BOUGUER GRAVITY MAP OF NEVADA WINNEMUCCA SHEET

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INTRODUCTION

The accompanying map is a compilation of gravity data on the Winnemucca sheet of the U. S. 1:250,000-scale (formerly A.M.S.) topographic map, which covers an area in north-central Nevada between 40° and 41° North latitude and 116° and 118° West longitude. The area includes parts of Elko, Eureka, Humboldt, Lander, and Pershing Counties. The data were compiled by using gravity stations obtained by the U. S. Army Map Service, U. S. Air Force, U. S. Geological Survey, University of Wisconsin, and the Nevada Bureau of Mines and Geology. Gravity information in the eastern third of the Winnemucca sheet area was previously published by Mabey (1964), and that in the central third by Erwin (1967), as indicated in the accompanying index map. Other gravity work immediately to the southwest of the Winnemucca sheet area is by Thompson (1959), and Wahl (1965).

Values of gravity observed by the several surveys were adjusted to the datum of the U. S. Air Force gravity base network (1970). Additional stations to complete the gravity coverage were obtained by the author, assisted by Edward W. Bittlesten, geological technician, Nevada Bureau of Mines and Geology. Field work to make the datum adjustments and to obtain the additional gravity stations was conducted during the period 1971 to 1973.

This project is part of a continuing geophysical program concerned with problems of mineral exploration, groundwater studies, environmental studies, and the gathering of basic data for the better understanding of the geology of the Basin and Range province.

Gravity surveys provide information that can be utilized in several ways for a better understanding of the geologic structure of the area. First, they are useful in defining alluvial-covered pediments that may contain buried extensions of known mineralized areas in adjacent bedrock blocks. Second, because of the relatively high density contrast between Quaternary alluvium and underlying denser rocks, it is possible to determine thicknesses of the alluvial deposits, knowledge that is very useful in groundwater studies. Third, knowledge of the distribution and thickness of low-density Tertiary and Quaternary rocks may also be useful in the study of hazards related to strong ground motion.

FIELD METHODS AND DATA REDUCTION

Standard geophysical methods (Nettleton, 1940) were used by the Nevada Bureau of Mines and Geology to establish new gravity stations and adjust to the datum. Two Worden gravimeters with sensitivities of 0.09606 and 0.4655 mgal per scale division were used simultaneously in much of this work. The gravity data are referenced to two U. S. Air Force gravity base stations: one at the Winnemucca airport, 40° 54.23′ North latitude, 117° 48.21′ West longitude, with an absolute gravity value of 979.82429 gals; and one at the Battle Mountain airport, 40° 36.44′ North latitude, 116° 52.43′ West longitude, with an absolute gravity value of 979.76862 gals. A base station network referenced to these Air Force stations, was established for the work by the author.

Stations were established by the author at bench marks, section corners, and other points shown on U. S. Geological Survey topographic maps. At a few stations where other control was not available, elevations were established by Paulin altimeter. Such stations are generally within a mile of known control and were not used as base stations for establishing other gravity points.

The data were reduced to sea level by using a reduction density of 2.67 g per cm^3 for rocks above sea level. Bouguer gravity values of the base-station network established by the author were obtained by using the International Gravity Formula $g = 978.0490\ (1 + 0.0052884 \sin^2 \theta - 0.0000059 \sin^2 2\theta)$. Standard latitude corrections were applied to gravity stations other than base stations. Partial terrain corrections were computed for stations in the more mountainous areas of the Fish Creek, Tuscarora, and Independence Mountains, and the Sonoma, Tobin, and East Ranges. The terrain correction is small in the valleys, in the order of 1 to 2 mgal, but in the higher mountain areas some corrections of about 10 mgal were necessary. The terrain correction system of Hammer (1939) was used. Computations were calculated to a distance from each station sufficient to leave a remainder of about 2 mgal. Although distortion due to terrain effect is present in the gravity map, it is felt that such distortion is not severe when a 5 mgal contour interval is used.

GENERAL GEOLOGY

The oldest rocks in the area are sedimentary and volcanic rocks of Paleozoic age. These can be divided into five assemblages: a lower Paleozoic eastern miogeosynclinal assemblage, composed of limestone and dolomite; a lower Paleozoic transitional assemblage, composed of interbedded limestone, clastic and volcanic rocks; a lower Paleozoic western eugeosynclinal assemblage composed of siliceous and volcanic rocks; an overlap assemblage composed of Mississippian to Permian clastic rocks; and a western oceanic assemblage composed of Mississippian to Permian siliceous and volcanic rocks (see Roberts, 1964; Roberts, and others, 1967; Stewart and McKee, 1970; Stewart and Carlson, unpublished data). On the accompanying map, the eastern miogeosynclinal and transitional assemblages are shown as one unit. These assemblages are exposed in the Sulphur Spring Range, the Simpson Park, Cortez, and Tuscarora Mountains, the Shoshone and the Sonoma Ranges, and the Osgood Mountains. The western eugeosynclinal assemblage is exposed throughout the map area. Exposures of the overlap assemblage are found in the Pinon Range and in Cortez and Battle Mountains. The western oceanic assemblage is exposed throughout the western half of the area. In general, all the Paleozoic assemblages are in complex thrust sheet and fault block relationships.

Mesozoic rocks, chiefly carbonate, clastic, and volcanic rocks, are exposed in the Cortez and Fish Creek Mountains, and the Tobin, Sonoma, and East Ranges. A leucogranite of Permian or Triassic age is exposed at Granite Mountain at the south end of the East Range. A Jurassic gabbroic complex with associated sedimentary rocks is present in the Stillwater Range in the southwest corner of the area (Tatlock, 1969). Intrusives of intermediate composition, ranging from Jurassic to early Tertiary in age, are exposed in most of the ranges of the area.

Tertiary sedimentary rocks of non-marine origin, chiefly sandstones and tuffs, and Quaternary alluvium, are exposed throughout the area, where they underlie most of the basins and large valleys. Tertiary and Quaternary volcanic rocks, chiefly andesites or basalts, occur in many of the ranges, especially the Fish Creek Mountains and the Sheep Creek Range. Exposures of quartz-latite crystal tuffs and rhyolite intrusive rocks have also been noted in the Battle Mountain area (Roberts, 1964).

As pointed out, the Paleozoic rocks are found in complex thrust fault and fault block relationships (which have developed since late Paleozoic time). The topographic basins in the area are separated from the ranges by north-south trending normal faults of late Tertiary and Quaternary age. Displacements on these faults may be as great as several thousands of feet. Many of the ranges are flanked by pediments that extend into the valleys.

The economic geology of the area encompassed by the Winnemucca sheet has been described by many workers. Nevada's principal gold producers are located in the Tuscarora and Cortez Mountains, where the mineralization occurs in the transitional assemblage rocks of Paleozoic age. Two important open-pit copper mines are located on Battle Mountain. Another copper deposit in the northwest part of the Tobin range has had some production in the past several years. The deposit consists of massive sulfides that occur in siliceous and volcanic oceanic rocks of the Western assemblage. Barite is an important commodity mined in the Battle Mountain vicinity. Numerous small precious- and base-metal mining districts also occur throughout the area (see *References*).

GRAVITY ANOMALIES

Discussion of the gravity results will be confined principally to the area not described in the published work of Mabey (1964) and Erwin (1967). A discussion of the gravity results in their respective areas is presented by these authors, and the reader is referred to those publications.

Mabey (1964) points out that the Paleozoic eastern assemblage rocks have an average density of about 2.7 g per cm^3, while the Paleozoic western assemblages probably have an average density of about 2.6 g per cm^3. However, it is doubtful that any significant local gravity effects caused by this relatively small density contrast could be recognized at the scale of this survey. Mesozoic sedimentary rocks have an average density about equal to the density of the Paleozoic rocks of the area. The Mesozoic gabbroic complex of the Stillwater Range has an average density of 2.8 g per cm^3 (Smith, 1968). Densities of Cenozoic sedimentary and volcanic rocks in Nevada have a wide range of values, from 1.8 g to 2.6 g per cm^3, as reported by Thompson (1959), Mabey (1964), Cook (1965), and Erwin (1967). Intrusive rocks of Jurassic to Tertiary age have an average density of about 2.6-2.7 g per cm^3. Significant density contrasts that might be expected in the area are: (1) between Cenozoic rocks in contact with Paleozoic or Mesozoic rocks; and (2) between the Mesozoic gabbroic complex and Paleozoic, Mesozoic, and Cenozoic rocks. Metasediments and metavolcanics, and basic intrusives, may also cause local gravity anomalies.

Interpretation of gravity anomalies is primarily qualitative. Quantitative estimates of thicknesses or depth of bedrock were based on two-dimensional body analysis. A density contrast of 0.4 g per cm^3 was assumed for estimating the thickness of Cenozoic rocks overlying pre-Cenozoic bedrock.

The large gravity lows in the valleys and basins are due chiefly to low-density Cenozoic sedimentary rocks overlying a denser pre-Cenozoic bedrock. Steep linear gradients parallel to the flanks of the ranges may be interpreted as reflections of late-Tertiary–Quaternary normal faulting or of steeply sloping pre-Cenozoic bedrock. Complex gravity anomalies in valley areas underlain by Cenozoic rocks suggest bedrock undulations such as local basins and pediments. Negative gravity anomalies may also be associated with thick accumulations of Cenozoic volcanics.

Examination of bedrock gravity values indicates a regional decrease towards the southeast, suggesting a crustal thickening in that direction. A significant westward gravity increase is noted beginning along a line from Dixie Valley in the southwest corner of the map area, north to the East Range. Other gravity features found on the map are discussed below.

Tuscarora - Independence Mountain Area

A narrow north-trending negative gravity anomaly is located between the Tuscarora and Independence Mountains at about T. 35 N., R. 51 E. This anomaly has a relative value of about 20 mgal, and the area is underlain by an estimated thickness of 3,000 feet of Tertiary - Quaternary sediments. The steep gravity gradient on the east flank of the Tuscarora Mountains suggests basin-and-range faulting or steeply sloping pre-Cenozoic bedrock. A northeast-trending Paleozoic bedrock high with an associated positive gravity anomaly separates the above gravity low from a 10-15 mgal negative gravity anomaly in T. 34 N., R. 53 E. Tertiary - Quaternary alluvium in this basin is estimated to be about 1,000 to 1,500 feet thick.

Sheep Creek Range - Boulder Valley Area

A northeast-trending negative 10 to 15 mgal anomaly coincident with Boulder Valley (T. 33 N., R. 47 E.) is underlain by an estimated 1,500 feet of Quaternary alluvium. The overburden seems to become thinner in the northeast portion of Boulder Valley near the west flank of the Tuscarora Mountains. Northeast of the Sheep Creek Range the gravity data indicates deeper pre-Cenozoic bedrock and a greater thickness of Cenozoic alluvium. A gravity high occupies the central portion of the Sheep Creek Range where Cenozoic volcanics, chiefly Tertiary andesite and olivine basalt flows, are exposed. This gravity anomaly is probably due to thickness or density variations in the volcanic rocks overlying the Paleozoic western assemblage rocks which are exposed on the west flank of the Sheep Creek Range. The steep linear gravity gradients on the west flank of the Sheep Creek Range probably indicate basin-and-range faulting. The Reese River gravity low extends north from the town of Battle Mountain, and appears to terminate west of the Sheep Creek Range in the vicinity of T. 35 N., R. 44 E.

North Battle Mountain - Humboldt River Area

North of Battle Mountain (T. 35 N., R. 43 E.) is an area which contains a relatively featureless gravity pattern that is interrupted by several minor positive gravity anomalies. This area probably is a Paleozoic bedrock high covered by about 500 feet of fill, a probable extension of the rather prominent pediment on the north side of Battle Mountain. It is interesting to note that the 5 mgal positive gravity anomaly in T. 35 N., R. 43 E. is coincident with hot spring activity. The south end of Pumpernickel Valley contains a long narrow negative gravity anomaly with a magnitude of about 10 mgal. An estimated 1,200 feet of alluvial fill causes this anomaly.

Grass Valley - Pleasant Valley Area

Large negative gravity anomalies are coincident to Grass and Pleasant Valleys. The Grass Valley anomaly is of about 25 mgal relative magnitude, and is due to an estimated 4,000 feet of alluvial fill that overlies pre-Cenozoic bedrock. Steep gravity gradients on both sides of the valley indicate the presence of range-front faults. The Pleasant Valley gravity anomaly is separated from the Grass Valley anomaly by a saddle or bedrock high anomaly. An estimated 2,000 to 2,500 feet of alluvial fill overlying pre-Cenozoic rocks probably causes the Pleasant Valley anomaly.

Stillwater - East Range Area

Examination of bedrock gravity values obtained in the Stillwater and East Ranges suggests a major increase in gravity, or a positive anomaly associated with these Ranges. The bedrock values obtained in the Stillwater and East Ranges, although sparse, average -145 to -150 mgal, a rather abrupt change when compared to the bedrock gravity observed in the Sonoma and Tobin Ranges immediately to the east, which have bedrock values of about -160 to -165 mgals. Bedrock values gradually decrease eastward across the sheet, probably due to crustal thickening, and attain values of about -175 mgal.

A possible interpretation is that the East Range is underlain at depth by a gabbroic or basic igneous complex similar to that exposed in the Stillwater Range. Speed (1962) describes the geology of the gabbroic complex exposed in the West Humboldt Range immediately west of the Stillwater Range. This igneous complex may also be present at depth west of the town of Winnemucca, where a prominent, positive gravity anomaly is found. Consideration of the following discussion seems to lend support to this interpretation. The gabbroic complex exposed in the Stillwater Range has an average density of about 2.8 g per cm^3 (Smith, 1968). Assuming a density of 2.6 g per cm^3 for Paleozoic and other Mesozoic rocks underlying the East Range, a positive 0.2 g per cm^3 density contrast would be observed. Consequently, a positive gravity anomaly could possibly be expected in areas underlain at depth by an inferred gabbroic complex as in the East Range. Further, a correlation can be shown between low-level aeromagnetic surveys (Smith, 1968), positive gravity anomalies, and the exposed gabbroic complex in the Clan Alpine and Stillwater Ranges immediately south of the Winnemucca sheet. Aeromagnetic surveys over the East Range (U. S. Geol. Survey, 1968, 1973) show a number of positive magnetic anomalies along the axis of this range. Smith (1968) gives high magnetic susceptibility values for the rocks of the gabbroic complex. The prominent positive gravity anomaly (-140 mgal) in the extreme northwest corner of the Winnemucca sheet is associated with a positive high altitude 100 gamma aeromagnetic anomaly (U. S. Geol. Survey, 1970). A similar correlation is found with the gravity anomaly on the north end of the East Range. An extension of the gabbroic complex from the Clan Alpine and Stillwater through the East Range (at depth) to west of the town of Winnemucca seems to be a plausible interpretation, based on these geophysical data. A similar positive gravity anomaly relationship may be present in the Augusta Mountains south of the Winnemucca sheet (Erwin, 1973).

West of the East and Stillwater Ranges, the gravity decreases rapidly, indicating deep basins filled with Cenozoic sediments. Steep gravity gradients along the east flank of the Stillwater Range suggest range-front faults. The part of Dixie Valley covered by this work shows a complex gravity pattern caused by basins and pediments extending out into the valley. Estimated thickness of fill in the basins is about 2,000 feet.

Fish Creek Mountain Area

A rather prominent east-west belt of Cenozoic volcanic rocks extends through the Fish Creek and Shoshone Mountains, and Toiyabe Range. A negative gravity anomaly is generally associated with this belt. The anomaly probably is due to relatively thick piles of low-density Cenozoic volcanics and sediments. The Cenozoic volcanics either are considerably thinner towards the north end of the Fish Creek Mountains, or are of higher density. Jersey Valley, Antelope Valley, and Carico Lake Valley contain a complex gravity pattern caused by local basins and pediments. These local basins could contain as much as several thousand feet of Cenozoic fill.

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