Lachschewitz

Geologisch-Paläontologisches Institut

und Museum

Christian-Albrechts-Universität

Kiel, Deutschland

Cruise Report Poseidon 229a/b

Kolbeinsey Ridge

Akureyri - Reykjavik

22.05.1997 - 11.06.1997

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POSEIDON
JAGO

Institut für Meereskunde
an der Universität Kiel

CRUISE REPORT

R. V. POSEIDON Cruise No.: POS 229/a

Dates of Cruise: 22.6.1997 - 2.6. 1997

General Subject of research: Detailed study of the shallow water hydrothermal system around Kolbeinsey and Grimsey islands

Port Calls: Akureyri, Akureyri

IfM-Department/CAU Institute: Geologisch-Paläontologisches Institut

Chief Scientist: Prof. Dr. P. Stoffers

Number of Scientists: 12

Project: Kolbeinsey-Ridge

1. Scientific Crew

Prof. Dr. P. Stoffers	GPI
Dr. Reiner Botz	GPI
Dr. Dieter Garbe-Schönberg	GPI
Dr. Marc Hannington	CAN
Beatrice Hautzel	IMR
Prof. Dr. Peter Herzig	TUBA
Karen Hissmann	MPI
Dr. Robert Huber	IMR
Dr. Jakob K. Kristjansson	ICETEC
Dr. Solveig K. Petursdottir	ICETEC
Jürgen Schauer	MPI
Manfred Schmitt	GCA
Markus Zimmmerer	GPI

GPI - Geologisch-Paläontologisches Institut der Universität zu Kiel,
Olshausenstr. 40, D-24118 Kiel, Germany

CAN - Canadian Geological Survey,
601 Booth Street, Ottawa, Onkia OE8, Canada

MPI - Max-Planck-Institut für Verhaltensphysiologie,
D-82319 Seewiesen, Germany

IMR - Institut für Mikrobiologie der Universität Regensburg,
Universitätsstr. 31, D-93053 Regensburg, Germany

TUBA - Institut für Mineralogie der TU/Bergakademie Freiberg,
Brennhausengasse 14, D-09596 Freiberg, Germany

ICETEC - Technological Institute of Iceland,
Kelduaholt, 19-112, Reykjavik, Iceland

GCA - Geochemische Analysen,
Glückaufstr. 50, D-31319 Sehnde-Ilten, Germany

2. Research program

The main cruise objective of this multidisciplinary project was to study and sample the shallow water hydrothermal systems around Kolbeinsey and Grimsey in detail. By means of the submersible JAGO in combination with F.S. POSEIDON we tried to gain information on

- the composition and origin of fluids and gases
- the type and extent of hydrothermal activity
- the phylogenetic variety of the microbial high-temperature ecosystem

3. Report on the cruise with technical details

F.S. POSEIDON left Akureyri at 8.00 a.m. on May 23rd for cruise 229a. The cruise ended on June 2nd at Akureyri. A short stop was made for the exchange of icelandic scientists on May 29th, also at Akureyri. During most part of the cruise the wheather was very good with clear sky and calm sea which meant ideal conditions for the diving operations. Diving was done during the day, in general two dives a day. Intensive profiling was done during the night. Usually, it took less than 30 minutes from the start of the diving operation till the descent of JAGO. A total of 16 dives were performed during the cruise: 9 dives at the Kolbeinsey Ridge, 5 dives east of Grimsey, 1 dive in the Skjalfandadjup area and 1 dive in the Fjord of Akureyri. Sampling of the degassing water from the sea botttom and of the hydrothermal precipitates was performed with a specially designed slurp gun and manipulator which were triggered by the submersible pilot.

In addition to the diving operation, two hydrocast stations were successfully done in the Grimsey hydrothermal field. Location and water depth of the individual dives is given in Tab. 1.

Table 1: Dives with submersible „JAGO“

Station No.	Dive No.	Latitude N	Longitude W	Water depth [m]	Date	Begin	End	Area
229	437	66° 38.74	17° 55.73	204	23.05.97	15:04	16:26	Grimsey
231	438	67° 05.73	18° 42.69	130	24.05.97	08:17	10:37	Kolbeinsey
233	439	67° 05.69	18° 42.78	139	24.05.97	14:45	20:19	Kolbeinsey
235	440	67° 05.42	18° 42.52	100	25.05.97	08:44	09:13	Kolbeinsey
236	441	67° 05.50	18° 42.37	160	25.05.97	11:40	15:15	Kolbeinsey
237	442	67° 05.48	18° 42.17	107	25.05.97	18:35	22:26	Kolbeinsey
238	443	67° 05.46	18° 42.64	100	26.05.97	08:47	11:21	Kolbeinsey
240	444	67° 05.46	18° 42.47	165	26.05.97	16:19	19:04	Kolbeinsey
242	445	67° 05.32	18° 42.66	146	27.05.97	08:40	11:45	Kolbeinsey
243	446	67° 05.46	18° 42.41	161	27.05.97	16:18	19:12	Kolbeinsey
244	447	65° 49.78	18° 06.58	57	28.05.97	08:46	11:24	Akureyri Fj.
246	448	66° 36.53	17° 39.44	398	29.05.97	09:44	13:17	Grimsey
248	449	66° 36.59	17° 39.02	420	29.05.97	14:10	21:19	Grimsey
249	450	66° 36.58	17° 39.13	406	30.05.97	08:48	12:35	Grimsey
251	451	66° 36.59	17° 39.13	406	30.05.97	16:25	19:31	Grimsey
256	452	66° 36.41	17° 39.23	378	31.05.97	12:58	17:43	Grimsey

4. Scientific report and first results

Volcanism and geothermal activity is common in Iceland, especially within the neovolcanic zone running from the Reykjanes Peninsula in the south to the northeastern coast from where it connects with the slow-spreading Kolbeinsey Ridge. A site of geothermal activity was discovered in 1974 on Kolbeinsey Ridge, 110 km north of Iceland, by the captain of a fishing trawler. Gas bubbles were seen at the sea surface within an area not greater than 50 m in diameter.

The geothermal site is on the top of a small volcano which rises from depths of 200 m to 90 m below the surface (Fig. 1). The dives were basically concentrated on the southern part of the volcano (Fig. 2).

During the dives with the submersible JAGO, a detailed seafloor survey was undertaken using video and photo systems. A description of the individual dives and a table of the samples collected is enclosed (see appendix). A plume of boiling and near-boiling water and gas bubbles emanates and discharges out of fissures or crater-like dips from the top of a small volcano at water depths of 100 and 110 m, which is clearly seen on the echo sounder recorder (Fig. 3). The thermal activity is very intense and shakes loose basaltic fragments on the seafloor. The highest temperature measured was 131° C. The hydrothermal material consists of an orange-reddish mud or a yellow-reddish Fe-hydroxide staining on highly altered basalt. The vent sites could be easily recognised by a whitish overgrowth of thick filamentous bacterial mats. These bacteria seem to belong to the larger types of the family *Beggiatoaceae*.

A large anhydrite chimney (total height about 30 m) was found in the Akureyri Fjord at 65°49.73N; 18°06.69W. The structure can clearly be seen on the echo sounder (Fig.4). The diameter was about 5 m at the top and about 20 m at the base. No special outflow was observed at the top. Smaller outflows were present at various places along the chimney.

The presence of a large active vent field east of Grimsey at about 66°36.40N; 17°

39.55E in about 400 m water depth was the most exciting discovery during this cruise. The vent field showed up on the echo sounder (Fig. 5). Based on closed spaced profiles the size and extent of the field could be mapped (Fig. 6). The field has a length of nearly 1000 m and a width of about 300 m. The area turned out to be a large anhydrite mound with numerous active anhydrite chimneys. Many of the high temperature vents showed boiling (Fig. 7). The highest temperature measured was 250 ° C. No typical vent fauna was observed.

Water samples were taken using the common Niskin-bottles carried by JAGO. The bottles were directly placed into the outflows. Gas bubbles have been collected using a water-filled (1.5 l; up-side down) glass bottle positioned in the gas stream. The water in the bottles was partly replaced by gas which further expanded during uplift. When JAGO reached the surface a diver closed the sample bottle under water and then disconnected it from the submersible.

Methods

Gas sampling and analysis. Water samples were degassed on board applying a combined ultrasonic/vacuum degassing technique. Compositional analyses of light hydrocarbons (C1-C6) and the stable carbon isotopic compositions of methane and carbon dioxide (note that $\delta\ ^{13}C\text{-}CO_2$ was determined in samples of free gas bubbles only) were performed applying standard technique. Quantitative chromotographic analyses of gaseous hydrocarbons were made using a Packard^R model 438 GC (50m long Al_2O3-KCl PLOT^R quartz capillary column; flame ionization detector). Gas chromatograph separation of hydrocarbons for isotope analysis was achieved with a similar GC system (except that a different column was installed; 1,8 m packed, Super QR 80-100 mesh, 1/4", 6,35mm; carrier gas He). Isotope values are given in the appendix in Tab. 1 representing mean values based on two measurements. Carbon isotope values are reported in δ-values on the PDB scale. The reproducibility of isotope analysis including conversion of hydrocarbons is +/- 0.12 °/oo. The isotope value of the international reference standard NBS-22 is -29.8 °/oo PDB.

Water sampling and chemistry. Two 5 l Niskin bottles were mounted on a frame at the front end of the submersible. For sampling of venting hydrothermal fluids the submersible was positioned in such a way that the Niskins came righ into the outlet of hydrothermal fluids. The Niskin bottles were then released from inside the submersible by a remote handling gear. Immediately after recovery and fixation of the submersible on-board RV Poseidon fluid samples were filled in pre-washed and nitrogen filled 1 liter FEP Teflon bottles for subsequent filtration and sample preparation. Any contact of the water sample with ambient air was avoided. A second aliquot (500 ml and 125 ml, respectively) was taken for the determination of total (dissolved and particulate) composition. Fluid and water samples were filtrated instantaneously after sampling on-boarrd ship. Samples were pressure-filtrated through 0.4 µm polycarbonate membrane filters (Nuclepore) using nitrogen 5.0 (99.9990 % N_2). Filtrates were splitted for on-shore determinations of anions (125 ml, HDPE bottles, no further sample treatment) and major and trace element composition (125ml, FEP Teflon bottles), respectively. A third aliquot (125 ml FEP Teflon bottles) for determination of total recoverable elements (dissolved and particulate) was taken directly from the 1 liter FEP bottle. The latter two aliquots were acidified with 5 drops ml subboiled hydrochloric acid. All sample preparation work was done in a class 100 clean bench. Titration alkalinity, pH, and dissolved oxygen were determined immediately after sampling on-board ship. The analytical procedures followed the standard procedures outlined in Grasshoff (1993). Precision of the determinations was ± 0.02-0.05 pH, and 0.05 ml O_2/l, respectively. Results are summarized in Tab. 2 in the appendix.

Microbiology. The hydrothermal fluid samples were dispensed into 100 ml and 500 ml glass bottles. The solid samples were crushed into small pieces and were stored in 100 ml Sovirel bottles. The bottles were filled up with seawater from the sample storage cylinder. The seawater had a strong smell of H2O. All bottles were sealed with rubber stoppers. In order to remove dissolved oxygen, aliquots of the samples were reduced by addition of sodium sulphide (0.025g-0.5g/l) and sodium dithionate (0.005g/l). The samples were stored at 4° C.

For in situ phylogenetic studies of the hydrothermal systems of Kolbeinsey and

Grimsey, DNA from aliquots of ten rock samples and four fluid samples was already prepared on board of F.S. POSEIDON. In addition, aliquots of the samples were fixed by the addition of formaldehyde (3 %, final concentration) for in situ hybridization studies.

5. Scientific equipment, instruments etc.

The cruise was purely aimed at sampling hydrothermal vents by means of the submersible JAGO. This was done very successfully. No problems occurred with JAGO. The handling of JAGO by the ships crew was very professional.

6. Station List

A list of stations occupied and samples collected as well as the first data on the composition of the gases and vent fluids are given in the appendix. A detailed discussion of these results will be given elsewhere.

7. Acknowledgements

We would like to thank the JAGO team, Karen Hissmann and Jürgen Schauer for their exceptional engagement during the cruise without this the great success of the cruise could not have been achieved. Last but not least, to Captain Bülow and his crew we offer our sincere thanks. It was fun working together. Prof. G. Kortum is thanked for his help to get the permission to work in the territorial waters of Iceland.

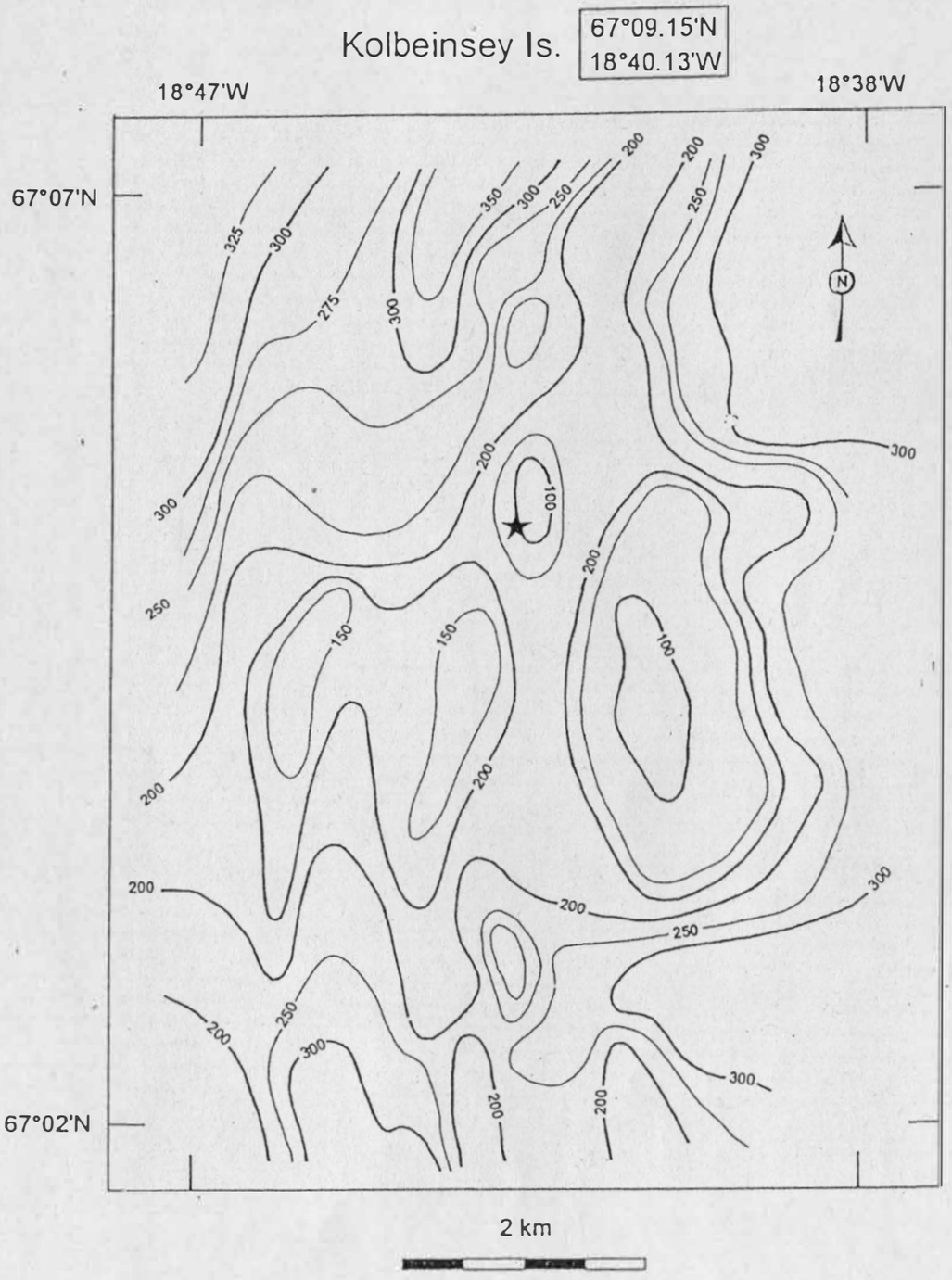

Fig. 1 **Bathymetry south of Kolbeinsey Island**
The star marks the approximate position of the hydrothermal site

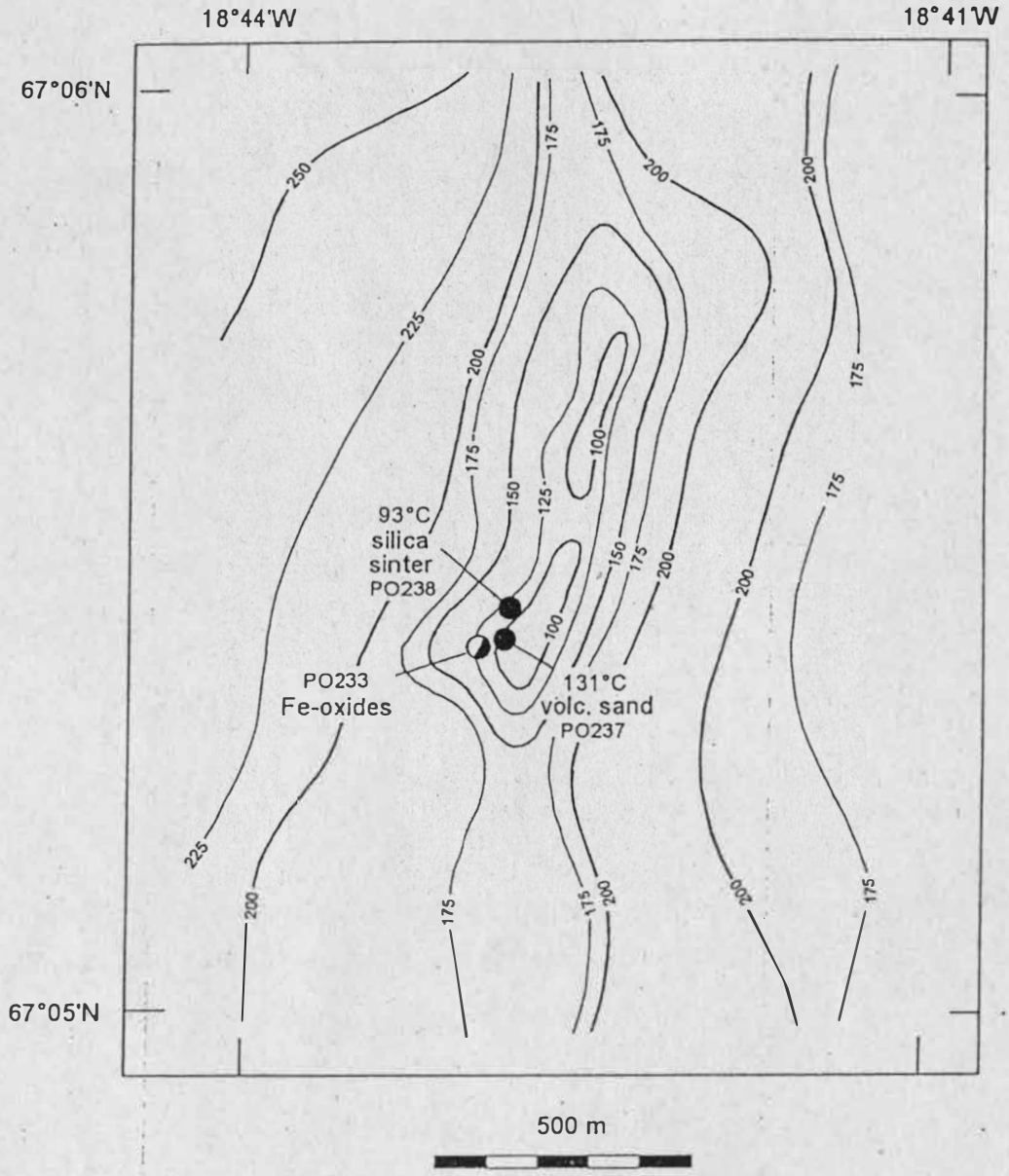

Fig. 2 **Detailed bathymetric map of the Kolbeinsey hydrothermal site**

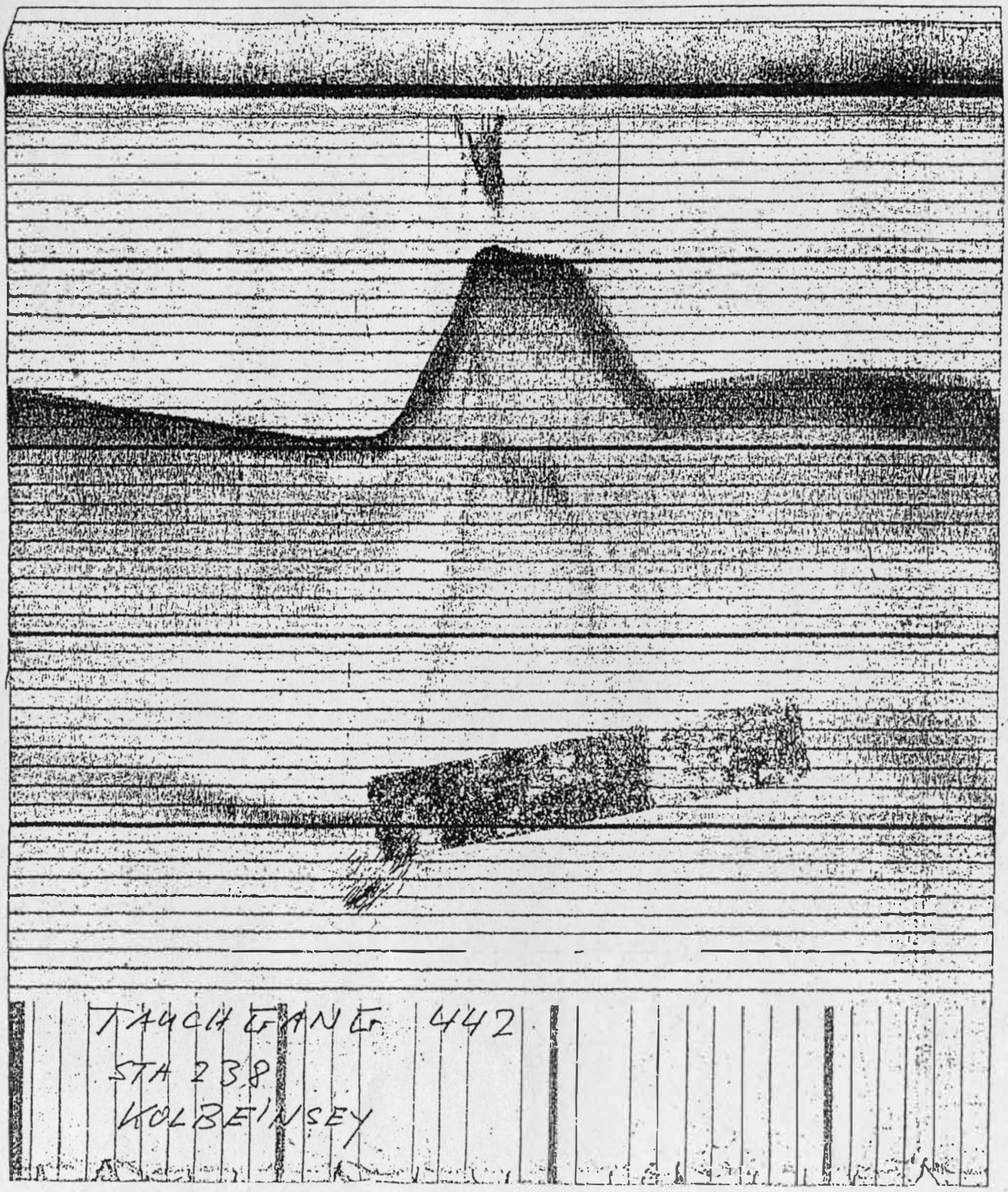

Fig. 3 Echo-sounding record showing the main outflow at the Kolbeinsey site

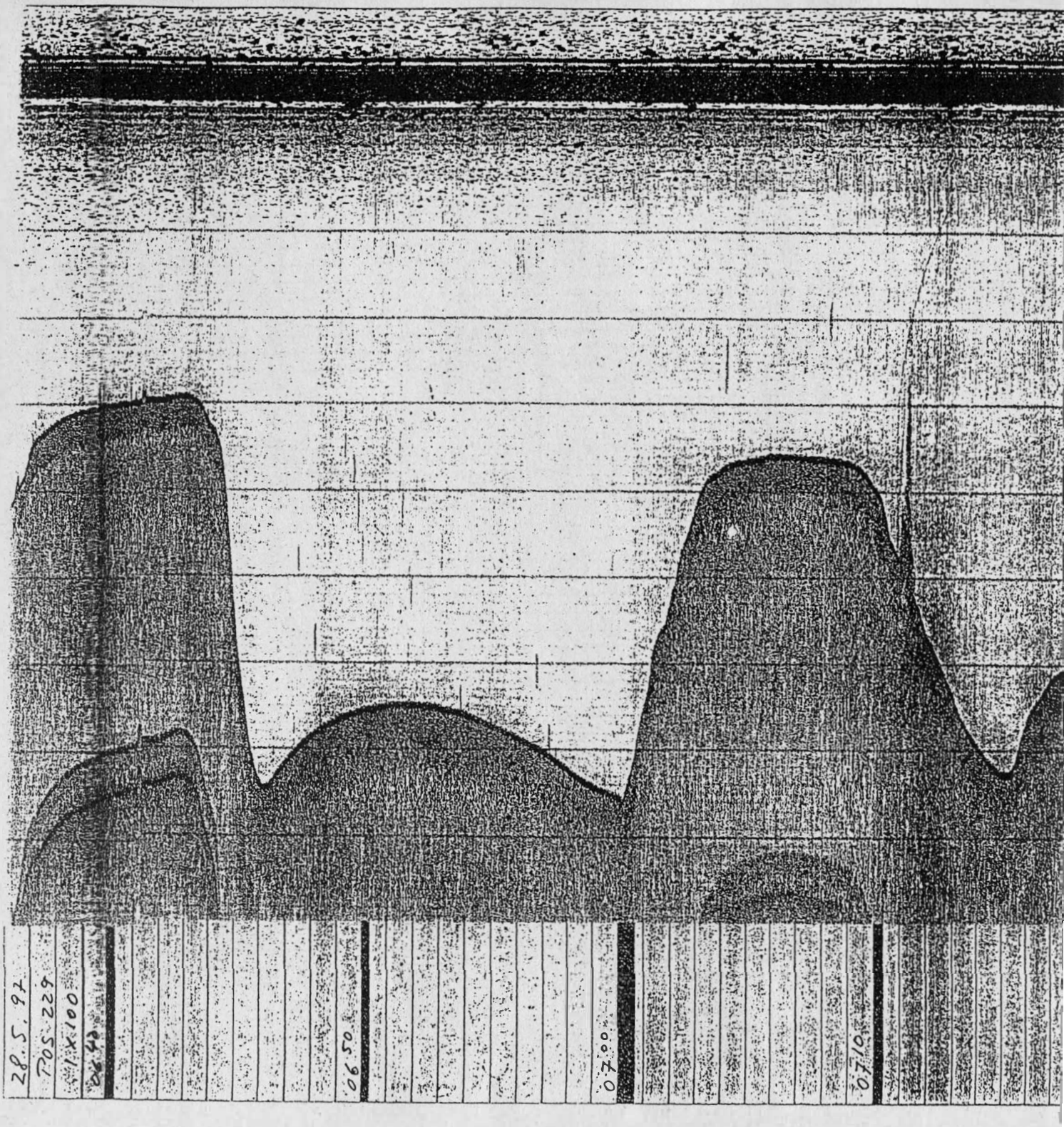

Fig. 4 Echo-sounding record of the large anhydrite chimney found in the Akureyri Fjord

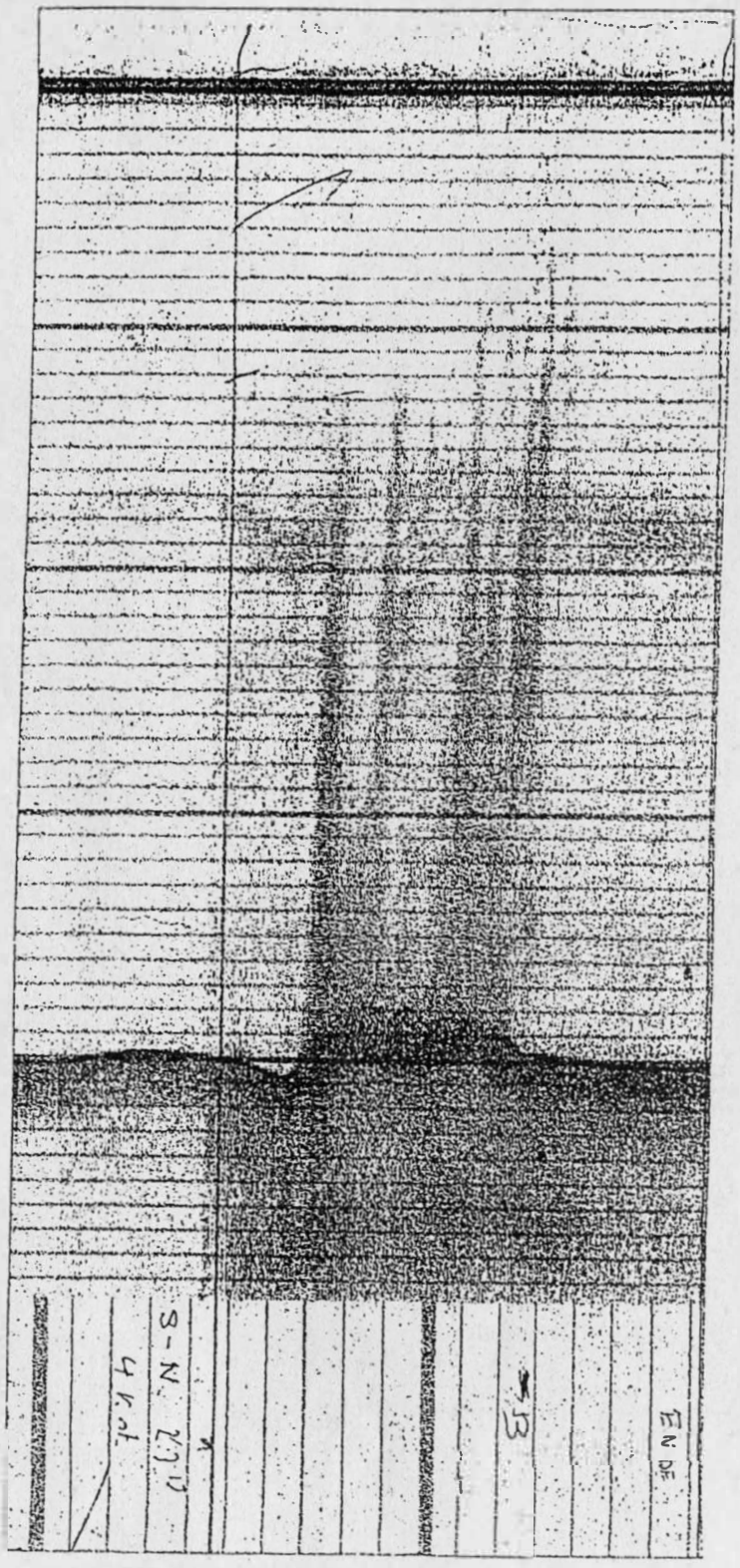

Fig. 5 Echo-sounding record of the hydrothermal field east of Grimsey showing intensive venting

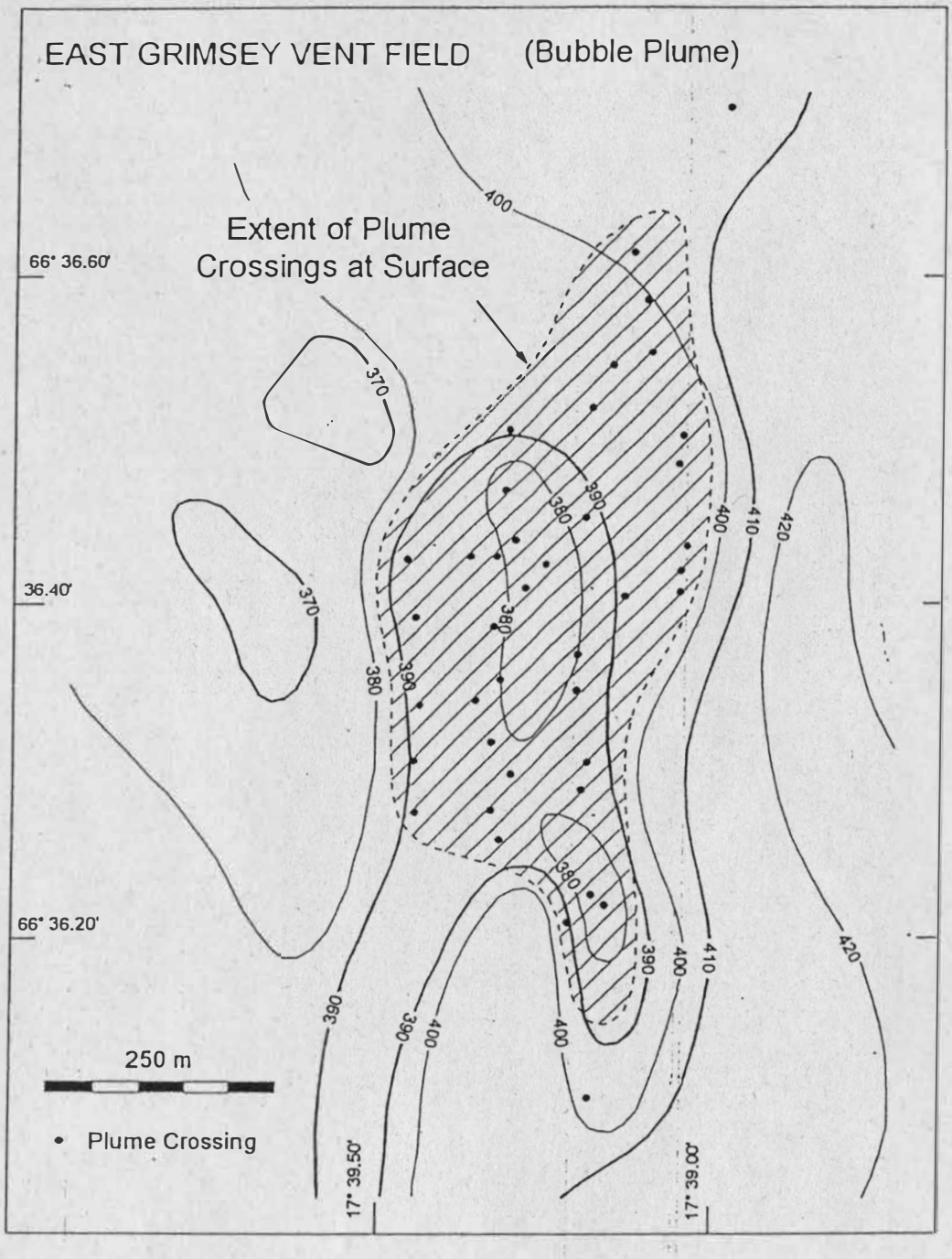

Fig. 6 **Extent of the East Grimsey vent field**

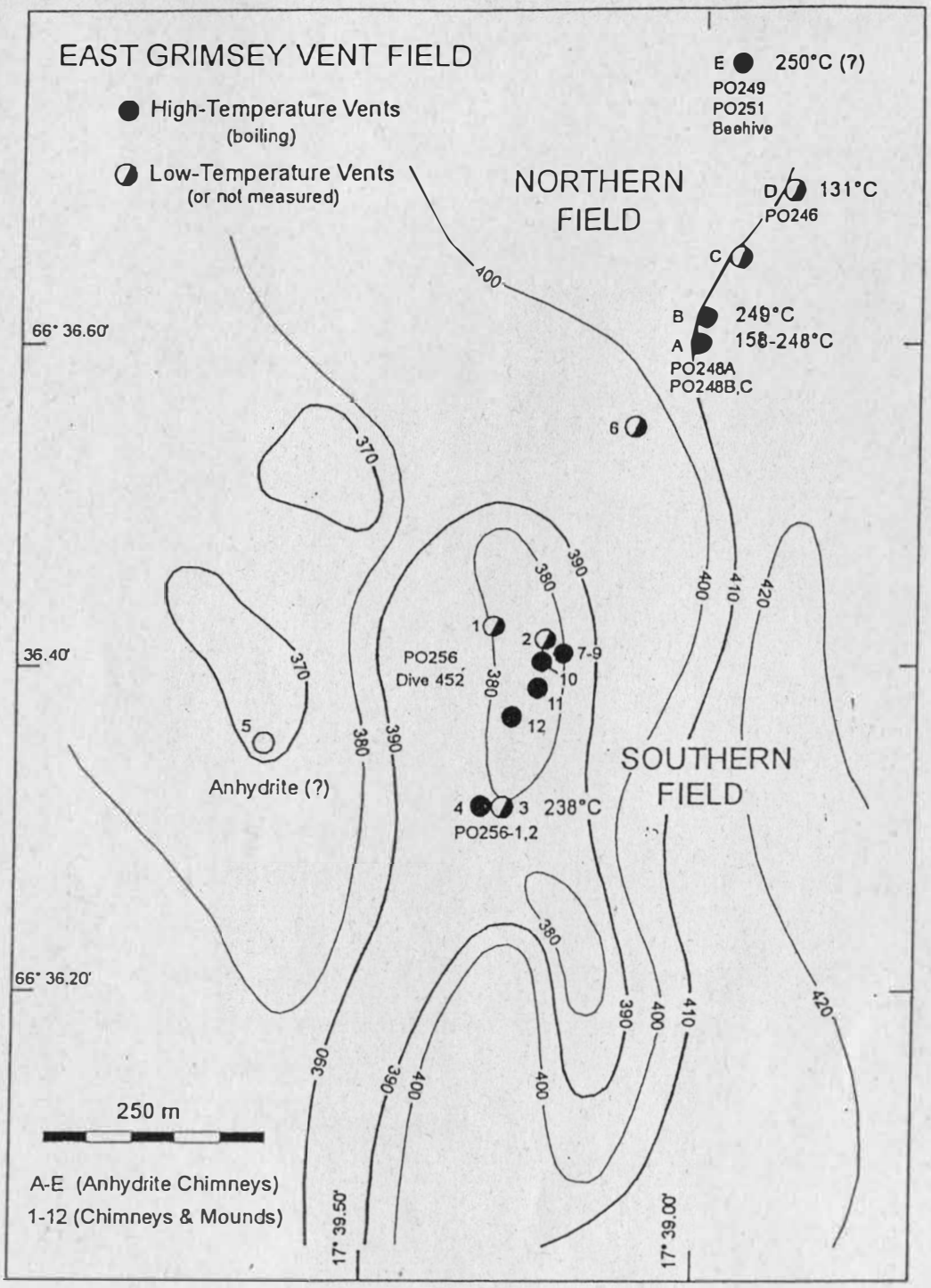

Fig. 7 Location of high and low temperature vents in the East Grimsey vent field

APPENDIX

STATION No.: 229 AREA: N' Grimsey Island
JAGO DIVE No.: 437
DATE: 23.05.1997
TIME: 15:04 - 16:26
DEPTH RANGE: 220 - 250 m
PILOT: Jürgen Schauer
OBSERVER: Mark Hannington

LOCATION: Grimsey Island

TARGET AREA: Small knoll at 80 m water depth, immediately northeast of Grimsey Island

OBJECTIVE: To find the location of marcasite samples dredged in fishing nets from a depth of 100 m. The small bathymetric high at Höll (immediately north of the target area) is reported to host minor anhydrite precipitates and "hot rocks" (34 m water depth). The target area is at a similar water depth and may also host active venting.

SUMMARY: The submersible landed in 240 m of water, south of the volcanic knoll. A strong bottom current out of the north prevented the submersible from making headway toward the knoll. Only a thick, relatively flat area of sediment cover (pale pelagic sediment and volcanic sand) was found east and west of the landing site. Dive aborted after 1 hour owing to lack of exposed basalt and difficulties maintaining desired course in the strong current.

SAMPLES TAKEN: None.

DIVE LOG:

Time	Depth (m)	Heading	Comments:
1508	-	-	deploying JAGO and beginning descent
1510	-	-	submerged
1522	220	-	already dark, murky water with abundant floc (thin threads up to 0.5 cm, yellow); does not appear to be normal plankton
			outside temperature of 3°C

Time	Depth (m)	Heading	Comments:
1525	240	343	sedimented bottom with slope heading up at 343^{o}
			thin sediment over (2 cm thick) with grey volcanic sand beneath
			few loose, scattered rocks (basalt covered by sponges)
			many small (2 cm) shrimp in lights, abundant brittle stars, rare flat fish
			sediment likely ponded in deeper water on south side of knoll
1530	240	323	30-40 small shrimp in lights
			1-2 basalt erratics every few m^2 (up to 20 cm across)
			mainly sediment covered; evidence of burrowing is notably absent
1535	240	360	trying to head north toward knoll; submersible cannot drive into 1-1.5 nm current
			coarser basaltic fragments in volcanic sand beneath thin pelagic sediment cover
1540	240	270	cannot make progress against current; turning west to head up slope
			numerous sponges on rare basalt rocks
			dredge or fish net tracks expose coarser volcanic sand beneath tan-coloured pelagic sediment
			larger blocks of 25-50 cm diameter; covered by sponges
1545	245	270	back to original landing spot
			fewer basalt erratics in this area, which is notably more sedimented
			current-parallel ripples (up to 2 cm high) in volcanic sand striking 010^{o}
1550	247	270	continuing to get deeper; cannot make headway against current
1600	250	-	returning to surface to re-survey of reposition submersible
1620	-	-	surfaced
1630	-	-	on deck

STATION No.: 231 AREA: Kolbeinsey Ridge

JAGO DIVE No.: 438

DATE: 24.05.1997

TIME: 08:17 - 10:37

DEPTH RANGE: 130 m

PILOT: Jürgen Schauer

OBSERVER:

LOCATION: S' Kolbeinsey Island

TARGET AREA: Kolbeinsey Ridge

OBJECTIVE: To locate and document venting sites for which indications had been found during echosounder profiling

SUMMARY: Dive was terminated due to strong currents.

STATION No.: 233 AREA: Kolbeinsey Ridge

JAGO DIVE No.: 439

DATE: 24.05.1997

TIME: 14:57- 19:58

DEPTH RANGE: 100 -129 m

PILOT: Jürgen Schauer

OBSERVER: Karen Hissmann

LOCATION: S' Kolbeinsey Island

TARGET AREA: Kolbeinsey Ridge

OBJECTIVE: To locate and document venting sites for which indications had been found during echosounder profiling

SUMMARY: Exploration of an 5 x 5 m area in 110-113 m water depth covered with red to light-brown sediment reveals small dips and fissures with venting fluids. The shimmering water had a temperature of 7.4 - 9 °C, the temperature of surrounding sediment was 5.4 °C. Neither mineralization nor bacterial mats and fauna typical for venting sites were found.

SAMPLES TAKEN: 1 rock sample

DIVE LOG:

Time	Depth (m)	Heading	Comments:
1457			Submerged at marking buoy at 67 05 54 N, 18 42 82 W
	129		following the buoy line, at the bottom at buoy weight in 129 m depth at the western slope of the Kolbeinsey Ridge
	110	180	upslope to a depth of 110 m, then in direction 180° until the slope direction changed to south, and then travelling back northwards
	113		Exploration of a red/light-brown sediment area at 110-113 m
	100-120		The surrounding of the sediment area and the depth zone between 100 and 120 m was characterized by big rocks and boulders overgrown with a rich benthic fauna (mainly sponges, soft corals). The sediment covered approximately an area of 5x5 m and was bare of big rocks. Small water venting dips and fissures were found between and below smaller rocks at the edges of the sediment area. The dips had an diameter of approximately 20-30 cm, shimmering of the crystal clear vented fluid was observed up to a distance of 20-30 cm above the outflows.

Time	Depth (m)	Heading	Comments:
			Measurements performed inside the openings with a temperature sensor attached to the submersible's manipulator arm revealed a water temperature between 7.4 and 9 °C. The ambient seawater had a temperature of 2.8 °C.
			Venting of gas was not observed. The edges of the outlets were bare of any mineralisation. Sediemnt sampled from the edges of the openings was obviously settled in thin layers. The temperature of the sediment was 5.4 °C.
			Bacterial mats and a typical vent fauna were absent. A smaller rock from the centre of the sediment plain was sampled.
1958			The dive was terminated by starting the ascent directly at the sediment area at 19:58. The surfacing position taken from board of the support vessel FS POSEIDON was 67 05 49 N, 18 42 85 W in a distance of about 100 m from the marking buoy.

STATION No.: 235 AREA: Kolbeinsey Ridge

JAGO DIVE No.: 440

DATE: 25.05.1997

TIME: 08:44- 09:13

DEPTH RANGE: 144 m

PILOT: Jürgen Schauer

OBSERVER: Karen Hissmann

LOCATION: S' Kolbeinsey Island

TARGET AREA: Kolbeinsey Ridge

OBJECTIVE: To locate and document further venting sites

SUMMARY: No bottom contact in expected water depth. Dive terminated.

STATION No.: 236 AREA: Kolbeinsey Ridge
JAGO DIVE No.: 441
DATE: 25.05.1997
TIME: 11:40 - 15:09
DEPTH RANGE: 160 -189 m
PILOT: Jürgen Schauer
OBSERVER: Karen Hissmann

LOCATION: S' Kolbeinsey Island

TARGET AREA: Kolbeinsey Ridge

OBJECTIVE: To locate and document further venting sites

SUMMARY: Bottom contact in 167 m water depth. Due to very strong currents, there was no chance to move the submersible upwards the slope. Dive terminated after several vain trials.

SAMPLES TAKEN: 1 water sample (150 m water depth)

STATION No.: 237 AREA: Kolbeinsey Ridge

JAGO DIVE No.: 442

DATE: 25.05.1997

TIME: 18:37 - 22:10

DEPTH RANGE: 104 -169 m

PILOT: Jürgen Schauer

OBSERVER: Karen Hissmann

LOCATION: S' Kolbeinsey Island

TARGET AREA: Kolbeinsey Ridge

OBJECTIVE: To locate and document further venting sites

SUMMARY: After ascending the western ridge flank covered with black sand and rocks and exhibiting well developed ripple marks the top plateau was reached in 104 m water depth. The plateau was covered with large rocks overgrown by soft corals. An active venting site was discovered in 104.5 m. Maximum water temperature of 72 °C was measured directly within one orifice. Boiling of the emerging fluids could be detected visually and acoustically. The fluids were rich in gas bubbles. No mineralization could be detected. A detailed description of benthic communities during the course of the dive is given. A typical vent fauna was not found but the venting site was dominated by the occurrence of bacterial mats within a radius of 20 m.

SAMPLES TAKEN: 1 rock sample

DIVE LOG:

Time	Depth (m)	Comments:
1837	165	Submerged at 67 05 29 N, 18 42 60 W at 18:37, bottom contact in 165 m at the west slope of the Kolbeinsey Ridge Travel direction: upslope against strong downslope current, travel course 130 degrees, slope angle approximately 35-40 degrees
	120	The slope between 165 and 120 m depth was covered with black lava sand and single rocks. The fauna was dominated by sessile tube worms (Polychaeta) sticking out of the sediment with their red tentacle-crowns, and large sponges growing on hard substrates. Single individuals of hydroid polyps (Corymorpha groenlandica) were also observed, the red sea bass, later frequently observed in shallower areas, was absent.

Time	Depth (m)	Comments:
		The slope angle slightly increased between 170 and 120 m depth. Here, impressive ripple marks in slope direction, which were probably caused by strong downslope currents, were the dominant feature. Large amounts of empty polychaet-tubes were trapped in the depressions. The height of the ripples was about 30-40 cm.
	117-104	In 117 m the structural complexity of the slope increased, accompanied by a distinct change of the faunistic composition. The large rocks and bolders were mainly covered by sponges and soft corals, sea basses hovering in the cervices below rocks were frequently encountered in this area. The end of the slope was reached at 104 m depth, the top was covered with huge bolders overgrown by white soft corals exposed to the current. Depth decreased again in direction of 90-100 degrees and a slope angle of 45 degrees. A small valley with a sediment bottom was reached at 111 m depth. Then the slope angle increased again in direction of 90-130 degrees and after few meters rocks and bolders were covered with a thin layer of white bacteria indicating a vent site close by. The large sponges and soft corals were immediately absent.
	104.5	The vent site was discovered in 104.5 m depth. It consisted of a large powerful water outflow in a 2 m deep depression (main outflow), two smaller dips beside the main outflow, a crater-like outflow of approximately 1 m diameter and located at the steep slope above the main outflow, and smaller seeps below rocks and stones at the edge of the vent centre which were overgrown by filamentous bacterial mats. The ambient seawater had a temperature of 2.7 degrees C. Since the opening of the main outflow was located in a deep depression out of reach for the submersible´s manipulator arm, the temperature was measured 2 meters above the opening. Here, the water had 15.8 degrees C. The temperature of one of the smaller outflows, measured with the temperature sensor sticking inside the opening, was 64 degrees C. Here, boiling and and bubbles were observed. The bubbles appeared irregularly and were of different diameter. Their volume increased by rising up in the hot water plume. The crater-like effluent had a temperature of 72 degrees C measured inside the opening. Here, boiling of the fluid produced sound waves which could be heard via the underwater telephone inside the submersible. Hydrothermal fluids of all effluents were crystal clear, the water was schimmering up to a height of at least 2 meters above the outflows. Rocks at the edges of the outflows were overgrown by white bacterial mats (filamentous type and layer type). Large pieces of these bacterial mats were torn off the rocks by the power of the water outflow and rised up inside the plume (those pieces were found in the water column also in larger distances to the vent side and were used as indicator while searching for vent sites). Rocks, exposed to the hot water fluids , were sampled from the edges of the outflows. Several sampled rocks broke into pieces before they were stored in the collecting basket indicating the porosity of the material. Mineralisation in form of crusts or chimneys were not observed at the effluents. A typical vent fauna as described for deep sea vent sites was not observed. The vent community was strongly dominated by bacterial mats growing on the rocks exposed to hot water outflows and smaller fissures. The encrusting colonial sponge Tethy aurautium (Demospongia) was found on rocks close to the outflows. Red sea anemones (probably Tealia felina) settled in dense aggregations on the larger rocks of the surrounding. Sea basses hovered below rocks overgrown with bacteria. The dominant invaders of the vent site observed in 1988 at the Kolbeinsey Ridge (Fricke et al. 1989, Marine Biology 102: 425-429), solitary sponges (Scypha quadrangulatum) and the hydroid polyp Corymorpha groenlandica were absent.

Time	Depth (m)	Comments:
		Single individuals of the polyps were encountered at the slope of the Ridge between 110 and 170 m depth. The rocks sampled at the edges of the hot water outflows were investigated for their meiofauna. Dominant species were yellow amphipods (Gammaridae) which occurred in large numbers on the eroded rocks, and red nematodes or oligochaets which were found below the bacterial mats in thin transparent mucus-tubes and in cracks and holes inside the rocks when parts of the material were broken off. The entire size of the vent site was estimated to be 5 x 5 m, the area around the vent centre where rocks were covered by a thin layer of bacterial mats had an estimated radius of about 20 meters.
2210	104	The dive was terminated in 104 m at 22:10 at the vent site. The surfacing position taken from board of the support vessel FS POSEIDON was 67 05 30 N, 18 42 42 W.

STATION No.: 238 AREA: Kolbeinsey Ridge

JAGO DIVE No.: 443

DATE: 26.05.1997

TIME: 08:50 - 11:20

DEPTH RANGE: 98 - 109

PILOT: Jürgen Schauer

OBSERVER: Jakob K. Kristjansson

LOCATION: S' Kolbeinsey Island

TARGET AREA: Hydrothermal field

OBJECTIVE: Sampling of hydrothermal fluids, gases and rocks

SUMMARY: A crater-like structure with abundant rocks and several vents was investigated. The biggest vent with outbursting, bubble-rich hydrothermal fluid was located in the center of the crater at 104 m water depth. Rocks in the surroundings were covered with filamentous (hairy) bacteria. The temperature measured in 6-10 cm sediment depth in an adjacent area with sandy sediment was 60 °C. A second hydrothermal vent field was found at 102 m within a rocky „crater“. Boiling could be observed.

SAMPLES TAKEN: some rock samples, rocks with brown staining, 2 water samples

DIVE LOG:

Time	Depth (m)	Comments:
0850		Diving started at 08.50 a.m..We went down at the buoy at 67° 05,46N; 18° 42,64W. According to the GPS of JAGO, the diving coordinates were 67°05,43N; 18° 42,65W.

Time	Depth (m)	Heading	Comments:
	109		We followed the buoy line down to 83 m water depth, then we lost the line and reached the bottom at 109 m water depth. There was almost no current. We
	103		went west, about 260 and up to 103 m when we came to an edge. Here the rocks had already some grey to white hairy cover, indicating the presence of sulfide oxidizing bacteria, Beggiatoa. As we went down the edge, the rocks were
	104		covered with Beggiatoa and white finger-like sponges. At 104-105 m water depth we came into a small crater with abundant rocks. Several vents were present. The biggest vent with a powerful outburst like boiling was situated in the center. Here we collected some rock samples. Then we moved to the flat sandy platform
	107		at the base of the rocky slope at 107m water depth and observed white patches on the sand next the slope. At these patches, barely visible venting occurred. At 5-10 cm depth, the temperature was 60°C. Here we collected rocks with brown staining. Next to the white patches, some orange patches occurred which probably represent dead oxidized bacteria mats.
	103		From this place we went southward directly to the buoy which was located at 103 m water depth. Then we continued southwest (about 220) and went up a flat hill
	98		with abundant Beggiatoa growth. At an edge of 98-99 m, we saw again a greyish cover on the bottom. We passed over the edge down a slope into a small rocky
	102		crater, similar to the first one. In the center of this crater , at about 102 m, there were 2 big openings; boiling was only observed at one site whereas the other larger one showed vigourous venting of shimmering water. Here we took 2 water samples. The temperature above the bottles was 15 °C.
1120			The dive ended at 11.20 a.m. We came up close to the buoy.

STATION No.: 240 AREA: Kolbeinsey Ridge

JAGO DIVE No.: 444

DATE: 26.05.1997

TIME: 16:20 - 19:10

DEPTH RANGE: 101 - 104

PILOT: Jürgen Schauer

OBSERVER: Beatrice Hautzel

LOCATION: S' Kolbeinsey Island

TARGET AREA: Active hydrothermal field

OBJECTIVE: Sampling of hydrothermal fluids, gases and rocks

SUMMARY: Two venting sites were sampled for subsequent gas, water chemistry, and micro-biological investigations. Maximum *in situ*- temperature in the venting fluids was 131 °C.

SAMPLES TAKEN: 2 rocks, 4 water samples, 1 gas sample (10 ml)

DIVE LOG:

Time	Depth (m)	Comments:
1610		Submersible was diving down near the buoy (67°03'46"N, 18°42'64"O). Because of a current at the surface, we drifted away from the buoy. After 30 m it became dark.
1620	166	We reached the bottom in 166 m depth, brownish bottom, slope. Orientation upwards the slope to 94 m depth, brownish bottom, red fishes, orange and pink sea anemones and white sponges.
1635	94	The funnel was lost in 94 m depth. Orientation to the pinger of the buoy. Turn to 190°. First white, floating Beggiatoa flocs; one dead whitish fish at the bottom in 92 m depth.
	97.5	large mats of Beggiatoa covering rocks, surrounding temperature: 3.2 °C
	102.9	black, sandy bottom
	104.4	We arrived at an active hydrothermal field; crater with two wide crevices, approximately 4 m^2; shimmering water and gas bubbles at both crevices; the crater forming rocks were covered with mats of Beggiatoa. Approximately 10 ml gas from the crater was sampled in a glass bottle. Surrounding temperature of the sea water: 3.6 °C;
	104.6	In a distance of 5 m to the first crater, a second active crater was discovered; approximately 2m^2, at the slope; shimmering water; much gas (small bubbles). In the center of the crater a yellow layer was visible (sulfur or bacteria?). Surrounding temperature: 5.3 °C. *In situ* temperatures were 40°C up to 131°C. Shrimps were observed near the active crater.

Time	Depth (m)	Comments:
		With the slurp-gun we sampled 1.5l hydrothermal fluid from the active zone of the crater in a glass bottle. The temperature was 131 °C.The sample was immediately reduced by addition of 0.05% Na_2S. At once, a whitish precipitate was observed.
		A second, 1.5l fluid sample was taken from a second crevice of the crater with a temperature ranging from 75°C to 85°C.
		In a distance of 1.5 m from the crater the Niskin-bottles were filled.
		Two rocks from the left edge of the crater were collected and stored in the basket.
		A video movie and pictures were taken from the second crater (J.Schauer).
1853 .		We were diving up.
1910		The submersible was at the surface, approximately 30 m south-east from the buoy.

STATION No.: 242 AREA: Kolbeinsey Ridge

JAGO DIVE No.: 445

DATE: 27.05.1997

TIME: 08:37 - 11:34

DEPTH RANGE: 120 - 107

PILOT: Jürgen Schauer

OBSERVER: Dieter Garbe-Schönberg

LOCATION: S' Kolbeinsey Island

TARGET AREA: hydrothermal vents near the buoy mooring 67° 05' 46 N, 18° 42' 64 W

OBJECTIVE: Sampling of hydrothermal fluids, gases, mineralized rocks and substrate for bacteria growth from different vents

SUMMARY: Two active vents in the northern hydrothermal field were investigated in detail and sampled with 2 Niskin bottles and 2 throughflow samples using the pump system. One vent was within a crater-like depression in volcanogenic sediments, the second 2 m apart in fragmented sheet flow lava. Maximum temperature in the vents was 125 and 132 °C. Only a very few gas bubbles could be observed in these vents.

SAMPLES TAKEN: 3 water samples. 2 rock samples, videos, photographs

DIVE LOG:

Time	Depth (m)	Comments:
0837	000	sampling frame with 2 Niskin bottles, 1 glas bottle upside down for gas sampling, pump and schnorchel installed; deployed, screw cap removed from glass bottle by scuba diver, descending from buoy. Glass bottle has already trapped a gas bubble.
0840	060	nearly dark, cloudy water due to high plankton abundance
0844	120	ground contact on the W flank of the ridge, only weak current pushing JAGO gently hill upwards; course 130 ° towards buoy pinger
0937	107	approaching a hydrothermal vent field with comparably low activity: occurrence of orange/ reddish coloured hydrothermal sediments (ironoxidehydroxides) covering fragmented lava flows, fauna continuously changing to very high abundances of white sponges with still some anemones, fish (Goldbarsch, seawolf), transmitting to a nearly complete cover of lava and sediments with white bacteria mats (with filamentous bacteria, sponges, still some sea anemones - Betacam video documentation), *Beggiatoa* abundant. Numerous small diffuse vents with low activity. No significant release of gas bubbles.

Time	Depth (m)	Comments:
1010		passing buoy mooring, heading course 200° towards the known hydrothermal field vent with high velocity emerging hydrothermal fluids, orange coloured bacteria blowing in the current at the outlet (Betacam video documentation), this vent to small for being sampled. Entering sediment covered valley (black volcanogenic sand, talus). Network of „fissures“ in the sediments are coloured by ironhydroxides and white bacteria seems (*Beggiatoa*). At the southern margin near the hillside a highly active vent within a funnel-like structure in unconsolidated sediments, sand to gravel-sized grains are resuspended in the current of the vent. Temperature of the fluids varying within centimeters from 9, 25, 80, up to 125 °C. Fluid is boiling near the outlets displaying a narrow, halo-like zone of newly formed vapor bubbles which disappear after approx. 5 cm. Sampling water and suspended sediment with the pump system and with a Niskin bottle (sample no. 242-2). Searching for the other highly active vent in this area but failing. Returning to the previous site where nearby a second fluid discharge can be detected which offers unhindered acces for measuring and sampling. Temperature again changes rapidly due to turbulent flow as well as to irregular activity (Siedeverzug within the channel?). Maximum temperature measured 132 °C. Fluid is boiling. Fluids enter the first sampled glass container by accident because valve had not been closed. The sampling tube jumps up and down due to explosive boiling within the tube. Finally, the tubing collapses due to weakening of the plastic under the high temperature. Sampling water with the pump system (sample no. 242-3, milky water in the glass container) and with a Niskin bottle (sample no. 242-1). One rock sample from within the vent orifice.
1127		beginning ascent
1134		surfaced

STATION No.: 243 AREA: Kolbeinsey Ridge

JAGO DIVE No.: 446

DATE: 27.05.1997

TIME: 16:18 - 19:20

DEPTH RANGE: 141 - 100

PILOT: Jürgen Schauer

OBSERVER: Peter Herzig

LOCATION: S' Kolbeinsey Island

TARGET AREA: hydrothermal vents

OBJECTIVE: Detailed search for precipitates, sampling of hydrothermal fluids, gases, mineralized rocks

SUMMARY: No hydrothermal precipitates or chimney-like features in the vent area were found, also no vent-specific fauna but abundant white bacteria mats.

SAMPLES TAKEN: 3 rock samples, 2 water samples

DIVE LOG:

Time	Depth (m)	Comments:
1618		descent at bouy position (67 05.46N, 18 42.64W)
1627	141	141 m (seafloor), terrain with basalt blocks covered with and overgrown by fauna, abundant fish, passed over a flat sheet flow area with patches of Fe-oxihydroxide in small depressions about 1-2 m in diameter, some areas have black staining (Mn-oxide?), sample 243-B
1640	108	found pinger at bouy and positioned marker (white bucket lit about 20 cm diameter and about 15 cm above a ground weight)
1700	100.6	found active hydrothermal area about 25 m SW (200 degrees) of pinger/marker position, observed boiling hydrothermal vents (131 degrees C) at 100.6 m; vent outlets are located in small depressions (pits) about 2-5 m in diameter and 1-2 m deep which may represent hydrothermal explosion crater in volcanic ash-like material; the fluids are clear and have gas bubbles which were collected for chemical and isotope analyses; there are no hydrothermal precipitates or chimney-like features in the vent area, also no vent-specific fauna but abundant white bacteria mats covering the rocks; collected a vesicular basalt with white alteration material (?) directly from the boiling zone (sample 243-A) and documented the boiling process in detail using the small camera on the Jago's arm as well the hand-held camera; boiling produces a bright halo at the boiling zone (exploding bubbles?) which has also been observed at other boiling vents (e.g., Axial Seamount, JFR).; sample 243-C was collected in about 2 m distance fromthe vent outlet; filled 5 L Niskin bottle very close to the vent and left the site at 18:56 to

1920 ascent; 19:07 at buoy, 19:20 end of operation.

STATION No.: 244 AREA: Eyjafjördur, Akureyri Fjord

JAGO DIVE No.: 447

DATE: 28.05.1997

TIME: 08:46 - 11:24

DEPTH RANGE: 63 - 57

PILOT: Jürgen Schauer

OBSERVER: Jakob K. Kristjansson

LOCATION: Akureyri Fjord

TARGET AREA: Chimney structure at

OBJECTIVE: Sampling of hydrothermal fluids, gases, and rocks

SUMMARY: A huge anhydrite chimney with about 30 m total height was detected at 60 - 65 m water depth which are suggested to be of hydrothermal freshwater origin.

SAMPLES TAKEN: rock samples (anhydrite), water samples

DIVE LOG:

Time	Depth (m)	Comments:
0835		Diving started at 08.35 a.m.. We went down at the buoy at 65°49 73N; 18°06 69W
	60	The water was clear for the first 5 m but became more and more cloudy with depth. We reached the seafloor at a depth of 63 m. We went uphill direction 230° to 60 m water depth. The slope was steep and very rocky. We continued for about 100 m in the direction 200°-230°. The slope was still very rocky. We reached a high cliff. An old fishing net and a rope were in front of us. We turned immediately. New direction 175 ° at 58-60 m water depth. Close to the buoy we saw a chimney on a slope to our left (east) side. The chimney consisted of whitish material (anhydrite?) and had a height of about 1.5 m. Active venting with shimmering water was observed. We took pictures and
	57.5	broke off the top 0.5 m of the chimney. Clear hot water emerged.
	59	We continued south then east and found another small chimney at 59 m water depth and sampled it. We went back to the first chimney and took some more rock pieces and water samples directly above the outflow. No gas bubbles were seen. We decided to end the diving and started going upwards. Then we discovered that we were at a vertical wall with numerous small outflows. It became clear that we went up along a huge chimney which stood straight up from the seafloor. The base was at 60 - 65 m and the top at 34 so the total height was about 30 m.

Time	Depth (m)	Comments:
		The diameter was about 5 m at the top, about 10 m at the middle part and probably about 20 m at the base of the chimney. This huge structure can clearly be seen on the echo sounder.
		No special outflow was observed at the top; numerous smaller outflows however were present at various places of the large tower-like structure. The chimney obviously composed of anhydrite was probably built from hot fresh water springs (60-80° C). The temperature probe was broken so no temperatures could be measured; however hot springs of 60 ° C are known from the northern tip of Hrisey island further out in the fjord.
1120		We came up at 11.20 a.m. at 65°4973 N; 18°0676 E.

STATION No.: 246 AREA: Grimsey
JAGO DIVE No.: 448
DATE: 29.05.1997
TIME: 09:44 - 13:10
DEPTH RANGE: 400 - 407 m
PILOT: Jürgen Schauer
OBSERVER: Mark Hannington

LOCATION: W' Grimsey Island

TARGET AREA: Bubble plume at 400 m water depth, on east side of deep valley adjacent to Grimsey

OBJECTIVE: To find the location of anhydrite samples dredged in fishing nets and during an earlier Icelandic research cruise. The target area contains numerous reported occurrences of anhydrite and has a dramatic bubble plume rising vertically from 400 m to surface. The dive began at the location of a buoy deployed at the site of the bubble plume.

SUMMARY: The submersible landed in 406 m of water, on a relatively flat and heavily sedimented bottom. A two-leg traverse to the northeast of the buoy marker (approximately 50 m) located two active vents consisting of anhydrite chimneys and warm water (130°C at the smaller vent and much higher fluid flow and temperatures at the larger vent). Both anhydrite mounds were found in areas of heavy sediment cover. Debris aprons of collapsed anhydrite chimneys were found surrounding both vents (to a distance of several meters). Individual chimneys were ≤1 m in height, and several toppled chimneys were found at each vent. An anhydrite chimney was sampled at the smaller vent (2-3 m in diameter, 406.8 m water depth). Temperature measured after sampling of the chimney reached 130°C. Three larger chimneys on a platform or mound of sediment-covered anhydrite were found at the northern vent (402.5 m depth, 20-30m NNE of the first vent). The mound-like vent measure approximately 10 m in diameter. Higher-temperature flow was observed at this vent, after the largest of the chimneys was knocked over. Temperature were not measured, owing to a

malfunction in the temperature probe, but the fluids melted a hydraulic line on the manipulator and also damaged the Niskin Bottle used to collect water from the vent. Fluid flow was more vigorous than at the smaller vent site, although boiling was not obvious at either site. A small stream of tiny bubbles was sampled at the base of the main spire, and flashing of the vent fluids may have been occurring at the vent orifice following sampling of the chimney. However a large bubble stream sufficient to have caused the echo-sounding profile does not seem to be emanating from these vents (cannot rule out the possibility that bubbles of CO2 are nucleating well above the vent site). An obvious source for the large bubble plume detected at surface was not identified during this dive, however, bubbles were observed near the surface at the end of the dive, approximately 30 m SE of the buoy.

SAMPLES TAKEN:

DIVE LOG:

Time	Depth (m)	Heading	Comments:
0946	-	-	submerged at buoy
0955	100	-	buoy line directly in front of submersible
1005	406	-	landed at buoy weight; bottom is relatively flat and heavily sedimented (normal tan-coloured pelagic sediment) dozens of small shrimp aggregating around submersible lights
1010	406.8	080	moving slowly to east to follow 400 m bathymetric contour small scale worms; many shrimp, unlike those observed at Kolbeinsey
1015	406.8	080	heavily sedimented bottom with local bioturbation; traveling approx. 0.5 m/s white boulder noted but could not be identified; otherwise flat, featureless bottom with minor ripple marks
1020	406.8	311	slope heading downward to south noted; course changed to 311° in order to proceed slightly uphill; 25-30 m ENE of buoy facing slope heading uphill to the north; slightly more rough bottom, microtopography minor debris (white chimney fragments up to 5 cm) on slope leading up to vent area
1021	406.8	310	small twin chimneys observed at top of shallow slope; white anhydrite basal mound with one small (30 cm) and one taller (50 cm) chimney one chimney adjacent to vent already fallen over base of chimneys suggests possible subsurface root of anhydrite with normal pelagic sediments onlapping the vent; grey patch on bottom adjacent to chimney shows weak fluid flow and shimmering, but no obvious halo of discoloured sediment surrounding the vent warm, shimmering water emanating from orifices and base of two small chimneys

Time	Depth (m)	Heading	Comments:
1040	406.7	310	video and 35 mm photographs
			knocked over large chimney and measured 129-130°C
			slightly darker grey colour where chimney grew out of vent
			one small piece of anhydrite from base of venting orifice in basket; smaller 30 cm chimney sampled intact and placed in sediment cylinder
			could not reach marker in basket
1055	406.9	310	installed 8 mm video to take additional photographs
1105	406.4	310-330	proceeding uphill on gentle slope; heavily sedimented bottom
			ripple marks; large shrimp resting on bottom
			proceeding 15 m at 330°
1105	403	090	turned briefly to east then back to 310-330°
1107	403	310-330	continuing uphill; encountered whit debris from fallen chimneys at base of low mound of anhydrite (approx. 8 m from vents)
1110	402.5	310	large complex of 3 anhydrite spires on base of low anhydrite mound (1 m high); slightly darker sediment on apron surrounding anhydrite mound
			3 chimneys, 1 m high each, 20-40 cm in diameter
			largest chimney is "beehive-like", with wider top than base and ribs around chimney
			second chimney is tall and thin, with twin vent orifices
			third chimney is cylindrical, with several small vent orifices on side
			large "beehive" vents hot fluids from basal zone and overgrowth of more recent anhydrite at side (produced most vigorous venting when knocked over)
			one small spire collapsed in between larger standing spires; one larger spire collapsed adjacent to beehive structure (covered with minor brown sediment, diffuse venting still occurs through collapsed rubble)
			very small, fine bubbles streaming from two small (<1 cm diameter) holes in base of anhydrite platform (sampled with glass bottle)
			no obvious vent specific animals; two small rat tails (10-15 cm long); several 1-2 cm diameter gastropods (snails) similar to those observed in sediments at Middle Valley; hundred of shrimp (periodically cooked in high-temperature upflow of broken chimney)
			large beehive and adjacent chimney collapsed while collecting bubbles from small bubble stream; collapsed beehive produced very vigorous flow
1143	401.9	-	continuing sampling of bubble stream (gas bubbles produce an effervescent vapour in the headspace of the glass bottle)
1205	401.5	-	completed sampling of bubbles
			repositioning to video vigorous venting from orifice where large beehive was knocked over
			interior of beehive is grey to white, indicating some but minor sulfides
			possible flashing ("puffing") of bubbles observed at orifice of smaller chimney, but obvious bubbling not present at high-temperature vents (some larger bubbles may be nucleating above the vent but not easy to observe)
			all fluids are clear; no sulfide precipitates observed
1220	401.8	-	video complete
			attempted temperature measurement, but thermocouple froze at a reading of 149°C; vent certainly appears to be much hotter than 150°C

Time	Depth (m)	Heading	Comments:
			hydraulic line of arm melted in vent and no longer functional; no samples can be retrieved and marker cannot be deployed
			Niskin Bottle triggered in most vigorous flow; apparently too hot and damaged interior of bottle (sample lost on deck of ship)
1230	405	310	moved off anhydrite mound
			heading northwest, but becoming steeper
			turned back toward buoy to close traverse
1235	405	220	travelling toward buoy to check for more vigorous venting and source of plume in area between anhydrite mound and buoy
			mostly sedimented bottom; locally small 1 m depressions in sediment, but otherwise flat
			locally bioturbated
1240	406	220	continuing towards buoy; 50 m travelled
1250	406	220	within 10-15 m of buoy; closed loop of traverse
1255	-	-	returning to surface

STATION No.: 248 AREA: Grimsey

JAGO DIVE No.: 449

DATE: 29.05.1997

TIME: 17:09 - 21:10

DEPTH RANGE: 396 - 407 m

PILOT: Jürgen Schauer

OBSERVER: Peter Stoffers

LOCATION: W' Grimsey Island

TARGET AREA: active hydrothermal field on top of anhydrite mounds

OBJECTIVE: Exploration of active chimneys and beehive structures, sampling of hydrothermal fluids and rocks

SUMMARY: several chimneys were investigated and sampled. Maximum water temperature measured inside orifice was 249 °C.

SAMPLES TAKEN: 2 water samples, 1 gas sample

DIVE LOG:

Time	Depth (m)	Comments:
1709		beginning descent from buoy
1733	407	bottom contact, soft sediment, heading slope upwards
1928	406.3	small chimney, hydrothermal fluids sampled with 2 Niskin bottles , sampling gas bubbles; max. temperature 249 °C
2042	396	beginning ascent
2110		operation ended

STATION No.: 249 AREA: Grimsey

JAGO DIVE No.: 450

DATE: 30.05.1997

TIME: 08:47 - 12:21

DEPTH RANGE: 392 - 406 m

PILOT: Jürgen Schauer

OBSERVER: Peter Herzig

LOCATION: W' Grimsey Island

TARGET AREA: active hydrothermal field on top of anhydrite mounds

OBJECTIVE: search for mineralized rocks and precipitates

SUMMARY: hydrothermal fluids in the beehive chimney field were sampled. Maximum temperature was 250 °C. Fluids were poor in bubbles, boiling was not observed.

SAMPLES TAKEN: anhydrite, 2 water samples, gas sample

DIVE LOG:

Time	Depth (m)	Comments:
0850		descent at bouy position (66 36.58N, 17 39.10W)
0913	406	406 m (seafloor), sediment
0915		go 125 degrees with about 10m/min.; sedimented area with small anhydrite chimneys (20 cm, inactive)
0920	410	410 m, sediment
0921		heading N with about 10m/min., about 5 m seafloor morphology (channels, pits)
0928	407	407 m, sediment
0929		close to eastern slope of ridge (407 m)
0930		close to top of ridge, small anhydrite chimneys with diffuse venting (about 20cm high)
0933	402	gas bubbles emanating from sediment at top of ridge (402 m), gas sampling; it appears that the entire hill consists of anhydrite precipitates
0942		heading 320 degrees, white patches, anhydrite outcrops and anhydrite talus

Time	Depth (m)	Comments:
0946		arrive at beehive chimney field which consists of 2 knocked down chimneys including the beehive chimney and one up-standing chimney about 1m high; vigerous venting, abundant shrimp that occasionally get cooked in the fluid; measured fluid temperature 250 degrees C; no boiling observed, little or no bubbles (CO2); take gas sample directly at the sediment surface; take water sample after kock down of the last up-standing chimney; take sample 249 (anhydrite)
1028	406	heading N-NW and try to follow top of ridge 10m/min., 406.3 m
1033		heading 340-360 degrees
1041		still in sedimented terrain with on indication of anhydrite
1044	403	heading 300-320 degrees (403 m)
1057		heading 270-290 degrees with 15-20m/min.
1105	392	sediment, no indication of anhydrite, 392 m
1107		stop at 392 m and determin the position of the buoy
1108		heading 150-180 degrees towards buoy
1113		cross pits and channels about 1-3 m deep
1133		heading 160-180 degrees
1140		heading 160-180 degrees
1143		heading 150 degrees in search for buoy
1147	405	believe to be close to buoy, search by turing on the spot, 405 m
1200		ascent to surface
1237		reach surface about 100 m SW of buoy
1250		end of operation

STATION No.: 251 AREA: Grimsey

JAGO DIVE No.: 451

DATE: 30.05.1997

TIME: 16:25 - 19:31

DEPTH RANGE: 402 - 406 m

PILOT: Jürgen Schauer

OBSERVER: Robert Huber

LOCATION: W' Grimsey Island

TARGET AREA: active hydrothermal field on top of anhydrite mounds

OBJECTIVE: sampling hydrothermal fluids and substrate for hyperthermophilic microorganisms

SUMMARY: hydrothermal fluids in the beehive chimney field and one chimney were sampled, and a temperature profile above a venting orifice was measured with the temperature probe.

SAMPLES TAKEN: small anhydrite chimney, 2 water samples, gas sample

DIVE LOG:

Time	Depth (m)	Comments:
1635		The submersible is on the surface of the sea next to the buoy, beginning of the dive at position 66°36´56´´N, 17°39´13W.
1700	406	We reached the sea floor in a depth of 406.4m directly at the buoy position
1705		Orientation in the direction of the active „bea hive“ smocker site, driving with maximum speed in the direction of 35°N.
1710		First little pieces of anhyrite became visible at the sea bottom, short stop
1712	403	Some small anhydrite pieces at the bottom
1713		We arrived at the active hydrothermal site (depth: 402.9m). The distace from the buoy to the vents was reached in ten minutes with a speed of about 10m/min, indicating a distance from the position of the buoy to the vents of about 100m. The „bee hive“ vent area covers about $10m^2$. In a distance of about three meters from the vents, a whitish Beggiatoa-field (about $4m^2$) is covering the sea bottom.

Time	Depth (m)	Comments:
		The „bee hive“ vent area is made of anhydrites. Some places of very strong, active venting with shimmering water were observed, the vent fluids were clear and transparent. The biggest venting area was about 50cmx10cm (vent1) with two additional smaller venting sponts in the close vicinity. The top (about 0.5m in length, 0.3m in diameter) was brocken and was lying in the viscinity of vent 1. A second vent area was located in a distance of about 1m from vent1, about 0.3m above the sea bottom. The active venting site has a diameter of about 10cm (vent2), the tip of the smoker is brocken an is lying at the sea bottom (about 0.6m high, 0.3m in diameter). Both smokers had a structure similar to „bee hives“.
		No typical vent macrofauna was observed. Two snails were observed and on of them was taken as a sample. Many different types of shrimps were present. If the came in contact with the hot venting fluids, the were killed at once and became whitish.
1733		The „bee hive“ site was documented with a video- and a photocamera.
1738		A temperature profile was determined at vent1: 248°C: Temperature probe directly at the opening of vent1 225°C: 10cm distance from the opening 130°C: 20cm distance; 102°C: 30cm; 100°C: 40cm; 87°C: 50cm; 78°C: 60cm
1758		Video documentation
1803		First Niskin-bottle was filled with fluid water from vent2 and was successfully closed.
1807		Second Niskin-bottle was filled with fluid water from vent1 and was successfully closed.
1815		The brocken chimney of vent1was collected and placed in the basket.
1828		A video movie of a single, moving snail was made.
1837		The brocken chimney of vent2 was collected and placed in the basket.
1858		Start to dive up
1903		Two white, dead shrimps were observed in a water depth of 326-320m. Most likely, the were floating up from the active site in the water column.
1923		First marine snow visible in a depth of 140m. At the surface: 66°36´60´´N; 17°39´60´´W.
1933		The submersible „Jago“ is on board of „Poseidon“.

STATION No.: 256 AREA: Grimsey
JAGO DIVE No.: 452
DATE: 31.05.1997
TIME: 16:25 - 19:31
DEPTH RANGE: 394 - 407 m
PILOT: Jürgen Schauer
OBSERVER: Mark Hannington

LOCATION: W' Grimsey Island

TARGET AREA: Large area of venting at south end of Grimsey Vent Field (mapped bubble plume at 380-400 m water depth, on east side of deep valley adjacent to Grimsey).

OBJECTIVE: To map out extent of vent field indicated in 18Khz profiles south of the area explored during May 28-30 (south of stations 246-251). The target area consists of a new large area (up to 300 m long) of venting on a bench or ridge at a depth of 380-400 m. A 1.5 km traverse around the vent field was planned to map the extent of venting and anhydrite chimneys.

SUMMARY: The submersible landed in 394 m, on a relatively flat and heavily sedimented bottom, approximately 150 m WNW of the buoy position (buoy located at eastern edge of main anhydrite field). Two low anhydrite mounds (10 m diameter and 4-5 m high) were located en route to the buoy, on the elongate high at the center of the field (Mounds #1 and 2), one at 75 m from buoy and the second at 20 m from buoy. A second leg, heading 180^{o} to south, travelled along the edge of the central high for 170 m to the southern end of the ridge. Two additional mounds were found at the southern end of the ridge (Mound #3 and 4). The low chimney structure at the top of Mound #4 was boiling (flame-like flashing at the tip of several outlets, but no bubbles). The chimneys are low, complex structures with multiple, spindle-shaped outlets. Most of the flow is from these outlets, although considerable fluid also is leaking from the base. At Mound #4, 110^{o}C was measured in the anhydrite apron surrounding the active chimney, suggesting that the entire mound structure is hot. The chimney at the top of

the mound was knocked over, and a temperature of 238°C was measured in the flow. Yellow-to-pink precipitates in the interior of the chimney were observed (as in 248B-2) and a small sample was collected. Gas tight and Niskin samples were collected in the main flow of this vent. A third leg at 270° located a second high ridge at 375 m depth, 250 m east of the main field. The ridge was composed of numerous massive corroded blocks in sediment (possibly an older anhydrite ridge that is no longer active). A fourth leg at 045° intersected the north end of the field. An area of diffuse venting and white patches of bacteria was located 200 m NE of the central ridge, in the direction of the old buoy position (near station 248). The traverse was closed by returning to the buoy at a heading of 200°, at a distance of 250 m. Six additional anhydrite mounds were located in the central portion of the field (Mounds #7-12). The individual mounds are about 10-20 m apart, and each mound was 10 m in diameter and 4-5 m in height. A low, complex chimney structure was found at the top of each mound, with chimney debris on the flanks. All of the chimneys were venting; most with evidence of boiling (short flame of two-phase fluid at the chimney tip). However, no bubbling was observed, except rare bubbles emerging from sediment nearby (no enough to account for the size of the plume observed in 18KHz and much less than observed in the northern field, e.g., station 248). No macro-fauna associated with the venting were noted, and little or no bacteria was observed on the main part of the mounds (some white patches of bacteria are noted in the sediments adjacent to the mounds). The absence of abundant filamentous bacteria suggests that the sulfur contents of the fluids are low. The main concentration of anhydrite mounds was found at the top of the central ridge, but the northern and southern parts of the ridge were not explored. The maximum dimensions of the field and the central ridge are estimated to be 300 m in length and 75-80 m wide.

SAMPLES TAKEN: rock samples, 2 water samples, 1 gas sample

DIVE LOG:

Time	Depth (m)	Heading	Comments:
1310	-	-	towed from buoy
1313	-	-	submerged
1335	394	-	landed west of buoy; bottom is relatively flat and heavily sedimented (normal tan-coloured pelagic sediment)
			pinger on buoy located at 110-115^{o}
1337	393	110	moving slowly to east to locate buoy position
			several small rat-tailed fish
1340	393	110	heavily sedimented bottom with local bioturbation; cloudy water
1345	391	103	slope up hill along course
1347	389	110	coming to edge of anhydrite mound at western side of central ridge; numerous anhydrite chimney fragments and few white patches of bacteria on bottom
			rare bubbles escaping from sediment surrounding the mound
			top of mound at 386 m; 30^{o} slope on sides of mound; approximately 8-10 m in diameter and 3-4 m high
			stopped at top of mound (Mound #1)
			1 m wide, low chimney at the top of the mound, with shimmering water from the base of the chimney (no obvious vent outlets and no flashing as observed later in the central portion of the field)
1352	382.6	110	continuing on course toward buoy
			less than 10 m from Mound #1, a second mound of similar dimensions is observed (now about 20 m from buoy)
			large, 2 m diameter, 1-2m high chimney complex on top of the mound has fallen over; mainly shimmering water from base of chimney
1400	385	110	continuing east to buoy, about 20 m away
			buoy situated at 385 m; stopped to set up camera for next traverse
1405	390.5	180	heading south along eastern edge of central ridge, following 390 m contour to locate southern limit of field
			still see some fragments of anhydrite (possibly from edge of ridge) but bottom is relatively flat and heavily sedimented
			few white patches of bacteria in sediment, suggesting that heat flow extends beyond edge of central field
1410	396	180	continuing traverse south along eastern edge of central ridge; still on 390-400 m contour
1414	406	180	slope heading down towards the south
			stopped to turn west
1415	407	270	heading up hill to west
1417	404	265	heavily sedimented bottom
1420	398.7	270	bottom becoming more rough (0.25 m topography)
			approaching the southern end of the central ridge at 397 m
			a few rat tails present
1423	390	260-270	coming up slope at southern end of central ridge
			white patches in sediment at base of Mound #3
			large broken crusts of anhydrite on surface of mound and low, squat chimney complex at top (389 m)
			stopped briefly (1425); continuing to west
1427	390	270	few meters from Mound #3, coming up onto an adjacent Mound #4 (less than 10-15 m away)
1430	383	-	Mound #4 consists of low 4-5 m ridge, striking north-south
			minimum depth of 383 m at top of mound, with 1-2 m high chimney complex at top
			three openings (spindle-shaped chimneys) with flame (two-phase flashing at tips)

Time	Depth (m)	Heading	Comments:
1445	383	-	positioning to knock over chimney for temperature measurement and water sampling
1500	383	-	after several attempts, knocked over chimney with keel of submersible yellow-to-pink material lining interior of chimney and opening at the base of the chimney maximum temperature of 238°C measured in strongest flow; 220°C measured in two-phase flame
1510	383	-	sampling small piece of Fe-oxide crust at base of chimney; however, only minor amounts of Fe-oxides in vicinity (PO-256-1) temperature of 111°C measured at depth of 10 cm below surface of mound in Fe-oxide sediments; diffuse venting may indicate extensive heat flow from mound structures sampled small piece from base of chimney (2-3 cm anhydrite wall with pink-to-yellow lining) (PO-256-2)
1520	383	-	positioning gas tight sample over vent; triggered in main upflow Niskin bottle triggered about 5-10 cm from main upflow steel gas-tight bottle still shimmering some minutes after sampling of hot water
1525	383.5	270	continuing west to locate rise in bathymetry at western edge of plateau
1528	390	270	initially getting deeper; proceeding into small valley before rising up onto next plateau west of the main field
1534	392.3	260	fracture in sediment at bottom of small gully (first evidence of tectonic extension in area)
1537	388	270	heading up hill to west onto plateau in western part of map area
1541	378	270	rugged topography, numerous large boulders (appear to be soft; possibly old corroded anhydrite); abundant sponges, anenomes, etc. on boulders white patches locally, suggesting that this may be a cooler or older anhydrite ridge (#5)
1543	377	270	few more patches and boulders
1547	378	045	turning to NW to cross over ridge and head back to the north end of the main vent field old rubble and boulders on top of ridge; possible old mound
1550	380	030-045	heading down other side of ridge onto low 490 m platform surrounding central ridge in main field
1557	392	045	onto plateau north of the central ridge and the main field (approximately 020° from buoy); defining north end of central ridge
1605	396	-	stopped to locate pinger at 150-160°
1607	396	045	continuing NE of central ridge toward previous position of buoy from earlier dives
1618	400	045	at edge of upper plateau NE of main field; small white patches on sedimented bottom indicating proximity to venting (possibly in area of station 248) (#6)
1620	400	200	turning to return to main field (heading to pinger at 200°)
1625	399	200	en route to pinger
1630	396	200	rising up toward central ridge
1634	390.5	220	passed small anhydrite mound with small 1 m chimney as we approach the buoy (approximately 15-20 m away) (Mound #7)
1636	390.6	220	continuing past mound (did not stop) scattered anhydrite blocks at bottom, indicating that we are at edge of ridge white patches locally, on low mounds

Time	Depth (m)	Heading	Comments:
1640	387	200	passed over another anhydrite mound, 10 m in diameter adjacent to buoy (Mound #8)
1642	390	200	another anhydrite mound immediately south of the buoy, rising to 382 m scattered anhydrite blocks at base of mound (Mound #9) white anhydrite from collapsed chimneys in gravity slides down the side of the mound a few patches of white bacteria at the base of the mound and on the sides low chimney complex at top of the mound, 1-2 m high, with 3-4 boiling outlets
1645	382	-	stopped to video
1652	382	225	continuing to cross central ridge SW of buoy another mound found 10-15 m south of buoy; capped by low chimney with multiple, spindle-shaped chimneys (all flashing) (Mound #10) stopped for 5 minutes
1658	381	225	continuing at 225
1702	389	225	coming up on another mound (Mound #11) about 20-25 m from pinger slabs of anhydrite crust on side of mound low, complex spire at top of mound with many outlets (at least 10); all spindle-shaped chimneys with obvious boiling (flames of two-phase fluid) stopped for 5 minutes to video
1707	385	225	continuing across central high area flat, sedimented bottom between mounds
1710	389.6	225	coming up on another mound (Mound #12) near center of field white patches and rare Fe-oxide staining around base and sides of mound low chimney complex, <0.5 m high on top of mound at 385 m; numerous boiling outlets
1715	-	-	ended dive in center of field large areas to north, south and west still to be explored

Results for pH, dissolved oxygen, and alkalinity of hydrothermal fluid samples

Sample No.	Vent temperature max. [°C]	pH	Diss. oxygen [ml O_2 l^{-1}]	Alkalinity [mequ]
Kolbeinsey				
233-1		7.99	6.82	-
238-1		7.04	-	-
240-1		7.43	6.15	2.49
240-2		6.81	4.71	2.44
242-1	132	7.86	6.30	2.58
242-2	125	7.94	7.01	2.70
242-3	132	6.07	n.d.	1.20
243-1	132	7.30	5.92	2.65
Akureyri Fjord				
244-1	-	8.02	6.32	2.76
Grimsey				
247-50m	2.3	8.04	7.74	2.78
247-150m	2.3	7.97	6.92	3.15
248-1	250	6.64	5.22	2.95
248-2	250	6.54	5.55	2.68
249-1	250	6.1	3.04	2.51
249-2	250	5.89	2.18	2.37
251-1	250	5.89	3.05	2.40
251-2	250	6.37	5.26	2.51
255-400m	2.7	7.86	6.74	2.71
256-1	238	6.78	6.10	2.48
256-2	238	6.39		

Preliminary results for hydrothermal fluid composition from the Kolbeinsey Ridge hydrothermal field

Sample ID		233-1	238-1	240-1	240-2	242-1	242-2	243-1
Lithium	µg l^{-1}	356	617	470	766	469	371	481
Manganese	µg l^{-1}	5	79	37	111	27	2	21
Rubidium	µg l^{-1}	115	160	133	179	138	117	126
Strontium	µg l^{-1}	8146	8208	8252	8351		8178	8298
Yttrium	µg l^{-1}	0.048	0.042	0.040	0.051	0.041	0.041	0.043
Molybdenum	µg l^{-1}	11.5	7.5	10.5	11.6	11.8	11.4	11.2
Silver	µg l^{-1}	0.019	0.018	0.023	0.018	0.030	0.024	0.013
Cadmium	µg l^{-1}	0.058	0.090	0.050	0.070	0.084	0.085	0.028
Indium	µg l^{-1}	0.033	0.033	0.034	0.022	0.036	0.034	0.034
Tin	µg l^{-1}	0.034	0.026	0.026	0.014	0.034	0.058	0.050
Antimony	µg l^{-1}	0.210	0.172	0.160	0.172	0.191	0.213	0.181
Caesium	µg l^{-1}	0.282	1.017	0.604	1.34	0.600	0.318	0.498
Barium	µg l^{-1}	6.3	192	86.1	267	80.1	14.1	63.9
Tungsten	µg l^{-1}	0.143	0.752	0.217	0.275	0.195		0.168
Thallium	µg l^{-1}	0.008	0.179	0.097	0.250	0.071	0.015	0.065
Lead	µg l^{-1}	0.094	0.081	0.061	0.040	0.056	0.042	0.032
Uranium	µg l^{-1}	2.98	2.96	3.08	3.06	3.12	3.24	3.22
Calcium	mg l^{-1}	383	412	396	437	398	379	391
Magnesium	mg l^{-1}	1230	1207	1220	1191	1224	1231	1207
Phosphate	mg l^{-1}	-	-	0.70	0.30	0.30	0.30	0.40
Silica	mg l^{-1}	-	-	187	550	171	24.9	128
Sulfate	mg l^{-1}	-	-	2.615	2.563	2.612	2.670	2.589

Preliminary results for hydrothermal fluid composition from the Grimsey hydrothermal field

Sample ID		248-1	248-2	249-1	249-2	251-1	251-2	256-1
Lithium	µg l^{-1}	754	786	1175	1955	1597	812	704
Manganese	µg l^{-1}	9	8	24	44	32	11	8
Rubidium	µg l^{-1}	211	204	337	514	435	223	194
Strontium	µg l^{-1}	7374	7419	7325	6912	7081	7492	7956
Yttrium	µg l^{-1}	0.042	0.044	0.090	0.038	0.051	0.046	0.035
Molybdenum	µg l^{-1}	9.48	9.37	6.59	3.81	5.62	9.09	11.0
Silver	µg l^{-1}	0.053	0.042	0.060	0.067	0.058	0.055	0.047
Cadmium	µg l^{-1}	0.086	0.073	0.144	0.138	0.128	0.127	0.111
Indium	µg l^{-1}	< 0.01	< 0.01	0.026	0.014	0.019	0.016	< 0.01
Tin	µg l^{-1}	0.051	< 0.05	0.378	0.219	0.270	0.161	0.053
Antimony	µg l^{-1}	0.154	0.183	0.152	0.130	0.181	0.156	0.217
Caesium	µg l^{-1}	2.89	2.67	5.67	9.58	7.96	2.99	2.24
Barium	µg l^{-1}	237	223	501	866	737	254	213
Tungsten	µg l^{-1}	0.228	0.283	0.363	0.483	0.397	0.219	0.294
Thallium	µg l^{-1}	0.246	0.217	0.500	0.875	0.788	0.269	0.181
Lead	µg l^{-1}	0.290	0.196	0.468	0.729	0.586	0.255	0.267
Uranium	µg l^{-1}	2.88	2.98	2.49	2.08	2.37	3.05	3.26
Calcium	mg l^{-1}	383	385	395	413	417	389	390
Magnesium	mg l^{-1}	1156	1147	1041	898	950	1130	1191
Phosphate	mg l^{-1}	0.20	0.40	0.90	0.40	0.20	4.90	
Silica	mg l^{-1}	674	798	1471	2307	2046	750	596
Sulfate	mg l^{-1}	2.470	2.458	2.253	1.977	2.088	2.449	2.496

Poseidon 229 Sample Summary:

Station	Location	Depth	Sample	Description
233	Low-Temperature Fe-oxide Site	113 m	PO-233A	• massive vesicular basalt, partly covered by Fe-oxyhydroxides; from low-temperature Fe-oxide area at western edge of ridge • Fe-oxides mainly in fractures; two worm tubes in folds in basalt, protruding into low-temperature fluid flow • on large pillow (?) fragment, 2 kg
233	Low-Temperature Fe-oxide Site	113 m	PO-233B	• soft, friable Fe-oxide crust; 1-2 cm thick Fe-oxyhydroxide layers in weakly cemented volcanic ash; locally abundant glassy shards • from weakly cemented volcanic ash near low-temperature 9°C vent area; recovered in sediment scoop
237	Southern Vent Area	104 m	PO-237-1	• crust of volcanic ash from southernmost vent area (near 131°C vent); 6 large pieces, 20-50 cm in diameter (10 kg total) • weakly indurated volcanic ash (<0.5 cm ash/lapilli) with coarser (up to 5 cm) clasts of altered basalt cemented into ash • minor black sulfidic mud and white bacteria on underside of crust
				PO-237-1a - underside of large crust sample - black volcanic ash, possibly cemented by dark-grey sulfidic material
				PO-237-1b - underside of large crust sample - grey-black sulfidic material with abundant white bacteria
				PO-237-1c - underside of large crust sample - black to brown bacteria-rich slime from vent orifice
				PO-237-1d - underside of large crust sample - patch of light grey material with trace disseminated pyrite (very fine-grained)
				PO-237-1e - underside of large crust sample - filamentous am. silica infilling pores and open cavities in volcanic sand
			PO-237-2	• crust of weakly indurated black volcanic sand containing larger clasts of vesicular basalt; larger basalt clasts are commonly altered and locally contain ultrafine disseminated pyrite • 4 pieces, 0.5-1.0 kg each
				PO-237-2a - vial of amorphous silica from pore spaces within volcanic sand of largest sample
				PO-237-2b - vial of am. silica from pore spaces in 1 kg sample
				PO-237-2c - vial of am. silica from pore spaces in 0.5 kg sample
				PO-237-2d - vial of am. silica from pore spaces in another 0.5 kg sample
			PO-237-3	• altered grey pebbles of vesicular basalt containing minor, fine-grained disseminated pyrite • possibly small rounded clasts from subseafloor alteration and mineralization beneath vents (blown out of crater during hydrothermal explosion?) • 3 small pebbles ; 0.3 kg total
				PO-237-3a - small piece for chemical analysis
				PO-237-3b - small piece for thin section
				PO-237-3c - small piece for archive
238	Northern Vent Area	104 m	PO-238A	• Fe-stained vesicular basalt from shallow depression in sandy bottom near 60°C vent; relatively inactive area • weakly altered • 2 pieces, 1 kg total

			PO-238B	• massive amorphous silica sinter buried beneath hot volcanic sand in depression near area of Fe-oxide staining (adjacent to 238A) • minor black sulfidic material in core of sample; mainly amorphous silica • 1 piece, 0.5 kg (cut into 3 slices)
				PO-238B-1a - am. silica from outer crust
				PO-238B-1b - bulk sample
			PO-238C	• volcanic rubble from area of active venting about 10 m away from 238A and 238B • vesicular basalt coated by white filamentous bacteria with black sulfidic material in fractures and traces of very fine-grained, disseminated pyrite lining fractures • red polycheate worms living among sulfidic material in fractures and beneath coating of white bacteria • 3 pieces up to 5 kg total
				PO-238C-1-2 - granular material with black sulfidic matrix from underside of largest block (5 ml vial)
				PO-238C-1-3 - granular material with black sulfidic matrix from underside of largest block (5 ml vial)
				PO-238C-1-4 - black sulfidic material in fractures and cavities and beneath filamentous bacteria from largest block (2 ml vial)
				PO-238C-1-5 - black sulfidic material in fractures and cavities and beneath filamentous bacteria from largest block (2 ml vial)
				PO-238C-1-6 - black sulfidic material in fractures and cavities and beneath filamentous bacteria from largest block (2 ml vial)
				PO-238C-1-7 - black sulfidic material in fractures and cavities and beneath filamentous bacteria from largest block (2 ml vial)
				PO-238C-2-1 - black sulfidic material in fractures and cavities and beneath filamentous bacteria from second largest block (2 ml vial)
				PO-238C-2-2 - black sulfidic material in fractures and cavities and beneath filamentous bacteria from second largest block (2 ml vial)
240	Southern Vent Area	104 m	PO-240	• black vesicular basalt with minor grey to white alteration and staining; thin sulfidic film on fractures and traces of disseminated pyrite, typical of "hot rocks" near vents
242	Southern Vent Area	104 m	PO-242	• weakly indurated volcanic ash from inactive depression about 25 m away from 131°C vent • larger fragments of altered basalt cemented in ash • thin coating of Mn-oxide and Fe-oxide on many ash fragments; minor amorphous silica filling pore spaces and cavities in ash • 2 pieces, 1 kg total
				PO-242-1 - grey, altered clasts cemented in volcanic ash
				PO-242-2 - Fe-stained, lapilli-sized fragments in volcanic ash
				PO-242-3 - Fe-oxides in pore spaces within volcanic sand
				PO-242-S - suspended volcanic sand and fine ash, including fine pyrite from slurp gun sample in main vent
242	Southern Vent Area	104 m	PO-243A-1	• large piece (1 kg) vesicular basalt from within vent (131°C) • surface coated with white filamentous bacteria and few red polycheates • fracture surfaces coated with grey-black sulfidic mud
			PO-243A-2	• highly altered, soft, friable ash or basalt (advanced stage of alteration; no remnants of original rock could be recognized) from immediate vent area • very fine pyrite disseminated within black sulfidic matrix • 8 small pieces, less than 0.5 kg total

			PO-243A-3	• moderately altered vesicular basalt coated in grey sulfidic mud • original rock altered to light grey colour • 2 small pieces
			PO-234B	• large block (1 kg) of ash crust with large (up to 5 cm) basalt clasts cemented in ash • coated in thin, black Mn-oxides, together with brown Fe-oxides • underside of ash crust is coated with fine, black sulfidic mud
				PO-238B-1 - Mn-oxide coating on outer surface of sample
				PO-238B-2 - black sulfidic matrix material on underside of crust
			PO-234C	• several small pieces of strongly altered vesicular basalt and cemented ash from within 131°C vent • includes light grey, altered vesicular basalt with coating of white filamentous bacteria and very fine pyrite within and surrounding vesicles
				PO-234C-1 - white am. silica on fracture (oxygen isotopes)
				PO-243C-2 - sample coated in thin film of colloform silica (SEM)
				PO-243C-3 - strongly altered material similar to PO-243A-2
244	Akureyri Bay	57 m	PO-244	• large sample (2 kg) and several smaller samples of tall anhydrite spire from warm water spring • spire-like chimney consists of massive anhydrite and minor amorphous silica in core • anhydrite is both fine-grained, and sinter-like, with minor coarse-granular anhydrite; most of the external part of the chimney is rotting (dissolving back into sea • extensive mats of algae cover the sample and have turned the anhydrite brown-yellow • cut into 4 slices
				PO-244-1a - dark grey mud from interior of spire (may be combination of rotting anhydrite and algae)
				PO-244-1b - am. silica from core of spire
				PO-244-2a - smaller piece of 1 kg spire; dark grey mud from interior
				PO-244-3 - misc. anhydrite, including ribbon-textured anhydrite and granular anhydrite (rotting; dissolving into ambient seawater)
246	East Grimsey (North)	406-402	PO-246A	• small anhydrite chimneys (up to 1 high) from central part of field • including 1 m high chimney that vented 130°C vent when knocked over • sample consists of intact chimney with dark grey needle-shaped anhydrite on outer crust and colloform anhydrite in central conduit (stained anhydrite or thin coating of pale yellow mineral)
				PO-246A-1 small intact chimney (25-30 cm); cut into several sections
			PO-246B	1 m high chimney that adjacent to 2046A that vented 130oC after being knocked over
				PO-246B-1 chimney tip
				PO-246B-2 smaller piece of 246B-1 for thin section
			PO-246C	• miscellaneous pieces from basket; one larger piece (15 cm diameter) cut into sections
248	East Grimsey (North)	410-402	PO-248A	• small chimney at southernmost end of field, venting 158°C water (249°C measured when chimney was knocked over) • bubbles streaming from sediments near small chimney structure • 1 kg total
				PO-248A-1a - small 15 cm high chimney top; fine-grained needles of anhydrite in interior

				PO-248A-1b - coarse granular anhydrite from base of small chimney (cut into sections)
				PO-248A-2 - small 15-20 cm diameter piece from base of taller anhydrite chimney where 130°C fluid was venting
				PO-248A-3 - miscellaneous pieces from bottom of basket (0.5-1 kg total)
			PO-248B	• two samples from active 249oC vent; from central conduit of large massive anhydrite chimneys (2 kg total)
				PO-248B-1 - small, intact (20 cm long) chimney top, with grey black dendritic and needle-shaped anhydrite in central conduit; pale yellow, 1 mm thick, coating on needles (unidentified)
				PO-248B-2 - larger, hard, massive anhydrite piece from central conduit of chimney that was knocked over (2 cm thick, massive anhydrite wall; 0.5 cm inner zone of crystalline anhydrite coated in pale yellow material; 0.5 cm outer zone of grey, dirty anhydrite) (one piece each to Freiberg and GSC)
				PO-248B-3 - two pieces of small (10 cm) delicate, thin-walled anhydrite chimneys; more massive colloform anhydrite at base
			PO-248C	• large massive anhydrite piece (1 kg) coated or stained dark yellow • coarse-grained anhydrite in core of sample is saturated with seawater and highly corroded (appears to be dissolving back into seawater); fragment from interior (?) of larger collapsed anhydrite chimney
249	East Grimsey (North)	403	PO-249	• small crust of massive anhydrite (0.5 kg), 0.5 m from beehive chimney at north end of field • fine needles and coarser anhydrite for fluid inclusions
251	East Grimsey (North)	402	PO-250	• intact chimney (0.4 m tall) adjacent to 250°C vent (beehive) at northern end of field (last remaining chimney still standing)
				PO-251-1 - largest piece (3 kg) of chimney (35 cm , intact); dark, stained anhydrite on interior and massive porous anhydrite on interior
				PO-251-2 - smaller 20 cm high chimney top (to Huber); 2 cm walls, 3 cm central conduit, and pale yellow precipitate in interior (as in 248B-2)
				PO-251-3 - 3 kg, 3 pieces of massive anhydrite with grey precipitate (stained anhydrite) lining central conduit of chimney fragments
256	East Grimsey (South)	383	PO-256	• southern area of vent field; small 1 m high, 2 m wide anhydrite chimney on top of low mound (Mound #4)
				PO-256-1 - small piece of Fe-oxides immediately adjacent to main chimney (not a common feature of the mound); 110oC temperature measured up to 10 cm below surface in Fe-oxides
				PO-256-2 - base of boiling chimney (238°C) after it was knocked over 2-3 cm thick anhydrite wall; grey smoky anhydrite on exterior; distinctive pink-to-yellow precipitate lining interior

Table 1:

Station	Area	Lat. [N]	Long. [W]	Tmax. [°C]	Depth [m]	Total gas [ml/L]	Matrix	CO_2 [ppmV]	CH_4 [ppmV]	C_2H_6 [ppmV]	C_3H_8 [ppmV]	C_4H_{10} [ppmV]	$C_1/(C_2+C_3)$	$\delta^{13}C1$ [‰PDB]	$\delta^{13}C2$ [‰PDB]	$\delta^{13}C3$ [‰PDB]	$\delta^{13}CO_2$ [‰PDB]
1	Kolbeinsey	67°05.54'	18°42.81'		113	51,0	water	4738	5					-52,3			-11,6
2	Kolbeinsey	67°05.48'	18°42.70'		104	38,0	water	3082	5					-49,4			-10,3
3	Kolbeinsey	67°05.46'	18°42.64'		102	27,7	water	8949	1471								
3	Kolbeinsey	67°05.46'	18°42.64'		102	28,2	water	8764	140								
4	Kolbeinsey	67°05.46'	18°42.64'	130	104	34,6	water	17683	315	1			450.1	-38,3			-9,9
4	Kolbeinsey						gas	9812	15339	37	7		414.6	-39,2			-7,8
5	Kolbeinsey	67°05.46'	18°42.64'	131	105	37,5	water	17584	804	8	5		61.8	-37,5	-52,9		
6	Kolbeinsey	67°05.46'	18°42.64'	>100	104	41,6	water	15880	291	3	1		67.6	-39,8			-9,1
6	Kolbeinsey						gas	16632	15934	41	7		333.3	-39,6			-5,7
7	Akureri	65°49.75'	18°06.68'	20	60	30,8	water	7887	33					-46,8			-15,1
8	Grimsey	66°36.56'	17°39.12'	200	404		gas	83440	243197	3601	35	3	66.9	-26,1	-16,1	-13,6	-2,9
9	Grimsey	66°37.59'	17°39.15'	249	407	53,0	water	195026	37341	554	44	4	62.4				
9							gas	411636	71666	1280	134	17	50.7	-29,5	-15,9		-2,4
10	Grimsey	66°36.56'	17°39.13'	250	406	61,0	water	544992	14944	247	19	3	56.1	-28,4	-15,5		-29,2
10							gas	10557	163303	2465	250	29	60.2	-29,4	-16,2	-17,0	-3,0
11	Grimsey	66°36,49'	17°39,21'	238	395	47,0	water	45266	10707	120	7		84.8	-27,9			-3,2

Institute of Marine Research

Cruise Report

R.V. POSEIDON Cruise No.: POS229b

Dates of Cruise: 2.6.97 - 11.6.97

General Subject of Research: Detailed sampling of the volcanic rocks from the southern Kolbeinsey ridge, the effects of the Iceland hotspot on the composition of the magmas at Kolbeinsey

Port Calls: Akureyri, Reykjavik

IfM-Department/ CAU Institute: Geologisch-Paläontologisches Instiut

Chief Scientist: Priv. Doz. Dr. C.W. Devey

Number of Scientists: 6

Project: SPAR

1. Scientific Crew

Dr. Colin Devey
Marc Krienitz
Frances Lichowski
Helge Möller
Jens Pracht
Marcus Zimmerer

All participant from the Geologisch-Paläontologisches Institut, Universität Kiel, Olshausenstr. 40, D-24118 Kiel

2. Research Program

The major cruise objective was a detailed sampling of the Southern Kolbeinsey Ridge between the Spar Offset and Kolbeinsey Island. This sampling should complement the previous sampling of the Middle and Northern Kolbeinsey Ridges carried out during the cruises POS210/1 (1995) and POS221 (1996). The samples collected were to be used to examine the influence of the Iceland hotspot on the magmatic processes at Kolbeinsey, not in terms of the large scale influence, which has already been studied in recent years, but in terms of the small-scale heterogeneities in melting processes and magmatic evolution which occur on a ridge.

3. Report on the cruise with technical details

The POSEIDON left Akureyri at 8 o´clock on the morning of the 3rd of June 1997 and headed for the northernmost dredge station planned at 68°45´N. Unfortunately at ca. 68°N solid sea-ice coverage blocked the passage northwards, and the dredge programm began at this latitude. Continuous strong (up to Force 10) north winds caused the ice limit to push relentlessly southward, and the planned 2 latitudinal minute sampling steps could not all be carried out. This restriction of the area of work lead to a decrease in the distance between sampling stations, and the southern part of the sampling area was covered at a density of 1 dredge per 1/2 minute (> 1 station per km). Sampling was systematically carried out on the axial high regions, as the Kolbeinsey Ridge, although slow spreading, is inflated in the region around Iceland and does not possess the typical slow-spreading axial graben. Most stations yielded fresh-looking samples with well-preserved glass selvages, dredges taken even a short distance from the axial high yielded only mud and dropstones, implying that the recovery of submarine basalt samples is a good sign that the active axis has been found (slow spreading rate and high sedimentation, especially during glacial time have swamped the axis in all regions except the presently-active volcanic zone). In total 54 dredge stations were occupied, of which almost all yielded basalt. The samples were prepared for analysis on board, glass crusts were separated and blocks for thin sections were cut. The dredging operation was carried out with cheap barrel dredges (consisting of a metre-long section of commercially-available 60cm-diameter welded steel pipe with a welded grid on the base, bolted-on teeth and three weak-links arranged in a Y formation for connection to the ships cable, total cost ca. 1500 DM) which have the advantages of easier handling on board, better load transmission to the seafloor (maximum of 3 teeth are in contact with the seafloor at any one time), and decrease risk of losing the dredge through breakage of the main cable (relative to a chain bag dredge, thinner weak links can be used for the same seafloor load). During the cruise ?? weak links were broken but no dredge lost.

Continued ice-drift made the chances of a return passage to Reykjavik via the west coast route seem increasingly unlikely, and on the evening of 7 June the decision was taken to begin the journey to Reykjavik via the east coast. The advent of severe bad weather on the east coast caused this decision to be reversed 12 hours later, at which time the sea conditions were such that further sampling would in any case have been unfeasible. The POSEIDON entered Reykjavik harbour at 22:00 on the 9 June, one day earlier than planned due to time saved on the west-coast route.

4. Scientifc Report and first results

Details of the samples recoved are given in section 6, the samples recovered were all basaltic in nature, and showed marked vesicularity especially at the shallow-water stations. At all sampling sites sponges were recovered, the shallower dregde hauls were characterised by large quantities of marine benthic organisms.

5. Scientific Equipment, instruments etc.

The cruise was purely aimed at sampling the volcanic ridge, and so only dredge stations were occupied and dredging was the only sampling method used. A gravity rock corer was on board the ship but not deployed due to the greater handling difficulties associated with its greater weight (ca. 1,5 tonnes).

6. Station List

The following is a list of stations occupied and samples collected. Coordinates and water depths are those givien at first bottom contact and at the end of bottom contact (usually taken where wire length = water depth)

Station	Location	Depth	Samples taken
257DS	67°59.99´N	660 m	Mud and dropstones (too far east?)
	18°08.41´W		
	to	to	
	68°00.08´N		
	18°07.39W	774 m	
258DS	67°55.91´N1	570	-1: Pillow sector, no glass, many veisicles ø 1-2mm, phenos <1mm
	8°22.86´W		-2: Pillow sector, aphyric, large vesicles, no glass
	to	to	-3: similar to 2
	67°56.35´N		-4: mud-supported basalt breccia
	18°22.22´W	665	-5: altered pillow, no glass, 10% vesicles ø 0.5-1mm
259DS	67°53.98´N	506 m	Empty
	18°25.20W		
	to	to	
	67°54.38´N		
	18°24.54´W	560m	
260DS	67°53,97´N	573 m	Empty
	18°24.88´W		
	to	to	
	67°54.34´N		
	18°24.23´W	586 m	
261DS	67°53.80´N	620 m	-1: Pillow sector, 3-5mm glass rim, 10% vesicles (ø 0.5 - 1mm) aphyric
	18°24.86´W		-2: Pillow sector, 2-3mm glass rim, aphyric, ca. 5% vesicles
	to	to	-3: Pillow sector, 1-4mm glass rim, aphyric, 20% vesicles (ø 1-2mm) thin
	67°54.44´N		sed. cover
	18°23.89´W	620 m	
262DS	67°52.01N	425 m	Empty, weak link broken
	18°26.04W		
	to	to	
	67°52.27N		
	18°25.40W	580 m	
263DS	67°51.90´N	515 m	-1: Sheet flow, aphyric, 1cm glass rim
	18°26.26´W		-2: Pillow sector, 5mm glass rim, aphyric, vesicles at margin
	to	to	-3: Sheet flow, aphyric, 0.5 - 1 cm glass rim
	67°52.99´N		-4: Pillow sector, aphyric, slightly altered, 1-2mm glass rim, appears older
	18°25.75´W	437 m	than other samples
			-5: Pillow sector, 2-3mm glass rim, aphyric
			-6: Small glassy rest of sheet flow

264DS	67°47.60´N	502 m	Mud
	18°27.32W		
	to	to	
	67°47.80´N		
	18°26.62´W	400 m	
265DS	67°43.66´N	380 m	Mud
	18°31.19´W		
	to	to	
	67°44.05´N		
	18°30.87´W	300 m	
266DS	67°43.69´N	275 m	-1:Pillow sector, vesicular, phenos, 1-2mm glass rim
	18°34.17´W		-2: Pillow sector, small plag.-phenos, 2-3mm glass rim
	to	to	-3: Pillow sector, small plag.-phenos, 3-5mm glass rim
	67°43.94´N		
	18°33.97´W	340 m	
267DS	67°43.38´N	427 m	-1: Sheet flow, 1-3mm glass rim, aphyric, slightly altered
	18°34.65´W		-2: Sheet flow, aphyric, glass rim
	to	to	-3: Pillow sector, 1-2mm glass rim, 5% vesicles (ø0.5 - 1mm), aphyric
	67°43.97´N		-4: Pillow sector, 1-3mm glass rim, aphyric, vesicles
	18°34.15´W	404 m	
268DS	67°41.70´N	390 m	-1: sheet flow fragment
	18°32.65´W		-2: Pillow sector, aphyric, glass rim, highly vesicular (ø 1-2mm)
	to	to	-3: Pillow sector, 10% vesicles (ø1-3mm)
	67°41.98´N		
	18°32.13´W	360 m	
269DS	67°39.72´N	356 m	-1: Sheet flow, aphyric, few vesicles
	18°33.33´W		-2: Sheet flow, aphyric, 20% vesicles (ø 1-5mm), 2-4mm glass rim
	to	to	-3: Pillow sector, glass rim (5mm), 10% vesicles (ø 1-2mm)
	67°39.90´N		-4: Pillow sector, aphyric, few vesicles ø1-2mm)
	18°32.66´W	355 m	-5: Pillow sector, aphyric, 1-3mm glass rim, 10-20% vesicles (ø1-2mm)
270DS	67°37.65´N	320 m	-1: Pillow sector, 5mm glass rim, aphyric, few vesicles
	18°32.07´W		-2: Pillow sector, 5-7mm glass rim, few vesicles (ø 1mm), muddy matrix
	to	to	-3: Pillow sector, 1-2cm glass rim, few vesicles
	67°37.94´N		-4: Pillow sector, 2-3 cm glass rim, muddy surface
	18°31.37´W	325 m	-5: Pillow sector, few vesicles, muddy
271DS	67°35.62´N	334 m	-1: sheet flow, 2-5mm glass rim, aphyric
	18°34.34´W		-2: Sheet flow, aphyric, 5mm glass rim, vesicular (ø 1-2mm)
	to	to	-3: Sheet flow, 5-7mm glass rim, highly vesicular (ø 20-30mm and 1-2 mm)
	67°35.63´N		
	18°34.07´W	250 m	
272DS	67°33.84´N	328 m	-1: Pillow sector, aphyric, 5-10mm glass rim, vesicular (ø 1-2mm)
	18°33.08´W		-2: Pillow sector, 5mm glass rim, aphyric, vesicular (1-2mm)
	to	to	-3: Pillow sector, aphyric, vesicular (ø 2-3mm), 1-2mm glass rim
	67°33.85´N		-4: Pillow sector, vesicular (ø1-2mm)
	18°32.86´W	350 m	
273DS	67°31.85´N	256 m	-1: Pillow sector, no glass, aphyric, highly vesicular (ø 0.5 - 2mm)
	18°37.44´W		-2: Pillow sector, aphyric, no glass, vesicular (0.5 - 2mm)
	to	to	
	67°23.08´N		
	18°37.22´W	255 m	
274DS	67°29.80	242 m	-1: Sheet flow, 2-3mm glass rim, aphyric, 20-30% vesicles (ø1-3mm)
	18°36.09´W		-2: Sheet flow, as -1
	to	to	
	67°30.11´N		
	18°36.26´W	298 m	
275DS	67°27.93´N	269 m	2 small glass-free, aphyric and vesicular (30%, ø 1-2mm) pillow sectors, too small for analysis
	18°31.01´W		
	to	to	
	67°28.54´N		
	18°31.50´W	285 m	

276DS	67°27.75´N	280 m	-1: Sheet flow, 1-3mm glass rim, 20% plag.-phenos (ø 1-3mm), 20%
	18°31.06´W		vesicles (ø2-4mm)
	to	to	-2: Pillow sector, no glass, 10% plag.-phenos. (ø0.5 - 1mm), 10% vesicles
	67°28.27´N		(ø0.5 - 1 mm)
	18°31.09´W	255 m	-3: Sheet flow, thin glass rim, 10-20% plag.-phenos. (ø2-4mm), 20-30%
			vesicles (ø 1-3mm)
277DS	67°25.91´N	274 m	Empty (broken weak link)
	18°33.50´W		
	to	to	
	67°26.26´N		
	18°33.48´W	240 m	
278DS	67°26.11´N	284 m	-1: Sheet flow, 3mm glass rim, 15% vesicles (ø 2-5mm)
	18°33.94´W		-2: Sheet flow, 1-2mm glass rim, 30% vesicles (ø3-4mm)
	to	to	
	67°26.42´N		
	18°34.02´W	273 m	
279DS	67°23.82'N	267 m	-1: Sheet flow, 4-5mm glassy rim, 15% vesicles (1-3mm)
	18°34.91'W		-2: Sheet flow, 4-5mm glassy rim, 15% vesicles (1-2mm)
	to	to	-3: Sheet flow, 4-5mm glassy rim, 10-15% vesicles (2-3mm), organic material
	67°27.065'N	240 m	-4: Sheet flow (altered), 4-5mm glassy rim, 15% vesicles , few organic material
	18°35.700'W		
280DS	67°23.119'N	232 m	-1: Sheet flow, 2-3mm glassy rim, 10% vesicles (1-2mm), few organic material
	18°36.287'W		-2: Sheet flow, 2-3mm glassy rim, 10% vesicles (1-2mm)
	to	to	
	67°22.961'N	173 m	
	18°36.582'W		
281DS	67°22.164'N	283 m	-1: Sheet flow, 3-4mm glassy rim, <5% vesicles (1-2mm),plag.-phenos, organic material
	18°37.434'W		-2: Sheet flow, 2-3mm glassy rim, 20% vesicles (0.5-1mm), aphyric, organic material
	to	to	
	67°22.069'N	250 m	
	18°37.846'W		
282DS	67°21.165'N	197 m	-1: small pillow sector, no glassy rim, 20% vesicles (1-3mm),plag.-phenos
	18°36.65'W		
	to	to	
	67°21.064'N	277 m	
	18°37.146'W		
283DS	67°21.274'N	271 m	-1: Sheet flow, 2-3mm glassy rim, 5% vesicles (1-2mm), few organic material
	18°37.440'W		-2: Sheet flow, -5mm glassy rim
	to	to	-3: Sheet flow, 1-3mm glassy rim, 10% vesicles (1-2mm)
	67°21.227'N	290 m	
	18°38.161'W		
284DS	67°20.277'N	195 m	-1: Pillow sector, 2-3mm glassy rim, 15% vesicles (1-2mm)
	18°37.242'W		-2: Sheet flow, 3-4mm glassy rim, 20% vesicles (1-2mm)
	to	to	
	67°19.935'N	262 m	
	18°38.464'W		
285DS	67°18.948'N	208 m	-1: Sheet flow, 10% vesicles (0.5-2mm), aphyric, organic material
	18°37.806'W		-2: Sheet flow, 10% vesicles (0.5-2mm), aphyric, organic material
	to	to	-3: Sheet flow, 10% vesicles (1-3mm), aphyric, organic material
	67°18.864'N	202 m	-4: Sheet flow, 10% vesicles (1-3mm), aphyric, organic material
	18°37.079'W		
286DS	67°19.341'N	311 m	-1: Sheet flow, 1-2mm glassy rim, 20% vesicles (1-2mm), aphyric, organic material
	18°38.064'W		-2: Sheet flow, 1-2mm glassy rim, 20% vesicles (0.5-2mm), aphyric, organic material

	to	to	-3: Sheet flow, 2-3mm glassy rim, 20% vesicles (-2mm), aphyric, organic material
	67°19.241'N	200 m	
	18°37.769'W		
287DS	67°18.057'N	185 m	no samples taken
	18°37.286'W		
	to	to	
	67°17.949'N	364 m	
	18°36.513'W		
288DS	67°18.030'N	247 m	-1: Sheet flow, vesicles (0.5-5mm), aphyric, organic material
	18°38.066'W		-2: Sheet flow, 1-2mm glassy rim, vesicles (0.5-1mm), aphyric, organic material
	to	to	-3: Sheet flow, vesicles (-1mm), aphyric, organic material
	67°17.905'N	215 m	-4: Sheet flow, 2-3mm glassy rim, vesicles (0.5-3mm), aphyric, organic material
	18°37.243'W		
289DS	67°17.051'N	238 m	-1: Pillow sector, 0.5-1mm glassy rim, 20% vesicles (1-2mm), aphyric, organic material
	18°39.294'W		-2: Sheet flow, 2-3 mm glassy rim, vesicles (0.5-2mm), aphyric, organic material
	to	to	-3: Pillow sector, 2-3mm glassy rim, 20% vesicles (1-2mm), organic material
	67°16.911'N	174 m	-4: Sheet flow, vesicles (1-3mm), aphyric, organic material
	18°39.070'W		-5: Sheet flow, 2-3 mm glassy rim, vesicles (2-3mm), organic material
290DS	67°15.866'N	326 m	-1: Pillow sector, ~1mm glassy rim, 20% vesicles (1-2mm), aphyric, organic material
	18°41.254'W		-2: Sheet flow, glassy rim, 10% vesicles (0.5-2mm), organic material
	to	to	-3: Pillow sector, ~1mm glassy rim (partly altered), 10% vesicles (1-10mm), organic material
	67°15.582'N	190 m	-4: Pillow sector, 3-5mm glassy rim, 20% vesicles (1-2mm), aphyric, organic material
	18°40.772'W		-5: Pillow sector, 3-5mm glassy rim, 5% vesicles (1-2mm), aphyric, organic material
291DS	67°14.928'N	263 m	-1: Pillow sector, ~5mm glassy rim, 10% vesicles (0.5mm), aphyric
	18°41.602'W		-2: Pillow sector, 1-3mm glassy rim, 20% vesicles (1-2mm), aphyric, organic material
	to	to	-3: Sheet flow, 3-6mm glassy rim, aphyric, organic material
	67°14.761'N	286 m	
	18°40.956'W		
292DS	67°14.070'N	130 m	-1: Sheet flow, 5-10 mm glassy rim, 20% vesicles (1-2mm), aphyric, organic material
	18°39.106'W		-2: Pillow sector, 1-3mm glassy rim, 20% vesicles (1mm), aphyric, organic material
	to	to	
	67°13.840'N	135 m	
	18°38.447'W		
293DS	66°37.805'N	460 m	-extra piece: hyrdothermal sample
	17°47.985'W		
	to	to	
	66°37.851'N	413 m	
	17°46.792'W		
294DS	66°38.021'N	462 m	no samples taken
	17°48.032'W		
	to	to	
	66°38.060'N	420 m	
	17°47.009'W		
295DS	66°33.978'N	462 m	- extra pieces: 3 hyrdothermal samples
	17°46.131'W		
	to	to	
	66°33.787'N	420 m	
	17°44.244'W		

	67°21.407'N 18°36.417'W	262 m	-4: Sheet flow, 1-4mm glassy rim, 5-10% vesicles
308DS	67°21.523'N 18°35.027'W	267 m	no samples taken
	to	to	
	67°21.440'N 18°34.136'W	324 m	
309DS	67°21.443'N 18°35.100'W	283 m	-1: Sheet flow, 1-3mm glassy rim, >20% vesicles (1-3mm), organic material
	to	to	
	67°21.368'N 18°34.146'W	313 m	
310DS	67°20.462'N	233 m	-1: Sheet flow, 1-3mm glassy rim, vesicles (0.5-2mm), aphyric, organic material
	18°38.319'W		-2: Pillow sector, 3-4mm glassy rim, vesicles (0.5-1mm), aphyric, organic material
	to	to	-3: Sheet flow, 2-5mm glassy rim, vesicles (0.5-3mm), aphyric, organic material
	67°20.382'N 18°37.211'W	200 m	
311DS	67°19.385'N 18°36.301'W	285 m	-1: Sheet flow, glassy rim, vesicles (0.5-1mm), aphyric -2: Sheet flow, glassy rim, vesiclesm, aphyric
	to	to	
	67°19.406'N 18°35.162'W	416 m	