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**SUBSURFACE TEMPERATURE AND HEAT  
FLOW - YUKON AND NORTHWEST  
TERRITORIES**

**J.A. Majorowicz and D.W. Morrow**



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**SUBSURFACE TEMPERATURE AND HEAT FLOW —  
YUKON AND NORTHWEST TERRITORIES**

By

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Although every effort has been made to ensure accuracy, this Open File Report has not been edited for conformity with Geological Survey of Canada standards.



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## SUMMARY

The five maps presented here cover the region of the Geological Atlas of the Northern Canadian Mainland Sedimentary Basin (60° to 70°N latitude and 110° to 142°W longitude; Fig. 1). These maps include a Geothermal Gradient Map (Fig. 2), a Map of temperatures at a subsurface depth of 500 m (Fig. 3), a Thermal Conductivity Map (Fig. 4), a Heat Flow Map (Fig. 5) and a map showing subsurface well control (Fig. 1). Geothermal gradient values and corresponding effective thermal conductivity values were used to calculate resulting heat flow values which relate to the heat source in the crust and upper mantle more directly than average thermal gradient.

A large scale northern Prairies heat flow anomaly evident from the map extends from the north-eastern Alberta - Northwestern Territories border approximately to parallel 65 between the Precambrian shield (Slave Province) and the Cordillera (Mackenzie Fold Belt). The large aerial scale of the anomaly (order of magnitude of  $10^2$  km) is of the order of magnitude of lithospheric thickness. In parts of the basin close to areas of high topographic elevation, including the Mackenzie Fold Belt, the magnitude of heat flow is much less, probably because of meteoric recharge and downward crossformational fluid flow through the Mackenzie and Franklin Mountains. The eastward offset of the position of the southern part of the heat flow anomaly may be due to the eastward flow of groundwater through the Devonian Presqu'île Barrier reef complex that extends east-northeastward across this region. It is hypothesised that the large regional scale heat flow anomaly is related to increased mantle upflow of heat under this region. Other smaller scale heat flow highs have been discovered north of parallel 65. They tend to have a north-south strike direction. The lowest heat flow values are in the northeastern part of the mapped area including the Mackenzie Delta and Beaufort Sea.





## DATA CONTROL

Subsurface temperatures were obtained from 595 wells within the region covered by the Geological Atlas of the Northern Canadian Sedimentary Basin (Fig. 1). This distribution is heavily concentrated in the Interior Plains from 60° to 63°N latitude and in the Mackenzie Delta - Beaufort Sea region and in the northern Yukon Territory. A relatively small number of wells occur along the Interior Plains east of Great Bear Lake between these areas of more dense control. Inevitably, this inhomogeneous distribution of well control imposes limitations on the reliability of map patterns generated from these well data in regions of sparse to non-existent control. In areas of good well control, the map patterns illustrated in this report are considered reliable.

## GEOHERMAL GRADIENT

The geothermal gradient was calculated from deep temperatures measured by industry in deep exploration wells in the area. These records, collected by the Geological Survey of Canada under supervision of Dr. Alan Jessop and part of the Canadian Geothermal Data Base, consist mostly of bottom hole temperatures (BHT) and drill stem test temperatures (DST). BHT data require corrections for disturbance to temperature due to the drilling process and were subsequently applied using information on circulation time, time since circulation ceased, depth and multiple temperature records. In cases where information on circulation time or time since circulation were not recorded or only single temperature records were taken, the statistical methods described for the Arctic Islands by Majorowicz and Embry (1995 manuscript in ISPG in review) and Majorowicz et al, (1990) for the Mackenzie Delta were used. Only BHT data from depths equal/greater than 1500 FT were used for analysis. It was noted that the shallow industrial temperature records were in most cases higher than true rock temperatures. Usually the deepest BHTs for the individual wells were in agreement with precise measurements taken by thermistor probes (Majorowicz et al, 1990). Comparison of precise thermistor temperatures taken in northern Alberta by Northern Geothermal in 1993 with BHTs from industrial wells shows that in many cases precise temperatures are not in agreement with BHTs at shallow depths: BHTs are usually too high. Comparison of industrial with high resolution thermal data in a sedimentary basin as presented by Jessop (1990) showed that they were in agreement within 10% for depths exceeding 600 m.

Temperature at the ground surface is the other element needed for computation of the vertical gradient ( $dT/dz$ , where  $T$  is temperature and  $z$  depth). Deeper temperatures and the ground temperatures were used to compute an average thermal gradient. Ground surface temperature has been changing by 2 C +/- 1 C over the last century in Alberta as shown by Majorowicz (1993), similar to northern Alaska (Lachenbruch and Marschall, 1986) and the Mackenzie Basin area (Taylor, 1994 pers.l comm.). Deeper temperatures are in equilibrium with temperature at the surface, lower by 2 C +/-1 than the present ground temperature. This correction was taken into account in computing thermal gradients for the study area.

Thermal gradient values for individual wells were used to map regional variations. A contour map is shown in Fig. 2. The values of  $dT/dz$  are in SI units (mK/m) and the contour interval was chosen



to be 10 mK/m. Average error of the thermal gradient estimate is 10%+/-5%. Thermal gradient values are as low as 20 mK/m in the area attached to the Canadian Shield mainly north of the parallel 64 and as high as 140 mK/m in some local areas in the shallowest part of the basin in the southern NWT. A large area of the Mackenzie Basin to the east of the Mackenzie Mountains is characterised by high thermal gradients of 50 mK/m -60 mK/m which is anomalous in comparison to average geothermal gradient of the Prairie basin (34 mK/m +/- 6 mK/m). High thermal gradients (50mK/m - 60 mK/m) in northern Yukon and in the northwestern part of the NWT in the foreland region of this part of the Northern Cordillera (Mackenzie Mountains) and north and east of it are also common (north of the parallel 65). Large variations of thermal gradients are observed in the north in the Beaufort area and Mackenzie delta (30 mK/m - 60 mK/m). Some anomalous single geothermal gradient values (> 200 mK/m) were rejected for the contouring.

The reason for these large regional variations in thermal gradients may be either large variations in thermal conduction, or large variations of deep terrestrial heat flow. Disturbance to geothermal gradients due to transfer of heat by forced gravity driven convection through movement of groundwater may be an additional reason for their large regional variability. These possibilities have been assessed further by the study of the effective thermal conduction.

#### SUBSURFACE TEMPERATURE AT -500 M

The map of subsurface temperature distribution at -500 m depth shown in Figure 3 was based on temperature calculated for each well based on average thermal gradient and mean annual ground temperature lowered by 2 C as the deeper thermal field is in equilibrium with this lower temperature because of recent ground warming in the NWT and Yukon, as documented by climate change studies as discussed previously. A contour interval of 5°C was chosen for the contouring.

Subsurface temperatures as high as 30°C are typical for the Interior Plains in the southern NWT. The highest values in the north, north of the 65th parallel are mainly observed closer to the Cordillera foreland area. The lowest subsurface temperatures (less than 5°C) are in the north mostly controlled by the 0°C temperature of the base of permafrost.

High temperatures at a fairly shallow subsurface depth (-0.5 km) can be of interest for low grade geothermal use especially with the use of heat pumps. Considering a very low mean annual surface temperature in the north, mainly less than 0°C, this heating energy potential might be feasible for future development of the north.

#### EFFECTIVE THERMAL CONDUCTIVITY

Effective thermal conductivities ( $K_{eff}$ ) for the Western Canada Sedimentary Basin were measured on rock samples of typical lithology types by the University of Alberta Geothermal Laboratory under supervision of Dr. F.W. Jones and reported by Beach et al (1987). In addition, data on thermal conductivities were reported by Garland and Lennox (1962) for central Alberta and Norman Wells in NWT and by Jessop and Vigrass (1989) for the southern Prairies basin. The estimates for the wells in the study area (see Appendix 1) were based on net rock analysis data from Canadian

Stratigraphic and from Dr. Alan Jessop (pers. comm.) and on average rock conductivities. The effects of systematic variations of water content with depth for clastic rocks and of temperature upon thermal conductivity were taken into account based on a simplified general model for clastic sediments by Gallagher (1989). Typical mean thermal conductivity values were taken from Majorowicz and Jessop (1993, Table 1)) where a detailed description of the technique was given. Error of estimating of effective thermal conduction was also completed, using values of uncertainties of average thermal conductivity of individual rock types (see Majorowicz et al, 1986 for details). The range of error of the estimate of the effective thermal conductivity is 16% +/- 6%. Therefore a contour interval for mapping regional variation of effective thermal conductivity was chosen as 0.3 W/m K.

The contour map of effective thermal conductivity is shown in Fig. 4. The variation of effective thermal conductivity throughout the mapped area between parallels 60 and 71 varies from 1.5 W/m K to 2.7 W/m K, with the highest values located in the northeastern and eastern shallow part of the basin in the proximity of the Canadian Shield. In the Interior Plains east of the Mackenzie Mountains, the lowest values of effective conductivity (1.8 W/m K) are in the west in the proximity of the mountain forelands while the highest values (2.7 W/m K) are in the east and north east where more conductive lower to middle Paleozoic carbonates are the dominant subsurface units. The less conductive shaley units of the Upper Devonian succession dominate the shallow subsurface succession farther west. The lowest values of the effective conductivity in the mapped area are in the north in the siliciclastic-dominated Mackenzie Delta and Beaufort Sea Basin sedimentary sequences (typically 1.5-1.8 W/m K).

The observed patterns cannot explain the large variations of thermal gradient, which are between 20 mK/m and 60 mK/m as shown above (see Fig. 2). The areas of the highest thermal gradients in the Mackenzie Basin are not associated with low thermal conductivity as would be expected in the case of uniform heat flow and the areas of the lowest thermal gradients in the Mackenzie Delta and Beaufort Sea Basins are not associated with the highest thermal conductivity. Instead the reverse is usually the case. Therefore the change in heat source reflected by the variations of the surface terrestrial heat flow is likely the cause.

## CONDUCTIVE HEAT FLOW

Conductive heat flow is calculated from average thermal gradient and effective thermal conductivity ( $HF = K_{eff} * (dT/dz)$ ). A contour map of conductive heat flow is shown in Figure 5. Conductive heat flow values were calculated for well sites for which thermal gradients are known (heat flow values in Appendix 1). Effective thermal conductivity was assigned for each site in the majority of cases from direct calculation or in few cases from values interpolated from the effective thermal conductivity map. Average error of heat flow calculation was estimated to be 25 mW/m<sup>2</sup> +/- 5 mW/m<sup>2</sup>. The contour interval was chosen to be 30 mW/m<sup>2</sup>.

The contour map (Fig. 5) shows large variations of heat flow in the area between the foothills and the Mackenzie Basin, from 30 mW/m<sup>2</sup> to 150+ mW/m<sup>2</sup>. A large area of approximately 300 km by 300 km exhibiting heat flow exceeding 90 mW/m<sup>2</sup> is called here the Mackenzie Corridor Heat Flow



Anomaly (MCHFA). The highest heat flow values from the exposed shield generally do not exceed  $80 \text{ mW/m}^2$  (Jessop, 1992) and typical values for the cratonic areas are  $62 \pm 25 \text{ mW/m}^2$  (Drury, 1989). It is important to note that most of the Mackenzie Basin has heat flow higher than  $120 \text{ mW/m}^2$  which qualifies this region as the largest high heat flow zone in Canada.

The heat flow zones are well confirmed by a large amount of data and the variations described are significant and much larger than the expected error of heat flow estimate. Heat flow from the Precambrian basement provinces calculated by Jessop (1992) varies from  $54 \text{ mW/m}^2$  for the Great Bear province to  $84 \text{ mW/m}^2$  for the Slave province. Basement heat flow input derived from numerous radiogenic heat production and uranium-lead dates of basement rocks, combined with concepts of heat flow provinces and a decline of heat flow with tectonic age, can be used as a reference value to estimate the magnitude of the excessive heat flow from the mantle. Basement heat flow calculated by Jessop (1992) based on the assumption that reduced heat flow (heat flow below the radioactive upper crustal layer and in simplification close to the lower crustal and mantle heat flow contribution) is the same in the basin as in the shield area because of the continuity of the exposed Precambrian structures beneath the sedimentary cover, the latter being well documented (Ross et al., 1991). The difference between calculated surface heat flows and basement heat flow estimates, less heat flow generated in the sedimentary column, gives the residual value which can be interpreted as an anomalous reduced heat flow. The anomalous area for which the difference between the surface heat flow less the sedimentary cover heat flow contribution (estimated to be less than 5% of the total heat flow) and basement heat flow predicted by Jessop (1992); is larger than  $30 \text{ mW/m}^2$  and reaches  $60 \text{ mW/m}^2$  locally is entirely located in the Mackenzie basin north of the Keg River barrier.

The anomalous area of the MCHFA in the southern area of the map is in contrast to much lower heat flow values to the north (mostly  $60\text{-}90 \text{ mW/m}^2$ ) with some local areas more than  $90 \text{ mW/m}^2$  and lows less than  $60 \text{ mW/m}^2$ . Large area of very low values  $30\text{-}60 \text{ mW/m}^2$  is typical for the far north and north eastern part of the mapped area which includes the Mackenzie Delta, the Beaufort Sea Basins and Yukon.

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APPENDIX 1 -  
WELL LOCATION, HEAT FLOW,  
GEOHERMAL GRADIENT AND  
EFFECTIVE THERMAL CONDUCTIVITY





Latitude, Longitude, Heat Flow ( $\text{mW/m}^2$ ), Geothermal Gradient ( $\text{mK/m}$ ), and Effective Thermal Conductivity ( $\text{W/m K}$ )

<u>Degrees North</u>	<u>Degrees West</u>	<u>(<math>\text{mW/m}^2</math>)</u>	<u>(<math>\text{mK/m}</math>)</u>	<u>(<math>\text{W/m K}</math>)</u>
60.41667000	-122.98330000	75.88513000	44.64	1.70
60.10667000	-124.12170000	72.49861000	39.19	1.85
60.11333000	-124.05830000	67.90748000	37.73	1.80
60.12500000	-124.10170000	73.04382000	40.58	1.80
60.11167000	-124.06500000	71.10927000	44.44	1.60
60.00667000	-124.26330000	71.66848000	44.79	1.60
60.08333000	-125.29500000	42.82944000	26.77	1.60
60.04500000	-125.02000000	56.81211000	35.51	1.60
60.19333000	-122.97830000	99.35045000	58.44	1.70
60.13833000	-128.48000000	85.24171000	53.28	1.60
60.29833000	-122.99830000	82.70766000	47.26	1.75
60.32500000	-124.43330000	88.41207000	55.26	1.60
60.29500000	-123.96500000	62.72611000	39.20	1.60
60.41500000	-123.02830000	64.02416000	37.66	1.70
60.24667000	-122.77830000	129.51920000	71.96	1.80
60.46833000	-123.59330000	87.19880000	51.29	1.70
60.40000000	-123.91000000	63.15429000	39.47	1.60
60.45500000	-123.86500000	57.59298000	36.00	1.60
60.41000000	-123.89830000	70.12225000	43.83	1.60
60.35667000	-123.94670000	73.23934000	45.77	1.60
60.43167000	-123.88330000	57.55490000	35.97	1.60
60.39833000	-123.81500000	54.87984000	34.30	1.60
60.53000000	-123.02170000	70.97322000	41.75	1.70
60.12667000	-124.12670000	65.58007000	40.99	1.60
60.54000000	-123.28670000	94.60175000	52.56	1.80
60.59167000	-123.68170000	86.41660000	45.48	1.90
60.64667000	-123.80170000	103.24990000	64.53	1.60
60.65333000	-124.58000000	58.03438000	36.27	1.60
60.62333000	-124.52000000	83.19250000	55.46	1.50
60.70667000	-122.73670000	75.88484000	44.64	1.70
60.77167000	-122.77170000	76.38515000	47.74	1.60
60.88000000	-122.61170000	62.21763000	38.89	1.60
60.84834000	-123.12170000	86.59309000	50.94	1.70
60.99500000	-123.55830000	63.73303000	33.54	1.90
60.24333000	-123.04500000	90.57438000	50.32	1.80
61.55667000	-122.57830000	131.37120000	52.55	2.50
61.77000000	-122.59830000	155.04740000	64.60	2.40
61.97500000	-122.69670000	150.71880000	60.29	2.50
61.91667000	-123.03000000	69.09718000	39.48	1.75
60.89667000	-123.89330000	81.66505000	48.04	1.70

62.16833000	-123.04670000	83.81638000	49.30	1.70
62.06167000	-123.17330000	83.17347000	43.78	1.90
62.03167000	-124.14330000	67.66682000	38.67	1.75
62.32500000	-121.95170000	143.21160000	47.74	3.00
62.31667000	-122.40170000	139.25070000	48.02	2.90
62.35667000	-122.47670000	143.11170000	53.00	2.70
62.41000000	-122.26500000	151.97010000	69.08	2.20
62.48500000	-123.87830000	119.45090000	41.19	2.90
62.48333000	-124.46670000	81.84624000	43.08	1.90
62.60667000	-122.89830000	149.68770000	51.62	2.90
63.15500000	-124.19670000	75.88622000	29.19	2.60
63.15500000	-124.19670000	84.37018000	32.45	2.60
63.15500000	-124.19670000	81.52136000	31.35	2.60
63.32833000	-124.94330000	67.78819000	21.18	3.20
63.67167000	-123.05830000	70.31175000	28.12	2.50
63.90000000	-124.46500000	79.22780000	34.45	2.30
63.88334000	-124.65500000	87.50074000	38.04	2.30
62.00000000	-122.46670000	116.32890000	48.47	2.40
63.15833000	-122.91670000	70.35683000	28.14	2.50
63.92833000	-124.87830000	81.57047000	35.47	2.30
63.84000000	-125.41830000	54.32414000	25.87	2.10
64.02167000	-122.92000000	76.88789000	23.30	3.30
64.13333000	-124.47170000	84.86712000	42.43	2.00
64.11833000	-125.07000000	59.05044000	32.81	1.80
64.14500000	-125.58170000	57.09914000	21.15	2.70
64.31667000	-125.32170000	53.42395000	31.43	1.70
84.36333000	-124.95000000	78.32399000	43.51	1.80
61.23500000	-122.75000000	117.47690000	48.95	2.40
66.12833000	-137.52830000	46.58775000	27.40	1.70
64.39333000	-125.02830000	91.78642000	41.72	2.20
64.41000000	-125.44670000	74.98763000	39.47	1.90
64.66167000	-125.94330000	91.86737000	36.75	2.50
60.38000000	-123.91000000	73.76411000	46.10	1.60
60.16333000	-124.13170000	66.72320000	41.70	1.60
60.44667000	-124.19830000	61.37664000	38.36	1.60
61.03333000	-123.80830000	113.04130000	41.87	2.70
61.01667000	-117.29830000	126.05900000	72.03	1.75
61.16167000	-117.52670000	92.89980000	58.06	1.60
60.97500000	-116.83330000	128.63670000	71.46	1.80
61.23500000	-117.47830000	110.28600000	64.87	1.70
61.27667000	-117.66000000	127.33330000	60.63	2.10
61.33500000	-117.01170000	164.38420000	71.47	2.30
61.43667000	-117.37670000	108.75140000	57.24	1.90
61.62500000	-117.59670000	182.49980000	70.19	2.60
61.66833000	-116.88830000	148.62320000	64.62	2.30

60.96167000	-116.88500000	100.17390000	52.72	1.90
61.14667000	-117.08830000	183.64360000	83.47	2.20
60.10333000	-122.24170000	109.50350000	57.63	1.90
60.08833000	-122.73500000	108.74230000	51.78	2.10
60.15667000	-122.17500000	98.38970000	61.49	1.60
60.12500000	-122.22670000	85.74028000	50.44	1.70
60.06167000	-122.38000000	79.14891000	43.97	1.80
60.04500000	-122.29170000	90.82242000	50.46	1.80
60.15667000	-122.62830000	130.98060000	59.54	2.20
60.14667000	-122.61330000	137.24020000	62.38	2.20
60.41833000	-122.46500000	94.16250000	52.31	1.80
60.34333000	-122.26830000	76.97745000	45.28	1.70
60.33500000	-122.62330000	88.10971000	48.95	1.80
60.47667000	-122.65330000	108.29930000	63.71	1.70
60.76000000	-122.38000000	79.11147000	49.44	1.60
60.90333000	-122.45670000	94.80074000	49.90	1.90
61.07000000	-122.04330000	64.30517000	40.19	1.60
61.19000000	-122.24830000	115.41840000	50.18	2.30
61.74000000	-122.89830000	125.37950000	50.15	2.50
62.54500000	-122.31830000	126.23340000	70.13	1.80
62.61833000	-122.39330000	127.31630000	48.97	2.60
64.21500000	-122.29000000	125.36160000	37.99	3.30
64.82333000	-124.83830000	78.35153000	32.65	2.40
64.84000000	-123.94170000	70.27220000	31.94	2.20
64.99667000	-124.08000000	97.49800000	51.31	1.90
65.33334000	-123.70330000	72.37046000	40.21	1.80
65.17000000	-124.21500000	91.83789000	30.61	3.00
65.45000000	-123.53000000	114.70680000	63.73	1.80
65.59167000	-124.48830000	101.66040000	39.10	2.60
65.55666000	-124.59670000	70.28167000	30.56	2.30
65.69000000	-123.20500000	54.48984000	22.70	2.40
65.85833000	-123.49330000	66.89772000	27.87	2.40
66.48666000	-124.59830000	71.52754000	31.10	2.30
65.46000000	-127.14000000	128.01060000	67.37	1.90
65.50500000	-127.23000000	108.11920000	43.25	2.50
65.34500000	-127.47830000	66.11789000	44.08	1.50
65.04333000	-126.77000000	64.15466000	35.64	1.80
65.36500000	-127.58000000	67.79836000	39.88	1.70
65.28667000	-126.88330000	60.84598000	33.80	1.80
65.16666000	-125.08500000	60.43674000	28.78	2.10
65.39333000	-124.72500000	124.05580000	44.31	2.80
64.93500000	-126.09500000	79.11725000	49.45	1.60
64.73666000	-125.63330000	129.14120000	64.57	2.00
64.76000000	-125.21670000	105.43220000	52.72	2.00
66.09333000	-137.92500000	53.17881000	31.28	1.70

65.56500000	-123.77500000	129.26370000	76.04	1.70
64.89500000	-125.30170000	102.51650000	44.57	2.30
64.84167000	-125.99170000	77.50049000	45.59	1.70
63.22667000	-123.90830000	85.59872000	35.67	2.40
63.51667000	-124.03670000	55.72303000	32.78	1.70
62.35167000	-123.12830000	84.63953000	49.79	1.70
61.20000000	-123.14500000	51.82428000	30.48	1.70
60.13500000	-121.08830000	88.30681000	51.95	1.70
60.15833000	-121.13830000	108.26770000	63.69	1.70
60.15833000	-121.08000000	70.41876000	41.42	1.70
60.01500000	-121.15000000	100.83640000	56.02	1.80
60.15000000	-121.42670000	66.64923000	37.03	1.80
60.01500000	-121.63500000	76.15788000	44.80	1.70
60.01500000	-121.80170000	96.85252000	53.81	1.80
60.25667000	-121.18670000	90.39297000	50.22	1.80
60.18833000	-121.13500000	92.66550000	51.48	1.80
60.46667000	-121.18000000	103.07960000	57.27	1.80
60.36666000	-121.04330000	95.96716000	56.45	1.70
60.39833000	-121.09830000	93.31209000	54.89	1.70
60.44000000	-121.41330000	65.03343000	38.25	1.70
60.40500000	-121.87500000	88.67690000	52.16	1.70
60.54667000	-121.49830000	75.66418000	44.51	1.70
60.61500000	-122.64830000	66.47073000	39.10	1.70
60.73833000	-121.37830000	74.21525000	43.66	1.70
60.72667000	-122.06330000	69.37280000	43.36	1.60
60.97833000	-121.87670000	91.73112000	57.33	1.60
60.84000000	-122.09670000	68.28381000	42.68	1.60
61.02500000	-121.35330000	80.11167000	47.12	1.70
61.23167000	-121.57670000	135.30870000	75.17	1.80
61.23333000	-121.84000000	136.26900000	59.25	2.30
61.73167000	-122.12000000	126.77850000	55.12	2.30
61.92833000	-121.94830000	123.43100000	51.43	2.40
62.05000000	-121.38670000	120.17010000	46.22	2.60
62.14500000	-121.93330000	125.65610000	57.12	2.20
62.28000000	-121.07330000	119.87050000	47.95	2.50
62.48000000	-121.45830000	133.42550000	49.42	2.70
62.67833000	-121.72170000	164.77590000	48.46	3.40
62.82167000	-121.75000000	126.21180000	39.44	3.20
63.41333000	-122.78330000	78.84941000	32.85	2.40
64.56167000	-122.66170000	73.89225000	23.84	3.10
60.05833000	-120.38670000	120.14200000	66.75	1.80
60.16167000	-120.46000000	77.72780000	43.18	1.80
60.19667000	-120.23000000	79.14162000	43.97	1.80
60.24000000	-120.37500000	86.92079000	48.29	1.80
60.30000000	-120.61670000	89.73219000	52.78	1.70

60.28833000	-120.57000000	86.92007000	48.29	1.80
60.45500000	-120.39500000	69.91783000	38.84	1.80
60.47667000	-120.68000000	105.23250000	61.90	1.70
60.59500000	-120.58670000	68.38164000	42.74	1.60
60.54500000	-120.93830000	76.90149000	48.06	1.60
60.83000000	-120.48000000	119.09750000	66.17	1.80
60.97833000	-120.03170000	98.50782000	54.73	1.80
60.98667000	-120.25000000	73.90754000	43.48	1.70
60.95333000	-120.31000000	104.34860000	57.97	1.80
60.96000000	-120.29830000	89.59307000	56.00	1.60
60.91833000	-120.52670000	91.45904000	57.16	1.60
61.12500000	-120.37500000	125.68260000	52.37	2.40
61.27167000	-120.78000000	124.20180000	54.00	2.30
61.23833000	-120.87830000	74.31061000	46.44	1.60
61.45333000	-120.63830000	177.09850000	65.59	2.70
61.37000000	-120.73500000	163.11020000	67.96	2.40
61.38000000	-120.73670000	162.84620000	62.63	2.60
61.55333000	-120.06170000	161.21060000	62.00	2.60
61.52500000	-120.41670000	137.33750000	62.43	2.20
61.89667000	-120.32670000	109.95870000	57.87	1.90
62.34000000	-120.24170000	160.71330000	53.57	3.00
62.35667000	-120.85330000	107.91560000	44.96	2.40
62.50000000	-120.10000000	123.55730000	42.61	2.90
63.18833000	-120.48500000	150.53080000	62.72	2.40
63.73667000	-120.61330000	95.91245000	38.36	2.50
60.02500000	-119.20000000	59.23388000	29.62	2.00
60.05333000	-119.82500000	73.49943000	38.68	1.90
60.08333000	-119.91330000	107.02270000	62.95	1.70
60.31333000	-119.31330000	49.15641000	27.31	1.80
60.27167000	-119.76500000	86.39494000	45.47	1.90
60.57333000	-119.68500000	92.36919000	48.62	1.90
61.06167000	-119.31330000	92.30433000	54.30	1.70
61.01167000	-119.32000000	106.18050000	58.99	1.80
61.45500000	-119.56330000	139.20930000	60.53	2.30
61.62500000	-119.50500000	112.32910000	66.08	1.70
61.58500000	-119.96670000	113.94940000	63.31	1.80
61.74667000	-119.46170000	178.29840000	74.29	2.40
62.28500000	-119.07330000	123.17030000	38.49	3.20
62.39000000	-119.57830000	88.36101000	42.08	2.10
60.10500000	-118.47670000	63.77012000	33.56	1.90
60.10500000	-118.32670000	77.28772000	38.64	2.00
60.29667000	-118.05000000	63.97286000	31.99	2.00
60.25000000	-118.28000000	82.27424000	37.40	2.20
60.35833000	-118.22170000	85.99802000	43.00	2.00
60.56167000	-118.08330000	91.23522000	48.02	1.90



60.70000000	-118.19500000	85.34351000	44.92	1.90
60.75834000	-118.14330000	68.43118000	36.02	1.90
60.81000000	-118.71670000	83.18524000	41.59	2.00
60.67167000	-118.85170000	72.60635000	38.21	1.90
60.97667000	-118.05830000	84.20153000	46.78	1.80
60.96500000	-118.07330000	110.97900000	61.66	1.80
60.98833000	-118.42830000	75.36384000	41.87	1.80
61.13667000	-118.64170000	101.87150000	53.62	1.90
60.92000000	-118.36330000	65.04958000	34.24	1.90
60.93500000	-118.76170000	64.38048000	37.87	1.70
61.09667000	-118.66000000	87.00597000	48.34	1.80
61.00667000	-118.75330000	82.98104000	41.49	2.00
61.20333000	-118.01670000	79.08892000	39.54	2.00
61.32000000	-118.17830000	105.31260000	61.95	1.70
61.29833000	-118.03330000	84.82150000	60.59	1.40
61.22667000	-118.23000000	113.16100000	53.89	2.10
67.01000000	-119.17830000	91.30475000	50.72	1.80
61.54333000	-118.01000000	115.28870000	60.68	1.90
61.67333000	-118.23000000	121.87570000	50.78	2.40
61.73500000	-118.33170000	94.13627000	42.79	2.20
61.81500000	-118.37170000	118.05060000	53.66	2.20
61.76500000	-118.55830000	104.32980000	45.36	2.30
61.74833000	-118.80000000	131.43700000	54.77	2.40
61.86333000	-118.27830000	119.36200000	54.26	2.20
62.19667000	-118.25170000	107.15930000	41.22	2.60
62.41833000	-118.49330000	173.63980000	91.39	1.90
62.94000000	-118.98330000	170.05020000	70.85	2.40
61.05000000	-118.24000000	89.08586000	44.54	2.00
60.02500000	-117.04000000	96.28834000	48.14	2.00
60.09333000	-117.23330000	76.27426000	38.14	2.00
60.01500000	-117.12330000	107.11580000	56.38	1.90
60.01167000	-117.29500000	71.85669000	37.82	1.90
60.02500000	-117.44670000	81.55918000	33.98	2.40
60.06500000	-117.33170000	89.78044000	44.89	2.00
60.06667000	-117.50830000	49.06623000	25.82	1.90
60.10667000	-117.91330000	65.76454000	32.88	2.00
60.02667000	-117.91170000	73.43736000	33.38	2.20
60.19667000	-117.57330000	68.88974000	36.26	1.90
60.18667000	-117.83000000	60.61506000	30.31	2.00
60.32833000	-117.90500000	65.27000000	34.35	1.90
60.40833000	-117.92670000	70.55462000	35.28	2.00
60.39667000	-117.92000000	89.20242000	46.95	1.90
60.66167000	-117.27170000	88.75324000	44.38	2.00
60.62333000	-117.88500000	86.30740000	43.15	2.00
60.62667000	-117.89500000	64.96079000	34.19	1.90

60.81833000	-117.15170000	83.80461000	44.11	1.90
60.71833000	-117.37170000	88.46950000	44.23	2.00
60.71000000	-117.40000000	100.91480000	53.11	1.90
60.74166000	-117.33000000	102.54620000	51.27	2.00
60.74500000	-117.45170000	115.16520000	60.61	1.90
60.79333000	-117.30000000	105.33260000	55.44	1.90
60.66667000	-117.72000000	80.59682000	42.42	1.90
60.67500000	-117.52000000	122.08800000	61.04	2.00
60.74667000	-117.45500000	111.72350000	58.80	1.90
60.67833000	-117.74830000	74.18479000	39.04	1.90
60.90667000	-117.36330000	91.35557000	48.08	1.90
60.92167000	-117.35170000	86.08460000	47.82	1.80
60.89167000	-117.37670000	79.18704000	41.68	1.90
61.15167000	-117.95000000	92.61638000	46.31	2.00
60.00333000	-117.42500000	62.89000000	33.10	1.90
60.88667000	-117.77000000	80.97646000	44.99	1.80
60.14000000	-116.96330000	98.74530000	49.37	2.00
60.05500000	-116.85170000	108.53370000	54.27	2.00
60.24500000	-116.02500000	151.47320000	58.26	2.60
60.21167000	-116.29500000	85.63120000	45.07	1.90
60.25667000	-116.60830000	97.89708000	48.95	2.00
60.25834000	-116.57830000	79.18436000	40.61	1.95
60.43833000	-116.02000000	124.30960000	59.20	2.10
60.47333000	-116.86000000	124.49550000	62.25	2.00
60.57000000	-116.74330000	102.08330000	51.04	2.00
60.90667000	-116.29170000	119.91670000	66.62	1.80
60.95667000	-116.60500000	141.26570000	61.42	2.30
60.84167000	-116.62500000	210.83400000	105.42	2.00
61.02167000	-116.49500000	111.22700000	55.61	2.00
61.13000000	-116.47670000	110.51510000	46.05	2.40
61.09000000	-116.66670000	151.42100000	72.11	2.10
61.53000000	-116.66330000	135.29380000	58.82	2.30
60.60167000	-116.22170000	149.51500000	87.95	1.70
60.59500000	-116.21670000	97.39246000	51.26	1.90
60.20833000	-115.95330000	167.08520000	59.67	2.80
60.36167000	-115.72000000	155.62470000	55.58	2.80
60.36167000	-115.73000000	126.92800000	45.33	2.80
60.42667000	-115.78170000	166.49200000	57.41	2.90
60.85167000	-115.67170000	161.58770000	52.13	3.10
60.92667000	-118.80170000	65.12628000	36.18	1.80
61.01000000	-118.58670000	87.15364000	43.58	2.00
64.34500000	-125.00170000	73.58463000	33.45	2.20
65.59000000	-128.17170000	98.71046000	54.84	1.80
65.60500000	-128.17670000	75.17572000	34.17	2.20
65.62833000	-128.20670000	67.33476000	30.61	2.20

65.74167000	-128.25830000	73.76497000	33.53	2.20
65.92333000	-128.57330000	145.17340000	58.07	2.50
65.61000000	-128.57330000	87.14540000	43.57	2.00
65.56000000	-128.83830000	84.84468000	40.40	2.10
65.83500000	-128.86330000	58.80878000	23.52	2.50
65.77333000	-129.13000000	94.94894000	43.16	2.20
65.86667000	-129.18330000	72.09121000	37.94	1.90
65.86333000	-129.20170000	79.76949000	37.99	2.10
65.70333000	-129.31670000	91.81849000	48.33	1.90
65.47500000	-129.52500000	80.72064000	40.36	2.00
65.46833000	-130.66330000	70.90054000	39.39	1.80
65.60667000	-130.89830000	61.99136000	38.74	1.60
65.44167000	-130.97170000	63.64118000	31.82	2.00
65.51667000	-131.81500000	68.69684000	34.35	2.00
65.88500000	-132.46330000	82.60252000	51.63	1.60
66.11333000	-126.36670000	52.09769000	22.65	2.30
66.03667000	-129.16330000	108.70980000	49.41	2.20
66.08000000	-132.45000000	89.86618000	49.93	1.80
66.14833000	-133.96830000	72.24900000	38.03	1.90
66.05000000	-136.85500000	60.66614000	33.70	1.80
66.04000000	-136.93500000	88.05723000	53.37	1.65
66.12000000	-137.30000000	56.92514000	29.96	1.90
66.14167000	-137.54170000	83.94682000	50.88	1.65
66.12167000	-137.51330000	55.61164000	32.71	1.70
66.04333000	-137.78330000	56.14443000	31.19	1.80
66.12334000	-137.80500000	46.41810000	29.01	1.60
66.10000000	-138.33330000	50.80268000	25.40	2.00
66.31333000	-128.36000000	115.27220000	45.20	2.55
66.29500000	-131.85000000	66.71388000	35.11	1.90
66.28500000	-133.52670000	73.51936000	38.69	1.90
66.31000000	-134.01670000	79.38234000	44.10	1.80
66.17667000	-134.31330000	60.20771000	35.42	1.70
66.24667000	-134.83500000	56.45972000	31.37	1.80
66.16833000	-137.43500000	54.79961000	30.44	1.80
66.20167000	-137.36500000	54.28486000	31.93	1.70
66.18667000	-138.69830000	58.34309000	29.92	1.95
66.48666000	-124.59830000	73.08248000	31.10	2.35
66.34500000	-128.96670000	58.44350000	23.38	2.50
66.35333000	-129.24500000	86.73764000	48.19	1.80
66.44334000	-130.14670000	107.23780000	56.44	1.90
66.39000000	-132.09830000	62.55200000	31.28	2.00
66.37666000	-133.20500000	106.22790000	66.39	1.60
66.42667000	-134.23500000	78.29272000	43.50	1.80
66.34167000	-134.72670000	64.78293000	34.10	1.90
66.41333000	-136.77330000	73.10776000	28.67	2.55

66.33667000	-137.21670000	65.72285000	36.51	1.80
66.34000000	-140.10330000	45.14754000	20.52	2.20
66.59167000	-130.34000000	62.55883000	27.20	2.30
66.56000000	-130.77000000	72.90029000	31.70	2.30
66.50833000	-134.07330000	98.56651000	51.88	1.90
66.60500000	-134.85000000	114.71630000	63.73	1.80
66.58667000	-134.76000000	114.99370000	60.52	1.90
66.51000000	-134.77500000	65.04834000	34.24	1.90
66.55334000	-137.83500000	85.40176000	47.45	1.80
66.54833000	-138.42500000	64.09167000	28.49	2.25
66.78167000	-132.82670000	57.04261000	27.16	2.10
66.74167000	-133.16670000	62.56637000	29.79	2.10
66.82833000	-133.40000000	88.22229000	37.54	2.35
66.81667000	-133.92170000	64.35648000	35.75	1.80
66.81167000	-135.30670000	66.98347000	37.21	1.80
66.69833000	-137.32830000	53.20049000	29.56	1.80
66.81500000	-138.14170000	75.63997000	34.38	2.20
66.85833000	-134.23330000	58.43807000	30.76	1.90
66.94000000	-134.86500000	57.37221000	31.87	1.80
66.96500000	-137.98330000	80.40834000	50.26	1.60
67.01500000	-124.21670000	59.87742000	26.03	2.30
67.04667000	-126.46330000	82.82258000	36.01	2.30
67.10333000	-130.87500000	71.28100000	32.40	2.20
67.10667000	-132.42830000	67.47560000	33.74	2.00
67.10667000	-132.41170000	64.92564000	33.30	1.95
67.13834000	-133.23830000	73.50508000	31.96	2.30
67.12833000	-133.57830000	72.12834000	36.06	2.00
67.15833000	-137.44500000	51.44930000	29.40	1.75
67.07667000	-137.25670000	52.95432000	31.15	1.70
67.06667000	-138.60000000	47.74757000	26.53	1.80
67.23500000	-125.15670000	95.63513000	42.50	2.25
67.23833000	-126.30670000	38.44335000	15.38	2.50
67.19500000	-129.38670000	100.96760000	42.07	2.40
67.19666000	-130.11500000	62.86150000	24.65	2.55
67.29000000	-132.35000000	85.00906000	42.50	2.00
67.25000000	-134.03000000	64.10306000	32.05	2.00
67.23333000	-135.57330000	53.24596000	28.78	1.85
67.33000000	-136.89170000	135.06900000	75.04	1.80
67.29000000	-137.89330000	51.76138000	28.76	1.80
67.33500000	-123.80830000	68.58430000	28.58	2.40
67.48500000	-129.87170000	90.18167000	40.08	2.25
67.42500000	-133.25330000	77.04765000	33.50	2.30
67.49500000	-135.38000000	72.71758000	36.36	2.00
66.55833000	-123.64170000	96.25938000	40.11	2.40
67.50166000	-124.17670000	62.54220000	27.19	2.30

67.51833000	-134.23830000	59.83514000	31.49	1.90
68.16167000	-134.72670000	42.07686000	21.04	2.00
67.59167000	-135.26330000	67.15871000	35.35	1.90
67.52333000	-137.98500000	49.48071000	28.27	1.75
67.67667000	-125.09330000	68.26978000	26.26	2.60
67.72667000	-136.83170000	104.35180000	41.74	2.50
67.75833000	-127.41330000	40.98003000	16.39	2.50
67.74500000	-128.79830000	161.84630000	67.44	2.40
67.67834000	-129.53500000	46.71003000	17.30	2.70
67.86833000	-130.72330000	46.08366000	23.04	2.00
67.91167000	-135.36670000	45.47090000	25.26	1.80
67.84500000	-135.40830000	48.02242000	32.01	1.50
69.40353000	-135.81750000	45.00000000	30.00	1.50
69.44180000	-135.84780000	70.00000000	28.00	2.50
69.38750000	-132.31890000	61.20000000	34.00	1.80
68.27084000	-135.12940000	56.70000000	27.00	2.10
68.10555000	-135.06670000	69.70000000	41.00	1.70
68.12083000	-135.15310000	66.50000000	35.00	1.90
69.88250000	-132.83910000	46.80000000	26.00	1.80
69.89972000	-130.93780000	66.50000000	35.00	1.90
69.50750000	-132.70220000	64.80000000	36.00	1.80
69.73583000	-131.96500000	68.40000000	36.00	1.90
69.73822000	-131.83920000	70.00000000	40.00	1.75
68.96333000	-133.93530000	44.80000000	32.00	1.40
69.27861000	-132.51640000	90.00000000	50.00	1.80
69.39606000	-135.50540000	67.20000000	32.00	2.10
69.61897000	-135.18080000	54.40000000	34.00	1.60
69.93892000	-134.36970000	51.00000000	30.00	1.70
69.51972000	-134.48110000	45.90000000	27.00	1.70
69.59500000	-134.34390000	52.80000000	24.00	2.20
69.61417000	-134.32110000	59.40000000	27.00	2.20
68.98695000	-133.49750000	50.75000000	29.00	1.75
68.99447000	-133.49000000	49.50000000	33.00	1.50
69.89445000	-131.08670000	79.95000000	39.00	2.05
68.83331000	-134.80530000	46.40000000	29.00	1.60
69.90889000	-131.44640000	92.80000000	32.00	2.90
69.51917000	-132.13110000	79.80000000	42.00	1.90
69.41695000	-134.50440000	55.80000000	31.00	1.80
69.44389000	-134.63970000	65.52000000	36.40	1.80
69.48000000	-134.71250000	44.80000000	28.00	1.60
69.44517000	-132.80350000	64.35000000	33.00	1.95
69.47806000	-132.90830000	52.50000000	35.00	1.50
68.34028000	-134.89690000	68.00000000	34.00	2.00
68.51305000	-134.53830000	57.60000000	36.00	1.60
69.82417000	-131.66700000	107.50000000	43.00	2.50



69.70861000	-131.61220000	51.20000000	32.00	1.60
69.71083000	-131.73190000	54.88000000	34.30	1.60
69.55083000	-135.93220000	52.80000000	33.00	1.60
69.65630000	-135.90580000	57.60000000	36.00	1.60
69.30305000	-135.30250000	45.90000000	27.00	1.70
69.32220000	-135.34340000	61.20000000	36.00	1.70
69.68528000	-134.85830000	40.50000000	27.00	1.50
69.02055000	-133.37610000	60.80000000	38.00	1.60
69.98194000	-130.51550000	75.20000000	47.00	1.60
68.97611000	-133.52580000	59.20000000	37.00	1.60
69.43195000	-132.62390000	59.50000000	34.00	1.75
68.78611000	-133.65420000	47.60000000	28.00	1.70
68.66250000	-133.71670000	57.60000000	32.00	1.80
69.40200000	-136.38610000	36.40000000	28.00	1.30
69.01667000	-133.54210000	54.40000000	34.00	1.60
69.40389000	-134.99280000	54.00000000	30.00	1.80
69.37156000	-134.89350000	51.20000000	32.00	1.60
69.35142000	-134.94460000	51.00000000	30.00	1.70
69.37055000	-134.94640000	57.00000000	30.00	1.90
69.38889000	-134.96830000	54.45000000	33.00	1.65
69.38192000	-135.00660000	60.80000000	32.00	1.90
69.90256000	-136.33890000	52.80000000	33.00	1.60
69.89692000	-136.19410000	33.80000000	26.00	1.30
69.22164000	-134.84020000	48.00000000	30.00	1.60
68.98944000	-134.61190000	43.20000000	27.00	1.60
68.84389000	-135.15610000	54.40000000	32.00	1.70
69.29139000	-133.06690000	57.80000000	34.00	1.70
69.44334000	-134.38560000	47.60000000	28.00	1.70
69.55833000	-134.61690000	47.60000000	28.00	1.70
69.33472000	-135.35690000	54.40000000	32.00	1.70
68.88775000	-133.76760000	51.20000000	32.00	1.60
69.06778000	-133.73250000	54.40000000	32.00	1.70
69.20028000	-133.36250000	64.00000000	32.00	2.00
68.76167000	-133.76670000	56.00000000	35.00	1.60
68.84778000	-134.41420000	40.50000000	27.00	1.50
69.41578000	-135.84160000	60.80000000	32.00	1.90
69.21389000	-134.71250000	47.60000000	28.00	1.70
68.65083000	-136.22750000	56.00000000	35.00	1.60
68.99555000	-134.77610000	63.00000000	35.00	1.80
68.77611000	-134.13060000	57.80000000	34.00	1.70
68.98333000	-133.57360000	51.20000000	32.00	1.60
68.88472000	-133.67670000	49.60000000	31.00	1.60
68.99695000	-133.53050000	66.60000000	37.00	1.80
68.67028000	-134.00860000	52.80000000	33.00	1.60
68.94806000	-133.59890000	48.60000000	27.00	1.80

68.66933000	-135.31120000	51.00000000	30.00	1.70
69.06555000	-135.80440000	46.80000000	26.00	1.80
69.19361000	-135.34080000	53.20000000	28.00	1.90
69.09167000	-135.10420000	36.80000000	23.00	1.60
69.88250000	-132.83940000	41.60000000	26.00	1.60
69.23167000	-134.97530000	44.80000000	28.00	1.60
69.43955000	-135.51550000	45.00000000	30.00	1.50
69.45461000	-135.85440000	67.50000000	27.00	2.50
70.09236000	-134.44590000	74.40000000	31.00	2.40
70.01667000	-134.31340000	72.85000000	31.00	2.35
70.72889000	-133.97440000	47.50000000	25.00	1.90
70.39342000	-135.19930000	42.50000000	25.00	1.70
70.38203000	-135.09280000	47.60000000	28.00	1.70
70.47633000	-136.28070000	52.80000000	33.00	1.60
70.46322000	-133.49570000	46.80000000	26.00	1.80
70.37997000	-136.51430000	73.80000000	41.00	1.80
70.03833000	-130.10780000	72.00000000	40.00	1.80
68.77222000	-137.45360000	44.80000000	28.00	1.60
69.75594000	-139.74290000	39.20000000	28.00	1.40
69.34184000	-138.94860000	40.50000000	27.00	1.50
69.13139000	-138.73470000	38.40000000	24.00	1.60
70.11389000	-133.32970000	56.00000000	28.00	2.00
69.94442000	-134.08870000	59.40000000	33.00	1.80
68.65173000	-133.94990000	54.00000000	30.00	1.80
69.77608000	-132.07570000	66.30000000	39.00	1.70
70.33659000	-132.21820000	46.80000000	26.00	1.80
69.82903000	-133.87250000	48.00000000	30.00	1.60
69.71333000	-131.91190000	68.40000000	36.00	1.90
68.95341000	-133.45830000	49.60000000	31.00	1.60
69.97556000	-130.13610000	68.80000000	43.00	1.60
69.86953000	-135.92140000	59.20000000	37.00	1.60
69.45805000	-134.19750000	46.50000000	30.00	1.55
69.63931000	-133.46360000	43.20000000	27.00	1.60
69.25914000	-135.06620000	41.60000000	26.00	1.60
69.46222000	-134.65700000	66.00000000	44.00	1.50
69.43217000	-132.82500000	57.60000000	36.00	1.60
69.31361000	-135.32390000	46.40000000	29.00	1.60
69.57000000	-135.38950000	39.00000000	26.00	1.50
69.38750000	-132.74310000	62.00000000	31.00	2.00
69.77111000	-134.32800000	42.00000000	28.00	1.50
68.73389000	-135.88250000	51.00000000	30.00	1.70
69.49722000	-134.27360000	49.50000000	30.00	1.65
69.55833000	-134.61670000	47.60000000	28.00	1.70
69.46555000	-135.41500000	50.40000000	28.00	1.80
69.33334000	-134.50000000	57.60000000	32.00	1.80

69.10139000	-134.61500000	48.60000000	27.00	1.80
69.00806000	-133.61500000	42.00000000	28.00	1.50
69.18916000	-133.30390000	66.00000000	44.00	1.50
68.95695000	-133.64440000	48.00000000	30.00	1.60
68.87750000	-133.69890000	52.80000000	33.00	1.60
69.30805000	-135.61560000	39.15000000	29.00	1.35
69.35306000	-135.42610000	36.40000000	28.00	1.30
69.14861000	-135.41500000	50.40000000	28.00	1.80
69.28503000	-135.23150000	61.20000000	36.00	1.70
70.77042000	-129.35730000	108.00000000	54.00	2.00
70.35000000	-134.10000000	47.60000000	28.00	1.70
70.15156000	-132.73570000	60.00000000	40.00	1.50
70.15144000	-132.72980000	51.00000000	34.00	1.50
70.01681000	-134.31330000	86.95000000	37.00	2.35
70.56805000	-134.17020000	49.40000000	26.00	1.90
69.20753000	-135.85750000	48.00000000	30.00	1.60
69.08389000	-135.05140000	43.50000000	29.00	1.50
70.26336000	-132.31240000	52.20000000	29.00	1.80
69.26000000	-135.01610000	47.60000000	28.00	1.70
68.84744000	-133.67460000	62.90000000	37.00	1.70
69.29150000	-135.24870000	44.20000000	26.00	1.70
69.27792000	-136.30360000	33.80000000	26.00	1.30
69.56000000	-134.48360000	40.50000000	27.00	1.50
68.88055000	-135.30420000	49.30000000	29.00	1.70
69.47334000	-135.83890000	45.00000000	30.00	1.50
69.98167000	-133.51500000	52.20000000	29.00	1.80
69.30500000	-133.09500000	61.20000000	36.00	1.70
69.90334000	-136.76000000	54.40000000	32.00	1.70
68.85500000	-133.50330000	59.50000000	35.00	1.70
69.80666000	-136.33170000	51.20000000	32.00	1.60
70.07833000	-133.80500000	59.40000000	33.00	1.80
69.75445000	-136.99830000	42.00000000	30.00	1.40
69.39167000	-135.84670000	39.90000000	21.00	1.90
70.05500000	-133.63000000	60.80000000	32.00	1.90
69.67834000	-133.77170000	45.00000000	25.00	1.80
69.32000000	-133.13830000	54.40000000	32.00	1.70
69.29000000	-133.18560000	66.60000000	37.00	1.80
69.31167000	-135.91670000	42.00000000	28.00	1.50
69.35500000	-132.81000000	45.90000000	27.00	1.70
69.81000000	-135.33170000	54.40000000	34.00	1.60
70.41000000	-134.51170000	46.80000000	26.00	1.80
69.91500000	-136.41830000	49.60000000	31.00	1.60
69.42333000	-135.00830000	51.30000000	27.00	1.90
70.44500000	-133.32500000	48.60000000	27.00	1.80
69.40000000	-132.90170000	53.20000000	28.00	1.90

68.80666000	-134.69670000	51.20000000	32.00	1.60
68.74500000	-134.15500000	48.00000000	30.00	1.60
69.64833000	-137.75830000	50.40000000	36.00	1.40
69.51000000	-132.65170000	54.00000000	30.00	1.80
70.32333000	-135.44170000	62.90000000	37.00	1.70
68.68333000	-133.74000000	56.10000000	33.00	1.70
69.35000000	-133.05000000	74.80000000	44.00	1.70
70.21167000	-129.54670000	87.40000000	46.00	1.90
69.33667000	-133.07830000	57.80000000	34.00	1.70
69.81500000	-133.03500000	59.50000000	35.00	1.70
69.70667000	-136.45830000	54.40000000	34.00	1.60
70.06667000	-137.21830000	51.20000000	32.00	1.60
69.76000000	-140.24000000	43.20000000	27.00	1.60
69.15000000	-133.25000000	54.40000000	34.00	1.60
70.24834000	-134.15670000	62.00000000	31.00	2.00

## FIGURE CAPTIONS

Figure 1. Map showing distribution of subsurface well control. The 595 wells are located primarily within the Interior Plains, the Mackenzie Delta and Beaufort Sea regions and in the northern Yukon Territory.

Figure 2. Map of the average geothermal gradient for the sedimentary succession. Contour interval is 10 mK/m. High gradients tend to dominate in areas close to or within the Canadian Shield.

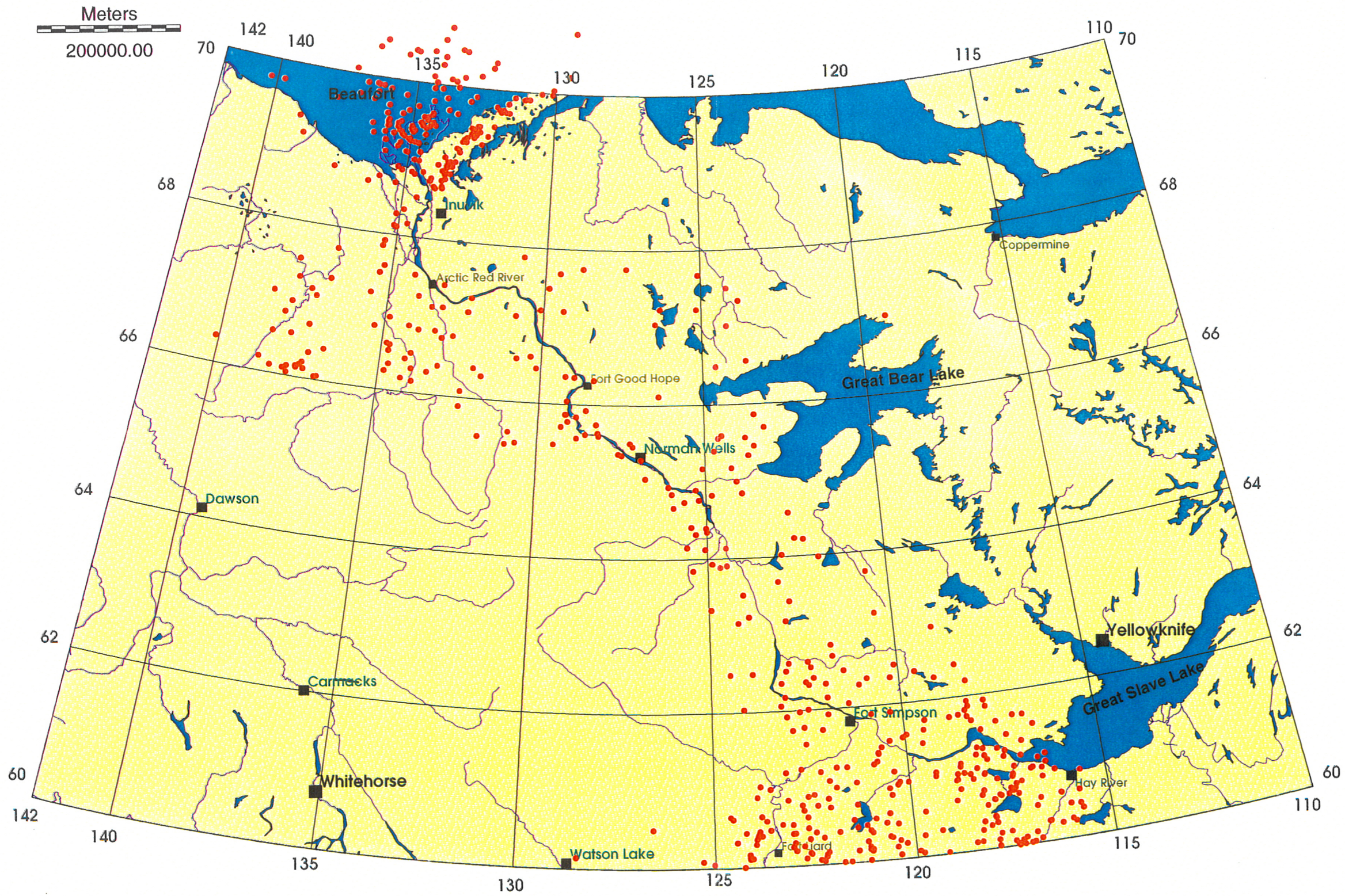
Figure 3. Map of temperature distribution at the -500 m level below the ground surface. Contour interval is 5 K ( $^{\circ}$ C). High temperatures occur in areas close to or within the Canadian Shield.

Figure 4. Map of effective thermal conductivity of the sedimentary succession. Contour interval is 0.3 W/m K.

Figure 5. Heat flow map for the sedimentary succession. High heat flow occurs in areas near or within the Canadian Shield. Contour interval is 30 mW/m<sup>2</sup>.

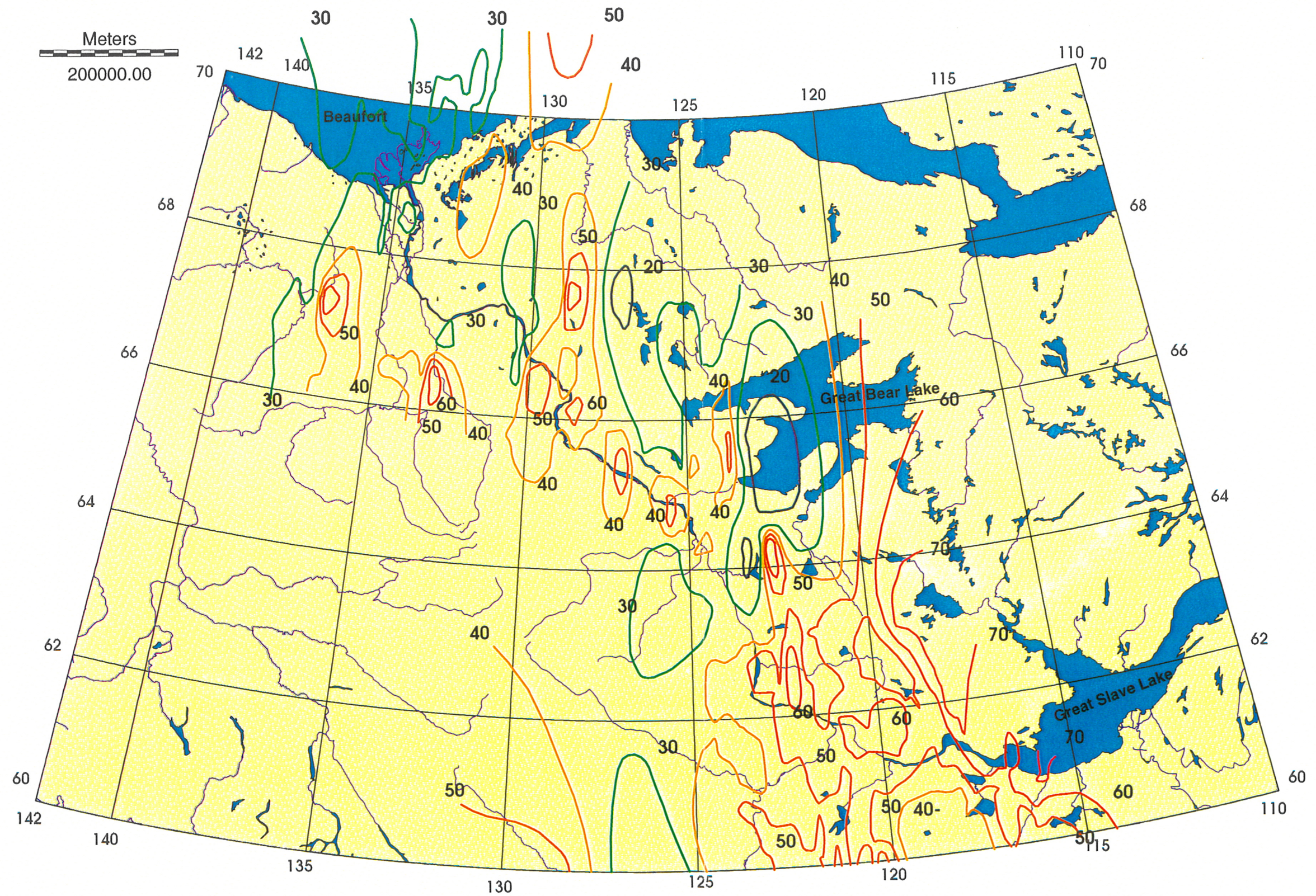


# SUBSURFACE TEMPERATURE WELL CONTROL





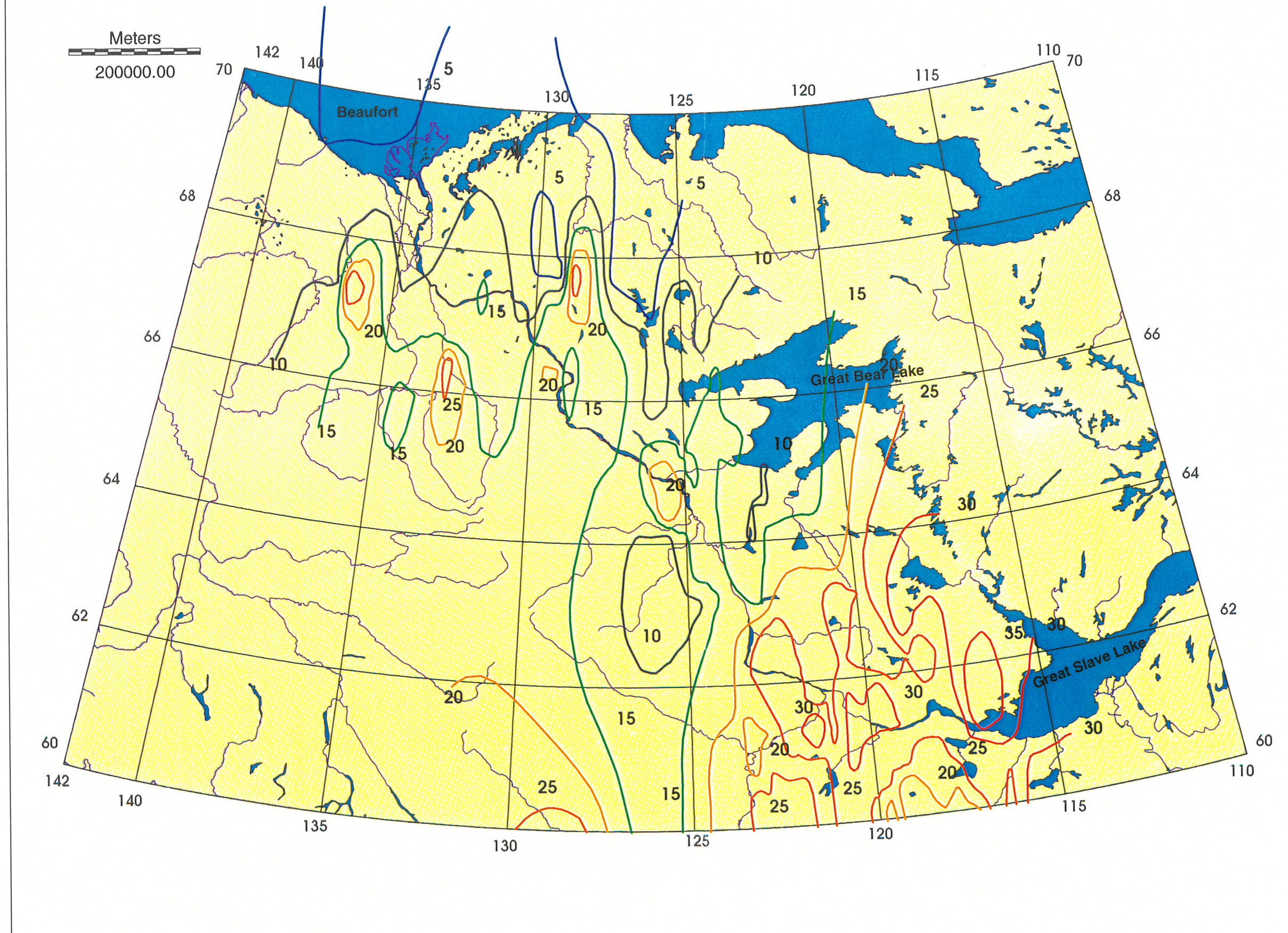
# GEOHERMAL GRADIENT (mK/m)



(MAJEROWICZ AND MURK  
FIG. 2



# TEMPERATURE (C) AT 500 METRES DEPTH

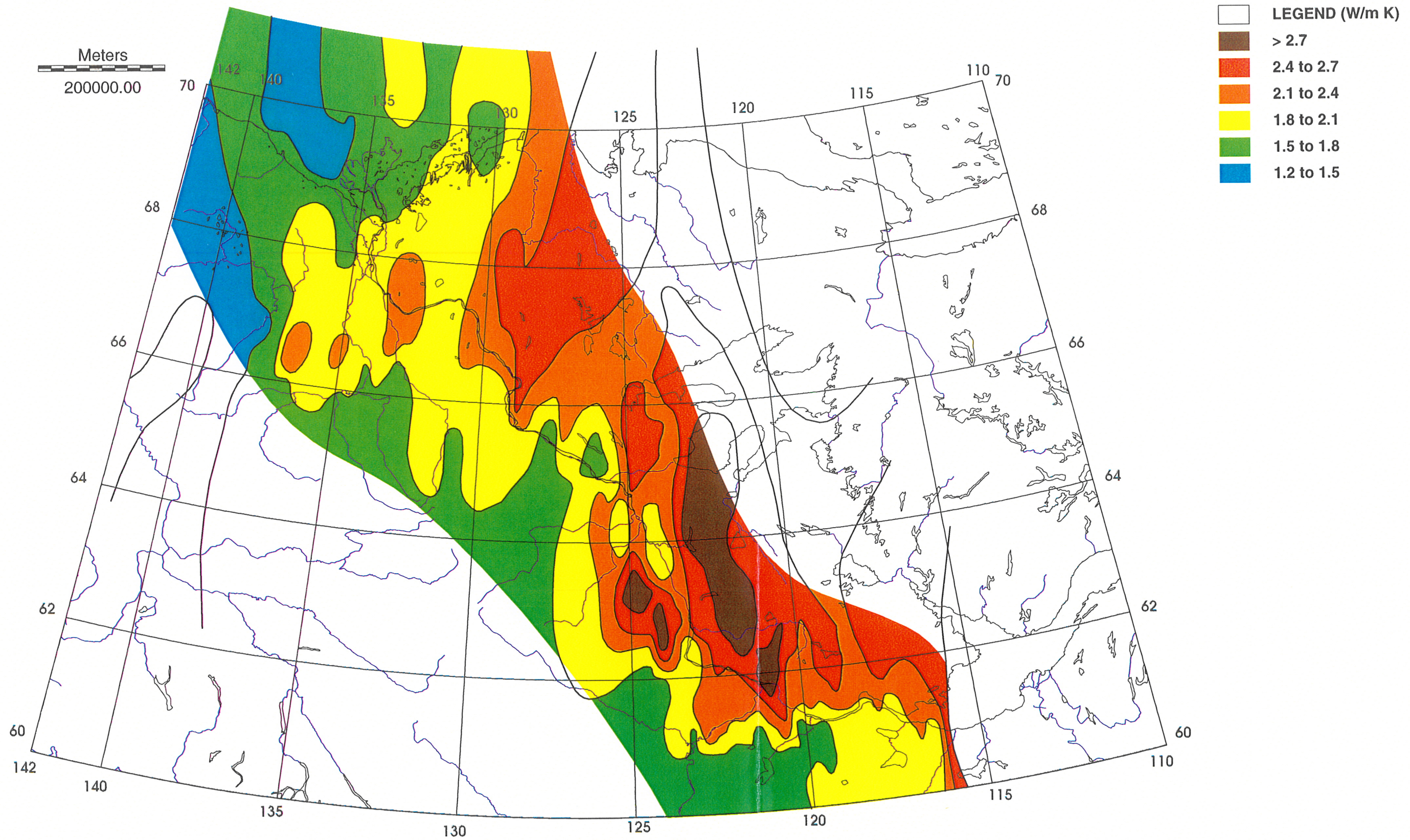


(MAJOROWICZ AND MORRIS)

FIG. 3



# EFFECTIVE THERMAL CONDUCTIVITY





# HEAT FLOW

Meters  
200000.00

- LEGEND (mW/m<sup>2</sup>)
- >150
  - 120 to 150
  - 90 to 120
  - 60 to 90
  - 30 to 60

