zoans and crinoids are the major contributors. Other organisms are commonly present but probably contributed little to the development of the banks.

Phylloid (leaflike) algae aid in formation of banks in 3 major ways: by baffling, trapping sediments, and binding sediments. Phylloid algae may have grown free on the substrate, may have locally attached to the substrate, or may be encrusting.

Algal banks may occur in the shape of a simple mound, a broad lense, or a complex combination of the two forms. Thicknesses of banks or bank complexes range from about 10 to 115 ft; horizontal distances range from less than 0.1 mi to more than 40 mi. The banks stood slightly above the surrounding sea floor. Algal banks occur in shallow, well-illuminated waters along the flanks of structures, along shelf margins, adjacent to deltas, and in shallow epicontinental seas.

There are 4 major types of porosity associated with algal banks: (1) between algal leaves, (2) within algal leaves, (3) beneath algal leaves (umbrella structure), and (4) as a result of dolomitization of algae and/or matrix.

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INTERPRETIVE TECHNIQUES USING EXPLORATION DATA BASE/APPLICATION PROCESSING SYSTEMS

Over the past 5–10 years several significant developments have taken place involving the use of computers in support of the exploratory process, particularly relating to the search for new oil and gas reserves. Digital seismic processing is one obvious example, and the development of large geologic well data bases is another.

Both of these areas have developed somewhat independently of the other for very valid reasons; however, it is now becoming apparent that new interpretive techniques could benefit from selective integration of these and other related areas, particularly from the data base standpoint.

For example, seismic interpretation methods could be enhanced in many cases if selected geologic information could be incorporated into certain phases of digital seismic processing. Conversely, the utility of well data files might be greatly enhanced if selected seismic data could be incorporated and utilized in a geologic data base. There are numerous problems involved in extensions of this type; however, through proper design of integrated exploration data bases and related application processing programs, it is possible and practical to develop new systems which can greatly enhance the interpretive phases of exploration both from a geophysical and geological standpoint.

Illustrations are given showing several possible ways to create an integrated exploration data base containing selective seismic and geologic information. Techniques for the retrieval of data for subsequent processing by application programs in support of geophysical and geologic interpretation are also shown.

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STRUCTURAL RELATIONS OF ARBUCKLE AND OUACHITA FACIES

Rocks of the Ouachita facies are thrust out over the Arkoma basin. As expected, part of the crustal shortening is taken up in the Arkoma basin by folding parallel with the strike of the thrust faults. This shortening can be observed in the outcrops. Unfortunately, the intersection of the Ouachita front with the Arbuckle

Mountains, the Ardmore basin, and the Marietta-Sherman basin is covered by the Cretaceous overlap. Therefore, the relation of the Ouachita facies with the Arbuckle facies can be determined only by subsurface information.

There is a regional southwest trend to the Ouachita front from where it disappears beneath the Cretaceous northeast of the Arbuckle Mountains to the Llano uplift in central Texas, indicating, in general, that the Ouachita facies was thrust from the southeast.

In the Ardmore and the Marietta-Sherman basins there are no indications of thrusting from the southeast. Rocks of the Ouachita facies are in contact with the Arbuckle facies by means of northwest-trending, high-angle reverse faults. The trend of folding in these basins is also northwest, with no northeast trending folding as one would expect in front of a thrust from the southeast. The Ardmore and Marietta-Sherman basins are characterized by large northwest-trending strike-slip faults. The best examples of these are the Reagan and Washita Valley faults which bound the Tishomingo uplift on the northeast and southwest, and the Mannsville-Madill-Aylesworth fault which parallels the Washita Valley fault.

It is concluded that in the Ardmore and Marietta-Sherman basins, the Ouachita facies is not in contact with Arbuckle facies by means of low-angle thrusting, but instead the Ouachita rocks have been shoved from the southeast in northwest-trending wedges. This action drove blocks of Arbuckle facies into confined spaces on the northwest and caused great crustal shortening along a southwest-northeast line resulting in the northwest trending structures of the Ardmore and Marietta basins.

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COMPARATIVE LITHOSTRATIGRAPHY OF WORLD'S MAJOR CARBONATE RESERVOIRS

Although it has been said that "oil is where you find it," yet any regional or worldwide comparative evaluation of producing carbonate lithologies will show that certain lithostratigraphic units have proved to be more prospective than others. Furthermore, it can be demonstrated that certain important time-equivalent reservoir rocks are remarkably similar in lithologic composition on a worldwide basis. This paper focuses on these worldwide time-equivalent developments of lithologically similar or identical reservoir facies.

The following different lithofacies constitute the most important types of carbonate reservoir rocks: reefs and banks (i.e. biogenic structures); oolites and calcarenites; detrital accumulations; conglomerates and breccias; and shallow-water shelf limestones.

These may occur in the form of unaltered limestones, recrystallized or dolomitized limestones, and replacement dolomites. On a worldwide basis, reefs and banks, together with oolite and calcarenite deposits, form by far the most productive carbonate reservoir facies.

At certain periods of geologic time certain specific lithofacies dominate in forming potential reservoir rocks. During Ordovician and Silurian times, replacement dolomites and dolomitized biogenic limestones prevailed. The Devonian System exhibits major reservoir potentials in unaltered or dolomitized reefoid facies. Mississippian, Pennsylvanian, and Lower Permian carbonate reservoirs represent primarily different types of biogenic bank deposits. Middle to Upper Permian producing lithologies encompass reef facies, as well as

dolomitized oolite and calcarenite deposits and dolomitized shallow-water shelf limestones. In Late Jurassic time, oolite and calcarenite accumulations, together with minor occurrences of reefoid facies, predominated in forming important petroleum reservoirs in the Vera Cruz region, Mexico, in the Smackover trend, and in the Arab D limestone of Saudi Arabia, Kuwait, and in its time equivalent in Israel. In the Cretaceous, reef facies are dominant. In the Tertiary, coral reefs and calcarenite deposits (Asmari Limestone, Iran) form the most important carbonate reservoirs. Such a generalized categorization by lithofacies refers strictly to major producing lithologies and does not exclude simultaneous production from minor carbonate reservoirs on a local basis.

A comparative evaluation of the reservoir potentialities of carbonate lithologies likely to be found in prospective new oil provinces should form a basis for more realistic profitability analyses.

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APPLICATION OF AIRBORNE SURVEYS TO SUBSURFACE GEOLOGY

No abstract.

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LIQUID INDUSTRIAL WASTE STORAGE BY UNDERGROUND INJECTION

With a yearly discharge of liquid industrial waste of more than 14 trillion gallons before treatment, underground injection is a valuable tool to aid industry with the problems of storing and treating its generated waste.

Disregarding mechanical factors, reservoir characteristics exert the greatest influence on operating safety and economics of injection systems. Ideally, a host reservoir should be a uniform salaquifer of large areal extent, substantial thickness, high porosity and permeability, and low pressure with adequate overlying and underlying aquicludes containing fluids compatible with injected wastes. There should be a minimum of faulting and abandoned wells near the injection site.

Compressibility of water, rock, and gas in solution, in addition to any previously removed fluids, provide the space necessary for injection into the host reservoirs. The pressure effect at various distances from the wellbore, for given times and volumes of injected fluids, is important in predicting long-range reservoir performance, effect on inadequately plugged wells in the vicinity, effect of injection near potentially valuable mineral deposits, and unintentional formation fracturing. Potentiometric levels and gradients should be determined for host reservoirs to help analyze and anticipate fluid movement and monitoring methods needed.

With over 300 waste-injection wells in operation today, the vast majority are injecting into reservoirs at depths of less than 6,000 ft. Approximately 70% are injecting into sandstone and unconsolidated sand and about 25% are injecting into limestone and dolomite, with the remaining percentage injecting into crystalline or evaporite sequences. Porosities in these wells range from under 10% to over 30%; permeabilities range from under 1 md to over 5 Darcys, giving a wide range of potential injection volumes and pressures and associated operating conditions.

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DEPOSITIONAL AND DIRECTIONAL FEATURES OF BRAIDED-MEANDERING STREAM

The Cimarron River in north-central Oklahoma shows characteristics intermediate between typical braided and meandering streams. The gradient is 1.8 ft/mi. at Perkins; the sinuosity is 1.5; the monthly average discharge ranges from 2 to 17,800 cu ft/second; and average channel depth at bankful stage is 15 ft.

The deposits are generally fine- to medium-grained, well-sorted sand, with scattered quartz and intraformational pebbles and thin beds of coarse-grained sand. Several clay drapes are present as thin discontinuous layers. Medium-scale crossbedding, horizontal bedding, and small-scale crossbedding are the dominant sedimentary structures. Compositionally the sand is an arkose, which suggests the Wichita uplift and the southern Rocky Mountains as ultimate source areas.

Irregularities and discontinuities in the sand deposits are due primarily to channel shifts during times of major floods and secondarily to deposition of clay during recession of high-water stages. The irregularities resulting from dissection of transverse dunes and superposition of ripples on dunes are thought to be of minor significance in causing reservoir variations.

Crossbedding, parting lineation, and grain orientation all define the sand trend very well and indicate that directional features in this type of sand deposit are useful in estimating reservoir trend. Directional imbibition parallels the dip of the crossbeds and grain orientation (and parting lineation) in horizontal beds.

Compared with typical meandering-stream deposits, the Cimarron River sand is thinner and contains less fine-grained clastics in the upper part of the sequence and as clay interbeds. It is finer grained than typical braided-stream sands, and current indicators show a wider directional range. The type of deposit represented by the Cimarron River sand may be similar to certain Pennsylvanian alluvial sandstones which were deposited as the gradient was reduced during the initial stages of eustatic rise in sea level.

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SPECTRUM EXTRAPOLATION TO INCREASE RESOLUTION

Stratigraphic traps have been receiving increasing attention in the search for hydrocarbons. Greater resolution of detailed features are required for stratigraphic interpretation. Three weapons—continuous average velocity, interval velocity, and amplitude—have been widely studied. The extraction of higher frequencies has been less studied except in the framework of Wiener filtering. An alternate method is possible using Fourier theorems to extrapolate the spectrum to higher frequencies achieving greater pulse compression.

This new approach can increase the resolution of velocity analyses, migration, and automatic statics. Certain reflective sequences obscured by loss of higher frequencies such as pinch-outs, structural flanks, and closely spaced reflectors commonly are resolved by the method. Application examples show this as a possibly effective weapon in stratigraphic trap analysis.

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HUNTON FIELDS, ANADARKO BASIN, OKLAHOMA AND TEXAS

No abstract.