SPECIAL REPORT 91-2

Sea Ice Observations From the Winter Weddell Gyre Study-'89

Debra A. Meese, John W. Govoni, Vladimir Churun, Boris Ivanov, Victor Komarovsky, Vasily Shilnikov and Andre Zachek

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February 1991

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Cover Ice scientists measuring ice thickness in the Weddell Sea Antarctica during the Winter Weddell Gyre Study-'89

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Prepared for
DIVISION OF POLAR PROGRAMS
NATIONAL SCIENCE FOUNDATION

91-2

US Army Corps
of Engineers
Cold Regions Research &
Engineering Laboratory

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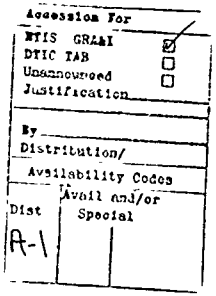
Zachek

February 1991



PREFACE

This report was prepared by Dr. Debra A Meese, Research Physical Scientist, and John W. Govoni, Physical Science Technician, of the Snow Ice Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory and Vladimir Churun, Boris Ivanov, Komarovskiy, Vasily Shilnikov and Andre Zachek of the Arctic and Antarctic Institute in Leningrad The data for this report were obtained during the Winter Weddell Gyre Study- 89 (WWGS-89) from the Soviet icebreaker *Akademik Fedorov*. The authors thank the Chief Scientist Nikolai Bagriantsev, the captain and the crew of the *Fedorov*. Special thanks go to the ice scientists from the Arctic and Antarctic Institute in Leningrad for their support and for providing copies of their ice maps for this report.

Weekly ice extent maps were provided by the Naval Polar Oceanography Center, Department of the Navy

This research was supported by the National Science Foundation through grant DPP#8512728.

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ILLUSTRATIONS

Sea Ice Observations From the Winter Weddell Gyre Study-'89

DEBRA A MEESE, JOHN W GOVONI, VLADIMIR CHURUN, BORIS IVANOV,
VICTOR KOMAROVSKIY, VASILY SHILNIKOV AND ANDRE ZACHEK

INTRODUCTION

The data for this report were obtained during the Winter Weddell Gyre Study-'89 (WWGS-89) from the Soviet icebreaker *Akademik Fedorov*. This study took place between September and November 1989 in the Weddell Sea, Antarctica. Several times each day throughout the cruise, we took notes on the ice conditions that the ship was passing through at that time. These notes included ice concentration, thickness, ice type, amount of ridging, number of icebergs in the area and other distinguishing characteristics. In addition, photos of the area were taken and are included in the next section.

During the cruise a Soviet ice scientist was stationed on the bridge 24 hours a day to compile detailed ice observation maps. These maps contain information for every mile of ice that was passed through during the cruise, including ice thickness, type and concentration, iceberg size, number and type, and the extent and size of leads. A following section consists of copies of their maps.

Every 30–60 miles during the cruise we would stop for an ice station where ice cores and water samples were taken for physical and chemical studies, ice thickness grids were drilled, and optical measurements were made. At each site Dr. Shilnikov from the Arctic and Antarctic Institute compiled an ice map of the station, including wind direction and speed, air temperature, ice type, ice thickness and other characteristics of the area. Copies of these maps are found in in the *Ice Station Maps* section.

Also presented here are daily satellite photos of the area the ship was traversing. Throughout the cruise these photos provided the ship's crew with information regarding ice conditions that the ship would be encountering.

The final section consists of weekly ice extent maps of the Weddell Sea obtained from the National Oceanographic and Atmospheric Administration (NOAA) upon our return to the U.S.

This report contains a complete observational analysis of the ice conditions encountered during this study in the Weddell Sea.

ICE LOG AND PHOTOGRAPHS

17 September 1989 (day 260) 1100 hours

57° 20.66' S, 37° 20.67' W
Heading 159
First icebergs visible

18 September 1989 (day 261)

0921 hours

58° 53.53' S, 36° 07.97' W
Heading 213.7
No ice visible yet

1833 hours

Still no ice. Ice edge appears to be retreating faster than we are mo
begun collecting water samples at the surface, 50 and 100 m depth
major ion analyses.

2300 hours

58° 48.34' S, 35° W
Hit ice edge. No pancake fields visible. Thin ice 15–30 cm thick.

19 September 1989 (Day 262) 0900 hours

60° 59.54' S, 33° 36.71' W
Heading 131
90% ice concentration - 5% older, thicker ice, 10% open with new
60 cm thick. Algae in all first-year ice almost to the snow line.

Figure 1. Tabular iceberg on 17 September

Figure 2. Wide view of pancake ice on 19 S

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DEBRA A. MEESE, JOHN W. GOVONI, VLADIMIR CHURUN, BORIS IVANOV, VICTOR KOMAROVSKIY, VASILY SHILNIKOV AND ANDRE ZACHEK

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e would stop for an ice station where ice cores and water mical studies, ice thickness grids were drilled, and optical Dr Shilnikov from the Arctic and Antarctic Institute ding wind direction and speed, air temperature, ice type, he area. Copies of these maps are found in the *Ice Station*

photos of the area the ship was traversing. Throughout the w with information regarding ice conditions that the ship

ice extent maps of the Weddell Sea obtained from the c Administration (NOAA) upon our return to the U.S. ational analysis of the ice conditions encountered during

18 September 1989 (day 261)

0921 hours

58° 53.53' S, 36° 07.97' W
Heading 213.7.
No ice visible yet.

1833 hours

Still no ice. Ice edge appears to be retreating faster than we are moving because of winds. We have begun collecting water samples at the surface, 50- and 100-m depths for chlorophyll-a, nutrient and major ion analyses.

2300 hours

58° 48.34' S, 35° W
Hit ice edge. No pancake fields visible. Floes are 15–30 cm thick.

19 September 1989 (Day 262) 0500 hours

60° 59.54' S, 33° 36.71' W
Heading 131.
90% ice concentration—[illegible] 10% open with new ice forming. First-year ice is 10–60 cm thick. Algae in all first-year ice adjacent to the snow line.

lar iceberg on 17 September

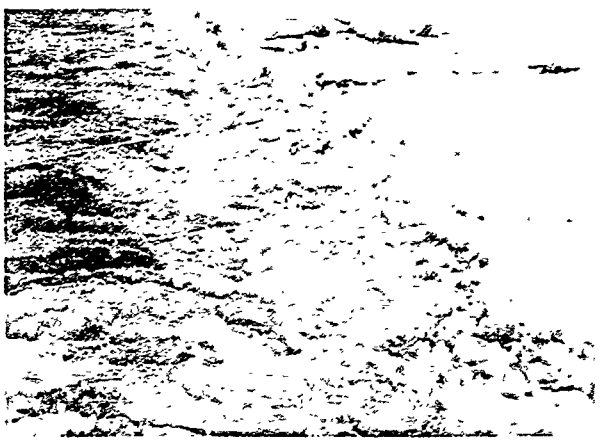


Figure [illegible] W[illegible] on 19 September

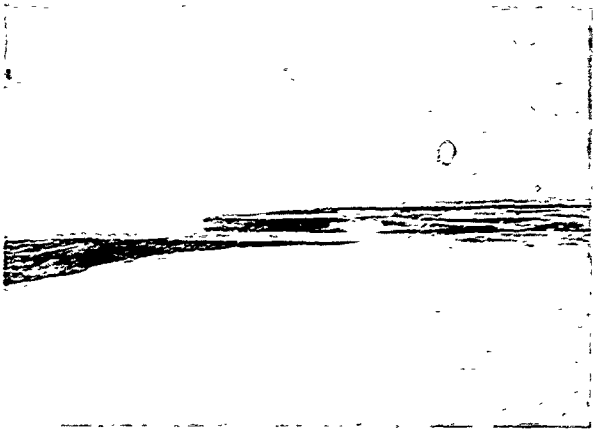


Figure 3. Ice concentration of 90% on 19 September.

20 September 1989 (day 263) 0630 hours

62° 11.11' S, 31° 16.16' W
Heading 117.1.
Foggy with blowing snow. Following lead. Ice varies from thick, older ice (20 cm) with 10–50 cm snow (with a lot of algae) to thinner ice of 2–10 cm with 2–5 cm snow. Very rapid changes between thin, new ice and very thick, older ice, with equal amounts of snow and ice. Large leads in area. Ice balls of all sizes in open leads.

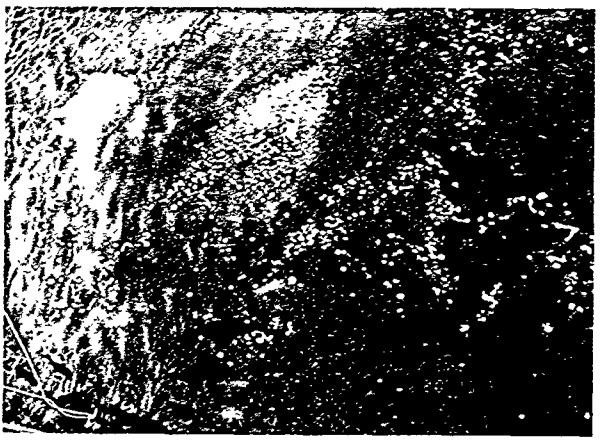


Figure 4 Ice balls in a lead on 20 September

21 September 1989 (day 264)

1125 hours

63° 38.69 S, 28° 30.65 W
Heading 94
Small ridges following open lead. 90% ice concentration (50–150 cm), 5% open water, 5% thin new ice refrozen leads 3–4 cm thick. Algae present in bottom layers of thicker ice. Some of the thicker ice contains no visible layers. Snow cover is 30–50 cm thick.

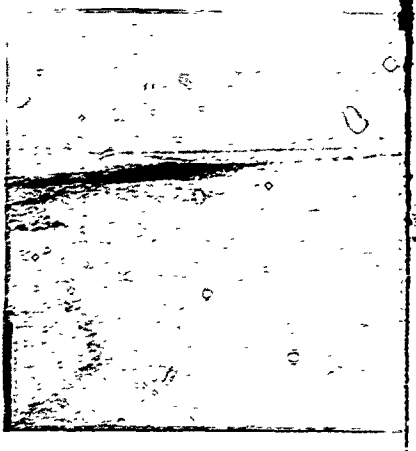


Figure 5 Ice concentration of 90% on 21 S

1245 hours

63° 48.03' S, 28° 15.45' W
Ice is 1 m thick with 20 cm of snow. Very little algae present

23 September 1989 (day 266) 1130 hours

66° 18.61 S, 23° 33.50' W
Heading 156.3.
Ice is 30 cm to 1 m thick, with visible layers. Not as much algae snow that is very compact. Going through area of extensive

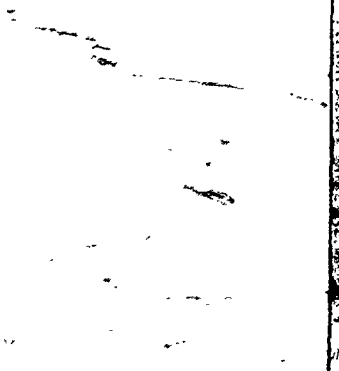
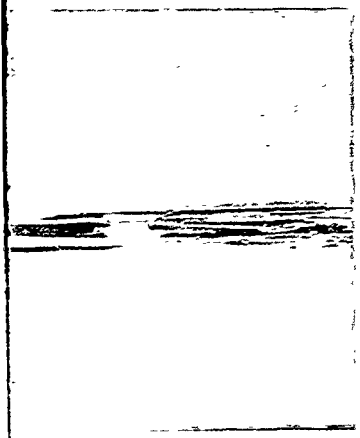


Figure 6 Ridges and leads in the ice pack

24 September 1989 (day 267)

67° 26.000 S, 20° 59.04' W
99% concentration. Some small ridges
heavy ridging



...ration of 90% on 19 September.

...rs

...d Ice varies from thick, older ice (20 cm) with 10–50 cm
...2 10 cm with 2–5 cm snow. Very rapid changes between
...n equal amounts of snow and ice. Large leads in area. Ice

...on a lead on 20 September

...concentration (50–150 cm), 5% open water, 5% thin.
...present in bottom layers of thicker ice Some of the
...cover is 30–50 cm thick

Figure 5. Ice concentration of 90% on 21 September.

1245 hours

63° 48.03' S, 28° 15.45' W
Ice is 1 m thick with 20 cm of snow Very little algae present. Ice has many visible layers

23 September 1989 (day 266) 1130 hours

66° 18 61' S, 23° 33.50 W
Heading 156.3.
Ice is 30 cm to 1 m thick, with visible layers Not as much algae as previously seen 20–30 cm of snow that is very compact. Going through area of extensive leads and ridging

Figure 6 Ridges and leads in the ice pack on 23 September

24 September 1989 (day 267)

67° 26 000 S, 20° 59 04' W
99% concentration Some small ridges Ice th... approximately 80 cm Coming into area of heavy ridging

Figure 7. Small ridges on 24 September.

25 September 1989 (day 268)

1300 hours

67° 51 71' S, 18° 47.75' W
100% concentration. 5–10 cm snow, 40–50 cm ice. Fairly heavy ridging. Snow and ice thickness increasing to approximately 50–70 cm ice and 40 cm snow

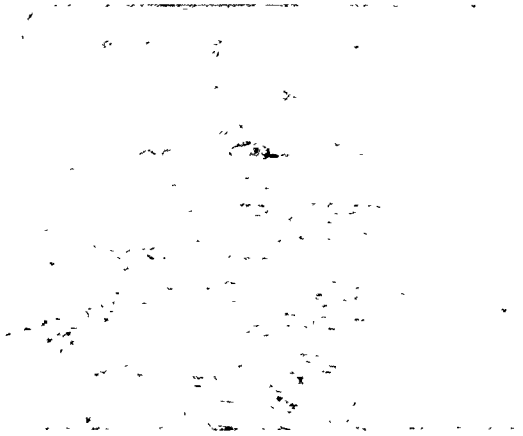


Figure 8 Ice concentration of 100% on 25 September

1700 hours

67° 50 24' S, 18° 23 98' W
70% concentration 20% new leads, 10–20% breccia 10–20 cm snow and 10–60 cm ice 40% ridges

Figure 9. Ice concentration of 70% on 25 Se

26 September 1989 (day 269) 1130 hours

67° 41.82' S, 17° 13 99' W
100% ice concentration Snow 10–20 cm, ice 40–50 cm Some rid

27 September 1989 (day 270)

0900 hours

67° 18.07' S, 14° 58 70' W
95% concentration. Floes are approximately 1 km with ridging in b
cm to 1 m of ice Little visible algae

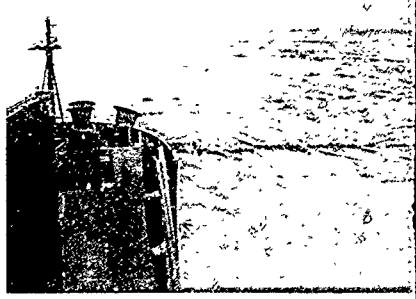
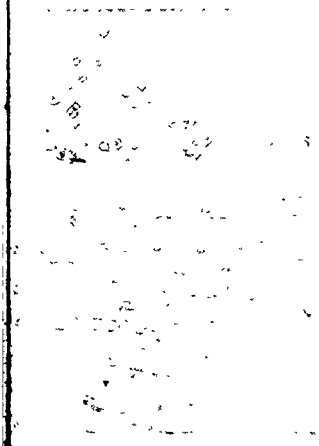


Figure 10 Ice concentration of 95 % with ridges betw

ll ridges on 24 September.

) cm ice Fairly heavy ridging Snow and ice thickness
and 40 cm snow.



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breccia 10–20 cm snow and 10–60 cm ice 40% ridges

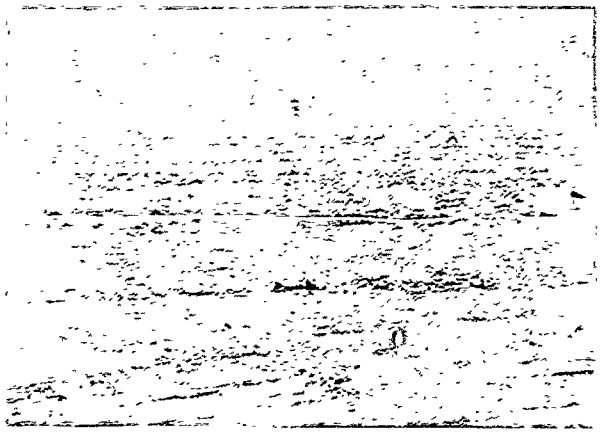


Figure 9 Ice concentration of 70% on 25 September.

26 September 1989 (day 269) 1130 hours

67° 41 82' S, 17° 13 99' W
100% ice concentration Snow 10–20 cm, ice 40–50 cm Some ridged areas

27 September 1989 (day 270)

0900 hours

67° 18 07' S, 14° 58 70' W
95% concentration Floes are approximately 1 km with ridging in between 10–60 cm snow and 10 cm to 1 m of ice Little visible algae

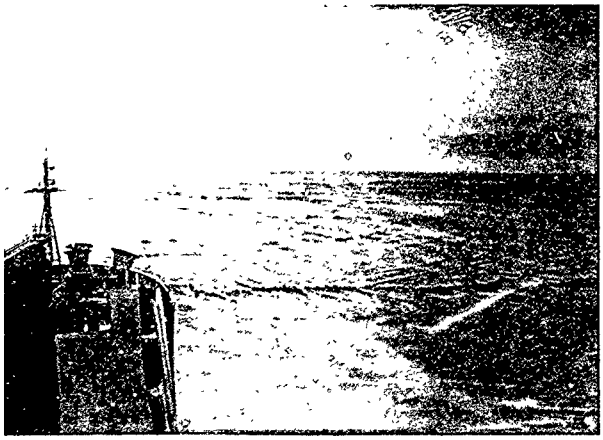


Figure 10 Ice concentration of 95% with ridges between floes on 27 September

1800 hours

67° 07.91' S, 13° 30.12' W
98% concentration. Snow is 20–40 cm, ice is 50 cm to 1 m. Heavily ridged area. Newly formed pancakes in lead.

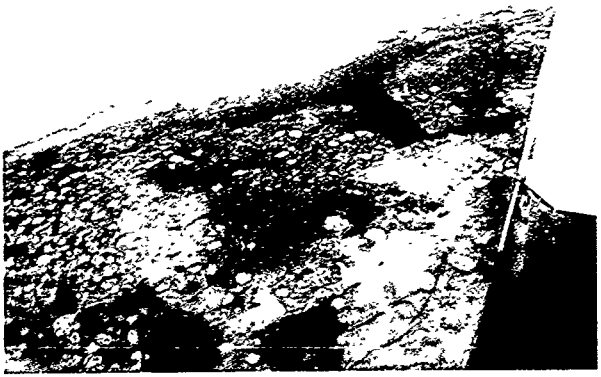


Figure 11 Newly formed pancakes in lead on 27 September

Figure 12 Heavily ridged area on 27 September

28 September 1989 (day 271)

0845 hours

66° 52 10' S, 11° 27 94' W
Foggy, visibility 100–200 m. Thin first year ice, 20–30 cm. Snow is 20–30 cm. Ice is layered. No visible algae.

1820 hours

66° 38 21' S, 10° 11 14' W
99% concentration. Snow is approximately 20–30 cm thick and the ice is 60–70 cm. New first-year ice, 25% ridged and brecciated. One berg visible.

29 September 1989 (day 272)

1515 hours

66 19.05' S, 07° 40.15' W
Ice is 60–70 cm with 0–20 cm of snow. Little visible algae. Follo
cm and very ridged.

Figure 13 Following lead on 29 Se

1940 hours

66° 10 48' S, 06° 44 36' W
Concentration is 80%. Ice is 50 cm to 1 m thick. Snow is cov

30 September 1989 (day 273)

0954 hours

65° 59 88' S, 04° 54 78' W
Ice concentration is 60% thick ice. All leads have 2–10 cm of ic
floes are 50 cm to 1 m with 20–30 cm of snow. 10–20% ridgin

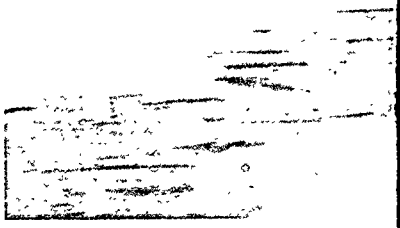
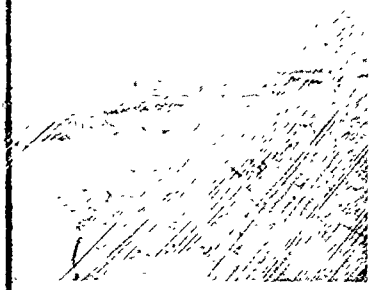


Figure 14 Lead with new ice on 30 Se

. ice is 50 cm to 1 m. Heavily ridged area. Newly formed

rmed pancakes in lead on 27 September



vily ridged area on 27 September

ow is 20–40 cm. Ice is layered no

els 20–30 cm thick and the ice is 60–70 cm. New first-year
g visible

29 September 1989 (day 272)

1515 hours

66° 19.05' S, 07° 40.15' W
Ice is 60–90 cm with 0–20 cm of snow. Little visible algae. Following lead. First-year ice is 10–20 cm and very ridged.

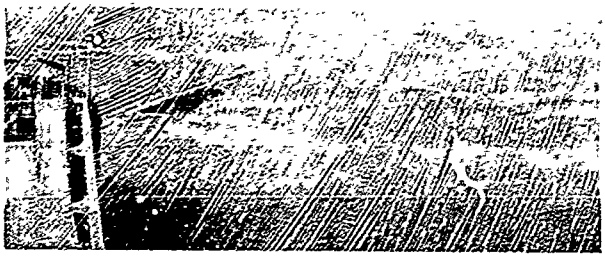


Figure 13 Following lead on 29 September

1940 hours

66° 10.48' S, 06° 44.36' W
Concentration is 80%. Ice is 50 cm to 1 m thick. Snow is compact and between 40–60 cm.

30 September 1989 (day 273)

0954 hours

65° 59.88' S, 04° 54.78' W
Ice concentration is 60% thick ice. All leads have 2–10 cm of ice with 10% open patches. Thicker floes are 50 cm to 1 m with 20–30 cm of snow. 10–20% ridging. Have been following leads.

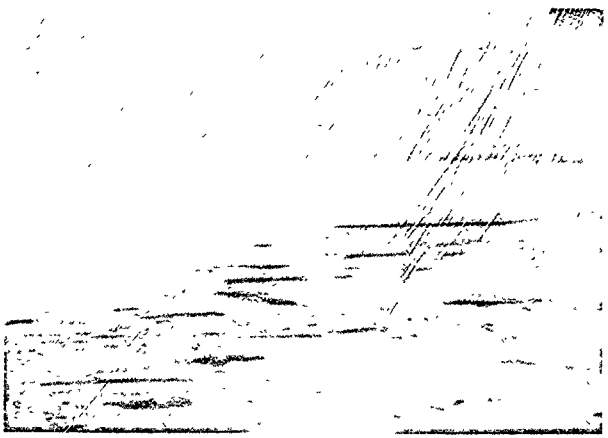


Figure 14 Lead with new ice on 30 September

1252 hours

65° 52.08' S, 04° 20.24' W
Visibility poor because of fog and blowing snow. Ice thickness ranges from 60 cm to 1 m. Snow is 20–40 cm and is compact. Small lead visible from ship, otherwise no open water.

1710 hours

65° 45.45' S, 03° 32.15' W
Poor visibility. Ice concentration is approximately 100%. Ice is 50–70 cm thick and snow is 0–10 cm thick.

1 October 1989 (day 274)

1033 hours

65° 24.17' S, 01° 14.69' W
90% concentration. Thin first-year ice of 10–20 cm. Snow is 1–5 cm thick. Light ridging in area

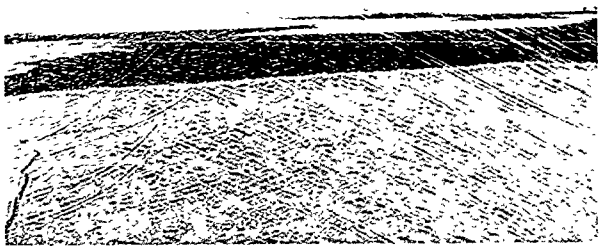


Figure 15 Thin first-year ice and leads on 1 October 1989

1630 hours

65° 16.02' S, 00° 35.71' W
Following leads 70% ice concentration. Ten or more bergs visible. Thin first-year ice of 5–30 cm with 2–5 cm snow. Some minor ridging.

Figure 16 Ice bergs visible in area on 1 October

2 October 1989 (day 275)

1251 hours

65° 02.45' S, 02° 46.19' E
90% concentration. Thick ice of 50–90 cm with 30 cm snow. Thick at the bottom. Pancake ice in leads. Two bergs visible.

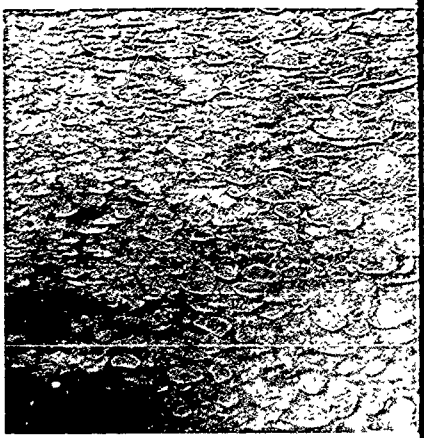


Figure 17 Pancake ice in lead on 2 Oct

1325 hours

65° 05.23' S, 02° 37.79' E
60% concentration. Following leads.

1525 hours

65° 21.29' S, 02° 13.55' E
90% concentration. Young ice between 30–40 cm with 0–5 cm snow. Ice visible.

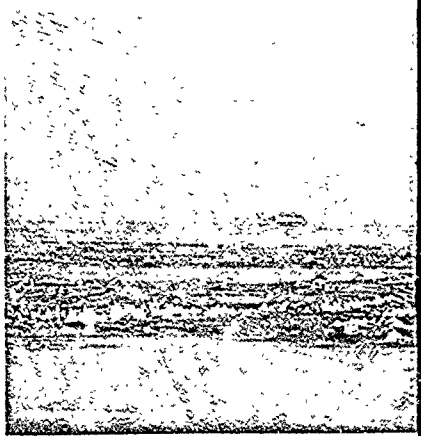
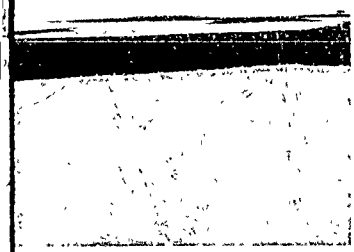


Figure 18 Brecciated ridged ice on 2 O

snow. Ice thickness ranges from 60 cm to 1 m. Snow is
le from ship, otherwise no open water.

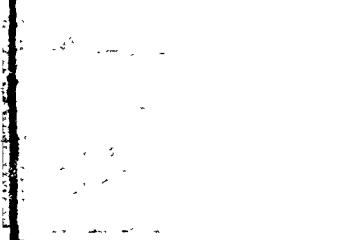
[illegible] 100% Ice is 50–70 cm thick and snow is 0– 6

0–20 cm Snow is 1–5 cm thick Light ridging in area



u ice and leads on 1 October 1989

en or more bergs visible Thin first-year ice of 5–30 cm



gs visible in area on 1 October

2 October 1989 (day 275)

1251 hours

65° 02 45' S, 02° 46.19' E
90% concentration Thick ice of 50–90 cm with 30 cm snow. Thicker ice has a 10-cm algal layer at the bottom. Pancake ice in leads Two bergs visible

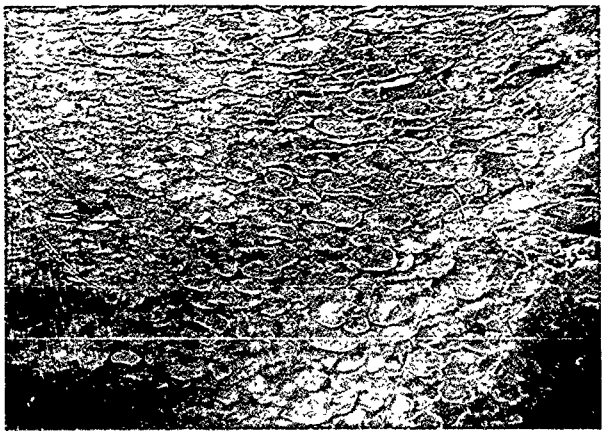


Figure 17 Pancake ice in lead on 2 October

1325 hours

65° 05 23' S, 02° 37 79' E
60% concentration Following leads

1525 hours

65° 21 29' S, 02° 13 55' E
90% concentration Young ice between 30–40 cm with 0–5 cm snow Very brecciated Four bergs visible

Figure 18 Brecciated ridged ice on 2 October

1845 hours

65° 26.99' S, 01° 53 59' E
95% concentration Heavily ridged area Ice is approximately 60–70 cm with 5–10 cm snow Ten bergs visible

3 October 1989 (day 276)

0930 hours

66° 18 99' S, 00° 17 67' W
Heading 217
85% concentration Mostly thin, new ice of 5–10 cm with 1 cm snow Thicker ice is brecciated (approximately 30%) Four icebergs visible

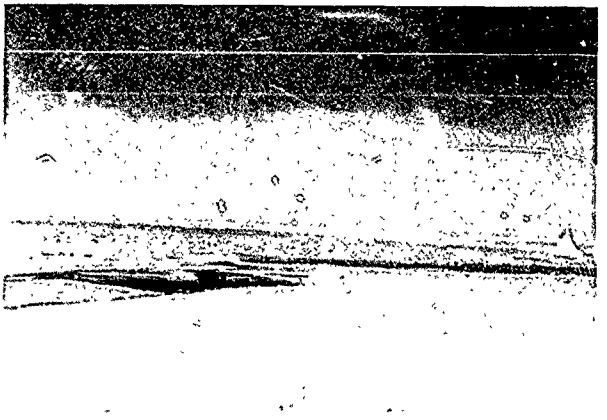


Figure 19 Thin, new ice surrounded by older, brecciated ice on 3 October

1740 hours

66° 33 53' S, 00° 52 98' W
In storm, visibility poor For approximately the last hour have been going through open water or very thin ice Now in ice 30–40 cm with 5 cm snow Some ridging and leads visible

4 October 1989 (day 277)

0750 hours

66° 31 68' S, 01° 54 13' W
Heading 346
95% concentration Young first-year ice of 30–40 cm with 2–5 cm snow Approximately 30% ridged One berg visible

Figure 20 Thin first-year ice with extensive ridgi

1430 hours

66° 05 82' S, 02° 02 00' W
Heading 336
90% concentration Thick ice of 60–80 cm with 40–50 cm snow with 10 cm snow More algae visible here than seen in the last co leads

5 October 1989 (day 278) 1630 hours

65° 11 62' S, 02° 47 94' W
Heading 214
80% concentration Thick ridged floe of [illegible] of 1–2 cm up to 10–30 cm with 5 cm snow

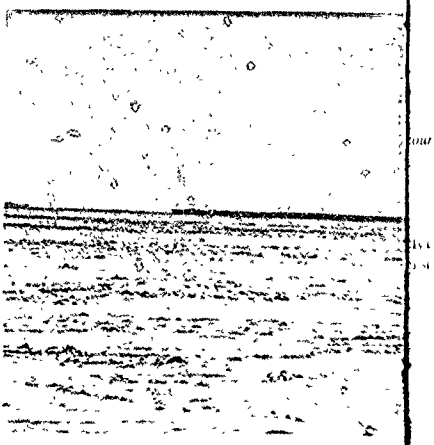


Figure 21 Large, tabular iceberg on

approximately 60–70 cm with 5–10 cm snow Ten

of 5–10 cm with 1 cm snow. Thicker ice is brecciated
ble

Figure 20 Thin first-year ice with extensive ridging on 4 October

1430 hours

66° 05 82' S, 02° 02 00' W
Heading 336
90% concentration Thick ice of 60–80 cm with 40–50 cm snow Thin ice near leads of 30–40 cm with 10 cm snow. More algae visible here than seen in the last couple of days Some pancakes in leads

5 October 1989 (day 278) 1630 hours

65° 11 62' S, 02° 07 94' W
Heading 294
80% concentration Thick, ridged floes of 1–2 m with 10 cm of snow, surrounded by thin, new ice of 1–2 cm up to 10–30 cm with 5 cm snow

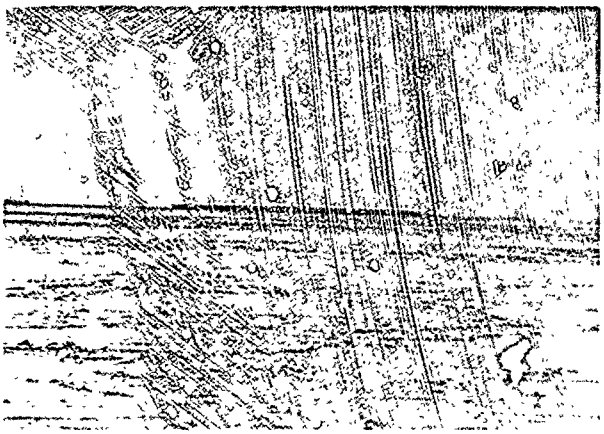


Figure 21 A tabular iceberg on 5 October

of 30–40 cm with 2–5 cm snow Approximately 30%

6 October 1989 (day 279)

0830 hours

65° 42 47' S, 01° 57.42' W
Heading 135 8
100% concentration Ice is 40 cm to 1 m with 10–30 cm snow Approximately 60% is ridged or brecciated

1100 hours

65° 46' S, 01° 50' W
Arrive at mesopolygon

7 October 1989 (day 280)

0900 hours

65° 52 01' S, 01° 51 50' W
Heading 153
Foggy, no horizon, visibility bad

1617 hours

65° 56 88' S, 01° 50 60' W
Heading 156 6
On station since 1030 Large cracks and leads opening up port and starboard Large lead from stem around port side

8 October 1989 (day 281) 1440 hours

66° 04 02' S, 02° 02 45' W
Foggy, windy Visibility very poor Cannot see leads

9 October 1989 (day 282)

0830 hours

65° 59 85' S, 02° 28 45' W
Storm is over, sunny day Leads surrounding ship between 1 and 1 5 km

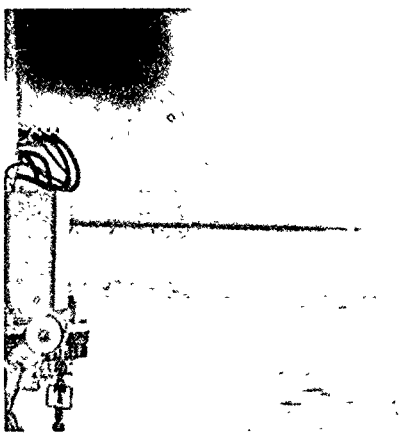


Figure 22 Mesopolygon after storm on 9 October Many leads had opened up around the ship

1945 hours

66° 05.20' S, 02° 35 49' W
No visible changes

10 October 1989 (day 283)

0900 hours

66° 11.39' S, 02° 49 78' W
Overcast Leads appear to be closing somewhat, but difficult to judge

2100 hours

66° 14 03' S, 02° 57 91' W
Crack from bow to lead on starboard side opened at noon Everything fl opening that are not visible because of thick snow Crack opened from the way to the lead behind the ship

11 October 1989 (day 284)

0815 hours

66° 16 96' S, 03° 03 13' W
Crack from bow to lead on starboard side is larger (approximately 20 causing it to refreeze Ice floe starting to close up CTD hole May have

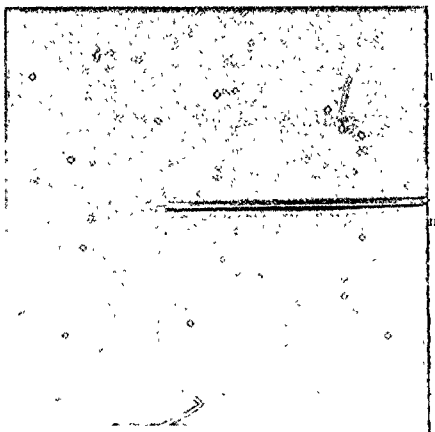


Figure 23 Leads surrounding ship on 11 O

1930 hours

66° 21 11' S, 03° 28 84' W
No visible changes

12 October 1989 (day 285)

0820 hours

66° 14 28' S, 03° 55 09 W
Visibility poor Ship has moved 20 m from last night Ice broken u drifted in Will be difficult to work on ice

1945 hours

66° 05 20' S, 02° 35.49' W
No visible changes

10 October 1989 (day 283)

0900 hours

66° 11 39' S, 02° 49.78' W
Overcast. Leads appear to be closing somewhat, but difficult to judge after snowfall last night.

2100 hours

66° 14 03' S, 02° 57 91' W
Crack from bow to lead on starboard side opened at noon Everything flooding and very wet Cracks opening that are not visible because of thick snow. Crack opened from stern of ship on port side all the way to the lead behind the ship

11 October 1989 (day 284)

0815 hours

66° 16 96' S, 03° 03 13' W
Crack from bow to lead on starboard side is larger (approximately 20 m wide) Snow blowing in is causing it to refreeze Ice floe starting to close up CTD hole May have to move ship Visibility poor.

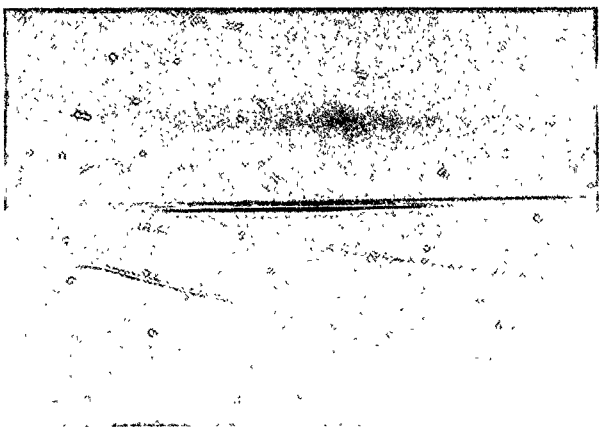


Figure 23 Leads surrounding ship on 11 October

1930 hours

66° 21 11' S, 03° 28 84' W
No visible changes

12 October 1989 (day 285)

0820 hours

66° 14 28' S, 03° 55 09' W
Visibility poor Ship has moved 20 m from last night Ice broken up around ship Everything has drifted in Will be difficult to work on ice

1545 hours

66° 10.75' S, 04° 03 06' W
Visibility has improved. More open water around us than before the storm. Leads and cracks covered with snow and impossible to distinguish from thick ice. All ice is more flooded than yesterday.

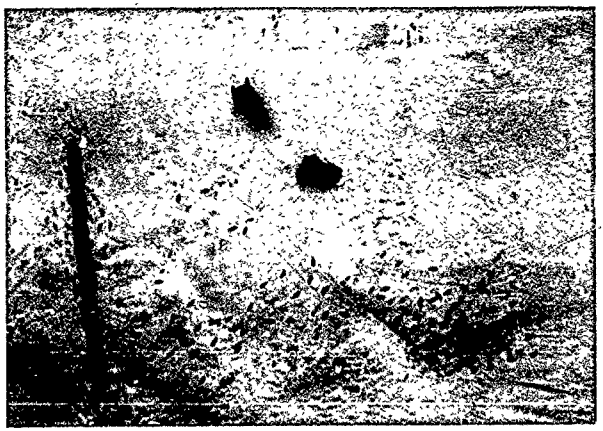


Figure 24. Frozen footprints in slush from flooding of ice surface on 12 October.

Figure 25. Leads covered with snow, indistinguishable from surrounding ice on 12 October.

13 October 1989 (day 286)

0820 hours

66° 04.71' S, 04° 11.89' W
Heading 146 1.

Wind has dropped and breakup seems to have stopped

1858 hours

66° 00.13' S, 04° 12.16' W
Not much change since this morning. Ice and snow hardening up. Snow bridges over cracks. Difficult to determine what's what.

14 October 1989 (day 287)

0845 hours

65° 56 13' S, 04° 12 98' W
Sunny day. Ice conditions did not change much over night Six

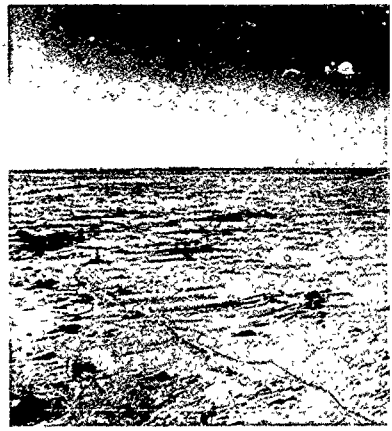


Figure 26. Six icebergs within sight of the ship

2053 hours

65° 52.4' S, 04° 18.89' W
Heading 149.4.
No visible changes.

15 October 1989 (day 288)

0815 hours

65° 49.38' S, 04° 19,17' W
Clear with low grou[illegible] fog. Some new cracks in the ice [illegible] ont
stem and around port side, approximately 0.5 to 1 km from t[illegible]

1840 hours

65° 44.28' S, 04° 16 54' W
Heading 147.3.
Ice conditions have not changed much during the day Lead

16 October 1989 (day 289)

0830 hours

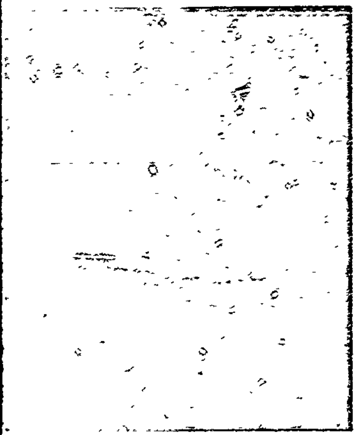
65° 35.98' S, 04° 18.77' W
Heading 146.8.
Bright sunny day. Lead on port side of ship has closed up. Th
the ship. Starboard side of ship has four patches of open water a
from 0 5–1.5 km in size.

1730 hours

65° 31.65' S, 04° 15.00' W
No change in ice conditions since this morning

around us than before the storm. Leads and cracks covered
from thick ice. All ice is more flooded than yesterday.

[illegible] 12 October



[illegible] indistinguishable from surrounding ice on 12 October

[illegible]

[illegible] up. Snow bridges over cracks

14 October 1989 (day 287)

0845 hours

65° 56.13' S, 04° 12.98' W
Sunny day. Ice conditions did not change much over night. Sea visible bergs.

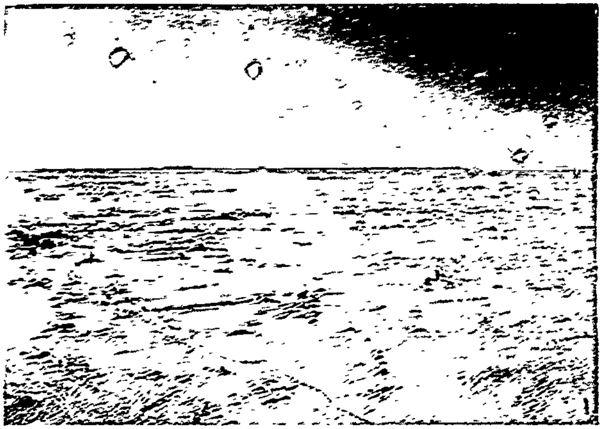


Figure 26 Sea icebergs [illegible] the ship on 14 October 1989

2053 hours

65° 52.4' S, 04° 18.89' W
Heading 149.4.
No visible changes.

15 October 1989 (day 288)

0815 hours

65° 49.38' S, 04° 19.17' W
Clear with low ground fog. Some [illegible] on the starboard side, one from the stern and around port side, approximately 0.5 to 1 km from the ship

1840 hours

65° 44.28' S, 04° 16.54' W
Heading 147.3
Ice conditions have not changed much [illegible] lead on port side of ship has opened

16 October 1989 (day 289)

0830 hours

65° 35.98' S, 04° 18.77 W
Heading 146.8
Bright sunny day. Lead on port side of ship has closed up. There seems to be a larger lead behind the ship. Starboard side of ship has four patches of open water approximately 3–4 km away that range from 0.5–1.5 km in size

1730 hours

65° 31.65' S, 04° 15.00 W
No change in ice conditions [illegible]

17 October 1989 (day 290) 0734 hours

65° 23.58' S, 04° 10.68' W
Ice conditions the same as last night. Crack on port side has ridged slightly. Ponds to starboard appear to be frozen this morning. *Polarstern* on horizon.

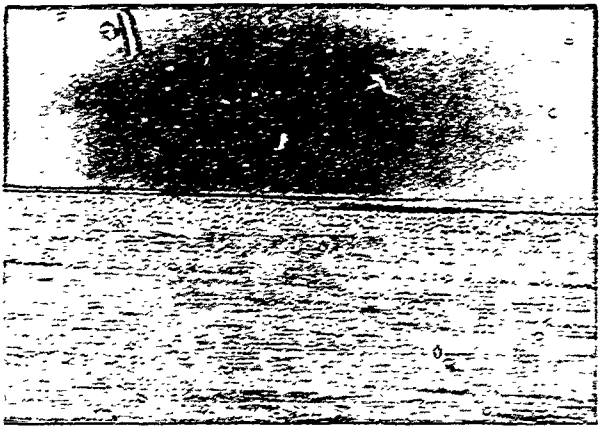


Figure 27. Frozen ponds on horizon on 17 October.

18 October 1989 (day 291)

0820 hours

65° 21.05' S, 04° 06.85' W
Heading 142.6.
Ice conditions have changed little since yesterday. Crack from starboard to outer lead has opened again. Ponds refreezing.

1550 hours

65° 25.59' S, 03° 45.32' W
Left mesopolygon at 1330 because the *Polarstern* broke up the floe when she left. 100% concentration. 85% is thick ice of 50–70 cm with 0–5 cm snow. 15% is refrozen leads of 2–15 cm. Heavy ridging covering approximately 20% of the area exists. Two bergs visible

Figure 28. Broken ice and track left by the Polarstern *18 October*

19 October 1989 (day 292)

1230 hours
64° 44.36' S, 03° 30.13' W
Heading 298.
Foggy, visibility poor. 100% concentration. Ice is approximately 5[illegible]
[illegible] ridging 1 mile [illegible]

1815 hours

64° 30.87' S, 03° 53.21' W
Heading 329.9.
70% concentration. Ice is 10–50 cm with 5–10 cm snow. Ice is [illegible]
bergs visible.

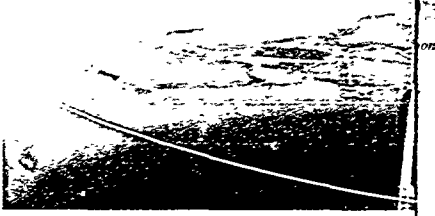


Figure 29. Ice concentration of 70% on [illegible]

20 October 1989 (day 293)

1300 hours

63° 16.90' S, 06° 25.66' W
80% concentration. Ice is approximately 30–40 cm with 0–5 cm [illegible]
with layer of frazil—no pancakes visible

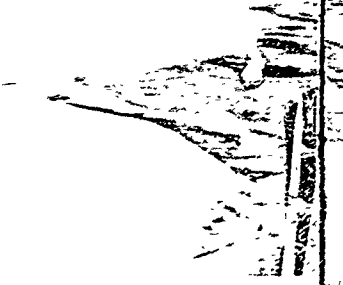


Figure 30. Ship following refrozen lead on 20 [illegible]

19 October 1989 (day 292)

1230 hours

64° 44.36' S, 03° 30.13' W
Heading 298.
Foggy, visibility poor. 100% concentration. Ice is approximately 50–80 cm with 10–30 cm snow. 10% ridging. Little algae visible.

1815 hours

64° 30.87' S, 03° 53.21' W
Heading 329.9.
70% concentration. Ice is 10–50 cm with 5–10 cm snow. Ice is approximately 40% ridged. Two bergs visible.

Figure 29 Ice concentration of 70% on 19 October

20 October 1989 (day 293)

1300 hours

63° 16.90' S, 06° 25.66' W
80% concentration. Ice is approximately 30–40 cm with 0–5 cm snow. Leads are about 50% of area with layer of frazil—no pancakes visible

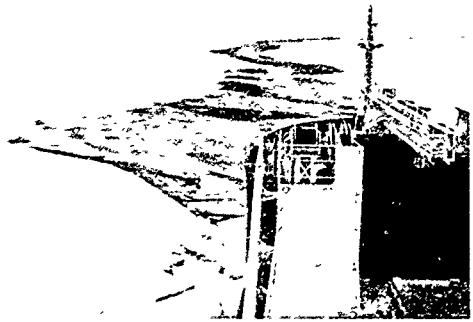


Figure 30 Ship following refrozen lead on 20 October

2050 hours

62° 53.08' S, 07° 11.40' W
Heading 346.
Snowing, visibility poor. 70% concentration. Hardest ice seen in the last two days. Ice is 40–50 cm with 5–10 cm snow.

21 October 1989 (day 294)

1005 hours

62° 06.44' S, 08° 56.36' W
Heading 330.
70% concentration. Following large leads. 5% pancakes in leads. Thick ice is 50–100 cm with 10–30 cm snow.

2013 hours

61° 26.35' S, 10° 12.72' W
Heading 345.
85% concentration. Leads have approximately 1 cm frazil—no pancakes. Ice is between 20–30 cm with 5 cm snow.

22 October 1989 (day 295)

0820 hours

61° 47.30' S, 11° 32 15' W
Heading 340.
Visibility poor because of snow. No photos. Ice is between 50 cm to 1 m with 30 cm of snow. A lot of brown color through at least the bottom half of the ice. On some ice there is a clear layer of ice below the algal layer.

1330 hours

60° 22 85' S, 11° 38 84' W
Heading 39 2
95 % concentration. Surface algal concentration seen. Ice is between 70–100 cm with 20 cm of snow.

Figure 31 Algal layer at snow/ice interface on 22 October

23 October 1989 (day 296)

0712 hours

58° 32.80' S, 13° 16 65' W
Heading 325.
50% concentration. All broken up floes in the remaining area are from 20–100 cm. Dark algal bands in most ice.

0727 hours

More surface algae. Ice rotten at snow/ice interface and is very

Figure 32 Getting close to ice edge on 24 October. Thin pancake ice in between

1714 hours

58° 09 62' S, 15° 28 78' W
Heading 283
Ve concentration. Ice in broken pieces. Bands of ice following

24 October 1989 (day 297)

1030 hours

58° 04 73' S, 22° 57 42' W
Heading 267 5
5% concentration

1056 hours

Too many bergs to count (more than 200)

23 October 1989 (day 296)

0712 hours

58° 32.80' S, 13° 16.65' W
Heading 325.
50% concentration. All broken up floes in the remaining area are pancake ice. Range of thickness from 20–100 cm Dark algal bands in most ice.

0727 hours

More surface algae. Ice rotten at snow/ice interface and is very dark.

Figure 32 Getting close to ice edge on 23 October Floes are broken up into smaller pieces with pancake ice in between

1714 hours

58° 09.62' S, 15° 28 78' W
Heading 283
3% concentration Ice in broken pieces Bands of ice following surface waves

24 October 1989 (day 297)

1030 hours

58° 04 73' S, 22° 57 42' W
Heading 267 5
5% concentration

1056 hours

Too many bergs to count (more than 200)

tion. Hardest ice seen in the last two days. Ice is 40–50 cm

s. 5% pancakes in leads Thick ice is 50–100 cm with 10–

mately 1 cm frazil—no pancakes. Ice is between 20–30 cm

Ice is between 50 cm to 1 m with 30 cm of snow A lot of the ice On some ice there is a clear layer of ice

ation seen Ice is between 70–100 cm with 20 cm of snow.

snow/ice interface on 22 October

Figure 33 More than 200 icebergs in area on 24 October

1615 hours

58° 03 39' S, 24° 55 14' W
Too many bergs to count Ice concentration 100%. Mostly older ice and ice breccia Incredible amounts of algae in floes and breccia. Water even looks brown in areas.

Figure 34 Older ice with ice breccia on 24 October

1702 hours

58° 03 27' S 25° 04 03' W
More breccia, fewer large floes Open water ahead Going through large berg population now, fewer ahead

Figure 35 Brecciated area on 24 Octo

1730 hours

58° 03 02' S, 25° 08.50' W
Swells beginning Pancakes mixed with breccia and small floes

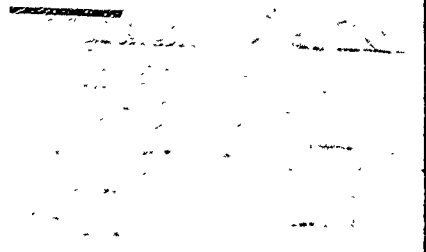
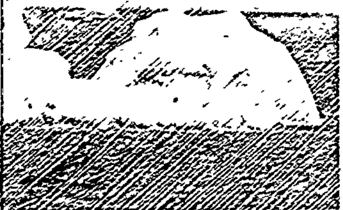


Figure 36 Iceberg near ice edge on 24 Oc

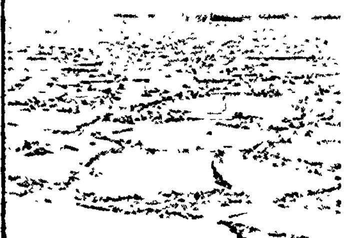
17?? hours

Pancake fields



...00 icebergs in area on 24 October

...m 100's Mostly older ice and ice breccia Incredible
...ice even looks brown in areas



...with ice breccia on 24 October

...ahead Going through large berg population now, fewer

Figure 35 Brecciated area on 24 October

1730 hours

58° 03 02' S, 25° 08 50' W
Swells beginning Pancakes mixed with breccia and small floes

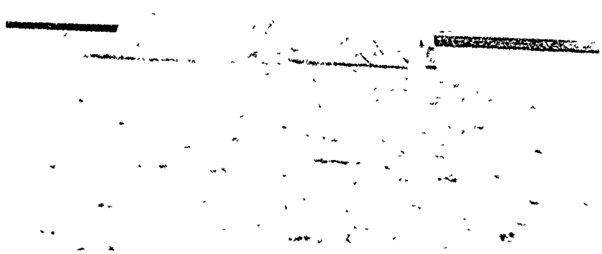
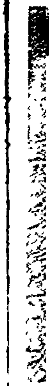


Figure 36 Iceberg near ice edge on 24 October

1732 hours

Pancake fields



173...

58°...
Ope...

Figure 37 Pancakes at ice edge on 24 October

1733 hours

58° 03 05' S, 25° 09 66' W
Open water

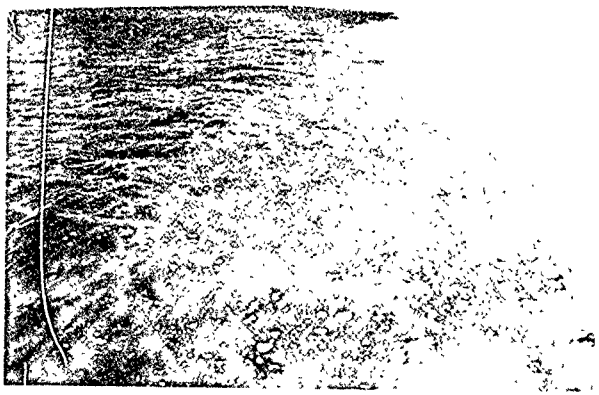


Figure 38 Ice edge, 24 October

25 October 1989 (day 298)

0816 hours

58° 41 00' S, 32 40 23' W
Heading 257 9
One iceberg, 0% ice concentration

0839 hours

One very large, tabular iceberg—10 km long and 30–35 m high

1718 hours

59° 10 93 S, 37° 12 98' W
Heading 258 3
No bergs No ice

26 October 1989 (day 299) 1210 hours

59° 10 86' S, 44° 37 45' W
Heading 250 9
No ice

27 October 1989 (day 300) 0822 hours

60° 30 30' S, 54° 00 93' W
Heading 289
No ice No bergs

The following section, provided by the Soviet ice scientists, is a continuous map of the ice conditions encountered during the cruise. A legend defining the symbols is provided as a foldout at the end of the section. Symbols define ice concentration, ice thickness characteristics and developmental stage of ice growth.

Legend on page 45.

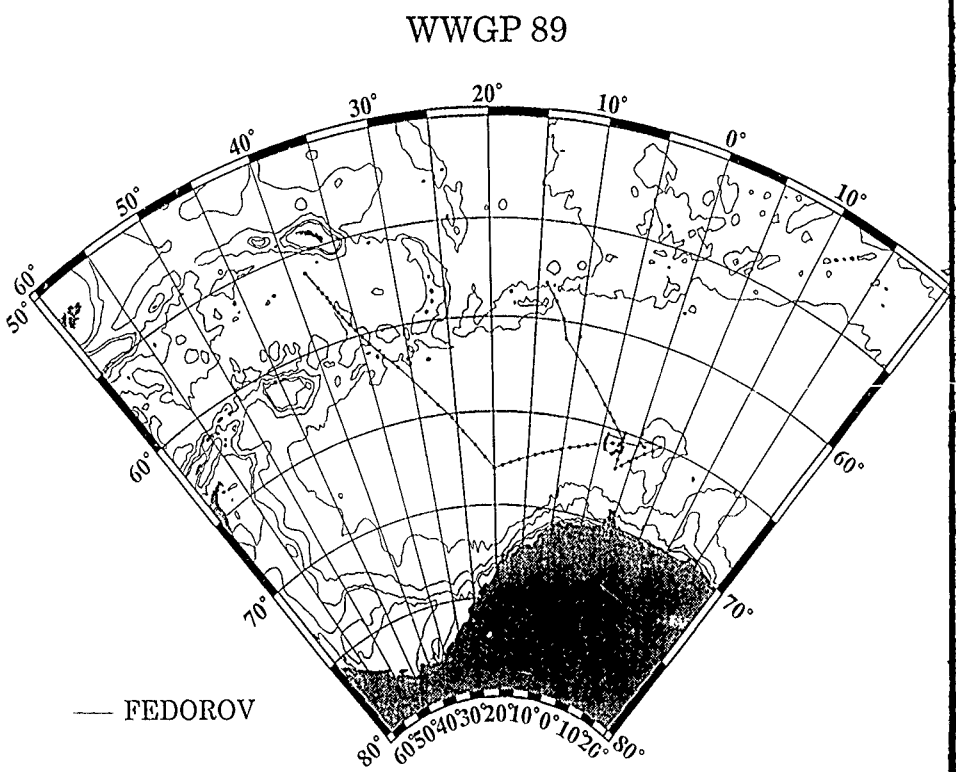
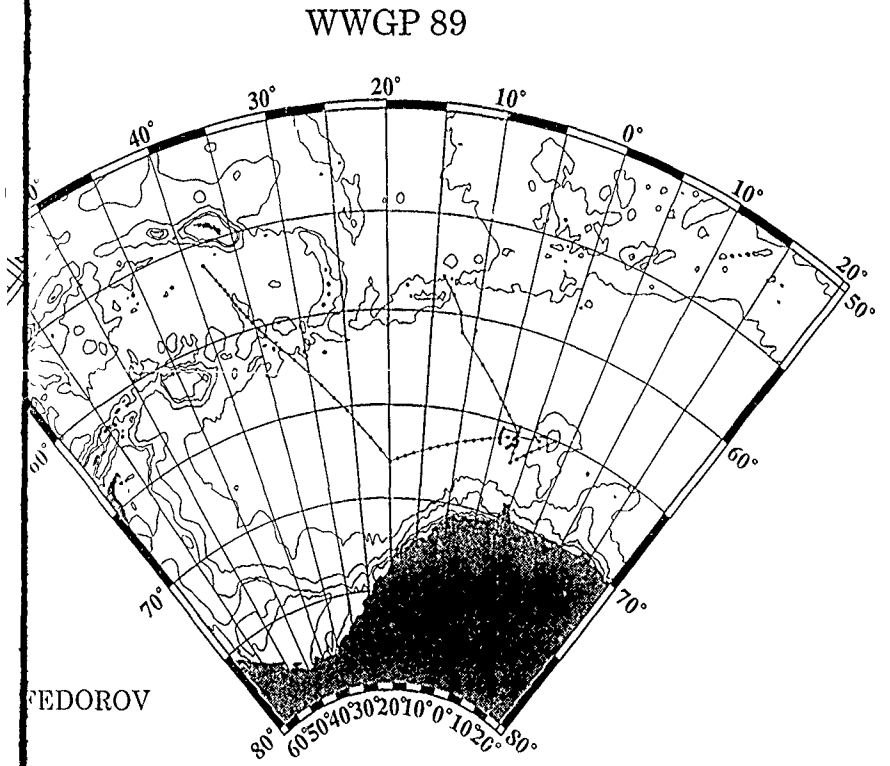


Figure 39 Fedorov's ship track. *The solid line represents the track of the* Fedorov. *CTD casts started at 56°S 37°W, and we stopped taking data at 5[illegible]. Each dot represents a CTD cast and in most cases an ice station.*

ng section, provided by the Soviet ice scientists, is a continuous map of the ice conditions encountered during the cruise A legend
mbols is provided as a foldout at the end of the section Symbols define ice concentration, ice thickness characteristics and
stage of ice growth

ge 45.



ship track The solid line represents the track of the Fedorov *CTD casts started at 56 S 37 W, and we stopped taking data at 58 S 14 W*
CTD cast and in most cases an ice station

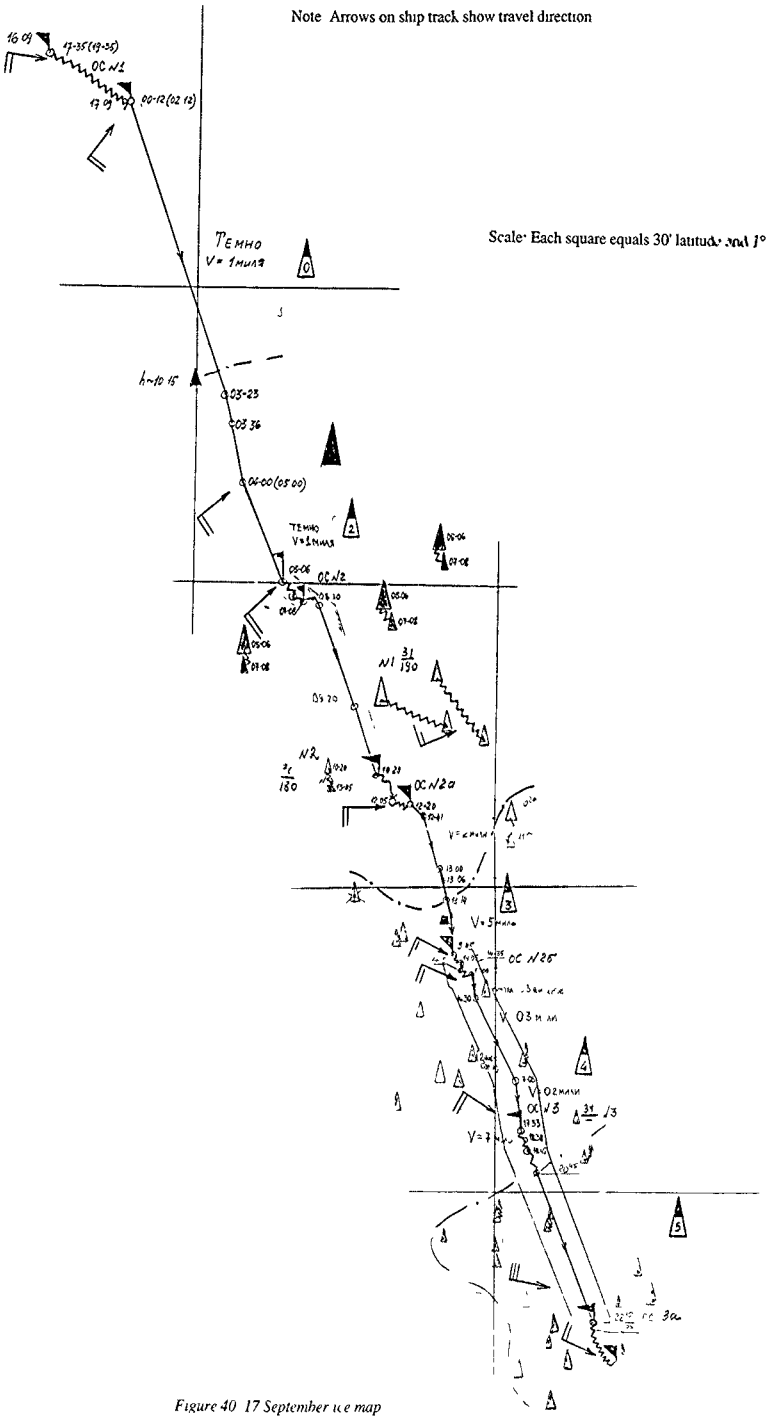
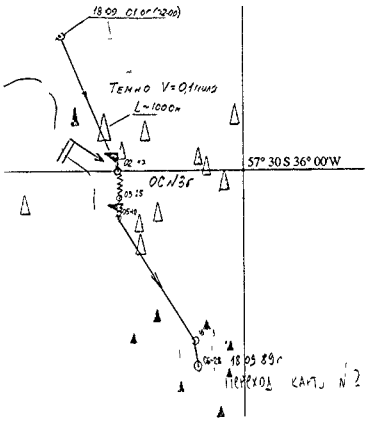


Figure 40 17 September ice map



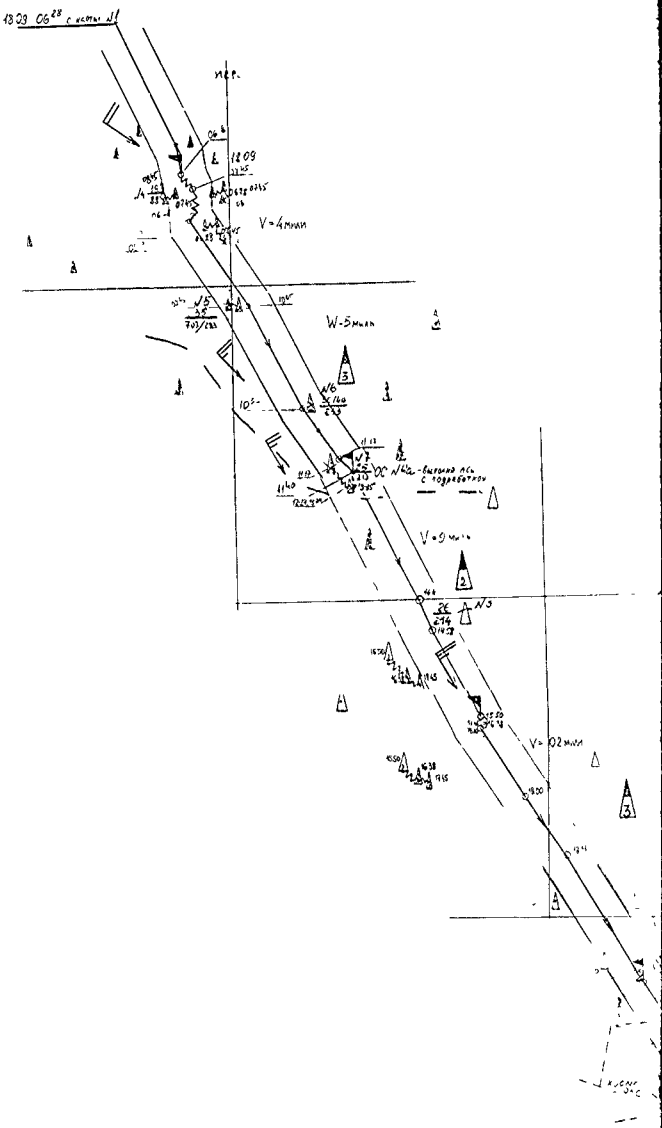


Figure 41 18 September ice map

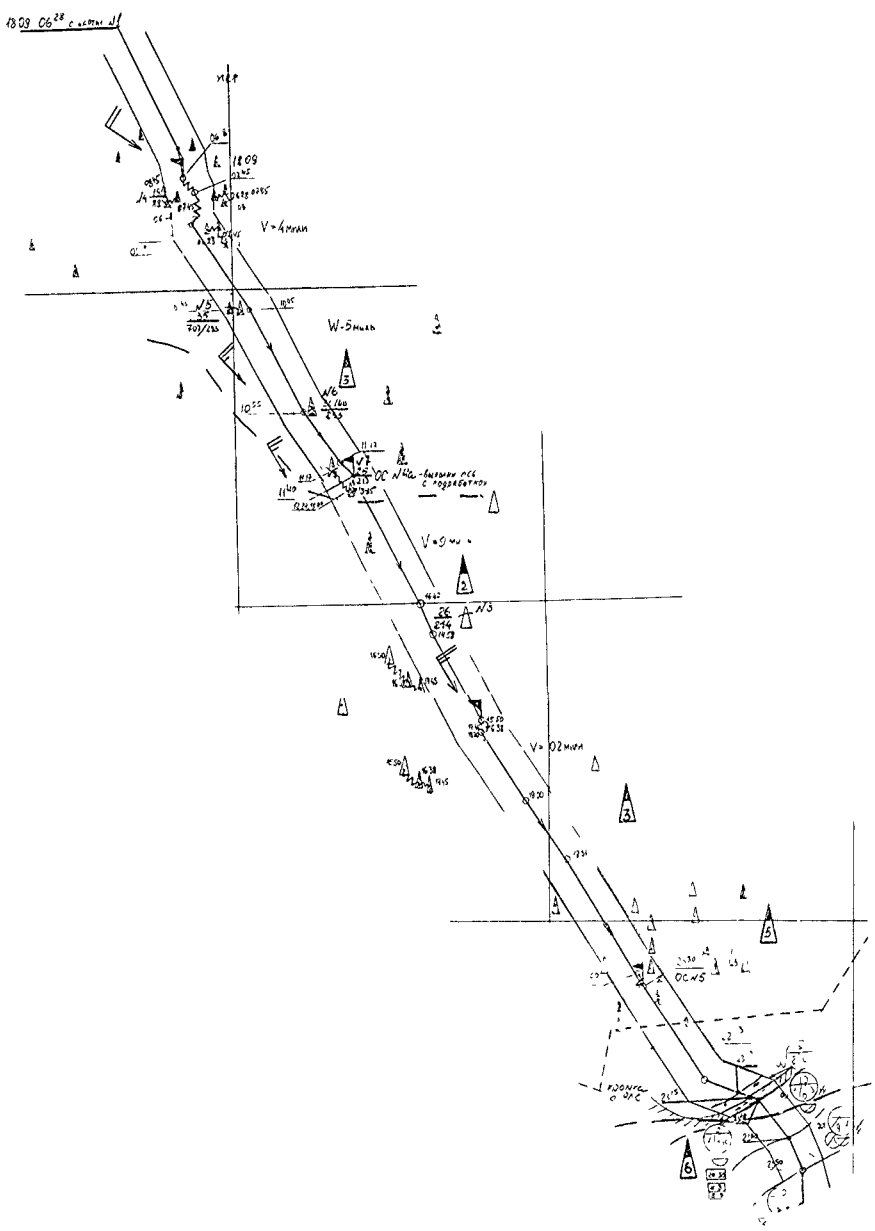


Figure 41 18 September ice map

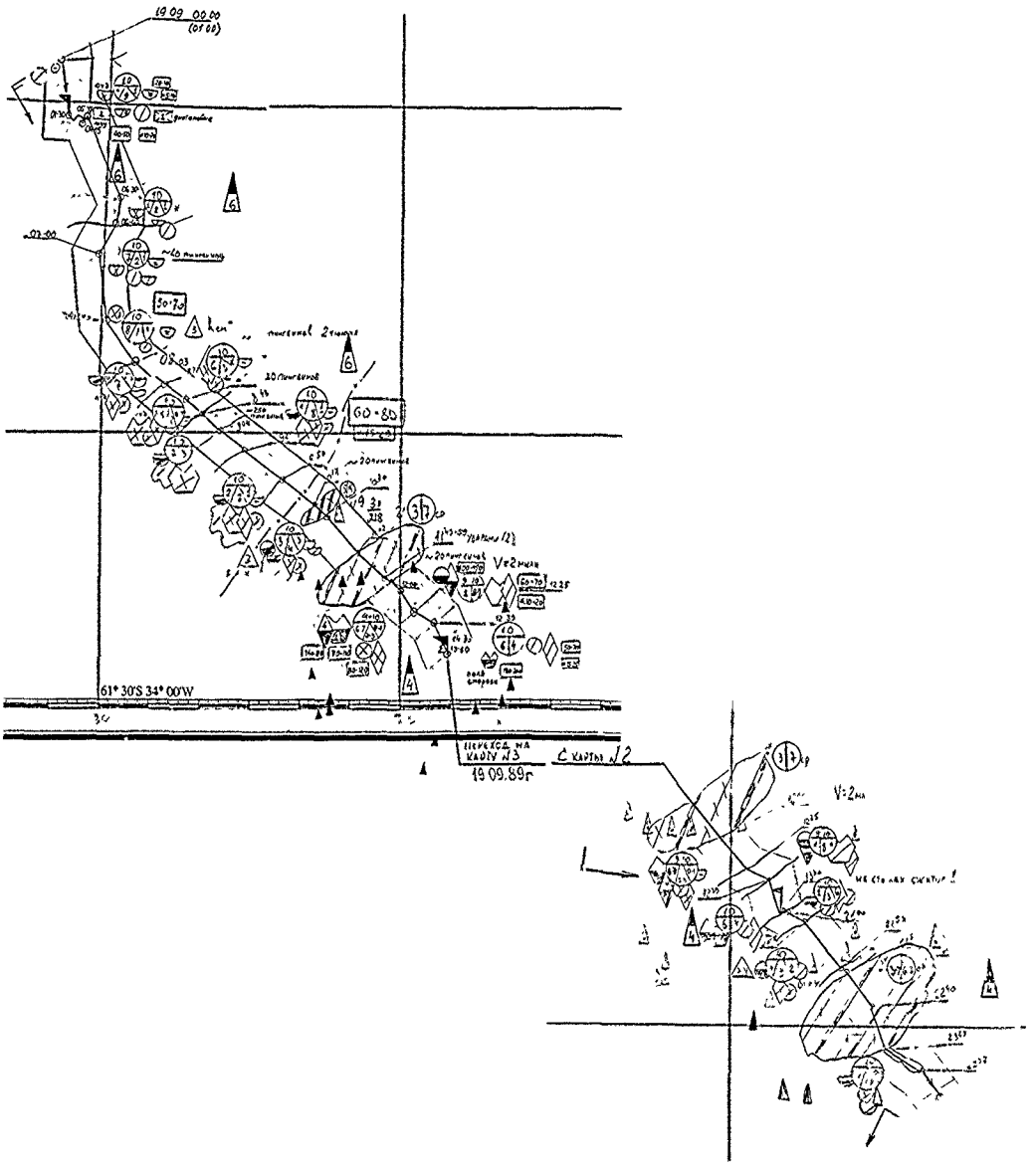


Figure 42. 19 September ice map.

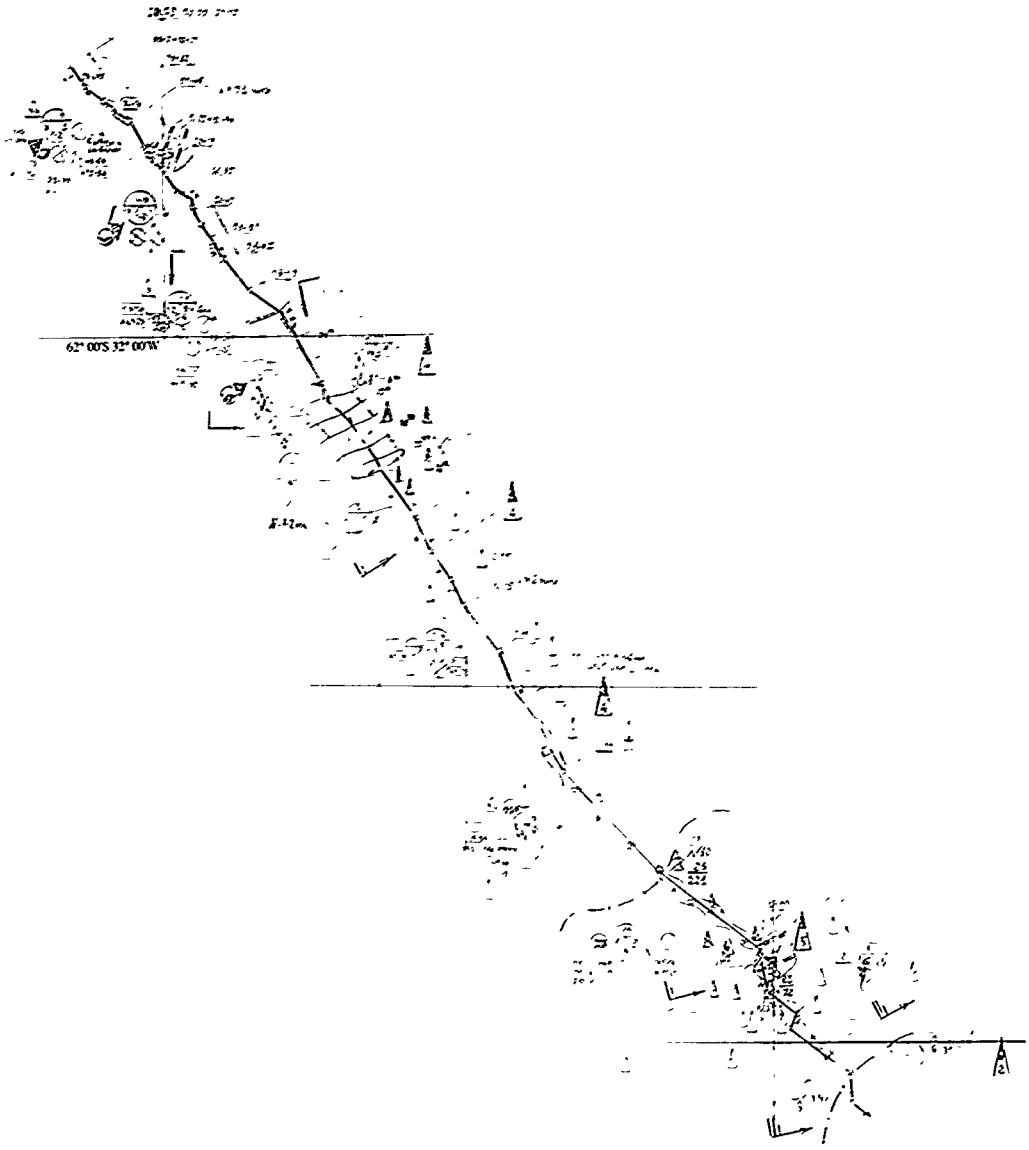


Figure 43 20 September ice map

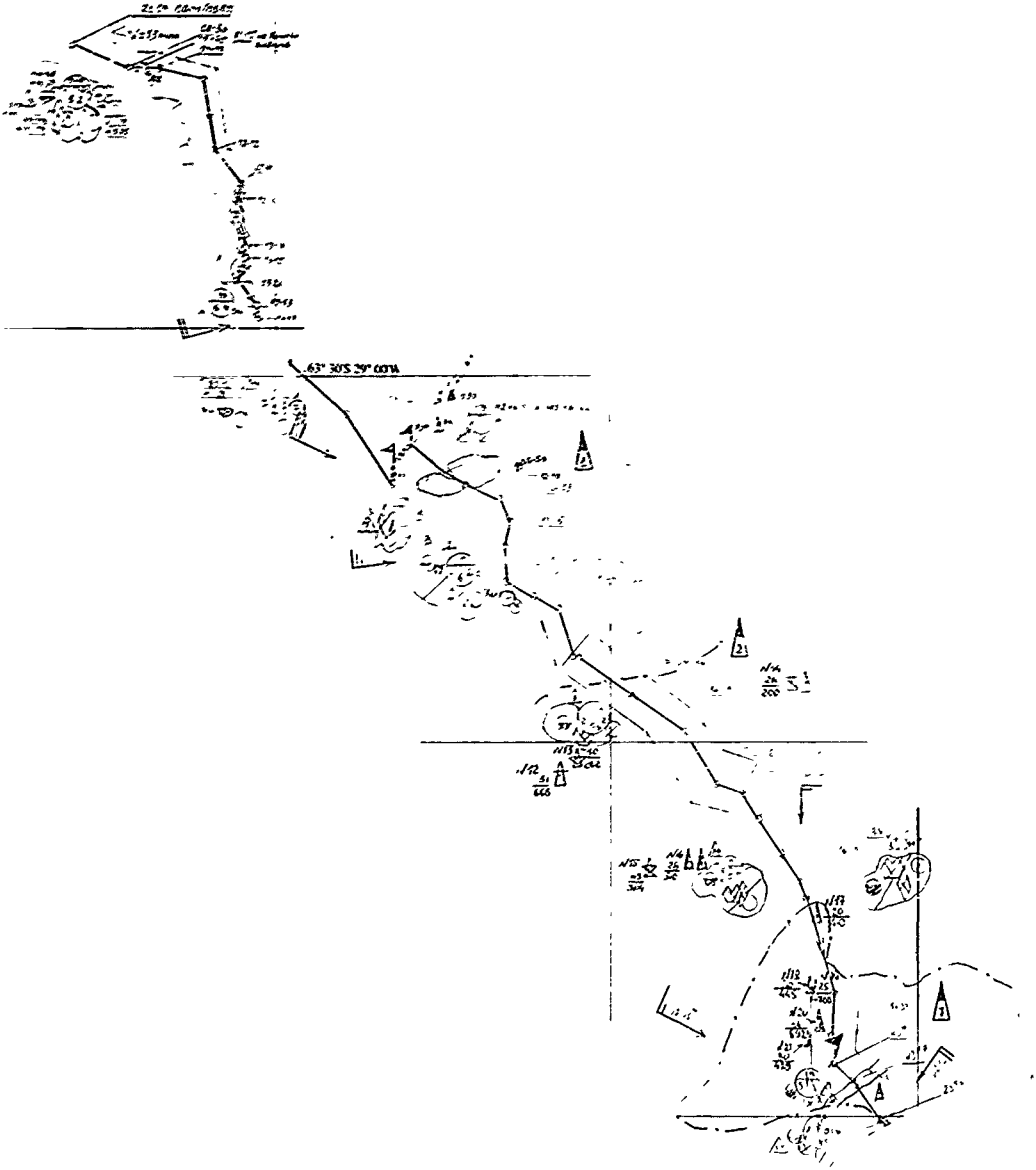


Figure 44 21 September ice map

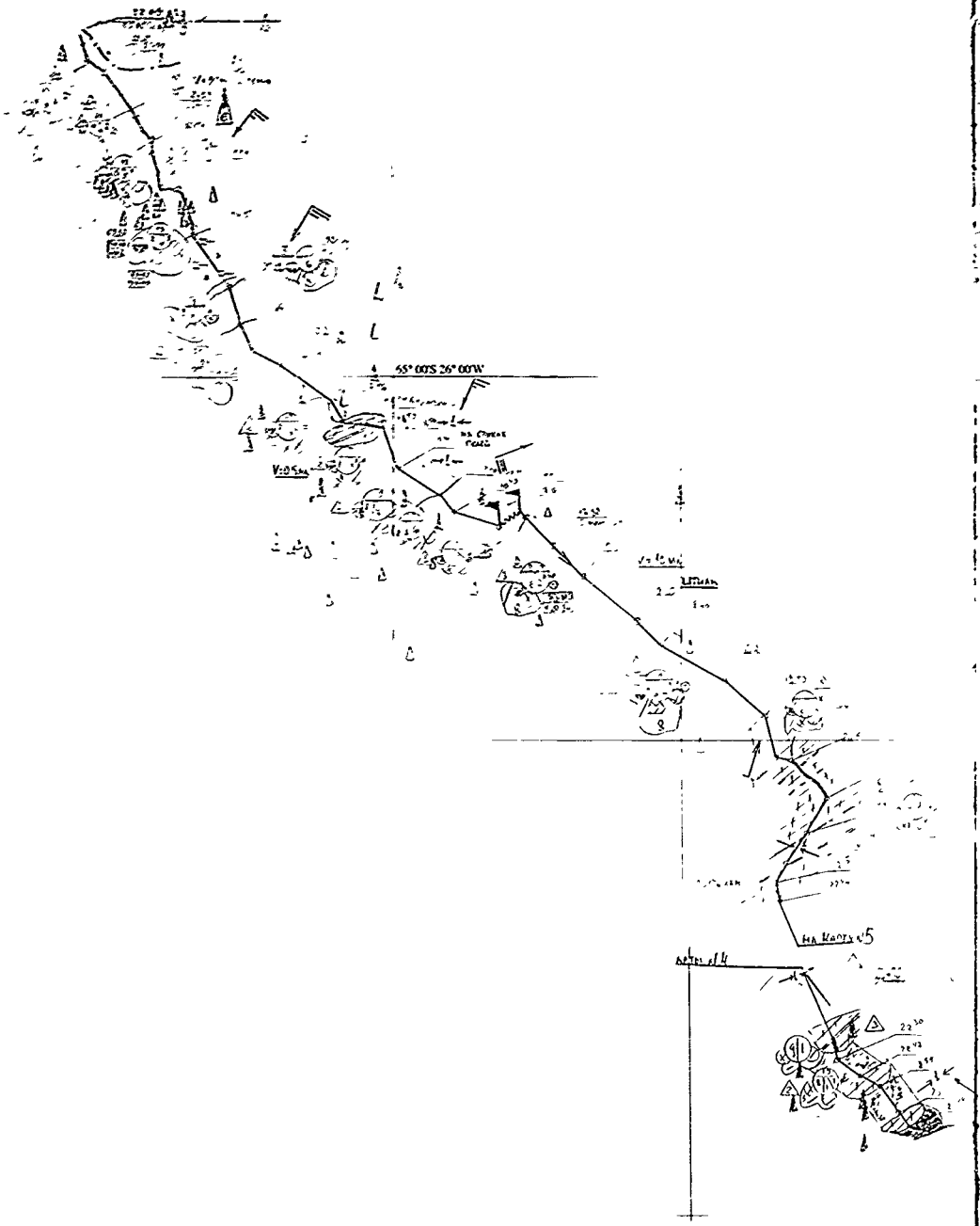


Figure 45 22 September ice map

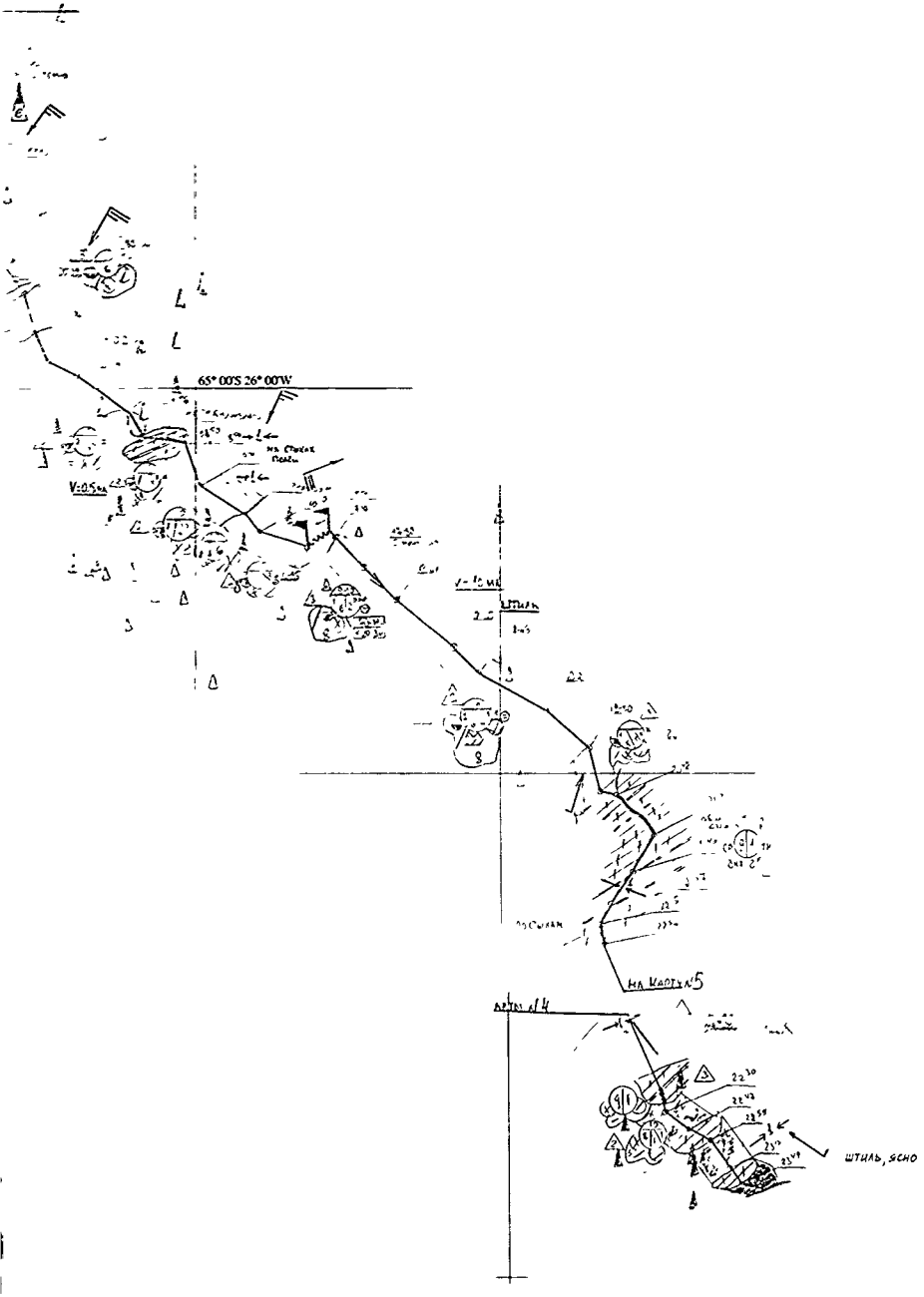


Figure 45 22 September ice map

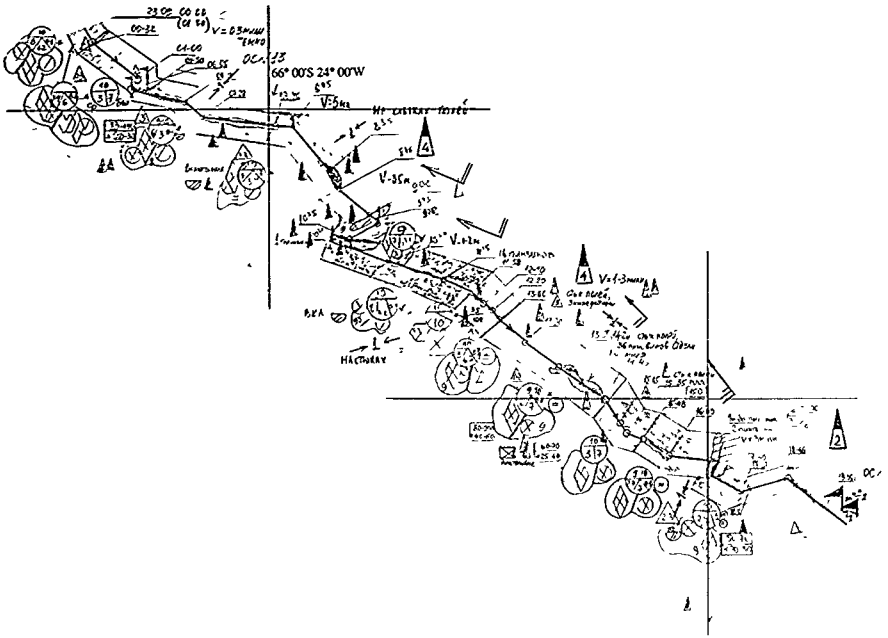


Figure 46 23 September ice map

Note scale change. Each square is equal to 30' latitude 2° longitude

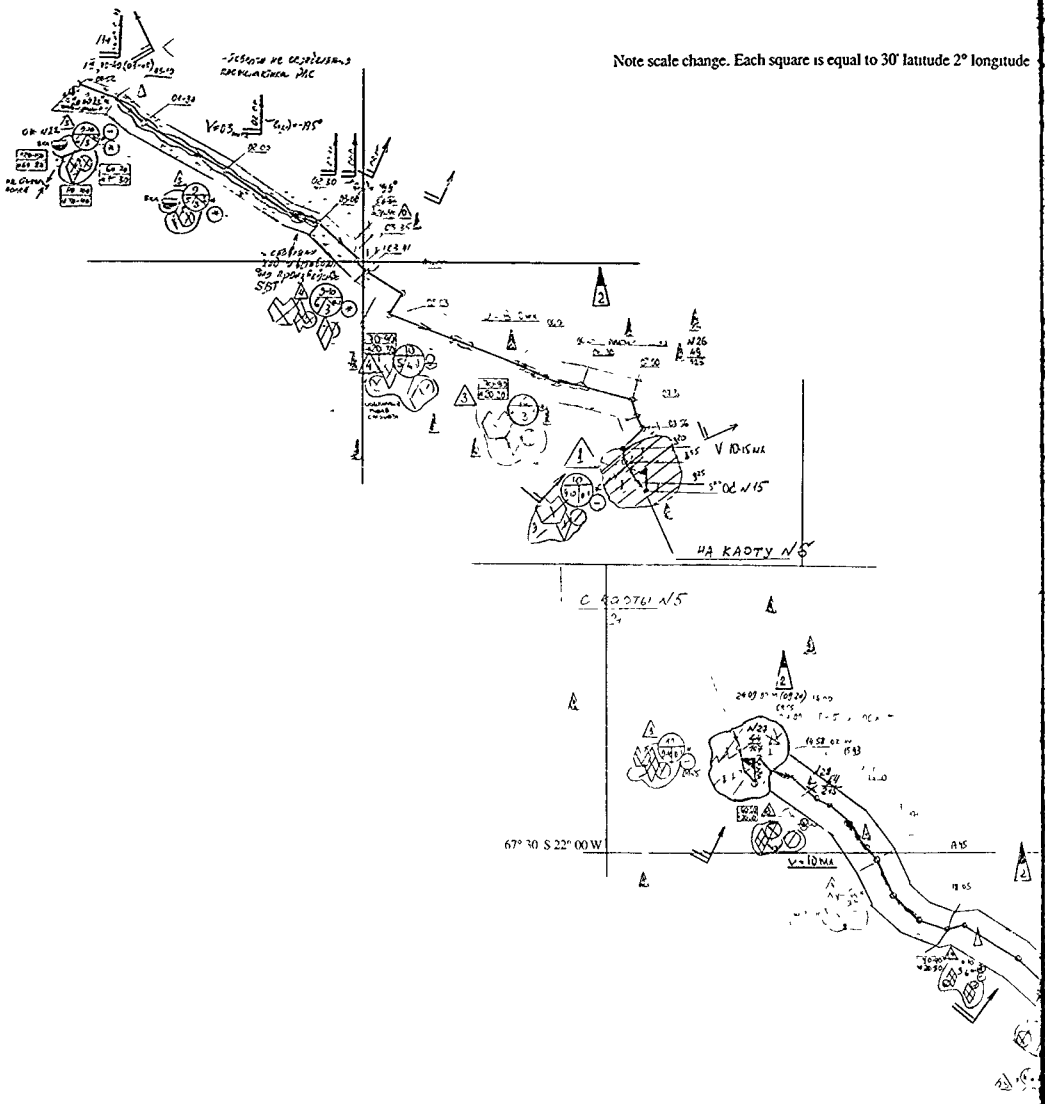


Figure 47 24 September ice map

Note scale change Each square is equal to 30' latitude 2° longitude

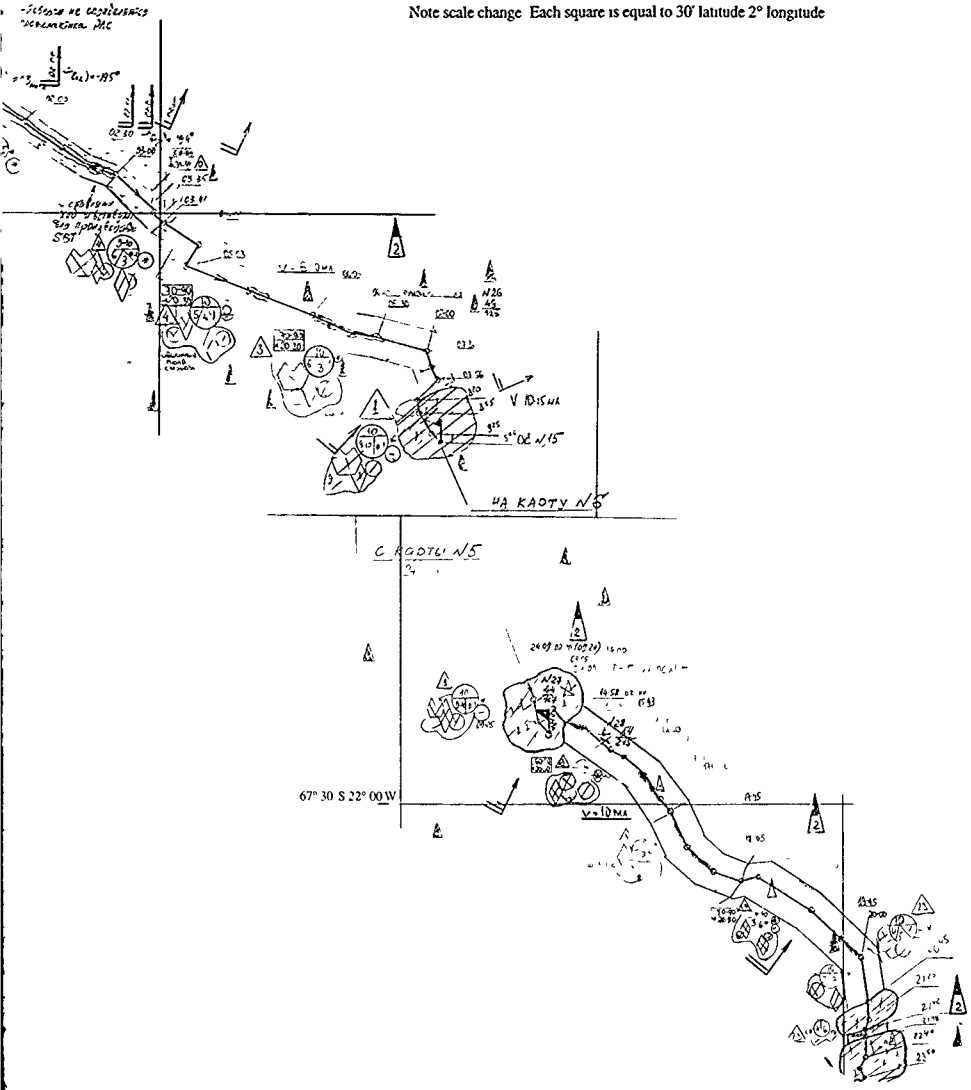


Figure 47 24 September ice map

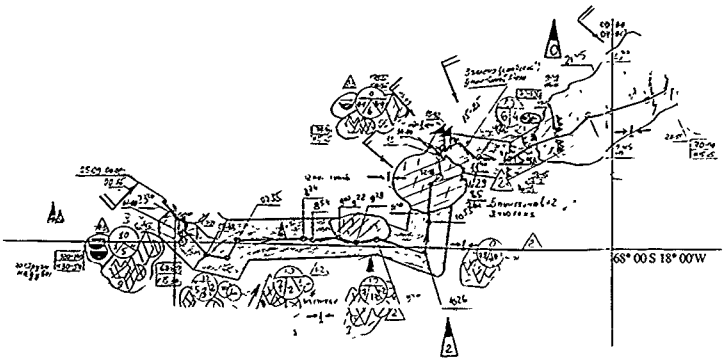


Figure 48 25 September ice map

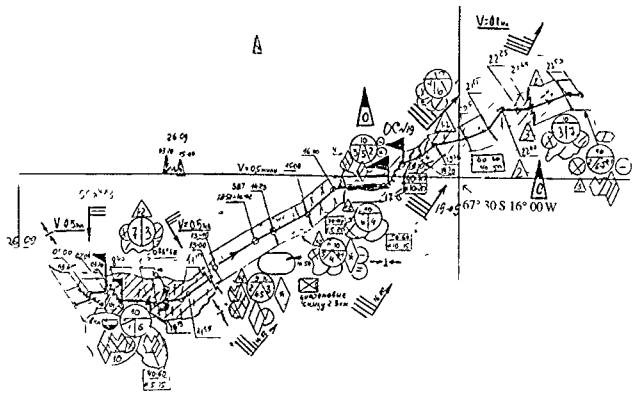


Figure 49 26 September ice map

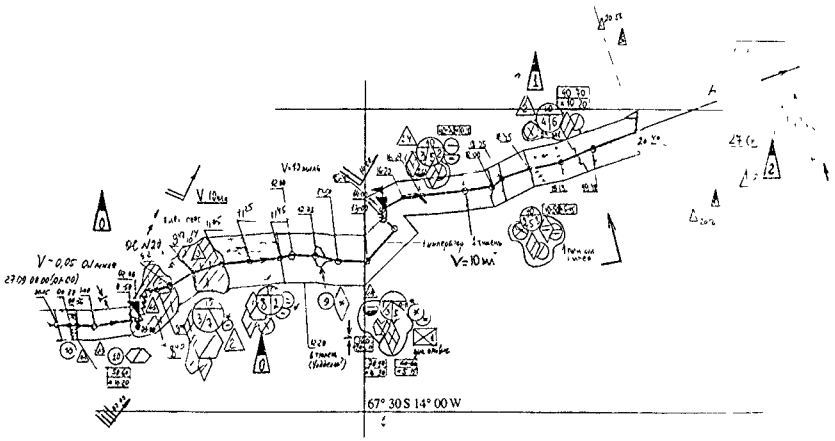


Figure 50 27 September ice map

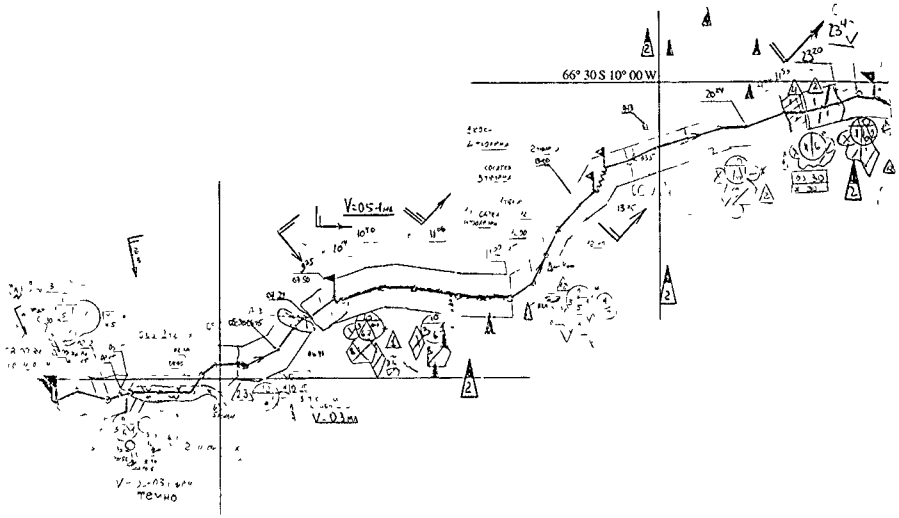


Figure 51 28 September ice map

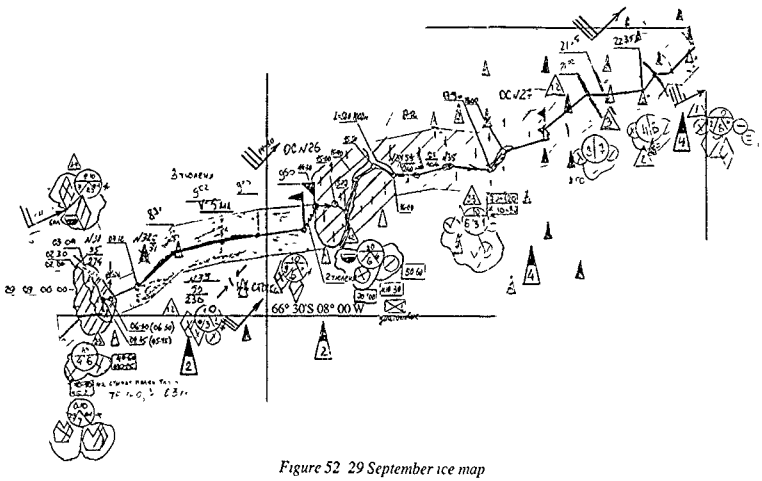


Figure 52 29 September ice map

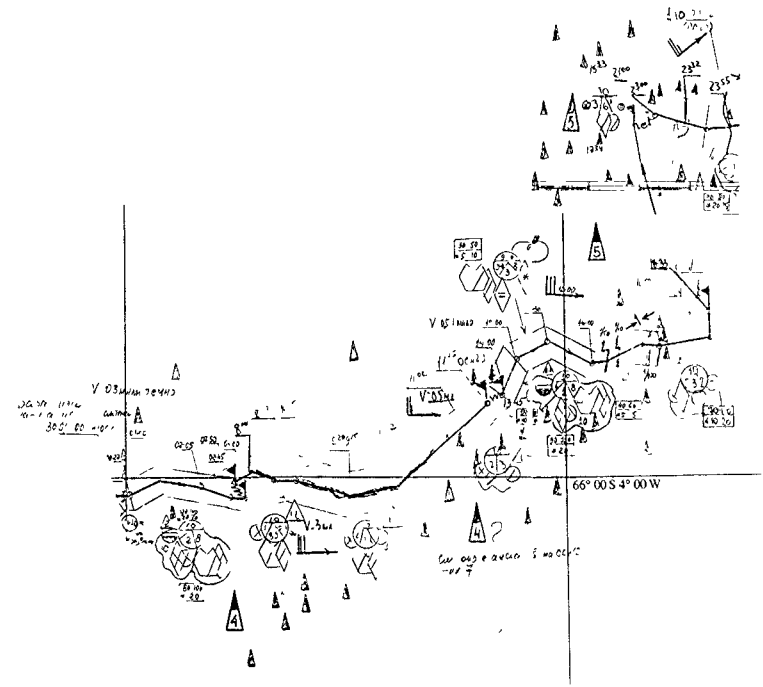


Figure 53 30 September ice map

Note scale change Each square is equal to 30' latitude and 1° longitude

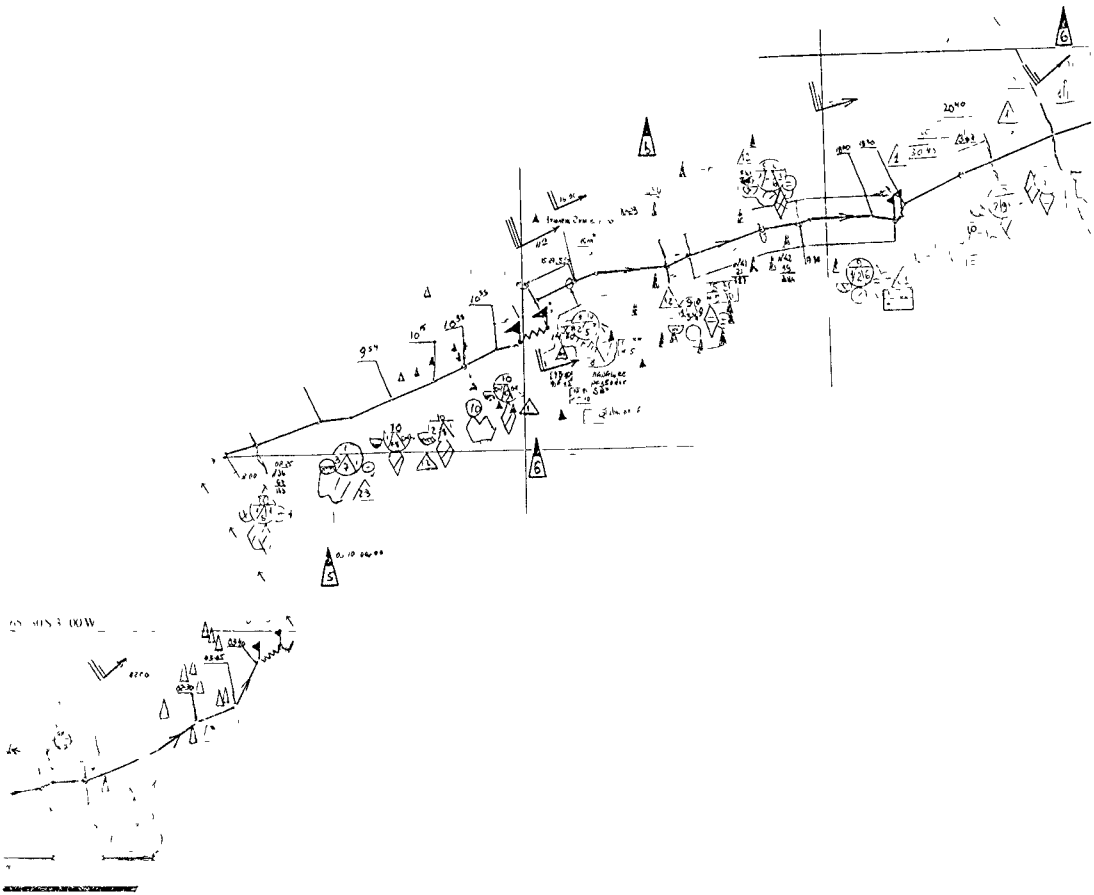


Figure 54 1 October ice map

Each square is equal to 30' latitude and 1° longitude

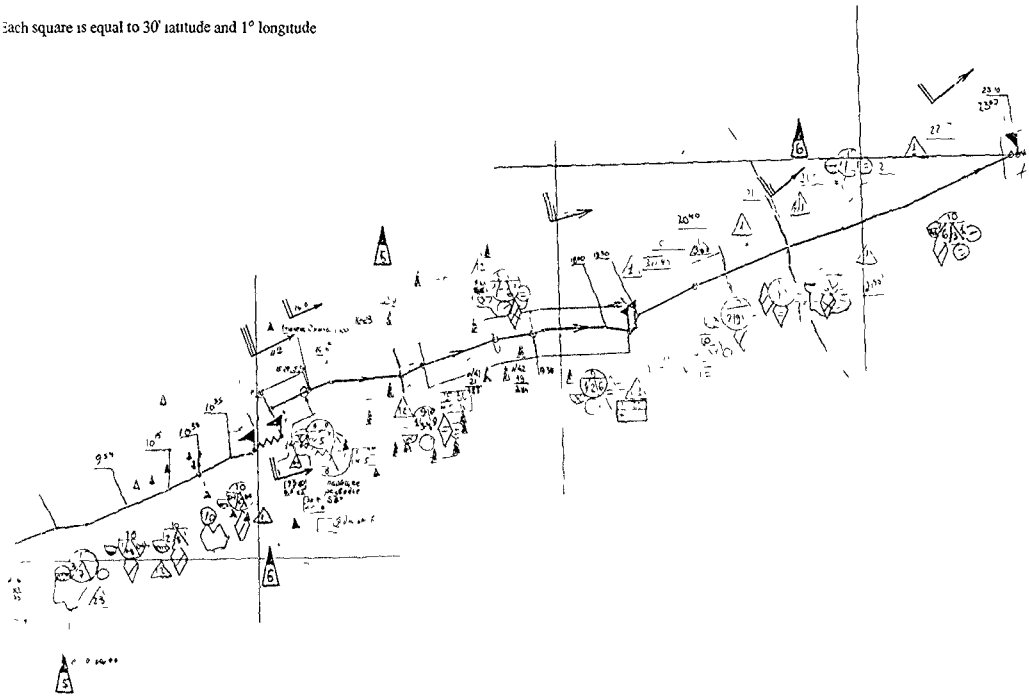


Figure 54 1 October ice map

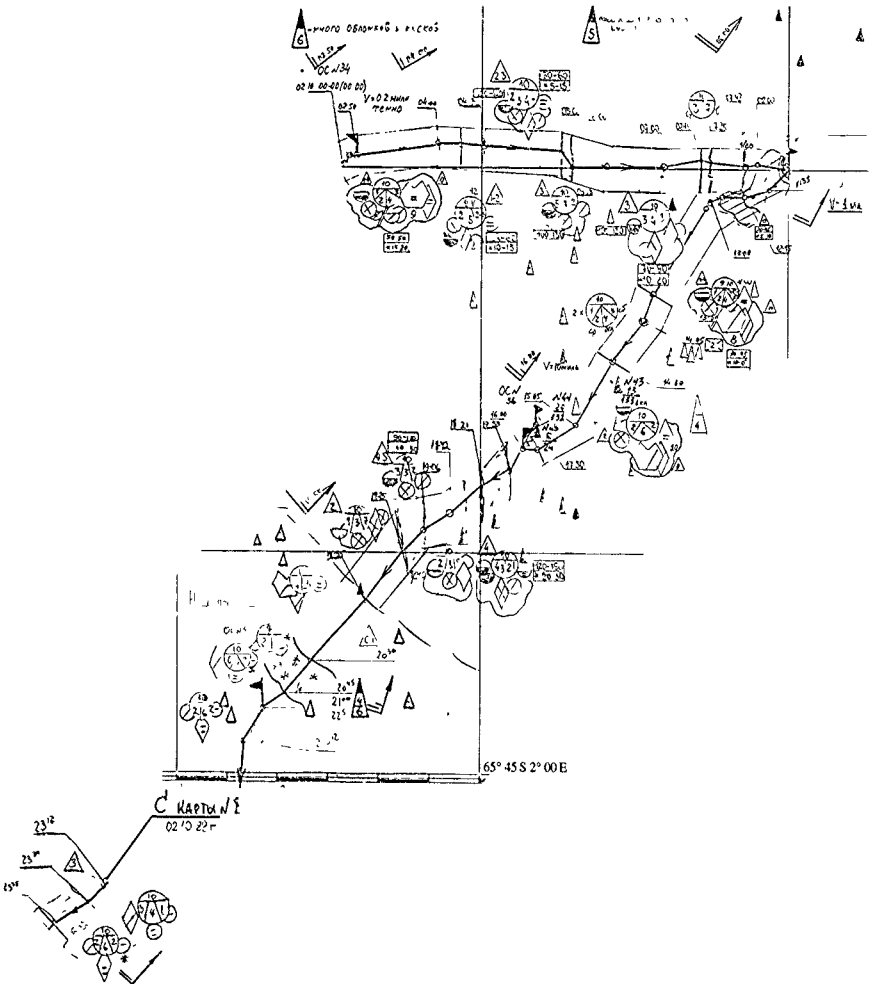


Figure 55 2 October ice map

Note scale change: Each square is equal to 30' latitude and 2° longitude.

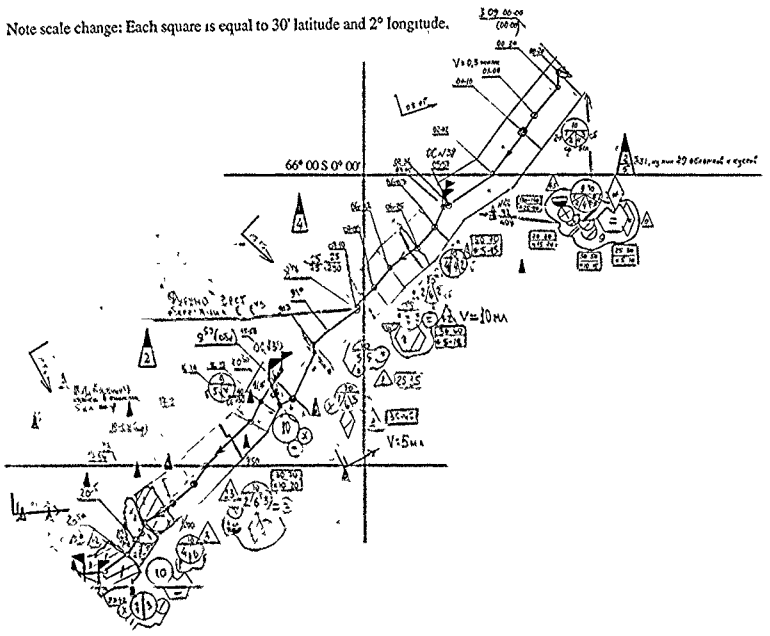
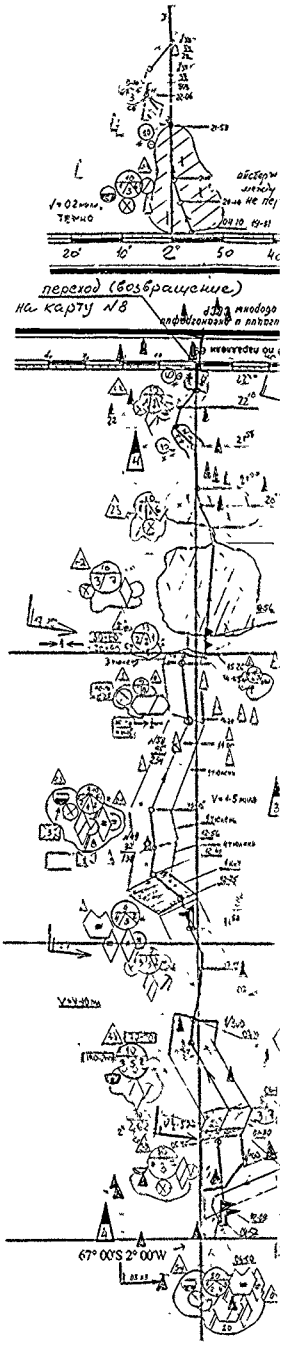


Figure 56. 3 October ice map.

Note scale change. Each square is equal to 30' latitu



, 30 latitude and 2° longitude.

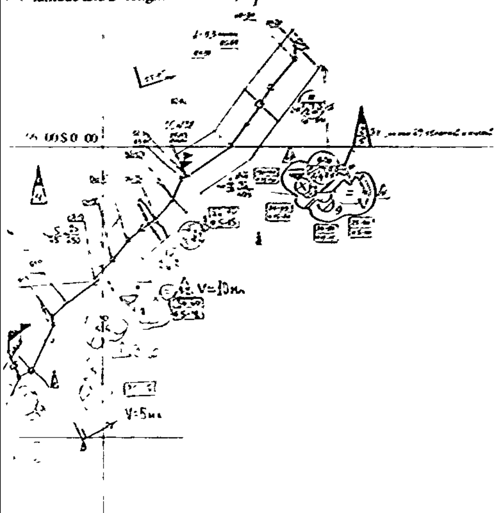


Figure 56. 3 October ice map

Note scale change: Each square is equal to 30' latitude and 1° longitude.

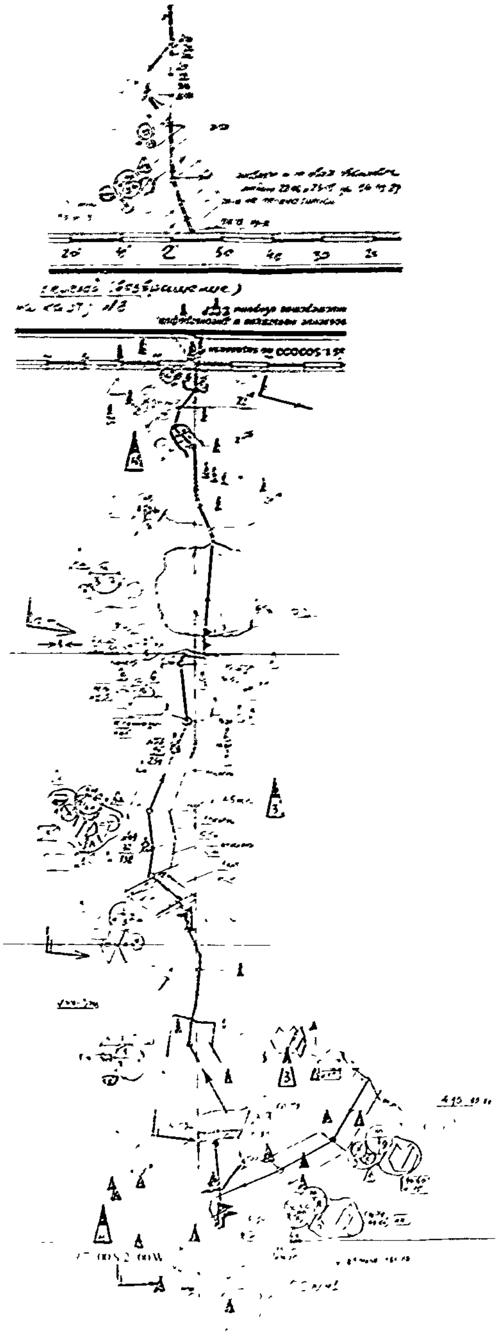


Figure 57. 4 October ice map

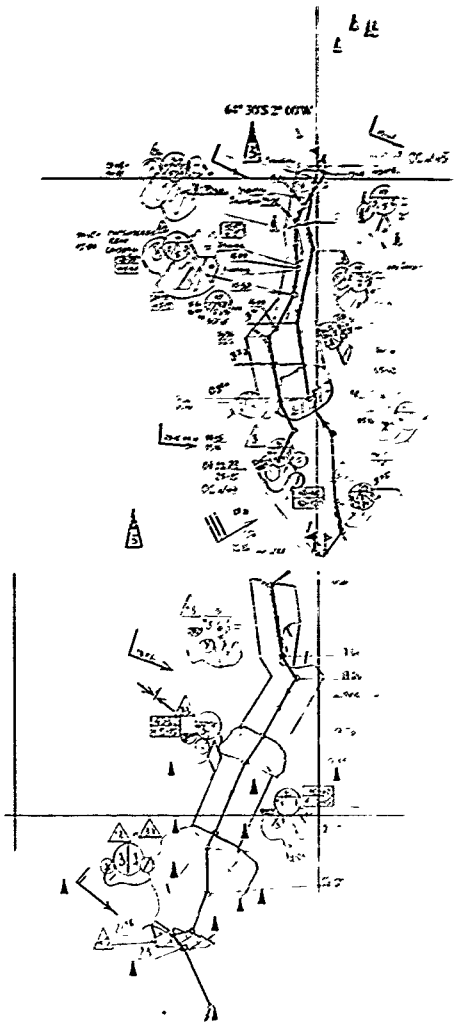


Figure 58 5 October tide map

Note scale change: In the left section each square is equal to 2° longitude;
in the right section each square is equal to 1° longitude.

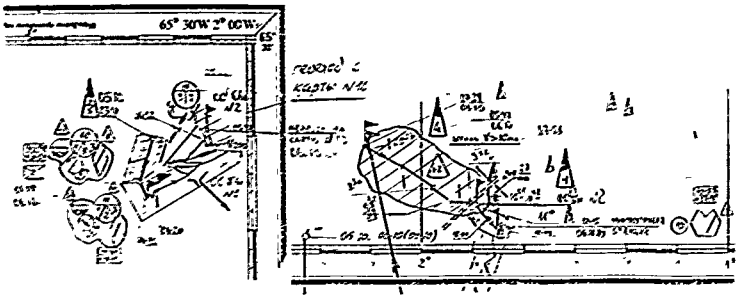


Figure 59 6 October ice map

Note scale change Each square is equal to 30' latitude and 30 longitude

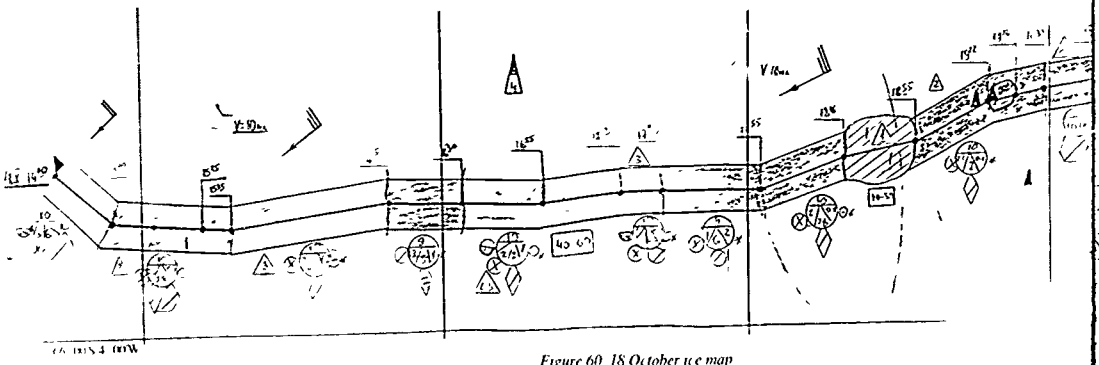


Figure 60 18 October ice map

te scale change: In the left section each square is equal to 2° longitude;
n the right section each square is equal to 1° longitude.

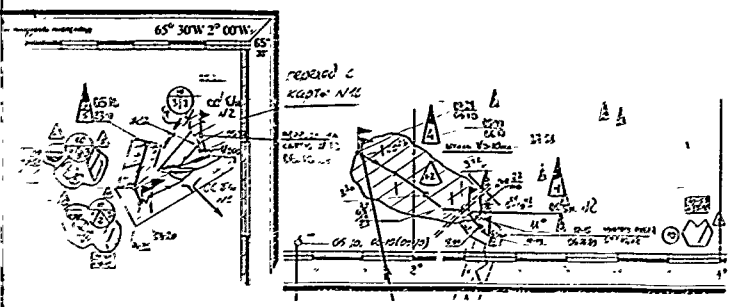


Figure 59 6 October ice map

Note scale change Each square is equal to 30 latitude and 30' longitude

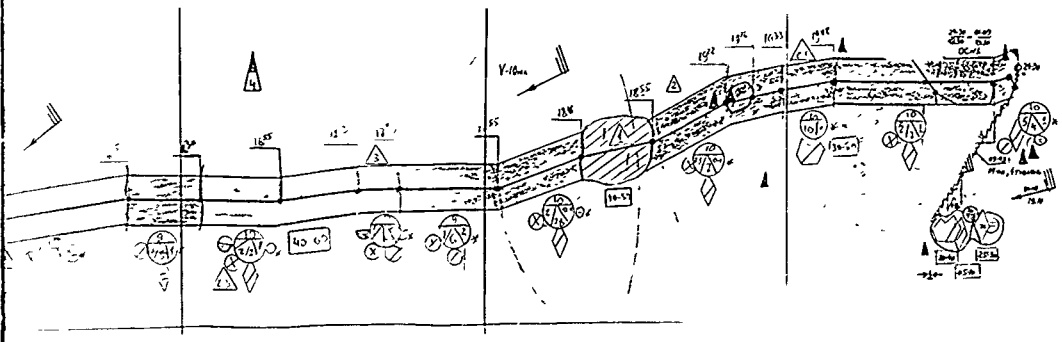
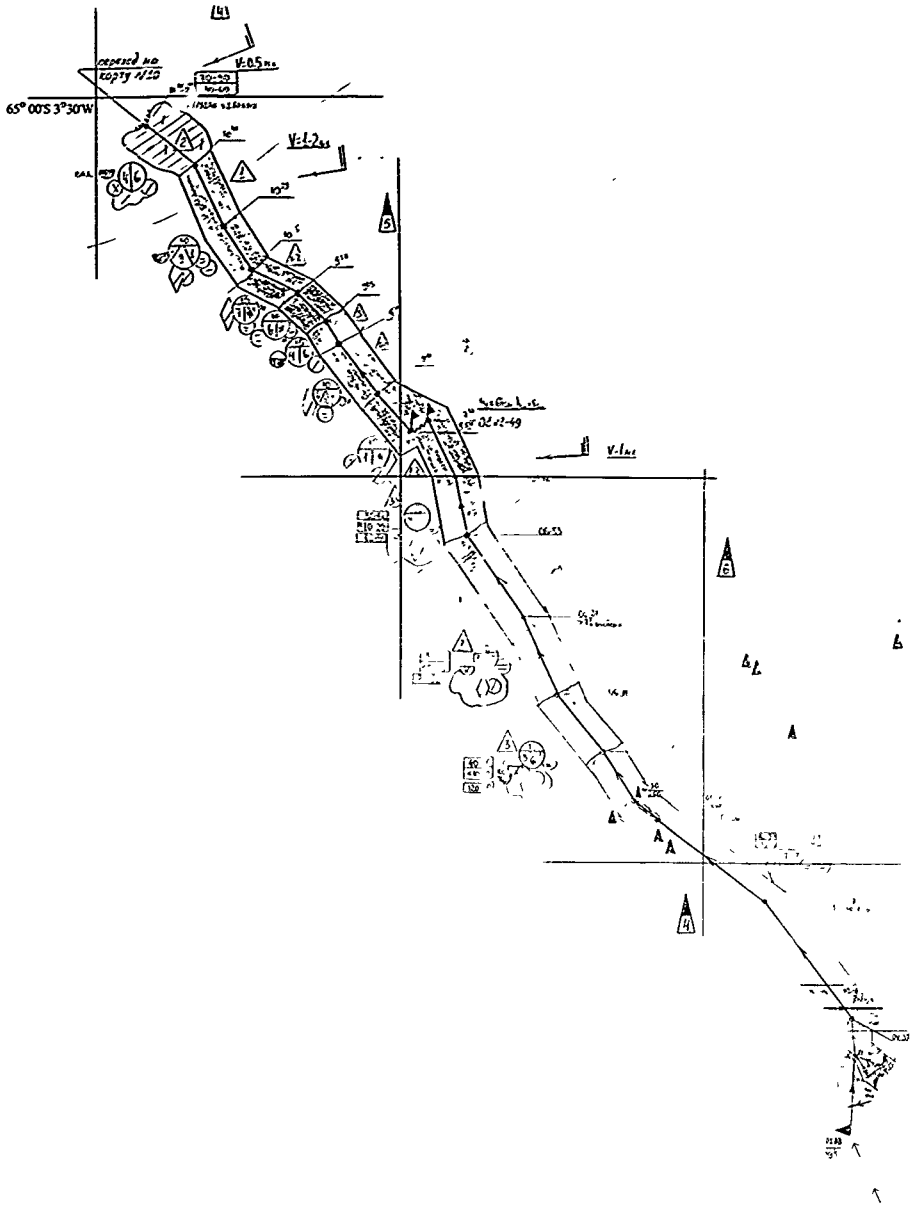
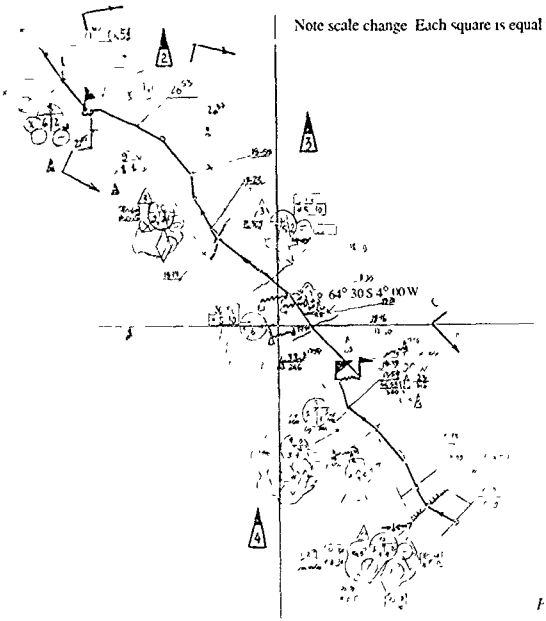


Figure 60 18 October ice map


65° 00'S 3° 30'W



Note scale change Each square is equal to 30' latitude and 1° longitude

Note Ship track direction reverses as the *Pedotov* was now leaving the ice

Figure 61 19 October ice map

Figure 62 20 October ice map

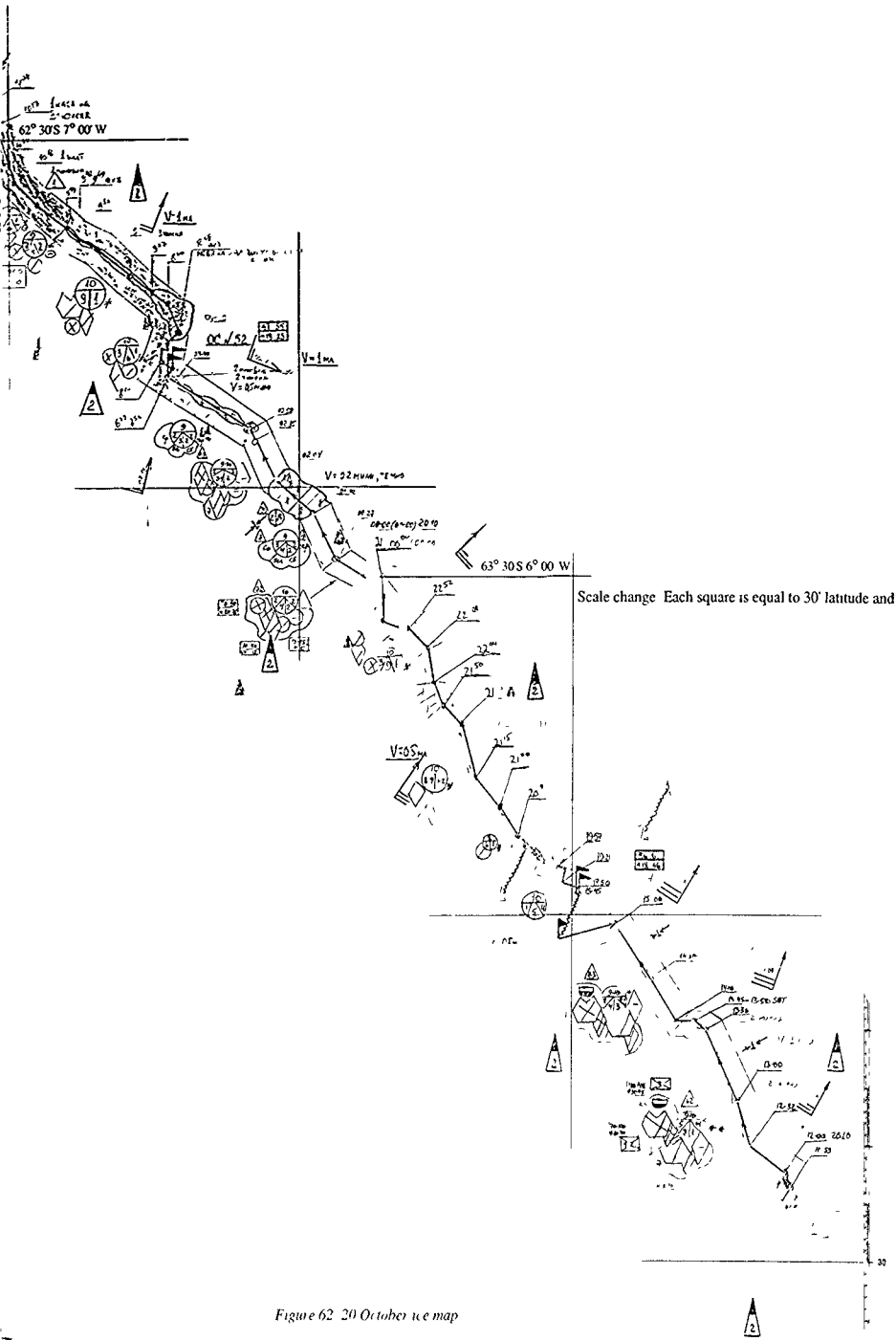


Figure 62 20 October ice map

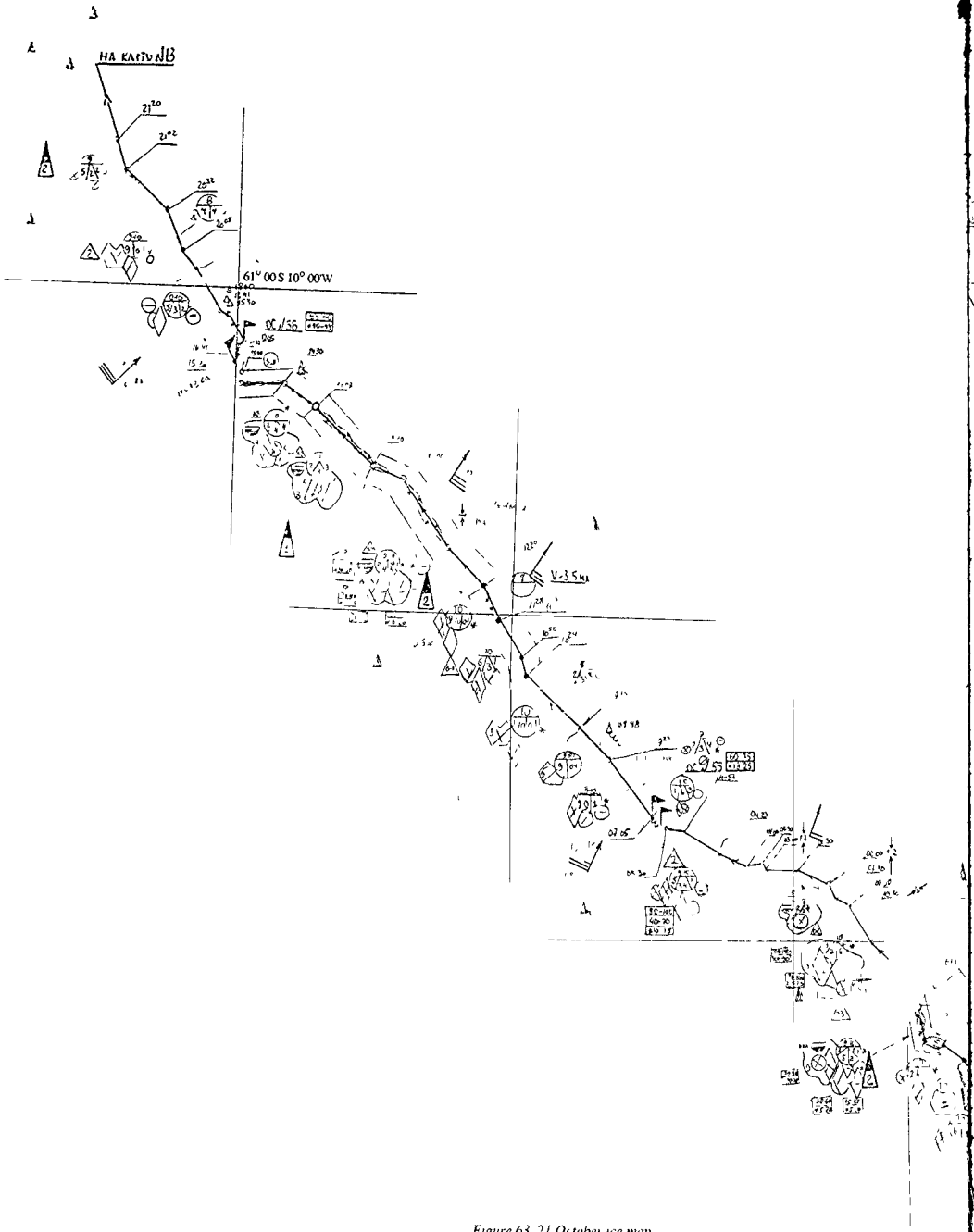


Figure 63 21 October ice map

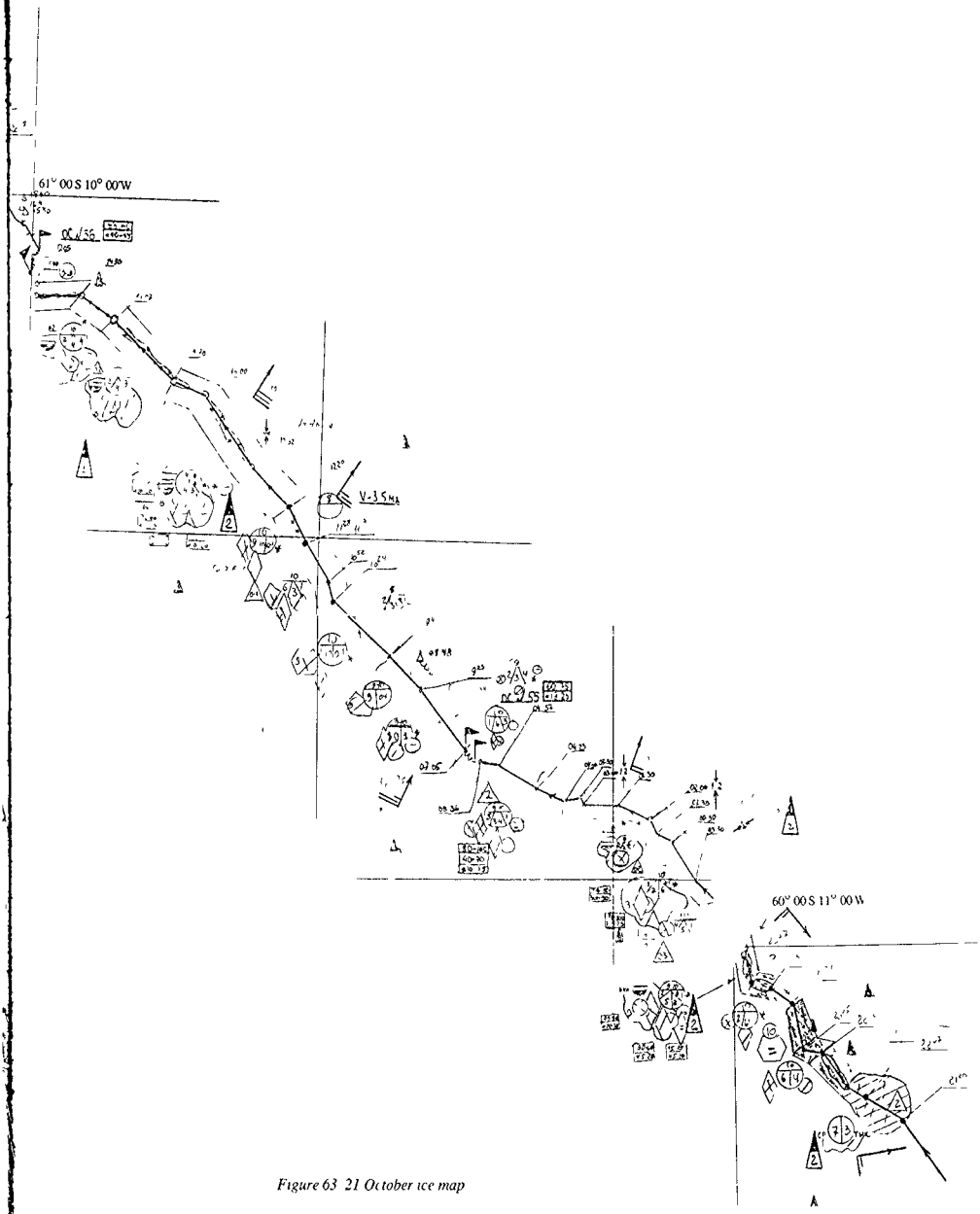


Figure 63 21 October ice map

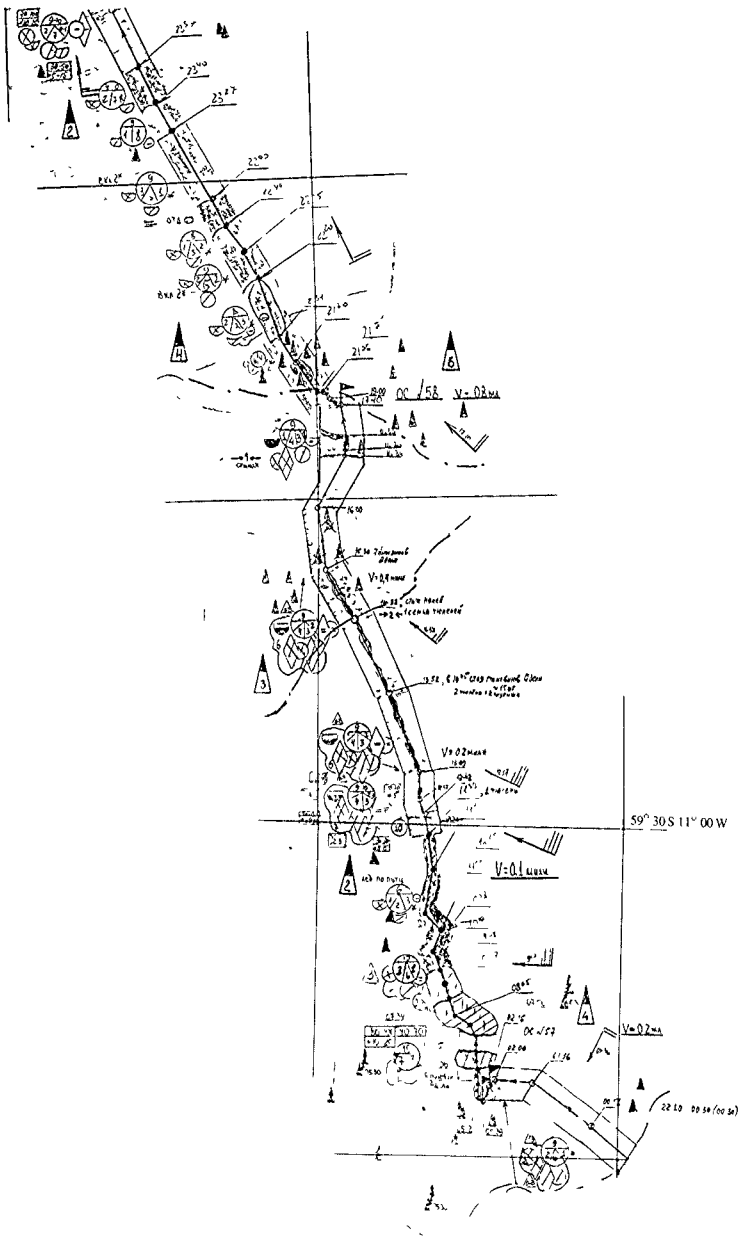


Figure 64 22 October ice map

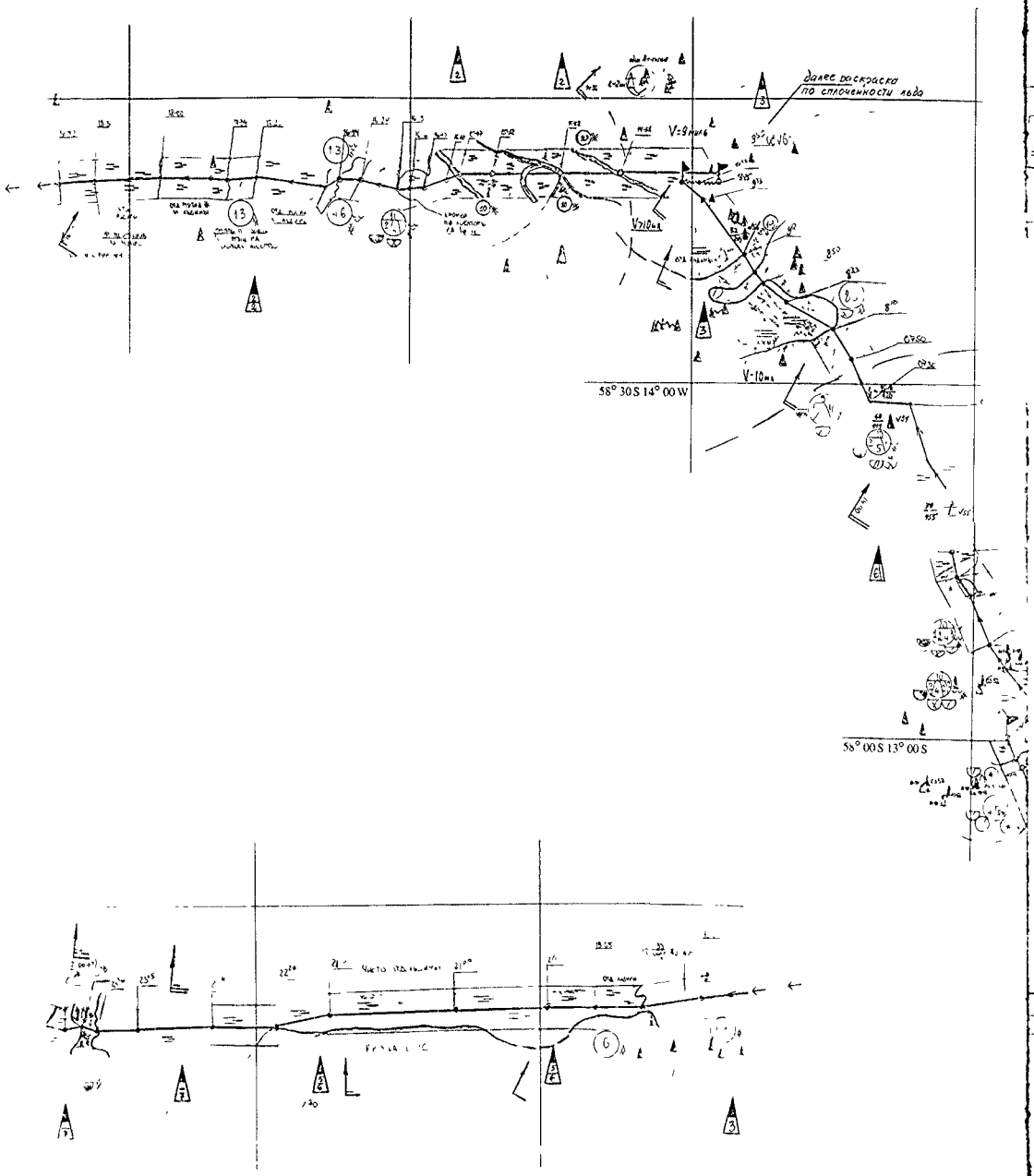


Figure 65 23 October ice map

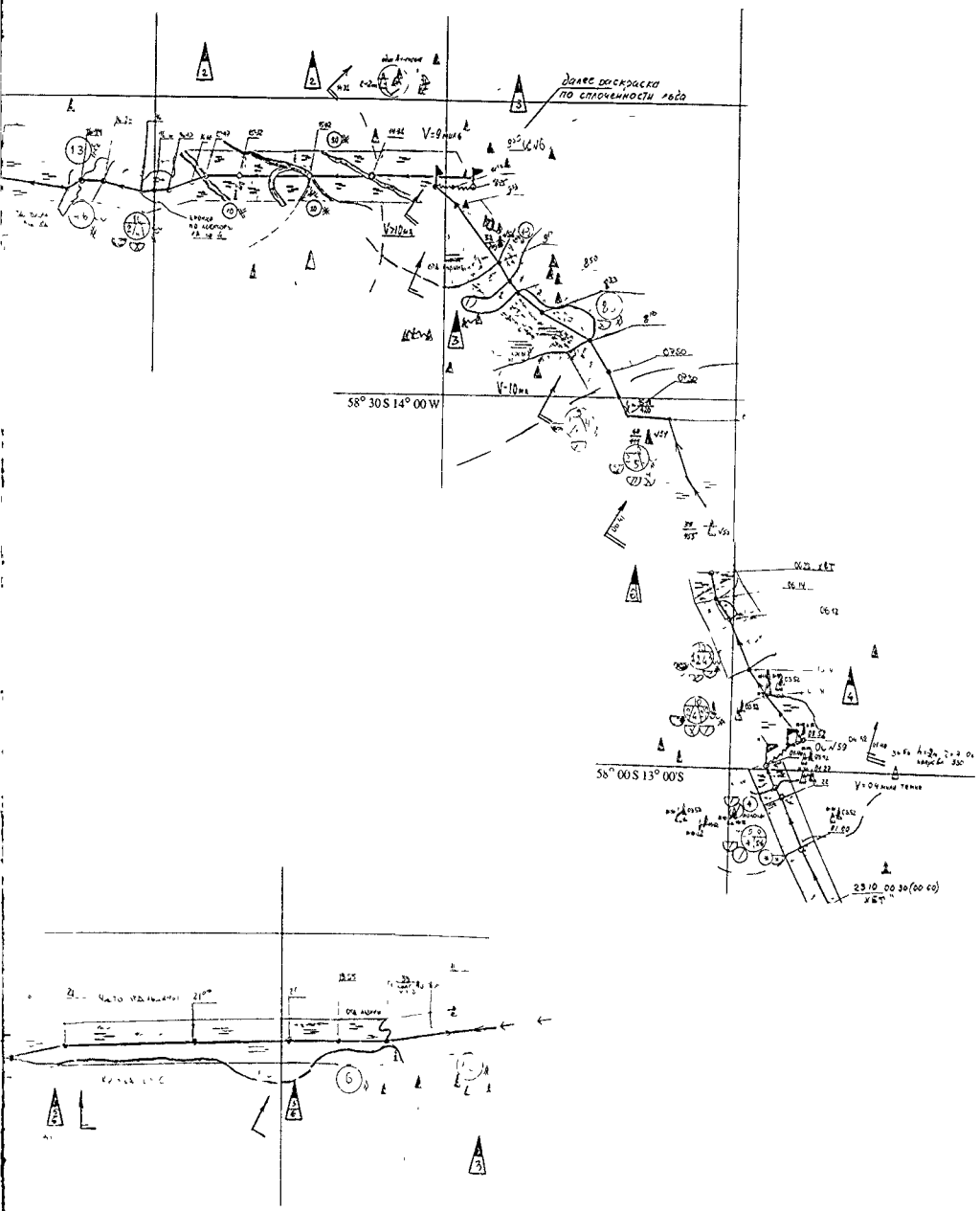
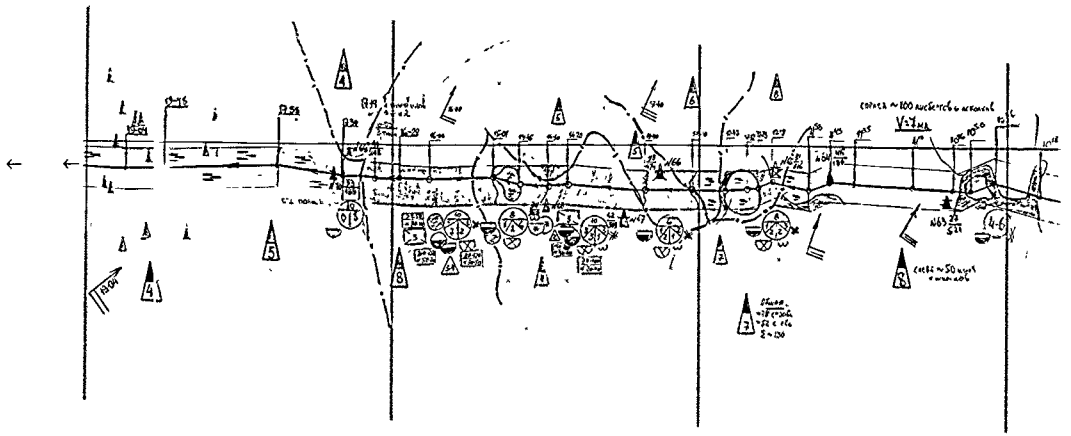
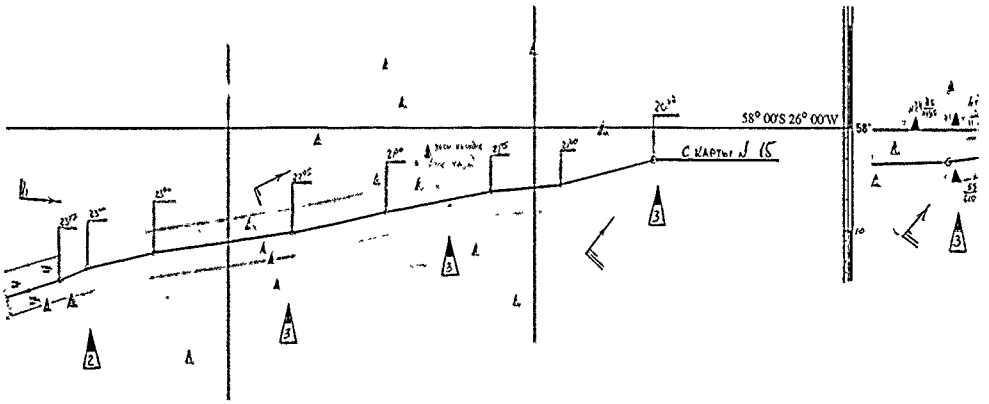
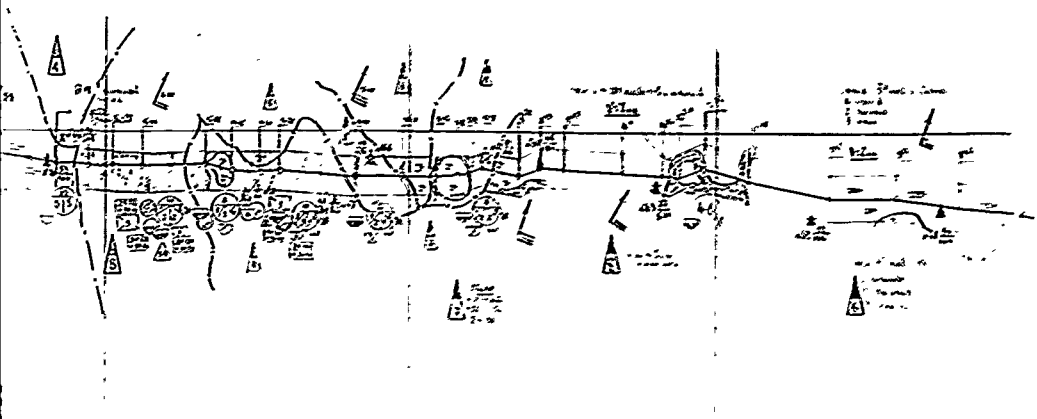
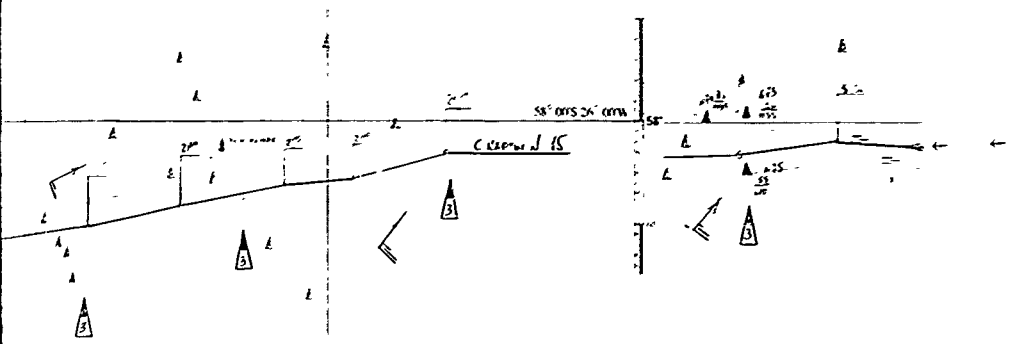


Figure 65 23 October ice map




58° 00'S 26° 00'W
58°
С. КАРТЫ № 15





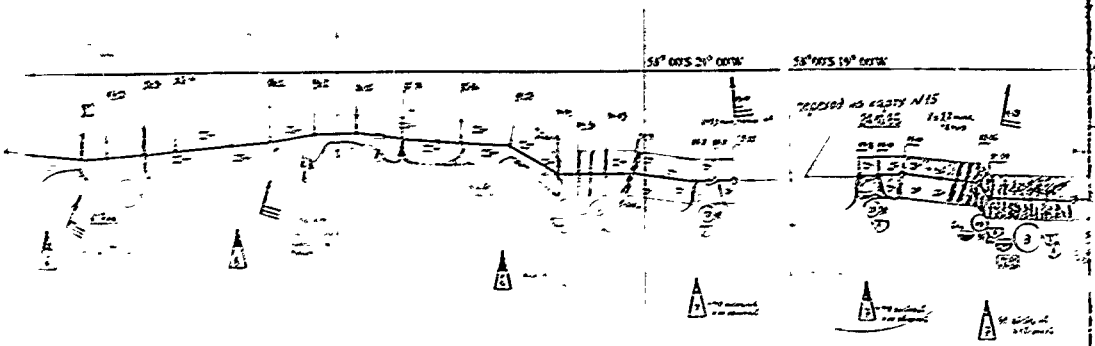


Figure 66 24 October ice map

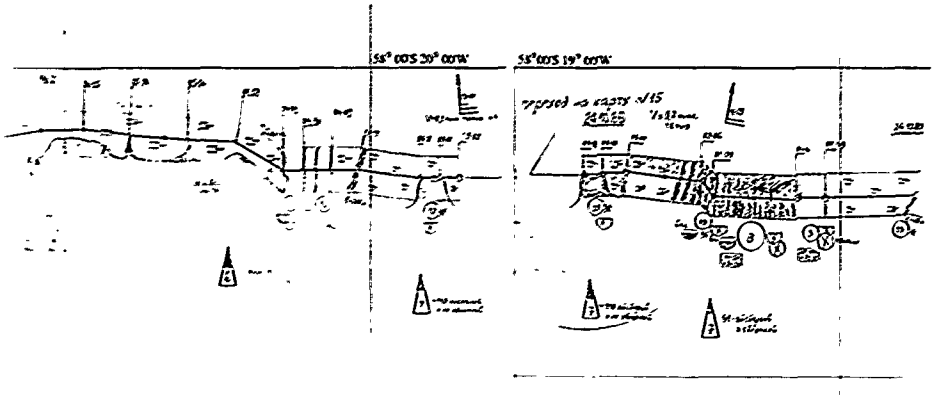
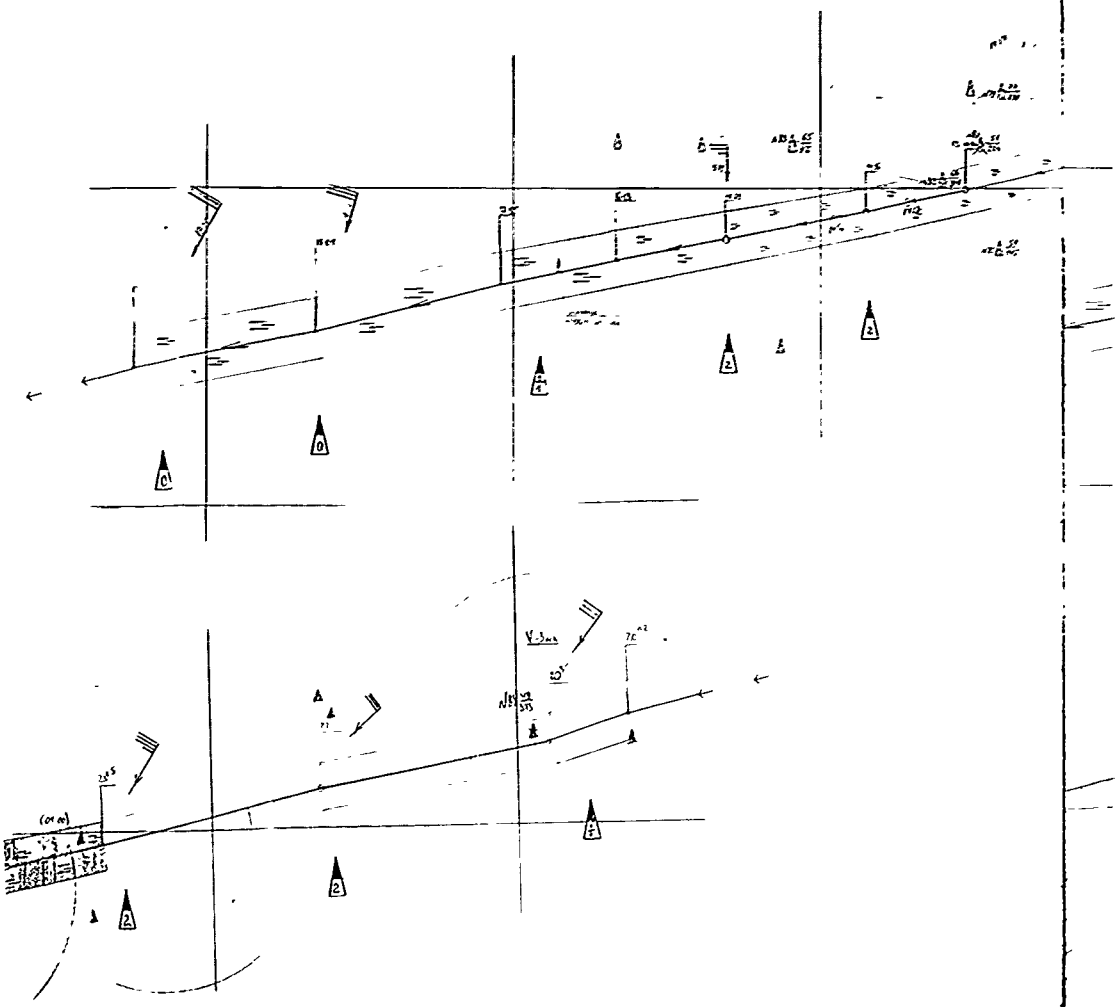
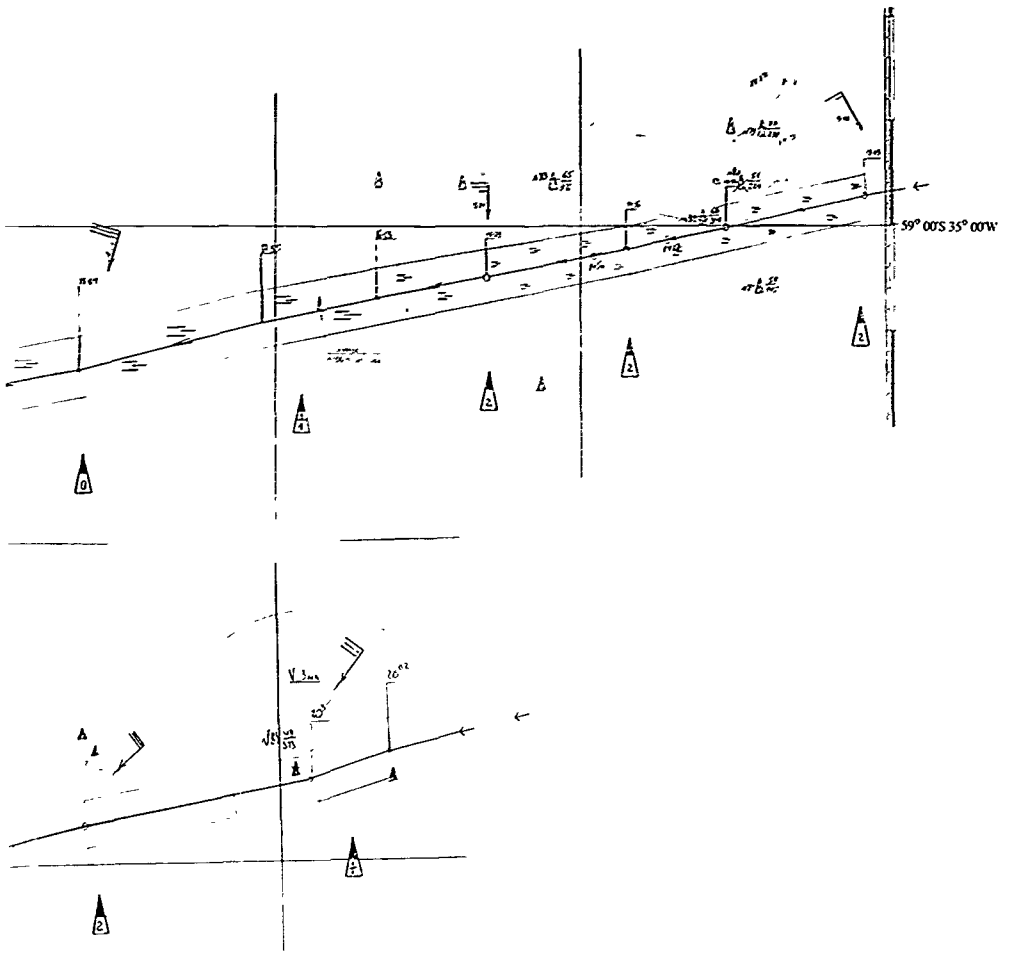


Figure 66 24 October ice map




59° 00'S 35° 00'W

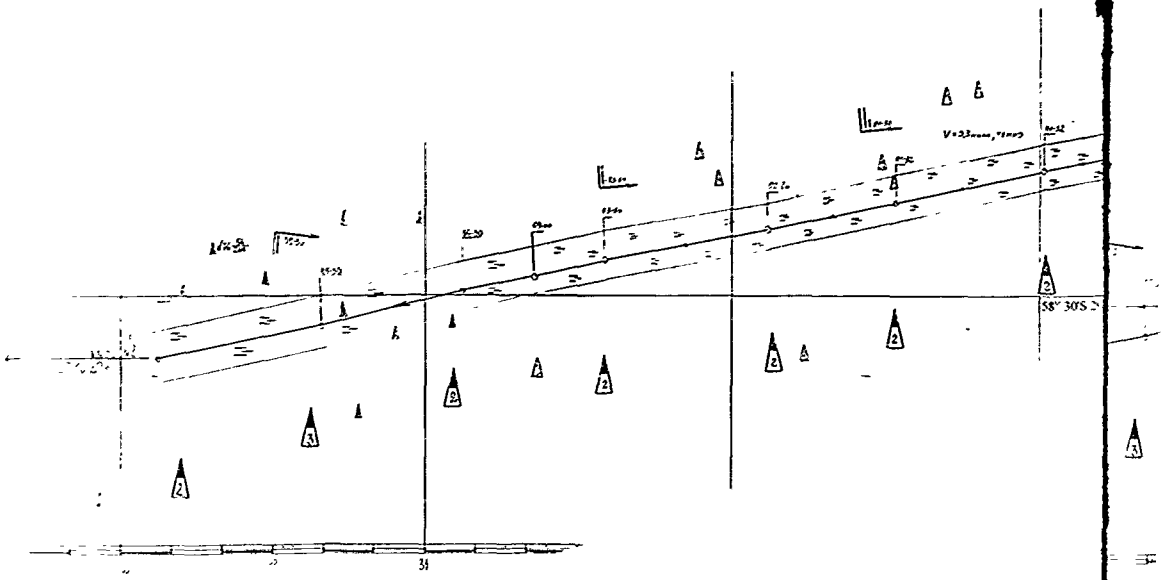


Figure 67 25 October use map

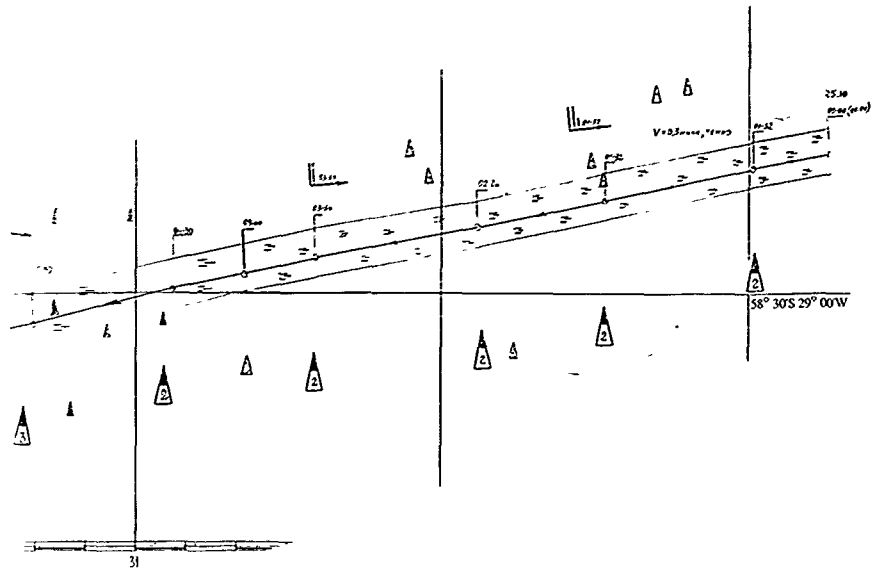
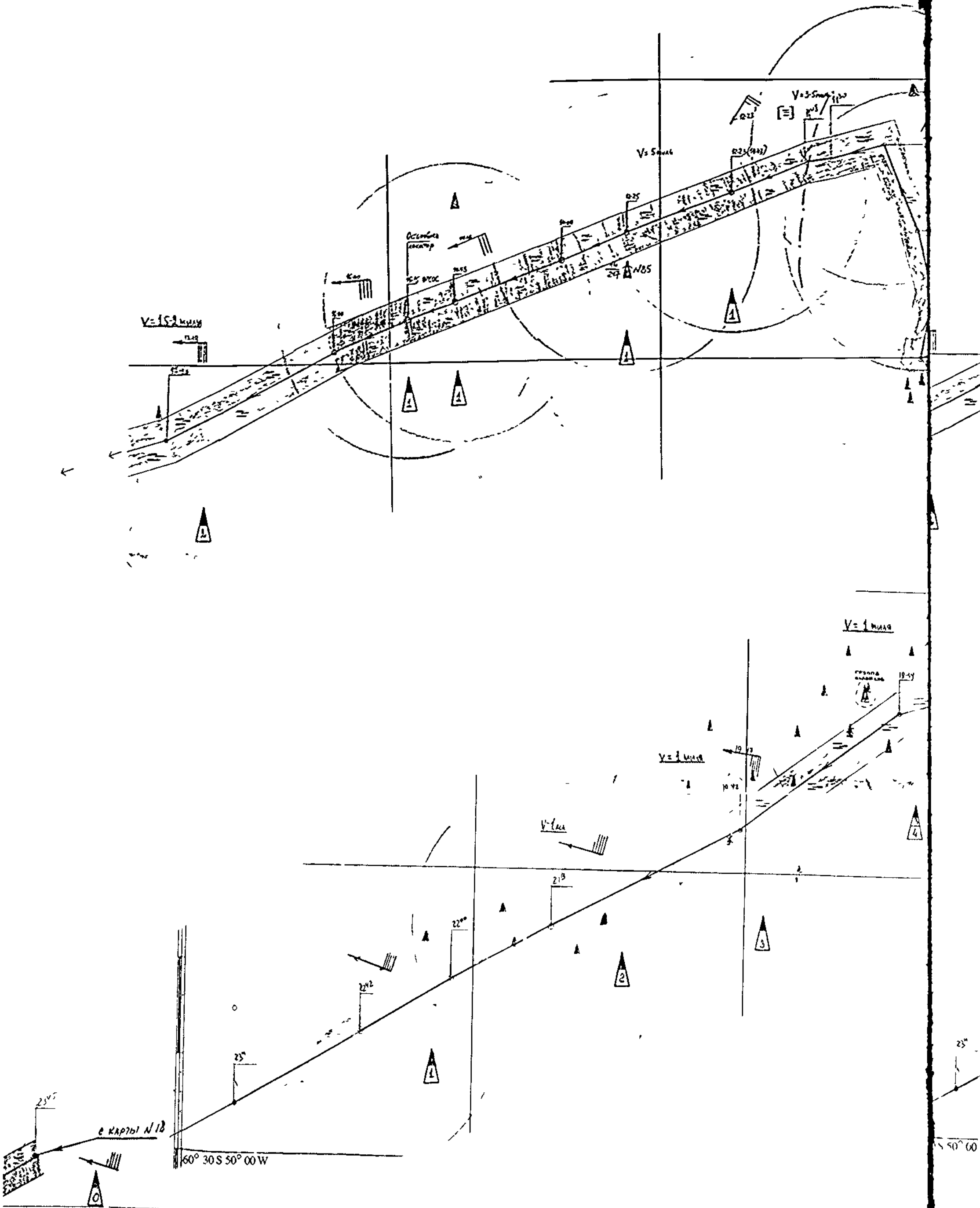
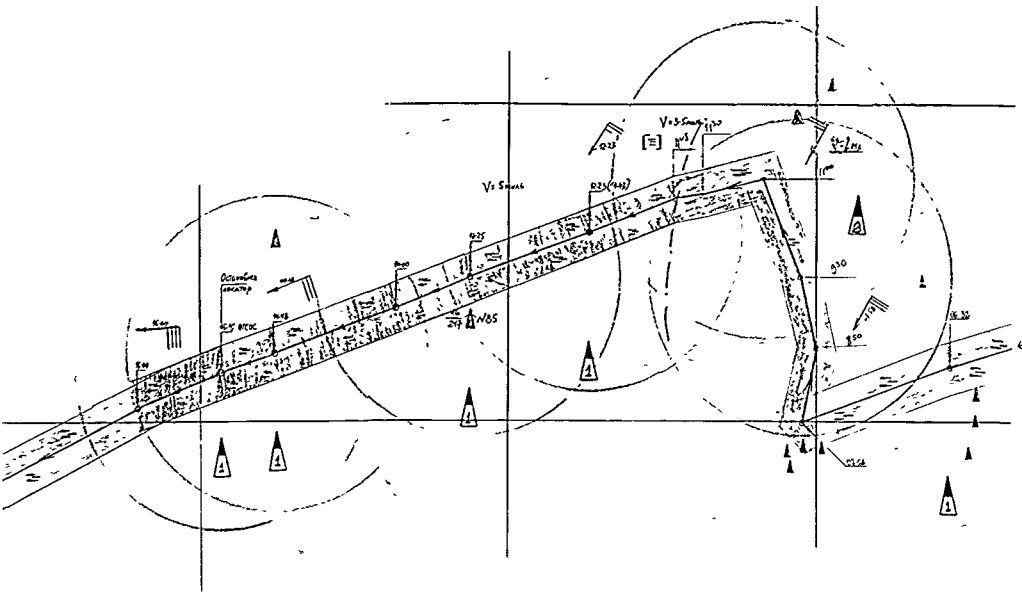
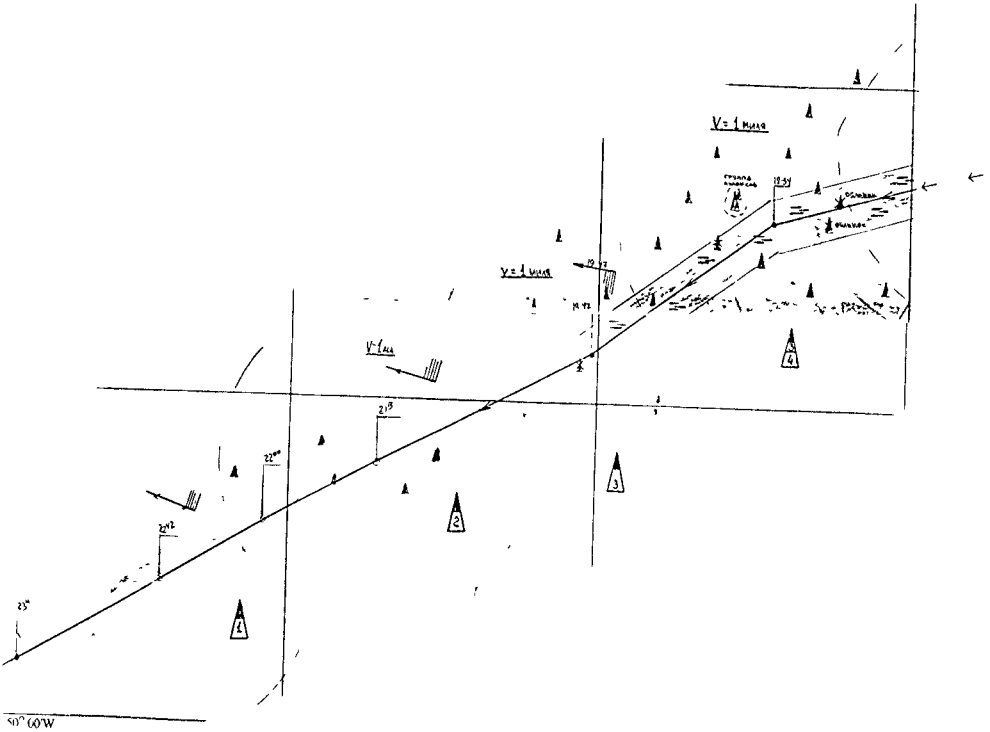


Figure 67 25 October ice map


V= 1 миля
с карты N 18
60° 30 S 50° 00 W





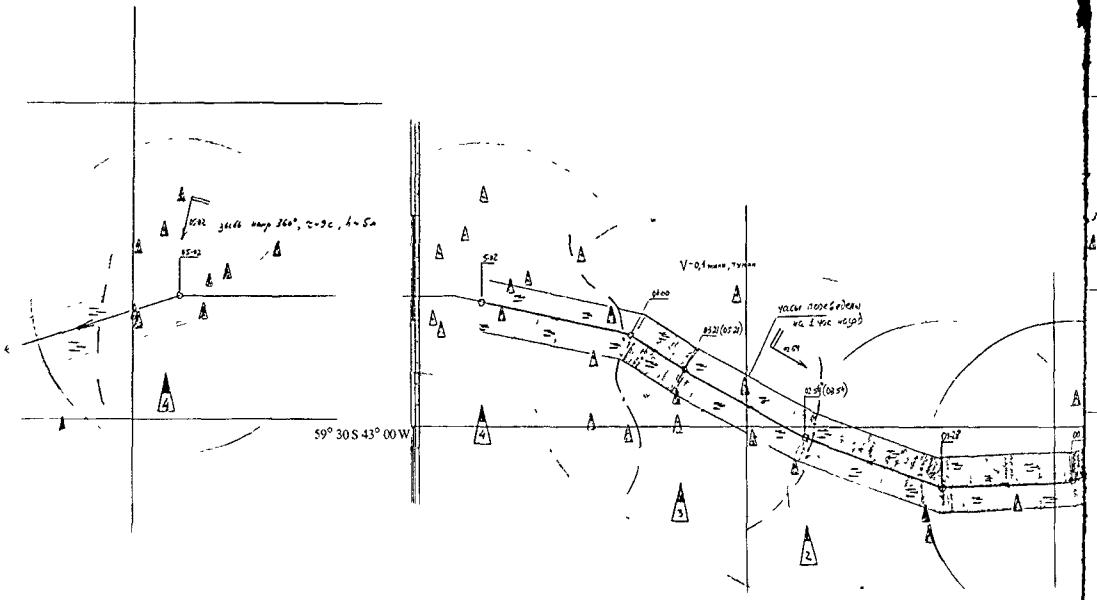


Figure 68 26 October ice map

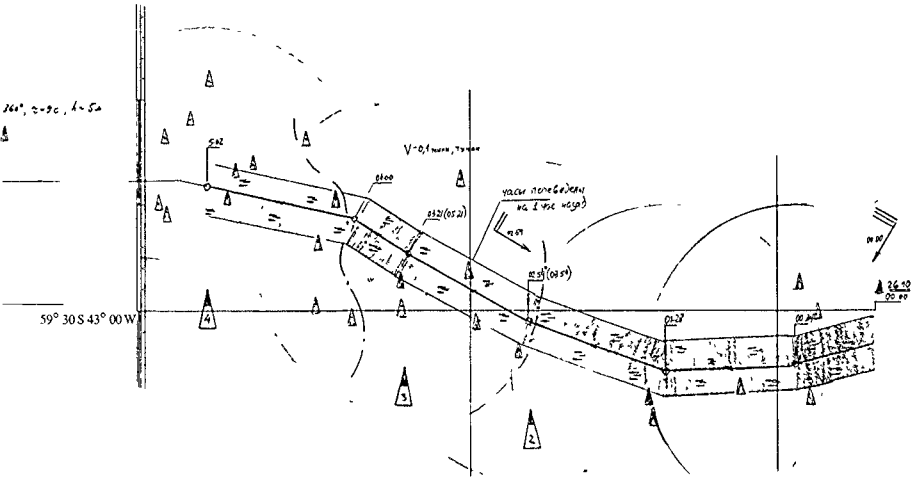
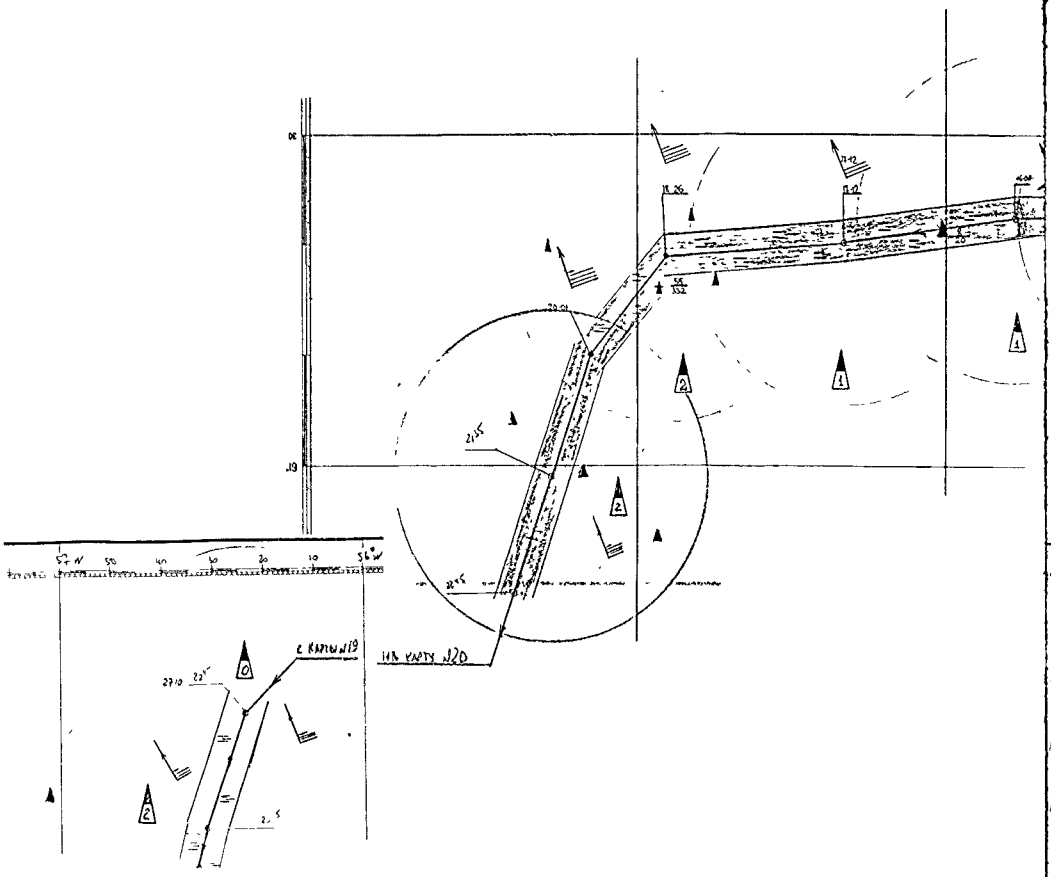
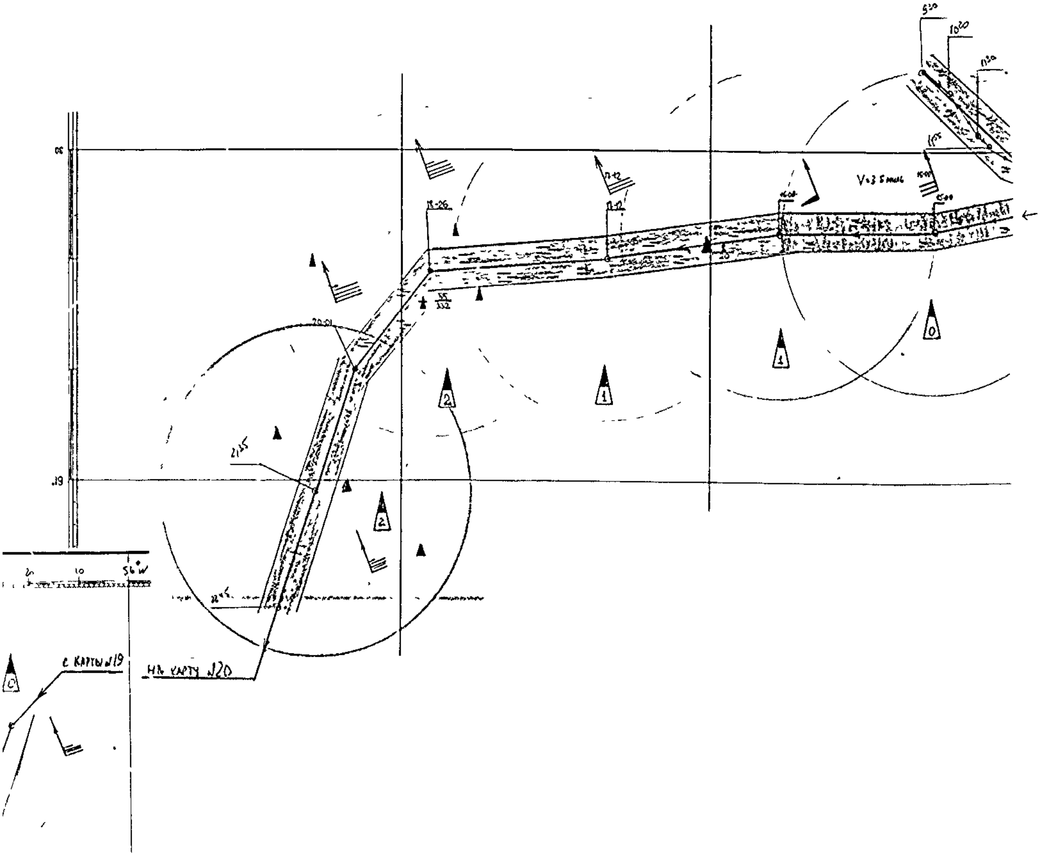


Figure 68 26 October ice map





С КАРТЫ №19
НА КАРТУ №20
56° W

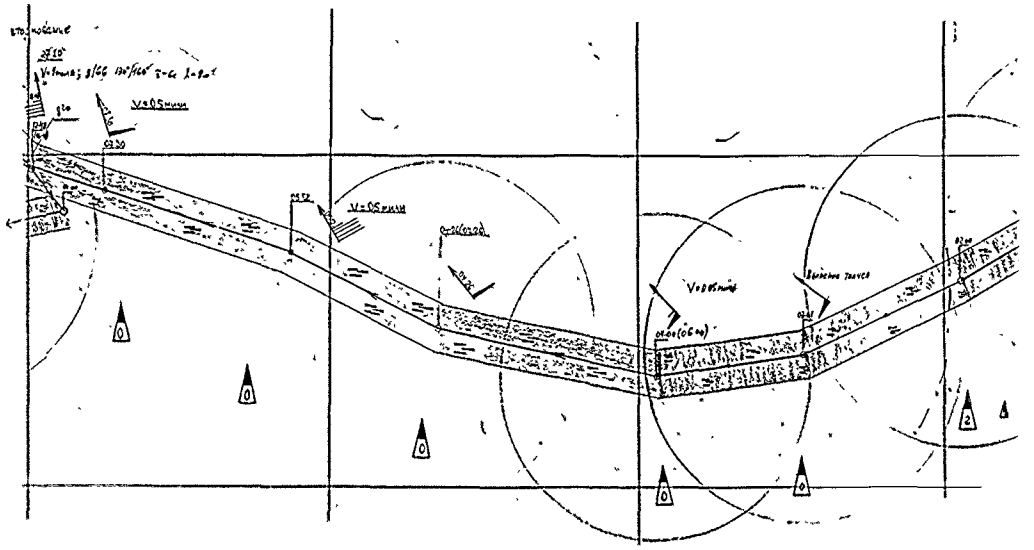


Figure 69. 27 October ice map.

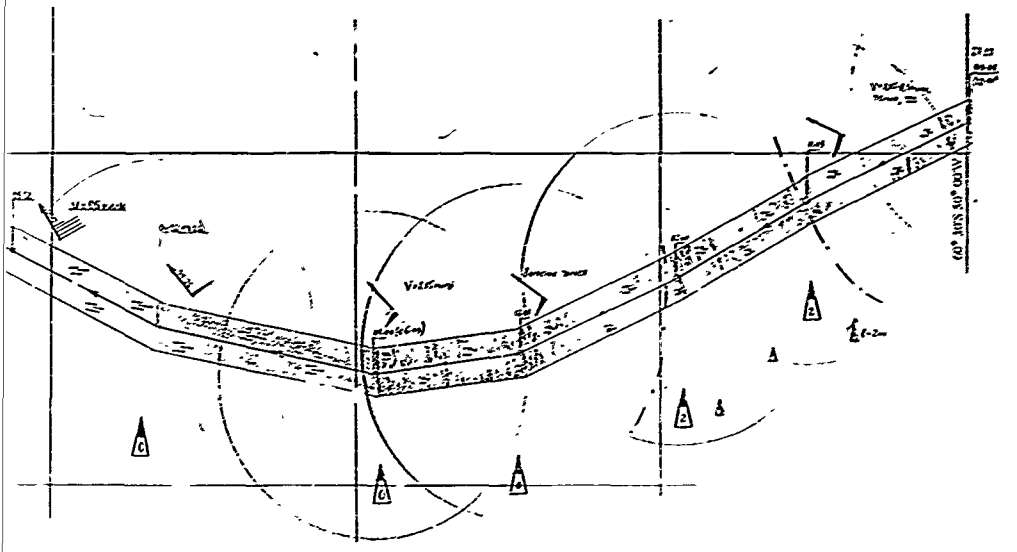


Figure 69 27 October ice map

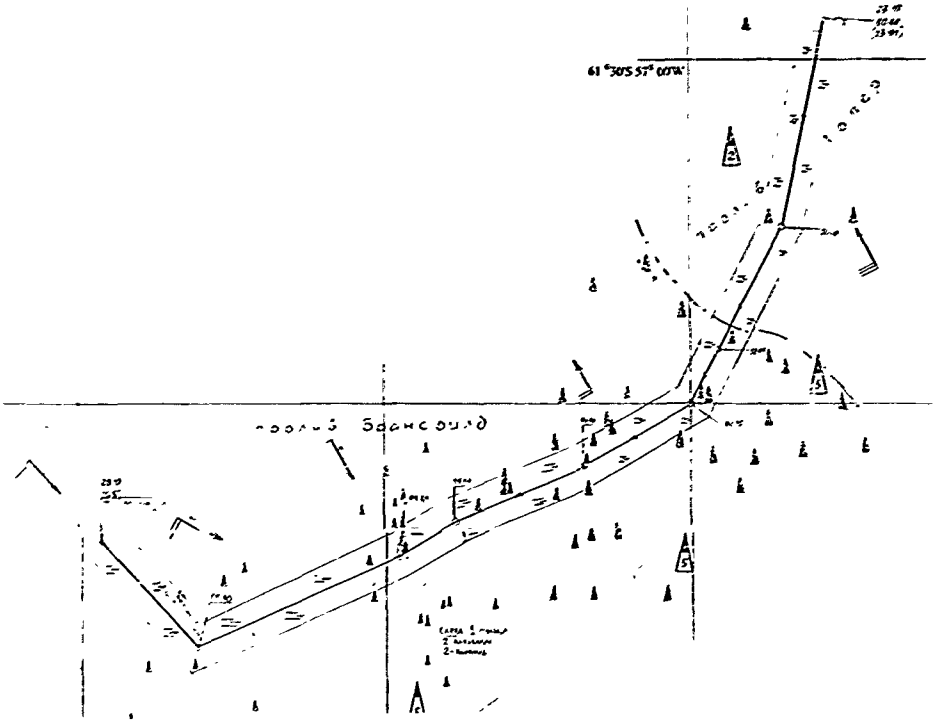
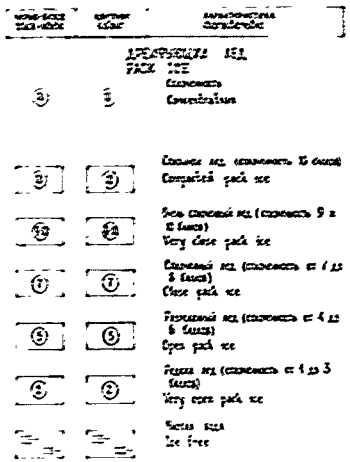
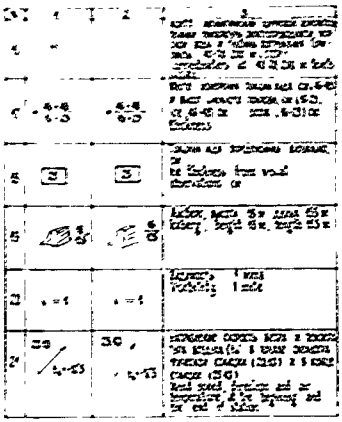
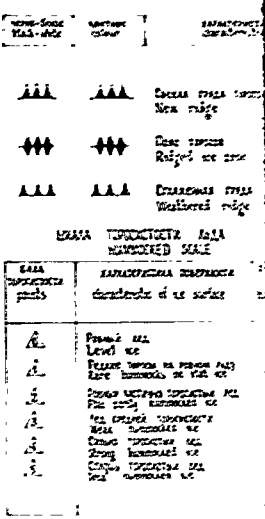
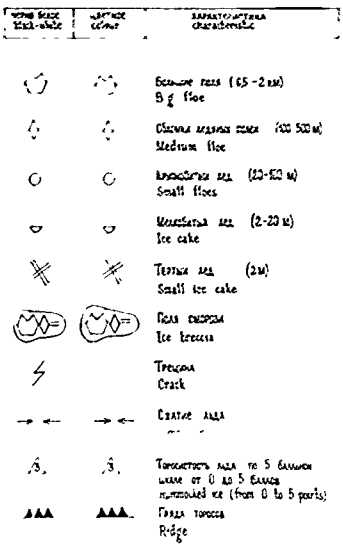


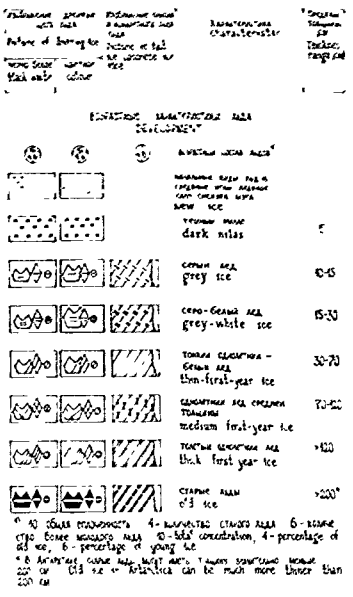
Figure 70 28 October ice map



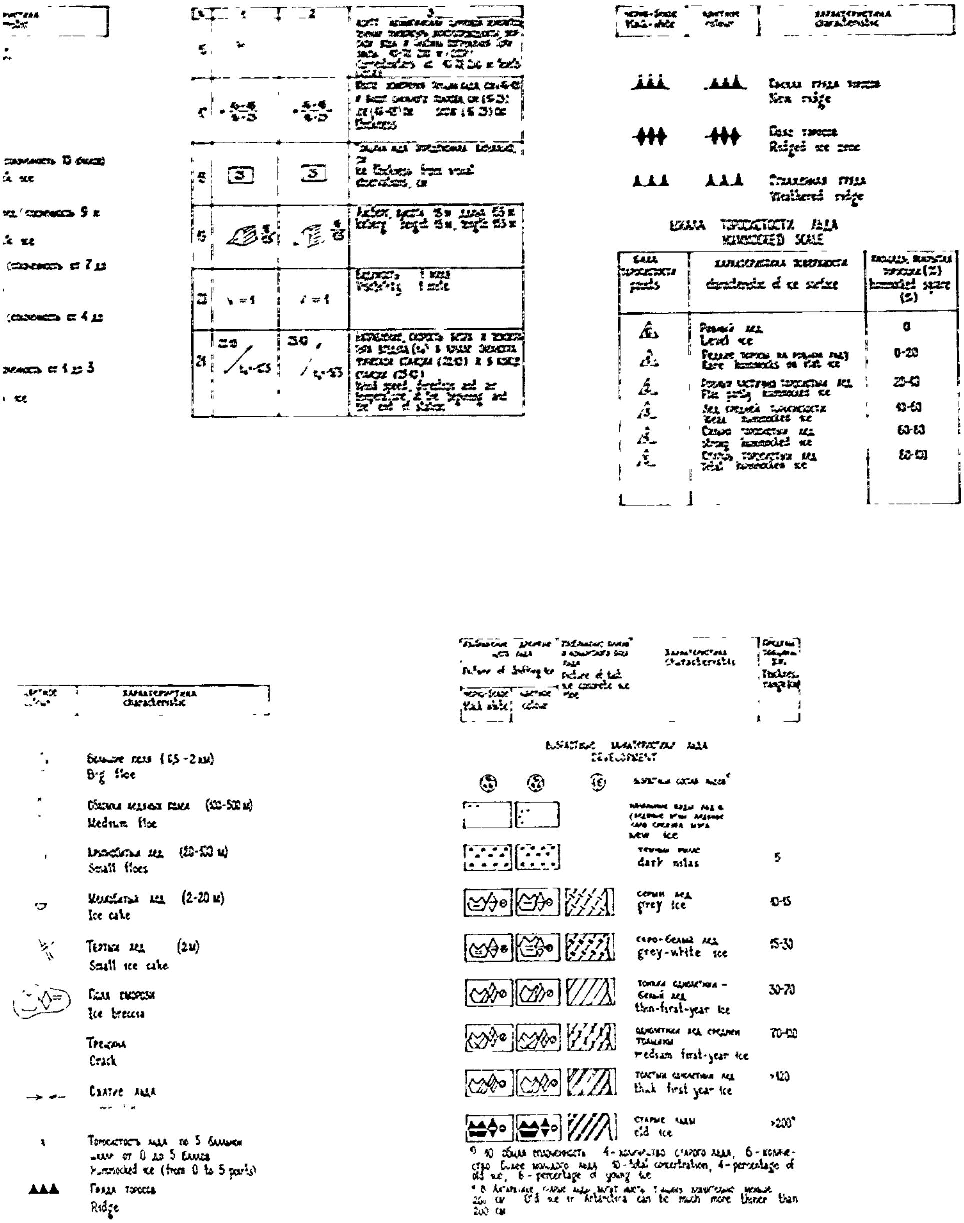






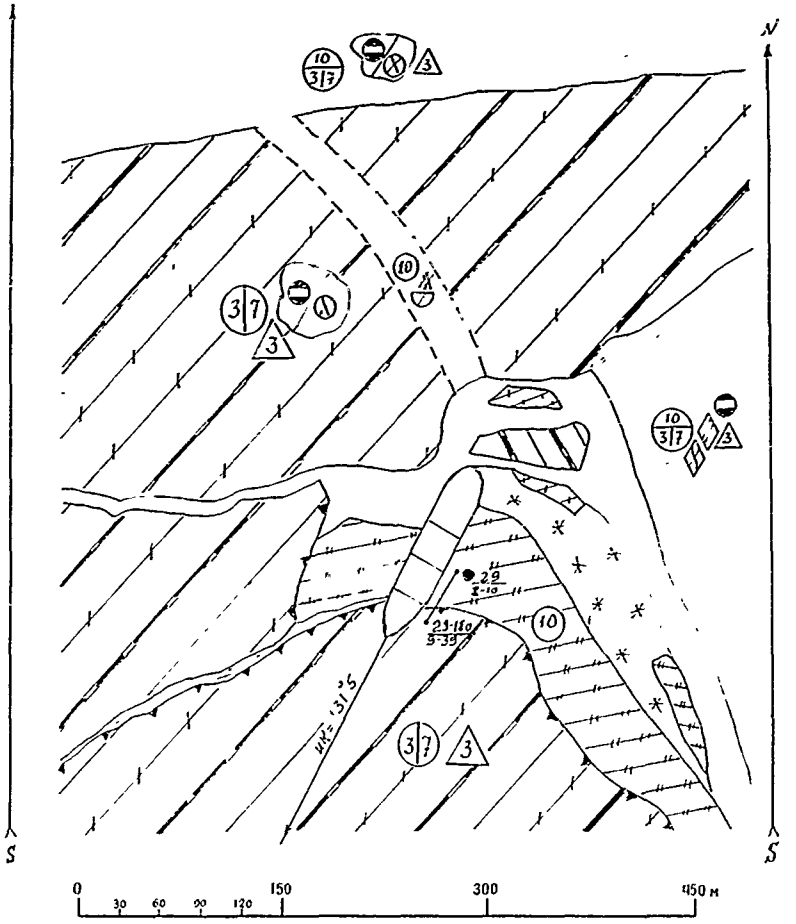


Legend for Soviet ice maps



Legend for Soviet ice maps

Legend on page 99.

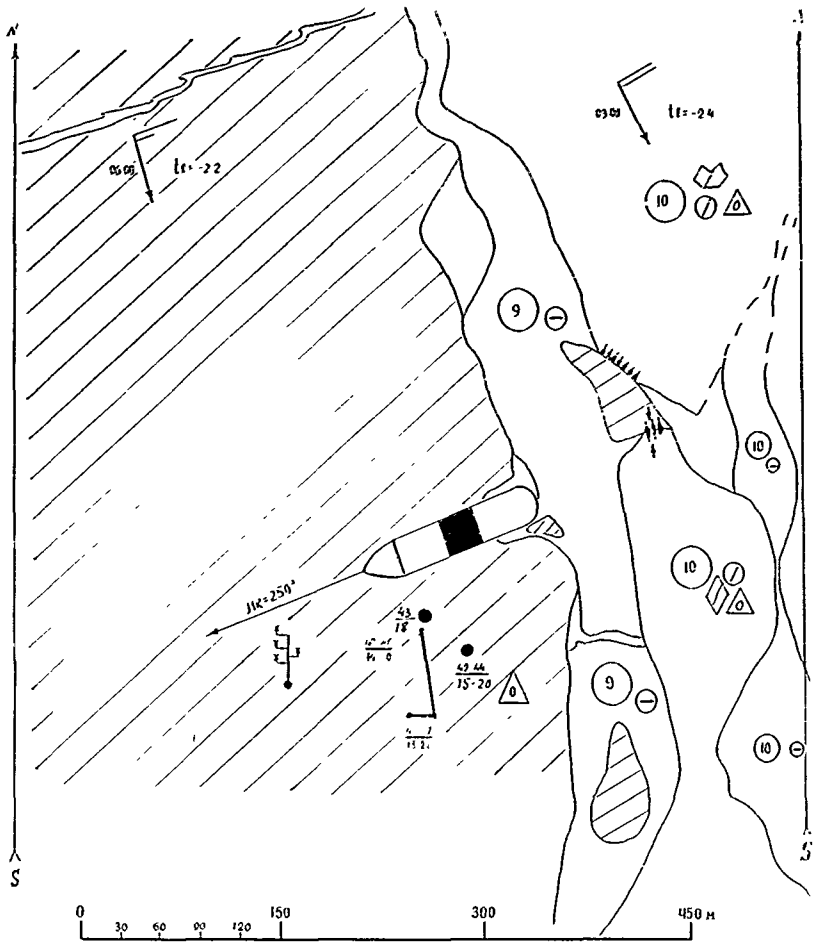


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 14-15 дата: 19 сентября 1989

координаты начала	координаты конца
φ = 61° 20.0 S	φ = 61° 19.5 S
λ = 32° 51.0 W	λ = 32° 49.8 W
время начала = 15h 30m GMT 14h 30m	время конца = 19h 30m GMT 20h 30m

Figure 7: 19 September, ice station 15

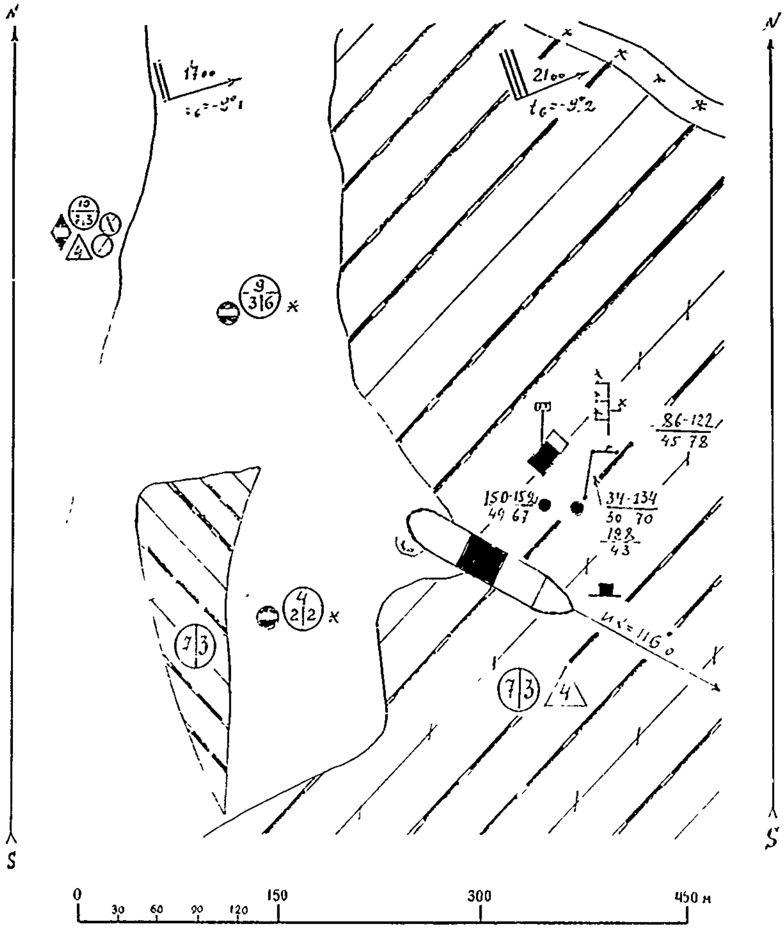


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 16 дата: 20 сентября 1989

координаты начала	координаты конца
φ = 62°05′ S	φ = 62 05 7 S
λ = 31°29′ W	λ = 31°26 7 W
время начала = 05h50m GMT 06h50m	время конца = 03h59m GMT 10h59m

Figure 72 20 September ice station 16



ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 17 дата 20 сентября 1989

координаты начала координаты конца

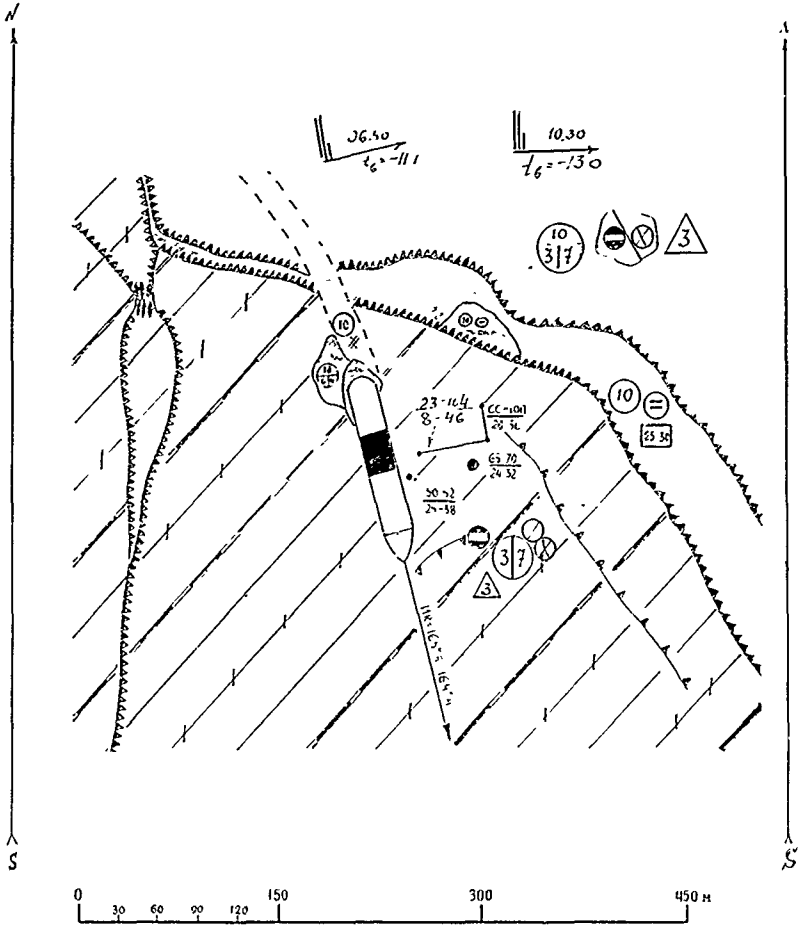
φ = 62° 54'4 s φ = 62° 53'5 s

λ = 22° 59'6 w λ = 22° 54'4 w

время начала = 16h 45m время конца 21h 30m

GMT 17h 45m GMT 22h 30m

Figure 73 20 September ice station 17

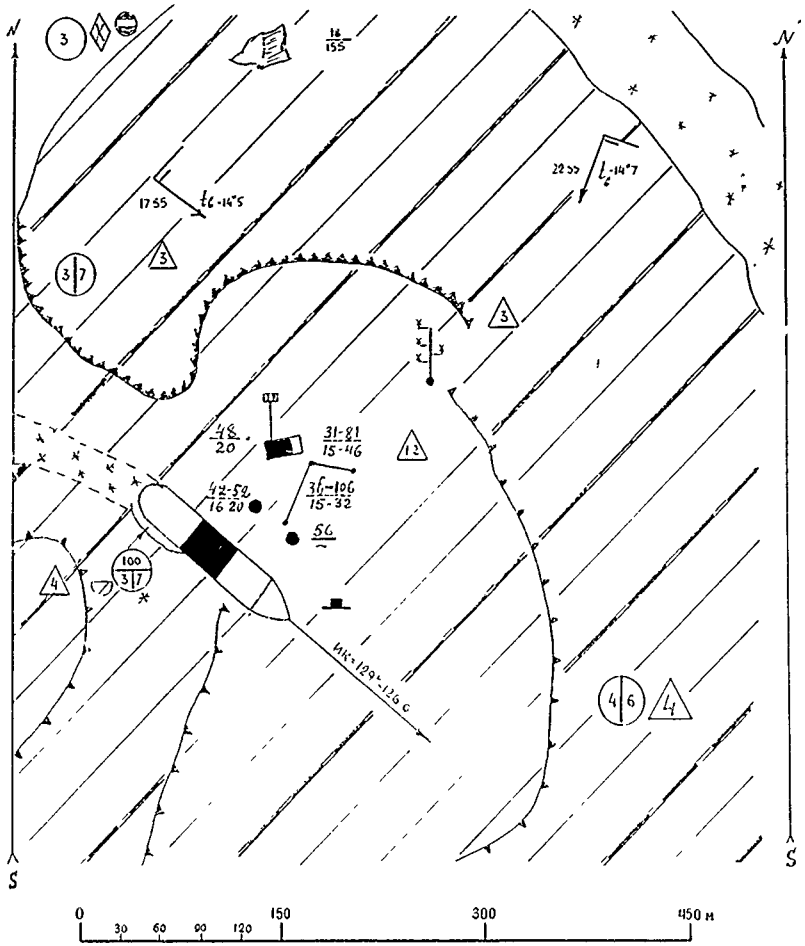


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 18 дата. 21 сентября 1989

координаты начала	координаты конца
φ = 63° 57 ′ s	φ = 63 35 ′ s
λ = 28 42 ′ w	λ = 28 52 ′ w
время начала = 05ʰ 45ᵐ	время конца = 10ʰ 50ᵐ
GMT 06ʰ 45ᵐ	GMT 11ʰ 50ᵐ

Figure 74 21 September ice station 18

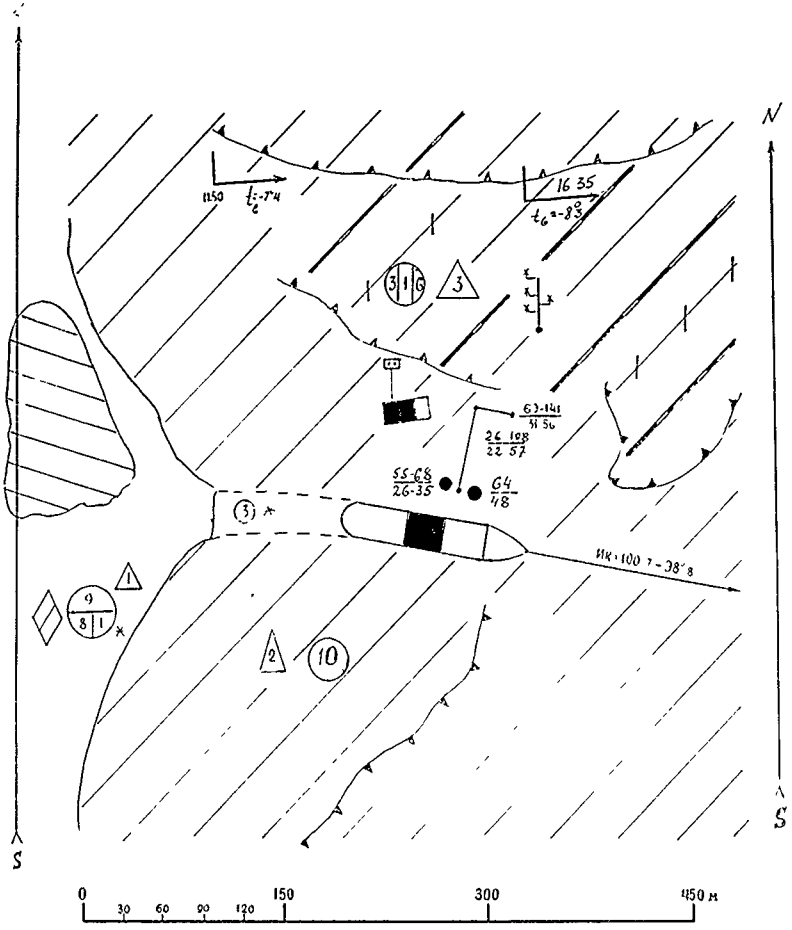


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 19 дата: 21 сентября 1989

координаты начала	координаты конца
φ = 64° 25' 0 s	φ = 64° 25' 6 s
λ = 27° 17 ,2 W	λ = 27° 16' 3 W
время начала = $17^h 55^m$	время конца = $22^h 55^m$
GMT $18^h 55^m$	GMT $23^h 55^m$

Figure 75 21 September, ice station 19

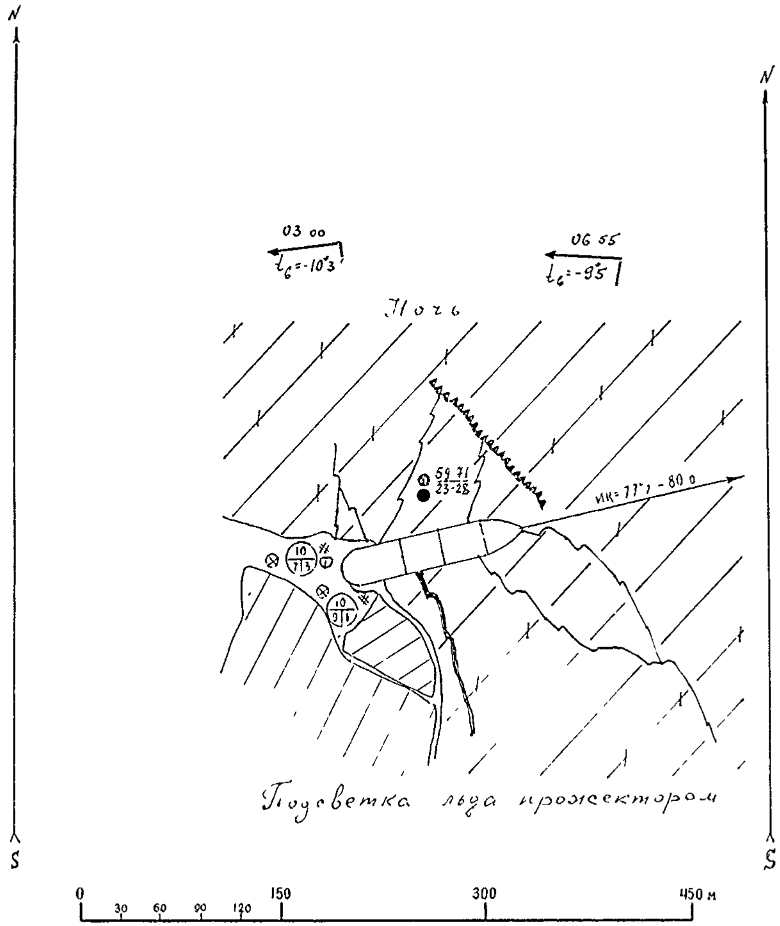


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 20 дата: 22 сентября 1989

координаты начала	координаты конца
φ = 65° 12' 2 s	φ = 65° 11' 6 s
λ = 25° 37' 6 w	λ = 25° 33 7 w
время начала = $11^h 50^m$	время конца = $16^h 35^m$
GMT $12^h 50^m$	GMT $17^h 35^m$

Figure 76 22 September, ice station 20



[illegible]

[illegible] 23 сентября 1989

[illegible]

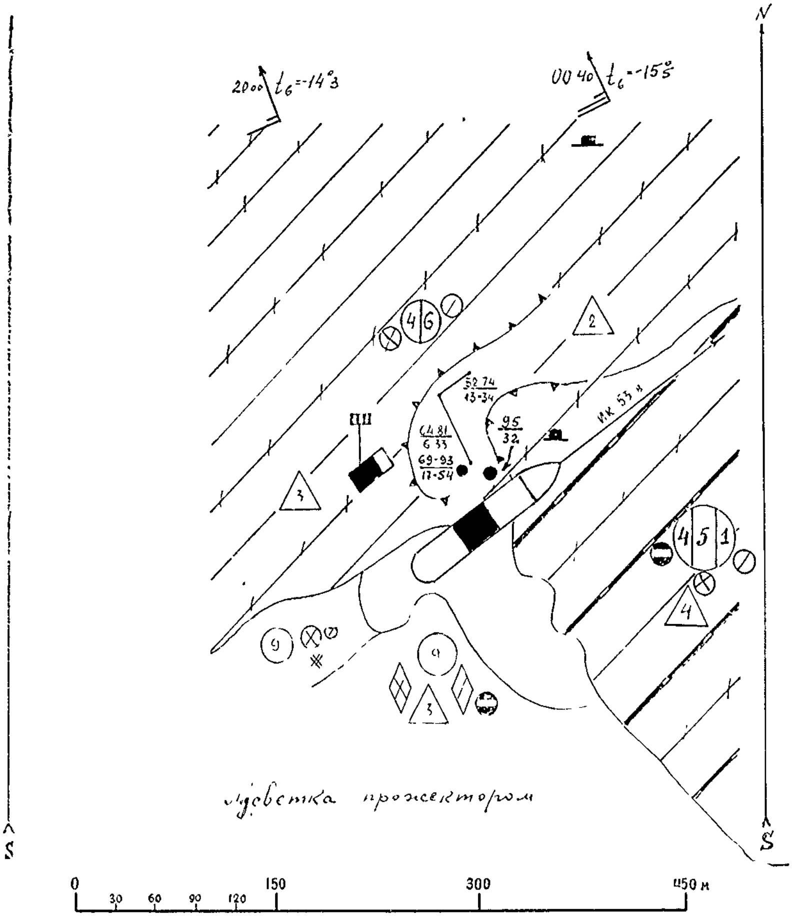
[illegible]

λ = 24 18 8 w

[illegible] 06ʰ5[illegible]

GMT 07ʰ55ᵐ

Figure 77 23 September ice station 21



ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 22 дата: 23-24 сентября 1989

координаты начала   координаты конца

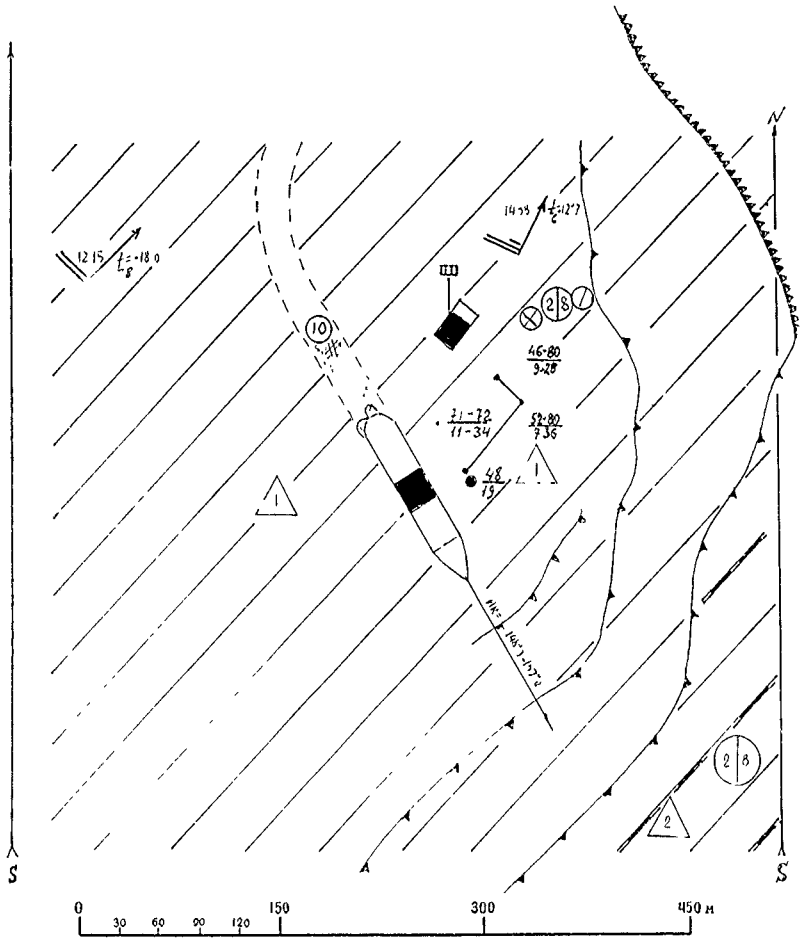
φ = 66°42 ? s   φ = 66 40 6 ?

λ = 20°39' в w   λ = ?? 43 в w

время начала = 20^h00^m время конца = 00^h40^m

GMT 21^h00^m GMT 01^h40^m

Figure 78 23–24 September ice station 22

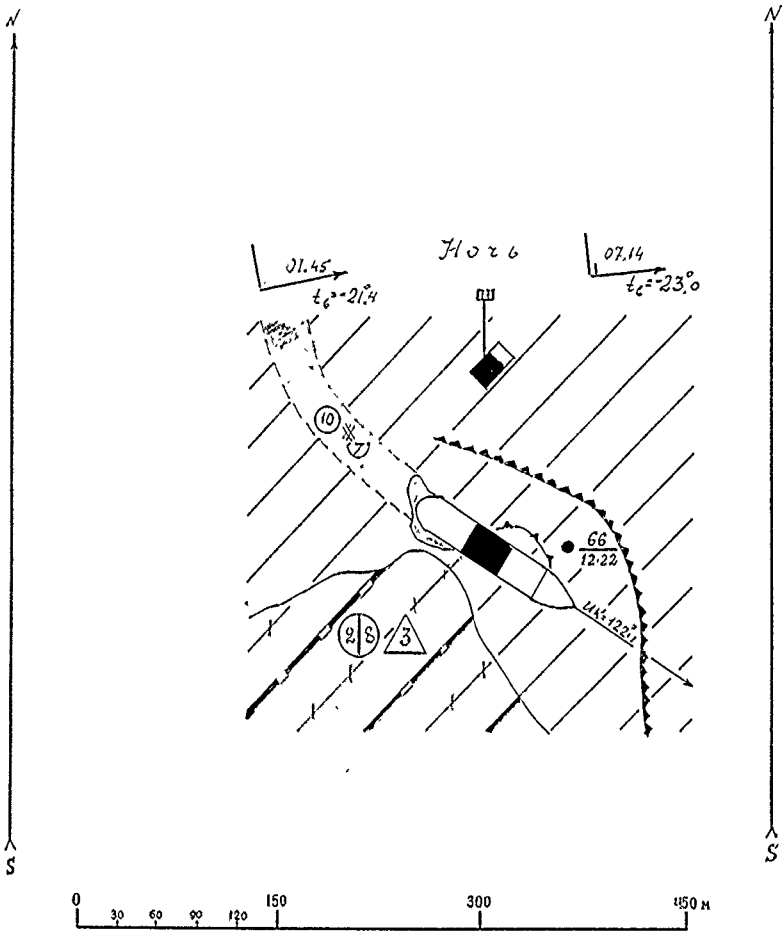


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 23 дата 24 сентября 1989

координаты начала	координаты конца
φ = 67° 22,9 с ш	φ = 67 20,5 с ш
λ = 21° 19,5 з д	λ = 21° 18,9 з д
время начала = 10ʰ 15ᵐ	время конца = 15ʰ 38ᵐ
GMT 11ʰ 15ᵐ	GMT 15ʰ 38ᵐ

Figure 19 24 September, ice station 23

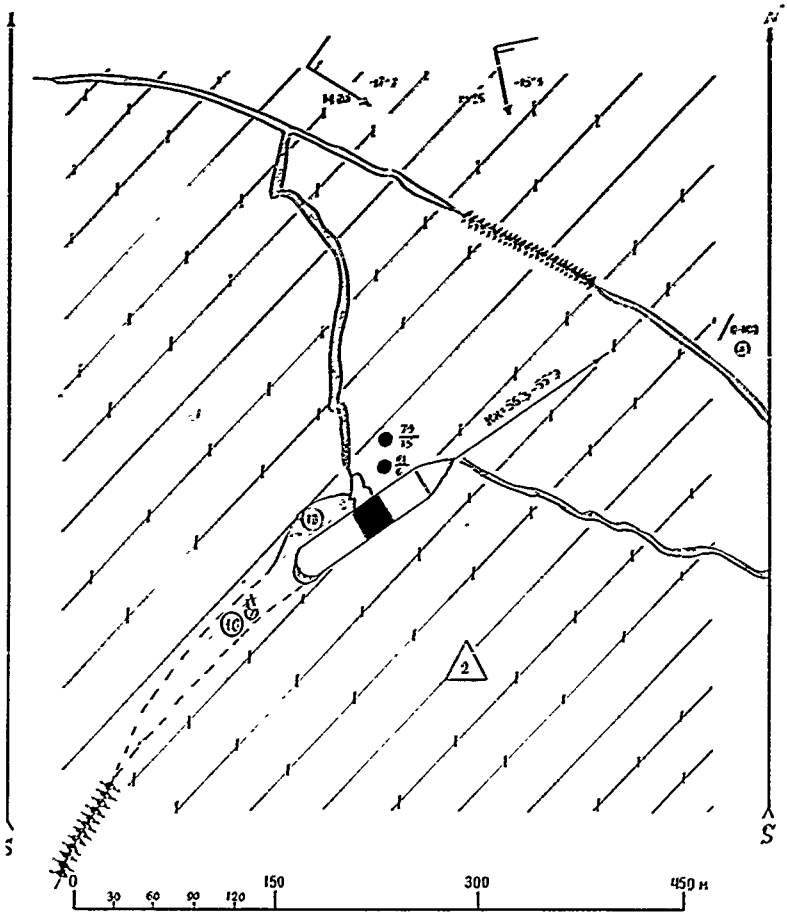


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 24 дата: 25 сентября 1989

координаты начала	координаты конца
φ = 68° 00' 1 s	φ = 67° 59' 2 s
λ = 19° 57' 4 w	λ = 19° 57' 3 w
время начала = $01^h 35^m$	время конца = $07^h 14^m$
GMT $02^h 35^m$	GMT $08^h 14^m$

Figure 80. 25 September, ice station 24.

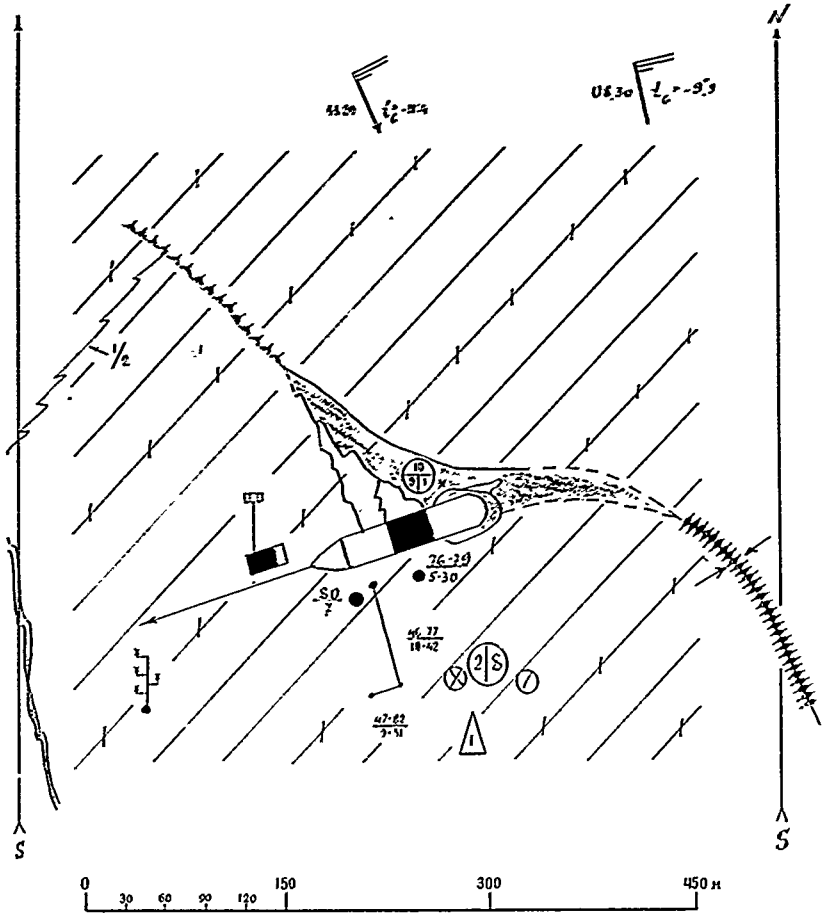


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 25 дата: 25 сентября 1989

координаты начала	координаты конца
φ = 67°50′4 S	φ = 67°50′5 S
λ = 18° 46′.6 W	λ = 18° 45′.5 W
время начала = 14^h00^m	время конца = 15^h25^m
СМГ 15^h00^m	СМГ 16^h25^m

Figure 81. 25 September, ice station 25.

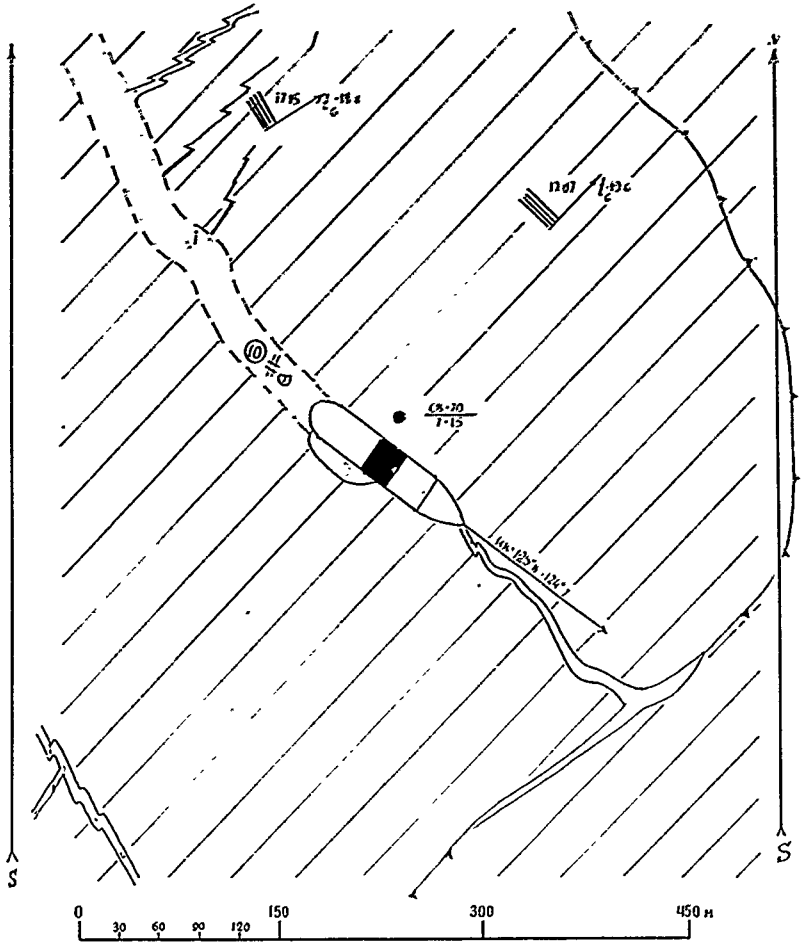


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 26 дата: 26 сентября 1989

координаты начала	координаты конца
φ = 67° 40' 6 s	φ = 67° 43' 5 s
λ = 17° 36' 4 w	λ = 17° 32' 2 w
время начала = 03ч 20м	время конца = 08ч 30м
GMT 04ч 20м	GMT 09ч 30м

Figure 82. 26 September, ice station 26.

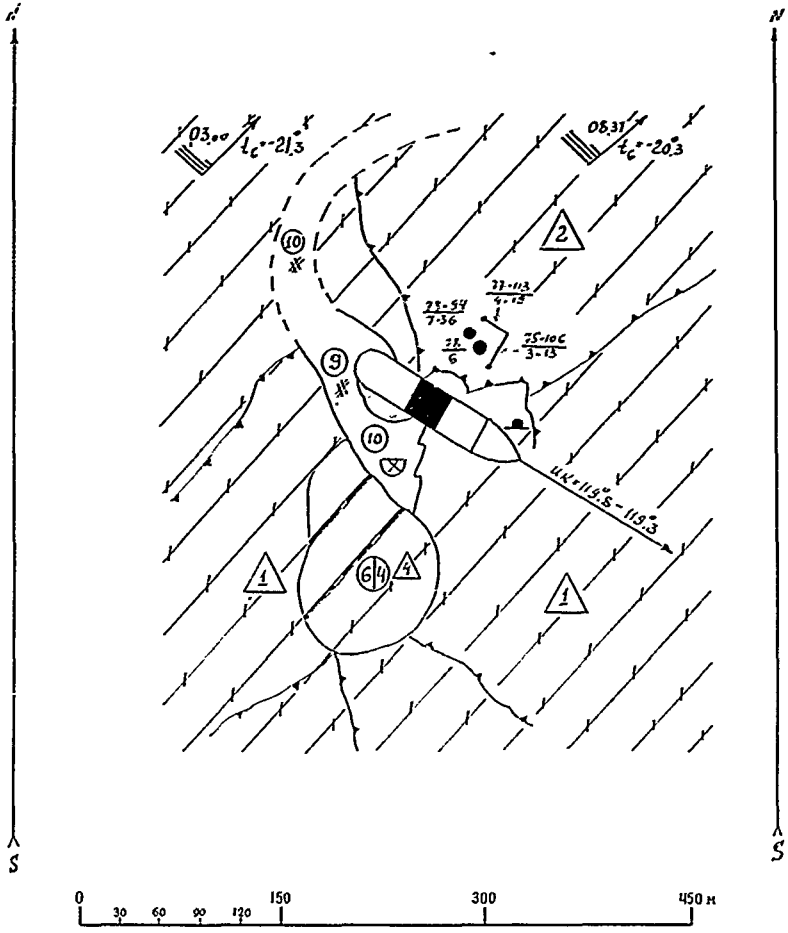


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 27 дата: 26 сентября 1989

координат начала	координат конца
$\varphi = 67^{\circ}\ 30.5\ S$	$\varphi = 67^{\circ}\ 28.8\ S$
$\lambda = 16^{\circ}\ 18.9\ W$	$\lambda = 16^{\circ}\ 15.8\ W$
время начала = $17^{h}\ 45^{m}$	время конца = $19^{h}\ 07^{m}$
GMT $18^{h}\ 45^{m}$	GMT $20^{h}\ 07^{m}$

Figure 83. 26 September, ice station 27.

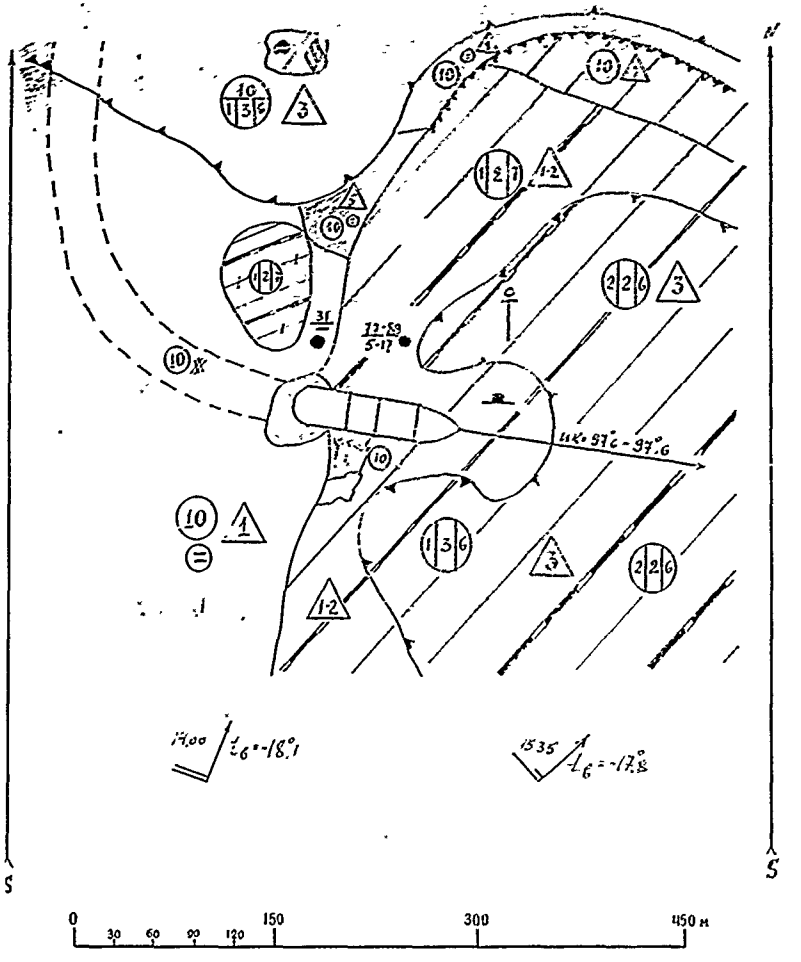


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 28 дата: 27 сентября 1989

координаты начала	координаты конца
φ = 67° 21,4 S	φ = 67° 18,0 S
λ = 15° 02,1 W	λ = 14° 59,0 W
время начала = 03ʰ 00ᵐ	время конца = 08ʰ 37ᵐ
GMT 04ʰ 00ᵐ	GMT 09ʰ 37ᵐ

Figure 84. 27 September, ice station 28.

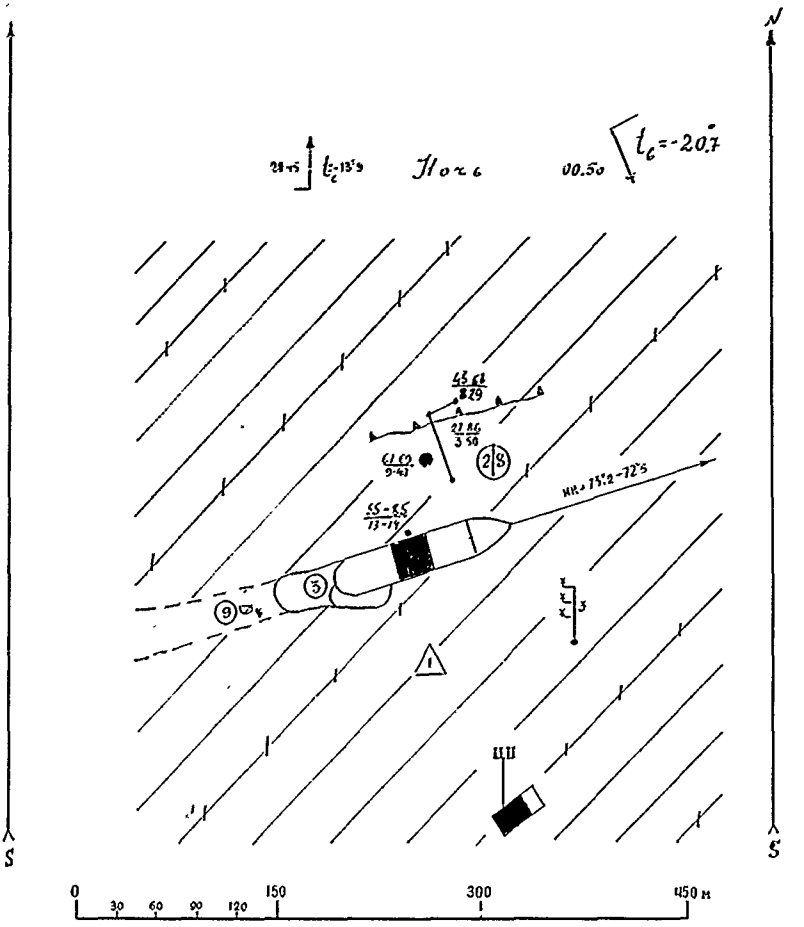


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 29 дата: 27 сентября 1989

координаты начала	координаты конца
φ = 67° 11'3 S	φ = 67° 09'8 S
λ = 15° 54'.0 W	λ = 15° 55'.0 W
время начала = 14ʰ 00ᵐ	время конца = 15ʰ 45ᵐ
GMT 15ʰ 00ᵐ	GMT 16ʰ 45ᵐ

Figure 85. 27 September, ice station 29.

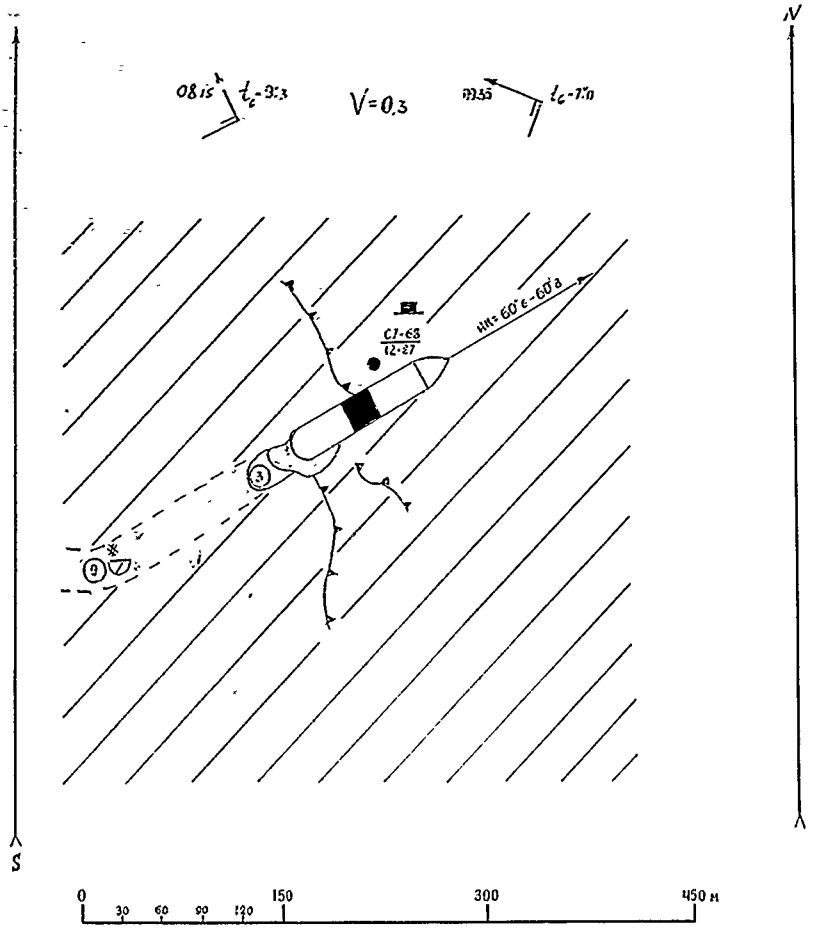


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 30 дата: 27-28 сентября 1989

координаты начала	координаты конца
φ = 67°02.5 S	φ = 67°02.3 S
λ = 12° 45.9 W	λ = 12° 44.4 W
время начала = 20ʰ40ᵐ	время конца = 00ʰ54ᵐ
СМГ 21ʰ40ᵐ	СМГ 01ʰ54ᵐ

Figure 86. 27–28 September, ice station 30.



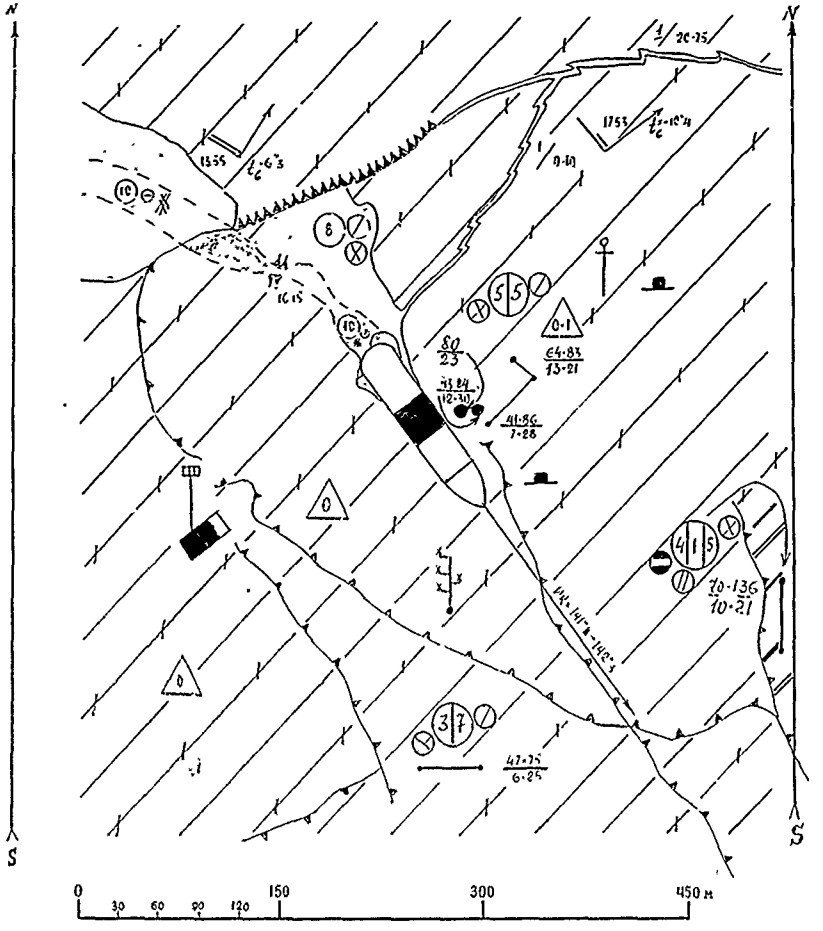
ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 31 дата: 28 сентября 1989

координатн начала
φ = 66°52'1 S
λ = 11°28.0 W
время начала = 08ʰ15ᵐ
СМТ 09ʰ15ᵐ

координатн конца
φ = 66°32'4 S
λ = 11° 26.9 W
время конца = 09ʰ35ᵐ
СМТ 10ʰ35ᵐ

Figure 87. 28 September, ice station 31.

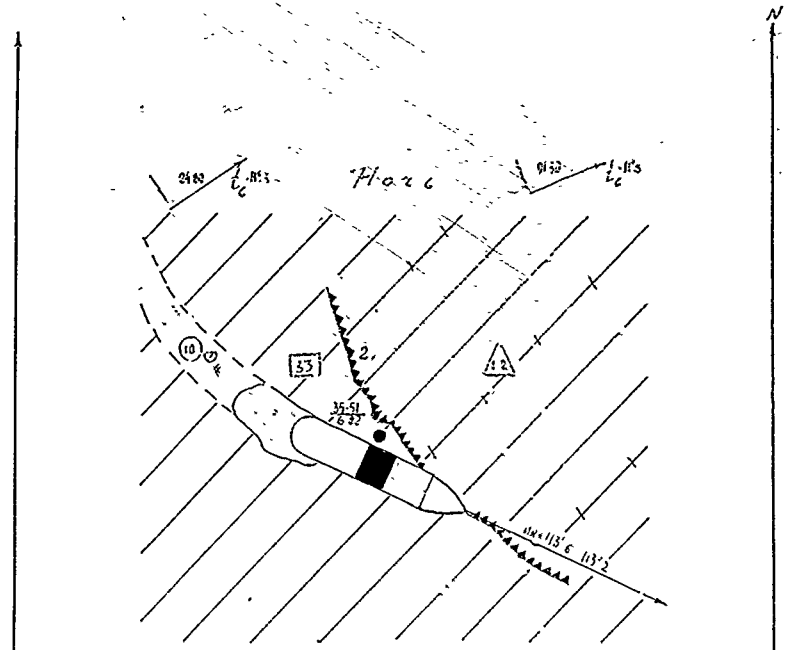


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 32 дата: 28 сентября 1989

координаты начала	координаты конца
φ = 66°41'9 S	φ = 66°38'5 S
λ = 10°17'6 W	λ = 10°14'6 W
время начала = 12ʰ40ᵐ	время конца = 17ʰ53ᵐ
GMT 14ʰ30ᵐ	GMT 18ʰ53ᵐ

Figure 88. 28 September, ice station 32.



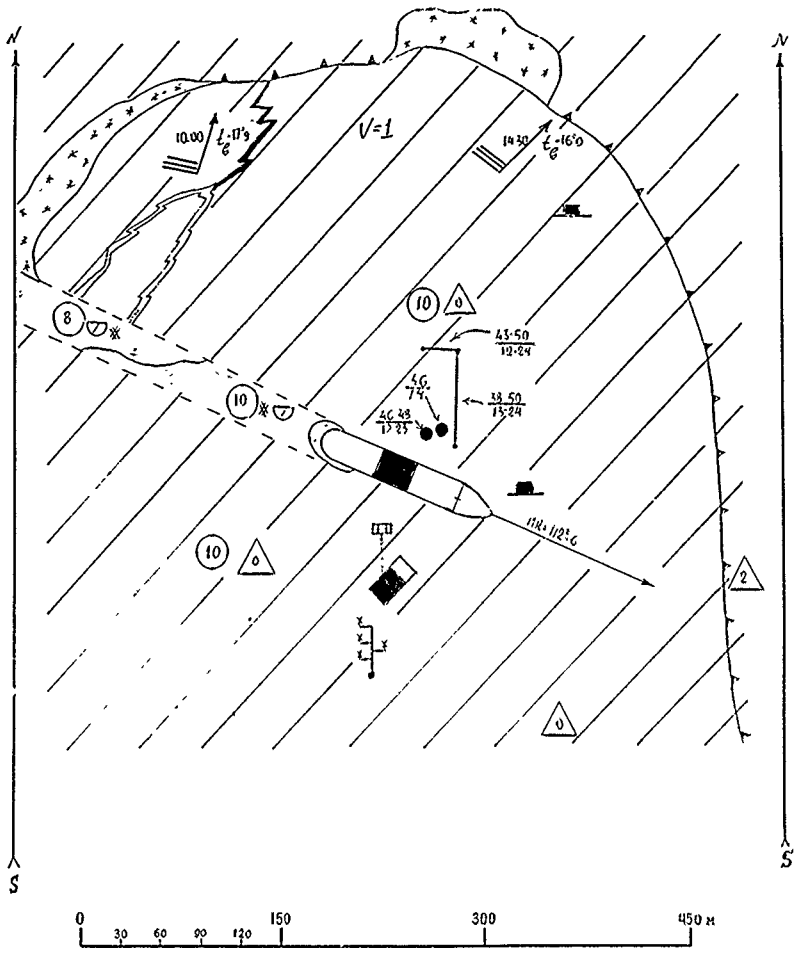
1. Для оценки ледовой обстановки использовали подсветку прожектором.
2. Высота гряды торосов 2 м, толщина льда в торосе 60-62 см.

ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 33 дата: 29 сентября 1989

координаты начала	координаты конца
φ = 66° 31.6 s	φ = 66° 31.5 s
λ = 89° 01.7 w	λ = 89° 01.6 w
время начала = 00ʰ00ᵐ	время конца = 01ʰ40ᵐ
GMT 01ʰ00ᵐ	GMT 02ʰ40ᵐ

Figure 89: 29 September, ice station 33.

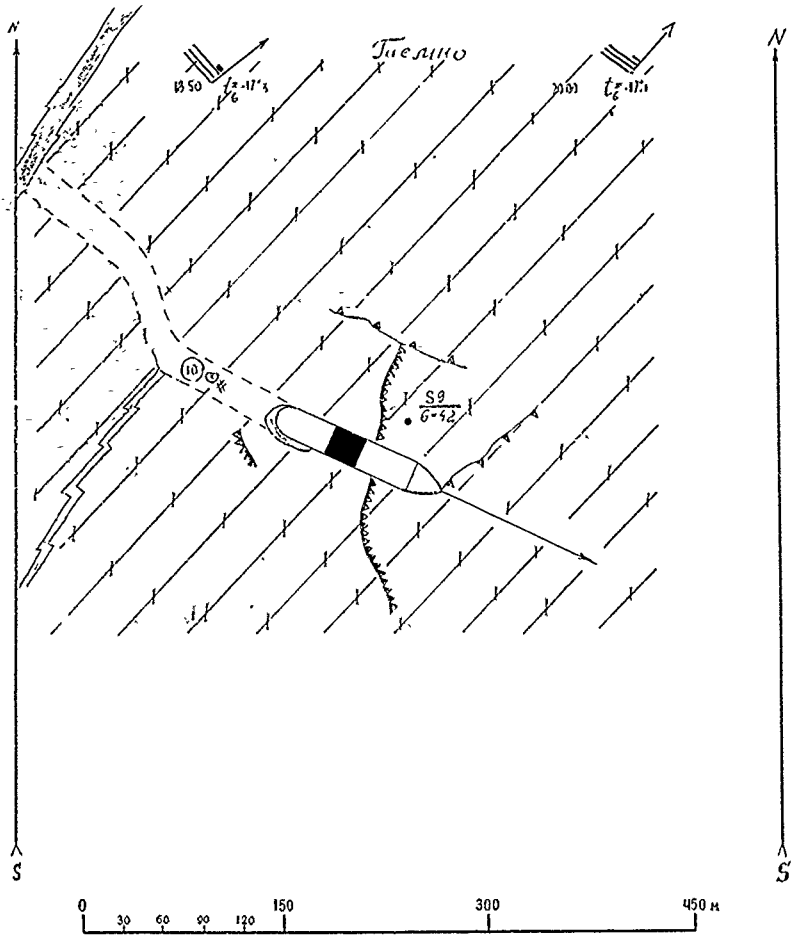


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 34 дата: 29 сентября 1989

координаты начала	координаты конца
φ = 66°21'1 S	φ = 66°18'8 S
λ = 07°49'.7 W	λ = 07°46'5 W
время начала = 10ʰ00ᵐ	время конца = 14ʰ30ᵐ
GMT 10ʰ00ᵐ	GMT 14ʰ30ᵐ

Figure 90. 29 September, ice station 34.

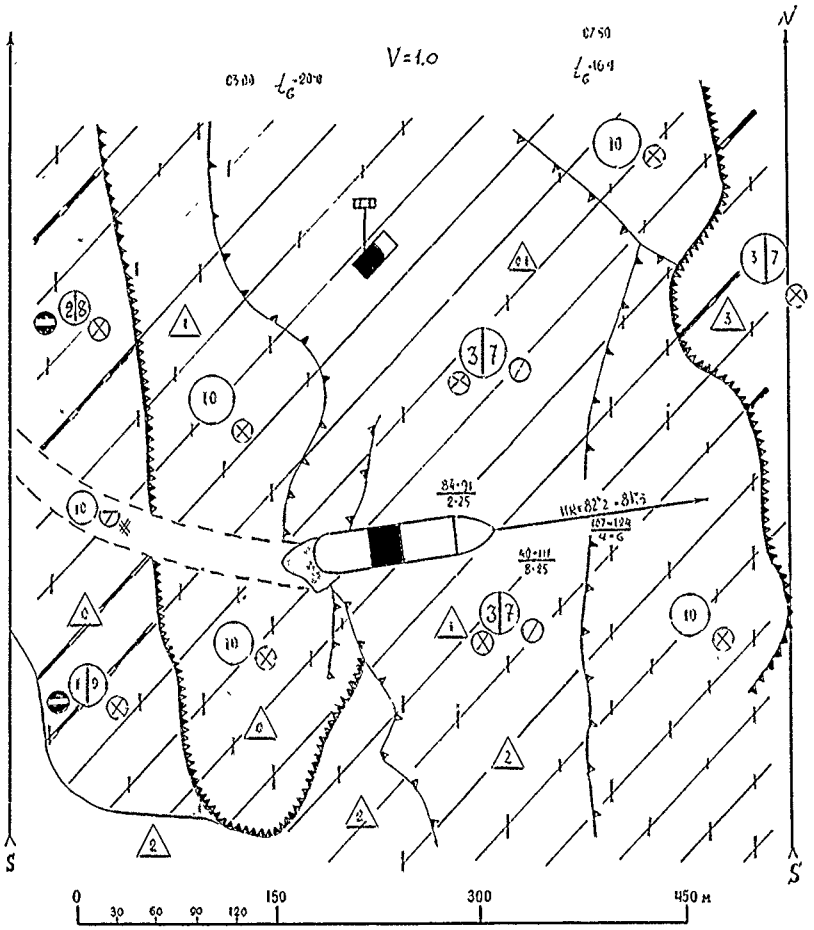


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 35 дата: 29 сентября 1989

координатн начала	координатн конца
φ = 66° 10' s s	φ = 66° 10' s s
λ = 06° 44' w	λ = 06° 44' w
время начала = 18ʰ 50ᵐ	время конца = 20ʰ 00ᵐ
GMT 18ʰ 50ᵐ	GMT 20ʰ 00ᵐ

Figure 91. 29 September, ice station 35.

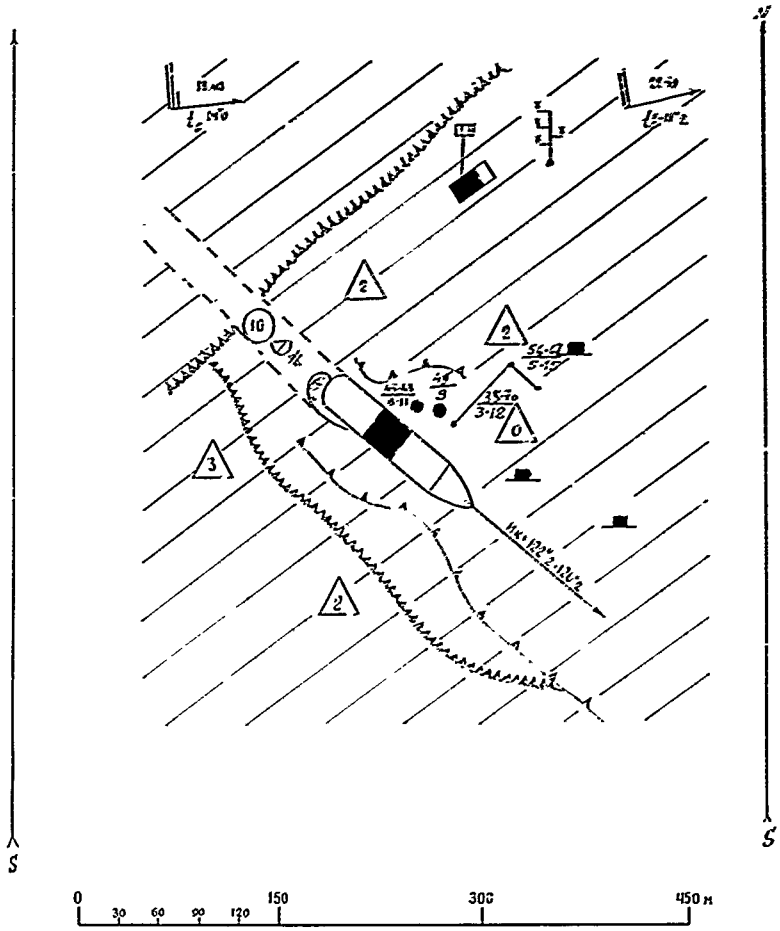


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 36 дата: 30 сентября 1989

координатн начала	координатн конца
φ = 66°02'.0 S	φ = 66°00'.6 S
λ = 05°54'.0 W	λ = 05°29'.9 W
время начала = 03ᵏ30ᵐ	время конца = 07ᵏ50ᵐ
GMT 03ᵏ30ᵐ	GMT 07ᵏ50ᵐ

Figure 92. 30 September, ice station 36.

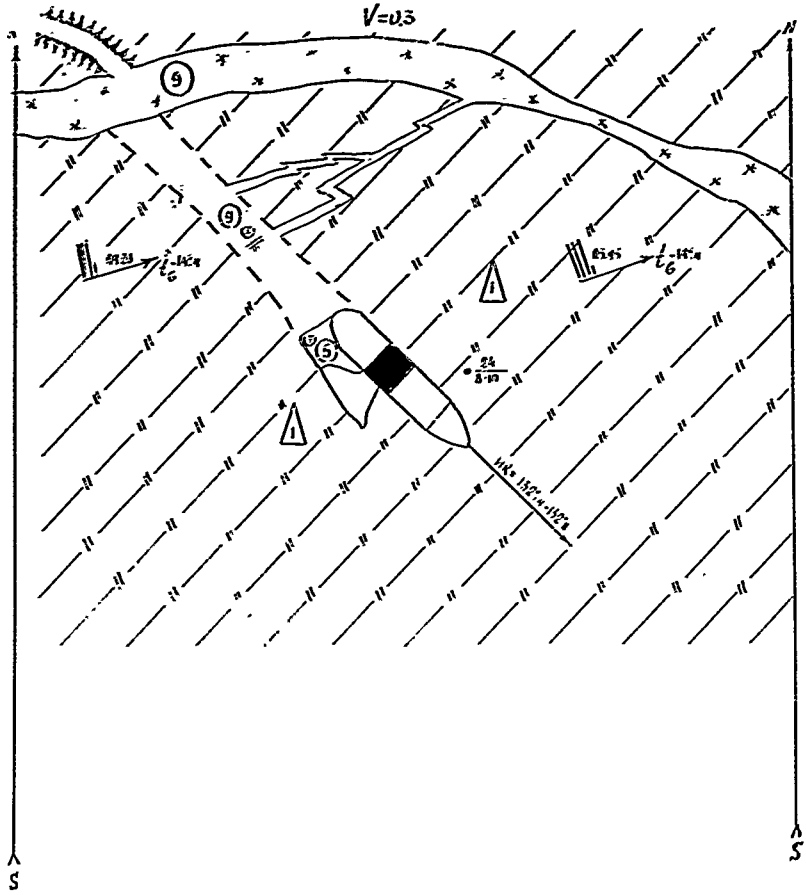


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 38 дата: 30 сентября 1989

координаты начала	координаты конца
$\varphi = 65^{\circ}42'6\,s$	$\varphi = 65^{\circ}41'7\,s$
$\lambda = 03^{\circ}21'1\,w$	$\lambda = 03^{\circ}15'8\,w$
время начала = $18^{h}40^{m}$	время конца = $22^{h}50^{m}$
GMT $18^{h}40^{m}$	GMT $22^{h}50^{m}$

Figure 93. 30 September, ice station 38.

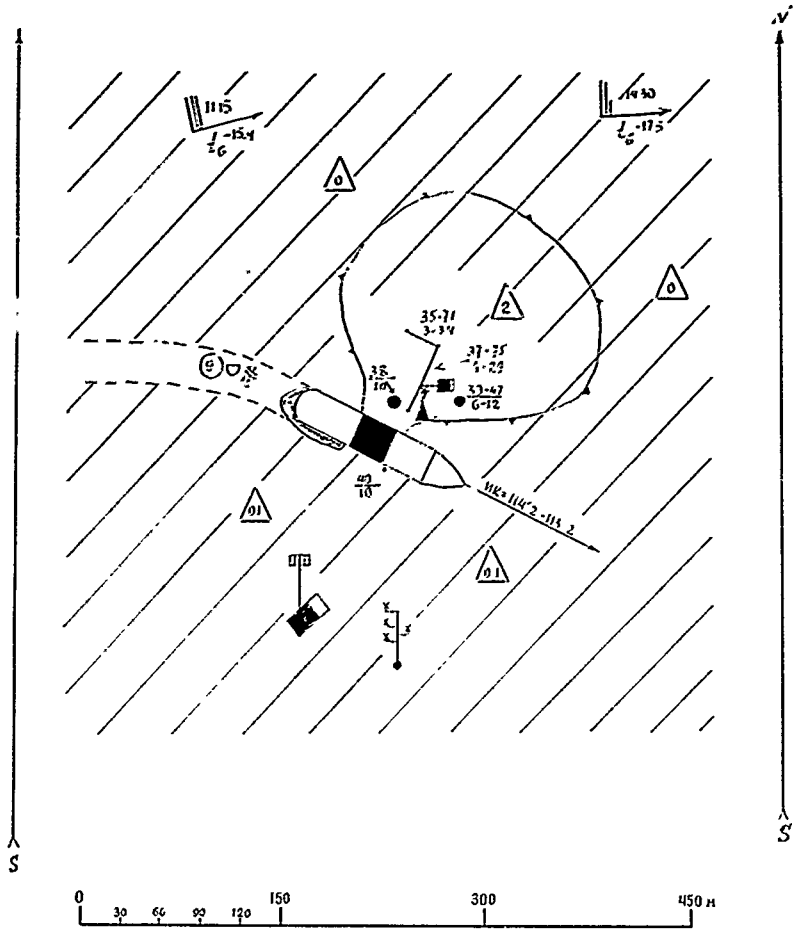


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 39 дата: 1 октября 1989

координатн начала	координатн конца
$\varphi = 65^{\circ}32'.2\ S$	$\varphi = 65^{\circ}31'.3\ S$
$\lambda = 02^{\circ}07'.0\ W$	$\lambda = 0..^{\circ}05'.3\ W$
время начала = $04^{h}20^{m}$	время конца = $05^{h}45^{m}$
GMT $04^{h}20^{m}$	GMT $05^{h}45^{m}$

Figure 94. 1 October, ice station 39.

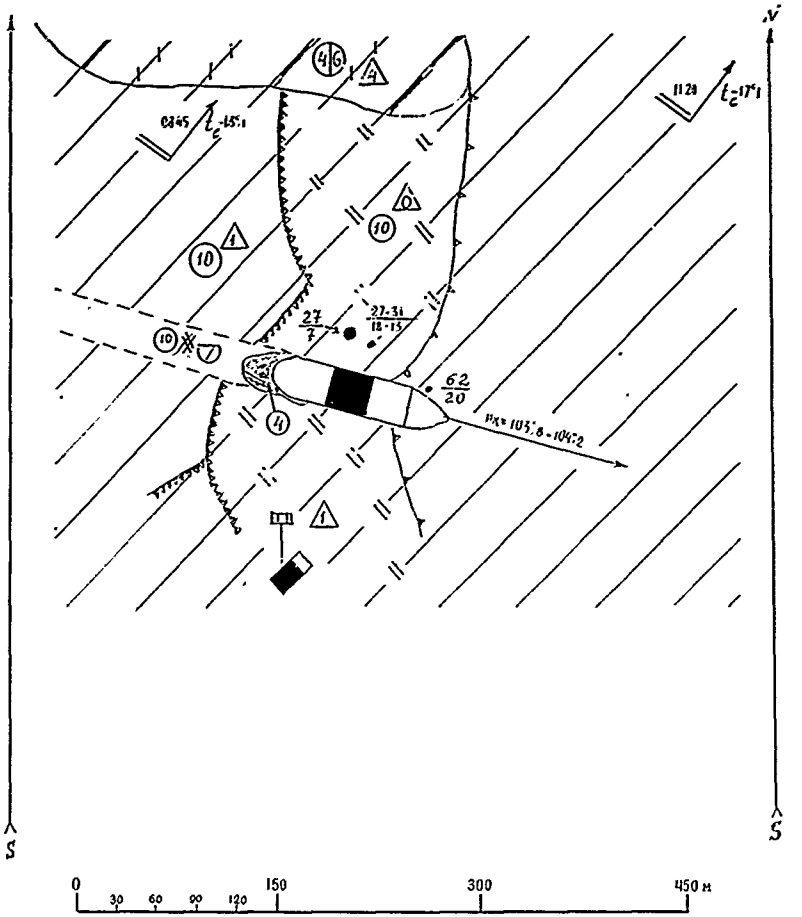


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 40 дата: 1 октября 1989

координаты начала	координаты конца
φ = 65° 21.9 S	φ = 65° 20.5 S
λ = 01° 00.7 W	λ = 00° 55.2 W
время начала = 11ʰ 15ᵐ	время конца = 14ʰ 30ᵐ
GMT 11ʰ 15ᵐ	GMT 14ʰ 30ᵐ

Figure 95. 1 October, ice station 40.

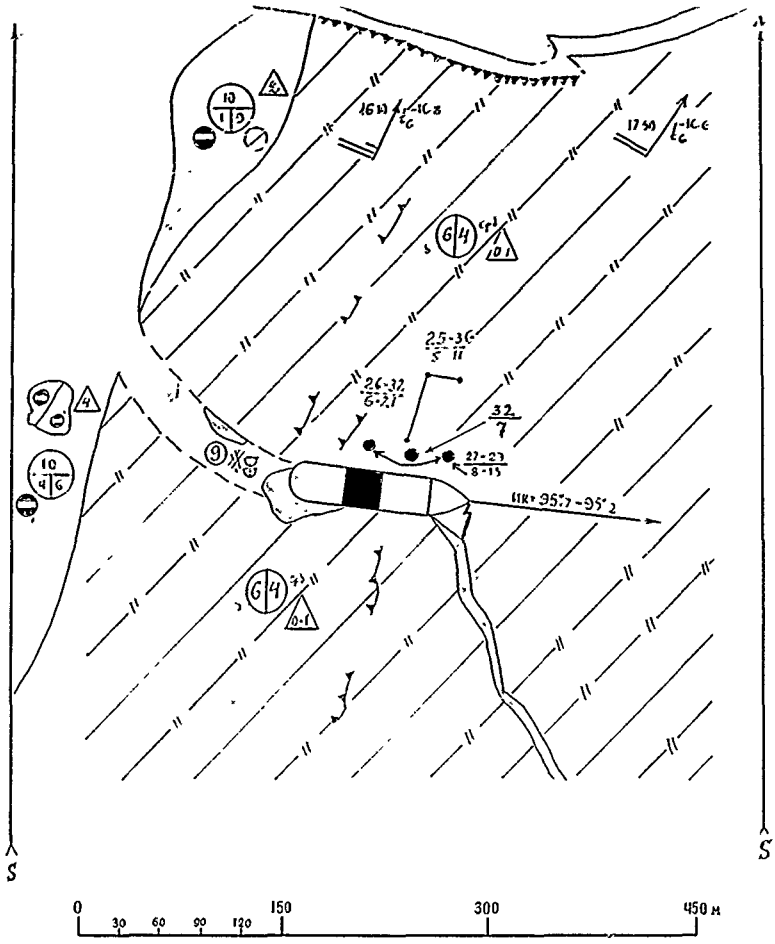


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 43 дата: 2 октября 1989

координаты начала	координаты конца
φ = 64° 59'.8 S	φ = 64° 58'.8 S
λ = 02° 59'.7 E	λ = 05° 00'.5 E
время начала = 08ʰ 55ᵐ	время конца = 11ʰ 20ᵐ
GMT 08ʰ 55ᵐ	GMT 11ʰ 20ᵐ

Figure 96. 2 October, ice station 43.

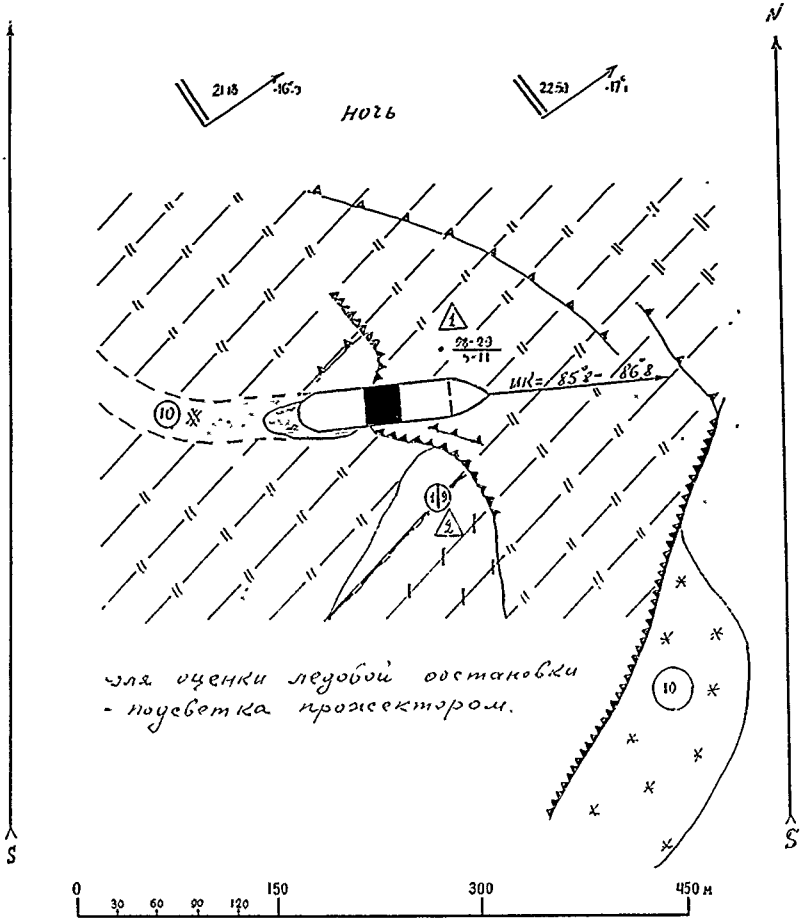


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 44 дата: 2 октября 1989

координаты начала	координаты конца
φ = 65°21'4 S	φ = 65°20'7 S
λ = 02°10'9 E	λ = 02°11'0 E
время начала = 16ʰ10ᵐ	время конца = 17ʰ30ᵐ
GMT 16ʰ10ᵐ	GMT 17ʰ30ᵐ

Figure 97. 2 October, ice station 44.

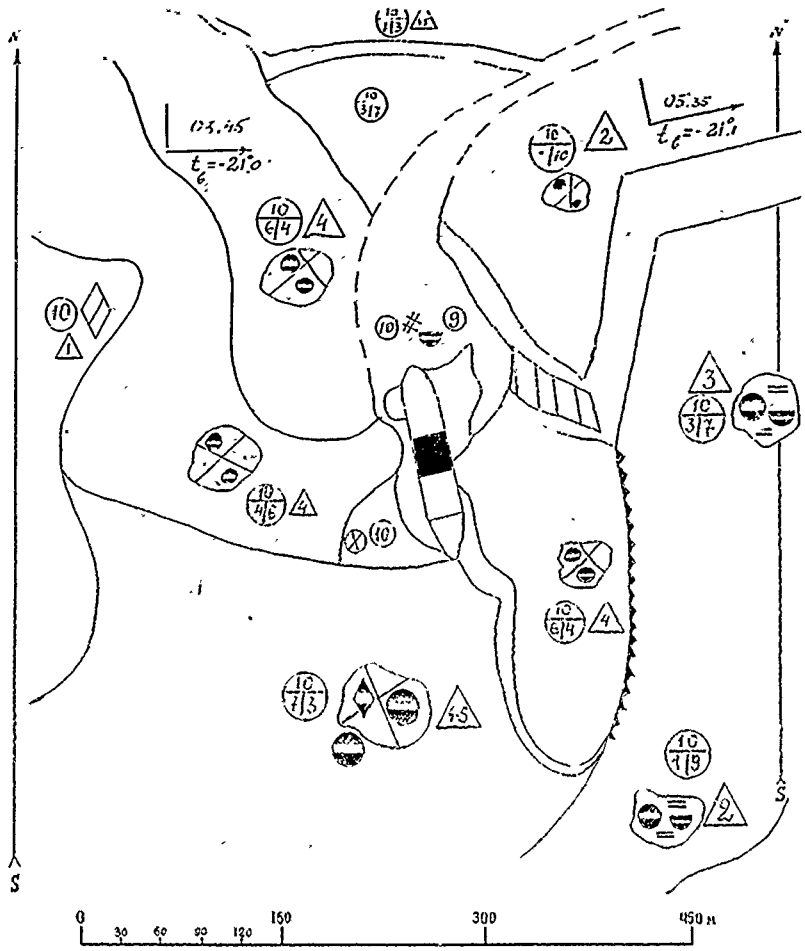


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 45 дата: 2 октября 1989

координаты начала	координаты конца
φ = 65° 42' 0 S	φ = 65° 41' 8 S
λ = 01° 17' 4 E	λ = 01° 17' 5 E
время начала = 21ʰ 10ᵐ	время конца = 22ʰ 50ᵐ
GMT 21ʰ 10ᵐ	GMT 22ʰ 50ᵐ

Figure 98. 2 October, ice station 45.

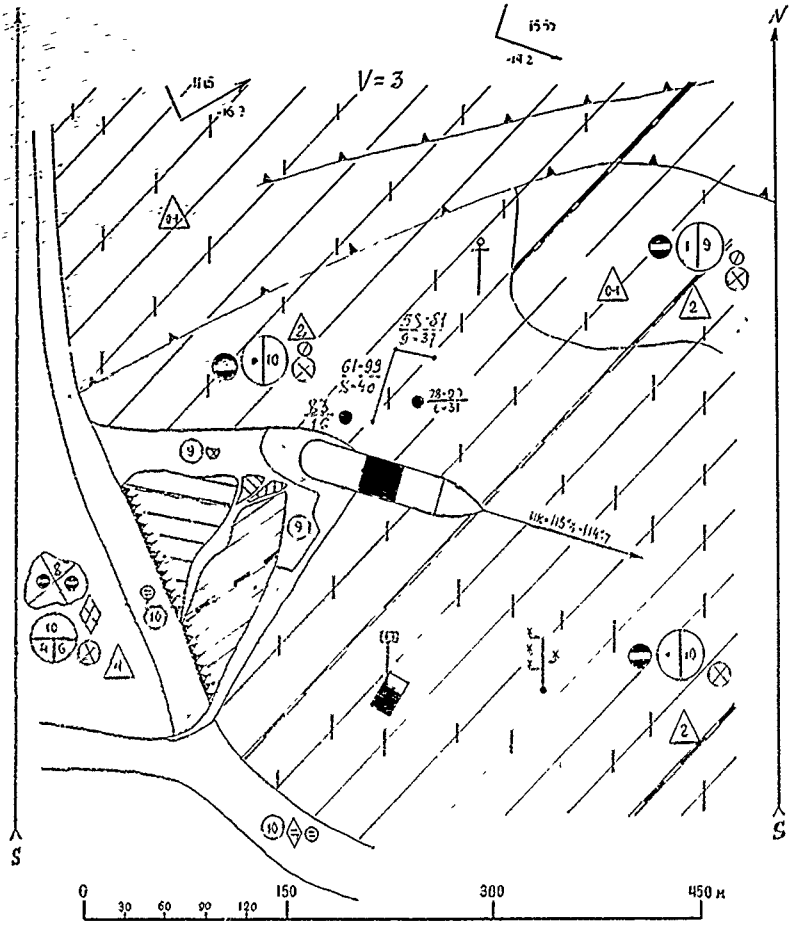


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция 46 дата: 3 октября 1989

координаты начала	координаты конца
φ = 66°03'2 S	φ = 66°02'8 S
λ = 00°22'4 E	λ = 00°22'7 E
время начала = 03ч45мин GMT 03ч45мин	время конца = 05ч35мин GMT 05ч35мин

Figure 99. 3 October, ice station 46.

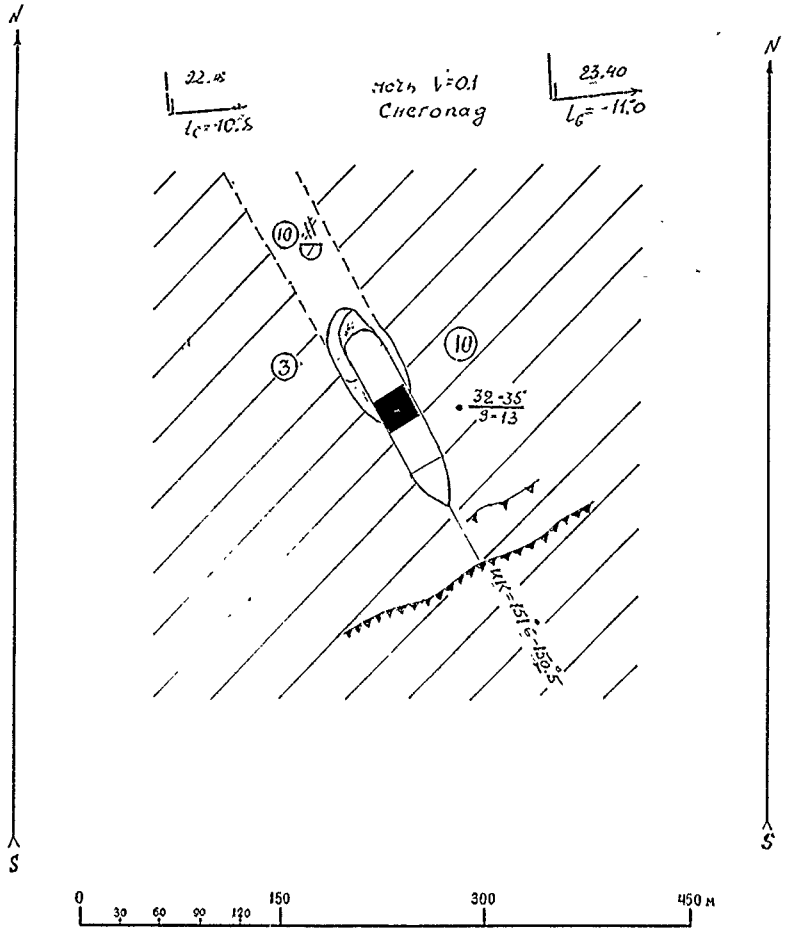


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 47 дата: 3 октября 1989

координаты начала	координаты конца
φ = 66° 21.5 s	φ = 66° 20.2 s
λ = 00° 26.7 w	λ = 00° 22.5 w
время начала = 11ʰ 15ᵐ	время конца = 15ʰ 55ᵐ
GMT 11ʰ 15ᵐ	GMT 15ʰ 55ᵐ

Figure 100. 3 October, ice station 47.

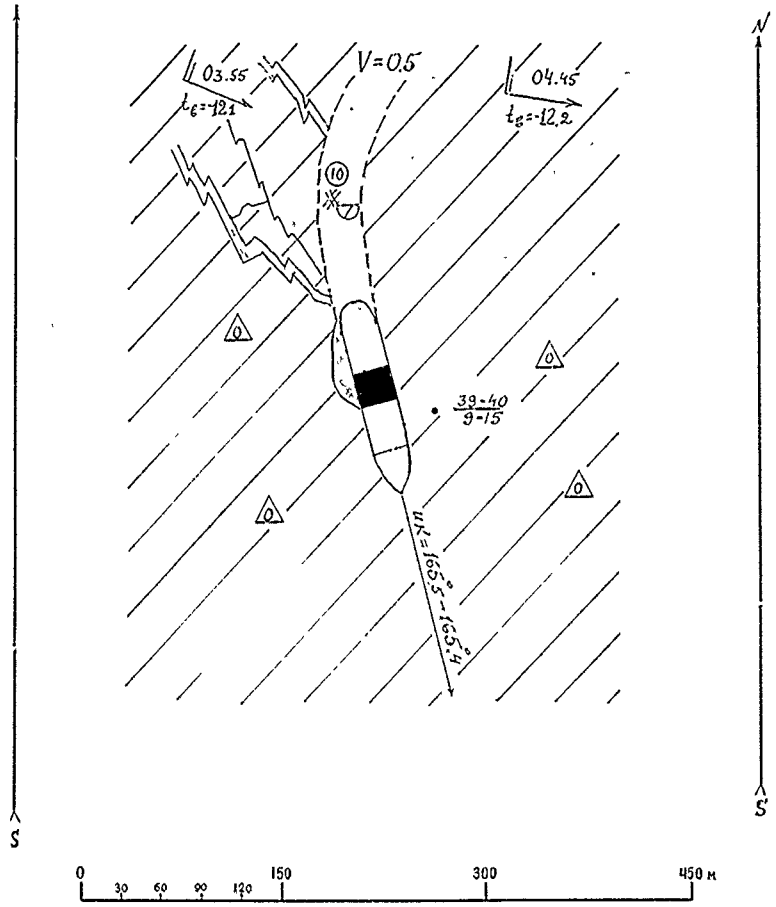


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 48 дата: 3 октября 1989

координати начала	координати конца
φ = 66° 42'.6 S	φ = 66° 42'.2 S
λ = 01° 16'.9 W	λ = 01° 15.1 W
время начала = 22ʰ 18ᵐ	время конца = 25ʰ 40ᵐ
GMT 22ʰ 18ᵐ	GMT 25ʰ 40ᵐ

Figure 101. 3 October, ice station 48.

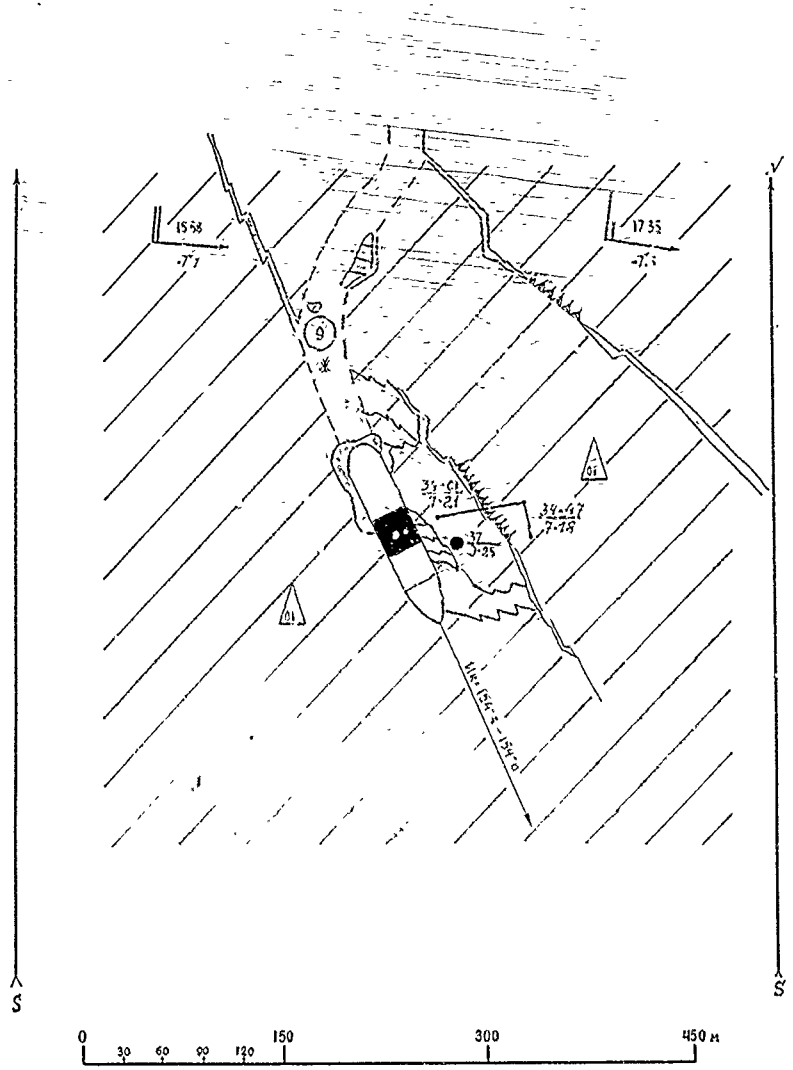


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция 49 дата: 4 октября 1989

координаты начала	координаты конца
φ = 66° 58.5 S	φ = 66° 58.5 S
λ = 01° 54.6 W	λ = 01° 53.9 W
время начала = 03^h55^m	время конца = 04^h50^m
GMT 03^h55^m	GMT 04^h50^m

Figure 102. 4 October, ice station 49.

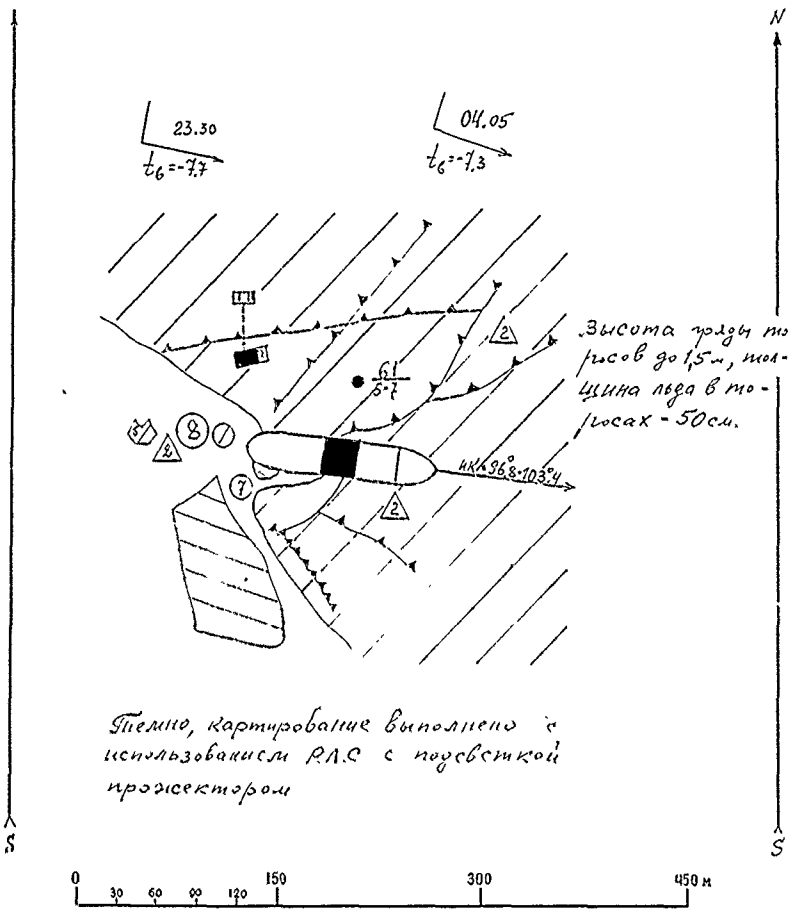


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 51 дата: 4 октября 1989

координаты начала	координаты конца
φ = 66°00′ S	φ = 66°01′ S
λ = 01°57′ W	λ = 01°57′ W
время начала = 16ʰ00ᵐ	время конца = 17ʰ35ᵐ
GMT 16ʰ00ᵐ	GMT 17ʰ35ᵐ

Figure 103. 4 October, ice station 51.

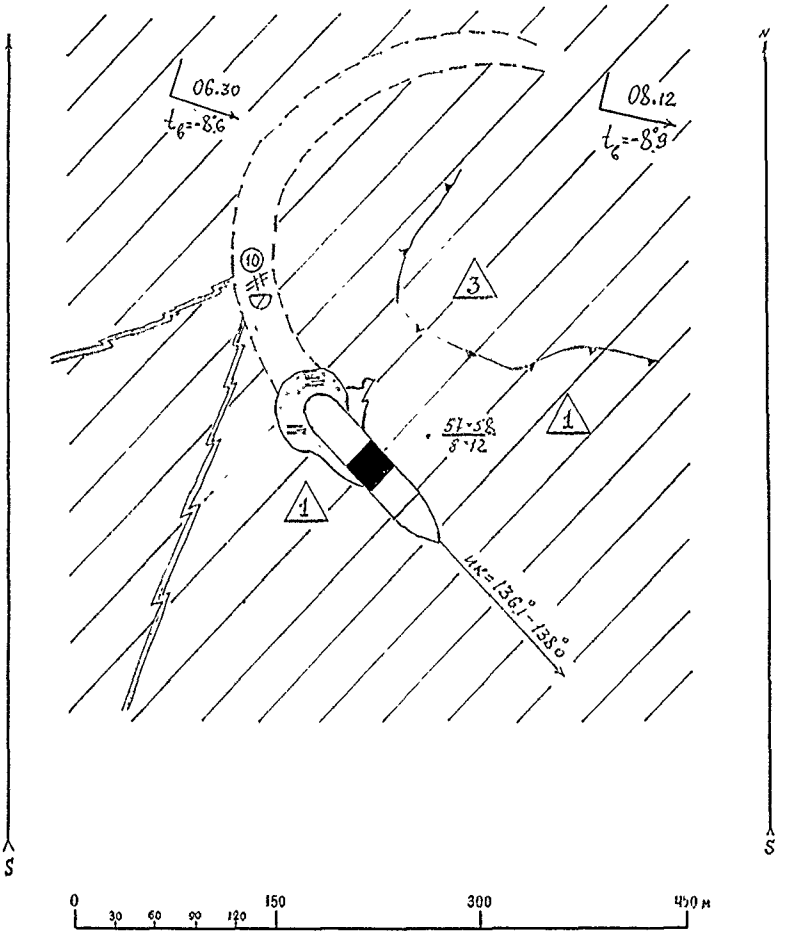


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 52 дата: 4-5 октября 1989

координаты начала	координаты конца
φ = 65° 20,6' S	φ = 65° 29,1' S
λ = 02° 00,2' W	λ = 01° 57,6' W
время начала = 25ʰ30ᵐ	время конца = 04ʰ05ᵐ
GMT 25ʰ30ᵐ	GMT 04ʰ05ᵐ

Figure 104. 4–5 October, ice station 52.

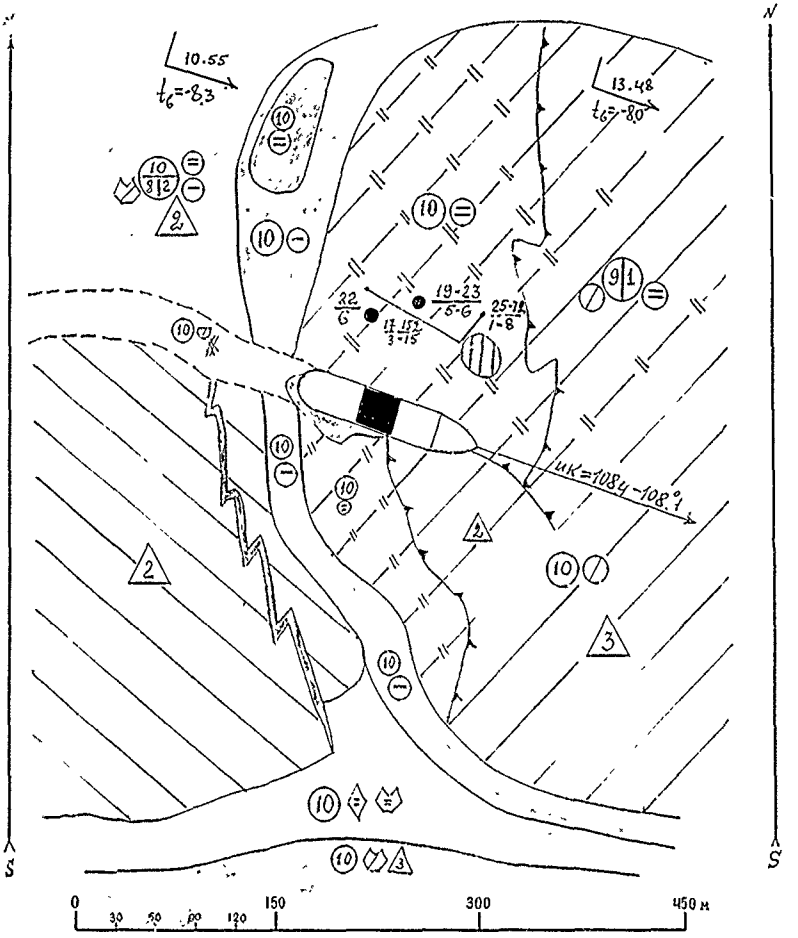


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 53 дата: 5 октября 1989

координат начала	координат конца
φ = 65°16.7′ S	φ = 65°17.1′ S
λ = 02°01.1′ W	λ = 02°00.9′ W
время начала = 06ʰ45ᵐ	время конца = 08ʰ12ᵐ
GMT 06ʰ45ᵐ	GMT 08ʰ12ᵐ

Figure 105. 5 October, ice station 53.

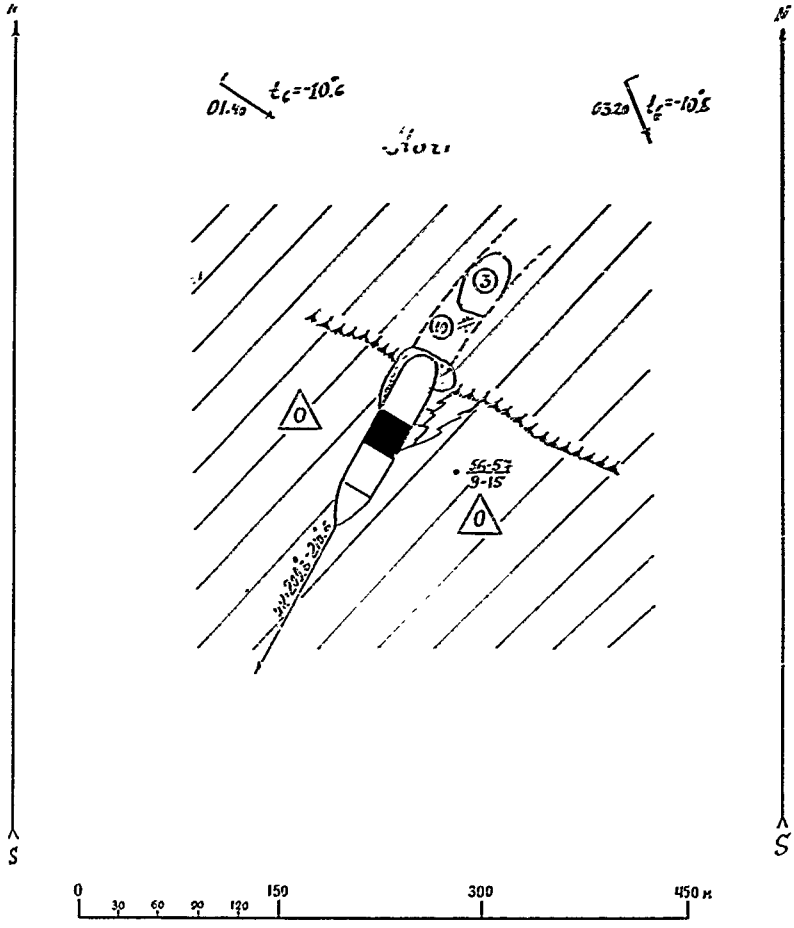


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 54 дата: 5 октября 1989

координаты начала	координаты конца
φ = 64° 59.1 S	φ = 64° 59.6 S
λ = 01° 58.9 W	λ = 01° 58.3 W
время начала = 10^h50^m	время конца = 13^h48^m
GMT 10^h50^m	GMT 13^h48^m

Figure 106.5 October, ice station 54.

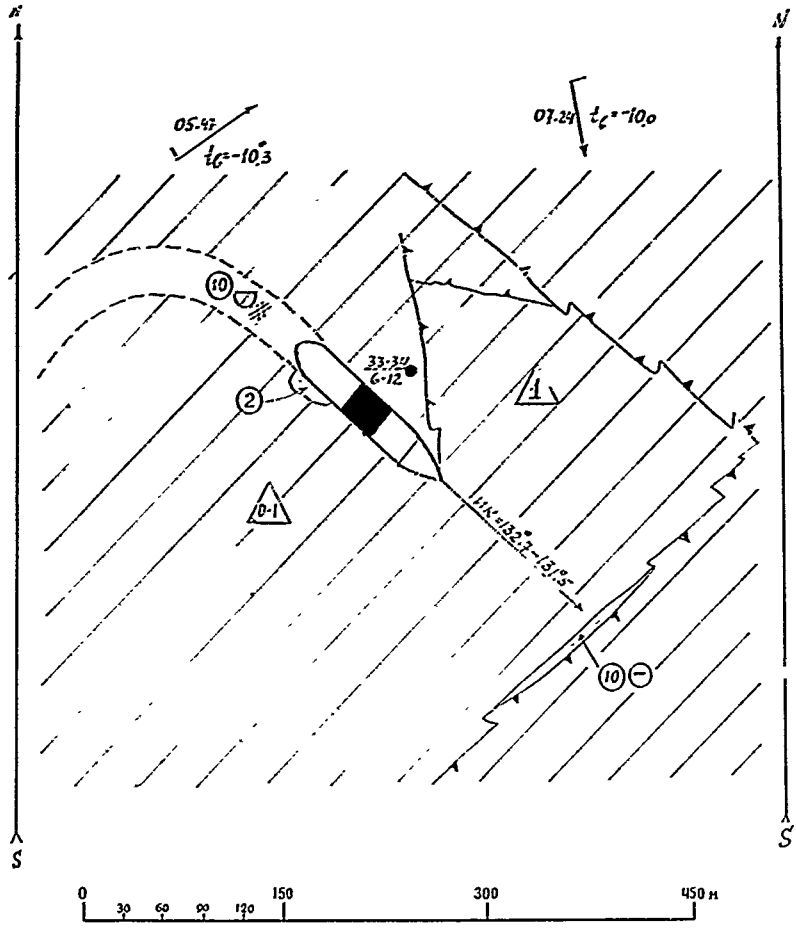


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 55 дата: 6 октября 1989

координаты начала	координаты конца
φ = 65° 46.3 с	φ = 65° 45.6 с
λ = 02° 27.7 W	λ = 02° 26.6 W
время начала = 01ʰ 40ᵐ	время конца = 03ʰ 20ᵐ
GMT 01ʰ 40ᵐ	GMT 03ʰ 20ᵐ

Figure 107. 6 October, ice station 55.

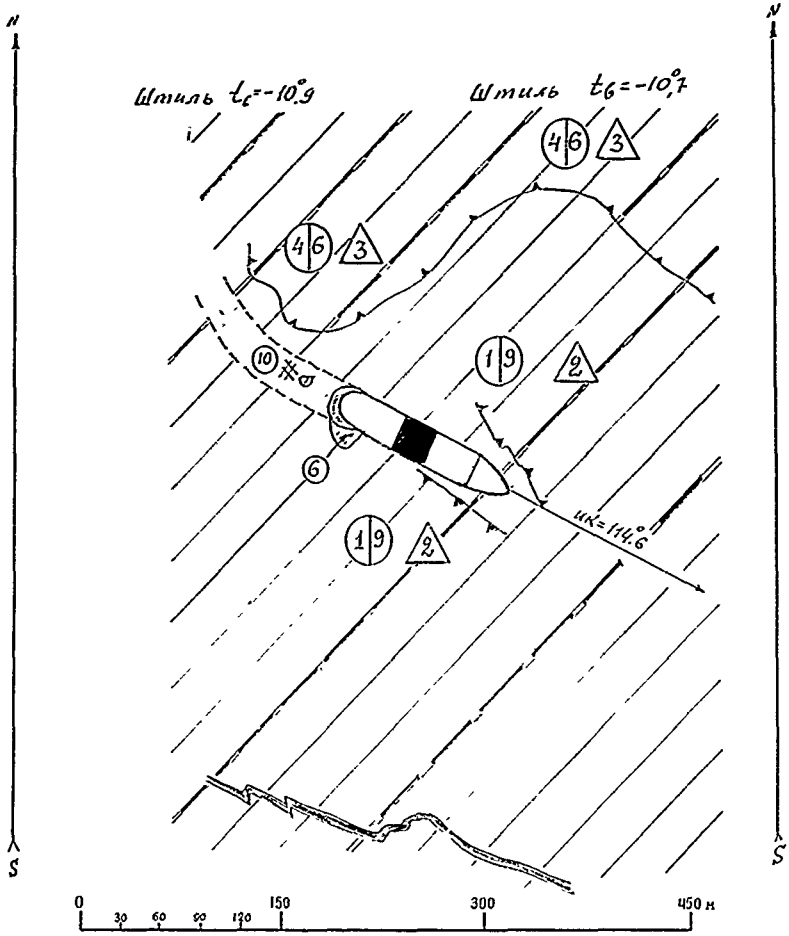


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 56 дата: 6 октября 1989

координатн начала	координатн конца
φ = 65°39'.7 S	φ = 65°39'.5 S
λ = 02°10.5 W	λ = 02°10'.8 W
время начала = 05^h47^m	время конца = 07^h24^m
GMT 05^h47^m	GMT 07^h24^m

Figure 108. 6 October, ice station 56.

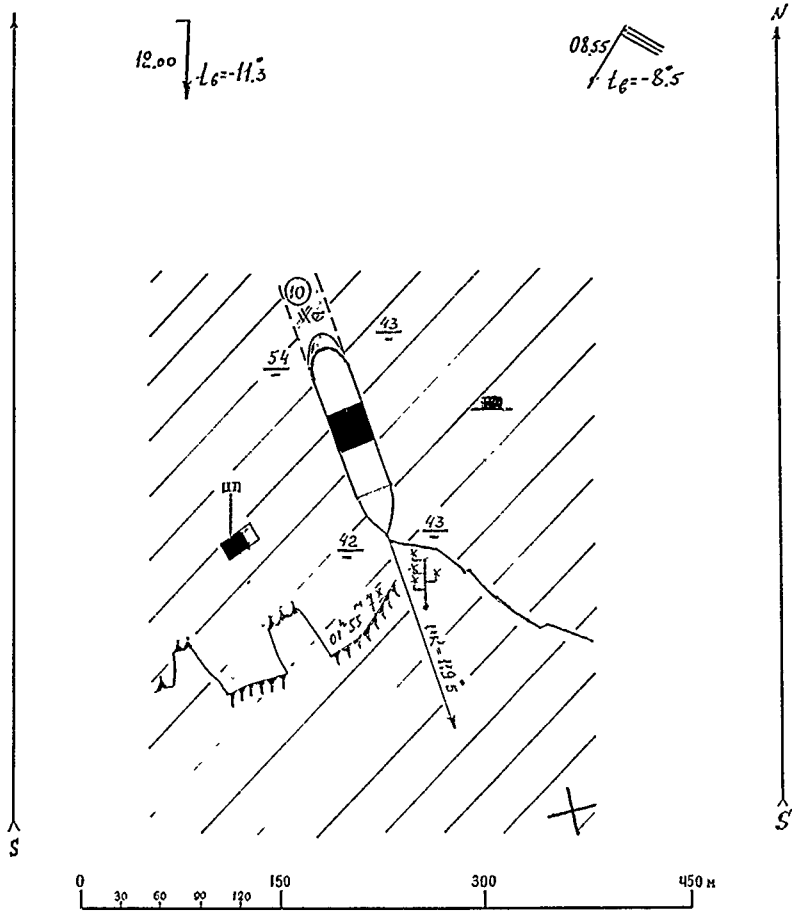


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 57 дата: 6 октября 1989

координаты начала	координаты конца
φ = 65° 43'7 s	φ = 65° 44'1 s
λ = 01° 40'7 w	λ = 01° 46'2 w
время начала = $10^h 42^m$	время конца = $11^h 42^m$
GMT $10^h 42^m$	GMT $11^h 42^m$

Figure 109. 6 October, ice station 57?

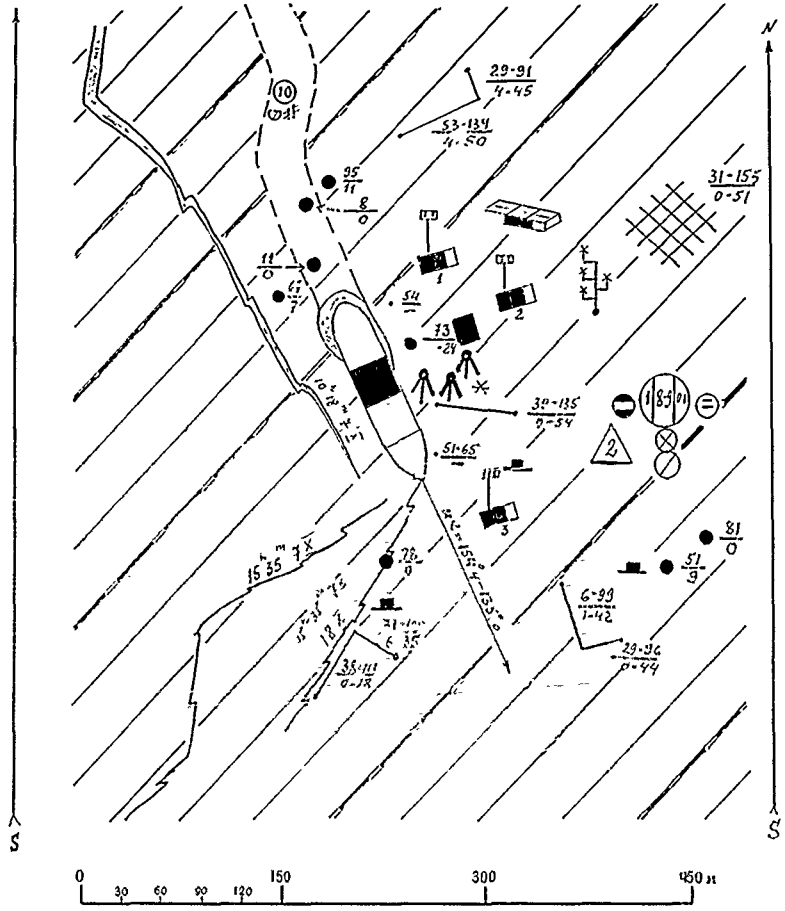


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция полигон № 1 дата: 6-7 октября 1989

координаты начала	координаты конца
φ = 65° 45.5' S	φ = 65° 52.0' S
λ = 01° 45.0' W	λ = 01° 51.5' W
время начала = $12^h 15^m$	время конца = $08^h 55^m$
GMT $12^h 15^m$	GMT $08^h 55^m$

Figure 110. 6–7 October, mesopolygon 1.

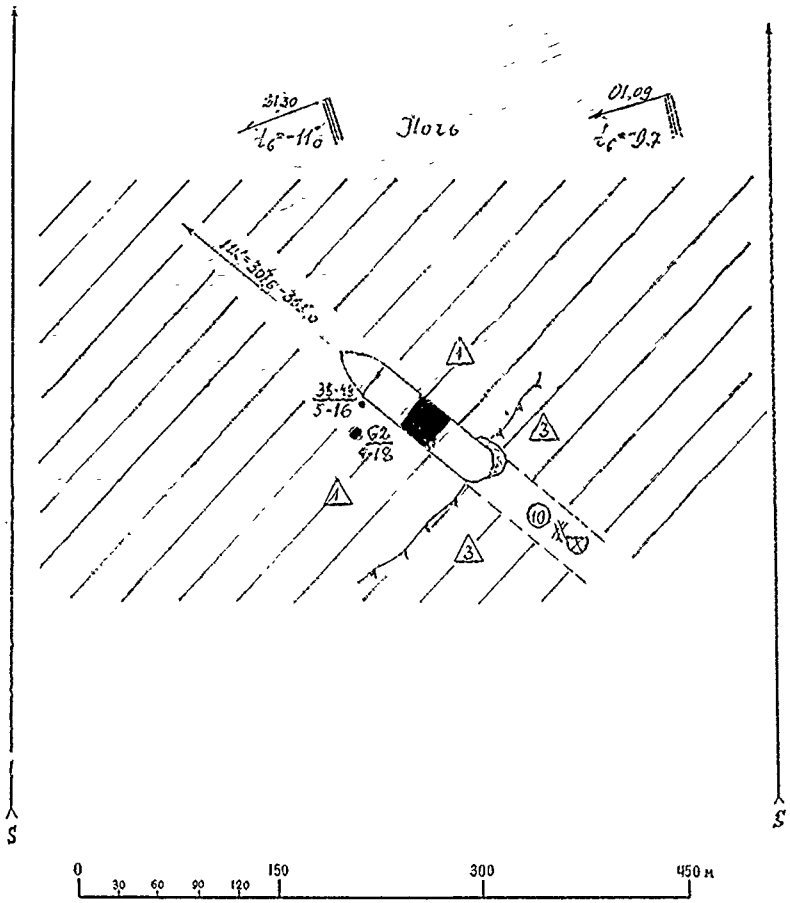


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция *Полигон 2* дата: 7-18 октября 1989

координаты начала	координаты конца
φ = 65° 52′,0 s	φ = 65° 23,6 s
λ = 01° 51,5 w	λ = 04° 08 5 w
время начала = 03ᵏ 15ᵐ	время конца = 14ᵏ 08ᵐ
09ᵏ 15ᵐ	14ᵏ 08ᵐ

Figure 111. 7–18 October, mesopolygon 2.

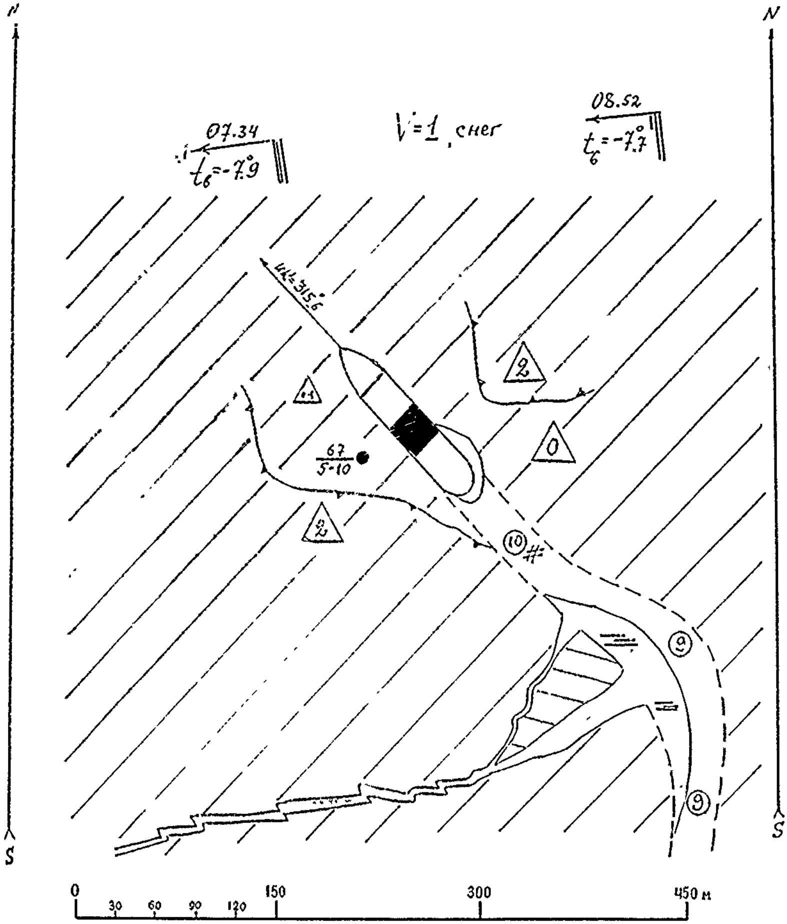


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 116 дата: 18-19 октября 1989

координаты начала	координаты конца
φ = 65° 20.8' S	φ = 65° 25.7' S
λ = 02° 07.7' W	λ = 02° 15.5' W
время начала = 21ʰ30ᵐ	время конца = 01ʰ09ᵐ
GMT 21ʰ30ᵐ	GMT 01ʰ09ᵐ

Figure 112. 18–19 October, ice station 116.



ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 117 дата: 19 октября 1989

координаты начала — координаты конца

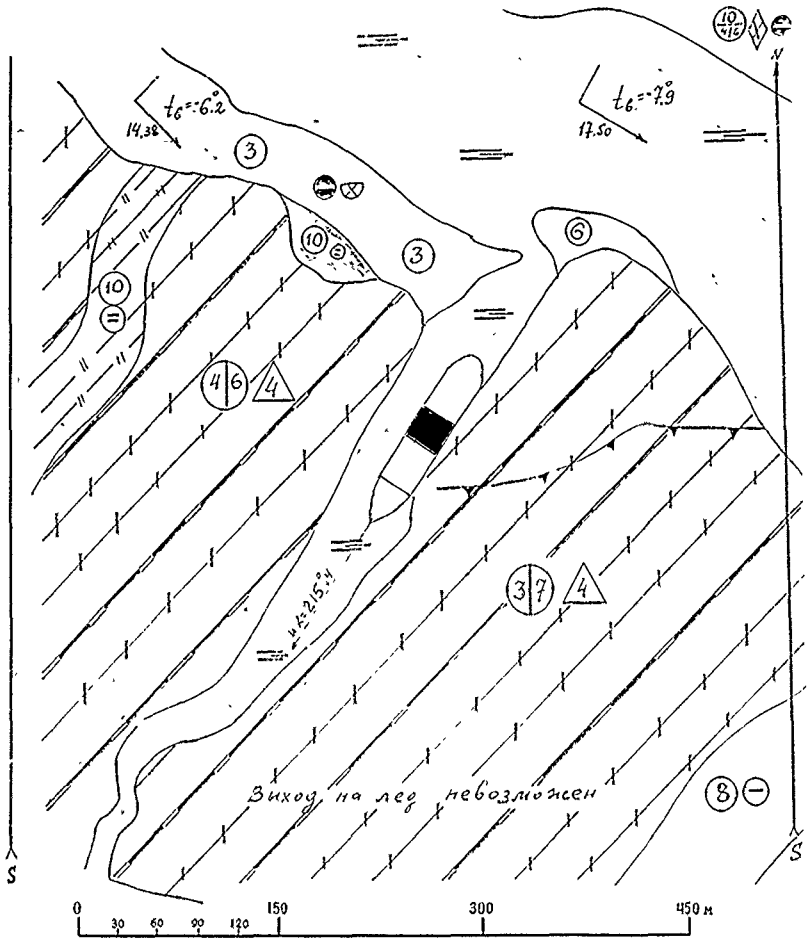
φ = 64° 57'8,S — φ = 64° 58'.2 S

λ = 02° 57'.2 W — λ = 02° 59'.1 W

время начала = 07ч 34м — время конца = 08ч 52м

GMT 07ч 34м — GMT 08ч 52м

Figure 113. 19 October, ice station 117.

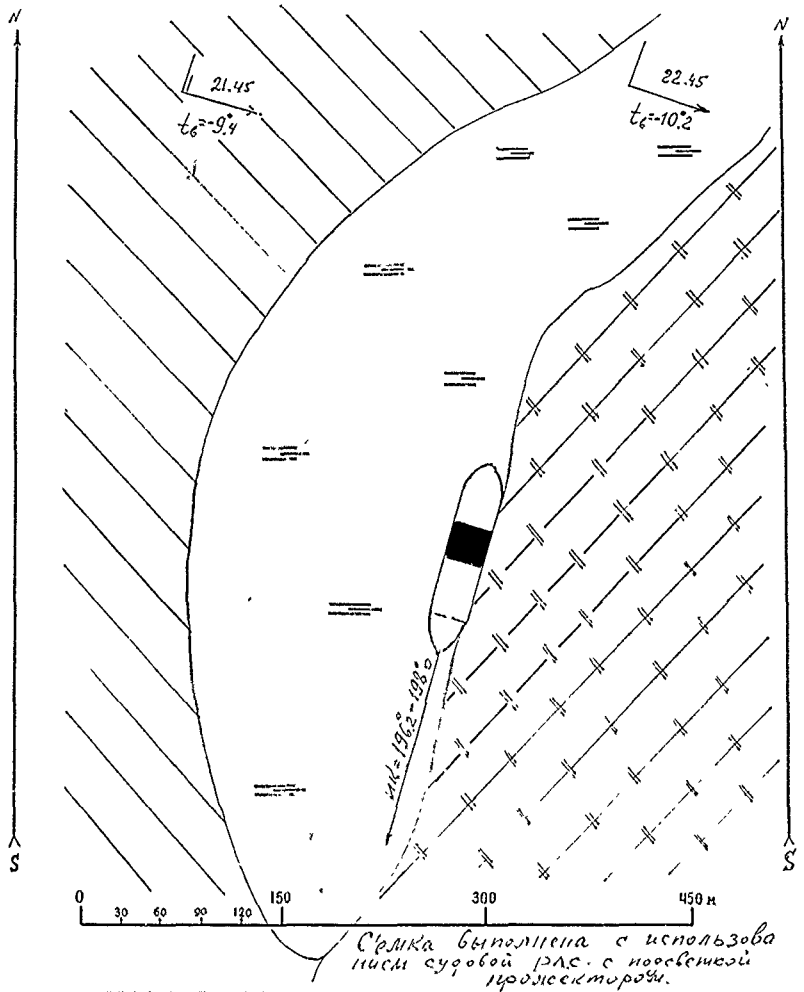


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 118 дата: 19 октября 1989

координаты начала	координаты конца
φ = 64°54.1 S	φ = 64° 34.1 S
λ = 05°48.3 W	λ = 05° 44.5 W
время начала = 14h38m	время конца = 17h50m
GMT 14h38m	GMT 17h50m

Figure 114. 19 October, ice station 118.

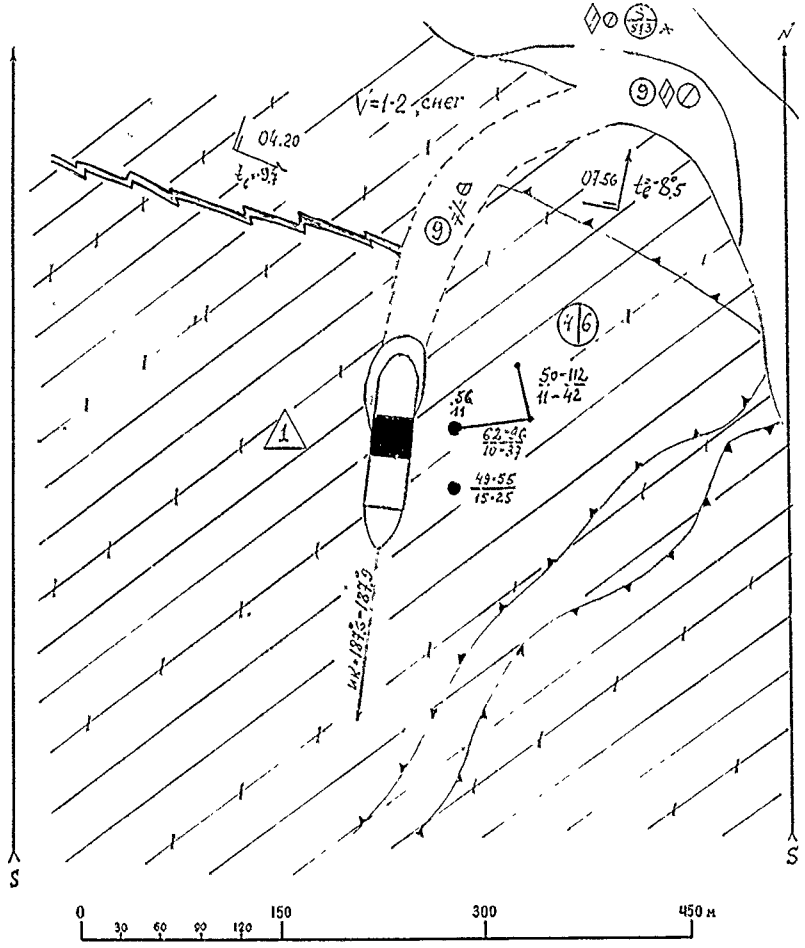


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 119 дата: 19 октября 1989

координаты начала	координаты конца
φ = 64° 12.9 S	φ = 64° 13.0 S
λ = 04° 38.8 W	λ = 04° 37.0 W
время начала = $21^h 45^m$	время конца = $22^h 45^m$
GMT $21^h 45^m$	GMT $22^h 45^m$

Figure 115. 19 October, ice station 119.

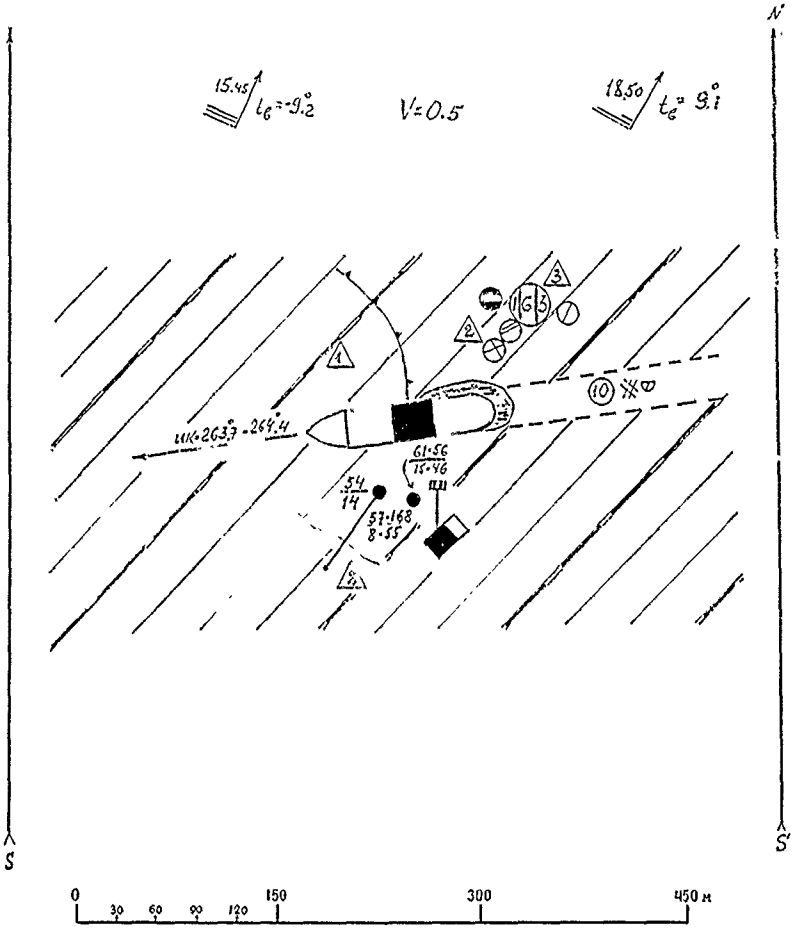


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 120 дата: 20 октября 1989

координаты начала	координаты конца
φ = 63° 50.5 S	φ = 63° 49.8 S
λ = 05° 27.1 W	λ = 05° 26.3 W
время начала = 04^h20^m	время конца = 07^h56^m
GMT 04^h20^m	GMT 07^h56^m

Figure 116. 20 October, ice station 120.

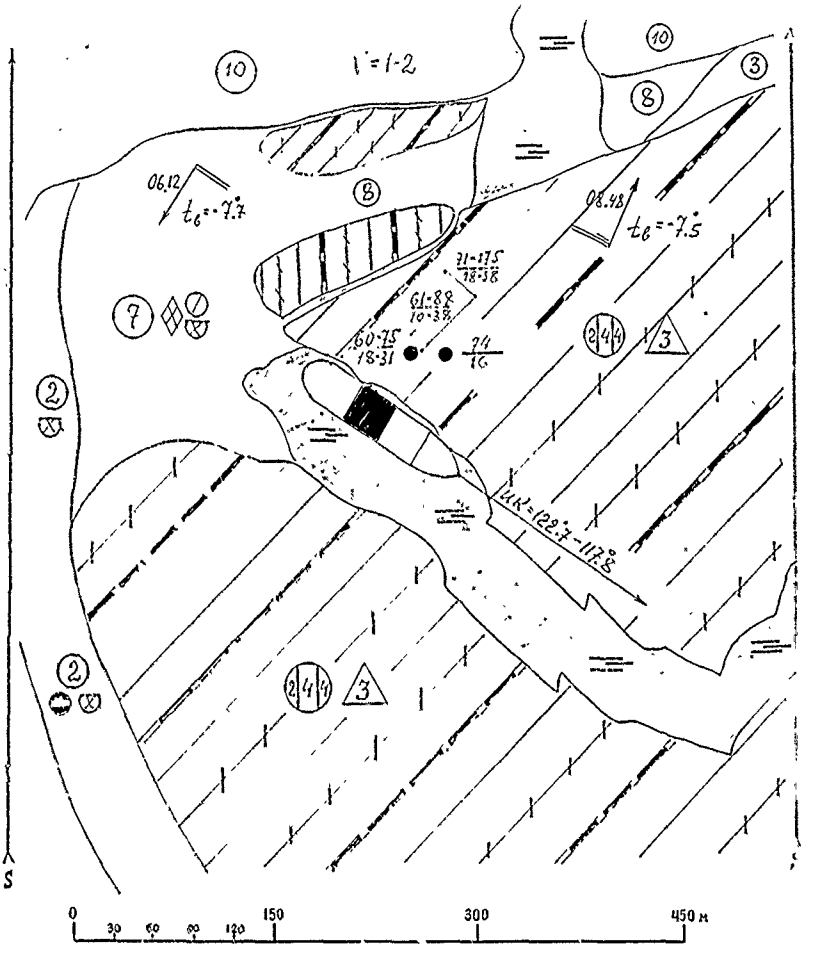


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 121 дата: 20 октября 1989

координатн начала	координатн конца
φ = 65° 02.1 s	φ = 62° 57.5 s
λ = 07° 02.1 w	λ = 06° 59.5 w
время начала = 16ʰ00ᵐ	время конца = 18ʰ50ᵐ
GMT 16ʰ00ᵐ	GMT 18ʰ50ᵐ

Figure 117. 20 October, ice station 121.

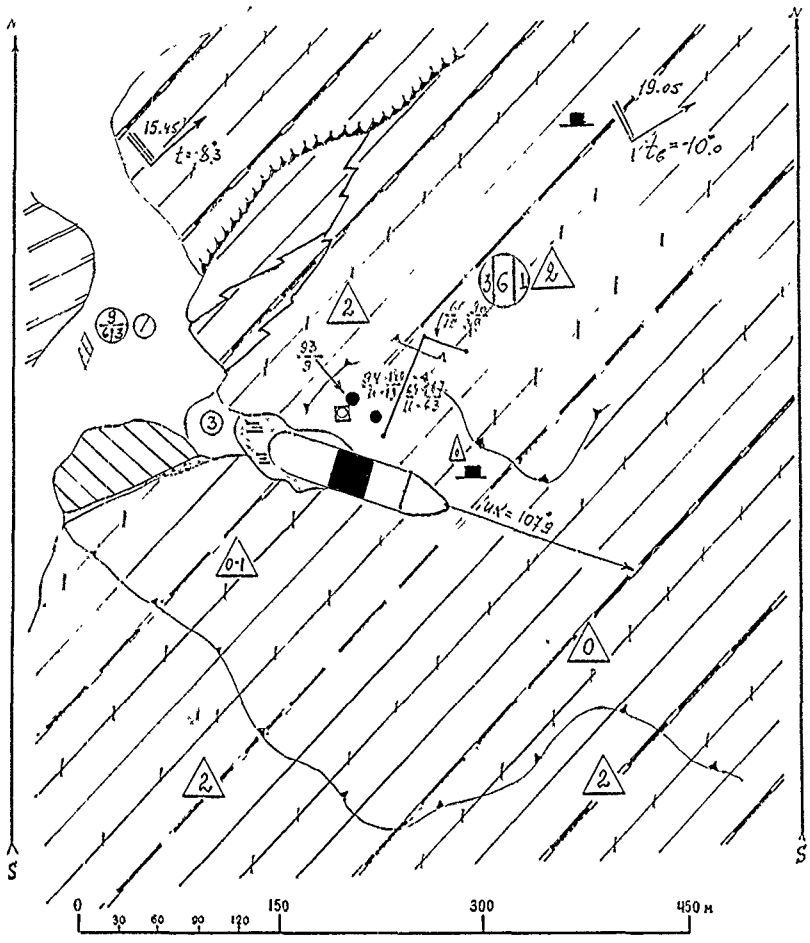


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 122 дата: 21 октября 1989

координаты начала	координаты конца
φ = 62° 19.1' s	φ = 62° 18.5' s
λ = 08° 27.8' w	λ = 08° 30.0' w
время начала = 06ʰ12ᵐ	время конца = 08ʰ48ᵐ
смг 06ʰ12ᵐ	смг 08ʰ48ᵐ

Figure 118. 21 October, ice station 122.

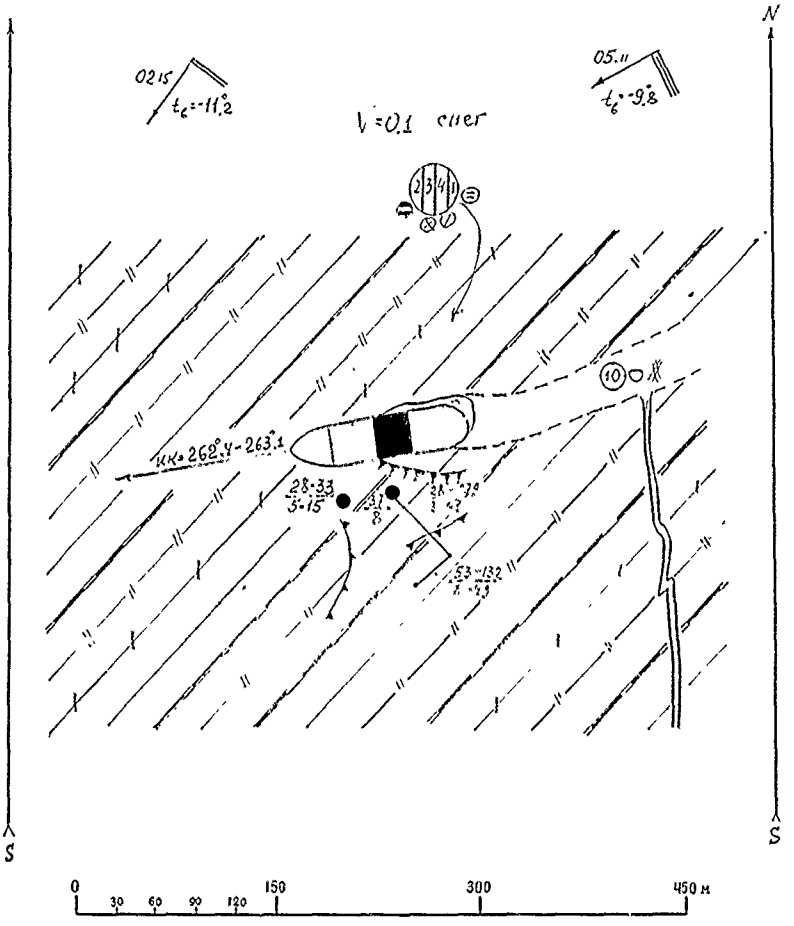


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 123 дата: 21 октября 1989

координаты начала	координаты конца
φ = 61° 37.1 s	φ = 61° 35.1 s
λ = 10° 00.8 w	λ = 09° 58.1 s w
время начала = 15ʰ45ᵐ	время конца = 19ʰ05ᵐ
GMT 15ʰ45ᵐ	GMT 19ʰ05ᵐ

Figure 119. 21 October, ice station 123.

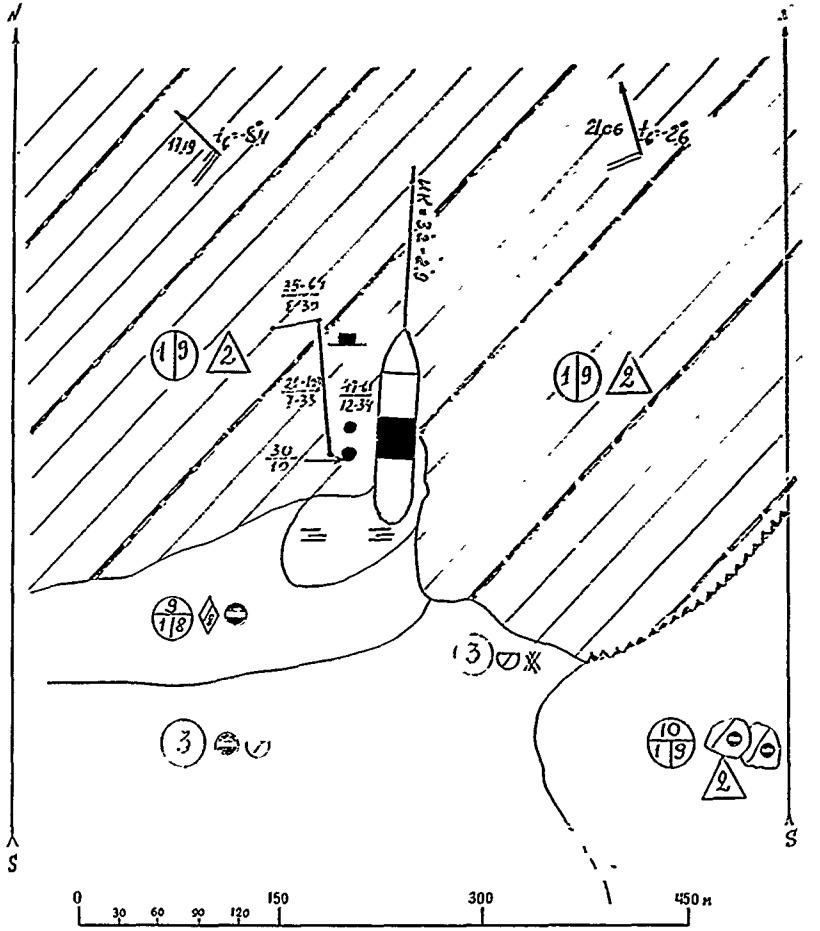


ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 124 дата: 22 октября 1989

координат начала	координат конца
φ = 60° 53.6 S	φ = 60° 55.0 S
λ = 11° 25.5 W	λ = 11° 27.1 W
время начала = 02^h15^m	время конца = 05^h39^m
GMT 02^h15^m	GMT 05^h39^m

Figure 120. 22 October, ice station 124.



ЛЕДОВАЯ ОБСТАНОВКА

Океанографическая станция № 125 дата: 22 октября 1989

координаты начала	координаты конца
$\varphi = 59^{\circ}51'.3\ s$	$\varphi = 59^{\circ}50'.0\ s$
$\lambda = 11^{\circ}55'.4\ w$	$\lambda = 11^{\circ}58'.6\ w$
время начала = $17^{h}10^{m}$	время конца = $21^{h}06^{m}$
СМГ $17^{h}10^{m}$	СМГ $21^{h}06^{m}$

Figure 121. 22 October, ice station 125.

УСЛОВНЫЕ ОБОЗНАЧЕНИЯ
DENOMINATIONS

РАЗНЫЕ ОБОЗНАЧЕНИЯ
SPECIFIC DENOMINATIONS

N	черно-белые BLACK-WHITE	цветные COLOUR	ХАРАКТЕРИСТИКА CHARACTERISTIC
N	1	2	3
1			НЭС „Ак.Федоров" ледовый дрейф в начале океанографической станции 412 и в конце 414 R/V „Ak.Fedorov" keeping at the beginning of station 412 at end 414
2			Канал во льду, проложенный судном Canal in the ice, made by the ship
3			ULTRASONIC ANEMOMETER THERMOMETER (KAIJO DENKI FRG) Акустический измеритель пульсаций скорости ветра и температуры (ФРГ)
4			ARGOS BUOY (FRG) Место установки Аргос-буй (ФРГ)
5			RADIATION MEASUREMENTS (FRG) Место измерения суммарного радиационного баланса (ФРГ)
6			Thickness profile (USA) Профиль толщины ледяного и снежного покрова (США)
7			Ice core site (USA) Место отбора кернов для исследования свойств льда (США)

N	1	2	3
8			Место отбора кернов для свойств льда (СССР) Ice core site (USSR)
9			Optical site (USA) Место проведения оптических измерений (США)
10			Термоградиентная установка (GRADIENT TOWER (USSR
11			Датчик деформации ледяного (СССР) Ice DEFORMATION MEASURE (USSR)
12			Походный альбедометр (С Albedo measurements (U
13			Место взятия проб льда для ... вания стратификации t° и S ... го покрова 13-15 октября Investigation of t° and S profiles in the ice 13-15 (USSR)
14			Место взятия проб льда для ... ния суточного хода t° и S ... льда 10-11 октября (СССР) Investigation of t° and S in the ice 10-11 october (U
15			Место для определения с... ледяного покрова с верхне... ти (СССР) Ice melting investigation

ЛЕДОВАЯ ОБСТАНОВКА

Ice station Океанографическая станция № 14-15 Date дата. 19 сентября 1989

координаты начала — Beginning location: φ = 61° 20'0 S, λ = 52° 51 0 W

координаты конца — Ending location: φ = 61° 19 5 S, λ = 52° 49 8 W

Beginning time время начала = 15ч30м UT 14ч30м

время конца = 19ч30м UT 20ч30м Ending time

Legend for ice station maps.

УСЛОВНЫЕ ОБОЗНАЧЕНИЯ
DENOMINATIONS

РАЗНЫЕ ОБОЗНАЧЕНИЯ
SPECIFIC DENOMINATIONS

...ТИЕ ...OUR	ХАРАКТЕРИСТИКА CHARACTERISTIC
2	3
	НЭС „Ак.Федоров" начало дрейфа в начале океанографической станции №2 и в конце №14 R/V „Ak.Fedorov" leaping at the beginning of station №2 at end №14
	Канал во льду, проложенный судном Canal in the ice, made by the ship
	UCTRASONIC ANEMOMETER THERMOMETER (KAIJO DENKI FRG) Акустический измеритель пульсаций скорости ветра и температуры (ФРГ)
	ARGOS BUOY (FRG) Место установки Аргос-буй (ФРГ)
	RADIATION MEASUREMENTS (FRG) Место измерения суммарного радиационного баланса (ФРГ)
	Thickness profile (USA) Профиль толщины ледяного и снежного покрова (США)
	Ice core site (USA) Место отбора кернов для исследования свойств льда (США)

N	1	2	3
8			Место отбора кернов для исследования свойств льда (СССР) Ice core site (USSR)
9			Optical site (USA) Место проведения оптических наблюдений (США)
10			Термоградиентная установка (СССР) GRADIENT TOWER (USSR)
11			Датчик деформаций ледяного покрова (СССР) Ice DEFORMATION MEASUREMENTS (USSR)
12			Походный альбедометр (СССР) Albedo measurements (USSR)
13			Место взятия проб льда для исследования стратификации t° и S‰ ледяного покрова 13-16 октября (СССР) Investigation of t° and S‰ profiles in the ice 13-16 october (USSR)
14			Место взятия проб льда для исследования суточного хода t° и S‰ по толщине льда 10-11 октября (СССР) Investigation of t° and S‰ profiles in the ice 10-11 october (USSR)
15			Место для определения стаивания ледяного покрова с верхней поверхности (СССР) Ice melting investigation (USSR)

ЛЕДОВАЯ ОБСТАНОВКА

Ice station Океанографическая станция № 14-15 Date дата: 19 сентября 1989

Beginning location координаты начала: φ = 61° 20'0 S, λ = 32° 51'0 W

Ending location координаты конца: φ = 61° 45'5 S, λ = 32° 49.8 W

Beginning time время начала = 13h30m GMT 14h30m

Ending time время конца = 19h30m GMT 20h30m

Legend for ice station maps.

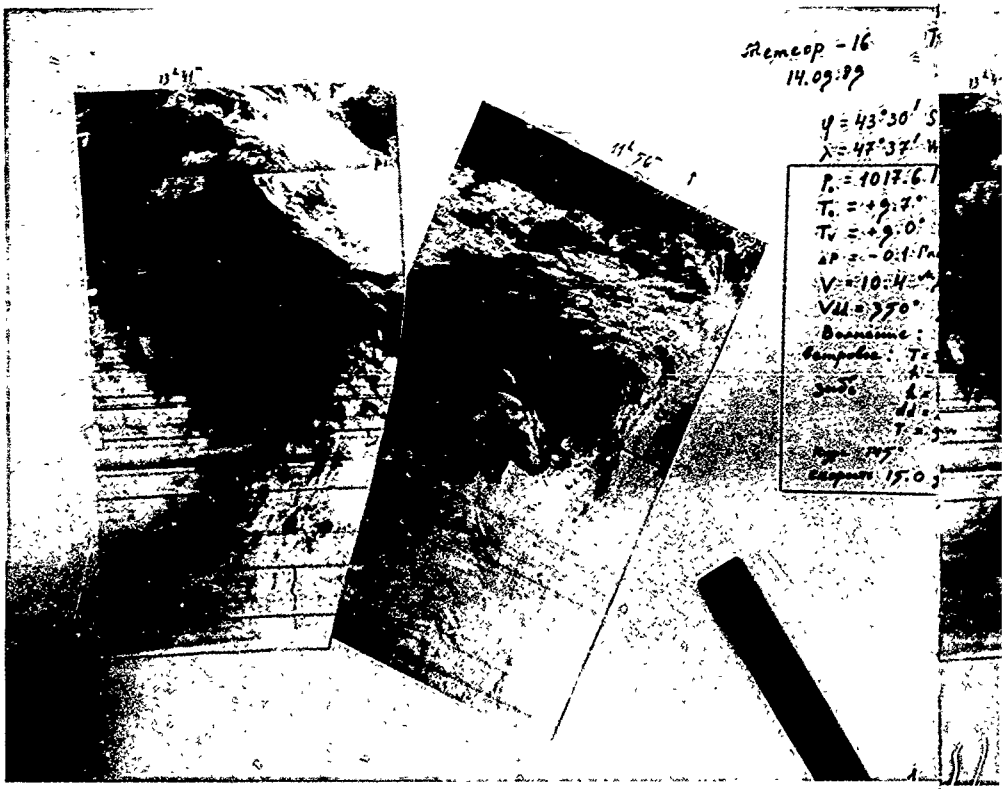


Figure 122. 14 September satellite photo, 43°31'S 47°37'W.

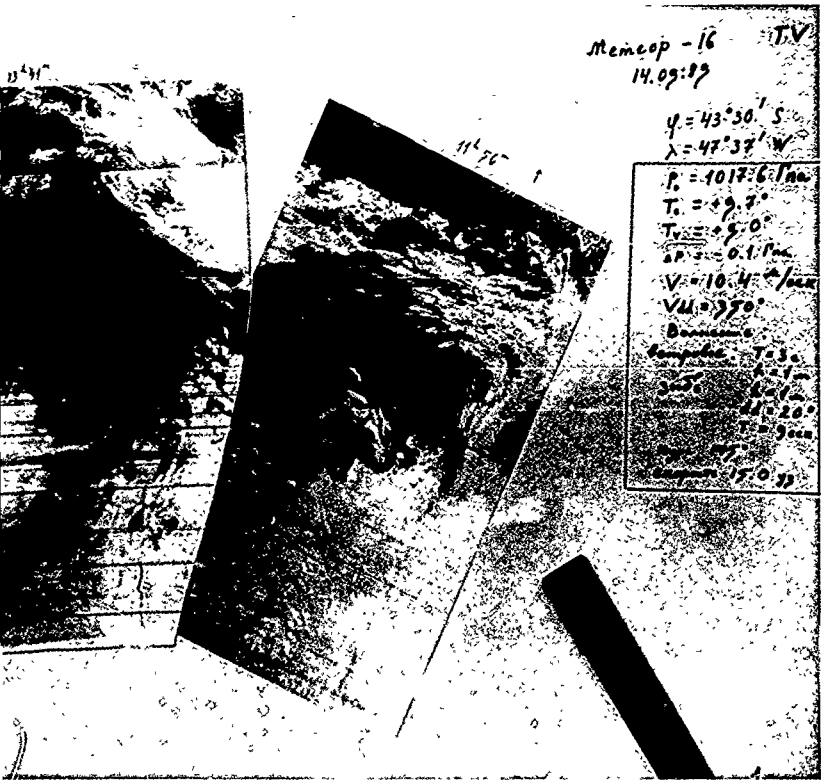


Figure 122. 14 September satellite photo, 43°31'S 47°37'W.

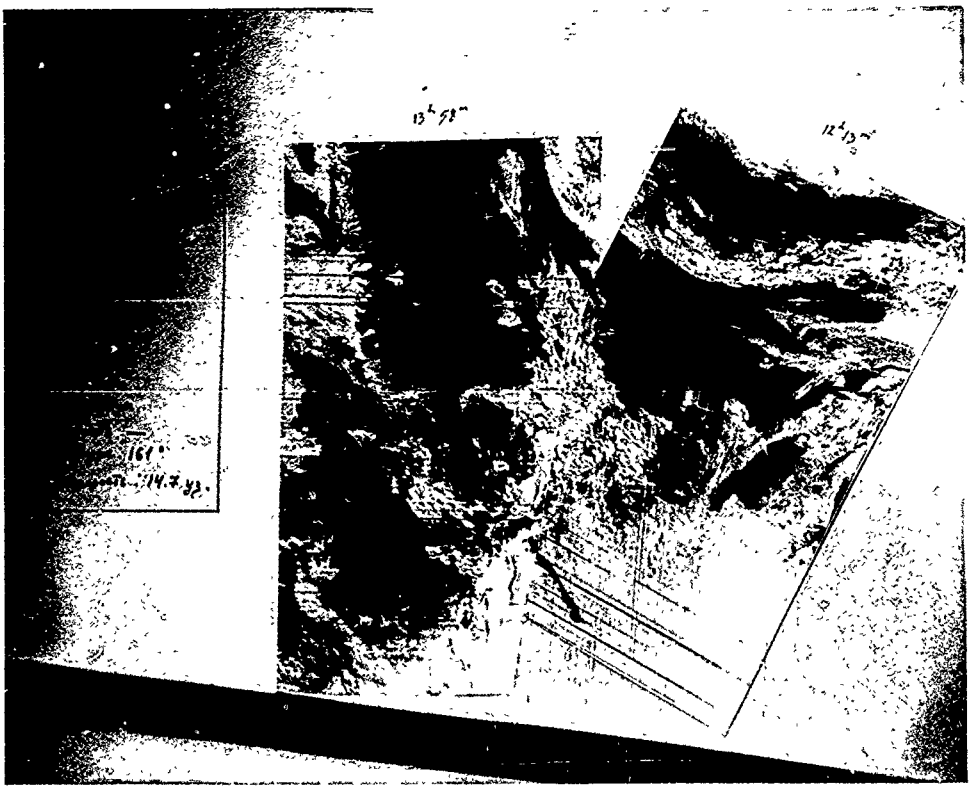


Figure 123. 15 September satellite photo, 48°30'S 42°59'W.

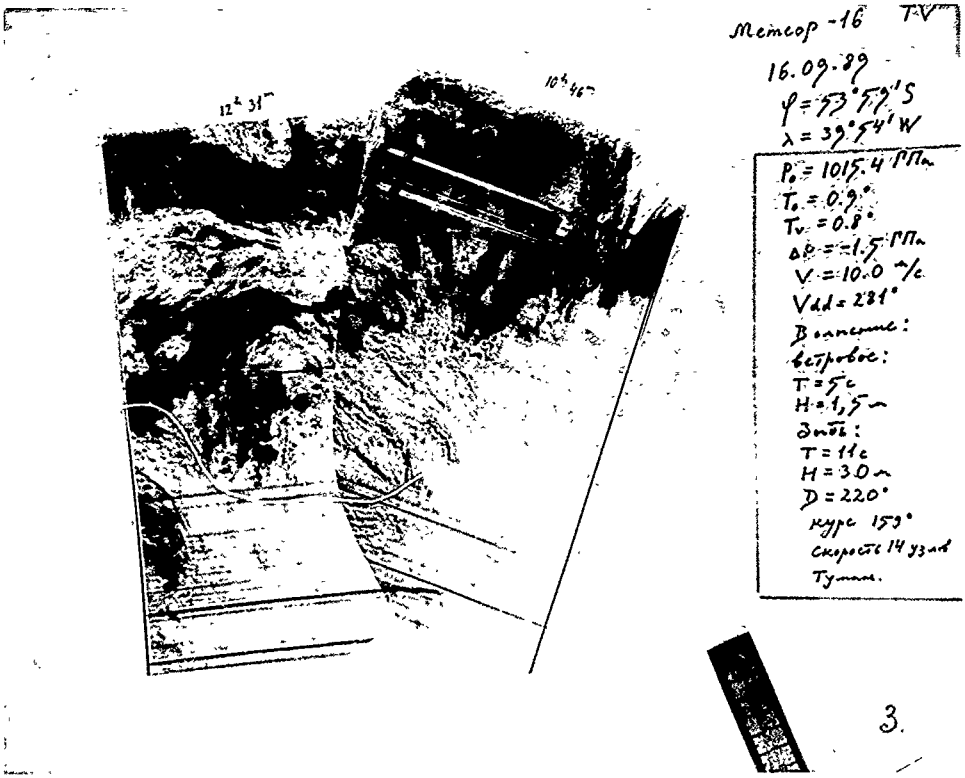


Figure 124. 16 September satellite photo, 53°59'S 39°54'W.

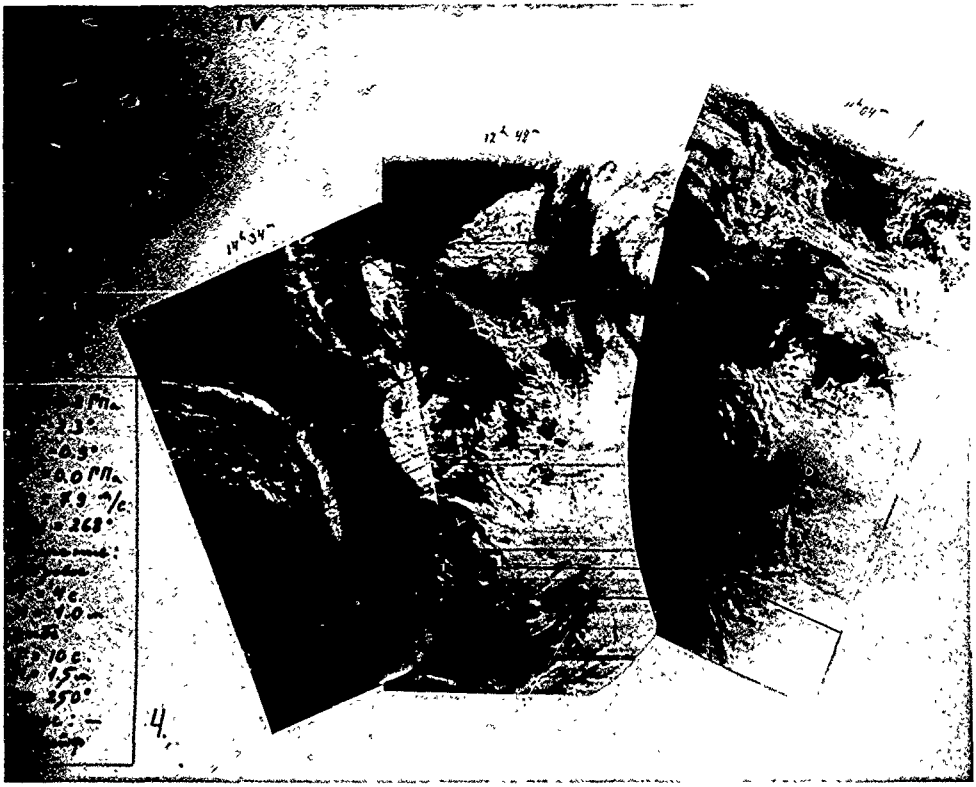


Figure 125. 17 September satellite photo, 57° 19'S 37° 24'W.

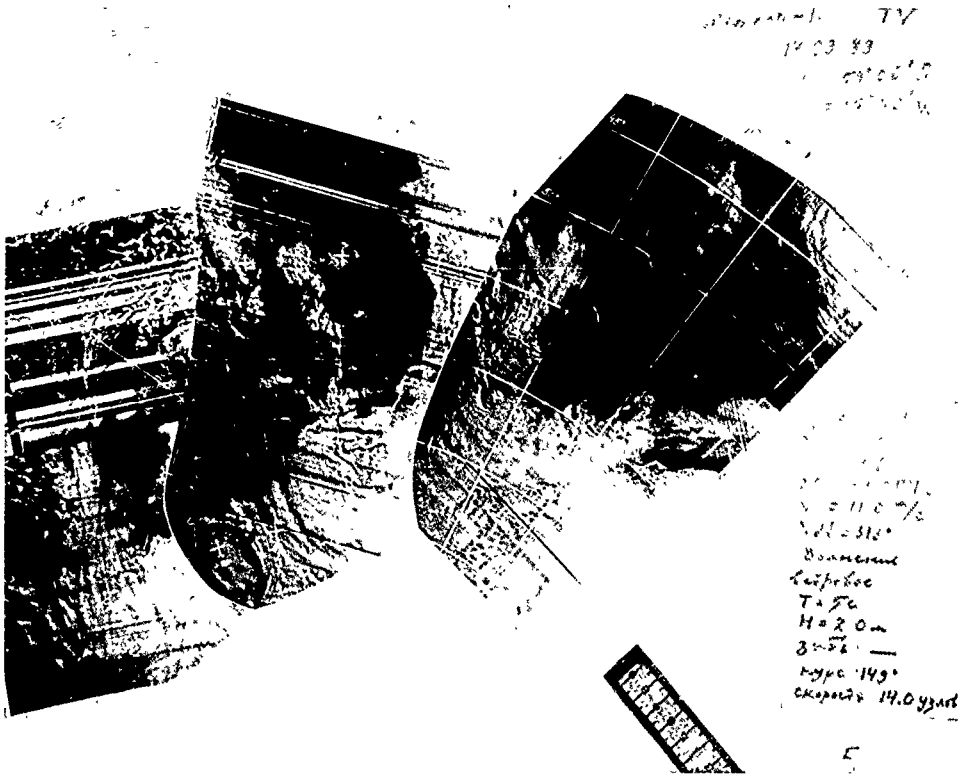


Figure 126. 18 September satellite photo, 59°06'S 35°52'W.

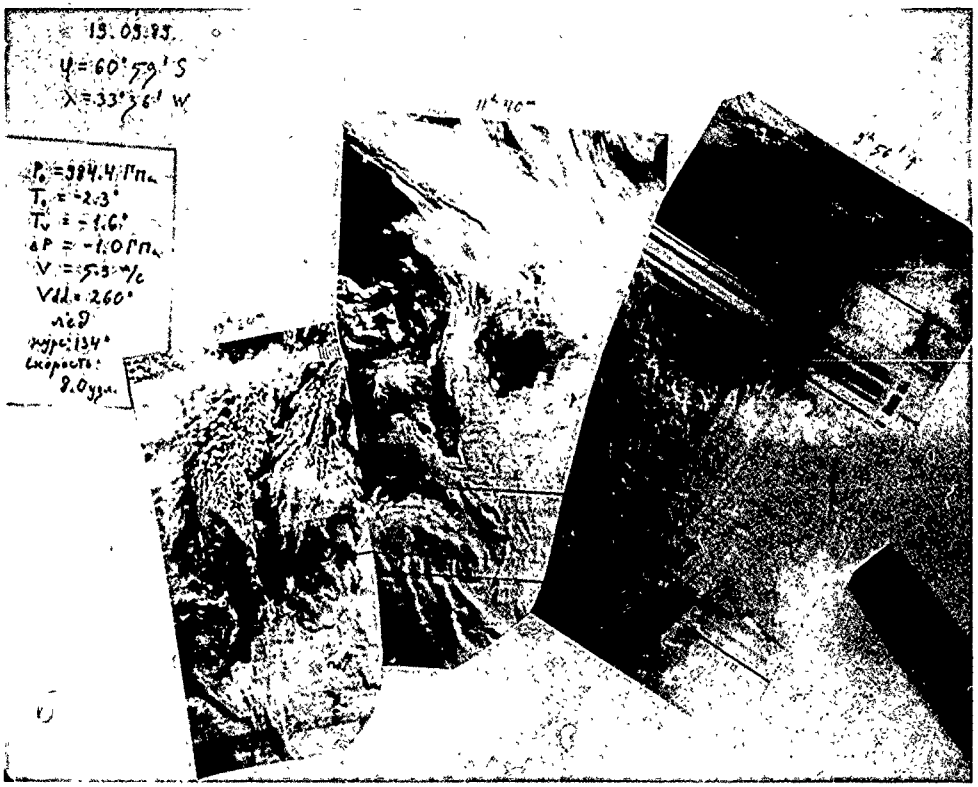


Figure 127. 19 September satellite photo, 60°59'S 33°36'W.

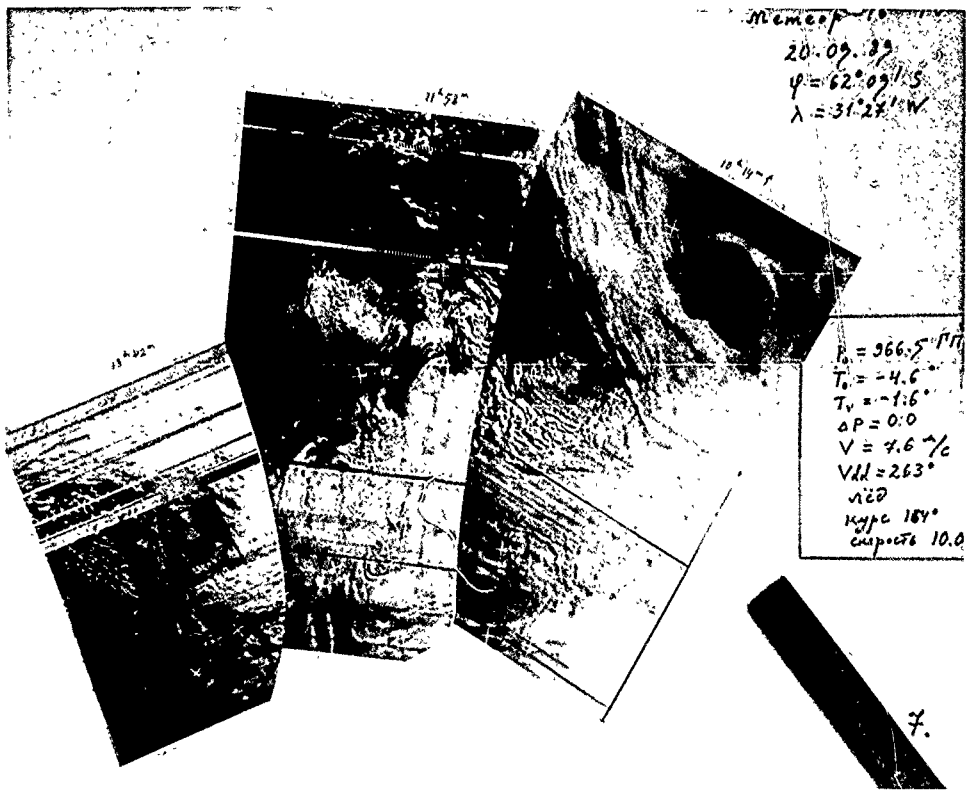


Figure 128. 20 September satellite photo, 62°09'S 31°27W.

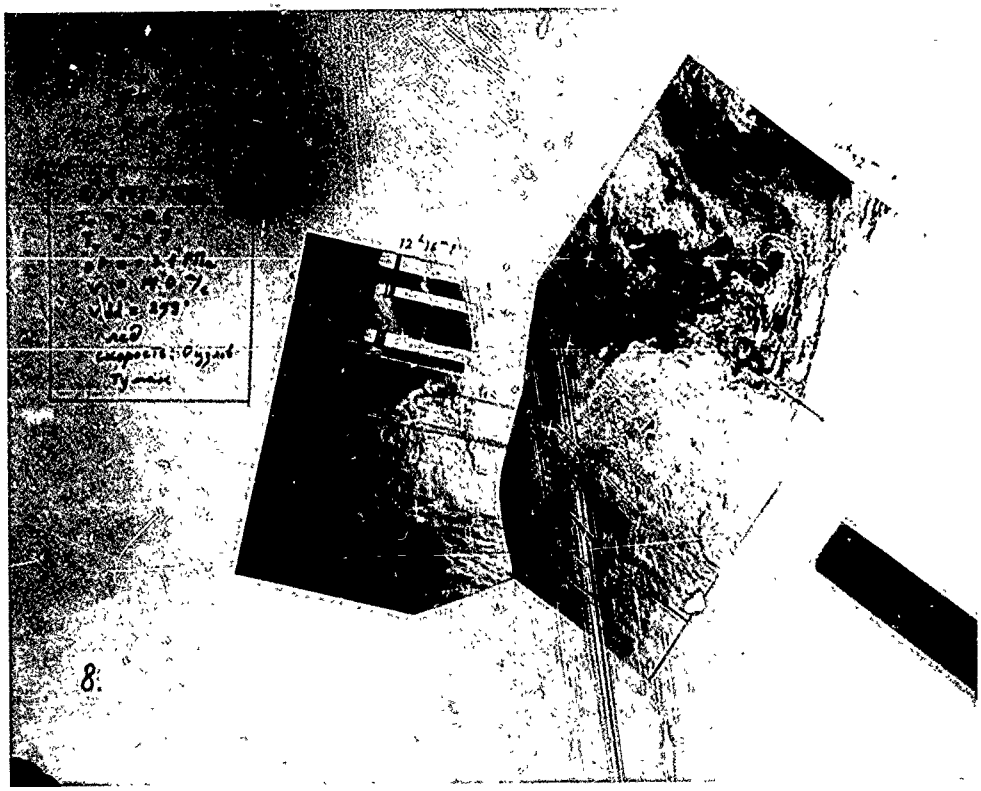


Figure 129. 21 September satellite photo, 63°36'S 28°40'W.

Figure 130. 22 September satellite photo, 65°09'S 25°51'W.

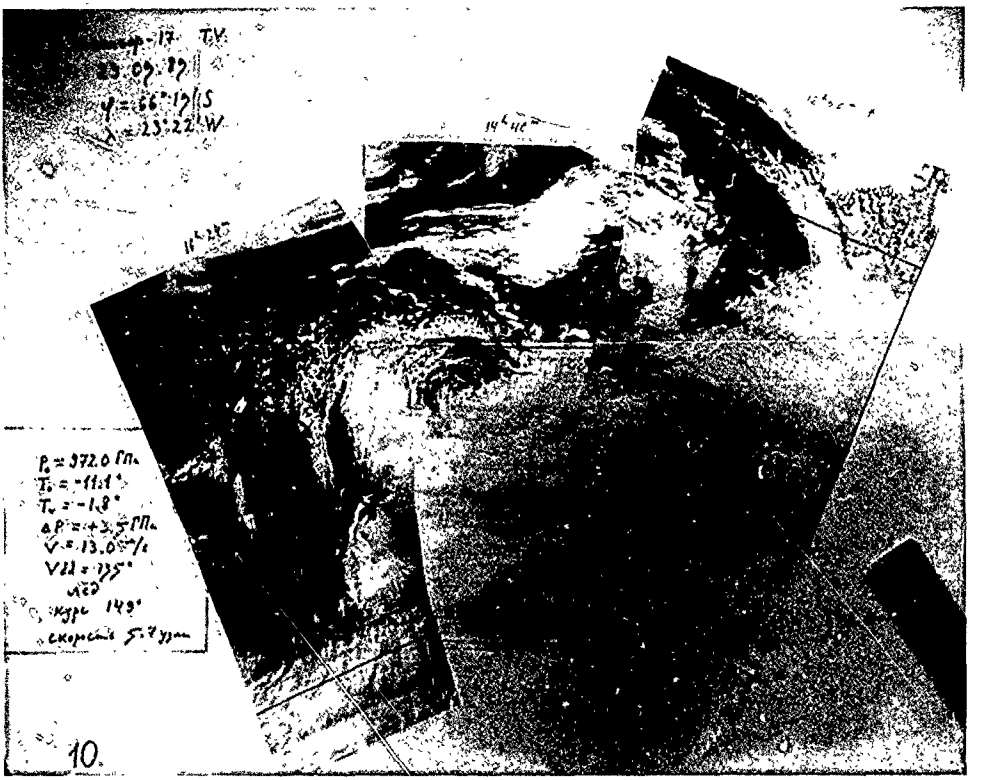


Figure 131. 23 September satellite photo, 66°19'S 23°22'W.

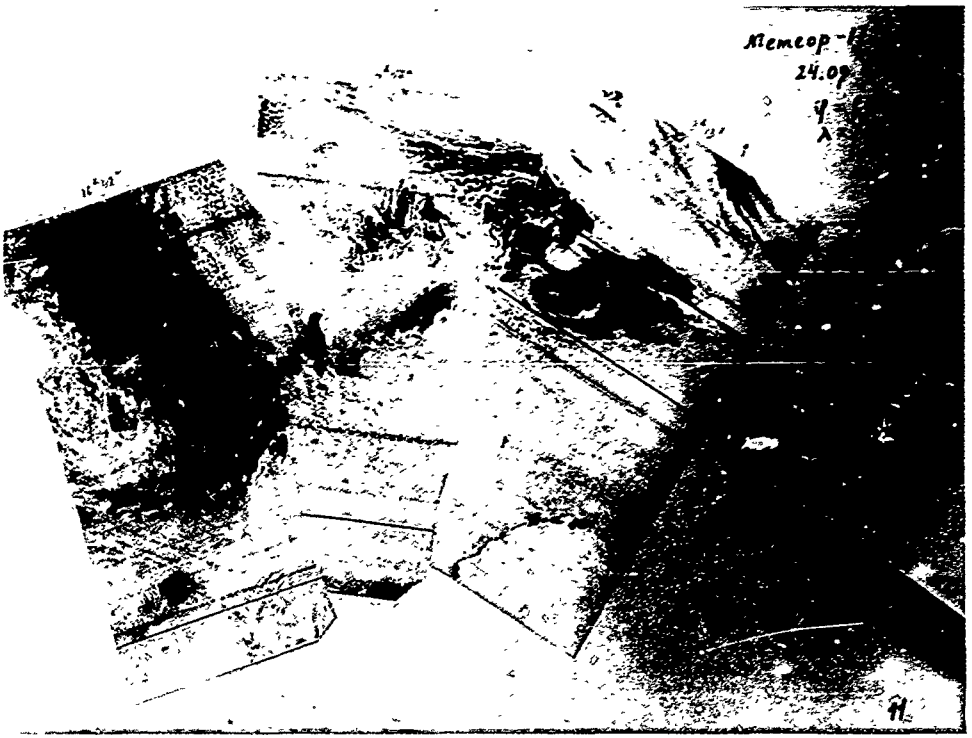


Figure 132. 24 September satellite photo, 67°22'S 21°19W.

Figure 133. 25 September satellite photo, 67°52'S 18°47'W.

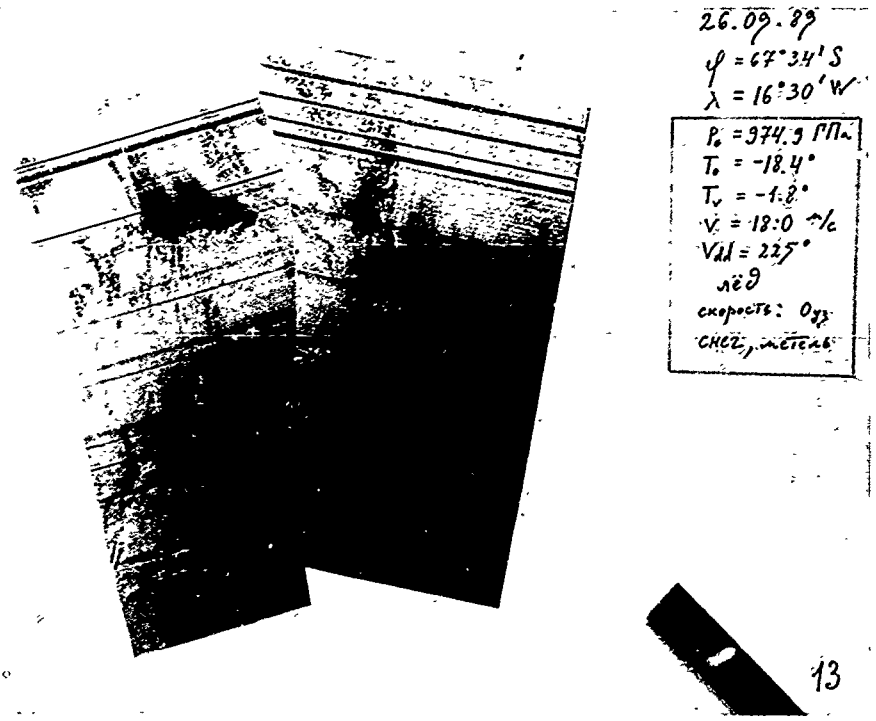


Figure 134. 26 September satellite photo, 67°34'S 16°30'W.

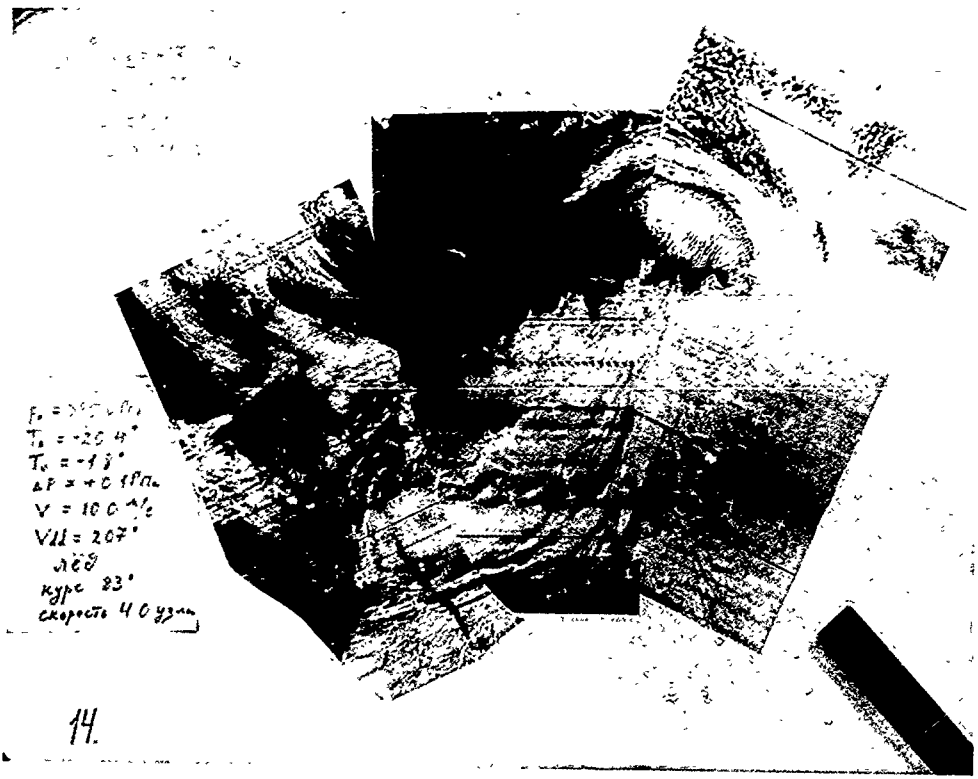


Figure 135. 27 September satellite photo, 67°30'S 13°51W.

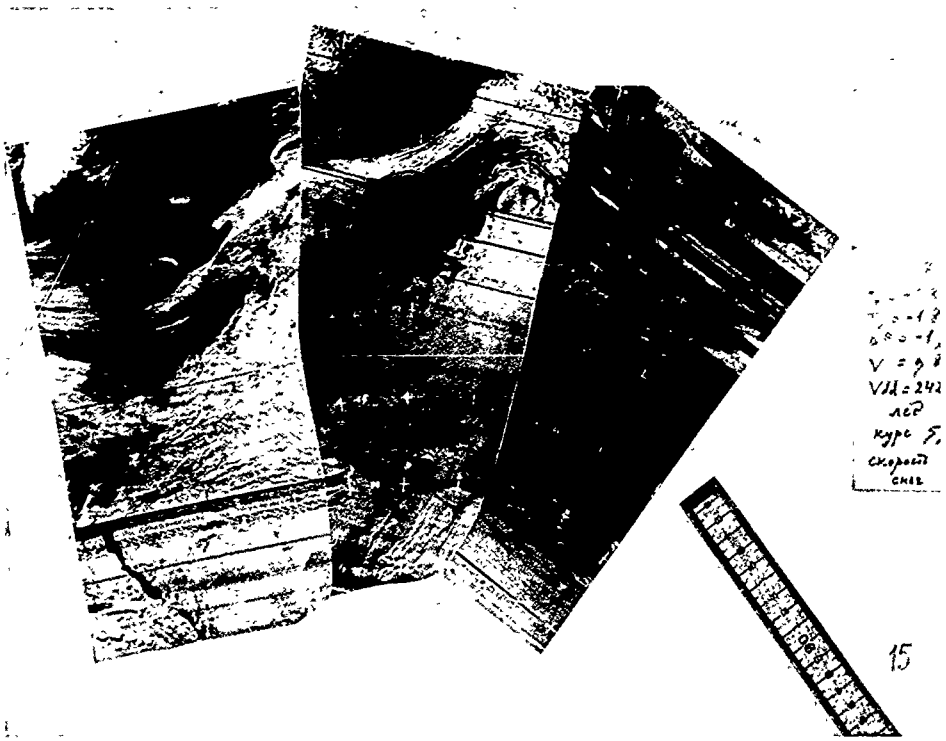


Figure 136. 28 September satellite photo, 66°52'S 10°40W.

Figure 137. 29 September satellite photo, 66°20'S 7°47'W.

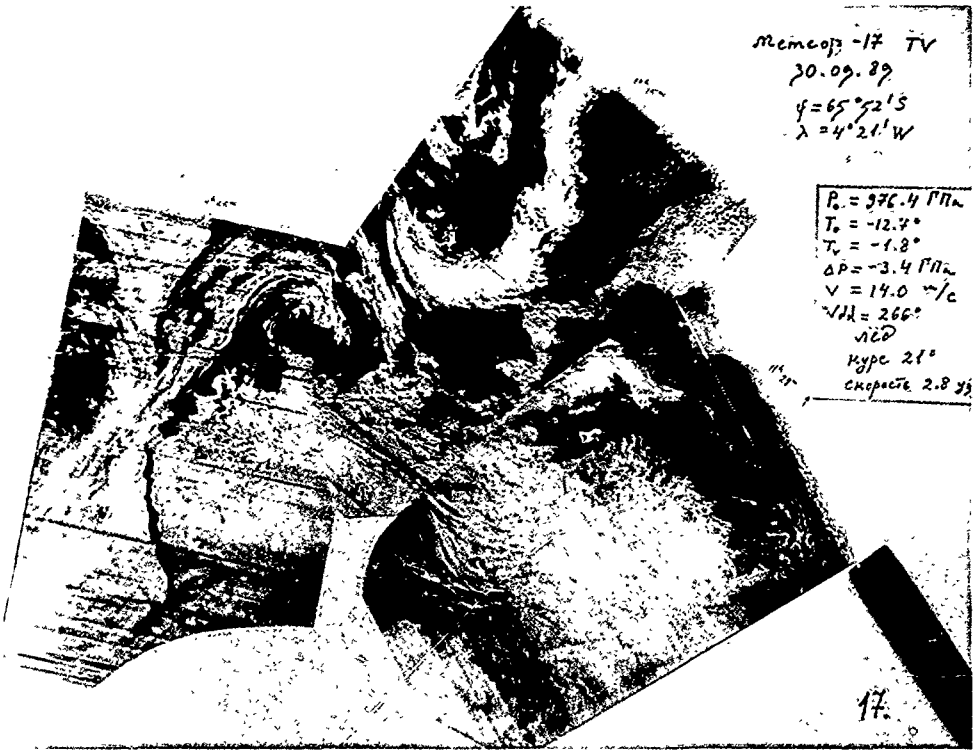


Figure 138. 30 September satellite photo, 65°52'S 4°21'W.

Figure 139. 1 October satellite photo, 65°21'S 0°58'W.

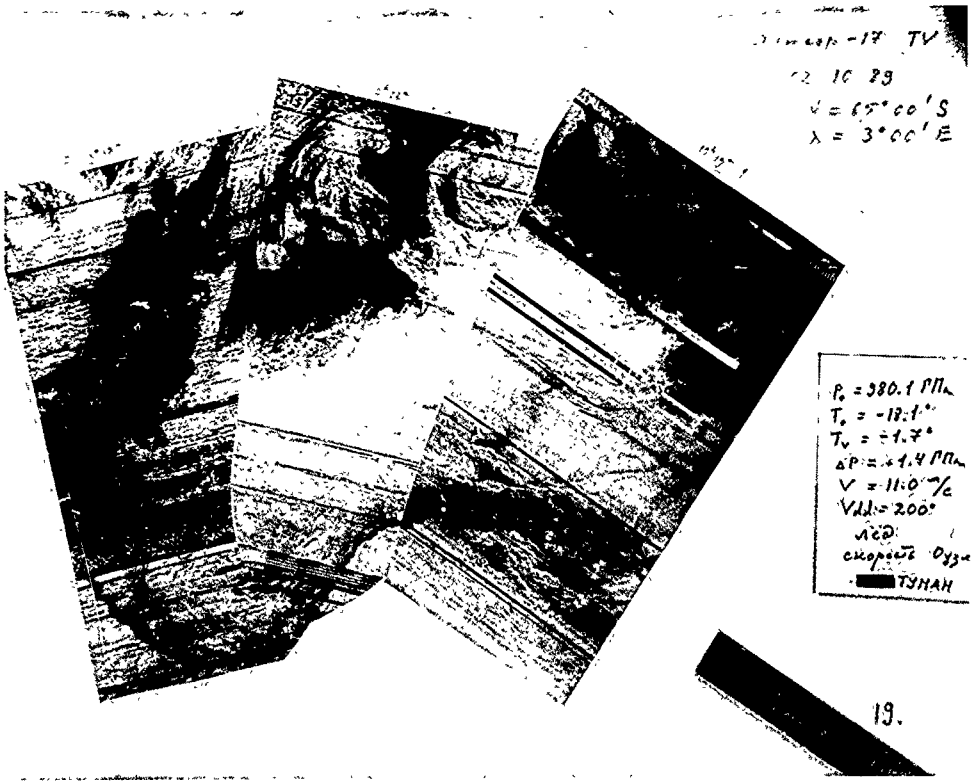


Figure 140. 2 October satellite photo, 65°00'S 3°00'E.

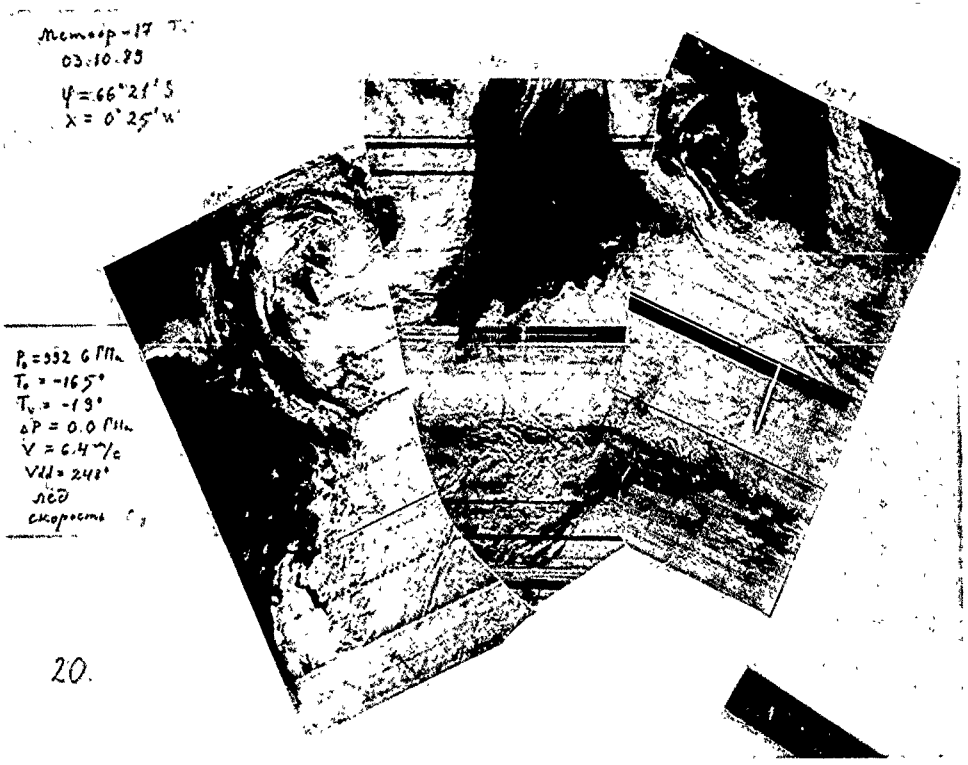


Figure 141. 3 October satellite photo, 66°21'S 0°25W.

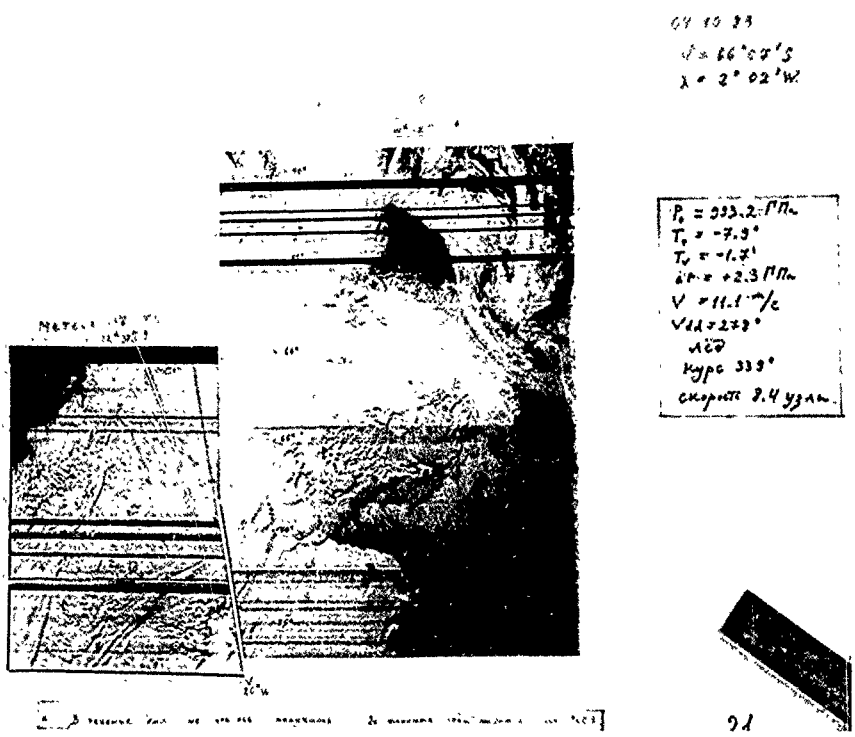


Figure 142. 4 October satellite photo, 66°07'S 2°02'W.

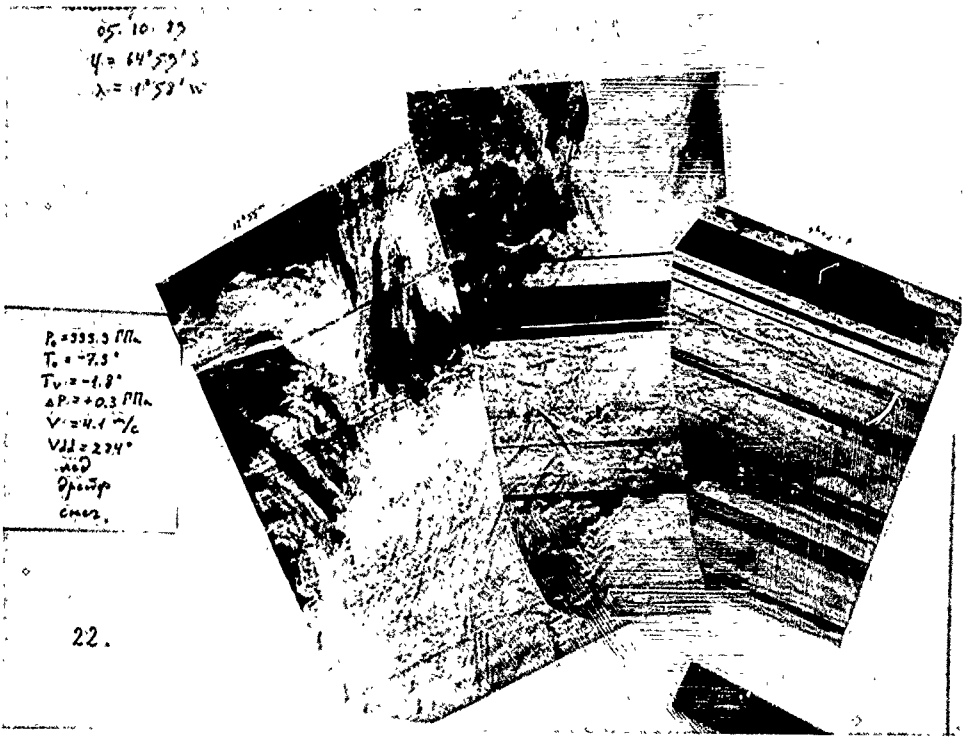


Figure 143. 5 October satellite photo, 64°59'S 1°58'W.

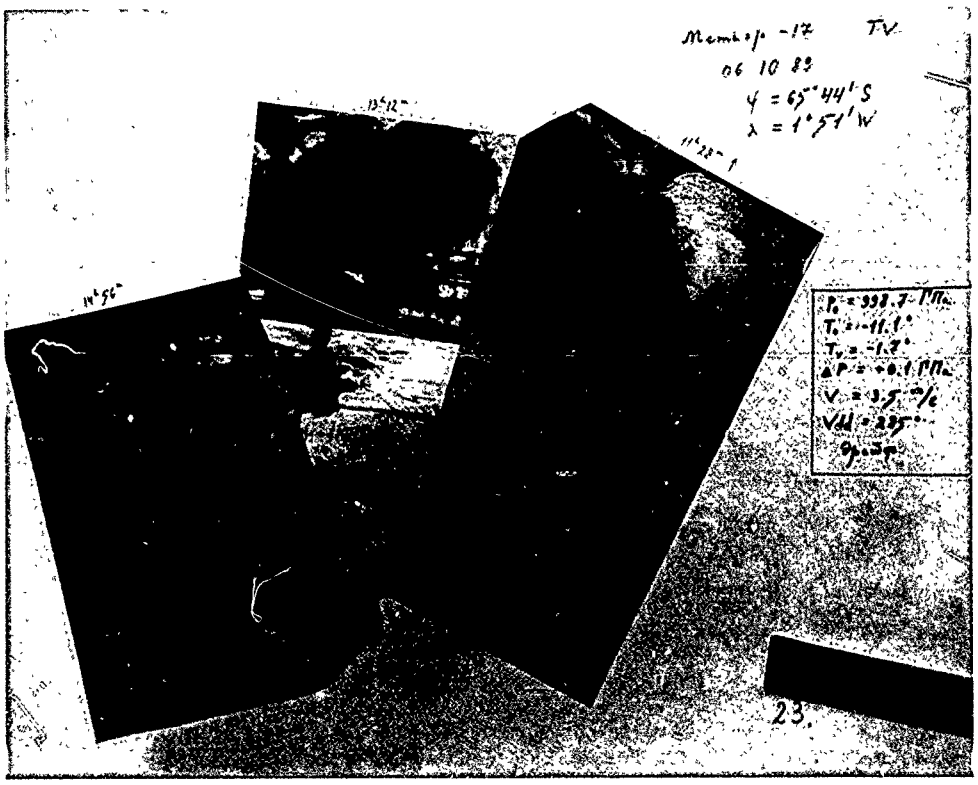


Figure 144. 6 October sateliite photo, 65°44'S 1°51'W.

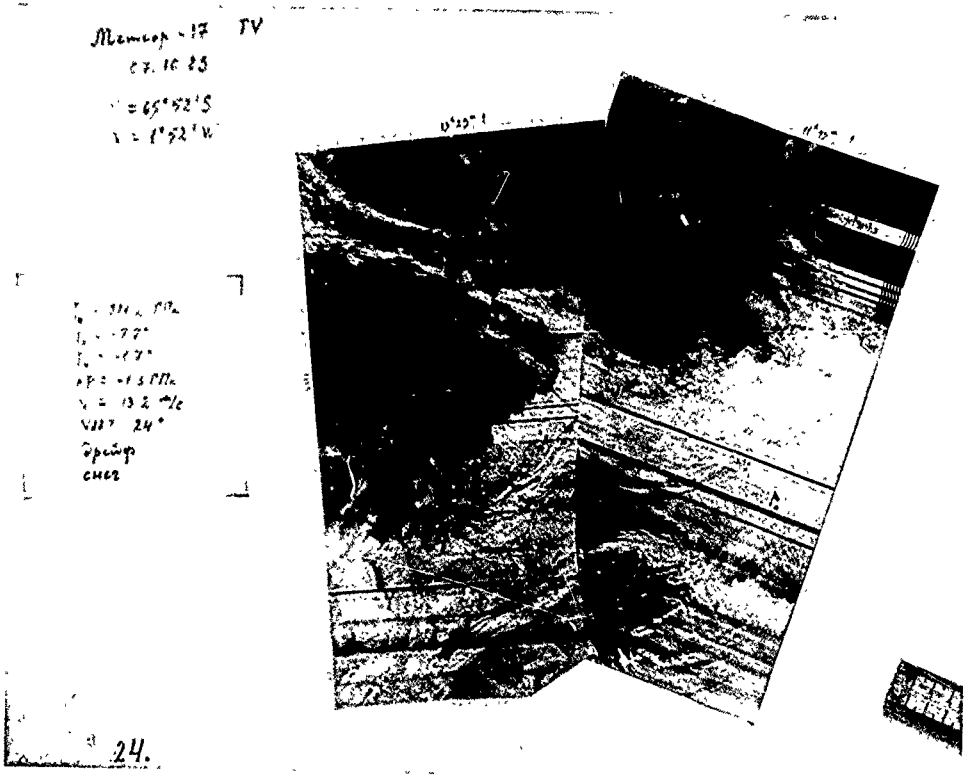


Figure 145. 7 October satellite photo, 65°52'S 1°52W.

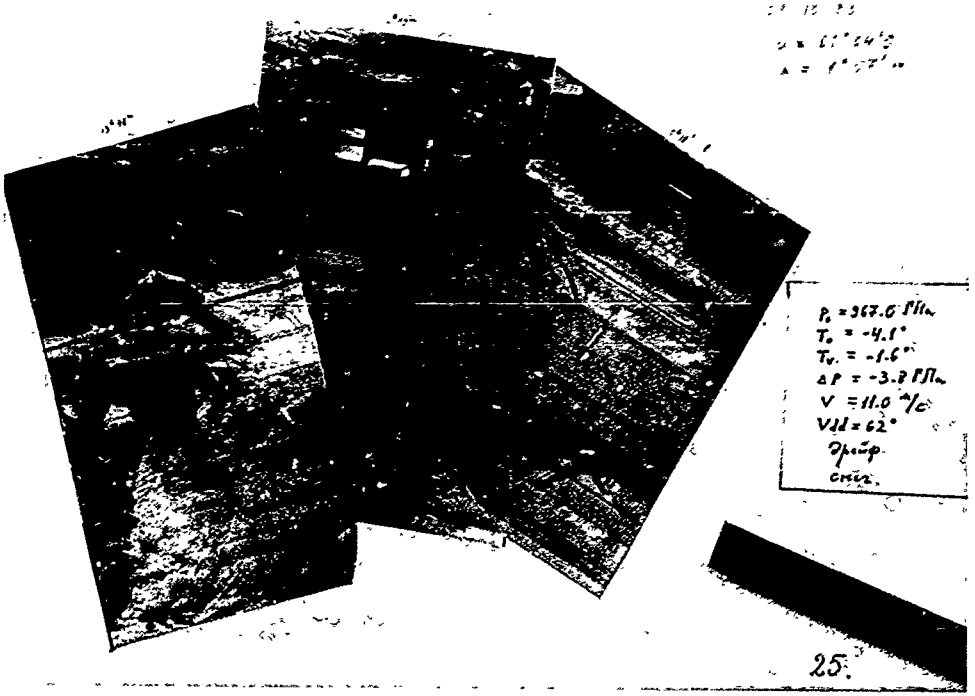


Figure 146. 8 October satellite photo, 66°04'S 1°57'W.

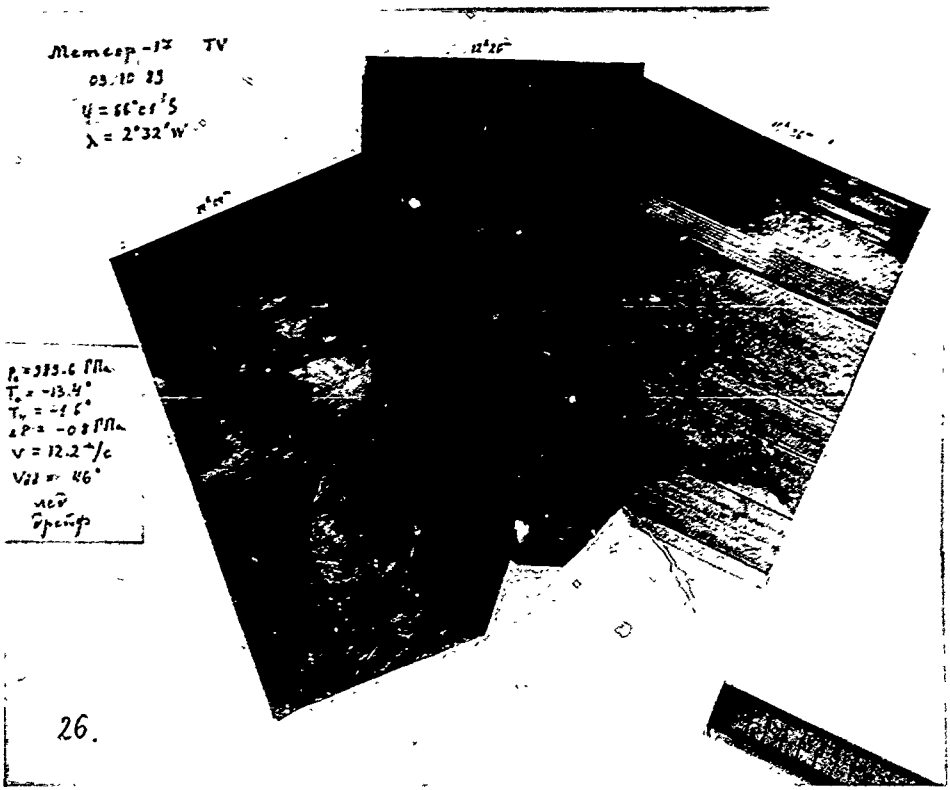


Figure 147. 9 October satellite photo, 66°01'S 2°32W.

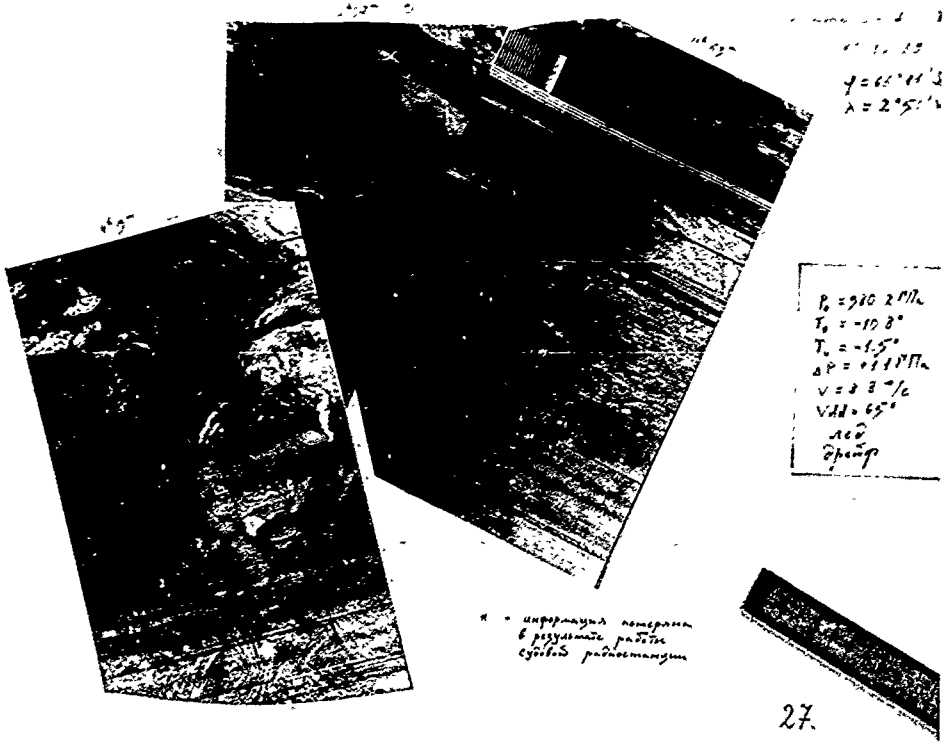


Figure 148. 10 October satellite photo, 66° 11'S 2°50W.

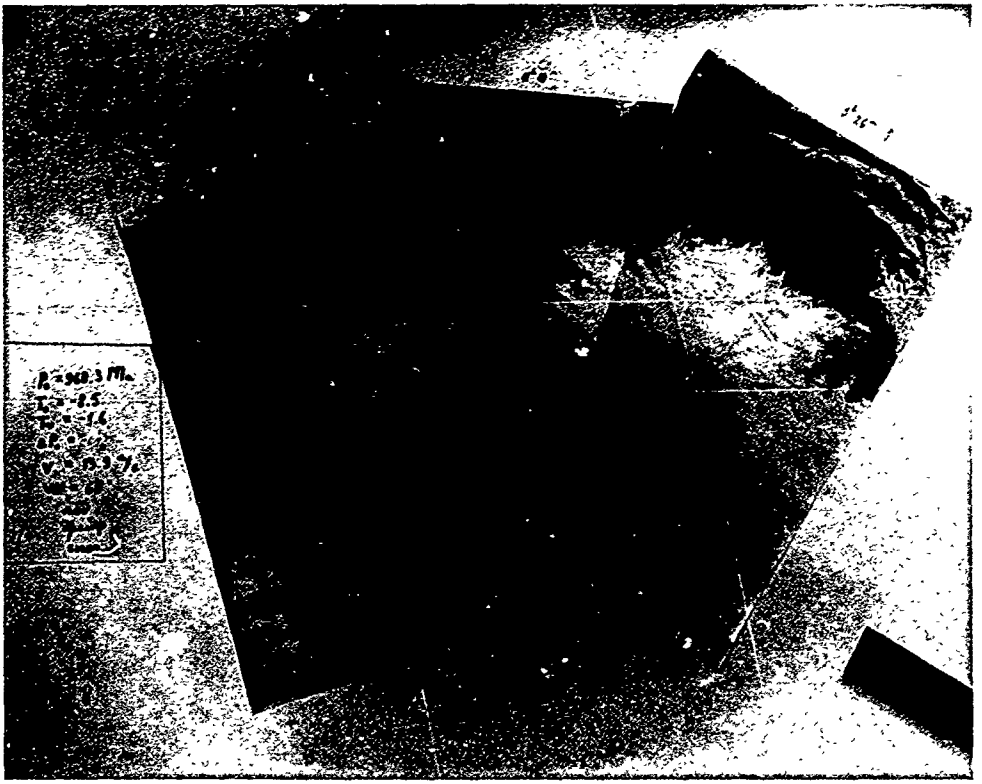


Figure 149. 11 October satellite photo, 66° 17'S 3° 05'W.

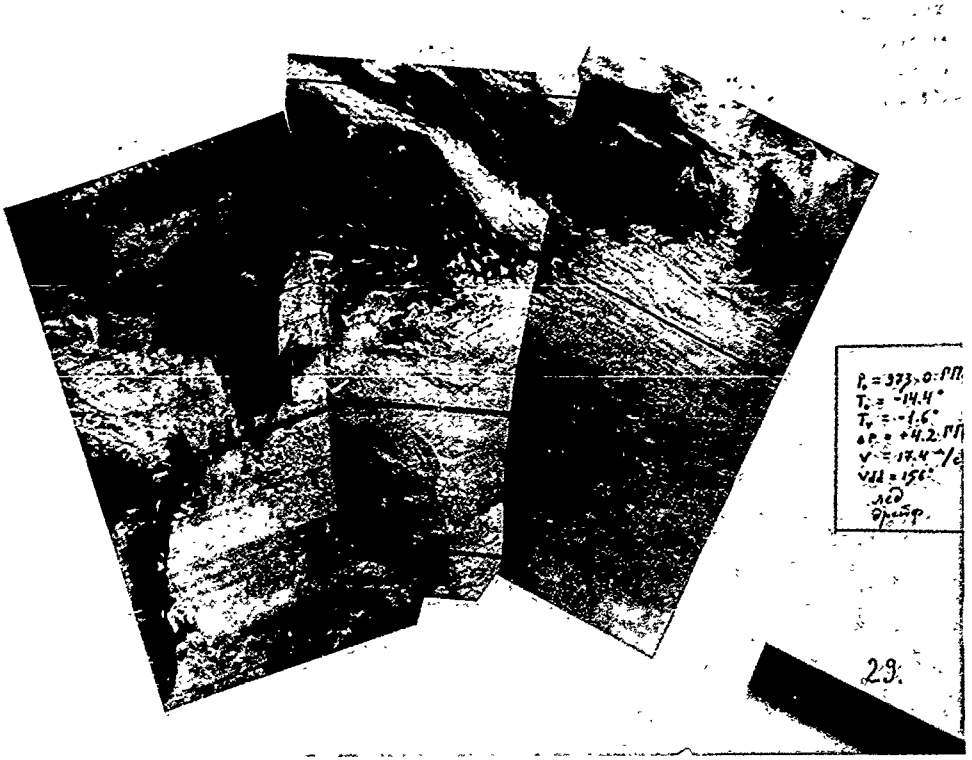


Figure 150. 12 October satellite photo, 66° 14'S 3° 57'W.

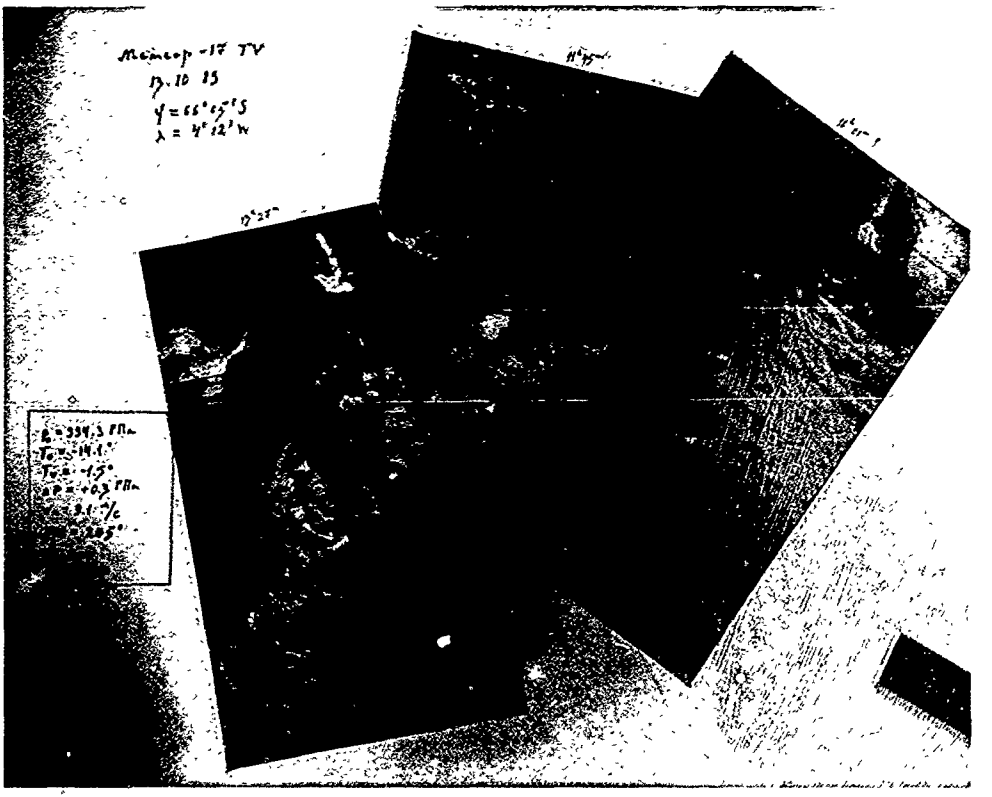


Figure 151. 13 October satellite photo, 66°05'S 4°12'W.

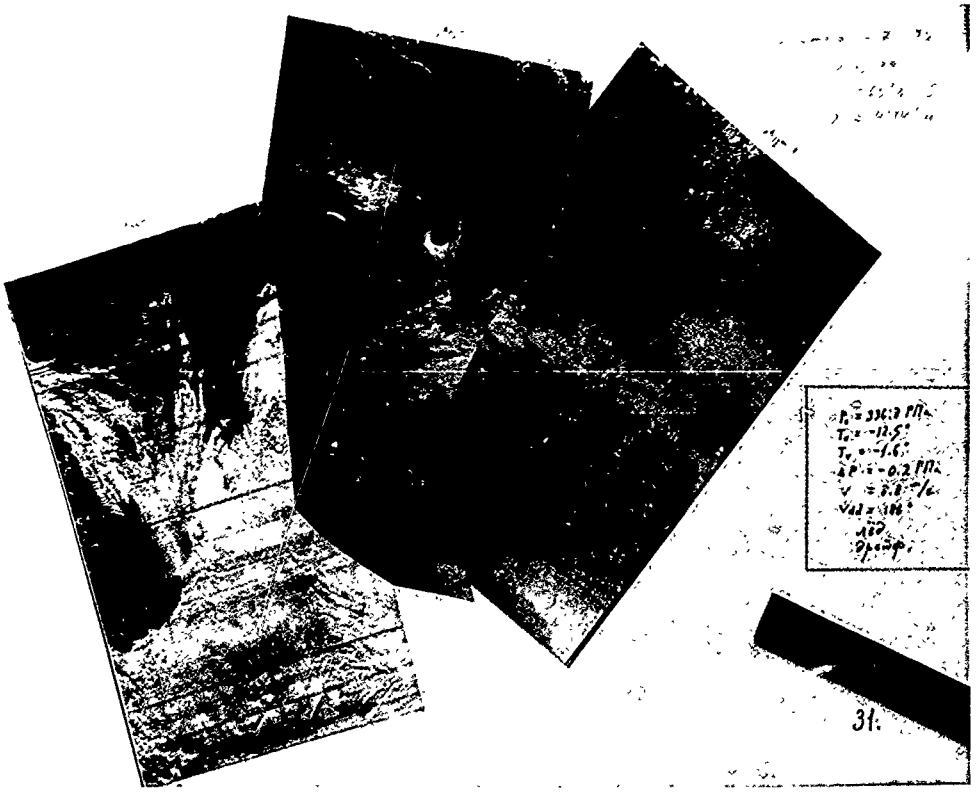


Figure 152. 14 October satellite photo, 65° 56'S 4° 14'W

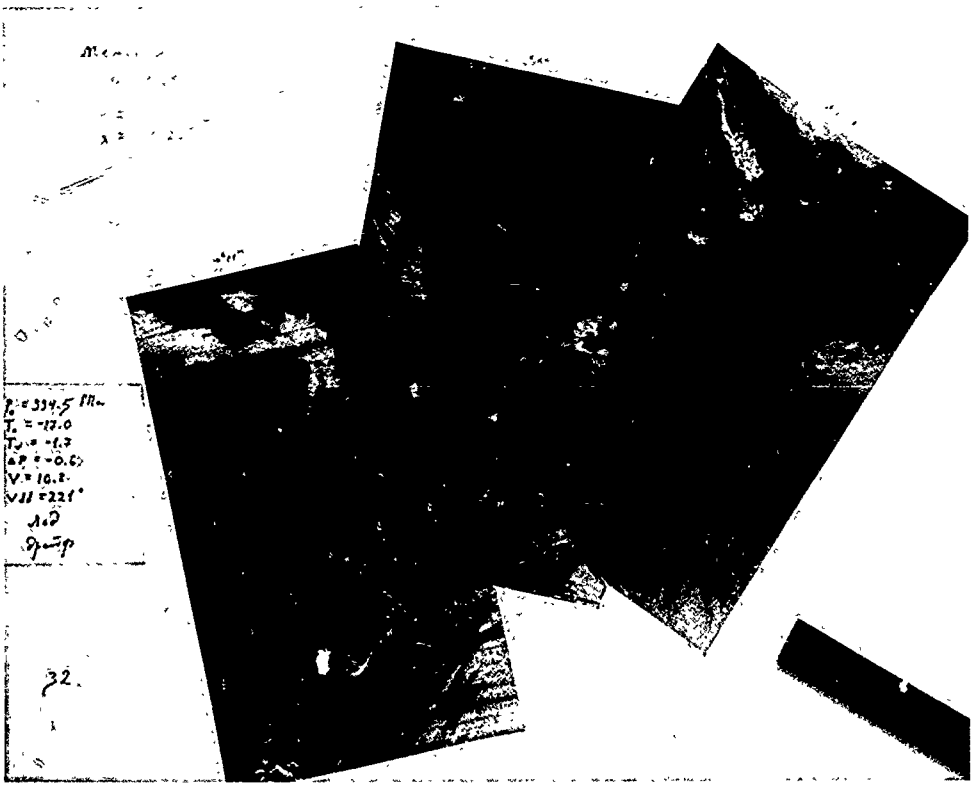


Figure 153. 15 October satellite photo, 65°48'S 4°20'W.

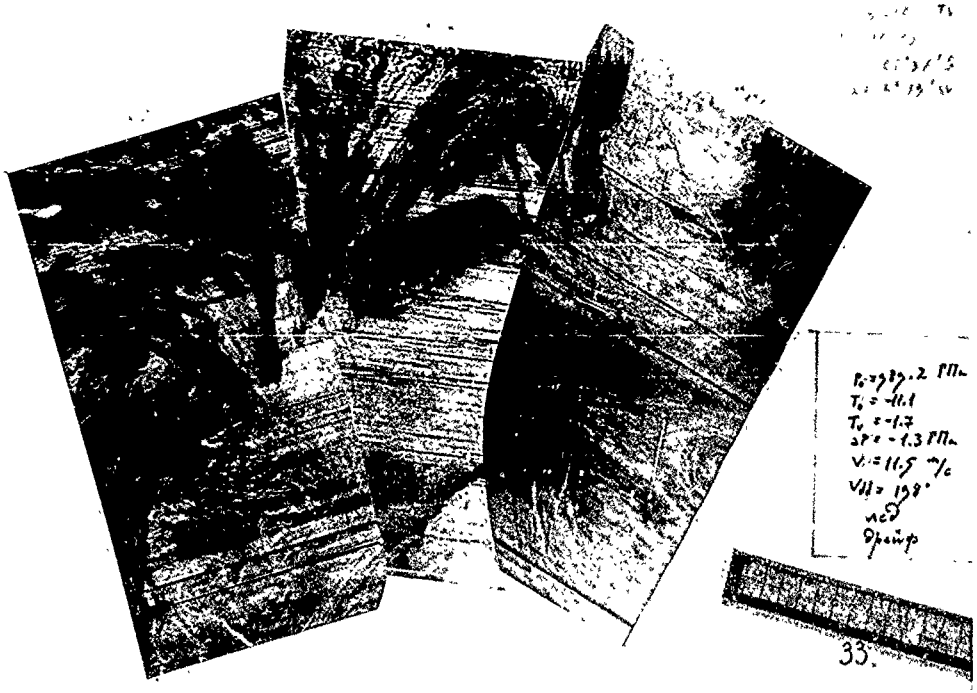


Figure 154 16 October satellite photo, 65°37'S 4°19W.

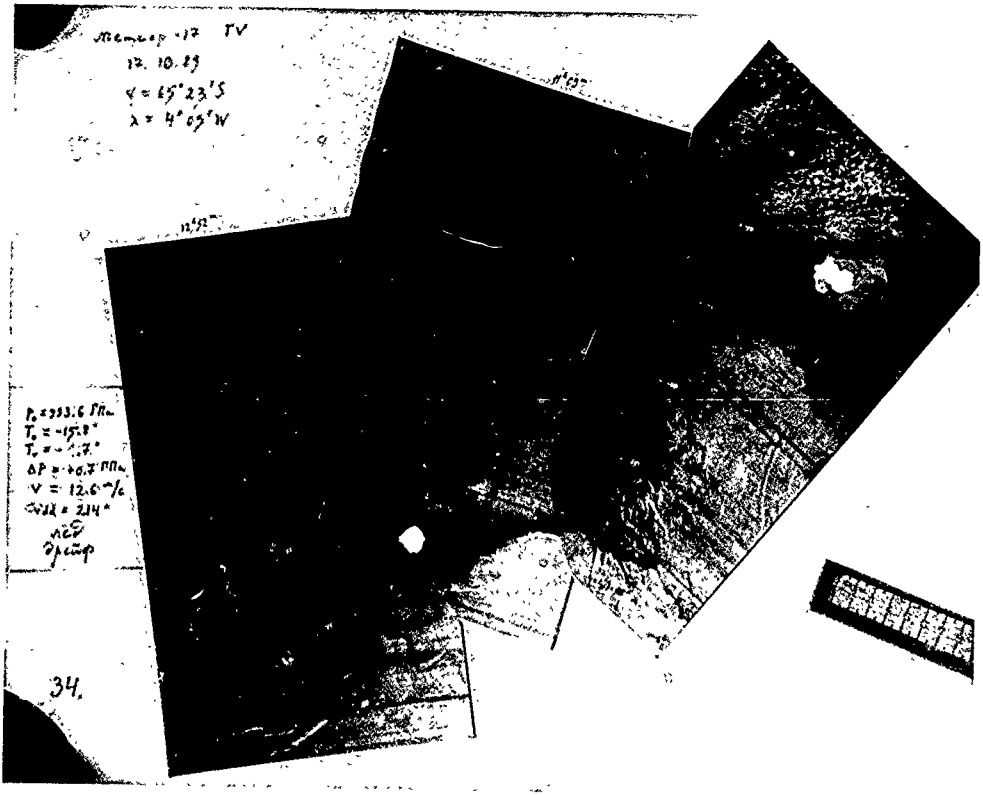


Figure 155. 17 October satellite photo, 65°23'S 4°09'W.

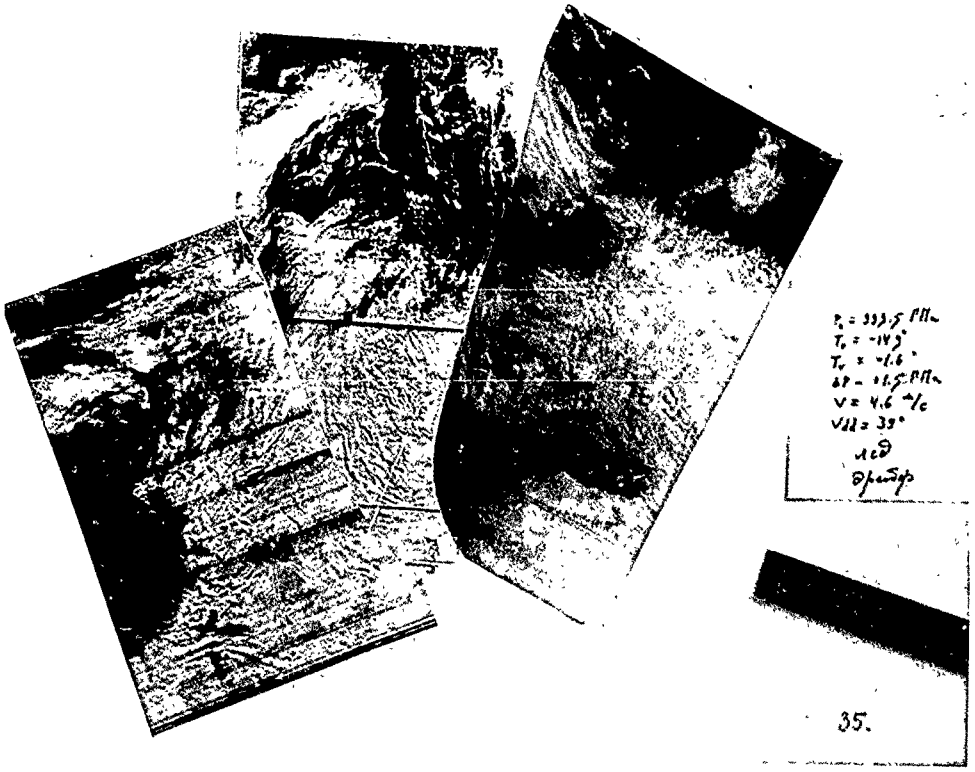


Figure 156. 18 October satellite photo, 65°22'S 4°07'W.

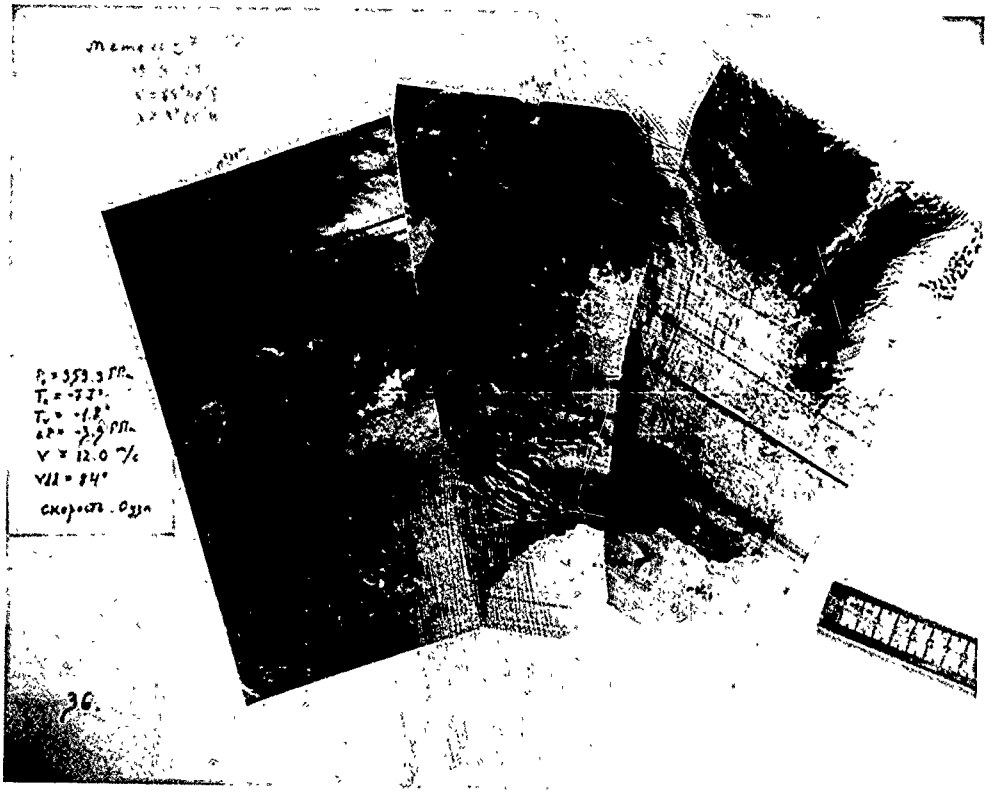


Figure 157. 19 October satellite photo, 64°48'S 3°00'W.

Figure 158. 20 October satellite photo, 63°49'S 5°28'W.

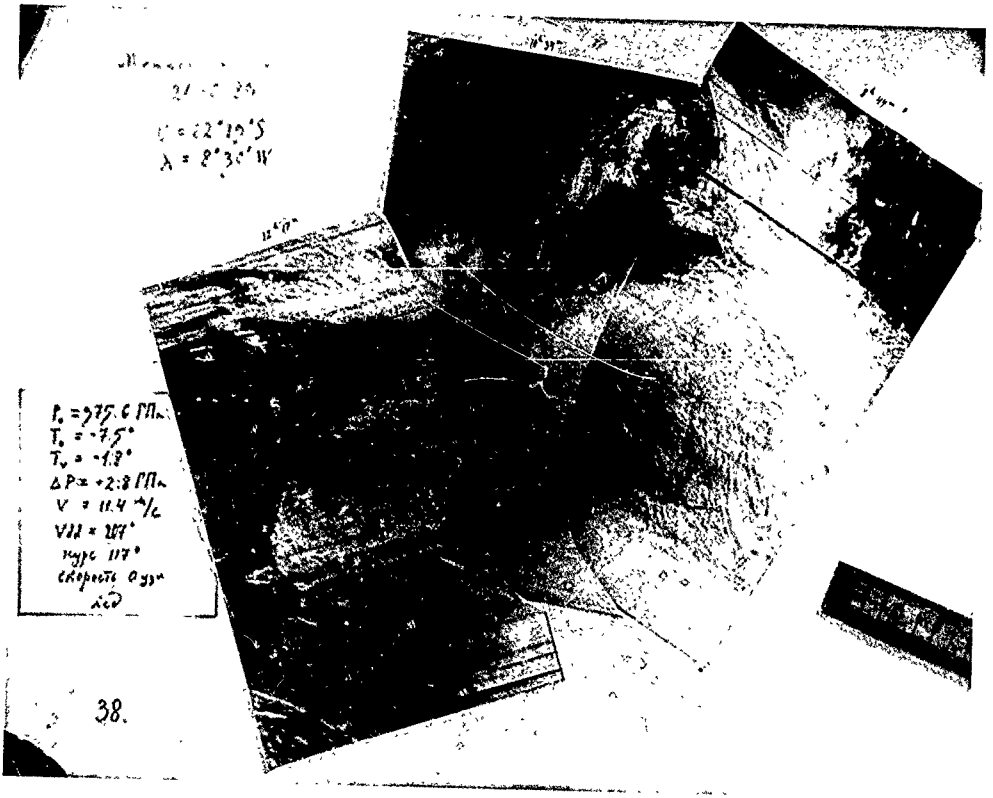


Figure 159. 21 October satellite photo, 62° 19'S 8° 30'W.

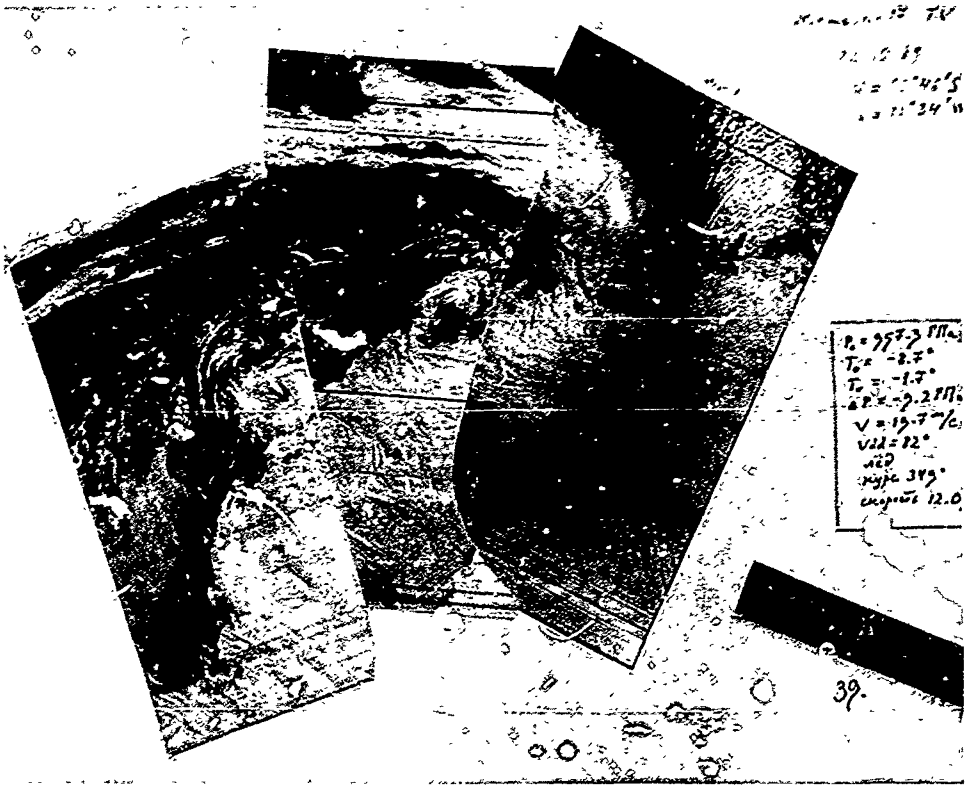


Figure 160. 22 October satellite phot ... °'6S 1 ... 34W.

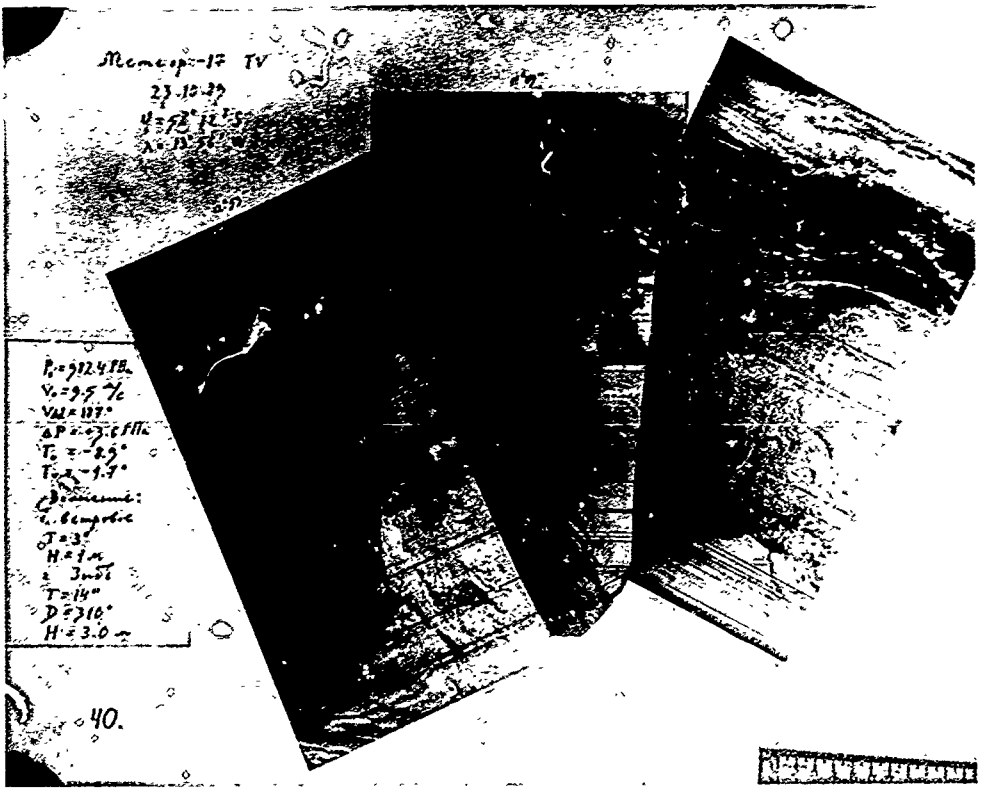


Figure 161. 23 October satellite photo, 58° 12'S 13° 56'W.

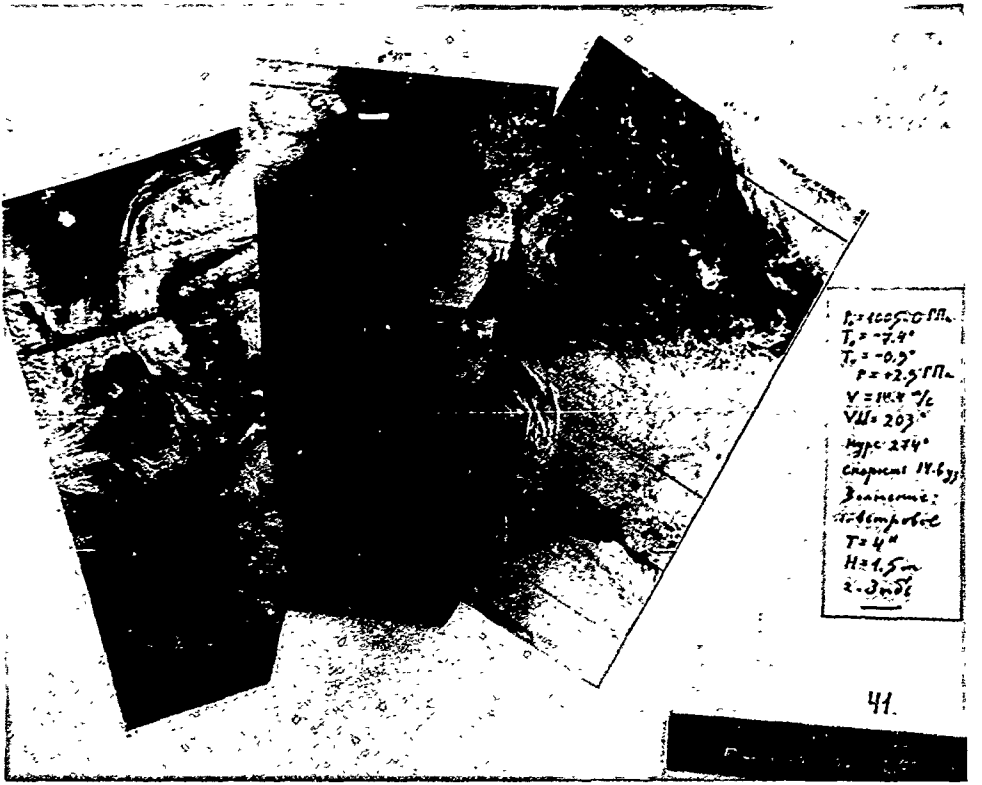


Figure 162. 24 October satellite photo, 58°06'S 22°36'W.

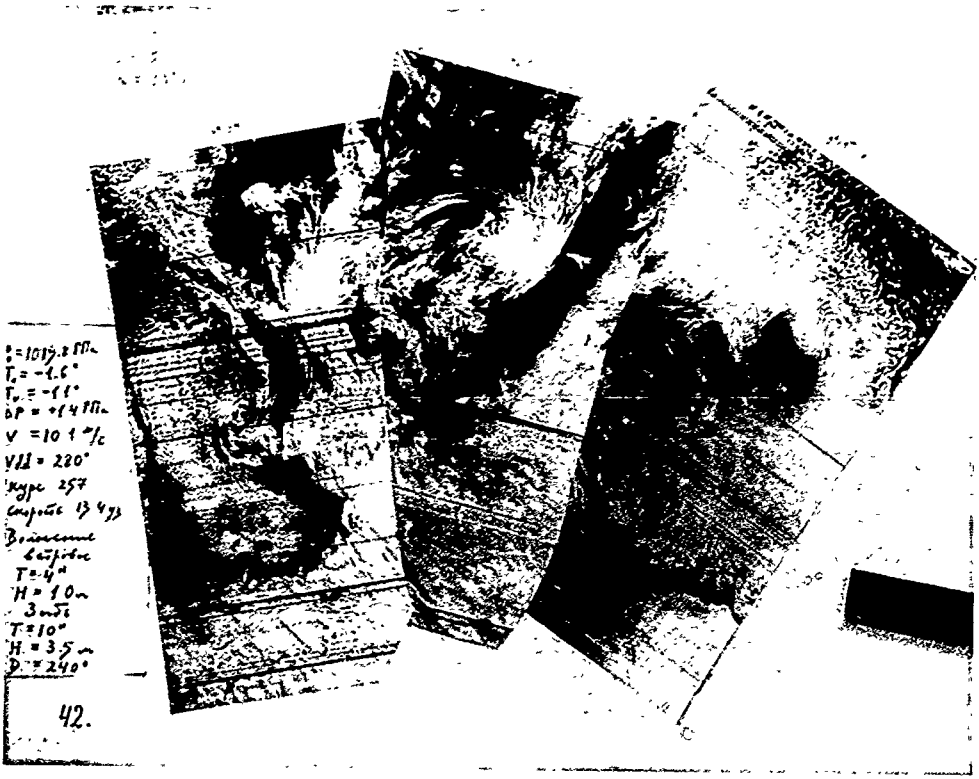


Figure 163. 25 October satellite photo, 58°49'S 33°57'W.

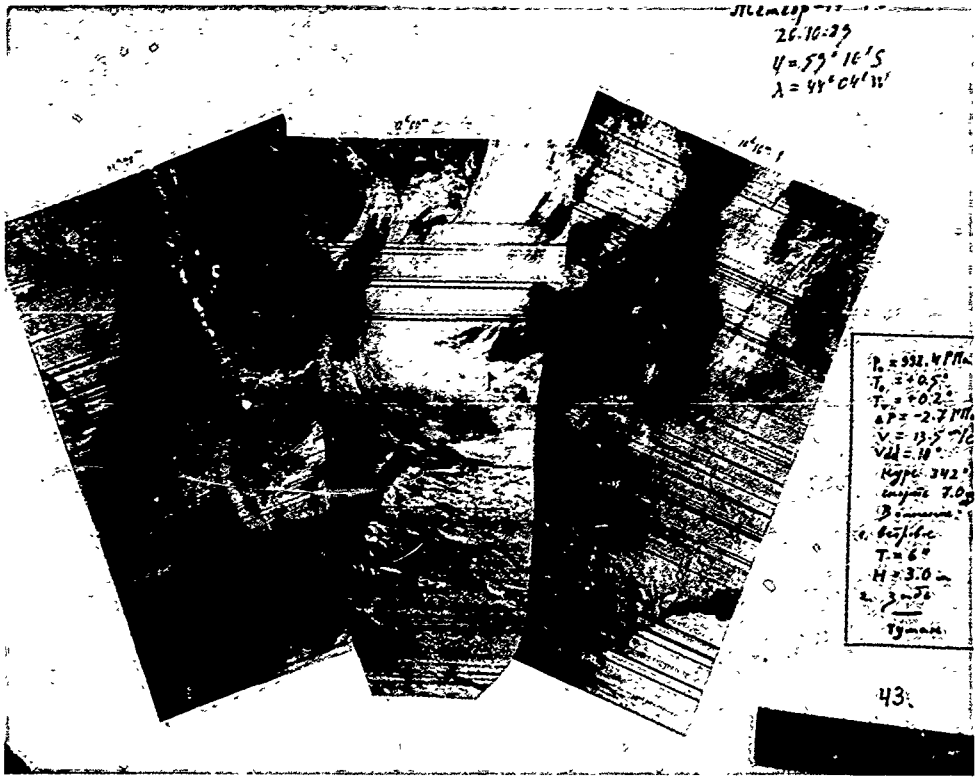


Figure 164. 26 October satellite photo, 59° 16'S 44° 04'W.

Figure 165. 27 October satellite photo, 60°23'S 54°15W

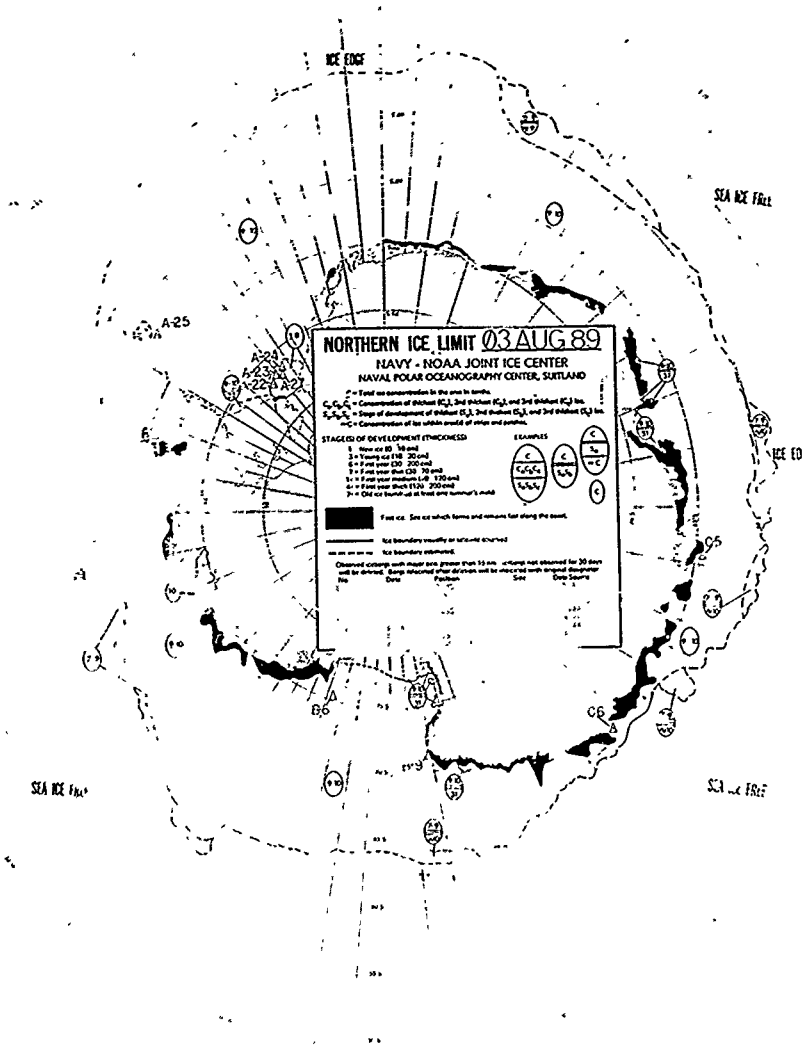


Figure 166. 3 to 9 August 1989 ice extent.

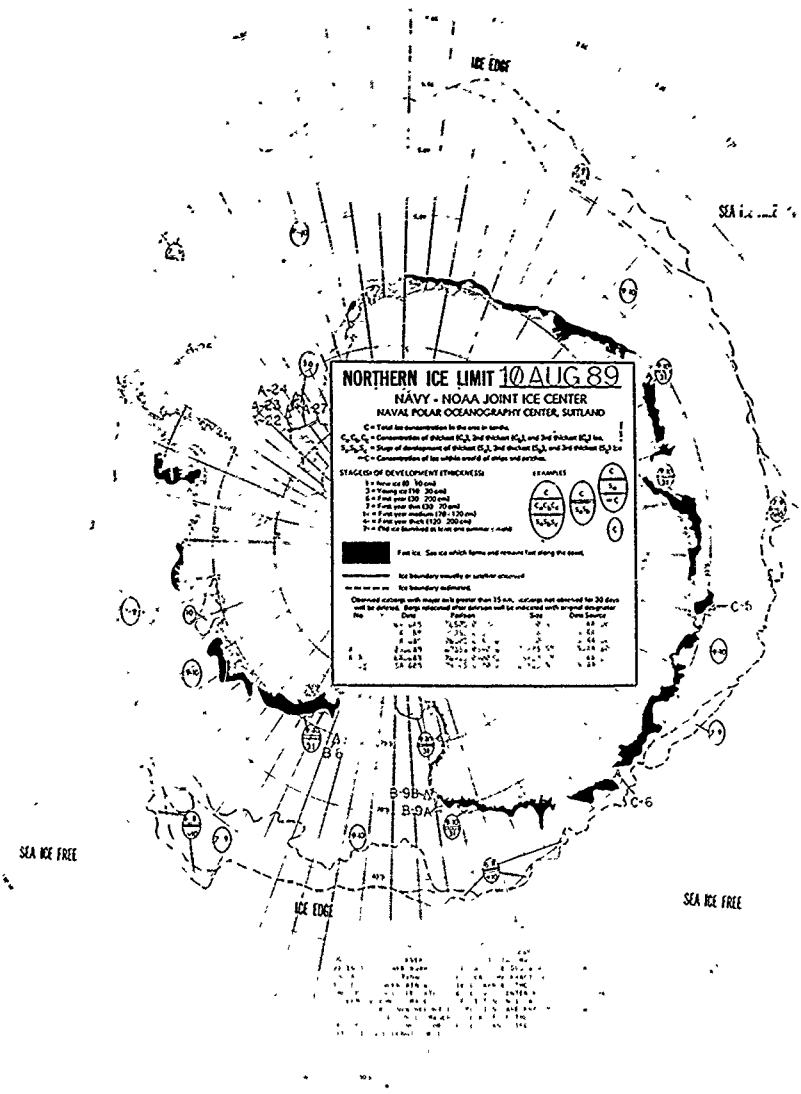


Figure 167. 10 to 16 August 1989 ice extent.

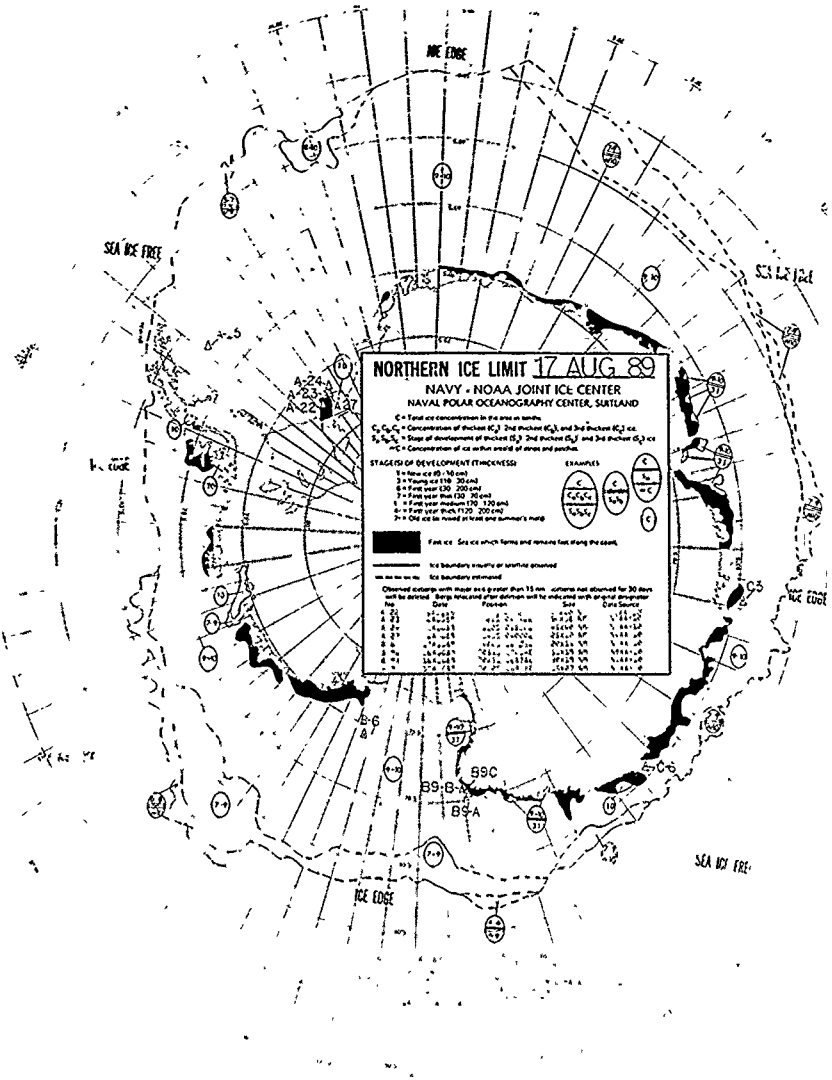


Figure 168 17 to 30 August 1989 ice extent.

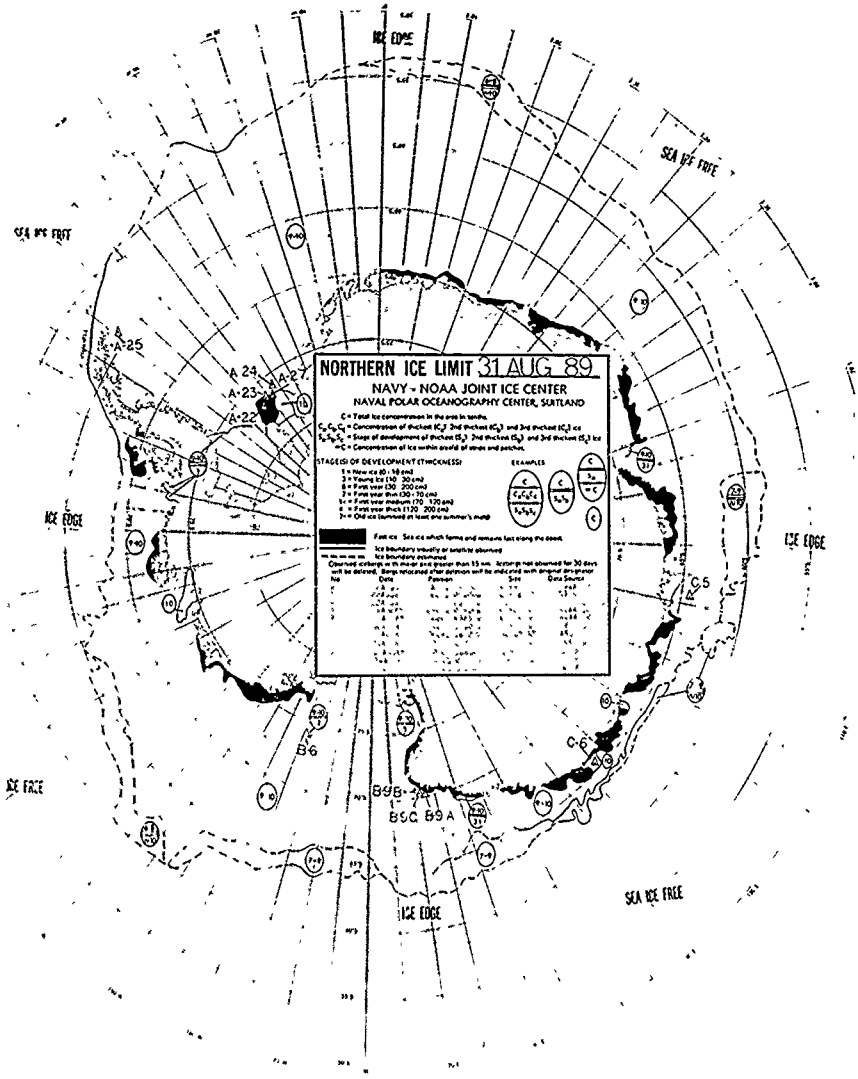


Figure 169. 31 August to 6 September 1989 ice extent.

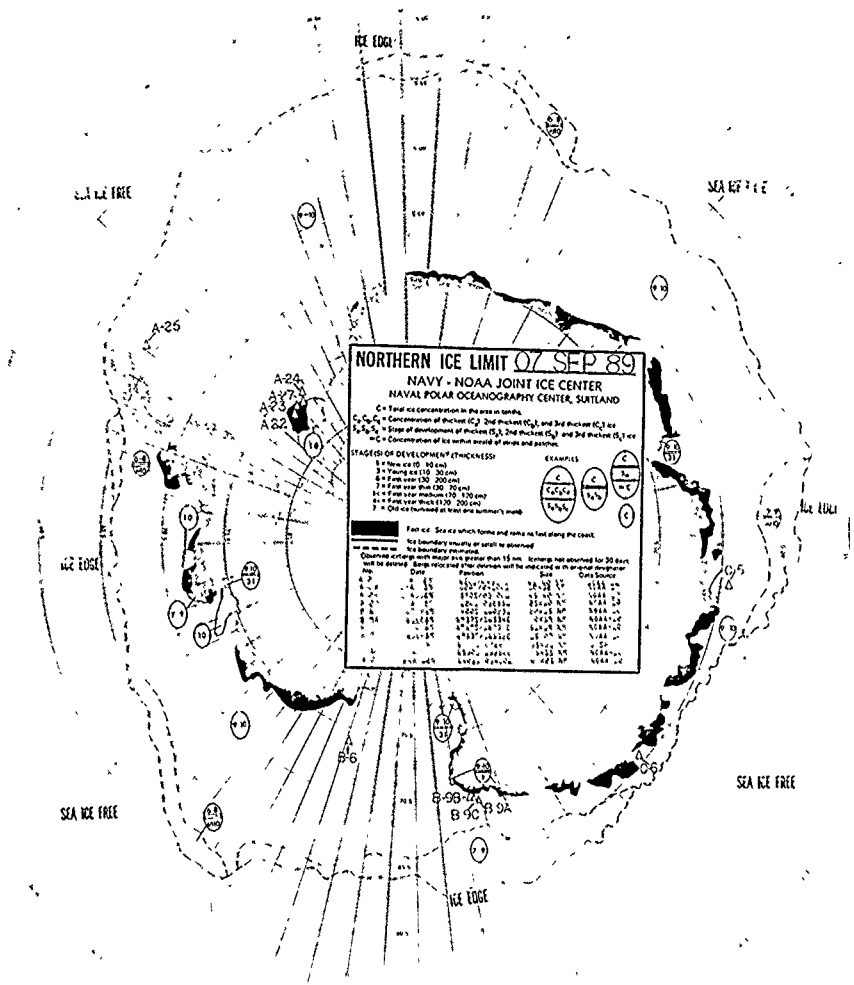


Figure 170. 7 to 13 September 1989 ice extent

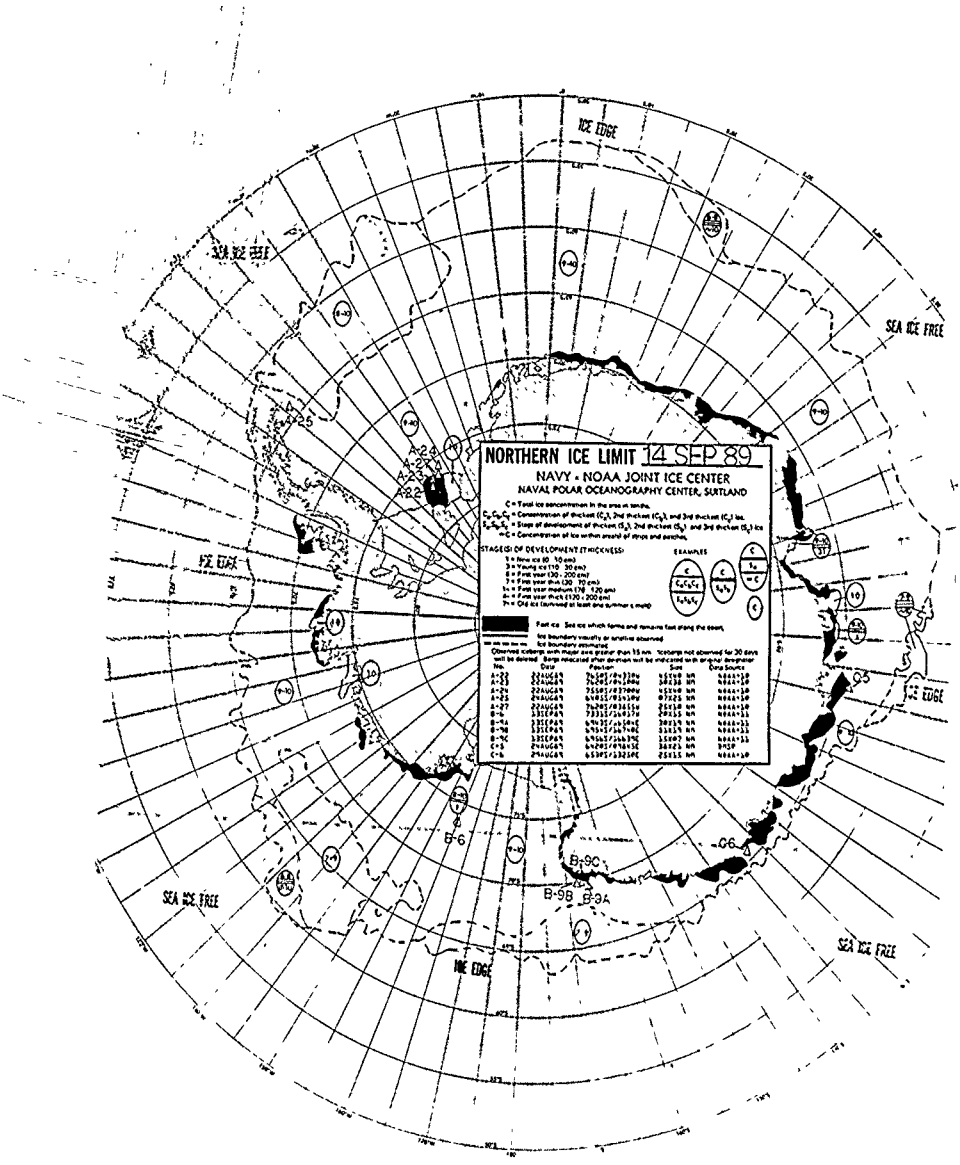


Figure 171. 14 to 20 September 1989 ice extent.

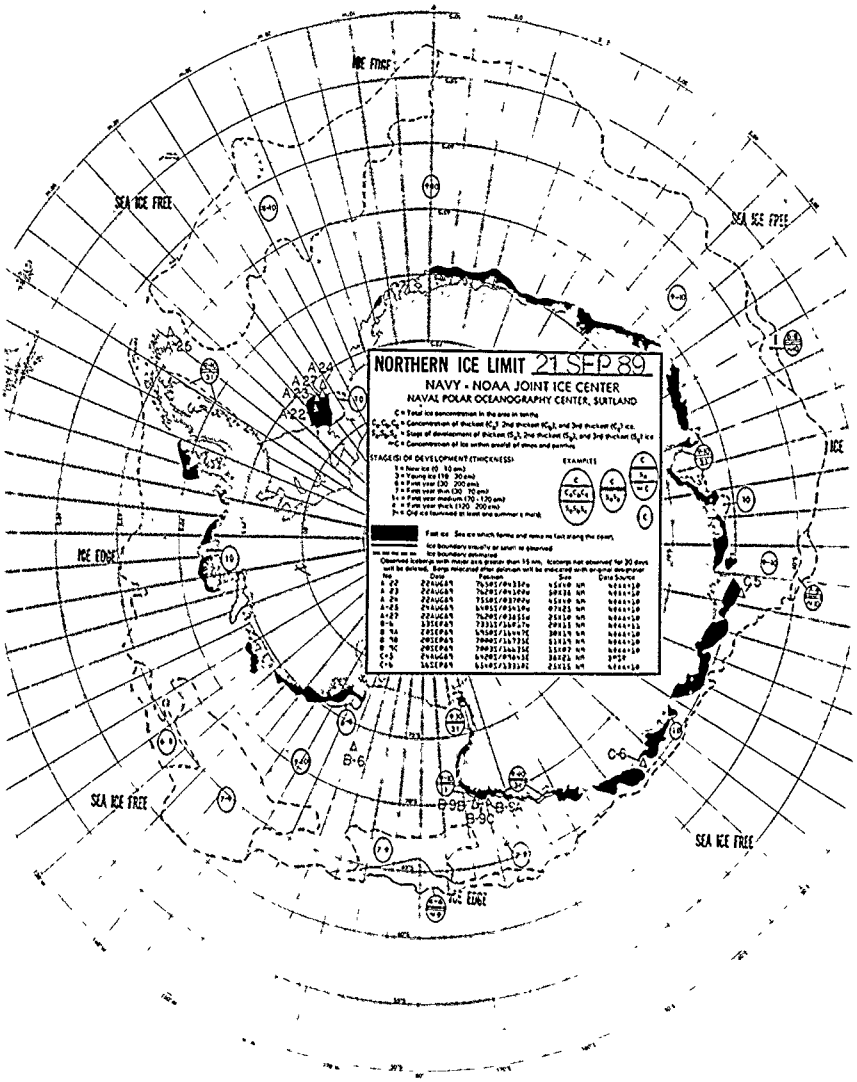


Figure 172. 21 to 27 September 1989 ice extent.

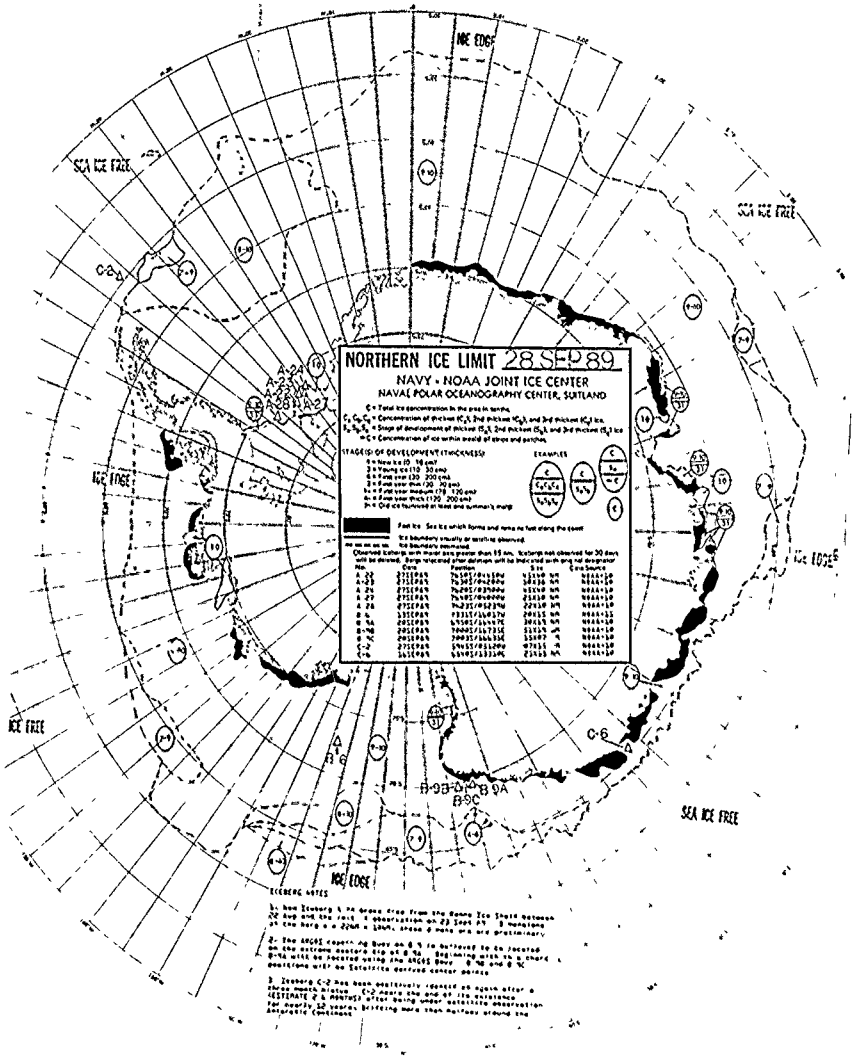


Figure 173. 28 September to 11 October 1989 ice extent

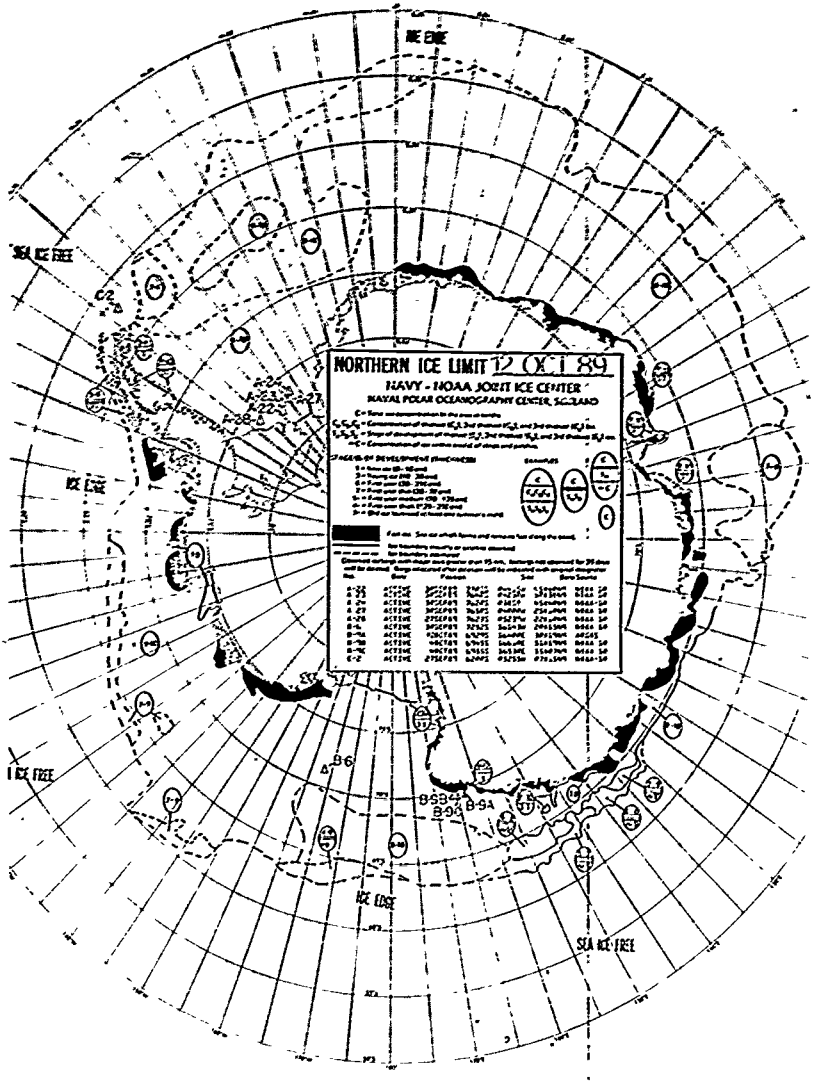


Figure 174. 12 to 18 October 1989 ice extent

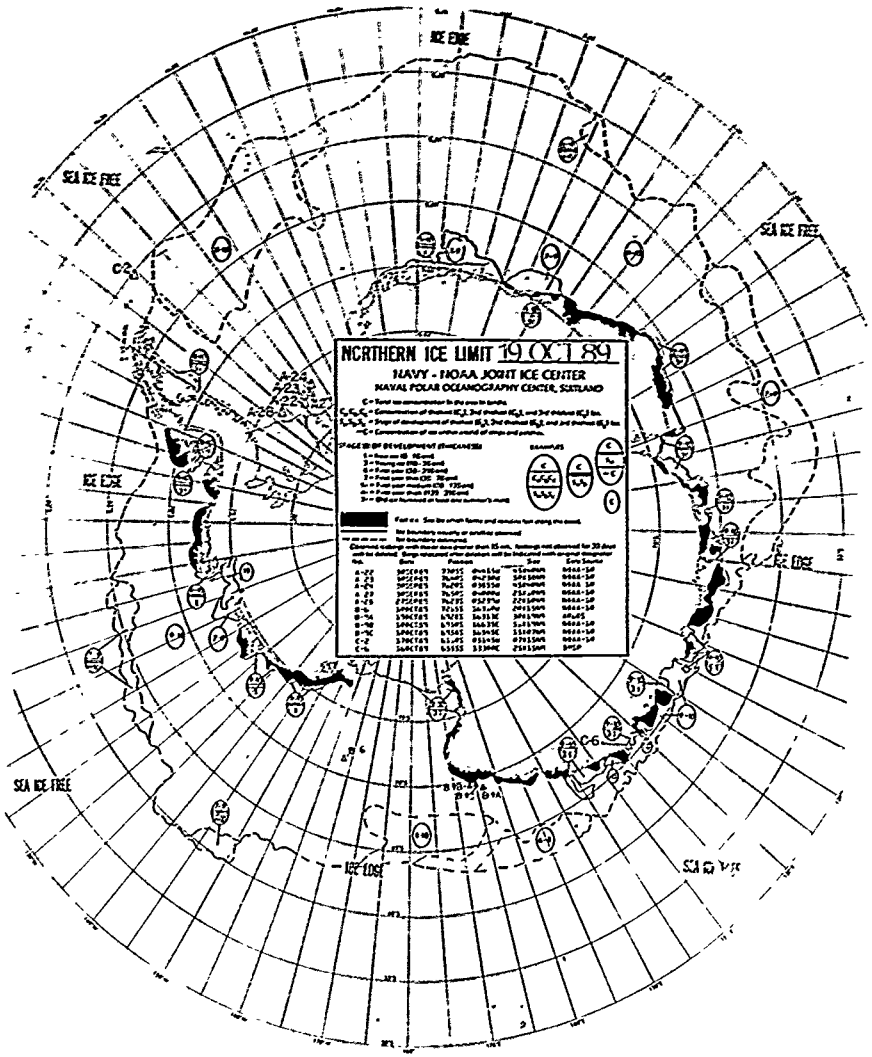


Figure 175. 19 to 25 October 1989 ice extent

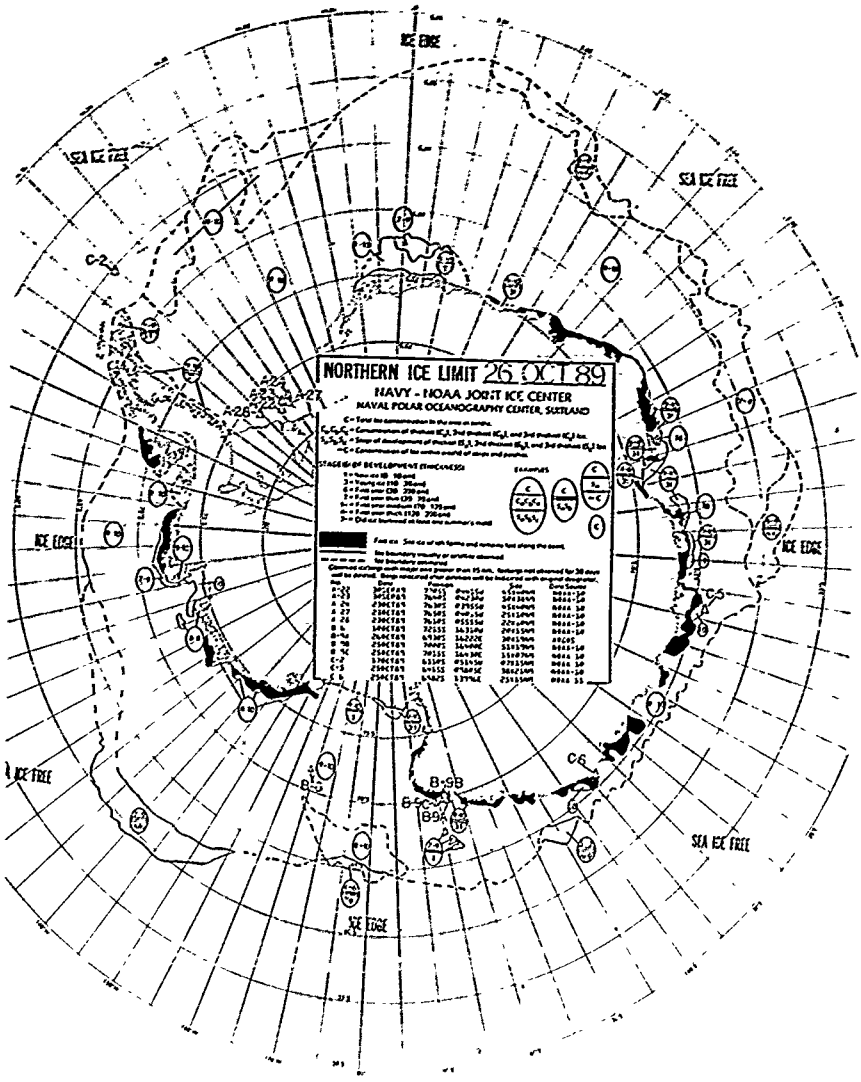


Figure 176. 26 October to 1 November 1989 ice extent.

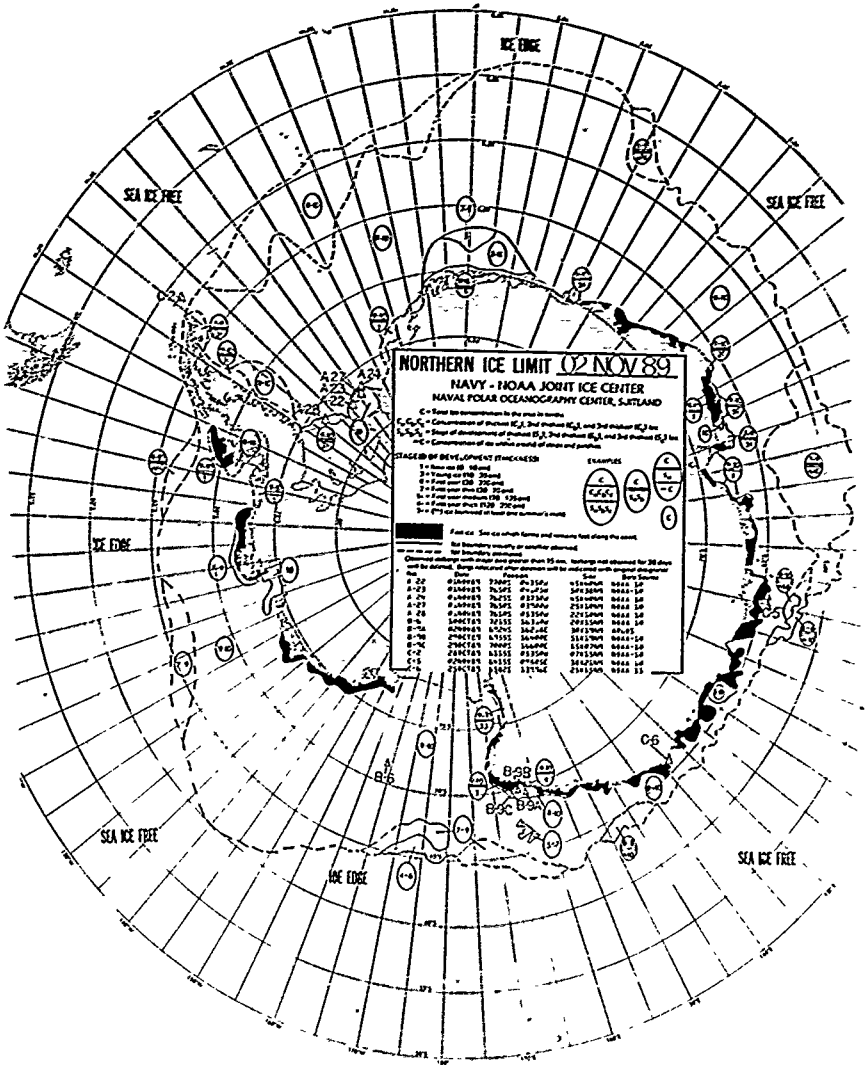


Figure 177. 2 to 8 November 1989 ice extent.

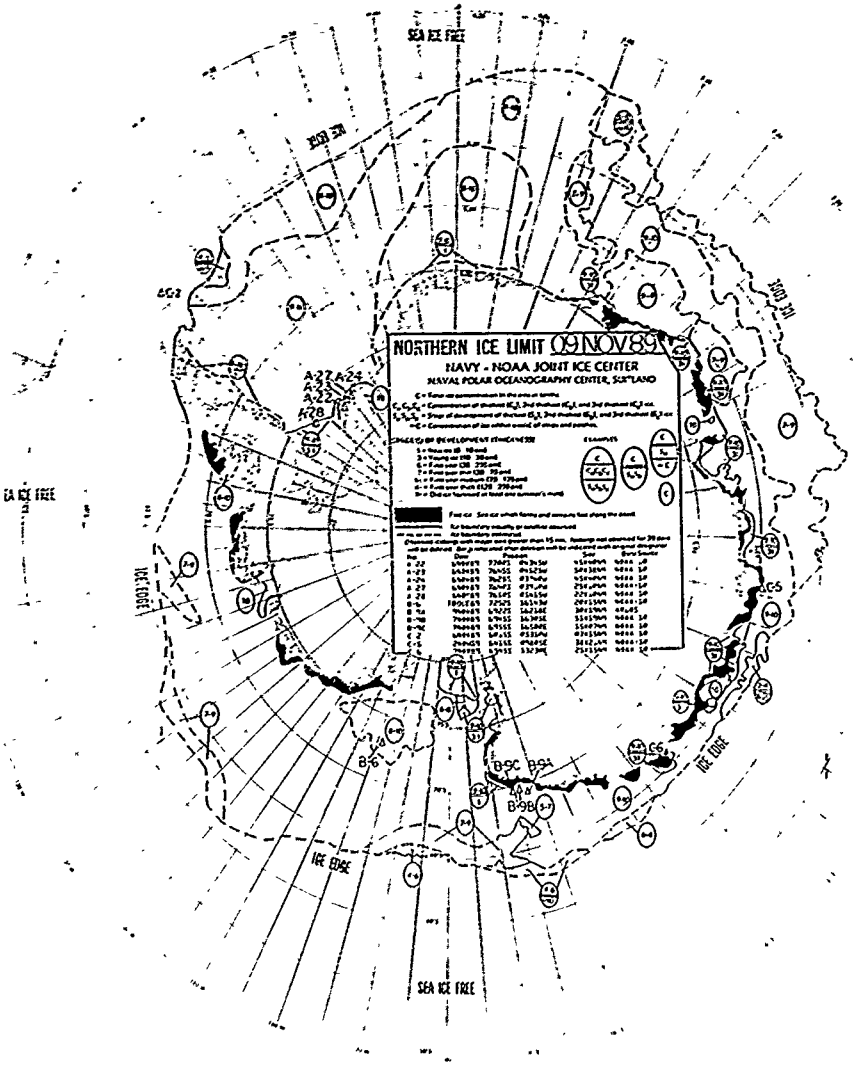


Figure 178. 9 to 15 November 1989 ice extent.

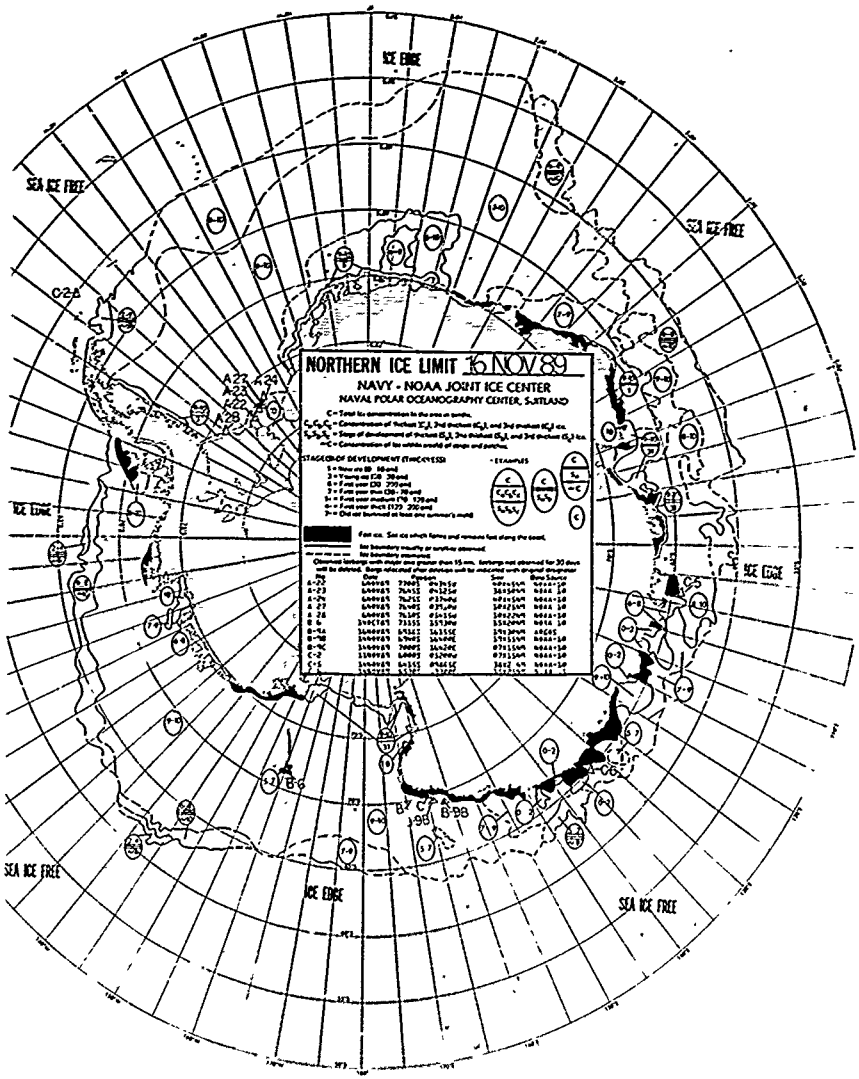


Figure 179. 16 to 22 November 1989 ice extent.

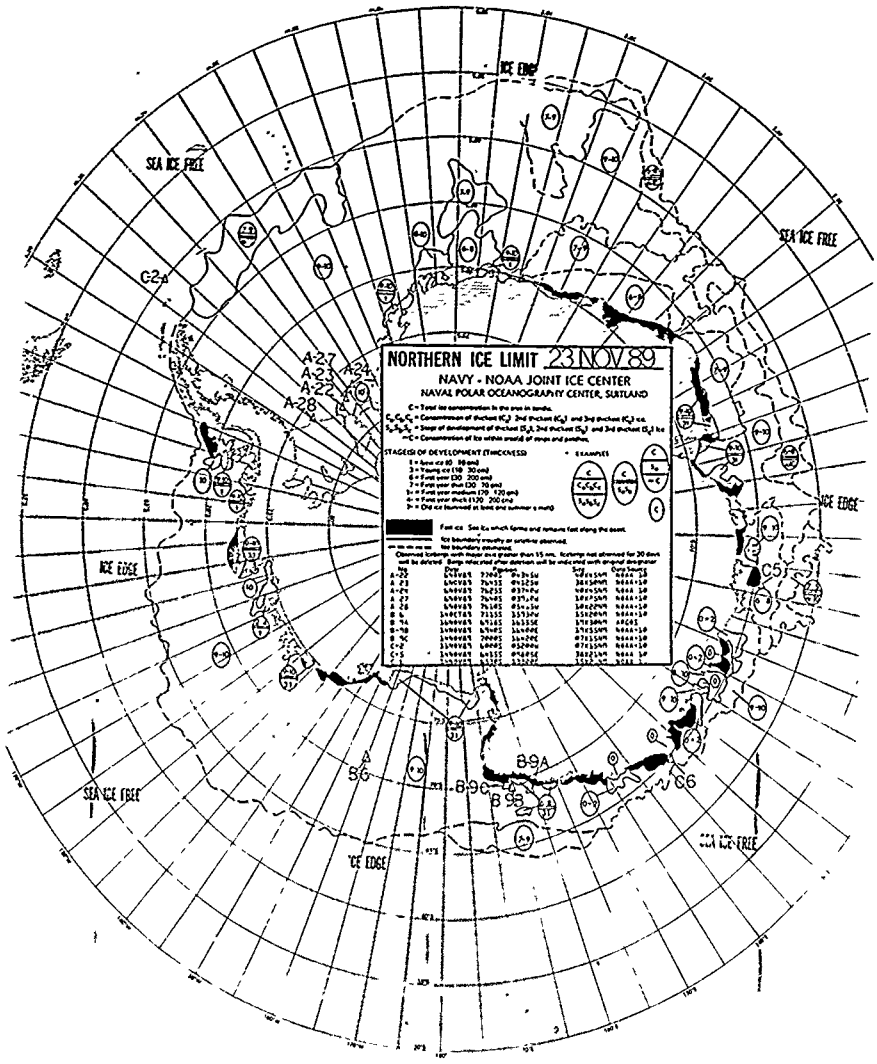


Figure 180. 23 to 29 November 1989 ice extent.

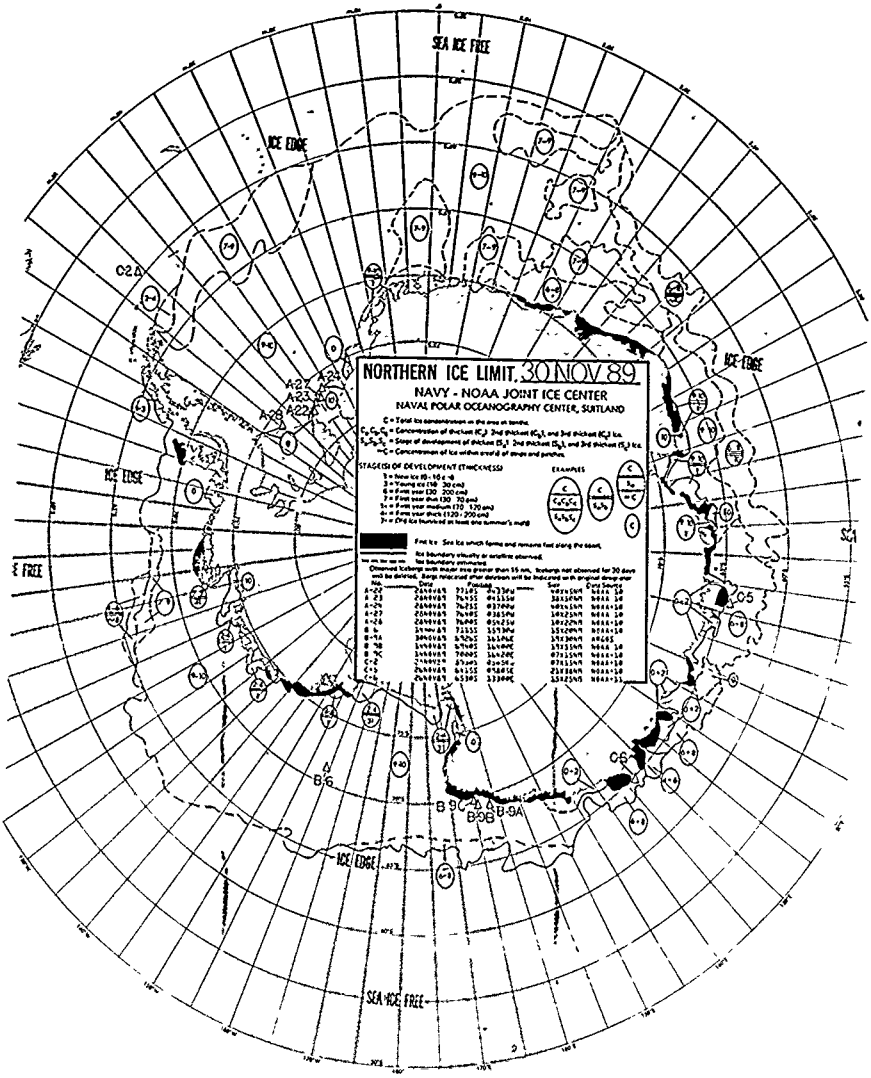


Figure 181. 30 November to 6 December 1989 ice extent

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During the Winter Weddell Gyre Study-'89 (WWGS-89), extensive ice observation records were collected by both U.S. and Soviet scientists. These data include a written and photographic log, a 24-hour location map, a site map of each ice station, daily satellite photographs and weekly ice extent maps. These combined data provide a complete analysis of the ice conditions encountered throughout the study.

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