A gravity survey of part of the Long Valley district, Idaho

By

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Introduction

Gravity surveys have been used extensively to obtain subsurface information in the intermontane basins of the western conterminous United States. The density contrast that usually exists between Cenozoic deposits in the basins and pre-Tertiary bedrock produces negative gravity anomalies, which can be interpreted in terms of subsurface structural features and bedrock configuration.

During the summer of 1957, 180 gravity stations were established in a part of Long Valley and all of Cascade Valley and Round Valley to obtain information on the surface configuration of the bedrock. The survey was made in support of geologic investigations of the monazite placer deposits by J. H. Mackin and D. L. Schmidt.

Gravity survey and reduction of data

Gravity stations, spaced at intervals ranging from a quarter of a mile to two miles apart, were established along roads in the valleys and at other points identified on topographic maps. Elevations of the stations were determined by leveling, stadia traverses and by means of photogrammetric methods using aerial photographs. The gravity observations were made using a Worden gravimeter with a sensitivity of about 0.5 mgal per scale division.

Gravity differences were measured relative to a base station, established in Cascade at the beginning of the survey and assigned an arbitrary observed gravity value. Base readings were repeated at intervals of 4 or 5 hours during the day to determine the combined instrumental drift and tidal variations. The gravimeter readings were corrected for drift, latitude, elevation and near station topographic effects. A factor of 0.06 mgal per foot, based on an average rock density of 2.67 g per cc, was used as the combined free-air and Bouguer correction. The assumed density of 2.67 g per cc is representative of the granitic rock in which the greatest range in elevation takes place. Maximum error in the Bouguer anomaly that could occur at any station owing to combined errors in horizontal location, elevation and observed gravity is probably not greater than 0.7 mgal.

Topographic corrections were made through the "J" zone of the Hammer chart (Hammer, 1939, p. 184-194), which corresponds to a 4.1 mile radial distance around each station. Through "J" zone, the topographic corrections for most of the stations in the valleys are less than 1.0 mgal, and maximum correction for stations in the mountains is 15 mgals. Topographic corrections for zones outside of the "J" zone probably do not differ between adjacent stations by more than 0.5 mgal. It is believed that the topographic corrections are not in error by more than 10 percent for the zones corrected.

Bouguer anomaly map

The Bouguer anomaly map with a contour interval of 2 mgals and the simplified geology are shown in figure 1 with the exception of local lows in Long and Cascade Valleys, the gravity values generally decrease toward the east at the rate of about 3 mgals per mile. High gravity gradients generally occur along the west sides of the valleys.

The map shows two noticeably different gravity contour patterns in Long Valley. There is a closed gravity low of about 27 mgals residual relief in the northern half of Long Valley, and eastward decreasing gravity values in the southern part. Although the gradient in the southern part of the valley is nearly uniform, it is slightly higher along the west side of the valley.

In Cascade Valley there is a high gradient along the west side and two closed gravity lows in the interior. The northern low occupies the northern one-third of the valley and has a residual gravity relief of about 12 mgals.

No measurable local gravity anomaly was found in Round Valley. The map shows a constant gravity gradient across Round Valley that is of about the same magnitude as the regional gradient across Cascade Valley.

Analysis of gravity anomalies

Two dimensional analyses similar to that described in Dobrin (1952, p. 96-99) were made of two gravity profiles crossing Long and Cascade Valleys. The locations of these profiles, A-A' near Donnelly, and B-B' about 3 miles south of Cascade, are shown on the Bouguer anomaly map. These profiles cross parts of the valleys where the valley fill is believed to be the thickest.

After removing an assumed linear regional gradient, the profiles were analyzed to determine a reasonable subsurface bedrock configuration that would produce the residual anomaly. The magnitude of the relief on the bedrock shown by the analysis is largely dependent upon the choice of the density contrast between the bedrock and the Cenozoic sediments. The bedrock in this area is the granitic rock of the Idaho Batholith and, except where weathered, its density is about 2.7 g per cc. It is not possible to determine accurately the density of the valley fill, which is considerably less than the bedrock, probably about 2.2 g per cc. The assumed density contrast of 0.5 g per cc between the bedrock and valley fill has been found to be generally applicable in other gravity surveys in the intermontane basins of the western United States (Thompson and Sandberg, 1958; Kane and Pakiser, 1961). Although the actual density contrast may differ by as much as 0.2 g per cc, the determined depths will be of the proper magnitude and the general bedrock configuration determined will be reliable. The o.5 g per cc density contrast probably represents an average density contrast.

The observed profile could be produced by the hypothetical geologic cross section shown along profile A-A' (fig. 2). On this diagrammatic cross section, two normal faults bound the north Long Valley block on the east and west. The analysis indicates that about 7,000 feet of sediments are in fault contact with bedrock near the base of West Mountain, and about 2,000 feet of sediments are in fault contact at the east edge of the valley. If the fault at West Mountain were replaced by a series of near vertical step faults similar to those shown by the dashed lines, the cross section would still be consistent with the gravity data.

Sufficient data for a detailed analysis over the southern part of Long Valley was not obtained because most of the area is covered by the Cascade Reservoir. A depth estimate based on the gravity attraction of an infinite, horizontal slab indicated a sediment thickness of 1,200 feet at Point "C" near the west edge of the reservoir.

Analysis of the eastern part of profile B-B' (fig. 3) across Cascade Valley indicates about 3,000 feet of sediments in fault contact with bedrock at the west edge of the Valley. The sediments thin eastward to the east edge of the valley where approximately 2,500 feet of sediments are in fault contact with bedrock..

Discussion of interpretation

Long Valley and Cascade Valley are structural basins bounded on all sides by steeply dipping normal faults. The gravity anomalies indicate that the basins are asymmetrical and that their deepest parts are along the west sides. Positions of the faults and the westward deepening of the basins suggest that the basins are tilted fault blocks.

Long Valley is divided into two approximately equal fault blocks. The fault block in northern Long Valley is bounded on the west by the West Mountain fault. Gravity data suggest that the southwest boundary of the block is formed by a branch of the West Mountain fault which trends southeast across Long Valley from the mountain front about 4 miles southwest of Donnelly. A fault indicated by a high gravity gradient about 2 miles east of Donnelly is probably the east boundary. There is no surface expression of either the southwest or east boundary faults. The southeast boundary of the fault block may be provided by a southwest trending fault mapped by Mackin and Schmidt; however, it is not indicated by the gravity data. This fault occurs almost entirely within bedrock, and this would explain the absence of gravity expression, because there is not a sufficient density contrast to cause a measurable gravity anomaly.

The fault block in southern Long Valley includes most of the area covered by the Cascade Reservoir and the bedrock ridge between Long and Cascade Valleys. This fault block is bounded on the west and southwest by the West Mountain fault, and on the east by the East Cascade Fault. The southeast trending branch of the West Mountain fault mentioned previously is common to both fault blocks in Long Valley. The absence of a pronounced gravity low over this fault block indicates a section of sediments much thinner than that over the north Long Valley fault block.

The small closed gravity low in northern Cascade Valley with a high gravity gradient along its western edge is interpreted as an expression of a shallow basin, deepest along the western edge where it is bounded by the East Cascade Fault. There is no indication in the gravity data of faulting along the eastern edge of this part of the valley. An eastward-trending fault at the Cascade Reservoir spillway mapped by Mackin and Schmidt and suggested by the gravity map, terminates the basin on the south. Left-lateral movement along this fault is indicated by the offset between this basin and another to the south.

A postulated fault block in southern Cascade Valley includes all of the valley south of the east trending fault at the reservoir spillway. The East Cascade Fault which is common to the fault blocks in southern Long Valley and southern Cascade Valley, is shown by the high gravity gradient that trends along the Union Pacific Railroad south of Cascade. The east boundary of this fault block is a north-trending fault along the east side of the valley.

Conclusions

The results of gravity and geologic mapping indicate that Long and Cascade Valleys are structural basins. The estimated 7,000 foot thickness of fill in north Long Valley is large for a basin only 6 miles wide. It is believed, however, that the method of analysis used provides a minimum depth. Depths and configurations of at least the major bedrock features obtained in the analysis are consistent with the gravity data and geologic information available.

A regional gravity gradient of about 3 or 4 mgals per mile with lower anomaly values to the east is present in the area. A small part of this gradient can be explained by distant topographic effects. The remaining part of this regional gradient may be caused by the gravity effect of the western border of the Idaho Batholith, or possibly it is the expression of a systematic decrease of density of the outer rock belts of the batholith mentioned by Schmidt (1958).

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This map is preliminary and has not been edited for conformity with Geological Survey format and nomenclature.

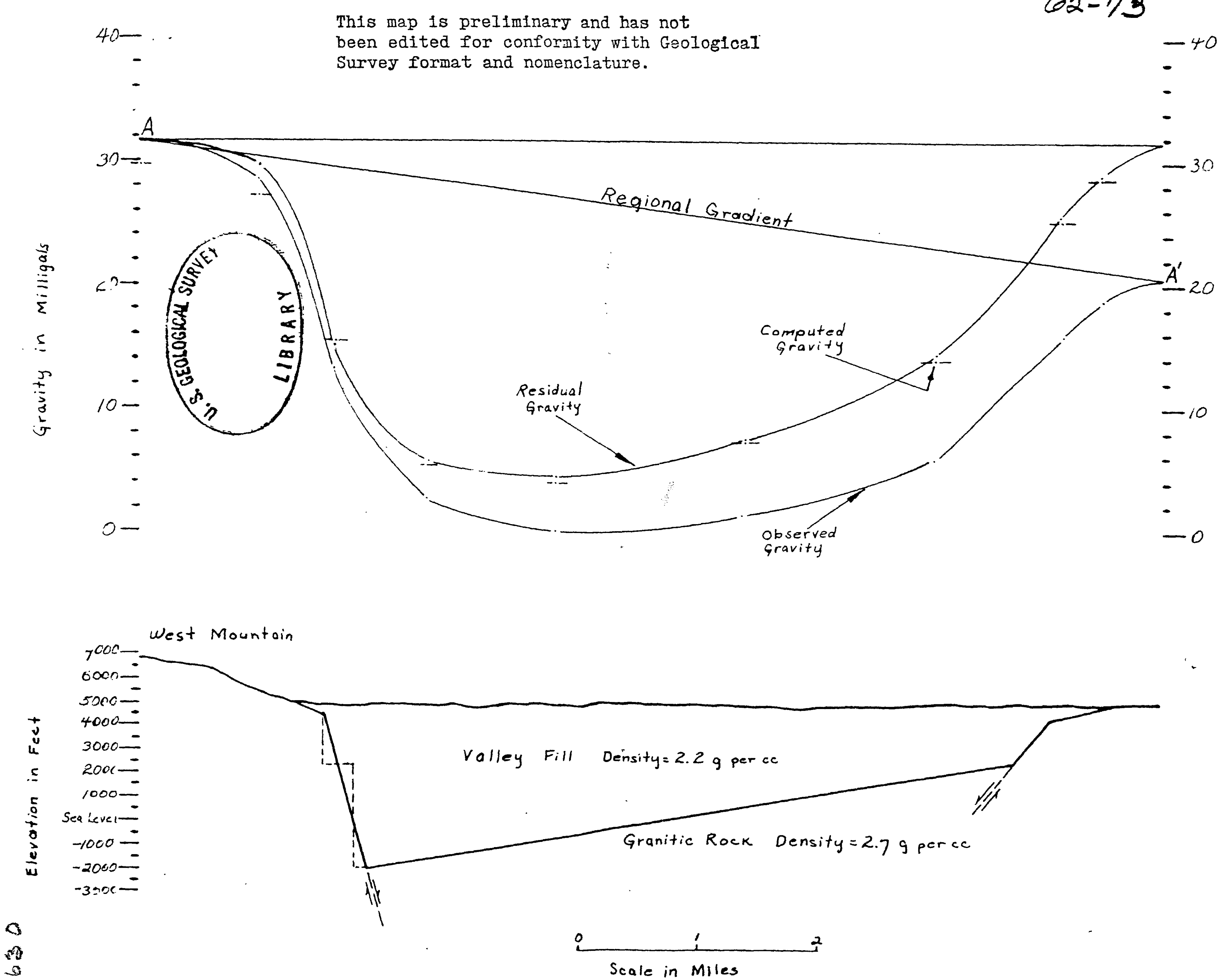

Fig. 2 Geologic cross section and Bouguer anomaly profile along line A-A'

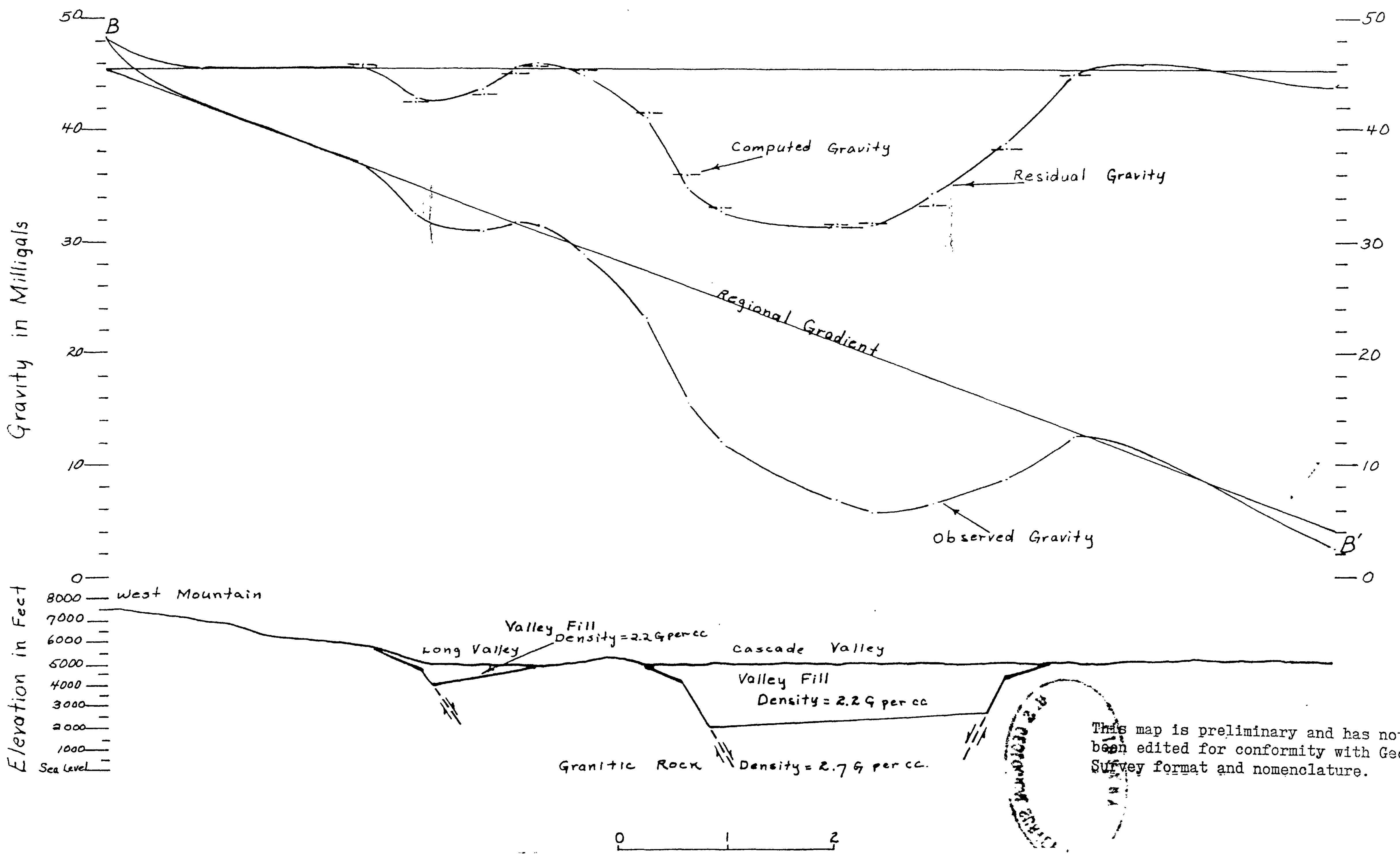

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Fig. 3 Geologic cross section and Bouguer anomaly profile along line B-B'