U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Digital isostatic gravity map of the Nevada Test Site and vicinity, Nye, Lincoln, and Clark Counties, Nevada, and Inyo County, California

By D.A. Ponce[1], E.A., Mankinen[1], J.G. Davidson[1], R.L. Morin[1], and R.J. Blakely[1]

Open-File Report 99-554–C

Prepared in cooperation with the Nevada Operations Office, U.S. Department of Energy (Interagency Agreement DE-A108-96NV11967)

1999

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

[1]U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025

ABSTRACT

An isostatic gravity map of the Nevada Test Site area was prepared from publicly available gravity data (Ponce, 1997) and from gravity data recently collected by the U.S. Geological Survey (Mankinen and others, 1999; Morin and Blakely, 1999). 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 large-scale faults whereas detailed gravity data can indicate the presence of smaller-scale faults.

INTRODUCTION

Gravity investigations of the Nevada Test Site area are part of an interagency effort by the U.S. Geological Survey (USGS) and the Department of Energy (Interagency Agreement DE-AI08-96NV11967) to help characterize the geology and hydrology of southwest Nevada. The Nevada Test Site area is located between lat. 36° 30' and 37° 30' N., and long. 115° 52.5' and 117° W.

An isostatic gravity map of the Nevada Test Site area was prepared from over 10,000 gravity stations, most of which are publicly available on a CD-ROM of gravity data of Nevada (Ponce, 1997). The map also includes gravity data recently collected by the U.S. Geological Survey (Mankinen and others, 1999; Morin and Blakely, 1999). A large subset of these gravity data were described in great detail by Harris and others (1989) that includes information on gravity meters used, dates of collection, sources, description of base stations, plots of data, and digital and paper lists of principal facts.

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, that is 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 models (DEMs), 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.

REFERENCES

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, Documentation, 22 p.; 88-644-B, Tables, 61 p., 88-644-C, 5 1/4-inch diskette.

Hayford, J.F., and Bowie, William, 1912, The effect of topography and isostatic compensation upon the intensity of gravity: U.S. Coast and Geodetic Survey Special Publication no. 10, 132 p.

Hammer, Sigmund, 1939, Terrain corrections for gravimeter stations: Geophysics, v. 4, p. 184-194.

Harris, R.N., Ponce, D.A., Healey, D.L., and Oliver, H.W., 1989, Principal facts for about 16,000 gravity stations in the Nevada Test Site and vicinity: U.S. Geological Survey Open-File Report 89-682-A, Principal facts documentation, 78 p.; 89-682-B, Gravity data listing on paper, 286 p.; and 89-682-C, Gravity data on diskette, 2 diskettes.

International Union of Geodesy and Geophysics, 1971, Geodetic reference system 1967: International Association of Geodesy Special Publication no. 3, 116 p.

Jachens, R.C., and Roberts, C.W., 1981, Documentation of a FORTRAN program, ‘isocomp’, for computing isostatic residual gravity: U.S. Geological Open-File Report 81-574, 26 p.

Mankinen, E.A., Hildenbrand, T.G., Roberts, C.W., and Davidson, J.G., 1998, Principal facts for new gravity stations in the Pahute Mesa and Oasis Valley areas, Nevada: U.S. Geological Survey Open-File Report 98-498, 14 p.

Morelli, Carlo, ed., 1974, The International Gravity Standardization Net 1971: International Association of Geodesy Special Publication no. 4, 194 p.

Morin, R.L., and Blakely, R.J., 1999, Principal facts for about 500 gravity stations in the vicinity of Amargosa Desert and Pahrump Valley, California and Nevada: U.S. Geological Survey Open-File Report 99-31, 18 p.

Plouff, Donald, 1966, Digital terrain corrections based on geographic coordinates (abs.): Geophysics, v. 31, no. 6, p. 1208.

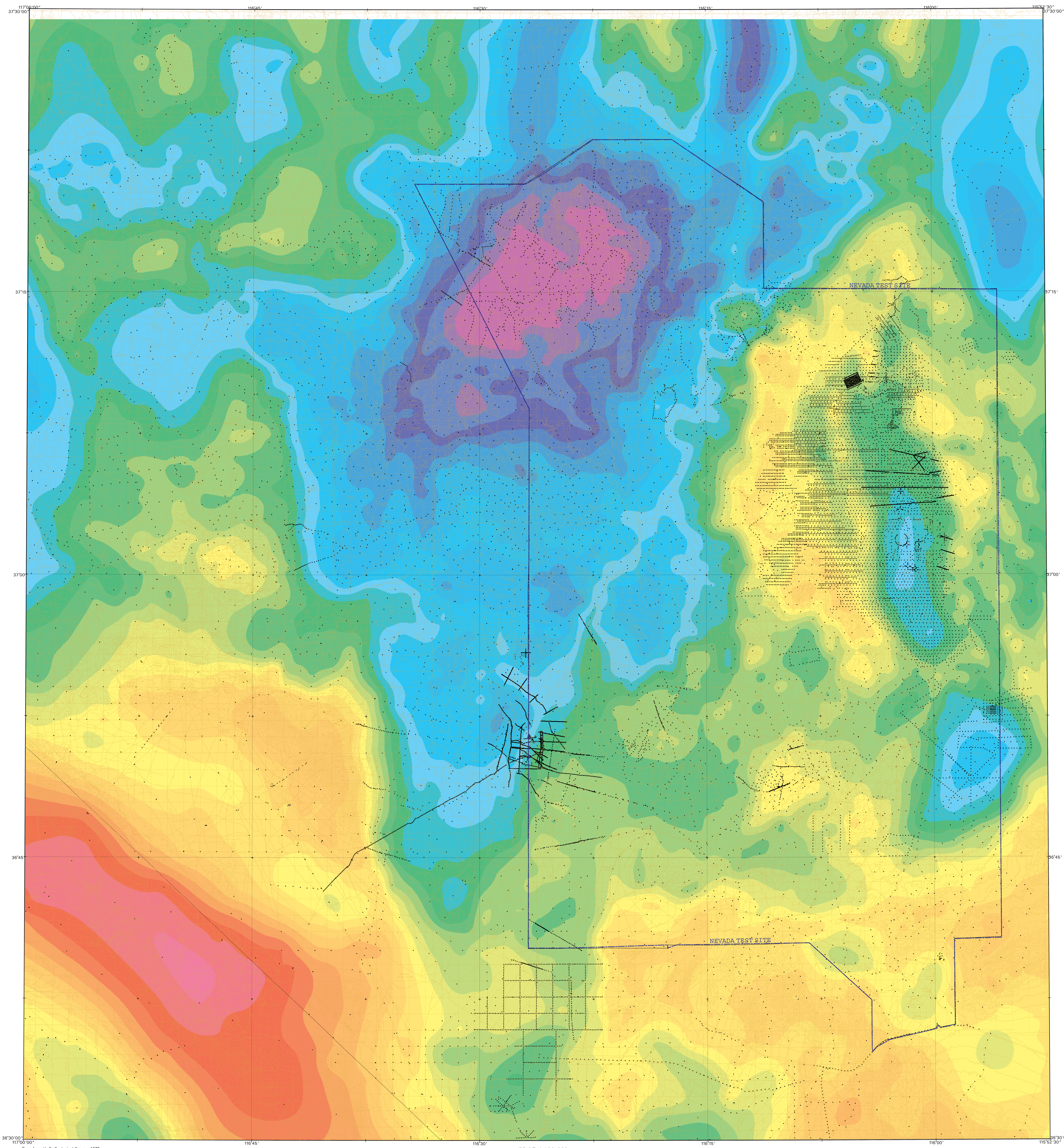
Ponce, D.A., 1997, Gravity data of Nevada: U.S. Geological Survey Digital Data Series DDS-42, CD-ROM, 27 p.

Swick, C.H., 1942, Pendulum gravity measurements and isostatic reductions: U.S. Coast and Geodetic Survey Special Publication no. 232, 82 p.

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the U. S. Department of Energy

OPEN FILE REPORT 99-554-C
PLATE 1 (OF 1)



Base from U. S. Geological Survey, 1979
Projection zone 11: Universal Transverse Mercator
1927 North American Datum

SCALE 1:120 000

1 0 1 2 3 4 5 6 7 8 9 10 KILOMETERS

1 0 1 2 3 4 5 MILES

CONTOUR INTERVAL 50 METERS
WITH SUPPLEMENTARY CONTOURS AT 10–METER INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

DIGITAL ISOSTATIC GRAVITY MAP OF THE NEVADA TEST SITE AND VICINITY, NYE, LINCOLN, AND CLARK COUNTIES, NEVADA AND INYO COUNTY, CALIFORNIA

by
D. A. Ponce, E. A. Mankinen, J. G. Davidson, R.L. Morin, and R. J. Blakely