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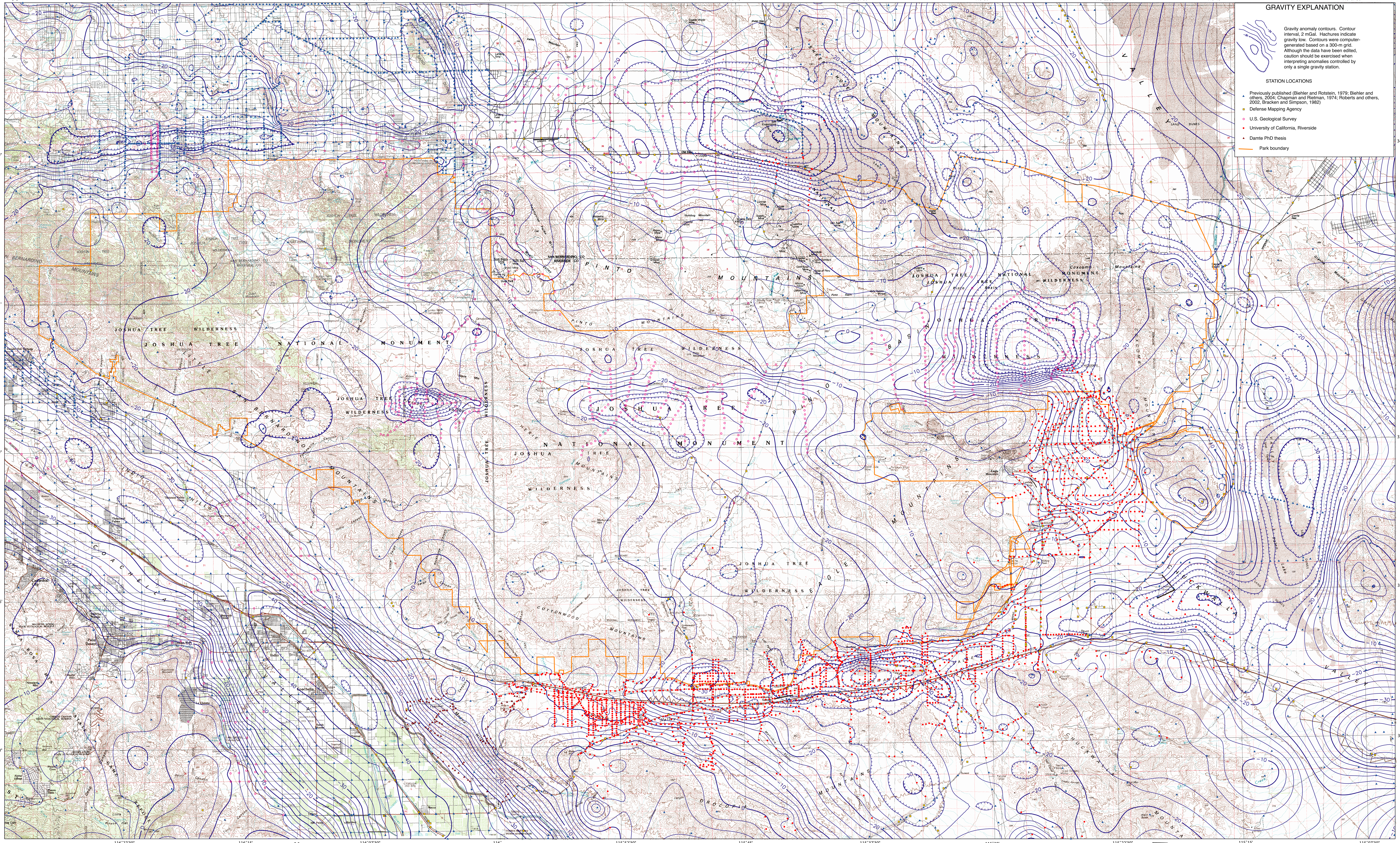

Topographic base from U.S. Geological Survey 1:100,000 Palm Springs, Big Bear Lake, Sheephole Mountains, and Eagle Mountains quadrangles.

PRELIMINARY ISOSTATIC GRAVITY MAP OF JOSHUA TREE NATIONAL PARK AND VICINITY, SOUTHERN CALIFORNIA

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ABSTRACT

This isostatic residual gravity map is part of an effort to map the three-dimensional distribution of rocks in Joshua Tree National Park, southern California. This map will serve as a basis for modeling the shape of basins beneath the Park and in adjacent valleys and also for determining the location and geometry of faults within the area. Local spatial variations in the Earth's gravity field, after accounting for variations caused by elevation, terrain, and deep crustal structure, reflect the distribution of densities in the mid- to upper crust. Densities often can be related to rock type, and abrupt spatial changes in density commonly mark lithologic or structural boundaries.

High-density basement rocks exposed within the Eastern Transverse Ranges include crystalline rocks that range in age from Proterozoic to Mesozoic and these rocks are generally present in the mountainous areas of the quadrangle. Alluvial sediments, usually located in the valleys, and Tertiary sedimentary rocks are characterized by low densities. However, with increasing depth of burial and age, the densities of these rocks may become indistinguishable from those of basement rocks. Tertiary volcanic rocks are characterized by a wide range of densities, but, on average, are less dense than the pre-Cenozoic basement rocks. Basalt within the Park is as dense as crystalline basement, but is generally thin (less than 100 m thick; e.g., Powell, 2003).

Isostatic residual gravity values within the map area range from about –44 mGal over Coachella Valley to about 8 mGal between the Mecca Hills and the Orocopia Mountains. Steep linear gravity gradients are coincident with the traces of several Quaternary strike-slip faults, most notably along the San Andreas Fault bounding the east side of Coachella Valley and east-west-striking, left-lateral faults, such as the Pinto Mountain, Blue Cut, and Chiriaco Faults (Fig. 1). Gravity gradients also define concealed basin-bounding faults, such as those beneath the Chuckwalla Valley (e.g. Rotstein and others, 1976). These gradients result from juxtaposing dense basement rocks against thick Cenozoic sedimentary rocks.

DATA SOURCES, REDUCTIONS, AND ACCURACIES

The isostatic gravity map was created from 6799 gravity stations. Previously published data are from regional compilations (Biehler and Rotstein, 1979; Biehler and others, 2004; Chapman and Rietman, 1974; Roberts and others, 2002) and wilderness studies (Bracken and Simpson, 1982). Other more recent sources of data include various theses from the University of California at Riverside (e.g. Bennett, 1990; Blackman, 1988; Schultz, 1989), National Geophysical Data Center (written commun., 1999), Damte (1997), and the U.S. Geological Survey from 2001-2007 (888 stations). Gravity stations are non-uniformly distributed in the region. Station spacing is on average 1 station per 2 km^2, although the station spacing is as low as 1 station per 25 km2 within parts of the wilderness areas within Joshua Tree National Park. Detailed profiles in Yucca, Hayfield, Shaver, and Chuckwalla Valleys were collected to support groundwater assessments in the area.

The datum of observed gravity for this map is the International Gravity Standardization Net of 1971 (IGSN 71) as described by Morelli (1974); the reference ellipsoid is the Geodetic Reference System of 1967 (GRS67; International Association of Geodesy and Geophysics, 1971). The observed gravity data were reduced to free-air anomalies using standard formulas (for example, Telford and others, 1976). Bouguer, curvature, and terrain adjustments to a radial distance of 166.7 km were applied to the free-air anomaly at each station to determine the complete Bouguer anomalies at a standard reduction density of 2670 kg/m^3 (Plouff, 1977). An isostatic adjustment was then applied to remove the long-wavelength effect of deep crustal and/or upper mantle masses that isostatically support regional topography. The isostatic adjustment assumes an Airy-Heiskanen model (Heiskanen and Vening-Meinesz, 1958) of isostatic compensation. Compensation is achieved by varying the depth of the model crust-mantle interface, using the following parameters: a crustal thickness of 25 km for topography at sea level, a crust-mantle density contrast of 400 kg/m^3, and a crustal density of 2670 kg/m^3 for the topographic load. These parameters were used because (1) they produce a model crustal geometry that agrees with seismically determined values of crustal thickness for central California, (2) they are consistent with model parameters used for isostatic corrections computed for the rest of California (Roberts and others, 1990), and (3) changing the model parameters does not significantly affect the resulting isostatic anomaly (Jachens and Griscom, 1985). The computer program ISOCOMP (Jachens and Roberts, 1981) directly calculates the attraction of an Airy-Heiskanen root by summing the attraction of individual mass prisms making up the root and thus calculating the isostatic adjustment. The resulting isostatic residual gravity values should reflect lateral variations of density within the mid- to upper crust. This statement is supported by the favorable comparison of the observed isostatic gravity field with that predicted from seismic velocities in southern California (Langenheim and Hauksson, 2001), although higher gravity values near the Salton Sea at the southern edge of the map may be produced in part by lower crustal density variations and/or crustal thinning in the Salton Trough (Langenheim and Hauksson, 2001).

Accuracy of the data used to create this map is estimated to be on the order of ±0.1 to ±0.5 mGal based on comparison of observed gravity values at duplicate stations from different data sources and expected uncertainty resulting from the total terrain correction and station elevation. Total terrain corrections for the stations collected for this study ranged from 0.04 to 39.31 mGal, with an average of 1.67 mGal. If the uncertainty from the terrain correction is considered to be 5 to 10% of the terrain correction, the largest uncertainty expected for the data is 3.9 mGal. However, the likely uncertainty due to the terrain correction is small (less than 0.2 mGal) for most of the stations. The elevations are known to ±1 m or better for most of the measurements, yielding an uncertainty due to elevation in the anomaly value of <0.2 mGal.

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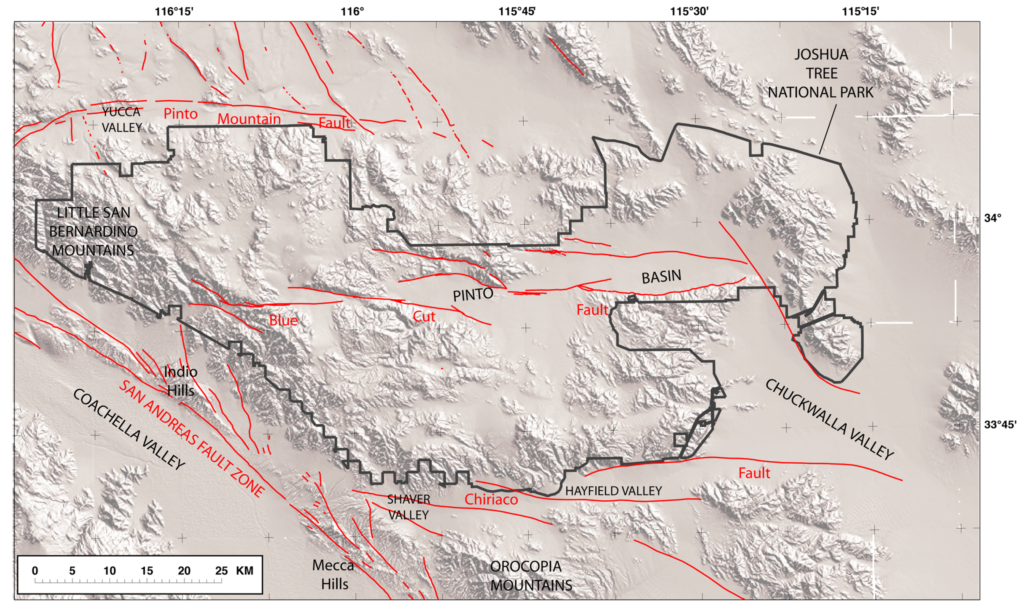

Figure 1. Shaded-relief map showing geographic features and faults (red lines).