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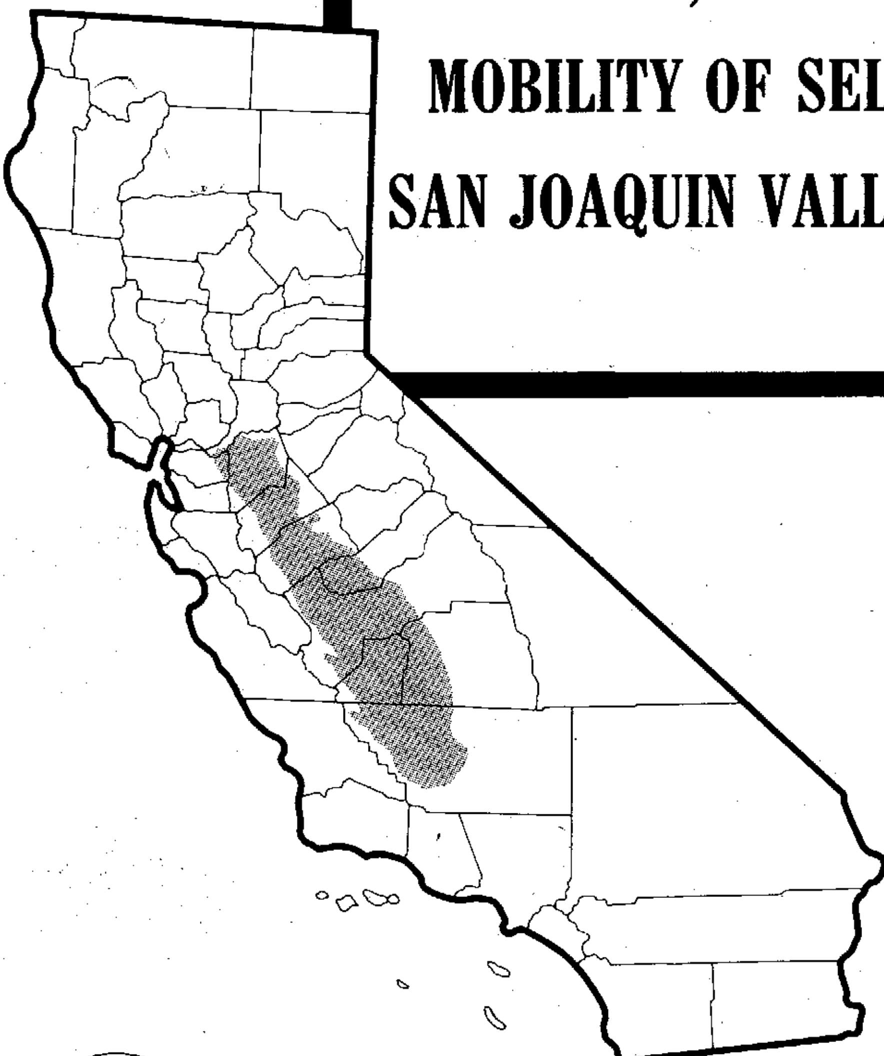

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 88-4186

REGIONAL AQUIFER SYSTEM ANALYSIS

Prepared in cooperation with the SAN JOAQUIN VALLEY DRAINAGE PROGRAM

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By *Robert J. Gilliom and others*

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GEOLOGIC SOURCE OF SELENIUM AND ITS DISTRIBUTION IN SOIL

by *Robert J. Gilliom*

A general evaluation of geologic sources of selenium and its distribution in soils of the entire San Joaquin Valley provides background information needed for more detailed analysis of the primary study area. Selenium in water, soils, and underlying sediments of the San Joaquin Valley originated from geologic formations exposed in adjacent mountains and was transported to the valley in particulate and dissolved forms derived from the weathering and erosion of source rocks (Barnes, 1985). Source rocks differ in selenium concentrations, in proximity to the valley floor or major stream channels, in resistance to weathering, and thus, in their significance as selenium sources to the valley. The relative significance of different types of source rocks in contributing selenium to the valley can be evaluated from selenium concentrations in soil.

Distribution of Selenium in Soils of the San Joaquin Valley

The distribution of selenium in soil was examined and mapped for the entire San Joaquin Valley by Tidball and others (1986a). Their analysis was based on samples of the top 12 inches of soil collected on an irregular grid, with an approximate spacing of about 6 miles between samples. The areal distribution of estimated total selenium concentrations for the 0- to 12-inch depth interval in soils is shown in figure 2. The dominant influence of Coast-Range sources of selenium is evident in the areal distribution shown on this map. Virtually all concentrations greater than the median of 0.13 mg/kg occur in alluvial sediments derived from weathering and erosion of Coast Range rocks. In contrast, soils of the eastern side of the San Joaquin Valley, which consist of sediments derived from rocks in the Sierra Nevada, are low in selenium--generally less than 0.13 mg/kg. For comparison, the median of 912 soil samples from throughout the United States was about 0.3 mg/kg (Shacklette and others, 1974). Only about 10 to 20 percent of the soils in the San Joaquin Valley are estimated to have concentrations of selenium that exceed the national median of 0.3 mg/kg.

The three areas of the valley where selenium in soil commonly exceeds 0.36 mg/kg, the 90th percentile of concentrations in valley soils, are (1) the alluvial fans east of Monocline Ridge, near Panoche and Cantua Creeks, (2) an area west of the town of Lost Hills, and (3) the Buena Vista Lake Bed area, southwest of Bakersfield (fig. 2; Tidball and others, 1986a). All three areas with the highest selenium concentrations in soil are adjacent to parts of the Coast Range where marine sedimentary formations are exposed. These sedimentary formations are sources of sediment from which the soils are derived. Available data indicate the presence of high selenium concentrations in subsurface agricultural drain water from some farmlands near all three areas (Deverel and others, 1984; California Department of Water Resources, 1986).

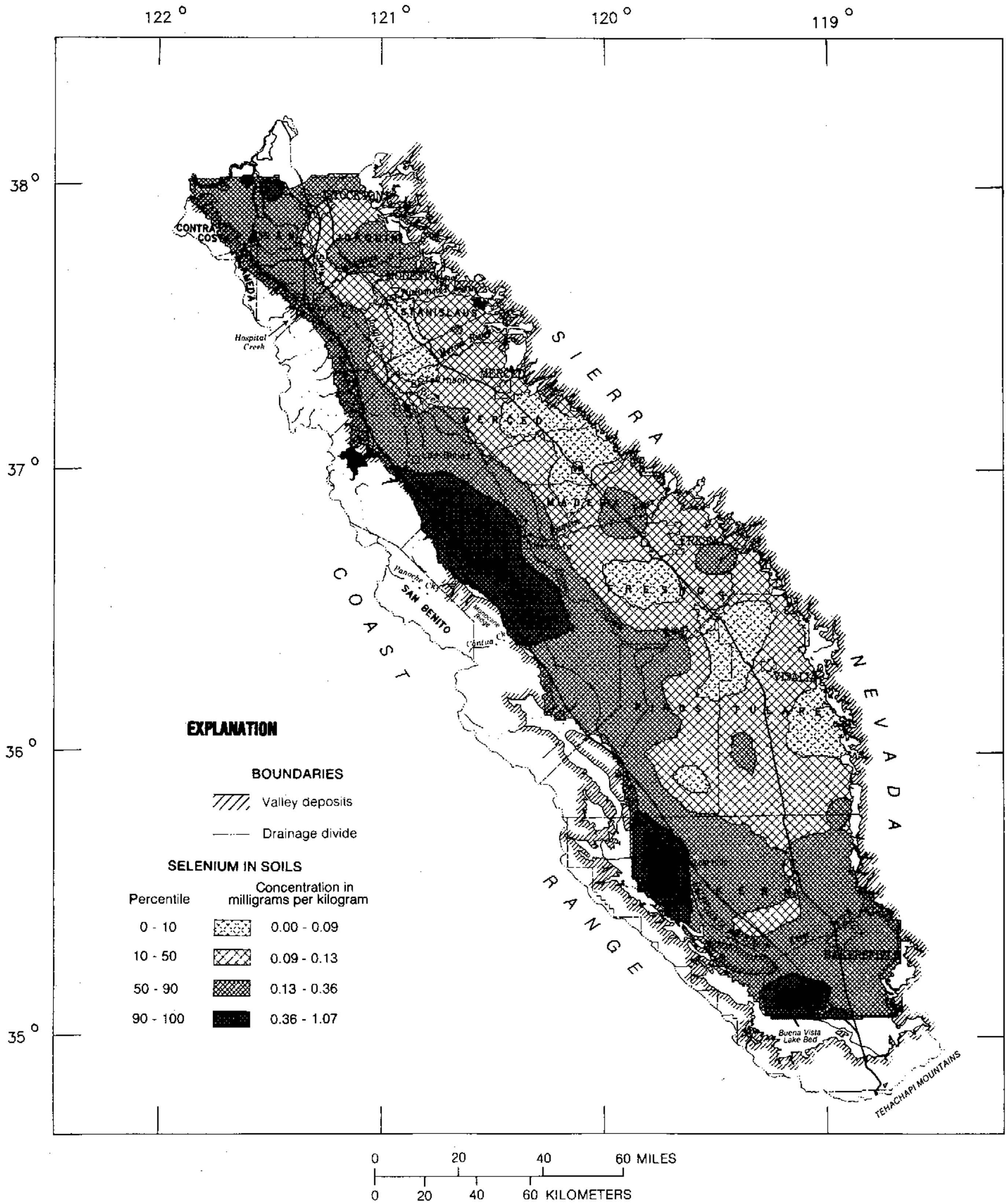

FIGURE 2.— Areal distribution of estimated total selenium concentrations for the 0- to 12-inch depth interval in soils of the San Joaquin Valley. (Adapted from Tidball and others, 1986a.)

Geologic maps of the Coast Range to the west of the San Joaquin Valley show the locations and extent of exposed formations (California Division of Mines and Geology, 1959a, 1959b, 1965, 1966, 1969). Eocene marine rock, including the Kreyenhagen Shale, is present in exposures in the Coast Range to the west of all three areas with concentrations of selenium in soil that exceed the 90th percentile for valley soils. Preliminary data reported by Lund and others (1987) for the Cantua Creek drainage indicate that samples of the Kreyenhagen Shale had selenium concentrations ranging from 3.1 to 18.6 mg/kg. The Kreyenhagen Shale is similar in character to the older Moreno Formation, for which 28 mg/kg of selenium was reported in 1941 for a sample collected near Hospital Creek, north of the primary study area (Lakin and Byers, 1941). Lund and others (1987) found that the Moreno Formation in the Cantua Creek drainage had selenium concentrations ranging from 0.2 to 2.4 mg/kg. In other parts of the United States, marine shales generally have the highest concentrations of selenium compared to other rocks (Sharma and Singh, 1983). On a broad scale, the occurrence of soil with high selenium correlates with the presence of geologic formations with high selenium concentrations.

Distribution of Selenium in Soils of the Central Part of the Western Valley

The central part of the western valley has the largest area with concentrations of selenium in soil that exceed the 90th percentile of concentrations for valley soils. The distribution of total selenium in soils in most of this area was examined in detail by Tidball and others (1986a). They collected soil samples from 721 sites on a 1-mi^2 grid basis in the area of the Panoche Creek and Cantua Creek alluvial fans. Soil samples were collected from the 66- to 72-inch depth and were composited for analyses; total selenium concentrations at this depth were similar to those at shallower depths. The areal distribution of estimated total selenium concentrations for the 66- to 72-inch depth interval in soils is shown in figure 3.

Selenium concentrations are highest between the alluvial fans of Cantua and Panoche Creeks, east of Monocline Ridge. Concentrations in that part of the area generally are greater than 1.14 mg/kg, which is the 90th percentile of all concentrations measured in the central part of the western valley (fig. 3). Selenium concentrations in soils of the alluvial fans of Cantua and Panoche Creeks generally range from 0.80 to 1.14 mg/kg. Concentrations along the eastern margin of the area and to the south of the Cantua Creek fan are lowest--generally less than 0.80 mg/kg, the median for the area.

Tidball and others (1986a, 1986b) were cautious about interpreting the precise geologic sources of selenium in soils. High selenium concentrations in soils of mudflows and other alluvial sediments east of Monocline Ridge, in the area between the alluvial fans of Cantua and Panoche Creeks, may be attributed to high selenium concentrations in the parent geologic formations of the adjoining hills. The Kreyenhagen Shale is exposed on Monocline Ridge (California Division of Mines and Geology, 1959a). Selenium concentrations in soils of the large alluvial fans of Cantua, Little Panoche, and Panoche Creeks are lower than in the interfan area, partly because they are composed of mixtures

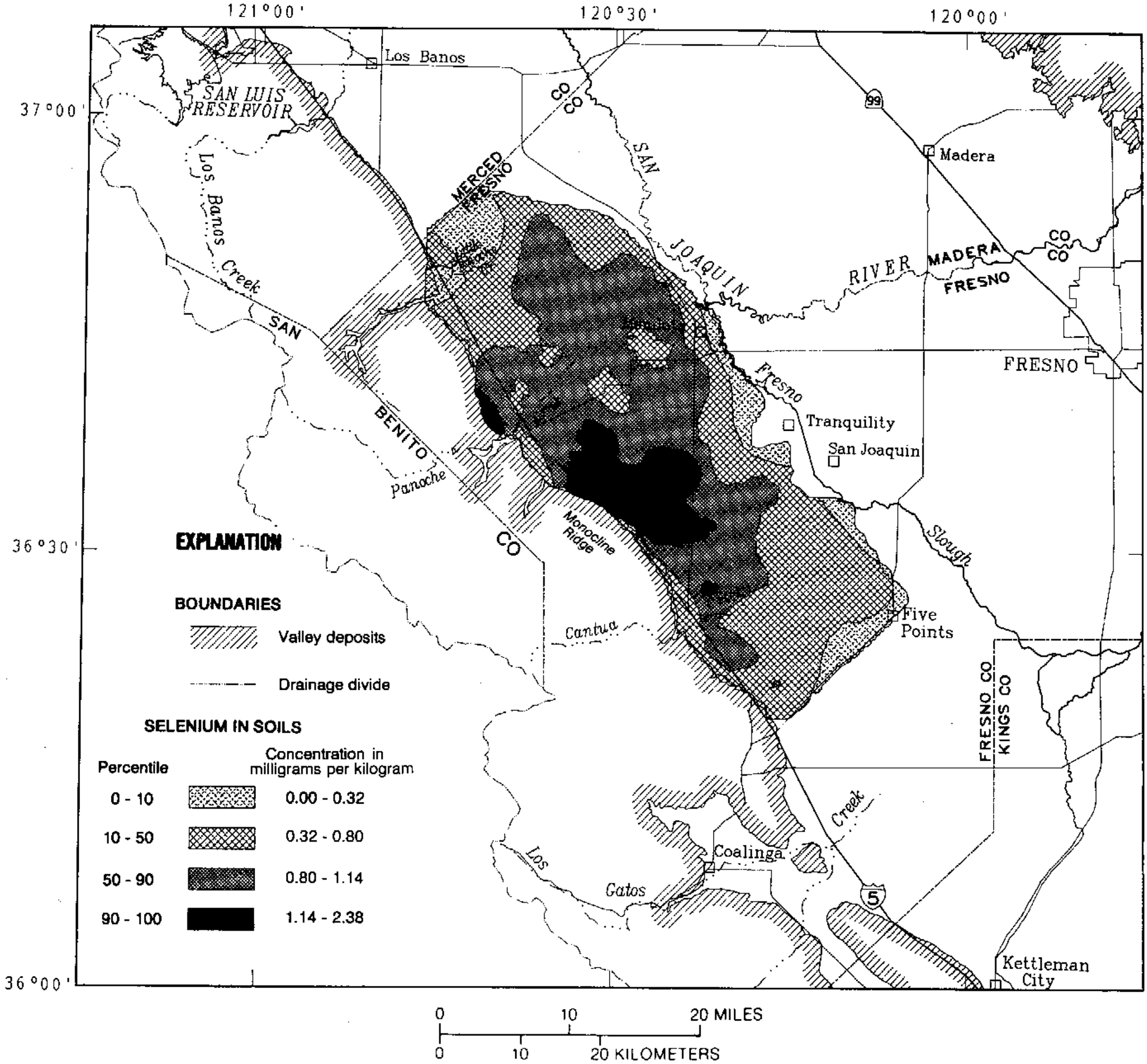

FIGURE 3.— Areal distribution of estimated total selenium concentrations for the 66- to 72-inch depth interval in soils of the central part of the western valley. (Adapted from Tidball and others, 1986a.)

of sediments from large and diverse drainage basins. In the basins of the larger streams, sediments originate from more different types of source materials than in the much smaller drainages associated with the interfan areas. The diversity of sediment sources in the large basins would tend to dilute the effect on soil selenium concentrations of sediment sources with the highest selenium concentrations. In addition, sediments of the fans of the three large streams have been exposed to more natural flushing by runoff water than the sediments deposited by the much smaller streams associated with the areas between the major fans (Belitz, 1988). Although these mechanisms may explain the present distribution of selenium in soil, only direct measurement of geologic source materials at locations where soil sediments originate can determine the geologic sources conclusively.

An exact correlation between the locations of soils and ground water with high selenium concentrations should not be expected. Soluble forms of selenium affect the quality of ground water and the distribution of soluble forms in soil can be different than the distribution of total selenium. The highest concentrations of soluble forms of selenium in soils and ground water can occur in places where hydrologic processes, such as evaporative concentration, contribute to the accumulation of soluble forms of selenium in water or soil. Thus, the highest concentrations of selenium in ground water may occur some distance away from the highest concentrations of total selenium in soil. A key to evaluating the origin and present-day distribution of high selenium concentrations in ground water is to understand the natural distribution of soluble forms of selenium and its redistribution by irrigated agriculture.