in its upper sector a major, pre-Pliocene, NNW-SSE-trending fault. Its floor is 3-4 km wide at the head and 25 km wide near the base of the rise; at present, the upper valley serves as a funnel for sediment moving downslope. The lower valley, filled by thick (about 700 m) sediment, indicates that the valley served as a sediment trap during most of Quaternary time.

The steep (to 15°), straight, northeast-southwest-trending Emile Baudot escarpment is a young, possibly still active, fault plane to which the main foundering of the rise is related. The down-dropping is so recent that pre-Pliocene bedrock on the rise remains partly exposed. The unconsolidated material on the rise is Quaternary sand and mud, turbidites, and hemipelagites, as well as older sediment reworked from the upper Balearic platform. Some of these sediments presumably originated at the proto-Ebro River system on the northwest and were deposited in deltaic and nearshore environments in an area which now lies between Mallorca and Menorca. The Ebro sediment source was cut off as a result of the separation of the Balearic block from the Iberian Peninsula before the deposition of the Miocene evaporites.

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PHYTOPLANKTON ABUNDANCE AND DIVERSITY DURING THE LATE DEVONIAN AND EARLY MISSISSIPPIAN OF OHIO

The Upper Devonian Chagrin and Cleveland Shales contain a diverse and abundant organic-walled microplankton assemblage of acritarchs and leiospheres with associated spores, whereas the Lower Mississippian Bedford Shale phytoplankton assemblage is greatly reduced. Ten-gram samples were examined at intervals of 10 ft or less for the entire 573 cores through the 3 formations, to determine microplankton abundance and diversity.

In these samples, spores are the most abundant element, followed by leiospheres and then acritarchs. More than 50 species of acritarchs and leiospheres, mostly new, have been identified in 62 samples of the Upper Devonian section, whereas one *Gorgonosphaeridium* species occurs abundantly in all Upper Devonian samples and is present in most Lower Mississippian samples.

General acritarch diversity decreases slightly up-section in the Chagrin Shale, and increases slightly in the basal Cleveland Shale; the decrease is more marked in the upper Cleveland Shale, and is most notable in the Bedford Shale. Acritarch abundance also lessens up-section through the Upper Devonian formations, with minima in the upper fourth of the Chagrin Shale and the upper half of the Cleveland Shale. Acritarchs are very scarce in the Bedford Shale.

As total phytoplankton abundance shows a marked decrease up-section, from the middle of the Chagrin Shale to the top of the Bedford Shale, a drop in net primary productivity is indicated for the Late Devonian and Early Mississippian of Ohio.

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CARBONATE PETROLOGY OF GREEN RIVER FORMATION (EOCENE), UINTA BASIN, UTAH

The Green River Formation contains a diverse suite of lacustrine carbonate rocks comparable to that of carbonate formations of marine origin. Fossils (calcareous algae, ostracodes, gastropods, pelecypods), coated grains, microcrystalline carbonate aggregates, sparry carbonate, microcrystalline carbonate, and terrigenous grains are the main rock-forming components of the lacustrine carbonates. The most abundant allochemical constituents are polygenetic microcrystalline carbonate aggregates (intraclasts, pelletoids) and fragmental algal "plates." Coated grains (ooliths, pisoliths, circumcrusts) are less common and probably are biochemical (algal?) precipitates. Microcrystalline carbonate is the most abundant orthochemical constituent, but neomorphic and pore-filling sparry calcite are present. Dolomicrite is ubiquitous and probably formed as a replacement product of calcium carbonate before lithification. Terrigenous constituents are present in nearly all carbonate rocks; they constitute as much as 50% of some carbonates. The similarity of lacustrine and marine carbonate rocks indicates that the 2 types can not be differentiated solely on the basis of petrographic relations.

Sedimentary structures, stratification, color, and lithologic associations and variations within the Green River Formation indicate that the carbonates were deposited in a wide range of lacustrine environments. Recognized depositional environments include mudflat, lagoonal, shoal, reef, and offshore.

Preliminary $\delta^{18}O$ and $\delta^{13}C$ analyses of carbonate rocks from the Green River Formation indicate a biogenic fractionation for the microcrystalline carbonate of ooliths, pisoliths, and certain microcrystalline carbonate aggregates, and an early diagenetic replacement origin for dolomicrite.

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COMPARISON OF GEOLOGIC CYCLES OF EARTH, MOON, AND MARS

The geologic cycle of a planet depicts the interaction of impact, surface, and internal tectonic processes on the planetary surface. The earth has a "closed-loop" geologic cycle in which source rocks are eroded but are continuously recycled. In contrast, the moon apparently has an "open-loop" geologic cycle in which the primitive crust is irreversibly destroyed. On the earth, impact plays a minor role and surface and tectonic processes are approximately equally active. That is, if averaged over the globe through geologic history, the rate of uplift equals the rate of erosion. On the moon, impact processes are dominant and there are only minor surface and tectonic effects. Preliminary interpretations of the rock cycle and the "ice cycle" of Mars are presented as sources of questions for future analysis. Apparently, the geologic cycle of Mars involves surface and tectonic phenomena as well as impact phenomena.

Surface processes active on Mars include eolian erosion and deposition. The "channels" in the equatorial regions are evidence of intermittent stream erosion. The tectonic processes of Mars have been investigated by mapping regional stress patterns from analysis of observed lineament (fracture) systems.

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FINANCIAL PROBLEMS ASSOCIATED WITH ENERGY CRUNCH

The satisfaction of virtually every human need for goods and services involves the use of energy. Two-thirds of all energy consumed in the United States is for business-related purposes and a third serves private needs. Both business and private sectors utilize energy primarily for essential purposes and there is very little scope for reduced consumption without harm to the nation's economy and its standard of living.

Obviously, an energy shortage would create a critical situation for the United States, and that is precisely the kind of predicament the nation now is in. All primary sources of energy—oil, natural gas, coal, water power, and nuclear power—currently are in short supply. The shortage has not evolved because the United States lacks sufficient energy resources, but rather because of economic and environmental restraints. These energy resources cannot be developed sufficiently under the system of price regulation that has existed for the last 2 decades and without a more realistic approach to the solution of environmental problems. Consequently, the nation will be forced to rely much more heavily on foreign sources of energy in the future. Most imported energy will be petroleum and there are various reasons for believing that the inflow would be subject to frequent and possibly prolonged interruptions. The cost of foreign oil appears certain to rise sharply in the years ahead and, coupled with a rapidly expanding volume of imported oil, soon will lead to an intolerable balance of payments trading deficit.

Clearly, it is imperative that the United States maintain a high degree of energy self-sufficiency. It must develop its own energy resources as rapidly as possible. The capital investment required will be enormous and the consumers of energy, both business and private, necessarily will have to pay more than in the past.

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BONNER FORMATION (PRECAMBRIAN BELT OF MONTANA) AS BRAIDED-STREAM SEQUENCE

The Bonner Formation of the Missoula Group probably represents a braided stream sequence that prograded over sea-margin mud flats from southwestern Montana, northward across western Montana. In the Pioneer Mountains close to its source, the Bonner is both crossbedded, coarse grained, feldspathic sandstone (quartzite), reflecting subaqueous dunes in low flow regime, and horizontally laminated sand-supported conglomerate, representing deposition by transitional flow. Northwestward near Missoula, the Bonner is chiefly directionally crossbedded, coarse feldspathic sandstone (quartzite), representing subaqueous dunes. Farther northwestward, near Superior, the Bonner is mostly horizontally laminated, fine to medium feldspathic sandstone with common directionally oriented, ripple-drift cross laminae and sparse crossbeds. Here the Bonner was deposited by transition flow so shallow that upon slowing to lower regime, the bed forms altered to ripples, not dunes. Here, the Bonner also contains oscillation-rippled, mud-cracked argillite and a few stromatolite beds, indicating mud-flat deposition.

By integrating these areas, one can interpret the Bonner to have been a giant pediplain or fan traversed by braided streams that were large enough near their sources to carry small cobbles in transition flow. Near Missoula, the streams were carrying mostly coarse sand in a lower flow regime and probably were dispersing across the pediplain. By the time they reached the vicinity of Superior, the braided streams were very shallow and were carrying medium to mostly fine sand, and were interdigitating with extensive mud flats bordering a sea. The wedge of Bonner may reflect renewed movement in the late Precambrian along the Willow Creek fault zone.

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SOMETHING NEW IN EXPLORATION

Hydrocarbons are daily becoming more difficult to locate in the subsurface. The future major discoveries will most likely come from stratigraphic traps, and one of the most valuable stratigraphic tools is gathering dust in almost everyone's files. This stratigraphic tool is the well log. With massive, inexpensive, well-log digitization capabilities and computer software for analysis of data from these logs, the routine, expensive, time-consuming work can be reduced drastically and permit the geologist to do more creative exploration. Results from the computer analysis of digital logs from many wells have developed leads for exploration trends, have located possible by-passed hydrocarbon-bearing zones, and have indicated better productive zones within a well.

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STRATIGRAPHIC EVIDENCE FOR TIMING AND NATURE OF LATE CENOZOIC DEFORMATION IN LOS ANGELES REGION, CALIFORNIA

Stratigraphic evidence suggests that the complex pattern of basins, uplifts, and major faults in southern California has resulted from three successive episodes of late Cenozoic deformation: middle Miocene, Miocene-Pliocene, and Pasadenan.

Surface exposures rimming the southeast Los Angeles basin record a middle Miocene phase of major block faulting on northwest- and north-trending faults; related widespread volcanism implies crustal extension. In late Miocene and earliest Pliocene times, the east-west-trending Transverse Range deformation dominated the northern Los Angeles basin. En echelon, northeasterly sinistral faults may have been the precursors of the east-west Santa Monica fault system, on which 6-8 mi of sinistral Miocene-Pliocene offset has occurred.

Major Pasadenan deformation, involving dextral offset on northwest-trending faults, and reverse faulting on elements of the Transverse Range system, began in late Pliocene time in the Los Angeles region and is continuing. In the Baldwin Hills, continuous deep-water sedimentation into mid-Pleistocene time has recorded several pulses of Pasadenan deformation. Latest Pliocene folding, which developed more than 2,000 ft of structural relief on the Inglewood anticline, was followed by dextral faulting which transected the anticline. Lateral displacement has totaled about 4,000 ft and has been accompanied by formation of an upthrust block on the northeast flank and a graben across the axis. During the past 30,000 years, uplift in this seismically active area has proceeded at 10 times the average Pleistocene rate.

In the late Cenozoic deep-water basins of California, detailed stratigraphic studies of deformation history are essential in testing alternative orogenic hypotheses, both in oil exploration and in the evaluation of fault hazards.

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CALIFORNIA OIL BASINS AND IMPINGEMENT OF EAST PACIFIC RISE AGAINST NORTH AMERICA

The East Pacific Rise reached California 24-29 m.y. ago north of the Murray fracture zone and 18-20 m.y. ago south of it, on the basis of correlations of offshore magnetic anomalies with the Heirtzler geomagnetic time scale. This rearranged Paleogene paleogeography and established Neogene oil basins, first north, then south of the Transverse Ranges. South San Joaquin basin, central Coast Range basins, and the northern edge of the Ventura basin originated in Zemorrian-Arikareean time, 22.5-26 m.y. ago. Los Angeles basin and southern California borderland basins originated in late Saucesian time, over 15.3 m.y. ago.

Basin initiation was accompanied by volcanism, with K-Ar dates averaging 23 m.y. in central California and 15-16 m.y. in southern California. The rift basins were silled, favoring deposition of sapropelic "Monterey" shale alternating with reservoir-quality sands from adjacent highlands. High heat flow accompanying the East Pacific Rise caused early generation and accumulation of Neogene oil from these sapropelic shales, and accumulation of some and perhaps all of the oil in Paleogene reservoirs. The basins underwent almost continuous deformation because of Pacific-North American relative plate motion, resulting in early formation of anticlinal and stratigraphic traps. After disappearance of the East Pacific Rise heat source, the lithosphere cooled, increased in density, and subsided. Deformation of basins that were generally subsiding prevented uplift and breaching of many early-formed traps.

Comparable relations with the East Pacific Rise are found in several untested basins in the southern California borderland, Colorado delta and northern Gulf of California, and southern Baja California.