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.)
April 2013
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

Nr. 6 (N. Ser.)
April 2013
ISSN Nr.: 2193-8113
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. Foraminifer 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


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 the German Foreign Office and the German Embassy in Wellington in this matter.

The MANIHIKI II project is funded by the “Bundesministerium für Bildung und Forschung” (BMBF) project award to K. Hoernle, G. Uenzelmann-Neben, D. Nürnberg, F. Hauff, R. Tiedemann, and R. Werner. We are grateful to the BMBF for continuing support of marine research. Additional funding has been provided by the GEOMAR Helmholtz Centre for Ocean Research Kiel and Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research.

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
Hoffsmoer, 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
Steng, 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
Hauff, Folkmar  GEOMAR
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)

Abegg, Fritz  Head ROV-Team  GEOMAR
Anders, Maria  Student  GEOMAR
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 Paleoeceanography  GEOMAR
Osborne, Anne  Scientist  GEOMAR
Peukert, Anne  Student  GEOMAR
Pieper, Martin  ROV-Team  GEOMAR
Poggenmann, 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
2.4. Institutions

AWI
Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Am Alten Hafen 12, 27570 Bremerhaven, Germany (http://www.awi.de)

GEOMAR
Helmholtz Centre for Ocean Research Kiel, Wischhofstr. 1–3, D-24148 Kiel, Germany (http://www.geomar.de)

Marinetechnik Kawohl
Helmut Kawohl, Marinetechnik, Am Kreuzkamp 27, 31311 Uetze, Germany (marinetech.-kawohl@t-online.de)

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

**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 IGNEOUS PROVINCES AND OCEANIC PLATEAUS IN THE SW-PACIFIC

The Manihiki Plateau is a huge submarine lava plateau (c. 0.8 Mill km²), approximately equal in size to France. Besides the significantly larger Ontong Java Plateau (> 1.5 Mill km²) and the somewhat smaller Hikurangi Plateau (c. 0.35 Mill km²) 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 and Eldholm 1993, Ingle and 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 be responsible for changes of the global environment and mass extinctions (e.g. Tarduno et al. 1998, Courtillot et al. 1999, Larson and 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. 2007, 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 and 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.

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 Suworov 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 alkaline 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 alkaline 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, 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 alkaline 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.
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“. 
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 Philander, 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 have 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 (Bacastow, 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 Philander, 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 CO₂, and the equatorial Pacific representing an important source for atmospheric CO₂. 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-Mélélé, 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).
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.

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.

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).
including up to several meter-sized blocks. 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).

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 capital 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 petrological 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.
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, and 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 unknown 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.

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.

<table>
<thead>
<tr>
<th>Station Number SO225</th>
<th>Dive No.</th>
<th>Date</th>
<th>Time Start (UTC)</th>
<th>At Bottom (UTC)</th>
<th>Off Bottom (UTC)</th>
<th>Time End (surface) (UTC)</th>
<th>Location</th>
<th>Depth (m)</th>
<th>ROV Bottom Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>166</td>
<td>27.11.2012</td>
<td>23:35</td>
<td>00:59</td>
<td>05:19</td>
<td>06:33</td>
<td>Manihiki: Danger Island Trough</td>
<td>4800</td>
<td>00:34</td>
</tr>
<tr>
<td>2</td>
<td>167</td>
<td>30.11./1.12.12</td>
<td>21:00</td>
<td>23:15</td>
<td>04:10</td>
<td>05:58</td>
<td>Manihiki: North Plateau</td>
<td>4600</td>
<td>04:55</td>
</tr>
</tbody>
</table>

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 block (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.

Responsible Scientists and Protocol Scientists:
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.

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 40Ar/39Ar 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.
**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.

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 pillow 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 pillow 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).

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 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°, 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.

**ROV-04 Rock Samples:** 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 greenshiss (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 phyrhic 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.
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 allow 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. Dredge 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.

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, alkalic 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. Multibeam 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 of 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).

Dredge 030DR12 was carried out immediately below SO193-DR26 at the base of the northwest-southeast striking, cliff forming scarp 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 phytic 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.

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 phryic 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 the southeastern termination of the main southwest facing cliff from 4,600 to 4,000 m b.s.l. Here variably oxidized, olivine phryic 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 phryic, 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 micocrystalline 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 micocrystalline groundmass (DR21-1 and -2, Fig. 5.32) to plagioclase phryic varieties (DR21-7 to -12) and spinifex textured groundmass (DR21-4 to -6).

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 40Ar/39Ar 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
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 relics 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.
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
Sample SO225-MUC-21-2 Nd GEOMAR 0-1 cm: 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 porphyritic 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.

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 phenocrysts replaced with limonite.
Sample SO225-MUC-21-2 AWI-I 2-3 cm: 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.

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 at the southeastern 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.](image)

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 pycnocline 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 O₂ are 5.5 - 5.6 mg l⁻¹ for all
stations. The minimum for station SO225-02-02 is 2.2 mg/l at 350 m. For station SO225-15-01, a minimum of 2.3 mg/l occurs at 280 m. For station SO225-53-04, the minimum is 2.7 mg/l 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\textsubscript{2} concentrations of up to 7.7 mg/l (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\textsubscript{2} concentrations of the downcast are obvious outliers and therefore, we only consider up-cast O\textsubscript{2} concentrations. However, a weak positive anomaly in dissolved oxygen concentrations characterized by an increase of 0.6 mg/l 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 mg/l. 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 (δ¹³C, δ¹⁸O), 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: δ¹⁸O; C: δ¹³C; D: Silicon isotopes, E: REE; F: Neodymium.

#### Station SO225-02-02 CTD

<table>
<thead>
<tr>
<th>Bottle</th>
<th>Depth (m)</th>
<th>Potential T (deg C)</th>
<th>Salinity (psu)</th>
<th>O₂ (mg l⁻¹)</th>
<th>sigma-theta (kg/m³)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2627</td>
<td>1.66</td>
<td>34.64</td>
<td>3.58</td>
<td>27.71</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>2</td>
<td>2022</td>
<td>2.02</td>
<td>34.62</td>
<td>3.42</td>
<td>27.67</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>3</td>
<td>1525</td>
<td>2.69</td>
<td>34.58</td>
<td>3.21</td>
<td>27.58</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>4</td>
<td>1028</td>
<td>4.15</td>
<td>34.52</td>
<td>2.70</td>
<td>27.39</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>5</td>
<td>730</td>
<td>5.54</td>
<td>34.50</td>
<td>2.81</td>
<td>27.21</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>6</td>
<td>531</td>
<td>7.06</td>
<td>34.54</td>
<td>2.99</td>
<td>27.05</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>7</td>
<td>491</td>
<td>7.31</td>
<td>34.55</td>
<td>3.02</td>
<td>27.02</td>
<td>E,F</td>
</tr>
<tr>
<td>8</td>
<td>491</td>
<td>7.31</td>
<td>34.55</td>
<td>3.02</td>
<td>27.02</td>
<td>E,F</td>
</tr>
<tr>
<td>9</td>
<td>462</td>
<td>7.66</td>
<td>34.57</td>
<td>2.93</td>
<td>26.98</td>
<td>A,B,C</td>
</tr>
<tr>
<td>10</td>
<td>382</td>
<td>9.19</td>
<td>34.64</td>
<td>2.53</td>
<td>26.81</td>
<td>E,F</td>
</tr>
<tr>
<td>11</td>
<td>381</td>
<td>9.17</td>
<td>34.64</td>
<td>2.56</td>
<td>26.81</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>12</td>
<td>283</td>
<td>13.88</td>
<td>34.92</td>
<td>3.12</td>
<td>26.15</td>
<td>E,F</td>
</tr>
<tr>
<td>14</td>
<td>243</td>
<td>17.70</td>
<td>35.37</td>
<td>4.01</td>
<td>25.63</td>
<td>E,F</td>
</tr>
<tr>
<td>15</td>
<td>243</td>
<td>17.70</td>
<td>35.37</td>
<td>4.01</td>
<td>25.63</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>16</td>
<td>134</td>
<td>24.75</td>
<td>36.35</td>
<td>4.62</td>
<td>24.44</td>
<td>E,F</td>
</tr>
<tr>
<td>17</td>
<td>134</td>
<td>24.75</td>
<td>36.35</td>
<td>4.62</td>
<td>24.44</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>18</td>
<td>51</td>
<td>29.62</td>
<td>35.37</td>
<td>5.42</td>
<td>22.14</td>
<td>E,F</td>
</tr>
<tr>
<td>19</td>
<td>51</td>
<td>29.62</td>
<td>35.37</td>
<td>5.42</td>
<td>22.14</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>20</td>
<td>10</td>
<td>29.75</td>
<td>35.35</td>
<td>5.44</td>
<td>22.07</td>
<td>E,F</td>
</tr>
<tr>
<td>21</td>
<td>10</td>
<td>29.75</td>
<td>35.35</td>
<td>5.44</td>
<td>22.07</td>
<td>A,B,C</td>
</tr>
</tbody>
</table>

#### Station SO225-15-01 CTD

<table>
<thead>
<tr>
<th>Bottle</th>
<th>Depth (m)</th>
<th>Potential T (deg C)</th>
<th>Salinity (psu)</th>
<th>O₂ (mg l⁻¹)</th>
<th>sigma-theta (kg/m³)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1817</td>
<td>2.28</td>
<td>34.60</td>
<td>3.23</td>
<td>27.63</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>2</td>
<td>1489</td>
<td>2.90</td>
<td>34.57</td>
<td>2.98</td>
<td>27.55</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>3</td>
<td>993</td>
<td>4.45</td>
<td>34.52</td>
<td>2.49</td>
<td>27.36</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>4</td>
<td>893</td>
<td>5.03</td>
<td>34.51</td>
<td>2.70</td>
<td>27.28</td>
<td>A,B,C</td>
</tr>
</tbody>
</table>
### Station SO225-15-01 CTD (continued)

<table>
<thead>
<tr>
<th>Bottle</th>
<th>Depth (m)</th>
<th>Potential T (deg C)</th>
<th>Salinity (psu)</th>
<th>O2 (mg l⁻¹)</th>
<th>sigma-theta (kg/m³)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>795</td>
<td>5.58</td>
<td>34.50</td>
<td>2.88</td>
<td>27.21</td>
<td>A,B,C</td>
</tr>
<tr>
<td>6</td>
<td>695</td>
<td>6.18</td>
<td>34.51</td>
<td>2.80</td>
<td>27.14</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>7</td>
<td>576</td>
<td>6.96</td>
<td>34.53</td>
<td>2.94</td>
<td>27.06</td>
<td>A,B,C</td>
</tr>
<tr>
<td>8</td>
<td>496</td>
<td>7.51</td>
<td>34.55</td>
<td>3.19</td>
<td>27.00</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>9</td>
<td>347</td>
<td>9.45</td>
<td>34.68</td>
<td>3.04</td>
<td>26.80</td>
<td>A,B,C</td>
</tr>
<tr>
<td>10</td>
<td>280</td>
<td>11.66</td>
<td>34.83</td>
<td>2.47</td>
<td>26.52</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>11</td>
<td>230</td>
<td>14.30</td>
<td>35.01</td>
<td>2.58</td>
<td>26.13</td>
<td>A,B,C</td>
</tr>
<tr>
<td>12</td>
<td>210</td>
<td>17.89</td>
<td>35.40</td>
<td>3.36</td>
<td>25.60</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>13</td>
<td>170</td>
<td>22.52</td>
<td>35.91</td>
<td>4.21</td>
<td>24.76</td>
<td>A,B,C</td>
</tr>
<tr>
<td>14</td>
<td>130</td>
<td>27.05</td>
<td>35.50</td>
<td>5.04</td>
<td>23.07</td>
<td>A,B,C</td>
</tr>
<tr>
<td>15</td>
<td>109</td>
<td>27.67</td>
<td>35.50</td>
<td>5.29</td>
<td>22.88</td>
<td>A,B,C</td>
</tr>
<tr>
<td>16</td>
<td>90</td>
<td>28.20</td>
<td>35.50</td>
<td>5.28</td>
<td>22.70</td>
<td>A,B,C</td>
</tr>
<tr>
<td>17</td>
<td>70</td>
<td>28.90</td>
<td>35.56</td>
<td>5.52</td>
<td>22.52</td>
<td>A,B,C</td>
</tr>
<tr>
<td>18</td>
<td>49</td>
<td>29.03</td>
<td>35.56</td>
<td>5.61</td>
<td>22.47</td>
<td>A,B,C</td>
</tr>
<tr>
<td>19</td>
<td>49</td>
<td>29.03</td>
<td>35.56</td>
<td>5.61</td>
<td>22.47</td>
<td>D</td>
</tr>
<tr>
<td>20</td>
<td>31</td>
<td>29.04</td>
<td>35.56</td>
<td>5.59</td>
<td>22.47</td>
<td>A,B,C</td>
</tr>
<tr>
<td>21</td>
<td>11</td>
<td>29.04</td>
<td>35.56</td>
<td>5.60</td>
<td>22.47</td>
<td>A,B,C</td>
</tr>
</tbody>
</table>

### Station SO225-21-01 CTD

<table>
<thead>
<tr>
<th>Bottle</th>
<th>Depth (m)</th>
<th>Potential T (deg C)</th>
<th>Salinity (psu)</th>
<th>O2 (mg l⁻¹)</th>
<th>sigma-theta (kg/m³)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5172</td>
<td>0.82</td>
<td>34.68</td>
<td>5.16</td>
<td>27.80</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>2</td>
<td>3992</td>
<td>1.08</td>
<td>34.67</td>
<td>4.34</td>
<td>27.78</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>3</td>
<td>3005</td>
<td>1.41</td>
<td>34.66</td>
<td>3.80</td>
<td>27.74</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>4</td>
<td>2009</td>
<td>2.09</td>
<td>34.62</td>
<td>3.04</td>
<td>27.66</td>
<td>E,F</td>
</tr>
<tr>
<td>5</td>
<td>2009</td>
<td>2.09</td>
<td>34.62</td>
<td>3.04</td>
<td>27.66</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>6</td>
<td>1493</td>
<td>3.01</td>
<td>34.57</td>
<td>2.66</td>
<td>27.54</td>
<td>E,F</td>
</tr>
<tr>
<td>7</td>
<td>1493</td>
<td>3.01</td>
<td>34.57</td>
<td>2.66</td>
<td>27.54</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>8</td>
<td>997</td>
<td>4.42</td>
<td>34.53</td>
<td>2.30</td>
<td>27.37</td>
<td>E,F</td>
</tr>
<tr>
<td>9</td>
<td>997</td>
<td>4.42</td>
<td>34.53</td>
<td>2.30</td>
<td>27.37</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>10</td>
<td>649</td>
<td>6.38</td>
<td>34.54</td>
<td>1.54</td>
<td>27.14</td>
<td>E,F</td>
</tr>
<tr>
<td>11</td>
<td>649</td>
<td>6.38</td>
<td>34.54</td>
<td>1.54</td>
<td>27.14</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>12</td>
<td>450</td>
<td>8.77</td>
<td>34.64</td>
<td>1.95</td>
<td>26.87</td>
<td>E,F</td>
</tr>
<tr>
<td>13</td>
<td>450</td>
<td>8.77</td>
<td>34.64</td>
<td>1.95</td>
<td>26.87</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>14</td>
<td>281</td>
<td>10.73</td>
<td>34.78</td>
<td>2.26</td>
<td>26.65</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>15</td>
<td>241</td>
<td>11.86</td>
<td>34.86</td>
<td>2.14</td>
<td>26.51</td>
<td>A,B,C</td>
</tr>
<tr>
<td>16</td>
<td>202</td>
<td>15.31</td>
<td>35.15</td>
<td>2.58</td>
<td>26.02</td>
<td>E,F</td>
</tr>
<tr>
<td>17</td>
<td>202</td>
<td>15.31</td>
<td>35.15</td>
<td>2.58</td>
<td>26.02</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>18</td>
<td>182</td>
<td>19.56</td>
<td>35.51</td>
<td>3.34</td>
<td>25.26</td>
<td>A,B,C</td>
</tr>
<tr>
<td>19</td>
<td>153</td>
<td>21.58</td>
<td>35.52</td>
<td>3.54</td>
<td>24.73</td>
<td>E,F</td>
</tr>
<tr>
<td>20</td>
<td>153</td>
<td>21.58</td>
<td>35.52</td>
<td>3.54</td>
<td>24.73</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>21</td>
<td>54</td>
<td>27.94</td>
<td>35.52</td>
<td>5.55</td>
<td>22.80</td>
<td>E,F</td>
</tr>
<tr>
<td>22</td>
<td>54</td>
<td>27.94</td>
<td>35.52</td>
<td>5.55</td>
<td>22.80</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>23</td>
<td>14</td>
<td>27.96</td>
<td>35.52</td>
<td>5.58</td>
<td>22.80</td>
<td>E,F</td>
</tr>
<tr>
<td>24</td>
<td>14</td>
<td>27.96</td>
<td>35.52</td>
<td>5.58</td>
<td>22.80</td>
<td>A,B,C</td>
</tr>
</tbody>
</table>
Station SO225-53-04 CTD

<table>
<thead>
<tr>
<th>Bottle</th>
<th>Depth (m)</th>
<th>Potential T (deg C)</th>
<th>Salinity (psu)</th>
<th>O₂ (mg l⁻¹)</th>
<th>sigma-theta (kg/m³)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3088</td>
<td>1.43</td>
<td>34.66</td>
<td>3.72</td>
<td>27.74</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>2</td>
<td>2006</td>
<td>1.97</td>
<td>34.62</td>
<td>3.50</td>
<td>27.67</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>3</td>
<td>1499</td>
<td>2.76</td>
<td>34.57</td>
<td>3.28</td>
<td>27.56</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>4</td>
<td>1001</td>
<td>4.27</td>
<td>34.49</td>
<td>3.17</td>
<td>27.35</td>
<td>A,B,C,D,E,F</td>
</tr>
<tr>
<td>5</td>
<td>802</td>
<td>5.11</td>
<td>34.48</td>
<td>3.04</td>
<td>27.25</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>6</td>
<td>703</td>
<td>5.64</td>
<td>34.47</td>
<td>3.22</td>
<td>27.18</td>
<td>E,F</td>
</tr>
<tr>
<td>7</td>
<td>703</td>
<td>5.64</td>
<td>34.47</td>
<td>3.22</td>
<td>27.18</td>
<td>E,F</td>
</tr>
<tr>
<td>8</td>
<td>506</td>
<td>7.86</td>
<td>34.52</td>
<td>3.02</td>
<td>26.92</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>9</td>
<td>505</td>
<td>7.87</td>
<td>34.52</td>
<td>3.04</td>
<td>26.92</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>10</td>
<td>396</td>
<td>9.82</td>
<td>34.59</td>
<td>2.81</td>
<td>26.66</td>
<td>E,F</td>
</tr>
<tr>
<td>11</td>
<td>396</td>
<td>9.82</td>
<td>34.59</td>
<td>2.81</td>
<td>26.66</td>
<td>E,F</td>
</tr>
<tr>
<td>12</td>
<td>278</td>
<td>15.55</td>
<td>35.09</td>
<td>4.05</td>
<td>25.92</td>
<td>E,F</td>
</tr>
<tr>
<td>13</td>
<td>277</td>
<td>15.57</td>
<td>35.09</td>
<td>4.06</td>
<td>25.91</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>14</td>
<td>198</td>
<td>21.38</td>
<td>35.96</td>
<td>4.45</td>
<td>25.62</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>15</td>
<td>168</td>
<td>23.54</td>
<td>36.27</td>
<td>4.59</td>
<td>24.74</td>
<td>E,F</td>
</tr>
<tr>
<td>16</td>
<td>168</td>
<td>23.54</td>
<td>36.27</td>
<td>4.59</td>
<td>24.74</td>
<td>E,F</td>
</tr>
<tr>
<td>17</td>
<td>99</td>
<td>25.85</td>
<td>36.24</td>
<td>5.10</td>
<td>24.02</td>
<td>E,F</td>
</tr>
<tr>
<td>18</td>
<td>98</td>
<td>25.88</td>
<td>36.24</td>
<td>5.10</td>
<td>24.01</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>19</td>
<td>50</td>
<td>28.10</td>
<td>36.07</td>
<td>5.66</td>
<td>23.17</td>
<td>E,F</td>
</tr>
<tr>
<td>20</td>
<td>50</td>
<td>28.10</td>
<td>36.07</td>
<td>5.66</td>
<td>23.17</td>
<td>A,B,C,D</td>
</tr>
<tr>
<td>21</td>
<td>11</td>
<td>29.05</td>
<td>35.72</td>
<td>5.40</td>
<td>22.58</td>
<td>E,F</td>
</tr>
<tr>
<td>22</td>
<td>10</td>
<td>29.05</td>
<td>35.72</td>
<td>5.41</td>
<td>22.58</td>
<td>A,B,C,D</td>
</tr>
</tbody>
</table>

**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 HgCl₂ solution (7.5 g/100 ml) and stored at 4°C.

**Stable oxygen and carbon isotopes (δ¹³C, δ¹⁸O)**

Stable isotope samples were taken at all four CTD stations. Slow and careful filling of 50 ml and 100 ml glass bottles for δ¹³C and δ¹⁸O 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 δ¹³C samples were poisoned with 100 µl of saturated HgCl₂ 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 4°C.

**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 4°C.

**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 acidify 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.

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

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](image)

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 m². 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.

![Image of backscatter profiles](image)

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.
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. Marinetech 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.

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

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

![Sampling scheme applied for SO225 sediment cores](image)

**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 BARTINGTTON 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.](image)

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).

![Figure 6.18: Magnetic susceptibility data of sediment cores SO225-7-2 and SO225-8-2 and -3, from the Western Plateaus.](image)

![Figure 6.18: Magnetic susceptibility data of sediment cores SO225-17-2 and -3, as well as SO225-19-2 and -3, from the North Plateau.](image)

**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 foraminiferal 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).
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 ooze 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 Warm pool 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 (Crinoidea), 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.
8. REFERENCES


Clague DA (1976) Petrology of basaltic and gabbroic rocks dredged from the Danger Island Troughs, Manihiki Plateau. In Schlanger, SO, Jackson, ED et al., Initial reports DSDP 33: 891–907


Gu D-F, Philander SGH (1997) Interdecadal climate fluctuations that depend on exchanges between the Tropics and extratropics. Science 275: 805-807


Hoernle K, Bogaard Pvd, Hauff F (2004a) A 70 Myr history (69-139 Ma) for the Caribbean Large Igneous Province. 32: 697-700


McClymont EL, Rosell-Mélé A (2005) Links between the onset of modern Walker circulation and the
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)

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

<table>
<thead>
<tr>
<th>Station no.</th>
<th>Device</th>
<th>Location</th>
<th>Recovery</th>
<th>Sample summary</th>
<th>on bottom</th>
<th>off bottom</th>
<th>depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lat °S</td>
<td>long °E</td>
<td>max</td>
</tr>
<tr>
<td>021POZ03</td>
<td>MN-St</td>
<td>ocean floor north of North Plateau</td>
<td>plankton 500 m water depth</td>
<td>-3,019</td>
<td>-164,996</td>
<td>-500</td>
<td>-500</td>
</tr>
<tr>
<td>021POZ03</td>
<td>MN-St</td>
<td>ocean floor north of North Plateau</td>
<td>plankton 500 m water depth</td>
<td>-3.01</td>
<td>-164,982</td>
<td>-500</td>
<td>-500</td>
</tr>
<tr>
<td>021POZ03</td>
<td>MN-St</td>
<td>ocean floor north of North Plateau</td>
<td>plankton 500 m water depth</td>
<td>-3,002</td>
<td>-164,986</td>
<td>-500</td>
<td>-500</td>
</tr>
<tr>
<td>021POZ04</td>
<td>KL 15 m</td>
<td>ocean floor north of North Plateau</td>
<td>empty core catcher teared off</td>
<td>-3,055</td>
<td>-165,056</td>
<td>-5182</td>
<td>-5182</td>
</tr>
<tr>
<td>022VR09</td>
<td>MB+PS</td>
<td>southern High Plateau to northern margin</td>
<td>420 nm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>023DR05</td>
<td>DR</td>
<td>High Plateau, N-margin</td>
<td>1/5 full lava fragments, sedimentary rocks, Mn crusts</td>
<td>-6,767</td>
<td>-162,748</td>
<td>-6,676</td>
<td>-162,743</td>
</tr>
<tr>
<td>024DR06</td>
<td>DR</td>
<td>High Plateau, N-margin</td>
<td>few rocks sedimentary rocks</td>
<td>-6,673</td>
<td>-162,745</td>
<td>-6,686</td>
<td>-162,739</td>
</tr>
<tr>
<td>025DR07</td>
<td>DR</td>
<td>High Plateau, N-margin</td>
<td>few rocks lava fragments</td>
<td>-6,732</td>
<td>-163,204</td>
<td>-6,737</td>
<td>-163,199</td>
</tr>
<tr>
<td>026DR08</td>
<td>DR</td>
<td>High Plateau, N-margin</td>
<td>large bloc lava fragments (in situ pillow breccia)</td>
<td>-6,762</td>
<td>-163,43</td>
<td>-6,766</td>
<td>-163,424</td>
</tr>
<tr>
<td>027DR09</td>
<td>DR</td>
<td>DIT, northernmost trough</td>
<td>1/6 full lava fragments, sedimentary rocks</td>
<td>-6,914</td>
<td>-163,841</td>
<td>-6,911</td>
<td>-163,833</td>
</tr>
<tr>
<td>028DR10</td>
<td>DR</td>
<td>DIT, second trough from north</td>
<td>empty core catcher teared off</td>
<td>-8,592</td>
<td>-163,996</td>
<td>-8,582</td>
<td>-163,996</td>
</tr>
<tr>
<td>029DR11</td>
<td>DR</td>
<td>DIT, second trough from north</td>
<td>1/5 full sedimentary rocks</td>
<td>-8,563</td>
<td>-163,925</td>
<td>-8,563</td>
<td>-163,917</td>
</tr>
<tr>
<td>030DR12</td>
<td>DR</td>
<td>southern DIT, tectonic (?) smt. at E-flank</td>
<td>1/3 full lava fragments, volcaniclastics, intrusive rocks</td>
<td>-9,383</td>
<td>-164,276</td>
<td>-9,379</td>
<td>-164,269</td>
</tr>
<tr>
<td>031DR13</td>
<td>DR</td>
<td>southern DIT, tectonic (?) smt. at E-flank</td>
<td>1/5 full lava fragments, volcaniclastics, Mn crusts</td>
<td>-9,384</td>
<td>-164,266</td>
<td>-9,382</td>
<td>-164,264</td>
</tr>
<tr>
<td>032DR14</td>
<td>DR</td>
<td>southern DIT, tectonic (?) smt. at E-flank</td>
<td>3/4 full lava fragments, volcaniclastics, Mn crusts</td>
<td>-9,374</td>
<td>-164,267</td>
<td>-9,372</td>
<td>-164,264</td>
</tr>
<tr>
<td>033DR15</td>
<td>DR</td>
<td>southern DIT, tectonic (?) smt. at E-flank</td>
<td>2 rocks volcaniclastics, Mn crusts</td>
<td>-9,352</td>
<td>-164,277</td>
<td>-9,348</td>
<td>-164,273</td>
</tr>
<tr>
<td>034DR16</td>
<td>DR</td>
<td>southern DIT, tectonic (?) smt. at E-flank</td>
<td>1/2 full lava fragments, volcaniclastics, Mn crusts</td>
<td>-9,302</td>
<td>-164,273</td>
<td>-9,299</td>
<td>-164,265</td>
</tr>
<tr>
<td>035DR17</td>
<td>DR</td>
<td>southern DIT, tectonic (?) smt. at E-flank</td>
<td>1/4 full lava fragments, volcaniclastics, Mn crusts</td>
<td>-9,285</td>
<td>-164,355</td>
<td>-9,286</td>
<td>-164,347</td>
</tr>
<tr>
<td>036DR18</td>
<td>DR</td>
<td>southern DIT, E-flank north of smt.</td>
<td>1/4 full lava fragments, metamorphic rocks, sedimentary rocks</td>
<td>-9,093</td>
<td>-164,294</td>
<td>-9,091</td>
<td>-164,286</td>
</tr>
<tr>
<td>037DR19</td>
<td>DR</td>
<td>southern DIT, E-flank north of smt.</td>
<td>few rocks lava fragments, volcaniclastics</td>
<td>1/4</td>
<td>-164,266</td>
<td>-9,048</td>
<td>-164,259</td>
</tr>
<tr>
<td>038DR20</td>
<td>DR</td>
<td>southern DIT, tectonic (?) smt. at E-flank</td>
<td>1/4 full lava fragments, volcaniclastics, Mn crusts</td>
<td>9,413</td>
<td>-164,245</td>
<td>-9,406</td>
<td>-164,239</td>
</tr>
<tr>
<td>039DR21</td>
<td>DR</td>
<td>southern DIT, W-flank (SO224 seismic line)</td>
<td>full lava fragments, sedimentary rocks</td>
<td>9,53</td>
<td>-164,29</td>
<td>-9,524</td>
<td>-164,396</td>
</tr>
<tr>
<td>040DR22</td>
<td>DR</td>
<td>southern DIT, E-flank (SO224 seismic line)</td>
<td>1 rock sedimentary rock with thick Mn crust</td>
<td>9,668</td>
<td>-164,304</td>
<td>-9,668</td>
<td>-164,297</td>
</tr>
<tr>
<td>041VER10</td>
<td>MB+PS</td>
<td>southern DIT to central High Plateau</td>
<td>130 nm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>042POZ01</td>
<td>TV-MUC</td>
<td>High Plateau, northern part</td>
<td>~1 cm foraminiferal sand to ooze (1 tube)</td>
<td>-9,214</td>
<td>-162,22</td>
<td>-3086</td>
<td>-3086</td>
</tr>
<tr>
<td>042POZ02</td>
<td>KL 10 m</td>
<td>High Plateau, northern part</td>
<td>empty 5 m segment teared off</td>
<td>-9,213</td>
<td>-162,22</td>
<td>-3089</td>
<td>-3089</td>
</tr>
<tr>
<td>042POZ03</td>
<td>KL 10 m</td>
<td>High Plateau, northern part</td>
<td>empty core catcher teared off</td>
<td>-9,214</td>
<td>-162,22</td>
<td>-3075</td>
<td>-3075</td>
</tr>
<tr>
<td>043VER11</td>
<td>MB+PS</td>
<td>northern to central High Plateau</td>
<td>110 nm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>044POZ01</td>
<td>TV-MUC</td>
<td>High Plateau, central part</td>
<td>1 - 6 cm light yellow foraminiferal sand (10 tubes)</td>
<td>-11,052</td>
<td>-161,532</td>
<td>-3005</td>
<td>-3005</td>
</tr>
<tr>
<td>044POZ02</td>
<td>KL 10 m</td>
<td>High Plateau, central part</td>
<td>empty core catcher teared off</td>
<td>-11,051</td>
<td>-161,065</td>
<td>-2990</td>
<td>-2990</td>
</tr>
<tr>
<td>044POZ03</td>
<td>SL 5 m</td>
<td>High Plateau, central part</td>
<td>Foraminiferal sand and foraminiferal ooze</td>
<td>-11,051</td>
<td>-161,532</td>
<td>-3012</td>
<td>-3012</td>
</tr>
<tr>
<td>044POZ04</td>
<td>SL 5 m</td>
<td>High Plateau, central part</td>
<td>Foraminiferal sand and foraminiferal ooze</td>
<td>-11,051</td>
<td>-161,532</td>
<td>-3011</td>
<td>-3011</td>
</tr>
<tr>
<td>045VER12</td>
<td>MB+PS</td>
<td>044POZ to Suvorov Trough</td>
<td>142 nm</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>046DR23</td>
<td>DR</td>
<td>Suvorov Trough</td>
<td>1/5 full lava fragments, Mn crusts</td>
<td>-10,645</td>
<td>-163,39</td>
<td>-10,643</td>
<td>-163,894</td>
</tr>
<tr>
<td>047VER13</td>
<td>MB</td>
<td>Suvorov Trough</td>
<td>246 nm 246 nm survey</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>048DR24</td>
<td>DR</td>
<td>Suvorov Trough</td>
<td>1/8 full lava fragments, volcaniclastics</td>
<td>-10,654</td>
<td>-163,883</td>
<td>-10,652</td>
<td>-163,876</td>
</tr>
<tr>
<td>049DR25</td>
<td>DR</td>
<td>Suvorov Trough</td>
<td>1/4 full lava fragments, volcaniclastics, Mn crusts</td>
<td>-10,668</td>
<td>-163,842</td>
<td>-10,659</td>
<td>-163,841</td>
</tr>
<tr>
<td>050DR26</td>
<td>DR</td>
<td>Suvorov Trough</td>
<td>empty</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>051DR27</td>
<td>DR</td>
<td>Suvorov Trough</td>
<td>full lava fragments, sedimentary rocks, Mn crusts</td>
<td>-10,681</td>
<td>-163,88</td>
<td>-10,68</td>
<td>-163,87</td>
</tr>
</tbody>
</table>
## Appendix I (Station list)

<table>
<thead>
<tr>
<th>Station no.</th>
<th>Device</th>
<th>Location</th>
<th>Recovery</th>
<th>Sample summary</th>
<th>on bottom</th>
<th>off bottom</th>
<th>depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lat °S E</td>
<td>lat °S E</td>
<td>max</td>
</tr>
<tr>
<td>052VER14</td>
<td>MB+PS</td>
<td>High Plateau, southern margin</td>
<td>196 nm</td>
<td></td>
<td>- -</td>
<td>- -</td>
<td></td>
</tr>
<tr>
<td>053POZ01</td>
<td>TV-MUC</td>
<td>High Plateau, southern margin</td>
<td>0.5 - 6 cm</td>
<td>light yellow foraminiferal ooze (11 tubes)</td>
<td>-13,521</td>
<td>-162,140</td>
<td>-3154</td>
</tr>
<tr>
<td>053POZ02</td>
<td>SL 10m</td>
<td>High Plateau, southern margin</td>
<td>288 cm</td>
<td>Foraminiferal ooze and nanno ooze</td>
<td>-13,520</td>
<td>-162,138</td>
<td>-3153</td>
</tr>
<tr>
<td>053POZ03</td>
<td>KL 15m</td>
<td>High Plateau, southern margin</td>
<td>1238 cm</td>
<td>Foraminiferal ooze and nanno ooze</td>
<td>-13,521</td>
<td>-162,140</td>
<td>-3150</td>
</tr>
<tr>
<td>053POZ04</td>
<td>CTD</td>
<td>High Plateau, southern margin</td>
<td>water</td>
<td></td>
<td>-13,510</td>
<td>-162,126</td>
<td>-3090</td>
</tr>
<tr>
<td>054VER15</td>
<td>MB+PS</td>
<td>Monowai</td>
<td>c. 50</td>
<td></td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
</tbody>
</table>

SO-225 deployments:

- **4** ROV-dives
- **23** Dredge hauls
- **11** TV-MUC
- **3** Gravity corer
- **16** Piston 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 DI T'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 DI T, 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 | CHEM | ARC | GL/MIN | ROV | 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 cm
- 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!

### 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
## Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>GRAIN</th>
<th>ROV No</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-ROV-2-3</td>
<td>Sampling Depth: 3278m Coordinates: lat 9°16,08’S, long 164°18,01’W 1. Rock Type: aphiric, finely crystallized, volcanic rock, altered 2. Shape / Angularity: rounded 3. Texture / Vesicularity: massive, not vesicular (rare voids up to 1mm elongate xls, perhaps cpx, altered glass. Gm. texture is intersertal to dolentic. 6. Phenocrysts: phenocrysts are hardly recognisable and probably not present 7. Matrix: matrix has intersertal texture and mainly composed by elongate plag xls. Relatively well crystallized 8. Secondary Minerals: smectites, possibly calcite (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: -</td>
<td>2</td>
<td>M1</td>
<td>L1</td>
<td></td>
<td><img src="image" alt="Picture of SO225-ROV-2-3" /></td>
</tr>
<tr>
<td>SO225-ROV-2-4</td>
<td>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: -</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td><img src="image" alt="Picture of SO225-ROV-2-4" /></td>
</tr>
</tbody>
</table>
## Appendix II (Rock Description)

### SO225-011ROV3

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 23:19hrs, 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:

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>


### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>NT</th>
<th>BOX</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-ROV-3-4 | Sampling Depth: 4384m 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 / Vesciularity: 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 | N2 | | ![Image 1](image1.jpg) ![Image 2](image2.jpg) |
| 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 / Vesciularity: -  
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 ophitic basalt to monocrystalline dolerite. Igneous rocks are similar to those, collected in this dive | 3 | 6 | C2 | | ![Image 3](image3.jpg) ![Image 4](image4.jpg) |
| 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: 28x12.5x20cm  
3. Shape / Angularity: angular shape  
4. Color of cut surface: dark green to grey color on broken surface  
5. Texture / Vesciularity: 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) | 3 | 6 | N3 | | ![Image 5](image5.jpg) ![Image 6](image6.jpg) |
| 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 / Vesciularity: -  
6. Phenocrysts: -  
7. Matrix: -  
8. Secondary Minerals: -  
9. Encrustations: 2-3mm black Mn-crust  
10. Comment: core consists of light brown chert-like material | 3 | 6 | N3 | | ![Image 7](image7.jpg) ![Image 8](image8.jpg) |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRA</th>
<th>GRA</th>
<th>GRA</th>
<th>GRA</th>
<th>GRA</th>
<th>GRA</th>
</tr>
</thead>
</table>
### Appendix II (Rock Description)

**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°04.22'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

**Sampling Depth: 4046m**
- **Sampling Depth:** 4046m
- **Coordinates:** lat 6°04.22'S, long 164°41.33'W
- **Rock Type:** dense, intrusive? rock with a tectonic+metamorphic overprint (altered)
- **Shape / Angularity:** angular shape
- **Color of cut surface:** grey color on broken, dry surface
- **Texture / Vesicularity:** coarse grains (phenocrysts) in a coarse grained matrix (no vesicles)
- **Phenocrysts:** 0.5-1cm olivines?, strongly altered
- **Matrix:** coarse grained, grey matrix
- **Secondary Minerals:** rock is strongly altered, Fe-oxides? in cracks
- **Encrustations:** 1-3mm Mn crust
- **Comment:** dense, coarse grained, intrusive rock with strongly altered phenocrysts, need to check thin section for datable mineral phases!

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
</tr>
</thead>
</table>
| SO225-013ROV04 | 1. Rock Type: volcanic rock, slightly altered
2. Size: 22x16x12cm
3. Shape / Angularity: angular shape
4. Color of cut surface: 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) |

**SO225-013ROV04**
- **Sampling Depth:** 4046m
- **Coordinates:** lat 6°04.22'S, long 164°41.33'W
- **Rock Type:** dense, intrusive? rock with a tectonic+metamorphic overprint (altered)
- **Size:** 28x18x13cm
- **Shape / Angularity:** angular shape
- **Color of cut surface:** grey-red to green color on dry, broken surface
- **Texture / Vesicularity:** coarse grains (phenocrysts) in a coarse grained matrix (no vesicles)
- **Phenocrysts:** 0.5-1cm olivines?, strongly altered
- **Matrix:** coarse grained, grey matrix
- **Secondary Minerals:** rock is strongly altered, Fe-oxides? in cracks
- **Encrustations:** 1-3mm Mn crust
- **Comment:** dense, coarse grained, intrusive rock with strongly altered phenocrysts, need to check thin section for datable mineral phases!

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
</tr>
</thead>
</table>
| SO225-013ROV04 | 1. Rock Type: volcanic rock, slightly altered
2. Size: 22x16x12cm
3. Shape / Angularity: angular shape
4. Color of cut surface: 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) |

**SO225-013ROV04**
- **Sampling Depth:** 4034m
- **Coordinates:** lat 6°04.22'S, long 164°41.33'W
- **Rock Type:** dense, intrusive? rock with a tectonic+metamorphic overprint (altered)
- **Size:** 12x7x6cm
- **Shape / Angularity:** angular shape
- **Color of cut surface:** grey color on dry surface
- **Texture / Vesicularity:** dense, fine grained structure (no vesicles)
- **Phenocrysts:** 1-2mm transparent feldspar phenocrysts
- **Matrix:** fine grained, grey matrix
- **Secondary Minerals:** recrystallized alteration veins
- **Encrustations:** 1-2mm Mn crust
- **Comment:** dense, fine grained, volcanic rock with fine grained matrix, plag phenocrysts and alteration veins

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
</tr>
</thead>
</table>
| SO225-013ROV04 | 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, fine grained, volcanic rock with fine grained matrix, plag phenocrysts and alteration veins |

**SO225-013ROV04**
- **Sampling Depth:** 4055m
- **Coordinates:** lat 6°04.10'S, long 164°41.31'W
- **Rock Type:** volcanic (intrusive?) rock
- **Size:** 18x14x7cm
- **Shape / Angularity:** angular shape
- **Color of cut surface:** grey color on broken, dry surface
- **Texture / Vesicularity:** fine grained, vesicles filled with Mn or minerals (>0.5mm size)
- **Phenocrysts:** 0.5-0.8mm olivine phenocrysts replaced by Fe-oxides
- **Matrix:** fine grained matrix (grey color)
- **Secondary Minerals: Fe-oxides replacing olivine
- **Encrustations:** 2-5mm Mn crust
- **Comment:** fine grained, volcanic rock with metamorphic overprint
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CR</th>
<th>AR</th>
<th>CH</th>
<th>GM</th>
<th>BOX</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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, partly 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 magnatic 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 (~0.5-8.0cm) filled with secondary minerals)  
2. Size: 15x9x14cm  
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: 3885m 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 | 2 | E2 | | | |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>Depth</th>
<th>Shape / Angularity</th>
<th>Rock Type</th>
<th>Coordinates</th>
<th>Matrix</th>
<th>Texture / Vesicularity</th>
<th>Phenocrysts</th>
<th>Secondary Minerals</th>
<th>Encrustations</th>
<th>Notes</th>
</tr>
</thead>
</table>
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
### Appendix II (Rock Description)

**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 boulders (6-7 tons); 1 large boulder (8.8t); Mn-encrusted pebbles; solidified sediment

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-5-1</td>
<td>Rock Type: volcanic? rock, very altered</td>
<td>4-5</td>
<td>1 sample photo</td>
<td><img src="image" alt="Sample Image" /></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 7x5x3cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: rounded shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: grey-brown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: fine grained, no vesicles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: no phenocrysts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine grained, grey matrix (brown near alteration cracks/veins)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: 0.5-1cm Mn crust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: dense, volcanic rock?, strongly altered with cracks and veins (rounded clast covered by Mn crust)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-5-2</td>
<td>Rock Type: sediment with magmatic veins?</td>
<td>4</td>
<td>1 sample photo</td>
<td><img src="image" alt="Sample Image" /></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 10x15x8cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: rounded, partly angular shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown (sediment), black (veins) on broken surface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: fine-grained sediment, zoned veins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine grained, brown matrix (sediment)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: reddish and green minerals in veins (~1mm size)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: 0.1-1cm Mn crust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: angular clast, sediment (claystone) with magmatic veins?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-5-3</td>
<td>Rock Type: volcanic rock?, altered (veins)</td>
<td>1</td>
<td>1</td>
<td><img src="image" alt="Sample Image" /></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 5x5x3cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: rounded shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: grey-brownish color on broken surface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: fine grained, no vesicles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: &lt;1mm black needles (pyroxene)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: brown, fine grained matrix with ~10% white grains</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: Fe-oxides in alteration veins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: 0.1-1cm Mn crust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: rounded clast (volcanic, altered), covered by Mn crust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-5-4</td>
<td>Rock Type: sediment (claystone)</td>
<td>1</td>
<td>1</td>
<td><img src="image" alt="Sample Image" /></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 5x9x8cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: rounded shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: grey-brown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: fine grained</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine grained matrix with alteration veins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: 1-2mm Mn crust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: claystone clast covered by Mn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-5-5</td>
<td>Rock Type: sediment (claystone)</td>
<td>1</td>
<td>1</td>
<td><img src="image" alt="Sample Image" /></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 5.5x3x7cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: rounded shape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: grey brown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: grey brown, fine grained</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: 1-5mm Mn crust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: sediment clast (claystone) covered by Mn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE #</td>
<td>SAMPLE DESCRIPTION</td>
<td>NOTES</td>
<td>PICTURE</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-------------------</td>
<td>-------</td>
<td>---------</td>
<td></td>
</tr>
</tbody>
</table>
**Appendix II (Rock Description)**

**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 16:12hrs, 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  

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>TS</th>
<th>CHEM</th>
<th>AR/Ar</th>
<th>GRA</th>
<th>GEOL</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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-phryic pillow lavas (size up to 30cm); At least 2 samples look promising for  

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>TS</th>
<th>CHEM</th>
<th>AR/Ar</th>
</tr>
</thead>
</table>
| 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 xts are up to 1mm along long side  
7. Matrix: matrix well crystallized, interstitial 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 |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHRM</th>
<th>GRAV</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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 crystalized interstitial, 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 | 3-5 | 2-3 | 1 | ![Picture] |
| 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 | | | | ![Picture] |
| 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 aphanic, amount of olivine <<1%, strongly altered and has no visible xls, suitable for Ar-Ar | 2 | | | | ![Picture] |
| 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 | | | | ![Picture] |
**Appendix II (Rock Description)**

**SO225-026DR08**

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

Dredge on bottom UTC 17/12/17 05:44hrs, lat 6°45.71'S, long 163°25.78'W, depth 5396m
Dredge off bottom UTC 17/12/17 06:55hrs, lat 6°45.99'S, long 163°25.42'W, depth 5143m
total volume: 7 piece (large)

Comments: First looked like Mn encrusted clasts, later due to homogeneity and angularity of clasts interpreted as lava top or pillow breccia

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-8-1</td>
<td>Rock Type: dense, volcanic rock, altered (Mn veins)</td>
<td>2</td>
<td>4-5</td>
<td></td>
<td></td>
<td><img src="image1.jpg" alt="Picture" /></td>
</tr>
<tr>
<td>1. Size: 10x15x12cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Shape / Angularity: angular shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Color of cut surface: brown color on broken surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Texture / Vesicularity: fine grained matrix, no vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Phenocrysts: ~10% white plag?; phenocrysts (~1-3mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Matrix: brown, fine grained matrix (porphyric) with plag? phenocrysts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Secondary Minerals: Mn veins, brown Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Encrustations: 1-3mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comment: dense, volcanic (porphyric) rock with white plag? phenocrysts and Mn veins indicating alteration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-8-2</td>
<td>Rock Type: dense, volcanic rock, altered (Mn veins)</td>
<td>1</td>
<td>4-5</td>
<td></td>
<td></td>
<td><img src="image2.jpg" alt="Picture" /></td>
</tr>
<tr>
<td>1. Size: 10x15x8cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Shape / Angularity: angular shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Color of cut surface: brown-grey color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Texture / Vesicularity: porphyric texture, no vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Phenocrysts: ~1-2mm plag? phenocrysts — partly intergrowth of white grains with green pyroxene? phenocrysts, fresh olivines? (~1mm)!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Matrix: fresh matrix: grey, altered areas: brown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Secondary Minerals: Mn veins, red brown Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Encrustations: 1-10mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comment: dense, porphyric rock with plag?, pyroxene and olivine? phenocrysts (altered rock)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-8-3</td>
<td>Rock Type: volcanic, altered</td>
<td>1</td>
<td>4-5</td>
<td></td>
<td></td>
<td><img src="image3.jpg" alt="Picture" /></td>
</tr>
<tr>
<td>1. Size: 10x8x7cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Shape / Angularity: angular shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Color of cut surface: brown-grey color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Texture / Vesicularity: see sample 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Phenocrysts: see sample 1, ~1mm titanite? grains (&lt;1%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Matrix: see sample 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Secondary Minerals: red-brown Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Encrustations: 1-2mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comment: see sample 1, 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-8-4</td>
<td>Rock Type: volcanic, altered</td>
<td>1</td>
<td>4-5</td>
<td></td>
<td></td>
<td><img src="image4.jpg" alt="Picture" /></td>
</tr>
<tr>
<td>1. Size: 8x8x7cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Shape / Angularity: angular shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Color of cut surface: brown-grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Texture / Vesicularity: no vesicles, porphyric</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Phenocrysts: ~1-2mm plag? phenocrysts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Matrix: fine grained, brown-grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Secondary Minerals: Mn veins, brown Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Encrustations: ~1mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comment: see sample 1, 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-8-5</td>
<td>Rock Type: volcanic, altered</td>
<td>1</td>
<td>4-5</td>
<td></td>
<td></td>
<td><img src="image5.jpg" alt="Picture" /></td>
</tr>
<tr>
<td>1. Size: 10x4x8cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Shape / Angularity: rounded/angular shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Color of cut surface: brown-grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Texture / Vesicularity: porphyric, no vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Phenocrysts: 1-2mm plag phenocrysts, ~1mm titanite? grains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Matrix: fine grained, brown-grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Secondary Minerals: black Mn veins, brown Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Encrustations: ~1mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comment: see sample 1, 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE #</td>
<td>SAMPLE DESCRIPTION</td>
<td>GS</td>
<td>CHRM</td>
<td>Age</td>
<td>GRID</td>
<td>NOTES</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------</td>
<td>----</td>
<td>------</td>
<td>-----</td>
<td>------</td>
<td>-------</td>
</tr>
</tbody>
</table>
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
</tr>
</thead>
</table>
### Appendix II (Rock Description)

#### 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

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRAIN</th>
<th>MATT</th>
<th>WRINKLE</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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  |        |       | ![Picture](SO225 DR-9-1) |

| 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: - |       |       |        |       | ![Picture](SO225 DR-9-2-x) |

| 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: - |       |       |        |       | ![Picture](SO225 DR-9-3-x) |

---

#### 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°34.97’S, long 163°59.81’W, depth 4309m

Total volume: empty!

Comments: -

**Appendix II (Rock Description)**

**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

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>TS</th>
<th>CHEM</th>
<th>AR/Ar</th>
<th>GL/MIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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: -  
10. Comment: foliated claystone with Mn crust | 2 |      |      |        |       | [Picture] |
| 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: - | | | | | | [Picture] |
| 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: - | | | | | | [Picture] |
| SO225-DR-11-4x | 1. Rock Type: brown, rounded claystone clast, partly covered by Mn crust (~1mm)  
2. Size: 10x10x8cm  
3. Shape / Angularity: -  
4. Color of cut surface: -  
5. Texture / Vesicularity: -  
6. Phenocrysts: -  
7. Matrix: -  
8. Secondary Minerals: -  
9. Encrustations: -  
10. Comment: - | | | | | | [Picture] |
**Appendix II (Rock Description)**

**Description of Location and Structure:** Central Danger Islands Trough; Profile below SO193-DR26; NW-SE striking scarp along eastern wall of DIT

Dredge off bottom UTC 19/12/12 23:17hrs, lat 9°22.73’S, long 164°16.07’W, depth 4004m

Dredge off bottom UTC 19/12/12 21:47hrs, lat 9°22.99’S, long 164°16.55’W, depth 4440m

**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

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>QUILM</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-12-1</td>
<td>1. Rock Type: volcanic rock, moderately to slightly altered</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2. Size: 13x14x8cm</td>
<td></td>
<td></td>
<td></td>
<td><a href="#">PICTURE</a></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: angular with slightly rounded rims</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: light grey with yellowish parts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: massive with rare elongated voids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: no obvious phenocrysts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine crystallized texture, aphanitic or intersertal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: some oxidation along veins, very little</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: very thin (&lt;1mm) Mn crust, some Mn in voids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: good for chemistry! Dating should be possible on g.m. fragments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SO225-DR-12-2 | 1. Rock Type: volcanic glass fragment in paleoplastic (pillow rim?) | 1 | | | [PICTURE](#) |
|               | 2. Size: 12x13x5cm | | | | |
|               | 3. Shape / Angularity: subrounded | | | | |
|               | 4. Color of cut surface: fresh, angular, black glass fragments in greenish-yellow paleoplastic | | | | |
|               | 5. Texture / Vesicularity: - | | | | |
|               | 6. Phenocrysts: no obvious phenocrysts | | | | |
|               | 7. Matrix: - | | | | |
|               | 8. Secondary Minerals: rare voids in glass filled with zeolite, paleoplastic, some white veins in paleoplastic | | | | |
|               | 9. Encrustations: - | | | | |
|               | 10. Comment: excellent glass for all analyses! | | | | |

| SO225-DR-12-3 | 1. Rock Type: hyaloclastite (paleoplastic) covered by Mn crust | 1 | | | [PICTURE](#) |
|               | 2. Size: 21x10x5cm | | | | |
|               | 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 paleoplastic 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 microprobeed to check for homogeneity! | | | | |

<p>| SO225-DR-12-4 | 1. Rock Type: volcanic rock, moderately altered | 1 | 2 | -3 | <a href="#">PICTURE</a> |
|               | 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 | | | | |</p>
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>Notes</th>
<th>Picture</th>
</tr>
</thead>
</table>
| 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 spotted with grey color  
5. Texture / Vesicularity: coarse grained  
6. Phenocrysts: ~60% olivine replaced with Fe-oxides, ~20% cpx, bottle green, ~20% plagioclase, 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 strongly altered. Coarse section must be inspected. Plag is likely altered. Thin section must be observed |
| 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 xts.  
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 |
| 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 dating |
| 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 |
| 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?) |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHM</th>
<th>CRT</th>
<th>CREW</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-12-10 | 1. Rock Type: volcanic rock, breccia, strongly altered  
2. Size: 56x32x28cm  
3. Shape / Angularity: angular  
4. Color of cut surface: -  
5. Texture / Vesicularity: fragments are homogeneous. All composed yellowish grey, finely crystalized rock with numerous voids (~50%) up to 2mm filled with calcite  
6. Phenocrysts: -  
7. Matrix: ground mass finely crystalized  
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 | ? | | | ![Picture](image) |
| 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: - | 3 | | | | | ![Picture](image) |
| 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 | 1 | | | | | ![Picture](image) |
| SO225-DR-12-12 | 1. Rock Type: volcanic rock, moderately altered  
2. Size: 13x6x4.5cm  
3. Shape / Angularity: -  
4. Color of cut surface: -  
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 | | | | | ![Picture](image) |
| 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 | | | | | ![Picture](image) |
| 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 | 1 | | | | | ![Picture](image) |
## Appendix II (Rock Description)

### SAMPLE # | SAMPLE DESCRIPTION | CHEM | GRA | GRAY | SQ.I | Grade | NOTES | PICTURE
---|---|---|---|---|---|---|---|---


SO225-DR-12-17 | Rock Type: palagonite 1. Size: 14x10x7cm 2. Shape / Angularity: rounded 3. Color of cut surface: olive green with brownish bands parallel to each other 4. Texture / Vesicularity: - 5. Phenocrysts: - 6. Matrix: - 7. Secondary Minerals: - 8. Encrustations: - 9. Comment: this rock is former hyaloclastite formed by glass fragments up to 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 | | | | | | ![Picture](image3)

### SO225-031DR013

**Description of Location and Structure:** Southern Danger Islands Troughs; Profile close to SO193-DR26; central part of the slope to lowermost terrace

Dredge on bottom UTC 19/12/12 02:36hrs, lat 9°23.03'S, long 164°15.98'W, depth 4086m

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 | CHEM | GRA | GRAY & SQ.MM | Grade | NOTES | PICTURE
---|---|---|---|---|---|---|---
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>SM</th>
<th>CHX</th>
<th>Cr</th>
<th>Fe</th>
<th>Mn</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-13-2 | 1. Rock Type: volcanic rock, altered  
2. Size: 8.5x6.5x6cm  
3. Shape / Angularity: angular, partly rounded  
4. Color of cut surface: grey color on broken surface  
5. Texture / Vesiculality: 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  
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: 12x9x6cm  
3. Shape / Angularity: angular, partly rounded shape  
4. Color of cut surface: grey color on broken surface  
5. Texture / Vesiculality: 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 / Vesiculality: 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 / Vesiculality: 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 / Vesiculality: -  
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! | 2   | 2   | 4   |     |     |      |         |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>NO. OF CHM</th>
<th>Ar Age</th>
<th>Grade</th>
<th>Color</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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  
9. Encrustations: 1-20mm Mn crust  
10. Comment: dense, volcanic rock (Ol-basalt) --> Pillow lava fragment | 1 | 3 | 4 | | | ![Picture](image) |
| 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  
9. Encrustations: 1-3mm Mn crust with palagonite (green)  
10. Comment: dense, volcanic rock (Ol-basalt) --> Pillow lava fragment with chilled margins, possible fresh glass! | 2 | 3 | 4 | | | ![Picture](image) |
| 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! | 4 | 5 | | | | ![Picture](image) |
| 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 | | | | ![Picture](image) |
| 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! | 4 | 5 | | | | ![Picture](image) |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-13-10 | 1. Rock Type: volcanic, altered (volcanoclastic 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     |       | ![Picture](SO225-DR-13-10) |
| SO225-DR-13-11 | 1. Rock Type: volcanic rock, altered  
2. Size: 30x30x20cm  
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     | 3-4   | ![Picture](SO225-DR-13-11) |
| 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 | 2     |       | ![Picture](SO225-DR-13-12) |
| 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: - | 2     |       | ![Picture](SO225-DR-13-13x) |
| 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: - | 2     |       | ![Picture](SO225-DR-13-14x) |
**Appendix II (Rock Description)**

**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 off bottom UTC 19/12/12 07:55hrs, lat 9°22.31’S, long 164°15.63’W, depth 3370m

Dredge off bottom UTC 19/12/12 06:33hrs, lat 9°22.47’S, long 164°16.01’W, depth 3793m

Total volume: 3/4 full

Comments: basaltic debris; brownish to reddish, oxidized, flat sized, subangular clasts

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHEM.</th>
<th>GRA.</th>
<th>QM.</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE #</td>
<td>SAMPLE DESCRIPTION</td>
<td>CH</td>
<td>GR</td>
<td>GM</td>
<td>NOTES</td>
<td>PICTURE</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>-------</td>
<td>---------</td>
</tr>
</tbody>
</table>
| 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 / Vescularty: 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-14-5 |
| 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 / Vescularty: microcryst. matrix, ~20% vesicles filled with black Mn/white-green minerals  
6. Phenocrysts: no phenocrysts  
7. Matrix: fine grained, brown matrix  
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-14-6 |
| 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 / Vescularty: dense, microcryst. matrix, vesicles ~5% partly filled with white/green minerals and black Mn  
6. Phenocrysts: no phenocrysts  
7. Matrix: fine grained, brown matrix  
9. Encrustations: ~1mm Mn crust  
10. Comment: volcanic rock with metamorphic overprint (alteration) and partly filled vesicles | 2 | 2 | 3-4 | | SO225 DR-14-7 |
| 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 / Vescularty: dense, microcryst. matrix, ~20% vesicles, partly filled with green white minerals or black Mn  
6. Phenocrysts: ~5% iddingsit. olivine  
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-14-8 |
| 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 / Vescularty: 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 | | SO225 DR-14-9 |
**Appendix II (Rock Description)**

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRM</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE #</td>
<td>SAMPLE DESCRIPTION</td>
<td>GRN</td>
<td>NOTES</td>
<td>PICTURE</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>--------------------</td>
<td>-----</td>
<td>-------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>SO225-DR-14-15</td>
<td>Rock Type: volcanic, strongly altered</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>1. Rock Type: volcanic, strongly altered</td>
<td>2</td>
<td>Size: 16x12x13cm</td>
<td>3</td>
<td>Shape / Angularity: rounded shape</td>
<td>4</td>
</tr>
<tr>
<td>SO225-DR-14-16</td>
<td>Rock Type: (volcanic), hyaloclastite?</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Rock Type: (volcanic), hyaloclastite?</td>
<td>2</td>
<td>Size: 11x6x9cm</td>
<td>3</td>
<td>Shape / Angularity: rounded</td>
<td>4</td>
</tr>
<tr>
<td>SO225-DR-14-17</td>
<td>Rock Type: hyaloclastite?, altered</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Rock Type: hyaloclastite?, altered</td>
<td>2</td>
<td>Size: 10x6x7cm</td>
<td>3</td>
<td>Shape / Angularity: -</td>
<td>4</td>
</tr>
<tr>
<td>SO225-DR-14-18</td>
<td>Rock Type: hyaloclastite?, altered</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Rock Type: hyaloclastite?, altered</td>
<td>2</td>
<td>Size: 16x16x10cm</td>
<td>3</td>
<td>Shape / Angularity: -</td>
<td>4</td>
</tr>
<tr>
<td>SO225-DR-14-19X</td>
<td>Rock Type: altered pillow fragment, covered by Mn crust (1-2cm thick) with typical chilled margins</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Rock Type: altered pillow fragment, covered by Mn crust (1-2cm thick) with typical chilled margins</td>
<td>2</td>
<td>Size: 30x20x10cm</td>
<td>3</td>
<td>Shape / Angularity: -</td>
<td>4</td>
</tr>
<tr>
<td>SO225-DR-14-20</td>
<td>Rock Type: fragments of Mn crust with green palagonite rim between the Mn crust and the basaltic rock</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Rock Type: fragments of Mn crust with green palagonite rim between the Mn crust and the basaltic rock</td>
<td>2</td>
<td>Size: fragments have size between 10-20cm</td>
<td>3</td>
<td>Shape / Angularity: -</td>
<td>4</td>
</tr>
</tbody>
</table>
## Appendix II (Rock Description)

### 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 boulders

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>TS</th>
<th>CHEM</th>
<th>CHAQ</th>
<th>GRADE</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-15-1</td>
<td>Rock Type: Mn encrusted palagonite fragment?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Size: 10x9x6cm</td>
<td></td>
<td></td>
<td></td>
<td>fresh glass</td>
<td></td>
<td><a href="#">Picture</a></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: angular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: green-brown color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Encrustations: 1-3cm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Comment: Mn encrusted palagonite fragment?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SO225-DR-15-2 | Rock Type: Mn encrusted breccia? | | | | | | |
| | 1. Size: 10x9x6cm | | | | | | |
| | 2. Shape / Angularity: rounded shape | | | | | | |
| | 3. Color of cut surface: green-brown to white color | | | | | | |
| | 4. Texture / Vesicularity: clasts ~5-15mm size | | | | | | |
| | 5. Phenocrysts: - | | | | | | |
| | 6. Secondary Minerals: - | | | | | | |
| | 7. Matrix: - | | | | | | |
| | 8. Encrustations: ~0.5cm Mn crust | | | | | | |
| | 9. 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

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>TS</th>
<th>CHEM</th>
<th>CHAQ</th>
<th>GRADE</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-16-1</td>
<td>Rock Type: volcanic rock, moderately to slightly altered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Size: 8x8x7cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: rounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: reddish brown to grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: massive with small irregular voids</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: olivine phenocrysts &lt;5% replaced with Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Matrix: matrix finely recrystallized</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Secondary Minerals: some oxidation and void fillings with second. minerals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Encrustations: thin (&lt;1mm) Mn crust on outer surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Comment: may be good for chemistry, thin section should be inspected</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SO225-DR-16-2 | Rock Type: volcanic rock, moderately to strongly altered | | | | | | |
| | 1. Size: 16x10x8cm | | | | | | |
| | 2. Shape / Angularity: subangular | | | | | | |
| | 3. Color of cut surface: dark reddish brown | | | | | | |
| | 4. Texture / Vesicularity: similar to sample 1 but has more vesicles of larger size | | | | | | |
| | 5. Phenocrysts: olivine ~5-7%, strongly oxidized | | | | | | |
| | 6. Matrix: - | | | | | | |
| | 7. Secondary Minerals: - | | | | | | |
| | 8. Encrustations: thin Mn crust on outer surface | | | | | | |
| | 9. Comment: strong oxidation suggests subaerial eruption. Numerous irregular vesicles suggest this, too. Chemistry may be problematic, because of second. minerals filling voids | | | | | | |

---

*page 30 of 61*
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>Notes</th>
<th>Picture</th>
</tr>
</thead>
</table>
| SO225-DR-16-3 | 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 small olivine (<5%)  
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: similar to sample 1 and 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 | ![Picture](image1.png) |
| 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 skeleton shape  
7. Matrix: matrix fine crystallized with likely fresh plag  
8. Secondary Minerals: oxidation is strong but some small areas of grey matrix are present  
9. Encrustations: thin Mn crust <1%, Mn precipitates in ground mass  
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 | ![Picture](image2.png) |
| SO225-DR-16-5 | 1. Rock Type: volcanic rock, moderately to strongly altered  
2. Size: 20x11x10cm  
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: 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 | ![Picture](image3.png) |
| 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 | ![Picture](image4.png) |
| 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 | ![Picture](image5.png) |
## Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>COLOR</th>
<th>AR-Ar</th>
<th>BEARING</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-16-8</td>
<td>1. Rock Type: volcanic rock, moderately altered</td>
<td>1</td>
<td>4+</td>
<td>1</td>
<td></td>
<td></td>
<td><img src="image" alt="SO225 DR-16-8" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 45x25x19cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: angular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brownish grey with large dark brown spots of vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: Ol (~5-7%) up to 1mm, all replaced by Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: matrix fine crist., aphanitic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: green, plag may be preserved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: ~0.5cm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: voids should be avoided when picking. May be ~good for chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-16-9</td>
<td>1. Rock Type: volcanic rock, strongly altered</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td><img src="image" alt="SO225 DR-16-9" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 20x20x8cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: rounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: greyish green with red-black spots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: similar to sample 8 but has more olivine (up to 10%), all altered. Chemistry is problematic!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-16-10</td>
<td>1. Rock Type: volcanic rock, strongly altered</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td><img src="image" alt="SO225 DR-16-10" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 20x12x6cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: subangular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown with dark spots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: massive with rare vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: similar to sample 8-9 but has lot of vesicles. Ol ~15% up to 2mm, all altered. Problematic for chemistry.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-16-11</td>
<td>1. Rock Type: volcanic rock, altered</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td><img src="image" alt="SO225 DR-16-11" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 22x22x8cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: subangular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown with dark spots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: massive with rare vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: Ol ~1-2% (~1mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: matrix fine to medium cryst., probably with fresh plag, large (~1cm) vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: ~2mm outer Mn crust, voids filled with Mn and oxidized palagonite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: alteration is somewhat spotty. Should be possible to separate grey fragments to Ar-Ar. Chemistry is somewhat problematic because of voids and Mn.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-16-12</td>
<td>1. Rock Type: volcanic rock, moderately altered</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td><img src="image" alt="SO225 DR-16-12" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 10x7x6cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: subrounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: grey with yellowish/green bands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: massive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: large Ol (up to 5mm) ~10-15%, all altered, replaced with Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: matrix fine-crist., no clear minerals and looks somewhat fluidal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: thin Mn crust, alteration of Ol and matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE #</td>
<td>SAMPLE DESCRIPTION</td>
<td>GRA</td>
<td>Ar-Ar</td>
<td>CHN</td>
<td>NOTES</td>
<td>PICTURE</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td>-------</td>
<td>---------</td>
<td></td>
</tr>
</tbody>
</table>
| 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    |     |       | ![Image](image1.png) |
| 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   |      |     |       | ![Image](image2.png) |
| 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: - | | | | ![Image](image3.png) |
| 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 crystalized and can be tried for Ar-Ar and chemistry after inspection of thin section. | 1   |      |     |       | ![Image](image4.png) |
### Appendix II (Rock Description)

**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

Drilled on bottom UTC 19/12/12 19:43hrs, lat 9°17.04’S, long 164°21.31’W, depth 4700m

Dredged 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. Volcanoclastics. Mn crusts; 2

fragments ~50cm across; ~20 smaller ones

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>SIZE</th>
<th>CR</th>
<th>AR</th>
<th>AN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-17-1</td>
<td>Rock Type: volcanic rock, strongly altered</td>
<td>2. Size: 87x27x20cm</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>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 Dredged on bottom UTC 19/12/12 19:43hrs, lat 9°17.04’S, long 164°21.31’W, depth 4700m Dredged 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. Volcanoclastics. Mn crusts; 2 fragments ~50cm across; ~20 smaller ones</td>
<td>2</td>
</tr>
<tr>
<td>SO225-DR-17-2</td>
<td>Rock Type: volcanic rock, strongly altered</td>
<td>2. Size: 22x15x12cm</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>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 Dredged on bottom UTC 19/12/12 19:43hrs, lat 9°17.04’S, long 164°21.31’W, depth 4700m Dredged 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. Volcanoclastics. Mn crusts; 2 fragments ~50cm across; ~20 smaller ones</td>
<td>1</td>
</tr>
<tr>
<td>SO225-DR-17-3</td>
<td>Rock Type: volcanic rock, strongly altered</td>
<td>2. Size: 16x12x8cm</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>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 Dredged on bottom UTC 19/12/12 19:43hrs, lat 9°17.04’S, long 164°21.31’W, depth 4700m Dredged 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. Volcanoclastics. Mn crusts; 2 fragments ~50cm across; ~20 smaller ones</td>
<td>1</td>
</tr>
<tr>
<td>SO225-DR-17-4</td>
<td>Rock Type: volcanic rock, strongly altered</td>
<td>2. Size: 20x17x10cm</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>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 Dredged on bottom UTC 19/12/12 19:43hrs, lat 9°17.04’S, long 164°21.31’W, depth 4700m Dredged 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. Volcanoclastics. Mn crusts; 2 fragments ~50cm across; ~20 smaller ones</td>
<td>1</td>
</tr>
<tr>
<td>SO225-DR-17-5</td>
<td>Rock Type: volcanic rock, altered</td>
<td>2. Size: 25x15x11cm</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>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 Dredged on bottom UTC 19/12/12 19:43hrs, lat 9°17.04’S, long 164°21.31’W, depth 4700m Dredged 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. Volcanoclastics. Mn crusts; 2 fragments ~50cm across; ~20 smaller ones</td>
<td>2</td>
</tr>
</tbody>
</table>
# Appendix II (Rock Description)

## 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, vitrophric
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.

## SO225-DR-17-7

1. **Rock Type**: volcaniclastic rock, totally altered
2. **Size**: 25x20x8cm
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 relics

## 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

## 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**: gray 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
## Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>CMX</th>
<th>GRN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-18-2 | 1. Rock Type: volcanic rock, altered  
2. Size: 18x11x12cm  
3. Shape / Angularity: rounded shape  
4. Color of cut surface: gray 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   |       | ![Picture](SO225-DR-18-2.jpg) |
| 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   |       | ![Picture](SO225-DR-18-3.jpg) |
| SO225-DR-18-4 | 1. Rock Type: volcanic, altered  
2. Size: 10x8x6cm  
3. Shape / Angularity: angular  
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  
9. Encrustations: ≤1-3mm Mn crust  
10. Comment: see sample 1! | 1     | 2   | 2-3 |       | ![Picture](SO225-DR-18-4.jpg) |
| SO225-DR-18-5 | 1. Rock Type: volcanic, altered  
2. Size: 30x20x20cm  
3. Shape / Angularity: angular  
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 |       | ![Picture](SO225-DR-18-5.jpg) |
| SO225-DR-18-6 | 1. Rock Type: volcanic, altered  
2. Size: 15x10x7cm  
3. Shape / Angularity: angular  
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 |       | ![Picture](SO225-DR-18-6.jpg) |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GR</th>
<th>GRA</th>
<th>CHEM</th>
<th>CHY</th>
<th>NUM</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-18-7 | Rock Type: volcanic, altered  
1. Size: 17x11x11cm  
2. Shape / Angularity: angular shape  
3. Color of cut surface: grey brown color on broken surface  
4. Texture / Viscosity: dense, microcryst. matrix. ~5% vesicles filled with black Mn, spinifex texture  
5. Phenocrysts: ≤1mm white greenish pyroxene needles (spinifex)  
6. Matrix: fine grained, grey brownish matrix  
7. Secondary Minerals: Mn in vesicles  
8. Encrustations: 3-6mm Mn crust  
9. Comment: see sample 1! | 2 1 3 |  |  |  |  |  |
| SO225-DR-18-8 | Rock Type: volcanic, altered  
1. Size: 12x9x9cm  
2. Shape / Angularity: angular shape (rounded Mn crust)  
3. Color of cut surface: grey color on broken surface  
4. Texture / Viscosity: dense, microcryst. matrix. ~2-3% vesicles filled with black Mn, spinifex texture  
5. Phenocrysts: white greenish pyroxene needles (spinifex)  
6. Matrix: fine grained, grey matrix  
7. Secondary Minerals: brown Fe-oxides in cracks, black Mn in vesicles  
8. Encrustations: ~5mm Mn crust (rock partly covered)  
9. Comment: see sample 1! | 1 2 3-4 |  |  |  |  |  |
| SO225-DR-18-9 | Rock Type: volcanic, altered  
1. Size: 30x25x22cm  
2. Shape / Angularity: angular shape  
3. Color of cut surface: brown greenish color on broken surface  
4. Texture / Viscosity: dense, microcryst. matrix. <5% vesicles filled with black Mn, spinifex texture  
5. Phenocrysts: white green pyroxene needles 1-10mm! (spinifex)  
6. Matrix: fine grained, grey-green matrix  
7. Secondary Minerals: Fe-oxides in veins, Mn in vesicles  
8. Encrustations: 1-2mm Mn crust  
9. Comment: volcanic rock formed in vesicles with spinifex texture and moldic texture  
10. Comment: volcanic rock with fine grained matrix and 1-10mm pyroxene needles with spinifex texture | 1 4 3-4 |  |  |  |  |  |
| SO225-DR-18-10 | Rock Type: volcanic, altered  
1. Size: 9x9x7cm  
2. Shape / Angularity: angular shape  
3. Color of cut surface: grey green color on broken surface  
4. Texture / Viscosity: fine grained matrix, ~15% vesicles filled with black Mn, spinifex texture  
5. Phenocrysts: 1-5mm greenish pyroxene needles (spinifex texture)  
6. Matrix: fine grained, green-grey matrix  
7. Secondary Minerals: brown Fe-oxides, Mn in vesicles, Fe-oxides also in veins  
8. Encrustations: no Mn crust  
9. Comment: volcanic rock with spinifex texture (pyroxene needles ~1-5mm) | 1 3 |  |  |  |  |  |
| SO225-DR-18-11 | Rock Type: volcanic, altered  
1. Size: 20x11x10cm  
2. Shape / Angularity: angular, partly rounded  
3. Color of cut surface: green-grey color on broken surface  
4. Texture / Viscosity: fine grained matrix, vesicles ~5% filled with black Mn, spinifex texture  
5. Phenocrysts: 1-3mm pyroxene needles (spinifex)  
6. Matrix: fine grained, grey matrix  
7. Secondary Minerals: Mn in veins and vesicles  
8. Encrustations: partly covered by Mn (~1-2mm thick)  
9. Comment: see sample 10 (pyroxene needles 1-3mm) | 2 3 |  |  |  |  |  |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRAIN SIZE</th>
<th>GRAIN NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-18-12</td>
<td>Rock Type: volcanic, altered</td>
<td>2</td>
<td>37</td>
<td><img src="image" alt="SO225-DR-18-12" /></td>
</tr>
<tr>
<td></td>
<td>1. Shape / Angularity: angular, partly rounded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 20x12x10cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Texture / Vesicularity: fine grained matrix ~20% vesicles filled with black Mn, spinifex texture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: green-grey color on broken surface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: 1-2mm greenish pyroxene needles (spinifex)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Encrustations: ~1mm Mn crust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Comment: see sample 10 (pyroxene needles 1-2mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SO225-DR-18-13 | Rock Type: volcanic, altered | 2 | 37 | ![SO225-DR-18-13](image) |
|  | 1. Shape / Angularity: angular shape | | | |
|  | 2. Size: 18x7x13cm | | | |
|  | 3. Texture / Vesicularity: dense, microcryst. matrix, ~20% vesicles filled with black Mn, spinifex texture | | | |
|  | 4. Color of cut surface: grey green color on broken surface | | | |
|  | 5. Phenocrysts: 1-5mm white/green pyroxene needles (spinifex) | | | |
|  | 7. Matrix: fine grained, grey green matrix | | | |
|  | 8. Encrustations: 1-3mm Mn crust | | | |
|  | 9. Comment: see sample 10 (pyroxene needles 1-5mm) | | | |

| SO225-DR-18-14 | Rock Type: metamorphic rock | 2 | | ![SO225-DR-18-14](image) |
|  | 1. Shape / Angularity: angular shape | | | |
|  | 2. Size: 30x60x7cm | | | |
|  | 3. Texture / Vesicularity: coarse grained matrix with ~1-8mm chlorite? needles | | | |
|  | 4. Color of cut surface: green/black color on broken surface | | | |
|  | 5. Phenocrysts: chlorite? (green 1-8mm needles) | | | |
|  | 6. Secondary Minerals: - | | | |
|  | 7. Matrix: coarse grained, green black matrix | | | |
|  | 8. Encrustations: ~1mm Mn crust | | | |
|  | 9. Comment: metamorphic rock, green schist with 1-8mm chlorite needles (1 sample ~10cm prepared for Sergej S.; 2 TS and 2 smaller fragments) | | | |

| SO225-DR-18-15 | Rock Type: metamorphic rock | 2 | | ![SO225-DR-18-15](image) |
|  | 1. Shape / Angularity: angular, partly rounded | | | |
|  | 2. Size: 27x35x12cm | | | |
|  | 3. Texture / Vesicularity: coarse grained matrix with ~1-10cm chlorite needles | | | |
|  | 4. Color of cut surface: green/black color | | | |
|  | 5. Phenocrysts: chlorite (green); 1-10mm | | | |
|  | 6. Secondary Minerals: - | | | |
|  | 7. Matrix: coarse grained, green black matrix | | | |
|  | 8. Encrustations: partly ~0.5cm Mn crust | | | |
|  | 9. Comment: see sample 14! | | | |

| SO225-DR-18-16 | Rock Type: sediment? | 2 | | ![SO225-DR-18-16](image) |
|  | 1. Shape / Angularity: angular, partly rounded | | | |
|  | 2. Size: 33x19x14cm | | | |
|  | 3. Texture / Vesicularity: light grey color on broken surface | | | |
|  | 4. Color of cut surface: light grey color on broken surface | | | |
|  | 5. Phenocrysts: - | | | |
|  | 7. Matrix: fine grained, light grey matrix | | | |
|  | 8. Encrustations: ~1mm Mn crust | | | |
|  | 9. Comment: sediment clast, claystone?, covered by Mn | | | |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CLAY</th>
<th>AR + OR</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-18-17</td>
<td>Rock Type: volcanic rock, altered</td>
<td>1 6</td>
<td>1 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Size: 26x19x11cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: angular, partly rounded shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: green grey color on dry surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: fine grained matrix, ~15% vesicles filled with Mn, spinifex texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: ~1-3mm pyroxene needles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Encrustations: 1-3mm Mn crust (partly)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Comment: volcanic rock with grey matrix and pyroxene needles with a spinifex texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SO225-DR-18-18X | 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 | 1 6 | 1 6 | | | |
| | 1. Size: | | | | | |
| | 2. Shape / Angularity: - | | | | | |
| | 3. Color of cut surface: - | | | | | |
| | 4. Texture / Vesicularity: - | | | | | |
| | 5. Phenocrysts: - | | | | | |
| | 6. Matrix: - | | | | | |
| | 7. Secondary Minerals: - | | | | | |
| | 8. Encrustations: - | | | | | |
| | 9. 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 06:50hrs, 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: -

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CLAY</th>
<th>AR + OR</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-19-1</td>
<td>Rock Type: volcanic, strongly altered</td>
<td>1 6</td>
<td>1 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Size: 19x12x8cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: angular/partially rounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: brown color on broken surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: brown, microcryst. matrix, ~10% vesicles filled with black Mn, spinifex texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: &lt;1mm, very altered, brownish pyroxene needles (spinifex)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Matrix: fine grained, grey matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Secondary Minerals: Mn in cracks and vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Encrustations: ~2mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Comment: volcanic rock, strongly altered with pyroxene needles with spinifex texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| SO225-DR-19-2 | Rock Type: volcanic, strongly altered | 1 6 | 1 6 | | | |
| | 1. Size: 16x14x8cm | | | | | |
| | 2. Shape / Angularity: rounded/partially angular | | | | | |
| | 3. Color of cut surface: brown color on broken surface | | | | | |
| | 4. Texture / Vesicularity: brown, microcryst. matrix, ~10% vesicles filled with Mn, spinifex texture | | | | | |
| | 5. Phenocrysts: ~1-2mm pyroxene needles (spinifex) | | | | | |
| | 6. Matrix: brown, fine grained matrix | | | | | |
| | 7. Secondary Minerals: Mn vesicles | | | | | |
| | 8. Encrustations: ~1-2mm Mn crust | | | | | |
| | 9. Comment: see sample 1! | | | | | |
### Appendix II (Rock Description)

#### SO22S-DR020

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>S</th>
<th>GRAIN</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>

**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 4562m

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

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>S</th>
<th>GRAIN</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO22S-DR020-25-1</td>
<td>1. Rock Type: volcanic rock, strongly altered&lt;br&gt;2. Size: 38x33x11cm&lt;br&gt;3. Shape / Angularity: angular fragment&lt;br&gt;4. Color of cut surface: reddish green&lt;br&gt;5. Texture / Vesicularity: massive&lt;br&gt;6. Phenocrysts: no phenocrysts&lt;br&gt;7. Matrix: mid-crystallized, ophitic matrix, cpx is fresh, perhaps plag in some small parts&lt;br&gt;8. Secondary Minerals: alteration is variable, in some parts glass is replaced with pargasite, in others appears to be preserved&lt;br&gt;9. Encrustations: ~3cm Mn crust on the outer surface, Mn precipitates along fractures&lt;br&gt;10. Comment: the rock is generally very altered but some fresh parts may be present and should be checked with thin section</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td><img src="image3.jpg" alt="Picture" /></td>
</tr>
</tbody>
</table>
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GR</th>
<th>CL</th>
<th>PH</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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 |  |  | SO225-DR-20-3 |
| 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 pervasive | 1 | 1 |  |  | SO225-DR-20-4 |
| 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-20-5 |
| 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 |  |  | SO225-DR-20-6 |
| 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 olivine 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 |  |  | SO225-DR-20-7 |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>GRAIN</th>
<th>CHEM</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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 phytic, 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-20-8](image) |
| 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 | 2 | 1 | | | ![SO225 DR-20-9](image) |
| 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: - | 2 | 1 | | | ![SO225 DR-20-10Mn](image) |

**SO225-039DR02**  
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

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>GRAIN</th>
<th>CHEM</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-21-1 | 1. Rock Type: volcanic rock, moderately altered  
2. Size: 22x20x14cm  
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 | | ![SO225 DR-21-1](image) |
| 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 | | ![SO225 DR-21-2](image) |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GR</th>
<th>CM</th>
<th>Ar-Ar</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-21-3</td>
<td>Rock Type: volcanic rock, moderately to strongly altered</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type: volcanic rock, moderately to strongly altered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 25x20x15cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: subrounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: green brown, black spots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: massive with very rare vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: no clear phenocrysts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: matrix is composed of needles of plag or cpx placed in altered glass/palagonite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: some precipitation of Mn oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: thin Mn crust outside</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: green spots appear to be more fresh than dark ones and should be picked for chemistry. Thin section should be investigated.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-21-4</td>
<td>Rock Type: volcanic rock, moderately altered</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type: volcanic rock, moderately altered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 26x15x11cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: subrounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: greenish grey with dark dots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: massive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: no clear phenocrysts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: matrix ophitic, spinifex-like glass is altered but in some parts looks OK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: Mn precipitations along fractures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: no outside crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: depending on thin section investigation can be tried for chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-21-5</td>
<td>Rock Type: volcanic rock, moderately to strongly altered</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type: volcanic rock, moderately to strongly altered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 27x19x16cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: subangular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: dark grey, yellowish</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: similar to sample 4 but with more oxidation. Grey parts appear to be fresh.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: may be good for chemistry with some picking. The crystals are likely cpx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-21-6</td>
<td>Rock Type: volcanic rock, moderately to strongly altered</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type: volcanic rock, moderately to strongly altered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 22x18x15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: yellowish dark grey with green spots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: similar to sample 4 but more oxidized</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: grey parts look OK for chemistry. Some xis are up to 7mm long colorless and can be plag. The freshest part is collected.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-21-7</td>
<td>Rock Type: volcanic rock, slightly altered</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type: volcanic rock, slightly altered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 15x9x9cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: subangular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: dark grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: massive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: rare plag microphenocrysts, needles up to 3mm long</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: matrix is fine-crystallized, intertental?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: thin veins of Mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: very good for chemistry and Ar-Ar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE #</td>
<td>SAMPLE DESCRIPTION</td>
<td>TS</td>
<td>CHRM Ar Age</td>
<td>Grade</td>
<td>Color</td>
<td>Notes</td>
</tr>
<tr>
<td>----------</td>
<td>--------------------</td>
<td>----</td>
<td>-------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
</tbody>
</table>
| 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 secondary 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: 15x6x6cm  
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 | plag |
## Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRADE</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-21-13 | Rock Type: volcanic, altered  
2. Shape / Angularity: angular, partly rounded  
3. Size: 10x9x8cm  
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 | | ![SAMPLE PHOTO] |
| SO225-DR-21-14 | Rock Type: volcanic, altered  
2. Shape / Angularity: rounded, partly angular  
3. Size: 10x12x6cm  
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 vesicles 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 | | ![SAMPLE PHOTO] |
| SO225-DR-21-15 | Rock Type: volcanic, altered  
2. Shape / Angularity: rounded, partly angular  
3. Size: 17x19x10cm  
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 | 3-4 | ![SAMPLE PHOTO] |
| SO225-DR-21-16 | Rock Type: volcanic, altered  
2. Shape / Angularity: rounded, partly angular  
3. Size: 17x13x12cm  
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 | 4 | ![SAMPLE PHOTO] |
| SO225-DR-21-17 | Rock Type: volcanic, altered  
2. Shape / Angularity: partly rounded  
3. Size: 10x9x14cm  
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 | 3-4 | ![SAMPLE PHOTO] |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHM</th>
<th>Ar- Age</th>
<th>Grade</th>
<th>Sub-Mineral</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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    |            |       | ![Picture](image1.png) |
| SO225-DR-21-19 | 1. Rock Type: volcanic, altered  
2. Size: 11x7x6cm  
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, 5mm 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    |            |       | ![Picture](image2.png) |
| SO225-DR-21-20 | 1. Rock Type: volcanic, altered  
2. Size: 4x9x6cm  
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! | 1   | 2       | 3-4    |            |       | ![Picture](image3.png) |
| 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  
9. Encrustations: ~1mm Mn crust  
10. Comment: see sample 20! | 1   | 2       | 3-4    |            |       | ![Picture](image4.png) |
| 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! | 1   | 2       | 3-4    |            |       | ![Picture](image5.png) |
**Appendix II (Rock Description)**

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>TS</th>
<th>CHEM</th>
<th>GRAF</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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) | | | | | | | ![Picture](image1.png) |

**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 off bottom UTC 21/12/12 02:50hrs, lat 9°38.60'S, long 164°17.83'W, depth 4200m  
Dredge on bottom UTC 23/12/12 00:25hrs, lat 10°38.72'S, long 163°53.65'W, depth 4601m  
Dredge off bottom UTC 23/12/12 01:15hrs, lat 9°40.09'S, long 164°17.83'W, depth 4200m  
Dredge on bottom UTC 23/12/12 02:50hrs, lat 10°38.72'S, long 163°53.65'W, depth 4601m  
Total volume: 1 ton  
Comments: Several bights up to 9 tons; sediment with thick Mn crust

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>TS</th>
<th>CHEM</th>
<th>GRAF</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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) | | | | | | | ![Picture](image2.png) |

**SO225-046DR023**

Description of Location and Structure: Suvorov-Trough; E-W trending ridge (SO193-DR18); lower S-W-facing flank.

Dredge off 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  
Dredge off bottom UTC 24/12/12 01:15hrs, lat 10°38.60'S, long 163°53.65'W, depth 3822m  
Total volume: 1/5 full  
Comments: -

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>TS</th>
<th>CHEM</th>
<th>GRAF</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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 | | | | | ![Picture](image3.png) |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GR</th>
<th>GRA</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-23-4</td>
<td>1. Rock Type: volcanic rock, strongly to moderately altered&lt;br&gt;2. Size: 18x13x8cm&lt;br&gt;3. Shape / Angularity: subrounded&lt;br&gt;4. Color of cut surface: greyish brown with black spots&lt;br&gt;5. Texture / Vesicularity: vesicular (~50% vesicles)&lt;br&gt;6. Phenocrysts: cpx phenocrysts ~5-7% up to 1mm, bottle green&lt;br&gt;7. Matrix: matrix ophitic to intersertal, altered with abundant Mn precipitates&lt;br&gt;8. Secondary Minerals: pervasive ground mass alteration, Mn in vesicles and in ground mass&lt;br&gt;9. Encrustations: outer Mn crust up to 1cm, yellowish white, soft material in vesicles close to margin&lt;br&gt;10. Comment: cpx is good and can be separated. Chemistry problematic -&gt; Mn-oxides. The rock is cpx phyllic basalt.</td>
<td>2</td>
<td>1</td>
<td>??</td>
<td><img src="image3.png" alt="Picture" /></td>
</tr>
</tbody>
</table>
## Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHEM</th>
<th>GRAIN</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-23-8 | 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 Sp? inclusions  
7. Matrix: matrix orthoclastic, 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, Sp? 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, similar to sample 7. Ol-Basalt but more Mn encrustations and some voids fill ew with white sec. stuff, Sp? may be fresh, thin section | 2 | | | |
| SO225-DR-23-9Mn | 1. Rock Type: several basalt clasts covered by massive Mn crust  
2. Size: 17x14x10cm  
3. Shape / Angularity: crust is 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 (3.3cm 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: - | | | | |
## Appendix II (Rock Description)

**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

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-24-1</td>
<td>Rock Type: large block of altered glass pillow (palagonite)</td>
<td>1</td>
<td>2</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><img src="image1.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 25x23x16cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: rounded/partly angular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: green (palagonite) with black spots (fresh glass?)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: good sample for picking of fresh glass fragments (fresh fragments are rounded and several cm thick)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-24-2</td>
<td>Rock Type: volcanic, altered</td>
<td>1</td>
<td>2</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><img src="image2.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 8x8x6cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: angular shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: grey color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: microcryst. matrix, ~1% vesicles, partly filled with Mn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: ~20% iddingsit. olivine ≤1-2mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: grey, fine-grained matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: iddingsit. olivines, Mn and Fe-oxides in cracks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: ≤1mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: dense, volcanic rock with relatively fresh matrix (Oliv-basalt) and altered olivines, fresh matrix spots can be used for chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-24-3</td>
<td>Rock Type: volcanic, altered</td>
<td>1</td>
<td>2</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><img src="image3.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 11x8x6cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: angular shape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: grey color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: microcryst. matrix, no vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: ~20% iddingsit. olivine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine grained, grey matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: ≤1mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: ≤1mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: see sample 2 (no vesicles)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-24-4</td>
<td>Rock Type: volcanic, altered</td>
<td>2</td>
<td>2</td>
<td>4-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><img src="image4.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>2. Size: 16x6x12cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: angular, partly rounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: microcryst. matrix with vesicles ≤1mm (partly filled)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: dark brown needles (pyroxene?), altered!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: brown, fine grained matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: Mn in vesicles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: partly covered with &lt;1mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: volcanic rock, strongly altered, chemistry will be difficult</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE #</td>
<td>SAMPLE DESCRIPTION</td>
<td>GRAIN</td>
<td>GRAV</td>
<td>CLAY</td>
<td>SCH</td>
<td>CHM</td>
<td>NOTES</td>
<td>PICTURE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>----------------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-24-5</td>
<td>1. Rock Type: volcanic, strongly altered</td>
<td>3</td>
<td>2</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 12x10x8cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: angular, partly rounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: microcryst., ~25% vesicles &lt;1mm (only several filled with Mn)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: very altered relicts of pyroxene? needles visible in matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: brown, fine grained matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: Mn in cracks, veins and vesicles, brown Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: 1-2mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: very altered, volcanic rock, chemistry will be problematic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-24-6</td>
<td>1. Rock Type: volcanic, altered</td>
<td>1</td>
<td>2</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 15x8x9cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: angular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: microcryst., ~20% vesicles, partly filled with Mn and alteration products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: relicts of pyroxene? needles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine grained, brown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: Mn in vesicles and along veins and cracks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: Mn crust partly 1mm thick</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: see sample 5!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-24-7</td>
<td>1. Rock Type: volcanic, strongly altered</td>
<td>2</td>
<td>2</td>
<td>5-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 15x8x9cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: rounded/partly angular</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: microcryst. matrix, ~20% vesicles filled with second. minerals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine grained, brown matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: calcite and Mn along cracks, Fe-oxides in matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: no Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: very altered, volcanic rock, useless for chemistry?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-24-8</td>
<td>1. Rock Type: volcanic, altered</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 11x7x8cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: angular, partly rounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: microcryst. matrix, vesicles ~20% filled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: relicts of pyroxene needles (5-2mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine grained, brown matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: Mn precipitates, Fe-oxides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: Mn crust ~1mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: altered, volcanic rock with filled vesicles, could be useless for chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-24-9</td>
<td>1. Rock Type: volcanic, altered</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: 9x6x6cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: subrounded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: brown (with darker areas)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: microcryst. matrix, vesicles ~20% filled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: fine grained, brown matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: Mn in veins</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: ~1mm Mn crust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: see sample 8!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE #</td>
<td>SAMPLE DESCRIPTION</td>
<td>NOTES</td>
<td>PICTURE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 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: relics 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    | ![Image](SO225-DR-24-10.jpg) |
| 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! | 2    | ![Image](SO225-DR-24-11.jpg) |
| 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! | 2    | ![Image](SO225-DR-24-12.jpg) |
| 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: -  
9. Encrustations: -  
10. Comment: see sample 11! | 2    | ![Image](SO225-DR-24-13.jpg) |
| 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: - | 2    | ![Image](SO225-DR-24-1x.jpg) |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHM</th>
<th>SAR</th>
<th>GRA</th>
<th>GMAN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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: - |     |       |       |       |         | ![Image](SO225-DR-24-14x.png) |
| 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: - |     |       |       |       |         | ![Image](SO225-DR-24-15x.png) |
| 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: - |     |       |       |       |         | ![Image](SO225-DR-24-16x.png) |
| 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: - |     |       |       |       |         | ![Image](SO225-DR-24-17x.png) |
| 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: - |     |       |       |       |         | ![Image](SO225-DR-24-18x.png) |
### Appendix II (Rock Description)

**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°39.53’S, long 163°50.43’W, depth 2556m

Dredge off bottom UTC 25/12/12 10:40hrs, lat 10°39.55’S, long 163°50.45’W, depth 2556m

Total volume: 1/4 full

**Comments:**
- Dredge off bottom UTC 25/12/12 10:40hrs, lat 10°39.55’S, long 163°50.45’W, depth 2556m

---

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHRM</th>
<th>Age</th>
<th>Grade</th>
<th>QUARTZ</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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. olivine (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 (O(-)-based?) | 1   | 2   | 4    | 4      | -     | ![Picture 1](image1.png) |
| 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. matrix, ~25% vesicles (~1mm) partly filled with white-green minerals  
6. Phenocrysts: ~5% iddingsit. olivine (completely altered)  
7. Matrix: fine grained, brown  
9. Encrustations: 2-10mm Mn crust  
10. Comment: see sample 1, but contains bigger vesicles with white-green stuff | 1   | 2   | 4-5  | -      | ![Picture 2](image2.png) |
| 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 white-yellow stuff  
6. Phenocrysts: ~10% iddingsit. Ol (~1-2mm)  
7. Matrix: fine grained, brown matrix  
9. Encrustations: 2-10mm Mn crust  
10. Comment: see sample 1, more altered compared to sample 1 | 1   | 2   | 4-5  | -      | ![Picture 3](image3.png) |
| 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  | -      | ![Picture 4](image4.png) |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CM</th>
<th>GRA</th>
<th>CHM</th>
<th>GEM</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| 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   | 4-6 |     |       | ![Picture](image) |
| 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  
9. Encrustations: ~2-12mm Mn crust  
10. Comment: see sample 1! | 1  | 3   | 4-6 |     |       | ![Picture](image) |
| SO225-DR-25-7 | 1. Rock Type: volcanic, strongly altered  
2. Size: 9x9x7cm  
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   | 4-6 |     |       | ![Picture](image) |
| 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   |     |       | ![Picture](image) |
| 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  |     |     |     |       | ![Picture](image) |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>SIZE</th>
<th>AGR</th>
<th>GRAIN</th>
<th>COLOR OF CUT SURFACE</th>
<th>PHENOCRYST</th>
<th>SECONDARY MINERALS</th>
<th>ENCRASTATIONS</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-25-10 | 1. Rock Type: volcanic, altered  
2. Shape / Angularity: rounded  
3. Color of cut surface: grey-brown  
4. Texture / Vesicularity: fine grained matrix, vesicles filled with black Mn and greenish second. minerals  
5. Phenocrysts: -  
6. Matrix: -  
7. Secondary Minerals: -  
8. Encrustations: -  
10. Comment: volcanic breccia covered by ~1cm Mn crust, sample is very altered, and has greyish matrix. -> might be good for picking! | 20x18x16cm | - | - | - | - | - | - | - | ![SO225-DR-25-10](image) |
| 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 | - | - | - | - | - | - | - | - | ![SO225-DR-25-11](image) |
| 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: greenish spots along cracks, Mn precipitates within the clast  
9. Encrustations: 1-4cm, massive (rounded), black Mn crust  
10. Comment: - | - | - | - | - | - | - | - | - | ![SO225-DR-25-12Mn](image) |
| 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-25-13Mn](image) |
| 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-25-14Mn](image) |
| 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: - | - | - | - | - | - | - | - | - | ![SO225-DR-25-15X](image) |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Sample Description</th>
<th>Chem</th>
<th>Age</th>
<th>Grain</th>
<th>Notes</th>
<th>Picture</th>
</tr>
</thead>
</table>
| S0225-Dr25-16X | 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. Phenocrystals: -  
7. Matrix: -  
8. Secondary Minerals: -  
9. Encrustations: -  
10. Comment: Prevailing purple, fine grained sandstones; partly cemented with Mn. Some blocks ~50cm in diameter; total volume: Full |  |  | | | |

Dredge on bottom UTC 25/12/12 14:44hrs, lat 10°38.29'S, long 163°44.74'W, depth 2940m  
Comments: -

### S0225-Dr25-27-1

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Sample Description</th>
<th>TSI</th>
<th>Chem</th>
<th>Age</th>
<th>Grain</th>
<th>Notes</th>
<th>Picture</th>
</tr>
</thead>
</table>
| S0225-Dr25-27-1 | 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. Phenocrystals: coarse grained, well crystallized cpx phenocrysts ~40%, ≤2mm in intergrowths, small Ol ≤1mm, ~15%, plag subphenocrystals, ≤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 | | |

Dredge on bottom UTC 21/12/12 13:28hrs, 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: Prevailing purple, fine grained sandstones; partly cemented with Mn. Some blocks ~50cm in diameter; volcanic rocks are Ol/Cpx phyric basalts moderately to strongly altered

### S0225-Dr25-27-2

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Sample Description</th>
<th>TSI</th>
<th>Chem</th>
<th>Age</th>
<th>Grain</th>
<th>Notes</th>
<th>Picture</th>
</tr>
</thead>
</table>
| S0225-Dr25-27-2 | 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. Phenocrystals: no obvious phenocrysts  
7. Matrix: matrix mid crystallized, aphanitic 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 | | |

Dredge on bottom UTC 21/12/12 13:28hrs, 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: Prevailing purple, fine grained sandstones; partly cemented with Mn. Some blocks ~50cm in diameter; volcanic rocks are Ol/Cpx phyric basalts moderately to strongly altered

#### Description of Location and Structure:
- Suvorov Trough; E-W-striking ridge. High Plateau flank. West facing slope beneath shallowest part of ridge
- Dredge on bottom UTC 25/12/12 14:44hrs, lat 10°38.29’S, long 163°44.74’W, depth 2940m
- 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: Prevailing purple, fine grained sandstones; partly cemented with Mn. Some blocks ~50cm in diameter; volcanic rocks are Ol/Cpx phyric basalts moderately to strongly altered

#### 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: Prevailing purple, fine grained sandstones; partly cemented with Mn. Some blocks ~50cm in diameter; volcanic rocks are Ol/Cpx phyric basalts moderately to strongly altered
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHM</th>
<th>MIN</th>
<th>GRA</th>
<th>VOL</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-27-3 | 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 similar to sample 2 but more oxidized with some more cpx, good for chemistry | 1 | 1 | ? | D | | ![Picture](SO225 DR-27-3) |
| SO225-DR-27-4 | 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 | D | G | | ![Picture](SO225 DR-27-4) |
| SO225-DR-27-5 | 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 | | | | ![Picture](SO225 DR-27-5) |
| SO225-DR-27-6 | 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 | | | | ![Picture](SO225 DR-27-6) |
| SO225-DR-27-7 | 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 interstitials (≤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 | ? | ? | | ![Picture](SO225 DR-27-7) |
<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>5CHN</th>
<th>Ar-Ar</th>
<th>GRN</th>
<th>GRAV</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
</table>
| SO225-DR-27-8 | 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., interstitial (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 | ? | ? |        | ![Picture](image1.png) |
| SO225-DR-27-9 | 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 |        | ![Picture](image2.png) |
| SO225-DR-27-10 | 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 | ![Picture](image3.png) |
| SO225-DR-27-11 | 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%  
8. Secondary Minerals: vesicles partly filled with light green stuff  
9. Encrustations: Mn encrustations along microfractures  
10. Comment: formerly Ol-phryic, glassy basalt. Should be OK for chemistry. Ar-Ar impossible | 1 | 1 | ![Picture](image4.png) |
| SO225-DR-27-12 | 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 | 1 | 1 | ![Picture](image5.png) |
### Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>GRAIN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-27-13</td>
<td>Rock Type: solidified sediment</td>
<td></td>
<td></td>
<td><img src="image1.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>1. Size: 14x12x12cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: subrounded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: dark red with light spots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Matrix: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Comment: fine-grained sandstone - predominant type in the dredge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-27-14</td>
<td>Rock Type: solidified sediment</td>
<td></td>
<td></td>
<td><img src="image2.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>1. Size: 16x7x9cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: angular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: purple, red to yellow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Matrix: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Comment: sandstone with diffuse layering - Predominant type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-27-15</td>
<td>Rock Type: solidified sediment</td>
<td></td>
<td></td>
<td><img src="image3.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>1. Size: 10x15x12cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: angular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: purple, red with grey layers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Matrix: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Comment: fine to mid grained sandstone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-27-16</td>
<td>Rock Type: solidified sediment</td>
<td></td>
<td></td>
<td><img src="image4.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>1. Size: 16x10x6cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: subangular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: greenish yellow with larger light and smaller black particles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Matrix: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Comment: breccia of Mn fragments (22mm) and solidified sediments (57mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-27-17</td>
<td>Rock Type: sediment breccia of solidified sediments cemented by Mn crust. Prevail purple sandstones (sample 12-13)</td>
<td></td>
<td></td>
<td><img src="image5.jpg" alt="Picture" /></td>
</tr>
<tr>
<td></td>
<td>1. Size: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Shape / Angularity: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Color of cut surface: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Matrix: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Comment: -</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix II (Rock Description)

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>SAMPLE DESCRIPTION</th>
<th>CHEM</th>
<th>AGE</th>
<th>GRAM</th>
<th>CL:MN</th>
<th>NOTES</th>
<th>PICTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO225-DR-27-1X</td>
<td>Rock Type: archive of sample 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type: archive of sample 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO225-DR-27-18Mn</td>
<td>Rock Type: 2cm Mn crust on Fe-rich, purple fine grained sandstone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Rock Type: 2cm Mn crust on Fe-rich, purple fine grained sandstone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Size: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Shape / Angularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Color of cut surface: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Texture / Vesicularity: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Phenocrysts: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Matrix: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Secondary Minerals: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Encrustations: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Comment: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix III (Core Photos)

SO225-02-1 KOL
(0-541 cm)
Appendix III (Core Photos)

SO225-07-2 KOL
(0-1012cm)

1.0 cm

0-100 cm

100-200 cm

201-300 cm

301-400 cm

401-500 cm

501-514 cm

514-612 cm

612-712 cm

712-812 cm

812-912 cm

912-1012 cm

Top

Base
Appendix III (Core Photos)
Appendix III (Core Photos)

SO225-08-3 KOL
(0-1618 cm)
Appendix III (Core Photos)

SO225-15-3 KOL
(0-1203cm)
Appendix III (Core Photos)

SO225-07-2 KOL
(0-1012cm)

Top

0-100 cm
100-201 cm
201-302 cm
302-402 cm
402-502 cm
502-514 cm
514-612 cm
612-712 cm
712-812 cm
812-912 cm
912-1012 cm

Base
Appendix III (Core Photos)

SO225-19-3 KOL
(0-1429 cm)
Appendix III (Core Photos)

SO225-44-3 SL
(0-39cm)
Appendix III (Core Photos)

SO225-44-4 SL
(0-470 cm)
Appendix III (Core Photos)

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

Foraminiferal sand, whitish to light brownish gray, patchy, moderately bioturbated, homogenous matrix, first meter strongly disturbed due to coring and sediment washout at 241-244 cm, 251-254 cm, 289-290 cm, 307-310 cm, 332-334 cm: burrows filled with white sediment, dark brown to black margins at 254-255 cm: black layer

Foraminiferal sand, grayish brown, strongly bioturbated, burrows up to 5 cm in diameter, filled with white sediment, dark brown to black margins at 341-344 cm, 251-254 cm, 289-300 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

FOROS SAND

FOSSILS
Foraminifera (undifferentiated)

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

FORAMINIFERAL OOZE

**LITHOLOGY**

**LEGEND**

**FOSSILS**

**DESCRIPTION**
Date: December 13, 2012

Described By: D. Nuernberg

Foraminifera (undifferentiated)

SECTION

Lost Core

FORAM SAND

Water Depth: 1826.00 m
Rig Floor to Sea Level: 0.00 m

Described By: D. Nuernberg

Date: December 13, 2012

Water Depth: 1826.00 m
Rig Floor to Sea Level: 0.00 m

FORAMINIFERAL Ooze

Very Disturbed

Calcispheres

Minolta Y (D65)

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

clay
silt
sand

Very Disturbed

Calcispheres

Minolta Y (D65)

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

clay
silt
sand

Very Disturbed

Calcispheres

Minolta Y (D65)

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

clay
silt
sand
<table>
<thead>
<tr>
<th>SO225-17-2 KOL</th>
<th>Foraminiferal ooze</th>
<th>Magnet. suscept. (SI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-0.93.8</td>
</tr>
</tbody>
</table>

**METERS**

**Lost Core**

**Foraminifera (undifferentiated)**

**Described By:** D. Nuernberg

**Date:** December 9, 2012

**Water Depth:** 3248.00 m

**Rig Floor to Sea Level:** 0.00 m

---

**FORAMINIFERAL OOZE**

**Bioturb.**

---

**DESCRIPTION**

- At 1200-1202 cm, foraminiferal sand, clayey, homogenous, foraminiferal ooze, very soupy, partly enriched with small lithogenic particles (Fe,Mn crusts) and abundant, bioturbated clayey foram/nanno ooze.
- At 1178-1183 cm, 1187-1191 cm: burrow/biologically disturbed, homogenous, slightly darker than above, rich olive brown, clearly defined lithostratigraphic contact, lower contact gradational over broader range, strongly bioturbated, sharp upper contact.
- At 1106-1108 cm, 1111-1112 cm, 1115-1116 cm: foraminiferal ooze as above, increasing in foraminifera, strongly darker than above, rich olive brown, clearly defined lithostratigraphic contact, lower contact gradational over broader range, strongly bioturbated, sharp upper contact.
- At 1050-1053 cm, 1055-1056 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 1000-1003 cm, 1005-1006 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 950-953 cm, 955-956 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 900-903 cm, 905-906 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 850-853 cm, 855-856 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 800-803 cm, 805-806 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 750-754 cm, 756-757 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 700-703 cm, 705-706 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 650-655 cm, 657-658 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 600-603 cm, 605-606 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 550-553 cm, 555-556 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 500-503 cm, 505-506 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 450-453 cm, 455-456 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 400-403 cm, 405-406 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 350-353 cm, 355-356 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 300-303 cm, 305-306 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 250-253 cm, 255-256 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 200-203 cm, 205-206 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 150-153 cm, 155-156 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 100-103 cm, 105-106 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 50-53 cm, 55-56 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
- At 0-3 cm: foraminiferal ooze as above, increasing in foraminifera, strongly bioturbated, sharp upper contact.
SO225-19-2 KOL
northern foothills of North Plateau 3°47.5440'S, -164°53.2310'W

METERS
Foraminifera (undifferentiated)
Minolta Y(D65)
m
SECTION
c
v

Date: December 12, 2012
Described By: D. Nuernberg
Water Depth: 3558.00 m Rig Floor to Sea Level: 0.00 m

---

Very Disturbed
Calcispheres

---

FORAMINIFERAL OOZE

---

FORAM SAND

---

Cocco Ooze

---

Magnet. suscept. (SI)
0.02.0

---

northern foothills of North Plateau 3°47.5440'S, -164°53.2310'W
37.5 75.7

---

FOSSILS

---

DISTURBANCE

---

LITHOLOGY

---

LEGEND

---

DESCRIPTION
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

<table>
<thead>
<tr>
<th>METERS</th>
<th>SECTION</th>
<th>Magnet. suscept. (SI)</th>
<th>Minolta Y(D65)</th>
<th>DEPTH SCALED IMAGES</th>
<th>BIOTURB.</th>
<th>ICHNOFACIES</th>
<th>FOSSILS</th>
<th>DISTURB.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>! STRONGLY DISTURBED BY CORING!</td>
</tr>
<tr>
<td>0.0</td>
<td>33.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Foraminiferal ooze, light brownish gray, soupy, homogenous, only working half preserved</td>
</tr>
<tr>
<td>37.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LEGEND**

<table>
<thead>
<tr>
<th>LITHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORAMINIFERAL OOZE</td>
</tr>
<tr>
<td>Lost Core</td>
</tr>
</tbody>
</table>
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

DEPTH SCALING IMAGES

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

Foraminiferal sand, becoming lighter downcore

LEGEND

LITHOLOGY
FORAMINIFERAL Ooze
FORAM SAND
Lost Core

FOSSILS
Calcispheres
Foraminifera (undifferentiated)
Date: December 28, 2012
Described By: D. Nuernberg
Water Depth: 3153.00 m  Rig Floor to Sea Level: 0.00 m

**SO225-53-2 SL**
High Plateau, southern margin  13°31.2500'S, -162°8.3390'W

---

**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
Foraminiferal ooze, white patches at 952-959 cm, homogenous, white patches at 966-969 cm.

846-857 cm, 860 cm, white patches at 860 cm, increasingly bioturbated below ca. 860 cm, increasingly darker at base, progressively darkening at 860 cm, increasingly bioturbated towards the surface, increasingly darker at base, progressively darkening at base.

829-830 cm, 846-857 cm, 860 cm, white patches at 860 cm, increasingly bioturbated below ca. 860 cm, increasingly darker at base, progressively darkening at base.

802-803 cm, 816 cm, 829-830 cm, 846-857 cm, white patches at 860 cm, increasingly bioturbated below ca. 860 cm, increasingly darker at base, progressively darkening at base.

777 cm, 782-783 cm, 795-796 cm, white patches at 795-796 cm, increasingly bioturbated below ca. 795-796 cm, increasingly darker at base, progressively darkening at base.

756-757 cm, 761-762 cm, 774-775 cm, white patches at 774-775 cm, increasingly bioturbated below ca. 774-775 cm, increasingly darker at base, progressively darkening at base.

715-717 cm, 720-721 cm, 732-733 cm, white patches at 732-733 cm, increasingly bioturbated below ca. 732-733 cm, increasingly darker at base, progressively darkening at base.

684 cm, 685 cm, 698-699 cm, white patches at 698-699 cm, increasingly bioturbated below ca. 698-699 cm, increasingly darker at base, progressively darkening at base.

658-659 cm, 671-672 cm, white patches at 671-672 cm, increasingly bioturbated below ca. 671-672 cm, increasingly darker at base, progressively darkening at base.

629-630 cm, 642-643 cm, 655-656 cm, white patches at 655-656 cm, increasingly bioturbated below ca. 655-656 cm, increasingly darker at base, progressively darkening at base.

599-600 cm, 612 cm, 629-630 cm, 642-643 cm, white patches at 642-643 cm, increasingly bioturbated below ca. 642-643 cm, increasingly darker at base, progressively darkening at base.

570 cm, 599-600 cm, 612 cm, white patches at 612 cm, increasingly bioturbated below ca. 612 cm, increasingly darker at base, progressively darkening at base.

542 cm, 555 cm, 570 cm, white patches at 570 cm, increasingly bioturbated below ca. 570 cm, increasingly darker at base, progressively darkening at base.

500 cm, 513 cm, 526 cm, white patches at 526 cm, increasingly bioturbated below ca. 526 cm, increasingly darker at base, progressively darkening at base.

486 cm, 487 cm, 490 cm, white patches at 490 cm, increasingly bioturbated below ca. 490 cm, increasingly darker at base, progressively darkening at base.
<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>RV CELTIC EXPLORER EUROFLEETS Cruise Report, CE12010 – ECO2@NorthSea, 20.07. – 06.08.2012, Bremerhaven – Hamburg, Eds.: P. Linke et al., 65 pp, DOI: 10.3289/GEOMAR_REP_NS_4_2012</td>
</tr>
</tbody>
</table>

For GEOMAR Reports, please visit: [https://oceanrep.geomar.de/view/series/GEOMAR_Report.html](https://oceanrep.geomar.de/view/series/GEOMAR_Report.html)

Reports of the former IFM-GEOMAR series can be found under: [https://oceanrep.geomar.de/view/series/IFM-GEOMAR_Report.html](https://oceanrep.geomar.de/view/series/IFM-GEOMAR_Report.html)