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Synthetic Sonic Logs for Delineation of Petroleum Reservoirs

A recent development in digital process technology yields synthetic sonic logs from seismic reflection data recorded at the ground surface. Synthetic sonic logs are similar to, and have most of the properties of, long source-receiver borehole sonic logs. The synthetics have been found to be particularly useful for the delineation of petroleum reservoirs, including the extent, thickness, and porosity of the reservoir rocks.

In a typical survey, field data, obtained from seismic line profiles across reservoirs, yield a sequence of synthetic sonic logs. Continuous vertical cross sections which display color-coded transit time units can be interpreted in terms of lithology, porosity, and related subsurface information, within the limits of interpretation of the single sonic curve and the resolution of the method.

Applications include the optimization of development drilling patterns to obtain maximum production, the design of secondary recovery programs and the positioning of injection wells, and the location of offshore drilling platforms to ensure maximum recovery.

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Turbidite-Deltaic Complex, Piru Gorge Sandstone Member of Ridge Rouge Formation (Pliocene), Ridge Basin, California

The Piru Gorge Sandstone member of the Ridge Route Formation (Pliocene) was deposited as a turbidite-deltaic complex within the tectonically active Ridge basin. In cross section, the Piru Gorge Sandstone is 190 m thick and over 5 km long. The sandstone consists of (1) a lower turbidite sequence, overlain by (2) multistacked channel-levee cycles, and (3) interchannel deposits. These sequences are arranged into several megasequences, each up to 60 m thick. The lower turbidite interval is up to 10 m thick and consists of facies B, C, and D of Mutti and Ricci Lucchi. The interval is interbedded with, and grades laterally into, lacustrine shale. The channel-levee sequence is up to 30 m thick and consists of crossbedded channel sandstone, slump folded strata, and levee deposits arranged in fining- and thinning-upward cycles. The sequence makes up the middle and upper parts of each megasequence. Interchannel deposits are interbedded with, and laterally transitional with, the channel-levee sequences. The deposits consist of thick intervals of organic-rich, bioturbated, mudcracked mudstone and sandstone that locally have rootlets and animal tracks.

Paleocurrent, thickness, and petrographic studies indicate the Piru Gorge Sandstone was derived primarily from the north-northwest with minor contributions from the east and west. Petrographic data indicate the arkosic sandstones were derived from granitic source terranes.

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Computer Processing of Production Data—Exploration Tool

Computer processing of monthly gas and oil production rates reported to the Texas Railroad Commission is being used as an exploration tool. This production data, reported by operators to the Railroad Commission, is available commercially in digital form and is updated on a monthly basis. The data include monthly production figures for both primary production and by-products along with test results. Computer programs have been developed to display this information as inventories, reports, and graphic plots. Summation logic incorporated in the programs allows the presentation of production curves (monthly and cumulative) for individual wells, reservoirs within a field, individual operators within a field, entire fields, formations within one or more counties, or any combination thereof.

Detailed monitoring of wells and fields leads to improved predictions of production sustainability. The effects of stimulation techniques can also be easily recognized. Production data from selected wells can be combined to generate a production history for a typical well.

Decisions regarding well completions have been made utilizing this data. Performance of key wells and fields near areas of interest are regularly monitored with data processing output. A minimal amount of manpower is required to keep updated production histories available for exploration use.

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Paleoecology of Miocene Barstow Formation Insect Fauna, Calico Mountains, California

The Upper Miocene Barstow Formation crops out in the western Mojave Desert. In the southern Calico Mountains, green petroliferous shale beds of the Barstow Formation contain calcareous nodules from which silicified organisms can be recovered by acid etching. Reconstruction of the physical environment during the time of deposition of the fossil-bearing beds is made by comparing the insects of the Miocene fauna with their modern analogs. The Barstow Formation in this area was deposited in a fairly large, warm lake whose waters were rich in dissolved minerals. Periodically the lacustrine environment was disturbed in a way which resulted in the death and preservation of many soft-bodied organisms. The Miocene lake was surrounded by grassy plains and upland areas supporting a grassy woodland. The climate of the region was semiarid with hot summers and mild winters.

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Holocene Facies Succession and Depositional Environments of Semi-Enclosed Windward Lagoon off Great Abaco Island, Bahamas

The Abaco windward lagoon, bounded bankward by Great Abaco Island and seaward by the discontinuous Abaco Cays, exhibits up to 6 m or more of lagoonal, non-reef derived sediments, 5 km from the marginal escarpment of northeastern Little Bahama Bank. Six sedimentary facies, distinguished by texture, composition, and molluscan fauna, record the changing depositional environments as water depth and circulation increased during the Holocene transgression. A skeletal grainstone and mixed (skeletal-ooid-aggregate) grainstone are limited to inter-island channel areas. Away from these channel energy windows, a maximum sequence of 4 depositional facies is observed. The bulk of sediments are a normal marine (N.M.) skeletal wackestone or mixed (pellet-skeletal) packstone. The N.M. wackestone dominates the western half of Abaco lagoon while the packstone occurrence

characterizes eastern Abaco lagoon where it overlies the wackestone facies, accounting for 50% of the normal marine section. The N.M. wackestone typically grades downward into a dark gray restricted marine (brackish to hypersaline) skeletal wackestone, ≷70 cm thick, and then to a dark brown nonmarine soil zone, ≤16 cm thick, above bedrock. Radiocarbon dates indicate flooding of Abaco lagoon at least by 7,446 YBP at −10 m, followed by the transition from restricted to normal marine conditions as early as 4,716 YBP. Sedimentation rates increase from 16 cm/1,000 years for the restricted marine wackestone, to 58-104 cm/1,000 years and 216 cm/1,000 years for the N.M. wackestone and packstone facies, respectively. The windward lagoon setting illustrates the caution required in prediction of facies continuity perpendicular to carbonate bank margins. Recognition of an ancient windward lagoon sequence may have important implications regarding sea level history and paleogeographic reconstruction.

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Heterobathyal Benthic Foraminifera: Bathymetric Migrations as Oceans Change

Reconstructions of the past distribution of Quaternary deep-water benthic foraminifera from both the Atlantic Ocean and Mediterranean Sea show that the bathymetric range of most common species has changed substantially through time.

An Atlantic Ocean abyssal biofacies characterized by *"Epistominella" umbonifera* periodically migrated hundreds of meters as ice-age climates influenced deep-water production in polar latitudes. At the same time, bathyal biofacies, especially ones characterized by *Uvigerina* and *Globocassidulina,* extended their bathymetric ranges as much as 2 km deeper.

In response to the Quaternary stagnations and recirculation associated with sapropel deposition in the eastern Mediterranean, most benthic foraminifera changed their bathymetric distributions. Deep-water biofacies (*Globobulimina, Articulina)* shallowed as deep basins became anoxic; shallower biofacies (miliolids) extended their ranges as recirculation oxygenated the deep water.

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Sedimentation and Diagenesis of Upper Smackover Grainstone, Jay Field Area, West Florida

The examination of core and logs from a well 3 mi (5 km) southwest of the Jay field has given considerable insight into the upper Smackover facies distribution, diagenesis, and the application of recent models for the sedimentation and diagenesis of this Jurassic reservoir. A 63-ft (19 m) thick unit of oolitic and oolite-oncolite grainstones is recognized in the upper Smackover. High-angle inclined bedding, visible on both core and dipmeter, with a consistent 15 to 20° northeast dip, demonstrates the presence of oolite bars. These bars formed a barrier which affected subsequent deposition and diagenesis in the Jay field area. A complicated diagenetic history of marine and vadose cementation, and pervasive and selective dolomitization have left a unique imprint on the porosity and permeability of these rocks.

Dipmeter results and petrographic analysis of the grainstones indicate that cementation and diagenesis have not been uniform. Within the large-scale cross-strata, permeable beds are interstratified with tightly cemented or compacted, impermeable beds. Horizontal flow should be greatest along the strike of the inclined units, because the flow would remain within the permeable planes of the inclined strata. Thus, dipmeter correlation permits an interpretation of the direction of bedding permeability anisotropy produced by the inclination of the pore system.

The characteristics of sedimentation and facies distribution in the Jay field area have previously been compared with a modern analog from Joulters Cay in the Bahamas. The Trucial Coast of the Persian Gulf in the Abu Dhabi region may be a better model. The style of deposition and distribution of carbonate and evaporite sediments, and diagenetic characteristics in the grainstone barriers and lagoons closely fit the sedimentation and diagenetic pattern in the Jay Field area.

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Chemical Evolution of Brines from Modern Coastal Marine Sabkha

Certain minerals in ancient clastic and carbonate rocks such as selenite and iron sulfides are commonly taken as indicators of a sabkha environment. The wind-tidal flat area of Laguna Madre, Texas (a silicoclastic sabkha), is a modern locus for the deposition of these minerals and thus affords an excellent opportunity to determine the controls on their deposition. The purpose of this research is to study the chemical evolution of the subsurface brines associated with the mineral deposition.

A system of 20 well sites has been established along the 22-km width of the tidal flats to investigate the chemistry and the hydrology of the sabkha system. The chemistry and peizometric potential of the waters were determined at each site from two wells (depths of 1.9 and 3.8 m) and from a shallow trench dug to intersect the water table. The chemical data from two sampling periods (August 1979 to March 1980) were reduced by computer. Using Br^- as a conservative ion, the results of this study are as follows: (1) the concentrated waters (2 to 9 times the salinity of seawater) are typically NaCl solutions which are high in Mg^{2+}, K^+, and SO_4^{2-} and low in Ca^{2+} and HCO^-_3; (2) the major source of water is from Laguna Madre with minor contributions from continental ground waters; (3) the mixing zone of the two waters is on the continental side of the chloride plateau; (4) the sabkha hydrology is dominated by wind-generated flood recharge with localized evidence of evaporitic pumping and reflux; (5) the chemistry of the brines primarily reflects the degree of evaporation of the Laguna Madre waters and the extent of flooding; (6) the brines are all undersaturated with respect to halite and supersaturated with respect to dolomite, but vary in saturation state with respect to gypsum and calcite.

Previous work in this area, and the two sampling periods of this study indicate minor changes in brine geochemistry as a function of season. In general, the chemical nature of the brines from the Laguna Madre sabkha is similar to brines of other active coastal sabkhas; variations can be attributed to differences in climate, geomorphology, and hydrology.

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Products and Processes of Ancient Arid Coastline: Lower Cutler Group (Permian), Southeastern Utah