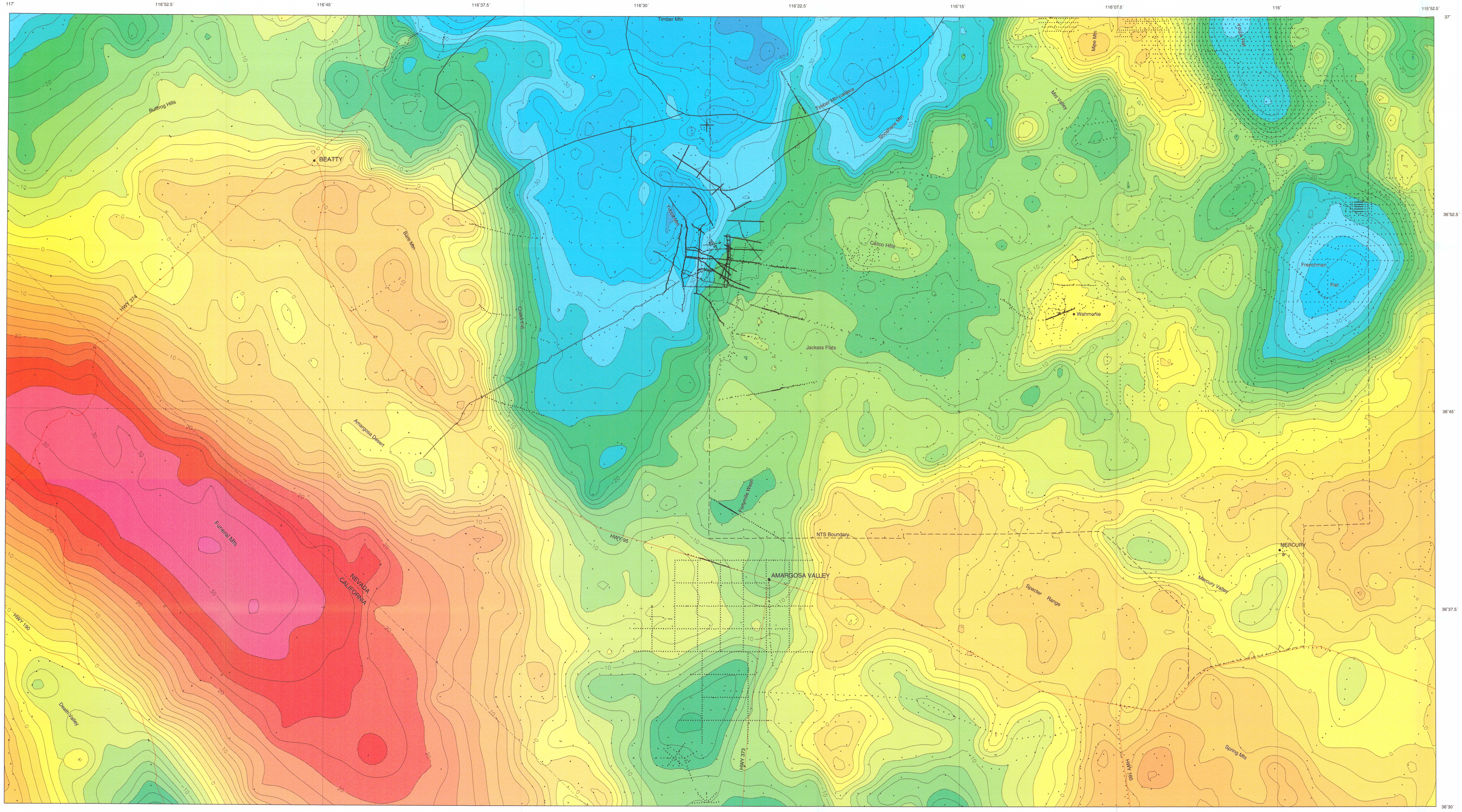
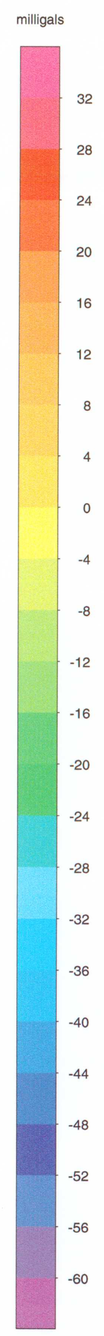


Universal Transverse Mercator
Projection Zone 11
1927 North American Datum

SCALE 1:100 000

0 5 10 15 20 25 KM

Black-line contour interval 2 milligals
Color-contour interval 4 milligals



LEGEND

- Gravity station
- Approximate caldera boundary
- Approximate boundary of NTS
- Highway
- State boundary

ISOSTATIC GRAVITY MAP OF THE BEATTY AND THE WESTERN PART OF THE INDIAN SPRINGS 1:100,000-SCALE QUADRANGLES, NEVADA

By
David A. Ponce
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ABSTRACT

An isostatic gravity map of the Beatty and the western part of the Indian Springs 1:100,000-scale quadrangles was prepared from publicly available gravity data (Ponce, 1997) and gravity data recently collected by the U.S. Geological Survey (unpub. data, 1997; 1998). Gravity data were processed using standard gravity data reduction techniques. Southwest Nevada is characterized by gravity anomalies that reflect the distribution of pre-Cenozoic carbonate rocks, thick sequences of volcanic rocks, and thick alluvial basins. In addition, regional gravity data reveal the presence of linear features that reflect Basin and Range faulting while detailed gravity data can indicate the presence of small faults.

INTRODUCTION

Gravity investigations of the Beatty and the western part of the Indian Springs 1:100,000-scale quadrangles were begun as part of an interagency effort by the U.S. Geological Survey (USGS) and the Department of Energy to help characterize the geology and hydrology of southwest Nevada. The Beatty quadrangle and margin is located between lat. 36° and 36° 30'N. and long. 115° 52.5' and 117°W.

An isostatic gravity map of the Beatty and the western part of the Indian Springs 1:100,000-scale quadrangles was prepared from over 9,600 gravity stations, most of which are publicly available on a CDROM of gravity data of Nevada (Ponce, 1997). The map also includes unpublished gravity data recently collected by the U.S. Geological Survey (unpub. data, 1997; 1998). A large subset of these gravity data were described in great detail by Harris and others (1989) that includes gravity meters used, dates of collection, sources, description of base stations, plots of data, and a digital and paper list of principal facts.

ACKNOWLEDGMENTS

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GRAVITY DATUM AND REDUCTION

All gravity data were reduced using standard gravity corrections including: (a) the Earth-tide correction, which corrects for tidal effects of the moon and sun; (b) instrument drift correction, which compensates for drift in the instrument's spring; (c) the latitude correction, which incorporates the variation of the Earth's gravity with latitude; (d) the free-air correction, which accounts for the difference in elevation between each station and sea-level; (e) the Bouguer correction, which corrects for the attraction of material between the station and sea-level; (f) the curvature correction, which corrects the Bouguer correction for the effect of the Earth's curvature to 166.7 km; (g) the terrain correction, which removes the effect of topography to a radial distance of 166.7 km; and (h) the isostatic correction, which removes long-wavelength variations in the gravity field inversely related to topography.

Observed gravity values are referenced to the International Gravity Standardization Net 1971 (IGSN 71) gravity datum (Morelli, 1974, p. 18). Free-air gravity anomalies were calculated using the Geodetic Reference System 1967 formula for the theoretical gravity on the ellipsoid (International Union of Geodesy and Geophysics, 1971, p. 60) and Swick's formula (1942, p. 65) for the free-air correction. Bouguer, curvature, and terrain corrections were added to the free-air correction to determine the complete Bouguer anomaly at a standard reduction density of 2.67 g/cm^3. Finally, a regional isostatic gravity field was removed from the Bouguer field assuming an Airy-Heiskanen model for isostatic compensation of topographic loads (Jachens and Roberts, 1981) with an assumed crustal thickness of 25 km, a crustal density of 2.67 g/cm^3, and a density contrast across the base of the model of 0.4 g/cm^3.

Terrain corrections, which account for the variation of topography near a gravity station, were computed using a combination of manual and digital methods. Terrain corrections consist of a three-part process: the innermost or field terrain correction, inner-zone terrain correction, and outer-zone terrain correction. Terrain corrections nearest the gravity station, the innermost or field terrain corrections, were estimated in the field and typically extend to a radial distance of 53 to 68 m.

Inner-zone terrain corrections were made using either Hayford and Bowie (1912) or Hammer (1939) systems that divide the terrain surrounding a gravity station into zones and equal area compartments. Average elevations for each compartment were manually estimated from the largest scale topographic maps available, usually USGS 1:24,000-scale maps. The terrain corrections were then calculated based on the average estimated elevation of each compartment. Inner-zone terrain corrections typically extend to a radial distance of 0.59 to 2.29 km. With the advent of computer processing and the availability of detailed digital elevation data, modern day inner-zone terrain corrections were computed using USGS 7.5' DEMs with a resolution of 30 m derived from USGS 1:24,000-scale topographic maps.

Outer-zone terrain corrections, to a radial distance of 166.7 km, were computed using a DEM derived from USGS 1:250,000-scale topographic maps and a procedure developed by Plouff (1966; Godson and Plouff, 1988). Digital terrain corrections are calculated by computing the gravity effect of each grid cell using the distance and difference in elevation of each grid cell from the gravity station.

DISCUSSION

Once gravity data are processed to isostatic anomalies they, in general, reflect lateral density variations in the mid to upper crust. Thus, gravity anomalies can be used to infer the subsurface geometry of known or unknown geologic features. Southwest Nevada is characterized by gravity anomalies that reflect the distribution of pre-Cenozoic carbonate rocks, thick sequences of volcanic rocks, and moderately thick alluvial basins. In addition, regional gravity data reveal the presence of linear features that reflect Basin and Range faulting while detailed gravity data can indicate the presence of small displacement faults.

As expected, regional gravity highs reflect exposed pre-Cenozoic rocks along the Funeral Mountains in the southwest part of the quadrangle. Gravity highs also delineate other exposed or buried at shallow depth pre-Cenozoic rocks at Bare Mountain in the west-central part, Calico Hills in the central part, Wahmonie in the east-central part, Mine Mountain in the northeastern margin, and at Specter Range in the southeastern part of the study area.

One of the most prominent gravity anomalies within the study area is the gravity low centered over Crater Flat that reflects a 4-km thick section of volcanic rocks. The steep gradient on the west side of the anomaly correlates with the Bare Mountain range front fault, but detailed gravity data indicate that it is displaced about 2 to 3 km east of the mapped location of the fault and due to the moderate east dip of the fault, which is consistent with seismic reflection data (Brocher and others, 1996). The steepest part of the gradient on the east side of the Crater Flat low, occurs on the east flank of Yucca Mountain and detailed gravity, magnetic, and seismic reflection data indicate that this probably reflects a series of down-to-the west normal faults (Brocher and others, 1996; Ponce, 1996). The Crater Flat low extends to the south, over Amargosa Valley and reflects a basin about 2 km thick. Steep gravity gradients along the margin of the gravity low reflect Basin and Range faulting, where on either side, Paleozoic rocks are exposed or buried at shallow depth.

Timber Mountain caldera, in the north-central part of the area, is one of several nested calderas in southwest Nevada. The Timber Mountain caldera is characterized by a broad circular gravity high when gravity data are reduced for more appropriate Bouguer densities of 2.2 to 2.4 rather than 2.67 g/cm^3. The gravity high reflects resurgence of the caldera, while adjacent gravity lows along the margin of Timber Mountain are associated with lower-density rocks in moat areas of the caldera. Gravity data indicate that volcanic rocks along Timber Mountain are about 3 km thick (Oliver and Ponce, 1995).

A gravity low over Frenchman Flat was briefly mentioned many years ago by Healey (1968) and is associated with low density basin fill material that is probably about 2 to 3 km thick. Gravity lows define other shallow to moderately deep basins in the area that include Death Valley in the southwest corner, the shallower Jackass Flats in the central part, Amargosa Valley in the south-central part, and Yucca Flat in the northeast corner of the study area.

Gravity anomalies on the Beatty and the western part of the Indian Springs quadrangles reflect a suite of geologic features that include the structure and topography of pre-Cenozoic rocks, Cenozoic calderas, Basin and Range faults, other faults, and moderately deep basins. These features play an important role in the regional and detailed geologic and hydrologic setting and evolution of southwest Nevada.

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