LANDSAT STRUCTURAL ANALYSIS REPORT

ON THE

JT 2, 3, 6, 7, 8, 9, 10 AND 11

MINERAL CLAIMS

KAMLOOPS MINING DIVISION

51 32'N; 119 53'W

JULY 4 - JULY 17TH, 1982

82M/12W

OWNED BY CONSOLIDATED REXSPAR MINERALS & CHEMICALS LTD.

WORK BY PLACER DEVELOPMENT LIMITED

AUGUST 1982

PETER KOWALCZYK
GEOPHYSICIST

TABLE OF CONTENTS

Figures   1 - 22

Slides   1 - 20

Attachment I

        Report on Landsat Image Analysis Using Canadian
        Centre for Remote Sensing Image Analysis System

LIST OF FIGURES

Not Microfilmed

STATEMENT OF EXPENDITURES

The images were processed at the Canadian Centre for
Remote Sensing in Ottawa May 18, 19 and 20th, 1982.
10 images were processed so costs have been
calculated pro rata.

10 images

Man days	P. Kowalczyk	
	Travel May 17, 21	2 man days
	at computer centre May 18, 19 and 20th	3 man days
		5 man days
	for 1 image	0.5 man days

Salary	P. Kowalczyk 0.5 x 200	$ 100.00
	Benefits including Compensation, Administration and Supervision @ 74% of Salary	74.00
	TOTAL:	$ 174.00

Room and Board   @ $70./day x 0.5 $ 35.00

Transportation - Vancouver Ottawa return
                   $743.00 x 0.1 (pro rata) $ 74.30

Magnetic tape of digital data $ 220.00

Report Writing $ 348.00

Drafting and Copying $ 50.00

                        TOTAL EXPENDITURE $ 901.30

                   PETER KOWALCZYK
                   GEOPHYSICIST

PLK/dd

Introduction:

An analysis of available LANDSAT data was conducted to examine regional structural data in the vicinity of the JT claims. The work was done in conjunction with some ground geophysics and geology done to further exploration on these claims.

Location and Access:

The claims are located approximately 6 kilometres south of the community of Birch Island. Access to the claims is by means of a two wheel drive vehicle along an old logging road which goes from the Thompson River valley to Foghorn Mountain (see Figure 1 for location).

Claim Status:

The claims status is as follows:

Name	No. of Units	Tag No.	Record No.	Anniversary Date
JT 2	20	68432	3655	July 14th
JT 3	20	68433	3656	July 14th
JT 6	1	68456	3659	July 14th
JT 7	1	68457	3660	July 14th
JT 8	1	68458	3661	July 14th
JT 9	1	68459	3662	July 14th
JT 10	1	68460	3663	July 14th
JT 11	1	68461	3664	July 14th

Previous Work:

Work by Barrier Reef mines located a massive sulfide outcrop which apparently was associated with a Dighem anomaly having a NE-SW strike direction. This anomaly was thought to continue onto the Rexspar property.

Also, in July 1982 5.46 line kilometers of magnetometer and VLF surveys were conducted by Placer Development to further define this anomaly. This work is reported on separately.

LANDSAT Analysis:

A DICS tape of scene 21640-18124 was purchased from the Canadian Centre for Remote Sensing. The DICS scene was referenced to NTS 92P9.

The magnetic tape was taken to the image analysis system operated by CCRS in Ottawa and enhanced using standard image enhancement techniques.
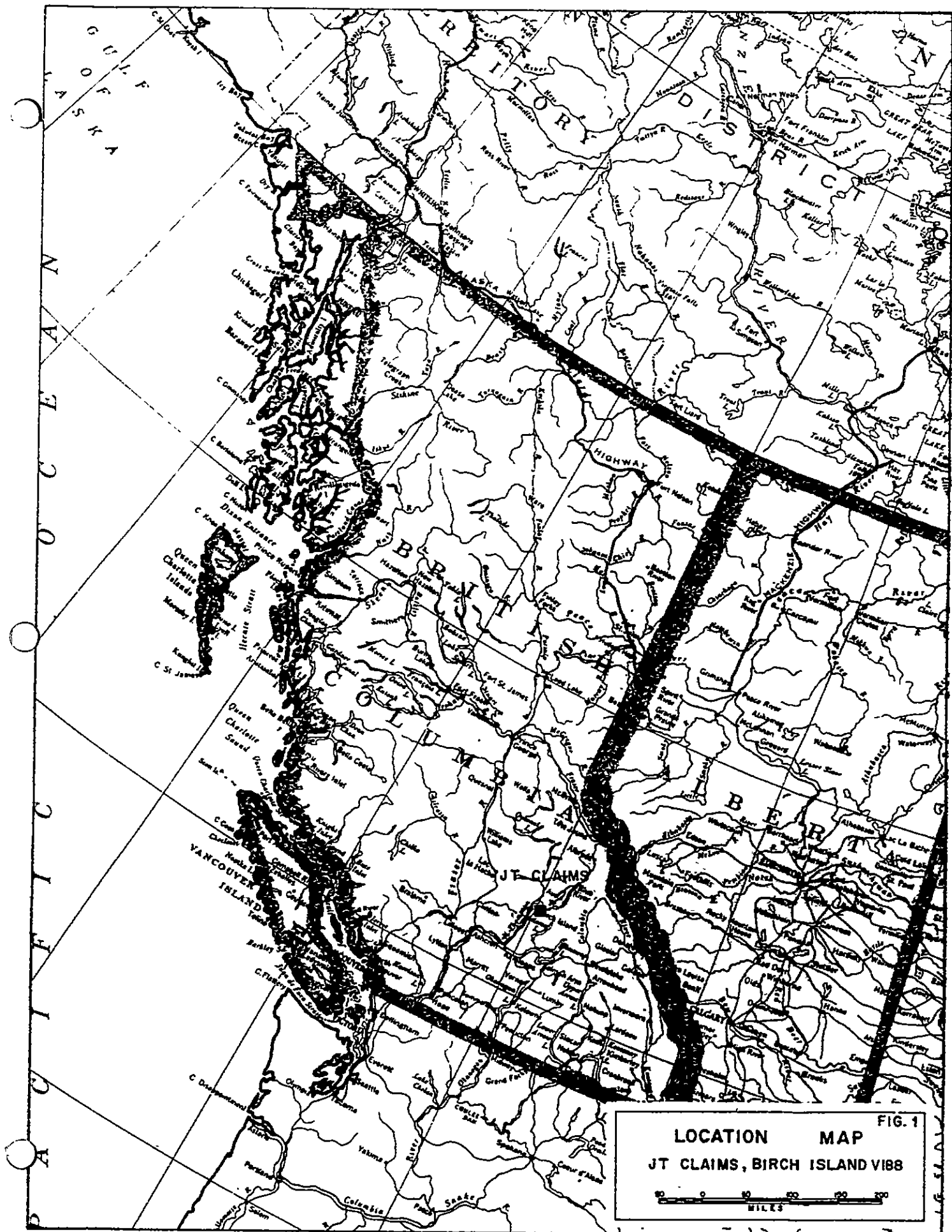
LOCATION MAP
JT CLAIMS, BIRCH ISLAND V188

FIG. 1

The image products were created as 35 mm slides.

The slides were printed as colour xeroxes, and an interpretation of structural trends and lineaments made at the scale of the colour xeroxes.

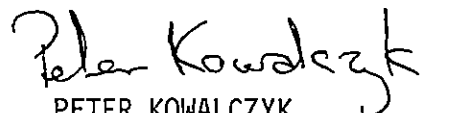The interpretation is attached as figure 2 of this report.

The methodology and definition of terms used is explained in the attachment: A Report On Landsat Image Analysis Using The CCRS Image Analysis System.

Discussion of Results:

A considerable number of lineaments are visible in the landsat scenes. These appear to comprise both major structural features and weaker linears which combined with textural features indicate stratigraphic trends and foliation trends within the rock units in the scene.

Conclusions and Recommendations:

The Landsat analysis has provided useful regional geological information. It should be combined with other geological and geophysical information available for these claims.

PETER KOWALCZYK
GEOPHYSICIST

PLK/dd

North Thompson River

JT CLAIMS

Plum Lake
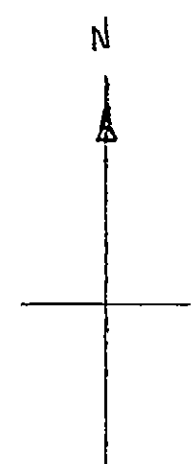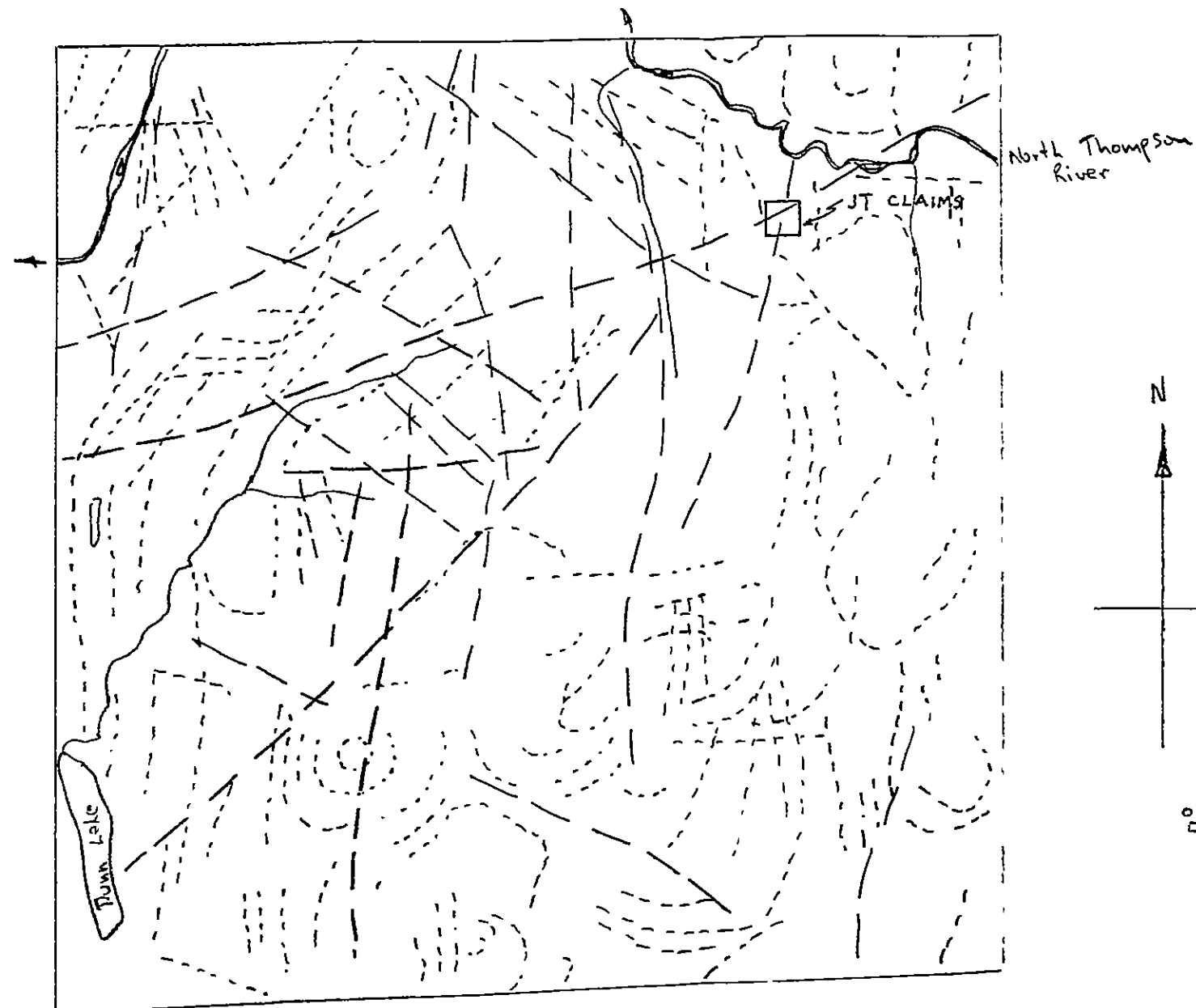
LEGEND

——— MAJOR LINEAMENT

---- MINOR LINEAMENT OR TEXTURAL FEATURE

N

0   5
KILOMETERS

PLACER DEVELOPMENT LTD	SUMMARY INTERPRETATION
LANDSAT INTERPRETATION	CCRS DIGITALLY ENHANCED DICS IMAGE
JT 2, 3, 6, 7, 8, 9, 10 & 11 CLAIMS	Scale 1:162288 Date 82/06/18
KAMLOOPS MINING DIVISION	Drawn PLK file V-188 BIRCH ISLAND B.C.

ATTACHMENT I

REPORT ON

LANDSAT IMAGE ANALYSIS

USING

CANADIAN CENTRE FOR REMOTE SENSING

IMAGE ANALYSIS SYSTEM

BY

PLACER DEVELOPMENT LIMITED

July 1981
Toronto, Ontario

TABLE OF CONTENTS

List of Figures

Appendix I
    Bibliography

Appendix II
    Glossary

Appendix III
    Sample Order form

Appendix IV
    Photographs and slides illustrating output products
    available from the Canadian Centre for Remote Sensing.

INTRODUCTION

A Landsat image of the Deception Lake area of Nova Scotia was analyzed using the Image Analysis System (IAS) of the Canadian Centre for Remote Sensing (CCRS). The purpose of this work was to assess the usefulness of Landsat images as an aid to geological exploration, and to become familiar with the types of output and the procedures used to create each type.

This report discusses the various types of output that have been developed as standard Landsat products by the CCRS.

Examples of the different outputs are attached as an appendix.

The work was done during a three day familiarization session in Ottawa at the computer facilities of the CCRS. This time was donated free of charge as part of a program transferring technology to private industry. Credit should be given to the Canadian Centre for Remote Sensing for refining the techniques used, and applying them to geological exploration.

RAW DATA INPUT

In order to process a Landsat image on the image analysis system a computer compatible tape (CCT) is required which contains the Landsat image in digital form. These tapes are available from various sources (the Shoe Cove or Prince Albert receiving stations in Canada, the EROS data centre in the U.S., and the Australian receiving station). Tapes from any of these sources can be processed by the Canadian Image Analysis System. Two types of computer compatible tapes are available. These are the regular Landsat image tapes, which contain the information in one Landsat image frame, and a newer type called a DICS tape.

The Deception Lake data was processed using a regular Landsat image tape. However there are sizeable advantages to using DICS tapes and any future processing should be done using this type of input data.

The regular Landsat image tape is not completely geometrically corrected, and when outputs are created at 1:50,000 they lie close to but not exactly over a 1:50,000 scale map. The flight path of the Landsat satellite is not N-S and this skews the edges of the image frame - at Deception Lake the picture was rotated about 9° with respect to map north. Also, the regular Landsat image has a basic pixel about 79 x 59 meters. For technical reasons the video output of the image analysis system has square pixels and this causes photographic products to have a 59/79 vertical scale compression. This problem is overcome on the plotter output, but this is black and white output and the colour slides from the video outputs cannot be projected over it at a common scale.

The DICS data tape overcomes many of these problems. The basic pixel is 50 meters by 50 meters. This means the aspect ratio of the photographic outputs is 1:1 and they can be projected directly over the plotter outputs. Also the DICS tapes are geometrically corrected and referenced to the UTM co-ordinate system. The pixels in a DICS image have a location accuracy of 50 meters ($\pm$ one pixel) and the edges of a DICS image are UTM grid N-S, which is nearly parallel to the edges of a normal 1:50,000 scale map, and can be readily located.

INPUT   **PROCESSING**   **OUTPUT**

Schematic representation of Canadian Image Analysis system. Landsat images are entered as digital tapes (CCT's).

STANDARD SYSTEM
- FILM TRANSPARENCIES
- INPUT SCANNER
- GEOMETRIC RADIOMETRIC CORRECTION
- DIGITAL TAPE
- IMAGE ANALYZER CONSOLE
- IMAGE MEMORY
- PDP 11/45 MINICOMPUTER
- GRAPHICS DISPLAY TERMINAL
- HISTOGRAM DISPLAY, DENSITOMETRY, TEXT DISPLAY
- STATISTICAL OUTPUT, THEME MAP, USER INTERACTION
- PRINTER, PLOTTER, COMPUTER COMPATIBLE TAPE DRIVE
- COLOR OR B&W DISPLAY

HARDWARE OPTIONS
- HIGH DENSITY DIGITAL OR ANALOG TAPE DRIVE
- HARDWARE OPTIONS
  - PDP 11/45 COMPUTER
  - ADDITIONAL / LARGER DISC DRIVES
  - HDDT INTERFACE
  - BULK CLASSIFIER
  - MOVING WINDOW DISPLAY
  - VIDEO TAPE INTERFACE
- PHOTOGRAPHIC CAMERA & MOUNT → COLOR/B&W TRANSPARENCIES OR PRINTS
- VIDEO TAPE RECORDER → VIDEO TAPES, OUTPUT TO REMOTE MONITORS
- COLOR FILM RECORDER → COLOR/B&W TRANSPARENCIES OR PRINTS
- GRAPHICS TERMINAL HARDCOPY UNIT → HARDCOPY OF GRAPHICS TERMINAL DISPLAYS

SOFTWARE OPTIONS

RADIOMETRIC CORRECTION	GAUSSIAN ANALYSIS	CLUSTER ANALYSIS
EDGE ENHANCEMENT	BULK CLASSIFICATION	POLYGON CURSOR
MULTICHANNEL INPUT	MAXIMUM LIKELIHOOD	MULTICHANNEL
SCENE REGISTRATION	ANALYSIS	PROCESSING
		HALFTONE VIDEO PRINT
		THEME BOUNDARY PLOT
		FILM RECORDER DRIVE

IMAGE 100

SYSTEM CONFIGURATION

A DICS data tape covers an area about ¼ that of a regular Landsat image. However, this is generally large enough to contain the area of interest in a geological program. The price of a Canadian DICS tape is about ½ that of a regular Landsat image.

IMAGE PROCESSING

Once the raw data tape has been read into the image analysis system it doesn't matter whether it comes from a Landsat image tape or a DICS tape. The image exists as a digital record within the computer data storage system and a 512 by 512 pixel picture can be brought forward into the image analysis system to be enhanced, or mathematically operated upon to display certain features. For a Landsat image tape a 512 by 512 pixel picture is about 25.6 km E-W and 35.8 km N-S. Any portion of the original scene can be easily brought forward into the image analysis system to be processed as a 512 by 512 pixel picture.

The 512 by 512 pixel image can be output from the image analysis system at any stage. Output comes in several forms. Black and white or grey scale plots can be output at any scale on an electrostatic plotter. The video screen can be photographed directly using a tripod mounted camera, or curvature free image of the screen may be photographed using a special remote video screen with a flat face slaved to the regular video screen. This remote, slaved camera is called the "Matrix" camera and it can take 8 x 10 polaroid prints of the image also. These photographic outputs are at an arbitrary scale.

The 512 by 512 pixel image can be processed in several different ways. The standard procedures which appear to be geologically useful are listed below and then explained in detail.

(1)   Enhanced, but untransformed raw data.
      i) Contrast stretched display bands 4, 5, 6, 7

      ii) Colour composite bands 4, 5, 6

(2)   Statistically separated pixels of similar spectral characteristics
      i) Output of unsupervised classification.

(3)   Output based on Biomass Ratio calculation
      i) Biomass ratio video output

      ii) Hipass filter of Biomass ratio

      iii) Extraction of Hipass filter of Biomass Ratio

(4)   Taylor Transformed data
      i) Colour composite Taylor transform

(5)   Principal Component Analysis
      i) Display of principal components

      ii) Extraction of highpass filter pased over first principal component.

(1) Enhanced but Untransformed Raw Data

      i) Contrast stretched display of bands 4, 5, 6, 7.

The digital picture sent down from the satellite is transmitted as a brightness value over a range of 1 to 256. However this covers a range of brightnesses from sunlit to dark black lakes. The actual range of greys of geologic interest in a picture is quite small, and in a normal print of a Landsat much of the area of interest is of a very similar tone even though the digital numbers representing that area do have a systematic, and significant variation over a narrow range.

This variation can be displayed by "stretching" this range of interest to cover the grey scale being used to create the image. This type of display is called a contrast stretched image, and in it lakes would appear uniformly black, and snow uniformly white, while the land area of interest would be seen in a full range of greys. This technique is quite general, for example someone interested in the lakes would stretch the range of greys for the brightness values typical of lakes, and reduce the contrast within the range of digital values characteristic of the rest of the image.

ii) Colour Composite of Bands 4, 5 and 6.

A false colour picture can be made of an area by printing a colour composite in which band 4 is printed as blue, band 5 as green, and band 6 as red. These are not the actual colours of these bands, but by combining three bands into a single colour picture variations between one band and another can be seen as a change in colour.

These colour composites can be made using the raw data, or using the contrast stretched values of the raw data. The contrast stretched values provide a picture which is easier to use as a geological aid.

(2) Unsupervised Classification of Bands 4, 5, 6, 7

An unsupervised classification is a procedure which is quite complicated mathematically, but in a general sense is not too difficult to follow. Combining the raw, untransformed data for bands 4, 5, 6 and 7 the computer procedure tries to group the responses from the pixels within the image into several separate classifications in which, within each classification, the responses are similar. Also, the responses within each classification tend to clump together, so that there can be said to be a statistically significant difference between each classification and the other classifications, and a statistically significant similarity between the pixels grouped in each classification.

The classifications are brought out as different coloured pixels on the video output or one by one as black pixels on a white background using the electrostatic plotter. In order to locate the image the lakes and water courses can be indicated as grey pixels in the plotter output and as green pixels in the video output.

(3) Biomass Ratio Products

i) Biomass Ratio

The ratio (Band 7):(Band 5) can be thought of as a lushness value, responding to the amout of vegetative growth in the area of each pixel. This is because growing plants have a strong reflectance in Band 7 (as they also do have in visible green light) and a strong absorbance in Band 5 (here they are absorbing radiation for photosynthesis). Under calibrated conditions

(for example, one crop type) the ratio (Band 7):(Band 5) can actually be converted to kg/m^2 of vegetative material. For this reason it is called the biomass ratio.

Changes in the biomass ratio might be related to watercourses or fracture systems, change in soil type, topographic changes or any other feature which might have an effect upon the growth of plants.

ii) Hipass filter of Biomass Ratio

Features of geologic interest may cause a change in the biomass ratio. It is these changes, not the actual biomass ratio itself, which are of interest. These can be made more visible by passing what is called a high pass (hipass) filter over the image of the biomass ratio. This is analogous to a first derivative or gradiometer magnetic survey, it responds to contacts or changes in the first quantity. The high pass filter used on the Canadian image analysis system has two parameters, size and strength[1]. A filter with a size of 25 x 25 pixels and a strength of 1 appears best for geological applications. A portion of the edge of the image is lost when the high pass filter is applied. For example a 25 x 25 pixel filter will start with the 13th pixel in from the edge.

[1] Strength is a mixing parameter for adding in some of the original picture. 1 outputs only the results of the high pass filter 0.5 outputs a sum of 0.5 time the high pass filter result and 0.5 of the original image. Size is the size of the filter operator and this controls the frequency response of the filter. Size must be some odd value (i.e. 3 x 3 or 9 x 9).

iii) Extraction of High pass Filter of Biomass Ratio.

In order to simplify the appearance of the high pass filter and to make it easier to see trends and features an extraction of the output can be done. In this procedure the model value of the grey scales is chosen as a cutoff, and any pixel darker than this is output as a black pixel, and any pixel lighter is left white. This output, although arrived at differently from the unsupervised classification, is smaller in the way it is presented. This output can also be presented as coloured pixels on the video output.

(4) Taylor Transformed data

The Taylor enhancement is a colour composite, similar in appearance to a false colour composite of bands 4, 5 and 6 but created quite differently. The colours are chosen by a complex mathematical procedure which separates changes in one band not related to changes in the others. Taylor enhancements are quite widely used in industry, particularly in forestry. In norther Ontario orange usually represents open rock, pink open land, dark green and blue conifer forests and light green and yellow hardwoods. Diseased areas may show up in pink. This product is usually shown as a colour print or slide.

(5) Principal Component Analysis

i) If one looks at the images from bands 4, 5, 6 and 7 it is obvious that these images are similar. Most of the information could be shown in one black and white image. If the variance from this first black and white image were presented in

a second black and white image, this would represent independent information appearing in some bands and not in others. Most of the differences between the various bands can be presented in the first two images. However a third and fourth image can be computed, which explain all the variances between the bands. These are called the principal components and they are computed by a General Purpose Transform (GPT) routine in the image analysis system computer. The third principal component looks like a television picture full of snow, and the fourth principal component looks like a very bad television picture full of snow. This indicates that 4 bands are really not needed for a Landsat image. Almost all of the changes from band to band can be explained as a variation of three independent variables in each pixel.

The first principal component looks like a normal photo, with good contrast. It is not exactly the same as a contrast stretched picture of one band, as it contains information from from all four bands. However it appears similar, and is probably useful for geological interpretation. Output can be as a grey scale plot or video.

ii) Extraction of Hipass filter on first principal component.

A high pass filter can be run over the first principal component, in the same manner as it can be run over the biomass ratio output. An extraction can then be done of this high pass filter and presented as video or as a plotter print.

INTERPRETATION AND PRESENTATION

The interpretation of Landsat data is quite qualitative. For the raw data, after it has been contrast stretched and for the principal components the images may be considered photographs, taken from an unusual vantage point.

Working with the extractions, or the unsupervised classifications, one is looking for linears, curvilinears or areas which can be differentiated on the basis of a particular texture within the image. The usual technique is to look at them at a low angle, and rotate them slowly, while sketching in on a transparent overlay the features recognized.

The colour composites and Taylor enhancements can be treated as colour photos, but it should be remembered that it is not always obvious what the hue and brightness changes represent, although some real quantity has changed to cause the variations seen.

The slide outputs of all of these products are a bit more difficult to work with, although the colour composites of the unsupervised classifications provide a way of combining several classifications into one picture. The slides are also useful for looking at the different outputs and checking that features seen on one are real, and present in others.

It should be remembered that the different types of output come from quite different methods, which have diverged at the raw data stage. For this reason features seen in two or more types of product are probably real, and stand a very small chance of being an artifact of the method.

Landsat images provide regional data, and it is very difficult to apply this data to a specific geologic problem on a large scale map. However, it is useful as part of an overview, like regional geochemistry, aeromagnetics, or radiometrics. For this reason, it should be presented at a consistent scale and referenced to a common co-ordinate system. It would make sense to present it at 1:50,000 in Canada, as are Placer's NTS based stream geochemistry base maps and most government geophysical releases. In the U.S. the 1:62,500 15' army map series would be a good base, as this is consistent across the U.S. and ¼ the scale of the 1:250,000 USGS quads.

Because these outputs are produced on an interactive computer system, almost any variation of colour, ratios, and combinations can be produced. Colour can be used to make some very striking pictures. However, if standard outputs are used, then experience gained on one project can be applied to inter-preting Landsat images on another. The products discussed in this report follow standards established by the Canadian Centre for Remote Sensing. Unless an entirely different methodology is used, it would be unwise to have any private Landsat processor present any images in a different format, or using different colours. To do so would disrupt the process of Placer personnel

becoming familiar with this data, and introduce disparities in the way we are handling it.

Black and white prints of the various electrostatic plotter outputs, which were originally 1:50,000 scale, and slides of the various video outputs are attached to this report.

In a production run of a Landsat image analysis a balance must be struck between quantity of output, and computer time required to produce them. Initially, the following might be a useful mix.

Black and White Plotter output

i) contrast stretched bands 4, 5, 6 and 7

ii) extraction of biomass ratio hipass filter

iii) first principal component

iv) extraction of hipass filter of first principal component

v) unsupervised classifications -1 to 6.

Slides

i) all of the plotter outputs

ii) false colour composite of bands 4, 5, 6

iii) Taylor enhancement

Even so, this represents 13 plotter prints, and running the plotter takes quite a lot of computer time. If the slides prove tractable to use, it might be enough to produce one 1:50,000 scale plot as a base map of, say, the first principal component, and then all the other outputs as slides.

During the operation of the image analysis system, every picture created is stored within the system's data storage facilities. At the end of a session the images are stored on a magnetic tape so that they can be reproduced again at a later date if the graphic output is damaged or lost.

OPERATION CONSIDERATIONS AND COST

In order to process a Landsat image on the Canadian Centre for Remote Sensing's Image Analysis System the computer tape containing the image must be bought by the user. This costs about $250.00 for a regular image and $125.00 for a DICS tape.

Time must be booked on the system. Priority is given to Canadian companies working on Canadian images and then to Canadian companies working on non-Canadian images. Placer will qualify on both counts, but non-Canadian jobs may face some delay.

Currently the use of the image analysis system is free. However charges of about $500.00 per session are contemplated in the near future as private companies are starting to provide similar services. $500.00 per session is very cheap when compared to commercial prices for the same product.

Two or three images (512 x 512 pixels) could probably be processed in one session during a production run. Costs for Placer personnel would be about $500/day counting transportation, accommodation and salary. This is based on a three day session, processing six to ten images. On this basis the cost per image would be about $300 to $500.

Interpretation should be done by a project geologist familiar with the locale containing the image.

Respectfully Submitted,

PK/of

Peter Kowalczyk

APPENDIX II - GLOSSARY

A lot of terms and abbreviations used within the field of image analysis are quite strange ·to the person who will use the end result. A brief glossary is included here.

CCRS   Canadian Centre for Remote Sensing. A division of Energy, Mines and Resources.

CCT   Computer Compatible Tape. The digital magnetic tape which contains a LANDSAT scene and which can be read by any computer system.

CIAS   The special computer system built at CCRS to analyze images - Canadian Image Analysis System.

CLASSIFICATION

A statistical procedure by which the pixels in a scene are sorted into groups with a similar signature. A classification may be supervised, in which case the signatures are known before hand or unsupervised, in which case they are not.

CONTRAST STRETCH

A range of greys containing features of interest is expanded into the whole range of greys available in the display with this procedure. Everything outside the original range selected will become either black or white.

ERTS   Earth Resources Technology Satellite. Now called LANDSAT. LANDSAT satellites are not named until successfully in orbit.

EXTRACTION

If a pixel is above a certain value then it is switched on and shown black or coloured in the final output. If it is not it is left blank.

FALSE COLOUR

A colour composite of 3 LANDSAT bands made by assigning 1 band to red, 1 to green, and 1 to blue. The usual scheme is to assign Band 4 to red, Band 5 to green and Band 6 to blue.

Blue *red*.

GPT   General Purpose Transform. A mathematical package of programs used at CCRS.

HIPASS or HIPASS FILTER

This procedure produces a map where the largest values (negative or positive) occur at the places the original map was changing most rapidly. It locates edges and is mathematically equivalent to a gradient or first derivative.

No actually a high frequency filter or bandpass as undefined.

IAP   Image Analysis Processor. The central processor within the IAS computer system.

IAS   Image Analysis System. The computer system used to process LANDSAT scenes.

PIXEL   The 79 by 59 meter rectangle which comprises the
        basic unit of a LANDSAT scene. Each pixel is
        assigned a number which is the average brightness
        within the pixel for the band the measurement is
        made within. When the pixels are put together they
        form the picture, much like the dots in a newspaper
        photo.

PRINCIPAL COMPONENTS
        Mathematically independent variables which can be
        combined linearly to explain the variances between
        the 4 LANDSAT bands.

SCENE   The basic unit in which LANDSAT images are distributed.
        A standard scene is displayed in the attached pictures
        with the line frame and time it was collected annotated
        on its edge. See Appendix IV, Figure 1.

SIGNATURE
        A characteristic combination of brightness values in
        different bands for a pixel or group of pixels, which
        allows them to be recognized as different from the
        other pixels in the scene.

TAYLOR ENHANCEMENT

A colour display of LANDSAT bands used by forestry workers. Specific colours often relate to specific types of vegetation, however the colours are not natural, and bear only a mathematical relationship to the colours seen by eye.

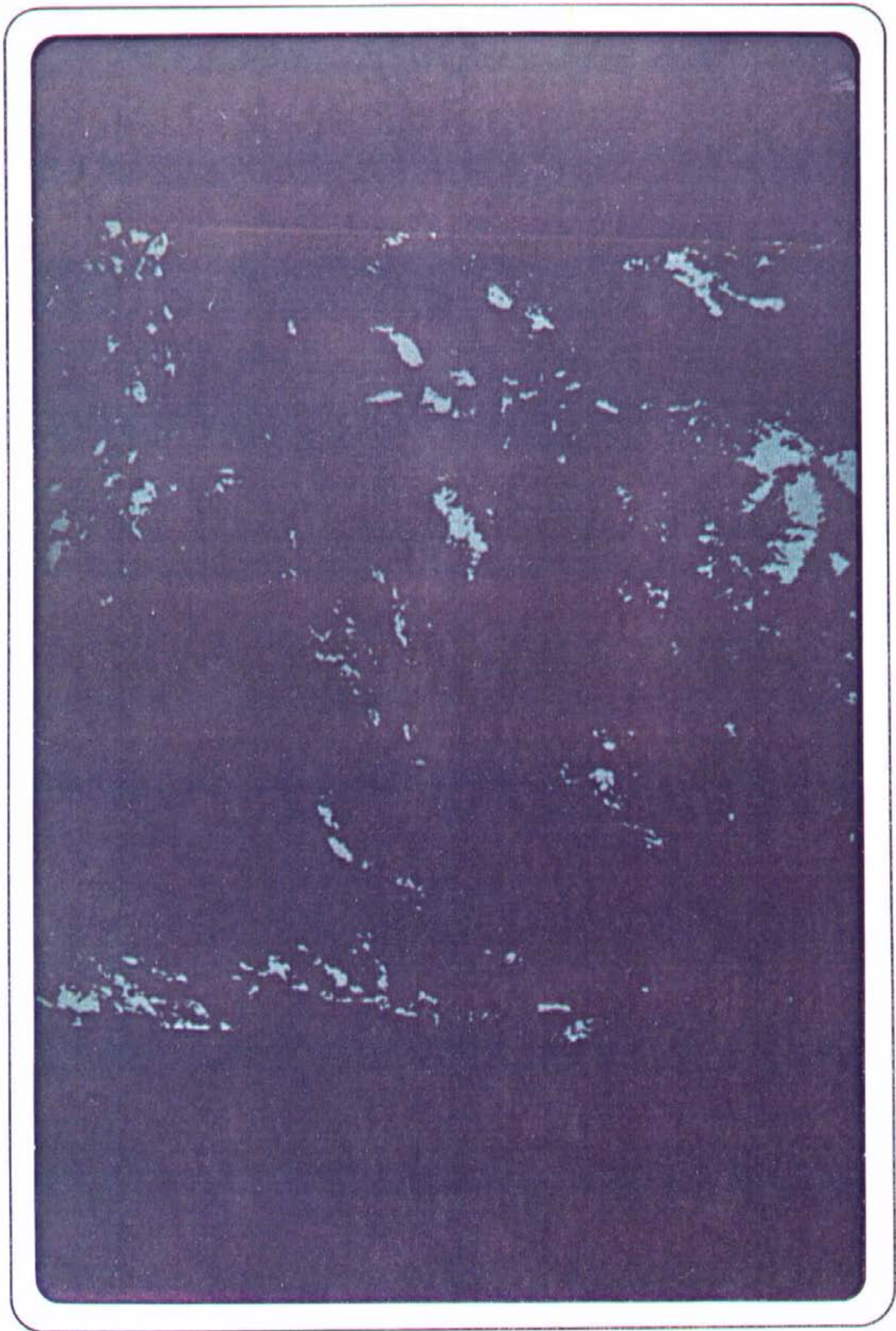Figure 3
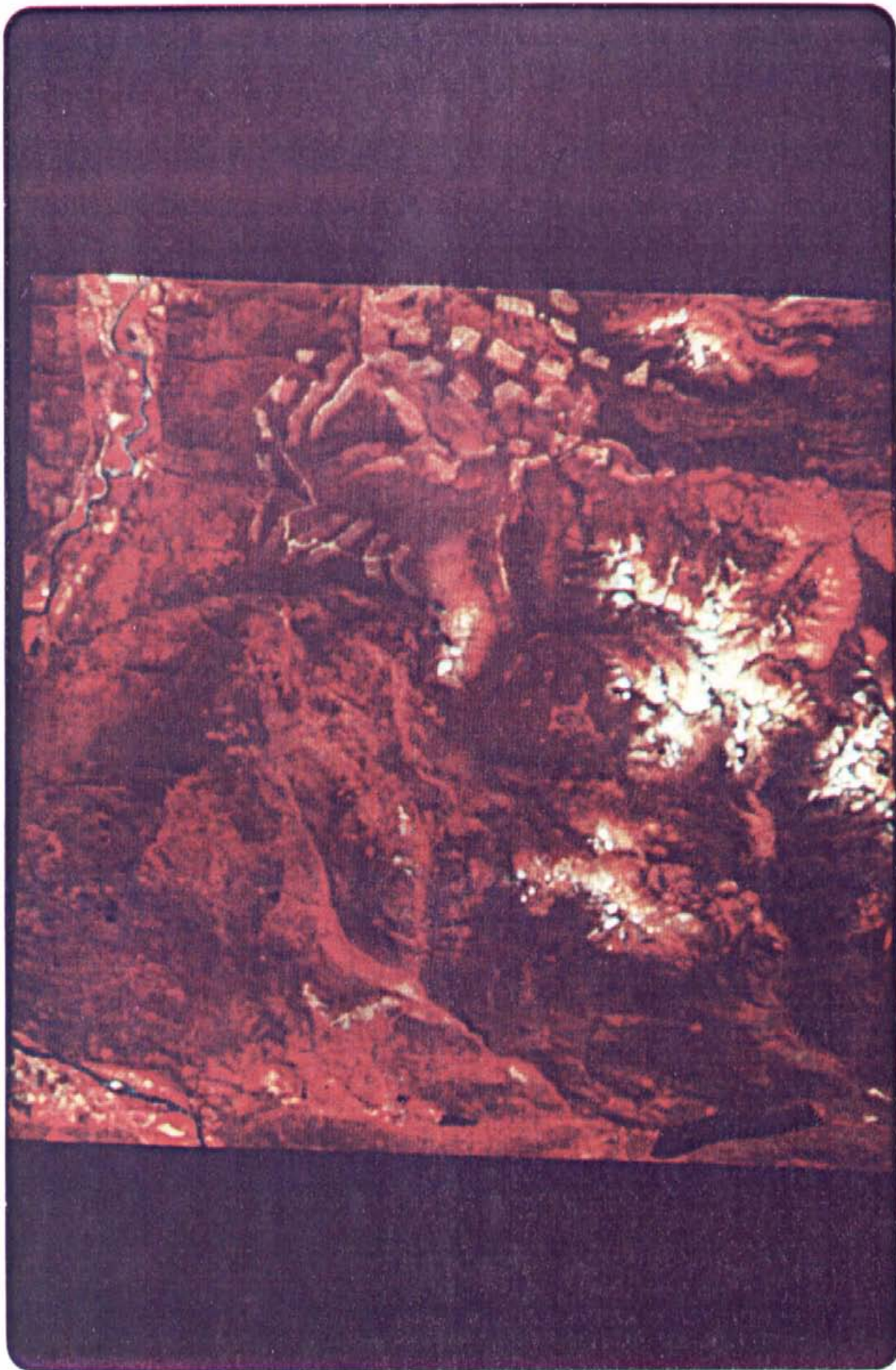
Figure 4

Figure 5

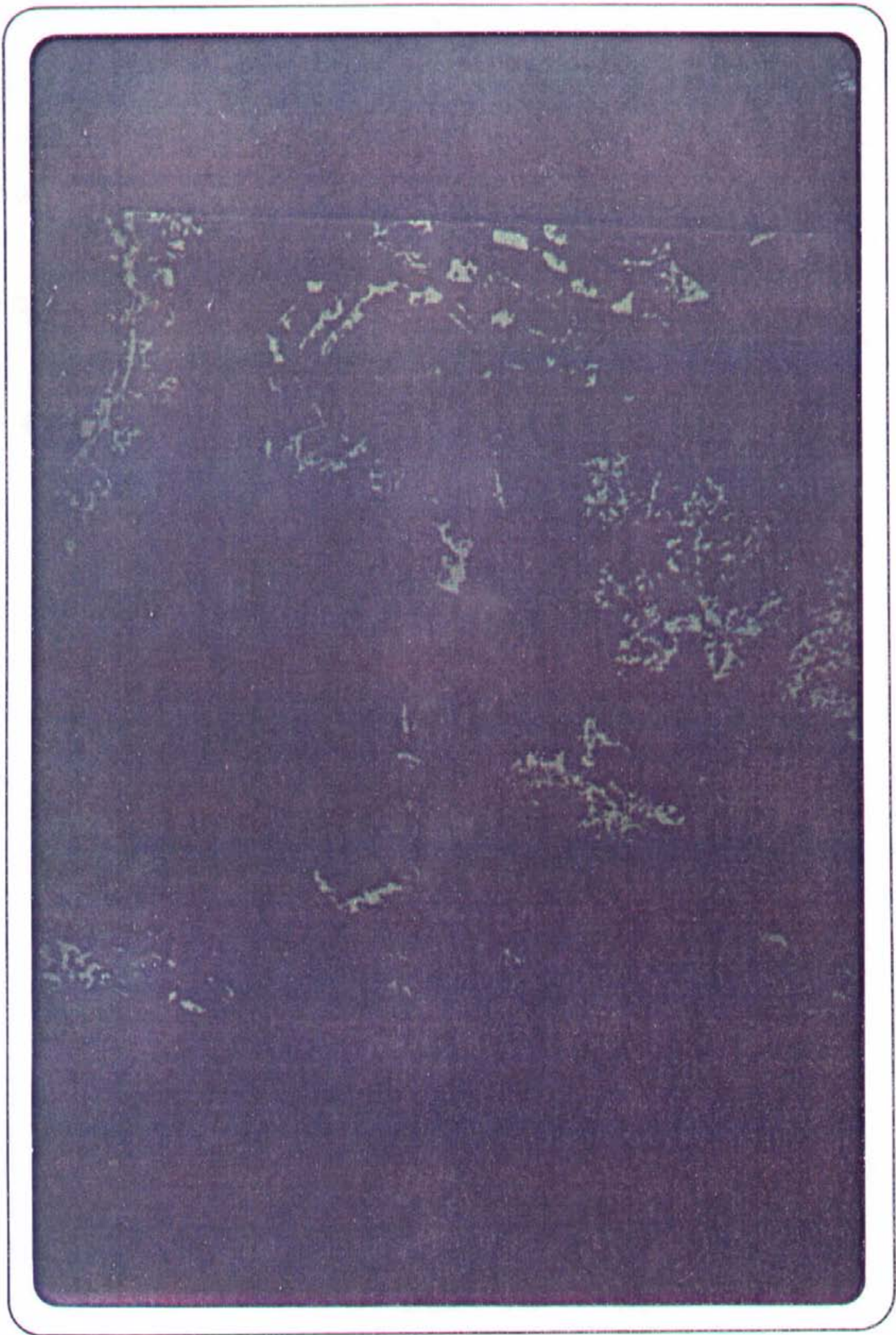Figure 6

Figure 7

Figure 8

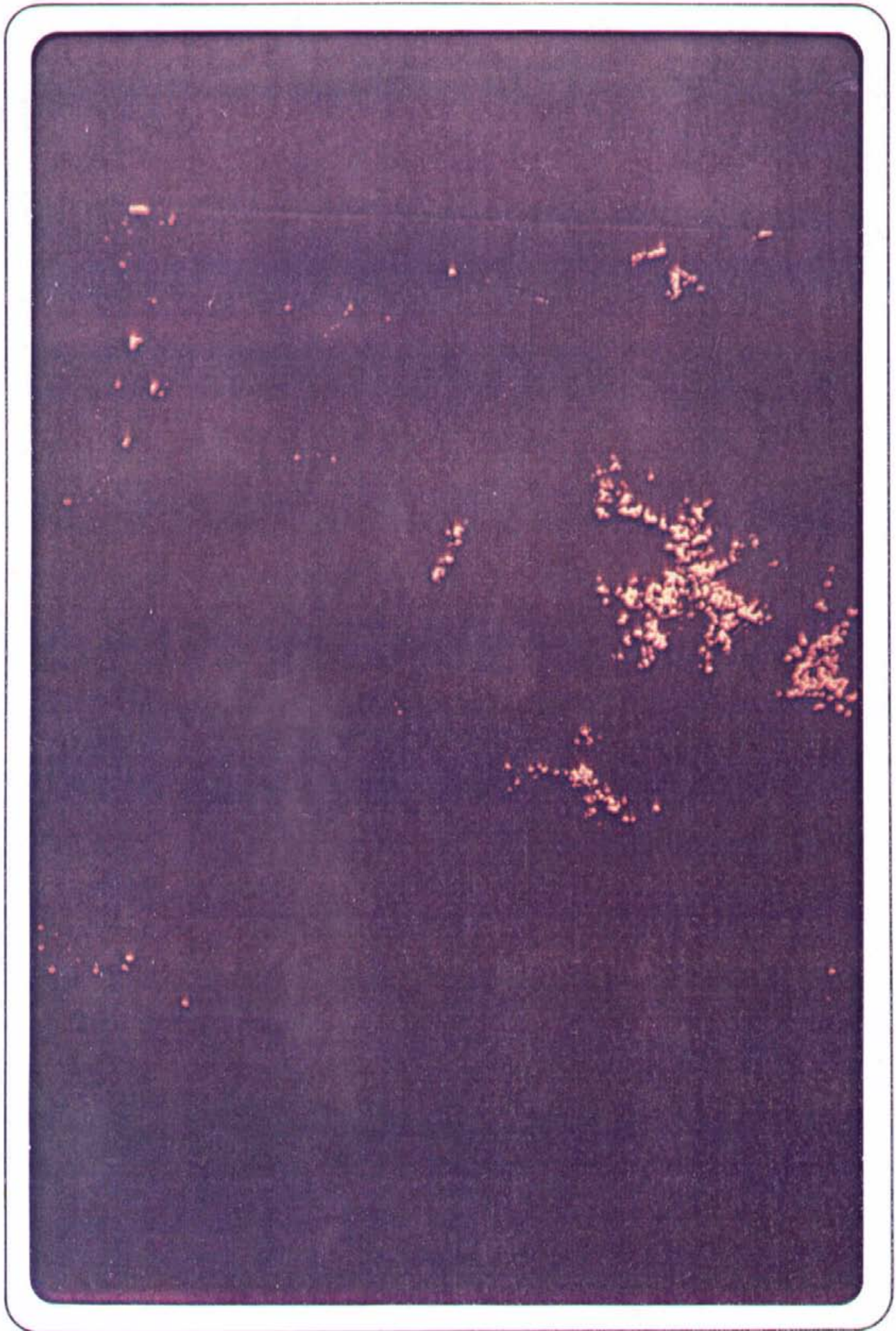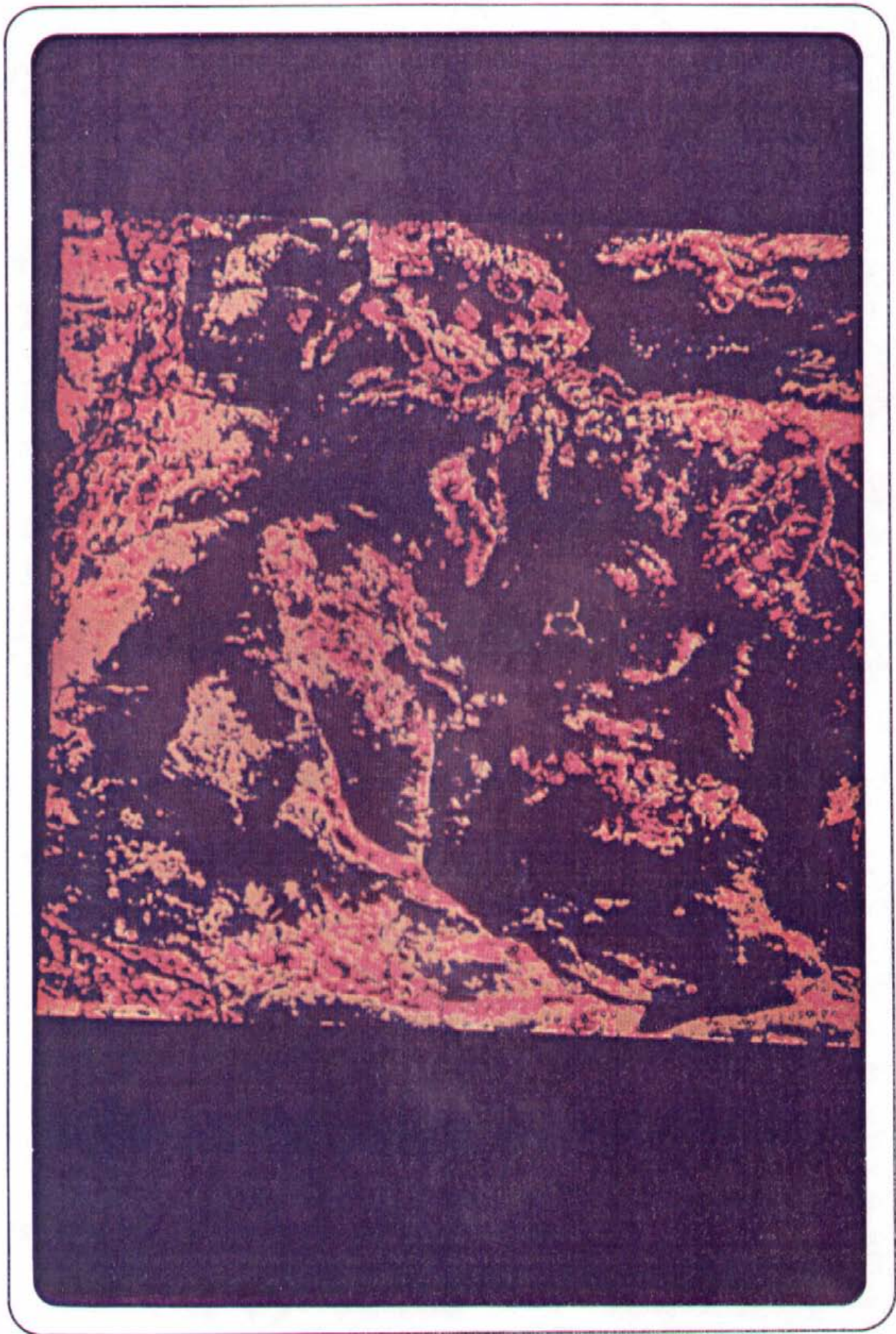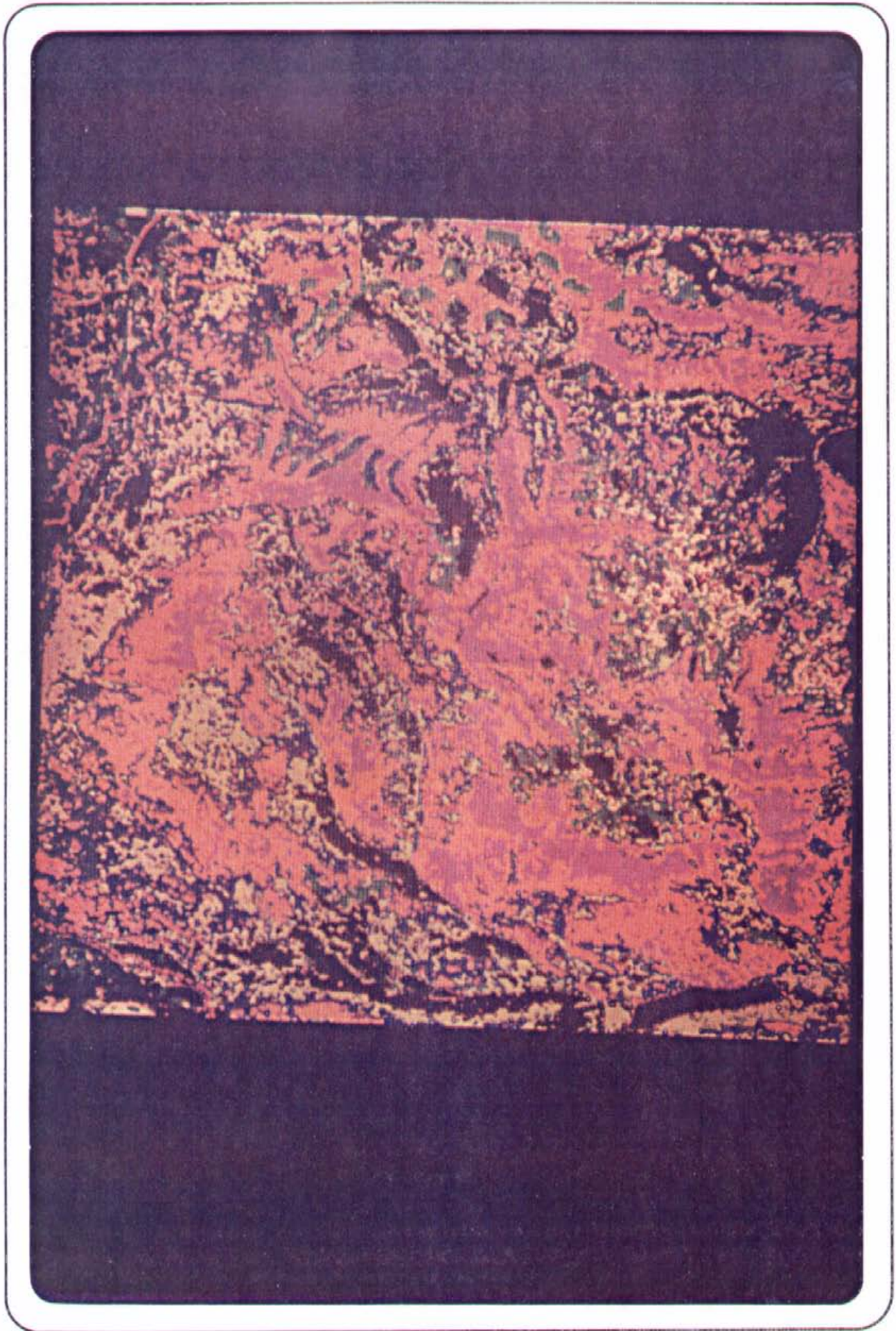Figure 9
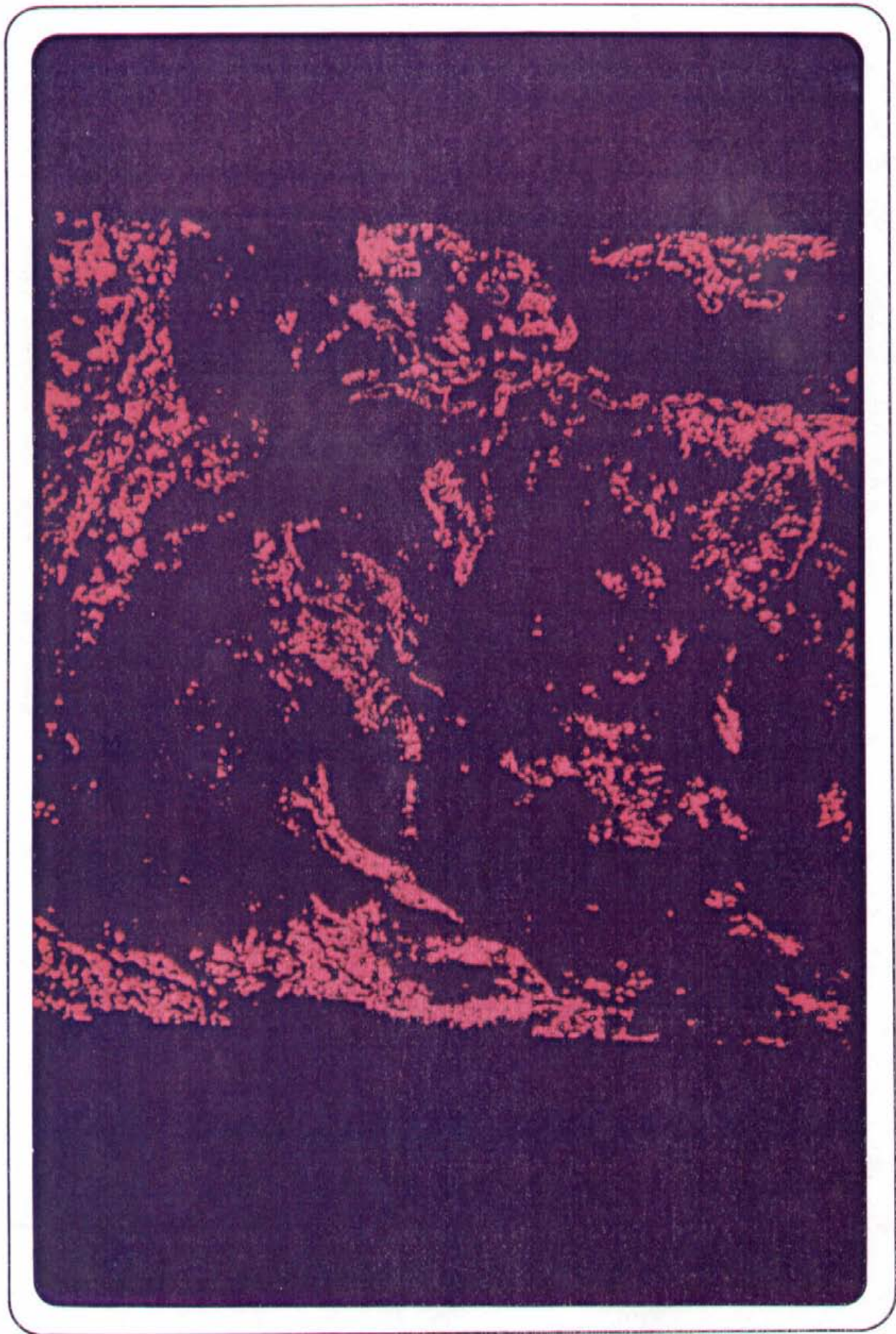
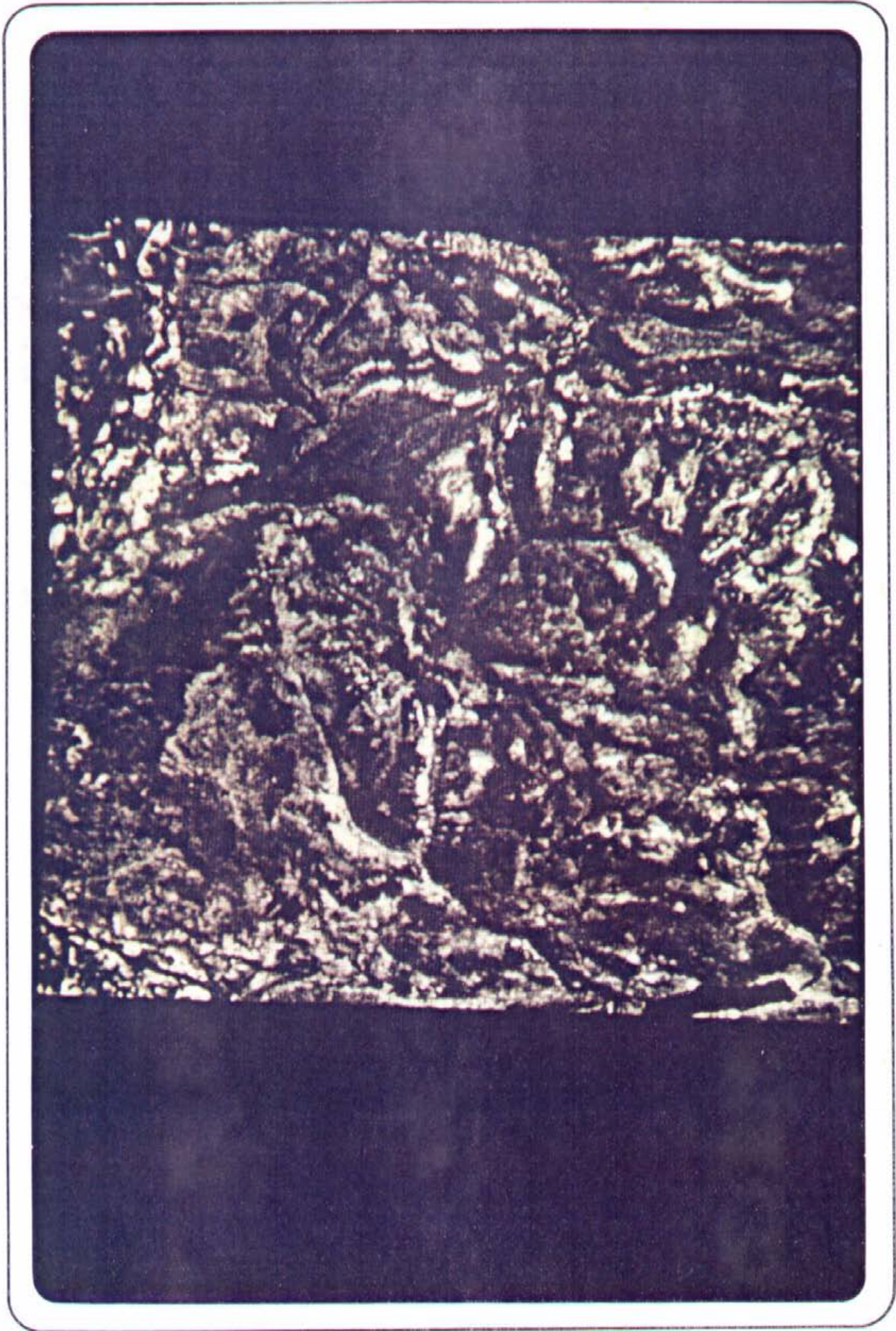Figure 10

Figure 11

Figure 12

Figure 13

Figure 14

Figure 15

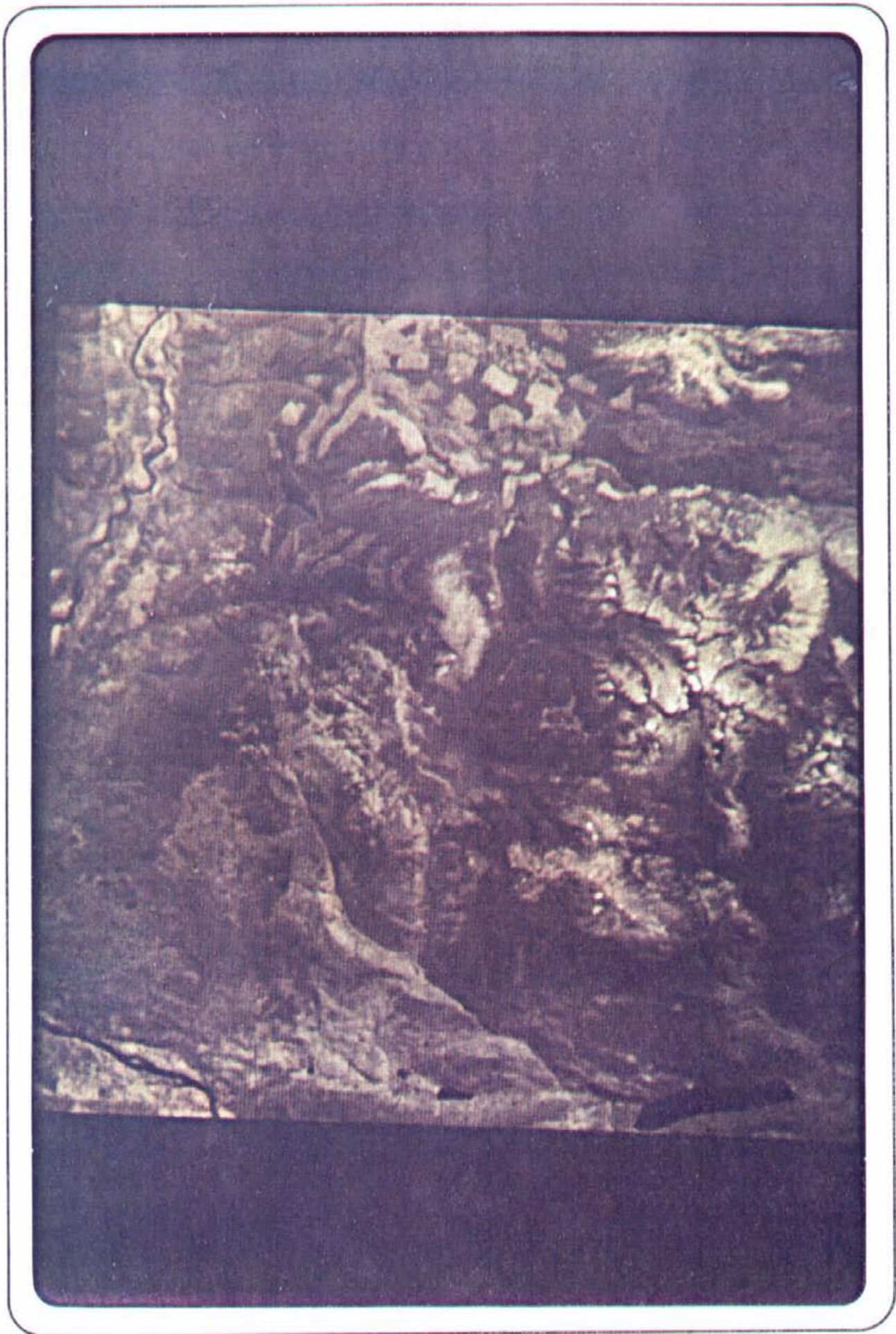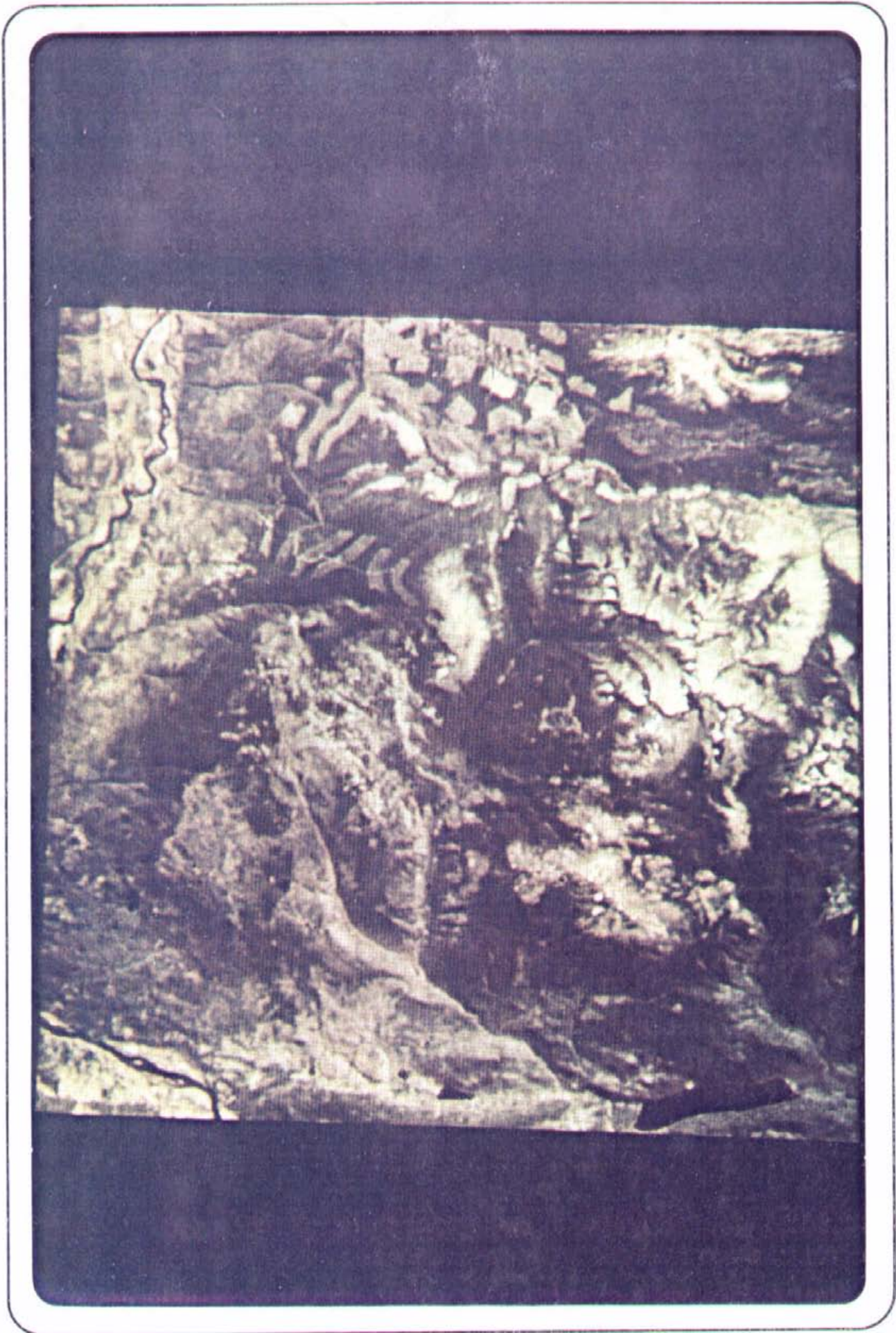Figure 16

Figure 17

Figure 18

Figure 19

Figure 20

Figure 21

Figure 22