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Map showing depth to pre-Cenozoic basement in the Death Valley ground-water model area, Nevada and California

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INTRODUCTION

This map shows the depth to pre-Cenozoic basement in the Death Valley ground-water model area. It was prepared utilizing gravity (Ponce and others, 2001), geologic (Jennings and others, 1977; Stewart and Carlson, 1978), and drill-hole information. Geophysical investigations of the Death Valley ground-water model area are part of an interagency effort by the U.S. Geological Survey (USGS) and the Department of Energy (Interagency Agreement DE-AI08-96NV11967) to help characterize the geology and hydrology of southwestern Nevada and parts of California. The Death Valley ground-water model is located between lat 35°00’ and 38°15’N., and long 115° and 118°W.

DEPTH TO BASEMENT PROCESS

An iterative gravity inversion method (Jachens and Moring, 1990) was used to determine the depth of Cenozoic basin deposits in southwestern Nevada and southeastern California, an area that encompasses the Death Valley ground-water model (Blakely and others, 2000). Gravity data used in this process were reduced using standard techniques that include terrain and isostatic gravity corrections. Isostatic gravity anomalies (Simpson and others, 1986) were used during the inversion process because they enhance or reflect shallow- to mid-crustal sources within the Earth.

The method separates the gravity field into two components: the field caused by pre-Cenozoic basement and the field caused by overlying younger basin deposits. An initial basement gravity field is determined by using just those stations located on pre-Cenozoic basement outcrops. The initial basement gravity field is only approximate because stations located on basement are influenced by the gravity effect of low-density deposits in nearby basins, especially for those stations near the edges of the basins. The difference between the isostatic gravity and basement gravity fields provides the first estimate of the basin gravity field, which is inverted to provide the first estimate of the basin shape. The gravitational effect of the basins are subtracted from each station located on basement, and a new and improved basement gravity field is determined. This process is repeated until successive iterations converge. Inversion of the final basin gravity field, constrained with a density-depth function (table 1), geology, and drill-hole information yields an estimate of the depth to pre-Cenozoic basement. The density of basement rocks is allowed to vary horizontally, whereas the density of basin-filling deposits increases with depth according to the density-depth relationships shown in table 1. The density-depth function is based on density information from rock samples, geophysical well logs, and borehole gravity data. For sedimentary deposits, we use a density-depth profile by Jachens and Moring (1990), and for volcanic deposits we use a density-depth profile by Hildenbrand and others (1999), derived from detailed geophysical studies of Pahute Mesa and vicinity. The digital data sets used in this study were gridded at an interval of 500 m using a computer program (Webring, 1981) based on a minimum curvature algorithm by Briggs (1974). The resulting grid was then interpolated to a 200-m grid to minimize pixel size, and then it was color contoured.

A number of limitations are inherent in the gravity data themselves, as well as in the inversion process. Some of the uncertainties are related to the gravity data coverage, especially for stations on basement outcrops; the density-depth function; accuracy or scale of the geologic mapping; simplifying assumptions regarding concealed geology; and the distribution of basement outcrops. Although this map is shown at a scale of 1:250,000, the process itself was regional in scope and caution should be exercised when using these results at a scale greater than about 1:500,000. A more detailed discussion of the limitations and accuracy of the method are provided by Jachens and Moring (1990).

Table 1.—Density-depth function for Cenozoic sedimentary and volcanic deposits.

Depth Range (m)	Density for sedimentary deposits kg/m^3	Density for volcanic deposits kg/m^3
0-200	2,020	1,900
200-600	2,120	2,100
600-1,200	2,320	2,300
>1,200	2,420	2,420

DISCUSSION

In general, gravity anomalies within the Death Valley ground-water model area reflect carbonate rocks, calderas, deep sedimentary basins, and linear geologic features such as faults. Many of these features play an important role as aquifers or confining units in the region and their distribution is important to the understanding of the hydrogeologic framework of the area. Pre-Cenozoic carbonate and crystalline rocks underlie most of the region and their subsurface distribution is especially important in evaluating the hydrogeology of the area. Tertiary volcanic rocks also play an important role in the hydrogeologic framework of the area and in the formation of large collapse calderas. Thick accumulations of these volcanic rocks are present in the central and northern part of the Death Valley ground-water model. Quaternary alluvial deposits exist throughout the study area and are composed of non-marine sedimentary and volcanic rocks, generally Oligocene and younger in age. These alluvial deposits play an important role in the saturated-zone hydrology of deep alluvial basins within the southwestern Nevada volcanic field (Grauch and others, 1999) and probably in other deep basins as well. Because of the density contrast between these lithologic types, gravity data can be inverted to determine the depth to basement throughout the Death Valley ground-water model.

In general, the depth-to-basement within basins in the study is similar to that of other basins in the state of Nevada (Jachens and Moring, 1990); most basins are less than about 2 km deep. Within the Death Valley ground-water model, several basins are greater than about 5 km in depth, including Death Valley, Pahrump Valley, Kawich Valley, and Tickaboo Valley. One of the deepest basins in the state of Nevada is related to the Silent Canyon caldera complex over Pahute Mesa, a volcanic center that is filled with low-density volcanic rocks that may reach depths as great as 6 km or more (McKee and others, 1999).

A number of other geophysical studies were undertaken to aid in characterizing the geologic and hydrogeologic setting of the region. A summary of geophysical investigations at Yucca Mountain that includes gravity, magnetics, electrical methods, seismic methods, heat-flow, and stress data were provided by Oliver and others (1995). Recent studies characterized the geophysical framework of the southwestern Nevada volcanic field (Grauch and others, 1999; Hildenbrand and others, 1999; Mankinen and others, 1999), and they identify a number of subsurface features that might control or influence ground-water flow. These features include resurgent calderas and prominent geophysical lineaments that probably reflect faults. Phelps and others (1999) describe the depth to basement in Yucca Flat, Nevada Test Site, Nevada. And finally, Blakely and others (1998, 1999, 2000) describe geophysical investigations in Death Valley, Amargosa Valley, and the Death Valley regional ground-water model.

The diverse physical properties of lithologic types that underlie this region are well suited to geophysical investigations. The contrast in density between pre-Cenozoic basement and overlying unconsolidated alluvium, for example, produces a distinctive pattern of gravity anomalies that can be used to estimate the depth of pre-Cenozoic basement in three dimensions. In most parts of the study area, this basement surface corresponds to the top of the carbonate aquifer, an important element of the hydrologic framework.

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