

METEOR-Berichte

Origin and Geodynamic Evolution of King's Trough: The Grand Canyon of the North Atlantic

Cruise No. M168 (GPF 20-3_080)

November 08 – December 08, 2020

Emden (Germany) – Emden (Germany)

KING'S TROUGH



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1 Cruise Summary

1.1 Summary

The goal of R/V METEOR expedition M168 was to investigate the origin and geodynamic evolution of the enigmatic King's Trough Complex, surrounding seamounts and the Azores-Biscay Rise in the North Atlantic Ocean northeast of the Azores. Before M168, these structures were still largely unexplored and their origin has been debated for decades. Investigation of the structures was conducted by extensive rock sampling with chain bag dredges, by bathymetric mapping with the ship's own multi-beam echo-sounding system (KONGSBERG EM 122) and by sub-bottom profiling (ATLAS PARASOUND P70). A total of 48 dredge hauls in water depths between 5,340 and 1,340 m were carried out at Palmer Ridge and associated Freen and Peake Troughs, at King's Trough, at the Gnitsevich Seamounts northwest of King's Trough and at the northernmost Azores-Biscay Rise including the North Charcot Seamount Complex directly in the east. Of these dredge hauls, 36 (= 76.6 %) yielded a variety of magmatic rocks comprising lava fragments and pillow lava occasionally containing fresh glass, gabbroic/dioritic and doleritic rocks, ultramafic rocks possibly of harzburgitic composition and volcanoclastic rocks. Bathymetric mapping revealed that King's Trough is much more complex than it appeared from previously available maps based on low resolution satellite altimetry. It seems to be composed of individual segments striking in slightly different directions and could possibly be formed by a series of strike-slip faults.

1.2 Zusammenfassung

Ziel der FS METEOR-Expedition M168 war es, den Ursprung und die geodynamische Entwicklung des rätselhaften King's Trough-Komplexes, der umliegenden Seamounts und des Azoren-Biskaya-Rückens im Nordatlantik nordöstlich der Azoren zu erforschen. Vor M168 waren diese Strukturen noch weitgehend unerforscht und ihr Ursprung ist seit Jahrzehnten umstritten. Die Untersuchung der Strukturen erfolgte durch umfangreiche Gesteinsbeprobungen mittels Kettensackdredgen, durch bathymetrische Kartierungen mit dem schiffseigenen Fächerecholot (KONGSBERG EM 122) und durch Sedimentecholot-Profilierungen (ATLAS PARASOUND P70). Insgesamt wurden 48 Dredgezüge in Wassertiefen zwischen 5.340 und 1.340 m am Palmer-Rücken und den dazugehörigen Freen- und Peake-Trögen, am King's Trough, an den Gnitsevich Seamounts nordwestlich des King's Trough und am nördlichsten Azoren-Biskaya-Rücken sowie am direkt östlich anschließenden North Charcot Seamount-Komplex durchgeführt. Von diesen Dredgezügen erbrachten 36 (= 76,6 %) eine Vielfalt an magmatischen Gesteinen, darunter Lavafragmente und Kissenlaven, von denen einige frisches Glas enthalten, gabbroische/dioritische und doleritische Gesteine, ultramafische Gesteine, die möglicherweise eine harzburgitische Zusammensetzung aufweisen, sowie vulkanoklastische Gesteine. Die bathymetrischen Kartierungen zeigten, dass der King's Trough viel komplexer ist als anhand der bisher verfügbaren, auf Satellitenaltimetrie mit geringer Auflösung basierenden Karten zu erwarten war. Der Trog scheint aus einzelnen Segmenten zusammengesetzt zu sein, die in leicht unterschiedliche Richtungen streichen, und könnte möglicherweise durch eine Reihe von Strike-Slip-Störungen gebildet worden sein.

2 Participants

2.1 Principal Investigators

Name	Institution
Dürkefälden, Antje, Dr.	GEOMAR
Werner, Reinhard, Dr.	GEOMAR
Geldmacher, Jörg, Dr. habil.	GEOMAR
Strehlow, Karen, Dr.	GEOMAR
Homrighausen, Stephan, Dr.	GEOMAR
Hoernle, Kaj, Prof.	GEOMAR

2.2 Scientific Party

Name	Discipline	Institution
Dürkefälden, Antje, Dr.	Chief Scientist	GEOMAR
Werner, Reinhard, Dr.	Co-Chief Scientist / Shift Leader	GEOMAR
Geldmacher, Jörg, Dr. habil.	Shift Leader	GEOMAR
Hauff, Folkmar, Dr.	Shift Leader	GEOMAR
Fassbender, Marc	Rock Sampling	GEOMAR/UO
Franzen, Luisa	Rock Sampling	GEOMAR
Hampel, Fabian	Rock Sampling	GEOMAR
Hauff, Silke	Rock Sampling	GEOMAR
Krohne, Kevin	Rock Sampling	GEOMAR
Lang, Jakob	Rock Sampling	GEOMAR
Sandhu, Avrinder	Rock Sampling	GEOMAR
Scheffler, Janne	Rock Sampling	GEOMAR
Schenk, Johanna	Rock Sampling	GEOMAR
Völkert, Anna	Rock Sampling	GEOMAR
Stelzner, Martin	Meteorological Technician	DWD

2.3 Participating Institutions

GEOMAR	Helmholtz-Zentrum für Ozeanforschung Kiel, Germany
UO	University of Ottawa, Canada
DWD	Deutscher Wetterdienst, Geschäftsfeld Seeschifffahrt, Hamburg, Germany



The M168 Shipboard Scientific Party

3 Research Program

3.1 Description of the Work Area

(J. Geldmacher)

The enigmatic King's Trough Complex (KTC), located 700 km NNE of the Azores, is a major structural feature in the North Atlantic. It consists of a 500 km long series of sub-parallel, NW-SE-oriented basins and linear ridges (Fig. 3.1). The most prominent basin is the eponymous King's Trough (350 km long, 80 km across), whose dimensions are comparable to those of the Grand Canyon in the USA. Linear ridges or elongated seamounts flank both sides, including the prominent "Antialtair Seamount", resulting in an overall relief of more than 4 km. Two smaller but deeper basins, Freen and Peake Troughs, are located at the SE end of King's Trough and are separated by the steep and narrow Palmer Ridge. The surrounding region is structurally complex and includes many seamounts of various sizes and shapes. Towards the NW, the seafloor is relatively elevated (~3 km average depth) and the rough terrain eventually transitions to the Mid-Atlantic Ridge (MAR) in ~300 km distance. To the SE, the seafloor is generally deeper (~5 km). Here, the KTC meets at a right angle with the NE-SW striking Azores-Biscay Rise (ABR) consisting of individual seamounts and ridges (Fig. 3.1).

The origin of the KTC has been a subject of debate for more than five decades. The structure runs oblique to the MAR and to present or past directions of seafloor spreading. The KTC can also not have been a major fracture zone, since any offset of magnetic lineations is small (Searle

& Whitmarsh, 1978). In addition, gravity measurements suggest that King's Trough is regionally compensated and therefore formed away from the MAR no earlier than ~30 Ma ago (Louden, 1983). It is particularly intriguing that the trough is flanked by seamounts/subparallel ridges (e.g. Antialtair Seamount, Fig. 3.1). If the ridges are volcanic and younger than the basement, how did they form? The magma has to rise along a normal (extensional) fault before the other side subsided (forming the trough) or there would not be a volcanic edifice on the edge but instead at the foot of the trough's flank. Therefore, if the seamounts are younger than the basement (and possibly of different chemical composition), which was uplifted (possibly buckled) during a preceding compressional event, then the age of these seamounts should date the beginning of activity along the fault but before extension caused the subsidence and thus formation of the basin.

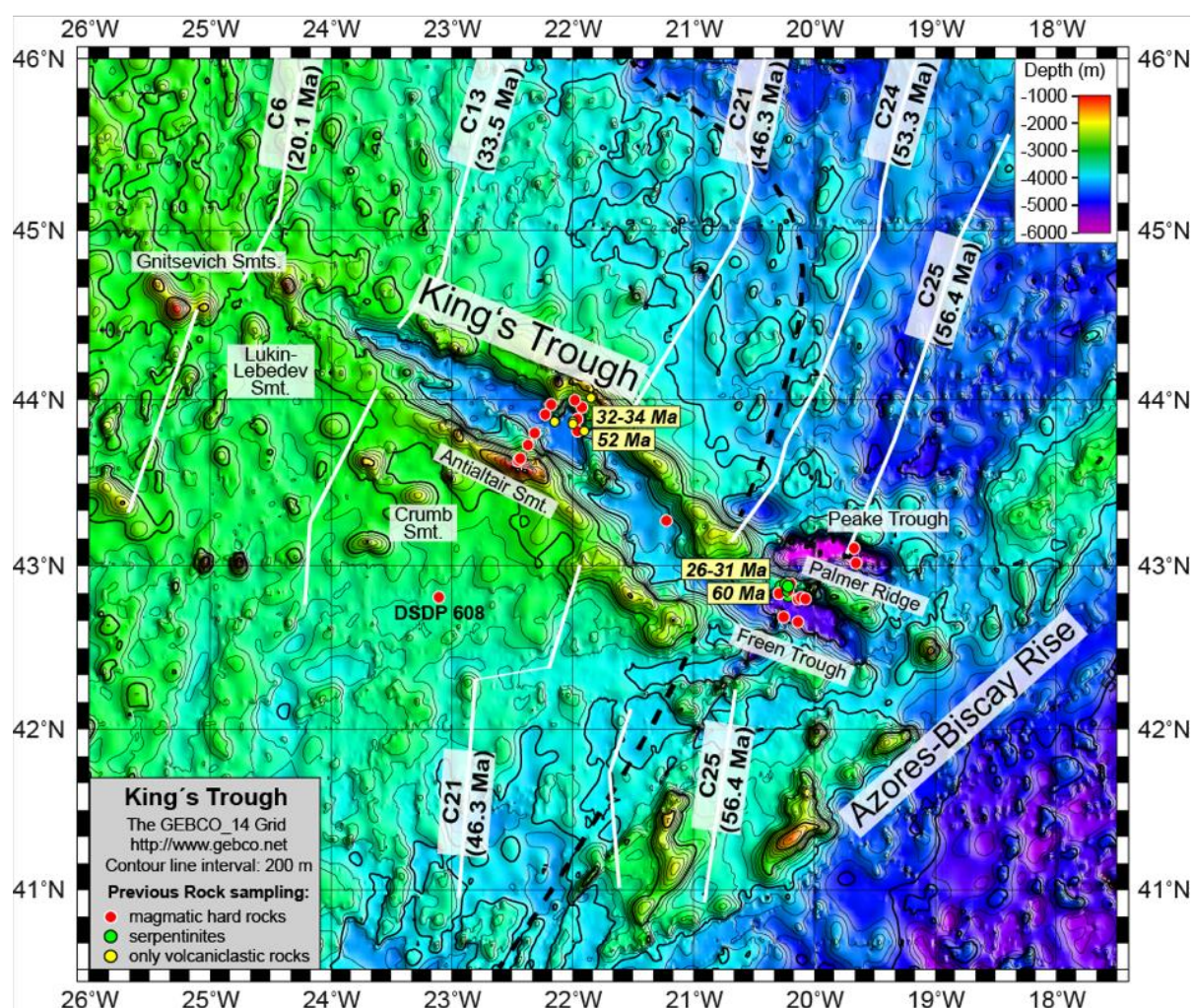
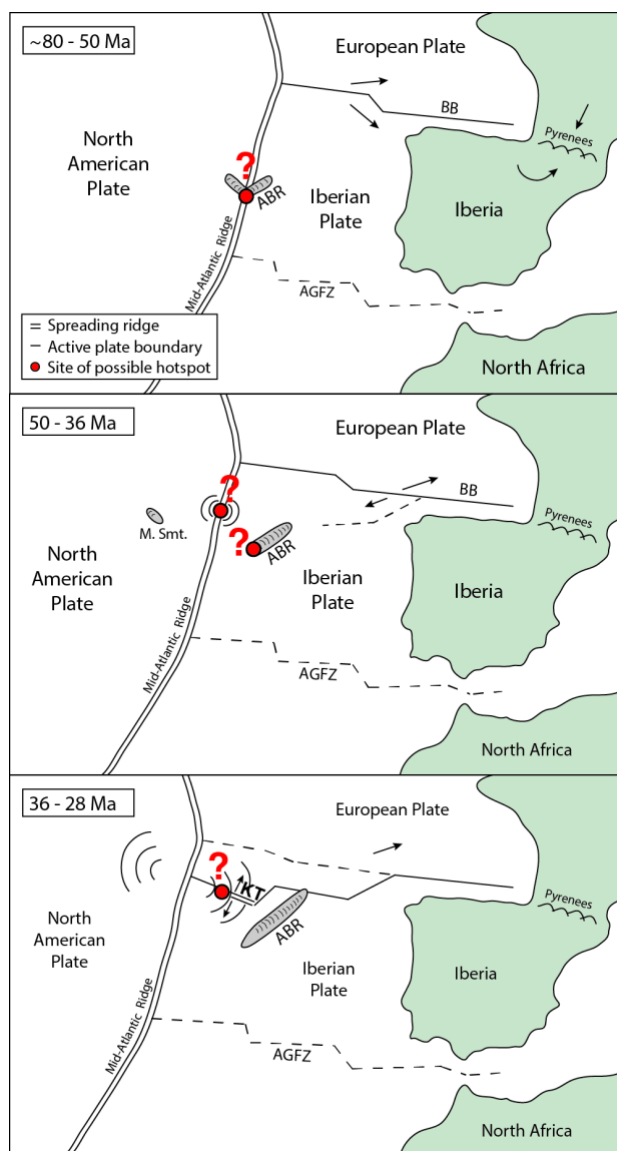


Fig. 3.1 Bathymetric map of the King's Trough area in the eastern North Atlantic based on satellite altimetry (The GEBCO_2014 Grid, version 20150318, <http://www.gebco.net>) with magnetic anomalies (white lines) and corresponding ages from Klitgord & Schouten (1986). Previous sampling sites: Cann & Funnell, 1967 (Freen Trough and Palmer Ridge; K/Ar ages of ~60 and 26-31 Ma), Stebbins & Thompson, 1978 (central King's Trough; no ages), Kidd et al., 1982 (northeastern flank of central King's Trough; K/Ar ages ~52 and 32-34 Ma) and Chernysheva et al., 2013 (Peake Trough and Palmer Ridge; no ages). Note that previously published K/Ar ages are partly older than the underlying crust.

Plate-kinematic modeling suggests that Iberia and the oceanic crust west of it acted as an independent plate from the Santonian-Campanian boundary on (83.5 Ma), with its northern plate boundary running along the Bay of Biscay axis (e.g., Macchiavelli et al., 2017), until Iberia was welded to the European plate by counter-clockwise rotation (Fig. 3.2). During this process (between 42 and 36 Ma), the plate boundary jumped to the region of the KTC until eventually jumping again to the Azores Gibraltar Fracture Zone, which represents the African-European plate boundary since ~28 Ma (e.g., Srivastava & Roest 1992; Macchiavelli et al., 2017). Extension across the plate boundary could therefore explain the formation of the troughs of the KTC but not the flanking ridges. Early seismic refraction profiles (Searle & Whitmarsh, 1978) revealed abnormally thick oceanic crust beneath the KTC area, which could point to the involvement of a mantle plume (providing excess heat and fertile material) during its production at the MAR. This assumption would be consistent with elevated bathymetry of the seafloor between 40° and 47°N that extends on the European side to about 21°W (just to the eastern end of King's Trough at a seafloor age of ~53 Ma), which can also be clearly seen in Fig. 3.1. Therefore, the plateau-like, elevated seafloor around and to the west of the KTC and the abundant seamounts could reflect the influence of a mantle plume (Fig. 3.2).

The morphological expression of a mantle plume is usually characterized by an age-progressive volcanic track, oriented in the direction of plate motion. Such an age-progressive hotspot track could not be established on the Iberian Plate so far and consequently, absolute plate motion of the Iberian Plate during the Cenozoic is controversial. A structure that could present such a hotspot track is the ~700 km long Azores-Biscay Rise (ABR), which seamounts and ridges rise 1,500 - 3,000 m above the surrounding seafloor. Because of the lack of any sampling, its origin is even more unclear than the KTC. Based on bathymetric considerations and very sparse geophysical data, Whitmarsh et al. (1982) proposed that the ABR may reflect the eastern branch of a paired aseismic ridge that was created by a ridge-centered hotspot (Fig. 3.2). Alternatively, the ABR could represent an intraplate hotspot track (Morgan, 1981) formed by seamounts that are younger than the underlying crust. If the postulated former ridge-centered or intraplate hotspot that created the ABR is identical with the assumed hotspot that apparently interacted with the MAR to form the elevated plateau on which King's Trough was later formed is completely unclear.

**Fig. 3.2**

Cartoon depicting a possible kinematic model (combined after Searle & Whitmarsh, 1978, Whitmarsh et al., 1982, Roest & Srivastava, 1991, Macchiavelli et al., 2017) assuming absolute westward movement of the Mid-Atlantic Ridge. Arrows show only relative plate motion. Absolute plate motion for the Iberian Plate and the number of involved hotspots are waiting to be constrained by the results of this expedition M168. BB= Bay of Biscay axis, KT= King's Trough, ABR= Azores-Biscay Rise, M. Smt.= Milne Seamount, AGFZ= Azores Gibraltar Fracture Zone. Present-day coastlines shown for reference.

3.2 Aims of the Cruise

(J. Geldmacher, A. Dürkefälden, K. Hoernle)

M168 aimed to investigate the geodynamic evolution of the central eastern Atlantic (Iberian Plate) that led to the origin of the King's Trough Complex, the seamounts surrounding King's Trough and the Azores-Biscay Rise. In particular, the following questions/objectives shall be addressed by the analyses of the newly obtained multi-beam bathymetric data in combination with the geochemical characterization and age dating of the recovered igneous rock samples:

King's Trough Complex (KTC): King's Trough, Freen and Peake Troughs including Palmer Ridge

1. What is the geochemical composition of the oceanic crust in which King's Trough is embedded? Is it regular (depleted) mid-ocean ridge basalt or do we find evidence that the local crust was formed by plume-ridge interaction (e.g., Searle & Whitmarsh, 1978)? Can we detect any possible temporal and spatial geochemical variations along the KTC?

2. Can the trough formation (presumably by extension along the temporary plate boundary between ~36 and 28 Ma) be linked to contemporary decompression melting-related volcanism on the upper King's Trough flanks? For example, Kidd et al. (1982) recovered 34-32 Ma old trachytes from upper flank dredge sites in the central King's Trough area and associate them with local fault scarps. In this case, the volcanism will be instrumental to reconstruct and constrain the date of the proposed plate boundary jump from the Bay of Biscay axis to King's Trough.
3. Can we confirm previous hypotheses of multi-stage volcanism at King's Trough (e.g. Cann 1971; Kidd et al., 1982)? Is the apparently secondary trachytic volcanism possibly not associated with trough formation but caused by plume volcanism?
4. Does Palmer Ridge represent an exposed cross-section of the entire oceanic crust (extrusive basalts, intrusive sills and gabbros and lithospheric mantle portion) as previously proposed (Cann & Funnell, 1967; Cann, 1971)? Obtaining samples from different depth intervals will then allow us to constrain the composition and possible heterogeneities of the oceanic lithosphere in the KTC area.

Seamounts west of King's Trough (Gnitsevich Seamounts)

1. Were the smaller seamounts on the plateau to the west of King's Trough (e.g., Gnitsevich Seamounts, Fig. 3.1) formed at the MAR or by intraplate processes?
2. Does the geochemical composition of their lavas suggest a mantle plume involvement as suggested to explain the elevation of the plateau west of King's Trough (Searle and Whitmarsh, 1978)?

Azores-Biscay Rise (ABR)

1. What is the origin of the ABR? Can we detect an age progression of the seamounts consistent with plate movement (a clear sign of hotspot formation) and is their geochemistry consistent with an intraplate formation? The obtained data will be crucial for constraining absolute Iberian plate motion.
2. Can the isotopic composition of the ABR lavas be related to any of the KTC magma sources, to the Azores hotspot, or to an elusive geochemical anomaly that is currently observed at the MAR axis at 45°N (e.g., White & Schilling, 1978)?

3.3 Agenda of the Cruise

(R. Werner, A. Dürkefälden)

To achieve the scientific goals of the King's Trough research project, cruise M168 should conduct extensive multi-beam mapping and rock sampling by dredging in the King's Trough area including surrounding seamounts and of the Azores-Biscay Rise (ABR) (Fig. 3.3). The entire ABR and the seamounts west of the King's Trough Complex (KTC) have never been sampled before. Previous dredging of the KTC mainly focused on two restricted areas (central King's Trough and Palmer Ridge; Fig. 3.1) and was conducted decades ago (see chapter 3.1).

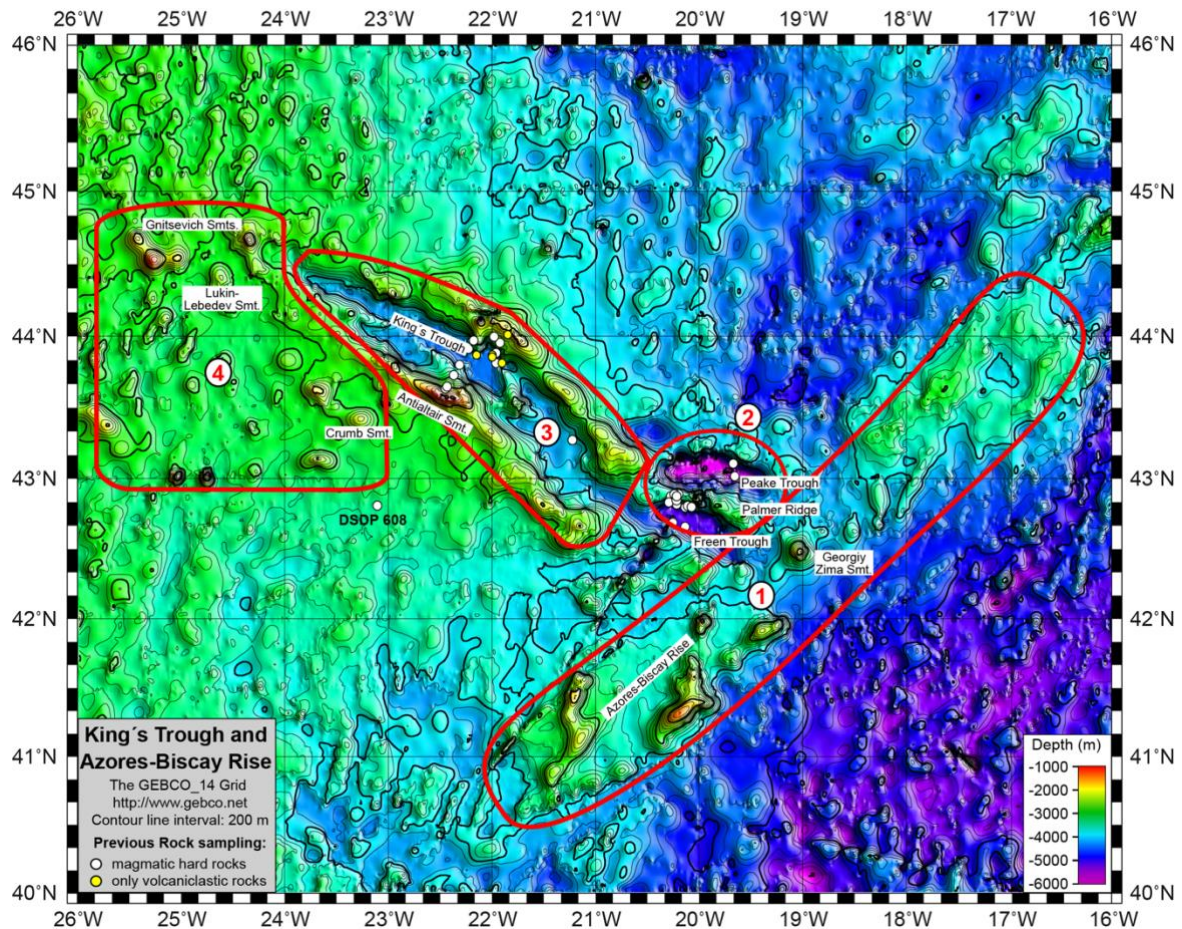


Fig. 3.3 Bathymetric map of the working area of cruise M168 (The GEBCO_2014 Grid, version 20150318, <http://www.gebco.net>). The red framed areas mark the key areas 1 to 4 for profiling and rock sampling by dredging.

Based on available data and information (see chapters 3.1 and 5.2.1), four key areas have been selected for multi-beam mapping and rock sampling on cruise M168 (Fig. 3.3):

1. Azores-Biscay Rise: To constrain the origin of the ABR and to test if an age progression of the ABR seamounts exists, it was planned to sample selected seamounts and volcanic ridges along the ~550 km long southwestern and central section of the ABR. A few of these features should be mapped and sampled in more detail in order to investigate if they have been formed by different magmatic phases (e.g., a shield phase and a younger magmatic event). Different magmatic phases, partly with age differences of tens of million years and also with various geochemical signatures, have been frequently observed at major volcanic seamounts (e.g., Geldmacher et al., 2005; Hoernle et al., 2010; Kipf et al., 2014; Homrighausen et al., 2018; Homrighausen et al., 2020) including seamounts, which are related to hotspot tracks. In particular, when testing for an age progression, it is crucial to recover samples from the shield (main) phase of volcanism forming these seamounts.

2) Freen and Peake Troughs and Palmer Ridge: Sampling at Palmer Ridge and the Freen and Peake Troughs should be mainly conducted by dredging several offset tracks across their steep flanks, which ideally cover the complete depth interval from their base at up to 6,000 m below

sea-level (mbsl) to the top at ~2,400 mbsl (c.f. chapter 5.2.2, Fig. 5.6). The purpose of this approach is to test whether oceanic lithosphere is exposed at these flanks (as previously proposed by Cann & Funnell, 1967 and Cann, 1971) and, if so, to recover a cross-section through the lithosphere that is as complete as possible (pillow lava and sheeted dikes from the upper crust, mafic and felsic intrusive rocks and cumulates from the lower crust, and serpentinites from the upper mantle). Such a sample set would allow us to constrain the composition and possible heterogeneities of the oceanic lithosphere in the KTC area.

3) King's Trough: The flanks of King's Trough should be sampled at several sites in particular in the eastern and western portions of the trough, which have never been sampled before. Together with the samples from the Freen and Peake Troughs and Palmer Ridge, this strategy will allow us to characterize possible temporal and spatial geochemical variations along the KTC. Multi-beam mapping, accompanying the dredging, aims to decipher tectonic processes during formation and evolution of the trough (see chapter 5.1.2). In addition to the mapping and dredging at the flanks of King's Trough, dredge stations should be carried out at the elongated seamounts being aligned on top of the flanks of the trough (e.g., Antialtair Seamount), among others to verify previous hypotheses of multi-stage volcanism at King's Trough. More detailed multi-beam mapping of selected features of King's Trough intends, for example, to detect different morphological units (= magmatic phases?), possible erosional platforms and terraces, respectively, tectonic features (e.g., faults) and to distinguish between tectonically and volcanically formed structures.

4) Seamounts W of King's Trough: Rock sampling at the seamounts located on the elevated seafloor to the west and southwest of King's Trough (e.g., Gnitsevich Seamounts) should reveal their origin (e.g., MAR, intraplate, plume involvement?) and constrain the relation of this significant seamount province to the KTC. As planned for the seamounts of the ABR and on the flanks of KTC, at least one selected seamount should be mapped and sampled in more detail to provide additional information on magmatic, volcanological, and tectonic processes.

4 Narrative of the Cruise

(A. Dürkefälden)

After a four-day quarantine in a hotel in Leer and after all 14 members of the scientific party of M168 had tested negative for COVID-19, the participants were brought to the port of Emden on November 7 and then embarked R/V METEOR. The equipment including two containers was already loaded. In the morning of November 8, the vessel left the port under nice weather conditions, passed the lock and entered the North Sea (Fig. 4.1). The five-day transit to the working area was used to unpack the containers, to set up the laboratories and to conduct other preparations for the cruise. After passage through the English Channel with fine weather and calm seas on November 9, the sea quickly became rougher and winds increased significantly when reaching the North Atlantic Ocean in the course of November 10.

On Thursday afternoon, November 12, R/V METEOR finally reached the central Azores-Biscay Rise, the first section of the working area (Fig. 4.2). First of all, a sound velocity profile was conducted using a sound probe to calibrate the EM 122 multi-beam echo-sounder system. In the evening, the first dredge haul (station -2) was conducted at the eastern flank of a small seamount but returned empty. Unfortunately, bad weather conditions with stormy winds and a

swell of 3 - 4 m did not allow further dredging until Saturday afternoon. Since bathymetric mapping was still possible, the time was used for further mapping of the central Azores-Biscay Rise in order to find appropriate sample stations. However, it turned out that this part of the rise would be difficult to sample due to only few steep enough slopes.



Fig. 4.1 Left: R/V METEOR on its way into the lock of Emden and further into the North Sea (picture: A. Dürkefälden). Right: Pillow lava fragment containing a thick rim with fresh glass recovered at the western end of Freen Trough (picture: F. Hampel).

In the evening of November 13, the vessel therefore headed for the Freen and Peake Troughs directly west of the rise. Despite continued high swell in otherwise sunny weather, we were able to carry out three dredge hauls (-3 to -5) on the western flanks of both troughs on November 14 and 15. Two dredge hauls returned numerous lava fragments including abundant fresh glassy margins (Fig. 4.1), whereas at one station at Peake Trough, only manganese crusts were recovered. Since the wind and wave conditions allowed dredging only in northern directions, sampling focused on the southern flank of Palmer Ridge on Sunday and Monday, November 15 and 16, and six dredge hauls (-6 to -11) were carried out at different depth intervals. One dredge returned empty, but the other dredges contained lava fragments with some fresh glass, a microgabbro/dolerite and volcanoclastic rocks. The next station (-12) was conducted at the southern flank of Freen Trough at the transition to King's Trough, when dredging in southern direction was possible for a short time, and some lava fragments and a volcanic breccia were recovered. On Tuesday morning, two attempts were made to sample the transition from Freen to King's Trough at the northern flank opposite of station -12 (-13 and -14), but the first dredge returned empty, whereas the second dredge haul, which was conducted directly above the previous dredge location, had to be aborted shortly after the dredge reached the seafloor because the weather conditions rapidly deteriorated.

From Tuesday, November 17, until the end of the week, the NE flank and the southeastern part of the SW flank of King's Trough including several of the flanking ridges were extensively mapped and sampled. Due to the difficult weather conditions with strong winds, work concentrated on mapping of both flanks on Tuesday and Wednesday. On Wednesday evening, November 18, decreasing wind and waves again allowed dredging and thus, the southeasternmost end of the SW flank was sampled (-15) and yielded volcanoclastics but no lava.

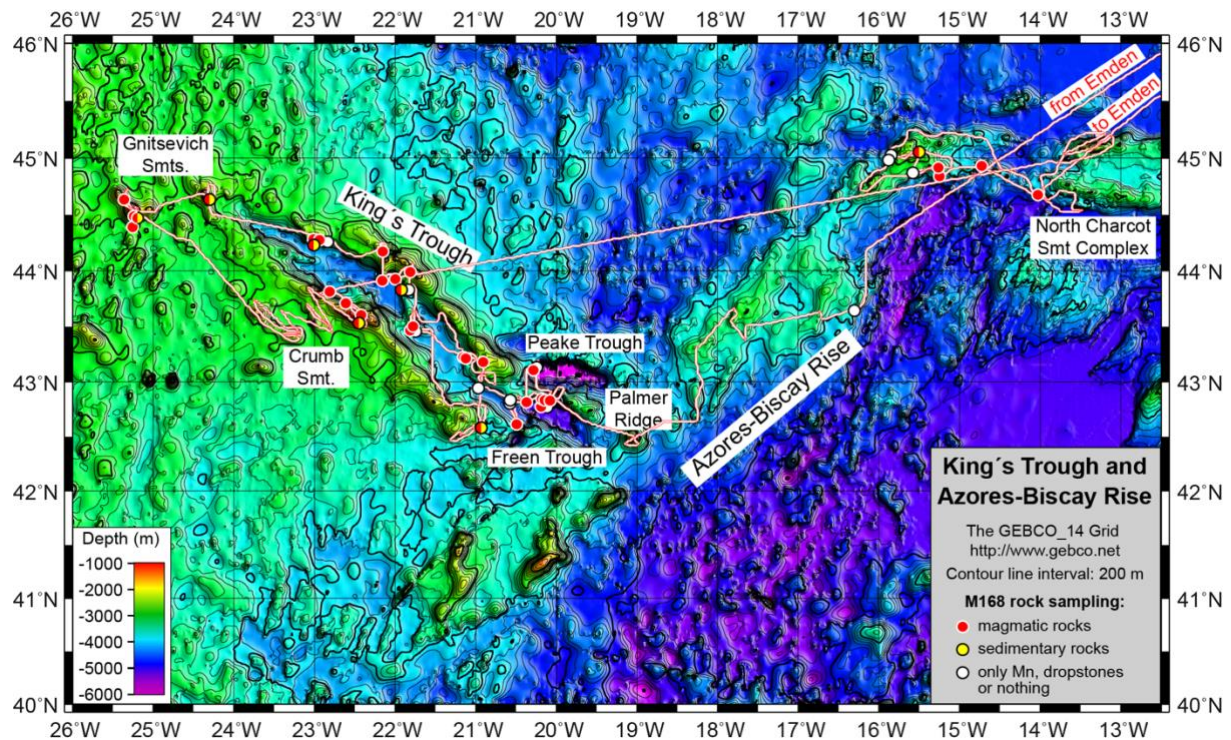


Fig. 4.2 Track chart of R/V METEOR cruise M168 showing the working area (KTC and ABR) including the sampling stations (data base for bathymetry: The GEBCO_2014 Grid, version 20150318, <http://www.gebco.net>).

Since dredging was restricted to northern to northeastern directions further on due to the weather conditions, sampling had to be focused on the NE King's Trough flank. Station -16 was conducted at the base of the southeasternmost part of this flank directly south of a ridge-like structure but returned empty. On the following day, November 19, three dredge hauls were carried out near the summit (-17) and at the base (-18 and -19) of the same ridge-like structure and recovered lava fragments, plutonic rocks and volcanoclastics. The next target was a triangular-shaped seamount located in the central portion of King's Trough between the two flanks, which was sampled at three locations. Whereas dredging at station -20 was unsuccessful, -21 and -22 yielded lava fragments and plutonic rocks. In the morning of November 20, R/V METEOR headed for the NE King's Trough flank north of the triangular-shaped seamount and six dredge hauls were conducted at the large elongated seamount opposite to Antialtair Seamount, a large seamount on the central SW flank, during this and the following day. One dredge haul (-23) at the base of the southern flank of the seamount only returned dropstones, but station -24 near the summit obtained several lava fragments. The next three stations (-25 to -27) were carried out at the lower section of the seamount and recovered lava fragments, subvolcanic/plutonic and pegmatitic rocks and volcanoclastics. Station -28 was again located at the summit but further northwest of station -24 and the dredge contained lava fragments from two large blocks. The vessel subsequently sailed further to the west-northwest to a seamount on the NE King's Trough flank. Of four dredge hauls (-29 to -32), which were conducted at different depth intervals on Sunday, November 22, three yielded lava fragments, subvolcanic

rocks, ultramafic rocks possibly of harzburgitic composition and volcanoclastics. The last dredge haul (-32) returned empty.

In the evening of November 22, R/V METEOR left King's Trough for a short time and reached the Gnitsevich Seamounts, a group of seamounts in the northwest of King's Trough belonging to a number of seamounts located on elevated, plateau-like, seafloor west of the trough. During the night and the following day, the easternmost seamount (-33), a large seamount west of it (-34 to -36) and the northwesternmost seamount were sampled (-37) under relatively calm weather conditions and yielded a variety of rocks comprising lava fragments, volcanoclastic rocks and dropstones (Fig. 4.3).



Fig. 4.3 Left: A successful dredge haul containing many large blocks (picture: A. Dürkefälden). Upper and lower right: The scientists collect the recovered rock samples and bring them into the lab where they are cut (pictures: F. Hampel).

Ship time did not allow for sampling of the seamounts further south-southwest and south of the Gnitsevich Seamounts and thus early in the morning of November 24, the vessel directly headed for the Crumb Seamount Group in the southeast located in the vicinity of the prominent Antialtair Seamount on the SW King's Trough flank. However, the weather conditions deteriorated by that time and stormy wind and rough seas with high swell made dredging impossible for the next two days. We instead mapped the Crumb Seamount Group as well as the adjacent Antialtair Seamount in detail so that we would be able to quickly choose and then sample appropriate slopes or flanks as soon as the weather conditions allow it. On Thursday, November 26, the wind and wave heights finally decreased and we successfully conducted four dredge hauls (-38 to -41), two at the summit and one at the northwestern base of Antialtair

Seamount, which returned several lava fragments and volcanoclastic rocks, and another dredge haul at the base of the SW King's Trough flank in the northwest of Antialtair Seamount, which recovered an ultramafic rock, possibly a harzburgite. Since a strong storm front was developing in our working area, our dredge program had to be canceled in the late evening of the same day. On the advice of the meteorologist from the German National Meteorological Service (DWD), who gave support via remote weather briefings from Hamburg during the expedition, R/V METEOR then sailed nearly 400 nm towards the east-northeast to get out of the influence of the storm front as much as possible. Unfortunately, this meant that due to time constraints, it was not possible to return to the working area in order to carry out more dredge stations at the SW flank of King's Trough and to sample the southwestern and central Azores-Biscay Rise as originally planned. However, the avoidance of the storm led to the northwesternmost part of the Azores-Biscay Rise, which R/V METEOR reached on Saturday, November 28, and provided the unexpected opportunity to collect samples from the rise after all. Since winds and waves were still too strong for dredging, a large E-W oriented ridge/seamount complex representing the end of the Azores-Biscay Rise and the North Charcot Seamount Complex adjoining directly in the east were partly mapped on November 28 and 29. During the next two days, on November 30 and December 1, the weather conditions improved and allowed dredging at eight locations at both structures. Two attempts (-42 and -43) at the western flank of the seamount complex belonging to the Azores-Biscay Rise were unsuccessful. One dredge haul was carried out at the summit cone (-44) and four at the southern flanks (-45 to -48) and returned lava fragments and volcanoclastics. Another dredge haul (-49) was conducted at the southern base of the North Charcot Seamount Complex and yielded lava fragments as well. This was the last station of cruise M168. Since another strong storm front approached the region between the British Isles and the working area, the vessel had to leave the area and start the return transit very early in the morning of Wednesday, December 2, two days earlier than originally planned, in order to reach the British Channel safely. After a four-day transit, which was used to pack the containers and to clean the laboratories, R/V METEOR arrived at the port of Emden in dull and cold weather in the morning of Sunday, December 6.

5 Preliminary Results

5.1 Bathymetric Mapping and Hydroacoustics

(R. Werner, J. Geldmacher)

5.1.1 Methods

Data Acquisition

A KONGSBERG Maritime EM 122 multi-beam echo-sounder system is permanently installed on R/V METEOR for continuous mapping of the seafloor. The system consists of several units. A transmitter/receiver transducer array is fixed below the keel of the vessel. A preamplifier unit contains the preamplifiers for the received signals. The transceiver unit contains the transmitter, 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 high

performance PC workstations. The operator software is the Seafloor Information System (SIS), which processes the collected data, applying corrections, displays the results and logs the data to internal or external disks.

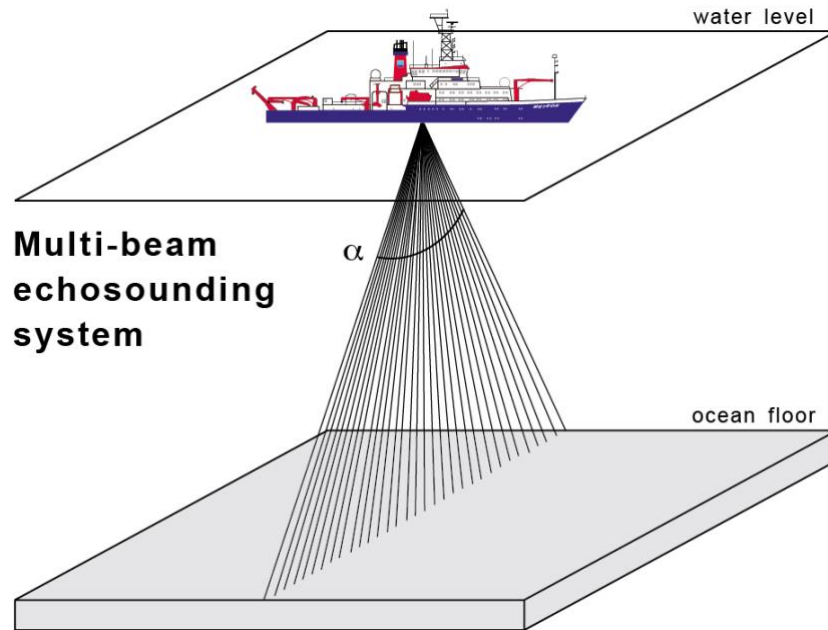


Fig. 5.1 Schematic sketch illustrating the principle mode of operation of multi-beam echo-sounding systems. The whole angular coverage sector (α) of the KONGSBERG EM 122 system is up to 150° .

The EM 122 system uses a frequency of about 12 KHz with a whole angular coverage sector of up to 150° (75° per port-/starboard side, Fig. 5.1). The depth range amounts to 20 - 11,000 m. The system has up to 288 beams and 432 soundings, respectively, per swath with pointing angles automatically adjusted according to achievable coverage or operator defined limits. 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 optimizes 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 yaw movements within ± 10 degrees and roll movements within ± 15 degrees are automatically compensated by the software. Thus, the EM 122 system can map the seafloor with a swath width about up to six times the water depth (to approximately 30 km). 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 velocity profile. During M168, one sound profile has been determined using a Lockheed Martin expendable sound velocimeter (XSV-02), ensuring the use of the correct sound velocity on this cruise. The XSV has been deployed in the northern area of the Azores-Biscay Rise when R/V METEOR reached the working area (see Appendix 12.1 for coordinates). For bathymetric data obtained during the transit from the border

of the French exclusive economic zone to the Azores-Biscay Rise, a sound velocity profile recorded on a previous cruise have been used.

Data Cleaning and Processing

The data cleaning procedure was accomplished by the QPS Qimera v. 1.7.2 software. After loading the raw data (.all files) from the EM 122 and the correct sound velocity profile, a dynamic surface has been created showing the ship's track and the raw data (Fig. 5.2).

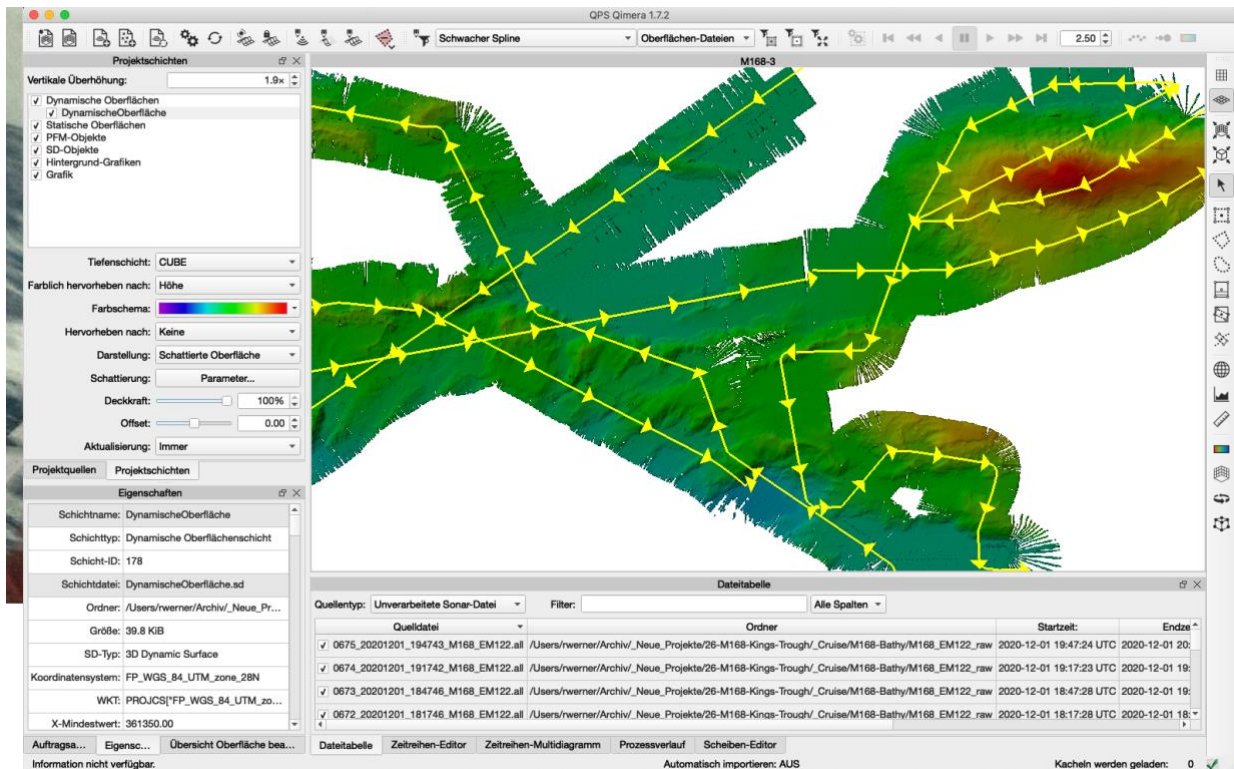


Fig. 5.2 Dynamic surface created with Qimera showing the raw data and the ship's track.

Qimera allows an automatic elimination of major erratic data points using a spine filter. Furthermore, there are several tools for detailed elimination of erratic data points, for example a swatch editor, a 2D editor or a 3D editor (Fig. 5.3) which all enable the operator to process each single beam stepwise. All editors display not only the cleaned data but also, if desired, the rejected data points and offer a variety of visualizations of the data (according to files, depth, intensity etc.). Additionally, the data can be cleaned and edited using CUBE (Combined Uncertainty and Bathymetry Estimator, by University of New Hampshire).

After data cleaning, a static surface has been generated from the dynamic surface creating a .sd file, which can be loaded in the QPS Fledermaus software, allowing 3D visualization of the cleaned data. Furthermore, the data can be exported in an ASCII x,y,z file format with header information for assembling, gridding and contouring with the GMT software (Wessel & Smith, 1995).

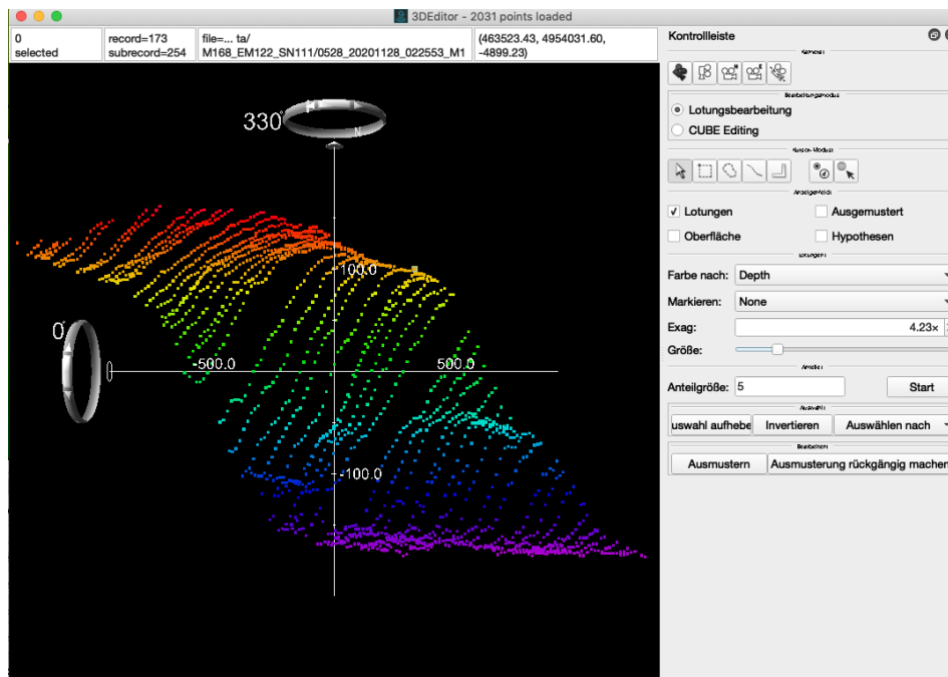


Fig. 5.3 3D editor of Qimera, a tool for elimination of erratic data points.

R/V METEOR is equipped with an ATLAS PARASOUND P70 sub-bottom profiler. Sub-bottom profilers (or sediment echo-sounding systems) are used to display sub-seafloor geological structures as, for example, marine sediment successions. Unfortunately, the PARASOUND system is not useful for the selection of appropriate dredge sites, since dredge tracks must be located at steep slopes (see chapter 5.2.1) and PARASOUND only works properly on slopes with a maximum of a few degrees of incline. Therefore, PARASOUND data have only been recorded during selected M168 bathymetric surveys, which covered more or less plain ocean floor, and on transits. The data acquisition included PHF and SLF data. All data have been copied on an external hard disk and sorted by the operator into folders according to data type (PHF, SLF and ASD, PS3, SEG Y). The entire PARASOUND data set will be transferred to international data banks and may be used by specialists for further shore-based processing and analyses.

5.1.2 Preliminary Results

Multi-beam echo-sounding on cruise M168 mainly aimed to test if potential sampling targets are appropriate for dredging and to define the exact positions of individual dredge tracks (see chapter 5.2.1 and Appendix 12.2). More or less systematic mapping of larger features has only been conducted in a very few areas (e.g. Palmer Ridge, Fig. 5.6) due to time constraints. Nevertheless, the tracks mapped along the flanks of King's Trough allow to establish a preliminary hypothesis about its origin and tectonic evolution. Based on the low resolution satellite altimetry data, King's Trough appeared to be a succession of sub-parallel, NW-SE-oriented basins flanked by linear ridges or elongated seamounts (Fig. 5.4) including Antialtair Seamount on the southwestern flank. Our selective multi-beam mapping along the trough flanks revealed that this structure is much more complex. The flanks do not form coherent lateral walls

but are composed of individual segments (ridges) that can strike in slightly different directions (between c. 90° and 130°). Apparently, the topographic heights (“flanking ridges”) do not just mount on the trough’s shoulders, but they form the actual trough’s flanks. At places (e.g. at 21°30’W, see Fig. 5.4), the ends of the segments extent “en echelon”-like into the trough basin. This pattern could indicate that King’s Trough initially formed by a series of strike-slip faults during the time when the region served as transient African-European plate boundary.

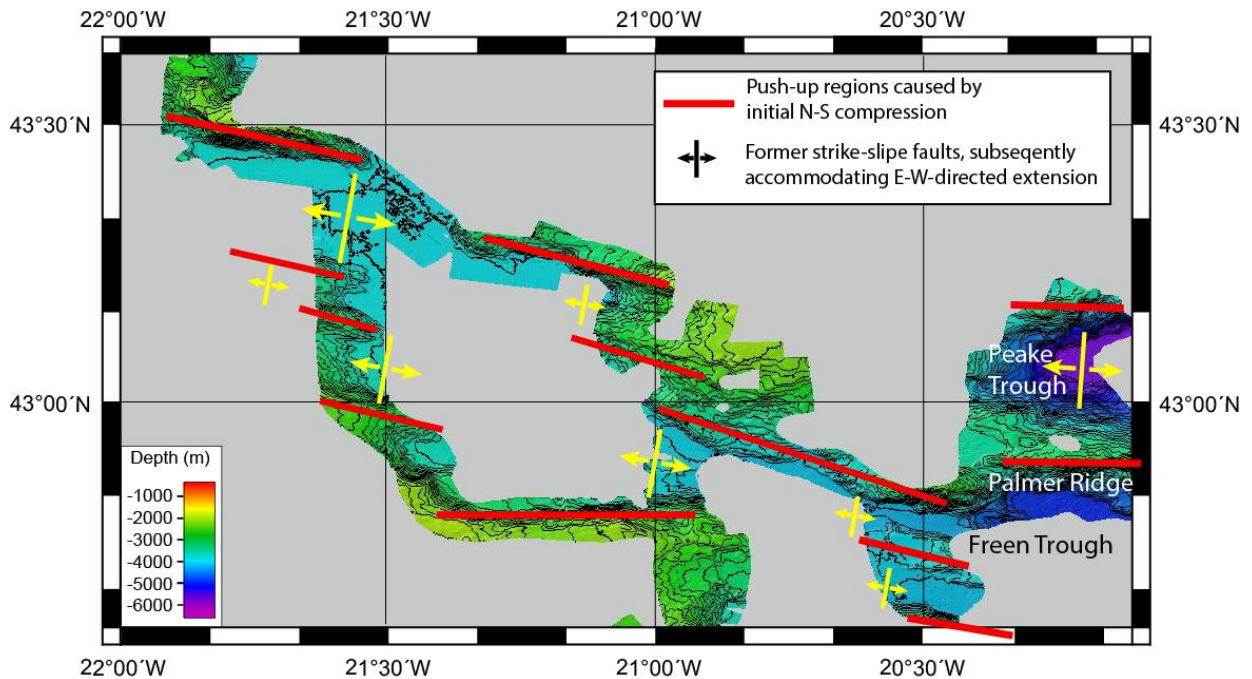


Fig. 5.4 Multi-beam bathymetry of the southeastern part of King’s Trough recorded during cruise M168 with simplified tectonic interpretation. See text for details.

A currently still speculative tectonic model explaining the simultaneous occurrence of ridges and basins could be a transition from an initially transpressional into a transtensional stress regime. Initially, a series of short, roughly N-S-striking, dextral strike-slip faults could have formed along the roughly E-W-oriented plate boundary. To explain the formation of the ridges, the transformation must be caused - or at least accompanied - by significant N-S directed compression. In the “step over” regions, the overall geometry and the dextral slip direction generated topographic uplifts, represented by the flanking ridges that today form the actual flanks of King’s Trough. Evidence for brittle deformation (parallel striations, harnisch surface and apparent cataclastic fabric – samples 21-1-1, 25-1-1, 25-1-10 and 25-1-11) was found on several rocks dredged from the central northeastern King’s Trough flank and the seamount in the center of the trough. In addition, the previously reported exposure of deep crustal lithologies on the topographic heights (Cann, 1971; Cann & Funnell, 1967), (preliminarily) supported by some of our dredged samples (apparent plutonic rocks such as gabbro and amphibolite and ultramafic rocks in dredge hauls -9, -17, -22, -25 and -11, -30, -40, respectively) is consistent with significant vertical tectonic movements. In a second stage, however, the region must have experienced E-W directed extension, causing opening of the N-S striking faults as true “pull

apart” basins, forming today's contiguous King's Trough basin(s). The occurrence of multiple, short transforms (as opposed to a major fracture zone) would also explain the only small overall offset of the magnetic lineations (Searle & Whitmarsh, 1978). Ultimately, the petrography and geochemistry of the obtained dredge samples from the trough flanks will help to test this complex model: If true, the igneous rocks should have similar (mid-ocean ridge basalt, MORB) composition and age as the surrounding seafloor (as constrained by the magnetic lineations).

5.2 Dredging

(F. Hauff, R. Werner, A. Dürkefälden and Shipboard Scientific Party)

5.2.1 Methods, Shipboard Procedure and Shore-based Analyses

Rock sampling on cruise M168 was carried out using rectangular chain bag dredges. Chain bag dredges are similar to large buckets with a chain bag attached to their bottom and steel teeth at their openings, which are dragged along the ocean floor by the ship's winch.

General station areas were chosen on the basis of a number of existing datasets. These mainly include predicted bathymetry, derived from gravity data and ship depth soundings (etopo by Smith & Sandwell [1997] and "The GEBCO_2014 Grid, version 20150318", <http://www.gebco.net>) as well as published data and maps, and profiles (e.g., Stebbins & Thompson, 1978, Kidd et al., 1982, Kidd & Ramsay, 1987; see chapter 3). In addition, Dr. Timm Schoening (GEOMAR) kindly provided us with multi-beam data from a track across the M168 work area recently recorded on R/V MERIAN cruise MSM96.

The final selection of dredge sites was critically dependent on detailed multi-beam echosounding surveys carried out at each site before dredging. Final positioning of the vessel at each dredge station was based on the bathymetric data including considerations of wind, swell and drift conditions. Dredge tracks were usually located - depending on the morphology of the structures - on steep slopes of scarps, canyon walls, fault zones, and the flanks of cones, ridges, and larger seamounts. This was mainly done to avoid areas of thick sediment cover.

Shipboard Procedure

Once onboard, the content of the dredge was first scanned for ice-rafted material (“dropstones”) which is common in parts of the M168 working area. Several criteria have been applied to minimize the likelihood of selecting glacial dropstones. These criteria include angularity of samples, especially those with freshly broken surfaces, because ice-rafted dropstones are typically rounded by glacial transport. Another important criteria is the homogeneity of rock types within a single dredge haul, because dropstones generally form very heterogeneous assemblages. Furthermore, dropstones are usually relatively young and do not have thick manganese crusts because these crusts grow extremely slowly. Applying these criteria, *in situ* rocks were selected for further processing. First, these were cleaned and cut using a rock saw. They were then examined with a hand lens and binocular 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. Best 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 respective site was weighted against the required time commitment.

Fresh blocks of representative samples were then cut for post-cruise thin section and microprobe preparation, geochemistry and further procedures to remove manganese and alteration products and/or to extract glass (if present). Each of these sub-samples, together with any remaining bulk sample, was described, labeled, photographed, and finally sealed in plastic bags for transportation to GEOMAR.

Shore-based Analyses

Magmatic rocks sampled by R/V METEOR from the ocean floor will be analyzed using a variety of different geochemical methods:

Ages of suitable rock samples will be determined by $^{40}\text{Ar}/^{39}\text{Ar}$ laser step-heating dating. Major element geochemistry by X-ray fluorescence (XRF) and electron microprobe (EMP) will constrain magma chamber processes. Trace element data, obtained 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. Phenocryst assemblages and compositions will be used to quantify magma evolution. Petrologic studies of the volcanic rocks will also help to constrain the conditions under which the melts crystallized. The composition of mafic basalts and basaltic glasses, as well as mafic melt inclusions, can be used to assess mantle temperatures at which melting took place, as well as pressures and degrees of melting. Sr, Nd, Hf and Pb (double spike) isotope ratios, determined by thermal ionization mass spectrometry (TIMS) and multi-collector ICP-MS, reflect the long-term evolution of the magma sources and thus serve as tracers to identify mantle domains and possibly recycled (crustal?) material. Morphological and volcanological studies will constrain eruption processes, eruption environment and evolution of the volcanoes.

Non-magmatic rocks and Mn-Fe oxides yielded by dredging can be transferred to co-operating specialists for further shore-based analyses.

5.2.2 Preliminary Results

This chapter summarizes station work and rocks obtained at 1) Palmer Ridge, Freen and Peake Trough, 2) King's Trough, 3) Gnitsevich Seamounts and 4) Northernmost Azores-Biscay-Rise and North Charcot Seamount Complex. For station details and description of individual samples see Appendix 12.2.

5.2.2.1 Palmer Ridge, Freen and Peake Troughs

A total of 12 dredges were carried out at Palmer Ridge and at Freen and Peake Troughs (Fig. 5.5). Eight dredges returned *in-situ* magmatic rocks. Prime focus was the southern flank of Palmer Ridge with five successful hauls (stations -6, -8, -9, -10 and -11, Fig. 5.6). The western limits of Freen and Peake Troughs were sampled at stations -3 and -5 respectively, while station -12 is located at the southern transition of Freen to King's Trough.

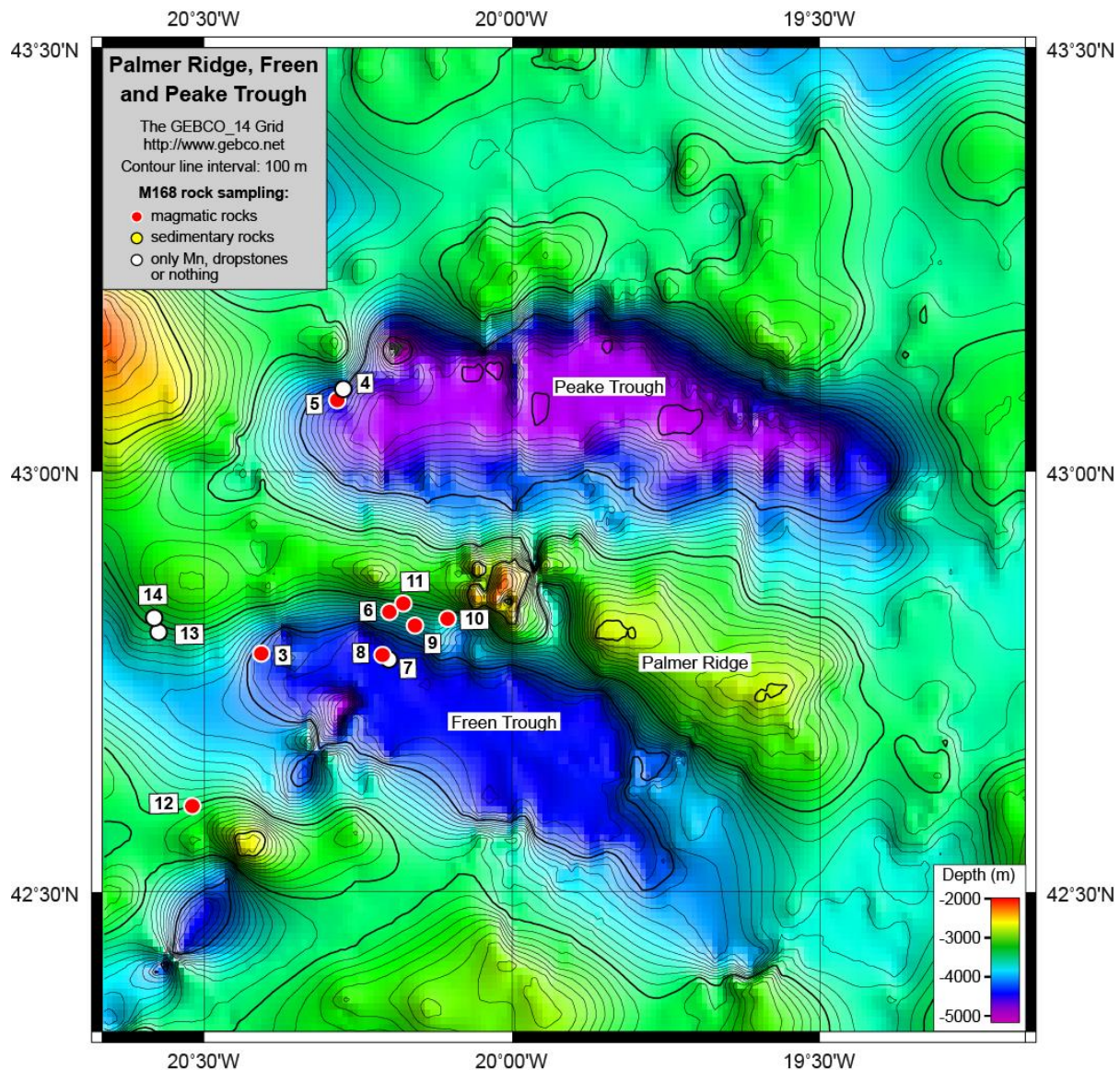


Fig. 5.5 M168 station map of Palmer Ridge and bounding Freen and Peake Troughs.

Dredges along the southern flank of Palmer Ridge primarily returned lava with variable, but rare Pl, Px and Ol phenocrysts along with aphyric varieties. The lavas are massive and non-vesicular throughout. Overall, most are fairly fresh to slightly altered and appear suitable for whole rock geochemistry and Ar-Ar dating of the groundmass. The only plutonic/subvolcanic rocks at Palmer Ridge were obtained at station -9 by microgabbros or dolerite (#1) along with volcanic rocks and a breccia with volcanic clasts (Fig. 5.7, middle picture) indicative for sampling talus at the base of Palmer Ridge. Particularly noteworthy are hyaloclastites/intra-pillow breccias at station -11 near the summit of Palmer Ridge that house abundant, up to several cm-sized, fresh glass fragments and spherules (Fig. 5.7, right picture). Fresh glass has also been reported at station -10 along with sparsely Px phyric lavas. An amphibolite described from here should be treated with caution as it may be a dropstone. Station -3 at the western end of Freen Trough obtained numerous moderately altered pillow fragments with abundant fresh glassy

margins (#1 to #11) with rare, altered Ol phenocrysts (Fig. 5.7, left picture). The second lithology (#12 to #17) includes lava fragments without glass that bear occasional glomerocrystic Pl in addition to altered Ol, but overall possess a fresher groundmass than the glassy pillows of the first lithological unit. Sample #17 appears to have the freshest groundmass that may be possible to date by Ar-Ar dating.

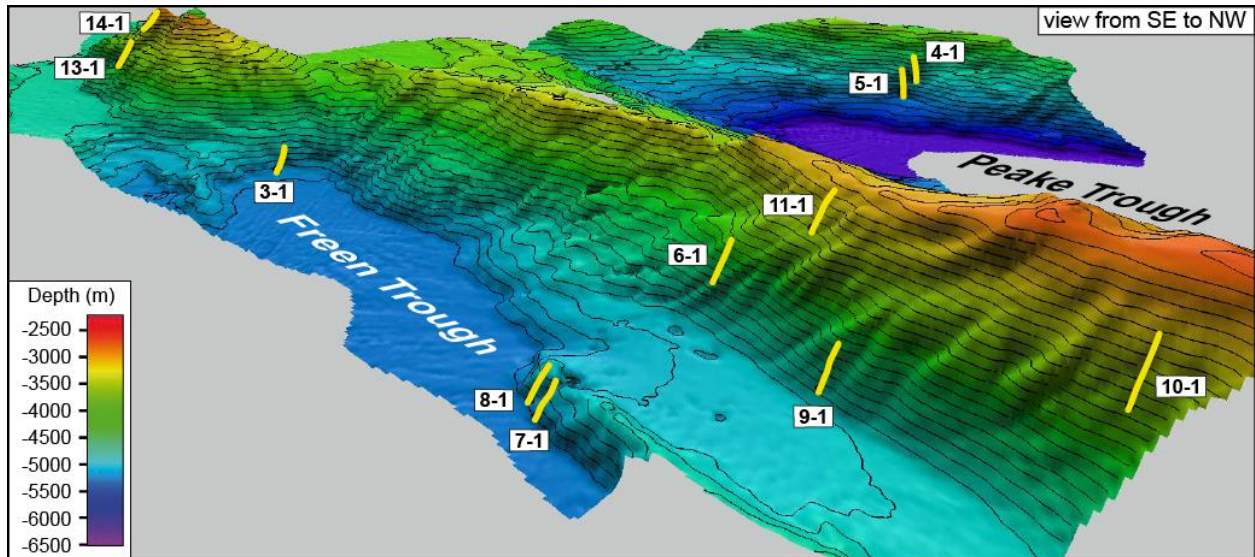


Fig. 5.6 3D-figure of Palmer Ridge and the bordering Peake and Freen Troughs with dredge stations M168-3-1 through 11-1 and M168-13-1 and 14-1. The map is based on multi-beam data recorded on M168 (stereo exaggeration: 2x; interval of contour lines: 100 m).

Station -5 at the western end of Peake Trough provided mostly non-vesicular, aphyric lava fragments ranging from fairly fresh (#1) to otherwise slightly and moderately altered. Fresh glass is reported from sample #2. A conglomerate (#6) with variable, subangular lava fragments indicates erosive processes along the slope. Nearby station -4 obtained only Mn crusts.

Station -12 at the southern transition of Freen to King's Trough obtained relatively homogeneous lava throughout. Some lava fragments are fairly fresh with altered Ol phenocrysts but in places dark grey groundmass is present that may be suitable for Ar-Ar dating. The overall amount of phenocrysts is <5% in most samples and dominated by Ol with occasional subordinate amounts of Px and Pl.

In summary, the M168 sites at Palmer Ridge and Freen and Peake Troughs returned predominantly pillow lava and lava fragments with occasional occurrence of fresh glass in sometimes considerable amounts. In many cases, the lavas are fairly fresh, but moderately altered varieties also occur. All lavas have low to near absent vesicularity and are mostly aphyric or have low amounts of Ol, Px and Pl phenocrysts. Intrusive gabbroic rocks were obtained at one site only. Despite a ~3 km elevation profile, Palmer Ridge appears to expose almost solely extrusive magmatic rocks that likely correspond to the uppermost basaltic layer of normal ocean crust.



Freen Trough: Altered pillow lava with fresh glass along chilled margin at top of picture.

Palmer Ridge: Breccia with angular clasts of fairly fresh, aphyric lava.

Palmer Ridge: Hyaloclastite with abundant fresh glass and angular lava fragments.

Fig. 5.7 Representative pictures of rocks obtained at Freen Trough and Palmer Ridge during cruise M168.

5.2.2.2 King's Trough

Of 22 dredges carried out at King's Trough, 18 returned *in-situ* magmatic rocks (Fig. 5.8). Due to prevailing weather and sea conditions, sampling had to focus on southward dipping slopes. Hence, the NE margin of King's Trough was primarily sampled (-17 to -19 and -24 to -31), but the central seamount complex of King's Trough includes a steep south facing slope that was targeted at three stations of which -21 and -22 obtained igneous rocks. The SW margin of King's Trough was targeted at Antialtair Seamount (-38 to -41) and the southeastern end of King's Trough at station -15. Although EM 122 multi-beam mapping along the SW flank of King's Trough revealed many promising northward dipping slopes, the overall sea- and wind conditions did not permit any sampling attempts.

The NE margin of the southeastern King's Trough was sampled along a WNW-ESE striking profile that aligns with the predominant, regional lineament pattern (as revealed by M168 mapping with the EM 122 system) extending from within the trough up to at least several tenth of km into the bounding slopes and hills of King's Trough. Interestingly, these lineaments are continued along strike on the opposite side of King's Trough indicating that they are across-basin features, which may be related to the formation of the troughs (c.f. chapter 5.1.2). Site -17 near the summit of such an \pm E-W striking ridge recovered variable igneous lithologies. Aphyric, mostly fairly fresh lava fragments comprise lithology 1 (#1 to #6; Fig. 5.9, left picture), while lithology 2 (#7 to #10) are fairly fresh, mostly Mn encrusted plutonics and subvolcanics (gabbro - diorite). Although less likely, a possible dropstone origin should be kept in mind for the latter. The third group (#11 to #13) consists of fairly fresh magmatic rocks that are brecciated and thus indicative for brittle tectonic deformation that may be related to faulting along the sampled lineament. A volcanic rock with strongly oxidized groundmass (#14) is solitary within this dredge in terms of alteration, whereas the fifth lithology (#15 and #16) comprises volcanic breccias made of moderately altered aphyric lava fragments. Further downslope, volcanoclastics, sediments, dropstones, chert and two volcanic rocks (#1 and #2) were recovered at site -18 near the basin floor of King's Trough. The volcanics are relatively fresh, almost non-vesicular and bear Px and Ol phenocrysts. Notably volcanoclastic sample #4 contains fresh black minerals that may be Amph, which could serve for Ar-Ar dating. Nearby station -19 again obtained volcanoclastics that resemble those of -18 along with a single, altered volcanic rock.

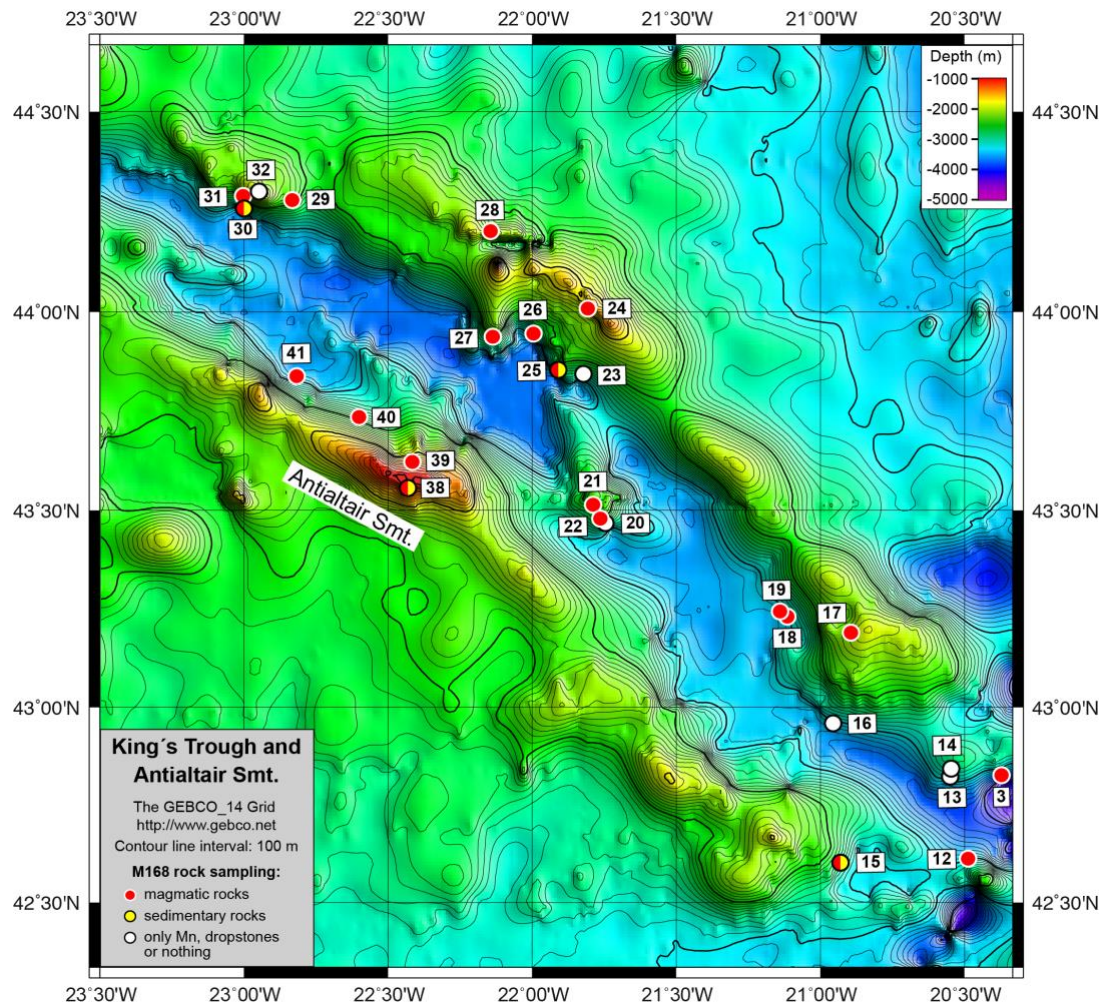


Fig. 5.8 M168 station map of King's Trough being morphologically divided into southeastern and northwestern sub-basins. A central seamount marks the boundary between the troughs. The NE and SW margins consist of elongated ridges of which Antialtair Seamount is the most prominent and shallowest.

A similar strategy to sample profiles from the basin floor into the adjacent hills was applied to the NE flank of King's Trough in its central and northwesternmost portion (Fig. 5.10). At station -24 in the summit region of the seamount opposite to Antialtair Seamount, loose volcanic rocks comprising slightly altered Ol phyric lava (#1), moderately altered lava (#2 and #3) and altered, slightly Pl phyric varieties (#4 and #5) were collected. A breccia block (#13 and #14) delivered numerous volcanic clasts (#6 to #12) that are variably altered and mostly slightly Pl phyric lavas. Sample #8, however, consists of two aphyric varieties of brown and grey colored clasts (Fig. 5.9, middle picture). The breccia and its clasts are of interest as they document older local erosion and lithification, whereas the single volcanic rocks seem to be younger debris. The other summit station -28 obtained two large blocks of breccias from which some clasts were taken as samples. These clasts are vesicular lava fragments, which are variably altered (slightly to moderately) and possess about 5% Ol and/or Px phenocrysts. Sample #4 may contain bits of fresh glass.

At the base of the hill complex, station -25 gave two large blocks and numerous smaller rocks. Almost all of them are angular to subangular and appear fractured. On the fractured rocks,

striations from brittle faulting are visible. The recovered lithologies are broadly subdivided into fairly fresh plutonics/subvolcanics (#1 to #6) with variable proportions of Pl and Px, slightly to moderately altered volcanics (#7 to #9 and #17) plus a strongly altered phyrlic lava (#16). Intriguing rocks are #10 and #11, which consist of volcanics with attached fully crystalline parts that resemble intrusions. The crystalline parts are fractured and resemble cataclasites. #12 is another subvolcanic rock but with abundant altered Ol. Pegmatitic rocks are sampled by #13 and #14. Provided that all rocks of site -25 are *in-situ*, the rock assemblage documents brittle faulting of volcanic and intrusive rocks. The association of faulted intrusive rocks attached to volcanics may further imply intrusion at depth of a volcanic series that includes pegmatites, followed by brittle deformation possibly related to the opening of King's Trough. Other sites at the base of the NE slope of the central King's Trough are sites -26 and -27. At site -26, eight relatively fresh, homogeneous volcanics and a single greenish volcanoclastic sediment were recovered. All volcanics are highly Ol + Pl phyrlic in variable proportions and in most cases relatively fresh (#1 to #8). Fresh Ol is described in #1. The base of the slope at this site thus appears to consist exclusively of Ol + Pl phyrlic lava. Nearby station -27 gave three volcanic rocks and three dropstones (granite, gneiss and quartzite). The latter were discarded. Distinguishing dropstones from *in-situ* rocks is, however, difficult at this site, because most volcanic rocks are quite rounded, which could be glacial or local erosion of e.g. beach cobbles from further upslope and may also explain the heterogeneous petrography. #1 is a mainly fresh, near aphyric lava fragment with striations of unclear origin (tectonic versus glacial) but the rock seems too angular for a dropstone. #2 is a highly phyrlic (30%) volcanic rock with Pl and Px? phenocrysts. Its rounded appearance and thin Mn coating make a dropstone origin likely. #3 is a rounded, medium to coarse grained volcanic rock with unspecified mineralogy. In conclusion, site -27 rocks may be dropstones after all.



King's Trough: Fresh, angular, aphyric lava fragment from the summit of a ridge, confining the trough.



King's Trough: Matrix supported breccia with slightly vesicular brown and grey clasts.



King's Trough: Px-Ol-bearing plutonic rock (harzburgite?) as clasts from a breccia at the base of the northwestern trough.

Fig. 5.9 Representative pictures of rocks obtained at King's Trough during cruise M168.

The northwesternmost stations of King's Trough (-29 to -31) sampled igneous rocks between 4,100 and 2,400 mbsl. A single piece of Ol phyrlic, moderately altered pillow basalt was freshly broken off from the ground at -29 (ca. 3,900 mbsl). The pillow may contain fresh glass along its chilled margin and is covered by a 2-3 cm thick Mn crust. Station -30 at similar depth (ca. 4,100

mbsl) recovered some loose rocks along with two large blocks of breccia/conglomerate that house igneous clasts. Overall, the dredge is hetero-lithological with #1 being fresh, moderately Pl-Px phyrlic, #2 being slightly altered, aphyric and #12 being moderately altered, aphyric lava fragments. #3 is a fully crystalline, probably subvolcanic rock. Samples #4 to #6 are all ultramafic Opx? + Ol plutonic clasts (harzburgite?) from breccia Block B indicating exposure of lithospheric mantle rocks nearby (Fig. 5.9, right picture). #7 is described as highly Pl-Px phyrlic lava and classified as possible dropstone. #8 is a volcanoclastic rock, while #9 and #10 are leucocratic plutonic and metamorphic rocks respectively. The latter two are likely dropstones. At station -31 (ca. 2,400 mbsl), the shallowest in the northwestern sampling area of King's Trough, a single Px-Pl phyrlic, slightly altered lava fragment was recovered. Other samples comprise volcanoclastics (#2) and Mn crust (#3 and #4).

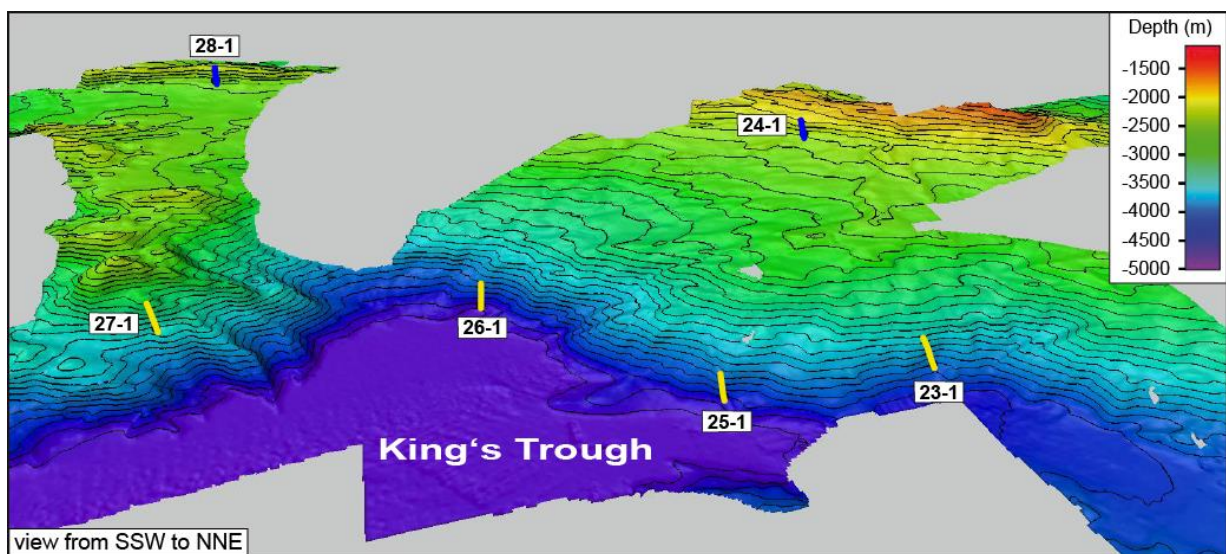


Fig. 5.10 3D-figure of the NE flank of King's Trough (central section) with dredge stations M168-23-1 through -28-1. Sampling at this section aimed to cover different units of the flank. Stereo exaggeration, contours and data sources as in figure 5.6.

A triangular shaped seamount in the center of King's Trough separates the two sub-basins and has a prominent \pm E-W striking, steep slope along its southern boundary. The strike of this fairly regular slope matches the regional lineament pattern and thus could be the surface expression of a fault. Obtaining *in-situ* rocks from it proved, however, difficult and returned only limited amounts at stations -21 and -22. A single faulted volcanic rock (lava?) with multiple fault planes was obtained at station -21. Dredge -22 is quite heterogenous ranging from variable lava fragments to plutonic rocks. The thickness of the Mn crust varies from <1 mm to 10 mm. A dropstone origin cannot be safely ruled out for any of the rocks under the aspect of dredge inhomogeneity and often thin Mn crust. However, if the slope is indeed related to transtensional faulting, uplift of plutonics and a mixture of lithologies is feasible. Samples #1 and #2 are aphyric lava fragments, whereas #3 is Ol-Px phyrlic. #4 is a felsic plutonic, while #5 appears more mafic. #6 is a fairly fresh Pl- and Px-bearing plutonic rock.

From the summit of Antialtair Seamount, Pl-Ol phyric lava were recovered at station -38 along a step at the southern flank that could be a former beach terrace. Sample #3 appears freshest, whereas samples #1 and #2 seem to be moderately to strongly altered. #4 is a strongly altered volcanoclastic rock. At the northern flank and roughly similar depth (ca 1,800 mbsl), station -39 received strongly altered volcanoclastic rocks that appear hydrothermally overprinted, but abundant palagonite may still contain bits of fresh glass (#1). A single clast of fairly fresh, Pl phyric, vesicular lava was obtained at station -40 along the northwestern base of Antialtair Seamount from ca. 3,400 mbsl. At station -41 at the very base of the ridge extending northwest of Antialtair Seamount, a single ultramafic Px-Ol-rich plutonic rock (harzburgite?) was recovered. A dropstone origin was initially disputed, but then it was realized that similar rocks were recovered at station -30 as clasts in a breccia. The dredge got severely stuck at station -41 and had to be recovered close to the drop point. Either the slope is too steep and/or consists of massive lithology as represented by the recovered harzburgite.

A single attempt to sample the southeastern end of King's Trough was carried out at station -15 along the south facing flank of a seamount bordering the trough. Only brecciated sediment with attached phosphorite along with a piece of breccia containing a pumice clast was recovered.

In summary, sampling of King's Trough focused on three areas: 1) the southeastern basin along its NE flank, 2) a central profile across King's Trough that includes Antialtair Seamount on the SW flank, a central seamount complex and the NE side of King's Trough opposite to Antialtair Seamount, and 3) the northwestern termination of King's Trough at its NE flank. Stations bounded to \pm E-W striking lineaments delivered igneous rocks that have evidently undergone brittle deformation as documented by striations and cataclases. Igneous rocks are dominated by volcanics, and plutonics are minor. The lavas are quite variable ranging from aphyric to slightly Pl, Ol and Px phyric and paired permutations of these minerals. In each area, sufficiently fresh volcanics for geochemistry and age dating were obtained. Occurrence and amounts of fresh glass are, however, much less frequent and voluminous than at Palmer Ridge and associated Freen and Peake Troughs. Plutonic/subvolcanic rocks of gabbroic to doleritic appearance were obtained at high grounds in the southeastern basin (-17) and at the base of King's Trough in its central part (-25). In both cases, volcanic rocks were also present. While at station -17 such co-existence seems related to faulting, station -25 seems to have sampled an *in-situ* igneous facies where volcanics were intruded by dikes(?) along with loose pegmatites. In terms of crustal depth, station -25 may mark the transition of extrusive series into a dike complex. Interestingly, similar looking ultramafic plutonic rocks consisting of Px (Opx?) and altered Ol and thus harzburgitic composition in form of clasts within a breccia at station -30 and *in-situ*(?) as loose block at station -41 document exposure of lithospheric mantle along the NE and SW border of King's Trough. Therefore, formation of King's Trough had not only an extensional component but also a significant vertical component.

5.2.2.3 Gnitsevich Seamounts

A total of five dredges containing igneous rocks (-33 to -37) were carried out at the Gnitsevich Seamount Group (Fig. 5.11). These seamounts lie to the northwest of the centerline of King's Trough strike on elevated seafloor that extends from here to the Mid-Atlantic Ridge. A single dredge (-33) was carried out at the easternmost Gnitsevich Seamount along its southeastern

slope. It returned mostly rounded dropstones ranging from granitic, gneissic and meta-sedimentary rocks to one angular amphibolitic rock. They were all discarded. Sampled rocks are carbonate crusts, cherty carbonate and one volcanoclastic/pumiceous rock (#1) with some fresh, greenish Px. Evidently, an encrusted slope with abundant dropstones was sampled. Station work then concentrated on the southeastern flank of the large, central Gnitsevich Seamount (Fig. 5.12).

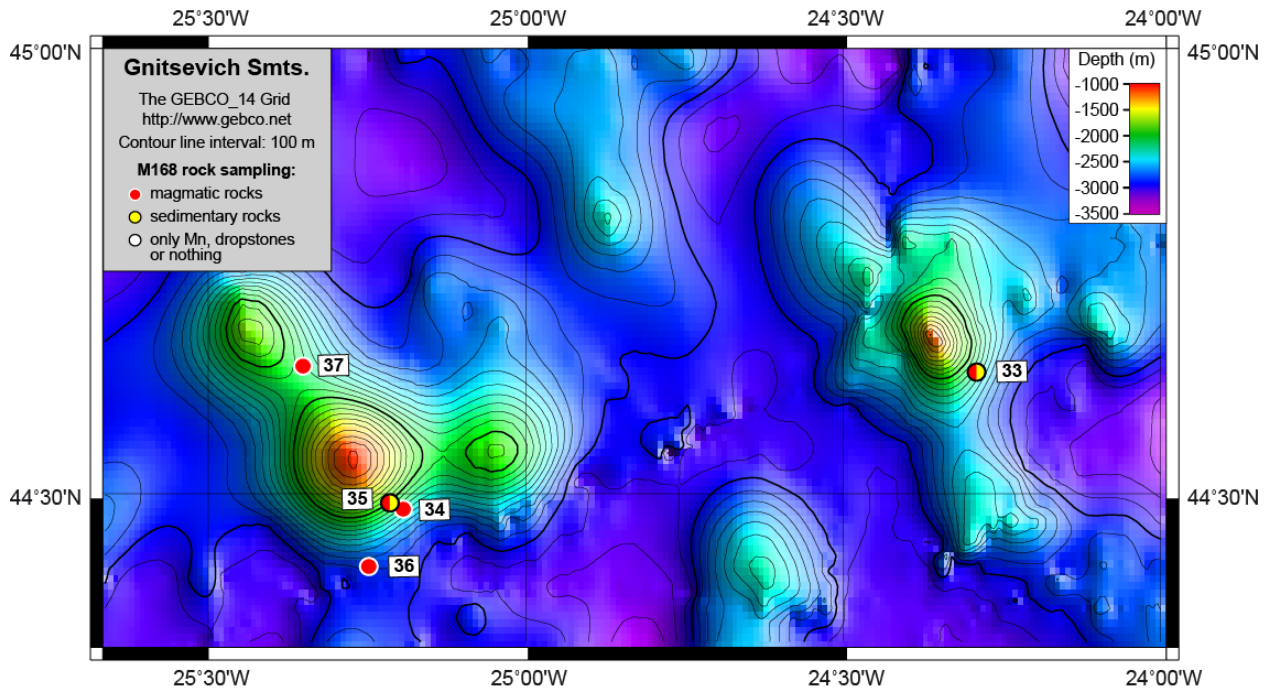


Fig. 5.11 M168 station map of the Gnitsevich Seamounts.

Dredge -34 again returned mainly dropstones including gneiss and muscovite-bearing metamorphics, which were rounded and had no Mn crust. One rock had glacial striations on one side. All dropstones were discarded. The two sampled *in-situ* volcanic rocks are both moderately altered, but differ in having Pl (1%) phenocrysts in #1 and Px (5% up to 1 mm) in #2. Dredge -35 at mid-slope returned half full with many large blocks that included volcanic rocks. Again, igneous rocks of continental provenance were abundant but were easily identified and discarded. Among the volcanics, three lava types were distinguished: 1) vesicular, Pl phyric (1%), fairly fresh (#1 to #6; Fig. 5.13, left picture); 2) massive, non-vesicular, Pl phyric (5-10%), fairly fresh (#7 to #12) with a subtype containing rare Px (#11 and #12); 3) lava of singular occurrence (#13 from block C) with very large vesicles and minor Pl (1%, 1 mm) phenocrysts. Roundness of the lava pieces resembles beach cobbles, consistent with the guyot type plateau summit of the seamount. Reef carbonates with corals and snail fragments (#14 to #16) were also collected. Sample #17 is a reddish volcanoclastic rock composed of baked lapilli. These observations indicate that the structure was once near sea-level and that the collected rocks were transported by gravity from higher grounds.

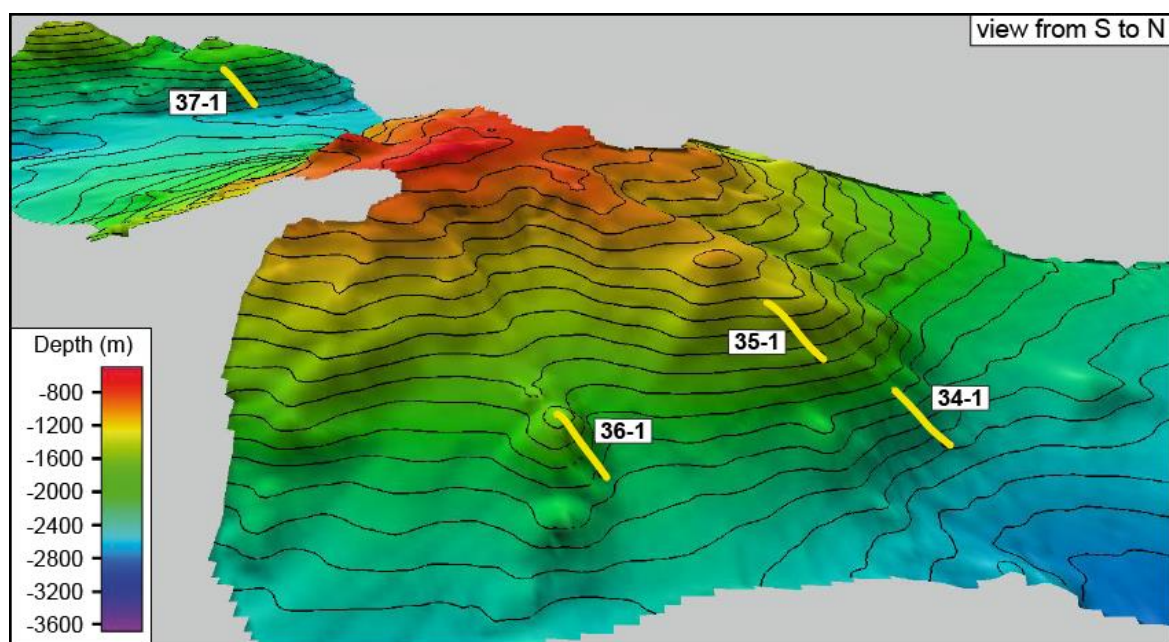


Fig. 5.12 3D-figure of the westernmost Gnitsevlch Seamounts with dredge stations M168-34-1 through -37-1. Multiple dredging of the seamount in the foreground aimed to sample different morphological units (i.e., base, upper part, satellite cone). Stereo exaggeration, contours and data sources as in figure 5.6.

At the base of the central Gnitsevlch Seamount, two lava types and volcanic breccia were recovered in dredge -36. Type 1 lava (#1) is from block A, slightly altered, moderately vesicular and with minor Px and altered Ol. The groundmass appears suitable for Ar-Ar dating. Type 2 lava (#2 to #5) is more vesicular, moderately altered and slightly Px and Ol phyric. Notably #5 has a chilled margin with minor amounts of fresh glass. In essence, type 1 and 2 lavas differ by vesicularity, which may simply reflect different portions of pillow lava. Samples #6 to #9 are volcanic breccias of which #6 bears small amounts of fresh glass. The northwesternmost Gnitsevlch Seamount was sampled at its southeastern flank. Dredge -37 returned evolved volcanic rocks. Notably samples #1 to #4 are dense lava fragments with mafic inclusions indicating magma mixing (Fig. 5.13, middle picture). Observed phenocrysts may comprise foides, indicative for silica-undersaturated melts. Samples #5 and #6 are also porphyritic, but more vesicular and have no mafic inclusions. Sample #7, though described as more altered, appears quite fresh in picture. In contrast to the other site -37 samples, #7 is aphyric with <1 mm Mn crust and thus may be a dropstone.

In summary, three Gnitsevlch Seamounts were sampled. The central and northwestern seamounts delivered the most suitable lava series for geochemistry and age dating at sites -35 to -37. The lavas vary from moderately vesicular to dense and often contain Pl phenocrysts, but Px-Ol phyric varieties also exist. Occurrence of rounded beach cobbles and shallow water reef carbonates along with a guyot type platform indicates that at least the central Gnitsevlch Seamount once was elevated above or near sea-level. Noteworthy is also the presence of mafic enclaves in a presumably more differentiated matrix at site -37 suggesting magma mixing within a lava flow. Here possible foides (leucite?) are also described indicating silica-undersaturated melts that are often associated with rejuvenated ocean island volcanism.



Gnitsevich Smts: Slightly altered, Pl phyric lava fragment with open, elongated vesicles. Rounded appearance implies erosion by waves.

Gnitsevich Smts: Fresh, porphyritic lava with dark grey (mafic?) inclusions indicating magma mixing.

Azores-Biscay Rise (ABR): Slightly altered, Ol phyric lava fragment from summit cone of northernmost ABR complex.

Fig. 5.13 Representative pictures of rocks obtained at the Gnitsevich Seamounts and the Azores-Biscay Rise during cruise M168.

5.2.2.4 Azores-Biscay Rise, North Charcot Seamount Complex

Due to weather conditions, ship time was limited to survey of the northwesternmost section of the Azores-Biscay Rise (ABR; Fig. 5.14). Here the ABR bends from a NE-SW aligned ridge/seamount complex into an E-W oriented ridge/seamount complex including the North Charcot Seamount, which is thus referred to as North Charcot Seamount Complex. This complex belongs to the Biscay-Charcot Seamounts. The area was mapped and sampled along an E-W profile. Of the eight dredges carried out six returned *in-situ* magmatic rocks.

After unsuccessful sampling at the western flank of the large seamount that marks the northern ABR termination, Ol phyric pillow lava (#1 to #3; Fig. 5.13, right picture), some with grey/fresh groundmass (#1 and #2) but altered Ol were obtained from the summit cone (-44, ca. 2,600 to 2,200 mbsl). Another variety is Pl-Ol phyric lava (#4 to #6) with strongly oxidized groundmass. Other samples are volcanic breccia (#7 and #8), a small Mn crust (#9), a larger block of carbonate breccia (#10) and numerous coral fragments and a larger sponge (#11). The occurrence of fossil, shallow water biology in conjunction with the plateau-like summit indicates that the summit of the seamount was once near sea-level. At the southern base (ca. 4,000 mbsl), station -45 returned a single, conspicuous glassy rock. Its origin is unclear and could be volcanoclastic or anthropogenic slag from steamship operations. A ~1 mm thick Mn crust, however, indicates a longer residence time on the ocean floor. Further upslope (ca. 3,200 mbsl) along the southeastern flank, strongly altered pillow fragments were obtained at site -46. #2 and #3 bear fresh glass. The pillows are dense, near non-vesicular lava with altered Ol and Px microphenocrysts. Another deep station (-47, ca 4,200 mbsl) along the basal part of the seamount again delivered strongly altered, non-vesicular pillow fragments with ~5% Pl microphenocrysts. Sample #2 possibly contains traces of fresh glass. At the transition from the ABR to the E-W striking North Charcot Seamount Complex, station -48 delivered slightly to moderately altered, Ol-Pl phyric lava fragments (#1 to #7); some with pillow type chilled margins but without glass. The last station of cruise M168, station -49, was carried out at the mid-slope of a ridge that

extends from the North Charcot Seamount Complex. The dredge yielded aphyric lava fragments ranging from slightly to strongly altered.

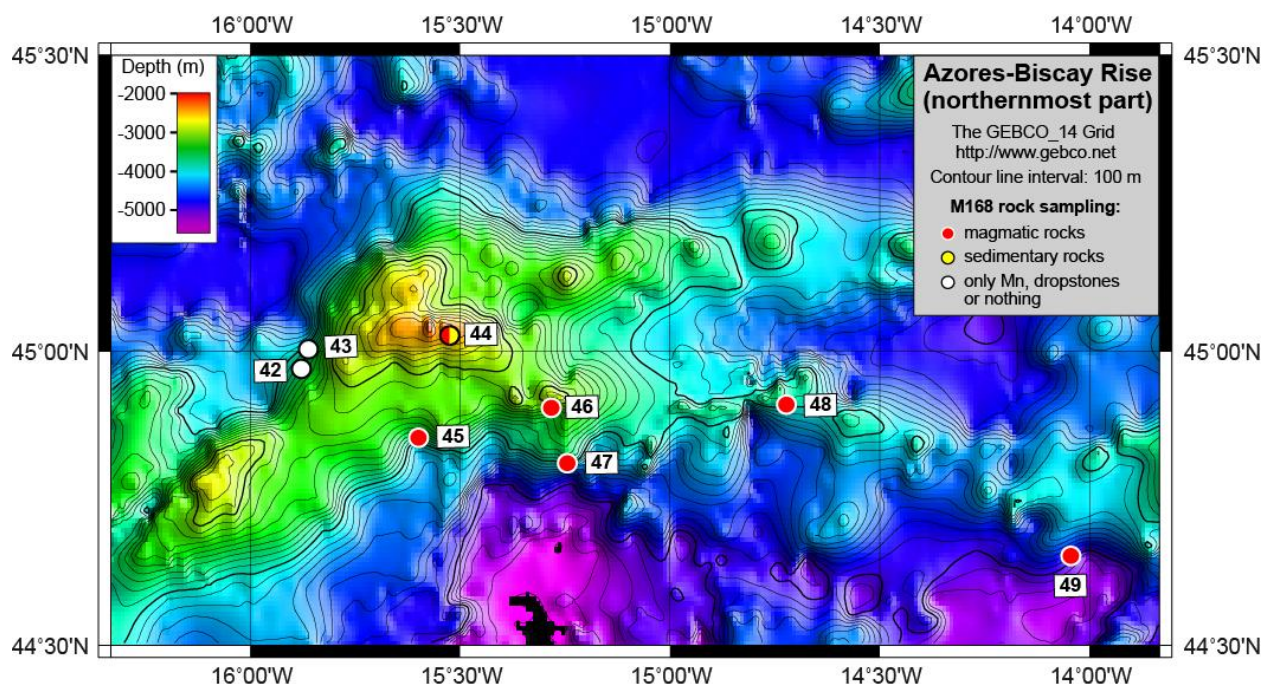


Fig. 5.14 M168 station map of the northernmost Azores-Biscay Rise and the western tip of the North Charcot Seamount Complex.

In brief, dredge sampling of the northern end of the Azores-Biscay Rise and the base of the North Charcot Seamount Complex returned pillow lavas in all six successful attempts. Ol and Ol-Pi phyrlic lavas were obtained from the summit cone of the northern ABR, whereas sampling along its southeastern flank and base provided non-vesicular, near aphyric lavas with very minor fresh glass. Similarly, the base of the North Charcot Seamount Complex seems to be composed of aphyric pillow fragments. Within the transition zone from the ABR to the North Charcot Seamount Complex, Ol-Pi phyrlic pillow lava was obtained. Geochemistry will show if the ABR lavas are of alkaline affinity consistent with intraplate volcanism and the North Charcot Seamount Complex lavas rather tholeiitic as expected from regional magnetic anomalies, which propose a spreading ridge origin for the North Charcot Seamount Complex (Verhoef et al., 1996).

6 Ship's Meteorological Station

(C. Heitmann-Bacza)

The expedition M168 of R/V METEOR started on November 8 in Emden. Weak to moderate south to southeast wind blew along the route to the English Channel under the influence of high pressure. On November 10, a cold front approached and caused south-westerly winds increasing up to 6-7 Bft. During the passage of that front on November 11, heavy gusts of wind force 8

from west to northwest were measured. The significant wave height rose to 4 m, at times up to 5 m. On the backside of the front, the wind decreased to 4 to 6 Bft. Tropical storm "Theta" moved south of the Azores on November 12, shifted a little more east and slowly filled up on November 16. However, this storm had no influence on the research area.

On Thursday, November 12, R/V METEOR reached the research area and a frontal system of a low-pressure system near Iceland approached from west. On Friday, it crossed with rain and showers, a south-westerly wind of 7 to 8 Bft and a significant wave height of 3 to 4 m. A swell from northwest to west, later southwest, of 3 to 4 m with occasional waves of up to 6 m was observed. At the back of the front, the wind veered to northwest and weakened to 4 to 6 Bft. There was a continued north-westerly swell of 3 m in the research area.

After a short weak influence of high pressure, another front of a secondary low followed on November 15, which moved over the British Isles. Winds of 5 to 6 Bft veered from southwest to northwest and rain and showers passed through. Subsequently, a high ridge moved through before a waving cold front of the former Hurricane "Eta" reached the research area on November 17. A south to southwest wind reached 6-7 Bft with gale force gusts, veered west to northwest to north reaching 7-8 Bft with further gale force gusts and a significant wave height of approximately 3-4 m. One swell came from northwest, a second one from south.

On November 20, a high moved from Newfoundland across the North Atlantic and further across the Bay of Biscay to east-northeast. The wind blew from north to east-southeast, later southwest, and weakened to around 4 Bft and a north-westerly to northerly swell of 2 to 3 m entered the research area. After weakening of this high pressure zone, following fronts of a storm low (988 hPa), which moved from Newfoundland to Iceland, expanded further south. Therefore, wind increased temporarily.

Another cold front of a low-pressure system near Iceland crossed the working area east-south-eastwards during November 24. On this front, a strong south-westerly wind blew with 7 Bft, with gusts of up to 9-10 Bft. At the backside, a strong to stormy north-westerly to northerly wind of up to 7 to 8 Bft blew during the next day. The significant wave height rose to 4-5 m, a swell came from northwest with 3 to 4 m and occasional waves reached 6 m. A short-wave trough with further showers followed. A new high (1040 hPa) approached from west and the wind increased again between these pressure areas. The high moved south of the Azores where it weakened. On November 26, wind decreased slowly to 5 Bft and temporarily blew from different directions. The significant wave height also decreased to 2 m.

A gale (1005 hPa) moved from west to the area southwest of Ireland on November 27. At an associated trough a secondary low developed, which moved first southwards and later to the southwest. At the same time, a high (1035 hPa) approached from Newfoundland and between these intensifying pressure areas, a strong to stormy north-westerly air stream of 6-7 Bft with squalls built up, reaching 8-9 Bft in the western and southern areas with gusts of 10-12 Bft. A significant wave height of up to 6-7 m was observed. During the transit to a northeastern research area, the northerly wind decreased from 7 Bft to 5-6 Bft. There sea state decreased from 4 m to 2-3 m. One swell came from northwest, a second swell from easterly directions.

The return transit to the English Channel started in the early morning of December 2 before a trough of a gale near Iceland shifted to the Bay of Biscay accompanied by wind increasing to 8 to 9 Bft with severe gale force gusts and sea with swell of 6 to 9 m. On December 6, the R/V METEOR reached the port of Emden with light breeze.

7 Station List M168

Abbreviations:

DR - Chain bag dredge

SVP - Sound velocity profile

XSV - Lockheed Martin expendable sound velocimeter

Station	Institute Identification	De-vice	Date [UTC]	Time [UTC]	Latitude [°N]	Longitude [°W]	Max. Depth [m]	Comment / Recovery
M168_1-1	n.a.	XSV	12.11.20	15:30	44°34.46'	15°19.54'	n.a.	SVP
M168_2-1	n.a.	DR	13.11.20	00:49	43°38.85'	16°15.68'	3997	empty
M168_3-1	n.a.	DR	14.11.20	15:38	42°49.32'	20°21.80'	5271	hard rocks
M168_4-1	n.a.	DR	15.11.20	00:00	43°07.90'	20°14.37'	4874	crusts
M168_5-1	n.a.	DR	15.11.20	05:02	43°07.43'	20°14.51'	5281	hard rocks
M168_6-1	n.a.	DR	15.11.20	13:43	42°50.41'	20°09.40'	4411	hard rocks
M168_7-1	n.a.	DR	15.11.20	18:14	42°47.08'	20°09.66'	5336	empty
M168_8-1	n.a.	DR	15.11.20	23:10	42°47.27'	20°10.10'	5329	hard rocks
M168_9-1	n.a.	DR	16.11.20	04:06	42°49.67'	20°06.91'	4789	hard rocks
M168_10-1	n.a.	DR	16.11.20	10:37	42°49.94'	20°03.79'	3766	hard rocks
M168_11-1	n.a.	DR	16.11.20	15:02	42°51.18'	20°07.95'	3537	hard rocks
M168_12-1	n.a.	DR	16.11.20	22:10	42°36.64'	20°28.68'	4386	hard rocks
M168_13-1	n.a.	DR	17.11.20	03:38	42°48.81'	20°32.10'	4086	empty
M168_14-1	n.a.	DR	17.11.20	07:37	42°49.99'	20°32.28'	3249	aborted due to bad weather conditions
M168_15-1	n.a.	DR	18.11.20	19:21	42°35.70'	20°55.44'	3413	clastic rocks
M168_16-1	n.a.	DR	19.11.20	01:01	42°56.73'	20°56.88'	4410	empty
M168_17-1	n.a.	DR	19.11.20	06:08	43°20.60'	20°53.32'	2420	hard rocks
M168_18-1	n.a.	DR	19.11.20	11:36	43°13.27'	21°06.97'	4242	hard rocks
M168_19-1	n.a.	DR	19.11.20	15:46	43°13.58'	21°07.67'	4297	hard rocks
M168_20-1	n.a.	DR	19.11.20	22:33	43°27.59'	21°45.03'	3994	empty
M168_21-1	n.a.	DR	20.11.20	02:44	43°29.93'	21°46.60'	3069	hard rocks
M168_22-1	n.a.	DR	20.11.20	06:44	43°28.21'	21°45.63'	3637	hard rocks
M168_23-1	n.a.	DR	20.11.20	13:39	43°49.62'	21°49.12'	4026	dropstones
M168_24-1	n.a.	DR	20.11.20	19:32	43°59.52'	21°48.01'	2298	hard rocks
M168_25-1	n.a.	DR	21.11.20	00:48	43°50.19'	21°54.53'	4340	hard rocks
M168_26-1	n.a.	DR	21.11.20	05:35	43°55.78'	21°59.80'	4508	hard rocks
M168_27-1	n.a.	DR	21.11.20	10:54	43°55.53'	22°08.04'	3444	hard rocks
M168_28-1	n.a.	DR	21.11.20	19:25	44°11.03'	22°08.50'	2490	hard rocks
M168_29-1	n.a.	DR	22.11.20	02:19	44°15.75'	22°49.57'	3830	hard rocks
M168_30-1	n.a.	DR	22.11.20	07:32	44°14.81'	22°59.79'	4108	hard rocks
M168_31-1	n.a.	DR	22.11.20	12:04	44°17.08'	22°56.78'	2390	hard rocks
M168_32-1	n.a.	DR	22.11.20	15:20	44°16.58'	22°54.01'	3308	empty
M168_33-1	n.a.	DR	23.11.20	02:39	44°38.48'	24°17.84'	2251	clastic rocks
M168_34-1	n.a.	DR	23.11.20	10:49	44°29.39'	25°11.63'	2390	hard rocks
M168_35-1	n.a.	DR	23.11.20	14:45	44°29.61'	25°12.78'	1701	hard rocks
M168_36-1	n.a.	DR	23.11.20	18:24	44°28.60'	25°14.66'	2028	hard rocks
M168_37-1	n.a.	DR	23.11.20	23:55	44°38.88'	25°20.83'	2404	hard rocks
M168_38-1	n.a.	DR	26.11.20	06:29	43°32.37'	22°25.65'	1643	hard rocks
M168_39-1	n.a.	DR	26.11.20	09:22	43°36.25'	22°24.76'	1865	clastic rocks
M168_40-1	n.a.	DR	26.11.20	13:17	43°42.95'	22°35.57'	3410	hard rocks
M168_41-1	n.a.	DR	26.11.20	18:40	43°49.11'	22°48.90'	4196	hard rocks
M168_42-1	n.a.	DR	30.11.20	09:20	44°58.14'	15°51.83'	4039	crusts
M168_43-1	n.a.	DR	30.11.20	13:01	45°00.11'	15°50.97'	3358	empty
M168_44-1	n.a.	DR	30.11.20	18:06	45°01.37'	15°31.05'	2614	hard rocks
M168_45-1	n.a.	DR	30.11.20	22:18	44°51.07'	15°35.13'	4210	clastic rocks
M168_46-1	n.a.	DR	01.12.20	03:19	44°54.05'	15°16.57'	3326	hard rocks
M168_47-1	n.a.	DR	01.12.20	07:16	44°48.34'	15°14.30'	4322	hard rocks
M168_48-1	n.a.	DR	01.12.20	13:37	44°54.41'	14°43.25'	4108	hard rocks
M168_49-1	n.a.	DR	01.12.20	20:28	44°39.20'	14°02.89'	4791	hard rocks

8 Data and Sample Storage and Availability

(A. Dürkefälden)

The rock samples recovered during cruise M168 will be stored at the Rock Repository at GEOMAR Helmholtz Centre for Ocean Research Kiel. They will be analyzed and dated at GEOMAR and cooperating institutions (e.g., Kiel University, Institute of Mineralogy and Petrography at the University of Hamburg) and the data will be published in peer-reviewed journals and thus made available to third parties. Upon request, reference samples will be made available to third parties after analysis, data interpretation and publication. The bathymetric and sediment echo sounding data as well as the sound probe data collected during M168 will be archived in the IT storage infrastructure at GEOMAR.

Data sharing and exchange will take place within the Ocean Science Information System (OSIS) maintained by the GEOMAR data management team. Bathymetric raw data are submitted to the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie, BSH). Processed bathymetric data will be uploaded to the World Data Center PANGAEA and the International Hydrographic Organization Data Centre for Digital Bathymetry (IHO DCDB). For a three year moratorium, however, the bathymetric data from the working area (excluding the transits to and from the working area) will be available to the project members only. Availability of the geochemical and age data is restricted until publication.

Table 8.1 Overview of data availability

Type	Database	Available	Free Access	Contact
M168 metadata	OSIS	Dec. 2020	Dec. 2020	aduerkefaelden@geomar.de
Rock sample data	OSIS, Georoc, PetDB	n/a	After publication	aduerkefaelden@geomar.de
Multi-beam echo-sounding data (working area) (KONGSBERG EM 122)	BSH, OSIS, PANGAEA	Jan. 2021	Jan. 2024	aduerkefaelden@geomar.de rwerner@geomar.de
Multi-beam echo-sounding data (transits) (KONGSBERG EM 122)	BSH, OSIS, PANGAEA	Jan. 2021	c. May 2021	aduerkefaelden@geomar.de rwerner@geomar.de
Sound probe data (XSV-02)	BSH, OSIS, PANGAEA	Jan. 2021	Jan. 2021	aduerkefaelden@geomar.de rwerner@geomar.de

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11 Abbreviations

ABR	Azores-Biscay Rise
Amph	Amphibole
Bft	Beaufort
KTC	King's Trough Complex
MAR	Mid-Atlantic Ridge
mbsl	meters below sea-level
Mn	Manganese
MORB	Mid-Ocean Ridge Basalt
Ol	Olivine
Opx	Orthopyroxene
Pl	Plagioclase
Px	Pyroxene
Smt	Seamount

Appendix 12.1: M168 Rock Sampling Summary

Type	Stat.	Location	total volume	Rec. DR	Station summary	start / on bottom		end / off bottom		depth (m)		Rock sampling			
						lat °N	long °W	lat °N	long °W	begin	end	Mag	VC	Sed	Mn
M168	1-1	Azores-Biscay-Rise NE, NE-corner	n.a.		<i>sound velocity profile for EM122 (2000 m) / sound probe</i>	0,000	0,000	n.a.	n.a.	0	2000	n.a	n.a	n.a	n.a
M168	2-1	Azores-Biscay-Rise NE, NE-corner	empty	0		43,648	-16,261	43,655	-16,262	4220	4003				
M168	3-1	Freen Trough, base of N-flank	few rocks	1	lava fragments	42,818	-20,367	42,826	-20,373	5270	4888	yes			
M168	4-1	Peake Trough, N-flank	few crusts	0	Mn-crusts	43,132	-20,240	43,137	-20,245	4881	4398				yes
M168	5-1	Peake Trough, base of NW-flank	few rocks	1	lava fragments, volcanoclastic rocks, Mn-crusts	43,124	-20,242	43,129	-20,247	5269	4703	yes	yes		yes
M168	6-1	Palmer Ridge, middle section of S-flank	few rocks	1	lava fragments	42,840	-20,157	42,847	-20,157	4379	3960	yes			
M168	7-1	Palmer Ridge, toe at base of S-flank	empty	0		42,785	-20,163	42,791	-20,163	5336	4991				
M168	8-1	Palmer Ridge, toe at base of S-flank	one rock	1	lava fragment	42,788	-20,168	42,794	-20,168	5328	4931	yes			
M168	9-1	Palmer Ridge, base of S-flank	1/6 full	1	lava fragments, volcanoclastic rocks, Mn-crusts	42,826	-20,116	42,828	-20,116	4784	4550	yes	yes		yes
M168	10-1	Palmer Ridge, middle section of S-flank	1/6 full	1	lava fragments, volcanoclastic rocks	42,832	-20,063	42,839	-20,063	3768	3134	yes	yes		yes
M168	11-1	Palmer Ridge, uppermost section of S-flan	1/5 full	1	lava fragments, volcanoclastic rocks, Mn-crusts	42,852	-20,137	42,860	-20,137	3480	3050	yes	yes		yes
M168	12-1	King's Trough, S-flank, SE-corner	few rocks	1	lava fragments, volcanoclastic rocks	42,611	-20,478	42,604	-20,472	4408	3922	yes	yes		
M168	13-1	Transition Freen to King's Trough	empty	0		42,815	-20,535	42,821	-20,535	4036	3633				
M168	14-1	Transition Freen to King's Trough	n.a.		<i>aborted due to bad weather conditions</i>	42,832	-20,539	42,843	-20,538	3248	3099	n.a	n.a	n.a	n.a
M168	15-1	King's Trough, SE-corner	few rocks	1	volcanoclastic and sedimentary rocks	42,595	-20,924	42,601	-20,924	3405	3057		yes	yes	
M168	16-1	King's Trough, SE-corner	empty	0		42,946	-20,950	42,951	-20,945	4408	4102				
M168	17-1	King's Trough, step on top of N-flank	1/6 full	1	lava fragments, plutonic and volcanoclastic rocks	43,178	-20,889	43,185	-20,888	2412	2001	yes	yes		
M168	18-1	King's Trough, N-flank	few rocks	1	lava fragments, volcanoclastic rocks	43,221	-21,116	43,229	-21,114	4242	3720	yes	yes		
M168	19-1	King's Trough, N-flank	few rocks	1	lava fragment, volcanoclastic rocks	43,226	-21,128	43,232	-21,124	4297	3861	yes	yes		
M168	20-1	Smt. in the center of King's Trough	empty	0		43,460	-21,751	43,467	-21,750	3993	3551				
M168	21-1	Smt. in the center of King's Trough	2 rocks	1	lava fragment (fault rock), dropstone	43,497	-21,777	43,501	-21,775	3071	2875	yes			
M168	22-1	Smt. in the center of King's Trough	few rocks	1	various magmatic rocks, partly (?) dropstones	43,469	-21,761	43,476	-21,758	3630	3106	yes			
M168	23-1	King's Trough, N-flank	3 rocks	0	dropstones	43,827	-21,818	43,834	-21,820	4051	3548				
M168	24-1	King's Trough, step on top of N-flank	1/5 full	1	lava fragments, volcanoclastic rocks	43,991	-21,800	43,997	-21,800	2287	2032	yes	yes		
M168	25-1	King's Trough, N-flank	1/4 full	1	lava frag., subvolcanic, various other magm. rocks, carbonate	43,837	-21,908	43,844	-21,908	4320	3964	yes		yes	
M168	26-1	King's Trough, N-flank	few rocks	1	lava fragment, volcanoclastic (?) rocks	43,930	-21,989	43,937	-21,996	4442	4103	yes	yes		
M168	27-1	King's Trough, N-flank	few rocks	1	lava fragment, volcanoclastic rocks	43,921	-22,134	43,927	-22,134	3410	3446	yes	yes		
M168	28-1	King's Trough, step on top of N-flank	?	1	lava fragments, Mn-crusts	44,184	-22,143	44,189	-22,143	2490	2181	yes			yes
M168	29-1	King's Trough, N-flank	one rock	1	lava fragment (pillow)	44,263	-22,826	44,268	-22,826	3920	3385	yes			
M168	30-1	King's Trough, N-flank	1/6 full	1	lava frag., subvolcanic, various other magm. rocks, limestone	44,247	-22,997	44,253	-23,001	4114	3571	yes		yes	
M168	31-1	King's Trough, N-flank	few rocks	1	lava fragment, volcanoclastic rock, Mn-crust	44,285	-22,946	44,290	-22,947	2380	1960	yes	yes		yes
M168	32-1	King's Trough, N-flank	empty	0		44,276	-23,000	44,283	-22,901	3307	2800				
M168	33-1	Gnitsevich Seamounts	few rocks	1	volcanoclastic rocks, carbonate, dropstones	44,641	-24,297	44,646	-24,297	2252	1897		yes	yes	
M168	34-1	Gnitsevich Seamounts	1/5 full	1	lava fragments, dropstones	44,490	-25,194	44,493	-25,202	2360	1980	yes			
M168	35-1	Gnitsevich Seamounts	1/2 full	1	lava fragments, volcanoclastic rocks, cabonate	44,494	-25,214	44,498	-25,225	1702	1340	yes	yes	yes	
M168	36-1	Gnitsevich Seamounts	few rocks	1	lava fragments, volcanoclastic rocks	44,393	-25,244	44,480	-25,250	2033	1656	yes	yes		
M168	37-1	Gnitsevich Seamounts	1/4 full	1	lava fragments	44,648	-25,347	44,653	-25,355	2408	1990	yes			
M168	38-1	King's Trough, Antialtair Seamount	few rocks	1	lava fragment, volcanoclastic and sedimentary rock	43,540	-22,428	43,545	-22,429	1643	1355	yes	yes	yes	
M168	39-1	King's Trough, Antialtair Seamount	two rocks	1	volcanoclastic rocks	43,604	-22,413	43,598	-22,413	1852	1394		yes		
M168	40-1	King's Trough, Antialtair Seamount	one rock	1	lava fragment	43,716	-22,593	43,710	-22,593	3409	3050	yes			

Appendix 12.1: M168 Rock Sampling Summary

Type	Stat.	Location	total volume	Rec. DR	Station summary	start / on bottom		end / off bottom		depth (m)		Rock sampling			
						lat °N	long °W	lat °N	long °W	begin	end	Mag	VC	Sed	Mn
M168	41-1	King's Trough, S-flank	few rocks	0	plutonic rock, crusts	43,819	-22,814	43,817	-22,815	4150	4023	yes			
M168	42-1	Azores-Biscay-Rise, northernmost Smt.	one rock	0	crust (phosphorite?)	44,969	-15,864	44,973	-15,857	4036	3550				
M168	43-1	Azores-Biscay-Rise, northernmost Smt.	empty	0		45,002	-15,850	45,006	-15,843	3339	2950				
M168	44-1	Azores-Biscay-Rise, northernmost Smt.	few rocks	1	lava fragments, volcanoclastic and sedimentary rocks, coral	45,023	-15,515	45,029	-15,518	2613	2230	yes	yes	yes	
M168	45-1	Azores-Biscay-Rise, northernmost Smt.	one rock	1	scoria-like rock fragment with Mn crust	44,851	-15,586	44,858	-15,586	4033	3601				
M168	46-1	Azores-Biscay-Rise, northernmost Smt.	few rocks	1	lava fragments (pillows)	44,901	-15,276	44,906	-15,276	3226	2980	yes			
M168	47-1	Azores-Biscay-Rise, northernmost Smt.	few rocks	1	lava fragments	44,806	-15,237	44,814	-15,239	4290	3830	yes			
M168	48-1	Azores-Biscay-Rise, E-extension of N-Smt.	few rocks	1	lava fragments, Mn-crusts	44,907	-14,721	44,914	-14,721	4110	3660	yes			yes
M168	49-1	North Charcot Smt.	few rocks	1	lava fragments	44,653	-14,048	44,659	-14,051	4791	4383	yes			
				36	dredges yielded magmatic and / or sed. rocks (76.6%)							33	19	7	8
Dredge Stations (DR): 48				11	dredges returned empty or yielded only dropstones and / or crusts (23.4%)							Mag: magmatic rocks			
				1	dredge haul has been aborted due to bad weather conditions							VC: volcanoclastic rocks			
												Sed: sedimentary rocks			
												Mn: Mn-crusts. - nodules			

Appendix 12.2: M168 Dredge Station Details and Rock Description

M168 Dredge Station Details and Rock Description

Abbreviations in Table Header:

TS: thin section billet
 CHEM: chemistry slab to prepare materials for geochemical analysis
 Ar/Ar: estimate of sample quality for $^{40}\text{Ar}/^{39}\text{Ar}$ dating
 Gl/MIN: potential glass and / or mineral separates
 SED: sediment
 REF: reference sample for immediate transport to home institution after cruise

3D-maps:

All 3D-maps shown in this appendix are based on multi-beam data recorded on M168 and have been generated using QPS Qimera 1.7.2. and Fledermaus 7.8.5 software (exaggeration: 2x; interval of contour lines: 100 m).

Abbreviations for Minerals and Materials:

Amph: amphibole MI: melt Inclusions
 Apt: apatite Mn: manganese
 Bi: biotite Mt: magnetite
 Cc: calcite Ol: olivine
 Chl: chlorite Opx: orthopyroxene
 Cpx: clinopyroxene Pl: plagioclase
 Fsp: feldspar Px: pyroxene
 Gc: geochemistry Qz: quartz
 Gm: groundmass Zr: zircon
 Ilm: ilmenite Cc: carbonate
 Pp: phosphate

M168-2-1

*no map available
 because of very poor data quality
 due to bad weather conditions*

Description of Location and Structure: Azores-Biscaya Rise at NE termination, Eastern flank of small NNE-SSW elongated seamount at edge of NE corner

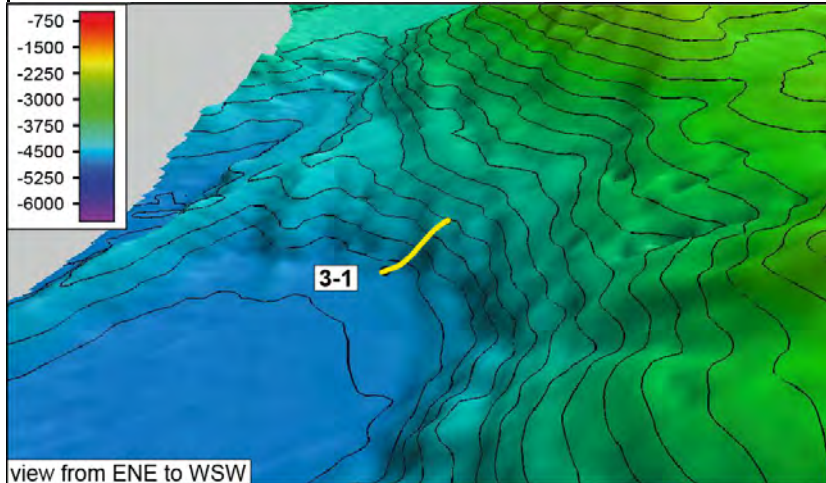
Dredge on bottom UTC 13/11/20 02:00 hrs, lat 43°38.85'N, long 16°15.68'W, depth 4218 m

Dredge off bottom UTC 13/11/20 03:20 hrs, lat 43°39.31'N, long 16°15.70'E, depth 4003 m

total volume: empty

Comments: catching cable wrapped around chain bag

M168-3-1



Description of Location and Structure: Freen Trough NW termination at base of N slope




Dredge on bottom UTC 14/11/20 17:404 hrs, lat 42°49.07'N, long 20°22.00'W depth 5219 m

Dredge off bottom UTC 14/11/20 18:32 hrs, lat 20°22.39'N, long 42°49.53'W, depth 4890 m


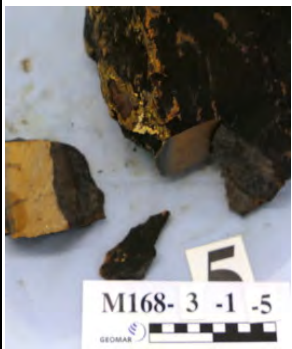
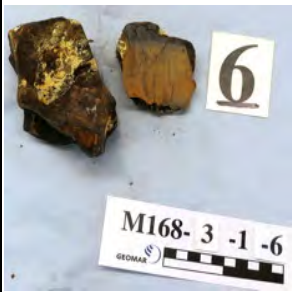

total volume: few rocks; pillow fragments with fresh glassy margins!

Comments: basically two lithological units recovered. Sample #1 to #10: pillow fragments with abundant fresh glassy margins and sample #11 to #17 unspecified lava fragments without glass but overall fresher groundmass. #17 appears to have freshest gm an may be possible to date by Ar-Ar.




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-3-1-1	1. Rock Type: volcanic, moderately altered but with fresh glassy margin <1cm 2. Size: 17x10x9 cm 3. Shape / Angularity: angular piece of pillow lava 4. Color of cut surface: greyish-brownish 5. Texture / Vesicularity: massive / very sparsely vesiculated <1% 6. Phenocrysts: altered Ol ($\leq 1\%$, ≤ 2 mm) 7. Matrix: fine-grained, oxidized groundmass 8. Secondary Minerals: Mn dendrites, palagonite in glass crust 9. Encrustations: glassy margin 10. Comment: abundant fresh glass, dense	x	x		GL				
M168-3-1-2	1. Rock Type: volcanic, moderately altered but with fresh glassy margin <1cm; overall similar to -1 2. Size: 18x10x12 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish-beige 5. Texture / Vesicularity: massive / partly phyr, sparsely vesiculated <10%, partly filled 6. Phenocrysts: altered Ol ($\leq 1\%$, 1-1.5 mm) 7. Matrix: fine-grained 8. Secondary Minerals: Mn dendrites, palagonite in glass crust, partly oxidized groundmass 9. Encrustations: glassy margin; 8mm Mn crust in places 10. Comment: fresh glass, dense	x	x		GL				
M168-3-1-3	1. Rock Type: volcanic, mildly to moderately altered but with fresh glassy margin. Alteration increases towards pillow margin 2. Size: 14x11x17 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish-brownish following alteration 5. Texture / Vesicularity: massive / phyr in places, sparsely vesiculated <10%, partly filled 6. Phenocrysts: altered Ol ($\leq 1\%$, 1-1.5 mm) 7. Matrix: fine-grained 8. Secondary Minerals: Mn dendrites, palagonite in glass crust, partly oxidized groundmass 9. Encrustations: glassy margin; Mn coating 10. Comment: possibly fresh glass	x	x		GL				




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-3-1-4	1. Rock Type: volcanic, moderately altered 2. Size: 18x18x15 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish following alteration 5. Texture / Vesicularity: massive / partly phyrlic, sparsely vesiculated <10%, partly filled 6. Phenocrysts: altered Ol ($\leq 1\%$, 1-2 mm); Pl (<1%, 1-1.5mm) 7. Matrix: fine-grained 8. Secondary Minerals: Mn dendrites, palagonite in glass crust, partly oxidized groundmass 9. Encrustations: Mn coating 10. Comment: possibly fresh glass				GL				
M168-3-1-5	1. Rock Type: volcanic, moderately altered 2. Size: 22x20x15 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: brownish 5. Texture / Vesicularity: massive / phyrlic, sparsely vesiculated <10%, partly filled 6. Phenocrysts: altered Ol ($\leq 1\%$, 1 mm) 7. Matrix: fine-grained 8. Secondary Minerals: Mn dendrites, palagonite in glass crust, oxidized groundmass 9. Encrustations: Mn coating, fresh glass in places 10. Comment: possibly fresh glass				GL				
M168-3-1-6	1. Rock Type: volcanic, moderately altered 2. Size: 10x11x7 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish 5. Texture / Vesicularity: massive / phyrlic, sparsely vesiculated <10%, partly filled 6. Phenocrysts: altered Ol ($\leq 1\%$, 0.5-1 mm) 7. Matrix: fine-grained 8. Secondary Minerals: Mn dendrites, palagonite in glass crust, oxidized groundmass 9. Encrustations: Mn coating, fresh glass in places 10. Comment: possibly fresh glass								
M168-3-1-7	1. Rock Type: volcanic, moderately altered 2. Size: 11x10x8 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish-grey 5. Texture / Vesicularity: massive / phyrlic, sparsely vesiculated <10%, partly filled 6. Phenocrysts: altered Ol (1%, 1-1.5 mm) 7. Matrix: fine-grained 8. Secondary Minerals: Mn dendrites, palagonite, oxidized groundmass 9. Encrustations: Mn coating, maybe fresh glass in places 10. Comment: possibly fresh glass								




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-3-1-8	1. Rock Type: volcanic, moderately altered 2. Size: 11x5.5x3 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish 5. Texture / Vesicularity: massive / aphyric, some phenocrysts, sparsely vesiculated <10%, partly filled 6. Phenocrysts: altered Ol (1%, 1-2 mm) 7. Matrix: fine-grained 8. Secondary Minerals: palagonite 9. Encrustations: Mn coating								
M168-3-1-9	1. Rock Type: volcanic, moderately altered 2. Size: 8x6x3 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish 5. Texture / Vesicularity: massive / phyrical, sparsely vesiculated <5%, partly filled 6. Phenocrysts: altered Ol (1%, 0.5-1 mm) 7. Matrix: fine-grained 8. Secondary Minerals: Mn dendrites, palagonite, oxidized groundmass 9. Encrustations: Mn coating, glass in places 10. Comment: possibly fresh glass				GL				
M168-3-1-10	1. Rock Type: volcanic, moderately altered 2. Size: 14x13x17 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish-beige 5. Texture / Vesicularity: massive / glomerocrystic, sparsely vesiculated <5%, partly filled 6. Phenocrysts: altered Ol (1%, 0.5-1 mm) 7. Matrix: fine-grained 8. Secondary Minerals: Mn dendrites, palagonite, oxidized groundmass 9. Encrustations: Mn coating								


M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-3-1-11	1. Rock Type: volcanic, pillow fragment with <1 cm thick fresh glass rim, otherwise altered; piece was not cut 2. Size: 7.5x4x6 cm 3. Shape / Angularity: angular 4. Color of cut surface: black fresh glass, brownish groundmass 5. Texture / Vesicularity: massive / aphyric 6. Phenocrysts: not visible 7. Matrix: fine-grained 8. Secondary Minerals: oxidized groundmass 9. Encrustations: Mn coating 10. Comment: 8mm fresh glassy margin, dense, outer layer with palagonite, interior fresh				GL				
M168-3-1-12	1. Rock Type: volcanic, strongly altered for most part. One side appears more greyish and fresher 2. Size: 5x4x3 cm 3. Shape / Angularity: angular 4. Color of cut surface: light brown to partially grey 5. Texture / Vesicularity: massive, aphyric with occasional altered Ol and Pl 6. Phenocrysts: Ol (<<1%, ≤ 1 mm), Pl (<<1%, ≤1mm) roundish 7. Matrix: fine-grained 8. Secondary Minerals: enhanced groundmass oxidation 9. Encrustations: thin Mn coating								
M168-3-1-13	1. Rock Type: volcanic, moderately altered 2. Size: 10x13x7 cm 3. Shape / Angularity: angular 4. Color of cut surface: reddish-brown with grey areas 5. Texture / Vesicularity: massive, dense, <1% vesicles <0.5mm open, possibly porphyric 6. Phenocrysts: Ol (<<1%, ≤ 2 mm), possible patches of glomerocrystic Pl (5-10%, 1-3mm) roundish. Could be an alteration feature as well 7. Matrix: fine-grained 8. Secondary Minerals: 30-40% groundmass oxidation 9. Encrustations: thin, <0.2mm Mn coating	x	x						

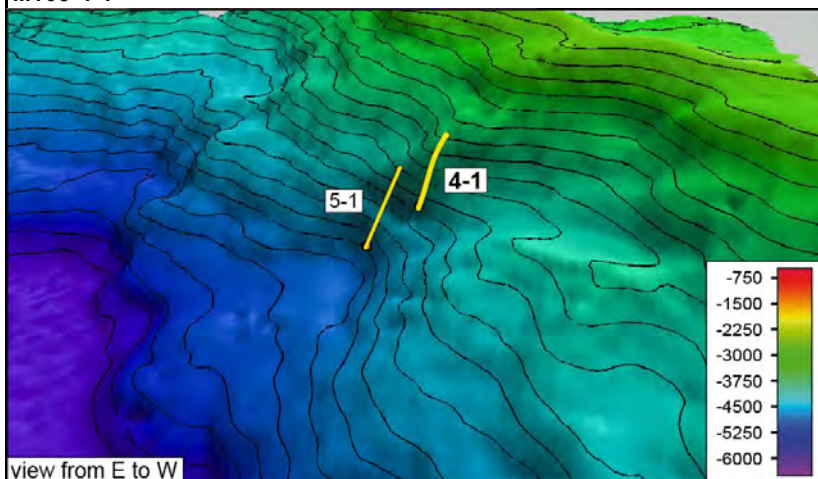
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-3-1-14	1. Rock Type: volcanic, moderately to strongly altered 2. Size: 12x9x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: reddish-brown 5. Texture / Vesicularity: massive, dense, <<1% vesicles <0.5mm open 6. Phenocrysts: appears aphyric but 10-15% white patches could be alteration or glomerocrystic Pl 7. Matrix: fine-grained 8. Secondary Minerals: abundant groundmass oxidation, lining of vesicles 9. Encrustations: thin, <0.1mm Mn coating 10. Comment: TS to be checked for Pl glomerocrysts	x	x						
M168-3-1-15	1. Rock Type: volcanic, moderately altered 2. Size: 7x6x3.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish-red 5. Texture / Vesicularity: massive, fairly dense, sparsely vesicular <1%, ≤0.5 mm Ø, open 6. Phenocrysts: aphyric with microphenocrysts of altered Ol 7. Matrix: fine-grained 8. Secondary Minerals: large vesicles 0.5-1 mm filled with greenish secondary minerals, partly oxidized groundmass 9. Encrustations: <0.5mm Mn coating	x	x						
M168-3-1-16	1. Rock Type: volcanic, moderately altered 2. Size: 7x6x3.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: reddish-grey 5. Texture / Vesicularity: massive / moderately vesicular (~5%, ≤0.5 mm ø) 6. Phenocrysts: altered Ol (<1%, ≤1.5 mm), unidentified black minerals, possibly Px (5%, <1 mm) 7. Matrix: fine-grained 8. Secondary Minerals: partly oxidized groundmass, patchy, no spatial gradient in alteration visible 9. Encrustations: <1 mm Mn crust	x							

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-3-1-17	1. Rock Type: volcanic, moderately altered 2. Size: 9x5x3.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish-brown 5. Texture / Vesicularity: dense, massive / slightly phyrlic 6. Phenocrysts: Ol (1-2%, <1 mm) altered to iddingsite in places green color that may be fresh Ol but could be secondary as well 7. Matrix: fine-grained 8. Secondary Minerals: some reddish groundmass staining 9. Encrustations: <<1 mm Mn coating 10. Comment: at first glance freshest groundmass of entire dredge. whole rock chemistry may worth doing	x	x	x ?					

M168-4-1




Description of Location and Structure: Peake Trough at western termination. Central portion of steep NW flank

Dredge on bottom UTC 15/11/20 01:26 hrs, lat 43°07.90'N, long 20°14.37'W depth 4881 m


Dredge off bottom UTC 15/11/18 03:10 hrs, lat 43°08.20'N, long 20°14.70'W, depth 4398 m

total volume: very few rocks, Mn crusts only

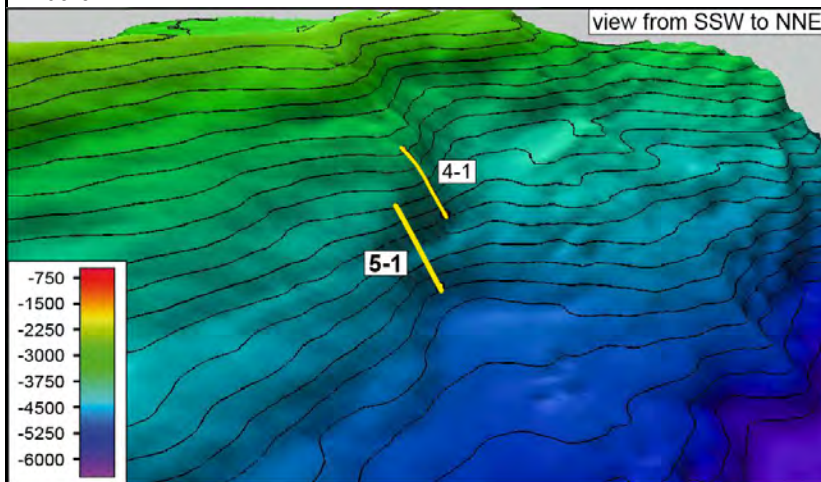
Comments: Only freshly broken Mn crusts which explains stong bites and hung up. One piece taken for reference.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-4-1-1	1. Rock Type: Mn crust, feshly broken from round shaped under ground; probably pillow lava. About 5-6 cm thick 2. Size: 20x16x9 cm 3. Shape / Angularity: subnagular to rounded 4. Color of cut surface: black							Mn for reference	

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-4-1-2	1. Rock Type: pure Mn crust 2. Size: 8.5x5x5 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: black								

M168-5-1



Description of Location and Structure: Peake Trough western termination. SE facing slope at NW margin of Peake Trough, from base to mid-section of main slope


Dredge on bottom UTC 15/11/20 06:31 hrs, lat 43°07.44'N, long 20°14.53'W depth 5269 m

Dredge off bottom UTC 15/11/20 08:52 hrs, lat 43°07.71'N, long 20°14.82'W, depth 4703 m




total volume: few rocks

Comments: mostly aphyric lava fragments ranging from fairly fresh in #1 to otherwise slightly and moderately altered.




#2 contains fresh glass. #6 is a conglomerate with variable, subangular lava fragments indicating erosive processes along the slope.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-5-1-1	1. Rock Type: volcanic, quite fresh, aphyric 2. Size: 10.5x8.5x3 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey to dark grey 5. Texture / Vesicularity: massive non-vesicular 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: none 9. Encrustations: <1 mm Mn coating 10. Comment: a fresh fragment of probably pillow lava	x	x						


M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-5-1-2	1. Rock Type: volcanic, slightly altered with a thin glass layer, aphyric 2. Size: 7.5x6.5x4.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: white-grey 5. Texture / Vesicularity: massive, slightly vesiculated 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: net structured, altered minerals orange brown 9. Encrustations: thin, <1 mm Mn coating 10. Comment: fresh glass	x	x		G I				
M168-5-1-3	1. Rock Type: volcanic, relatively fresh, aphyric 2. Size: 6x5.5x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, slightly vesiculated, <1%, <1 mm, filled with white and orange secondary minerals 6. Phenocrysts: a few nests of altered Ol (potentially?) 7. Matrix: fine-grained 8. Secondary Minerals: some vesicle fillings, Mn along cracks 9. Encrustations: Mn coating, <1 mm 10. Comment: maybe Ol though altered	x	x						
M168-5-1-4	1. Rock Type: volcanic, slightly altered, aphyric 2. Size: 8x8x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, slightly vesiculated, <1%, <1 mm 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: vesicle fillings, crack fillings with orange secondary minerals, some Mn patches 9. Encrustations: thin Mn coating, <1 mm	x	x						

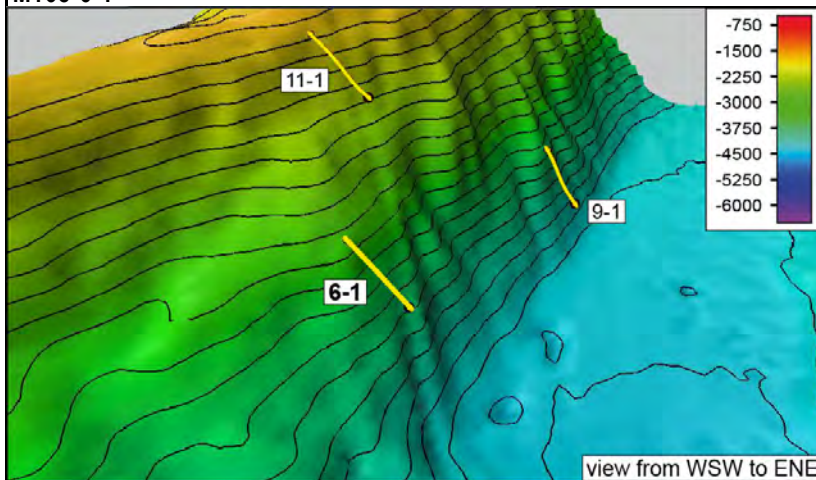
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-5-1-5	1. Rock Type: volcanic, aphyric, altered with many veins and cracks with secondary minerals 2. Size: 5.5x5x3.5 cm 3. Shape / Angularity: subangular to subrounded 4. Color of cut surface: grey but many orange & white infilled cracks and patches 5. Texture / Vesicularity: massive, slightly vesiculated, ca 1% and higher than sample -1 to -4 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: filled cracks, vesicles and patches with orange-whitish & greenish secondaries, probably some palagonite 9. Encrustations: Mn coating, <1 mm and palagonite? coating 10. Comment: glass?				GI?				
M168-5-1-6	1. Rock Type: conglomerate with different volcanic clasts, slightly altered to altered 2. Size: 9.5x7.5x5.5 cm 3. Shape / Angularity: conglomeratic with subangular clasts 4. Color of cut surface: orange brownish to grey, depending on the clast 5. Texture / Vesicularity: differs from clast to clast 6. Phenocrysts: differs from clast to clast 7. Matrix: differs from clast to clast 8. Secondary Minerals: clasts glued together with white to yellow secondary minerals, probably carbonatic. Some holes between the clasts filled with Mn, Mn patches 9. Encrustations: Mn coating, <1.5 mm 10. Comment: conglomerate indicates erosion and transport							cutting jobs assigned	
M168-5-1-7	1. Rock Type: Mn crust 2. Size: 20.5x18x6.5 cm 10. Comment: tiny bits of volcanic rock beneath the Mn crust								

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-5-1-8	1. Rock Type: Mn crust 2. Size: 11.5x8x5.5 cm 10. Comment: layers of beige secondary minerals with dendrites of Mn								

M168-6-1



Description of Location and Structure: Palmer Ridge, southern flank, central part


Dredge on bottom UTC 15/11/20 14:57 hrs, lat 42°50.42'N, long 20°09.42'W depth 4379 m

Dredge off bottom UTC 15/11/20 16:14 hrs, lat 42°50.82'N, long 20°09.40'W, depth 3960 m





total volume: few rocks

Comments: comprise sparsely Ol phyric, dense lava fragments (#1 to #3) along with aphyric varieties (#4 to #6).


Freshest samples are #1, #4 and #5. Gm of the latter may be suitable for Ar-Ar dating

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-6-1-1	1. Rock Type: volcanic, sparsely phyric 2. Size: 17x17x13 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, sparsely phyric, non-vesicular 6. Phenocrysts: brownish, altered Ol (3%), dark grey blue Px? (1%) 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: Mn coating, 1 mm 10. Comment: probably piece of sheet flow	x	x	GM?					

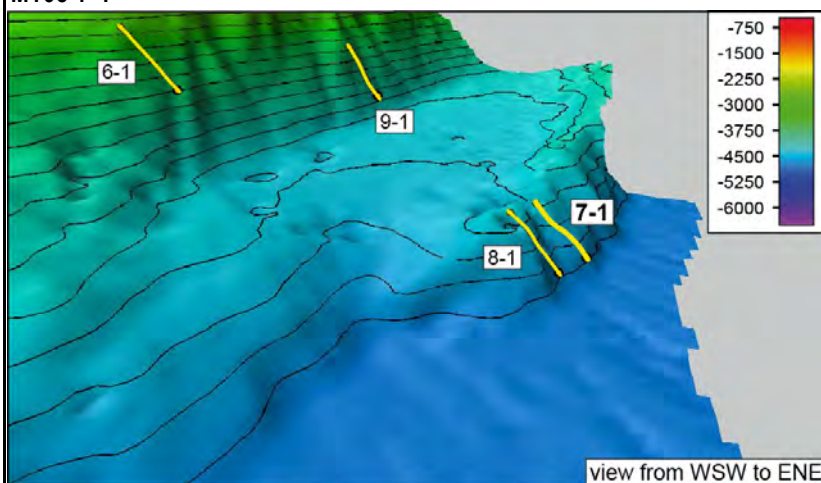
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-6-1-2	1. Rock Type: volcanic, sparsely phyrlic, similar to - 1 2. Size: 9x8x2.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, sparsely phyrlic, non-vesicular 6. Phenocrysts: brownish, altered Ol (3%), dark grey blue Px? (1%) 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: Mn coating <1 mm								
M168-6-1-3	1. Rock Type: volcanic, sparsely phyrlic, similar to - 1 2. Size: 8x9x4 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, sparsely phyrlic, non-vesicular 6. Phenocrysts: brownish, altered Ol (3%), dark grey blue Px? (1%) 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: Mn coating <1 mm								
M168-6-1-4	1. Rock Type: volcanic, aphyric, fairly fresh 2. Size: 7x7x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, aphyric, non-vesicular 6. Phenocrysts: - 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: Mn coating <1 mm	x	x	GM?					
M168-6-1-5	1. Rock Type: volcanic, aphyric, relatively fresh, similar to -4 2. Size: 11x7x8 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, aphyric, non-vesicular 6. Phenocrysts: - 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: Mn crust ~1 mm								

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-6-1-6	1. Rock Type: volcanic, aphyric 2. Size: 8x6x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: light grey 5. Texture / Vesicularity: massive, aphyric, non-vesicular 6. Phenocrysts: - 7. Matrix: medium-grained 8. Secondary Minerals: - 9. Encrustations: insignificant Mn coating in places								

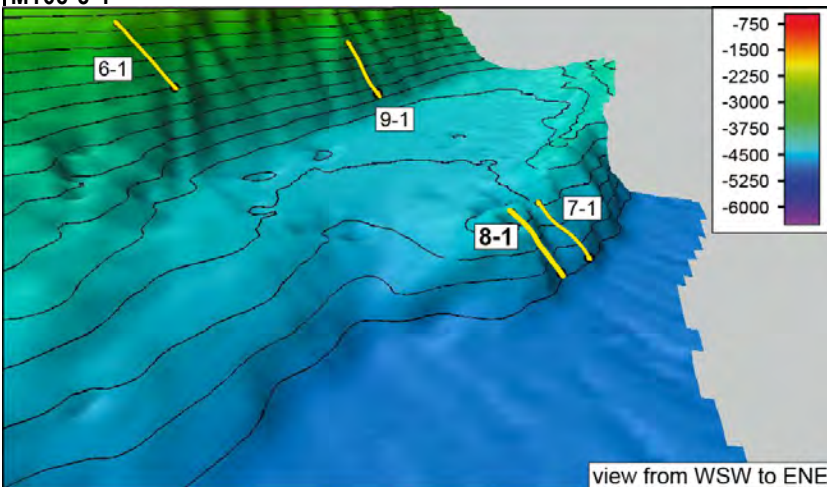
M168-7-1



Description of Location and Structure: Palmer Ridge southern slope. Step at lowermost most portion of S facing ridge slope.

Dredge on bottom UTC 15/11/20 19:53 hrs, lat 42°47.09'N, long 20°09.76'W depth 5336 m
 Dredge off bottom UTC 15/11/20 21:05 hrs, lat 42°47.46'N, long 20°09.76'W, depth 4991 m
total volume: empty


M168-8-1



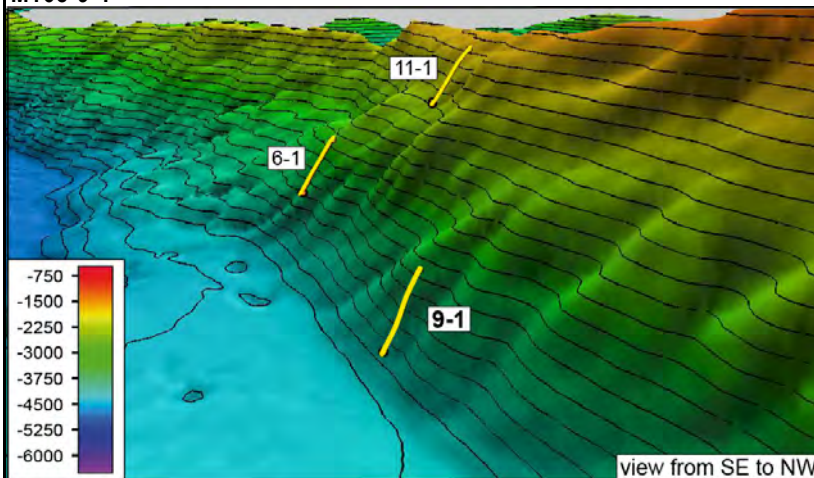
Description of Location and Structure: Palmer Ridge, lowermost part at step. Just 1/4 nm further W of Station -7

Dredge on bottom UTC 16/11/20 00:41 hrs, lat 42°47.27'N, long 20°10.10'W depth 5328 m
 Dredge off bottom UTC 16/11/20 01:55 hrs, lat 42°47.61'N, long 20°10.10'W, depth 4931 m
total volume: one small rock
Comments: small piece of strongly altered, Pl phyr lava

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-8-1-1	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 5.5x4x5.5 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: greyish-brown 5. Texture / Vesicularity: massive, phyr, low vesicularity (<10%) 6. Phenocrysts: altered Plag (~10%, 1-2mm) 7. Matrix: fine-grained groundmass with distinct phenocrysts 8. Secondary Minerals: altered Ol and Plag 9. Encrustations: none	x	x						

M168-9-1



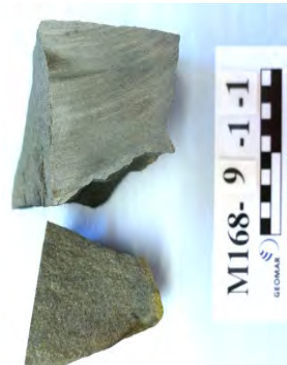
Description of Location and Structure: Palmer Ridge southern flank, base of main south facing slope. Track covers lower 1/5.

Dredge on bottom UTC 16/11/20 06:00 hrs, lat 42°49.51'N, long 20°06.96'W depth 4784 m




Dredge off bottom UTC 16/11/20 07:56 hrs, lat 42°49.69'N, long 20°06.93'W, depth 4550 m

total volume: few rocks and one larger block


Comments: relatively fresh magmatic rocks sampled. #1 is a microgabbro or dolerite of either subvolcanic or from within a thick lava flow / lake with Pl, Ol and possibly Px microphenocrysts. #3 to #4 are aphyric lava fragments with those from #4 originating from a breccia. #5 is a Mn crust with attached magmatic host material.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-9-1-1	1. Rock Type: igneous, probably plutonic / subvolcanic, aphyric, fresh 2. Size: 57x22x19 cm original size of block A 3. Shape / Angularity: subangular to angular 4. Color of cut surface: (blueish) grey 5. Texture / Vesicularity: massive, very homogeneous, non-vesicular 6. Phenocrysts: none; probably microphenocrysts of Fsp, Ol and some black minerals 7. Matrix: fine- to medium-grained 8. Secondary Minerals: rare Mn dendrites 9. Encrustations: Mn crust up to 2.5 cm but mostly thin coated Mn crust 10. Comment: sample taken are pieces of block A; could be a micro-gabbro or dolerite	x	x						

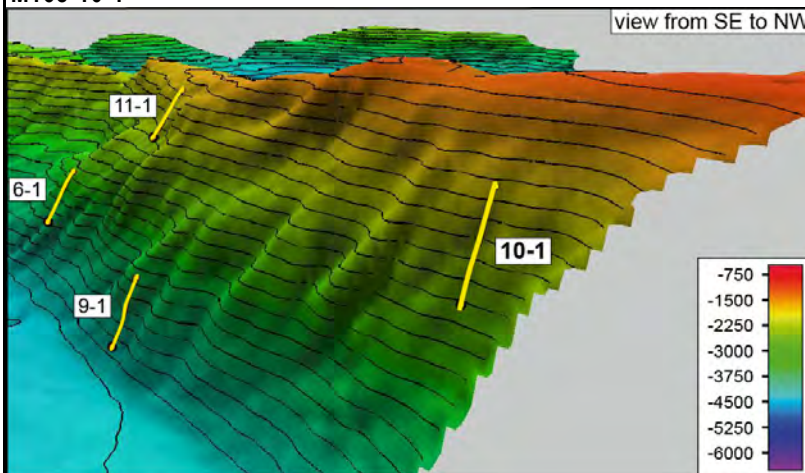
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-9-1-2	1. Rock Type: volcanic, aphyric, fresh 2. Size: 10.5x8x6 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: (blueish) grey 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: none; microphenocrysts? 7. Matrix: fine- to medium-grained; but looks finer than -1 8. Secondary Minerals: cracks and veins filled with white and green minerals 9. Encrustations: Mn crust <2 mm	x	x						
M168-9-1-3	1. Rock Type: magmatic rock, fresh, aphyric, probably volcanic 2. Size: 7.5x5.5x5 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: (blueish) grey 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: none; microphenocrysts? 7. Matrix: fine-grained 8. Secondary Minerals: a few cracks filled with white-greyish minerals 9. Encrustations: alteration crust (<3 mm) yellow brown, Mn coating (<1 mm)	x	x						
M168-9-1-4	1. Rock Type: breccia with large, fresh volcanic clasts 2. Size: 34x18x16 cm 3. Shape / Angularity: angular, brecciated 4. Color of cut surface: clasts = grey 5. Texture / Vesicularity: clasts = massive, non-vesicular 6. Phenocrysts: clasts = none but Plag microphenocrysts 7. Matrix: fine-grained clasts and medium-grained clasts 8. Secondary Minerals: rarely cracks with yellow mineral infill 9. Encrustations: Mn crust up to 1.5 cm 10. Comment: breccia with fresh magmatic clasts, good for geochemistry. Clasts glued together with white / yellow secondary mineral assemblage, probably Cc or Pp. Clasts partly enclosed by Mn crust.	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-9-1-5	1. Rock Type: Mn crust with tiny bits of magmatic host rock 2. Size: 14.5x10x5.5 cm 3. Shape / Angularity: 4. Color of cut surface: 5. Texture / Vesicularity: 6. Phenocrysts: 7. Matrix: 8. Secondary Minerals: 9. Encrustations: Mn crust up to 2 cm thick 10. Comment: host rock appears brecciated								

M168-10-1




Description of Location and Structure: Palmer Ridge, central section, steep S facing slope, track covers middle part

Dredge on bottom UTC 16/11/20 11:40 hrs, lat 42°49.94'N, long 20°03.80'W depth 3768 m





Dredge off bottom UTC 16/11/20 13:06 hrs, lat 42°50.36'N, long 20°03.80'W, depth 3134 m

total volume: full



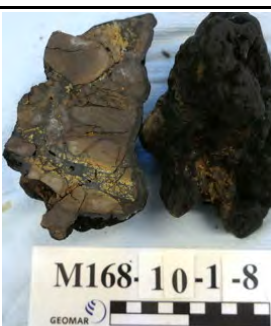

Comments: contains sparsely Px phyric lava fragments with rare Pl (#1 to #7). Samples #7, #10 and #11 possibly with glass. #8 is aphyric, #9 a volcanoclastic rock, #10 a pillow fragment with glassy margin, #11 a hyaloclastite and #12 a subvolcanic amphibolite. Attention #12 could be an unidentified dropstone as it is rounded with patches of Mn and the only such rock in the dredge.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-10-1-1	1. Rock Type: volcanic, sparsely phyric 2. Size: 13x10x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, slightly vesicular (<1%), sparsely phyric 6. Phenocrysts: black phenocrysts Px? (5%), greyish white Pl (2-3%) 7. Matrix: fine-grained groundmass 8. Secondary Minerals: unclear 9. Encrustations: thin Mn encrustation <1mm	x	x						




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-10-1-2	1. Rock Type: volcanic, sparsely phyric, similar to - 1 2. Size: 9x8x2.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, slightly vesicular (<1%), sparsely phyric 6. Phenocrysts: rounded blackish phenocrysts Px? (3%), greyish white Pl (2-3%) 7. Matrix: fine- to medium-grained groundmass 8. Secondary Minerals: - 9. Encrustations: very thin Mn encrustation <1mm	x							
M168-10-1-3	1. Rock Type: volcanic, sparsely phyric, similar to - 1 2. Size: 9x5x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, slightly vesicular (<1%), sparsely phyric 6. Phenocrysts: rounded blackish phenocrysts Px? (3%) 7. Matrix: fine-grained groundmass 8. Secondary Minerals: some in vesicles and veins 9. Encrustations: very thin Mn encrustation <1mm								
M168-10-1-4	1. Rock Type: volcanic, phaneritic 2. Size: 18x15x11 cm 3. Shape / Angularity: subangular 4. Color of cut surface: blackish grey 5. Texture / Vesicularity: phyric, vesicular (<1%) 6. Phenocrysts: rounded grey, angular Fsp? between yellow rounded phenocrysts O? (10%) 7. Matrix: coarse-grained 8. Secondary Minerals: altered Ol 9. Encrustations: Mn >1mm	x	x						
M168-10-1-5	1. Rock Type: volcanic, slightly phyric 2. Size: 20x9x13 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey with brown circular spots 5. Texture / Vesicularity: slightly vesicular (<1%), phyric 6. Phenocrysts: black phenocrysts Px? (5%), white phenocrysts Pl (<1%) 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: Mn encrustation up to 3 mm 10. Comment: conglomerate on the margins	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	GI/MIN	SED	REF	NOTES	PICTURE
M168-10-1-6	1. Rock Type: volcanic, phyrlic, little altered 2. Size: 10x8x7 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: phyrlic 6. Phenocrysts: altered black phenocrysts Px? (5-10%) 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: Mn encrustation <1 mm								
M168-10-1-7	1. Rock Type: volcanic, little altered, clast? 2. Size: 17x6x9 cm 3. Shape / Angularity: rounded to subangular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: phyrlic, 1-2% vesicles 6. Phenocrysts: black phenocrysts Px? (2-3%) 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: Mn crust up to 1 cm, possibly contains fresh glass patches	x			GI?				
M168-10-1-8	1. Rock Type: volcanic, aphyric, clast? 2. Size: 13x8x12 cm 3. Shape / Angularity: rounded 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: aphyric, rare vesicles 6. Phenocrysts: black phenocrysts Px? (>1%) 7. Matrix: fine-grained 8. Secondary Minerals: lots of veins and cracks 9. Encrustations: Mn crust >1 mm								
M168-10-1-9	1. Rock Type: volcanoclastic?, aphyric rock, moderately altered 2. Size: 27x15x25 cm 3. Shape / Angularity: slightly rounded, not angular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: 2-3% vesicles 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: none 9. Encrustations: Mn encrustation up to 1 cm 10. Comment: some large vesicles, texture appears folded								

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-10-1-10	1. Rock Type: volcanic, pillow lava fragment with glassy margin and Mn crust 2. Size: 9x5x7.5 cm 3. Shape / Angularity: rounded, pillowish 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: 15% vesicles 6. Phenocrysts: red-brown phenocrysts 7. Matrix: fine-grained 8. Secondary Minerals: Mn in vesicles 9. Encrustations: Mn crustation 1 cm 10. Comment: may contain some fresh glass				some fresh Gl				
M168-10-1-11	1. Rock Type: conglomerate of volcanic clasts in hyaloclastic matrix 2. Size: 12x9x7 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey to black 5. Texture / Vesicularity: clasts are sparsely phyrlic, no vesicles 6. Phenocrysts: <1% dark phenocrysts, <1 mm 7. Matrix: clasts are fine-grained 8. Secondary Minerals: clasts, none, just concentric halo; matrix is altered glass (palagonite) 9. Encrustations: none 10. Comment: may contain some fresh glass	x			little fresh Gl				
M168-10-1-12	1. Rock Type: subvolcanic (amphibolite?) 2. Size: 16x5x10 cm 3. Shape / Angularity: rounded 4. Color of cut surface: dark grey - black 5. Texture / Vesicularity: epigranular, massive, no vesicles 6. Phenocrysts: 60% dark minerals 0.5-3 mm (Amph?), 40% Fsp laths, very well preserved, suitable for dating 7. Matrix: holocrystalline 8. Secondary Minerals: white vein fillings, CC? 9. Encrustations: few patches with thin (<1 mm) Mn coating	x	x		Fsp, Amph			consider dropstone!!	

M168 Dredge Station Details and Rock Description



M168-11-1

A bathymetric map showing depth contours from -750m to -6000m. The map is oriented from SSW to NNE. Three locations are marked with yellow lines and labels: 11-1, 6-1, and 9-1. The map shows a series of parallel ridges and valleys. A color scale on the left indicates depth: -750 (red), -1500 (orange), -2250 (yellow), -3000 (green), -3750 (blue), -4500 (dark blue), -5250 (purple), -6000 (black).





Description of Location and Structure: Palmer Ridge.
Uppermost section of central part of ist southern flank

Dredge on bottom UTC 16/11/20 16:04 hrs, lat 42°51.13'N, long 20°08.22'W depth 3480 m
Dredge off bottom UTC 16/11/20 17:24 hrs, lat 42°51.57'N, long 20°08.22'W, depth 3050 m
total volume: Many large blocks, apparently igneous +





Comments: dredge comprises slightly to moderately altered, quite dense, near non-vesicular lava fragments with variable amounts of Pl, Ol and Px but also aphyric varieties (#1 to #14). No systematic grouping possible which may reflect sampling of talus. Samples #15 to #20 are hyaloclastites that contain abundant fresh glass shards and spherules. In particular noteworthy are #15 and #20 which are real glass bonanzas!

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-11-1-1	1. Rock Type: volcanic, slightly Pl + Ol phyric, moderately altered, pillow fragment with chilled margin 2. Size: 13.5x14.5x24 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: greyish with orange tint 5. Texture / Vesicularity: phyric, low vesicularity (<5%) 6. Phenocrysts: Pl (<5%, 1mm), altered Ol (<1%, 1mm) 7. Matrix: fine-grained 8. Secondary Minerals: alteration halo, oxidized gm 9. Encrustations: 1 cm Mn crust	x	x						
M168-11-1-2	1. Rock Type: volcanic, lava fragment, moderately altered, aphyric 2. Size: 11x19x10 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish 5. Texture / Vesicularity: relatively homogenous, dense, low vesicularity 6. Phenocrysts: insignificant 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, slightly oxidized 9. Encrustations: thin Mn crust and Mn coating	x	x						





M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-11-1-3	1. Rock Type: volcanic, lava fragment, moderately altered, slightly phyric lava fragment 2. Size: 10x9x5.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish, yellow tint 5. Texture / Vesicularity: fine grained homogeneous, low vesicularity <5% 6. Phenocrysts: <5% altered Ol <1 mm 7. Matrix: fine-grained gm, homogenous 8. Secondary Minerals: slightly oxidized gm, altered Ol 9. Encrustations: thin Mn coating / crust	x	x						
M168-11-1-4	1. Rock Type: volcanic, quite aphyric, moderately altered lava fragment 2. Size: 10x9x5.5 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: greyish, yellowish tint towards alteration halo 5. Texture / Vesicularity: massive, fine grained, phyric in places, cracks with Cc? / Pp?, Mn dendrites 6. Phenocrysts: insignificant 7. Matrix: fine-grained gm 8. Secondary Minerals: slight alteration halo, slightly oxidized gm 9. Encrustations: thin <0.3mm Mn coating / crust	x	x						
M168-11-1-5	1. Rock Type: volcanic, near aphyric lava fragment, moderately altered 2. Size: 6x7x5.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish, yellow tint 5. Texture / Vesicularity: dense, low vesicularity <10% partially filled 6. Phenocrysts: few altered Ol <1 mm 7. Matrix: fine-grained gm 8. Secondary Minerals: slightly oxidized gm and altered Ol 9. Encrustations: thin <0.2mm Mn coating	x	x						
M168-11-1-6	1. Rock Type: volcanic, Pl + Ol phyric lava, moderately to strongly altered 2. Size: 12x9x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: beige 5. Texture / Vesicularity: fine grained, phyric in places, filled cracks, low vesicularity <10% partially filled 6. Phenocrysts: Pl <5%, 1mm; altered Ol <5% 1 mm 7. Matrix: fine-grained gm 8. Secondary Minerals: oxidized gm 9. Encrustations: thin Mn coating								




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-11-1-7	1. Rock Type: volcanic, moderately altered lava fragment, Ol phyric 2. Size: 8x4x5 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: greyish, beige towards alteration zone 5. Texture / Vesicularity: phyric, low vesicularity <10% partially filled 6. Phenocrysts: altered Ol <10%, 1 mm; spinel? 7. Matrix: fine-grained gm 8. Secondary Minerals: oxidized gm, altered Ol 9. Encrustations: thin Mn coating 10. Comment: may contain a few fresh glass shards				Gl?				
M168-11-1-8	1. Rock Type: volcanic, moderately altered lava fragment 2. Size: 10x7x3 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish, beige, yellowish 5. Texture / Vesicularity: dense, massive, low vesicularity <5% 6. Phenocrysts: a few altered Ol <5%, 1 mm 7. Matrix: fine-grained gm 8. Secondary Minerals: oxidized gm 9. Encrustations: thin Mn coating 10. Comment: may contain a few fresh glass shards				Gl?				
M168-11-1-9	1. Rock Type: volcanic 2. Size: 8x4x5 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: greyish, beige towards alteration zone 5. Texture / Vesicularity: phyric, low vesicularity <10% partially filled 6. Phenocrysts: altered Ol <10%, 1 mm; spinel? 7. Matrix: fine-grained gm 8. Secondary Minerals: oxidized gm, altered Ol 9. Encrustations: thin Mn coating								
M168-11-1-10	1. Rock Type: volcanic, lava fragment slightly to moderately altered 2. Size: 15x9x9 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, phyric, low vesicularity <10% 6. Phenocrysts: Pl <1%, altered Ol <5%, large Px needles <5% 7. Matrix: fine-grained 8. Secondary Minerals: slightly oxidized gm, altered Ol 9. Encrustations: thin Mn crust	x	x						



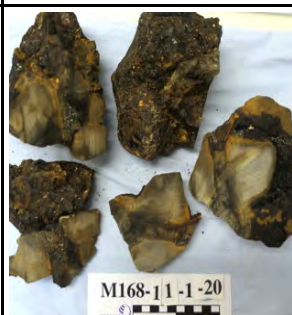
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-11-1-11	1. Rock Type: volcanic, slightly to moderately altered 2. Size: 8.5x6x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish-yellowish tint 5. Texture / Vesicularity: aphyric, partly phyrlic in places 6. Phenocrysts: a few Pl 7. Matrix: fine-grained 8. Secondary Minerals: network-like Pl alteration 9. Encrustations: thin Mn coating	x	x						
M168-11-1-12	1. Rock Type: volcanic 2. Size: 13x9x10.5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: beige-yellow tint 5. Texture / Vesicularity: homogenous, low vesicularity <5% 6. Phenocrysts: insignificant, a few altered Pl 7. Matrix: fine-grained 8. Secondary Minerals: oxidized gm, altered Pl, a few Mn dendrites 9. Encrustations: thin Mn coating	x	x						
M168-11-1-13	1. Rock Type: volcanic 2. Size: 10.5x8.5x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish-beige 5. Texture / Vesicularity: phyrlic, low vesicularity <1%, partly filled 6. Phenocrysts: Pl + Px 7. Matrix: fine-grained 8. Secondary Minerals: oxidized gm 9. Encrustations: thin Mn coating <0.2 mm	x	x						
M168-11-1-14	1. Rock Type: volcanic, fractured lava fragment, moderately altered 2. Size: 14x14x11 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: greyish-yellowish tint 5. Texture / Vesicularity: phyrlic, fractured, cracks, low vesicularity <1% 6. Phenocrysts: Px needles <15% 7. Matrix: fine-grained 8. Secondary Minerals: oxidized gm, altered Pl 9. Encrustations: thin Mn coating 0.3 mm	x	x						


M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-11-1-15	1. Rock Type: volcanic breccia with large fresh glass shards! 2. Size: 22x20x10 cm 3. Shape / Angularity: rounded 4. Color of cut surface: diverse, grey clastics, dark matrix, brown alteration 5. Texture / Vesicularity: breccia, non-vesicular, vesicles in basaltic clasts 6. Phenocrysts: 7. Matrix: fine-grained altered matrix containing cm sized, fresh glass shards 8. Secondary Minerals: 9. Encrustations: thin Mn crust ~2 mm 10. Comment: sample taken for glass analysis	x			Gl			slab with glass shards and basalt clasts cut	
M168-11-1-16	1. Rock Type: volcanic, hyaloclastite, altered but contains patches with fresh glass ! 2. Size: 14x8x6 cm 3. Shape / Angularity: rounded 4. Color of cut surface: black where fresh glass 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: palagonite and Mn invading sample 9. Encrustations: 3 mm Mn crust around entire sample 10. Comment: sample taken for glass analysis				Gl			glass to be prepared	
M168-11-1-17	1. Rock Type: volcanic, pillow fragment with chilled margin and intra-pillow breccia attached 2. Size: 7.5x9x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brownish grey to orange 5. Texture / Vesicularity: massive, <5% vesicles ø 0.5mm 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: severe gm oxidation, palagonite replacing glass 9. Encrustations: Mn patches, all black material attached is glass rind 10. Comment: sample taken for glass analysis				Gl			glass to be prepared	

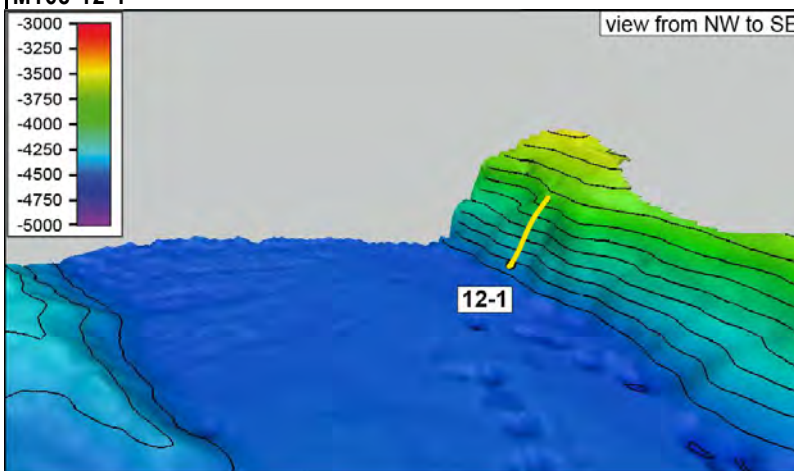
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-11-1-18	<p>1. Rock Type: volcanic breccia, presumably hyaloclastite, strongly altered but with a few fresh glass pieces!</p> <p>2. Size: 13.5x8.5x5 cm</p> <p>3. Shape / Angularity: rounded overall</p> <p>4. Color of cut surface: black to orange-yellow</p> <p>5. Texture / Vesicularity: brecciated</p> <p>6. Phenocrysts: none</p> <p>7. Matrix: mm sized glass shards</p> <p>8. Secondary Minerals: Mn penetrating rock along cracks, palagonite replacing glass</p> <p>9. Encrustations: 1 mm Mn crust around entire sample</p> <p>10. Comment: sample taken for glass analysis, volume sufficient for spot analysis</p>				GI			glass to be prepared	
M168-11-1-19	<p>1. Rock Type: volcanic, strongly altered pillow fragment with fresh glass !</p> <p>2. Size: 18.5x17x12 cm</p> <p>3. Shape / Angularity: triangular shaped pillow fragment</p> <p>4. Color of cut surface: grey to light brown</p> <p>5. Texture / Vesicularity: massive, non-vesicular</p> <p>6. Phenocrysts: none</p> <p>7. Matrix: fine-grained</p> <p>8. Secondary Minerals: strong groundmass oxidation in network patchy fashion.</p> <p>9. Encrustations: 3-5 mm Mn crust around entire sample</p> <p>10. Comment: sample taken for for glass. whole rock too altered for meaningful analysis</p>				GI			glass to be prepared	
M168-11-1-20	<p>1. Rock Type: volcanic, hyaloclastite with abundant fresh glass. About seven representative pieces taken from block B (30x51x41 cm)</p> <p>2. Size: pieces range from ø10 to 20-30 cm</p> <p>3. Shape / Angularity: angular</p> <p>4. Color of cut surface: variable colors. Grey lava fragments, black glass, orange-yellow palagonite</p> <p>5. Texture / Vesicularity: lava fragments slightly vesicular <5%, ø <0.5mm, open</p> <p>6. Phenocrysts: Fsp <1%, <1mm</p> <p>7. Matrix: fine-grained</p> <p>8. Secondary Minerals: palagonite</p> <p>9. Encrustations: 1-2 cm Mn crust</p> <p>10. Comment: 4. to 7. refer to lava clasts. This seems to be a pillow breccia with abundant fresh glass between lava clasts. Glass spheres up to several cm ø. This is a real glass bonanza! Glass to be checked for heterogeneities, thus individual clast to analyzed. Maybe better to prepare multiple polished TS?</p>				GI			glass to be prepared	

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-11-1-21	1. Rock Type: Mn crust, 4-5 cm thick with 10 cm thick lava attached; lava is altered 2. Size: 27x26x15 cm 3. Shape / Angularity: pillow shape, rounded 4. Color of cut surface: lava, light grey 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: aphyric 7. Matrix: fine-grained 8. Secondary Minerals: oxidized Ol (<5mm, <3%) 9. Encrustations: 4-5 mm thick Mn crust 10. Comment: 4. to 8. refer to lava attached. Sample taken for Mn crust							Mn reference sample	

M168-12-1



Description of Location and Structure:


King's Trough, SE corner, S facing slope, steep slope of canyon wall

Dredge on bottom UTC 16/11/20 23:24 hrs, lat 42°36.63'N, long 20°28.68'W depth 4400 m





Dredge off bottom UTC 17/11/20 00:45 hrs, lat 42°36.25'N, long 20°28.81'W, depth 3922 m

total volume: few rocks



Comments: Relatively homogeneous lithology throughout, some lava fragments are fairly fresh, Ol altered, gm dark grey in places and may be suitable for Ar-Ar dating. Overall amount of phenocrysts <5% in most samples and is dominated by Ol and occasionally subordinate amounts of Px and Pl.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-12-1-1	1. Rock Type: volcanic, mafic, fairly fresh 2. Size: 10x8x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish 5. Texture / Vesicularity: massive, phyr, low vesicularity (<5%) 6. Phenocrysts: Ol altered, few Px needles 7. Matrix: fine-grained 8. Secondary Minerals: slightly oxidized matrix, altered Ol 9. Encrustations: Mn coating 0.3 mm	x	x						

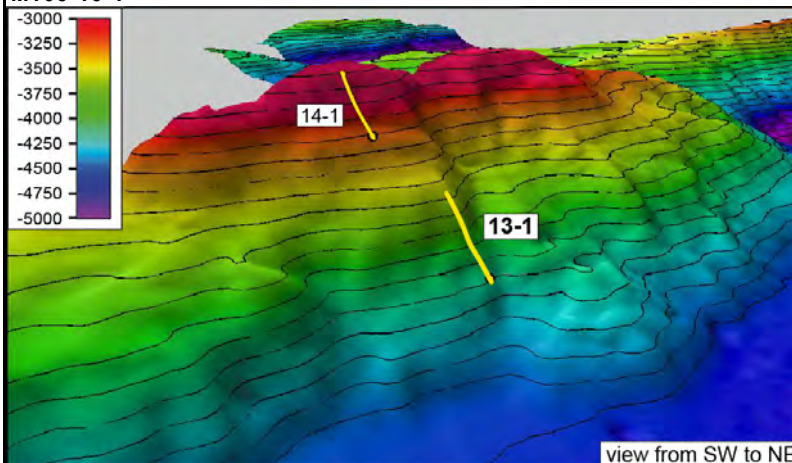
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-12-1-2	1. Rock Type: volcanic, mafic, moderately altered 2. Size: 12x10x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: beige-yellow tint, grey spots 5. Texture / Vesicularity: massive, phyrlic, low vesicularity (<5%) 6. Phenocrysts: most Ol altered (<10%), some Ol altered 7. Matrix: fine-grained 8. Secondary Minerals: oxidized matrix, altered Ol 9. Encrustations: Mn-coating, occasionally <0.4	x	x						
M168-12-1-3	1. Rock Type: volcanic breccia 2. Size: 8x7x7.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: phyrlic clasts, low vesicularity (<5%) 6. Phenocrysts: Ol, Px, Fsp mostly altered 7. Matrix: fine-grained 8. Secondary Minerals: FeOH oxides, altered Ol, altered Pl 9. Encrustations: none	x	x						
M168-12-1-4	1. Rock Type: volcanic breccia 2. Size: 12x10x6 cm 3. Shape / Angularity: rounded 4. Color of cut surface: grey 5. Texture / Vesicularity: grey clasts, brown matrix, black Mn crust 6. Phenocrysts: Pl <1%, slightly altered 7. Matrix: fine-grained 8. Secondary Minerals: oxidized matrix 9. Encrustations: Mn crust								
M168-12-1-5	1. Rock Type: volcanic 2. Size: 11x11x7 cm 3. Shape / Angularity: subangular-rounded 4. Color of cut surface: grey, yellow tint 5. Texture / Vesicularity: phyrlic, low vesicularity <1% 6. Phenocrysts: Ol altered <5%, Pl + Px <1% 7. Matrix: fine-grained 8. Secondary Minerals: few FeOH oxides, altered Ol, oxidized gm 9. Encrustations: occasionally Mn crusts								

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-12-1-6	1. Rock Type: volcanic 2. Size: 7.5x5x4 cm 3. Shape / Angularity: subangular 4. Color of cut surface: bright grey, spotted beige 5. Texture / Vesicularity: phyrlic, low vesicularity <10% 6. Phenocrysts: Pl altered, Ol altered 7. Matrix: fine-grained 8. Secondary Minerals: spotted alteration, altered Ol, oxidized matrix 9. Encrustations: slight Mn coating								
M168-12-1-7	1. Rock Type: volcanic 2. Size: 8x6.5x5 cm 3. Shape / Angularity: subangular-rounded 4. Color of cut surface: grey, spotted beige 5. Texture / Vesicularity: phyrlic, low vesicularity <10%, filled 6. Phenocrysts: Pl <10% 7. Matrix: fine-grained 8. Secondary Minerals: spotted alteration, oxidized matrix 9. Encrustations: slight Mn coating								

M168-13-1



Description of Location and Structure:

Transition Freen Trough to King's Trough, S-facing flank of hill that marks the boundary between the two troughs. Track covers mid-section of slope

Dredge on bottom UTC 17/11/20 04:45 hrs, lat 42°48.81'N, long 20°32.11'W depth 4086 m

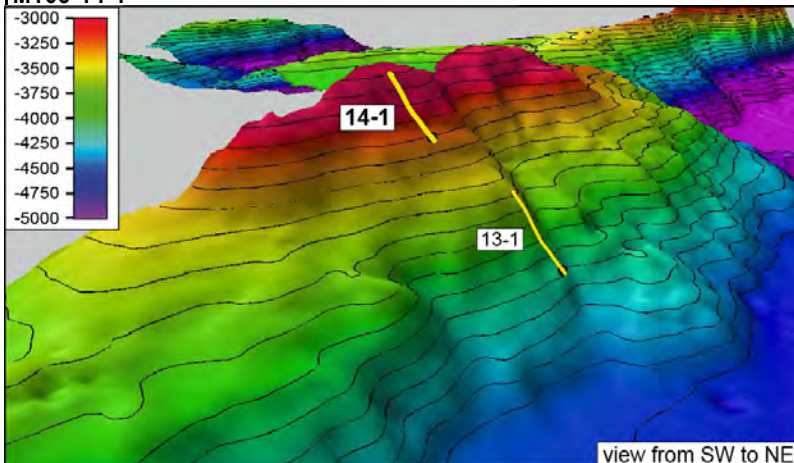
Dredge off bottom UTC 17/11/20 06.09 hrs, lat 42°49.27'N, long 20°32.09'W, depth 3633 m

total volume: empty

Comments:

M168 Dredge Station Details and Rock Description

M168-14-1



Description of Location and Structure:

Transition Freen Trough to King's Trough. Repeat of station -13 up section. Track covers uppermost part of S-facing slope

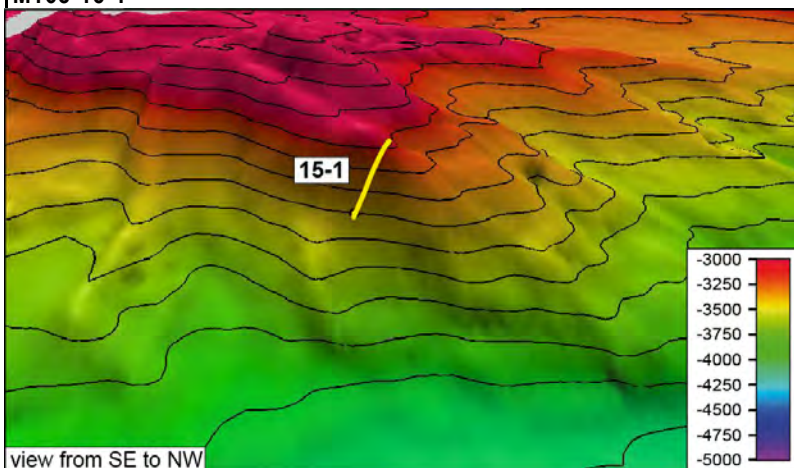
Dredge on bottom UTC 17/11/20 08:32 hrs, lat 42°49.90'N, long 20°32.33'W depth 3248 m

Dredge off bottom UTC 17/11/20 08:58 hrs, lat 42°50.60'N, long 20°32.28'W, depth 3099 m

total volume: empty

Comments: station aborted due to weather conditions. Max rope length 3343

M168-15-1



Description of Location and Structure:

SE corner of King's Trough. S-flank of little seamount forming the SE edge of King's Trough

Dredge on bottom UTC 18/11/20 20:18 hrs, lat 42°35.69'N, long 20°55.44'W depth 3405 m




Dredge off bottom UTC 18/11/20 21:26 hrs, lat 42°36.03'N, long 20°55.43'W, depth 3057 m

total volume: few rocks



Comments: Brecciated sediment with Pp attached. #2 is a breccia that contains a pumice clast. No magmatic basement rocks recovered in this dredge.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-15-1-1	<ol style="list-style-type: none"> 1. Rock Type: brecciated sediment with thick phosphorite attached 2. Size: 30x30x18 cm 3. Shape / Angularity: subangular rounded 4. Color of cut surface: sediment clasts = yellowish brownish, phosphorite = white, Mn Crust = black 5. Texture / Vesicularity: brecciated 6. Phenocrysts: does not apply 7. Matrix: white phosphorite, does not fizz with HCl 8. Secondary Minerals: 9. Encrustations: Mn crust 10. large boulder, four pieces. Possibly pumice clasts in white phosphorite matrix 								

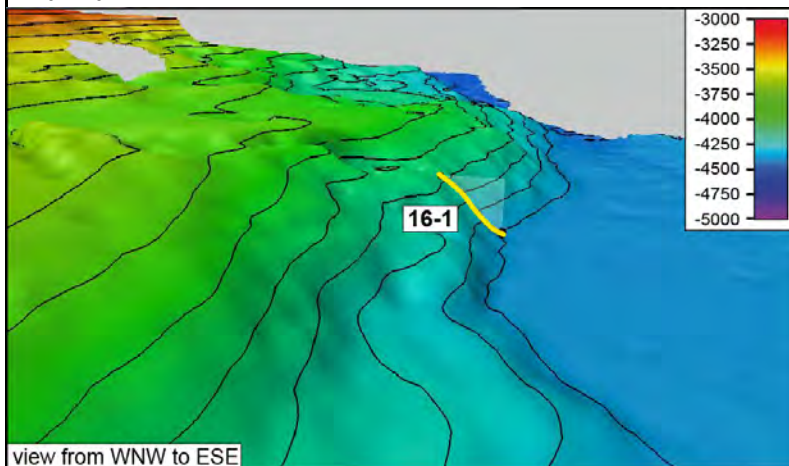
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-15-1-2	1. Rock Type: breccia 2. Size: 9x6.5x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: clasts = greyis white to yellowish white and greenish grey clasts, whitish matrix 5. Texture / Vesicularity: brecciated 6. Phenocrysts: does not apply 7. Matrix: white phosphorite matrix; clasts are 1) a greyish-greenish pumice and 2) greyish-yellowish-tintish very soft clay 8. Secondary Minerals: 9. Encrustations: thin Mn coating 10. contains a pumice clast								
M168-15-1-3	1. Rock Type: unknown; Mn crust? volcanic slag, scoria? 2. Size: 9x8x5 cm 3. Shape / Angularity: rounded 4. Color of cut surface: brownish dark 5. Texture / Vesicularity: cracks filled with small clasts 6. Phenocrysts: none 7. Matrix: black 8. Secondary Minerals: 9. Encrustations: 10. very light, could be oddly Mn crust, could be volcanic slag that picked up some clasts								
M168-15-1-4	1. Rock Type: sediment 2. Size: 8x5x4 cm 3. Shape / Angularity: rounded 4. Color of cut surface: greyish, heterogenous 5. Texture / Vesicularity: semi rounded clasts ø 1mm of Fsp & Px, clast supported 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: Mn coating 10. probably an arkose								

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-15-1-5	1. Rock Type: sediment 2. Size: 7.5x6x4 cm 3. Shape / Angularity: rounded 4. Color of cut surface: greyish-brownish 5. Texture / Vesicularity: heterogenously distributed clast sizes 2-0.5mm, fine grained greyish matrix, sometimes clast supported, sometimes matrix supported 6. Phenocrysts: none 7. Matrix: 8. Secondary Minerals: 9. Encrustations: thin Mn coating 10. arcose, more coarse grained than -4, less homogeneous								
M168-15-1-6	1. Rock Type: sediment, two pieces taken 2. Size: 11x7x6 cm, 6x4.5x4 cm 3. Shape / Angularity: rounded 4. Color of cut surface: beige, yellowish, greenish 5. Texture / Vesicularity: one fine and one more coarse grained variety, both pieces exceptionally soft 6. Phenocrysts: none 7. Matrix: 8. Secondary Minerals: 9. Encrustations: thin Mn coating 10. looks like the coarser grained areas is the matrix and the fine grained pieces are clasts								

M167-16-1



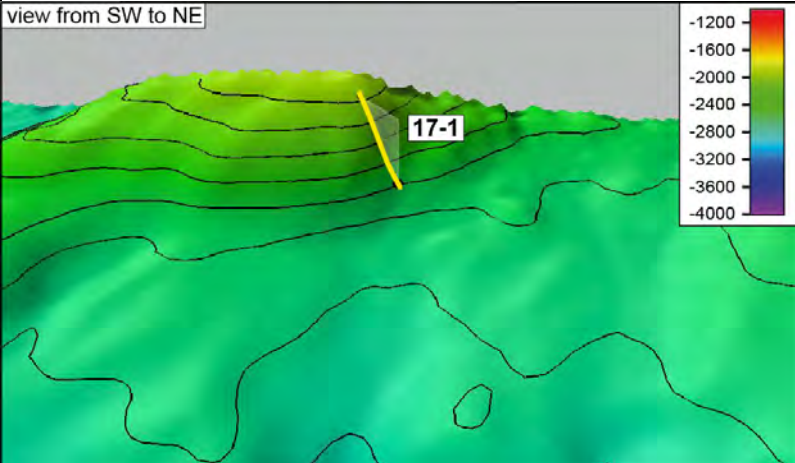
Description of Location and Structure:
 King's Trough at SE termination.
 Small step rising from the basin floor, gentle SW dipping slope

Dredge on bottom UTC 19/11/20 02:15 hrs, lat 42°56.73'N, long 20°56.88'W depth 4408 m
 Dredge off bottom UTC 19/11/20 03:29 hrs, lat 42°57.07'N, long 20°56.72'W, depth 4102 m
total volume: empty

M168 Dredge Station Details and Rock Description

M168-17-1

view from SW to NE



Description of Location and Structure:



King's Trough SE termination, northern half. Top region of WNW-ESE striking ridge that mirrors the regional lineation pattern; probably strike slip faults related to pull apart basin fomation. S-facing slope. Track aims to reveal composition of the ridge in terms of uplifted ocean crust vs synrift magmatism. Ridge is about 15-20 km north of King's Trough.

Dredge on bottom UTC19/11/20 06:50 hrs, lat 43°10.68'N, long 20°53.36'W depth 2412 m





Dredge off bottom UTC 19/11/20 08:01 hrs, lat 43°11.10'N, long 20°53.26'W, depth 2001 m

total volume: some rocks





Comments: Mostly fine grained basalts; some plutonic rocks; probably diorite / gabbro and volcanic breccia. A dropstone was discarded. Overall five lithologies discriminated. Lithology 1 (#1 to #6): aphyric lava fragments, mostly fairly fresh. Lithology 2 (#7 to #10) fairly fresh, mostly Mn encrusted plutonics and subvolcanics (gabbro - diorite) dropstone origin should be considered. Lithology 3 (#11 to #13) brecciated, fairly fresh magmatic rocks. Lithology 4 (#14) altered, gm oxidized volcanic rock. Lithology 5 (#15 & #16) volcanic breccia with moderately altered aphyrc lava fragments.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-17-1-1	1. Rock Type: volcanic, lava fragment, fresh, aphyric 2. Size: 19x13x11 cm piece from block A (37x16.5.14 cm) 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: veins filled with white / yellowish mineral 9. Encrustations: Mn crust < 2mm	x	x					Lithology 1	
M168-17-1-2	1. Rock Type: volcanic, lava fragment, fresh, aphyric 2. Size: 11x7x5 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: veins filled with white / yellowish mineral 9. Encrustations: Mn crust < 1mm 10. coarse grained, white secondary minerals in veins and cracks							Lithology 1	




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-17-1-3	1. Rock Type: volcanic, lava fragment, fresh, aphyric 2. Size: 6.5x5x3.5 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: grey to slightly yellowish 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: veins and cracks filled with white to orange minerals 9. Encrustations: Mn crust < 1mm	x						Lithology 1	
M168-17-1-4	1. Rock Type: volcanic, lava fragment, slightly altered 2. Size: 12.5x6x5.5 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: patches of grey and yellowish grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: sparsely phyric (~1%) probably Pl 7. Matrix: fine-grained to medium-grained 8. Secondary Minerals: a few veins with white / yellow or dark minerals 9. Encrustations: Mn crust < 1mm	x	x					Lithology 1	
M168-17-1-5	1. Rock Type: volcanic, lava fragment, slightly altered 2. Size: 7x4x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey core, yellowish-grey rim 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: one prominent vein filled with white / yellowish mineral (coarse) 9. Encrustations: Mn crust < 2mm							Lithology 1	
M168-17-1-6	1. Rock Type: volcanic, aphyric lava fragment, relatively fresh 2. Size: 13x9x4.5 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: many cracks, a few veins partly filled with coarse grained white to orange mineral 9. Encrustations: Mn crust < 1.5mm 10. prominent crack filled with coarse white / yellowish mineral	x						Lithology 1	




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-17-1-7	1. Rock Type: plutonic, quite fresh 2. Size: piece from block B (30x12.5x16 cm) 3. Shape / Angularity: quite angular 4. Color of cut surface: grey if drey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none; a lot of Pl in matrix 7. Matrix: medium-grained 8. Secondary Minerals: none 9. Encrustations: very thin Mn crust < 0.5mm 10. piece of block A. Diorite or gabbro. Could be dropstone. Very thin Mn coating. Salt and pepper structure.	x	x					dropstone? Lithology 2	
M168-17-1-8	1. Rock Type: plutonic, quite fresh 2. Size: 22x12x15 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey / yellowish 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none; a lot of Pl in matrix 7. Matrix: medium-grained 8. Secondary Minerals: many cracks filled with coarse grained white mineral 9. Encrustations: partially encrusted with Mn < 1.5mm 10. could be diorite / gabbro. Consider that this could be dropstone	x	x					dropstone? Lithology 2	
M168-17-1-9	1. Rock Type: plutonic, relatively fresh 2. Size: 10x6x6.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none; Pl in matrix 7. Matrix: medium-grained 8. Secondary Minerals: cracks filled with white to orange mineral 9. Encrustations: Mn crust < 2 mm 10. diorite / gabbro?	x	x					dropstone? Lithology 2	
M168-17-1-10	1. Rock Type: plutonic, relatively fresh 2. Size: 10x4.5x4 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none; many Pl needles 7. Matrix: medium-grained 8. Secondary Minerals: cracks open or filled with white mineral 9. Encrustations: thin Mn crust < 1 mm 10. diorite / gabbro?							dropstone? Lithology 2	

M168 Dredge Station Details and Rock Description

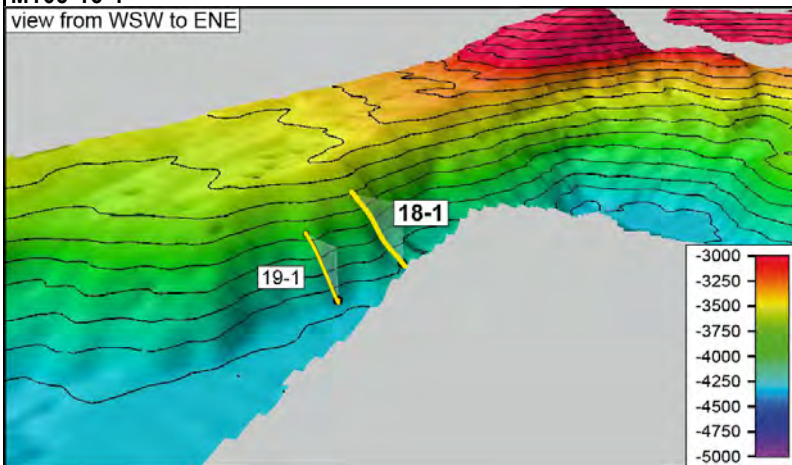
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-17-1-11	1. Rock Type: magmatic, brecciated, relatively fresh 2. Size: 13x9x5.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none; sparsely phyric Pl (1-5%) 7. Matrix: fine- to medium-grained 8. Secondary Minerals: many cracks, brecciated filled with white mineral 9. Encrustations: very thin Mn coating <1 mm 10. good visible Pl needles							Lithology 3	
M168-17-1-12	1. Rock Type: magmatic, could be plutonic 2. Size: 12x6x5.5 cm 3. Shape / Angularity: subangular to subrounded 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: none; Pl in matrix 7. Matrix: medium-grained 8. Secondary Minerals: many cracks / veins filled with whitish secondary mineral 9. Encrustations: Mn coating <1 mm 10. Pl needles	x						Lithology 3	
M168-17-1-13	1. Rock Type: magmatic, partly fresh 2. Size: 9x6x4 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey to greenish-grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: sparsely phyric; Pl needles (1-5%) 7. Matrix: fine- to medium-grained 8. Secondary Minerals: cracks filled with white mineral, some spots & cracks of red to dark mineral 9. Encrustations: Mn crust <1 mm 10. Pl needles	x						Lithology 3	

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-17-1-14	1. Rock Type: magmatic, altered 2. Size: 11x6.5x6 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: yellowish - red 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: many cracks filled with white and red minerals 9. Encrustations: Mn crust <1.5 mm	x						Lithology 4	
M168-17-1-15	1. Rock Type: volcanic breccia 2. Size: 26x15x10 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greenish - grey (chlorite?) 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: most clasts aphyric 7. Matrix: most clasts fine-grained 8. Secondary Minerals: orange & red minerals in cracks; overall greenish character (chlorite?) 9. Encrustations: Mn crust up to 0.5 cm	x						Lithology 5	
M168-17-1-16	1. Rock Type: volcanic breccia 2. Size: 15x12.5x6 cm 3. Shape / Angularity: subangular to subrounded 4. Color of cut surface: greenish - grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: most clasts aphyric 7. Matrix: most clasts fine-grained 8. Secondary Minerals: cracks and spots of white mineral, overall greenish (chlorite?) 9. Encrustations: Mn crust up to 0.5 cm	x						Lithology 5	

M168-18-1

view from WSW to ENE



Description of Location and Structure:
 King's Trough southern (!) part.
 Lower section of NE facing slope
 from base to middle section





Dredge on bottom UTC 19/11/20 12:45 hrs, lat 43°13.27'N, long 21°06.97'W depth 4242 m

Dredge off bottom UTC 19/11/20 14:15 hrs, lat 43°13.75'N, long 21°06.83'W, depth 3720 m




total volume: few rocks

M168 Dredge Station Details and Rock Description

Comments: volcanoclastics, sediments, dropstones, chert and two volcanic rocks (#1 & #2). The latter are relatively fresh, almost non-vesicular and bear Px and Ol phenocrysts. Volcaniclastic sample #4 contains fresh black minerals that may be Amph for Ar-Ar dating.

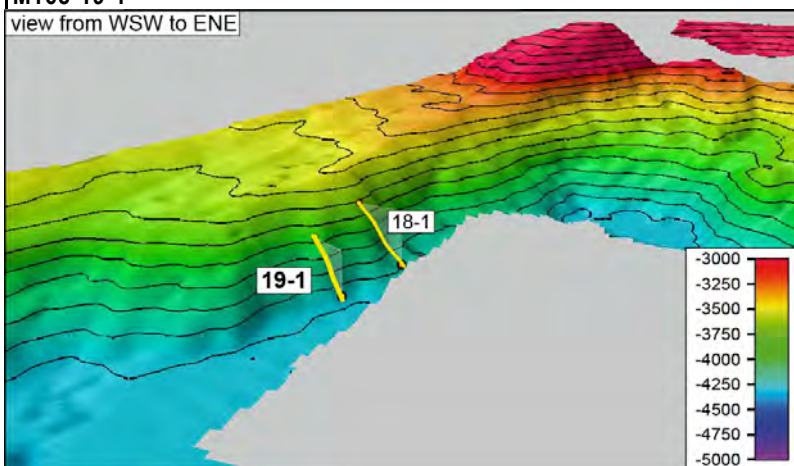
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-18-1-1	1. Rock Type: volcanic, phyric, quite fresh 2. Size: 4.5x5x4 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: phyric, <1% vesicularity 6. Phenocrysts: Ol, yellow, Px, dark - black (1-2%) 7. Matrix: fine-grained 8. Secondary Minerals: white material, Cc? 9. Encrustations: Mn crust <<1 mm	x	x						
M168-18-1-2	1. Rock Type: volcanic, phyric, fresh to slightly altered 2. Size: 5x4x4 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey, in parts brownish 5. Texture / Vesicularity: phyric, <1% vesicularity 6. Phenocrysts: 15% Px, black, max 5mm, white inclusions filled up by black minerals 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: Mn crust <<1 mm	x	x						
M168-18-1-3	1. Rock Type: volcanoclastic rock, moderately phyric, altered 2. Size: 6x4x6 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: clast brown altered 5. Texture / Vesicularity: clast moderately phyric 6. Phenocrysts: Pl (5-10%, up to 2mm) 7. Matrix: 8. Secondary Minerals: - 9. Encrustations: very Mn coating	x							
M168-18-1-4	1. Rock Type: volcanoclastic rock 2. Size: 10x9x5 cm 3. Shape / Angularity: rounded 4. Color of cut surface: dark green to black 5. Texture / Vesicularity: clastic, no vesicles 6. Phenocrysts: individual particles: lythic fragments and black fresh mineral, could be Amph 7. Matrix: coarse sand to pebble size 8. Secondary Minerals: - 9. Encrustations: none 10. check Amph if good for dating	x		x ?					

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Al/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-18-1-5	1. Rock Type: volcanoclastic 2. Size: 9.5x6x4 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: greenish-brown 5. Texture / Vesicularity: clastic, no vesicles 6. Phenocrysts: most clasts are lithic fragments 7. Matrix: coarse sand to pebble size 8. Secondary Minerals: - 9. Encrustations: none, very thin Cc + Mn in places								
M168-18-1-6	1. Rock Type: volcanoclastic 2. Size: 11.5x6x3 cm 3. Shape / Angularity: angular 4. Color of cut surface: 5. Texture / Vesicularity: see sample -5 6. Phenocrysts: see sample -5 7. Matrix: see sample -5 8. Secondary Minerals: see sample -5 9. Encrustations: see sample -5								
M168-18-1-7	1. Rock Type: chert? 2. Size: 7x6x2.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey 5. Texture / Vesicularity: very dense, no vesicles 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: partly very Mn coating 10. dropstone can not be ruled out								

M168-19-1

view from WSW to ENE



Description of Location and Structure:

King's Trough; repeat of M168-18-1; 0.5nm WNW of station -18





Dredge on bottom UTC 19/11/20 16:56 hrs, lat 43°13.58'N, long 21°07.67'W depth 4297 m

Dredge off bottom UTC 19/11/20 18:13 hrs, lat 43°13.93'N, long 21°07.41'W, depth 3861 m



total volume: few small rocks

Comments: volcanoclastics, single altered volcanic rock. The volcanoclastics resemble those of M168-18-1

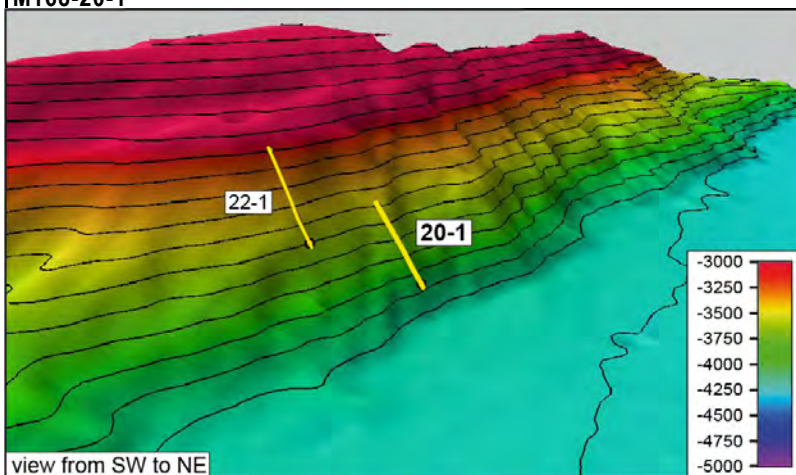
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-19-1-1	1. Rock Type: phyrlic volcanic rock, moderately altered 2. Size: 8x6x4 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: grey, in parts brownish 5. Texture / Vesicularity: phyrlic / moderately vesicular (~15%) 6. Phenocrysts: 25%, max 5mm; two types black and greyish 7. Matrix: massive, fine-grained 8. Secondary Minerals: few vesicles filled with transparent mineral 9. Encrustations: <1 mm in parts								
M168-19-1-2	1. Rock Type: volcanoclastic rock 2. Size: 11x7x7 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark green 5. Texture / Vesicularity: clastic, no vesicles 6. Phenocrysts: lithic fragments, black mineral grains (Px or Amph) 7. Matrix: none 8. Secondary Minerals: 9. Encrustations: Mn crust <1 mm 10. Amph?	x							
M168-19-1-3	1. Rock Type: volcanoclastic rock 2. Size: 7x7x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: similar to -2 5. Texture / Vesicularity: similar to -2 6. Phenocrysts: similar to -2 7. Matrix: similar to -2 8. Secondary Minerals: similar to -2 9. Encrustations: Mn crust <1 mm 10. unclear if black minerals are Amph; 120° degree angles								
M168-19-1-4	1. Rock Type: volcanoclastic rock 2. Size: 9x8x6 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: reddish-brown 5. Texture / Vesicularity: similar to -2 6. Phenocrysts: similar to -2 7. Matrix: similar to -2 8. Secondary Minerals: similar to -2 9. Encrustations: very thin Mn coating								

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-19-1-5	1. Rock Type: volcanoclastic rock 2. Size: 7x4.5x6 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: similar to -4 5. Texture / Vesicularity: similar to -2 6. Phenocrysts: similar to -2 7. Matrix: similar to -2 8. Secondary Minerals: similar to -2 9. Encrustations: partial 3mm Mn coating								
M168-19-1-6	1. Rock Type: volcanoclastic rock 2. Size: 7x3x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: camouflage color 5. Texture / Vesicularity: clastic 6. Phenocrysts: - 7. Matrix: Cc 8. Secondary Minerals: Cc 9. Encrustations: very thin Mn coating								

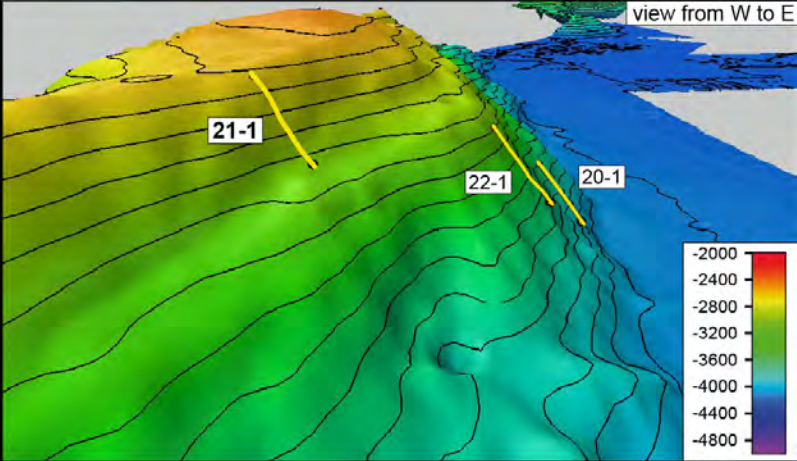

M168-20-1




Description of Location and Structure:
 Seamount in the center of King's Trough. Steep southern slope near base

Dredge on bottom UTC 19/11/20 23:40 hrs, lat 43°27.61'N, long 21°45.06'W depth 3993 m
 Dredge off bottom UTC 20/11/20 01:09 hrs, lat 43°28.01'N, long 21°45.02'W, depth 3532 m
total volume: empty despite reasonable good bites

M168 Dredge Station Details and Rock Description

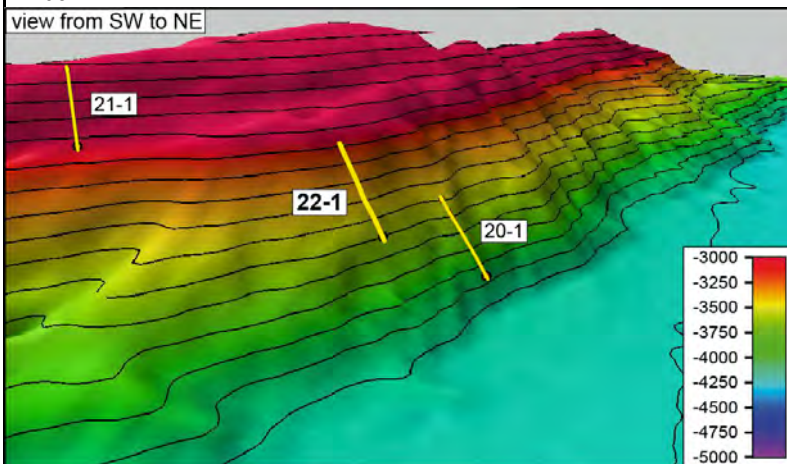
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 60%;"> <p>M168-21-1</p>  </div> <div style="width: 35%;"> <p>Description of Location and Structure: Central King's Trough; same seamount as station -19. South facing flank along top region. The seamount is rather a WNW-ESE elongated ridge.</p> </div> </div>									
<p>Dredge on bottom UTC 20/11/20 03:37 hrs, lat 43°29.06'N, long 21°46.59'W depth 3071 m Dredge off bottom UTC 20/11/20 05:20 hrs, lat 43°30.06'N, long 21°46.49'W, depth 2875 m <i>total volume: two rocks</i> <i>Comments: two rocks. Sample #1 is a faulted volcanic rock (lava?) with multiple fault planes. One plane contains mm-spaced striations from brittle faulting; sample #2 is an angular, slightly foliated granite that is clearly a dropstone despite its strong angularity.</i></p>									
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-21-1-1	1. Rock Type: volcanic, moderately altered lava fragment that was part of a brittle fault as evidenced by striations on one side 2. Size: 7x4x5.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: variable colors, greyish fine grained part (1) and coarser yellowish-greenish part (2) 5. Texture / Vesicularity: (1) fine grained, (2) phyrlic, no vesicles 6. Phenocrysts: few in (2) 7. Matrix: - 8. Secondary Minerals: looks recrystallized, cannot define minerals 9. Encrustations: thin Mn coating 10. Comment: this rock probably originates from a fault, is generally in good condition and striations are visible on one side. Use to obtain primary geochemical information doubtful.	x							

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	GI/MIN	SED	REF	NOTES	PICTURE
M168-21-1-2	1. Rock Type: intrusive, granitic, weakly foliated, fresh, dropstone 2. Size: 8x6.5x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: white & black 5. Texture / Vesicularity: coarse grained, holocrystalline 6. Phenocrysts: Fsp, Qz, Bi 7. Matrix: - 8. Secondary Minerals: 9. Encrustations: 10. Comment: dropstone, foliated granite, taken to demonstrate that dropstones can be very angular								

M168-22-1

view from SW to NE



Description of Location and Structure:


King's Trough central smt. Same slope as in station -19 and -20, now middle part.

Dredge on bottom UTC 20/11/20 07:45 hrs, lat 43°28.12'N, long 21°45.63'W depth 3630 m




Dredge off bottom UTC 20/11/20 09:14 hrs, lat 43°28.55'N, long 21°45.49'W, depth 3106 m

total volume: few rocks (6)



Comments: quite heterogenous dredge ranging from variable lava fragments to plutonic rocks. Thickness of Mn crust varies from <1 mm to 10 mm. A dropstone origin cannot be safely excluded for any of the rocks under the aspect of dredge homogeneity and thin Mn crust but if the slope is related to transtensional faulting, uplift of plutonics and mixture of lithologies is feasible. #1 & #2 are aphyric lava fragments while #3 is Ol-Px phyric lava. #4 is a felsic plutonic while #5 appears more mafic. #6 is a fairly fresh Pl & Px bearing plutonic rock.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	GI/MIN	SED	REF	NOTES	PICTURE
M168-22-1-1	1. Rock Type: magmatic, likely volcanic, fresh 2. Size: 12x5.5x5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: dark grey 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: dark red FeOH long cracks 9. Encrustations: very thin <0.5mm Mn coating	x	x						

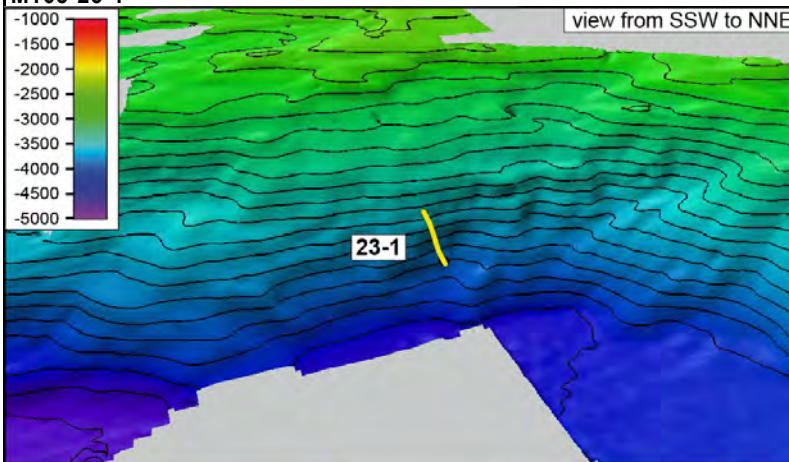
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	GI/MIN	SED	REF	NOTES	PICTURE
M168-22-1-2	1. Rock Type: volcanic, relatively fresh 2. Size: 14x4.5x5 cm 3. Shape / Angularity: subangular to subrounded 4. Color of cut surface: grey to yellowish 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: none 7. Matrix: fine- to medium-grained; graded 8. Secondary Minerals: 1-3mm thick, dark reddish Fe-minral, possibly replacing phenocrysts (pseudomorphs) 9. Encrustations: very thin <0.5mm Mn coating 10. Comment: rare fresh(?) Ol. To be confirmed by TS	x	x						
M168-22-1-3	1. Rock Type: igneous, highly phyric, relatively fresh, probably volcanic 2. Size: 6x4x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greenish grey 5. Texture / Vesicularity: cumulate-ike, non-vesicular 6. Phenocrysts: Ol up to 3mm, 10-15%, graded distribution; Px up to 5mm 15-20% maybe more but altered 7. Matrix: fine-grained 8. Secondary Minerals: cracks filled with orange material 9. Encrustations: very thin <0.2mm Mn coating 10. Comment: fresh & altered Ol. Could be something like an ankaramite or perodite / pyroxenite but looks volcanic	x	x						
M168-22-1-4	1. Rock Type: igneous, probably plutonic, highly phyric, relatively fresh 2. Size: 6x4.5x3.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: Qtz (15% up to 3mm), Pl (1-5% up to 3mm) 7. Matrix: fine- to medium-grained 8. Secondary Minerals: a few dark red minerals, FeOH 9. Encrustations: very thin <0.2mm Mn coating 10. Comment: probably rich in Bi, could be felsic, magnetic. Consider dropstone origin	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-22-1-5	1. Rock Type: plutonic, fresh 2. Size: 10.5x8x4 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: dark grey 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: 5 to 10mm long different minerals. Some are black, others black-greenish, small Qtz. Difficult to differentiate because of overall dark color of the rock 7. Matrix: medium- to coarse-grained 8. Secondary Minerals: none 9. Encrustations: up to 9mm Mn crust 10. Comment: somehow looks like Larvikite/Anorthosite (with Labradorite). Likely a dropstone but has relatively thick Mn crust!	x							
M168-22-1-6	1. Rock Type: plutonic, fresh 2. Size: 7.5x5.5x4 cm 3. Shape / Angularity: angular 4. Color of cut surface: salt-pepper colored (white-black) 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: Pl up to 4mm, >30-40%; Px up to 2mm, >40% 7. Matrix: medium- to coarse-grained 8. Secondary Minerals: none 9. Encrustations: Mn coating < 0.5mm 10. Comment: 45% white, 55% black, dropstone or/and gabbro/diorite	x							

M168-23-1



Description of Location and Structure:

King's Trough, N-flank. Central part lower section, a few nm E of Cann and Kidd stations

Dredge on bottom UTC 20/11/20 14:46 hrs, lat 43°49.63'N, long 21°49.07'W depth 4051 m

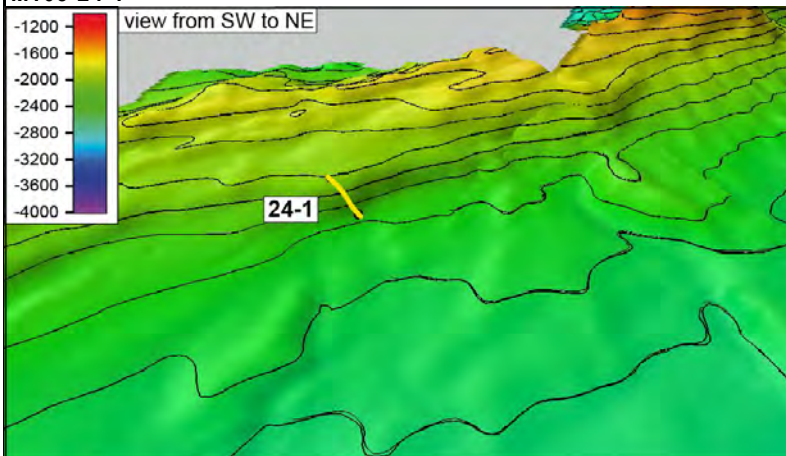
Dredge off bottom UTC 20/11/20 16:11 hrs, lat 43°50.05'N, long 21°49.19'W, depth 3548 m

total volume: three rocks

Comments: sedimentary dropstones; all discarded

M168 Dredge Station Details and Rock Description

M168-24-1



Description of Location and Structure:

King's Trough northern flank.

Summit of smt opposite to Antialtair Smt. at the southern margin of King's Trough

Dredge on bottom UTC 20/11/20 20:13 hrs, lat 43°59.48'N, long 21°48.01'W depth 2287 m





Dredge off bottom UTC 20/11/20 21:28 hrs, lat 43°59.80'N, long 21°47.97'W, depth 2032 m

total volume: one large block of breccia and few smaller volcanic


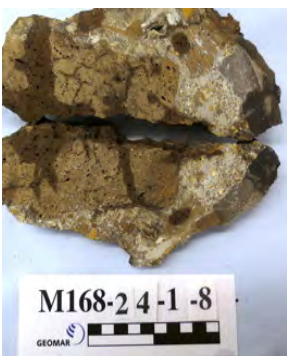


Comments: Loose volcanic rocks #1 to #5, comprising slightly altered Ol phyric lava (#1), moderately altered lava (#2 & 3) and altered slightly Pl phyric varieties (#4 & #5). Samples #6 to #12 are volcanic clasts from breccia block A and #13 & #14 are representative pieces of this breccia. The volcanic clasts are variably altered, slightly Pl phyric lavas but #8 are two aphyric lava clasts of brown and grey color. The breccia and its clasts are of interest as they document older local erosion and lithification whereas the single volcanic rocks seem to be younger debris.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-24-1-1	1. Rock Type: volcanic, phyric lava, slightly altered 2. Size: 9x8x6.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: phyric, 10% vesicles 6. Phenocrysts: Ol (10%, 1mm) altered 7. Matrix: fine-grained 8. Secondary Minerals: none 9. Encrustations: none 10. Comment: enclosed a volcanoclastic piece	x	x						
M168-24-1-2	1. Rock Type: volcanic, aphyric lava, moderately altered 2. Size: 13x9x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown 5. Texture / Vesicularity: aphyric, 15% vesicles up to 2mm, partly filled with Cc 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: Cc filling vesicles 9. Encrustations: partly Mn encrusted up to 1mm	x	x						





M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-24-1-3	1. Rock Type: volcanic, aphyric lava, moderately altered 2. Size: 11x8x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown 5. Texture / Vesicularity: aphyric, 15% vesicles up to 1mm, partly filled 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: Cc filling vesicles like -2 but more altered overall 9. Encrustations: Mn crust up to 10mm 10. Comment: phyrice, elongated vesicles, highly vesicular	x	x						
M168-24-1-4	1. Rock Type: volcanic, phyrice lava, slightly altered 2. Size: 13x7x4.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish to light brown 5. Texture / Vesicularity: phyrice, no vesicles 6. Phenocrysts: elongated white Pl laths up to 2mm, <1%; black and brown minerals 7. Matrix: fine-grained 8. Secondary Minerals: none 9. Encrustations: Mn crust in places mm	x	x						
M168-24-1-5	1. Rock Type: volcanic, altered 2. Size: 10.5x9x6 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: brownish 5. Texture / Vesicularity: phyrice, no vesicles 6. Phenocrysts: white Pl needles < 2mm, <1% 7. Matrix: fine-grained 8. Secondary Minerals: oxidized gm 9. Encrustations: thin Mn coating	x	x						
M168-24-1-6	1. Rock Type: volcanic, mildly altered; clast from block A 2. Size: 12x8x5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: phyrice, 15% vesicles, elongated 0.5-2mm 6. Phenocrysts: white Pl needles (15%, < 3mm) 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: thin Mn coating 10. Comment: bloc A = conglomerate, original size 52x47x22 cm	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-24-1-7	1. Rock Type: volcanic, altered, clast from bloc A 2. Size: 8.5x6x4.5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: brown, redish tint 5. Texture / Vesicularity: phyric, 15-20% vesicles, elongated 0.5-2mm 6. Phenocrysts: white Pl needles (5%, < 3mm), some could be filled vesicles 7. Matrix: fine-grained, altered 8. Secondary Minerals: - 9. Encrustations: thin Mn coating 10. Comment: bloc A = conglomerate, original size 52x47x22 cm	x	x						
M168-24-1-8	1. Rock Type: breccia, matrix supported with large cm sized clasts, piece from bloc A 2. Size: 20x11x11 cm 3. Shape / Angularity: angular 4. Color of cut surface: two large clasts brown and grey to be probed for chemistry. Fine grained multi-colored matrix 5. Texture / Vesicularity: breccia, matrix supported 6. Phenocrysts: 7. Matrix: coarse-grained matrix 8. Secondary Minerals: none 10. Comment: two large clasts: 1 = brown large elongated vesicles, phyric, similar to sample -3; 2 = grey phyric similar to sample -6	x: for each clast	x: for each clast					Clast A = brown, Clast B = grey	
M168-24-1-9	1. Rock Type: clast from breccia bloc A, volcanic, mildly altered 2. Size: 9.5x5x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey - yellow tint 5. Texture / Vesicularity: Pl phyric, low vesicularity <1% 6. Phenocrysts: Pl (10%, <2mm) 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: thin Mn coating	x	x						
M168-24-1-10	1. Rock Type: clast from breccia bloc A, volcanic, altered 2. Size: 5x3.5x3.5 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: grey - yellow tint 5. Texture / Vesicularity: slightly phyric, no vesicles 6. Phenocrysts: Pl needles (<1%, <1mm) 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: thin Mn coating	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-24-1-11	1. Rock Type: clast from breccia bloc A, volcanic, mildly altered 2. Size: 6x4.5x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: uncut; grey - yellow tint 5. Texture / Vesicularity: phyrlic, no vesicles 6. Phenocrysts: Pl needles but piece was uncut 7. Matrix: fine-grained 9. Encrustations: thin Mn coating 10. Comment: needs to be cut; presumably like sample -10								
M168-24-1-12	1. Rock Type: clast from breccia bloc A, volcanic, altered 2. Size: 11x7x6.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish-yellowish tint; mud- like 5. Texture / Vesicularity: phyrlic, low vesicularity 6. Phenocrysts: Pl (10-20%, 1-3mm) 7. Matrix: fine-grained, brown highly altered / oxidized 8. Secondary Minerals: oxidized gm 9. Encrustations: none								
M168-24-1-13	1. Rock Type: breccia, piece from bloc A 2. Size: 16x10x10 cm 3. Shape / Angularity: angular 4. Color of cut surface: multicolored greyish matrix 5. Texture / Vesicularity: coarse grained matrix <4mm, large clasts <3cm. clast 1: brown, phyrlic, highly vesicular, clast 2: brown, dense, mostly aphyric, few but large vesicles, clasts 3: grey, phyrlic, vesicular 9. Encrustations: thin Mn coating								
M168-24-1-14	1. Rock Type: breccia, piece from bloc A 2. Size: 18x102x12 cm 3. Shape / Angularity: angular 4. Color of cut surface: multicolored breccia 5. Texture / Vesicularity: coarse grained matrix diverse clasts. Some clasts are partly rounded, some clasts are part of an older breccia. clast 1: breccia, dense, fine-grained matrix, large angular clasts, clast 2: brown, dense, aphyric, clasts 3: grey-reddish, aphyric, vesicular, clast 4: grey, vesicular, aphyric								

M168 Dredge Station Details and Rock Description

M168-25-1

A bathymetric map showing depth contours from -1000 to -5000 meters. A yellow line labeled '25-1' indicates the dredge track. The view is from SSE to NNW.





Description of Location and Structure:
NW King's Trough along its NE flank. SW dipping slope at base. Track runs across small nose.

Dredge on bottom UTC 21/11/20 02:01 hrs, lat 43°50.24'N, long 21°54.49'W depth 4320 m
Dredge off bottom UTC 21/11/20 03:31 hrs, lat 43°50.61'N, long 21°54.45'W, depth 3964 m
total volume: 1/4 full





Comments: two large blocks and numerous smaller rocks recovered. Almost all of them are angular to subangular and appear fractured. On the fractured rocks striations from brittle faulting visible. Recovered lithologies are broadly subdivided into fairly fresh plutonics / subvolcanics (#1 to #6) with variable proportions Pl & Px, slightly to moderately altered volcanics (#7 to #9 and #17) plus a strongly altered phyrlic lava (#16). Intriguing rocks are #10 and #11 which consist of volcanics and fully crystalline parts that resemble intrusions. The crystalline are fractured and resemble a cataclasite. #12 is another subvolcanic rock but with abundant altered Ol. Pegmatitic rocks are sampled by #13 & #14.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-25-1-1	1. Rock Type: igneous, probably subvolcanic, slightly altered, pieces of block A 2. Size: 25x22x12 cm pile of several pieces, block A: 37x25x25 cm 3. Shape / Angularity: block A was angular, lots of fractures make rock split up into angular pieces 4. Color of cut surface: dark grey 5. Texture / Vesicularity: massive / non vesicular 6. Phenocrysts: appears holocrystalline with equigranular minerals; likely Px + Pl, 50:50, <1mm 7. Matrix: medium-grained 8. Secondary Minerals: none 9. Encrustations: thin <0.2mm Mn coating 10. Comments: angularity and thin Mn coating speaks against dropstone. Abundant fractures consistent with fault environment. Rock would have been broken up if ice rafted. Probably subvolcanic, dike?	x	x						




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-25-1-2	1. Rock Type: igneous, probably subvolcanic, fresh, pieces of block B 2. Size: 17x14x7 cm & 14x10x8 cm pieces from block B: 40x35x18 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: light grey 5. Texture / Vesicularity: massive / non vesicular 6. Phenocrysts: Ol <5mm, Pl <4mm, Px <1mm 7. Matrix: fine- to medium-grained 8. Secondary Minerals: none 9. Encrustations: ~1mm Mn coating 10. Comments: large Ol	x	x						
M168-25-1-3	1. Rock Type: intrusive / subvolcanic, quite fresh 2. Size: 8x5x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey (blueish) 5. Texture / Vesicularity: massive / non vesicular 6. Phenocrysts: Pl + Px, 60:40, <2mm 7. Matrix: medium-grained 8. Secondary Minerals: none 9. Encrustations: thin Mn coating	x	x						
M168-25-1-4	1. Rock Type: intrusive / subvolcanic, slightly altered 2. Size: 8x5x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey (blueish) 5. Texture / Vesicularity: massive / non vesicular 6. Phenocrysts: Pl (>15%, <2mm); Ol (>5%, <2mm) 7. Matrix: fine- to medium-grained 8. Secondary Minerals: 9. Encrustations: very thin Mn coating	x							
M168-25-1-5	1. Rock Type: intrusive / subvolcanic, relatively fresh 2. Size: 11x6x4 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey (blueish) 5. Texture / Vesicularity: massive / non vesicular 6. Phenocrysts: Pl + Px, 70:30 7. Matrix: fine- to medium-grained 8. Secondary Minerals: few cracks and veins filled with white / yellowish minerals 9. Encrustations: none	x							



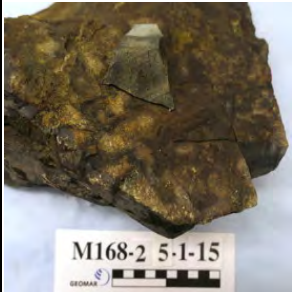

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-25-1-6	1. Rock Type: intrusive / subvolcanic, slightly altered 2. Size: 10x6x3 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey, dark grey patches 5. Texture / Vesicularity: massive / non vesicular 6. Phenocrysts: Pl (25%), Px (5%), altered Ol? 7. Matrix: fine- to medium-grained 8. Secondary Minerals: vein filled with white mineral 9. Encrustations: Mn coating (<0.2mm) 10. Comments: Ol?	x							
M168-25-1-7	1. Rock Type: volcanic, slightly altered 2. Size: 8x6x4 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / 1% vesicles <1mm 6. Phenocrysts: Ol (1%, <1mm); Pl (~2%, <1mm) 7. Matrix: fine-grained 8. Secondary Minerals: dark red / orange Fe mineral up to 1mm ø, "swimming" in matrix 9. Encrustations: Mn coating up to 1mm 10. Comments: Ol?	x	x						
M168-25-1-8	1. Rock Type: volcanic, moderately altered 2. Size: 13x6x7 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish with yellow to greenish patches, small vein whitish and salmon like color 5. Texture / Vesicularity: non vesicular, small cracks. cut surface: oddly altered looking sample due to cutting. fresh broken surface: crystalline 6. Phenocrysts: 7. Matrix: medium- grained, patchy alteration but homogeneous mineral distribution 8. Secondary Minerals: patchy alteration of Pl 9. Encrustations: thin Mn coating 10. Comments: pegamite facies								
M168-25-1-9	1. Rock Type: volcanic, moderately altered 2. Size: 23x18x7 cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: greyish darker and lighter patches 5. Texture / Vesicularity: non vesicular, few cracks. 6. Phenocrysts: presumably large crystals 7. Matrix: medium-grained 8. Secondary Minerals: patchy alteration, cracks filled with white / yellowish minerals, altered Pl 9. Encrustations: <2mm Mn crust 10. Comments: magnetic! pegamite facies	x							


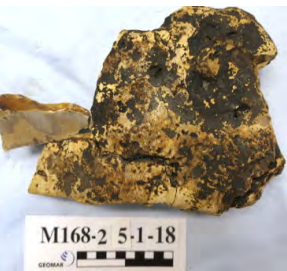
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-25-1-10	<p>1. Rock Type: magmatic rock, two parts. One part 60% volcanic, the other part is crystalline, moderately altered</p> <p>2. Size: 14x9x6 cm</p> <p>3. Shape / Angularity: angular</p> <p>4. Color of cut surface: grey mostly; crystalline part white and salmon like color</p> <p>5. Texture / Vesicularity: non-vesicular, mostly massive, crstalline part shows some cracks</p> <p>6. Phenocrysts: none</p> <p>7. Matrix: mostly fine- to medium-grained in crystalline part</p> <p>8. Secondary Minerals: cracks filled with orange / white / yellowish minerals</p> <p>9. Encrustations: thin Mn coating</p> <p>10. Comments: Conspicuous; rock has two different looking parts. Aphyric volcanic with faulted material attached</p>	x	x						
M168-25-1-11	<p>1. Rock Type: magmatic rock, volcanic, two parts, slightly altered. Volcanic rock with cataclasite attached.</p> <p>2. Size: 16x10x4 cm</p> <p>3. Shape / Angularity: subangular to angular</p> <p>4. Color of cut surface: mostly grey, some salmon like colored patches in part two, Fsp?</p> <p>5. Texture / Vesicularity: non-vesicular, cracks</p> <p>6. Phenocrysts: none</p> <p>7. Matrix: mostly fine-grained (70%), medium-grained in part two (30%)</p> <p>8. Secondary Minerals: cracks filled orange / white / yellowish minerals. altered Fsp</p> <p>9. Encrustations: thin Mn coating</p> <p>10. Comments: Conspicuous; rock has two different looking parts (70:30). aphyric volcanic with faulted, cataclastic material attached</p>	x	x						
M168-25-1-12	<p>1. Rock Type: subvolcanic rock / intrusive</p> <p>2. Size: 8x5x5 cm</p> <p>3. Shape / Angularity: angular</p> <p>4. Color of cut surface: grey, yellowish / greenish grey around cracks, fluids?</p> <p>5. Texture / Vesicularity: massive / non-vesicular</p> <p>6. Phenocrysts: Pl (40%, <2mm), altered Ol (>30%, <1mm), some Px (<1%, up to 5mm)</p> <p>7. Matrix: fine- to medium-grained</p> <p>8. Secondary Minerals: green / yellow minerals in and around cracks</p> <p>9. Encrustations: negligible Mn coating</p> <p>10. Comments: a lot of Ol</p>	x	x						

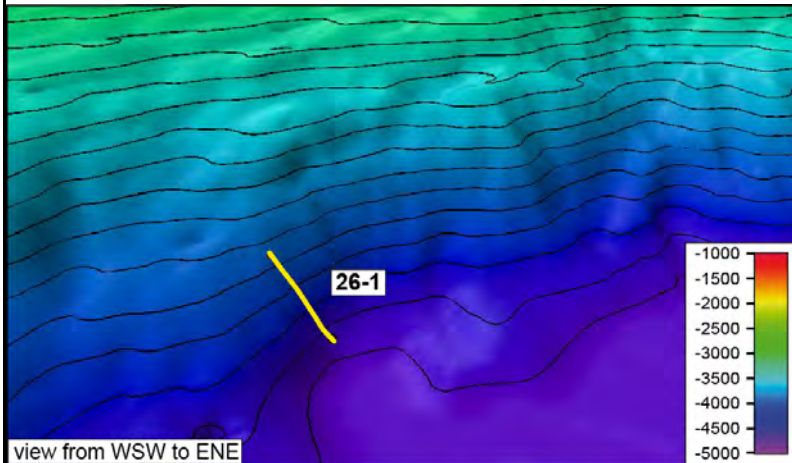
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-25-1-13	<ol style="list-style-type: none"> 1. Rock Type: magmatic rock, coarse, fully crystalline, maybe a pegmatite, slightly altered 2. Size: 18x14x12cm 3. Shape / Angularity: angular to subrounded 4. Color of cut surface: greenish grey, partly salmon colored 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: rock is mostly made of coarse grained Fsp (>80%), grey to salmon colored 7. Matrix: coarse-grained 8. Secondary Minerals: dark-red Fe mineral <1%, <1mm, Mn dendrites 9. Encrustations: 0-2mm Mn crust 								
M168-25-1-14	<ol style="list-style-type: none"> 1. Rock Type: magmatic rock, pegmatite like, slightly altered to altered 2. Size: 12x9x6cm 3. Shape / Angularity: angular 4. Color of cut surface: greenish grey to green 5. Texture / Vesicularity: non-vesicular, looks sheared 6. Phenocrysts: mostly Fsp, some Px, a few Ol 7. Matrix: medium- to coarse-grained 8. Secondary Minerals: many cracks filled with white & green minerals, strong alteration of the rocks around some cracks (fluid pathways) 9. Encrustations: Mn coating <0.2mm 								
M168-25-1-15	<ol style="list-style-type: none"> 1. Rock Type: magmatic rock, quite altered 2. Size: 23x22x14cm 3. Shape / Angularity: subangular to angular 4. Color of cut surface: greenish grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: mostly greenish altered Fsp / Pl (50%) 7. Matrix: medium-grained 8. Secondary Minerals: white / green, yellowish filled cracks 9. Encrustations: 1-3mm Mn coating 								
M168-25-1-16	<ol style="list-style-type: none"> 1. Rock Type: volcanic, highly phyric, relatively altered 2. Size: 7x5x4cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: 1% vesicles 6. Phenocrysts: Px (5%, up to 4mm), Pl (3-5%, up to 3mm), both still fresh. Strongly altered mineral was probably Ol (~10%, up to 5mm) 7. Matrix: fine-grained 8. Secondary Minerals: some vesicles filled with yellow / orange material 9. Encrustations: Mn coating <0.2mm 	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-25-1-17	1. Rock Type: volcanic, sparsely phyric, slightly altered 2. Size: 6x6x5cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: light grey 5. Texture / Vesicularity: 5-7% vesicles up to 2mm 6. Phenocrysts: Ol up to 5mm, Pl up to 2mm, together 1-2% 7. Matrix: fine- grained 8. Secondary Minerals: white vesicle fillings, probably some black filled vesicles too 9. Encrustations: Mn coating <0.2mm 10. Comments: Ol!	x	x						
M168-25-1-18	1. Rock Type: sediment, Cc crust 2. Size: 28x14x5cm 3. Shape / Angularity: subrounded 4. Color of cut surface: beige to grey brown 5. Texture / Vesicularity: 6. Phenocrysts: 7. Matrix: very fine-grained (clay fraction) 8. Secondary Minerals: Mn dendrites 9. Encrustations: Mn coating <0.5 mm 10. Comments: Cc crust, fizzes with HCl, possibly also contains chert fragments								

M168-26-1



Description of Location and Structure:
 King's Trough, NW basin at NE flank. S-facing slope covers lowermost section




Dredge on bottom UTC 21/11/20 06:49 hrs, lat 43°55.80'N, long 21°59.83'W depth 4442 m

Dredge off bottom UTC 21/11/20 08:04 hrs, lat 43°56.29'N, long 21°59.73'W, depth 4103 m




total volume: a few rocks

Comments: 8 relatively fresh volcanics and a single greenish volcanoclastic sediment recovered. All volcanics are highly Ol + Pl phyric in variable proportions and mostly relatively fresh (#1 to #8). Fresh Ol described in #1. The base of the slope at this site appears to consist of Ol+Pl phyric lava.




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-26-1-1	1. Rock Type: volcanic, highly phyric, quite fresh 2. Size: 14x8.5x13 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: <1% vesicles 6. Phenocrysts: Ol (10%, up to 4mm); Pl (10-15%, up to 4mm) 7. Matrix: fine-grained 8. Secondary Minerals: white mineral in cracks 9. Encrustations: thin Mn coating <0.2 mm 10. Comments: fresh Ol!	x	x						
M168-26-1-2	1. Rock Type: volcanic, highly phyric, quite fresh 2. Size: 10x4x3.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: Ol (10%, up to 4mm); Pl (10%, up to 3mm) 7. Matrix: fine-grained 8. Secondary Minerals: white / red in cracks; dark red Fe-mineral as grains 9. Encrustations: Mn coating <0.2 mm 10. Comments: Ol!	x							
M168-26-1-3	1. Rock Type: volcanic, highly phyric, relatively fresh 2. Size: 8.5x3.5x6 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: Ol (10%, <6mm); Pl (5-10%, <5mm), Px (<1%, <4mm) 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: basically no coating, slickenside-like outer layer 10. Comments: Ol	x	x						

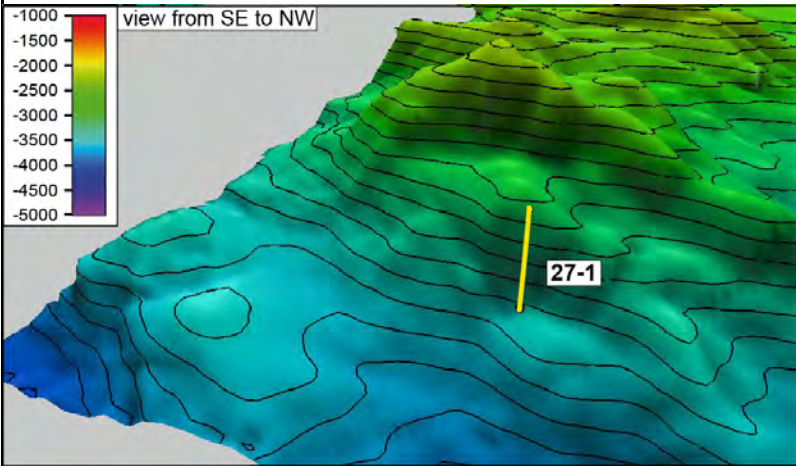

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-26-1-4	1. Rock Type: volcanic, highly phyric, slightly altered 2. Size: 8x6.5x4.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish / grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: Ol up to 4 mm; Pl up to 6 mm) 7. Matrix: fine-grained 8. Secondary Minerals: cracks filled with white to grey mineral, a few small metallic / golden grains (pyrite?) 9. Encrustations: thin Mn coating <0.2 mm; patches of white-crystalline coating 10. Comments: altered in patches (brown). Looks like sample is highly phyric but cut surface seems unrepresentative	x	x						
M168-26-1-5	1. Rock Type: volcanic, highly phyric, relatively fresh 2. Size: 6x4.5x3 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey with dark grey and beige minerals 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: Ol (10-15% up to 4 mm); Pl (10-15% up to 3 mm; Px ~1% 7. Matrix: fine-grained 8. Secondary Minerals: a few cracks filled with white mineral 9. Encrustations: thin Mn coating <0.2 mm; white-crystalline coating in patches 10. Comments: Ol								
M168-26-1-6	1. Rock Type: volcanic, highly phyric, relatively fresh 2. Size: 7.5x3x4 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: Ol (10-15% up to 5 mm); Pl (~10% up to 5 mm) 7. Matrix: fine-grained 8. Secondary Minerals: red Fe mineral in core of big phenocrysts, cracks filled with white mineral 9. Encrustations: no Mn coating, patchy white crystalline coating, shiny slickenside-like layer 10. Comments: Ol								





M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-26-1-7	1. Rock Type: volcanic, highly phyrlic, relatively fresh 2. Size: 7.5x4x4 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: Ol (10-15% up to 6 mm); Pl (~10% up to 4 mm), Px ~1% 7. Matrix: fine-grained 8. Secondary Minerals: white cracks 9. Encrustations: no Mn coating, white crystalline coating 10. Comments: Ol								
M168-26-1-8	1. Rock Type: volcanic, highly phyrlic, relatively fresh 2. Size: 5x6x4 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: Ol (10% up to 5 mm); Pl (5-10% up to 3 mm) 7. Matrix: fine-grained 8. Secondary Minerals: white cracks 9. Encrustations: Mn coating <0.2mm, white crystalline coating 10. Comments: Ol								
M168-26-1-9	1. Rock Type: volcanoclastic? sediment, brecciated 2. Size: 14x10.5x8.5 cm 3. Shape / Angularity: brecciated, subrounded 4. Color of cut surface: blueish - green 5. Texture / Vesicularity: 6. Phenocrysts: 7. Matrix: mostly fine-grained blue green stuff (clay fraction) 8. Secondary Minerals: 9. Encrustations: thin Mn coating <1 mm 10. Comments: brecciated sediment with some magmatic clasts, blueish-green color --> glauconite/chlorite, could be volcanoclastic								

M168 Dredge Station Details and Rock Description

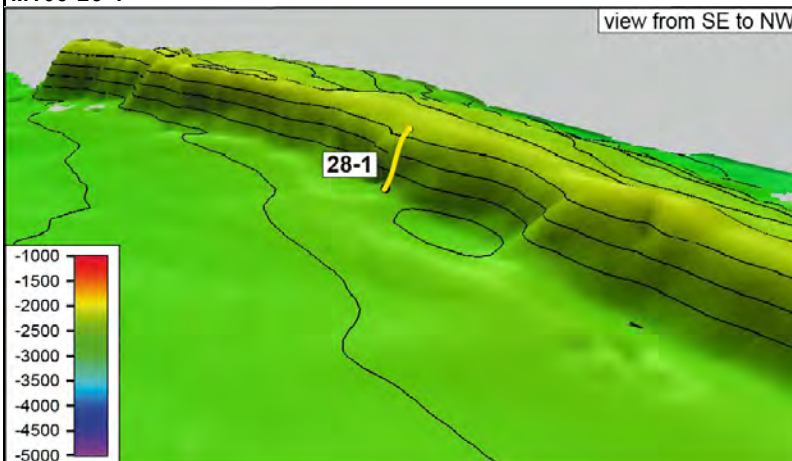
M168-27-1 		Description of Location and Structure: King's Trough, N-flank. WNW-ESE striking ridge-like feature (fault scarp) on KT flank. Middle part of S-facing slope							
<p>Dredge on bottom UTC 21/11/20 11:52 hrs, lat 43°55.25'N, long 22°08.04'W depth 3410 m Dredge off bottom UTC 21/11/20 15:23 hrs, lat 43°55.59'N, long 22°08.06'W, depth 3390 m <i>total volume: few rocks</i> <i>Comments: Three volcanic rocks and three dropstones (granite, gneiss and quartzite). The latter were discarded. Distinguishing dropstones from in-situ rocks is difficult because most volcanic rocks are relatively rounded beach pebbles (from above?) and a heterogeneous assemblage. #1 is a mainly fresh, near aphyric lava fragment with striations of unclear origin (tectonic vs glacial) but the rock is too angular for a dropstone. #2 is a highly phyrlic (30%) volcanic rock with Pl and Px? phenocrysts. Its rounded appearance and thin Mn coating make a dropstone origin likely but could be a beach cobble as well. #3 is a rounded, medium to coarse grained volcanic rock with unspecified mineralogy. Dropstone origin cannot be ruled out with certainty.</i></p>									
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-1-27-1	1. Rock Type: volcanic, sparsely phyrlic, mainly fresh 2. Size: 7x8x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: dense, no vesicles, flow texture? 6. Phenocrysts: <1%, max 1mm long, black green partly surrounded by white minerals (Pl?) 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: almost no Mn-crust 10. Comments: possible striations?, polished surface?. But too angular to be a dropstone	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-1-27-2	1. Rock Type: volcanic, phyrlic, slightly altered 2. Size: 5x4x5 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: bronish grey 5. Texture / Vesicularity: phyrlic, no vesicles 6. Phenocrysts: 30%, white elongated, black green, brown spots (altered?), rectangle black white elongated (Fsp?) max. 1mm long, black green partly surrounded by white minerals (Pl?), 1 x 10mm 7. Matrix: medium-grained 8. Secondary Minerals: 9. Encrustations: Mn-crust <1mm 10. Comments: Most likely not a dropstone, despite rounded shape and thin Mn coating	x	x						
M168-1-27-3	1. Rock Type: phaneritic, dense igneous rock 2. Size: 5x8x4 cm 3. Shape / Angularity: rounded 4. Color of cut surface: greenish - grey 5. Texture / Vesicularity: no vesicles, green, black, white minerals 6. Phenocrysts: black / white Pl?, bronze colored ore mineral 7. Matrix: medium- to coarse-grained 8. Secondary Minerals: 9. Encrustations:very Mn coating 10. Comments: dropstone can not be ruled out	x							
M168-1-27-4	1. Rock Type: volcanoclastic, altered 2. Size: 5x5x2 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown, orange, white 5. Texture / Vesicularity: clastic, vesicularity 1%, 1mm ø 6. Phenocrysts: 7. Matrix: 8. Secondary Minerals: 9. Encrustations: no crust								
M168-1-27-5	1. Rock Type: Quartz vein 2. Size: 8x5x3 cm 3. Shape / Angularity: subangular 4. Color of cut surface: white, yellow 5. Texture / Vesicularity: 6. Phenocrysts: 7. Matrix: 8. Secondary Minerals: 9. Encrustations: partly thin Mn crust 10. Comments: on one side remaining country rock (possibly schist) or dense aphyric volcanic is still attached. Possibly dropstone								

M168 Dredge Station Details and Rock Description

M168-28-1



Description of Location and Structure:

Summit of smt opposite to Antialtair Smt (N of it) on E flank of King's Trough. Small but steep step on summit (similar to station -24 but much further NW of it).

Dredge on bottom UTC 21/11/20 20:09 hrs, lat 44°11:01'N, long 22°08.56'W depth 2490 m




Dredge off bottom UTC 21/11/20 21:13 hrs, lat 44°11.31'N, long 22°08.55'W, depth 2181 m

total volume: few rocks

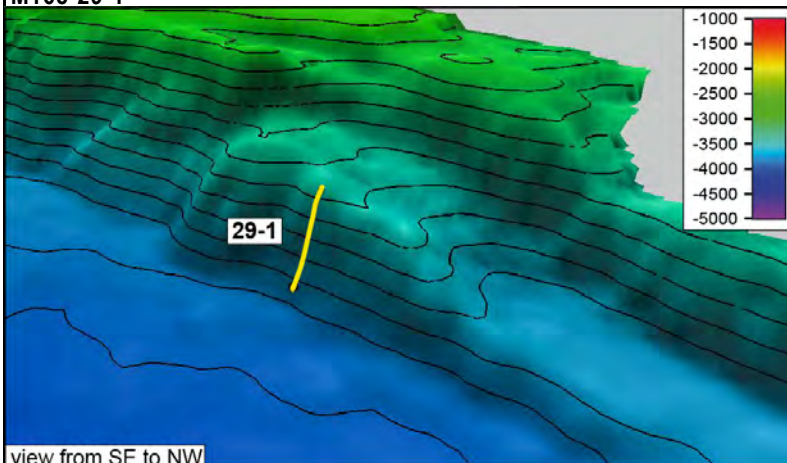
Comments: two large blocks A (25x21x16) and B (22x14x15) were recovered but description lacks info if samples originate from these blocks. Sample #1 to #4 are vesicular lava, variably altered (slight to moderately) and about 5% Ol and /or Px phenocrysts. #4 may contain bits of fresh glass. Unfortunately pictures were taken of the wet rocks and thus hardly anything is visible.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-28-1-1	1. Rock Type: volcanic, vesicular basalt, slightly altered 2. Size: 19x9x25 cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey 5. Texture / Vesicularity: phyric, vesicularity 15%, up to 1mm ø, partly filled with orange crystals or Cc 6. Phenocrysts: Px (5%) 7. Matrix: fine-grained 8. Secondary Minerals: Cc fillings 9. Encrustations: thick Mn crust >5cm 10. Comments: piece of sheet flow with chilled margin	x	x						
M168-28-1-2	1. Rock Type: volcanic, vesicular basalt, slightly to moderately altered 2. Size: 21x12x13 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown to dark grey 5. Texture / Vesicularity: vesicularity 5%, <1mm ø, less filling than in -1 6. Phenocrysts: 5%, likely altered Ol or Px 7. Matrix: fine-grained 8. Secondary Minerals: like -1 9. Encrustations: like -1; thick Mn crust >5cm	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-28-1-3	1. Rock Type: volcanic, vesicular basalt, moderately altered 2. Size: 10x23x15cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown to dark grey 5. Texture / Vesicularity: vesicularity 10%, up to 2mm ø, partly filled with orange crystals, few with Cc 6. Phenocrysts: 10%, 2-3mm, unidentified 7. Matrix: medium-grained 8. Secondary Minerals: like -1 9. Encrustations: like -1	x	x						
M168-28-1-4	1. Rock Type: volcanic, vesicular basalt, moderately altered; small sheets of fresh glass! 2. Size: 6x5x4cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown 5. Texture / Vesicularity: vesicularity 5%, <1mm, some filled 6. Phenocrysts: none 7. Matrix: fine-grained 8. Secondary Minerals: like -1 9. Encrustations: 1cm Mn crust 10. Comments: Check for fresh glass!	x	x		G I				
M168-28-1-5	1. Rock Type: Mn crust for reference 2. Size: 20x13x8cm 3. Shape / Angularity: 4. Color of cut surface: black 5. Texture / Vesicularity: no structure 6. Phenocrysts: 7. Matrix: fine-grained 8. Secondary Minerals: 9. Encrustations: 8cm Mn crust 10. Comments: no structure, massive, not magnetic								

M168-29-1



Description of Location and Structure:

King's Trough, NW basin, N flank. E-W striking step? Faults. Track targets lower fault along S-facing slope


M168 Dredge Station Details and Rock Description

Dredge on bottom UTC 22/11/20 03:25 hrs, lat 44°15.75'N, long 22°49.57'W depth 3920 m

Dredge off bottom UTC 21/11/20 04:38 hrs, lat 44°16.05'N, long 22°49.57'W, depth 3385 m

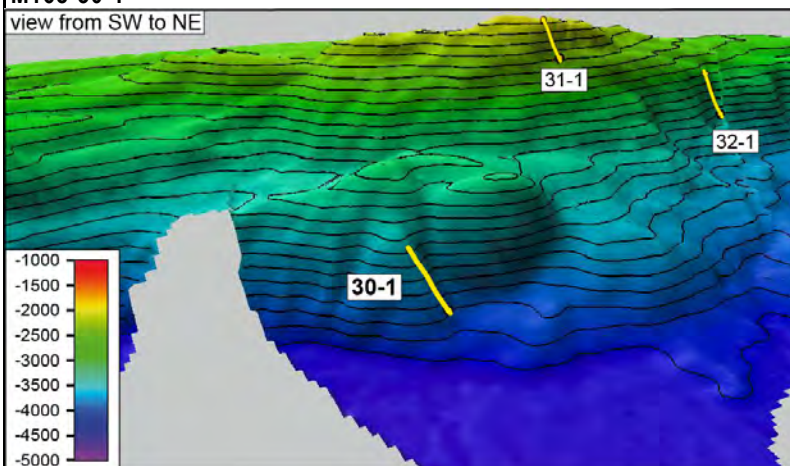
total volume: one rock

Comments: Ol phyric pillow basalt moderately altered. Freshly broken off from ground that coincides with single large 10t bite at 3709 m cable. Possibly fresh glass in chilled margin. 2-3 cm Mn encrusted.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	At/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-29-1-1	1. Rock Type: volcanic, pillow lava, freshly broken off the ground at 3709m cable length with 100kN released, moderately altered 2. Size: 21x21x15 cm 3. Shape / Angularity: Mn crust dominated surface but pillow shape still visible 4. Color of cut surface: greyish to brownish 5. Texture / Vesicularity: Ol phyric, vesicularity 15%, partly filled, well rounded vesicles 6. Phenocrysts: altered Ol (5%, ~1mm) 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, slightly oxidized gm, palagonite 9. Encrustations: 2-3cm Mn crust 10. Comments: pillow lava, chilled margins, clearly visible alteration halo, possibly fresh glass in chilled margins, small veins	x	x		G I				

M168-30-1

view from SW to NE



Description of Location and Structure:

King's Trough NW Trough, NE corner. Smt complex along N margin. Prominent lower plateau. Steep SE dipping slope above basin floor




Dredge on bottom UTC 22/11/20 08:40 hrs, lat 44°14.81'N, long 22°59.81'W depth 4114 m

Dredge off bottom UTC 22/11/20 10:11 hrs, lat 44°15.20'N, long 23°00.03'W, depth 3571 m



total volume: some rocks, two large blocks. A (25x20x17 cm) sediment / conglomerate, B (37x17x19 cm) sedimentary, non-lithified conglomerate that contains several igneous clasts.

Comments: Unfortunately it is not documented which samples are clasts from block A and B and which are solitary rocks. Only #4 is stated to be a clast from block B, though similar lithologies occur in #5 and #6. Dredge is heterolithological. #1 (fresh, moderately Pl + Px phyric), #2 (slightly altered, aphyric) and #12 (moderately altered, aphyric) lava fragments. Sample #4 to #7 are presumably all ultramafic, harzburgitic clasts from breccia Block B indicating exposure of mantle rocks nearby. #7 is described as highly Pl+Px phyric lava; dropstone origin unclear. #8 is a volcanoclastic rock while #9, #10 are leucocratic plutonic and metamorphic rocks respectively. Finally #11 is a silica rich limestone.




M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-30-1-1	1. Rock Type: volcanic, fresh, moderately phyrlic 2. Size: 18x13x8.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive / non-vesicular 6. Phenocrysts: Pl (5-10%, up to 5 mm), Px (1-5%, <1.5 mm) 7. Matrix: fine- to medium-grained 8. Secondary Minerals: a few dark red Fe-mineral grains <1mm 9. Encrustations: thin Mn coating <0.2mm 10. Comment: fresh Pl	x	x						
M168-30-1-2	1. Rock Type: volcanic, aphyric, brecciated, slightly altered 2. Size: 7.5x7x6.5 cm 3. Shape / Angularity: subangular, brecciated 4. Color of cut surface: light grey 5. Texture / Vesicularity: massive, <1% vesicles 6. Phenocrysts: Pl (1%, <1 mm, rarely up to 2mm) 7. Matrix: medium-grained 8. Secondary Minerals: many cracks, filled with orange mineral 9. Encrustations: very thin Mn coating <0.2mm 10. Comment:	x	x						
M168-30-1-3	1. Rock Type: igneous, fully crystalline, probably subvolcanic, relatively fresh 2. Size: 11x6.5x4.5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: greenish-grey 5. Texture / Vesicularity: massive, non-vesicular 6. Phenocrysts: aphyric; rock is made of Pl (80%, <1mm), Ol (<<1%; <1mm) 7. Matrix: fine- to medium-grained 8. Secondary Minerals: none 9. Encrustations: thin Mn coating <0.2mm 10. Comment: a lot of Pl	x	x						





M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-30-1-4	<p>1. Rock Type: volcanic?, intrusive?, highly phyric, quite altered, clast from block B</p> <p>2. Size: 37x17x19 cm original size of block B, no size provided for clast sample -4</p> <p>3. Shape / Angularity: subrounded clasts, rounded conglomerate</p> <p>4. Color of cut surface: grey and brown clasts</p> <p>5. Texture / Vesicularity: non-vesicular</p> <p>6. Phenocrysts: mostly consists of very altered Ol(?) and quite fresh Px up to 8mm. Altered and unaltered Px (greenish / fresh) together with orange altered Ol. Pl (5% up to 2mm)</p> <p>7. Matrix: mainly consists of coarse minerals, rather plutonic than volcanic</p> <p>8. Secondary Minerals: orange material replacing Ol</p> <p>9. Encrustations: thin Mn coating <0.2mm</p> <p>10. Comment: Px could be omphacite. Several magmatic clasts in this conglomerate wrapped individually. They resemble ultramafic plutonics sampled during SO249 at Shirshov Ridge in the Bering Sea and the Stalemate fracture zone in front of the Western Aleutians on the Pacific plate. Specifically the M168 rocks here petrographically resemble harzburgites of SO249.</p>	x	x						
M168-30-1-5	<p>1. Rock Type: highly phyric magmatic rock, quite altered, similar to -4</p> <p>2. Size: 10x9x3 cm</p> <p>3. Shape / Angularity: subangular</p> <p>4. Color of cut surface: grey and brown freckled</p> <p>5. Texture / Vesicularity: non-vesicular</p> <p>6. Phenocrysts: Ol orange, heavily altered + Px, rel. fresh, greenish up to 5 mm. Both make up ~80% of the rock. Pl 5%</p> <p>7. Matrix: mainly consists of coarse grained minerals</p> <p>8. Secondary Minerals: FeOH replacing Ol</p> <p>9. Encrustations: thin Mn coating</p> <p>10 Comments: Px may be omphacite, Ol doubtful. Probably a harzburgite.</p>	x							

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-30-1-6	1. Rock Type: highly phyric magmatic rock, quite altered, overall similar to -5 2. Size: 8.5x6x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey and brown freckled 5. Texture / Vesicularity: non-vesicular 6. Phenocrysts: Ol orange, heavily altered + Px, rel. fresh, greenish up to 10 mm. Both make up ~80% of the rock. Pl 5% 7. Matrix: mainly consists of coarse grained minerals 8. Secondary Minerals: see -5 9. Encrustations: see -5 10 Comments: see -5								
M168-30-1-7	1. Rock Type: highly phyric volcanic(?) rock, slightly altered 2. Size: 9.5x7x6 cm 3. Shape / Angularity: subangular 4. Color of cut surface: dark grey-black 5. Texture / Vesicularity: if volcanic, highly phyric, 45% phenocrysts, non-vesicular 6. Phenocrysts: Pl, white (20%, up to 5 mm) angular, Ol, orange altered (~5%, 2mm), Px?, black up to 1cm, brown material <5mm, maybe altered gm 7. Matrix: light grey, fine-grained 8. Secondary Minerals: veins filled with Cc 9. Encrustations: no crust								
M168-30-1-8	1. Rock Type: volcanoclastic?, moderately altered 2. Size: 25x20x17 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish with grey-black clasts 5. Texture / Vesicularity: clastic, non-vesicular 6. Phenocrysts: black mineral up to 5mm Px?, white crystallized groundmass in veins around other clasts, transparent Qtz? 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: - 10 Comments: piece from block B (37x17x19 cm)	x						piece from block B	

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-30-1-9	1. Rock Type: plutonic, inequigranular, dropstone? 2. Size: 6x6.5x3.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: center: inequigranular crystals, no clear mineral form \varnothing 3 mm, edges: smaller minerals, not clearly shaped, no vesicles 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: veins filled with Cc 9. Encrustations: thin Mn crust <1mm 10 Comments: dropstone? Larvikite / anorthosite with labradorite??	x							
M168-30-1-10	1. Rock Type: metamorphic rock? 2. Size: 6x4.5x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey white 5. Texture / Vesicularity: phyrlic with two (3cm) crystals without clear boundary, non-vesicular. 6. Phenocrysts: white phenocrysts, green dots (~1mm) Ol? 7. Matrix: fine-grained 8. Secondary Minerals: veins filled with Cc 9. Encrustations: thin Mn crust <1mm 10 Comments: if it would not be so angular a dropstone origin could be considered. However angular dropstones were found in other stations.								
M168-30-1-11	1. Rock Type: silicate-rich limestone 2. Size: 5.5x4x3.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: brownish-white 5. Texture / Vesicularity: massive, dense 6. Phenocrysts: - 7. Matrix: very fine-grained 8. Secondary Minerals: 9. Encrustations: thin Mn crust <1 mm								
M168-30-1-12	1. Rock Type: volcanic, moderately altered 2. Size: 8x7.5x1.5 cm 3. Shape / Angularity: angular 4. Color of cut surface: greenish, brownish-grey 5. Texture / Vesicularity: aphyric, non vesicular 6. Phenocrysts: - 7. Matrix: medium-grained 8. Secondary Minerals: - 9. Encrustations: partly very thin Mn crust	1							

M168 Dredge Station Details and Rock Description



M168-31-1
view from SE to NW

31-1

Legend: -1000, -1500, -2000, -2500, -3000, -3500, -4000, -4500, -5000

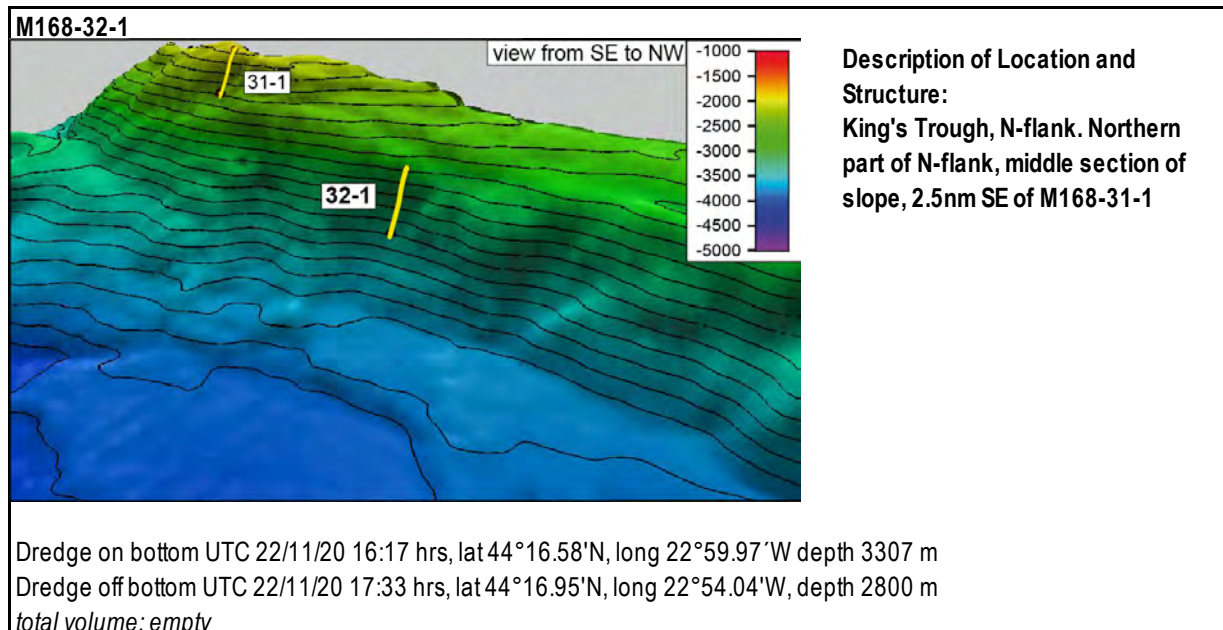
Description of Location and Structure:
King's Trough N-flank. Northern section of N-flank, upper part (top), ~3nm NE of M168-30-1

Dredge on bottom UTC 11/11/20 12:46 hrs, lat 44°17.08'N, long 22°56.77'W depth 2380 m
Dredge off bottom UTC 22/11/20 14:08 hrs, lat 44°17.42'N, long 22°56.84'W, depth 1960 m
total volume: few rocks
Comments: A single Px+Pl phyr, slightly altered lava fragment recovered. Other samples comprise volcanoclastics (#2) and Mn crust (#3, #4)

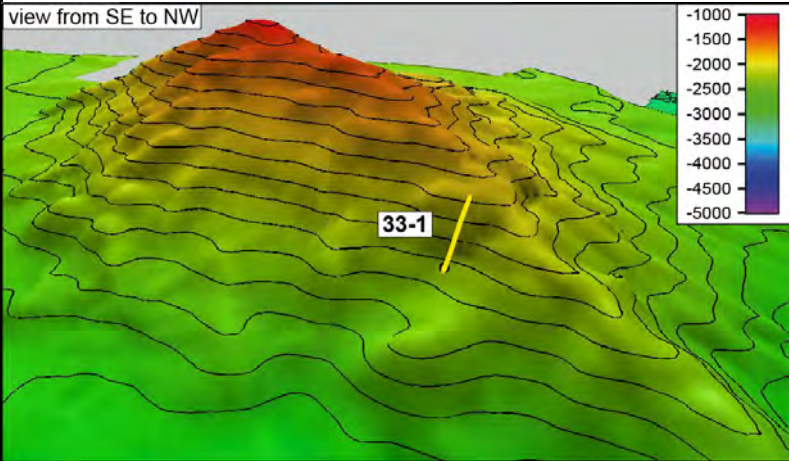

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-31-1-1	1. Rock Type: volcanic, sparsely phyr, slightly altered 2. Size: 10x7x2 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: phyr (~5%), vesicles only on the altered rim 6. Phenocrysts: Px, black up to 1 mm; Pl, white, roundish, ~1 mm 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: partly Mn encrusted up to 3 mm	x	x						
M168-31-1-2	1. Rock Type: volcanoclastic, altered 2. Size: 10x11x7 cm 3. Shape / Angularity: subangular 4. Color of cut surface: orange brown / dark grey 5. Texture / Vesicularity: clastic 6. Phenocrysts: Ol??, fresh?, green; Px black <1 mm; Pl transparent white ~2 mm 7. Matrix: - 8. Secondary Minerals: fillings and geodes with white transparent mineral (Cc, fizzes with 3% HCl) 9. Encrustations:	x							

M168 Dredge Station Details and Rock Description



SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-31-1-3	1. Rock Type: Mn crust 2. Size: 12x9x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: black with orange stripes 5. Texture / Vesicularity: layered, one phenocryst, space between layers partly filled with orange mineral 6. Phenocrysts: orange-whitish mineral 3x10 mm, green mineral <1 mm in orange matrix 7. Matrix: - 8. Secondary Minerals: 9. Encrustations:								 <p style="text-align: center;">M168-31-1-3</p> <p style="text-align: center;"><small>GEOMAR</small></p>
M168-31-1-4	1. Rock Type: Mn crust, like -3 2. Size: 10x6x4 cm 10. Comments: similar to -3								 <p style="text-align: center;">M168-31-1-4</p> <p style="text-align: center;"><small>GEOMAR</small></p>



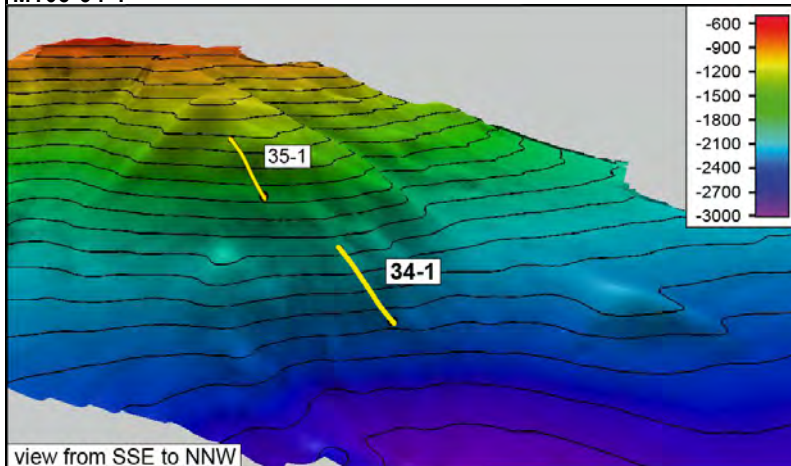
M168 Dredge Station Details and Rock Description

<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="width: 60%;"> <p>M168-33-1 view from SE to NW</p>  </div> <div style="width: 35%;"> <p>Description of Location and Structure: Gnitsevich Seamounts. Eastermost smt, central section of S-flank</p> </div> </div>									
<p>Dredge on bottom UTC 23/11/20 03:19 hrs, lat 44°38.43'N, long 24°17.83'W depth 2252 m Dredge off bottom UTC 23/11/20 00:50 hrs, lat 44°38.77'N, long 24°17.83'W, depth 1897 m total volume: few rocks Comments: Most are rounded dropstones ranging from granitic, gneissic, meta-sedimentary, one angular amphibolite-like rock. Sampled rocks are Cc crust, cherty Cc and one volcanoclastic with some fresh, greenish Px. Dredge sampled encrusted slope with abundant dropstones.</p>									
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-33-1-1	<ol style="list-style-type: none"> 1. Rock Type: volcanoclastic, pumiceous, strongly altered but with rare, fresh Px, dark green, 1-3 mm 2. Size: 8x5.5x3 cm 3. Shape / Angularity: rounded to subangular 4. Color of cut surface: dark brown to red-brown 5. Texture / Vesicularity: highly vesicular, mm sized clast (pumice?), overall clast supported 6. Phenocrysts: rare Px (<<1%, ≤ 1-3 mm), fresh, dark green; maybe good for EMP and LA-ICPMS. A single more fresher clast with grey groundmass contains white filled vesicles? that may also be Pl. Some orange spots may be altered Ol. 7. Matrix: highly vesicular 8. Secondary Minerals: thoroughly oxidized gm, altered Ol 9. Encrustations: <5 mm Mn crust on one side 10. Comments: The fresh Px may be good for spot analysis to retrieve some petrological information 				large, fresh Px				

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-33-1-2	1. Rock Type: Cc crust with abundant worm burrows / holes 2. Size: 16x9x4 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: white to greyish with black spots 5. Texture / Vesicularity: dense Cc but with 50%, ø 5-10 mm worm burrows 6. Phenocrysts: - 7. Matrix: very fine-grained 8. Secondary Minerals: 9. Encrustations: Mn coating, except underside which is freshly broken off the ground								
M168-33-1-3	1. Rock Type: dense cherty Cc, fizzes with 3% HCl 2. Size: 6x5.5x2 cm 3. Shape / Angularity: angular 4. Color of cut surface: light grey to white 5. Texture / Vesicularity: massive / dense 6. Phenocrysts: - 7. Matrix: very fine-grained 8. Secondary Minerals: - 9. Encrustations: no Mn coating, except underside which is freshly broken off 10. Comments: likely a dropstone								

M168-34-1





Description of Location and Structure:
Gnitsevich Seamounts. Central smt, SE flank, lower slope

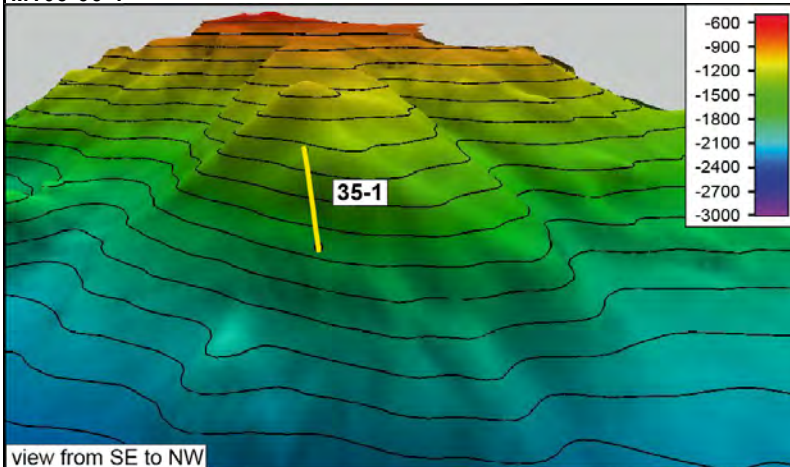
Dredge on bottom UTC 23/11/20 11:30 hrs, lat 44°29.38'N, long 25°11.62'W depth 2360 m
 Dredge off bottom UTC 23/11/20 12:49 hrs, lat 44°29.55'N, long 25°12.12'W, depth 1980 m
 total volume: 1/5 full, including one large block

Comments: volcanic rocks and dropstones. Most rocks are clearly dropstones including gneiss, muscovite bearing metamorphics. All are rounded and have no Mn crust. One rock had glacial striations on one side. All dropstones were discarded. The two in-situ volcanic rocks are both moderately altered but differ in having Pl (1%) phenocrysts in #1 and Px (5% up to 1mm) in #2.

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-34-1-1	1. Rock Type: volcanic, moderately altered 2. Size: 29x13x7 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: brown 5. Texture / Vesicularity: phyric, no vesicles 6. Phenocrysts: Pl (1%, up to 1mm), moderately preserved 7. Matrix: fine-grained 8. Secondary Minerals: oxidized gm 9. Encrustations: 1.5 cm Mn crust	x	x						
M168-34-1-2	1. Rock Type: volcanic, moderately altered, patchy alteration 2. Size: 23x14x10 cm 3. Shape / Angularity: rounded 4. Color of cut surface: grey 5. Texture / Vesicularity: phyric, no vesicles 6. Phenocrysts: Px?, black (5%, up to 1 mm) 7. Matrix: fine-grained 8. Secondary Minerals: oxidized gm 9. Encrustations: 1.5 cm Mn crust	x	x						

M168-35-1



Description of Location and Structure:
Gnitsevich Seamounts. Central smt, SE flank, close to M168-34-1 but further upslope

Dredge on bottom UTC 23/11/20 15:16 hrs, lat 44°29.61'N, long 25°12.81'W depth 1702 m






Dredge off bottom UTC 23/11/20 16:36 hrs, lat 44°29.89'N, long 25°13.24'W, depth 1340 m

total volume: half full, several very large blocks, mostly volcanic after all but large continental crust type dropstones were also present.





Dropstones were discarded

Comments: Three lava types recovered 1) vesicular, Pl phyric (1%) fairly fresh, sample #1 to #6 ; 2) massive, non vesicular, Pl phyric 5-10%, fairly fresh, samples #7 to #12, a subtype of 2) contains rare Px (#11, #12). Type 3) lava is of singular occurrence (sample #13 from block C) with very large vesicles and minor Pl (1%, 1mm). Roundness of the lava pieces resembles beach cobbles consistent with the guyot type plateau summit of the smt. #14 to #16 are reef carbonates with corals (#14) and snail fragments in #15. #17 is a reddish volcanoclastic rock composed of baked lapilli. These observations indicate that the structure was once near sealevel.

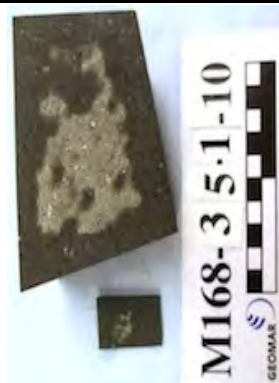



M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-35-1-1	1. Rock Type: volcanic, mildly altered 2. Size: 15x10x11 cm 3. Shape / Angularity: rounded to subangular (beach cobble?) 4. Color of cut surface: grey 5. Texture / Vesicularity: phyric, 20% vesicles up to 3 mm, elongated, partly filled 6. Phenocrysts: Pl (5%, 1-2 mm), mildly altered 7. Matrix: fine-grained 8. Secondary Minerals: none 9. Encrustations: patchy Mn coating 10 Comments: Type 1 lava	x	x					type 1 lava	
M168-35-1-2	1. Rock Type: volcanic, mildly altered, similar facies as -1, slightly more altered 2. Size: 16x10x7 cm 3. Shape / Angularity: rounded to subangular (beach cobble?) 10 Comments: 4. to 9. similar to sample -1. Type 1 lava, vesicles partly filled with secondaries	x	x					type 1 lava	
M168-35-1-3	1. Rock Type: volcanic, identical to -1, less frequently filled vesicles 2. Size: 21x11x10 cm 10 Comments: 3. to 9. similar to sample -1. Type 1 lava	x	x					type 1 lava	
M168-35-1-4	1. Rock Type: volcanic, identical to -1, no alteration halo, less filling of vesicles 2. Size: 19x9x9.5 cm 10 Comments: 3. to 9. similar to sample -1. Type 1 lava	x	x					type 1 lava	
M168-35-1-5	1. Rock Type: volcanic, similar to -2, slight alteration halo, a few cracks filled with FeOH 2. Size: 22x16x9 cm 4. Color of cut surface: greyish with slight yellow tint 10 Comments: 3. and 5. to 9. similar to sample -2. Type 1 lava	x						type 1 lava	





M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-35-1-6	1. Rock Type: volcanic, same facies as -1 to -5 but slightly to moderately altered as manifested by higher gm oxidation; gm more dense 2. Size: 11x10x7 cm 3. Shape / Angularity: rounded (beach cobble?) 4. Color of cut surface: grey with strong yellow tint 5. Texture / Vesicularity: phyric, 20% vesicles, up to 2 mm, partly filled 6. Phenocrysts: Pl (1-5%, up to 2 mm) 7. Matrix: fine-grained 8. Secondary Minerals: FeOH in some vesicles 10 Comments: a few Mn patches	x						type 1 lava	
M168-35-1-7	1. Rock Type: volcanic, fresh to mildly altered, phyric; type 2 lava 2. Size: 18x21x13 cm 3. Shape / Angularity: rounded (beach cobble?) 4. Color of cut surface: grey 5. Texture / Vesicularity: dense, phyric, but with abundant small vesicles 6. Phenocrysts: Pl needles (5-10%, up to 2 mm), fresh to mildly altered 7. Matrix: fine-grained 8. Secondary Minerals: patchy Mn coating 10 Comments: type 2 lava	x	x					type 2 lava	
M168-35-1-8	1. Rock Type: volcanic, similar to -7 2. Size: 26x21x9 cm 10. Comments: 3. to 9. similar to -7 but few Px needles in places; type 2 lava	x	x					type 2 lava	
M168-35-1-9	1. Rock Type: volcanic, similar to -7 but slight alteration halo with Mn dendrites along edge of sample 2. Size: 18x11x10 cm 10. Comments: 3. to 9. similar to -7; type 2 lava	x						piece from bloc C (30x20x20 cm),	


M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-35-1-10	1. Rock Type: volcanic, similar to -8 but no alteration halo, no Mn dendrites 2. Size: 12x13x9 cm 10. Comments: 3. to 9. similar to -8; type 2 lava	x	x					type 2 lava	
M168-35-1-11	1. Rock Type: volcanic, mildly altered 2. Size: 10x12x8 cm 3. Shape / Angularity: rounded (beach cobble?) 4. Color of cut surface: grey with slight yellow tint 5. Texture / Vesicularity: dense, phyrlic, 1-5% small vesicles, open 6. Phenocrysts: Pl (1%, up to 1 mm), fresh to mildly altered; single Px (<<1%, 2mm) 7. Matrix: fine-grained 8. Secondary Minerals: patchy Mn coating 10 Comments: type 2 lava	x	x					type 2 lava with rare Px	
M168-35-1-12	1. Rock Type: volcanic, similar to -11 2. Size: 18x10x5 cm 10 Comments: 3. to 9. similar to -11, type 2 lava	x						type 2 lava with rare Px	
M168-35-1-13	1. Rock Type: volcanic, moderately altered, phyrlic, piece of block C (44x17x27) 2. Size: 13x16x11 cm 3. Shape / Angularity: subangular block 4. Color of cut surface: grey with greenish tint 5. Texture / Vesicularity: phyrlic, very large vesicles, cavities filled at edge 6. Phenocrysts: Pl (1%, up to 1 mm), fresh to mildly altered 7. Matrix: fine-grained gm 8. Secondary Minerals: FeOH stains 9. Encrustations: patchy Mn 10 Comments: type 3 lava	x	x					type 3 lava	

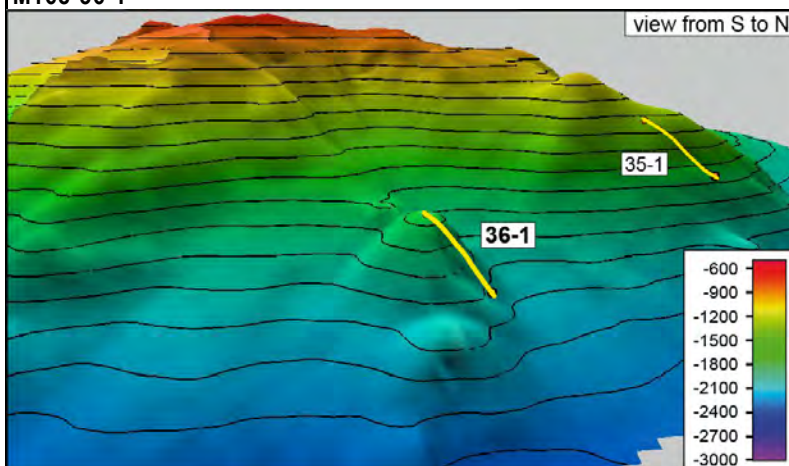
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-35-1-14	1. Rock Type: reef carbonate (mainly corals) 2. Size: 20x16x18 cm 3. Shape / Angularity: subangular 4. Color of cut surface: white 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: partly thin Mn coating								
M168-35-1-15	1. Rock Type: lithified dense carbonate rock 2. Size: 12x10x9 cm 3. Shape / Angularity: subangular 4. Color of cut surface: light grey 5. Texture / Vesicularity: micritic, dense carbonate 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: almost no Mn coating 10 Comments: 2 cm long snail shell, fossil!								
M168-35-1-16	1. Rock Type: lithified dense carbonate rock, similar to -15 2. Size: 9x8x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: light grey 5. Texture / Vesicularity: micritic, dense carbonate 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: almost no Mn coating								
M168-35-1-17	1. Rock Type: volcaniclastic rock composed of baked lapilli 2. Size: 9x5x7 cm 3. Shape / Angularity: roundish 4. Color of cut surface: dark grey to redish 5. Texture / Vesicularity: clastic, dense, no vesicles 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: none								

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-35-1-18	1. Rock Type: granite (dropstone) with carbonate crust cover 2. Size: 20x22x14 cm 3. Shape / Angularity: subangular 4. Color of cut surface: light grey to pinkish 5. Texture / Vesicularity: plutonic 6. Phenocrysts: alkali Fsp, Qtz, Micas 7. Matrix: - 8. Secondary Minerals: - 9. Encrustations: up to 4 cm carbonate crust on one side, which probably marks the depositional top of the dropstone. Carbonate contains coral fragments and forminifers. 10 Comments: Only small cut slab was taken to demonstrate that dropstones can have thicker carbonate crusts when deposited in shallower waters resulting from fast grow in contrast to Mn crust in deep waters.								

M168-36-1



Description of Location and Structure: Gnitsevit Smts. Smt 3 (large central volcano), small cone on its S-flank, from ± base to top.




Dredge on bottom UTC 23/11/20 19:01 hrs, lat 44°28.59'N, long 25°14.66'W depth 2033 m

Dredge off bottom UTC 23/11/20 20:01 hrs, lat 44°28.81'N, long 25°15.01'W, depth 1656 m



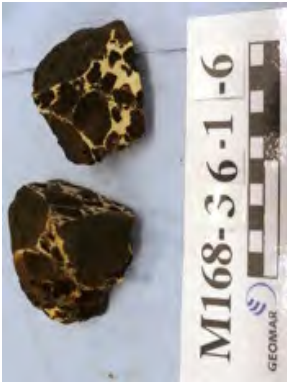

total volume: few rocks

Comments: Two lava types and volcanic breccia recovered. Type 1 lava (sample #1) is from block A, slightly altered, moderately vesicular and with minor Cpx and Ol (altered). Gm may be good for Ar-Ar dating. Type 2 lava is sampled from #2 to #5, is more vesicular, moderately altered and slightly Cpx and Ol phyric. Sample #5 has a chilled margin with minor amounts of fresh glass. In essence type 1 and 2 lava differ by vesicularity which may simply reflect different portions of pillow lava. Samples #6 to #9 are volcanic breccias of which #6 bears small amounts of fresh glass.

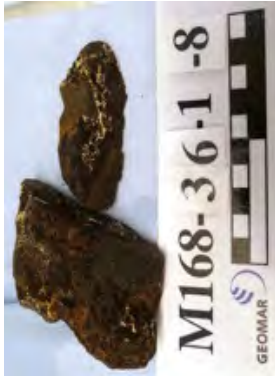

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-36-1-1	1. Rock Type: volcanic, slightly altered, piece from block A (53x36x22 cm) 2. Size: 17x10x14 cm 3. Shape / Angularity: subangular block A 4. Color of cut surface: grey 5. Texture / Vesicularity: slightly phyr, massive / vesicularity (~15%, 1-2 mm), partly filled 6. Phenocrysts: rare Cpx (<2%), Ol (<2%) mostly altered but some cores look fresh 7. Matrix: fine-grained, Pl laths, probably also Ol & Cpx 8. Secondary Minerals: white Cc vesicle fillings 9. Encrustations: - 10. Comments: needs picking, gm looks ok for Ar-Ar	x	x	x				type 1 lava	
M168-36-1-2	1. Rock Type: volcanic, slightly phyr, moderately altered, piece was attached to block A (53x36x22 cm) 2. Size: 14x10x13 cm attached to block A; different lithology than -1 3. Shape / Angularity: subangular block A 4. Color of cut surface: rounded nose attached to block A 5. Texture / Vesicularity: highly vesicular (25%, 1-5 mm) mostly partially filled with secondaries 6. Phenocrysts: altered orange (Ol?) and black phenocrysts (Px?), both types (5%, 0.5-1 mm) 7. Matrix: very fine-grained 8. Secondary Minerals: Mn as vesicle fillings ! 9. Encrustations: some Mn coating up to 3mm and biological encrustation 10. Comments: needs picking, gm looks ok for Ar-Ar	x	x					type 2 lava	
M168-36-1-3	1. Rock Type: volcanic, pillow fragment, altered, similar to -2 but was not attached to block A 2. Size: 6x5x9 cm 3. Shape / Angularity: roundish 4. Color of cut surface: dark grey (in contrast to altered appearance) 5. Texture / Vesicularity: highly vesicular (25%, <1 mm) 6. Phenocrysts: black (Px?, 5%, 1-2 mm), some orange (altered Ol, 2%, <1 mm) 7. Matrix: very fine-grained 8. Secondary Minerals: white and black vesicle fillings 9. Encrustations: some Mn coating up to 3mm and biological encrustation 10. Comments: chilled margin contains altered glass that is just to altered to be useful	x	x					type 2 lava	

M168 Dredge Station Details and Rock Description

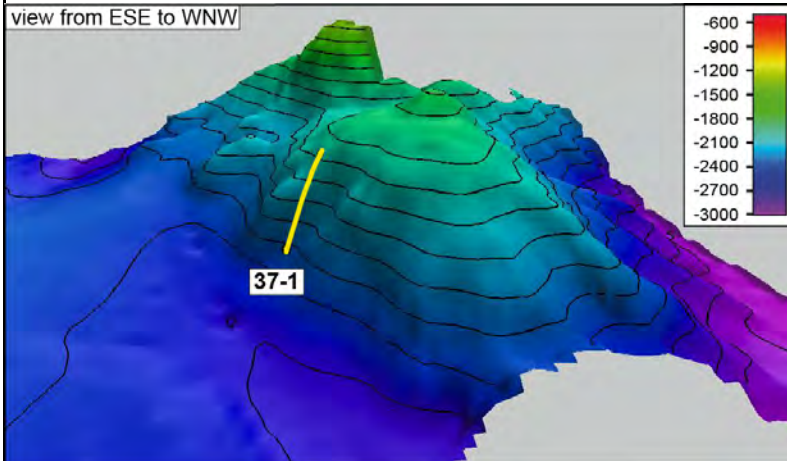
SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-36-1-4	1. Rock Type: volcanic, similar to -3 2. Size: 10x8x4.5 cm 3. Shape / Angularity: roundish 4. Color of cut surface: like -3 5. Texture / Vesicularity: like -3 6. Phenocrysts: some well preserved dark Cpx? and yellow (Ol?), size and abundance of both minerals similar to -3 7. Matrix: like -3 8. Secondary Minerals: some vesicle fillings 9. Encrustations: some Mn coating up to 3mm and biological encrustation	x	x					type 2 lava	
M168-36-1-5	1. Rock Type: volcanic, similar to -3 2. Size: 10x5x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: like -3 5. Texture / Vesicularity: like -3 6. Phenocrysts: like -3 7. Matrix: like -3 8. Secondary Minerals: like -3 9. Encrustations: insignificant 10. Comments: altered glass rim may contain some very small remaining fresh glass fragments	x			G?			type 2 lava	
M168-36-1-6	1. Rock Type: volcanic breccia, clasts very similar to -3 2. Size: 10x6x5 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: reddish-brownish, grey clasts in white matrix 5. Texture / Vesicularity: clasts very similar to -3 6. Phenocrysts: like -3 7. Matrix: very fine-grained, white 8. Secondary Minerals: white and black fillings 9. Encrustations: very thin Mn in selected areas 10. Comments: white cement enclosing the clasts does not fizz with HCl. Altered glass rims of clasts contain some little remaining fresh glass!				G I				
M168-36-1-7	1. Rock Type: volcanic breccia, similar to -6 2. Size: 10x9x5.5 cm 3. Shape / Angularity: angular 10. Comments: 4. to 9. similar to -6. no preserved glass in chilled margin.								

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-36-1-8	1. Rock Type: volcanic breccia, similar to -7 2. Size: 7x7x4 cm 10. Comments: 3. to 9. similar to -7								
M168-36-1-9	1. Rock Type: volcanic breccia, similar to -7 but mainly the altered glass rim 2. Size: 6x6x3 cm 10. Comments: 3. to 9. similar to -7. Altered glass rim may contain some fresh glass!				G I				

M168-37-1

view from ESE to WNW



Description of Location and Structure:

Gnitsevich Smts. NE most cone. SE facing slope from base to mid-plateau





Dredge on bottom UTC 24/11/20 00:36 hrs, lat 44°38.88'S, long 25°20.83'W depth 2408 m

Dredge off bottom UTC 24/11/20 01:58 hrs, lat 44°39.15'N, long 25°21.29'W, depth 1990 m




total volume: several large rocks, volcanic plus 4 dropstones

Comments: Phyric, evolved volcanic rocks were obtained. Sample #1 to #4 are dense lava with mafic inclusions, indicating magma mixing. Minerals may comprise foides indicative for silica undersaturated melts. Sample #5 & #6 are also porphyric but more vesicular and have no mafic inclusions. Sample #7 is described as more altered but appears quite fresh in picture. It is aphyric with <1mm Mn crust. It may be a dropstone.

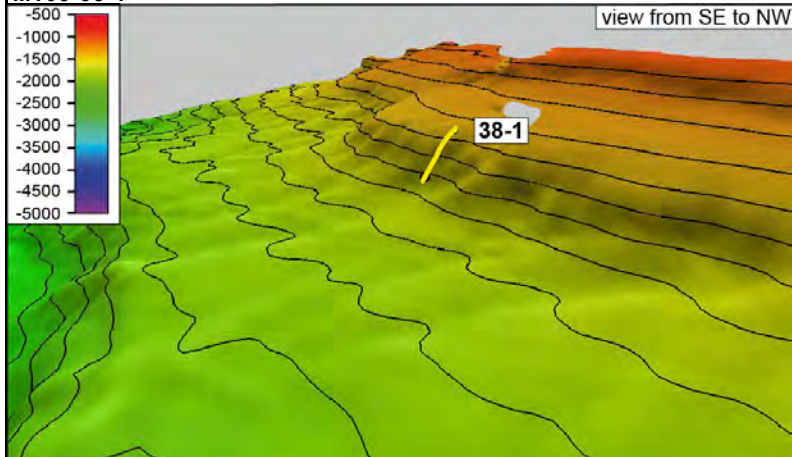
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-37-1-1	1. Rock Type: volcanic, evolved, phyrlic, pretty fresh with mafic inclusions (magma mixing?) 2. Size: 26x18x18 cm, this the entire block B 3. Shape / Angularity: subangular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: porphyric, no vesicles 6. Phenocrysts: Foide?, angular (15%, 2-5 mm); transparent elongated (5%, 1-3 mm); black, spiky (4%, 1-3 mm). In mafic inclusions, black elongated mineral (10%, 1-3mm) 7. Matrix: fine-grained in both lithologies 8. Secondary Minerals: - 9. Encrustations: up to 5mm Mn crust 10 Comments: magma mixing with mafic inclusions. TS should cover the contact between mafic inclusions and evolved host rock. Attention during rock preparation to separate darker and lighter parts!	x	x					from block B, attention magma mixing!	
M168-37-1-2	1. Rock Type: volcanic, similar to -1, also with small mafic inclusions 2. Size: 17x8x7 cm 3. Shape / Angularity: subrounded 9. Encrustations: <1 mm Mn crust 10 Comment: 4. to 8. similar to -1. Magma mixing with mafic inclusions as in -1. Extra care to separate both lithologies when preparing bulk rock analysis	x	x					magma mixing!	
M168-37-1-3	1. Rock Type: volcanic, similar to -1 2. Size: 14x11x5 cm 3. Shape / Angularity: subrounded 9. Encrustations: <1 mm Mn crust 10 Comment: 4. to 8. similar to -1. Very small mafic inclusions. Extra care to separate both lithologies when preparing bulk rock analysis							magma mixing!	
M168-37-1-4	1. Rock Type: volcanic, similar to -1 2. Size: 10x9x3.5 cm 3. Shape / Angularity: flat, subangular 9. Encrustations: 9 mm Mn crust 10 Comment: 4. to 8. similar to -1.							magma mixing!?	

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-37-1-5	1. Rock Type: volcanic, porphyric, pretty fresh 2. Size: 12x12x6.5 cm 3. Shape / Angularity: roundish 4. Color of cut surface: grey-brown 5. Texture / Vesicularity: porphyric, 10% vesicles, open 6. Phenocrysts: white Pl? (8%, up to 5 mm), black needles (3%, <1mm) 7. Matrix: very fine-grained 8. Secondary Minerals: - 9. Encrustations: 2-3 mm Mn crust	x	x						
M168-37-1-6	1. Rock Type: volcanic, porphyric, fairly fresh rock 2. Size: 11x9x4 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: light grey 5. Texture / Vesicularity: porphyric 6. Phenocrysts: white angular Pl? (5%, 2-6 mm), thin black needles (2%, <2mm) 7. Matrix: very fine-grained 8. Secondary Minerals: - 9. Encrustations: 2-3 mm Mn crust	x	x						
M168-37-1-7	1. Rock Type: volcanic, aphyric, moderately altered 2. Size: 12x16x10 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brownish grey 5. Texture / Vesicularity: aphyric, patchy, non-vesicular 6. Phenocrysts: - 7. Matrix: fine-grained 8. Secondary Minerals: rusty vein 9. Encrustations: insignificant, <1mm at most 10 Comment: dropstone cannot be ruled out but seems unlikely	x	x						

M168-38-1






Description of Location and Structure: Summit Antialtair Smt (southern slope). Small step making up the upper summit plateau on S flank of the seamount. The plateau could be a beach terrace.

Dredge on bottom UTC 26/11/20 06:59 hrs, lat 43°32.37'N, long 22°25.65'W depth 1643 m
 Dredge off bottom UTC 26/11/20 07:57 hrs, lat 43°32.69'N, long 22°25.71'W, depth 1355 m




M168 Dredge Station Details and Rock Description

total volume: a few rocks

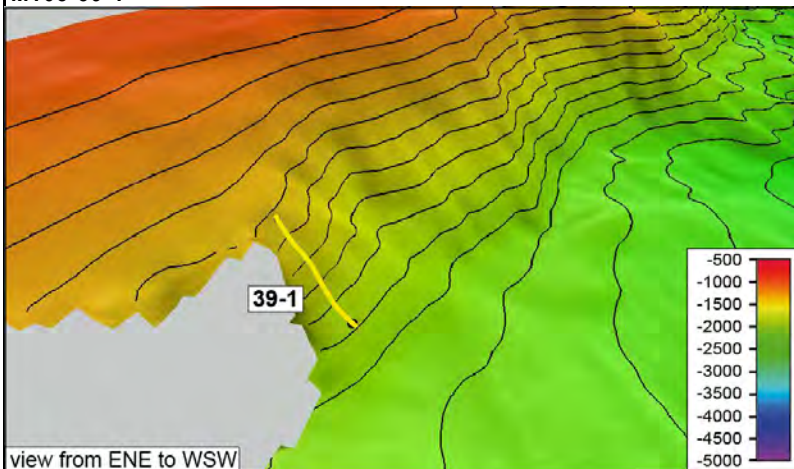
Comments: overall three pieces of Pl-Ol phyric lava were recovered. According to description sample #3 appears freshest whereas #1 and #2 seem moderately to strongly altered. Description emphasizes occurrence of Ol but lacks statement about its condition; probably altered. Sample #4 is a strongly altered volcanoclastic rock.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	GI/MIN	SED	REF	NOTES	PICTURE
M168-38-1-1	1. Rock Type: volcanic, moderately phyric, moderately to strongly altered 2. Size: 36x17x24 cm block A 3. Shape / Angularity: subrounded to rounded 4. Color of cut surface: brown (grey brown) 5. Texture / Vesicularity: massive, 1-2% vesicles 6. Phenocrysts: Pl (5-10%, up to 4 mm), Ol (<1%, up to 1mm) altered (?) 7. Matrix: fine-grained 8. Secondary Minerals: abundant Mn patches, some orange grains that are probably altered Ol 9. Encrustations: up to 5 mm Mn crust 10. Comment: pieces of block A taken; individual size not documented; Ol!	x	x					from block A	
M168-38-1-2	1. Rock Type: volcanic, moderately to highly phyric, moderately to strongly altered 2. Size: 27x15x17 cm 3. Shape / Angularity: subrounded to rounded 4. Color of cut surface: brown (orange brown) 5. Texture / Vesicularity: massive, 1-2% vesicles 6. Phenocrysts: Pl (10%, up to 3.5 mm), Ol (1-2%, up to 1mm) altered (?) 7. Matrix: fine-grained, mostly brown oxidized gm with grey, medium-grained patches 8. Secondary Minerals: Mn patches, vesicles filled with white mineral 9. Encrustations: up to 5 mm Mn crust 10. Comment: grey clast-like patches (<1.5 cm) "floating" in brownish gm. Biogenic (?) cemented conglomerate with lava clast, Ol!	x	x						
M168-38-1-3	1. Rock Type: volcanic, moderately phyric, slightly altered 2. Size: 8x6.5x5 cm 3. Shape / Angularity: rounded 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, 5-10% vesicles 6. Phenocrysts: Pl (5-10%, up to 3 mm), Ol (<1%, up to 1mm) altered (?) 7. Matrix: fine-grained 8. Secondary Minerals: brown and black minerals in vesicles and as patches 9. Encrustations: 1 mm Mn crust 10. Comment: some Ol	x	x					described as freshest rock in dredge	

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-38-1-4	1. Rock Type: volcaniclastic, very altered with thick Mn crust 2. Size: 8x5.5x2.5 cm 3. Shape / Angularity: subrounded 4. Color of cut surface: grey with green, brown and orange clasts 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: many Mn patches 9. Encrustations: up to 1.3 cm Mn crust								
M168-38-1-5	1. Rock Type: coarse grained, lithified sediment with Mn crust 2. Size: 10x7x4.5 cm 3. Shape / Angularity: subrounded to rounded 4. Color of cut surface: yellow / orange, grey 5. Texture / Vesicularity: - 6. Phenocrysts: - 7. Matrix: - 8. Secondary Minerals: Mn patches and dendrites, orange weathered grains 9. Encrustations: up to 1.3 cm Mn crust 10. Comment: strong reaction with HCl								
M168-38-1-6	1. Rock Type: Mn crust up to 4 cm thick 2. Size: 20x13x5 cm 10. Comment: a few small pieces of volcanic host rock fragments attached								

M168-39-1





Description of Location and Structure: Antialtair Smt. NE facing slope, central part

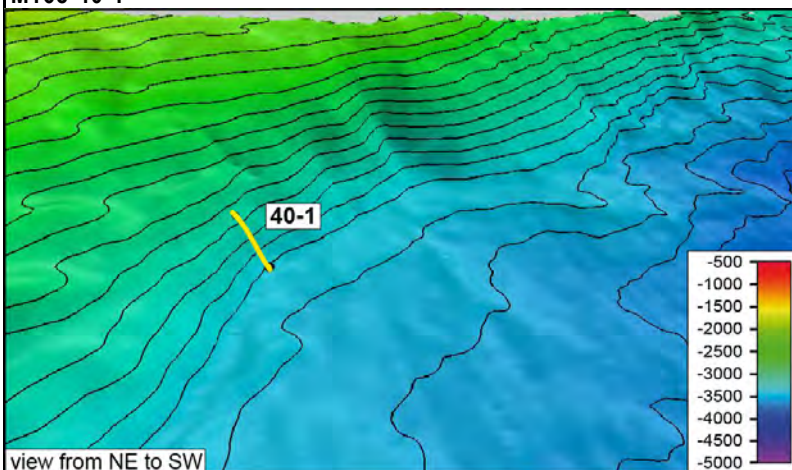
Dredge on bottom UTC 26/11/20 09:55 hrs, lat 43°36.24'N, long 22°24.76'W depth 1852 m
 Dredge off bottom UTC 26/11/20 11:11 hrs, lat 43°35.89'N, long 22°24.78'W, depth 1394 m
total volume: two rocks

M168 Dredge Station Details and Rock Description

Comments: Volcaniclastic rocks, strongly altered. Sample -1 appears hydrothermally overprinted but abundant palagonite may contain bits of fresh glass

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Al/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-39-1-1	1. Rock Type: volcaniclastic, strongly altered by hydrothermal (?) fluids 2. Size: 24x22x13 cm 3. Shape / Angularity: angular at bottom (freshly broken off the ground), subrounded along top 4. Color of cut surface: brown to orange 5. Texture / Vesicularity: 1-5% but difficult to judge 6. Phenocrysts: Pl up to 5mm, variation in distribution and alteration 7. Matrix: original matrix was probably fine-grained 8. Secondary Minerals: many different secondary minerals (white, black, yellow, orange, red) 9. Encrustations: Mn crust up to 1.5 cm 10. Comment: formerly a good volcanic rock but strongly altered by possible hydrothermal fluids. A lot of palagonite to be thoroughly searched for possible fresh glass	x	x						
M168-39-1-2	1. Rock Type: volcaniclastic, moderately (?) altered 2. Size: 8x12x4 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown with many differently colored clasts 8. Secondary Minerals: Mn patches, white minerals in cracks 9. Encrustations: Mn crust up to 1.5 cm								

M168-40-1




Description of Location and Structure: Antialtair Smt. NW part of NE facing slope at lower section

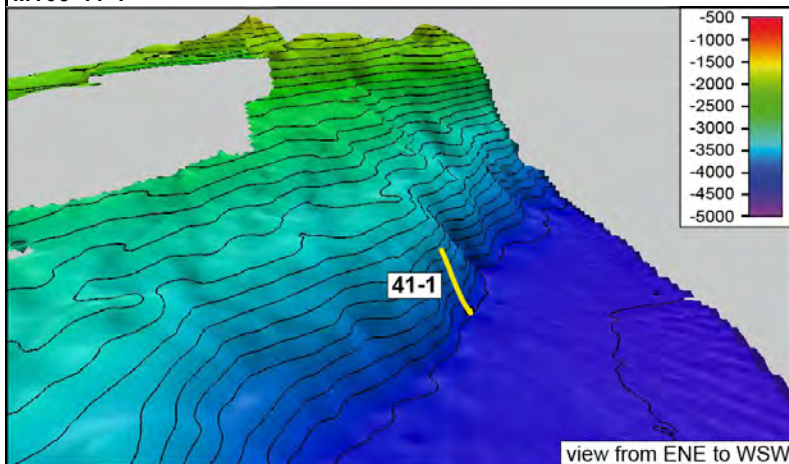
Dredge on bottom UTC 26/11/20 14:15 hrs, lat 43°42.95'N, long 22°35.57'W depth 3409 m
 Dredge off bottom UTC 26/11/20 15:17 hrs, lat 43°42.61'N, long 22°35.57'W, depth 3050 m
 total volume: single rock

Comments: moderately to fresh vesicular lava, 10% vesicles, subrounded. Probably debris from Antialtair Smt

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/MIN	SED	REF	NOTES	PICTURE
M168-40-1-1	1. Rock Type: volcanic, lava fragment, mildly altered to fresh 2. Size: 10x7x7 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: grey, slight yellow tint 5. Texture / Vesicularity: phyric, vesicular (15%, <1mm) partly filled, Mn lining 6. Phenocrysts: Fsp (10%, 1.5 mm) altered?, Ol? (<1%, <1mm), altered 7. Matrix: fine-grained 8. Secondary Minerals: a few Fe oxides, a large cavit filled with chlorite?, Mn filling of vesicles 9. Encrustations: none 10. Comment: Vesicles lined with Mn, some filling of vesicles, both to be avoided when picking for bulk rock chemistry. Gm and Fsp may be suitable for Ar-Ar dating	x	x	x ?					

M168-41-1



Description of Location and Structure: King's Trough 13nm NW of Antialtair Smt. Steep N dipping canyon wall from the basin floor towards the break in slope in the lower 1/3 of the entire slope. About 45° steep!



Dredge on bottom UTC 26/11/20 19:50 hrs, lat 43°49.11'N, long 22°48.82'W depth 4150 m

Dredge off bottom UTC 26/11/20 22:23 hrs, lat 43°49.02'N, long 22°48.88'W, depth 4023 m

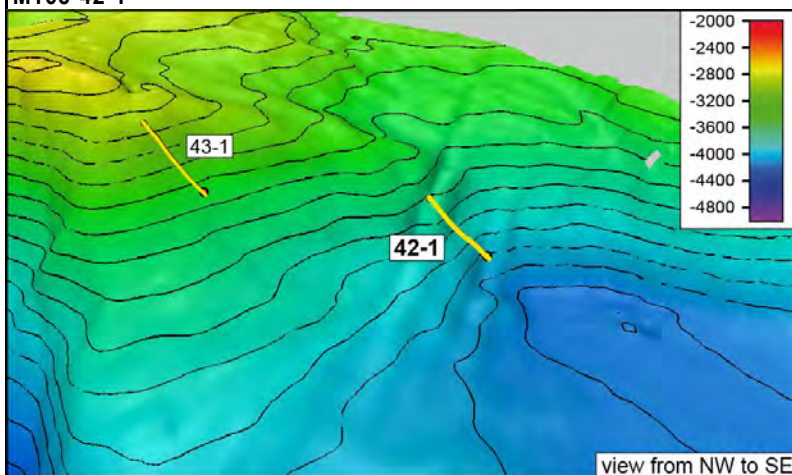
total volume: one large block and one small clast.

Comments: probably an ultramafic Px-Ol rich rock, dropstone origin disputed. Notably similar were recovered at M168-30-1 as clasts in breccia. Dredge got severely hung up and had to be recovered close to drop point. Slope seems too steep and possibly consists of massive lithology.

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-41-1-1	<p>1. Rock Type: mafic plutonic, moderately altered, harzburgite?</p> <p>2. Size: 40x29x11.5 cm</p> <p>3. Shape / Angularity: angular slab</p> <p>4. Color of cut surface: "salt & pepper"</p> <p>5. Texture / Vesicularity: holocrystalline, equigranular</p> <p>6. Phenocrysts: white, black and orange minerals, 1-3 mm. Orange are altered Ol, black are fairly fresh Px, white are Fsp?</p> <p>7. Matrix: -</p> <p>8. Secondary Minerals: orange are FeOH replacing Ol</p> <p>9. Encrustations: Thin, 0.5 mm Mn coating.</p> <p>10. Comment: Unclear if this is a dropstone but could also be a local diorite. Looks similar to clast M168-30-1-4 recovered from a breccia. Resembles ultramafic rocks recovered at Shirshov Rigde during SO249.</p>	x	x	?					
M168-41-1-2	<p>1. Rock Type: plutonic, similar to -1, but unclear if broken off from -1 or separate.</p> <p>2. Size: 14x8x2 cm</p> <p>3. Shape / Angularity: thin angular plate</p> <p>4. Color of cut surface: see sample -1</p> <p>5. Texture / Vesicularity: see sample -1</p> <p>6. Phenocrysts: dominance of black and orange minerals. In contrast to -1, almost no white minerals</p> <p>7. Matrix: -</p> <p>8. Secondary Minerals: see sample -1</p> <p>9. Encrustations: very thin, 0.2 mm Mn coating.</p> <p>10. Comment: the fragile shape rules out dropstone origin.</p>								

M168-42-1




Description of Location and Structure: Azores-Biscay-Rise, northernmost large smt, NW facing slope, middle section

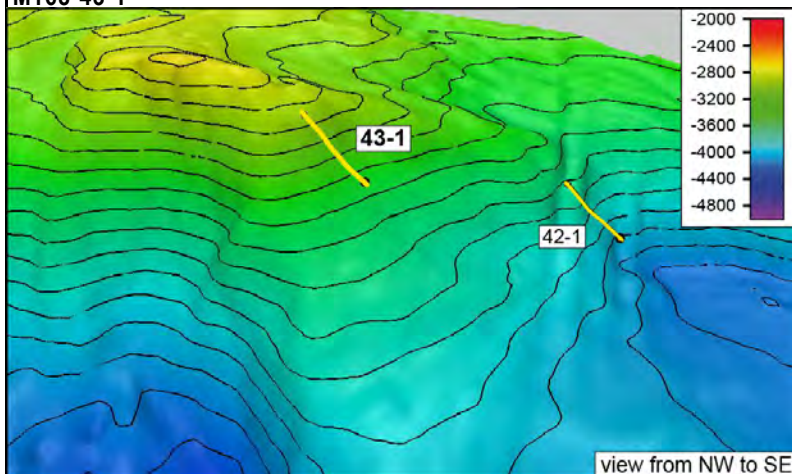
Dredge on bottom UTC 30/11/20 10:27 hrs, lat 44°58.15'N, long 15°51.82'W depth 4036 m
Dredge off bottom UTC 30/11/20 11:41 hrs, lat 44°58.40'S, long 15°51.39'W, depth 3550 m
total volume: single rock

M168 Dredge Station Details and Rock Description

Comments: Phosphorite crust

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	GI/MIN	SED	REF	NOTES	PICTURE
M168-42-1-1	1. Rock Type: Crust, phosphorite, minimal reaction to HCl, Mn coated holes and Mn dendrites / patches 2. Size: 9.5x3.5x5.5 cm 10. Comment: phosphorite?								

M168-43-1



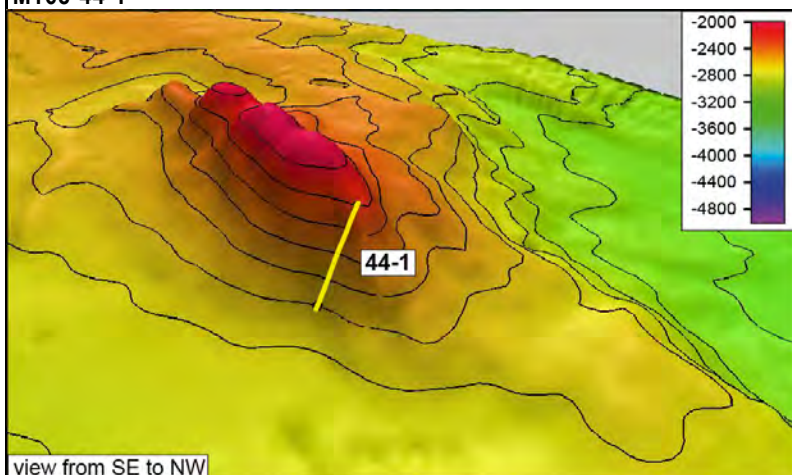
Description of Location and Structure: Azores-Biscay-Rise, northernmost large smt, NW facing slope, upper section (1.5nm NNE of M168-42-1)

Dredge on bottom UTC 30/11/20 13:57 hrs, lat 45°00.11'N, long 15°50.97'W depth 3339 m

Dredge off bottom UTC 30/11/20 15:09 hrs, lat 45°00.36'N, long 15°50.55'W, depth 2950 m

total volume: empty

M168-44-1



Description of Location and Structure: Azores-Biscay-Rise, northernmost large smt, small E-W striking ridge at summit, SE slope of ridge from middle to upper part




Dredge on bottom UTC 30/11/20 18:51 hrs, lat 45°01.39'N, long 15°30.92'W depth 2613 m

Dredge off bottom UTC 30/11/20 20:00 hrs, lat 45°01.73'N, long 15°31.05'W, depth 2230 m




total volume: few volcanic rocks + coral and sponge fragments

Comments: Ol phyric pillow lava, some with grey / fresh gm (-1), Ol altered. One variety is Fsp+Ol phyric but with strongly oxidized gm. Other samples are a small Mn crust, a large block of Cc breccia and numerous coral fragments and a larger sponge

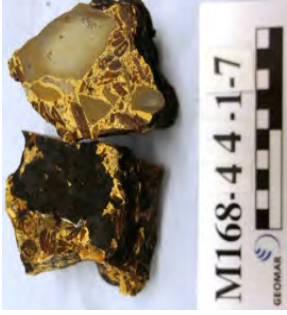



M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-44-1-1	1. Rock Type: volcanic, mildly altered, freshest rock of dredge 2. Size: 8x4x7 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish, patchy parts with orange tint 5. Texture / Vesicularity: phyrlic, non-vesicular 6. Phenocrysts: altered Ol (1%, up to 1.5 mm), maybe some fresh Ol left 7. Matrix: fine-grained, gm full of Pl needles 8. Secondary Minerals: altered Ol, Mn dendrites, in places patchy oxidized gm 9. Encrustations: Mn coating 10. Comment: freshest rock of dredge, no alteration halo, gm may be good for Ar-Ar dating	x	x	x ?					
M168-44-1-2	1. Rock Type: volcanic, moderately altered, well preserved grey core 2. Size: 13x9x5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: greyish at core otherwise beige-brownish 5. Texture / Vesicularity: phyrlic, non-vesicular, dense 6. Phenocrysts: altered Ol (5%, up to 2 mm) altered? 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, Mn dendrites, oxidized gm 9. Encrustations: Mn coating 10. Comment: core good for chemistry, gm Ar-Ar dating questionable	x	x						
M168-44-1-3	1. Rock Type: volcanic, moderately altered, some preserved grey patches 2. Size: 14x10x8 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: greyish to brownish 5. Texture / Vesicularity: phyrlic, non-vesicular, dense 6. Phenocrysts: altered Ol (5%, up to 1 mm), Fsp? (1% up to 1 mm) altered? 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, Mn dendrites, oxidized gm 9. Encrustations: Mn coating 10. Comment: some parts may be good for chemistry after intense picking. Occurrence of Fsp makes this rock differ from Ol phyrlic samples -1 & -2	x	x						


M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-44-1-4	1. Rock Type: volcanic, moderately to strongly altered 2. Size: 10x8x5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: greyish to beige-brown 5. Texture / Vesicularity: phyrlic, non-vesicular, dense 6. Phenocrysts: altered Ol (5%, 1-2 mm), Fsp (10% up to 1 mm) altered? 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, Mn dendrites, oxidized gm 9. Encrustations: Mn coating 10. Comment: chemistry not recommended. Check Fsp for freshness in relation to Ar-Ar dating								
M168-44-1-5	1. Rock Type: volcanic, moderately to strongly altered 2. Size: 12x10x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: beige to brown 5. Texture / Vesicularity: phyrlic, non-vesicular, dense 6. Phenocrysts: altered Ol (5%, 1-1.5 mm), Fsp (10% up to 0.5 mm) altered? 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, Mn dendrites, oxidized gm 9. Encrustations: Mn coating 10. Comment: chemistry not recommended. Check Fsp for freshness in relation to Ar-Ar dating	x							
M168-44-1-6	1. Rock Type: volcanic, strongly altered 2. Size: 13x8x6 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: brown to beige-yellowish 5. Texture / Vesicularity: phyrlic, non-vesicular, dense 6. Phenocrysts: altered Ol (5%, 2 mm), Fsp (10% up to 0.5 mm) altered?, yellowish tint 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, Mn dendrites, strongly oxidized gm 9. Encrustations: Mn coating 10. Comment: chemistry not recommended but may be necessary if Fsp is good Ar-Ar dating	x	x						

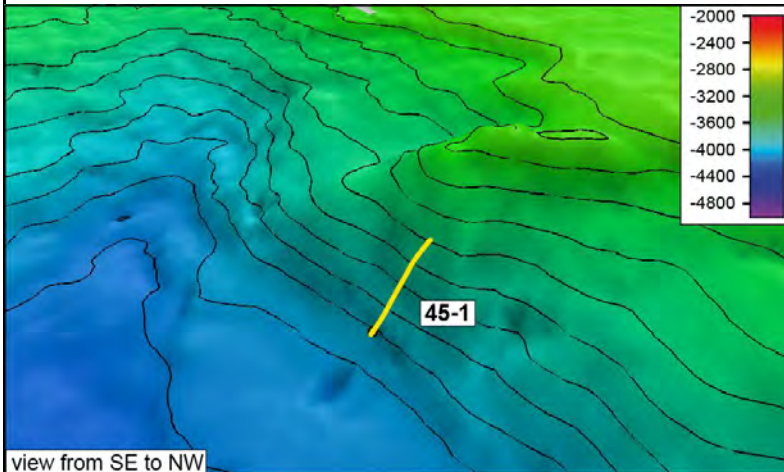
M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	GI/MIN	SED	REF	NOTES	PICTURE
M168-44-1-7	1. Rock Type: volcanic breccia, altered 2. Size: 10x5x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: breccia clasts are grey and brown in yellow matrix 5. Texture / Vesicularity: variable clast sizes, grey clasts up to 4-5 cm, brown clasts up to 1.5 cm 6. Phenocrysts: grey clasts aphyric to phyrlic, basaltic, brown clasts altered glass shards? 7. Matrix: white matrix fizzes with HCl 8. Secondary Minerals: - 9. Encrustations: Mn coating								
M168-44-1-8	1. Rock Type: volcanic breccia, altered 2. Size: 7x4.5x4.5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: grey clasts and brown clasts in whitish matrix 5. Texture / Vesicularity: variable clast sizes, grey clasts up to 2 cm, brown clasts up to 2 cm; clast supported 6. Phenocrysts: grey clasts phyrlic basaltic, brown clasts altered glass shards? 7. Matrix: matrix fizzes with HCl 8. Secondary Minerals: - 9. Encrustations: Mn coating								
M168-44-1-9	1. Rock Type: pure Mn crust, 2.5cm thick 2. Size: 8x6x2.5 cm							Reference Mn crust	
M168-44-1-10	1. Rock Type: sediment, carbonate breccia 2. Size: 15x15x10 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: beige 5. Texture / Vesicularity: different clasts and mussel fragments 6. Phenocrysts: 7. Matrix: fizzes with HCl but not very intense, quite lithified rock 8. Secondary Minerals: 9. Encrustations: Mn coating								

M168 Dredge Station Details and Rock Description


SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-44-1-11	1. Rock Type: biology, various pieces of corals and a sponge								

M168-45-1



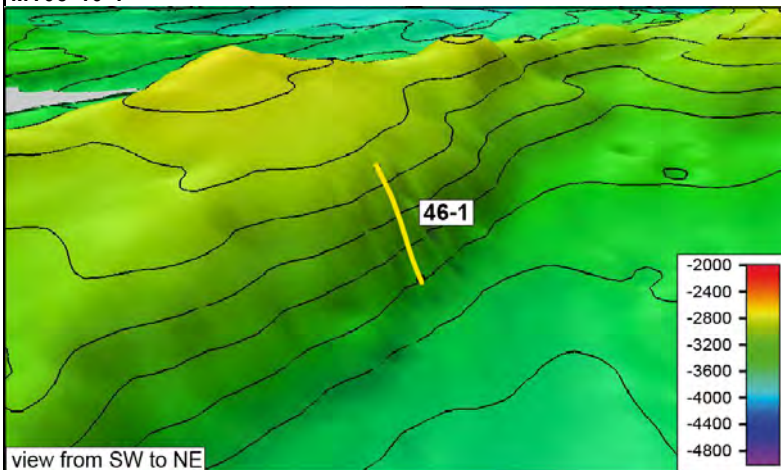
Description of Location and Structure: Large, triangular shaped smt at NE end of Azores-Biscay-Rise. SSE facing flank from base to mid-section

Dredge on bottom UTC 30/11/20 23:24 hrs, lat 44°51.07'N, long 15°35.13'W depth 4033 m
Dredge off bottom UTC 01/12/20 00:44 hrs, lat 44°51.47'N, long 15°35.18'W, depth 3601 m
total volume: single rock
Comments: Conspicuous glassy rock. Unclear if volcanoclastic, slag or something else.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-45-1-1	1. Rock Type: unclear, 2. Size: 6.5x6x3 cm 3. Shape / Angularity: subangular 4. Color of cut surface: reddish-brown, yellow-black 5. Texture / Vesicularity: glassy with many secondary constituents 8. Secondary Minerals: orange vein and vesicle fillings 9. Encrustations: ~1 mm Mn crust 10. Comment: partly glassy with fresh glass but unclear if of volcanic origin. Glass is dark red (hydrated?). Some kind of slag from steamship?								

M168 Dredge Station Details and Rock Description

M168-46-1



Description of Location and Structure: northernmost smt of Azores-Biscay-Rise. 13nm E of M168-45-1 at same wall like southern slope but haul starts 700 m higher

Dredge on bottom UTC 01/12/20 04:14 hrs, lat 44°54.05'N, long 15°16.56'W depth 3226 m


Dredge off bottom UTC 01/12/20 05:32 hrs, lat 44°54.37'N, long 15°16.56'W, depth 2980 m

total volume: three rocks

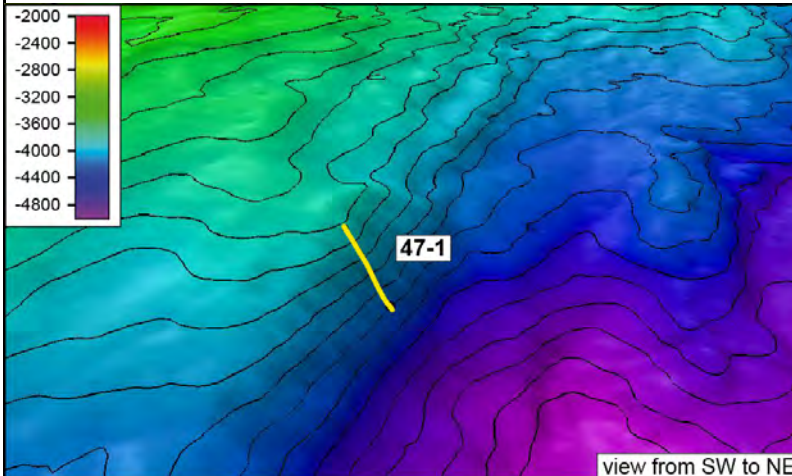
Comments: strongly altered pillow fragments. Sample -2 & -3 with fresh glass. Dense, near non-vesicular lava with altered Ol and Px microphenocrysts

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	GI/MIN	SED	REF	NOTES	PICTURE
M168-46-1-1	1. Rock Type: volcanic, pillow fragment, moderately altered 2. Size: 10x9.5x8 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: dense, slightly phyrlic (microphenocrystic), <3% vesicles <1mm, all filled 6. Phenocrysts: microphenocrysts; altered Ol (<2 mm), Px (<1 mm) 7. Matrix: fine-grained, thin Pl needles visible 8. Secondary Minerals: vesicle fillings 9. Encrustations: up to 5 mm Mn crust	x	x						
M168-46-1-2	1. Rock Type: volcanic, pillow fragment, strongly altered, similar to -1 2. Size: 16x12x6 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: dense, slightly phyrlic (microphenocrystic), <3% vesicles <1mm, mostly open (!) 6. Phenocrysts: microphenocrysts; altered Ol (~5%, <1 mm) 7. Matrix: fine-grained, thin Pl needles visible 8. Secondary Minerals: pervasive gm oxidation 9. Encrustations: up to 8 mm Mn crust 10. Comment: fresh?! glass crust covered by Mn; requires careful picking	x	x		x				

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-46-1-3	1. Rock Type: volcanic, pillow fragment, strongly altered, similar to -2 2. Size: 12x10x6 cm 10. Comment: 3. to 8. similar to sample -2. Few fragments of fresh glass along the chilled margin but much less than in -2				x				

M168-47-1




Description of Location and Structure: Northernmost Azores-Biscay-Rise seamount, southern slope. 6nm E of M168-46-1 but 700 m deeper; lowermost flank

Dredge on bottom UTC 01/12/20 08:33 hrs, lat 44°48.38'N, long 15°14.22'W depth 4290 m



Dredge off bottom UTC 01/12/20 09:58 hrs, lat 44°48.82'N, long 15°14.31'W, depth 3830 m

total volume: three rocks

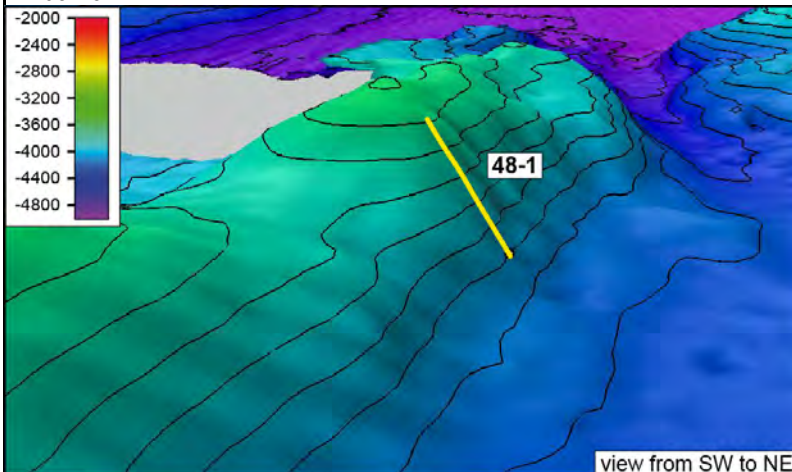
Comments: strongly altered pillow lava fragments with Fsp (micro-) phenocrysts. Sample -2 possibly contains remains of fresh glass

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-47-1-1	1. Rock Type: volcanic, pillow fragment, strongly altered 2. Size: 9x8x6 cm 3. Shape / Angularity: subangular to subrounded 4. Color of cut surface: orange-brown 5. Texture / Vesicularity: massive, dense, non-vesicular, slightly microphenocrystic 6. Phenocrysts: Pl microphenocrysts <1 mm, possibly altered Ol phenocrysts 7. Matrix: fine-grained, thin Pl needles visible 8. Secondary Minerals: strongly altered primary minerals, orange grains (Ol?), Mn dendrites 9. Encrustations: Mn crust up to 2 cm	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-47-1-2	1. Rock Type: volcanic, pillow fragment, strongly altered 2. Size: 10x9x4.5 cm 3. Shape / Angularity: subangular to subrounded 4. Color of cut surface: brown-orange 5. Texture / Vesicularity: massive, dense, non-vesicular, slightly Pl microphenocryst phyrlic 6. Phenocrysts: Pl microphenocrysts (5%, <1 mm) 7. Matrix: fine-grained 8. Secondary Minerals: strongly altered primary minerals (orange brown grains), cracks filled with Mn and white mineral, Mn dendrites 9. Encrustations: Mn crust up to 2 cm 10. Comment: altered glass, check if some fresh glass remained	x			x			fresh glass?!	
M168-47-1-3	1. Rock Type: magmatic rock, relatively fresh 2. Size: 7.5x7x4.5 cm 3. Shape / Angularity: rounded 4. Color of cut surface: grey with salmon colored mineral 5. Texture / Vesicularity: massive, dense, non-vesicular 6. Phenocrysts: white <1%, <1 mm, partly altered 7. Matrix: fine-grained, thin Pl needles visible 8. Secondary Minerals: white minerals partly altered to orange-yellow 9. Encrustations: Mn coating 10. Comment: foliated? dropstone?	x							

M168-48-1



Description of Location and Structure: Eastern extension of northern Azores-Biscay-Rise (ABR) smt. E-W striking fault zone E of northernmost ABR smt. S facing step from base to top.





Dredge on bottom UTC 01/12/20 14:50 hrs, lat 44°54.44'N, long 14°43.28'W depth 4110 m

Dredge off bottom UTC 01/12/20 16:14 hrs, lat 44°54.84'N, long 14°43.28'W, depth 3660 m





total volume: few rocks

Comments: slightly to moderately altered, Ol+Pl phyrlic lava fragments (#1 to #7) some with pillow type chilled margins but without glass. #8 is a Mn crust.

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-48-1-1	1. Rock Type: volcanic, lava fragment, mildly altered 2. Size: 9x6x5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey 5. Texture / Vesicularity: massive, dense, phyrlic, non-vesicular 6. Phenocrysts: altered Ol (5% up to 1 mm) 7. Matrix: fine-grained with Pl needles 8. Secondary Minerals: altered Ol, oxidized gm 9. Encrustations: Mn coating	x	x						
M168-48-1-2	1. Rock Type: volcanic, lava fragment, alteration halo but fairly fresh core 2. Size: 7x4.5x4 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish weakly altered core, brownish alteration halo 5. Texture / Vesicularity: massive, dense, phyrlic, filled vesicles 6. Phenocrysts: Fsp (1%, 1 mm) slightly altered 7. Matrix: fine-grained with Pl needles 8. Secondary Minerals: oxidized gm 9. Encrustations: Mn coating	x	x						
M168-48-1-3	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 7.5x5x4.5 cm 3. Shape / Angularity: angular to subangular 4. Color of cut surface: greyish to brownish 5. Texture / Vesicularity: massive, dense, aphyric, homogeneous, <1% vesicles 6. Phenocrysts: maybe very few altered Ol 7. Matrix: fine- to medium-grained 8. Secondary Minerals: - 9. Encrustations: Mn coating	x	x						
M168-48-1-4	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 9x6x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: grey to beige 5. Texture / Vesicularity: massive, dense, phyrlic, <1% vesicles, filled 6. Phenocrysts: altered Ol (<1%, <1mm) 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, oxidized gm 9. Encrustations: Mn coating	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-48-1-5	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 9x6x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish 5. Texture / Vesicularity: massive, dense, phytic, <1% vesicles, filled 6. Phenocrysts: altered Ol (<1%, <1mm) 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, oxidized gm 9. Encrustations: Mn coating	x	x						
M168-48-1-6	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 9x6x4 cm 3. Shape / Angularity: rounded 4. Color of cut surface: brownish 5. Texture / Vesicularity: massive, dense, phytic, <1% vesicles, filled 6. Phenocrysts: altered Ol (<1%, <1mm) 7. Matrix: fine-grained 8. Secondary Minerals: altered Ol, oxidized gm, Mn dendrites 9. Encrustations: Mn coating								
M168-48-1-7	1. Rock Type: volcanic, lava fragment, chilled margin 2. Size: 7x5x6 cm 3. Shape / Angularity: subangular to rounded 4. Color of cut surface: beige, orange to greenish 5. Texture / Vesicularity: network alteration, grey clasts, vesicles partly filled 6. Phenocrysts: 7. Matrix: fine-grained 8. Secondary Minerals: oxidized gm 9. Encrustations: Mn coating								
M168-48-1-8	1. Rock Type: Mn crust 2. Size: 10x7x4 cm								

M168 Dredge Station Details and Rock Description

M168-49-1





view from SW to NE

Description of Location and Structure: North Charcot Smt. Very base of at SW corner; a ridge that is connected to the main North Charcot structure. Steep SE facing slope. Track covers middle to upper slope

Dredge on bottom UTC 01/12/20 21:45 hrs, lat 44°39.20'N, long 14°02.86'W depth 4791 m
Dredge off bottom UTC 01/12/20 23:02 hrs, lat 44°39.55'N, long 14°03.05'W, depth 4383 m
total volume: seven rocks
Comments: Aphyric lava fragments ranging from slightly to strongly altered.

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-49-1-1	1. Rock Type: volcanic, lava fragment, slightly altered 2. Size: 7x7x5 cm 3. Shape / Angularity: angular 4. Color of cut surface: grey 5. Texture / Vesicularity: aphyric, slightly vesicular (~7%, ~1mm), partly filled with white & black material 6. Phenocrysts: . 7. Matrix: fine-grained, thin Fsp needles preserved 8. Secondary Minerals: Cc, Mn in vesicle filling 9. Encrustations: thin Mn crust, <1 mm 10. Comment: gm might be suitable for Ar-Ar dating. Chemistry tholeiitic?	x	x	x					
M168-49-1-2	1. Rock Type: volcanic, pillow (?) fragment, altered 2. Size: 24x24x15 cm 3. Shape / Angularity: subangular 4. Color of cut surface: greyish, brown 5. Texture / Vesicularity: sparsely phyric, quite dense, massive, ~1% vesicles <1mm), 50% filled with white & black material 6. Phenocrysts: altered Ol (<1%, <1 mm), black-white Px? (1x0.5 mm) 7. Matrix: fine-grained 8. Secondary Minerals: filled cracks with white, transparent and reddish material 9. Encrustations: Mn crust up to 6 mm 10. Comment: GC piece contains filled cracks that require careful picking. Outer chilled margin with altered glass.	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-49-1-3	1. Rock Type: volcanic, fragment, altered, similar to -1 2. Size: 5x8x4 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish, brown 10. Comment: 5. to 9. similar to -1	x							
M168-49-1-4	1. Rock Type: volcanic, lava fragment, moderately to strongly altered 2. Size: 6x7x8 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish, brown 5. Texture / Vesicularity: dense with ~3% vesicles <2mm, partly filled, sparsely phyric 6. Phenocrysts: altered Ol (5%, <2 mm) 7. Matrix: fine-grained 8. Secondary Minerals: oxidized gm 9. Encrustations: thin Mn crust <6 mm 10. Comment:	x	x						
M168-49-1-5	1. Rock Type: volcanic, lava fragment, strongly altered 2. Size: 6x8x9 cm 10. Comment: 3. to 9. similar to -4 but more altered								
M168-49-1-6	1. Rock Type: volcanic, lava fragment, moderately altered 2. Size: 5x5x8 cm 3. Shape / Angularity: angular 4. Color of cut surface: greyish, brown 5. Texture / Vesicularity: dense with <5% vesicles <1mm, mostly open (!) 6. Phenocrysts: rare up to 2mm black Px? 7. Matrix: fine-grained 8. Secondary Minerals: - 9. Encrustations: thin Mn crust <1 mm 10. Comment: differs from other samples in dredge by absence of Ol. May have different chemistry!	x	x						

M168 Dredge Station Details and Rock Description

SAMPLE #	SAMPLE DESCRIPTION	TS	CHEM	Ar/Ar	G/Min	SED	REF	NOTES	PICTURE
M168-49-1-7	1. Rock Type: volcanic, pillow (?) fragment, very strongly altered 2. Size: 3x4x3.5 cm 3. Shape / Angularity: subangular 4. Color of cut surface: brown 10. Comment: 5. to 9. like -4								