

field indicates that the coal-bearing strata accumulated during seven minor progradations of the shoreline of the Cretaceous seaway.

The lower and middle coal zones consist of eight and six seams, respectively, and were deposited in a swamp 20 km wide on the landward side of a barrier-island complex. The upper coal zone consists of a single seam that accumulated in interdistributary swamps in a deltaic setting.

The three coal zones were deposited during the three of the seven progradations that are completely developed. The remainder are incompletely developed and do not contain significant coal seams.

Complete vertical sequences of barrier-island and deltaic progradation are present in the Straight Cliffs Formation. Incomplete progradational sequences are usually composed of transition, shoreface, and fore-shore deposits.

The repetitious nature of the several progradations and transgressions of barrier-island deposits and the local incompleteness of their development suggest periodic fluctuations in the quantity of sediment supplied by longshore transport currents from deltas northwest of the study area. Delta-lobe abandonments probably resulted in the periodic interruption of sediment supplied to the barrier-island complex and allowed sufficient time for compactional subsidence in the barrier complex to cause minor transgressions.

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#### Geologic and Structural History of Zagros Foldbelt, Iran

The earliest discernible event in the Zagros area, which is structurally the northern part of the Arabian continental block, was the deposition of the Infracambrian Hormuz salt, presumably in a rift basin with a north-south boundary on its west side. The overlying shallow-marine miogeoclinal shale-carbonate sequence through the Cambrian is overlain by deeper water Ordovician and Silurian shales, representing a progressive foundering of the rift margin. A second rift event, oriented along the present northern margin of the Zagros foldbelt, began in the pre-Permian, represented by a significant angular unconformity at the base of the shelfal, largely carbonate, Permian to Late Cretaceous sequence.

Sharp change from carbonate to marl deposition along this margin in the latest Cretaceous suggests rapid deepening associated with arrival at a north-dipping oceanic subduction zone, which almost immediately thrust melange and ophiolites up over the edge of the shelf. This entire ensemble has been colliding with the Central Iranian Block along a second north-dipping subduction zone since the Miocene, resulting in essentially concentric folding of the Infracambrian to Miocene shelf sequence, largely upon a basal detachment within the Infracambrian Hormuz salt but also involving the basement in north-dipping thrusts and in tear faulting, and involving the salt in numerous compressionally induced diapiric structures. The syntectonic, evaporitic, Miocene-Pliocene Fars Group rocks represent deposition in a basin restricted by the actual colli-

sion event. They are involved in the Zagros folding, and also in enormous, southward directed gravity glides down the regional topographic gradient resulting from the orogeny. The huge oil and gas traps of the area are within the concentric Zagros fold structures, in strata ranging from Permian to Miocene in age.

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#### Geology of Calvin Field—Deep Basinal Jurassic Play in North Louisiana Salt Basin

Calvin field is currently being developed by Getty Oil Co. but was discovered in 1941 with a Paluxy gas sand completion by Hunt Oil Co. In 1972-73 Texaco drilled two Cotton Valley wildcats which were plugged and abandoned but had interesting Cotton Valley gas shows. In 1976, Getty Oil Co. (Skelly) 1 Bodcaw blew out in a Cotton Valley sand section. Getty Oil and Bodcaw Oil and Gas have established and extended production, completing seven additional wells. To date, the productive limits of the field have not been defined but considerable information is at hand, including that concerning the generally poor porosity and permeability of reservoir rock. Presently six wells, and an extension to the northeast, appear potentially productive in one or more of eight Lower Cretaceous and Upper Jurassic formations. Greatest potential appears to be in Upper Jurassic (Cotton Valley) sand section. These reservoir sands interfinger with gray marine shales over the structure and are absent off the southern flanks.

Calvin structure was formed before the close of Jurassic time on an uplifted carbonate shelf when salt movement created trough-like depressions to the northwest and southeast. The resulting faulted anticlinal feature experienced local erosion and subsequent infilling with coarse clastics brought down from the Ouachita foothills to the north and deposited in a localized deltaic environment. Marine transgression from the south immediately followed with the accumulation of extensive regional sand bars and beach deposits. The Upper Jurassic section may have been buried several thousands of feet deeper in Tertiary time than the present 12,500 to 13,000 ft (3,810 to 3,962 m).

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#### Mason Lake Field, Musselshell County, Montana

In the Mason Lake field, the discovery of oil in the 1st Cat Creek sandstone, Lower Cretaceous in age, occurred in March 1978. Further ongoing development in the area is presently defining the limits of the field.

Discovery of the oil potential from the 1st Cat Creek sandstone occurred while development drilling to the 3rd Cat Creek sandstone was in progress. This potential had gone undetected for several wells because oil shows were absent in dry samples and rarely detectable in wet samples. The high-gravity oil (47°) may partly offer some explanation as to the unusual disappearing behavior of the oil in the dry drill cuttings. In 1964, electric-log analysis and drill-stem tests of this zone in the general area offered little evidence of potential oil production.

Wildcat exploration for the elusive 1st Cat Creek pay zone will require detailed stratigraphic studies accompanied by careful well-site sample analysis, well-chosen suites of electric logs, and modern gas-detection equipment.

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#### Paleoecologic Determination of Bathymetric Position of Organic Buildups—Example from Lower Paleozoic of Appalachians

Bathymetry of organic buildups may determine their reservoir potential. Whether a buildup was formed on a shelf, at a shelf edge, or downslope toward a potential source basin may determine distance of hydrocarbon migration, porosity and permeability history, and reservoir "sealing" events. Although there are physical paleobathymetric indicators, the most sensitive criteria are paleobiologic in nature. Our case study example involves several buildups in the Appalachian Ordovician. Depth was initially established on sedimentologic and stratigraphic bases; paleoecologic analysis of upslope versus downslope buildups led to generalizations which may apply to other Paleozoic buildups. Shelf, upslope, and downslope buildups have features in common such as abundant and diverse echinoderms, gray to red mudmounds, and abundant cross-bedded grainstones (although cross-beds are of different origin in shallow and deeper locales). Significant paleoecologic differences exist. Upslope and shelf buildup communities were dominated by echinoderms and arborescent bryozoa, with red and green algae. Some encrusting red algae were binders of mud-mounds. Endolithic borers were abundant. Downslope buildups were constructed by echinoderms, and encrusting bryozoa acted as binders of mud-mounds; algae are absent, and evidence of boring is rare.

Ecologic distinction between the settings may have resulted from differences in light intensity, abundance of suspended organic detritus in bottom waters (a resource derived from shelf areas), and the height above the sediment of suspended food. In shallow water, resuspended detritus allowed suspension feeding at many levels while deeper water conditions allowed suspension feeders, chiefly bryozoa, only very near the bottom.

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#### Evaluation of Uranium Potential of Frontier Areas by Functional Source-Rock Analysis

Rapid, inexpensive evaluation of the potential of frontier areas for epigenetic uranium deposits can be conducted using functional source-rock analysis analogous to that employed in the petroleum industry. Association of uranium-rich volcanic glass with nearly all such deposits suggests that their uranium came from glass. Concentration of uranium in ores is about  $10^3$

times that in glass-rich sources, so great volumes of depleted rock should mark favorable areas.

Fresh rhyolite glass contains uranium adsorbed on shard surfaces, soon washed off, and 5 to 10 ppm internal uranium, which is released when the glass converts to a crystalline assemblage. Only under certain circumstances does released uranium migrate. Studies conducted in south and west Texas and in Nevada on volcanic rocks and sediments that originally contained abundant volcanic glass lead to the following conclusions: conversion in soil or by very early diagenesis, and low temperature conversion of glassy ash flows to clay release uranium for migration; high temperature conversion by divitrification or vapor phase crystallization and diagenesis in open hydrologic systems trap uranium near its site of release. Structures and textures produced during each of these processes are distinctive and can be recognized in the field or in thin section. Furthermore, the processes probably produce distinctive chemical effects other than depletion of uranium. Functional source rock exploration for uranium consists of field, petrographic, and geochemical detection of depleted rock that altered in a favorable fashion. Evaluation of likely migration routes; geologic, geochemical, and radiometric exploration for traps; and drilling programs can then be concentrated in the most favorable areas.

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#### Seismic Stratigraphy in Low-Energy Carbonate Depositional Environment

Seismic stratigraphic mapping in carbonate rocks has been historically concentrated on the shelf margin environment where unit geometry and abrupt facies-velocity changes are often easily discernible with the seismic tool. In contrast, low-energy, more subtle shelf interior stratigraphic features have attracted less geophysical attention. This report describes the study of seismic data from five United States oil fields which produce from reservoirs formed from shelf interior deposits. Three Smackover fields, a Permian basin producer, and a Williston basin example are compared.

Review of the depositional model indicates the difficulty of seismic mapping in non-reef carbonates. If sedimentary accretion is nearly vertical, porosity traps are predicted to exhibit only lateral change in unit velocity. In regressive or transgressive sequences, the geologic model indicates that angular discordance due to sediment buildup in combination with a velocity contrast generates an angular feature that has a different velocity pattern. These five fields provide examples of both trap types.

Jay field (Florida) and Walker Creek field (Arkansas) both produce from the Smackover Formation and are (seismic-defined) stratigraphic traps which illustrate angular discordance and velocity contrast owing to regressive buildup. The trapping mechanism at Big Escambia Creek (Alabama), also productive from the Smackover, is from a transgressive pulse devoid of vertical buildup. Hence, the porosity trap is indicated only by a lateral velocity change without angular discordance.

Subsurface geologic sections of San Andres produc-