HSU HUAIDA, Petroleum Geology Research Section, Wuhan College of Geology, Beijing, People's Republic of China

Seismic Stratigraphic and Sedimentologic Studies of Paleogene Sediments, Eastern Coastal Region, China

The study area includes the Bohai basin of north China and Dongtai basin of east China. Regional cycles of sea level change during the Tertiary in the Bohai basin correlate fairly well with global cycles, but differ from those in the Dongtai basin where the lowest sea level occurred at the end of the Eocene. The paleogene sediments, which were previously considered to be of continental origin, are now shown to be marine deposits because of the presence of abundant nannoplankton. This reinterpretation of the Paleogene indicates that transgression had taken place in these areas at that time, and that the closure of the paleosea between the North China and South China plates was delayed for a long time. Fan-delta and turbidite facies occur in anticlines of different dimensions, some of which form traps for oil and gas accumulations. Abnormal formation pressures occur in Eocene shale sections and contributed to the formation of shale diapirs, growth faults, and some large-scale gravitational slide blocks. The slide blocks are the most important structural features of the region.

HUA, BAOQUIN, and LIN XIXIANG, Lanzhou Inst. Geology, Lanzhou, People's Republic of China

Abnormal Formation Pressure of Qaidam Basin and Its Cause

Qaidam basin is a Mesozoic and Cenozoic inland oil basin where the abnormal formation pressure is as developed as in many offshore regions.

The abnormal formation pressures are found at depths below 3,200 m in relatively depressed regions. Their pressure gradients are from 0.14 to 0.22 atm/m.

The causes of abnormal formation pressure in this region are as follows.

1. Compaction unequilibrium is the principal cause of high pressure. Abnormal pressure occurs not only in the zone of fine-grained rocks, but also in the interbedded strata of sandstone and shales as long as the rate of deposition is rapid enough at the time when abnormal pressure is produced.

2. In this region, an aquathermal pressure effect is also apparent; the geotemperature gradient is 35°C/km, and the actual average rate of pore pressure increase since isolation is 0.31 atm/m, significantly higher than 0.23 atm/m of the average overburden pressure gradient.

3. Because there is not any montmorillonite content in some sequences developing abnormal pressure, montmorillonite-illite conversion and dehydration are not prerequisites for the abnormal pressure.

In addition, growth faulting of some regions and the volume expansion produced by thermal degradation of organic matter may also enhance the formation pressure.

HUMPHRIS, C. C., JR., Chevron U.S.A. Inc., New Orleans, LA

Relationship of Structural Development and Cenozoic Sedimentation, Northern Gulf of Mexico

Development of structure in the northern Gulf of Mexico, mainly listric faulting and salt features, is directly related to Cenozoic sedimentation. Essentially all oil and gas production in this region occurs in structural features resulting from faulting and/or salt movement.

A thick section of continental shallow-water sediments rimming the entire Gulf of Mexico was deposited during overall Gulf subsidence in Mesozoic time. Very little sedimentation took place in the central Gulf, so that, at the close of the Mesozoic the central Gulf probably was of abyssal depths. Cenozoic sedimentation surpassed the rate of subsidence causing sediments to prograde across the Mesozoic shelf margin, with greatest deposition occurring gulfward of this margin. These depocenters or areas of thickest sedimentation prograded gulfward throughout time (in response to sediment supply) and migrated northeastward from south Texas to south Louisiana.

Listric or growth faults that formed contemporaneously with deposition are a common structural feature developed during Cenozoic sedimentation. These features are apparently caused by differential loading of higher density sandstones on prodelta shales near the shelf margin. In those areas underlain by thicker salt, such as the Miocene and younger depocenters, there is greater involvement of salt in growth-fault development.

Salt features, the other major type of producing structure, are developed by salt movement as a direct response to Cenozoic sediment loading. Initiation of salt movement is believed to be due to differential loading of prograding sediments. Further salt movement and structual development are completely dependent on continued sedimentation.

HUSSAIN, MAHBUB, Univ. Texas at Dallas, Richardson, TX, and JOHN K. WARREN, Univ. Texas at Austin, Austin, TX

Origin of Laminae in Holocene-Pleistocene Evaporitic Sequence of Salt-Flat Playas, West Texas and New Mexico

Salt-flat playas of West Texas–New Mexico are represented by a series of north-south aligned Holocene-Pleistocene dried salt lakes. Shallow (up to 100 cm) cores on the alkali flats of these lakes reveal a well-defined sequence of alternating dark and light laminae in the evaporitic sediments. These laminites bear a close resemblance to the laminated calcite-, dolomite-, and anhydrite-bearing sequences of the Middle Devonian Winnipegosis Formation of western Canada, Permian Castile Formation of west Texas and New Mexico, and recent sediments from hypersaline pools of the Gulf of Aqaba and other locations. XRD studies, augmented by petrographic evidence, show that laminites from the salt-flat playas are comprised of layers of differing mineral composition. The darker layers are dominated by gypsum (average 36.89%), halite (average 27.71%), calcite (average 17.74%), and dolomite (average 15.81%), whereas lighter layers are impoverished in calcite and dolomite and consist mainly of gypsum (average 72.86%) and halite (average 27.14%). Beside the mineralogic variations, the laminae also differ significantly in the abundance of total organic matter (TOM) content, with darker laminae being invariably richer (average 51% TOM in contrast to average 21% in lighter laminae). Micritic sediments that are relatively less altered by later recrystallization have retained a higher concentration of organic matter. In the gypsiferous sediments, which seem to owe their origin to a micritic mass, the organic matter is widely dispersed. In addition to the interspersed organic matter in evaporitic laminae, laminae comprised exclusively of algal mats also are common in these sequences. Liquids chromatographic studies reveal that these algal mats are remarkably similar in their hydrocarbon content to that of the algal mats that are now growing sporadically on the moist playa surfaces. These observations suggest that the laminite sequence of the salt-flat playa sediments have originated in a restricted shallow basin characterized by alternating periods of desiccation (precipitation of gypsum and halite) and freshening (algal growth and deposition of micritic sediments).

HUTLEY, JANET KAMON, Texaco U.S.A., New Orleans, LA

Triassic/Jurassic Faulting Patterns of Conecuh Ridge, Southwest Alabama

Two major fault systems influenced Jurassic structure and deposition on the Conecuh Ridge, southwest Alabama. Identification and dating of these fault systems are based on seismic-stratigraphic interpretation of a 7-township grid in Monroe and Conecuh Counties. Relative time of faulting is determined by fault geometry and by formation isopachs and isochrons. Smackover and Norphlet Formations, both Late Jurassic in age, are mappable seismic reflectors and are thus reliable for seismic-stratigraphic dating.

The earlier of the 2 fault systems is a series of horsts and grabens that trends northeast-southwest and is Late Triassic to Early Jurassic in age. The system formed in response to tensional stress associated with the opening of the Atlantic Ocean. The resulting topography was a series of northeast-southwest-trending ridges. Upper Triassic Eagle Mills and Jurassic Werner Formations were deposited in the grabens.

The later fault system is also a series of horsts and grabens trending perpendicular to the first. This system was caused by tensional stress related to a pulse in the opening of the Gulf of Mexico. Faulting began in Early Jurassic and continued into Late Jurassic, becoming progressively younger basinward. At the basin margin, faulting produced a very irregular shoreline. Submerged horst blocks became centers for shoaling or carbonate buildups. Today, these blocks are exploration targets in southwest Alabama.

HYLTON, A. K., and D. F. MERRIAM, Wichita State Univ., Wichita, KS

Depositional Environment of Lower Permian Stone Corral Formation

The Lower Permian Stone Corral Formation is a 5-8 ft thick unit of dolomitic limestone and shale in a sequence of red beds that crops out in south-central Kansas. It forms a good stratigraphic marker bed in the subsurface, where it consists mainly of anhydrite (the Cimmaron anhydrite) up to 100 ft thick.

At outcrop, the formation is weathered and consists of 2 interfingering facies—a crinoidal-echinoidal grainstone (in the north) and a laminated mudstone (in the south). Both the grainstone and mudstone exhibit diagenetic alteration. The grainstone is composed of well-rounded allochems of crinoid and echinoid fragments with scattered ooids, sponge spicules, peloids, and possible foraminifers and ostracods. Layers of sponge spicules alternate with peloid or ooid layers. The mudstone facies has a clotted texture and has laminations defined by the occurrence of fenestral fabric and peloids. Dolomite occurring in the Stone Corral Formation is of secondary origin.

The grainstone is interpreted as being lagoonal in origin, whereas the mudstone facies is interpreted as supratidal. The grumous (clotted) texture may indicate phreatic diagenesis. The absence of anhydrite on outcrop, where it was presumably leached by surface waters leaving the less soluble dolomite, is additional evidence for a regional disconformity above the unit on the eastern side of a large, shallow, evaporitic basin.

IRWIN, FRANK, and RAYMOND C. FLETCHER, Texas A&M Univ., College Station, TX

Mechanical Analysis of Salt Dome Growth in East Texas Basin

Analysis of the early pillow phase of salt dome growth is used to interpret observations of salt dome growth in the East Texas basin. Two limiting models are those of "redistribution" (R), in which erosion and sedimentation keep the overburden surface planar, and "no redistribution" (NR), in which the topography induced by dome growth is not modified. Spacing between nearest neighbor domes, (13 ± 4 km) and initial salt thickness ($h = 1.8 \pm 0.3$ km) yields a spacing/thickness ratio of 7, with range from 4 to 11. If salt viscosity (η) is less than overburden viscosity (η_1), and overburden thickness is $h_1 \geq h$, this implies $0.01 < \eta/\eta_1 < 1$ for both (R) and (NR). Growth rate is proportional to amplitude ($dA/dt = A/t^*$), where A is half the relief between the pillow top and the lowest point of the peripheral sink, and t* is a characteristic time. For a salt viscosity of 10^{18} poise, and a density contrast of 0.2 g/cm^3, t* ranges from 0.1 to 1 m.y. for (R), with values 2-5 times larger for (NR). For the former, a dome with 100-m amplitude grows at rates ranging from 1,000 to 100 m/m.y.; maximum reported rates of 40-100 m/m.y. are in fair agreement. Both facies patterns around domes and slower growth rates can be explained by the presence of substantial dome-induced topography. Spatial patterns and growth histories of groups of domes are investigated by following the development of a variety of local perturbations.

ISSLER, DALE R., and CHRIS BEAUMONT, Dalhousie Univ., Halifax, Nova Scotia, Canada

Modeling Thermal Evolution and Petroleum Potential of Basins Formed by Extension

In recent years, considerable progress has been achieved in modeling the subsidence and temperature histories of sedimentary basins. A knowledge of the mechanisms of basin formation may make it possible to compute the variation of heat flow with time, and consequently the temperature distribution in the sediments with time, if the basin geometry and sediment material properties are known. Further studies are necessary to understand how thermal conductivity, radiogenic heat production, and ground-water flow influence the subsurface temperature distribution in different types of basins.

Model-derived temperatures can be used to make theoretical predictions of organic maturity using chemical reaction kinetic theory. In addition to vitrinite reflectance, a promising technique involves looking at aromatization-isomerization (A-I) reactions associated with biologic marker compounds that commonly occur in most organic-rich sediments. These are unimolecular, first-order reactions that precede the main phase of oil generation and therefore can be used to locate the top of the "oil window." The Labrador continental margin off northeastern Canada is a typical rifted margin, believed to have formed by stretching of the crust and subcrustal lithosphere during rifting, followed by thermal contraction subsidence. A 1-dimensional, finite element model that considers nonuniform extension and allows for variations in sediment thermal properties was used to compute the thermal history of sediments in this region. It is assumed that thermal conduction is the primary mode of heat transfer in this style of basin and that advection of heat by fluid motion is negligible. Model results can be compared with direct maturity measurements (A-I products, vitrinite reflectance), crustal thickness estimates from seismic refraction experiments, and corrected bottom-hole temperatures or heat-flow measurements.

JAMES, W. C., and E. W. PORTER,* Univ. Texas at El Paso, El Paso, TX

Influence of Pressure, Salinity, Temperature, and Grain Size on Silica Diagenesis and Reservoir Quality in Quartzose Sandstones

Based on calculated silica solubilities (1-4 km depth range), there is a suggested predictable effect of pressure (P), temperature (T), and salinity (S) on silica diagenesis. Silica distribution under various P-T-S conditions is in turn influenced by grain-size differences. Quartz solubility related to increasing grain-contact pressure with depth is about 7 times greater at 4 km than at 1 km ($m_S = 1.5 \times 10^{-3}$ vs. 2.0×10^{-4}). The differences between solubilities based on hydrostatic and point-contact pressures (orthorhombic closest packing) increase with increasing depth (excluding overpressured areas). At greater depths, local precipitation of silica appears more likely, whereas at shallower depths, larger scale silica migration may occur preceding precipitation. The effect of increasing salinity generally decreases solubility regardless of depth (e.g., at 3 km and 3 m, $m_S = 8.9 \times 10^{-4}$; at 6 m, $m_S = 7.5 \times 10^{-4}$); hence, reservoir-quality loss by pressure solution is impeded in those sandstones containing more saline pore fluids. Pressure solution is far more active in basins characterized by high heat flow. Very fine-, fine-, and medium-grained sand laminae (perfect sorting; several grain diameters thick) will experience 500, 64, and 8 times (all other factors equal) the amount of pressure solution compared to coarse-grained sand. Chemical potential gradients are suggested among centimeter-scale size laminated intervals, resulting in migration of silica to coarser grained areas before precipitation. Reservoir-quality loss in the finer laminae is caused primarily by pressure solution, whereas, in coarser intervals, silica precipitation is mainly responsible.

JOHNSON, DAVID A., and CATHERINE A. NIGRINI, Woods Hole Oceanographic Inst., Woods Hole, MA

Time-Transgressive Neogene Radiolarian Events: Equatorial Indian and Pacific Oceans

Fifty radiolarian events (first or last occurrences) of Quaternary and Neogene age were identified in a transect from 5 drill sites (503, 573, 289, 586, 214) in the equatorial Indian and Pacific Oceans, extending from the Panama basin to the 90°E Ridge. Using an "absolute" chronology for each site based on correlation with the paleomagnetic time scale, we have estimated the degree of synchroneity or time-transgressiveness for each datum. Of those events that appear to be synchronous within the probable uncertainty of our estimate (ca. 0.3 m.y.), 85% are last occurrences. Of those events that are unmistakably time-transgressive (i.e., 1 m.y. or more), 75% are first occurrences in which the taxon evolves earliest in the Indian Ocean and progressively later in the western and eastern Pacific. This study, to our knowledge, is the first to document nonsynchroneity of microfossil events within a given latitudinal zone. If this effect proves characteristic of other microfossil groups as well (foraminifera, nannofossils, diatoms), it has important implications for biostratigraphy, geochronology, and plankton evolution. In particular, it suggests a reevaluation of events that presently define zonal boundaries, using precisely dated material, perhaps with the ultimate consequences of favoring last occurrences over first occurrences. The earlier evolution of taxa in the Indian Ocean is particularly unexpected in view of the strong westward zonal flow in low latitudes.