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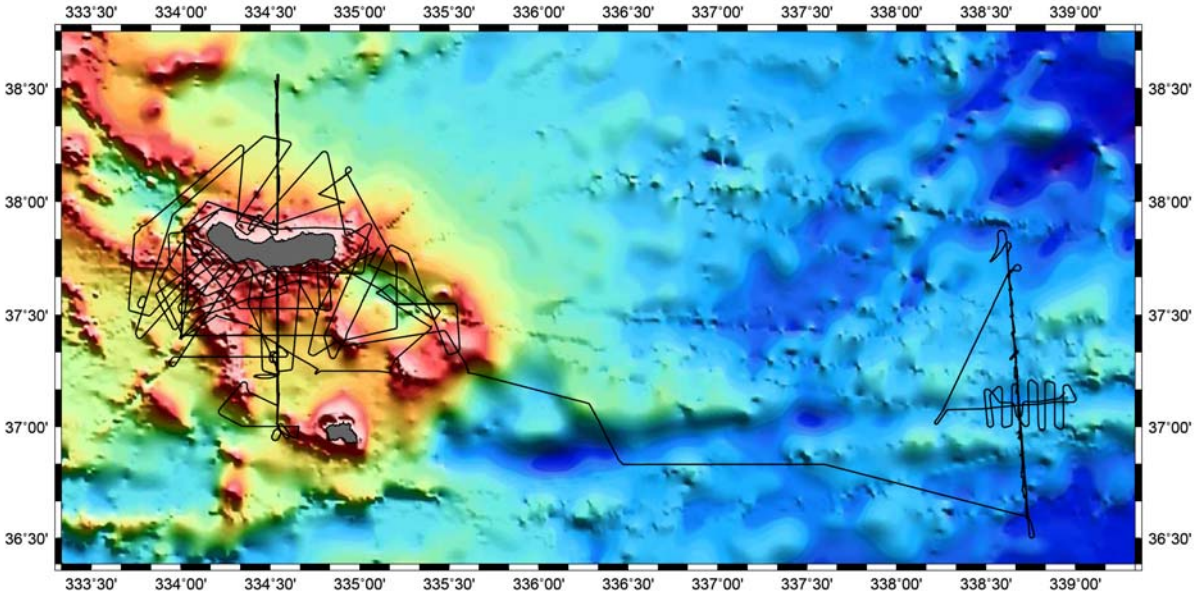
Short Cruise Report
RV METEOR Cruise M79/2
São Miguel/ Azores to Las Palmas / Gran Canaria / Spain
26 August – 21. September 2009
Chief Scientist: Christian Hübscher
Captain: Thomas Wunderlich



Cruise track M79/2. Gravity and hydroacoustic data were recorded throughout the survey.

Objectives

The expedition aims on the analysis of the structure, dynamic and natural hazard potential of the Atlantic section of the European-African plate boundary in the area of the eastern Azores and Gloria Fault. The measurements included marine geophysical experiments like refraction and reflection seismics, potential field recordings (gravity & magnetics), parametric sediment subbottom profiling and multibeam. Additionally, a previously deployed submarine passive seismological long-term deployment was recovered in order to study the local submarine seismicity of the Terceira rift. The seismological studies contribute to a pilot experiment on Sao Miguel that is carried within the BMBF research focus on 'Early Warning Systems'.

Narrative

Sunday the 23rd of August the RV Meteor entered the port in Ponta Delgada, the capital of São Miguel (an island of the Azores). Loading activities started immediately after arrival and only three hours later all the equipment of our predecessors had been unloaded and ours had been taken aboard. On Tuesday Captain Wunderlich and his crew welcomed us aboard when the scientific party from Hamburg and Portugal finally moved into their new homes for the following month. Instantaneously we started to install the equipment on deck and in the laboratories. Technical maintenance, gravity tight measurement, meetings and introductions to the working routine on the ship took place in turns so that in the late evening the scientific resorts were ready for sea. Both affiliates from cooperating institutes from the Azores and the German Honorar-Konsul Rieks visited us during the port call.

Wednesday the 26th of August RV Meteor put to sea on schedule. From the very beginning the gravity field as well as the hydroacoustic mapping of the seafloor were recorded. These systems were continuously active as long as the ship was located in an area for which a research permit was given.

Only ten sea miles south of the harbour respectively directly after the pilot had disembarked the recovery of the first ocean bottom seismograph (OBS) began. In spring time this year several OBS have been deployed around São Miguel with the RV Poseidon within the scope of a project sponsored by the BMBF. With excellent interplay between scientists and crew we recovered 17 of 19 stations. Two stations did not react on the releasing signal and they had to be given up.

On Friday the systematic geophysical investigation of the sea floor around Sao Miguel started. Detailed bathymetric maps were created be means of the mutibeam system. These maps revealed that the sea floor is much stronger dissected than one could guess after studying elder bathymetric maps. Another geophysical method is the so-called reflection seismics. This technique enables us to map the crustal structure along the route and up to depth of two kilometers, similar to a radiograph. This is the principle: An airpulser generates shock waves which penetrate the ocean bottom. The waves are reflected by boundaries between different types of rock and recorded by a sensor system (the 'streamer') which is towed behind the ship. From these recordings a seismic section is computed, which represents a 'snapshots' of the bedrock structure.

Anomalies recorded by the new magnetometer bear witness to the magmatic processes located so deep in the earth crust that they cannot be attained by the seismic methods. The continuously recorded acceleration of gravity is distinguished by the spatial distribution of the specific density. There from conclusions can be

drawn about the spatial distribution of certain rocks and moreover about the existence of hot and consequently lighter magma.
At the beginning of the second week we finished our first geophysical overview measurements around Sao Miguel. The seismic imaging techniques as well as the hydro acoustic techniques show e.g. how and where oceanic currents are diverted and regional intensified by the complex physiography of the ocean bottom. This process strongly affects the depositional pattern of sediments. Geometry and stratigraphy of the resulting contoured drift will enable us to draw a conclusion about the spatial and temporal variability of these currents.
At the steep submarine slopes of São Miguel sediment deposits were found which have been relocated by submarine land slides. They often feature an astonishing good interior stratification. The seismic data of the submarine land slides and of the contoured drift shows numerous interior reflexions with high amplitudes. Their signal characteristics point strongly to the existence of fluids and/or gas.
In the course of this second week we measured a profile of over 150 km length with the seismic refraction method. With this technique cross-sections through the earth crust can be produced. The several beds of the crust can be distinguished by their geometry as well as by the propagation velocity of seismic waves.
The centre of this profile was on the volcano Fogo on São Miguel. Therefore a total of 18 OBS were sited at a depth of almost 3000 meters. Afterwards we released shock waves with large-volume air pulser in time intervals of 60 seconds. Colleagues from the geophysical institutes of Hamburg, Bremerhaven and the Azores had installed land stations along the profile on the island before to make sure a complete overlap of the profile. After the recording was finished the OBS were recollected.
Until Saturday of the third week we continued the profile surveying at the slopes and in the adjacent basins and ridges around São Miguel. Thereby the design of the profiles is based on those data which we had obtained during the first week. In the course of the survey progress the digital maps of the ocean bottom became more and more detailed. They show the spatial formation of structures which are described in the form of cross-sections by the seismic refraction and potential field measurement. Based on this information the design of the profiles could be specified. The obtained data were discussed every evening during the so-called *Science Meetings* and afterwards the planning was adapted to the new findings and the resulting hypothesis.
At the 12th September about noon the surveying in the work area around São Miguel was finished. The total length of the 50 profiles which had been measured with all the for us available geophysical methods (seismic reflexion, magnetic, gravimetry, sediment echo sounder and multibeam) adds up to 1800 km. In addition, narrow 2000 km of gravity und hydro acoustic data was recorded along the complete route.
After completing of the surveying we took a 200 km long transit eastwards to the second work area at the Gloria fault at which the African and the Eurasian earth plate pass by each other. Probably this is where the epicentre of the strongest ever recorded earthquake is located.
Altogether 18 OBS were deployed at a depth of about 5000 m along a narrow 140 km long profile which runs vertically to the Gloria fault. Immediate afterwards we released shock waves at intervals of 120 m. Those waves cross the water column and the earth crust up to the crust mantle boundary where they propagate and at last run back through the crust until they reach the OBS.
In a later stage of analysis those parameters are combined with the potential data so that beds are further described through their specific densities and the magnetic characteristics. With all these bits of information a model can be devised. The

following salvage of the OBS went according to plan owing to the good weather, the driving skills of the guard mates and a route map which was cleverly puzzled out. Afterwards the central basin through which the Gloria fault runs was measured with seismic reflexion.
Friday afternoon we finished the scientific research program and took to a transit towards the final harbour of our journey. Altogether we collected more than 5000 km of gravity data, about 4500 km of PARASOUND and MULTIBEAM recordings and we measured more than 2000 km of multichannel seismic profiles simultaneous to the magnetic recordings. Furthermore two deep seismic sounding profiles were surveyed each with 18 OBS. Downtime caused by technical problems adds to about five hours what is very little. In the forenoon of Monday the 21st September we entered port in Las Palmas.

Acknowledgements

We like to thank captain Thomas Wunderlich, his officers and crew of RV Meteor for their support of our measurement programme and for creating a very friendly atmosphere on board. We also appreciate the scientific support by our Portugese colleagues from the Azores and Lissabon. The ship time of RV Meteor was provided by the Deutsche Forschungsgemeinschaft.

Participants

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Profile list

Source	Profile	Start				Ende				Length[km]
		Date	UTC	Longitude	Latitude	Date	UTC	Lon	Lat	
GI-Gun	HH09-01	28.08.2009	22:47:48	25°3,72	36°6,66	29.08.2009	04:08:02	24°47,71	37°43,17	49
GI-Gun	HH09-02	29.08.2009	04:08:09	24°47,71	37°43,17	29.08.2009	07:26:00	24°47,58	37°26,68	30
GI-Gun	HH09-03	29.08.2009	07:26:00	24°47,58	37°26,68	29.08.2009	10:45:00	25°8,07	37°22,71	29
GI-Gun	HH09-04	29.08.2009	10:50:00	25°8,439	27°22,581	29.08.2009	12:35:00	25°17.096'	37°19.87'	15
GI-Gun	HH09-06	29.08.2009	12:35:00	25°17,085'	37°20,2654'	29.08.2009	15:11:00	25°13,408'	37°33,004	23
GI-Gun	HH09-07	29.08.2009	15:13:00	25°13,417'	37°33,126	29.08.2009	17:09:00	25°14,209'	37°43,027'	18
GI-Gun	HH09-0708	29.08.2009	17:09:00	25°14,299'	37°43,027'	29.08.2009	18:14:00	25°19,694'	37°41,675	7
GI-Gun	HH09-08	29.08.2009	18:14:00	19:14	30.08.2009	29.08.2009	23:24:00	25°22,638'	37°15,322'	48
GI-Gun	HH09-09	30.08.2009	00:22:50	25°27,59'	37°15,81'	30.08.2009	05:27:35	25°27,78'	37°41,3'	46
GI-Gun	HH09-10	30.08.2009	06:11:54	25°31,383'	37°40,371'	30.08.2009	07:47:51	25°33,3'	37°32,4'	15
GI-Gun	HH09-11	30.08.2009	07:48:37	25°33,3'	37°32,4'	30.08.2009	11:04:22	25°32,70'	37°15,91'	30
GI-Gun	HH09-12	30.08.2009	18:15:41	25°27,35'	37°15,08'	30.08.2009	21:46:37	25°37,2'	37°32,7'	35
GI-Gun	HH09-13	30.08.2009	21:53:41	25°37,2'	37°33,4'	30.08.2009	23:16:09	25°35,95'	37°40,88'	14
GI-Gun	HH09-14	30.08.2009	23:49:15	25°37,19'	37°41,95'	31.08.2009	01:32:08	25°45,05'	37°34,14'	17
GI-Gun	HH09-15	31.08.2009	01:39:05	25°45,83'	37°33,64'	31.08.2009	03:42:24	25°59,22'	37°30,52'	21
GI-Gun	HH09-16	31.08.2009	04:16:27	26°00,29	37°32,70	31.08.2009	07:09:57	25°44,01'	37°42,15	29
GI-Gun	HH09-17	31.08.2009	08:39:00	25°50,09'	37°46,88'	31.08.2009	12:50:23	26°10,02'	37°30,07'	42
GI-Gun	HH09-18	31.08.2009	13:02:10	26°11,08'	37°29,85'	31.08.2009	13:52:36	26°16,73'	37°31,06'	8
GI-Gun	HH09-19	31.08.2009	14:06:32	26°17,44'	37°31,99'	31.08.2009	17:34:22	26°15,57'	37°51,0'	35
GI-Gun	HH09-20	31.08.2009	17:42	26°15,10'	37°51,6'	01.09.2009	00:16:16	25°40,55'	38°14,74'	66
GI-Gun	HH09-21	01.09.2009	00:36:24	25°38,93'	38°13,85'	01.09.2009	03:56:13	25°41,06'	37°55,64'	34
GI-Gun	HH09-22	01.09.2009	04:10:04	25°40,24	37°54,80'	01.09.2009	05:57:11	25°28,45'	37°52,68'	17
GI-Gun	HH09-23	01.09.2009	06:11:09	25°27,60'	37°53,59'	01.09.2009	12:40:48	25°27,591'	38°29,085'	64
Bolt-Gun	HH09-24	02.09.2009	22:32:56	25°27,598'	37°1,044'	03.09.2009	04:22:00	25°27,59'	37°18,26'	32
Bolt-Gun	HH09-24b	03.09.2009	09:06:56	25°29,124'	37°17,72'	03.09.2009	15:44:27	25°27,66'	37°37,19'	34
Bolt-Gun	HH09-25	04.09.2009	04:21:00	25°27,57'	37°51,88'	04.09.2009	16:34:16	25°27,59'	38°25,5'	69
sparker	HH09-26	06.09.2009	14:23:16	25°27,6'	37°05,0'	06.09.2009	18:19:11	25°27,591'	37°20,791'	30

GI-Gun	HH09-27	06.09.2009	19:32:16	26°25,42'	37°18,81'	07.09.2009	01:24:27	26°01,99'	37°18,81'	53
GI-Gun	HH09-28	07.09.2009	02:20:22	26°01,81'	37°16,68'	07.09.2009	08:20:37	25°41,217'	37°42,151'	62
GI-Gun	HH09-29	07.09.2009	09:15:33	25°45,051'	37°44,325'	07.09.2009	13:41:46	26°01,41'	37°26,3'	56
GI-Gun	HH09-30	07.09.2009	13:58:27	26°02,88'	37°26,72'	07.09.2009	15:46:26	26°08,22'	37°34,85'	17
GI-Gun	HH09-31	07.09.2009	16:00:32	26°07,57'	37°35,89'	07.09.2009	19:39:33	25°49,46'	37°47,18'	33
GI-Gun	HH09-32	07.09.2009	21:18:24	25°55,63'	37°48,53'	07.09.2009	22:37:06	25°49,029'	37°44,485'	12
GI-Gun	HH09-33	07.09.2009	22:54:15	25°49,172'	37°43,343'	08.09.2009	04:20:27	26°13.06'	37°21.95'	50
GI-Gun	HH09-34	08.09.2009	04:56:19	26°15.02'	37°25.49'	08.09.2009	13:10:28	25°58,167'	37°59,550'	46
GI-Gun	HH09-34c	08.09.2009	14:01:32	25°57,383'	37°59,999'	08.09.2009	19:16:51	25°32,35'	38°17,17'	48
GI-Gun	HH09-35	08.09.2009	20:56:00	25° 23.30'	38° 14.81'	09.09.2009	02:01:25	25°41,491'	37°53,955'	46
GI-Gun	HH09-36	09.09.2009	03:04:33	25°36,869'	37°51,707'	09.09.2009	11:34:41	25°12,05'	38°13,07	62
GI-Gun	HH09-37	09.09.2009	11:58:02	25°10,668'	38°12,416'	09.09.2009	13:08:13	25°09,313'	38°07,479'	9
GI-Gun	HH09-38	09.09.2009	20:52:08	24°56,264'	37°52,81'	10.09.2009	02:58:51	25°11,808'	37°24,544'	56
GI-Gun	HH09-39	10.09.2009	04:33:55	25°8,041	37°18.995	10.09.2009	11:01:12	24°50,14'	37°48,00'	59
GI-Gun	HH09-40	10.09.2009	12:10:00	24°43.512	37°45.852	10.09.2009	17:04:47	24° 31.18'	37° 20.81'	49
GI-Gun	HH09-41	10.09.2009	18:43:04	24°26,53'	37°21,91'	10.09.2009	20:39:45	24°27,47'	37°32,28'	19
GI-Gun	HH09-42	10.09.2009	20:58:01	24°29,22'	37°32,95'	11.09.2009	03:20:10	25°09,00'	37°43,60'	64
GI-Gun	HH09-43	11.09.2009	03:43:16	25°10,45'	37°42,60'	11.09.2009	05:33:40	25°09,58'	37°32,45'	18
GI-Gun	HH09-44	11.09.2009	05:57:44	25°11,14'	37°31,26'	11.09.2009	10:08:05	25°40,00'	37°31,70'	43
GI-Gun	HH09-45	11.09.2009	10:16:23	25°40,79'	37°32,04'	11.09.2009	14:15:58	25°58,40'	37°48,88'	40
GI-Gun	HH09-46a	11.09.2009	14:34:18	26°0,129'	37°48,58'	11.09.2009	15:19:25	26°02,66'	37°45,21'	7
GI-Gun	HH09-46b	11.09.2009	16:49	26°4,95'	37°42,13'	11.09.2009	17:33:16	26°07,54'	37°38,62'	7
GI-Gun	HH09-47	11.09.2009	17:42	26°07,46'	37°37,83'	11.09.2009	20:19:59	25°59.85'	37°24.9'	26
GI-Gun	HH09-48	11.09.2009	20:30:36	25°58.67'	37°24.55'	12.09.2009	03:38:14	25°9,700'	37°24.521'	72
GI-Gun	HH09-49	12.09.2009	04:29:03	25°05,28'	37°21,68'	12.09.2009	09:20:58	24°25,80'	37°32,05'	49
GI-Gun	HH09-50	12.09.2009	09:35:35	24° 30,714'	37° 25,044'	12.09.2009	11:17:42	24° 24,55'	37° 17,08'	17
Bolt-Gun	HH09-51	14.09.2009	01:17:29	21°23,020'	37°47,910'	14.09.2009	20:38:10	21°15,41'	36°30,65'	143
GI-Gun	HH09-52	16.09.2009	18:55:25	21°42,38'	37°04,62'	17.09.2009	01:04:41	21°0,79'	37°06,67'	63
GI-Gun	HH09-53	17.09.2009	02:39:17	21°04,08'	37°10,33'	17.09.2009	04:29:05	21°04,02'	37°00,15'	19
GI-Gun	HH09-54	17.09.2009	05:07:53	21°06,92'	37°00,75'	17.09.2009	07:04:42	21° 06,96'	37°11,28'	19
GI-Gun	HH09-55	17.09.2009	07:43:01	21°10,20'	37°11,42'	17.09.2009	09:48:21	21°10,65	36°59,87'	21
GI-Gun	HH09-56A	17.09.2009	10:32:41	21°12,47'	37°1.39'	17.09.2009	?	?	?	11

GI-Gun	HH09-56B	17.09.2009	11:43:57	21°12,64'	37°08,05'	17.09.2009	12:17:33	21°12,72'	37°11,06'	6
GI-Gun	HH09-57	17.09.2009	12:57:46	21°15,84'	37°11,61'	17.09.2009	14:53:41	21°15,60'	37°00,95'	20
GI-Gun	HH09-58	17.09.2009	15:34:48	21°18,47'	37°01,92'	17.09.2009	17:12:24	21°19,352'	37°10,850'	19
GI-Gun	HH09-59	17.09.2009	17:39:01	21°21,32'	37°10,56'	17.09.2009	18:25:09	21°31,312'	37°0,958'	18
GI-Gun	HH09-60	17.09.2009	20:06:30	21°24,63'	37°00,79'	17.09.2009	22:08:10	21°24,63'	37°09,97'	16
GI-Gun	HH09-61	17.09.2009	23:13:58	21°28,66'	37°08,07'	18.09.2009	00:51:03	21°27,50'	37°07,6'	13
GI-Gun	HH09-62	18.09.2009	01:24:11	21°29,52'	37° 0,74'	18.09.2009	03:18:06	21°30,54'	37°09,27'	16
GI-Gun	HH09-63	18.09.2009	04:00:29	21°27,637'	37°8,948'	18.09.2009	09:39:16	21°06,67'	37°07,63'	46

Coordinates of ocean-bottom recorders along refraction line 2 (across Gloria Fault)

Nr.	Deployment		Recovery		Water depth	Type
	Lat	Lon	Lat	Lon	[m]	
1	36°35.689'N	21°15.881'W	36°35.424'N	21°16.461'W	4931	OBS
2	36°41.586'N	21°16.461'W	36°41.058'N	21°17.365'W	4486	OBS
3	36°45.351'N	21°16.819'W	36°44.964'N	21°17.406'W	4566	OBH
4	36°49.130'N	21°17.199'W	36°48.749'N	21°17.791'W	4455	DEPAS
5	36°52.885'N	21°17.563'W	36°52.884'N	21°17.586'W	4151	OBS
6	36°57.183'N	21°18.017'W	36°56.704'N	21°18.402'W	3766	OBS
7	36°59.314'N	21°18.232'W	36°58.850'N	21°18.666'W	3835	OBS
8	37°02.541'N	21°18.529'W	37°02.686'N	21°18.788W	3824	OBH
9	37°06.847'N	21°18.960'W	37°06.508'N	21°19.141'W	4465	OBS
10	37°11.154'N	21°19.366'W	37°11.011'N	21°19.325'W	3936	DEPAS
11	37°13.831'N	21°19.607'W	37°13.634'N	21°19.405'W	3935	OBS
12	37°17.592'N	21°20.020'W	37°17.255'N	21°19.835'W	4100	OBH
13	37°20.285'N	21°20.275'W	37°20.065'N	21°19.927'W	4097	OBS
14	37°25.638'N	21°20.777'W	37°25.662'N	21°20.808'W	3879	OBH
15	37°29.954'N	21°21.224'W	37°29.810'N	21°20.930'W	4235	DEPAS
16	37°33.207'N	21°21.574'W	37°33.022'N	21°21.079'W	4250	OBS
17	37°36.875'N	21°21.905'W	37°36.726'N	21°21.379'W	4208	OBH
18	37°41.247'N	21°22.336'W	37°41.187'N	21°21.565'W	4553	OBS

Coordinates of ocean-bottom recorders along refraction line 1 (across Sao Miguel)

	Deployment		Recovery		Water depth	Type
Nr.	Lat	Lon	Lat	Lon	[m]	
N1	38°26.884'N	25°27.601'W	38°26.88'N	25°27.600'W	2893	OBS
N2	38°23.151'N	25°27.594'W	38°23.16'N	25°27.590'W	2844	OBH
N3	38°17.770'N	25°25.584'W	38°17.78'N	25°27.580'W	2709	OBS
N4	38°12.326'N	25°27.592'W	38°12.266'N	25°27.400'W	2463	DEPAS
N5	38°07.016'N	25°27.596'W	38°6.888'N	25°27.215'W	2280	OBS
N6	38°1.617'N	25°27.576'W	38°01.476'N	25°27.452'W	1899	OBS
N7	37°56.296'N	25°27.568'W	37°56.216'N	25°27.657'W	1332	OBH
N8	37°52.477'N	25°27.624'W	37°52.48'N	25°27.630'W	555	OBS
S9	37°41.29'N	25°27.54'W	37°41.29'N	25°27.520'W	204	OBS
S10	37°40.650'N	25°27.440'W	37°40.65'N	25°27.440'W	374	OBH
S11	37°37.989'N	25°27.654'W	37°38.042'N	25°27.836'W	895	DEPAS
S12	37°34.312'N	25°27.576'W	37°30.090'N	25°27.954'W	1076	OBS
S13	37°30.088'N	25°27.594'W	37°30.100'N	25°27.613'W	1470	OBH
S14	37°26.083'N	25°27.580'W	37°26.08'N	25°27.580'W	1755	OBS
S15	37°23.025'N	25°27.587'W	37°23.01'N	25°27.590'W	1929	DEPAS
S16	37°18.994'N	25°27.594'W	37°19.096'N	25°27.434'W	2037	OBS
S17	37°15.114'N	25°27.583'W	37°14.827'N	25°27.449'W	2192	OBH
S18	37°08.990'N	25°27.588'W	37°8.99'N	25°27.590'W	2200	OBS