Dating of Pre-Tertiary Attenuation Structures in Upper Paleozoic and Mesozoic Rocks and the Eocene History in northeast Nevada and northwest Utah

Nevada Petroleum Society 1994 Fieldtrip Guidebook

Charles H. Thorman, Constance J. Nutt and Christopher J. Potter,
Editors

Dating of Pre-Tertiary Attenuation Structures in Upper Paleozoic and Mesozoic Rocks and the Eocene History in northeast Nevada and northwest Utah

Nevada Petroleum Society 1994 Fieldtrip Guidebook

Charles H. Thorman, Constance J. Nutt and Christopher J. Potter,
Editors

PUBLISHED BY THE NEVADA PETROLEUM SOCIETY, INC.
RENO, NEVADA
AUGUST 1994

Dating of Pre-Tertiary Attenuation Structures in Upper Paleozoic and Mesozoic Rocks and the Eocene History in northeast Nevada and northwest Utah

Nevada Petroleum Socity 1994 Fieldtrip Guidebook

Published by: Nevada Petroleum Society
P.O. Box 11526
Reno, Nevada 89510-1526

Printed in the United States of America.

This Guidebook was desktop published by Sally J. Dyson, U.S. Geological Survey, MS 939, Box 25046, DFC, Denver, CO 80225

The correct citation for this volume is:

Thorman, C.H., Nutt, C.J. and Potter, C.J. , eds., 1994, Dating of Pre-Tertiary Attentuation Structures in Upper Paleozoic and Mesozoic Rocks & The Eocene History in northeast Nevada and northwest Utah: Nevada Petroleum Society, Sixth Annual Fieldtrip Guidebook, 126 p.

Contents

Isostatic Residual Anomaly Gravity Map of the east-central part of the Elko 1°x2° Quadrangle, Nevada

Stephen L. Robbins, *U.S. Geological Survey, MS 939, Box 25046, DFC, Denver, CO 80225*
David A. Ponce, *U.S. Geological Survey, MS 989, 345 Middlefield Road, Menlo Park, CA 94025*

INTRODUCTION

This map (Plate 1), an isostatic residual anomaly (IRA) gravity map, covers an area that is mostly within the eastern half of the Elko 1°x 2° quadrangle, Nevada, between lat. 40° 14' N. and 40° 48' N. and long. 114° 2' W. and 115° 10' W. The map scale is 1:250,000 and the color contour interval is 2.5 mGal. A simplified version of Coats' (1987) geologic map of Elko County is superimposed on the gravity map. There are four numbers on the map that represent density values of upper Paleozoic rocks collected from outcrops at these locations. See Table 1 for a preliminary summary of rock density values in and around (mostly to the west of) the study area. A, B, and C indicate locations of three of the four planned stops for this fieldtrip.

The gravity map is based on 717 gravity stations with variable spacing; 557 stations are within the map area and 160 are just outside of it. Data from 247 of these stations are from the U.S. Defense Mapping Agency files (St. Louis, Mo.) and the remainder are from USGS surveys or other unpublished sources.

The observed gravity (OG) values are based on ties to the U.S. Department of Defense base station no. 0310-1 at Wells, Nev. (Jablonski, 1974), with an OG value of 979,730.81 mGal. This value is based on the IGSN 1971 datum (Morelli, 1974). The data were reduced using the GRS-1967 formulas (International Association of Geodesy, 1971) and the assumed average crustal density of 2.67 g/cm^3. The terrain effect for each of the stations was calculated and removed out to a distance of 166.7 km using the computer program BOUGUER (Godson and Plouff, 1988). Isostatic corrections were made using a computer program by Simpson and others (1983) assuming an Airy-Heiskanen compensation model where the parameters used are (1) density of the topographic load — 2.67 g/cm^3, (2) depth of compensation below sea level — 25 km, and (3) density contrast at the crust-mantle boundary — +0.40 g/cm^3. After the gravity data were reduced to IRA values, the gravity map was generated by using the computer program "Interactive Surface Modeling" by Dynamic Graphics, Inc.[1] (Berkeley, Ca.), which gridded the scattered data at a 0.5- km interval and then created a color plot file which was then plotted on a CalComp plotter[1].

The accuracies of all OG values are better than ±0.20 mGal, with the USGS OG values being better than ±0.05 mGal. The accuracies of the terrain correction (TC) values are better than ±10 percent of the calculated values of the inner zones, which were determined manually. For this map, the maximum TC error could be ±0.67 mGal. However, except for some of the mountain stations, most TC accuracies are better than ±0.10 mGal. Therefore, more than 90 percent of the IRA values are accurate to better than ±0.30 mGal.

REGIONAL INTERPRETATION

Isostatic residual gravity anomalies were calculated to remove long-wavelength variations in the gravity field to enhance gravity anomalies caused by the upper and middle parts of the crust. In general, gravity anomalies reflect lateral changes in rock density and can be used to infer lithologic variation and geologic structure. The IRA gravity map reveals that the lowest gravity values occur over thick Cenozoic deposits in Butte and Goshute Valleys and that the highest values occur over Paleozoic carbonate rocks in the Pilot and Toano Ranges.

All the major valleys in the study area are characterized by large gravity lows that reflect intermediate to deep Cenozoic basins. A rough estimate of the depth to basement in these sedimentary basins can be made by determining the amplitude of the gravity anomaly, assuming a density contrast of 0.4 g/cm^3 between sedimentary and basement rocks and calculating the thickness of material needed to account for the gravity anomaly using an infinite horizontal sheet model.

Associated with Goshute and Antelope Valleys, in the central part of the study area, is one of several

[1]Use of brand names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 1. Preliminary density values for rocks in north-central Nevada.

Rock Assemblage	Sampling Method	Range of ρ (g/cm³)	Mean ρ (g/cm³)
Quarternary deposits	2 hand; 1 well-log	1.19-2.52	2.00?
Tertiary sedimentary rocks	1 hand; 1 well-log	2.49-2.76	2.50
Tertiary volcanic rocks			
rhyolites, andesites, and tuffs	5 hand; 3 well-log	1.35-2.49	2.20
Cretaceous sedimentary rock	1 hand	2.42	2.42
Paleozoic rocks			
Upper (Permian-Mississippian)	7 hand; 1 well-log	2.10-2.94	2.60
Lower (Devonian-Cambrian)	17 hand; 1 well-log	2.44-2.96	2.68
Granitic rocks	2 hand; 1 well-log	2.51-2.74	2.60

north-south-trending gravity lows in northeast Nevada that extends for about 100 km. The amplitude of the anomaly is about 30 mGal, which suggests a depth to basement of about 2.3 km. A gravity low in Clover Valley of about 22 mGal implies a depth to basement of about 1.7 km. Butte Valley, which contains the lowest gravity values in the study area, may be a southern extension of the Clover Valley Basin and may contain over 2.3 km of Cenozoic fill.

Prominent isostatic residual gravity highs are associated with mountain ranges throughout the study area, particularly the Pequop Mountains, Toana Range, and Goshute Mountains. In general, these gravity highs reflect high-density Paleozoic rocks. In a number of areas, gravity data indicate the presence of pediments of pre-Tertiary rocks. A gravity high associated with Delcer Buttes in the southwestern part of the study area indicates that the exposed granitic and Paleozoic rocks extend for some distance beneath alluvium at shallow depth (because there is little data here, the extent of the anomaly is not known), and in the area where the Cherry Creek Range and the Pequop Mountains meet in the south-central part of the study area, gravity data indicate that pre-Cenozoic rocks extend across this gap at shallow depth.

REFERENCES

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

Godson, R.H., and Plouff, Donald, 1988, BOUGUER version 1.0, a microcomputer gravity-terrain-correction program: U.S. Geological Survey Open-File Report 88-644-A-B, 13 p., 1 diskette.

International Association of Geodesy, 1971, Geodetic reference system 1967: International Association of Geodesy Special Publication 3, 116 p.

Jablonski, H.M., 1974, World relative gravity reference network—North America, parts 1 and 2: U.S. Defense Mapping Agency Aerospace Center Reference Publication 25 [originally published 1970, revised 1974], approximately 1,500 p.

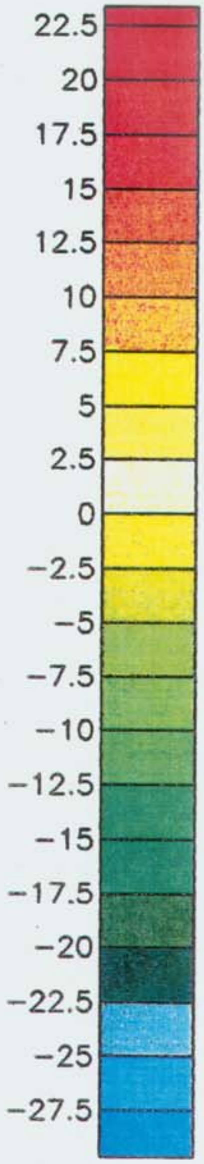
Morelli, C., ed., 1974, The International Gravity Standardization Net 1971: International Association of Geodesy Special Publication 4, 194 p.

Simpson, R.W., Jachens, R.C., and Blakely, R.J., 1983, AIRYROOT; a FORTRAN program for calculating the gravitational attraction of an Airy isostatic root out to 166.7 km: U.S. Geological Survey Open-File Report 83-883, 66 p.

EXPLANATION

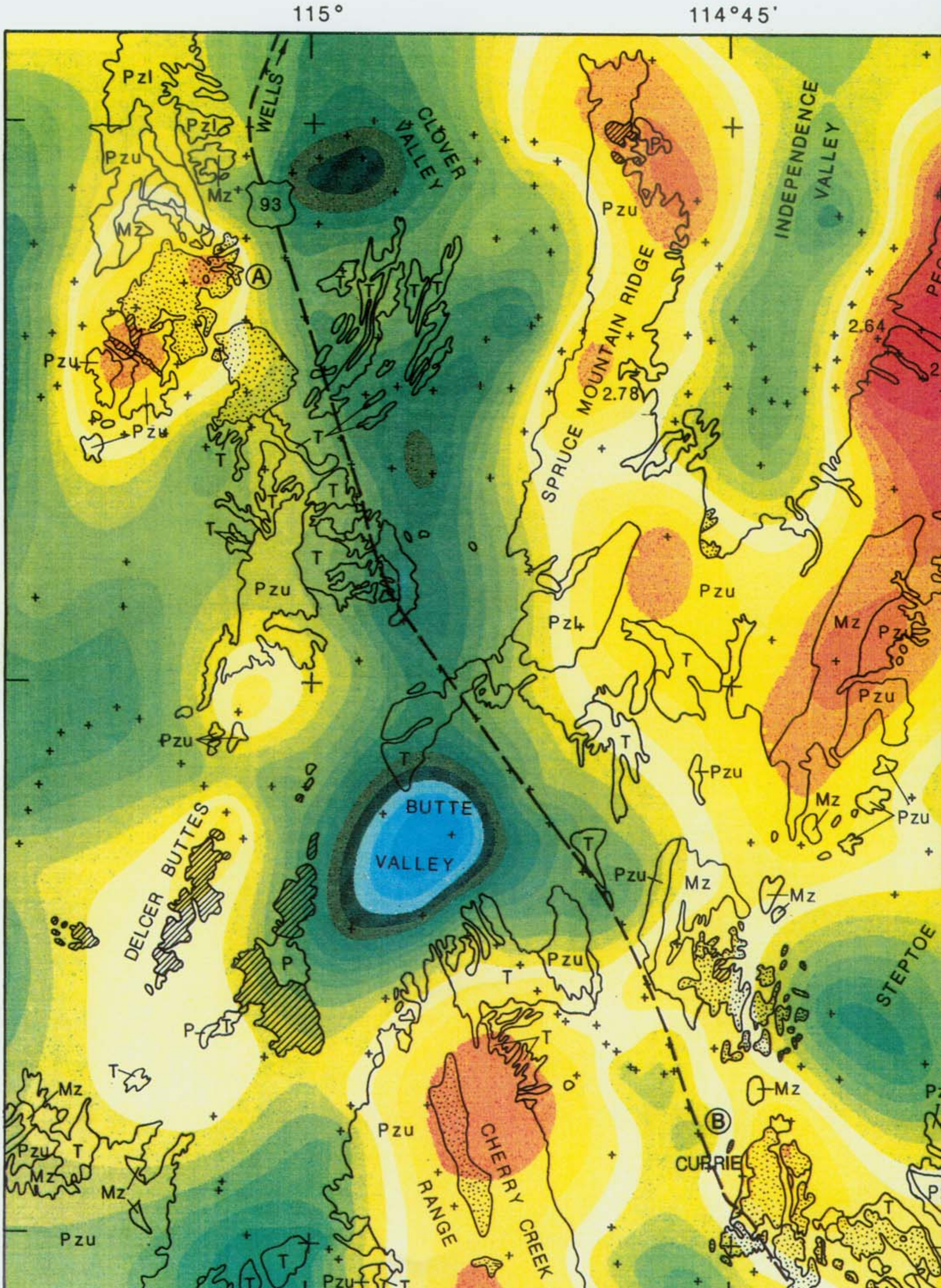
- Quaternary sedimentary deposits
- T — Tertiary sedimentary rocks
- Tertiary volcanic rocks
- Mz — Mesozoic sedimentary rocks
- Pzu — Upper Paleozoic rocks (Permian-Mississippian)
- Pzl — Lower Paleozoic rocks (Devonian-Cambrian)
- Granitic rocks
- \+ Gravity stations

CONTOURS
Milligals

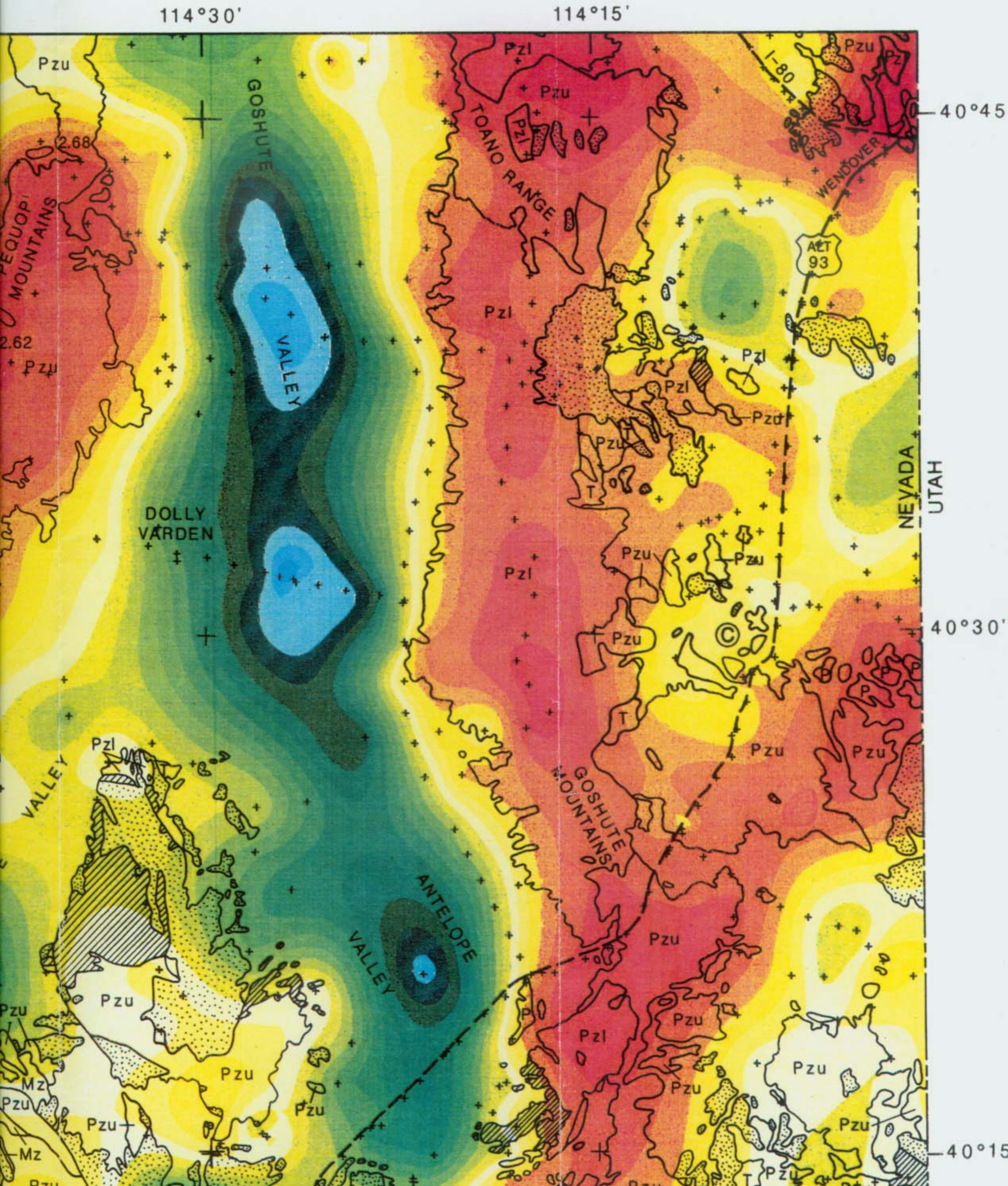


FIELD TRIP STOPS

- (A) Southern East Humbolt Range
- (B) Northern Currie Hills
- (C) Ferguson Mountain



115°
114°45'
WELLS
93
CLOVER VALLEY
SPRUCE MOUNTAIN RIDGE
INDEPENDENCE VALLEY
BUTTE VALLEY
DELCER BUTTES
CHERRY CREEK RANGE
STEPTOE
CURRIE
A
B
2.64
2.78
Pzl
Pzu
Mz
T
P



114°30'
114°15'
40°45'
40°30'
40°15'
Pzu
Pzl
2.68
2.62
PEQUOP MOUNTAINS
GOSHUTE VALLEY
TOANO RANGE
I-80
WENDOVER
ALT 93
DOLLY VARDEN
NEVADA
UTAH
T
©
GOSHUTE MOUNTAINS
ANTELOPE VALLEY
VALLEY
Mz
P

Aeromagnetic Map of the east-central part of the Elko 1° By 2° Quadrangle, Nevada

D.A. Ponce, *U.S. Geological Survey, MS 989, 345 Middlefield Road, Menlo Park, CA 94025*

INTRODUCTION

An aeromagnetic map of northeast Nevada (Fig. 1) was prepared from a subset of a merged aeromagnetic map of the State of Nevada (Hildenbrand and Kucks, 1988). The data used to compile the map are essentially the National Uranium Resource Evaluation aeromagnetic data for the Elko quadrangle (Geodata International, Inc, 1979). The original data were collected along east-west flightlines, spaced 5 km (3 mi) apart, and at about 120 m (400 ft) above the ground surface. These data were gridded using a minimum curvature algorithm at a 1-km (0.6-mi) interval, upward continued to 305 m (1,000 ft) above the ground surface, and merged with similarly processed aeromagnetic data. In addition, a regional geomagnetic reference field was removed from each survey based upon location and the date the survey was flown. Because of the wide flightline spacing, the low flightline elevation, and the upward continuation process, magnetic anomalies caused by small or shallow sources may be missing or poorly resolved.

Typically, magnetic anomalies are caused by local concentrations of magnetic minerals, primarily magnetite, and can be used to map the subsurface distribution of rocks containing these minerals. Magnetic anomalies reflect the shape as well as the depth of the source rocks. In general, based on a comparison of aeromagnetic (Fig. 1) and geologic (Stewart and Carlson, 1978) maps, most rocks within the mapped area are non-magnetic to weakly magnetic. Paleozoic carbonate rocks are essentially nonmagnetic, Jurassic and Cretaceous plutonic rocks are moderately magnetic, and Tertiary volcanic rocks are weakly to moderately magnetic.

INTERPRETATION

A number of conspicuous magnetic anomalies are associated with Jurassic, Cretaceous, and Tertiary plutonic rocks throughout the area (Fig. 1). A broad magnetic high along the western margin of the aeromagnetic map correlates to normally polarized plutons that crop out at Delcer Buttes. The amplitude and shape of the anomaly indicates that these plutons are probably connected at depth and extend westward beneath alluvial cover. Plutonic rocks that crop out at West Buttes are near the east flank of the anomaly centered at Delcer Buttes but do not appear to be related to the magnetic anomaly. Other plutonic rocks that appear to be essentially non-magnetic or are too small to be resolved by the 5-km (3-mi) flight-line spacing are Jurassic and Cretaceous diorite bodies and a Jurassic to Tertiary granitic body in the southern part of the East Humboldt Range.

Small exposures of Jurassic and Cretaceous diorite occur (Stewart and Carlson, 1978) in the northern part of the area, at the northern edge of Spruce Mountain Ridge. These rocks are associated with a broad low-amplitude aeromagnetic anomaly that extends northestward into an adjacent valley. The broad aeromagnetic anomaly may reflect plutonic rocks at depth.

The largest aeromagnetic anomaly within the study area is associated with a 125 Ma monzonite and syenite stock (Schilling, 1965) in the Dolly Varden Mountains. This anomaly is part of an areally extensive northwest-trending aeromagnetic feature. Although a large part of the Dolly Varden Mountains consist of Paleozoic rocks, the aeromagnetic anomaly suggests that the entire mountain range is underlain by moderately magnetic plutonic rocks.

Broad high-amplitude aeromagnetic anomalies are associated with two quartz monzonite stocks near White Horse Flat in the southeastern part of the study area. The western stock is about 140 Ma (Schilling, 1965) and intrudes Devonian dolomite and limestone. Both plutons are moderately magnetic with an average magnetic susceptibility of about 0.0008 and a range of 0.0005 to 0.0010 cgs-unit for 11 samples.

Other aeromagnetic anomalies within the study area are related to volcanic rocks with various magnetic properties. An aeromagnetic high-low pair is associated with volcanic rocks in the western part of the study area north of Dry Lake Flat. Another high-low aeromagnetic anomaly is associated with Tertiary volcanic rocks that crop out in the eastern part of the study area south of Wendover.

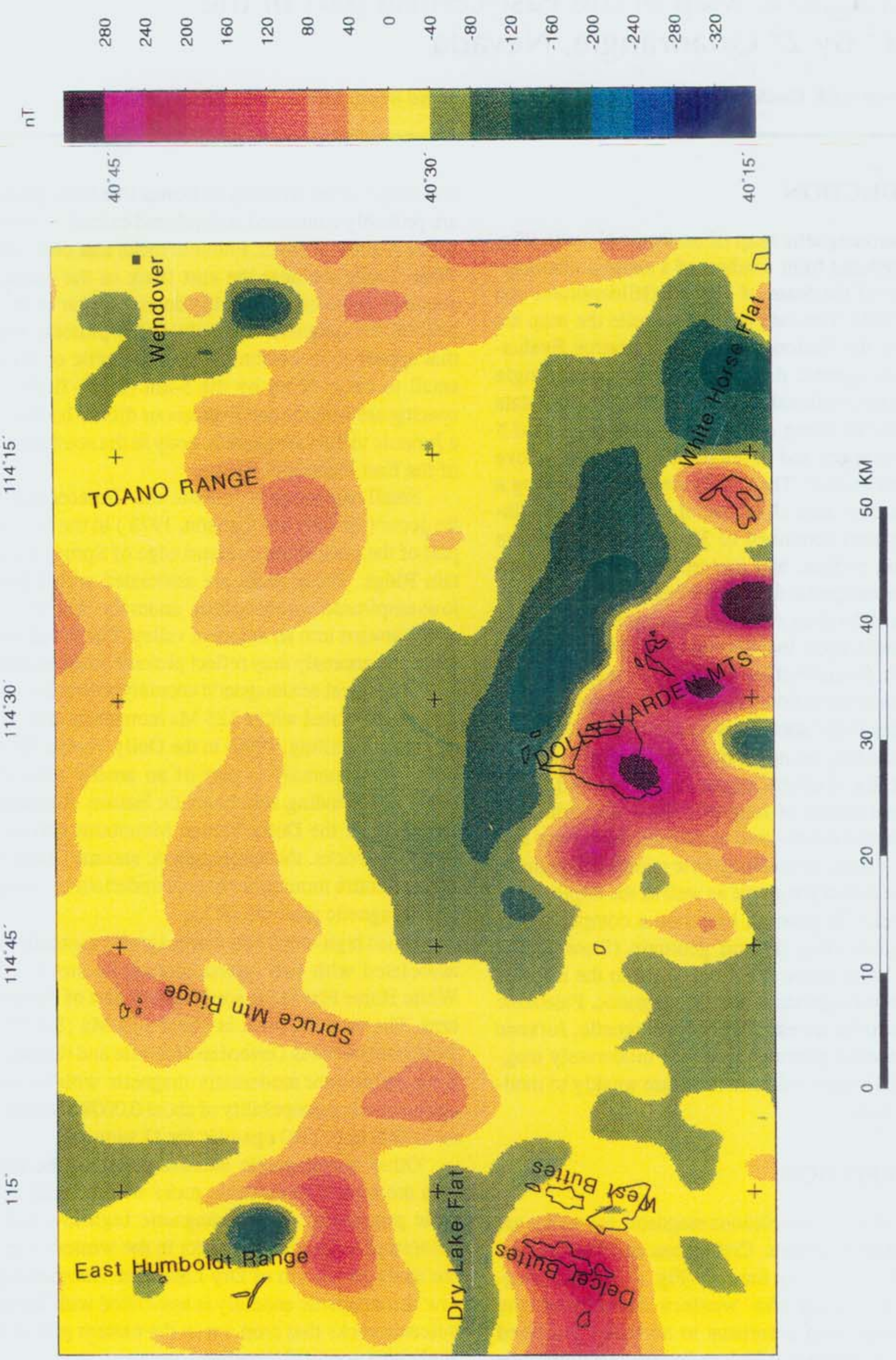


Figure 1. Aeromagnetic map of a part of the Elko quadrangle. Mapped plutonic rocks are outlined (from Stewart and Carlson, 1978).

REFERENCES

Geodata International, Inc., 1979, Aerial radiometric and magnetic survey, Elko quadrangle, Nevada and Utah: National Uranium Resource Evaluation program, GJBX-159(79); Grand Junction, Colo., U.S. Department of Energy, variously paged.

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

Hildenbrand, T.A., and Kucks, R.P., 1988, Total intensity magnetic anomaly map of Nevada: Nevada Bureau of Mines and Geology Map 93A, scale 1:750,000.

Schilling, J.H., 1965, Isotopic age determinations of Nevada rocks: Nevada Bureau of Mines and Geology Report 10, 79 p.

Basin Geometry of the Goshute Indian Reservation, Eastern Nevada and Western Utah

D.A. Ponce, *U. S. Geological Survey, MS 989, 345 Middlefield Road, Menlo Park, CA 94025*
J.A. Sampson, *U. S. Geological Survey, MS 964, Box 25046, DFC, Denver, CO 80225*

INTRODUCTION

Gravity, magnetic, and magnetotelluric data were collected as part of a study to characterize the basin geometry of the Goshute Indian Reservation and vicinity of eastern Nevada and western Utah. The study area is bounded by the Goshute Mountains to the north, Kern Mountains to the south, Antelope Mountains to the west, and Snake Valley to the east and includes the Deep Creek Range and South Mountains (Fig. 1). The general stratigraphy is composed of Precambrian schist and quartzite, over 11,000 m of Paleozoic clastic and carbonate rocks, Mesozoic granitic rocks, and Tertiary volcanic and intrusive rocks. Precambrian and Paleozoic rocks are exposed in the Deep Creek Range, Mesozoic granitic rocks include a stock at Gold Hill and the two-mica Tungstonia Granite (Best, 1974) at Kern Mountains, and Tertiary volcanic rocks crop out in the southwestern and northern parts of the Goshute Indian Reservation. The central part of the Deep Creek Range is truncated by the 39-Ma Ibapah pluton. (See Bick, 1966; Stacy and Zartman, 1978; and Nutt and others, 1992).

GRAVITY AND MAGNETIC STUDIES

An isostatic gravity map of the study area (Fig. 1), computed to enhance upper- and mid-crustal geologic features, reveals three prominent alluvial basins on or adjacent to the Goshute Indian Reservation: Antelope Valley, Deep Creek Valley, and Snake Valley. A depth to pre-Tertiary basement in each basin can be inferred by determining the amplitude of the gravity anomaly associated with the basin, assuming a density contrast between alluvial deposits and basement, and using a semi-infinite sheet approximation. An assumed density contrast of about 0.4 g/cm^3 between alluvium and pre-Tertiary sedimentary rocks is used to estimate the thickness of alluvial deposits. If the density contrast is smaller, the calculated thickness is larger and conversely, if the density contrast is larger, the required thickness is smaller.

A 25-mGal gravity low over Antelope Valley, along the east side of the Reservation indicates a depth to pre-Cenozoic basement of about 2 km. The deepest part of the basin is about 6 km southeast of Tippet. The northernmost part of the basin is not well constrained by gravity data and the basin may continue to the north for some distance. A gravity low extends for about 40 km along Deep Creek Valley from southeast of Ferber Flat to Johnson Canyon. The maximum amplitude of the anomaly is about 25 mGal about 12 km northwest of Ibapah indicating a depth to basement of about 2 km. The amplitude of the gravity anomaly decreases to 10-15 mGal near Goshute which corresponds to a depth to basement of about 1 km. The depth to basement may be less than a few hundred meters in Johnson Canyon, south of Goshute. Another prominent gravity low occurs on the east side of the Deep Creek Range over Snake Valley. The maximum amplitude of the gravity anomaly is about 25 mGal indicating a depth to basement of about 2 km.

A broad isostatic gravity high characterizes the South Mountains, in the southwestern part of the Goshute Indian Reservation (Fig. 1) that reflects exposed high-density Paleozoic carbonate and clastic rocks. The gravity high approximately corresponds to the location where there is a change from faulted and folded rocks in the Reservation to less faulted and folded rocks to the south. Magnetic data (Nutt and others, 1992) indicate that rocks in the South Mountains are essentially non-magnetic, with the exception of moderately magnetic Eocene volcanic rocks in the northwestern part of the South Mountains that produce a prominent magnetic high. The extent of the magnetic high suggests that these volcanic rocks extend beneath Antelope Valley, along the western boundary of the Reservation.

A gravity high over the South Mountains has a prominent nose that extends about 6 km northward into the alluvium covered central part of the Reservation (Fig. 1). This gravity anomaly reflects a north-trending pediment of pre-Tertiary rocks at shallow depth. A gravity profile along the foot of South Mountains reveals that an 8-mGal anomaly is associated with the suspected pediment (Fig. 2). A ground magnetic traverse (Fig. 2) coincident with the gravity profile indicates that the suspected pediment is

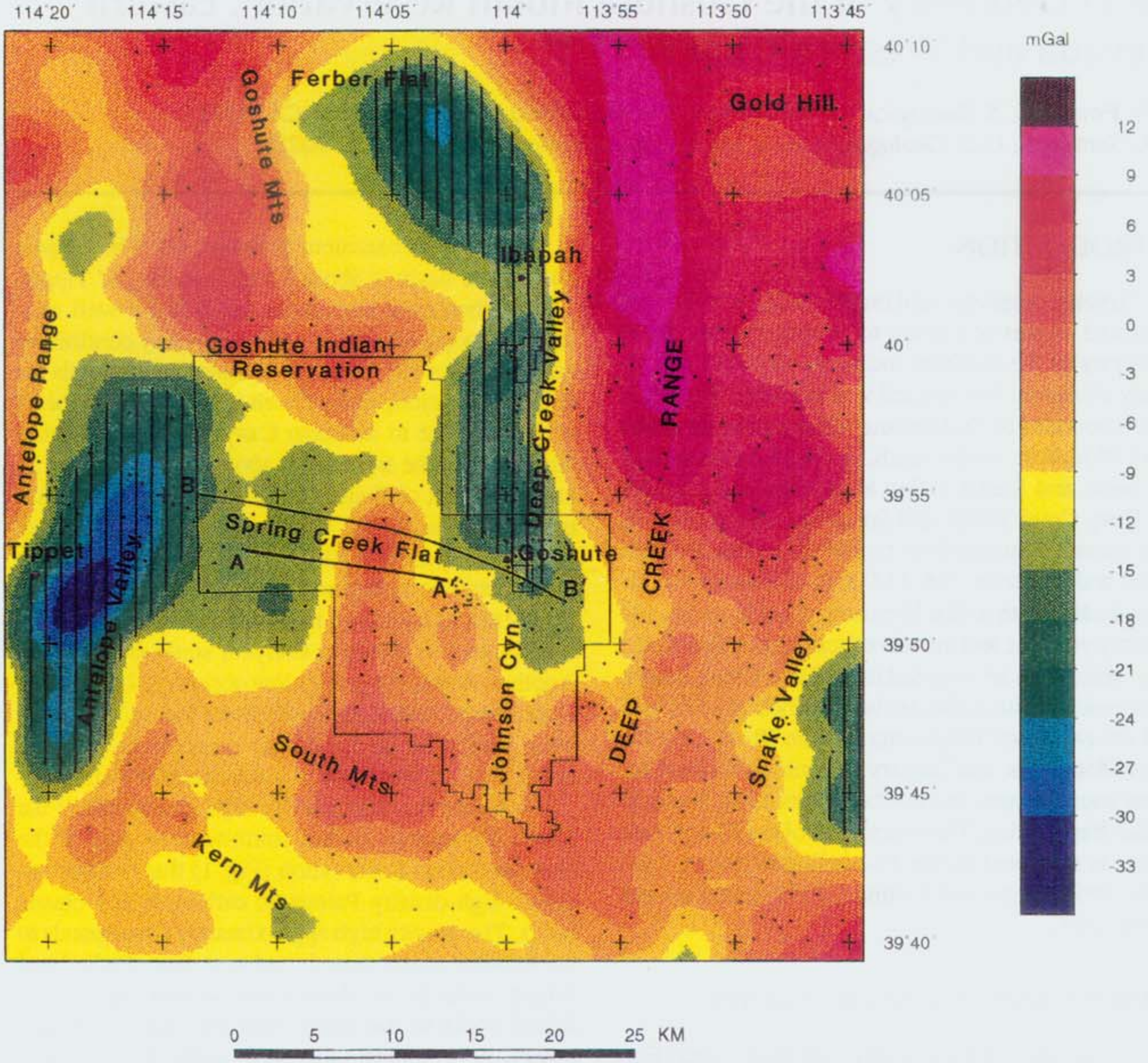


Figure 1. Isostatic gravity map of the Goshute Indian Reservation and vicinity. Ruled areas show approximately where depth to basement is greater than about 1 km.

not associated with a magnetic anomaly, which if present, would indicate that the source rocks are Tertiary volcanic rocks rather than Paleozoic rocks.

MAGNETOTELLURIC STUDIES

A magnetotelluric (MT) electrical geophysical survey was conducted within the Goshute Indian Reservation, just north of the South Mountains. Two-dimensional modeling (Fig. 3) of the data was used to map subsurface geologic features that have contrasting electrical resistivities. Pronounced variations in rock lithologies and faults separating different rock types can be indentified in the MT model. Objectives were to locate the range-bounding fault along the west side of Deep Creek Range and to estimate the overburden thickness in the valleys to the west of the Deep Creek Range.

The MT profile B-B' consists of 18 sounding locations and extends eastward approximately 25 km across the Goshute Indian Reservation (Figs. 1 and 3). The results of the two-dimensional MT model (Fig. 3) suggests that the depth to basement is approximately 2 km beneath Antelope Valley and most of Spring Creek Flat. The overburden thickness appears to be somewhat less in Deep Creek Valley adjacent to the Ibapah pluton (Fig. 3). Eocene volcanic rocks that crop out at MT station 3 do not appear to be thick and probably overlie sediments. The western range-bounding fault is indicated by changes in the subsurface

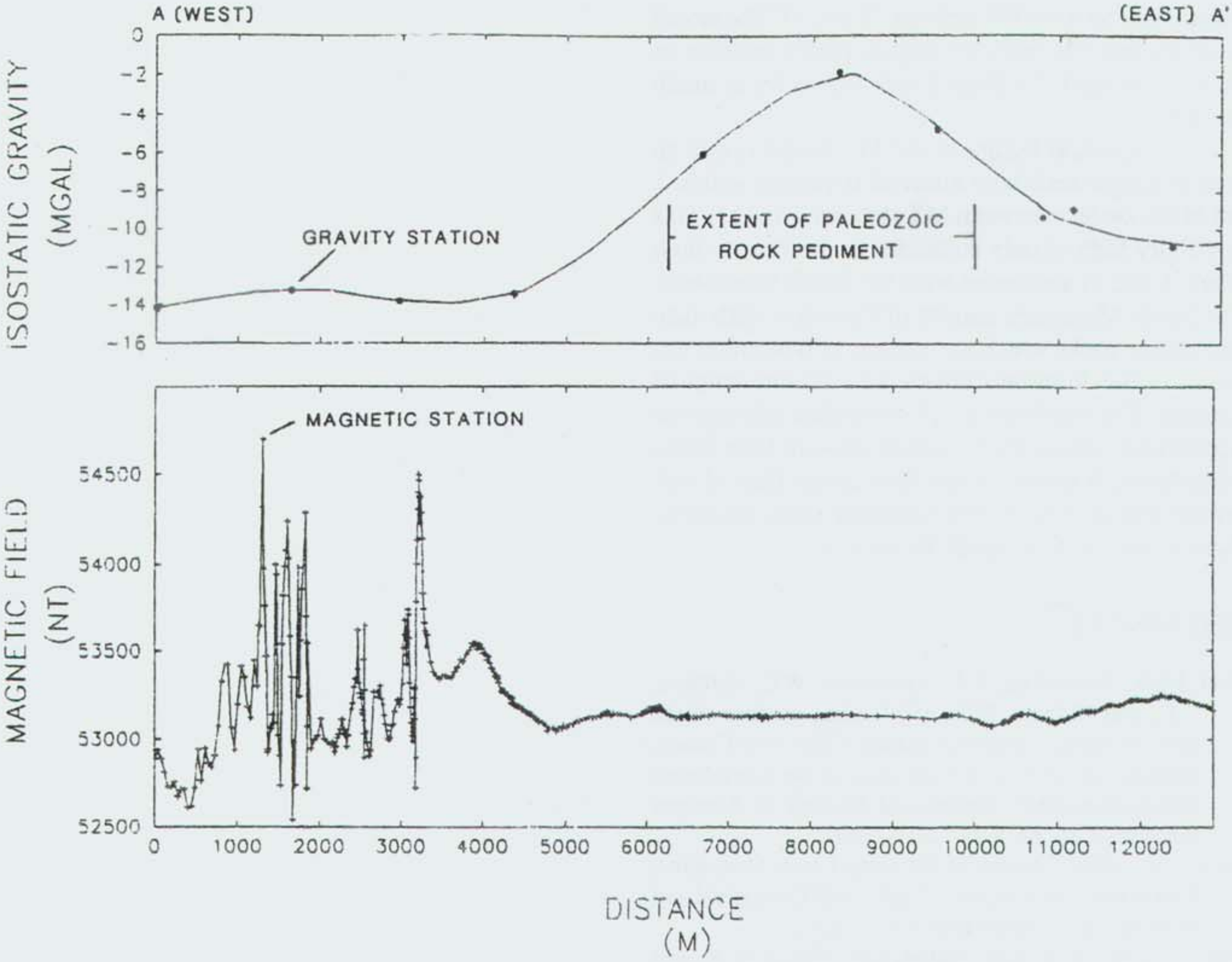


Figure 2. Gravity and magnetic traverse across the Goshute Indian Reservation.

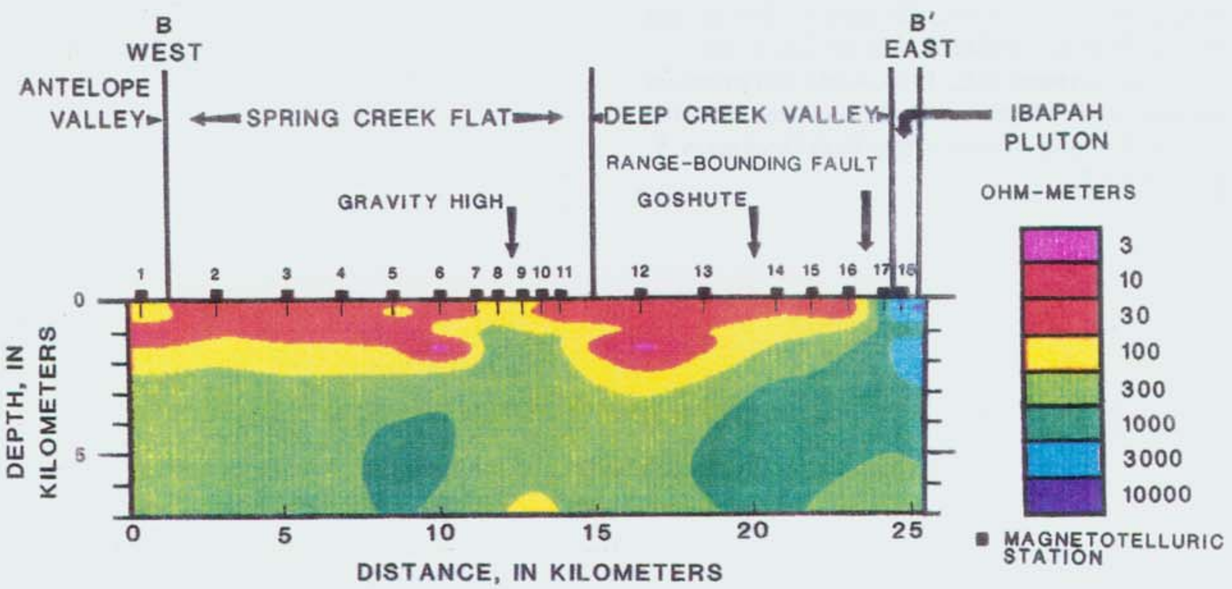


Figure 3. Magnetotelluric resistivity cross-section across the Goshute Indian Reservation.

resistivities between MT stations 16 and 17. The model suggests that the resistive Ibapah pluton extends to the west beneath the Deep Creek Valley by as much as 3 km.

An important feature of the MT model is that an area of higher resistivity material is present within 1 km of the surface between MT stations 7 and 11. This resistivity high closely coincides to the gravity high (Figs. 1 and 2) associated with the South Mountains. The South Mountains consist of Paleozoic carbonate and clastic rocks which are known to host silver deposits in the Johnson Canyon area 10 km south of Goshute. The combined geophysical data indicate that a pediment extends about 6 km northward from South Mountatins, is buried by less than about 1 km of valley fill, and is composed of Paleozoic rocks similar to those exposed in the South Mountains.

REFERENCES

Best, M.G., Armstrong, R.L., Graustein. W.C., Embree, G.F., and Ahlborn, R.C., 1974, Mica granites of the Kern Mountains Pluton, Eastern White Pine County, Nevada—Remobilized basement of the Cordilleran Miogeosyncline?: Geological Society of America Bulletin, v. 85, no. 8, p. 1,277-1,286.

Bick, K.F., 1966, Geology of the Deep Creek Mountains, Tooele and Jaub Counties, Utah: Utah Geological and Mineralogical Survey Bulletin 77, 120 p.

Nutt, C.J., Eppinger, R.G., Miller, S.H., Ponce, D.A., and Sampson, J.A., 1992, Geologic, geochemical, and geophysical studies for the Goshute Indian Reservation, Nevada and Utah, precious-mineral assessment project, in Manydeeds, ed., Mineral frontiers on Indian land: Bureau of Indian Affairs, Division of Energy and Mineral Resources Publication G-92-2, p. 51-69.

Stacy, J.S., and Zartman, R.E., 1978, A lead and strontium isotopic study of igneous rocks and ores from the Gold Hill mining district, Utah: Utah Geology, v. 5, no. 1, p 1-15.