

during the past century is the burning of fossil fuel. The carbon isotopic composition of certain species of planktonic foraminifera accurately reflects the C-13 composition of CO<sub>2</sub> in the ocean surface water, and also records the -0.4 ppm change in surface water. This change was measured by comparing living planktonic foraminifera C-13 composition with the C-13 values measured in fossil planktonic foraminifera from core tops. During deglaciation periods in the Pleistocene, certain species of planktonic foraminifera and benthic foraminifera record synchronous global C-13 fluctuations of approximately +0.8 ppm which indicates a flux of  $1.2 \times 10^{18}$  g carbon from the ocean to the biosphere. These figures suggest that the biosphere doubled in mass in less than 10,000 years, presumably owing to rapid climate change. We can extrapolate these findings in modern and Pleistocene planktonic and benthic foraminifera to measure carbon fluxes in the Tertiary and Late Cretaceous. How well periods of rapid organic carbon production correspond to periods of significant carbon burial and maturation is not yet known.

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#### Geostatistical Approach in Coal Resource Estimation

The conventional reserve/resource estimation methods (triangular, polygonal, and isopach) are briefly described and then compared against a new geostatistical approach. The comparison is based on estimates using real-world data from southern Illinois. The geostatistical procedure employed is a kriging technique called the intrinsic random functions of order k, using spherical covariance models. While the intrinsic random function approach is usually considered to be a local estimation procedure, the introduction of sampling methodology allows its extension to global estimation problems without excessive cost for computation. The major advantages of the geostatistical approach are that it provides a built-in measure of the precision of its estimates, thus allowing the determination of confidence limits, and also gives additional insight into the spatial variability of coal seams. The estimates are improved as more geological information of the coal deposits becomes available.

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#### Subsidence and Thermal History of Southern Oklahoma Aulacogen—Implication for Petroleum Exploration

Evolution of the southern Oklahoma sedimentary basin has been constructed from the stratigraphic record in deep wells, using the back-stripping method, and by analysis of the rate of subsidence. For this analysis, rate of subsidence has been considered a significant recorder of the cumulative effect of the factors which control basin subsidence. Similarity of subsidence curves constructed in this study to other models indicates, in gen-

eral, the application of the concept of thermally-controlled isostatic subsidence for the evolution of the southern Oklahoma basin.

Two distinct mechanisms of subsidence are proposed for the evolution of the basin. First, elastic flexure of the lithosphere controlled the initial 20 m.y. of subsidence. Second, reactivation of aulacogen boundary faults may account for differential subsidence.

An anomaly in the rate of subsidence curve suggests a short phase of sediment compaction and fluid migration near the termination of the subsidence stage. This compaction might be a sensitive indication of change in the state of stress from extension to compression, possibly related to the regional tectonic setting.

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#### Sergipe-Alagoas Basin, Brazil—Source-Rock Characterization and Evaluation

Cores, drill-cuttings, and oil samples from the Sergipe-Alagoas basin were studied in detail to characterize and evaluate the source rocks of the area and correlate the oil with the probable source-rocks.

The content of organic matter was determined by conventional Leco analyses. The types of organic matter in each sample were determined qualitatively by visual microscopic examination. The thermal maturity was ascertained by light hydrocarbons (C<sub>1</sub> to C<sub>4</sub>) analyses, organic extract composition, character of the C<sub>15</sub>+ saturated hydrocarbons, thermal alteration index (TAI) and, in a few places, by measurements of vitrinite reflectance.

The results of the study indicate that source rocks are present in stratigraphic sections belonging to three depositional cycles: nonmarine, transitional (evaporitic), and marine. Source rocks from each cycle yield oils of distinct character. Three oil systems were distinguished: (1) Barra de Itiuba/Serraria, (2) Carmópolis, and (3) Calumbi.

The source rocks of the Sergipe-Alagoas basin are of good quality but the total volume of hydrocarbons that might be expelled is probably not very large, since the source beds are relatively thin and probably discontinuous.

This study also indicates that entrapped hydrocarbons of the Sergipe-Alagoas basin have migrated short distances.

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#### Geothermal Resources Evaluated by Well Logs

Well logging in the petroleum industry developed over five decades into a mature industry, whereas geothermal well logging is a relatively new enterprise.

The present discussion focuses on the types of geothermal reservoirs encountered, geologic and reservoir engineering objectives, and qualitative and quantitative interpretive formation evaluation techniques based on geophysical wireline logs.

Specific field case studies illustrate the state-of-the-art technology, including examples from the Geyser dry