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Heat Flow Determinations in the Cordillera: 1988–1992

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ABSTRACT

Heat flow measurements have been made using boreholes drilled for mineral exploration throughout the Canadian Cordillera. Values determined at 21 sites during the years 1988-1992 are presented, with measurement parameters and details. Data presented here include those from regions where insufficient data are available for a regional analysis.

The error indicated for the measurements, from the standard deviation of Bullard plots, is between 0.1 and 3.0 mW/m^2 for accepted values. However the quality assigned, better for sites with subdued topography and sites with more boreholes, and less for sites influenced or suspected to be influenced by water flows, is between 5 and 25%, with the possible error judged to be greater than 15% at only 2 sites.

INTRODUCTION

Heat flux data in the Canadian Cordillera are obtained mainly from exploration boreholes drilled by the mining industry. The distribution of suitable sites for heat flux measurements is limited to areas of exploration activity. The results of these measurements are stored in a data base and are retrieved when enough values are accumulated to be able to define and interpret the heat flow and tectonic implications of a specific area.

This report includes data from 21 sites where 111 holes were logged during the period from 1988 to 1992. Table 1 summarizes the hole locations, thermal conductivity measurements, heat flux measurements and associated heat generation results. The distribution of sites and accepted heat flux values for each site are shown in Fig. 1. A brief description of the results from each site is presented as well as a graphical presentation of all the measured temperatures and thermal conductivity values against depth for each hole. The temperature-depth graphs are plotted on a relative temperature axis so the appropriate temperature scale is indicated on each graph.

The temperatures were measured with a standard bead-type thermistor encased in a brass probe connected to a four-conductor cable and lowered down the hole using a backpack winch. Thermistor resistance was measured with a Wheatstone bridge, taking into account cable resistance. Temperatures were calculated to an absolute accuracy of .01°C but the accuracy of any temperature relative to another is .002K. The probe depths were recorded by a pulley attached to the top of the casing and readings were taken usually every 3 m.

In general, deep holes with uniform temperature gradients are assumed to have conductive heat flux. The presence of temperature reversals, where the temperature gradient is negative at the top of many holes, can be evidence for changes in surface temperature caused by climatic effects or by changes in terrain such as deforestation (Lewis and Wang, 1992). Some temperature disturbances, such as non-uniform gradients or changes in gradient down the hole unrelated to conductivity variation, can be indicators of water flow which may preclude the use of those data to determine equilibrium heat flux (eg. Drury et al., 1984). In order to be more certain that the measured heat flux is an equilibrium value representing the site, it is preferred to determine heat flux in as many deep holes as possible at one site. Sites with only one hole, with several shallow holes or holes with evidence of water flows influencing some of the temperatures, produce results with higher uncertainty (Table 1).

In mountainous terrain heat is refracted toward valleys, so a correction must be applied to most holes to account for this effect. A two-dimensional finite element program by Finkh (1981) developed from the method of Lee and Henyey (1974) is used to correct the heat flux in areas of steep, mountainous terrain where a straight valley is flanked by parallel mountain ridges in a two-dimensional configuration. In areas where the topography is more moderate or is not two-dimensional, a correction developed by Jeffreys (1940) is applied to account for the effects of refraction. The largest corrections are needed for measurements at the top of mountains or in valley bottoms but most of the holes logged are somewhere in between these two topographic extremes. Several of the holes are collared in bedrock underground where the topographic effects are smaller.

Most of the data outlined in this open file are unpublished results. The results and interpretations from holes at Cranbrook, Port Alberni, Mount Washington and Texada Island are presented in Lewis et al. (1992) and those from Porcher Island are given in Lewis et al. (1991), but all are included in Table 1 as part of the compilation of data acquired during these 5 field seasons.

SITE DESCRIPTIONS

SITE 159 Seneca

This property is a volcanogenic massive sulphide prospect hosted by Jurassic felsic to intermediate volcanic rocks of the Harrison Lake Formation (McKinley et al., 1994), located about 90 km east of Vancouver. Of the nine holes logged, five were used to determine the heat flux for the area. Water flow within the volcanics was present in almost all holes as shown by the non-uniform nature of the temperature measurements with depth (Fig. 2). However these five holes had consistent heat flux results without large perturbations in the temperature gradient for the lower part of the hole from which heat flux was calculated.

Topography in this area just west of Harrison Lake is quite steep rising above a river valley so a two-dimensional correction was applied to the measured value. Corrected results range from 82.0 to 90.6 mWm^{-2} with an average of 85 mWm^{-2}, much higher than previously measured values of 50 mWm^{-2} (Lewis et al., 1985) from a single hole on the same property, and 65 mWm^{-2} from a hole previously drilled 24 km away for testing of low temperature geothermal potential (Bentkowski and Lewis, 1988).

Site 353 Island Copper

Island Copper Mine, at the north end of Vancouver Island, is a porphyry Cu-Mo deposit related to Early Jurassic quartz feldspar dikes and hydrothermal breccias of the Island Plutonic Suite intruded into the Lower Jurassic Bonanza volcanic pyroclastic sequence (Panteleyev and Koyanagi, 1994). The hole was drilled less than two km northwest of the open pit. The measured heat flux is 68 mWm^{-2} calculated from a relatively uniform temperature gradient which appears to be unaffected by water movement (Fig.3). No topographic correction was applied due to the low relief in the area. A comparable heat flux value of 65 mWm^{-2} was previously measured in a single hole (Lewis et al., 1985).

Site 369 Fish Lake

The holes at Fish Lake, about 120 km west of Williams Lake, penetrate a Cretaceous to Eocene calc-alkaline quartz diorite stock and dike complex intruding volcanic rocks of Upper Cretaceous Kingsvale Group (Preto, 1992). Two holes, about 100 m apart, indicate a conductive heat flow regime with no evidence of significant water flow disturbing the temperatures (Fig. 4).

Topographic relief in the area is not very large, being on the western edge of the Interior Plateau so a Jeffreys correction was applied to account for the small effects of refraction. The corrected average heat flux for the two holes is 103 mWm^{-2}.

Site 375 Silbak-Premier Mine

Situated about 20 km north of Stewart, this is a transitional epithermal polymetallic vein deposit hosted by Late Triassic to Early Jurassic Hazelton Group volcanics associated with the intrusion of the Early Jurassic Texas Creek granodiorite (Alldrick et al., 1987). Three of the four holes at this site are underground holes and the fourth is about two km northwest of the mine site on a mountain slope. The shallowest underground hole shows a variable temperature gradient, and the measured heat flux from the bottom part of the hole is quite low compared to the other values. The other two underground holes have relatively uniform gradients in the lower part of the holes from which the heat flux is calculated. The surface hole is very deep in comparison and measured temperatures show a reasonably constant gradient with only minor temperature perturbations due to small water flows (Fig.5).

Site 393 Snip Mine

The mesothermal Au vein deposit is 5 km north and down-slope of the Johnny Mountain mine, and occurs in Upper Triassic sedimentary rock of the Stuhini Group cut by mineralized shear-hosted veins (Britton et al., 1990a). Fifteen holes were measured from underground at various levels over an elevation difference of 192 m. Eleven holes were near horizontal (<15°) and the remainder dipped from 36 to 51°. All bottom hole temperatures were plotted with respect to depth below the surface, which varied from 32 to 249 m depending on the spatial distribution of the holes. A linear regression on the non-uniform variation of temperature with depth shows an estimated gradient of 29.6 mKm^{-1}. One hole (393-16) showed a linear gradient for the bottom 19 m of 27.3 mKm^{-1}, comparable to the overall gradient. However, for the calculation of heat flux for this site, the value for this single hole is used (Fig. 13).

Although the holes were measured from underground, 900 m of topographic relief is steep enough to have a small effect on the temperatures. The corrected heat flux is 73.8 mWm^{-2}, about 2% higher than measured. However, the possible errors due to water flows and surficial effects at this site and two more sites (394 and 397) are so large that the values are not accepted and are not included in Table 1.

Site 394 Expo

This property, at the northern end of Vancouver Island, is a Cu-Mo-Au porphyry deposit hosted in Jurassic stocks and dikes intruding a Lower Jurassic volcanic assemblage of the Bonanza Group (Panteleyev and Koyanagi, 1994). The holes were drilled at the top of a hill and show evidence of temperature disturbances due to water flow. If the bottom part of both holes is assumed to be conductive, the results agree within 5% (Fig. 14).

Topographic relief ranges over 475 m, although the surrounding area is much more subdued. A two-dimensional correction was applied, and the corrected value for the two holes is 55 mWm^{-2}. However, previously measured heat flux from northern Vancouver Island averages 68 mWm^{-2} (Lewis et al., 1994), and the present value is rejected due to the effects of water flow.

Site 396 Butler Lake

This Cu-Au porphyry property, 200 km west of Williams Lake, is within Lower Cretaceous intermediate volcanics intruded by diorite (Roddick et al., 1985). The temperature gradient of the deeper hole is relatively uniform, although temperature disturbances in the upper part of the hole indicate some water movement. The other hole has a similar gradient but the temperatures are not linear (Fig. 15).

These holes are located at the easternmost edge of the Coast Mountains, so the topography is quite steep. A two-dimensional profile across the creek valley where the holes were drilled corrects the average heat flux to 68 mWm^{-2}.

Site 397 Wann

This property, about 10 km southeast of the Expo property, is an epithermal Au deposit hosted by Lower Jurassic Bonanza volcanics related to the intrusion of the Jurassic Island Plutonic Suite (Panteleyev and Koyanagi, 1994). Except for the reversal due to surface effects at the top of the hole, the temperature gradient is very uniform and seemingly unaffected by water flow (Fig. 16).

The hole is in an area of moderate relief to the south down to sea level, but the hill to the north slopes more steeply up to 600 m. A Jeffreys correction was used to lower the heat flux to 56 mWm^{-2}, but this value is rejected due to the effects of suspected water flows.

Site 398 Tulsequah Chief

The holes were drilled within Carboniferous submarine volcanic, volcaniclastic and sedimentary rocks which have been intruded by contemporaneous plugs, dikes and sills (Sherlock et al., 1994) about 240 km southeast of Whitehorse. Both holes are located in an old mine and were drilled from underground at the same elevation. The deep hole has a uniform temperature gradient for most of its depth. Although the shallower hole also has a relatively uniform gradient, the measured gradient is 79% higher than that of the deep hole and is probably affected by water flow beneath it (Fig. 17).

Topography in this area south of Atlin is very steep, ranging over 1400 m of relief. The refractive effects of a wide river valley only slightly affect the measured temperatures. The heat flux, corrected by the two-dimensional method, is 74 mWm^{-2}.

Site 399 Kemess

This property is a Au-Cu porphyry deposit about 425 km northwest of Prince George, hosted by Late Triassic to Lower Jurassic high-level calc-alkaline intrusions and associated Takla Group volcanic and sedimentary rocks (Lefebure and Malott, 1991). The temperatures were measured in seven holes in two areas; six shallow holes in the lower, less steep area and a deep hole in a cirque to the north with about 400 m difference in collar elevations. All the shallow holes show some disturbance by water flow, and the heat flux results range from 59.5 to 87.9 mWm^{-2}. The deep hole has a very uniform temperature gradient (Fig. 18).

Generally the topography in the area is quite steep, ranging over 800 m, but the shallow holes are near the bottom of a wide river valley. A two-dimensional correction was calculated parallel to the wide valley to account for effects of steep slopes to the north and south. The refractive effects at the deep hole at the top of a steep-sided mountain are much more difficult to calculate because the topography is not two-dimensional for the finite element program, and it is too steep to be accurately corrected by the Jeffreys method. The corrected heat flux for the area was the average of the shallow holes, 75 mWm^{-2}.

Site 400 Clear Lake

This is a shale-hosted Pb-Zn deposit, 100 km northeast of Carmacks, within carbonaceous argillite of Devono-Mississippian Earn Group bounded by the Tintina Fault on the east (INAC, 1993). Of the eight holes measured, seven had uniform temperature gradients seemingly undisturbed by water flow. One of the deeper holes showed evidence of a disturbance at about 225 m below which the heat flux increased by almost 50% (Fig. 19). This value was not used in the average for the area.

The topography is relatively flat so no corrections were needed. However the area was deforested by a burn 25 years before the holes were logged. The effects of this deforestation cause the ground surface temperatures to increase and eventually, over time, affect the temperatures at depth (Lewis and Wang, 1992; Bentkowski and Lewis, 1992). A correction was applied to account for these temperature changes. The average heat flux increases from 109 to 118 mWm^{-2} with the burn correction.

DISCUSSION

Lewis et al. (1994) have defined an average heat flux value for northern Vancouver Island of 68 mWm^{-2} based on both shallow (100m) and deeper measurements, comparing the tectonic evolution of this part of the island to the extensional history of the Queen Charlotte Basin. The result from the hole at Island Copper (site 353) agrees with this average. However the two other sites from northern Vancouver Island (sites 394 and 397) are approximately 19% lower than this average, 55 and 56 mWm^{-2} respectively.

Heat flux of 85 mWm^{-2} measured at Seneca (site 159) is consistent with the heat flux observed about 100 km to the north where the heat flux increases from west to east, from 25 to 80 mWm^{-2} over a distance of 20 km (Lewis et al., 1988). This variation in heat flux reflects the thermal changes associated with the subduction of the Juan de Fuca Plate beneath the western margin of North America.

The results from sites north of 55° can be compared to heat flux measurements by Jessop et al. (1984) from northern B.C. and southern Yukon within the Intermontane Belt which range from 58-103 mWm^{-2} (corrected for topographic effects). The corrected values presented in this report similarly range from 59 mWm^{-2} from Takla-Rainbow (site 383) to 111 mWm^{-2} at the Silbak-Premier Mine (site 375), but over a larger area which includes sites on the eastern edge of the Intermontane Belt. The five sites in the Stewart-Iskut River area (sites 375, 390, 391, 392, and 393) range from 72 to 111 mWm^{-2} but the three low values have much higher uncertainties.

The one measurement in the Yukon at Clear Lake (site 400) of 118 mWm^{-2} is probably influenced by its proximity to the Tintina Fault and possible water movement associated with the fault. Additional data from the Yukon measured in 1993 from Faro, also near the Tintina Fault, may confirm this result.

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TABLE 1

SITE	LOCATION			COLLAR ELEV. (m)	MEASURED INTERVAL (m)	THERMAL CONDUCTIVITY			HEAT FLUX (mW/m²)			HEAT GENERATION			ACCEPTED HEAT FLUX (mW/m²)	UNCER-TAINTY %
		lat.(N)	long.(W)			n	(W/mK)	S.D.	obs.	corr.	S.D.	n	(μW/m³)	S.D.		
159-5	Seneca	49°20.1’	121°57.9’	257	100-198	16	3.54	0.43	95.5	89.3	1.1	3[b]	0.28	0.02	85	10
-7		49°20.2’	121°58.0’	288	50-157	13	3.71	0.17	90.6	82.0	1.4					
-8		49°18.5’	121°56.3’	139	110-151	15	3.18	0.33	105.1		3.4					
-10		49°20.0’	121°58.2’	198	110-148	14	3.27	0.44	143.4		17.1					
-11		49°20.0’	121°58.4’	169	105-256	27	3.65	0.40	86.7	76.1	1.1					
-12		49°20.1’	121°58.6’	169	242-377	36	4.02	0.31	132.4		1.9					
-13		49°20.2’	121°58.6’	169	100-288	28	3.72	0.42	99.7	87.5	1.1					
-14		49°20.1’	121°58.5’	168	50-115	10	3.65	0.43	38.8		3.1					
-15		49°20.0’	121°58.4’	173	94-293	30	3.75	0.47	103.3	90.6	0.7					
353-10	Island Copper	50°37.1’	127°30.3’	104	200-390	42	2.76	0.57	67.9		0.9	10[b]	0.84	0.17	68	5
369-1	Fish Lake	51°27.9’	123°37.4’	1463	320-814	81	4.02	0.79	101.2	100.0	0.3	3	0.48	0.03	103	5
-2		51°27.9’	123°37.3’	1493	80-438	42	4.08	0.79	107.7	106.4	0.7	4	0.87	0.13		
375-6	Silbak-Premier	56°03.2’	130°01.0’	240[a]	50-84	8	3.40	0.59	69.7		2.4	6[b]	1.59	0.17	111	10
-8		56°03.2’	130°01.0’	240[a]	20-102	10	3.59	0.66	125.8	119.8	2.0					
-9		56°03.2’	130°01.0’	240[a]	25-116	14	3.64	1.20	110.8	105.5	3.0					
-10		56°04.5’	130°02.8’	472	130-540	56	3.82	0.62	106.7	108.9	0.3					
379-1	Zeballos	50°01.0’	126°47.3’	483	10-260	21	3.13	0.09	53.0	49.0	0.1	3	0.75	0.09	46	10
-3		50°00.8’	126°48.1’	328	80-107	9	2.79	0.16	42.1	30.2	2.0	1	0.68			
-4		50°00.8’	126°48.0’	346	110-144	14	2.86	0.13	43.6	33.0	0.3	1	0.86			
-5		50°00.8’	126°48.1’	336	50-127	13	2.89	0.13	39.2	27.9	0.5					
-6		50°01.0’	126°47.7’	379[a]	10-58	9	2.86	0.14	39.3	43.7	0.5					
[c]380	Cranbrook	49°26.9’	115°56.3’	1204	600-1058	48	3.53	0.95	95.6	91.6	0.9				92	10
[c]381		49°25.8’	115°56.7’	1135	55-230	14	4.02	0.51	104.8	98.7	1.7				99	10
[d]382-1	Porcher Island	54°01.4’	130°35.3’	110	273-360	26	3.14	0.22	72.2	71.7	1.7	11	0.89	0.19	67	15
-2		54°01.4’	130°35.3’	109	70-115	6	3.52	0.23	132.8		4.5	2	0.96	0.08		
-3		54°01.4’	130°35.3’	117	50-140	8	3.43	0.14	112.4		1.7	3	0.90	0.02		
-4		54°01.4’	130°35.2’	114	100-150	9	3.50	0.12	78.1		3.6	3	0.98	0.11		
-5		54°01.8’	130°35.3’	46	130-206	17	2.81	0.42	62.4	61.9	0.5	5	0.50	0.10		

TABLE 1 (cont'd)

SITE	LOCATION			COLLAR ELEV. (m)	MEASURED INTERVAL (m)	THERMAL CONDUCTIVITY			HEAT FLUX			HEAT GENERATION			ACCEPTED HEAT FLUX (mW/m^2)	UNCER-TAINTY %
		lat.(N)	long.(W)			n	(W/mK)	S.D.	obs.	corr. (mW/m^2)	S.D.	n	($\mu W/m^3$)	S.D.		
383-3	Takla-Rainbow	55°39.5'	125°17.2'	1610	50-132	10	2.65	0.22	54.9		1.3				59	15
-4		55°39.6'	125°17.7'	1620	100-154	11	2.95	0.30	62.1	58.0	1.0					
-5		55°39.7'	125°17.9'	1622	89-118	4	2.50	0.19	63.4	59.2	0.2					
[c]384-1	Port Alberni	49°09.1'	124°39.7'	981	480-555	10	3.21	0.40	47.9	48.7	1.2	5	0.29	0.01	40	10
-2		49°09.8'	124°40.0'	355	100-433	36	3.43	0.37	54.4	42.4	0.2					
-4		49°09.9'	124°40.3'	349	100-350	35	3.10	0.38	48.3	37.6	0.4					
[c]385	Mt. Washington	49°46.8'	125°18.2'	1097	381-540	25	3.12	0.81	39.4	41.5	0.8				42	15
[c]386-1	Texada Island	49°45.4'	124°32.6'	47	200-249	28	3.16	0.79	41.5		1.1				33	15
-2		49°45.2'	124°32.5'	87	110-168	16	3.21	0.42	20.7		0.7					
-4		49°42.8'	124°32.2'	210	99-210	11	3.72	0.18	26.8	27.0	1.0					
-5		49°42.8'	124°32.1'	190	50-96	4	3.65	0.17	22.5		0.8					
-7		49°42.6'	124°32.0'	205	50-86	5	3.36	0.58	8.0		0.3					
-9		49°42.8'	124°32.0'	188	105-152	15	3.49	0.49	34.9		1.7					
-10		49°42.8'	124°31.7'	175	50-166	14	3.58	0.39	18.1	18.1	0.3					
-11		49°45.2'	124°32.8'	67	200-287	26	3.51	0.27	36.2		0.3					
-13		49°45.1'	124°32.4'	85	100-202	18	3.66	0.52	33.2		0.8					
-14		49°45.4'	124°32.7'	58	310-385	33	3.03	0.19	32.8		0.6					
-15		49°45.4'	124°32.8'	66	225-386	30	3.31	0.41	34.7	34.1	0.4					
-16		49°45.3'	124°32.8'	70	255-419	38	3.18	0.31	32.6		0.1					
387-1	Mt. Milligan	55°07.6'	124°01.8'	1145	70-175	23	2.40	0.29	69.6		0.8				70	10
-2		55°07.6'	124°01.6'	1129	100-259	34	2.14	0.32	59.1		0.6					
-3		55°07.7'	124°01.0'	1070	100-173	16	2.47	0.30	77.9		1.3					
-4		55°07.6'	124°01.3'	1100	100-182	18	2.15	0.32	62.8		0.7					
-5		55°07.4'	124°01.0'	1066	100-206	28	2.35	0.27	81.6		0.6					
-6		55°07.4'	124°00.8'	1090	135-205	20	2.33	0.39	67.1		0.5					
-7		55°07.4'	124°01.0'	1076	50-65	8	2.31	0.24	98.8		4.4					
-8		55°07.3'	124°01.7'	1130	50-167	22	2.50	0.25	73.6		0.7					

TABLE 1 (cont'd)

SITE	LOCATION			COLLAR ELEV. (m)	MEASURED INTERVAL (m)	THERMAL CONDUCTIVITY			HEAT FLUX			HEAT GENERATION			ACCEPTED HEAT FLUX (mW/m²)	UNCER-TAINTY %
		lat.(N)	long.(W)			n	(W/mK)	S.D.	obs.	corr. (mW/m²)	S.D.	n	(µW/m³)	S.D.		
389-1	Anyox	55°26.7'	129°49.7'	240	350-487	42	3.39	1.51	83.0	82.6	0.7	24[e]	2.21	1.26	83	15
-2		55°26.8'	129°49.8'	215	70-92	8	4.94	1.56	85.0		5.6					
-3		55°26.8'	129°49.6'	235	250-302	29	3.89	1.92	93.8		4.1					
-4		55°26.4'	129°49.7'	131	340-420	41	2.93	1.19	103.2		1.8					
390-3	Eskay Ck.	56°38.9'	130°26.4'	950	190-240	23	2.97	0.64	80.4		3.5				90	15
-6		56°39.3'	130°26.3'	771	112-176	16	2.91	0.63	65.2		1.5					
-8		56°39.2'	130°25.7'	779	190-390	33	2.61	0.48	91.3	83.0	0.4					
-9		56°39.2'	130°26.4'	841	138-196	14	2.90	0.69	121.6		2.4					
-15		56°39.6'	130°26.0'	856	70-179	16	3.34	0.51	103.0		0.5					
-16		56°39.6'	130°26.0'	864	50-197	12	3.55	0.61	94.4		1.7					
-17		56°39.6'	130°26.0'	874	50-150	13	4.48	1.20	115.2		2.5					
-19		56°39.4'	130°26.1'	818	50-120	9	3.56	1.07	130.7		3.2					
-20		56°39.4'	130°26.1'	812	50-121	10	2.99	0.76	101.2		0.6					
-21		56°39.4'	130°26.1'	812	150-468	41	3.33	0.87	106.5	96.8	0.5					
391-4	Sulphurets	56°28.0'	130°11.1'	1410	100-160	14	3.54	1.20	70.6	58.5	1.4	1	1.45		62	10
-5		56°28.2'	130°10.8'	1394	60-104	10	3.49	0.59	84.1	62.5	1.8					
-6		56°28.3'	130°10.8'	1394	70-146	12	3.41	0.61	80.4	66.0	0.8					
392-2	Johnny Mountain	56°37.6'	131°03.7'	1055[a]	20-76	6	2.93	0.13	91.1	98.0	1.4				98	25
-3		56°37.6'	131°03.7'	1050[a]	70-97	7	2.75	0.54	115.5		1.9					
396-2	Butler Lake	51°44.2'	124°37.8'	1753	85-179	22	3.45	0.78	67.0	57.8	1.9	5	0.21	0.01	68	25
-3		51°44.0'	124°38.0'	1798	45-140	17	3.89	0.59	91.1	77.9	1.3					
398-1	Tulsequah Chief	58°44.2'	133°35.8'	122[a]	50-181	20	4.28	1.00	141.8	114.6	2.4				74	15
-2		58°44.5'	133°35.4'	122[a]	110-643	61	3.05	0.87	79.2	73.7	0.5					
399-1	Kemess	57°00.2	126°45.9'	1305	50-170	16	2.12	0.43	59.5	58.3	1.1	2	1.22	0.05	75	15
-2		57°00.2'	126°45.8'	1312	60-149	10	1.88	0.19	86.5	84.6	2.9					
-3		57°00.3'	126°45.7'	1324	40-121	10	2.05	0.35	84.9	83.2	1.1					
-4		57°00.4'	126°45.6'	1342	50-93	9	2.17	0.23	72.8	71.3	2.8					
-6		57°00.2'	126°45.3'	1328	40-93	9	2.11	0.21	70.6	69.1	1.2					
-7		57°00.2'	126°45.3'	1318	90-123	12	2.05	0.19	87.9	86.0	1.9					
-11		57°03.5'	126°45.7'	1753	210-430	39	3.56	0.84	73.8		1.1					

TABLE 1 (cont'd)

SITE	LOCATION		COLLAR ELEV.	MEASURED INTERVAL	THERMAL CONDUCTIVITY			HEAT FLUX			HEAT GENERATION			ACCEPTED HEAT FLUX	UNCER-TAINTY
	lat.(N)	long.(W)	(m)	(m)	n	(W/mK)	S.D.	obs.	corr. (mW/m^2)	S.D.	n	(μW/m^3)	S.D.	(mW/m^2)	%
400-1 Clear Lake	62°47.2'	135°09.1'	710	85-112	10	4.84	0.50	115.3	126.9	1.7				118	15
-2	62°47.2'	135°09.2'	693	100-229	24	4.76	0.54	116.2	119.2	0.5					
-4	62°47.2'	135°09.2'	691	250-388	37	4.88	0.79	155.4		0.8					
-5	62°47.1'	135°09.3'	695	75-193	17	4.91	0.44	108.8	119.4	1.5					
-6	62°47.1'	135°09.1'	697	110-405	36	4.80	0.95	127.3	129.4	0.5					
-7	62°47.0'	135°09.3'	704	140-250	13	4.91	0.79	95.4	98.0	0.5					
-8	62°47.0'	135°09.4'	712	85-124	13	4.87	0.57	99.0	121.2	2.0					
-9	62°47.0'	135°09.3'	708	80-210	16	4.54	0.37	104.1	109.1	0.5					

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a underground holes

b 15 underground holes at different elevations (site 393)

c interpretation in Lewis et al., 1992

d interpretation in Lewis et al., 1991

e heat generation data from Lewis and Bentkowski, 1988

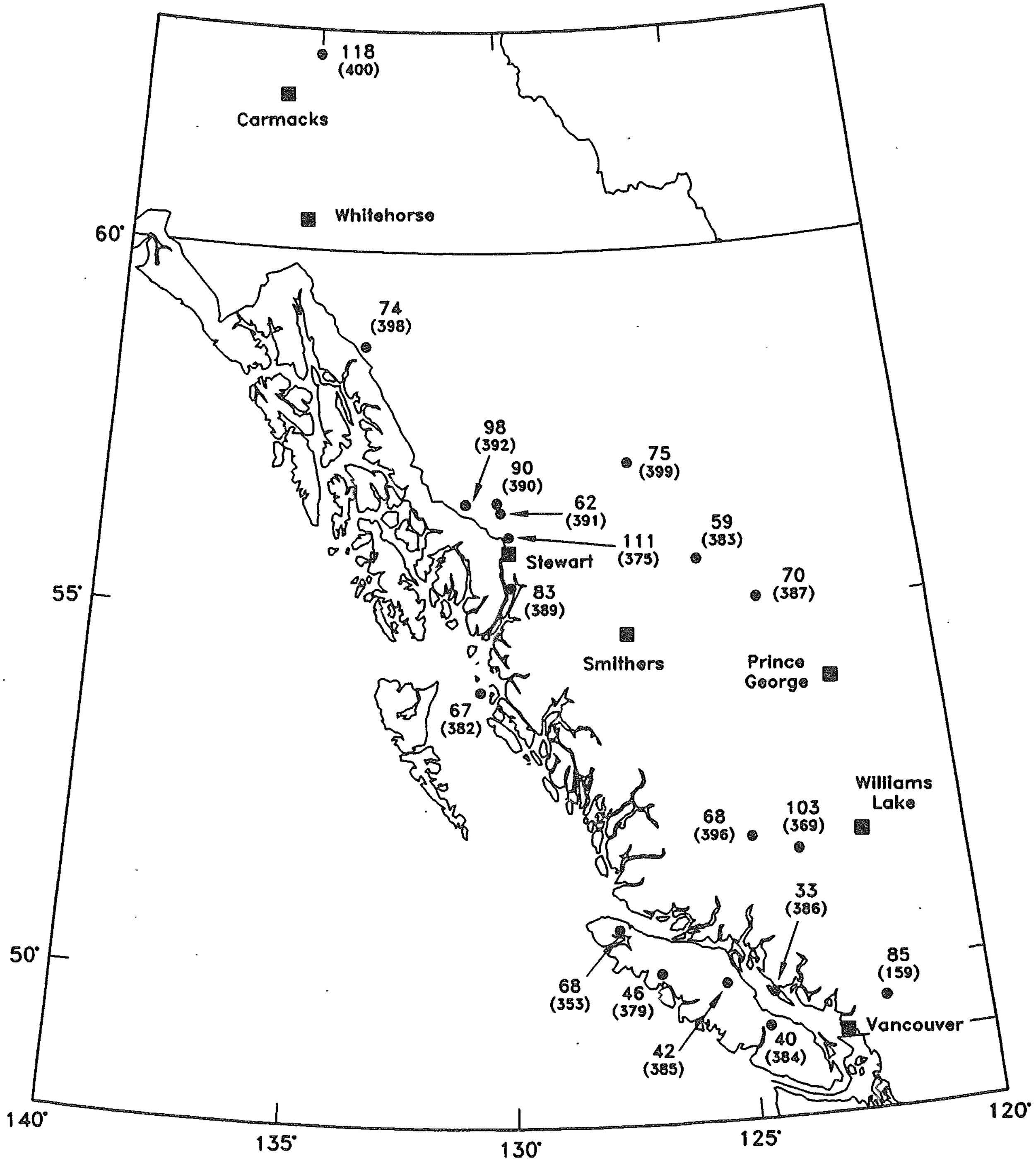

Fig. 1 Heat flows (in mW/m²) and sites (number in brackets).

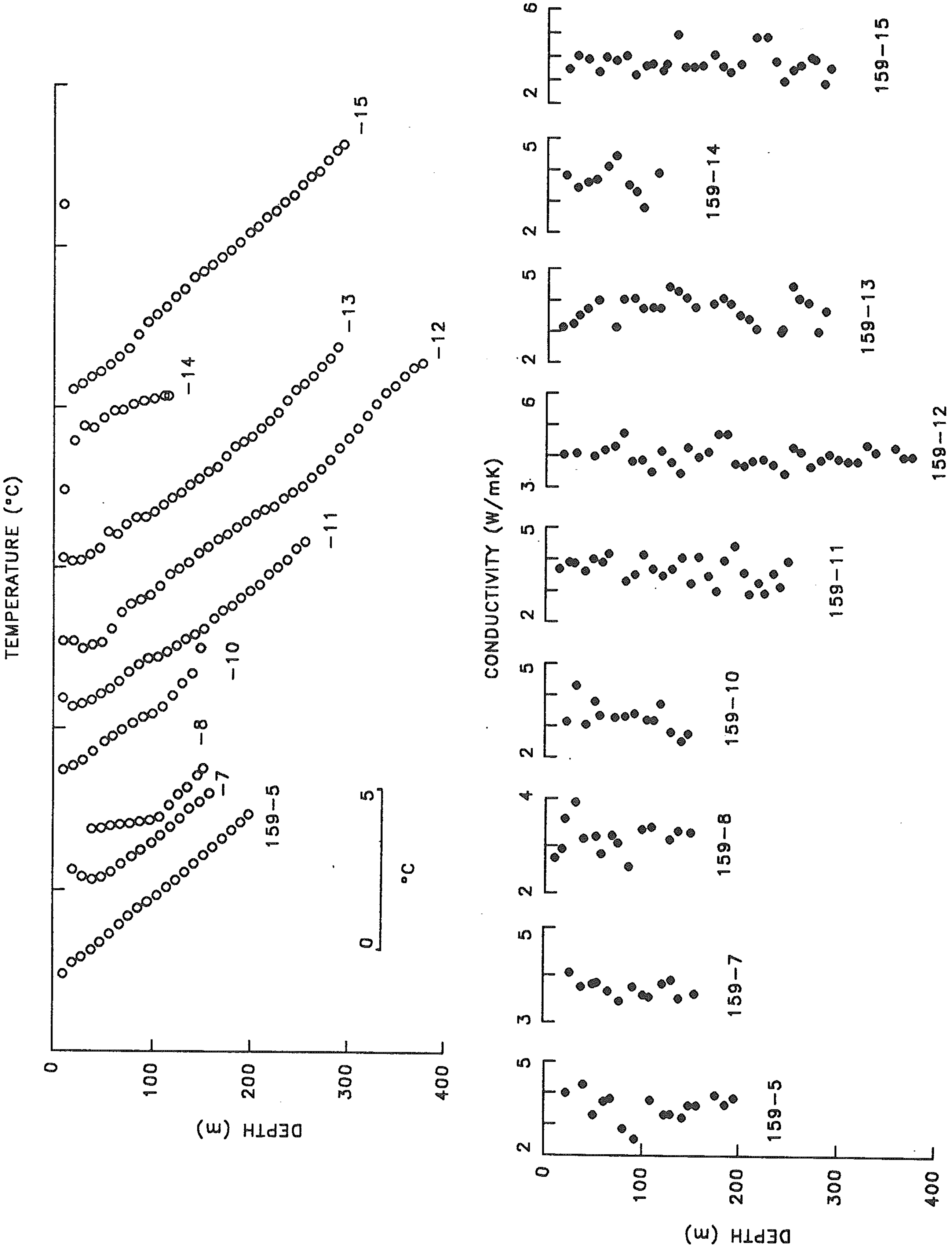

Fig. 2 Measured temperatures and thermal conductivities as a function of depth at Seneca, site 159.

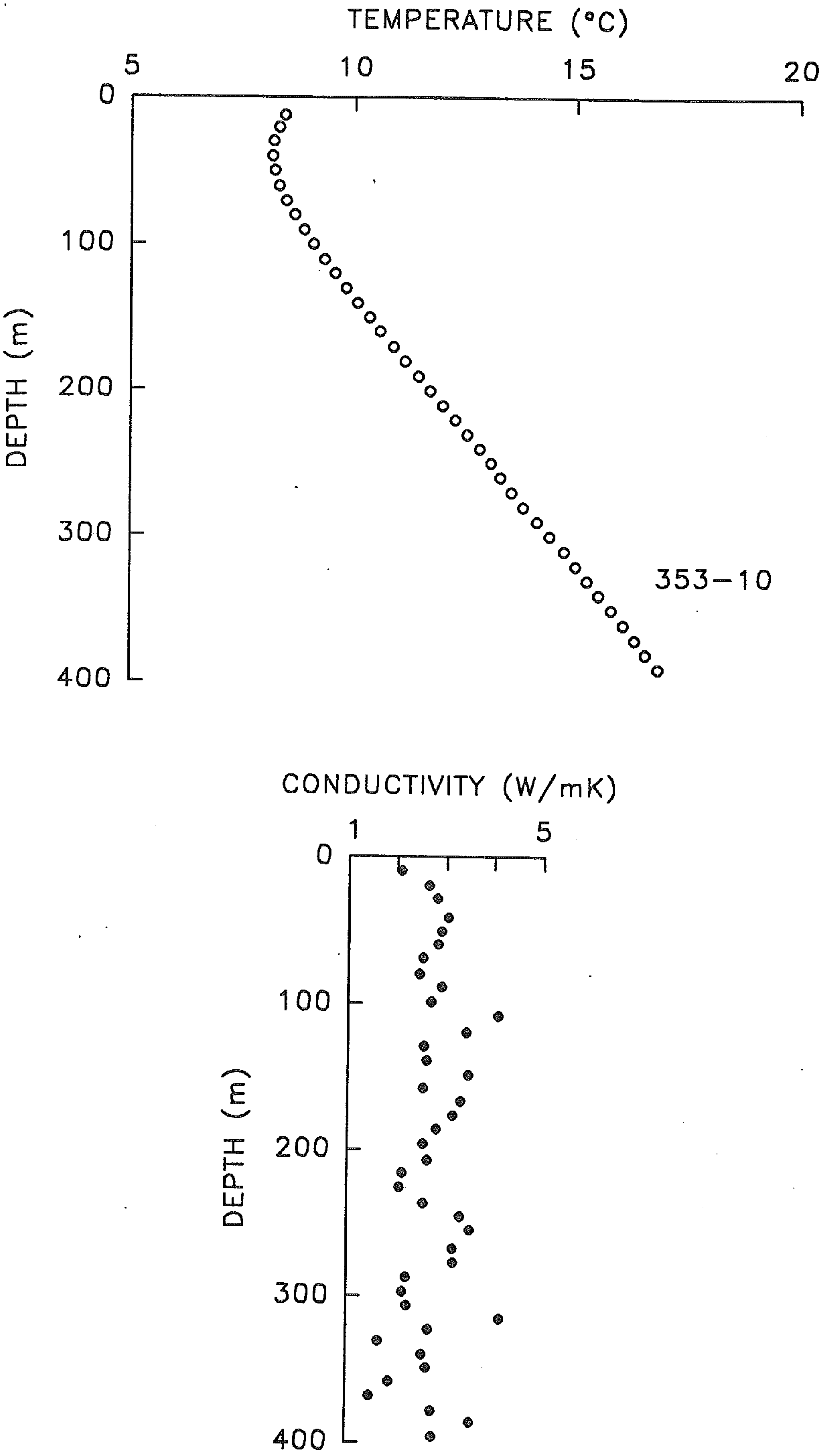

Fig. 3 Measured temperatures and thermal conductivities as a function of depth at Island Copper, site 353.

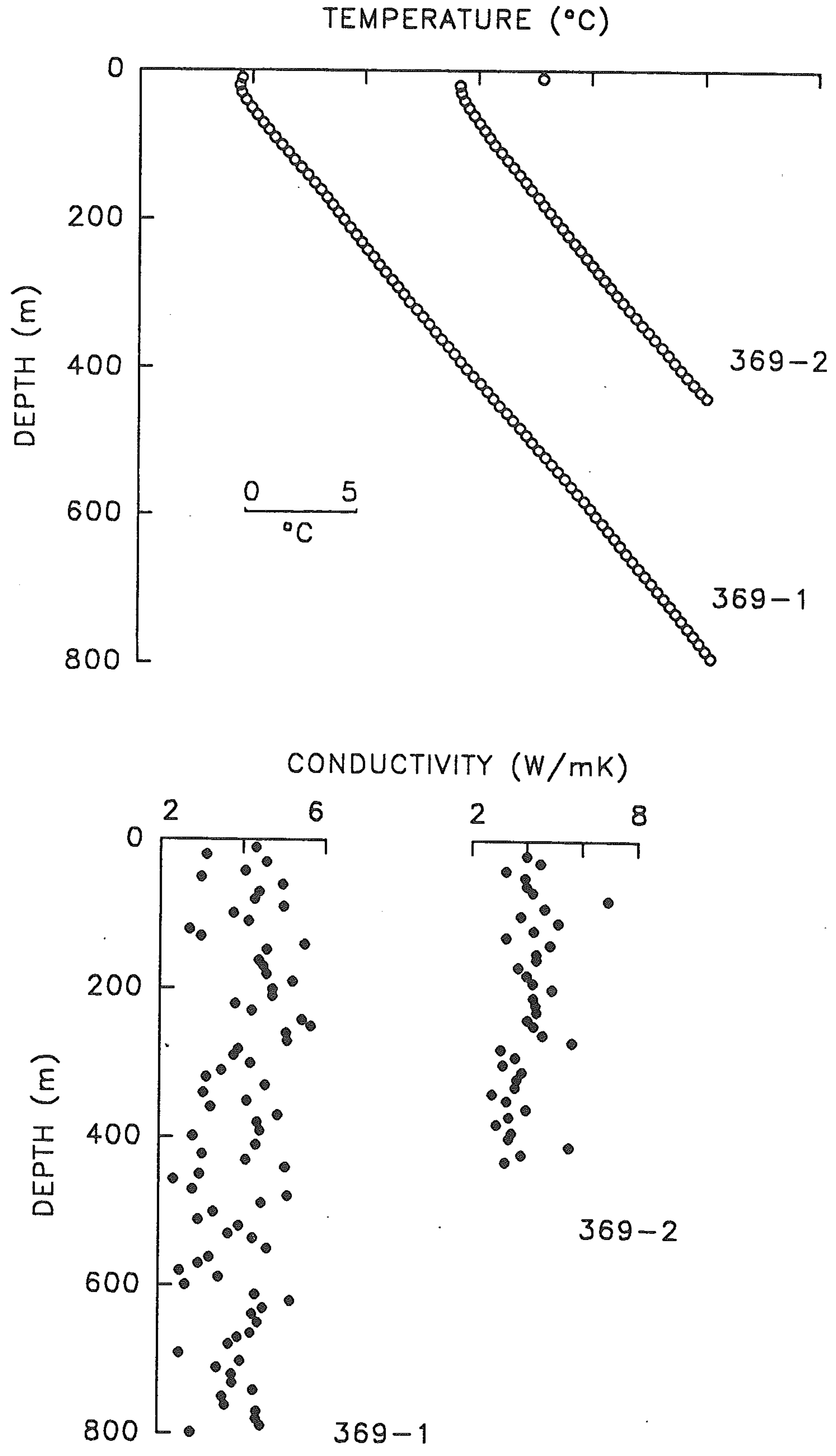

Fig. 4 Measured temperatures and thermal conductivities as a function of depth at Fish Lake, site 369.

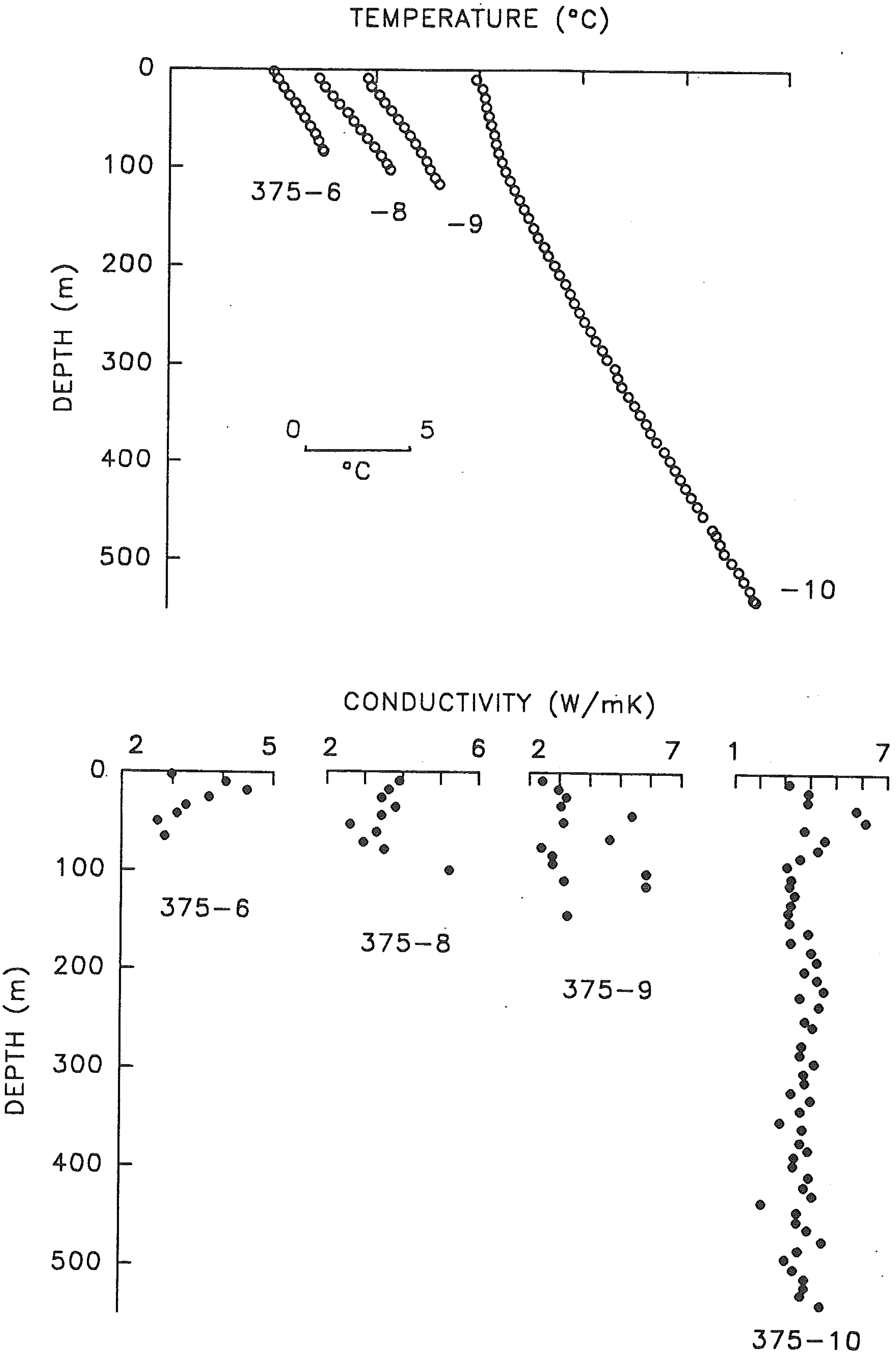

Fig. 5 Measured temperatures and thermal conductivities as a function of depth at Silbak-Premier Mine, site 375.

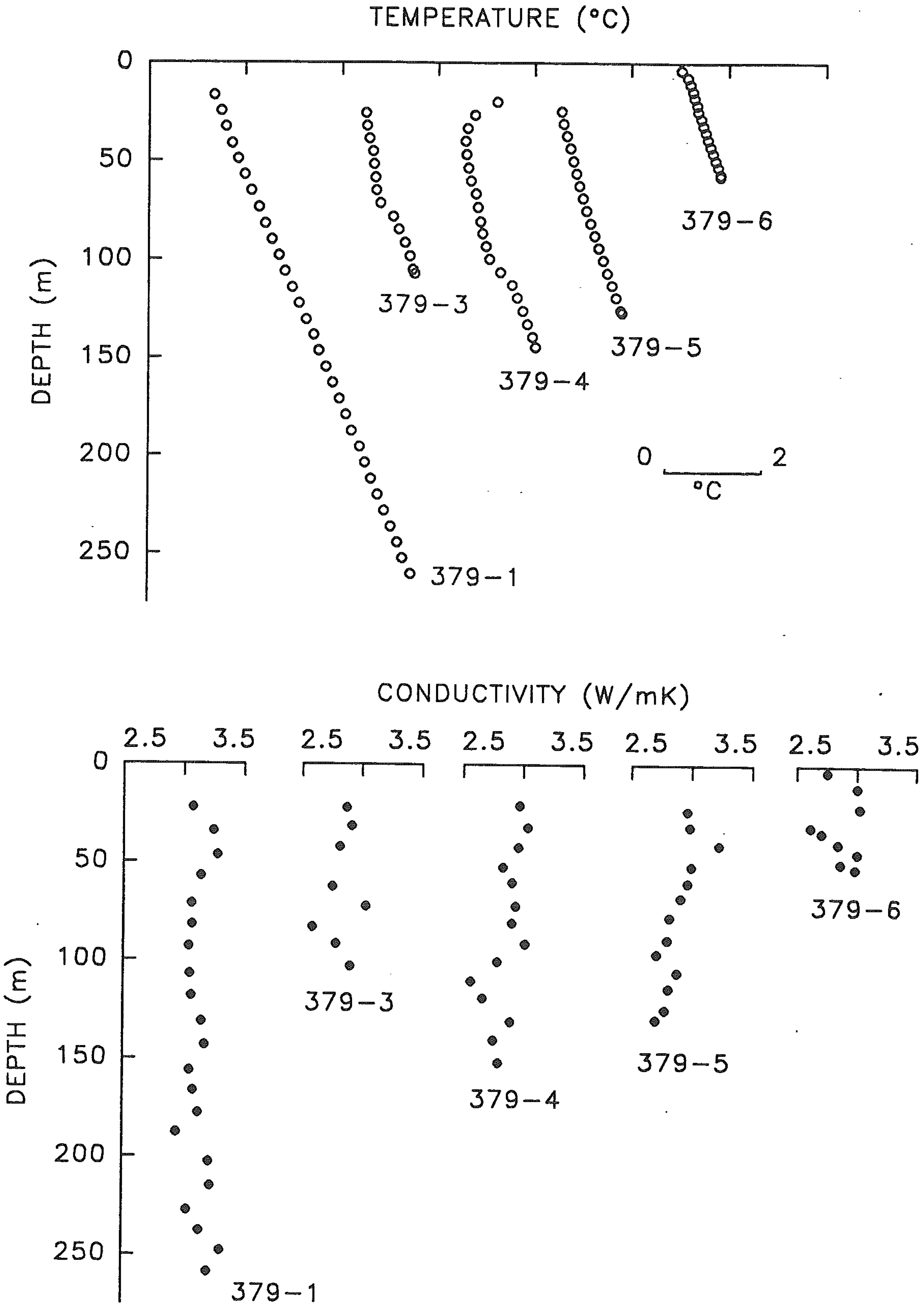

Fig. 6 Measured temperatures and thermal conductivities as a function of depth at Zeballos, site 379.

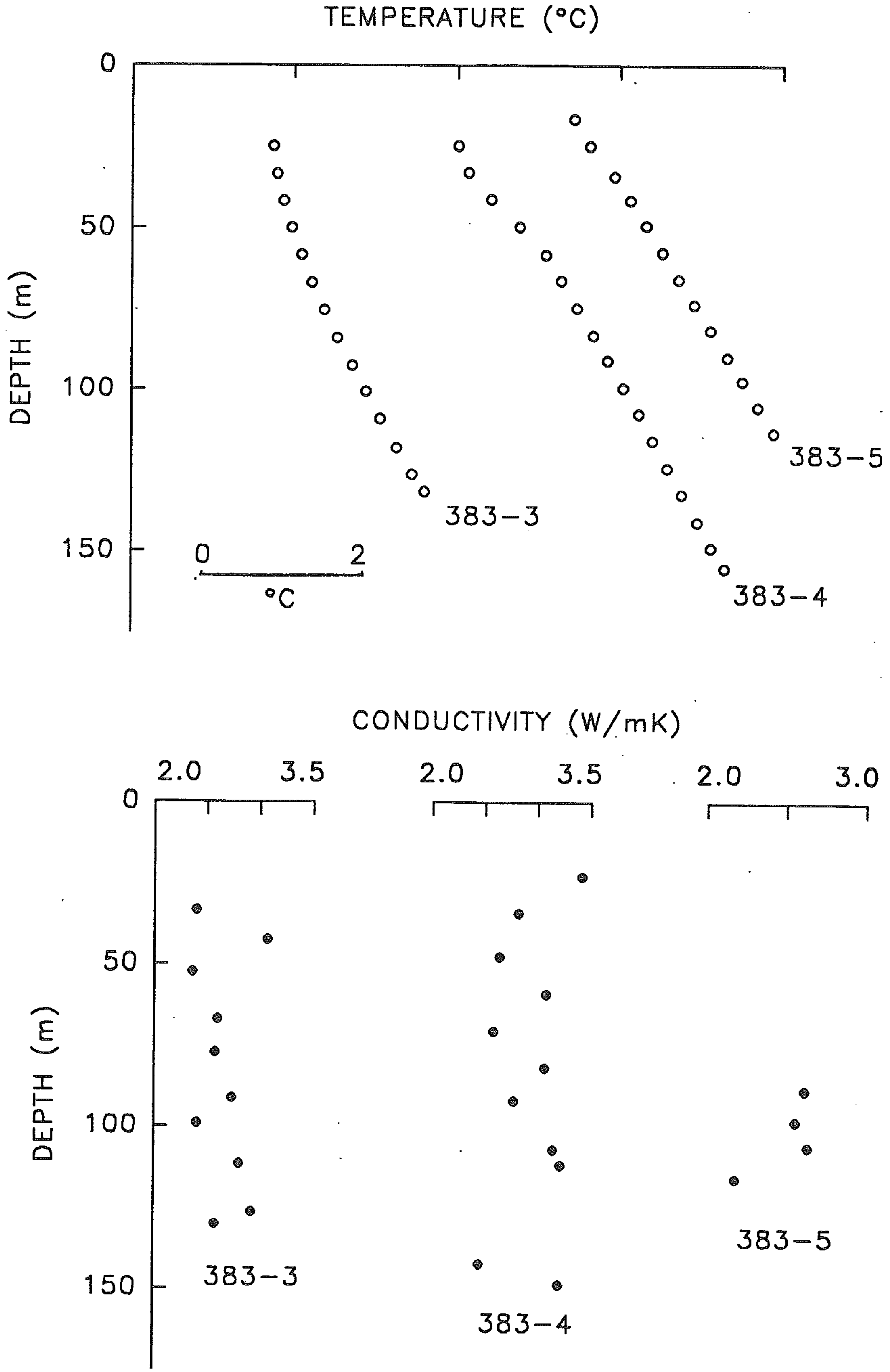

Fig. 7 **Measured temperatures and thermal conductivities as a function of depth at Takla-Rainbow, site 383.**

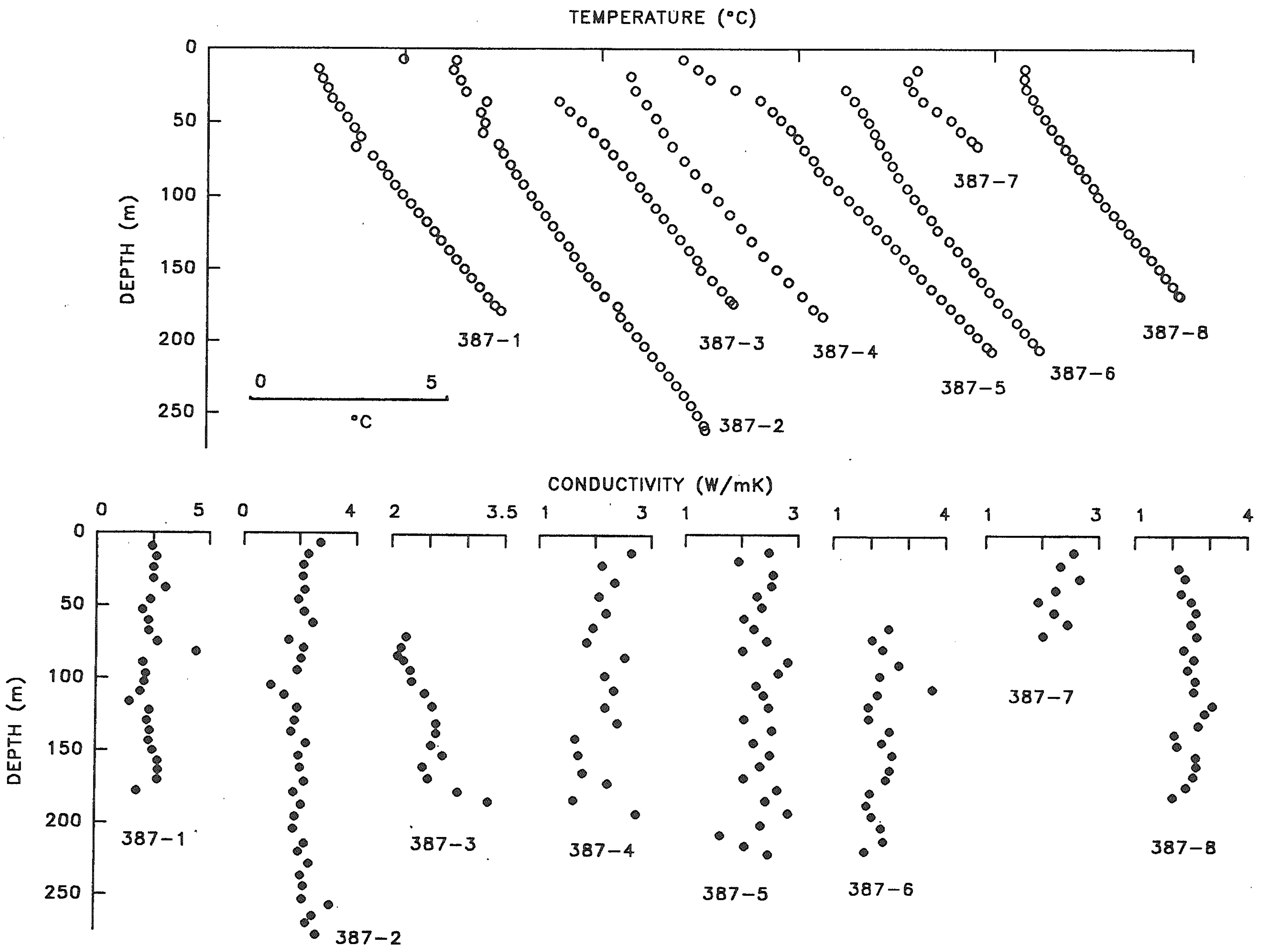

Fig. 8 Measured temperatures and thermal conductivities as a function of depth at Mt. Milligan, site 387.

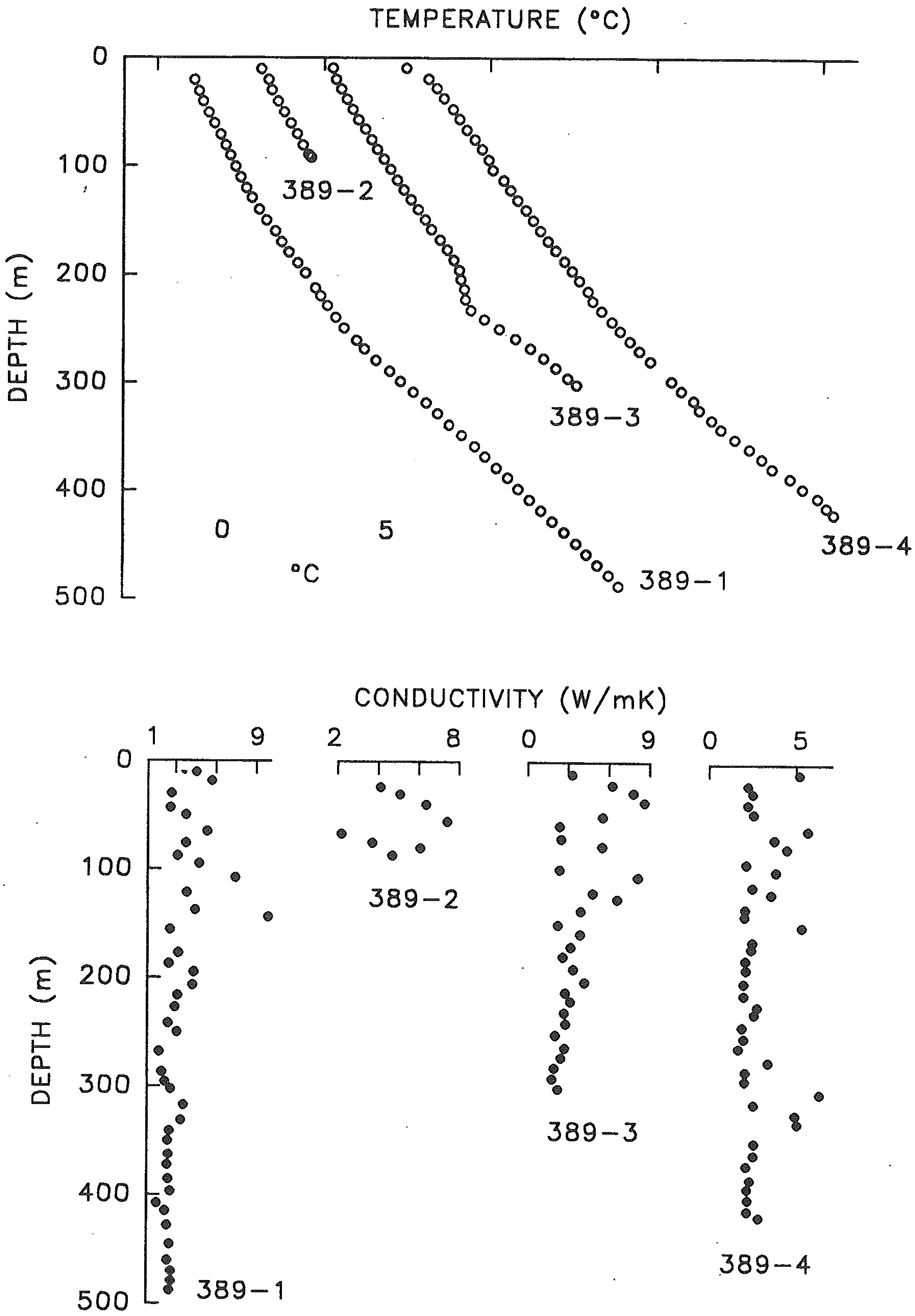

Fig. 9 Measured temperatures and thermal conductivities as a function of depth at Anyox, site 389.

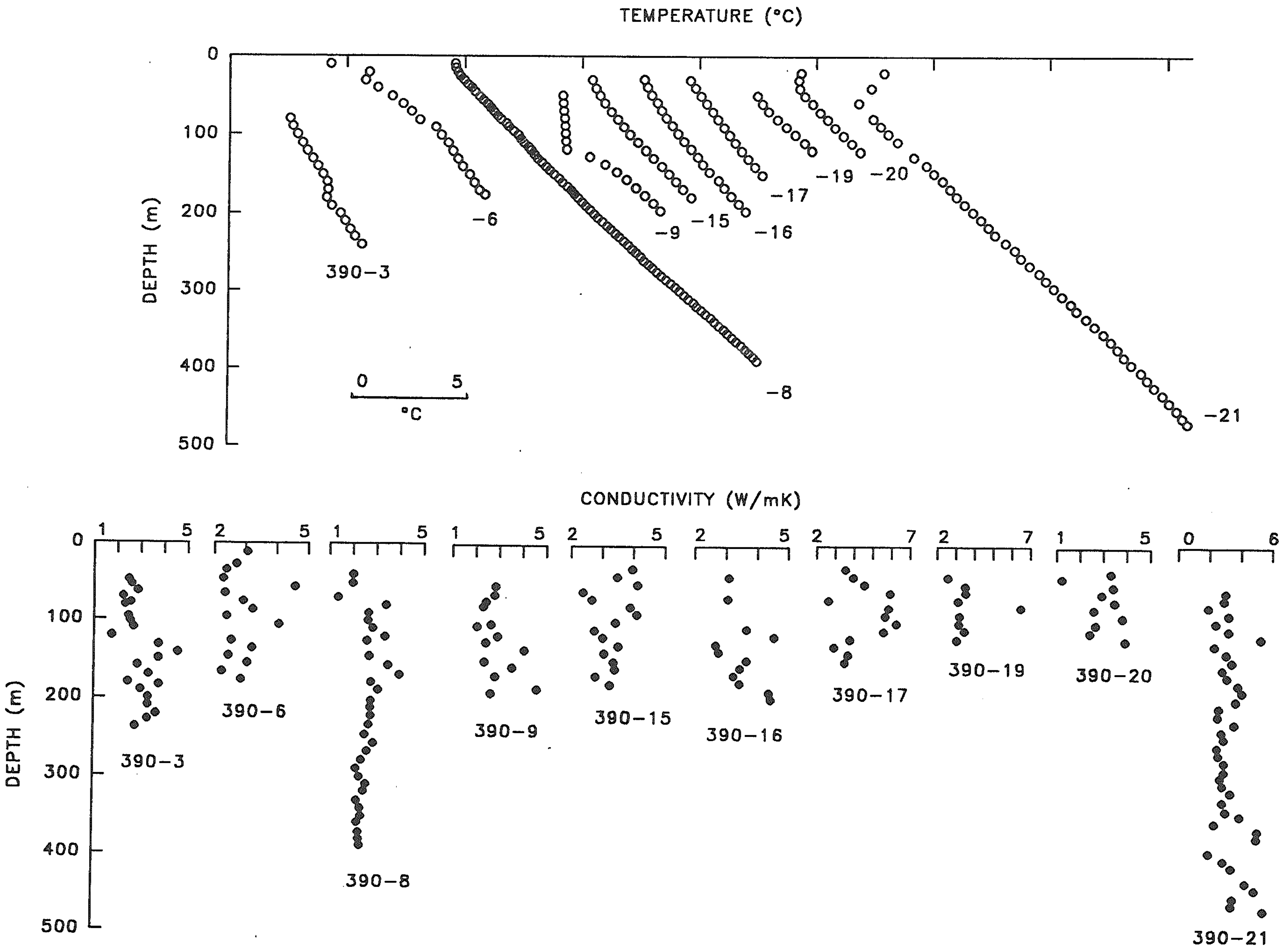

Fig. 10 Measured temperatures and thermal conductivities as a function of depth at Eskay Creek, site 390.

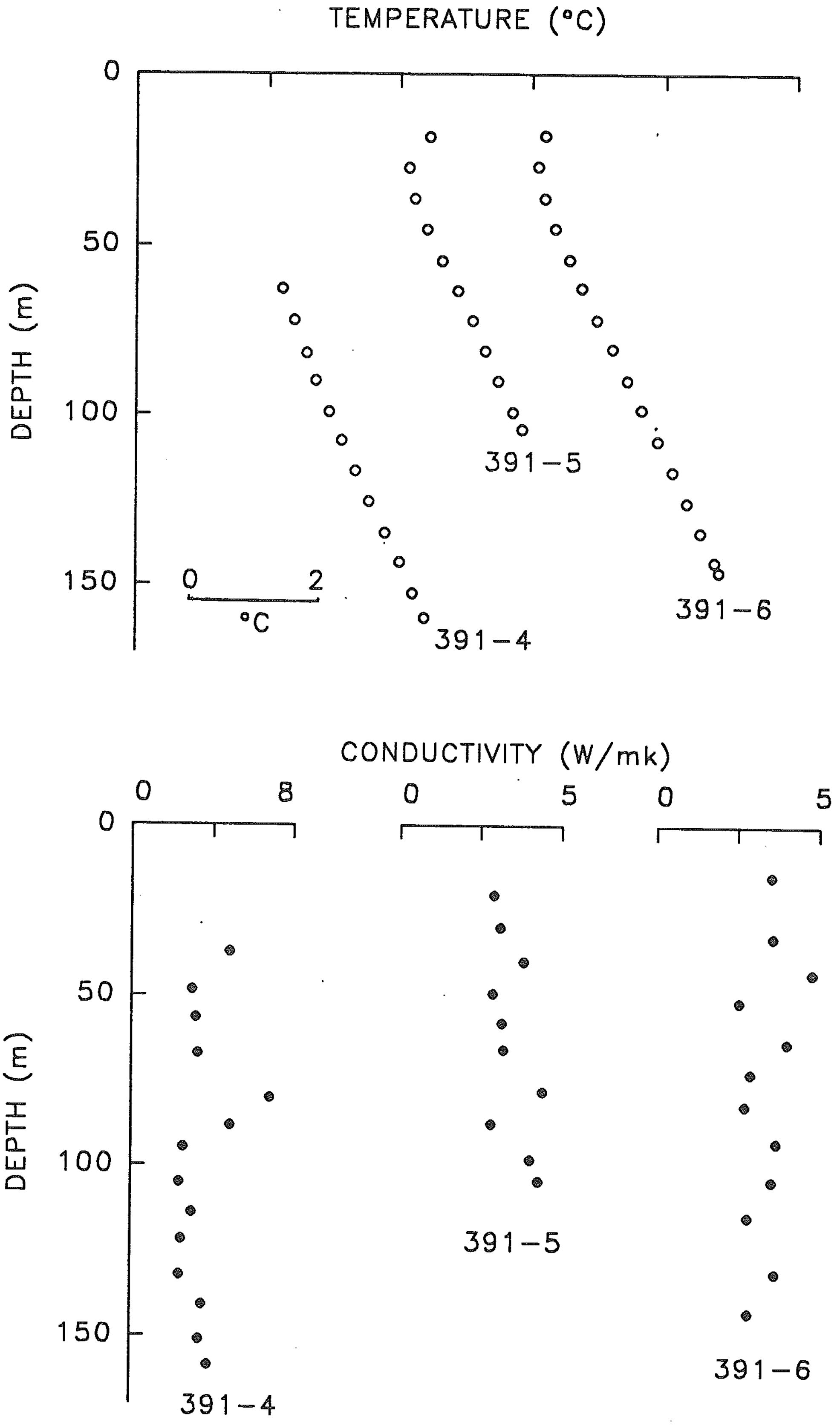

Fig. 11 Measured temperatures and thermal conductivities as a function of depth at Sulphurets, site 391.

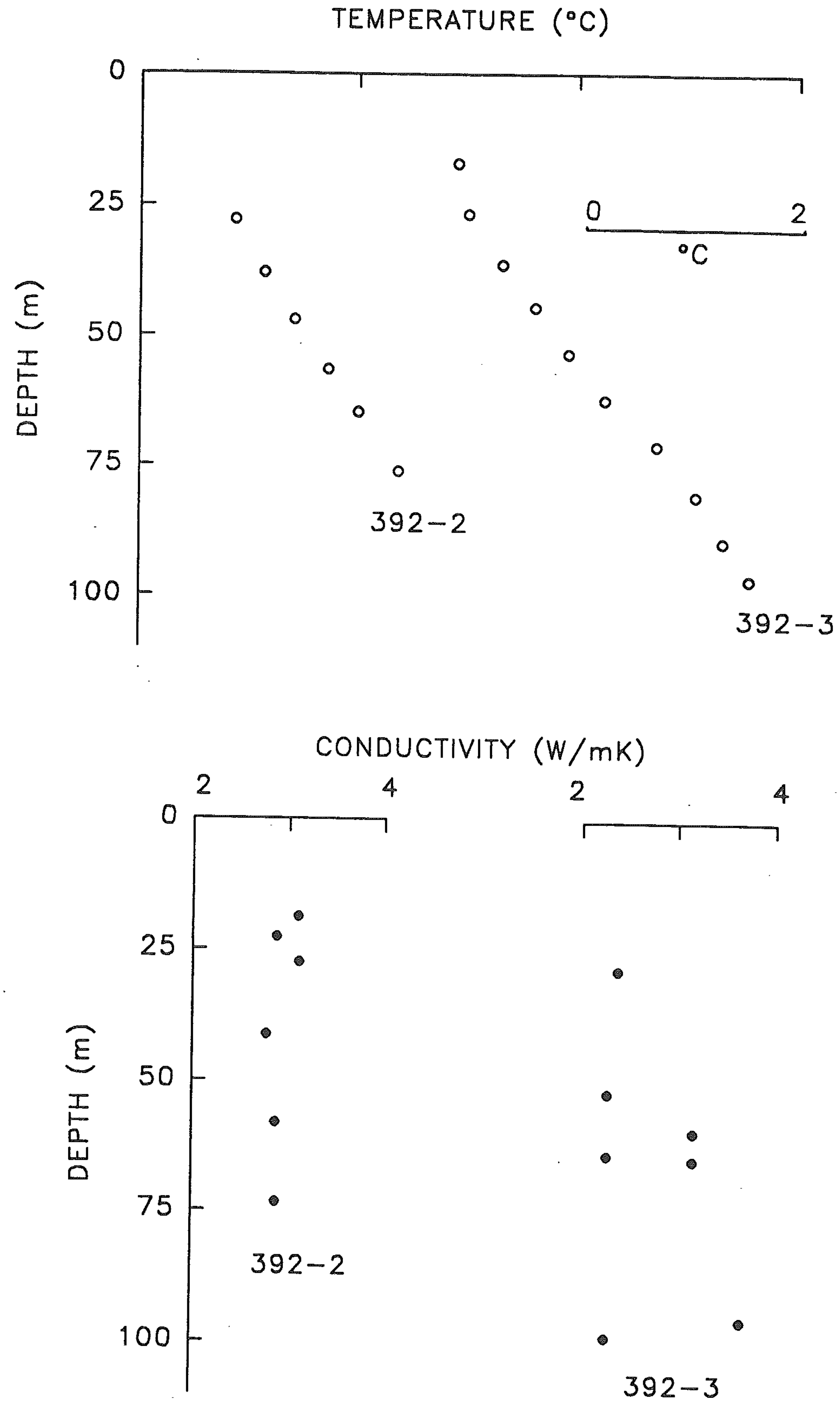

Fig. 12 Measured temperatures and thermal conductivities as a function of depth at Johnny Mountain Gold Mine, site 392.

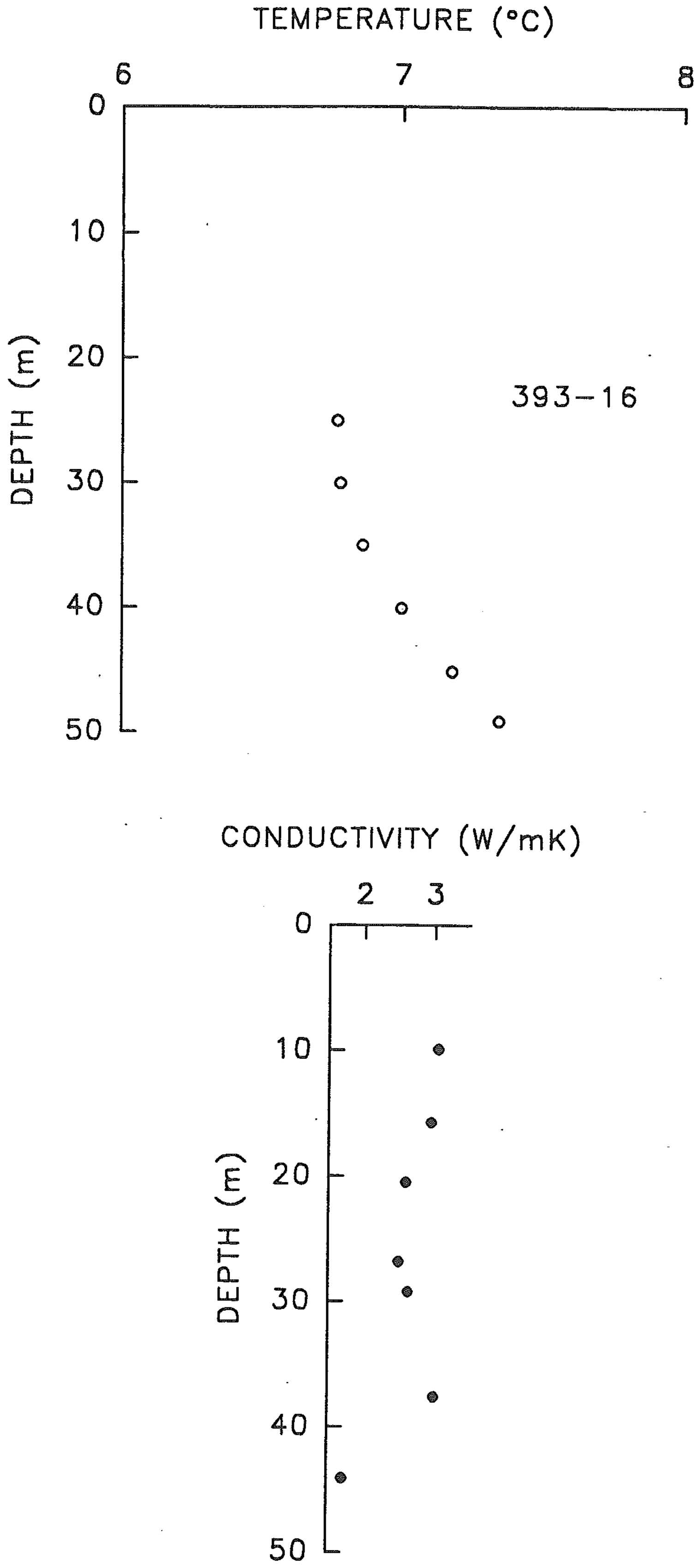

Fig. 13 Measured temperatures and thermal conductivities as a function of depth at Snip, site 393.

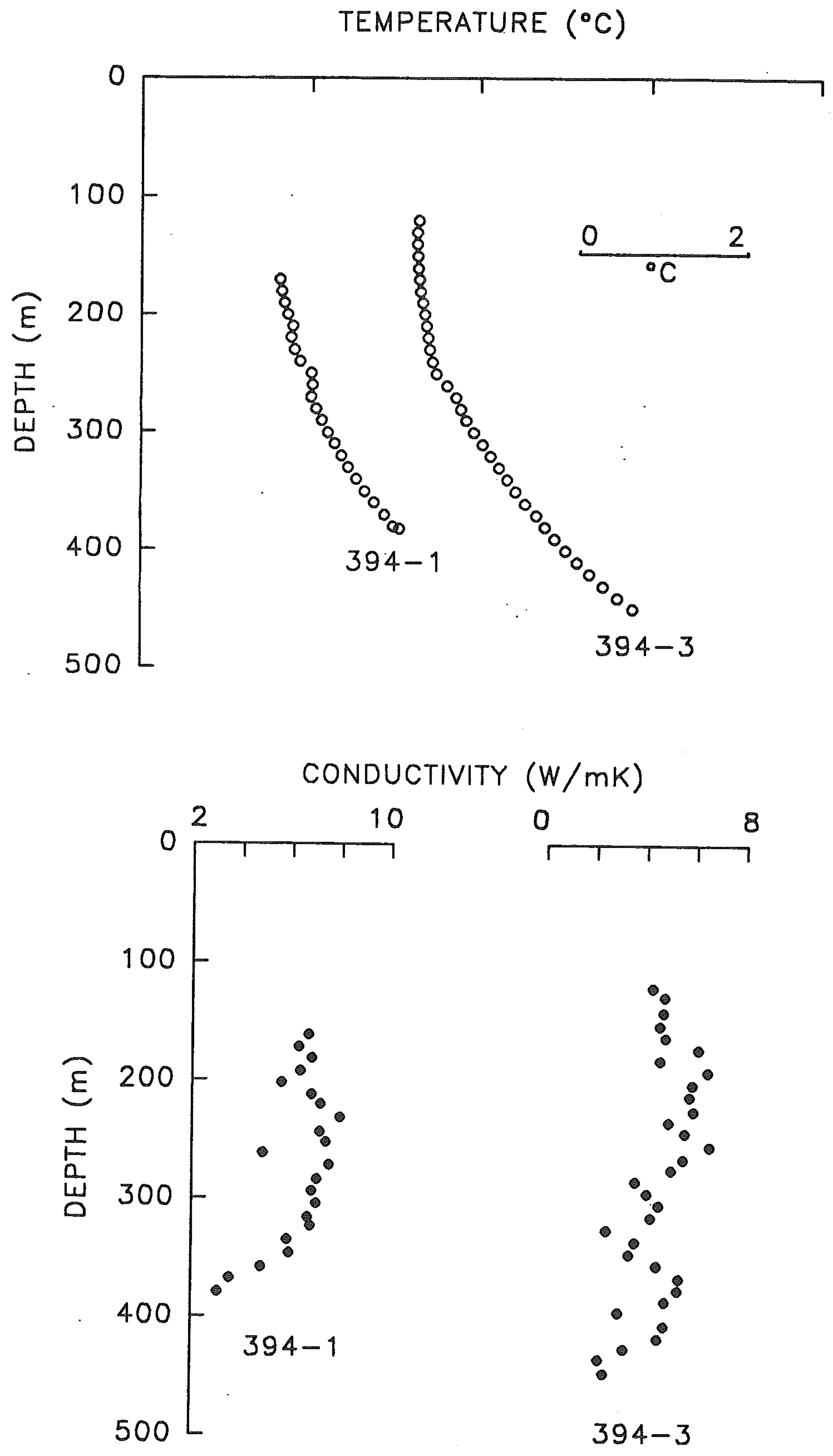

Fig. 14 Measured temperatures and thermal conductivities as a function of depth at Expo, site 394.

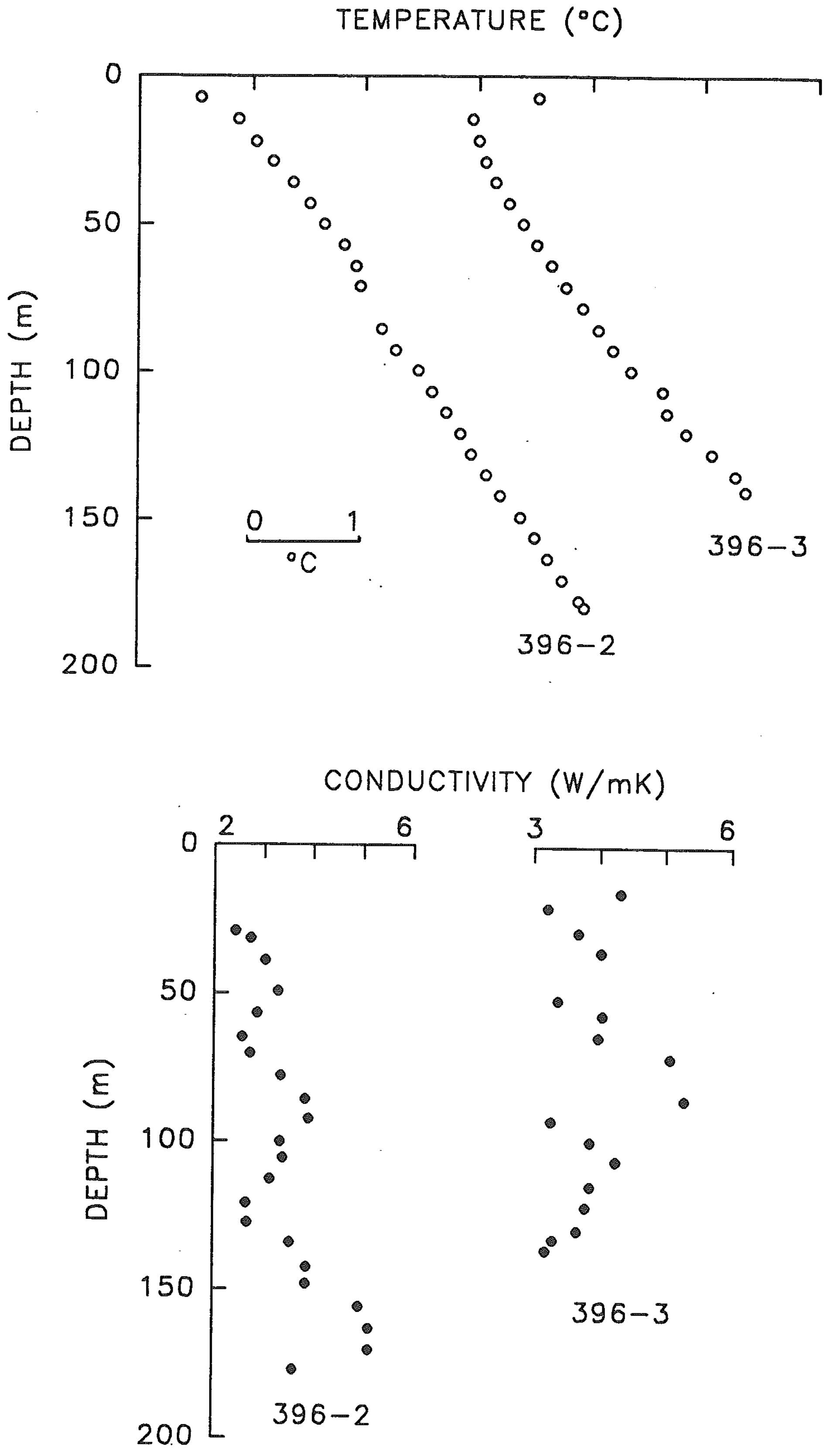

Fig. 15 Measured temperatures and thermal conductivities as a function of depth at Butler Lake, site 396.

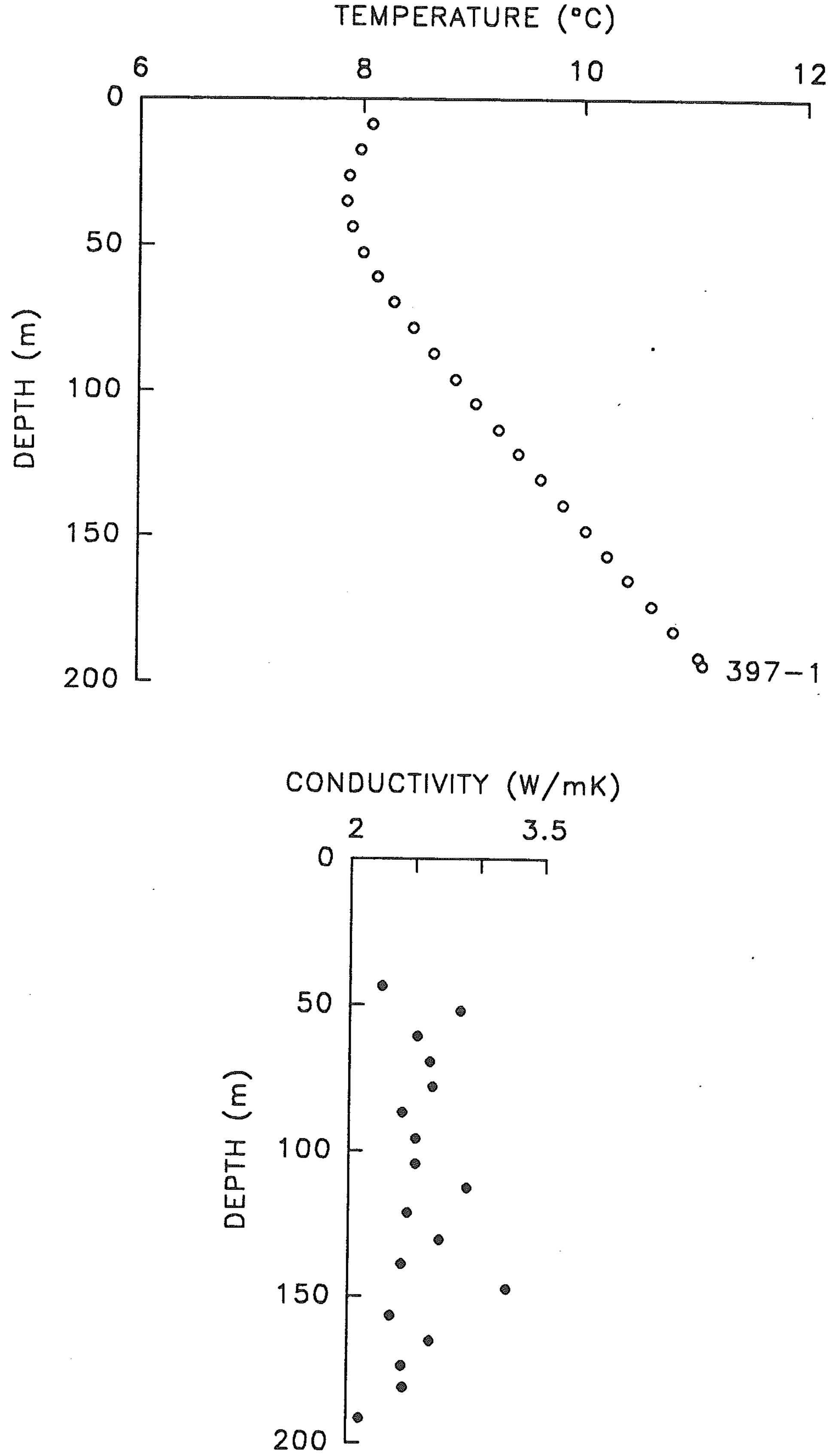

Fig. 16 Measured temperatures and thermal conductivities as a function of depth at Wann, site 397.

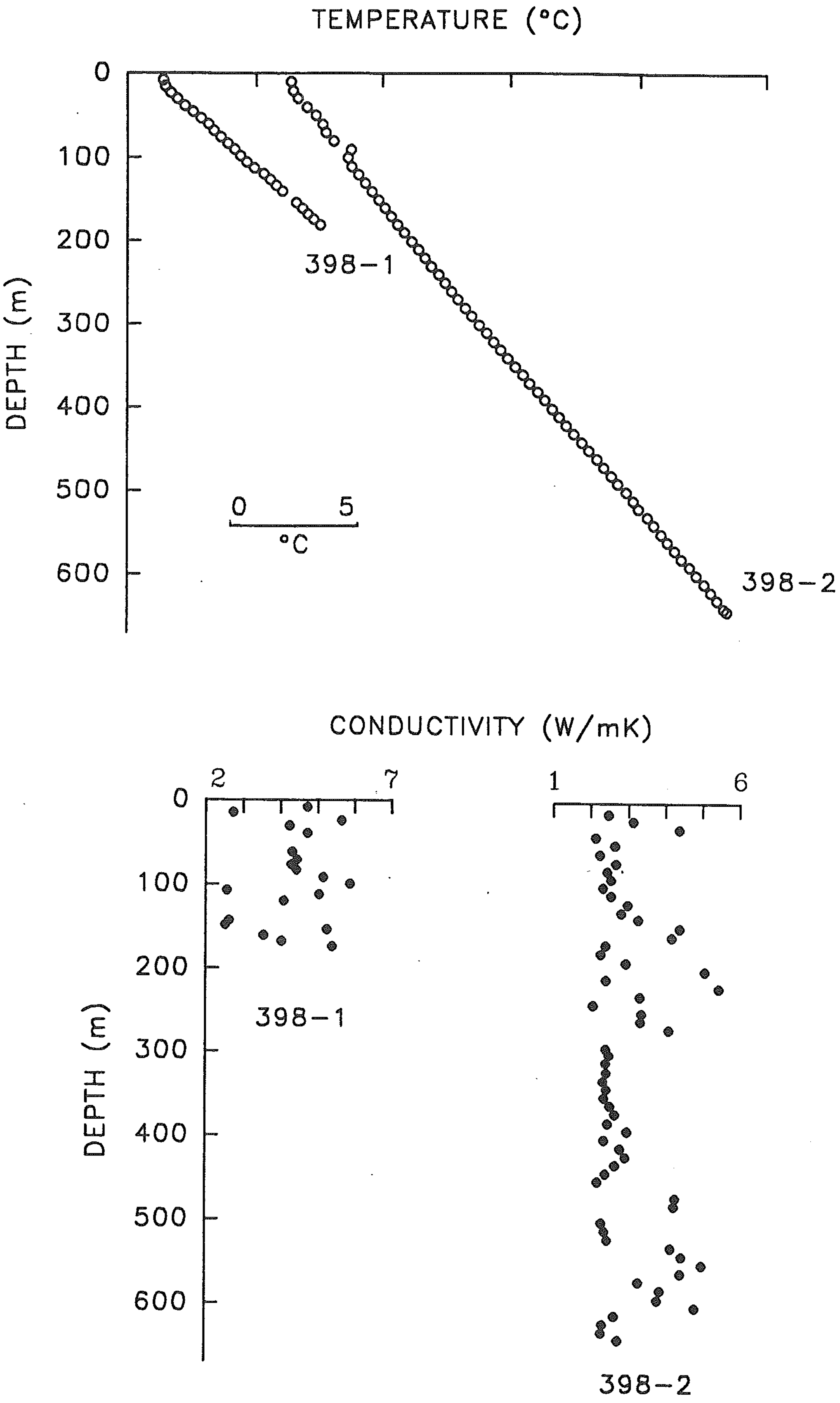

Fig. 17 Measured temperatures and thermal conductivities as a function of depth at Tulsequah Chief, site 398.

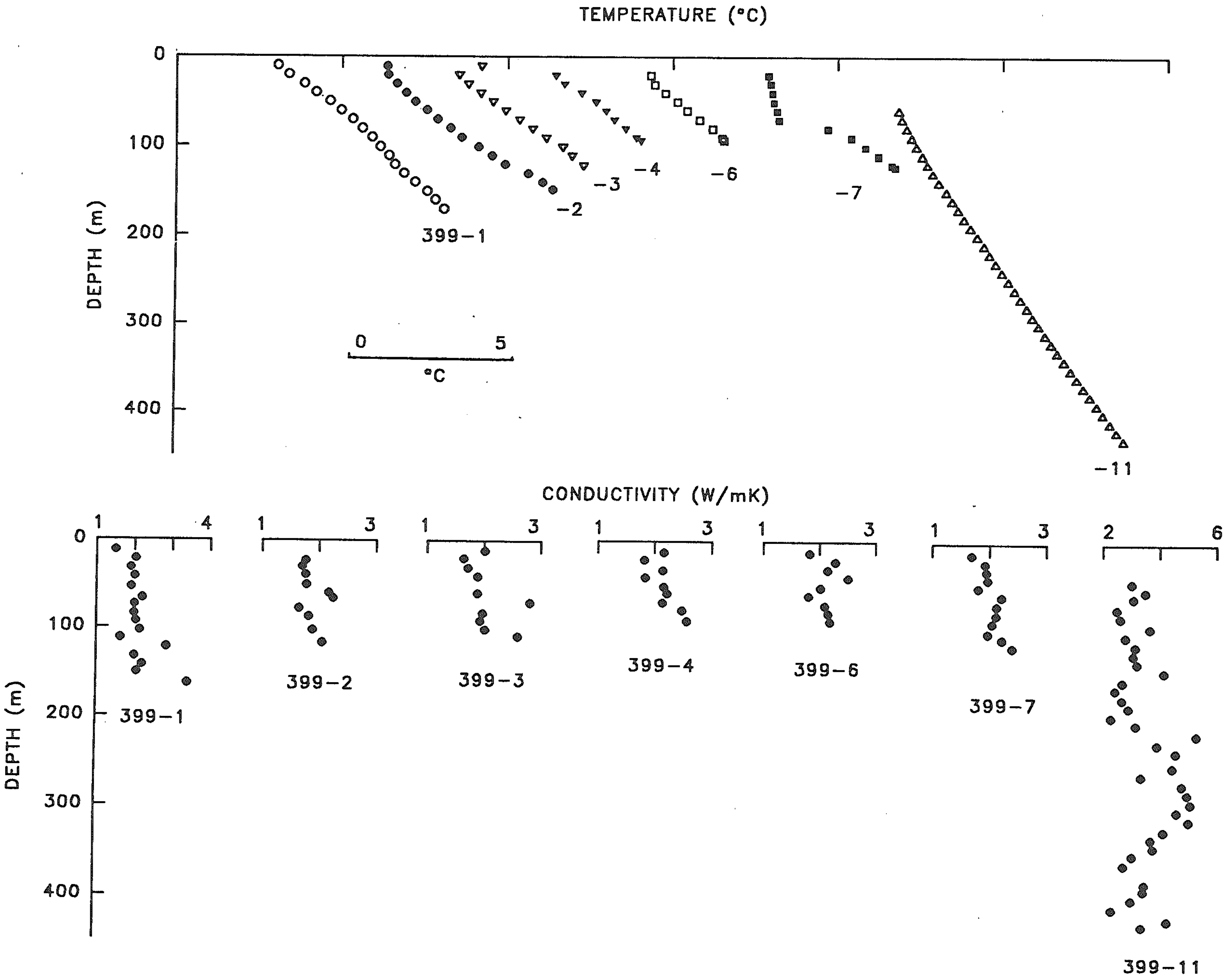

Fig. 18 Measured temperatures and thermal conductivities as a function of depth at Kemess, site 399.

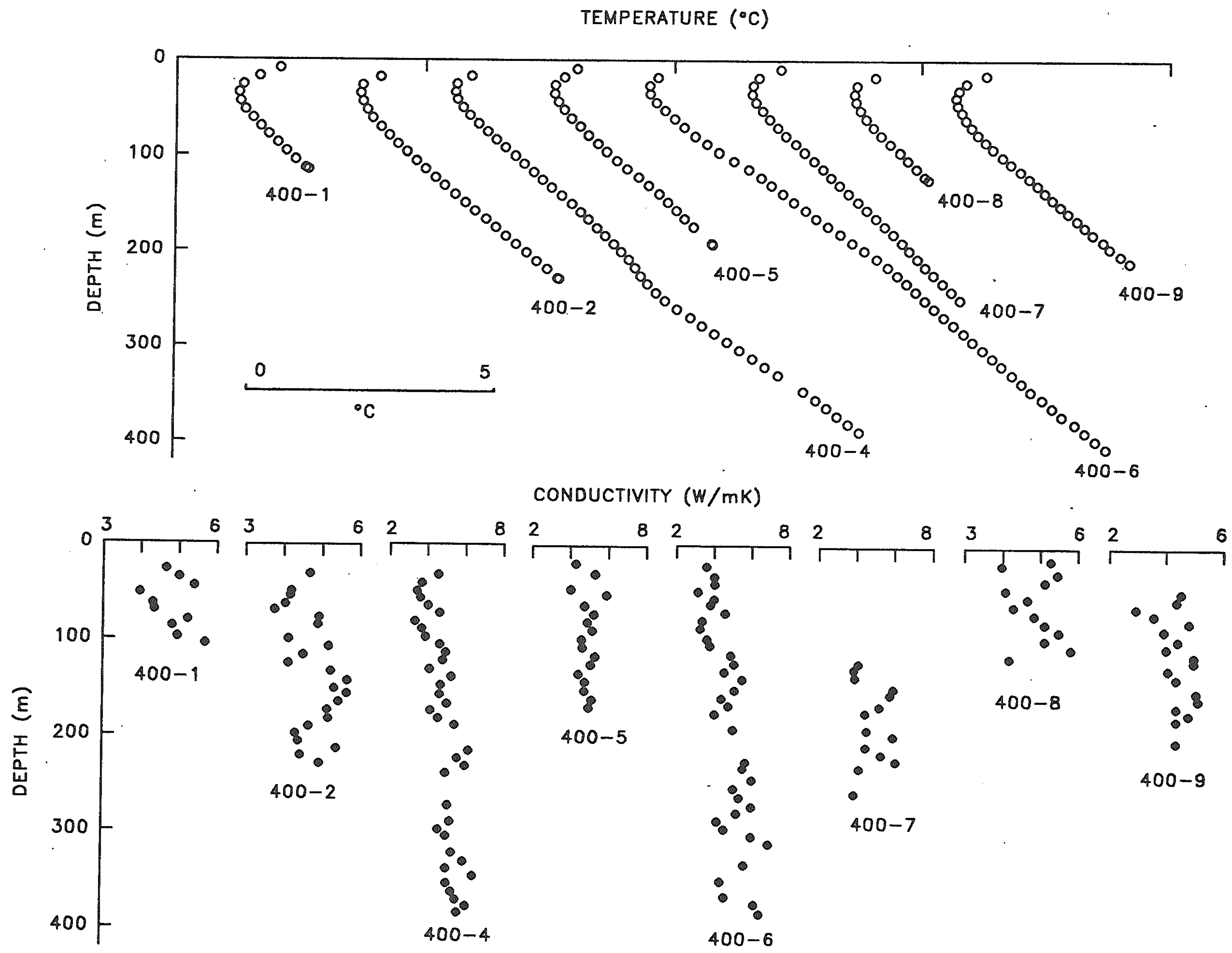

Fig. 19 Measured temperatures and thermal conductivities as a function of depth at Clear Lake, site 400.