interval spans most of the zone of oil generation, as supported by a continuous decrease in H/C atomic ratios of the kerogen and hydrogen index from pyrolysis of the whole rock. The ratio of extractable organic matter (bitumen) to total organic carbon increases with depth, recording the formation and reservoiring of hydrocarbons in the chalk. The extractable organic matter becomes enriched in saturated hydrocarbons at the expense of non-hydrocarbons with increasing depth of burial, while the saturated hydrocarbons themselves become more like crude-oil hydrocarbons and less like immature, bitumen hydrocarbons in the deepest samples. The Austin Chalk appears to have acted as a source rock for at least part of the crude oil reservoired in and produced from the formation.

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Tectonics, Sedimentation, and Petroleum Geology of Transform Margin of Central California

Although wrench tectonics of the San Andreas transform fault system dominate the structure of modern central coastal California, regional sedimentary basin evolution and petroleum geology are best viewed in the context of transform tectonics superposed on an older convergent margin regime. Convergence along the central California margin continued from the Mesozoic until the mid-Tertiary, interrupted briefly in earliest Tertiary time by strike-slip faulting related perhaps to oblique subduction. Convergence finally ceased in the Oligocene with the diachronous propagation of the San Andreas marginal transform system. Apparently, the locus of shear within the transform system migrated shoreward and continentward with time to the present position of the San Andreas fault, progressively involving granitic basement in lateral translations.

Regional tectonics strongly control the character of central California sedimentary basins and distribution of sedimentary facies. The expansive patterns of Cretaceous and earliest Tertiary forearc basin sedimentation, less favorable in reservoir provenance, organic source-rock character, and burial history, were replaced in early Tertiary time by deposition in localized borderland basins related to strike-slip faults. However, it was the full development of the marginal transform system during the Neogene which provided the requisite elements for a productive and still prospective petroleum province: discrete, moderate-sized, structurally controlled sedimentary basins; deposition through rapid subsidence of thick piles of organic-rich marine sediments in silled, anoxic borderland basins; favorable reservoir provenance through deep dissection of granitic uplifts; and extensive, early wrench tectonic structuring of basin fill, often influencing syntectonic patterns of sedimentation.

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Geology of Mesozoic Basement Rocks from Well Cores in Santa Maria Basin, Santa Barbara County, California

The Mesozoic rocks underlying the Tertiary cover in the Santa Maria basin, California, consist of an Upper Cretaceous sedimentary sequence overlying dismembered ophiolitic rocks of undetermined age. The ophiolitic rocks are ophicalcites, basalts, greenstones, dike and sill rocks, gabbros, and serpentenized peridotites in a Franciscan assemblage. The Upper Cretaceous rocks are sandstones, mudstones, and shales that were deposited in a submarine fan environment. They are characterized by tectonic disruption in the form of brecciation and chaotic mixing. These basement rocks of the Santa Maria basin were compared to rocks of similar age surrounding the basin in terms of petrography, sedimentary structures, and facies relations. Two major groups of strata were compared: relatively undisturbed sedimentary rocks correlated to the Great Valley sequence and the disrupted Franciscan rocks of the Cambria, Point San Luis, and Pfeiffer Beach slabs. The Santa Maria basin basement rocks are similar to the latter group.

Mesozoic rocks underlying the Santa Maria basin were formed in a converging plate boundary regime on the inner trench-slope. The ophiolitic rocks and the overlying deep-water cherts and pelagic sediments were accreted in fold and thrust segments as the downgoing oceanic plate was subducted. The accreted material formed linear ridges which trapped younger sediments in a trench-slope basin. Sediments from several different source areas accumulated in these localized basins and were tectonically deformed with continuation of subduction in the trench. The rocks resulting from this process are called the Franciscan melange.

The Santa Maria basin formed above these Franciscan rocks following collision of the Farallon-Pacific spreading center with the trench off California in Oligocene time. The subsequent transform regime produced major right-lateral strike-slip fault movements and associated downwarping of the Santa Maria area. Deep-water, middle Miocene sediments were deposited in this newly formed basin in contact with the Mesozoic rocks.

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Detailed Reservoir Geology—Basis for Enhanced Recovery Model, Wasson San Andres Field, West Texas

Core studies in the CO_2 pilot area of Shell's Denver unit in the Wasson San Andres field of west Texas revealed two basic end-member rock types: pelletal packstones, which exhibit high porosity and permeability due to the effective inter-pellet pore fabric; and moldic wackestones, which have lower porosity and significantly lower permeability, due to the disconnected fabric of the moldic pores. The majority of the rock section consists of a mixture of these end-member rock types due to cyclical variations in the degree of organic burrowing, which created the pellet packstones by reworking the original wackestone lithology. The high quality pellet packstones are dominant in rocks with greater than 15% porosity. The geologic model of the pilot area thus consists of numerous correlative high porosity zones composed dominantly of packstones, interbedded with poorer quality moldic wackestones.

An examination of cores from representative wells throughout the Denver unit also documented the occurrence of pelletal packstones, dominantly in rocks with greater than 15% porosity. By using digitized sonic logs from 688 wells in the Denver unit and the LOGPAK program, isopach mapping of packstone thickness in each of the correlative field-wide San Andres subzones was accomplished. Recognition of the detailed zonation of rock types from the pilot area in wells throughout the major part of the Denver unit permitted expansion of the pilot area model to the larger Denver unit model.

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Salinas Basin—Subtle Traps All

The Salinas basin has predominantly barren surface anticlines. The heavy oil giant, San Ardo, was found accidentally on a surface syncline. Finding new traps in this basin requires stripping back the stratigraphy to the time of accumulation, generally late Miocene. One starts at the top with the best available surface geology and geomorphology. The tilted Gabilan Mesa peneplain surface can be untilted by isopaching the thickness from the Mesa surface to the top of the Miocene. At this point we have a map of the structure before the late Pliocene to Recent deformation. San Ardo shows up at this point with 400 ft (122 m) of closure exactly coinciding with the present outline of the oil field and matching the 400-ft (122 m) oil column, in marked contrast to the present day structure contours on the producing horizons. Further isopaching of discrete stratigraphic intervals within the upper part of the Miocene produces a picture of the structure shortly after the deposition of the producing zones. In addition, shoreward sand strandlines and seaward sand shale-up lines can be defined. Analysis of this geologic history also shows the probable location of deltaic areas and longshore bars. Early loci of oil accmulation and wedge edges of permeability are apparent from this synthesis. Several small oil fields of the Salinas basin have been found deliberately by unraveling the subtle geologic history to the time of accumulation and deposition.

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Worldwide Review of Seals for Major Accumulations of Natural Gas

About 62% of the caprock seals for the world's 176 giant gas fields are shales and about 38% are evaporites. These two lithologies make up essentially all of the caprock for the 2,650-Tcf of gas expected to be recovered from these fields. Caprock thickness data is lacking from many fields, but 20 to several hundred meters are typical.

Optimal conditions for seal preservation occur in areas which had a comparatively simple geologic evolution. Complex fold belts and overthrust belts are commonly subject to seal destruction. Of the world's 25 largest gas fields, 21 are in cratonic settings and four in fold belts; those in fold belts have evaporite seals.

Lateral continuity of caprock has a favorable impact on the retention of gas over large areas such as the Arabian platform.

Gas hydrate accumulations illustrate both seal and reservoir. Seal destruction is caused by changes in the phase equilibrium.

Considerable multidisciplinary research still needs to be done to quantify knowledge of seal prediction for giant gas fields.

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Buried-Hill-Type Oil Fields in Northern Part of China

Large-scale exploration for oil and gas started in north China during the 1960s, with Tertiary formations considered the main exploratory objective. In 1975, oil finds in Sinian dolomite beneath the Tertiary unconformity led to the discovery of the prolific Renqiu oil field, a buried-hill type. Since then, there has been intensified exploration for buried-hill oil pools. To date, more than 40 buried-hill oil and gas pools, and nine suites of oil-bearing formations, have been discovered. Reserves from these oil fields constitute 22% of the regional total, and current production accounts for 30% of the total. The success ratio in the exploration for hydrocarbons in the buried hills is 10 to 30%.

Based on the distribution of source rocks, and the pattern of oil migration, the buried-hill oil fields are categorized as follows: (1) hydrocarbons migrated into the reservoir through the unconformity surface and the fault planes, (2) through the unconformity surface, (3) through the fault planes, and (4) through the fault planes and then along the unconformity surface.

Two main types of the buried hills are classified according to the characteristics of their development during the Tertiary: (1) subsidence type, and (2) elevation and denuded type. The two types of reservoirs form a composite oil and gas accumulation zone with distinctive reservoir sequences. These factors provide a theoretical basis for finding various types of oil and gas pools on different parts of the buried hills.

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Mississippian Continental Margins of Conterminous United States

The paleogeographic, paleotectonic, and paleobathymetric reconstruction of continental margins around the present western, southern, and eastern sides of the conterminous United States can be defined for a brief span (about 1.5 m.y.) of Mississippian time. Interpretations are made by applying a biostratigraphic and sedimentological model for the Deseret starved basin of Utah and Nevada to recently published shelf-margin studies. The time span is that of the middle Osagean *anchoralis-latus* conodont zone. Precise dating and paleobathymetric interpretations are based on the biostratigraphy and paleoecology of conodonts, and also of corals, calcareous and agglutinate foraminifera, and radiolarians. At this time, a shallow tropical sea covered most of the southern North American craton and was the site for sedimentation of a broad carbonate platform. Surrounding this carbonate platform was a starved trough comprising several bathymetrically distinct starved basins. These starved basins lay on the inner (continentward) sides of foreland basins that were bordered on their outer sectors by orogenic highlands. The highlands formed in response to convergences or collisions with the North American continent by an oceanic plate to the west, by South America to the south, and by Africa and Europe to the east. During a eustatic rise of sea level that accompanied the orogenies and reached its maximum during the *anchoralis-latus* zone, the carbonate platform prograded seaward and carbonate sediments cascaded over the passive shelf margins to intertongue with thin carbonate slope deposits and very thin (~10 m) phosphatic basinal sediments. Simultaneously, thick (~500 m) flysch and deltaic terrigenous sediments, such as the Antler flysch on the west and the Borden and Pocono deltaic deposits on the east, were shed into the outer parts of the foreland basins from active margins along the orogenic highlands. This Mississippian reconstruction provides a unique opportunity for comparing and contrasting shelf-slope boundaries in parts of contemporaneous passive and active margins on three sides of a Paleozoic continent.

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The Time is Now for All Explorationists to Purposefully Search for Subtle Trap