U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-2191

EXPLANATION

MAGNETIC CONTOURS - Showing residual magnetic intensity of the earth's field (total intensity minus the geomagnetic reference field updated to the dates of the aeromagnetic survey). Hachures indicate closed areas of lower magnetic intensity.

A Magnetic anomaly discussed in the text.

Fault - Mapped and inferred

SCALE 1:100 000

KILOMETERS 0 1 2 3 4 5 6 7 8 9 10

MILES 0 1 2 3 4 5

FEET 5000 0 5000 10000 15000 20000 25000

CONTOUR INTERVAL 50 METERS
WITH SUPPLEMENTARY CONTOURS AT HALF-METER INTERVALS
To convert meters to feet multiply by 3.2808
To convert feet to meters multiply by 0.3048

CALIFORNIA

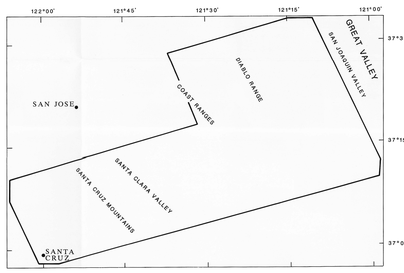

Figure 1. Index map showing the limits of the aeromagnetic survey in the San Jose area.

INTRODUCTION

This report describes the aeromagnetic survey of the San Jose, California area, presents a preliminary analysis of the aeromagnetic data, and discusses the major anomalies. The aeromagnetic survey (fig. 1) encompasses about 1,363 mi^2 (3,533 km^2) and provides new information about possible locations of faults and buried magnetic rocks.

DATA COLLECTION

The aeromagnetic survey was done by the U.S. Geological Survey (Abrams and others, 1991) to assist in interpreting and mapping the subsurface of the San Jose area, locating geological features such as concealed faults and faults in inaccessible areas, and identifying lithologic differences (Fig. 2). The data were acquired as part of the National Geological Mapping Program of the U.S. Geological Survey. The survey was made during November 1989 and February, March, and April 1990 using the Short Take Off and Landing aircraft belonging to the U.S. Geological Survey. The aircraft was piloted by Charles Thompson and crew members were Charles Mitchell, Donald Rohret, Roy Kipfinger, and Richard Sneddon. The aircraft was flown in a N 60 E direction at an average speed of ninety knots, five hundred feet (150 meters) above ground, and the survey had a 0.25 statute mile line spacing. A Geometrics model G-813 proton precession magnetometer, having a sensitivity of 0.5 gammas and a cycle time of 0.5 seconds, recorded variations of the total intensity of the Earth's magnetic field. The magnetometer was mounted on the aircraft's right wingtip. The flight path was positioned by the LORAN navigation system. The flight tapes were reduced using unpublished algorithms of Robert Bracken (U.S. Geological Survey, written commun., 1990). The data were projected using Universal Transverse Mercator Projection (Central Meridian = 123°, Base Latitude = 0°) and gridded at a 0.15-km spacing, using a computer program written by Webring (1981) that is based on a minimum curvature algorithm (Briggs, 1974). The International Geomagnetic Reference Field (IGRF, 1985) was removed from the grid using a program written by Sweeney (1990). The aeromagnetic contour map was made using CONTOUR, a program by Godson and Webring (1982).

Aeromagnetic anomalies express variations in the strength and direction of the Earth's magnetic field. The magnetic anomalies in the Earth's magnetic field are caused by two kinds of magnetization (1) induced and (2) remanent magnetization. The net effect of the two magnetizations is the observed anomaly field. The magnitudes of anomalies are related to the content of magnetic minerals in the source rocks (Nettleton, 1962). A significant characterization of a magnetic anomaly is its variation with distance between the magnetometer and source rock; the deeper the source, the lower the amplitude and the broader the wavelength. In the study area, serpentinite, volcanic rocks, and mafic rocks of the Franciscan assemblage contain enough magnetic minerals to cause magnetic anomalies (Hanna and others, 1972). Sedimentary rocks are usually lacking in magnetic minerals; consequently, they show no magnetic response on an aeromagnetic map. In the San Jose area, the anomalies that appear to be of greatest use in defining fault systems are linear or elongate features which reflect magnetic material confined to narrow fault zones (Brabb and Hanna, 1981). Surface expression of faults has been identified (Brabb and Hanna, 1981) by studies of geomorphic forms, such as offset streams, shutter ridges, sag ponds, and linear valleys; however, to detect covered faults, we depend on geophysical methods such as this aeromagnetic survey. In comparison, no distinct signatures related to faults are present on the Bouguer gravity map of the area (Robbins and others, 1976); not even across the Diablo Range where the Tesla-Ortigalita fault separates the Franciscan formation from the Valley sequence, a setting where a gravity gradient might be expected.

GEOLOGY

The San Jose aeromagnetic survey covers part of the Coastal Ranges and part of the San Joaquin Valley, which is a part of the southern part of the Great Valley (Fig. 1). Within the map area are sections of the Santa Cruz Mountains, the Santa Clara Valley, the Diablo Range, and the San Joaquin Valley. The rock units range in age from pre-Cretaceous to Holocene. The Coast Ranges have two different basement rocks; Franciscan and Salinian, which are in contact with each other along the San Andreas fault. Northeast of the San Andreas fault (Morris and Webb, 1990) the Franciscan subduction complex composed of oceanic crustal rocks. Southwest of the San Andreas fault lies the Salinian block, a granitic-metamorphic complex. The Franciscan basement consists of a typical array of graywacke, volcanic sills and dikes, deep water cherts, and ultrabasic intrusives with serpentine derivatives (Morris and Webb, 1990). Stratified marine and nonmarine sedimentary rocks overlay the Franciscan rocks northeast of the San Andreas fault. Southwest of the San Andreas fault, a much thinner Tertiary sedimentary rock section (marine deposits) overlies the Salinian granitic basement. The proximity of these two basement rocks is postulated to be the result of large displacements along the San Andreas fault.

The Coast Range is intensely folded with fold axes trending parallel to the faults. The San Jose area is characterized by its NW-SE fabric, which is caused by strike-slip faults. The resultant valleys, ridges, and lithologic strips and slivers are approximately parallel to the coast. The faults include the Zayante, the Butano, the San Andreas, the Silver Creek, the Calaveras, the Hadrone Springs, and the Tesla-Ortigalita. The Santa Clara Valley is west of the Calaveras fault, and the valley is crossed by the Teresa fault in the northern part of the valley and the Chesbro fault in the southern part.

The Franciscan Formation forms the core of the Diablo Range (Morris and Webb, 1990). The Diablo Range is anticlinal with younger strata dipping outward from the axis of the range. This archlike structure can be traced for almost 90 mi (150 km), an unusually long distance in any Coast Range fold. Some of the anticlinal features are diapirs composed of serpentinized ultra-mafic rock and other Franciscan volcanic and sedimentary rocks, which have been forced up along faults into and through younger rocks (Morris and Webb, 1990). The serpentinites are thought to have been derived from the upper mantle. The Franciscan formation outcrops between the Hadrone Springs fault and the Tesla-Ortigalita fault and is overlain on the eastern side of the Diablo Range by Cretaceous marine rocks. Another sliver of marine rocks overlies the Franciscan Formation between the Calaveras fault and the Hadrone Springs fault.

The Great Valley is a large sediment-filled basin consisting of an enormous thickness of eingeoclinal (marine shelf) late Jurassic to late Cretaceous sedimentary rocks; the thickest section is about 28,000 ft (8.5 km) thick and is east of the Diablo Range. The surface of the Great Valley is composed of Quaternary sediment. The part of the Great Valley that is within the map area lies off the eastern flank of the Diablo Range.

INTERPRETATION OF MAGNETIC ANOMALIES

The contour interval on the aeromagnetic map is 10, 20, 100, or 500 gammas, depending on the local gradient. The residual aeromagnetic values are between -451 and 1694 gammas. The topographic relief is between 13 ft (4 meters) below sealevel to 3,600 feet (1,100 meters) above sealevel. When comparing the aeromagnetic map with the topographic map, there are no obvious correlations between anomalies and topography. The magnetic contour map shows that the contrasting subsurface rocks and structural patterns on one side of the San Andreas fault are very different from the other side. The increasing gradient of the magnetic anomaly contour corresponds to increasing magnetization. In this survey most of the aeromagnetic relief appears to be associated with large quantities of known or inferred serpentinized ultra-mafic rocks that are northeast of the San Andreas fault and with various volcanic and plutonic rocks of the Franciscan formation (Hanna, 1972). The Bouguer anomaly map of the San Jose quadrangle (Robbins and others, 1976) suggests a thickening of the crust from west to east as indicated by a gradual decrease in the gradient from about 10 mGal over the Franciscan formation in the Santa Cruz Mountains south of San Jose to about 20 mGal over the Diablo Range. On the east side of the Diablo Range the gravity gradient decreases about 3-4 mGal/km across the San Joaquin Valley.

The magnetic field within the study area is influenced by the NW-SE structural pattern. This pattern is also present on the Bouguer gravity map (Robbins and others, 1976). The rocks which cause the anomalies in the area include volcanic rocks, basalt and andesite, ophiolite, and the underlying Franciscan assemblage, which is mostly greenstone and serpentinite. Many of the anomalies trend approximately parallel to the overall structural pattern. Most of these linear anomalies are produced by serpentinite associated with the fault zones. Some of the linear anomalies appear to be truncated by faults; for example, the Calaveras fault truncates magnetic anomalies along the Chesbro and the San Jose faults (Brabb and Hanna, 1981).

The Boulder Creek anomaly (Brabb and Hanna, 1981), a broad anomaly is southwest of the San Andreas fault and labeled A on the map. This anomaly has an unknown source beneath possibly a mile of sedimentary cover (Brabb and Hanna, 1981), and it is confined to the subsurface between the Zayante and Butano faults. A linear magnetic high labeled B on the map leads southeast from the Boulder Creek anomaly. The source rock may be the same rock which caused the Boulder Creek anomaly but the source rock is closer to the surface. Confirmation of identical sources on the basis of gravity data cannot be established because of the large accumulation of low density sedimentary cover. Further southeast between the Zayante and the San Andreas faults is a linear low labeled C on the map which coincides with a gravity low produced by a thicker section of Tertiary sediment (Robbins and others, 1976).

The area between the San Andreas and Hadrone Springs fault is structurally complex and the linear anomalies which coincide with major faults, such as the Sargent, Calaveras, San Jose, Silver Creek, and Santa Teresa faults, are due to the content of serpentinite in and along the faults. Several linear lows in this area contain little or no magnetic rock but may nevertheless express faults.

Northeast of the Hadrone Springs fault is a magnetically quiet area (the Bouguer gravity indicates an equally quiet area east of Hadrone Springs fault) where the gradient increases very slowly to the east to the broad, highly magnetic anomaly overlying the Diablo Range and labeled D and E on the map. Each anomaly has a distinctive multiple bifurcation of magnetic trends near the anomaly crest (Brabb and Hanna, 1981). The sources may be fragments of a tabular serpentinized ultramafic rock known to separate the northeast-sloping contact between the Franciscan assemblage and Jurassic and Cretaceous marine sedimentary rocks of the Great Valley sequence in many places in the Coast Ranges of Northern California and Oregon (Brabb and Hanna, 1981). These anomalies have the highest amplitudes and broadest wavelengths in the San Jose area. The anomalies show little gravity relief, which indicates that the Franciscan rocks that make up the Diablo Range have a fairly uniform density and constant thickness.

Sources of other magnetic anomalies in the area are inferred to be various volcanic and plutonic rocks in the Franciscan Formation. The magnetic low (labeled F on the map) on the west side of the San Joaquin Valley coincides with a gravity low (Robbins and others, 1976). This magnetic low occurs over the thickest part of the section of Cretaceous and Cenozoic sediments that fill the Valley to a depth of 6-8 km (Callaway, 1971). Of the two linear anomalies that follow the general northwest structural pattern of the San Joaquin Valley, the one closest to the eastern flank of the Diablo Range is interpreted to be a fault which appears to coincide with a stream course. The other linear anomaly follows Highway 5 and is probably caused by powerlines.

SUMMARY

This map presents data collected from an aeromagnetic survey flown in 1989 and 1990 in the San Jose area. Magnetic data gathered in the survey is more detailed than has previously been collected in this area. The map shows the magnetic expression of the northwest-trending ridge-and-valley-fault structure of the San Jose area as well as other magnetic anomalies. Many of the linear anomalies are caused by ultra-mafic rocks associated with faults. The most spectacular of the anomalies occur over the Diablo Range and show the highest amplitude and broadest wavelength. The aeromagnetic data shown on the map provide a base for future studies of the structure and tectonic development of the San Jose area.

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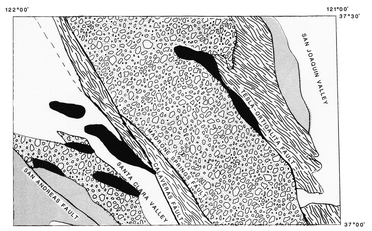

EXPLANATION

Contact

Fault

Cenozoic continental sedimentary rocks and alluvium

Cenozoic marine sedimentary rocks

Late Mesozoic shelf and slope sedimentary rocks

Franciscan Formation

Ultra-mafic rocks chiefly of Mesozoic age

Figure 2. Simplified geologic map of the San Jose area (from Morris, 1976, 1990)

AEROMAGNETIC MAP OF THE SAN JOSE AREA, CALIFORNIA

By
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1992

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