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MAP THE DISTRIBUTION OF GLACIOFLUVIAL DEPOSITS AND ASSOCIATED GLACIAL LANDFORMS

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16. Abstract

A background of granular materials investigations and present highway-related airphoto work in Maine is outlined. Black and white and simulated color products as received from NASA were analyzed by several methods. Stereo viewing, image projection, color viewing and electronic analysis are described. Identification of pits and excavations in granular formations was readily acheived by all methods, but few significant discoveries of formations were made. Some snow-enhanced features of large size were identified ERTS and correlated with high altitude photography. The resolution and registration of ERTS imagery is presently not adequate for detecting small features for detailed surficial geologic mapping. U-2 photography has been extremely useful and fills a gap in our airphoto inventory.

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PREFACE:

(a) Objectives: (1) To utilize very small scale imagery for the detection of glacial landforms by photo interpretation methods, and (2) to compare various imagery types, scales and formats for optimum extraction of data.

(b) Scope: (1) to develop a landform classification system for small scale imagery, (2) compile a surficial geologic map of Maine with emphasis on probable potential and known glacial deposits of economic importance, and (3) to apply the data to expand the on-going materials inventory studies within the Bureau of Highways.

(c) Conclusions: The limits of available time, funds and facilities were factors restricting the pursuits of the investigation. Standard photo interpretation techniques and existing MDOT equipment were the primary methods of data extraction proposed. Proposal objectives, and anticipated results and products, were very optimistic. Numerous and thorough investigative efforts of data extraction from ERTS imagery were made using mostly standard photo interpretation methods and basic equipment at hand. For the types of information and uses desired, described under 'objectives' and 'scope', it is concluded that, for the methods employed, the resolution and registration of ERTS imagery, at present, is not adequate for identifying and mapping small landform units to fulfill the original intent of the proposal to the satisfaction of the investigator. General viewing of broad features can be accomplished and some smaller formations may occasionally be identified, but detail essential to the development of a landform classification system by standard photo interpretation methods is lacking.

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Background and Introduction

The glacial granular formations within Maine are the State's largest and primary mineral resource. The economic importance of sand and gravel deposits to the Bureau of Highways and to the construction industry has long been recognized. As early as 1930, without benefit of aerial photography, a comprehensive survey of the glacial road materials of the State, and including sands and gravels useful for building construction, was initiated by the University of Maine in cooperation with the Maine State Highway Commission. (Leavitt and Perkins, 1934). The survey, covering 70% of the State, is still a very useful reference for investigators.

A cooperative study to correlate the relationships of natural features of eskers and associated terrain discernible on airphotos with materials in the deposits was conducted by the Maine State Highway Commission and the U.S. Bureau of Public Roads during the 1960-63 field seasons. (Gunn, 1961; Woodman, 1962; Stoeckeler, 1964). Several possible criteria for predicting quality and quantity from airphoto interpretation were investigated, with good to inconclusive results.

Investigations of granular sources utilizing conventional aerial photographs and photo interpretation techniques have been standard procedure within the Materials and Research Division of the Bureau of Highways[1] for twenty years. Color and color infrared photography has been available for select areas for the past seven years. The resulting Materials Inventory study reports are included in the detailed soils reports for all major highway projects.

A large quantity of ground truth information has been compiled, therefore, in the form of airphoto, field and laboratory data relative to glacial landforms,

1. The Maine State Highway Commission became the Bureau of Highways within the Maine Department of Transportation July 1, 1972.

obtained for several hundred materials studies, currently on file in the Materials and Research Division.

In addition to highway related studies, much work has been done by early explorers and by the academic community. Hitchcock (1862) and Stone (1899) recognized the surficial glacial features of the State and, to a degree, their economic importance. Trefethen (1944) studied the lithology of eskers and recognized the generally local origin of materials. Borns (1965) has interpreted glacial stratigraphy to correlate the geologic sequence of events within Maine and adjacent areas. Goldthwait (1949) and Bloom (1960) have studied Marine clays and sea level fluctuations, and correlated them with glacial and post glacial granular deposits within the State. Additional work by these and others has also contributed greatly to the knowledge of Maine's Pleistocene epoch.

There is, then, a vast storehouse of data available regarding Maine's glacial deposits. The majority of formations, large and small, are recognized and known, except for those that may exist in the State's northwestern wilderness area.

With the advent of the ERTS program, it was thought that various small scale diagnostic features of satellite imagery could be, (1) used to detect glacial landforms by photo interpretation methods, and (2) compared with other imagery types scales and formats to determine optimum extraction of data. The scope of the proposal was to (1) develop a landform classification system for small scale imagery, (2) compile a surficial geologic map 6f Maine with emphasis on economic glacial deposits, and (3) apply the data to on-going and future materials inventory studies.

ERTS-1 imagery has been studied in three-dimensional models, by photographic and projected enlargement, color-enhancement, color projection, by false color composite transparencies and prints, and by density slicing. Varying degrees of success have been achieved by each method. U-2 support aircraft underflight photography has been a valuable ground truth source.

This report summarizes the results of efforts to evaluate and use imagery as a tool for investigating the surficial features of the State of Maine. Cloud-free and nearly cloud-free scenes were used as they became available. Due to the vagaries of the weather and extreme day to day changes in this part of the country, such scenes were the exception rather than the rule. It is felt, however, that a sufficient number of clear scenes were ultimately received to pursue the objectives of the proposal.

STEREO VIEWING

Since one of the prime objectives of the proposal was to use photo interpretation methods for detecting landforms, the potentials of stereo viewing of ERTS imagery were explored. Although it was initially understood that the ERTS system was not designed for stereo coverage per se, it was known that side-lap of imagery would be available, particularly at the higher latitudes, and several investigators were interested in its potential applications. Poulton (1972), after working with earlier Apollo imagery, experimented with ERTS side-lap coverage and determined it to be a definite advantage to participants using the human PI approach to image analysis.

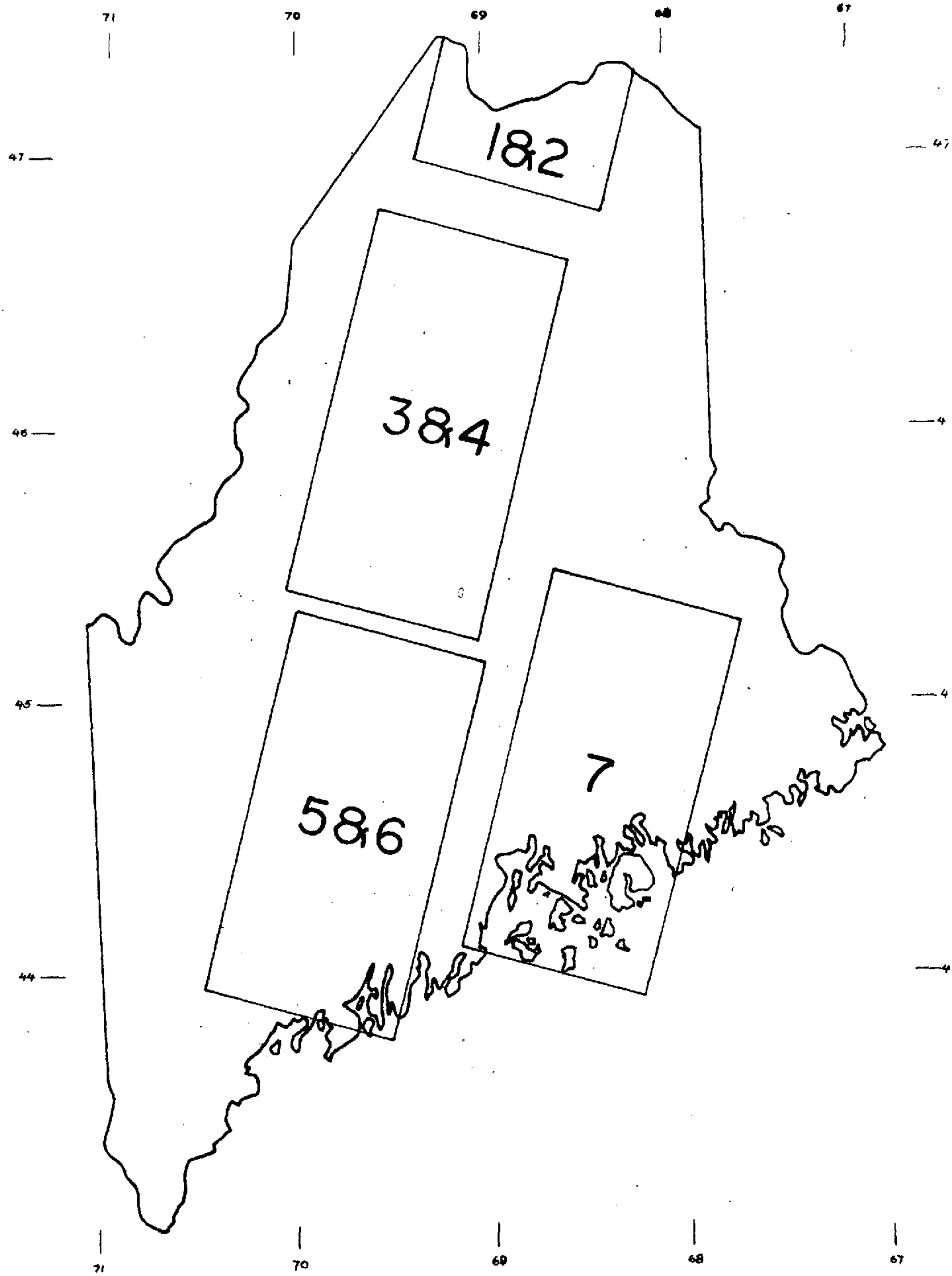
As was expected, several months elapsed between ERTS-1 launching and the receipt of adjacent orbital imagery suitable for stereo viewing. In April of 1973 the first good stereograms of clear February imagery were assembled. Ultimately about twenty stereo pairs having no cloud cover to moderate cloud obscuration were selected for initial viewing and evaluation. These pairs included adjacent sequential orbits, various date and seasonal combinations of orbital coverage, and combinations of spectral bands. Seven typical pairs of images, or stereograms, of areas shown in Figure 1 of 9X9" black and white prints having 43% sidelap coverage have been studied in detail using only 2X and 4X binocular reinforcement. The following data were extracted:

STEREOGRAM 1 - Northern Aroostook County

Image ID: 1023-14591, 15AUG72, Band 5

Image ID: 1040-14534, 1 SEP72, Band 5

The eighteen day difference in scenes reinforces subtle tonal patterns. Good parallax for stereo viewing is present. Pit locations in outwash and terrace formations of the Saint John River valley can generally be differentiated



ERTS-I STEREOGRAM COVERAGES

Figure I

from fields by their brighter tone. Extensive logging road patterns have associated borrow locations, interpreted by small bright areas. These indicate, to a degree, potential and/or possible granular sites in localized outwash and kame formations. Correlation of these features with conventional airphotos, where available, is generally good.

STEREOGRAM 2 - Northern Aroostook County

Image ID: 1202-14543, 10FEB73, Band 5

Image ID: 1203-15002, 11FEB73, Band 5

This sequential pair of images, covering the same area as stereogram 1, has excellent parallax for stereo viewing, enhanced by snow cover. Gross features of bedrock structure and fracture patterns are readily apparent. Smaller terrain formations, however, are not as apparent. Snow cover in the Saint John River valley obliterates pits identified on stereogram 1. They can not be differentiated from adjacent fields.

STEREOGRAM 3 - Northwestern Portion

Image ID: 1202-14550, 10FEB73, Band 5

1203-15004, 11FEB73, Band 5

Imagery obtained on these two sequential orbits provides excellent stereo viewing in a mountainous wilderness region. The large esker system extending southerly from the southern shore of Moosehead Lake can be identified by the large excavations. Extensive outwash areas in the Seboomook Lake area are tentatively identified, as are several smaller ridges in the northern extremities of the scene coverage, which may be moraines. Snow cover greatly enhances stereo viewing of the bedrock ridges (Squaw Mountain, Little Squaw Mountain, Mount Kineo, and others) and slightly enhances some of the glacial landforms, as mentioned above, that are less obvious on summer images of the region.

STEREOGRAM 4 - Northwestern Portion

Image ID: 1220-14551, 28FEB73, Band 5

1203-15004, 11FEB73, Band 4

This stereo pair is essentially the same as stereogram 3. The left scene was imaged eighteen days later, with band 4 being used instead of band 5. Very little difference in tonal quality is noticed, and less detail is available with band 4. Stereo viewing and snow enhancement of the large features is about the same as in stereogram 3. The same glacial features are identified.

STEREOGRAM 5 - Southwest Central Portion

Image ID: 1040-14543, 1SEP72, Band 5

1077-15002, 8OCT72, Band 5

The 37 day difference in scenes in this stereogram somewhat reinforces tonal patterns, thus enhancing the overall viewing. Apparent relief for stereo viewing is slight. Pits developed in known granular formations can be identified, especially in the large Lake Auburn delta, the Androscoggin Lake esker and in eskers in Turner and Livermore. Excavations are generally identifiable and distinguished from adjacent fields by their brighter tone. Several new pit areas were thus identified and subsequently ground checked.

STEREOGRAM 6 - Southwest Central Portion

Image ID: 1220-14553, 28FEB73, Band 5

1257-15012, 6APR73, Band 5

This stereogram, covering the same area as stereogram 5, consists of a late winter and early spring combination of scenes imaged 37 days apart. Considerable snow and ice are present in both scenes. Parallax is enhanced by the snow cover in this region of relatively subdued topography. Apparent relief is greater than in stereogram 5. Granular formations and associated excavations are identified with difficulty, and then only if the observer is aware of their presence.

STEREOGRAM 7 - East Central and Seaboard Area

Image ID: 1202-14552, 10FEB73, Band 5
1219-14495, 27FEB73, Band 5

Scenes for this stereogram were imaged eighteen days apart, with about the same snow and ice conditions. Snow-enhanced parallax gives excellent stereo viewing of large terrain features and some of the larger surficial formations. The very large Pineo Ridge deltaic formation in Cherryfield, Washington County, can be identified. The formation is covered primarily by blueberry barren vegetation, imaged as a white expanse very similar to many surrounding lakes. Therefore, identification is primarily because of prior knowledge of its location. A few of the larger moraines of coastal Washington County are tentatively identified.

The following observations are made from examination of black and white ERTS-1 stereograms:

At the start of stereo examination of ERTS scenes it was recognized that the observer accustomed to using conventional photography would have to adapt to a new concept of scale and relative sizes when viewing the very small scale imagery.

Three-dimensional viewing of mountainous areas and associated rock structures is excellent. Features in more subdued topography, however, are much less obvious, and only the more prominent formations are discernible by relief difference. Glacial formations are detected mainly by the existance of excavations, which may image differently than fields, and by prior knowledge of their occurrence.

Sequential orbital imagery generally produces better three-dimensional viewing. Tonal differences within imagery obtained eighteen to thirty-seven days apart and within the same season are often reinforced to provide added detail for the observer, and the stereo effect is adequate. However, extreme tonal differences in images of a stereopair, such as summer-winter or winter-spring, usually produce a confusing scene of high contrast to the observer, that tends to obscure detail.

Winter imagery, especially of the more sparsely settled areas of the State, is often preferable to summer imagery for landform detection, as snow cover tends to produce an'edge effect' enhancement of smaller relief features. This was also observed in monocular image projection studies.

In general, band 5 is found to be superior for landform and granular excavation detection, when such features are of large enough area and/or relief to be identified. For the purposes of this study, other bands ted to show less detail. Band 5 used with band 4 or 6 in a stereogram is found to have little added enhancement or stereoscopic value.

Apparent stereo relief is very often attained by viewing two spectral bands of the same image. This pseudostereo effect is due to tonal variations and differing spectral imaging within the scene, and found to be helpful for the delineation of some formations.

Image Projection

Portions of selected ERTS-1 70MM positive transparencies were used to produce 35 mm slides for projection at various scales. The projected images were then studied, and direct tracings made of identified and salient features for comparison with maps and aerial photographs. From the study of about twenty frames of statewide coverage, the following observations were made, and data obtained.

In summer imagery, it was generally found that features suggestive or indicative of granular deposits, rather than the actual formations, could be identified on the projected enlarged images. Therefore, pits and series of pits could be detected, but those deposits that have not been extensively exploited display few criteria for detection by the projection method. Formations known to exist in wooded terrain could not be detected unless pits were present. Deposits in relatively open terrain were identified by the traces of pits, which displayed a lighter tone than the surrounding areas. Excavations floored by water or wet soils are found to image as darker areas in band 6, in summer imagery. It should be noted, however, that these features were looked for where prior knowledge and ground truth data indicated their presence. The application of pit identification criteria on the imagery thus obtained was extended to similar features in relatively unknown areas of the scene. It was found that only about 25 per cent correlation was attained using these various tonal hues for comparison and identification of pits (not formations) outside the pilot area.

Example: Image ID - 1364-14544, 22JULY73, bands 5 and 6

The numerous pits developed in the large Winterport esker and delta formations can be identified as described above.

In winter imagery of larger glacial features having appreciable relief, it was found that snow enhancement and low sun angle were definite benefits in some scenes. Figure 2 represents a tracing made from a 1:125,000 projection enlargement of a portion of ERTS-1 scene 1202-14550, imaged 10FEB73. Band 5 was used, but there is little apparent difference in bands 4,5 or 6 when used for projection of winter imagery. This is generally wilderness area southeast of Mount Katahdin, known to have many glacially-produced terrain features. The larger eskers and morainic ridges were identifiable on the projection, as were many smaller lineations, because of the lighter lines of snow demarcation at their bases. All linear features thought to be glacially associated were sketched. Figure 3 is a tracing of the Mount Katahdin area, north of the area of figure 2. The large Basin Pond moraine and a section of the Wassataquoik esker were plainly visible as enhanced lineations on the projected imagery. Small morainic ridges were also sketched, as in figure 2.

Using U-2 mission RC-10 photography as ground truth for comparison of the ridge features detected on ERTS imagery, it was found there is very good correlation of the larger formations and a generally good correlation of the smaller lineations. Numerous woods haul roads exist in the region that are constructed parallel with the topography. Therefore, some of the small lines indicated as "morainic ridges" in figures 2 through 5 are actually traces of roads rather than glacial terrain.

Figure 4 is a composite print of an overlay, figure 2, and U-2 photograph Number 8357 taken 31JAN73, showing the correlation of ERTS-detected features with stereo-determined ground configurations.

Figure 5 is a composite print of an overlay, figure 3, and U-2 RC-10 photograph Number 8355 taken 31JAN73 showing the correlation of ERTS-detected features in the Mount Katahdin region. It will be noted that the ERTS scene and

OVERLAY DELINEATION OF SNOW-ENHANCED GLACIAL FEATURES IN A WILDERNESS AREA (MOUNT KATAHDIN AND MILLINOCKET LAKE REGION, MAINE) DETECTED ON ERTS-1 SCENE 1202-14550, IMAGED 10 FEB 73, BAND 5, PROJECTION SCALE 1:125,000. BOLD IDENTIFIED FEATURES CORRELATE WITH U-2 RC-10 PHOTOGRAPH NO.8357, 31 JAN 73.

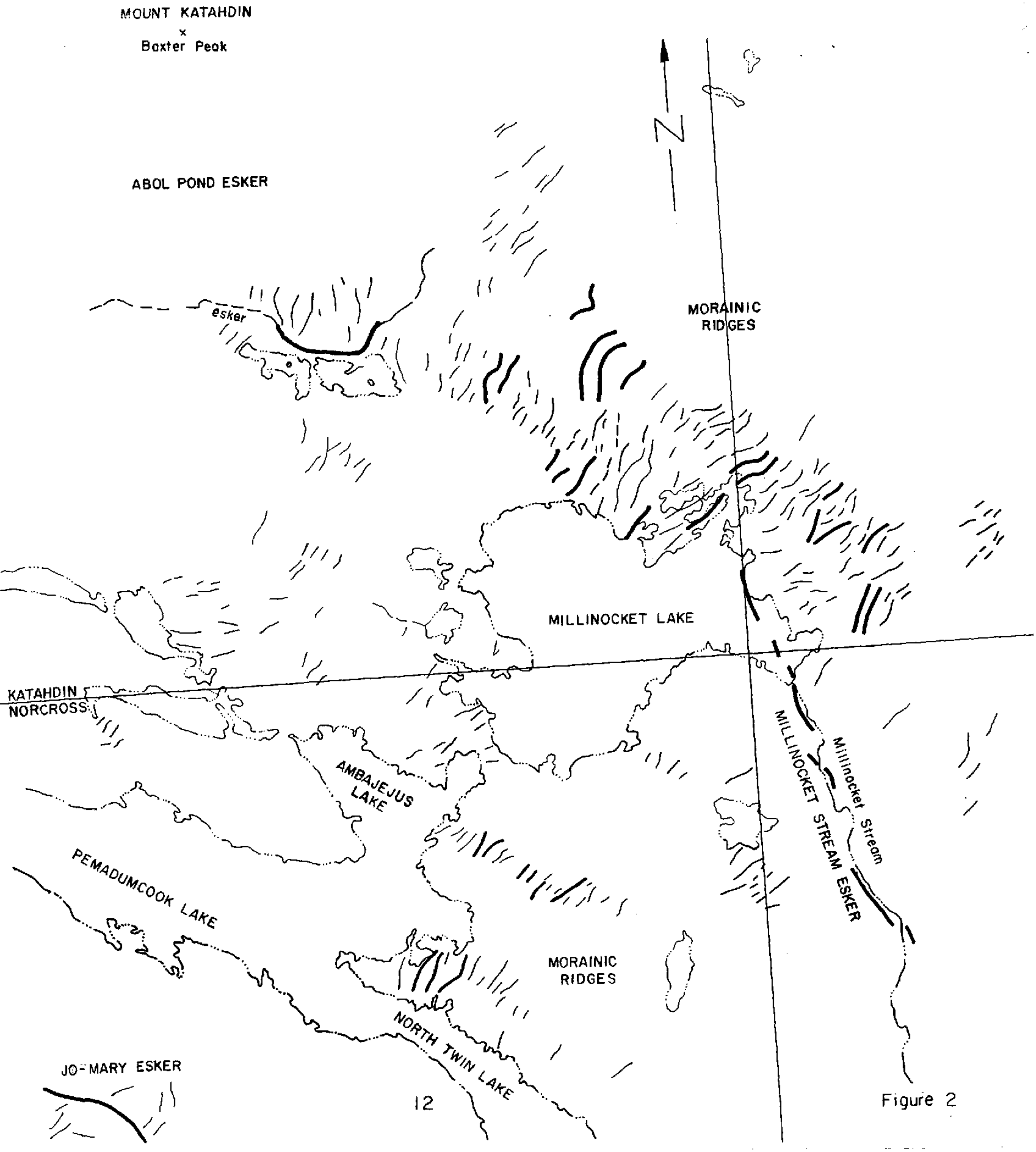


Figure 2

OVERLAY DELINEATION OF SNOW-ENHANCED GLACIAL FEATURES IN A WILDERNESS AREA (MOUNT KATAHDIN REGION, MAINE) DETECTED ON ERTS-1 SCENE 1202-14550, IMAGED 10 FEB 73, BAND 5, PROJECTION SCALE 1:125,000 BOLD IDENTIFIED FEATURES CORRELATE WITH U-2 RC-10 PHOTOGRAPH NO. 8355, 31 JAN 73.

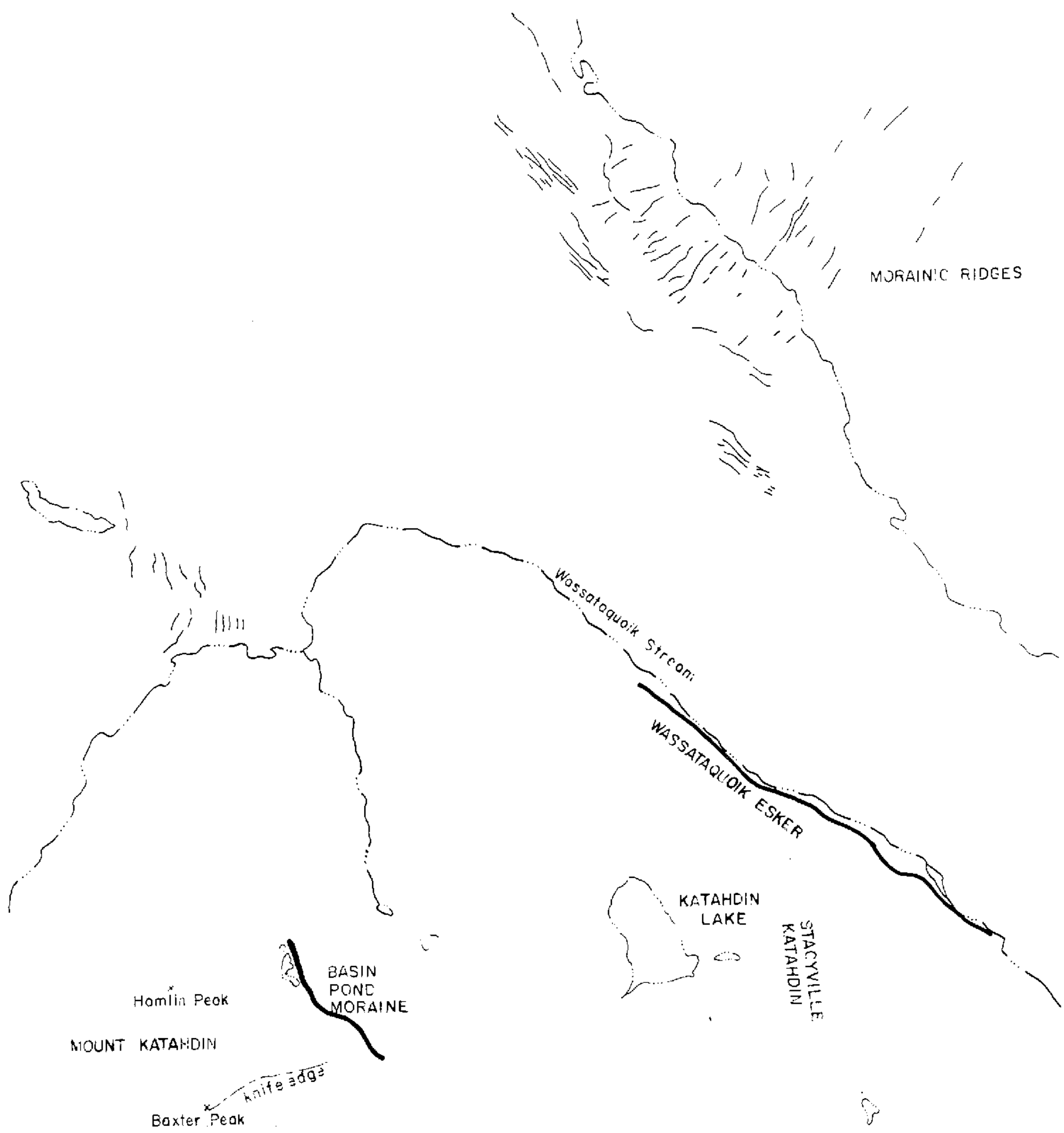
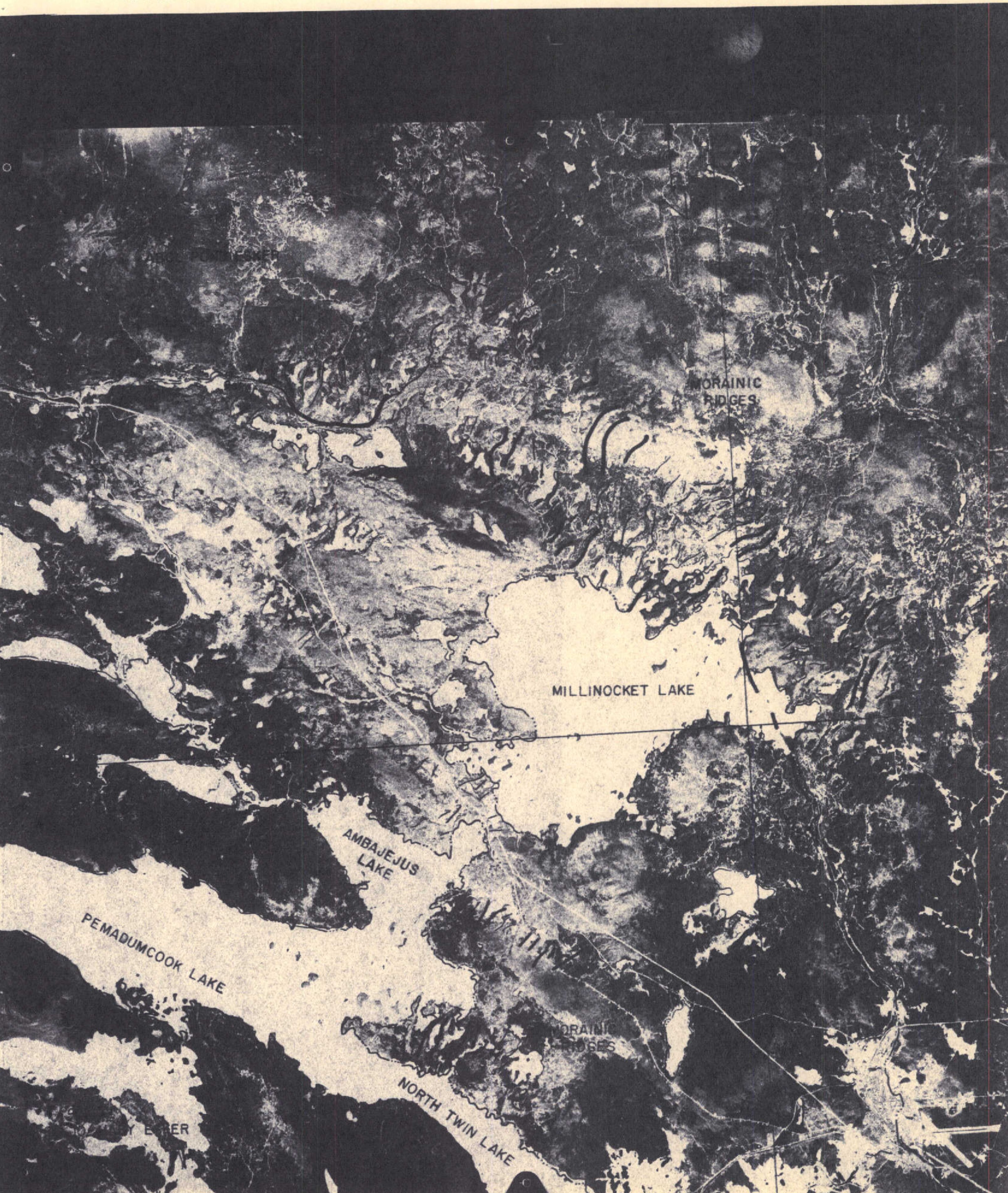


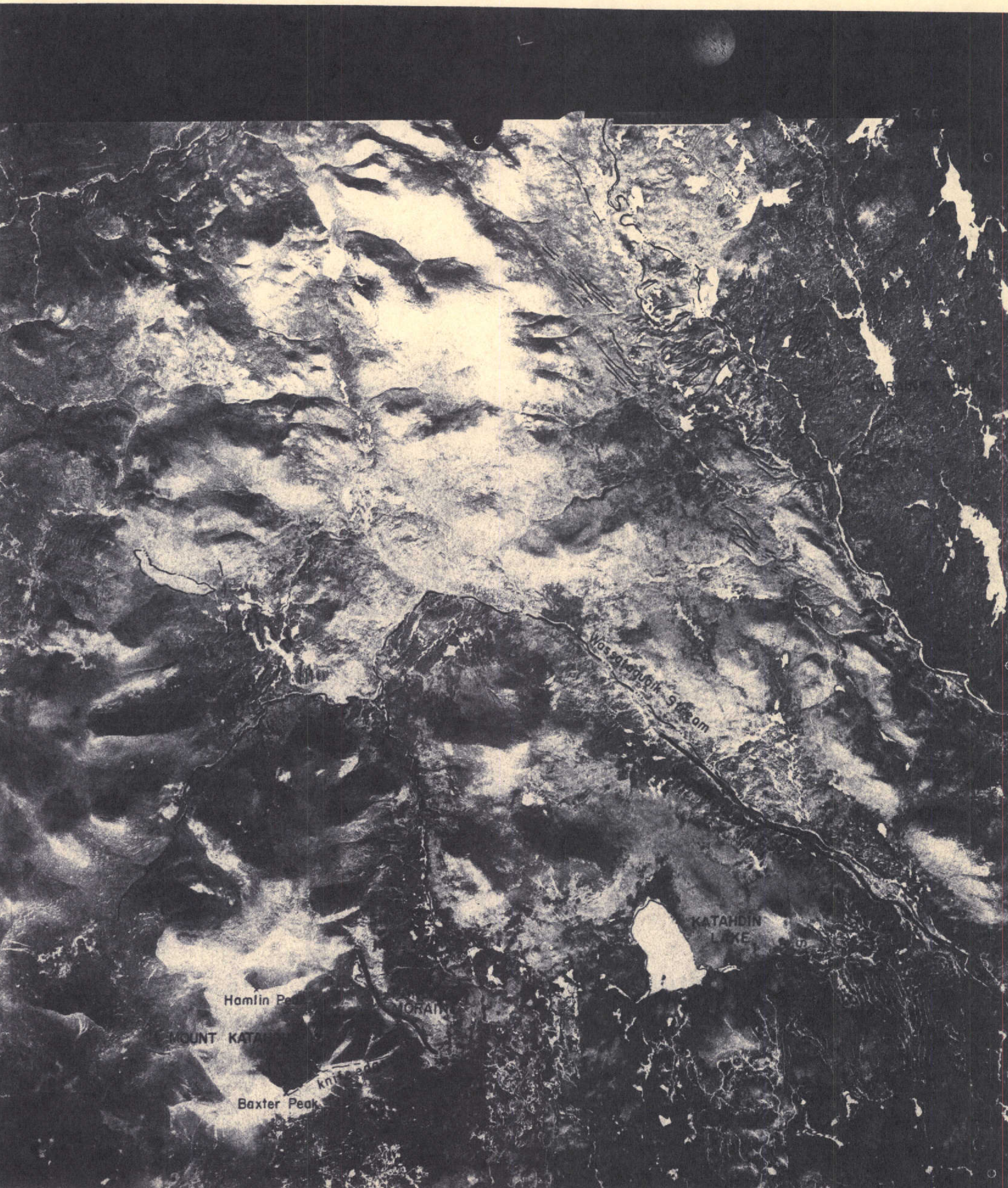
Figure 3

Figure 4

OVERLAY DELINEATION OF SNOW-ENHANCED GLACIAL FEATURES IN A WILDERNESS AREA (MOUNT KATAHDIN AND MILLINOCKET LAKE REGION, MAINE) DETECTED ON ERTS-1 SCENE 1202-14550, IMAGED 10 FEB 73, BAND 5, PROJECTION SCALE 1:125,000. BOLD IDENTIFIED FEATURES CORRELATE WITH U-2 RC-10 PHOTOGRAPH NO 8357, 31 JAN 73.



OVERLAY DELINEATION OF SNOW-ENHANCED GLACIAL FEATURES IN A WILDERNESS AREA (MOUNT KATAHDIN REGION, MAINE) DETECTED ON ERTS 1 SCENE 1202-14550, IMAGED 10 FEB 73, BAND 5, PROJECTION SCALE 1:125,000 BOLD IDENTIFIED FEATURES CORRELATE WITH U-2 RC-10 PHOTOGRAPH NO 8355, 31 JAN 73.



the photography for figures 2 through 5 were imaged only eleven days apart, indicating probably very similar snow conditions.

Projection studies of winter scenes were conducted with two additional ERTS images. Areas having relatively low relief and the absence of large terrain features show no detection benefit from snow enhancement. In the coastal region of Washington County, in image 1219-14495, 27FEB73, apparent good identification was made of several of the many large moraines. However, the available U-2 photography over the area, taken 24MAR73, has enough cloud obscuration to render it less desirable for ground truth, and definite corollaries were not established.

COLOR PRODUCTS

It was initially postulated that vegetation patterns imaged in ERTS color scenes might be useful for the delineation of some granular landforms, and that subtle (or distinct) color variations might be a clue, at least, to the existance of deposits. Several select ERTS scenes were retrospectively requested from NASA and ordered from the General Electric Company. Several images, including some of the above, were set up in the I^2S equipment at the GSFC User Facilities and photographed from the veiwscreen in March of 1973.

The first color products from NASA, received in March, were bulk color infrared composite 9" prints and transparencies of Image 1040-14540, 1SEP72. Eventually, about seventeen color composites of different scenes representing summer, fall and winter imagery have been received to date. All of the color products were studied in detail to determine what could be seen to identify glacio fluvial deposits.

Scene 1040-14543, CIR simulation, images a region of the state having seven major esker systems that extend for many miles on a general north-south trend. All of the systems have been extensively worked for granular materials within the populated areas, and to a lesser degree in wilderness portions, or where they occur remotely situated away from major highways. The resulting pits and elongate series of pits can be detected quite easily in the color transparency, where they generally image a somewhat brighter yellow shade than adjacent and surrounding fields. However, it should be noted that in all cases the observer was aware of their presence and knew where to look. At the southwest corner of the scene, pits can be identified along the Androscoggin River, northerly to Lake Auburn and northwesterly to the edge of the scene. In a similar manner, other systems can be traced by their pit configurations in Wayne, Augusta, Waterville, Unity, Bangor-Hampden-Bucksport and Great Pond, as one scans northeasterly across the scene. Scattered pits developed in other associated or detached formations can also be detected, where known. It is again emphasized that pits, not formations, are being identified. It was determined that the visual identification of pits in relatively unfamiliar regions could be attained with some confidence because of their fairly constant brighter signature.

All color products received to date have been scrutinized using the unaided eye, conventional 2X and 4X magnification and the Zeiss "Zoom 95" stereoscope. The content of shades of blue and green imaged within the overall pink to magenta vegetation colors in summer scenes was specifically studied for its potential as a landform indicator. Results have been as indicated for scene 1040-14543. Finite variations in color tones and hues in summer color infra red products are found to be insufficient for use as vegetative guides to glaciofluvial landform identification for the purposes of this investigation.

Spring and summer color composite scenes received to date are listed below. All are band 4, 5, 7 combinations, both prints and transparencies. Precision prints and transparencies were received for those scenes indicated by asterisks.

1257 - 15015, 6APR73

1327 - 14492, 15JUN73

1023 - 15003, 15AUG72

1040 - 14540, 1SEP72 *

1040 - 14543, 1SEP72 *

1040 - 14545, 1SEP72

1059 - 15001, 20SEP72

Winter color scenes in Maine image in darker colors than summer scenes in snow-free areas and in coniferous forest stands. Tonal differences are even less than in summer coverage, and snow cover effectively masks landform features. Study of all winter scenes revealed no significant detection of formations from the color aspect. On one color stereogram (Image 1202-14550, 10FEB73 and Image 1203-15004, 11FEB73) two large eskers and several moraine ridges could be seen because of the 'edge effect' of snow enhancement.

Winter composite scenes received to date are listed below. All are band 4, 5, 7 combinations, both prints and transparencies.

1167 - 15004, 6JAN73

1168 - 15063, 7JAN73

1183 - 14485, 22JAN73

1183 - 14491, 22JAN73

1202 - 14543, 10FEB73

1202 - 14550, 10FEB73

1202 - 14552, 10FEB73

1202 - 14555, 10FEB73

1203 - 15000, 11FEB73

1203, 15004, 11FEB73

1203, 15011, 11FEB73

The 70mm. chips of a few selected cloud-free scenes were used to produce composite color simulations on the I^2S viewscreen at NASA User Facilities, GSFC, Greenbelt, Maryland. Various combinations of color filters, illuminations and camera settings were used, to simulate both color infrared and 'natural color'. Slides were made from the viewscreen and later projected, for possible landform identification.

It was found that the I^2S C.I.R. renditions very closely approximate the NASA color products, intensity variations being the major difference. Close study indicates that, as with other color products discussed on page 17, a very good correlation of existing excavations can be made, but landform identification is not reliable on the projected photography.

Data for three typical I^2S simulations are listed below. A NIKON camera and High Speed Ektachrome film were used throughout.

1. ERTS ID 1040 - 14543, 1SEP72

   Band 4: Blue Filter, Illumination 3

   Band 5: Green Filter, Illumination 9

   Band 7: Red Filter, Illumination 3

   (1/15 @ f2.0)

   Maine Coastal Area, CIR simulation

2. ERTS ID 1040 - 14540, 1SEP72

   Band 4: Blue Filter, Illumination 3

   Band 5: Green Filter, Illumination 9

   Band 7: Red Filter, Illumination 3

   (1/30 @ f1.4)

   Mount Katahdin Region, CIR simulation

3. ERTS ID 1040 - 14550, 1SEP72

Band 4: Blue Filter, Illumination 4

Band 5: No Filter, Illumination 6

Band 7: Green Filter, Illumination 6

(1/30 @ f2.0)

Mount Katahdin Region, Natural Color Simulation.

ELECTRONIC ANALYSIS

In June of 1973, this writer and Mr. Ernest Stoeckeler (ERTS Proposals MMC203 and 205) spent four days at the General Electric Space Division facility in Valley Forge, Pennsylvania using the 'GEMS/Image 100' multispectral information extraction system. Simply stated, the system uses a conventional color TV monitor as the principal display means, in combination with digital format computerization. Multispectral analysis utilizes the fact that like objects in a scene usually have similar spectral properties. The input scanner and connector of the GEMS system scans color imagery (photography) and converts the resulting video into digital format for subsequent processing. The GEMS spatial cursor, electronically generated and manually variable in size and position, is placed over an image known to contain the feature of interest. Theoretically, the TV viewscreen would then display, after proper programming by the GE Technical Operator, the same features or signature, shown as yellow enhancement, throughout an entire ERTS scene. Therefore, the purpose of using the GEMS system was to determine if reliable signatures for data pertinent to the three MDOT proposals could be established, using available ERTS imagery and U-2 photography.

ERTS transparent color composites and Vinten 014(CIR) U-2 70 mm. Photographs were utilized for the proposed extraction of data . (It was found, after arriving at the GE facility, that simulated CIR transparencies of several ERTS scenes, prepared by the General Electric Co. laboratory in Maryland for the

MDOT proposals, were unsuitable for use in the GEMS system because of poor registration and resolution.) Extensive ground truth data were obtained for all major points of interest prior to the GEMS trip, such that topographic maps, U-2 underflight photography, conventional airphoto coverage and field notes were at hand for ready reference during the GEMS operations.

Many trials were made of subscenes of ERTS Scene 1040-14543, 1SEP72, attempting to establish various signature, initially, of softwoods, hardwoods, water, vegetation damage areas (proposal MMC 205) terrain formations, pit areas, etc. etc. It was found that some fairly simplified signatures (i.e. woods) could be established for a subscene (about 1/36 of a complete scene), but the same signature would be unreliable for carry over to adjacant areas. Signatures for the top of a scene, therefore, were found to be completely erroneous for subscenes in the southern position. Extremely small variations in color densities, resolution and registration throughout a scene, it was found, would require separate scans for each desired signature in each subscene.

Somewhat better results were achieved using a Vinten 014 70 mm. frame taken 20SEP72, covering part of the same area as the ERTS image. Vegetation signatures were obtained that appeared more closely aligned to actual ground conditions, but problems were encountered as with the ERTS imagery. No usable signatures pertaining to landforms were extracted. The best correlation of signature to ground conditions was attained, again, for pits, where the cursor placement would result in a generally good pit signature, but would also enhance extraneous bare earth areas having similar spectral properties.

U-2 AIRCRAFT PHOTOGRAPHY

U-2 support aircraft underflight photography obtained by NASA missions out of Moffet Field California has been an invaluable resource of timely ground truth data for this proposal and the other MDOT proposals, MMC 203 and 205. In addition, the coverage is an extremely useful reference file for on-going and future projects of the Materials and Research Division of the Maine Bureau of Highways and other State agencies. The receipt of satellite imagery and "high-flight" photography has stimulated keen interest in the ERTS program in several State agencies, particularly those in the fields of geology, forestry, planning, resources and fish and game management. RC-10 photography, of particular interest by reason of its more conventional and familiar format, is in constant demand on a loan basis. We were fortunate in receiving generally excellent, mostly cloud-free coverage of about 95% of the state, obtained on eight different missions flown between 20 August 1972 and 17 September 1973. Index maps of RC-10 photo centers of the U-2 flights are included as an appendix to this report.

SUMMARY

The time lapse involved in receiving clear imagery, especially retrospectively ordered color products, was initially a deterrent to the pursuits of the proposal. Sufficient scenes were eventually received, however, to explore all facets of study. It is felt that imagery was studied in a sufficient number of methods and details to determine the feasibility of the use of very small scale imagery for developing a landform classification system and compiling surficial geologic maps of glacial features by photo interpretation methods. It was, therefore, determined that the resolution and registration of ERTS satellite imagery, at present, is inadequate for the identification and mapping of small landform units utilizing available standard photo interpretation equipment, to fulfill the original objectives and scope of the proposal. In following the various appraisal and study steps required for evaluation, it became obvious that ERTS imagery does have tremendous potentials for synoptic studies and those

requiring repetitive seasonal coverage. Investigations concerning land use, hydrology, snow cover and others utilizing small-scale criteria should benefit greatly from the ERTS program.

U-2 aircraft underflight photography furnished as an adjunct to the three Maine ERTS proposals and one SKYLAB investigation has been of extreme value for ground truth correlations. Coverage of about 95% of the State was achieved between August 1972 and September 1973, with some duplication of coastal areas. This photography, which includes the four 70 mm format Vinten bands and 9" RC-10 format, will therefore constitute an extremely valuable file for future multi-agency and multidisciplinary use.

CONCLUSIONS

It is here emphasized that in the original proposal for this investigation it is stated that "standard airphoto interpretation techniques in current use" (by Maine Department of Transportation Soils Research Scientists) "will be applied to the ERTS A data - " etc. It is realized that photo analysis techniques exist, other than those used in the investigation, that may not be as sensitive to the types of limitations encountered. However, in view of the relatively very low requested funding of $9,652.00 and the lack of sophisticated photo analysis equipment available at MDOT facilities, the endeavors of the investigation were necessarily restricted in latitude to those described in this report. Retrospection of the proposal objectives and results, and products anticipated, now indicate an inordinate optimism of achievements expected within the limiting confines of funds, time and facilities available, and an admitted naivete with regards to the ERTS 1 imagery products. The original thought and intent of the proposal was that ERTS imagery might be a useful 'in house' tool and adjunct for various highway-related investigations, much the same as standard aerial photography presently being used, without having to resort to the utilization of sophisticated and expensive equipment for data extraction. Therefore, the findings expressed and/or implied relative to the various methods employed and described on pages 4 through 21 should be qualified as to the type of study that was actually undertaken.

Stereoscopic viewing analysis (pages 4 through 9) is a straightforward attempt at photo interpretation of imagery utilizing 2X, 4X, and larger magnification of image overlap areas as proposed. Certain large features were detected, but the smaller features, i.e., formations and deposits which may be of equal or greater importance to specific highway projects, were not identified.

Image projection analysis (pages 9 though 16) involved the relatively simplified expedient of carefully scrutinizing enlarged scenes of ERTS imagery. Again, certain features could be discerned, according to their location and individual characteristics. The effect of snow enhancement on winter imagery was beneficial for the detection of linear formations in the central position of the State. In general, however, the detection of new formations statewide was not accomplished.

Color products were analyzed primarily for vegetation patterns (pages 16 through 20). The concept of vegetation association detection for glacial landforms could not be resolved except in a very general manner, and not to a suitable degree of satisfaction. It was felt that the use of density slicing apparatus and similar equipment was beyond the range of the proposal because of the cost and time involved. The only attempt at electronic analysis (pages 20 and 21) did not produce any useful results.

APPENDIX

U-2 UNDERFLIGHT COVERAGE

PLOT MAPS OF RC-10 PHOTO

CENTERS FOR EIGHT MISSIONS:

20 AUG 72

20 SEP 72

27 JAN 73

31 JAN 73

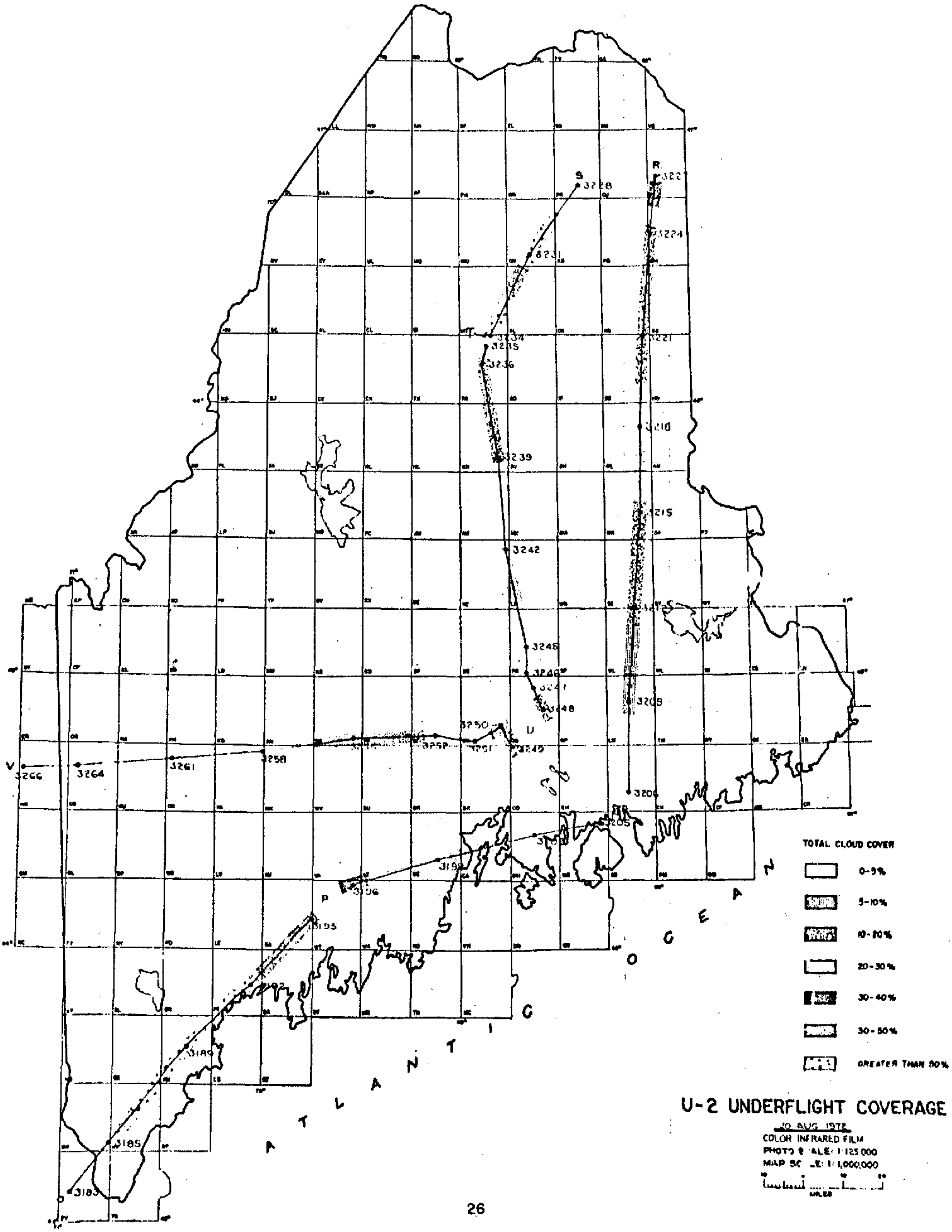
24 MAR 73

3 JUN 73

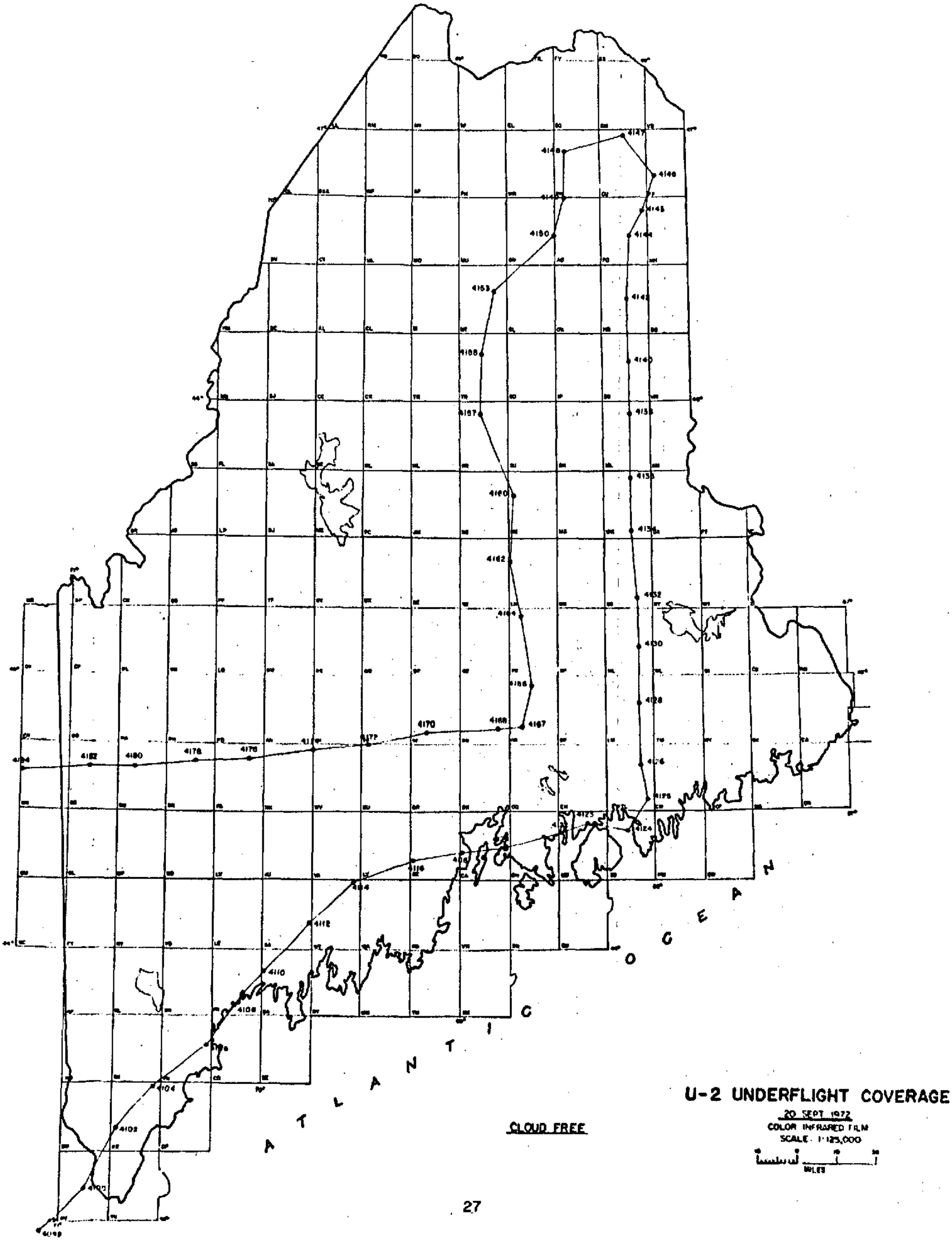
13 SEP 73

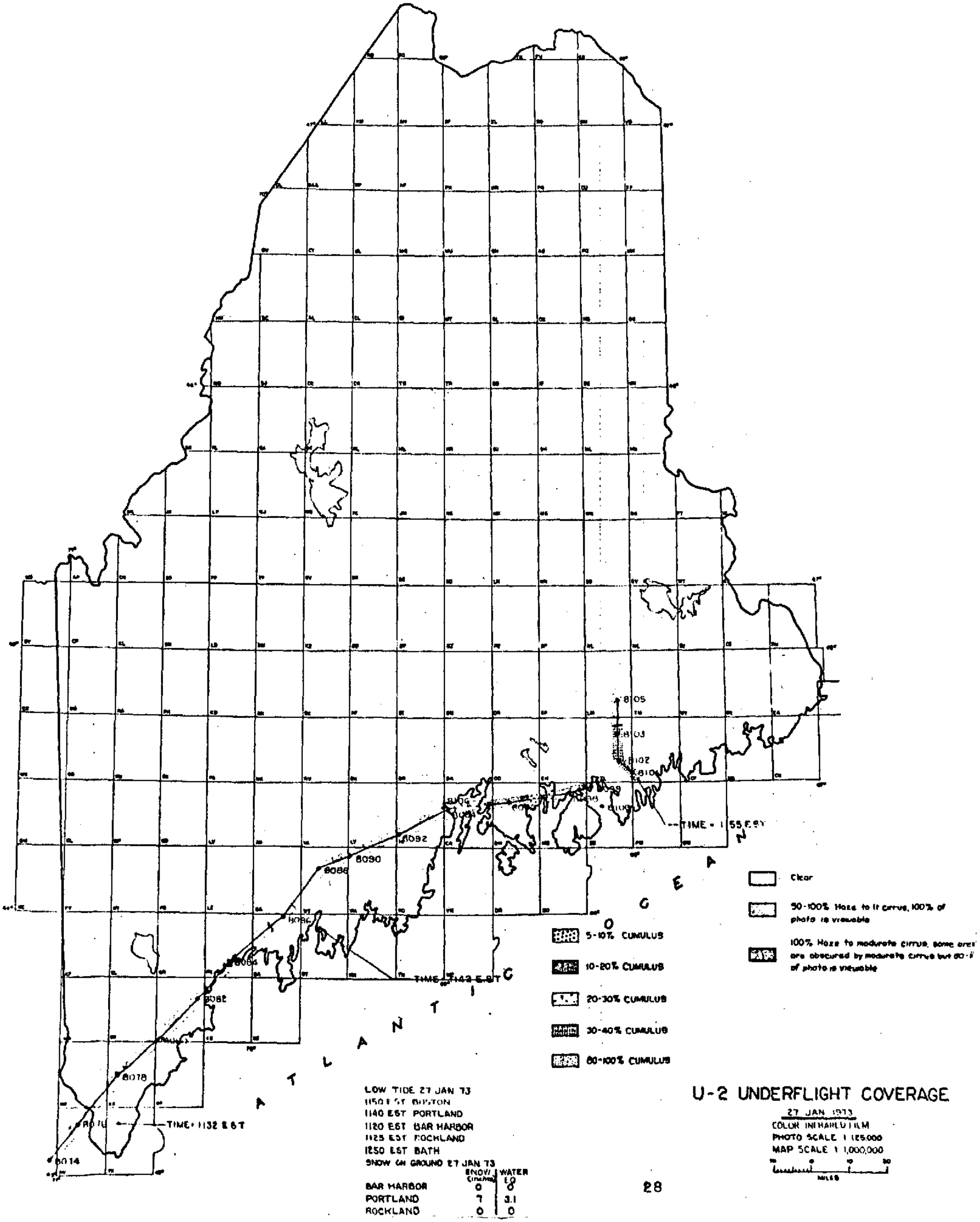
17 SEP 73

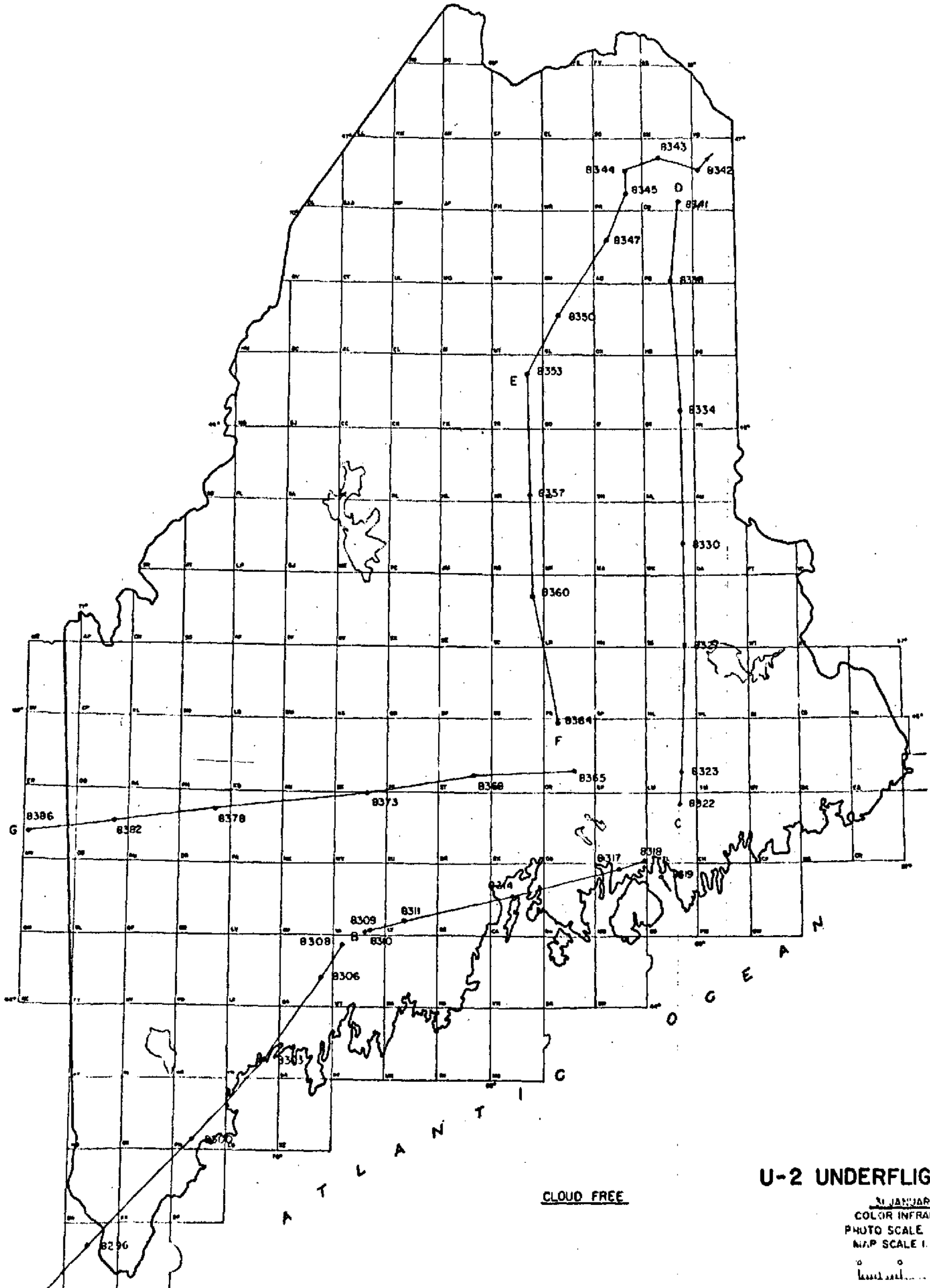
Composite map of 24 MAR, 3 JUN and 17 SEP 73 missions showing nearly complete state coverage.



S
3228
R
3227
3224
3231
3221
3234
3235
3236
3218
3239
3215
3242
3245
3246
3247
3248
3209
3250
U
3249
3251
3258
3261
V
3266
3264
3206
3205
3199
3196
P
3195
3189
3185
3183
A T L A N T I C
O C E A N
TOTAL CLOUD COVER
0-5%
5-10%
10-20%
20-30%
30-40%
30-50%
GREATER THAN 50%
U-2 UNDERFLIGHT COVERAGE
10 AUG 1972
COLOR INFRARED FILM
PHOTO SCALE: 1:125,000
MAP SCALE: 1:1,000,000
MILES

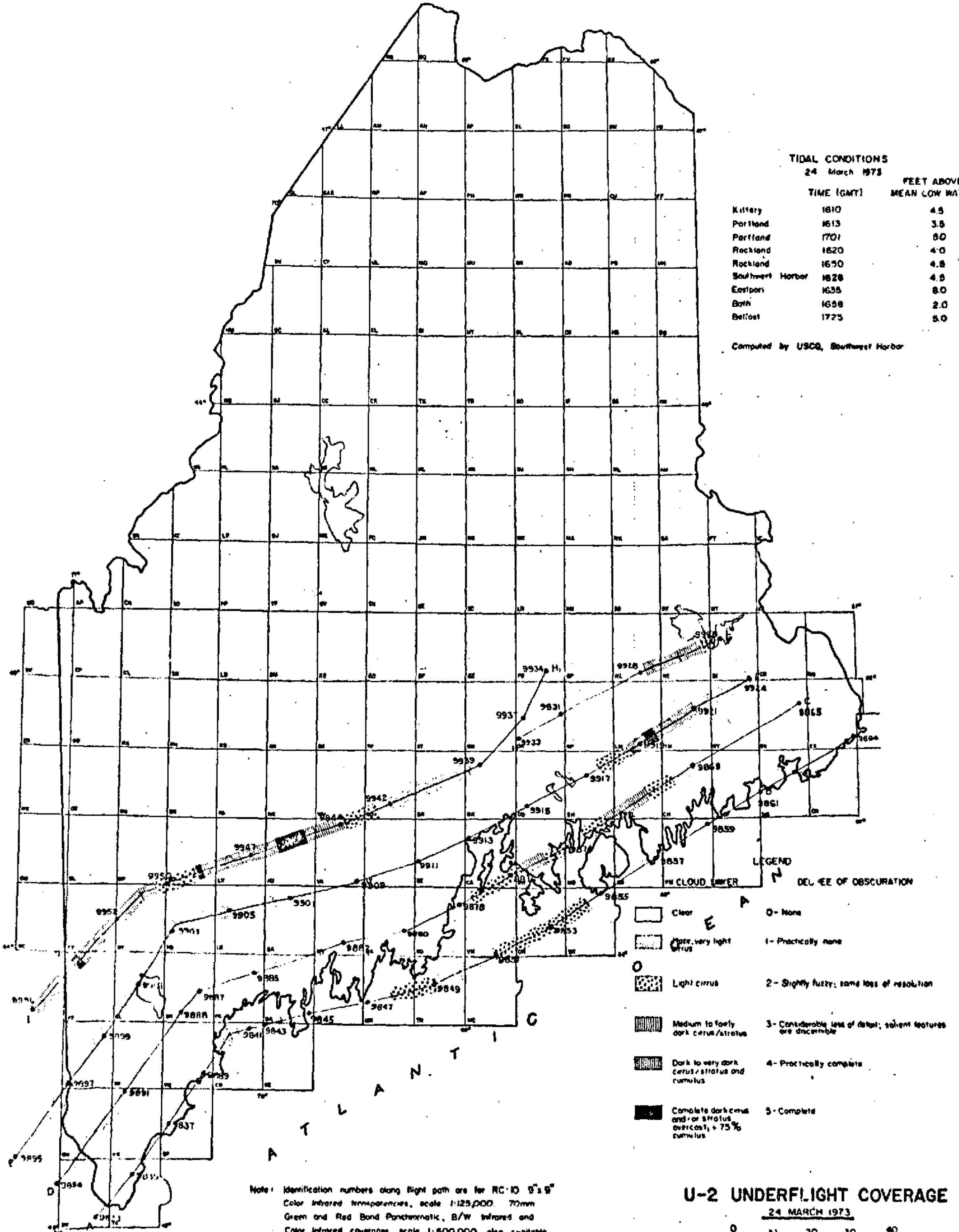

U-2 UNDERFLIGHT COVERAGE
20 SEPT 1972
COLOR INFRARED FILM
SCALE 1:125,000
MILES
CLOUD FREE
ATLANTIC OCEAN


8105
8103
8102
8101
8100
8099
8098
8096
8094
8092
8090
8088
8086
8084
8082
8078
8014
TIME • 1155 EST
TIME • 1143 EST
TIME • 1132 EST
ATLANTIC OCEAN
5-10% CUMULUS
10-20% CUMULUS
20-30% CUMULUS
30-40% CUMULUS
80-100% CUMULUS
Clear
50-100% Haze to lt cirrus, 100% of photo is viewable
100% Haze to moderate cirrus, some area are obscured by moderate cirrus but 80-% of photo is viewable
LOW TIDE 27 JAN 73
1150 EST BOSTON
1140 EST PORTLAND
1120 EST BAR HARBOR
1125 EST ROCKLAND
1250 EST BATH
SNOW ON GROUND 27 JAN 73
SNOW (inches) | WATER EQ
BAR HARBOR 0 | 0
PORTLAND 7 | 3.1
ROCKLAND 0 | 0
U-2 UNDERFLIGHT COVERAGE
27 JAN 1973
PHOTO SCALE 1 125,000
MAP SCALE 1 1,000,000
MILES



U-2 UNDERFLIGHT COVERAGE

31 JANUARY 1973
COLOR INFRARED FILM
PHOTO SCALE 1:125,000
MAP SCALE 1:1,000,000



TIDAL CONDITIONS
24 March 1973

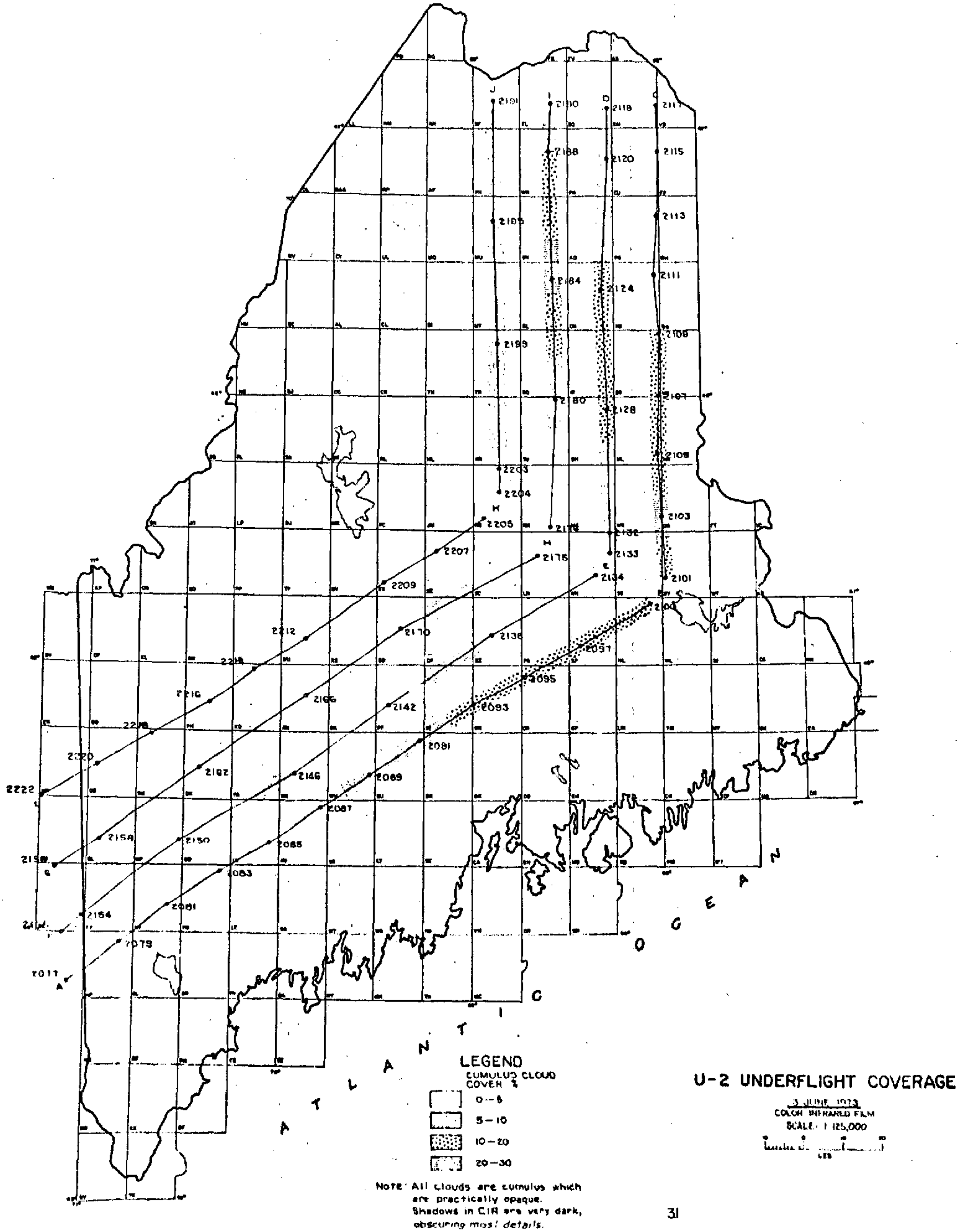
	TIME (GMT)	FEET ABOVE MEAN LOW WATER
Kittery	1610	4.5
Portland	1613	3.5
Portland	1701	6.0
Rockland	1620	4.0
Rockland	1650	4.8
Southwest Harbor	1628	4.5
Eastport	1635	8.0
Bath	1658	2.0
Belfast	1725	5.0

Computed by USCG, Southwest Harbor

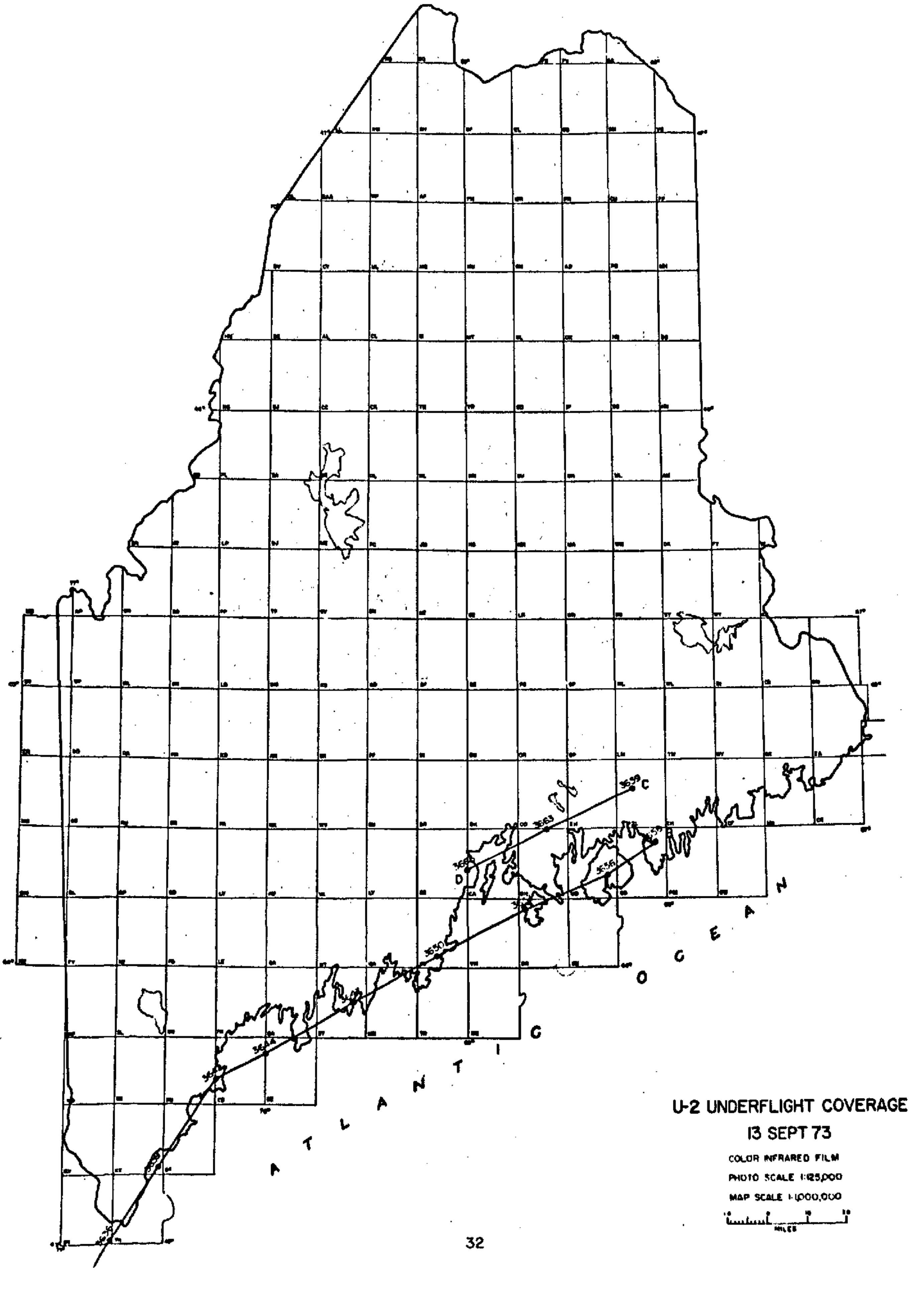
Note: Identification numbers along flight path are for RC-10 9"x 9" Color Infrared transparencies, scale 1:125,000. 70mm Green and Red Band Panchromatic, B/W Infrared and Color Infrared coverages, scale 1:500,000, also available.

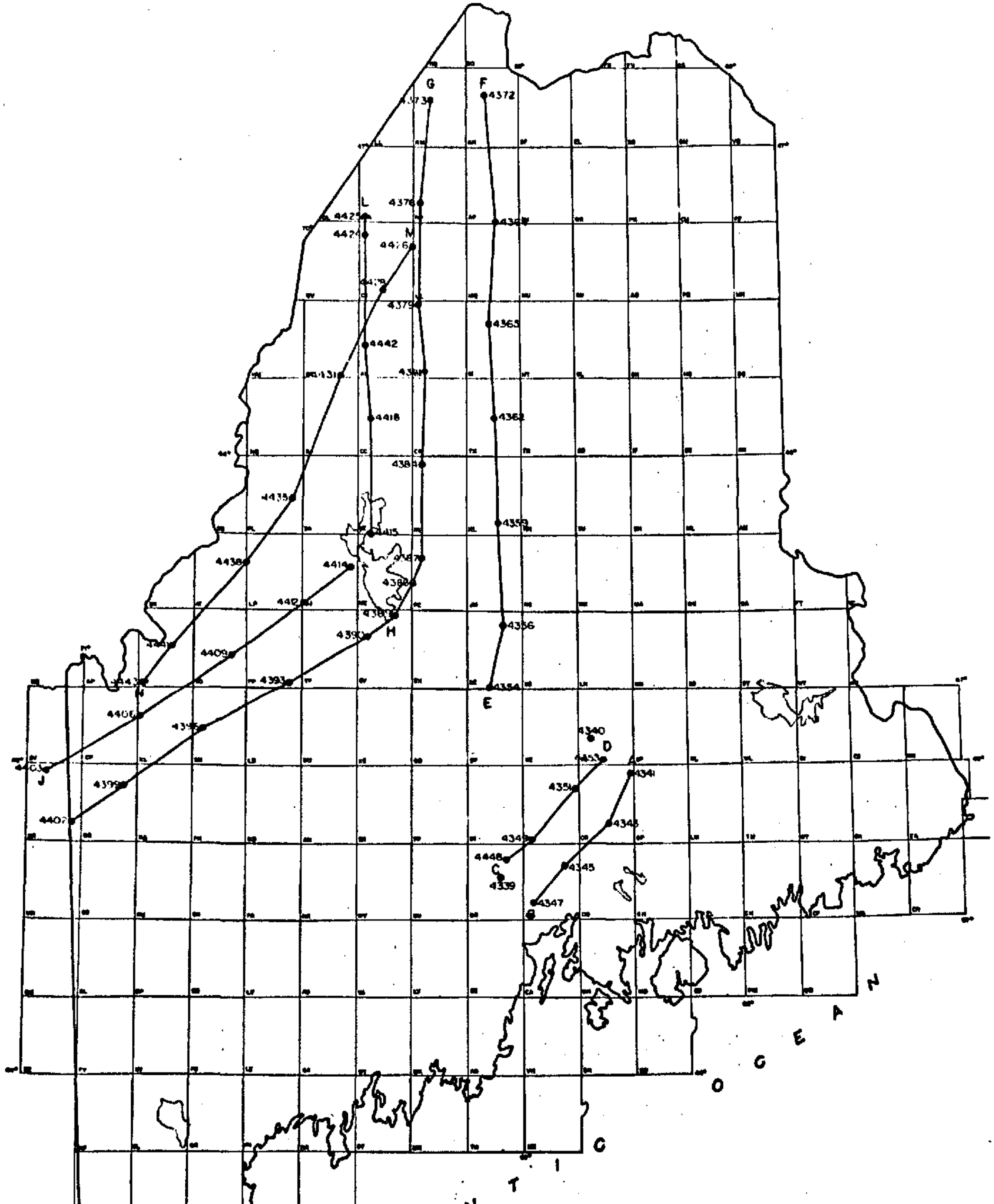
U-2 UNDERFLIGHT COVERAGE

24 MARCH 1973

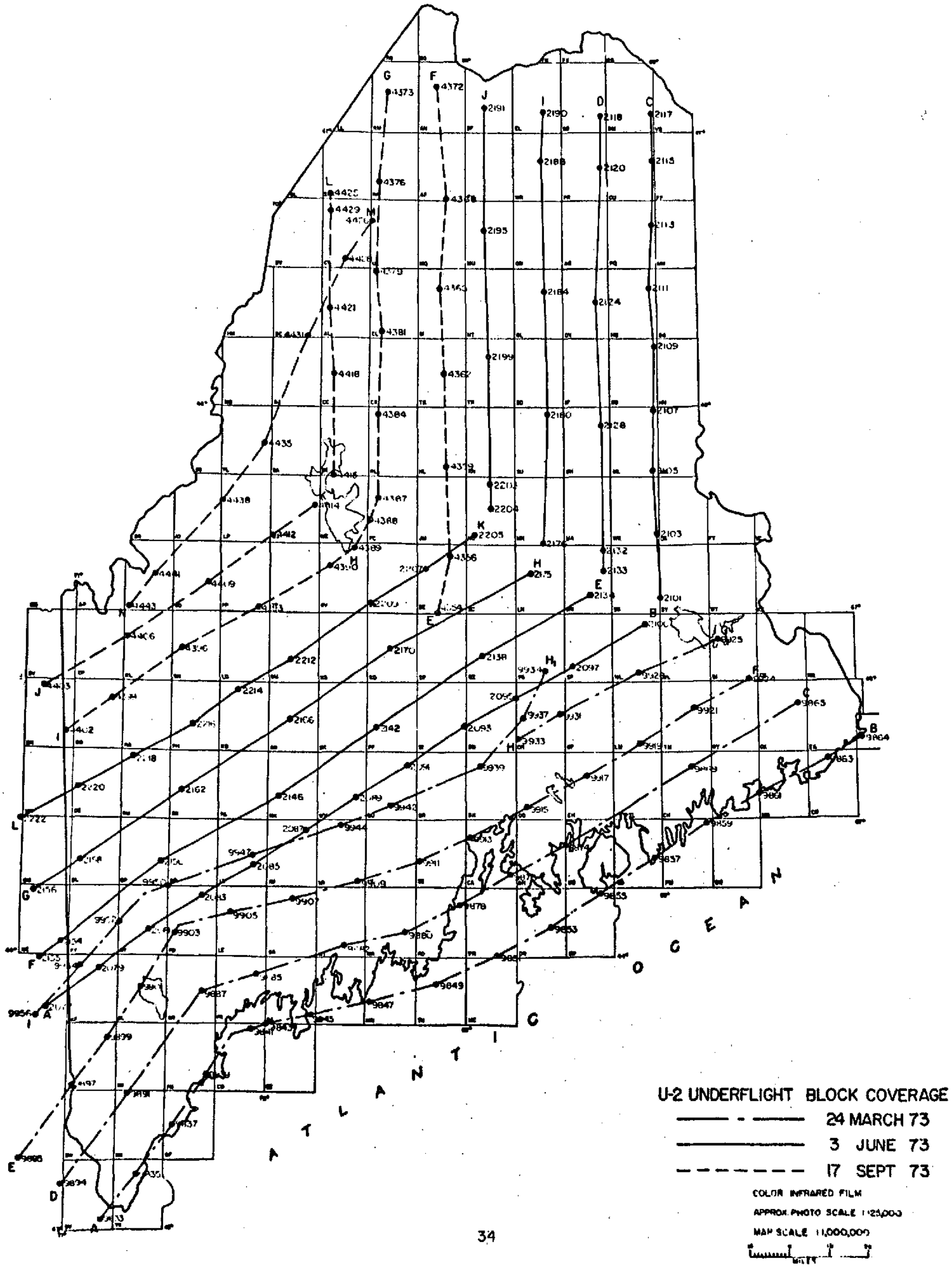


ATLANTIC OCEAN
LEGEND
CUMULUS CLOUD COVER %
0–5
5–10
10–20
20–30
Note: All clouds are cumulus which are practically opaque. Shadows in CIR are very dark, obscuring most details.
U-2 UNDERFLIGHT COVERAGE
3 JUNE 1973
COLOR INFRARED FILM
SCALE: 1:125,000


A T L A N T I C
O C E A N
U-2 UNDERFLIGHT COVERAGE
13 SEPT 73
COLOR INFRARED FILM
PHOTO SCALE 1:125,000
MAP SCALE 1:1,000,000
MILES



U-2 UNDERFLIGHT COVERAGE
17 SEPT 73
COLOR INFRARED FILM
PHOTO SCALE 1:25,000
MAP SCALE 1:1,000,000


ATLANTIC OCEAN
U-2 UNDERFLIGHT BLOCK COVERAGE
24 MARCH 73
3 JUNE 73
17 SEPT 73
COLOR INFRARED FILM
APPROX PHOTO SCALE 1:25,000
MAP SCALE 1:1,000,000

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INDEX OF SUBJECTS