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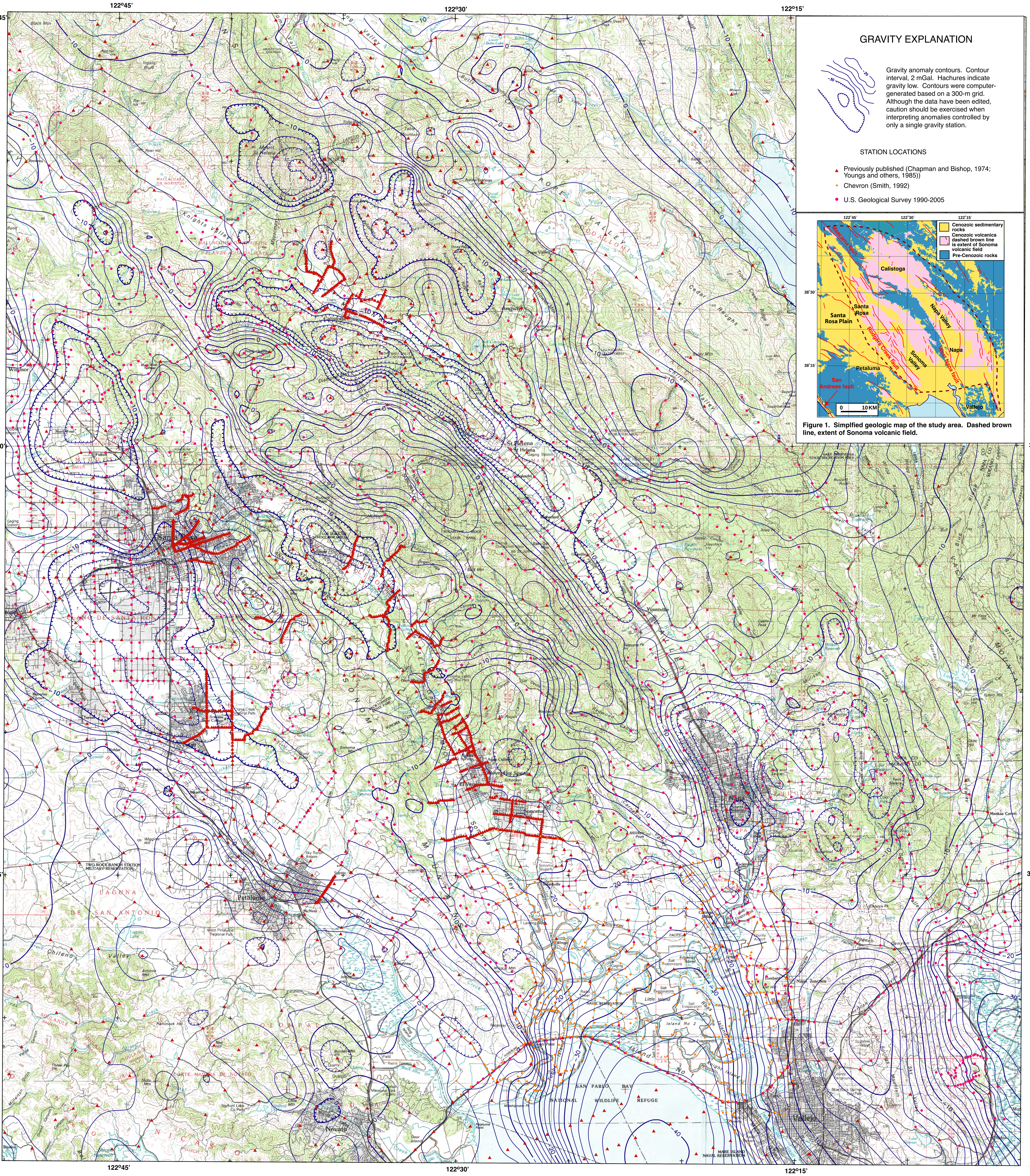

Figure 1. Simplfied geologic map of the study area. Dashed brown line, extent of Sonoma volcanic field.

Introduction

This isostatic residual gravity map is part of a three-dimensional mapping effort focused on the subsurface distribution of rocks of the Sonoma volcanic field in Napa and Sonoma counties, northern California. This map will serve as a basis for modeling the shapes of basins beneath the Santa Rosa Plain and Napa and Sonoma Valleys, and 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 explained below) 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 boundaries.

High-density basement rocks exposed within the northern San Francisco Bay area include those of the Mesozoic Franciscan Complex and Great Valley Sequence (fig. 1) present in the mountainous areas of the quadrangle. Alluvial sediment 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 in densities, but, on average, are less dense than the Mesozoic basement rocks.

Isostatic residual gravity values within the map area range from about –41 mGal over San Pablo Bay (southern edge of map) to about 11 mGal near Greeg Mountain 10 km east of St. Helena. Steep linear gravity gradients are coincident with the traces of several Quaternary strike-slip faults, most notably along the West Napa fault bounding the west side of Napa Valley (Langenheim and others, in press), the projection of the Hayward fault in San Pablo Bay (Parsons and others, 2003), the Maacama Fault, and the Rodgers Creek fault in the vicinity of Santa Rosa (fig. 2). These gradients result from juxtaposing dense basement rocks against thick Tertiary volcanic and sedimentary rocks.

Data Sources, Reductions, and Accuracies

The isostatic gravity map was created from 4,404 gravity observations. Sources of data include surveys by the California Geological Survey (formerly known as the California Division of Mines and Geology; Chapman and Bishop, 1974; Youngs and others, 1985; 2256 stations), Chevron (Smith, 1992; 619 stations with values interpolated from contour map), and the U.S. Geological Survey (this study; 1527 stations). Gravity stations are non-uniformly distributed in the region. Station spacing is on average 1 station per 1 km^2, although the station spacing is as low as 1 station per 4 km^2 within parts of the Mayacmas Mountains and Sonoma Mountain. Detailed profiles that cover the central part of Sonoma Valley, the cities of Santa Rosa and Calistoga were collected to support geothermal assessments in the area (Youngs and others, 1985).

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 sea-level crustal thickness of 25 km, a crust-mantle density contrast of 0.40 g/cm^3, and a crustal density of 2.67 g/cm^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 adjustments 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 reflect lateral variations of density within the mid- to upper crust, as shown by a study in southern California (Langenheim and Hauksson, 2001) which yielded a favorable comparison of the observed isostatic gravity field with that predicted from seismic velocities in the middle and upper crust.

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 errors in station elevation. Total terrain corrections for the stations collected for this study ranged from 0.16 to 38.39 mGal, with an average of 1.93 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 3.8 mGal. However, the possible uncertainty caused by the terrain correction is small (less than 0.2 mGal) for most of the stations. The elevation of the measurement is known to ±1 m or better for most of the measurements, yielding an uncertainty in the anomaly value of ±0.18 mGal.

ACKNOWLEDGMENTS

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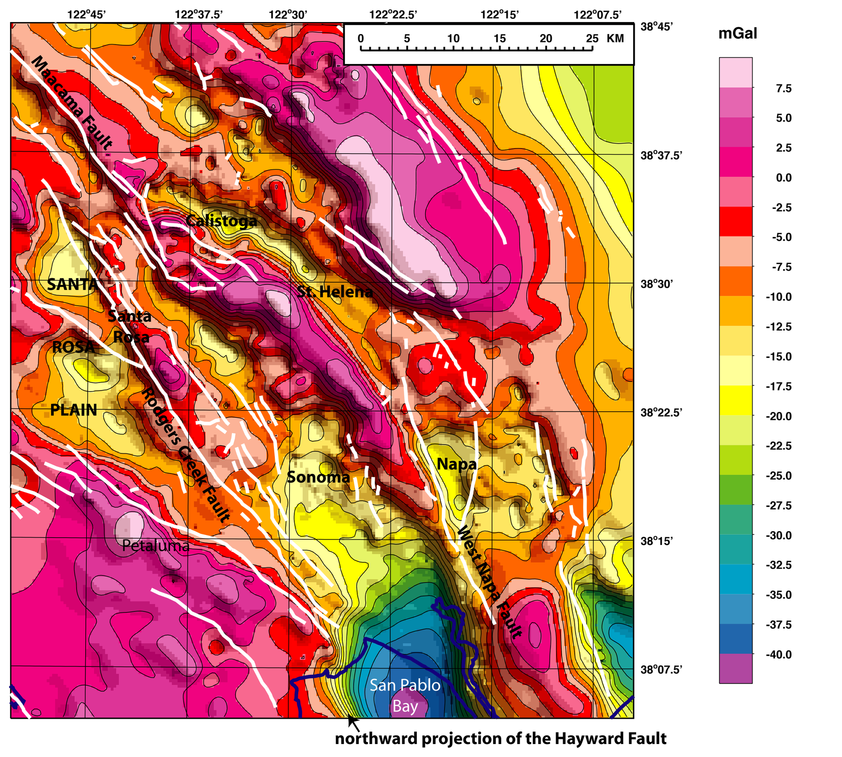

Figure 2. Shaded-relief color representation of the isostatic gravity map. Illumination is from the northeast. White lines, faults; blue line, coastline. Contour interval is 2.5 mGal.

PRELIMINARY ISOSTATIC GRAVITY MAP OF THE SONOMA VOLCANIC FIELD AND VICINITY, SONOMA AND NAPA COUNTIES, CALIFORNIA

V.E. Langenheim, C.W. Roberts, C.A. McCabe, D.K. McPhee, J.E. Tilden, and R.C. Jachens
2006

California Index Map