rence of late secondary porosity, and the presence of fluid pressures in excess of normal hydrostatic pressure. Physical, geochemical, and lithologic parameters associated with these deep, highly porous reservoirs should be monitored during deep exploratory drilling in other areas. Overpressuring, abundant CO_2 and H_2S, and the development of late secondary porosity may indicate the presence of unexpected carbonate reservoir rocks deep in sedimentary basins.

FUNKHOUSER, L. W., Standard Oil of California, San Francisco, CA, and F. X. BLAND and C. C. HUMPHRIS, JR., Chevron U.S.A. Inc., New Orleans, LA

Deep Tuscaloosa Gas Trend of South Louisiana

The deep Tuscaloosa gas trend of south Louisiana is one of the most significant exploration plays in the United States in recent years. This trend, productive from an expanded Tuscaloosa sand-shale sequence of Upper Cretaceous age, covers a band approximately 30 mi (48 km) wide and 200 mi (322 km) long, from the Texas line on the west and extending past Lake Pontchartrain on the east.

Regional studies begun by Chevron in 1964 demonstrated the probability of an unexplored sedimentary section lying just south of the Lower Cretaceous carbonate bank edge which crosses south Louisiana. Improved regional seismic data later verified the presence of such a unit, termed "the wedge," located between reflectors identified as Upper Cretaceous chalk and Lower Cretaceous carbonates.

The discovery well of the Tuscaloosa wedge was drilled in the False River area in May 1975, when Chevron tested 20 MMCFG/D from a sand at 19,800 ft (6,035 m) in the 1 Alma Plantation, 15 mi (24 km) northwest of Baton Rouge. Chevron confirmed the trend with a discovery in December 1975 at Rigolets field, 125 mi (201 km) southeast of False River field.

The productive section of the Tuscaloosa is interpreted to be a shallow-water deposit built by progradation southward across the Lower Cretaceous carbonate bank edge. Down-to-the-south faulting in this expanded section, together with deep salt movement, has produced most of the structural features that are now productive from the Tuscaloosa.

One hundred and fifteen exploratory wells have been completed along the Tuscaloosa trend, resulting in the discovery of 19 fields. Several apparent discoveries are currently being tested. Proved plus potential reserves discovered through May 1981 are estimated to be approximately 5 TCF. This reserve estimate should increase significantly with continued drilling.

MEISSNER, FRED F., Bird Oil Corp., Denver, CO

Abnormal Pressures Produced by Hydrocarbon Generation and Maturation and Their Relation to Processes of Migration and Accumulation

Abnormally high pore-fluid pressures may be produced as a result of hydrocarbon generation from organic matter (kerogen) contained in "source rocks." Contributing processes include: (1) collapse of rock matrix as overburden-supporting solid kerogen is converted to non-expelled fluid hydrocarbons and (2) volume increases produced by the conversion of kerogen to hydrocarbons. Overpressures may also be created by volume increases associated with the thermally progressive conversion of oil to wet gas/condensate and to dry gas within the pores of either the source rock or associated isolated hydrocarbon-saturated nonsource rocks. Generation-type overpressures may be reinforced or maintained by (1) fluid-volume expansions caused by higher temperatures associated with further burial and by (2) capillary entry pressure phenomena associated with expulsion/migration. The occurrence, maintenance, and degree of fluid overpressuring appear to be dependent on time, temperature, volume of kerogen/hydrocarbons undergoing transformation, and the relative isolation of the rocks with respect to regionally extensive high-permeability rocks.

Regions of hydrocarbon-generation overpressure have been documented in several basins. They are present as vertically and laterally restricted "cells" or "pods" centering around actively generating source-rock units in basin-bottom positions. Hydrocarbons in most places appear to be the overpressuring fluid and the only initially producible fluid species present.

Actively generating source rocks within the pressure cells may be characterized by (1) abnormally high electrical resistivities and abnormally low sound velocities. Resistivity increases may be caused by the replacement of conductive pore water with nonconductive hydrocarbons. Low sound velocities may be caused by (1) the replacement of higher velocity pore water with lower velocity hydrocarbons and (2) the effects of abnormal pressure on porosity enhancement or preservation through dilation or undercompaction.

Overpressures produced by hydrocarbon generation are the primary motivating forces causing primary expulsion from source rocks to conventional reservoir rocks. These overpressures may cause the spontaneous hydraulic fracturing of a source rock. The process facilitates fluid expulsion and may also create an associated "in-situ" fracture-type reservoir. The process may also create far-reaching fractures which propagate upward or downward from the source rocks and control vertical migration through great thicknesses of seemingly impermeable confining strata.

After active high-rate hydrocarbon generation has ceased in a basin, owing either to (1) decreases in temperature produced by uplift or lower heat flow or to (2) loss of generation capacity due to "over-maturity," the associated pod of *abnormally high* pressures may be replaced by a pod of *abnormally low* pressures associated with closed apparent minimum potential energy ("potentiometric") "sinks." This stage of pressure evolution is controlled by the imbibition of water into the initially overpressured area of high hydrocarbon saturation. Contributing processes may include (1) the volume contraction of pore-fluid hydrocarbons caused by decreases in temperature, (2) the establishment of topographically introduced hydrodynamic conditions, (3) the solution-diffusion of hydrocarbons (primarily methane) outward from the system, and (4) the capillary imbibition of water.

Significant accumulation of hydrocarbons in highly unconventional basin-bottom positions may occur in either the overpressured or underpressured stages of basin hydrocarbon generation-migration evolution.

When water is imbibed into the original site of hydrocarbon generation and overpressure, and the associated unstable localization of hydrocarbon saturation has been dissipated and destroyed during an associated stage of underpressure, pore pressure conditions will eventually return to near normal states.

MONGER, JAMES W. H., Geol. Survey of Canada, Vancouver, B.C.

Stratigraphic Evolution of North American Cordillera

Much of the North American Cordillera is a tectonic collage of allochthonous crustal fragments accreted to the western margin of the craton from middle Paleozoic time onward. This feature is obscured by the three, major, through-going, late Mesozoic–early Tertiary elements of the Cordillera, namely (1) the eastern fold and thrust belt, formed largely from the displaced Proterozoic to Jurassic sedimentary prism (or miogeocline) that once fringed the craton, (2) the western accretionary prisms or subduction complexes, and (3) extensive granitic rocks. These impose a superficial simplicity on this 8,000-km-long fold belt. Its intrinsic complexity is reflected by the segmented nature of the Cordillera.

The Alaskan–western Yukon, Canadian–northwestern United States, California-Coloradan, and Mexican segments each have distinctive geologic characteristics different from those of adjoining segments. In part, these differences are due to features formed late in Cordilleran history, such as pervasive, dextral strike-slip faults in Alaska and Canada, and rotations and extensions in the conterminous United States. Other, far more fundamental, differences emerge from stratigraphic analysis of rocks west of the fold and thrust belt.

The western rocks can be divided into more than 40 terranes, each with distinctive laterally persistent stratigraphy which is different from those of neighboring terranes, and each is commonly separated from neighboring terranes by major faults. Each terrane consists of one or more tectonostratigraphic assemblages, interpreted mainly as deposits of volcanic arcs and ocean basins but including some rocks of probable continental origin. In addition, many terranes have paleontologic and paleomagnetic records different from those of coeval, colatitudinal deposits on the craton, so that the western Cordillera is interpreted as a collage of small crustal fragments accreted in different ways and times to the western margin of North America.

The Alaska–western Yukon segment is largely composed of small terranes, many of southerly derivation, each of which apparently remained a discrete entity until accretion late in Mesozoic time. The Canadian–northwestern United States segment is dominated by two large composite terranes made up of smaller fragments, again mainly derived from the south, that coalesced prior to accretion. The inner terrane accreted to the miogeocline in the Jurassic and the outer to the inner in the Cretaceous. Boundaries of the two composite terranes with one another and the miogeocline coincide with the two metamorphic, granitic, and deformational welts that dominate the Canadian Cordillera. Because the times of development of these welts also are the times of accretion, the welts are interpreted as being due largely to collisions of crustal fragments, rather than subduction of oceanic crust with accompanying upper plate magmatism. The California-Coloradan segment reflects successive accretions of small discrete fragments from middle Paleozoic time onward, together with possible removal of terranes, some of which subsequently possibly lodged farther north in the Cordillera. Recent studies in Mexico suggest that it, too, is made up of allochthonous fragments.

From the foregoing, it should be obvious that only the most rigorous and detailed geologic studies will enable us to understand the evolution of such a long-lived mountain belt as the Cordillera. This is only to be expected from the rapidly changing, complex patterns of movement known from recent plate movements.

SCHOWALTER, TIM T., Mosbacher & Pruet Oil Producers, Denver, CO

Interpretation of Subsurface Hydrocarbon Shows

Hydrocarbons occur in the subsurface in four modes: (1) continuous-phase oil or gas; (2) isolated droplets of oil or gas; (3) dissolved hydrocarbons; and (4) hydrocarbons associated with kerogen-bearing rocks. Any of these modes of occurrence can result in a subsurface hydrocarbon "show." Each type of show has strongly different implications for exploration and must be differentiated as the first step in show interpretation. Only continuous-phase occurrences of oil and gas indicate that a trapped and potentially producible accumulation of hydrocarbons has been discovered. Free oil or gas recovery from the formation, or subsurface hydrocarbon saturations of greater than 50%, indicate a continuous-phase occurrence.

Continuous-phase shows can be interpreted quantitatively. The static hydrocarbon column downdip from a continuous-phase occurrence can be calculated from one well bore if the subsurface oil or gas saturation, capillary properties, hydrocarbon-water interfacial tension, oil density, and water density of the reservoir are known. Producing wells are by definition continuous-phase oil or gas, and estimates of oil-water or gas-water contacts from this type of analysis can be useful in orderly and profitable field development.

Continuous-phase oil or gas can extend either updip or downdip from a commercial reservoir. Continuous-phase shows can also be interpreted quantitatively to determine how large an oil or gas column is required downdip to explain the show. By this method it can be determined whether an exploratory well penetrated the updip waste zone or downdip transition zone of an oil or gas field. Field studies indicate that quantitative interpretation of a noncommercial show can provide reliable estimates of the downdip hydrocarbon column. This type of data can be used in a systematic manner to explore for subtle stratigraphic and combination traps.