of rubble, and which otherwise break down the formation to increase the effective wellbore radius, frequently will be indicated.

Another major obstacle is the necessity of minimizing skin damage resulting from the drilling, completion, and stimulation processes. A third obstacle has to do with economics which is dependent on the cost-effectiveness of the exploration and exploitation procedures that are followed in particular cases. Although it would be convenient to have evidence that a high selling price (e.g., due to market demand) would circumvent the major constraints and avoid the attending problems, the evidence points on the contrary to the need for achieving a technologic breakthrough before the full impact of economics will be felt.

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In-Situ Testing of Well-Shooting Concepts

The creation of multiple fractures from a wellbore has been demonstrated for a high-energy gas fracturing concept. In this concept, the gas pressure pulse due to the deflagration of a propellant is designed to give (1) pressure-loading rates sufficient to initiate multiple fractures, (2) peak pressures below the flow stress of the formation to avoid rock compaction, and (3) a duration of burn sufficient to allow gas penetration and extension of the fractures. Three experiments were conducted adjacent to a mine drift and the results were observed directly by mineback through the experimental areas. Tests with three different propellants to give different burning rates and, hence, different pressure loadings and pulses resulted in phenomenologically different behavior. Mineback of the intermediate test (pressure loading rate of 20 psi (138 kPa) /msec, peak pressures of 13,800 psi (95,151 kPa), and burn time of 9.0 msec) indicated 12 separate fractures from 0.5 to 8.0 ft (0.15 to 2.4 m) long for the 20-lb (9 kg) propellant charge. Tests with a faster and slower burning propellant yielded only single fractures less than 5 ft (1.5 m) long and features normally associated with explosive and hydraulic fracturing, respectively.

Multiple fracturing alleviates many of the postulated limitations of explosive and hydraulic fracturing techniques for the effective stimulation of Devonian shales. An expected test series is being conducted as part of the Eastern Gas Shales Program to examine several techniques for multiple fracturing based on this controlled-pressure-loading concept. Test results will be evaluated with respect to the application of such techniques for formation evaluation and stimulation of that resource.

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Implications of Gaseous Hydrocarbon Geochemistry of Shallow Core Sediments from Florida-Hatteras Slope

Light-hydrocarbon ($C_1$ to $C_4$) concentrations and compositions were determined in sediments from 23 piston cores on the Florida-Hatteras slope and innermost Blake Plateau. On the basis of seismic profiles, cores were taken from slump masses, an accretionary wedge, channel cuts, fault zones, and over a diapir.

Maximum total $C_1$ to $C_4$ hydrocarbon concentrations in the sediments analyzed were less than 38 ppm. Light-hydrocarbon concentrations of less than 10 ppm were found in most samples, and methane, ethane, and ethylene were generally the major components. At two sample sites, however, concentrations were greater than 10 ppm. Samples from a channel cut contained hydrocarbons through butane with total $C_1$ to $C_4$ concentrations of nearly 25 ppm. Samples from the diapir site contained mainly methane although ethane and propane were present; the total $C_1$ to $C_4$ concentrations were under 38 ppm.

Geochemical surveys that measure light hydrocarbons in surficial sediments have been used as a prospecting tool in offshore petroleum and natural gas exploration. In the shelf and slope areas being considered, background distributions must be established to distinguish anomalous hydrocarbon concentrations that result from natural seeps. Extremely low concentrations of light hydrocarbons and the presence of biologically formed ethylene in the sediments from this study area imply that background levels are possibly due to microbial production of gas from near-surface organic matter rather than by diffusion from underlying petrolific sources. The ubiquitous occurrence of low concentrations, in the ppb range, of the hydrocarbons through butane in slope sediments may arise from microbial production either directly as metabolic by-products or indirectly as degradation products. The possibility that microbes may be related to the occurrence of low concentrations of light hydrocarbons through butane in surface sediments must therefore be considered when evaluating petroleum potential from near-surface data.

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Interpretation and Statistical Analysis of Kentucky and West Virginia Open-Flow Data, Incorporating Geochemical Information

Cluster and regression analyses have been used to screen for predictive models and to test whether open-flow data can provide insight to aid in the assessment of near-optimum design for gas production from Devonian shale. The analysis shows that data from a Kentucky–West Virginia frac study should be partitioned. The vertical stress variable ($X_6$) was found to be the key variable; it is directly related to depth. Maximum flow occurs when $3{,}400 < X_6 < 4{,}100$ and minimum flow occurs when either $X_6 < 3{,}000$ or $X_6 > 4{,}100$. This zonation characteristic of the high flow values implies that the location of the prolific reservoir is the key to successful well production. This reservoir effect is consistent with our recent geochemical data and an extension of the geochemical cross section can be made. The optimization aspect was addressed using nonlinear (quadratic) models. Usable, optimal parameters valid on a regional basis can be generated. The study serves to illustrate that priority should be given to the effort to