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Paper G 1

EVALUATION OF ERTS-1 IMAGERY FOR GEOLOGICAL SENSING OVER THE DIVERSE GEOLOGICAL TERRANES OF NEW YORK STATE

Yngvar W. Isachsen, Robert H. Fakundiny and Stephen W. Forster, *Geological Survey, New York State Museum and Science Service, Albany, New York*

ABSTRACT

Film positives of ERTS-I imagery, both as received from NASA and photographically reprocessed, are being analysed by conventional and color additive viewing methods. The imagery reveals bedrock and surficial geological information at various scales. Features which can be identified to varying degrees include boundaries between major tectonic provinces, lithological contacts, foliation trends within massive gneisses, faults, and topographic lineaments.

In the present imagery the greatest amount of spectral geology is displayed in the Adirondack region where bedrock geology is strongly linked to topography. Within this basement complex, the most prominantly displayed features are numerous north-northeast trending faults and topographic lineaments, and arcuate east-west valleys developed in some of the weaker metasedimentary rocks. The majority of the faults and lineaments shown on the Geologic Map of New York at 1:250,000 appear in the ERTS imagery. In addition, many new linears were detected, as well as a number of anomalous curvilinear elements, some circular in plan and measuring up to 25 km in diameter which do not bear any strong relationship to mapped geological contacts. One of these, centered on Cranberry Lake, has a radial pattern of linears and resembles a spoked wheel. The possibility that this spectral feature is an astrobleme will be investigated on the ground when snow conditions permit, and earlier by observation from small aircraft.

Surficial features observed in the imagery include the following: Harbor Hill and Ronkonkama moraines, in part, revealed by cultural enhancement, Tully moraine revealed by land-use discontinuity, glaciated valleys and cross channels south of Syracuse, glacial streamline forms atop Tug Hill Plateau, ice marginal channels in the Watertown quadrangle, and tonally distinguished glacial lake deposits south of Plattsburgh and northeast of Black Lake. Tonal variations in ERTS imagery taken September 6 and 7 in western New York, however, show no obvious correlation with glacial deposits, but a poor correlation with the mapped distribution of major soil groups.

1. INTRODUCTION

This report summarizes results to date of a project to evaluate the usefulness of ERTS-I imagery as a spectral geological tool in the diverse geological terranes on New York State. The study concentrates on the

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geologically useable (i.e. sufficiently cloud-free) imagery obtained over New York, although major new structural elements will be studied where they extend into adjacent regions.

New York State lies astride five tectonic provinces (Fisher and others, 1971). A major platform of essentially undeformed Lower and Middle Paleozoic strata on Proterozoic basement underlies most of the state. A second platform, of Cretaceous strata on P- ozoic basement, forms the substrate of Long Island. Between these orms lies the Appalachian Orogen or Foldbelt, with subdivisions including reactivated Proterozoic rocks of the Hudson Highlands, and major thrust sheets and submarine gravity slides of the Taconics. South of the Hudson Highlands is the Triassic Basin. Lastly, the Adirondack Dome in the northern part of the state exposes Proterozoic basement rocks as an extension of the Grenville Province of the Canadian Shield. As would be expected, the amount and kind of spectral geological information varies considerably from province to province.

2. ERTS-1 ANALYSIS

ERTS-I imagery received to da cals 125 frames covering 32 scene areas over New York State as well as portions of adjacent states and Canada. It has been catalogued and categorized in terms of geological usefulness as a function of cloud distribution. An inventory of imagery on hand through Feb 73, in terms of geological usefulness, is as follows: useful (0-50 percent cloud cover), 50 percent; marginally useful (50-70 percent cloud cover), 10 percent; useless (70-100 percent cloud cover), 40 percent.

The entire state is now covered by at least one image having greater than 70 percent cloud-free area (figure 1), and all except the three scenes in the western part of the state re 100 percent cloud-free.

For all useable imagery covering New York State, film positives have been analyzed in transmitted white light for spectral signatures which may have a geological linkage. These data are traced onto clear mylar and combined into a state-wide "spectral geological map" at 1:1,000,000 (figure 2), which is updated as new imagery arrives. For the late summer and fall imagery, bands 5 and 7 compliment each other and contain all the spectral signatures which appear to be geologically-linked; no additional data were found on bands 4 and 6.

After the more obvious spectral geological features were extracted from the standard black and white film positives, it was decided to experiment with other methods as follows:

1. Multispectral color-additive viewing of 70 mm positives of bands 4, 5, 6 and 7, as received from NASA, using a Spectral Data Corporation Model 64 Viewer-Projector. Despite considerable experimentation with a variety of scenes, no information was added to that obtained by conventional viewing in transmitted light.

2. Experimentation to determine what effect photographic reprocessing to produce higher contrast prints might have on the identifiability of linears in ERTS-I, band 5, using transmitted white light. Image 1079-15122-5 (orbit 192) was chosen for the experiment because it includes a portion of several structural provinces, namely: the Adirondack Mountains crystalline rocks, the Alleghany Plateau consisting of Silurian and Devonian strata, the Mohawk and Hudson Valleys underlain by variably faulted and folded Cambrian and Ordovician sedimentary rocks, and the Taconic Mountains which consist of allocthonous Cambrian clastic rocks.

The photographic reprocessing method used was as follows: convert, by contact printing, a 70 mm ERTS-I negative to a 70 mm Kodalith film positive. Convert this high-contrast product by contact printing, to a high contrast negative using Kodak Professional Copy film, and develop in D-72.

Paper enlargements were then made of both the 1:1,000,000 reprocessed and unreprocessed 70 mm negatives, and identifiable linears were scribed on clear mylar overlays. A comparison showed that all linears identifiable on one image were clearly recognizable on the other, although the expression of linears was greater on the high-contrast reprocessed image.

3. Pre-formatting of ERTS-I 70 mm film positives for multispectral viewing to avoid the time-consuming task of separately registering each map in the Viewer every time a scene is to be viewed. A successful method was devised as follows: on a 9.5 x 12 inch piece of 0.005 inch clear mylar, roughly locate the position of the four viewer windows in the 9.5 inch roll film holder and draw two perfectly parallel horizontal lines to guide the placement of the upper edge of the 70 mm film positives. Using these lines, tape the images in perfect parallelism. This pre-formatted array will permit rapid registration, requiring only limited x-y adjustment, the need for rotational adjustment having been eliminated.

4. Multispectral color additive projection of the photographically reprocessed imagery has been initiated. The resulting photographic products are striking in appearance, but additional analysis will be required before their usefulness can be evaluated.

3. ERTS-I AND BEDROCK GEOLOGY

A variety of known bedrock geological features visible to varying degrees in ERTS-I imagery include the following: 1. boundaries between major tectonic provinces; 2. lithological contacts within tectonic provinces; 3. foliation trends within massive gneisses; 4. faults and topographic lineaments; and 5. mine dumps and tailings ponds. In addition, numerous new linear and curvilinear features are discernible, as well as some highly speculative linears. (The word "linear" rather than "lineament" is used in the sense of Dennis, 1967, p. 103, to designate "lines of unsure origin on areal photographs"). Several examples of each of the above bedrock geological categories are itemized below, and may be referred to in figures 1 and/or 2:

1. Boundaries between major tectonic provinces: the contact between the Adirondack basement and onlapping Cambrian rocks is well defined along the southwest border of the Adirondacks, along the north-central border, and along part of the southeastern border. In the southeastern part of the State, the angular unconformity separating Silurian-Devonian strata from the more deformed Ordovician rocks is clearly defined. The same holds for the parallel contact to the west which marks the western limit of Acadian folding. Further to the southeast, the contact between the Hudson Highlands and the Triassic basin is visible.

2. Lithological contacts within tectonic provinces: north of the Adirondacks, the contact between the Cambrian Potsdam sandstone and the overlying Theresa arenaceous dolostone is marked by a fairly sharp transition from light to dark tone. The broad arcuate valleys crossing the Adirondacks reflect lithological variations within the crystalline rocks. South and southwest of the Adirondacks, the arcuate lines result from lithological variations in the Devonian stratigraphic section.

3. Foliation trends within massive gneisses: some of the arcuate spectral trends in the Adirondacks occur within single map units of massive gneisses.

4. Faults and topographic lineaments: these are indicated by the solid lines in figure 2.

5. Mine dumps and tailings ponds: these are shown by the heavier dots and line in the northwest Adirondacks (figure 2).

6. New linear and curvilinear elements, and highly speculative linears: numerous examples are shown on figure 2. A numerical summary of the Adirondack linear information shown on figures 1 and 2 is tabulated below:

Category	Number	Combined length, km
Known lineaments and faults seen on ERTS-I imagery	232	1890
New and anomalous linears seen on ERTS-I imagery	329	3060
Total linears seen on ERTS-I imagery	561	4950
Known lineaments and faults not discernible on ERTS-I imagery	297	1750

Bearing in mind that the numbers in categories 2 and 3 will be modified as analysis of anomalies progresses, the above numbers should be regarded as approximations.

It may be noteworthy that the known lineaments and faults missed on the ERTS-I imagery tend to be concentrated in the eastern Adirondacks where the film positives received from NASA are abnormally dense. It is therefore possible that the ERTS-I multispectral scanner actually sensed more than 50 percent of Adirondack lineaments and faults.

7. Curvilinears. This term is applied to broadly curved spectral line data, and numerous examples can be seen in figure 2. Most of these have not yet been evaluated. One, however, is of particular interest; namely, the "spoked wheel" or Cranberry Lake anomaly which centers on Cranberry Lake in the west-central Adirondacks. A comparison of this feature with mapped geological contacts (Buddington and Leonard, 1962; Fisher and others, 1971) shows only a partial correspondence; in part the "wheel" cuts directly across the trend of resistant crystalline rock units. The possibility that this structure is an eroded astrobleme remains to be field-checked.

4. ERTS-1 AND SURFICIAL GEOLOGY

The available late summer and early fall imagery was examined for surficial geological features of two kinds: essentially two-dimensional features, such as end moraines, glacial lake shorelines and glacial drainage channels; and features having some areal extent, such as glacial lake deposits.

End moraines searched for were the Harbor Hill and Ronkonkama moraines of Long Island, the Fort Covington moraine of the St. Lawrence Valley, the Valley Heads moraine of the Finger Lakes region, and the series of moraines south and east of Lake Erie in western New York State. Of these, only a short segment of the Valley Heads moraine south of Syracuse and portions of the Harbor Hill and Ronkonkama moraines were detectable on the imagery (images 1080-15180-5 and 1096-15074-5); these segments were visible only where enhanced by land use differences.

Glacial drainage channels occur in several areas, but are particularly well shown in the Syracuse area and on the northern flank of the Tug Hill Plateau (image 1080-15180-7).

Glacial lake shorelines were searched for throughout the State, as was the shoreline of the Champlain Sea in the St. Lawrence Lowland. None were seen.

Glacial deposits recognized on the imagery to date are limited to two. Sand deposits of glacial Lake Vermont mapped by Denny (1967) show up on image 1079-15115-7 south of Plattsburgh as an area of dark tone. The same applies to a sand area mapped by MacClintock and Stewart (1965) which extends from the village of Malone westward to the St. Lawrence River (image 1080-15174-7).

South of Lake Ontario an extensive area of drumlins is spectrally enhanced by land use patterns (scenes 1080-15180 and 1046-15292-5).

Because one of us (Fakundiny) has a particular familiarity with the surficial geology of the western part of the State, it was decided, despite the inferiority of the present imagery (images 1080-15180-5 and 1046-15292-5), to attempt an evaluation of tonal variations. Comparisons made with generalized soils maps at 1:1,000,000 of Arnold and others

(1967) and of the Genesee/Finger Lakes Region Planning Board (1970) show only a 10 percent correspondence of soils contacts and tonal boundaries, and that correspondence applies mainly to valley bottoms; it thus appears to be principally a correlation with topography.

5. ONCLUSIONS

As anticipated in our original research proposal, ERTS-I imagery has revealed a number of hitherto unknown spectral linears which may turn out to be geologically-linked. It is therefore very likely that ERTS-I imagery will prove useful in regional fracture analysis. A number of unsuspected and intriguing curvilinear anomalies have also been recognized in the imagery and will be investigated further.

The paucity of spectral evidence for geological contacts (both bedrock and surficial) in the central and western parts of the State may be due to accentuated land-use camouflage during the growing season. Spring imagery which pre-dates the growing season will be carefully scrutinized with this in mind.

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Figure 1. ERTS-I mosaic of New York State made from Bruning prints of 9.5 inch multispectral scanner film positives of band 7. Images used in this mosaic are 1027-15231, 1027-15233, 1027-15240, 1046-15292, 1046-15295, 1077-15014, 1079-15115, 1079-15122, 1079-15124, 1079-15131, 1080-15174, 1080-15180, 1080-15183, 1096-15072, 1096-15074. SCALE: 1mm = 3.5 km.

Figure 2. Spectral geological <u>work map</u> of New York State. In the Adirondacks, solid lines signify known faults and topographical lineaments; dotted lines represent spectral anomalies not all of which have yet been checked against cultural features; the heavy dots and line represent mine dumps and tailings ponds. Elsewhere, the range from solid to dotted lines is a rough index of reliability. Spectral features produced by known lithological variations are omitted. SCALE: 1 mm = 5 km.