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SIR,

Reference overlooked in “Determination of timing and location of water movement and ice-layer formation by temperature measurements in sub-freezing snow” by Pfeffer and Humphrey

In our recent paper (Pfeffer and Humphrey, 1996), we neglected to make reference to a very closely related previous paper (Echelmeyer and others, 1992). Since part of Echelmeyer and others’ work is nearly identical to part of ours, we want to draw attention here to their work. Their temperature measurements and subsequent analysis led to inferences about refreezing and piping at depth which are compatible with our conclusions. Their work also shows evidence of pipes transporting water to greater depths than at our site (a more shallow snowpack overlying superimposed ice), and provides additional convincing evidence of the effectiveness of piping and layering processes in transporting water through sub-freezing snow.

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17 March 1997

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SIR,

Comments on “Temperate ice permeability, stability of water veins and percolation of internal meltwater” by L. Lliboutry

This paper begins by saying: “According to Nye (1976), the outburst of glacier-dammed lakes, in particular the well-known Icelandic jökulhlaups, should proceed from irreversible broadening of the capillary veins”. The paper quoted, in fact, says exactly the opposite. Indeed, it has a complete section (section 6) explaining why vein flow should *not* lead to jökulhlaups. It is hard to see how such a fundamental misunderstanding could arise but I am glad to have this opportunity of correcting it.

A few lines further on there is a second point. Professor Lliboutry says “Nye’s (1976) theory... contradicts Nye and Mae (1972)” but does not elaborate further. No contradiction was intended. If he could say what kind of contradiction he has in mind here, I could try to resolve it.

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24 February 1997

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SIR,

Reply to the comments by J. Nye on “Temperate ice permeability, stability of water veins and percolation of internal meltwater” by L. Lliboutry

Professor Nye is right and I apologize. I do not remember whether I intended to say “...Icelandic jökulhlaups *might* proceed...” instead of “should proceed”, or if my wrong assertion came from not reading again Nye’s (1976) paper before writing my introduction. Anyway, my sentence should not refer to jökulhlaups and read: “According to Nye (1976), an irreversible broadening of the water veins can occur if the pressure difference between the ends of the vein is fixed.”

The essential point is that Nye’s stability analysis of water discharge through capillary veins was unsound, because capillary and salinity effects were ignored. Nye applied to veins Röthlisberger theory for large waterways. In this theory, melting at the walls comes only from the energy loss due to the water discharge. For capillary veins, this term, as well as the shrinking by plasticity, are totally negligible. The heat flux that reaches the walls is almost exclusively (with my notations)

$$\phi = \frac{2\pi K_i}{\ln(D/d)}(\theta_L - \theta_V)$$

where θ_L and θ_V are the temperatures within the ice at the lenses walls and at the veins walls, respectively. Both are

governed by interfacial energies and respective salinities. The heat flux would exist without any water discharge. A stable regime exists, however, because for some vein size $\theta_L = \theta_V$.

Nye's (1976) "contradicts" Nye and Mae (1972) because it ignores the important findings of this previous work. It was clearly asserted in the abstract: "Internal melting and freezing at grain boundaries and veins will occur in temperate glacier ice, with some effect, not discussed here, on its permeability to water." My paper affords this missing discussion and shows that it is not "some" effect; it turns to be the essential one.

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26 March 1997

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Sir

Acknowledgement of Professor Lliboutry's reply to "Comments by J. Nye on "Temperate ice permeability, stability of water veins and percolation of internal meltwater" by L. Lliboutry"

I am grateful to Professor Lliboutry for his response. On the second point, he is perfectly right in pointing out that my (Nye, 1976) paper omitted the heat flow between lenses and veins; this had indeed been treated quantitatively by Nye and Mae (1972), but ignoring any effect of the different salinities and without considering in detail the effect on permeability. I am glad to see that Professor Lliboutry has now given attention to the effect this heat flux may have on the permeability of glaciers to water.

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26 March 1997

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- Nye, J. F. 1976. Water flow in glaciers: jökulhlaups, tunnels and veins. *J. Glaciol.*, **17** (76), 181–207.
Nye, J. F. and S. Mae. 1972. The effect of non-hydrostatic stress on intergranular water grains and lenses in ice. *J. Glaciol.*, **11** (61), 81–101.