Orientation of the pipe one year later, in August 1952, is shown by Curve B (Fig. 1). Deformation during this interval is more easily seen if plotted against a straight vertical line (Fig. 2). During the first year no perceptible differential flow occurred in the uppermost 90 meters of the glacier. Below that depth flowage was slight but at a relatively uniform rate except for some irregularity and a small acceleration below 275 meters. Total differential flow between the top and bottom of the 305-meter pipe was only 1·75 meters. The absolute amount of flow is not known, for the test site is too far from fixed triangulation points to permit such a measurement.

The deformation is, as yet, too slight to permit firm conclusions as to the mode of flow in this sheet of ice, and further observations of the pipe will have to be made in subsequent years. The results to date do not support the concept of extrusion flow. Deformation of the pipe suggests that flowage occurs more readily at depth than close to the surface, as might be expected, but the surface ice appears to be carried along by the flowing ice beneath in a manner contrary to the mechanism of extrusion flow.

The possibility of extrusion flow below the depth of the bore hole cannot be wholly eliminated, because of the small magnitude of differential flowage recorded so far, but it seems unlikely because extrusion flowage would entail a reversal in direction of the present source.

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THE ANTARCTIC PACK ICE IN WINTER

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Abstract. A summary of the winter conditions at the edge of the pack ice around Antarctica, as observed on 16 occasions by the R.R.S. *Discovery II* between 1932 and 1951, is followed by a more detailed account of each visit. The state of the ice on the northern fringe of the pack is noted especially with reference to the various stages in the formation of pack ice. Detailed reference is also made on each occasion to the meteorological conditions obtaining not only during the ship's stay on the ice edge but for 2 or 3 days beforehand. Despite the limited number of observations possible it would appear that the state or condition of the ice edge, at any one point in winter, is largely dependent on local weather conditions, and it is suggested that, basically, the condition of the ice edge falls into three or, possibly four main categories.

Attention is drawn to the possible relationship between the sea surface temperature and the condition of the ice on the fringe of the pack but it is considered probable that the surface temperature has a greater effect on the distribution of pack ice generally, rather than on the state of the ice edge locally.

Zusammenfassung. Einer Zusammenfassung der Winterzustände am Rande des Packeises um die Antarktis herum, wie sie bei 16 Gelegenheiten von den R.R.S. *Discovery II* zwischen 1932 und 1951 beobachtet wurden, folgt ein ausführlicherer Bericht jedes einzelnen Besuches. Bei jeder Gelegenheit wird auch eingehend auf die meteorologischen Bedingungen hingewiesen, die nicht nur während sich das Schiff um die Eisränder aufhielt erhalten wurden, sondern auch für 2 oder 3 Tage vorher. Trotzdem nur eine begrenzte Anzahl von Beobachtungen möglich war, scheint es, dass die Beschaffenheit des Eisrandes zu jeder Zeit im Winter hauptsächlich von lokalen Wetterbedingungen abhängt, und es wird vorgeschlagen, dass die Beschaffenheit des Eisrandes grundlegend in drei oder möglicherweise vier Hauptkategorien zerfällt.

Es wird auf das mögliche Verhältnis zwischen der Temperatur der Seeoberfläche und der Beschaffenheit des Eises am Rande des Packeises aufmerksam gemacht, aber es wird als wahrscheinlich angenommen, dass die Oberflächentemperatur eher einen grösseren Einfluss auf die Verteilung des Packeises im grossen und ganzen hat als auf die Beschaffenheit des Eisrandes lokal.

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A PAPER on the distribution of the Antarctic pack ice was published in the *Discovery Reports* in 1940 [1] and further observations on the distribution and movement of pack were the subject of a short paper in this Journal in 1948.[2] This latter paper, which was based on work carried out before World War II, and mainly by the Discovery Committee's ships, included little on the subject of the Antarctic pack ice in winter. As will be well understood few ships cruise in the neighbourhood of the Antarctic pack ice in winter from choice, or indeed in the course of their normal activities. It is thus difficult to obtain accurate information not only about the formation and distribution of pack at this season but also with regard to the factors which control the formation and distribution. These factors comprise air and sea temperatures, wind speeds and directions and meteorological conditions generally. And it must be realized that with probably only one observing ship available such data which have been obtained are widely scattered in time and distance. For instance, over a period of three winter months, we may only have data relating to one approach to, and return from, the ice edge in each of three different sectors of the Southern Ocean.

Nevertheless, observations made by the *Discovery II* during one winter month in 1950, and the whole winter of 1951, show a considerable measure of agreement with similar observations made during the same ship's first circumpolar cruise in the winter of 1932. It was also of interest to find, in the areas from which previous observations were lacking, that the northern limit of pack ice in winter usually lay tolerably close to the tentative limit which had been assumed by Mackintosh and Herdman in 1940.[1] These observations are discussed in detail later in this paper but for convenience there follows here a brief tabular statement giving the date, sector and position in which the ice was met, together with a very short description of the conditions obtaining at the edge of the ice.

Date	*Sector*	*Position* *lat.*	*long.*	*Ice Conditions*
22.vi.32.	Australian.	61° 25′ S.,	154° 56′ E.	Sludge and new pancake ice, gradually merging into heavy pancake ice.
10.ix.32.	Pacific.	62° 30′ S.,	158° 23′ W.	Scum, new ice and light pancake ice.
12.vii.38.	Atlantic.	55° 30′ S.,	00° 09′ W.	Sludge and heavy pancake ice.
18.vii.38.	,,	56° 00′ S.,	19° 57′ E.	Sludge ice and streams of brash stretching out in a northerly direction from the main body of ice.
18.viii.38.	,,	57° 18′ S.,	00° 15′ E.	Streams of brash, sludge and new pancake ice.
24.viii.38.	,,	56° 40′ S.,	20° 29′ E.	Direct contact with heavy pancake ice.
25.ix.38.	,,	55° 35′ S.,	00° 27′ E.	Loose and then heavy pancake ice.
30.ix.38.	,,	55° 04′ S.,	18° 06′ E.	Extensive area of sludge ice, with heavy pancake visible to the south.
1.ix.50.	Indian.	57° 54′ S.,	98° 24′ E.	Streams of sludge, then heavy pancake ice.
12.vi.51.	Pacific.	65° 45′ S.,	143° 00′ W.	Ice crystals, scum and sludge ice very gradually merging into heavy pancake ice.
24.vi.51.	,,	63° 52′ S.,	76° 50′ W.	Sludge, with moderate to heavy pancake ice to the south. Some old ice imprisoned in the heavy pancake.
10.vii.51.	Atlantic.	58° 16′ S.,	35° 19′ W.	Sludge and very young pancake ice, growing heavier to the south.
12.vii.51.	,,	57° 16′ S.,	28° 10′ W.	Sludge and new pancake ice.
16.vii.51.	,,	57° 22′ S.,	10° 44′ W.	Thin, transparent pancakes, with old diatom-stained pieces among them.
28.viii.51.	Indian.	50° 15′ S.,	64° 05′ E.	Loose pieces and moderately heavy pancake ice.
9.ix.51.	,,	56° 50′ S.,	80° 42′ E.	Loose pieces and moderately heavy pancake ice.

In 1932 the *Discovery II* was investigating winter conditions on the ice edge, especially in relation to the distribution of the larval forms of *Euphausia superba* and Mr. Dilwyn John, the Scientific Officer-in-Charge, stated, after their first contact with the winter pack, that there was no evidence of a clear-cut edge to the solid pack in this season, and that the pancake ice merely grew thicker as the ship penetrated southwards. On this occasion (22 June, 1932), with the northern edge of the ice lying in lat. 61° 25′ S., long. 154° 56′ E., at the point where the ice was first met, the ship was working in newly formed pack ice for some 30 hours, and penetrated to a distance of 10 miles. No old ice was seen, winds were light to moderate south-easterly and the lowest air temperature recorded (while the ship was actually in pack ice) was −11·6° C. Drift ice and brash were reported to seaward of the main body of ice.

Later in the same winter, on 10 September, when the ship was in the Pacific sector, contact with the ice edge was made in lat. 62° 30′ S., long. 158° 23′ W. The air temperature was −9° C. and, despite a strong south-by-west wind (force 7), new ice was forming. Within an hour, and while on the same course (south-east by south) the ship was passing through pancake ice. Shortly afterwards, and while still in fairly open pancake, she was hove-to for scientific work and did not penetrate farther south. By the time these stations had been completed the wind had risen and a whole gale was blowing from north-west-by-west. When it was possible to proceed again, on a course approximately north-east, there was little sign of new ice. Much drift ice, however, was reported. On account of the northerly component in the wind the air temperature had, by now, risen to −1° C. but the next day, while the ship was still on the same course, it fell again rapidly to a minimum of −13·5° C., following a shift of wind to the south-west. During the succeeding 24 hours the wind reached moderate gale force and much drift ice was reported; in fact, on one occasion, when the ship was hove-to for scientific observations, a belt of heavy pack drifted down on the ship so fast that some nets were lost before evasive action could be taken.

Winter observations on the ice edge were also made by the *Discovery II* during the winter of 1938, on a series of repeated cruises south and south-west of Cape Town and between the meridians of Greenwich and that of long. 20° E. No attempt was made to penetrate other than the fringe of this winter ice, which was located in each of the months of July, August and September. In July heavy pack was reported in lat. 55° 32′ S., on the Greenwich meridian shortly after the sea surface temperature had fallen to −1·7° C. Some small patches of sludge ice * had been seen just previously but, as winds of storm force then prevailed it is unlikely on that account alone that any large quantity of new ice would be seen. Admittedly, the air temperature was then −6° C. but it had only recently fallen abruptly from 0·5° C. when a sudden shift of wind—from north-north-west to west-south-west—occurred some 8 hours previously when the ship was only 70 miles north of the ice edge.

Another contact with the pack was made a few days later, in approximately lat. 56° S., long. 20° E., also in extremely bad weather. Winds had been south-west or west-south-west, and ranging from force 11 to force 8 in the preceding 24 hours, and air temperatures were low throughout (−11·3° C. was the lowest recorded). Despite the high wind, a fair amount of sludge ice was seen, and there were streams of brash reaching out in a northerly direction.

On the next cruise, in August, streams of sludge ice were seen in lat. 55° 49′ S., on the Greenwich meridian (the position in which we had met the pack a month earlier), and it was expected that the pack itself was near. The ship continued south, however, in clear water and it was not until we reached the latitude of 57° 18′ S. that we came up with the main body of ice. Some sludge

* In the definitions of descriptive terms in general use for the various kinds of ice found at sea in the Antarctic, as given in the *Antarctic Pilot*,[3] "sludge" or "slush" is the term used to describe the initial stages in the freezing of sea water; *i.e.* when it assumes a greasy or oily appearance, and a scum of ice crystals is formed on the surface.

It is my opinion that there is, at any rate in winter, a marked difference between "scum" and "sludge" (or "slush"). In the definition given above the initial stage, such as the oily condition shown in Fig. 1 (p. 192) should be referred to as "scum," and the slightly later stage, consisting of a thick, soupy mass of crystals, extending some inches below the surface, and almost becoming pancake ice, as "sludge" (see Fig. 2). As will be shown later in this paper the "scum" stage is very easily dispersed, whereas "sludge" ice is more stable: it can have a considerable effect on the speed of a ship pushing through it, whereas "scum" is washed on one side by the bow wave. "Sludge" kills the bow wave.

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ice, with streams of brash, was seen 15 miles north of the pack, and a belt of young pancake ice, about 1 mile wide, lay to the north of the heavy ice. Moderate west to north-westerly winds had prevailed throughout the previous three days, with a minimum air temperature of −2° C. The sea surface temperature had, however, remained low, at −1·6° C., southwards from the July ice position. Farther to the east, in the same month, contact was made, direct with the pack itself, in lat. 56° 40′ S., long. 20° 29′ E., without any sludge ice, brash or new pancake being reported. Winds were west-north-west to west, and of gale force during the 24 hours prior to meeting the ice, and air temperatures over the same period were seldom lower than −1° C. A temperature of −6° C. was, however, recorded on the edge of the pack itself.

The third winter cruise from Cape Town in 1938 brought contact with the ice, in the form of loose pancake ice, towards the end of September, in lat. 55° 35′ S., long. 00° 27′ E. This was very much the position in which it had been found in the preceding July. Neither sludge ice nor brash were seen, and the belt of loose pancake ice to seaward of the the heavy pancake ice was barely 2 miles wide. For several days beforehand there had been a northerly component in the moderate to fresh westerly winds experienced and air temperatures had been relatively high. The minimum logged was −2·8° C., just before sighting the ice. As on the earlier cruises of this winter contact was again made with the ice farther east a few days later. The northerly component remained in the wind until 24 hours before we met the ice here and then the wind suddenly veered to the south-west, and increased to storm force (11 on the Beaufort Scale) within a few hours. Fortunately, this storm soon blew itself out, and was succeeded by calm conditions. The air temperature, which had dropped to −10°C. as the south-west wind rose, remained at this level when the wind dropped, and it was on the same evening (30 September) that newly formed sludge ice was met, in approximately lat. 55° S., long. 18° E. Heavier ice lay immediately to the south.

Twelve years elapsed before we were able to resume our winter ice observations, during the winter of 1950. At this time the ship was proceeding south, in the month of August, on the meridian of 90° E. Strong to gale force westerly winds, with a moderately southerly component, were experienced for two days before reaching the latitudes in which the pack might be expected to lie but air temperatures were not very low (the average was −2·3° C.). On 1 September the winds were light easterly but shifted to east-north-east and increased in strength. Air temperatures rose slightly to −1° C. but the sea temperature was falling rapidly and streams of sludge ice were met during the early afternoon. This was a moderately wide belt of sludge (about 8 miles across) and the main body of pack was entered in lat. 57° 54′ S., long. 98° 24′ E. Here the ice was heavy, with pancakes 5 ft. (1·5 m.) in diameter at the fringe, and 10–15 ft. across farther in. On account of the low visibility and poor weather conditions then obtaining no attempt was made to penetrate into the pack for any appreciable distance.

The following winter *Discovery II* left Sydney at the end of May, 1951, to carry out a circumpolar cruise east about the Antarctic Continent. It was hoped to make contact with the pack twice in the Pacific Sector, follow the edge for some distance in the Atlantic Sector and reach it once and, possibly, twice, on the run between South Africa and Western Australia. The weather at the ice edge was reasonably good in most places and the whole programme was satisfactorily completed. On the first occasion of meeting the ice, on 12 June, in lat. 65° 43′ S., long. 143° W., the ship had been steaming on a south-easterly course through streams and patches of very newly formed ice crystals and scum for some hours previously, and the transition from this state to very small pancake ice was almost imperceptible. In other words the scum gradually gave place to sludge and the latter was gradually forming into pancake ice. There was little or no wind and a calm sea (a condition which had obtained for the preceding three or four days), but there was a slight swell. The air temperature was −4·5° C. and the sea surface temperature −1·6° C. When the ship reached latitude 66° 06′ S., the pancakes had grown much larger and were very tightly packed, so it was decided to turn away to the north-east. Calm conditions persisted, however, and with a lower temperature (−6·1° C.) it was found that, instead of the pancakes becoming smaller as the ship progressed on a northerly course, they were increasing in size and weight. By nightfall the ice was heavy, with floes 12–15 ft. (3·7–4·6 m.) in diameter, but still preserving their pancake shape. The weather was still calm when this heavy ice was cleared early the following day but young pancakes and sludge ice persisted for some hours afterwards. Ice crystals and scum were still covering large areas of the sea north of this and it was some hours before completely clear water was reached. It is also of interest to note that here the northern edge of the pack lay roughly in the tentative position assigned some years ago by Mackintosh and Herdman.[1]

The weather was not so good for the approach to the pack along the meridian of 77° W. Sludge ice was met on 24 June in lat. 63° 46′ S., and was followed by clear water, but this clear space did not extend for any distance and the main body of ice was found in lat. 63° 52′ S.—considerably north of the position in which it had been expected to lie. Air temperatures were not particularly low—the lowest was —2·2° C.—but winds were strong from the south and south-west —conditions which would probably preclude the formation of much new ice. In the fringe of the pack itself conditions were much the same as those found farther west earlier in the month—*i.e.* small pancake ice with the pancakes increasing progressively in size towards the south. It was noted, however, that there was a certain amount of old ice present, heavily stained with diatoms. The presence of this old ice is a little difficult to explain, but it is known that in this area there is, in most years, little movement of the pack, and that even in summer only the outer fringe breaks away. This may have been such a year, and as our visit was preceded by some days of stormy weather, with gales mainly from the west and south-west, it is possible that conditions not only inhibited the formation of new ice but that older ice from the previous winter season—which had not broken away during the following summer—had been driven to the north.

The next contact with the ice this winter was in mid-July, in the Atlantic Sector, south of South Georgia. The weather had been fine for several days previously, with moderate westerly winds, when sludge and very young pancake ice were sighted in lat. 58° 16′ S., long. 35° 19′ W. Five miles south of this position moderately heavy new pancake ice was encountered and after pushing farther to the south through this, for a distance of about 1½ miles, it was found, as had been found in the Pacific earlier in the winter, that the pancake ice merely became heavier and more tightly packed. One difference was, however, noted, and that was the presence of ice scum and sludge ice between the floes. This condition was not seen in the Pacific Sector.

The prevalence of westerly winds, with their only moderately low air temperatures (−1·7° C. at the ice edge) probably accounts for the absence here of ice crystals or scum, whereas the sludge ice, being heavier, would not disperse except under much warmer conditions, both of air and sea.

Two days later the ice edge was found again in lat. 57° 16′ S., long. 28° 10′ W., and for some hours the ship was passing through new pancake ice and sludge. Passing through the South Sandwich Group close to the south of Vindication and the Candlemas Islands heavy pack was found, stretching away to the north, and it was necessary to steam north and even north-west before the ship could proceed east again. The trend of the ice-edge then became slightly south of east, and the final contact this winter, in the Atlantic Sector, was made in lat. 57° 22′ S., long. 10° 44′ W. Here the ice differed in character from any other ice I have seen at the edge of the pack in winter. The floes were small, round and thin, but definitely of pancake form. There was not, however, the pronounced raised rim such as normally occurs and they had a brittle and transparent appearance, as if composed of hard ice, rather than of a mass of ice crystals, with overlying snow and frozen spray. When the ship passed through them there was a loud crackling sound—quite different from the smooth "swish" of a passage through newly formed pancake ice. Scattered among these small floes were pieces of worn, diatom-stained ice. The area in which this ice was found should normally be cleared of the main body of pack ice in summer, though it is possible that the cold surface water here (of Weddell Sea origin) may, in certain years, hinder the disappearance of all the pack. This would account for the small worn pieces containing diatoms. There is little doubt, however, that the small, hard and thin pancakes were not the remains of the previous season's ice, but were of fairly recent origin. One explanation may, perhaps, be offered—did we arrive on the ice edge here at a time when a period of relatively warm winds from the north-west had just had enough time to start the melting of the fringe of pack consisting of moderately heavy pancake ice? On the date when the ship met the pack in this area the edge was almost at the northern limit for winter and strong north-north-west and north-westerly winds had been experienced for several days beforehand. The air temperature at the ice edge was 0° C. and 24 hours previously had been 0·5° C.

After favourable conditions generally in the Pacific and Atlantic Sectors it was disappointing not to be able to make a close examination of the winter ice in the Indian Ocean Sector. The weather near the ice in August was, however, poor, with low visibility. Gales, mainly from a north-westerly direction, succeeded each other rapidly for some days on the approach to the ice in long. 64° E., and both in long. 64° E. and 81° E. did the ship arrive on the ice edge just as darkness fell. Durban to Fremantle, via the ice edge, Kerguelen, Heard Island and the ice again is a very long run, even for *Discovery II*, and consideration of our limited reserve of fuel made it impossible for us to heave-to and await daylight or better weather conditions. Despite the mist and failing light it could, however, be seen on each occasion that there was neither scum nor sludge ice and that, apart from a few loose pieces a mile or so to seaward of it, the edge of the pack consisted of moderately heavy pancake ice. In long. 64° E. air temperatures, for the 24 hours before reaching the ice, ranged between −0·5° C. and 0·5° C. and the wind, which was mainly north-westerly, averaged force 8. In such conditions it is unlikely that very new ice would be present.

From these rather limited observations, spread over a number of years it is, I think, possible to make some generalizations about the conditions which prevail on or near the ice edge in winter. It must be remembered, though, as I mentioned earlier, that it is almost impossible for one ship to provide really adequate data on this subject unless it were found possible for the ship to make repeated observations in one small area over a period of some weeks, or even months.

The general direction of drift of a very large mass of pack ice is largely influenced by the surface currents, although the wind does play its part. Locally, however, and especially on the fringe of the pack, the drift is probably more dependent on the prevailing winds. These winds are strong in winter and it would appear from our observations that, basically, winter conditions at the ice edge probably fall into three or, possibly, four main categories. First, when calm conditions prevail low air temperatures are to be expected and ice crystals, or scum ice (Fig. 1, p. 192), and then the heavier sludge ice (Fig. 2, p. 192) will be found some distance to the north of the heavier pancake ice, though not normally north of the −1·5° C. surface isotherm. Gradually the sludge will become small pancake ice (Fig. 3, p. 192) and these pancakes will merely become larger and thicker as a ship pushes southward (Figs. 4, 5, p. 192 and 6, p. 193). The second category is that which results, when conditions are influenced by a strong and persistent southerly wind. In this instance air temperatures will again be low—possibly very low—and new ice will probably be forming in the calm water in the lee of the heavier ice. At the same time the effect of the wind will be to cause a surface drift in a northerly direction and new ice, perhaps even larger floes, will stream out in an irregular fashion for some distance from the pack. Owing to the strong winds and rough surface conditions it is probable that no signs of scum ice, or sludge, will be seen except immediately in the vicinity of the heavier ice. Next, we have the conditions set up by strong winds with a northerly component. In the lower latitudes where the northern fringe of the pack ice is found in winter these winds with a northerly component are usually from a westerly direction and the air temperature rises rapidly. Despite the relatively warmer air stream blowing over it the cold surface water near to the pack is little—if at all—affected, yet new ice does not form readily and much of the newly formed scum, sludge and pancake ice on the fringe of the main body will melt, causing an apparent retreat of the ice edge. This rapid dispersal of the new ice is probably helped by the fact that the normal surface drift to the east in these latitudes is strengthened by a wind blowing approximately in the same direction. It is also possible that the waves and turbulence set up by the strong winds may bring to the surface slightly warmer water which will help to dissolve the new ice. The temperature of the surface water at which new ice will form is rather critical and a rise of even 0·2° C. may have a distinct effect. A spell of calm weather, or moderately southerly

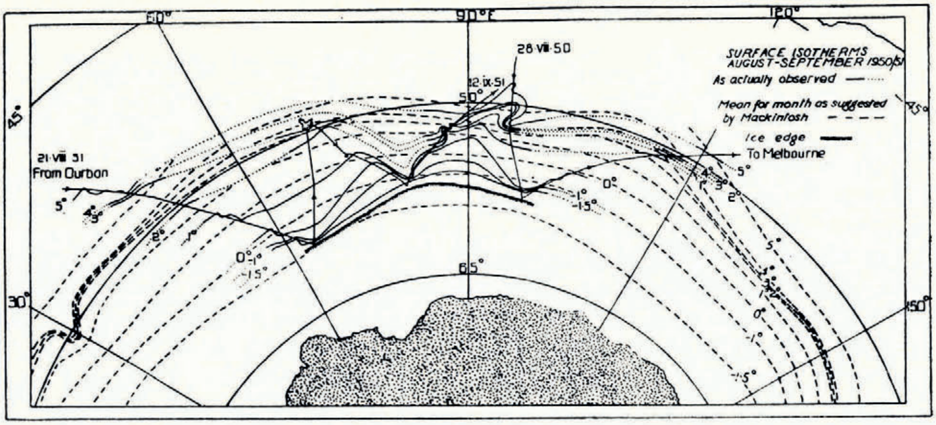

Fig. 7

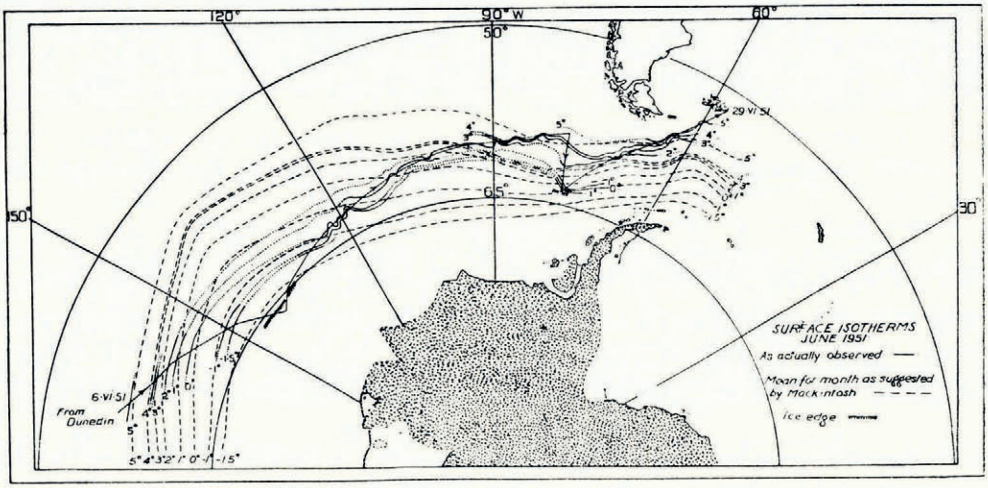

Fig. 8

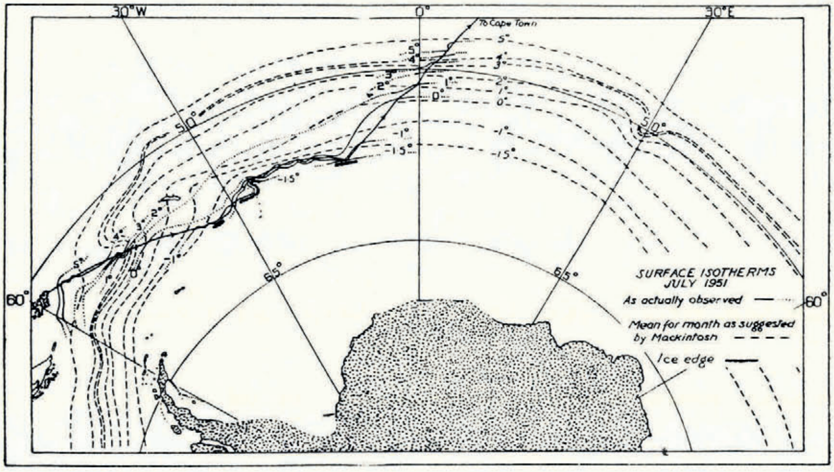

Fig. 9

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winds will, however, soon bring about conditions suitable for the growth of more new ice. Finally, there are the conditions which prevail when the wind is blowing directly from the west and is neither sufficiently warm to melt sludge and new pancake ice nor cold enough to promote the growth of new ice. In these circumstances it appears that scum ice may disappear but that sludge ice will persist to the north of the pack, at any rate in a moderately wide belt.

Exceptional conditions in the state of the ice edge in winter, which do not conform to any of the above categories have, of course, been found to exist. So little is known, however, about the weather here at this time of year that it is not possible, even in the light of our present knowledge, to do more than note these variations.

At this stage it is, perhaps, advisable to remember (as has been pointed out in previous papers [1, 2]) that seldom does the northern edge of the winter pack ice follow a reasonably straight line. The general direction of the edge lies, of course, east-and-west but, no matter how sharp the line of demarcation may be it follows a tortuous course, with deep bays and promontories which may extend for many miles either into or out from the main body of ice. Whether this tortuous shape derives from local conditions of weather or, perhaps, from variations in the surface temperature of the sea, still remains a matter for conjecture. In this paper I have hoped to draw attention to some conditions of the Antarctic ice edge which in all probability are due largely to the effect of the weather locally in winter but, except incidentally, little reference has been made to the possible effect of surface temperature. The distribution of surface temperature in Antarctic waters is the subject of a paper by Mackintosh,[4] and in this paper he deals with observations taken up to, and including, the Antarctic summer of 1938-39. It is of interest to note that the winter observations made more recently by the *Discovery II* (1950-51) confirm the sometimes tentative distribution of surface temperature suggested by Mackintosh for the winter months. There can be little doubt that surface temperature is closely linked with the problem of the total distribution of the Antarctic pack in all seasons, but at the same time it seems to me more probable that the shape and condition of the ice edge in winter depends on the local weather. The study of the rather complex relationship between surface temperature and the distribution of pack ice is outside the scope of this paper and, in any case, almost certainly requires more data than we now possess. It may, however, be of interest to compare the positions of such winter isotherms as were actually determined by the *Discovery II* in 1950 and 1951 with those as suggested by Mackintosh. The recently determined isotherms are shown in Figs. 7, 8 and 9 (p. 190) plotted as actually determined, in relation to those representing the probable mean for the month, as shown by Mackintosh. As the latter remarks, the isotherms shown in his paper represent only the major features and not only may there be some appreciable widespread variations, but numerous local variations as well. These remarks, as will be seen, are fully confirmed by the recent observations.

I am indebted to Dr. N. A. Mackintosh, who has read this paper in manuscript, for some helpful suggestions with regard to the dispersal of ice in winter.

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Fig. 1 (top left). Oily appearance of water caused by scum ice and ice crystals
Photograph by P. M. David

Fig. 2 (centre). Newly-formed sludge ice, with new pancake ice forming in it

Fig. 3 (bottom left). Heavy or thick sludge ice and moderately young pancake ice

Fig. 4 (bottom right). Moderately heavy, but open, pancake ice (easily navigable)

Fig. 5 (top right). Moderately heavy, but close, pancake ice in still weather conditions (navigable, but not easily)

Photographs in Figs. 2–6 by the National Institute of Oceanography

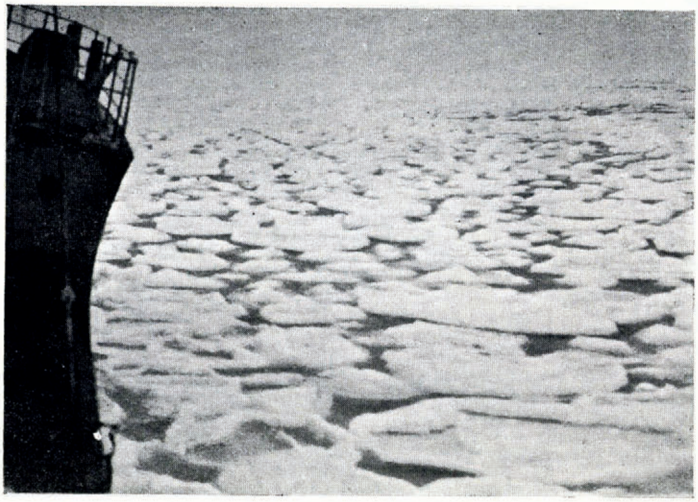

Fig. 6. Heavy winter pancake ice

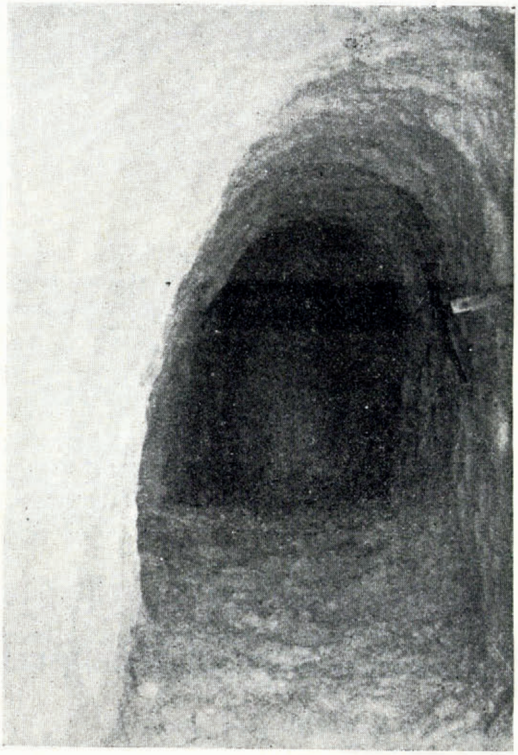

Fig. 4. Present end of Silbersatted tunnel (61 m. long in 1952.)

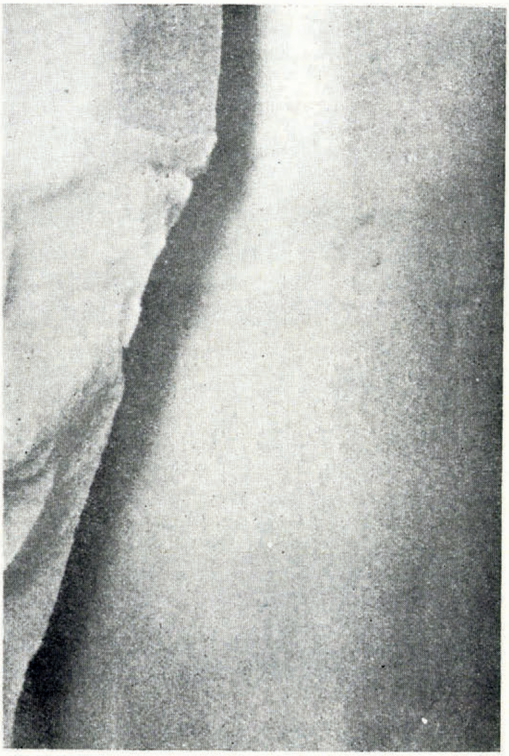

Fig. 5. Open crack in tunnel 61 m. below surface

(*See text pp. 195 and 196*)

Photographs by J. E. Fisher

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Fig. 1 (top left). Oily appearance of water caused by scum ice and ice crystals

Photograph by P. M. David

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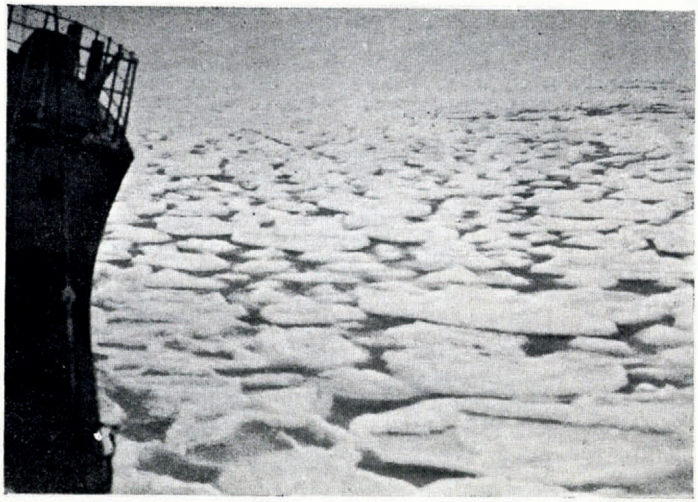

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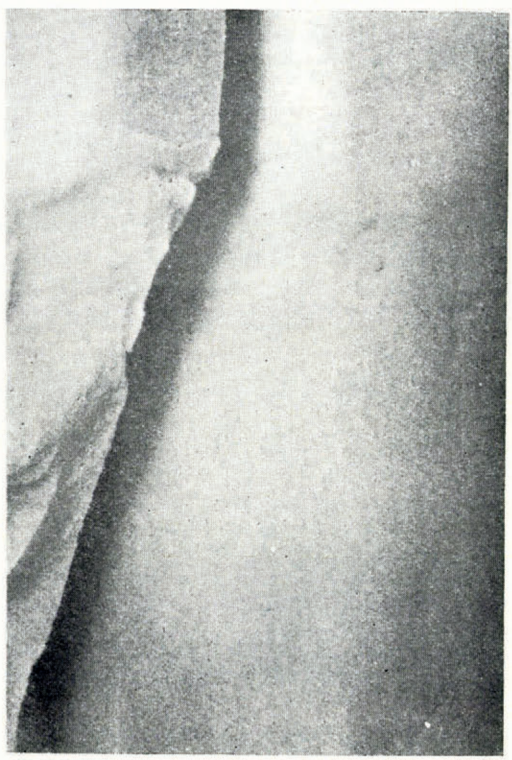

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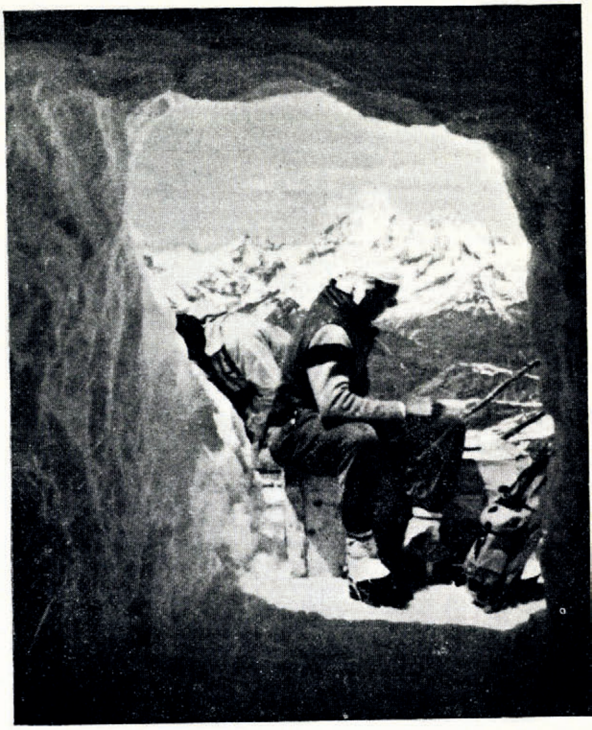

Fig. 1 (*top*). *Monte Rosa. The black dot near the summit shows the position of the tunnel*
Fig. 2 (*bottom left*). *The tunnel entrance is seen to the right of the large rock near the bottom of the picture*
Fig. 3 (*bottom right*). *Looking out through the tunnel entrance*

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