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DISCUSSION OF THE McDERMITT GRAVITY SHEET, MAP #86

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DISCUSSION OF THE McDERMITT GRAVITY SHEET, MAP #86
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by John W. Erwin

INTRODUCTION

This report presents a discussion and interpretation of the McDermitt gravity map, Nevada Bureau of Mines and Geology Map #86, by Erwin, Ponce, and Wagini (1985). The area includes parts of Elko and Humboldt Counties in north-central Nevada between 41° and 42° North latitude, and 116° and 118° West longitude. The data were obtained from data sets compiled by the Defense Mapping Agency (DMA), U.S. Geological Survey (USGS), Cogbill (Northwestern University), Chevron Oil, and the Nevada Bureau of Mines and Geology (NBMG). Locations of gravity stations and 5 milligal contours are plotted on a generalized geological base map at a scale of 1:250,000. Gaps in the existing data were filled in with additional stations obtained by John Erwin of NBMG and Alexander Wagini of USGS. NBMG fieldwork was conducted during 1980–84 with the assistance of Norman Stevens, geological technician, NBMG.

Previous geophysical work consists of USGS open-file aeromagnetic maps, (see Erwin and others, 1980), and NURE airborne radiometric-magnetic surveys published by the Bendix Field Engineering Corporation (U.S. Department of Energy, 1979). Crustal seismic refraction profiles were conducted between Elko and Mountain City by Hill and Pakiser (1967). See also Hill's (1963) gravity work in southern Idaho. Considerable private seismic and gravity work has been done by major oil companies as there is interest in oil exploration beneath the Tertiary volcanics in the northern area of map.

This project is part of a continuing geophysical program conducted jointly by NBMG and USGS, the objective being to complete gravity coverage of the 17 1° × 2° AMS sheets covering Nevada. At the time of this writing, 13 gravity maps have been published; the Ely sheet is the most probable next publication. In conjunction with the gravity program, a companion set of aeromagnetic maps will also be published. Gravity surveys offer a means for a better understanding of the geology of the Basin and Range province. In addition, the well-known application of pediment definition can be quite useful in exploration of alluvial-covered areas which may host mineralized bedrock. Other applications are groundwater and engineering studies.

FIELD METHODS AND DATA REDUCTIONS

Standard methods were used by NBMG to establish new gravity stations and to tie the work of others into a common datum. Stations established by NBMG were measurements at benchmarks, section corners, road intersections, and other controls found on USGS 7½′ and 15′ quadrangles. Two primary Air Force base stations were used by NBMG and a network of three secondary base stations was established at strategic USGS benchmarks. These stations are tabulated below:

Winnemucca
Air Force ACIC 0474-1
Location: 40°54.23′N, 117°42.21′W
Elevation: 4,298 feet
Absolute gravity: 979810.53 milligals (IGSB71)

McDermitt
Air Force ACIC 2354-1
Location: 41°59.92′N, 117°42.91′W
Elevation: 4,429 feet
Absolute gravity: 979905.94 milligals (IGSN71)

Midas
NBMG Station MCD#2 BM U75
Location: 41°14.67′N 116°47.63′W
Elevation: 5,745 feet
Absolute gravity: 979761.20 milligals (IGSN71)

Little Humboldt River
NBMG Station #369 BM
Location: 41°29.00′N,l 116°59.92′W
Elevation: 4,835 feet
Absolute gravity: 979846.77 milligals (IGSN71)

Little Humboldt River
NBMG Station #453 BM 57FMK
Location: 41°55.58′N, 116°41.25′W
Elevation: 5,168 feet
Absolute gravity: 979865.57 milligals (IGSN71)

A LaCoste-Romberg gravimeter (Model G #509) was used by NBMG in all field work. Traverses were run from the base station with a daily closure. The elevation of the USGS stations is known to the nearest foot which corresponds to a Bouguer error of ±0.06 milligals assuming a reduction density of 2.67 gm/cm³ was used in calculating the Bouguer values. The theoretical gravity is given by the reference ellipsoid (GRS67). Terrain corrections were computed by USGS in Menlo Park, California under the direction of David Ponce of USGS. The computer program, written by Plouf (1977), uses elevation data from Army Service magnetic tapes. Corrections were taken to a distance of 166.7 km from the station. Inner-ring corrections were not calculated for purposes of this map. The gravity contours are computer drawn.

GENERAL GEOLOGY

The McDermitt sheet encompasses an area where the Basin and Range province merges with the Snake River Plateau province. The Humboldt River-Snake River drainage divide is located in the northern portion of the map. The Owyhee plateau is deeply dissected by stream canyons of the Snake River drainage system and represents a dramatic contrast to typical basin-and-range topography found elsewhere in Nevada.

The oldest rocks in the area are sedimentary rocks of Paleozoic age and are found in the eastern and central part of the sheet. These can be divided into three assemblages: lower Paleozoic eastern and foreland-shelf assemblages composed principally of limestones and dolomite; a transitional assemblage of lower Paleozoic rocks which are autochthonous with respect to the Roberts Mountains thrust—it is composed of limestone, chert, shales, and in places is interstratified with the carbonate assemblage; and a lower Paleozoic western siliceous and a upper Paleozoic western siliceous assemblage which are principally cherts, shales, argillites, greenstones, volcanic breccia, and pillow lavas. The eastern-foreland assemblages are exposed in the Independence, Bull Run, and Osgood Mountains. Windows of these rocks are exposed in the Independence Mountains where the overlying western assemblage thrust plates have been eroded. Western and transitional assemblages are exposed principally in the Independence, Tuscarora, and Osgood Mountains, and the Hot Springs Range.

Mesozoic sedimentary and sparse volcanic rocks underlie most of the western part of the sheet, particularily in the Hot Springs and Santa Rosa Ranges, Blue Mountain, and the Bloody Run, Slumbering, and Krum Hills. These units are Late Triassic to Early Jurassic in age. Cretaceous granitic and intermediate intrusives are exposed in many of the ranges throughout the McDermitt sheet.

Tertiary sedimentary rock of nonmarine origin and Quaternary alluvium are exposed throughout the area where they underlie most of the basins and valleys. The prominent Owyhee Desert lava plateau in the north-central portion of the map is underlain by thick Tertiary basalt and andesitic flows, ignimbrites, and rhyolitic flows. Flanking this plateau to the west and south are extensive Tertiary rhyolitic flows and shallow intrusives, ash-flow tuffs, welded and non-welded siliceous tuffs. Tertiary volcanic rocks are widely exposed throughout the map area, some of which are in complex fault relationship with Paleozoic rocks as found the the Tuscarora Mountains (Roberts, 1964; Stewart and Carlson, 1978; Coats, 1987).

Topographic basins in the southern basin-and-range portion of the map are generally separated from the ranges by north-south trending normal faults of late Tertiary and Quaternary age. Displacements on these faults may be several thousand feet. Pediments may extend out into the valleys along the flanks of the ranges. Mesozoic rocks of this area are found in thrust-fault and block-fault 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 feature.

MODELS, DENSITIES, AND REGIONAL GRAVITY

My interpretation of the gravity anomalies located in the McDermitt 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 interpretation of what are considered local gravity anomalies. The elongated negative 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. In contrast, pediments are generally associated with low rates of change in the gravity. Negative anomalies can also be associated with thick Cenozoic volcanic piles or calderas. The opposite would be true, or course, with higher density rocks. The McDermitt sheet differs considerably from other northern Nevada gravity maps because of extensive rhyolitic and basaltic volcanic cover, particularly the Owyhee Desert area. Volcanic rocks create interpretational difficulties due to their variable densities as will be seen later.

Interpretation is based on rock densities, assumed or known. Discussions of this subject have been presented by this author and many others in previous publications and most recently by Plouff (1987). Densities of the Paleozoic assemblages exposed in the area average about 2.6–2.7 gm/cm^3. Mesozoic sedimentary rocks with minor volcanics have an average density approximately equal to the Paleozoic rocks. Intrusive rocks, Jurassic to Tertiary, have an average density of about 2.7–2.8 gm/cm^3. Tertiary sedimentary and volcanic rocks in Nevada have a wide range of densities from 1.8 to 2.8 gm/cm^3. Generally, the most significant local gravity anomalies in the area are associated with Tertiary rock types.

A strong complex regional gradient is present on the gravity map. Assuming a linear bed-to-bedrock gradient, one observes a southeasterly gradient of about -50 to -60 milligals. This is probably due to crustal effects south and east of the McDermitt area. Hill and Pakiser's (1967) seismic work seems to support this interpretation. Their north-south refraction profile, part of a larger survey, suggests total crustal thickening beneath the Snake River Plain. At the transition between the Basin and Range province and the western Snake River Plain, the depth to the top of the crustal intermediate basaltic layer decreases and its thickness increases abruptly. Further interpretation of this work suggests an absence of a granitic layer beneath the Snake River Plain. In

contrast to this, the crust in the Basin and Range province includes a granitic layer resulting in lower Bouguer gravity values. The more positive Bouguer values observed in the Owyhee Desert area are probably due to the basaltic layer at depth. Aeromagnetic data also suggest thicker basalts beneath the Owyhee Desert north of about 41°45'N. Work of Hill (1963) indicates that the Snake River Plain graben is isostatically undercompensated whereas the Basin and Range is probably compensated.

LOCAL ANOMALIES

For purposes of interpretation, the following density assumptions were made:

Czs-Czvr 2.2 gm/cm^3
Pzs-Mzs 2.6 gm/cm^3
Czvb 2.8 gm/cm^3

Two-dimensional models were used for depth estimates as previously mentioned except in the analysis of the Tuscarora-Owyhee gravity low. Crude finite models were utilized in this case.

Quinn River-Silver State Valley Area

Elongated gravity lows extend southward from the town of McDermitt (T47N,R38E) to the Krum Hills (T36N,R36E). These anomalies have a relative amplitude of about -20 to -40 milligals and are underlain by 4,000 to 8,000 feet of Tertiary-Quaternary sedimentary and alluvial hill. Bedrock is probably Mesozoic sedimentary and intrusive rock. The rhyolitic volcanics southwest of McDermitt are probably low-density rocks which have densities comparable to the Tertiary-Quaternary fill of the valley. These volcanic rocks may be relatively thin as the peripheral gradients are fairly high, suggesting underlying Mesozoic rocks. Gravity decreases to the northwest of the sheet possibly due to the presence of a caldera. A pediment extends out into the valley in the vicinity of Daveytown (T40N,R36E).

Paradise Valley Area

An elongated gravity low extends south from the settlement of Paradise Valley. Locally, the anomaly is divided by saddles in the bedrock. Maximum relative gravity lows of about -20 to -40 milligals are located in this area. These anomalies can yield an estimated 4,000 to 8,000 feet of fill that probably overlies Mesozoic-Paleozoic rocks. Extensive pediment is located in the area of T37N to T39N,R38E. Structurally, this area is probably an eastward-tilted block. The relatively featureless gravity near Golconda Butte (T37N,R39E) may be an area of thin cover (< 1,000 feet) but is complicated by the presence of Tertiary basalts which may mask estimated depths.

Eden Valley Area

This valley (T39N and T40N,R41E) appears to be underlain by thin Tertiary and Quaternary sedimentary cover. The relative gravity lows of about 5 to 10 milligals indicate 1,000 to 1,500 feet of cover overlying sedimentary or volcanic rocks. North of Eden valley (T41N and T42N, R42E and R43E) is an area of probable thin (< 1,000 feet) rhyolitic cover. A residual gravity map would very likely produce a positive anomaly closure at this location. Paleozoic sedimentary rocks could underlie these volcanics.

East Flank Osgood Mountains Area

Pediment extends northeast along the east flank of the Osgood Mountains and can probably be projected to the Tertiary volcanics at T39N and T40N,R43E. Relatively low gravity gradients suggest that the pediment may extend well out into the valley. This is, of course, an obvious exploration target area due to proximity to the Pinson, Getchell, and Chimney gold deposits. The valley to the east (T36N and T37N,R42E and R43E) can be considered a northern extension of Pumpernickel Valley. Estimated depth to bedrock here is about 2,000 feet.

Independence Valley Area

The following dry well information is included for interpretation purposes:

NBMG well #207
Filon Exploration Ellison #1 (1977)
sec. 4, T40N,R52E
T.D. 4,460 feet

Source rock analysis data: interval 4,230–4,300 feet: Elko Fm.

There is a relative change in gravity of about -20 milligals from Paleozoic bedrock on the east side of the valley to the center. An assumed density contrast of -0.3 gm/cm^3 would yield an estimated 5,000 feet of Tertiary fill overlying Paleozoic bedrock. One should notice the difference between the gradients on the west and east sides of the valley. The lower gradient on the west side is probably due to the presence of low-density Tertiary volcanics which are extensively exposed in the Tuscarora Mountains.

Bull Run Basin

Dry well information:

NBMG well #32
Richfield K. D. Scout well (1957)
sec. 22, T43N,R52E
T.D. 3,390 feet
0–2,350 feet Tertiary sediments
2,350–3,390 Paleozoics (see Decker, 1962)

The small -10 milligal anomaly in the Bull Run basin could be interpreted as about 2,000 feet of light sedimentary rocks overlying more dense Paleozoic rocks. However, I suspect faulting has complicated the gravity patterns so that at this scale interpretation is probably quite speculative. West of the N-S Owyhee fault (T42N to T44N,R51E), the elongated negative anomalies probably represent a down-dropped block of Tertiary sediments and volcanics. Vertical displacement is estimated to be about 5,000 feet.

Owyhee Desert-Tuscarora Mountains Area

Dry well information:

NBMG well #443
Exxon #1 Four Mile Butte Federal (1985)
sec. 8, T43N,R49E
T.D. 14,464 feet
0–1,400 feet basalt, gravels, tuffs
1,400–1,500 feet basalt
1,500–4,000 feet ash-tuffs
4,000–4,500 feet dense basalts
4,500–14,464 feet siliceous tuff, ignimbrites(?)

The Owyhee Desert in the north-central portion of the map is an area of extensive exposures of Cenozoic basalts (Czvb) and is flanked by Cenozoic rhyolitic rocks (Czvr). The basaltic unit is principally the Big Island Formation (Tbi). This Miocene unit includes olivine basalts, gravels, basaltic cinder tuff, and lava cones. The rhyolitic rocks in contact with these basaltic rocks are flows, tuffs, and ignimbrites (Coats, 1987). Lithologic logs of well #443 indicate an upper basaltic unit about 5,000 feet thick overlying about 10,000 feet of ignimbrites(?). Overall, the composite density of this volcanic pile could be in the range of 2.3 gm/cm^3.

Early Tertiary ignimbrites (~41 m.y.) are exposed throughout the northern part of the Tuscarora Mountains. They were apparently deposited as a single cooling unit and are quite thick—at least 1,000 feet. They are in fault contact with Paleozoic rocks as shown on the map (Coats, 1987).

As discussed earlier, regional gravity effects due to basaltic thickening and lack of a granitic layer may account for the increase in gravity values toward Idaho. The rather featureless gravity pattern over the basaltic plain is interrupted by two small gravity lows at T46N,R49E and T45N,R43E which are probably caused by shallow rhyolitic rocks. Uncertainty of densities makes depth estimates quite speculative.

Of particular interest is the pronounced NW-SE gravity low in the vicinity of well #443. Removal of the regional gravity effects would make this anomaly more obvious. This low could be caused by a thick section of ignimbrites underlying younger basaltic cover that extends out from the Tuscarora Mountains. The size of this anomaly suggests a large caldera may be present in this area that is partially covered by younger basalts. A similar case could be made for the area south of Capitol Peak (T44N, R41E) although the gravity data are sparse.

BIBLIOGRAPHY

Coats, R. R., 1987, Geology of Elko County, Nevada: Nevada Bureau of Mines and Geology Bulletin 101. 112 p.

Decker, R. W., 1962, Geology of the Bull Run quadrangle, Elko County, Nevada: Nevada Bureau of Mines and Geology Bulletin 60, 65 p.

Erwin, J. W., Nichols, S. L., Godson, R. H., and Hill, P. L., 1980, Aeromagnetic map index of Nevada: Nevada Bureau of Mines and Geology Map 62.

Erwin, J. W., Ponce, D. A., and Wagini, A., 1985, Bouguer gravity map of Nevada, McDermitt sheet: Nevada Bureau of Mines and Geology Map 86.

Hill, D. P., 1963, Gravity and crustal structure in the western Snake River Plain, Idaho: Journal of Geopysical Research, v. 68, no. 70.

Hill, D. P. and Pakiser, L. C., 1967, Seismic-refraction study of crustal structure between the Nevada Test Site and Boise, Idaho: Geological Society of America Bulletin v. 78, no. 6, p. 685–704.

National Geophysical Data Center, 1984, DMa gravity file of the U.S. National Oceanic and Atmospheric Administration, Boulder, CO.

Plouff, D., 1977, Preliminary documentation for a FORTRAN program to compute terrain corrections based on topography digitized on a geographic grid: U.S. Geological Survey Open-File Report 77-535.

———, 1987, Bouguer gravity anomaly and isostatic residual gravity maps of the Walker Lake 1° × 2° quadrangle, California and Nevada: U.S. Geological Survey Map MF-1382-E.

Roberts, R. J., 1964, Stratigraphy and structure of the Antler Peak quadrangle, Humboldt and Lander Counties, Nevada: U.S. Geological Survey Professional Paper 459-A, 93 p.

Roberts, R. J., Montgomery, K. M., and Lehner, R. E., 1967, Geology and mineral resources of Eureka County, Nevada: Nevada Bureau of Mines and Geology Bulletin 64, 152 p.

Stewart, J. H., and Carlson, J. E., 1978, Geological map of Nevada: U.S. Geological Survey, scale 1:500,000.

U.S. Department of Energy, 1979, McDermitt aerial radiometric and magnetic survey: Publication no. GJBX168-79.

Willden, R., 1964, Geology and mineral deposits of Humboldt County, Nevada: Nevada Bureau of Mines and Geology Bulletin 59, 154 p.