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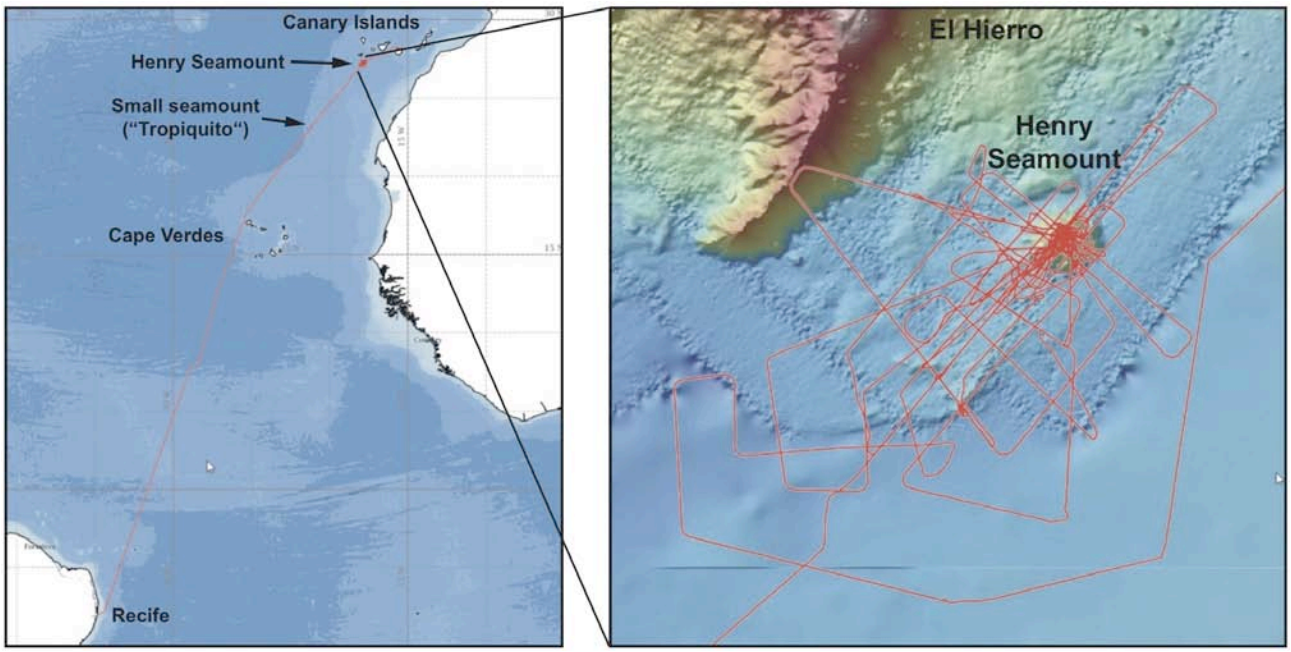
Short Cruise Report
R/V METEOR M146

Recife - Las Palmas de Gran Canaria
17th March 2018 - 16th April 2018

Chief Scientist: Dr. Andreas Klügel
Captain: Rainer Hammacher



Bathymetric map with ship track (red lines) of R/V METEOR cruise M146. The first three working stations were located at a small seamount in international waters between the Cape Verde and Canary Islands, all other stations in the vicinity of Henry Seamount ca. 40 km southeast of El Hierro island.

Objectives

The research program of cruise M146 had the main objective of discovering and documenting fluid venting sites at Henry Seamount, an extinct 126 Ma old volcano located 40 km to the southeast of El Hierro (Canary Islands, Spain). Evidence of recent fluid discharge at this seamount was provided by rock and shell samples from a reconnaissance dredging campaign during Meteor cruise M66/1 in 2005. The inferred fluid discharge could reflect hydrothermal circulation of seawater through the old oceanic crust, a process that is globally important for cooling of the lithosphere, chemical exchange between crust and ocean, and marine ecosystems. This type of circulation requires basement outcrops through the impermeable sediment cover, which can be provided by seamounts and island flanks. Only few venting seamounts unrelated to active volcanism have been documented so far; these are located on warm and relatively young Pacific crust. Henry Seamount would be the first documented example on old (>60 Ma) oceanic crust.

The main research questions for cruise M146 were:

- Does Henry Seamount show hydrothermal activity? The strategy to identify potential venting sites involved a) ship- and AUV-based multibeam bathymetry and sub-bottom profiling (PARASOUND); b) multichannel hydroacoustics with sparker sound source and streamer to recognize basement outcrops and sub-bottom structures; c) heat flow measurements along profiles to detect anomalies caused by fluid flow; d) analysis of hydroacoustic data for possible flares in the water column; e) TV sledge for video coverage of selected tracks; and f) deployment of temperature loggers and MAPRs (Miniature Autonomous Plume Recorder) recording possible anomalies in temperature and redox potential in the water column.
- What is the extent of venting, how many vent sites can be identified? From the previous dredging campaign two discharge sites on Henry Seamount could be inferred, but they were not yet precisely located, imaged, and sampled.
- Are venting sites restricted to basement outcrops and places with only thin sediment cover? Corroboration of this hypothesis would support models of seamounts acting as major breathing holes for old seafloor covered by sediment.
- What are the mineral and biological outcomes of fluid discharge? The few dredged samples obtained thus far provide a limited picture of mineral deposits and fauna at the venting sites. It was aimed to take samples by gravity corer and/or grab sampler to place constraints on the nature of the vent fluids.
- Is there increased heat flow at Henry Seamount and its vicinity due to the influence of the Canary hotspot? Heat flow data from M146 would not only indicate sites of fluid recharge or discharge, but would also contribute to global heat flow compilations and help to quantify the driving forces of hydrothermal circulation through ageing ocean crust.

Narrative

The METEOR disembarked from Recife in the morning of March 17th and began her transit to the first working area, a small seamount located ca. 100 km southwest of Tropic Seamount between the Cape Verde and Canary Archipelagos, which was provisionally named "Tropiquito". On March 19th at 12:16 ship time the METEOR crossed the Equator at 031°39' W, and on the following day the Mid-Atlantic Ridge. After the exclusive economic zone (EEZ) of Brazil was left on March 20th, hydroacoustic data were permanently recorded. On March 21st a test of the seismic equipment to compare the performance of the airgun and sparker sound sources was successfully carried out. From the morning of March 23rd until the afternoon of March 25th the ship passed the EEZ of Cape Verde to the west of the archipelago, and no hydroacoustic data were recorded.

The station work of M146 began on the evening of March 26th at "Tropiquito" seamount. The work comprised a sound velocity profile, a seismic profile accompanied by hydroacoustic mapping, and four heat flow measurements. It was found that the seamount is significantly steeper and taller than is apparent from the sparse bathymetric data existing thus far. On the next day the METEOR headed to Henry Seamount and reached the area on the evening of March 28th. The work began with a sound velocity profile, followed by a set of traverses with multichannel hydroacoustics using

a sparker sound source, and multibeam echosounding, across the seamount and its vicinity. This first survey lasted until the evening of the following day and provided an excellent base for the subsequent investigations. From March 29th until 31st the station work comprised three gravity cores, two of which were succesful, and 19 heat flow determinations along two SW-NE oriented profiles. One profile was located near the base of Henry Seamount, the other crossed a conspicuous bathymetric step southwest of it. The heat flow profiles showed local anomalies but no unequivocal trend. The work was followed by another set of traverses with multichannel hydroacoustics and multibeam echosounding to extend the previously mapped area.

The Eastern holiday on April 1st began with the first AUV deployment during M146. The mission was successfully finished, yielding high-quality bathymetric and backscatter data from the top of Henry Seamount. On the late afternoon the TV sled was deployed and towed in the same area above some marked features, which on the AUV maps showed relatively strong backscatter. The live camera and the high-resolution still camera, additionally mounted on the sled frame, provided exciting images of features such as former clam colonies, local basement outcrops, and an inferred fluid venting site. Good weather conditions still prevailing, the AUV was also deployed during the next two days. Both missions were accomplished without any problem, resulting in additional detailed maps from the seamount. In the night of April 2nd, the area south of Henry Seamount was investigated by another set of traverses with multichannel hydroacoustics and multibeam echosounding. On the evening of April 3rd another TV sled deployment in the summit area again showed highly interesting features including "clam graveyards" with hundreds to thousands of shells. Temperature loggers and MAPRs mounted on the TV sled indicated local temperature and chemical anomalies.

On April 4th each the gravity corer and grab sampler were deployed twice to sample the top of Henry Seamount. Whereas the corer could not catch any sediment, one grab yielded a sediment package with some clam shells and other biota. The sampling was followed by the third TV sled deployment, during which the southwestern foot of the seamount was explored. This area showed mainly monotonous pale sediment, strongly contrasting with the shell-rich summit area. The same area was subsequently investigated during the fourth AUV dive on April 5th. This dive, however, was automatically terminated by the vehicle in the afternoon, because it had drifted during deployment and came too close to the bottom. Yet a large part of the planned area was successfully mapped. From the afternoon until the morning of the next day, 10 heat flow determinations were carried out from the northern boundary of Henry Seamount towards the northeast. These measurements finished a ca. 45 km long heat flow profile across the seamount and its vicinity.

The fifth AUV dive took place on April 6th in the summit region. Whilst the vehicle was on its mission, two grab samples were taken from the summit region at safe distance. The recovered sediment packages contained abundant shells and other biota. After the AUV had successfully accomplished its mission and was recovered in the late afternoon, the Spanish vessel ANGELES ALVARIÑO approached the METEOR. A scientist from the Spanish Institute of Oceanography was brought to the METEOR and joined our scientific party for the rest of the cruise as part of a collaboration. From the evening until the next morning a traverse with multichannel hydroacoustics and multibeam echosounding was conducted from Henry Seamount towards the submarine extension of El Hierro's southern ridge, and back.

In the morning of April 7th a first attempt was undertaken to determine local heat flows in the summit region of Henry Seamount. Owing to apparently thin sediment cover, however, the heat probe could not sufficiently penetrate the sediment. In the afternoon two dredges were hauled on a small prominent cone southwest of Henry Seamount, in order to find out whether it represents a volcanic edifice possibly related to the Canary Islands. The first dredge was empty and the second yielded only a sparse amount of hard sticky sediment, suggesting that this cone is a rather old structure. After the dredging eight heat flow measurements were performed on a NW-SE traverse across this cone until the morning of April 8th. Back to the summit of Henry Seamount, two grab sampler stations retrieved some sediment with shells. During the following night, a heat flow traverse towards the southernmost extension of El Hierro resulted in three localities without lance

penetration and five successful ones. During stormy weather the ship returned to the summit of Henry Seamount on April 9th, where three attempts to deploy the heat flow lance yielded one successful measurement. This was followed by one grab sample yielding sediment with some shells.

A TV sled survey during the following night could locate and document a number of features discovered in the summit region during previous surveys. On April 10th two localities next to observed ORP anomalies were sampled by two grabs and one gravity core. The second grab retrieved surprisingly fresh, coarse basaltic ash and lapilli with local white crust having a distinct sulphide smell. The gravity core contained brownish sediment underlain by the same type of volcanic ash. After the sampling another TV sled survey of the summit region was carried out until the morning of April 11th. Then the AUV was deployed for its sixth dive to map the summit region. After it was on its track, two grab samples at selected localities yielded abundant large bright shells with basaltic ash and lapilli, and brown sediment with some shells. After AUV recovery another TV sled tow surveyed the southeastern part of Henry Seamount, revealing features similar to those on the summit. On April 12th the seventh AUV mission mapped the remaining part of the summit area, and two concurrent grab samples yielded sediment and shells. This was followed by the last TV sled deployment during M146 to survey the eastern summit region.

On the morning of April 13th a gravity core was successfully taken at the southwestern base of Henry Seamount, yielding sediment with noticeable ash layers. Afterwards a multichannel hydroacoustics and multibeam echosounding survey was conducted to fill gaps in the existing traverses. This was followed by a 6 m gravity core near presumed collapse deposits to the south of the seamount, also yielding sediment with ash layers. Then twelve heat flow measurements were performed in the same area along a NW-SE profile. On April 14th a scheduled AUV deployment was cancelled due to strong swell, and two grab samples were taken instead. Subsequent attempts to carry out more heat flow measurements at the seamount summit failed because the lance could not penetrate into the sediment. The last station of M146 was a multichannel hydroacoustics and multibeam echosounding survey lasting from the evening until April 15th around noon. The METEOR then began her way towards Gran Canaria, with final hydroacoustic mapping whilst in the working area. On the morning of April 16th the METEOR called at the port of Las Palmas.

Acknowledgements

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Participants M146

No.	Name	Discipline	Institution
1	Klügel, Andreas, Dr.	Chief scientist	GeoBremen
2	Bachmann, Anna Katharina	Geology, hydroacoustics	GeoBremen
3	Barrett, Rachel	Reflection seismics	GeoKiel
4	Büttner, Hauke	AUV team	MARUM
5	Fleischmann, Timo	Heat flow	GeoBremen
6	Fraile Nuez, Eugenio, Dr.	Oceanography, Spanish observer	IEO-COC
7	Held, Philipp, Dr.	Reflection seismics	GeoKiel
8	Jähmlich, Heiko	Reflection seismics	GeoKiel
9	Kaul, Norbert, Dr.	Heat flow	GeoBremen
10	Kramer, Laura	Geology, hydroacoustics	GeoBremen
11	Krastel, Sebastian, Prof. Dr.	Reflection seismics	GeoKiel
12	Lenz, Kai-Frederik	Reflection seismics	GeoKiel
13	Lindhorst, Katja, Dr.	Reflection seismics	GeoKiel
14	Meinecke, Gerrit	AUV team	MARUM
15	Melcher, Anne-Christin	Geology, hydroacoustics	GeoBremen
16	Nazarenko, Daria	Artist (guest)	KunstHalle
17	Raeke, Andreas	Meteorology	DWD
18	Renken, Jens	AUV team	MARUM
19	Rentsch, Harald	Meteorology	DWD
20	Römer, Miriam, Dr.	Geology, hydroacoustics	GeoBremen
21	Schmidt, Jan-Niklas	Heat flow	GeoBremen
22	Spiesecke, Ulli	AUV team	MARUM
23	Stange, Nikolas	Geology, hydroacoustics	GeoBremen
24	Strack, Anne	Geology, hydroacoustics	GeoBremen
25	Villinger, Heinrich, Prof. Dr.	Heat flow	GeoBremen
26	Wintersteller, Paul	Hydroacoustics	GeoBremen

GeoBremen	Fachbereich Geowissenschaften der Universität Bremen, Germany
GeoKiel	Institut für Geowissenschaften der Universität Kiel, Germany
MARUM	Zentrum für Marine Umweltwissenschaften der Universität Bremen, Germany
IEO-COC	Centro Oceanográfico de Canarias, Santa Cruz de Tenerife, Spain
DWD	Deutscher Wetterdienst, Hamburg, Germany
KunstHalle	Kunsthochschule Burg Giebichenstein, Halle, Germany

Station list of R/V METEOR cruise M146

Date	Station No.		Gear	Time	Latitude	Longitude	Depth	Remarks
2018	M146_	GeoB		[UTC]	N	W	[m]	
26.03.	1-1	22801-1	SVP	18:29-19:50	22°50.076	21°22.527	4387	SVP probe
26.03.	2-1	22802-1	SEIS	20:31-05:12	22°51.275 - 23°13.001	21°21.763 - 21°08.095	4406 - 4344	Traverse across small seamount; airgun
27.03.	3-1	22803-1	HF	06:58-13:26	23°05.218 - 23°06.694	21°13.094 - 21°12.216	4336 - 4345	4 heat flow measurements
28.03.	4-1	22804-1	SVP	19:28-19:28	27°02.116	17°59.927	3760	XBT until 1000 m depth
28.03.	5-1	22805-1	SEIS	20:29-18:11	27°05.026 - 27°23.953	17°58.692 - 17°51.260	3765 - 3604	Traverse across Henry Smt; sparker
29.03.	6-1	22806-1	GC	20:35-22:50	27°06.986	17°57.133	3778	3m GC, 186 cm recovery
29.03.	7-1	22807-1	HF	23:28-14:46	27°06.956 - 27°11.736	17°56.961 - 17°52.944	3765 - 3670	12 heat flow measurements

30.03.	8-1	22808-1	GC	15:57-18:20	27°11.300	17°53.357	3694	3m GC, 286 cm recovery
30.03.	9-1	22809-1	GC	21:04-22:57	27°20.030	17°42.926	3000	3m GC, no recovery
31.03.	10-1	22810-1	HF	00:19-10:31	27°15.244 - 27°18.191	17°50.031 - 17°47.528	3704 - 3660	7 heat flow measurements
31.03.	11-1	22811-1	SEIS	11:47-06:13	27°16.351 - 27°18.661	17°51.128 - 17°51.372	3709 - 3701	Set of traverses, with sparker
01.04.	12-1	22812-1	AUV	08:43-17:22	27°19.828 - 27°19.592	17°45.849 - 17°46.087	3062 - 3061	AUV dive successful
01.04.	13-1	22813-1	OFOS	18:04-06:37	27°20.151 - 27°20.061	17°45.965 - 17°44.977	2957 - 3285	TV sled with 2 MTL and 1 MAPR
02.04.	14-1	22814-1	AUV	06:52-18:22	27°19.803 - 27°17.529	17°44.896 - 17°45.019	3061 - 3061	AUV dive successful
02.04.	15-1	22815-1	SEIS	19:05-06:24	27°16.152 - 27°14.908	17.48.842 - 17°52.921	3692 - 3695	Set of traverses, with sparker
03.04.	16-1	22816-1	AUV	07:23-18:53	27°19.909 - 27°20.909	17°45.639 - 17°47.702	3044 - 3062	AUV dive successful
03.04.	17-1	22817-1	OFOS	19:39-06:45	27°19.842 - 27°20.389	17°45.634 - 17°46.432	3050 - 3187	TV sled with 2 MTL and 2 MAPR
04.04.	18-1	22818-1	GC	07:05-09:13	27°19.716	17°45.546	3082	3m GC, little recovery
04.04.	19-1	22819-1	GS	09:39-12:00	27°20.142	17°45.920	2990	Grab did not release
04.04.	20-1	22820-1	GS	12:00-15:05	27°20.135	17°45.924	2993	Sediment, many shells and other biota
04.04.	21-1	22821-1	GC	15:52-17:52	27°20.167	17°45.929	2994	3m GC, no core recovery
04.04.	22-1	22822-1	OFOS	18:40-05:54	27°18.649 - 27°18.209	17°46.702 - 17°45.552	3327 - 3502	TV sled with 2 MTL and 2 MAPR
05.04.	23-1	22823-1	AUV	06:08-14:38	27°18.145 - 27°18.124	17°47.640 - 17°47.394	3336 - 3336	AUV dive successful, finished earlier
05.04.	24-1	22824-1	HF	15:40-05:24	27°21.546 - 27°25.542	17°44.709 - 17°41368	3336 - 3336	10 heat flow measurements
06.04.	25-1	22825-1	AUV	05:43-17:53	27°25.542 - 27°19.562	17°41.368 - 17°46.635	3336 - 3036	AUV dive successful
06.04.	26-1	22826-1	GS	10:19-12:42	27°20.172	17°46.058	3012	Sediment, partly cemented, many shells and other biota
06.04.	27-1	22827-1	GS	13:10-15:54	27°20.202	17°46.062	3034	Sediment, many shells and other biota, basalt fragments
06.04.	28-1	22828-1	SEIS	18:53-07:08	27°18.225 - 27°14.245	17°44.498 - 17°43.106	3606 - 3747	Set of traverses, with sparker
07.04.	29-1	22829-1	HF	08:17-11:24	27°20.119 - 27°20.183	17°45.986 - 17°46.046	2985 - 3005	5 attempts, all failed
07.04.	30-1	22830-1	DR	13:09-15:48	27°09.309 - 27°09.461	17°51.994 - 17°52.001	3742 - 3635	Dredge empty
07.04.	31-1	22831-1	DR	16:13-18:47	27°09.297 - 29°09.656	17°51.856 - 17°51.981	3747 - 4172	Dredge empty, bits of sediment
07.04.	32-1	22832-1	HF	21:09-10:44	27°07.531 - 27°11.982	17°50.255 - 17°53.791	3763 - 3669	8 heat flow measurements
08.04.	33-1	22833-1	GS	12:58-15:57	27°20.0	17°45.881	3053	No recovery
08.04.	34-1	22834-1	GS	16:01-18:27	27°20.064 -	17°45.850	2995	Some sediment, some dark shells
08.04.	35-1	22835-1	HF	19:15-08:14	27°20.203 - 27°21.982	17°48.415 - 17°54.773	3661 - 3645	5 heat flow measurements
09.04.	36-1	22836-1	HF	11:25-15:02	27°19.053 - 27°19.501	17°45.647 - 17°46.309	3200 - 3200	1 heat flow measurements
09.04.	37-1	22837-1	GS	16:15-18:49	27°19.503	17°46.333	3082	Sediment, many dark shells and other biota
09.04.	38-1	22838-1	OFOS	19:26-07:37	27°19.504 - 27°20.287	17°46.333 - 17°46.054	3075 - 3063	TV sled with 2 MTL and 2 MAPR

10.04.	39-1	22839-1	GS	07:50-10:33	27°20.243	17°46.050	3060	Sediment, few shells
10.04.	40-1	22840-1	GS	11:05-13:32	27°20.175	17°46.080	3025	Some sediment, coarse basaltic ash and lapilli, some shells
10.04.	41-1	22841-1	GC	14:29-16:40	27°19.294	17°45.717	3145	3m GC, two attempts, 38 cm recovery
10.04.	42-1	22842-1	OFOS	17:40-05:55	27°20.302 - 27°19.509	17°46.062 - 17°46.485	3090 - 3145	TV sled with 2 MTL and 2 MAPR
11.04.	43-1	22843-1	AUV	06:10-19:01	27°19.477 - 27°18.010	17°46.492 - 17°45.417	3145 - 2998	AUV dive successful
11.04.	44-1	22844-1	GS	10:17-12:43	27°20.223	17°46.071	3061	Sediment, some basaltic ash, many white shells and other biota
11.04.	45-1	22845-1	GS	13:33-16:03	27°20.056	17°45.893	2998	Sediment, some basalt fragments, many dark shells and other biota
11.04.	46-1	22846-1	OFOS	19:33-06:27	27°18.202 - 27°18.200	17°45.136 - 17°44.721	3605 - 2999	TV sled with 2 MTL, 2 MAPR, CTD
12.04.	47-1	22847-1	AUV	06:43-18:57	27°19.889 - 27°18.595	17°45.638 - 17°47.548	2998 - 3042	AUV dive successful
12.04.	48-1	22848-1	GS	10:05-13:17	27°20.232	17°46.055	3042	Sediment, some basaltic fragments, many shells and other biota
12.04.	49-1	22849-1	GS	14:01-17:09	27°19.701	17°46.371	3035	Sediment, few shells
12.04.	50-1	22850-1	OFOS	19:35-05:37	27°19.406 - 27°19.503	17°45.103 - 17°46.462	3160 - 3180	TV sled with 2 MTL, 2 MAPR, CTD
13.04.	51-1	22851-1	GC	06:11-08:21	27°17.546	17°48.090	3655	3m GC, 239 cm recovery, 21 cm cc
13.04.	52-1	22852-1	SEIS	08:53-15:02	27°17.570 - 27°07.975	17°49.092 - 17°44.035	3645 - 3743	Set of traverses, with sparker
13.04.	53-1	22853-1	GC	16:06-18:20	27°14.155	17°47.278	3705	6m GC, 332 cm recovery
13.04.	54-1	22854-1	HF	18:58-06:09	27°14.164 - 27°15.766	17°47.278 - 17°49.717	3704 - 3702	11 heat flow measurements
14.04.	55-1	22855-1	GS	07:50-10:30	27°18.956	17°45.432	3230	Sediment, few shells and other biota
14.04.	56-1	22856-1	GS	10:45-13:14	27°18.957	17°45.425	3241	Sediment, few shells
14.04.	57-1	22857-1	HF	13:50-17:06	27°19.212 - 27°19.578	17°45.682 - 17°45.748	3232 - 3112	3 attempts, all failed
14.04.	58-1	22858-1	SEIS	18:02-10:18	27°13.518 - 26°58.342	17°45.833 - 17°52.933	3741 - 3734	Set of traverses, with sparker

Gear: AUV: MARUM SEAL-5000; OFOS: TV sled; SEIS: multichannel hydroacoustics with multibeam echosounding; HF: heat flow lance; GC: gravity corer; GS: grab sampler; DR: dredge; SVP: sound velocity profile.