volcanic (porphyric) rock with white plag? phenocrysts and Mn veins indicating alteration	2	2; min. sep.	4-5			
SO225-DR-8-2	1. Rock Type: volcanic rock, altered (Mn veins) 2. Size: 10x11x8cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown-grey color 5. Texture / Vesicularity: porphyric texture, no vesicles 6. Phenocrysts: ~1-2mm plag? phenocrysts --> partly intergrowth of white grains with green pyroxene? phenocrysts, fresh olivines? (~1mm)! 7. Matrix: fresh matrix: grey, altered areas: brown 8. Secondary Minerals: Mn veins, red brown Fe-oxides 9. Encrustations: 1-10mm Mn crust 10. Comment: dense, porphyric rock with plag?, pyroxene and olivine? phenocrysts (altered rock)	1	2; min. sep.	4-5	olivine? (fresh)		
SO225-DR-8-3	1. Rock Type: volcanic, altered 2. Size: 10x8x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown-grey color 5. Texture / Vesicularity: see sample 2 6. Phenocrysts: see sample 1, ~1mm titanite? grains (<1%) 7. Matrix: see sample 2 8. Secondary Minerals: red-brown Fe-oxides 9. Encrustations: 1-2mm Mn crust 10. Comment: see sample 1, 2	1	3; min. sep.	4-5			
SO225-DR-8-4	1. Rock Type: volcanic, altered 2. Size: 8x8x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown-grey 5. Texture / Vesicularity: no vesicles, porphyric 6. Phenocrysts: ~1-2mm plag? phenocrysts 7. Matrix: fine grained, brown-grey 8. Secondary Minerals: brown Fe-oxides, Mn veins 9. Encrustations: ~1mm Mn crust 10. Comment: see sample 1, 2	1	2; min. sep.?	4-5			
SO225-DR-8-5	1. Rock Type: volcanic, altered 2. Size: 10x4x8cm 3. Shape / Angularity: rounded/angular shape 4. Color of cut surface: brown-grey 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: 1-2mm plag phenocrysts, ~1mm titanite? grains 7. Matrix: fine grained, brown-grey 8. Secondary Minerals: black Mn veins, brown Fe-oxides 9. Encrustations: ~1mm Mn crust 10. Comment: see sample 1, 2	1	2	4-5			

Appendix II (Rock Description)

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-8-6	1. Rock Type: volcanic, altered 2. Size: 8x5x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown-grey 5. Texture / Vesicularity: no vesicles, porphyric 6. Phenocrysts: 1-2mm plag? phenocrysts 7. Matrix: fine grained, brown-grey 8. Secondary Minerals: black Mn veins 9. Encrustations: ~1mm Mn crust 10. Comment: see sample 1, 2	1	2; min. sep.?	4-5			
SO225-DR-8-7	1. Rock Type: volcanic, altered 2. Size: 10x7x6cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey-brown 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: 1-2mm plag? phenocrysts 7. Matrix: fine grained, grey-brown 8. Secondary Minerals: black Mn veins 9. Encrustations: 1-5mm Mn crust 10. Comment: see sample 1, 2	1	2	4-5			
SO225-DR-8-8	1. Rock Type: volcanic, altered 2. Size: 15x12x5cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: 1-2mm plag? phenocrysts 7. Matrix: fine grained, brown-grey 8. Secondary Minerals: black Mn veins 9. Encrustations: 1-2mm Mn crust 10. Comment: see sample 1, 2	1	2	4-5			
SO225-DR-8-9	1. Rock Type: volcanic, altered 2. Size: 15x11x10cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown-grey 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: 1-2mm plag phenocrysts 7. Matrix: fine grained, brown-grey 8. Secondary Minerals: black Mn veins 9. Encrustations: 0.1-2cm Mn crust 10. Comment: see sample 1, 2	1	2; min. sep.: plag!	4-5			
SO225-DR-8-10	1. Rock Type: volcanic, strongly altered 2. Size: 14x10x8cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey brown 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: 1-2mm plag phenocrysts, ~1mm olivine grains? 7. Matrix: fine grained, brown 8. Secondary Minerals: black Mn veins (0.1-1cm thickness) 9. Encrustations: 1-3mm Mn crust 10. Comment: see sample 1, 2	2	3; min. sep.: ol?				
SO225-DR-8-11	1. Rock Type: volcanic, altered 2. Size: 14x10x8cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey-brown 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: 1-2mm plag phenocrysts, ~1mm olivine grains? 7. Matrix: fine grained, brown 8. Secondary Minerals: black Mn veins 9. Encrustations: 1-2mm Mn crust 10. Comment: see sample 1, 2	1	2; min. sep.: ol?				

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-8-12x	1. Rock Type: basalt piece (altered) from lava debris?, (grey brown) with 1-2mm Mn crust 2. Size: 13x5x6cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-8-13x	1. Rock Type: basalt piece (altered) see sample 12x, with Mn veins, 1-5mm Mn crust, grey brown 2. Size: 12x10x9cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-8-14x	1. Rock Type: basalt piece (altered) see sample 12x, with Mn veins, 1-15mm Mn crust, grey brown 2. Size: 11x17x10cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-8-15x	1. Rock Type: basalt piece (altered) see sample 12x, with Mn veins, ~1mm Mn crust, brown color 2. Size: 13x8x4cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-8-16x	1. Rock Type: basalt piece (altered) see sample 12x, with Mn veins, 1-2cm Mn crust, brown color 2. Size: 20x13x12cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-
027DR09
Description of Location and Structure: Northernmost Danger Island Trough; N-S striking ridge in the center of the basin; W-facing slope from bottom to top
Dredge on bottom UTC 17/12/12 14:00hrs, lat 6°54.86'S, long 163°50.47'W, depth 5801m
Dredge off bottom UTC 17/12/12 15:37hrs, lat 6°54.64'S, long 163°49.98'W, depth 5142m
total volume: 1/6 full
Comments: several mid-sized bites 5-7 tons; 2 larger bites 8-9 tons; 1 hung up; solidified sediment; light brown

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-9-1	1. Rock Type: volcanic, altered 2. Size: 17x11x13cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: dense, microcrystalline, no vesicles 6. Phenocrysts: ~1mm black pyroxene? phenocrysts 7. Matrix: brown, fine grained brown matrix 8. Secondary Minerals: Mn crust 9. Encrustations: ~1mm Mn crust (between clasts ~1cm) 10. Comment: 3 volcanic clasts covered by Mn	1		4-5			
SO225-DR-9-2x	1. Rock Type: brown colored claystone with rounded shape 2. Size: 12x9x7cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-9-3x	1. Rock Type: brown colored claystone with rounded shape 2. Size: 16x8x5cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-
028DR010
Description of Location and Structure: Central Danger Island Trough; Small N-S trending tectonic (?) ridge in the S-W part of the northern central basin; E-facing slope ±from bottom to top
Dredge on bottom UTC 18/12/12 06:03hrs, lat 8°35.52'S, long 163°59.78'W, depth 4676m
Dredge off bottom UTC 18/12/12 07:39hrs, lat 8°34.974'S, long 163°59.81'W, depth 4309m
total volume: empty!
Comments: -

SO225-
029DR011
Description of Location and Structure: Central Danger Island Trough; Southern end of central DIT. W-facing slope of small NW-SE trending ridge

Dredge on bottom UTC 18/12/12 12:01hrs, lat 8°39.16'S, long 163°55.48'W, depth 4544m
Dredge off bottom UTC 18/12/12 13:23hrs, lat 8°39.19'S, long 163°55.99'W, depth 4115m
total volume: 1/5 full
Comments: red sediment. Possibly 1x basalt fragment

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-11-1	1. Rock Type: foliated sediment 2. Size: 10x10x4cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown color 5. Texture / Vesicularity: fine-grained clay 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: ~1mm Mn crust 10. Comment: foliated claystone with Mn crust	2					
SO225-DR-11-2x	1. Rock Type: brown, rounded claystone clast with ~1mm Mn crust 2. Size: 10x7x6cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-11-3x	1. Rock Type: brown, rounded claystone clast with ~1mm Mn crust 2. Size: 15x5x9cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-11-4x	1. Rock Type: brown, rounded claystone clast, partly covered by Mn crust (~1mm) 2. Size: 19x10x8cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-030DR012
Description of Location and Structure: Central Danger Islands Trough; Profile below SO193-DR26; NW-SE striking scarp along eastern wall of DIT
Dredge on bottom UTC 19/12/12 21:47hrs, lat 9°22.99'S, long 164°16.55'W, depth 4440m
Dredge off bottom UTC 19/12/12 23:17hrs, lat 9°22.73'S, long 164°16.07'W, depth 4004m
total volume: 1/3
Comments: 1 very large fragment of volcanic breccia and ~15 smaller, angular to rounded volcanic rocks and one wehrlite; Two samples of hyaloclastite with fresh glass

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-12-1	1. Rock Type: volcanic rock, moderately to slightly altered 2. Size: 13x14x8cm 3. Shape / Angularity: angular with slightly rounded rims 4. Color of cut surface: light grey with yellowish parts 5. Texture / Vesicularity: massive with rare elongated voids 6. Phenocrysts: no obvious phenocrysts 7. Matrix: fine crystallized texture, aphanitic or intersertal 8. Secondary Minerals: some oxidation along veins, very little otherwise 9. Encrustations: very thin (<1mm) Mn crust, some Mn in voids 10. Comment: good for chemistry! Dating should be possible on g.m. fragments	2	2	2	-		
SO225-DR-12-2	1. Rock Type: volcanic glass fragment in palagonite (pillow rim?) 2. Size: 12x13x5cm 3. Shape / Angularity: subrounded 4. Color of cut surface: fresh, angular, black glass fragments in greenish-yellow palagonite 5. Texture / Vesicularity: - 6. Phenocrysts: no obvious phenocrysts 7. Matrix: - 8. Secondary Minerals: rare voids in glass filled with zeolite, palagonite, some white veins in palagonite 9. Encrustations: - 10. Comment: excellent glass for all analyses!	1			several small pieces for glass picking		
SO225-DR-12-3	1. Rock Type: hyaloclastite (palagonite) covered by Mn crust 2. Size: 21x18x15cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: similar to sample 2 but consists of numerous glass fragments up to 4cm in diameter, placed in dark olive green palagonite matrix 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: like sample 2 it is excellent sample for EMP (major elements), LAICMPS (trace elements), dating and isotopes. Several separate fragments must be microprobed to check for homogeneity!	1			several small pieces for glass picking		
SO225-DR-12-4	1. Rock Type: volcanic rock, moderately altered 2. Size: 6x6x4cm 3. Shape / Angularity: subrounded fragment 4. Color of cut surface: dark grey 5. Texture / Vesicularity: massive with ~5% large (up to 5mm) voids 6. Phenocrysts: no obvious phenocrysts 7. Matrix: intersertal medium grained texture with likely fresh plag, pyroxene 8. Secondary Minerals: alteration appears medium, voids are filled with Mn coatings + Fe-oxides 9. Encrustations: very thin outer Mn crust 10. Comment: rel. fresh basalt, may be ~good for chemistry and Ar-Ar dating but voids should be carefully avoided	1	2	~3	plag in fine fraction		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-12-5	1. Rock Type: intrusive rock, moderately to strongly altered 2. Size: 25x15x8cm 3. Shape / Angularity: rounded 4. Color of cut surface: reddish brown spotly with grey color 5. Texture / Vesicularity: coarse grained 6. Phenocrysts: ~60% olivine replaced with Fe-oxides, ~20% cpx, bottle green, ~20% plag?-amorphous, filling space between idiomorphous olivine and cpx 7. Matrix: no voids 8. Secondary Minerals: - 9. Encrustations: ~5mm Mn crust 10. Comment: the rock is werlite, cpx well preserved and should be enough for isotopes. Plag is likely altered. Thin section must be inspected	3	1		cpx sep.?		
SO225-DR-12-6	1. Rock Type: volcanic rock, moderately altered 2. Size: 15x13x10cm 3. Shape / Angularity: subangular with Mn coating 4. Color of cut surface: greenish grey with red spots 5. Texture / Vesicularity: vesicular texture with many small voids 6. Phenocrysts: Ol phenocrysts up to 2mm replaced with Fe-oxides. May include Sp xls. 7. Matrix: ground mass aphanitic with small plag, which appears to be fresh 8. Secondary Minerals: - 9. Encrustations: Mn encrustation <1mm thick 10. Comment: the rock is not bad for chemistry, but voids with sec. minerals should be avoided	1	1	3-	small plag sep.?		
SO225-DR-12-7	1. Rock Type: volcanic rock, moderately altered 2. Size: 18x8x6cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey with yellow spots 5. Texture / Vesicularity: moderately vesicular 6. Phenocrysts: no obvious phenocrysts 7. Matrix: ground mass medium grained, intersertal plag appears fresh 8. Secondary Minerals: voids are filled with Mn and yellow stuff 9. Encrustations: very thin Mn film on surface 10. Comment: basalt petrographically similar to sample 4 but more coarsely crystallized. Generally not bad for chemistry if voids are avoided. Plag can be separated for Ar-Ar	2	1	2-	plag		
SO225-DR-12-8	1. Rock Type: volcanic rock, moderately altered 2. Size: 14x11x7cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey with yellow spots 5. Texture / Vesicularity: massive 6. Phenocrysts: no obvious phenocrysts 7. Matrix: ground mass mid to coarsely grained. Intersertal with fresh plag and cpx 8. Secondary Minerals: some alteration marks it spotty in appearance 9. Encrustations: very thin Mn crust 10. Comment: the rock is likely andesite. Good for chemistry and probably for Ar-Ar-dating	1	1	2+	plag		
SO225-DR-12-9	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 14x7x7cm 3. Shape / Angularity: subrounded 4. Color of cut surface: reddish grey 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: the rock is overall similar to sample 8 but more oxidized (altered?)	1	1	?	plag?		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-12-10	1. Rock Type: volcanic rock, breccia, strongly altered 2. Size: 56x32x26cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: fragments are homogeneous. All composed yellowish grey, finely crystallized rock with numerous voids (~50%) up to 2mm filled with calcite 6. Phenocrysts: - 7. Matrix: ground mass finely crystallized 8. Secondary Minerals: rock cemented with calcite veins 9. Encrustations: thin Mn crust is on surface 10. Comment: lots of voids make the rock difficult for chemistry. Perhaps calcite can be leached out from crusted rock	1	1	?			
SO225-DR-12-10x	1. Rock Type: a large piece (~1/2) of the block (sample 10) taken as archive sample 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-12-11	1. Rock Type: volcanic rock, strongly altered 2. Size: 15x8x8cm 3. Shape / Angularity: rounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 8 but more altered	3					
SO225-DR-12-12	1. Rock Type: volcanic rock, moderately altered 2. Size: 13x6x4.5cm 3. Shape / Angularity: - 4. Color of cut surface: grey, slightly yellowish with dark spots 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: the rock is similar to sample 1 but has vesicles filled with Mn oxides that makes it difficult for chemistry	1					
SO225-DR-12-13	1. Rock Type: volcanic rock, moderately altered 2. Size: 12x10x3cm 3. Shape / Angularity: subangular 4. Color of cut surface: - 5. Texture / Vesicularity: the rock has mid to coarse grained texture and numerous voids (~40%) filled with Mn oxides 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: the rock looks similar to sample 8 and 9. But many voids make it difficult for chemistry	1					
SO225-DR-12-14	1. Rock Type: volcanic rock, strongly altered 2. Size: 13x6x7cm 3. Shape / Angularity: rounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 6, Ol-basalt with few olivine xls replaced by Fe-oxides, not good for chemistry				sp?		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-12-15	1. Rock Type: volcanic rock, strongly altered 2. Size: 12x7x6cm 3. Shape / Angularity: subrounded 4. Color of cut surface: brown with red spots 5. Texture / Vesicularity: similar to sample 14, more vesicles 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: not very good	1			sp?		
SO225-DR-12-16	1. Rock Type: volcanic rock, strongly altered 2. Size: 9x8x8cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 6, 14, 15, Ol-basalt (~10% Ol), strongly altered	1			sp?		
SO225-DR-12-17	1. Rock Type: palagonite 2. Size: 14x10x7cm 3. Shape / Angularity: rounded 4. Color of cut surface: olive green with brownish bands parallel to each other 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: this rock is former hyaloclastite formed by glass fragments up to 2-3mm. The glasses have olivine xls (up to 1.5mm) inside (~20%) and have typical shape of glass shards. It could be tuff, totally altered. The rock looks useless, although it can be crushed and spinel separated.	2			sp?		

SO225-031DR013
Description of Location and Structure: Southern Danger Islands Troughs; Profile close to SO193-DR26; central part of the slope up to lowermost terrace
Dredge on bottom UTC 19/12/12 02:30hrs, lat 9°23.03'S, long 164°15.98'W, depth 4068m
Dredge off bottom UTC 19/12/12 03:33hrs, lat 9°22.93'S, long 164°15.60'W, depth 3655m
total volume: -
Comments: -

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-13-1	1. Rock Type: volcanic rock, altered 2. Size: 13x8x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcrystalline texture, vesicles ≤1mm (~10%) partly filled 6. Phenocrysts: ~15% olivine phenocrysts, strongly altered (1-3mm) 7. Matrix: fine grained, grey matrix with altered olivine phenocrysts 8. Secondary Minerals: brown Fe-oxides, alteration products of olivine 9. Encrustations: ~1mm Mn crust 10. Comment: dense, volcanic rock, strongly altered with altered olivine phenocrysts (Ol-basalt)	1	2	3-4	maybe fresh glass?		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-13-2	1. Rock Type: volcanic rock, altered 2. Size: 8.5x8.5x6cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcrystalline matrix, ≤1mm vesicles, partly filled with secondary minerals 6. Phenocrysts: ~20% iddingsit. olivine phenocrysts (1-6mm), brown 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: iddingsit. olivine, calcite? in vesicles 9. Encrustations: 1-2mm Mn crust 10. Comment: see sample 1	1	2	3-4			
SO225-DR-13-3	1. Rock Type: volcanic rock, altered 2. Size: 12x9x9cm 3. Shape / Angularity: angular, partly rounded shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcrystalline texture, vesicles (~5%) partly filled with secondary minerals 6. Phenocrysts: ~20% olivine phenocrysts, iddingsit. (1-3mm) 7. Matrix: fine grained, grey matrix with iddingsit. olivines 8. Secondary Minerals: iddingsit. olivine 9. Encrustations: - 10. Comment: see sample 1	2	2	3-4			
SO225-DR-13-4	1. Rock Type: volcanic rock, altered 2. Size: 34x23x14cm 3. Shape / Angularity: angular shape, partly rounded 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, vesicles ~10% partly filled 6. Phenocrysts: 1-3mm iddingsit. olivine phenocrysts (~5%) 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: iddingsit. olivine 9. Encrustations: ~1-3mm Mn crust 10. Comment: see sample 1	1	2	3-4			
SO225-DR-13-5	1. Rock Type: volcanic rock, altered 2. Size: 36x18x16cm 3. Shape / Angularity: rounded, partly angular shape 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. texture, ~5% vesicles filled with second. minerals 6. Phenocrysts: 1-3mm iddingsit. olivine phenocrysts 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: iddingsit. olivine (brownish) 9. Encrustations: 1-10mm Mn crust 10. Comment: dense, volcanic rock (Ol-basalt), strongly altered (iddingsit. olivines) and filled vesicles	2	2	4			
SO225-DR-13-6Mn	1. Rock Type: part of sample 5, covered by thick Mn crust 2. Size: 36x18x16cm 3. Shape / Angularity: rounded 4. Color of cut surface: black, massive Mn crust 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: Mn crust 1-4cm thick 10. Comment: part of sample 5 covered by massive Mn crust (Mn sample), sample in Mn box!						

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-13-7	1. Rock Type: volcanic, altered 2. Size: 10x6x9cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: fine grained texture, vesicles ~5% filled with white calcite? and green minerals 6. Phenocrysts: 1-2mm iddingsit. olivine phenocrysts 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: white calcite? and green minerals filling vesicles 9. Encrustations: 1-20mm Mn crust 10. Comment: dense, volcanic rock (Ol-basalt) with filled vesicles and altered olivine phenocrysts	1	3	4			
SO225-DR-13-8	1. Rock Type: volcanic, altered 2. Size: 36x18x27cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: fine grained texture, vesicles ~5% filled with calcite? 6. Phenocrysts: 1-2mm iddingsit. olivine phenocrysts (brownish) 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: calcite? in filled vesicles, iddingsit. olivines 9. Encrustations: 1-3cm Mn crust with palagonite (green) 10. Comment: dense, volcanic rock (Ol-basalt) --> Pillow lava fragment with chilled margins, possible fresh glass!	2	3	4	possible fresh glass in green palagonite		
SO225-DR-13-8a	1. Rock Type: greenish palagonite between hard rock (sample 8) and the Mn crust 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: possible fresh glass fragments inside!						
SO225-DR-13-9	1. Rock Type: volcanic, altered (pillow debris?) 2. Size: 39x27x16cm 3. Shape / Angularity: angular 4. Color of cut surface: brown color (basalt clasts) 5. Texture / Vesicularity: dense, microcryst. texture, vesicles <5% filled with calcite? 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: palagonite 9. Encrustations: Mn crust 0.5-4cm thick 10. Comment: Mn encrusted pillow lava fragment with palagonite between basalt and the Mn crust			4-5	possible fresh glass in green palagonite		
SO225-DR-13-9a	1. Rock Type: greenish palagonite fragment from pillow lava (sample 9) 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: possible fragments of fresh glass inside!						

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-13-10	1. Rock Type: volcanic, altered (volcaniclastic hyaloclastite) 2. Size: 10x9x7cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: greenish/brown-red color 5. Texture / Vesicularity: greenish coarse grained matrix with red-brownish clasts (0.5-1cm) 6. Phenocrysts: - 7. Matrix: greenish, coarse grained matrix 8. Secondary Minerals: - 9. Encrustations: no Mn crust 10. Comment: green brown hyaloclastite with 0.5-1cm clasts	1					
SO225-DR-13-11	1. Rock Type: volcanic rock, altered 2. Size: 39x39x20cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown color on broken surface, partly grey 5. Texture / Vesicularity: dense, microcryst. texture, vesicles ~10% filled with white calcite? 6. Phenocrysts: 1-3mm olivine phenocrysts (iddingsit.) 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: iddingsit. olivine (brown), brown Fe-oxides, palagonite between basalt and Mn crust 9. Encrustations: Mn crust on the upper surface ~4cm 10. Comment: dense, basaltic pillow lava fragment with palagonite rim and 4cm Mn crust	2	3	3-4			
SO225-DR-13-12	1. Rock Type: Mn encrusted pillow lava with thick palagonite rim 2. Size: 24x13x10cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: green/black 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: Mn encrusted, thick palagonite rim of a pillow breccia						
SO225-DR-13-13x	1. Rock Type: altered basalt clast with rounded shape, 1-2mm iddingsit. olivine phenocrysts, brown matrix, vesicles are filled with calcite? 2. Size: 11x10x6cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-13-14x	1. Rock Type: altered basalt clast with rounded, partly angular shape, brown matrix with 1-3mm iddingsit. olivine phenocrysts, vesicles are filled with calcite? 2. Size: 10x8x6cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-
032DR014
Description of Location and Structure: Southern Danger Islands Trough; Profile close to SO193-DR26 central part of the slope up to 2. (lower) terrace
Dredge on bottom UTC 19/12/12 06:33hrs, lat 9°22.47'S, long 164°16.01'W, depth 3793m
Dredge off bottom UTC 19/12/12 07:55hrs, lat 9°22.31'S, long 164°15.63'W, depth 3370m
total volume: 3/4 full
Comments: basaltic debris; brownish to reddish, oxidized, fist sized, subangular clasts

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-14-1	1. Rock Type: volcanic, altered 2. Size: 50x38x24cm 3. Shape / Angularity: angular, partly rounded shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~1% vesicles filled with second. minerals 6. Phenocrysts: ~1% iddingsit. olivine phenocrysts 1-2mm 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: calcite? in veins (alteration), iddingsit. olivine, vesicles filled with green minerals 9. Encrustations: Mn crust 2-4cm 10. Comment: volcanic rock (with metamorphic overprint) and iddingsit. olivine phenocrysts	2	3	3			
SO225-DR-14-2	1. Rock Type: volcanic rock, altered 2. Size: 16x11x12cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: grey brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~10% vesicles filled with white and green minerals 6. Phenocrysts: - 7. Matrix: fine grained, brown-grey-green matrix 8. Secondary Minerals: brown Fe-oxides, vesicles filled with Mn 9. Encrustations: ~1mm Mn crust 10. Comment: dense, volcanic rock with metamorphic overprint and filled vesicles	1	2	3			
SO225-DR-14-3	1. Rock Type: volcanic rock, altered 2. Size: 13x8x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey-brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~10-15% vesicles filled with green minerals 6. Phenocrysts: - 7. Matrix: fine grained, grey-brown matrix 8. Secondary Minerals: Fe-oxides and calcite? in cracks, iddingsit. olivines in matrix 9. Encrustations: no Mn crust 10. Comment: dense, volcanic rock with metamorphic overprint and filled vesicles	1	2	3-4			
SO225-DR-14-4	1. Rock Type: volcanic rock, altered 2. Size: 13x7x9cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: grey brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~10% vesicles filled with white-green minerals and black Mn 6. Phenocrysts: - 7. Matrix: fine grained, grey-brown matrix 8. Secondary Minerals: calcite? in veins and vesicles 9. Encrustations: ~1mm Mn crust 10. Comment: dense, volcanic rock, metamorphically overprinted (veins) and with filled vesicles	1	2	3-4			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-14-5	1. Rock Type: volcanic rock, altered 2. Size: 11x10x6cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: brown-grey color on broken surface 5. Texture / Vesicularity: microcryst. matrix, vesicles ~10-15% partly filled with black Mn or green-white minerals 6. Phenocrysts: ~5% iddingsit. olivine (brown) 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: Mn in veins, iddingsit. olivine, green-white minerals filling vesicles 9. Encrustations: ~1mm Mn crust 10. Comment: dense, volcanic rock, met. overprinted (altered) with partly filled vesicles and iddingsit. olivine phenocrysts	1	2	3-4			
SO225-DR-14-6	1. Rock Type: volcanic, altered 2. Size: 8x10x5cm 3. Shape / Angularity: rounded, partly angular shape 4. Color of cut surface: grey-brown color on broken surface 5. Texture / Vesicularity: microcryst. matrix, ~20% vesicles filled with black Mn/white-green minerals 6. Phenocrysts: - 7. Matrix: fine grained matrix (grey-brown) 8. Secondary Minerals: black Mn, white green minerals in vesicles, 1-2mm, green chlorite? grains 9. Encrustations: ~1mm Mn crust 10. Comment: dense, volcanic rock, met. overprinted (altered) with filled vesicles	1	2	4			
SO225-DR-14-7	1. Rock Type: volcanic, altered 2. Size: 13x12x9cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, vesicles ~5% partly filled with white/green minerals and black Mn 6. Phenocrysts: no phenocrysts 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: sec. minerals in vesicles (green-white) 9. Encrustations: ~1mm Mn crust 10. Comment: volcanic rock with metamorphic overprint (alteration) and partly filled vesicles	2	2	3-4			
SO225-DR-14-8	1. Rock Type: volcanic, altered 2. Size: 11x11x10cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~20% vesicles, partly filled with green white minerals or black Mn 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: green white minerals in vesicles 9. Encrustations: partly no or ~1mm Mn crust 10. Comment: volcanic rock, see sample 7	1	2	3-4			
SO225-DR-14-9	1. Rock Type: volcanic, altered 2. Size: 14x8x10cm 3. Shape / Angularity: angular 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~10-15% vesicles filled with green white minerals 6. Phenocrysts: ~5% iddingsit. olivine phenocrysts 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: sec. minerals in vesicles (green/white) 9. Encrustations: partly covered with ~1mm Mn crust 10. Comment: dense, volcanic rock with filled vesicles and iddingsit. olivine	2		5			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-14-10	1. Rock Type: volcanic, strongly altered 2. Size: 10x9x7cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: dense matrix, ~10% vesicles filled with calcite? and Mn 6. Phenocrysts: ~1-2mm iddingsit. olivine phenocrysts 7. Matrix: brown, fine grained matrix 8. Secondary Minerals: calcite? in vesicles, iddingsit. olivine 9. Encrustations: ~1mm Mn crust 10. Comment: volcanic rock with met. overprint and iddingsit. olivines	2		5-6			
SO225-DR-14-11	1. Rock Type: volcanic, altered 2. Size: 14x6x9cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: see sample 10	2		6			
SO225-DR-14-12	1. Rock Type: volcanic, altered 2. Size: 13x11x10cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown color 5. Texture / Vesicularity: microcryst. Matrix, vesicles ~10% partly filled 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: brown Fe-oxides? 9. Encrustations: partly covered by <1mm Mn crust 10. Comment: volcanic rock, strongly altered with partly filled vesicles	2		6			
SO225-DR-14-13	1. Rock Type: volcanic, strongly altered 2. Size: 13x10x10xcm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color 5. Texture / Vesicularity: microcryst. matrix, ~20% vesicles filled with Mn, grey minerals or white calcite? 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: green white minerals in vesicles 9. Encrustations: partly covered by ~1-2mm Mn crust 10. Comment: volcanic, strongly altered rock with filled vesicles	2		6			
SO225-DR-14-14	1. Rock Type: volcanic, altered 2. Size: 17x13x10cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: brown color 5. Texture / Vesicularity: fine grained matrix, ~30% vesicles filled with black Mn and white calcite?+green minerals 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: see sample 13!	2	2	5			

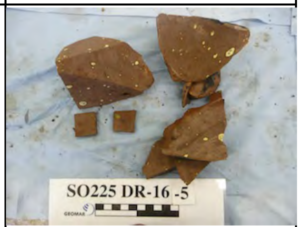
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-14-15	1. Rock Type: volcanic, strongly altered 2. Size: 16x12x13cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: brown color 5. Texture / Vesicularity: fine grained matrix, ~15% vesicles, partly filled 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: green white minerals in vesicles, relicts of brown, iddingsit. olivine 9. Encrustations: ~1-2mm Mn crust 10. Comment: dense, volcanic rock, strongly altered with partly filled vesicles	2	3	5			
SO225-DR-14-16	1. Rock Type: (volcanic), hyaloclastite? 2. Size: 11x6x9cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown color 5. Texture / Vesicularity: fine grained matrix, most of vesicles filled, ~0.5cm clasts 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: - 9. Encrustations: partly covered by ~1mm Mn crust 10. Comment: hyaloclastite?, clast with partly filled vesicles	2		6			
SO225-DR-14-17	1. Rock Type: hyaloclastite?, altered 2. Size: 10x8x7cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: see sample 16 (clasts ~2mm)	2		6			
SO225-DR-14-18	1. Rock Type: hyaloclastite?, altered 2. Size: 16x16x10cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: see sample 16 (clasts ~3mm)	2		6			
SO225-DR-14-19X	1. Rock Type: altered pillow fragment, covered by Mn crust (1-2cm thick) with typical chilled margins 2. Size: 30x20x10cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-14-20	1. Rock Type: fragments of Mn crust with green palagonite rim between the Mn crust and the basaltic rock 2. Size: fragments have size between 10-20cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: 6 fragments for glass picking, Mn crust is partly 2cm thick, partly basalt clasts in fragments, possible fresh glasses within palagonite!				possible fresh glass fragments		

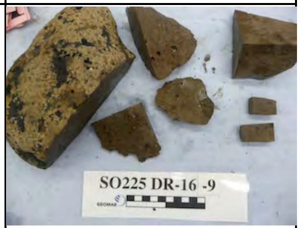
SO225-
033DR015
Description of Location and Structure: Southern Danger Islands Trough; Profile close to SO193-DR26; upper part of the slope going from terrace 2 to terrace 3
Dredge on bottom UTC 19/12/12 11:02hrs, lat 9°21.11'S, long 164°16.63'W, depth 3397m
Dredge off bottom UTC 19/12/12 12:12hrs, lat 9°20.86'S, long 164°16.35'W, depth 2947m
total volume: 2 rocks
Comments: many small bites

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-15-1	1. Rock Type: Mn encrusted palagonite fragment? 2. Size: 10x8x6cm 3. Shape / Angularity: angular 4. Color of cut surface: green-brown color 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: 1-3cm Mn crust 10. Comment: Mn encrusted palagonite fragment?	1			fresh glass?		
SO225-DR-15-2	1. Rock Type: Mn encrusted breccia? 2. Size: 11x9x6cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: green-brown to white color 5. Texture / Vesicularity: clasts ~5-15mm size 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: ~0.5cm Mn crust 10. Comment: volcanic breccia covered by Mn crust						

SO225-
034DR016
Description of Location and Structure: Southern Danger Islands Trough; Top region of SO193-DR26 structure. Steep SW-facing cliff below top
Dredge on bottom UTC 19/12/12 14:42hrs, lat 9°18.13'S, long 164°16.40'W, depth 2858m
Dredge off bottom UTC 19/12/12 16:22hrs, lat 9°17.93'S, long 164°15.90'W, depth 2172m
total volume: 1/2 full
Comments: Basalt fragments; large volcaniclastic blocks; Mostly altered Ol basalts; Some rocks are very oxidized and appear to be erupted / weathered subaerial

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-16-1	1. Rock Type: volcanic rock, moderately to slightly altered 2. Size: 8x8x7cm 3. Shape / Angularity: rounded 4. Color of cut surface: reddish brown to grey 5. Texture / Vesicularity: massive with small irregular voids 6. Phenocrysts: olivine phenocrysts <5% replaced with Fe-oxides 7. Matrix: matrix finely recrystallized 8. Secondary Minerals: some oxidation and void fillings with second. minerals 9. Encrustations: thin (<1mm) Mn crust on outer surface 10. Comment: may be good for chemistry, thin section should be inspected	1	1				
SO225-DR-16-2	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 16x10x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark reddish brown 5. Texture / Vesicularity: similar to sample 1 but has more vesicles of larger size 6. Phenocrysts: olivine ~5-7%, strongly oxidized 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: thin Mn crust on outer surface 10. Comment: strong oxidation suggests subaeral eruption. Numerous irregular vesicles suggest this, too. Chemistry may be problematic, because of second. minerals filling voids	1	1				

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-16-3	1. Rock Type: volcanic rock, moderately altered 2. Size: 35x22x22cm 3. Shape / Angularity: angular 4. Color of cut surface: reddish brown (similar to sample 2) 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 2, the sample is taken because in some parts voids are empty, free of second. minerals. These parts should be picked for chemistry. The lava appears erupted on surface like sample 1 and 2.	1	1				
SO225-DR-16-4	1. Rock Type: volcanic rock, moderately altered 2. Size: 23x20x10cm 3. Shape / Angularity: angular 4. Color of cut surface: reddish brown with black and red spots 5. Texture / Vesicularity: massive with rare vesicles 6. Phenocrysts: rare olivine (2%) often of sceleton shape 7. Matrix: ground mass finely recrystallized with likely fresh plag 8. Secondary Minerals: oxidation ist strong but some small areas of grey matrix are present 9. Encrustations: thin Mn crust <1%. Mn precipitates in ground mass 10. Comment: this is submarine basalt. Rel. good for chemistry because of rare vesicles and moderate alteration. Ar-Ar can be tried on grey, carefully selected parts.	1	1	3	plag?		
SO225-DR-16-5	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 20x11x10cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: overall similar to sample 4 but has rare large vesicles filled with olive green second. mineral, may be good for chemistry if the second. minerals and Mn precipitates are avoided	2	1				
SO225-DR-16-6	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 27x15x8cm 3. Shape / Angularity: subrounded 4. Color of cut surface: brown with black and dark red dots 5. Texture / Vesicularity: - 6. Phenocrysts: rare small olivine (<5%) 7. Matrix: matrix fine crystallized, minerals are not discernable 8. Secondary Minerals: quite a lot of vesicles, all filled with smectite 9. Encrustations: Mn crust ~1cm thick 10. Comment: difficult for chemistry but may be analysed to define trends of alteration	1	1				
SO225-DR-16-7	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 33x17x18cm 3. Shape / Angularity: angular 4. Color of cut surface: reddish to brown to violet 5. Texture / Vesicularity: vesicular basalt 6. Phenocrysts: rare olivine (<3%) 7. Matrix: similar to sample 1-3 8. Secondary Minerals: voids are filled with yellowish, soft material and palagonite, some small voids with Mn 9. Encrustations: - 10. Comment: like other samples can be difficult for chemistry because of voids. Picking is required	2	1				

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-16-8	1. Rock Type: volcanic rock, moderately altered 2. Size: 45x25x19cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish grey with large dark brown spots of vesicles 5. Texture / Vesicularity: - 6. Phenocrysts: Ol (~5-7%) up to 1mm, all replaced by Fe-oxides 7. Matrix: matrix fine cryst., aphanitic 8. Secondary Minerals: green, plag may be preserved 9. Encrustations: ~0.5cm Mn crust 10. Comment: voids should be avoided when picking. May be ~good for chemistry	1	1	4+	plag?		
SO225-DR-16-9	1. Rock Type: volcanic rock, strongly altered 2. Size: 20x20x8cm 3. Shape / Angularity: rounded 4. Color of cut surface: greyish green with red-black spots 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 8 but has more olivine (up to 10%), all altered. Chemistry is problematic!	2	1				
SO225-DR-16-10	1. Rock Type: volcanic rock, strongly altered 2. Size: 20x12x6cm 3. Shape / Angularity: subangular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 8-9 but has lot of vesicles. Ol ~15% up to 2mm, all altered. Problematic for chemistry.	2	1				
SO225-DR-16-11	1. Rock Type: volcanic rock, altered 2. Size: 22x22x8cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown with dark spots 5. Texture / Vesicularity: massive with rare vesicles 6. Phenocrysts: Ol ~1-2% (≤1mm) 7. Matrix: matrix fine to medium cryst., probably with fresh plag, large (≤1cm) vesicles 8. Secondary Minerals: - 9. Encrustations: ~2mm outer Mn crust, voids filled with Mn and oxidized palagonite 10. Comment: alteration is somewhat spotty. Should be possible to separate grey fragments fo Ar-Ar. Chemistry is somewhat problematic because of voids and Mn.	1	1	3	plag?		
SO225-DR-16-12	1. Rock Type: volcanic rock, moderately? altered 2. Size: 10x7x6cm 3. Shape / Angularity: subrounded 4. Color of cut surface: grey with yellowish/green bands 5. Texture / Vesicularity: massive 6. Phenocrysts: large Ol (up to 5mm) ~10-15%, all altered, replaced with Fe-oxides 7. Matrix: matrix fine-cryst., no clear minerals and looks somewhat fluidal 8. Secondary Minerals: - 9. Encrustations: thin Mn crust, alteration of Ol and matrix 10. Comment: the rock looks not bad for chemistry as it has no voids. Thin section should be inspected before. Possible that rock is actually badly altered. The rock is primitive Ol-basalt.	1	1				

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-16-13	1. Rock Type: volcanic rock, strongly altered 2. Size: 14x9x9cm 3. Shape / Angularity: subrounded 4. Color of cut surface: reddish brown with red spots 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 12, Ol-basalt. Appears to be more altered. Thin section should be inspected before chemistry! The rock is Ol-basalt.	1	1				
SO225-DR-16-14	1. Rock Type: volcanic rock, altered 2. Size: 22x22x12cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: breccia of basaltic fragments cemented by whitish silicate matrix. Basalts look similar to samples 7-9. Mostly aphiric, very altered basalts. No glass visible. Small fragment taken for thin section.	2					
SO225-DR-16-14Mn	1. Rock Type: 3/4 of sample 14 taken as Mn crust sample, the crust is 1-2cm thick with round surface 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-16-15	1. Rock Type: volcanic rock, very altered 2. Size: 38x27x22cm 3. Shape / Angularity: subangular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 14 with larger rock fragments. One fragment looks mid crystallized and can be tried for Ar-Ar and chemistry after inspection of thin section.	1					

SO225-035DR017
Description of Location and Structure: Southern Danger Islands Trough; Base of SO193-DR26 structure. Small ridge running parallel to main NW-SE faults; NW facing slope
Dredge on bottom UTC 19/12/12 19:43hrs, lat 9°17.04'S, long 164°21.31'W, depth 4700m
Dredge off bottom UTC 19/12/12 21:02hrs, lat 9°17.19'S, long 164°20.81'W, depth 4288m
total volume: 1/4 full
Comments: due to failure of bow thruster profile extended 430m; lava fragments. Volcanoclastites. Mn crusts; 2 fragments ~50cm across; ~20 smaller ones

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-17-1	1. Rock Type: volcanic rock, strongly altered 2. Size: 87x27x20cm 3. Shape / Angularity: large angular fragment, covered by Mn crust 4. Color of cut surface: red with greenish spots 5. Texture / Vesicularity: vesicular (~30%) 6. Phenocrysts: - 7. Matrix: fine to mid grained matrix, voids of irregular shape, filled with palagonite or empty 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: the rock looks very similar to shallow dredge 16 which can indicate debris from high plateau. Chemistry is difficult because of voids. Thin section inspection required!	2	1				
SO225-DR-17-2	1. Rock Type: volcanic rock, strongly altered 2. Size: 22x15x12cm 3. Shape / Angularity: rounded and covered by thick Mn crust 4. Color of cut surface: - 5. Texture / Vesicularity: massive with few vesicles 6. Phenocrysts: Ol ~10% up to 1mm 7. Matrix: matrix is ophitic, microcrystalline, very oxidized 8. Secondary Minerals: - 9. Encrustations: thick Mn crust, Mn along numerous cracks dessecting the rock 10. Comment: picking required before doing chemistry	1	1				
SO225-DR-17-3	1. Rock Type: volcanic rock, strongly altered 2. Size: 16x12x6cm 3. Shape / Angularity: subangular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 2, has more Mn inside the sample	1	1				
SO225-DR-17-4	1. Rock Type: volcanic rock, strongly altered 2. Size: 20x17x10cm 3. Shape / Angularity: rounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 2, 3, some more voids, filled with palagonite. Thin film of Mn on surface.	1	1				
SO225-DR-17-5	1. Rock Type: volcanic rock, altered 2. Size: 25x15x11cm 3. Shape / Angularity: subrounded 4. Color of cut surface: greenish grey with yellow spots 5. Texture / Vesicularity: vesicular (~20%) 6. Phenocrysts: no clear phenocrysts 7. Matrix: matrix mid crystallized (altered), no clear plag seen 8. Secondary Minerals: voids filled with second. minerals, some are open 9. Encrustations: ~4cm Mn crust (removed during preparation) 10. Comment: the rock appears to be different from other samples. Thin section should be inspected for fresh plag.	2	1				

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-17-6	1. Rock Type: volcaniclastic rock, altered, cemented by Mn crust 2. Size: 39x19x10cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: taken to separate clasts, the clasts are composed by homogen. aphiric basalt with small voids 6. Phenocrysts: - 7. Matrix: matrix is microcrystalline, vitrophiric 8. Secondary Minerals: secondary palagonite in voids and replaces glass in the breccia 9. Encrustations: the clasts are cemented by Mn crust 10. Comment: several small pieces are taken for chemistry. They should be cleaned from Mn before chemical analyses.	1	1				
SO225-DR-17-7	1. Rock Type: volcaniclastic rock, totally altered 2. Size: 25x20x6cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: palagonite (former glass clasts) cemented by thick Mn crust, 1/2 sample is taken to carefully check for glass relicts						
SO225-DR-17-8Mn	1. Rock Type: Mn crust 2. Size: 27x19x9cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: ~4cm crust cementing basalt fragments. Sample is similar to sample 6!						

SO225-036DR018
Description of Location and Structure: Southern Danger Islands Trough; Eastern flank ~15nm north of DR11-16; lower part of the slope from base to small terrace
Dredge on bottom UTC 20/12/12 02:02hrs, lat 9°05.61'S, long 164°17.64'W, depth 4768m
Dredge off bottom UTC 20/12/12 03:21hrs, lat 9°05.45'S, long 164°17.19'W, depth 4314m
total volume: 1/4
Comments: Several large, up to 0.5m blocks and numerous middle to small sized fragments; All rocks belong to 3 groups: 1) basaltic? Pillows; 2) greenschists; 3) partly solidified sediment

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-18-1	1. Rock Type: volcanic rock, altered 2. Size: 20x18x12cm 3. Shape / Angularity: angular, partly rounded shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, round vesicles (~5%) filled with black Mn, spinifex texture 6. Phenocrysts: ~1mm white/brownish pyroxene? needles (spinifex) 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: Mn in vesicles (black), brown Fe-oxides in veins and cracks 9. Encrustations: Mn crust partly 0.5-3cm 10. Comment: dense, volcanic rock with fine grained matrix and spinifex texture	1	3	2			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-18-2	1. Rock Type: volcanic rock, altered 2. Size: 18x11x12cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~1%vesicles filled with Mn, spinifex texture (needles ≤1mm) 6. Phenocrysts: ≤1mm white brownish pyroxene? needles (spinifex) 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: Mn (black in vesicles), red brown Fe-oxides in cracks and veins 9. Encrustations: Mn crust ~2-6mm 10. Comment: see sample 1!	1	3	2			
SO225-DR-18-3	1. Rock Type: volcanic, altered 2. Size: 13x7x9cm 3. Shape / Angularity: angular 4. Color of cut surface: grey brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, rounded vesicles? filled with black Mn (~1%), spinifex texture 6. Phenocrysts: ≤1mm white brownish pyroxene? needles (spinifex) 7. Matrix: fine grained, grey brownish matrix 8. Secondary Minerals: black Mn filling vesicles? 9. Encrustations: no Mn crust (only small spots covered with ~1mm Mn crust) 10. Comment: see sample 1!	2	2	2			
SO225-DR-18-4	1. Rock Type: volcanic, altered 2. Size: 10x8x6cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~1% vesicles? filled with black Mn, spinifex texture 6. Phenocrysts: ~1mm grey brownish pyroxene? needles (spinifex) 7. Matrix: grey, fine grained matrix 8. Secondary Minerals: black Mn in vesicles?, brown Fe-oxides in cracks and veins 9. Encrustations: ~1-3mm Mn crust 10. Comment: see sample 1!	1	2	2-3			
SO225-DR-18-5	1. Rock Type: volcanic, altered 2. Size: 30x20x20cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey-brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~5% vesicles filled with black Mn, spinifex texture 6. Phenocrysts: ≤1mm grey brownish pyroxene? needles (spinifex) 7. Matrix: grey, fine grained matrix (brownish near cracks) 8. Secondary Minerals: Mn (black in vesicles), brown Fe-oxides in cracks 9. Encrustations: partly no, partly 2-5mm Mn crust 10. Comment: see sample 1!	2	3	2-3			
SO225-DR-18-6	1. Rock Type: volcanic, altered 2. Size: 15x10x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, vesicles (~10%) filled with black Mn, spinifex texture 6. Phenocrysts: 1-2mm grey-green pyroxene needles (spinifex) 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: black Mn in vesicles 9. Encrustations: no Mn crust 10. Comment: see sample 1!	1	2	2-3			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-18-7	1. Rock Type: volcanic, altered 2. Size: 17x11x11cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey brown color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~5% vesicles filled with black Mn, spinifex texture 6. Phenocrysts: ≤1mm white greenish pyroxene needles (spinifex) 7. Matrix: fine grained, grey brownish matrix 8. Secondary Minerals: Mn in vesicles 9. Encrustations: 3-6mm Mn crust 10. Comment: see sample 1!	2	1	3			
SO225-DR-18-8	1. Rock Type: volcanic, altered 2. Size: 12x9x9cm 3. Shape / Angularity: angular shape (rounded Mn crust) 4. Color of cut surface: grey color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~2-3% vesicles filled with black Mn, spinifex texture 6. Phenocrysts: white greenish pyroxene needles (spinifex) 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: brown Fe-oxides in cracks, black Mn in vesicles 9. Encrustations: ~5mm Mn crust (rock partly covered) 10. Comment: see sample 1!	1	2	3-4			
SO225-DR-18-9	1. Rock Type: volcanic, altered 2. Size: 30x25x22cm 3. Shape / Angularity: angular shape 4. Color of cut surface: brown greenish color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, <5% vesicles filled with black Mn, spinifex texture 6. Phenocrysts: white green pyroxene needles 1-10mm! (spinifex) 7. Matrix: fine grained , grey-green matrix 8. Secondary Minerals: Fe-oxides in veins, Mn in vesicles 9. Encrustations: 1-2mm Mn crust 10. Comment: volcanic rock with fine grained matrix and 1-10mm pyroxene needles with spinifex texture	1	4	3-4			
SO225-DR-18-10	1. Rock Type: volcanic, altered 2. Size: 9x9x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey green color on broken surface 5. Texture / Vesicularity: fine grained matrix, ~15% vesicles filled with black Mn, spinifex texture 6. Phenocrysts: 1-5mm greenish pyroxene needles (spinifex texture) 7. Matrix: fine grained, green-grey matrix 8. Secondary Minerals: brown Fe-oxides, Mn in vesicles, Fe-oxides also in veins 9. Encrustations: no Mn crust 10. Comment: volcanic rock with spinifex texture (pyroxene needles ~1-5mm)	1		3			
SO225-DR-18-11	1. Rock Type: volcanic, altered 2. Size: 20x11x9cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: green-grey color on broken surface 5. Texture / Vesicularity: fine grained matrix, vesicles ~5% filled with black Mn, spinifex texture 6. Phenocrysts: 1-3mm pyroxene needles (spinifex) 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: Mn in veins and vesicles 9. Encrustations: partly covered by Mn (~1-2mm thick) 10. Comment: see sample 10 (pyroxene needles 1-3mm)	2		3			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-18-12	1. Rock Type: volcanic, altered 2. Size: 20x12x10cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: green-grey color on broken surface 5. Texture / Vesicularity: fine grained matrix ~20% vesicles filled with black Mn, spinifex texture 6. Phenocrysts: 1-2mm greenish pyroxene needles (spinifex) 7. Matrix: fine grained, green matrix 8. Secondary Minerals: black Mn in vesicles and cracks, Fe-oxides (red-brown) in vesicles 9. Encrustations: ~1mm Mn crust 10. Comment: see sample 10 (pyroxene needles 1-2mm)	2		3?			
SO225-DR-18-13	1. Rock Type: volcanic, altered 2. Size: 18x7x13cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey green color on broken surface 5. Texture / Vesicularity: dense, microcryst. matrix, ~20% vesicles filled with black Mn, spinifex texture 6. Phenocrysts: 1-5mm white/green pyroxene needles (spinifex) 7. Matrix: fine grained, grey green matrix 8. Secondary Minerals: Mn in vesicles, brown Fe-oxides 9. Encrustations: 1-3mm Mn crust 10. Comment: see sample 10 (pyroxene needles 1-5mm)	2		3?			
SO225-DR-18-14	1. Rock Type: metamorphic rock 2. Size: 30x60x7cm 3. Shape / Angularity: angular shape 4. Color of cut surface: green/black color on broken surface 5. Texture / Vesicularity: coarse grained matrix with ~1-8mm chlorite? needles 6. Phenocrysts: chlorite? (green 1-8mm needles) 7. Matrix: coarse grained, green black matrix 8. Secondary Minerals: - 9. Encrustations: ~1mm Mn crust 10. Comment: metamorphic rock, greenschist with 1-8mm chlorite needles (1 sample ~10cm prepared for Sergej S.; 2 TS and 2 smaller fragments)	2					
SO225-DR-18-15	1. Rock Type: metamorphic rock 2. Size: 27x35x12cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: green-black color 5. Texture / Vesicularity: coarse grained matrix with ~1-10cm chlorite needles 6. Phenocrysts: chlorite (green); 1-10mm 7. Matrix: coarse grained, green black matrix 8. Secondary Minerals: - 9. Encrustations: partly ~0.5cm Mn crust 10. Comment: see sample 14!						
SO225-DR-18-16	1. Rock Type: sediment? 2. Size: 33x19x14cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: light grey color on broken surface 5. Texture / Vesicularity: fine grained matrix, no vesicles 6. Phenocrysts: - 7. Matrix: fine grained, light grey matrix 8. Secondary Minerals: Mn in cracks 9. Encrustations: ~1mm Mn crust 10. Comment: sediment clast, claystone?, covered by Mn						

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-18-17	1. Rock Type: volcanic rock, altered 2. Size: 26x19x11cm 3. Shape / Angularity: angular, partly rounded shape 4. Color of cut surface: green grey color on dry surface 5. Texture / Vesicularity: fine grained matrix, ~15% vesicles filled with Mn, spinifex texture 6. Phenocrysts: ~1-3mm pyroxene needles 7. Matrix: fine grained, grey-green matrix 8. Secondary Minerals: Mn in vesicles, Fe-oxides? (brown) 9. Encrustations: 1-3mm Mn crust (partly) 10. Comment: volcanic rock with grey matrix and pyroxene needles with a spinifex texture			~3			
SO225-DR-18-18X	1. Rock Type: two rocks: (1): 21x14x15cm, (2): 19x13x10cm, greenschist with chlorite needles, both pieces are partly covered by Mn (~1mm thick), greenschist has coarse grained, green-black matrix 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-037DR019
Description of Location and Structure: Southern Danger Islands Trough; Eastern flank ~15nm north of DR11-16; upper part of the slope from small terrace to top
Dredge on bottom UTC 20/12/12 06:56hrs, lat 9°02.98'S, long 164°15.93'W, depth 4192m
Dredge off bottom UTC 20/12/12 08:40hrs, lat 9°02.68'S, long 164°15.52'W, depth 3583m
total volume: few rocks
Comments: -

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-19-1	1. Rock Type: volcanic, strongly altered 2. Size: 19x12x8cm 3. Shape / Angularity: angular/partly rounded 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: brown, microcryst. matrix, ~10% vesicles filled with black Mn, spinifex texture 6. Phenocrysts: <1mm, very altered, brownish pyroxene needles (spinifex) 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: Mn in cracks and vesicles 9. Encrustations: ~2mm Mn crust 10. Comment: volcanic rock, strongly altered with pyroxene needles with spinifex texture	1		6			
SO225-DR-19-2	1. Rock Type: volcanic, strongly altered 2. Size: 16x14x8cm 3. Shape / Angularity: rounded/partly angular 4. Color of cut surface: brown color on broken surface 5. Texture / Vesicularity: brown, microcryst. matrix, ~10% vesicles filled with Mn, spinifex texture 6. Phenocrysts: ~1-2mm pyroxene needles (spinifex) 7. Matrix: brown, fine grained matrix 8. Secondary Minerals: Mn vesicles 9. Encrustations: ~1-2mm Mn crust 10. Comment: see sample 1!	1		6			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-19-3Mn	1. Rock Type: volcanic breccia with thick Mn crust 2. Size: 18x9x10cm 3. Shape / Angularity: Mn crust rounded 4. Color of cut surface: black 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: crust is ~2cm thick 10. Comment: volcanic breccia with massive, 2cm thick Mn crust						
SO225-DR-19-4Mn	1. Rock Type: volcanic breccia with thick, massive Mn crust 2. Size: 26x17x10cm 3. Shape / Angularity: Mn crust rounded 4. Color of cut surface: black 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: crust up to 8cm thick (massive) 10. Comment: volcanic breccia with massive, 8cm thick Mn crust						

SO225-038DR020
Description of Location and Structure: Southern Danger Islands Trough; Cliff SE of SO193-DR26. SW facing slope beneath lowermost terrace
Dredge on bottom UTC 20/12/12 14:22hrs, lat 9°24.77'S, long 164°14.72'W, depth 4582m
Dredge off bottom UTC 20/12/12 15:56hrs, lat 9°24.33'S, long 164°14.33'W, depth 3980m
total volume: 1/4 full
Comments: Mn crusts; some with lava fragments; Lavas are Ol basalts with up to 20% Ol. All badly altered; A few pieces appear more fresh and recommended for chemistry

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-20-1	1. Rock Type: volcanic rock, strongly altered 2. Size: 39x33x11cm 3. Shape / Angularity: angular fragment 4. Color of cut surface: reddish green 5. Texture / Vesicularity: massive 6. Phenocrysts: no phenocrysts 7. Matrix: mid-crystallized, ophitic matrix, cpx is fresh, perhaps plag in some small parts 8. Secondary Minerals: alteration is variable, in some parts glass is replaced with palagonite, in others appears to be preserved 9. Encrustations: ~3cm Mn crust on the outer surface , Mn precipitates along fractures 10. Comment: the rock is generally very altered but some fresh parts may be present and should be checked with thin section	1	1				
SO225-DR-20-2	1. Rock Type: volcanic rock, strongly altered 2. Size: 12x11x7cm 3. Shape / Angularity: subangular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 1 but has some Mn precipitates along fractures	1	1				

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-20-3	1. Rock Type: volcanic rock, altered 2. Size: 9x8x5cm 3. Shape / Angularity: subangular 4. Color of cut surface: yellow grey with red spots 5. Texture / Vesicularity: massive 6. Phenocrysts: Ol ~10-15% up to 2mm, all altered, replaced by Fe-hydroxide 7. Matrix: matrix glassy with tiny cpx 8. Secondary Minerals: glass is totally altered and replaced with yellow aggregate of sec. minerals and brownish material in less altered parts 9. Encrustations: encrustations are Mn precipitates along fractures 10. Comment: very primitive basalt with spinifex ground mass and olivine phenocrysts, chemistry is problematic	1	1		Sp?		
SO225-DR-20-4	1. Rock Type: volcanic rock, strongly altered 2. Size: 10x7x5cm 3. Shape / Angularity: angular fragment from Mn cement 4. Color of cut surface: - 5. Texture / Vesicularity: massive with olivine phenocrysts and spinifex matrix texture 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: overall similar to sample 3 but appears more fresh and better for chemistry and it has more greyish matrix and oxidation is not pervassive	1	1		sp?		
SO225-DR-20-5	1. Rock Type: volcanic rock, altered 2. Size: 26x22x12cm 3. Shape / Angularity: subangular (fragment extracted from breccia in Mn matrix) 4. Color of cut surface: reddish grey with dark dots 5. Texture / Vesicularity: massive texture, vesicles (≤1mm) ~5% filled with second. minerals 6. Phenocrysts: no or few olivine phenocrysts ~1mm 7. Matrix: matrix ophitic, spinifex-like 8. Secondary Minerals: badly altered, cpx might be fresh, voids are filled with dark brown second. minerals 9. Encrustations: Mn encrustations along fractures 10. Comment: chemistry should be done because this rock represents one of several types of rocks from the dredge. The protolith of this rock could be similar to those from dredge 18!	1	1				
SO225-DR-20-6	1. Rock Type: volcanic rock, altered 2. Size: 9x8x5.5cm 3. Shape / Angularity: subangular fragment from breccia cemented by Mn 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: this is Ol phyric, massive basalt similar to sample 4. Amount of olivine is up to 20%, Sp. is present, overall not good for chemistry but Sp. is preserved	1	1		sp?		
SO225-DR-20-7	1. Rock Type: volcanic rock, strongly altered 2. Size: 12x7x6cm 3. Shape / Angularity: subrounded fragment from Mn crusts 4. Color of cut surface: red with yellow dots 5. Texture / Vesicularity: massive, rare voids (≤6mm) are filled with Fe-hydroxides 6. Phenocrysts: Ol phenocrysts (≤2mm) ~20% (oxidized) 7. Matrix: matrix was very glassy with ~50% glass, now replaced with olive green palagonite (spinifex texture) 8. Secondary Minerals: - 9. Encrustations: some Mn precipitates are present 10. Comment: not good for chemistry but inspection of thin section is worth to do	1	1				

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-20-8	1. Rock Type: volcanic rock, altered 2. Size: 18x13x11cm 3. Shape / Angularity: subangular fragment from breccia 4. Color of cut surface: greyish red with light dots 5. Texture / Vesicularity: vesicular 6. Phenocrysts: Ol (≤1mm) ~10-15%, all oxidized 7. Matrix: matrix phyric, fine xls of cpx, the greyish color suggests moderate alteration 8. Secondary Minerals: - 9. Encrustations: some Mn precipitates along fractures 10. Comment: chemistry should be done. This and sample 4 appear to best from this dredge	2	1				
SO225-DR-20-9	1. Rock Type: volcanic rock 2. Size: 18x5x9cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: fragment of typical breccia with basaltic fragments and palagonite replaced glass						
SO225-DR-20-10Mn	1. Rock Type: Mn crust with basaltic fragment 2. Size: 21x18x12cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: crust thickness up to 5cm 10. Comment: -						

SO225-039DR021
Description of Location and Structure: Southern Danger Islands Trough; Western side of DIT. Profile intersects with SO224 seismic line. SE facing slope of nose
Dredge on bottom UTC 20/12/12 20:35hrs, lat 9°31.81'S, long 164°23.39'W, depth 4433m
Dredge off bottom UTC 20/12/12 22:08hrs, lat 9°31.45'S, long 164°23.78'W, depth 3773m
total volume: full
Comments: pillow and sheet lava fragments up to 40cm in diameter

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-21-1	1. Rock Type: volcanic rock, moderately altered 2. Size: 22x26x14cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark grey, slightly brownish 5. Texture / Vesicularity: massive 6. Phenocrysts: no visible phenocrysts 7. Matrix: matrix mid-crystallized, intersertal, plag appears to be fresh 8. Secondary Minerals: thin veins, plate joining 9. Encrustations: thin Mn crust (<1mm) 10. Comment: the rock looks pretty fresh. Should be good for chemistry and Ar-Ar	2	1	2	plag		
SO225-DR-21-2	1. Rock Type: volcanic rock, moderately altered 2. Size: 10x8x6cm 3. Shape / Angularity: subrounded 4. Color of cut surface: greenish dark grey 5. Texture / Vesicularity: massive, similar to sample 1 but has more alteration, red dots of palagonite in ground mass 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: should be good for chemistry, Ar-Ar on plag microliths possible	1	1	2-	plag		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-21-3	1. Rock Type: volcanic rock, moderately to strong altered 2. Size: 25x20x15cm 3. Shape / Angularity: subrounded 4. Color of cut surface: green brown, black spots 5. Texture / Vesicularity: massive with very rare vesicles 6. Phenocrysts: no clear phenocrysts 7. Matrix: matrix is composed of needles of plag or cpx placed in altered glass/palagonite 8. Secondary Minerals: some precipitation of Mn oxides 9. Encrustations: thin Mn crust outside 10. Comment: green spots appear to be more fresh than dark ones and should be picked for chemistry. Thin section should be investigated	2	1	3	plag		
SO225-DR-21-4	1. Rock Type: volcanic rock, moderately altered 2. Size: 26x15x11cm 3. Shape / Angularity: subrounded 4. Color of cut surface: greenish grey with dark dots 5. Texture / Vesicularity: massive 6. Phenocrysts: no clear phenocrysts 7. Matrix: matrix ophyric, spinifex-like glass is altered but in some parts looks OK 8. Secondary Minerals: Mn precipitations along fractures 9. Encrustations: no outside crust 10. Comment: depending on thin section investigation can be tried for chemistry	1	1				
SO225-DR-21-5	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 27x19x16cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey, yellowish 5. Texture / Vesicularity: similar to sample 4 but with more oxidation. Grey parts appear to be fresh. 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: may be good for chemistry with some picking. The crystals are likely cpx	1	1		cpx		
SO225-DR-21-6	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 22x18x15 3. Shape / Angularity: - 4. Color of cut surface: yellowish dark grey with green spots 5. Texture / Vesicularity: similar to sample 4 but more oxidized 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: grey parts look OK for chemistry. Some xls are up to 7mm long colorless and can be plag. The freshest part is collected.	1	1		plag? px?		
SO225-DR-21-7	1. Rock Type: volcanic rock, slightly altered 2. Size: 15x9x9cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey 5. Texture / Vesicularity: massive 6. Phenocrysts: rare plag microphenocrysts, needles up to 3mm long 7. Matrix: matrix is fine-crystallized, intersertal? 8. Secondary Minerals: - 9. Encrustations: thin veins of Mn 10. Comment: very good for chemistry and Ar-Ar	1	1	1	plag		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-21-8	1. Rock Type: volcanic rock, altered 2. Size: 16x13x11cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: grey color 5. Texture / Vesicularity: massive, ~1% vesicles filled with second. minerals (green) 6. Phenocrysts: brown white plag? needles (~2mm) 7. Matrix: microcryst. grey brown matrix 8. Secondary Minerals: thin Mn veins, greenish minerals in vesicles 9. Encrustations: rock partly covered by Mn crust 10. Comment: massive, volcanic rock with plag? needles, could be good for dating!	2	1	1-2	plag		
SO225-DR-21-9	1. Rock Type: volcanic, slightly altered 2. Size: 10x6x4cm 3. Shape / Angularity: angular shape 4. Color of cut surface: dark grey-brown on broken surface 5. Texture / Vesicularity: massive, no vesicles 6. Phenocrysts: white plag phenocrysts (~1-1.5mm), dark green-grey pyroxene? needles (<1mm) 7. Matrix: fine grained matrix (grey) 8. Secondary Minerals: calcite and Mn in cracks 9. Encrustations: - 10. Comment: massive, volcanic rock with plag and cpx?, plag very good for dating!	1	1	1	plag		
SO225-DR-21-10	1. Rock Type: volcanic, altered 2. Size: 20x10x10cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: grey brown color 5. Texture / Vesicularity: massive, no vesicles 6. Phenocrysts: plag needles (white) 1-3mm 7. Matrix: microcryst. grey green matrix 8. Secondary Minerals: calcite and Mn in cracks and veins 9. Encrustations: partly covered by ~1mm Mn crust 10. Comment: massive, volcanic rock, partly covered by Mn with 1-3mm plag needles -->plag very good for dating!	1	1	1-2	plag!		
SO225-DR-21-11	1. Rock Type: volcanic, altered 2. Size: 15x10x8cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: grey brown color 5. Texture / Vesicularity: massive, ≤1cm vesicles filled with green minerals 6. Phenocrysts: white plag? needles ≤1mm 7. Matrix: microcryst. grey brown matrix 8. Secondary Minerals: Mn veins, Fe-oxides (brown), green minerals in vesicles 9. Encrustations: partly covered with ~1mm Mn crust 10. Comment: massive, volcanic rock with small plag needles (≤1mm) --> could be useful for dating!	1	1	2-3	plag?		
SO225-DR-21-12	1. Rock Type: volcanic, very altered 2. Size: 15x8x8cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown, partly grey color 5. Texture / Vesicularity: massive, vesicles ~5% partly free, partly filled with secondary minerals 6. Phenocrysts: grey-brown needles, altered plag/px? 7. Matrix: microcryst. brown grey matrix 8. Secondary Minerals: calcite and Mn in veins, Fe-oxides (brown) 9. Encrustations: ~1mm Mn crust 10. Comment: volcanic, very altered rock with altered plag/px? needles	2	1	4			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-21-13	1. Rock Type: volcanic, altered 2. Size: 10x9x8cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: brown, fresh area: grey 5. Texture / Vesicularity: massive, small amount of vesicles filled with greenish minerals and Mn 6. Phenocrysts: - 7. Matrix: microcryst. green-grey to brown matrix 8. Secondary Minerals: Mn in vesicles and veins, greenish minerals in vesicles 9. Encrustations: ~1-2mm Mn crust 10. Comment: volcanic rock, altered with a relatively fresh, grey area	1	1	3?			
SO225-DR-21-14	1. Rock Type: volcanic, altered 2. Size: 10x12x6cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: grey (fresh area), brown (altered area) 5. Texture / Vesicularity: massive, ≤1% vesicles filled with white-yellow minerals 6. Phenocrysts: ≤1mm white plag and green-grey pyroxene needles 7. Matrix: microcryst. grey-brown matrix 8. Secondary Minerals: Mn in veins and cracks, Fe-oxides in veins 9. Encrustations: partly covered by ~1mm Mn crust 10. Comment: massive, volcanic rock with relatively fresh areas and plag and pyroxene needles, plag needles could be useful for dating!	1	1	3?	plag		
SO225-DR-21-15	1. Rock Type: volcanic, altered 2. Size: 17x19x10cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown-grey 5. Texture / Vesicularity: massive, no vesicles 6. Phenocrysts: grey-green pyroxene? needles, partly brown (altered), 1-3mm size 7. Matrix: microcryst. grey-brown matrix 8. Secondary Minerals: Mn and calcite in veins/cracks 9. Encrustations: 1-3mm Mn crust 10. Comment: massive, volcanic rock, altered, with cpx needles	1	1	3-4			
SO225-DR-21-16	1. Rock Type: volcanic, altered 2. Size: 17x13x12cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color 5. Texture / Vesicularity: massive; <5% vesicles filled with Mn 6. Phenocrysts: brown (up to 1cm) needles concentrated in some areas, making radial pattern (spinifex?) -->pyroxene? 7. Matrix: microcryst. brown matrix 8. Secondary Minerals: Mn in vesicles and cracks 9. Encrustations: partly covered by ~1cm Mn crust 10. Comment: massive rock with pyroxene? needles making radial pattern	2	1	4			
SO225-DR-21-17	1. Rock Type: volcanic, altered 2. Size: 10x16x14cm 3. Shape / Angularity: partly rounded 4. Color of cut surface: brown-grey color 5. Texture / Vesicularity: massive, <1% vesicles filled with Mn 6. Phenocrysts: 1-3mm brown pyroxene needles with spinifex-like texture 7. Matrix: fine grained, microcryst. matrix 8. Secondary Minerals: Mn in veins and vesicles 9. Encrustations: ~1mm Mn crust 10. Comment: massive rock, with pyroxene needles with a spinifex-like texture	2	1	3-4			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-21-18	1. Rock Type: volcanic, altered 2. Size: 9x10x5cm 3. Shape / Angularity: rounded 4. Color of cut surface: grey-brown 5. Texture / Vesicularity: massive, no vesicles 6. Phenocrysts: <1mm plag needles (white), <1mm (brown) pyroxene needles 7. Matrix: microcryst. green-brown matrix 8. Secondary Minerals: Mn in veins, Fe-oxides (brown) 9. Encrustations: ~1mm Mn crust 10. Comment: massive rock with plag/pyroxene needles, plag could be useful for dating!	2	1	3-4	plag?		
SO225-DR-21-19	1. Rock Type: volcanic, altered 2. Size: 11x7x9cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: grey-brown color 5. Texture / Vesicularity: massive, <5% vesicles filled with Mn 6. Phenocrysts: <1mm plag needles, ≤3mm iddingsit. olivines? 7. Matrix: microcryst. grey-brown matrix 8. Secondary Minerals: iddingsit. olivines, Mn in veins and vesicles 9. Encrustations: ~1mm Mn crust 10. Comment: massive, volcanic rock with iddingsit. olivines? and small plag needles	1	2	3-4			
SO225-DR-21-20	1. Rock Type: volcanic, altered 2. Size: 4x9x8cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown color 5. Texture / Vesicularity: massive matrix, ~20% vesicles filled with black Mn 6. Phenocrysts: - 7. Matrix: brown, microcryst. matrix 8. Secondary Minerals: Mn in veins and vesicles 9. Encrustations: ~1mm Mn crust 10. Comment: very altered pillow margin, could be useful for glass separation!				glass?		
SO225-DR-21-21	1. Rock Type: volcanic, altered 2. Size: 3x7x6cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown color 5. Texture / Vesicularity: massive, <5% vesicles partly filled with Mn 6. Phenocrysts: ≤0.5mm, brown pyroxene needles 7. Matrix: brown, microcryst. matrix 8. Secondary Minerals: Mn in veins and vesicles, calcite? in cracks 9. Encrustations: ~1mm Mn crust 10. Comment: see sample 20!				glass?		
SO225-DR-21-22	1. Rock Type: altered, volcanic 2. Size: 5x5x6cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color 5. Texture / Vesicularity: massive, <5% vesicles, partly filled with Mn 6. Phenocrysts: very altered, <1mm pyroxene needles 7. Matrix: microcryst., brown matrix 8. Secondary Minerals: Mn in vesicles and cracks, Fe-oxides (brown) 9. Encrustations: ~1-2mm Mn crust 10. Comment: see sample 20!				glass?		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-21-23	1. Rock Type: layered sediment 2. Size: 39x23x12cm 3. Shape / Angularity: angular 4. Color of cut surface: brown-grey color 5. Texture / Vesicularity: layered texture 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: layers of brownish clay, black Mn and green, altered glass? fragments (no Mn crust)						

SO225-040DR022
Description of Location and Structure: Southern Danger Islands Trough; Eastern side of DIT. Profile intersects with SO224 seismic line. N-W facing slope from bottom to top
Dredge on bottom UTC 21/12/12 02:50hrs, lat 9°40.07'S, long 164°18.25'W, depth 4601m
Dredge off bottom UTC 21/12/12 04:15hrs, lat 9°40.09'S, long 164°17.83'W, depth 4200m
total volume: 1 rock
Comments: Several bites up to 9 tons; sediment with thick Mn crust

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-22-1Mn	1. Rock Type: massive Mn crust with layered sediment 2. Size: 28x17x13cm 3. Shape / Angularity: rounded shape 4. Color of cut surface: Mn has black, sediment brown color 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: layered sediment covered by massive Mn crust (~5cm)						

SO225-046DR023
Description of Location and Structure: Suvorov-Trough; E-W trending ridge (SO193-DR18); lower S-W-facing flank
Dredge on bottom UTC 23/12/12 02:50hrs, lat 10°38.72'S, long 163°54.00'W, depth 4309m
Dredge off bottom UTC 24/12/12 00:25hrs, lat 10°38.60'S, long 163°53.65'W, depth 3822m
total volume: 1/5 full
Comments: -

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-23-1	1. Rock Type: volcanic, slightly to moderately altered 2. Size: 23x17x13cm 3. Shape / Angularity: rounded 4. Color of cut surface: grey (fresh), brown (altered) 5. Texture / Vesicularity: coarse grained matrix, vesicles ~10-15% filled with amorphous quartz 6. Phenocrysts: ≤1mm plag crystals (transparent) 7. Matrix: brown-grey, coarse grained matrix 8. Secondary Minerals: quartz in vesicles, brown Fe-oxides in altered areas 9. Encrustations: 1-15mm Mn crust 10. Comment: dense, volcanic rock with possible fresh plag phenocrysts, could be useful for Ar-Ar dating	1	2	2-3	mineral separation plag?		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-23-2	1. Rock Type: volcanic, altered 2. Size: 19x28x15cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown-grey color (brown in altered areas) 5. Texture / Vesicularity: coarse-grained matrix, ~15% vesicles 1-6mm partly filled with yellow-green minerals 6. Phenocrysts: - 7. Matrix: coarse-grained, brown-grey matrix 8. Secondary Minerals: amorphous quartz in vesicles, some vesicles filled with yellow-green stuff 9. Encrustations: 0.2-1cm Mn crust 10. Comment: dense, volcanic rock with partly filled vesicles (lava)	1	2	4			
SO225-DR-23-3	1. Rock Type: volcanic, altered 2. Size: 52x37x17cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: grey-brown (brown=altered areas) 5. Texture / Vesicularity: coarse grained, vesicles ~15% (up to 1cm size) filled with quartz 6. Phenocrysts: - 7. Matrix: coarse grained matrix (grey-yellow) 8. Secondary Minerals: amorphous quartz in vesicles, Fe-oxides (brown) 9. Encrustations: 1-10mm Mn crust 10. Comment: dense, volcanic rock with grey (fresh) areas and ~1cm vesicles	1	2	4			
SO225-DR-23-4	1. Rock Type: volcanic rock, strongly to moderately altered 2. Size: 16x13x9cm 3. Shape / Angularity: subrounded 4. Color of cut surface: greyish brown with black spots 5. Texture / Vesicularity: vesicular (~50% vesicles) 6. Phenocrysts: cpx phenocrysts ~5-7% up to 1mm, bottle green 7. Matrix: matrix ophitic to intersertal, altered with abundant Mn precipitates 8. Secondary Minerals: pervasive ground mass alteration, Mn in vesicles and in ground mass 9. Encrustations: outer Mn crust up to 1cm, yellowish white, soft material in vesicles close to margin 10. Comment: cpx is good and can be separated. Chemistry problematic -> Mn-oxides. The rock is cpx phyric basalt.	2	1		px		
SO225-DR-23-5	1. Rock Type: volcanic, strongly altered 2. Size: 14x14x8cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark grey to brown 5. Texture / Vesicularity: rare vesicles (5-7mm) 6. Phenocrysts: no phenocrysts visible 7. Matrix: matrix ophitic, fine xls, altered with oxidation and abundant Mn-oxides 8. Secondary Minerals: vesicles filled with white and black minerals, fine veining of Mn oxides 9. Encrustations: ~2cm Mn crust 10. Comment: likely basalt, matrix variably oxidized and perhaps possible to pick out grey parts. Mn precipitates abundant and difficult to avoid.	2	1		?		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-23-6	1. Rock Type: volcanic, altered 2. Size: 27x18x9cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish grey with white and black fillings of vesicles 5. Texture / Vesicularity: vesicular, some large voids up to 2cm long, open or filled with white mineral 6. Phenocrysts: no visible phenocrysts 7. Matrix: matrix fine to mid crystallized with abundant Mn oxide and oxidized. 8. Secondary Minerals: vesicles unequally distributed, from 50% to no vesicles, filled with white material, some with Mn-oxides, fine Mn oxide veining 9. Encrustations: - 10. Comment: lava, basalt, chemistry problematic	1					
SO225-DR-23-7	1. Rock Type: volcanic, strongly altered 2. Size: 10x6x6cm 3. Shape / Angularity: subrounded 4. Color of cut surface: reddish brown with red dots 5. Texture / Vesicularity: massive 6. Phenocrysts: Ol-phenocrysts (altered/oxidized), ~20% up to 1-1.5mm with black Spl? inclusions 7. Matrix: matrix ophitic, microcrystalline 8. Secondary Minerals: strong oxidation, pervasive alteration of phenocrysts and matrix 9. Encrustations: fine Mn veining close to sample margin, semicontinous thin Mn film on outer surface 10. Comment: primitive basalt, Spl may be fresh. Chemistry depending on thin section	1			sp?		
SO225-DR-23-8	1. Rock Type: volcanic, altered 2. Size: 14x8x6cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: basaltic fragment mantled by Mn crust, siminar to sample 7, Ol-Basalt but more Mn encrustations and some voids fillew with white sec. stuff, Sp may be fresh, thin section	2			sp?		
SO225-DR-23-9Mn	1. Rock Type: several basalt clasts covered by massive Mn crust 2. Size: 17x14x10cm 3. Shape / Angularity: crust ist rounded, the clasts are angular 4. Color of cut surface: black color 5. Texture / Vesicularity: - 10. Comment: massive Mn crust (0.5-2cm), black color						
SO225-DR-23-10Mn	1. Rock Type: several basalt clasts covered by massive Mn crust 2. Size: 17x12x8cm 3. Shape / Angularity: Mn crust is rounded, clasts are rounded, partly angular 4. Color of cut surface: black 10. Comment: massive Mn crust (3.5cm thickness), black color						
SO225-DR-23-3X	1. Rock Type: 2 big fragments of sample 3 taken as backup, description see sample 3 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-
048DR024
Description of Location and Structure: Suvorov Trough; E-W-trending ridge; upper middle S-W-facing flank

Dredge on bottom UTC 25/12/12 04:52hrs, lat 10°39.24'S, long 163°53.00'W, depth 3601m
Dredge off bottom UTC 25/12/12 06:21hrs, lat 10°39.10'S, long 163°52.54'W, depth 3014m
total volume: 1/8 full
Comments: volcanic fragments; pillow fragments; possibly glass

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-24-1	1. Rock Type: large block of altered glass pillow (palagonite) 2. Size: 25x23x16cm 3. Shape / Angularity: rounded/partly angular 4. Color of cut surface: green (palagonite) with black spots (fresh glass?) 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: good sample for picking of fresh glass fragments (fresh fragments are rounded and several cm thick)				glass picking!		
SO225-DR-24-2	1. Rock Type: volcanic, altered 2. Size: 8x8x5cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color 5. Texture / Vesicularity: microcryst. matrix, ~1% vesicles, partly filled with Mn 6. Phenocrysts: ~20% iddingsit. olivine ≤1-2mm 7. Matrix: grey, fine-grained matrix 8. Secondary Minerals: iddingsit. olivines, Mn and Fe-oxides in cracks 9. Encrustations: ≤1mm Mn crust 10. Comment: dense, volcanic rock with relatively fresh matrix (Ol-basalt) and altered olivines, fresh matrix spots can be used for chemistry	1	2	3?			
SO225-DR-24-3	1. Rock Type: volcanic, altered 2. Size: 11x6x6cm 3. Shape / Angularity: angular shape 4. Color of cut surface: grey color 5. Texture / Vesicularity: microcryst. matrix, no vesicles 6. Phenocrysts: ~20% iddingsit. olivine 7. Matrix: fine grained, grey matrix 8. Secondary Minerals: ≤1mm Mn crust 9. Encrustations: ≤1mm Mn crust 10. Comment: see sample 2 (no vesicles)	1	2	3?			
SO225-DR-24-4	1. Rock Type: volcanic, altered 2. Size: 16x9x12cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: brown color 5. Texture / Vesicularity: microcryst. matrix with vesicles ≤1mm (partly filled) 6. Phenocrysts: dark brown needles (pyroxene?), altered! 7. Matrix: brown, fine grained matrix 8. Secondary Minerals: Mn in vesicles 9. Encrustations: partly covered with <1mm Mn crust 10. Comment: volcanic rock, strongly altered, chemistry will be difficult	2	2	4-5			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-24-5	1. Rock Type: volcanic, strongly altered 2. Size: 12x10x8cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: brown color 5. Texture / Vesicularity: microcryst., ~25% vesicles <1mm (only several filled with Mn) 6. Phenocrysts: very altered relicts of pyroxene? needles visible in matrix 7. Matrix: brown, fine grained matrix 8. Secondary Minerals: Mn in cracks, veins and vesicles, brown Fe-oxides 9. Encrustations: 1-2mm Mn crust 10. Comment: very altered, volcanic rock, chemistry will be problematic	3	2	5?			
SO225-DR-24-6	1. Rock Type: volcanic, altered 2. Size: 15x8x9cm 3. Shape / Angularity: angular 4. Color of cut surface: brown 5. Texture / Vesicularity: microcryst., ~20% vesicles, partly filled with Mn and alteration products 6. Phenocrysts: relicts of pyroxene? needles 7. Matrix: fine grained, brown 8. Secondary Minerals: Mn in vesicles and along veins and cracks 9. Encrustations: Mn crust partly 1mm thick 10. Comment: see sample 5!	1	2	5?			
SO225-DR-24-7	1. Rock Type: volcanic, strongly altered 2. Size: 15x8x9cm 3. Shape / Angularity: rounded/partly angular 4. Color of cut surface: brown color, some areas have a dark brown color 5. Texture / Vesicularity: microcryst. matrix, ~20% vesicles filled with second. minerals 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: calcite and Mn along cracks, Fe-oxides in matrix 9. Encrustations: no Mn crust 10. Comment: very altered, volcanic rock, useless for chemistry?	2	2	5-6			
SO225-DR-24-8	1. Rock Type: volcanic, altered 2. Size: 11x7x8cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: brown 5. Texture / Vesicularity: microcryst. matrix, vesicles ~20% filled 6. Phenocrysts: relicts of pyroxene needles (≤2mm) 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: Mn precipitates, Fe-oxides 9. Encrustations: Mn crust ~1mm 10. Comment: altered, volcanic rock with filled vesicles, could be useless for chemistry	2					
SO225-DR-24-9	1. Rock Type: volcanic, altered 2. Size: 9x8x8cm 3. Shape / Angularity: subrounded 4. Color of cut surface: brown (with darker areas) 5. Texture / Vesicularity: microcryst. matrix, vesicles ~20% filled 6. Phenocrysts: - 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: Mn in veins 9. Encrustations: ~1mm Mn crust 10. Comment: see sample 8!	1					

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-24-10	1. Rock Type: volcanic, strongly to moderately altered 2. Size: 8x7x13cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: white brown (badly altered), grey (fresh areas) 5. Texture / Vesicularity: microcryst. matrix, ~15% vesicles (~1mm) filled with second. minerals 6. Phenocrysts: relicts of brown pyroxene? needles, very altered 7. Matrix: fine grained, brown-white-grey matrix 8. Secondary Minerals: Mn along cracks and veins, second. minerals in vesicles, Fe-oxides in matrix 9. Encrustations: 1-10mm Mn crust 10. Comment: volcanic rock, very altered with fresh areas, picking of fresh areas will be necessary!	2	2				
SO225-DR-24-11	1. Rock Type: rounded palagonite clast 2. Size: 9x5x5cm 3. Shape / Angularity: rounded 4. Color of cut surface: green color with black and reddish spots 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: palagonite clast (altered) with black areas which could have some fresh glass particles inside!, no Mn crust, picking necessary!						
SO225-DR-24-12	1. Rock Type: rounded palagonite clast 2. Size: 12x7x7cm 3. Shape / Angularity: - 4. Color of cut surface: green brown, partly black 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: see sample 11!						
SO225-DR-24-13	1. Rock Type: palagonite fragment (very altered) 2. Size: 8x8x5cm 3. Shape / Angularity: angular, partly rounded 4. Color of cut surface: green-brown-white areas, some black areas 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: brown areas: iddingsit Ol grains?, cracks filled with Mn 9. Encrustations: - 10. Comment: see sample 11!						
SO225-DR-24-1x	1. Rock Type: large palagonite block with partly fresh? glass fragments 2. Size: 22x18x17cm 3. Shape / Angularity: - 4. Color of cut surface: green 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: partly ~0.5cm Mn crust 10. Comment: -						

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-24-14x	1. Rock Type: palagonite rim (up to 4 cm thick) with very altered basalt inside, fresh? glass fragments are visible 2. Size: 18x16x11cm 3. Shape / Angularity: rounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: no Mn crust 10. Comment: -						
SO225-DR-24-15x	1. Rock Type: very altered palagonite crust with cracks filled with Mn and up to 2cm Mn crust, some spots reveal possible fresh glass fragments, sample is subrounded 2. Size: 12x6x10cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-24-16x	1. Rock Type: very altered palagonite crust with cracks filled with Mn, Mn crust is ~0.5cm thick, subrounded shape, some spots reveal possible fresh glass fragments (black) 2. Size: 10x9x4cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-24-17x	1. Rock Type: altered palagonite crust, partly covered with ~1mm Mn crust, green-brown spots, rounded/partly angular, some spots reveal possible fresh glass fragments 2. Size: 9x6x10cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-24-18x	1. Rock Type: 5 very badly altered basalt clasts (rounded to angular, 7-12cm size), brown color, different alteration degrees, partly covered with 1-10mm Mn crust 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-049DR025
Description of Location and Structure: Suvorov Trough; E-W-trending ridge (SO193-DR18); western part; S-flank; upper slope to top

Dredge on bottom UTC 25/12/12 09:22hrs, lat 10°40.06'S, long 163°50.51'W, depth 2975m
Dredge off bottom UTC 25/12/12 10:40hrs, lat 10°39.53'S, long 163°50.43'W, depth 2556m
total volume: 1/4 full
Comments: -

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-25-1	1. Rock Type: volcanic, moderately altered 2. Size: 10x9x8cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color 5. Texture / Vesicularity: microcryst. matrix, ~20% vesicles partly filled with second. minerals and Mn 6. Phenocrysts: completely iddingsit. olivine (<1-2mm) 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: iddingsit. Ol (brown), Mn in vesicles and veins, greenish minerals in vesicles 9. Encrustations: 2-20mm Mn crust 10. Comment: dense, volcanic rock with strong alteration, difficult for chemistry (Ol-basalt?)	1	2	4			
SO225-DR-25-2	1. Rock Type: volcanic, altered 2. Size: 11x10x11cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color 5. Texture / Vesicularity: microcryst., ~25% vesicles (~1mm) partly filled with white-green minerals 6. Phenocrysts: ~5% iddingsit. olivine (completely altered) 7. Matrix: fine-grained, brown 8. Secondary Minerals: Mn in veins, iddingsit. Ol, white green stuff in vesicles 9. Encrustations: 2-10mm Mn crust 10. Comment: see sample 1, but contains bigger vesicles with white-green stuff	1	2	4-5?			
SO225-DR-25-3	1. Rock Type: volcanic, altered 2. Size: 12x7x6cm 3. Shape / Angularity: rounded, partly angular 4. Color of cut surface: brown color 5. Texture / Vesicularity: microcryst. matrix, ~25% vesicles filled with green-white stuff 6. Phenocrysts: ~10% iddingsit. Ol (≤1-2mm) 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: iddingsit. Ol, Mn in veins/cracks, calcite in cracks and vesicles 9. Encrustations: 2-10mm Mn crust 10. Comment: see sample 1!, more altered compared to sample 1	1	2	4-5			
SO225-DR-25-4	1. Rock Type: volcanic, strongly altered 2. Size: 9x6x7cm 3. Shape / Angularity: angular, partly rounded shape 4. Color of cut surface: brown color 5. Texture / Vesicularity: microcryst. matrix, ~30% vesicles partly filled with white stuff 6. Phenocrysts: ≤1mm altered relicts of pyroxene? (brown needles) 7. Matrix: fine grained, brown 8. Secondary Minerals: Mn and calcite in vesicles, Fe-oxides 9. Encrustations: 1-3mm Mn crust 10. Comment: strongly altered rock (volcanic) with altered pyroxene? needles	1	2	4-5			

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-25-5	1. Rock Type: volcanic, altered 2. Size: 10x7x8cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown 5. Texture / Vesicularity: microcryst. Matrix, ~15% vesicles filled with Mn, calcite and green minerals 6. Phenocrysts: - 7. Matrix: fine grained, brown 8. Secondary Minerals: Mn and calcite in vesicles 9. Encrustations: 1-3mm Mn crust 10. Comment: strongly altered, volcanic rock, bad for chemistry	1	2	4-5			
SO225-DR-25-6	1. Rock Type: volcanic, altered 2. Size: 13x10x8cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown 5. Texture / Vesicularity: microcryst. Matrix, ~25% vesicles, partly filled with white green minerals 6. Phenocrysts: ~1mm iddingsit. olivine? 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: brown, iddingsit. Ol, green-white minerals in vesicles, Mn along veins 9. Encrustations: ~2-12mm Mn crust 10. Comment: see sample 1!	1	3	4-5			
SO225-DR-25-7	1. Rock Type: volcanic, strongly altered 2. Size: 9x8x7cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown 5. Texture / Vesicularity: microcryst. Matrix, ~20% vesicles, partly filled with quartz and calcite 6. Phenocrysts: ~1mm altered pyroxene? needles 7. Matrix: fine grained, brown matrix 8. Secondary Minerals: quartz in vesicles and veins, calcite in vesicles 9. Encrustations: ~0.5cm Mn crust 10. Comment: very altered, volcanic rock, bad for chemistry	2	2	4-5			
SO225-DR-25-8	1. Rock Type: volcanic, strongly altered 2. Size: 27x19x20cm 3. Shape / Angularity: rounded 4. Color of cut surface: brown 5. Texture / Vesicularity: microcryst. matrix, ~10% vesicles filled with white-green stuff 6. Phenocrysts: - 7. Matrix: brown, fine grained 8. Secondary Minerals: Mn in cracks/veins, white-green minerals in vesicles 9. Encrustations: 1-10mm Mn crust 10. Comment: see sample 7!	1	2	5			
SO225-DR-25-9	1. Rock Type: volcanic, strongly altered 2. Size: 15x13x8cm 3. Shape / Angularity: rounded (clast is subrounded) 4. Color of cut surface: brown 5. Texture / Vesicularity: microcryst. matrix, ~10% vesicles filled with black Mn and green-white minerals 6. Phenocrysts: - 7. Matrix: fine grained, brown 8. Secondary Minerals: Mn and (green-white) minerals in vesicles 9. Encrustations: 0.5-1cm Mn crust 10. Comment: volcanic clast (subrounded) strongly altered and covered by thick Mn crust	2					

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-25-10	1. Rock Type: volcanic, altered 2. Size: 9x7x5cm 3. Shape / Angularity: rounded 4. Color of cut surface: grey-brown 5. Texture / Vesicularity: fine grained matrix, vesicles filled with black Mn and greenish second. minerals 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: volcanic breccia covered by ~1cm Mn crust, sample is very altered, but has greyish matrix -> might be good for picking!	1+sep. matrix					
SO225-DR-25-11	1. Rock Type: amorphous SiO2? 2. Size: 20x18x16cm 3. Shape / Angularity: - 4. Color of cut surface: brown-light grey 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: greenish spots along cracks, Mn precipitates within the clast 9. Encrustations: partly covered by Mn crust (~1mm) 10. Comment: some SiO2? clast partly covered by Mn	2					
SO225-DR-25-12Mn	1. Rock Type: Mn encrusted pillow breccia clast with basaltic part and palagonite (strongly altered) 2. Size: 21x18x13cm 3. Shape / Angularity: rounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: 1-4cm, massive (rounded), black Mn crust 10. Comment: -						
SO225-DR-25-13Mn	1. Rock Type: Mn encrusted, brown, basaltic clast 2. Size: 18x16x10cm 3. Shape / Angularity: rounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: Mn crust is black, massive and 0.5-4cm thick 10. Comment: clast transported from far away						
SO225-DR-25-14Mn	1. Rock Type: massive ~10cm thick Mn clast with zoned layers with some brown white inclusions within the core, the layers vary in color (some are brighter, some darker) 2. Size: 18x14x11cm 3. Shape / Angularity: rounded 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-25-15X	1. Rock Type: large Mn encrusted block of different clasts (basaltic? and palagonite), sample represents the top of a pillow breccia 2. Size: 19x13x16cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-25-16X	1. Rock Type: Mn encrusted fragment of a pillow breccia with palagonite and different basaltic? clasts (angular), -> top of a pillow breccia 2. Size: 10x9x8cm 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

SO225-
050DR026
Description of Location and Structure: Suvorov Trough; E-W-striking ridge on High Plateau side; N-Facing slope beneath shallowest part of ridge
Dredge on bottom UTC 25/12/12 13:28hrs, lat 10°37.85'S, long 163°44.84'W, depth 2999m
Dredge off bottom UTC 25/12/12 14:44hrs, lat 10°38.29'S, long 163°44.74'W, depth 2540m
total volume: Empty
Comments: -

SO225-
051DR027
Description of Location and Structure: Suvorov Trough; E-W-striking ridge. High Plateau flank. West facing base slightly of DR23&24
Dredge on bottom UTC 21/12/12 02:50hrs, lat 9°40.07'S, long 164°18.25'W, depth 4601m
Dredge off bottom UTC 21/12/12 04:15hrs, lat 9°40.09'S, long 164°17.83'W, depth 4200m
total volume: Full
Comments: Prevail purple, fine grained sandstones; parly cemented with Mn. Some blocks ~50cm in diameter; Volcanic rocks are Ol/Cpx phyric basalts moderately to strongly altered

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-27-1	1. Rock Type: volcanic, moderately altered 2. Size: 37x25x18cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark grey with green spots 5. Texture / Vesicularity: massive, no vesicles 6. Phenocrysts: coarse grained, well crystallized cpx phenocrysts ~40%, ≤2mm in intergrowths, small Ol ≤1mm, ~15%, plag subphenocrysts, ≤1mm in well crystallized matrix 7. Matrix: - 8. Secondary Minerals: some Mn precipitates 9. Encrustations: no apparent encrustations 10. Comment: lava? of primitive basalt. Should be good for chemistry and likely Ar-Ar. Cpx, plag can be separated	2	1	2-3	px? plag?		
SO225-DR-27-2	1. Rock Type: volcanic, moderately to slightly altered 2. Size: 10x10x8cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey with yellowish parts 5. Texture / Vesicularity: massive, no vesicles 6. Phenocrysts: no obvious phenocrysts 7. Matrix: matrix mid crystallized, aphanytic texture composed by cpx (plag?), star-like intergrowth forming texture like "frost flowers" 8. Secondary Minerals: oxidation along microfractures and also some Mn dots and encrustations 9. Encrustations: - 10. Comment: fragment of lava. Probably the most fresh sample in the dredge. Chemistry should be good. Ar-Ar questionable.	1	1	2	plag?		

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-27-3	1. Rock Type: volcanic, moderately to slightly altered 2. Size: 12x6x6cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey with yellowish spots 5. Texture / Vesicularity: massive 6. Phenocrysts: ~5% cpx phenocrysts up to 1mm 7. Matrix: matrix ophitic with numerous needle-like cpx stars (Frost-flowers) 8. Secondary Minerals: oxidation, Mn precipitates along fractures 9. Encrustations: - 10. Comment: lava simiar to sample 2 but more oxidized with some more cpx, good for chemistry	1	1	?	cpx		
SO225-DR-27-4	1. Rock Type: volcanic, moderately to strongly altered 2. Size: 14x7x8cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 3 but more oxidized	1	1		cpx?		
SO225-DR-27-5	1. Rock Type: volcanic, moderately altered 2. Size: 15x10x5cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 2-3 but more oxidized and some Mn precipitates	2	1				
SO225-DR-27-6	1. Rock Type: volcanic, moderately to slightly altered 2. Size: 9x6x5cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: a rock very similar to sample 2. Just a small piece. Good for chemistry. Thin Mn film should be avoided at picking	1	1				
SO225-DR-27-7	1. Rock Type: volcanic, moderately altered 2. Size: 18x13x6cm 3. Shape / Angularity: angular 4. Color of cut surface: dark greenish grey with red spots 5. Texture / Vesicularity: massive 6. Phenocrysts: 20% Ol phenocrysts, all altered, oxidized (size ≤2mm) 7. Matrix: matrix coarse crystallized with predominant prismatic cpx and plag in interstistials (≤0.5mm) 8. Secondary Minerals: some Mn precipitates 9. Encrustations: thin Mn film on the surface 10. Comment: Ol phyric basalt, oxidized but may be still good for chemistry, Ar-Ar questionable. Thin section should be looked for fresh plag	2	1	?	?		

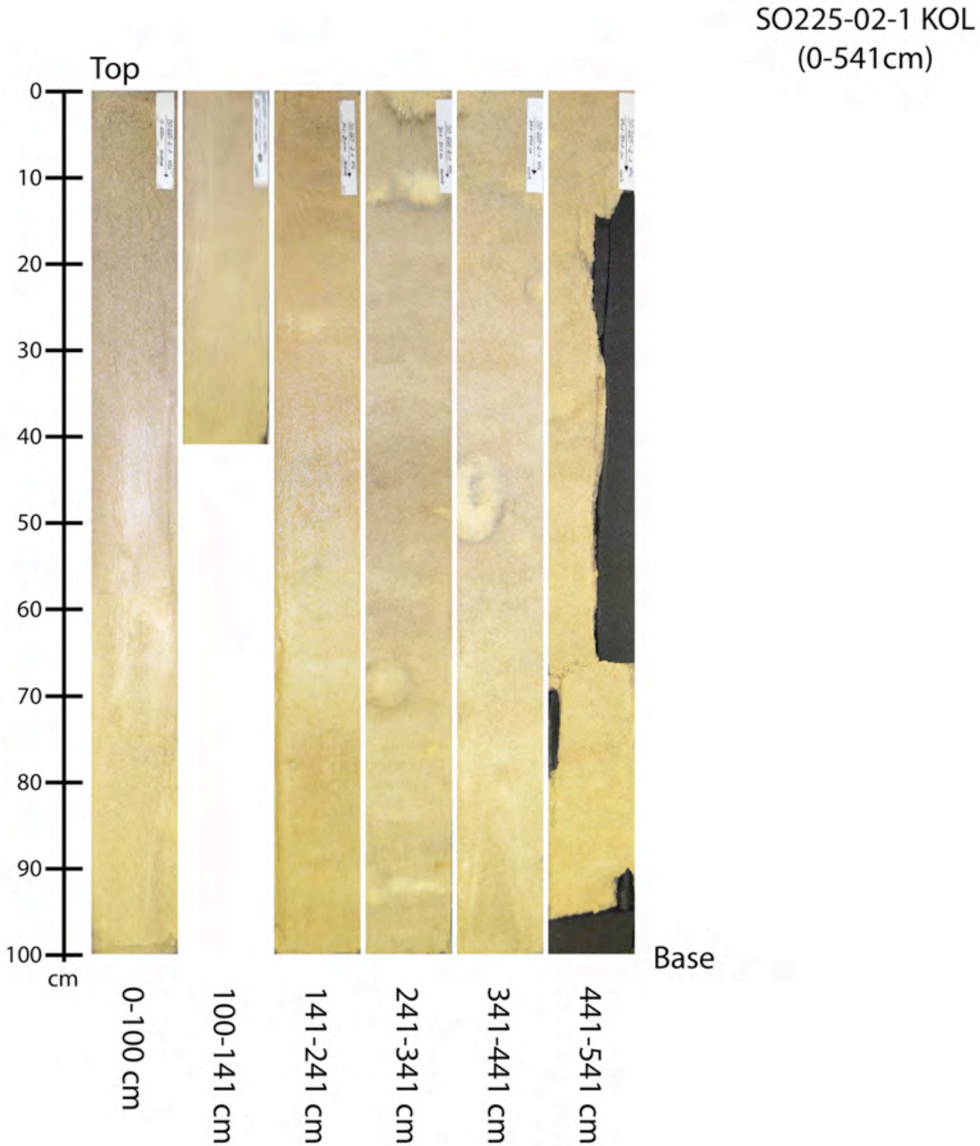
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-27-8	1. Rock Type: volcanic, moderately to strongly altered 2. Size: 13x10x6cm 3. Shape / Angularity: subangular 4. Color of cut surface: greenish grey, yellow 5. Texture / Vesicularity: massive 6. Phenocrysts: no phenocrysts 7. Matrix: matrix coarse cryst., intersertal (ol+cpx+plag) 8. Secondary Minerals: some Mn precipitates, oxidation, ol replaced with Fe-oxides, plag is likely altered 9. Encrustations: some Mn precipitates, thin Mn film on surface 10. Comment: lava, basalt. Similar in type to sample 2-4 but more coarsely crystallized.	1	1	?	?		
SO225-DR-27-9	1. Rock Type: volcanic, strongly altered 2. Size: 12x8x8cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 8. A bit more crystallized and has a lot of Mn precipitates in matrix.	1	1				
SO225-DR-27-10	1. Rock Type: volcanic rock, moderately to strongly altered 2. Size: 11x10x7cm 3. Shape / Angularity: angular 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: similar to sample 9, less coarse crystallized, altered with Mn precipitates	1	1				
SO225-DR-27-11	1. Rock Type: volcanic rock, moderately altered 2. Size: 8x9x3cm 3. Shape / Angularity: angular 4. Color of cut surface: greenish grey with red dots 5. Texture / Vesicularity: vesicular, ~10% vesicles ≤1mm 6. Phenocrysts: Ol phenocrysts ≤2mm replaced with Fe-oxides ~15% 7. Matrix: matrix ophitic, fine xls in altered glass. 8. Secondary Minerals: vesicles partly filled with light green stuff 9. Encrustations: Mn encrustations along microfractures 10. Comment: formerly Ol-phyric, glassy basalt. Should be OK for chemistry, Ar-Ar impossible	1	1				
SO225-DR-27-12	1. Rock Type: sediment, solidified 2. Size: 16x18x10cm 3. Shape / Angularity: purple brown, dark red 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: fine to mid-grained sandstone with lots of Fe-oxides, layered						

Appendix II (Rock Description)

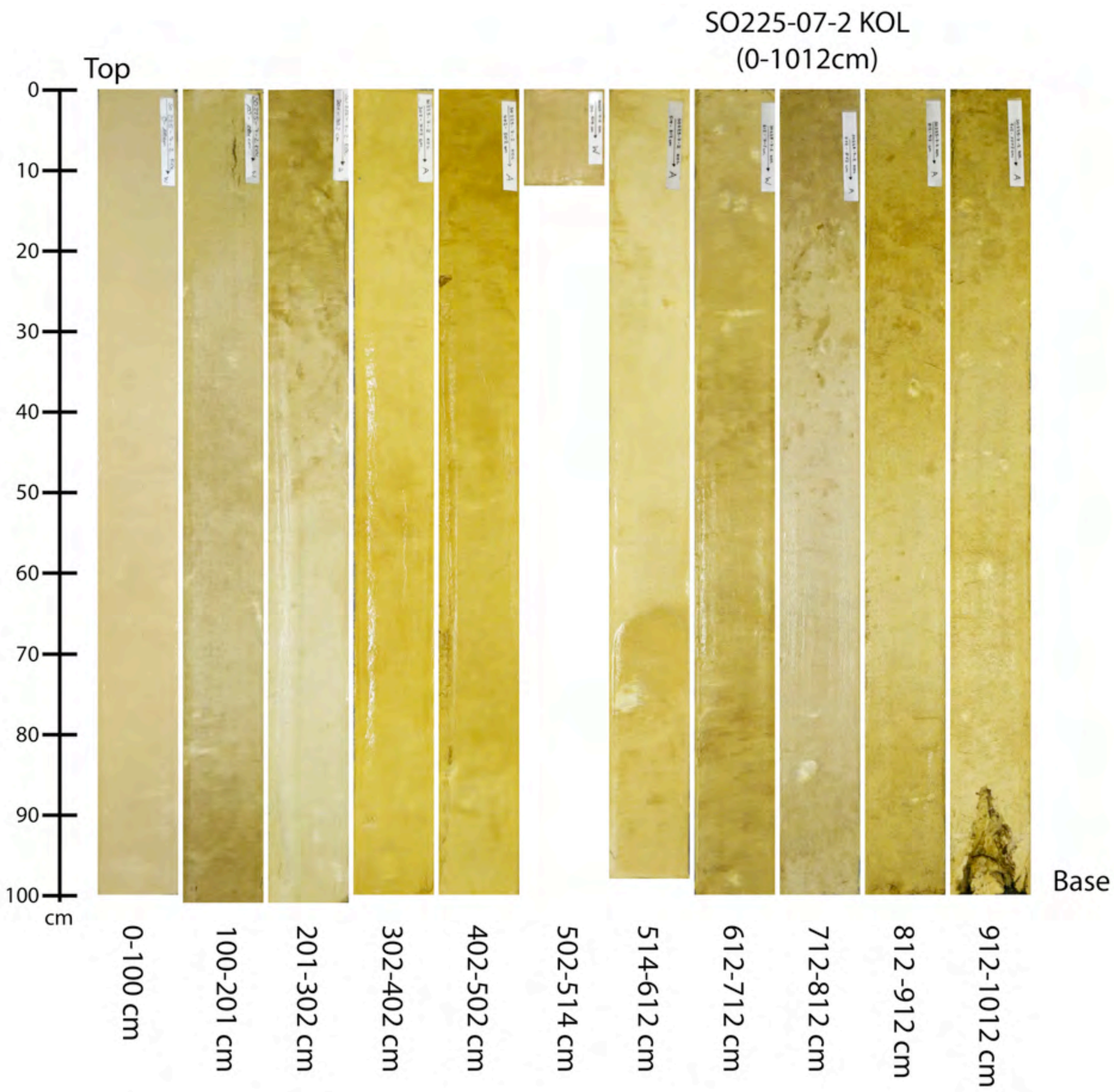
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	Grade	GL/MIN	NOTES	PICTURE
SO225-DR-27-13	1. Rock Type: solidified sediment 2. Size: 14x12x12cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark red with light spots 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: fine-grained sandstone ->predominant type in the dredge							
SO225-DR-27-14	1. Rock Type: solidified sediment 2. Size: 16x7x9cm 3. Shape / Angularity: angular 4. Color of cut surface: purple, red to yellow 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: sandsone with diffuse layering --> Predominant type							
SO225-DR-27-15	1. Rock Type: solidified sediment 2. Size: 10x15x12cm 3. Shape / Angularity: angular 4. Color of cut surface: purple, red with grey layers 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: fine to mid grained sandstone							
SO225-DR-27-16	1. Rock Type: solidified sediment 2. Size: 16x10x6cm 3. Shape / Angularity: subangular 4. Color of cut surface: greenish yellow with larger light and smaller black particles 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: breccia of Mn fragments (22mm) and solidified sediments (≤7mm)							
SO225-DR-27-17	1. Rock Type: sediment breccia of solidified sediments cemented by Mn crust. Prevail purple sandstones (sample 12-13) 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -							

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar Grade	GL/MIN	NOTES	PICTURE
SO225-DR-27-1X	1. Rock Type: archive of sample 1 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						
SO225-DR-27-18Mn	1. Rock Type: 2cm Mn crust on Fe-rich, purple fine grained sandstone 2. Size: - 3. Shape / Angularity: - 4. Color of cut surface: - 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10. Comment: -						

Appendix III (Core Photos)



Appendix III (Core Photos)



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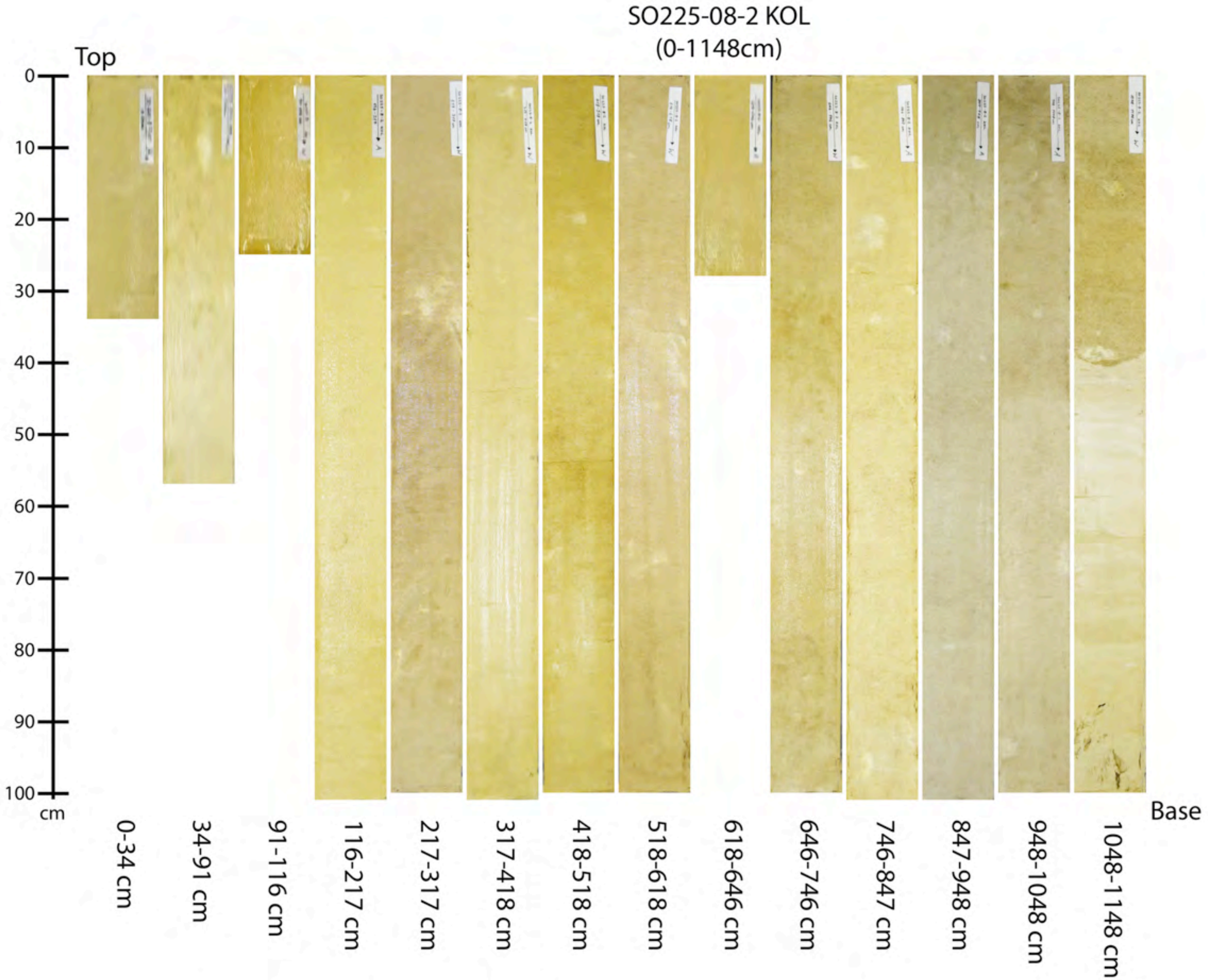

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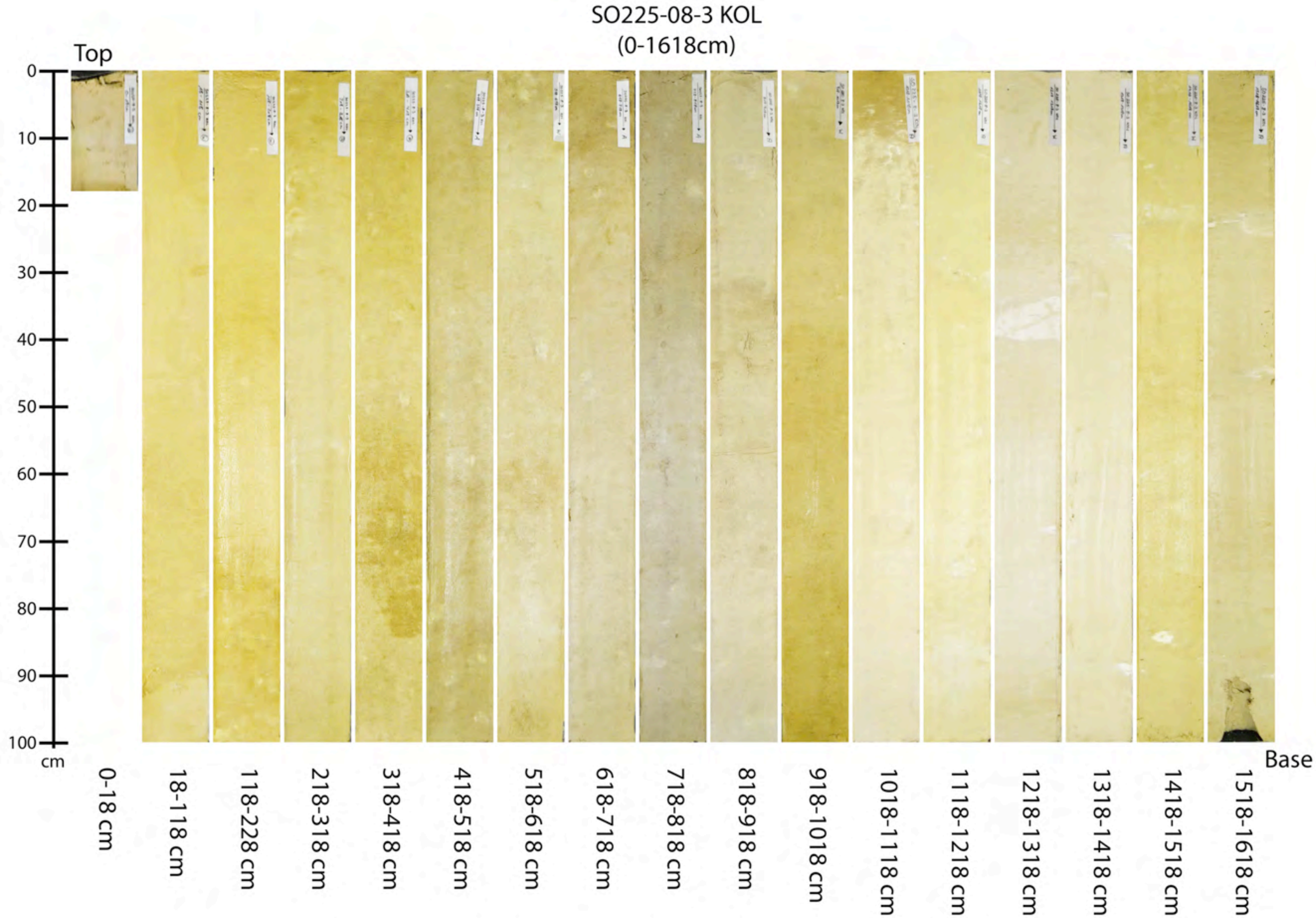

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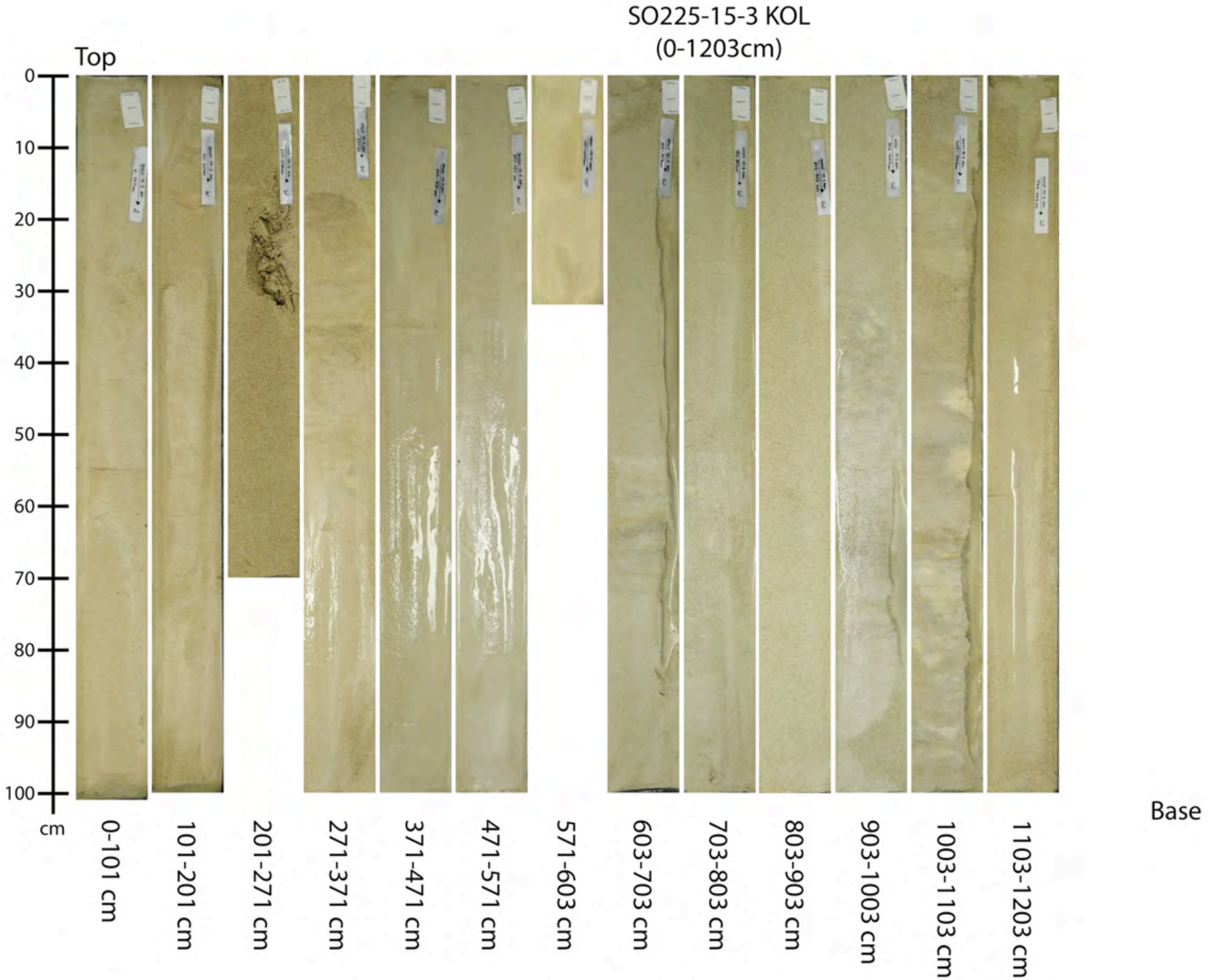

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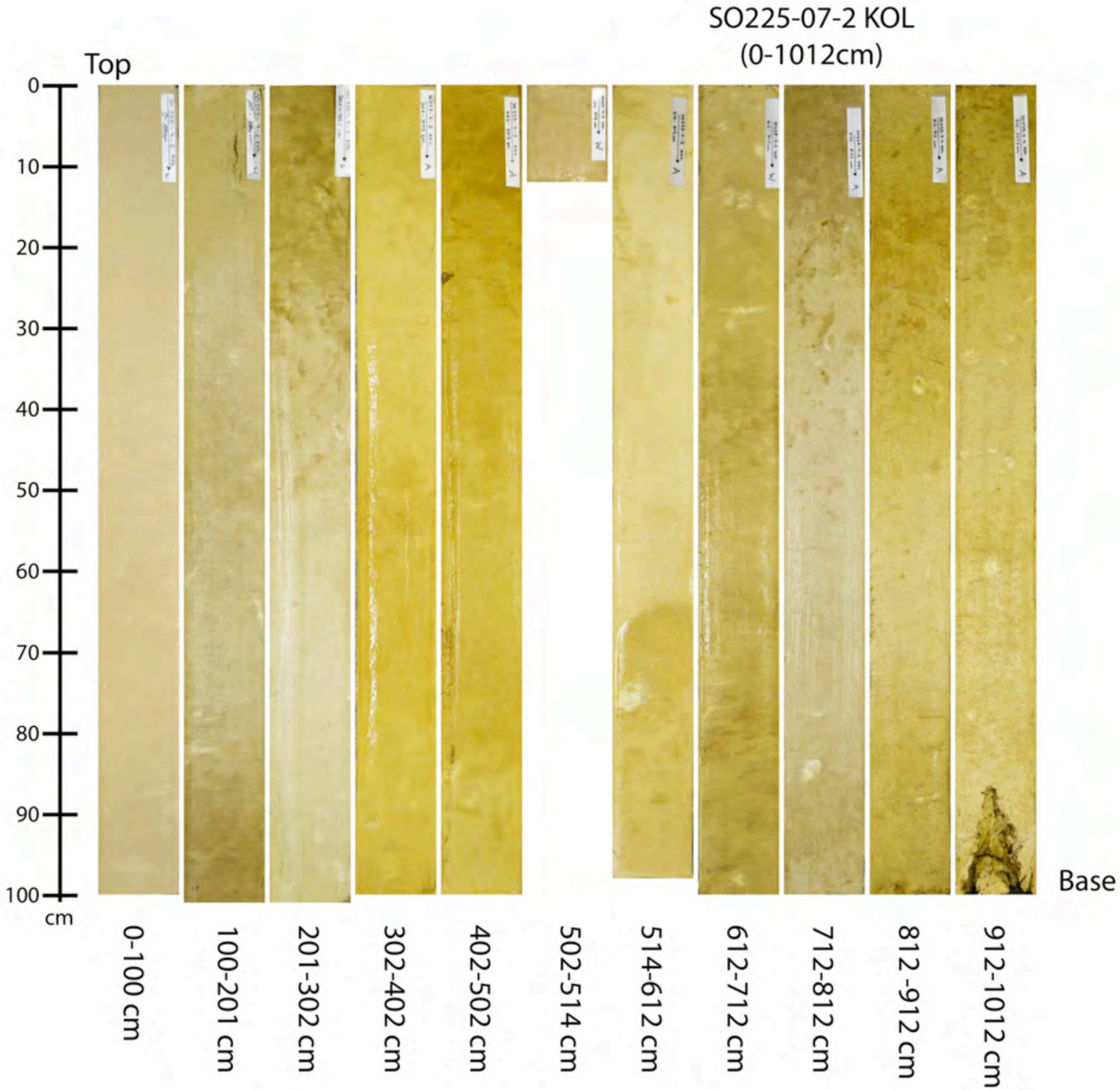

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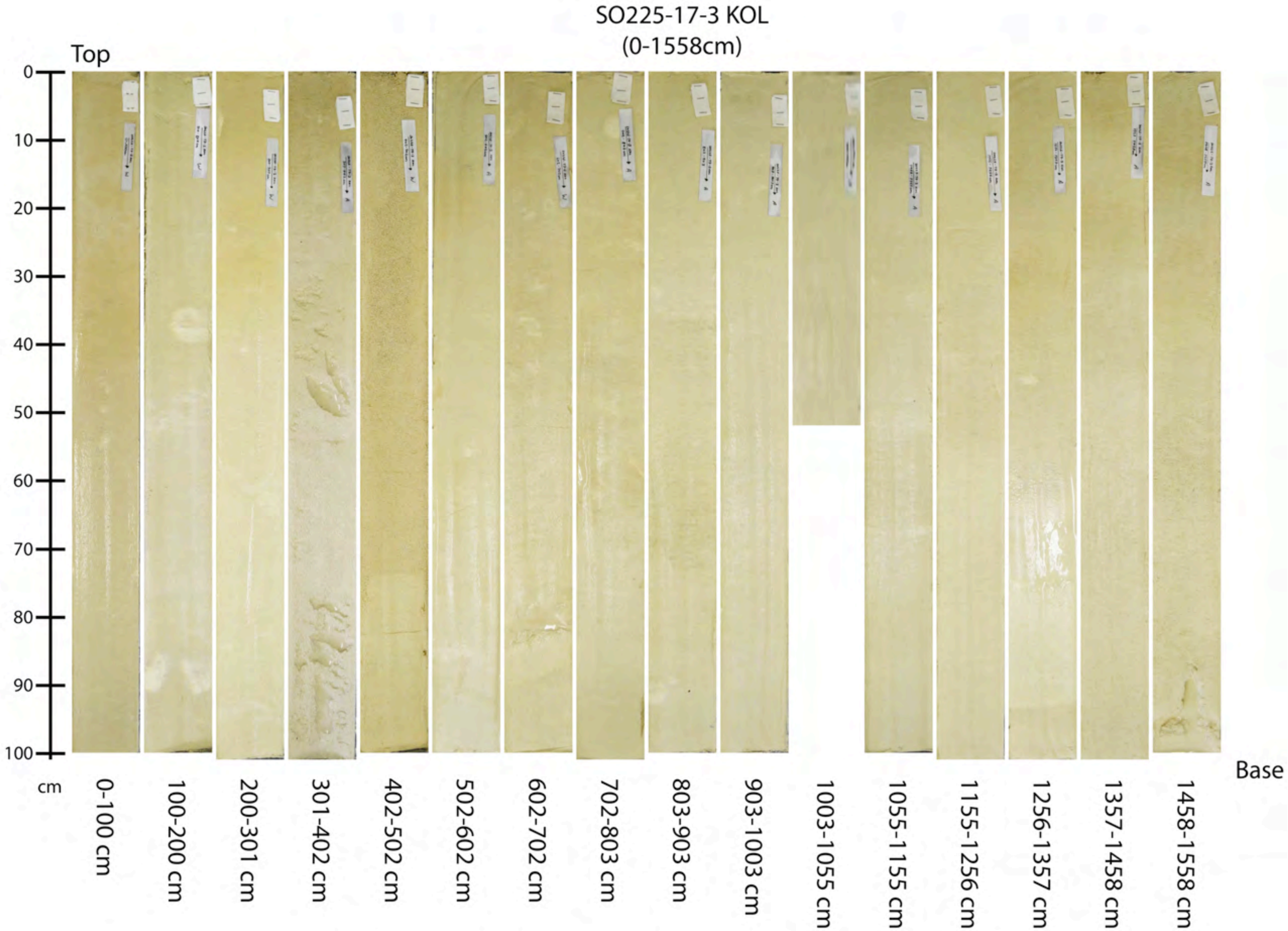

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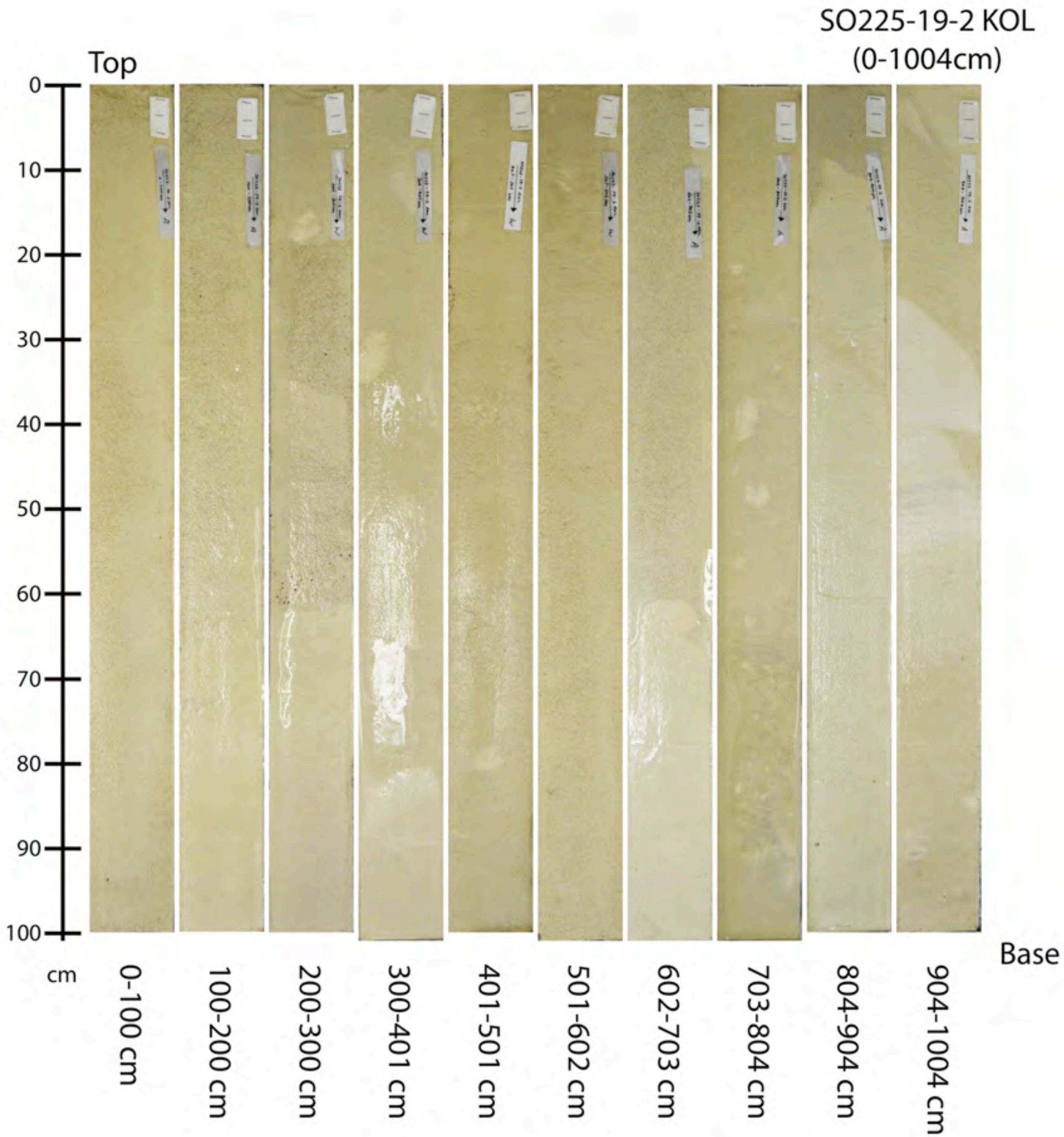

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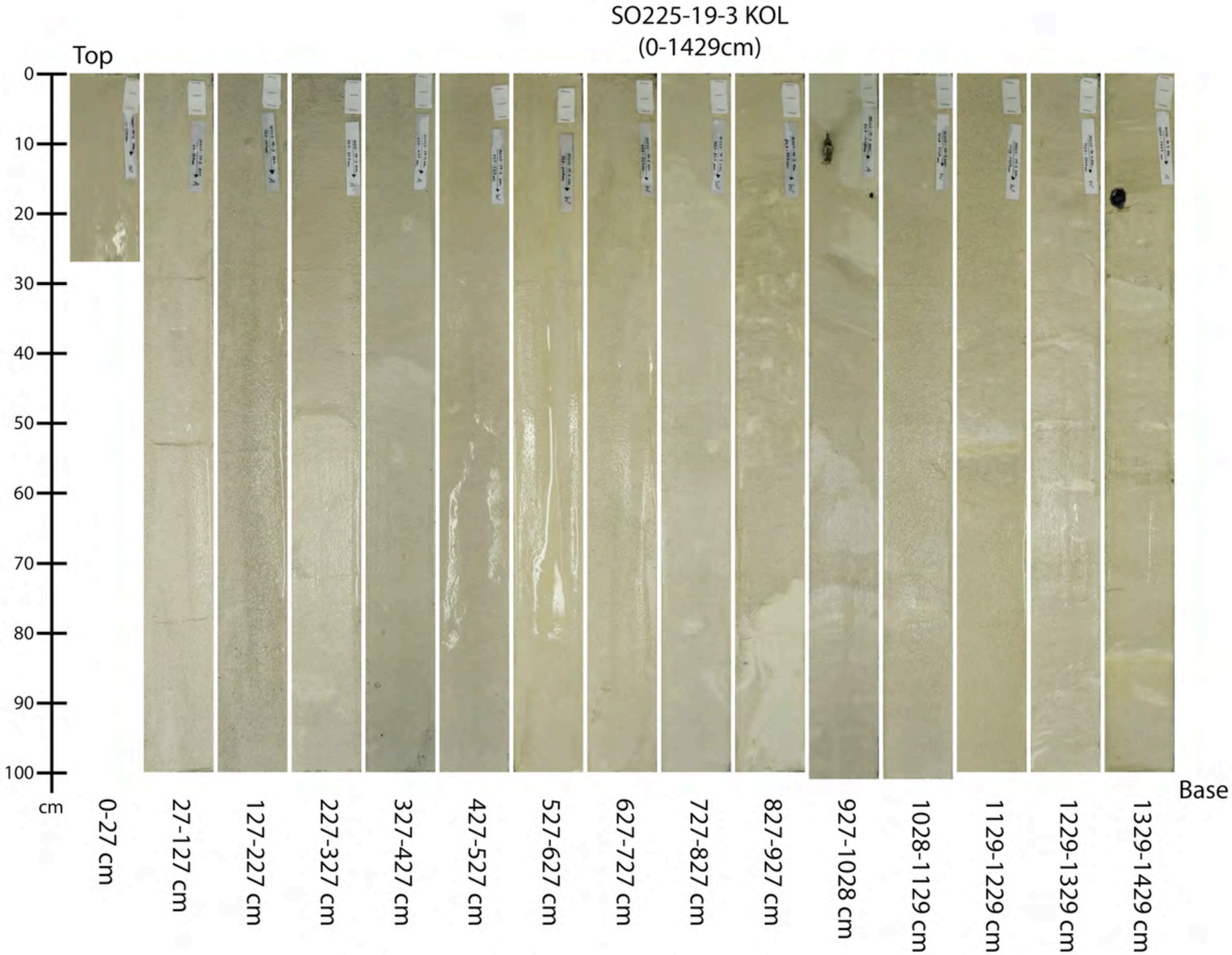
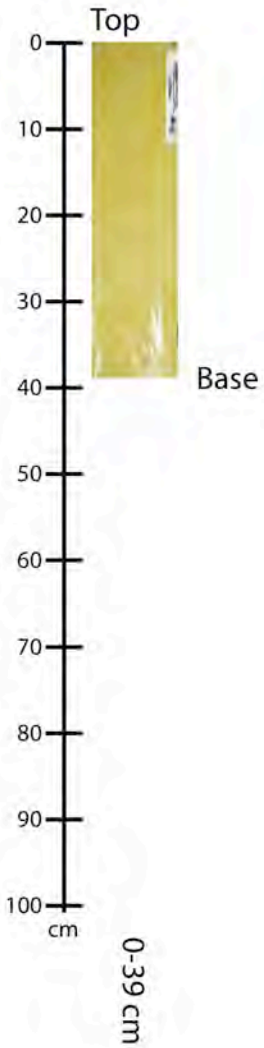
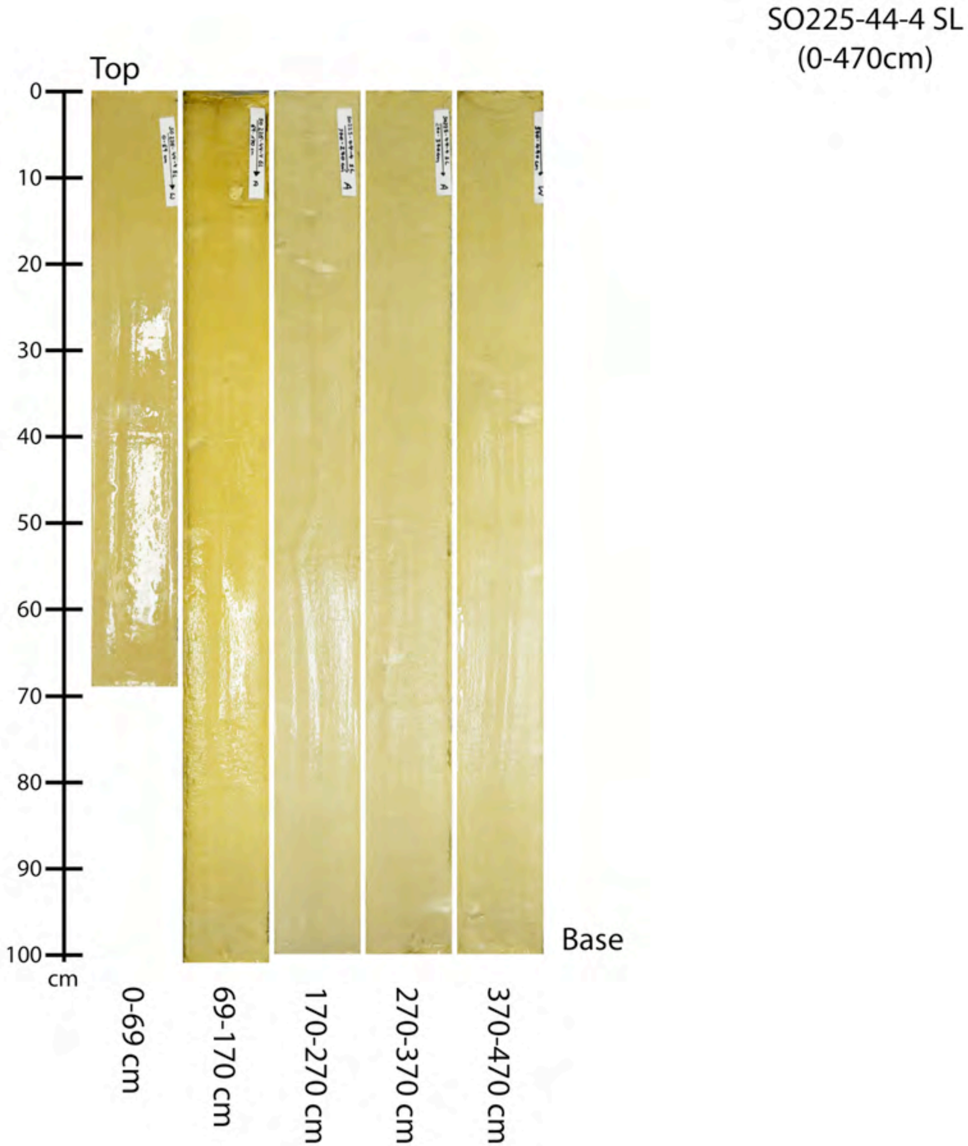


Appendix III (Core Photos)

SO225-44-3 SL
(0-39cm)

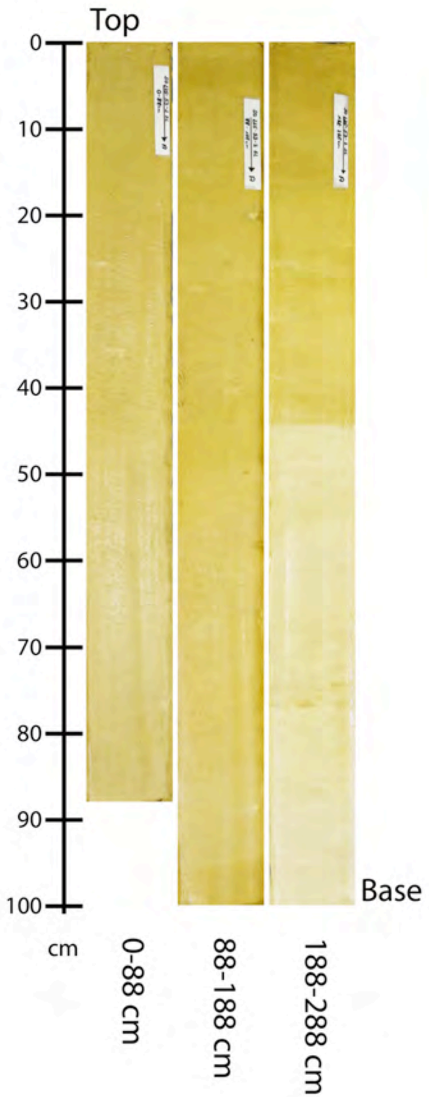


Appendix III (Core Photos)

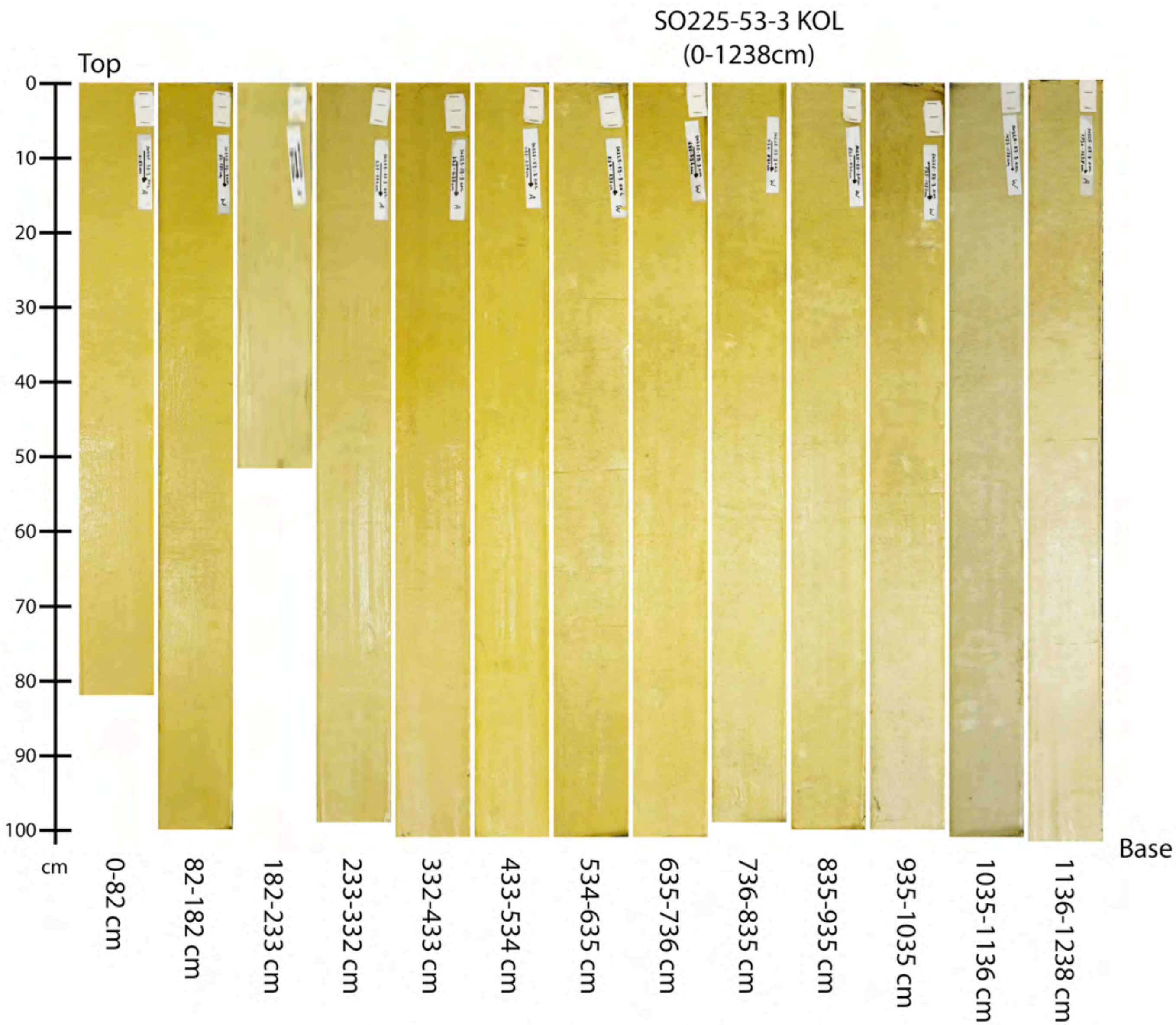


Appendix III (Core Photos)

SO225-53-2 SL
(0-288cm)



Appendix III (Core Photos)



Appendix IV: Core Descriptions

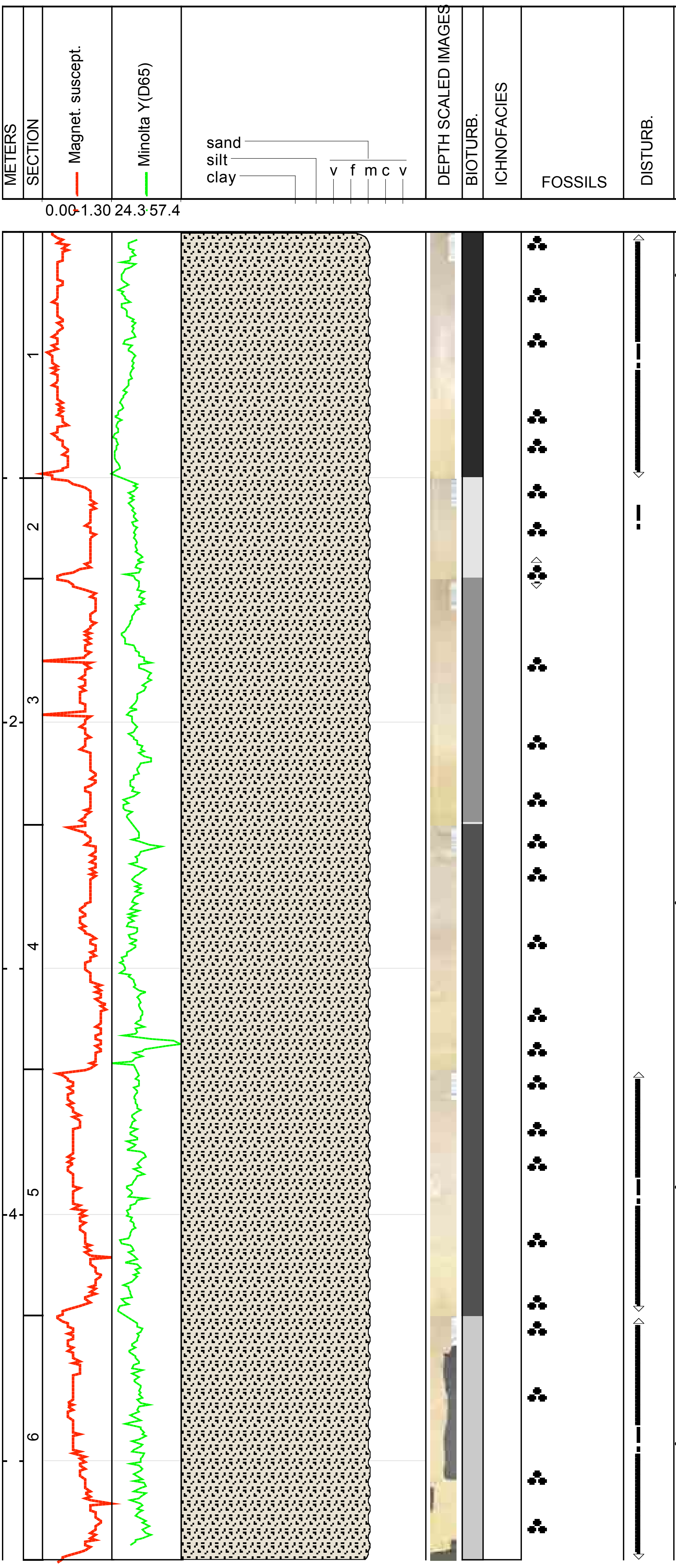
SO225-2-1 KOL

Western Plateaus, southern part 9°58.7490'S, -166°13.5860'W

Date: November 26, 2012

Described By: D. Nuernberg

Water Depth: 2358.00 m Rig Floor to Sea Level: 0.00 m



DESCRIPTION

Forаmininferal sand, whitish to light brownish gray, patchy, moderately bioturbated, homogenous matrix, first meter strongly disturbed due to coring and sediment washout

Foraminiferal sand, grayish brown, strongly bioturbated, burrows upt to 5 cm in diameter, filled with white sediment, dark brown to black margins

at 241-244 cm, 251-254 cm, 289-290 cm, 307-310 cm, 332-334 cm: burrows filled with white sediment

at 254-255 cm: black layer

Foraminiferal sand, whitish to light whitish brown, strongly bioturbated section, section strongly disturbed in lower part due to coring and washout

at 382-392 cm: large burrows filled with white sediment, black margins

Foraminiferal sand as above, whitish to light whitish brown, bioturbated hardly seen, partly layered, section strongly disturbed in lower part due to coring and washout

at 382-392 cm: large burrows filled with white sediment, black margins

LEGEND

LITHOLOGY

FORAM SAND

Lost Core

FOSSILS

Foraminifera (undifferentiated)

CORE DISTURBANCE

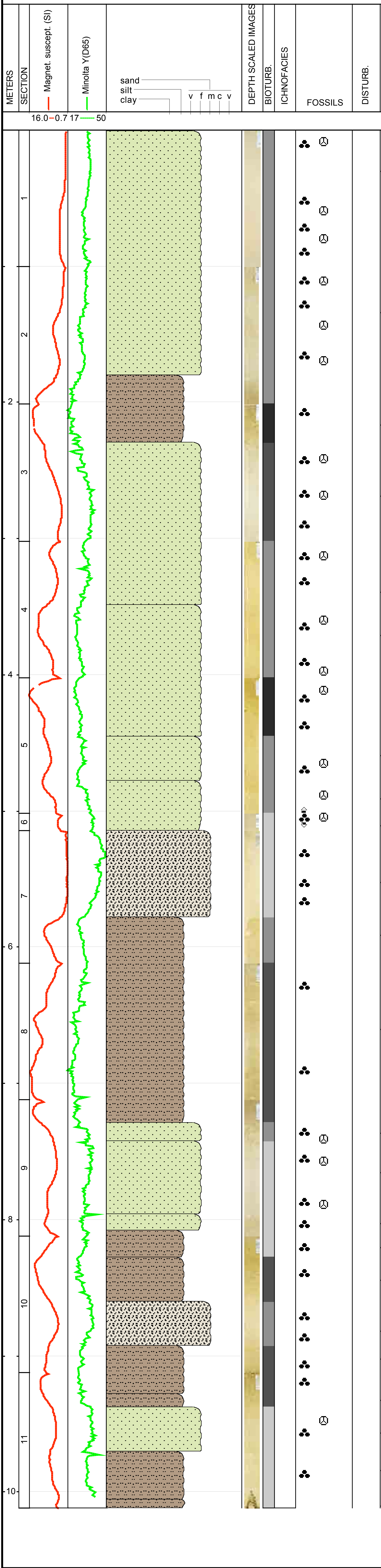
Moderately Disturbed

SO225-7-2 KOL

central Western Plaeteaus 8°57.0270'S, -165°2.4260'W

Date: December 11, 2012
Described By: D. Nuernberg
Water Depth: 3530.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR



DESCRIPTION

Foraminiferal ooze, clayey silty, light yellowish brown, bioturbated, large burrows (cm in diameter) filled with white sediment (foram/ nanno ooze) at bottom of section

Foraminiferal ooze as above

below 130 cm: gradually darkening to yellowish-brown coarse foraminiferal ooze, silty clayey, bioturbated, large burrows (cm in diameter) filled with white foram/nanno ooze all over section, prominent at 160-161 cm, 179-182 cm

below 180 cm: gradually darkening to brownish sandy clayey silt, rich in foraminifera

Sandy clayey silt, brownish, rich in foraminifera, strongly bioturbated, brown burrows at 210-230 cm, becoming lighter downcore, uneven and bioturbated lower contact

Foraminiferal ooze, whitish gray as at top, strongly bioturbated in particular at 230-250 cm

at 290-301 cm: increasingly burrows (cm in diameter) filled with white nanno ooze

Foraminiferal ooze, whitish gray, coarse, homogenous, below 319 cm: increasing number of burrows, uneven contact to below

below 349 cm:
Foraminiferal ooze, clayey silty, gradually darkening downcore to light brown, strongly bioturbated, patchy appearance, gradational contact to below

at 297-299 cm: burrow (cm in diameter) filled with white nanno ooze and brown foraminiferal ooze

Foraminiferal ooze, light yellowish brown, silty clayey, lightening downcore, homogenous, bioturbated

Foraminiferal ooze, whitish gray, homogenous, gradational and bioturbated upper contact

at 486-489 cm: large burrow (cm in diameter) filled with white nanno ooze

(interglacial) Foraminiferal sand, whitish gray, homogenous, soupy, at base: increasing amount of black lithogenic particles (Fe,Mn-crusts), reworked, sharp but uneven lower contact

(glacial) Clayey silt, light yellowish brown, rich in foraminifera, bioturbated, large burrows (cm in diameter) at 686-691 cm, filled with white nanno ooze, homogenous, less soupy and less soft than foraminiferal sand from above

(glacial) Clayey silt, light yellowish brown, rich in foraminifera, stiff, becoming increasingly darker towards section base, strongly bioturbated, patchy appearance, large burrows (cm in diameter) all over section, silled with white grayish foram sand from above

transitional sediment to lower part, strongly bioturbated, burrows abundant, patchy

Foraminiferal ooze, grayish light brown (not as whitish as further above), homogenous, less burrows than above

Foraminiferal ooze as above, slightly stiffer and darker, at 795-797 cm: large burrow filled with white grayish foraminiferal ooze

Clayey silt, gray, lighter than above, homogenous, rich in foraminifera

Clayey silt, slightly darker brwonish than above, patchy, rich in foraminifera, strongly bioturbated, at 849-851 cm: burrow (cm in diameter) filled with white nanno ooze

(interglacial) Foraminiferal sand, clayey silty, bioturbated, brown sediment patches from above

(glacial) Clayey silt, dark grayish brown, rich in foraminifera

transitional sediment to lower part, strongly bioturbated, patchy

Foraminiferal ooze, silty clay, light grayish brown, homogenous

at 928 cm, 932 cm, 947 cm, 958-959 cm, 972 cm, 983 cm, 990 cm: burrows (cm in diameter) filled with foram/nanno ooze

Clayey silt, light brown, rich in foraminifera, homogenous, stiff

Silty clay, dark greenish to olive brown, stiff, dewatered, no foraminifera

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE — FORAM SAND — Lost Core — Sandy silt

FOSSILS

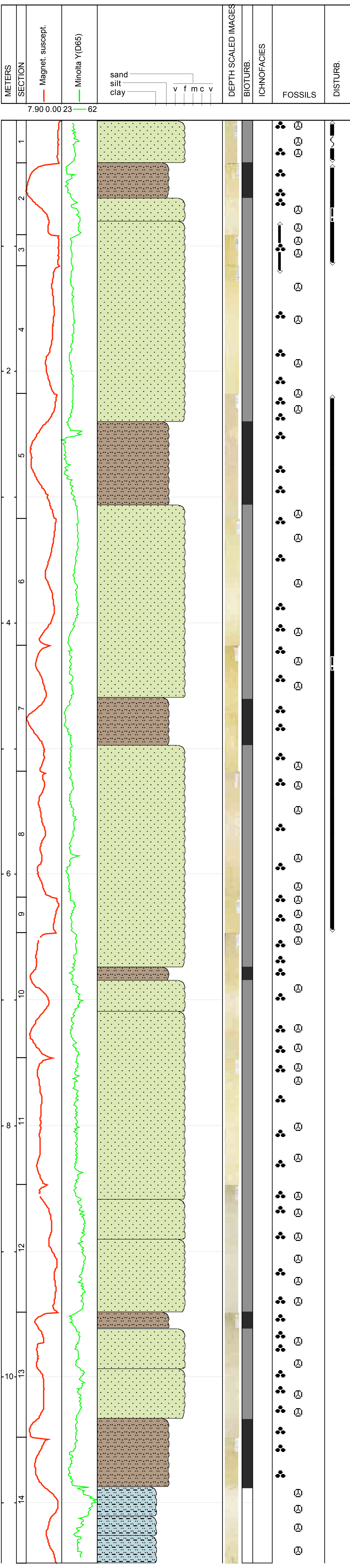
Calcispheres — Foraminifera (undifferentiated)

SO225-8-2 KOL

northern Western Plaeteaus 7°11.9140'S, -165°3.1770'W

Date: December 3, 2012
Described By: D. Nuernberg
Water Depth: 3567.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR



DESCRIPTION

Foraminiferal ooze, light brownish gray, rich in foraminifera, coarse, homogenous, bioturbated

! STRONGLY DISTURBED DUE TO CORING !

Clayey silt (glacial), light olive-brown, patchy appearance, rich in foraminifera, strongly bioturbated

at 43-47 cm: large burrow, filled with white sediment

(transitional) Foraminiferal ooze, gradual color and lithology change downcore from glacial-type sediment to interglacial foram ooze, becoming lighter downcore, less bioturbated, fewer burrows

Foraminiferal ooze (interglacial), whitish gray, homogeneous, coarse

as above
Foraminiferal ooze, light brownish gray, homogenous, moderately bioturbated

Clayey silt (glacial), brownish olive gray, rich in foraminifera, strongly bioturbated, dwoncore changing into transitional sediment: lighter than above, less bioturbated, at 245-258 cm, 291 cm, 297-299 cm: burrows (cm in diameter) filled with white foram/ nanno ooze

! STRONGLY DISTURBED SECTION !

Foraminiferal ooze, light brownish gray, homogenous, soupy

at 319-320 cm, 350-351 cm: burrows (cm in diameter) filled with white foram/nanno ooze

! DISTURBED BY CORING !

as above, but gradually darkening and coarsening downcore, homogenous

Silty clay (glacial), brownish olive gray, rich in foraminifera, not quite typical glacial sediment as above, but less bioturbated

at 437-438 cm, 459-460 cm, 482-484 cm: burrows (cm in diameter), filled with white foram/ nanno ooze

! SECTION STRONGLY DISTURBED !

Foraminiferal ooze (transitional), light brownish gray, clayey silty, becoming lighter and less bioturbated downcore

at 552-586 cm: lighter appearance, more whitish due to abundant white burrows/patches

! STRONGLY DISTURBED BY CORING !

Foraminiferal ooze (interglacial), light whitish gray, homogenous, coarse due to foraminifera, soupy, darkening downcore

! STRONGLY DISTURBED BY CORING !

Clayey silt (glacial), olive brownish gray, patchy appearance, rich in foraminifera, not as typical as further upcore

Foraminiferal ooze, light whitish gray, gradational upper and lower contacts, white burrows/patches at 698-700 cm

(transitional) Foraminiferal ooze to foram rich clayey silt

(transitional) Foraminiferal ooze, light whitish gray to brownish gray, homogenous, coarse, gradual transition to below, moderately bioturbated

at 757-759 cm, 765-770 cm, 775-776 cm, 780-781 cm, 835-837 cm, 839-842 cm: burrows/patches (cm in diameter) filled with white foram/nanno ooze

Foraminiferal ooze, brownish gray, slightly lighter than above, homogenous

(interglacial) Foraminiferal ooze, whitish gray, homogenous, coarse

at 857-858 cm, 882-884 cm, 925-926 cm: burrows/patches (cm in diameter) filled with white foram/ nanno ooze

(glacial) Clayey silt, light brownish olive gray, patchy appearance, rich in foraminifera, strongly bioturbated, uneven and strongly bioturbated lower contact to transitional sediment below

(transitional) Foraminiferal ooze to foram rich clayey silt, becoming lighter downcore, decreasing bioturbation downcore

(interglacial) Foraminiferal ooze, whitish gray, homogenous, grading gradually into sediment below

(glacial) Clayey silt, olive brownish gray, slighty darker than above and further darkening downcore, homogenous, coarse, sharp uneven lower contact

at 958 cm, 962 cm, 980 cm, 994-995 cm, 1006-1009 cm, 1012-1017 cm, 1040-1042 cm: burrows/ patches (cm in diameter) filled with white foram/nanno ooze

Coccolith ooze, very white, pur, fine, clayey, rare in foraminifera

Coccolith ooze, light brownish-white, rich in foraminifera, sharp upper contact, clearly darker than above and below

Coccolith ooze, light brownish white, fine

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE — Cocco Ooze — Lost Core

Sandy silt

FOSSILS

Calcispheres — Foraminifera (undifferentiated)

CORE DISTURBANCE

Moderately Disturbed — Very Disturbed

SO225-8-3 KOL

northern Western Plateaus 7°11.8990'S, -165°3.1810'W

Date: December 4, 2012
Described By: D. Nuernberg
Water Depth: 3589.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR

DESCRIPTION

Forminiferal sand, whitish-gray, coarse sandy, no fine fraction, very soupy, homogenous

Foraminiferal ooze, clayey silt, dominant in foraminifers, slightly darker and stiffer than above, homogenous, unven contact to above

Foraminiferal ooze, clayey silt, dominant in foraminifers, light gray to light grayish brown, gradually darkening and stiffening downcore, homogenous, soupy

Foraminiferal sand, whitish-gray, foraminifers dominant, soupy, no fine fraction

Foraminiferal ooze, clayey silt, dominant in foraminifers, light gray to light grayish brown, , homogenous

at 163 cm, 183 cm: burrow filled with white fine sediment

(glacial?) sandy silt, light olive-gray to brown, rich in foraminifers, strongly bioturbated, patchy

at 195 cm, 201 cm, 209 cm, 217 cm: burrows filled with white sediment (rich in coccoliths)

(transitional type) foraminiferal ooze, sandy silt, light brownish gray, becoming light downcore and changig to light whitish-gray, rich in foraminifers, strongly bioturbated, patchy

(interglacial) Foraminiferal sand, whitish-gray to light brownish-gray, homogenous, soupy

at 273 cm, 304 cm: burrows (-2 cm in diameter) filled with white sediment (rich in coccoliths)

(glacial) sandy silt, light olive-brown, rich in foraminifers, strongly bioturbated, upper contact gradational, lower contact unven and strongly bioturbated

at 339 cm, 354 cm, 367 cm, 405 cm: burrows (cm in diameter) filled with white sediments (rich in coccoliths)

(transitional) foraminiferal ooze, sandy silt, light brownish-gray, homogenous, slightly bioturbated

(transitional type) foraminiferal ooze, sandy silt, light brownish-gray, homogenous, changing dwoncore into glacial type of sediment

(glacial) sandy silt, light olive-gray to brown, rich in foraminifers, strongly bioturbated, patchy

at 426 cm, 458 cm, 465 cm, 469 cm, 476 cm, 498 cm, 505 cm, 514 cm: burrows (cm in diameter), filled with white sediment

(interglacial) Foraminiferal sand, light brownish-gray, homogenous, soupy, coarse, uneven and strongly bioturbated contact to above

Foraminiferal ooze, sandy silt, light brownish-gray, homogenous, uneven and strongly bioturbated contact to above

(glacial) sandy silt, brown, slightly darker than above, more silty and clayey than above, uneven lower contact, rich in foraminifera

(transitional type) Foraminiferal ooze, light grayish-brown, homogenous, bioturbated, gradually becoming darker and stiffer downcore

at 521-523 cm, 558-560, 571 cm, 586 cm, 591 cm: burrows (cm in diameter), filled with white sediment

(transitional type) Foraminiferal ooze, becoming lighter downcore, light brownish gray at base, strongly bioturbated, uneven contacts to above and below

Foraminiferal ooze, light brownish-gray, coarse, stiff, bioturbated

at 626 cm, 636-637 cm, 663.664 cm, 704-705 cm: burrows (cm in diamter) filled with white sediment

(interglacial) Foraminiferal sand, light whitish gray, homogenous, coarse, soupy, gradational lithological change to above.

at 735-736 cm, 771-772 cm, 793-795 cm, 799 cm, 803-804 cm, 805-806 cm, 829-835: burrows (cm in diameter) filled with white sediment

(glacial) sandy silt, rich in foraminifera, dark brown, strongly bioturbated, contacts to above and below strongly bioturbated, uneven, not sharp

(interglacial) Foraminiferal sand, typical as above

at 984 cm, 1013-1016: burrow (cm in diameter) filled with white sediment

(transitional type) Foraminiferal ooze, light brownish-gray, rich in foraminifera, homogenous

(glacial) sandy silt, olive-brown, rich in foraminifera, homogenous

(glacial) sandy clayey silt, extremely dark olive-brown, rich in foraminifera, lower contact strongly bioturbated, uneven but clear and sharp lower contact to underlying sediment

Coocolith ooze, white, slight color changes from 1028-1050 cm with patchy appearance, homogenous, rich in foraminifera above 1050 cm

Coccolith ooze, white to light grayish-white, homogenous, slight internal color changes, patchy appearance, very fine, abundant in foraminifera, bioturbation burrows common

at 1143-1145 cm, 1163-1164 cm, 1185-1187 cm, 1200-1203 cm: burrows (cm in diameter) filled with white sediment

at 1251-1257 cm: large lense/layer of white coccolith ooze with large burrows
at 1285-1286 cm: burrow (cm in diameter) filled with white sediment

at 1342-1344 cm, 1347-1351 cm, 1387-1388 cm, 1405-1407 cm: burrows (cm in diameter) filled with white sediment

coccolith ooze, whitish-gray, homogenous, rich in foraminifera

at 1432-1433 cm, 1438-1440 cm, 1464-1465 cm, 1482 cm, 1500-1502 cm: burrows (cm in diameter) filled with white sediment

at 1535-1542 cm, 1562-1565 cm, 1607-1608 cm: burrows (cm in diameter) filled with white sediment

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE
Sandy silt
Cocco Ooze
FORAM SAND
Lost Core

FOSSILS

Calcispheres
Foraminifera (undifferentiated)

CORE DISTURBANCE

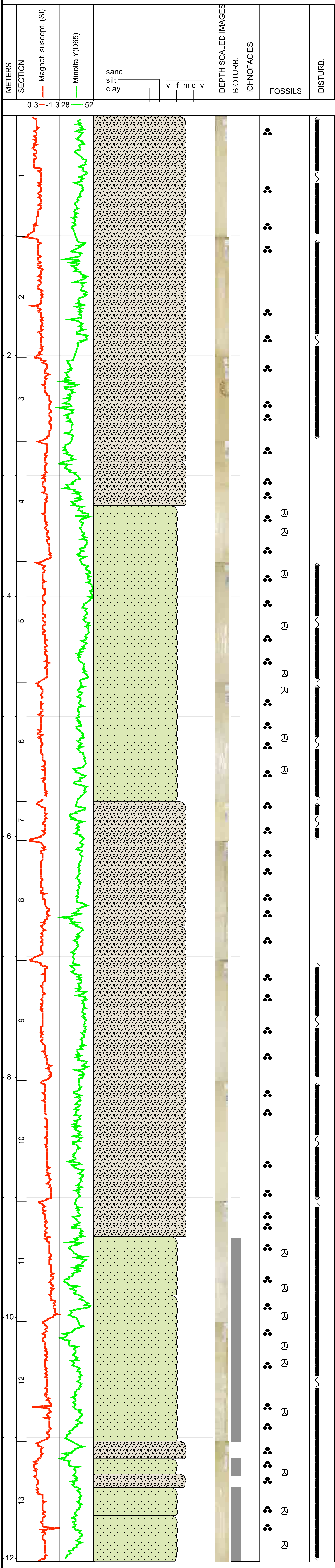
Moderately Disturbed
Soupy

SO225-15-3 KOL

North Plateau, southern part 5°47.8600'N, -164°46.0010'W

Date: December 13, 2012
Described By: D. Nuernberg
Water Depth: 1826.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR



DESCRIPTION

Foraminiferal sand, light whitish gray, coarse, soupy ! NOT ORIGINAL LAYERING! completely disturbed section due to coring and outwash

at ca. 220-230 cm: sediment disturbed by nylon socket

Foraminiferal sand, whitish gray to dark brownish gray, appearing darker than above due to black/ brown streaks and layers, coarse, soupy, no longer disturbed sediment (only marginally)

Foraminiferal ooze, light grayish white, soupy, more silty and clayey than above, homogenous

STRONGLY DISTURBED SECTION Foraminiferal ooze and foraminiferal sand as above, homogenous, soupy ! No original bedding, strongly mixed !

as above

Foraminiferal sand, whitish gray, homogenous ! STRONGLY DISTURBED ! NO ORIGINAL LAYERING !

Foraminiferal sand, whitish gray, appears darker than above due to black layers/patches, horizontally layered, more silty and clayey

! DISTURBED BY OUTWASH !

Foraminiferal sand, whitish gray, coarse, homogenous, soupy

Foraminiferal sand, whitish gray, homogenous, coarse, soupy, partly mixed with foraminiferal ooze, more clayey silty

! STRONGLY DISTURBED SECTION !

as above

! STRONGLY DISTURBED SECTION !

Foraminiferal ooze, clearly darker appearance than above, due to black patches, streaks and layers, soupy, more silty and clayey, strongly bioturbated, at 936-939 cm: burrows (cm in diamter) filled with with foram/nanno ooze

! STRONGLY DISTURBED SECTION !

Foraminiferal ooze, whitish, soupy, mixed with foraminiferal sand, whitish gray

! STRONGLY DISTURBED SECTION !

as above

! STRONGLY DISTURBED SECTION !

Foraminiferal ooze, whiter than sand from above, strongly bioturbated, at 1146-1149 cm, 1154-1158 cm: burrows (cm in diameter) filled with white foram/ nanno ooze

Foraminiferal ooze, light brownish olive gray, darker than above (glacial?), partly layered, rich in foraminifera, less soupy, strongly bioturbated, at 1168-1171 cm, 1182-1184: white patches

! STRONGLY DISTURBED SECTION !

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE — FORAM SAND — Lost Core

FOSSILS

Calcispheres — Foraminifera (undifferentiated)

CORE DISTURBANCE

Very Disturbed

SO225-17-2 KOL

North Plateau, central part 4°45.9770'S, -164°37.0390'W

Date: December 9, 2012

Described By: D. Nuernberg

Water Depth: 3248.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR

DESCRIPTION

Foraminiferal sand, partly ooze, whitish-gray, coarse, soupy, homogenous (interglacial)

at 62-68 cm: core disturbance due to nylon socket
below 82 cm: large clasts of white, stiff, silty clayey foram ooze

! SECTION DISTURBED DUE TO OUTWASH ! NO ARCHIVE HALF !

as above, increasing portion of foraminiferal ooze, very soupy, partly enriched with small black/dark lithogenic particles (Fe,Mn crusts)

Foraminiferal ooze, light brownish-gray, silty clayey, no more soupy, stiffer (transitional), homogenous

at 222.225 cm, 262-274 cm: large white clasts of clayey foram/nanno ooze

layer of pure foraminiferal sand, dry, dewatered

Foraminiferal ooze (transitional), whitish gray, silty clayey, homogenous, burrows abundant, bioturbated

Foraminiferal sand, whitish gray, coarse, soupy, homogenous, sharp contact to above, no fine fraction

Foraminiferal sand, brownish gray, coarse, homogenous, fining downcore, transition to below is rather gradational over broader range, strongly bioturbated, large burrows filled with fine-grained foram/nanno ooze

Foraminiferal ooze, whitish to light brownish gray, silty clayey, homogenous

at 623-625 cm, 645-646 cm, 650-655 cm, 665-666 cm, 684-687 cm: burrows/patches (cm in diameter) filled with white foram/nanno ooze

Foraminiferal ooze as above, light brownish gray, patchy, partly dark lithogenic particles abundant

at 709-803 cm, 731-737 cm, 750-754 cm, 809-819 cm: burrows/patches (cm in diameter) filled with white foram/nanno ooze
at 798-804 cm: large circular patch/burrow (6 cm in diameter) filled with white foram/nanno ooze
at 782-785 cm: whitish layer, no lithological change

Clayey sand silt (glacial?), dark gray, slightly darker than above, rich in foraminifera, strongly bioturbated, sharp upper contact, lower contact gradational, uneven, bioturbated, grading into sediment below

Foraminiferal ooze, slightly darkening below 877 cm, homogenous, even but bioturbated contact to below
at 862-864 cm, 880-884 cm, 886-889 cm: white burrows

Clayey silt (glacial), light olive brown, clearly darker than above, rich in foraminifera, strongly bioturbated, lower contact gradational and strongly bioturbated

transitional sediment, clayey silt to foraminiferal ooze, becoming lighter downcore, strongly bioturbated, grading into sediment below

Foraminiferal ooze (transitional), light whitish gray, silty clayey, homogenous, bioturbated

at 1135-1137 cm, 1141-1142 cm, 1168-1171 cm, 1179-1183 cm, 1187-1188 cm: patches/burrows (cm in diameter) filled with white foram/nanno ooze

Foraminiferal ooze, very light whitish gray, stiff, clayey, homogenous, bioturbated, minor color change

as above, slighty darker, brownish white gray

Foraminiferal ooze, light whitish gray, clayey silty, homogenous, strongly bioturbated
at 1353-1357: burrow/pactch (cm in diameter) filled with white foram/nanno ooze

Foraminiferal ooze, light whitish gray, clayey, intercalated with more sandy parts of foraminiferal sand, homogenous, bioturbated, patchy appearance in parts

at 1428-1429 cm, 1504-1505 cm: burrows/patches filled with white foram/nanno ooze

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE | FORAM SAND | Lost Core

Sandy silt

FOSSILS

Calcispheres | Foraminifera (undifferentiated)

CORE DISTURBANCE

Very Disturbed

SO225-17-3 KOL

North Plateau, central part 4°45.9700'S, -164°37.0010'W

Date: December 14, 2012
Described By: D. Nuernberg
Water Depth: 3247.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR

DESCRIPTION

Foraminiferal ooze, light brownish white, clayey silty, homogenous, soupy

at 50-51 cm, 54-55 cm: burrows (cm in diameter) filled with white sediment

Foraminiferal ooze, light brownish white to gray, less soupy downcore

at 36-41 cm, 48-54 cm, 85-91 cm: burrows/ patches (cm in diameter) filled with white sediment

as above

at 233-24 cm, 61-62: burrows/patches (cm in diameter), filled with white sediment

as above, sharp but uneven contact to below

at 308-310 cm: burrow/ patch (cm in diameter), filed with white sediment

Foraminiferal sand, whitish-gray, homogenous, soupy, slightly disturbed sediment

Foraminiferal sand as above, sharp and even contact to below

Foraminiferal ooze, grayish-white, silty clayey, homogenous, stiff

Foraminiferal ooze as above, becoming downcore more whitish due to higher portion of coccolith ooze, homogenous

at 557-559 cm, 586-589 cm: increasingly white patches of coccolith ooze

Foraminiferal to coccolith ooze, light grayish white, homogenous, soupy, white patches/burrows all over section but particularly

at 620-621 cm, 630-631 cm, 635-638 cm, 641-642 cm

Foraminiferal sand, grayish white, more stiff, less soupy than above, homogenous

at 703-704 cm, 709-710 cm: large white patches/ burrows

Foraminiferal ooze, appears darker than above and below, strongly bioturbated, many burrows, less soupy

Foraminiferal ooze, grayish white, homogenous, soupy

at 835-836 cm:: white burrows

Foraminiferal ooze, slightly darker olive gray than above, bioturbated, more clayey and silty

Foraminiferal ooze, whitish gray, soupy, homogenous, white burrows

Foraminiferal ooze, very light whitish gray, rich in coccoliths, slightly bioturbated

as above

Forамininferal ooze, light whitish gray, soupy, rich in coccoliths, bioturbated

at 1185-1186 cm, 1188-1190 cm, 1205-1207 cm: burrows (cm in diameter) filled with white sediment

Foraminiferal ooze, clearly darker than above, light whitish brownish gray, homogenous, soupy, stiff

at 1121-1123 cm: white burrow

as above, gradually darkening downcore, in particular at section base due to more black and brownish streaks, bioturbated

Foraminiferal ooze to coccolith ooze, very bright white, homogenous, slightly bioturbated

as above, gradually darkening downcore towards light olive gray

at 1295-1301: white burrows

Foraminiferal ooze, very fine, homogenous and soupy

Foraminiferal sand, light whitish gray, hoogenous, even and sharp contact to above and below

Foraminiferal ooze, light brownish gray, homogenous as above, becoming lightly lighter downcore, no bioturbation visible

as above,no lithological change

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE | FORAM SAND | Lost Core

CONTACTS

Sharp

FOSSILS

Calcispheres | Foraminifera (undifferentiated)

CORE DISTURBANCE

Slightly Disturbed

SO225-19-2 KOL

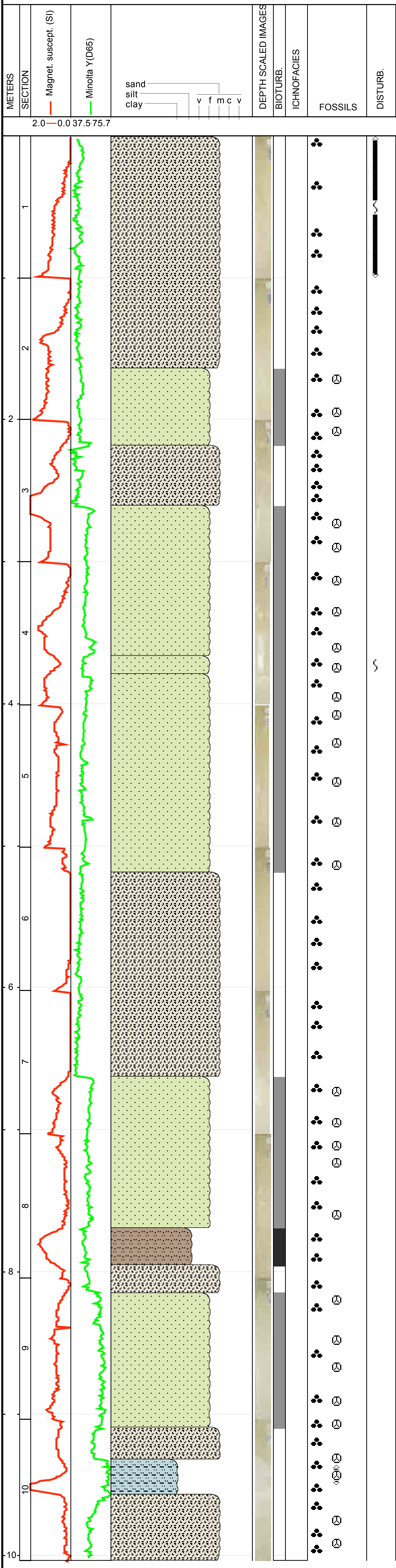
northern foothills of North Plateau 3°47.5440'S, -164°53.2310'W

Date: December 12, 2012

Described By: D. Nuernberg

Water Depth: 3558.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR



DESCRIPTION

Foraminiferal sand, whitish gray, pure, coarse, homogenous, soupy

! STRONGLY DISTURBED SECTION!
! ONLY WORK HALF PRESERVED !

Foraminiferal ooze, whitish gray, no significant color change to above, clayey silty, more stiff, less soupy than above, uneven, bioturbated lower contact

Foraminiferal sand, as above, whitish gray, coarse, soupy, homogenous, enriched with small brown and black lithogenic particles, angular (Fe,Mn crusts?)

Foraminiferal ooze, whitish gray, silty clayey, homogenous, strongly bioturbated

at 314-317 cm, 330-337 cm, 348-351 cm, 354-360 cm, 360-365 cm: burrows (cm in diameter) filled with white foram/ nanno ooze

Foraminiferal ooze, light whitish brown, very fine, very homogenous, stiff, dry

! STRONGLY DISTURBED !

Foraminiferal ooze, grayish white, silty clayey, homogenous, rich in foraminifera

at 439-440 cm, 458-460 cm, 478-481 cm: burrows (cm in diameter) filled with white foram/nanno ooze

Foraminiferal sand, whitish gray, pure, coarse, soupy, homogenous, no bioturbation visible

Foraminiferal ooze, whitish gray, stiff, homogenous, upper contact possibly bioturbated

as above, increasingly bioturbated downcore with burrows filled with white foram/nanno ooze at 724-725 cm, 735-744 cm, 749-752 cm, 758-759 cm, 765-766 cm

(glacial) sandy clayey silt, more greenish olive white, patchy appearance, black mottles, rich in foraminifera, strongly bioturbated

Foraminiferal sand, whitish gray, soupy

Foraminiferal ooze, brownish white, partly nanno ooze, soupy, homogenous, no bioturbation visiblem upper contact strongly bioturbated, or due to coring very uneven, but sharp

Foraminiferal sand, whitish gray, homogenous, soupy, sharp but uneven contact to below due to core disturbance

Nanno ooze, white, clearly lighter than foram ooze, more stiff and fine, homogenous, rich in foraminifera, layering visible in lower part due to black streaks

(transitional) Foraminiferal sand, whitish gray, soupy, white burrows at 993-998

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE

Sandy silt

Cocco Ooze

FORAM SAND

Lost Core

FOSSILS

Calcispheres

Foraminifera (undifferentiated)

CORE DISTURBANCE

Very Disturbed

SO225-19-3 KOL

northern foothills of North Plateau 3°47.5370'S, -164°53.2330'W

Date: December 10, 2012
Described By: D. Nuernberg
Water Depth: 3558.00 m   Rig Floor to Sea Level: 0.00 m

GEOMAR

DESCRIPTION

strongly disturbed by coring/outwash

Foraminiferal sand (pure), coarse, whitish gray, homogenous

! strongly disturbed by coring/outwash !

200-227 cm: increasing portion of lithogenic particles, black to brown (Fe,Mn crust), reworked from downslope transport

Foraminiferal sand, whitish gray, coarse, homogenous

Foraminiferal ooze, more clayey silty, rich in foraminifera, homogenous

Foraminiferal sand layer, sharp upper and lower contacts

Foraminiferal sand, grayish white, homogenous, strongly bioturbated, clearly lighter than above
at 296-299 cm: layer of foraminiferal sand, enriched with reworked, dark lithogenic fragments (Mn,Fe crusts) from downslope transport
at 315-317 cm, 347-349 cm: burrows (cm in diameter), filled with white foram/nanno ooze sharp even contact to below

Foraminiferal ooze, clayey silty, whitish, clearly lighter than above, homogenous, strongly bioturbated
at 422-427 cm: lense of foram sand with abundant reworked lithogenic particles (Fe,Mn crust)

Foraminiferal sand, light grayish white, soupy, coarse, homogenous, bioturbated

Foraminiferal ooze, more clayey silty, grayish white, clearly lighter than above, homogenous, bioturbated, soupy
at 779-780 cm, 804-806 cm: burrows (cm in diameter) filled with white foram/nanno ooze

(glacial) sandy silty clay, light olive brown, rich in foraminifera, strongly bioturbated, sharp lower contact

Foraminiferal sand (pure), gray, soupy, homogenous

Coccolith ooze, light white, rich in foraminifera, homogenous, uneven sharp contact to above

Coccolith ooze, white, strongly disturbed and mixed with Foraminiferal ooze, whitish gray, silty

at 936-939 cm: large (3 cm) rounded pebble of lithified sandstone (downslope transport), light brown with black Fe,Mn coating

at 990-995 cm: probably shell remain and ichnofossils

Foraminiferal ooze, whitish gray, gradational contact to upper nanno ooze, white, lower contact uneven and bioturbated

Foraminiferal sand, whitish gray, soupy, coarse, homogenous, large burrows/patches abundant, filled with with sediment, e.g. at 1103-1104

Sandy clayey silt (trnasitional to glacial?), brownish gray, rich in foraminifera, strongly bioturbated

Foraminiferal sand, compact layer, light whitish gray, homogenous, upper contact gradational and bioturbated, lower contact sharp, lowermost cm more light brownish

as above

Foraminiferal sand, whitish gray, as above

Foraminiferal ooze, whitish gray to grayish white, strongly bioturbated

at 1266-67 cm, 1278-79 cm, 1286-1288 cm: white layers of nanno ooze

Foraminiferal ooze as above, whitish gray to grayish white, strongly bioturbated

at 1346-1349 cm: round pebble (2 cm in diameter), black "cannonball", small pebbles abundant, due to downslope transport
at1358-1359 cm: thin (1 cm) layer of pebbles (< 0.5 cm), reworked lithified sediment and volc. crusts, sharp lower contact

Foraminiferal ooze to sandy clayey silt, strongly bioturbated, many white burrows/ patches

Foraminiferal sand, whitish gray, soupy

at 1410-1417 cm: Foraminiferal ooze, top cm white, below more brownish gray, uneven contact to above

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE
Cocco Ooze
Lost Core
Sandy silt
FORAM SAND

FOSSILS

Calcispheres
Foraminifera (undifferentiated)

CORE DISTURBANCE

Very Disturbed

SO225-44-3 SL

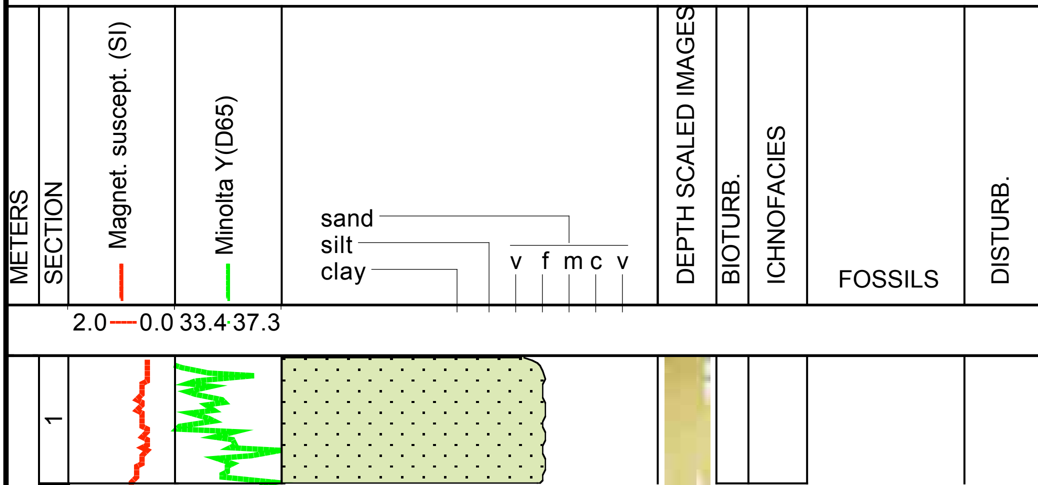
High Plateau, southern part 11°3.0770'S, -161°31.9110'W

Date: December 25, 2012

Described By: D. Nuernberg

Water Depth: 3005.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR



DESCRIPTION

! STRONGLY DISTURBED BY CORING !

Foraminiferal ooze, light brownish gray, soupy, homogenous, only working half preserved

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE

Lost Core

SO225-44-4 SL

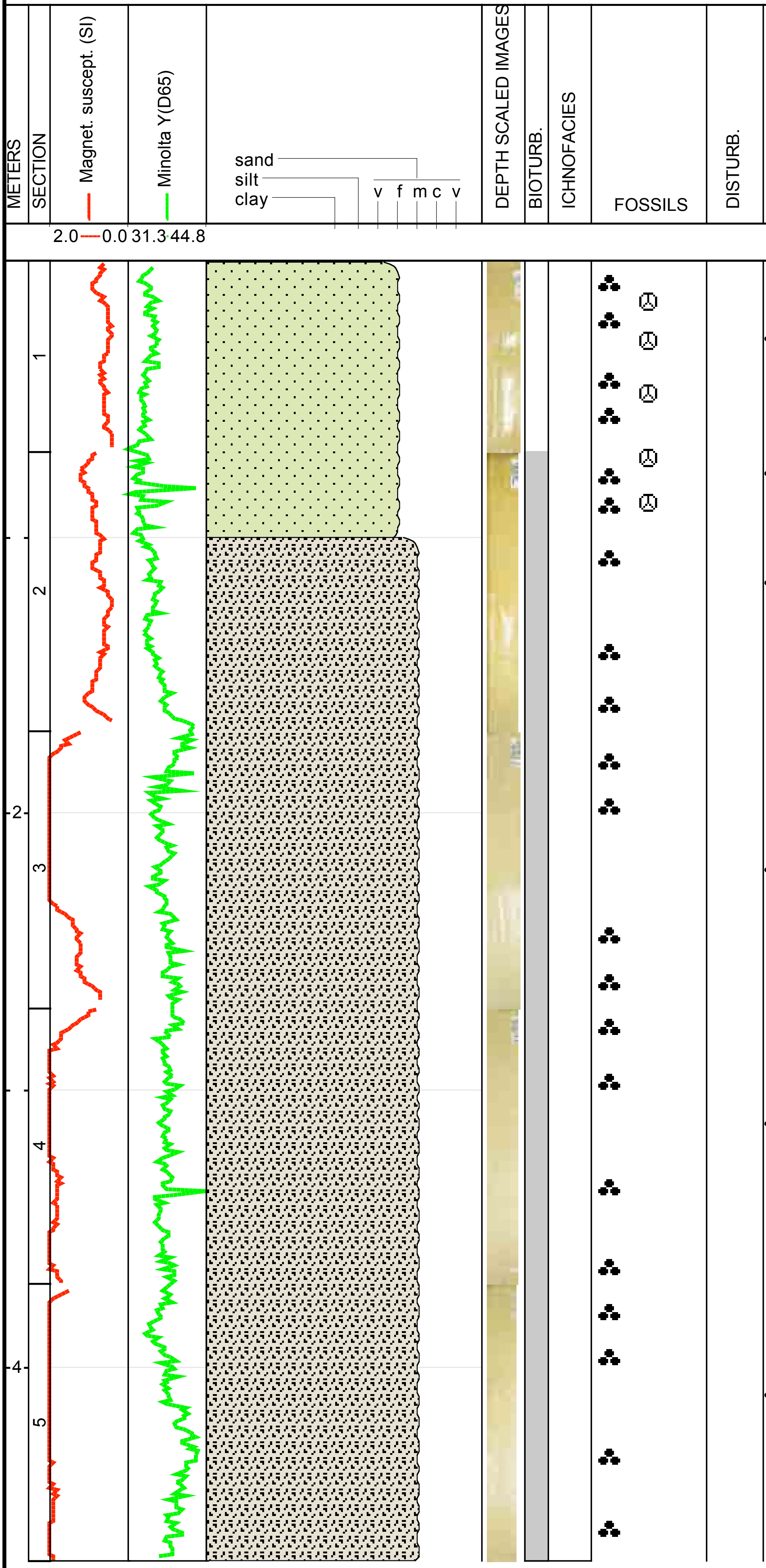
High Plateau, southern part 11°3.0800'S, -161°31.9200'W

Date: December 25, 2012

Described By: D. Nuernberg

Water Depth: 3005.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR



DESCRIPTION

! STRONGLY DISTURBED BY CORING !

Foraminiferal ooze, light brownish gray, soupy, homogenous

at 25-26 cm, 36-39 cm, 58-59 cm: burrows/ patches (cm in diameter) filled with white foram/ nanno ooze

as above
at 80-82 cm:: burrows/ patches (cm in diameter) filled with white foram/ nanno ooze

grading gradually into

Foraminiferal sand, whitish gray, soupy, coarse, homogenous

as above
at 175-176 cm, 184-185 cm, 190-192 cm, 197-198 cm: white patches

as above
at 278-280 cm, 336-337 cm: burrows (cm in diameter) filled with white foram/nanno ooze

as above

Foraminiferal sand, becoming lighter downcore

at 405-408 cm, 425 cm, 463-465 cm: burrows (cm in diameter) filled with white foram/nanno ooze

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE

FORAM SAND

Lost Core

FOSSILS

Calcispheres

Foraminifera (undifferentiated)

SO225-53-2 SL

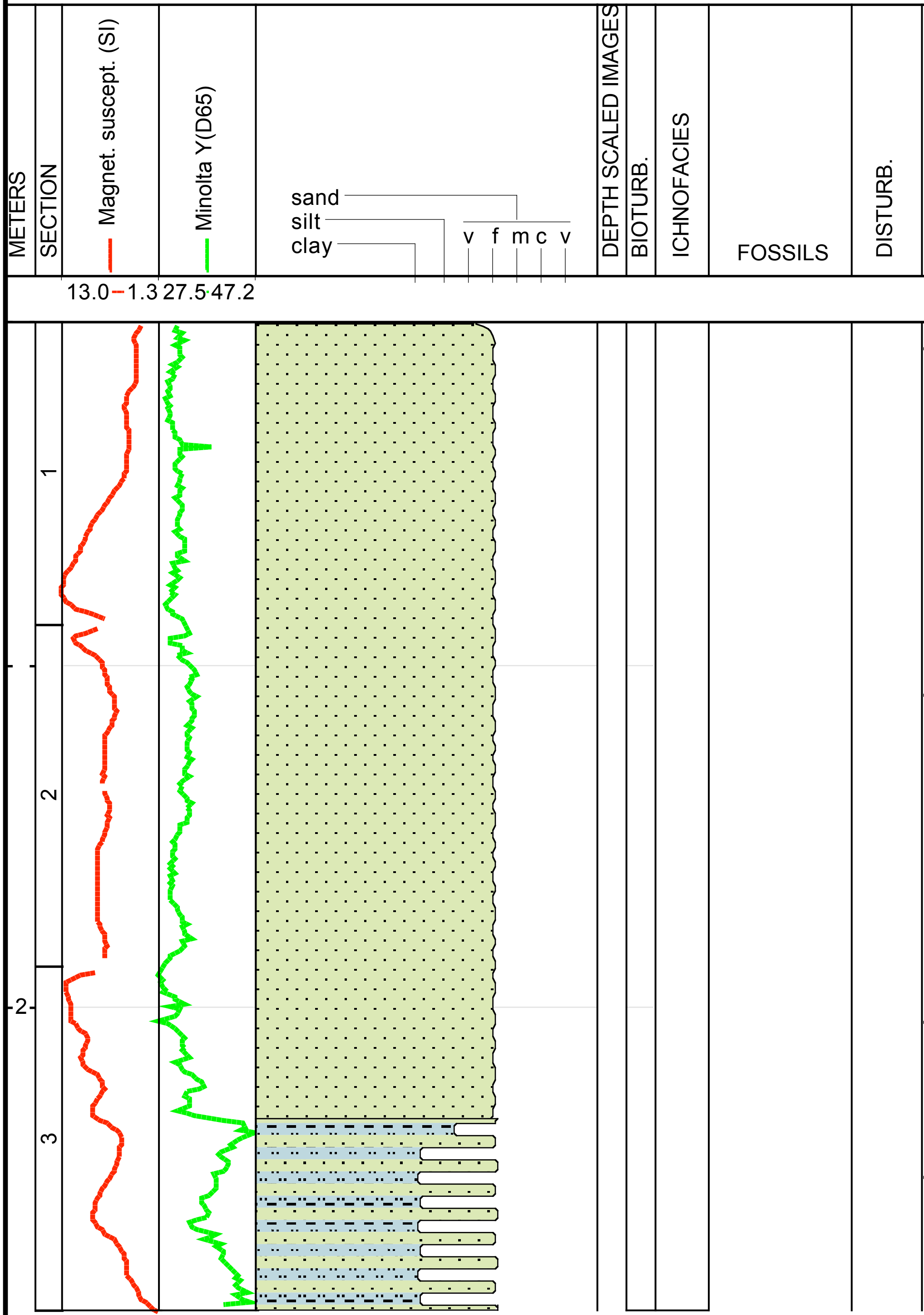
High Plateau, southern margin 13°31.2500'S, -162°8.3390'W

Date: December 28, 2012

Described By: D. Nuernberg

Water Depth: 3153.00 m   Rig Floor to Sea Level: 0.00 m

GEOMAR



DESCRIPTION

← Foraminiferal ooze, light brownish gray, coarse, homogenous, soupy in upper part of section, "rubberlike", white patches/burrows at 24-25 cm, 34-35 cm

← as above, stiff, less soupy, white patches/ burrows at 109 cm, 129-130 cm

← as above, white patches/ burrows at 214-215 cm

← at 232 cm: sharp, even contact to sediment below, clear color change

Nanno/Foraminiferal ooze, whitish gray, coarse, rich in foraminifera and nannoplankton (white!), partly darker appearance due to brown patches

LEGEND

LITHOLOGY

FORAMINIFERAL OOZE

Cocco Ooze

Lost Core

SO225-53-3 KOL

High Plateau, southern margin 13°31.2610'S, -162°8.3310'W

Date: December 29, 2012
Described By: D. Nuernberg
Water Depth: 3152.00 m Rig Floor to Sea Level: 0.00 m

GEOMAR

DESCRIPTION

Foraminiferal ooze, light brownish gray, coarse, homogenous, soupy in upper part of section, "rubberlike", white patches/burrows at 48-50 cm, 65-67 cm

as above, no color change, no clear lithological change, gradually fining downcore, less soupy, white patches/burrows at 118-119 cm, 152-154 cm

as above, soupy, light brownish gray

at 232 cm: sharp, even contact to sediment below, clear color change

Nanno/Foraminiferal ooze, whitish gray, coarse, rich in foraminifera and nannoplankton (white!), partly darker appearance due to brown patches

Foraminiferal ooze as above, slightly less brownish, soupy, white patches at 279-280 cm, 303-306 cm, 316-317 cm

as above, homogenous, less soupy

Foraminiferal ooze as above, no lithological change, white patches at 445-446 cm, 463-464 cm, 477-478 cm, 485-486 cm

as above, white patches at 536-537, 560-561 cm, 586-587 cm, 625-626 cm

as above, still light brownish gray, homogenous, soupy, coarse, in parts darker appearance due to bronw mottles/streaks, few white patches at 715-717 cm

as above

Foraminiferal ooze, slightly lighter than above, very small color change, homogenous, coarse, white patches at 769-771 cm, 797-799 cm

Foraminiferal ooze as above, more grayish, slightly lighter below ca. 860 cm, increasingly bioturbated below ca. 860 cm, white patches at 846-857 cm, 923-925 cm

(glacial) Foraminiferal ooze, slightly darker than above, (dark) brownish gray, coarse, homogenous, white patches at 952-959 cm, 966-969 cm, 985-987 cm

(transitional) Foraminiferal ooze, gradually lightening downcore, patchy appearance due to stronger bioturbation

Foraminiferal ooze, light brownish gray, clearly lighter than above, increasing portion of nanno ooze, homogenous

Foraminiferal ooze with large portion of nanno (coccolith) ooze, whitish gray, still very coarse due to abundant foraminifera, but silty clayey, soupy, increasingly bioturbated downcore, increasingly white patches below ca. 1100 cm: at 1098-1100 cm, at 1116-1120 cm, incerasingly darker at 11083-1106 cm, darkening at base

As above, slightly darker foraminiferal to nanno ooze, strongly bioturbated down to 1169 cm, patchy appearance, uneven, gradational and bioturbated contact to below

at 1169-1238 cm: no lithological change but clearly lighter, whitish gray foraminiferal to nanno ooze, white patches at 1185-1186 cm, 1191-1193 cm, 1198-1200 cm

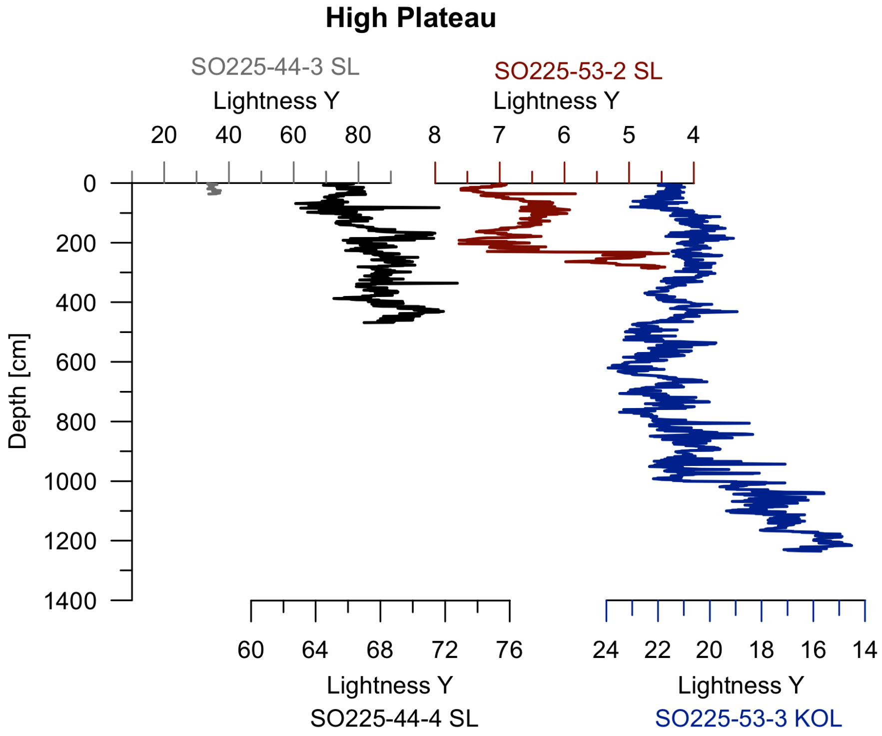
LEGEND

LITHOLOGY

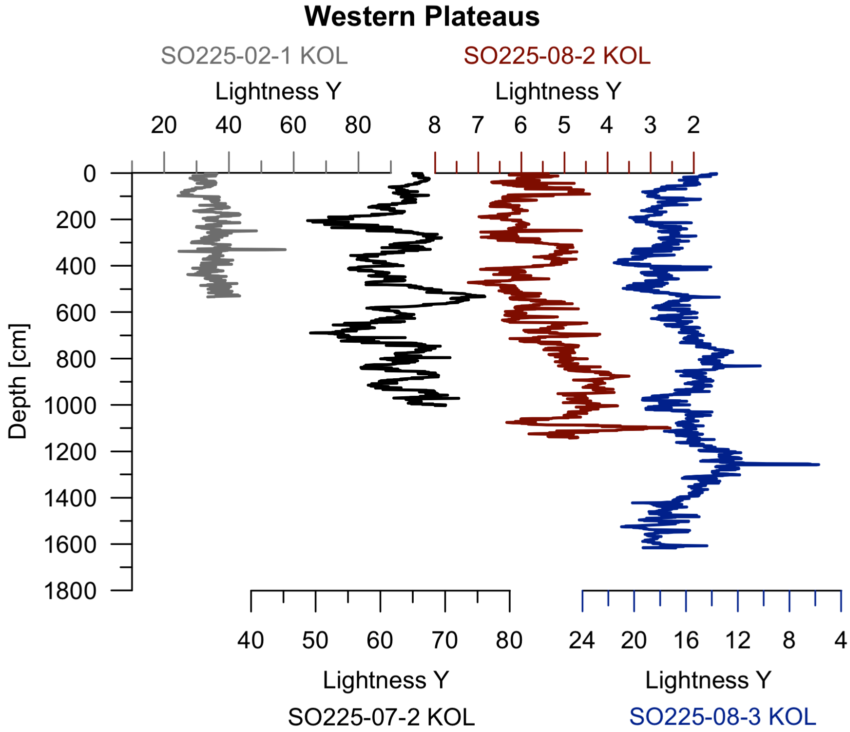
FORAMINIFERAL OOZE — Cocco Ooze — Lost Core

FOSSILS

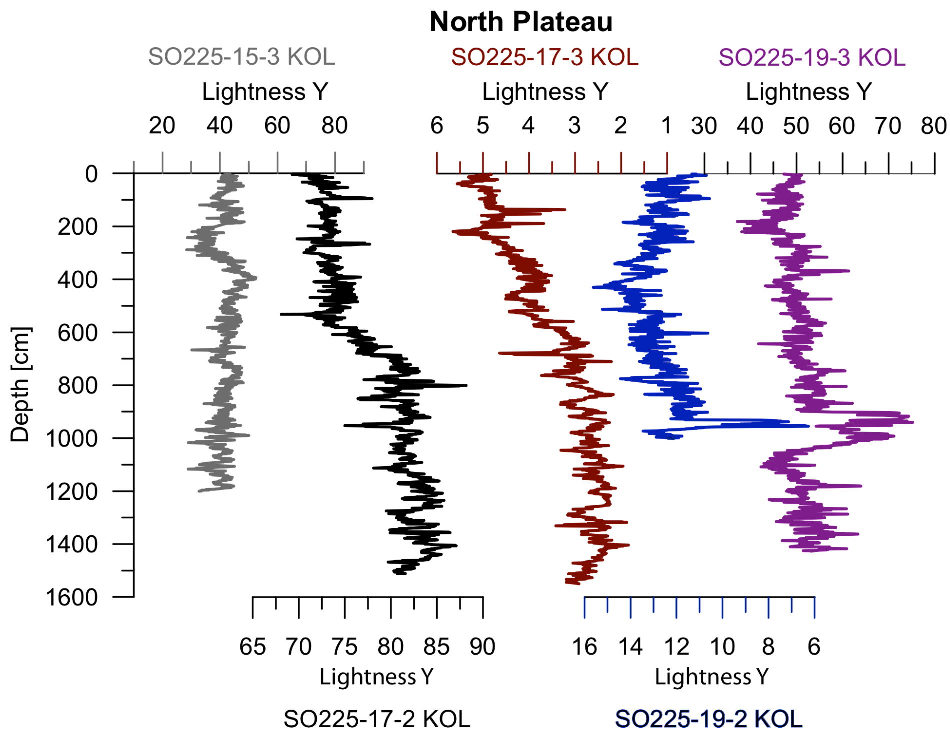
Calcispheres — Foraminifera (undifferentiated)



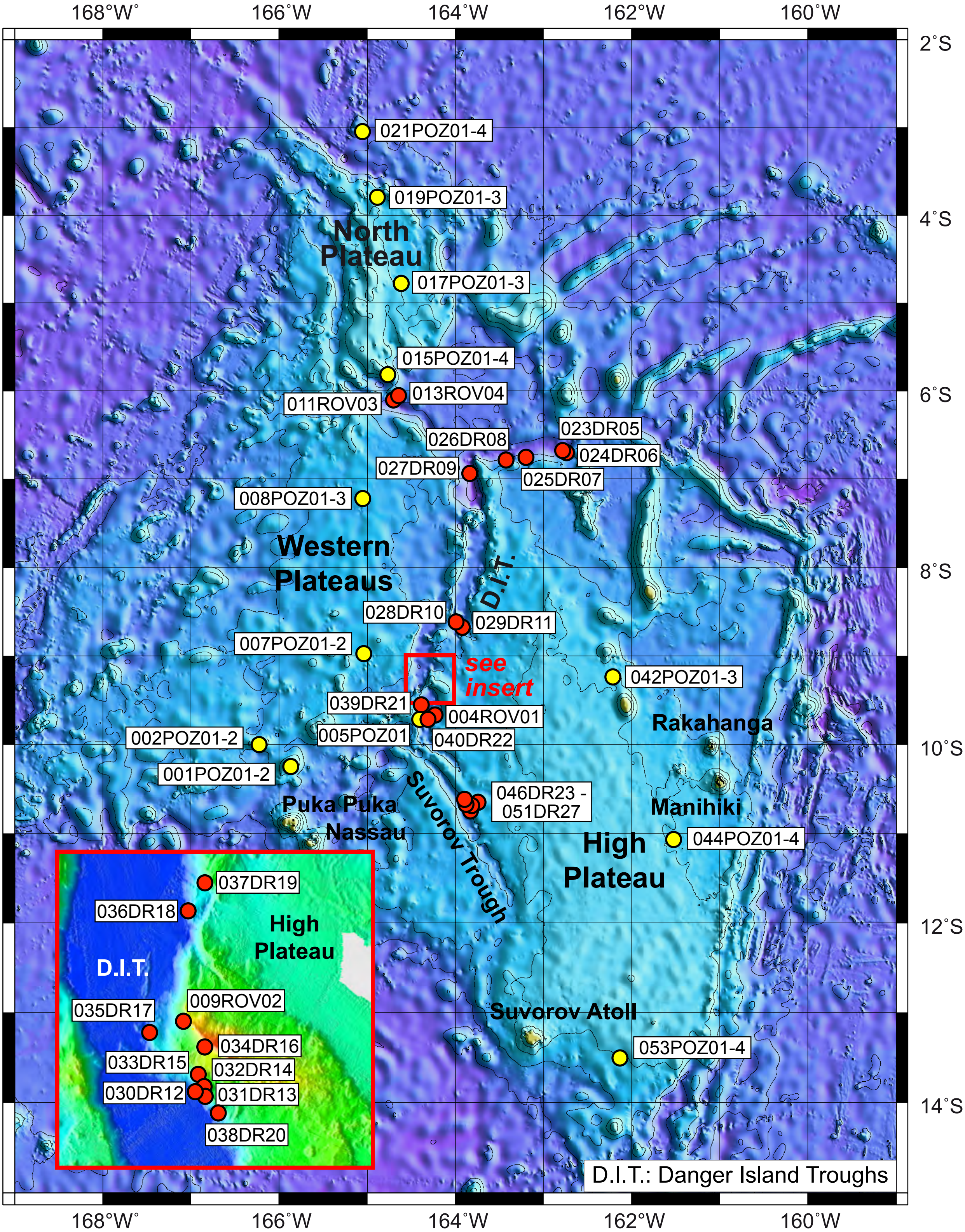
High Plateau
SO225-44-3 SL
Lightness Y
20
40
60
80
SO225-53-2 SL
Lightness Y
8
7
6
5
4
Depth [cm]
0
200
400
600
800
1000
1200
1400
60
64
68
72
76
Lightness Y
SO225-44-4 SL
24
22
20
18
16
14
Lightness Y
SO225-53-3 KOL



Western Plateaus
SO225-02-1 KOL
SO225-08-2 KOL
Lightness Y
20 40 60 80
8 7 6 5 4 3 2
Depth [cm]
0 200 400 600 800 1000 1200 1400 1600 1800
40 50 60 70 80
24 20 16 12 8 4
Lightness Y
SO225-07-2 KOL
SO225-08-3 KOL



North Plateau
SO225-15-3 KOL
SO225-17-3 KOL
SO225-19-3 KOL
Lightness Y
20 40 60 80
6 5 4 3 2 1
30 40 50 60 70 80
Depth [cm]
0 200 400 600 800 1000 1200 1400 1600
65 70 75 80 85 90
16 14 12 10 8 6
Lightness Y
SO225-17-2 KOL
SO225-19-2 KOL


168°W°
166°W
164°W
162°W
160°W
2°S
4°S
6°S
8°S
10°S
12°S
14°S
021POZ01-4
019POZ01-3
North Plateau
017POZ01-3
015POZ01-4
013ROV04
011ROV03
026DR08
023DR05
024DR06
027DR09
025DR07
008POZ01-3
Western Plateaus
D.I.T.
028DR10
029DR11
007POZ01-2
see insert
042POZ01-3
039DR21
004ROV01
005POZ01
040DR22
Rakahanga
002POZ01-2
001POZ01-2
046DR23 - 051DR27
Puka Puka
Nassau
Suvorov Trough
Manihiki
High Plateau
044POZ01-4
037DR19
036DR18
High Plateau
D.I.T.
035DR17
009ROV02
034DR16
033DR15
032DR14
030DR12
031DR13
038DR20
Suvorov Atoll
053POZ01-4
D.I.T.: Danger Island Troughs

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