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ANALYSIS OF ERTS-1 LINEAR FEATURES IN
NEW YORK STATE

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16. Abstract

All ERTS-I linears confirmed to date have topographic expression although they may appear as featureless tonal linears on the imagery. A bias is unavoidably introduced against any linears which may parallel raster lines, lithological trends, or the azimuth of solar illumination. Ground study of ERTS-I topographic lineaments in the Adirondacks indicates: outcrops along linears are even more rare than expected, fault breccias are found along some NNE lineaments, chloritization and slickensiding without brecciation characterize one EW lineament whereas closely-spaced jointing plus a zone of plastic shear define another. Field work in the Catskills suggests that the prominent new NNE lineaments may be surface manifestations of normal faulting in the basement, and that it may become possible to map major joint sets over extensive plateau regions directly on the imagery. Fall and winter images each display some unique linears, and long linears on the fall image commonly appear as aligned segments on the winter scene. A computer-processed color composite image permitted the extraction of additional information on the shaded side of mountains.

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PREFACE

This progress report summarizes significant results obtained since submission of the previous Type II report, on a project to evaluate the usefulness of ERTS-I imagery in regional tectonic mapping and synthesis. The investigation concentrates on New York State. Work to date continues to demonstrate the particular suitability of ERTS-I imagery to detect topographically-expressed features, including large scale structures which would probably never have been discovered without a regional synoptic capability such as that provided by ERTS-I.

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1. INTRODUCTION

1.1 The major objective of this investigation is to extract a maximum amount of geological information from ERTS-I imagery, and thus to evaluate its usefulness in regional geological studies. The results of our studies to date have been detailed in previous reports to NASA, in NASA/GSFC Symposium Volumes on the results of ERTS-I investigations (Isachsen and others, 1973, 1974), and in other publications (Isachsen 1973, 1974, and Fakundiny, 1974). They show that the greatest contributions of ERTS-I imagery in New York State have been in regional tectonic analysis, and more especially in the delineation of new linear features.

1.2 The current report will present the results of our continuing analysis of new imagery and field investigations of ERTS-I linear and curvilinear anomalies. No attempt will be made to reiterate the methods employed in data handling, imagery analysis, and field work, nor to discuss the general geology of the State and its representation on ERTS-I imagery. However, to facilitate the reading of this report, it is worth restating briefly the stages through which our investigation proceeds:

> Stage I: Delineation on overlays of all spectral signatures which *may* be geologically-linked.
>
> Stage II: Evaluation of these signatures in terms of existing information of all kinds in order to eliminate man-induced signatures and previously-mapped geological features, thus leaving a residue of ERTS-I anomalies to be field-checked.
>
> Stage III: Evaluation of these Stage II anomalies by observation and photography from small aircraft, and by conventional field methods.
>
> Stage IV: Use of the field-validated geological features in the preparation of an ERTS-enhanced tectonic map of New York State.
>
> Stage V: Publication of both interim and final results.

2. EXPERIMENTATION WITH COMPUTERIZED IMAGE PROCESSING OF ERTS-I DATA

2.1 The present investigation has depended almost solely upon conventional photogeological analysis of imagery coupled with multispectral color-additive viewing using an SDC viewer-projector. This approach has been highly successful in extracting linear and curvilinear information from the imagery. Indeed it is apparently the only way in which this task can be performed at the present time. According to A. Gillespie (telephone communication) the problems connected with direct digital production of a linear map from imagery, (as opposed to an operator-produced map) are formidable, due mainly to the difficulty of determining a coherent weighting system.

2.2 Quite another matter, however, is the capability of existing computer image processing techniques to yield greatly-enhanced images for geological study (e.g. Goetz and others, 1973; Vincent, 1973).

2.3 In the interest of having a "first look" at the potential of such image processing, an afternoon (24Oct73) was spent at NASA/GSFC with the generous assistance of Ms. Lottie Brown experimenting with computer processing of the 11Oct72 ERTS-I scene of the northwest Adirondacks. Unfortunately time was too short to adequately explore the potentialities of much of the image processing tasks which can be performed with Goddard's IDAM program. Nevertheless, the following image processing was done, and 35 mm daylight Ektachrome color transparencies were made of the video screen for study:

1. For the whole scene, density stretching of band 4 (stretched to 30 levels) and the production of a color composite of bands 4, 5, and 7 (bands 5 and 7 had a good density-level spread to begin with) to test for improvement in delineation of linear features.

2. 4x enlargement of the above color composite (assigning 4 TV pixels to one ERTS-I pixel) of Blue Mountain Lake area to see if any previously undetected linears could be found which might correspond with the northeast-trending fault plane solution for the earthquake swarms that occurred from May 1971 to April 1972 (Sbar and others, 1972) and again during July 1973 (Aggarwal and others, 1973).

3. Similar enlargement of Mt. Whiteface to see if recent landslide scars not visible on routinely-processed Goddard color composite imagery could be seen.

2.4 An evaluation of the color transparencies obtained above produced the following results:

1. No new linears were found in the scene nor were previously observed linears notably enhanced. This is probably because the density level spread on the original imagery of bands 5 and 7 was already favorable for linear detection.

2. No linears were delineated along the trace of the plane of epicenters. In view of the low magnitude of the quakes (3.6) this is not surprising. It was admittedly a "long shot", attempted mainly because field work during the earthquake activity showed that existing fractures in the epicenter area have strikes in the same sector as the 2-3.5 km deep quakes (figure 41). More will be said about ERS-I and seismicity in New York in a later section.

3. The enlargement of the Mt. Whiteface area did facilitate the recognition of landslides, even on the shaded side of the Mountain (figure 14); the slides do not show on unenhanced imagery.

3. ERTS-I LINEARS IN NEW YORK STATE

3.1 In this study, the word "linear" is used in the sense of Dennis (1967, p. 103) to designate a line of uncertain origin on aerial photographs or imagery. The term lineament, on the other hand, is reserved for a naturally-occurring linear feature (e.g. Hobbs, 1904a, 1904b; Lattman, 1958), i.e. one that has been confirmed to exist on the ground.

3.2 At the present state of investigation, Stage I compilation of linear and curvilinear features has been completed for the State although incoming imagery is routinely screened for new data.

3.3 In the photogeologic phase of imagery analysis, at least three types of biases are unavoidably introduced. Linear features which parallel trends of lithology or foliation are omitted, although there are doubtless places where field work would demonstrate the existence of colinear joint concentrations. A bias also exists against linears which may be perfectly aligned with the multispectral scanner raster lines in the imagery. A third bias is introduced by the azimuth of solar illumination which preferentially highlights linear valleys at high angles to the direction of illumination, and diminishes the identifiability of those parallel to it (Isachsen, 1973).

3.4 Stage II studies have been completed in the Adirondacks and are nearly finished for southeastern New York. Stage III investigations are furthest advanced in the Adirondacks, although preliminary results have been obtained from ground studies in the Catskill region which has been selected as a sample area for the geological calibration of ERTS imagery over the Allegheny Plateau. Because of the enormity of the State in terms of ground checking, the evaluation of individual ERTS-I linear and curvilinear anomalies will doubtless occupy the attention of field geologists well into the future, as new geological mapping is undertaken.

3.5 The discussions of linear features which follow will concentrate on Stage III linears in the Adirondacks, a comparison of the linear data seen on fall versus winter imagery in the Catskills, and Stage III linear studies in the Catskills.

4. ERTS-I LINEAR FEATURES IN THE ADIRONDACK MOUNTAINS

4.1 Linear Features Observed in Stage III Study

4.1.1 Field studies in the Adirondacks, carried on by both conventional ground methods and by observation and photography from low level aircraft, has permitted further definition and identification of ERTS-I linear anomalies. The result has been to declassify some, re-classify others, and to add a small additional number which were originally considered too marginally expressed on the imagery to be designated as photogeologic linears. Before giving a tabulation of these changes, photographic illustrations of both previously-mapped and new lineaments will be discussed in order to show the capabilities and limitations of ERTS-I imagery for the detection and mapping of topographic lineaments. In the illustrations selected, preference has been given to those occurring within the major body of metanorthosite in the Marcy Massif because of its relative homogeneity and massiveness as compared with surrounding rocks (Isachsen and Moxham, 1968; Isachsen and Fisher, 1971).

4.1.2 A location map and descriptive information is given for linears still "in good standing" in the Appendix.

4.1.3 The longest clearly-defined topographic lineament in the Adirondacks is the previously-mapped feature that extends from the Marcy Massif metanorthosite south-southeast, across nearly every Adirondack rock type, to the southern boundary of the Adirondacks where it passes beneath Paleozoic strata without any apparent offset in the cover rocks (figure 39). Geomorphically, the most impressive part of this lineament is the Long Lake section (figure 2). It is interesting that this, the longest linear feature, occurs near the western limit of intense lineament development (figures 39 and 40).

4.1.4 A previously-mapped lineament in the high peaks region, located entirely within the Marcy Massif, is that which passes through Avalanche Lake located in the shadow of Mt. Colden (Figure 3). An orthogonal lineament set crossing Mt. Colden cannot be distinguished on the ERTS-I imagery owing to a combination of its small scale and its near parallelism to the multispectral scanner raster lines.

4.1.5 Several of the arms of Cranberry Lake in the east central Adirondacks are broad linear valleys developed in granitic gneiss (figures 39 and 4). Extensions of these lineaments, first observed from low level aircraft (figure 4), were found on re-examination to be visible in the imagery (linears 176a and 176b in Appendix II). A view of another arm of Cranberry Lake showing lineament 175 appears in figure 5. ERTS-I imagery has been especially useful in this part of the Adirondacks where topographic maps predate stereomapping methods.

4.1.6 A rocky shoreline along Lake Champlain permitted interesting aerial documentation of ERTS-I lineaments. Shoreline expression includes the formation of coves, discontinuity in the shoreline cliffs, and inclination of joints near the structures suggestive of conjugate shears associated with faulting.

4.1.7 Another lineament located in metanorthosite is shown in figure 8. It illustrates well a question that continues to plague us in the identification of photolinearson ERTS, namely, what minimum length is required before a linear feature can be classified a topographic lineament and hence assumed to be structurally controlled? The question arises again in considering figures 14 and 15. In the present illustration, however, the continuation of the linear beyond the head of the valley is judged a valid reason for the classification. A ground check is desirable to ascertain the cause of the lineament.

4.1.8 Figure 9 illustrates a previously-mapped fault in mangerite which appears in the imagery to have an eastward extension.

4.1.9 More subtle lineaments are seen in the Seward Range (figures 10 and 11). These contrast sharply with the strong geomorphic expression of other linears in the same metanorthosite massif farther east (figure 1 and 3). Indeed, they occur near the western limit of strong lineament development and deserve ground study and verification.

4.1.10 Figure 12 shows part of topographic lineament 309 which joins together two previously-mapped linear elements, and extends one of them, to define a single lineament 50 km long.

4.1.11 An example of the difficulty that can be experienced in identifying a topographic lineament, even from the best vantage point, is shown in figure 13. The linear feature is faint, at best, in the photograph despite its clarity in the imagery.

4.1.12 Figures 14 and 15 illustrate a linear valley which is tentatively classified as a topographic lineament because it notches the ridge. Its possible continuation beyond the ridge is obscured in shadow even on the computer-enhanced image.

4.1.13 A short, straight lineament is illustrated on the east side of Catamount Mountain in the northern Adirondacks (figure 16). It is quite possible that Taylor Pond should also be classified as a lineament inasmuch as it is developed within a relatively massive charnockite.

4.1.14 A subtle linear valley cutting Follensby Pond in the central Adirondacks (figure 17) is classified as a topographic lineament because it transects lithologic boundaries at right angles. The apparent cuesta in the photograph reflects eastward dipping foliation in a mangeritic gneiss.

4.1.15 Another subtle linear valley is shown in figure 18. Although unimpressive in this lighting, the linear is well displayed on the imagery and is tentatively classified a topographic lineament.

4.1.16 An example of a declassified linear is shown in figure 19. Although fairly convincing on the imagery, it turns out to be a ridge crest enhanced by a vegetation boundary but without any apparent geological control; it is located entirely within gabbroic metanorthosite.

4.1.17 In contrast to linear valleys described above which are well defined on the imagery but very subtle in the field, there are other shorter ones which have the opposite characteristics. One example is a newly-discovered lineament trending N42W (figure 20). Perhaps the reason it is not delineated on ERTS is that it too closely parallels the azimuth of solar illumination. A photograph taken of the opposite side of the MacIntyre Range (figure 21) shows numerous lineaments cutting the mountainside. The most pronounced of these, that which passes on the left of snow-capped Algonquin Peak, is a new lineament not originally identified on the imagery. It strikes N82W at a high angle (55°) to the azimuth of solar illumination. Another of these lineaments trends N40W, within 13° of the solar illumination direction, and is barely visible on the imagery. The other steeply inclined lineaments are in shadow on the imagery. Note, however, the two lines running from left to right midway up the mountain. One of these shows clearly on the imagery as a new lineament. Each of these lineament sets will be studied in the field to determine and compare their origins. They appear to offer an intriguing prospect for regional basement stress analysis.

4.1.18 Another photograph of the MacIntyre Range, taken south of the preceding illustration, shows the blocky upper surface of the Range produced by intersecting orthogonal and oblique lineaments (figure 22). Two major previously-mapped lineaments, appearing broadly curved in this view, cross the picture from left to right. At least five other, newly discovered lineaments are shown but none of these can be mapped with confidence in the imagery. In the left middleground a vertical lineament crosses Cliff Mountain (see also figure 23). It is not clearly visible in the imagery.

4.1.19 A further example of newly discovered lineaments which are below the detectability of ERTS-I resolution (either summer or winter) are illustrated in figure 24. Local cloud cover during U-2 flight obscured this Peak, so the trends of these lineaments are not yet known.

4.1.20 An exceptional exposure of a fault surface in the Adirondacks is that exposed in the east-west open pit operation of the Barton Garnet Mine in North Creek, eastern Adirondacks (figure 26). The fault zone marks the contact between charnockite on the right (south) and the garnetiferous olivine metagabbro which is being mined. The fault zone is about 3 meters wide, nearly vertical, and characterized by slickensiding oriented in several directions and intense chloritization. As can be seen in figure 26, the fault surface is quite irregular. It strikes east-west and dips about 75° north in the western (near) end of the pit and swings through the vertical at the eastern end. Also visible are broad rolls in the surface which have subhorizontal axes. The fault zone is about 3 meters wide, is chloritized but not brecciated, and shows both horizontal and vertical slickensiding. Away from the excavation the fault cannot be recognized owing to an absence of outcrops. Although brecciation does not characterize this east-west fault, it can be seen in several Adirondack road cuts along the major north-northeast set of topographic lineaments.

4.1.21 An example of closely-spaced jointing as a cause for the development of a linear stream channel segment is illustrated in figure 25. About 50 meters upstream a healed plastic shear zone between two facies of metanorthosite occurs, suggesting the possibility of rejuvenated brittle deformation along an old shear zone.

4.2 Status of ERTS-I Linears in the Adirondack Region

4.2.1 On the Geologic Map of New York, 1961 edition, (Fisher and others, 1961) Isachsen added in the Adirondack region numerous topographic lineaments which could be seen clearly on 1:62,500 topographic maps made by stereophotogrammetric methods. The contour interval of these maps is 20 feet. The linear features were designated "topographic lineaments" to distinquish their status from that of mapped faults. Interestingly, the two are, in most instances, indistinquishable topographically except where mapped faults have only slight topographic expression. To this group can now be added new topographic lineaments found on the ERTS-I imagery. These will be discussed subsequently.

4.2.2 As in previous reports, we continue to classify ERTS-I linear features using descriptive terms; for topographic lineaments the terms are geomorphic (table 1). The importance of avoiding genetic terminology in the presentation of photogeologic data, even for planetary studies, appears to require periodic emphasis (e.g. Schmitt, 1966; Schultz and Ingerson, 1973).

4.2.3 The breakdown of ERTS-I linear features resulting after Stage II and incomplete Stage III investigations in the Adirondack Mountains is shown in table 1. At the head of the table are listed the declassified Stage I linears. These comprise about 20 percent of the original total of linears (435-30 curvilinears = 405); they will not be considered further. Each of the remaining linears was classified both in terms of its photogeologic description (left column) and its topographic expression (CTL, TL, or NTL of table 1, see footnote) in order to determine the number of new ERTS-I topographic lineaments. It can be seen that both the CTL and TL categories are topographic lineaments by definition (postponing for the present the question of possible additional requirements besides straightness and topographic expression, such as minimum length and other geomorphic characteristics). The same applies to NTL linears in photogeologic classes one through four which must have topographic expression even though they might appear, for example, as featureless, dark vegetation strips which are determined from airfoto index sheets to occur along straight stream courses. Such linears would be placed in class 1 under NTL. Summing all these topographic lineaments yields a total of 238, or nearly 75 percent of the total number, 321.

4.2.4 Before comparing previous and present totals, it should be noted that the present totals refer only to linear features; 30 curvilinears from the previous list have been omitted. Also omitted is the earlier designation "ridge crests" because the linears involved

Table 1. PRESENT RESULTS OF STAGE II AND STAGE III EVALUATION OF ERTS-I LINEAR FEATURES IN THE ADIRONDACKS

Photogeological Classification	Topographic Expression				
	CTL	TL	NTL	Totals	Previous Totals
I. Declassified Stage I Linears					
1. Man-caused photolinears which are unrelated to natural features, *e.g.* highways, transmission lines, railroad beds, canals, etc.			20	20	20
2. Normal lithological contacts and foliation trends	43	2	9	54	51
3. Unverifiable on the ground as linear features				17	
SUBTOTALS	43	2	29	91	71
II. Retained Stage II and Stage III Linears					
1. Straight segments of stream courses			5	5	96
2. Straight stream valleys	101	22		123	27
3. Winding streams			3	3	7
4. Elongate lakes or straight lake shorelines	2		2	4	7
5. Edge of topographic high or aligned segments of same	7			7	8
6. Dark vegetation strips			8	8	30
7. Natural vegetation borders			6	6	7
8. Combinations of two or more of above, indicating topographic expression which predominates	80	16	33	129	57
9. Unexplained			36	36	125
SUBTOTALS	190	38	93	321	364
TOTALS	233	40	122	412	435**

*CTL = clearly a topographic lineament on imagery and on ground
TL = topographic lineament on ground but not obviously so on imagery
NTL = not a topographic linear feature on imagery, and not yet check on ground

**Present and previous totals are reconciled by subtracting 30 curvilinears from the previous total and adding 7 new linears. Previous totals are from Isachsen, 1973.

were not caused by any variations in structure (or lithology), the terrane involved being relatively homogeneous metanorthosite of the Marcy Massif. Rather, they are explainable as residual linear ridges bounded by parallel topographic lineaments. Allowing for these changes, the following are notable reclassifications:

1. Seventeen linears were declassified as unverifiable on the ground as linear features.

2. About 75 percent of the dark vegetation strips were found to coincide with "straight stream valleys" and were hence transferred from a botanical to a geomorphic category.

3. About 65 percent of the "unexplained" linears were reclassified, many as combinations of geomorphic and botanical categories.

4. About 95 percent of the "straight segments of stream courses" were reclassified into other categories, mainly "straight stream valleys".

5. ERTS-I LINEAR FEATURES IN THE CATSKILL MOUNTAINS

5.1 Introduction

5.1.1 As noted in our last Type II report (Isachsen and others, 1973) a vertical aerial photograph (1:24,000) taken by NASA in support of this investigation proved to be a useful calibration device to determine how short a linear may be mapped on ERTS-I imagery with confidence. We were surprised to learn that linears on the 1:1,000,000 imagery spaced as little as 1 km apart, and as short as 1.5 km appear as straight, deep valleys on the aerial photography. As a result of this discovery we re-analyzed the imagery for the southern part of the State and delineated linears with new courage. The resulting map is shown as figure 40.

5.2 Comparison of Linear Content in Fall and Winter Imagery

5.2.1 In the process of re-analyzing the imagery, it was decided to compare, for the southeastern part of the State, the best fall and winter imagery available (figures 28 and 29). The goal was to evaluate the expected enhancement effects of low sun angle and snow cover on topographic and tonal linears. Both black and white transparencies of bands 5 and 7 were studied, and also color composite prints and transparencies. The area studied extends from Coxsackie on the north to Haverstraw on the south, and from Oneonta on the west to the Hudson River on the east (figures 30 and 31). It is covered by a block of thirty 15 minute quadrangles, six in an east-west direction by five from north to south. Results of the analysis are shown in figures 30 through 34.

5.2.2 The winter imagery for these thirty quadrangles shows 1175 topographic and 30 tonal linears whereas the fall imagery displays 730 topographic and 211 tonal linears. The "winter linears", however, although more numerous, are much shorter (usually less than 10 km long) and some represent segments of single longer linears observed in the fall imagery. Many of the shorter winter linears (less than 4 km long) do not appear on the fall imagery, however, and the summed lengths of all linears appearing on the winter imagery may well exceed those on the fall imagery.

5.2.3 The snow cover has a dual effect: it eliminates cultural signatures and accentuates topography. Thus, about sixty tonal linears on the fall imagery appear as topographic linears on the winter scene. Three tonal linears in the winter image, all with a northeast orientation, appear as topographic linears on the fall image (figure 33). Their topographic expression is confirmed on topographic maps. Of the linears that appear exclusively on the winter image (figures 29 and 32) only one is longer than 10 km, and most are shorter than 5 km. The greatest density of linears seen only on the winter imagery appear in the Catskill Mountains in a broad east-west band. Several of the linears that appear exclusively in the fall imagery exceed 10 km in length. These show no preferred orientation.

5.2.4 About one-third of the linears appearing in the fall image are not recognized in the winter image, whereas about one-fourth of the linears on the winter image are not expressed on the fall image. Predominant azimuth, density, length, ratio of tonal linears to topographic linears, and curvatures appear to differ from one geologic province to another on the winter imagery much as they do in the fall scene.

5.2.5 Formational contacts are accentuated in the winter image, especially in the Shawangunk Mountains.

5.2.6 In conclusion, a satisfactory analysis of linear features can be made by combining the linears found on one clear winter scene and one clear fall scene, using positive transparencies of band 7. However, color composite film positives or prints of bands 4, 5, and 7 proved to be extremely valuable for defining the regional valley patterns and displaying the linears that would be derived from separate analysis of positive transparencies of each band.

5.3 Stage III Reconnaissance in the Northern Catskill Mountains

5.3.1 In an initial field evaluation of linears in the northern Catskills, joints and geomorphological features have been studied at 18 localities in three 15 minute quadrangles spanning the northern Catskill Mountains (figure 27). The field data have been summarized in table 2, from which the following conclusions may be drawn.

[illegible] OF ERTS 1 LINEAR AND GROUND DATA IN THE NORTHERN CATSKILL MOUNTAINS

FIELD LOCATION NUMBER	LINEAR NO. AND AZIMUTH	AZIMUTH OF TOPOGRAPHIC FEATURE	ATTITUDE OF JOINTS MASTER SET UNDERLINED	7½' QUADRANGLE (15' QUADRANGLE)	REMARKS	DEGREE OF CORRESPONDENCE OF LINEAR WITH GROUND DATA
1	*Topo 131 N15E	Valley N15E	N15E, 85E	Leeds (Coxsackie)	Folded Limestone - Jointed, jointing perpendicular to bedding and parallel to fold axes	Perfect with valley and joint set
2	Tonal 36 N40W	Flood Plain Valley N40W	No Outcrop	Leeds (Coxsackie)	Catskill Creek	Perfect with valley, no rock outcrops
3	Summer Tonal 29 curved: east end N60W, west end N75W, winter topo N20E	NE Catskill Front Front trends ≈ N60W	N20E, 80E N60W, 70NE	Freehold (Durham)	Redbed Sandstones and shales, N60W 70NE joint is slightly curved convex upward	Summer tonal perfect with northern front of Catskills and subordinate joint set; winter linear perfect with valley and master joint set
4	Near topo127 N60W	NE Catskill Front Front trends ≈ N60W	N60W, 90 N50E, 90	Freehold (Durham)		Perfect with valley and master joint set
5	Topo 127 N60W Topo 128 N20E	Catskill Front ≈N60W Narrow Valley N30E	N60W, 80NE N35E, 85W	Hensonville (Durham)	N35E 85W joint curved and irregular	Perfect with northern point of Catskills and subordinate joint set Good with valley, fair with master joint set
6	Topo 128 N20E	Narrow Valley N30E	N35E, 90 N60W, 90	Hensonville (Durham)	N35E joints are plumose and planar	Fair with valley; valley parallels master joint set
7	Tonal 31 N20E	Narrow Valley N10E	N50E, 80NW N35W, 80E	Hensonville (Durham)	Tonal linear 28 trends, N10E ∴ geomorph reason for valley not understood	Good with valley, poor with joints
8	Topo 110 Curved, generally N-S Topo 109 N35E	Narrow Valley segment N40W, part of larger valley system trending N15E, Valley side N30E	N40W, 90 N30E, 82NW N85E, 78S (All moderately weak)	Ashland (Gilboa)	In Stone Quarry N40W joint curved N30E joint curved and plumose concave downward N85E curved	One linear poor with valley, and lacks correlation with joints, other linear perfect with valley side and with joints
9	Topo 107 N75E	Major Valley segment west end N75E	N75-80E, 75-90N (weak)	Ashland (Gilboa)	Near Stone Quarry Joint only in sandstone	Perfect with valley, and subordinant joint set
10	Near Topo 104 N15E	Outcrop on hillside near a straight valley-hillside trending N40W	N50W, 90	Ashland (Gilboa)	Poorly jointed outcrop on hillside in sandstone	No correspondence with valley or joint set
11	Topo 123 N15E	Narrow Valley N15E	N15E, outcrop Status uncertain	Ashland (Gilboa)	No outcrops that are definitely in place Hillside boulders have joints ll to valley but not sure how much creep has taken place	Perfect with valley and joint set
12	Small unnumbered topo N75W	Narrow Valley N80W Narrow Valley N5E	N80W, 84N N32W, 80E N5E, 90	Prattsville (Gilboa)		Perfect with valley and master joint set
13	Small unnumbered topo N40W	Two valleys meet: N40W N30E Small Valley N65E	N80W, 80S N25W, 74NE N72E, 90	Prattsville (Gilboa)	N72E joint is curved	Fair with valley and master joint set Small valley perfect with subordinant joints
14	Small unnumbered winter topo N40W	Short, narrow valley Segment N30E	N30E, 90	Prattsville (Gilboa)	Joint is curved only one joint set in outcrop	Perfect with valley and master joint set
15	Topo 92 N45E Small unnumbered winter linear N75W	Short narrow valley generally N65E, nearby short valley ¼ mile to the north N75W	N80W, 90 N10E, 60W	Prattsville (Gilboa)		Perfect with valley, no correspondence with joints; perfect between joints, unnumbered linear and short valley ¼ mile north of outcrop
16	Topo 1147 N60E	Narrow Valley N60E	N55E, 76N	Roxbury (Hobart)	Only good joint set in outcrop	Perfect with valley and joint
17	Topo 1147 N60E	Narrow Valley and N60E	N50E, 80N N55W, 75SW	Roxbury (Hobart)		Good with valley and master joint
18	Unnumbered linear E-W	Narrow, very straight valley E-W	No outcrops	Roxbury (Hobart)	Very straight valley trending E-W which shows as barely recognizable linear on ERTS image. No outcrops were found.	Perfect with valley, no rock outcrop

*TOPO = TOPOGRAPHIC LINEAR; TONAL REFERS TO NON-TOPOGRAPHIC LINEAR
[illegible]

1. The overwhelming majority of ERTS-I linears are topographic. Tonal linears are almost entirely restricted to the Hudson Valley (figure 30).

2. Topographic linears on the imagery, even as short as 1 km, correspond to straight valleys in the field.

3. In twelve of the nineteen outcrops found in such valleys, a joint set was displayed parallel to the axis of the valley. Four other outcrops studied have joints oriented within 15 degrees of the valley axes, and one outcrop with poorly expressed joints shows no correspondence between joint and linear directions.

4. Individual outcrops generally show one, two, or three joint sets. One set is usually more prominently developed than the others, and it is commonly this set which parallels the axis of the valley.

5. Within a given 15 minute quadrangle, local joint set patterns vary in azimuth from one part of the quadrangle to another, and the straight valleys vary correspondingly.

6. Several of the tonal linears turned out to be topographically expressed in the field, and one corresponds to the Catskill river.

5.3.2 The foregoing results point to a direct relationship between the long axes of straight valley segments as seen on the ERTS-I imagery, and the strike of major joint sets. Similar parallel relationships have been found using aerial photographs in nearby portions of the Allegheny Plateau by Lattman and Nickelsen (1958), and elsewhere by Boyer and McQueen (1964). Indeed Hobbs (1904b) showed an impressive correlation, without the benefit of either photography or imagery, between linear drainage systems and joint directions in the Finger Lakes region to the west, so the prospects for mapping joint systems directly on ERTS-I imagery appear very promising. If subsequent field investigations across the Allegheny Plateau confirm this relationship, ERTS-I imagery will prove to be the most economical method available for mapping major joint sets over large regions.

5.4 <u>Stage III Study of the Stony Clove Topographic Lineament</u>

5.4.1 Attention has been directed in an earlier NASA report and publication (Isachsen, 1973) to the straight, north-northeast-trending Wall of Manitou which borders the Catskill Mountains on the east, and the series of closely-spaced, parallel topographic lineaments which occur west of the Front (figure 28). A low-level aerial photograph of one of these, Stony Clove, shows the head of the valley to be narrow and steep-walled, carved into flat-lying shales and sandstones (figure 35). The aerial view suggests that the east wall may be slightly down-dropped. Field altimetry to check this possibility was inconclusive, inasmuch as an elevation difference of only five meters across a valley width of 100 meters in continental sediments can be explained without resort to faulting. Of interest, however, is the fact that the valley is developed along a steeply-dipping conjugate joint system. On the west side of the valley, east-dipping joints are dominant. On the east side, westward dips predominate (figure 36). The orientation of the 32° acute angle is compatible with the interpretation that this system of conjugate joints, and the trace of the valley itself, are reflected basement structures such as might be produced by minor dip-slip reactivation along a basement fault. In support of this interpretation, it may be noted that the entire set of north-northeast-trending topographic lineaments in the eastern Catskills is aligned with lineaments of similar strike and spacing in the exposed basement rocks of the eastern Adirondacks (figures 39 and 40). The relief of Clove Valley is 2000 feet, the valley floor is 1800 feet above sea level and the basement surface is about 10,800 feet below sea level (Rickard, 1973, plate 18).

5.4.2 If the above conclusions are supported by future work, they may provide a means of recognizing in the Allegheny Plateau reflected basement normal faults which are manifested at the surface by a conjugate joint system, the acute angle of which is bisected by a vertical axis of maximum principal stress. Such lineaments would be distinguishable from other valleys which are controlled by vertical joint sets. This will be tested by additional field work.

5.4.3 Another, very different method may exist for distinguishing genetic types of lineaments: those having normal background levels of radioactivity and those having on the order of 2x background. John Gabelman of the U.S. Atomic Energy Commission has made reconnaissance surveys of gamma radiation along a number of the major topographic lineaments in the Allegheny Plateau of New York and Pennsylvania, using a portable Mt. Sopris scintillometer on highway traverses (oral communication). He has found the level of radiation along such lineaments to be nearly two times the normal background count. On traverses up tributary valleys, the count returns to normal. A nearly twice-background radiation level was found along the east-northeast lineament followed by Route 7, between Binghamton and Cobleskill.

5.4.4 Inasmuch as our work in the Catskills has shown the existence of at least two genetic types of joint-controlled lineaments, one which parallels vertical joints and the other conjugate system of inclined joints, we plan, as a result of Gabelman's observations, to accompany future fracture analysis in the field with routine scintillometer measurements. We will do this less in the expectation of discovering highly anomalous areas (although continental sandstones such as occur in the Catskill facies <u>are</u> favorable uranium host rocks), than in the hope of finding an indirect means of discriminating between genetically different types of fracture systems.

6. ERTS-I AND STORM DAMAGE ANALYSIS, LAKE ONTARIO

6.1 Introduction

6.1.1 Although outside the main objectives of this study, fascination with the extensiveness of sediment plumes along the south shore of Lake Ontario shown on ERTS-I imagery of 23Mar73 (figure 37), but not on earlier imagery, led us to newspaper accounts of the storm activity that was the cause, and to a brief investigation of the potential of ERTS-I for studying storm effects on the Great Lakes. The total time involved in this analysis was only two hours.

6.1.2 On March 17, 1973 according to The Rochester Democrat Chronicle of the succeeding two days, 10 to 15 foot waves, caused by 50 to 60 mile-per-hour winds, damaged hundreds of homes along the Lake Ontario shoreline and forced evacuation of many families. Accompanying heavy rain caused lakeshore flooding along a 33-mile stretch from Webster to Hamlin, which includes Rochester. The shoreline erosion was the most severe in 20 years, and damage was estimated at more than 10 million dollars.

6.2 Dispersal Patterns of Suspended Particles Caused by the Storm

6.2.1 Two effects of the storm were analyzed in the imagery, namely, shoreline erosion and the dispersal pattern of suspended particles. The best combination of imagery for studying the extent of sediment plumes appeared to be band 5 and band 7 of 23Mar73 (no. 1243-15244). Band 5 was projected in red and band 7 in blue, using an SDC viewer.

6.2.2 Figure 37 illustrates the shape and magnitude of dispersed sediment. Definite longshore transport of sediment to the east can be seen clearly, and at the eastern end of the lake a curl extends some 60 km offshore. Complex currents around the mouth of the Genesee River at the left side of the photograph are evidenced by the westward hook shape of the river sediment from the point at which it enters the Lake to approximately 7 km offshore.

6.2.3 Two months after the storm, no hook shape was apparent, but the Genesee River plume still extended about 7 km out from the shore, (image no. 1297-15243 of 16May73). Two months later, however, it had returned to the normal 1 km from the shore (image no. 1351-15230 of 9Jul73). For unknown reasons we have received only one 70 mm image, band 7, of the intermediate orbit (3June73), so cannot determine if the plume had diminished to normal dimensions by that time.

6.3 Shoreline Erosion Produced by the Storm

6.3.1 The major erosional effects of the storm on the Lake Ontario shoreline were identified through multi-temporal study of band 7 for 19Aug72 (red filtered) and 23Mar73 (unfiltered), using an SDC viewer. A comparison was also made using a Zoom Transferscope. Either instrument would have been satisfactory for the study.

6.3.2 The following effects were noted:

1. About 20 km west of the mouth of the Genesee River, the west end of an offshore bar appears to have been either eroded or inundated by storm waters, and the remainder appears to have been narrowed (compare figures 38a and 38b). Pronounced flooding of bays can also be seen in this area.

2. In the eastern third of figures 38a and 38b (area east of Sodus Bay) several bay-mouth bars are either narrowed or no longer visible, flooding has occurred in a number of places, and a bay appears to have been created which does not appear on the 19Aug72 image.

3. In the later imagery of 9Jul73 which shows that water elevations have largely returned to the 19Aug72 levels, the western end of the pre-storm offshore bar west of the Genesee River is still not visible, indicating that it was not merely inundated, but eroded by the storm.

6.3.3 This very brief study serves to illustrate the potential offered by ERTS-I imagery for analyzing erosional and transportational processes along the shorelines of major lakes.

7. ERTS-I AND SEISMICITY IN NEW YORK STATE

7.1 One of the most intensively studied seismic areas in the world which is located entirely within a continental plate (rather than at its margin) is Blue Mountain Lake in the central Adirondacks. It can be seen in figure 39 as an elliptical black spot, about 5 km long in an east-west direction, located approximately 15 km south of the center of the Adirondacks. It was here, during the summer of 1973, that earthquake prediction was successfully achieved (Aggarwal and others, 1973). Another reason for a continuing interest in the seismicity of this area (as well as several others within the North American plate), is its possible contribution to an understanding of the driving forces for plate motion. For these reasons, and because of the potential value of an ERTS-enhanced fracture map for relating seismicity and tectonics, it was decided to search the imagery, U-2 photography, and the epicenter area itself for relevant fracture data.

7.2 Moderate size earthquakes (up to magnitude 3.6) and many microseisms at Blue Mountain Lake were recorded during July and August, 1971 by portable seismographs which were installed after two events had occurred on May 23, 1971 (Sbar and others, 1972). Quakes of similar magnitude were recorded in this area again in August 1973, by Lamont-Doherty Geological Observatory and the Geological Survey of the New York State Museum and Science Service (Aggarwal, 1973). Shallow earthquake foci (<2.0 km) were confined to a tabular zone trending N12W and dipping 25 degrees to the east, while the deeper quakes (2-3.5 km) occurred on a surface striking N31E and dipping 59° east. First motion studies showed both focal mechanisms to be thrust faulting, in agreement with the horizontal east-west compressive stresses known to characterize the eastern United States (Sbar and others, 1973).

7.3 The deeper quakes occur along a surface which strikes parallel to the direction of the prominent northeast faulting in the eastern Adirondacks as shown on the map of linears (figure 40) and the rose diagrams of figure 41; the tabular zone of shallower quakes on the other hand, trends in the direction of less prominent north-northwest fractures. A detailed ground search in the epicenter area disclosed only joints, but no evidence of fresh movement along their surfaces. Thirty-four joints were seen and measured. Nearly all dip more steeply than 80°. Those with strikes in the northeast quadrant show a very broad spread without any maxima. In the northwestern quadrant, however, strikes are concentrated in the sector N15-30W. Thus, for whatever it may be worth at this stage, the strike of the steeply-dipping fault surface of the deeper quakes parallels prominent Adirondack fault trends which also dip steeply, whereas that of the shallower quakes lies near one end of the N15-40W trend of local jointing.

7.4 No linears could be found in the Blue Mountain area on either the ERTS-I imagery (even after the computer image processing described in section 2) or in U-2 color infrared transparencies. Another confusing feature of the Blue Mountain seismicity is its occurrence west of the region of closely-spaced faults and topographic lineaments (figure 39). A possible explanation may be that the fault surfaces in the eastern Adirondacks are steep to vertical, and hence do not provide suitably oriented shear surfaces for reactivation by the regional horizontal east-west compressive stresses in the region.

7.5 An interesting sidelight of the field study may be worth mentioning. Seven distinct earthquakes were heard emmanating from beneath a swamp which centers on the epicenter area. The sounds emitted for individual quakes were a low, resonating "thong","kathong",or"kong". A subsequent check of the seismic records showed that the timing of these sounds corresponded to the occurrence of earthquakes of -1 intensity on the Richter scale.

7.6 A map showing locations of the more reliably located earthquake source areas in the State is now being gleaned from the literature to evaluate possible spatial relationships between epicenters and fracture systems displayed on an ERTS-enhanced fracture map of New York State.

8. CONCLUSIONS

8.1 The greatest contribution of ERTS-I imagery in New York State continues to be in the field of regional tectonic analyses, more especially in the delineation of new linear features many of which have been verified on the ground, and circular features which remain problematical. All ERTS-I linears confirmed to date have been topographic features on the ground, although many of these appear on the imagery as tonal linears without relief, or as combinations of tonal and topographic features.

8.2 In the Adirondacks, the use of low level aerial observation and photography, coupled with ground investigation, has resulted in the elimination of about five percent of the original number of ERTS-I linear features remaining after the exclusion of those which are man-caused or lithologically controlled. In addition, it has led to the discovery of a system of intersecting orthogonal and oblique fractures which cut the relatively homogeneous and massive Marcy Massif metanorthosite. These, together with the previously-mapped and new ERTS-I topographic lineaments will hopefully provide enough data, after ground study, to permit a regional basement stress analysis.

8.3 Ground study of ERTS-I anomalies in the Adirondacks indicate that: 1) outcrops are even more rare than expected along the traces of topographic lineaments, 2) fault breccias are found along some of the north-northeast lineaments, 3) chloritization and slickensiding, without brecciation, were found along an east-west lineament, and 4) closely-spaced joints and a zone of plastic shear was found along another east-west lineament.

8.4 Use of the NASA/GSFC program for image processing (IDAM) suggests that some additional detail may be recovered on the shaded sides of mountains using the program sequence for contrast stretching, color-compositing, and enlarging.

8.5 A search of ERTS-I imagery and U-2 photography failed to disclose new linears along the computed thrust fault sites of the Blue Mountain earthquakes of 1971 and 1973 in the central Adirondacks.

8.6 A comparison of linears on fall and winter imagery covering southeastern New York State showed that long linears on the fall imagery appeared as short segments on the winter imagery, that some additional short linears ($\lesssim$4 km) occur on the winter imagery. Of the linears which appear exclusively on the fall imagery, several exceed 10 km in length. Those which are restricted to the winter imagery tend to be less than 5 km long. About one-third of the linears appearing on the fall imagery are not seen on the winter imagery, and approximately one-fourth of those on the winter image are not expressed on the fall image. Thus, for complete mapping of ERTS-I linear features it is advisable to use the best fall and winter images; color composites are preferred, although nearly equal results can be obtained using band 7 alone.

8.7 Field work in the northern Catskills shows a fairly good correspondence between the directions of linear valleys and master joint sets. If subsequent field work confirms this relationship across the Allegheny Plateau, ERTS-I imagery will prove to be the most economical method available for mapping major joint sets over large regions.

8.8 Field study of the Stony Clove topographic lineament, one of several which parallel the straight eastern terminus of the Catskill Mountains known as the Wall of Manitou, show it to be controlled by a parallel system of conjugate joints with acute angle bisected by a vertical plane.

The north-northeast lineament set of which Stony Clove is an example are interpreted as the traces of upward-propogated vertical movement on reactivated basement faults. This would provide the vertical maximum principal stress suggested by the conjugate joints. This interpretation is supported by the fact that the entire Stony Clove set of lineaments is aligned with lineaments of similar strike and spacing where the basement crops out to the north-northeast in the eastern Adirondacks.

8.9 It is tentatively extrapolated that many of the north-northeast lineaments which appear to terminate at the southern border of the Adirondacks actually extend across the Mohawk Valley and southward beneath the Allegheny Plateau. This model will be further tested in the field.

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Figure 1. ERTS-I image of northeastern Adirondacks showing sites from which photographic illustrations were taken. Barbs on the dots indicate view directions, and the accompanying numbers refer to figures in the text. Band 7 of 10Oct72 (no. 1079-15115). Scale, 1:500,000

Figure 2. Aerial view south-southwest along the longest (115 km) clearly-defined topographic lineament in the Adirondack Mountains. About 30 km of the lineament are visible in the photograph.

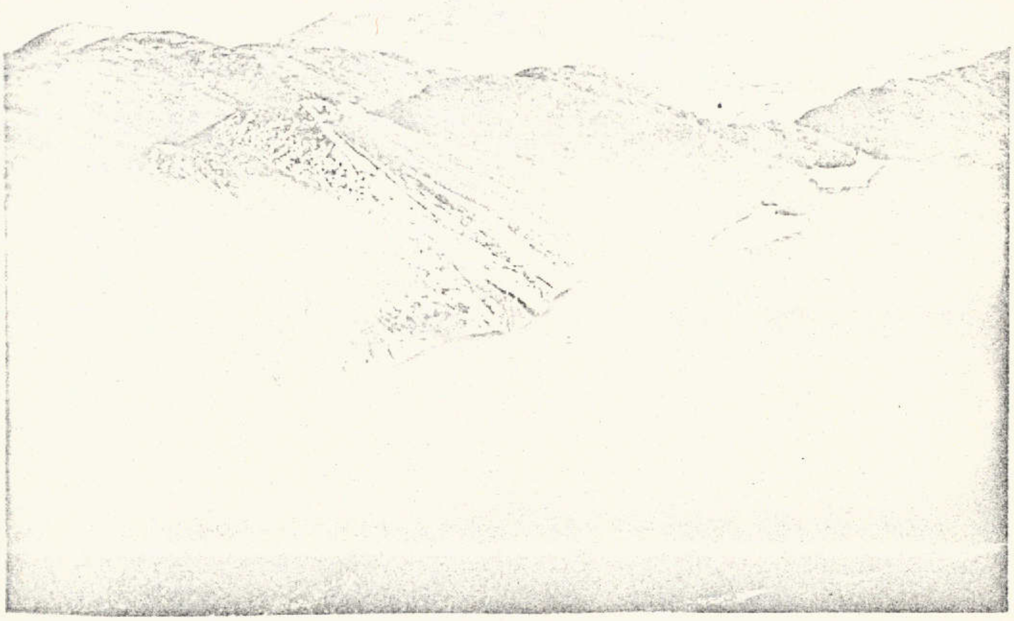

Figure 3. View looking southwest along the previously-mapped Avalanche Lake lineament which borders Mt. Colden. The topographic lineaments crossing Mt. Colden orthogonally cannot be distinquished on the imagery. The most deeply incised of these is eroded along the Mt. Colden meta-gabbro dike.

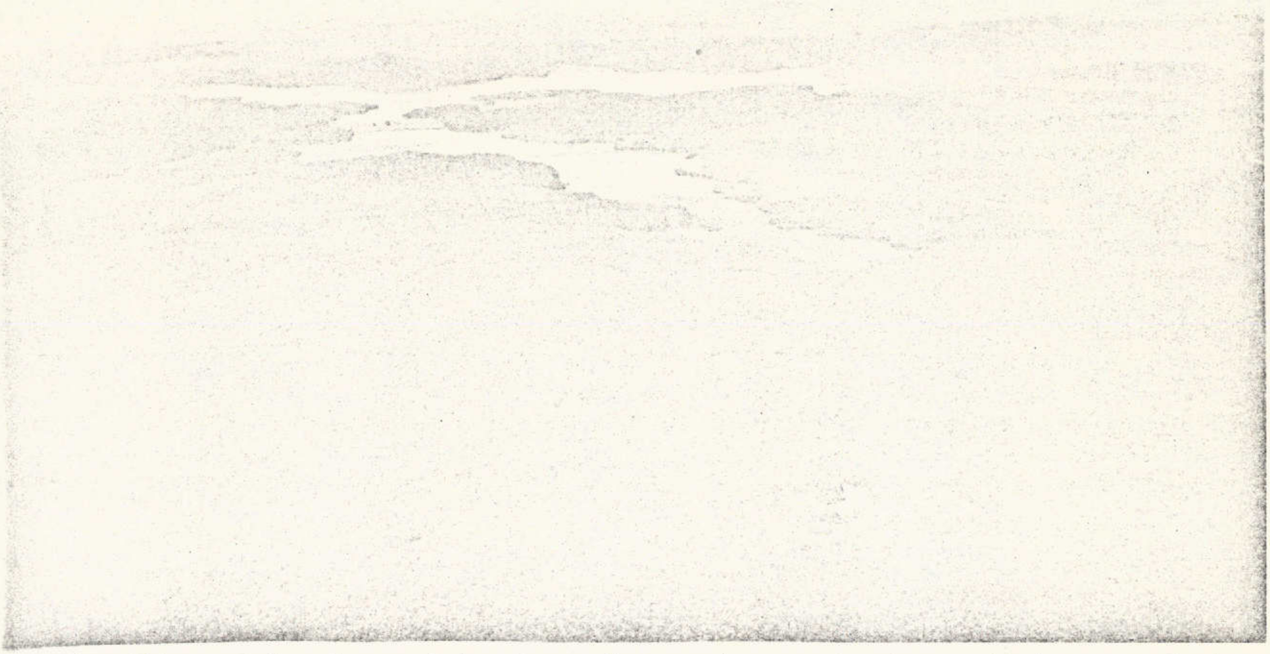

Figure 4. View of Cranberry Lake from the southwest showing radial arms of the Lake as well as two new topographic lineaments visible on the ERTS-I imagery, which converge at the southern end of the Lake. Bedrock is mainly granitic gneiss.

Figure 5. View looking northeast up linear 175 which forms the west-southwestern arm of Cranberry Lake. Bedrock is mainly granitic gneiss.

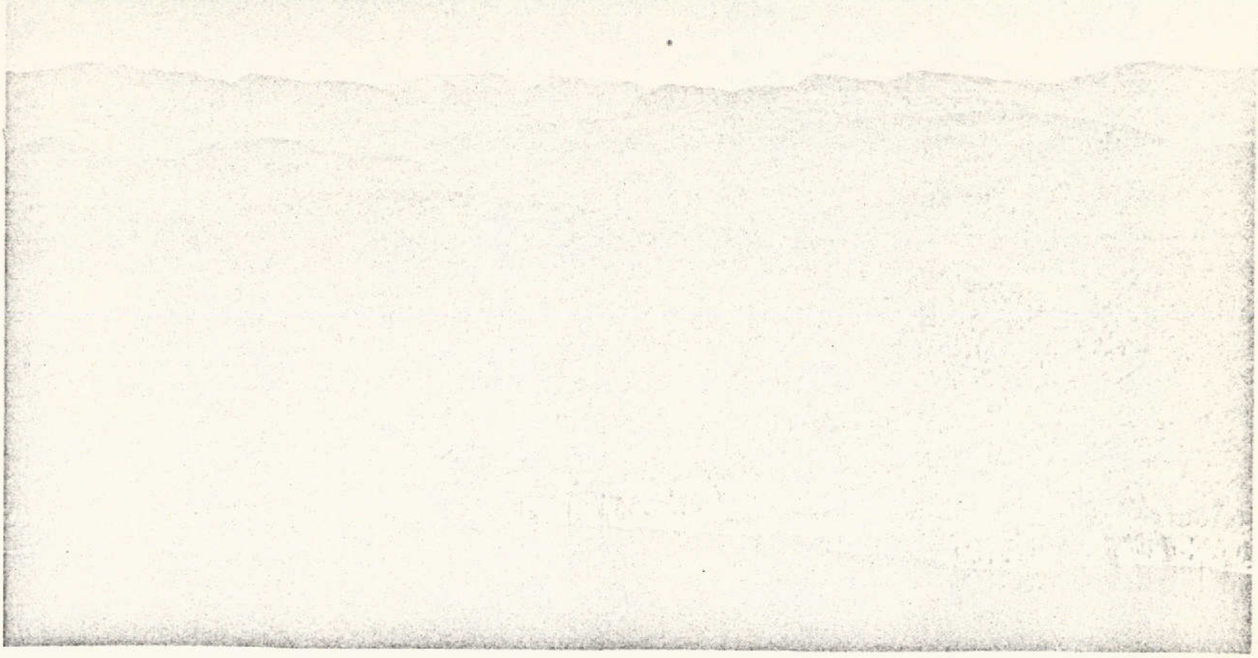

Figure 6. View of the west shore of Lake Champlain showing two topographic lineaments (343a on left and 343 on right) converging toward the camera; aerial reconnaissance along the shoreline cliffs shows a break in outcrop at both sites (see figure below). A narrow belt of mixed gneisses parallels the shore, beyond which the bedrock is gabbroic metanorthosite gneiss.

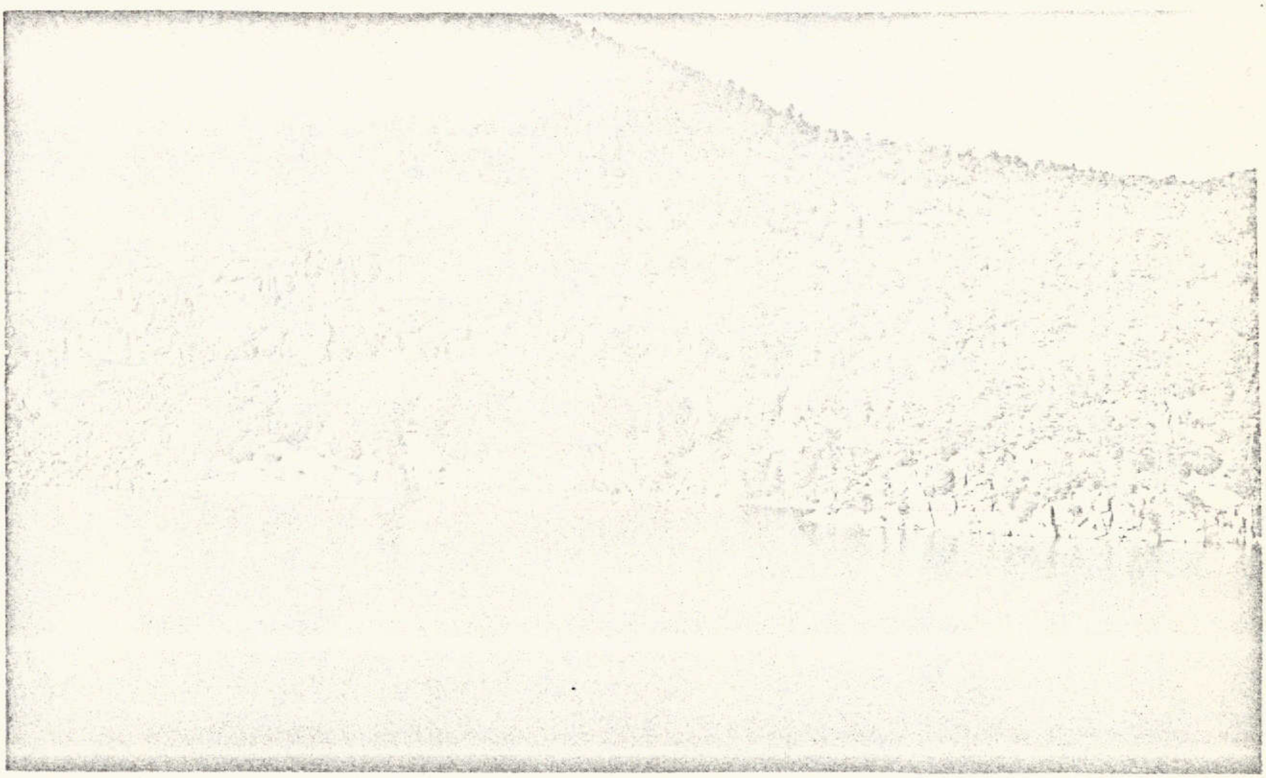

Figure 7. Closer view of lineament 343 showing shoreline expression, namely, cove indentation, discontinuity in shoreline cliffs, and inclined fracture traces in cliffs near the lineament.

Figure 8. View westward up topographic lineament 354, entirely in metanorthosite, which continues to the west beyond the divide. Orthogonal valley in foreground roughly follows contact between the metanorthosite and an olivine metagabbro body.

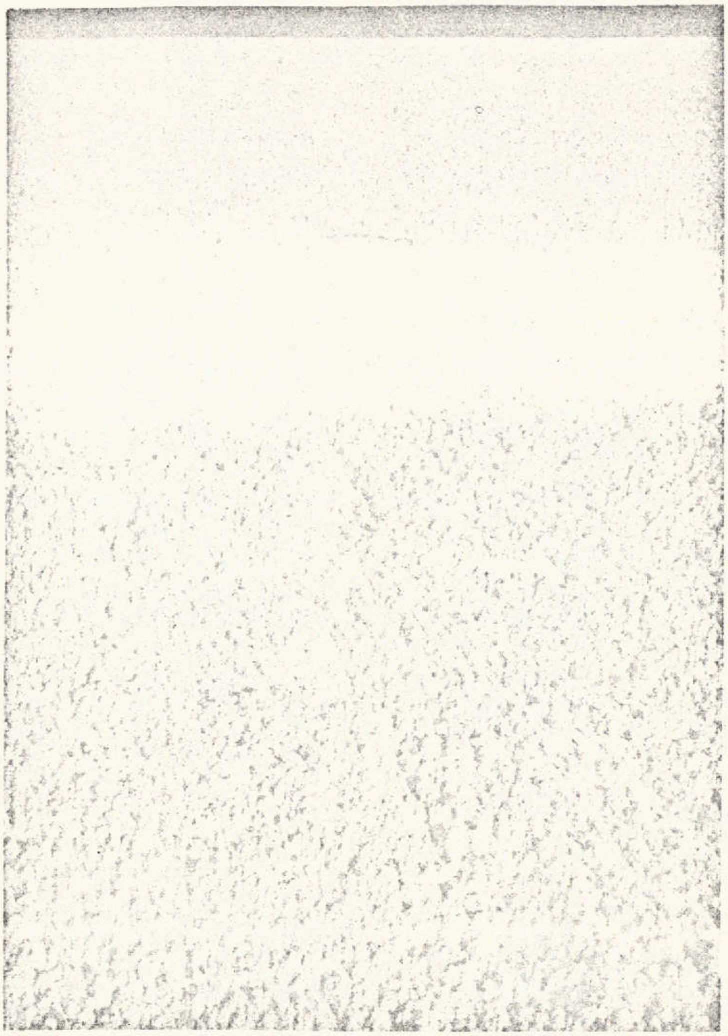

Figure 9. Looking eastward toward Lincoln Pond along topographic lineament 356.

Figure 10. View north-northeast along lineament 215 in the Seward Mountains, entirely within metanorthosite. The valley immediately to the left is linear 216, and that adjacent to the right a previously mapped topographic lineament which is better shown to figure 11.

Figure 11. Looking north-northeast along previously-mapped topographic lineament which separates the Seward Mountains on the left from Mt. Seymour on the right, entirely within metanorthosite.

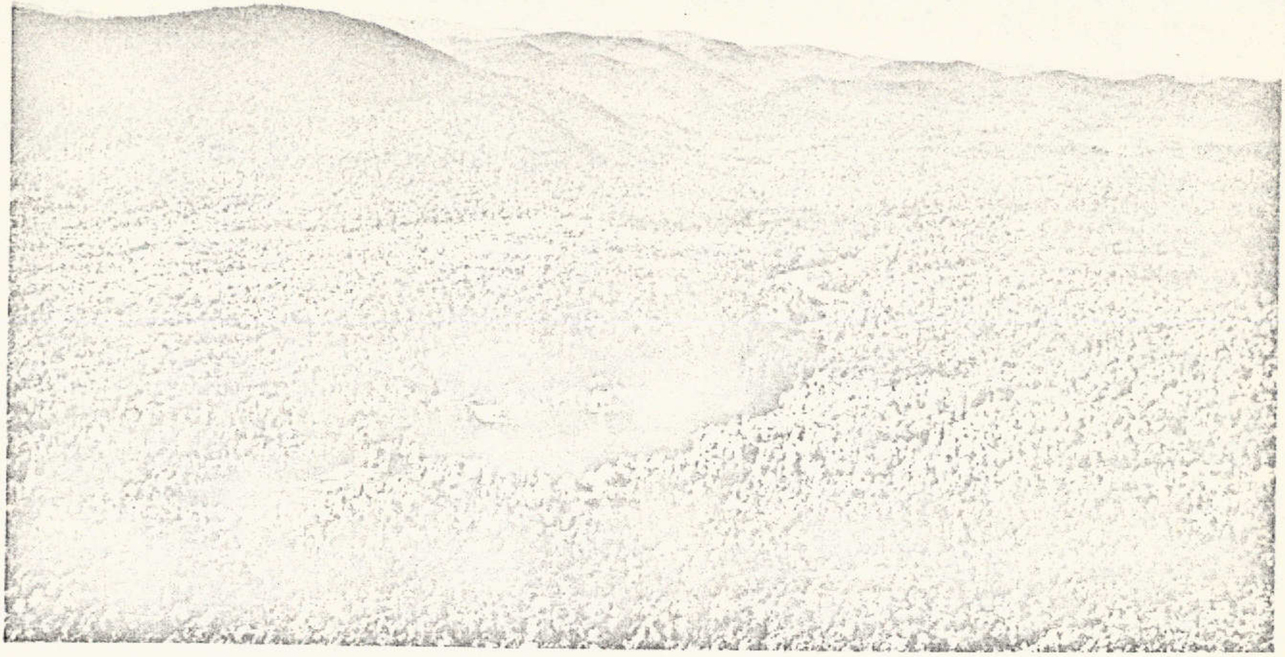

Figure 12. Topographic lineament 309 looking southwest from Chatiemac Lake.

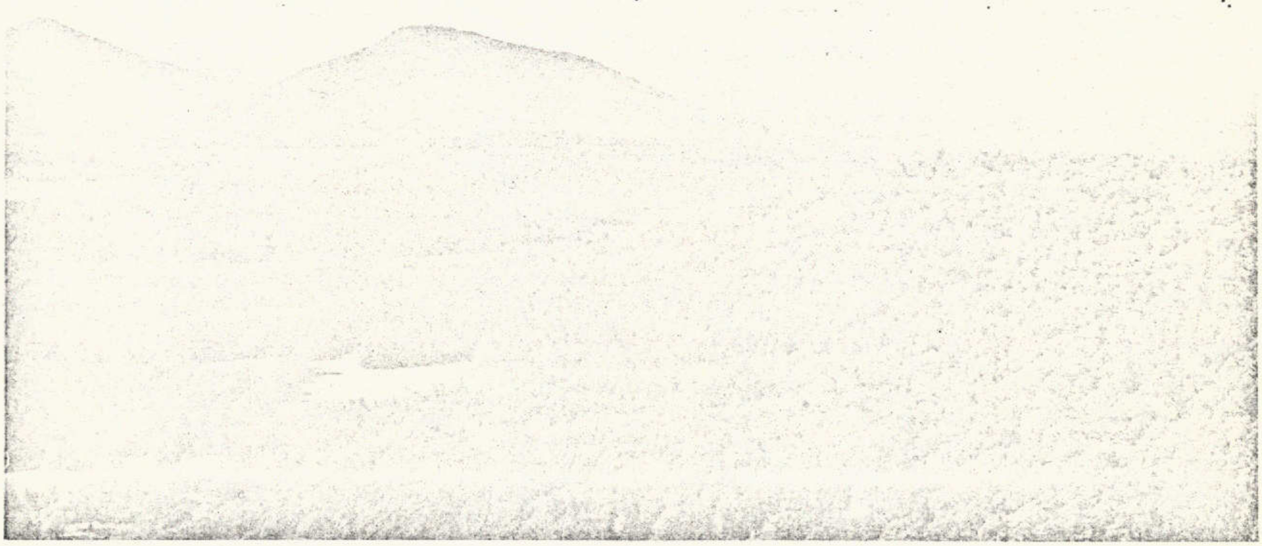

Figure 13. Looking southwest along linear 350 which borders the hill in the middleground; seen from the best vantage point.

Figure 14. Third generation print made from Ektachrome slide of 4X computer-generated color composite of Mt. Whiteface. The photograph is unconventionally oriented to facilitate comparison with figure below. Note bare summit and landslide scars on shadowed side of Mountain.

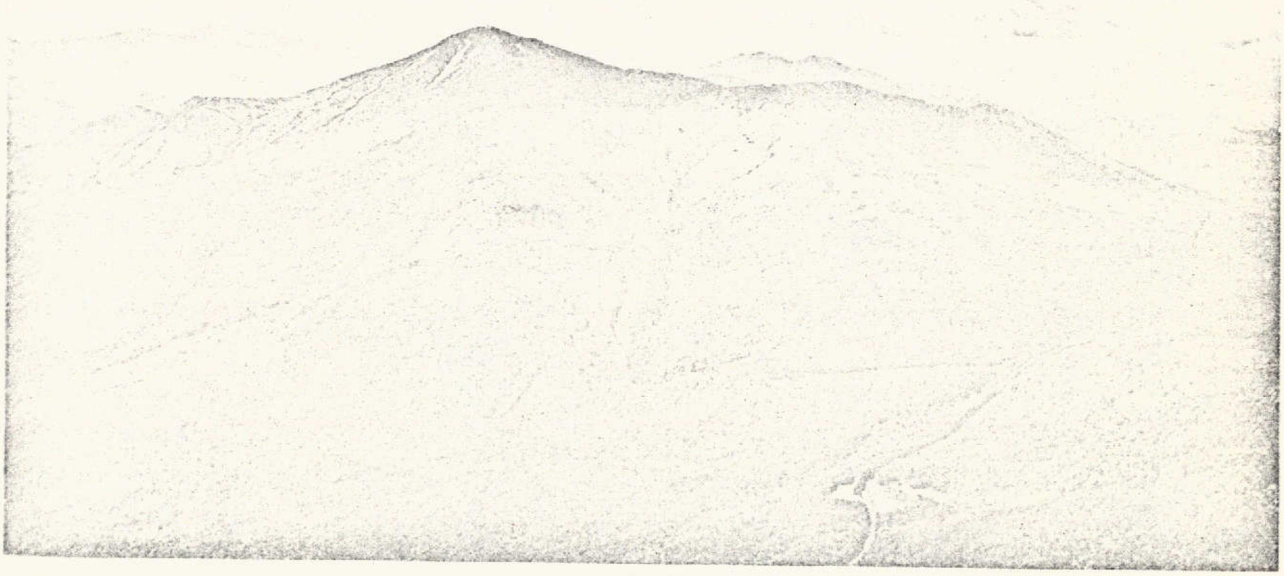

Figure 15. Mt. Whiteface, looking southwest up linear valley of White Brook. Note four fresh landslide scars of 1971. Mt. Whiteface is dominantly metanorthosite.

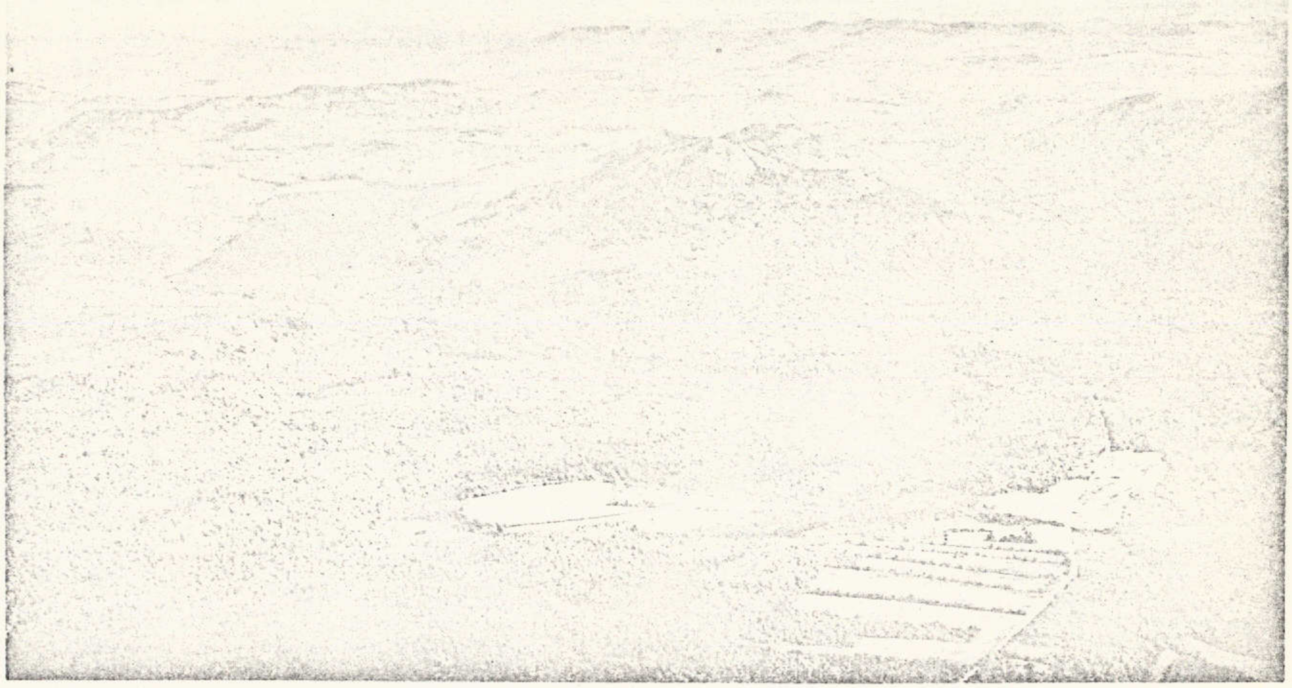

Figure 16. View northeast toward Catamount Mountain which is banded on the east by lineament 264 and on the west by Taylor Pond, the shorelines of which parallel this lineament.

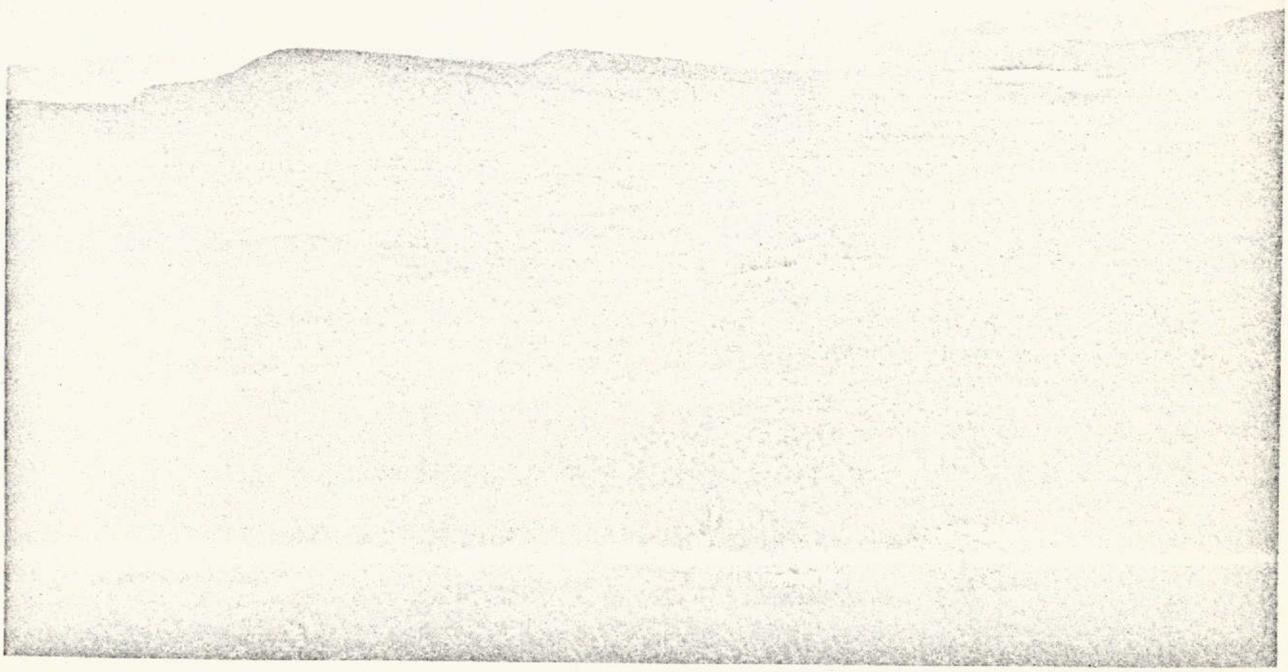

Figure 17. View looking north toward Follensby Pond. Linear valley 219 crosses photograph diagonally from lower left corner to beyond the Pond, and cuts orthogonally across metasediments, charnockite, and metanorthosite.

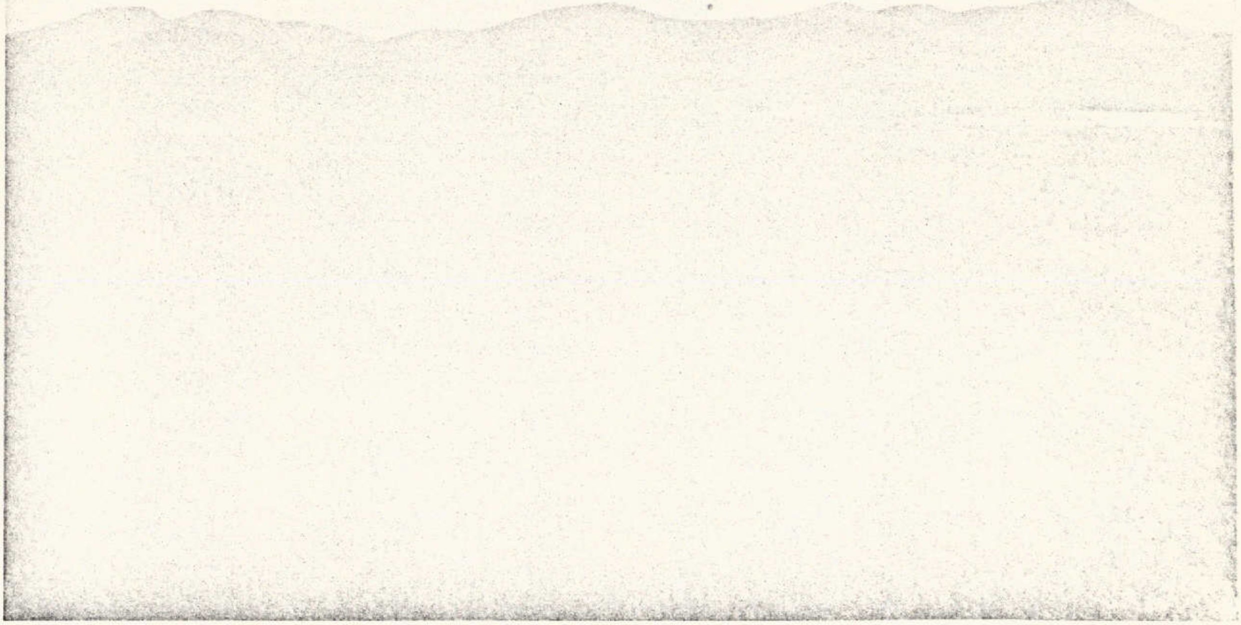

Figure 18. Linear valley 348 extending northeastward from lower left corner to middle of picture. Although well displayed on ERTS-I imagery, the valley is only faintly visible in this view under midday solar illumination.

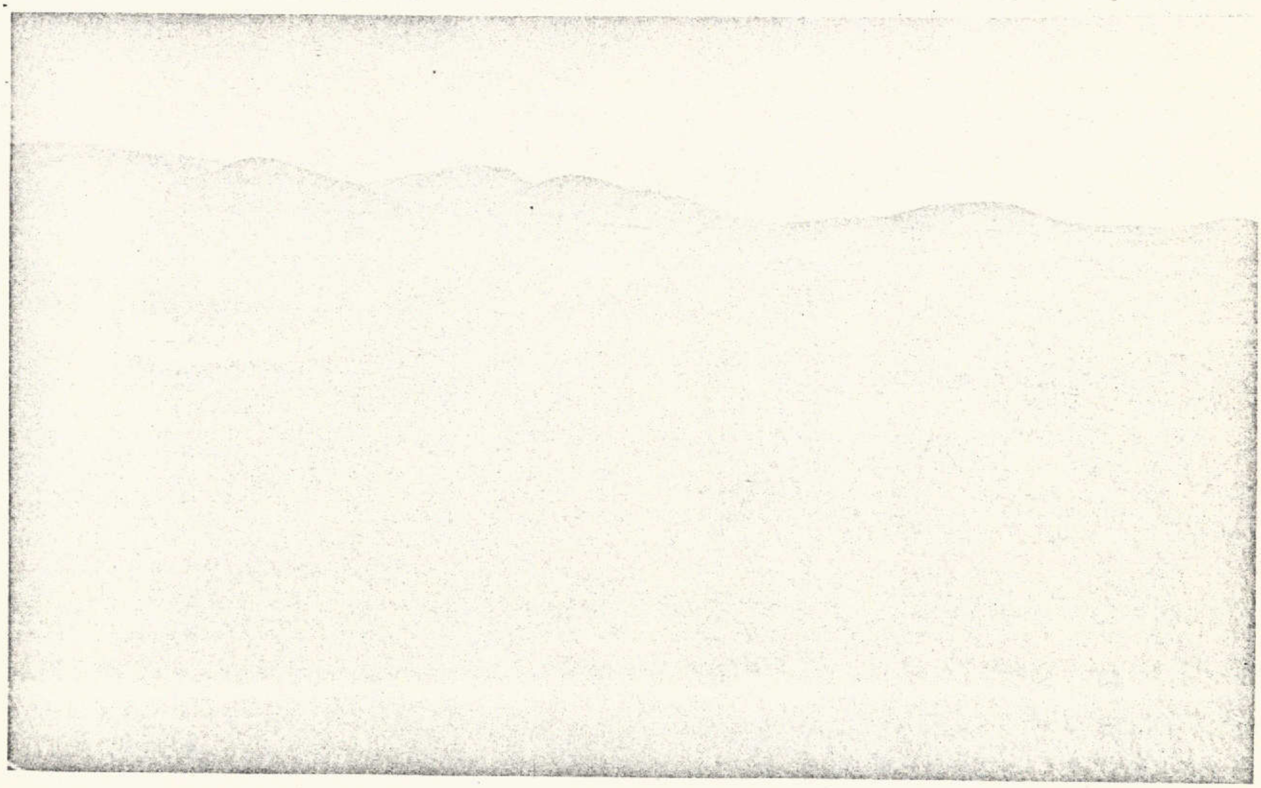

Figure 19. Looking northeastward along linear 349 which is located parallel to and immediately north of topographic lineament 348. It is seen to be a ridge-line demarcation between conifers on the south and mixed hardwoods on the north; it was declassified as a linear.

Figure 20. Linear valley in MacIntyre Range trending N42W between Iroquois and Boundary Peaks, the latter barely discernible as a peak. Snow-covered Algonquin Peak is farther to the right. Entire area is within the Marcy metanorthosite massif.

Figure 21. View of MacIntyre Range looking southwest, with Algonquin, Boundary, and Iroquois Peaks from north to south. The numerous linears shown are discussed in text.

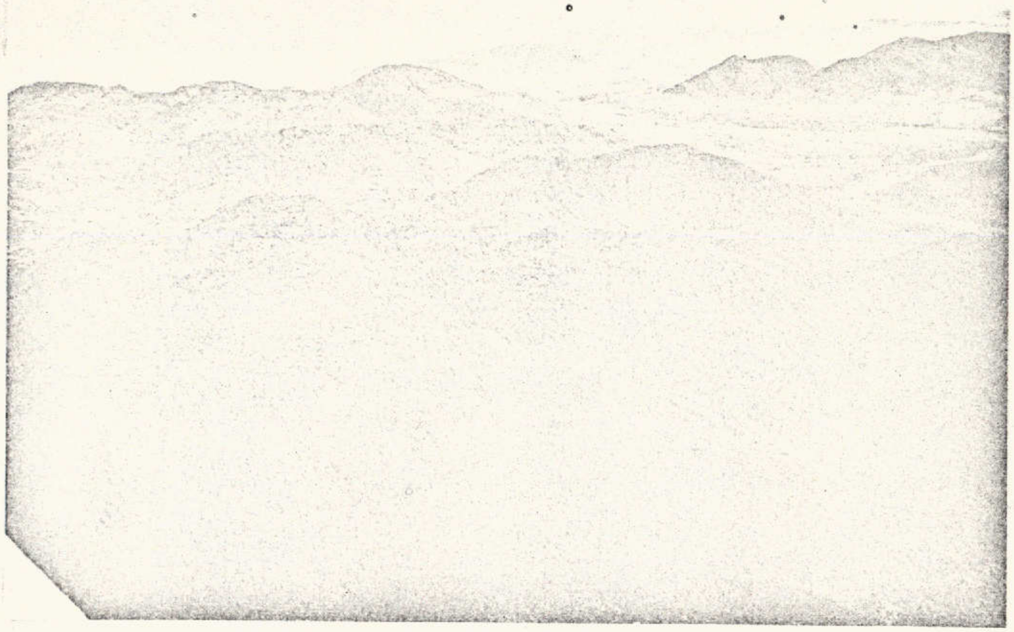

Figure 22. Aerial view taken over the lip of Wallface, looking southeast, showing blocky nature of the MacIntyre Range produced by intersecting topographic lineaments; photograph taken south along the Range from the preceding figure. The vertical lineament shown in the left middleground crosses Cliff Mountain (see below).

Figure 23. Looking westward at recent landslide bounding topographic lineament that crosses Cliff Mountain. This linear is marginally visible in ERTS-1 imagery but could not be drawn with confidence. Scene is entirely within metanorthosite.

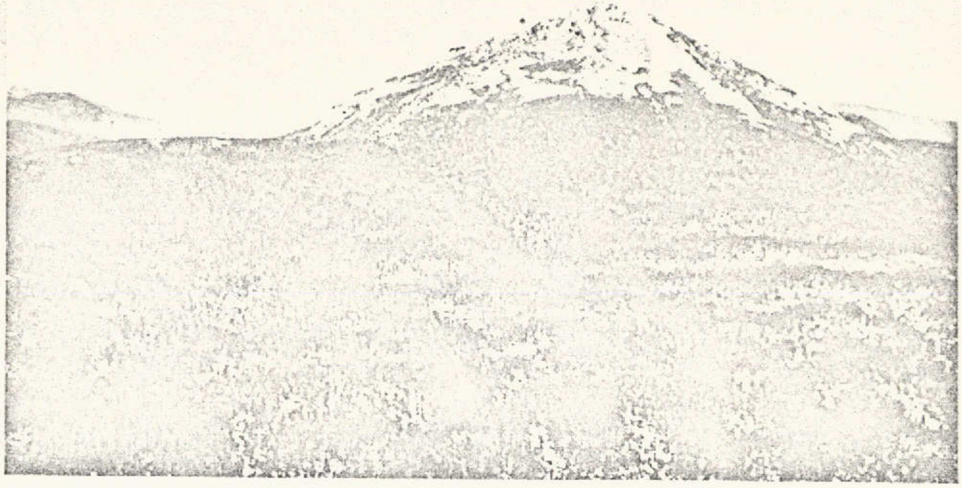

Figure 24. View of Mt. Marcy (metanorthosite) looking north-easterly. The northerly-trending topographic lineaments on the Mountain, here enhanced by snow, are beyond the resolution of ERTS-1 imagery.

Figure 25. Looking westward across the lip of Roaring Brook Falls showing the closely spaced joints which control the stream bed trend.

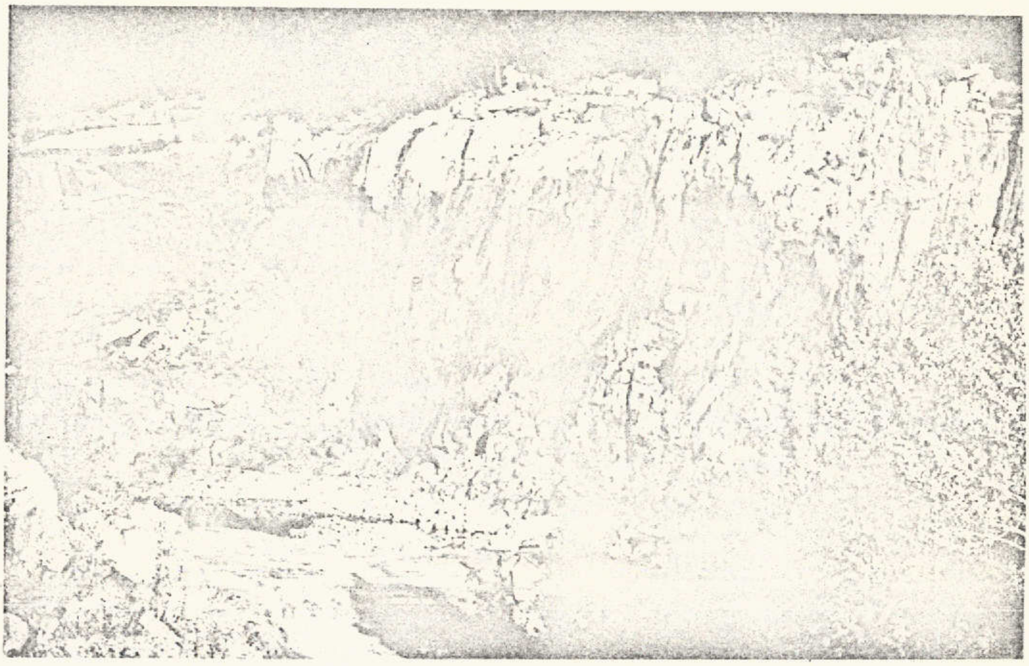

Figure 26. Excavated fault surface at Barton Garnet Mine in the southeastern Adirondacks. The fault marks the contact between the garnetiferous olivine metagabbro ore in the pit and charnockite to the right.

Figure 27. ERTS-I image of Catskill Mountains and adjacent portions of the Allegheny Plateau showing location of field stations discussed in text. Scale, 2mm=1km

Figure 28. Print made from color composite of 10Oct72 image (no. 1079-15124) of southeastern New York State showing area of comparative analysis described in text. Scale, 1 mm=1 km.

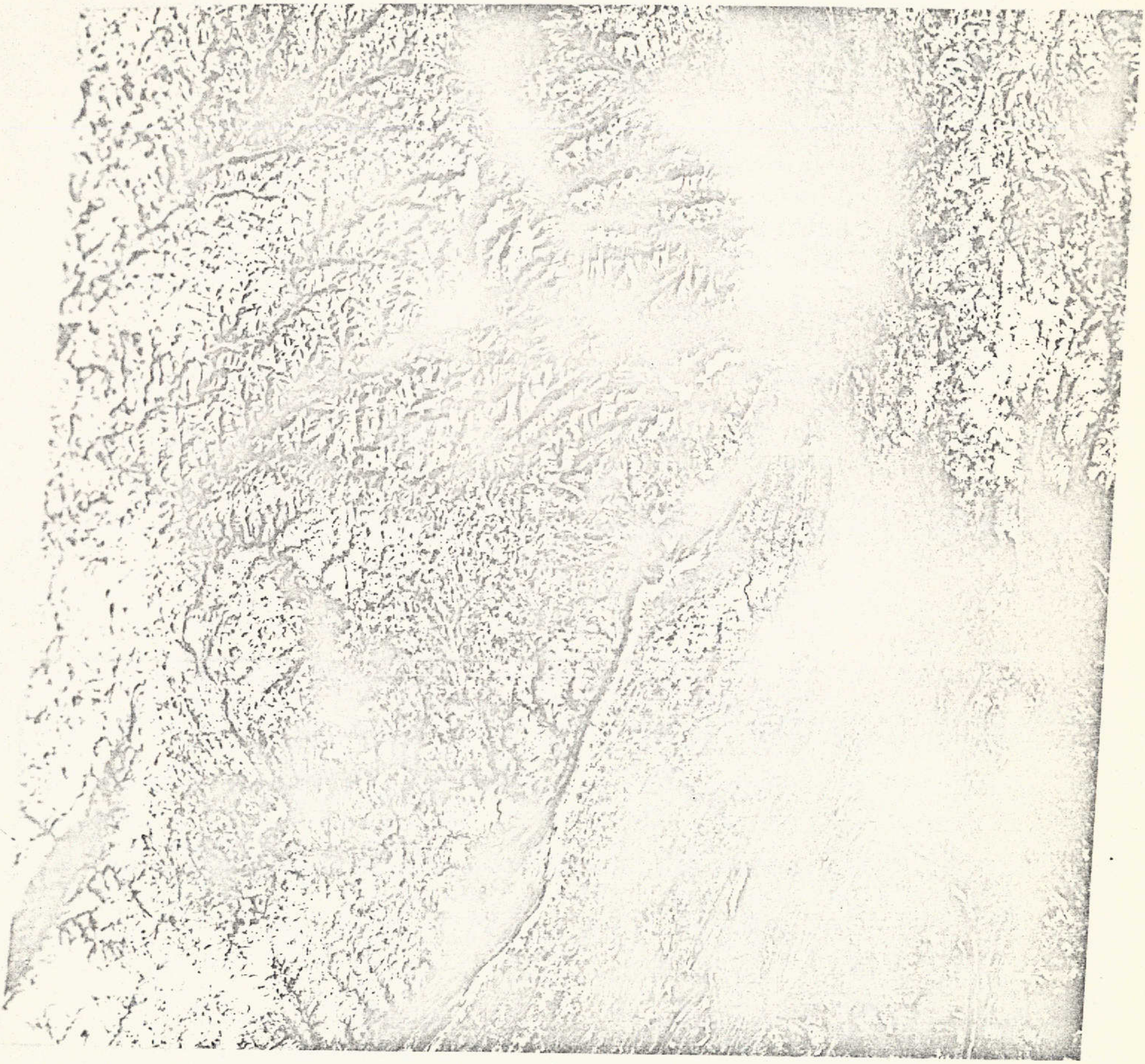

Figure 29. Print made from color composite of 13Feb73 image (no. 1205-15132) of southeastern New York showing area of comparative analysis described in text. Scale, 1mm=1km.

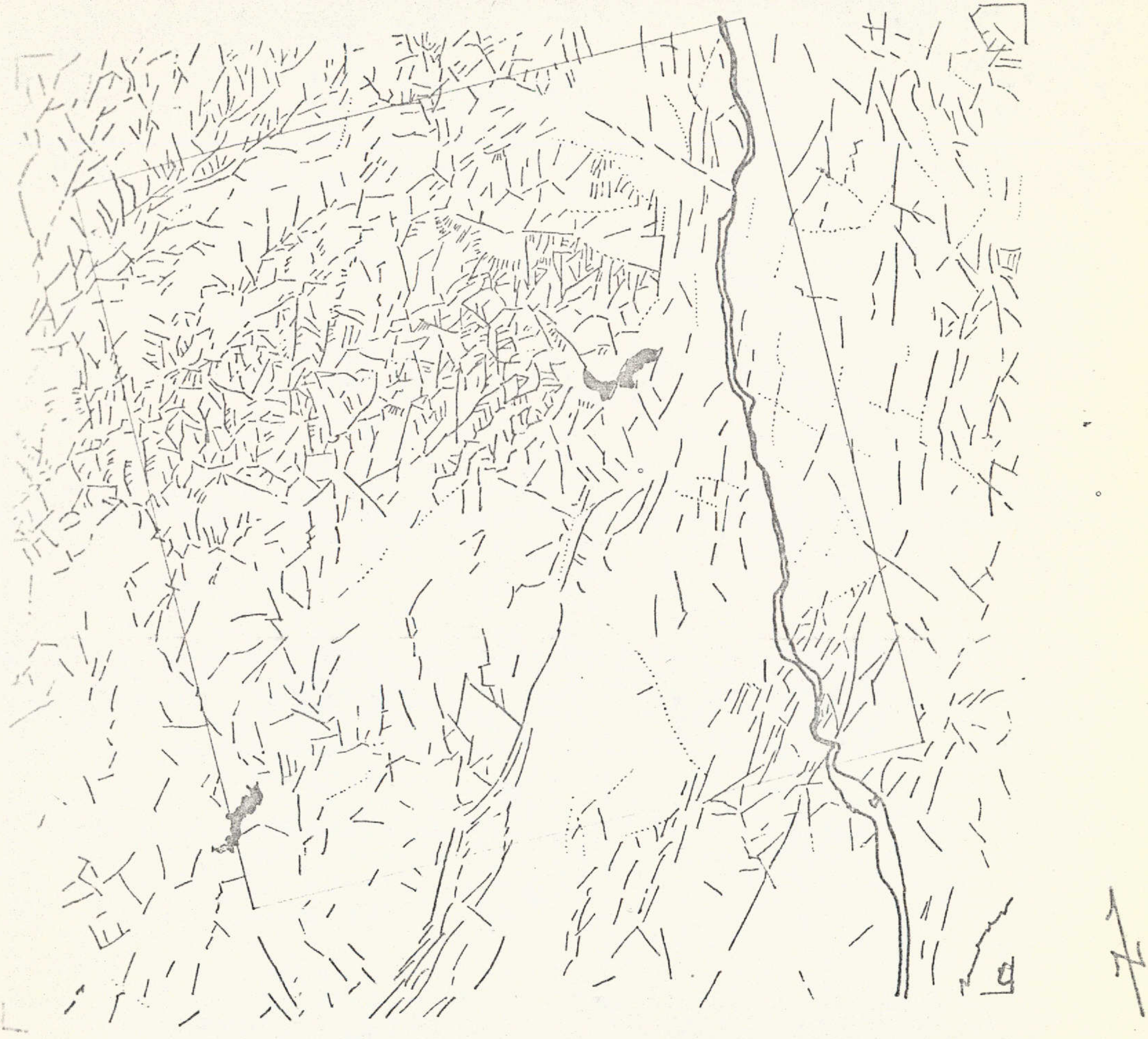

Figure 31. Topographic (solid line) and tonal (dotted line) linears seen on the winter image shown in figure 29. Scale, 1mm=1km.

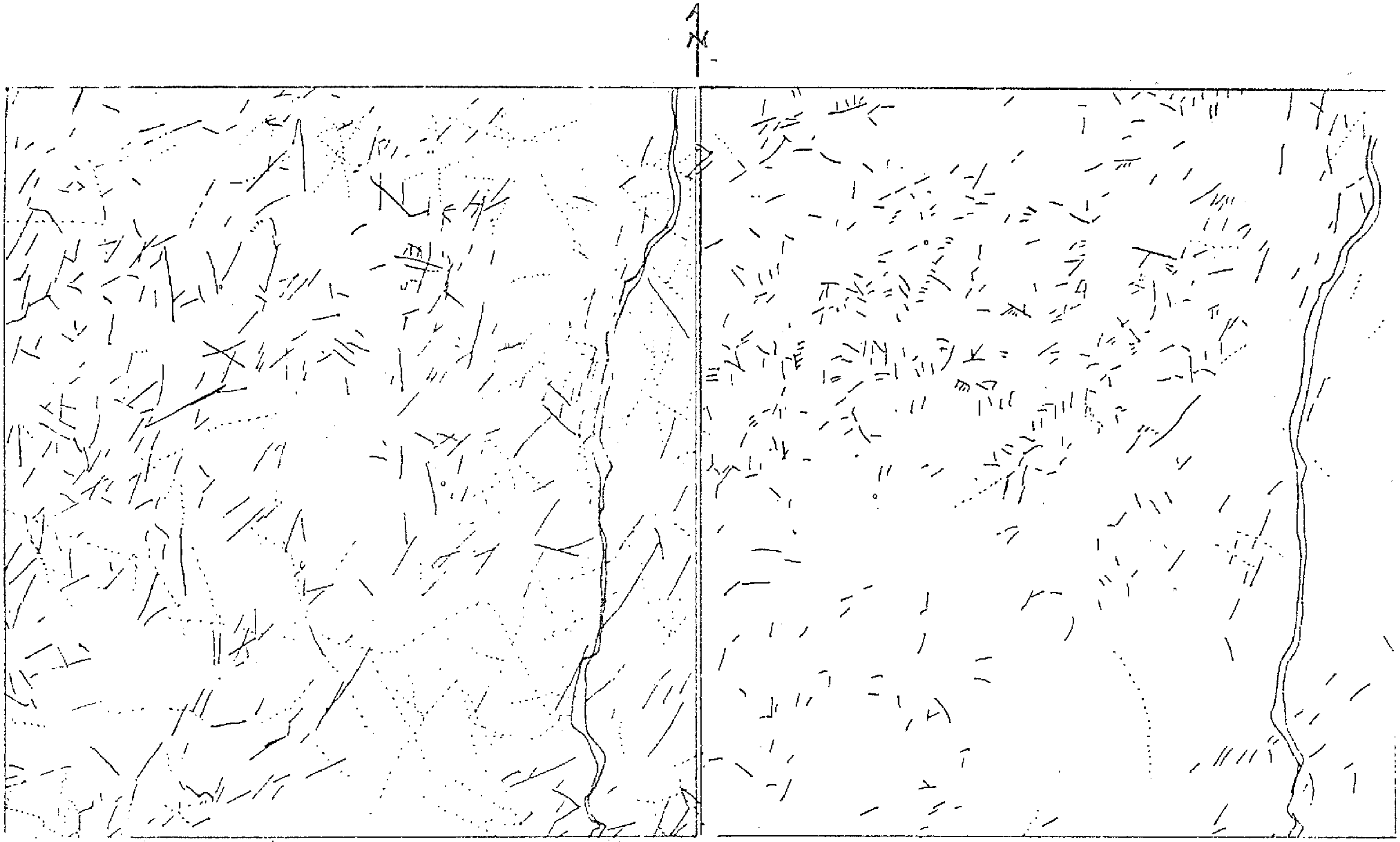

Figure 32. Maps comparing linears seen on color composite fall image (figure 28) but not on winter image (figure 29), and visa versa; fall image on left, winter image on right. Scale, 1mm=1km.

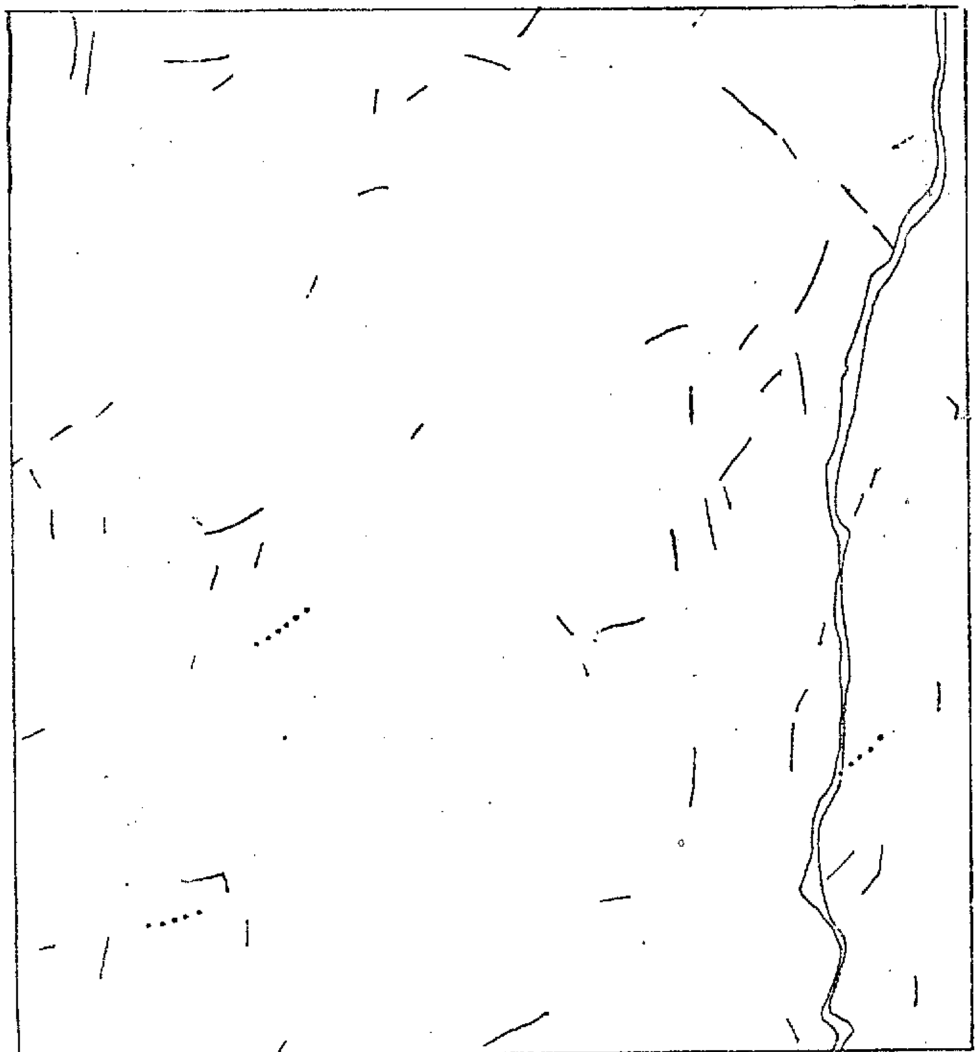

Figure 33. Map showing tonal linears on fall imagery which appear as topographic linears on winter imagery (solid lines) and tonal linears on winter imagery which appear as topographic linears on fall imagery (dotted lines). Compare with figures 30 and 31. Scale, 1mm=1km

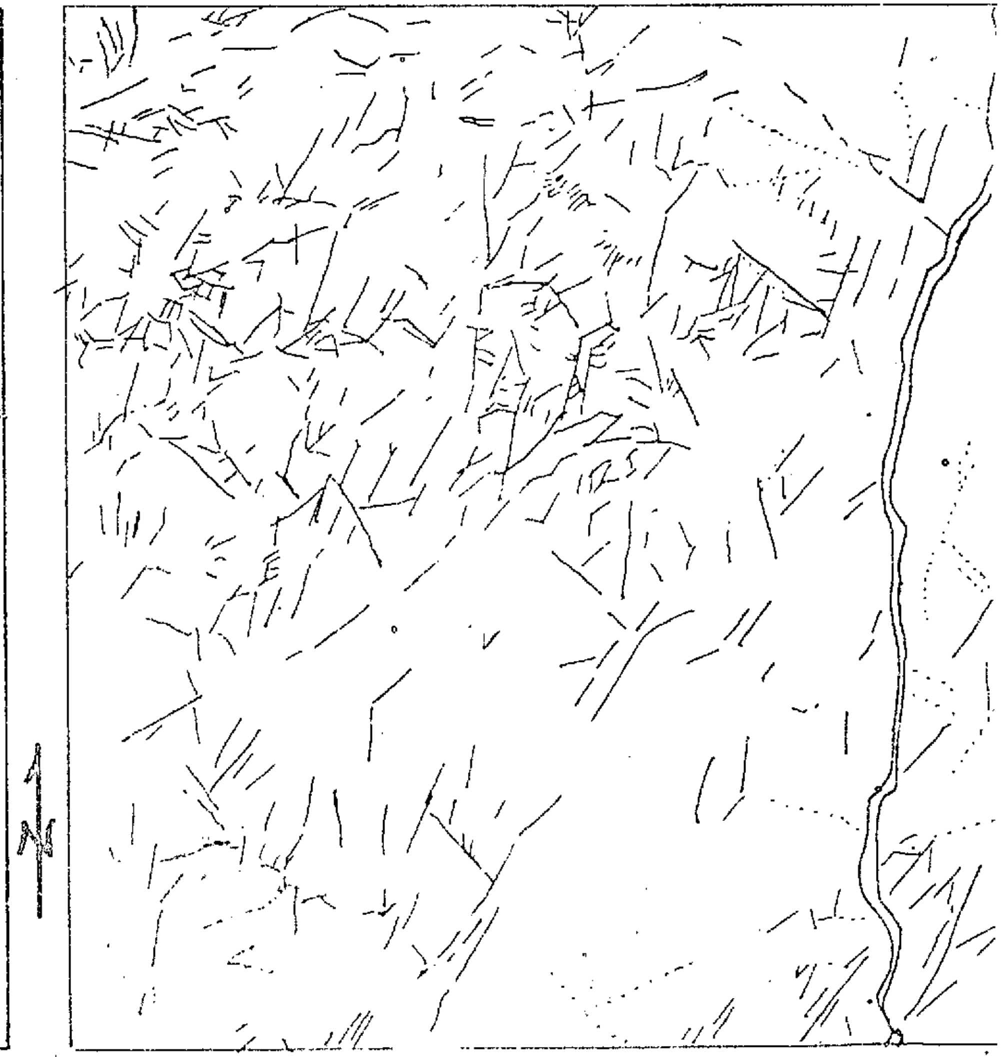

Figure 34. Map showing linears common to the summer and winter imagery of figures 28 and 29.

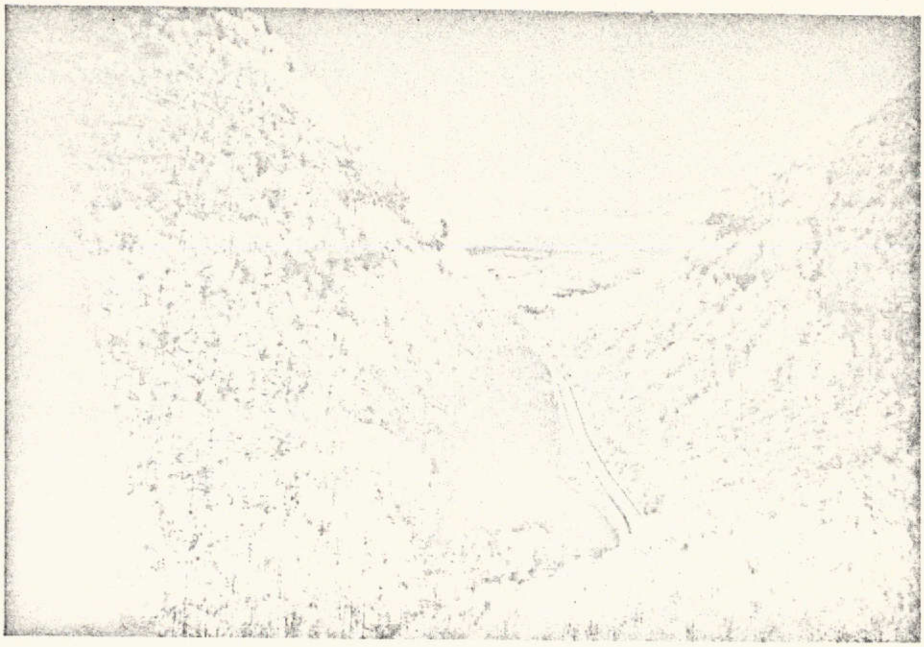

Figure 35. Stony Clove drainage divide, looking north-northeast. Outcrop along lower sandstone member on east side of valley is shown in figure below. Print made from color infrared transparency.

Figure 36. Lowermost cross-bedded sandstone cliff along east wall of Stony Clove, looking north. Note dominance of westward dipping joint set (which parallels valley) and conjugate joints at east side of outcrop; dips are 75°E and 73°W making an acute angle of 32°.

Figure 37. South shore of Lake Ontario showing patterns of suspended sediment following severe storm which occurred five days previously. Band 5, image no. 1243-15244, of 23Mar73.

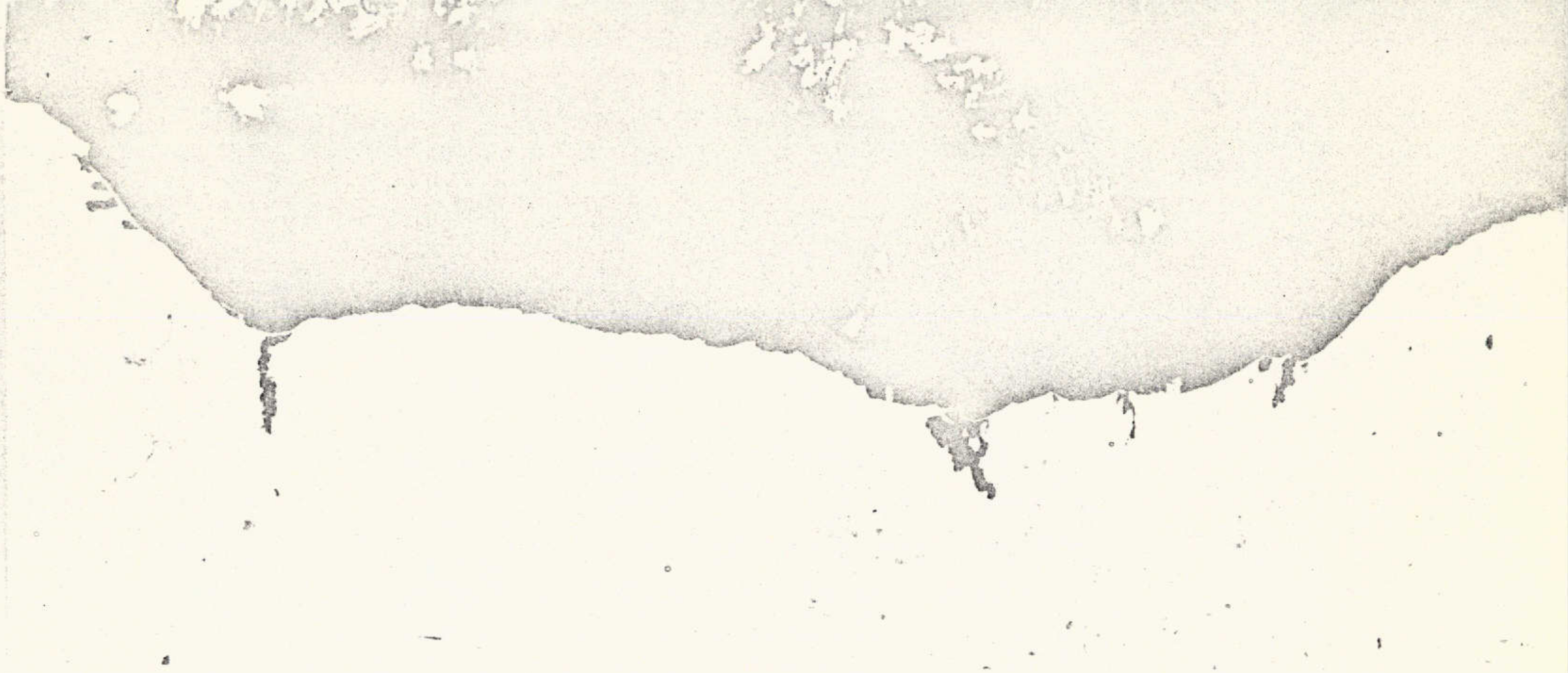

Figure 38a. South shore of Lake Ontario prior to storm of 17Mar73. Band 7, image no. 1027-15233, of 19Aug72.

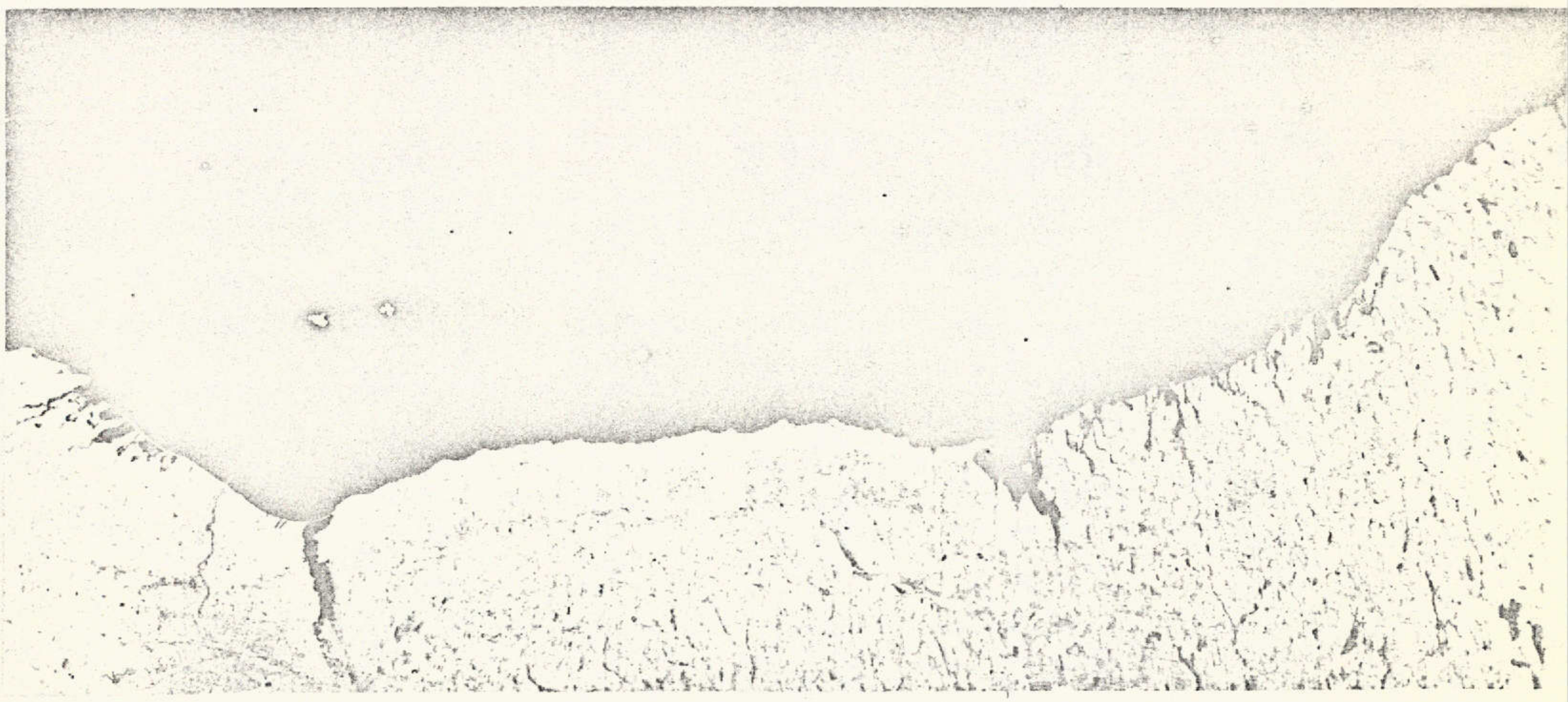

Figure 38b. South shore of Lake Ontario five days after storm of 17Mar73. Band 5, image no. 1243-15244, of 23Mar73.

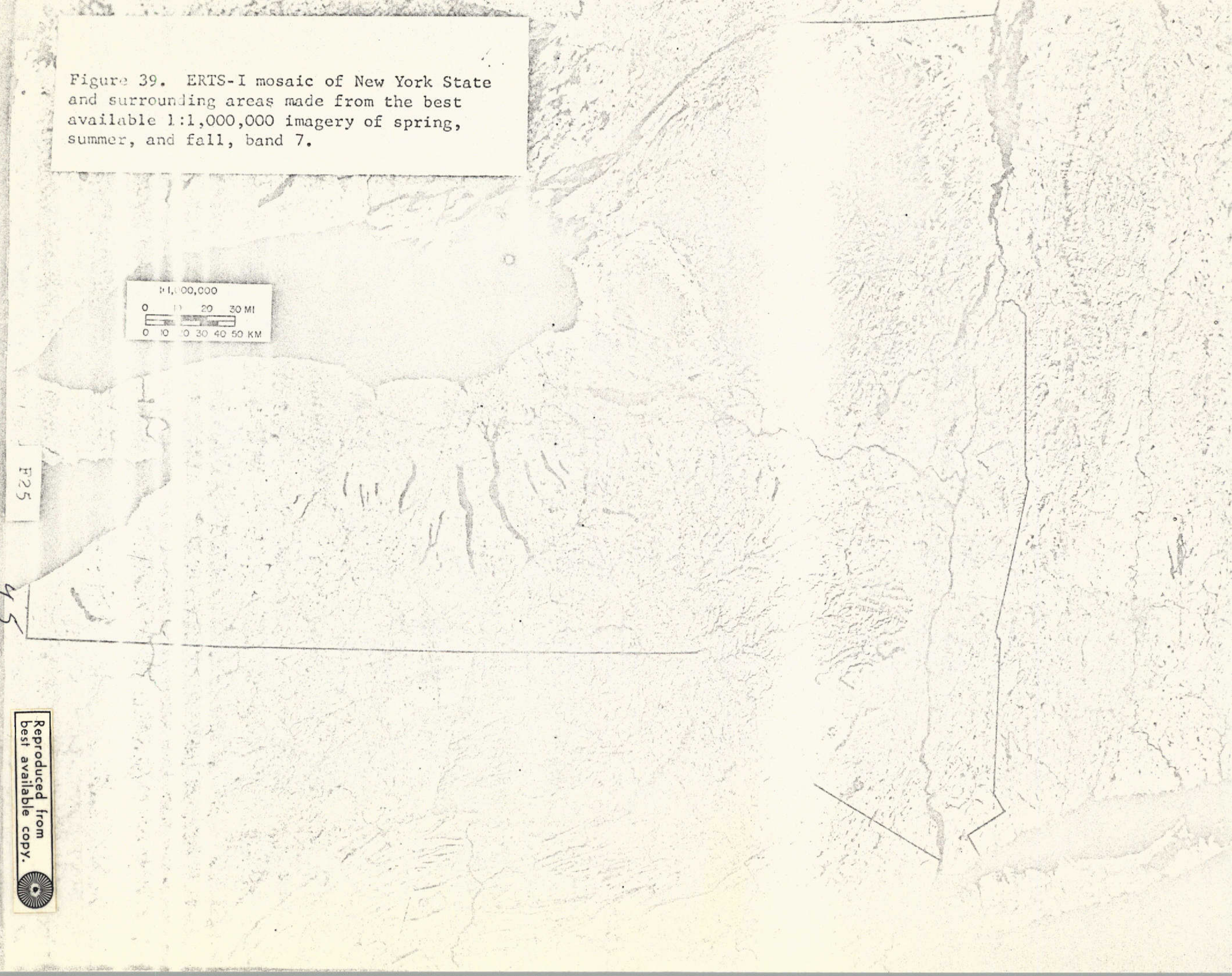

Figure 39. ERTS-I mosaic of New York State and surrounding areas made from the best available 1:1,000,000 imagery of spring, summer, and fall, band 7.

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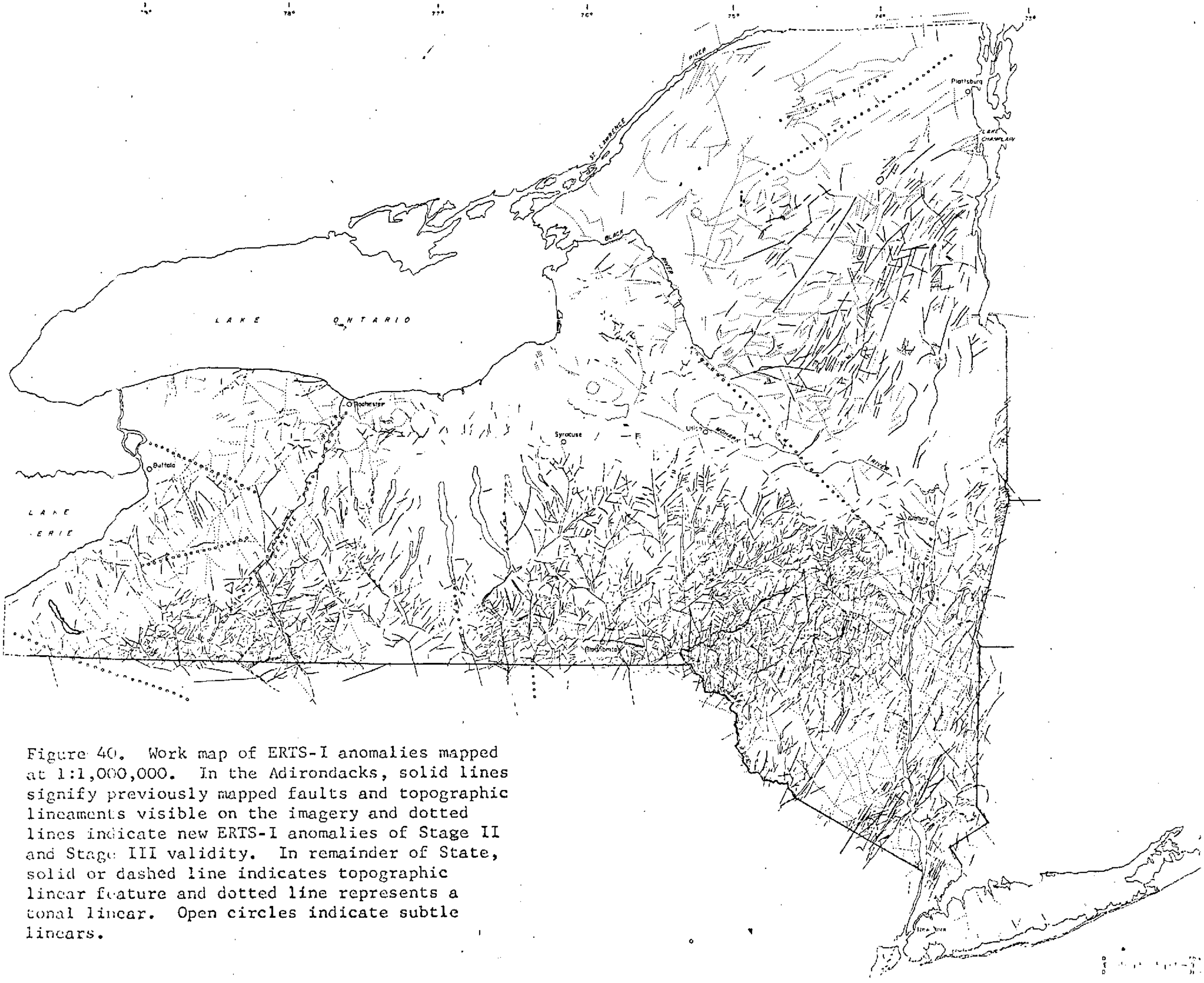


Figure 40. Work map of ERTS-I anomalies mapped at 1:1,000,000. In the Adirondacks, solid lines signify previously mapped faults and topographic lineaments visible on the imagery and dotted lines indicate new ERTS-I anomalies of Stage II and Stage III validity. In remainder of State, solid or dashed line indicates topographic linear feature and dotted line represents a tonal linear. Open circles indicate subtle linears.

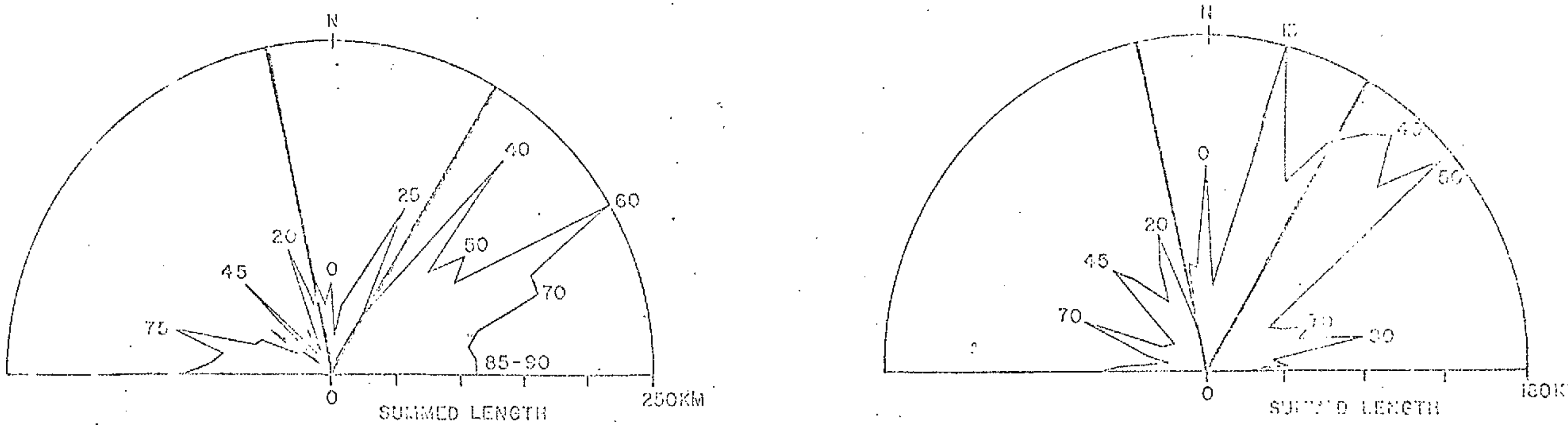
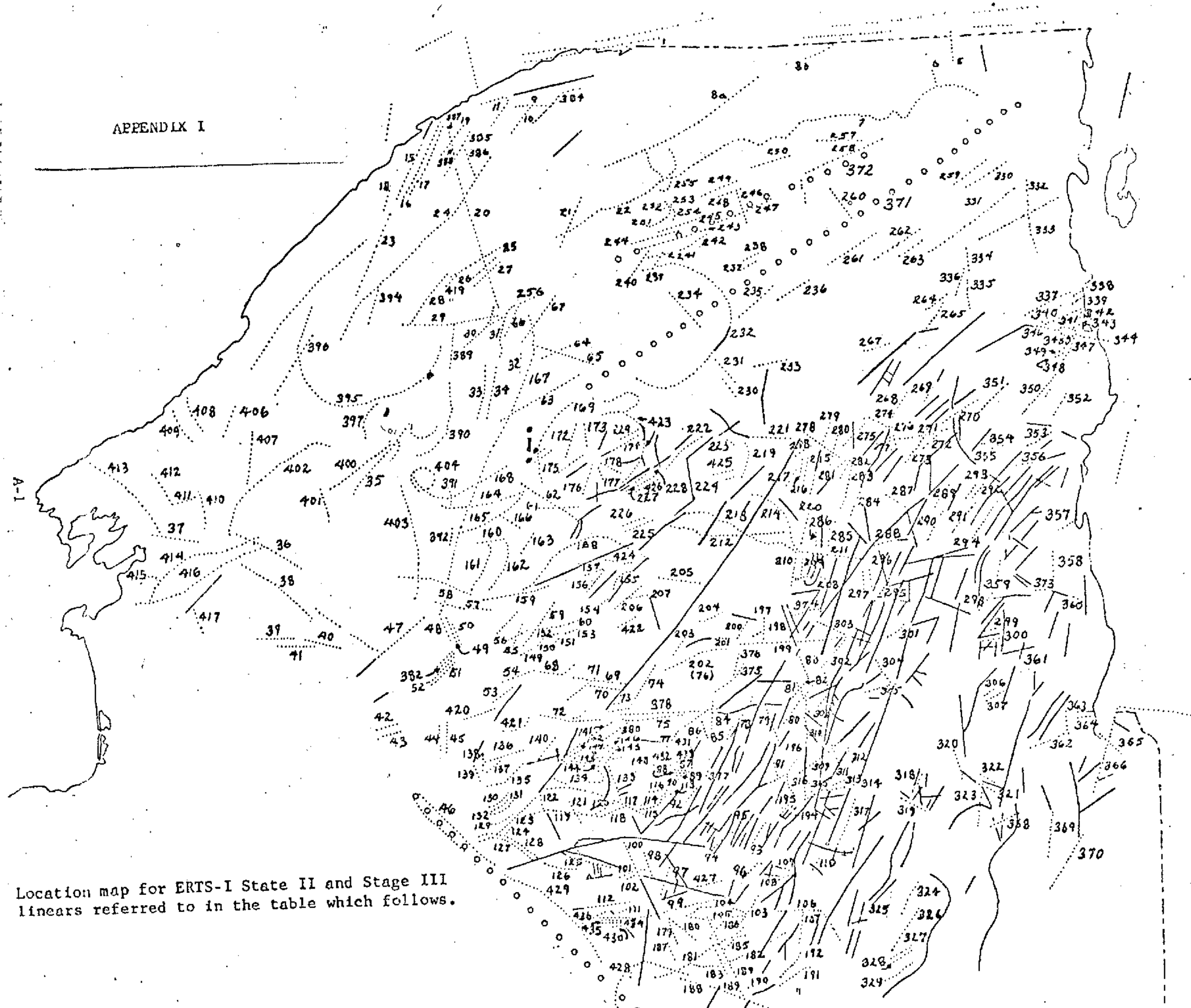


Figure 41. Length weighted rose diagrams of ERTS-I linear anomalies and previously-mapped faults and topographic lineaments showing, by heavy lines, fault plane solutions for the Blue Mountain seismic events recorded by Sbar and others (1972).

APPENDIX I



Location map for ERTS-I State II and Stage III linears referred to in the table which follows.

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STAGE II AND III LINEAR ANOMALIES IN THE ADIRONDACK REGION

Ident. No.*	Air-foto Index Sheet	Strike	Length in km	Airfoto Index Identification	Field Identification and Remarks CTL=clearly a topographic lineament on imagery and on ground TL=topographic lineament on ground but not obviously so on imagery NTL=not a topographic linear feature on imagery or ground	Photo No.
5	96	N2W	8	Allen Brook (straight stream)	CTL	
6	96	N17W	7	dark vegetation strip	NTL	
15	53	N25E	9	southern half is several forest areas aligned and a stream section	NTL	
16	53	N24E	13	linear wooded area and stream	NTL	
17	53	N26E	6	road at southern end; rest is unexplained	NTL	
18	53	N20E	6	unexplained	NTL	
19	65	N41E	8	border of dark vegetation and stream	NTL	
20	66	N12W	35	unexplained	NTL	
24	53	N42E	38	southern 1/3 is Beaver Creek; road and fields are mid 1/3; northern 1/3 is the Grass River	NTL	
25	66	N60E	14	lithology and road and unexplained	NTL	
28	54, 66, 67	N40E	14	southern ½ parallels lithology; northern ½ is probably a stream	NTL	

29	54, 67	N80E	8	road segment in center, possible woodland boundary	NTL
31	67	N62E	1	stream valley	NTL
32	67	N5E	4	unexplained	NTL
33	67	N12E	12	unexplained	NTL
36	43, 56	N67W	14	northwest ½ is a road, southeast ½ is unexplained	NTL
39	56	N89E	9	unexplained; possible vegetation border	NTL
40	56	N75W	8	tree-lined stream valley	TL
41	56	N89W	8	unexplained	NTL
42	57	N77E	6	winding stream	NTL
43	57	N74E	5	unexplained	NTL
44	57	N1W	9	parallels lithology; also short section of river	CTL
45	70	N2E	7	appears to parallel lithology and stream segment	CTL
46	71, 58	N47W	17	southern ½ is road and stream northern ½ is an elongate woodland	NTL
48	69	N21W	7	southern 2/3 parallels lithology; northern 1/3 is unexplained	CTL
49	69	N19W	7	southern 2/3 parallels lithology; northern 1/3 is unexplained	CTL

50	69	N19W	5	southern 2/3 parallels lithology; northern 1/3 is unexplained	CTL
55	69	N20E	6	unexplained	CTL
57	69	N86W	13	straight stream valley	CTL
58	69	N28E	5	straight stream valley	CTL
61	68	N90E	9	southwest ½ is stream, northeast ½ is unexplained	CTL
62	68	N55W	14	southeast 2/3 is a straight stream; rest is probable stream	CTL
63	67	N61E	18	northeast 4/5 is straight stream; southwest 1/5 is unexplained	CTL
64	67	N67E	8	straight stream valley	CTL
65	67	N70W	15	mid 1/3 is unexplained; remainder is winding stream	CTL
66	67	N27E	8	straight valley	CTL
68	70	N77W	5	unexplained	NTL
69	70, 85	N82W	9	mid section is lake shore; rest is unexplained	CTL
70	70, 85	N80W	8	valley and lake shore	CTL
71	70	N53E	7	southern 2/3 is stream; northern 1/3 is apparent dry valley	CTL

72	70	N82W	15	straight stream valley	CTL
73	85	N84E	4	straight stream valley	CTL
74	85	N48E	17	stream valley	CTL
76	85	N74E	16	edge of topographically high area	CTL
77	85	N46E	21	stream valley	CTL
78	85	N35E	31	southern 3/4 is stream valley; northern ¼ is unexplained	CTL
79	85	N21W	8	Indian Lake and unexplained	CTL
81	85	N11W	5	sub-parallel to stream valley	CTL
82	85	N40E	6	straight valley	CTL
83	85	N17W	6	edge of topographically high area	CTL
84	85	N5E	6	stream valley	CTL
85	85	N19W	5	stream valley	CTL
86	85	N31E	6	apparent dry valley	CTL
91	85	N19W	4	straight valley	CTL
92	86	N41E	7	straight valley	CTL
93	86	N38E	6	possible vegetation border	NTL
94	86	N48E	5	stream valley	CTL
96	86	N43E	7	small valley	TL
97	86	N24E	7	straight valley	CTL
98	86	N18W	6	lake and stream	CTL

100	86	N19W	10	unexplained	NTL
103	86	N32E	7	straight valley	CTL; breccia on Gloversville quadrangle (J.M.**)
105	86	N87W	15	stream valley	CTL
106	86	N56W	7	highway and stream	CTL
107	86, 87	N4E	3	northern part is stream; rest is unexplained	CTL; lithologic contact in southern part (J.M.)
108	86	N67E	5	valleys with drak vegetation	CTL
110	86	N31E	4	straight valley	CTL
111	86	N64E	5	straight valley	CTL
112	71, 86	N85E	10	straight valley	CTL
113	86	N53E	6	straight stream valley	CTL
114	86	N68E	6	stream + unexplained	CTL
117	71, 86	N73W	26	stream valley	CTL
119	71	N79W	19	½ length is stream valley; rest is unexplained	CTL
120	71	N61E	7	straight river valley	CTL
121	71	N30W	6	mid 1/3 is stream; rest is unexplained	CTL
122	71	N9W	4	straight stream valley	CTL
123	71	N48E	12	straight stream valley	CTL
124	71	N44E	3	straight stream valley	CTL
125	71	N75W	10	straight stream valley	CTL
126	71	N76W	7	unexplained	CTL
129	71	N67E	6	stream valley	TL
133	70, 71	N18W	11	straight stream valley	CTL

135	70	N60E	13	winding stream	CTL
136	70	N76E	9	straight valley + unexplained	CTL
137	70	N52E	7	straight stream valley	CTL
138	70	N1W	5	small stream valley	CTL
139	70	N28W	4	lake and dark vegetation	NTL
141	70	N58E	7	northern ¼ is stream; southern 3/4 is a road	CTL
148	70, 85	N82E	8	stream valley	CTL
149	69	N65E	3	stream valley	CTL
150	69	N46E	2	stream valley	CTL
151	69	N42E	3	border of dark vegetation area (also edge of topographic high)	CTL
152	69	N60E	7	stream valley	CTL
153	69	N75E	3	lake shoreline	NTL
154	69	N69E	4	unexplained	NTL
155	69, 84	N49E	8	stream valley	CTL
156	69	N42E	7	stream valley	CTL
157	69	N70E	5	straight valley	CTL
159	69	N76E	16	lake shoreline and boundary between topographic high and low areas	CTL

160	69	N84E	6	several aligned stream valleys + lake	CTL	
163	69	N32E	6	stream and lake	CTL	
164	68	N80E	21	winding stream	CTL	
165	68	N52E	12	stream and road	CTL	
166	68	N68W	4	½ is stream; rest is unexplained	NTL	
167	67, 68, 69	N19E	67	long linear composed of several stream, lakes and roads	CTL	
169a	68	N68E	6	stream valley	CTL	II-3-4
169b	68	N45E	5	lake arm + stream	CTL	II-3-4
170	68	N55E	5	lake	CTL	
171	68	N57E	4	unexplained	NTL	
172	68	N21E	8	stream and unexplained low area	CTL	
173	68	N6W	6	Cranberry Lake shoreline	NTL	
174	68, 63	N63E	8	stream valley	CTL	
175	68	N60E	7	narrow WSW arm of Cranberry Lake	CTL	II-3-5
176a	68	N44E	4	stream valley + lake arm	CTL	
176b	68	N44E	10	stream valley + lake arm	CTL	
177	68	N17W	3	portions of two lakes and topographically low area	CTL	
179	87	N12W	2	lake + dark vegetation patches	TL	
180	87	N55W	8	stream + lake + unexplained	TL	
182	87	N88W	9	stream + lake shore + dark vegetation area	CTL	

183	87	N22W	9	road and dark vegetation area + small valley	NTL; fault, metagabbro against charnockite (J.M.)
184	87	N25W	7	road + lake + low areas	TL
185	87	N55E	20	stream + unexplained	CTL; fracturing along stream and also to north beyond linear on imagery (J.M.)
186	87	N43E	5	lake + unexplained + stream	CTL
187	87	N24W	4	unexplained	NTL; in glacial deposits (J.M.)
188	87	N73W	21	stream + road + unexplained	CTL; SE ½ is glacial except central knob which is lithologic contact; W ½ is close to fold axes and crosses lithologic contact (J.M.)
189	87	N44W	4	unexplained	NTL; in glacial deposits
190	87	N79W	5	unexplained	NTL; fault between Precambrian and Paleozoic (J.M.)
191	87	N61E	6	stream + dark vegetation	NTL; in Paleozoic rocks
193	87	N68E	7	unexplained + short stream segment	TL; E ½ is lithologic contact, remainder not mapped (J.M.)
194	86	N57W	4	straight valley	CTL
195	86	N42E	3	straight valley	CTL
197	84	N5E	5	straight valley	CTL
198	84	N69E	2	straight valley	CTL
199	84	N89E	23	stream + boundary of topographically high area	CTL
200	84	N33E	5	straight valley	CTL
201	84	N86W	3	unexplained	NTL
202	70	N45E	4	edge of topographic high	CTL
203	84	N40E	5	straight valley with dark vegetation	CTL

204	84	N71E	6	stream valley	CTL	
205	84	N80W	10	stream + low areas with darker vegetation	CTL	
206	84	N51E	8	stream valley	CTL	
207	84	N82E	6	stream valley	CTL	
208	84	N88W	6	stream + lake + stream	CTL	
209	84	N7E	4	stream valley + unexplained	CTL	
210	84	N12E	6	dark vegetation strip	NTL	
211	84, 100	N81W	12	valley + lake + road	CTL	
212	83	N85W	31	stream + small lake	CTL	
215	83	N11E	9	straight valley	CTL; a Seward Mountain lineament	II-3-10
216	83	N11E	5	straight valley + unexplained	CTL; a Seward Mountain lineament	II-3-10
217	83	N39E	5	unexplained	NTL	
218	83	N60E	6	unexplained	NTL	
219	83	N11E	9	stream valley + lake shoreline	CTL	
220	83	N14E	8	lake shoreline + edge of topographic high	CTL	
221	83	N85W	10	straight stream valleys	CTL	
223	83	N52W	3	lake shore + unexplained	NTL	
224	83	N75E	2	stream valley	CTL	
229	83	N63E	5	straight stream valley	CTL	
230	82	N35W	6	unexplained	NTL	

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231	82	N40W	6	stream + unexplained + stream	NTL
234	82	N40W	11	stream valley + unexplained location only approximate	TL
235	82	N49E	11	unexplained	NTL
236	82, 97	N61E	8	valley + unexplained	NTL
237	81	N60E	5	ridge	CTL
238	81	N73E	4	ridge	CTL
239	81	N33E	5	stream valley	CTL
240	81	N37E	9	stream + unexplained + stream	CTL
241	81	N81E	6	stream valley	CTL
242	81	N62E	9	stream valley	CTL
243	81	N73E	8	stream + unexplained + stream	CTL
244	81	N80E	12	unexplained	NTL
245	81	N73E	11	unexplained	NTL
246	81	N16W	8	stream valleys	CTL
247	81	N71E	13	straight valley with dark vegetation	CTL
248	81	N73E	5	stream valley	TL
249	81	N73E	9	stream valley + unexplained	TL
250	81	N76E	9	dark vegetation patches + unexplained	CTL
252	81	N67W	2	stream valley	TL

253	81	N42W	1	stream valley	TL
254	81	N2W	5	stream valley	TL
256	67	N62E	11	stream + transmission line	CTL
257	96	N38W	10	several stream valleys	CTL
258	96	N68E	20	"cuesta" ridge of northern Adirondacks; not visible on index	CTL
260	97	N36W	4	straight stream valley	CTL
261	97	N60E	12	stream + unexplained + stream	CTL
262	97	N60E	8	stream valley	CTL
263	97	N58E	6	straight stream	NTL
264	98	N57E	6	stream valley	CTL
265a	98	N65E	4	straight valley	CTL; Mt. Whiteface
267	98	N77E	7	dark vegetation strip	NTL
268	98	N37E	7	southern 3/4 is stream; northern ¼ is unexplained	CTL
269	98	N37E	5	straight valley	CTL
270	99	N60E	10	two aligned valleys	CTL
271	99	N83E	12	unexplained + straight valley	CTL
272	99	N48E	4	straight valley	CTL
274	99	N70W	9	small valley	TL
275	99	N53E	7	straight valley	CTL
276	99	N11W	5	stream valley	TL
278	99	N54W	13	stream + unexplained	CTL

279	99	N24E	6	stream + unexplained	CTL	
280	99	N15E	9	two small stream valleys	CTL	
281	99	N54E	5	stream valley	CTL	
282	99	N36E	4	stream valley	CTL	
283	99	N15E	14	unexplained + stream	CTL	
284	99	N24E	6	stream + lakes	CTL	
285	99	N6E	4	straight stream valley	CTL	
286	99	N1E	4	stream valley	CTL	
287	99	N52W	4	stream + unexplained	CTL	II-2-21
288	99	N76E	5	stream + lake	CTL	
290	99	N38E	9	stream + unexplained ridge	TL	II-2-18
291	99	N42E	9	straight valley	CTL	
294	99, 116	N38E	10	sharp valley with dark vegetation	TL	
295	100	N35E	6	wide stream valley with dark vegetation	TL	
296	100	N0E	9	unexplained	NTL	
297	100	N2W	8	stream valley	CTL	
298	100	N38E	5	stream + unexplained	TL	
299	100, 117	N74E	6	stream valley	TL	
301	100	N56E	6	stream valley	TL	
302	100, 101	N41E	11	stream valley	CTL	

303	100	N64W	8	stream + unexplained	TL
305	101	N75E	4	stream + unexplained	TL
306	101	N58E	4	two straight valley with dark vegetation	CTL
307	101	N61E	5	dark vegetation areas around stream	CTL
309	101	N48E	20	stream + unexplained	CTL; North Creek - Schroon Lake Village topographic lineament connects two previously-mapped segments, and extends one for a total length of 50 km. II-3-1
310	101	N0E	5	stream valley with dark vegetation	CTL
311	101	N14W	6	stream valley	CTL
312	101	N18W	4	stream + valley with dark vegetation	CTL
313	102	N25E	5	straight stream valley with dark vegetation	CTL
314	102	N81E	8	stream valley	CTL
315	102	N6W	3	stream valley	CTL
316	102	N7W	4	stream valley	TL
317	102	N57E	3	straight stream valley	CTL
318	102	N26E	7	straight stream valley	TL
319	102	N64W	7	stream + unexplained	TL; fault, chlorite, slickensides (J.M.)
320	101, 102	N13W	7	stream	NTL
321	102	N56W	5	dark vegetation strip	NTL
322	102	N55W	6	small valley with dark vegetation strip	CTL
323	102	N11E	10	small valley with dark vegetation strip	CTL

324	102	N29E	8	stream valley	CTL	
325	102	N12E	6	straight valley with dark vegetation	TL; possible stratigraphic offset (J.M.), breccia west through Bachellorville pegmatites (J.M.)	
326	103	N39E	12	stream + unexplained	TL	
330	114	N63E	11	irregular dark vegetation strip	NTL	
331	97, 114	N54E	11	dark vegetation + unexplained + dark vegetation	NTL; clear line on imagery but unclear in field	
332	114	N4W	16	dark vegetation strip	NTL	
333	114	N64E	20	stream + unexplained + stream	NTL	
334	114	N5W	6	stream valley	CTL	
335	114, 116	N4W	8	stream valley	CTL	
336	114, 115	N20E	8	unexplained	NTL	
337	115	N66E	12	unexplained + lake	TL	
338	115	N63E	4	valley with small relief	TL	
339	115	N64E	4	valley with small relief	TL	
340	115	N50E	7	unexplained	NTL	
341	115	N69E	9	stream + unexplained	NTL	
342	115	N26E	4	unexplained	NTL	
343	115	N13W	2	unexplained	CTL; unnamed creek to Willsboro Bay	II-3-
343a	115	N74E	2.5	stream valley	CTL; Rattlesnake Mt. lineament	II-3-
346	115	N78W	7	unexplained	NTL	
347	115	N27E	7	stream + dark vegetation border	NTL	

350	115	N43E	13	unexplained + stream + unexplained	CTL; Elizabethtown - Burpee Brook	II-3-
351	115, 116	N34E	11	unexplained + stream	CTL	
352	115, 116	N32E	8	two stream valleys	TL	
353	116	N61E	6	unexplained	NTL	
354	116	N82W	6	stream valley	CTL; Roaring Brook; continues beyond divide	II-3-
355	116	N36E	7	two stream valleys	CTL	
356	116	N82E	7	stream valley	CTL; fault in mangerite at western end	II-3-
357	116	N65E	5	short straight stream valley	TL	
358	117	N5E	6	lake + stream	NTL	
359	117	N6E	2	lake + stream + dark vegetation area	CTL	
360	117	N69W	4	stream + unexplained	TL	
361	118	N74E	5	unexplained	NTL	
362	118	N70E	9	unexplained + lake + unexplained	NTL	
363	118	N7W	4	stream + unexplained	NTL	
364	118	N80E	4	unexplained	NTL	
365	118	N45W	8	stream + dark vegetation area	NTL	
366	118	N19E	4	winding stream + canal	CTL	
368	119	N69E	7	stream + unexplained	CTL	
369	119	N13E	11	unexplained	NTL	
370	119	N33E	3	canal + unexplained	NTL	

371	67, 81, 82, 97, 113	N58E	75	stream + unexplained + dark vegetation areas	CTL
372	81, 97	N69E	61	edge of topographic high + lake	CTL
373	117	N88E	3	road + lake	CTL
374	100	N84E	8	broad stream valley	CTL
375	85	N48E	11	stream valley	CTL
376	85	N17E	5	stream valley	CTL
377	85	N28E	2	dark vegetation strip	NTL
378	85	N89E	19	stream valley	CTL
384	65	N54E	16	combination of stream and vegetation borders	NTL
385	65, 66	N35E	12	dark vegetation border	NTL
386	65	N19W	8	dark vegetation border	NTL
387	65	N13W	3	dark vegetation border	NTL
388	65	N7W	3	dark vegetation border	NTL
391	68	N9W	7	dark vegetation area + stream valley	CTL
392	69	N10E	3	parallels lithology + dark vegetation area	CTL
393	69, 56	N74W	18	Beaver River	NTL
394	54	N17E	9	stream	NTL
400	55	N56E	18	stream + parallels lithology	CTL
402	55	N74W	5	railroad + stream	NTL
403	55, 56	N10W	21	river + dark vegetation area	NTL

405	56	N54W	18	unexplained	NTL
407	43	N8E	12	stream + unexplained	NTL
409	42, 43	N30W	9	unexplained + vegetation border	NTL
410	43	N12W	5	stream + road	NTL
412	43	N33W	9	unexplained	NTL
413	43	N46W	25	unexplained	NTL
414	43, 44	N69E	26	railroad + dark vegetation strip	CTL
415	44	N66W	4	stream + dark vegetation strip	TL
416	44	N86E	35	stream + unexplained	CTL
417	44	N21W	9	stream + unexplained	NTL
418	53, 54	N49E	26	railroad + black lake	CTL
419	66	N49E	4	unexplained	NTL
420	70	N72E	8	stream valley	CTL
421	70	N66E	9	stream + unexplained	CTL
422	84	N62E	6	stream valley with dark vegetation strip	CTL
424	69	N83W	6	stream with surrounding irregular dark vegetation strip	TL
425	83	N80E	5	unexplained + stream + dark vegetation strip	CTL

426	83	N63E	6	lake + stream	CTL
427	86	N77E	7	small stream valley	CTL; cuts diagonally across stratigraphy (J.M.)
429	71	N46W	35	stream + lake	NTL
431	85	N46E	7	stream	TL
432	85	N7E	5	dark vegetation strip	NTL
433	85	N53E	4	straight valley	CTL
437	97	N35E	7.5	valley + lake shore + ridge	CTL

*Numbers not shown in table represent linears that were declassified as a result of field study, because they are caused by man or because they are lithologically controlled.
**Oral communication from James McLelland