GRAVITY SURVEY

ON THE

GLASS BUTTES GEOTHERMAL EXPLORATION PROJECT

LAKE COUNTY, OREGON

FOR

ORMAT TECHNOLOGIES INC.

DATA ACQUISITION REPORT

ISSUE DATE: 12 October 2011

ZONGE JOB NUMBER 10110

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GRAVITY SURVEY

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INTRODUCTION

Zonge Geosciences, Inc. performed a gravity survey on the Glass Buttes Geothermal Exploration Project, located in Lake County, Oregon for ORMAT Technologies Inc. The survey was conducted during 21 June 2010 to 26 June 2010.

The survey area is located in T23S, R21-23E and lies within the Glass Buttes, Hat Butte, and Potato Lake, Oregon 1:24,000 topographic sheets. A total of 180 gravity stations were acquired along five profile lines. These stations are in addition to 355 gravity stations acquired in 2009 under Zonge job number 2009.109. Station locations are shown in Figure 1 and Plate 1. Plates are included in the back pocket of this report and are included as figures in Appendix A.

This survey was conducted by Kam Moezzi, Geophysical Crew Chief, for Zonge Geosciences, Inc. under Zonge job number 10110.

This report covers data acquisition, instrumentation and processing for job number 10110.

INSTRUMENTATION

Gravity data were acquired with a LaCoste & Romberg Model-G gravimeter, serial number 233. These gravity meters have a reading resolution of .01 milligals and a typical repeatability of .01 milligals. Specifications for these instruments are included in Appendix B. Positioning was obtained with Leica Geosystems model SR530 GPS receivers. These are survey-grade receivers capable of centimeter-level accuracy. GPS receiver specifications are included in Appendix C.

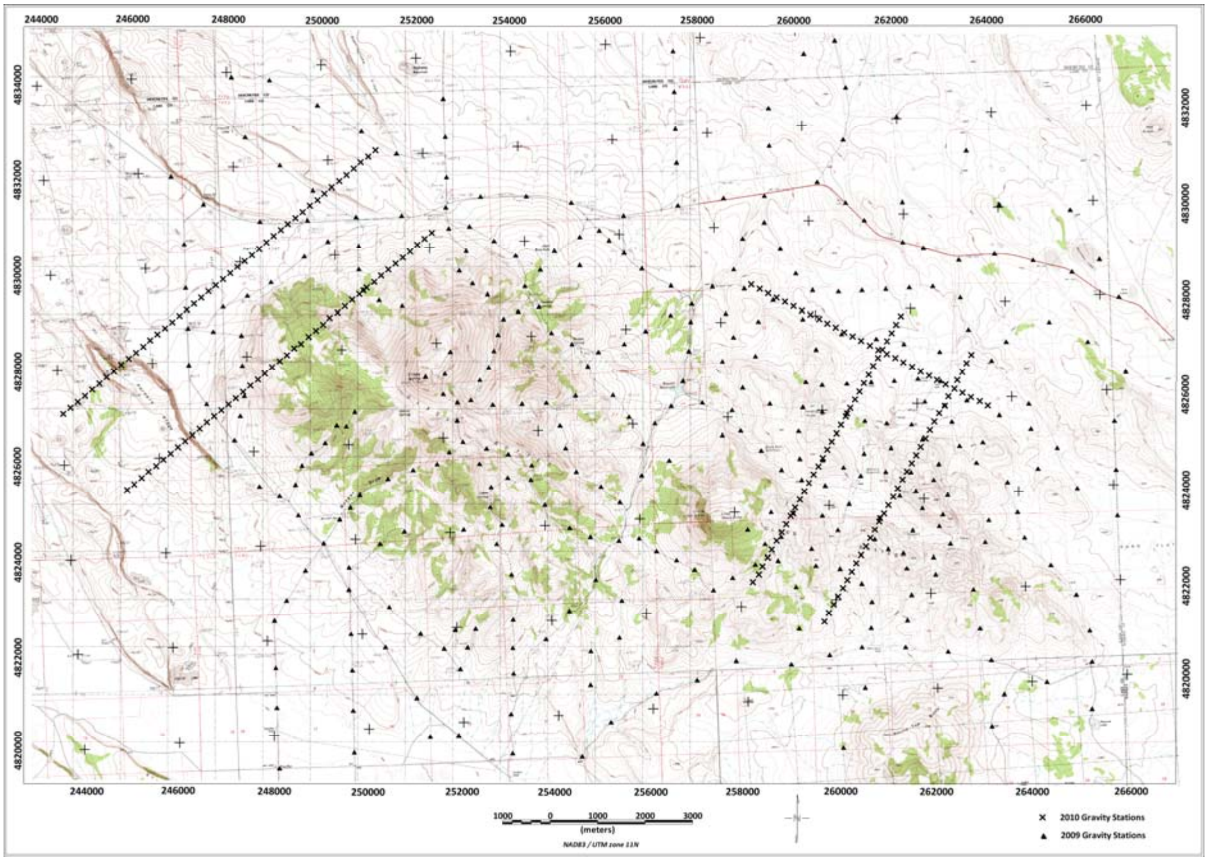


Figure 1: *Station location map.*

DATA ACQUISITION

GPS DATA

Carrier-phase GPS data were acquired for two to five minute sessions at each station during simultaneous acquisition at a fixed GPS base station. Real Time Kinematic (RTK) mode was used to acquire GPS data for this survey. Operation in RTK mode allowed for on-site evaluation of positioning solution quality and stake out. At locations where radio reception was lost, GPS observations were made for 5-minute occupations. A discussion of positioning quality is included under the section titled Data Quality, GPS.

One GPS base station was used for this survey. The position of base station (1000) was determined by submitting an 8 hour GPS occupation of this point to the National Geodetic Survey (NGS) On-line Positioning User Service (OPUS). OPUS processed this observation file with respect to 3 Continuously Operating Reference Stations (CORS).

Control point specifications and OPUS data solutions are listed in Appendix D.

GRAVITY DATA

Gravity measurements were made in a series of looped-traverses that were closed within a maximum of 10.5 hours for the local survey. At least two measurements were made at each occupation.

One local gravity base (1000) was established for this survey. The value for this base was determined from three loop-traverses to the Department of Defense (DoD) base # 1280-1 located in Burns, Oregon.

The gravity value and position for this base is shown in Appendix E.

DATA QUALITY

The average loop closure for the local survey was 0.04 milligals. Individual loop closures are tabulated in Appendix F.

Gravity measurement precision is evaluated by making repeat readings at selected gravity stations. For this survey, 6 gravity measurements were repeated, and 4 repeat measurements were made at 2009 survey stations. The average difference between repeat measurements is 0.03 milligals, and the maximum difference is 0.05 milligals. Repeated gravity measurements are tabulated in Appendix G.

An important factor that determines the accuracy of the reduced measurement is the accuracy in determining a station's location, particularly the elevation. The vertical gradient of the earth's field is approximately -.308596 milligals per meter of increase in elevation. The Bouguer correction is .1119 milligals per meter of elevation increase, for a density of 2.67 gm/cm^3. This results in a total error in the Bouguer Anomaly of 0.1967 milligals per meter of elevation error, for a reduction density of 2.67 gm/cm^3.

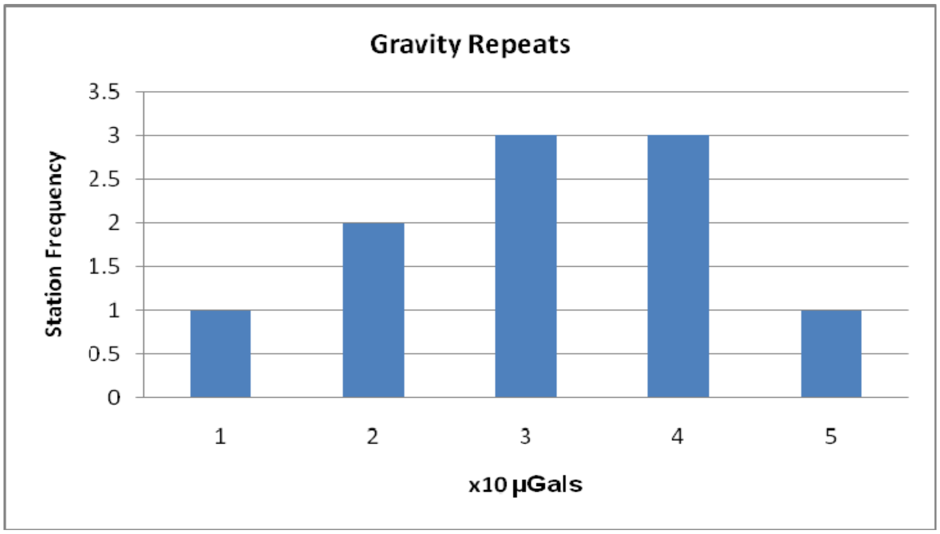


Figure 2: *Histogram of Gravity Repeats*

GPS positioning precision is evaluated by making repeated GPS measurements at randomly selected stations. Comparison of 10 duplicate GPS measurements that were made over a range of field conditions and baseline lengths, show a maximum elevation difference of 7 cm. A tabulation of repeated GPS measurements is presented in Appendix G.

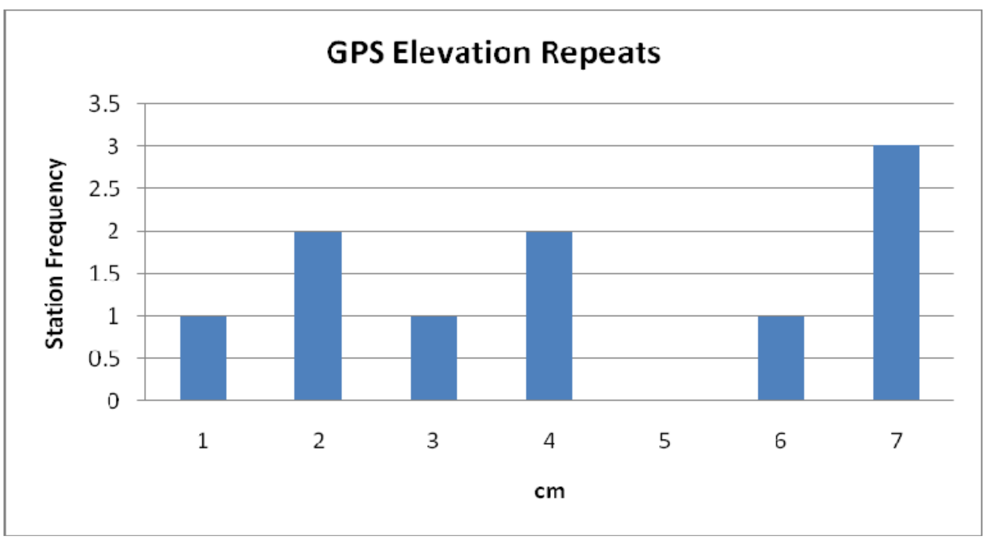


Figure 3: *Histogram of GPS Repeats*

DATA PROCESSING

GPS PROCESSING

Locations of the gravity stations were determined as baselines from the GPS base in WGS-84 coordinates and ellipsoidal heights. The Real Time Kinematic (RTK) solutions were used where available. Where RTK solutions were not available, the GPS observations were processed after data acquisition (post-processing) using Leica Geo-Office™ software. Stations that required post-processing are noted in the data files with a "PP" designation for the class.

The WGS84 ellipsoidal heights were converted to geoidal (orthometric) heights in the NAVD88 datum using the NGS program, GEOID 2003. Daily .raw files are provided in UTM zone 11N, NAD 83 datum.

GRAVITY PROCESSING

The basic processing of gravimeter readings to calculate the observed gravity was made using software from Geosoft LTD of Toronto, Canada. The assigned gravity value for the local gravity base (1000) was established from three loop-traverses to the Department of Defense (DoD) base # 1280-1 located in Burns, Oregon.

Gravity base specifications are listed in Appendix E.

The observed gravity is the gravitational acceleration, in milligals, that is determined by relative measurements made in a loop from a gravity base, after the meter readings have been corrected for instrument height, instrument scale factor, instrument drift and earth tides.

The long-term instrument drift is the rate at which each particular instrument accumulates error due to instrument factors such as vibration, battery voltage changes, and elastic relaxation, among others. It is minimized by proper technique, and warm up of the instrument.

Earth tides cause variations in observed gravity for land-based surveys of up to approximately .03 milligals per hour. Corrections are computed by use of pre-programmed theoretical tide tables that are a part of the Geosoft™ gravity reduction software. The effect of earth tides can be further minimized by frequently tying loops to local gravity bases.

The observed gravity is a function of position (geographic latitude and elevation) and variations in the density of the subsurface material. A series of reductions is made to remove the gravity variation caused by position so that the gravity variations caused by subsurface density distribution remain.

A latitude correction must be made to the observed gravity measurements because the earth is not spherical, but has a slightly larger radius at the equator. It includes terms for both the Newtonian attraction of the earth as a flattened spheroid and the centrifugal force caused by the earth's rotation. The latitude correction is calculated for the International Ellipsoid of 1967 (International Association of Geodesy, 1971).

$$g_\phi = g_a(1 + f_2 \sin^2\phi + f_4 \sin^4\phi)$$

where:

g_ϕ = Latitude correction (gravity reference field on the ellipsoid).

ϕ = Latitude of the gravity observation.

$$f_2 = -f + \frac{5}{2}m + \frac{1}{2}f^2 - \frac{26}{7}fm + \frac{15}{4}m^2$$

$$f_4 = -\frac{1}{2}f^2 + \frac{5}{2}fm$$

$$m = \omega^2 a^2 b/(kM) = 3.44980143430 \times 10^{-3}$$

$$f = (a-b)/a = 1/298.24716742$$

a= Semi-major axis of the ellipsoid = 6378160 meter

b= Semi-minor axis of the ellipsoid = 6356775 meters

ω = Angular velocity of the Earth

M= Mass of the Earth

k= Newton's gravitational constant

The elevation correction has two parts: the free air correction and the Bouguer correction. The free air correction compensates for the variation of the earth's gravitational field with distance away from the center of the earth. The approximate and often-used correction is -0.308596 milligals per meter above the ellipsoid. In practice this is usually referenced to the Geoid due the fact that until recent advent of GPS technology, elevations were derived by leveling, which are by their nature, referenced to the Geoid. For this survey all elevations are referenced to the Geoid by use of the Geoid 2003 model.

The free air correction is calculated using the following formula:

$$\Delta g_{fa} = g_a - g_1 h_s + g_2 h_s^2 - g_l$$

where,

$$g_1 = .308768 - 0.00043986 \sin^2 \phi$$

$$g_2 = 7.212x10^{-8}$$

g_{fa} = free air anomaly in milligals

g_a = observed gravity

g_l = latitude correction

h_s = station elevation in meters

The Bouguer correction compensates for the mass of material located between the station elevation and the Geoid (mean sea level). The Bouguer correction is calculated on the basis of the gravitational attraction of a horizontal slab of infinite extent whose thickness is equal to the elevation difference between the stations of interest and mean sea level:

$$g_{ba} = g_{fa} - 0.0419088*[\rho h_s]$$

where,

g_{ba} = Simple Bouguer anomaly in milligals

g_{fa} = free air anomaly

ρ = density of rock

The Complete Bouguer Anomaly includes those corrections found in the Simple Bouguer Anomaly as well as corrections for the effect of the surrounding topography and the curvature of the earth (Bullard B correction).

$$g_{cba} = g_{ba} + g_{BB} + g_{tc}$$

The Bullard B correction is used to correct for the fact that the mass of rock between the Geoid and the station elevation is a spherical shell as opposed to an infinite horizontal slab. The correction used by Zonge Geosciences is based on the formula given by LaFehr (1991):

$$g_{BB} = 2\pi k\rho(\mu h_s - \lambda R),$$

where

g_{BB} = Bullard B Correction

R = Earth radius to the station ($R_0 + h$, where R_0 is the earth's radius)

$2\pi k\rho$ is the simple Bouguer slab formula; μ and λ are dimensionless coefficients whose definitions are given in the appendix of LaFehr's 1991 paper.

Terrain corrections for topography from 10 meters to 15 kilometer radius were made from National Elevation Dataset (NED) 1/3 Arc Second (9m) data using software (RASTERTC™) described by Cogbill (1990). This algorithm performs a surface fit from a user specified inner radius (10 m) out to a selected intermediate radius (15 km). Terrain corrections are computed for this interval using a numerical integration of the surface along radial lines at 5-degree increments. From the intermediate radius (15 km) out to an outer radius (167 km), terrain corrections are made using the approximation that each elevation represents the elevation of a rectangular compartment equal to the area of the elevation sample (cell size). The effect of each compartment is calculated using a line element formula.

Corrections from 15 km to 167 km were made using Shuttle Radar Topography Mission (SRTM) "Finished" 3 Arc Second (90m) digital terrain data. A curvature correction to the terrain model was computed at distances beyond 14 km.

Simple and Complete Bouguer gravity anomalies were computed for densities ranging from 1.40 gm/cm^3 to 2.90 gm/cm^3. If the density of the near-surface rocks differs from the reduction density, then an elevation dependent error will result. This error is approximately 1.25 microgals per foot for each 0.1 gm/cm^3 difference in density (Hinze, 1990). The density which minimizes the correlation between elevation and the reduced gravity is generally chosen as the reduction density for further processing and plotting. A principle fact file providing densities ranging from 1.40 gm/cm^3 to 2.90 gm/cm^3 is included on a CD-ROM located in the back pockets of this report.

DATA PRESENTATION

Plan maps are provided as plates in the back pockets of this report. Plates 1-4 are registered in UTM Zone 11N, NAD83 and plotted at a scale of 1:50000.

Plate 1 shows the locations of gravity stations on a topographic base. Plate 2 shows the Complete Bouguer Anomaly at a reduction density of 2.25 gm/cm^3. Plate 3 shows the calculated first vertical derivative of the Complete Bouguer Anomaly at a reduction density of 2.25 gm/cm^3 upward continued 400 meters. Plate 4 shows the horizontal gradient of the Complete Bouguer Anomaly at a reduction density of 2.25 gm/cm^3 upward continued 200 meters. These plates are also included as page-size plots in Appendix A and as ArcView ™ tiff files on the Data CD-ROM.

Digital data files are included on a CD-ROM. A description of the CD contents can be found in Appendix H.

SAFETY AND ENVIRONMENTAL ISSUES

No health, safety incidents or accidents occurred during the course of this survey. No environmental damage was sustained as a result of the survey progress.

Vehicle travel was limited to existing roads during this survey.

Respectfully submitted,

Grady Pearce
Geophysicist
Zonge Geosciences, Inc.

REFERENCES

Cogbill, A. H., 1990, Gravity terrain corrections calculated using digital elevation models: Geophysics, **55**, 102-106.

Hinze, W. J., 1990, The role of gravity and magnetic methods in engineering and environmental studies. In, Ward, S. H., ed. Geotechnical and Environmental Geophysics, Society of Exploration Geophysicists, Investigations in Geophysics, **5**, 75-126

LaFehr, T. R., 1991a, An exact solution for the gravity curvature (Bullard B) correction: Geophysics, **56**. 1179-1184.

APPENDIX A. PLATES AS FIGURES

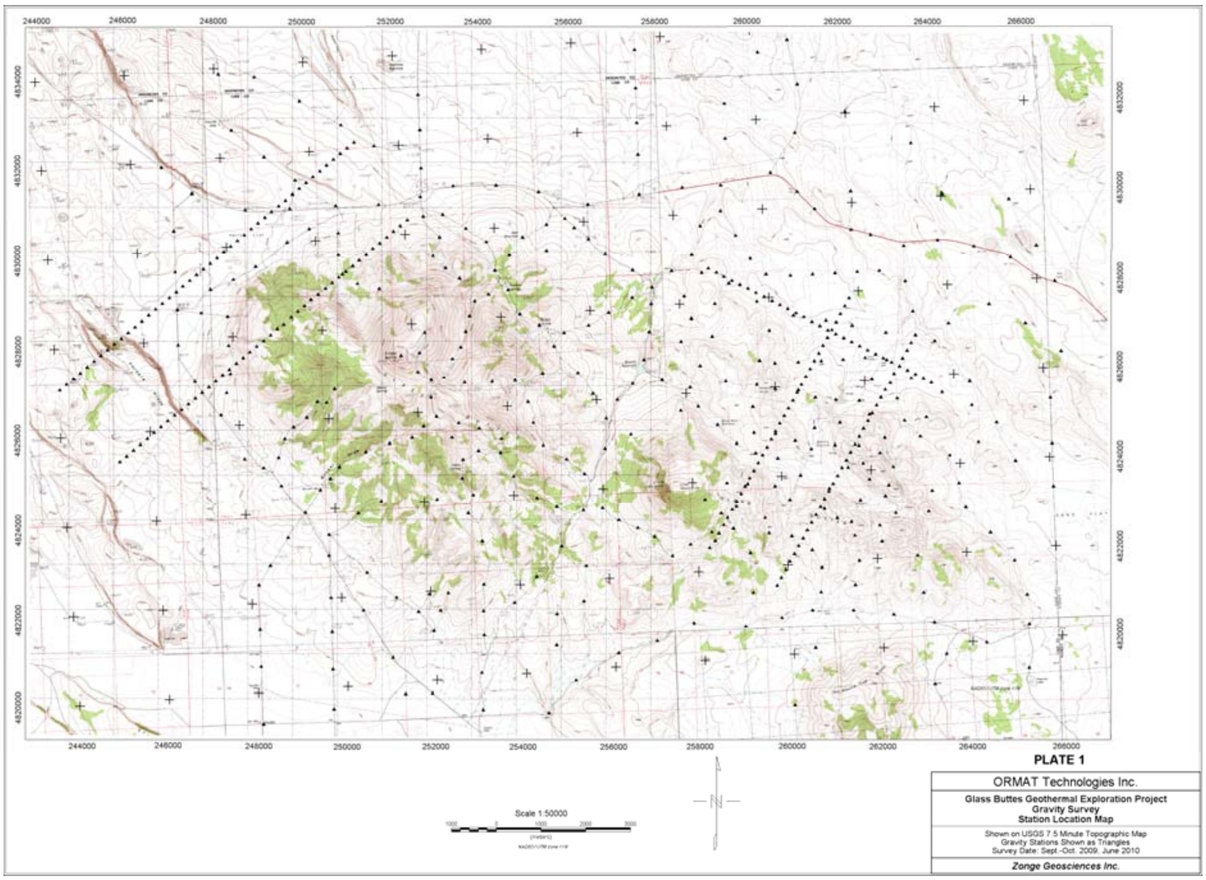


Figure A1: *Station location map.*

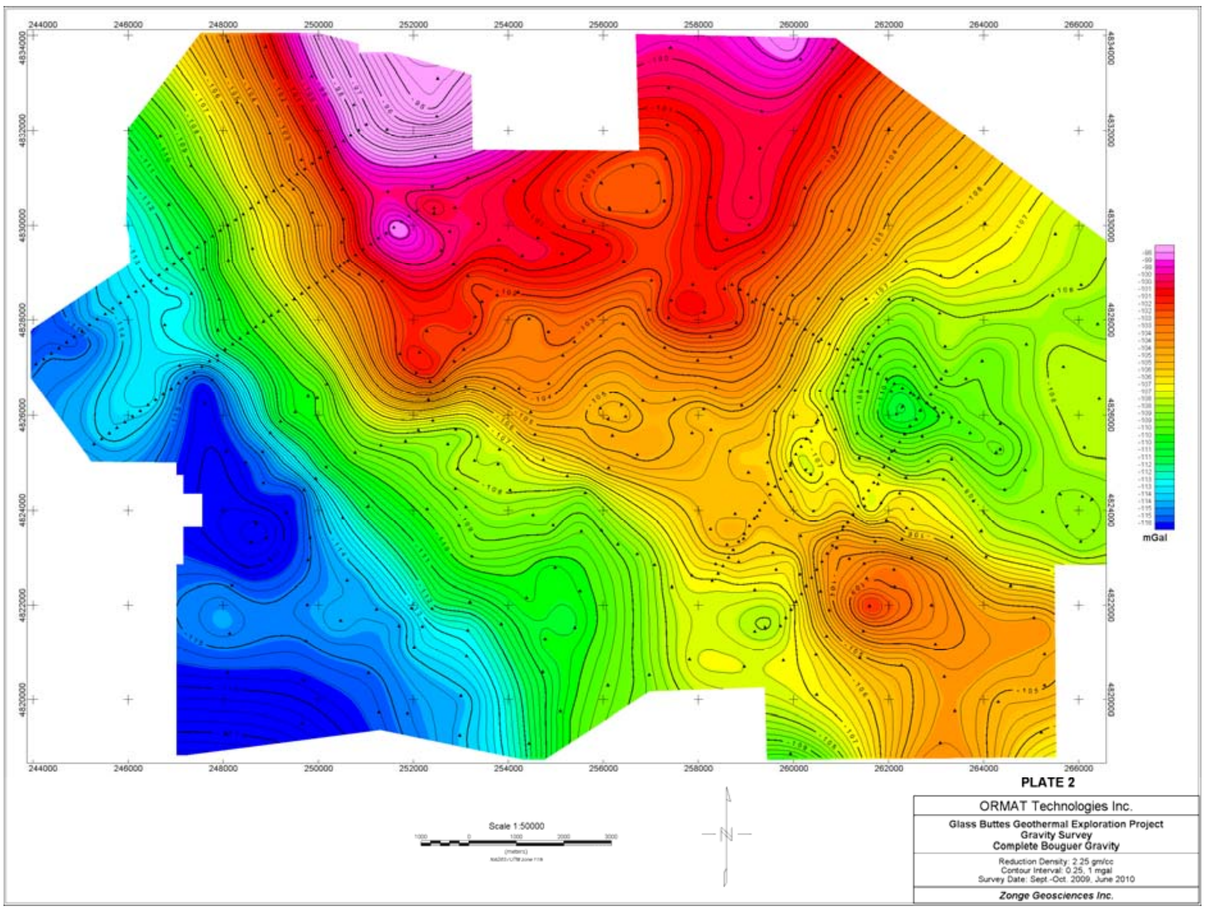


Figure A2: *Complete Bouguer Anomaly 2.25 gm/cc.*

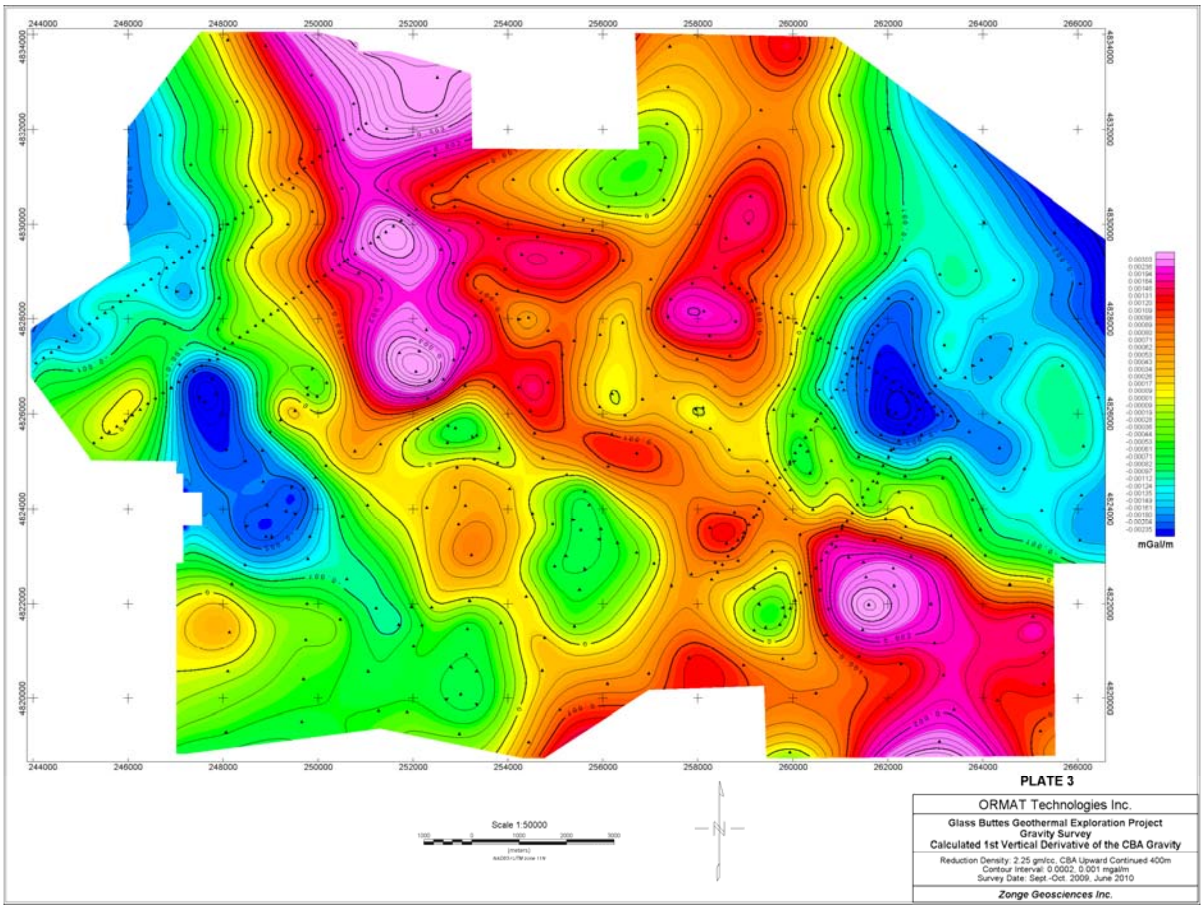


Figure A3: *Calculated First Vertical Derivative of CBA Gravity Upward Continued 400m @ 2.25 gm/cm*^{3}

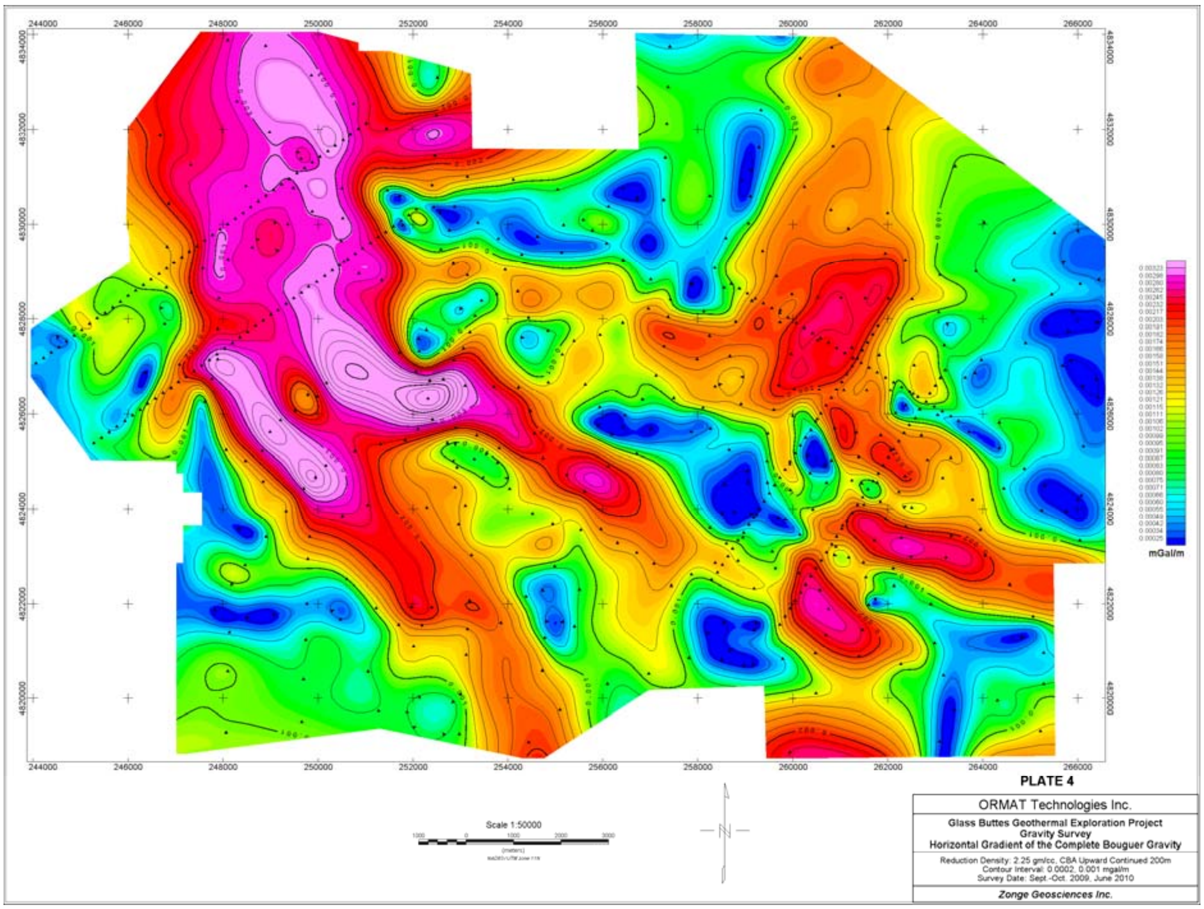


Figure A4: *Horizontal Gradient of the CBA Gravity Upward Continued 200m @ 2.25 gm/cm^3*

APPENDIX B. GRAVITY METER SPECIFICATIONS

Range	7000 milligal
Accuracy	0.04 milligals
Drift	1 milligal per month or less
Repeatability	0.01 milligal
Length	7-3/4 inches (19.7 cm)
Width	7 inches (17.8 cm)
Height	9-7/8 inches (25.1 cm)
Weight	7 pounds (3.2 kg)
Weight of suitable battery	5 pounds (2.3 kg)
Weight of meter, battery, and case	22 pounds (10.0 kg)

LaCoste & Romberg Model-G Gravity Meter Specifications

Counter Reading	Value in Milligals	Factor for Interval
2800	2953.29	1.05518
2900	3058.81	1.05526
3000	3164.34	1.05534
3100	3269.87	1.05542
3200	3375.41	1.05550
3300	3480.96	1.05560
3400	3536.52	1.05570

Meter reading conversion factors for LaCoste & Romberg Model G, SN-233

APPENDIX C. GPS RECEIVER SPECIFICATIONS

Leica Geosystems SR530 survey receiver

Kinematic Survey	L1/L2 P-code and full cycle carrier, or L1 C/A code, L1/L2 full cycle carrier and cross-correlation of the encrypted P-code
Modes:	Continuous Stop and Go Pseudostatic (pseudokinematic) survey Fast Static survey
Accuracy	10mm + 2 ppm baseline rms for Real-time kinematic
Occupation	Continuous: 0.2 sec. Measurement time Stop & Go: 2 sec. (minimum) with 5 satellites
Tracking:	12 channels of L1/L2 P-code and full cycle carrier phase or 12 channels L1 C/A code, L1/L2 full cycle carrier phase and cross correlation of the encrypted P-code

APPENDIX D. GPS BASE DESCRIPTIONS

NGS OPUS SOLUTION REPORT
========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy

```
     USER:                                DATE: September 30, 2009
RINEX FILE: 1000272n.09o                  TIME: 10:46:13 UTC

 SOFTWARE: page5  0909.08  master11.pl 081023     START: 2009/09/29  13:52:00
 EPHEMERIS: igu15512.eph [ultra-rapid]             STOP: 2009/09/29  20:37:00
 NAV FILE: brdc2720.09n                        OBS USED: 17385 / 17718  :  98%
 ANT NAME: LEIAT502        NONE                # FIXED AMB:    56 /    58  :  97%
ARP HEIGHT: 0.825                          OVERALL RMS: 0.013(m)

 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)          ITRF00 (EPOCH:2009.7444)

        X:    -2316061.735(m)  0.011(m)        -2316062.513(m)  0.011(m)
        Y:    -4007512.365(m)  0.007(m)        -4007511.128(m)  0.007(m)
        Z:     4375510.094(m)  0.024(m)         4375510.114(m)  0.024(m)

      LAT:   43 34 54.52575      0.017(m)       43 34 54.54144      0.017(m)
    E LON:  239 58 30.33457      0.013(m)      239 58 30.27697      0.013(m)
    W LON:  120  1 29.66543      0.013(m)      120  1 29.72303      0.013(m)
   EL HGT:         1391.654(m)  0.017(m)              1391.174(m)  0.017(m)
 ORTHO HGT:   1411.227(m)   0.038(m)  [NAVD88 (Computed using GEOID03)]

                  UTM COORDINATES    STATE PLANE COORDINATES
                   UTM (Zone 10)         SPC (3602 OR S)
Northing (Y) [meters]     4829728.577          212850.547
Easting (X)  [meters]      740199.882         1538368.764
Convergence  [degrees]     2.05197609           0.32503358
Point Scale                1.00030974           0.99992058
Combined Factor            1.00009149           0.99970242

US NATIONAL GRID DESIGNATOR: 10TGP4020029729(NAD 83)

                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DH3761 MDMT MEDICINE MOUNTAIN CORS ARP    N422506.012     W1211317.707  161981.9
AH2507 REDM REDMOND CORS ARP              N441535.145     W1210852.316  117526.4
AH8524 BURN BURNS JUNCTION CORS ARP       N424646.187     W1175036.652  198512.9

               NEAREST NGS PUBLISHED CONTROL POINT
PB0565      C 374                    N433516.    W1200146.      758.2
```

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

APPENDIX E. GRAVITY BASE DESCRIPTIONS

Gravity Base	WGS84 Lat D.ddddd	WGS84 Lon D.ddddd	WGS84 Elevation (m)	NAVD88 Elevation (m)	Gravity milligals
1000	43.58181271	-120.0249071	1391.654	1411.227	980087.810

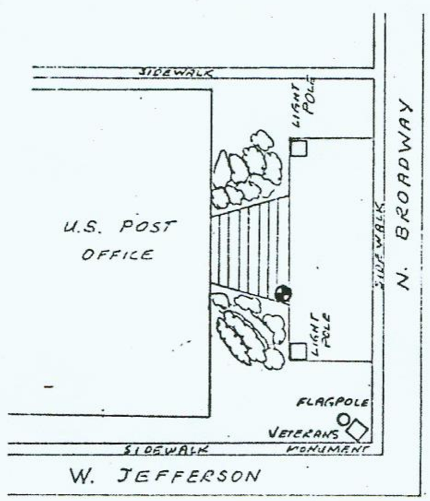
GRAVITY BASE STATION

LATITUDE: 43° 35.3'N (1)	STATION DESIGNATION: BURNS
LONGITUDE: 119° 03.2'W (1)	
ELEVATION: 1266.4 METERS (1)	COUNTRY/STATE: USA/Oregon
REFERENCE CODE NUMBERS: ACIC 1280-1; IGB 15639B	ADOPTED GRAVITY VALUE: g= 980 110.28 mgals
	ESTIMATED ACCURACY: ± 0.1 mgals — DATE: MONTH/YEAR 12/71

DESCRIPTION AND/OR SKETCH

Burns, Oregon, at the US Post Office, on the south end of the first step above the sidewalk, at the North Broadway entrance.

Station is located in Burns, Oregon, at the US Post Office, at the intersection of North Broadway and West Jefferson Streets. (1)



(1)

REFERENCE SOURCE

(1) 03682

ACIC HQ FORM FEB 69 0-415

APPENDIX F. LOOP CLOSURES

Date	Base	Loop #	Duration	Closure (mG)	Abs_Closure (mG)
22-Jun	1000	1	8:11	0.044	0.044
23-Jun	1000	1	9:50	0.049	0.049
24-Jun	1000	1	10:47	0.032	0.032
25-Jun	1000	1	8:28	-0.022	0.022
				Average Closure	0.036

APPENDIX G. GPS AND GRAVITY REPEATS

Station	NAD83Z10_E	NAD83Z10_N	NAVD88	Abs_G	Time	Date
108	262527.64	4826423.69	1416.77	980075.17	12:18:50	10.01
90108	262528.54	4826422.14	1416.71	980075.22	10:37:08	6.22
Diff	**-0.9**	**1.55**	**0.07**	**-0.05**		
275	258842.61	4822902.54	1615.61	980032.89	8:17:31	10.06
90275	258843.01	4822904.01	1615.67	980032.93	9:07:23	6.23
Diff	**-0.4**	**-1.47**	**-0.06**	**-0.04**		
280	260565.98	4822293.68	1521.13	980054.90	14:11:34	10.05
90280	260566.96	4822293.29	1521.09	980054.94	10:53:47	6.23
Diff	**-0.98**	**0.39**	**0.04**	**-0.04**		
1576	262802.07	4826255.91	1421.06	980074.66	10:49:55	6.22
91576	262802.11	4826255.87	1421.06	980074.69	15:41:55	6.23
Diff	**-0.04**	**0.04**	**0.00**	**-0.04**		
1418	246810.61	4829072.17	1373.48	980084.33	7:46:06	6.24
91418	246810.5	4829072.16	1373.50	980084.30	13:53:54	6.25
Diff	**0.11**	**0.01**	**-0.03**	**0.03**		
1419	246965.94	4829190.69	1373.16	980084.64	7:53:16	6.24
91419	246965.99	4829190.71	1373.15	980084.64	14:02:45	6.25
Diff	**-0.05**	**-0.02**	**0.02**	**-0.01**		
200	246806.5	4828670.11	1374.37	980083.06	15:28:50	10.03
90200	246806.59	4828670.07	1374.44	980083.09	14:15:47	6.25
Diff	**-0.09**	**0.04**	**-0.07**	**-0.03**		
1457	247221.62	4826790.49	1392.58	980075.37	12:13:50	6.24
91457	247221.72	4826790.46	1392.56	980075.39	14:25:34	6.25
Diff	**-0.1**	**0.03**	**0.02**	**-0.02**		
1517	261462.94	4827348.69	1406.80	980079.87	12:05:27	6.22
91517	261462.96	4827348.65	1406.73	980079.85	15:16:51	6.25
Diff	**-0.02**	**0.04**	**0.07**	**0.02**		
1564	260750.41	4827503.89	1405.22	980082.25	9:24:17	6.22
91564	260750.29	4827503.87	1405.18	980082.22	15:25:36	6.25
Diff	**0.12**	**0.02**	**0.04**	**0.03**		

APPENDIX H. DATA DISK CONTENTS

Data

GlassButtes_Gravity.csv: Comma separated ASCII XYZ file containing gravity principal facts for this survey.

The following are columns included in this file.

Stn: Station Number
Date: Date
Time: Local time (GMT-7)
Meter: Gravity meter serial number
Reading: Meter counter reading
NAD83Z10_UTM_E: UTM Easting, Zone 10N, meters. NAD83
NAD83Z10_UTM_N: UTM Northing, Zone 10N, meters. NAD83
NAD83Z11_UTM_E: UTM Easting, Zone 11N, meters. NAD83
NAD83Z11_UTM_N: UTM Northing, Zone 11N, meters. NAD83
NAVD88: Station elevation, meters. NAVD88 vertical datum
NGVD29: Station elevation, meters. NGVD29 vertical datum
Obs_Grav: Observed gravity, milligals
TC10m_167Km: Terrain corrections, 10 m to 167Km for 1.00 gm/cm^3
TC_Density: Density used for terrain corrections and curvature correction 1 gm/cm^3
Curv_Cor: Bullard B, curvature correction for 1.00 gm/cm^3
Free_Air: Free Air gravity, milligals
SBA_200, etc.: Simple Bouguer Anomaly for 2.00 gm/cm^3, etc
CBA_200, etc.: Complete Bouguer Anomaly for 2.00 gm/cm^3, etc

G233.sfc: Meter calibration file for Model-G serial number 233.
MMDDYY.raw files: Daily raw instrument dump files. X, Y in NAD83 UTM Zone 11N. Elevation in NAVD88 vertical datum.

Plots

Digital images in Geosoft map[1] and ArcView tiff file formats. Coordinates in NAD83, UTM Zone 11N, meters.

Plate 1: Station Location Map.

Plate 2: Complete Bouguer Anomaly Gravity @ 2.25 gm/cm^3

Plate 3: Calculated First Vertical Derivative of CBA Gravity Upward Continued 400m @ 2.25 gm/cm^3

Plate 4: Horizontal Gradient of the CBA Gravity Upward Continued 200m @ 2.25 gm/cm^3

Report

Glass_Buttes_Grav_LR: Gravity data acquisition logistics report (this report) in Adobe PDF format.

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[1] ***Requires Geosoft Oasis Montaj Viewer software. Free download available at:***
http://www.geosoft.com/downloads/index.asp