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REPORTS ON CURRENT WORK

TEMPERATURES IN THE DEVON ISLAND ICE CAP, ARCTIC CANADA

By W. S. B. PATERSON

(Polar Continental Shelf Project, Department of Energy, Mines and Resources, Ottawa K1A 0E4, Canada)

ABSTRACT. Temperatures have been measured in a 299 m bore hole that reaches the base of the ice near the divide of the main ice cap on Devon Island in the Canadian Arctic Archipelago. Temperature ranges from −23.0°C at a depth of 20 m to −18.4°C at the bottom. The difference between surface and bottom temperatures is about 1.5 deg less than expected for a steady state. Recent climatic warming seems the most likely explanation of the discrepancy. The temperature gradient in the lowest 50 m is approximately linear and corresponds to a geothermal heat flux of 1.5 h.f.u. This value may be invalid, however, because temperatures at and below this depth have probably been perturbed by changes of surface temperature during the past several thousand years, particularly by the warming at the end of the last glaciation. A detailed analysis of the results is in progress.

DISCUSSION

W. F. BUDD: Do you have any measurements for control of elevation change with time (or balance) to be able to separate climatic temperature changes from changes due to the ice-cap elevation variation?

W. S. B. PATERSON: By comparing the decrease in length of the bore hole in one year with the annual mass balance (10 year average) I conclude that the ice cap, at the drill site, is thickening slightly at present. However, I do not know for how long this thickening has been taking place.

FUTURE REGARD TO THE ATOMIC WASTE DISPOSAL PROBLEM

K. PHILBERTH

(Peter-Rosegger-Strasse 6, 8031 Puchheim, West Germany)

ABSTRACT. The waste disposal in an ice sheet need not rely on storage periods longer than some hundreds of years. Three hundred years after dumping, the radioactive power of the fission products has decreased to about 10^{-4} times the value of two-year-old waste. Six hundred years after dumping, it has decreased to about 10^{-6} times the two-year value. There are only four radioactive fission isotopes with half-lives between six years and 60 000 years: ^{85}Kr (10 years) has practically disintegrated after 300 years. ^{90}Sr (with its daughter ^{90}Y) and ^{137}Cs (both 30 years) are reduced to 10^{-3} after 300 years and to 10^{-6} after 600 years. ^{151}Sm (85 years) has an extremely low disintegration energy; the waste contains only a very small percentage of this isotope.

Radiation and thermal power of all fission products with long half-lives (more than 60 000 years) are many orders of magnitude smaller than those of all other fission products in waste that has been stored for several years. Furthermore, long-lived fission products have almost no radiation other than β-radiation. Future research is necessary as to whether and to what extent such long-lived isotopes, and possibly other isotopes (e.g. ^{239}Pu or ^{14}C), have to be separated and as to how it could be done in the safest and most economical way. The technology of separating and recycling ^{239}Pu, an extremely valuable fissionable fuel, is being developed in view of the increasing importance of breeder reactors. The separate disposal of long-lived isotopes would not raise serious thermal or handling problems; for example, they could be deposited in a highly concentrated form into a deep geological formation.

Should the waste be retrievable or not? That is ultimately a philosophical question. Which is more reliable, man or Nature? Should we trust that our descendants will have sufficient knowledge and goodwill to keep the waste safe and not misuse it—or should we rely more on Nature not to bring the waste into the biosphere by unexpected catastrophic events?

The proposed ice-sheet disposal—be it in deep ice layers or near the surface—avoids the main dangers of both aspects. Under normal glaciological conditions the waste containers are practically irretrievable from the beginning (deep-layer deposit) or after some centuries (near-surface deposit). If, however, a catastrophic climatic change should melt away the ice sheets very quickly, the ablation melts off one after the other of the upper layers while the deep layers still remain cold. Under these circumstances the containers are "self-retrieving": they come to the surface of the ice or of the ice-freed bedrock and can easily be picked up. Further research on such a melt-out process and on the durability of the waste containers and their solidified contents should be carried out.

CREEP INSTABILITY OF ICE SHEETS

Garry K. C. Clarke

(Department of Geophysics and Astronomy, University of British Columbia, Vancouver, British Columbia V6T 1W5, Canada)

Abstract. The equation governing the growth or decay of a temperature perturbation T' in an ice slab under shear stress σ_{xy} is

$$\frac{\partial^2 T'}{\partial y^2} - \frac{V}{\kappa}\frac{\partial T'}{\partial y} + \frac{aT'}{K} = \frac{1}{\kappa}\frac{\partial T'}{\partial t}$$

where K and κ are respectively the thermal conductivity and diffusivity of ice, V is the advection velocity normal to the bed and

$$a = \frac{\partial}{\partial T}\left[2B_0 \exp\left(-Q/RT\right) \sigma_{xy}{}^{n+1}\right]$$

is the rate of increase of strain heating with temperature assuming a power law for flow. For a slab of infinite thickness under constant stress and at constant ambient temperature T, Fourier analysis gives $-k^2 + a/k < 0$ as the condition for stability where k is the wave number of a sinusoidal perturbation. When the slab has finite thickness the stability depends on the sign of the eigenvalues λ_m of the perturbation equation and on the boundary condition at the ice–rock interface. In general the eigenfunctions and eigenvalues must be found by approximate methods such as the Rayleigh–Ritz procedure but in the case where the stress and ambient temperature are constant over the slab thickness and there is no advection the eigenfunctions are either sines or cosines depending on the boundary conditions.