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Heat Flow and the Pleistocene Ice Margin

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Several observations lead us to suggest that the geothermal gradient measurements near the Pleistocene ice margin require re-analysis to account for the effects of micro-climates at the drill holes, including modification of the temperature gradients by recent climate change and by post-glacial warming. Post-glacial climatic changes affect temperature gradients in the upper two kilometers of the crust and this has not been consistently accounted for in previously published heat flow values. Human and natural drivers affecting our climate lead us to suggest that the geothermal gradients in shallow boreholes have been significantly underestimated of present day heat flow. In most cases, heat flow increases with depth in northern hemisphere periglacial regions in Eurasia and North America. This includes temperature gradients increasing with depth in thick clastic rocks in the Williston Basin where compaction causes an increase in thermal conductivity. Using a pollen analyses in upland lakes in southern Manitoba indicate that MJJA surface temperatures are 13 ˚C higher than they were 12,500 ka. Conductive heat flow models using the pollen temperature history as a forcing signal for surface temperature produce temperature vs. depth profiles with increasing gradients that are similar to profiles observed in the Williston Basin. Other observational evidence includes heat flow calculated from radioactivity in Minnesota is systematically higher than borehole measurements. This evidence leads us to believe the temperature has increased 15˚C since the last glaciation and temperature gradients are underestimated by 25-40%. This study proposes corrections for post-glacial warming using conductive heat flow models based on 15 degrees of warming and for recent warming.