deficiency corresponding to the gravity low was determined to be about $5 \times 10^{18}$ g, which is equivalent to 4,000 cubic miles of material 0.3 g per $cm^3$ less dense than the surrounding material. If this volume of material is spread over a circular area 40 miles in diameter, the average thickness would be nearly 20,000 feet.

The Yellowstone Plateau gravity data could also be explained in part by (a) a thickening of the low-density silicic upper part of the earth's crust from, say, 15 to 21 km, (b) a magma chamber, or (c) a silicic batholith.

Hamilton (1959, p. 228) has suggested that the rhyolites of the Yellowstone Plateau " * * * may be the upper crust of a lopolith which has been forming with a complex history since early Pliocene time, an extrusive lopolith roofed by its own differentiates, its mafic bulk hidden beneath its felsic cover * * *". The mafic bulk of such a lopolith would presumably be dense, especially if it is the mafic fraction of which the silicic differentiate has a mass deficiency as large as $5 \times 10^{18}$ g. The lack of a positive gravity expression of such a dense mass, assuming that it immediately underlies the rhyolite, must mean that the proposed lopolith does not exist. If the rhyolite differentiated from a mafic magma, it was at such a great depth that the gravity expression of the mafic fraction is overwhelmed by the gravity low of the near-surface low-density rocks of the Yellowstone Plateau. Alternatively, the rhyolites of the Yellowstone Plateau could have been formed from silicic magma generated by partial fusion of relatively shallow crustal rocks.

The gravity data are consistent both with F. R. Boyd's (written communication) conclusion that the Yellowstone Plateau marks the site of a gigantic caldera formed by collapse into a huge underlying magma chamber which may still exist, and with Daly's (1933, p. 142–143) suggestion that the rhyolite may be the foundered crust of a roofless batholith of low density, that is, a silicic batholith.

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## 105. GRAVITY, VOLCANISM, AND CRUSTAL DEFORMATION IN THE SNAKE RIVER PLAIN, IDAHO

By D. P. Hill, Harry L. Baldwin, Jr., and L. C. Pakiser, Denver, Colo.

A net of gravity recordings was established over 6,800 square miles of the Snake River Plain in southwestern Idaho during 1959 and 1960.

The western Snake River Plain is a relatively flat lava plain that trends northwest and ranges in width from 40 to 100 miles. It is bounded on the southwest by the Owyhee Mountains and on the northeast by the mountains of the Idaho batholith. The average elevation of the plain is about 3,000 feet above sea level.

The highlands immediately to the north and south of the plain are composed mainly of silicic volcanic rocks of early Pliocene age and of granite of Cretaceous age. A veneer of basalt flows of middle Pliocene age covers the silicic volcanic rocks in the lower elevations. The western Snake River Plain is a graben filled with Pliocene and Pleistocene sedimentary rocks and interbedded basalt flows to a depth of at least 3,000 feet below the surface of the plain (H. E. Malde and H. A. Powers, written communication, 1961). Subsidence of the graben took place along a series of faults trending northwest. The most prominent fault zone forms a sharp escarpment along the northern edge of the Snake River Plain. Malde (1959) estimates that the aggregate throw along this zone is at least 9,000 feet.

The net of 1,859 gravity stations has an average density of one station per 3.7 square miles. The

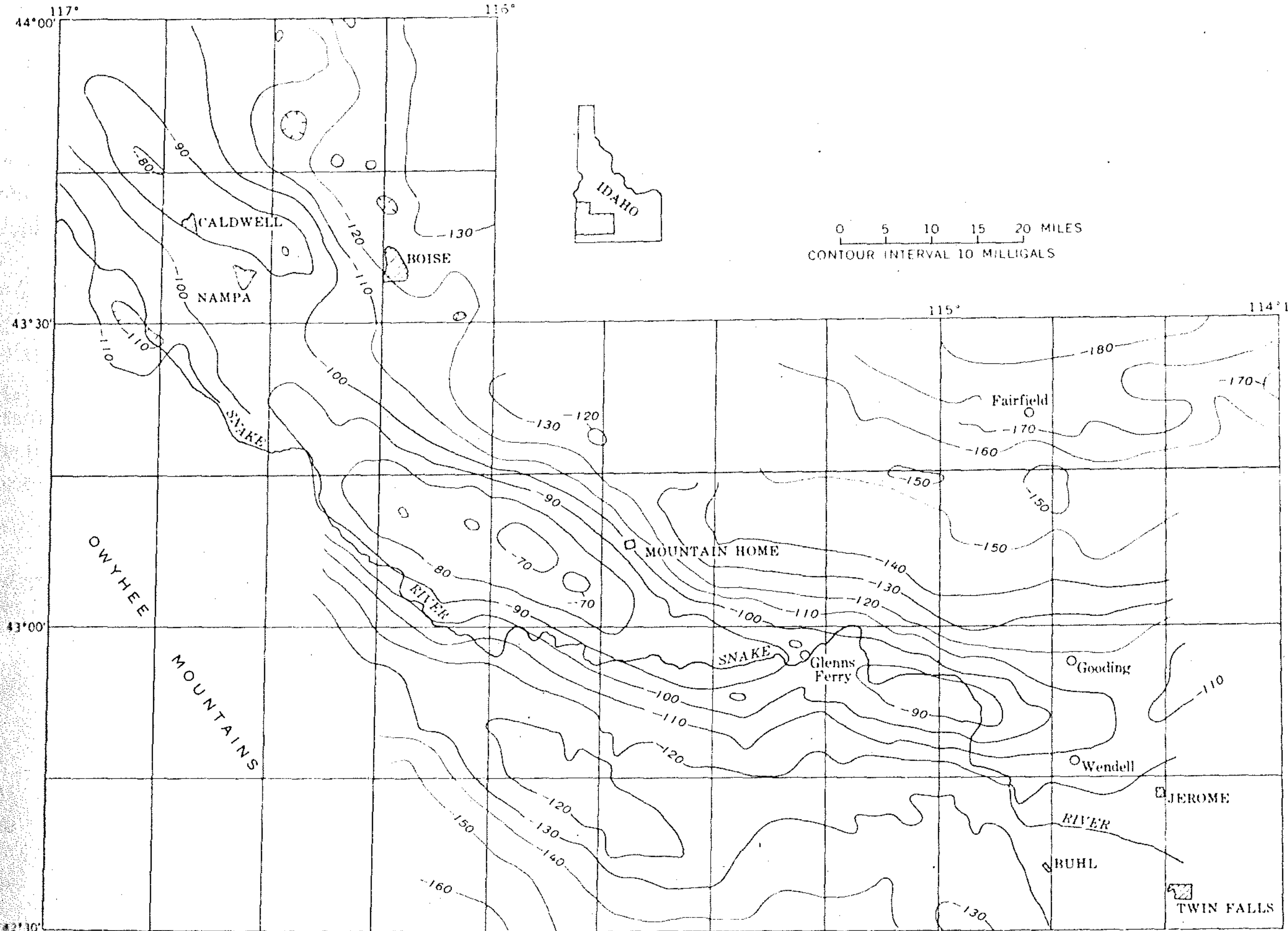


FIGURE 105.1.—Simple-Bouguer gravity map of part of the Snake River Plain, Idaho.

vertical and horizontal control for the survey was taken from Geological Survey 7½- and 15-minute topographic maps. The gravity data were reduced to simple-Bouguer values assuming a density of 2.67 grams per $cm^3$ down to sea level. These simple-Bouguer values are represented as gravity contours plotted at a 10-milligal contour interval on figure 105.1.

The major anomalies form three elongated, en echelon gravity highs, oriented in a northwest direction. The axes of the gravity highs are parallel to the major fault zones of the region.

The central gravity high is the largest of the three; it extends for 95 miles from Wendell northwestward to about 10 miles south of Nampa, has a maximum amplitude of about 70 mgals, and a maximum simple-Bouguer gravity of −66.5 mgals. Gradients are steepest on the northeast side of the anomaly, reaching 6 to 8 mgals per mile in places. The high is divided into two parts in the vicinity of Glenns Ferry, Idaho. The eastern section of the high is slightly offset to the northeast with respect to the western section.

The northern and southern gravity highs are similar in outline and amplitude; both are approximately 35 miles long and have amplitudes of about 20 mgals. The northern high is offset about 15 miles northeast from the central high, and the southern high is offset about the same distance southwest from the central high.

Preliminary two-dimensional analyses, based on an assumed density contrast of 0.3 grams per $cm^3$, have been made along several profiles normal to the axes of the gravity highs. These analyses take into account the fact that the gravity highs are over the relatively low-density sedimentary deposits of Pliocene and Pleistocene age. The tops of the anomaly-causing bodies are at least 3,000 feet below the surface as the thickness of these sedimentary deposits is known. Results of the two-dimensional analyses suggest that the anomaly-causing bodies extend at least 16,000 feet below sea level and may reach 60,000 feet below sea level, depending on how the shape of the bodies and the regional gravity are assumed. In the preferred interpretation the disturbing masses are approximated by tabular bodies, the largest about 90 miles long, 4 to 6 miles wide, and extending from about 5,000 to 60,000 feet below sea level.

A graphical integration using Gauss's theorem over the surface of the gravity map was used to estimate the total mass excess of the anomalous bodies. A mass excess of about $1 \times 10^{19}$ grams, or $1 \times 10^{13}$ tons, is obtained if the simple-Bouguer background is taken as −120 mgals. The volume of this mass excess for material 0.3 grams per $cm^3$ more dense than the surrounding material would be approximately 8,000 cubic miles.

Several geological hypotheses have been offered in explanation of the gravity highs. The most important of these are:

1. The Snake River Plain is a broad downwarp that has been filled with extensive basalt flows.
2. The plain is a graben bounded by faults with large vertical displacements. Volcanism has accompanied the subsidence. The resulting lava flows filled the depression, yielding thick accumulations of basalt.
3. Crustal stresses have caused large en echelon fissures under the Snake River Plain. These fissures have been injected with basalt or basalt-like material.

In light of the evidence presented in this paper, the authors believe that the anomalies are explained by a combination of the second and third hypotheses.

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## 106. GRAVITY, VOLCANISM, AND CRUSTAL DEFORMATION IN LONG VALLEY, CALIFORNIA

By L. C. PAKISER, Denver, Colo.

*Work done in cooperation with the California Division of Mines*

A gravity survey made during 1955 and 1956 in and around Long Valley, Mono County, Calif., led to the discovery of a pronounced elliptical gravity low bounded by steep gradients that coincide approximately with the margin of the basin and with the exposed boundary between Cenozoic volcanic and sedimentary rocks and pre-Tertiary crystalline rocks. The area of the anomaly inside the zone of steep gradients is about 150 square miles, the steepest gradient on the east end of the anomaly is 20 mgals per mile, and the maximum local gravity relief is 78 mgals (fig. 106.1). This is the largest local difference in gravity in the Great Basin reported to date. A prominent gravity high, only suggested at the 10-mgal contour interval of the gravity map (fig. 106.1), was found near the center of the gravity low a short distance west of the intersection of sections *A–A′* and *B–B′*.

An aeromagnetic survey of the Long Valley area was flown in 1956.

The areal geology shown on figure 106.1 has been generalized from reports by Gilbert (1941), and Rinehart and Ross (1957), and from unpublished work between 1952 and 1959 by C. D. Rinehart, D. C. Ross, and N. K. Huber (C. D. Rinehart, written communication). I am grateful to Mr. Rinehart for permission to use the results of the geologic mapping in this study.

### RELATIONS OF GRAVITY AND GEOLOGY

Gravity tends to be high over exposures of pre-Tertiary rocks and relatively low over areas where Cenozoic deposits are found at the surface (fig.