The initial modeling began with an hypothesis based on well logs, COCORP data, and other geologic information. After the subsurface structures were defined, depth and velocity plots were produced. Normal incidence rays were then traced from each horizon to specified shot points. The ray-tracing plot gives a good indication of the quality of resolution one can expect from a particular subsurface geometry. The synthetic profile was produced by first applying a broad-band pulse, then applying a Ricker wavelet to each trace. A gain function was applied to enhance the section for interpretation. Forward seismic modeling in the Anadarko basin enhances interpretation by giving an idea of the seismic resolution one can expect and letting the interpreter test a geologic hypothesis against the seismic profiles.

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Exploration—The Past is the Key to the Future

Contrary to conventional wisdom, the history of crude oil prices has been one of volatile swings. Natural gas prices, somewhat more stable, have nevertheless undergone large percentage changes from year to year. Such abrupt changes have caused fluctuations in cash flow and have necessitated the cycles of expenditure evident in the past.

In good times the petroleum industry reinvests almost all of its revenue in finding, developing, and producing oil and gas fields. The reinvestment percentage logically shrinks in poorer times. For exploration alone, the reinvestment rate has averaged 25% since 1944.

Gas discoveries are dominant in new discoveries, and revenue from gas fields is rising as a percent of total wellhead revenue. However, more than half of all revenue is still from oil fields. Revenue is the dominant factor affecting activity. Thus, the ability to forecast future prices determines the ability of the industry to foresee its future.

The petroleum industry's myopic record shows a lack of prescience in the ability to divine future price levels. Any forecast of future activity is limited to the accuracy of the assumptions about revenue.

Given these major uncertainties, a series of forecasts based on several scenarios appears prudent.

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Geology of Petroleum in Campos Basin, Brazil

A schematic model of oil generation, migration, accumulation, and alteration is presented for the Campos basin, a sedimentary province covering an area of nearly 31,000 km^2 (12,000 mi^2) offshore southeastern Brazil, where an estimated 1 billion m^3 (6.3 billion bbl) of oil in place has been discovered since 1974.

Source rocks for this oil belong to the Lower Cretaceous Lagoa Feia Formation; oil generation probably started in the Miocene. At that time, a series of local windows opened in the regional evaporite seal at the top of the Lagoa Feia Formation and focused the upward escape of hydrocarbons, mainly along halokinetic fault surfaces. Reservoirs of Albian, Late Cretaceous, and Tertiary age were charged and their porosities enhanced by natural fracturing, solution, and/or grain rearrangement. Original oil (postulated range of 30°-35° API gravity) underwent differentiation by migration, reflected in relative enrichment of aromatics and of the light ^{12}C stable carbon isotope. Alteration of oil by water occurs if one of the two fluids in contact is allochthonous; bacterial alteration is important in low-temperature regimes. Oil entrapment is helped by hydrodynamic conditions, with the intake area of the Paraiba do Sul river delta supposedly playing an important part.

Lopatin-type plots gave the first clue for establishing this model, which takes into account a large number of facts about the basin, such as well and seismic information, clay diagenesis, water and petroleum geochemistry, pressure data, and their geologic field relationships.

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Sedimentary Petrology and Depositional Environment of Sandstones of Scow Bay, Indian and Marrowstone Islands, Northwestern Washington

The unnamed middle Eocene sandstones of Scow Bay that are well exposed on the beaches of Indian and Marrowstone Islands, northwestern Washington, document a previously unknown local basement high that shed sediment south onto a subsea fan from the San Juan Islands terranes. The sandstones are lithic arenites with a variety of lithic grains, predominantly volcanic and sedimentary (including chert). Rare quartz-plagioclase plutonic and low-grade metamorphic (mainly chlorite-rich) lithic grains are also present. Quartz and plagioclase comprise most of the nonlithic grains. Rare heavy minerals and potassium feldspar are also present. The San Juan Islands terranes were the source area. Paleocurrent directions obtained from flute casts support this interpretation.

The sandstones are thin to very thick-bedded with minor shale interbeds and at least two 20 to 30-m (65 to 100-ft) thick shale beds. The sandstone beds are commonly structureless, although dish structures, poorly developed parallel lamination, load casts, and shale rip-up clasts are abundant locally. Soft sediment deformation, including slumps, is locally evident. Amalgamation of thinner sandstone beds into very thick (3-5 m, 10-16 ft) beds is common but often difficult to recognize owing to their structureless nature. The exposure along the east coast of Indian Island reveals at least 11 thinning- and fining-upward sequences. The sandstones were deposited as channel-fill sequences on the midfan region of a subsea fan. The thick shale beds were deposited between active channels.

MELLO, MÁRCIO ROCHA, GUILHERME DE O. ESTRELLA, and PAULO CÉSAR GAGLIANONE, PETROBRÁS, Rio de Janeiro, Brazil

Hydrocarbon Source Potential in Brazilian Margin Basins

Twenty thousand samples from the Brazilian continental shelf basins were analyzed to characterize and evaluate the hydrocarbon source potential of the areas.

The geochemical evaluation of the rock and oil samples was performed by organic carbon determinations, Rock-Eval pyrolysis, vitrinite reflectance, thermal alteration index, liquid and gas chromatographies, gas chromatography–mass spectrometry, and carbon isotope analyses.

Three source rock systems have been identified: lower Neocomian shales deposited in a continental environment, upper Neocomian shales grading from continental to lagoonal environment, and Aptian shales related to evaporitic and lacustrine sequences.

Upper Cretaceous and Tertiary open marine slope sediments are not considered as source rocks. Locally, these sediments present high organic carbon content but show an extremely poor hydrocarbon yield. Anoxic depositional conditions, nevertheless, can be traced locally along some levels of the Santonian to Cenomanian shales and marls. These sediments are generally immature in the Brazilian margin basins and no oil was generated from this section.

Three oil families were distinguished through oil-to-oil and oil-to-source rock correlations: the lower Neocomian continental type, the upper Neocomian continental to lagoonal type, and the Aptian evaporitic to lacustrine related sequences.

The geochemical studies, together with geologic and geophysical data, provided the basis to display some models for the migration pathways and habitat of oils in the Brazilian margin basins.

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Mapping Dikes from Thematic Mapper Imagery: Raton Basin

Analysis of 1:48,000-scale thematic mapper (TM) imagery of a portion of the Raton basin, supplemented with 1:80,000-scale black and white stereo aerial photographs and geologic and topographic maps, shows that many more dikes are present in the basin than are shown on previously published maps. In comparison with the geologic map, this study allowed mapping of a greater number of dikes, and extension, or connection, on refinement of the trend and/or location of many previously mapped dikes. Only a small number of dikes (or portions of dikes) were mapped in the field by previous investigators, for which no evidence was shown on TM imagery, aerial photography, or topographic maps.

Comparison of the TM imagery with the aerial photography reveals that TM imagery may be a better tool for locating dikes. Clearly, smaller objects can be identified and greater detail can be mapped using aerial photography as compared with TM imagery. For example, the photogra-