sile strength on the order of 1 MPa. Using this value, onecan see from the plots in Figure 1 that the basal tensile stress never reaches this magnitude. This would indicate that this model is insufficient for describing the failure of ice under the influence of buoyant stress alone. Values for tensile strength given by Vaughan are on the order of 0.1–0.5 MPa, comparable to the stress maxima in Figure 1, but these data are primarily determined from surface studies where the effects of firn lessen the tensile strength of the ice. They are therefore considered irrelevant in a discussion of buoyant stresses initiating fracture at the base of a glacier, so is ignored.

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The Editor,
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SIR,

Reply to the comments of J. P. Kenneally on "Buoyancy-driven lacustrine calving, Glacier Nef, Chilean Patagonia" by D. Benn and C. R. Warren

We are grateful to James Kenneally for drawing our attention to an error in our modelling work, which was the result of an unfortunate structural flaw in the programming. His recalculations show that the maximum tensile stress at the base of a buoyant glacier tongue (modelled as a rigid beam) is almost an order of magnitude less than that given in our original paper, and is hence unlikely to account for the large tabular icebergs at Glaciar Nef. But if the buoyant calving mechanism that we proposed cannot account for the pattern of calving at the glacier, what can? This question is of more than site-specific importance. Significant numbers of Patagonian outlet glaciers are undergoing rapid calving retreats in deep (>150 m) proglacial lakes, or have done so in recent years (Warren and Aniya, 1999; Harrison and others, 2001; Skvarca and others, 2002), and calving behaviour similar to that observed at Glaciar Nef has also been reported in Alaska, U.S.A. (Lingle and others, 1993). Buoyant forces are the most intuitively obvious explanation for the many large tabular icebergs that are typical of such contexts. Such forces have been identified as triggers for deep-water lacustrine calving at numerous sites around the world (Holdsworth, 1973; Derbyshire, 1974; Theakstone, 1989), and in our original paper we presented several lines of evidence demonstrating the importance of such forces at Glaciar Nef. It seems, however, that buoyancy acting alone exerts insufficient stress to initiate crack propagation at the glacier bed.

Our buoyant calving model neglects the effects of progressive bending of the ice in response to the torque imposed by ice buoyancy. As pointed out in our original paper, bending of the ice will reduce the tensile stress at the ice base by accommodating through creep part of the buoyant force and associated torque. We therefore suggested that the buoyant calving mechanism is likely to require special conditions such as rapid surface ablation and stress build-up. Kenneally's work shows that, even under such conditions, basal tensile stresses are never likely to be large enough to cause the calving of large, coherent sections of the glacier terminus.

Our model also neglects longitudinal stresses in the glacier arising from a down-glacier reduction in basal shear stress and an increase in sliding velocity near the grounding line. We believed this omission to be justified because up-glacier retreat of the grounding line at Glaciar Nef had not been accompanied by a series of calving events. We therefore assumed that longitudinal stresses near the grounding line were too small to initiate calving, and did not consider them. It is, however, interesting to speculate whether calving events at Glaciar Nef (and at other glaciers which approach or reach flotation) could be explained by a *combination* of longitudinal stretching and buoyancy-induced torque. Individually, neither mechanism may be sufficient to initiate fracture, but in some circumstances their combined effect may be large enough to cause high-magnitude/low-frequency calving. Unfortunately, glacier geometry, velocity and subglacial topography are insufficiently well known at Glaciar Nef to test this hypothesis. The calving problem is a multifaceted one, and different combinations of processes may operate in different circumstances. Available evidence from glaciers terminating in deep lakes indicates that, acting in concert with other factors, torque arising from buoyant forces plays a role in calving.

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