SONOMA-LIVERMORE BASIN PROVINCE (008)

By Leslie B. Magoon

INTRODUCTION

The Sonoma-Livermore Province, located west of the Sacramento Basin Province (9) and east of the Central Coastal Province (11), is composed of a series of northwest-trending Neogene successor basins: the Sonoma, Orinda, and Livermore Basins. These Neogene basins lie east and north of the San Francisco Bay area; San Pablo Bay separates the Sonoma Basin to the north from the Orinda and Livermore Basins to the south. The Hayward Fault bounds the west side of the Orinda and Sonoma basins. The Healdsburg and Rogers Creek Faults bound the east side of the Sonoma Basin, whereas the Diablo Range bounds the east side of the Livermore Basin. The Franciscan Formation and Pliocene volcanic rocks occur in the northeast part of the province. The entire province is about 115 mi in length and about 35 mi in width, and covers 2,649 sq mi. New field wildcats drilled in this province are 108 with two over 12,000 ft.

During the Mesozoic and early Cenozoic, this area was the outer arc ridge of the west-facing forearc basin whose main north-south axis was coincident with the Sacramento and San Joaquin Basins. Farther east, the Sierra Nevada Batholith was the site of andesitic volcanic arc activity and the provenance for most of the pre-Miocene siliciclastic material deposited in this province. The geology in the Sonoma-Livermore Province is further complicated by the Mendocino triple junction which transformed a convergent continental margin into a strike-slip margin in the middle Miocene (14-13 Ma).

The convergent-margin stratigraphy in the Sonoma-Livermore Province is difficult to reconstruct for the successor basins because of sparse outcrop exposures and overlying strike-slip stratigraphy and faulting. The stratigraphic section for this province is for the Livermore Basin (McLean, 1993). Stratigraphic names change frequently, even within the same basin. For purpose of discussion, the province is broken up into areas that, where appropriate, are coincident with the Neogene successor basins. The Sonoma and Napa, California, areas are to the north of the San Pablo and Suisun Bays, and the Orinda, Concord, and Livermore areas are south of the bays. The Jurassic and Cretaceous Franciscian Formation underlies the entire province and is in fault contact with either the overlying Jurassic (Knoxville Formation on the Concord Block) or the Cretaceous (mostly the Upper Cretaceous Great Valley sequence). Locally, Paleocene, Eocene, and Oligocene rocks occur in the Concord and Napa areas, and is reported to have been penetrated by wells in the Sonoma area (Hobson, 1971). Rock units deposited in the early part of the middle Miocene are on a west-facing forearc shelf, with the strand line deposits in the Livermore area--the more marine facies are to the west in the Orinda, California, area.

The strike-slip stratigraphy in this province commences in the middle Miocene (14-13 Ma) when the Mendocino triple junction passed by on its northward journey (Graham and others, 1984). As the triple

junction passed, the right-slip Hayward Fault moved first, which was then followed, but to a lesser extent, by the right-slip Calaveras Fault, and so on to the east. This strike-slip motion provided the shearing needed to form the Neogene successor basins: the Sonoma, Orinda, Concord, and Livermore Basins. Widespread volcanism occurred with the formation of these basins during the Pliocene in the Napa area. These successor basins were then filled by middle Miocene and younger sedimentary rocks represented by the Contra Costa Group, a series of nonmarine formations, and the San Pablo Group, a series of marine rocks. Pliocene through Holocene rock units overly these Miocene rocks.

Several small petroleum accumulations occur in this province. In the Sonoma Basin, the Petaluma oil field was discovered in 1926. This field, now shut in, produced a total of 14,000 BO and 1.3 BCFG from Pliocene strata and volcanic rocks at a depth of 1,200 ft. The one-well Cotati gas field, discovered in 1983, produces commercial gas from Pliocene strata (McLean, 1988). In the Orinda Basin, the Pinol Point field, which was discovered in 1969, was abandoned after producing 14,000 BO from the upper Miocene Neroly Formation and the Pliocene Orinda Formation. In the Livermore Basin, exploratory drilling resulted in the discovery of the Livermore oil field in 1967, which produces from the Eocene Tesla Formation and the upper Miocene Cierbo Formation at a depth of up to 5,000 ft and is located on a folded and faulted anticlinal nose (Hafenbrack and Sonneman, 1976). Cumulative production to the end of 1992 from the field was 1.683 MMBO, with an estimated 16 MBO left to produce (California Department of Conservation, 1993). Discovered in 1952, the Hospital Nose gas field is now abandoned after having produced 14 MMCFG from a depth of about 5,000 ft in an Upper Cretaceous reservoir rock.

The origin of the petroleum in the Sonoma-Livermore Province is unclear, but at least two explanations are possible. First, the petroleum could be locally derived from the successor basins in which they are found, that is the middle Miocene and younger overburden rock was sufficiently thick to generate oil and gas from the underlying sedimentary rocks. To date, an adequate source rock is yet to be found anywhere in the section. Reservoir and seal rocks in the form of traps are present as well as sufficient overburden rocks to thermally mature the source rock, if present. In addition, the locally derived petroleum charge post-dates trap formation; that is, the timing is correct.

The second possibility for the origin of the petroleum is that the oil and gas migrated in from the Sacramento Basin area prior to the middle Miocene and the formation of the successor basins. According to Zieglar and Spotts (1978), oil and gas generation could have taken place as early as Late Cretaceous and may have been mostly completed by middle Miocene time. Migration distances would be up to 35 mi, or much less than proposed for the petroleum systems in the Sacramento Basin. If this is the appropriate interpretation, then after the oil and gas migrated into the area, the petroleum remigrated during the formation of the strike-slip basins. This might explain the small volume of petroleum found in

this area and the lack of oil and gas in some structures, such as the Tassajara Anticline in the Livermore Basin.

ACKNOWLEDGMENTS

Scientists affiliated with the American Association of Petroleum Geologists and from various State geological surveys contributed significantly to play concepts and definitions. Their contributions are gratefully acknowledged.

CONVENTIONAL PLAYS

0801. SONOMA-LIVERMORE PLAY

This play is predicated upon petroleum migrating into traps within the various areas in pre-middle Miocene time and then remigrating into present-day traps as the successor basins formed. This interpretation for the origin of presently known petroleum accumulations favors one play for the entire province rather than a separate play for each successor basin. The play covers the Sonoma, Orinda, Concord, and Livermore Basins wherever there is Great Valley sequence and younger rocks. About 1.7 MMBO have been discovered (most of it in the Livermore oil field), and about 1.3 BCFG have been discovered, mostly in the Petaluma field.

Reservoirs: Reservoir rocks include sandstone in the Capay Formation, Domengine Formation, Markley Sandstone, Sobrante Sandstone, San Pablo Group (Briones and Cierbo sandstones, and Neroly Formation). and Contra Costa Group (Orinda Formation), Purisima Formation (Petaluma field), and fractured volcanic rock (Cotati field). Seals are the shales and shaly siltstone within most of the reservoir rocks.

Source rocks: Based on the Brentwood oil field and the Rio Vista gas field, both oil and natural gas are possible. The source rocks are suspected to be the same as in the Sacramento Basin, such as the Winters Shale or possibly the Moreno Shale, and Sacramento Shale.

Traps: Trap type anticipated for this play are faulted anticlines, stratigraphic traps, anticlines, and fault traps associated with strike-slip movement.

Exploration status and resource potential: Several small petroleum accumulations occur in this province. About 58 new field wildcats have been drilled with two wells deeper than 12,000 ft. In the Sonoma Basin, the Petaluma oil and gas field was discovered in 1926. This field, now shut in, produced a total of 14,000 BO and 1.3 BCFG from Pliocene strata and volcanic rocks at a depth of 1,200 ft. The one-well Cotati gas field, discovered in 1983, produces commercial gas from Pliocene strata (McLean, 1988). In the Orinda Basin, the Pinol Point field, which was discovered in 1969, was abandoned after producing 14,000 BO from the upper Miocene Neroly Formation and the Pliocene Orinda Formation. In the Livermore Basin, exploratory drilling resulted in the discovery of the Livermore oil field in 1967, which produces from the Eocene Tesla Formation and the upper Miocene Cierbo Formation at depths as great as 5,000 ft and is located on a folded and faulted anticlinal nose. Cumulative production to the end of 1992 from the field 1.683 MBO, with an estimated 16 MBO left to produce (California Department of Conservation, 1993). Discovered in 1952, the Hospital Nose gas field is now abandoned after having produced 14 MCFG from a depth of about 5,000 ft in an Upper Cretaceous reservoir rock. The play has a dry hole ratio of 12:1 (58:5).

UNCONVENTIONAL PLAYS

There are no unconventional plays described in this province report. However, unconventional plays listed in the surrounding provinces may include parts of this province. Individual unconventional plays are usually discussed under the province in which the play is principally located.

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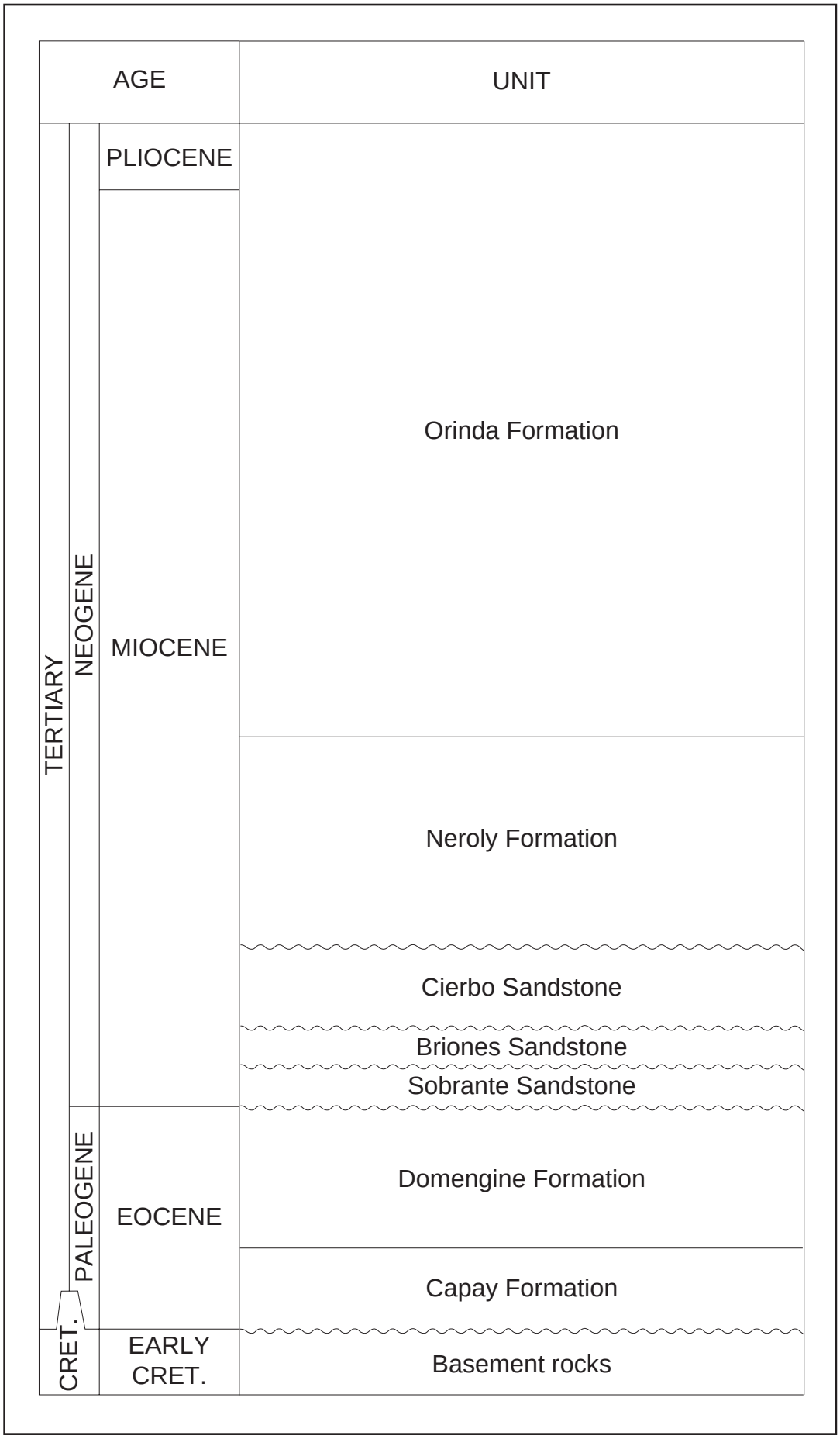
AGE
UNIT
TERTIARY
NEOGENE
PALEOGENE
PLIOCENE
MIOCENE
EOCENE
CRET.
EARLY CRET.
Orinda Formation
Neroly Formation
Cierbo Sandstone
Briones Sandstone
Sobrante Sandstone
Domengine Formation
Capay Formation
Basement rocks