of normal open shelf and slope deposits from other regions. Early results suggest that basin plains are underlain predominantly by ponded turbidites with internal reflecting horizons of near horizontal initial attitude which conform to their flat featureless surface. Lateral continuity of these reflectors appears to be large compared to those within the gently sloping aprons and sea fans of the basins. Reflection profiles of the peripheral regions of the Tyrrhenian Sea show horizontally-bedded, probably ponded turbidites in closed slope-basins and hemipelagic sediments blanketing and conforming to underlying topography in open-slope areas. Similar features are recorded in profiles from the continental terrace and marginal basin of the East China Sea and other regions. Filled marginal basins are believed to be quantitatively important in retaining terrigenous sediments within the continental framework.

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Mudlumps: Diapiric Structures in Mississippi Delta Sediments

Mudlump islands are surface manifestations of intrusive clay masses that result from depositional processes at the mouths of major Mississippi River distributaries. The stratigraphy and structure of mudlumps at the South Pass mouth have recently been studied through a drilling and coring program which included holes to depths of 700 feet. Subsurface information obtained establishes the interrelationship between older shelf and prodeltaic river deposits and younger, progradational delta front and river mouth bar sediments.

Mudlumps are interpreted as being near-surface expressions of older shelf and prodelta clays diapirically intruded into and through overlying bar deposits. The intrusion culminates in shallow-angle thrust faulting which has resulted in vertical displacement of older clays as much as 350 to 400 feet. New mudlumps, revealed during the period of study, display surface exposures of shelf deposits uplifted and thrust from depths in excess of 350 feet. Between diapiric clay masses are synclinal troughs filled with as much as 400 feet of rapidly accumulated, near-strandline bar sands, silts, clays, and organic material.

Rapid deposition of thick, localized masses of heavier bar sediments directly upon lighter, plastic clays leads to an unstable situation which is relieved by diapiric intrusion of the clays with the resulting formation of mudlumps.

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A Depositional Model for the Jackfork (Mississippian) Group of Arkansas

Two linear, isolated belts of Jackfork clastics in the Arkansas Ouachita Mountains exhibit differences in sand-shale percentages, sedimentary structures, composition, and thickness, permitting one to make assumptions concerning the depositional model. Along the Frontals, the 5,400-foot-thick section is 70 per cent shale, generally lacking fissility and siliceous marker beds and is often contorted, containing irregular sandstone blocks. Medium bedded, fine grained arenites contain laminations, cross-stratification, ripple marks, and scattered tool marks oriented 255°, whereas massive, ridge-forming arenites are almost structureless. The 6,000-foot-thick southern section is approximately 70 per cent fine grained, poorly sorted arenites, containing schist fragments and feldspar. The remaining wackes, siltstones, and mudstones show little evidence of strong currents or steep slopes.

Petrographic and paleocurrent studies suggest the derivation of the clastics from a large, well-drained provenance to the east, consisting predominantly of quartzites and mature sandstones. Some clastics may have bypassed the Illinois Basin, the resulting laminated and cross-stratified arenites having formed from southwest flowing traction currents. Rubble bedding, possibly initiated by faulting, resulted when subaqueous mudflows disrupted the non-lithified arenites to form rounded exotic blocks. Structureless, generally massive arenites may have entered the basin by mass sediment flow from a more eastern or southeastern direction, possibly being swept off the Appalachian land mass by westward flowing currents.

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Conodonts from the Wabamun Group (Upper Devonian) from the Canadian Subsurface

The Upper Devonian Wabamun Formation was named for 562 feet of limestone and dolomite in Anglo-Canadian's Wabamun Lake well, south of Edmonton, Alberta. Subsequently, the formation was elevated to group status in the Stettler area where it was divided into the upper, thin, Big Valley Limestone and the lower, predominantly evaporitic and dolomitic, Stettler Formation. These latter units are not generally recognizable outside the Stettler area, where these strata are termed "Wabamun Group undivided" or simply "Wabamun Formation."

According to previous studies (Wonfor and Andrichuk, 1956), Wabamun rocks in the Stettler area attained a pre-Mississippian thickness, ranging from less than 500 feet in the east to over 800 feet in the west. The general structural setting is on the regional southwesterly dip of the Alberta basin. The Wabamun strata are part of the basin's lower Paleozoic sequence of carbonates, shales, siltstones, and evaporites of Cambrian through Mississippian ages, overlying a crystalline Precambrian basement.

Wabamun conodonts have been recovered from cores from three wells near the towns of Edmonton, Westerose, and Calgary. The conodont fauna thus far revealed has been abundant and diverse. Named and unnamed species of the platform genera *Palmatolepis* and especially *Polygnathus* are abundant, as are the bars and blades of the species representing the genera *Spathognathodus*, *Apatognathus*, *Hindeodella*, *Pelekysgnathus*, *Trichonodella*, and *Angulodus;* the cones of *Acodina* and *Drepanodus* also characterize the Wabamun fauna. Two species are believed to represent a genus of bar-type conodont never before described; another species of a cone-type unit represents a hitherto unnamed genus.

Previously published studies of conodont faunas have not, with a very few exceptions, generally included the conodonts from subsurface or exposed rocks in western Canada. For this reason, comparison of new material with similar Canadian conodonts is impossible or impractical for the most part. Comparison of the Wabamun conodonts is therefore made with the better-known Devonian faunas of the United States and western Europe.

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Internal Structure and Growth of Salt Domes

Grand Saline salt dome, Texas, and Winnfield salt dome, Louisiana, have well-developed cap rock on top of them and topographic lows at the surface. In contrast to this, the Five Islands domes of South Louisiana form topographic highs at the surface and give evidence of recent and perhaps fairly rapid movement. Differences in types of fold structure observed in these domes also suggest more recent and rapid movement of the South Louisiana domes. Salt petrofabric patterns indicate that there is a more distinct preferred orientation of salt crystals in the central parts of domes than in their periphery. The relatively stable domes have a more distinct orientation than those that have been subject to Recent differential movement.

The best preferred orientation patterns of salt from Grand Saline are derived from samples taken farthest from the dome margin, and can be related to dodecahedral or cubic gliding of halite if the axial planes of the folds are considered to be the planes of motion. Samples from Winnfield dome show less distinct preferred orientation patterns than those from Grand Saline, but are interpreted as combinations of cubic and dodecahedral gliding or superimposed patterns resulting from successive movements of the salt in different directions. Recent surveying of a water-etch line formed about 27 years ago inside the Winnfield dome when the mine was temporarily flooded show irregularities that may indicate slight differential movement during that interval. Irregular uplift probably tends to blur or destroy the patterns of preferred orientation that formed during slow unidirectional movement, and distinct petrofabric patterns therefore probably indicate a condition of relative stability.

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GEOLOGY OF GULF COAST SALT DOMES

More than 300 diapiric structures formed by the intrusion of relatively pure salt are known in Alabama, Mississippi, Louisiana, Arkansas, and Texas. In form, they are rod-like, domal, anticlinal, and ridge-like; they rise vertically or nearly so; and they expand or contract with depth. Some reflect growth by a succession of differently positioned, local uplifts, as well as shifts in the locus of principal growth. Many are capped by residual masses of anhydrite, altered in varying degrees to gypsum, sulphur, and calcite.

Modern theory postulates growth resulting from density differences between the salt and surrounding sediments through (1) upthrusting (upward movement of salt through sediments in response to gravitational inequilibrium), or (2) downbuilding (maintenance of an essentially static level by the salt while the surrounding sediments subside). Model studies suggest that variations in overburden and faulting are primary motivators of growth.

The "parent" bed from which the salt came exists at depths which range from less than 10,000 to approximately 30,000 feet and is judged to have been as much as 5,000 feet thick. It may have covered as much as 150,000–200,000 square miles and may have had a volume of 50,000–100,000 cubic miles. The presence of large amounts of calcium sulphates peripheral to the Gulf of Mexico basin suggests that the salt is a precipitate from brines concentrated in the Gulf basin or in partially restricted marginal basins.

Surrounding sediments are arched adjacent to or over the salt masses. They may thin against or over the salt to more than half their normal thickness. Normal faults frequently disrupt them; reverse faults are extremely rare. Grabens, occasional horsts, multiple offsets in single or different directions, and radial, tangential, or peripheral faults often combine to form complex patterns.

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OUTLINING OF SHALE MASSES BY GEOPHYSICAL METHODS

Shale masses are here defined as large bodies of shale at least several hundred feet in thickness. These may be formed either as diapiric masses (as described by Atwater and others) or as depositional masses. The shale masses exhibit the following properties by comparison to the normal section: (1) low velocities, in the range of 6,500′/sec to 8,500′/sec, with very little increase of velocity with depth, (2) low densities—in the range 2.1 to 2.3, (3) low resistivities—approximately 0.5 ohm-meters, and (4) high pressures—about 0.9 overburden pressure. These properties all seem to be caused by the high porosity and low permeability of these large shale masses.

Maps and cross-sections of Ship Shoal Block 113 field, offshore Louisiana, illustrate how a shale mass is outlined by geophysical means. Low velocities were measured by acoustic logs and verified by refraction shooting. Low densities were deduced from gravity maps. Low resistivities were observed on the electric logs and high pressure was deduced from drilling difficulties with heaving shales.

The shale mass, like the salt mass (commonly combined to form the domal mass), may form the updip seal for stratigraphic accumulation of oil.

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RHYTHMIC SEDIMENTATION IN UPPER PART OF MADERA LIMESTONE, NORTHERN MANZANO MOUNTAINS, NEW MEXICO

The Manzano Mountains, on the east edge of the Rio Grande Valley south of Albuquerque, are fault-block mountains tilted to the east. Precambrian rocks that make up the main mass of the mountains are overlain by about 180 feet of clastic rocks assigned to the Sandia Formation of Middle Pennsylvanian age, which in turn is conformably overlain by the Madera Limestone of Middle and Late Pennsylvanian age. Fusulinid faunas indicate that the lower part of the Madera Limestone, about 600 feet thick, was deposited during Des Moines time, and the upper part of the Madera Limestone, about 780 feet thick, during Missouri and Virgil time.

As exposed near Tajique, the upper part of the Madera Limestone consists of three similar sequences of limestone and clastic rocks, designated units B, C, and D, of Missouri, early and middle Virgil, and later Virgil ages, respectively.

Unit C, the best exposed and most typical, consists of a basal channel-like deposit of arkose and siltstone as much as 90 feet thick which, to the east, may be truncated by reef-like masses of limestone. It grades upward into siltstone followed by gray shale that contains local red beds and becomes calcareous toward the top. A limestone unit as much as 140 feet thick conformably overlies the shale. The basal part of the limestone is commonly yellowish gray, poorly bedded calcilutite that contains many algal (?) bodies. The calcilutite grades upward into light olive-gray, well-bedded, bioclastic calcarenite composed in large part of comminuted shell

[1] Deceased. Formerly with Mid-Tex Oil & Gas Co., Midland, Texas.