CAT. 43
IN
43736
p-8

Application of Shuttle Imaging Radar to Geologic Mapping

A Final Report
Contract # 957201

Theodore C. Labotka
Department of Geological Sciences
The University of Tennessee
Knoxville, Tennessee 37996-1410

28 February 1986

(NASA-CR-179952) APPLICATION OF SHUTTLE IMAGING RADAR TO GEOLOGIC MAPPING Final Report (Tennessee Univ.) 8 p CSCL 08G
N87-13837
Unclas
G3/43 43633

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by the National Aeronautics and Space Administration.

Abstract

Images from the Shuttle Imaging Radar - B (SIR-B) experiment covering the area of the Panamint Mountains, Death Valley, California, were examined in the field and in the laboratory to determine their usefulness as aids for geologic mapping. The covered area includes the region around Wildrose Canyon where rocks ranging in age from Precambrian to Cenozoic form a moderately rugged portion of the Panamint Mountains, including sharp ridges, broad alluviated upland valleys, and fault-bounded grabens. The results of the study indicate that the available SIR-B images of this area primarily illustrate variations in topography, except in the broadly alluviated areas of Panamint Valley and Death Valley where deposits of differing reflectivity can be recognized. Within the mountainous portion of the region, three textures can be discerned, each representing a different mode of topographic expression related to the erosion characteristics of the underlying bedrock. Regions of Precambrian bedrock have smooth slopes and sharp ridges with a low density of gullies. Tertiary monolithologic breccias have smooth, steep slopes with an intermediate density of gullies with rounded ridges. Tertiary fanglomerates have steep rugged slopes with numerous steep-sided gullies and knife-sharp ridges. The three topographic types reflect the consistancy and relative susceptibility to erosion of the bedrock; the three types can readily be recognized on topographic maps. At present, it has not been possible to distinguish on the SIR-B image of the mountainous terrain the type of bedrock, independent of the topographic expression.

ORIGINAL PAGE IS
OF POOR QUALITY

Objectives

The study was an assesment of the techniques and strategies for quantitative interpretation of SIR-B data for lithologic identification and geologic mapping. The brightness, or backscatter, of units as a function of incidence angle can be used to discriminate surfaces of different relative roughness and to determine actual roughness of geologic surfaces. The roughness can be used to infer rock types through knowledge of their weathering characteristics.

Characterization of rock types in terms of backscatter and texture in multi-incidence angle SIR-B images can be used in conjunction with images from other sensors to assist in lithologic identification. The information contained in multi-incidence angle SIR-B images is complementary to information in images acquired at other wavelengths such as visible-near infrared, mid-infrared, and thermal infrared. Each wavelength region contributes information on different physical parameters that, taken together, may yield a solution to the problem of rock type identification from space.

The target area used for testing the usefulness of SIR-B images as aids to geologic mapping is a portion of the Panamint Mountains and Death Valley, in eastern California. The region is arid and contains a great amount of relief, ranging from -90 to +3600 m. The rock types that make up the Panamint Mountains include Precambrian gneiss, schist, marble, and quartzite, which have been folded and faulted during Late Cretaceous time. Along the western margin of the range, these rock types were brecciated and faulted to form a slide mass during Late Tertiary time. At about the same time, thick sections of fanglomerate were deposited in the nascent Panamint Valley. Uplift of the Panamint Range in Late Tertiary to Quaternary time resulted in a rugged mountain range surrounded by deeply alluviated, fault-bounded valleys. The four types of deposits, Precambrian rocks, Tertiary slide masses, Tertiary fanglomerates, and Quaternary valley fill, each have a characteristic topography resulting from the erosion characteristics of each. Regions of Precambrian bedrock have smooth slopes and sharp ridges with a low density of gullies. Tertiary monolithologic breccias have smooth, steep slopes with an intermediate density of gullies with rounded ridges. Tertiary fanglomerates have steep rugged slopes with numerous steep-sided gullies and knife-sharp ridges. And the Quaternary valley fill is relatively flat, but interrupted by recent fault scarps. The topographic and lithologic variety makes the Panamint Mountain area an ideal location to test the usefulness of the SIR-B images.

Results

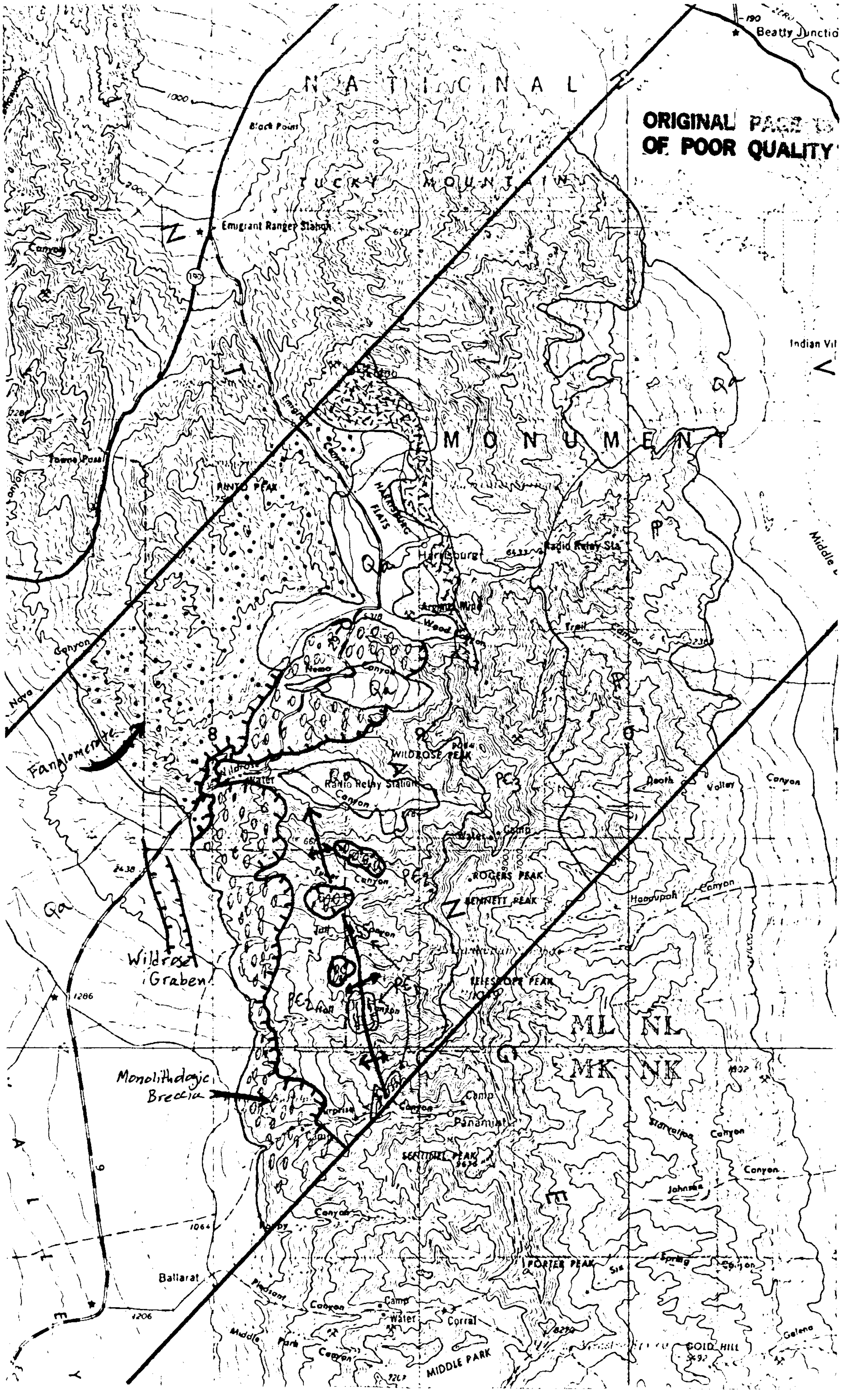
The topography and geology of the area covered by the SIR-B image are shown in Figure 1, and the image is shown in Figure 2. The quality of the image in many areas is poor where the return signal was weak and noisy. This is particularly true in Panamint Valley and in the upland Harrisburg Flats. However, the quality in Death Valley is good, where the salt pan, encrusted salt deposits, modern alluvial deposits, and desert pavement are all clearly seen. In Panamint Valley, the contrast between deposits is low, but modern and ancient alluvial deposits can be distinguished, particularly near the mouth of Wildrose Canyon where the alluvium has been faulted, forming Wildrose Graben. Although contrast in the mountainous portion of the image is low, the three topographic types can be recognized. The Precambrian bedrock areas show relatively smooth slopes and a low density of gullies. The monolithologic breccia deposits have smooth slopes but a high density of gullies, and the fanglomerate deposits have rugged slopes and a high density of gullies.

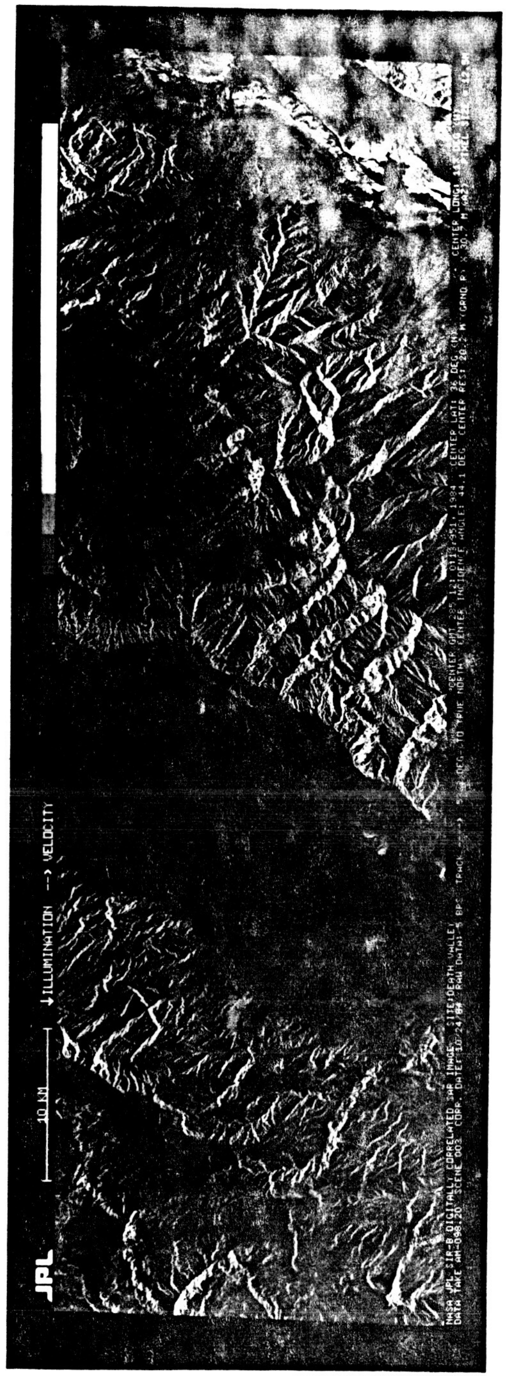
One of the tests of the usefulness of the radar image was to distinguish among these three types of bedrock in regions of low relief where topographic expression is ambiguous. The appropriate area is in Harrisburg Flats. During this funded period, a portion of Harrisburg Flats was mapped on a scale of 2" = 1 mile, and all three bedrock types were found to be present over large areas. Unfortunately, the radar signal from this region was weak and noisy, making the recognition of the three rock types from the radar image difficult. Continued mapping of the region where the radar signal was strong is required to test the ability to distinguish different rock types based on their scattering properties, independent of their topographic expression.

The results of this preliminary study where presented to the Geological Society of America Annual Meeting in Orlando, Florida, on 31 October 1985. A copy of the abstract is attached. These preliminary results will be published in *Geology* later this year.

Figure 1. Simplified geologic map of the portion of the Panamint Mountains cover by the SIR-B image. The covered area lies between the NE-trending lines. The stippled pattern represents Tertiary fanglomerate, the circled pattern represents monolithologic slide breccias, the hatchured pattern represents the Skidoo granite, and the unpatterened area represents bedrock. PC_1 is Middle Proterozoic gneiss, PC_2 is Late Proterozoic Pahrump Group, PC_3 is Late Proterozoic metasedimentary rock, and IP is Paleozoic rock.

Figure 2. SIR-B image. NE flight path, SE illumination direction, 44^0 incidence angle.


N A T I O N A L
Beatty Junctio
Black Point
Emigrant Ranger Station
Canyon
Towne Pass
PINTO PEAK
M O N U M E N T
Indian Vi
HARRISBURG FLATS
Harrisburg
Radio Relay Sta.
Wood Canyon
Nemo Canyon
Nova Canyon
Fanglomerate
WILDROSE PEAK
Radio Relay Station
Wildrose
Water
Canyon
Trail Canyon
Death Valley Canyon
ROGERS PEAK
BENNETT PEAK
Hanaupah Canyon
TELESCOPE PEAK
Wildrose Graben
Monolithologic Breccia
Surprise
Canyon
Panamint
SENTINEL PEAK
Johnson
Canyon
PORTER PEAK
Ballarat
Pleasant Canyon
Camp
Water
Corral
Middle Park Canyon
MIDDLE PARK
GOLD HILL
Galena
Qa
ML NL
MK NK


JPL
10 KM
↓ILLUMINATION --> VELOCITY

1985 GSA ABSTRACT FORM

USE THIS FORM FOR ALL 1985 GSA MEETINGS (SECTION & ANNUAL MEETINGS)

YOU MUST COMPLETE ALL SECTIONS BELOW, 1 THROUGH 7

① **TYPE YOUR ABSTRACT IN THE SPACE BELOW**, using fresh black carbon ribbon. Follow the format shown on the attached instructions. Blue lines below show **absolute** limits. *Do not fold abstract*, mail flat with reinforcement to avoid retyping charge.

№ 58481

UPLIFT OF THE PANAMINT MOUNTAINS, CALIFORNIA:
A RADAR VIEW FROM THE SPACE SHUTTLE

LABOTKA, Theodore C., Dept. of Geological Sciences, The University of Tennessee, Knoxville, TN 37996

The Shuttle Imaging Radar (SIR)-B was launched in October, 1984, as a multi-incidence angle, digitally correlated experiment. Although all aspects of the experiment were not realized, the central part of Death Valley and the Wildrose area of the Panamint Mountains were viewed at an incidence angle of 44°. This is a region that has been undergoing extension since Tertiary time. The radar image is a considerable aid in distinguishing various deposits that formed as a result of uplift of the Panamint Mountains. The rocks that compose the Panamint Mountains are classed as one of three types: deformed and metamorphosed Mesozoic basement rocks, slide masses composed of variably brecciated basement rocks, and uplifted and east-tilted fanglomerates. Each rock type has a distinct surface texture easily seen in the SIR-B image. The basement rocks are smooth with sharp, well defined ridges. The slide masses have a reticulated topography with a high density of steep-sided ridges. The fanglomerates have a dimpled texture resulting from a high density of short, steep side ridges. The SIR-B image is very detailed in areas of low relief where active alluvial systems are much brighter than old surfaces with well developed desert pavements. Numerous fault scarps are also clearly visible and features like Wildrose Graben are prominent in the image. The SIR-B image is used in conjunction with Thematic Mapper and aerial photography as a mapping tool for deciphering the relative developments of slide masses and fanglomerates. The images have helped identify previously unrecognized slide masses, including masses containing Tertiary basalt. The results indicate that slide mass development continued after the deposition of the fanglomerates, although the large masses that make up the west scarp of the range formed prior to the fanglomerates.

② **SELECT ONE — AND ONLY ONE**— of the following categories for review purposes. Select the one in which reviewers can best be expected to review your abstract properly. Category selected does not necessarily determine the final technical session assigned.

- ☐ 1 archaeological geology
- ☐ 2 coal geology
- ☐ 3 economic geology
- ☐ 4 engineering geology
- ☐ 5 environmental geology
- ☐ 6 general geology
- ☐ 7 geochemistry
- ☐ 8 geology education
- ☐ 9 geomorphology
- ☐ 10 geophysics
- ☐ 11 geoscience information
- ☐ 12 glacial geology
- ☐ 13 history of geology
- ☐ 14 hydrogeology
- ☐ 15 marine geology
- ☐ 16 mathematical geology
- ☐ 17 micropaleontology
- ☐ 18 mineralogy/crystallography
- ☐ 19 oceanography
- ☐ 20 paleontology/paleobotany
- ☐ 21 petroleum geology
- ☐ 22 petrology, experimental
- ☐ 23 petrology, igneous
- ☐ 24 petrology, metamorphic
- ☐ 25 petrology, sedimentary
- ☐ 26 planetary geology
- ☐ 27 Precambrian geology
- ☐ 28 Quaternary geology
- ☒ 29 remote sensing
- ☐ 30 sedimentology
- ☐ 31 stratigraphy
- ☐ 32 structural geology
- ☐ 33 tectonics
- ☐ 34 volcanology

③ **TYPE OF SESSION PREFERRED:**
See instructions for information on each session type.
☐ Oral only ☒ Poster only ☐ Either type
☐ Symposia ____________________
(Title of symposia for which your abstract was invited)

④ **PERCENTAGE OF THIS PAPER PREVIOUSLY PRESENTED** 0 **WHERE AND WHEN PRESENTED**

⑤ **CAN YOU BE A SESSION CHAIRMAN?**
If so, please complete:
Topic ____________________
Your name ____________________
Telephone (late June/early July) ____________________

⑥ **SPEAKER'S IDENTITY AND MAILING ADDRESS:**
Speaker's status (check one):
1 ☒ GSA Mem or Fel 2 ☐ GSA Student Assoc
3 ☐ Professional geologist (but not GSA mbr) 4 ☐ Student (not GSA Assoc)

Speaker's name
Address T. Labotka
Address dept Geological Sciences
City State Zip Univ. Tenn, Knoxville
Country Knoxville TN 37996
Office Telephone: (615) 974 2366
Home Telephone: (615) 974 4112
Dates we can reach you: except 1 July - 25 July

⑦ **SEND ORIGINAL + FIVE COPIES OF ABSTRACT TO APPROPRIATE ADDRESS SHOWN ON INSTRUCTIONS SHEET AND ON BACK OF THIS FORM. ALL ABSTRACTS MUST ARRIVE ON OR BEFORE DEADLINE SHOWN FOR EACH MEETING.**

ORIGINAL PAGE IS OF POOR QUALITY