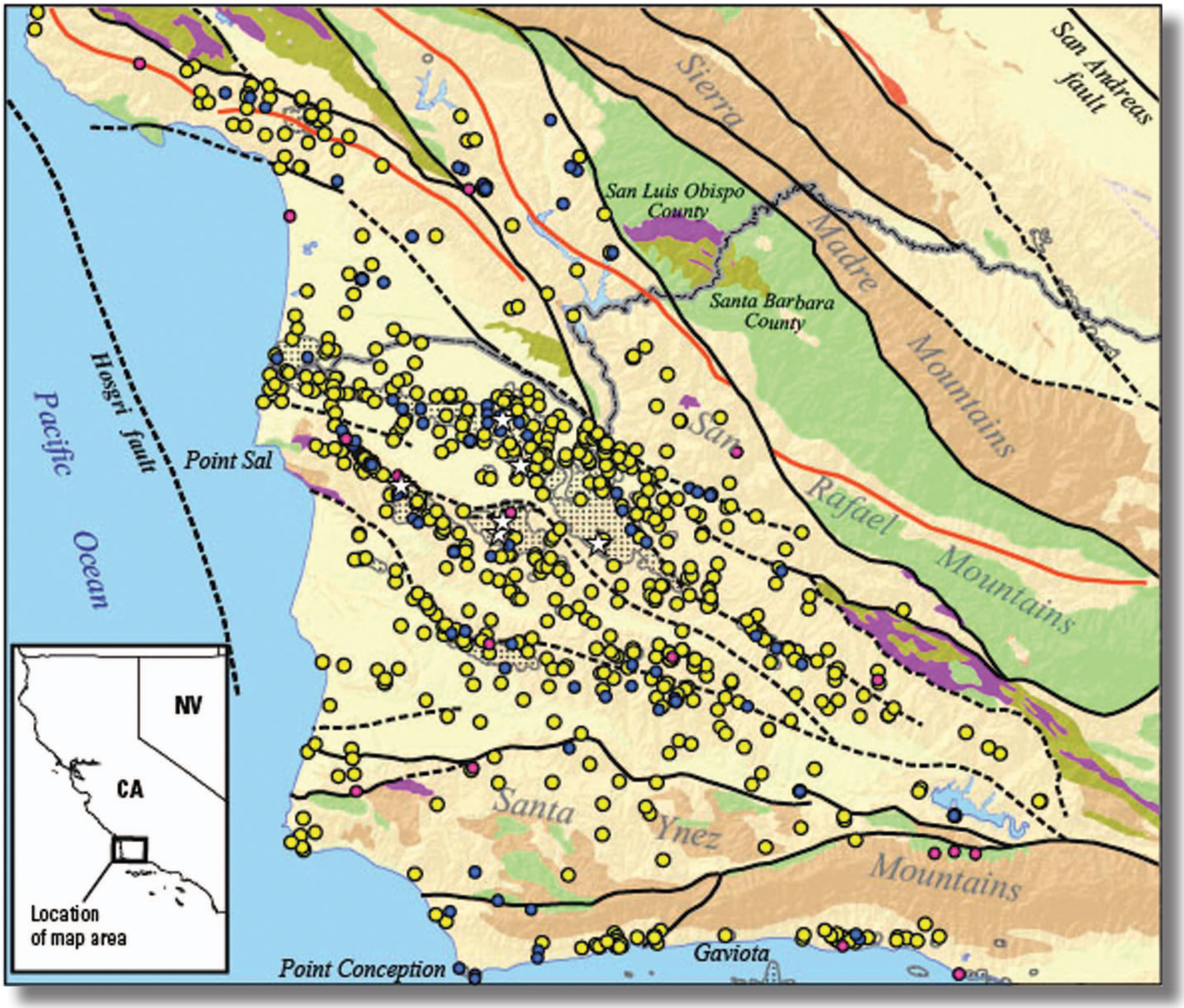
Digital Tabulation of Stratigraphic Data from Oil and Gas Wells in the Santa Maria Basin and Surrounding Areas, Central California Coast



Open-File Report 2010–1129

U.S. Department of the Interior
U.S. Geological Survey

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By Donald S. Sweetkind, Marilyn E. Tennyson, Victoria E. Langenheim, and Lauren E. Shumaker

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Tables

(Click on the link to access pdf file for each table)

Conversion Factors

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
meter (m)	1.094	yard (yd)
	Volume	
cubic meter (m^3)	6.290	barrel (petroleum, 1 barrel = 42 gallons)

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Elevation, as used in this report, refers to distance above the vertical datum.

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Abstract

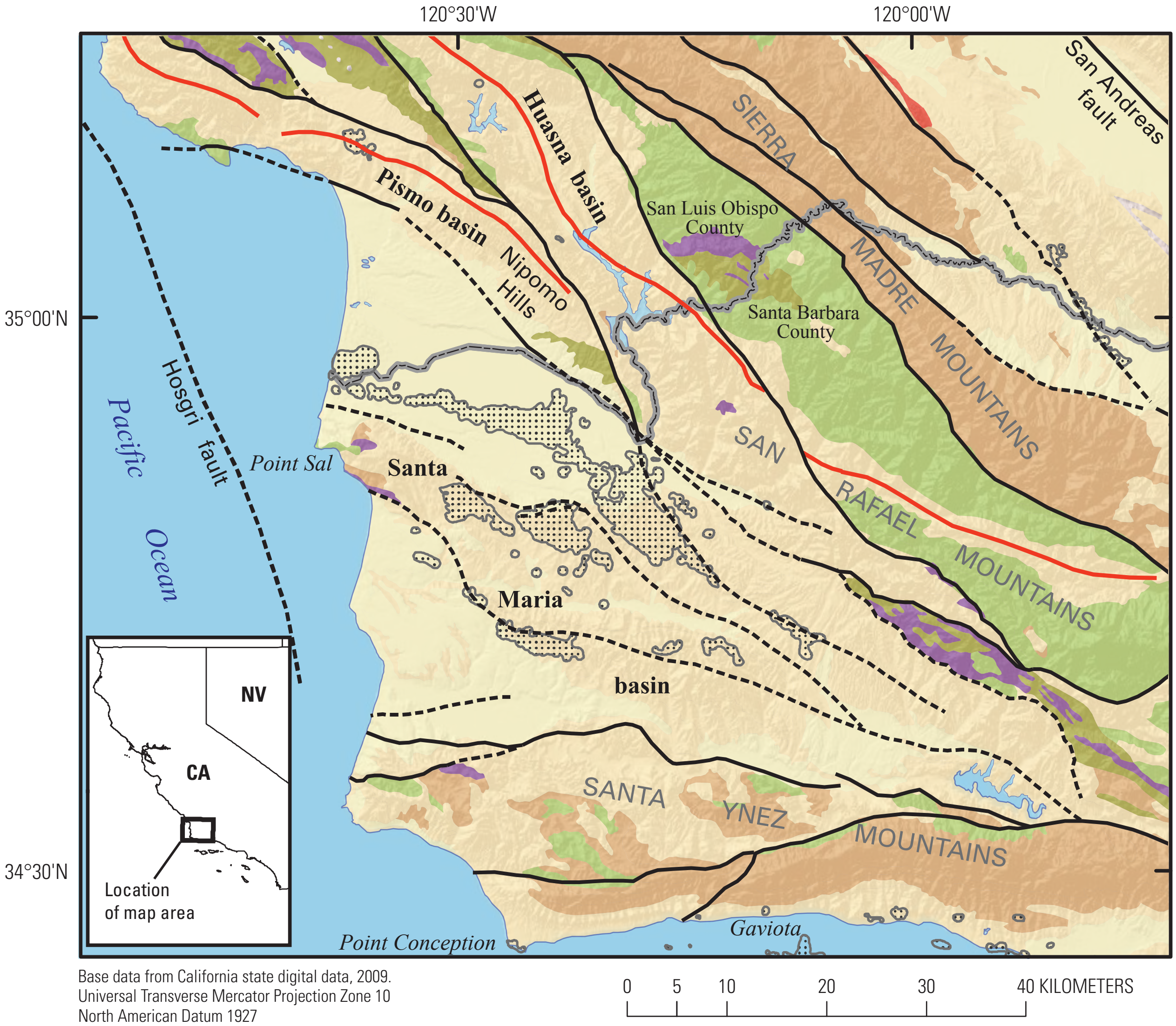
Stratigraphic information from 694 oil and gas exploration wells from the onshore Santa Maria basin and surrounding areas are herein compiled in digital form from reports that were released originally in paper form. The Santa Maria basin is located within the southwesternmost part of the Coast Ranges and north of the western Transverse Ranges on the central California coast. Knowledge of the location and elevation of stratigraphic tops of formations throughout the basin is a first step toward understanding depositional trends and the structural evolution of the basin through time.

Introduction

The Santa Maria basin is a triangular basin located to the southwest of the Sierra Madre and San Rafael Mountains of the Coast Ranges and north of the Santa Ynez Mountains of the western Transverse Ranges on the central California coast (fig. 1). The onshore part of the basin contains a thick Neogene sedimentary section and is considered to extend offshore to the west and northwest as far as the Hosgri fault (Hoskins and Griffiths, 1971) (fig. 1). The offshore part of the Santa Maria basin is considered to lie west of the Hosgri fault (Hoskins and Griffiths, 1971; Miller and Meltzer, 2002) (fig. 1). The combined basin has produced more than 875 million barrels of oil cumulatively through 2008 from the onshore region (California Department of Conservation, 2008) and more than 100 million barrels of production and considerable additional potential resource from the offshore portion (Mayerson, 1997). Two smaller synclinal basins, the Pismo and Huasna basins, preserve generally similar Neogene strata and lie to the north of the Santa Maria basin (fig. 1).

The Santa Maria basin contains a Neogene sedimentary sequence as much as 4.5 km thick. These strata record the history of Miocene basin subsidence associated with the development of the transform margin and subsequent gradual shoaling and emergence associated with the Neogene rotation of the Transverse Ranges to the south of the basin (Hornafius and others, 1986; Luyendyk, 1991; McCrory and others, 2009). Initial subsidence and tectonism within the Santa Maria basin are recorded by lower Miocene nonmarine sediments of the Lospe Formation that are interpreted to have been shed from uplifted blocks along basin-forming faults (Stanley and others, 1996). Subsequent deposition of bathyal marine, mostly clastic-poor Miocene sedimentary rocks of the Point Sal and Monterey Formations filled in early Miocene extensional lows and onlapped and blanketed structural paleohighs. Uplift and structural inversion of the basin began in the early Pliocene, resulting in north-vergent thrust faults and folding Miocene and Pliocene strata into anticlines, which are the structural traps for much of the petroleum found in this basin (Woodring and Bramlette, 1950; Namson and Davis, 1990; Tennyson, 1995b). Many of the faults that transect the basin (fig. 1) may have significant strike-slip offset as displacement was transferred from the Transverse Ranges to the major faults of the central Coast Ranges (Hornafius and others, 1986; Luyendyk, 1991; McCrory and others, 2009). Stratigraphic and structural reconstructions of the basin bear on the Neogene tectonic evolution of the region, the translation and rotation of the Transverse Ranges, and the partitioning of slip amongst a system of faults to the north of the Transverse Ranges and to the west of the San Andreas fault (fig. 1). Knowledge of the location and elevation of stratigraphic tops of formations throughout the basin is a first step toward understanding depositional trends and the structural evolution of the basin through time.

In this data report we compile stratigraphic information from oil and gas exploration and development wells from the onshore Santa Maria basin and surrounding areas (fig. 2). The intent of this report is to compile in digital form drill-hole stratigraphic data from reports that originally were released only in paper form. The digital data compiled here are suitable for incorporation within a geographic information system (GIS) and use in construction of three-dimensional geologic framework models that can be used to address regional stratigraphic and structural questions.

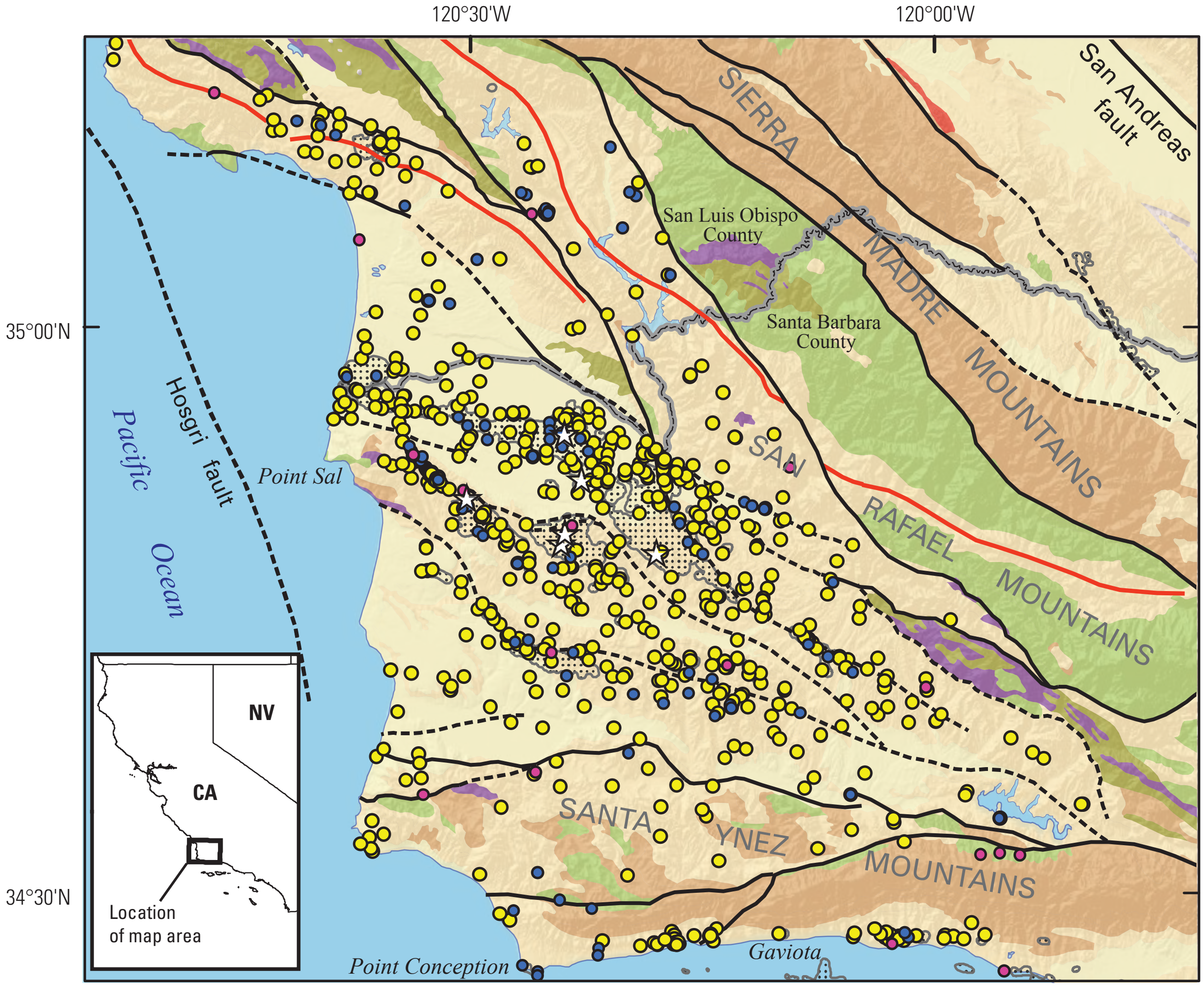


EXPLANATION

(Geologic units and structures modified from Saucedo and others, 2000, in conjunction with Jennings, 1977; Hall, 1973; Hall and others, 1979; and Vedder and others, 1989)

- Quaternary sediments
- Neogene sedimentary and minor volcanic rocks
- Paleogene sedimentary rocks
- Mesozoic sedimentary and minor volcanic rocks
- Franciscan Complex
- Coast Range ophiolite and serpentinite
- Salinian granite and related rocks
- Water
- Oil field
  (California Department of Resources, Division of Oil, Gas and Geothermal digital data)
- Fault, mapped at surface
  Only faults that bound major structural blocks are shown
- Fault, from subsurface data
- Synclinal fold axis
  Only major folds in Huasna and Pismo basins are shown

Figure 1. Simplified geologic map of the Santa Maria basin and surrounding areas.



Base data from California state digital data, 2009.
Universal Transverse Mercator Projection Zone 10
North American Datum 1927

0 5 10 20 30 40 KILOMETERS

EXPLANATION

(Geologic units and structures as in figure 1)

Oil field
(California Department of Resources, Division of Oil, Gas and Geothermal digital data)

Well with complete stratigraphic section

Well with faulted section

Well with limited stratigraphic data

Well with borehole gravity or biostratigraphic data

Figure 2. Simplified geologic map of the Santa Maria basin and surrounding areas showing location of wells compiled in the report.

Geologic Setting

The stratigraphic section of the Santa Maria basin ranges from Jurassic to Holocene age and includes between 3,000 to nearly 8,000 meters of strata (Woodring and Bramlette, 1950). The Santa Maria basin is floored mainly by Mesozoic rocks of the Franciscan Complex and Coast Range ophiolite, although these rocks are exposed only around the margin of the basin and at Point Sal in the west-central part of the basin (fig. 1). Around the margins of the basin, basement rocks are present beneath Oligocene to lower Miocene nonmarine sandstone and conglomerate (Sespe and Simmler Formations), upper Oligocene to lower Miocene nearshore sandstone (Vaqueros Formation), and lower Miocene bathyal mudstone (Rincon Shale) and volcanic rocks (Tranquillon Volcanics and Obispo Formation) (Dibblee, 1995) (fig. 3). In the center of the basin, lower Miocene nonmarine sediments of the Lospe Formation and marine sediments of the Point Sal Formation are present on basement (Stanley and others, 1996) (fig. 3). The deepest subsidence of the basin generally corresponded with deposition of the siliceous, petroliferous, lower to upper Miocene Monterey Formation (Woodring and Bramlette, 1950). Uppermost Miocene to Quaternary marine and nonmarine clastic units such as the Sisquoc Formation, Foxen Mudstone, Careaga Sandstone, and the Paso Robles Formation record the filling of the basin and the emergence of flanking uplifts (Woodring and others, 1943; Woodring and Bramlette, 1950; Dibblee, 1995) (fig. 3).

The Monterey Formation is the chief source of oil in the basin (Crawford, 1971). Oil reservoirs include fractured shale and chert of the Monterey Formation and permeable units within the Sisquoc and Point Sal Formations and within the Pismo Formation in the Pismo and Huasna basins to the north of the Santa Maria basin Reservoir (Crawford, 1971). Oil accumulations are mostly trapped in fractured Monterey Formation anticlines, in fractured Monterey Formation rocks truncated by an unconformity along the northeastern flank of the basin, or in Pliocene sandstone lenses above an unconformity on the northeastern basin margin (Tennyson, 1995b).

The Santa Ynez Mountains to the south of the basin exposed a Cretaceous and Paleogene marine sedimentary section that is typical of the Transverse Ranges and the offshore Ventura basin (Dibblee, 1995; Dickinson, 1995) (fig. 3). This section does not appear to extend beneath the Santa Maria basin; where Jurassic and Cretaceous rocks are exposed near Point Sal, none of the Paleogene rocks are present beneath Neogene strata, and none are described definitively in the well data.

Data Compilation Methodology

Below, we describe specific aspects of the datasets used and particular details of location and stratigraphic issues we faced during data compilation.

Sources of Well Data

The California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (CA DOGG) routinely publishes information from exploratory drilling throughout California. The drilled depths to the tops of the formations penetrated in the well are compiled by the State from records submitted by oil companies as wells are completed. A summary table of data for all wells drilled to 1963 and year-by-year tables for wells drilled between 1960 and 1980 was published in 1982 (California Division of Oil, Gas, and Geothermal Resources, 1982). Data on wells between 1980 and the present are published yearly in the Annual Report of the State Oil and Gas Supervisor (for example, California Department of Conservation, 2008); these reports are available online from the CA DOGG (*http://www.conservation.ca.gov/dog/pubs_stats/annual_reports/Pages/annual_reports.aspx/* accessed February 2010). About 60 percent of the wells in this digital compilation were originally released in paper form by Tennyson (1995a). These data were compiled for oil and gas wells in the Santa Maria basin from the CA DOGG records described previously. We have compiled about 150 additional wells, not reported by Tennyson (1995a), from the CA DOGG records.

Stratigraphic tops from 310 wells were reported by Hall (1982) as the underlying data used in the creation of subcrop and structure contour maps of western San Luis Obispo and Santa Barbara Counties in California. Some of these data were reported in Tennyson (1995a); we transcribed the remaining data and checked well information against both Tennyson (1995a) and CA DOGG records.

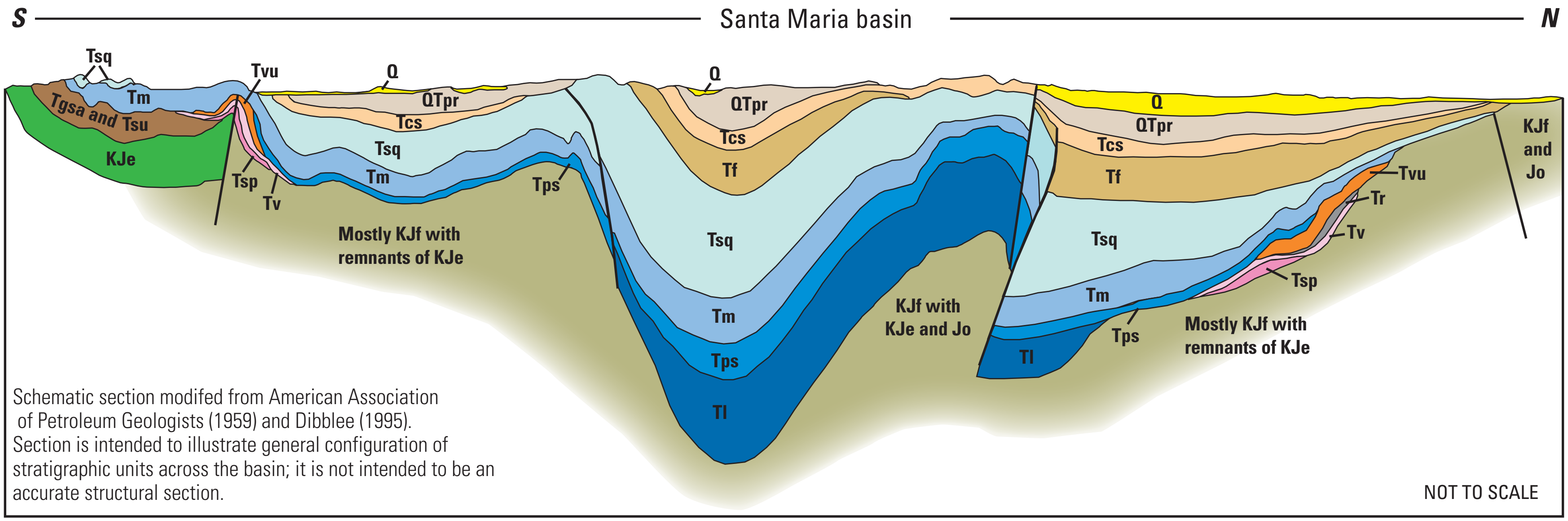
Petrologic studies of core samples from wells within the Santa Maria basin that penetrated Jurassic and Cretaceous rocks have been published by Gray (1980) and McLean (1991). These data consist primarily of reinterpretation of basement lithology based on analysis of detrital modes of sandstone. We have used these data to modify the stratigraphic assignments of Jurassic and Cretaceous rocks in specific wells.

For a handful of drill holes, additional stratigraphic information was obtained for those drill holes that have borehole gravity surveys (Beyer and others, 1985) or were used for backstripping (McCrory and others, 1995).

Well Location

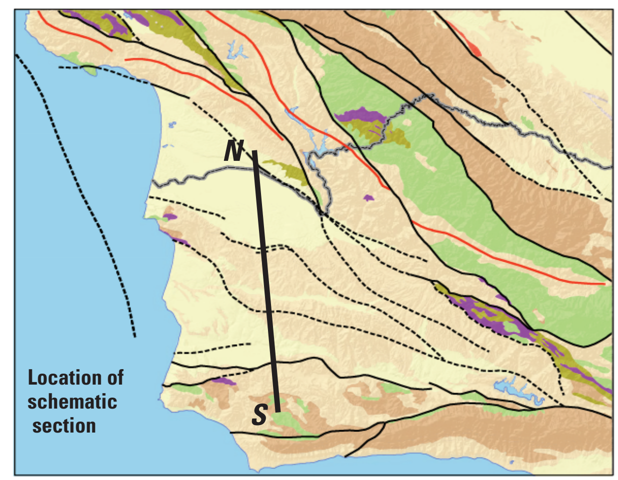
Well locations were obtained in a digital well location database from the CA DOGG (*http://www.conservation.ca.gov/dog/maps/Pages/goto_welllocation.aspx/* accessed February 2010). The information contained in the database includes API number; operator; well name and number; section, township, and range; and the latitude and longitude.

Wells tabulated by Tennyson (1995a) and Hall (1982) were located only by township, range and section. These wells were linked to corresponding records in the CA DOGG digital database by matching well information such as township,



Stratigraphic units shown are those compiled in data tables:

Q : Undivided Quaternary deposits
QTpr : Paso Robles Formation
Tcs : Careaga Sandstone
Tf : Foxen Mudstone
Tsq : Sisquoc Formation
Tm : Monterey Formation
Tps : Point Sal Formation
Tl : Lospe Formation
Tvu : Miocene volcanic rocks, undivided
Tr : Rincon Shale
Tv : Vaqueros Formation
Tsp: Sespe Formation
Tgsa : Gaviota Formation
Tsu: Eocene marine sandstones, undivided
KJe : Espada Formation
KJf : Franciscan Complex
Jo : Jurassic ophiolite



See figure 1 for explanation of geologic units and structures; colors not intended to match schematic stratigraphic section.

Figure 3. Schematic cross section of the Santa Maria basin.

range, section, operator, lease name, well number, and total drilled depth. A small number of wells from previously published reports (Hall, 1982; Tennyson, 1995a) do not appear in the CA DOGG digital database so that the only available location information is township, range, section. For these wells, the latitude and longitude are given at the center of the section. Where multiple wells are reported within the same section, the wells were offset from the center of the section by an arbitrary distance of 50 m. Well location data are shown in *table 1* (click on the link to access pdf file for this table).

Stratigraphic Assignments

A wide variety of formation names have been reported for similar stratigraphic intervals in the Santa Maria basin. The variety stems from real stratigraphic variation across the basin, changes in stratigraphic nomenclature and assignment over time, and nomenclatural differences between companies or individual geologists. For the most part, we have compiled the formation tops as they were reported, with no interpretation or modification of reported depths. Our only interpretive step was to group the various formation tops reported to be intercepted downhole into the small number of stratigraphic units (*table 2*; fig. 3 (click on the link to access pdf file for this table)). Wherever possible, we have assigned stratigraphic unit names to be consistent with the USGS geologic names lexicon (*http://ngmdb.usgs.gov/Geolex/* accessed May 2010). Stratigraphic assignments also relied on published discussions of regional stratigraphic variations (Jenkins, 1943; Dibblee, 1950, 1973, 1995). Stratigraphic descriptions and age assignments have been adapted from Woodring and Bramlette (1950) and from Tennyson (1992).

We have separated the wells into three categories: (1) wells in which a complete stratigraphic section is reported, (2) wells for which there is only a limited amount of stratigraphic information (for example, only the identity of the rocks intercepted at the bottom of the well), and (3) wells that intersected a faulted stratigraphic section (table 2). Wells were interpreted to intersect faulted sections where older rocks were reported to overlie younger rocks or where fault zones were reported downhole. We made no attempt to identify structural omission or thinning of units by normal faults.

Interpretation of Mesozoic Basement Rock Lithology

Mesozoic basement rocks of the Santa Maria basin have been variously described as Franciscan Complex, Knoxville Formation, or other Cretaceous and Jurassic formations. Careful interpretation of these data in conjunction with analysis of sandstone petrofacies suggests that the basin is floored by Mesozoic rocks of the Franciscan Complex, with lesser amounts of Coast Range ophiolite and overlying marine sandstones that are generally equivalent to Great Valley sequence rocks (Gray, 1980; McLean, 1991). Sandstone petrofacies analysis using core samples clarified a number of previous stratigraphic assignments and identified basement domains of basement rock types (Gray, 1980; McLean, 1991). However, these analyses were conducted on a limited number of wells, leaving the stratigraphic classification in the remaining basement intercepts uncertain. We have applied the basement petrofacies domains of McLean (1991) to help resolve basement rock stratigraphic nomenclature where previous assignments appeared problematic. However, in the absence of additional information, considerable uncertainty remains for specific wells.

Explanation of Column Headings and Abbreviations in Data Tables

This data tabulation includes well location (table 1), stratigraphic (table 2), and basement lithologic (*table 3,* click on the link to access pdf file for this table) information for wells we have collected from the Santa Maria basin (fig. 2). Below, we describe the column headings and content of each data field within the three tables. Well records in each of the three tables are related to each other by two identifiers: ID, a unique well identifier assigned by us, and, where available, the API well number (APINUMBER), described herein. Each table contains data for the same 694 wells. The digital data tables that accompany this online report are identical to the tables described herein except that each of the three tables of digital data includes well location information (latitude, longitude, northing, and easting) to facilitate the use of each table within a geographic information system.

Well Location Data (Table 1)

ID: ID is a unique well identifier assigned by us. This number is useful in those cases where a well has no API well number.

APINUMBER: The API well number (APINUMBER) is a unique, permanent, numeric identifier assigned to each well drilled for oil and gas in the United States. The numbers reported here are abbreviated versions of the full API well number and consist of a 3-digit county code followed in sequence by a 5-digit unique well identification number within the county.

Hall_well_no: The well number assigned by Hall (1982) in the tabulation of well data used for compilation of subcrop and structure contour maps of western San Luis Obispo and Santa Barbara Counties, Calif.

ArcID: A unique well identifier assigned within a Geographic Information System (GIS) by Tennyson (1995a).

Data_type: wells are assigned to one of three categories that describe the relative completeness of the stratigraphic section intersected: (1) complete section, wells in which a complete stratigraphic section is reported; (2) limited information, wells for which there is only a limited amount of stratigraphic information; for example, only the identity of the rocks intercepted at the bottom of the well; and (3) faulted section, wells that intersected a faulted stratigraphic section.

Data_source: Published source from which well stratigraphic data were transcribed.

TWN, RGE, SEC, BM: Denotes location of the well according to its location in the rectangular system for the subdivision of public lands by the United States Public Land Survey. Identification consists of the township number (TWN), north or south; the range number (RGE), east or west; and the section number (SEC). In California, township and range designations are referenced to one of three principal base line and meridians (BM) that serve as the reference point for measuring north or south townships and east or west ranges. All wells in the study area are referenced to either the Mount Diablo (MD) or San Bernardino (SB) base line and meridians. The dividing line separating the region referenced to the San Bernardino base line and meridian and the area referenced to the Mount Diablo base line and meridian roughly follows the Santa Barbara County–San Luis Obispo County boundary in the northern part of the study area.

OPERATOR, LEASE, WELL_NO: Well operator (OPERATOR), lease name (LEASE), and well number (WELL_NO) within the lease. These attributes were obtained in a digital well-location database from the CA DOGG (*http://www.conservation.ca.gov/dog/maps/Pages/goto_welllocation.aspx/* accessed February 2010). We have modified some name abbreviations for clarity and consistency, but for the most part we have retained names, abbreviations, and punctuation as reported by the CA DOGG. Operator names as reported in the CA DOGG digital well-location database occasionally differed from those reported in the yearly prospect well records, indicating that the operator changed since completion of the well. In most such cases, the lease name and well number remain the same.

Well_Elev_feet: The elevation, in feet above mean sea level, of the well collar or the beginning of drilling. Typically, the well elevations are reported at the height of the rotary Kelly bushing on the drilling rig; however, we were not able to verify the vertical datum used for each well elevation. As such, we have not corrected elevations to true land-surface elevation. Wells without a reported elevation were assigned a land-surface elevation based on a 10-m-resolution digital elevation model.

TD_feet: Total drilled depth, in feet (TD_feet). In some cases the total depth as reported in the CA DOGG digital well-location database differs from the depth originally reported in the yearly prospect well records. We did not try to identify the source of such discrepancies; we simply used the data as reported in the DOGG digital database. This tabulation does not account for directional drilling where the well bore deviates, either intentionally or unintentionally, from vertical.

Year: Year that the well was completed, as reported by the CA DOGG.

FIELD: The producing oil and gas field or region in which the well is located, as reported by the CA DOGG.

LATITUDE, LONGITUDE: Well locations, in decimal degrees, as reported in a digital well-location database obtained from the CA DOGG (*http://www.conservation.ca.gov/dog/maps/Pages/goto_welllocation.aspx/* accessed February 2010). Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Northing, Easting: Well locations, in meters, in Universal Transverse Mercator (UTM) projected coordinate system, UTM zone 10, North American Datum of 1927 (NAD 27)

Well Stratigraphic Data (Table 2)

We have grouped the various stratigraphic unit tops that were reported to be intercepted downhole into the small number of stratigraphic units listed in table 2. Stratigraphic assignments were chosen to be consistent with the USGS geologic names lexicon (*http://ngmdb.usgs.gov/Geolex/* accessed May 2010). Stratigraphic assignments also relied on published discussions of regional stratigraphic variations (Jenkins, 1943; Dibblee, 1950, 1973, 1995) and stratigraphic descriptions of the Santa Maria basin (Woodring and others, 1943; Woodring and Bramlette, 1950; Tennyson, 1992). Table 2 lists drilled depth in feet to the top of each given formation. Formation tops with a depth of zero are exposed at land surface and indicate that the well spudded in the listed formation.

ID: ID is a unique well identifier assigned by us. This number is useful in those cases where a well has no API well number.

APINUMBER: The API well number.

Q: Undivided Quaternary deposits. Includes alluvium, stream channels, flood plains, alluvial fans, terraces, the Pleistocene Orcutt Sand and subsurface units described as Pleistocene Santa Barbara Formation.

QTpr: Paso Robles Formation. Nonmarine alluvial sand and gravel; gravel composed mostly of clasts of Monterey Formation; upper Pliocene and lower Pleistocene. Described by Woodring and Bramlette (1950).

Tcs: Careaga Sandstone. Fine to coarse-grained sandstone and conglomerate; upper Pliocene. Described by Woodring and others (1943).

Tf: Foxen Mudstone. Marine claystone, siltstone, and fine-grained sandstone; middle and upper Pliocene. Described by Woodring and others (1943).

Tsq: Sisquoc Formation. Marine diatomite and laminated siliceous to diatomaceous siltstone and shale; upper Miocene and lower Pliocene. Includes laminated siliceous rocks of the Pismo Formation in the Huasna and Pismo basins (fig. 1) and fine-grained sandstones of the Santa Margarita Sandstone to the northwest of the Huasna basin. Described by Woodring and others (1943).

Tm: Monterey Formation. Marine laminated to thin-bedded siliceous shale, calcareous mudstone and dolostone; upper lower, middle, and upper Miocene. Described by Woodring and others (1943), and Woodring and Bramlette (1950).

Tps: Point Sal Formation. Bathyal marine mudstone and fine-grained sandstone; upper lower Miocene to lower middle Miocene. Described by Woodring and others (1943).

Tl: Lospe Formation. Nonmarine (alluvial fan and lacustrine) conglomerate, sandstone, siltstone, and mudstone; upper lower Miocene. Locally includes several thick tuffs. Present in outcrop near Point Sal (fig. 1). Described by Woodring and others (1943). In the vicinity of San Luis Obispo to the north of the Santa Maria basin, Hall and others (1979) mapped the Lospe Formation as underlying the Vaqueros Formation, and therefore Oligocene. However, the Lospe Formation in the Santa Maria basin has been defined as lower Miocene (Stanley and others, 1996), so units identified as Lospe Formation to the north of the basin cannot be correlated with the Lospe Formation in the Santa Maria basin.

Tvu: Miocene volcanic rocks, undivided, including Tranquillon Volcanics of Dibblee (1950) and Obispo Formation (Schneider and Fisher, 1996). Tranquillon Volcanics recognized along southern flank of the Santa Maria basin; Obispo Formation recognized on northern flank of the basin and in the Nipomo Hills. Volcanic rocks of the Santa Maria basin are described by Cole and Stanley (1998).

Tr: Rincon Shale. Bathyal marine claystone or mudstone with dolomite nodules. Locally includes sandstone; lower Miocene (Saucesian). Formation is recognized throughout the western Transverse Ranges (Dibblee, 1950, 1966).

Tv: Vaqueros Formation. Fine-to coarse-grained pebbly sandstone with abundant mollusks; upper Oligocene to lower Miocene. Described by Dibblee (1973, 1995).

Tsp: Sespe Formation. Nonmarine conglomerate, sandstone, and mudstone; upper Eocene to lower Miocene. Includes rocks identified as Alegria Formation in the Point Conception and Gaviota areas of the western Transverse Ranges (fig. 1); described by Dibblee (1950). Equivalent to the continental red beds of the Simmler Formation in southern Coast Ranges (Dibblee, 1995).

Tgsa: Gaviota Formation of Jenkins (1943) and Sacate Formation of Dibblee (1950), undifferentiated; marine sandstone and interbedded silty shale; upper Eocene to Oligocene. Twelve holes are reported to intercept these units.

Tsu: Eocene marine sandstones, undivided. Includes units identified as Cozy Dell Shale, Matilija Sandstone, and Anita Shale (Dibblee, 1950, 1966; Dickinson, 1995). Twenty-six holes are reported to intercept one or more of these units. Where one of the Eocene units is identified in a drill hole, underlying units of the Eocene section are typically intercepted and recorded. For example, where the Cozy Dell Shale is identified, the underlying Matilija Sandstone and Anita Shale are also typically reported. Depth values in this column record only the first, highest formation top of the Eocene marine section.

KJe: Espada Formation of Dibblee (1950) and equivalents, including sedimentary rocks identified as Knoxville Formation, also includes Jalama Formation of Dibblee (1950) and units described as Jurassic shale. Submarine fan deposits. Argillaceous to silty shale and sandstone; some pebble to cobble conglomerate with clasts of quartzite, chert, and volcanic clasts. Upper Cretaceous to Upper Jurassic. Elsewhere on the central California coast, equivalent rocks with similar lithology are mapped as Atascadero and Toro Formations (Seiders, 1983). Tennyson (1995a) compiled these rocks as Espada Formation to maintain consistency with geologic mapping in the western Transverse Ranges (Dibblee, 1950, 1966); we have chosen to retain that nomenclature here.

KJf: Franciscan Complex. Pervasively sheared shale and sandstone containing tectonic blocks of graywacke, blueschist, chert, metavolcanic rocks or greenstone, serpentinite, and other rock types. Jurassic and Cretaceous. Includes blocks of chert and graywacke.

Jo: Ophiolite. Includes pillow basalt, greenstone, diabase dikes and sills, gabbro, diorite, plagiogranite, and ultramafic rocks, including serpentinite, harzburgite, and pyroxenite. Upper Jurassic (Tithonian).

Mesozoic Basement Lithology Information (Table 3)

ID: ID is a unique well identifier assigned by us. This number is useful in those cases where a well has no API well number.

APINUMBER: The API well number.

Basement_depth: Depth, in feet, to the highest intercepted Mesozoic basement lithology, including units KJe, KJf, and Jo.

Basement_elev: Absolute elevation, in feet, of the highest intercepted Mesozoic basement lithology, including units KJe, KJf, and Jo. Elevation calculated using reported well elevation.

Interp_basement_type: Our preferred assignment for Mesozoic basement lithology, based on consistency of interpreted stratigraphic assignment from all data sources and comparison to sandstone petrofacies analysis of Gray (1980) and McLean (1991). Stratigraphic unit abbreviations: GVu, upper Great Valley sequence petrofacies, following the usage of McLean (1991); KJf, Franciscan assemblage; um, ultramafic or ophiolitic(?) rocks; KJe, Espada Formation of Dibblee (1950) and equivalents, including sedimentary rocks identified as Knoxville Formation.

DOGG_Fm_at_TD: Reported stratigraphic unit present at the bottom of the well, as transcribed from the tabulation of prospect well records published yearly in the Annual Report of the State Oil and Gas Supervisor (for example, California Department of Conservation, 2008). Reported stratigraphic units vary in format and include rock-stratigraphic and time-stratigraphic units. Stratigraphic unit and age assignments have not been verified; rather, we have merely transcribed directly from the prospect well records. Reported stratigraphic unit abbreviations: Tcs, Careaga Sandstone; Tf, Foxen Mudstone; Tsm, Santa Margarita Formation; Tsq, Sisquoc Formation; Tm, Monterey Formation; Tps, Point Sal Formation; Tl, Lospe Formation; Ttr, Tranquillon Volcanics of Dibblee

(1950); Tr, Rincon Shale; Tv, Vaqueros Formation; Tsp, Ts, Sespe Formation; Tg, Gaviota Formation of Jenkins (1943); Tsl, Sacate Formation of Dibblee (1950); Tgsa, Tg-sa, Gaviota Formation of Jenkins (1943) and Sacate Formation of Dibblee (1950), undifferentiated; Tma, Matilija Sandstone; Tp, Pattiway Formation; Kj, Jalama Formation of Dibblee (1950); KJk, Knoxville Group; KJe, Espada Formation of Dibblee (1950); KJf, Franciscan Complex; Jsh, Jurassic shale; Jo, ophiolite; Jch, Jurassic chert.

Hall_Fm_TD: Reported stratigraphic unit present at the bottom of the well, as transcribed from Hall's (1982) tabulation of well data used for compilation of subcrop and structure contour maps of western San Luis Obispo and Santa Barbara Counties in California. Reported stratigraphic units vary in format and include formal names or, occasionally, just a general lithology. Reported stratigraphic unit name abbreviations: Qpr, Paso Robles Formation; Tsq, Sisquoc Formation; Tm, Monterey Formation; Tps, Point Sal Formation; To, Obispo Formation; Tl, Lospe Formation; Ttr, Tranquillon Volcanics of Dibblee (1950); Tv, Vaqueros Formation; Ts, Sespe Formation; Tgs, Gaviota Formation of Jenkins (1943) and Sacate Formation of Dibblee (1950), undifferentiated; Tsl, Eocene marine sandstones, undivided. Includes units identified as Cozy Dell Shale, Matilija Sandstone, and Anita Shale (Dickinson, 1995); Ks, Cretaceous shale; KJk, Knoxville Group; KJe, Espada Formation of Dibblee (1950); KJf, Franciscan Complex; Jsh, Jurassic shale; Jo, ophiolite.

McLean_Fm_TD: Interpreted Mesozoic basement rock intercepted, as reported by McLean (1991). Bottom-hole unit assignments were obtained from his figure 2; these data were tied to our well database by spatially referencing the figure in a GIS using a digital topographic base. Abbreviations use the terminology developed by McLean (1991) as follows: GVl, lower Great Valley sequence petrofacies; GVu, upper Great Valley sequence petrofacies; KJf, Franciscan assemblage; lM, lower Miocene Lospe Formation; um, ultramafic or ophiolitic(?) rocks.

Gray_bsmt_lith: Type of Mesozoic basement rock intercepted, as interpreted by Gray (1980). Bottom-hole unit assignments were obtained from her plate 2; these data were tied to our well database by spatially referencing the figure in a GIS using a digital topographic base. Abbreviations use the terminology developed by Gray (1980) as follows: Mv, Miocene volcanics; ts, trench-slope clastic rocks; tsc, trench-slope carbonates; gv, Great Valley clastic rocks; ov, ophiolitic volcanics; ovc, ophicalcites (interpillow limestone); ods, ophiolitic dike and sill rocks; op, ophiolitic plutonics; ou, ophiolitic ultramafics.

Gray_bsmt_age: Wells in which definitive age assignment exists for Mesozoic basement rock, as reported by Gray (1980). Cretaceous ages are reported by Gray (1980) on the basis of palynology and are denoted by "K."

Gray_TS_descript: Sandstone petrofacies description of Mesozoic basement rock lithology from thin section, as reported by Gray (1980). Abbreviations in parentheses correspond to the interpreted basement rock lithologies of Gray (1980), described previously.

COMMENTS: Any additional information not easily added to one of the previously described columns. Entries in this column are in part derived from the CA DOGG prospect well data and in part are our annotations.

Summary

This data tabulation includes stratigraphic information from selected oil and gas exploration wells from the onshore Santa Maria basin. Data are compiled from various sources and reduced to a limited number of stratigraphic units. This report makes available in digital form a large subsurface well dataset so that subsurface stratigraphic data are available in digital form for incorporation within a geographic-information system (GIS) and use in construction of three-dimensional geologic framework models that can be used to address regional stratigraphic and structural questions.

References Cited

American Association of Petroleum Geologists (AAPG), 1959, Correlation section across Santa Maria basin from outcrop in Santa Ynez Mountains northerly to outcrop north of Santa Maria River, California: Pacific Section AAPG Published Correlation Sections 12, scales 1:4,000 and 1:1,000.

Beyer, L.A., Robbins, S.L., and Clutson, F.G., 1985, Basic data and preliminary density and porosity profiles for twelve borehole gravity surveys made in the Los Angeles, San Joaquin, Santa Maria, and Ventura Basins, California: U.S. Geological Survey Open-File Report 85–42, 69 p.

California Department of Conservation, 2008, 2008 Annual Report of the State Oil and Gas Supervisor: Division of Oil, Gas, and Geothermal Resources Publication PR06, 272 p., accessed February 2010 at *ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2008/*.

California Division of Oil, Gas and Geothermal Resources, 1982, Oil and gas prospect wells drilled in California through 1980: California Division of Oil, Gas and Geothermal Resources Report TR01, 258 p.

Cole, R.B., and Stanley, R.G., 1998, Volcanic rocks of the Santa Maria province, California: U.S. Geological Survey Bulletin 1995–R, p. R1–R35.

Crawford, F.D., 1971, Petroleum potential of Santa Maria Province, California, *in* Cram, I.H., ed., Future petroleum provinces of the United States—Their geology and potential: American Association of Petroleum Geologists Memoir 15, p. 316–328.

Dibblee, T.W., Jr., 1950, Geology of southwestern Santa Barbara County, California–Point Arguello, Lompoc, Point Conception, Los Olivos, and Gaviota quadrangles: California Division of Mines and Geology Bulletin 150, 95 p., 17 plates.

Dibblee, T.W., Jr., 1966, Geology of the central Santa Ynez Mountains, Santa Barbara County, California: California Division of Mines and Geology Bulletin 186, 99 p.

Dibblee, T.W., Jr., 1973, Stratigraphy of the southern Coast Ranges near the San Andreas fault from Cholame to Maricopa, California: U.S. Geological Survey Professional Paper 764, 45 p.

Dibblee, T.W., Jr., 1995, Tectonic and depositional environment of middle and upper Cenozoic sequences of coastal southern California region, *in* Fritsche, A.E., ed., Cenozoic paleogeography of the western United States – II: SEPM (Society for Sedimentary Geology), Pacific Section, v. 75, p. 213–245.

Dickinson, W.R., 1995, Paleogene depositional systems of the western Transverse Ranges and adjacent southernmost Coast Ranges, *in* Fritsche, A.E., ed., Cenozoic paleogeography of the western United States—II: SEPM (Society for Sedimentary Geology), Pacific Section, v. 75, p. 53–83.

Gray, L.D., 1980, Geology of Mesozoic basement rocks in the Santa Maria Basin, Santa Barbara and San Luis Obispo counties, California: San Diego, Calif., San Diego State University, Master's thesis, 78 p.

Hall, C.A., Jr., 1973, Geologic map of the Morro Bay South and Port San Luis quadrangles, San Luis Obispo County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF–511, scale 1:24,000.

Hall, C.A., Jr., 1982, Pre-Monterey subcrop and structure contour maps, western San Luis Obispo and Santa Barbara Counties, south-central California: U.S. Geological Survey Miscellaneous Field Studies Map MF–1384, 6 sheets, scale 1:62,500, 28 p.

Hall, C.A., Jr., Ernst, W.G., Prior, S.W., and Wiese, J.W., 1979, Geologic map of the San Luis Obispo–San Simeon Region, California: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–1097, scale 1:48,000, 3 sheets.

Hornafius, J.S., Luyendyk, B.P., Terres, R.R, and Kamerling M.J., 1986, Timing and extent of Neogene tectonic rotation in the western Transverse Ranges, California: Geological Society of America Bulletin, v. 97, p. 1476–1487.

Hoskins, E.G., and Griffiths, J.R, 1971, Hydrocarbon potential of northern and central California offshore, *in* Cram, I.H., ed., Future petroleum provinces of the United States—Their geology and potential: American Association of Petroleum Geologists Memoir 15, v. 1, p. 212–228.

Jenkins, O.P., ed., 1943, Geologic formations and economic development of the oil and gas fields of California: California Division of Mines Bulletin 118, 773 p.

Jennings, C.W., 1977, Geologic map of California: California Department of Conservation, Division of Mines and Geology Geologic Data Map no. 2, scale 1:750,000.

Luyendyk, B.P., 1991, A model for Neogene crustal rotations, transtension, and transpression in southern California: Geological Society of America Bulletin, v. 103, p. 1528–1536.

Mayerson, Drew, 1997, Santa Maria–Partington Basin, *in* Dunkle, C.A., and Piper, K.A., eds., 1995 National Assessment of United States Oil and Gas Resources—Assessment of the Pacific Outer Continental Shelf Region: Minerals Management Service OCS Report 97– 0019, p.84–95.

McCrory, P.A., Wilson, D.S., Ingle, J.C., Jr., and Stanley, R.G., 1995, Neogene geohistory analysis of Santa Maria Basin, California, and its relationship to transfer of central California to the Pacific Plate: U.S. Geological Survey Bulletin 1995–J, 41 p.

McCrory, P.A., Wilson, D.S., and Stanley, R.G., 2009, Continuing evolution of the Pacific–Juan de Fuca–North America slab window system—A trench–ridge–transform example from the Pacific Rim: Tectonophysics, v. 464, p. 30–42.

McLean, Hugh, 1991, Distribution and juxtaposition of Mesozoic lithotectonic elements in the basement of the Santa Maria Basin, California: U.S. Geological Survey Bulletin, 1995–B, 12 p.

Miller, K.C., and Meltzer, A.S., 2002, Structure and tectonics of the central offshore Santa Maria and Santa Lucia basins, California—Results from the PG&E/EDGE Seismic Reflection Survey, *in* Keller, M.A., ed., Evolution of sedimentary basins/onshore oil and gas investigations—Santa Maria Province: U.S. Geological Survey Bulletin 1995–Z, 12 p., 4 plates.

Namson, J.S., and Davis, T.L., 1990, Late Cenozoic fold and thrust belt of the southern Coast Ranges and Santa Maria Basin, California: American Association of Petroleum Geologists Bulletin, v. 74, p. 467–492.

Saucedo, G.J., Bedford, D.R., Raines, G.L., Miller, R.J., and Wentworth, C.M., 2000, GIS data for the geologic map of California: Sacramento, California Department of Conservation, CD 2000–07.

Schneider, Jean-Luc, and Fisher, R.V., 1996, Obispo Formation, California— Remobilized pyroclastic material: U.S. Geological Survey Bulletin 1995–O, p. O1–O21.

Seiders, V.M., 1983, Correlation and provenance of upper Mesozoic chert-rich conglomerate of California: Geological Society of America Bulletin, v. 94, p. 875–888.

Stanley, R.G., Johnson, S.Y., Swisher, C.C. III, Mason, M.A., Obradovich, J.D., Cotton, M.L., Filewicz, M.V., and Vork, D.R., 1996, Age of the Lospe Formation (Early Miocene) and origin of the Santa Maria Basin, California, *in* Keller, M.A., ed., Evolution of sedimentary basins/onshore oil and gas investigations—Santa Maria Province: U.S. Geological Survey Bulletin 1995–M, 37 p.

Tennyson, M.E., 1992, Preliminary geologic map of Santa Maria 30' x 60' quadrangle, California: U.S. Geological Survey Open-File Report 92–189, 9 p.

Tennyson, M.E., 1995a, Tables of subsurface formation depths for exploration wells in Santa Maria Basin, Santa Barbara and San Luis Obispo counties, California, compiled from publications of the California Division of Oil and Gas: U.S. Geological Survey Open-File Report 95–14, 22 p.

Tennyson, M.E., 1995b, Santa Maria Basin province (012), *in* Gautier, D.L., Dolton, G.L., Takahashi, K.I., and Varnes, K.L., eds., 1995 National assessment of United States oil and gas resources—Results, methodology, and supporting data: U.S. Geological Survey Digital Data Series DDS–30, 1 CD–ROM.

Vedder, J.G., Howell, D.G., and McLean, H., 1989, Geologic map of Chimney Canyon quadrangle and part of Huasna Peak quadrangle, California: U.S. Geological Survey Open-File Report 89–161, scale 1:24,000.

Woodring, W.P., and Bramlette, M.N., 1950, Geology and paleontology of the Santa Maria district, California: U.S. Geological Survey Professional Paper 222, 185 p.

Woodring, W.P., Bramlette, M.N., and Lohman, K.E., 1943, Stratigraphy and paleontology of the Santa Maria district, California: American Association of Petroleum Geologists, v. 27, p. 1335–1360.

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Team Chief Scientist, USGS Central Mineral Resources
Box 25046, Mail Stop 973
Denver, CO 80225
(303) 236-1562

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