Climate Reconstruction from Borehole Temperatures

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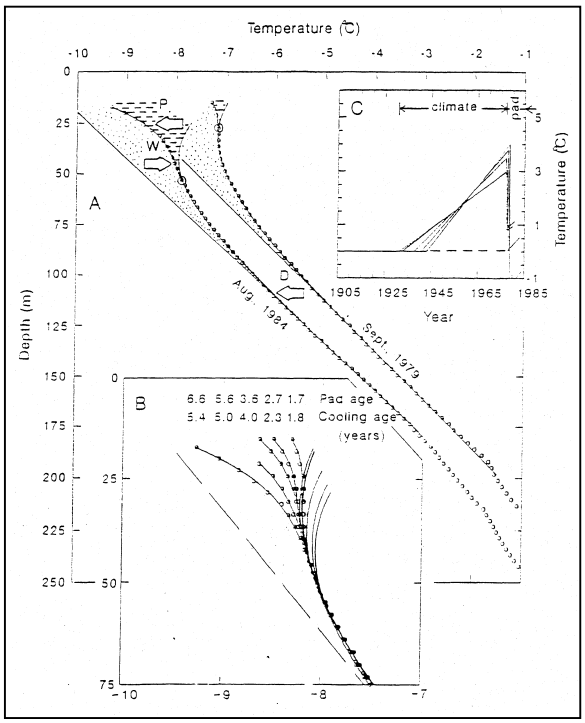


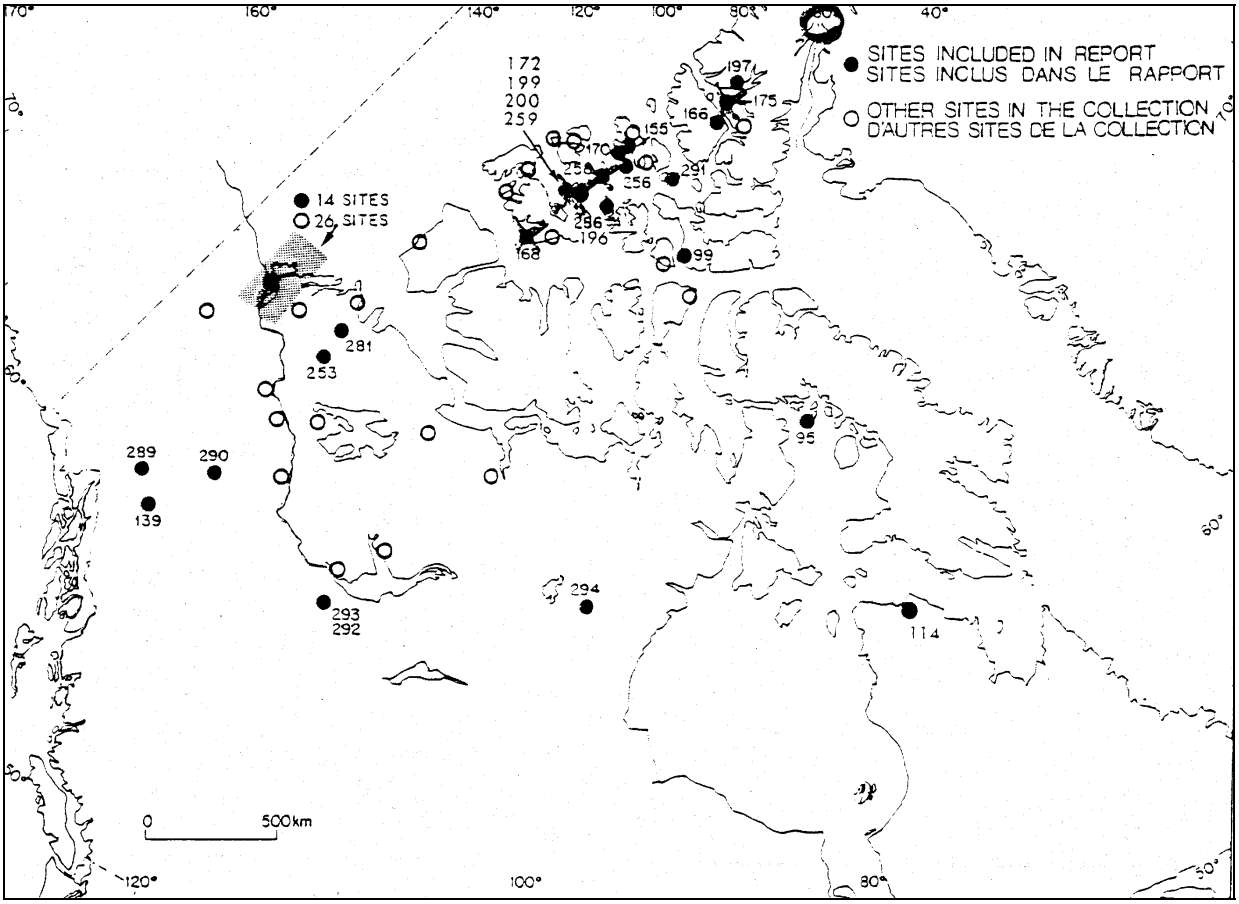
Many of you are aware of a seminal paper of Lachenbruch and Marshall of the US Geological Survey published in Science in 1986. They demonstrated that with a very accurate subsurface temperature profile going down several hundred meters, there were often variations in those profiles that were a direct physical consequence of temperature change near the ground surface. In the same paper they suggested that closer to the surface you may be able to see subtle variations on an annual basis that also reflect surface temperature changes on a much shorter time scale than they had looked at. Curvatures such as those shown in this figure might be the result of a temperature change over the last 100 years or so. They suggest that if there were the opportunity to measure temperatures in these wells on an annual or biannual basis, it might be possible to monitor ongoing climate change. In the particular example they present here, the interpretation isn't a climate change. However, it illustrates that if you can get accurate measurements in the upper 50 meters, it won't cost very much and it will allow monitoring of short-term climate change in the same way that their analysis examines longer-term change.

While at the GSC in the early 90's, Vic Allen, Margo Burgess and I got involved in an analysis of this sort. Many of you are familiar with the large network of petroleum exploration wells and mine holes that we had logged. There are about 140 sites across all of Arctic Canada where we have temperatures greater than 125 meters. There are hundreds of others with shallower temperatures. Only a couple of dozen of these are suitable for this type of interpretation of curvature by inversion analysis. Problems with the other sites include drilling disturbances and unknown thermal conductivity variations and so on that eliminate them.

Virtually all of these sites are inaccessible now. All of the petroleum exploration sites except for 6 or 7 are legally abandoned and filled with cement. We have access to about 6 or 8 of these legally abandoned sites however, scattered throughout the north. We have been able to get permission to reenter then occasionally to get logs. In 1992-93, we instrumented some of these wells with 65 m temperature cables, including dataloggers that sit entirely within the well.

This allowed the wells to be resealed at the tops, and thus still be legally considered sealed and abandoned.

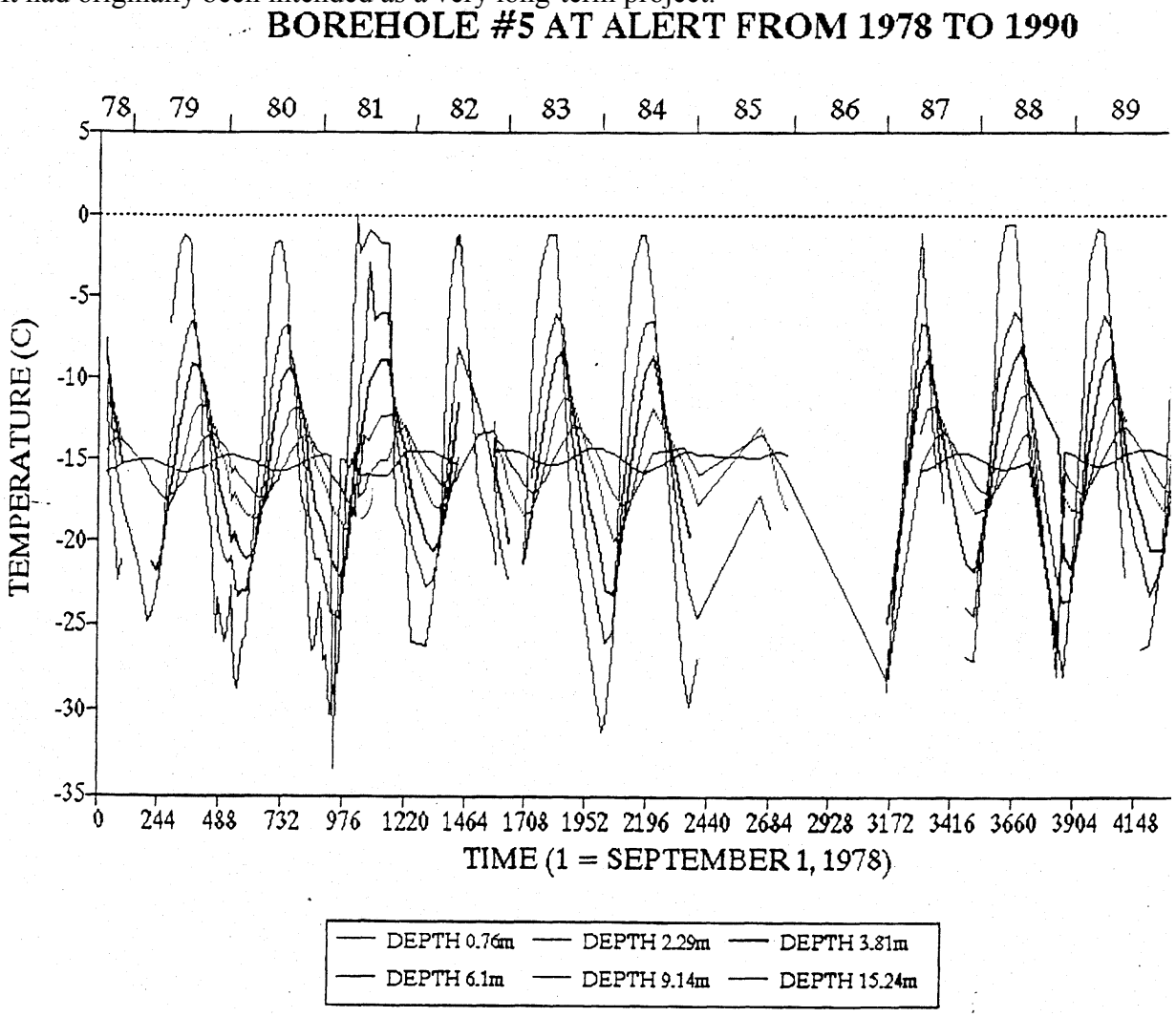
Shortly after the cables were installed, the program was effectively put into limbo by budget cuts. This year we have put together a proposal and have received funding to go back and rejuvenate some of these sites. Margo and I will be going up in April to redesign the experiment to better meet our needs, including replacing the loggers with higher precision equipment.



We will be reviving the program at three or four sites (see map). If you compare this to the map prepared by Sharon Smith for Jerry Brown, these sites fill a large hole in the coverage of Canada. We will install 5 m cables, with readings perhaps once per day, with site visits perhaps once every three years. On a longer-term basis, we can take down-hole temperature logs down to 500-700 meters, although that would be marginal information at this time.

This summer we will also visit Alert to rejuvenate another program that was started there in 1978. At that time, in collaboration with Roger Brown of the National Research Council and the Department of National Defense, we put in a temperature-observing program at five sites, with shallow cables at 50 to 60 meters depth. The data has been collected manually about once a month (once every three months at some sites) from September 1978. We hope to rejuvenate the program by installing automatic data acquisition. In addition, we hope to install air temperature sensors at this site as well as at some of the sites I was discussing earlier.

We want to make a long-term commitment to these sites, even though we only have the money to rejuvenate the programs. We would ask this group to vet this, and help decide whether this should continue in the long term. It's important that projects like this don't disappear soon after they are started. An experience from the past was project that received major funding over five or six years. As the budget started to shrink, it was suggested that the installation be pulled out. It had originally been intended as a very long-term project.



A final comment: EMR spent on the order of $50,000 to archive much of the data that had been collected at Schefferville. Much of it was in paper form but some was digital as well. It was put onto 9-track tape and placed in someone's office. I'm not sure now whether anyone can read that tape. Having spent that much money, it would have been simple at the time to send all that data to one of the World data centers like the one in Colorado, who are set up to archive data like that. They would have ensures that the tapes got refreshed regularly, or transferred to new media. They also would have handled requests for the data.