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GEOPHYSICS IS HERE TO STAY

The ever-increasing need for oil in the world market demands that the search for new oil, both on land and under the oceans, be continued or even escalated. The area of intensive search has shifted from land to the continental shelves. Geophysical methods are the most practicable tools for investigating the water-covered areas of the world because conventional geologic observations are severely limited. Recent improvements have been made in seismic energy sources, field recording procedures, and data enhancement. Three or more independent geophysical variables can be recorded simultaneously in offshore work as the ship proceeds. This technique permits a more complete analysis of the subsurface geology than previously was possible.

Job stability is needed to attract and hold good personnel. The advent of the processing center has provided some stability insofar as job location is concerned but a greater force is needed to eliminate the extreme swings in the work load. Although geophysics as a profession will have its ups and downs along with the rest of the industry, geophysicists will cooperate fully in the total exploratory effort to find new oil and gas at a profit.

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SUBDUCTION, OROGENY, AND MAINSTREAM MANTLE CONVECTION

Orogenic belts are the fossil sites of lithospheric plate subduction. Subduction along continental edges forms huge compressive drag folds or rotation zones which are expressed as fan-shaped arrangements of schistosity, folds, and dip-slip faults. Associated thrust belts are small, and are antithetic to the subduction. Large thrust belts synthetic to the subduction are typical of subduction zones which have oceanic crust in the upper plate, but may also develop as late stages of extreme rotation in continental upper plates. Most mountain systems are composed of several converged subduction zones, and most subduction zones have flipped or reversed their direction of subduction.

On the basis of the difference in crustal response to westward versus eastward underthrusting along active subduction zones, we postulate that an eastward-flowing mainstream is present within the earth's upper mantle. Coupled to convection cells beneath the oceanic ridges, the mainstream forms a pattern of migrating zones of primary and secondary upwelling which, in a kinematic model, indicates (1) that a form of asymmetric sea-floor spreading has created the small ocean basins behind island arcs, (2) that the depth to the base of convection increases systematically eastward from ridge to ridge, (3) that secondary zones of mantle upwelling underlie such features as the East African rifts, and (4) that plates descend into the mantle along subduction zones in response to the removal of material from below.

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STRATIGRAPHIC REVISION, EDWARDS GROUP (LOWER CRETACEOUS) OF TEXAS, AND REGIONAL SURFACE-SUBSURFACE SYNTHESIS

Porous carbonate rocks called "Edwards" form a widespread aquifer in the Edwards Plateau region of west-central Texas and prolific petroleum reservoirs beneath the coastal plain of south-central Texas. Recently completed surface mapping in the Edwards Plateau and subsurface mapping in south-central Texas permit correlation of Edwards rocks in both areas, and allows the entire central Texas region to be viewed as an evolving carbonate depositional complex. To better express this surface-subsurface synthesis, a new stratigraphic nomenclature is proposed: Edwards is elevated to group status, 2 new outcropping formations are recognized in the Edwards Plateau, and 2 new formations are defined in the subsurface of south-central Texas. Previously unverified disconformities at and near the top of the Edwards have been documented and a boundary that was considered to be disconformable is now interpreted to be conformable.

Regional structural-depositional elements that influenced Edwards deposition are reflected by lithofacies and isopach patterns. Dominant elements on the Comanche shelf formed a vast "sediment trap" in which shallow marine and tidal flat carbonates and evaporites accumulated preferentially over the Central Texas platform, protected by the Stuart City reef on the southeast, the Devils River bank on the southwest, and the broad North Texas shelf-lagoon on the northwest and northeast. Edwards and associated rocks record the progressive inundation of the Central Texas platform.

Porosity in the subsurface Edwards is related chiefly to early exposure on positive tectonic elements, whereas porosity in the surface and near-surface Edwards is related chiefly to the present geomorphic cycle.

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HISTORICAL GEOLOGY FROM LATE NEOGENE PLANKTONIC FORAMINIFERA

Study of the JOIDES, Deep Sea Drilling Project, Leg 1, Gulf of Mexico Sites 02 and 03; study of Texas A&M Sigsbee Knoll piston core #64-A-9-5E; and study of the Jamaica surface localities of E. Robinson (SEPM 1969 field trip) reveal a complete late Neogene history.

Marine planktonic histories are synchronous in the Gulf of Mexico, the Caribbean, and the Pacific. Across these geographic provinces from the tropics to the poles, however, the synchronous climatic events are expressed by differing and commonly unique assemblages of temperature sensitive planktonic foraminifers.

Mirror image analogs of the tropical history are represented by warmer (right coiling) and cooler (left coiling) "*pachyderma* group" biostratigraphic records in the late Neogene of Alaska and New Zealand.

These paleoclimatic events of several million years duration, based on K/A dating, are described as follows.

(1) The end of the middle Miocene warm climatic event approximately 15 m. y. ago coincides with the extinction of the "*fohsi* group" at the top of the Montpellier Formation of Jamaica and the Cipero Formation of Trinidad.

(2) The relatively cooler late Miocene recorded 2 cooler and 2 warmer events characterized by the "*nepenthes* group" and ended approximately 11 m. y. ago.

(3) A worldwide early Pliocene warm climax 7 m. y. ago was preceded by an intense cooler event of extinction and coiling changes, the "Sigsbee zone."

(4) Progressively cooling and fluctuating climates typify the late Pliocene (with *Globorotalia tosaensis*) which ended with the cold climax of the first intense Pleistocene glaciation and extreme low sea level stand.

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ALGAL MUDSTONE MOUNDS IN MORROWAN STAGE (LOWER PENNSYLVANIAN) IN NORTHEASTERN OKLAHOMA

The middle of the Morrowan Stage is marked by the development of an algal carbonate mudstone. The area of exposure covers 700 sq mi in northeastern Oklahoma with a maximum development of 60 ft in the southwestern 30 sq mi of the outcrop. A broad algal bank and smaller algal mounds developed within the area of maximum thickness, on the southwestern margin of the Ozark uplift. This area has high faunal diversity and the bank is cut irregularly by channels of skeletal sandstone. Northeastward, the faunal diversity of the unit is low, and the mudstone thins owing to replacement by skeletal grainstones and shale.

The algal mounds are up to 6 ft high and 10 ft across. The core material consists of *Archaeolithophyllum* and *Cuneiphycus* mudstone and boundstone, whereas the flank and intermound material consists of coarse skeletal packstone and wackestone. Influx of fine terrigenous clastics occurred during formation of this unit, as shale is present in small thin streaks and pockets. Locally, oolitic packstones and beds of algal oncoliths are found in the top. The mudstone is encompassed between skeletal grainstone throughout the areas of exposure.

The overall dearth of skeletal debris, abundance of algae, occurrence of stromatolite-type boundstone, burrowing, and occurrence of dolomite indicate that the mudstone was formed in a shallow subtidal or tidal-flat environment. Abundant recrystallization of matrix mud to microspar and pseudospar has taken place, and dolomite, ferroan dolomite, and siderite are present locally as replacement of skeletal debris and mud matrix.

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POSITIVE ELEMENTS WITHIN OUACHITA TECTONIC BELT IN TEXAS

Two major positive elements south and east of the foreland basins marginal to the Ouachita tectonic belt in Texas have been confirmed by wells drilled by Shell Oil Company and by seismic data in and adjacent to the concealed structural belt.

Foreland facies sediments (dominantly carbonates) of early and possibly middle Paleozoic age were drilled on the Devils River uplift in southwest Texas. In addition, much of the Devils River uplift is apparently underlain by a Precambrian intrabasement basaltic flow(?) which has been mapped from seismic reflections and penetrated in Shell No. 1 Stewart.

The presence of a second major linear positive element covered by lower Paleozoic foreland rocks has been established in east-central Texas by seismic records and by Shell No. 1 Barrett. This faulted anticlinorial structure, herein named the Navarro uplift, is at least 25 mi behind the leading edge of overthrust Ouachita facies rocks. It appears to be similar in structural position and history to the Devils River uplift but the data are insufficient to determine definitely the structural style of either.

Foreland strata are metamorphosed to greenschist facies. Some formation fluids and minor hydrocarbon shows were recovered but the quality of the reservoir was generally poor. The carbonates on the Navarro uplift contain extensive shear and flowage structures and resemble the marbles in wells on the south flank of the Devils River uplift.

Isotopic age dates from both Ouachita facies and foreland rocks record multiple Paleozoic thermal events and probable accompanying deformation along the tectonic belt. The isotopic data also suggest the presence of a post-Precambrian, pre-Late Cambrian volcanic and metasedimentary province in the area of the Devils River uplift.

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CAN AN OCEAN DRY UP? RESULTS OF DEEP-SEA DRILLING IN MEDITERRANEAN

Between 5 and 6 m. y. ago, at the climax of an episode of evaporite deposition, a series of events occurred on the floor of the Mediterranean Sea which left a fossil imprint reminiscent of a parched salina. The primary evidence of this unexpected happening was unearthed in the uppermost layers of a bedded sequence of evaporite salts of late Miocene age which were retrieved from beneath the present sea floor during Leg 13 of the Deep Sea Drilling Project. In continuous sections of core the shipboard scientific team discovered a remarkable transition from sterile chemical precipitates (gypsum, anhydrite, and halite) to deep-sea pelagic sediment. At all the sites drilled, the transition occurred between Miocene salts and Pliocene biogenic ooze.

In the eastern Mediterranean, the transition consisted of a 10-cm thick zone of dolomite gravel containing littoral benthonic fauna. Beneath the Balearic abyssal plain in the western Mediterranean, the corresponding zone is a 2-m thick bed of flat-pebble conglomerate directly overlying a massive unit of current-bedded gypsiferous sandstone. In the central Tyrrhenian basin the transition involved a pebbly breccia composed of lateritic soils, strikingly similar in lithology to the *limons rouges* of littoral sequences in North Africa and Italy.

The most plausible explanation of these findings is that a once actively precipitating deep brine basin became choked off from the open ocean and evaporation continued to the point of desiccation. Thereafter, the newly formed desert disappeared under a major marine inundation.

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GEOLOGIC APPLICATIONS OF REMOTE SENSING

For optimum geologic application of remote sensing, the user should understand the advantages, limitations, and characteristics of the various types of imagery. Selection of the optimum sensor or combination of sensors will depend upon these factors plus the nature of the terrain, geology, and the problem at hand.

Newer types of films and image processing have greatly expanded the geologic potential of conventional black and white aerial photography. Infrared color film and multiband photography extend the sensitivity range and provide greater spectral discrimination. These techniques can enhance subtle variations in soil, vegetation,