SACRAMENTO BASIN PROVINCE (009)

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INTRODUCTION

The Sacramento Basin, which occupies the north half of the Great Valley of California, is an elongate, northwest-trending structural trough. The trough is filled with as much as 40,000 ft of Jurassic to Holocene, marine and nonmarine siliciclastic rocks deposited in a convergent margin between late Mesozoic and early Cenozoic time. The province, which is 210 mi long and 60 mi wide, is bordered on the west by the Coast Range Thrust, on the north by the Klamath Mountains, on the east by the Cascade Range and Sierra Nevada, and arbitrarily on the south by the Stanislaus-San Joaquin County line. The province covers an area of 11,820 sq mi.

The Sacramento Basin is primarily a gas-producing province with only two small oil fields (Brentwood (8.2 MMBO) and West Brentwood (1.6 MMBO)), located in the southern part of the basin and 73 gas fields . Major gas fields, with estimated recoverable gas as of January 1991, are Rio Vista (3.5 TCFG), Grimes (885 BCFG), Willows-Beehive Bend (387 BCFG), Lathrop (359 BCFG), Lindsey Slough (279 BCFG), and Union Island (261 BCFG). Cumulative production through 1990 is 8.2 TCFG with 13 MMBO.

Exploration in this province started in 1918, and by the end of 1990 almost 2,600 new field wildcats had been drilled. The most active period of exploration occurred between 1960 and 1980. About 2,300 wells were drilled to depths that ranged from 3,000 to 10,000 ft, with several wells approaching 20,000 ft. The dry hole ratio is 35:1 (2,600:75) or a success rate of almost 3 percent (table 9.1). Discovery dates and volumes for fields are found with the plays assessed in this province.

Based on stratigraphic and geographic occurrence, hydrocarbon composition (Jenden and Kaplan, 1989), and direction traps filled, two gas systems are identified in this province, the Dobbins-Forbes(?) and the Winters-Domingene(?). The Northern Forbes-Kione Play (0901) and the Southern Forbes-Kione Play (0902) correspond to the Dobbins-Forbes(?) system, and the Winters through Domingene Play (0903) to the Winters-Domingene(?) system. The first two plays are separated by an arcuate line near T. 12N. which separates the discovered accumulations to the north (play 0901) from the lack of accumulations on the south (play 0902).

The hydrocarbons for both systems originate from gas-prone source rocks in the area of the "delta depocenter" (Zieglar and Spotts, 1981), which is suspected to be the Dobbins Shale or Forbes Formation for the Dobbins-Forbes(?) system and the Winters Shale or Sacramento Shale for the Winters-Domingene(?) system. Regional seal rocks that partition the systems are the Prince Canyon fill and Capay Shale in the north and, in the south, the Sacramento Shale. The burial-history curve of Zieglar and Spotts

(1981) indicates that gas could have started to migrate by the early Tertiary for the Dobbins-Forbes(?) and by Oligocene for the Winters-Domingene(?) systems.

Trap geometry was established by Oligocene time. Basin-wide faulting occurred prior to deposition of the late Eocene to Oligocene because the late Eocene through Miocene-Pliocene nonmarine sedimentary rocks (< 4,000 ft) truncate these faults. From the direction that producing fields were charged, it is apparent long-range gas migration occurred from south to north for up to 125 mi, and gas with associated oil migrated from west to east for as much as 40 mi. Although these distances are long, geology and gas geochemistry support this hypothesis sufficiently to be a basis for the plays.

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CONVENTIONAL PLAYS

0901. NORTHERN FORBES-KIONE PLAY

This confirmed gas play covers 7,108 sq mi in all of the northern Sacramento Basin Province and is defined by the similarity of the gas production that comes mostly from the reservoir rocks in the Kione and Forbes Formations. This play is separated from plays 902 and 903 by an arcuate line drawn south of the Dunnigan Hills, Buckeye, Kirk, Robbins, and Nicolaus fields. Discovered reserves are 2.2 TCFG in 28 fields, with the largest three fields, from south to north, being Grimes (885 BCFG), Willows-Beehive Bend (387 BCFG), and Malton-Black Butte (135 BCFG). Traps are mostly combination (22) with some structural (3) and stratigraphic (3).

Reservoirs: Late Cretaceous sandstones in the Forbes and Kione are the principal reservoir rocks in this play; however, others must be included. For example, sandstone in the Venado, Sites, and Guinda Formations are Late Cretaceous, and the sandstone in the Princeton Canyon fill and in the Capay Shale are Tertiary in age. The producing reservoir rocks range in thickness from 11 to 490 ft and average 93 ft.

Source rocks and timing and migration of hydrocarbons: The identity of the mature source rock for the gas in this play is uncertain. The Dobbins Shale and possibly the shales in the Forbes Formation where they are buried to the greatest depth just west of the Rio Vista gas field in the "delta depocenter" are the most likely source rocks for this gas. TOC data in Jenden and Kaplan (1989) indicate the Forbes and Dobbins Formations contain about 1 weight percent total organic carbon where it is immature, or a marginal gas-prone source rock.

Based on the burial-history curve of Zigler and Spotts (1978) in the delta depocenter, the Dobbins and Forbes Formations generated gas in Late Cretaceous (80 Ma) to the Miocene (10 Ma). The gas migrated north, through the Forbes Formation (in play 902) in a moderately overpressured section, to the 901 play area. In the play area, the gas accumulated in primarily stratigraphic traps that later were deformed into structural traps.

Exploration status and resource potential: The 28 discovered accumulations are located along a north-south corridor up the middle of this play where most of the new field wildcats are drilled. Beyond this corridor is the most likely area where the undiscovered accumulations will be found. The discovered traps are mostly combination traps that range in depth from 980 ft to 6,260 ft, with an average depth of 3,684 ft, and are sealed by shale on depositional contacts. The size of the trap, as measured from productive acreage, ranges from 60 acres to 26,060 acres and averages 2,489 acres.

0902. SOUTHERN FORBES-KIONE PLAY (HYPOTHETICAL)

This hypothetical play covers 4,712 sq mi in all of the southern Sacramento Basin Province and is defined by the downdip extension of the Forbes Formation. This play underlies the Winters through Domingene

Play 903 and is separated by the shale of the Sacramento Formation above and on the north by the arcuate line at the southern boundary of the Northern Forbes-Kione Play 901. Discovered reserves are lacking, because the 2.2 TCFG discovered in the Northern Forbes-Kione Play (901) had to migrate through this play area (902) from the downdip mature source rock. This play has high potential if adequate traps occur above the top of the overpressured (> 0.7 psi/ft) rocks.

Reservoirs: Late Cretaceous sandstones in the Forbes Formation are the principal reservoir rocks in this play; however, others must be included, such as the sandstone of the Guinda Formation. The reservoir rocks are all bound by the shale and siltstone facies in their respective formations.

Source rocks and timing: The source rock for this play is unknown but is suspected to be the Dobbins Shale and possibly shales in the Forbes Formation. These shales are gas-prone and most likely contain structured organic matter (Zieglar and Spotts, 1978). Data is lacking in the literature because the source rock is beyond the drill-bit, the data exists but is still in oil company files, or the source rock is lean and has been overlooked.

Based on the burial-history curve of Zigler and Spotts (1978) in the delta depocenter, the Dobbins and Forbes Formations generated gas in Late Cretaceous (80 Ma) to the Miocene (10 Ma). As the gas was generated, it migrated updip toward play 901 to the north.

Exploration status: The exploration status for this play is difficult to evaluate because the objective for most of the new field wells are traps above the Sacramento Formation. A depth map to the base of the Sacramento Shale shows the depth a new field well must drill before it evaluates this play. Based on this map, 52 wells test this play.

Resource potential: Because traps above the Sacramento Shale fail to overly deeper traps, traps in the Forbes interval are seldom found by deepening wells below a producing field. In addition, lenticular sandstone bodies, which are excellent stratigraphic traps, are commonly found in the Forbes Formation. For these reasons, exploration within this interval is difficult. High potential for substantial reserves exists is obvious if adequate traps occur above the top of the overpressured (< 0.7 psi/ft) rocks).

0903. WINTERS THROUGH DOMINGENE PLAY

This confirmed play covers 4,712 sq mi in all of the southern Sacramento Basin Province and is defined by the gas production from 47 fields whose reservoir rocks are above the Sacramento Formation. The Southern Forbes-Kione Play 902 directly underlies the Sacramento Formation. The largest four fields are: Rio Vista (3,500 BCFG, 1,521 MBO); Lathrop (358.5 BCFG); Lindsey Slough (279 BCFG, 1,230 MBO), and Union Island (261 BCFG, 10 MBO). Discovered reserves are 6.6 TCFG and 14 MMBO in 47 fields.

Reservoirs: Reservoir rocks that range in age from Late Cretaceous to Oligocene, with the Domengine Formation of Eocene age providing most of the production. Other reservoir rocks include sandstone in the Winters Formation, Starkey sands, Mokelumne River Formation, Martinez Formation, Capay Formation, Nortonville Shale, Markley Formation, Lathrop sands, Tracy sands, Blewett sands, Azevedo sands, and Garzas sand. Most of these sandstones were deposited in a marine environment. Reservoirs range in thickness from 4 to 550 ft. Porosities and permeabilities range from 18 to 34 percent, and 5 to 2,406 mD.

Traps: Adjacent siltstones and shales are seals for these reservoir rocks. Regional seals include the Sacramento Formation, which underlies the play area; shales in the Eocene as well as in the nonmarine Miocene to Pliocene provide the overlying seal. Traps are mostly combination (36) but include structural (19) and stratigraphic (4) as well. More than one trap type can occur in a field.

Source rocks: The suspected source rock for gas is most likely the Winters Shale but could be the Sacramento Formation. The Moreno Shale could be the source rock for the oil. In either case, the source rock is mostly gas-prone but generates some high-gravity oil or condensate (39û-49¡ API).

Based on the burial-history curve of Zigler and Spotts (1978) in the delta depocenter, the Winters Formation generated gas in Late Cretaceous (70 Ma) to the Miocene (10 Ma). The gas migrated east, through the Midland Fault. In the play area, gas accumulated in primarily combination traps. Drill depth to the reservoir rock is as much as 9,100 ft.

Exploration status and resource potential: The 47 discovered accumulations are located in the southern half of the Sacramento Basin Province where 1,703 new field wildcats have been drilled. The discovered traps are mostly combination or structural traps that range in depth from 2,200 ft to 9,700 ft with an average depth of 5,178 ft, and are sealed by overlying shale. The size of the trap, as measured from productive acreage, ranges from 90 acres to 25,000 acres and averages 2,235 acres. The reservoir rock ranges in thickness from 13 ft to 350 ft, and averages 95 ft with porosities that range from 18 percent to 34 percent and average 25 percent, and permeabilities that range from 5 mD to 2406 mD and averages 496 mD. New field wildcats that penetrate this play provide a dry hole ratio of 36:1 (1703:47), or a success rate of 2.8 percent. New discoveries will mostly likely be found between producing fields.

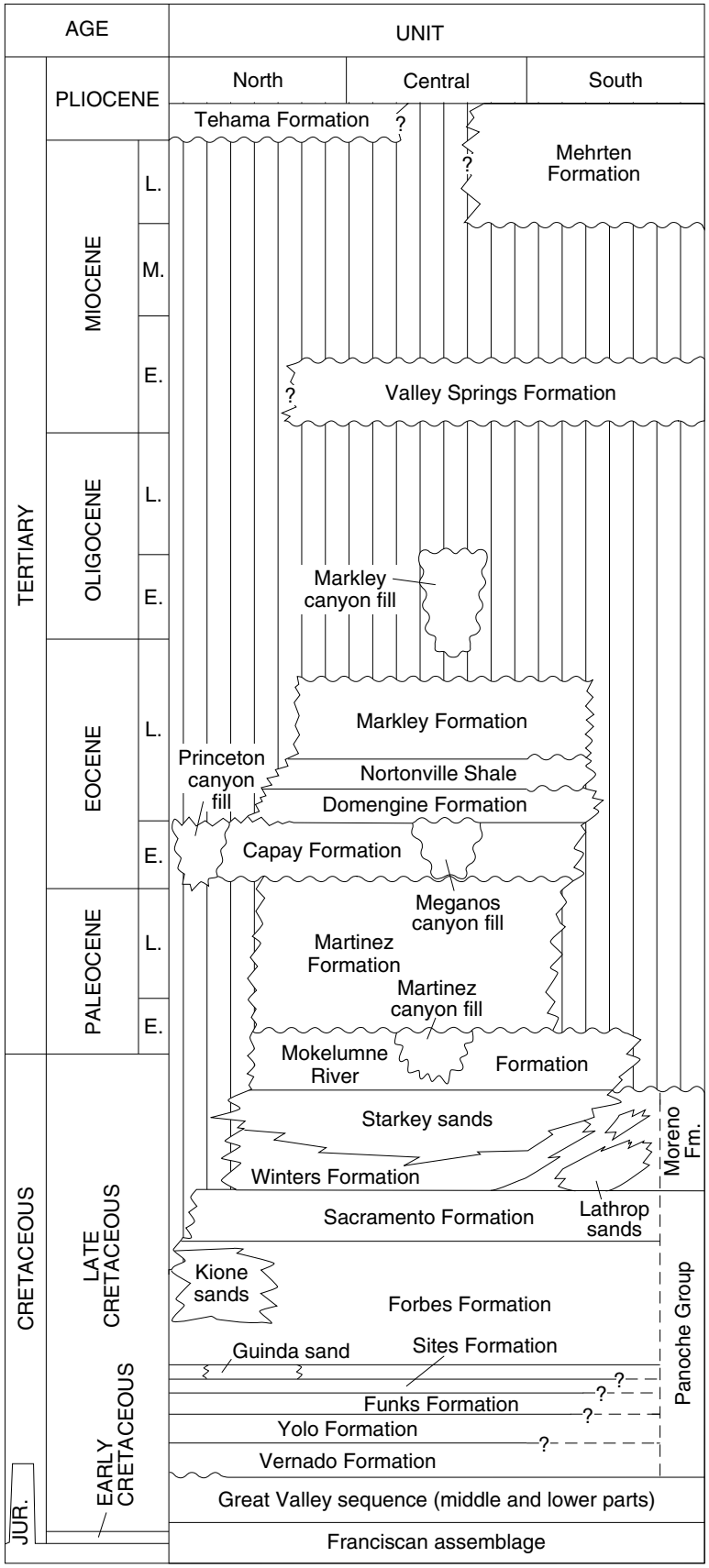
UNCONVENTIONAL PLAYS

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.

REFERENCES

Jenden, P.D., and I.R. Kaplan, 1989, Origin of natural gas in Sacramento basin, California: American Association of Petroleum Geologists Bulletin 73, no. 4, p. 431-453.

Zieglar, D.L., and J.H. Spotts, 1978, Reservoir and source-bed history of Great Valley, California, American Association of Petroleum Geologists, v. 62, no. 5, p. 813-826.


AGE
UNIT
North
Central
South
TERTIARY
PLIOCENE
Tehama Formation
?
?
Mehrten Formation
MIOCENE
L.
M.
E.
?
Valley Springs Formation
OLIGOCENE
L.
E.
Markley canyon fill
EOCENE
L.
Markley Formation
Princeton canyon fill
Nortonville Shale
Domengine Formation
E.
Capay Formation
Meganos canyon fill
PALEOCENE
L.
Martinez Formation
Martinez canyon fill
E.
Mokelumne River Formation
Starkey sands
Moreno Fm.
Winters Formation
CRETACEOUS
LATE CRETACEOUS
Sacramento Formation
Lathrop sands
Kione sands
Forbes Formation
Guinda sand
Sites Formation
?
?
Funks Formation
?
Yolo Formation
?
Vernado Formation
Panoche Group
EARLY CRETACEOUS
JUR.
Great Valley sequence (middle and lower parts)
Franciscan assemblage