The Arctic presents one of the world's most hostile environments, and any of man's enterprises in this area are subject to formidable logistical and operational problems. MINI-CREW proved to be very successful in this environment, and with modification lends itself to practical and efficient seismic operations in other parts of the world.

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COMPARATIVE COMPOSITIONAL STUDIES OF ORGANIC MATTER IN VARIOUS DEEP-SEA DRILLING PROJECT CORES

The Deep-Sea Drilling Project (JOIDES) is providing cored samples taken through the sedimentary layers of the deep ocean basins and continental rises. Preliminary organic geochemical studies on spot samples from cores in the Atlantic and Pacific Oceans have yielded data which suggest that planktonic versus terrigenous components in the total extractable organic matter may be distinguished. The biologic markers of terrestrial detritus used in this study are the high-weight paraffins (odd numbered $n-C_{27}$-$n-C_{33}$) with the corresponding high-weight fatty acids (even numbered $n-C_{22}$-$n-C_{30}$) and triterpenes. Some specific terrigenous markers found are a series of dehydroabietic acids, traceable to a conifer rosin derivation.

In addition, a remarkable degree of preservation of certain suites of organic compounds, such as monolefins and diolefins (phytadienes), has been found in anoxic recent marine cores, decreasing markedly with depth, for example, in a continuous calcareous clay and organic carbon-rich sediment from the Cariaco Trench. A concentration correlation of the phytadienes with the chlorin pigments is positive, indicating the source of these olefins is phytoplankton chlorophyll metabolized by zooplankton and thus preserved.

Recently available continuous cores from the Cariaco Trench and the Bengal fan promise to yield an excellent opportunity to analyze further and then compare planktonic, calcareous clay-rich anoxic sediments with oxic sandy-silt sequences having a high terrigenous component.

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ECONOMIC VARIABLES IN PRODUCTION OF OIL FROM OIL SHALE

The oil-shale production cost estimates reported by the National Petroleum Council in December 1972, as part of an overall study of the U.S. energy situation are the most recent publicly available data on oil-shale economics. Using the basic NPC costs, this paper examines several important parameters affecting shale oil's economic viability. Other factors pertinent to consideration of oil shale as a domestic fuel source, such as the leasing of Federal oil shale lands, water availability, and environmental restraints are reviewed.

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HUASTECA SERIES (MIDDLE AND UPPER JURASSIC) AND ITS RELATION WITH POZA RICA RESERVOIR, MEXICO

Jurassic rocks, with a stratigraphic thickness close to 400 m, have been cored in 172 wells in an area of over 8,000 sq km. These rocks are quite important because they are the only rocks in Mexico of this age that produce petroleum. A lithostratigraphic study did not explain the nature of the reservoir, the time-stratigraphic method was used to comprehend the lithofacies changes, which occur at the stage level. Stratigraphic study based on analysis of cores from the western Sierra Madre Oriental established nine zones of ammonites: *Wagnericeras, Kepplerites, Reineckeia, Discosphinctes, Ataxioceras, Idoceras, Virgataxioceras, Mazapilites,* and *Suarites* (Bathonian-Tithonian). Pelecypods also were present in the cores.

The common occurrence of the same fossils in other characteristic beds, which have been identified by radioactive well logs, permits their use as time-stratigraphic markers. These data were used to make subsurface structural and isopach maps.

In the northwestern Poza Rica area the Middle Jurassic transgression began during the Bathonian. Later it advanced to the central, east, and west parts, and the covered area is characterized by distinct transgressive lithofacies. The last phase of the transgression was in the early Tithonian in the southeast part of the trend, and calcarenites were formed which now produce hydrocarbons (San Andres). In northwestern Poza Rica, the San Andres calcarenitic member is within the uppermost part of the lower Kimeridgian stage.

The reservoirs are stratigraphic and structural traps. On the southeast the San Andres calcarenitic member can be subdivided at the stratigraphic level in the lower Tithonian; this fact is related to the occurrence of oil or salt water.

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EXOTIC BLOCKS OF FOREREEF SLOPE, CRETACEOUS VALLES-SAN LUIS POTOSI PLATFORM (MEXICO)

The outcrops of the folded Sierra Madre Oriental in the Xilitla, San Luis Potosi area, allow the study of contemporaneous, shallow-water, rudistid-reef, forereef, and basinal carbonate sediments.

The "Tamabra" and Mendez Formations represent the forereef and basinal sediments and also the host rocks of the platform-derived exotic blocks. Parts of these formations are composed largely of lithoclastic fragments of rudistid reefs, or shallow-water, fossiliferous carbonates mixed with basinal, fossiliferous micrite containing planktonic foraminifers, radiolarians, calcispheres, and a few ammonites. These sediments show such sedimentary structures as graded bedding, and thin horizontal, and convolute laminations; many of these features are arranged in combinations analogous to Bouma's sequence of turbidite structures. The exotic blocks are formed mainly of rudistid biomicrite (biolithite?); their stratigraphic thicknesses range from 10 to 95 m.

Stratigraphic correlations between the reef and forereef or basinal sediments were made by using fossils to determine the probable displacement of the exotic blocks; by palinspastic reconstructions of Barremian, Albian, and Maestrichtian times, approximate displacement of 5.5, 3.5, and 1 km, respectively, were inferred.

Although the Valles-San Luis Potosi platform is the counterpart of the subsurface Cretaceous Golden Lane platform, it does not have comparable large displacements of sediments which were derived from the reefs of the latter. These sediments were transported 10-15 km or more from the Golden Lane and are now contained in the "Tamabra Formation." Perhaps this large displacement has not yet been discovered in the Valles-San Luis Potosi platform, or perhaps the patterns of sedimentation differed, because the tectonic settings of the platforms were different.

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APPLICATION OF COAL PETROGRAPHIC METHODS IN RELATING LEVEL OF ORGANIC METAMORPHISM TO GENERATION OF PETROLEUM

The generation of petroleum is a thermal process dependent on the maximum temperature and on the duration of the maximum heating phase attained by the source rock. The coalification process, which is governed by the same factors, offers a convenient means of determining the stage of thermal alteration of organic matter, because coals form a continuous metamorphic series ranging from peat to graphite.

The LOM scale (level of organic metamorphism) devised by Hood and Gutjhar is used to correlate a variety of measures of

organic metamorphism; under ideal conditions, LOM is nearly linear with maximum burial depth. Comparison of reflectance data of vitrinite obtained from coal-bearing with other strata provides the most satisfactory method of describing the progression of organic metamorphism through a major segment of the coal-rank scale. Vitrinite reflectance studies in noncoal-bearing sequences are commonly complicated by the presence of higher reflectance vitrinite, which may result from the physical incorporation of vitrinite from older rocks or from oxidation caused by winnowing action or bioturbation. Interpretation of the reflectance data strongly hinges on a sequence of samples, a knowledge of the lithology, and knowledge of the depositional environment.

Geochemical maturity parameters, such as the *n*-paraffin ratio and the naphthene-ring index, indicate that the generation of petroleum is at a maximum for a source rock with a thermal history corresponding to a high-volatile *B* to medium-volatile bituminous coal rank (LOM 9 to 11.5), which falls within a vitrinite reflectance (*Ro*) of 0.72 to 1.20%. Studies in California and Alaska Tertiary basins show that the onset of geochemical maturity occurs at LOMs of 9-11. The depths to this zone range from 10,000 to 17,000 ft; the differences depend chiefly on variations in geothermal gradient.

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PROGRESS IN ARCTIC OCEAN SEDIMENT STUDIES

A few years ago the only information available on the deep Arctic Ocean sediments and history was based on a few short cores taken incidentally from floating ice islands by Americans and Russians. Summer work in the Beaufort, Chukchi, Laptev, Kara, and Barents Seas provided additional information but only for the marginal parts of the Arctic Ocean. Beginning in 1963, a systematic coring program was initiated from ice-island T-3 by Lachenbruch and Marshall of the U.S. Geological Survey. To date, 550 cores have been taken along the drift course of T-3, covering almost 1 million sq km of the central Arctic Ocean. Such coverage of an ocean from an iceberg is unique.

Because these cores represent the only record for such a large part of this important ocean, study has been designed to yield maximum data concerning mineralogy, petrology, paleontology, sedimentary structures, glacial erratics, paleomagnetism, and heat flow. Paleomagnetism has provided a stratigraphic framework for all of the studies. The objective of a paleoecologic interpretation of the Arctic Ocean has led to a variety of data, including information on the permanence of the ice pack and identification of the oldest sediment (Cretaceous) known in the central Arctic Ocean. Also, studies on paleomagnetism, sediments, silicoflagellates, and Foraminifera have combined in a unique manner to help establish a time reference for plate tectonics of the Arctic Ocean.

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GENERATION OF LIGHT HYDROCARBON GASES IN DEEP-SEA SEDIMENTS

Several hundred analyses have been made both on board the *Glomar Challenger* and in the laboratory on gas samples returned from the Deep-Sea Drilling Project (JOIDES). Methane was the dominant gas in all samples, commonly amounting to more than 99% of the total. Small quantities of ethane or propane were observed in areas of high heat flow, or over a possible petroleum reservoir.

Significant quantities (40 X 10^9 cu ft/cu km) of methane can be generated in the interstitial water of deep-ocean sediment where reducing conditions are initiated by rapid burial of organic matter. Comparison of carbon isotope (C^{13}/C^{12}) ratios of coexisting methane and dissolved carbonate indicates that the methane originates by bacterial CO_2 reduction. This mechanism does not involve the formation of ethane or higher hydrocarbons, or require the rupture of carbon-carbon bonds. Therefore, bacterial methane is chemically and (usually) isotopically distinct from hydrocarbon gases derived from thermocatalytic maturation of organic matter. Bacterial methane production generally begins when all sulfate is reduced, and continues with increasing depth of burial in the sediment, as long as symbiotic bacteria provide the required substrates, carbon dioxide, and hydrogen.

At some depth in the sediment column, depending on temperature and concentration, methane can exceed solubility in the interstitial water, migrate upward as a gas, and reach saturation at shallower depths. If the height of the overlying water column is greater than about 1.5 km, the gaseous methane may be converted to the solid clathrate hydrate within the uppermost (about 500 m thick) layer of sediment, where temperatures are below 20-25°C.

Stabilization of methane as a solid gas hydrate could be an important factor in the accumulation of natural gas deposits by (1) preventing loss of gaseous methane from the sediments; (2) allowing upward migration of gaseous methane at a pace controlled by the sedimentation rate; and (3) producing an enrichment of gaseous methane in the zone just below the lower limit of stability of the gas hydrate.

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SEDIMENTARY EVOLUTION OF NORTHERN APENNINES AS CONSEQUENCE OF EMBRYONIC TETHYAN SPREADING DURING LATE TRIASSIC-EARLY JURASSIC

Mesozoic Tethyan sedimentation may be explained tentatively by assuming a paleogeographic east-west-trending, narrow furrow dividing Europe from Africa. Along its northern margin are aligned the Carpathians, Northern Alps, Corsica-Sardinia, and Beticum; along the southern side are the Dinarides, Southern Alps, Apennines, Sicily, and the Atlas Mountains.

A slow transgression from Late Permian to early Lias is recognized from the Dolomites through Lombardy and Tuscany, and as far south as Sicily and the Atlas Mountains. The transgressive sequence overlying the continental facies is composed of clastic, shallow-marine deposits, evaporites, clayey or carbonate lagoon/tidal-flat deposits, shelf limestones, and cherty, pelagic limestones, or uninterrupted shelf sequences. The same facies sequence is recognized in the horizontal plane in two main directions along the main transgressive trend, and perpendicular to the isopach lines symmetrically disposed on both sides of the furrow. This situation is detected from Late Permian to Late Triassic, and is related to a slow downwarping. During early to middle Hettangian, a carbonate-shelf facies spread over the area, testifying to general marine conditons.

In late Hettangian time, a pelagic realm covered the region, and the facies distribution was controlled by faults parallel with or perpendicular to the main furrow. Thus, pelagic basins between small carbonate platforms were formed abruptly, attesting to the disintegration of the previous larger platform. However, tectonic control maintained the previous trend. In fact, the first pelagic facies are late Hettangian in Tuscany and Pliensbachian in Umbria. During Malm time, in the Ligurian region, continental crust broke up with extrusion of ophiolites which promoted jasper sedimentation, diminishing from Tuscany toward Umbria.

We conclude that the embryonic tectonic movements are detectable over great distances, through a slow shifting of facies in time and space. The rapid tectonic movements, instead,