USGS-OF-86-205

USGS-OF-86-205

United States Department of the Interior

Geological Survey

BOREHOLE GRAVITY METER SURVEY IN DRILL HOLE USW G-4, YUCCA MOUNTAIN AREA, NYE COUNTY, NEVADA

by

D. L. Healey, F. G. Clutsom, and D. A. Glover

Open-File Report 86-205

Prepared in cooperation with the U.S. Department of Energy
(Interagency Agreement DE-AI08-78ET44802)

Denver, Colorado
1986

Copies of this Open-File Report
may be purchased from

Open-File Services Section
Branch of Distribution
U.S. Geological Survey
Box 25425 Federal Center
Denver, Colorado 80225

PREPAYMENT IS REQUIRED

Price information will be published
in the monthly listing
"New Publications of the Geological Survey"

FOR ADDITIONAL ORDERING INFORMATION

CALL: Commerical: (303) 236-7476
FTS: 776-7476

USGS-OF-86-205

USGS-OF-86-205

United States Department of the Interior
Geological Survey

BOREHOLE GRAVITY METER SURVEY IN DRILL HOLE USW G-4, YUCCA MOUNTAIN AREA, NYE COUNTY, NEVADA

by

D. L. Healey, F. G. Clutsom, and D. A. Glover

Contents

Illustrations

Tables

Page

ABSTRACT

Drill hole USW G-4 was logged with the U.S. Geological Survey borehole gravity meter (BHGM) BH-6 as part of a detailed study of the lithostratigraphic units penetrated by this hole. Because the BHGM measures a larger volume of rock than the conventional gamma-gamma density tool, it provides an independent and more accurate measurement of the in situ average bulk density of thick lithologic units. USW G-4 is an especially important hole because of its proximity to the proposed exploratory shaft at Yucca Mountain.

The BHGM data were reduced to interval densities using a free-air gradient (F) of 0.3083 mGal/m (0.09397 mGal/ft) measured at the drill site. The interval densities were further improved by employing an instrument correction factor of 1.00226. This factor was determined from measurements obtained by taking gravity meter BH-6 over the Charleston Peak calibration loop.

The interval density data reported herein, should be helpful for planning the construction of the proposed shaft.

INTRODUCTION

At the request of the U.S. Department of Energy (DOE) the U.S. Geological Survey (USGS) has been investigating the geology and geophysics of Yucca Mountain (fig. 1) to evaluate the potential of this area as a repository for the storage of high-level nuclear waste. Funding for this study is provided by DOE as part of the Nevada Nuclear Waste Storage Investigations (NNWSI). The area is located along the western margin of the Nevada Test Site (NTS) in southern Nevada.

The DOE plans to construct a large-diameter exploratory shaft about 91 m (300 ft) northeast of drill hole USW G-4. Because of its proximity, the lithostratigraphic units that will be penetrated by this shaft are represented by those found in USW G-4. Therefore, a complete knowledge of the physical properties of these units is desirable. This knowledge should eliminate any unexpected problems while the shaft is being constructed.

The BHGM survey of USW G-4 was planned to gain as much information as possible from the gravity observations. Utilizing the highly detailed lithologic log reported by Spengler and Chornack (1984) and the digitized gamma-gamma density data provided by D. C. Muller and J. E. Kibler (U.S. Geological Survey written commun., 1985) the logging depth points in USW G-4 were selected.

The purpose of this report is to describe the results of the BHGM survey of USW G-4. The survey was made on April 4 and 5, 1985. A total of 87 gravity observations (including base stations) was obtained. From these observations, 68 interval density calculations were made. LaCoste and Romberg slim hole BHGM BH-6 was used to log USW G-4. This meter was used previously to log four other drill holes in the Yucca Mountain area.

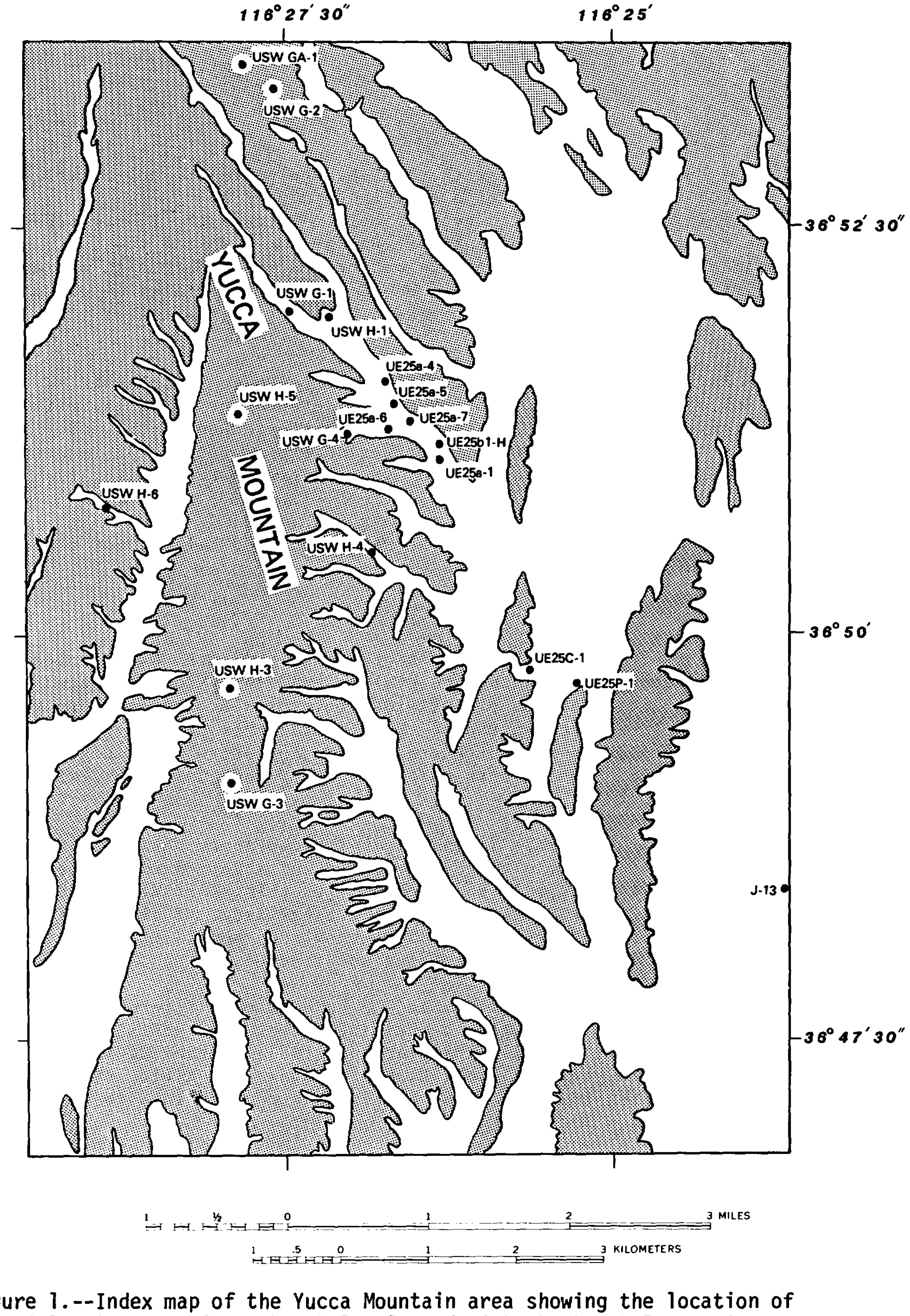

Figure 1.--Index map of the Yucca Mountain area showing the location of drill hole USW G-4. Other holes logged with the borehole gravity meter (USW G-3, UE-25p#1, UE-25c#1, and USW H-1) are also shown.

Acknowledgments

We wish to thank F. E. Rush of Water Resources Division (WRD) for his assistance in having the two strings of tubing removed from USW G-4, and for arranging to have the caliper log run. We also thank C. T. Warren (WRD) for the on-site logistical support provided. The logistical support provided by the USGS Core Library staff is also appreciated. J. E. Kibler (USGS) provided computer plots of the gamma-gamma density data and also the plots of the BHGM interval density data.

REDUCTION PROCEDURES

Much has been written concerning the fundamentals of BHGM logging data acquisition, reduction, and interpretation. Reports that cover BHGM surveys in the vicinity of the NTS include: Healey, 1970; Kososki, Robbins, and Schmoker, 1978; Schmoker and Kososki, 1978; Robbins, Schmoker and Hester, 1982; and Healey, Clutsom, and Glover, 1984. For a complete bibliography of subsurface gravimetry (prior to 1980) the reader is referred to Robbins, 1980.

The BHGM observations were corrected for the effects of Earth tides, instrument drift, and terrain. Data reduction was accomplished by the use of computer program BHGRAV.77, written by A. Cogbill, Los Alamos National Laboratory. BHGRAV.77 calculates the effects of Earth tides and instrument drift and applies the appropriate corrections to the gravity data. This program also calculates the terrain correction for each observation point downhole, out to a radial distance of 21.944 km. The inner zone terrain compartment elevations (through Zone H; Hammer, 1939) were determined by visual analysis of topographic maps and from sketches of the drill site. Digitized topography (digitized at 30 second intervals of latitude and longitude) was utilized by the reduction program to carry the terrain correction out to the specified radial distance from the drill hole. Figure 2 shows the calculated terrain corrections for the gravity observations in drill hole USW G-4.

The corrections for instrument drift were calculated from the replicate observations made periodically at base stations (repeated stations) at selected depths in the borehole. Figure 3 is a drift curve plotted from the base station observations to check the performance of BH-6. Noisy conditions were encountered after 1700 hours until cessation of logging on April 4, 1985. There might have been a very minor tare (abrupt shift in response) in the observations for base B1796 at about 1945 hours. However, repeated (tie) observations on April 5, 1985 for B578 (at 14:41 and 15:35) and B1796 (at 16:12 and 17:45) indicated that the reading differences were not abnormal. These small differences are easily corrected and have no appreciable effect on the calculated interval densities.

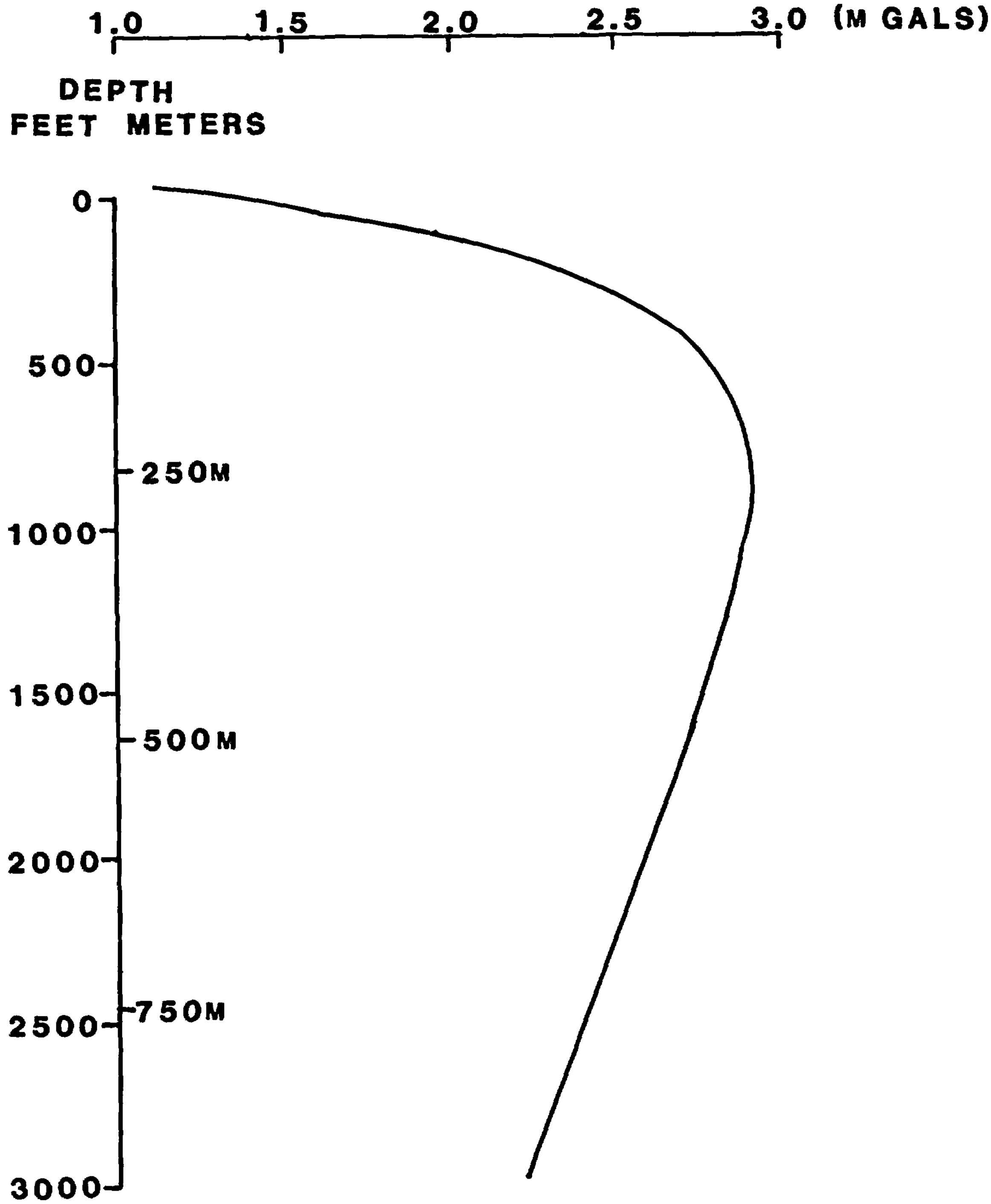

Figure 2.--Plot of calculated terrain correction values in drill hole USW G-4. Correction for the free-air gradient (F) measurement above the ground surface is also shown.

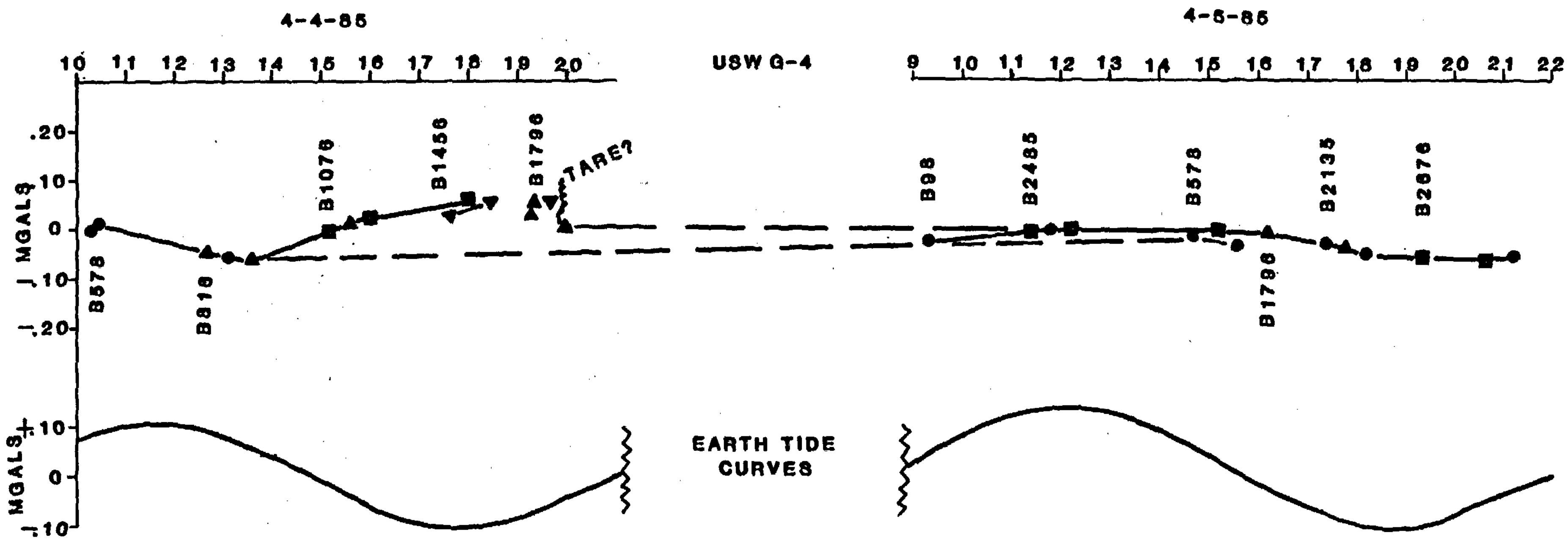

Figure 3.--Drift curve determined from base station observations in drill hole USW G-4. *Earth tide curves are also shown.* Symbols indicate repeated base observations.

The in-situ bulk density, in megagrams per cubic meter (Mg/m^3), between two observation points, vertically separated, in a drill hole (assuming near horizontal beds) is given by Robbins (1981) as

$$\rho_b = \frac{F-\Delta g/\Delta z}{0.02556} \qquad (1)$$

where F is the free-air gradient of gravity in mGals/ft; Δg is the measured difference in gravity between two points corrected for the effect of adjacent terrain, Earth tides, and instrument drift; Δz is the vertical distance separating the two points.

Free Air Gradients

An inspection of equation 1 shows that the free-air gradient (F) has a direct effect on the calculated interval density. Experience on Pahute and Rainier Mesas has shown that the measured F can vary as much as -9.76 to +6.22 percent from the assumed normal value of 0.3086 mGal/m (0.09406 mGal/ft) (Powers and Healey, 1985, p. 4; Healey, 1970, p. B61, Healey, 1985, unpublished data). In Yucca Flat, with the exception of one station thought to be erroneous, all the measured values fall below the "normal" value (Powers and Healey, 1985, p. 4, 11 and 12; Schmoker and Kososki, 1978; Robbins, Schmoker and Hester, 1982, p. 9, 11, 14 and 16). McCulloh (1966) indicated that the local and regional geologic effect could cause F to vary by more than ± 10 percent from the theoretical value.

Because of this range in F values, it was deemed necessary to measure F at each drill hole logged with the BHGM at Yucca Mountain. Free-air gradient measurements were obtained at USW G-4 on June 26-27, 1984 in anticipation that USW G-4 would eventually be logged. The observations were made on the ground surface and on top of the Bureau of Land Management (BLM) tower truck (Loving and Sappington, 1966; Powers and Healey, 1985). Six ground and five tower observations were obtained using LaCoste and Romberg meter G-177. G-177 had been calibrated on the Charleston Peak calibration loop (Ponce and Oliver, 1981). The data from the USW G-4 measurement are shown in table 1 along with the data from previously reported holes (Healey and others, 1984).

The free-air gradient (F) is determined from the following relationship

$$F = \frac{\Delta g + Tc}{\Delta h} \qquad (2)$$

where Δg is the difference in gravity (in mGal) measured on the ground surface and at some point vertically above the ground; Tc is the difference in the terrain correction between the two points, and; Δh is the vertical distance separating the two points. Changing F by 1.0 percent causes a change in the calculated interval density of 0.037 Mg/m^3 (Powers and Healey, 1985, p. 7). If we were only concerned with relative differences between intervals downhole this shift would not matter. Because we are concerned with the true bulk density, it is desirable to measure F at each hole logged with the BHGM.

STRATIGRAPHY

Detailed information on the lithostratigraphic units penetrated by drill hole USW G-4 was reported by Spengler and Chornack (1984). This detailed information was very helpful when planning the USW G-4 BHGM survey. A generalized stratigraphic column (excerpted from Spengler and Chornack, 1984) showing depths and thicknesses of the various units is shown in table 2.

INTERVAL DENSITIES

The in-situ interval bulk densities calculated from the USW G-4 BHGM data are shown in table 3. The input parameters, depth (in feet and meters), and the relative gravity (in mGals) are listed in columns 2, 3, and 4. The calculated parameters, vertical gradient (mGal/m), the interval density (Mg/m^3) and the weighted average density (Mg/m^3) are listed in columns 5, 6 and 7.

The computer plot of these density data is shown on fig. 4.

Table 1.--Summary of Data Obtained from Free-air Gradient Measurements at Yucca Mountain, Nevada Test Site

Drill Hole	Coordinates Nevada State (ft)	Elev. ground (ft) (m)	Measured values ΔH (ft) (m)	Measured values Δg (mGal)	Gravity value (top) (bottom)	Terrain correction (top) (bottom)	Corrected Δg (mGal)	Calculated FAG (mGal/ft) (mGal/m)
USW G-3	N.752,780 E.558,483	4856 1480.11	34.77 10.60	----	(assumed "normal" value)			0.09406[1] 0.3086
UE-25p#1	N.756,171 E.571,485	3654 1113.74	34.8 10.61	3.054	3274.759 3277.813	0.537 0.819	3.336	0.09586[2] 0.3147
UE-25c#1	N.757,095 E.569,768	3708 1130.20	34.8 10.61	3.163	3270.913 3274.076	0.625 0.767	3.305	0.09497[2] 0.3116
USW G-4	N.765,807 E.563,082	4165 1269.49	34.85 10.62	3.034	3232.095 3235.129	1.129 1.370	3.275	0.09397 0.3083

[1] Free-air gradient measurements attempted on April 13, 1983 and June 26, 1984.

[2] Free-air gradient measurements made on April 13, 1983 and reported by Healey and others, 1984, p. 6.

Table 2.--Summary of major lithostratigraphic units and contacts in drill hole USW G-4 (modified from Spengler and Chornack, 1984)[1]

Stratigraphy	Depth to bottom of interval meters (feet)	Thickness of interval meters (feet)
Alluvium	9.1 ? (30?)	9.1 ? (30.0?)
Paintbrush Tuff		
Tiva Canyon Member	42.1 (138.0)	33.0 (108)
Bedded tuff	45.1 (148.0)	3.0 (10)
Paintbrush Tuff--cont.		
Yucca Mountain Member	45.4 (148.8)	0.3 (0.8)
Bedded tuff	51.3 (168.2)	5.9 (19.4)
Paintbrush Tuff--cont.		
Pah Canyon Member	69.5 (228.0)	18.2 (59.8)
Topopah Spring Member	428.8 (1406.8)	359.3 (1178.8)
Bedded tuff	429.6 (1409.4)	0.8 (2.6)
Rhyolite lavas and tuffs of Calico Hills		
Tuffaceous beds of Calico Hills	536.9 (1761.4)	107.3 (352.0)
Crater Flat Tuff		
Prow Pass Member	682.0 (2237.5)	145.1 (476.1)
Bedded tuff	684.0 (2244.2)	2.0 (6.7)
Crater Flat Tuff--cont.		
Bullfrog Member	833.1 (2733.3)	149.1 (489.1)
Bedded tuff	839.9 (2755.6)	6.8 (22.3)
Crater Flat Tuff--cont.		
Tram Member (to total depth)	914.7 (3001.0)	74.8 (245.4)

[1]For a complete lithostratigraphic log of USW G-4 the reader is referred to Spengler and Chornack, 1984, p. 62-77.

Table 3.--Summary of Borehole Gravity Data Showing Calculated Interval and Average Densities in Drill Hole USW G-4. Free-air Gradient Used = 0.3083 mGal/m (0.09397 mGal/ft)

Count	Depth (ft)	Depth (m)	Gravity mGal	Gradient mGal/m	Interval Density (Mg/m^3)	Average Density (Mg/m^3)
1	98.00	29.87	0.000	----	Indefinite	----
2	138.00	42.06	1.616	0.13255	2.096	2.096
3	168.20	51.27	3.268	0.17944	1.537	1.855
4	188.00	57.30	4.455	0.19681	1.329	1.740
5	201.00	61.26	5.263	0.20379	1.246	1.677
6	228.00	69.49	6.930	0.20261	1.260	1.591
7	243.00	74.07	7.709	0.17023	1.646	1.596
8	265.50	80.92	8.475	0.11169	2.345	1.697
9	284.50	86.72	9.179	0.12172	2.225	1.751
10	305.00	92.96	9.945	0.12255	2.215	1.797
11	355.00	108.20	11.808	0.12221	2.219	1.879
12	400.40	122.04	13.427	0.11699	2.281	1.939
13	420.00	128.02	14.238	0.13587	2.056	1.946
14	438.00	133.50	14.997	0.13828	2.027	1.951
15	470.00	143.26	16.397	0.14351	1.965	1.952
16	510.00	155.45	18.209	0.14862	1.904	1.947
17	528.00	160.93	19.041	0.15166	1.868	1.944
18	552.00	168.25	20.210	0.15988	1.770	1.935
19	578.00	176.17	21.431	0.15398	1.840	1.930
20	600.00	182.88	22.404	0.14517	1.945	1.930
21	620.00	188.98	23.274	0.14280	1.974	1.932
22	634.00	193.24	23.839	0.13238	2.098	1.936
23	650.00	198.12	24.482	0.13182	2.105	1.941
24	670.00	204.22	25.246	0.12534	2.182	1.950
25	686.00	209.09	25.818	0.11715	2.279	1.959
26	706.00	215.19	26.485	0.10941	2.372	1.972
27	732.00	223.11	27.343	0.10832	2.385	1.989
28	774.00	235.92	28.786	0.11270	2.333	2.010
29	816.00	248.72	30.462	0.13092	2.115	2.017
30	830.00	252.98	31.020	0.13090	2.115	2.018
31	862.00	262.74	32.318	0.13307	2.090	2.021
32	892.00	271.88	33.520	0.13137	2.110	2.025
33	912.00	277.98	34.304	0.12869	2.142	2.028
34	929.00	283.16	34.951	0.12494	2.187	2.031
35	956.00	291.39	35.979	0.12483	2.188	2.036
36	1002.00	305.41	37.712	0.12364	2.202	2.044
37	1033.00	314.86	38.883	0.12392	2.199	2.049
38	1050.00	320.04	39.538	0.12630	2.170	2.052
39	1076.00	327.96	40.591	0.13289	2.092	2.053
40	1104.00	336.50	41.612	0.11972	2.249	2.058
41	1128.00	343.81	42.531	0.12562	2.178	2.061
42	1198.00	365.15	44.993	0.11537	2.301	2.076
43	1224.00	373.08	45.892	0.11348	2.323	2.082
44	1242.00	378.56	46.507	0.11208	2.340	2.086

Table 3.--Summary of Borehole Gravity Data Showing Calculated Interval and Average Densities in Drill Hole USW G-4. Free-air Gradient Used = 0.3083 mGal/m (0.09397 mGal/ft)--Continued

Count	Depth (ft)	Depth (m)	Gravity mGal	Gradient mGal/m	Interval Density (Mg/m^3)	Average Density (Mg/m^3)
45	1293.00	394.11	48.281	0.11415	2.315	2.096
46	1353.60	412.58	50.335	0.11117	2.351	2.108
47	1373.00	418.49	51.097	0.12888	2.140	2.109
48	1409.00	429.46	52.643	0.14087	1.997	2.105
49	1456.50	443.94	54.792	0.14849	1.906	2.098
50	1552.00	473.05	59.052	0.14635	1.931	2.087
51	1663.00	506.88	63.977	0.14556	1.941	2.077
52	1705.00	519.68	65.841	0.14557	1.941	2.074
53	1761.00	536.75	68.119	0.13348	2.085	2.074
54	1796.10	547.45	69.632	0.14139	1.990	2.072
55	1870.00	569.98	72.559	0.12996	2.127	2.074
56	1928.40	587.78	74.702	0.12039	2.241	2.080
57	1954.60	595.76	75.579	0.10985	2.367	2.084
58	2050.30	624.93	79.688	0.14085	1.997	2.080
59	2135.00	650.75	83.109	0.13254	2.096	2.080
60	2266.50	690.83	88.558	0.13594	2.055	2.079
61	2340.00	713.23	91.237	0.11957	2.251	2.084
62	2412.00	735.18	93.789	0.11630	2.290	2.091
63	2559.00	779.98	99.048	0.11738	2.277	2.102
64	2676.00	815.64	102.791	0.10496	2.425	2.116
65	2733.00	833.02	105.051	0.13008	2.125	2.117
66	2755.60	839.91	105.902	0.12349	2.204	2.117
67	2810.00	856.49	108.165	0.13651	2.049	2.116
68	2834.00	863.80	109.113	0.12954	2.132	2.116
69	2950.00	899.16	113.081	0.11223	2.338	2.125

CONCLUSIONS

(1) BHGM surveys provide highly accurate values of interval bulk density when reduced using a measured value for the free-air gradient (F).

(2) The BHGM measures a large volume of rock, not just the thin veneer measured by the gamma-gamma density tool. Therefore, the BHGM is relatively insensitive to anomalous conditions near the borehole wall (drill-induced fracturing and mud invasion), and relatively sensitive to rock conditions away from the drill hole. This attribute will be utilized in a study of the lithophysal zones within the Topopah Spring Member of the Paintbrush Tuff.

(3) The proximity of USW G-4 to the planned vertical shaft makes the data obtained in that borehole very important. The results will be used to assess mining conditions and to evaluate overburden densities. The BHGM density data will undoubtedly play an important role in the shaft planning.

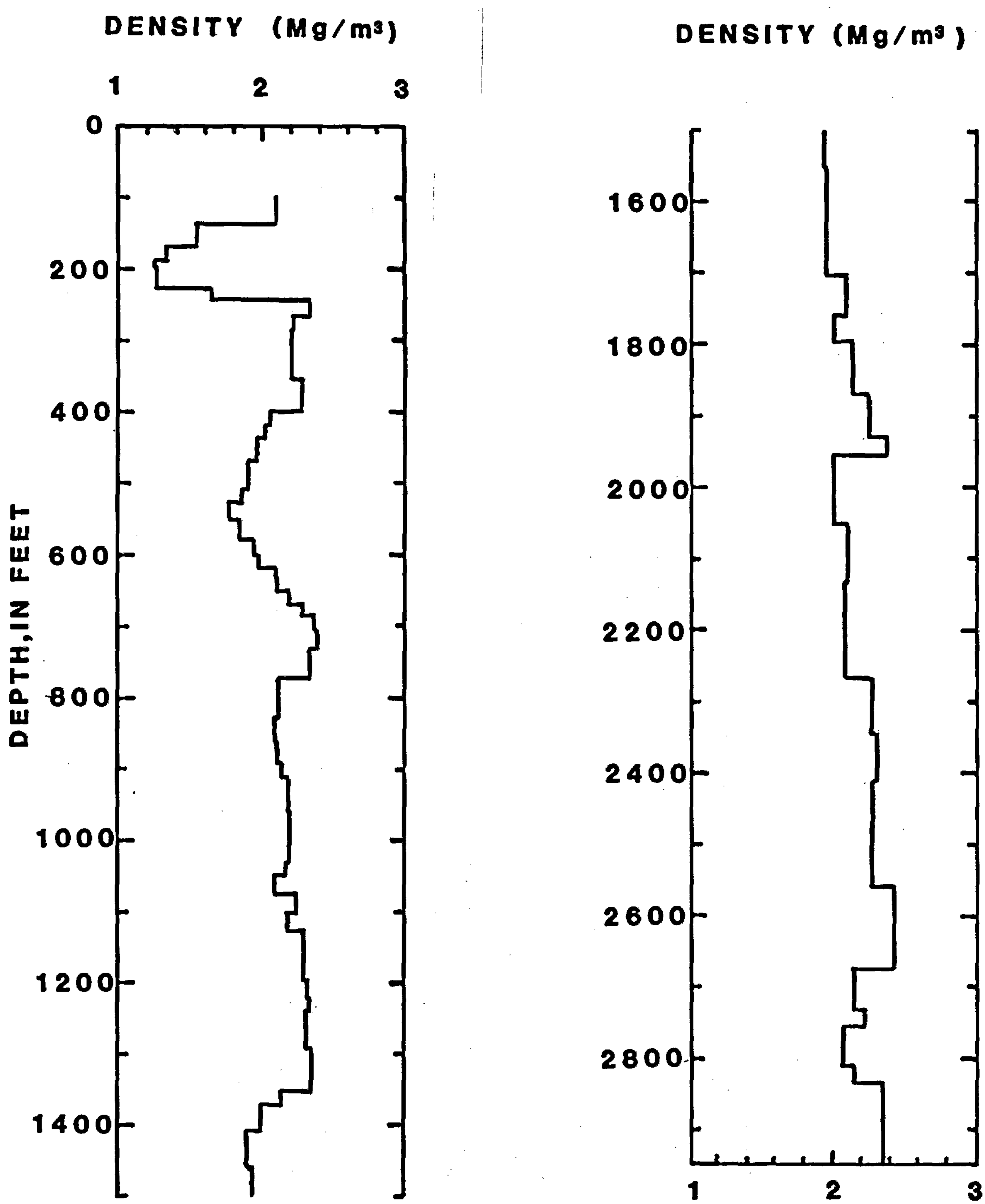

Figure 4.--Plot of interval densities calculated from borehole gravity data in drill hole USW G-4.

REFERENCES

Hammer, Sigmund, 1939, Terrain corrections for gravimeter stations: Geophysics, v. 4, no. 3, p. 184-194.

Healey, D. L., 1970, Calculated in situ bulk densities from subsurface gravity observations and density logs, Nevada Test Site and Hot Creek Valley, Nye County, Nevada, in Geological Survey Research 1970: U.S. Geological Survey Professional Paper 700-B, p. B52-B62.

Healey, D. L., Clutsom, F. G., and Glover, D. A., 1984, Borehole gravity meter surveys in drill holes USW G-3, UE-25P#1 and UE-25C#1, Yucca Mountain area, Nevada: U.S. Geological Survey Open-File Report 84-672, 16 p.

Kososki, B. A., Robbins, S. L., and Schmoker, J. W., 1978, Principal facts for borehole gravity stations in test well Ue19z, exploratory drill hole PM-1, and water well 5a, Nevada Test Site, Nye County, Nevada: U.S. Geological Survey Open-File Report 78-983, 16 p.

Loving, H. B., and Sappington, W. L., 1966, Truck-mounted hydraulic-lift surveying tower, in Geological Survey Research 1966: U.S. Geological Survey Professional Paper 550-B, p. B218-B221.

McCulloh, T. H., 1966, The promise of precise borehole gravimetry in petroleum exploration and exploitation: U.S. Geological Survey Circular 531, 12 p.

Ponce, D. A., and Oliver, H. W., 1981, Charleston Peak gravity calibration loop, Nevada: U.S. Geological Survey Open-File Report 81-985, 20 p.

Powers, P. S., and Healey, D. L., 1985, Free-air gradient observations in Yucca Flat, Nye County, Nevada: U.S. Geological Survey Open-File Report 85-530, 18 p.

Robbins, S. L., 1980, Bibliography with abridged abstracts of subsurface gravimetry (especially borehole) and corresponding in situ rock density determinations: U.S. Geological Survey Open-File Report 80-710, 47 p.

______ 1981, Reexamination of the values used as constants in calculating rock density from borehole gravity data: Geophysics, v. 46, no. 2, p. 208-210.

Robbins, S. L., Schmoker, J. W., and Hester, T. C., 1982, Principal facts and density estimates for borehole gravity stations in exploratory wells Ue4ah, Ue1h, Ue1q, Ue2co, and USW-H1 at the Nevada Test Site, Nye County, Nevada: U.S. Geological Survey Open-File Report 82-277, 33 p.

Schmoker, J. W., and Kososki, B. A., 1978, Principal facts for borehole gravity stations in test wells Ue10j, Ue7ns, and Ue5n, Nevada Test Site, Nye County, Nevada: U.S. Geological Survey Open-File Report 78-22, 11 p.

Spengler, R. W., and Chornack, M. P., 1984, Stratigraphic and structural characteristics of volcanic rocks in core hole USW G-4, Yucca Mountan, Nye County, Nevada, with a section on Geophysical logs by Muller, D. C., and Kibler, J. E.: U.S. Geological Survey Open-File Report 84-789, 77 p.

Appendix

Calibration of BHGM BH-6

Calibration of BHGM BH-6

Quality Assurance

In compliance with the Quality Assurance Procedure for Borehole Gravity Measurement and Data Reduction Technical Detailed Procedure GPP-12, R0, dated 3/20/85, the USGS slim-hole BHGM BH-6 was taken over the Charleston Peak calibration loop on 4/8/85. The details of this calibration loop were reported by Ponce and Oliver (1981). Preliminary results from recent absolute gravity stations established at Mercury and at the Kyle Canyon Ranger station (CPEA) were described by Ponce, D. A., and Oliver, H. W. (written commun., 1985). Figure 5 is a sketch map showing the location of the Charleston Peak calibration loop (after Ponce and Oliver, 1981).

Field Procedures

During normal operation in a borehole, the BHGM is suspended from a seven-conductor wireline cable and operated from a logging truck. The logging truck supplies the required 115 VAC power supply via an AC generator. The generator is located on the back of the truck and is suspended on air shock mounts to minimize vibration transferred to the ground surface. A 'dog house' on the back of the truck provides the field team a convenient location to operate the instrument and record data.

Operating a borehole gravity meter as a surface instrument imposes a number of problems. To obtain surface gravity data the borehole gravimeter was operated as a semi-portable system. The system consisted of four components: the surface console, a stripchart recorder, downhole electronics module, and the downhole sensor module. Support equipment consisted of the logging truck, a 12 VDC to 24 VDC converter connected to the logging truck battery, and a 24 VDC to 115 VAC inverter. During the surface-gravity loop survey the 115 VAC inverter provided power to the gravity meter and kept the system warmed up and operational without using the logging truck's generator which could not be run while the logging truck was on the road and moving from station to station.

At each gravity station the four components of the measurement system were removed from the logging truck. A 100-ft extension cable permitted the system to be located away from vibration associated with the engine of the logging truck. The sensor module was set over the gravity station plate and the surface console, stripchart recorder, and downhole electronics module were set on a portable table. After an appropriate waiting period, the tuning of the gravity meter was performed and then the data were obtained. At least three data readings were taken at each station to be sure that the gravimeter was operating properly. After obtaining the data the equipment was loaded into the logging truck and transported to the next station.

A number of problems were experienced during this surface gravity loop survey. The most serious ones were the loading and unloading of the system, orienting the sensor module over the station, and operating the 12-volt converter. The repeated loading and unloading of the system caused a shift of the levels which required retuning the meter. Power variations may have caused poor temperature control of the sensor.

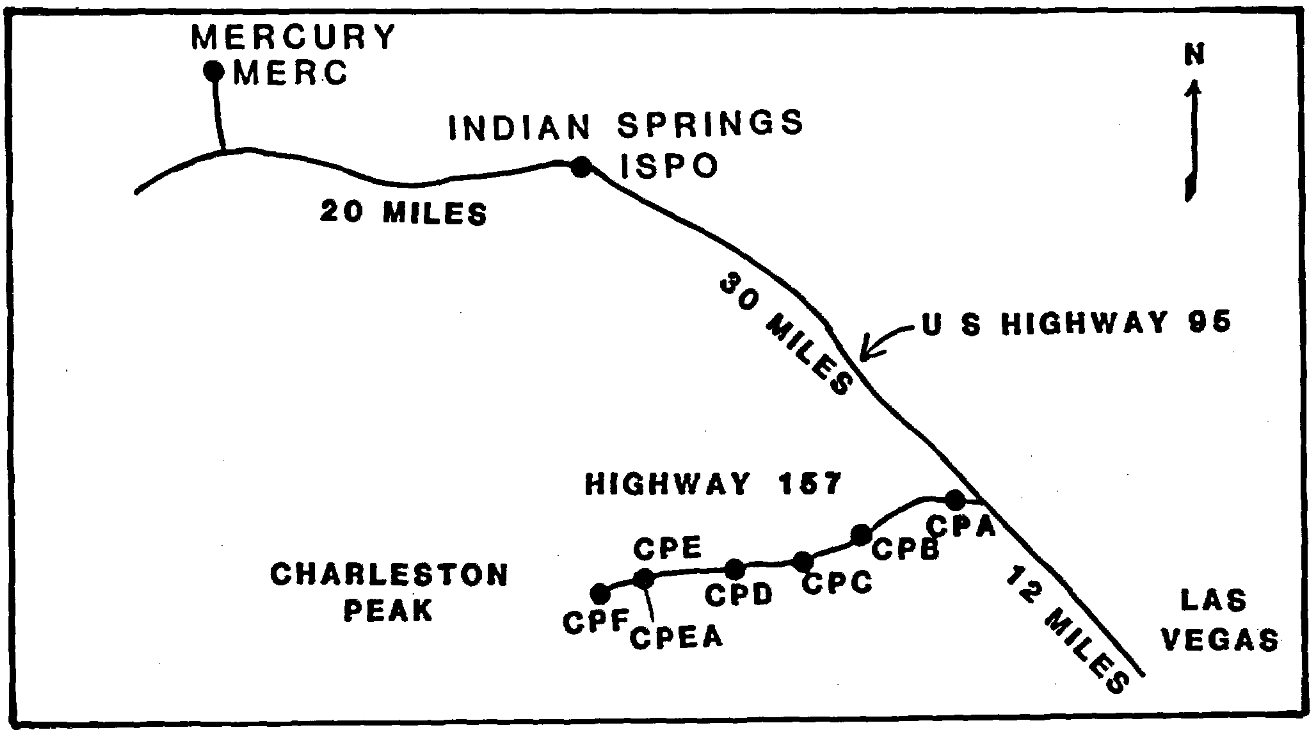

Figure 5.--Sketch map of the Charleston Peak calibration loop (after Ponce and Oliver, 1981).

Results

The data obtained from the Charleston Peak calibration loop observations with BHGM BH-6 are shown in Table 4. The drift rate of BH-6 during this day was excessive (0.743 mGal) and was nonlinear (not parallel between MERC and ISPO bases) (fig. 6).

The reasons for the excessive drift are believed to be the operation of the BHGM on the 24 VDC batteries of the logging truck, the physical handling of the system components, and the induced vibrations from adjacent vehicular traffic and wind. It is an abnormal situation to operate a BHGM on the ground surface. Under normal downhole operating conditions the drift of BH-6 is almost negligible.

Because of the nonlinearity of the drift curves for base stations Merc and ISPO, the afternoon reading at ISPO was not used. Comparing the calculated correction factors for ISPO (Table 4) shows why. The morning ISPO (1.00224) and the CPEA (1.00228) factors agree within 0.0001. The afternoon ISPO factor of 1.00512 definitely is not usable. The average factor of 1.00226 was used to correct the USW G-4 data reported herein.

Plans

Future calibration loop observations made with BHGM BH-6 will be made with a new improved procedure and better equipment. A separate 24 VDC battery system will be installed to reduce power fluctuations to the 115 VAC inverter. A flexible seven-conductor cable has been obtained. Using this cable, only the downhole components will have to be located outside of the truck and over the base station, and the console and recorder can remain inside the vehicle. Furthermore, the survey will be conducted from a smaller vehicle (a van or a pickup), which will facilitate the operation. It was difficult getting the large logging truck close to each of the three bases logged, particularly the CPEA site.

Table 4.--Determination of Calibration Factor for Borehole Gravity Meter BH-6, Charleston Peak Calibration Loop, April 8, 1985.

Station	Time	OBS[1] gravity reading (mGals)	Average value (mGals)	Merc[2] drift value (mGals)	Difference Δg (mGals)	Δg (mGals)	Factor (mGal/ft)
ISPO[3]	0821	926.052					
ISPO	0830	926.077	926.058	903.748	+22.310	[4]/ +22.36	1.00224
ISPO	0836	926.045					
CPEA[3]	1225	688.356					
CPEA	1231	688.350					
CPEA	1235	688.348	688.351	904.040	-215.689	[5]/ -216.181	1.00228
CPEA	1237	688.348					
ISPO	1500	926.479					
ISPO	1504	926.456	926.468	904.222	+22.246	[4]/ +22.36	1.00512

[1]Corrected for Earth tides and converted to mGals.

[2]Drift values determined by linear regression from Mercury base values. Mercury base values (morning and afternoon) are not listed.

[3]ISPO refers to the Indian Springs Post Office; CPEA refers to the absolute gravity station at the Kyle Canyon Ranger Station.

[4]Published value for station (relative to Mercury) (Ponce and Oliver, 1981, p. 4).

[5]Ponce and Oliver, 1985, written commun. describing preliminary results for four absolute gravity measurements in southern Nevada.

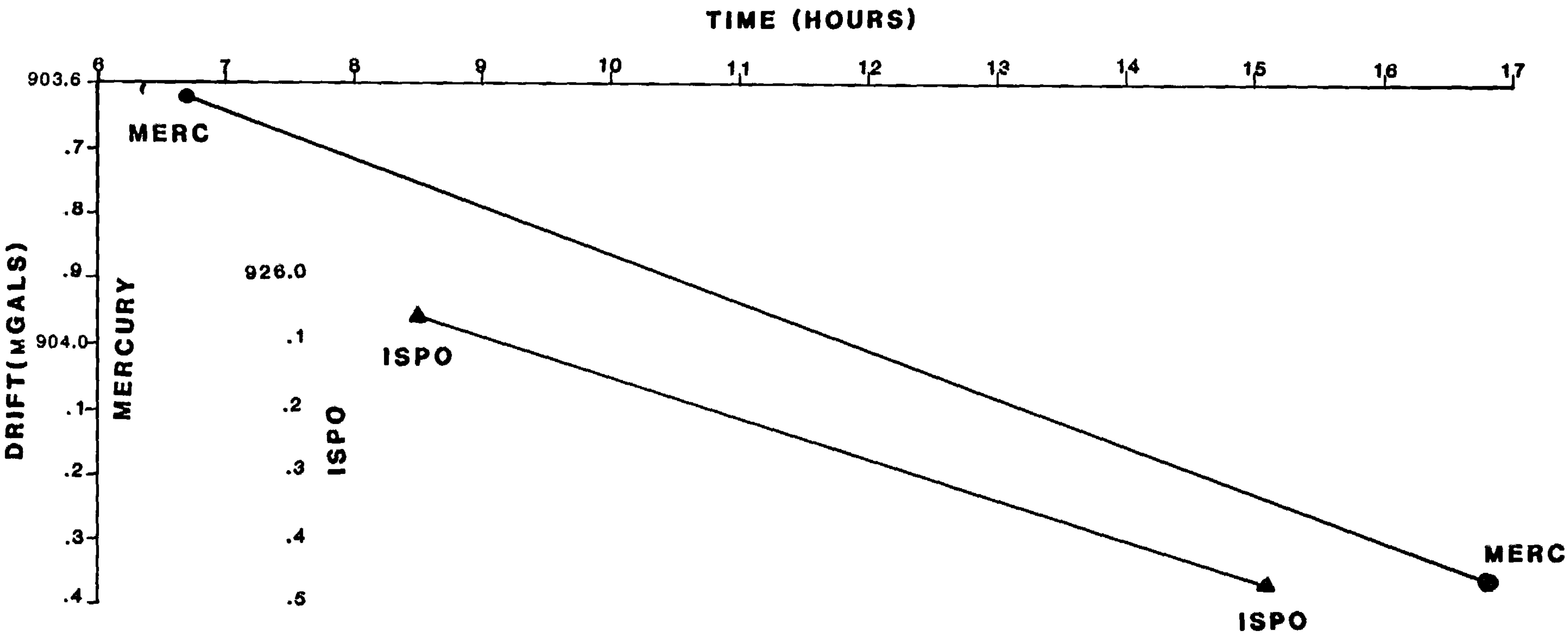

Figure 6.--Plot of drift curves for borehole gravity meter (BHGM) BH-6 readings at Charleston Peak calibration loop base Mercury (MERC) and Indian Springs Post Office (ISPO).