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Gravity data for the State of Nevada on magnetic tape

by

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Abstract

Gravity data assembled for a state gravity map to be published by the Nevada Bureau of Mines are available from the EROS data center on magnetic tape. The first 18 files of the tape contain principal facts for individual data points, organized by 1° x 2° quadrangle. The approximately 71,000 individual data points are from numerous sources including the Defense Mapping Agency data base and U.S. Geological Survey files. Each data record contains geographic position, observed gravity, terrain correction, Bouguer gravity anomaly ($\rho = 2.67$ g/cm^3), and isostatic residual anomaly (Airy Heiskanen, T = 25 km, $\Delta\rho = 0.4$ g/cm^3). The 19th and 20th data files are 2 km square grids of complete Bouguer and isostatic residual gravity values based on the data in the preceding files. The 9-track magnetic tape is written at 1,600 bytes-per-inch (BPI) in ASCII format with an 80-character record and 4,000-character (50 record) block size.

Gravity sources

These Nevada gravity data consist primarily of data from the Defense Mapping Agency (DOD) data base (available from the National Geophysical and Solar-Terrestrial Data Center, Boulder, Colorado 80303). Additional data from U.S. Geological Survey (USGS) files in Denver, Colorado and Menlo Park, California are included. Most of the USGS data are documented in published Bouguer gravity anomaly maps and principal facts reports for the following 1° x 2° quadrangles in Nevada (see appendix for source DOD references):

- Caliente (Healey and others, 1981b)
- Death Valley (Healey and others, 1980b)

- Ely (Ponce and others, 1984)
- Goldfield (Healey and others, 1980a)
- Kingman (Bracken and Kane, 1983)
- Las Vegas (Kane and others, 1979)
- Lund (Bol and others, 1983)
- Millett (Erwin and Bittleston, 1977)
- Reno (Erwin and Berg, 1977)
- Tonopah (Healey and others, 1981a; Bol and others, 1983)
- Walker Lake (Plouff, 1984)

Gravity reduction

The observed gravity datum is the International Gravity Standardization Net of 1971 (IGSN 71; Morelli, 1974). Bouguer gravity anomalies were computed using the 1967 Geodetic Reference System (GRS 67) formula for theoretical gravity at sea level (International Association of Geodesy, 1971) as implemented on a computer (Cordell and others, 1982). A Bouguer reduction density of 2.67 g/cm^3 was used. Terrain corrections were calculated for the region extending radially to 167 km from each station using a digital terrain model based on a 15 second geographic grid (Plouff, 1977). Inner zone terrain corrections from the station to a distance of 0.59 km (Hayford zone D; Swick, 1942) were done by hand for most USGS stations. For stations obtained from the DOD, inner zone corrections were approximated by computer. A curvature correction for the deviation of the spheroidal Earth from the Bouguer approximation has also been applied. Gravity stations were removed from the data set if their Bouguer anomalies varied unrealistically from nearby stations. Most of the Bouguer values are estimated to be accurate to better than 1 milligal (mGal; 1 mGal = 10^{-5} m/s^2). However, individual stations in regions of variable topography may have errors as great as 4 mGal because of errors in terrain correction.

Isostatic residual gravity anomalies were calculated by removing a regional field from the Bouguer anomalies. This isostatic regional was calculated based on an Airy-Heiskanen model of local isostatic compensation (Heiskanen and Moritz, 1967). The isostatic model is described by the following parameters: a compensation depth of 25 km below sea level, a density contrast at depth of 0.4 g/cm^3, and a surface load density of 2.67 g/cm^3. These parameters agree with those used for the isostatic gravity map of California (Jachens and Griscom, 1985; Roberts and others, 1981). The utility of the isostatic residual anomaly is discussed by Simpson and others (1986).

A shift of approximately -2 mGal occurs between Bouguer values reduced using the IGSN 71 datum and GRS 67 formula and Bouguer values reduced with the older Woollard and Rose (1963) datum and 1930 International Gravity formula (Swick, 1942) used for the complete Bouguer gravity map of California (Oliver and others, 1980). Care must be taken if these data are to be combined with older data sets of California to prevent a 2 mGal step across the state boundary. Oliver (1980, page 52) discusses the datum conversion in some detail. All data on this tape are relative to the IGSN 71 datum and GRS 67 formula.

Tape characteristics

Density: 1,600 bytes per inch (BPI)

Record size: 80 characters

Block size: 4,000 characters (50 records)

Format: Ascii, unlabeled

Files: 20 files. File order and contents are given in table 1. The first 18 files each contain data from a 1° by 2° quadrangle (see figure 1). The last two files contain gridded Bouguer and isostatic residual gravity values (see figures 2 and 3).

Tape file header

The first 10 lines of each tape file contain descriptive information about the file. The gravity data begin at record (line) number 11 and have the format given in table 2. A description of the 10 header lines follows:

1. Type of file (1=grid, 7=ASCII) and creation date.
2. Name of the file.
3. Description of file contents.
4. FORTRAN format of each data record.
5. Information on file format.
6. Information on gridded data parameters (for gridded data only).
7. More information about gridded data parameters (for gridded data only).
8. May contain descriptive text.
9. May contain descriptive text.
10. May contain descriptive text.

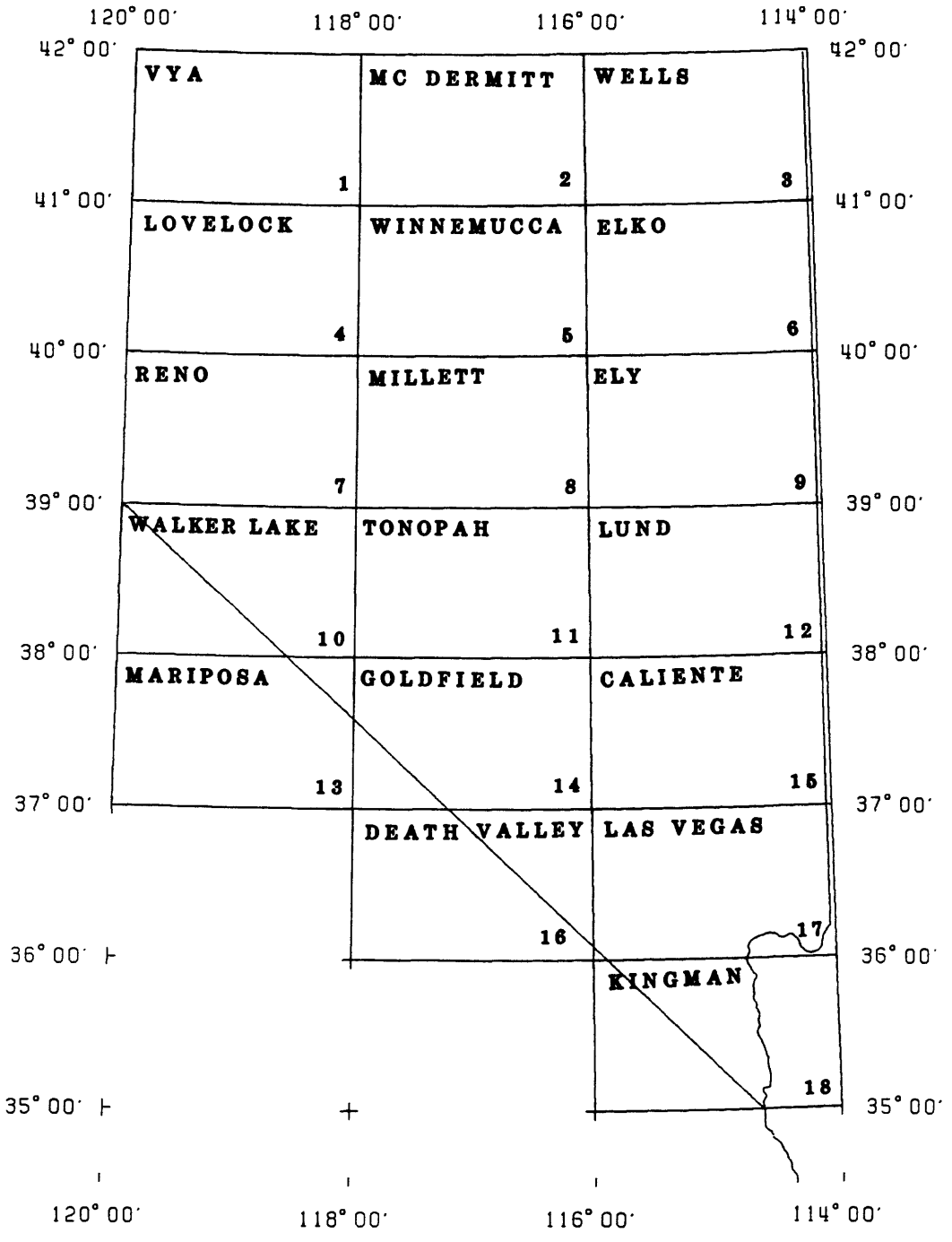

Figure 1: 1° x 2° quadrangles of Nevada. Numbers indicate order of the gravity data files on the tape.

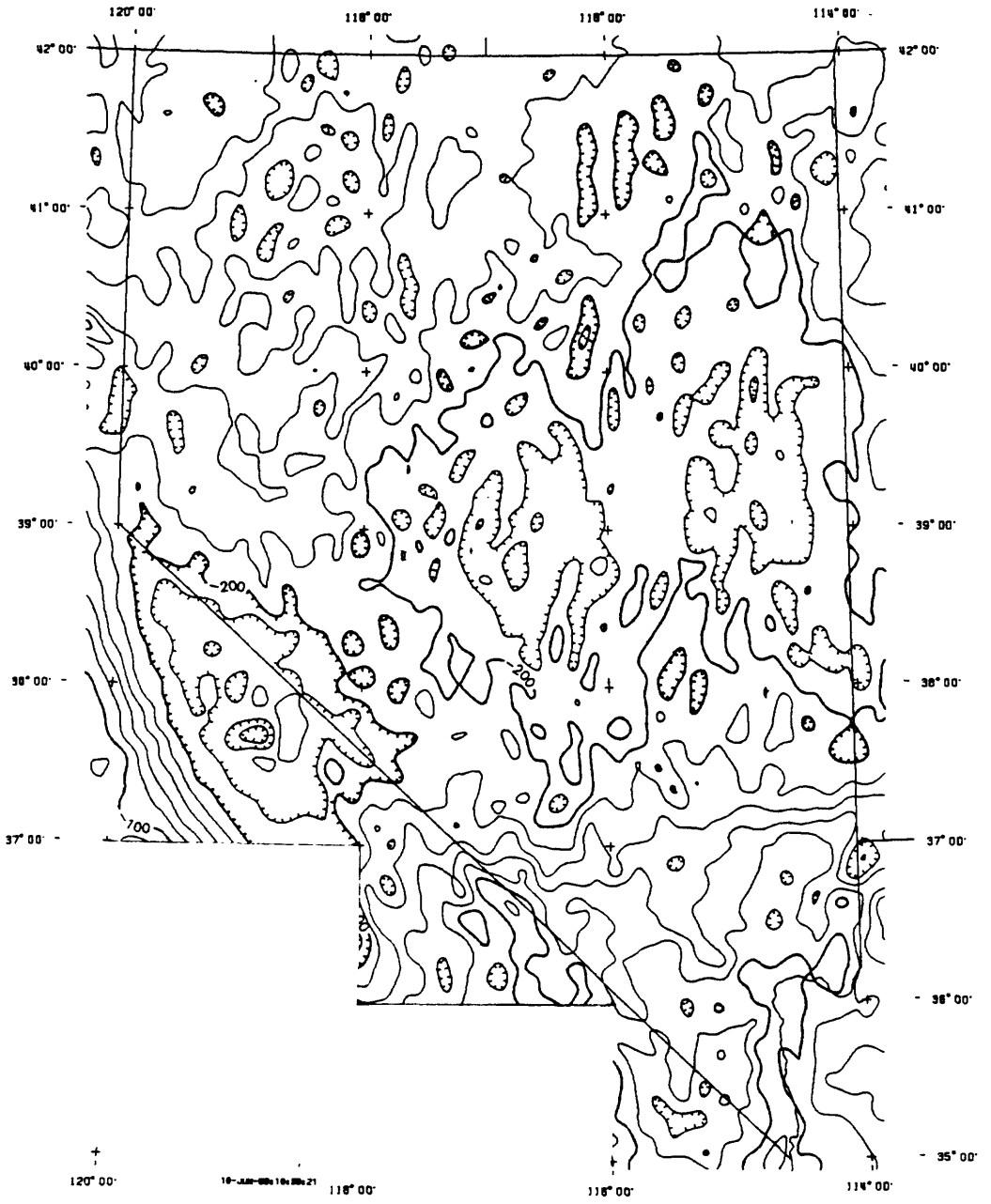

Figure 2: Contents of file 19, complete Bouguer gravity grid of Nevada. Contour interval: 20 mGal, Scale 1:5,000,000. This plot was smoothed (contains only wavelengths greater than 20 km), so it is not identical to the grid.

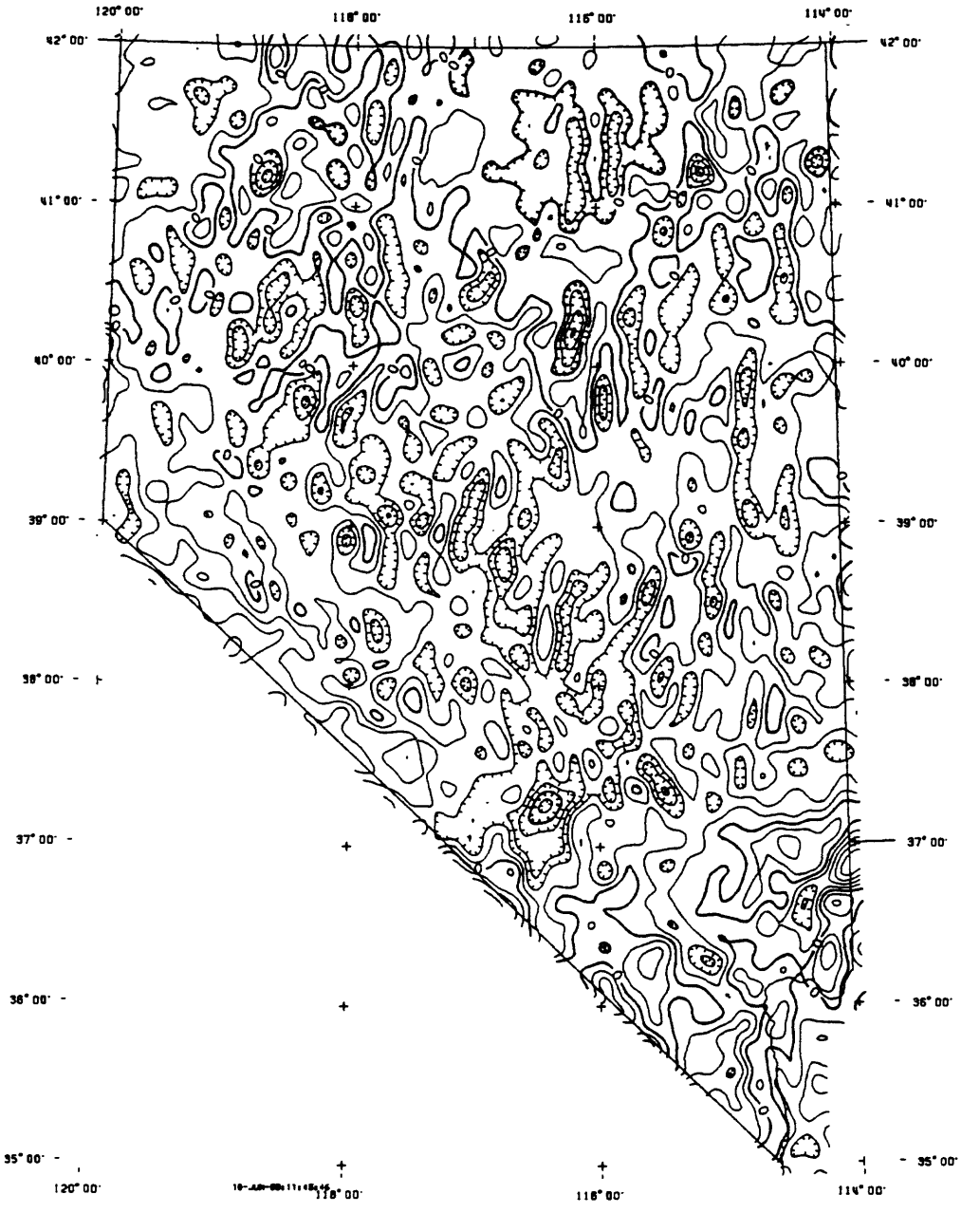

Figure 3: Contents of file 20, isostatic residual gravity of Nevada. Contour interval: 10 mGal, Scale 1:5,000,000. This plot contains only wavelengths greater than 20 km, but the grid on tape is not filtered.

Table 1: TAPE FILES

File	Description	Latitude	Longitude	Contents
1	Vya quadrangle	41 - 42 N	118 - 120 W	1,285 stations
2	McDermitt quadrangle	41 - 42 N	116 - 118 W	2,069 stations
3	Wells quadrangle	41 - 42 N	114 - 116 W	1,661 stations
4	Lovelock quadrangle	40 - 41 N	118 - 120 W	2,400 stations
5	Winnemucca quadrangle	40 - 41 N	116 - 118 W	2,291 stations
6	Elko quadrangle	40 - 41 N	114 - 116 W	901 stations
7	Reno quadrangle	39 - 40 N	118 - 120 W	4,547 stations
8	Millett quadrangle	39 - 40 N	116 - 118 W	3,563 stations
9	Ely quadrangle	39 - 40 N	114 - 116 W	2,997 stations
10	Walker Lake quadrangle	38 - 39 N	118 - 120 W	5,663 stations
11	Tonopah quadrangle	38 - 39 N	116 - 118 W	6,861 stations
12	Lund quadrangle	38 - 39 N	114 - 116 W	8,454 stations
13	Mariposa quadrangle	37 - 38 N	118 - 120 W	3,514 stations
14	Goldfield quadrangle	37 - 38 N	116 - 118 W	14,168 stations
15	Caliente quadrangle	37 - 38 N	114 - 116 W	4,475 stations
16	Deathvalley quadrangle	36 - 37 N	116 - 118 W	8,697 stations
17	Las Vegas quadrangle	36 - 37 N	114 - 116 W	3,503 stations
18	Kingman quadrangle	35 - 36 N	114 - 116 W	2,654 stations
19	Nevada Bouguer 2 km grid	35 - 42 N	114 - 120 W	397 rows by 282 columns
20	Isostatic residual 2 km grid	35 - 42 N	114 - 120 W	394 rows by 269 columns

Gravity data format

Beginning with line 11, each of the first 18 data files contains the principal facts for gravity measurements in Nevada. Each record (line) of the file contains information for a single gravity measurement (a "station"). The data are organized in a columnar format (see table 2).

The final 5 columns indicate the data source according to Table 3. The first 4 characters of the station name indicate the original sources of DOD data (see appendix).

Gravity data example

For example, here are the first twenty lines of the first file (gravity data for the Vya quadrangle) on the tape. The "␣" indicates a space in the file:

```
FILETYPE=␣␣␣␣7␣CREATION␣DATE:␣27-NOV-1987␣15:27:41.12
VYA.DAT
USGS␣Nevada␣gravity:␣Vya␣quadrangle,␣lat␣41␣-␣42␣N,␣lon␣118␣-␣120␣W
```

Table 2: ASCII format for gravity data

Columns	Input Format	Item
1-8	A8	Station name
10-11	F2.0	Latitude, degrees
12-15	F4.2	Latitude, minutes to 0.01 min
16	1X	Not used (blank)
17-19	F3.0	Longitude, degrees
20-23	F4.2	Longitude, minutes to 0.01 min
24-29	F6.1	Elevation, to 0.1 ft
30-36	F7.2	Observed gravity, to 0.01 mGal with leading 9 removed
37-40	A4	Four digit accuracy code (optional)
41-46	F6.2	Free-air anomaly to 0.01 mGal
47-52	F6.2	Simple Bouguer anomaly to 0.01 mGal
53-57	F5.2	Inner zone terrain correction to 0.01 mGal
58-62	F5.2	Total terrain correction to 0.01 mGal
63	1X	Not used (blank)
64-69	F6.2	Complete Bouguer anomaly to 0.01 mGal
70-75	F6.2	Isostatic residual anomaly to 0.01 mGal
76-80	A5	Data source (see table 3)

Table 3: Data source codes

Source ID	Source
DOD	Defense Mapping Agency (see also appendix)
DPxx	D.A. Ponce, USGS, Menlo Park, CA (oral communication, 1985)
Hxxx	D.L. Healey, USGS, Denver, CO (oral communication, 1985)
LANL	Los Alamos National Laboratory
Mxxx	USGS, Menlo Park, CA

```
(a80)
ASCII␣␣␣IN␣#/LINE␣␣␣␣80␣OUT␣#/LIN␣␣␣␣80␣␣␣␣␣IN/OUT␣␣␣␣␣1
USGS␣TAPE␣FILE␣HEADER␣.....␣DATA␣BEGINS␣AT␣RECORD␣#11
USGS␣TAPE␣FILE␣HEADER␣.....␣DATA␣BEGINS␣AT␣RECORD␣#11
USGS␣TAPE␣FILE␣HEADER␣.....␣DATA␣BEGINS␣AT␣RECORD␣#11
USGS␣TAPE␣FILE␣HEADER␣.....␣DATA␣BEGINS␣AT␣RECORD␣#11
USGS␣TAPE␣FILE␣HEADER␣.....␣DATA␣BEGINS␣AT␣RECORD␣#11
␣764E429␣415970␣1183830␣421597993336␣␣␣␣␣␣-1786-16164␣␣␣␣␣3␣␣292␣-16003␣␣␣␣542DOD
21791048␣412450␣118␣␣80␣412997989947␣␣␣␣␣␣␣-710-14796␣␣␣␣␣0␣␣␣␣␣2␣-14917␣␣␣1045DOD
21791049␣412490␣118␣290␣412017990017␣␣␣␣␣␣␣-794-14846␣␣␣␣␣0␣␣␣␣␣1␣-14974␣␣␣␣953DOD
21791050␣412520␣118␣530␣412307988961␣␣␣␣␣␣-1866-15928␣␣␣␣␣1␣␣␣␣-5␣-16061␣␣␣-168DOD
21791051␣412560␣118␣760␣411917988775␣␣␣␣␣␣-2150-16199␣␣␣␣␣0␣␣␣␣-7␣-16335␣␣␣-464DOD
21791052␣412590␣118␣989␣411527988451␣␣␣␣␣␣-2555-16591␣␣␣␣␣0␣␣␣␣-7␣-16726␣␣␣-874DOD
21791054␣412660␣1181440␣412207989261␣␣␣␣␣␣-1785-15845␣␣␣␣14␣␣␣␣17␣-15956␣␣␣-112DOD
```

```
21791055␣412700␣1181740␣411387990022␣␣␣␣␣-1162-15192␣␣␣␣6␣␣␣24␣-15297␣␣␣552D0D
21791056␣412730␣1181950␣411617989521␣␣␣␣␣-1686-15725␣␣␣␣3␣␣␣33␣-15820␣␣␣␣39D0D
21791057␣412820␣1182160␣412017989186␣␣␣␣␣-2118-16170␣␣␣␣3␣␣␣36␣-16262␣␣-377D0D
```

Gridded data format

The final (19th and 20th) files on the tape contain data interpolated to a square 2 km grid covering the state of Nevada. The data were interpolated using the minimum curvature algorithm of Briggs (1974) using a computer program (Webring, 1981). The data were first projected from geographic (latitude and longitude) to Cartesian (km) coordinates with the Lambert conformal conic projection (standard parallels of 33° N and 45° N) and a central meridian of 117° W and a base latitude of 0°.

To help clarify the contents of the file header, the following is a detailed description of the information in the first ten lines of the 19th (Bouguer gravity grid) file (refer to the example in the following section). Please note that the 20th data file (isostatic residual grid) has a slightly different number of rows and columns (see table 1).

1. The first line lists the file type (1 for grid) and the creation date of the tape file.

2. The second line is the file name.

3. The third line contains 80 characters of descriptive information.

4. The fourth line is the FORTRAN format for writting one tape record. In this case the format of "(5E16.8)" indicates that 5 real numbers are written to a line, each in scientific notation with 8 decimal places and occupying 16 spaces total.

5. The next line indicates that this is a grid file, that 5 numbers are written per tape record, that 283 numbers make up one grid row, and that 57 tape records are required to contain the values in one grid row.

6. The sixth line contains the grid's identification string (56 characters), the name of the program which created the grid (8 characters, in this case "min-curv"), and the central meridian and base latitude of the projection. In this case the central meridian is 117° and the base latitude is 0°.

7. The seventh line lists the number of columns (282), number of rows (397), number of values per grid position (1), projection of the grid (4=Lambert), the position of the first column (280.898 kilometers to the west of the central meridian), the distance between columns (2 km), the position of

the first row (4177. km north of the base latitude), and the distance between rows (2 km).

8. The eighth, ninth and tenth lines are just space fillers to keep all the tape headers the same length.

So, this file contains (beginning at record 11) the values contained in a 397 x 282 matrix. Each row on the tape actually contains 283 values. The first value in a row is a special value which is used to indicate the row spacing of grids with irregularly spaced rows. For normal evenly spaced grids this value is ignored. Therefore, there are a total of 112,351 (397x283) values in this tape file. Each row begins at the begining of a tape record. As indicated in the 4th line of the header, each grid row occupies 57 tape records. That means there are 22,629 (57x397) tape records required for all the rows and columns. Since there are ten header records, the total file length is 22,639 records.

The first value in the first row is located at the position indicated by the column and row origin parameters. The second row is north (positive row spacings) of the first at the distance indicated by the row spacing (2 km). Similarly, the column spacing indicates the direction (positive east) and distance between columns in the grid (also 2 km).

The southwest corner of the grid is in California (see figure 1). This portion of the grid (the 1° x 2° quadrangles not labeled on figure 1) does not contain valid gravity data. The Bouguer grid (file 19) has extrapolated values in this region, but they are unconstrained by data outside the labeled quadrangles. The isostatic residual grid (file 20) is clipped near the Nevada - California border (as indicated by figure 3). The portion of the grid within California contains values of 9999.

Gridded data example

Here are the first lines of the 19th file on the tape. As in the previous example, "␣" indicates a space in the tape file.

```
FILETYPE=␣␣␣␣1␣CREATION␣DATE:␣23-JAN-1988␣12:14:30.44
NEVCBA.SG
Complete␣Bouguer␣gravity␣-␣Nevada
(5E16.8)
GRID␣␣␣IN␣#/LINE␣␣␣␣5␣OUT␣#/LIN␣␣283␣␣␣␣IN/OUT␣␣␣57
NEVADA␣CBA␣GRAVITY␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣␣min-curv-117.000␣␣␣0.000
␣␣282␣␣397␣␣␣1␣4␣-0.28089783E+03␣␣0.20000000E+01␣␣0.41770742E+04␣␣0.20000000E+01
THE␣TWO␣LINES␣ABOVE␣CONTAIN␣GRID␣SPECIFICATIONS.
LINE␣1:␣GRID␣ID␣(a56),␣CREATION␣PROGRAM␣(a8),␣C␣MERID,␣BASE␣LAT
LINE␣2:␣#COL,␣#ROW,␣#VAL,␣PROJ,␣X␣ORIG.,␣DEL␣X,␣Y␣ORIG.,␣DEL␣Y
```

```
␣␣0.00000000E+00␣-0.12786800E+03␣-0.12794800E+03␣-0.12802522E+03␣-0.12809824E+03
␣-0.12816611E+03␣-0.12822820E+03␣-0.12828423E+03␣-0.12833400E+03␣-0.12837749E+03
␣-0.12841496E+03␣-0.12844661E+03␣-0.12847260E+03␣-0.12849397E+03␣-0.12851204E+03
␣-0.12852831E+03␣-0.12854398E+03␣-0.12855946E+03␣-0.12857542E+03␣-0.12859244E+03
␣-0.12861096E+03␣-0.12863152E+03␣-0.12865440E+03␣-0.12867972E+03␣-0.12870723E+03
␣-0.12873651E+03␣-0.12876672E+03␣-0.12879674E+03␣-0.12882567E+03␣-0.12885272E+03


    ..... 50 lines removed to shorten the example  .....


␣-0.12200755E+03␣-0.12300253E+03␣-0.12390498E+03␣␣0.00000000E+00␣␣0.00000000E+00
␣␣0.00000000E+00␣-0.12790877E+03␣-0.12798059E+03␣-0.12804956E+03␣-0.12811414E+03
␣-0.12817342E+03␣-0.12822716E+03␣-0.12827507E+03␣-0.12831737E+03␣-0.12835435E+03
␣-0.12838652E+03␣-0.12841415E+03␣-0.12843748E+03␣-0.12845763E+03␣-0.12847600E+03


    ..... File continues on tape, truncated here to shorten the example
....
```

Acknowledgements

The gravity data listed here represent many man-years of field work. I thank specifically Don Healey and Dave Ponce of the USGS for access to their computer data files. The compilation of gravity data between 36° and 38° north was supported by the Nevada Operations Office of the U.S. Department of Energy under Interagency Agreement DE-AI08-78ET44802.

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1 Appendix 1: Sources of DOD gravity data

Department of Defense Mapping Agency gravity sources are keyed to the first four numbers in the gravity station record on tape. The number of points given in this list refers to the total number of points in the original DOD data base, not the number in this data file. The sources for DOD gravity data on the accompanying tape are listed here by id number:

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1083 United States Coast and Geodetic Survey, National Gravimeter Base Network: USC and GS, NOAA, 3836 PTS.

2078 Wollard, G. P., Tripp SS, Rockies, authority unknown, 1029 PTS.

2149 U.S. Geological Survey, Crustal studies, line seven, Eureka-Fallon Nevada Profile: USGS, NV, 150 PTS.

2179 U.S. Geological Survey, Gravity reductions, Nevada Basin and Range Project Group 1.

2207 U.S. Geological Survey, Gravity data Owens Valley California: USGS, CA, 1458 PTS.

2231 Mabey, D. R., Death Valley California Gravity Data: USGS, CA 1955, 1299 PTS.

2235 U.S. Geological Survey, Gravity data, Carson Sink, Nevada: USGS, NV, 456 PTS.

2293 U.S. Geological Survey, Gravity data in Sierra, Nevada: USGS, CA, 1961, 543 PTS.

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2716 U.S. Geological Survey, Gravity survey, Madera County, California: USGS, 1964, 512 PTS.

2733 Geodetic Survey Squadron, 1st National Gravity Base Net and Excenters, 1st GSS, 1967, 252 PTS.

2773 U.S. Geological Survey, Gravity data in Alturas, California area: USGS, 1967, 424 PTS.

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