CORRESPONDENCE

The Editor,
The Journal of Glaciology

SIR,

Ice action on shores

In two recent issues of the *Journal* L. Goldthwait (Vol. 3, No. 22, p. 99-102) and J. N. Jennings (Vol. 3, No. 28, p. 228-29) have drawn attention to the dominant role of ice expansion in the formation of shoreline ramparts. I wish to draw attention to an earlier article by R. L. Nicholls (*Journal of Glaciology*, Vol. 2, No. 13, p. 172-73) and to some observations of my own, all from the Eastern Canadian Arctic, that demonstrate the formation of ramparts, at least in this area by large ice floes charging on to the shore after a change in wind direction.

It is not clear from L. Goldthwait's article how many of the observed rocks were actually seen to be pushed by expansion of the ice. The lakes in New England and in other adjacent parts of the United States and Canada are notorious for the damage caused by ice to the summer chalets on their shores, and I have discussed the problem with a number of the chalet occupants. Their general view was that the damage was caused by ice expansion, but on questioning them in detail I came to the conclusion that their opinions were of little value because they are not witnesses of the events; they arrive in their chalets to find the damage after the ice has gone and leave before the ice reappears in winter.

When Professor R. P. Goldthwait and I first set foot on Generator Lake in the centre of Baffin Island in the early spring of 1950 it was completely covered with 5 to 6 ft. (1·5 to 1·8 m.) of ice and some 15 in. (0·38 m.) of snow, and Goldthwait posed the question as to whether ice expansion or drifting of ice floes caused the striking boulder ramparts which stood some 4 ft. (1·2 m.) above lake level. At the time I believe we agreed there was no evidence to suggest that any rampart building action had occurred during the previous winter.

I lived near the shore of this lake for the rest of the summer and saw plenty of ice floes building ramparts. The ice broke up into major portions in the middle of July and the lake rose by about 2 ft. (0·6 m.) in level; even by the end of August, when winter was setting in, about 40 per cent of the lake surface was still covered with large floes. During August, when the floes had their greatest freedom and there were frequent storms, we would sometimes go to bed with all the ice packed into the far shore some 4 miles (6·4 km.) away and be awakened by the thundering roar of large floes charging up the shore close by. The ice, as much as 4 ft. thick, sometimes rafted as it came ashore and sometimes stood end up on the beach 12 ft. (3·6 m.) high. Large boulders and sediments were pushed ashore some 10 to 20 ft. (3 to 6 m.). Occasionally odd rocks found their way on to the top of the ice and were rafted away with it on the return of an off-shore wind.

All the evidence we obtained at Generator Lake showed that the ramparts were formed by drifting floes riding up the shore and the actions we witnessed could account for all the relic ramparts around the lake. Admittedly we do not know what occurs during winter.

In the coastal inlets of Baffin there is a large tide and many boulder ramparts, but the most prominent are more like reefs and only become visible at low tide; they are a hazard to the landing of boats. When the tide is low at Frobisher, Pangnirtung and Clyde one has to clamber over a ridge of slippery boulders before walking up the beach. I discussed the formation of the boulder reefs with several of the people who had lived in these places for several years. They all reported having seen ice floes, and occasionally small bergs, charging ashore and pushing up the boulders and sea mud during the time of break-up of the sea ice. The possibility of ice expansion being an important agency at these places seems rather unlikely as the ice fringing the shore is continuously ruptured by the large tides.

In winter at Frobisher the view from the airport across the frozen bay is dominated by a curious array of ice hummocks. They were sufficiently curious for us to dig right through one of them; when we first penetrated the hummock it was low tide and we came to the top of one of the boulders forming the reef. We came back across the ice a few hours later and, on looking into the hole, found that the boulder had disappeared; we saw only water. Apparently the hummocks are caused by the upstanding boulders poking up and displacing the sea ice at the same point every time the tide falls. The hummocks increase progressively in height during the winter because the sea ice grows downwards at high tide where the boulders leave hollows in its lower surface.

W. H. WARD

147 Rickmansworth Road,
Watford, Herts.
10 August 1958