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Federal Lands Assesment Program:

Sonoma and Livermore Basins, California

(Province 79)

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Open-File Report

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CONTENTS

Depth of occurrence

Exploration status

References cited

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Introduction

The Sonoma and Livermore basins are remnants of Neogene basins preserved in the structural and topographic low areas north and east of San Francisco Bay (Fig. 1). The Sonoma basin contains one producing gas field and one abandoned oil field, and the Livermore basin contains one producing oil field and one abandoned gas field. Production in both basins is from Neogene strata.

During the middle Miocene, the San Francisco Bay region was a west-facing shelved, forearc basin that became involved in the San Andreas transform orogene (Graham and others,1984). The onset of wrench fault tectonics in middle to late Miocene time created a several offshore depocenters with sediment sources in nearby uplifted areas. Onset of wrench faulting also triggered eruption of volcanic rocks that became interfingered with marine and nonmarine clastic rocks. In Pliocene and early Pleistocene time the area was dominated by rapid subsidence accompanied by local uplift and a waning of volcanism. As a result, some basins developed internal drainage systems with lacustrine and flood plain sedimentation.

Undiscovered hydrocarbon accumulations in the Neogene sequences of the Sonoma and Livermore basins are estimated to be small. The Petaluma and Cotati fields in the Sonoma basin have produced commercial quantities of gas from Pliocene strata. A depleted oil zone in the Petaluma gas field, and a small field in the Livermore basin have produced about 1,500,000 bbls of oil. The gas zones in the Petaluma field are currently (1987) shut in.

Most of the data in this report on the petroleum geology of the Livermore basin are from Hafenbrack and Sonneman (1976), and the regional framework geology is from Graham et al., (1984). Data on the Sonoma basin are from Hobson (1971), and California Division of Oil and Gas reports.

Stratigraphy of the Livermore basin

Franciscan Complex

The Sonoma and Livermore basins are floored by rocks of the Franciscan Complex or Franciscan Assemblage. The Franciscan consists of tectonically disrupted rocks of diverse lithology and structural complexity. One type of widespread unit is melange, which contains blocks of banded chert, metagraywacke, altered basalt, blueschist, greenstone, variably serpentinized fragments of ultramafic rocks (ophiolite) in a scaly argillaceous matrix. Some areas in the Franciscan contain structurally coherant sequences of graywacke, chert, and pillow basalt, as well as tectonic slices or klippe of arkosic sandstone, siltstone, and shale that are petrologically similar to the Mesozoic Great Valley Sequence. Franciscan rocks are well exposed in the Mt. Diablo area and in the Diablo Range that forms the southern flank of the Livermore basin (Fig. 2).

Rocks of Late Mesozoic and Eocene age

Sedimentary rocks that presumably underlie the Livermore basin are well exposed in a homoclinal sequence along the south side of the Mt. Diablo uplift. The oldest part of the Tertiary section consists of approximately 875 m (2800 ft) of strata assigned to the Eocene Capay and Domengine formations (Fig. 3). The Capay consists of gray marine claystone interbedded with thin sandstone turbidites, which interfinger eastward with massive marine sandstone of the Domengine Formation that is well-exposed to the southeast of Mt. Diablo. The Eocene rests unconformably on unnamed Upper Cretaceous (Campanian) strata of the Great Valley Sequence. Eocene strata along the south side of the Livermore basin are a called the Tesla Formation, and are probably correlative with the Capay and Domengine formations.

Rocks of Miocene age

Sobrante Formation--The oldest Miocene rocks known in the Livermore basin are called the Sobrante Formation, consisting of approxiamtely 155 to 218 m (500 to 700 ft) of gray to blue gray coarse-grained sandstone and minor amounts of pebble conglomerate (Fig. 3). Sobrante strata are interpreted to be a shallow marine transgressive unit of the Luisian stage. The formation is coeval with biogenic siliceous shales of the Monterey Formation that is exposed west of the Hayward fault.

Briones and Cierbo formations--The Sobrante Formation is unconformably overlain by about 140 m (450 ft) of shallow marine sandstone and pebble conglomerate called the Briones Formation (Fig.3). The Briones grades upward into a sequence of shallow marine coarse-grained sandstone and conglomerate called the Cierbo Formation. Cierbo sandstone, which produces oil in the Livermore field, locally laps onto Upper Cretaceous strata and the Franciscan.

Neroly Formation--The Neroly Formation is an upper Miocene (Delmontian) sequence of shallow marine and nonmarine (flood plain) sandstone, volcaniclastic conglomerate, tuff, and shale that gradationally overlies the Cierbo Formation (Fig. 3) and also overlaps Mesozoic rocks.

Rocks of Upper Miocene, Pliocene, and Pleistocene age

Orinda Formation--A 4,375 m thick (14,000 ft) sequence of lacustrine claystone, and floodplain coarse-grained sandstone and volcanic-rich conglomerate called the Orinda Formation, gradationally overlies the Neroly Formation (Fig. 3). The Orinda contains a mammalian vertibrate fauna that yields a radiometric age 9.9 Ma.

Livermore Gravels--A lower Pleistocene sequence called the Livermore Gravels unconformably overlies all older units, and completes the sedimentary section in the Livermore basin.

Play Description

Name: Livermore Basin Neogene

The Neogene section is considered to be the only significant hydrocarbon play in the Livermore basin.

Reservoir rocks

The most likely reservoir rocks in the basin are the shallow marine sandstone beds in the Cierbo and Briones formations. Oil in the Livermore field is 25° to 29° API gravity, and is produced from sandstone in the Miocene Cierbo Formation.

Traps and seals

Traps in the Livermore basin are mainly formed by northwest trending en-echlon anticlines that have formed in reponse to right-lateral movement on the Hayward and Calaveras faults, which are part of the San Andreas transform system. Transverse faults on the nose of some folds may form traps of secondary importance. The Tassajara anticline is the largest fold in the Livermore basin, but exploratory wells located on structure have tested dry (Fig. 4).

Source rocks

The source of the oil and gas in the Livermore basin is not known. Organic rich shales of the Monterey Formation do not exist in the Livermore basin (Fig. 1), but the claystone of the Capay and Domengine formations that unconformably underlie the Neogene section might be a possible source.

Timing and migration

Little is known about the details of the timing and migration paths of the hydrocarbons that have been discovered in the Livermore basin. Subsidence and folding appear to have been most active during the Pliocene, so a reasonable assumption is that migration and accumulation took place in late Pliocene or early Pleistocene time.

Depth of occurrence

Oil in the Livermore field is produced from perforations between drill depths of 576 to 632 m (1845 and 2024 ft). In the deep parts of the basin, the Cierbo Formation (which produces in the Livermore field) may be as deep as 1875 to 2500 m (6000 to 8000 ft), (Fig.4).

Exploration status

The major structures of the Livermore basin have been drilled, but have yielded little success. The Tassajara anticline has been drilled by wells as deep as 3135 m (10,032 ft), with no shows. Drilling was originally stimulated by significant seeps that had been known since the early 1800's. Oil in the Livermore field is produced with a substantial amount (59%) of water. Cummulative oil production in 1976, nine years after dicovery, was 1,071,700 bbls, and by 1986 had reached 1,567,000 bbls. More than 55 wells had been drilled in and around the oil field by 1986, of which 11 produce approximately 90 bbl/day. Reserves in 1987 were listed by the California Division of Oil and Gas at 132,000 bbl.

A well drilled approximately 3 miles southwest of the Livermore field in the early 1950's produced 14,183 Mcf from the now abandoned Hospital Nose field. The well was drilled to 2206 m (7062 ft), and produced from a zone in Upper Cretaceous sandstone at approximately 1650 m (5280 ft) (Hafenbrack and Sonneman, 1976).

Sonoma Basin Plays

The Sonoma basin is a structural depression that lies north of San Pablo Bay (Fig. 1). The basin is flanked on the west by northward extending splays of the Hayward fault system, and flanked on the east by uplifted parts of the Franciscan Assemblage and associated tectonic slivers of Late Mesozoic strata of the Great Valley Sequence (Fig.1). Wells in the deepest part of the basin have penetrated Eocene, Oligocene, Miocene, and Pliocene strata. A small field located approximately 6 km (4 mi) east of the town of Petaluma, and called the Petaluma field has produced gas and oil from the Pliocene Purisima Formation. A one-well field discovered in 1983 near the town of Cotati, produces commercial gas also from Pliocene strata.

Play Description

Name: Sonoma Basin Neogene

Neogene strata are considered to be the only significant play in the Sonoma basin.

Reservoir Rocks

Sandstone beds in the Pliocene Purisima Formation have conventional intergranular porosity in the Petaluma field where they have produced gas and oil. Gas in the Cotati field is reportedly produced from fracture porosity in volcanic rocks (Mefferd, 1986).

Traps and seals

Hydrocarbons in the Petaluma field are trapped by a faulted anticline, and presumably sealed by interbedded mudstone and shale. Folds within the basin probably formed in response to compression associated with San Andreas fault system wrench tectonics in Pliocene and early Pleistocene time.

Source rocks

Little is known about the source of the oil and gas in the Sonoma basin. Potential source rocks exist in most of the Tertiary and Late Mesozoic marine strata in the basin and surrounding areas.

Timing and migration

Hydrocarbons in the Petaluma field probably migrated into the trapping anticline sometime during the late Pliocene or early Pleistocene, in response to major movements along the San Andreas fault system.

Depth of occurrence

The Petaluma field produces gas from two zones and produced oil from a zone located stratigraphically between the two gas zones. The productive interval is approximately 6.5 m (20 ft) thick, between drill depths of 209 and 387 m (670 and 1240 ft) (Mefferd, 1986).

Exploration status

Hydrocarbons in the Petaluma field were discovered in the 1940's, and production was most active between 1951 and 1956. By the end of 1986, the field was inactive and had no producing wells and 9 shut-in wells. Cummulative production figures are 14 Mbbl for oil, and 1.2 Bcf for gas with 0.2 Bcf remaining to be produced. Oil reserves are estimated to be zero, Mefferd (1986).

The Cotati field has one well that in 1986 produced 265 Mcf/day; cummulative production is listed as 235 MMcf through 1986. Reserves are estimated to be approximately 265 Mcf (Mefferd, 1986).

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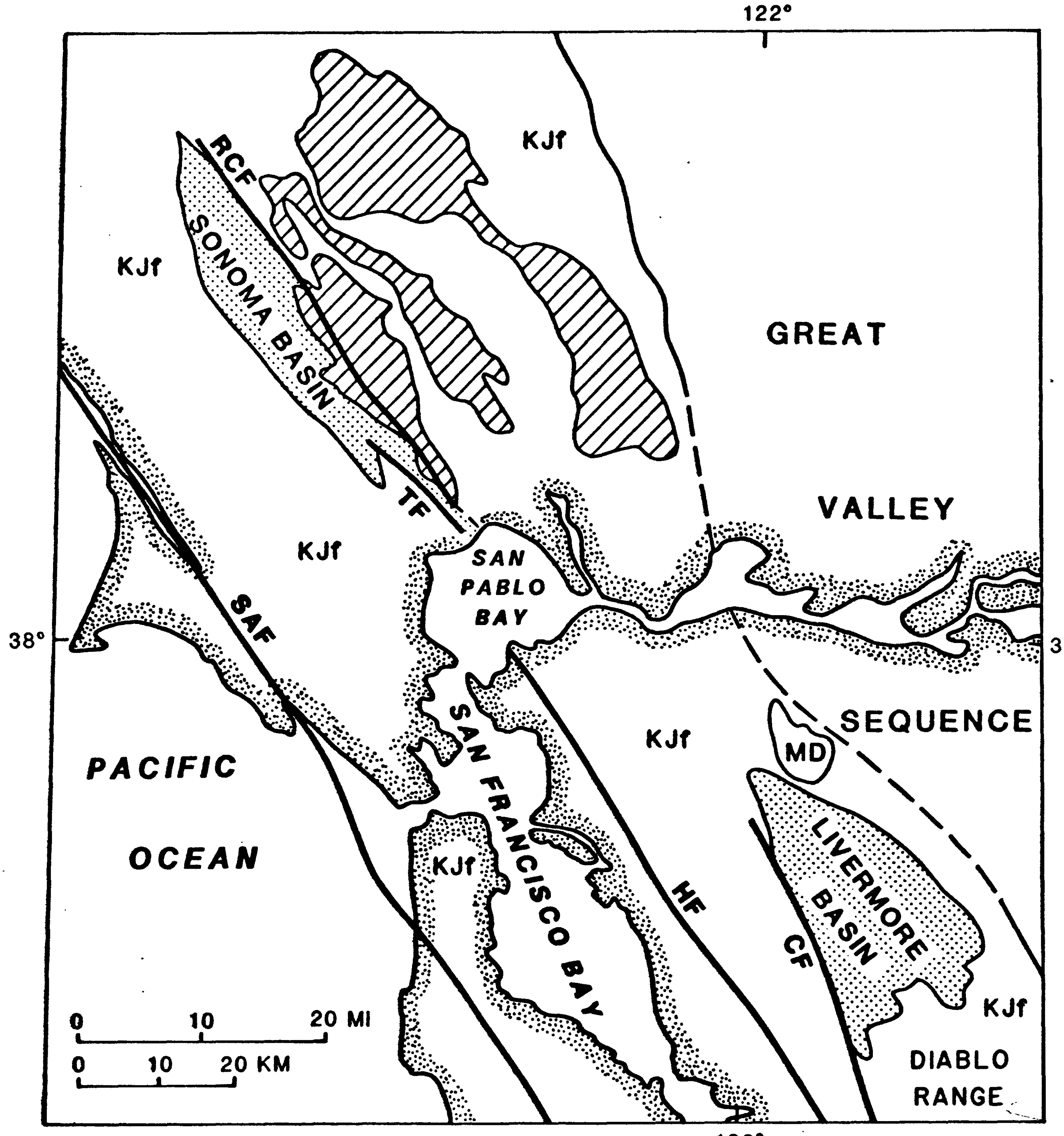

Figure 1. Map showing location of Sonoma and Livermore basins (stippled areas) and important geologic and geographic features. KJf, areas underlain by Franciscan basement rocks; Diagonal pattern, Tertiary (mostly Miocene) volcanic rocks; CF, Calaveras fault; HF Hayward fault; MD, Mount Diablo uplift; RDF, Rogers Creek fault; SAF, San Andreas fault; TF, Tolay fault.

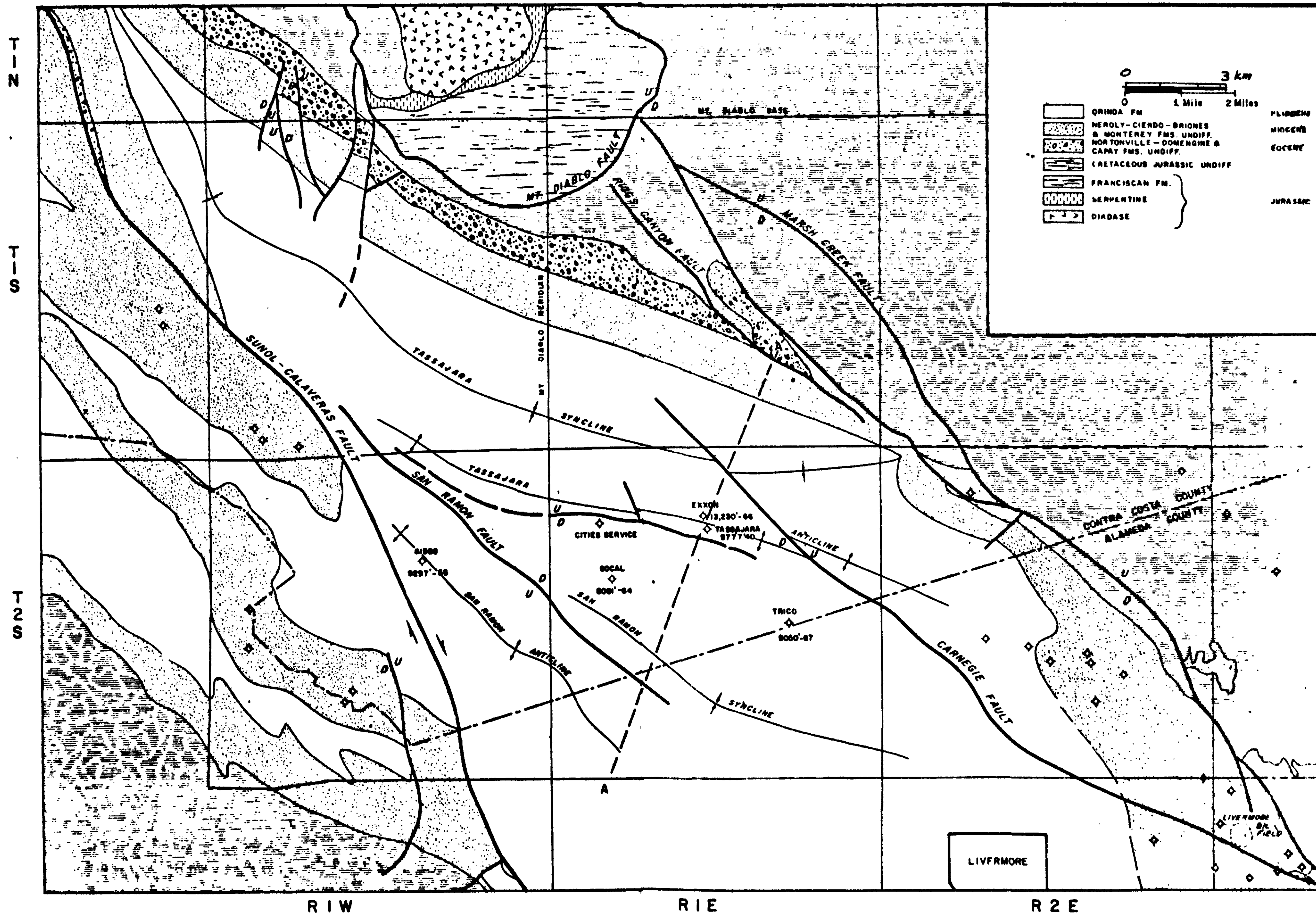

Figure 2. Generalized geologic map of the Livermore Valley area. From Hafenbrack and Sonneman (1976).

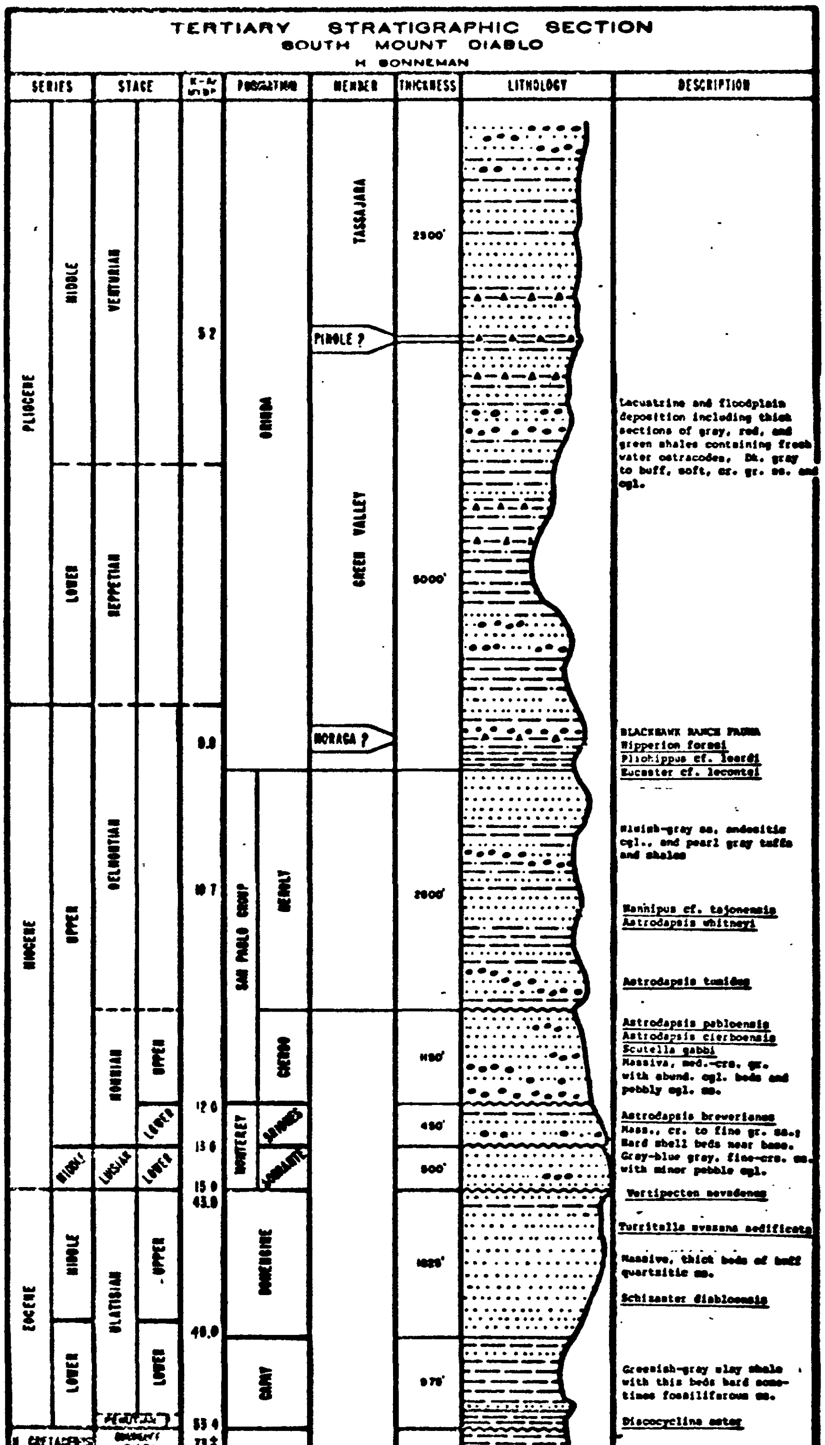

Figure 3. Composite columnar section of strata exposed south of Mount Diablo. From Hafenbrack and Sonneman (1976).

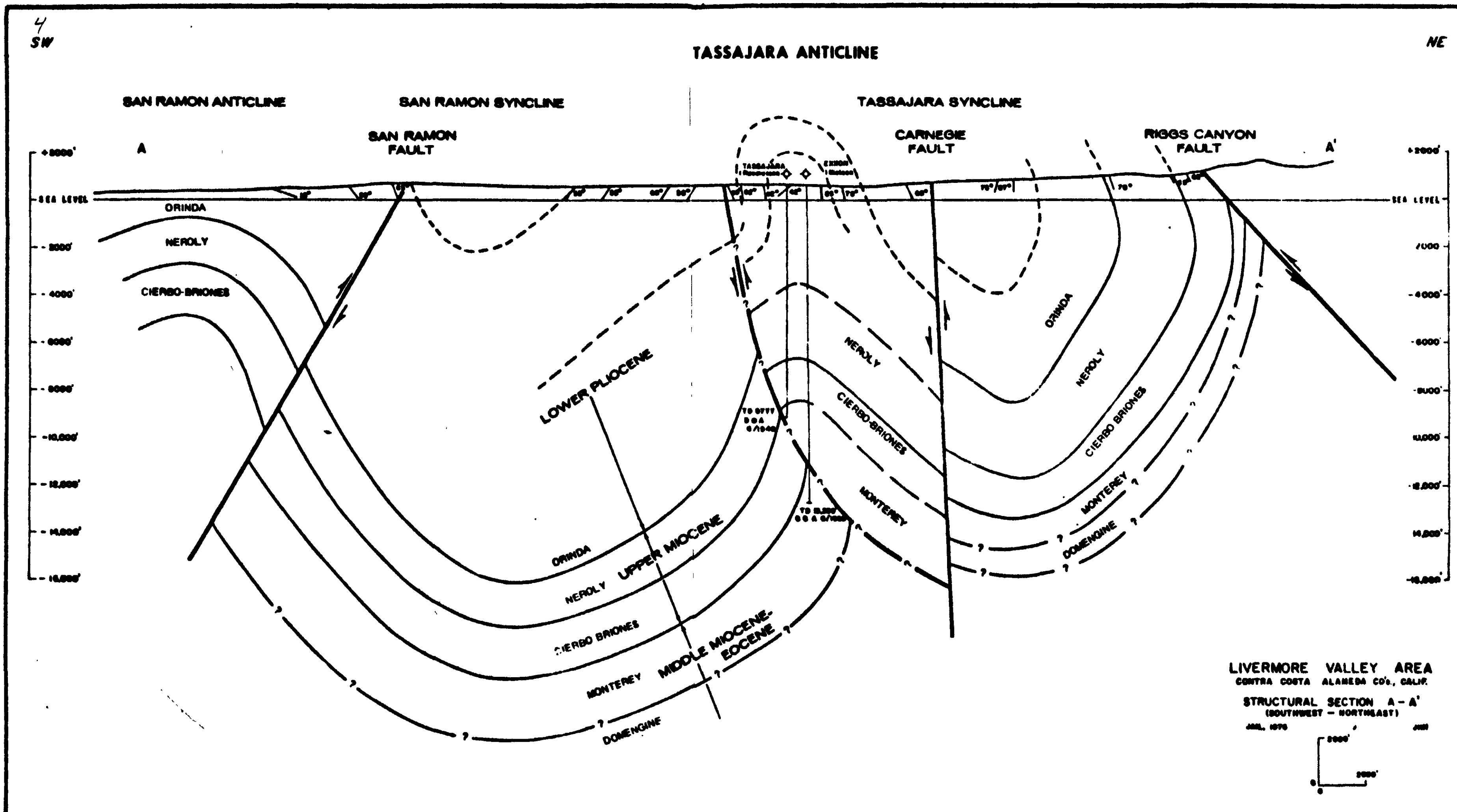

Figure 4. Structure section A-A' through Livermore basin. Location shown in Figure 1. Modified from Hafenbrack and Sonneman (1976).

9