region, frequently called the Gulf or Gulf Coast geosyncline, is in reality only a segment of the larger feature.

Character and degree of deformation vary appreciably but they appear to be principally due to vertical stresses resulting from isostatic and gravity adjustments, density differentials, igneous emplacements, sedimentary loading, subsidence—whatever the cause, crustal thickening and flow, bulging around the perimeter of depocenters, or combinations of these. Segments of the geosynclinal mass, involved in orogenic activity which created the Sierra Madre Oriental of Mexico, constitute the Coahuila and Chiapas marginal folded provinces. Here, structural types normally attributed to compressional stresses, or to large-scale gravity sliding, predominate. Elsewhere, the presence of intrusions, volcanic flows, and tuffaceous materials discloses episodes of Triassic, late Cretaceous, and Tertiary igneous activity.

Large structural features, such as the Ocala, Sabine, Tamaulipas, and Teziutlán uplifts, and the Mississippi and Rio Grande embayments, are mobile "sags and swells" or "welts and furrows" in the developing geosynclinal province. Certain of these appear to have been positioned, possibly effected, by landward and seaward deviations (salients and recesses) in the late Paleozoic orogenic belts.

Major systems of normal, strike faults, or of pronounced monoclinal flexures are common. They are closely related to (1) fracturing of the continental margins in the early stages of the geosynclinal development, and (2) subsidence associated with rapid sedimentation. Other normal faults of divergent orientations are also numerous. Reverse and thrust faults predominate in the more deformed areas of Mexico and Guatemala.

Salt structures, many of them diapiric, are common in the salt basins of Mississippi, Arkansas, Louisiana, Texas, Tamaulipas, Veracruz, and Tabasco. Clusters of them reflect a close association of thick salt and superjacent thick sediments and, to less degree, zones of faulting and flexing.

Many of the structural features—positive or negative, large or small—have not always maintained the same form and position. As entities, they have tended to persist in a general area but the apex of maximum uplift or downwarp of a particular feature frequently has shifted in space and time. In all cases, however, the different structural features have exerted their own individual influence on the form, character, thickness, or pattern of adjacent sedimentary materials.

The oldest strata which can be considered an integral part of the geosyncline are thick, probable Triassic redbeds. Superjacent strata consist of widespread evaporites, notably halite, and redbeds which may be Triassic, Jurassic, or both, in age. Younger Jurassic, Coahuilan, Comanchean, and early Gulfian rocks vary lithically from coarse, marginal, or continental clastics to basin and platform or shelf carbonates. Thick evaporites, predominantly anhydrite, are present in the late Jurassic, Coahuilan, and Comanchean of the Gulf region in Mississippi, Louisiana, Arkansas, Texas, Tamaulipas, Nuevo Leon, Coahuila, Campeche, Yucatán, Guatemala, and probably Chiapas. Extensive, calcareous-argillaceous, marine Cretaceous beds constitute evidence of the maximum spread of oceanic waters upon North America during the Mesozoic and Cenozoic. Subsequently, in the Tertiary, waves of clastic sediments progressed into the geosynclinal province. Paleogene sedimentation centered in the Rio Grande delta region of southern coastal Texas whereas Neogene deposition was concentrated in southern Louisiana and adjacent offshore area. Tertiary thicknesses in each area exceed 25,000 feet. In the Florida and Yucatán platforms, on the other hand, deposition of carbonates predominated during the entire Mesozoic and Cenozoic.

Major sedimentary units of the geosynclinal mass are arranged in belts roughly concordant with the general trend of the modern shore. In gross form, they resemble flattened link sausages, the thick portions corresponding with centers or loci of deposition (depocenters) of particular sedimentational epochs. Several depocenters of the same age constitute a regional axis of deposition (depoaxis), the locations of which have gradually shifted gulfward since the Jurassic. Major reversals of this gulfward migration occurred in the Cretaceous and Tertiary and resulted in widespread cyclic sedimentary sequences (cyclothems).

The major source of sedimentary supply for the Atlantic segment of the geosyncline was eastern United States and Canada, particularly the Appalachian Mountains. In the northern Gulf region, Mesozoic materials were also apparently derived mainly from eastern United States but great quantities of Cenozoic detritals came from western United States. Some local land areas supplied sediment in Mexico, Guatemala, and British Honduras during the Triassic, Jurassic, and early Cretaceous but, throughout most of the Cretaceous and Cenozoic, the principal supply sources for these areas were lands at the west or south.

Thick redbeds, of Triassic or probable Triassic age, within or adjacent to the province, suggest that the geosyncline was initiated by fracturing of the continental margins when the continent generally was elevated following late Paleozoic orogenies. A major system of perimetrical faults, so remarkably accordant with structural trends in the Ouachita structural belt as probably to be related to or controlled by them, effected an almost closed, more or less starved, Gulf basin. Great quantities of NaCl and $CaSO_4$ were precipitated by an as yet unproven mechanism. Deposition of evaporites was followed by clastics and carbonates. Filling of the Gulf basin by seaward building (prograding) of sedimentary masses occurred for long periods, creating widespread conditions ideal for the generation and entrapment of hydrocarbons.

With progradation, depression of the continental edges continued; the sedimentary masses increased generally in thickness, possibly because of concentration in belts of less width; and tilting and uplift of the landward margins of the older rocks of the geosyncline occurred. Sags, swells, faults, salt structures and so on, measurably deformed and affected the sedimentary materials. These processes of accretion and deformation continue today, gradually adding girth and natural resources to the continental area.

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CURRENT RESEARCH OF THE U. S. GEOLOGICAL SURVEY

The research program of the U. S. Geological Survey comprises a multitude of investigations within two broad categories: research related to the appraisal, development, and utilization of our mineral resources—minerals, mineral fuels, and water—and research whose primary aim is to advance geologic and hydrologic knowledge. Within these two extremely broad fields, the concept of "target areas," including topical "targets" as well as geographic ones, enables us to develop our research program through concerted attacks on broad problems of regional or topical importance.

The principal targets in our research on natural resources, accounting for about 60 per cent of our current research effort, are generally in terms of specific commodities. The lines of attack on these targets include district and regional geologic mapping projects and hydrologic studies, as well as related laboratory investigations.

In research aimed primarily at increasing our scientific knowledge, the geographic targets range from entire states or drainage basins to groups of a few quadrangles; topical targets are the understanding of a variety of fundamental geologic, oceanographic, and hydrologic principles and processes. These basic research projects, which account for about 40 per cent of the Survey's current research effort, include field studies as well as experimental investigations.

Our new long-range program, embarked upon this year, calls for expansion of our mapping and research activities approximately 70 per cent over the next 10 years. Some phases of this long-range program are not measurable in specific units because they are largely concerned with basic research, in which the achievement of one goal may beget several others; in these phases the level of effort is being increased to anticipate and meet the increased requirements that must come with the Nation's continued economic growth. Some finite goals of the more specific phases of the program are: (1) complete once-over topographic map coverage of the entire U. S. with standard 7½- or 15-minute quadrangles by 1976; (2) complete geologic map coverage at 1:250,000 by 1980, and at 1:62,500 by the year 2000; and (3) complete aeromagnetic coverage, at 1-mile spacing, by 1973.

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Pre-Maquoketa (Middle Ordovician) Cyclic Sediments in the Upper Mississippi Valley Area

Five cycles are recognized in the pre-Maquoketa (Middle Ordovician) marine strata of the Upper Mississippi Valley area: two in Cambrian rocks and three in Ordovician rocks. A sixth unit, at the base of this cyclic section, shows some cyclic characteristics, but is considered to be of non-marine origin.

A complete cycle includes the following units: Phase 4, carbonate deposits; Phase 3, fine-grained sandstone, fossiliferous, dolomitic, and glauconitic and (or) green shale; Phase 2, interbedded coarse-grained sandstone, locally conglomeratic, fossiliferous, dolomitic, and glauconitic, and poorly sorted sandstone composed of particles ranging in grain size from silt to coarse sand; Phase 1, orthoquartzitic sandstone deposits.

Analogous units in each cycle contain similar attributes of mineralogy, grain size, sorting, fossil content, sedimentary structures, contact relations, geometry, and lateral variations. The thickness of cyclic components may vary and components may be locally absent.

Cycles are believed to represent transgressive depositional environments caused by periodic rejuvenation of the land and inner shelf areas with contemporaneous activity in neighboring basins. Materials delivered to the shelf range in grain size from clay to granules. As land areas were worn down, sediments of Phase 1 accumulated on the shelf, building it upward. As the supply of sediment to the shelf decreased, wave and current energy was diverted toward reworking shelf deposits. Deposits of Phase 2 indicate alternating conditions of low and high energy which produced beds of well sorted coarse- and medium-grained sand alternating with poorly sorted beds of materials ranging in size from silt to granules. During Phase 1 and Phase 2 finer particles were kept in suspension. In Phase 3 these finer particles, together with those removed from shelf deposits during reworking, were deposited. Deposits of Phase 3 are fine-grained sandstone and (or) shale which are commonly dolomitic and glauconitic. Intraformational conglomerates are common. Phase 4 is characterized by carbonate deposition believed to have begun when energy conditions reduced sufficiently for the shelf bottom to stabilize and support life.

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Trace Elements in Recent and Fossil Mollusk Shells

Analyses were performed for iron, magnesium, manganese, strontium, barium, and mineralogy in the shells of seven species of mollusks collected over much of their present-day environmental range. Correlations between the shell composition and water temperature and salinity were determined in order to evaluate the feasibility of a paleoecological tool using these elements. Significant relationships were observed, but they are generally too weak to be used for paleoecological determinations and are not consistent between species. Differences in salinity cause greater changes in shell composition than differences in temperature, but salinities above 25 ppt. do not greatly affect the shell composition.

Unrecrystallized Miocene and Pleistocene shells of five of the same species were analyzed for comparison with the Recent shells. The average magnesium and manganese contents of the aragonitic fossil shells are lower, whereas the strontium, barium, and iron contents are higher than in Recent shells of the same species. The mean strontium and magnesium contents are lower in the fossil shells of the single calcitic species studied, and the remainder of the elements do not differ significantly. The difference in composition of fossil and Recent shells are attributed to post-depositional effects.

Paleoecological studies based on the composition of carbonate skeletons, radioactive disequilibrium age dating, and the oxygen isotope paleotemperature method should be used with the realization that changes in the trace element content of both aragonite and calcite can occur without recrystallization.

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Patterns of Flow and Channeling in Tidal Inlets

Tidal inlets penetrating narrow barriers and with or without tidal deltas typically have a central trough with terminal channel fans. The trough is centrally narrowly branched at each end with multiple, lesser, converging lateral channels. Deltaic sand, where present, tends to form peripheral shoals and shoals separating the two sets of channels. The trough is a narrow horizontal slot, ratio 1/24 to 1/75 in typical examples. Deep holes occur in axial and other narrows.

Detailed studies by others show that the individual channels of an inlet can usually be identified as either entering or issuing channels, subject to being shifted by longshore currents as the tidal phases change. Without further direct current studies, the gross flow characteristics of the channel systems may be interpreted from the described conditions. In both flood and ebb (rising and falling) phases, the water level is higher on one side of the barrier than the other. For the high sheet of water to get through the inlet, it must drain centripetally into it along all unobstructed radii, a *tidal drain.* The wide