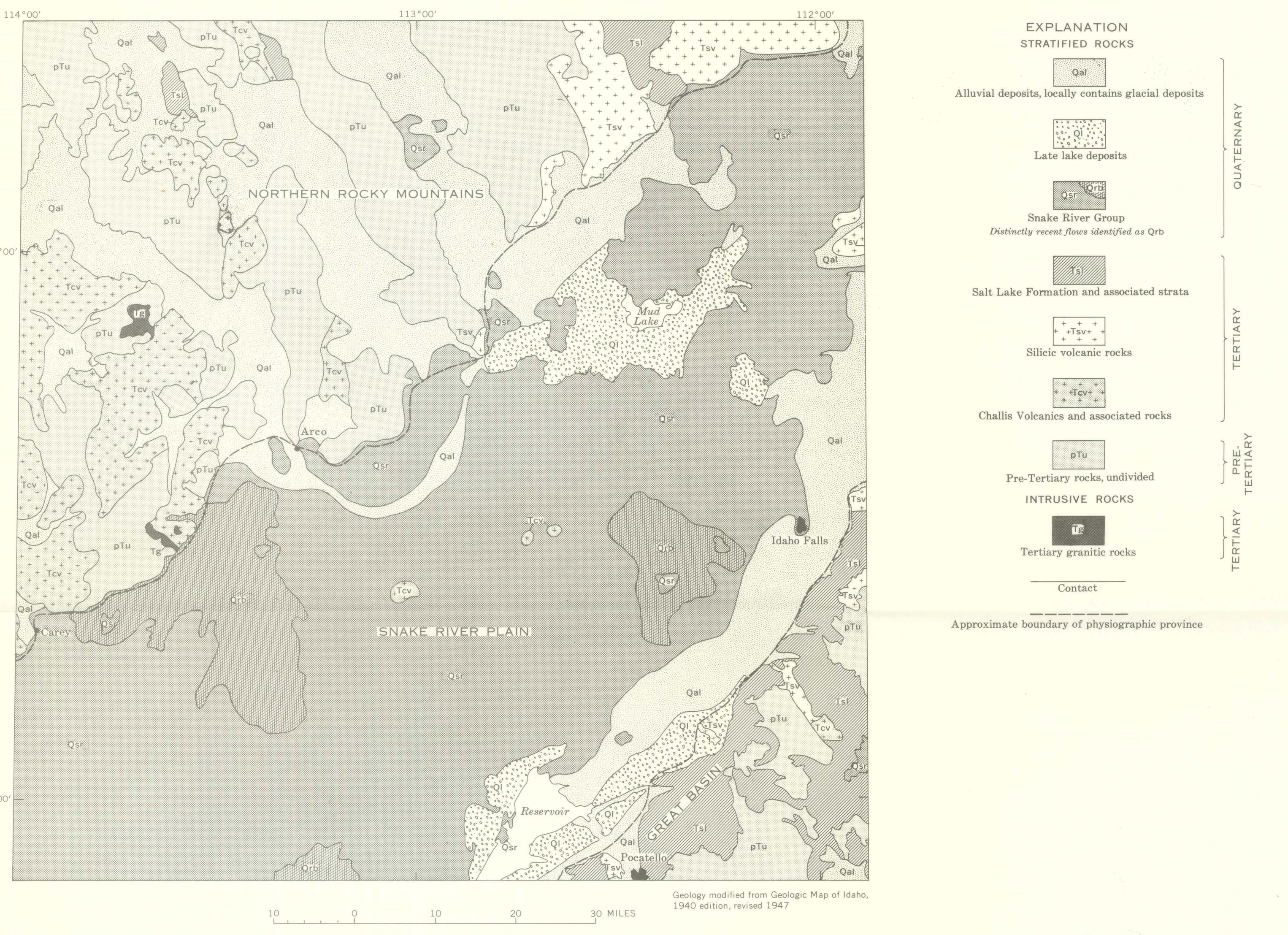
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
DIVISION OF BIOLOGY AND MEDICINE
U.S. ATOMIC ENERGY COMMISSION

GEOPHYSICAL INVESTIGATIONS
MAP GP-446



GENERALIZED GEOLOGIC MAP OF THE NATIONAL REACTOR TESTING STATION AREA, IDAHO

Aeroradioactivity and related geology

The natural gamma aeroradioactivity level within the National Reactor Testing Station (NRTS) survey area ranged from 200 to 2100 cps (counts per second). The highest radioactivity levels occur over areas of siliceous volcanic rocks along the northeastern and eastern borders of the survey area. The lowest levels occur over the lava flow southwest of Idaho Falls and the low-lying area northeast of American Falls Reservoir. Radioactivity levels over the Snake River Plain generally ranged from 400 to 800 cps with values as high as 1600 cps noted around Big Southern Butte. Aeroradioactivity not related to natural causes was measured only within the NRTS reservation, and is more comprehensively discussed in another report (Bates, in preparation).

Most of Idaho is contained within three physiographic provinces (Fenneman and Johnson, 1946). They are, from north to south, the Northern Rocky Mountains, the Columbia Plateaus, and the Basin and Range. Within the survey area the Columbia Plateaus province is represented by the Snake River Plain section, the Basin and Range province by the Great Basin section, and the Northern Rocky Mountains province is not subdivided. The rugged topography in the Northern Rocky Mountains and the Basin and Range provinces confined the airborne surveying almost entirely to the Snake River Plain. The geologic information contained in this report has been taken from the reports of many geologists. An outline report on the geology of Idaho by Ross and Forrester (1958) was most useful in correlating the work of these men.

In the Northern Rocky Mountain province complexly folded and faulted carbonate and clastic rocks of Paleozoic age unconformably overlie rocks of the Belt Series. Unconformably overlying the Paleozoic rocks are remnants of volcanic rocks of intermediate composition of middle Tertiary age. On the east flank of the Beaverhead Range silicic rocks and unconsolidated lacustrine and fluviatile sediments of late Tertiary age are exposed. Several isolated areas of Quaternary basalt are present on the east flank of the Lemhi Range. Quaternary alluvial deposits are present along the streams and form the surface of the major valleys.

The Great Basin section of the Basin and Range province contains a thick sequence of complexly folded and faulted strata of Paleozoic and Mesozoic age. These rocks are predominately carbonate rocks with lesser amounts of quartzite and sandstone and minor amounts of shale. Unconformably overlying these are rocks of late Tertiary age which include conglomerate, sandstone, shale, and marl, with some interbedded volcanic ash and tuff. Rhyolitic and basaltic flows are contemporaneous with and later than the Tertiary sedimentary rocks. Quaternary alluvium covers the flats between the mountains and the Snake River and is present along most of the streams.

The Snake River Plain passes through the survey area from the southwest corner to the northeast corner and includes more than one-half of the area. Over most of the central and southern parts of the area basalt flows are exposed or are covered by only a few feet of unconsolidated deposits. In the northeastern part of the area basalt is less commonly exposed, being covered by lacustrine and eolian deposits. Rising above the level of the basalt flows are numerous small buttes and cones, some of which were the source of the flows. Three prominent buttes, East Butte, Middle Butte, and Big Southern Butte, tower 1000 feet or more above the surrounding flows. East Butte is composed of trachyte and rhyolitic rocks, Big Southern Butte is mostly rhyolite with some basalt, and Middle Butte is entirely basalt. These three buttes are middle Tertiary in age and older than the surrounding Quaternary basalt flows. Well records indicate that the thickness of the basalt is in excess of 1500 feet in some places. The rocks of the Plain are remarkably free from faults and those present generally have displacements of 5 feet or less. Many of the flows erupted from fissures which may reflect buried faults or zones of weakness. The basalt flows contain both blocky and ropy flows, the ropy flows predominating.

Lake beds consisting of unconsolidated clay, silt, and sand occur in the area south and east of Mud Lake and extend as far west as the Birch Creek and Lost River sinks opposite the entrance of the valley of Birch Creek. These deposits cover an area of at least 140 square miles but in places are covered by loess, other eolian deposits, and Recent alluvium. Other lake deposits of lesser areal extent occur in the area north and northwest of Roberts and along the west bank of the Snake River from the southern edge of the survey area northeast almost to Pingree. Recent alluvial deposits occur along the Snake River and opposite the valleys of Big Lost River, Little Lost River, and Birch Creek.

Radioactivity levels within the Northern Rocky Mountains province are a reflection of the geology of the province. High radioactivity levels, as much as 2100 cps, 15 miles northwest of Dubois in the northeastern part of the survey area, are associated with areas of siliceous volcanic rocks and areas of alluvium derived from these rocks. The linear pattern of some of these anomalies is a reflection of the concentration of radioactive minerals in channels of intermittent streams which drain the area of siliceous volcanic rocks. A few miles north of Carey along the western edge of the map, a smaller, though equally intense anomaly is associated with exposures of the Challis Volcanics.

Owing to the rugged terrain of the remainder of the province within the survey area, parallel east-west traverse lines could not be flown. Single-line traverses were made, however, of Doublespring Pass and the valleys of Birch Creek, Little Lost River, and Big Lost River. The alluvial floor of the valley of Birch Creek was derived from arenaceous and carbonate rocks of the surrounding mountains and has a low radioactivity level. Some siliceous volcanic rocks are within the drainage area of Little Lost River and still more within the Big Lost River drainage area. This is reflected by the radioactivity data in that the average radioactivity levels within the valley of Little Lost River (500 to 600 cps) are higher than those in the valley of Birch Creek (400 to 500 cps) and levels within the valley of Big Lost River are still higher (800 to 900 cps). Opposite the mouth of Antelope Creek which drains an area of Challis Volcanics, the radioactivity level of the alluvium is 800 to 1000 cps.

Several different geologic units are present within the Snake River Plain and most are reflected in the radioactivity data. Around Mud Lake, along the northwest shore of American Falls Reservoir, and immediately north of Roberts, Quaternary lake beds have a radioactivity level of 600 to 900 or 1000 cps, which is higher than the surrounding Snake River Group and Quaternary alluvium.

Alluvial deposits northwest of Mud Lake and along the Snake River range in level from 400 to 800 cps and average about 500 to 700 cps.

Sharp radioactivity highs are present over the Challis Volcanics at Big Southern Butte and East Butte. The radioactivity level (1000 to 1600 cps) is similar to that associated with silicic volcanic rocks to the north and east.

There is considerable variation in radioactivity level of the Snake River Group. Levels range from 300 to 350 cps for the lava southwest of Idaho Falls to 700 to 1100 cps over a serrate flow in the Craters of the Moon National Monument. Both of these are relatively recent flows. The remaining older flows have a narrower range and intermediate levels of radioactivity. During the survey it was noted that a thin partial cover of alluvial and eolian material increased radioactivity levels by 50 to 100 cps over that of the adjacent bare basalt. It was also noted that the radioactivity level of blocky lava was 50 to 100 cps higher than that of nearby ropy lava. This probably does not indicate a difference in radioactive mineral content but rather is a reflection of the greater surface area exposed, per unit volume, by the blocky lava.

The delineation of some lava flows by the radioactivity data is excellent. The large relatively recent flow southwest of Idaho Falls is almost perfectly outlined by a radioactivity low with a range of 300 to 500 cps. The 800 to 900 cps high within this low surrounds a window through which soil-covered older flows are exposed. Another recent flow outlined by the radioactivity data extends north and south from Cedar Butte in the center of the Snake River Plain. The flow has a radioactivity level of 300 to 500 cps. Delineation of the flow by the radioactivity data is particularly good north of the Union Pacific tracks. The most recent flows are in the western part of the survey area and include the Craters of the Moon National Monument. The eastern and northern borders of these flows are accurately outlined by the eastern and northern edge of a 400 to 700 cps radioactivity unit. Unlike other recent flows, these flows have an intermediate to high radioactivity level and considerable variation in level from one part of the flow to another.

On the basis of the radioactivity data it is possible to draw some tentative conclusions regarding some of the recent flows. The uniform radioactivity level of the flow to the north, east, and south of Cedar Butte suggests a flow of flows from several vents with a common magma source. Commonly, the later stages of a magma are higher in radioactive mineral content than earlier stages of the same differentiating magma. Therefore, if the lava body was formed by multiple flows, they were probably closely spaced in time. The 700 to 1000 cps radioactivity unit on the west flank of Cedar Butte may represent a later-stage differentiate of the same magma body.

The lava body southwest of Idaho Falls has a uniform radioactivity level of 300 to 350 except for the small southwest extension which has a radioactivity level of 300 to 500 cps. The differing radioactivity levels may indicate two different source magmas for the body of lava, or more likely may indicate a common source with a slightly different time of outwelling, the southwest extension being the later differentiate.

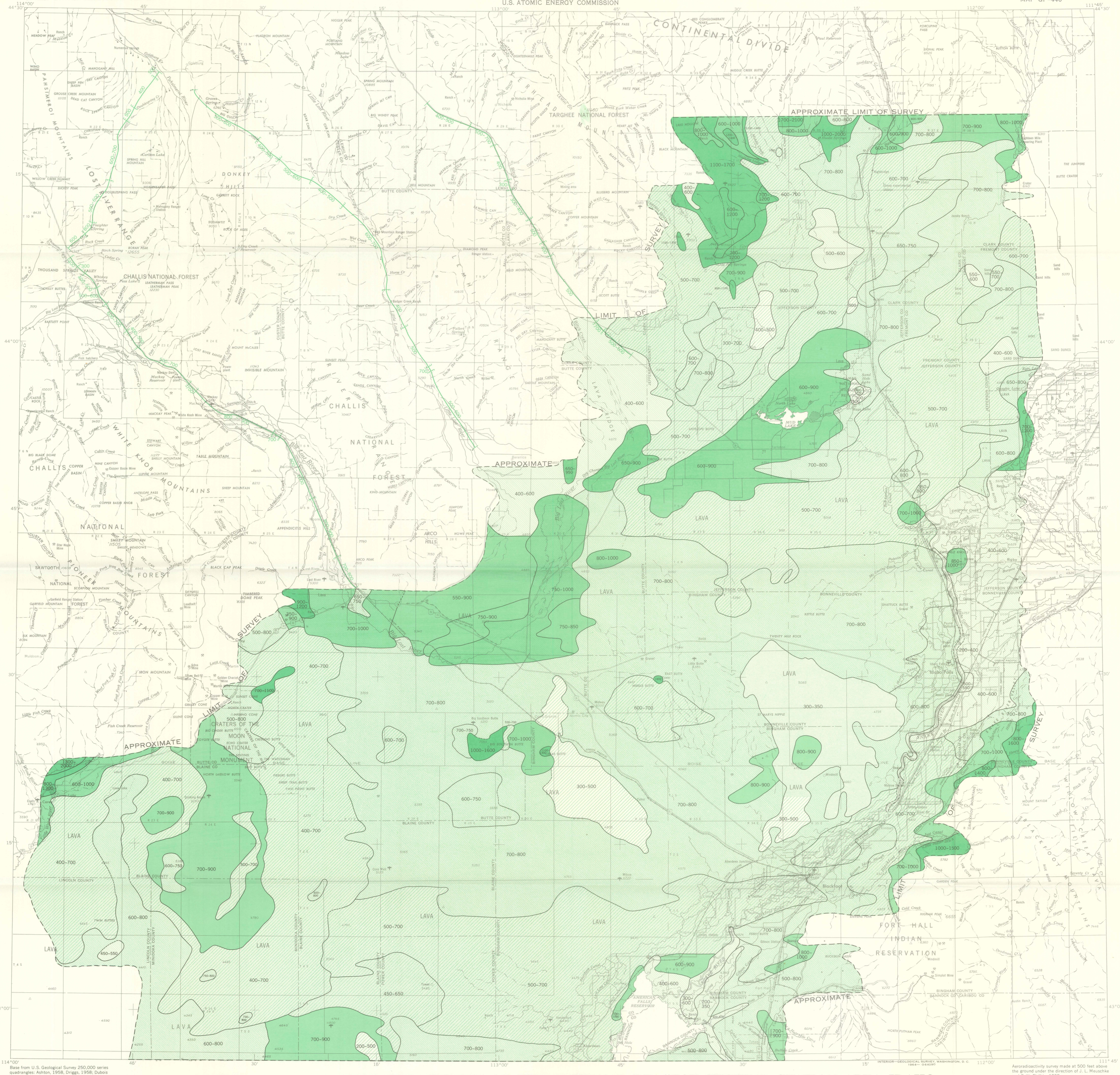
The picture is more complicated in the Craters of the Moon area. There cinder cones, lava bombs, and other products of explosive eruption are present in addition to lava flows. The radioactivity level of this flow (Qrb) increases toward the center. The outer zone has a radioactivity level of 400 to 700 cps, the intermediate zone has a level of 700 to 900 cps, and along the northern edge of the monument boundary there is a 700 to 1100 cps radioactivity unit. This could indicate an increase in radioactive mineral content in each succeeding flow due to differentiation of the magma. Considering the relatively small area involved, it probably does not indicate different magma sources. The 500 to 800 cps unit centered on the northern half of the monument is over an area in which explosive volcanic rock types predominate.

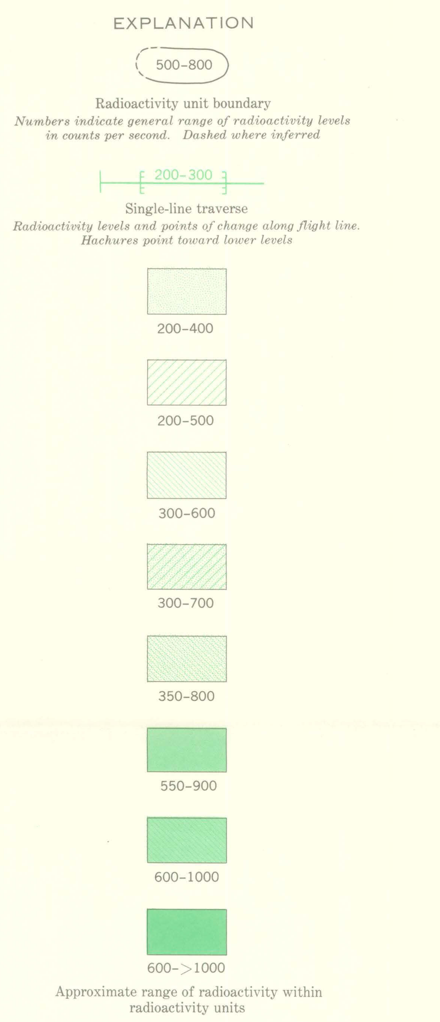
In areas flown, the Paleozoic and Mesozoic sedimentary rocks generally had a radioactivity level of 800 cps or less. All values in excess of this level are over areas of silicic volcanic rocks or areas of alluvium derived in large part from these rocks.

Bates, R. G., in preparation, Aeroradioactivity survey and areal geology of the National Reactor Testing Station area, Idaho (ARMS-I): U. S. Atomic Energy Comm. Rept. CEX-59.4.10, available from Office of Technical Services, Dept. of Commerce, Washington, D. C., 20235.

Fenneman, N. M., and Johnson, D. W., 1946, Physical divisions of the United States: U. S. Geol. Survey map, 1:7,000,000.

Ross, C. P., and Forrester, J. D., 1958, Outline of the geology of Idaho: Idaho Bur. Mines and Geol., Bull. 15.





EXPLANATORY TEXT

The survey was made with scintillation-detection equipment (Davis and Reinhardt, 1957) installed in a twin-engine aircraft. Parallel east-west flight traverses spaced at one-mile intervals were flown at a nominal altitude of 500 feet above the ground. The flight path of the aircraft was recorded by a gyrostabilized continuous-strip-film camera. The radioactivity data were compensated for deviations from the 500-foot surveying altitude, and for the cosmic-ray component.

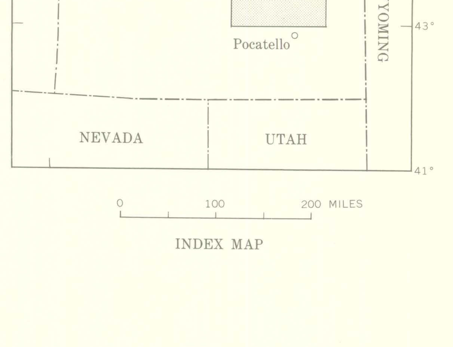
The effective area of response of the scintillation equipment at an altitude of 500 feet is that encompassed by a circle approximately 1000 feet in diameter, and the radioactivity recorded is the average radioactivity of that area. The scintillation equipment records only pulses from gamma radiation with energies greater than 50 kev (thousand electron volts). A cesium-137 source is used during periodic calibrations to assure uniformity of equipment response.

The gamma-ray flux at 500 feet above the ground has three principal sources: cosmic radiation, radionuclides in the air (mostly radon daughter products), and radionuclides in the surficial layer of the ground. The cosmic component is determined twice daily by calibrations at 2000 feet above the ground, and is removed from the radioactivity data.

The component due to radionuclides in the air at 500 feet above the ground is difficult to evaluate. It is affected by meteorological conditions, and a tenfold change in radon concentration is not unusual under conditions of extreme temperature inversion. However, if inversion conditions are avoided, the air component may be considered to be fairly uniform on a given day in a particular area, and will not mask the differences in radioactivity levels that reflect changes in the ground component.

The ground component comes from the approximate upper few inches of the ground. It consists of gamma rays from natural radionuclides, principally members of the uranium and thorium radioactive decay series and potassium-40, and fallout of radioactive nuclear-fission products. Locally the amount of fallout, if present, must be small, as the lowest total radioactivity measured is 200 counts per second in areas not affected by absorption of gamma rays by water. The distribution of fallout in the area surveyed is assumed to be uniform.

Davis, F. J., and Reinhardt, P. W., 1957, Instrumentation in aircraft for radiation measurements: Nuclear Sci. and Eng., v. 2, no. 6, p. 713-727.



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Base from U.S. Geological Survey 250,000 series quadrangles: Ashton, 1958; Driggs, 1958; Dubois 1958; Idaho Falls, 1958; Pocatello, 1958; and Preston, 1958

Aeroradioactivity survey made at 500 feet above the ground under the direction of J. L. Meuschke and P. W. Philbin, 1959

NATURAL GAMMA AERORADIOACTIVITY OF THE NATIONAL REACTOR TESTING STATION AREA, IDAHO

By
Robert G. Bates

SCALE 1:250 000

1964

For sale by U.S. Geological Survey, price 75 cents