BOUGUER GRAVITY MAP OF CALIFORNIA

DEATH VALLEY SHEET

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GRAVITY DATA

The Death Valley sheet area is located in east-central California between 36° and 37° North latitude and 116° and 118° West longitude (figure 1). The gravity data for this sheet were compiled by Chapman and Healey and consist of values from approximately 1,600 stations. Of these gravity values, approximately 375 are from stations occupied by California Division of Mines and Geology field parties during the period 1968–1970; most of the remainder are the result of work by the U. S. Geological Survey (Mabey, 1963, 1966; Pakiser and others, 1964; Healey and Miller, 1971; and unpublished data furnished by H. W. Oliver, D. R. Mabey, D. L. Peterson and T. H. Nilsen). A large part of the California Division of Mines and Geology field work and data reduction was accomplished with financial assistance and the loan of equipment from the U. S. Army Map Service. The sources of the data are shown on the map sheet.

Approximately 160 of the gravity stations were reached by helicopter; the remainder were reached by ground transportation or on foot. Most stations were read near bench marks and sites of spot elevations shown on U. S. Geological Survey topographic maps and unpublished manuscript sheets. Elevations of many additional stations were obtained either by photogrammetric methods or by plane table, level, and transit surveys during the U.S. Geological Survey gravity survey.

The values of observed gravity from the various surveys were adjusted to a common datum by the use of a network of gravity base stations which had been established in this part of California by Chapman (1966), Mabey (1966), and Robbins (1971). This base network is on the datum of Behrendt and Woollard (1961) and Woollard and Rose (1963) that has been tied to stations of the national gravity base station network in California and Nevada (Schwimmer and Rice, 1969).

La Coste-Romberg geodetic gravity meters were used for the more recent surveys beginning about 1968, whereas Worden and Frost meters were used for most of the earlier work. The calibrations of meters used for the recent surveys were determined on one or more of the U.S. Geological Survey calibration ranges in California (Barnes and others, 1969). The meter calibrations and datum used for the earlier surveys were checked and adjusted where necessary by reoccupying some common stations and comparing values of observed gravity.

For data gathered in 1968 and later, inner zone terrain corrections were made manually to 2.29 km using Hayford-Bowie templates (Swick, 1942); additional corrections for the distance between 2.29 and 166.7 km were calculated by a U.S. Geological Survey computer program (Plouff, 1966). Terrain corrections for the earlier data were carried out to a radius of 166.7 km where necessary by using manual calculations with some interpolation of values (Mabey, 1963). All data were processed to complete Bouguer anomalies by means of a U.S. Geological Survey reduction program, using a density of 2.67 g/cm^3.

Errors in the gravity values resulting from uncertainties in horizontal and vertical control and observed gravity may exceed a few tenths of a mgal for some of the stations. Terrain corrections range from small in areas of gentle relief to very large in areas of steep local relief; for example, the terrain correction for a station at Death Valley Junction was about 0.3 mgal; that for a station on Telescope Peak was about 80 mgal. Because terrain corrections may be in error by as much as 10 percent, the error in the Telescope Peak gravity value could be as much as about 8 mgal. This is an extreme case, however, because of the unusual magnitude of the terrain correction. Most such errors are probably less than a mgal.

Bouguer anomaly values were contoured with a 5 mgal interval and are overprinted on the Death Valley sheet of the Geologic Map of California, Olaf P. Jenkins edition (Jennings, 1958). A tabulation of the principal facts for the stations used and a map showing station numbers and locations are available on request from the California Division of Mines and Geology, Sacramento, California.

REGIONAL GEOLOGY

The Death Valley sheet area lies wholly within the Basin and Range physiographic province. The southern edge of the province terminates approximately along the Garlock fault, about 30 miles south of the area. The western limit of the Basin and Range province terminates along the east edge of the Sierra Nevada only a few miles west of the west edge of the area.

The rocks of the region are typical of those that occur in much of the southwestern part of the Basin and Range province. The stratigraphic succession is moderately complete for rocks of late Precambrian through Paleozoic age. The strata rest on metamorphosed Precambrian rocks, are intruded by Mesozoic rocks, and are, in turn, overlain by Cenozoic sedimentary and volcanic flow rocks.

The valleys and mountains are mostly fault controlled, and most of the faults are probably younger than Miocene in age. Many displacements along faults have occurred during Quaternary time, as evidenced by the many scarps in Quaternary fan deposits. Many of the ranges have been tilted downward on the east as a result of rotation on large normal faults. This is demonstrated by the steep west slopes of the ranges, the common dip of strata to the east, and the common occurrence of the youngest strata on only the east slopes of ranges. The central parts of Death Valley and Panamint Valley have their lowest parts along the east side of the valleys, suggesting, too, that these valleys have been similarly rotated.

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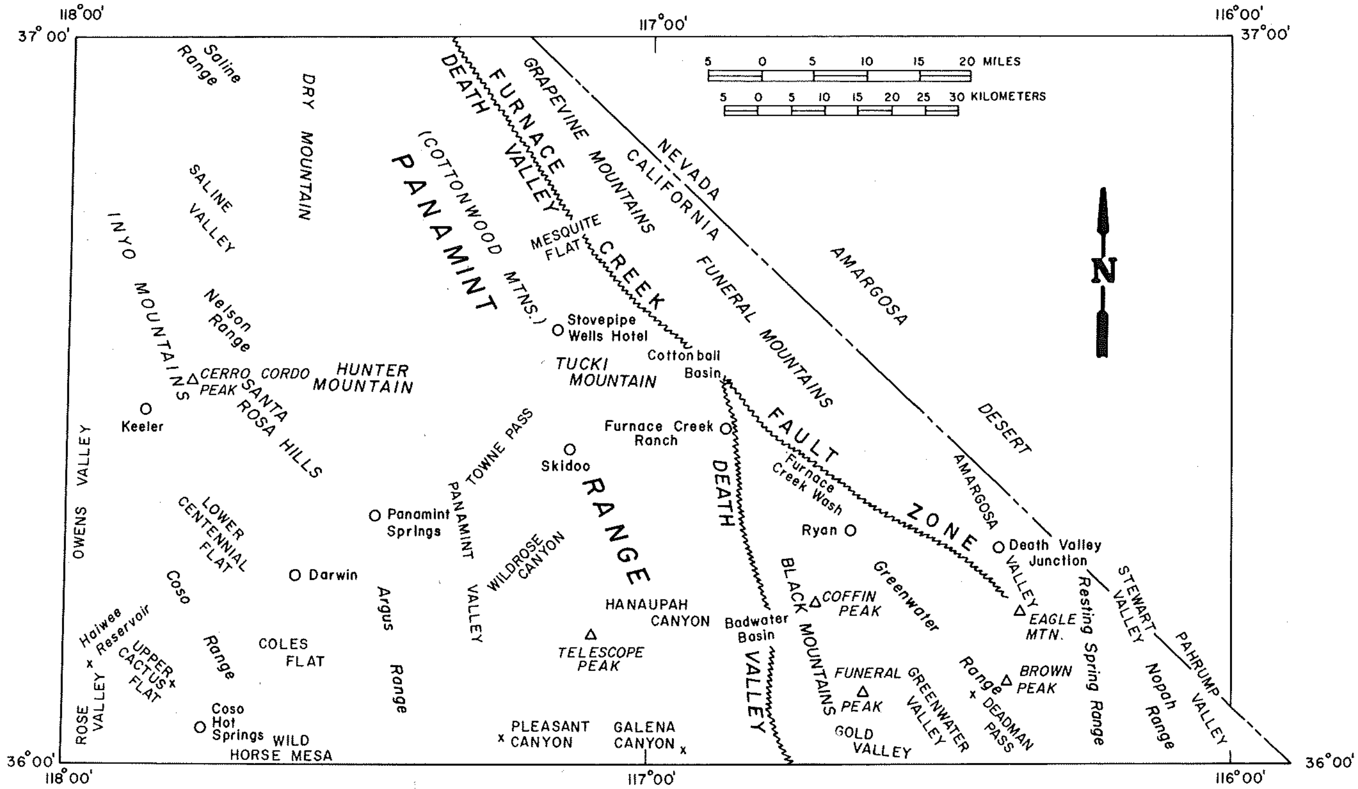

Figure 1. Index map showing location of geographic names used in this report.

The most abundant of the recognized faults are normal faults that trend mainly north to northeast. The normal faults are closely related to northwest-trending lateral-slip faults—the Saline Valley fault zone and the Death Valley-Furnace Creek fault zone (Wright and Troxel, 1967, p. 948).

DESCRIPTIVE GEOLOGY

Precambrian Rocks

Precambrian rocks in the area of the Death Valley sheet are divided informally according to their relative age into three groups: earlier Precambrian rocks, later Precambrian rocks, and even younger Precambrian strata that grade upward into Cambrian strata. The division of earlier and later Precambrian rocks is based, in part, on a strong contrast in the degree of metamorphism of rocks in the Death Valley region, as well as on a regional unconformity that separates them. The younger Precambrian rocks (€ ? on the map) include sedimentary rocks that rest unconformably upon the earlier and later Precambrian rocks.

Some of the earlier Precambrian rocks that are exposed within the Death Valley sheet area have been dated by radiometric methods. Rocks exposed in the east side of the Panamint Range, barely south of the south border of the map sheet, have yielded ages ranging from 1660 million years to 1780 million years (Wasserberg and others, 1959; Silver and others, 1962). Because most of the rest of the earlier Precambrian rocks in the map area are similar in composition and degree of metamorphism and lie beneath the regional unconformity, they are usually considered to be of the same general age.

Earlier Precambrian rocks are exposed low on the west side of the Panamint Range, in a small area of Tucki Mountain, and in the Black Mountains. Diorite in the Black Mountains is shown on the map as being earlier Precambrian, but its age has not been confirmed by radiometric methods.

The earlier Precambrian rocks are meta-igneous and metasedimentary in origin, and most are strongly foliated. They probably include rocks of the highest density in the area.

The later Precambrian rocks include the sedimentary strata of the Pahrump Group, which is divisible into the Crystal Spring Formation, the Beck Spring Dolomite, and the Kingston Peak Formation. The third group of Precambrian rocks, the succession of younger rocks that overlie the Pahrump Group, includes successively, the Noonday Dolomite, Johnnie Formation, and Stirling Quartzite. Within the limits of this area, most of the Pahrump rocks are moderately to strongly metamorphosed. Additionally they are increasingly metamorphosed from south to north. From a relatively unmetamorphosed state in the east flank of the southern part of the Panamint Range, the rocks progressively increase in metamorphic grade to their northernmost outcrop limit in the northern part of the Panamint Range in Tucki Mountain. Similar rocks in the Funeral Mountains are increasingly metamorphosed from south to north (Troxel and Wright, 1968). Likewise the overlying Precambrian strata in both ranges are progressively metamorphosed from south to north. For instance, siltstone in the southern part of the Funeral Mountains is the stratigraphic equivalent of garnet muscovite schist or staurolite muscovite schist in the northern part of the range. The increase in metamorphic grade undoubtedly has some influence upon the gravity pattern in the region but may be too slight to be detected.

Rocks of the Pahrump Group are sedimentary in origin except for a sill of diabase that generally occurs wherever the lowest formation, the Crystal Spring Formation, is exposed. The Pahrump Group crops out mainly as a nearly continuous band along the upper west flank of the Panamint Range and a less-continuous band in the Funeral Mountains. The rocks that overlie the Pahrump Group, too, are sedimentary in origin and are, in large part, silicic clastic rocks. The post-Pahrump sedimentary strata of Precambrian age underlie the entire crestal and eastern flank of the Panamint Range, a large part of the Funeral Mountains, and small parts of the western flank of the Resting Spring Range.

Paleozoic Rocks

Paleozoic rocks exposed in the area of the Death Valley sheet are, for the most part, carbonate strata of marine origin. The carbonate strata tend to grade westward to clastic strata. Younger Paleozoic rocks contain less carbonate strata than older Paleozoic rocks. Paleozoic rocks are found in abundance in all of the ranges on the Death Valley sheet except the Black Mountains, the Greenwater Range, and the Coso Range. They appear to be unmetamorphosed nearly everywhere except near margins of intrusive igneous rock masses.

Mesozoic Rocks

Mesozoic rocks, mainly intrusive igneous rocks of granitic composition, occur west of Death Valley. A relatively thin, southeast-trending band of Triassic marine sedimentary rocks and Jura-Triassic volcanic rocks crop out for a few miles along the southwest side of the Inyo Mountains. Isolated masses of metamorphosed sedimentary and volcanic rocks in the Coso Range also may be Mesozoic in age.

Cenozoic Rocks

Tertiary rocks. The Tertiary rocks comprise intrusive and extrusive igneous rocks and nonmarine sedimentary rocks. Intrusive igneous rocks in the form of small plutons occur in the southern part of the Greenwater Range, the Black Mountains, and in the Panamint Range.

Extrusive and associated shallow intrusive rocks are common throughout the area of the Death Valley sheet. They comprise a series of flows and pyroclastic rocks of probable early to mid-Tertiary age that are generally basic to intermediate in composition; a series of flows and pyroclastic rocks of middle to late Tertiary age that are intermediate to acidic in composition; and basalt and andesite flows of very late Tertiary age. Because age determinations of most igneous rocks in the area are moderately scarce, ages of these rocks are not everywhere well established. Ages determined by the potassium-argon method for nine samples of Tertiary volcanic rocks from the Black Mountains range from 5.3 to 8.0 million years (Fleck, 1970, p. 2810). Most Tertiary volcanic rocks appear to have formed in highland areas.

Tertiary sedimentary rocks range in age from Oligocene to Pliocene. Fine-grained lacustrine strata were laid down in several Tertiary basins which, for the most part, continue to be reflected by the modern topography. No single basin seems to have a complete section of Tertiary sedimentary rocks. The lake beds are subordinate to the coarse fan debris that was deposited over a much larger area than were the lake beds.

Quaternary rocks. Quaternary rocks consist of valley playa sediments, coarse fan debris that flanks every mountain range, and local basalt to andesite extrusive rocks.

MINERAL RESOURCES

A wide variety of both metallic and nonmetallic minerals and commercial rock materials occur or have been mined from deposits that lie within the limits of the area encompassed by the Death Valley sheet (figure 2). Those metals that have been of most economic significance in approximate order of value are lead, gold, silver, tungsten, zinc, antimony, and iron. The nonmetallic and commercial rock materials, in approximate order of value, are borate minerals, saline minerals, talc, volcanic rocks, and carbonate rocks. The reader should refer to other published reports for authoritative or specific data regarding the mineral resources (for example, see Norman and Stewart, 1951).

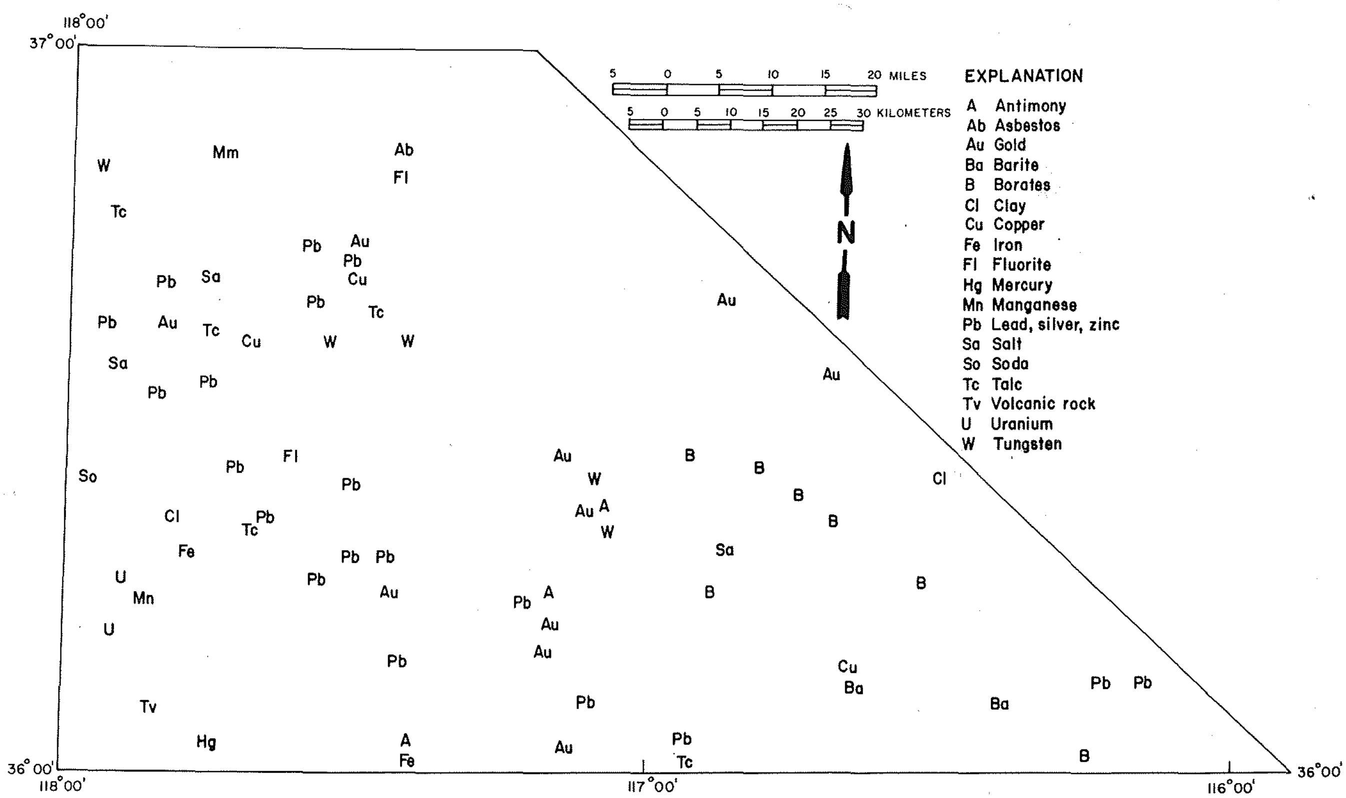

Figure 2. Index map showing approximate locations of selected mineral resources of the Death Valley sheet area ***(after Norman and Stewart, 1951, plate 1).***

Sulfide minerals and the oxide minerals derived from them have been the principal sources of antimony, copper, lead, silver, and zinc. Most of the economic deposits and lesser occurrences of these metals lie within a belt about 10 miles wide that extends between the southern part of the Inyo Mountains southeastward to Galena Canyon on the east side of the Panamint Range. These deposits occur chiefly in Paleozoic carbonate host rocks.

Tungsten occurs in sedimentary strata adjacent to granitic rocks in the Panamint Range, Hunter Mountain, and the Inyo Mountains. The principal tungsten mineral is scheelite, which occurs both in disseminated form and in veins. The known occurrences of tungsten mineralization lie along the northeast margin of the belt of sulfide minerals.

Saline minerals, including borates, are associated mainly with Cenozoic lake bed deposits. They occur at Owens Lake (soda), Saline Valley (salt), Furnace Creek Wash (borates), Death Valley (borates, salt), and near Shoshone (borates).

The principal areas of gold mineralization are in the Funeral Mountains, Panamint Range, Inyo Mountains, and the Argus Range. The gold occurs mainly in or adjacent to the northwest-trending belt of sulfide minerals, where it is usually found in quartz veins either in Mesozoic granitic intrusive rocks or in adjoining sedimentary rocks.

Talc is associated with Precambrian diabase where the diabase has intruded and altered Precambrian carbonate rocks, as in the southern Panamint Range. Talc also occurs as a product of alteration of Paleozoic sedimentary rocks in the southern part of the Inyo Mountains.

REGIONAL GRAVITY FIELD

Gravity values in the Death Valley sheet area range from a low of less than —220 mgal in Owens Valley, on the west edge of the map sheet, to highs of more than —80 mgal each in the Funeral Mountains, just southwest of the California-Nevada state line, and in the Black Mountains, east of Death Valley, near the south edge of the map. Gravity values generally decrease both westward and northward throughout most of the map sheet area. A few miles west of the west edge of the area the decrease in the gravity field culminates in a major north-trending negative anomaly, the axis of which is centered near the crest of the Sierra Nevada. This large negative anomaly has been attributed largely to the isostatic effect of the Sierra Nevada (Oliver and Mabey, 1963, p. 1296).

The northward component of decrease in the gravity field on the Death Valley sheet probably results from the fact that anomaly values plunge northward along the trough of the Sierra Nevada minimum at the rate of about a mgal per mile (Oliver and Mabey, 1963, p. 1296). The gradient of the resulting regional gravity field increases northwestward from less than a mgal per mile in the southeastern part of the sheet, to about 2 mgal per mile in the northwestern part of the sheet. Thus, the relatively low gravity value in Owens Valley (—220 mgal), for example, results from the superposition of a negative anomaly associated with the valley on a regional gravity minimum.

On the basis of the fact that gravity values in the area near Death Valley are higher than those associated with the Sierra Nevada to the west and with the Basin and Range to the northeast in Nevada, Hunt and Mabey (1966, p. A99) suggest that the crust is relatively thin near Death Valley and that it thickens both westward and northeastward.

GRAVITY ANOMALIES

The gravity field in the Death Valley sheet area is characterized by large local gravity anomalies that have the usual association of highs with mountain ranges and lows with the intervening valleys typical of most of the rest of the Basin and Range province. Thus, the general pattern of the gravity field is one of north- to northwest-trending predominantly elongate anomalies superimposed on the regional field. This pattern reflects the general topographic, and many of the structural, trends of the area.

Considering the regional gravity gradient, the highest anomaly values in the area are generally associated with Paleozoic and older rocks exposed in the mountain ranges. The lowest anomaly values are generally over Cenozoic sediments and sedimentary rocks in the basins, as might be expected. Gravity anomalies in areas underlain mainly by Mesozoic granitic intrusive rocks are usually at an intermediate level, perhaps close to the normal regional background. These results tend to show over-all agreement with the measured values of densities for the various rock units in the area, summarized in table 1. Granitic rocks have an average density of close to 2.67 g/cm^3, the density used for the gravity reductions; in contrast, metamorphic rocks have a higher average density (range 2.53–3.08 g/cm^3, average 2.80 g/cm^3), and Cenozoic rocks and sediments, a lower density (range 1.89–2.40 g/cm^3, average between 2.1 and 2.2 g/cm^3). Tertiary volcanic rocks exhibit a wide range in densities, from 1.76 to 2.73 g/cm^3, but probably average about 2.4 g/cm^3. Paleozoic clastic and carbonate rocks have an average density of about 2.72 g/cm^3, which is close to the value used for the gravity reductions (2.67 g/cm^3).

Elevations which occur on the Death Valley sheet range from 11,049 feet at Telescope Peak in the Panamint Range to —282 feet in Death Valley, at a point about 15 miles east of Telescope Peak. Because of this large range in elevation, gravity anomalies over rock units which have average densities that differ appreciably from the reduction density used (2.67 g/cm^3) tend to be emphasized. This fact may be a part of the explanation for the steep local gravity gradients and large anomalies found at various places on the Death Valley sheet, especially where dense rocks in mountainous areas adjoin less dense Cenozoic rocks in the valleys.

Discussion of the interpretation of gravity anomalies in large parts of the Death Valley sheet have been presented in earlier publications. Mabey (1963) described the major gravity anomalies in the area south of about 36° 50′ and east of Owens Valley; Kane and Pakiser (1961) and Pakiser and others (1964) presented an interpretation of the Owens Valley anomaly; Mabey (1961) considered anomalies in the Darwin area; and Healy and Press (1964) discussed Rose Valley in the southwestern corner of the map sheet. New gravity data have been added to the Death Valley sheet in many areas, particularly in the mountain regions, since the dates of the publications listed above. Although the new data provide additional details in these areas, as well as coverage in other previously unsurveyed areas, the over-all observations and conclusions reported in the earlier publications remain essentially unchanged. The reader is referred to these papers for additional details.

Southern Owens Valley

The eastern part of Owens Valley has a pronounced gravity minimum (—220 mgal) which is centered in Owens Lake on the western edge of the area. As suggested by Kane and Pakiser (1961, p. 14), the gravity field in Owens Valley indicates a broad, deep basin with a northerly trend. Contours that reflect a steep gravity gradient trend northwest across the northeastern part of Owens Lake and are parallel to the trend of the adjoining Inyo Mountains. This gradient suggests the presence of a fault or faults which, in this area, must be located well out in the valley west of the bedrock-alluvium contact at the base of the Inyo Mountains. The steep gradient becomes more diffuse southward, but it can be traced as far as Lower Centennial Flat in the northern part of the Coso Range.

On the basis of a residual anomaly of 40 mgal over the valley, Pakiser and others (1964, p. 28) estimated the thickness of valley fill in the deepest part of Owens Valley near Owens Lake to be about 8,000 feet, assuming an effective density contrast of 0.5 g/cm^3. From the center of Owens Lake southward, the gravity minimum narrows; but it continues into

Table 1. Tabulated density data from samples obtained from, or adjacent to, the Death Valley area.

Age		*Number of samples*	*Density* (g/cm^3) *Range*	*Average*	*Remarks and references*
Quaternary	Alluvium	5	1.89–2.13	1.93	Core data, China Lake (von Huene, 1960, p. 89).
	Alluvium	--	----	2.2–2.3	Owens Valley area (Pakiser, Kane, and Jackson, 1964).
	Alluvium	--	----	2.01	Mean of more than 7000 feet, Yucca Flat, Nevada (Healey, 1970, p. B61).
	Alluvium	--	----	2.18	Mean of more than 18,000 feet, Hot Creek Valley, Nevada (Healey, 1970, p. B61).
	Alluvium	--	2.0–2.1	2.1	Three density profiles (von Huene, 1960, p. 87).
	Alluvium	--	2.0–2.4	----	Southern Owens Valley (Kane and Pakiser, 1961, p. 13).
	Alluvium	--	----	2.2	Virginia City-Mount Rose area (Thompson and Sandberg, 1958, p. 1271).
	Alluvium	3	2.48–2.72	2.60	Argus Range (von Huene, 1960, p. 88).
Tertiary	Volcanic rocks (undifferentiated)	22	1.36–2.37	----	Long Valley area (Pakiser, Kane, and Jackson, 1964, p. 22).
	Volcanic rocks (undifferentiated)	--	----	2.40	Death Valley area (estimated) (Mabey, 1963).
	Rhyolite	--	----	2.35	Hot Creek Valley, Nevada (Healey, 1970, p. B55).
	Tuff and rhyolite	--	2.06–2.42	2.22	Data from 14 holes, Pahute Mesa, Nevada (Healey, 1968, p. 153).
	Basalt	6	2.59–2.73	2.66	Long Valley (Pakiser, Kane, and Jackson, 1964, p. 22).
Pre-Tertiary	Plutonic rocks (undifferentiated)	8	2.55–2.90	2.67	Mountains around Indian Wells Valley (von Huene, 1960, p. 88).
	Plutonic rocks (undifferentiated)	--	2.55–2.75	2.65	Inyo Mountains-Coso Mountains (Kane and Pakiser, 1961, p. 13).
	Plutonic rocks (undifferentiated)	10	2.42–2.69	2.60	Long Valley area (Pakiser, Kane, and Jackson, 1964, p. 22).
	Plutonic rocks (undifferentiated)	--	----	2.67	Black Mountains area (Mabey, 1963).
Paleozoic	Clastic and carbonate	--	----	2.75	Inyo Mountains (Kane and Pakiser, 1961, p. 13).
	Clastic and carbonate	--	2.60–2.85	2.69	Black Mountains area (Mabey, 1963).
Precambrian	Metamorphic rocks	8	2.67–3.08	2.86	Black Mountains area (Mabey, 1963).
	Metamorphic rocks	24	2.53–2.98	2.76	Clark County, Nevada (Kane, 1963).
	Metamorphic rocks	9	2.63–2.94	2.78	Long Valley area (Pakiser, Kane, and Jackson, 1964, p. 22).

Rose Valley in the southwestern corner of the map sheet. Utilizing seismic refraction data as well as the gravity data, Pakiser and others (1964, plate 1) interpreted the relatively steep gradients on both sides of the southern end of the valley as representing a system of north-trending faults. The fault or faults marking the western side of southern Owens Valley and Rose Valley lie west of the limits of the map sheet throughout much of their lengths but are present in the southwestern corner of the map sheet west of Haiwee Reservoir and Coso Junction. Although the fault displacement evidently decreases southward, Healy and Press (1964, p. 354) found a maximum depth of valley fill of about 5,500 feet in Rose Valley on the basis of gravity data, assuming a density contrast of 0.5 g/cm^3.

Inyo Mountains—Argus Range

The Inyo Mountains are marked by a prominent northwest-trending positive gravity anomaly. The anomaly is associated chiefly with Paleozoic and Mesozoic sedimentary rocks except near the west edge of the area at a latitude of about 36° 45′ N where a relatively narrow segment of the anomaly (−150 contour) is located over Mesozoic granitic rocks. This segment is one of the few examples of a prominent gravity high over granitic rocks in the Death Valley sheet area and may indicate either that these particular rocks are unusually dense or that they are underlain by denser rocks at shallow depth. Gravity values near the northwestern corner of the area decrease to about −195 mgal over granitic rocks on the eastern flank of the Inyo Mountains. This low value probably reflects the northwestward-dipping regional gravity gradient rather than a local geologic feature.

The positive anomaly southeast of Cerro Gordo Peak in the Inyo Mountains widens and continues southeastward through the Santa Rosa Hills. West of Panamint Springs gravity values reach a maximum of greater than −130 mgal. The trend of the anomaly turns southward along the east edge of Argus Range near Panamint Springs, but the anomaly decreases in amplitude in this direction, and gravity values become less than −140 mgal at latitude 36° 05′ N.

The center of the −130 mgal positive anomaly closure west of Panamint Springs is north of the northern end of the Argus Range in an area largely covered by Tertiary volcanic rocks and alluvium. Scattered outcrops of Paleozoic sedimentary rocks, however, suggest that these rocks may underlie much of this area. As a result of a study of the Darwin area, Mabey (1961, p. C276) concluded that the local gravity anomaly of more than 10 mgal may be caused by dense, altered sedimentary rocks (calc-hornfels) along the eastern side of an intrusive body. The presence of an intrusive body in this area is suggested by an aeromagnetic anomaly northeast of Darwin.

The Coso Range

The Coso Range, between southern Owens Valley and Rose Valley and the Argus Range, consists of a series of hills of generally moderate relief but lacks the prominent linear trend characteristic of the Basin and Range province. Rock types exposed in the Coso Range are principally Mesozoic granitic rocks which are capped in some areas by Quaternary volcanic rocks, chiefly basaltic flows.

The Coso Range area is characterized by a pattern of irregular small gravity anomalies superimposed on the northwestward-decreasing gravity field. Small local negative closures of about 5 mgal amplitude or less are in the southwestern part of Upper Cactus Flat, east of Coso Hot Springs, and in the northern part of Lower Centennial Flat. A small positive closure is northeast of Coles Flat, and another small high is on the southern border of the map area south of Sugarloaf Mountain. These small anomalies could be caused by such factors as variable thicknesses of alluvium or density contrasts between and within the volcanic rocks and the granitic basement rocks. In particular, the negative anomaly east of Coso Hot Springs may be caused by alluvium in the valley, possibly a small graben or caldera, or by a combination of alluvium and volcanic rocks; but the anomaly in the south part of Upper Cactus Flat must be a reflection of variations of density within the basement granitic rocks. The proximity of both of these negative anomalies to the geothermal steam prospects near Coso Hot Springs could be significant. Because this area is characterized by Quaternary volcanism, one or both of these negative anomalies could conceivably be caused by a youthful intrusive mass which would also serve as the source of heat in this area.

The positive anomaly over the Argus Range near the south edge of the map area increases in amplitude southward and broadens westward to include an area underlain by granitic and volcanic rocks in the southeastern part of the Coso Range. The reason for this westward bulge in the contours is not apparent from the geologic map, but it could be caused by an increase in the average basement rock density in this area.

Panamint Valley

Panamint Valley is marked by a broad north-trending gravity low that extends well up into the western flank of the Panamint Range between Wildrose Canyon and Towne Pass where Cenozoic nonmarine sedimentary rocks are exposed. Mabey (1963) estimated a thickness of 2,000 to 3,000 feet of Cenozoic rocks in the central part of the valley based on the gravity anomalies, but the rocks might be appreciably thicker if most of the subsurface rocks are relatively dense Tertiary units. Northward, the Cenozoic rocks in the valley evidently decrease in thickness; and a northeast-trending saddle in the anomaly between Panamint Springs and Lake Hill Mountain suggests the existence of a bedrock divide at a shallow depth in this area.

There is no distinctive change in the gravity gradient between basement rocks exposed in the Argus Range and the Cenozoic sediments and sedimentary rocks in Panamint Valley. This indicates that, along the eastern front of the Argus Range, there is no steeply dipping fault boundary separating thick Cenozoic deposits in the valley and bedrock in the mountain range. Gravity data in the vicinity of the eastern side of the valley and the adjoining Panamint Range also show no evidence that faults displace thick Cenozoic deposits.

Saline Valley

Granitic rocks are exposed in a large area at the northern end of Panamint Valley in the vicinity of Hunter Mountain, but gravity values in this area show little exception to the northwest-dipping regional trend. Farther northwest, Saline Valley is marked by a very prominent northwest-trending gravity minimum. The local gravity relief in Saline Valley is probably more than 40 mgal. However, as pointed out by Mabey (1963), the gravity gradients that extend onto bedrock outcrops along the margins of the valley cannot be explained by low-density material underlying the valley. These gradients are observed over bedrock outcrops along the north side of the Nelson Range where Mabey (1963) estimated a northward decrease in the anomaly of about 15 mgal in 3½ miles and on the northeast side of Saline Valley where there is a westward decrease of about 14 mgal in 2 miles. Only a part of these decreases in anomaly values toward the north and west could be caused by steepening of the regional gravity gradients. One possible explanation is that Saline Valley is underlain principally by granitic rocks and that more dense metamorphic rocks are present in and underlying the Inyo Mountains, the Nelson Range, and the Panamint Range to the west, south, and northeast, respectively. Another possibility is that the Saline Valley area is underlain at depth by a large granitic intrusive mass with a lower density than that of the usual Mesozoic plutonic basement rocks.

Steep gravity gradients on the edges of and within Saline Valley on the west and south sides in particular suggest that multiple fault zones exist and are generally parallel both to the Inyo Mountains and the Nelson Range. There is not, however, positive gravity evidence for a fault on the Panamint Range side of the valley. On the basis of the gravity data, Mabey (1963) estimated a maximum thickness of about 3,000 feet of Cenozoic sedimentary rocks in the valley north of the dry lake.

A nose in the gravity contours extends westward from the positive gravity anomally associated with the Panamint Range into the southeastern part of the Saline Range, north of Saline Valley, where it is joined by a northward-trending positive anomaly from the Inyo Mountains. Much of the Saline Range is covered by Cenozoic basaltic volcanic rocks, but the presence of scattered outcrops of Paleozoic sedimentary rocks suggests that these rocks near the surface may be the chief cause of the positive gravity anomalies.

Panamint Range

The Panamint Range is marked by a broad north-northwest-trending positive anomaly that extends entirely across the Death Valley sheet. The anomaly decreases to the south and to the northwest from Tucki Mountain where the maximum gravity value of more than −85 mgals occurs. To the south, the anomaly is divided into two noses by a northwesterly trending low saddle northeast of Telescope Peak. The cause of this low saddle is not readily apparent. A zone of lower density rocks, possibly an extension of the granite of Hanaupah Canyon (Hunt and Mabey, 1966), may be the cause of this low saddle.

To the north, the Cottonwood Mountains segment of the Panamint Range is marked by a positive north-trending anomaly. The northward decrease in the regional gravity field is readily apparent.

The mass of Precambrian metamorphic rocks in the Panamint Range south of Tucki Mountain does not seem to be adequately reflected in the gravity data, thus suggesting either that this large mountain range is partly isostatically compensated as suggested by Mabey (1963) or that the metamorphic rocks in the range may overlie rocks of relatively low density beneath the range. West-dipping low-angle faults exposed in a few places along the east edge of the Panamint Range may indicate a major fault zone that separates the rocks in the Panamint Range from rocks beneath the range. The gravity data suggest that the rocks of the Panamint Range extend eastward beneath Death Valley and that no major faults offset Cenozoic rocks on the east side of this range.

Grapevine Mountains—Funeral Mountains

The Grapevine and Funeral Mountains are marked by a single positive anomaly that extends from the north boundary of the Death Valley sheet southeastward to the vicinity of Death Valley Junction. The gravity field attains a maximum value of more than −80 mgals in an area where a broad expanse of Precambrian metamorphic rocks crop out. The anomaly decreases, both north and south, away from these metamorphic rocks.

The general form of the anomaly fits fairly well with the outcrop pattern of the metamorphosed sedimentary rocks and suggests that the surface between the metamorphosed rocks and overlying less dense rocks dips gently beneath the Grapevine Mountains to the northwest and the southern part of the Funeral Mountains to the southeast.

Black Mountains

The Black Mountains are made up mainly of dense Precambrian diorite and metamorphic rocks, which are intruded by Cenozoic granitic rocks and overlain by Cenozoic volcanic and sedimentary rocks. The general form of the gravity anomalies in the Black Mountains coincides with the outcrop pattern of the various rock types. Thus, a prominent gravity high in the Gold Valley-Funeral Peak area (−80 mgal contour) characterizes the west part of this mountain range where the dense rocks crop out. Also, a low saddle occurs in the gravity field west of Coffin Peak in an area where Cenozoic rocks and several small granitic intrusions crop out.

The linear trend and gentle east slope to the gravity pattern suggest that the dense rocks extend northward into Death Valley beneath the covering Cenozoic rocks and that the less dense rocks thicken eastward.

Death Valley

A prominent gravity low extends the entire length of Death Valley. Based on closures within the anomaly, Mabey (1963) divided Death Valley from north to south into Mesquite Flat, Cottonball, and Badwater Basins. He estimated these basins to be filled with 10,000, 7,000, and 9,000 feet of low density Cenozoic rocks, respectively.

The Northern Death Valley-Furnace Creek fault zone is defined by the steep gravity gradients along the east sides of Mesquite Flat and Cottonball Basins. To the south, the steep gravity gradient along the east side of Badwater Basin marks a steeply-dipping fault zone. Irregularities in this steep gradient on the west side of the Black Mountains may reflect branching faults. Another major north- to northwest-trending fault is indicated west of Cottonball Basin, and a northeast-trending fault is suggested north of Tucki Mountain (Mabey, 1963).

The Death Valley gravity low bifurcates, and the east branch continues southeastward in Furnace Creek Wash and across a saddle northeast of Ryan, where it connects with a closed low west of Death Valley Junction. The fault indicated by Mabey (1963) near the mouth of Echo Canyon appears to be part of the Northern Death Valley-Furnace Creek fault zone. Denny and Drewes (1965) project the fault zone into the Ash Meadows quadrangle at a point 4.5 miles west of Death Valley Junction. Beyond this point, the linear trend of the gravity data is interrupted by a negative anomaly associated with Amargosa Valley, and the pattern of anomalies suggests that the fault dies out or breaks up into several segments.

The gravity data indicate that the Cenozoic sediments and sedimentary rocks are deepest on the east side of Death Valley adjacent to the range-bounding faults. This suggests that the Panamint Range-Death Valley block is tilted eastward, as is also suggested by the eastward tilt of Cenozoic rocks on the east side of the Panamint Range.

Greenwater Range and Greenwater Valley

A large closed gravity low centered near Brown Peak (−120 mgal contour) dominates the southern part of the Greenwater Range and includes Greenwater Valley. The northern part of the range is marked by a narrow gravity high that extends across the mouth of Furnace Creek Wash to Ryan, continues south along the ridge, and then turns southwest across northern Greenwater Valley.

This narrow high trend apparently delineates a zone of more dense rock beneath the covering Cenozoic volcanic rocks and alluvium. Most of the area of the Greenwater Range low anomaly is believed to be underlain by Tertiary volcanic and sedimentary rocks several thousands of feet thick (Mabey, 1963).

Southern Amargosa Desert

An extensive gravity low characterizes the full length of the Amargosa Desert (Healey and Miller, 1971). Northeast of Death Valley Junction in Amargosa Valley, this anomaly widens and bifurcates and there is a closed low of less than −125 mgals which straddles the California-Nevada state line. The western and widest part of the low extends southward to the vicinity of Eagle Mountain. This part of the Amargosa Desert is believed to be underlain by 3,000 to 4,000 feet of Cenozoic rocks (Healey and Miller, 1971).

The east branch of the Amargosa Desert low extends southeastward into Stewart Valley east of the north end of the Resting Springs Range along the California-Nevada state line. A gravity high extends into Stewart Valley as a nose from the north end of the Nopah Range and interrupts the Stewart Valley low. Southeast of this nose, the negative anomaly continues along Pahrump Valley into the area of the Kingman sheet to the southeast (Healey, 1973.)

The southeastward-trending branch of the Amargosa Desert low apparently marks the course of a major fault zone. However, in Stewart Valley and northward, the east side of the basin is downdropped (R. H. Moench, written communication, 1965). In Pahrump Valley, the steep gravity gradient off the Nopah Range indicates that the west side of the basin is down. Wilhelms (1963) mapped a high-angle range-front fault that extends the length of the Nopah Range, and the gravity data apparently define this fault.

ECONOMIC SIGNIFICANCE

The Death Valley sheet gravity data may be of value in exploration for some of the mineral commodities that are found in this area. These data provide information both on the distribution and thickness of low density Cenozoic deposits and on the possible presence of certain rock types in the subsurface. For example, gravity data have been used in the Kramer district, in the Trona sheet area to the south, to locate additional Tertiary basins that may contain boron deposits (Mabey, 1960, p. 70–71). In other places, pediments, or areas covered by relatively thin Cenozoic deposits, are suggested by the gravity data; these areas are of interest in prospecting for minerals found closely associated with the basement rocks. An example of a possible pediment area is on the southwestern side of the Funeral Mountains between the Northern Death Valley Furnace Creek fault and the Keane Wonder fault where the gravity data indicate a shallow cover of Cenozoic deposits.

In the Darwin area, the local gravity high attributed by Mabey (1961, p. C276) to dense altered Paleozoic sedimentary rocks may represent a favorable area for prospecting, particularly for some of the metals including lead, zinc, and silver. It is possible that other positive gravity anomalies in the Death Valley sheet area represent masses of similarly altered, and possibly mineralized, rocks.

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