In Cooperation with the Southern Nevada Water Authority (SNWA)

Principal Facts for Gravity Stations Collected in 2010 from White Pine and Lincoln Counties, East-Central Nevada

By Edward A. Mankinen and Edwin H. McKee

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Conversion Factors

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilogram per cubic meter (kg/m^3)	0.06242	pound per cubic foot (lb/ft^3)

Vertical coordinate information is referenced to the North American Vertical Datum of 1929 (NAVD29).
Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD27).

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By Edward A. Mankinen and Edwin H. McKee[1]

Abstract

Increasing demands on the Colorado River system within the arid Southwestern United States have focused attention on finding new, alternative sources of water. Particular attention is being paid to the eastern Great Basin, where important ground-water systems occur within a regionally extensive sequence of Paleozoic carbonate rocks and in the Cenozoic basin-fill deposits that occur throughout the region. Geophysical investigations to characterize the geologic framework of aquifers in eastern Nevada and western Utah began in a series of cooperative agreements between the U.S. Geological Survey and the Southern Nevada Water Authority in 2003. These studies were intended to better understand the formation of basins, define their subsurface shape and depth, and delineate structures that may impede or enhance groundwater flow. We have combined data from gravity stations established during the current study with previously available data to produce an up-to-date isostatic-gravity map of the study area, using a gravity inversion method to calculate depths to pre-Cenozoic basement rock and to estimate alluvial/volcanic fill in the valleys.

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Introduction

Historically, the arid Southwestern United States has been sparsely populated, but the construction of dams, aqueducts, and pumping of groundwater has allowed the relatively recent growth of major population centers throughout the Great Basin. Increasing demands on existing water supplies, specifically the Colorado River system, have focused attention on finding new, alternative sources, particularly in the eastern part of the Great Basin, where a major aquifer system occurs in a regionally extensive, thick stratigraphic sequence of Paleozoic carbonate rocks. A second important ground-water system occurs in the Cenozoic basin-fill deposits found throughout the region. Geophysical investigation of several of these Cenozoic basins, using gravity, magnetic, and audiomagnetotelluric (AMT) methods, have been undertaken in a series of cooperative agreements between the U.S. Geological Survey (USGS) and the Southern Nevada Water Authority (SNWA) beginning in 2003. These cooperative studies have covered an area of approximately 60,000 km^2 in eastern Nevada and western Utah (fig. 1). Gravity and ground magnetic data were described by Scheirer (2005), Mankinen and others (2006, 2007, 2008), and Mankinen and McKee (2009), and AMT data by McPhee and others (2009 and references therein). The objective of the current study was to obtain detailed gravity data along selected traverses to delineate the structures bounding and dividing some of these basins. These investigations will help characterize the geophysical framework of the region by better understanding the formation of basins, defining their subsurface shape and depth, and delineating structures that may impede or enhance groundwater flow.

Geologic Setting

Geologic summaries of White Pine and Lincoln Counties, Nev., were presented by Hose and others (1976), Tschanz and Pampeyan (1970), and Dixon and others (2007), and additional geologic information by Hose and Blake (1970), Ekren and others (1977), Stewart and Carlson (1978), and Stewart (1980). The oldest rocks in the region (fig. 1) belong to the Precambrian McCoy Creek Group, in which the most abundant rock type is massive quartzite. Similar rocks extend stratigraphically upward to include the Lower Cambrian Prospect Mountain Quartzite. These metamorphic rocks are overlain by thick sequences of predominately carbonate rocks, ranging in age from Middle Cambrian through Lower Triassic. The total stratigraphic thickness of the carbonate sequence ranges from about 1.5 to as much as 9 km, and the composite unit is present throughout the entire east two-thirds of the Great Basin (Plume, 1996).

The eastern Great Basin was uplifted and eroded during the Mesozoic, with continental deposition occurring locally during that time. Plutons likely exist beneath all calderas throughout the region, and many have been inferred elsewhere from interpretations of geophysical anomalies (Grauch and others, 1988; Ponce, 1990). Although these plutons range in age from Jurassic through Tertiary, all the plutons are grouped with the basement rocks because they are similar in density to most of the pre-Cenozoic rocks but differ greatly from later volcanic and other basin-fill rocks.

Immediately overlying the pre-Cenozoic basement rocks are thin, locally exposed continental sedimentary rocks, capped by voluminous, regional ash-flow sheets derived from widely scattered calderas (Best and others, 1989; Rowley and others, 1995), largely during Oligocene time. Major extensional faulting began throughout the Basin and Range Province at about 17 Ma (McKee, 1971; Christiansen and McKee, 1978; Stewart, 1978) and formed the horst-graben terrain that is well expressed in the study area (fig. 1). Most valleys are drained internally and contain playas. Basin fill typically consists of downdropped early Cenozoic outflow sheets overlain by alluvial material derived from the erosion of adjacent mountain ranges. Interbedded basaltic lava flows also are present in many areas.

Procedures

Gravity data were obtained by using a LaCoste and Romberg meter (G17C), and observed gravity values were referenced to two base stations. The first base station (***ELYA***) at the Ely, Nev. airport at lat 39°17.59' N., long -114°50.52' W., is tied to the International Gravity Standardization Net 1971 (ISGN 71) gravity datum (Morelli, 1974) and has an observed gravity value of 979,480.08 mGal. The second base station (***ELYW2***), at a U.S. Coast and Geodetic Survey vertical-angle benchmark stamped "Ely West Base 1944 Reference Mark 2," approximately 35 km southeast of Ely at lat 39°01.54' N., long -114°34.72' W., has an observed gravity value of 979,462.96 mGal (D.A. Ponce, USGS, written commun., 2005). Locations of gravity stations were determined by using a differential Global Positioning System (DGPS) receiver, with corrections provided by Continually Operated Reference Station (CORS) satellites. Locations after postacquisition processing are accurate to within 1 m, both horizontally and vertically.

Gravity Data

We established 99 new gravity stations (table 1) along traverses in selected areas as shown in figures 2 through 4. Observed gravity at each station was adjusted by assuming a timedependent linear drift between readings of a base station at the start and finish of each daily survey; this adjustment compensates for drift in the instrument's spring. Observed gravity values are considered accurate to within about 0.05 mGal, on the basis of repeated measurements over several mountain calibration loops (Barnes and others, 1969; Ponce and Oliver, 1981).

Gravity data were reduced by using standard gravity corrections (Blakely, 1995) and a reduction density of 2,670 kg/m^3. Field terrain corrections (zones A and B of Hayford and Bowie, 1912) were carried out to 68 m by using templates and charts (Plouff, 2000). Inner-zone terrain corrections, which are needed to account for topographic variations near a gravity station, were obtained to a radial distance of 2 km by using digitized topography in a digital elevation model (DEM) (D. Plouff, written commun., 2006). Outer terrain corrections, from 2 to 167 km, also were calculated by using digitized topography and the procedure of Plouff (1977). The resulting gravity anomaly is termed the complete Bouguer anomaly. A regional isostatic field was calculated by using an Airy-Heiskanen model (Heiskanen and Vening Meinesz, 1958) for local compensation of topographic loads (Jachens and Roberts, 1981; Simpson and others, 1986). The model assumes a nominal crustal thickness of 25 km, a crustal density of 2,670 kg/m^3, and a 400-kg/m^3 density contrast between the crust and mantle. This regional isostatic field was subtracted from the complete Bouguer anomaly, thus removing long-wavelength variations in the gravity field that are inversely related to topography. The resulting isostatic residual gravity anomaly, therefore, reflects local density distributions within mid-crustal to upper-crustal levels.

Gravity data obtained during the current study, along with their associated parameters, are listed in table 1 and are available online for download as an Excel spreadsheet. Existing gravity datasets for the region were obtained from the reports by Ponce (1997), Bankey and others (1998), Kucks and others, 2006), and Mankinen and McKee (2009 and references therein) and from USGS data obtained for the Basin and Range Carbonate Aquifer Study (BARCAS) Project (Sweetkind and others, 2007; Watt and Ponce, 2007). Because gravity data for the study area were obtained by many different observers at different times, we examined the composite dataset to remove duplicate and inconsistent entries. To test for possible errors, we first compared reported station elevations with elevations interpolated from 10- and 30-m DEMs, using the procedure of D. Plouff (written commun., 2005). Large elevation differences indicate possible errors in station location or elevation, and so each station identified was examined individually to confirm the discrepancy. Some of these errors that occurred because of imprecise locations (for example, lack of significant digits in published reports) corrected with a high degree of confidence. If the source of the discrepancy could not be determined and corrected, the station was omitted from the dataset. The revised data set contains 17,930 observations, including 1,895 observations added by USGS-SNWA cooperative studies. The data were gridded at a spacing of 0.5 km by using the minimum-curvature algorithm of Webring (1981), and the resulting isostatic residual gravity field (fig. 5) is considered reliable for subsequent analyses.

Gravity Inversion

To first order, the isostatic residual gravity field (fig. 5) reflects the pronounced contrast between dense (~2,670 kg/m^3) pre-Cenozoic basement rocks and the significantly less dense (generally <2,500 kg/m^3) overlying volcanic and sedimentary basin fill. Because of this relation, the gravity-inversion method of Jachens and Moring (1990) can be used to separate the isostatic residual anomaly into pre-Cenozoic basement and younger basin fields, thereby providing an estimate of the thickness of Cenozoic volcanic rocks and sedimentary basin fill. A modified version of this method (B.A. Chuchel, unpubl. data, 2005) allows basement gravity values to be approximated by correcting the isostatic gravity anomaly at sites where depth to basement is known from deep boreholes (Garside and others, 1988; Hess, 2004) or inferred from seismic data. At sites where wells did not penetrate the full thickness of basin fill, the maximum depths reached were used as minimum constraints in the iterative process. Information on oil and gas wells in Nevada and Utah is posted0 at http://www.nbmg.unr.edu/lists/oil/oil.htm and http://ogm.utah.gov/oilgas/, respectively (both accessed January 27, 2011).

The accuracy of thickness estimates derived by the gravity-inversion technique depends on the assumed density-depth relation of the Cenozoic volcanic and sedimentary rocks, and on the initial density assigned to the basement rocks. Density of basement rocks is assumed to be 2,670 kg/m^3, which seems appropriate in the study area, where major exposures consist of late Precambrian through late Paleozoic marine carbonate and quartzose sedimentary rocks. Subvolcanic Cenozoic intrusions are included here as part of the basement because they are similar in physical properties to most of the older rocks but differ greatly from the eruptive and basin-fill sedimentary sequences. The density-versus-depth relation we use (table 2) is the same used by Jachens and Moring (1990) and Saltus and Jachens (1995), and is similar to those relations shown to be widely applicable to other volcanic basin-fill deposits throughout Nevada (Blakely and others, 1998, 2000; Mankinen and others, 2003). Results of the inversion were gridded at a spacing of 2.0 km by using the minimum-curvature algorithm of Webring (1981). The resulting map (fig. 6) was regridded to 0.5 km to conform to the gravity map.

Conclusions

Gravity data collected during the course of our cooperative studies have allowed a highly detailed definition of basins in the study area. The gravity data shown in figure 5 will be used to identify major density contrasts in order to help locate potential subsurface faults and geologic contacts that may control regional groundwater flow (for example, Mankinen and McKee, 2009). Comparing the depth-to-basement map in figure 6 with a previously published map (Saltus and Jachens, 1995) illustrates the importance of an improved data distribution and incorporation of drillhole data unavailable for the earlier interpretation. Thickness of basin fill exceeds 3 km in many valleys in the region (fig. 6) and approaches ~6.5 km in Dry Lake Valley.

Acknowledgements

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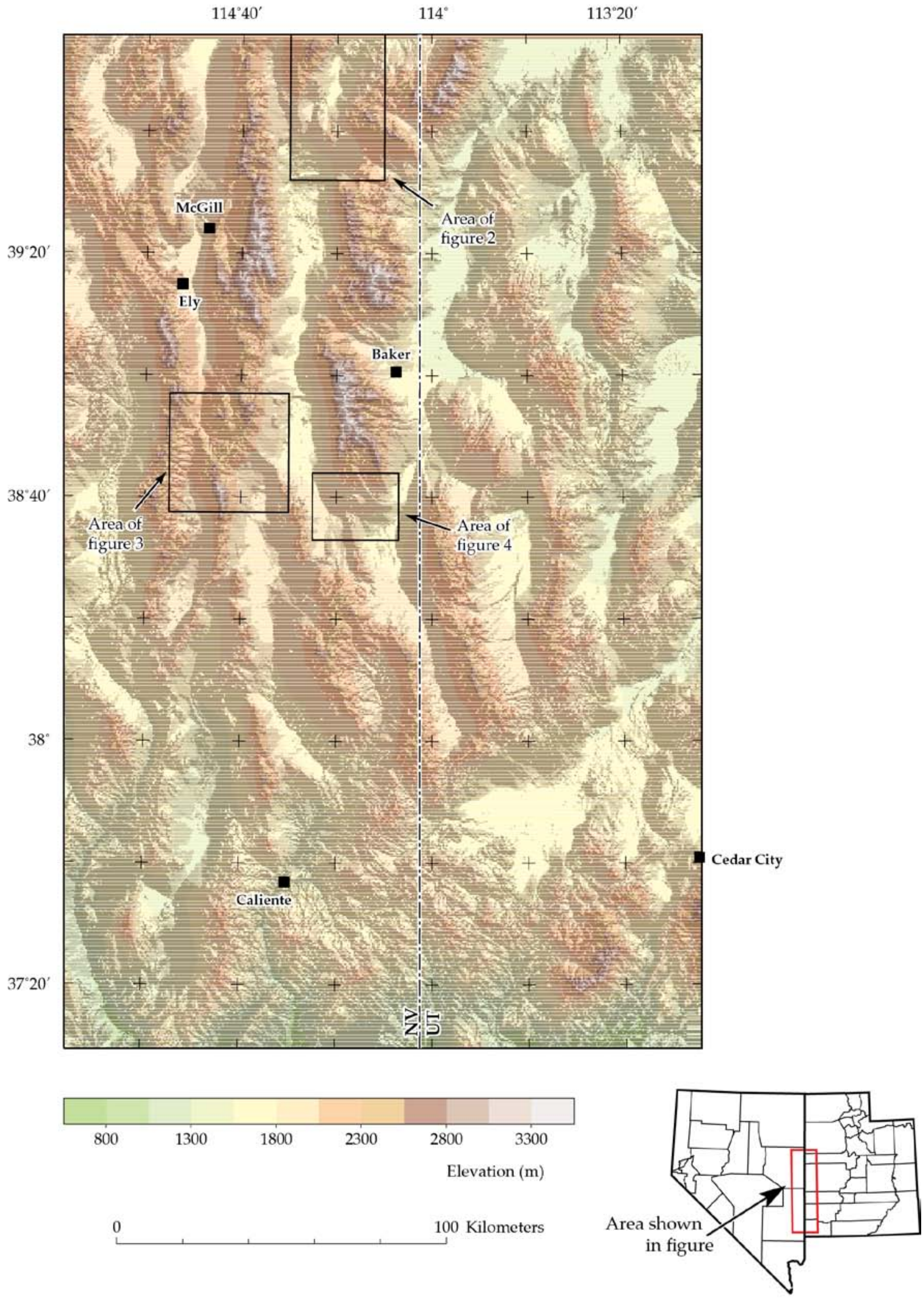

Figure 1. Shaded-relief map of eastern Nevada and western Utah, showing areas investigated for USGS-SNWA cooperative studies, 2003 to 2010.

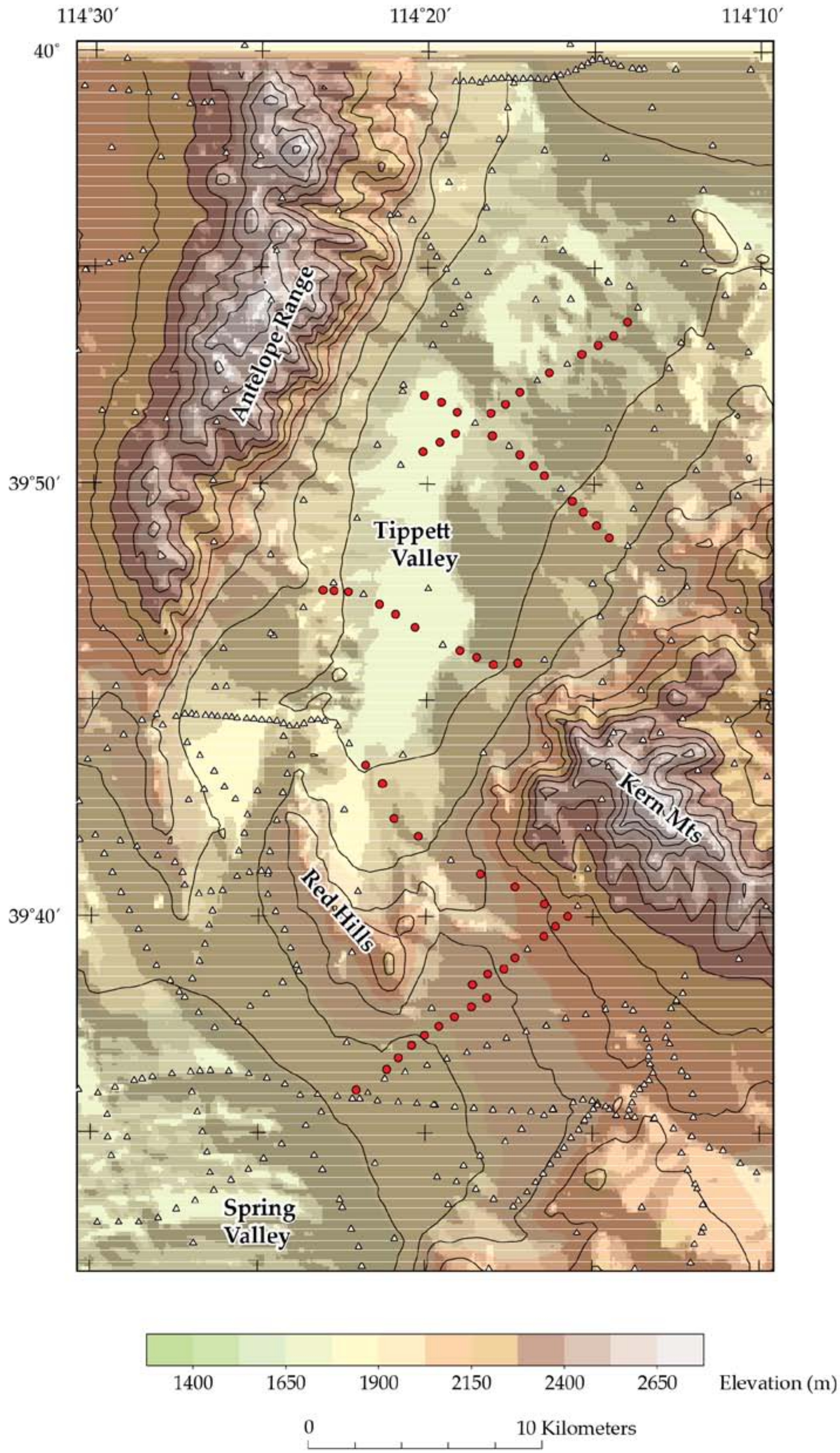

Figure 2. Shaded-relief map of Antelope Valley (Tippett Valley) area, Nev.. Triangles, previously available gravity stations; colored dots, stations added during current study. Contour interval, 100 m.

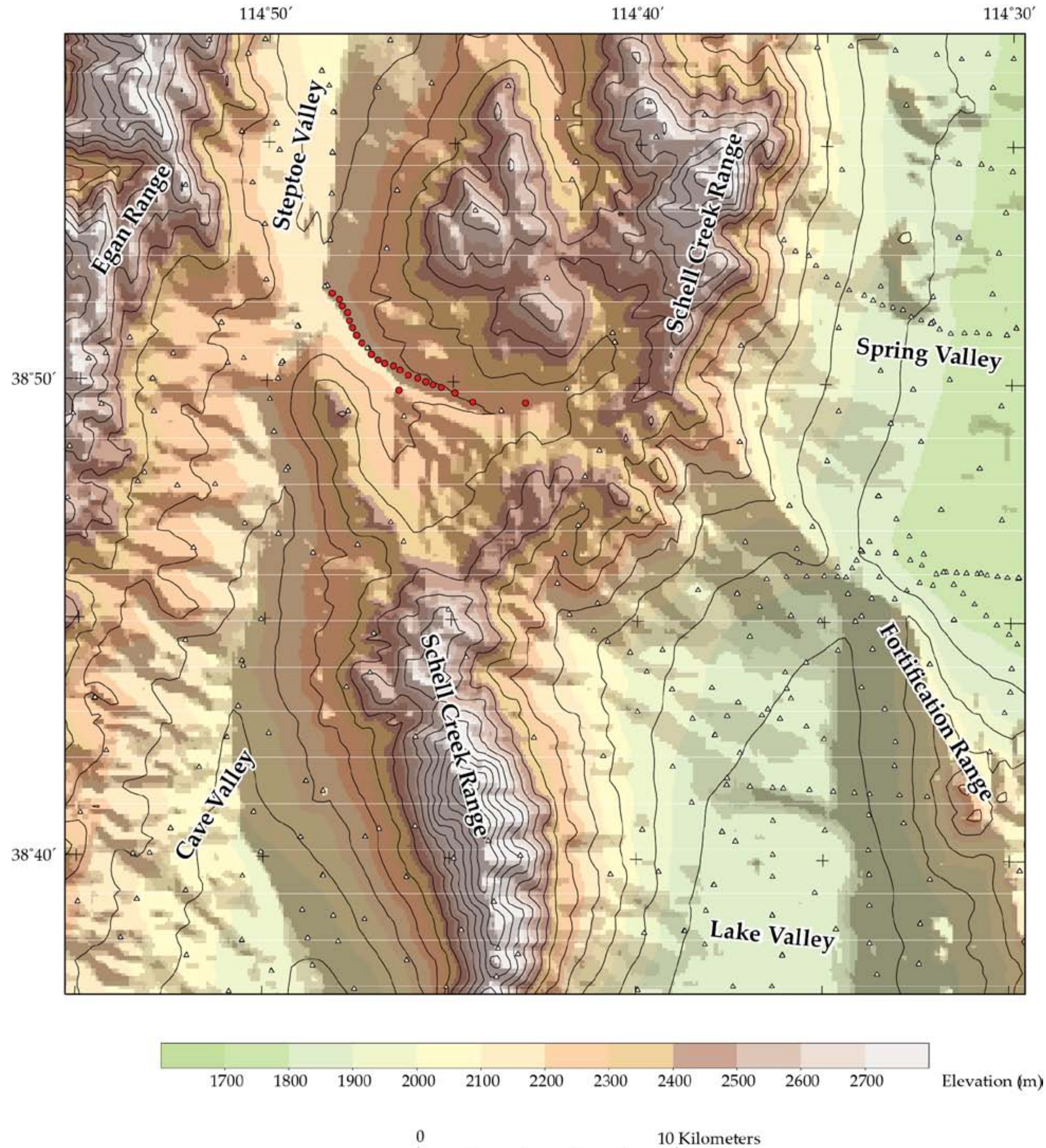

Figure 3. Shaded-relief map of Steptoe, Spring, Cave, and Lake Valleys area, Nev.. Triangles, previously available gravity stations; colored dots, stations added during current study. Contour interval, 100 m.

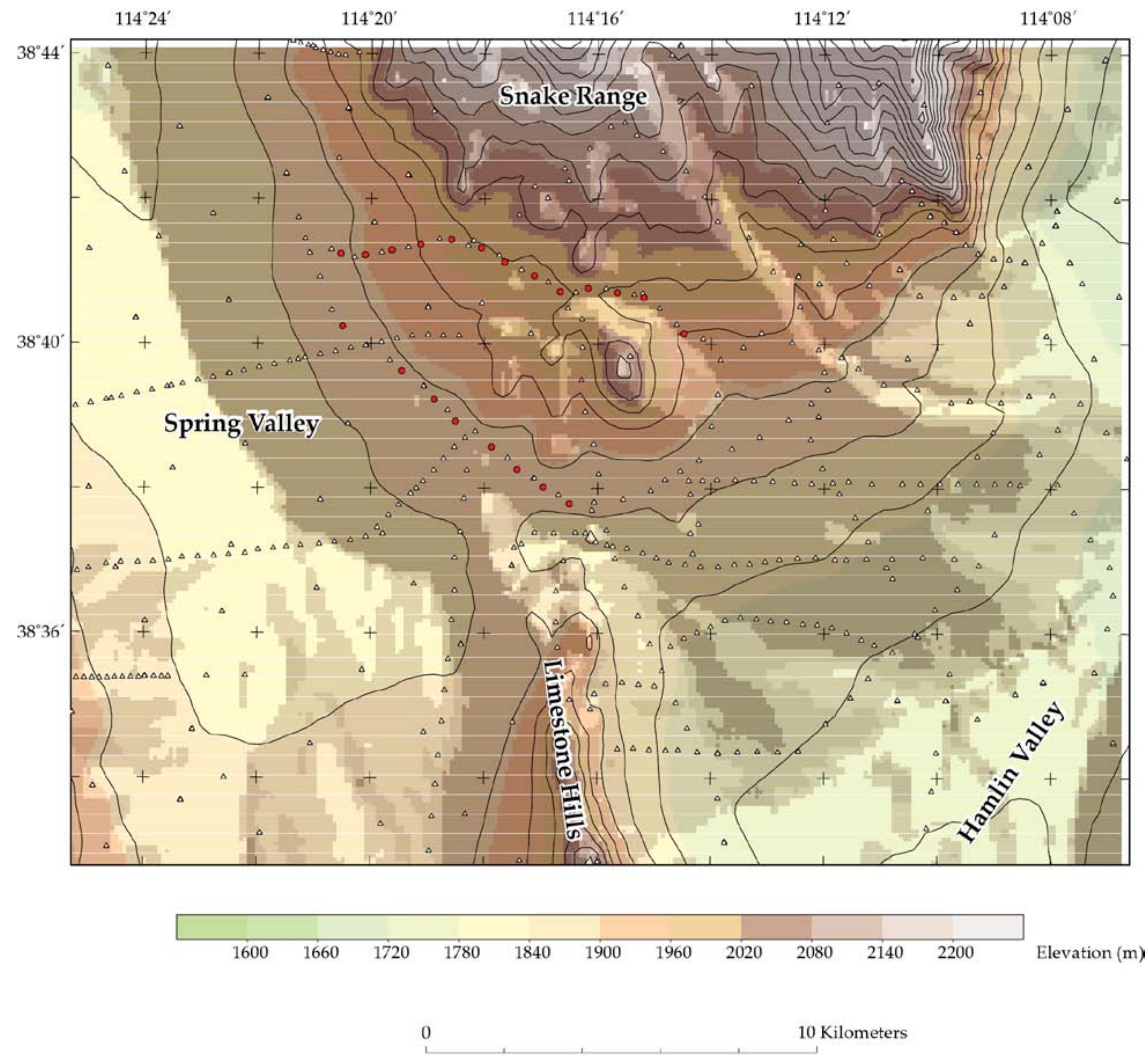

Figure 4. Shaded-relief map of Limestone Hills area, Nev. Triangles, previously available gravity stations; colored dots, stations added during current study. Contour interval, 50 m.

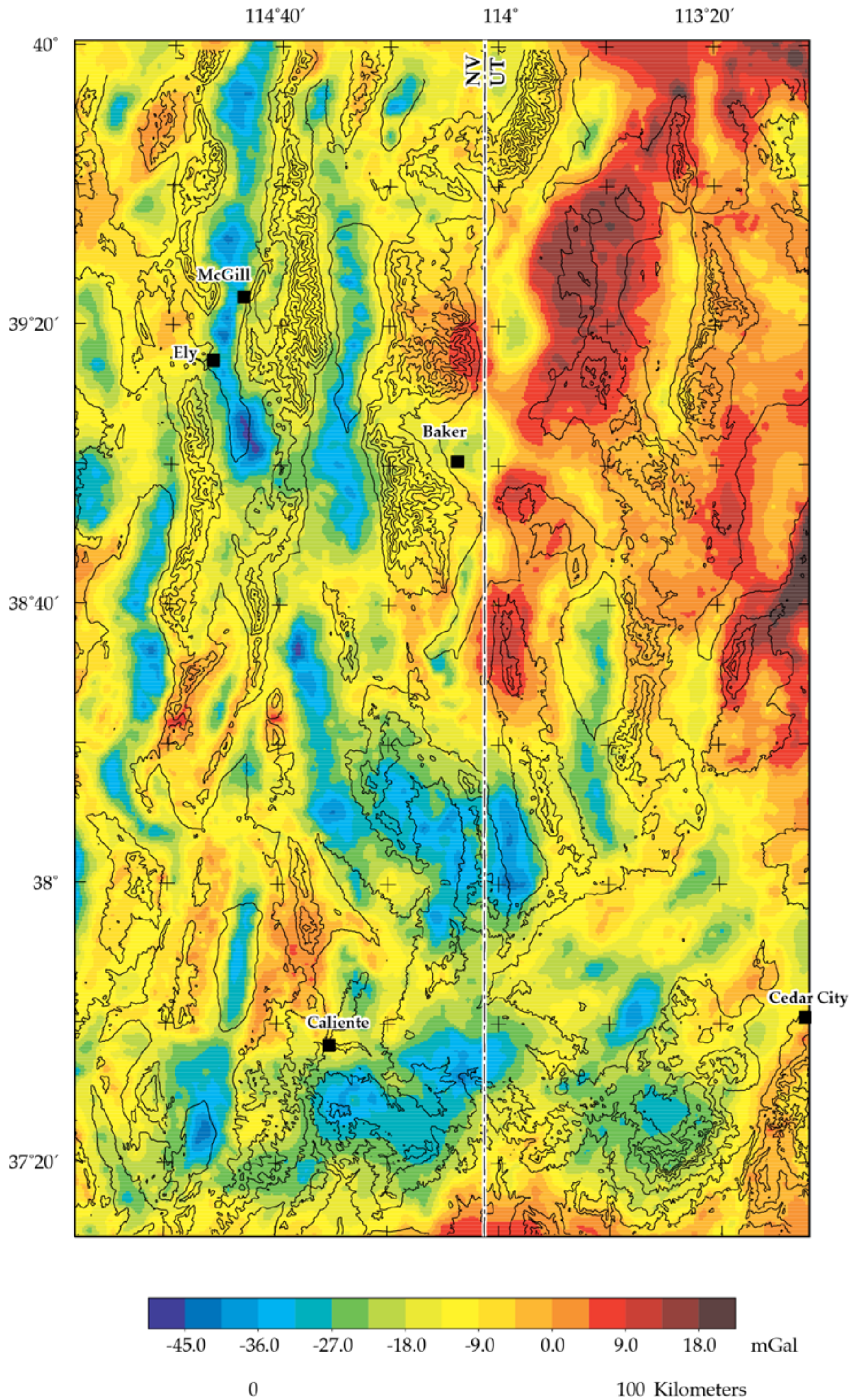

Figure 5. Isostatic-gravity field in eastern Nevada and western Utah (fig. 1). Anomalies reflect local density variations in midcrust and upper crust. Gravity lows (cool colors) generally indicate sedimentary material within valleys; gravity highs (warm colors) generally reflect denser basement rocks in mountain ranges. Contour interval, 300 m.

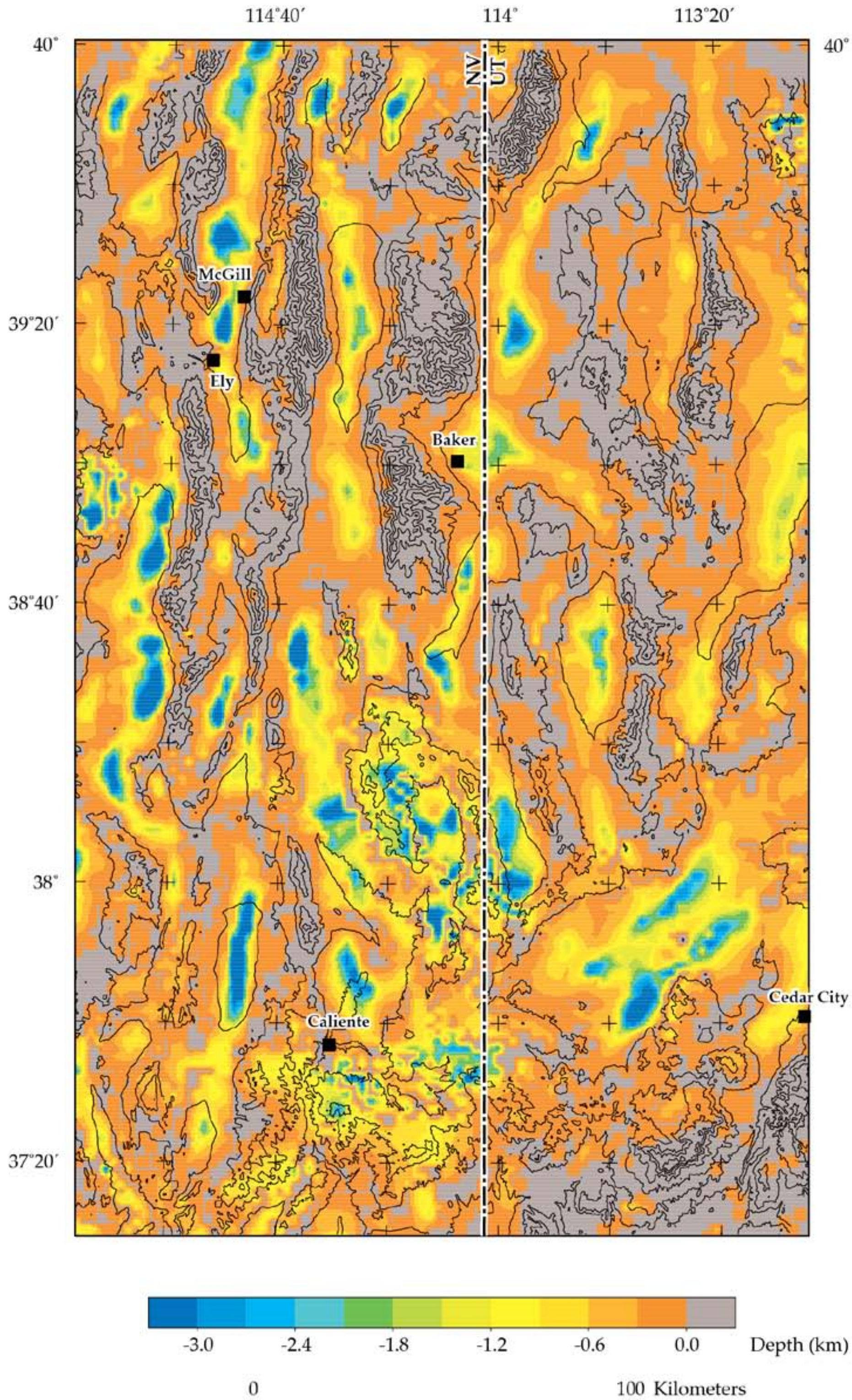

Figure 6. Depth to pre-Cenozoic basement in eastern Nevada and western Utah (figs. 1, 5), calculated using the gravity inversion method of Jachens and Moring (1990). Deepest blue colors denote all depths greater than 3 km. Contour interval, 300 m.

Table 1. Principal facts for new gravity stations, White Pine & Lincoln Counties, Nevada

[Station coordinates, NAD27; elevations, NAVD29; Bouguer anomaly calculated by using a reduction density of 2,670 kg/m³; terrain corrections calculated out to 166.7 km]

Station Name	Longitude °W	Latitude °N	Elevation (meters)	Observed Gravity (mGal)	Free Air Anomaly (mGal)	Total Terrain Correction (mGal)	Complete Bouguer Anomaly (mGal)	Isostatic Anomaly (mGal)
10SNW100	-114.8285	39.1807	1992.7	979462.58	-18.97	1.30	-242.15	-31.94
10SNW101	-114.8045	38.8640	2150.7	979422.98	18.17	1.38	-222.61	-17.14
10SNW102	-114.8013	38.8618	2153.1	979422.73	18.87	1.40	-222.17	-16.71
10SNW103	-114.7998	38.8595	2155.8	979422.62	19.79	1.39	-221.56	-16.16
10SNW104	-114.7977	38.8573	2157.6	979421.51	19.41	1.43	-222.10	-16.73
10SNW105	-114.7967	38.8545	2160.7	979420.38	19.50	1.45	-222.34	-17.03
10SNW106	-114.7953	38.8520	2163.6	979419.54	19.76	1.46	-222.38	-17.14
10SNW107	-114.7935	38.8493	2166.9	979418.25	19.75	1.52	-222.71	-17.52
10SNW108	-114.7912	38.8467	2171.6	979416.83	20.00	1.52	-222.98	-17.81
10SNW109	-114.7867	38.8427	2176.3	979416.87	21.83	1.51	-221.68	-16.57
10SNW110	-114.7837	38.8408	2181.8	979416.07	22.90	1.48	-221.26	-16.19
10SNW111	-114.7807	38.8395	2181.5	979414.50	21.37	1.51	-222.74	-17.68
10SNW112	-114.7770	38.8387	2181.9	979412.93	19.98	1.54	-224.13	-19.10
10SNW113	-114.7740	38.8373	2186.1	979411.00	19.46	1.57	-225.10	-20.11
10SNW114	-114.7702	38.8355	2193.0	979409.29	20.05	1.53	-225.31	-20.34
10SNW115	-114.7660	38.8345	2195.5	979408.78	20.39	1.62	-225.17	-20.22
10SNW116	-114.7623	38.8333	2200.4	979408.29	21.51	1.64	-224.57	-19.64
10SNW117	-114.7590	38.8322	2200.7	979411.43	24.86	1.78	-221.13	-16.21
10SNW118	-114.7553	38.8313	2202.3	979411.37	25.35	1.81	-220.77	-15.90
10SNW119	-114.7493	38.8295	2205.8	979410.45	25.68	1.98	-220.67	-15.88
10SNW120	-114.7413	38.8263	2216.1	979408.52	27.20	1.95	-220.33	-15.52
10SNW121	-114.7175	38.8260	2243.6	979402.00	29.20	2.13	-221.22	-16.43
10SNW122	-114.7743	38.8302	2195.2	979406.97	18.86	1.45	-226.82	-21.99
10SNW123	-114.3423	38.6873	1882.0	979468.01	-4.03	0.76	-215.36	-14.19
10SNW124	-114.3352	38.6870	1896.3	979469.52	1.93	0.79	-210.98	-9.85
10SNW125	-114.3273	38.6882	1916.3	979465.77	4.22	0.84	-210.87	-9.80
10SNW126	-114.3188	38.6895	1940.0	979462.15	7.78	0.93	-209.87	-8.88
10SNW127	-114.3098	38.6907	1964.8	979461.73	14.92	1.02	-205.42	-4.49
10SNW128	-114.3010	38.6887	1982.0	979460.21	18.87	0.99	-203.43	-2.65
10SNW129	-114.2942	38.6855	1984.7	979460.29	20.06	0.94	-202.59	-1.90
10SNW130	-114.2853	38.6823	1971.2	979460.70	16.60	0.92	-204.56	-3.93
10SNW131	-114.2778	38.6787	1975.9	979458.69	16.35	0.92	-205.33	-4.80
10SNW132	-114.2695	38.6795	1992.1	979455.33	17.91	0.98	-205.53	-5.08
10SNW133	-114.2610	38.6785	1979.9	979460.18	19.09	0.98	-202.98	-2.59
10SNW134	-114.2532	38.6773	1965.4	979465.05	19.61	1.06	-200.76	-0.47
10SNW135	-114.2413	38.6690	1927.2	979468.46	11.97	1.06	-204.12	-3.95
10SNW136	-114.2750	38.6298	1844.9	979482.70	4.28	0.51	-203.14	-2.99

10SNW137	-114.2827	38.6337	1849.5	979478.97	1.64	0.51	-206.30	-6.05
10SNW138	-114.2903	38.6377	1860.2	979477.41	3.01	0.51	-206.12	-5.84
10SNW139	-114.2978	38.6428	1868.5	979476.09	3.81	0.51	-206.25	-5.89
10SNW140	-114.3085	38.6488	1874.1	979474.77	3.68	0.51	-207.01	-6.53
10SNW141	-114.3148	38.6538	1878.7	979476.86	6.75	0.54	-204.42	-3.83
10SNW142	-114.3243	38.6603	1881.4	979476.89	7.02	0.56	-204.43	-3.73
10SNW143	-114.3418	38.6707	1864.4	979472.05	-3.94	0.60	-213.47	-12.54
10SNW144	-114.3853	39.7923	1815.3	979585.26	-5.27	1.09	-208.79	-6.63
10SNW145	-114.3797	39.7922	1798.8	979589.77	-5.83	1.04	-207.56	-5.49
10SNW146	-114.3727	39.7917	1780.1	979594.05	-7.27	1.00	-206.95	-4.98
10SNW147	-114.3570	39.7870	1739.1	979593.01	-20.55	0.94	-215.68	-13.86
10SNW148	-114.3490	39.7832	1734.8	979585.79	-28.74	0.88	-223.46	-21.77
10SNW149	-114.3390	39.7780	1732.8	979582.05	-32.65	0.87	-227.14	-25.55
10SNW150	-114.3167	39.7692	1734.5	979587.92	-25.47	1.10	-219.92	-18.68
10SNW151	-114.3083	39.7665	1744.5	979592.11	-17.97	1.27	-213.37	-12.26
10SNW152	-114.3000	39.7638	1768.6	979590.62	-11.77	1.47	-209.68	-8.73
10SNW153	-114.2878	39.7643	1795.0	979588.63	-5.67	1.85	-206.17	-5.55
10SNW154	-114.2423	39.8128	1853.1	979582.25	1.54	1.10	-206.21	-7.36
10SNW155	-114.2485	39.8175	1828.7	979587.46	-1.17	1.00	-206.29	-7.36
10SNW156	-114.2552	39.8227	1804.2	979591.80	-4.85	0.93	-207.30	-8.28
10SNW157	-114.2608	39.8268	1787.2	979594.58	-7.69	0.86	-208.29	-9.16
10SNW158	-114.2747	39.8367	1750.8	979596.48	-17.88	0.79	-214.47	-15.19
10SNW159	-114.2800	39.8405	1742.1	979594.73	-22.66	0.78	-218.30	-18.92
10SNW160	-114.2872	39.8447	1728.2	979592.26	-29.77	0.79	-223.84	-24.32
10SNW161	-114.3008	39.8520	1716.8	979585.11	-41.11	0.85	-233.83	-34.11
10SNW162	-114.3185	39.8610	1711.3	979583.60	-45.10	1.06	-237.00	-37.04
10SNW163	-114.3265	39.8648	1712.7	979585.12	-43.49	1.25	-235.36	-35.34
10SNW164	-114.3348	39.8675	1715.5	979589.98	-38.00	1.50	-229.93	-29.75
10SNW165	-114.3017	39.8607	1715.7	979584.78	-42.54	0.86	-235.13	-35.54
10SNW166	-114.2943	39.8642	1716.9	979586.93	-40.33	0.82	-233.10	-33.74
10SNW167	-114.2872	39.8688	1719.0	979588.87	-38.15	0.78	-231.19	-32.09
10SNW168	-114.2725	39.8763	1726.5	979592.00	-33.41	0.71	-227.35	-28.79
10SNW169	-114.2562	39.8835	1731.1	979596.65	-27.95	0.66	-222.47	-24.37
10SNW170	-114.2480	39.8870	1736.9	979598.08	-25.06	0.63	-220.25	-22.43
10SNW171	-114.2402	39.8907	1740.3	979599.95	-22.46	0.61	-218.06	-20.50
10SNW172	-114.2335	39.8960	1741.5	979602.60	-19.90	0.60	-215.65	-18.38
10SNW173	-114.3192	39.8528	1712.7	979582.61	-44.95	1.00	-237.06	-36.96
10SNW174	-114.3272	39.8495	1713.8	979581.57	-45.35	1.08	-237.50	-37.19
10SNW175	-114.3355	39.8458	1718.9	979581.89	-43.12	1.15	-235.78	-35.23
10SNW176	-114.3675	39.5998	1806.5	979565.58	-10.56	0.81	-213.37	-9.45
10SNW177	-114.3525	39.6077	1840.3	979562.39	-4.01	0.88	-210.55	-7.02
10SNW178	-114.3467	39.6122	1853.6	979557.88	-4.82	0.86	-212.87	-9.50
10SNW179	-114.3402	39.6170	1868.9	979555.11	-3.32	0.84	-213.10	-9.95
10SNW180	-114.3337	39.6210	1881.6	979549.90	-4.97	0.86	-216.15	-13.21
10SNW181	-114.3267	39.6245	1892.2	979545.44	-6.46	0.84	-218.85	-16.10
10SNW182	-114.3188	39.6280	1914.1	979539.78	-5.68	0.86	-220.51	-18.01
10SNW183	-114.3105	39.6320	1934.7	979535.30	-4.18	0.87	-221.30	-18.99

10SNW184	-114.3028	39.6355	1951.1	979532.95	-1.77	0.89	-220.71	-18.61
10SNW185	-114.3098	39.6405	1929.7	979540.67	-1.10	0.94	-217.59	-15.35
10SNW186	-114.3023	39.6447	1965.0	979535.16	3.90	0.97	-216.52	-14.52
10SNW187	-114.2942	39.6467	1988.7	979531.60	7.47	1.02	-215.54	-13.76
10SNW188	-114.2888	39.6508	2007.8	979529.07	10.48	1.09	-214.62	-13.02
10SNW189	-114.2743	39.6593	2058.2	979519.93	16.10	1.34	-214.38	-13.27
10SNW190	-114.2687	39.6632	2081.2	979516.65	19.57	1.49	-213.32	-12.40
10SNW191	-114.2625	39.6670	2108.8	979513.63	24.73	1.70	-211.05	-10.32
10SNW192	-114.2742	39.6715	2076.0	979519.93	20.52	1.70	-211.59	-10.64
10SNW193	-114.2888	39.6783	2019.9	979532.05	14.72	1.58	-211.22	-9.92
10SNW194	-114.3062	39.6832	1962.6	979545.83	10.41	1.35	-209.36	-7.65
10SNW195	-114.3372	39.6977	1867.1	979561.15	-4.99	1.09	-214.32	-11.99
10SNW196	-114.3492	39.7045	1828.7	979569.81	-8.77	0.93	-213.96	-11.39
10SNW197	-114.3550	39.7178	1797.3	979577.15	-12.32	0.88	-214.04	-11.50
10SNW198	-114.3635	39.7248	1780.8	979583.06	-12.11	0.87	-211.99	-9.35

Table 2. Cenozoic density-depth function for eastern Nevada and western Utah.

Depth range (km)	**Sedimentary rocks (kg/m^3)**	**Volcanic rocks (kg/m^3)**
0 to 0.2	2,020	2,220
0.2 to 0.6	2,120	2,270
0.6 to 1.2	2,320	2,320
> 1.2	2,420	2420