

Inter-sand-bar deposits consist of carbonaceous dolosiltite which does not contain skeletal grains. A sample transect from sand-bar crests to inter-bar basins shows a continuous, progressive gradation from sparry calcarenite to dolosiltite.

During deposition of upper Salem sediments, a fine-grained calcisphere calcarenite overlapped all three facies described above. This facies was deposited in restricted, shoaling conditions, as indicated by the presence of dolomite, quartz silt, and clay minerals.

The final phase of Salem deposition is represented by a thin but persistent, laminated, argillaceous dolosiltite. Scour-and-fill structures, dolomite rhombs, and a lack of fossil grains indicate that this was an intertidal mud flat deposit comparable with New York Devonian "waterlimes."

DOWDS, JOHN P., Consultant, Oklahoma City, Okla.

EXPLORATION DECISION-MAKING: TEN-YEAR FORECAST AND CASE HISTORY ON ANADARKO SHELF, 1956-1966

An 8,000-square-mile area of the Anadarko basin shelf in Oklahoma and Kansas was studied in 1956 to provide a forecast that hydrocarbons would be found in 50-80 per cent of a series of drilling ventures. Since 1956, more than 1,000 square miles have been proved productive and have been developed with a success ratio in excess of the predicted 50-80 per cent.

Conventional geological and reservoir engineering methods were used, augmented by probability/statistical theory which quantified and codified an exploration strategy to guide in the acquisition of leases. The deterministic *versus* the probabilistic approach to finding productive hydrocarbons is the problem. Because geology/land/engineering/economics are inter-related and inexact sciences in the oil business, more reliance must be placed on probability and statistics. There is no sharp demarcation between the beginning of one discipline and the beginning of another. The ideas on probability theory that commonly fall into disuse or misuse can be powerful mathematical tools in the search for hydrocarbons.

Geological maps, sections, and intervals are based on the original work. Rock and hydrocarbon distributions are then examined as a practical problem in statistical geometry by information theory, Bayesian methods, and the Laplace law of succession, much as a meteorologist can study cloud and weather patterns.

Regarding engineering, the pressure decline *versus* cumulative production of the predominantly gas reservoirs can be correlated statistically with the entropy of the shelf by random well sampling, or from wells selected by rigid, fixed patterns.

The economics and conversion to dollars can be figured through time by the amount of gas produced and the price paid by the pipeline companies. Leasehold and drilling costs are further related to the original forecast.

The mathematics serve well to predict the present status of this gigantic gas province from a small amount of data available in 1956. The continuing and expansive development of the reserves is testimony to the integrity of the approach through operations research methods.

DYK, ROBERT, Consultant, London, Eng.

EXPLORING NORTH SEA

Exploration for oil and gas in the North Sea has been carried on at a high level since the first licenses were granted in 1964. Several commercial gas fields have been discovered in British waters.

The North Sea basin has been a depositional site for potentially productive sediments at different times since the early Carboniferous. Interpretation of seismic data is complicated by variable thicknesses of Permian salt overlying the older productive strata.

DYMOND, J., Lamont Geological Observatory, Columbia University, New York, N.Y., L. LIDZ, and E. BONATTI, Institute of Marine Science, University of Miami, Miami, Fla.

ABSOLUTE AGE, STRATIGRAPHIC CORRELATION, AND MINERALOGY OF ASH LAYERS IN TERTIARY SEDIMENTS FROM ATLANTIC OFF FLORIDA

Volcanic ash layers were penetrated in three of the sediment cores recovered during 1965 off Florida as part of the JOIDES deep drilling program. The ash in these cores consists of shards of fresh acidic glass with a size distribution centered in the 30-60-micron fraction. In all samples, the ash is in Oligocene strata, as indicated by planktonic Foraminifera such as *Chilohuembelina cubensis*, *Globoanomalina micra*, *Globovalia postcretacea*, and *G. yeguaensis*. Such a fauna is typical of the Vicksburg Group of the United States, and other Oligocene sections in Europe and Africa. Potassium-argon dates of the ashes provide absolute ages for the Oligocene. These JOIDES ash layers appear not to be correlative with ash beds found in the Tertiary Oceanic Formation of Barbados.

ECHOLS, DOROTHY J., Department of Geology, Washington University, St. Louis, Mo., and ARTHUR E. WEGWEISER, Department of Geology, Edinboro State College, Edinboro, Penn.

NAKED FORAMINIFERA FROM SHALLOW-WATER ENVIRONMENTS

Abundant live and dead Foraminifera having different degrees of calcification were found in samples collected in bays, marshes, and lagoons along the northeastern coast of the United States. Live standing crops of uncalcified, "chitin-like" Foraminifera have not been discussed previously in detail, and specific reasons for the occurrence of abundant multi-chambered "chitinous" inner linings have not been postulated.

The bottom sediment at all locations from which a large live standing crop of uncalcified Foraminifera or abundant inner "chitinous" linings was recovered consists of fine silt and clay with abundant fecal pellets and (or) decomposed vegetation. This supports previous observations that low pH conditions are important in the occurrence of these forms.

However, results of the present study make it possible to suggest that the presence of a particularly acid alga which lives in the areas collected may be a specific cause of local lack of calcification in live standing crops of Foraminifera, and that bottom-dwelling invertebrates play a significant role in the local environment by consuming calcareous Foraminifera and excreting their "chitinous" linings.

EVERNDEN, J. F., 6621 Wakefield Drive, Alexandria, Va.

RADIOMETRIC DATING OF CENOZOIC EPOCHS

As a result of (1) careful selection of datable samples in close and demonstrable correlation with fossiliferous beds and (2) perfection of radiometric dating techniques, an excellent understanding of the time scale of the Cenozoic epochs has been achieved. This knowledge extends from the base of the Paleocene to