E-TR-33-DM

MX SITING INVESTIGATION

GRAVITY SURVEY - DELAMAR VALLEY NEVADA

The Earth Technology Corporation

E-TR-33-DM

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GRAVITY SURVEY - DELAMAR VALLEY NEVADA

Prepared for:

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Ballistic Missile Office (BMO)
Norton Air Force Base, California 92409

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Gravity data from Delamar Valley and Pahroc Valley were studied together for the purpose of making a geological interpretation which includes estimates of the overall shape of the structural basin, the thickness of alluvial fill, and the location of concealed faults. The estimates will be useful in modeling the dynamic response of ground motion in the basin and in evaluating groundwater resources. Gravity data and interpretation covering the part of Pahroc Valley referred to as "Eastern Pahroc Valley" (that part east of South Pahroc Range) in our ~~Verification report (Ertec, 1981b) are included in this report.~~

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FOREWORD

Methodology and Characterization studies during Fiscal Years 1977 and 1978 (FY 77 and 78) included gravity surveys in ten valleys in Arizona (five), Nevada (two), New Mexico (two), and California (one). The gravity data were obtained for the purpose of estimating the gross structure and shape of the basins and the thickness of the valley fill. There was also the possibility of detecting shallow rock in areas between boring locations. Generalized interpretations from these surveys were included in Ertec Western's (formerly Fugro National) Characterization Reports (FN-TR-26a through e).

During the FY 77 surveys, measurements were made to form an approximate 1-mile grid over the study areas, and contour maps showing interpreted depth to bedrock were made. In FY 79, the decision was made to concentrate on verifying and refining suitable area boundaries. This decision resulted in a reduction in the gravity program. Instead of obtaining gravity data on a grid, the reduced program consisted of obtaining gravity measurements along profiles across the valleys where Verification studies were also performed.

The Defense Mapping Agency (DMA), St. Louis, Missouri, was requested to provide gravity data from their library to supplement the gravity profiles. For Big Smoky, Hot Creek, and Big Sand Springs valleys, a sufficient density of library data was available to permit construction of interpreted contour maps instead of just two-dimensional cross sections.

In late summer of FY 79, supplementary funds became available to begin data reduction. At that time, inner zone terrain corrections were begun on the library data and the profiles from Big Smoky Valley, Nevada, and Butler and La Posa valleys, Arizona. The profile data from Whirlwind, Hamlin, Snake East, White River, Garden, and Coal valleys, Nevada, became available from the field in early October 1979.

A continuation of gravity interpretations has been incorporated into the FY 80-81 program, and the results are being summarized in a series of valley reports. Reports covering Nevada-Utah gravity studies are numbered "E-TR-33-" followed by the abbreviation for the subject valley. In addition, more detailed reports of the results of FY 77 surveys in Dry Lake and Ralston valleys, Nevada, were prepared. Verification studies were continued in FY 80 and 81, and gravity studies were included in the program. DMA continued to obtain the field measurements, and there was a return to the grid pattern. The interpretation of the grid data allows the production of contour maps which are valuable in the deep basin structural analysis needed for computer modeling in the water resources program. The

gravity interpretations will also be useful in Nuclear Hardness and Survivability (NH&S) evaluations.

The basic decisions governing the gravity program are made by BMO following consultation with TRW, Inc., Ertec Western, and the DMA. Conduct of the gravity studies is a joint effort between DMA and Ertec Western. The field work, including planning, logistics, surveying, and meter operation is done by the Defense Mapping Agency Hydrographic/Topographic Center (DMAHTC), headquartered in Cheyenne, Wyoming. DMAHTC reduces the data to Simple Bouguer Anomaly (see Section A1.4, Appendix A1.0). The Defense Mapping Agency Aerospace Center (DMAAC), St. Louis, Missouri, calculates outer zone terrain corrections.

Ertec Western provides DMA with schedules showing the valleys with the highest priorities. Ertec Western also recommended locations for the profiles in the FY 79 studies with the provision that they should follow existing roads or trails. Any required inner zone terrain corrections are calculated by Ertec Western prior to making geologic interpretations.

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1.0 INTRODUCTION

1.1 OBJECTIVE

Gravity data from Delamar Valley and Pahroc Valley were studied together for the purpose of making a geological interpretation which includes estimates of the overall shape of the structural basin, the thickness of alluvial fill, and the location of concealed faults. The estimates will be useful in modeling the dynamic response of ground motion in the basin and in evaluating ground-water resources. Gravity data and interpretation covering the part of Pahroc Valley referred to as "Eastern Pahroc Valley" (that part east of South Pahroc Range) in our Verification report (Ertec, 1981b) are included in this report.

1.2 LOCATION

Delamar Valley is located in the southeastern part of Nevada (Figure 1) in Lincoln County. The town of Caliente, Nevada, is approximately 15 miles (24 km) east on U.S. Highway 93. Access throughout the valley is good due to an extensive network of well-maintained, unpaved roads. The valley is primarily undeveloped desert rangeland.

Delamar Valley is bounded on the east and southeast by the Delamar Mountains and on the west by the South Pahroc Range (Figure 2). U.S. Highway 93 forms the northern boundary and also separates Delamar Valley from Dry Lake Valley.

The area covered by this report lies between North latitudes 37°10' and 37°45' and West longitudes 114°40' and 115°05'. The

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LOCATION MAP
DELAMAR VALLEY, NEVADA

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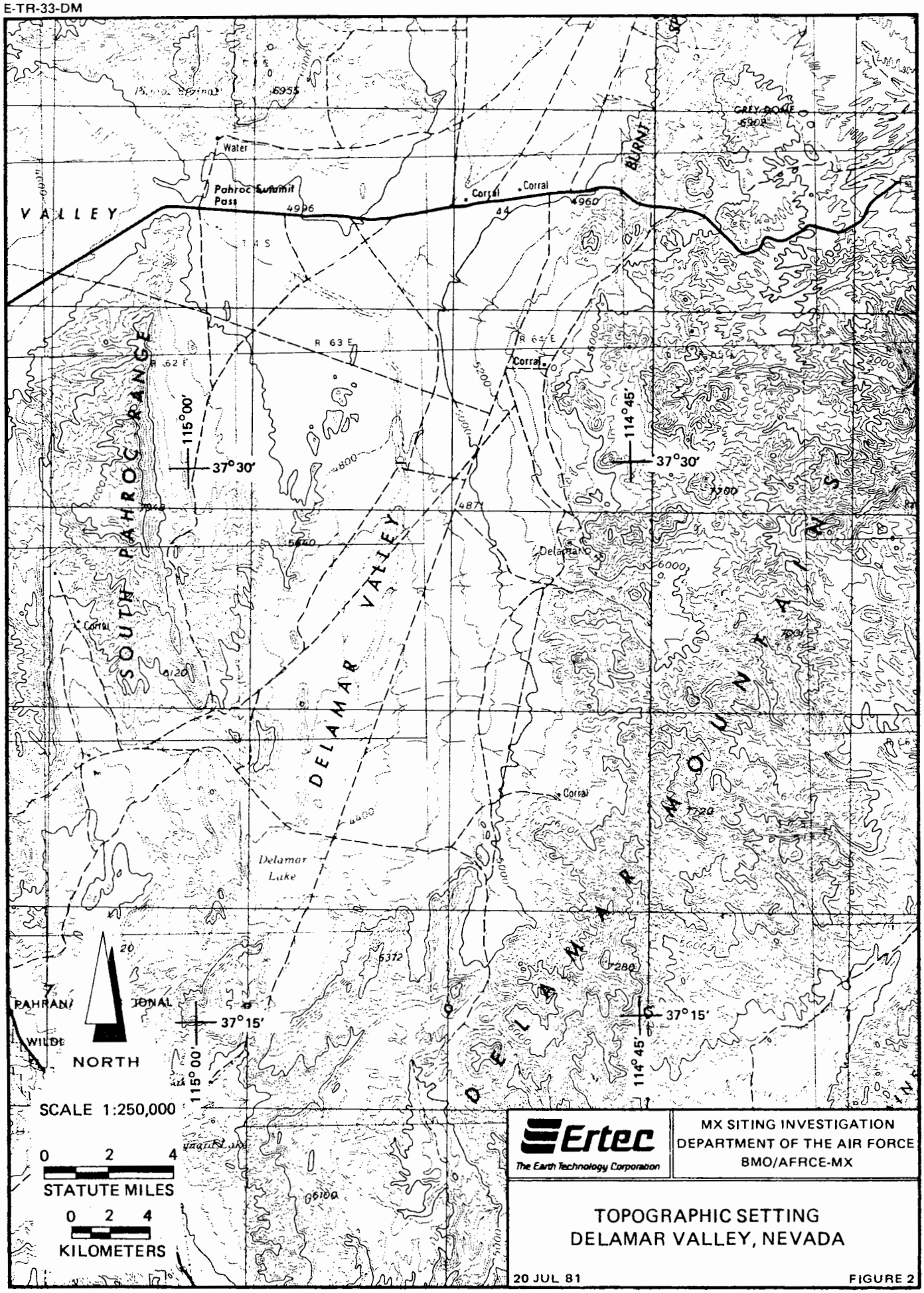
FIGURE 1

E-TR-33-DM



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TOPOGRAPHIC SETTING
DELAMAR VALLEY, NEVADA

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FIGURE 2

valley is approximately 22 miles (35 km) long and the width varies from 8 to 12 miles (13 to 19 km).

1.3 SCOPE OF WORK

Five primary work elements were completed during this study. They are:

1. Computation and merging of terrain corrections;
2. Synthesis of regional and valley-specific geological data;
3. Evaluation of the regional field and residual separation;
4. Inverse modeling to estimate depth to bed rock; and
5. Interpretation of structural relationships.

The gravitational field within Delamar Valley was defined by measurements from 418 stations. The principal facts for these stations are listed in Appendix A2.0, and their distribution is shown in Drawing 1.0. The Defense Mapping Agency Aerospace Center (DMAAC) supplied 246 gravity stations from its library, and 172 new gravity measurements were made by the Defense Mapping Agency Hydrographic Topographic Center/Geodetic Survey Squardon (DMAHTC/GSS).

Delamar Valley and Pahroc Valley were studied together, with the results presented in separate reports. The rectangular region containing both valleys is the area between North latitudes 37° 10' and 37° 45' and West longitudes 114° 40' and 115° 15'. There are 516 gravity stations in the region. All were used to establish a common regional gravity trend for the two valleys.

Following residual separation, the geologic modeling of the two valleys was done independently. This report includes Delamar

Valley and Eastern Pahroc Valley (east of the South Pahroc Range).

2.0 GRAVITY DATA REDUCTION

DMAHTC/GSS obtained the basic observations for the new stations and reduced them to Simple Bouguer Anomalies (SBA) as described in Appendix A1.0. Up to three levels of terrain corrections were applied to the new stations to convert the SBA to the Complete Bouguer Anomaly (CBA). Only the first two levels of terrain corrections described below were applied to the library stations.

First, the DMAAC, St. Louis, Missouri, used its library of digitized terrain data and a computer program to calculate corrections out to 104 miles (167 km) from each station. When the program could not calculate the terrain effects near a station, a ring template was used to estimate the effect of terrain within approximately 3000 feet (914 m) of the station. The third level of terrain corrections was applied to those stations where relief of 10 feet (3 m) or more was observed within 130 feet (40 m). In these cases, the elevation differences were measured in the field at a distance of 130 feet (40 m) along six directions from the stations. These data were used to calculate the effect of the very near relief.

The principal facts and CBA values for the Delamar Valley stations are listed in Appendix A2.0.

3.0 GEOLOGIC SUMMARY

Delamar Valley is located within the Great Basin section of the Basin and Range physiographic province.

The Delamar Mountains, east of the valley, are composed primarily of middle Tertiary lavas (andesite and dacite) overlain by late Tertiary tuffs (Tschanz and Pampeyan, 1970; and Ekren and others, 1977). Some carbonates and siliceous clastic rocks (shales and quartzites) crop out in the central portion of the range near the Delamar mining district. On the west, the South Pahroc Range and the southern end of the North Pahroc Range are composed mainly of late Tertiary volcanic rocks.

Delamar Valley has a typical Basin and Range fault-block structure which is the result of late Tertiary and Quaternary block faulting due to tensional stresses directed in an east-west or northwest-southeast direction. The Pahroc fault is a zone of normal displacement near the foot of the South Pahroc Range. The scarp formed by the Pahroc fault separates the main part of the South Pahroc Range from alluvial flats and low volcanic hills to the east. Numerous small faults and joints trend both northerly and easterly in these low volcanic hills. This is thought to be an area of small fault blocks of varying and differential separation which step down to the east (Ertec, 1981a).

On the east side of Delamar Valley, a range bounding fault is interpreted in alluvial fans at the base of the Delamar Mountains.

This interpretation is based on a surface scarp in the alluvium (Ertec, 1981a). The northeast trending Buckhorn and Maynard Lake Faults bound the south end of Delamar Valley. They are major faults in the Pahranagat Shear Zone which is postulated to have from 10 to 12 miles (16 to 19 km) of pre-Quaternary left-lateral separation (Tschanz and Pampeyan, 1970).

The valley fill is divided into older and younger deposits. The older deposits consist of non-indurated to partly indurated alluvial-fan deposits containing primarily silt, sand, and gravel derived from adjacent highland areas. These deposits possibly include some rocks of volcanic origin. The younger valley fill includes clay, silt, sand, and gravel and is largely restricted to modern intermittent stream channels and playa areas. Depth to ground water ranges from 300 feet (91 m) in the northern part of the valley to more than 1000 feet (305 m) beneath the playa area in the southwestern part of the valley (Eakin, 1963).

4.0 INTERPRETATION

The basis of interpretation is the Complete Bouguer Anomaly (CBA). Contours of the CBA gravity field and the the gravity station locations are shown in Drawing 1.

Mathematical treatment of irregularly spaced data is inefficient. In order to simplify the computer processing, the station CBA and elevation data are reduced to sets of values at uniformly spaced points (nodes) in a geographic array, or grid. The values at each node are calculated from the station data within a circular area around the node. A bell-shaped weighting function assigns greater weight to the nearer data points. The node spacing is chosen to match the average data spacing. A 1.2-mile (2-km) grid spacing was used for this analysis.

4.1 REGIONAL-RESIDUAL SEPARATION

A fundamental part of the gravity interpretation is the separation of regional effects from the local effects of the valley and its fill. The CBA contains long wavelength components from deep and broad geologic structures extending far beyond the valley. These long wavelength components, called the regional gravity, were approximated by upward continuation of the gravity field. Upward continuations were made to successively higher elevations until the negative anomaly over the valley was essentially smoothed out. The final continuation was calculated for an elevation of 170,000 feet (51,816 m). This regional field was subtracted from the CBA and the resulting residual gravity anomaly was adjusted by a constant -2.0 milligals so

that the zero residual would approximately fit the existing rock outcrops.

4.2 DENSITY SELECTION

The construction of a geologic model from the residual anomaly requires selection of density values representative of the alluvial fill and of the underlying rock. Because only very generalized density information is available, the geologic interpretation of the gravity data can be only a coarse approximation. Five borings were drilled approximately 100 feet (30 m) into the alluvium during Verification studies (Ertec, 1981a). The average of the densities measured at the bottom of these borings was 2.0 g/cm^3. To account for compaction with depth (Woollard, 1962; and Grant and West, 1965), a density of 2.3 g/cm^3 was used in the modeling process.

The basement rocks underlying the alluvium of Delamar Valley are assumed to be similar to the rocks comprising the adjacent mountain ranges. These ranges are comprised of late Tertiary volcanic rocks unconformably overlying Paleozoic carbonate rocks. Published values for Paleozoic carbonate and clastic rocks typically range between 2.6 to 2.9 g/cm^3. The carbonate rocks in Nevada and Utah are commonly reported to be relatively high in density, on the order of 2.8 g/cm^3. This value was selected to represent the density of the basement rock. The density of siliceous to intermediate volcanic rocks generally ranges between 2.0 to 2.5 g/cm^3 depending on the degree of welding, compaction, and alteration. The older volcanics in the

Delamar Valley area are probably at the higher end of this density range, being approximately equivalent to dense alluvium or between the density of alluvium and the density of bed rock. The information available regarding the volume and characteristics of subsurface volcanic rocks in Delamar Valley is insufficient to make an estimate of their effect on the geologic model. The density contrast used for modeling was -0.50 g/cm^3.

4.3 MODELING

Modeling was done with the aid of a computer program which iteratively calculates a three-dimensional solution of gravity anomaly data (Cordell, 1970). The gravity anomaly is represented by discrete values on a two-dimensional grid. The source of the anomaly (the volume of low-density valley fill) is represented by a set of vertical prism elements. The tops of the prisms lie in a common horizontal plane. The bottoms of the prisms collectively represent the bottom of the valley fill. Each prism has a cross-sectional area equal to one grid square and a uniform density. A grid square of 1.2 miles by 1.2 miles (2 km by 2 km) was selected as representative of the gravity station distribution. Computations were made for three iterations of mutually interactive prism adjustments. The root-mean-square error between the observed residual gravity field and the field calculated for the final model of the entire valley was less than 0.3 milligal.

The calculated thickness of the valley fill depends upon the residual anomaly and the density contrast (i.e., fill density

minus rock density) used. Since neither fill nor rock density is perfectly known, nor even uniform, the calculated thickness should be expected to contain a corresponding degree of uncertainty. A source of error in modeling Delamar Valley as a simple alluvium-basement rock system is the widespread volcanic material throughout the valley.

One seismic refraction line (DM-S-13) and one boring (WR-T1) were used as constraints in the modeling process. Their locations are marked in Drawing 2. The refraction line is located near the mountain flank. It found a 10,000 feet per second (3048 mps) velocity at a depth of 55 feet (17 m) which may represent the basement material. The alluvial fill material in the center of the valley is at least 1195 feet (364 m) thick according to the boring. The calculated thickness of fill, or interpreted depth to rock, is contoured in Drawing 2.

4.4 DISCUSSION OF RESULTS

The interpreted geologic structure of Delamar Valley is shown on the depth-to-rock contour map (Drawing 2). The interpretation is based on geologic information from published reports, analysis of aerial photographs, and geologic field reconnaissance as well as gravity data. The analysis of the gravity data included calculation of the second vertical derivative (SVD) of the CBA field. One property of the SVD is that its zero value marks the steepest gradients of the input CBA field. This property was used to guide the placement of faults in the structural interpretation. The interpreted faults represent only the major

fault systems which probably comprise many smaller fault zones. There may be other discrete faults that had a minor role in basin formation but with displacements so small that they were not resolved by the widely spaced gravity data available for this study.

The depth-to-rock contours define an elongate north-south trending basin coincident with the valley physiography. These contours (Drawing 1) define two north-trending subsurface basins. The northern basin is about 2500 feet (762m) deep and the southern basin is about 5000 feet (1524 m) deep.

The subsurface structural configuration of the northern part of Delamar Valley is complex compared to the relatively simple, deeply faulted grabens in the southern part of the valley and in Dry Lake Valley to the north. Structurally, it is a horst between these two grabens. A major fault system is indicated along the base of the Delamar Mountains by the gravity data but the Pahroc fault on the west side of the valley which is so prominent on the surface, is not clearly indicated. The positions of the Pahroc fault on Drawing 2 are based primarily on surface geologic and geomorphic data. The irregular gravity contours between the Pahroc fault and the Delamar Mountains suggest a relatively shallow basement (bed rock) complex of small fault blocks separated by numerous small-displacement, normal faults. These faults are not reflected in the gravity data because their small displacements do not create large density contrasts. This interpretation is consistent with surface

geology which shows numerous normal-faulted bedrock outcrops scattered throughout this part of the valley.

The southern basin contains a graben with a depth of 5000 feet (1524 m). The western side of the graben has a steeper linear gradient separating it from South Pahroc Range than is indicated on the east side along the Delamar Mountains. The eastern margin of the graben appears to be characterized by two major fault systems; one very near the base of the Delamar Range which is probably related to the basin-bounding fault farther to the north, and a shorter basin-ward fault. These north-south bounding faults appear to be terminated against the northeast trending Buckhorn Fault which is part of the Pahranagat Shear Zone.

5.0 CONCLUSIONS

Delamar Valley gravity data indicates the northern half of the valley is a horst buried by about 1500 feet (457 m) of alluvium. A graben about 5000 feet (1524 m) deep forms the southern half of the valley.

The calculated depths to carbonate bed rock are only approximate because little is known about the actual density distribution which has been represented by a simple two-density model. Also, the residual gravity anomaly is necessarily based on an interpreted regional field. An average density contrast of -0.50 g/cm^3 between the alluvium and bed rock was used to calculate the thickness of the valley-fill material. Future studies that acquire better density data or measure actual depths to bed rock in deep parts of the valley can be used to refine the gravity interpretation.

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APPENDIX A1.0

GENERAL PRINCIPLES OF THE GRAVITY EXPLORATION METHOD

A1.0 GENERAL PRINCIPLES OF THE GRAVITY EXPLORATION METHOD

A1.1 GENERAL

A gravity survey involves measurement of differences in the gravitational field between various points on the earth's surface. The gravitational field values being measured are the same as those influencing all objects on the surface of the earth. They are generally associated with the force which causes a 1-gm mass to be accelerated at 980 cm/sec^2. This force is normally referred to as a 1-g force.

Even though in many applications the gravitational field at the earth's surface is assumed to be constant, small but distinguishable differences in gravity occur from point to point. In a gravity survey, the variations are measured in terms of milligals. A milligal is equal to 0.001 cm/sec^2 or 0.00000102 g. The differences in gravity are caused by geometrical effects, such as differences in elevation and latitude, and by lateral variations in density within the earth. The lateral density variations are a result of changes in geologic conditions. For measurements at the surface of the earth, the largest factor influencing the pull of gravity is the density of all materials between the center of the earth and the point of measurement.

To detect changes produced by differing geological conditions, it is necessary to detect differences in the gravitational field as small as a few milligals. To recognize changes due to

geological conditions, the measurements are "corrected" to account for changes due to differences in elevation and latitude.

Given this background, the basic concept of the gravitational exploration method, the anomaly, can be introduced. If, instead of being an oblate spheroid characterized by complex density variations, the earth were made up of concentric, homogeneous shells, the gravitational field would be the same at all points on the surface of the earth. The complexities in the earth's shape and material distribution are the reason that the pull of gravity is not the same from place to place. A difference in gravity between two points which is not caused by the effects of known geometrical differences, such as in elevation, latitude, and surrounding terrain, is referred to as an "anomaly."

An anomaly reflects lateral differences in material densities. The gravitational attraction is smaller at a place underlain by relatively low density material than it is at a place underlain by a relatively high density material. The term "negative gravity anomaly" describes a situation in which the pull of gravity within a prescribed area is small compared to the area surrounding it. Low-density alluvial deposits in basins such as those in the Nevada-Utah region produce negative gravity anomalies in relation to the gravity values in the surrounding mountains which are formed by more dense rocks.

The objective of gravity exploration is to deduce the variations in geologic conditions that produce the gravity anomalies identified during a gravity survey.

A1.2 INSTRUMENTS

The sensing element of a LaCoste and Romberg gravimeter is a mass suspended by a zero-length spring. Deflections of the mass from a null position are proportional to changes in gravitational attraction. These instruments are sealed and compensated for atmospheric pressure changes. They are maintained at a constant temperature by an internal heater element and thermostat. The absolute value of gravity is not measured directly by a gravimeter. It measures relative values of gravity between one point and the next. Gravitational differences as small as 0.01 milligal can be measured.

A1.3 FIELD PROCEDURES

The gravimeter readings were calibrated in terms of absolute gravity by taking readings twice daily at nearby USGS gravity base stations. Gravimeter readings fluctuate because of small time-related deviations due to the effect of earth tides and instrument drift. Field readings were corrected to account for these deviations. The magnitude of the tidal correction was calculated using an equation suggested by Goguel (1954):

$$C = P + N\cos\phi\,(\cos\phi + \sin\phi) + S\cos\phi\,(\cos\phi - \sin\phi)$$

where C is the tidal correction factor, P, N, and S are time-related variables, and ϕ is the latitude of the observation point. Tables giving the values of P, N, and S are published annually by the European Association of Exploration Geophysicists.

The meter drift correction was based on readings taken at a designated base station at the start and end of each day. Any difference between these two readings after they were corrected for tidal effects was considered to have been the result of instrumental drift. It was assumed that this drift occurred at a uniform rate between the two readings. Corrections for drift were typically only a few hundredths of a milligal. Readings corrected for tidal effects and instrumental drift represented the observed gravity at each station. The observed gravity values represent the total gravitational pull of the entire earth at the measurement stations.

A1.4 DATA REDUCTION

Several corrections or reductions are made to the observed gravity to isolate the portion of the gravitational pull which is due to the crustal and near-surface materials. The gravity remaining after these reductions is called the "Bouguer Anomaly." Bouguer Anomaly values are the basis for geologic interpretation. To obtain the Bouguer Anomaly, the observed gravity is adjusted to the value it would have had if it had been measured at the geoid, a theoretically defined surface which approximates the surface of mean sea level. The difference between the "adjusted" observed gravity and the gravity at the geoid calculated for a theoretically homogeneous earth is the Bouguer Anomaly.

Four separate reductions, to account for four geometrical effects, are made to the observed gravity at each station to arrive at its Bouguer Anomaly value.

a. Free-Air Effect: Gravitational attraction varies inversely as the square of the distance from the center of the earth. Thus, corrections must be applied for elevation. Observed gravity levels are corrected for elevation using the normal vertical gradient of:

FA = -0.09406 mg/ft (-0.3086 milligals/meter)

where FA is the free-air effect (the rate of change of gravity with distance from the center of the earth). The free-air correction is positive in sign since the correction is opposite the effect.

b. Bouguer Effect: Like the free-air effect, the Bouguer effect is a function of the elevation of the station, but it considers the influence of a slab of earth materials between the observation point on the surface of the earth and the corresponding point on the geoid (sea level). Normal practice, which is to assume that the density of the slab is 2.67 grams per cubic centimeter was followed in these studies. The Bouguer correction (B_c), which is opposite in sign to the free-air correction, was defined according to the following formula.

$B_c = 0.01276\ (2.67)\ h_f$ (milligals per foot)

$B_c = 0.04185\ (2.67)\ h_m$ (milligals per meter)

where h_f is the height above sea level in feet and h_m is the height in meters.

c. Latitude Effect: Points at different latitudes will have different "gravities" for two reasons. The earth (and the geoid) is spheroidal, or flattened at the poles. Since points at higher latitudes are closer to the center of the earth than points near the equator, the gravity at the higher latitudes is larger. As the earth spins, the centrifugal acceleration causes a slight decrease in the measured gravity. At the higher latitudes where the earth's circles of latitude are smaller, the centrifugal acceleration diminishes. The gravity formula for the Geodetic Reference System, 1967, gives the theoretical value of gravity at the geoid as a function of latitude. It is:

$$g = 978.0381\ (1 + 0.0053204 \sin^2 \phi - 0.0000058 \sin^2 2\phi)\ \text{gals}$$

where g is the theoretical acceleration of gravity and ϕ is the latitude in degrees. The positive term accounts for the spheroidal shape of the earth. The negative term adjusts for the centrifugal acceleration.

The previous two corrections (free air and Bouguer) have adjusted the observed gravity to the value it would have had at the geoid (sea level). The theoretical value at the geoid for the latitude of the station is then subtracted from the adjusted observed gravity. The remainder is called the Simple Bouguer Anomaly (SBA). Most of this gravity represents the effect of material beneath the station, but part of it may be due to irregularities in terrain (upper part of the Bouguer slab) away from the station.

d. Terrain Effect: Topographic relief around the station has a negative effect on the gravitational force at the station. A nearby hill has upward gravitational pull and a nearby valley contributes less downward attraction than a nearby material would have. Therefore, the corrections are always positive. Corrections are made to the SBA when the terrain effects were 0.1 milligal or larger. Terrain corrected Bouguer values are called the Complete Bouguer Anomaly (CBA). When the CBA is obtained, the reduction of gravity at individual measurement points (stations) is complete.

A1.5 INTERPRETATION

To interpret the gravity data, the portion of the CBA that might be caused by the light-weight, basin-fill material must be separated from that caused by the heavier bedrock material which forms the surrounding mountains and presumably the basin floor. The first step is to create a regional field. A regional field is an estimation of the values the CBA would have had if the light-weight sediments (the anomaly) had not been there. Since the valley-fill sediments are absent at the stations read in the mountains, one approach is to use the CBA values at bedrock stations as the basis for constructing a second order polynomial surface to represent a regional field over the valley.

Where there are insufficient bedrock stations to define a satisfactory regional trend, another approach is to estimate the regional by the process of upward continuation of the CBA field.

In Potential Theory, a field normal to a surface, regardless of its actual source, may be considered as originating in an areal distribution of mass on that surface. If the field strength is known the surface density of mass (grams per square centimeter) can be calculated. The observed gravity field at the surface of the earth approximately fulfills the requirements of this theory: thus the observed (Bouguer anomaly) field can be used to compute a surficial distribution of mass which would reproduce the field, and most importantly, account for the gravity field anywhere above the surface of observation. On this basis, the Bouguer anomaly field is readily "continued" to level surfaces above the ground.

An important property of such "upward continuation" is that the resultant field (which can be represented by a contour map), with increasing altitudes of continuation, changes more with respect to shallow sources than it does with respect to deeper sources. The anomalous parts of the field ascribed to shallow density distribution tend to vanish as the continuation is carried upward whereas the field produced by deeper sources changes only slightly, so that upward continuations produce "regional"-type fields.

The difference between the CBA and the regional field is called the "residual" field or residual anomaly. The residual field is the interpreter's estimation of the gravitational effect of the geologic anomaly. The zero value of the residual anomaly is not exactly at the rock outcrop line but at some distance on the

"rock" side of the contact. The reason for this is found in the explanation of the terrain effect. There is a component of gravitational attraction from material which is not directly beneath a point.

If the "regional" is well chosen, the magnitude of the residual anomaly is a function of the thickness of the anomalous (fill) material and the density contrast. The density contrast is the difference in density between the alluvial and bedrock material. If this contrast were known, an accurate calculation of the thickness could be made. In most cases, the densities are not well known and they also vary within the study area. In these cases, it is necessary to use typical densities for materials similar to those in the study area.

If the selected average density contrast is smaller than the actual density contrast, the computed depth to bedrock will be greater than the actual depth and vice-versa. The computed depth is inversely proportional to the density contrast. A ten percent error in density contrast produces a ten percent error in computed depth. An iterative computer program is used to calculate a subsurface model which will yield a gravitational field to match (approximately) the residual gravity anomaly.

The second vertical derivative (SVD) of gravitational field is used to aid the interpreter in evaluating the subsurface mass distribution. Once the CBA field has been projected onto a uniform grid system, its SVD at the grid nodes is readily computed.

In accordance with Laplace's Equation in Free Space, the negative of the second vertical derivative is equal to the sums of the second derivatives in the x-direction and in the y-direction. The second vertical derivative is an indication of the curvature of the Bouguer anomaly field. In particular the zero-value of the SVD indicates the inflection in the field as it changes from "concave-upward" (algebraically negative SVD) to "convex-upward" (algebraically positive SVD). In a general way the zero SVD falls on the tightest contours of the field and where contours are nearly parallel its location can be established by eye. However, where contours diverge, converge, or change direction this is not always so readily done. The zero SVD contour line may be an indicator of a line of faulting, the pinchout of a stratum, truncation of a stratum at an unconformity or merely a marked change in shape or in density of a geologic unit.

APPENDIX A2.0

DELAMAR VALLEY, NEVADA

GRAVITY DATA

DELAMAR VALLEY GRAVITY DATA

STATION IDENT.	LAT. DEG	MIN	LONG. DEG	MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM	OBSV GRAV	THEO GRAV	FAA	CBA +1000
6746	37	1071	114	4143	34039T	0	160411697	705031559	68192030		-4040	84510
6741	37	1113	114	4613	38901T	0	283411758	698061539	09192091		-1580	85433
6747	37	1163	114	4400	35312T	0	217411867	701181553	73192171		-3570	84597
6830	37	1205	114	5722	60499T	01	815411891	681611384	04192225		3070	84275
6745	37	1214	114	4016	35279T	0	189411966	706841550	29192238		-4020	84139
6837	37	1292	114	5063	56030T	0	327412073	691321430	47192351		3390	84627
6831	37	1325	114	5385	56680T	0	369412124	686551426	94192399		3600	84659
6836	37	1360	114	4704	50869T	0	369412211	696601459	86192450		1370	84409
6939	37	1419	114	4135	39091T	0	209412341	704991522	33192535		-3520	83349
6835	37	1585	114	5185	59701T	0	535412611	689401401	56192776		3530	83715
6832	37	1591	114	5775	50089T	0	338412603	680671453	60192785		-300	82948
6845	37	1708	114	4333	56831T	0	563412868	701931406	14192955		1110	82303
6910	37	1763	114	4915	50689T	0	223412949	693311449	33193035		-410	82523
6909	37	1768	114	5644	45679T	0	138412935	682541484	13193042		-1650	82908
6908	37	1907	114	5743	45522T	0	134413188	681021484	28193244		-1990	82624
6913	37	1963	114	5133	47841T	0	153413312	690011468	53193325		-1460	82373
6638	37	1998	114	5530	45522T	0	139413364	684131477	62193376		-2780	81829
6911	37	2067	114	4723	55928T	0	291413518	696021425	83193476		1710	82941
6912	37	2086	114	4996	49800T	0	209413544	691981459	51193504		-700	82529
6907	37	2109	114	5775	46560T	0	113413561	680471477	90193537		-1850	82353
6846	37	2115	114	4191	72779T	01	109413626	703851308	31193546		5730	82039
6628	37	2247	114	5410	45561T	0	134413828	685801467	96193738		-4070	80524
6645	37	2272	114	5025	48428T	0	148413887	691471460	10193774		-2200	81428
6849	37	2396	114	4495	65499T	0	640414135	699241373	48193955		5000	83320
6624	37	2400	114	5769	48179T	0	143414099	680441468	64193960		-1770	81943
6623	37	2478	114	5956	53369T	0	236414238	677651443	73194074		490	82546
6639	37	2485	114	5294	46050T	0	137414272	687411463	78194084		-4380	80057
6833	37	2494	114	4590	60449T	0	318414313	697791403	70194097		3130	82848
6644	37	2498	114	4975	48442T	0	156414307	692111463	49194103		-2180	81456
6625	37	2521	114	5605	46690T	0	121414328	682811478	35194136		-2370	81821
6627	37	2658	114	5297	46529T	0	135414592	687291466	26194336		-3930	80335
6640	37	2681	114	5201	47110T	0	124414637	688701465	32194369		-3520	80534
6850	37	2690	114	4404	61250T	0	267414682	700451402	61194382		3490	82887
6643	37	2696	114	4873	51621T	0	177414676	693531448	49194391		-980	81587
6626	37	2732	114	5538	46621T	0	128414721	683711477	54194443		-2820	81408
6641	37	2884	114	5103	48701T	0	126415016	690061460	52194665		-2790	80726
6642	37	2925	114	4728	56381T	0	226415105	695571427	84194724		1090	82106
2327	37	2956	114	5720	52100T	0	151415129	680941450	84194769		-660	81721
2326	37	2996	114	4290	69390T	0	429415252	701991342	99194827		4740	81519
1902	37	3262	114	4006	62740T	0	303415754	706051385	33195215		2330	81253

DELAMAR VALLEY GRAVITY DATA

STATION IDENT.	LAT. DEG	MIN	LONG. DEG	MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM	OBSV GRAV	THEO GRAV	FAA	CBA +1000
7100	373555		114410562369T			0	218416292	7044614009319564		3100		82068
1358	373570		114412062310T			0	218416319	7042414020319566		3140		82128
7142	373650		114426058957T			0	194416462	7021414282919578		2490		82594
1002	373661		114537149419T			0	99416444	6857914712619579		6	-2180	81069
1001	373670		114549449921T			0	94416457	6839714709919580		9	-1750	81324
1003	373672		114525948809T			0	99416468	6874314741419581		2	-2480	80969
0990	373674		114522548629T			0	100416473	6879314741819581		5	-2650	80870
1360	373680		114521848625T			0	102416484	6880314750119582		4	-2570	80942
7125	373685		114509548133T			0	106416498	6898414764519583		1	-2900	80786
0999	373687		114564049961T			0	95416484	6818214702719583		4	-1810	81245
0991	373692		114508948091T			0	114416511	6899214763719584		1	-2960	80744
0992	373699		114501948461T			0	105416526	6909514755519585		1	-2710	80865
0993	373706		114491849072T			0	107416543	6924314726419586		1	-2430	80937
1361	373713		114587349656T			0	101416524	6783814740619587		2	-1750	81421
0997	373714		114595549711T			0	99416523	6771714795019587		3	-1160	81989
0423	373717		114414758852T			0	194416590	7037714336119587		7	2840	82964
0994	373722		114481449459T			0	116416576	6939614739519588		5	-1960	81286
0424	373724		114404960259T			0	179416607	7052114238319588		8	3170	82809
0995	373726		114469649951T			0	138416587	6956914804419589		1	-860	82248
1004	373729		114527349199T			0	97416573	6872014741419589		5	-2200	81117
7124	373730		114469050089T			0	137416595	6957814806819589		6	-710	82347
0998	373732		114582250899T			0	108416561	6791214719619589		9	-820	81928
0996	373736		114460051191T			0	159416609	6971014777519590		5	20	82729
1359	373747		114456751194T			0	172416631	6975814737219592		1	100	82832
0989	373776		114508648100T			0	100416666	6899314801819596		3	-2690	81000
0299	373793		114431458451T			0	262416725	7012814345319598		8	2440	82772
0301	373802		114407862290T			0	251416750	7047514144319600		1	4030	83041
0300	373808		114418661470T			0	355416757	7031614188219601		0	3690	83085
0298	373818		114443756929T			0	260416767	6994614452119602		5	2040	82890
0936	373819		114455650381T			0	147416764	6977114821319602		6	-420	82547
0938	373819		114472248501T			0	117416758	6952714855819602		6	-1840	81737
0892	373819		114483348041T			0	107416755	6936414846019602		6	-2370	81347
0987	373820		114499647549T			0	103416751	6912414871319602		8	-2580	81303
0988	373820		114515848819T			0	101416745	6888514820119602		8	-1900	81551
0937	373825		114464349272T			0	124416772	6964314824719603		5	-1440	81884
0863	373857		114548952110T			0	120416803	6839714779619608		1	720	83080
0986	373862		114507348041T			0	101416826	6900914857719608		9	-2320	81401
0316	373884		114407765981T			0	570416902	7047213877919612		1	4720	82790
0859	373891		114543952680T			0	121416867	6846914784819613		1	1260	83431
0939	373895		114460948629T			0	122416903	6969014871819613		7	-1670	81862

DELAMAR VALLEY GRAVITY DATA

SSTATION IDENT.	LAT. DEG	MIN	LONG. DEG	MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM	OBSV GRAV	THEO GRAV	FAA	CBA +1000
0985	37	3896	114	5217	4990	2T	0	110416884	6879	6148	142196138	-1050	82040
0870	37	3896	114	5886	5162	1T	0	208416862	6781	2147	564196138	-10	82588
0940	37	3907	114	5024	9800	T	0	162416929	6984	6149	068196154	-240	82942
0941	37	3907	114	7244	7539	T	0	109416921	6952	0148	879196154	-2550	81339
0893	37	3907	114	8344	7201	T	0	103416917	6935	8148	730196154	-3020	80983
0984	37	3907	114	5162	4960	0T	0	114416906	6887	6148	018196154	-1480	81724
0982	37	3912	114	4949	4711	9T	0	102416923	6918	9149	207196162	-2630	81402
0317	37	3917	114	4015	6903	9T	0	1030416965	7056	2136	510196169	5270	82770
0311	37	3921	114	4359	5180	1T	0	159416960	7005	6148	346196175	890	83389
0860	37	3936	114	5665	5638	1T	166	279416943	6813	5144	336196197	1170	82395
0942	37	3939	114	4588	4827	1T	0	119416985	6971	9149	080196201	-1710	81949
0983	37	3949	114	5060	4753	9T	0	130416987	6902	4149	087196216	-2410	81510
0312	37	3959	114	4408	5069	9T	0	154417028	6998	2148	877196230	330	83204
0857	37	3960	114	5542	5599	1T	0	195416992	6831	5145	318196232	1750	82855
0856	37	3971	114	5418	5310	0T	0	143417016	6849	7146	797196248	490	82533
0313	37	3982	114	4312	5202	1T	0	159417074	7012	2148	156196264	820	83249
0943	37	3994	114	5024	8921	T	0	126417090	6984	3149	348196281	-910	82526
0944	37	3994	114	4614	4752	0T	0	112417086	6967	8149	135196281	-2440	81462
0945	37	3995	114	4724	4679	1T	0	105417084	6951	6148	977196283	-3290	80855
0894	37	3996	114	4835	4668	0T	0	101417082	6935	3148	865196284	-3510	80671
0976	37	4001	114	4943	4680	1T	0	100417087	6919	4149	072196291	-3190	80950
0980	37	4017	114	5140	4923	9T	0	125417110	6890	4148	327196315	-1670	81665
0977	37	4037	114	5045	4763	1T	0	104417150	6904	2149	077196344	-2460	81404
0874	37	4043	114	5577	6018	0T	0	332417144	6826	0142	423196353	2670	82492
0326	37	4059	114	4246	5277	9T	0	171417219	7021	6147	788196376	1050	83231
7139	37	4060	114	4250	5287	4T	0	168417221	7021	0147	815196377	1160	83318
0946	37	4081	114	4518	4772	0T	0	114417250	6981	5149	782196408	-1730	82104
0947	37	4082	114	4625	4668	0T	0	105417248	6965	8149	290196409	-3210	80975
0948	37	4083	114	4723	4633	9T	0	99417247	6951	4149	040196411	-3780	80519
0895	37	4083	114	4834	4639	1T	0	95417243	6935	1148	963196411	-3810	80465
0975	37	4087	114	4936	4671	9T	0	100417247	6920	1148	999196417	-3470	80700
0850	37	4090	114	5431	5039	T	0	166417236	6847	3145	998196421	1340	82746
0334	37	4114	114	4253	5221	1T	0	150417321	7020	3148	170196456	820	83170
0974	37	4118	114	5041	4772	0T	0	97417300	6904	5149	114196462	-2460	81367
0344	37	4154	114	4161	5388	1T	0	168417398	7033	7147	153196514	1320	83118
0911	37	4167	114	4517	4734	9T	0	110417409	6981	3149	823196533	-2170	81790
0912	37	4169	114	4548	4680	1T	0	108417412	6976	7149	939196536	-2570	81578
0917	37	4169	114	4696	4607	0T	0	97417407	6955	0149	121196536	-4080	80307
0913	37	4170	114	4576	4646	0T	0	106417413	6972	6149	908196538	-2920	81336
0914	37	4170	114	4602	4629	9T	0	103417412	6968	8149	699196538	-3280	81023

DELAMAR VALLEY GRAVITY DATA

STATION IDENT.	LAT. DEG	MIN	LONG. DEG	MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM	OBSV GRAV	THEO GRAV	FAA	CBA +1000
0915	37	41.70	114	46	3146.2T	0	101417411	69645149	4801965	38	-3640	80721
0916	37	41.70	114	46	6546.0 9T	0	99417410	69595149	2231965	38	-3950	80429
7128	37	41.70	114	50	3547.3 6T	0	97417397	69051149	3511965	38	-2440	81437
0918	37	41.71	114	47	2346.0 7T	0	95417409	69510149	0791965	39	-4120	80265
0919	37	41.71	114	47	5346.0 7 9T	0	94417408	69466149	0681965	39	-4120	80254
0920	37	41.71	114	47	8046.0 8 9T	0	94417407	69426149	1061965	39	-4080	80294
0921	37	41.71	114	48	0746.1 1 9T	0	95417406	69386149	1221965	39	-4030	80335
0923	37	41.71	114	49	0246.4 4 0T	0	93417403	69247149	1421965	39	-3710	80543
0931	37	41.71	114	51	1048.3 0 1T	0	104417396	68941149	1131965	39	-1990	81644
0922	37	41.72	114	48	7646.2 8 0T	0	94417406	69285149	1451965	41	-3860	80454
0926	37	41.72	114	49	8347.0 2 1T	0	95417402	69128149	2951965	41	-3010	81045
0927	37	41.72	114	50	1047.2 9 0T	0	96417401	69088149	3371965	41	-2720	81246
0933	37	41.72	114	51	6248.9 0 1T	0	108417396	68865148	8761965	41	-1660	81768
0924	37	41.73	114	49	2846.6 0 1T	0	95417406	69209149	1531965	42	-3550	80645
0929	37	41.73	114	50	5747.7 7 9T	0	99417402	69019149	2531965	42	-2340	81459
0925	37	41.74	114	49	5746.8 2 1T	0	93417407	69166149	2091965	44	-3290	80833
0930	37	41.74	114	50	8347.9 7 9T	0	100417403	68981149	2201965	44	-2190	81550
7143	37	41.75	114	53	2050.7 3 8T	0	144417396	68632148	3301965	45	-480	82354
0337	37	41.76	114	47	1479.9 9T	0	121417427	69880149	9041965	46	-1490	82261
0932	37	41.76	114	51	3448.5 4 0T	0	104417405	68906149	0431965	46	-1840	81704
0934	37	41.77	114	52	0449.4 9 1T	0	111417404	68803148	6301965	48	-1360	81871
0935	37	41.77	114	52	3149.8 3 9T	0	118417403	68763148	5551965	48	-1110	82008
0343	37	41.81	114	42	7851.3 8 1T	0	138417444	70163148	8001965	54	570	83198
0345	37	42.02	114	41	2855.0 9T	0	178417488	70383146	2051965	84	1830	83088
1919	37	42.03	114	50	3747.5 2 0T	0	97417458	69047149	3871965	86	-2500	81397
7137	37	42.10	114	45	6046.3 9 4T	0	107417487	69748150	2071965	96	-2740	81547
0949	37	42.11	114	53	3467.4 9T	0	107417490	69787150	2201965	98	-2400	81757
0973	37	42.18	114	52	2749.4 9 1T	0	123417479	68767148	7711965	108	-1280	81963
0878	37	42.21	114	53	4353.0 4 1T	0	147417481	68597147	0111965	112	290	82347
0950	37	42.32	114	46	3745.8 6 0T	0	99417525	69634149	4281966	28	-4060	80399
0355	37	42.51	114	40	6360.0 1 0T	0	233417581	70476142	8621966	56	2650	82423
0350	37	42.56	114	44	3248.0 2 2T	0	134417577	69934150	2521966	63	-1240	82514
0951	37	42.59	114	47	2145.8 4 0T	0	94417572	69509149	1791966	68	-4370	80094
0971	37	42.62	114	49	2646.4 9 9T	0	95417571	69208149	2911966	72	-3640	80595
0354	37	42.65	114	41	3662.9 7 9T	0	735417604	70368140	8111966	76	3370	82635
0952	37	42.78	114	45	6145.9 8 1T	0	104417613	69743150	2941966	95	-3140	81274
0901	37	42.89	114	48	2845.9 2 8T	0	92417624	69351149	2791966	111	-4220	80202
0970	37	42.89	114	50	2547.1 1 9T	0	99417617	69061149	7721966	111	-2610	81419
0881	37	43.10	114	52	7850.1 2 1T	0	150417648	68688149	0311966	142	-560	82500
7144	37	43.10	114	56	7557.8 5 4T	0	284417635	68105144	2901967	42	1960	82524

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0882	37	43.13	114	53	7653081T	20	156417650	68544147212196746		390		82476
0371	37	43.23	114	41	6861099T	0	673417710	70319142284196761		2990		82833
0372	37	43.24	114	42	6752080T	0	149417708	70173148438196762		660		83059
0374	37	43.45	114	43	8947710T	0	141417743	69993150879196793		-1030		82841
0376	37	43.45	114	49	7460089T	0	111417739	69834150649196793		-2790		81601
0954	37	43.46	114	46	0745801T	0	97417737	69673149463196794		-4240		80227
0955	37	43.46	114	47	1745801T	0	91417733	69511149205196794		-4500		79971
0966	37	43.48	114	49	4046381T	0	96417729	69183149547196797		-3620		80656
0968	37	43.48	114	51	0547759T	0	110417724	68941149855196797		-2010		81810
0969	37	43.48	114	51	6148350T	0	117417722	68859149656196797		-1660		31967
0967	37	43.63	114	50	1546890T	0	100417754	69073149904196819		-2800		81300
0375	37	43.81	114	43	7148159T	0	140417810	70018150851196845		-690		83030
0370	37	44.01	114	41	7052192T	0	150417854	70312148606196875		820		83180
0381	37	44.01	114	42	5950249T	0	167417851	70181149688196875		80		83117
7130	37	44.05	114	50	0046765T	1	95417833	69093150066196880		-2820		81326
0957	37	44.30	114	45	2145951T	0	101417895	69795150147196917		-3540		80891
0887	37	44.30	114	53	3051319T	0	152417868	68607148532196917		-110		82542
0958	37	44.32	114	47	3145801T	0	89417892	69487149233196920		-4600		79869
0964	37	44.32	114	50	6247310T	0	105417880	69001150272196920		-2140		81825
0889	37	44.32	114	55	1456142T	0	197417865	68337146118196920		2000		83057
0886	37	44.34	114	52	7250341T	0	131417877	68692149068196923		-500		82461
7115	37	44.35	114	43	3743576T	0	140417911	70065150609196924		-610		82960
0379	37	44.37	114	43	4148550T	0	128417915	70059150557196927		-700		82868
0368	37	44.42	114	40	9954370T	0	131417933	70415147171196934		1370		82971
7151	37	44.50	114	40	9654281T	0	129417948	70419147155196946		1260		82899
0962	37	44.57	114	50	0346699T	0	99417929	69086150158196956		-2870		81309
0378	37	44.59	114	44	8466499T	0	108417952	69901150969196959		-2250		81998
0390	37	44.65	114	53	7952021T	0	164417931	68534148163196968		120		82554
0380	37	44.80	114	42	5555000T	0	285417997	70184146452196990		1190		82725
0369	37	44.91	114	41	3159659T	0	521418022	70365143179197006		2280		82471
0960	37	44.95	114	58	8458697T	0	93418013	69694149609197012		-4250		80193
0959	37	44.95	114	47	8545801T	0	88418006	69405149297197012		-4630		79838
0961	37	44.99	114	52	1249121T	0	123417999	68777149752197018		-1060		82313
2227	37	10.20	115	7	0299907T	0	288411538	67653158762191956		-4970		85088
7	37	12.10	115	42	0320117T	0	165411879	67128156124192232		-5990		83255
6925	37	12.16	115	40	6320117T	0	164411890	67149156137192241		-5990		83264
1369	37	12.25	115	27	3314507T	0	201411911	67345156920192254		-5740		83741
6819	37	13.40	115	4	1396197T	0	200412131	67684152455192421		-2690		84000
2226	37	13.40	115	47	0319697T	0	174412117	67049156062192421		-6280		82994
6818	37	15.80	115	19	0455227T	0	294412570	67454148606192759		-1330		83434

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6904	371755		115	45336670T		0	157412885	67059154324193023			-4200	83457
6817	371853		115	12146860T		0	256413077	67546147327193165			-1750	82526
6905	371908		115	38139039T		0	118413170	67159152663193245			-3850	82948
6906	372058		115	29241880T		0	114413451	67285151074193463			-2980	82844
6621	372201		115	37643599T		0	160413712	67156150523193671			-2130	83160
6622	372239		115	1645801T		0	125413794	67686148619193726			-2010	82485
6619	372308		115	25247192T		0	176413914	67335149234193827			-190	83886
6618	372579		115	39750030T		0	248414411	67110146971194221			-180	83008
2319	372804		115	7059521T		0	408414837	67584141190194548			2620	82748
2318	373158		115	5055341T		0	301415492	67600143601195063			590	82031
2317	373335		115	5052920T		0	220415820	67593145345195321			-190	81980
1362	373615		115	25546398T		0	189416331	67280149549195729			-2520	81839
2307	373734		115	5048862T		0	110416557	67577148620195902			-1310	82130
1874	374067		115	15054780T		0	235417170	67417145574196388			700	82275
2315	374444		115	19050751T		0	114417866	67343149246196937			40	82864
0928	374172		1145037		0	0	276417400	69049149328196541			-2490	81290
DMV001	373567		115	69	5754S	252	466416248	67556142189195659			685	81778
DMV002	373314		115	129	6483C	671	696415778	67477136925195290			2654	81909
DMV004	373117		115	186	7668S	1085	1910415412	67401128200195004			5376	82217
PRV013	373936		115	492	4615S	1	102416917	66919150208196197			-2556	81806
PRV077	372802		115	392	6284S	227	599414823	67109138961194545			3561	82954
PRV080	372552		115	58	6570S	75	81240414371	67611135608194182			3265	82855
DMV066	372576		1144690		6226Y	286	568414461	69628138875194216			3258	82877
DMV071	372761		1144750		5447Y	42	227414801	69532143814194486			593	82284
DMV102	372296		1145499		4561Y	0	114413916	68446147175193809			-3711	80847
DMV104	372501		1145480		4593S	0	114414295	68456147311194107			-3571	80877
DMV105	372595		1145500		4625Y	1	114414469	68433147518194244			-3201	81140
DMV120	372370		1145877		5041Y	38	175414040	67886145486193917			-989	82031
DMV121	372255		1145746		5547S	183	578413832	68084141549193750			6	81848
DMV131	372229		1145624		5016S	598	259413788	68265144838193712			-1667	82082
DMV135	371678		1145687		4600C	2	154412767	68194148120192911			-1501	82966
DMV146	372063		1145356		4600C	0	126413489	68667147325193471			-2855	81581
DMV147	371937		1145393		4624V	0	128413255	68618147940193288			-1831	82526
DMV169	372185		1144570		6517S	379	603413742	69822136276193648			3968	82723
DMV171	371990		1144826		6436S	368	1038413372	69453136541193365			3754	83209
DMV400	373393		1144563		6418S	408	382415976	69779137888195405			2889	81789
PRV024	374043		1145986		6652S	634	1229417131	67659137133196353			3391	82566
PRV204	372661		115	177	6486C	15	776414569	67432137446194340			4154	82823
PRV203	373033		115	453	6282C	145	547415249	67011139023194881			3269	82534
PRV202	373258		115	410	5742C	9	357415666	67065142604195209			1437	82219

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PRV078	372901		115	178	7950V	482460415013		67421126359194689		6505		81898
PRV043	373195		115	488	5592C	30	368415547	66953143499195117		1012		32337
PRV035	373361		115	379	5423C	12	261415857	67107145035195359		715		82491
PRV021	374221		115	55	5792S	6	293417458	67550144017196612		1918		82462
PRV020	374184		115	201	5650S	20	343417385	67337144386196558		1003		82096
PRV015	374073		115	318	5636S	21	518417176	67170144179196396		827		82143
PRV023	373782		115	103	5086S	15	128416645	67497147342195972		-765		82031
PRV022	373952		115	131	5128S	6	141416958	67449148323196220		364		83021
DMV153	371845		1145152		5109S	12	220413093	68977145409193154		338		83145
DMV151	371537		1145131		5965S	19	669412524	69021140409192707		3844		84187
DMV140	371837		1145492		4698S	3	170413160	68473147606193215		-1396		82753
DMV126	371592		1145774		5009S	17	350412605	68069145363192786		-282		83001
DMV119	372604		1145888		5542Y	1	404414473	67860142654194257		556		82059
DMV117	372956		1145724		5210Y	2	152415129	68088144642194769		-1094		81290
DMV113	372403		1145591		4789Y	5	169414111	68306146735193965		-2160		81680
DMV063	373046		1144537		6704S	8	517415335	69833136028194900		4228		81887
DMV065	372793		1144575		7095Y	301088414866		69788133179194532		5430		82348
DMV026	373139		1145495		5258U	15	203415475	68418143997195036		-1554		80731
DMV005	373151		115	7	5581C	33	339415481	67663142994195053		467		81804
DMV027	373261		1145488		5013Y	9	93415701	68423145861195213		-2174		80830
DMV032	373181		1145332		4929U	5	97415558	68656146183195097		-2526		80764
DMV040	373290		1145193		5131Y	3	134415764	68856145761195256		-1205		81431
DMV058	373596		1144642		6215S	45	656416349	69654140242195701		3036		82540
DMV061	373156		1144716		6577S	38	754415532	69565136870195060		3715		82074
DMV067	372347		1144544		6339Y	6	402414042	69854138700193883		4480		83268
DMV109	372897		1145587		5345Y	22	331415024	68292143599194633		-752		81360
DMV111	372621		1145650		4884Y	27	187414512	68210146812194282		-1506		82050
DMV118	372979		1145891		5494Y	9	223415166	67841143152194803		56		81550
DMV124	372084		1145892		5071S	14	340413511	67875144921193501		-855		82203
DMV125	371841		1145910		5182S	24	466413061	67858144144193148		-234		82582
DMV130	372215		1145760		5421S	14	696413757	68064142690193692		18		82239
DMV132	372095		1145641		4942S	28	348413539	68245145607193517		-1400		82120
DMV136	371540		1145583		5342S	7	415412515	68353143875192711		1441		83643
DMV150	371656		1145392		6372V	81376412736		68631136730192879		3826		83476
DMV172	371860		1144751		5822S	5	360413134	69569140639193176		2259		82766
DMV173	371646		1144611		7357V	372247412744		69785129072192865		5458		82649
DMV401	371609		1144844		6356S	28	752412667	69443136311192811		3324		82425
DMV003	373255		115	81	5488C	0	303415671	67550144125195205		571		82156
PRV012	373819		115	484	4547S	0	102416701	66935150176196026		-3059		81534
PRV016	373980		115	355	4801V	0	108417003	67119149322196261		-1757		81977

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PRV017	373859		115	359	4666V	0	102416779	671181499591960 84			-2214	81973
PRV018	373798		115	226	4762V	0	101416670	673161496261959 95			-1554	82305
PRV025	373691		115	93	4919V	0	133416477	675151483501958 40			-1196	82160
PRV027	373470		115	191	5233V	0	208416065	673801460681955 18			-200	82160
PRV028	373569		115	208	5015V	0	124416247	673511475041956 62			-961	82059
PRV029	373677		115	24347900T		0	102416446	672951490061958 19			-1734	82031
PRV030	373736		115	374	4621V	0	103416551	671001494201959 05			-2997	81345
PRV031	373620		115	360	4714V	0	105416337	671251491611957 36			-2211	81816
PRV032	373508		115	331	4950C	0	135416131	671721478031955 73			-1185	82067
PRV036	373436		115	444	4829C	0	162415994	670091489091954 68			-1113	82578
PRV037	373538		115	484	4631C	0	116416182	669461493421956 17			-2692	81629
PRV038	373651		115	486	4533C	0	106416391	669391502541957 81			-2867	81778
PRV076	372960		115	491	6058S	0	623415113	669571406781947 75			2920	82881
DMV006	373049		1145920		5317Y	0	184415295	677951445761949 05			-288	81761
DMV007	373302		1145932		5148Y	0	139415762	677681456681952 73			-1156	81425
DMV008	373409		1145945		5061Y	0	125415960	677441463851954 29			-1413	81450
DMV009	373551		1145952		4963Y	0	105416222	677281473571956 36			-1571	81606
DMV010	373644		1145822		4927Y	0	99416398	679161473431957 71			-2060	81235
DMV011	373469		1145822		4948Y	0	101416075	679231469491955 16			-2000	81225
DMV012	373358		1145802		5016Y	0	104415870	679571462411953 55			-1907	81089
DMV013	373217		1145849		5150Y	0	131415608	678931454501951 49			-1231	81335
DMV014	373130		1145848		5206Y	0	146415447	678981450851950 23			-942	81448
DMV015	373045		1145764		5137Y	0	138415292	680251453441948 99			-1208	81409
DMV016	373134		1145723		5080Y	0	118415458	680821455801950 28			-1639	81153
DMV017	373273		1145723		5018Y	0	103415715	680771459931952 31			-2012	80976
DMV018	373407		1145684		4930Y	0	102415964	681291466631954 26			-2366	80921
DMV019	373555		1145712		4888Y	0	103416237	680811473381956 41			-2301	81130
DMV020	373598		1145603		4918Y	0	95416320	682401472911957 04			-2129	81192
DMV021	373468		1145600		4877Y	0	102416080	682501472531955 15			-2363	81105
DMV022	373293		1145601		4939Y	0	98415756	682551463511952 60			-2427	80826
DMV023	373183		1145649		4998Y	0	103415551	681891460211951 00			-2041	81015
DMV024	373050		1145649		5025U	0	112415305	681951460131949 06			-1601	81372
DMV025	373017		1145535		4937Y	0	111415248	683641462761948 58			-2119	81153
DMV028	373380		1145490		4865Y	0	110415921	684151466971953 87			-2904	80613
DMV029	373555		1145491		4914Y	0	95416244	684071471871956 41			-2208	81127
DMV030	373470		1145381		4850Y	0	109416091	685721471401955 18			-2734	80833
DMV031	373293		1145380		4830Y	0	112415763	685811469871952 60			-2817	80821
DMV033	373059		1145377		4820Y	0	105415331	685951467801949 19			-2778	80887
DMV034	373376		1145298		4825U	0	118415920	686981470901953 81			-2882	80779
DMV035	373454		1145257		4839Y	0	116416065	687551470671954 94			-2887	80725

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DMV036	37	3555	114	5271	4854Y	0	102416251	687301472041956 41	-2756		80790	
DMV037	37	3586	114	5086	4897S	0	102416315	690011469411956 87	-2659		80740	
DMV038	37	3469	114	5131	4937V	0	107416097	689401465441955 16	-2510		80759	
DMV039	37	3380	114	5160	4946V	0	105415932	689011463811953 87	-2458		80778	
DMV041	37	3184	114	5180	4887S	0	113415568	688801463591951 01	-2750		80695	
DMV042	37	3086	114	5228	4809S	0	109415386	688131467121949 58	-2989		80718	
DMV043	37	3086	114	5114	4919S	0	118415389	689811459831949 58	-2682		80659	
DMV044	37	3217	114	5091	5016S	0	117415632	690101456791951 49	-2264		80745	
DMV045	37	3356	114	5013	5159V	0	124415892	691191448371953 52	-1962		80566	
DMV046	37	3483	114	4987	5092S	0	117416128	691511455221955 37	-2092		80658	
DMV047	37	3577	114	4894	5103V	0	120416305	692841456821956 73	-1966		80749	
DMV048	37	3474	114	4813	5323 2T	0	153416117	694081446001955 23	-826		81172	
DMV049	37	3362	114	4868	5399S	0	150415908	693321436681953 60	-880		80856	
DMV050	37	3243	114	4927	5314S	0	152415636	692501440471951 87	-1123		80900	
DMV051	37	3133	114	4979	5111 9T	0	142415481	691781450601950 27	-1857		80850	
DMV052	37	3029	114	4956	5127S	0	148415289	692161450571948 76	-1566		81095	
DMV053	37	3035	114	4844	5364S	0	181415304	693811436491948 84	-752		81133	
DMV054	37	3144	114	4835	5377V	0	203415506	693901441211950 43	-316		81547	
DMV055	37	3611	114	4748	5211S	0	150416373	694981460961957 23	-585		81792	
DMV056	37	3255	114	4795	5613S	0	200415713	694441432511952 05	874		81929	
DMV057	37	3409	114	4711	5622V	0	189416001	695611435301954 29	1013		82027	
DMV059	37	3483	114	4605	5681S	0	190416141	697141436241955 37	1555		82368	
DMV060	37	3293	114	4654	5935S	0	257415788	696501416181952 60	2217		82231	
DMV064	37	2934	114	4667	5970Y	0	307415124	696461420961947 37	3548		83493	
DMV068	37	2309	114	4731	5352V	0	245413966	695791444451938 28	987		82978	
DMV069	37	2429	114	4795	5143V	0	253414185	694801456741940 03	74		82786	
DMV070	37	2570	114	4836	5105Y	0	206414445	694131456011942 08	-562		82233	
DMV072	37	2847	114	4684	5681Y	0	278414962	696251426051946 11	1462		82364	
DMV073	37	2927	114	4795	5472Y	0	197415106	694581431521947 27	-76		81458	
DMV074	37	2823	114	4858	5261V	0	179414912	693701437491945 76	-1313		80922	
DMV075	37	2695	114	4871	5162Y	0	177414675	693561448401943 90	-968		81603	
DMV076	37	2497	114	4975	4844Y	0	158414305	692111463411941 02	-2173		81463	
DMV077	37	2405	114	4957	4838Y	0	161414135	692421463561939 68	-2081		81579	
DMV078	37	2311	114	4910	4973Y	0	176413963	693151455581938 31	-1471		81743	
DMV079	37	2272	114	5026	4843Y	0	149413887	691451460051937 74	-2191		81440	
DMV080	37	2355	114	5105	4702V	0	141414038	690251463371938 95	-3308		80796	
DMV081	37	2460	114	5130	4680V	0	137414231	689841462771940 48	-3727		80448	
DMV082	37	2626	114	5030	4873Y	0	140414542	691251460721942 89	-2356		81163	
DMV083	37	2721	114	5046	4882V	0	139414717	690971461821944 27	-2300		81188	
DMV084	37	2782	114	4981	5021Y	0	153414832	691901454421945 16	-1820		81208	

DELAMAR VALLEY GRAVITY DATA

STATION IDENT.	LAT. DEG	MIN	LONG. DEG	MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM	OBSV GRAV	THEO GRAV	FAA	CBA +1000
DMV085	372902		1144943		5140Y	0	159415055	692411446021946 91			-1714	80914
DMV086	372966		114506149560T			0	131415169	690641455591947 84			-2583	80645
DMV087	372884		114510348711T			0	127415016	690061460571946 65			-2766	80747
DMV088	372811		114513648081T			0	124414880	689601464711945 58			-2838	80887
DMV089	372730		114517647500T			0	130414729	689051466121944 40			-3126	80803
DMV090	372574		1145180		4696V	0	143414440	689061462881942 14			-3731	80395
DMV091	372260		1145196		4655V	0	133413859	688951465221937 57			-3427	80830
DMV092	372368		1145240		4603V	0	144414057	688261464361939 14			-4159	80285
DMV093	372886		1145233		4743V	0	116415016	688141468121946 67			-3219	80720
DMV094	372956		1145196		4797Y	0	114415146	688661464371947 69			-3187	80565
DMV095	372952		1145332		4764V	0	109415134	686661468081947 63			-3121	80739
DMV096	372782		1145310		4689V	0	133414821	687051470131945 16			-3375	80766
DMV097	372658		1145298		4653Y	0	138414592	687281466271943 36			-3919	80349
DMV098	372554		1145359		4618S	0	145414397	686421466681941 84			-4056	80338
DMV099	372486		114529446050T			0	139414274	637411463791940 86			-4369	80064
DMV100	372406		114533345850T			0	131414125	686871464501939 69			-4370	80122
DMV101	372327		114537245669T			0	144413977	686331465771938 54			-4298	80270
DMV103	372409		1145467		4582S	0	123414126	684891471041939 74			-3749	80746
DMV106	372698		1145418		4655S	0	128414662	685491470911943 94			-3494	80757
DMV107	372850		1145419		4747V	0	114414943	685421469611946 15			-2980	80943
DMV110	372735		1145554		4673Y	0	132414726	683471478251944 48			-2645	81549
DMV112	372501		1145628		4690Y	0	134414291	682481478751941 07			-2094	82043
DMV114	372400		1145770		4818Y	0	143414099	680421468541939 60			-1763	81947
DMV115	372535		1145759		4863V	0	202414349	680531469091941 57			-1481	82135
DMV116	372704		1145724		4962V	0	164414663	680981467991944 03			-905	82335
DMV122	372238		114591446900T			0	122413795	678361479381937 25			-1649	82476
DMV123	372173		114584547500T			0	120413677	679411474041936 30			-1523	82396
DMV127	371793		1145761		4538S	0	133412977	680801485481930 78			-1823	82832
DMV128	371971		1145810		4540C	0	109413305	680001485621933 37			-2049	82575
DMV129	372109		114577546660T			0	114413561	680471477881935 37			-1837	82362
DMV133	372012		114565245430T			0	117413386	682321485071933 97			-2136	82486
DMV134	371902		1145682		4538C	0	136413181	681921483981932 37			-2132	82527
DMV137	371635		1145548		4887S	0	307412692	684011471831928 49			327	83966
DMV138	371773		1145505		4972S	0	247412948	684591460381930 49			-218	83071
DMV139	371831		1145613		4543Y	0	136413052	682971484371931 33			-1942	82699
DMV141	371998		114553145522T			0	141413364	684111477561933 76			-2782	81834
DMV142	372078		114549245499T			0	127413513	684661475081934 92			-3164	81444
DMV143	372171		114544945499T			0	126413686	685251471651936 28			-3642	80965
DMV144	372247		114541045561T			0	136413828	685801467941937 38			-4067	80529
DMV145	372180		1145280		4600C	0	135413708	687741469281936 41			-3422	81024

DELAMAR VALLEY GRAVITY DATA

STATION IDENT.	LAT. DEG MIN	LONG. DEG MIN	ELEV. +CODE	TER-COR. IN/OUT	NORTH UTM	EAST UTM	OBSV GRAV	THEO GRAV	FAA	CBA +1000
DMV148	371957	1145257	4696S	0	141413297	688181472501933 17			-1372	82252
DMV149	371823	1145294	4898S	0	188413048	687691470231931 22			2	83480
DMV152	371690	1145172	5656S	0	456412806	689541415101929 29			1814	82979
DMV154	371963	1145133	4784S	0	154413312	690011468531933 25			-1450	82387
DMV155	372082	1145195	4692V	0	136413530	689041468901934 98			-2452	81681
DMV156	372166	1145119	4755V	0	153413688	690131464291936 20			-2442	81493
DMV157	372136	1145005	4958C	0	165413636	691821458931935 77			-1023	82232
DMV158	372021	1145017	5128S	0	209413423	691691449091934 10			-239	82480
DMV159	371826	1145018	4929S	0	191413062	691761461591931 26			-579	82801
DMV160	371686	1145028	5052V	0	206412803	691671453821929 23			5	82980
DMV161	371584	1144994	5593S	0	373412616	692221420951927 75			1959	83256
DMV163	371671	1144861	5776C	0	404412781	694151403961929 01			1857	82561
DMV164	371763	1144915	5069S	0	228412949	693311449331930 35			-396	82543
DMV165	371905	1144956	5025V	0	205413211	692641454661932 41			-483	82583
DMV166	372113	1144866	5228V	0	220413598	693881449791935 43			638	83027
DMV167	372190	1144908	5076V	0	184413739	693231456291936 55			-255	82616
DMV168	372170	1144762	5352S	0	233413707	695391436781936 26			422	82401
DMV170	372071	1144725	5593S	0	281413526	695981425681934 82			1725	82930

END OF LIST

E-TR-33-DM

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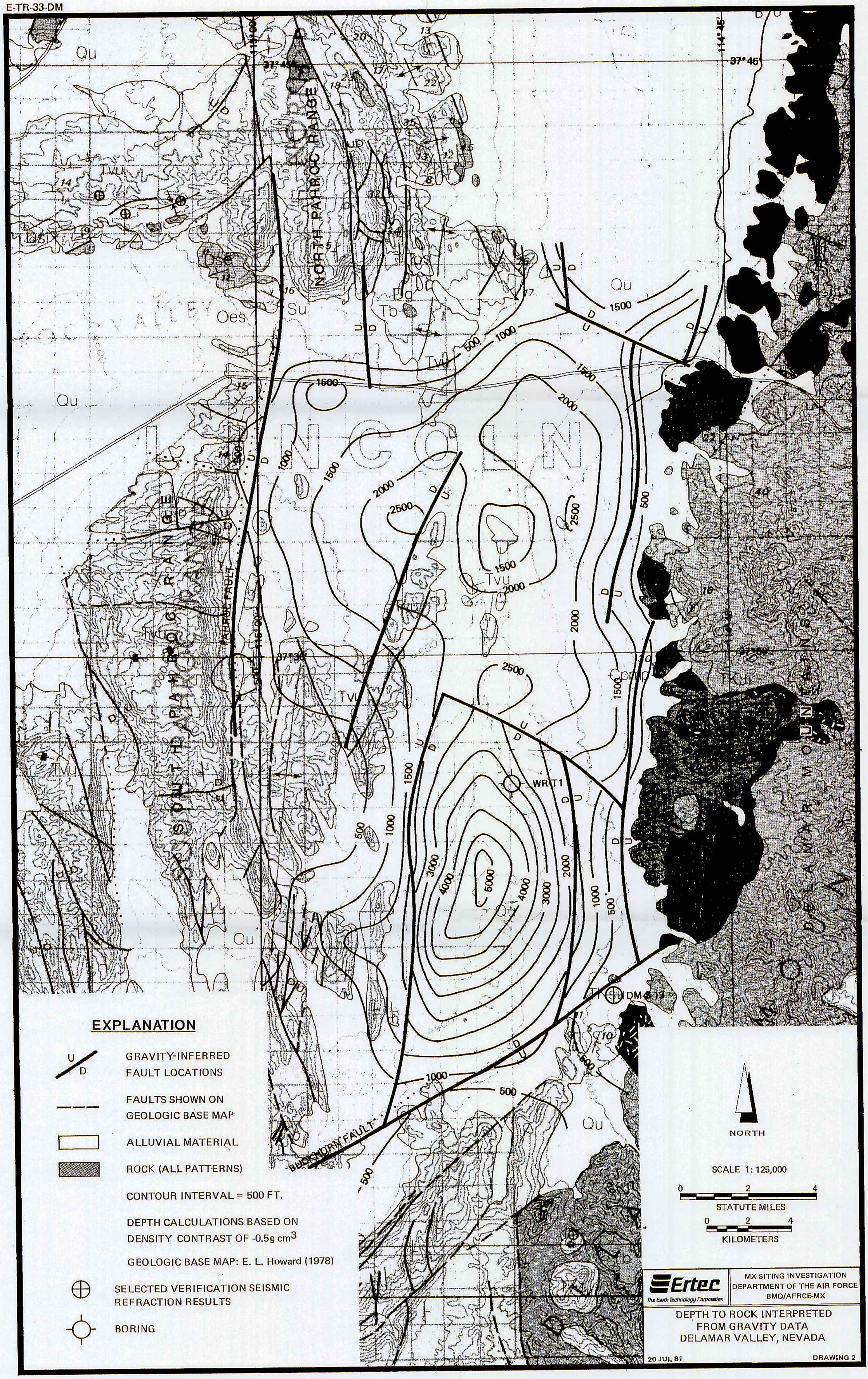
E-TR-33-DM



EXPLANATION

- GRAVITY-INFERRED FAULT LOCATIONS
- FAULTS SHOWN ON GEOLOGIC BASE MAP
- ALLUVIAL MATERIAL
- ROCK (ALL PATTERNS)

CONTOUR INTERVAL = 500 FT.

DEPTH CALCULATIONS BASED ON DENSITY CONTRAST OF -0.5g cm^3

GEOLOGIC BASE MAP: E. L. Howard (1978)

- SELECTED VERIFICATION SEISMIC REFRACTION RESULTS
- BORING

NORTH

SCALE 1: 125,000

0 2 4 STATUTE MILES

0 2 4 KILOMETERS

Ertec The Earth Technology Corporation

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

DEPTH TO ROCK INTERPRETED FROM GRAVITY DATA DELAMAR VALLEY, NEVADA

20 JUL 81

DRAWING 2