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

Technical Letter
NASA-76
June 1967

Dr. Peter C. Badgley
Program Chief,
Earth Resources Survey
Code SAR - NASA Headquarters
Washington, D.C. 20546

Dear Peter:

Transmitted herewith is one copy of:

TECHNICAL LETTER NASA-76

INFRARED IMAGERY OF PART OF THE HIGH CASCADE RANGE

AND McKENZIE RIVER VALLEY, OREGON*

by

Donald A. Swanson**

Sincerely yours,

W A Fischer

William A. Fischer
Research Coordinator
Earth Orbiter Program

U. S. Government Agencies Only

*Work performed under NASA Contract No. R-09-020-015

**U.S. Geological Survey, Menlo Park, California

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Donald A. Swanson**

June 1967

These data are preliminary and should not be quoted without permission

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

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Introduction

Continuous infrared imagery in the 3-5 micron band was obtained by airplane for part of the High Cascade Range and McKenzie River Valley of Oregon during a south to north overflight on August 14, 1966. The image strip is about 3-4 miles wide and extends from 18 miles south of Crater Lake northward to North Sister and McKenzie Pass, where it veers westward and follows McKenzie River as far as its confluence with Willamette River just north of Eugene (fig. 1). This report briefly evaluates the infrared imagery in terms of physical (principally geologic) and cultural features as portrayed on published geologic maps (Wells and Peck, 1961; Williams, 1957; Taylor, 1965). Technical Letter NASA-19 (Swanson, 1966) evaluates K-band radar imagery of a strip adjacent to the western edge of the present infrared imagery; unfortunately the two do not coincide.

The overflight lasted from 2004 to 2102 hours and took place largely during twilight, since sunset was at 2020 hours. No rain had fallen within the preceding 24 hours, but there was heavy haze during the flight. No surface temperature measurements were made, and no data are available on the emissivity of the surface material; hence comparisons and discussion of results are entirely qualitative.

The flight was at an altitude of 16,000 feet, and the ground surface varies from a few hundred feet to over 10,000 feet in elevation, with an average elevation for the High Cascade Range of 5000-6000 feet. The scale of the imagery varies somewhat because of elevation differences, but in general is about 1:81,000 in a direction parallel to the flight path. Normal to the flight path, however, the scale progressively decreases away from the center line of the imagery strip, largely because of the scanning methods (Fischer and others, 1964, fig. 4). The image is distorted as a consequence of the variable scale, and ground features are foreshortened toward either edge of the recording film.

General geology

Most of the flight path is over the High Cascade Range (Callaghan, 1933), which is composed principally of Pliocene to Recent high-alumina basalt and basaltic andesite with minor obsidian, tuff, ash, and pumice. Constructional volcanic landforms, such as cinder cores, stratovolcanoes (up to more than 10,000 feet high), smooth extensive lava plains, and bulbous silicic domes and flows are little modified by erosion except where glaciated. Some lava flows are so young that vegetation is sparse to absent on them, and numerous cinder cones are likewise devoid of vegetation owing both to youth and to high permeability. Local fumarolic activity, hot springs, and young lava flows indicate that the area is volcanically active and probably subject to future eruptions.

The western leg of the flight path follows McKenzie River Valley, which is cut chiefly into a sequence of lower Tertiary volcanic rocks which forms the Western Cascade Range (Callaghan, 1933; Peck and others, 1964). This sequence is composed principally of basaltic to dacitic flows, breccias and tuffs, and includes more numerous silicic rocks than do the High Cascades. Western Cascade rocks have been buried, locally zeolitized, deformed, eroded, and intruded by andesitic dikes and plugs; consequently original constructional landforms are not preserved. Youthful volcanism has not been reported from the Western Cascades.

Evaluation

Geologic interpretation of the infrared imagery of this area is hampered in two ways:

(1) Most of the area is clothed by moderately dense to heavy pine and fir forests. As a result, any potentially detectable differences in infrared emission between various surface rock units, such as andesite and basalt, are overshadowed by the energy radiated by the vegetation and by warmer air trapped within the forest. The amount of energy radiated by the vegetation and entrapped air is significant, since the forested terrain is much lighter (warmer) on the image than the recently logged, clear-cut areas (fig. 7) and service roads (fig. 3) scattered throughout the forest.

(2) The imagery was obtained so close to sunset that radiance distribution was controlled by the degree of exposure to the late afternoon sun, not by the slight lithologic differences between the various rock units. West-facing slopes, regardless of lithology, altitude, or vegetation, are lighter (warmer) than other slopes because of having received late afternoon and early evening sunlight. Even glaciers on the Sisters are indistinguishable because of this "shadow" effect. A useful result of the "shadow" effect, however, is the portrayal, in apparent relief, of large volcanoes such as Bachelor Butte, Broken Top, and Middle and North Sister; this "shadow" effect would be greatly reduced and peaks would consequently be less prominent on an image obtained later at night when solar radiation had dissipated.

Young basalt flows whose blocky surfaces are uneroded and unvegetated--such as the Collier flow (Taylor, 1965; Peterson and Groh, 1965, fig. 26)--are depicted clearly on the imagery, for they are lighter (relatively warmer) than nearby older, eroded, and forested flows (fig. 2). Basalt flows with similar light gray tones occur near Odell Butte (fig. 3), and at the north end of Davis Lake (fig. 7); they are probably also barren of vegetation, judging from their lack of green (forest) overprint on the Army Map Service topographic map of the area (Crescent sheet, 1:250,000). Roads surfaced with blacktop asphalt show a light gray tone similar to the barren flows. Both the basalt and the blacktopped roads are of similar color, and they apparently possess similar thermal characteristics.

Some cinder cones show as dark areas on the image regardless of which direction their slopes face. They contrast especially prominently with surrounding unvegetated, relatively warm flows as, for example, just northeast of Odell Butte (fig. 3) and adjoining Davis Lake (fig. 7) where cinder cones are shown on the geologic map of Williams (1957). Unpaved, graded roads, many of which are coated with a cinder aggregate, appear in shades of gray similar to the cinder cones, probably because of their similar composition and degrees of compaction and denseness.

The dacite at Rugged Crest atop the north rim of Crater Lake (Williams, 1942) is somewhat darker (cooler) than the adjacent timbered pumice flat underlain by loosely consolidated glowing avalanche deposits. From photographs in Williams' (1942) paper, the dacite appears to be forested no more thickly than the nearby part of pumice flat. No explanation for the tonal difference between the pumice flat and the dacite is readily apparent.

Light areas occur on the crest of Miller and Cappy Mountains and Burn Butte along the Little Deschutes River 4-5 miles north of Miller Lake (fig. 4). Miller Mountain is composed of glaciated basalt and andesite of Plio-Pleistocene age, and Cappy Mountain and Burn Butte are underlain by rhyolite of Pleistocene age (Wells and Peck, 1961). They are free of vegetation, in contrast to most of the surrounding area, judging from the pattern of green (forest) overprint on the map of the Crescent (1:250,000) AMS quadrangle. The lack of vegetation and probable lack of soil cover on the rugged peaks, and the twilight time of flight, may explain their relative warmth.

Valley walls below the tops of Miller and Cappy Mountains and Burn Butte (fig. 4) are lighter (warmer) on the infrared imagery than nearby forests, but darker than the mountaintops. This intermediate degree of radiance may come from thinly vegetated, active talus piles that probably mantle the steep valley slopes.

The part of the image that includes McKenzie River Valley reveals little of the underlying geology, mostly because of the heavy timber cover. Parts of the valley covered by alluvium (fig. 5) are darker than elsewhere, perhaps because the alluvium is grassy and marshy, but no other geologic rock unit could be recognized. Clear-cut logged areas on adjoining hills show especially well as dark patches (fig. 6).

Hot springs are purported to occur near the head of McKenzie River. Several light spots dot the imagery of this area, but the presence of buildings, fresh basalt, and west-facing slopes, and the distortion of the imagery where the flight path turned westward, preclude positive identification of the hot springs.

Lakes and streams abound in the High Cascades, and they form some of the lightest areas on the infrared imagery (fig. 7). Adjacent mudflats, however, are dark (fig. 7), as are meadows (probably water soaked (fig. 7)) and clear-cut logged areas (fig. 6). The brightest parts of the imagery are tiny spots which cluster along the shores of Miller, Wickiup, South Twin, and Todd Lakes, and at various communities in McKenzie River Valley (fig. 7). Probably they are chiefly dwellings and campfires near the lakes, and buildings and sawmills along McKenzie River.

A general scheme from darkest (relatively coolest) to lightest (relatively warmest) grays on the imagery is:

clear-cut logged areas, mudflat, meadow, logging roads

graded but unpaved roads

timbered areas

unvegetated young basalt flows with little modified surfaces, eroded but barren older flows, paved (blacktop) roads, some lakes

some lakes and some paved roads

buildings, campfires, and sawmills

In summary, the infrared imagery of this area shows little of geologic interest because of overwhelming topographic control of early evening radiance and because of heavy forest cover. Lakes, lava flows barren of vegetation, paved roads, and heated cultural facilities are apparent.

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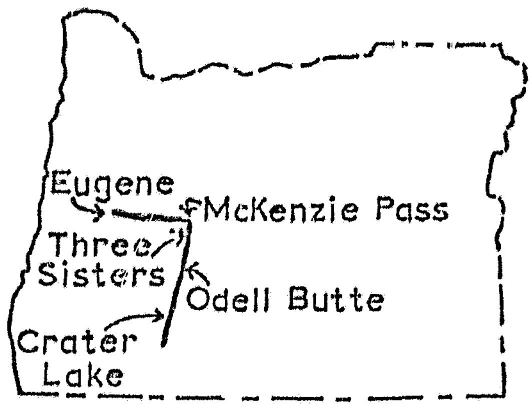

Figure 1. Index map showing path of infrared imagery and principal localities mentioned in text.

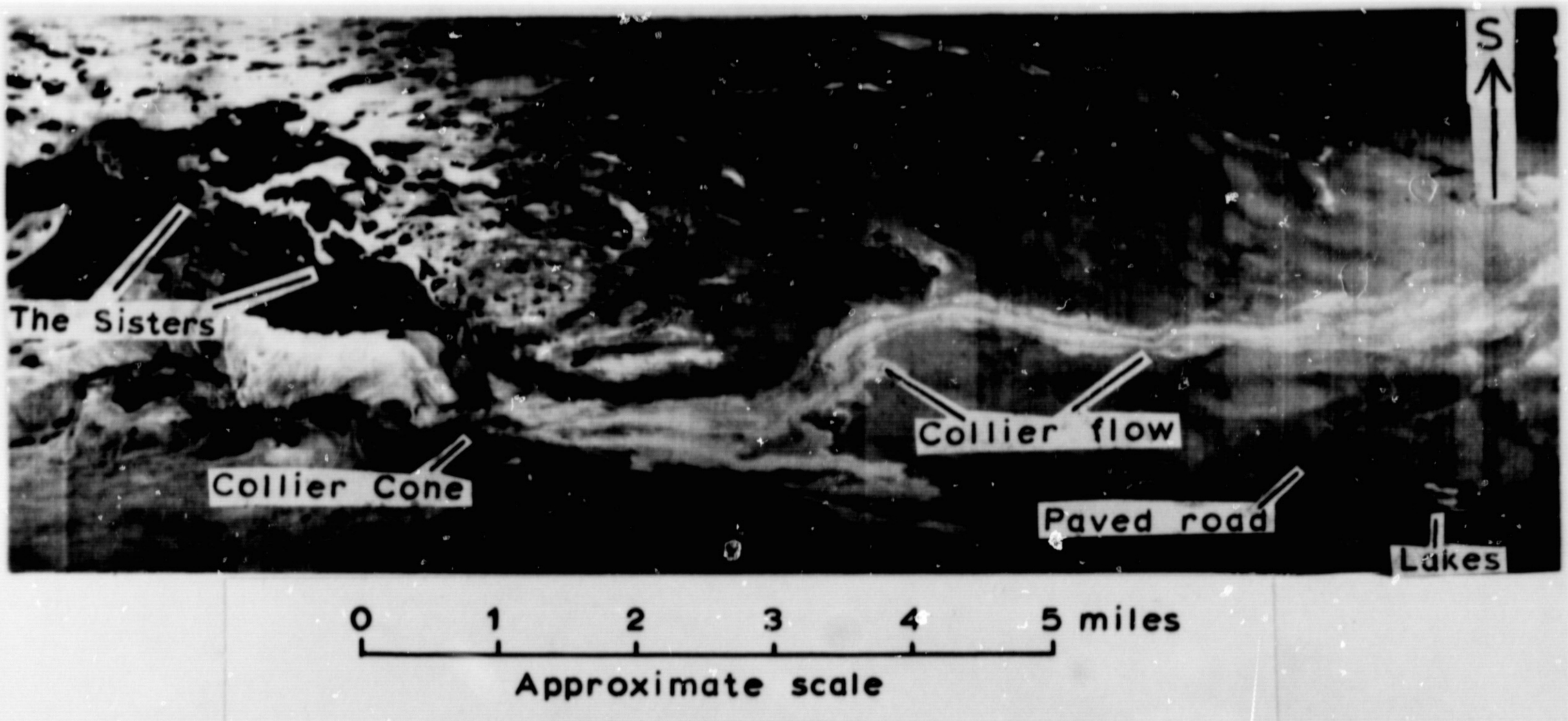

Figure 2. Photograph of infrared image of North and Middle Sister-Collier Cone area showing young, unvegetated Collier basalt flow (light gray) reaching from Collier Cone several miles down McKenzie River Valley. View looks approximately south. Note striking "shadow effect" on east-facing cliffs of North and Middle Sister, owing to strong contrast with west-facing warm slopes during twilight.

Area is timbered, except for Collier flow and high, steep slopes of North and Middle Sister.

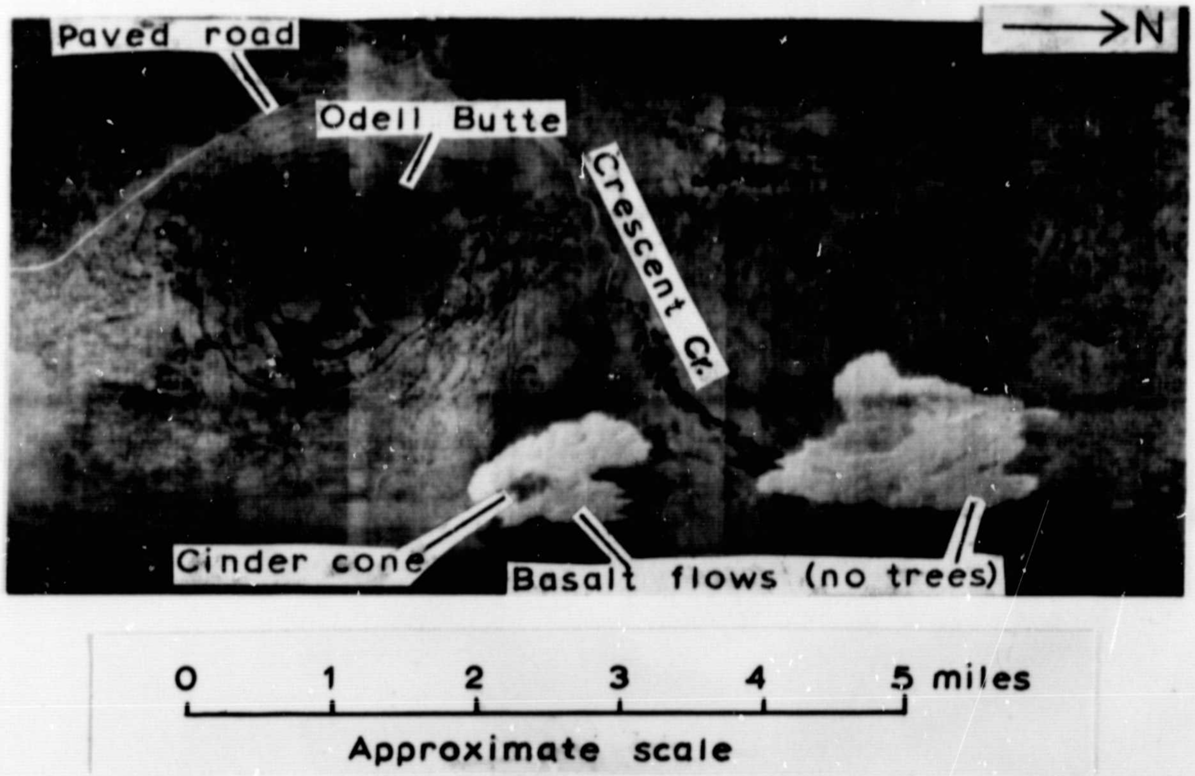

Figure 3. Photograph of infrared image of Odell Butte area. Dark concentric lines around Odell Butte are ungraded, perhaps abandoned, logging roads. White, "fluffy" patches are young, unvegetated basalt flows, and dark patch on southernmost patch is a cinder cone (see Williams, 1957). Small dark patches near north edge of photograph are probably water-soaked meadows.

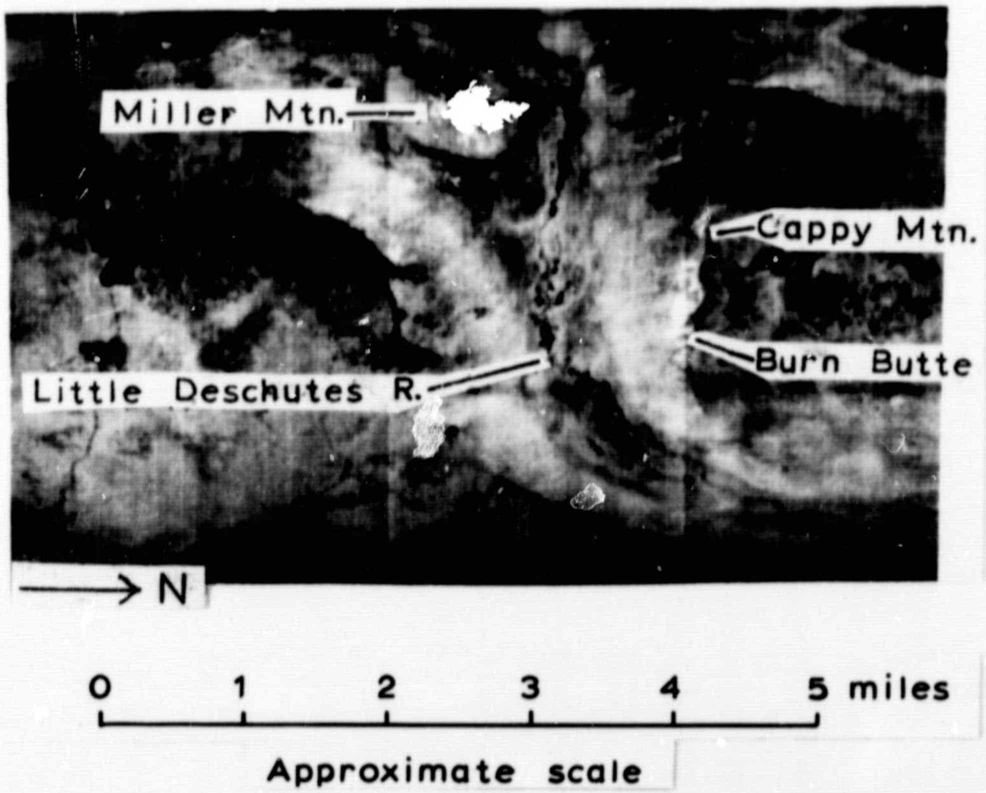

Figure 4. Photograph of infrared image of Miller and Cappy Mountains, Burn Butte, and Valley of upper Little Deschutes River. Lightest patches are Plio-Pleistocene basalt, andesite, and rhyolite, which are barren of soil cover and vegetation. Steep valley sides appear warmer (lighter gray) than surrounding heavily timbered areas, probably because the valley sides are covered by talus cones lacking much vegetation. Light line in upper left is scratch on negative. Darkest spot near south edge of photograph may be a water-soaked meadow. It is not known what the large area of intermediate darkness just north of the darkest spot represents.

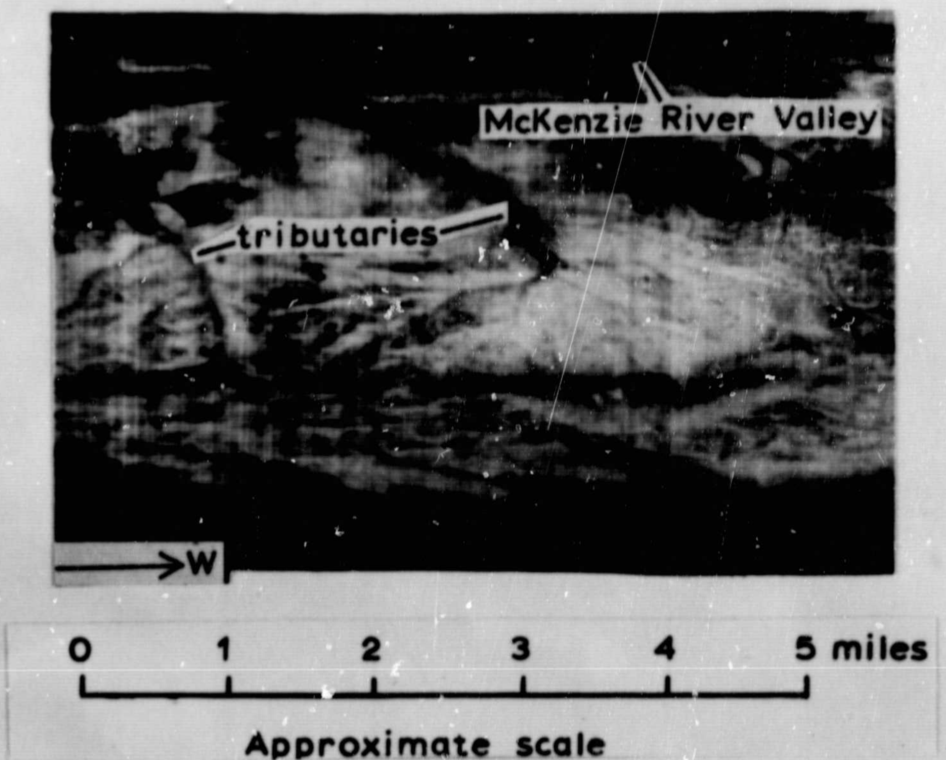

Figure 5. Photograph of infrared image of part of McKenzie River Valley and adjacent hills. Dark areas along McKenzie River and its tributaries are probably water-soaked alluvial plains and grassy marshes. Hillsides are covered with dense conifers, principally various firs.

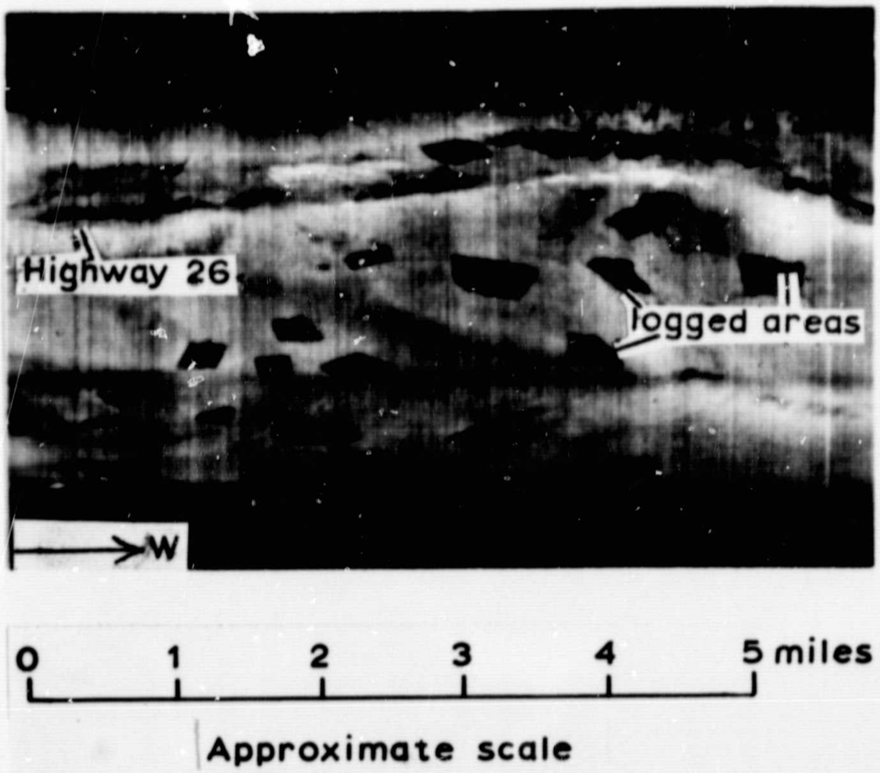

Figure 6. Photograph of infrared image of part of upper McKenzie River Valley. Dark areas are clear-cut logged areas surrounded by conifer forest. Highway 126 shows as light line in valley at left. What the light-colored areas in right part of photograph represent is not known, but they may be bare rock outcrops.

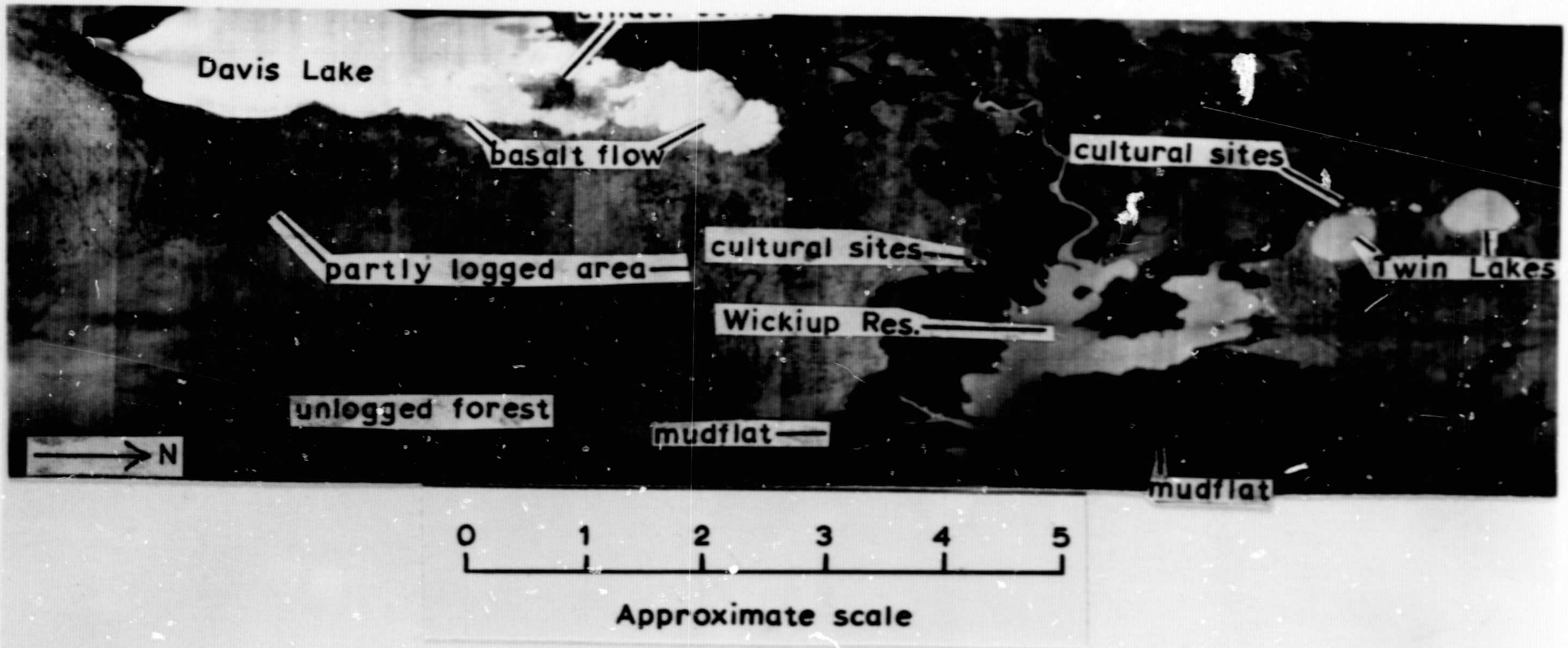

Figure 7. Photograph of infrared image of Davis Lake-Wickiup Reservoir-Twin Lakes area. The basalt flow at the north end of Davis Lake is barren of vegetation. A cinder cone perches atop it. Lakes are also light colored, but adjacent mudflats, grassy marshes, and water-soaked meadows are dark. Lightest points that cluster near south Twin Lake and Wickiup Reservoir most likely represent heated summer homes, campfires, and other cultural establishments. Dark lines south of Wickiup Reservoir are probably ungraded logging roads in various stages of usage. Area free of roads east of Davis Lake is covered by unlogged forest.