signals the beginning of the second phase of Smackover exploration—the search for combination structural/stratigraphic and wholly stratigraphic traps—and the rebirth of exploration for large reserves in a mature segment of the trend.

The regionally regressive depositional character of the Smackover in this area afforded an excellent setting for the formation of many stratigraphic traps. Porous carbonate zones, successively higher within the Smackover section, were deposited southward across the shelf. The updip terminus of each zone abuts an impermeable seal to form an ideal stratigraphic trap. The sinuous nature of the updip terminus, in many places in conjunction with low relief structural noses or closures, entraps the hydrocarbon accumulation laterally. In addition, many variations in the regional situation, due to the local depositional patterns of individual zones, tend to complicate the simple stratigraphic trap.

Lithologically, the most characteristis reservoir rock is an oolitic-pelletal limestone with intergranular porosity. Porosity up to 30% is not unusual, but average porosity ranges from 10 to 20%. Various degrees of porosity destruction have resulted from the infilling of the primary porosity with sparry calcite cement. Where wave action was not sufficient to winnow out carbonate muds, no primary porosity was developed.

The diverse nature of the stratigraphic traps opens up unlimited exploration opportunity on acreage once considered worthless because it was not located on closed structures. The stratigraphic phase of exploration now promises to be as profitable as was the structural phase in this "old" producing area.

BLOOMER, R. R., Consulting Geologist, Abilene, Tex.

FLUVIAL, DELTAIC, AND SLOPE RESERVOIR SANDSTONE IN WEST-CENTRAL TEXAS

More than 300 Lower Permian sandstone oil and gas fields are present in an area of about 7,000 sq mi on the Eastern shelf and slope of the Midland basin. All these fields appear to be in stratigraphic traps in fluvial, deltaic, and slope depositional environments. Two Lower Permian Cook fluvial sandstone systems extend in a downdip direction across the Eastern shelf to the shelf edge, where progradational Cook sandstone facies form two high-constructive deltas. These are the proximal parts of a thick terrigenous clastic wedge of sediments covering the eastern slope.

Outcrops of Cook channel-fill deposits grade upward from conglomerate and quartz sandstone, to gray shale. Downdip from outcrop to the shelf edge, Cook sandstone is present in one meander belt system 82 mi long. The upper 30 mi is about five mi wide and bounded by shale and two thin lenticular limestone beds. The belt narrows to about one mi where adjacent limestone beds are thicker and were more resistant to lateral channel erosion. About 58 mi downdip from outcrop, the meander belt divides into two belts. Each belt is about one mi wide and bounded by shale and thick limestone beds to the shelf edge.

Point bars (with characteristic electric-log SP curves), crevasse splays, and/or natural levees are discernible in the meander belts. Many stratigraphic traps are present in point bars, in sandstone belts perpendicular to regional dip, and in belts of sandstone that overlie buried reefs, hills, structures, and other channel sandstones. Paleocreekology is applicable in locating topographic features on the paleoshelf.

Both Cook sandstone deltas, nearly joining, are in an area of 295 sq mi. Delta-plain facies consist of interbedded dark gray shale, fine-grained, lenticular sandstones, and thin coal lenses underlain by thick, medium-grained sandstone facies in distributary channels. Electric-log SP curves of the channel sandstones are characteristic. Delta front distributary mouth bar and sheet-sandstone facies overlie thick prodelta shale and thin, lenticular sandstone. The Group 4000 "Cisco" sandstone field is the only oil field of any significance in the two deltas. It produces from delta-plain sandstone facies.

West of the shelf edge, the Cook wedge of shale and sandstone lenses reaches a maximum thickness of about 1,300 ft at midslope and thins basinward. The base is a maximum gradient of about 3° at midslope. The Northeast Bloodworth "Canyon" sandstone field produces from Cook sandstone, probably a turbidite and slump deposit, evidently deposited in a submarine channel. The Jameson "Strawn" sandstone field, about 35 sq mi in area, produced from Cook lower slope sandstone lenses, probably part of a submarine fan.

BUIS, O. J., and K. HALL, Shenandoah Oil Corp., Quito, Ecuador

GEOLOGY OF ORIENTE REGION OF COLOMBIA, ECUADOR, AND PERU

No abstract available.

DALRYMPLE, D. W., Phillips Petroleum Co., Bartlesville, Okla.

EKOFISK FIELD, ITS GEOLOGY AND PETROGRAPHY

The Ekofisk field is a landmark in the history of petroleum exploration. With recoverable reserves estimated at 1 billion bbl, it is the first major oil discovery in the now-burgeoning North Sea oil patch. Ekofisk is on a salt structure, and produces from approximately 700 ft of highly porous Danian limestone. Scanning electron micrographs show that this limestone is a typical chalk, formed almost entirely of coccoliths and planktonic foraminifers. Extensive fracture systems have been noted in cores. The original intergranular porosity of the rock is reduced in places by the precipitation of secondary calcite cement, possibly associated with stylolite formation

DICKEY, P. A., and L. MASROUA, Univ. Tulsa, Tulsa, Okla.

APPLICATION OF RESERVOIR-PRESSURE DATA IN PROSPECTING

The search for stratigraphic traps is basically the search for barriers to the movement of fluids. Such barriers can be identified more surely by pressure information than by stratigraphic correlation. We think of normal reservoir pressure as "that necessary to sustain a column of water to the surface." However, when oil or gas is in lenticular sands, the initial reservoir pressures may be much less or much more than "normal." Examples of low pressures are found in the Cretaceous of New Mexico and Alberta, and the Morrow of western Oklahoma. Abnormally high pressures are found in many areas of the world, especially in Tertiary sediments, but also in the Pennsylvanian Morrow sandstones of central Oklahoma. In Blaine County there are about 10 separate Morrow reservoirs. All the wells in each reservoir have similar initial pressures and subsequent pressure-decline histories, which differ markedly from one reservoir to another. It should be possible from well performance, or even good drillstem-test data, to tell which reservoir a wildcat well has penetrated, or whether it has found an entirely new reservoir. Thus the regional extent of each reservoir can be ascertained very early during exploration.

ELAM, J. G., Consulting Geologist, Midland, Tex.

TECTONIC EVOLUTION OF VAL VERDE-DELAWARE BASIN, TEXAS

The Val Verde-Delaware basin is a marginal foreland basin genetically related to the Ouachita overthrust belt and its associated subduction zone. Proximal structures to the overthrust belt evidence compressional folding and faulting indicative of a horizontal maximum principal stress, but the dominant principal stress of the more distal and productive structures is vertical. A similar tectonic style is evidenced for the Permian basin as a whole.

Isopachs indicate that structural growth began early and continued intermittently throughout the Paleozoic. Maximum instability occurred during the Mississippian, Pennsylvanian, and Wolfcampian with concurrent uplift of the producing structures and subsidence of the intervening grabens. The period of instability is coincident with the period of maximum activity along the Ouachita subduction zone.

Thermal and isostatic activity related to the subduction zone may have caused the differential vertical uplift and subsidence. The stress system appears to be caused by fluid movements in the crust or subcrust. As lighter material was subduced to mantle depths there was some partial melting and diapiric rise of these lighter materials. The complete process is not fully understood.

Rigid basement blocks were tilted and uplifted along basement faults. The overlying sediments behaved plastically, and basement faults die out abruptly upward in the section. Faulting is rarely found in the borehole, but steep to overturned beds are common. Minor faulting in the producing fields appears to have served as a conduit for rising hydrothermal fluids which cause some secondary cementation and loss of porosity and permeability. This has caused some structurally well-located wells to be dry or noncommercial.

The tectonic style of the Val Verde-Delaware basin is similar to that of many foreland basins throughout the world.

FRANK, R. W., Schlumberger Well Services

FORMATION EVALUATION WITH LOGS IN DEEP ANADARKO BASIN

The complex lithology, and the nature of the "measurement environment," make the "deep Anadarko basin" one of the more difficult log-evaluation problems facing the industry anywhere today. Methods for solving this problem are adapted to various conditions of hole size, temperature, pressure, salinity, and gasified mud, as well as to the particular case of salt-saturated drilling fluid, high temperatures, and deep invasion. Log-evaluation methods include Quick-Look interpretation techniques employing the Dual Laterolog and/or the Compensated Neutron/Formation Density (Compensated) as well as the advanced computation system, CORIBAND. Evaluation systems available are capable of a highly consistent and reliable evaluation of this complex reservoir.

HENNES, M. E., Consulting Dept., Core Laboratories, Inc., Dallas, Tex.

DEPOSITIONAL ANTICLINES OF DEEP ENVIRONMENTS—PAST SUCCESS AND FUTURE EXPLORATION

As the energy quest probes deeper into the oceanic environment, enormous depositional anticlines formed by deep current action are being documented, and certain of these with favorable rock properties beckon the explorationist.

Wind-driven surface currents such as the Gulf Stream can shape these anticlines at the outer edges of detrital sedimentation, where high-velocity currents sweep the bases of continental slopes. Similarly, the "bottom" currents, which are moving at slower velocities deeper on the continental rises, will form varied anticlinal profiles characteristic of particular bottom conditions. Redistributed terrigenous materials, which in great part compose these anticlines, are carried into both current systems by spasmodic gravity sliding and turbidity currents.

A striking example of wind-driven current deposition is present in the Florida Strait where calcareous sands from the Florida reef area are swept by the Gulf Stream along a trough, thence onto a broad anticlinal rise. Examples typifying "bottom" current anticlines are numerous in the North Atlantic, and deep-water coring programs have partly documented their sediments.

A wind-driven current origin can explain plausibly the Poza Rica trend in Mexico. As the Golden Lane Reef contributed its Tamabra talus downslope into swift currents of the Chicontepec foredeep, anticlines were shaped at the base of the slope. Similar origins are suggested for other examples in the geologic record.

Significant reserves in anticlines formed by forceful currents will be found beyond the reefs and laterally away from the deltas in the deep environment where the subtle character of these features must come to be recognized. Reservoirs such as Poza Rica attest to the excellent structural and reservoir qualities which can be realized in an inspired search for such targets.

KIER, R. S., Univ. of Texas at Austin and Bur. Economic Geology, Austin, Tex.

REGIONAL DEPOSITIONAL MODEL FOR EARLY PENNSYLVANIAN OF CENTRAL TEXAS

No abstract available.

LAPLANTE, R. E., Amoco Production Co., Research Dept., Tulsa, Okla.

PETROLEUM GENERATION IN GULF COAST TERTIARY SEDIMENTS

Organic detritus in sediments is composed principally of carbon, hydrogen, oxygen, and nitrogen. At the time of deposition, only small amounts of hydrocarbons are present. However, this organic matter has the potential to generate hydrocarbons in quantities that depend largely on its hydrogen content.

Organic matter disseminated in sediments, when heated, undergoes carbonization by mechanisms very similar to the thermochemical processes responsible for coalification. Carbonization is a thermal process marked by the generation of volatiles relatively rich in oxygen and hydrogen, and the formation of a kerogen residue increasingly enriched in carbon. The most significant oxygen-rich volatile is carbon dioxide, and the most significant hydrogen-rich volatiles are hydrocarbons.

Measurement of changes in the elemental composition of the organic matter as a function of depth can determine the principal volatile products of the carbonization reactions. Data from the Gulf Coast Tertiary indicate that carbon dioxide is the principal volatile product of early carbonization, and that hydrocarbons are not significant products until the later stages. Amounts of hydrocarbons generated during carbonization are vast compared to those from any other natural source or process.

The data indicate that the rate of carbonization or, more specifically, hydrocarbon generation is a chemical process which follows the general rules of chemical kinetics. As sediment age decreases, the temperature required to reach the level of carbonization associated with hydrocarbon generation increases. For example, significant hydrocarbon generation occurs in the Oligocene at a log temperature of 170°F and above; for lower Miocene log temperature is 186°F; and for upper Miocene log temperature is 205°F. Appreciably higher temperatures are required for significant hydrocarbon generation in post-Miocene sediment.

Kerogen with relatively low hydrogen levels (*e.g.*, similar to levels found in coals) probably would generate gas rather than oil. Thus, the relatively low hydrogen level in organic matter from these wells suggests that the sections penetrated would be better sources for gas than oil.

MCGLASSON, E. H., Mobil Oil Corp., Houston, Tex.

SILURIAN-DEVONIAN OF WEST TEXAS AND SOUTHEASTERN NEW MEXICO

During the early Paleozoic, a shallow depositional basin called the Tobosa basin developed in western Texas and southeastern New Mexico. The basin was bounded on the north and east by low-lying land masses and probably opened to the south into the subsiding Ouachita-Marathon geosyncline. Throughout Silurian and Early and Middle Devonian times the