Deep Ground Temperatures, Ekati Mine, NWT

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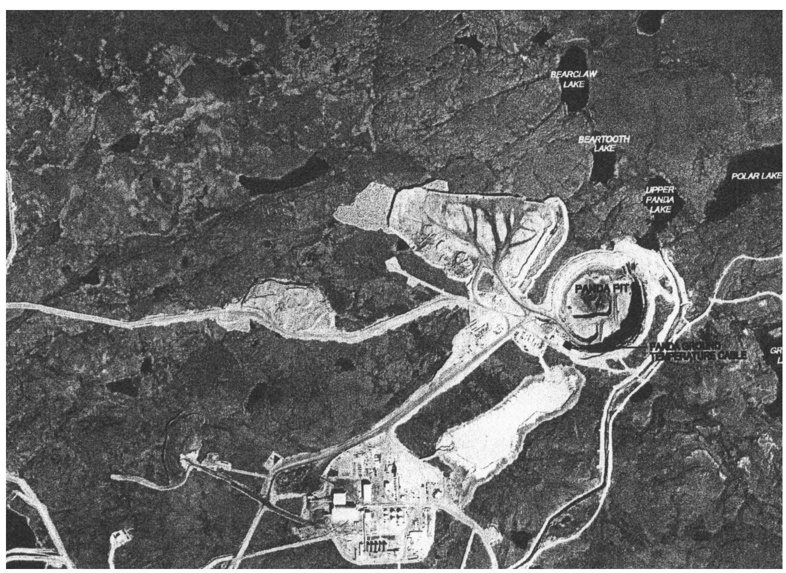
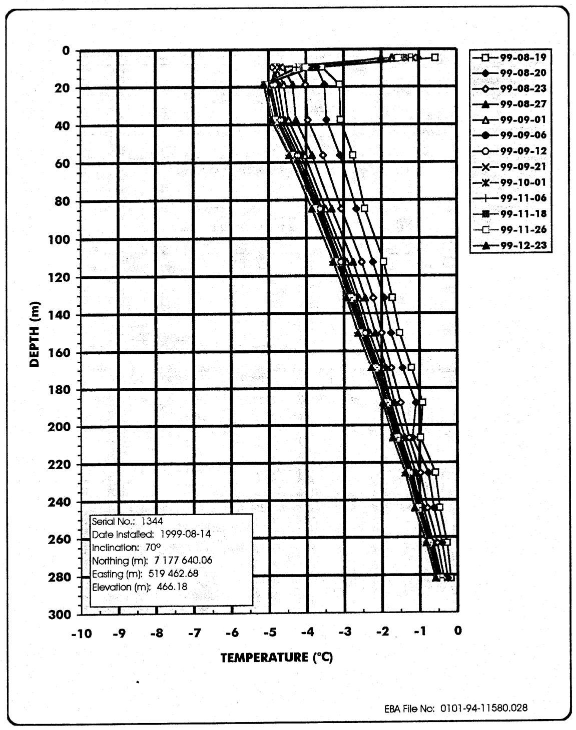
I believe that I am the only industry representative on the agenda today. As a consulting engineer, I want to remind you that consulting engineers design structures for their clients, and in the process of doing that in the north we collect a lot of data. The data is often focused on the principal activity of supporting our designs. However, there are some cases where some of the data that we collect does have some scientific value, and may be of some interest. The message that I bring today is that it may be useful to consider some forms of collaboration to facilitate data transfer from industry to science.

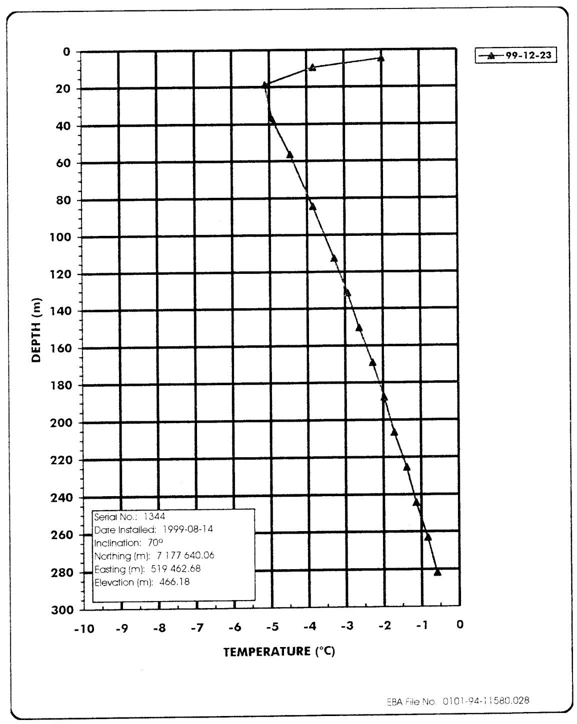
I'll show a couple of examples of deep ground temperatures today. The first is from the Ekati diamond mine site, in the heart of the Northwest Territory. Those of you who attended the International permafrost Conference in Yellowknife in 1998 would have had an opportunity to take the field trip to the Ekati mine. It's in a region of continental climate, and is at least 400 km away from the nearest ocean. The other data are from the Boston Gold project, part of the Hope Bay Volcanic Belt, which is a gold project in its advanced exploration stage. It’s on the edge of Bathurst Inlet, and while it's not right on the coast it's close enough to Coronation Gulf that it can be considered a marine environment.



Ekati is a diamond mine operation in the process of creating a large open pit that will eventually go to 300 m depth. The pit is about 3 years old. It started with pre-stripping to the granitic bedrock, with a relatively small pipe of kimberlite that you can see in the air photo. There was a lake called Panda Lake that has been drained, with a diversion channel here. There is a second Lake here, which is the second pit to be developed. In this picture it has been partially drained. As part of the engineering on this project, we estimated that the permafrost at this site went to a depth of 250 m: We were uncertain, and felt that that was a relatively conservative number. The inflow to the pit is groundwater, that is somewhat controlled by permafrost in the granitic rock. We installed the cable between the pit under construction and the next pit to be opened up. It was installed to a depth of almost 300 m.

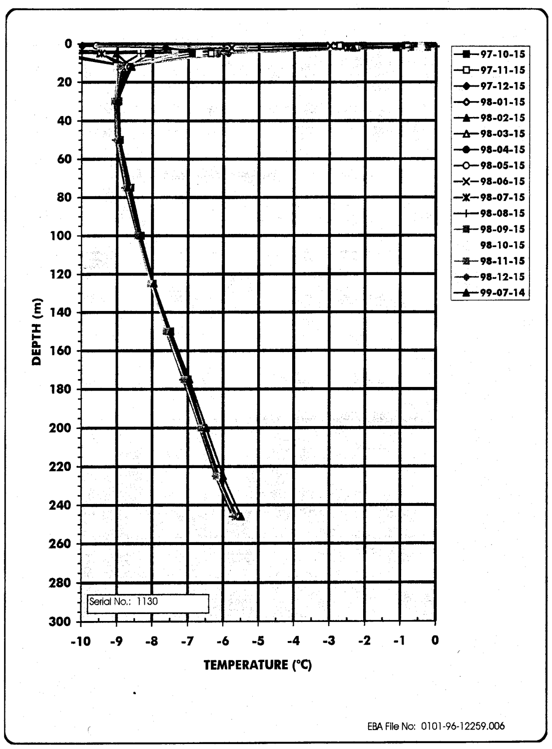
The purpose of the installation was to determine the depth of permafrost, since it could affect sub-permafrost ground water, which could lead to larger flows than we are predicting. It was installed in August 1999. This is the temperature profile: these measurements were taken manually quite soon after installation; I haven't weeded out any data. The last set on readings were taken last month, and the readings have pretty much stabilized.

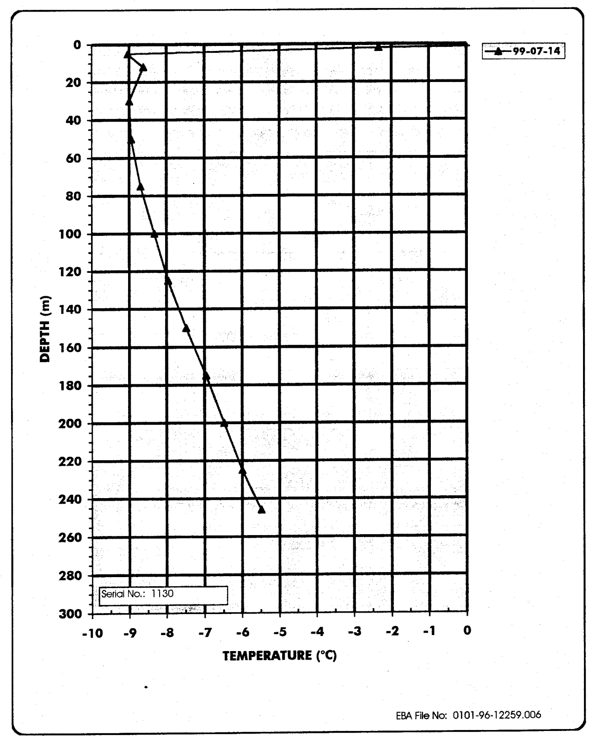




If you look at the last set of readings, you can see we didn't hit the bottom of permafrost with out cable, but extrapolation of the profile gives the bottom at 320 m, a relatively accurate estimate of what permafrost thickness is at that location. That was the principal objective in this installation. There are other things to see in this profile. If you look at it in terms of what Al Taylor discussed earlier, you can look for what I would call the Lachenbruch anomaly. Lachenbruch's work on the north slope of Alaska shows a kind of curvature in the profile, which Al showed this morning. I just wanted to look at it to see if there was the same anomaly in this profile. Clearly, it's not there: it's a pretty standard profile.

I will come back to that profile later. The other site is at Bathurst Inlet. We have a cable that was installed in the summer of 1997, monitored with a data logger form installation until last summer. We have a relatively stable geothermal gradient at this site as well. Again, looking at just the last set of readings, you can see what the gradient looks like. Both of these installations are in what would be called homogeneous material. A nice uniform igneous rock, so that there are no significant conductivity contrasts, no real layering to any extent, and there is no moisture movement within the permafrost because of the temperatures involved, so that this should be a classical heat conduction analysis.





Here are the time-temperature records for some typical depths (100, 150 and -250 m depth). The datalogger was in place and operating for about 14 months, taking readings twice a day during that period. We can see a fair bit of noise in the data, and equilibration early on. If we tried to do some simple linear curve fitting to that, it really doesn't tell us anything with 14 months of data, although there is no indication of a warming trend over that period of time, with a slope of about 10^{-7}.

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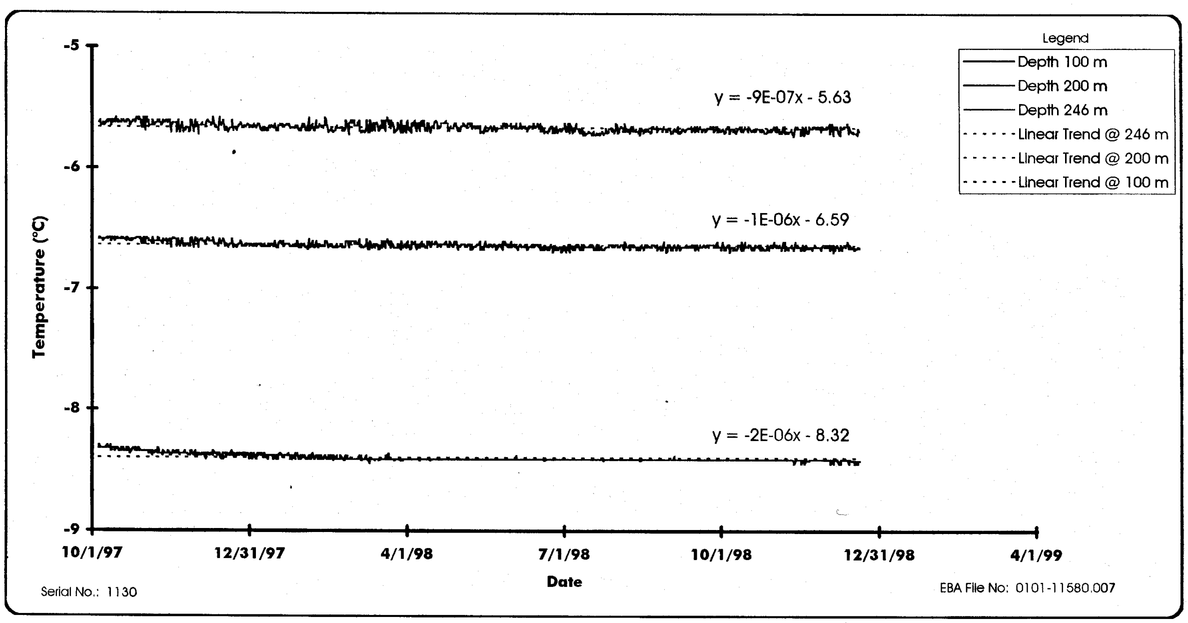
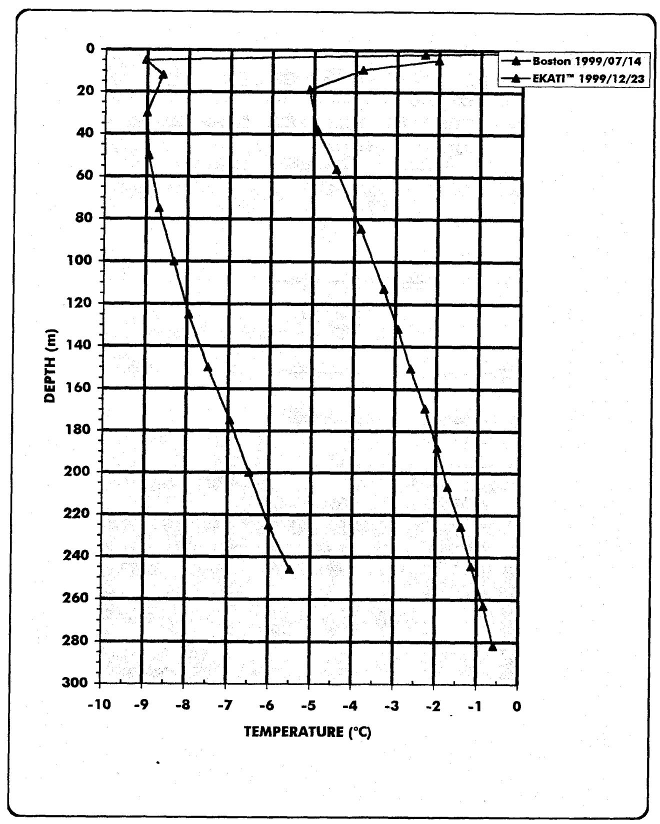


To come back to what both curves are telling us, this shows both curves on the same graph. Obviously, the curve from further north is quite a bit colder, but the shapes of these curves are substantially different. In Ekadi, we see a curve that is clearly convex to the warm side. Without analyzing these, you would have a hard time convincing me that there is any evidence in that record of climatic warming. In fact, the curvature suggests that there could be climatic cooling. The other curve is clearly convex to the cold side. Toward the top, although we don't have a clear Lachenbruch anomaly, we can see the change in gradient that he has reported. I could be convinced that there is a warming trend happening at that particular site.



I present this because it is interesting data. We don't often get the opportunity to install cables to these depths where we can really get a gradient. We've installed cables at Polaris mines down to about 300 m. We have also installed one at the Diavik project. I don't happen to have that data. However, it's becoming easier and easier as we get into mining activities (whether they are deep mines, open pits or underground) to justify this kind of installation.

I'll conclude with the simple comment that it is a challenge to fabricate and install a thermistor cable to 300 meters and have it work for a reasonable length of time. We've been constructing our own cables and installing them across the arctic for nearly 30 years, and I think it's taken 20 years to get to the point that we are doing it right. They have evolved to the point that we now have what we believe is a fairly reliable system for these unique installations. They can tolerate hydrostatic heads of 300 meters, and the tension that develops in the installation.