HERKOMMER, MARK A., Sohio Petroleum Co., Dallas, TX

Contour Mapping Using A Microcomputer—Techniques for Improvement

There are 3 basic steps to contouring by microcomputer: control-point data analysis, generating a regular grid of estimated values, and contouring. Because each of these steps requires a significant amount of time and computer resource, techniques have been developed to improve grid parameter selection, speed gridding, and edit computer-generated contour maps. Grid cell size is a critical parameter used during the gridding stage of computer mapping and must be selected with consideration given to control-point distribution. A histogram showing control points per grid cell is a simple graphical presentation that illustrates before gridding is actually performed the effectiveness of the selected grid increment in producing the desirable grid characteristics of having one control point per grid cell. Gridding is accomplished in 2 steps at every node: gathering the control points for estimating, and actual calculation. Using collection and estimating techniques such as nearest-neighbor searches and inverse-distance moving weighted averaging, several thousand nodes can be calculated in a few minutes. Often, the generated grid (contour map) is satisfactory with exceptions in 1 or 2 areas. Using an interactive computer technique known as contour editing, geologic knowledge and experience can be infused into the map. When editing contour, the computer mapper indicates the way the contours should behave. The entered values are then used to calculate back to the grid nodes (without regridding the whole map area) so that when the grid is recontoured, the contours mimic the contour revisions.

HERRING, DONNA M., Univ. Cincinnati, Cincinnati, OH

Facies and Paleogeography of Middle Silurian Bisher and Lilley Formations, Adams County, Ohio

Six facies are recognized in the conformable Bisher and Lilley Formations of south-central Ohio. Areal distribution of microfacies indicates biohermal accumulation of the Lilley Formation, suggests new paleogeographic interpretation of the formations, and may explain morphologic differences among some Silurian reefs.

The Bisher Formation is subdivided by bedding and silicification. Isopachous mapping indicates that the lower Bisher was deposited as a carbonate sand blanket which was covered by north-northeast-trending upper Bisher silty carbonate sediment ridges. Intervening troughs received finer grained sediments and were populated by a moderately diverse fauna.

Highly diverse faunas of the Lilley Formation occur in bioclastic, biohermal, and biostromal facies which are subdivided by bedding, grain composition, and apparent transport of grains. Isopachous and lithofacies maps display a distinct relationship between Lilley and Bisher facies distributions. Bioclastic Lilley facies fill Bisher troughs, biohermal facies overlie Bisher ridges, and biostromal facies blanket the filled troughs and populated ridges.

The Bisher and Lilley Formations represent part of a Silurian regressive sequence on the northeast margin of the Cincinnati arch. As easterly derived clastic input decreased, Lilley fauna populated Bisher ridges. Rate of drop in sea level nearly equaled rate of subsidence in the area. Circulation was curtailed by basin infilling and shallowing seas in late Lilley time. These new conditions favored the relatively restricted fauna and lithologies of the conformably superjacent Peebles formation, a massive dolomite of Middle Silurian age.

HOLMES, CHARLES W., U.S. Geol. Survey, Corpus Christi, TX

Diagenetic Effects of Salt Intrusions—An Alternate Model of Caprock Development

Mineralogical, chemical, and isotopic changes were found as depth increased in texturally homogenous sediment recovered from six 300-m (985-ft) boreholes on the outer shelf and slope of the northwestern Gulf of Mexico. In 2 of the 3 boreholes on the shelf and in all 3 boreholes on the slope, sediments of late Pleistocene age were found to be directly in contact with salt at the top of piercement structures. The other borehole was drilled on the flank of a salt intrusion also penetrating late Pleistocene sediment. In sediments over the top of the salt, the abundance of expandable clays (smectite) compared with nonexpandable clays (illite) decreases with depth. Within the carbonate fraction, $\delta^{13}C$ values range from -2% near the salt-sediment interface to 1% at the surface. This deviation is apparently a response to reprecipitation adjacent to the salt-sediment interface, with lighter isotopes derived from oxidation of the isotopically light organic matter. No mineralogical, chemical, or isotopic trends were found in sediments on the flank of the salt intrusion.

Clay transformation caused by heat of the salt stock releases a significant amount of intercellular water ($\approx 200\ L/m^3$ or $1.5\ gal/ft^3$), which dissolves the leading edge of the salt intrusion leaving a residual concentration of granular anhydrite. High sulfate concentration in the presence of organic material sets chemical conditions by which sulfate is reduced to sulfide and bicarbonate is formed. The subsequent buildup of bicarbonate leads to precipitation of calcite and also formation of more water to continue dissolution of salt. Isotopic data of the carbonate fraction in sediment above the salt mass supports this model.

The most commonly accepted model of cap rock formation requires the intrusion of a salt stock into a flowing aquifer, a unit which supplies water needed to dissolve salt concentrate, the anhydrite, and provide the subsequent chemical environment for gypsum and calcite formation. In the proposed model, water is the result of diagenesis caused by sediment-salt interaction. Cap rock formation then may occur well below base level and well out on the continental slope.

HOLMES, MICHAEL, Consultant, Denver, CO

A New Method of Estimating Risk-Adjusted Reserve and Economic Potential of Exploratory Prospects

Most explorationists follow one of two approaches when analyzing risk. (a) Application of single probability estimates combined with unique reserve potentials. Often, development potential is incorporated incorrectly on a no-risk basis. (b) Detailed analysis using, for example, Monte Carlo approaches, requiring an abundance of data and computer processing.

The method presented here combines advantages of both approaches, and permits rapid calculations using data routinely available.

Before a prospect is drilled, precise reserve volumes are unknown. However, the likely range of reserves should be predictable with some certainty. The explorationist should also be able to estimate associated ranges of probabilities by careful matching with previous history in the area (or analogous area) combined with specific geologic conditions unique to the prospect.

Reserve and probability ranges are estimated for the initial exploratory well, and presuming success, for subsequent development wells. Examples are: 2% probability of 200,000 bbl of oil, maximum; 25% probability of 10,000 bbl of oil, exploratory; 70% probability of 10,000 bbl of oil, development (latter 2 are economic limits).

Data are plotted on cumulative probability logarithmic plots because reserve estimates, like field size distributions, should be logarithmically distributed. Expected volume reserves (initial well and development wells) are incorporated with costs and prices, using Bayesian principals, to predict economic outcome before any drilling commences.

Analytic procedures are described, together with predictions of several exploratory programs compared with actual outcome. If the prospect group is sufficiently large, pre-drilling predictions are generally within 30% of actual results.

HOOK, JAMES E., and STJEPKO GOLUBIC*, Boston Univ., Boston, MA

Morphological and Morphometric Characterization of Microborings Caused by Heterotrophic Endoliths

Microbial endoliths leave morphologically characteristic and preservable boring traces within carbonate substrates. When cast in resin and studied by scanning electron microscopy, these morphologies can be correlated with distribution, environmental conditions, or geological age of the substrate for use as paleoenvironmental indicators. This paper assesses morphological characteristics of a cluster of ichnotaxa comparable to the description of the genus *Dodgella* (cladochytrid, lower fungi). These forms have a worldwide distribution in Holocene marine sediments and are commonly preserved in fossil shells. The microborings studied have the following morphological elements in common: sac-like enlargements (sporangia) with narrow necks (for spore release) opening to the substrate surface, and fine filaments (hyphae) interconnecting the sporangia.

The following characteristics of these three elements are compared: sporangia—shape, size, direction of the main axis, and degree of complexity; necks—length, cross section, and profile; hyphae—average width, constancy of diameter, branching, and mode of sporangial connection. The separation of three ichnotaxa within this cluster of forms is based on reconstruction of probable life cycles, morphometric analysis on the population level, and identification of the influence of different substrates on the morphology of the borings.

HOPKINS, JOHN C., Univ. Calgary, Calgary, Alberta, Canada

Channel-Fill Deposits Formed by Aggradation in Deeply Scoured, Superimposed Distributaries of Lower Kootenai Formation

Three well-exposed channels of the lower Kootenai formation have several unusual features in common. The channels are contained within crevasse and bay-fill sequences, but the contacts between channel-fill deposits and laterally adjacent strata are erosional. The channels have a broad U-shape, range up to 300 m (985 ft) wide and 35 m (115 ft) deep, and exhibit a distinctive style of fill. Channel filling occurred in increments by accretion from the bottom up and sides in, to form a concave layering which is more or less symmetrical about the axis of each channel. Lithology of the fill of each channel is quite different, however, and ranges from mudstone, to interbedded sandstone and mudstone, to sandstone.

The channels are interpreted as superimposed distributaries formed by avulsion when the locus of sedimentation moved from one lobe to another. The lithology of the channel-fill deposits appears to be a function of the abandonment mechanism. A mud-filled channel forms where abandonment is rapid, as is the case with upstream diversion of a trunk river system. Sand and mixed sand-mudfills predominate where a distributary is progressively abandoned, for example where the discharge is diverted into an alternate favored distributary.

Superimposed channels are difficult to map in the subsurface by geologic means alone. They cut across the trend of adjacent facies so their presence cannot be predicted from analysis of the containing strata.

HOSKIN, CHARLES M., and JOHN K. REED, Harbor Branch Foundation, Fort Pierce, FL

Carbonate Sediment Produced by Rock-Boring Urchin, *Echinometra lucunter*, and Infauna, Black Rock, Little Bahama Bank

Bioerosion studies on Black Rock Island, Little Bahama Bank, were conducted during 4 cruises in 1982-83 on the 405-m (1,300-ft) long island of carbonate eolianite. The urchin population (mean 37 adults m^{-2}, 92 × 10^3 total) bores in a 6-m (20-ft) wide zone at depths of 0.5-3 m (2-10 ft). Scuba divers using rock chisels collected rocks, some with urchins in their boreholes and similar size rocks without urchins. The samples were placed separately in 20L, 62.5 μm screen-walled buckets for 2 days (18 useable measurements). Urchins produced spherical to elliptical pellets 1–2 mm in diameter. Disaggregated pellets contained no particles greater than 1.00 mm, 46% unimodal sand (mode = 177 μm), and 54% mud. Urchins produced a mean of 242 ± 146 mg sediment $urchin^{-1}$ day^{-1} (dry weight), equivalent to a mean of 8.9 g m^{-2} day^{-1} or 9 tons $year^{-1}$ for the entire population. Urchin boreholes were 17–126 cm^3 (mean = 72 cm^3). Calculating from boring-rate measurements, the boreholes were excavated in 0.7–10.3 years (mean = 2.9 years).

Rocks without urchins (controls) produced a mean of 0.50 ± 0.07 mg organic-free sediment cm^{-2} day^{-1} (dry weight). These particles were produced by bioerosion of an infauna (4.5–13.8 g dry weight) of eunicid and sipunculid worms, sponges, *Lithotrya* barnacles, pelecypods, and microborers. Inorganic sediment weight was correlated (r = 0.97) with surface area of the control rocks. Controls produced 5.0 g m^{-2} day^{-1} (36% of total), equivalent to 6.5 tons $year^{-1}$.

HOUGHTON, JOHN C., and LAWRENCE J. DREW, U.S. Geol. Survey, Reston, VA

Estimation of Oil and Gas Resources in Frontier Basins from Field-Size Distributions in Analogous Explored Basins

Oil and gas resource estimates for frontier outer continental shelf basins were expressed as field-size distributions. A list of AAPG basins was prepared to include field-level information on "original reserves" (reserves plus cumulative production) for oil and gas based on data from files maintained by the U.S. Energy Information Administration and the University of Oklahoma Petroleum Data System. Various distributions, including the 2-parameter lognormal distribution, were fit to each of the basins. In addition, basin-wide geologic characteristics were assigned to each basin. The research analyzed the statistical linkage between the fitted distributions and the geologic characteristics so that inferences could be made about the appropriate parameters for the field-size distributions in the basins to be evaluated.

HOUSEKNECHT, DAVID W., Univ. Missouri, Columbia, MO

Intergranular Pressure Solution and Porosity Evolution in Quartzose Sandstones

Compared to cementation by quartz, carbonates, and clay minerals, intergranular pressure solution has long been viewed as a minor control of porosity evolution in quartzose sandstones. However, quantitative cathodoluminescence petrography and scanning electron microscopy of Paleozoic and Mesozoic sandstones from various geologic settings suggest that intergranular pressure solution is the diagenetic process that most fundamentally influences porosity and permeability evolution in a majority of cases.

Intergranular pressure solution dictates tightness of grain packing, size and geometry of primary pores, and diameter and morphology of contacts between framework grains; it also commonly predates pervasive cementation. Consequently, intergranular pressure solution is the fundamental control of minus-cement porosity. Although there is a close relationship between intergranular pressure solution and cementation in some sandstones, they are independent in others. For this reason, the percentage of minus-cement porosity actually occluded by cement is not systematic and is therefore difficult to predict.

Numerous geologic variables have been documented that influence the amount of intergranular pressure solution that occurs in quartzose sandstones. On a local scale, relatively fine-grained sandstones and sandstones containing between 3 and 9% early authigenic clay have experienced more intergranular pressure solution than other sandstones. Regionally, among sandstones of equal age, grain size, and clay percentage, those that have been exposed to greater rates of burial, greater total depth of burial, and higher temperatures have experienced more intergranular pressure solution.

These results suggest that an enhanced understanding of intergranular pressure solution may lead to a capability of predicting quartzose sandstone reservoir quality.

HOVORKA, SUSAN D., Bur. Econ. Geology, Austin, TX

Textures Formed During Shallow Water Halite Deposition—An Example from Permian of Palo Duro Basin, Texas

The Palo Duro basin, part of the broad northern shelf of the Midland basin during the Late Permian, accumulated cyclic, regressive, carbonate-anhydrite-halite sequences. Detailed interpretation of more than 2,000 m (6,500 ft) of halite core from 9 wells drilled by the United States Department of Energy in the northern Palo Duro basin permitted recognition of textures formed during halite deposition.

Textures formed on the bottom of a halite-saturated water body include color banding due to variation in composition and amount of impurities in halite beds, and vertically elongated anhedral halite mosaic, formed due to competition for space on the pool floor. Abundant fluid inclusions trapped along halite growth faces reflect rapid precipitation of halite in shallow water. Darker halite with sparse inclusions may have formed less rapidly in slightly deeper water.

Anhydrite partings, truncating the bottom-deposited fabrics, represent