High-density fracture areas, located within high-potential exploration areas (as defined by the other four exploration parameters) should have high potential for Devonian shale or "Clinton" sandstone natural gas production.

TILLMAN, J. EDWARD, Gruy Companies, Arlington, VA

Targeting Zones of Fracture-Enhanced Production

Many wells in the Appalachians produce from reservoir rocks which have fracture-enhanced matrix porosity. In these rocks, natural fractures are essential for significant production because matrix porosities are highly variable and commonly low. However, only certain penetrative, interconnected, and open fractures are capable of significantly increasing production. It therefore becomes necessary to differentiate these production-related fractures from other fractures in order to predict their occurrence.

The most definitive method for differentiating fractures is by combining petrofabric and geochemical techniques. Basic to this approach are geochemical and textural data on paragenesis and homogenization of methane-bearing inclusions in matrix and vein minerals. This approach has been routinely used in the Appalachians to differentiate and characterize fracture systems and identify their involvement in the migration, entrapment, and production of hydrocarbons. The results provide the explorationist with an improved capability to predict locations of highly fractured zones within potential reservoir rocks.

This approach has helped to define the main fracture domains in New York: the foreland fold; foreland fracture, intraformational fracture, basement fault, strike-slip fault; and normal fault domains. Analysis of the fracture fabrics in each domain has revealed those fractures that are open under the contemporary stress field and that enhance bulk-rock permeability.

For efficient targeting of zones of fracture-enhanced permeability, exploration programs need to concentrate on the production-related fractures. Once these fractures have been identified, analysis of structural contours, isopachs, lineaments, seismic profiles, production trends, logs, and surface petrofabric data can prove to be more rewarding.

TING, FRANCIS T.C., West Virginia Univ., Morgantown, WV

Use of Optical Axis of Vitrinite as an Indicator of Paleo- and In-Situ Stresses in Coal and Coal-Bearing Strata

Increasing level of coalification causes realignment of the optical axis of vitrinite in a direction coinciding with the direction of the maximum compressive stress, either vertical load stress or the resultant of vertical load stress and lateral tectonic stress. Measurable tilting of the optical axis occurs in horizontal coal bed in Beckley, West Virginia, region coinciding with the reported occurrence of strong in-situ lateral stress in the area. The average angle of tilting is 14° in the deeper buried Beckley Seam, and 7° in the shallow Sewell Seam. The former has severe ground-control problems. The basic assumption invoked is that coal, being organic in nature, is readily deformed under relatively lower temperature and pressure conditions than the inorganic host rocks.

VALANE, RONALD F., and JOHN J. JANSKY, U.S. Mine Safety and Health Admin., Pittsburgh, PA

Application of Remote Sensing to Underground Coal Mining: Observations and Experience

Remote sensing in the form of linear analysis has been used for a number of years for the prediction of roof stability in underground coal mines. The advantages and limitations of this predictive method determined from the 6-year working experience of the Roof Control Division of the Mine Safety and Health Administration will be presented. The effectiveness of this method can be quite variable on both a regional and local scale. Factors contributing to this variation, such as mining practices and mine geology, will be discussed.

While the precise nature of the influence of a linear is not always known, a number of observations and experiences provide for a better understanding of the effects of these features. In addition to roof falls and poor roof conditions, more subtle characteristics of some linears have been observed: (1) time-dependent behavior with roof stability deteriorating with time; (2) roof stability which was good during development becoming poor upon retreat mining; and (3) water closely associated with some linears causing mining and roof control problems.

The predictive technique of linear analysis will not delineate all areas where poor roof conditions will be encountered, nor will roof instability be experienced along all linears plotted using this method. To be effective this technique must be integrated with existing engineering and geologic knowledge and practices.

WIRAM, VANCE P., AMAX, Coal Co., Indianapolis, IN

"Cat-Scan" Geological Assessment Required in Planning Today's Coal Mine

Sophistication of tools and depth of investigations required of a geologist in pre-planning analyses of a coal reserve are analogous to the pre-operative "cat-scan" evaluation a patient might experience prior to surgery. Before a cubic yard of earth is moved, all geologic materials to be encountered in the mining process must be properly identified and characterized both physically and chemically. Today's coal geologists use the latest in computer, petrographic, geophysical, and geochemical techniques to accomplish such a "pre-op" assessment. Geologists, hydrologists, soil scientists, and planning engineers must thoroughly understand the behavioral traits of the various geologic materials in order to prepare viable economic and environmental mining and reclamation plans. Every facet of the mining process is geologic dependent. Reconstruction of prime farmlands is dependent on the presence or absence of suitable rooting materials. Success or failure of a permanent stream relocation is controlled by our ability to understand and properly engineer the behavioral characteristics of geologic materials encountered.

Geologic pre-planning must be twofold in its approach. The geologist must always be looking for attributes and limiting factors of various geologic materials. Limiting factors are defined as those properties of the geology that have the potential for creating undesirable results in mining and reclamation. Undesirable results may range from decreased coal production to environmental degradation and consequent regulatory violations and bond forfeiture. Pre-planning efforts should also accentuate the positive attributes or favorable properties of the geology. A constant effort should be made to define those geologic materials that have potential for achieving maximum revegetation productivity and hydrologic benefits following reclamation.

WOLOSZ, THOMAS H., State Univ. New York at Stony Brook, NY

A Model for Faunal Succession and Reef Growth in Edgecliff Bioherms (Middle Devonian Onondaga Formation)

Two small bioherms from the Edgecliff Member of the Onondaga Formation in Greene County, eastern New York, have been studied in order to formulate a model for Edgecliff reef development. Roberts Hill reef is approximately 720 ft (220 m) in length and 50 ft

(15 m) thick, while Albrights reef (an erosional remnant) is 480 ft (146 m) in length and 13 ft (4 m) thick. Both exhibit an overall faunal succession showing both lateral and vertical trends which closely agree with the description of subsurface pinnacle reefs from south-central New York by Kissling (1979). Similar to these larger structures, the absence of stromatoporoids, and the subordinate role of massive favositids result in the lack of a true framestone core. Mound development was due almost entirely to the abundant growth of colonial rugosans which created a bafflestone core.

The core of the mound was constructed by a succession of three genera of colonial rugosans, all of which exhibit the same spreading phaceloid morphology, but with corallite branches being small and delicate in *Acinophyllum*, thick and robust in *Cyathocylindrium*, and intermediate in size in *Cylindrophyllum*. Initial core growth began on the carbonate mud sea-floor of the basal Edgecliff with the formation of thickets of *Acinophyllum* which developed into low bafflestone mounds. Core growth was continued by *Cylindrophyllum*, then capped by *Cyathocylindrium*. Surrounding this rugosan core, low-angle (8 to 10°) crinoidal packestone flanks developed which were colonized by large favositid colonies which show a dominance change from *Emmonsia* in the fore-reef to *Favosites* in the back-reef. However, these favositids acted only as minor sediment stabilizers.

The final stage of reef growth at Roberts Hill consisted of a recolonization of the fore-reef crinoidal packestones by the original core building fauna, with *Cyathocylindrium* acting as the initial recolonizer, followed by a mixed assemblage of *Cylindrophyllum* and *Eridophyllum* (another phaceloid rugosan). A repeated cycle of crinoidal flank formation, followed by rugosan colonization of these flanks, could extend both the lateral and vertical growth of the mound and result in large structures similar in size to those found in the subsurface in south-central New York.