to be the result of a violent explosion caused by meteorite impact in very early Cincinnatian time.

Each recognizable stratigraphic interval thins over the brecciated core of the structure. Part of this thinning may be the result of differential compaction, comparable with that found over Silurian reefs. The possibility also exists that the brecciated core has been gradually and continuously uplifting, either by rebound after impact or by internal pressures locally exerting an upward movement through the area of disturbed rocks.

Isopach and structure maps indicate that the structural deformation continued into the Pennsylvanian Period and perhaps to the present time. Relative uplift of the dome has taken place at a gradually reducing rate, particularly after Devonian time.

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SYMMETRY, STRATIGRAPHY, AND PETROGRAPHY OF CYCLIC CRETACEOUS DEPOSITS OF THE SAN JUAN BASIN

Late Cretaceous strata of the San Juan Basin consist cyclically interstratified non-marine, nearshore marine, and offshore marine clastic sediments which were deposited both during marine transgressions and regressions. Thickness of the transgressive and regressive parts of these cyclic sequences varies, permitting subdivision into two types of cycles: symmetrical and asymmetrical. In symmetrical cycles the thickness of transgressive and regressive parts are nearly equal; in asymmetrical cycles the transgressive sandstone is thin or absent.

The Hosta-Point Lookout wedge is an example of a symmetrical cycle. At its base the transgressive marine Hosta Sandstone overlies non-marine strata of the Crevasse Canyon Formation. The Hosta Sandstone grades upward into the offshore marine Satan Shale. The Satan Shale marks the mid-point of the cycle and the maximum marine inundation; it grades upward into the regressive marine Point Lookout Sandstone. The Point Lookout is overlain by the non-marine Menefee Formation. Southwestward, toward the former shoreline, the Satan Shale pinches out and the transgressive and regressive sandstones merge into a single massive sandstone, which is also called the Point Lookout Sandstone. Still farther southwestward this massive sandstone grades into non-marine strata of the Crevasse Canyon and Menefee formations.

The Mulatto-Dalton cycle is asymmetrical for it lacks a basal transgressive sandstone. Instead, the offshore Mulatto Shale directly overlies the non-marine Dilco Coal with only scattered marine sand lenses at the contact. The Mulatto Shale grades southwestward (toward the former shoreline) and upward into the regressive marine Dalton Sandstone which in turn grades southwestward into, and is overlain by, non-marine deposits of the Crevasse Canyon Formation.

Petrography is closely related to the sandstone depositional environments as follows.

Sandstone Type	*Petrography*
Regressive	Upward increase in maximum and median grain diameter; upward decrease in abundance of primary dolomite grains
Transgressive	Upward decrease in maximum and median grain diameter; upward increase in abundance of primary dolomite grains
Nonmarine	Wide range of grain sizes; primary dolomite grains absent; abundant carbonaceous material

These petrographic properties may be used to identify and correlate units in problem areas.

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DIMPLE LIMESTONE MICROFOSSILS FROM THE MARATHON REGION OF TEXAS

Several exposures of the Dimple limestone in the western part of the Marathon region of Texas contain microfossils indicative of a shallow-water carbonate shelf biocoenose. Diagnostic microfossils include species of the fusulinid genera *Millerella*, *Staffella*, *Eochubertella*, *?Profusulinella* and *Fusulinella*, as well as algae and smaller Foraminifera. The fusulinids demonstrate that the Dimple Limestone is, at least in part, no older than Bendian (Atokan).

The limestone beds examined from the western and northwestern parts of the Marathon region consists, in part, of grainstones containing fossil fragments which indicate exposure to wave action. Graded bedding is generally absent, in contrast to the well graded turbidite beds (Thomasson and Thomson, 1963) on the east and southeast which contain redeposited, shallow-water benthonic fossils. Whether the western outcrops comprise redeposited material or *in situ* shelf sediments, the contained fossils establish at least a maximum age limit for the beds.

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ROLE OF GRAVITY DATA IN OFFSHORE EXPLORATION

Oil men, geophysicists, and geologists have been searching for years to find a direct method for locating oil and gas deposits. Strangely enough, an old method, gravity, comes very close to being such a method in certain areas such as the salt-dome province of South Louisiana. Most of the oil and gas fields of South Louisiana, both onshore and offshore, are associated with salt domes or salt masses. The gravity method is almost infallible in locating salt domes or salt masses.

The usual geophysical exploration procedure, a reconnaissance gravity survey followed by detailed seismic surveys of the gravity anomalies found, was not practical or feasible in the beginning of offshore exploration. Gravity exploration costs approximately ten times as much offshore as onshore and seismic exploration costs one third as much offshore as onshore. Except for a few instances, most companies completely dismissed gravity data in connection with their offshore prospecting. Improved underwater gravity meters and electronic surveying now make offshore gravity surveys practical and feasible but still rather costly. However, since the advent of joint participation by companies in extensive gravity programs, gravity data are now available at a nominal cost.

The next problem was to convince geophysicists, geologists, and management that they should obtain and use gravity data together with seismic data to evaluate offshore prospects. Many exploration people had been led to believe that the seismic method had rendered the gravity method obsolete and unnecessary.

There are numerous examples of failures on offshore seismic prospects which were selected and drilled without confirmation by gravity anomalies. In some areas seismic data are not at all conclusive, due to misleading multiple reflections, poor energy return and stray reflections, the sources of which can not be definitely determined. Since most oil fields in South Louisiana are associated with gravity anomalies, it makes sense to be sure there is a gravity anomaly to confirm the existence of a seismic structure.

There are still many structures, or prospects, to be leased and drilled offshore. The proper use of gravity data will greatly increase the ratio of successes to failures.

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NATURAL GAS REGULATION IN THE FUTURE

The pipeline transmission companies and producers may expect more liberal treatment in the future from the courts and the Federal Power Commission because this will be essential in the public interest. The Supreme Court, in the now famous CATCO case, directed the Commission to their responsibility under the Natural Gas Act to fix rates consistent with maintaining a supply of natural gas to the consumers.

We must assume that the courts and the Commission will not lose sight of this responsibility, but recent decisions disclose that this regulatory agency is not aware of the fact that they are faced at this time with maintaining a supply of natural gas to consumers.

The transmission companies must build and finance additional pipelines to meet increasing demands of consumers, but they have the problem today of obtaining the necessary funds at reasonable costs with the bloom being off pipeline investments. Consideration must be given to the depreciating rate base, rate of return, and other factors which determine the attractiveness of pipeline investments.

The Commission has recently followed the practice of not only using area pricing for the purpose of placing a lid on producers' prices, but also for rolling back existing area prices. The failure of many companies to bid on offshore acreage offered recently by the Federal Government and the State of Louisiana in areas known to contain proven or potential natural gas-producing acreage should be a warning that producers are losing their incentive to take the costly capital risks to drill for natural gas. This will have its effect on the supply of gas in 5 or 10 years. However, it is not believed that producers can hope for more liberal treatment until the Commission is convinced that there will be a shortage of natural gas in the near future.

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MANNED SPACEFLIGHT—A CHALLENGE TO GEOLOGISTS AND GEOPHYSICISTS

The advent of man in space opens new opportunities in the disciplines traditionally concerned with the surface and interior of the Earth. The synoptic view of the Earth's surface from an orbiting manned spacecraft affords a new avenue for investigation of regional geology. Considerable research and imagination are required to exploit it. The techniques developed may be expected to have important applications later in the exploration of Mars.

Men landing on the Moon will be able to apply the methods and instruments of geophysics and classical geology that are already well developed in the study of the Earth. Constraints of weight and time in spaceflight operations, however, require that considerable effort be spent in adapting these methods and instruments for optimum use in manned lunar missions. The ultimate results of this effort will include not only new knowledge about the Moon, but also new ideas, new techniques, and light-weight sophisticated instruments that can be applied in the study of the Earth.

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IMPACT SEISMIC TECHNIQUES

During the past few years there has been a general increase in the use of Impact Seismic Techniques to obtain geophysical data. In the extension and development of these techniques there has been some divergence from the original classic McCollum 2-patch technique. One such development has been the use of a large pattern of drops at a single drop area recorded by a standard multi-trace seismic unit. This is sometimes referred to as the "Mobil" technique. Another system in which a series of drop patterns are recorded along a standard seismic spread so as to provide for horizontal data stacking is designated the "Drop-Along" technique.

The relative merits of each of these techniques are discussed and their general areas of application outlined. Examples are presented showing results obtained by their use, as well as comparisons with each other and with standard shooting methods.

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CRUSTAL STRUCTURE UNDER THE CONTINENTAL TERRACE OF WESTERN NORTH AMERICA

Long reversed refraction profiles along the outer edge of the continental terrace have been made in numerous locations from Guatemala to the Bering Sea to determine the nature of the crustal section beneath the sediments. Off Guatemala, the structure is consistent with the theory that volcanic rocks and sediments have been laid down over a typical oceanic section, depressing the Moho as the upper surface built up to Pleistocene sea-level. Off western Alaska a thick section of material with granitic velocity is overlain by thick sediments; the Moho is down almost to continental depth, and the section appears to be similar to the adjacent continent.

Off the coasts of Canada, California, and Mexico, a more confusing structure is found. Depth to the Moho is between the Alaskan and Guatemalan values but does not show a progressive change. At some stations, the crustal velocities are similar to the continent; at other stations, crustal velocities are oceanic. In some places, the mantle velocity is abnormally low.

The depth to the Moho at all stations from Alaska to Guatemala is intermediate between continental and oceanic values. The mean depth is 21 km. From the data now on hand, one can only conclude that the crustal structure beneath the shelf is not uniform and cannot be reconciled with any simple hypothesis of either stability or growth of the continental mass.

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TV BOREHOLE CAMERA—A VISUAL APPROACH TO GEOPHYSICAL LOGGING

In recent years, miniaturization of electronic components has led to development of "seeing-eye" TV cameras capable of entering small-diameter boreholes. Commercially available cameras now can operate in 3-inch holes to depths exceeding 5,000 feet. Some cameras look downhole; others view sideward by means of rotating mirrors. Built-in compass systems permit accurate surveys of hole orientation and attitudes of planar elements intersecting the borehole.