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IR NO. 68-115

INFORMAL REPORT

INFRARED SCANNING THE ARCTIC PACK ICE

DECEMBER 1968

NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

INFORMAL REPORT

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ABSTRACT

The U. S. Naval Oceanographic Office conducted its first infrared scanning experiment in the Arctic Basin during daylight conditions in April 1964. Many miles of coincident infrared scanner imagery and vertical photography were obtained over a large area of the Arctic Basin pack ice between North Ellesmere Island and 87°N and in Baffin Bay. A surface control site for "ground truth" data was established on the pack ice at the drifting ice station ARLIS II, then located at 86°30'N 48°57'W. Several overflights at various altitudes were made in this area. The experiment demonstrated that quality sea ice information can be obtained during daylight periods using infrared scanning systems. Incorporating present state-of-the-art instrumentation and imagery interpretation capabilities, the infrared reconnaissance system could be used effectively for identification and mapping of recent zones of ice canopy deformation. Continued airborne experiments and surface environmental studies under varying atmospheric conditions, varying seasons and conditions of light will be necessary to become proficient in translating infrared data into usable information with high confidence levels.

This report presents illustrations of infrared imagery with coincident visual photography. A discussion of interpretations is presented along with brief mention of applications and limitations of the infrared scanner to Navy sea ice studies.

R. D. KETCHUM, JR.
W. I. WITTMANN

Sea Ice Branch
Exploratory Oceanography Division
Research and Development Department

APPROVED FOR RELEASE: Edward L Ridley
Director
Exploratory Oceanography Division

DATE: 2 Dec 68

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INTRODUCTION

The U. S. Naval Oceanographic Office (NAVOCEANO) supports fleet activities in polar operations by supplying forecast services. A capability for accurate and reliable forecasts of pack ice conditions depends on accumulative knowledge of past ice conditions and an understanding of the physical processes which control pack ice motion and deformation. Present polar reconnaissance programs designed to gather the needed information are strongly restricted due to reliance on visual observation by highly-trained aerographer's mate ice observers with the inherent human limitations of quantitatively estimating magnitudes of ice canopy features. The remoteness of the polar regions, adverse weather conditions and long periods of darkness are further limitations. Consequently, NAVOCEANO is directing efforts toward the use of airborne remote sensors in the arctic environment. Hopefully, remote sensor imagery will yield more exact and comprehensive data, adaptable to computer analysis. Additionally, the development of remote sensor observation procedures and interpretive techniques will be applicable to future programs involving spacecraft sensors.

In recent years, the development of infrared scanning equipment has led to its successful utility by many agencies in a variety of environmental investigations. Although infrared investigators of the sea ice environment have been limited, outstanding contributions to this field have been made by the U. S. Army Cold Regions Research and Engineering Laboratory. This agency has worked closely with the Infrared Laboratories, University of Michigan and the Defence Research Board, Canada, in infrared investigations of sea ice and snow-covered terrain. Several technical publications resulting from this work have provided valuable guidance in similar studies undertaken by NAVOCEANO.

The first NAVOCEANO infrared scanner mission over pack ice areas was conducted in April 1964. Many miles of sea ice in the Arctic Basin and Baffin Bay were covered simultaneously with the infrared scanner and with conventional aerial photography. A test site was established on the Arctic Basin pack ice at the drifting ice station ARLIS II. The field party obtained ground truth data at the test site including observations of surface temperature simultaneously with the infrared over-flights. Figure 1 shows the area covered.

A second flight to ARLIS II was planned to repeat the exercises four or five days later. However, this flight was cancelled owing to aircraft maintenance problems. The second mission would have attempted to follow the same course over the pack ice set during the first mission. This would have permitted observation of changing pack ice conditions. Additional observations of the effect of varying environmental conditions at the test site could have been studied.

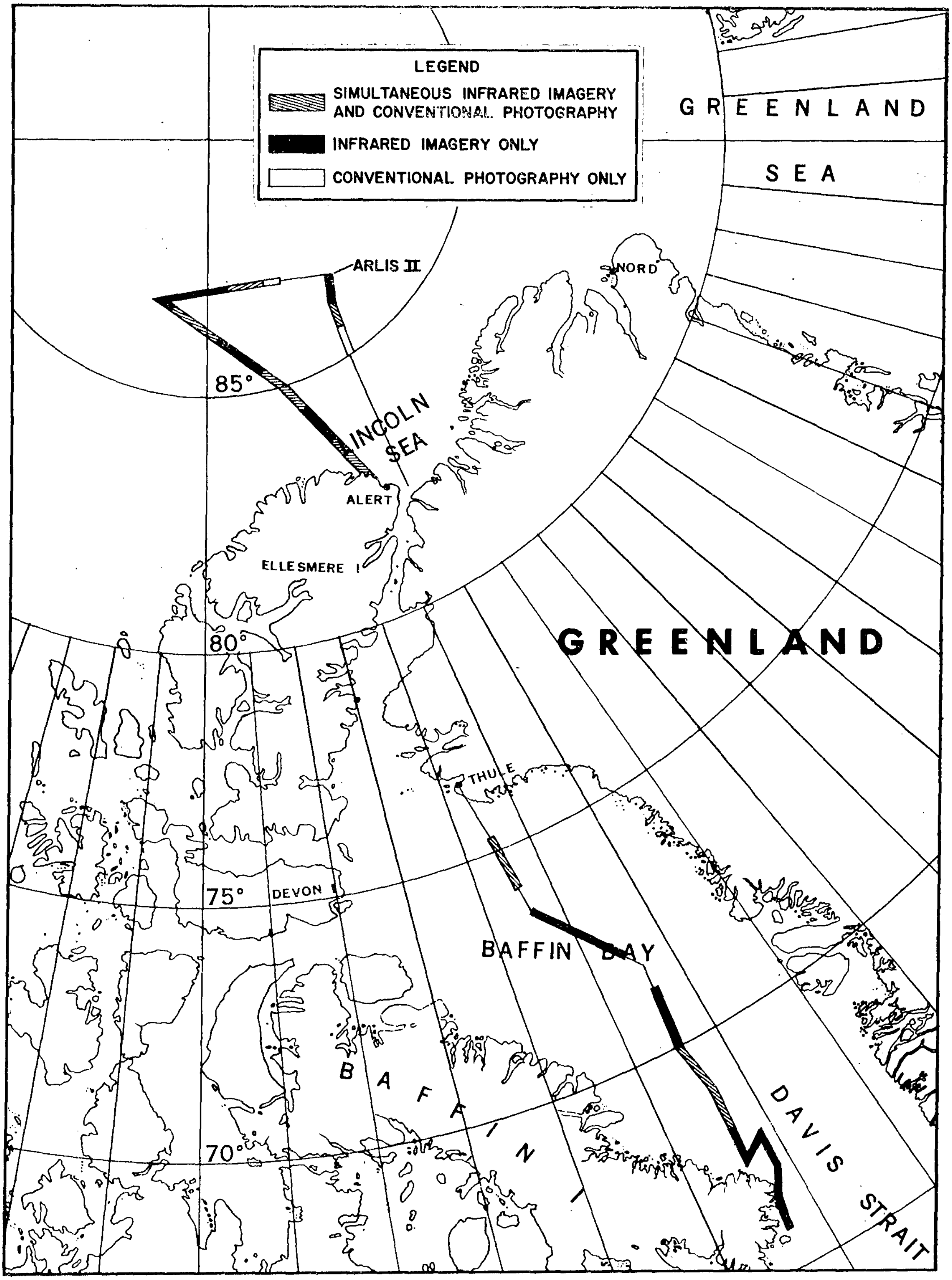


FIGURE I DEPICTS AREAS COVERED BY INFRARED SCANNER AND PHOTOGRAPHY ON 8 APRIL 1964 IN ARCTIC BASIN AND 12 APRIL 1964 IN BAFFIN BAY

During evaluation, consideration was given to the following factors: (1) the value of infrared imagery in furnishing sea ice information, (2) the value of infrared in furnishing sea ice information not normally registered on conventional photography, and (3) the effect of altitude on the quality and quantity of sea ice information.

RESULTS

Sea Ice Information. NAVOCEANO sea ice reconnaissance programs provide sea ice information for ship routing forecasts and for scientific investigations which study the areal and seasonal distribution and behavior of sea ice. Sea ice features of primary concern to the sea ice forecaster and investigator are (1) ice concentration, (2) stage of ice development or age (universally defined as directly proportional to ice thickness), (3) water openings, (4) ice forms or size of fragments, (5) topography or roughness, (6) ice edges, (7) snow cover, and (8) stage of melt.

The daylight infrared imagery interpreted during this experiment indicated high potential for detection and identification of most of these features. Much of the desired information could be obtained as well from the IR records as the photo records. The greater ground resolution offered by the photograph provides more clues for interpretation and permits extraction of more detailed information. However, often the greater surface detail provided by the photograph is not necessary. On the other hand, the thermal image provides a much stronger capability in detection and identification of ice fracture patterns and early stages of ice development. During the early months of ice growth, identification of relative ice thickness is possible using the thermal image. Frequently this is a very difficult and extremely subjective interpretation on the photo -- often it is impossible.

Aside from the nighttime capability, the real advantage of the infrared scanner over conventional aerial photography in sea ice reconnaissance lies in this capability to better detect, identify and classify by age, patterns of fractures and stages of ice development. Further exploitation of this capability is justified when considering the extreme importance of these features in sea ice studies.

SurfaceThermal Patterns. The pack ice surface thermal patterns imaged during this experiment generally were dominated by heat conducted from the relatively warm water beneath the ice or by solar radiation. Factors such as ice thickness, snow depth, density inequalities in the ice and snow cover, and surface topography were indirectly responsible for thermal differences at the surface.

Polar ice (ice older than one year) characteristically 6-12 feet thick but containing scattered, weathered hummocks whose draft may exceed 100 feet, is generally snow covered, frequently by highly compacted deep drifted snow. The ice thickness and snow cover prevent strong surface thermal differences due to heat flow from the water. The same may also be true for very old winter ice (ice less than one year old) forms which have attained sufficient thickness and snow cover. Consequently solar radiation dominated surface temperatures of thick ice forms. Under these conditions surface features such as pressure ice and snow cover played an important role in affecting surface temperature differentials. Strong evidence of the effect of solar radiation on polar ice image patterns is indicated by comparison of photo tones on the photography caused by reflectivity and photo tones on the imagery caused by temperature and emissivity.

In the case of thinner winter ice and other younger forms of ice, surface temperatures are more strongly influenced by heat conducted from the water beneath the ice. Here too, however, relative ice thicknesses and snow cover are significant in determining surface temperature differentials. Estimations of relative ice thicknesses are often possible.

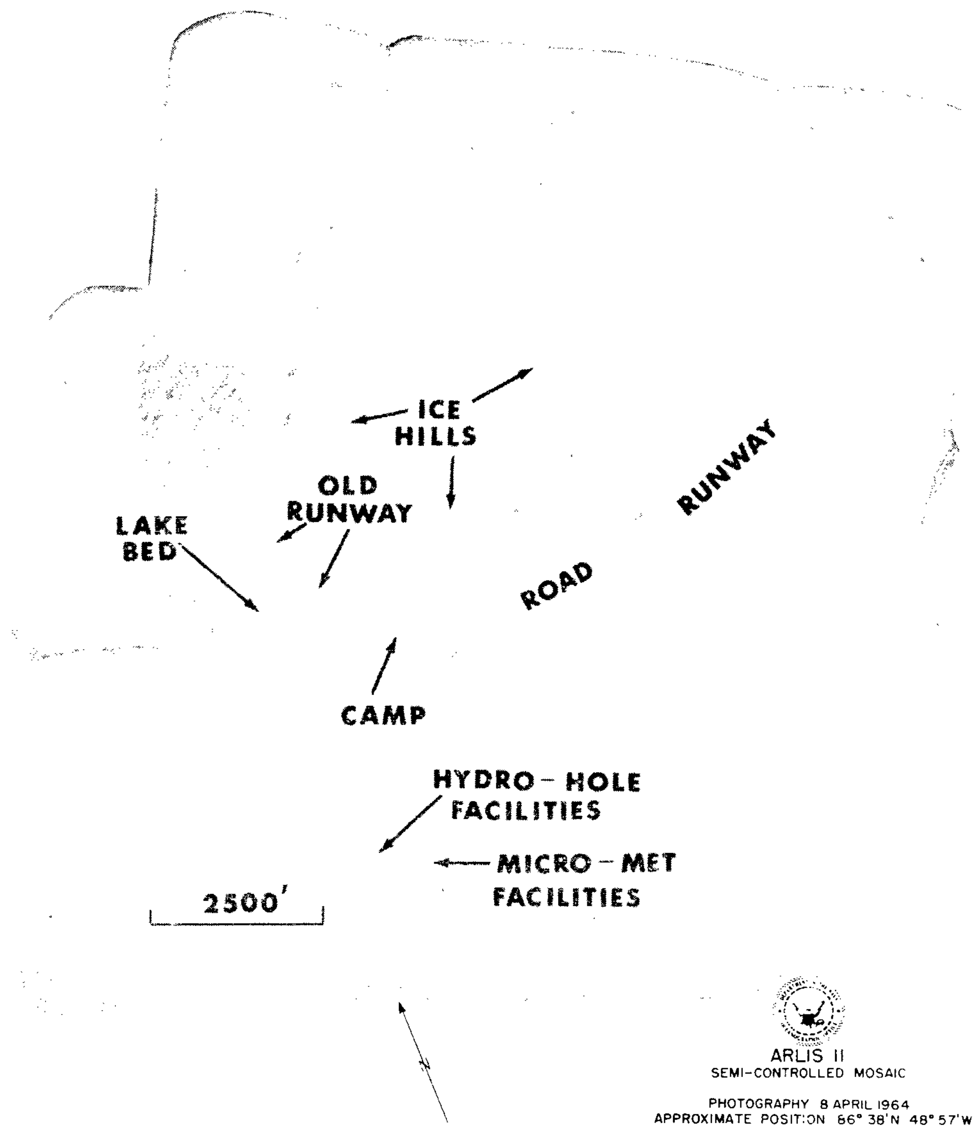
In the Arctic environment, a wide range of natural surface temperatures may be encountered in a single scan by the infrared system. Since the system is limited in the number of temperature variations which can be recorded during a single scan, some relatively large surface temperature differentials often are not detected when a wide temperature range exists. However, when a surface displays a narrow temperature range, more minor temperature differentials can be recorded by the system. Manifestations of this limitation are easily recognized in some of the image examples discussed below.

Another important factor which determined the image thermal pattern was the instantaneous field of view. Apart from the inherent properties of the infrared system, this factor varies according to aircraft altitude and angle of incidence to the surface feature.

INFRARED IMAGERY

ARLIS II Imagery. The day before the overflights, ARLIS II experienced northeast winds up to 25 knots, with heavy blowing snow. Air temperature was about minus 30°C. On 8 April, during the period of overflights, winds were very light at 1-3 knots and air temperatures were minus 27°-29° C. Sky conditions included very thin, scattered, high clouds. The infrared scanner observations were made around local noon time when the sun altitude was about 16 degrees. Figures 2 through 5 show examples of data collected at the drifting ice station ARLIS II.

INFRARED IMAGE



COMPOSITE PHOTOGRAPHY

FIGURE 2 INFRARED STRIP IMAGERY OVER ARLIS – II AND COMPOSITE PHOTOGRAPHY TAKEN DURING SAME PERIOD.
DATE: 8 APRIL 1964 IR TIME: 1620 GMT LOCATION: 86°38'N 48°57'W (ARLIS II)

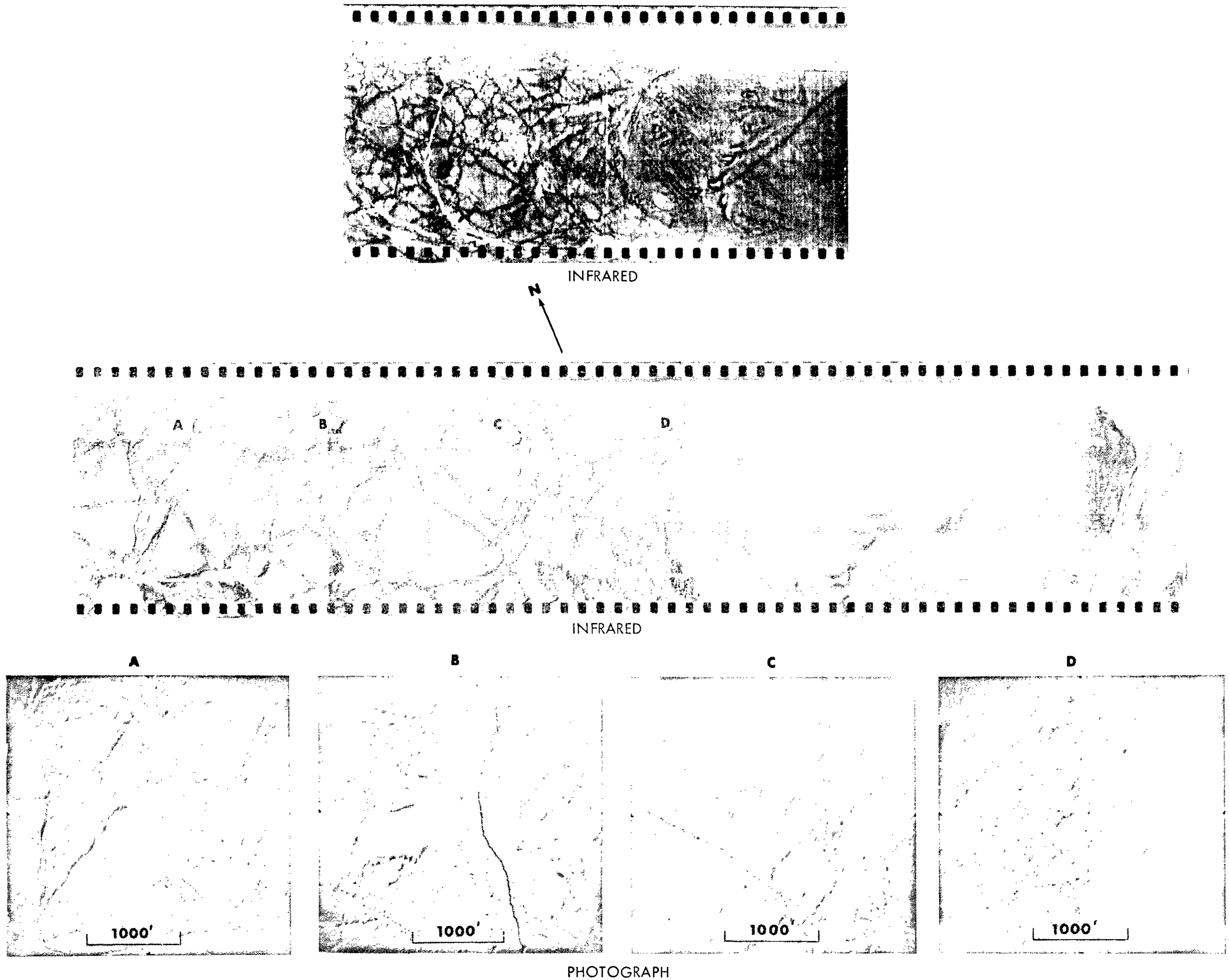


FIGURE 3 DATE: 8 APRIL 1964 TIME: 1630-1700 GMT LOCATION: 86°38'N 48°57'W (ARLIS - II)

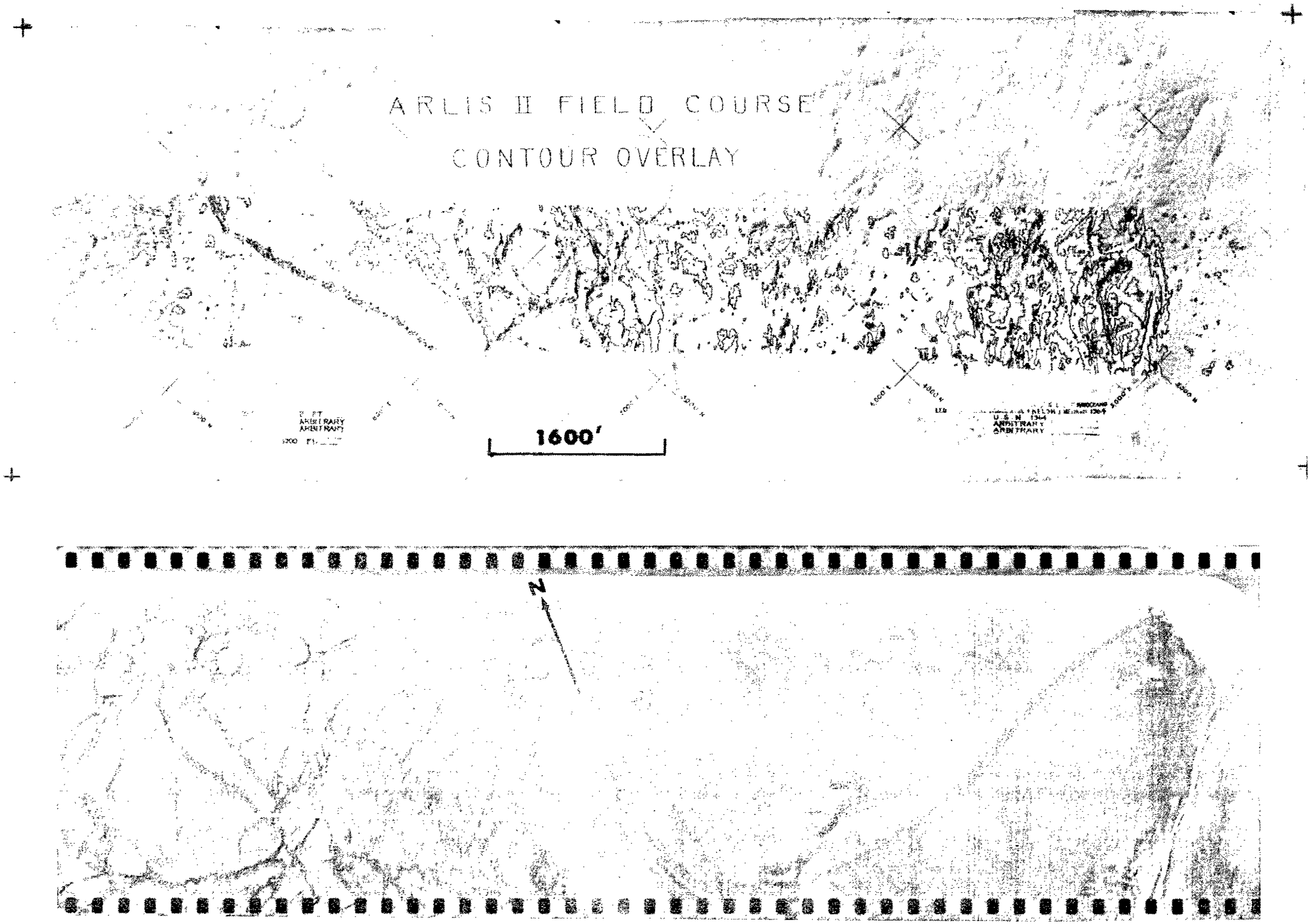


FIGURE 4 CONTOURED PHOTOGRAPHIC COMPOSITE (2-FOOT CONTOUR INTERVAL) AND SIMULTANEOUS INFRARED STRIP IMAGERY OVER ARLIS - II TEST SITE

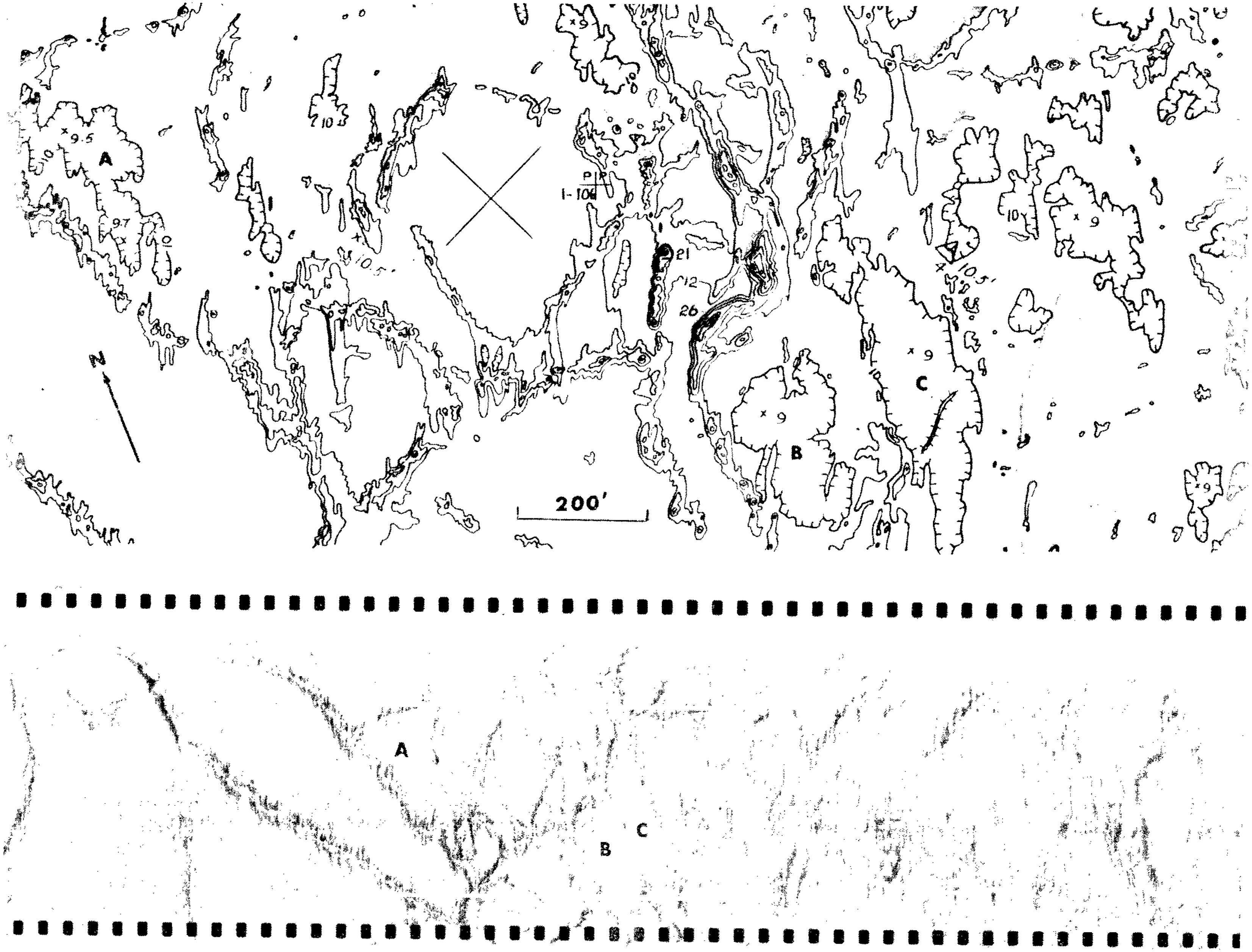


FIGURE 5 ENLARGED SECTION OF CONTOURED PHOTOGRAPH AND LOW ALTITUDE THERMAL IMAGE OF ARLIS – II TEST SITE

Figure 2 shows infrared imagery of ARLIS II with composite photography collected during the same period. The infrared image of the ice island is differentiated from the pack ice surroundings by its size and shape and its relatively smooth and dark image tone. The compacted snow road and compacted snow runway can be detected as dark (cold) lineations. An old abandoned runway is also discerned as a dark lineation. This runway is hardly perceptible on the photography. An old lake bed which formed on the island during the summer melt of 1961 is portrayed as an oblate warm spot. This snow covered feature is completely imperceptible on the photography. The camp complex, with its inherent heat, images sharply with its cooler background. The heated shelters of the station hydro-hole and micrometeorology facilities also are easily distinguished from their cooler backgrounds. The rock-covered ice hills, formed over the years from differential melting, stand out sharply as warm features because of solar heating on their sides. Note, however, that the pack ice pressure ridges (dark lineations on pack ice) do not display signs of solar heating on this image. The pressure ridges are smaller than the ice hills and the instantaneous field of view from this altitude precluded distinct portrayal of the heated sides of pressure ridges.

Figure 3 shows two infrared strips extending over the test site on the pack ice and ARLIS II. The strips were taken several minutes apart. The photographs were taken simultaneously with the lower altitude infrared imagery. In comparing the same areas and features on the two infrared strips, it is noted that little sea ice detail is sacrificed by the higher altitude observation, although a greater amount of information becomes available from the higher altitude because of the greater field of view. It is interesting to note that solar heating of pressure ridges is more evident on the low altitude imagery. This is due to the smaller instantaneous field of view from a lower altitude. Comparing the photograph and the infrared image of Area A, we see light gray thermal lineations which represent partially snow-filled cracks. The patches of medium gray tone on the thermal image are identified on the photograph as areas of snow covered winter ice. In Area B, the open crack seen on the photograph is much smaller than indicated by the thermal image. The winter ice bordering the opening (which may be covered with new or young ice) was not distinguished from the opening by the infrared system. Area D shows the boundary between the pack ice and the ice island. Most noticeable is the difference in surface roughness of the two areas. The pack ice roughness is well portrayed on the thermal image due to the differential heating effects of solar radiation. The highest pressure ridges imaged are in Area C. The pressure ridge at right-center of the area is 17 feet high. A large part of Area C consists of medium gray toned thermal images. These areas consisted of deeply drifted snow, some of which had been deposited during the storm the day before. A difference can be noted on the photograph between these relatively undisturbed, uncompacted snow surfaces and the surrounding wind-etched, compacted snow surfaces. Field party observations, which extended from the ice island to just beyond Area C, confirmed these differences in snow cover, however, did not consider this to be an area of winter ice, but rather polar ice. Ice thickness was not determined. An important question arises here as to whether these areas are winter ice and if so, are the surface temperatures controlled by heat conduction or solar radiation. It is suggested that the surface temperature differences were due to differential heating and cooling rates of two different snow covers having unequal densities and surface characteristics. However, this does not exclude the possibility that these areas include thick winter ice.

During the field work, horizontal and vertical control points were established over the test site. Using the stereo-photography obtained during the overflights, a photographic mosaic of the test site was constructed. A contour overlay with a two foot interval was constructed using a Kelsh Plotter. Figure 4 shows the photo mosaic with contour overlay and a simultaneous thermal image. The contoured area, which is outlined on the thermal image, is 1,000 feet wide and more than one mile long. An elevation datum was established by arbitrarily assigning 10 to a low point. Using the contour overlay it becomes apparent that the surface areas portrayed in medium gray tones, (the areas which consist of the recently drifted, uncompacted snow) were areas of lowest surface elevations. These depressed areas would be expected to accumulate drifting snow. Areas of winter ice among the thicker polar ice floes would characteristically have lower surface elevations. Briefly then, we may expect areas of thick winter ice to accumulate large quantities of drifting snow. (The maintenance of snow cover on relatively thin winter ice is prohibited by heat conducted to the ice surface and by sweeping effects of the wind). However, it can't be stated categorically that all depressed surface elevations represent winter ice (or younger) zones.

Figure 5 shows an enlarged section of the contoured photograph mosaic and a very low altitude infrared imagery strip taken over the test site. The depicted contoured area is delineated on the thermal image. The largest areas of lowest elevation are labeled A, B, C, on the contour overlay and on the thermal image. These are the major areas of newly drifted snow which appear warm on the thermal image. The warmer surface temperature is believed to be due to solar radiation. It is suggested that solar heating is more effective on these smooth snow surfaces than on the adjacent rougher snow surfaces where shadows have the effect of retarding solar heating. Furthermore, the older, compacted snow, which had a greater density, is more favorable for heat conduction than the uncompacted snow, thus heat loss will be more rapid tending to leave it cooler.

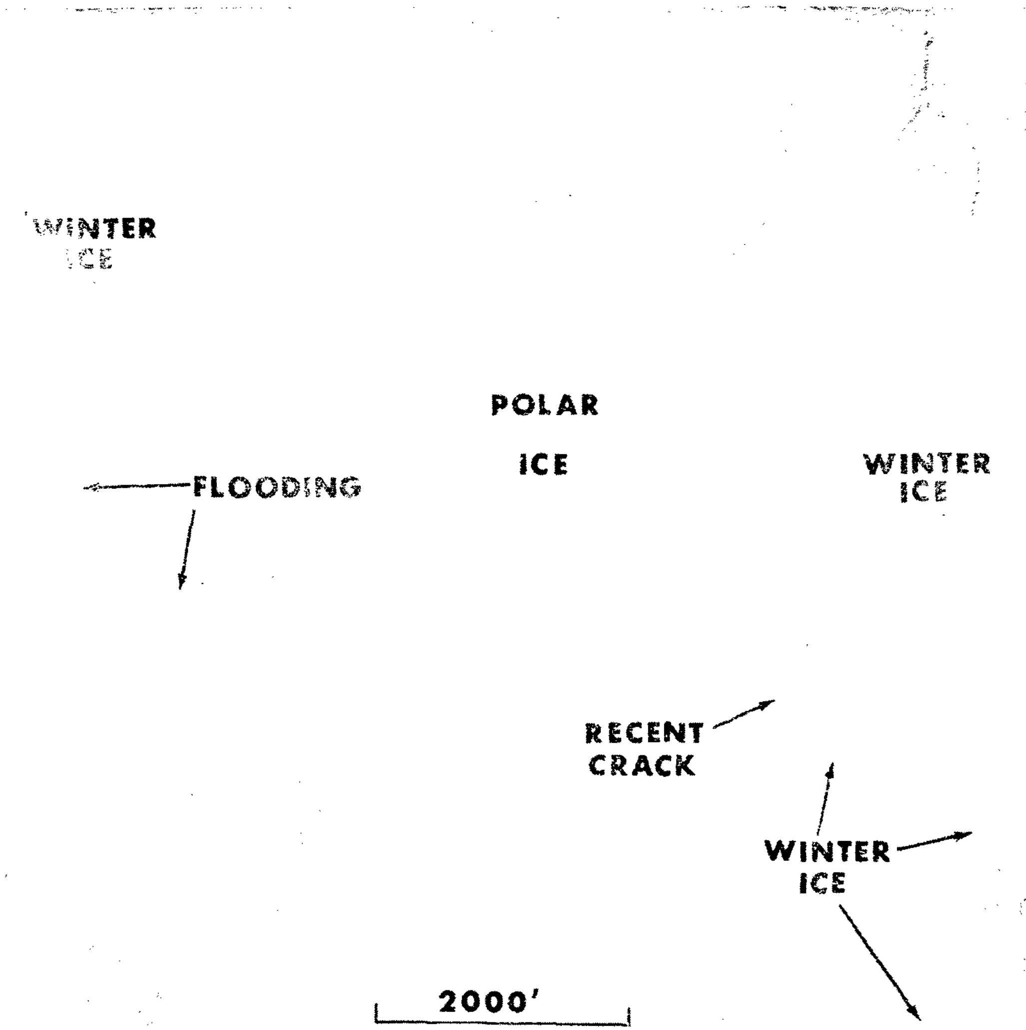
During analysis of the infrared imagery taken in the Arctic Basin during this mission, the questionable identification of other similar warm surface patterns arose several times. It could not be accurately determined if the surfaces were warmed primarily by heat conduction through a relatively thin, snow covered winter ice or by solar radiation on an uncompacted, undisturbed snow covered thick winter ice or polar ice. Correct interpretation of this condition would be extremely important to submariners or heat budget investigators using similar imagery.

ARCTIC BASIN IMAGERY

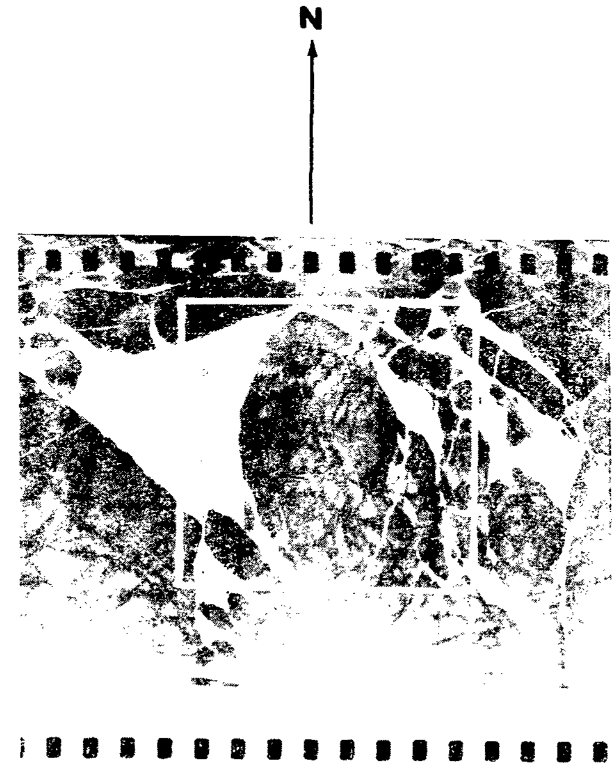
Figures 6 through 11 are examples of simultaneous photography and infrared imagery taken at various points over the Arctic Basin north of Greenland and Ellesmere Island. The photographed area is outlined on the imagery to facilitate comparison.

In Figure 6, recently developed narrow cracks and areas of winter ice in the polar pack ice are easily identified on the photograph and thermal image. The very warm toned thermal pattern of the winter ice areas indicates that these zones consist of recently formed thin ice. Further evidence of this brief existence is revealed in the relatively smooth and undisturbed condition of the surface. Areas of this nature have a profound effect on air-surface heat exchange in the Arctic Basin. The most recent fracturing is discerned as dark toned lines on the photo and light toned lines on the thermal image. The fractures cross winter ice and polar ice, seemingly without regard for ice thickness. The finest cracks in polar ice can be detected on the thermal image, when newly formed, because of their high temperature contrast with a cold polar ice background. Flooding of the winter ice, associated with the most recent fracturing, is depicted in very warm tones on the thermal image.

Figure 7 shows a wide zone of winter ice within the polar pack ice. The winter ice zone is portrayed in warm tones on the thermal image. The cold lineations criss-crossing the zone represents the pressure ridges which are also evident on the photography. Pressure ice effectively increases the ice thickness, thus retarding heat conduction to the surface. Note the thermal bands of medium gray tone closely associated with the pressure ridging and rafting. These bands undoubtedly represent areas where pressure ice has been forced under the level ice. This condition is not perceptible on the photograph. The light toned thermal lineation crossing the winter ice zone is directly associated with the ridging depicted in this area on the photograph. The high radiation temperature of the crack has masked the effect of temperature differential caused by the ridge, leaving it undetectable. The crack can not be identified on the photograph. The crack was probably caused by the weight of the ridge on the thin winter ice. The winter ice

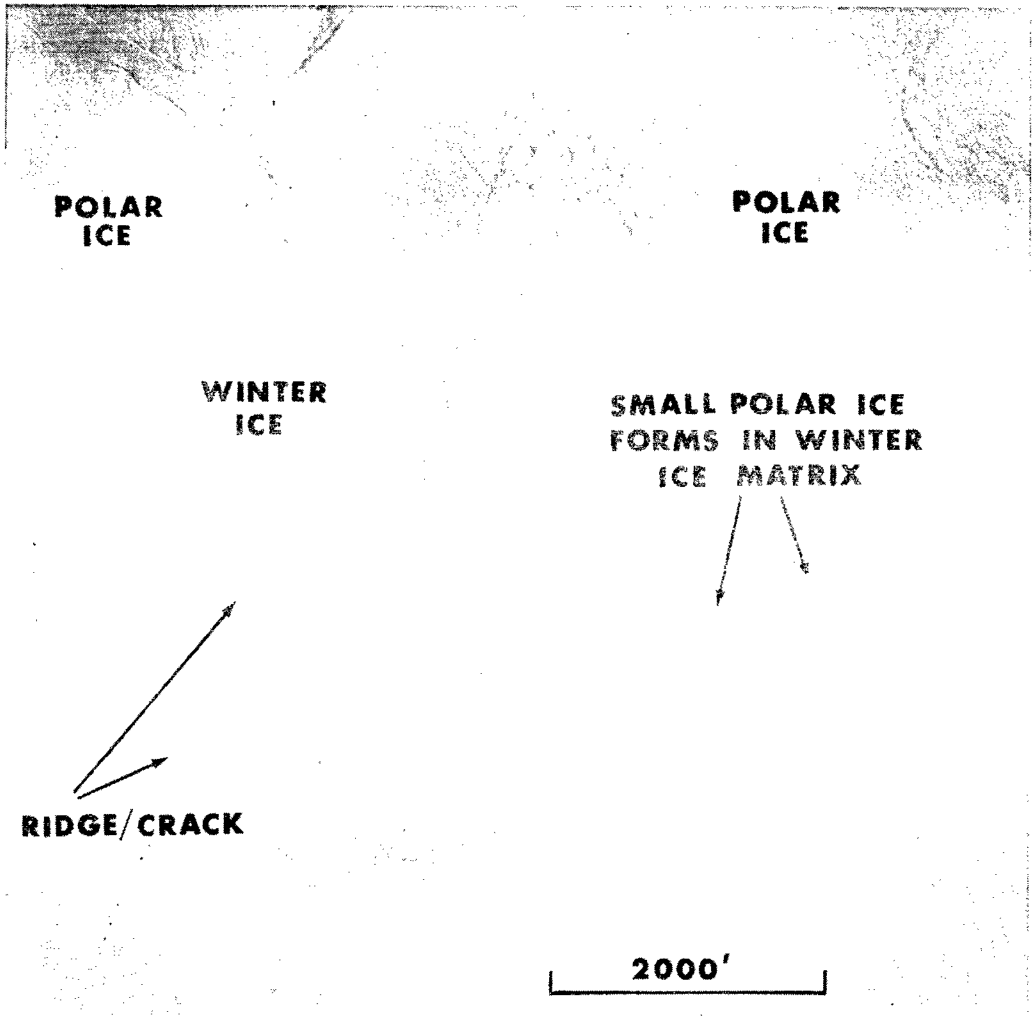


PHOTOGRAPHY



INFRARED

FIGURE 6 DATE: 8 APRIL 1964 TIME: 1810 GMT LOCATION: ARCTIC BASIN 87.1N 73.8W



PHOTOGRAPH

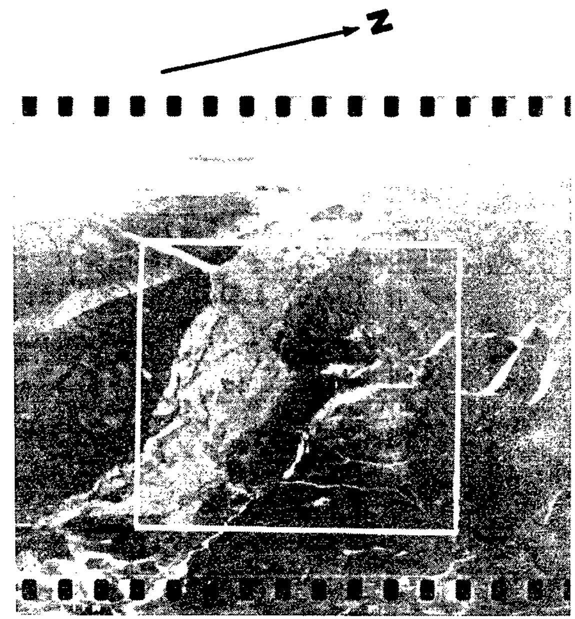


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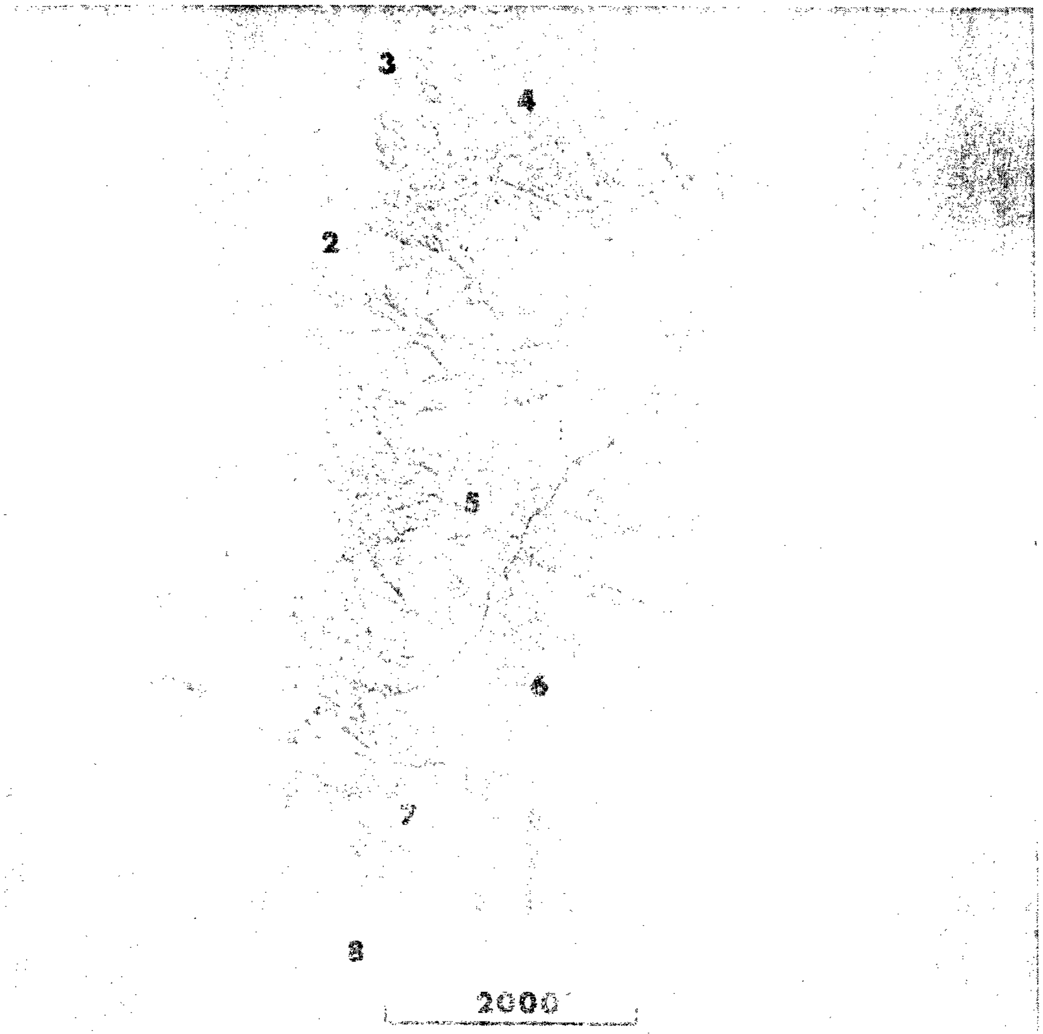
FIGURE 7 DATE: 8 APRIL 1964 TIME: 1604 GMT LOCATION: ARCTIC BASIN 85.8N 54.4W



PHOTOGRAPH

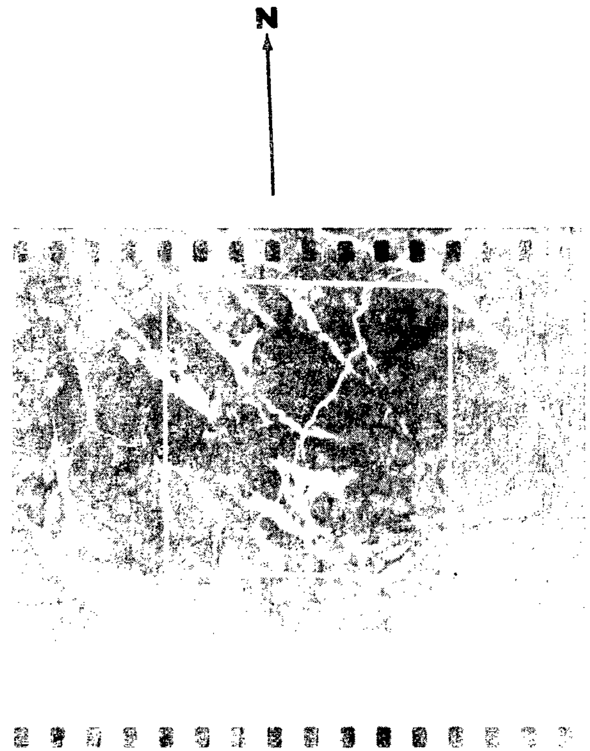


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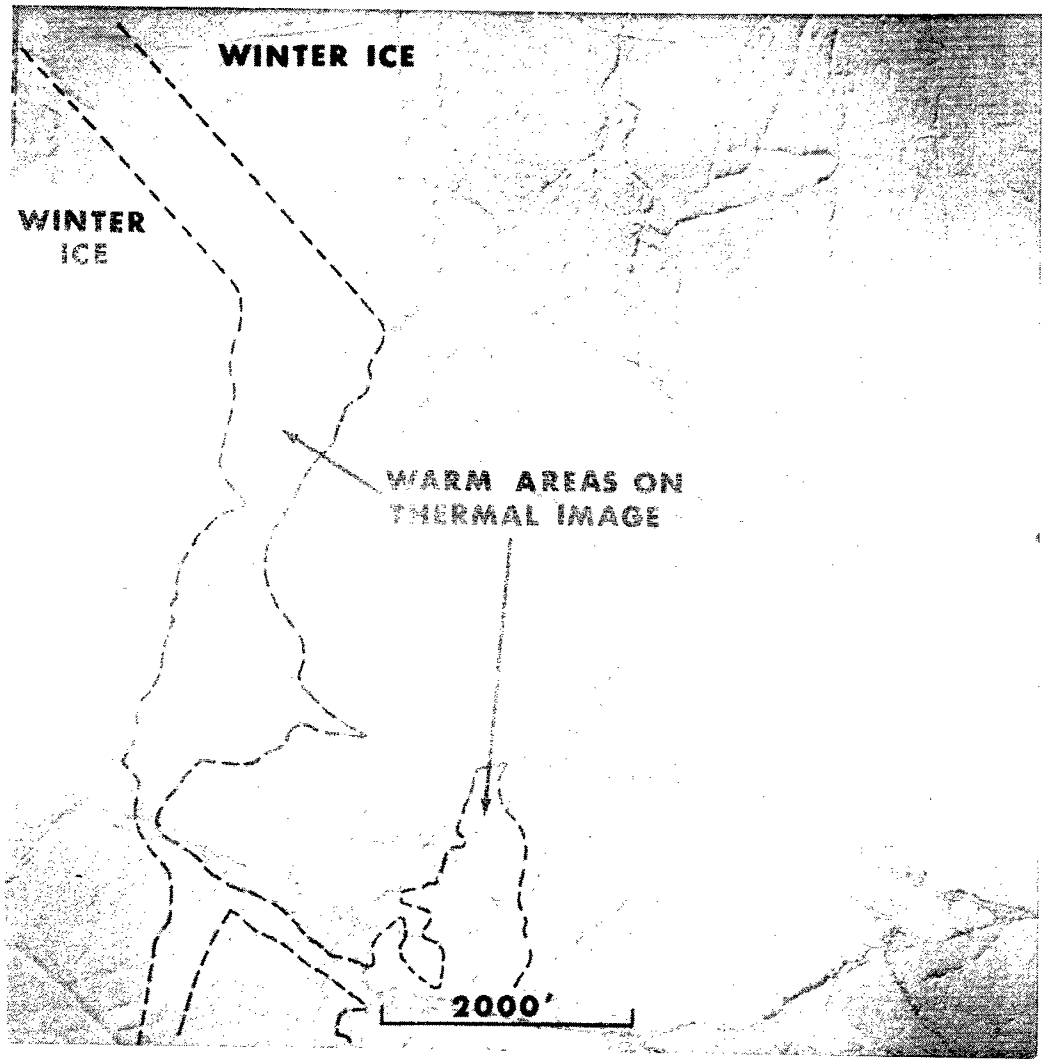
FIGURE 8 DATE: 8 APRIL 1964 TIME: 1807 GMT LOCATION: ARCTIC BASIN 87.0N 71.0W



PHOTOGRAPH

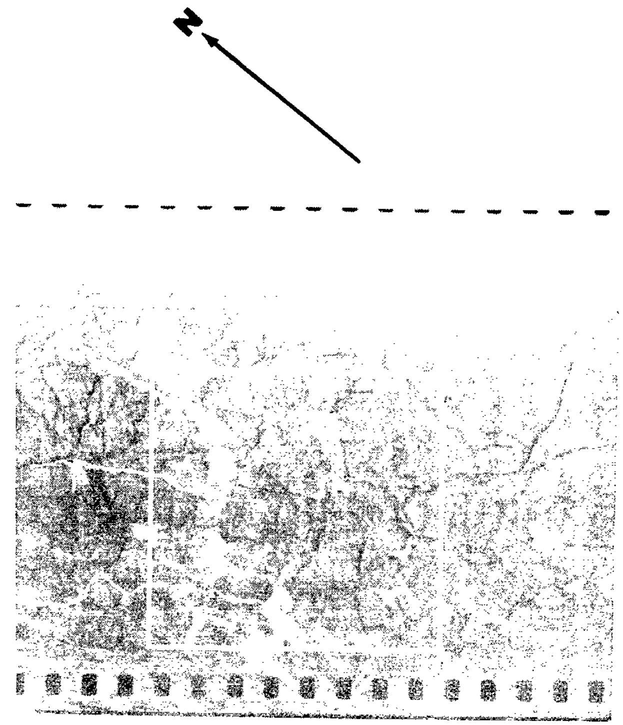


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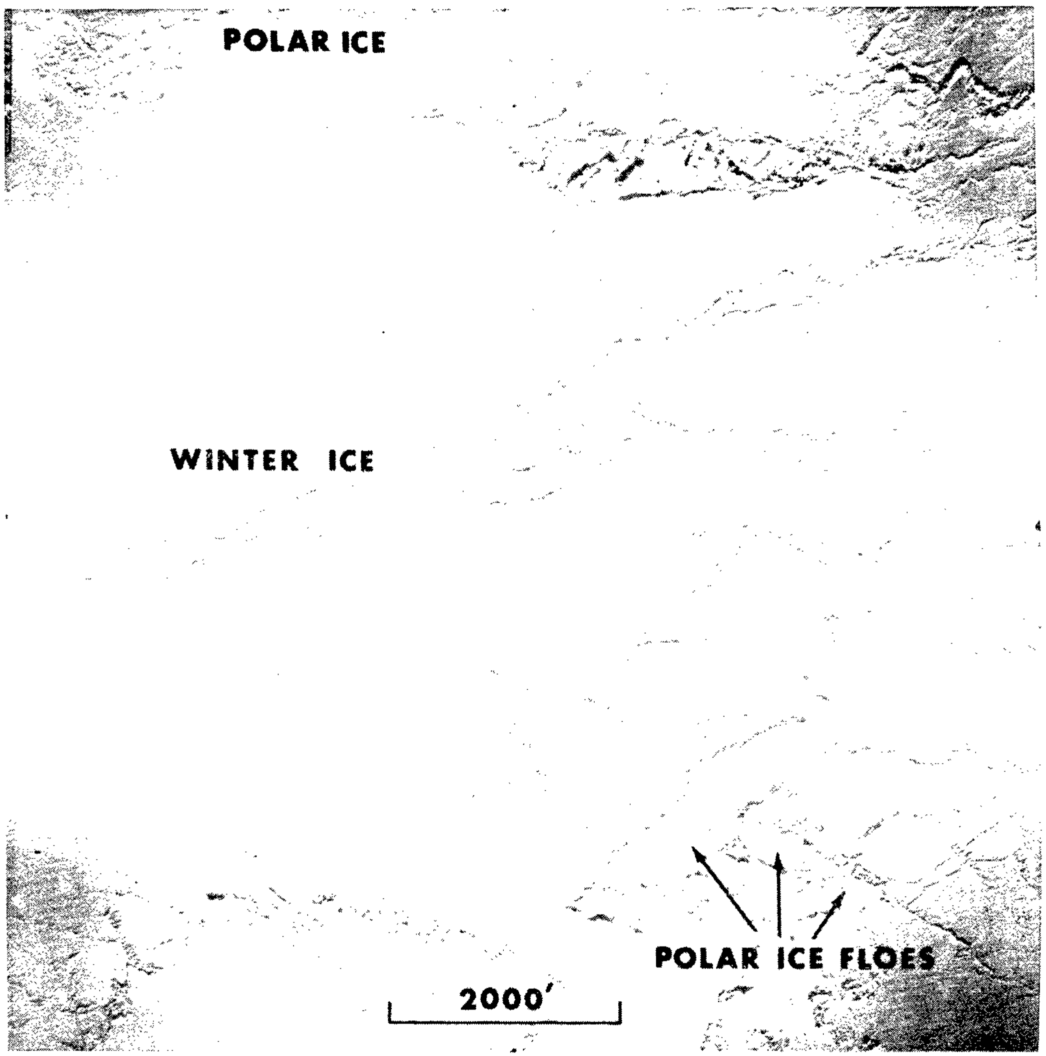
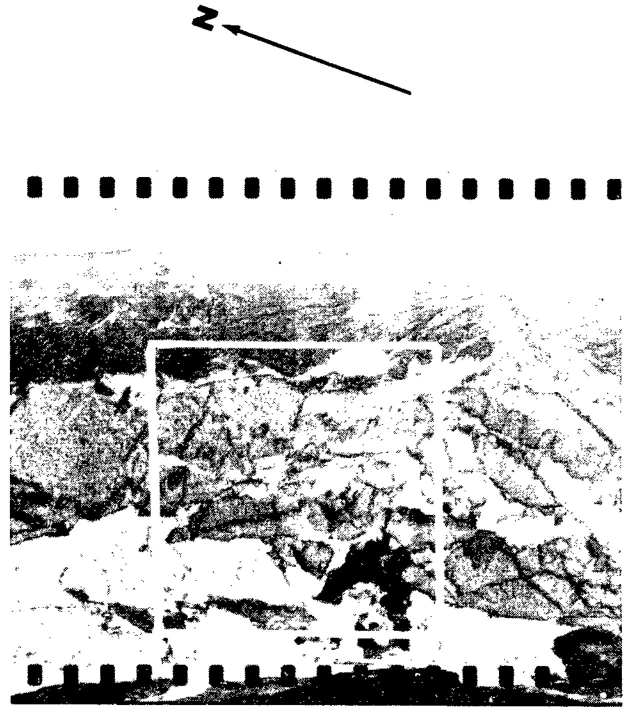
FIGURE 9 DATE: 8 APRIL 1964 TIME: 1922 GMT LOCATION: ARCTIC BASIN 85.1N 73.2W

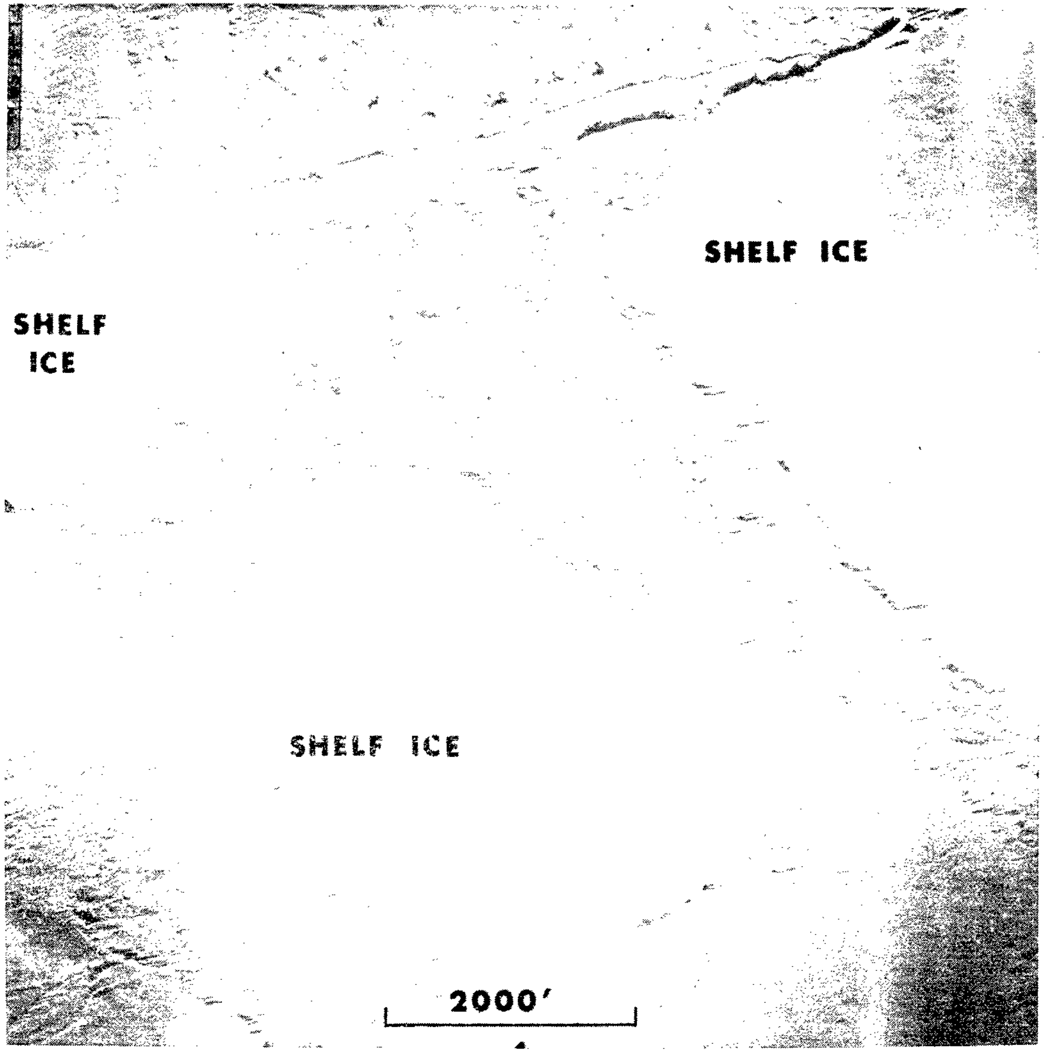


PHOTOGRAPH

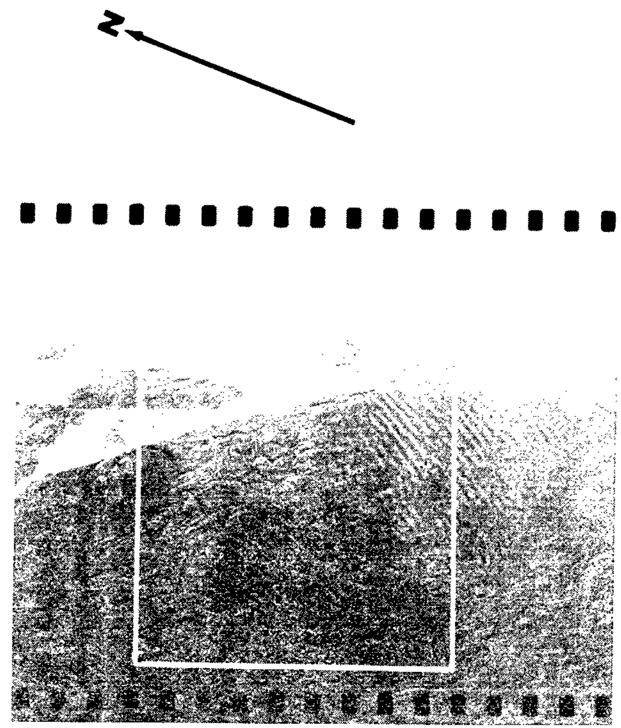


INFRARED

FIGURE 10 DATE: 8 APRIL 1964   TIME: 2004 GMT   LOCATION: ARCTIC BASIN 83.0N 64.0W



PHOTOGRAPH



INFRARED

FIGURE 11 DATE: 8 APRIL 1964 TIME: 2008 GMT LOCATION: ARCTIC BASIN 82.8N 63.5W

zone in the right-center portion of the photograph contains numerous small polar ice forms. Although most of these small polar ice forms are not distinguishable on the infrared imagery, they have the effect of darkening the thermal image gray tone.

In Figure 8 orientation patterns of winter ice areas are not nearly as discernible on the photograph as on the thermal image. The light toned areas stand out clearly against the dark toned polar ice background on the thermal image. However, on the photograph the photo tones of these areas (numbered) blend with the background tone of the polar ice and, since the areas are scattered and relatively small, their immediate detection is much more difficult. Most significant is the suggested dynamic history. The light toned patches on the thermal image indicate a fairly recent northwest-southeast fracturing of the ice canopy followed by a period of divergent action in this area. Subsequently, different stresses on the ice field have produced a much more recent northeast-southwest fracture. The thermal image not only permits easier detection of recent fracture zones in the polar pack ice, but also enables the interpreter to more readily group fractures of the same deformation period and to chronologically date deformation periods. This type of information is very significant to dynamic studies which relate ice deformation to factors such as changing ice motion caused by the changes in the wind stress field.

In Figure 9 a recently formed fracture pattern is very distinctive in the thermal image. However, it would be extremely difficult to identify this configuration on the photography without the aid of the thermal image. The band of medium gray crossing the thermal image probably represents an area of relatively old winter ice. This area, outlined, is not immediately discernible on the photograph due to snow cover. Close examination of the photograph reveals the area lacks old weathered pressure ridges and hummocks which are characteristic of the older polar ice. In the upper left corner of the photograph, a great deal of the ice surface would be interpreted as winter ice based on this criteria. Much of this area appears cool on the thermal image. It can not be stated with confidence whether the warmer thermal image is due to heat conduction through a relatively thin ice and snow cover or to solar heating on an uncompacted snow surface, or both.

In Figure 10 a wide zone of winter ice of varying age in the polar pack is easily recognized on the photograph and the thermal image. On the thermal image, two distinct periods of winter ice growth are clearly indicated by the light gray and medium gray image tones. This winter ice stage gradation is not perceptible on the photograph. The phenomena obviously represents two distinct periods of divergence or rarefraction in the polar pack ice. The ridged and rafted winter ice retard heat flow to the surface, thus is readily depicted on the thermal image by the random cold lineations. The many small snow drifts seen scattered over the winter ice on the photograph image as many dark specks on the thermal imagery. It is interesting to note that these relatively shallow snow accumulations very effectively isolate heat flow from the warm ice surface beneath them. Additionally note the apparent high surface thermal contrast between the two areas of winter ice. Photo interpretations clues indicate these areas are not much different in age — or thickness. It seems likely that there is a non-linear change in surface radiation temperature with small changes in ice thickness during the early stages of growth. The polar ice floes in the winter ice, in the lower-right corner, stand out as very cold features on the thermal image.

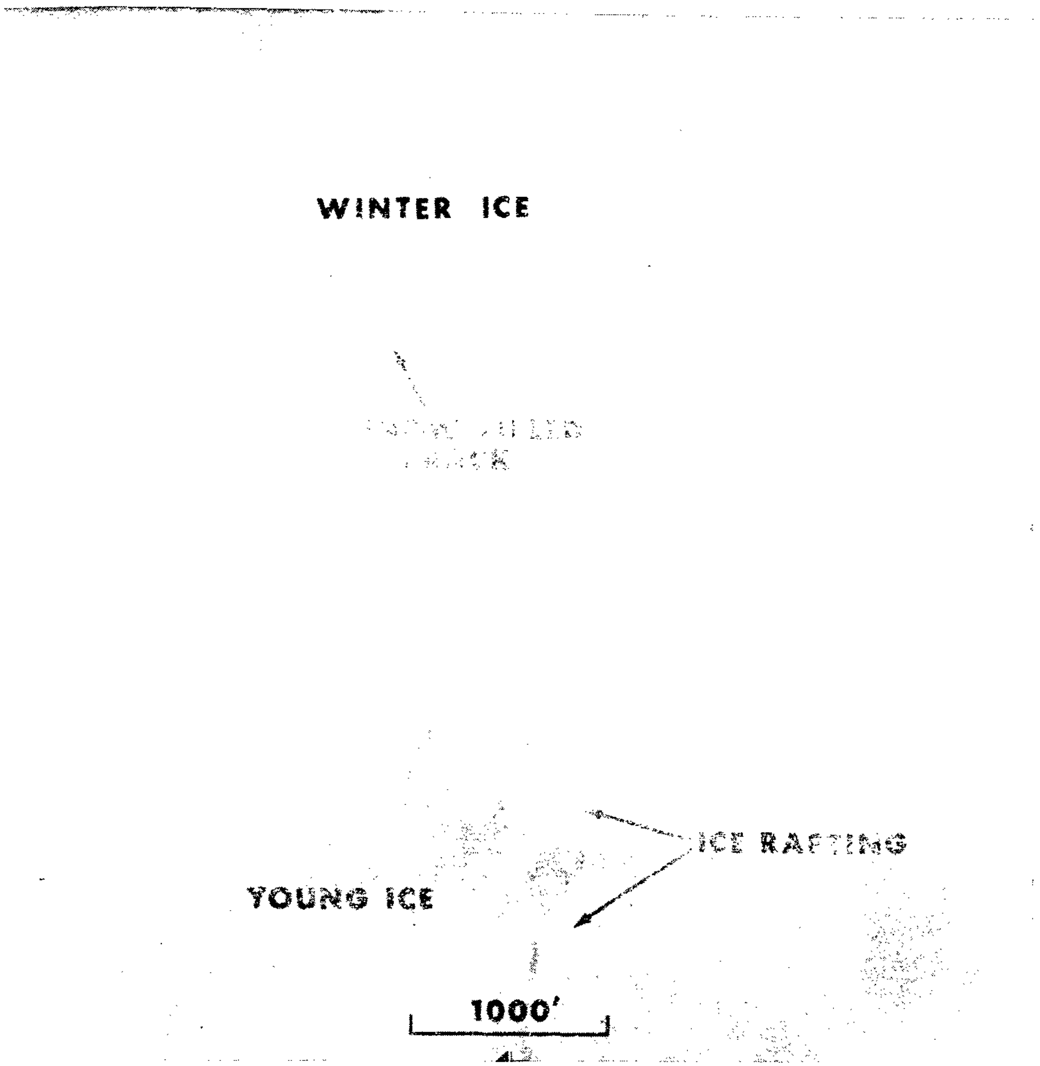
Figure 11 shows pieces of shelf ice frozen in the Arctic Basin pack ice off Cape Joseph Henry, North Ellesmere Island. The shelf ice forms are easily identified on the photography and thermal image because of their smooth, undulating surfaces. Solar heating on the slopes of the undulations caused the thermal image pattern. The snow drift pattern over the polar ice is evident on both records and indicates the direction of the most recent strong winds. It is interesting to note the differences in frequency of surface undulations of the larger pieces of shelf ice and the smaller piece at the upper-left corner of the photographed area.

BAFFIN BAY IMAGERY

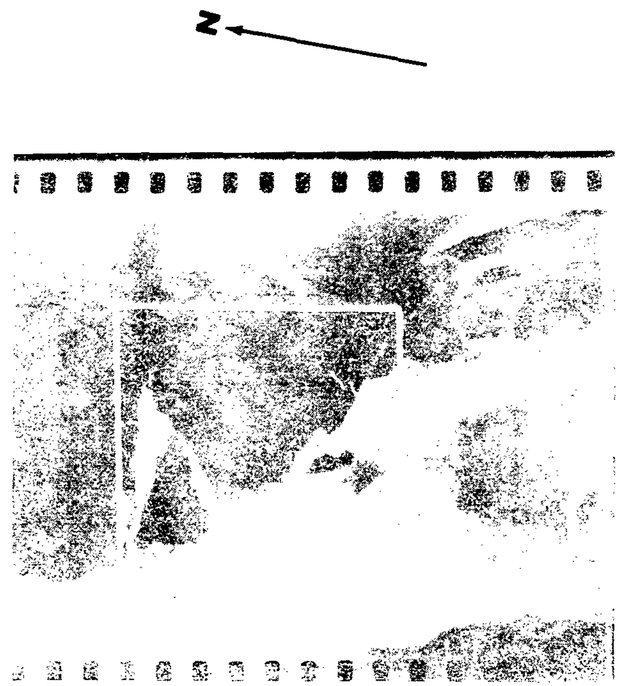
Figures 12 through 15 are examples of simultaneous photography and infrared imagery taken over Baffin Bay during the early morning on 12 April 1964.

Figure 12 shows a thin ice cover in northern Baffin Bay. Two distinct ages of ice are interpreted. The top half of the photographed area depicts a lightly snow covered thin winter ice which has suffered from some pressure ridging. On the thermal image the thin winter ice appears in dark (cool) tones and the pressure ice formations are distinguished by their darker tones. Evidence of underice rafting or pressure ice is revealed by the darker toned bands associated with the pressure ridges. A snow-filled crack crossing the winter ice is barely depicted on the image as a warm-toned line. Snow free thin ice is shown on the bottom of the photograph. This ice is probably new ice (less than 2 inches thick) or young ice (2-6 inches thick). Extensive ice rafting in the young ice is depicted in light tones on the photograph and dark tones on the thermal image.

In Figure 13, the winter ice on the right side of the photograph is interpreted to be older because of the extensive pressure ridging. On the thermal image the pressure ridges are clearly portrayed as a network of random cold features contrasted with a warm toned winter ice background. Since different heat flow rates control the thermal image, the pressure ridge formations have a widened appearance caused by the insulating effect of snow drifted around the ridges. Although the ridged area represents an older stage of development than

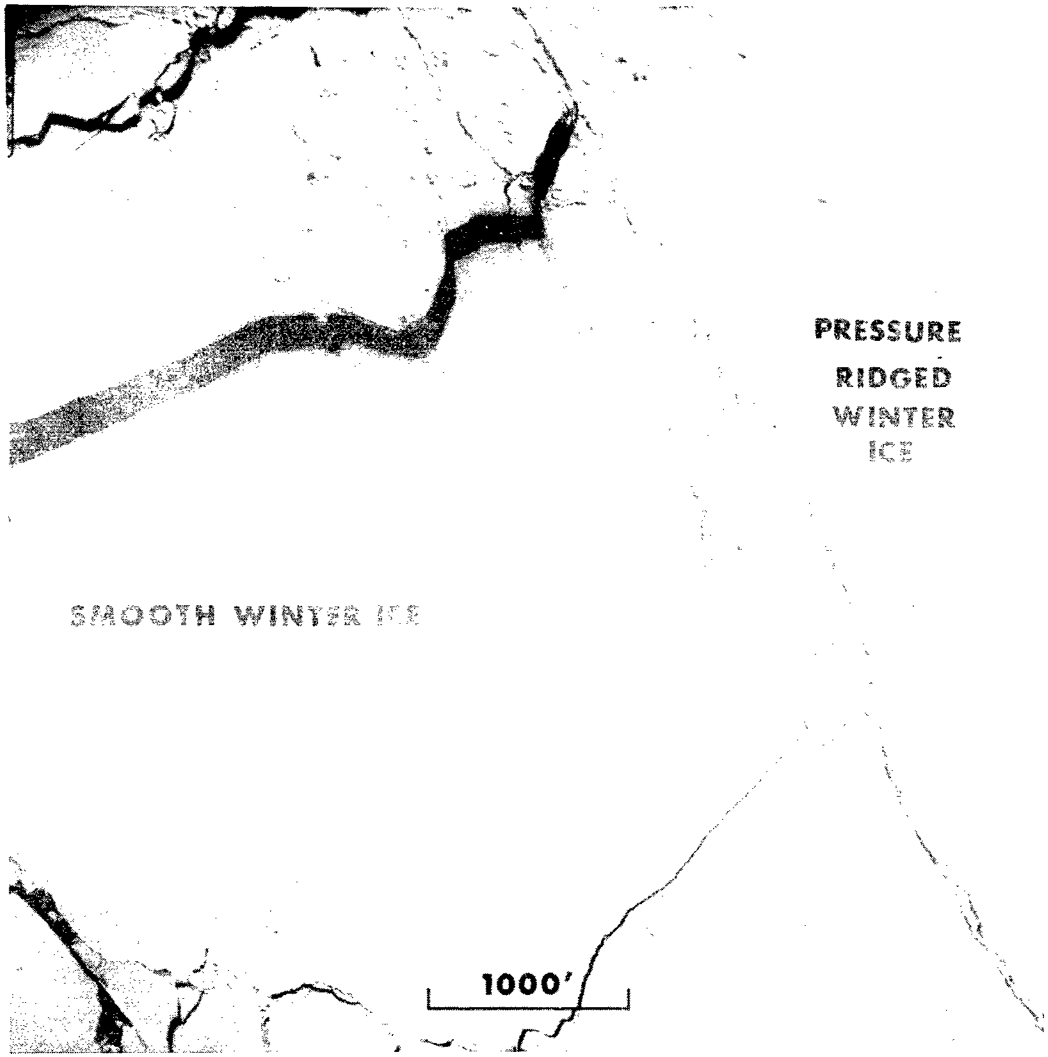


PHOTOGRAPH



INFRARED

FIGURE 12 DATE: 12 APRIL 1964 TIME: 1046 GMT LOCATION: BAFFIN BAY 74.4N 67.3W



PHOTOGRAPH

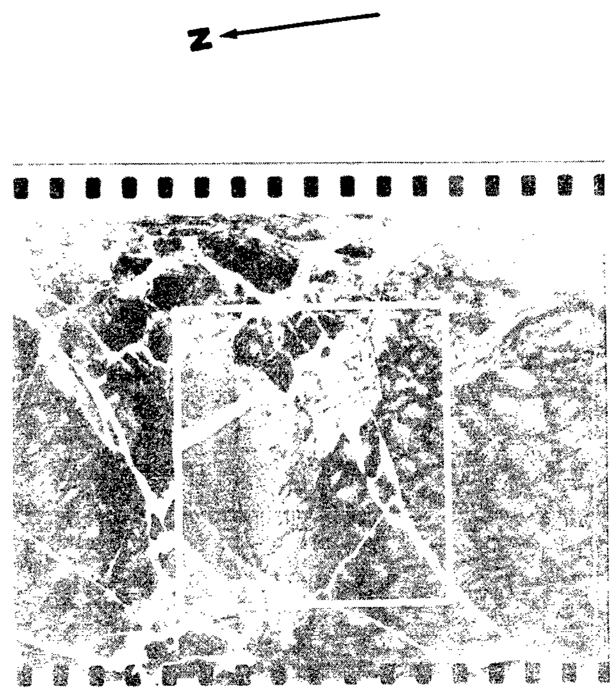


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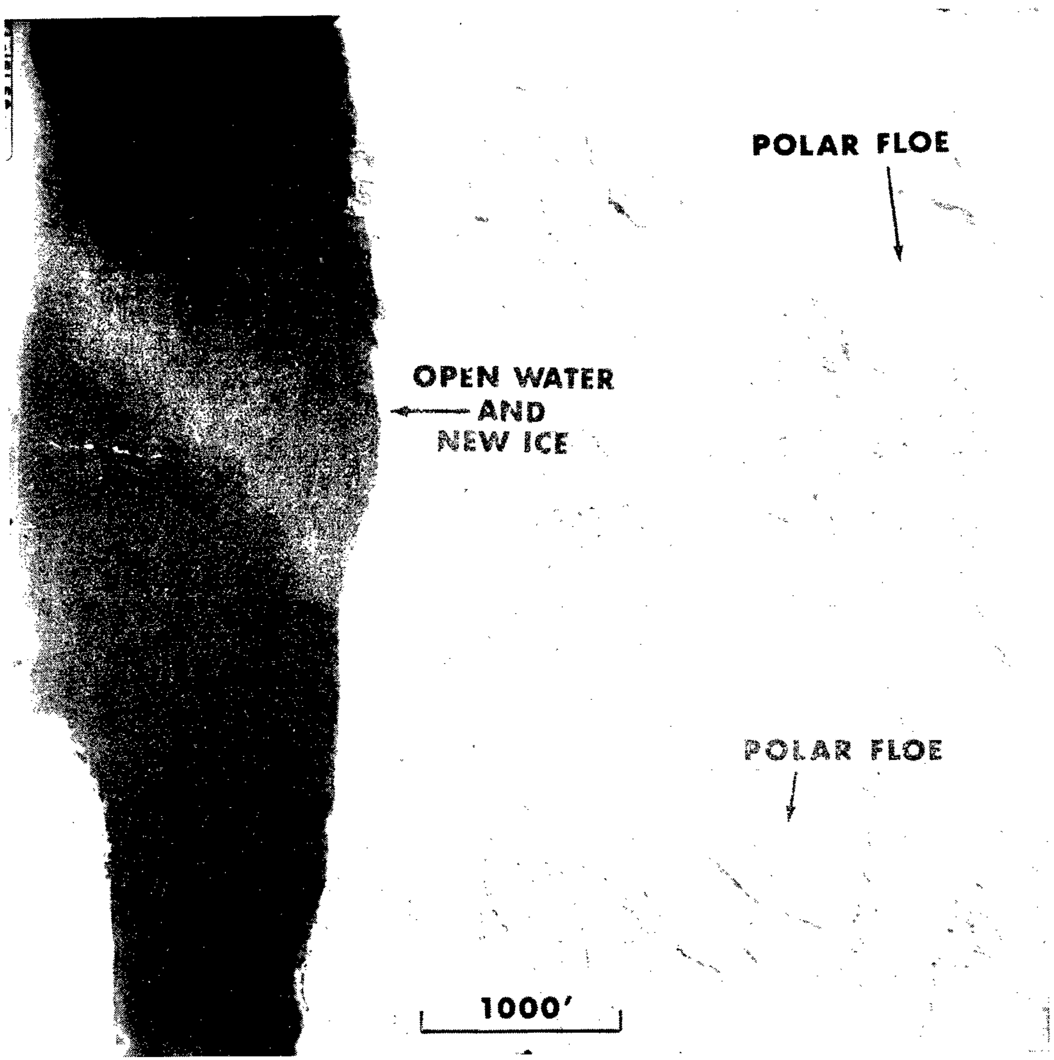
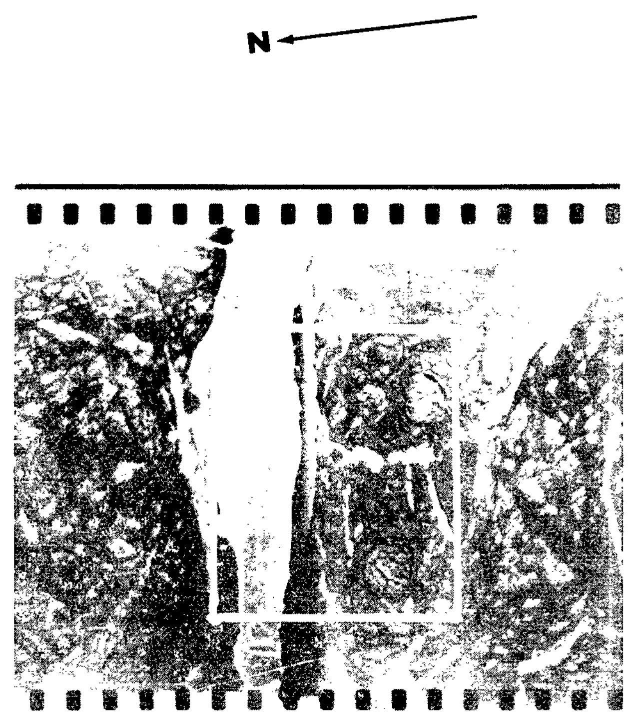
FIGURE 13 DATE: 12 APRIL 1964 TIME: 1233 GMT LOCATION: BAFFIN BAY 69.0N 61.7W

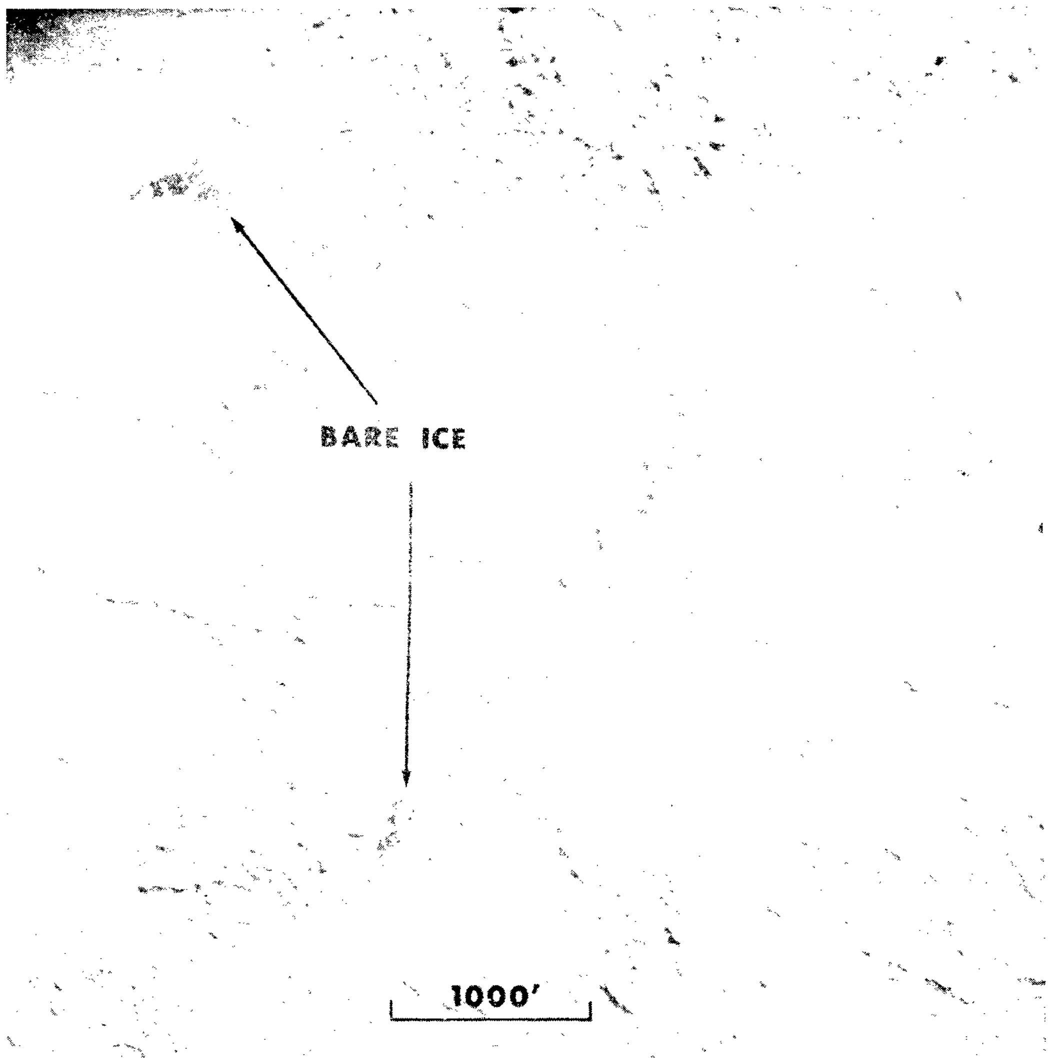


PHOTOGRAPH

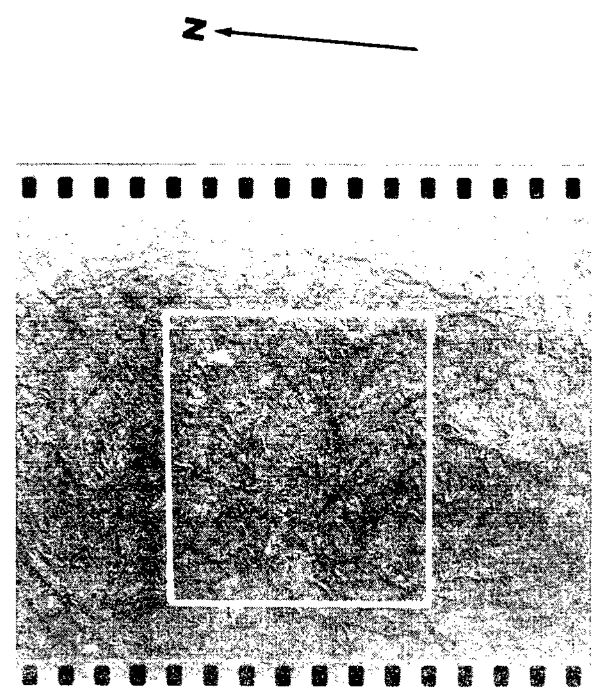


INFRARED

FIGURE 14 DATE: 12 APRIL 1964 TIME: 1235 GMT LOCATION: 68.9N 61.7W (BAFFIN BAY)



PHOTOGRAPH



INFRARED

FIGURE 15 DATE: 12 APRIL 1964 TIME: 1054 GMT LOCATION: BAFFIN BAY 74.1N 67.2W

the smooth surface on the left, the general background gray tones of the two areas appear similar on the thermal image. Note that part of the smooth winter ice is not covered by the many small snow drifts apparent over most of the area. This may indicate a different age between this area and the adjacent smooth area which is speckled with snow drifts. However, the background gray tone would not indicate this.

Figure 14 shows a wide lead with apparent areas of open water and very thin ice. When the infrared system began scanning this area (flight from left to right) images of surface temperature variations were wiped out due to the wide surface temperature range. But when the scanning was confined to the lead area where the total surface temperature range was much smaller, image tonal variations began to appear, distinguishing open water and very thin ice areas. Leaving the lead, a wide surface temperature range is again encountered. Two old wind-swept and well rounded polar ice floes, depicted on the right side of the photo appear warm on the thermal image compared to their background of winter ice which contains small polar ice fragments. This is probably due to differential effects of solar heating on the floes and their surroundings.

Figure 15 shows a portion of an old windswept polar ice floe in Baffin Bay. The distinct comparison between the illumination pattern on the photo and the thermal pattern on the image indicates the radiation temperature was dominated by solar heating. The hottest areas shown are patches of bare ice. These areas have a low reflectivity, thus appear in dark tones on the photo. The higher radiation absorption rate makes these areas warm compared to their surroundings.

CONCLUSIONS

The results of this investigation pertain to the extraction of sea ice information from infrared imagery taken during daylight conditions, and in general, under clear sky or scattered cloud conditions. The experiment demonstrated that quality sea ice information can be obtained during daylight periods using infrared scanning systems. Although the thermal imagery provides less sea ice surface detail than the photograph, it provides more useful and accurate information concerning the very important parameter of stage of ice development.

Incorporating present state-of-the-art instrumentation and imagery interpretation capabilities, the infrared reconnaissance system could be used effectively in the identification and mapping of recent zones of ice canopy deformation. An IR reconnaissance program designed to continually survey a given region would enable correlation of ice fracture systems with moving air pressure systems in the Arctic Basin and with other influencing environmental phenomena. A program of this nature would be highly productive in ice prediction investigations.

Surface thermal patterns vary markedly with changing conditions along the air-ice-water interface. Consequently, continued airborne experiments and surface environmental studies under varying atmospheric conditions, varying seasons and conditions of light will be necessary in order to become proficient in translating infrared data into usable information with high confidence levels.

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UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*	2a. REPORT SECURITY CLASSIFICATION
U. S. NAVAL OCEANOGRAPHIC OFFICE	UNCLASSIFIED
	2b. GROUP

3. REPORT TITLE

INFRARED SCANNING THE ARCTIC PACK ICE

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Informal Report

5. AUTHOR(S) *(First name, middle initial, last name)*

R. D. Ketchum, Jr. W. I. Wittmann

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1968	30	4

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. HF 05 552 302	IR NO. 68-115
c. 709-FE-DAF	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d. 62101N	

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Naval Oceanographic Office

13. ABSTRACT

The U. S. Naval Oceanographic Office conducted its first infrared scanning experiment in the Arctic Basin during daylight conditions in April 1964. Many miles of coincident infrared scanner imagery and vertical photography were obtained over a large area of the Arctic Basin pack ice between North Ellesmere Island and 87°N and in Baffin Bay. A surface control site for "ground truth" data was established on the pack ice at the drifting ice station ARLIS II, then located at 86°30'N 48°57'W. Several overflights at various altitudes were made in this area. The experiment demonstrated that quality sea ice information can be obtained during daylight periods using infrared scanning systems. Incorporating present state-of-the-art instrumentation and imagery interpretation capabilities, the infrared reconnaissance system could be used effectively for identification and mapping of recent zones of ice canopy deformation. Continued airborne experiments and surface environmental studies under varying atmospheric conditions, varying seasons and conditions of light will be necessary to become proficient in translating infrared data into usable information with high confidence levels.

This report presents illustrations of infrared imagery with coincident visual photography. A discussion of interpretations is presented along with brief mention of applications and limitations of the infrared scanner to Navy sea ice studies.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
INFRARED SCANNING THE ARCTIC PACK ICE						