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January 1982

NBMG OPEN-FILE REPORT 82-8

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

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

See NBMG Map 53 (1977)

photo copy price

NBMG OPEN-FILE REPORT

INTRODUCTION

This report is a discussion of gravity work and an interpretation of the results designed to supplement the Millet 1x2° gravity map, Nevada Bureau of Mines and Geology (NBMG), Map 53, by Erwin (1977). The area is bounded by latitude 39°00′ to 40°00′N and 116°00′ to 118°00′W and includes parts of Churchill, Lander, Eureka, Nye 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 1217 gravity stations are shown on the map as data points. Compilation of 869 of these data points was provided by the Defense Mapping Agency (DMA) which includes unpublished DMA and U. S. Geological Survey data (USGS) (1972). The principal contributor to the Millet sheet gravity data is Healy (1967). The NBMG portion of the field work was conducted during 1972-76 and consisted of 348 gravity stations which served as 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 W. Bittleston, NBMG geologic field technicians. Other gravity work in the area has been conducted by Thompson (1958). In addition to the gravity studies, seismic refraction studies have been done by Eaton (1963), Stauber (1970), Priestley (1978), and Priestley, Ryall, and Fazie (1981); while Smith (1966) has published the results of aeromagnetic work in Dixie Valley. Aeromagnetic maps over the area have been published by the USGS (1972) and the NBMG (1977).

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. Gravity surveys 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). This base station value has been changed since the completion of this work and now has a value of 979.6746 gals under the International Gravity Standardization Network (1971).

NBMG fill-in stations were established at bench marks, section corners, and other existing control shown on USGS 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 reference to 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

The oldest rocks in the area are found in the central and eastern part of the Millet sheet; they are sedimentary and volcanic rocks of Paleozoic age. These can be divided into four assemblages: a lower Paleozoic eastern miogeosynclinal assemblage composed principally of limestone and dolomite; a lower Paleozoic western eugeosynclinal assemblage composed of siliceous and volcanic rocks; an overlap assem-blage composed of Mississippian to Permian clastic rocks, and a western oceanic assemblage composed of Mississippian to Permian siliceous to volcanic rocks (see Roberts, 1964; Roberts and others, 1967; Stewart and Carlson, 1974; and Stewart and McKee, 1977). The lower Paleozoic eastern assemblage is exposed in the Fish Creek Range, Roberts Mountains, Monitor Range, and Toiyabe Range. The western eugeosynclinal assemblage is exposed in the Roberts Mountains, the northern Simpson Peak Mountains, the Toquima and Toiyabe Ranges. A few exposures of the overlap assemblage are found in the Sulphur Springs Range, Simpson Park, and northern Toiyabe Range. Scattered exposures of the western oceanic assemblage are found in the northern Toiyabe, Shoshone, Augusta, and New Pass Mountains. In general, all the Paleozoic assemblages are in complex thrust sheet and fault block relationships.

Mesozoic rocks are found mainly in the western

third of the Millet sheet. Within the Millet sheet, Mesozoic rocks, chiefly carbonate, clastic, and volcanic rocks, are exposed mainly in the New Pass, Augusta, and Clan Alpine Mountains. A Jurassic gabbroic lopolith is located in the Clan Alpine and Stillwater Ranges (Speed, 1976). Intrusives of granitic to intermediate composition, ranging from Cretaceous to early Tertiary, are exposed in most of the ranges of the Millet sheet (see Stewart and Carlson, 1974; Willden and Speed, 1974; and Speed, 1976).

Tertiary sedimentary rocks of non-marine origin, chiefly sandstones and tuffs, lake deposits, and Quaternary alluvium, are exposed throughout the area of the sheet and underlie most of the basins and valleys. Tertiary and Quaternary volcanic rocks are exposed in most of the ranges of the Millet area. Within the Millet sheet, the Cenozoic volcanic rocks in general consist principally of extensive silicic pyroclastic rock, welded and non-welded ash-flow tuffs. Basalt and andesites are subordinate.

Structurally, from the Stillwater Range eastward, the topographic basins 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 these ranges are flanked by pediments that extend into the valley. The Paleozoic rocks in the ranges in this area are found in complex thrust fault and fault-block relationships which have developed since late Paleozoic time. Structural features of Mesozoic age are chiefly folds, thrusts, and high-angle faults. Late Tertiary high-angle faults are a common structural feature within this area. The area within the Millet sheet is rather typical basin-and-range geology.

MINERAL RESOURCES

The Reese River silver district is located at Austin, Lander County, in the Millet sheet. Other numerous small gold-silver districts are found throughout the area of this report. Significant molybdenum mineralization occurs in the Mount Hope district. Nonmetallic deposits in the Millet sheet area include barite, clays, and fluorspar. Geothermal power potential has been recognized for many years in the Dixie Valley-Carson Sink area and has been subjected to considerable exploration activity in the last few years. For a summary discussion of the economic geology of the area, the reader is referred to the county geologic studies (Roberts, 1967; Stewart and McKee, 1970; Willden and Speed, 1974).

GRAVITY ANOMALIES

My interpretation of the gravity anomalies located in the Millet sheet is principally qualitative. Quantitative estimates of valley fill and/or Cenozoic volcanic cover were based on two-dimensional analysis. In general, the following concepts apply to the interpretaion 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 Ranges 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 1.7 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 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, 1959) discussed the regional Bouguer anomaly which decreases from -160 mgal eastward from the Carson Sink area through the Stillwater Range to about -215 mgal near Austin and Eureka. 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 (Pakiser, 1963).

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, 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 decrease to about -210 to -215 mgal in the eastern part of the sheet. 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 that crustal thickness increases eastward.

ANTELOPE VALLEY—BEAN FLAT—MONITOR VALLEY AREA

Gravity lows are found in Antelope Valley extending northward to Bean Flat in (T16N,R50E) to (T20N,R49E). These anomalies have a relative maximum value of about 20 to 40 mgals and are underlain by an estimated 4000 to 8000 feet of Tertiary-Quaternary sediments and alluvium. A relatively shallow bedrock area is indicated by the gravity data in the area northeast of Lone Mountain. Relatively shallow bedrock extends westward from Twin Spring Hills (T19N,R49E) and divides the basins underlying Bean Flat and the area in (T19N,R47E). The steep gravity gradients on the northeast side of Antelope Valley are due to the density contrast between Paleozoic rocks and alluvial fill (T18N,R51E). Across Antelope Valley the smaller density contrast between Cenozoic volcanics and alluvial fill is reflected by a more gentle gravity gradient (T18N,R50E). The Paleozoic sedimentary rocks in the Monitor Range (T16N,R49E) have an associated gravity high of 5 to 10 mgals in contrast to the Cenozoic volcanics. The results suggest a thin (1000-2000 ft.) Cenozoic volcanic rock cover overlying the Paleozoic sedimentary rocks. Two gravity lows in Monitor Valley (T14N,R47E) have relative values of about 10 mgals and 20 mgals respectively. These two lows are due to about 2000 and 4000 feet of Quaternary alluvial fill respectively.

BIG SMOKY VALLEY AREA

A large negative gravity anomaly underlies Big Smoky Valley (T15N,R44E) and has a relative value of about 35 mgals. This is probably due to about 7000-8000 feet of Quaternary alluvial fill in contrast to the older high density rocks underlying the ranges on the flanks of the valley. Steep gravity gradients on the west side of the valley indicate normal basin-and-range faulting. Structurally this area is probably a westward-tilted block.

GRASS VALLEY AREA

Steep gravity gradients along the east side of Grass Valley flanking the Simpson Mountains (T32N,R48E) suggest normal basin-and-range faulting with several thousand feet of displacement. This has produced a long, narrow basin trending northeastward beneath the valley. A gravity low is centered in (T22N,R46E) and is probably underlain by about 5000 feet of Cenozoic sedimentary and volcanic rocks. This gravity feature illustrates the similarities of the densities of Cenozoic sedimentary and volcanic rocks; for this reason they are sometimes considered as one unit for purposes of gravity interpretation.

REESE RIVER AREA

About 8000-9000 feet of alluvial fill is probably the cause of the 40 mgal low situated in (T14N,R40E). A shallow bedrock area or saddle underlies (T16N,R42E) and divides the basins underlying the valley. Southwest of Austin the valley basin probably has a maximum thickness of about 2000-3000 feet (T17N,R42E—T18N,R43E). The alluvial cover appears to thin going northwest from these basins. Northwest of Austin in Reese River Valley the gravity results generally are rather featureless suggesting shallow bedrock. The alluvial fill may be at most about 1000 feet underlying the gravity low in (T12N,R42E).

SMITH VALLEY—NEW PASS AREA

Three gravity lows (T16N,R35E) are located in Smith Valley, each with about the same relative magnitude. The determination of the relative gravity values is complicated by the presence of low-density Cenozoic volcanic rocks in the mountain ranges on the flanks of the valleys. The gravity lows probably indicate about 4000 to 6000 feet of alluvium and Cenozoic volcanic rocks. It is interesting to note that the gravity high dividing the basins in (T15N,R38E) seems to correlate with pre-Cenozoic rocks that probably trend across the valley there at shallow depth.

Paleozoic and Mesozoic sedimentary and metamorphosed rocks in the nothern Desatoya Mountains near New Pass have an associated gravity high (T21N,R40E). This high extends eastward across the bedrock area in (T20N,R41E) and reflects the Paleozoic rocks underlying the area.

North from the New Pass area in what is known as Antelope Valley is an area of relatively featureless gravity, except in (T24N,R41E) where a negative gravity anomaly of about 30-35 mgals is found. This anomaly probably represents about 6000-7000 feet of alluvial fill. It is noteworthy to observe the general increase in Bouguer values in the Augusta Mountains west of Antelope Valley (T24N,R40E). The magnitude of the Bouguer values is of the order of -160 mgals, which represents a considerable change from the -180 to -200 values immediately to the east. This is the abrupt break in Bouguer values that is observed in this general area. It is associated with Mesozoic metasediments and metavolcanic rocks and may also be related to the mantle thickness as previously discussed.

CLAN ALPINE—DESATOYA MOUNTAINS—EDWARDS CREEK VALLEY AREA

This area lies at about 117°45'E and 39°00' to 39°45'N. The Desatoya Mountains are underlain by a general negative gravity anomaly of complex form at (T15N,R36E) and (T16N,R37E). This anomaly may represent the thicker portion of the volcanic pile in what may be a caldera structure. The north-trending zone at (T15N,R36E) probably represents the extension of the Mesozoic rock exposed in (T14N,R36E) beneath the Cenozoic volcanics.

A gravity high is associated with the exposed Mesozoic metamorphic rocks and Jurassic gabbro in the Clan Alpine Mountains. These rocks have sufficiently higher density than the Cenozoic volcanic rocks, and therefore produce a significant positive anomaly in (T21N,R37E). This positive anomaly extends southeastward across Edwards Creek Valley and is probably due to Mesozoic rocks under a thin alluvial cover. Edwards Creek Valley is probably relatively shallow, being on the order of 1000-2000 feet to bedrock.

DIXIE VALLEY—STILLWATER RANGE AREA

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 5000-6000 feet. Dixie Valley is probably a complex westward tilted block. A negative gravity anomaly is centered in (T24N,R37E). Depth to bedrock beneath this anomaly 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. The positive gravity anomaly in (T22N,R37E) is associated with a positive airborne magnetic anomaly (Smith, 1967). This anomaly is very likely due to a shallow gabbro intrusive which is exposed to the north of the anomaly and in the Stillwater Range. The gravity high extends north along the flank of the Clan Alpine Mountains and is probably due to gabbro and metamorphic rocks concealed by a thin alluvial cover. Dixie Valley has been the focus of much geophysical work over the past 20 years, a great deal of it being applied to geothermal exploration. The reader is referred to the References for further study.

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