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Manuscript  
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NTIS HC #3-25

GEOGRAPHIC APPLICATIONS OF ERTS-I IMAGERY  
TO RURAL LANDSCAPE CHANGE IN EASTERN TENNESSEE

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Abstract

NASA's Earth Resources Technology Satellite has been orbiting the earth and transmitting image data since July. Because of its capabilities in sensing the same geographic point every 18 days and providing a 13,225 square mile view from each image, ERTS has challenged us to the task of interpreting landscape change from a regional perspective. A multistage sampling experiment was conducted using low (10,000') and high (60,000') altitude aircraft imagery in comparison with orbital (560 miles) ERTS imagery. Although the aircraft data provide detailed landscape observations similar to ground truth data, they cover relatively small areas per image frame for irregular static slices of time. By comparison, ERTS provides repetitive observations in a regional perspective for broad areal coverage. Microdensitometric and computer techniques are being used to analyze the ERTS imagery for gray tone signatures, comparisons, and ultimately for landscape change detection.

Since July, NASA's Earth Resources Technology Satellite or ERTS-I has been orbiting the earth in a sun-synchronous polar orbit 560 miles above the earth's surface. Operational sensors on board consist of four channels of a multispectral scanner system which operate from .5 to 1.1 microns. Three return beam vidicon cameras are also on board but have not

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(E73-10040) GEOGRAPHIC APPLICATIONS OF  
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IN EASTERN TENNESSEE (Tennessee Univ.)  
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Details of illustrations in  
this document may be better  
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Original photography may be purchased from:  
NASA Data Center  
10th and Dakota Avenue  
Sioux Falls, SD 57198

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been activated since August. Data gathered by the multispectral scanner system are transmitted to ground stations and principally to Goddard Space Flight Center where the inputs in digital format are processed into photographic imagery and digital tapes. A useful capability of the system is the repetitive coverage offered by ERTS. Every 18 days the satellite passes over the same geographic location at almost precisely the same hour thus providing a temporal as well as a spatial dimension to the system.

Approximately 735 photographic images are produced each day. Since July over 180,000 images have flooded the Goddard Data Handling Facility and the some 300 principal investigators who are examining the data nationwide. The University of Tennessee Geography Remote Sensing Project receives and analyzes some 32 images in the 70 mm and 9½ x 9½ formats in color and in black and white on an 18 day cyclic basis.

Among the capabilities of this experimental remote sensing satellite is the large area coverage: a 115 mile linear distance edge to edge on the imagery which provides a coverage of 13,225 square miles per image frame (Fig. 1).

Unlike conventional large scale aerial photography which, since the early 1930's has been an obvious data source

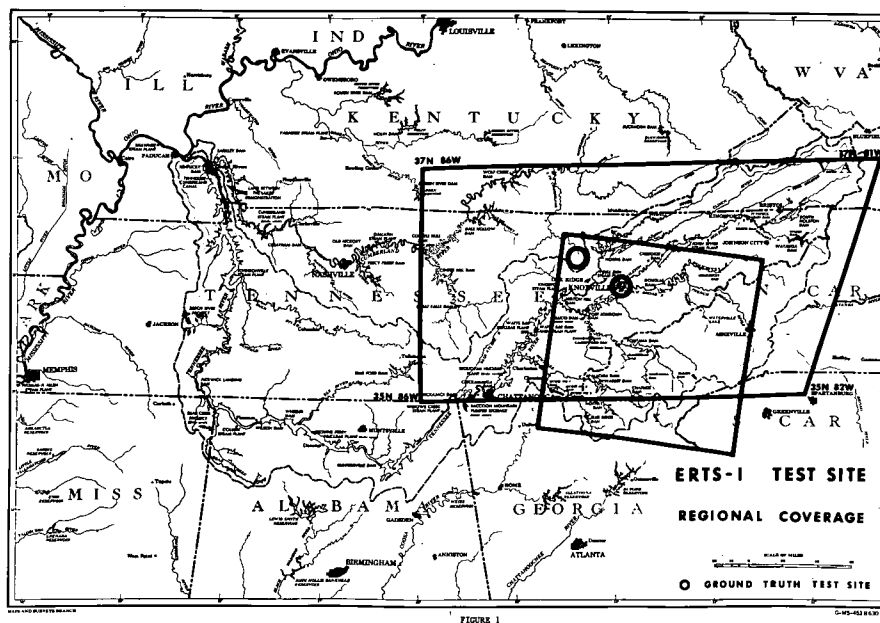


Fig. 1. Map of ERTS-I Test Site and the regional coverage from a single ERTS image.

GEOGRAPHIC APPLICATIONS OF ERTS-I IMAGERY

for landscape examiners, ERTS-I imagery provides a significant regional perspective and at the same time possesses enough image clarity to make landscape signatures interpretable.

Using techniques of comparison in a multi-stage sampling procedure let us examine a case in point in the detection of regional landscape change produced by surface stripmining in Tennessee.<sup>1</sup> Conventional low altitude imagery (10,000') produces readily identifiable stripping signatures at a scale that is too specific for broad coverage applications. Local change can be detected by the loss of vegetation and surface soil on primary excavations. However, such a scale denies the observation of more long range and perhaps more significant regional consequences induced by surface mining.

Intermediate scale imagery until recently has been the most productive for regional interpretation. Some of the most useful has been the high altitude (60,000') imagery generated by the NASA RB-57 aircraft program. Here again, however, the areal extent of the coverage fails to produce an adequate regional scale. The RB-57 imagery on a 9" x 9" format encompasses 289 square miles per frame. Thus approximately 45 high altitude images would be required to cover a 13,225 square mile area, the same area covered on a single frame from ERTS.

ERTS-I not only provides a regional scale perspective, it also allows for repetitive observations at regular intervals on an 18 day cycle. With such a data base of cyclic coverage, landscape change can not only be detected but also monitored. Quantitative data which can be extracted from the imagery can provide a base from which to calculate further landscape alteration.

Promising in this regard is a current densitometric analysis of the ERTS imagery for monitoring landscape change. Although the experiment has just begun, it involves the microdensity scanning of an image of a surficially mined area in which strip mines appear in light tones against a dark forested background (Fig. 2 and 3).

Gray tone densities are then digitized and computer processed into a computer map printout and a histogram (frequency distribution). By comparing such machine analyzed data from different dates of satellite observations, one could determine if the percentage of gray tones (light) for the strip mined area had increased at the expense of the dark tones for the



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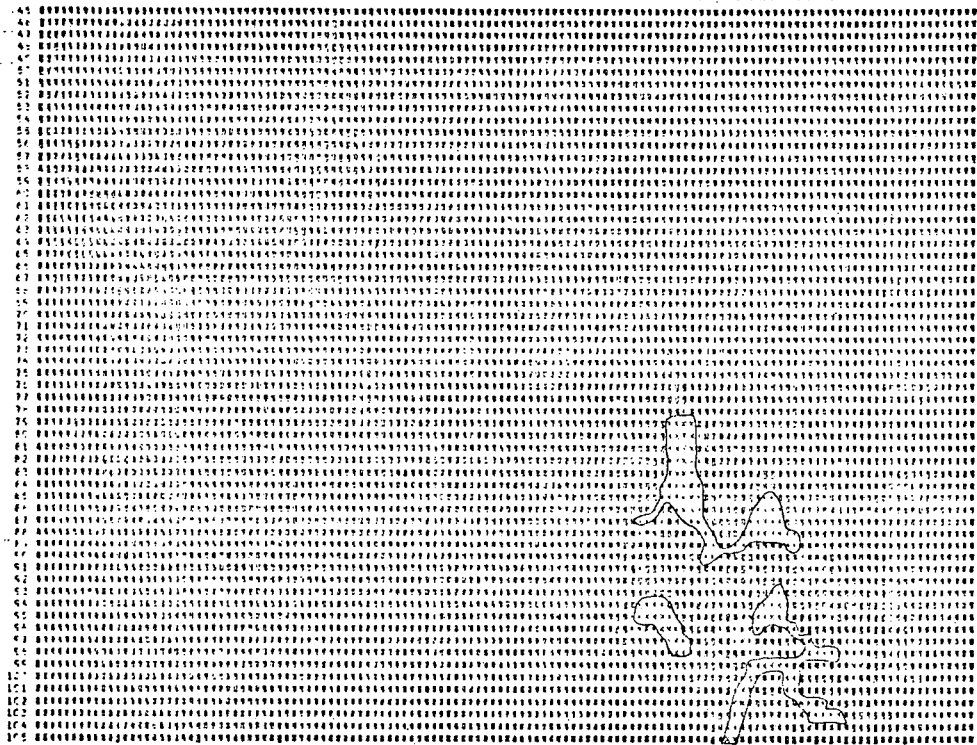


Fig. 2 Densitometer scan and computer printout from an ERTS image of strip mines on the Cumberland Plateau. Reduction 10X. Note light tones in lower right correspond with actual strip mines as indicated in figure 3.

same area. One, then, should be able to conclude that forest cover had been altered and that strip mines were increasing because of the increased frequency of light toned signatures. However, care must be taken to exclude roads, streams, and particularly clouds which may be mistaken for light toned mine scars in the data scan and analysis.

Associated with and visible from a regional perspective other landscape elements are being detected and monitored for change such as: forest alterations, highway construction, urban growth and suburban encroachment on rural areas, and the annual round of cyclic and seasonal changes associated with agricultural and forested areas. Thus it is from this point of view that the Earth Resources Technology Satellite program challenges us to interpret the earth's landscapes periodically from a perspective which until this decade was available only from discriminating map productions.

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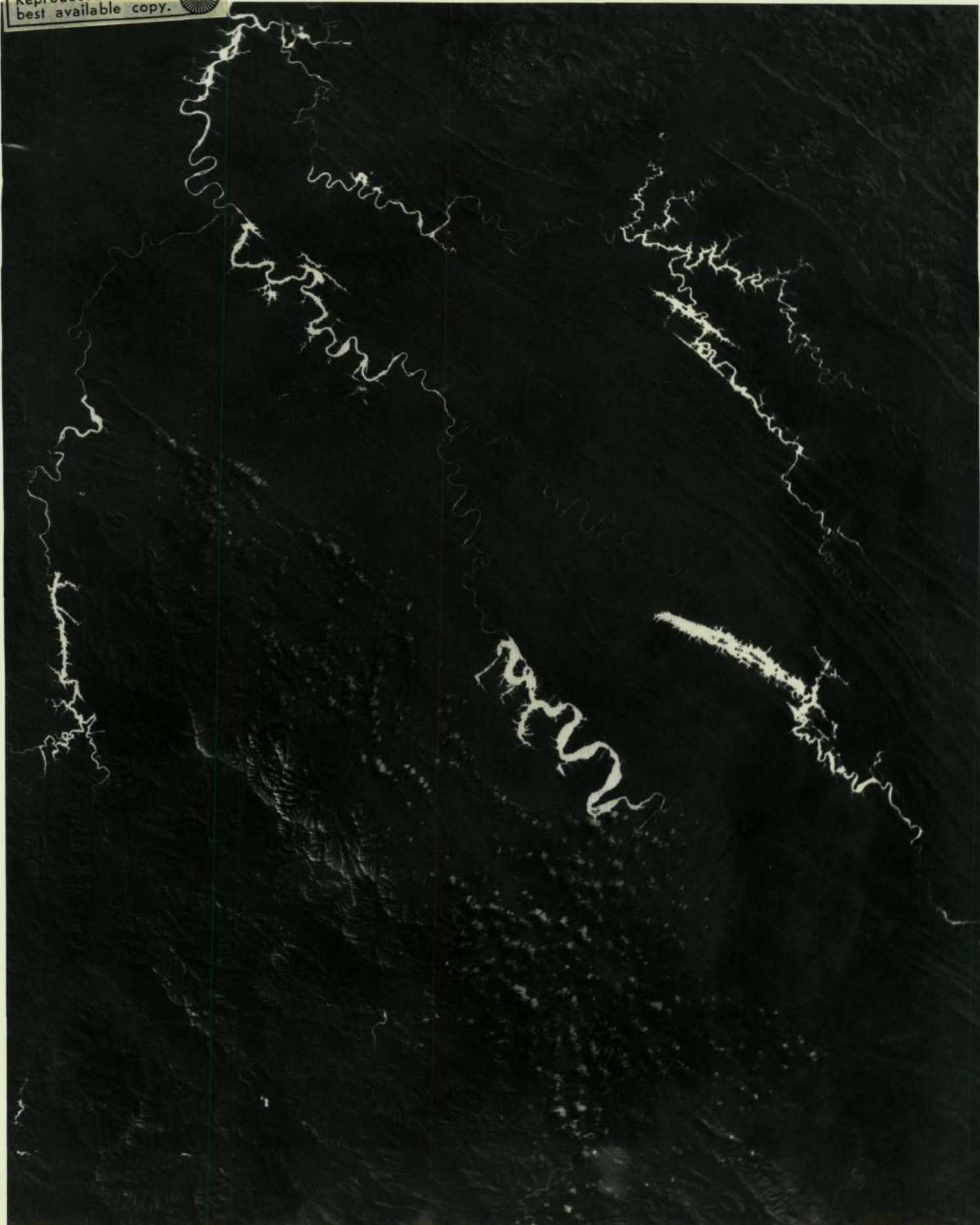


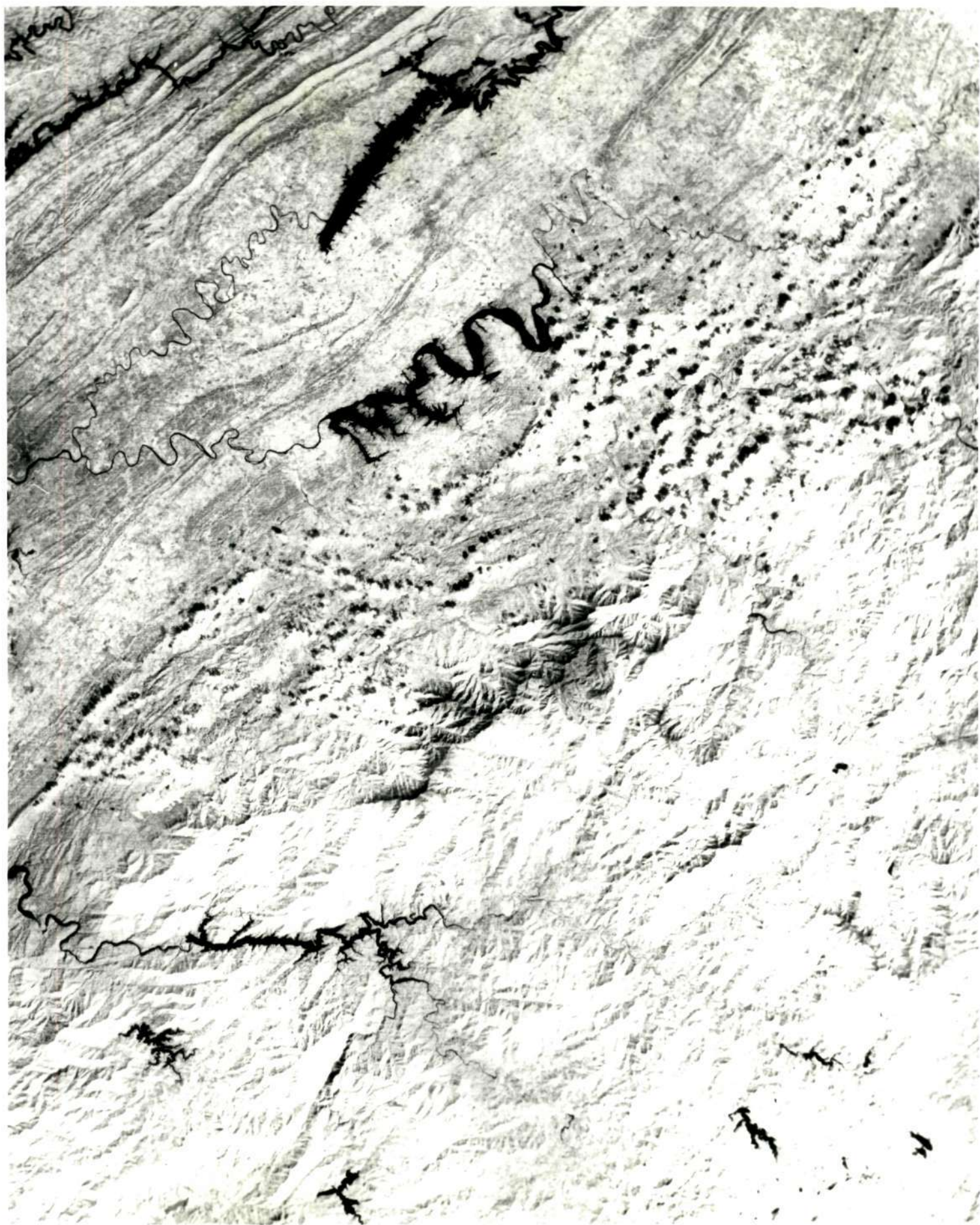
Fig. 3  
ERTS-I image  
of Eastern  
Tennessee.  
October 15,  
1972. Note  
strip mines  
indicated by  
arrow which  
correspond  
with those  
in the scan  
in figure 2.  
K=Knoxville

References

<sup>1</sup>Rehder, John B. Geographic Applications of ERTS-A Imagery to Rural Landscape Change. Type II Report. NASA Contract NAS5-21726. NASA-ERTS Geography Remote Sensing Project, University of Tennessee, Knoxville, Tennessee, December 1972.

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ERTS - I IMAGERY DESCRIPTION FORM

NASA-ERTS Geography Remote Sensing Project  
Department of Geography  
University of Tennessee  
Knoxville, Tennessee 37916

Dr. John B. Rehder - P.I.  
James R. O'Malley - Assistant

Standard Print: \_\_\_\_\_

Enhanced Image: Enhancement of surface moisture on  
the windward slopes of the Great Smoky Mountains

Image Type: MSS band 7

Altitude: 560 miles

Location: eastern Tennessee/ western North Carolina

Date: October 15, 1972 / 10:43 am

Interpretation/Description: center. Dark tones indicate  
prominant areas of surface moisture on the western windward  
slopes of the Great Smoky Mtns. The area experienced rains  
of 2" one day before this observation. Other water signatures  
are indicated by dark tones for TVA reservoirs to the north.

Technical Information  
print paper: Kodak Medalist F-4

Enlarger: Beseler

Lens: Schneider 105mm

Aperture: f 5.6

Exposure Time: 65 seconds

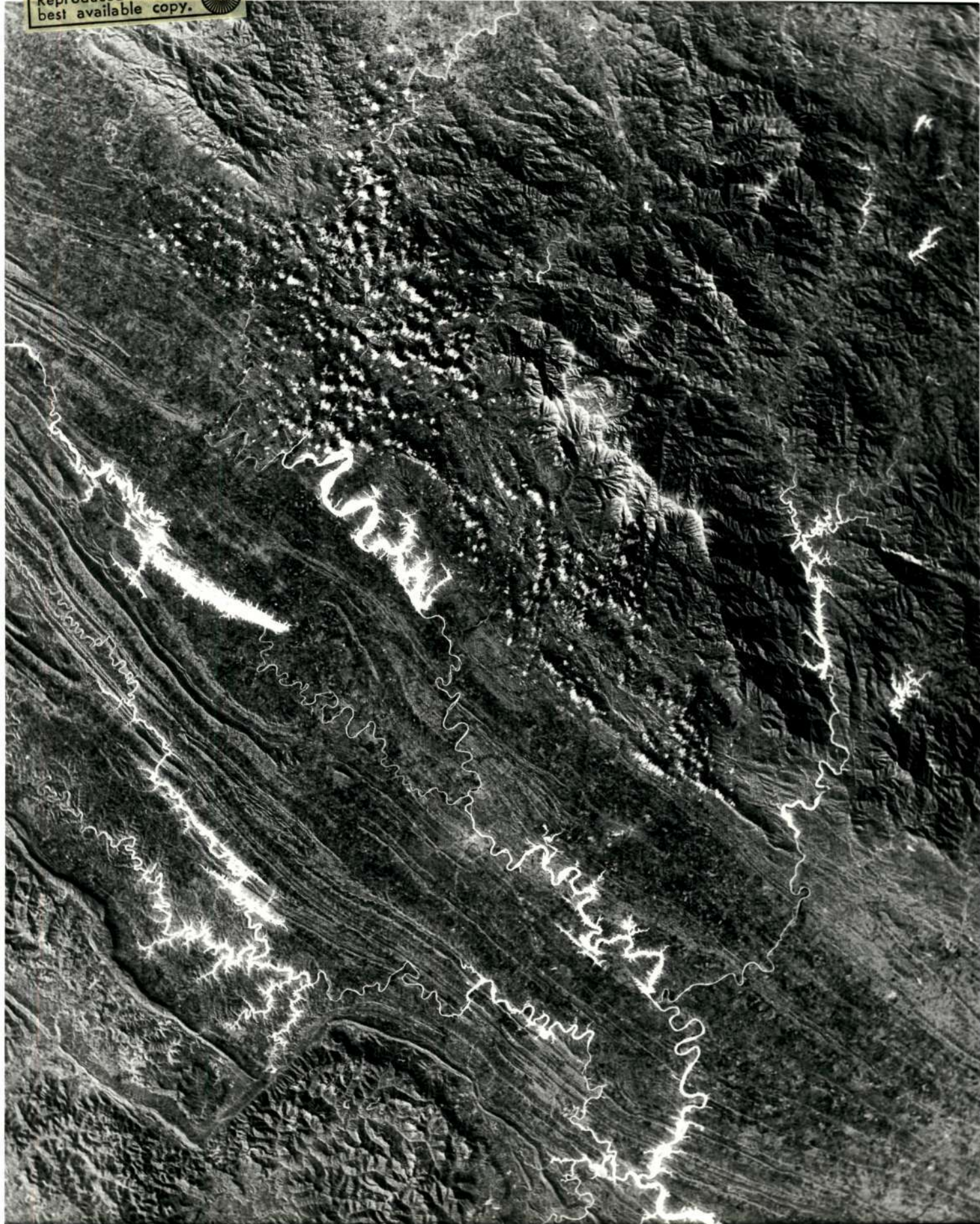
Developer/Developing Time Kodak Ektaflo #1  
58 seconds

Stop Bath: Kodak Ektaflo Stop Bath

Fixer: Kodak Rapid Fixer



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Standard Print: \_\_\_\_\_

Enhanced Image: Enhancement of topographic and hydrologic features.

Image Type: MSS band 7-printed through positive transparency

Altitude: 560 miles

Location: eastern Tennessee/ western North Carolina

Date: October 15, 1972 10:43 am

Interpretation/Description: Negative print enhances light toned hydrologic features-reservoirs, streams, and surface moisture. Topographic grain, surface roughness, slope angles and lineated ridges are sharply enhanced.

Technical Information

print paper: Kodak Medalist F-4

Enlarger: Beseler

Lens: Schneider 105mm

Aperture: F 8

Exposure Time: 10 seconds

Developer/Developing Time Kodak Ektaflo #1

1.5 minutes

Stop Bath: Kodak Ektaflo Stop Bath

Fixer: Kodak Rapid Fixer



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Standard Print: \_\_\_\_\_

Enhanced Image: Enhancement of cultural landscape features:  
agricultural lands, highways, cities, and surface mines.

Image Type: MSS band 5- printed through positive transparency

Altitude: 560 miles

Location: eastern Tennessee/ western North Carolina

Date: October 15, 1972 10:43 am

Interpretation/Description: Negative print enhances cultural  
landscape features by reproducing them in dark tones. Roads  
appear as dark lines (Interstate 81 upper right), cities as  
large dark masses (Knoxville left of center), broad agricultural  
lands to the East, and strip mines as dark lines to the West.

Technical Information

print paper: Kodak Medalist F-4

Enlarger: Beseler

Lens: Schneider 105mm

Aperture: f 4.5

Exposure Time: 5 seconds

Developer/Developing Time Kodak Ektaflo #1

1 minute

Stop Bath: Kodak Ektaflo Stop Bath

Fixer: Kodak Rapid Fixer

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Standard Print: X-to be compared with Images 1-4,6

Enhanced Image: \_\_\_\_\_  
\_\_\_\_\_

Image Type: MSS band 5

Altitude: 560 miles

Location: eastern Tennessee

Date: October 15, 1972 10:43 am

Interpretation/Description: Cultural landscape features  
shown by lighter tones. Cleared land in light shades  
in center of image. Dark forested areas to the West.  
Strip mines appear as white irregular lines within  
the western forested area - Cumberland Plateau.

Technical Information

print paper: Kodak Medalist F-4

Enlarger: Beseler

Lens: Schneider 105mm

Aperture: f 5.6

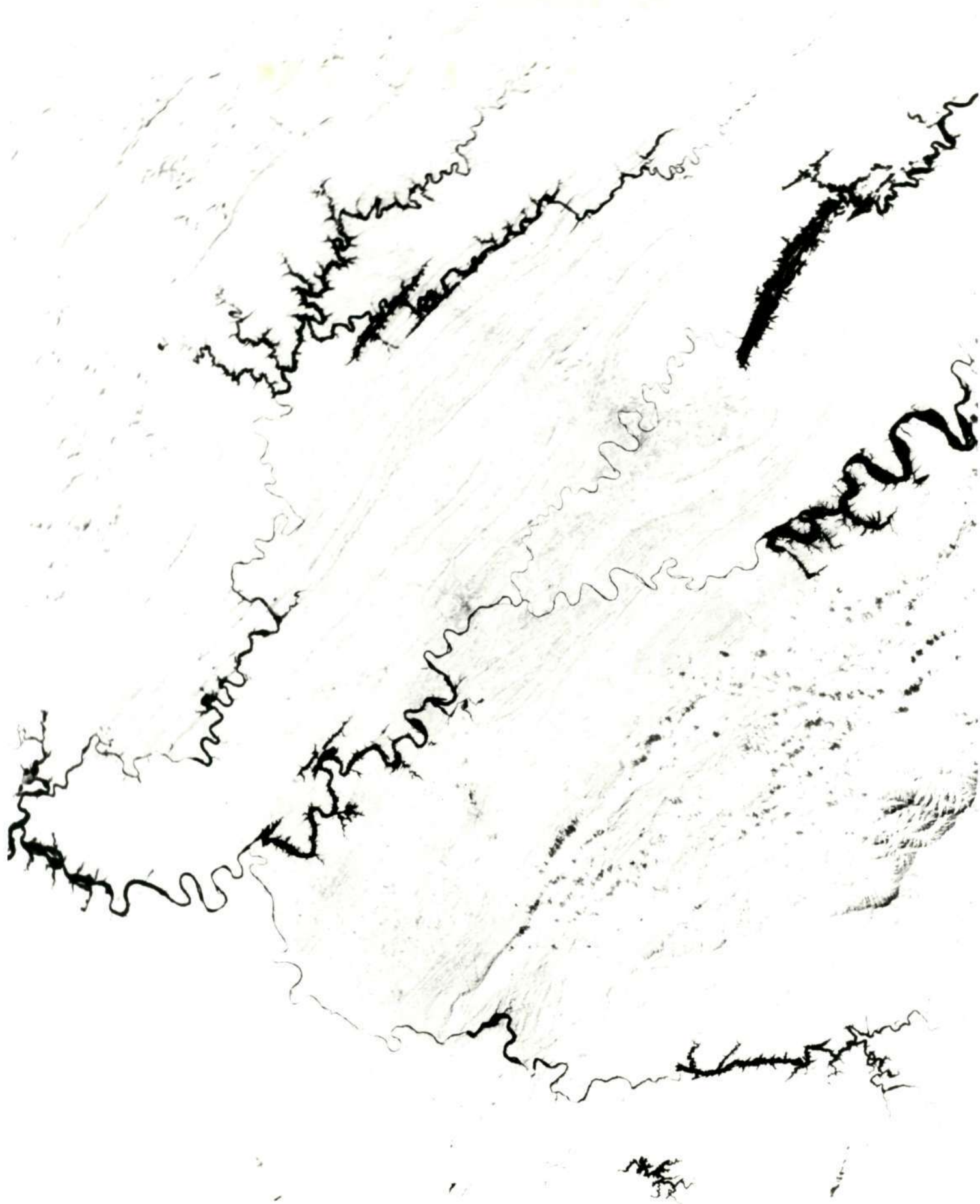
Exposure Time: 35 seconds

Developer/Developing Time Kodak Ektaflo #1

1.5 minutes

Stop Bath: Ektaflo Stop Bath

Fixer: Kodak Rapid Fixer



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James R. O'Malley - Assistant

Standard Print: \_\_\_\_\_

Enhanced Image: Enhancement of Hydrologic features  
\_\_\_\_\_

Image Type: MSS band 7

Altitude: 560 miles

Location: eastern Tennessee

Date: October 15, 1972 10:43 am

Interpretation/Description: Streams and TVA reservoirs  
appear in dark tones with other physical features  
suppressed.  
\_\_\_\_\_  
\_\_\_\_\_

Technical Information  
print paper: Kodak Medalist F-1

Enlarger: Beseler

Lens: Schneider 105mm

Aperture: f 4.5

Exposure Time: 10 seconds

Developer/Developing Time Kodak Ektaflo #1  
30 seconds

Stop Bath: Kodak Ektaflo Stop Bath

Fixer: Kodak Rapid Fixer



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Standard Print: \_\_\_\_\_

Enhanced Image: Enhancement of surface relief

Image Type: MSS band 7

Altitude: 560 miles

Location: Southern Appalachians/ E. Tenn./ W. N.C.

Date: December 7, 1972 10:38 am

Interpretation/Description: Topographic texture

enhanced in dark tones to indicate slope angles and relief in the Southern Appalachians. The French Broad River and Asheville, N.C. are located to the left of center.

Technical Information

print paper: Kodak Medalist F-h

Enlarger: Beseler

Lens: Schneider 105mm

Aperture: f 5.6

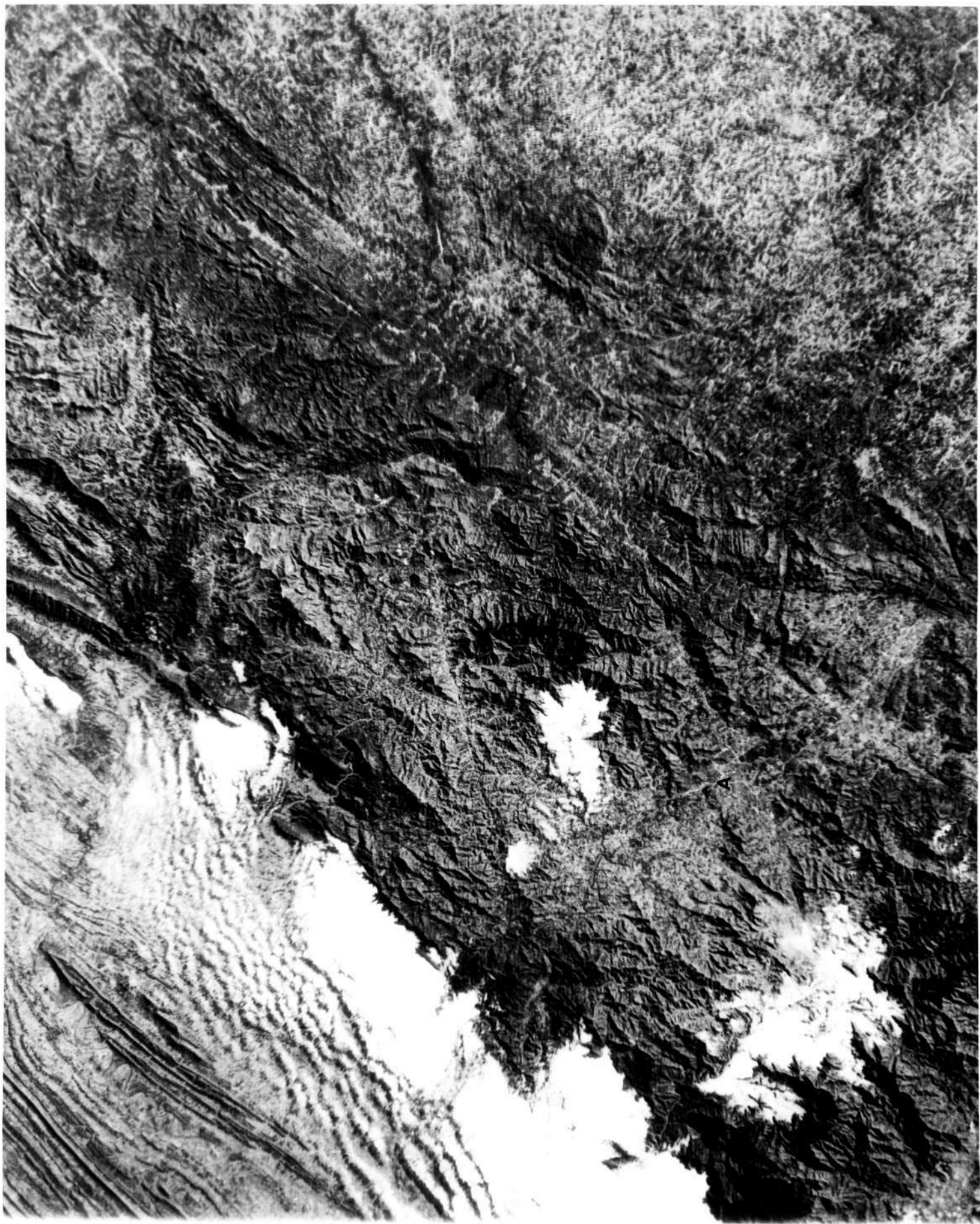
Exposure Time: 30 seconds

Developer/Developing Time Kodak Ektaflo # 1

22 seconds

Stop Bath: Kodak Ektaflo Stop Bath

Fixer: Kodak Rapid Fixer



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Standard Print: X- to be compared with Images 7, 9

Enhanced Image: \_\_\_\_\_

Image Type: MSS band 5

Altitude: 560 miles

Location: Southern Appalachians/ E.Tenn/ W. N.C.

Date: December 7, 1972 10:38 am

Interpretation/Description: Physiographic provinces  
of the Piedmont (east), Southern Appalachians- Blue Ridge,  
and Great Smoky Mountains (center), and the Ridge and  
Valley Province to the west. A= Ashville, N.C.

Technical Information

print paper: Kodak Medalist F-1

Enlarger: Beseler

Lens: Schneider 105mm

Aperture: F 8

Exposure Time: 40 seconds

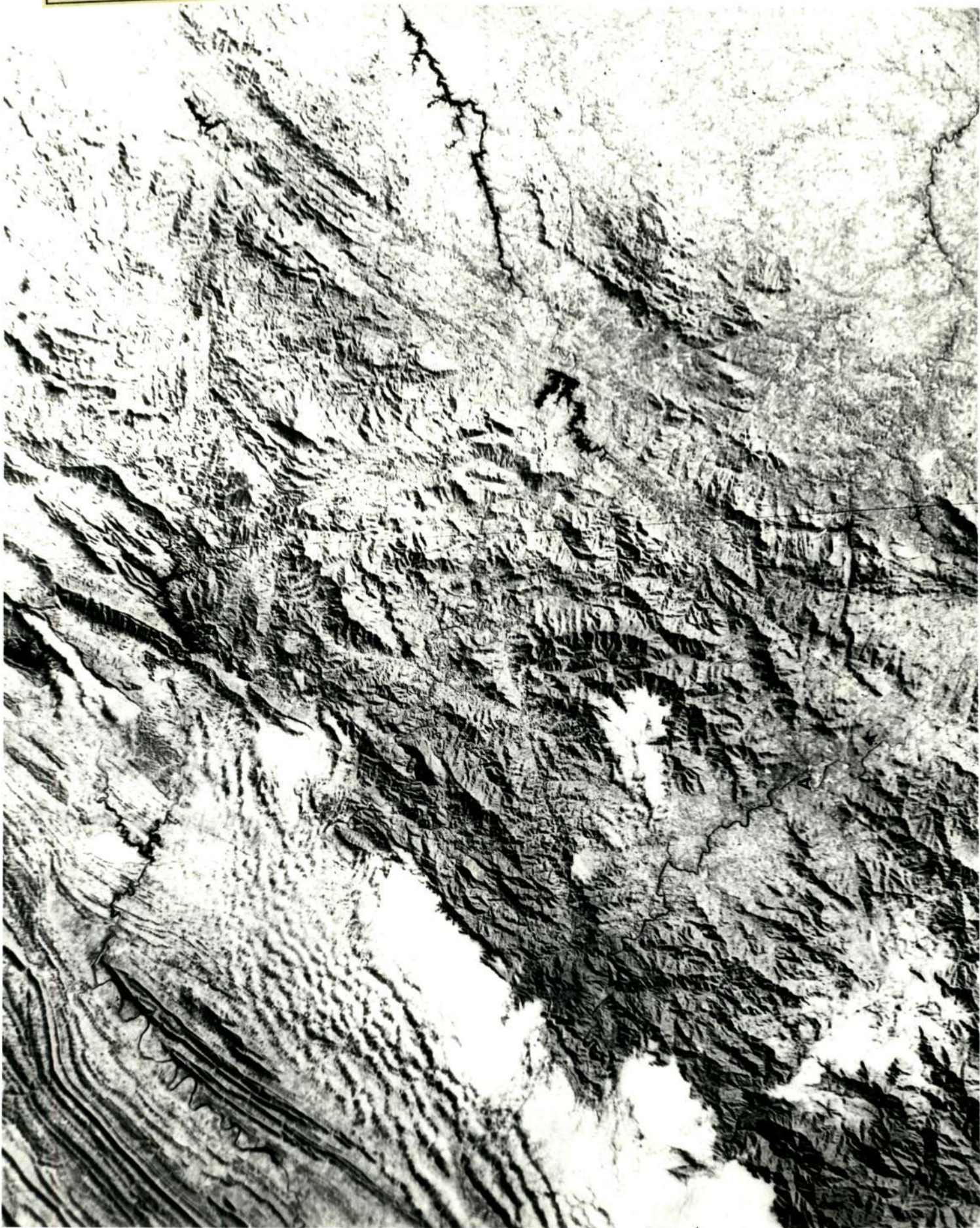
Developer/Developing Time Kodak Ektaflo #1

1.5 minutes

Stop Bath: Kodak Stop Bath

Fixer: Kodak Rapid Fixer

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Knoxville, Tennessee 37916

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James R. O'Malley - Assistant

Standard Print: X- to be compared with Images 7,8

Enhanced Image: \_\_\_\_\_  
\_\_\_\_\_

Image Type: MSS band 7

Altitude: 560 miles

Location: Southern Appalachians/ E. Tenn./ W. N.C.

Date: December 7, 1972 10:38am

Interpretation/Description: Physiographic provinces  
of the Piedmont (east), Southern Appalachians - Blue Ridge,  
Great Smoky Mountains (center), and the Ridge and Valley  
to the Northwest. Hydrologic features appear in the  
darkest tones. A= Asheville, N.C.

Technical Information

print paper: Kodak Medalist F-4

Enlarger: Eeseler

Lens: Schneider 105mm

Aperture: f 8

Exposure Time: 25 seconds

Developer/Developing Time Kodak Ektaflo #1

1.5 minutes

Stop Bath: Kodak Ektaflo Stop Bath

Fixer: Kodak Rapid Fixer