dramatically new or different from other evaluations of this basin, and limitations due to vegetative cover, volcanic rocks, and scarce subsurface control still handicap any appraisal.

Potential structural traps and many potentially good reservoir intervals are present. The upper Eocene section contains abundant coal, which provides a potential source for dry gas, either by bacterial or thermal generation. A good source for oil, however, has not been documented. Some fine-grained units within the Oligocene and Miocene section do indicate areas of abundant organic productivity and some approach to the conditions necessary to generate at least 2 to 3 gallons of oil per ton of rock. Also, analogy with the Eocene-Oligocene section of the Gulf of Alaska suggests that a Poul Creek-type oil shale could well exist in this basin, with perhaps 100 to 300 million bbl of undiscovered reserves a reasonable, although highly speculative, forecast. Assuming that a kerogen-rich, potential oil source rock is present, it remains difficult to document areas where burial depths in this relatively low heat-flow basin have been sufficient for thermal maturation, especially for rocks younger than Eocene. We have little doubt, however, that areas of sufficient burial depth do exist and hope to document that in our current work.

The abundant shows of gas in wells, including Mist, and active seeps, over the entire basin, and a corresponding scarcity of significant oil shows, active seeps, tar deposits, or kerogen-rich shales, suggest that coal-derived gas may well be the primary hydrocarbon resource. Based on a thermal maturation model and the potential volumes of coal buried below about 15,000 ft (4,572 m), this resource could total a trillion cubic ft of gas. Low temperature, bacterial generation of methane from the low-rank coals could double that total, although the probability of retaining this gas within the system is less than for the thermally derived gas.

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Yowlumne Oil Field

No abstract.

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Sandstone Compositions Related to Plate Tectonic Settings

Sandstone compositions are a function of provenance and depositional basin and both of these are determined by plate tectonics. Modal analyses of major framework grain types—quartz, polycrystalline quartz, potassium feldspar, plagioclase, volcanic lithic grains, and sedimentary lithic grains—plotted on a series of four triangular diagrams can be used to distinguish between the main provenance types.

Quartz-rich sands come from cratonal sources and are deposited in basins on the craton and at quiet continental margins (miogeoclines and opening ocean basins). Arkosic sands are shed from uplifted blocks on continental basement into rift troughs and wrench basins associated with transform faults. Volcanic lithic sands have volcanic arc provenances and are deposited in trenches, forearc basins, and marginal seas. Undissected arcs produce very lithic-rich sand; more mature and eroded arcs produce a mixture of volcanic lithic and plutonic (mainly quartz and feldspar) detritus. Sands rich in quartz or chert plus sedimentary lithic grains come from subduction complexes, collision orogenic belts, and foreland uplifts and are deposited in closing ocean basins, successor basins, and foreland basins.

Data from both modern sands and ancient sandstones of known tectonic settings fit the above picture; influence of climate and diagenesis on sand composition must be less important than that of tectonic setting. Hence knowing the detrital modes of sandstones provides a way of determining the original tectonic setting of the rocks, and framework grain composition of sands can be predicted from their tectonic setting.

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Diagenetic Reactions in Monterey Formation, Pismo Syncline, California

The diagenesis of the Miocene Monterey Formation in the Pismo syncline can be described in five phases: (1) silica, (2) carbonate, (3) clay, (4) organics, and (5) seawater. During progressive diagenesis resulting from increasing temperatures due to burial, the reactions that characterize the four solid phases in contact with seawater are: (1) opal A $\rightarrow$ opal CT $\rightarrow$ quartz; (2) 2 $CaCO_3$ + Mg^{++} $\rightarrow$ $MgCa(CO_3)_2$ + Ca^{++}; (3) Mg^{++} + Na-clay $\rightarrow$ 2 Na^+ + Mg-clay, and 2 NH_4^+ + Mg-clay $\rightarrow$ Mg^{++} + 2 NH_4-clay; and (4) $C_nH_{2n+1}COOH \rightarrow C_nH_{2n+2} + CO_2$, and $C_nH_{2n+2} \rightarrow \times\ CH_4 + 2C_{(n-x/2)}H_{n-x+2}$.

These reactions are not independent of one another, for example the opal A $\rightarrow$ opal CT $\rightarrow$ quartz reaction sequence is not strictly a function of temperature. In addition to temperature this reaction also appears to be influenced by at least the chemical potential of Mg^{++}. Thus, the reaction sequence is highly sensitive to the presence of other phases that compete for Mg^{++}.

Isotopic data suggest that most of the dolomitization of $CaCO_3$ occurs in the presence of light CO_2($\delta^{13}C = -13$ to -17). The light CO_2 is probably a result of decarboxylation reactions. The source of Mg^{++} during dolomitization appears to be concentrated subsurface fluids (seawater), with the rate controlling mechanism being dilution. The dilution in turn is a function of the opal A $\rightarrow$ opal CT $\rightarrow$ quartz reactions and the accompanying dewatering.

During early diagenesis the organics underwent both fermentation and sulphate reduction, but the most significant organic reactions were decarboxylation and cracking. The decarboxylation reactions appear to have been pervasive, whereas the cracking reactions have been documented only deep in the center of the syncline (>6,500 ft).

The clays, mainly smectites, were probably subjected to early cation exchange reactions and may have affect-

ed both the formation of early dolomite concretions and the reaction opal A → opal CT. We have found no evidence to suggest a smectite → illite reaction, probably due to the low activity of K^+ and the high activity of H_4SiO_4 during diagenesis.

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Oil and Gas Exploration Wells in Pedregosa Basin

In the Pedregosa basin and adjoining areas covering 49,500 sq mi (110,700 sq km) in southeastern Arizona, southwestern New Mexico, northwestern Chihuahua, and northeastern Sonora, 37 petroleum-exploration wells have penetrated Paleozoic and/or Precambrian rocks. Several shows of oil and gas have been reported, but no commercial production has been found to date. Many of the wells have been drilled on basin and range uplifts where reservoirs tend to be flushed with meteoric water. The best remaining prospects lie below the deeper parts of graben valleys where preservation of petroleum is more likely.

The highest ranking objective of the region is in Upper Pennsylvanian-Lower Permian rocks at the margin of the Alamo Hueco basin where shallow-marine dolostone reservoirs are juxtaposed to deep-marine, organically rich, limestone and mudstone source rocks. A regional isopach and facies map of the Pennsylvanian shows that the basin axis trends generally southeastward from southern Hidalgo County, New Mexico, across the Ascension-Villa Ahumada area of Chihuahua. Several other petroleum-exploration objectives are indicated in the Paleozoic and Mesozoic rocks.

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Stratigraphic and Structural Relations to Pre-Tertiary Rocks on Perimeter of Santa Maria Basin

On the perimeter of the Santa Maria basin three tectono-stratigraphic terranes of pre-Tertiary rocks are recognized. In ascending stratigraphical and structural order, these are: the Franciscan assemblage, the Coast Range Ophiolite, and the Great Valley sequence. Where exposed in the western Santa Ynez and San Rafael Mountains, the Franciscan assemblage is a melange of chiefly graywacke, argillite, chert, and blueschist rocks. The Coast Range Ophiolite forms a discontinuous tectonized belt of outcrops along the southwest edge of the San Rafael Mountains; parts of the dismembered ophiolite are exposed at Cuyama Gorge, Tepusquet-Colson Canyon, north side of Figueroa Mountain, Little Pine Mountain, and Santa Ynez River west of Gibraltar Dam. Rock types include harzburgite, pyroxenite, gabbro, diorite, pillow basalt, tuff, and serpentinite. Throughout the ophiolite belt, serpentine-rimmed cold intrusions invade sedimentary strata as young as middle Miocene. The Great Valley sequence includes Tithonian through Maestrichtian submarine-fan strata as well as fluviodeltaic strata of probable Campanian age. The latter crop out in the Sisquoc River area directly west of the Sur-Nacimiento fault zone. Along the north flank of the Santa Ynez Mountain, structural superposition resulting from truncation along thrust planes has juxtaposed beds as young as Valanginian above the Franciscan assemblage.

The structural and stratigraphic relations of the three terranes support the concept of a regionally persistent late Mesozoic forearc basin and accretionary subduction complex that may have extended from the Klamath Mountains of Oregon to as far south as the Vizcaino Peninsula of Baja California, Mexico.