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TERRAIN: A Terrain Correction Program for Gravity Data
(User's Guide and Documentation for Rev. 0)

by

Laura F. Serpa

and

Kenneth L. Cook

January 1981

Work performed under Contract No. DE-AC07-80ID12079

EARTH SCIENCE LABORATORY
University of Utah Research Institute
Salt Lake City, Utah

Prepared for
U.S. Department of Energy
Division of Geothermal Energy

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ACKNOWLEDGMENTS

The terrain correction program was written by Don Plouff and subsequently modified by R. H. Godson, both with the USGS. The program was modified for use on the University of Utah's UNIVAC 1108 by Laura F. Serpa, with the assistance of Stephen C. Gabbert and Carleen Nutter, under the supervision of Kenneth L. Cook. Funding for the project was provided by the USGS, grant no. 14-08-0001-G-533, and the Department of Energy, Division of Geothermal Energy, contract numbers DE-AC07-78ET28392 and DE-AC07-80ID12079. This report was compiled from appendix C in the topical report number DOE/ET/28392/39 by Laura F. Serpa and Kenneth L. Cook dated January 1980.

PROGRAM DESCRIPTION

The terrain correction program was initially written by Plouff (1966, 1977) and modified by Godson (1978, written communication) for the U. S. Geological Survey. The program was modified for use on the University of Utah UNIVAC 1108 digital computer. A comparison of the results from over 1000 stations has shown that TERRAIN.REVO gives results which agree with the U. S. Geological Survey program to within a round-off error of 0.02 mgal.

Gabbert (1980) is currently completing a preliminary study of the accuracy of TERRAIN which will provide some guidelines on the terrain conditions for which hand terrain corrections are necessary for the inner zones. Hand calculations can be made using the Hammer (1939) zone charts. At present, TERRAIN offers the option of calculating terrain corrections for radial distances of 0.0, 0.895, 1.53, or 2.615 km from the station to a radial distance of 166.7 km.

TERRAIN accesses terrain data stored on a magnetic tape to create terrain maps digitized at 30 sec., 1 min., and 3 min. of arc intervals of the area to be used for the terrain corrections. The 30 sec. digitized terrain data are used to calculate the terrain corrections for radial distances of between 0.0 and 5.0 km from the station. Additionally, the inner-zone terrain corrections are calculated assuming a ground surface which is sloping between the station and the compartment and a complete circular join (for use with hand terrain corrections) is calculated (Plouff, 1977).

The 1 min. digitized topography is used for radial distances of between 5.0 and 21.0 km from the station and the 3 min. topography beyond 21.0 km. For the 1 min. and 3 min. digitized data, the program calculates the terrain correction using flat-topped compartments. A correction for the earth's curvature is calculated beyond 14 km. All terrain locations and distances are calculated in a latitude-longitude reference system.

The program appears to give reasonably accurate and repeatable results and is therefore an improvement over hand terrain corrections. For approximately 900 stations, the computer costs were approximately \$30. The cost for hand-computed inner-zone terrain corrections are estimated at about \$300 (based on 900 stations @ 6 min. per station times \$3.00 per hour). This represents a significant cost savings over complete hand terrain corrections, assumed to be about \$4000 (@ 1.5 hours per station).

Plouff (1977) has shown that the program incorporates improvements over the terrain correction program of Kane (1962) which has been used in the past at the University of Utah. The TERRAIN program appears to be a significant improvement for the calculation of terrain corrections for gravity data at the University of Utah. Additional study of this technique by

PROGRAM DESCRIPTION

Gabbert (1980) and during future gravity studies should result in a more precise understanding of the accuracy of this program.

PROGRAM EXECUTION

TERRAIN is simple to use but may require half an hour or more time to execute on the computer. Because all of the file manipulation is done inside the program, the user needs only a minimal understanding of the computer. Before the program is executed, a data file must exist containing the gravity information for each station. The format used for the data is the same as the format of the output from the reduction program, but repeated stations and headings must be deleted. The format is as follows:

STAT. NO., LAT (deg, min), LONG (deg, min), ELEV
(A6, I4, 1X, F6.2, I4, 1X, F6.2, 2X, F6.0)

****Note, no file used in this program can have a name longer than 5 characters.

The following is a sample of the execution of the program:

```
>@XQT, U TERRAIN. ABS
ENTER INPUT GRAVITY FILE NAME
>BLRK1.
ENTER SECOND BOUGUER DENSITY
>2.5
ENTER FILE TO STORE TERRAIN CORRECTIONS IN
>FILT.
ENTER 1 FOR REPEAT RUN OF SAME AREA
  OTHERWISE A 0
>0
ENTER LOWER RIGHT LAT & LONG BOUNDARY OF DATA, DEG & NEAREST
  15 MIN
>38, 30, 112, 0
ENTER UPPER LEFT LAT & LONG BOUNDARY OF DATA
>39, 30, 113, 0
ENTER 0 IF STATION ELEVATIONS ARE ABOVE SEA LEVEL & ON LAND
ENTER 1 IF STATIONS ARE ON LAND & SOME ARE BELOW SEA LEVEL
ENTER -1 IF STATION ELEVATIONS ARE DEPTHS BELOW SEA LEVEL.
ENTER -2 IF STATION ELEVATIONS ARE DEPTHS OF BOTTOM BELOW
  STATIONS
>0
ENTER INNER TERRAIN DATA SPACING--(15 OR 30)
>30
ENTER DISTANCE IN KM (0., .895, 1.53, OR 2.615) WHERE COMPUTER
  CORRECTIONS START
>.895
@ASG, A BLRK1.
STATUS = 0
@USE 9., BLRK1.
STATUS = 0
@ASG, UP FILT.
STATUS = 0
@ASG, UP FILE3.
```

```

STATUS =          0
@USE 8., FILE3.
STATUS =          0
ENTER NUMBER OF TAPE CONTAINING ELEVATIONS
>1674
@ASG, TR 1., BC9, 1674
@ASG, UP TERR1.
STATUS =          0
@USE 10., TERR1.
STATUS =          0
@ASG, UP TERR2.
STATUS =          0
@USE 11., TERR2.
STATUS =          0
@ASG, UP TERR3.
STATUS =          0
@FREE, A 9. STATUS IS          0
@FREE, A 10. STATUS IS         0
@FREE, A 11. STATUS IS         0
@FREE, A 12. STATUS IS         0
@FREE, A 14. STATUS IS         0
TERRAIN CORRECTIONS COMPLETED

```

NORMAL EXIT. TIME: 231432 MILLISECONDS.

TERRAIN uses two densities; the first density will always be 2.67 g/cc. The program automatically assumes this value for the first density but will also calculate terrain corrections for the second density specified. TERRAIN creates two new files in the user's space without headings for subsequent use. The name of the first file must be catalogued. The second file, named FILE3, will contain headings and an explanation of the output, as well as any error messages. No previous file with this name should exist in the user's space or it will be erased and written over.

During the execution, three terrain files are created in the user's space. TERR1 contains 30 sec. digitized topography, TERR2 contains 1 min. digitized topography, and TERR3 contains 3 min. digitized topography. These files are large and should be deleted after all the terrain corrections are complete. However, creating these files is one of the more expensive parts of this program. If a second run is anticipated, the computer costs can be reduced by retaining the terrain files and entering a '1' to signify a repeat run during the execution.

To create the terrain files, the boundaries of the survey area must be entered to the nearest 15 min. of latitude and longitude outside the survey area. Within Utah, all stations are assumed to be on land and above sea level. No other options have been

tested for TERRAIN. The inner terrain data spacing for Utah is currently 30 sec. TERRAIN may be modified at a later date to accept 15 sec. data.

The terrain corrections can be started at radial distances of 0.0, 0.895, 1.53, or 2.615 km from the station. These distances correspond to the station location, or zones F, G, and H, respectively, of the Hammer zone charts. If the terrain correction is started at 0.0 km, the user has the option of calculating an inner terrain correction to any of the above Hammer zones, except zone F which requires 15 sec. digitized terrain data.

Figure 1 is a flow diagram of TERRAIN.

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