THE ARCTIC

Peppering of Pingos

from our Geomagnetism Correspondent

ARCTIC seas are not, for obvious reasons, heavy shipping areas, with the result that bathymetry is poorly known and possible hazards to shipping are almost completely uncharted. The discovery of oil in Alaska and the use in 1969 of the SS Manhattan to test the feasibility of waterborne access to the oil fields have led, however, to an extensive programme for charting of northern seas and the investigation of the seafloor, chiefly by Canada. As a result of such studies in the Beaufort Sea, Shearer *et al.* (*Science,* **174**, 816; 1971) are now able to report their discovery of a feature of the ocean floor which is of both practical and academic interest—the pingo.

The road to the discovery was actually begun by an observation taken during the voyage of the Manhattan to Prudhoe Bay in 1969. At one point during passage through the Beaufort Sea (actually about 120 km north-west of Atkinson Point, Northwest Territories) there occurred a rapid shoaling which led to a reduction of water depth from 49 m to 23 m within a horizontal distance of 200 m followed by an equally abrupt return to the original depth. The region including this topographic feature has since been the subject of a more detailed bathymetric, sonar, gravimetric, magnetic, seismic and sampling survey which has led to the discovery that the original feature—nicknamed the "Admiral's Finger"—is far from unique. The whole area is in fact peppered with similar underwater mounds rising from an otherwise smooth seafloor. Each such mound is usually irregularly and asymmetrically shaped with one side steeper than the other. The base diameter averages 400 m, the average elevation is 30 m, and in most cases a moat up to 10 m deep surrounds the base. Within the 5,000 km^2 survey area seventy-eight mounds were discovered scattered apparently at random and with depths of water above their summits ranging from 15.4 to more than 45 m.

In a region where shipping is already subject to the iceberg hazard, the existence of mounds scattered randomly around the seafloor is, of course, a matter of severe practical importance. Academic interest, on the other hand, centres on their cause. The mounds do not seem to correlate with any other of the geophysical parameters measured simultaneously with bathymetry. The magnetic field, though measured to the nearest gamma, indicated no anomalies in the sub-bottom structure; nor did the gravity field measured to the nearest milligal. Moreover, seismic studies showed the sub-bottom reflectors to be more or less horizontal beneath the mounds.

What are these mounds? Basing their argument largely on a comparison between the morphology of the mounds and that of similar structures found 120 km to the south on the Tuktoyaktuk Peninsula, Shearer and his colleagues suggest that the features are pingos—hills which have a central core of ice. This being the presumed case, all that needs to be decided is when and how they were formed.

There seem to be two main possibilities—the terrestrial origin and the submarine origin. By the first the mounds are the submerged portions of pingos formed above sea level during the last glacial maximum when, as a consequence, the sea was about 100–150 km below its present level. The exposed portions of the present Beaufort Sea floor, outside the ice margin but subject to permafrost, would have contained lakes which did not freeze completely to the bottom. Some of these would subsequently have been shoaled either by infilling or draining to produce a body now defined as a pingo. The problem with this idea, however, is that it is difficult to imagine that subsequent wave action would not have eroded the pingos away by now.

The second possibility is that the mounds are pingos "in the genetic sense"—formed in the submarine environment since the postglacial rise in sea level. If the lakes in the previous example were not shoaled before the inundation by seawater, the remaining fresh lakewater would have to mix with seawater when such inundation took place. In this case the unfrozen water of the lake would come under the thermal influence of the overwhelming sea. Because the seawater temperature was almost certainly below −1° C—that is, lower than the temperature of the lakewater—the 0° C isotherm below the old lake would have moved downwards into the sediment thereby causing a freezing of the interstitial water and the consequent upheaval of the overlying material.

Of the two theories Shearer and his colleagues favour the second because of the erosion problem. They then go on to estimate the minimum age of a mature pingo by estimating the time required to freeze the depression of the permafrost layer formed in the insulated region beneath the original lake bed. Making reasonable assumptions about the size and shape of the depression, the thermal conductivity of the sediment, the surface temperature and geothermal heat flow, they come up with the figure of 5,000 years. In other words, on this estimate—and if pingos are of submarine origin—the postglacial rise in sea level must have taken place before 5,000 years ago.

A New Magnetic Reversal at 12,500 Years?

IN next Monday's *Nature Physical Science* (December 27) Mörner *et al.* report their discovery of a reversely magnetized sediment section about 12,500 years old. The section in question is part of an oriented core, 14.5 m long, from Gothenburg, south-west Sweden, which spans the time range 12,600 years to 8,600 years before present (from the early Ågård Interstadial to the mid-Boreal)—and there is little doubt that this dating is correct. The stratigraphy of southern Scandinavia is well known and a well dated climatic zone system has been determined for this range of time. For the Gothenburg core both climatic and stratigraphic dating agree well.

The core contains thirteen stratigraphic units, only the lowermost (earliest) sample (layer 13) of which is reversely magnetized. The boundary between units 13 and 12 is the boundary between the Ågård Interstadial and (above) the Fjärås Stadial and has previously been dated at 12,400 years old. Thus in the view of Mörner and his colleagues 12,400 years represents the upper boundary of a reversal event in the archaeological section of the Brunhes normal epoch.

The palaeomagnetic measurements, including magnetic cleaning up to 200 oersteds, show that the remanent magnetizations are stable—but normal for units 1–12 and reversed for unit 13. Mörner and his colleagues are thus well supported in their report that reversely magnetized material exists in the late Weichselian. But the contention that this represents a genuine field reversal is much less secure. For one thing no search for self-reversal characteristics is reported; and no confirmation from other sections is yet available. Moreover, although the probability that many short events remain to be discovered is now widely accepted, it is equally clear that the definition of short events is likely to be difficult—partly because a given short event will tend to be recorded less often, partly because such events are hard to distinguish from the spurious effects unavoidable in the Earth sciences, and partly because if self reversal operates at all it is likely to manifest itself exactly in this small scale situation.

The best known, and better documented, short reversed event alleged to lie in the Brunhes is, of course, the so-called Laschamp event; and this is far from being widely accepted as valid. Under these circumstances it may seem a little premature to name the new, apparent event.