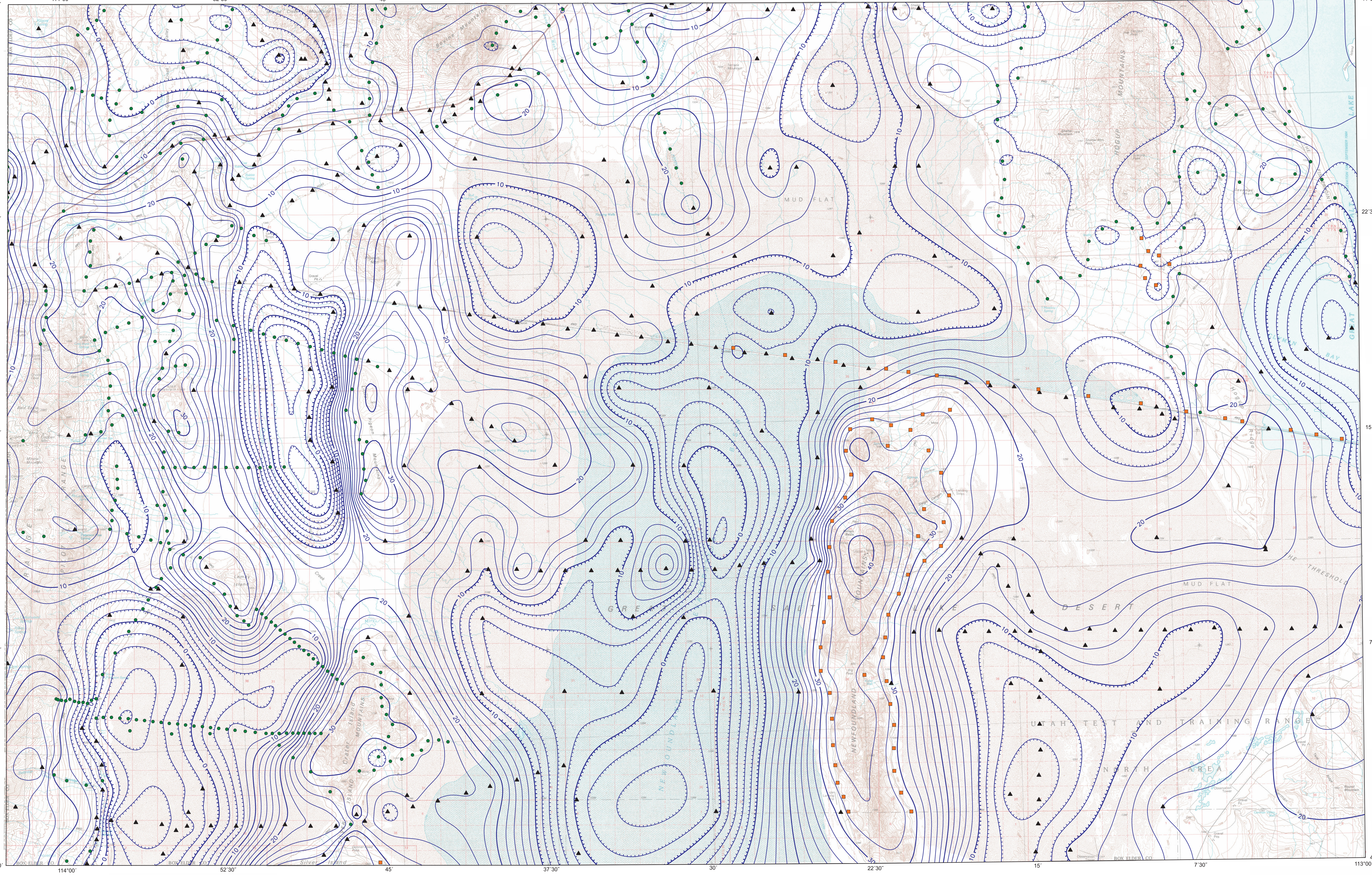
Utah Geological Survey
a division of
Utah Department of Natural Resources
in cooperation with
U.S. Department of the Interior
U.S. Geological Survey



Topographic base from U.S. Geological Survey 1:100,000 Newfoundland Mountains and Wells quadrangles. Projection, Universal Transverse Mercator. 1927 North American Datum.

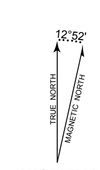
ISBN 978-1-55791-879-6

SCALE 1:100,000

2 0 2 4 6 Miles

2 0 2 4 6 Kilometers

Topographic contour interval 20 meters (Newfoundland Mountains) and 40 meters (Wells)
Supplementary contour interval 5 meters (Newfoundland Mountains) and 20 meters (Wells)



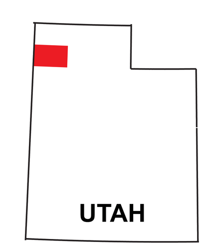
APPROXIMATE MEAN DECLINATION, 2013

PRELIMINARY ISOSTATIC RESIDUAL GRAVITY MAP OF THE NEWFOUNDLAND MOUNTAINS AND EAST PART OF THE WELLS 30´ x 60´ QUADRANGLES, BOX ELDER COUNTY, UTAH

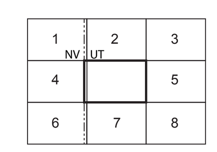
V.E. Langenheim[1], N.D. Athens[1], B.A. Chuchel[1], H. Willis[2], N.E. Knepprath[1], J. Rosario[1], J. Roza[1], S.M. Kraushaar[1], and C.L. Hardwick[2]

2013

[1]U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025-0046
[2]Utah Geological Survey, P.O. Box 146100, Salt Lake City, UT 84114-6100



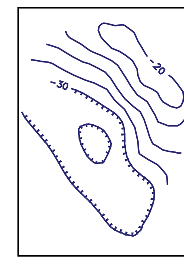
STUDY AREA



1. Jackpot
2. Grouse Creek
3. Tremonton
4. Wells
5. Promontory Point
6. Wendover
7. Bonneville Salt Flats
8. Tooele

ADJOINING 30' X 60' QUADRANGLE NAMES

EXPLANATION



Gravity anomaly contours. Contour interval, 2 mGal. Hachures indicate gravity low.

MEASUREMENT LOCATIONS

- ▲ Older data (Bankey and others, 1998)
- ■ Utah Geological Survey 2011-2012
- ● U.S. Geological Survey 2011-2013

ABSTRACT
This isostatic residual gravity map is part of a cooperative effort to map the three-dimensional distribution of rocks in northwest Utah. This map will serve as a basis for modeling the shape of basins and for determining the location and geometry of faults within the area. The map presents gravity anomalies contoured at an interval of 2 milligals (mGal) on a topographic base at a scale of 1:100,000. Figure 1 shows gravity-anomaly contours with a color ramp applied to 2 mGal intervals, with artificial shading of the gravity field, at a scale of approximately 1:400,000. Local spatial variations in the Earth's gravity field, after minimizing variations caused by elevation, terrain, and deep crustal structure, reflect the distribution of densities in the mid- to upper crust. Densities commonly are related to rock type, and abrupt spatial changes in density commonly mark lithologic or structural boundaries.

Relatively high-density basement rocks exposed within the Newfoundland, Little Pigeon, and Silver Island Mountains include metamorphic and sedimentary rocks that range from Proterozoic to Mesozoic in age. These rocks are locally intruded by Jurassic and Tertiary plutons (Miller and others, 1987). Alluvial sediments, usually located in the valleys, and Tertiary sedimentary rocks are characterized by lower densities. However, with increasing depth of burial and age, the densities of these rocks may become indistinguishable from those of basement rocks. Tertiary volcanic rocks are characterized by a wide range of densities, but are less dense, on average, than the pre-Cenozoic basement rocks. Tertiary basalt is as dense as crystalline basement, but is probably less than 100 m thick, as mapped in the Grouse Creek 30' x 60' quadrangle to the north (Miller and others, 2012).

Isostatic residual gravity values within the map area range from about –10 mGal over Grouse Creek Valley to about 34 mGal over the Newfoundland Mountains. Steep, linear gravity gradients bound the Newfoundland, Silver Island, and Little Pigeon Mountains, Lemay Island, and the eastern margin of the Pilot Range. These gradients result from juxtaposing dense basement rocks against thick Cenozoic sedimentary rocks and have been inferred to mark basin-bounding faults (Cook and others, 1964).

DATA SOURCES, REDUCTIONS, AND ACCURACIES
The isostatic residual gravity map was created from 742 gravity measurements. Previously published data are from a regional compilation (Bankey and others, 1998) and are supplemented by new data collected in 2011-2013 by the Utah and U.S. Geological Surveys. Gravity measurements are non-uniformly distributed in the region and located mostly along roads. Station spacing is on average 1 station per 8 km^2, although the station spacing is as low as 1 station per 50 km^2 within remote parts of the quadrangle, such as in the Great Salt Lake Desert. Contours were computer-generated based on a 400-m grid using the principle of minimum curvature (Briggs, 1974). Although the data have been edited, caution should be exercised when interpreting anomalies controlled by only a single gravity station.

The datum of observed gravity for this map is the International Gravity Standardization Net of 1971 (IGSN 71) as described by Morelli (1974); the reference ellipsoid is the Geodetic Reference System of 1967 (GRS67; International Union of Geodesy and Geophysics, 1971). The observed gravity data were reduced to free-air anomalies using standard formulas (for example, Telford and others, 1990). Bouguer, Earth curvature, and terrain adjustments to a radial distance of 166.7 km were applied to the free-air anomaly at each station to determine the complete Bouguer anomalies at a standard reduction density of 2670 kg/m^3 (Plouff, 1977). An isostatic adjustment was then applied to remove the long-wavelength effect of deep crustal and/or upper mantle masses that isostatically support regional topography. The isostatic adjustment is based on an Airy-Heiskanen model of isostatic compensation (Heiskanen and Vening-Meinesz, 1958). Compensation is achieved by varying the depth of the model crust-mantle interface, using the following parameters: a crustal thickness of 25 km for topography at sea level, a crust-mantle density contrast of 400 kg/m^3, and a crustal density of 2670 kg/m^3 for the topographic load. These parameters were used because (1) they were consistent with model parameters used for isostatic corrections computed for adjacent Nevada (Ponce, 1997), and (2) changing the model parameters did not significantly affect the resulting isostatic anomaly (Jachens and Griscom, 1985). The computer program ISOCOMP (Jachens and Roberts, 1981) directly calculates the attraction of an Airy-Heiskanen root by summing the attraction of individual mass prisms making up the root and thus calculating the isostatic adjustment. The resulting isostatic residual gravity values should reflect lateral variations of density within the mid- to upper crust.

Accuracy of the data used to create this map is estimated to be about ±0.1 to ±0.5 mGal based on comparison of observed gravity values at duplicate measurements from different data sources and expected uncertainty resulting from the total terrain correction and measurement elevation. Some of the older data were located using a 1:250,000-scale quadrangle and plot parallel to roads. Where the elevation of the data point could be correlated to a benchmark elevation on a road, the data point was relocated and anomalies and terrain corrections recalculated. Total terrain corrections for the measurements collected for this study, which include a correction for the Earth's curvature, ranged from 0.22 to 9.58 mGal, with an average of 0.57 mGal. If the uncertainty of the terrain correction is considered to be 5% to 10% of the terrain correction, the largest associated uncertainty expected for the data is 1 mGal. However, the likely uncertainty due to the terrain correction is small (less than 0.2 mGal) for most of the measurements. The elevations are known to 1 m or less for most of the measurements, yielding an uncertainty due to elevation in the anomaly value of less than 0.2 mGal.

ACKNOWLEDGMENTS
We thank Kevin Denton, Don Plouff, Don Clark, and Grant Willis for their reviews of the map. We thank various landowners for granting access. The study was supported by the U.S. Geological Survey National Cooperative Geologic Mapping Program and the Utah Geological Survey.

REFERENCES
Bankey, V., Grauch, V.J.S., and Kucks, R.P., 1998, Utah aeromagnetic and gravity maps and data--A web site for distribution of data (on-line version): U.S. Geological Survey Open-File Report 98-0761. Available at http://pubs.usgs.gov/of/1998/ofr-98-0761/ [last accessed December 26, 2012].

Briggs, I.C., 1974, Machine contouring using minimum curvature: Geophysics, v. 39, p. 39-48.

Cook, K.L., Halverson, M.O., Stepp, J.C., and Berg, J.W., Jr., 1964, Regional gravity survey of the northern Great Salt Lake Desert and adjacent areas in Utah, Nevada, and Idaho: Geological Society of America Bulletin, v. 75, p. 715-740.

Heiskanen, W.A., and Vening-Meinesz, F.A., 1958, The Earth and its gravity field: New York, McGraw-Hill Book Company, Inc., 470 p.

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 Griscom, A., 1985, An isostatic residual gravity map of California—A residual map for interpretation of anomalies from intracrustal sources, *in* Hinze, W.J., editor, The utility of regional gravity and magnetic maps: Society of Exploration Geophysicists, Tulsa, Oklahoma, p. 347-360.

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

Miller, D.M., Clark, D.L., Wells, M.L., Oviatt, C.G., Felger, T.J., and Todd, V.R., 2012, Progress report geologic map of the Grouse Creek 30' x 60' quadrangle and the Utah part of the Jackpot 30' x 60' quadrangle, Box Elder County, Utah and Cassia County, Idaho (Year 3 of 4): Utah Geological Survey Open-File Report 598, 1 plate, 31 p., scale 1:62,500.

Miller, D.M., Hillhouse, W.C., Zartman, R.E., and Lanphere, M.A., 1987, Geochronology of intrusive and metamorphic rocks in the Pilot Range, Utah and Nevada, and comparison with regional patterns: Geological Society of America Bulletin, v. 99, p. 866-879.

Morelli, C. (editor), 1974, The International Gravity Standardization Net, 1971: International Association of Geodesy Special Publication no. 4, 194 p.

Plouff, D., 1977, Preliminary documentation for a FORTRAN program to compute gravity terrain corrections based on topography digitized on a geographic grid: U.S. Geological Survey Open-File Report 77-535, 45 p.

Ponce, D.A., 1997, Gravity map of Nevada: U.S. Geological Survey Digital Data Series DDS-42, 28 p. Available at http://pubs.usgs.gov/dds/dds-42/ [last accessed December 26, 2012].

Telford, W.M., Geldart, L.O., Sheriff, R.E., and Keyes, D.A., 1990, Applied geophysics (second edition): New York, Cambridge University Press, 770 p.

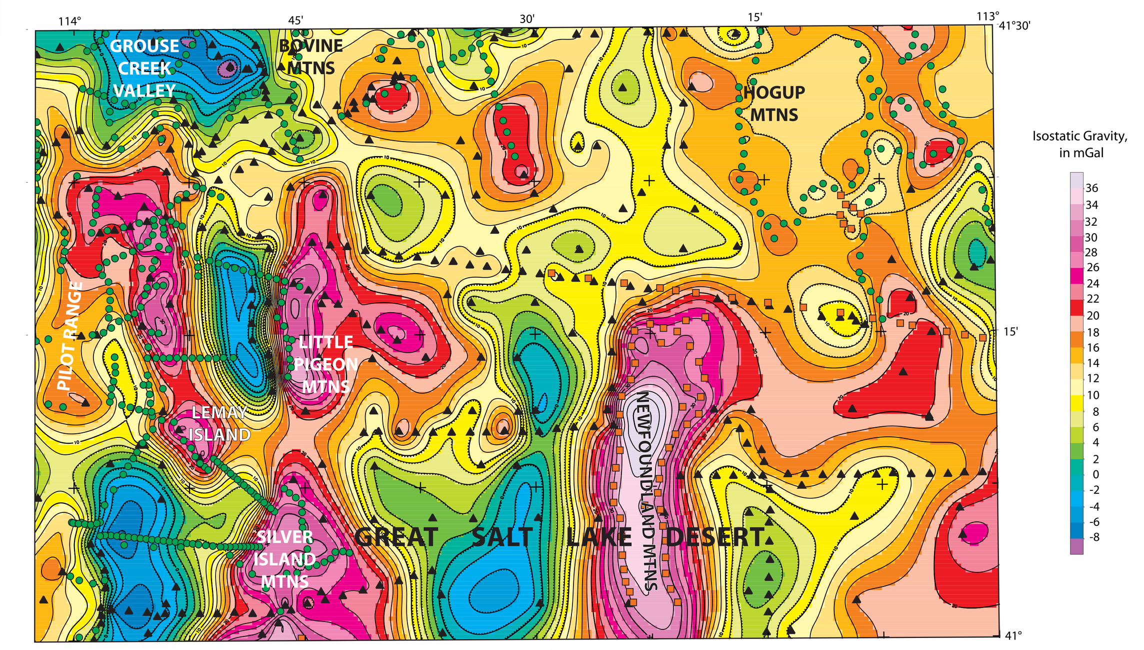


Figure 1. Colored isostatic residual gravity map. Symbols are gravity measurements shown with same shape and color as in main map, but smaller.

Preliminary Isostatic Residual Gravity Map of the Newfoundland Mountains and East Part of the Wells 30´ x 60´ Quadrangles, Box Elder County, Utah

by V.E. Langenheim, N.D. Athens, B.A. Chuchel, H. Willis, N.E. Knepprath, J. Rosario, J. Roza, S.M. Kraushaar, and C.L. Hardwick

2013

Utah Geological Survey Miscellaneous Publication 13-4

ABSTRACT

A new isostatic residual gravity map of the Newfoundland Mountains and east part of the Wells 30' x 60' quadrangles of Utah is based on compilation of preexisting data and new data collected by the Utah and U.S. Geological Surveys. Pronounced gravity lows occur over Grouse Creek Valley and locally beneath the Great Salt Lake Desert, indicating significant thickness of low-density Tertiary sedimentary rocks and deposits. Gravity highs coincide with exposures of dense pre-Cenozoic rocks in the Newfoundland, Silver Island, and Little Pigeon Mountains. Gravity values measured on pre-Tertiary basement to the north in the Bovine and Hogup Mountains are as much as 10 mGal lower. Steep, linear gravity gradients may define basin-bounding faults concealed along the margins of the Newfoundland, Silver Island, and Little Pigeon Mountains, Lemay Island and the Pilot Range.

CITATION

Langenheim, V.E., Athens, N.D., Chuchel, B.A., Willis, H., Knepprath, N.E., Rosario, J., Roza, J., Kraushaar, S.M., and Hardwick, C.L., 2013, Preliminary Isostatic Residual Gravity Map of the Newfoundland Mountains and East Part of the Wells 30´ x 60´ Quadrangles, Box Elder County, Utah: Utah Geological Survey Miscellaneous Publication 13-4, 1 plate, scale 1:100,000.

NOTICES

This map was funded by the Utah Geological Survey and the U.S. Geological Survey, National Cooperative Geologic Mapping Program. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

GRAVITY DATA CONTENTS

The three data files included in Utah Geological Survey Miscellaneous Publication 13-4 are given as ascii data files and as Excel files on this CD, and are online at geology.utah.gov/maps/geophysmap/index.htm.

File newfie-old3-iso.xls contains previously collected data from Bankey and others (1998). Files newfie-ugs-iso.xls and newfie-usgs-130923.xls contain data collected in 2011–2013 by the Utah Geological Survey and U.S. Geological Survey, respectively.

The format of the data files are described below.

The horizontal and vertical locations for the stations are on the North American Datum 1927 (NAD27) and the North American Vertical Datum 1929 (NAVD29), respectively.

The gravity stations (iso.xls) were referenced to the International Gravity Standardization Net 1971 (IGSN71) datum and the reference ellipsoid is the Geodetic Reference System 1967 (GRS67). The free-air anomalies were calculated using a modified version of formulas from Swick (1942). The complete Bouguer anomalies were calculated from the free-air anomalies using the Bouguer correction, terrain corrections, a curvature correction, and a reduction density of 2670 kg/m3 (2.67 g/cc). Isostatic corrections were calculated using an Airy-Heiskanen model of isostatic compensation. The depth of the crust-mantle boundary was controlled using the following parameters: a crustal thickness at sea level of 25 km, a density contrast of 400 kg/m3 (0.40 g/cc) between the crust and mantle, and a crustal density of 2670 kg/m3 (2.67 g/cc).

EXPLANATION OF PRINCIPAL FACT FORMAT FOR GRAVITY STATIONS

(newfie-old3-iso.xls, newfie-ugs-iso.xls, and newfie-usgs-130923.xls)

Fixed format. Format is as follows:

STATION NAME: An alphanumeric combination of up to 8 characters used for station identification. Columns 0–8

LATD: Degree latitude. Columns 9–11

LATM: Minute latitude. Columns 12–17

LOND: Degree longitude. Columns 18–21

LONM: Minute latitude. Columns 22–27

ELEV: Elevation. Columns 28–35

OG: Observed gravity. Columns 36–45

FAA: Free-air anomaly. Columns 52–58

SBA: Simple Bouguer anomaly. Columns 59–66

ITC: Inner terrain correction out to a radius of various distances (see TC CODE) from the station, for a density of 2.67 g/cc. Columns 67–73

TC: Total terrain correction from the station to 166.7 km for a density of 2670 kg/m3 (2.67 g/cc). Columns 74–80

TC CODE: Letter denoting the extent of the inner-zone correction, according to the Hayford-Bowie and Hammer templates (f=895 meters; M=2000 meters). Note in old-gc-iso3.xls data that have tc codes of M have had their locations or elevations adjusted. See Spielman and Ponce (1984) for additional explanation. Column 82

CBA: Complete Bouguer anomaly reduced for a density of 2670 kg/m3 (2.67 g/cc). Columns 83–90

ISO: Isostatic residual anomaly values. Columns 91–98.

Example of format for gravity file

36030032 41 52.60 113 8.08 4804.8 979887.32 2.09 -161.78 0.03 0.77 f -162.40 12.69

STATION NAME: 36030032

LATD:	41 degrees North
LATM:	52.60 minutes
LOND:	113 degrees West
LONM:	8.08 minutes
ELEV:	4804.8 feet
OG:	979887.32 mGal
FAA:	2.09 mGal
SBA:	-161.78 mGal
ITC:	0.03 mGal
TC:	0.77 mGal
TC_CODE:	f (895 m)
CBA:	-162.40 mGal
ISO:	12.69 mGal

REFERENCES

Bankey, V., Grauch, V.J.S., and Kucks, R.P., 1998, Utah aeromagnetic and gravity maps and data—A web site for distribution of data (on-line version): U.S. Geological Survey Open-File Report 98-0761.

Spielman, J.B., and Ponce, D.A., 1984, Handtc, a Fortran program to calculate inner-zone terrain corrections: U.S. Geological Survey Open-File Report 84-777, 24 p.

Swick, C.A., 1942, Pendulum gravity measurements and isostatic reductions: U.S. Coast and Geodetic Survey Special Publication 232, 82 p.