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SYNTHETIC APERTURE RADAR IMAGERY OF THE AIDJEX TRIANGLE

by

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ABSTRACT

Imaging radar mosaics of the AIDJEX triangle are presented together with a brief discussion of the radar sensor used in the data collection.

INTRODUCTION

During the 1975-76 AIDJEX field program, airborne radar imagery of the AIDJEX triangle was obtained during 15 flights in April, August, and October 1975 and April 1976 as part of the AIDJEX remote sensing activities [Weeks et al., 1974; Campbell et al., 1976]. This report presents the preliminary mosaics and discusses the radar instrument used.

RADAR SENSOR AND IMAGING GEOMETRY

The sensor used was the Jet Propulsion Laboratory (JPL) L-band dual-polarization synthetic-aperture imaging radar. During the April 1976 flights, an X-band channel was added to the system. The radar, as well as other remote sensors, was mounted on the NASA Ames CV-990 aircraft.

The basic parameters of the radar sensor are summarized in Table 1. This sensor is a research instrument and, as such, has been subjected to numerous

TABLE 1

JPL IMAGING RADAR PARAMETERS

	L-Band	X-Band
Transmitted peak power	7 kW	50 kW
Frequency (wavelength)	1215 MHz (25 cm)	9600 MHz (3 cm)
PRF	1 kHz at platform velocity ($v = 250$ m sec ⁻¹)	Same as L-band
Pulsewidth	1.25 μ sec	Same as L-band
Bandwidth	10 MHz	Same as L-band
Antenna, phased array	75 cm \times 25 cm for each polarization	81 cm \times 3 cm for each polarization
Polarization	HH, HV, and VV	HH
Beam	Range beamwidth 90° centered 45° of vertical azimuth beamwidth 18°	Range beamwidth centered at azimuth beamwidth 1.5°
Recorder	Goodyear 102	Same

design and hardware modifications during the 1975-76 period. As a result, the quality of the data is much better for the last three series of flights than for the first one, in April 1975. A Sensitivity Time Control (STC) system has been added which increases the receiver gain as a function of time to compensate for the decrease in brightness across the image. Most of the data were taken with HH polarization (i.e., transmitted and received waves are horizontally polarized). Some data were taken in the HV and VV polarization modes.

The radar produces a high resolution (25 \times 25 m), two-dimensional representation of the Earth's surface. The image brightness is directly proportional to the radar backscatter cross section of the surface, which in turn is a function of the properties (roughness, inhomogeneities, and dielectric constant) of the surface and the region immediately below it. Given sufficient power, the radar resolution is independent of the altitude of the sensor platform. Thus, the type of image presented here is somewhat similar

to what is expected from the imaging radar sensor; the reader is referred to the literature [Goodman, 1968; Rihaczek, 1969; Harger, 1970].

The JPL SLAR system is different from the usual synthetic-aperture imaging radars which operate at grazing angles, in that it is specifically designed to simulate a spaceborne radar. Thus, we obtain data from the nadir location (directly along the flight line beneath the aircraft) and out to an angle of 55° off nadir. As seen in Figure 1, this configuration leads to a geometric deformation (compression) in the near range. Although the compression can be geometrically corrected through digital processing [Thompson et al., 1972], the images presented in this report have not been corrected. Figure 2 gives an example of such geometric correction.

Another observable effect in the radar imagery is a change in the average brightness across the image. This effect is due to a decrease in the average backscatter cross section and the increase in the distance from the radar antenna to the Earth's surface (i.e., slant range) as the incidence angle increases. Thus, on the average, the imagery appears brighter in the near range (especially at the nadir), and this obviously has a direct influence on the interpretation. The controllable calibrated gain system (STC) which increases the receiver gain compensates for this decrease in brightness. However, although this gain compensation is integrated into the system, it is still difficult to make absolute comparisons of image brightness from ground areas at different ranges of the radar imager. A comparison of the April 1975 and October 1975 mosaics clearly shows the results of the addition of STC to the radar system.

Because a synthetic-aperture radar uses coherent electromagnetic waves to synthesize the long baseline aperture, there is a speckled appearance in the radar imagery similar to that observed when a rough surface is illuminated with coherent laser light. This speckling must also be considered when conducting detailed interpretations.

Although the altitude has no major effect on the resolution of the radar imagery (because it is synthetic-aperture rather than real aperture or "brute force" radar), the width of the imaged swath on the Earth's surface is directly related to the altitude of the aircraft. The antenna has a "field of view" which extends from nadir through 90° to the right of the aircraft. However,

the area imaged is limited by the maximum width of the film in the optical recorder. For the JPL system this is limited to a 14 km swath for a flight altitude of 10,000 m.

RADAR MOSAICS

Figure 3 indicates the general drift of the AIDJEX triangle during the study period. A total of 18 mosaics of imaging radar data are presented in Figures 4-21 as a catalog of the available data (Table 2). During the flights over the triangle, it was often possible to fly a full and complete radar

TABLE 2

SAR MOSAICS OF THE AIDJEX TRIANGLE INCLUDED IN THIS REPORT

Figure No.	Phase	Date	Band/Polarization
4	I	13 Apr 1975	L(HH)
5	I	21 Apr 1975	L(HH)
6	I	22 Apr 1975	L(HH)
7	I	24 Apr 1975	L(HH)
8	I	26 Apr 1975	L(HH)
9,10	II	18 Aug 1975	L(HH),L(HV)
11	II	22 Aug 1975	L(HH)
12	II	27 Aug 1975	L(HH)
13	III	10 Oct 1975	L(HH)
14	III	15 Oct 1975	L(HH)
15	III	26 Oct 1975	L(HH)
16,17	IV	12 Apr 1976	L(HH),X(HH)
18,19	IV	16 Apr 1976	L(HH),X(HH)
20,21	IV	21 Apr 1976	L(HH),X(HH)

mosaic of the area. In other instances, the constraints of other aspects of the mission allowed only a partial mosaic. This is because the SAR collects data only to the right of the aircraft flight track; two flights in opposite directions, or more closely spaced flights in one direction, would be required for complete SAR mosaics. For both complete and incomplete mosaics, we have placed the imagery on a grid to indicate their locations within the AIDJEX triangle.

Each mosaic has been annotated as being "uncorrected." This term refers to three items:

1. No type of averaging has been applied to the signal for the changes in radar sensitivity with increased range. This is especially prominent in the phase I mosaics (April 1975), which were collected before the STC was added to the system.
2. No geometric corrections have been performed on the mosaics to remove distortions resulting from the slant range format of the SAR configurations (Figure 1).
3. The mosaics have not been made with "photogrammetric" accuracy and, therefore, the positions of the various data strips on the underlying grid are offered primarily for general locations and not for detailed studies.

ACKNOWLEDGMENT

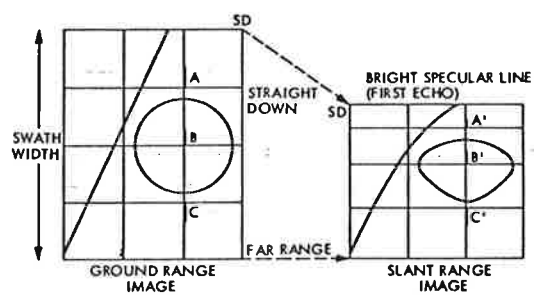
This paper presents the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract NAS7-100, sponsored by the National Aeronautics and Space Administration.

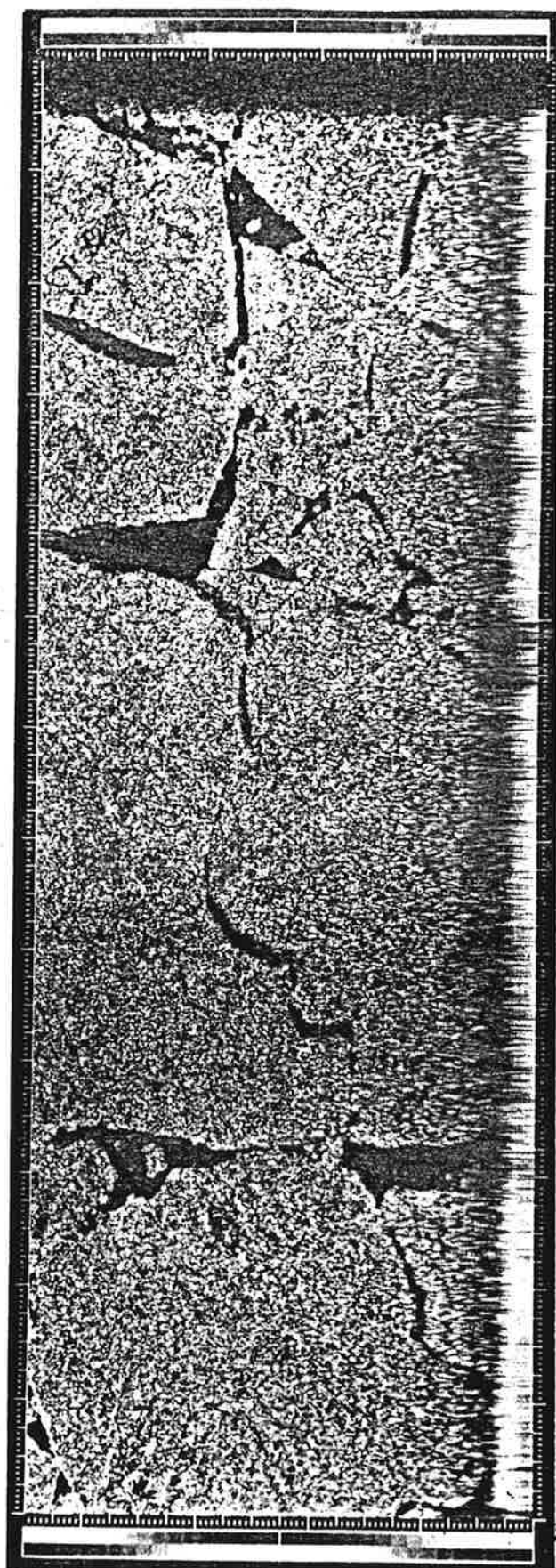
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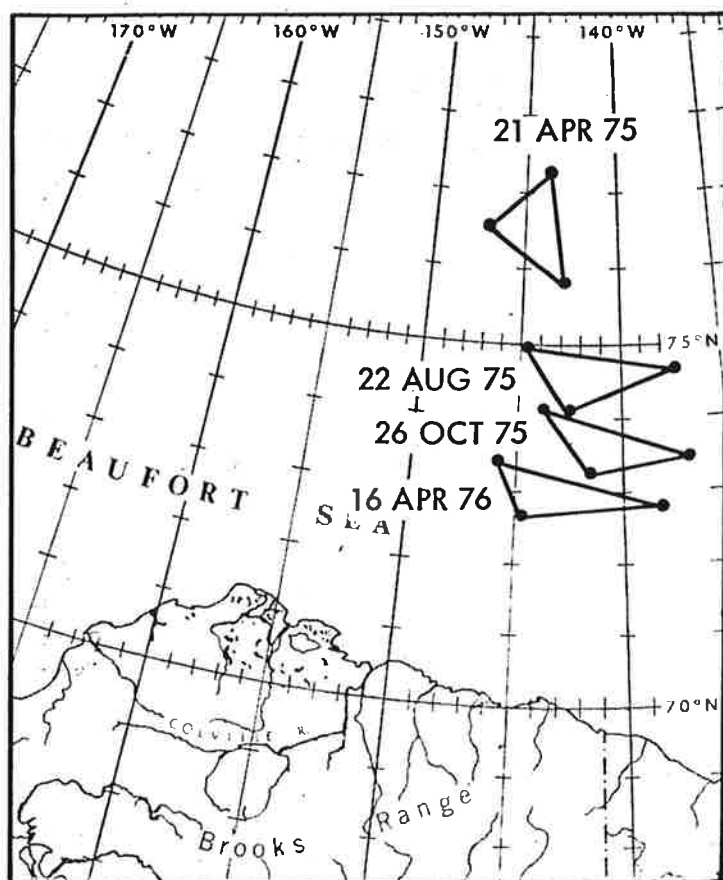
- Campbell, W. J., et al. 1976. Microwave remote sensing of sea ice in the AIDJEX main experiment. IUCRM Hamburg Meeting, 1976.
- Goodman, J. E. 1968. *Introduction to Fourier Optics*, McGraw-Hill, San Francisco, CA.
- Harger, R. O. 1970. *Synthetic Aperature Radar Systems*, Academic Press, N.Y.
- Rihaczek, A. W. 1969. *Principles of High Resolution Radar*, McGraw-Hill, N.Y.
- Thompson, T. W., R. S. Bishop, and W. E. Brown. 1972. Progress report on 25 cm radar observations of the 1971 AIDJEX studies. *AIDJEX Bulletin*, 12, 1-15.
- Weeks, W. F., M. D. Coon, and W. J. Campbell. 1974. The remote sensing program required for the AIDJEX model. *AIDJEX Bulletin*, 27, 22-44.

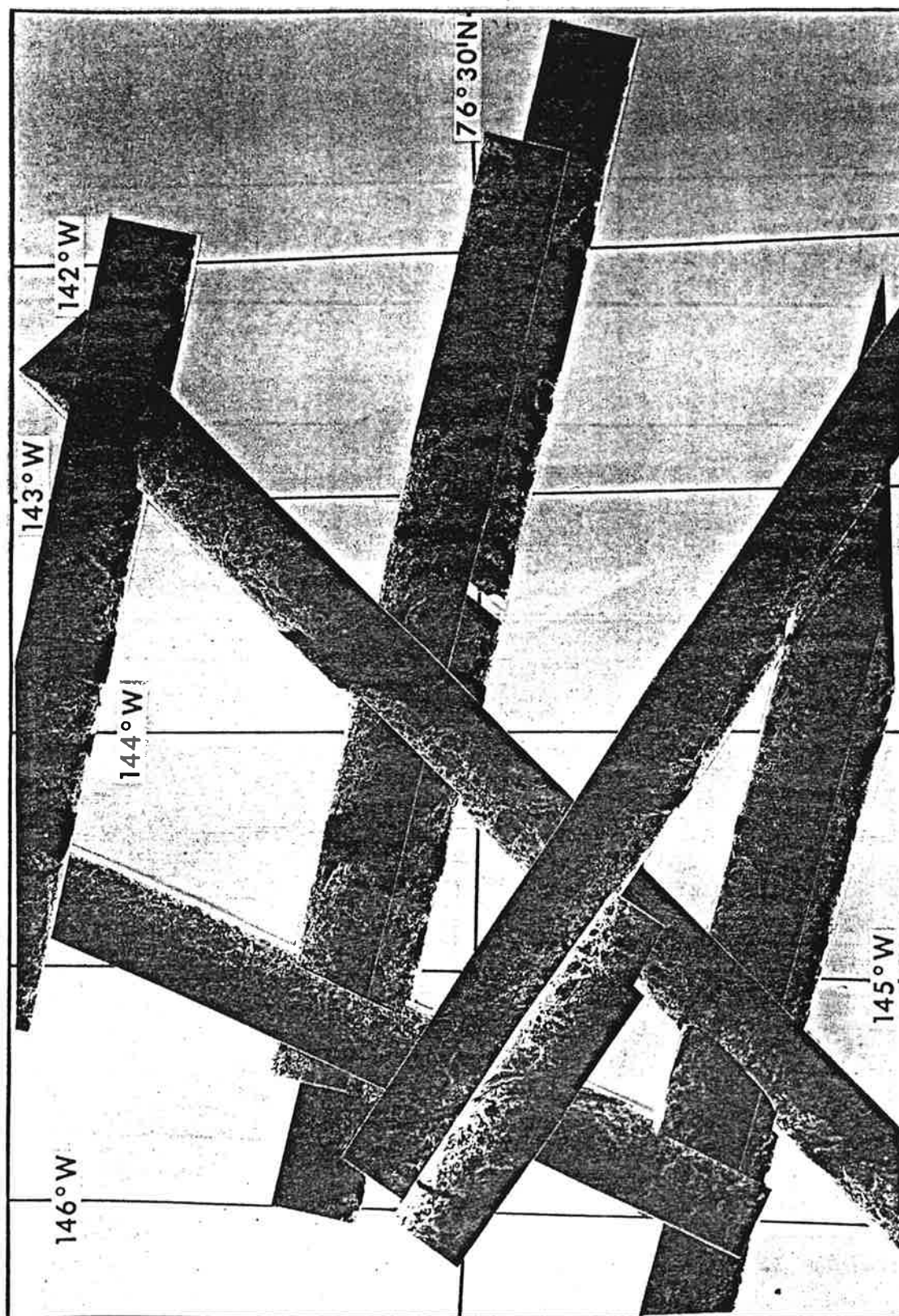
FIGURE LEGENDS

- Fig. 1. Geometry of synthetic aperture radar imagery from JPL radar system.
- Fig. 2. Geometric correction of JPL L(HH) SAR imagery. (2a) original imaged data, (2b) geometrically corrected SAR data. Note major geometric changes in near range (left, stretching) and far range (right, compression).
- Fig. 3. Locations of AIDJEX triangle during collection of SAR data.
- Fig. 4. Uncorrected L(HH) mosaic, 13 April 1975.
- Fig. 5. Uncorrected L(HH) mosaic, 21 April 1975.
- Fig. 6. Uncorrected L(HH) mosaic, 22 April 1975.
- Fig. 7. Uncorrected L(HH) mosaic, 24 April 1975. Note presence of only parallel data sets, without overlap, making it impossible to tie the data together.
- Fig. 8. Uncorrected L(HH) mosaic, 26 April 1975. (See comment for Fig. 7.)
- Fig. 9. Uncorrected L(HH) mosaic, 18 August 1975. Note difference in tone between northernmost data run and rest of mosaic; it is a function of the system settings and can be corrected by image processing.
- Fig. 10. Uncorrected L(HV) mosaic, 18 August 1975. (Compare with Fig. 9.)
- Fig. 11. Uncorrected L(HH) mosaic, 22 August 1975. (See comment for Fig. 7.)
- Fig. 12. Uncorrected L(HH) mosaic, 27 August 1975. (See comment for Fig. 7.) Banding in central strip of mosaic is caused by recording film's being light-struck at end of roll.
- Fig. 13. Uncorrected L(HH) mosaic, 10 October 1975. (See comment for Fig. 9.)
- Fig. 14. Uncorrected L(HH) mosaic, 15 October 1975. (See comment for Fig. 12.)
- Fig. 15. Uncorrected L(HH) mosaic, 26 October 1975. Note lack of image overlap, a result of slight navigational error in south-central portion of area.
- Fig. 16. Uncorrected L(HH) mosaic, 12 April 1976. (See comment for Fig. 7.)
- Fig. 17. Uncorrected X(HH) mosaic, 12 April 1976. Compare with Fig. 16.
- Fig. 18. Uncorrected L(HH) mosaic, 16 April 1976. Note large amount of overlap and small areas of missing data in southwest portion of study area.
- Fig. 19. Uncorrected L(HH) mosaic, 16 April 1976. Compare with Fig. 18.
- Fig. 20. Uncorrected L(HH) mosaic, 21 April 1976. Note breaks in south-central data strip caused by slight change in azimuth scale when compared with adjacent strip.
- Fig. 21. Uncorrected X(HH) mosaic, 21 April 1976. Compare with Fig. 20.







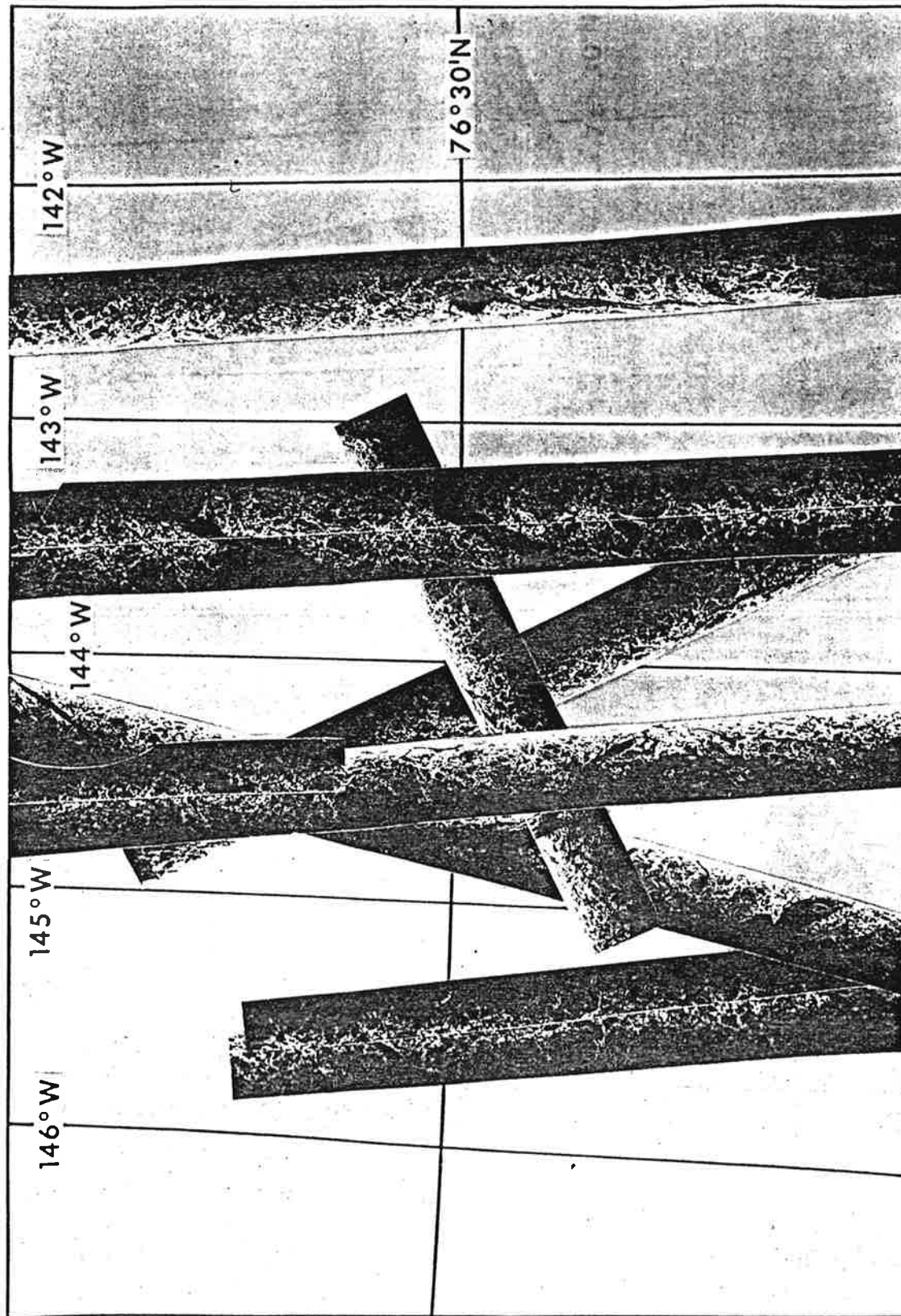


ARCTIC
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PROGRAM—I



AIDJEX TEST SITE SYNTHETIC APERTURE RADAR MOSAIC
L-BAND -HH POLARIZATION (UNCORRECTED)

Figure 4 13 APRIL 1975



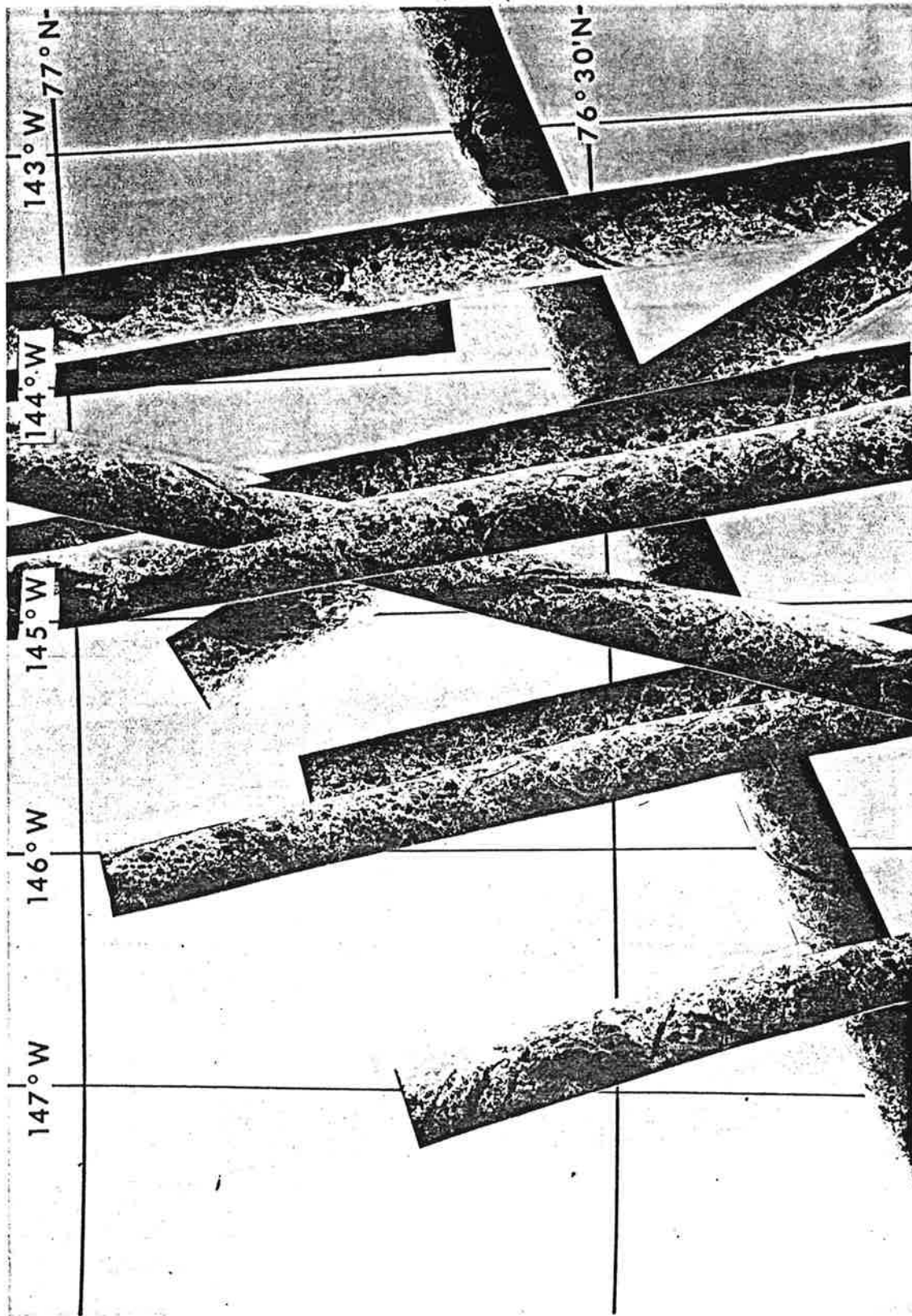
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EXPERIMENT
PROGRAM-I



AIDJEX TEST SITE SYNTHETIC APERTURE RADAR MOSAIC
L-BAND -HH POLARIZATION (UNCORRECTED)

21 APRIL 1975

Figure 5

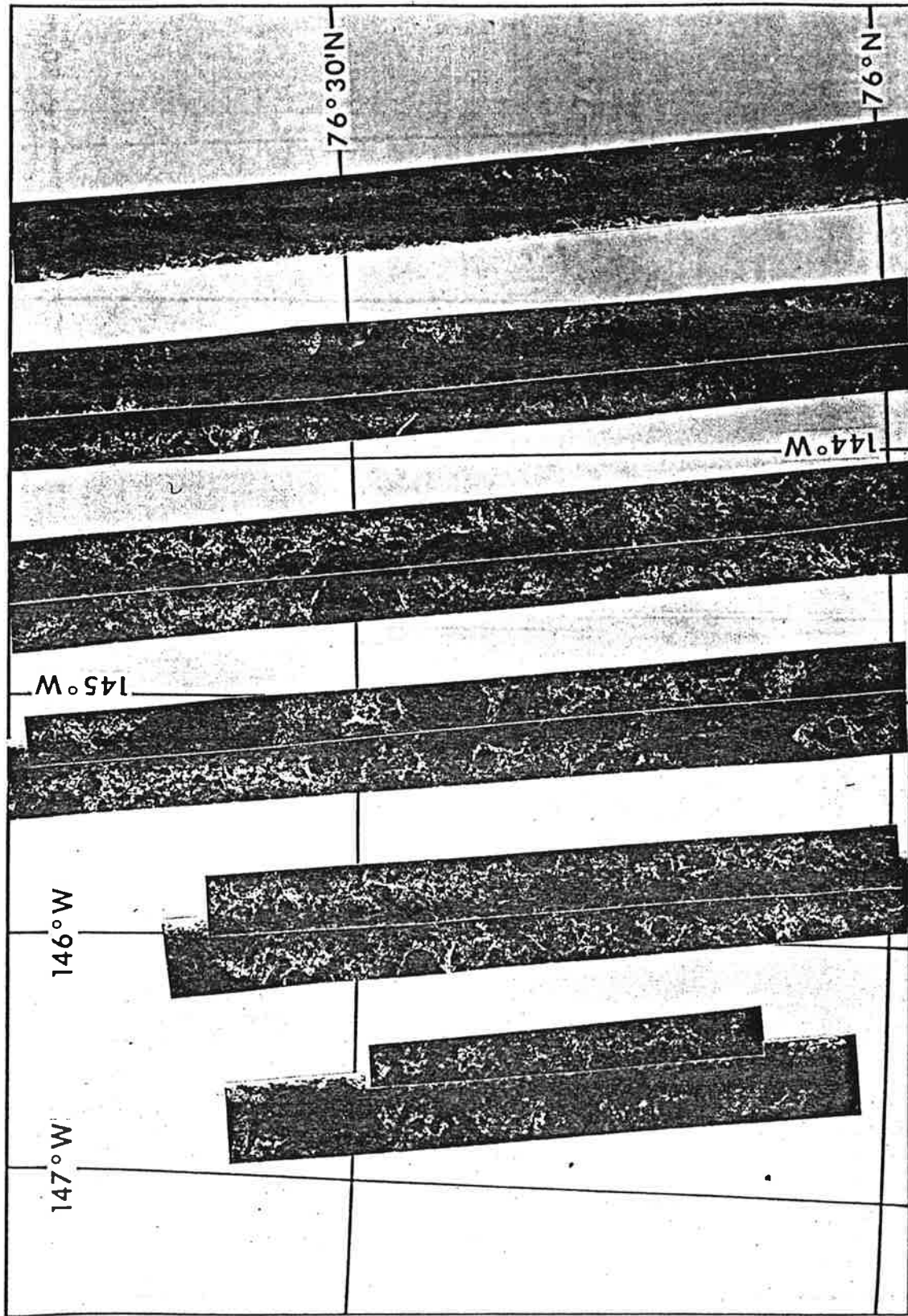


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EXPERIMENT
PROGRAM - I



22 APRIL 1975

Figure 6

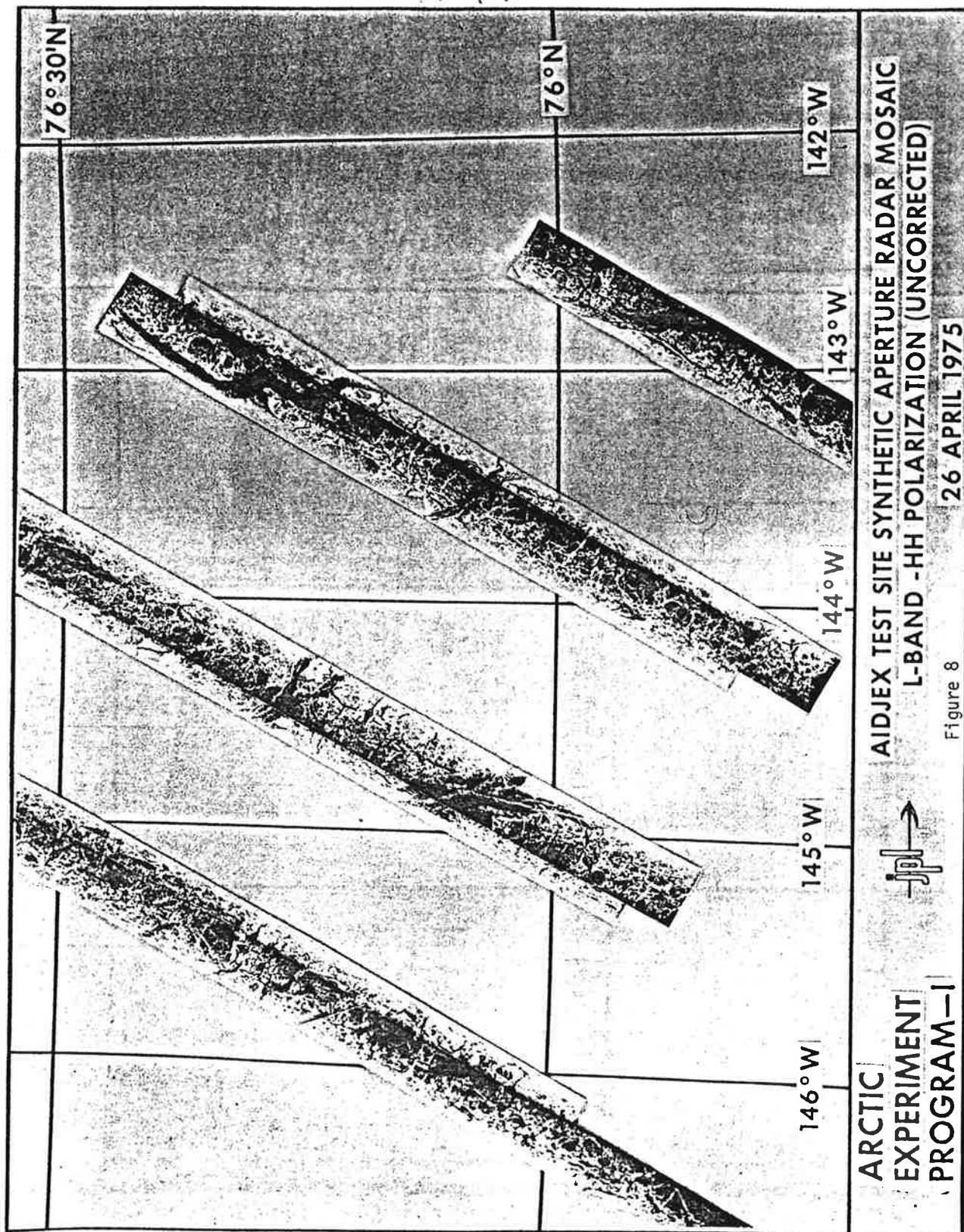


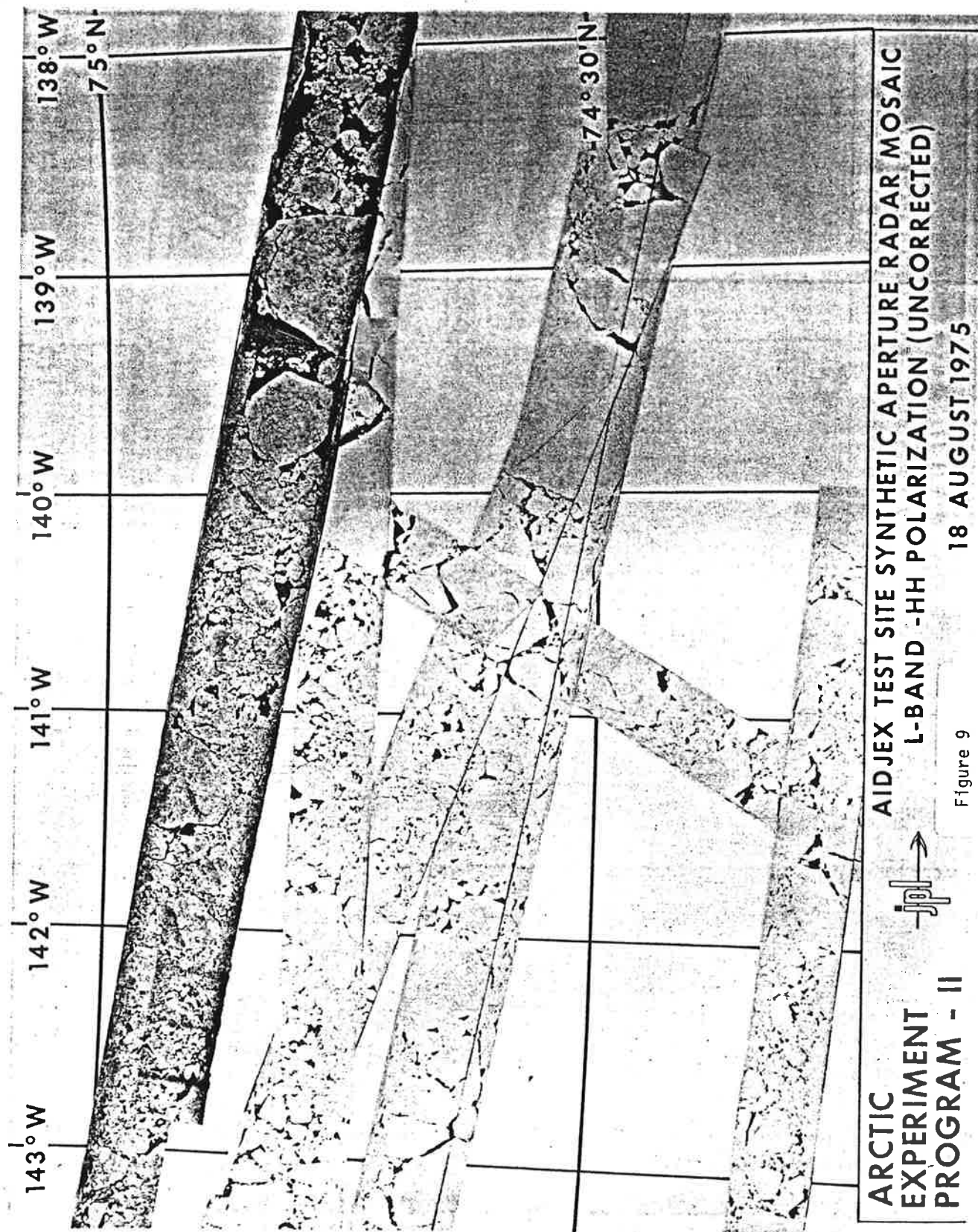
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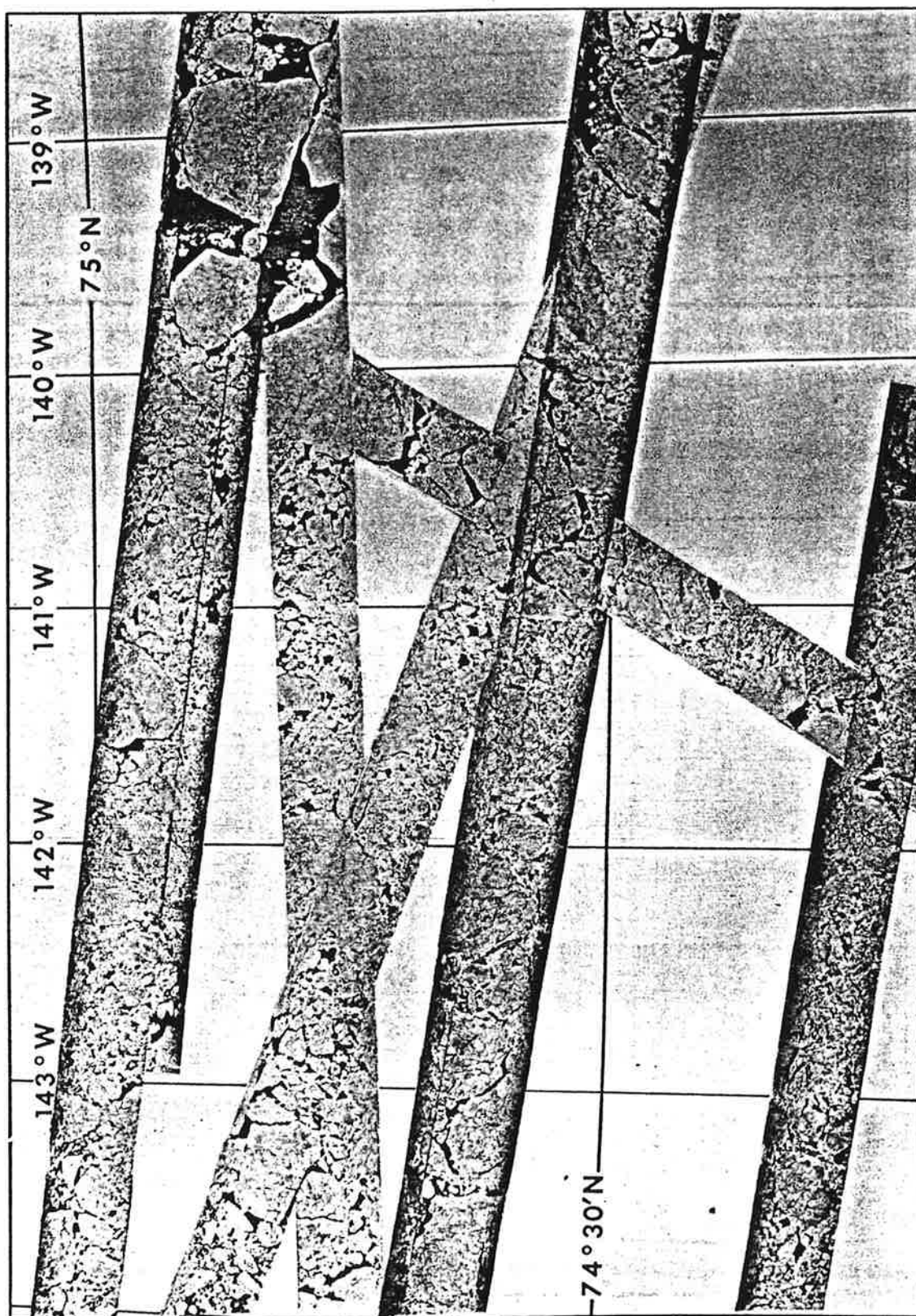


AIDJEX TEST SITE SYNTHETIC APERTURE RADAR MOSAIC
L-BAND -HH POLARIZATION (UNCORRECTED)

Figure 7 24 APRIL 1975







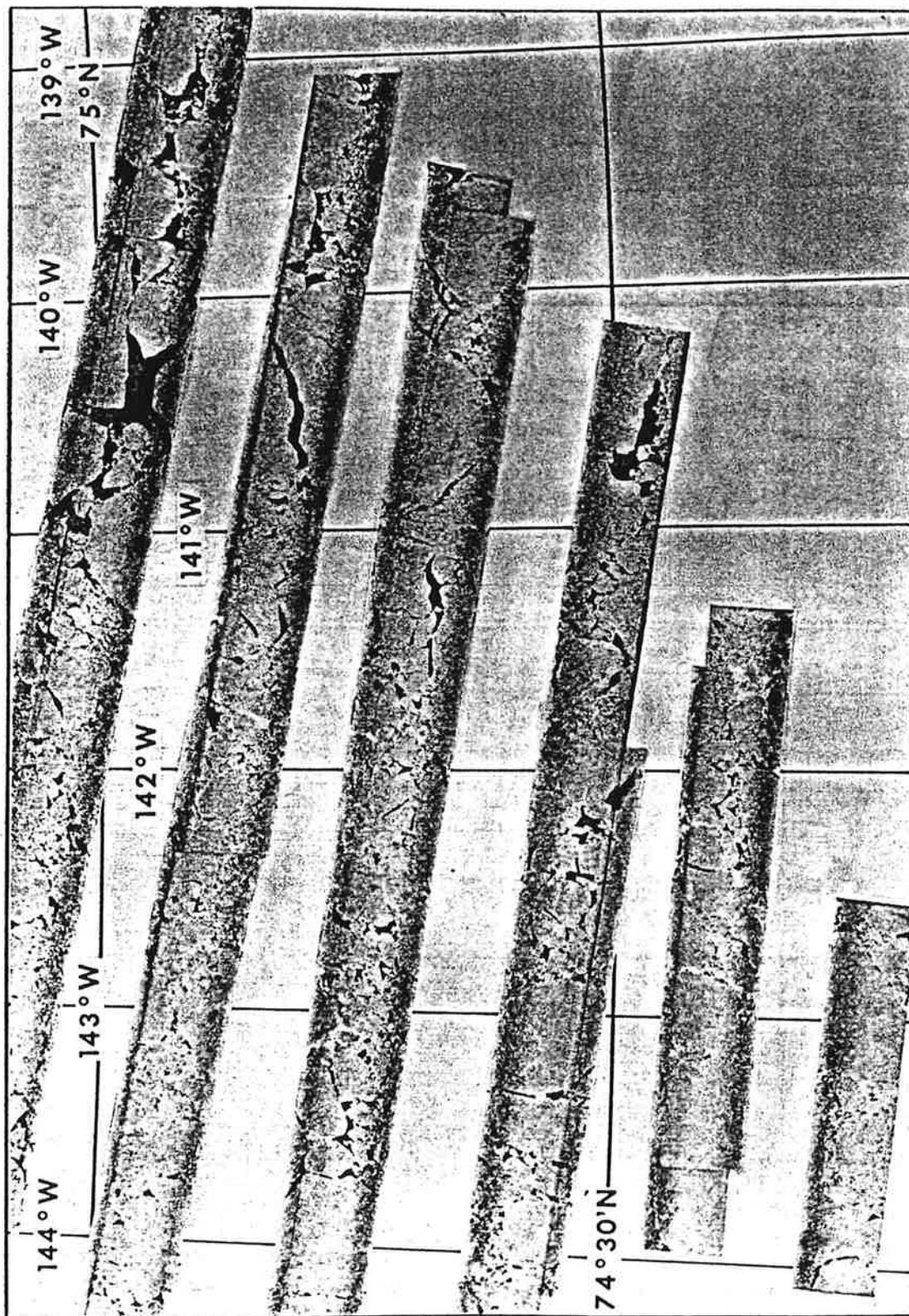
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AIDJEX TEST SITE SYNTHETIC APERTURE RADAR MOSAIC
L-BAND -HV POLARIZATION (UNCORRECTED)

18 AUGUST 1975

Figure 10



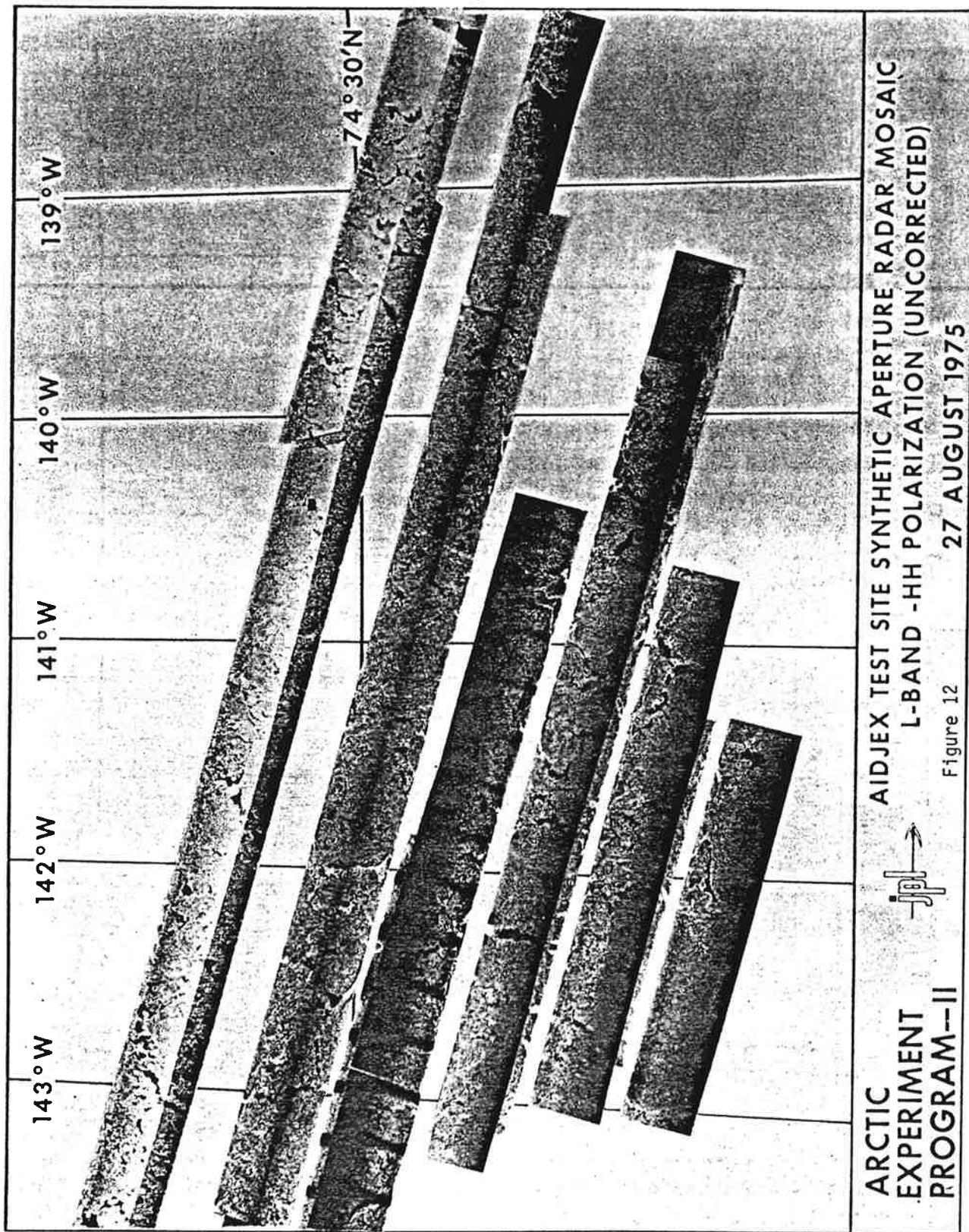
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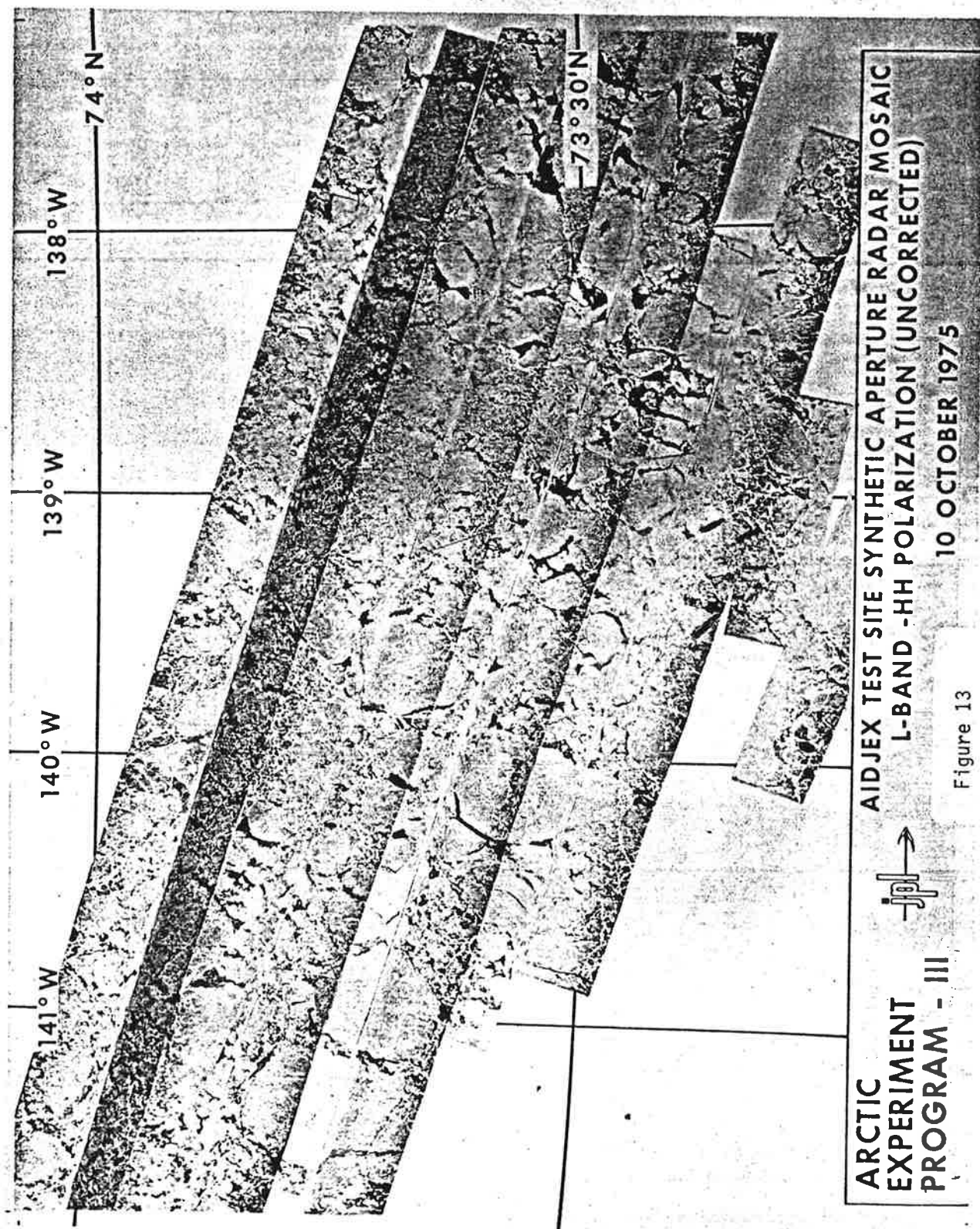


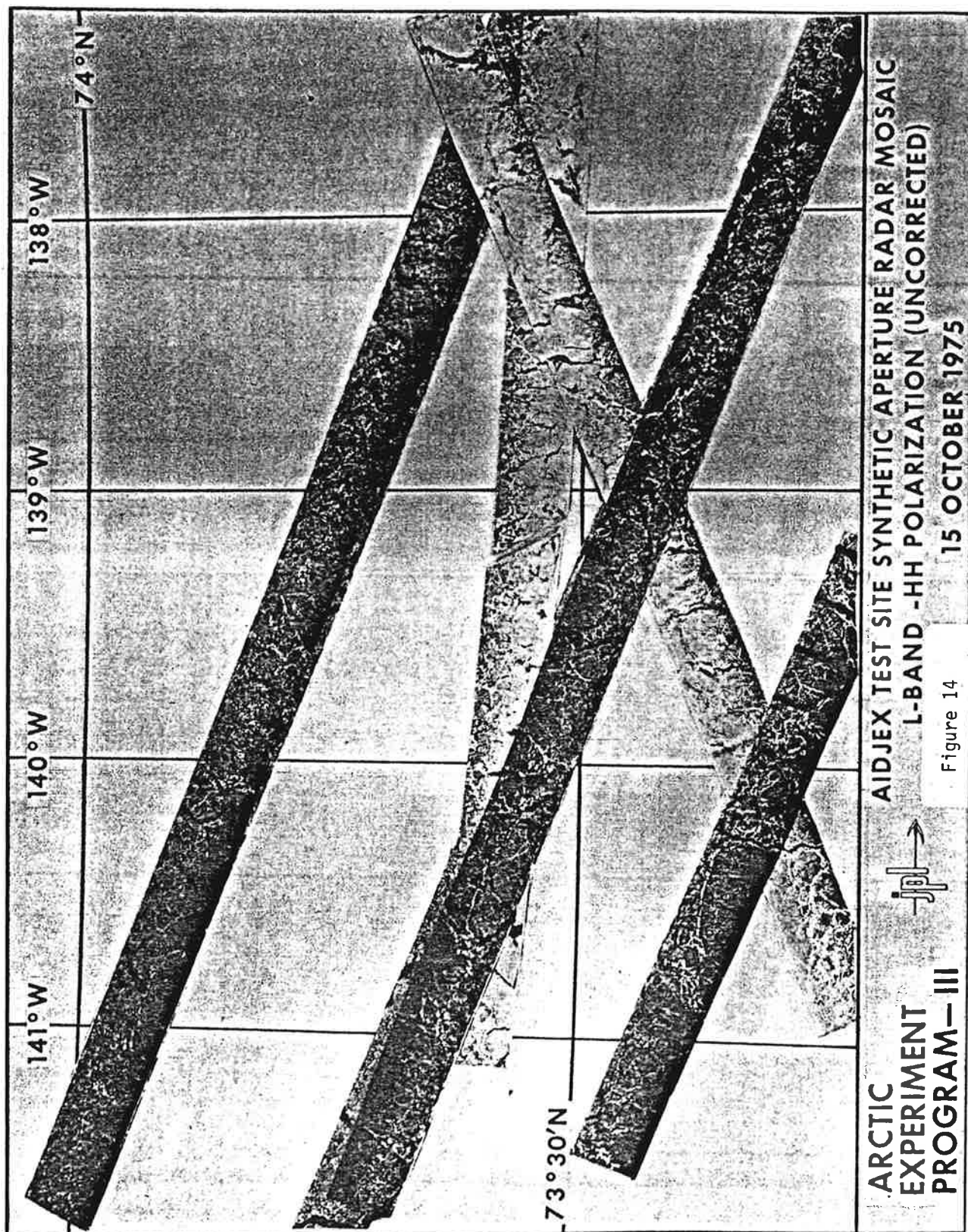
AIDJEX TEST SITE SYNTHETIC APERTURE RADAR MOSAIC
L-BAND -HH POLARIZATION (UNCORRECTED)

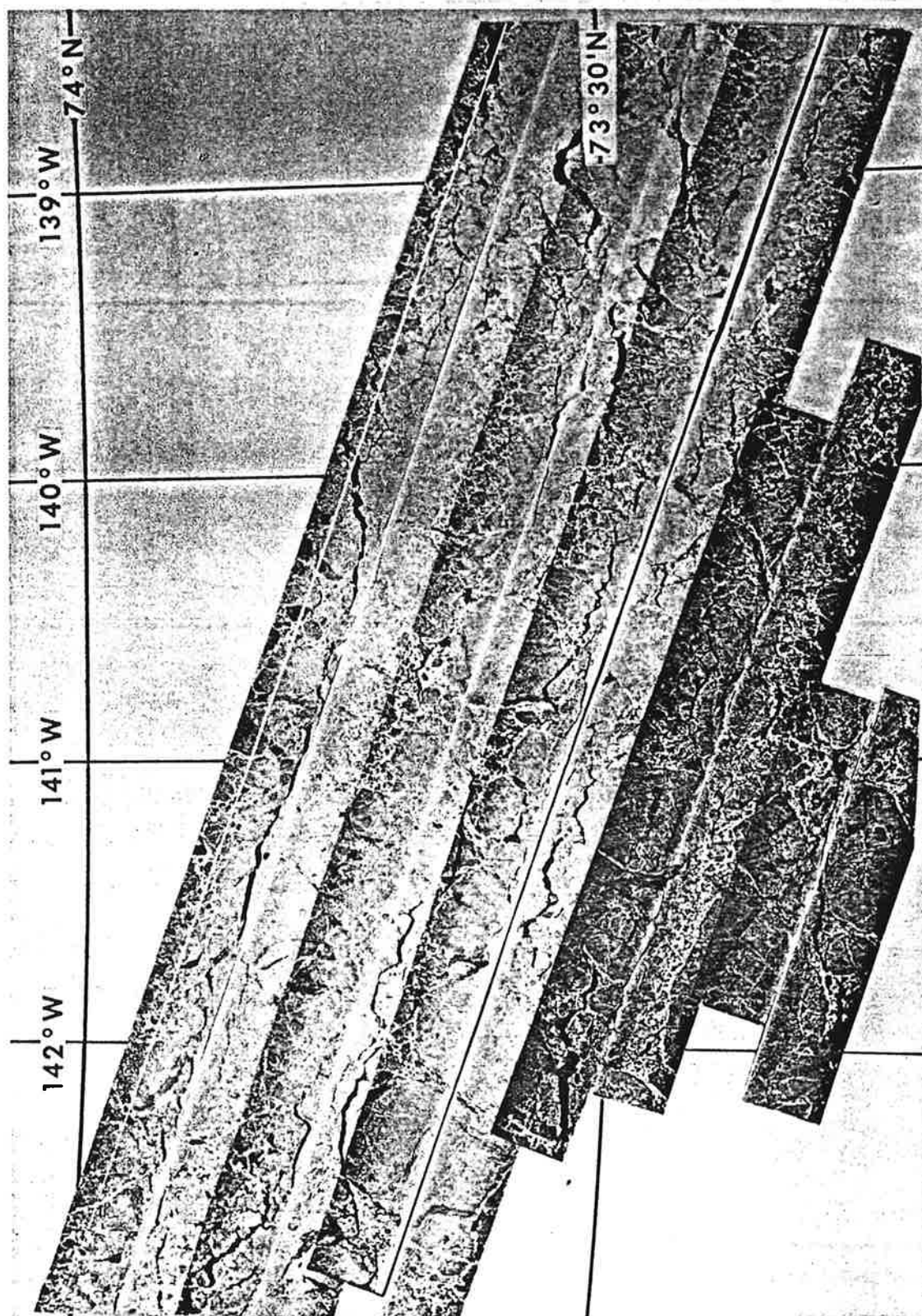
Figure 11

22 AUGUST 1975







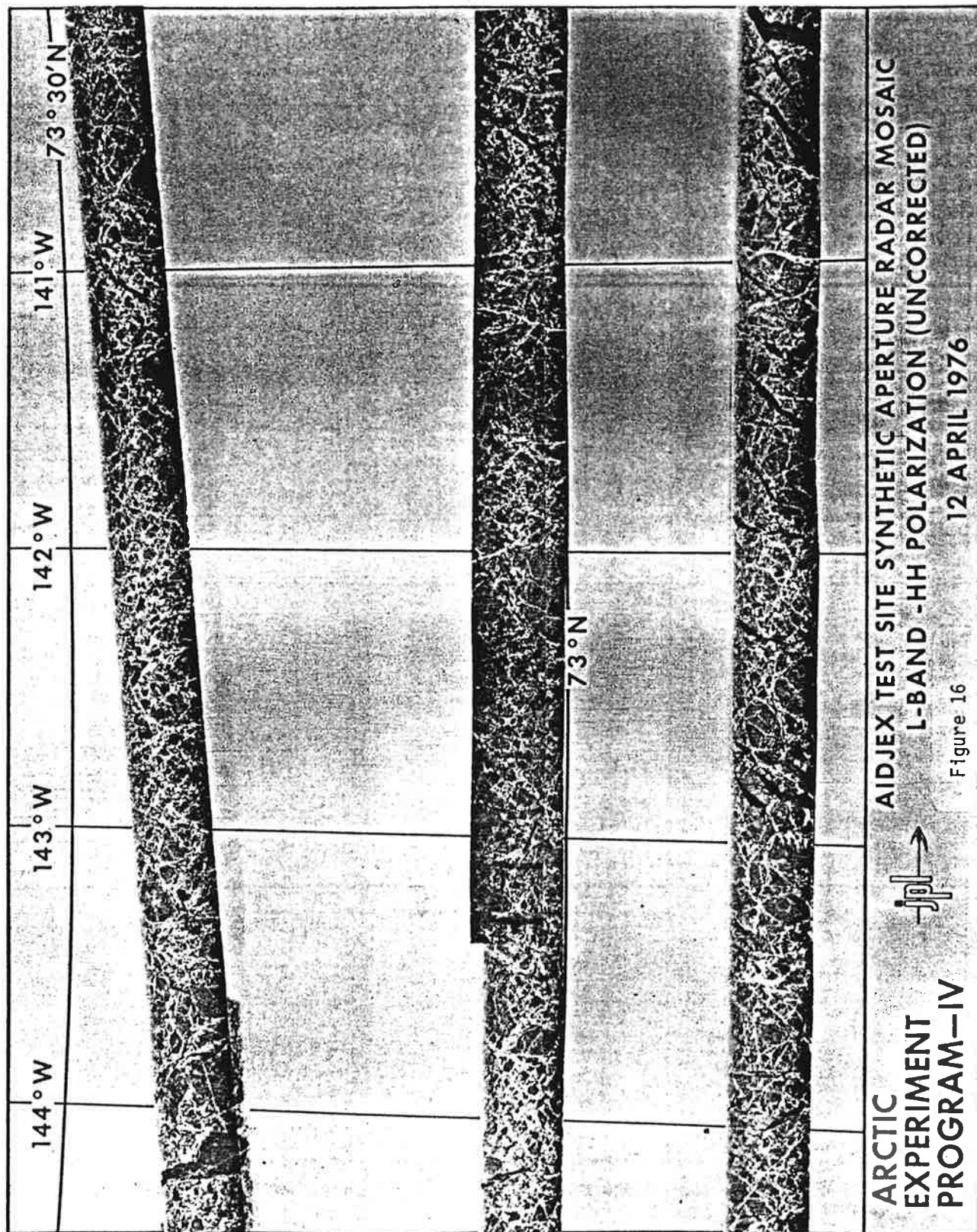


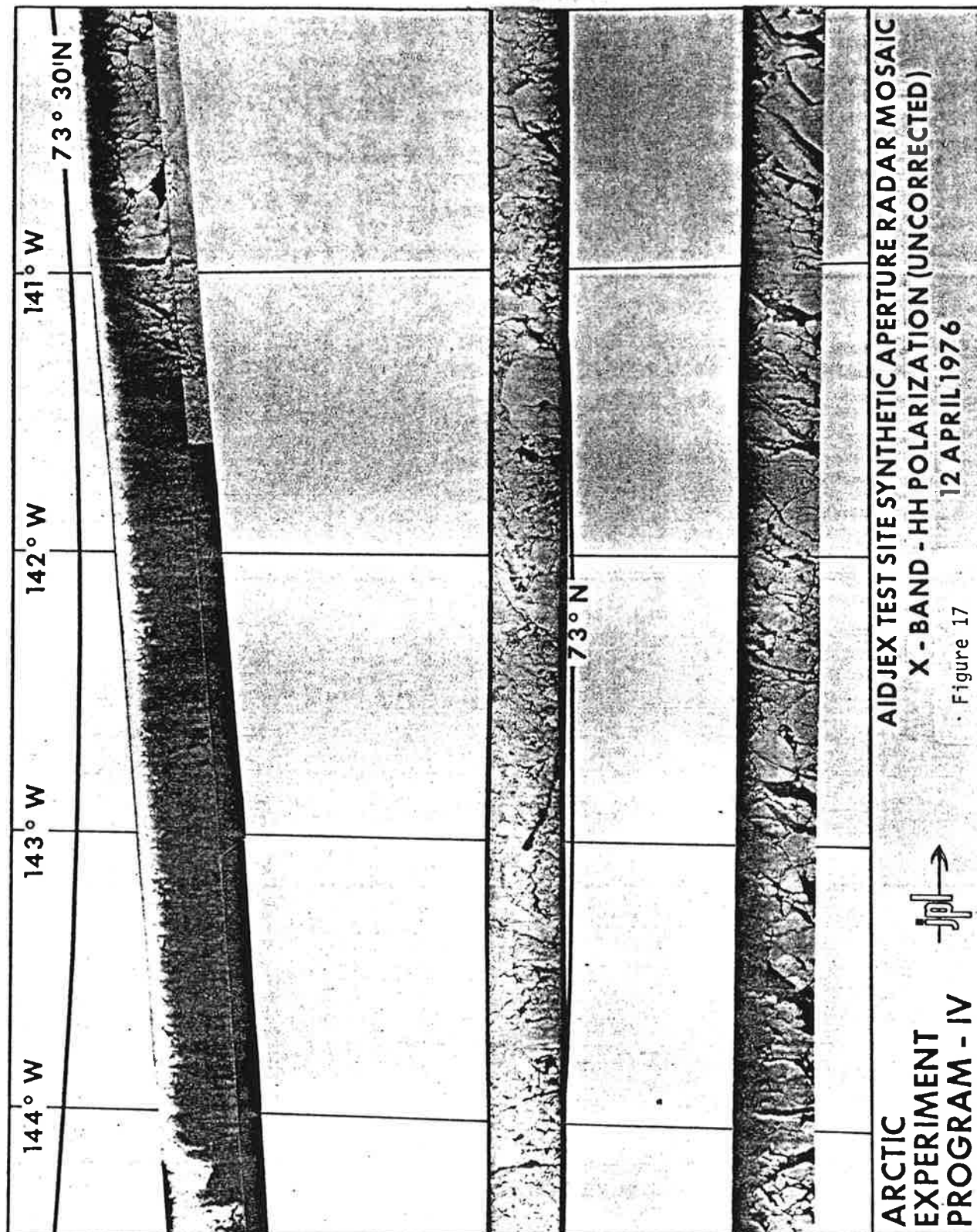
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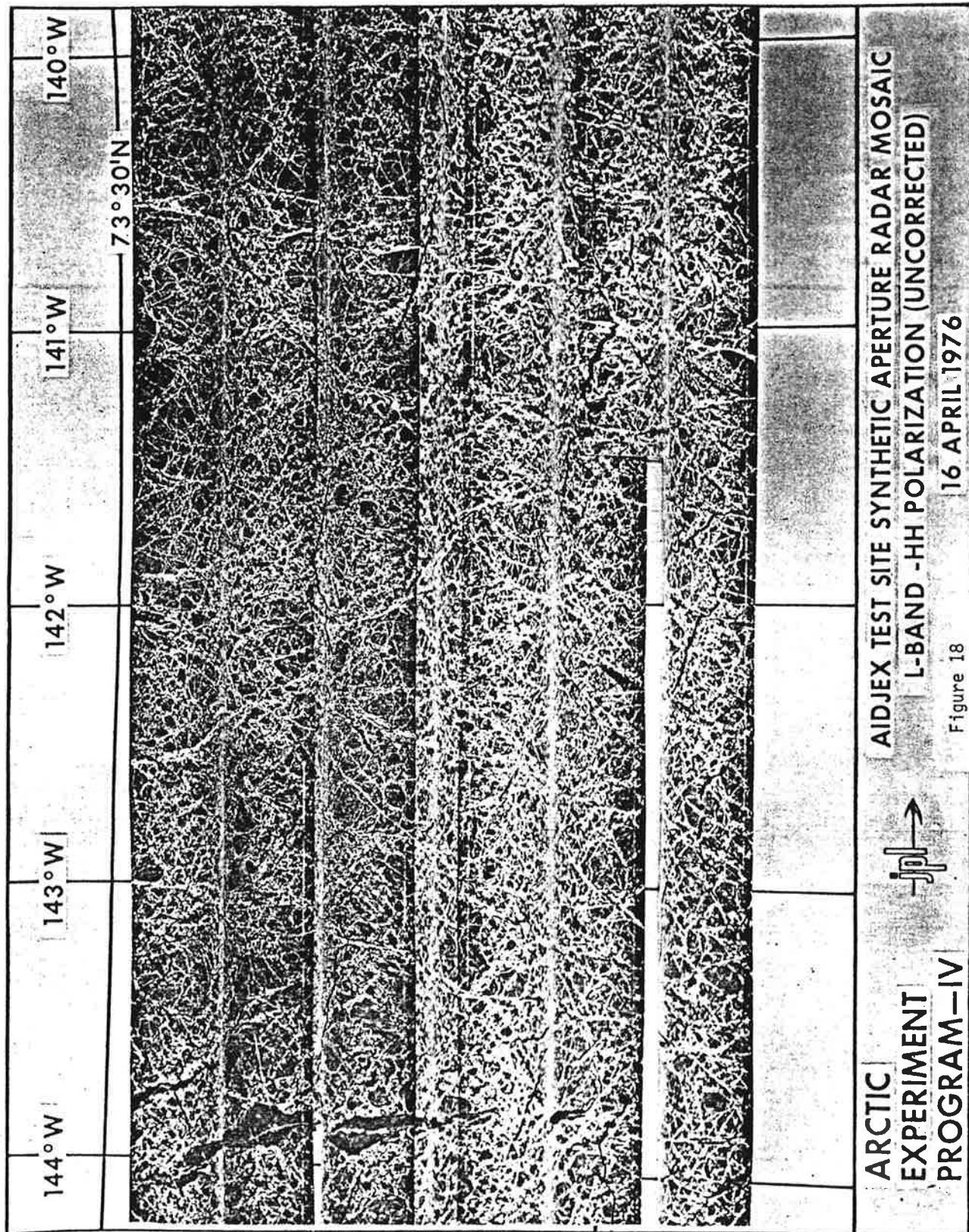


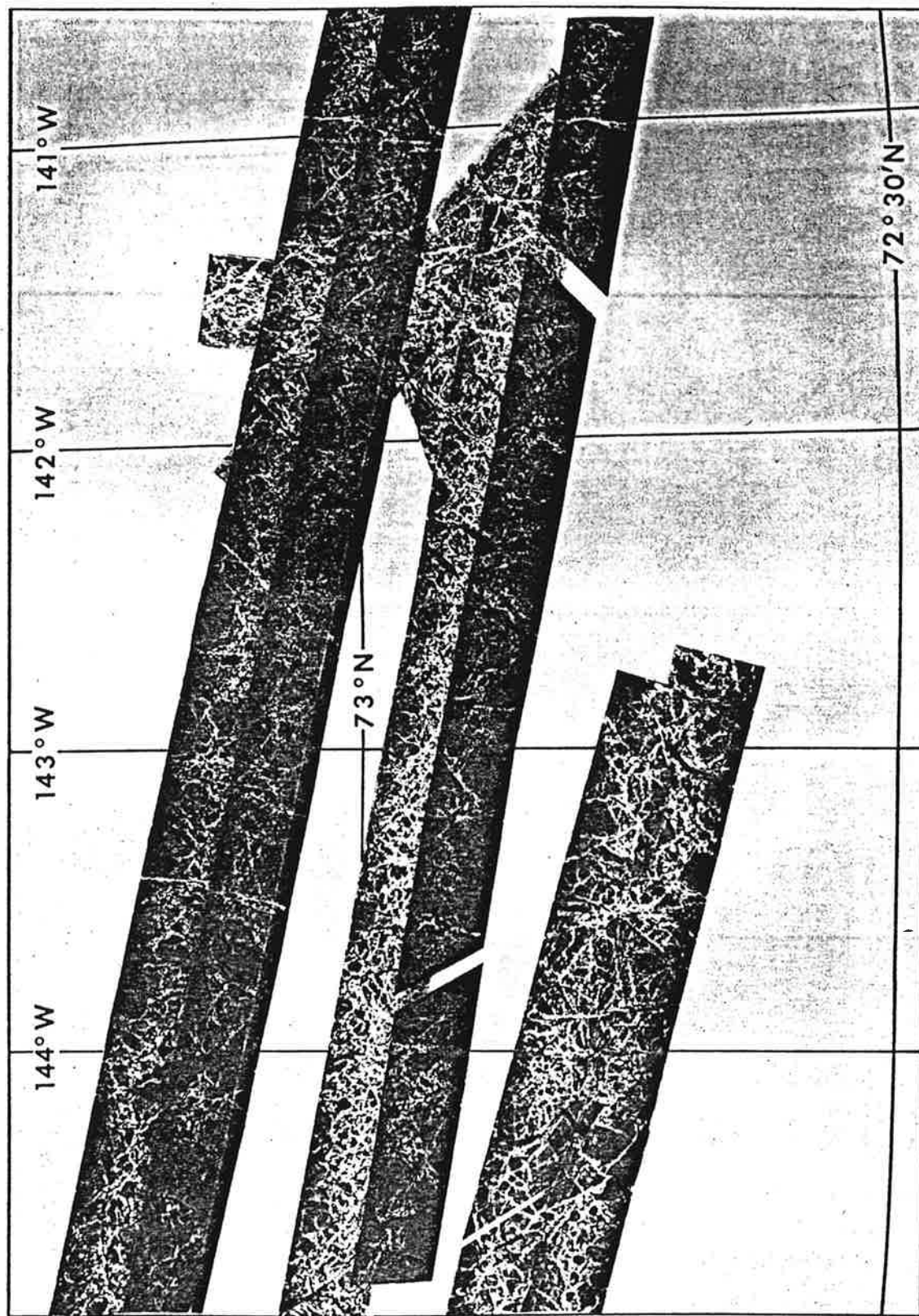
26 OCTOBER 1975

Figure 15









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→ jpl

AIDJEX TEST SITE SYNTHETIC APERTURE RADAR MOSAIC
L-BAND -HH POLARIZATION (UNCORRECTED)

Figure 20

21 APRIL 1976

