Shale Member of the Purgatoire Formation. Deposits include shoreface, beach (foreshore) and dune, estuarine and tidal channel, marine marginal bay and swamp/marsh in a generally progradational sequence associated with marine regression in the Western Interior.

The shoreface sand, characterized by ripple lamination, bioturbation and the trace fossils *Teichichnus* and *Thalassinoides*, is fine-grained, 5-10 m (15-30 ft) thick and grades into the underlying Kiowa Shale. Beach and associated dune deposits are 2-5 m (6-16 ft) thick, medium to fine-grained, medium to thick-bedded, tabular-planar cross-bedded, and lenticular; cross-bed paleocurrent headings are northeasterly and northwesterly. Estuarine channel deposits are 3-5 m (10-16 ft) thick, trough to tabular-planar cross-bedded, and medium to coarse-grained with local conglomerate overlying the scoured base which commonly cuts into the Kiowa Shale or overlying shoreface sandstone; rip-up clasts and wood pieces are common but trace fossils are rare; southeasterly and southwesterly paleocurrents predominate.

Tidal channel deposits are thinner (up to 2 m or 6 ft) and finer grained (medium to fine-grained) than the estuarine channel deposits; they occur within fine-grained sandstone and mudrock sequences, are trough cross-bedded, and commonly contain trace fossils (e.g., *Skolithos*) and wood fragments. Marine marginal (tidal flat or bay?) deposits comprise fine-grained sandstone, siltstone and interbedded shale, that are 1-3 m (3-10 ft) thick with abundant burrows, small ripple marks, and parallel lamination. These grade into the fine to very fine-grained sandstones, siltstones, shales, and coals of the swamp/marsh deposits that are 1-5 m (3-16 ft) thick and contain ripple marks, burrows, other trace fossils, and parallel lamination.

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Role of Stepovers in Strike-Slip Tectonics

We show that the key to understanding the tectonic complexity of large strike-slip fault systems is fault stepovers. Secondary structures such as folds, thrust or reverse faults, cracks, dikes, normal faults, or smaller strike-slip faults, known to occur in strike-slip environments, localize in stepovers between en echelon faults. Two types of en echelon geometry are recognized: (1) strike-slip faults that are en echelon in map view with discontinuities along the strike of faults; (2) strike-slip faults that are en echelon in cross-sectional view with discontinuities along the dip direction of faults.

Depending on the sense of stepover, discontinuities along the strike of faults result in pull-apart basins and push-up ranges, several examples of which are presented to illustrate the associated structures and their complexities. Discontinuities along the dip direction of strike-slip faults are poorly known because of the lack of field observations. Data from seismicity, however, can be used to fill this gap. One example of such en echelon fault geometry is found along the Calaveras fault, California. It is inferred that stepovers along the dip direction of strike-slip faults may produce secondary strike-slip faulting on inclined planes connecting the en echelon segments of the major fault. As the amount of overlap increases, features similar to pull-apart basins or push-up ranges are expected to occur.

Causes for the formation of discontinuities and control of the sense of stepover are not well known. Some possible factors are: spatial variability of the coefficient of friction, spatially variable elastic moduli, high pore pressure, and interaction between neighboring faults in an array of faults. The first two would give rise to both senses of stepover, whereas the last two lead only to one sense of stepover, which induces pull-apart basins.

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Lithofacies Control of Lignite Distribution and Ground-Water Quality, Wilcox Group (Eocene), East-Central Texas

Deep lignite resources (200-2,000 ft; 61-610 m) were evaluated regionally using 1,470 geophysical well logs to interpret lithofacies, lignite occurrence, and resistivity (water quality). The regional distribution of lithofacies indicates that in the region, the Wilcox Group is a fluvial-deltaic system. The primary fluvial system entered the Wilcox coastal plain west of Waco, Texas, trended southeast, and supplied a 75-mi (120-km) wide fluvial-deltaic system comparable in size to the Mississippi system.

Lignites are most abundant in the Calvert Bluff Formation (upper Wilcox). Lower Calvert Bluff lignites are thickest and most extensive southwest of the Navasota River, whereas those of the upper Calvert Bluff are thickest northeast of the Brazos River. In the shallow subsurface, Calvert Bluff lignites are found in dip-elongate low-sand areas (flood plains) between channel-sand belts. Basinward, laterally continuous lignites coincide with high net sand areas comprised of distributary channel sands indicative of a delta-plain setting.

The Wilcox Group is a major aquifer. Maps of resistivity values show that Wilcox channel sands are conduits for ground-water flow. High values of formation resistivity (low total dissolved solids) exist in recharge areas at outcrop and around salt domes. Elongate trends of high resistivity values extend tens of miles basinward and coincide with axes of major sands. Resistivity values decrease basinward and the 20 ohm-m contour delineates the downdip limit of fresh water.

Lithofacies and lignite occurrence maps are guides to exploration for deep lignite. Resistivity maps can be used to explore for ground-water resources.

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High-Potential Geothermal Energy Resource Areas of Nigeria and Their Geologic and Geophysical Assessment

The widespread occurrence of geothermal manifestations in Nigeria is significant because the wide applicability and relative ease of exploitation of geothermal energy is of vital importance to an industrializing nation like Nigeria. There are two known geothermal resource areas (KGRAs) in Nigeria: the Ikogosi Warm Springs of Ondo State and the Wikki Warm Springs of Bauchi State. These surficial effusions result from the circulation of water to great depths through faults in the basement complex rocks of the area. Within sedimentary areas, high geothermal gradient trends are identified in the Lagos subbasin, the Okitipupa ridge, the Auchi-Agbede area of the Benin flank/hinge line, and the Abakaliki anticlinorium. The deeper Cretaceous and Tertiary sequences of the Niger delta are geopressured geothermal horizons. In the Benue foldbelt, extending from the Abakaliki anticlinorium to the Keana anticline and the Zambuk ridge, several magmatic intrusions emplaced during the Late Cretaceous line the axis of the Benue trough. Positive Bouguer gravity anomalies also parallel this trough and are interpreted to indicate shallow mantle. Parts of this belt and the Ikom, the Jos plateau, Bauchi plateau, and the Adamawa areas, experienced Cenozoic volcanism and magmatism.

Geothermal gradients indicate that steam would be encountered at a depth of about 6,000 ft (1,800 m) in the Lagos and Auchi-Agbede areas, and at about 4,250 ft (1,300 m) in the Abakaliki area. A combination of heat-flow measurements and analysis of existing aeromagnetic data would provide a basis for the determination of geothermal gradients in the undrilled resource areas and the determination of depths to Curie isogeotherm (about 570°C, 1,058°F) in the basement complex and the intrusive areas from thermal attenuation of the remanent magnetic field. The separate but preferably combined application of gravity analysis, and electrical, refraction-seismic, electromagnetic, and telluric methods would help in the accurate delineation and evaluation of Nigeria's known and suspected geothermal resource areas for future detailed investigations and possible exploitation.

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Printer-Posted Maps from a Well-Data File

A series of microcomputer programs have been written to aid the geologist in building a well-data file, selectively retrieving data from the file, and generating posted maps on a printer. The system uses an IBM PC with 64K of memory, one disk drive, and an Epson MX 100 printer. The programs are written in BASICA to run under DOS 1.1. The system has been used to conduct regional geologic studies in the Michigan basin and to make field studies.

The data files contain well-identification information such as well names, location, API number, completion date, elevation, and total