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INVESTIGATION OF A PLUG OF MULTI-YEAR OLD SEA ICE IN THE MOUTH OF NANSEN SOUND

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ABSTRACT

A plug of ice lies in the mouth of Nansen Sound between Ellesmere and Axel Heiberg Islands, its northern boundary joining Lands Lokk to Cape Stallworthy and its southern boundary extending west from White Point. This plug, from 21 to 39 years old and over six metres thick at its northern edge, appears to have formed through normal winter accretion and low summer ablation.

Stationary ice formations of this kind provide unique laboratories for the study of the development of multi-year sea ice.

RÉSUMÉ

Un bouchon de glace s'étend à l'entrée de "Nansen Sound" entre les Iles "Ellesmere" et "Axel Heiberg". La limite nord de ce bouchon unit "Lands Lokk" à "Cape Stallworthy" et so limite sud s'étend à l'ouest de "White Point". Nieux de 21 à 39 ans et d'une épaisseur supérieure à six mètres à son extrémité nord, ce bouchon semble résultér d'une croissance hivernale normale et d'une faible ablation estivale.

Les formations stationnaires de glace de ce type sont des laboratoires uniques pour l'étude de l'évolution de la glace de mer pérennante.

INVESTIGATION OF A PLUG OF MULTI-YEAR OLD SEA ICE IN THE MOUTH OF NANSEN SOUND

INTRODUCTION

The Defence Research Board's work in this area dates from May 1968 when an oceanographic party from Tanquary Fiord set up a camp to acquire synoptic temperature, salinity and current data on new polar pack ice, 300 metres north of the pressure ridge formed between polar pack and multi-year ice near the mouth of Nansen Sound (Fig.1).

An attempt to drill a hole through the multi-year ice 400m south of its edge was made by drilling to 7.1m, the limit of auger extensions, and then stemming 4 Kg of nitrone blasting agent into the hole and shooting. After 14 hours water had seeped into the hole to within 1m of the ice surface where it remained. Assuming a density of 0.85 to 0.95 for ice (1), a thickness of 10m was calculated.

Subsequently, a hole was drilled to set up a tide gauge at the mouth of Audhild Bay, where the ice was found to be 4.6m thick, 100m from shore. In travelling west it was found that the ice plug extended across Nansen Sound from Ellesmere to Axel Heiberg Islands with no evidence of recent shore leads having formed.

An aerial survey made in September 1969 showed the ice plug extending 53 Km into Nansen Sound with a lead bisecting it into a northern section of 630 Km^2 and a southern section of 910 Km^2 in area. Ice thickness measurements made in June 1964 in the southern section indicated normal two-year old ice, although a well defined ridge and trough system were encountered at the mouth of Emma Fiord.

FIELD WORK 1970-71

During the spring of 1970 and 1971 a more detailed investigation of the area was made. Ice thickness (Fig.2) and ice core samples were obtained, 68 ablation stakes installed and the boundaries of the plug defined. Four solar radiation integrators were set up between Lands Lokk and White Point. Ice core samples obtained have been analyzed for crystal structure, salinity and biological content.

The relief of the surface of the plug varies with the snow cover. On the Ellesmere Island side where there is less wind and 60cm of undisturbed snow, the hummocks are 1m high with a 10m separation (Fig.3). In the center of the plug the hummocks are 2m high with 40m separation (Fig.4), while on the Axel Heiberg side the hummocks are 3m high separated by large ponds of wind polished ice (Fig.5).

Ice cores taken show horizons of surface dirt and ice-trapped biological material which was most evident under the ponds on the western side of the plug. These clear areas may allow solar radiation to penetrate the ice early in the season, accelerating the biological growth which by increasing the opacity of the water and raising its temperature reduces the ice thickness below the ponds. A number of amphipod Gammarus Wilkitzkii were obtained from the cores, some trapped as high as 1m above the bottom of the ice (Fig.6).

DISCUSSION OF RESULTS

Using the measurements of one-year old ice, made in 1964 and 1970, the total ice accretion can be estimated on the basis of 6,000 freezing degree (-1.8°C) days (2) and by plotting curves of ice accumulation at varying summer ablation rates (3). Figure 7 shows that ice can reach 6.1m thickness in 40 years if the ablation is 0.4m/year. An ablation rate of 0.4m/year was measured at the northern section of the plug, while an ablation rate of 0.8m/year is indicated for the southern section. Observation of the cloud cover in the area bears out this difference as very heavy clouds frequently hang over the mouth of Nansen Sound while clear weather is more evident in the White Point area.

On the east side of the ice plug, between the Fjeldholmen Islands and Kreuger Island piles of rock debris (Fig.8), rafted by the ice and standing 2m above the surrounding surface, were found in 1968. These features are shown in their present location on July 1950 aerial photography and are similar in appearance to piles of rock debris lining the ice below the Svartevaeg Cliffs (Fig.9). This material could have fallen on a previous ice plug and been rafted across the Sound at a time when that plug had broken up. An indication of such a breakup is given by early travellers in the area.

R.E. Peary, who traversed the northern end of Nansen Sound in 1906, stated that "the ice in the Strait was to all appearance a

continuation of that forming the glacial fringe of the Grant Land coast" (4). Cpl. H.W. Stallworthy, travelling in the same area in 1932, found a "bad surface consisting of new pressure ice" which prevented him crossing from Axel Heiberg Island to Lands Lokk. The Greenlander Eetookashoo, who was with Stallworthy and had also accompanied Cook in 1908 and MacMillan in 1914 in this region, was surprised to see new pressure ice and signs of open water north of Axel Heiberg Island (5). From this we can assume a maximum age of 39 years for the present ice plug.

Ice from a previous plug in the mouth of Nansen Sound or a similar formation occurring elsewhere may be the source of ice island SP-6 which had a thickness of 12m when occupied in 1966 (6). If SP-6 had originated in Nansen Sound prior to 1932 it would have had to circulate in the Arctic Basin for 25 years until it was occupied in 1956. During the course of such a drift a net decrease in its thickness might be expected. It is possible for it to have had a thickness of up to 24m when it broke away (3).

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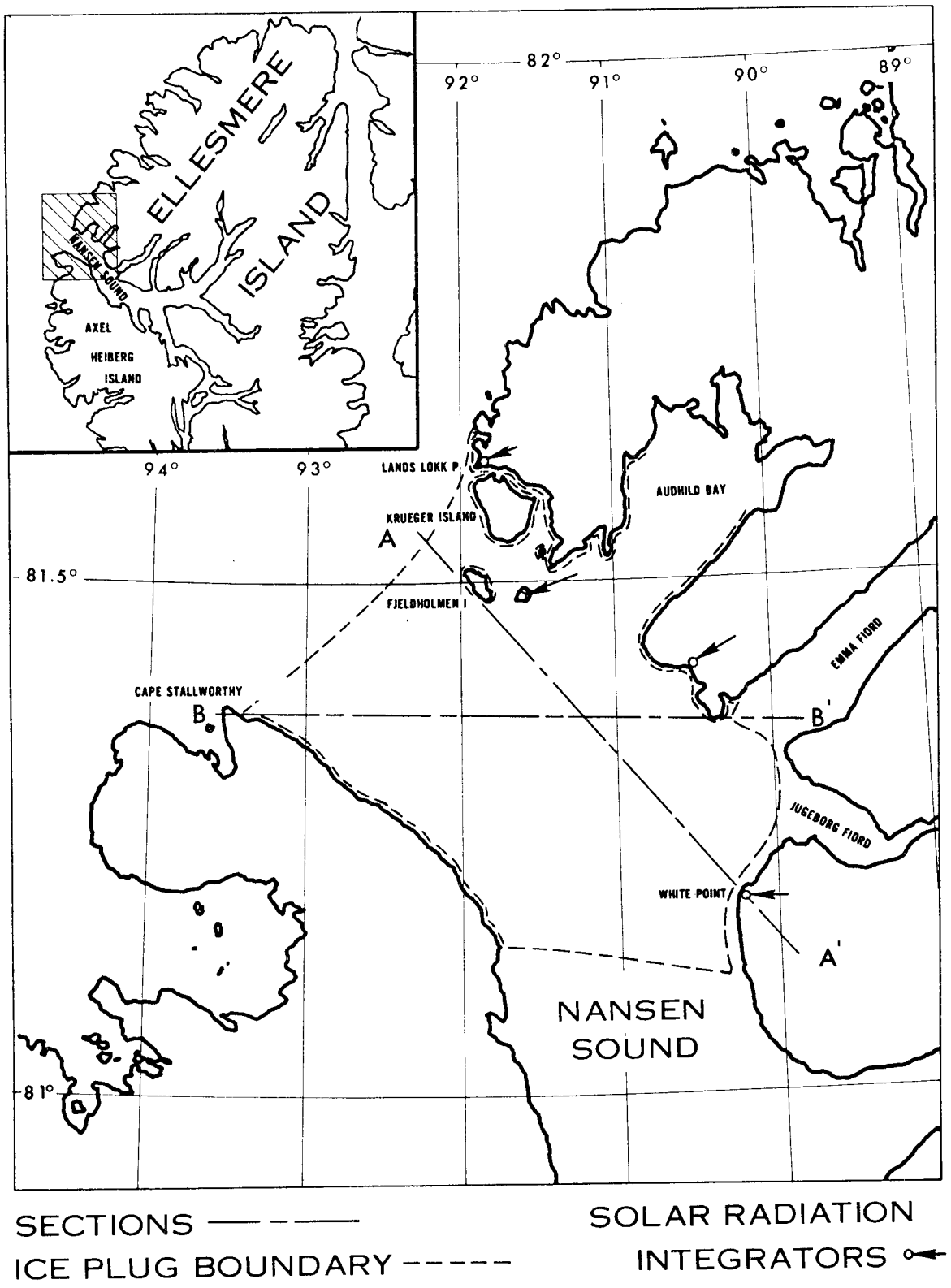

Fig. 1. Map of the mouth of Nansen Sound, illustrating the position of the ice plug and surveyed sections.

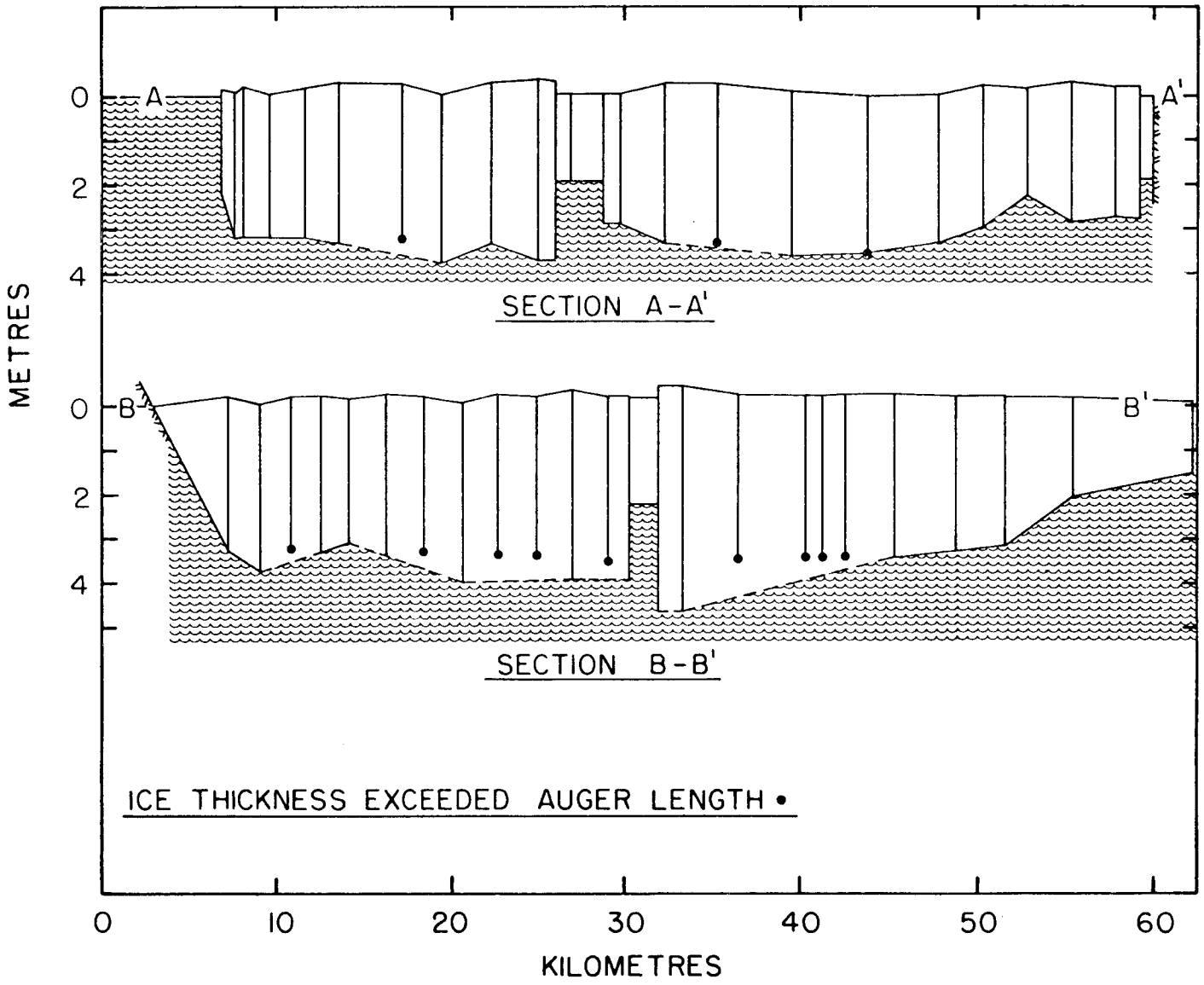

Fig. 2. Indicated thicknesses through sections A-A' and B-B'.

Fig. 3. Ice surface at the eastern side of the ice plug.

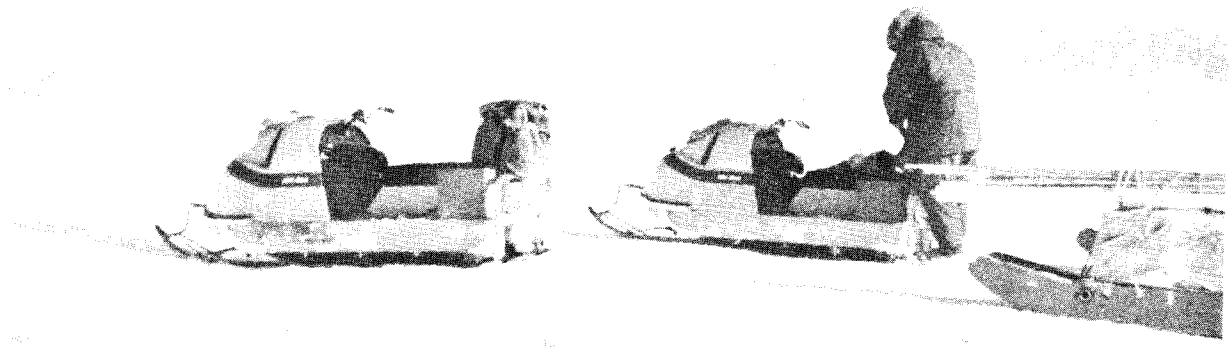

Fig. 4. Ice surface at the center of the ice plug.

Fig. 8. Ice rafted rock debris near Kreuger Island.

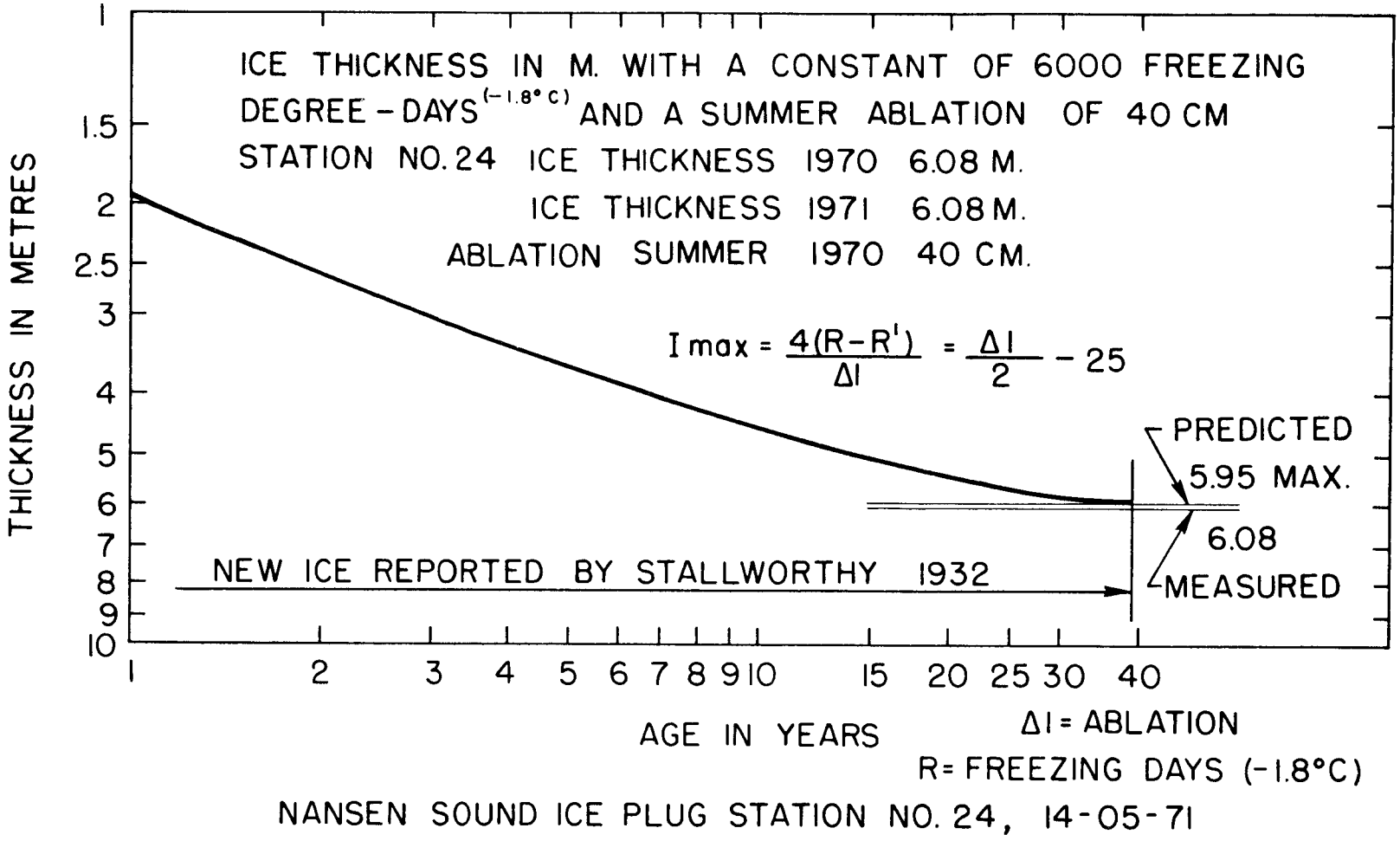

Fig. 7. Ice accretion at the 40cm/year ablation rate based on 6,000 deg. days (-1.8°C).

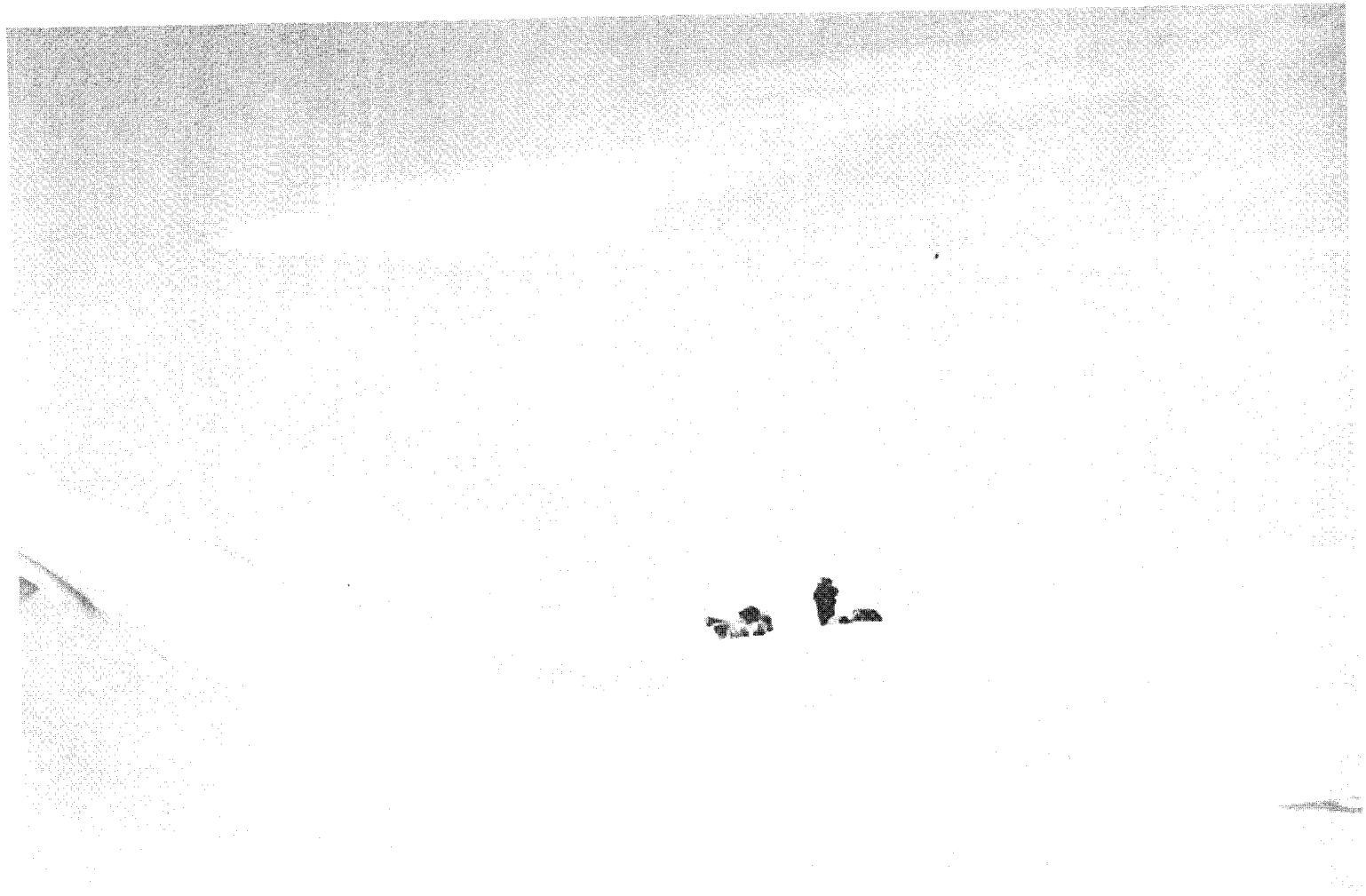

Fig. 5. Ice surface at the western side of the ice plug.

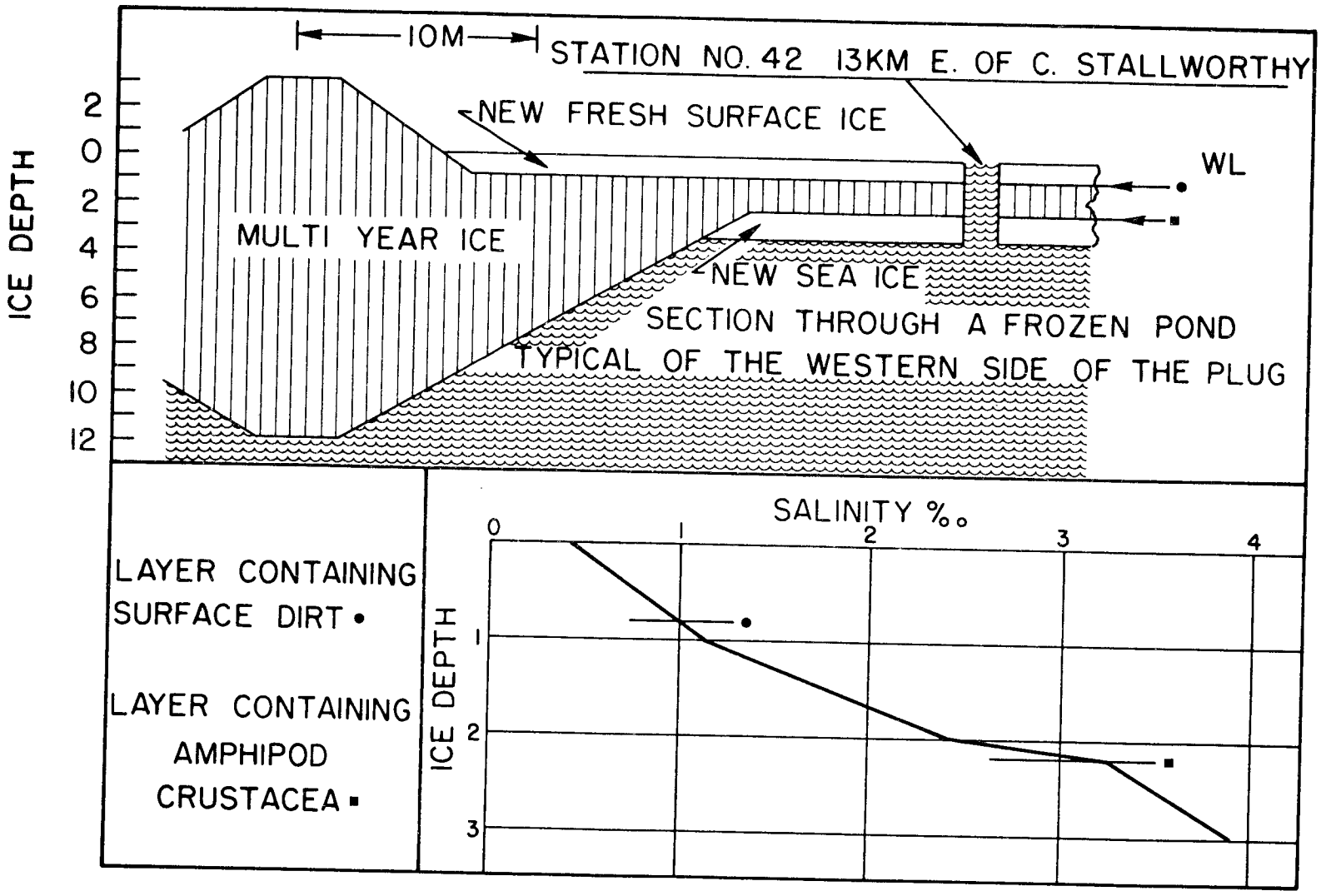

Fig. 6. Section through a typical "pond" on the western side of the ice plug.

Fig. 9. Ice rafted rock debris below the Svartevaeg cliffs.

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