UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

PRELIMINARY APPRAISAL OF GRAVITY AND MAGNETIC DATA AT SYNCLINE RIDGE, WESTERN YUCCA FLAT, NEVADA TEST SITE, NYE COUNTY, NEVADA

By

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ABSTRACT

A gravity and magnetic study of the Syncline Ridge area was conducted as part of an investigation of argillite rocks of the Eleana Formation under consideration as a medium for the possible storage of high-level radioactive waste.

Bouguer gravity anomaly data, viewed in light of densities obtained by gamma-gamma logs and previous work of D. L. Healey (1968), delineate two regions of steep negative gradient where Cenozoic rocks and sediments are inferred to abruptly thicken: (1) the western third of the study area where Tertiary volcanic rocks are extensively exposed and (2) the northeast corner of the area where Quaternary alluvium is exposed and where volcanic rocks are inferred to occur at depth. In the remainder of the area, a region extending contiguously from Mine Mountain northwestward through Syncline Ridge to the Eleana Range, the gravity data indicate that the Eleana Formation, where not exposed, is buried at depths of less than about 200 m, except in a limited area of exposed older Paleozoic rocks on Mine Mountain. Quaternary alluvium and Tertiary volcanic rocks are inferred to occur in this region as veneers or shallow dishes of deposit on Tippipah Limestone or Eleana Formation.

Low-level aeromagnetic anomaly data, covering the western two-thirds of the study area, delineate relatively magnetic tuff units within the Tertiary volcanic rocks and provide a very attractive means for distinguishing units of normal polarization from units of reversed polarization. If used in conjunction with results of previous magnetization studies of G. D. Bath (1968), the low-level survey may prove to be an effective tool for mapping specific tuff members in the volcanic terrane.

The important question of the feasibility of discriminating high-quartz argillite from low-quartz argillite of the Eleana Formation using surface gravity data remains unresolved. If the more highly competent, denser, high-quartz phase should occur as stratigraphic units many tens of meters thick, closely spaced gravity data may reliably detect these units. If the high-quartz phase occurs only as relatively thin units, interbedded with low-quartz phase, borehole gravity surveying can be used much more effectively than equivalent surface gravity surveying.

INTRODUCTION

A gravity and magnetic study of the Syncline Ridge area, western Yucca Flat, Nevada Test Site, was conducted as part of an assessment of a terrane of argillitic rocks under consideration for the possible storage of high-level radioactive waste. The rocks of interest, unit J of the Eleana Formation, were studied on regional and local scales using a variety of geophysical techniques. The current study focuses on a regional study of Bouguer gravity and aeromagnetic anomalies forming part of an integrated geophysical project coordinated by Donald B. Hoover.

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GEOLOGIC SETTING

A generalized geologic map of the study area (fig. 1) showing major stratigraphic units and structures is derived from Orkild (1963) and Hoover and Morrison (1980), the later reference offering a comprehensive summary of the geology of the Syncline Ridge area. The study area includes older Paleozoic rocks, the Devonian and Mississippian Eleana Formation, the Pennsylvanian and Permian (?) Tippipah Limestone, Tertiary volcanic rocks, and Quaternary alluvium.

The older Paleozoic rocks, which crop out on the northern and eastern flanks of Mine Mountain, occur as thrust plates overlying the Eleana Formation and Tippipah Limestone. These rocks serve as a principal aquifer to Yucca Flat east of the study area and, on the basis of drill hole and geologic data are probably buried at least 2,000 m at Syncline Ridge.

The Eleana Formation, which has been divided into ten lithologic units of clastic sedimentary rocks (Poole and others, 1961), occurs most extensively in the Eleana Range northwest of Syncline Ridge. In the Syncline Ridge area, the region of greatest interest, the sparse outcrops of Eleana Formation are predominantly unit J and have an inferred stratigraphic thickness of 1,100 m. Unit J is composed of three subunits: siliceous argillite and siltstone, argillite, and quartzite. The argillite subunit, the chief candidate for a repository medium (Hoover and Morrison, 1980), contains thin layers of low-quartz (<45 % quartz) argillite separated by high-quartz (>90 % quartz) argillite. Because the low-quartz argillite is relatively incompetent, the high-quartz argillite is more desirable as a repository medium. Remote detection of the relative percentages of low-quartz and high-quartz argillite on the basis of contrasting physical properties is difficult. If the low-quartz phase is consistently lower in density and lower in electrical resistivity than the high-quartz phase, it is possible that detailed gravity and electrical surveys can be successfully used to remotely detect relative percentages of the phases.

The Tippipah Limestone is largely confined to a broad tract of outcrops at Syncline Ridge. The upper part of the formation is 850 to 900 m thick and forms most of Syncline Ridge. The lower part of the formation is a series of interbedded limestone, siltstone, and argillite approximately 100 to 200 m thick.

Tertiary volcanic rocks crop out west and south of the Eleana Range and at the southern margin of Syncline Ridge. Tertiary volcanic rocks include: welded tuff of Red Rock Valley west of the Eleana Range, zeolitized tuff of the tunnel beds of Rainier Mesa, the Paintbrush Tuff, and the Rainier Mesa member of the Timber Mountain Tuff on the north, west and south sides of the Syncline Ridge area. All of the volcanic rocks are of Miocene age. Although the thickness of volcanic rocks is less than 200 m within most of the Syncline Ridge area, the thickness may range from 200 to 500 m to the west and south margin of the Syncline Ridge area and in the valley between Mine Mountain and Syncline Ridge (Hoover and Morrison, 1980, p. 18).

Structures in the study area include major folds, Mesozoic lateral and thrust faults, high-angle normal faults associated with Tertiary volcanic centers, and normal faults related to Basin and Range faulting. Two major folds occur in the Syncline Ridge area: the Eleana Range anticline and the Syncline Ridge syncline. The anticline is asymmetric with a steeper limb on the west side. The syncline is nearly bisected by an axial fault exposed in the south and central parts of Syncline Ridge. Hoover and Morrison (1980) divide the Syncline Ridge area into three blocks delineated by Mesozoic lateral faults (fig. 1). Local thrust faults are present in the Eleana Range and beneath Syncline Ridge. High-angle normal and reverse faults parallel the major fold trends and are inferred to have displacements of about 100 to 200 m on the basis of mapped geologic relations.

GRAVITY INTERPRETATION

General

Gravity data in the study area are derived from two independent sources: a regional, though detailed, survey of Healey and others (1980, 1981) confined mainly to areas marginal to Syncline Ridge and two local surveys restricted to the northeast and northwest parts of Syncline Ridge. The principal facts for the local surveys are presented in Appendix 1.

Most of the gravity stations of both sources were established using LaCoste and Romberg Geodetic Gravity Meter G177. The calibration factor used for this meter in terms of mGal per scale division is 1.0002, on the basis of data obtained on the Mt. Hamilton, California, mountain calibration loop in 1968 (Barnes and others, 1969). More recent data from the Charleston Peak, Nevada, and the Mt. Hamilton calibration loops indicate that the calibration factor is now 1.0003 (Ponce and Oliver, 1981); the 1.0002 factor is assumed to have been applicable during the periods of the surveys under discussion.

Standard gravity corrections were made on all the gravity data and include: (a) the earth-tide correction, (b) the instrument drift correction, (c) the free-air correction, (d) the Bouguer correction, (e) the latitude correction, (f) the curvature correction, and (g) the terrain correction. All gravity values were ultimately referenced to station WA-128 at McCarran International Airport, Las Vegas, Nevada (Woollard and Rose, 1963, p. 100). All gravity values were subsequently converted to the Geodetic Reference System of 1967 (International Union of Geodesy and Geophysics, 1971) and the

IGSN 1971 gravity datum (Morelli, 1974, p. 18). Bouguer gravity anomaly values were computed for a reduction density of 2.67 g/cm^3 and include terrain corrections to a radius of 166.7 km from each station. The terrain correction from 0.0 to 2.57 km or 4.40 km were made using Hammer templates (Hammer, 1939). The terrain corrections from 2.57 km or 4.40 km to 166.7 km were made using a program by Plouff (1977) based on a grid of geographic coordinates where average elevations are digitized from topographic maps.

All gravity stations are located on bench marks, photogrammetric "spot" elevations, or on surveyed points. Photogrammetric spot elevations are generally considered accurate to within ½ of the 6-meter contour interval or ±3 m. About 27 spot elevations in the central part of the Syncline Ridge area were developed by the Topographic Division, USGS, Menlo Park, California, and are considered accurate to within about 3.5 m. Surveyed points near the east margin of the study area were obtained by precise leveling surveys under private contract.

Density Data

The principal source of rock density information within the study area are gamma-gamma logs (fig. 2) of boreholes UE16d and UE11 (fig. 1) in the northwest and eastern parts of the area. These logs provide data to depths of 911 m and 1,615 m, respectively. Mean densities and associated standard deviations corresponding to the inferred stratigraphic section are summarized in table 1, assuming a normally distributed population of density values. Effects of borehole washouts, as noted on caliper logs, have been taken into account.

On the basis of the gamma-gamma log information, there is no significant density contrast between the argillite and quartzite rock units of the Eleana Formation and no significant contrast between the Eleana Formation and the Tippipah Limestone. The only appreciable contrast shown on the logs occurs between Quaternary alluvium and the underlying Tippipah Limestone or Eleana Formation, a contrast of about 0.50 g/cm^3. The heterogeneous lithologic character of the stratigraphic section, which over vertical distances of tens of meters carries various proportions of limestone, siltstone, quartzite, and argillite, is reflected in the high standard deviation of as much as 0.3 g/cm^3 shown in table 1.

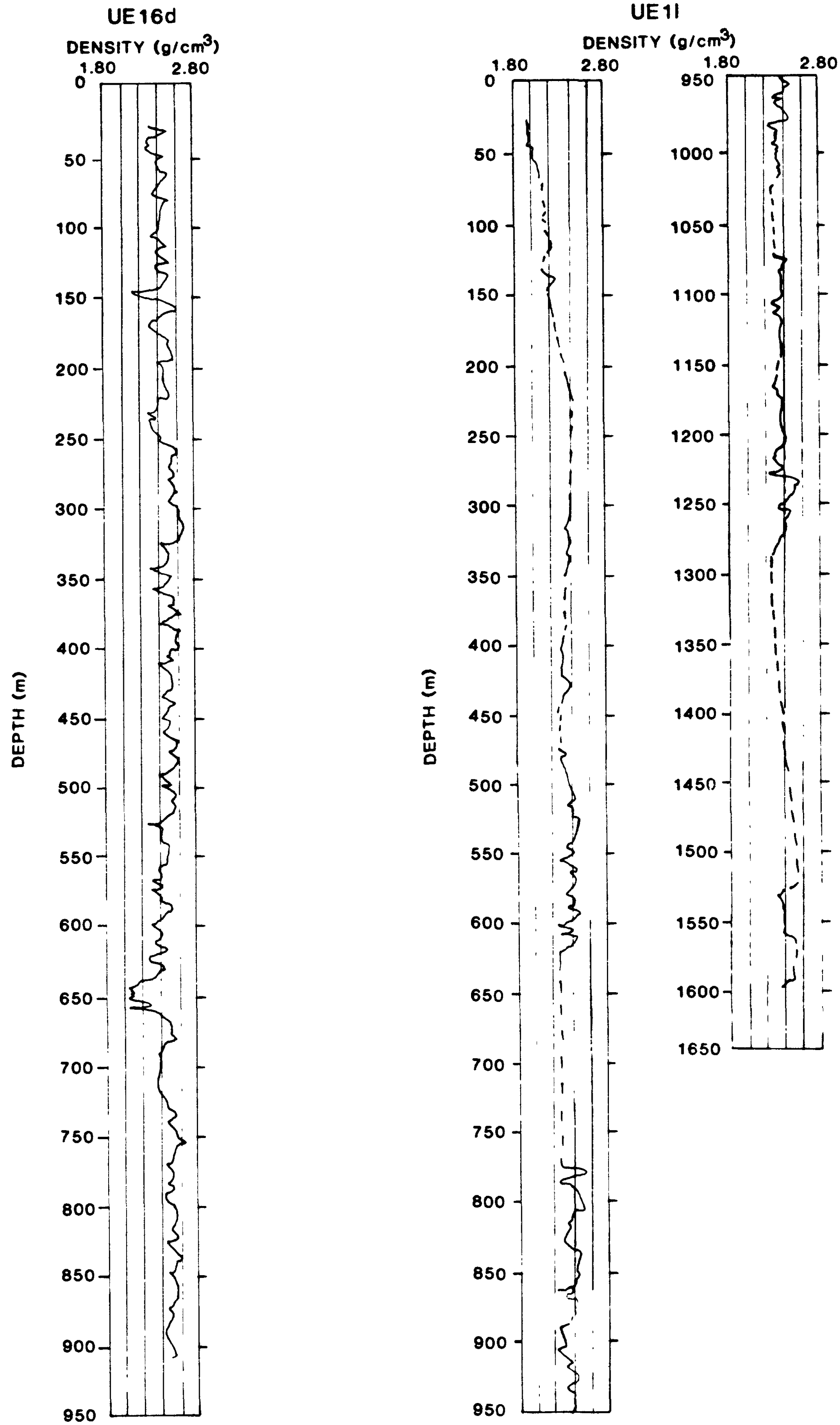

Figure 2.-- Gamma-gamma logs showing subsurface rock density for boreholes UE16d and UE1l.

Table 1. -- Rock density data from gamma-gamma well logs. Depth intervals and rock units after D. L. Hoover (written commun., 1978).

Depth interval (m)	Rock unit	Number of samples	Mean density (g/cm³)	Standard deviation
		Borehole UE16d		
0 - 27	Qal[1]	n.a.[2]	n.a.	n.a.
27 - 539	PPt[3]	148	2.50	±0.09
539 - 782	Mejuq[4]	65	2.45	±0.23
782 - 911	Mejua[5]	47	2.53	±0.06
		Borehole UE11		
0 - 61	Qal	3	1.98	±0.04
61 - 302	Mejuq	n.a.	n.a.	n.a.
302 - 396	Mejua	n.a.	n.a.	n.a.
396 - 606	Mejuq	48	2.48	±0.05
606 - 1,414	Mejua	119	2.42	±0.30
1,414 - 1,614	Mejl[6]	11	2.42	±0.07

[1]Quaternary alluvium
[2]Not available
[3]Tippipah Limestone
[4]Upper quartzite member of Eleana Formation, unit J
[5]Argillite member of Eleana Formation, unit J
[6]Lower quartzite member of Eleana Formation, unit J

Independently determined densities of the Eleana Formation, based on core samples in the Syncline Ridge area and drill hole-data of unit J (table 2), generally agree with results of the gamma-gamma logs with one notable exception. Densities of high-quartz argillite samples collected from outcrops in the Syncline Ridge area have a mean bulk density about 0.1 g/cm^3 higher than average argillite densities inferred from gamma-gamma logs. As noted in the section on geologic setting, the high-quartz argillite occurs interbedded with low-quartz argillite throughout borehole sections of the argillite subunit of unit J of the Eleana Formation. If the high-quartz argillite should occur in units as thick as 100 m, the higher density may cause an observable increase in the regional gravity anomaly. However, if the high-quartz argillite occurs thinly bedded, as has been observed in well logs, the increased density is probably not sufficient to cause a significant gravity anomaly. Comparisons of gravity anomaly values with drill-hole data indicate that it is not possible to readily distinguish low-quartz Eleana Formation from high-quartz ones, presumably because of the pervasive interbedding of the two phases.

Table 2. -- Mean bulk densities from drill hole data.
After Hoover and Morrison (1980, p. 66-67)

Depth interval (m)	Lithology	Number of samples	Mean bulk density (g/cm^3)	Range of density	Remarks
n.a.[1]	High-quartz argillite[2]	33	2.62	2.51 - 2.75	Syncline Ridge area[2]
61 - 1,414	Argillite and quartzite[3]	180	2.36	2.02 - 2.57	UE11[4]
454 - 914	do[3]	136	2.47	2.02 - 2.66	UE16d[4]
0 - 914	do[3]	276	2.51	1.85 - 2.73	UE17e[4]

[1]Not available
[2]Core samples
[3]Unit J, Eleana Formation
[4]Drill hole log data

Bouguer Gravity Anomalies

The Bouguer gravity anomaly map (fig. 3) shows three regions of contrasting anomalies: (1) the western third of the study area, Area A characterized by a gradient with values decreasing westward at a rate of 5 to 12 mGal/km, (2) the northeastern corner of the study area, Area B characterized by a gradient with values decreasing northeastward at about 7 mGal/km, and (3) the central and southeastern part of the study area, Area C generally characterized by gravity highs. For purposes of qualitative interpretation it is convenient to associate values more negative than -155 mGal as "lows" and values less negative than -155 mGal as "highs".

In the western third of the area, Area A, the -155 mGal contour line approximately delineates the mapped contact between volcanic rocks to the west and the Eleana Formation or Tippipah Limestone to the east. The major gravity low expressed by the conspicuous gravity gradient indicates that the volcanic rocks are much lower in density than the Eleana Formation or Tippipah Limestone.

In the northeastern corner of the area, Area B, the -155 mGal contour line and neighboring gradient mark a major lateral change in subsurface density approximately perpendicular to the trend of Syncline Ridge and approximately at the northeastern margin of Syncline Ridge. The gradient appears to be the continuation of the flank of a major gravity low centered over Quaternary alluvium at Yucca Flat just east of the study area, where the alluvium increases in thickness to about 1 km (Healey, 1968, fig. 2; Healey and others, 1980). This abrupt decrease in gravity may also be caused by buried volcanic rocks, an interpretation supported by drill-hole data from an area 3 km east of Syncline Ridge (Hoover and Morrison, 1980, figs. 3 and 9) and by the inferred low density of volcanic rocks in the eastern third of the area.

The -155 mGal contour line marks the steepening edge of the gravity gradient in Area B and represents a lateral contrast in subsurface density that coincides with inferred Mesozoic faults exhibiting Tertiary rejuvenation (Hoover and Morrison, 1980, fig. 3). It is remarkable that the -155 mGal contour line essentially coincides with the approximate geographic limit of the Walker Lane shear zone (Hoover and Morrison, 1980, fig. 8) where Carr (1974) inferred an offset of the shear zone in the Syncline Ridge area. The sharp lateral contrast in subsurface densities causing the gradient may also be related, though in a subtle way, to a major flexure in the axis of the Antler orogenic trough (Hoover and Morrison, 1980, fig. 4) marking the structural and depositional framework of the Eleana Formation over great distances (Poole, 1974). The spatial association of the lateral density contrast with both the limit of the shear zone and the major flexure of the orogenic trough axis may imply that the lateral contrast has resulted largely from tectonism rather than erosion.

In the central and southeastern parts of the area, Area C, a region extending contiguously from the Eleana Range southeastward through Syncline Ridge to Mine Mountain, gravity anomalies are highest. The highest values occur in a lobe marked by the -150 mGal contour line, extending from the southeastern corner of the study area northwestward across the southern parts of Syncline Ridge and the Eleana Range. This region of highest gravity values

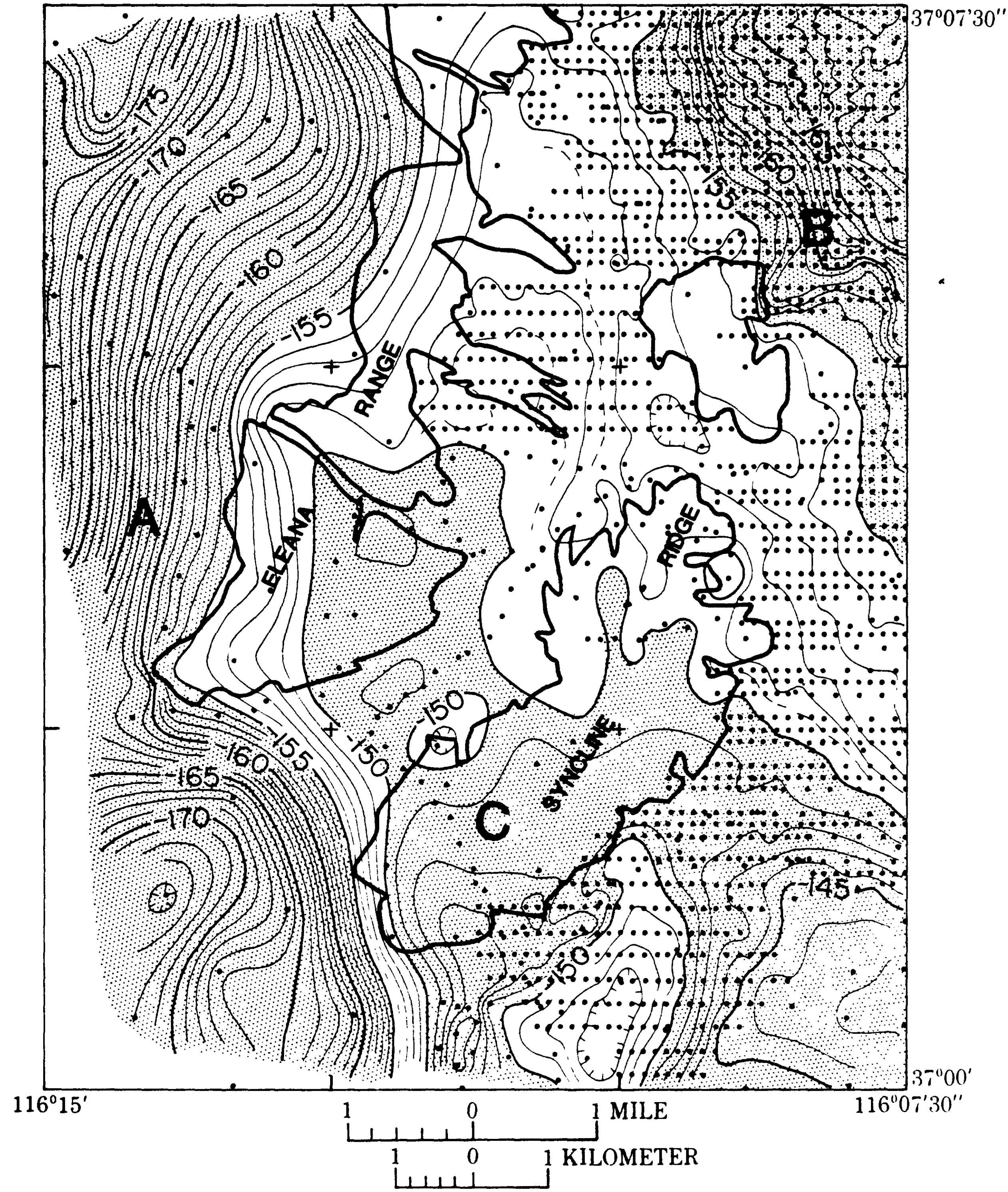

Figure 3. -- Complete Bouguer gravity anomaly map of the Tippipah Spring 7 1/2 quadrangle map. Contour interval 1 mGal. Dashed contour interval 1/2 mGal. Reduced for a density of 2.67 g/cm^3. Hachures indicate gravity lows. Major surface outcrops of the Eleana Formation at Eleana Range and Tippipah Limestone at Syncline Ridge are outlined. The three regions of contrasting Bouguer anomalies are shaded and labeled A, B, and C.

is largely associated with extensive exposure of Tippipah Limestone, Eleana Formation, and older Paleozoic rocks, which collectively represent the highest density rocks of the study area. This region of highest gravity values is interrupted by two superimposed gravity lows: (1) a sharply defined low south of Syncline Ridge marking an inferred increase in thickness of alluvium, perhaps to as much as 150 m, and (2) a subtly defined low between Syncline Ridge and the Eleana Range marking only a slight increase in alluvial thickness, perhaps to about 75 m.

In the region having values ranging from -150 to -155 mGal, the suppression of the gravity highs is caused largely by extensive occurrences of low-density alluvium that in many places covers Tippipah Limestone, Eleana Formation, and older Paleozoic rocks to depths of 50 m or less. The part of this region that forms a north-trending belt extending from the southern extremity of Syncline Ridge northward through most of the Eleana Range, appears to be an eastward extension of the pronounced gravity gradient associated with low-density volcanic rocks in the western third of the area. Likewise, the part of this region that covers the northern half of Syncline Ridge appears to be a gently inclined extension of the conspicuous gradient associated with low-density alluvium and possibly low-density subsurface volcanic rocks in the northeastern corner of the area.

MAGNETIC DATA

General

A high-level aeromagnetic survey (Boynton and others, 1963) was flown over the study area in 1960 and 1961 with east-west flight lines spaced 0.5 mi (0.8 km) apart at a barometric elevation of 8,000 ft (2.4 km). Although data from this original survey, uncorrected for a reference field, indicated that the study area is magnetically quiet, recompilations of Bath (written communication, 1978), Sweeney and others (1978), and Zietz and others (1977) show the area to be diagonally transected by a broad, northwest-trending, low-amplitude negative anomaly. Further compilations of G. D. Bath (written commun., 1978) using the high-level data confirmed that the low-amplitude negative anomaly within the study area is part of a regional magnetic trough that extends from Yucca Flat northwestward to a region just north of Timber Mountain, approximately 30 km northwest of the study area.

Study of an eastward extension of the original survey by Bath (1976), using additional low-level aeromagnetic data and ground magnetic data, indicated the need for low-level coverage for purposes of identifying geologic structures. A low-level aeromagnetic survey (U.S. Geological Survey, 1979) designed mainly for the Timber Mountain area (Kane and others, 1981) was flown over the western two-thirds of the study area in 1978 with east-west flight lines spaced 0.25 mi (0.4 km) apart at a constant terrain clearance of 400 ft (120 m). The resulting map (fig. 4) represents a preliminary contouring by the U.S. Geological Survey using copies of digital tapes of magnetic field data from which an updated International Geomagnetic Reference Field, Epoch 1975.0 (Barraclough and Fabiano, 1978) has been subtracted.

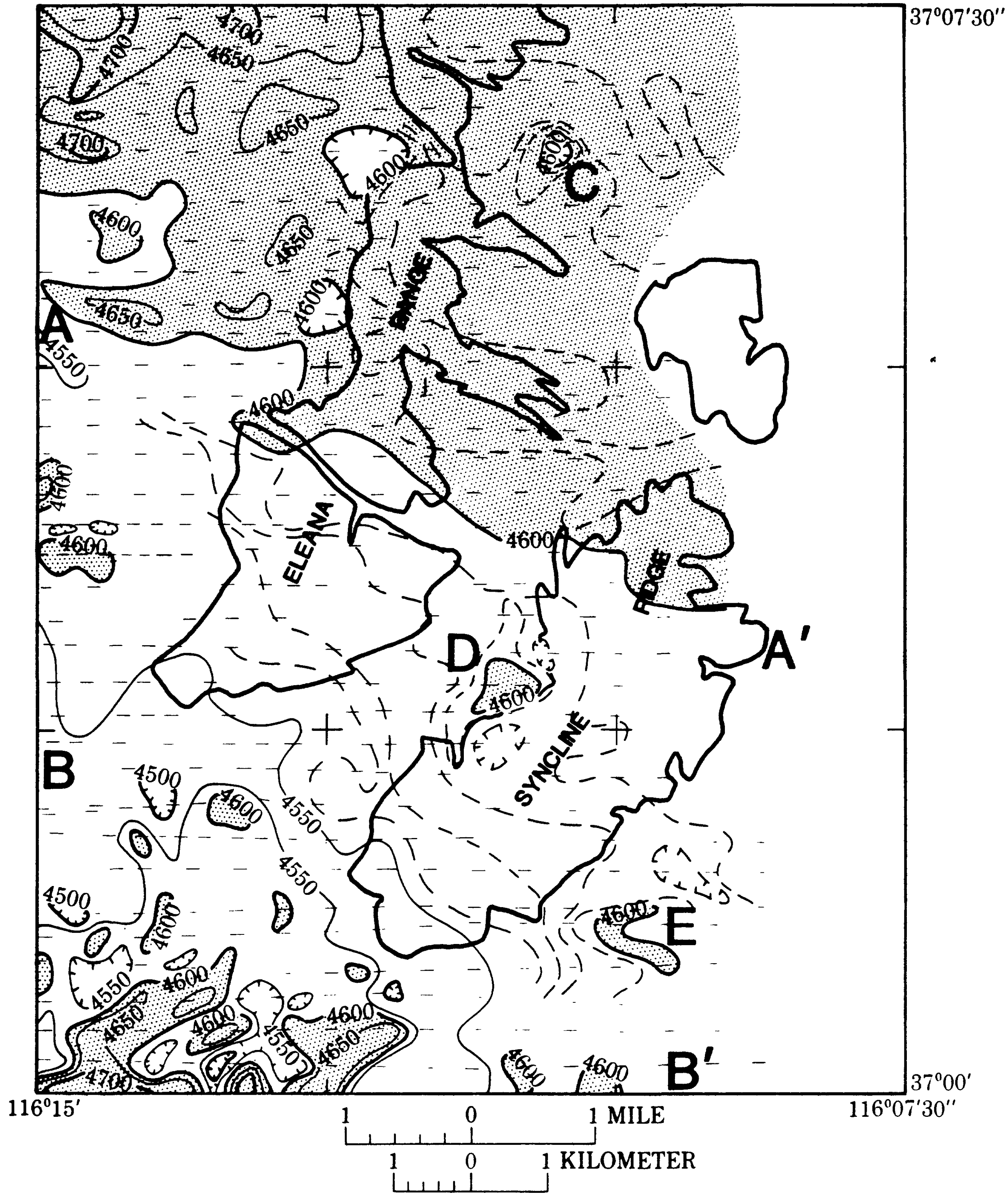

Figure 4. -- Aeromagnetic anomaly map of the Tippipah Spring 7½ quadrangle. Survey flown 400 ft (122 m) above ground along east-west lines spaced one-quarter mile (0.4 km) apart. Contour interval 50 gammas. Dashed contour interval 10 gammas. Regions of higher intensity above 4,600 gamma are shaded. Major surface outcrops of the Eleana Formation and Tippipah Limestone are outlined. Corrected for IGRF 1975 with a 5,000-gamma constant added.

Magnetization Data

On the basis of studies by Bath (1968,1976) and consistent with occurrences of anomalies relative to exposed rocks, the only anomaly-producing rocks in the study area are a select number of units of Tertiary volcanic rocks. Among units in the Tertiary stratigraphic section, as modified by Hoover and Morrison (1980, Table 1, p. 19), the normally magnetized Topopah Spring Member of the Paintbrush Tuff and the reversely magnetized Rainier Mesa Member and normally magnetized Ammonia Tanks Member of the Timber Mountain Tuff are capable of generating significant anomalies (Bath, 1968). Total magnetizations of the Topopah Spring and Ammonia Tanks Members average about 10^{-3} emu/cm^3 with Q values (ratio of remanent to induced magnetization) of about 3. Total magnetizations of the Rainier Mesa Member average about 3×10^{-3} emu/cm^3 with Q values of about 10 (Bath, 1968).

Aeromagnetic Anomalies

As stated above, high-level aeromagnetic data indicate that the study area is magnetically flat except for a low-amplitude negative anomaly trending northwest and crossing the southern parts of Syncline Ridge and the Eleana Range. Although the low-level survey (fig. 4) decomposes this coherent anomaly into a large number of short-wavelength anomalies, the low-amplitude negative anomaly can still be discerned as a large area of less than 4,600 gammas intensity, confined approximately between lines A-A' and B-B'. A possible interpretation is that the regions of higher field intensity, northeast of A-A' and southwest of B-B', contain rocks that are predominantly normal in polarity or that are mainly reversed in polarity (or some combination of these two conditions). While this interpretation may apply in part, a more plausible interpretation is that the region of low intensity is a residual negative anomaly or a region of low magnetization nested between two regions of higher intensity associated with weakly to moderately magnetic rocks.

In the western third of the study area, where the volcanic rocks are inferred to thicken to hundreds of meters on the basis of gravity data, the anomaly-producing rocks are variously polarized in normal and reversed directions. In this area, southwest of Syncline Ridge and southwest and west of the Eleana Range, it is likely that local positive anomalies reflect normally polarized rocks and local negative anomalies reflect reversely polarized rocks. Farther east, correlation of local anomalies with isolated volcanic rock exposures is striking: at C (fig. 4) a negative anomaly is developed over a limited exposure of tuff 1 at Grouse Canyon and at D a positive anomaly occurs over a small exposure of normally magnetized tuff on the northwest flank of Syncline Ridge. The origins of other local anomalies, such as the arcuate one at E do not correlate with a volcanic surface outcrop but may indicate the occurrence of volcanic rocks at shallow depth.

CONCLUSIONS

Bouguer gravity anomaly, low-level aeromagnetic anomaly, density, and magnetization data collectively indicate the following, relative to the Eleana Formation, the principal target of the investigation: (1) in an area extending northwestward from Mine Mountain, through Syncline Ridge, to the Eleana Range, the Eleana Formation, where not exposed, occurs at depths of less than approximately 200 m, except for a small region of exposed older Paleozoic rocks; (2) in the region of shallowly buried Eleana Formation, occurrences of volcanic rock cover are delineated by low-level aeromagnetic anomaly data, which also discriminate normally polarized from reversely polarized tuff units; and (3) selective detection of high-quartz argillite relative to low-quartz argillite using surface gravity data is not feasible if the high-quartz and low-quartz varieties are intimately interbedded, as observed in boreholes.

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APPENDIX 1

Principal facts for 160 local gravity stations on the Tippipah Spring 7½ minute quadrangle, Nye County, Nevada. PROJ NAME is a three-character project name. STA NAME is the gravity station name. LAT (latitude) and LONG (longitude) are expressed in degrees and decimal minutes. ELEV is the station elevation and is reported to the nearest foot. OG is the observed gravity in mGal. Accuracy code is a four-character code describing location, elevation, latitude, and observed gravity accuracies. FAA is the free-air gravity anomaly in mGal. SBA is the simple Bouguer gravity anomaly in mGal. INNER is the inner-zone terrain correction in mGal. TC is the total terrain correction in mGal, calculated to a radial distance of 166.7 km. CBA1 and CBA2 are the complete Bouguer gravity anomalies in mGal reduced for densities of 2.67 and 2.50 g/cm^3, respectively.

PROJ NAME	STAT NAME	LAT deg	LAT min	LONG deg	LONG min	ELEV feet	OG mGal	ACCURACY CODE	FAA mGal	SBA mGal	INNER mGal	TC mGal	CBA1 2.67	CBA2 2.50
NTS	whk01	37	0.39	116	9.16	4932.9	979460.86	T633	14.34	-153.91	2.69	3.66	-151.65	-141.08
NTS	whk02	37	0.39	116	9.25	4973.0	979459.15	T633	16.37	-153.24	2.36	3.36	-151.29	-140.62
NTS	whk03	37	0.38	116	9.33	4994.0	979458.15	T633	17.46	-152.87	2.31	3.33	-150.95	-140.23
NTS	whk04	37	0.39	116	9.58	5292.0	979437.19	T633	24.44	-156.06	4.99	6.42	-151.08	-139.90
NTS	whk05	37	0.35	116	9.80	5497.0	979422.74	T633	29.82	-157.67	7.33	9.22	-149.91	-138.47
NTS	whk06	37	0.34	116	9.92	5501.0	979422.00	T633	29.60	-158.02	7.06	8.94	-150.55	-139.08
NTS	whk07	37	0.31	116	10.28	5304.0	979440.18	T633	29.62	-151.28	1.72	3.09	-149.63	-138.22
NTS	whk08	37	0.31	116	10.17	5283.0	979440.58	T633	28.04	-152.15	1.55	2.90	-150.69	-139.31
NTS	whk09	37	0.31	116	10.04	5382.0	979434.60	T633	31.37	-152.19	2.64	4.21	-149.43	-137.92
NTS	whk10	37	0.30	116	9.91	5163.0	979448.88	T633	25.31	-150.78	1.06	2.26	-149.95	-138.79
NTS	whk11	37	0.31	116	9.83	5201.0	979445.15	T633	24.92	-152.47	1.34	2.60	-151.30	-140.08
NTS	whk12	37	0.31	116	9.78	5208.0	979445.24	T633	25.65	-151.98	2.52	3.79	-149.62	-138.46
NTS	whk13	37	0.32	116	9.61	4922.0	979462.83	T633	16.21	-151.66	1.93	2.88	-150.18	-139.59
NTS	whk14	37	0.32	116	9.41	4809.0	979470.85	T633	13.64	-150.38	1.07	1.96	-149.81	-139.40
NTS	whk15	37	0.33	116	9.15	4683.0	979478.27	T633	9.13	-150.59	0.70	1.56	-150.40	-140.24
NTS	whk16	37	0.41	116	10.13	4720.0	979478.00	T633	11.11	-149.87	0.27	1.32	-149.92	-139.67
NTS	whk17	37	0.39	116	10.03	4810.0	979471.46	T633	13.32	-150.73	0.46	1.44	-150.58	-140.24
NTS	whk18	37	0.39	116	9.80	4864.0	979467.32	T633	14.25	-151.65	0.66	1.61	-151.43	-140.88
NTS	whk19	37	0.37	116	10.67	4794.0	979472.15	T633	12.75	-150.75	0.32	1.38	-150.76	-140.35
NTS	whk20	37	0.36	116	10.75	4822.0	979470.90	T633	14.30	-150.16	0.24	1.29	-150.26	-139.79
NTS	whk21	37	0.35	116	10.63	4883.0	979466.98	T633	16.29	-150.25	0.40	1.41	-150.25	-139.64
NTS	whk22	37	0.34	116	10.38	4998.0	979459.29	T633	19.56	-150.90	0.85	1.86	-150.45	-139.63
NTS	whk23	37	0.36	116	10.28	5016.0	979458.07	T633	19.68	-151.40	1.38	2.40	-150.41	-139.58
NTS	whk24	37	0.35	116	9.35	4957.0	979460.51	T633	16.73	-152.34	2.24	3.22	-150.52	-139.87
NTS	whk25	37	0.34	116	9.27	4766.0	979473.33	T633	11.77	-150.78	0.85	1.73	-150.43	-140.11
NTS	whk26	37	0.35	116	9.05	4652.0	979482.75	T633	10.29	-148.38	0.57	1.44	-148.31	-138.21
NTS	whk27	37	0.37	116	9.03	4648.0	979481.59	T633	8.52	-150.01	0.59	1.46	-149.91	-139.82
NTS	na001	37	0.49	116	9.75	4757.0	979474.21	P333	9.66	-152.58	0.05	1.25	-152.71	-142.37
NTS	na002	37	0.49	116	9.87	4773.0	979473.34	P333	10.30	-152.49	0.03	1.25	-152.62	-142.25
NTS	na003	37	0.49	116	9.97	4778.2	979473.34	P333	10.79	-152.18	0.09	1.34	-152.23	-141.85
NTS	na004	37	0.49	116	10.07	4796.1	979472.65	P333	11.78	-151.80	0.07	1.33	-151.85	-141.44
NTS	na005	37	0.49	116	10.16	4807.2	979472.26	P333	12.43	-151.52	0.04	1.32	-151.59	-141.15
NTS	na006	37	0.49	116	10.27	4798.9	979473.29	P333	12.68	-150.99	0.08	1.42	-150.95	-140.53
NTS	na007	37	0.49	116	10.37	4811.2	979472.77	P333	13.32	-150.77	0.12	1.50	-150.66	-140.22
NTS	na008	37	0.49	116	10.48	4842.0	979471.19	P333	14.63	-150.51	0.08	1.47	-150.43	-139.92
NTS	na009	37	0.49	116	10.58	4882.3	979468.71	P333	15.94	-150.58	0.09	1.48	-150.50	-139.90
NTS	na010	37	0.49	116	10.68	4907.4	979467.24	P333	16.83	-150.54	0.09	1.50	-150.44	-139.79
NTS	na011	37	0.49	116	10.78	4927.1	979466.18	P333	17.62	-150.42	0.08	1.53	-150.30	-139.61
NTS	na012	37	0.49	116	10.90	4938.5	979465.53	P333	18.04	-150.40	0.09	1.60	-150.20	-139.49
NTS	na013	37	0.49	116	11.00	4968.4	979463.67	P333	18.99	-150.47	0.11	1.65	-150.22	-139.45
NTS	na014	37	0.49	116	11.10	4988.4	979462.44	P333	19.64	-150.50	0.13	1.73	-150.18	-139.37
NTS	na015	37	0.49	116	11.20	5018.2	979460.46	P333	20.47	-150.69	0.21	1.85	-150.25	-139.38
NTS	na016	37	0.49	116	11.30	5074.4	979456.90	P333	22.19	-150.88	0.20	1.84	-150.46	-139.47
NTS	na017	37	0.49	116	11.40	5118.4	979454.07	P333	23.49	-151.09	0.40	2.06	-150.45	-139.37
NTS	na018	37	0.49	116	11.52	5187.4	979449.57	P333	25.48	-151.44	0.39	2.08	-150.80	-139.58
NTS	na019	37	0.49	116	11.62	5205.8	979448.26	P333	25.90	-151.65	0.28	2.00	-151.08	-139.82
NTS	na020	37	0.49	116	11.72	5240.8	979446.16	P333	27.09	-151.66	0.24	1.98	-151.12	-139.77
NTS	na021	37	0.51	116	10.58	4901.1	979467.72	P333	16.49	-150.67	0.10	1.55	-150.52	-139.89
NTS	na022	37	0.51	116	10.68	4907.9	979467.46	P333	16.87	-150.52	0.11	1.62	-150.30	-139.66
NTS	na023	37	0.51	116	10.78	4933.2	979465.88	P333	17.66	-150.60	0.13	1.68	-150.32	-139.63
NTS	na024	37	0.51	116	10.88	4974.5	979463.34	P333	19.01	-150.66	0.14	1.71	-150.35	-139.57
NTS	na026	37	0.51	116	11.10	5043.6	979459.01	P333	21.17	-150.85	0.20	1.88	-150.38	-139.46
NTS	na027	37	0.51	116	11.20	5073.8	979457.02	P333	22.02	-151.03	0.23	1.96	-150.48	-139.50
NTS	na028	37	0.51	116	11.30	5104.4	979455.07	P333	22.95	-151.15	0.30	2.08	-150.48	-139.44
NTS	na029	37	0.51	116	11.42	5143.6	979452.55	P333	24.11	-151.32	0.40	2.24	-150.50	-139.39
NTS	na030	37	0.51	116	11.52	5197.1	979449.15	P333	25.74	-151.51	0.54	2.40	-150.55	-139.32
NTS	na033	37	0.52	116	11.40	5228.9	979447.15	P333	26.48	-151.86	0.69	2.63	-150.66	-139.39
NTS	na035	37	0.52	116	11.20	5153.4	979452.13	P333	24.37	-151.40	0.33	2.17	-150.65	-139.51
NTS	na036	37	0.52	116	11.10	5105.9	979455.18	P333	22.95	-151.19	0.30	2.07	-150.54	-139.50
NTS	na037	37	0.52	116	10.98	5059.4	979458.06	P333	21.46	-151.10	0.25	1.95	-150.57	-139.62
NTS	na038	37	0.52	116	10.88	5017.1	979460.86	P333	20.28	-150.84	0.26	1.91	-150.34	-139.48
NTS	na039	37	0.52	116	10.78	4990.5	979462.44	P333	19.36	-150.85	0.15	1.74	-150.52	-139.70
NTS	na040	37	0.52	116	10.68	4979.4	979463.10	P333	18.98	-150.85	0.15	1.68	-150.58	-139.78
NTS	na041	37	0.52	116	10.58	4969.3	979463.50	P333	18.43	-151.05	0.11	1.58	-150.85	-140.10
NTS	na042	37	0.52	116	10.48	4939.9	979465.40	P333	17.57	-150.91	0.13	1.57	-150.75	-140.03
NTS	na043	37	0.52	116	10.37	4909.8	979467.17	P333	16.51	-150.95	0.08	1.48	-150.86	-140.20
NTS	na044	37	0.52	116	10.27	4899.8	979467.53	P333	15.93	-151.19	0.06	1.42	-151.16	-140.52
NTS	na045	37	0.52	116	10.16	4890.0	979467.79	P333	15.27	-151.51	0.06	1.39	-151.52	-140.90
NTS	na046	37	0.52	116	10.07	4874.1	979468.52	P333	14.50	-151.73	0.04	1.34	-151.79	-141.20
NTS	na047	37	0.52	116	9.97	4861.3	979468.92	P333	13.70	-152.10	0.07	1.35	-152.15	-141.59
NTS	na048	37	0.52	116	9.85	4841.2	979470.01	P333	12.90	-152.22	0.10	1.36	-152.25	-141.73
NTS	na049	37	0.54	116	9.87	4864.9	979469.17	P333	14.07	-151.85	0.12	1.42	-151.83	-141.27
NTS	na050	37	0.54	116	9.95	4893.2	979467.29	P333	14.85	-152.04	0.08	1.38	-152.06	-141.43
NTS	na051	37	0.54	116	10.07	4916.0	979466.11	P333	15.81	-151.86	0.06	1.39	-151.88	-141.20
NTS	na052	37	0.54	116	10.16	4929.6	979465.58	P333	16.56	-151.57	0.06	1.41	-151.56	-140.85
NTS	na053	37	0.54	116	10.27	4939.7	979465.35	P333	17.28	-151.19	0.06	1.45	-151.14	-140.42
NTS	na054	37	0.54	116	10.37	4951.4	979464.82	P333	17.85	-151.02	0.08	1.51	-150.91	-140.17
NTS	na055	37	0.54	116	10.47	4964.6	979464.05	P333	18.32	-151.00	0.11	1.59	-150.82	-140.05
NTS	na056	37	0.54	116	10.58	4993.1	979462.38	P333	19.33	-150.96	0.10	1.63	-150.75	-139.92
NTS	na057	37	0.54	116	10.68	5026.0	979460.50	P333	20.54	-150.88	0.13	1.70	-150.60	-139.70

PROJ NAME	STAT NAME	LAT deg	LAT min	LONG deg	LONG min	ELEV feet	OG mGal	ACCURACY CODE	FAA mGal	SBA mGal	INNER mGal	TC mGal	CBA1 2.67	CBA2 2.50
NTS	na058	37	0.54	116	10.78	5058.8	979458.44	P333	21.57	-150.97	0.16	1.78	-150.60	-139.64
NTS	na059	37	0.54	116	10.88	5087.0	979456.64	P333	22.42	-151.08	0.21	1.89	-150.61	-139.59
NTS	na060	37	0.54	116	10.98	5142.0	979452.92	P333	23.87	-151.51	0.43	2.18	-150.76	-139.64
NTS	na061	37	0.54	116	11.10	5145.2	979452.78	P333	24.03	-151.46	0.54	2.41	-150.47	-139.36
NTS	na062	37	0.54	116	11.18	5268.6	979444.74	P333	27.59	-152.10	0.68	2.61	-150.93	-139.57
NTS	na063	37	0.54	116	11.30	5332.6	979440.47	P333	29.33	-152.54	0.88	2.91	-151.08	-139.59
NTS	na064	37	0.55	116	11.20	5254.8	979446.07	P333	27.36	-151.86	0.48	2.48	-150.82	-139.47
NTS	na065	37	0.55	116	11.10	5220.6	979448.33	P333	26.40	-151.66	0.30	2.22	-150.87	-139.58
NTS	na066	37	0.55	116	10.98	5198.8	979449.48	P333	25.50	-151.82	0.25	2.06	-151.19	-139.94
NTS	na067	37	0.55	116	10.88	5190.7	979449.76	P333	25.02	-152.02	0.32	2.07	-151.39	-140.15
NTS	na068	37	0.55	116	10.78	5106.4	979455.49	P333	22.83	-151.33	0.24	1.92	-150.83	-139.78
NTS	na069	37	0.55	116	10.68	5089.1	979456.37	P333	22.08	-151.50	0.18	1.80	-151.12	-140.09
NTS	na070	37	0.55	116	10.58	5050.4	979458.88	P333	20.96	-151.29	0.11	1.68	-151.03	-140.08
NTS	na071	37	0.55	116	10.47	5017.2	979460.86	P333	19.81	-151.31	0.12	1.64	-151.08	-140.20
NTS	na072	37	0.55	116	10.37	4990.3	979462.33	P333	18.76	-151.44	0.09	1.57	-151.28	-140.45
NTS	na073	37	0.55	116	10.27	4988.1	979462.25	P333	18.47	-151.65	0.07	1.51	-151.56	-140.73
NTS	na074	37	0.55	116	10.15	4969.7	979463.11	P333	17.60	-151.90	0.10	1.49	-151.81	-141.02
NTS	na075	37	0.55	116	10.07	4934.7	979465.27	P333	16.47	-151.83	0.08	1.45	-151.78	-141.07
NTS	na076	37	0.55	116	9.95	4927.0	979465.76	P333	16.24	-151.80	0.10	1.43	-151.77	-141.07
NTS	na077	37	0.55	116	9.85	4929.0	979465.48	P333	16.14	-151.97	0.08	1.39	-151.99	-141.28
NTS	na078	37	0.46	116	11.62	5107.3	979454.62	P333	23.46	-150.73	0.26	1.75	-150.40	-139.33
NTS	na079	37	0.46	116	11.52	5076.8	979456.53	P333	22.51	-150.64	0.17	1.66	-150.40	-139.39
NTS	na080	37	0.46	116	11.42	5054.3	979457.83	P333	21.69	-150.69	0.11	1.58	-150.53	-139.56
NTS	na081	37	0.46	116	11.32	5029.7	979459.28	P333	20.83	-150.72	0.11	1.55	-150.58	-139.66
NTS	na082	37	0.46	116	11.22	5012.3	979460.16	P333	20.07	-150.88	0.12	1.53	-150.76	-139.88
NTS	na083	37	0.46	116	11.12	4976.1	979462.64	P333	19.15	-150.57	0.11	1.50	-150.47	-139.67
NTS	na084	37	0.46	116	11.00	4960.4	979463.59	P333	18.63	-150.56	0.17	1.53	-150.44	-139.67
NTS	na085	37	0.46	116	10.90	4897.0	979467.61	P333	16.69	-150.33	0.14	1.51	-150.22	-139.59
NTS	na086	37	0.46	116	10.78	4872.6	979469.25	P333	16.03	-150.15	0.14	1.48	-150.07	-139.49
NTS	na087	37	0.46	116	10.68	4876.6	979468.60	P333	15.76	-150.57	0.12	1.42	-150.54	-139.95
NTS	na088	37	0.46	116	10.58	4832.7	979471.19	P333	14.22	-150.60	0.11	1.41	-150.58	-140.09
NTS	na089	37	0.46	116	10.48	4825.7	979471.51	P333	13.88	-150.70	0.10	1.37	-150.72	-140.24
NTS	na090	37	0.46	116	10.38	4780.4	979474.13	P333	12.25	-150.80	0.08	1.37	-150.81	-140.42
NTS	na091	37	0.46	116	10.27	4764.3	979474.88	P333	11.48	-151.01	0.04	1.31	-151.08	-140.73
NTS	na092	37	0.46	116	10.16	4747.4	979475.61	P333	10.62	-151.29	0.05	1.30	-151.37	-141.05
NTS	na093	37	0.46	116	10.07	4731.3	979476.31	P333	9.81	-151.56	0.05	1.30	-151.64	-141.36
NTS	na094	37	0.46	116	9.97	4702.6	979477.79	P333	8.59	-151.80	0.05	1.31	-151.86	-141.64
NTS	na095	37	0.46	116	9.87	4685.0	979478.53	P333	7.68	-152.11	0.06	1.32	-152.16	-141.98
NTS	na096	37	0.46	116	9.75	4688.3	979477.63	P333	7.09	-152.81	0.07	1.28	-152.90	-142.71
NTS	na097	37	0.46	116	9.65	4678.4	979477.78	P333	6.31	-153.26	0.05	1.25	-153.38	-143.21
NTS	na098	37	0.46	116	9.57	4670.5	979478.19	P333	5.98	-153.32	0.07	1.26	-153.4[illegible]	-143.28
NTS	na099	37	0.46	116	9.45	4659.5	979478.95	P333	5.70	-153.22	0.03	1.21	-153.3[illegible]	-143.25
NTS	na100	37	0.46	116	9.35	4647.1	979479.89	P333	5.48	-153.02	0.05	1.22	-153.17	-143.06
NTS	na101	37	0.46	116	9.25	4632.9	979480.87	P333	5.12	-152.89	0.14	1.30	-152.95	-142.89
NTS	na102	37	0.46	116	9.13	4635.8	979480.96	P333	5.48	-152.63	0.19	1.30	-152.69	-142.62
NTS	na103	37	0.46	116	9.03	4653.0	979479.68	P333	5.82	-152.88	0.34	1.41	-152.83	-142.73
NTS	na104	37	0.47	116	11.72	5168.8	979450.49	P333	24.90	-151.39	0.17	1.76	-151.06	-139.86
NTS	na105	37	0.47	116	11.62	5158.7	979451.28	P333	24.74	-151.21	0.17	1.74	-150.89	-139.71
NTS	na106	37	0.47	116	11.52	5136.8	979452.65	P333	24.05	-151.15	0.13	1.69	-150.89	-139.75
NTS	na107	37	0.47	116	11.40	5102.1	979454.81	P333	22.95	-151.07	0.14	1.67	-150.82	-139.76
NTS	na108	37	0.47	116	11.30	5063.9	979457.23	P333	21.78	-150.93	0.16	1.66	-150.69	-139.71
NTS	na109	37	0.47	116	11.20	5063.1	979457.18	P333	21.65	-151.03	0.18	1.65	-150.80	-139.82
NTS	na110	37	0.47	116	11.10	5007.7	979460.83	P333	20.10	-150.70	0.19	1.63	-150.48	-139.62
NTS	na111	37	0.47	116	11.00	4998.0	979461.31	P333	19.66	-150.80	0.21	1.62	-150.59	-139.75
NTS	na112	37	0.47	116	10.90	4938.5	979465.21	P333	17.97	-150.46	0.36	1.76	-150.10	-139.40
NTS	na113	37	0.47	116	10.78	4907.4	979467.24	P333	17.08	-150.30	0.27	1.65	-150.05	-139.41
NTS	na114	37	0.47	116	10.68	4905.0	979466.97	P333	16.58	-150.71	0.12	1.45	-150.66	-140.01
NTS	na115	37	0.47	116	10.58	4858.8	979469.78	P333	15.05	-150.67	0.17	1.50	-150.56	-140.01
NTS	na116	37	0.47	116	10.48	4829.2	979471.75	P333	14.24	-150.47	0.08	1.41	-150.45	-139.97
NTS	na117	37	0.47	116	10.38	4813.9	979472.32	P333	13.37	-150.82	0.06	1.36	-150.84	-140.39
NTS	na118	37	0.47	116	10.27	4784.3	979473.81	P333	12.08	-151.10	0.06	1.35	-151.13	-140.74
NTS	na119	37	0.47	116	10.16	4753.8	979475.43	P333	10.83	-151.31	0.09	1.38	-151.30	-140.98
NTS	na120	37	0.47	116	10.07	4758.2	979474.74	P333	10.55	-151.73	0.04	1.29	-151.82	-141.48
NTS	na121	37	0.47	116	9.97	4748.2	979474.92	P333	9.79	-152.15	0.04	1.27	-152.26	-141.94
NTS	na122	37	0.47	116	9.87	4722.1	979476.17	P333	8.59	-152.47	0.07	1.30	-152.54	-142.28
NTS	na123	37	0.47	116	9.75	4708.6	979476.64	P333	7.79	-152.80	0.05	1.26	-152.91	-142.68
NTS	na124	37	0.47	116	9.66	4712.7	979476.20	P333	7.74	-153.00	0.04	1.22	-153.15	-142.91
NTS	na125	37	0.47	116	9.57	4702.1	979476.77	P333	7.31	-153.06	0.03	1.20	-153.23	-143.01
NTS	na126	37	0.47	116	9.45	4683.2	979478.21	P333	6.97	-152.76	0.06	1.23	-152.90	-142.72
NTS	na127	37	0.51	116	10.52	4905.2	979467.40	P333	16.55	-150.75	0.10	1.51	-150.64	-139.99
NTS	na128	37	0.51	116	10.48	4898.5	979467.82	P333	16.34	-150.73	0.09	1.48	-150.64	-140.01
NTS	na129	37	0.51	116	10.38	4867.4	979469.57	P333	15.17	-150.84	0.09	1.47	-150.77	-140.20
NTS	na130	37	0.51	116	10.27	4847.8	979470.80	P333	14.56	-150.78	0.09	1.43	-150.74	-140.22
NTS	na131	37	0.51	116	10.16	4848.9	979470.21	P333	14.07	-151.31	0.05	1.35	-151.35	-140.82
NTS	na132	37	0.51	116	10.07	4839.6	979470.31	P333	13.30	-151.77	0.04	1.31	-151.84	-141.33
NTS	na133	37	0.51	116	9.95	4820.3	979471.20	P333	12.37	-152.03	0.06	1.31	-152.11	-141.63
NTS	na134	37	0.51	116	9.87	4805.0	979471.87	P333	11.60	-152.28	0.04	1.28	-152.38	-141.94
NTS	na135	37	0.51	116	9.75	4783.4	979473.36	P333	11.06	-152.08	0.11	1.34	-152.13	-141.73
NTS	na136	37	0.51	116	9.66	4828.8	979470.40	P333	12.37	-152.32	0.27	1.46	-152.25	-141.77
NTS	na139	37	0.52	116	9.79	4825.9	979471.07	P333	12.52	-152.07	0.00	1.25	-152.21	-141.72