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Produced by the NASA Center for Aerospace Information (CASI)
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Acting Program Chief,  
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Dear Bob:

Transmitted herewith is one copy of:

INTERAGENCY REPORT NASA-124  
PRELIMINARY EVALUATION OF INFRARED AND RADAR  
IMAGERY, WASHINGTON AND OREGON COASTS*

by

Parke D. Snavely, Jr.**  
and  
Norman S. MacLeod**

The U.S. Geological Survey has released this report in open files. Copies are available for consultation in the Geological Survey Libraries, 1033 GSA Building, Washington, D.C. 20242; Building 25, Federal Center, Denver, Colorado 80225; 345 Middlefield Road, Menlo Park, California 94025; and 601 E. Cedar Avenue, Flagstaff, Arizona 86001.

Sincerely yours,

William A. Fischer  
Research Coordinator  
EROS Program

*Work performed under NASA Contract No. W-12589 and  
Task No. 160-75-01-54-10  
**U.S. Geological Survey, Menlo Park, California
Preliminary Evaluation of Infrared and Radar Imagery, Washington and Oregon Coasts*

by
Parke D. Snavely, Jr.**

and
Norman S. MacLeod**

September 1968

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

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Task No. 150-75-01-54-10
**U.S. Geological Survey, Menlo Park, California
PRELIMINARY INTERPRETATION OF INFRARED AND RADAR
IMAGERY, WASHINGTON AND OREGON COASTS

by

Parke D. Snavely, Jr.
and
Norman S. MacLeod

U.S. Geological Survey
Menlo Park, California
This preliminary evaluation of the applications of infrared imagery to problems in marine geologic mapping (Task No. 160-75-01-54-10) is intended to serve as a Mission Analysis Report of NASA Convair 240, Mission 55 flown on August 16, 1967.

The images contained in this report are negative prints in which bright areas represent cool materials and black areas are relatively warm.
Introduction

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Figure 1. Infrared image of the mouth of the Quinault River, Washington.

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Figure 5. Infrared image of large scale ripple marks, Willapa Bay, Washington.
Introduction

This report summarizes the preliminary interpretation of infrared and radar imagery of parts of the Washington and Oregon coast. This coastal area is an ideal testing site for remote sensing techniques such as, in contrast to other imagery testing sites, it has a dense cover of vegetation and bedrock is poorly exposed. Thus it serves to define limitations of imagery in areas not ideally suited for geologic interpretation of conventional aerial photographs.

Much of the geology of this coastal area has been mapped as part of the U. S. Geological Survey's regional geologic mapping program. More recently, detailed investigations of the geology of the Oregon and Washington coast have been undertaken as part of the study of the stratigraphy, structure, economic potential and origin of the continental shelf extending from the continental margin to the Coast Ranges. Because much of the existing mapping of the coastal belt is reconnaissance, more detailed mapping of selected areas has been required for the interpretation of some features shown by the imagery. Field studies of most of these features will be completed by September, 1968, and a detailed report of the infrared and radar imagery will be prepared.
Infrared imagery of the coastline of the northern U.S. coast was acquired by a U.S. Army satellite 123丁. Imagery was to be in the 3 to 14 micron band. The images were obtained on August 20, 1967 between 1745 and 1845 hours local time at an altitude of 15,000 feet.

Scale on the 70 mm film on which the imagery is recorded varies somewhat but in most areas is about 1:70,000; scale parallel to the flight path differs from that normal to the path resulting in slight distortion. Selected parts of the original imagery were enlarged 3.5 times for detailed analyses.

The coastal area shown in the infrared imagery is characterized by high annual rainfall and dense vegetation. Several rivers whose headwaters are in the Olympic Mountains discharge into the sea along the northern Washington coast; among the larger of these are the Soladuck, Hoh, Quest, and Quinaut Rivers. The Chehalis, Willapa, and the Columbia Rivers discharge to the sea in the southern coast through Grays Harbor, Willapa Bay and the Columbia estuary.

Lower Eocene to Pliocene sediments and volcanic rocks crop out on wave-cut platforms, sea cliffs, and rugged headlands between Grays Harbor and Cape Flattery along the Washington coast. Pleistocene glacial debris blankets most of the inland area and locally extends beyond the coast line. South of Grays Harbor to the Columbia River the coastal area is characterized by broad beaches, and spits that are mantled by dune deposits; Tertiary bedrock is exposed only in a few places.
with which to inhibit the complete growth of such structures. And... provide data on the thermal infrared characteristics. Additional analyses of the imagery indicate that it is of special value in showing the bedrock geologic features. Variations in rock lithology could not be determined on the imagery nor could most structural elements such as large faults. A slight linear thermal anomaly is almost near Point Granville over the trace of a large north trending fault. It is very faint and would probably not have been noted had the presence of the fault not been known. It appears as a narrow band of slightly higher relative temperature extending from a raised terrace onto the adjacent beach, and probably is produced by discharge of relatively warm spring water along the fault trace.

Color aerial photographs of the coastal area, on the other hand, show geologic features such as bedding, lithologic contacts, and faults very clearly. Enhanced, false-color composites of an infrared image of a wide wave-cut platform on the coast near Quicks Island are now being prepared. These may enhance lithology-produced thermal variations not otherwise visible in the infrared imagery. An enhanced, false-color composite of a color aerial photograph of this same area is also being prepared in order to provide an additional basis for comparison of infrared imagery and color aerial photographs.

Even though the infrared imagery has not been particularly useful in respect to showing bedrock features, it does show remarkable thermal variations in sea water adjacent to the coast. These are significant
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The apron off the Gaimnait River is composed of at least two impinging plumes, one of which appears older. The axis of the older Gaimnait plume, and also that of the much fainter of two plume developed off the Quuits River, is parallel to but located about 5000 feet from that of the younger plume. The individual plumes contain more than five pronounced concentric thermal bands. The outer limit of each band is sharp and contains relatively warm water; the water temperature within individual bands decreases gradually landward. Small faint concentric bands occur within and parallel to borders of the larger bands.

These concentrically banded thermal plumes most likely formed as a result of pulsing discharge of fresh river water in dynamic
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Some part of this text is blurred or difficult to read, resulting in a loss of information. However, the following text can be interpreted as:

"Several infrared images made at about 2 hour intervals between high tides would provide the data needed to interpret plume origin."
A wave-resistant belt 250 to 450 feet wide immediately adjacent to the coast where no wave-cut platforms are present is shown by a wave-cut platform pattern. The width of such belts provides a measure of the disposal of beach sediments by wave action. Blanket or wave activity that probably formed during the earlier section of wave-cut platforms is shown by the infrared images between Sand Point and Cape Alava, Coast Trinangles, and in several other places on the Washington coast (Figure 4). Coastal features pattern coastal rocks, small islands, and headlands show the direction of net transport of surface water as a result either of longshore currents or prevailing winds. Thermal eddies in surface water of small coastal environments are shown in the imagery and result from topographic interference with surface water transport.

Large-scale rhomboid ripples show in the infrared imagery in Willapa Bay (Figure 5). The ripples have wave lengths of about 200 feet and have superimposed sand waves which trend normal to the rhomboid...
nipples. Both wave forms are probably the result of wave action flow on tidal flats during ebbing tides. After these features are investigated in the field they will be reported upon more fully.

Radar Imagery

Preliminary interpretation of radar imagery of a 10-mile-wide strip of the Oregon Coast extending from the California border to the Columbia River is reported in Snavely and Wagner (1968). Since submittal of that report, field evaluations of the radar imagery have continued but, because of the large area involved, are not yet complete. Principal conclusions presented in the technical letter are: (1) radar imagery provides a very clear rendition of the topography and in essence "defoliates" the thick cover of vegetation; (2) rocks of high density and surface roughness underlie areas depicted on the imagery with light tones, and rocks with low density and (or) high water content underlie areas which appear dark on the imagery; and (3) fault traces can be discerned on the imagery by juxtaposition of areas with different tonal rendition and by associated linear topographic features.

Reconnaissance field mapping during the last year has shown that several anomalous linear features on the imagery are expressions of previously unrecognized faults. The largest of these faults trends northeast from near the mouth of Drift Creek (north of Lincoln City) for a distance of at least 10 miles and is expressed on the radar imagery as an aligned series of hills and streams. Field investigations
have shown that several other similar linear features on the radar imagery, however, result from topographical expression of particularly resistant beds. Therefore, careful field investigations are a prerequisite to geologic evaluation of the radar imagery.

Additional field work including detailed ground and aeromagnetic surveys are planned during the summer of 1963 on an arcuate volcanic structure, described in Snavely and Wagner (1966) which occurs 10 miles south of Astoria. It is anticipated that the investigations of this structure and field studies of other structural elements shown on the radar imagery will be completed during the summer of 1963 and a comprehensive report on the geologic evaluation of the radar imagery will then be issued.

Reference Cited:

Figure 1. Enlarged infrared (8 to 14 μ) image of mouth of Quinault River, Taholah, Washington. Two plumes of relatively warm river water spread seaward from near river mouth. Note the well defined thermal bands with sharp outer margins and gradual inward decrease in relative temperature. Sand bar is present on south side of river mouth. Rectangular light areas north of river are logging tanks. Distance from bridge to river mouth is about 3600 feet.
Figure 1.
Figure 2. Infrared (8 - 14 μ) image of mouth of Quents River.

Thermally banded plume extends southwest from river mouth. Faint older plume is visible immediately to left, and concentric to, river mouth. Marshy area (light) on southwest extension river below bridge probable is former river channel. Distance from bridge to river mouth is 5,600 feet.
Figure 2.
Figure 3. Infrared (8 to 14 μ) image of mouth of Rio River shows banding thermal place. Dotted pattern is due to recent sedimentation by wave-agitation. Distance from river mouth to right hand margin of image is 3,000 feet.
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