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Report on DELP 1989 Cruise in the TTT Junction Areas Part 4: Heat Flow Measurements in the western Sagami Bay

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Abstract

During the first leg of the DELP-89 cruise, heat flow values have been determined at 32 sites along four lines that were approximately perpendicular to the trend of the topographic inflection line to the southeast of Hatsushima Island in the western Sagami Bay. Anomalously high heat flow values up to 479 mW/m^2 were again observed at the largest biological community, where a high heat flow value of 1680 mW/m^2 had been discovered in 1988. This localized anomaly can be attributed to the interstitial fluid seepage at the community. Also, heat flow values along each line decrease away from the topographic inflection toward the Sagami Trough. Shallow magma below the topographic inflection line could conductively heat up the sediment above, which would result in the heat flow anomaly.

1. Introduction

The western Sagami Bay area is located between the Sagami Trough and the Izu Peninsula. A large biological community consisting mainly of *Calyptogena* was discovered off Hatsushima Island and was investigated with the submersible "Shinkai 2000" of the Japan Marine Science and Technology Center (Hashimoto *et al.*, 1987; Ohta *et al.*, 1987). The community is in an area that is elongated along the topographic inflection line of the eastern slope of the Izu Peninsula at water depth of 1100–1200m (Fig. 1).

The heat flow in this area was first measured in 1988 (Gamo *et al.*, 1988), when a heat flow anomaly of 1680 mW/m^2 was discovered at the community site. Since then, we have conducted both closely-spaced and widely distributed heat flow surveys around the community together with geochemical, geological and other geophysical studies. Results of the heat flow measurements have already been reported (Kinoshita *et al.*, 1991). Here, therefore, we briefly report the results obtained during the DELP-89 cruise only.

Heat flow measurements on this cruise had two objectives: to determine the

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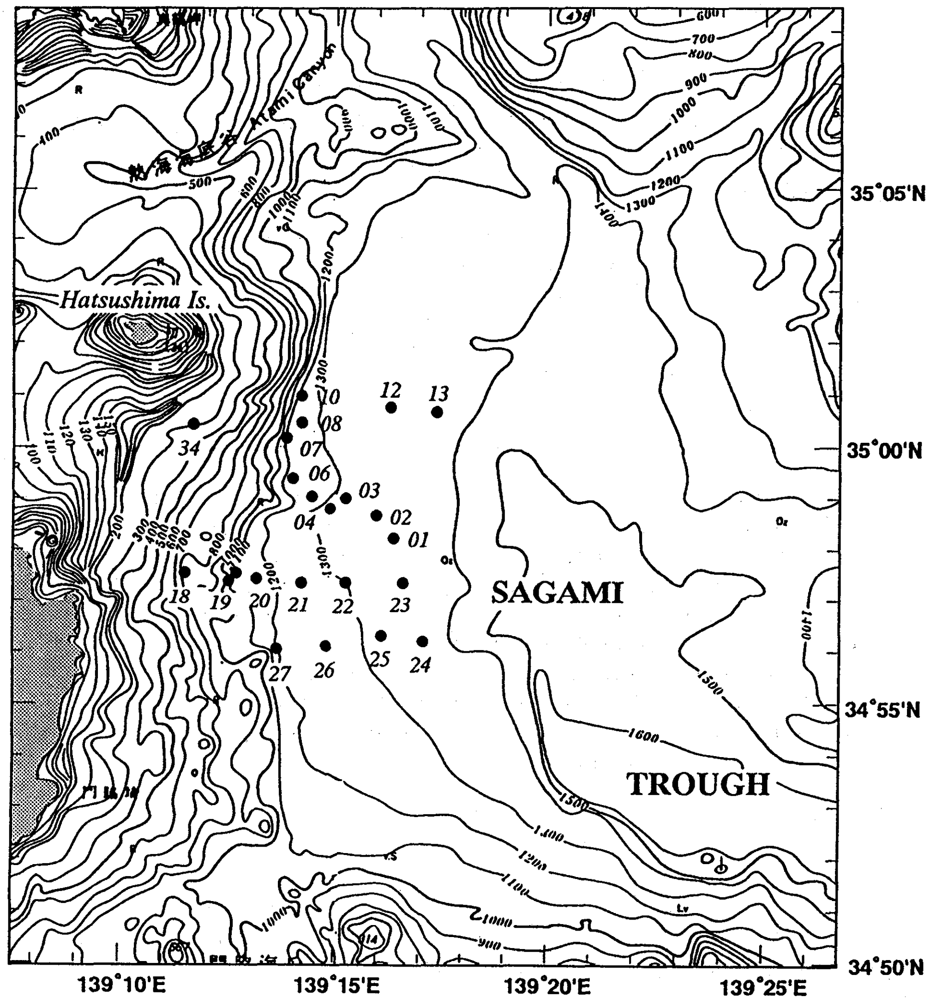

Fig. 1 Location of heat flow stations in the western Sagami Bay plotted on a bathymetry map. Numbers attached indicate station numbers shown in Table.

localized thermal regime around the community through closely-spaced heat flow measurements and to survey the regional thermal features in the western Sagami Bay.

2. Heat Flow Determination

A heat flow value is determined through measurements of temperature gradient and thermal conductivity. Details of the methods in these measurements are described in Kinsohita *et al.* (1991). We made no thermal conductivity measurements during this cruise. Therefore all heat flow values have been determined from the measured temperature gradient and the assumed thermal conductivity estimated from values obtained at nearby stations.

For the measurement of temperature gradient we used both Ewing and Bullard type

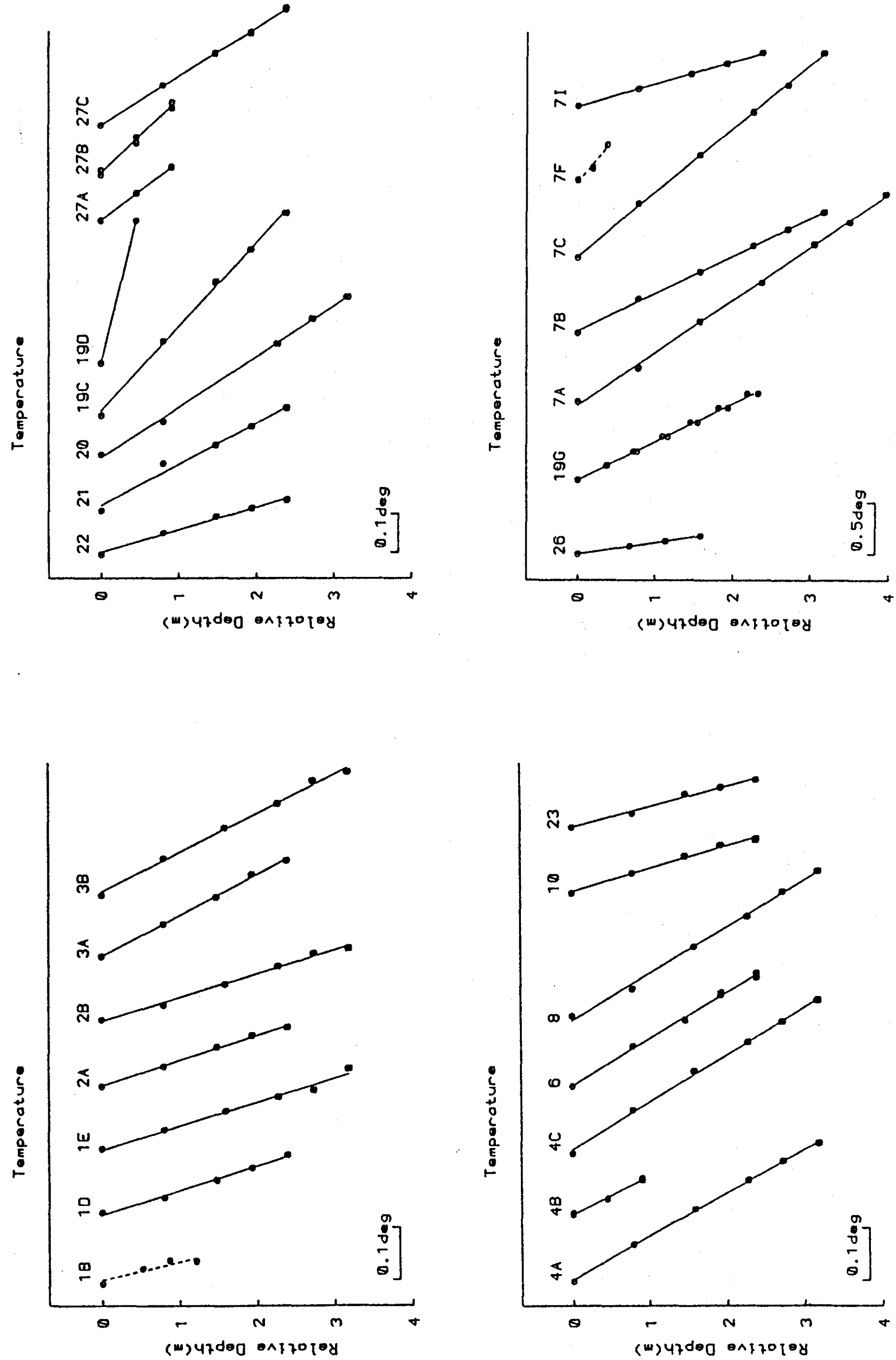

Fig. 2 Temperature versus depth profiles obtained during DELP-89 cruise. Straight lines are least squares fits of the data; broken lines indicate less reliable ones.

Table. Results of heat flow measurements in the western Sagami Bay

Station		Latitude	Longitude	D (m)	PR	PEN (m)	N	G (mK/m)	K (W/m K)	Q (mW/m²)
DELP89	HF01A	34°58.29'N	139°16.44'E	1400	EL	fell	–			
	HF01B	34°58.18'N	139°16.37'E		EL	tilt	4	(>34)	0.87*	(>30)
	HF01C	34°58.18'N	139°16.41'E		EL	fell	–			
	HF01D	34°58,20'N	139°16.46'E		EL	3.0	5	47	0.87*	40
	HF01E	34°58.26'N	139°16.53'E		EL	3.0	5	47	0.87*	40
	HF02A	34°58.69'N	139°15.97'E	1380	EL	3.0	5	49	0.87*	42
	HF02B	34°58.64'N	139°16.05'E		EL	3.5	6	46	0.87*	40
	HF03A	34°59.02'N	139°15.35'E	1360	EL	3.0	5	79	0.87*	68
	HF03B	34°58.96'N	139°15.37'E		EL	3.5	6	76	0.87*	65
	HF04A	34°58.80'N	139°14.93'E	1350	EL	3.5	6	84	0.79*	66
	HF04B	34°59.02'N	139°14.48'E	1300	EL	1.0	3	74	0.79*	58
	HF04C	34°59.11'N	139°14.50'E	1280	EL	3.5	6	92	0.79*	73
	HF06	34°59.40'N	139°14.11'E	1240	EL	3.0	5	90	0.76*	68
	HF08	35°00.40'N	139°14.25'E	1260	EL	4.0	6	91	0.76*	69
	HF10	35°00.87'N	139°14.51'E	1250	EL	3.0	5	45	0.76•	34
	HF13A	35°00.82'N	139°17.09'E		EL	1.8	3	82	0.87*	72
	HF13B	35°00.69'N	139°17.30'E		EL	fell				
	HF13C	35°00.65'N	139°17.38'E		EL	2.5	3	88	0.87*	77
	HF13D	35°00.48'N	139°17.71'E		EL				0.87*	
	HF12A	35°00.78'N	139°16.32'E		EL	fell				
	HF12B	35°00.73'N	139°16.37'E		EL	1.8	3	109	0.87*	96
	HF10A	35°00.83'N	139°14.37'E	1300	B	fell			0.76*	
	HF10B	35°00.83'N	139°14.41'E		B	fell				
	HF10C	35°00.81'N	139°14.42'E		B	fell				
	HF23	34°57.42'N	139°16.63'E	1390	EL	3.0	5	40	0.87*	35
	HF22	34°57.42'N	139°15.35'E	1345	EL	3.0	5	58	0.87*	50
	HF21	34°57.36'N	139°14.27'E	1295	EL	3.0	5	105	0.87*	91
	HF20	34°57.49'N	139°13.26'E	1195	EL	3.5	5	129	0.87*	112
	HF19A	34°57.71'N	139°12.61'E	1190	EL	fell				
	HF19B	34°57.72'N	139°12.59'E	1060	EL	fell				
	HF19C	34°57.62'N	139°12.83'E		EL	3.0	5	214	0.76*	162
	HF19D	34°57.63'N	139°12.53'E		EL	0.5	2	(>795)	0.76*	(>602)
	HF19E	34°57.53'N	139°12.61'E		EL	fell				
	HF19F	34°57.62'N	139°12.57'E		EL	fell				
	HF18A	34°57.50'N	139°11.65'E	865	EL	fell				
	HF18B	34°57.51'N	139°11.60'E		EL	fell				
	HF18C	34°57.50'N	139°11.66'E		EL	fell				
	HF27A	34°56.23'N	139°13.84'E	1200	EL	1.5	3	150	0.76*	113
	HF27B	34°55.81'N	139°13.58'E	1200	EL	1.5	3	187	0.76*	142
	HF27C	34°55.49'N	139°13.82'E		EL	3.0	5	124	0.76*	94
	HF26	34°56.11'N	139°14.89'E		EL	3.0	4	109	0.87*	95
	HF25A	34°56.22'N	139°16.02'E	1345	EL	1.2	3	77	0.87*	67
	HF25B	34°56.42'N	139°16.25'E		EL	1.2	3	50	0.87*	44
	HF24	34°56.19'N	139°17.14'E	1385	EL	1.2	3	64	0.87*	56
	HF19G	34°57.41'N	139°12.61'E	1110	B	2.5	7	364	0.76*	276
	HF07A	35°00.07'N	139°13.93'E	1220	EL	4.0	6	503	0.79*	397
	HF07B	35°00.09'N	139°13.99'E	1270	EL	3.5	6	358	0.79*	283
	HF07C	35°00.13'N	139°13.85'E		EL	3.5	6	607	0.79*	479
	HF07E	34°59.93'N	139°13.53'E		EL	fell				
	HF07F	34°59.98'N	139°13.62'E	1075	EL	fell	3	(>400)	0.79*	(>316)
	HF07G	34°59.97'N	139°13.64'E	1130	EL	fell				

Table. (continued)

HF07H	34°59.99'N	139°13.66'E	1160	EL	fell				
HF07I	35°00.12'N	139°13.99'E		EL	3.0	5	216	0.79*	171
HF34A	35°00.44'N	139°11.78'E		EL	fell				

Notes:
D : water depth.
PR : Probe type: B is the Bullard type, and EL and ES the Ewing type (4.5m and 3m long) probes respectively.
PEN : Length of probe or corer in the sediment. 'fell' indicates unsuccessful penetration.
N : Number of temperature data used to obtain temperature gradient.
G : Temperature gradient. Values in parentheses are less reliable ones. '>' indicates that the probe was tilted by more than 40°.
K : Thermal conductivity values. '*' indicates a nearby value, not an in-situ one.
Q : Heat flow. '>' and parentheses mean the same as in G.

geothermal probes (for the details see Kinoshita *et al.*, 1990). Fig. 2 is plots of relative temperature versus subbottom depth at each station. As seen in this figure, most of the profiles are linear within the limit of errors.

The obtained heat flow values are listed in Table.

3. Result of Heat Flow Measurements

As shown in Fig. 1, we basically measured heat flow along four lines which are approximately perpendicular to the topographic inflection line. Station HF-7 is the closest to the biological community. Two heat flow measurements at HF-18 and HF-34 were attempted on the landward slope of the Izu Peninsula; they were not successful.

Fig. 3 shows the heat flow distribution obtained during this cruise. Anomalously high heat flow values up to 479 mW/m^2 were again observed at the largest community, where a high heat flow value of 1680 mW/m^2 had been discovered on the previous KT88-1 cruise (Gamo *et al.*, 1988). Sakai *et al.* (1987) reported an extremely high and localized anomaly in methane content in the bottom water just above the community, suggesting seepage of interstitial water through fissures beneath the community. Therefore, this localized anomaly in heat flow distribution can be attributed to the interstitial fluid venting beneath the community, which carries the heat more effectively than conductive heat transfer would.

Another feature is that the heat flow values suddenly decrease eastward from several hundred mW/m^2 at the topographic inflection line to less than 100 mW/m^2 in the trough. The width of the high heat flow anomaly is estimated to be around 2 km. In the flat area, heat flow is low and uniform, arouns 50 mW/m^2. Although we could obtain no heat flow data to the west of the cliff, this supports that the horizontal extent of the anomaly is restricted to a narrow zone along the inflection line. The cause for this anomaly remains unknown, but a shallow magma intrusion below the community, which can easily be expected because this area is located on the volcanic front of the Izu-Bonin Arc, could conductively heat up the sediment lying above, resulting in the high heat flow. Also, this heat source could drive the interstitial water circulation around the community as described in Kinoshita *et al.* (1991).

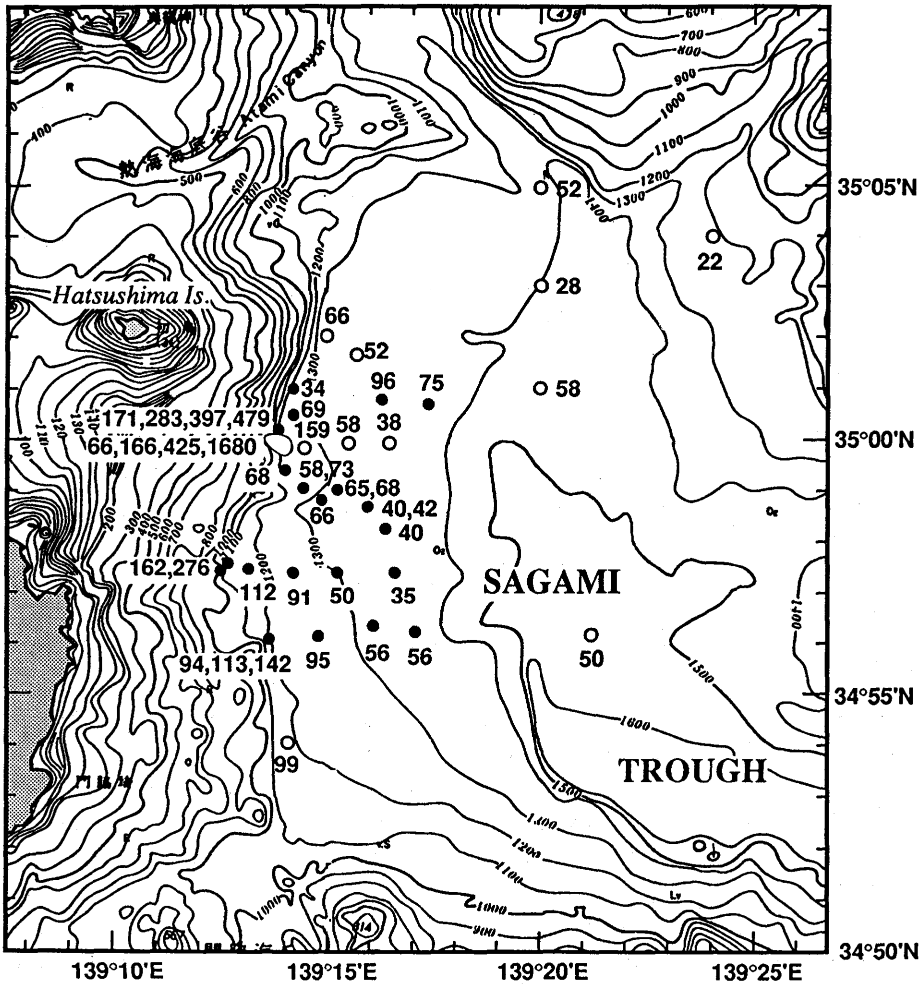

Fig. 3 Heat flow distribution in the western Sagami Bay (unit: mW/m²) obtained during DELP-89 cruise (solid circles), compared with previously obtained values (open circles).

4. Conclusions

Anomalously high heat flow values up to 479 mW/m² were observed at a biological community located off Hatsushima Island in the western Sagami Bay. It can be attributed to interstitial fluid seepage beneath the community.

Heat flow values decrease away from the topographic inflection toward the flat Sagami Trough, where they are uniform, around 50 mW/m². Shallow magma below the topographic inflection line could conductively heat up the sediment above.

Acknowledgments

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1989 年度 DELP 海溝三重会合点海域調査研究航海報告
第四部：相模湾における海底地殻熱流量の測定

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1989 年に行われた DELP 航海第 1 節において，相模湾西部での熱流量測定が行われた．初島南東沖の断層（伊豆東方線）から東方に向かっておよそ 4 本の測線上で 32 個の熱流量値が決定された．断層上ではシロウリガイ群集が発見されており，以前の航海で 1680 mW/m^2 という高熱流量値が得られていたが，この場所で再び最大 479 mW/m^2 に達する高熱流量分布が得られた．これはおそらく，シロウリガイ群集の下で断層（伊豆東方線）に沿って間隙水の上昇が起こっているためではないかと考えられる．また熱流量値はこの断層から東に離れるに従って低くなり，トラフ底では 50 mW/m^2 程度の一様な値をとる．高熱流量の範囲は断層から 2 km 程度であり，断層付近にある浅部の熱源によって伝導的に熱せられている可能性がある．