source, will determine the success of America's industrial progress in the global community. Without a sound energy base, new industries cannot be started. Without the assurance of adequate energy supplies, existing industries cannot grow or even maintain production on a modest scale. We must therefore carefully examine our energy needs, our energy supplies, and our energy alternatives. We must continually reassess our economic and geologic models to formulate our future petroleum exploration programs to meet our goals. The challenges of America's future economic and industrial growth will be met only if we in the energy-related professions and industries diligently work toward a successful transition in energy, economics, and exploration.

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Normalizing Exploration Functions for Powder River, Denver, and Midland Basins

A method of normalizing exploration functions for petroleum basins leads to an effective basis for comparing their exploration histories. In this study, an exploration function of a basin is a plot of cumulative footage drilled versus cumulative oil reserves discovered. However, 2 different basins may have the same amount of absolute drilling, but one basin may be much smaller and therefore more extensively explored. It is more meaningful to compare exploration functions independent of basin size. One way to do this is to plot the cumulative footage drilled per basin volume versus cumulative oil reserves discovered—i.e., normalizing the exploration functions according to basin size.

Exploration functions and their corresponding normalized functions based on historical data have been drawn for the Powder River, Denver, and Midland basins and their subdivisions. The subdivisions are horizontal depth zones, vertical well density zones, and the blocks formed by the intersections of those zones. The volume used for determining a normalized function corresponds to the volume of sedimentary rock within the basin, zone, or block under consideration.

Results show that normalizing exploration functions makes a difference in the apparent extent to which a basin has been explored. Furthermore, the rate of finding oil and the forecasted total amounts of oil can be determined. Of the 3 basins considered, Midland basin is the best choice for further oil exploration.

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Fast Reservoir Calculations Using Seismic Data and Well Logs

A fast, new technique has been implemented to encourage effective, realistic appraisals of hydrocarbon prospects at an early stage in the exploration of an area. A FORTRAN program using a modest amount of memory uses wavelet-processed, inverted seismic data control and existing petrophysical information to predict the dollar value of in-place reserves at potential drilling locations.

The data base is composed of the following input: (1) an estimate of the volume of closure of the anomaly, determined from conventional seismic structure mapping; (2) spatial distribution of transit times at the level of interest, which contribute to calculation of effective porosity in a volumetric sense; and (3) well-logging parameters such as water saturation, true resistivity, water resistivity, shale fractions, and other coefficients that characterize the properties of the rock system. Also, an interpreter may superimpose a geologic model by smoothing and interpolating such data appropriately.

Recovery of reliable low-frequency velocity information from inversion is critical. Acoustic and electric data are crossplotted to determine, in a statistical sense, how plausible it is that the rock-fluid system being described is the anticipated target zone.

Fast reservoir calculations in the Western Canada and Williston basins have produced reasonable bids for Crown land sales.

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Fracturing and Brecciation Along the Max Meadows Thrust, Southwestern Virginia

Fracturing is an important mechanism of porosity development in deformed hydrocarbon provinces such as the Eastern Overthrust belt,

but the sizes and shapes of fractured zones place critical constraints on exploration strategies. Fracturing and brecciation associated with the Max Meadows thrust, along which the Cambrian Rome Formation have been emplaced atop the younger Cambrian Elbrook and Conococheague Formations of the Pulaski thrust sheet, are controlled by lithology, proximity to the fault, and mesoscopic folding. Within the Max Meadows sheet, Rome carbonates are highly fractured and, in fold cores near the fault, brecciated. Rome mudstones and sandstones are tightly folded, and near the fault have developed both an incipient axial planar cleavage and a set of closely spaced fractures striking perpendicular to fold axes. In comparison, the wholly carbonate sequence of the Pulaski sheet had earlier been folded into a large syncline characterized by bedding-parallel shear in shaly and thin-bedded layers, flexural slip folding, and localized fracturing of thick layers. Thus breccia and fracture porosity zones in the study area are highly localized, of irregular geometry, and essentially restricted to the upper thrust sheet. Zones of tectonic breccia and fracture porosity are not attractive exploration targets, then, unless they occur as uniform and widespread broken zones in sedimentologically and mechanically homogeneous beds.

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Determining Pore-Water Salinities from SP Response: A Thermodynamic Reevaluation

Quantitative knowledge of the salinity of deep formation waters is critical in assessing the degree of hydrocarbon saturation in sands, in predicting methane solubility, and in deducing pathways of fluid migration. Calculation of salinity from the spontaneous potential (SP) response of borehole logs using conventional algorithms can yield inaccurate values, particularly for geopressured waters. Thus, a theoretical reevaluation has been made of the relation between pore-water salinity in NaCl-dominated waters and SP response, taking into account pressure as a variable and recently-developed, improved, thermodynamic models for brines.

The following expression satisfactorily relates pore-water salinity, as molality of total dissolved NaCl, to the static spontaneous potential (SSP) over P-T-salinity conditions of sedimentary interest:

$$\log m \, \text{NaCl (pore water)} = (SSP \times F)/(2.303 \, RT \times b \times t) + \log m \, \text{NaCl}$$
$$\text{(mud filtrate)}$$

where m = molality, F = faraday constant, R = gas constant, and T = absolute temperature. The complex, non-ideal behavior of NaCl solutions can be described by a single, pressure-temperature dependent, concentration independent variable, b. The term t accounts for the differential mobility of Na^+ and Cl^- ions through sands and shales.

Use of the equation provides several important advantages over conventional techniques: (1) pore water salinity is given explicitly as a dependent variable, facilitating analysis of error; (2) the expression is simple and avoids use of electrical resistivities, which have no direct theoretical role in the relation between SP and salinity; (3) the improved thermodynamic base provides a more rigorous means of assessing the effects of grain size, mineralogy, and streaming potential on SP response.

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Western Gulf of Mexico Continental Slope Geology, Hazards, and Processes Atlas

An analysis of approximately 18,074 km (11,231 mi) of high-resolution geophysical records (3.5 kHz and 1,000-joule sparker) in the western Gulf of Mexico has delineated relationships between sedimentation patterns, diapiric activity, tensional tectonic features, and sediment instability. The continental slope of the Gulf of Mexico is the most promising petroleum frontier on the conterminous United States continental margin. However, adequate regional geologic information with which to conduct lease sales and manage lease operations does not exist. Mapping was done at 1:250,000 and selected features were synthesized on a regional scale of 1:1,000,000 as part of the U.S. Geological Survey Continental Margin Mapping Project. Because the reconnaissance spacing of the tracklines makes topical investigations difficult, in a few areas the U.S. Geological Survey has gathered more closely spaced lines to examine particular features. Analysis of one of these areas near the large slide reported by Lehner in 1969 indicates a possible relationship between rapid sediment loading and diapiric rise.