UNIVERSITY OF NEVADA RENO

Nevada Bureau of Mines and Geology
University of Nevada Reno
Reno, Nevada 89557-0088
(702) 784-6691

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DISCUSSION OF A SET OF REGIONAL GRAVITY
DATA FOR THE RENO 1 BY 2° SHEET, NEVADA

by John W. Erwin

This information should be considered preliminary. It has not
been edited or checked for completeness or accurary.

See NBMG Map 58 (1977)

[redacted]

NBMG OPEN-FILE REPORT

INTRODUCTION

This report is a discussion of gravity work and an interpretation of the results designed to supplement the Reno 1° x 2° gravity map, Nevada Bureau of Mines and Geology (NBMG), Map 58, Erwin (1977). The area is bounded by latitude 39° to 40°00'N and 118°00' to 120°00'W and includes parts of Douglas, Carson, Washoe, Storey,Churchill, and Mineral Counties, Nevada. The map is at a scale of 1:250,000, has a 5 mgal gravity contour interval, and includes a generalized geologic base.

A total of 1890 gravity stations have been established in the area by a number of individuals and groups. Compilation of these data was provided by the DOD Mapping Agency (DMA, 1972) which includes DMA and unpublished USGS data in addition to those listed below. The NBMG portion of the field work was conducted during 1972-76 and consisted of 347 stations which provided cross-ties between the existing gravity (data points) plus fill-in stations in areas of inadequate coverage. NBMG field work was done by the author with the assistance of John C. Berg and Edward Bittleston, NBMG geologic field technicians. Some of the earliest gravity work in the area was conducted by Thompson (1958). Other workers have conducted gravity surveys during the succeeding years, e.g. Wahl (1965), Gimlett (1967), Erwin (1970) and Speed (1976). In addition to the gravity studies, seismic refraction studies have been done by Eaton (1963), and Meister (1966); Smith (1966) has written on aeromagnetic work in Dixie Valley. Published aeromagnetic maps over the area are U.S. Geol. Survey (1972) and NBMG (1977). The results of electrical studies in Carson Sink have been published by Stahd (1976) and Zohdy (1976).

The purpose of this report is to describe the data gathering procedures and present an interpretation of the data. Gravity surveys can be useful in determining the thickness and distribution of low-density Tertiary volcanic and sedimentary rocks and Quaternary alluvium in contrast to relatively more dense pre-Tertiary rocks. This information may be of use in mineral and petroleum exploration, groundwater studies, and geothermal exploration. This type of work may also contribute to the basic understanding of the Basin and Range Province geology not only in a regional sense but also within a continental and crustal framework.

FIELD METHODS AND DATA PRODUCTION

Standard geophysical methods for gravity surveys (Dobrin, 1976) were used throughout the NBMG survey work. Two Worden gravimeters working as pairs were used in the gravity survey. Their sensitivities are 0.09006 and 0.4655 milligals per scale division. Gravity data were referenced to the University of Nevada prime base station ACIC 0454-1, U.S. Air Force (7/67) which has an observed gravity of 979.6886 gals at an elevation of 1386 meters (4547 feet). The International Gravity Formula (1930) yields a simple Bouguer value of -178.3 milligals for the base station. This gravity station has a revised value of 979.0746 gals since the completion of this work under the International Gravity Standardization Network (1971).

NBMG fill-in stations were established at bench marks, section corners, and other existing control shown on U.S. Geological Survey topographic maps.

The data were reduced to the sea-level datum by using a density of 2.67 gm per cm^3 for rocks above sea-level. Simple Bouguer values were obtained from the observed gravity by using the International Gravity Formula (1930). Terrain corrections were applied to all stations. The computer calculations for the terrain corrections were run by the U.S. Geological Survey, Menlo Park, California using the program designed by Don Plouff of the U.S. Geological Survey. Hand corrections were necessary within the inner-ring (0.229 km, Hayford Bowie). Generally hand corrections to the stations in the valleys were ignored as these corrections were negligible compared to the machine computed portion of the total correction.

The estimated error of the simple Bouguer gravity values is ± 1.0 mgal. Terrain correction error is difficult to estimate but may be 2 or 3 mgal in mountainous terrain. At a contour interval of 5 mgals, this error is considered acceptable.

GENERAL GEOLOGY

Within the Reno sheet, Mesozoic rocks are exposed in most of the mountain ranges. These rocks can be divided into two basic units: principally sedimentary rocks composed of shale, mudstone, sandstone, and carbonate rocks with sparse volcanic rock; and volcanic and sedimentary rock composed of shale, sandstone, volcanogenic clastic rocks, andesite, rhyolite and local carbonate units. The sedimentary group is found mainly in the Stillwater and West Humboldt Ranges. The sedimentary-volcanic group is found throughout the sheet, in such areas as the Sand Spring Range, Clan Alpine Mountains, Trinity Range and other areas within the sheet. A Jurassic gabbroic lopolith is exposed in the Stillwater and West Humboldt Ranges. Granitic to intermediate intrusive rocks of Jurassic to early Tertiary are exposed in most of the ranges of the Reno sheet (see Bonham, 1969; Stewart and Carlson, 1974; Speed, 1976).

Tertiary sedimentary rocks of non-marine origin, chiefly sandstones and tuffs, lake deposits, and Quaternary alluvium are exposed throughout the area and underlie most of the basins and valleys. Tertiary and Quaternary volcanic rocks are exposed in most of the ranges of the Reno area. The ranges in

the western two-thirds of the Reno sheet are underlain principally by Cenozoic volcanic rocks consisting of andesite and basalt flows and local intrusives of mafic and intermediate composition (see Bonham, 1969; Stewart and Carlson, 1974).

The central portion of the Reno sheet which includes Carson Sink represents a transitional zone between the Basin and Range province on the east and the Sierra Nevada province on the west. This broad topographic low, principally the Carson Sink, is underlain by extensive Tertiary to Quaternary volcanic rocks (principally basalts and andesites), lake deposits, and Quaternary alluvium. The topographic features are atypical of the Basin-and-Range Province. They reflect both Tertiary-to-present faulting and compositional features of Pliocene volcanism (Bonham, 1969). The Carson Sink has been postulated to be a graben or rift zone in an area of extreme geologic complexity; for example the gabbroic lopolith exposed in the West Humboldt and Stillwater Ranges (see Bonham, 1969; Willden and Speed, 1974; Speed, 1976). The ranges in this area have been tilted, faulted, and folded in a complex manner from middle Tertiary to the present. The pre-Tertiary structural geology is obscure because of the isolated nature of the pre-Tertiary exposures.

The Sierra Nevada province bounds the Reno 2° sheet on the west. This uplifted and tilted block, developed since Oligocene time, is made up principally of the Mesozoic Sierra Nevada composite batholith. Roof pendants of Mesozoic metavolcanic rocks are exposed in the area, overlain by Cenozoic volcanic rocks. Long, narrow basins underlain by Quaternary alluvium are found along the east flank of the Sierra Nevada for example, to the north of Reno, Washoe Valley and Carson Valley. These basins are separated from the ranges by normal faults which may have displacements of many thousands of feet.

MINERAL RESOURCES

Some of Nevada's principal gold-silver producing districts lie in the Reno area. The Virginia City-Gold Hill district, Storey County, is located in the Virginia Range southeast of Reno. Other small gold-silver districts are found throughout the area of this report. The extreme south edge of the Reno sheet includes part of the Yerington district, Lyon County, which is a major copper producer. Until 1978, this area was the site of Anaconda's open-pit operation. Other metallic mineralization found in the area of the report includes antimony, lead, mercury, nickel-cobalt, tungsten, uranium, and zinc deposits.

Non-metallic deposits in the Reno sheet include bentonite and other clays, borates, fluorspar, gypsum, limestone, and diatomite. Diatomite deposits are important producers in the Reno area where they occur in rocks of Pliocene age. Geothermal power potential has been recognized for many years in the Dixie Valley-Carson Sink area. Several potential producing wells have been drilled in the Hot Springs Mountains south of Brady's Hot Springs in recent years. For a summary discussion of the economic geology of the area, the reader is referred to the county geologic studies (Roberts, 1967; Bonham, 1969; Stewart and McKee, 1970; Willden and Speed, 1974).

GRAVITY ANOMALIES

My interpretation of the gravity anomalies in the Reno sheets is principally qualitative. Quantitative estimates of valley fill and/or Cenozoic volcanic cover were based on two-dimensional analysis. Aeromagnetic data were used to complement the gravity interpretation where applicable (U.S. Geol. Survey, 1972; Nevada Bur. Mines and Geology, 1977).

In general, the following concepts apply to the interpretation of what are considered local gravity anomalies in the area. Regional anomalies will be discussed later. The large negative gravity anomalies in the valleys and basins are due chiefly to low-density Cenozoic sedimentary rocks and/or volcanic rocks overlying more dense pre-Cenozoic bedrock. Steep linear gradients parallel to the flanks of the ranges may be interpreted as due to normal-faulting or steeply dipping bedrock. Complex gravity patterns in valleys underlain by Cenozoic rocks suggest bedrock undulations such as local basins and pediments. Negative anomalies may be associated with thick Cenozoic volcanic piles or calderas. Mesozoic metasedimentary, metavolcanic, and gabbroic complex rocks may have substantial gravity highs associated with them in areas where they are in contact with Cenozoic rocks.

The above interpretation concepts are based on densities assumed or known for the geological units in the area. Discussions of this subject are found in Thompson (1959), Mabey (1964), Cook (1965), Healy (1966), Smith (1968), and Erwin (1977). Densities of the Paleozoic assemblages exposed in the area are on the average about 2.6-2.7 g per cm^3. Mesozoic sedimentary rocks have an average density approximately equal to the Paleozoic rocks of the area. The Mesozoic gabbroic complex of the Stillwater and Clan Alpine Range has an average density of 2.8 g per cm^3 (Smith, 1966). Mesozoic metavolcanic rocks may be quite dense, about 2.9-3.0 g per cm^3 (Erwin, 1970). Mesozoic metasedimentary rocks may have densities of about 2.7-2.8 g per cm^3, somewhat less than the metavolcanic rocks. Cenozoic sedimentary and volcanic rocks in Nevada have a wide range of densities from -1 to 2.5 g per cm^3 (Thompson, 1959; Mabey, 1964; Cook, 1965; Healy, 1966). Intrusive rocks, Jurassic to Tertiary age, have an average density of about 2.6-2.7 g per cm^3. Generally, the most significant local gravity anomalies in the area are associated with Cenozoic rocks rather than Paleozoic and Mesozoic rocks.

Thompson (1958-59) discussed the regional Bouguer anomaly which decreases from -160 mgal eastward in the Carson Sink area through the Stillwater Range to about -215 mgal near Austin and Eureka, Nevada. This could possibly be accounted

for by isostatic compensation for the increase in average elevation. Variations in crustal thickness in the Basin and Range Province seem to be related to regional altitude above sea level.

Examination of the bedrock values from the Stillwater Range eastward shows a rather abrupt increase in the regional gradient just east of the Stillwater Range. This steep regional gradient has also been noted to the north in the Winnemucca 2° sheet (Erwin, 1975). Eaton's (1963) seismic refraction data suggest a change in the inclination of the mantle east of Fallon: "that is, it seems that the eastward dip of the mantle begins (or increases)." Based on seismic data, Eaton's (1963) interpretation is that the M discontinuity descends from a depth of 20 km beneath the Coast Range, California, to about 40 km beneath the high Sierra Nevada. East of the Sierra Nevada it rises rapidly to about 22 km beneath the Carson Sink and then dips downward toward Eureka, Nevada, where it reaches a depth of 32 km. Based on this data the crust beneath the Fallon-Carson Sink area is surprisingly thin (Eaton, 1963). Priestley (1978) and Priestley, Ryall, and Fazie (1981) have arrived at similar conclusions.

Bedrock gravity values average about -190 to -195 mgal in the high Sierra Nevada and increase to about -160 mgal in the Carson Sink area and then decrease, as previously described, to about -210 to -215 mgal eastward towards Eureka, Nevada. These data correlate with the seismic interpretations and suggest that the regional Bouguer anomaly is due to the density contrast between crustal and mantle material (M discontinuity) and variation in crustal thickness.

FAIRVIEW VALLEY—DIXIE VALLEY—STILLWATER RANGE AREA

Fairview Valley contains a broad negative gravity anomaly centered in T16N,R33E. This anomaly is probably due to about 5000-6000 feet of alluvial fill. The steep gravity gradients on the west flank of the valley that extend northward to Dixie Valley mark a basin-and-range fault zone. This zone probably has a vertical displacement of 3000-4000 feet. Recent faulting is evidenced by prominent fault scarps along the flanks of the valley. Fairview Valley is most probably a complex westward tilted block. A broad pediment feature has developed northwest of Chalk Mountain.

Dixie Valley is flanked on the west side by steep gravity gradients that are the result of large, vertical displacement, basin-and-range faults. The order of this displacement is probably about 5000 to 6000 feet. A negative gravity anomaly is centered in T20N,R35E. Depth to bedrock beneath this anomaly in the Dixie Valley area probably reaches a maximum of 7000 to 8000 feet. Meister's (1966) seismic work supports these depths, and is also in agreement with Speed's (1976) anomalies. Dixie Valley has been the focus of much geophysical work over the past 20 years most of which has been applied to geothermal exploration. The reader is referred to the references for further study.

Positive gravity anomalies are associated with the exposed gabbroic complex in the Stillwater Range (T23N,R35E). The rhyolitic volcanic pile at the south end of the range has a moderate negative gravity anomaly associated. These results could be expected considering the densities of gabbro and rhyolite.

CARSON SINK AREA

As discussed previously, the -150 to -160 mgal Bouguer values obtained in the Carson Sink area represent a considerable increase over the value obtained in eastern Nevada. These values are suggestive of crustal thinning, and seismic data support this interpretation.

Considerable exploratory drilling for petroleum and geothermal energy has taken place in the Carson Sink area. Some of the data from these wells are available for interpretation purposes (Bendix Eng. Co., 1978). Aeromagnetic data is also available and is quite useful in conjunction with the gravity data (Nevada Bur. of Mines and Geology, 1979). The interpretation of the Carson Sink gravity is complicated by the presence of Tertiary volcanic and sedimentary rocks underlying the Quaternary alluvial deposits. There may be essentially no density contrast between these Tertiary and Quaternary units.

An 11,000-foot well drilled by Standard Oil Company of California, is located in S33,T24N,R33E. It penetrated Tertiary sedimentary rocks and volcanic tuffs to a total depth of 11,000 feet. The gravity low (T22N,R32E) to the south of this hole probably represents a significant basin. This gravity anomaly has a magnitude of about -40 mgal relative to Mesozoic bedrock in the Stillwater Range. A density contrast of about 0.3 g per cm^3 yields theoretical depths to bedrock similar to that encountered in the well. Based on a density contrast of 0.3 g per cm^3, the maximum depth to Mesozoic bedrock (?) associated with this gravity anomaly is about 10,000-11,000 feet. To the west a basin (T23N,R31E) is interpreted to have about 6000-7000 feet of fill using the same assumed density. Lone Rock (T23N,R32E) associated with a gravity high is probably a bedrock high extending out from the West Humboldt Range. See Wahl (1965), Speed (1976), Stahl (1976) and Zohdy (1976) for additional interpretation.

South of Fallon (T17N,R29E) a number of oil and gas wells have been drilled in the area underlying the 15-20 mgal gravity low which indicates a basin. The deepest wells in this location are: the Halbouty, (T17N,R29E), T. D. 7060 ft., and the Reggie No. 1, (T18N,R29E), T. D. 6500 ft. According to somewhat incomplete well logs, both wells penetrated Quaternary-Tertiary rocks to total depth (Garside, L. J., Schilling, J. H., 1976). Assuming that a density of 0.3 g per cm^3 may be a reasonable contrast, the interpreted depth of Quaternary-Tertiary "fill" is about 8000 feet.

Bendix Engineering Company, NURE Project (Bendix Eng. Co., 1978) drilled a bore hole in S16, T19N,R27E to a total depth of 8700 feet. The hole

was in Tertiary sediments to about 4300 feet., Tertiary volcanics and tuffs to 5100 feet, andesitic basalt to about 7700 feet, and Mesozoic dacite porphyry and meta-andesite to 7700 feet. This hole is in the southern portion of a N-S trending gravity anomaly. Assuming a density contrast of 0.3 gm per cm^3, this -20 mgal anomaly is interpreted to be due to approximately 5000 feet of Tertiary sedimentary and volcanic rocks overlying Mesozoic bedrock. The depth interpretations in this area are probably complicated by the presence of low density volcanic rock.

Two geothermal wells drilled by Phillips Petroleum Company are located in S21 and S29,T22N,R27E. These holes encountered Mesozoic greenstone at about 2800 feet and 4800 feet respectively. This is in an area of positive gravity and aeromagnetic anomalies which may be due to Mesozoic basement at a shallower depth than was found in the Bendix hole.

The steep gravity gradient along the west flank of the Stillwater Range represents a major fault with a possible vertical displacement of 10,000 feet. The gravity gradients along the West Humboldt Range in T23N,R29E also suggest faulting.

FALLON-RENO

The gravity low obtained in Rawhide Flats (T14N,R30E) probably is due to about 3000-4000 feet of alluvial fill and Tertiary volcanic rocks overlying pre-Tertiary rocks. This valley extends southeast toward the Sand Springs Range, and another low is found in T14N,R31½E that is probably due to about 2000 feet of fill. These two lows are separated by a bedrock high or saddle in T14N,R31E.

Campbell Valley (T14N,R27E) is probably underlain by 2000-3000 feet of alluvial fill, based on the -15 to -20 mgal anomaly found in this area. Mason Valley has been previously studied by Erwin (1970) and the reader is referred to this publication for more detailed information. In general, Mason Valley is underlain by several thousand feet of alluvial fill.

Two negative gravity anomalies are found in the Pine Nut Mountains and at Churchill Butte (T16N,R23E and T17N,R23E). These anomalies are probably due to 3000-4000 feet of Tertiary volcanic rocks representing the thicker portion of the Tertiary volcanic rocks in the area.

A northeast trending gravity high is located in the vicinity of T18N,R23E. This anomaly is associated with Mesozoic metamorphic and intrusive rocks which are exposed or concealed by only a thin Tertiary volcanic rock cover. This gravity trend may extend southwest into the Pine Nut Mountains.

Dodge Flat, just north of Fernley (T12N,R24E), is underlain by a gravity low which is probably caused by a 2000-3000 foot deep basin. The gravity low at Nixon (T33N,R23E) is most likely due to an alluvial basin about 4000-5000 feet in depth.

Several features are of interest in the Virginia Range east of Reno. An elongated, north-south gravity high centered in T19N,R21E is apparently associated with scattered exposures of Mesozoic rocks and is probably due to more dense Mesozoic rock present beneath a thin cover of Tertiary volcanic rocks. The gravity low centered in T20N,R22E and extending northwesterly into Warm Springs Valley may represent a thicker portion of the Tertiary volcanic rocks in the Virginia Range.

For a discussion of the gravity in the Warm Springs Valley area, the reader is referred to Gimlett (1967). Generally, Warm Springs and Hungry Valley are interpreted to be several thousand feet in depth, based on the gravity data. The valleys north of Reno that are underlain by relatively featureless gravity patterns are very likely to be quite shallow, on the order of 500-1000 feet in depth.

To the west of Reno, a 2000-foot basin is indicated (T19N,R19E) by the gravity low situated there. A bedrock high extends southward under Reno-Sparks immediately to the east of the above basin. For a more detailed discussion of the Reno-Sparks area the reader is referred to the NBMG Reno Environmental Folio publication (Erwin, 1976).

The U.S. Geological Survey (1976) has interpreted the Washoe Valley gravity low to be due to about 4000 feet of alluvial fill. In the immediate vicinity of Carson City it appears that depth to bedrock is approximately 1000 feet. To the south, in Carson Valley, the bedrock drops off sharply, to possibly 5000 feet. The southwest-trending gravity high that extends into Carson Valley (T14N,R21E) most likely represents Mesozoic bedrock at shallow depth beneath alluvial cover.

The implications of the Sierra Nevada gravity and its relation to crustal thickness have been previously discussed. With the exception of the small gravity low at T18N,R18E, which probably represents a thickening of the Tertiary volcanic rocks, the remaining Sierra Nevada local gravity is rather featureless due in part to sparse data.

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