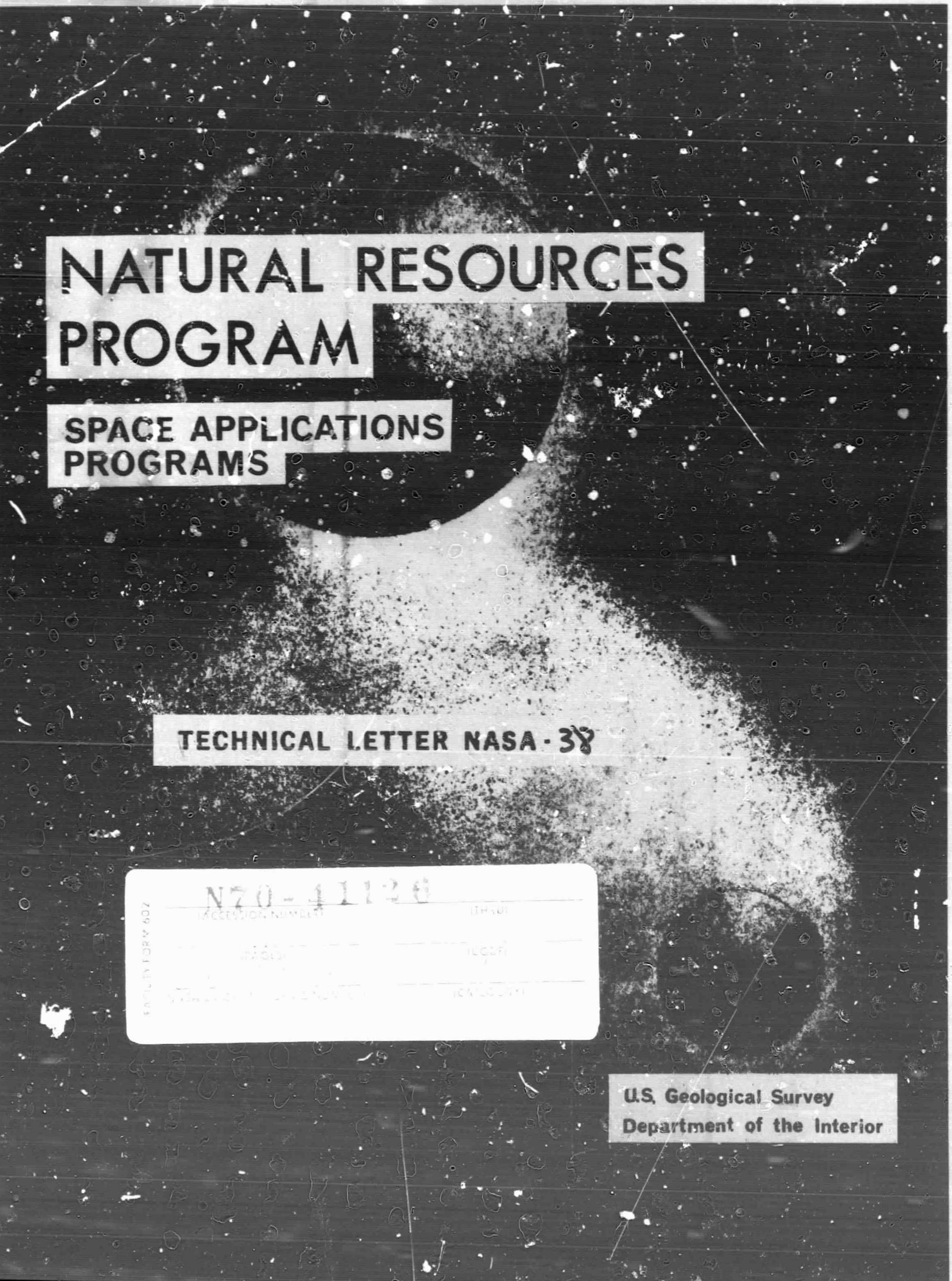

NATURAL RESOURCES PROGRAM

SPACE APPLICATIONS PROGRAMS

TECHNICAL LETTER NASA-38

U.S. Geological Survey
Department of the Interior

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

Technical Letter
NASA-38
August 1966

Dr. Peter C. Badgley
Chief, Natural Resources Program
Office of Space Science and Application
Code SAR, NASA Headquarters
Washington, D.C. 20546

Dear Peter:

Transmitted herewith are 2 copies of:

TECHNICAL LETTER NASA-38

GEOLOGICAL EVALUATION OF RADAR IMAGERY,

SOUTHWESTERN AND CENTRAL UTAH*

by

Lowell S. Hilpert**

Sincerely yours,

William A. Fischer
Research Coordinator
Earth Orbiter Program

*Work performed under NASA Contract No. R-09-020-015
**U. S. Geological Survey, Salt Lake City, Utah

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TECHNICAL LETTER NASA-38

GEOLOGICAL EVALUATION OF RADAR IMAGERY, SOUTHWESTERN AND CENTRAL UTAH*

by

Lowell S. Hilpert**

August 1966

These data are preliminary and should not be quoted without permission

Prepared by the Geological Survey for the National Aeronautics and Space Administration (NASA)

*Work performed under NASA Contract No. R-09-020-015
**U.S. Geological Survey, Salt Lake City, Utah

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GEOLOGICAL EVALUATION OF RADAR IMAGERY,

SOUTHWESTERN AND CENTRAL UTAH

by

Lowell S. Hilpert

ABSTRACT

Radar imagery was obtained with a high frequency side-looking radar in southwestern and central Utah along three flight lines having an aggregate length of about 650 mi. A selective evaluation indicates the radar imagery might be useful to broadly classify some rock units on the basis of their surficial textures or other characteristics. Tonal contrasts, however, in the areas that have been evaluated, probably represent differences in the degree of soil development, moisture content of the soils, and the vegetative cover. If so, these features may indirectly be useful for classifying the bedrock.

Geologic structures are readily visible in the imagery where they are expressed physiographically and show with about the same clarity as in conventional photography. Subsurface structures without physiographic expression were not observed in the imagery.

Radar imagery might be useful in terrain and trafficability analyses, especially when used in conjunction with other types of imagery, such as ordinary photography. Railroads clearly show in the radar imagery, but only some roads can be seen. Blacktop roads show as dark lines if they are more than about 30 ft wide. Graded and unimproved dirt roads and blacktop roads less than 30 ft wide can also be detected as light lines where they are flanked by road cuts or earth fills. The imagery of concrete surfaced roads could not be evaluated, as there are none in the areas flown.

INTRODUCTION

Radar imagery of the following strips in Utah were received for geologic evaluation on March 18, 1966:

Flight 91.

Run 3. Fillmore (north) to Panguitch (south).

6. South end Mineral Range (east) to South end Wah Wah Range (west).

7. Central Wah Wah Range (west) to central Mineral Range (east).

8. North end Mineral Range (east) to north end Wah Wah Range (west).

9. North end Wah Wah Range (southwest) to central Sanpitch Mountains (northeast).

Flight 92.

Run 1. Provo (northwest) to San Rafael Swell (southeast).

Flight 93.

Run 1. Escalante Valley (south) to Simpson Mountains (north).

The imagery was requested by the U.S. Geological Survey and flown on October 19-20, 1965. It was obtained by a high frequency (K-band) side-looking radar set and consists of two parallel images, one of which was made with signals transmitted and received horizontally, producing a "like" image. The other (lower) image was made with the transmitted signal polarized in the horizontal, as above, but with the receiving antenna in the vertical mode, producing a "cross-polarized" image.

Width of the flight strips is about 10 mi; lengths range from about 50 to 150 mi, aggregate about 650 mi. They cover a complex variety of rocks that range from flat-bedded sedimentary rocks in the Colorado Plateaus province to highly folded and faulted sedimentary, volcanic, and metamorphic rocks in the Rocky Mountains and Basin and Range provinces. The rocks range in age from Precambrian to Quaternary (fig. 1).

Throughout most of the flight areas the vegetative cover ranges from sparse grassland, sage, and scattered junipers in the valleys and on mountain flanks below 7,500 ft elevation to a somewhat heavier cover of scrub oak, aspen, and scattered forests of pine and spruce at higher elevations (generally 7,500 to 10,000 ft). In some of the irrigated valleys, forage crops and other vegetation locally provide a heavy cover.

This report is a brief geologic evaluation of selected parts of the radar imagery, as based on a comparison with the 1:250,000-scale Utah geologic map (Stokes, et al, 1961-64), some selected photo coverage, and two days of field reconnaissance in the Delta-Milford area.

Radar imagery--physical aspects

Scale. Measurements made between selected points along the flight strips show a range in scale from 1:148,500 to about 1:220,000 and an average of about 1:160,000.

Resolution of cultural features. Many cultural features show with marked clarity, some, however, are intermittantly visible; their visibility varying with the angle of incidence of the radar beam with the surface. Most prominent are linear features such as railroads, highways, canals, ditches, and airstrips. Railroads are most distinctive and show clearly whether they are parallel or transverse to the flight lines. The strong energy return from railroads probably relates to the shape of the steel rails or the angular shape of the road ballast rather than the angle of incidence of the radar signal on the rails, road cuts or embankments. Roads generally are poorly defined but only blacktop and dirt roads are represented in the flight strips and the road surfaces are nearly all 30 ft or less in width. Blacktop shows as a dark band if it is about 50 ft or more wide, but cannot be resolved if much narrower. Where it is narrower than about 50 ft, however, a road may be defined in the imagery from the adjoining road cuts and embankments. These relations are demonstrated by the imagery of U. S. Highway 6 and 50 and the Delta airport, both of which are surfaced with blacktop (fig. 2).

The airport consists of two 150-ft-wide airstrips and a 50-ft-wide taxi strip, which show as dark bands, but the taxi strip is much the faintest. The highway immediately west of the airport is a faintly discernible light streak on the cross-polarized image. The highway surface, about 30 ft wide, is coated with blacktop and bounded by a shallow borrow pit. Apparently the highway image is a reflection of the borrow pit embankment and the blacktop surface is too narrow to be resolved, whereas the airstrip images result from their wider blacktop surfaces. They are not paralleled by any appreciable borrow pits.

Dirt roads are not discernible except where graded; and graded roads are discernible only where they parallel road cuts or embankments, which show as light streaks and may result from the higher angle of incidence of the radar waves. A similar pattern is shown by canal banks.

In the area northeast of Delta (fig. 2) the rectangular pattern probably results from the relative moisture content of the tilled fields and perhaps partly from contrast in the crops, and from the light streaks of the canal embankments. The fields are bounded by a network of dirt and blacktop roads, but their surfaces do not show. Waterways such as reservoirs, rivers, and canals, show as dark areas or streaks, but only where they exceed about 25 ft in width.

The differences in resolution of the respective road surfaces railroads, embankments, and waterways indicate that the radar imagery might be a useful tool for terrain and trafficability analyses, especially when used with other types of imagery such as ordinary photography.

Radar imagery--geologic aspects

Structural details of rock units show in the radar imagery about the same as in conventional photography and are an expression of their physiographic detail. Some image tones correlate with rock types. This correlation probably results from their surface textures, or from a uniform soil development, moisture content of the soils, or vegetative cover on their surfaces.

In Flight 91, Run 9, for example, a Quaternary basalt flow (Qb) shows a lighter value than the adjoining Tertiary basalt (T_2bf) and Quaternary lake bed sediments (Qlc) (see figure 3). Although rock density and composition could be factors, they are not considered to be marked factors because the older basalt (T_2bf) cannot be differentiated from the lake sediments (Qlc). The different values are more likely the result of the degree of soil development, their relative moisture content, and perhaps their respective degree and type of vegetative cover. These matters need further evaluation. In the same area, a fault scarp is a prominent feature, which shows in greater detail and extent than the related fault structure on the geologic map. There is no indication, however, that any part of the fault structure shows that is not expressed topographically.

In the area east of Provo a patch of Tertiary rocks that is bounded by faults labelled A and B (see figure 4) shows a darker value than the bounding rocks, particularly darker than the Permian and Pennsylvanian rocks along the left side of fault A. The first assumption is that the older and more indurated rocks image with a lighter tone than the younger rocks because of their composition or surface texture. Although this may be true, soil cover, or lack of it, is probably a greater factor. Soil develops most readily on the softer Tertiary rocks, especially on the tuffaceous pyroclastics (T_1ap) and the soil, holds moisture, that in turn supports a heavy plant cover. Collectively, the moist soils and vegetation could be expected to absorb much of the radar energy. Although the radar imagery might show values that represent differences in rock density or other characteristics, it is more probable the values represent differences in the respective soil covers, the soil water content, and the vegetative cover. These matters need further study.

CONCLUSIONS

Radar imagery may be useful to broadly classify some rock units on the basis of their image tone. Some differences in image tone correlate with differences in rock density, composition, and surface texture. Most tonal contrasts in the evaluated areas, however, probably represent differences in the degree of soil development, soil moisture content, and the vegetative cover. If so, these characteristics may be useful for indirectly classifying some bedrock.

Geologic structures that are reflected physiographically are readily visible in the radar imagery in which they show with about the same clarity as in conventional photography.

Radar imagery might be most useful for terrain and trafficability analyses, especially when used with other types of imagery, such as conventional photography. Railroads show clearly, apparently because of the steel rails or road ballast. Blacktop and dirt roads show only under certain conditions. The blacktop is visible as a dark surface where it exceeds about 30 ft in width. When it is less than about 30 ft wide, the road surface does not show and traces of the roadway cannot be discerned except from the light tones produced by the attendant embankments of road cuts and fills. Graded and unimproved dirt roads apparently show only where there are parallel embankments and fills. Similarly, waterways show as dark areas where they exceed about 25 ft in width; where they are less than about 25 ft wide their presence may be indicated by the light tones of embankments, similar to roadways.

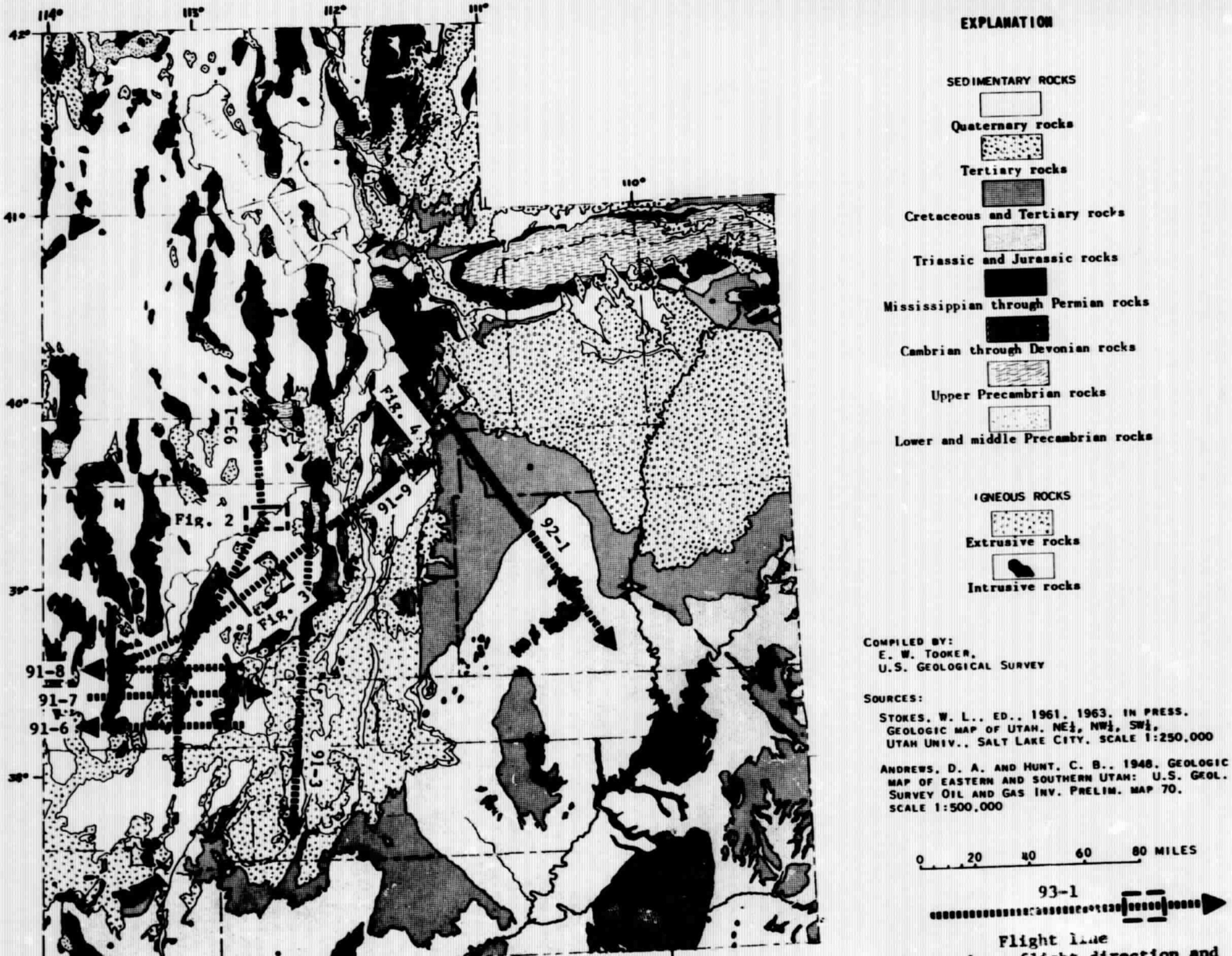


Figure 1.—Geologic map of Utah showing flight lines for radar imagery and locations of figures referred to in text.

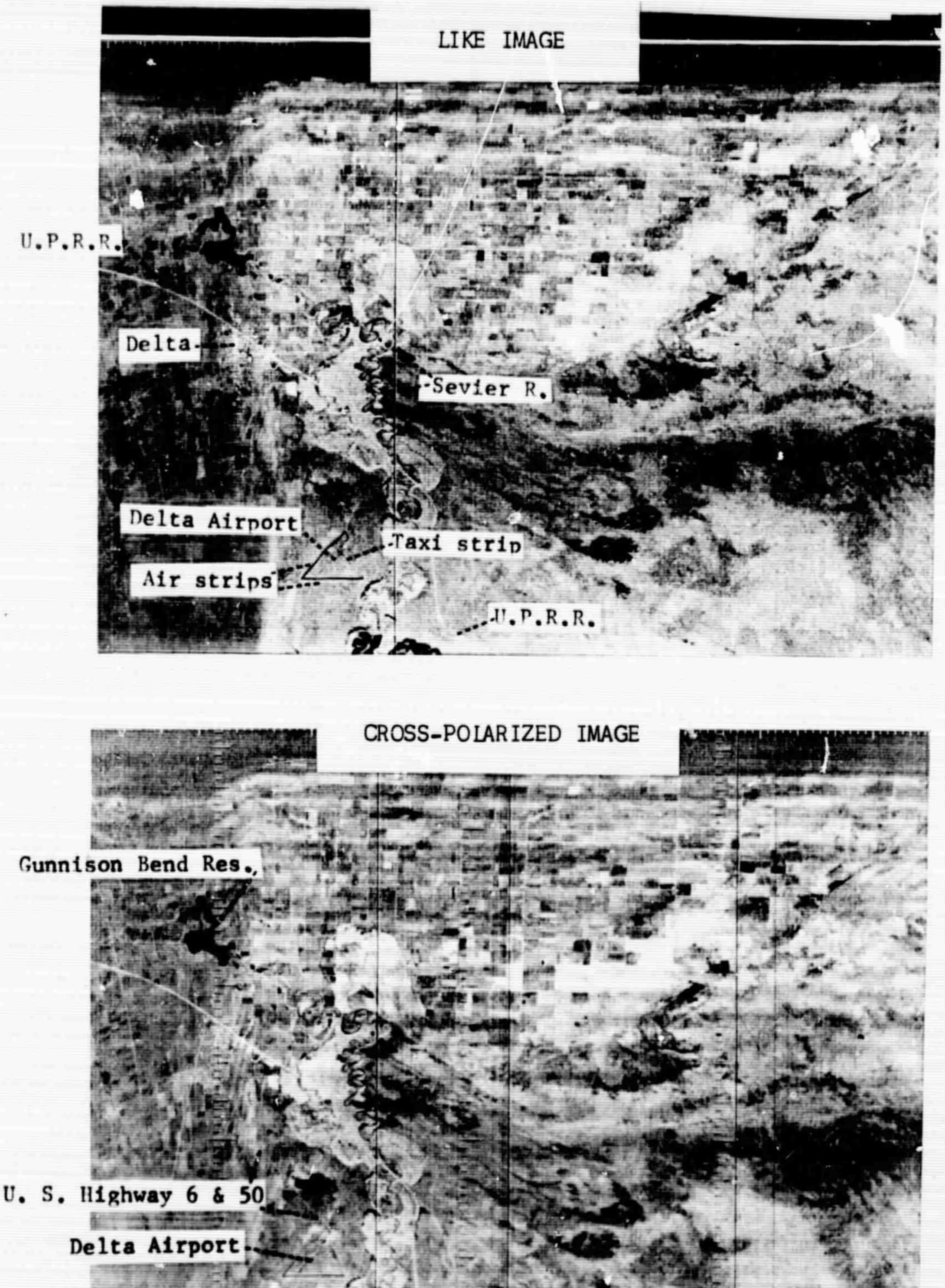


Figure 2.--Radar imagery showing cultural features in Delta, Utah area.

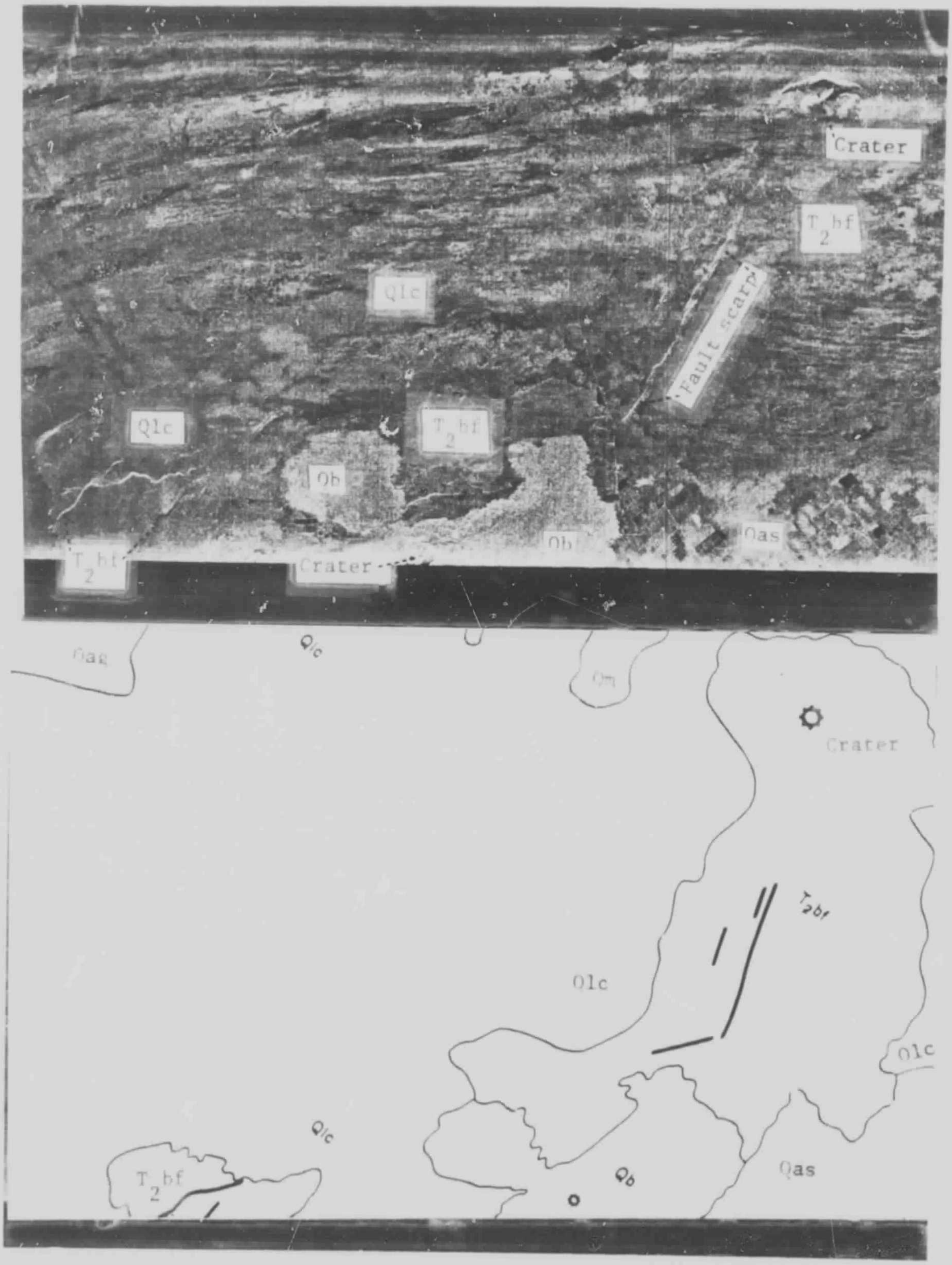
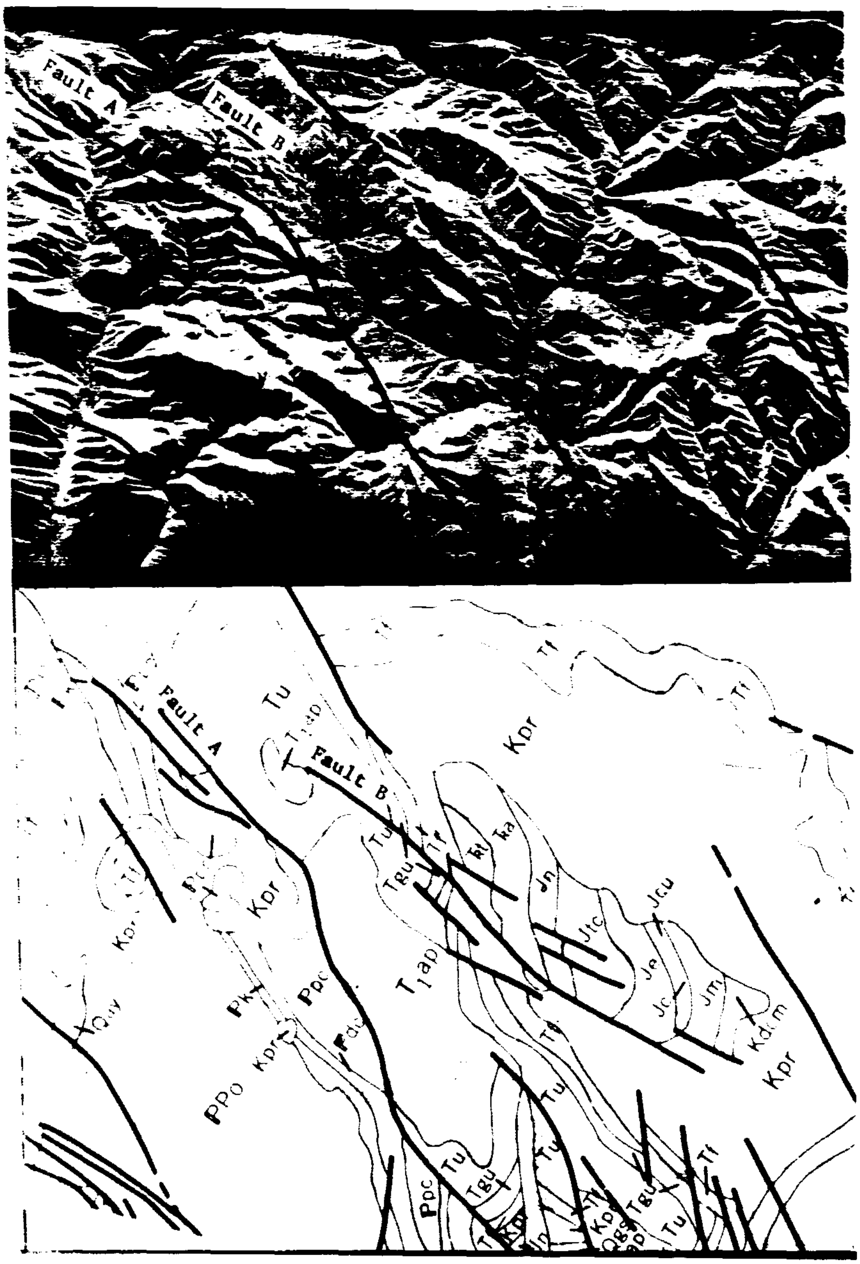


Figure 3.--Radar imagery and geologic map of area south of Delta, Utah, showing tonal contrast between Quaternary basalt flow (Qb) and Tertiary basalt flow (T_2bf), Quaternary lake clay (Qlc), Quaternary silty alluvium (Qas), and Quaternary gravelly alluvium (Qag). Fault structures are also shown. (Geology is abstracted from Geologic map of southwestern Utah, 1963, Lehi Hintze, compiler).



EXPLANATION

Quaternary

Qgs--Gravel
Qay--Alluvium

Tertiary?

T_1ap--Andesitic pyroclastics

Tertiary

Tgu--Green River Formation
Tu--Uinta Formation
Tf--Flagstaff Limestone

Cretaceous

Kpr--Price River Formation
Kdcm--Dakota and Cedar Mountain Formations

Jurassic

Jm--Morrison Formation
Jcu--Curtis Formation
Je--Entrada Sandstone
Jtc--Twin Creek Limestone
Jn--Nugget Formation

Triassic

TRa--Ankareh Formation
TRt--Thaynes Formation

Permian

Ppc--Park City Formation
Pdc--Diamond Creek Sandstone
Pk--Kirkman Limestone

Permian and Pennsylvanian

PPo--Oquirrh Formation

(From Geologic map of Utah, NE1/4, (1961)

Figure 4.--Radar imagery and geologic map near Provo, Utah, showing tonal contrast between Tertiary sedimentary and pyroclastic rocks and pre-Tertiary sedimentary rocks.