tion was folded. The formation may have been compressed as it was translated through a concave part of the Glooscap fault.

The 1,800-m thick Parrsboro Formation was then deposited in the Parrsboro area during the late Namurian and early Westphalian. The Parrsboro Formation consists of fining-upward sandstone units, thin sandstone beds, and mudstones with roots. It is interpreted as a fluvial and lacustrine sequence. The great thickness of the formation may be due to the formation of an extension basin in a convex part of the fault system. A basal conglomerate of the Parrsboro Formation was derived from the east, presumably from the uplifted area at the concave part of the fault. Throughout the rest of the formation a gradual change in the paleocurrent direction from eastward to southwestward may be due to migration of the depocenter of the extension basin.

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Preliminary Molluscan Biostratigraphy of Gulf of Alaska Tertiary Province

Studies of large collections of mollusks from numerous measured stratigraphic sections in the Gulf of Alaska Tertiary province permit recognition of eleven molluscan zones within the Poul Creek and Yakataga Formations. Correlation of these zones throughout the province illustrates the time-transgressive nature of the boundary of the two formations—a transgression across four molluscan zones between Kayak Island to the west and the Lituya district to the east. The age variation of the base of the Yakataga Formation is from earliest early Miocene to late Miocene. The use of these molluscan zones elucidates the disconformable relation between the two formations and the local absence of entire zones.

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Porosity Evolution of Niagaran Thornton Reef, Northeastern Illinois

The Thornton Reef has long been a model of reef sedimentology, but as thick tar occurs in the upper 22 m of the porous and deeply eroded buildup, Thornton is also a well-exposed fossil oil field.

Thornton Reef is about 2 km in diameter and bowl-shaped in cross section. The reef consists of radially and steeply dipping flank beds of dolomitized crinoidal wackestone and minor coral boundstone. Reef porosity (5 to 10%) is dominantly secondary, consisting of fossil molds, vugs, intercrystal voids, and fractures. At time of deposition porosity was probably high (50 to 70%), and consisted largely of intraparticle and interparticle pores of all sizes. Abundant hardgrounds and palisade-cemented grainstones suggest major reduction of depositional porosity by syndepositional submarine and marine phreatic carbonate cementation. Secondary dolomite preferentially replaced abundant fine-grained carbonate sediment but only partly replaced fossils. Leaching removed the remaining calcitic parts of the fossils, slightly enhancing porosity. Extensive fracturing of the reef began at deposition and continued throughout the reef's geologic history, producing fractures that may extend hundreds of meters laterally. The fractures may be open or filled with syndepositional carbonate or younger terrigenous sediment. Thornton Reef's superb exposures and reservoir scale assure its importance to geologists studying reef facies and porosity.

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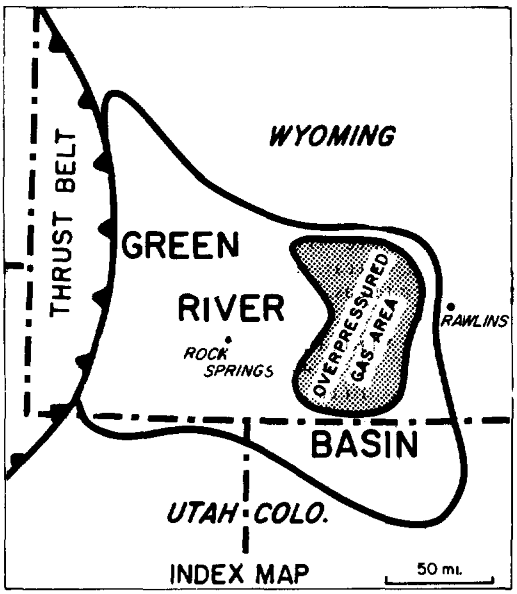
Eastern Green River Basin—A Developing Giant Gas Supply from Deep Overpressured Upper Cretaceous Sandstones

During the past 4 years, a previously unexplored 3,000 sq-mi (4,828 sq km) overpressured area in the eastern Green River basin has developed into a major gas province which should ultimately produce more than 20 Tcf of gas. Production is from lenticular sandstones in the Upper Cretaceous Lewis Shale and Mesaverde Group. Abnormally high fluid pressure gradients of .5 to .86 psi/ft are caused by the generation of natural gas from coals in the Mesaverde Group and perhaps from other source rocks. Gas generation from coals is believed to increase exponentially with increases in temperature and depth. Therefore, the largest volumes of gas and the highest pressures have been generated in the deepest parts (15,000 to 20,000 ft, 4,572 to 6,096 m) of the basin. The deepest areas are sparsely explored but may prove to be the most productive parts of the overpressured area for the following reasons. (1) Higher pressures result in more gas in the available pore space. (2) Sufficient gas should have been generated at these depths to fill all available pore space in Mesaverde and Lewis sandstones. More total pay should thus be expected than in shallower areas where water production is a common problem. (3) Higher pore-fluid pressures increase the ease with which natural fracturing of rock



units can occur and more fracturing should enhance reservoir performance. (4) Younger sandstones in the Upper Cretaceous Lance and Paleocene Fort Union Formations are also overpressured in the deepest basin areas because of gas generation from associated coals. These formations should contain significant gas accumulations.

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Examples of Abnormal Fluid Pressure Produced by Hydrocarbon Generation

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 solid kerogen to hydrocarbons.

Hydrocarbon generation overpressures exist in the following basins: Williston, Powder River, Anadarko, Delaware, Uinta, and San Joaquin. The phenomenon probably also exists elsewhere. These regions of overpressure represent vertically and laterally restricted "cells" or "pods" in which hydrocarbons are the overpressuring fluid and the only initially producible fluid species present. The pressure cells center around actively generating source-rock units.

Actively generating source rocks within the pressure cells may be characterized by abnormally high electrical resistivities and abnormally low sound velocities. Resistivity increases may be caused by the replacement of conductive pore water with non-conductive 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 under-compaction.

Hydrocarbon generation overpressures lead to the spontaneous hydraulic fracturing of the source rock and may create associated fracture-type reservoirs. They may also create fractures which propagate upward or downward from the source rocks and control vertical migration through large thicknesses of seemingly impermeable confining strata.

When a source rock ceases to generate, abnormal pressures may decay, resulting in normal or subnormal pressure conditions.

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Stable Isotope Evidence for Modern Freshwater Diagenesis of Cretaceous Edwards Limestone, San Antonio Area, Texas

The Cretaceous Edwards Limestone in south-central Texas was deposited in alternating shallow-marine, intertidal, and supratidal environments and underwent normal early diagenesis. First-stage calcites include calcitic shell material, unaltered marine micrite, submarine cement, and meteoric phreatic or shallow subsurface cements. The first-stage calcites yield isotopic values of $\delta^{13}C$ from -1.0 to $+3.5$ and $\delta^{18}O$ from -6.0 to $+3.0$.

Dolomite in the Edwards occurs in a variety of forms. These forms range from "dirty" rhombs (1 to 5 μm), petrographically very similar to but isotopically slightly lighter than modern tidal flat dolomites ($\delta^{18}O$ of 0.5 and $\delta^{13}C$ of 3.0 for the most hypersaline dolomites), to perfectly formed rhombs (30 to 40 μm) interpreted as freshwater dolomite ($\delta^{18}O$ of -5.7 and $\delta^{13}C$ of 1.7).

The Edwards was divided into two diagenetic zones by Miocene faulting along the Balcones fault zone. On the upthrown side of the fault, an oxidized freshwater aquifer developed. This water is now saturated with calcite, but undersaturated with dolomite and gypsum. Relatively stagnant brackish and reduced water on the downthrown side of the fault is saturated with calcite, dolomite, and gypsum. Differences in the chemistry of the interstitial fluids in these zones are related to different types of diagenesis.

Second-stage calcites, which can be separated regionally and petrographically from first-stage calcites, formed after faulting and result from reactions between first-stage calcites and dolomites and fresh water introduced after faulting. These reactions can be written generally as: Fresh Water + Dolomite + Gypsum $\rightarrow$ Brackish Water + Calcite. Second-stage calcites are as light as -7.5 ppm $\delta^{13}C$ and -10.0 ppm $\delta^{18}O$, and these values vary inversely while the ratios of first-stage calcite cements are heavier and vary together. The second-stage calcites are considerably lighter because they have grown in equilibrium with meteoric water containing some organically derived carbon, and sometimes at considerable depth.

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Organophosphorites in Carboniferous Rocks of Central United States

Although generally called "black shales," "sheety shales," or "paper shales," thinly bedded black rocks in upper Carboniferous successions in the Illinois basin and Mid-Continent are actually fissile coals. Thin section examination demonstrates that these rocks are as much as 90% carbon by volume. In addition to carbon, all these rocks contain large amounts of non-skeletal and much skeletal phosphate as fecal masses, gastric residues, teeth, bones, cartilage, brachiopod shells, and conodonts. We have elected the term "organophosphorite" for these rocks rather than "shale," because many of them contain less than 10% terrigenous clay.

Sources of the organic carbon, including kerogens, were varied and distributed among several plant and animal groups. Driftwood is common and testifies to input from terrestrial plants. Algal components probably dominated the plant fraction, but have left only vague traces. Animal phyla from Protozoa through Chordata are represented, but with heavy bias toward