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HISTORICAL IMPLICATIONS OF A CHANGING EARTH-MOON RELATIONSHIP

For some time now, there has been broad agreement among astronomers that the distance from the earth to the moon is not a physical "constant," that it has been gradually increasing. The generally accepted *rate* of increase, however, has been so slow that during most of recorded *geologic* time, the moon could not have affected earth processes any more significantly than it does today.

Recent work by Munk of Scripps and MacDonald of NASA reopens the debate on the history of the earth-moon system. They have shown that earlier conclusions by Jeffreys and others may be in error. Extrapolation backward into geologic time, if a drastically increased rate of change in the distance to the moon is assumed, suggests a moon close enough to earth to produce major effects on geologic processes, perhaps of catastrophic proportions.

Investigations by Ewing in the South Atlantic, using seismic reflection techniques, have indicated a widespread surface below the present sea floor. Tentative interpretations of this surface by Heezen and others suggest it may represent a major event in the history of ocean sedimentation, perhaps a world-wide fall of volcanic ash or even cosmic dust.

The correlation of possible ancient earth-moon positions with known events in the geologic time table, as well as with such "uniformitarianistic" phenomena as tidal action, is thought-provoking. Recent research appears to be significant enough to warrant a closer coupling between historical geology and the "new" astronomy.

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THE EFFECT OF DECREASE IN POROSITY WITH DEPTH ON FUTURE DEVELOPMENT OF OIL AND GAS RESERVES IN SOUTH LOUISIANA

Geologists and engineers have frequently made the premise that the amount of gas in place per unit volume increases as greater depths are penetrated, because of the attendant higher reservoir pressures. In order to test the validity of this premise, a study was made of the effect of depth of burial upon the other variables in the standard formula used to calculate the amount of oil and gas in place.

Sandstone porosity data were obtained for more than 13,000 samples of conventional cores, including samples from 101 fields of South Louisiana. A curve constructed from these data demonstrates that the amount of void space per unit volume available for the accumulation of oil and gas decreases with increasing depth. This decrease in porosity, 1.265 per cent of total volume per 1,000 feet of burial, is the most important single factor controlling the amount of oil or gas in place per unit volume of sandstone reservoir rock. Exploration and development management should be conscious of the diminishing returns to be anticipated as greater depths are explored.

Porosities associated with abnormally pressured reservoirs were studied, as was the incidence of abnormally pressured reservoirs in South Louisiana as a function of depth of burial. The porosities of the abnormally pressured reservoirs, averaged by 1,000 foot depth increments, fit a straight line plot of porosities from all reservoirs.

It appears to be a reasonable hypothesis that the observed decrease in sandstone porosities with depth provides the mechanism creating the abnormal pressures so frequently encountered in oil and gas reservoirs of South Louisiana.

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SAN PEDRO DE MATURÍN DIAPIR, VENEZUELA

The San Pedro de Maturín diapir, a structural culmination along the Tonoro anticline, appears to be ideally situated for the entrapment of oil and gas migrating updip on the north flank of the eastern Venezuela basin. It parallels, and is located a few miles south of, the highly productive Santa Barbara-Jusepín trend; reservoir rocks, stratigraphic equivalents of productive zones along the latter trend, occur in the San Pedro de Maturín area. Seismic data suggest structural development at least during later Tertiary time. Paleoenvironmental data corrobate this and indicate that the initiation of structural growth occurred during the deposition of deeper water sediments, continuing as the basin filled in later Tertiary time. Seemingly favorable geological characteristics have resulted in testing of the Tonoro anticline in many locations. Numerous oil and gas shows are known but no sustained commercial production has been found.

Diapiric intrusions in the core of the Tonoro anticline may be partly or entirely responsible for the absence of commercial oil accumulations in the San Pedro de Maturín structure. The core of the structure is almost certainly diapiric, as shown by the anomalous relationships of Foraminifera, the presence of high pressure, low volume pockets of hydrocarbons, the presence of heaving slickensided shales, and the limited lateral extent of the La Pica sands in the core of the structure.

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A RÉSUMÉ OF RIVER DELTA TYPES

Deltas and deltaic sediments are produced by the rapid deposition of stream-borne materials in relatively still-standing bodies of water. Notwithstanding the effects of subsidence and water level movements, most deltaic sediments are deposited off the delta shoreline in the proximity of the river's mouth. As these materials build upward to the level of the still-standing body of water, the remainder of deltaic sediments are deposited on shore, within the delta's flood plains, lakes, bays, and channels.

Nearly 2,500 years ago, Herodotus, using the Nile as an example, stated that the land area reclaimed from the sea by deposition of river sediments is generally deltoid in shape. The build-up and progradation of deltaic sediments produces a distinct change in stream gradient from the fluvial or alluvial plain to the deltaic plain. Near the point of gradient change the major courses of rivers generally begin to transport much finer materials, to bifurcate into major distributaries, and to form subaerial deltaic plains. The boundaries of the subaerial plain of an individual delta are the lateral-most distributaries, including their related sediments, and the coast line. Successively smaller distributaries form subdeltas of progressively smaller magnitudes.

Deltas may be classified on the basis of the nature of their associated water bodies, such as lake, bay, inland sea, and marine deltas. Other classifications may be based on the depth of the water bodies into which they prograde, or on basin structure.

Many delta types have been described previously. Most of these have been related to the vicissitudes of sedimentary processes by which they form. Names were derived largely from the shapes of the delta shorelines. The configuration of the delta shores and many other depositional forms expressed by different sedimentary facies appear to be directly proportional to the relative relationship of the amount or rate of river sediment influx with the nature and energy of the coastal processes. The more common and better understood types, listed in order of decreasing sediment influx and increasing energy of coastal processes (waves, currents, and tides), are: birdfoot, lobate, cuspate, arcuate, and estuarine. The subdeltas of the Colorado River in Texas illustrate this relationship. During the first part of this century, the river, transporting approximately the same yearly load, built a birdfoot-lobate type delta in Matagorda Bay, a low-energy water body, and began to form a cuspate delta in the Gulf of Mexico, a comparatively high-energy water body. Many deltas are compounded; their subdeltas may be representative of two or more types of deltas, such as birdfoot, lobate, and arcuate. Less-known deltas, such as the Irrawaddy, Ganges, and Mekong, are probably mature estuarine types. Others, located very near major scarps, are referred to the "Gilbert type," which is similar to an alluvial fan.

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ORIGIN AND TECTONIC SIGNIFICANCE OF HIGH FLUID PRESSURES, CENTRAL VALLEY AND COAST RANGE, CALIFORNIA

Abnormally high fluid pressures exist within the Cretaceous sediments of the Sacramento Valley and probably exist within similar sediments of the San Joaquin Valley. The existing fluid potential distribution and chemistry of the pore waters strongly suggest that the abnormally high fluid potentials result from tectonic compaction stemming from continuous uplift of the California Coast Range, at least from late Tertiary into Recent time. This uplift has squeezed, as in a closing vice, the prism of Mesozoic sediments within and between the rising Coast Range and the relatively stable Sierran basement. The distribution of these high fluid potentials, laterally and with depth, suggests that the great majority of the Mesozoic sediments occupying the Coast Range has fluid pressures which approximate those exerted by the lithostatic load. Low-angle thrusting may be an important future structural event of this region as a result thereof. The production of such high fluid potentials by regional tectonic compaction may be a normal occurrence during the regional uplift of a geosynclinal system.

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BASINS OF PERMIAN SEDIMENTARY ROCKS IN SOUTHERN NEVADA

Basinal Permian sedimentary rocks of southern Nevada accumulated west and northwest of the Las Vegas hinge-line in a depocenter east of the Southern Nevada Highland; a substantially thinner contemporaneous shelf or platform facies formed to the east and southeast. Transgressive-regressive sedimentation in Wolfcampian through Early Guadalupian time accounted for variations in facies in the basin, shelf and bank margins, banks, lagoons, and deltas. Organic reefs, back reefs, and fore reefs dominated the sedimentary pattern at some times and places.

Sediments of Wolfcampian and Early to Medial Leonardian age consist of 4,500 feet of fusulinal, coralline, algal, bryalgal, and micritic limestones, and thick bioclastic limestones. This sequence comprises the Spring Mountains Formation, a basinal succession that accumulated in the miogeosyncline.

During Medial to Late Leonardian time, influx of terrigenous material from adjacent uplands accounted for substantial amounts of silty and sandy detritals in the carbonates which were forming on the shelf, hinge-line, and proximal parts of the basin; areally extensive red-colored sandy limestones, dolomitic siltstones and sandstones, and sandy dolomites thus formed in lagoonal, intertidal, bank, bank margin, and epineritic zones. This sequence is 3,000 feet thick, and comprises an unnamed formation; it interfingers across the hinge-line area and onto the platform with deltaic, neritic, and eolian sandstones and red beds of the Queantoweap, Hermit, and Coconino Formations.

Late Leonardian and Early to Medial Guadalupian time saw the filling of the basin; red -bed sedimentation of the Toroweap siltstone-shale-gypsum sequence was followed by carbonate sedimentation of the upper Toroweap and Kaibab. This succession is normally less than 1,000 feet thick in the Spring Mountains, but thickens to the east. The Kaibab Formation is in large measure reefal, and resembles the reef-tract of the West Texas Permian, but differs in that it is stretched out, has greater length, and is substantially thinner. The sponge *Actinocoelia* sp., cf. *A. maeandrina* Finks is characteristic.

The Triassic Moenkopi Formation rests unconformably upon the Kaibab; east of Las Vegas the formation is dominated by red beds, but in the Blue Diamond Mountain area it contains more than 700 feet of micritic, oolitic, pelletal, and algal limestones (=Virgin Limestone Member) near its base.

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DIAPIRS IN THE WESTERN PYRENEES AND THEIR FORELAND (SPAIN)

The diapirs of the western Pyrenees and their foreland have cores mainly of salt and evaporites of Triassic (Keuper) age. Their shapes and tectonic positions differ. They are surrounded or overlain mainly by Cretaceous and Tertiary sediments. Groups of diapirs demonstrate distinct alignments. The distribution of the diapirs is believed to be controlled by variation in the thickness of the Upper and Lower Cretaceous sediments. These sediments, which reach a maximum thickness of at least 8,000 m., exerted the necessary pressure to start the movement of the saliferous beds towards the flanks of the trough. Shifting of the trough axis in Upper Cretaceous time separated the salt accumulation into two distinct welts. Diapirism started in early Cretaceous time and must have reached its maximum activity during the late Cretaceous because most of the diapirs had reached the surface prior to late Tertiary time.

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