of the large river environment. As the basin subsided further, the major drainage facies encroached onto the flanks of the La Barge platform, resulting in buildups of thick channel, bar, and point-bar sands into the lower energy muds and silts. It is at this transition between the high- and low-energy environments the Paleocene is most commonly productive.

In early Eocene time the disturbed belt gave a last shudder, reflected by the La Barge thrust and other faults that break Paleocene strata. Of particular interest are two east-dipping thrusts, and the tendency for the young thrusts to terminate as tear faults which assist in controlling accumulation. Tectonic activity since early Eocene time has been confined primarily to regional elevation and slight basinward tilting.

The Frontier sandstones are the major gas reservoirs on the platform, and demonstrate a marked thinning from west to east. The second Frontier appears to reflect paralic depositional environments and strikingly variable reservoir conditions. Following deposition of the second Frontier, transgression resulted in the deposition of a few thousand feet of marine shale, except over the western part of the La Barge area, where a major drainage from the west built a delta into the shallow Coloradan sea. This unit is locally called the first Frontier.

Regression from west to east in Montanan time deposited the fluival and paludal sediments of the Mesaverde Formation. Littoral transitional sands at the base of the Mesaverde commonly are productive both on subcrop and across structure.

Isopach maps of Cretaceous units suggest the existence of the Moxa arch, a structural feature that now plunges southward from the La Barge platform. It was a northward-plunging positive feature during Cretaceous deposition. In latest Cretaceous and early Paleocene times, the Big Piney-La Barge area was uplifted and folded into a large anticlinal feature, with erosion stripping away newly deposited Mesaverde.

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GEOMETRY AND MORPHOLOGY OF CRUSTACEAN BURROWS IN TORREY PINES AND BODEGA ESTUARIES, CALIFORNIA

Resin casts were used to document the geometry and morphology of crustacean burrows from two California estuaries. Burrows studies include those of two ghost shrimps (*Callianassa californiensis* and *C. longimana*), a fiddler crab (*Uca crenulata*), and two grapsoid crabs (*Pachygrapsus crassipes* and *Hemigrapsus oregonensis*). Further documentation is under way with the use of direct observations and radiographs of ghost shrimp burrowing through layered sediment in aquaria.

The *Callianassa* burrows are in muddy to clean sand found in the lower parts of tidal creeks and on sand flats. Their burrows have a main shaft up to 1 m long with constant diameter (up to 2 cm) except for narrowing produced by excurrent activity either at the surface or between burrow systems, and except for enlarged turn-around nodes commonly present at branches or direction changes. Up to 5 openings were observed per system; they are connected by twos and threes in horizontal to inclined Y's with the junction of the Y up to 15 cm below the surface. The geometry of the main shaft is dependent on species, intertidal position, sediment size, and layering. The burrows have a smooth internal and external morphology.

The grapsoid burrows are on and above the banks of tidal creeks in slightly silty clay to slightly muddy sand. They vary from complex shapes, with several layers and entrances in a box-type framework, to a simple U-shape depending on topography, tidal level, and the number of organisms and species per system. Commonly two *H. oregonensis*, one *P. crassipes*, and one or more *U. crenulata* are found using parts of the same burrow system. The numerous entrances allow only lateral passage but internal enlargements permit turning around and passage of individuals. In cross section the burrows are lenticular, and the morphology of the walls *is very knobby*. Burrow entrances of *Uca crenulata* are at, or near, higher high water and extend either into a grapsoid system or a simple J-shape (up to 20 cm), both of which may have a Y-shaped entrance. The entrance and extremity chamber are about twice the diameter of the knobby, cylindrical shaft which normally has a diameter less than 1 cm.

MCKELVEY, V. E.

USGS VIEWPOINT

No abstract available.

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INTERACTIONS BETWEEN MICROBIAL POPULATIONS AND ORGANIC-MATTER DISCHARGES

Organic matter in the form of waste discharges entering an aquatic environment stimulates the growth of the resident microorganisms. The size of the resultant microbial population depends on the quantity of organic matter and the ease with which the organisms can metabolize this to obtain energy and nutrients. The oxygen supply that is essential for energy conversion is the dissolved oxygen of the water. As long as oxygen is available bacteria can oxidize the organics to simpler compounds such as CO_2, H_2O, NO_3^-, PO_4^- and mitigate adverse environmental effects.

In the natural environment microbial populations are made up of heterogeneous groups of species. Each group has a different set of nutritional requirements, and the ability to utilize specific compounds shows a great deal of variation. Complex mixtures of wastes require a heterogeneous mixture of microbial types to bring about complete degradation.

Crude petroleum is an example of a complex organic mixture. No single microbial species can bring about its complete degradation. However, a mixed population provided with the proper environmental conditions can bring about dramatic changes in oil composition. These changes follow a predictable sequence proceeding from the light-molecular-weight compounds to the heavier end of the molecular-weight spectrum and are related to natural weathering processes that occur in the marine environment.

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UPPERMOST CARBONIFEROUS STRATIGRAPHY AND DEPOSITIONAL HISTORY NEAR HUNTINGTON, WEST VIRGINIA

Excellent exposures of Conemaugh strata are present in road cuts along both sides of the Ohio and Big Sandy rivers near their confluence. Dense locality spacing permits a detailed 3-dimensional reconstruction of these repetitive, vertically and laterally diverse rocks. Most of the succession was deposited by an actively prograding delta and consists of upper-delta-plain channel, natural levee, lacustrine, and oxidized flood-plain deposits. Lesser amounts of lower delta-plain sediments include laminated, interdistributary bay and backswamp deposits, and a few thin coal seams and seat rocks.

Intercalated into the lower delta-plain sediments is one prominent, laterally extensive marine unit correlated with the Ames Member of southeastern Ohio. In this area, the Ames is tripartite and as much as 40 ft thick. The lowest part is a bluish-green, calcareous, highly fossiliferous shale, with a megafauna dominated by *Neochonetes*. It becomes coarser grained and less fossiliferous upward and is succeeded by a brackish-marine, fissile, maroon shale with pectens and ostracods. The maroon shale similarly grades upward into a massive, calcareous, crinoidal sandstone, formed as a regressive barrier, that ranges in thickness from 0 to 22 ft within a few miles. The entire marine succession was formed under extremely near-

shore conditions of reduced salinity and belongs to the *Cavusgnathus*-biofacies.

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WIDE-LINE PROFILING

A technique developed and perfected in France by Compagnie Generale de Geophysique makes it possible to record, process, and interpet reflected events originating from every direction.

The field layout is the same as that for conventional, multiple-coverage, seismic-reflection profiling. The only difference is that shot points are placed along oblique lines, so as to obtain several parallel, regularly spaced, depth-point lines. After processing, these lines yield comparable, although not identical, seismic sections, and a computer is able to analyze, by the cross correlation process, the slight shift of reflection events caused by lateral gradients.

A complete software was developed and the longitudinal dips, lateral dips, total dips, migration offsets, and time corrections are produced by a Calcomp plotter. The basic document is a section obtained by stacking the individual parallel sections after removing events which do not correlate laterally. The Calcomp displays provide the necessary parameters for migrating all events in three dimensions.

Considerable improvement over old methods was provided in tectonically complex areas. In other cases, an apparent unconformity resulted from 2 lateral events of opposite dips, a reflection on a fault plane beyond the seismic line was identified, and good results were obtained using lateral dip criteria in an area where high multiplication had been unsuccessful.

The advantage of wide-line profiling is that it expands the multiplication in lateral directions at a small cost increase. The software developed by CGG sorts out the seismic arrivals and provides tools for migration in a true three dimensional space.

The wide-line profiling technique has now reached the industrial stage and was used successfully in areas with complex structural geology, such as Spain, France, Italy, Libya, Angola, and Canada.

MILLER, E. B.

OIL INDUSTRY VIEWPOINT

No abstract available.

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SILURIAN CONODONTS FROM DEATH VALLEY, CALIFORNIA

The northern part of the Panamint Range, Inyo County, California, contains many early and middle Paleozoic marine formations, but precise stratigraphic relations are poorly known for lack of abundant megafossils and because of postdepositional dolomitization and silicification of the rocks.

The type section of the Hidden Valley Dolomite consists of 1,365 ft of light- to dark-gray, chert-bearing dolomite. On the basis of megafossil evidence, previous workers considered that the major part was Silurian and the upper 65 ft was Early Devonian.

Approximately 1,000 conodonts were identified from samples collected in a measured section about 1.5 mi north of the type section. Specimens from the uppermost 50 ft of the underlying Ely Springs Dolomite indicate a Late Ordovician or Early Silurian age. Conodonts from the Hidden Valley Dolomite indicate the presence of the European and eastern North American *Neospathogathodus celloni* zone and the younger *Pterospathodus amorphognathoides* zone within the lower 325 ft of the formation. Both zones are of Llandovery age (C_2- C_6) and represent the first report of Early Silurian conodont zones from the Death Valley area. The middle part of the formation yielded no conodonts, but a sparse fauna about 150 ft below the upper boundary contains specimens *Polygnathus linguiformis* and *Icriodus latericrescens*, suggesting an Early Devonian age. No diagnostic Devonian conodonts were recovered from the lower 100 ft of the overlying Lost Burro Formation.

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TECTONIC AND STRATIGRAPHIC EVIDENCE FOR MIOCENE GULF OF CALIFORNIA

The correlation of clasts in Eocene river gravels in Baja California with the sources for the clasts in Sonora has indicated the necessity for the dilation of the northern Gulf of California depression prior to, or concurrent with, the 23-18 m.y. opening of the Basin Range province in Sonora. The appearance of an extensive, basin-filling seaway in Baja California and Sonora during the Miocene is consistent with a regional subsidence resulting from crustal extension. The presence of shelf-type lower Miocene marine sediments on both coasts of Baja California Sur, between Loreto and La Paz, suggests that the marine waters entered the early Gulf across a shallow, nontectonic seaway which opened to the Pacific Ocean.

The recognition of the early Miocene seaway extending into the northern Gulf, coupled with a later (4-10 m.y.) opening of the modern Gulf, supports the idea of a Gulf formed in at least 2 tectonic stages.

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GEOLOGIC EVOLUTION OF NORTH-NORTHEAST CONTINENTAL MARGIN OF BRAZIL

The Brazilian north-northeast continental shelf, between 35° and 47° west, is composed of the offshore Barreirinhas, Piaui, Ceará and Potiguar basins. The total area within the 200-m bathymetric contour, excluding the shallow basement area, encompasses approximately 51,000 sq km. The sedimentary sections of these basins can be subdivided in several genetic sequences of strata, which by comparison, from older to younger, show the tectosedimentary and paleogeographic evolution of the area.

The Equatorial Atlantic rift (which probably started in Eo-Cretaceous time) had its great development in Aptian time. From the beginning of the rift opening to the end of Albian time, all the coastal basins were of the semigraben type tilted to the south. From Cenomanian to Santonian time, these basins gradually evolved into northward-opening marginal-type basins. At the end of this period, the final separation of South America and Africa took place, developing a north-south compressional stress in the fracture zones. As a result, folding, reverse faulting, transcurrent faulting, and grabens developed. From Campanian to Holocene, these coastal basins maintained their northward-open, marginal-basin characteristics.

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SEDIMENTARY AND TECTONIC HISTORY OF CRETACEOUS FLYSCH IN SOUTHWESTERN ALASKA

Cretaceous deep-water sedimentary rocks are discontinuously exposed or have been dredged, along 1,700 km of the outer continental margin of the Alaska Peninsula-Bering Sea shelf. In the Shumagin and Sanak Islands, on the continental shelf near the southwestern end of the Alaska Peninsula, the deep-sea sediments are comprised of monotonous sections of thin (4 cm) to thick (10 m) bedded sandstone and mudstone, showing grading, convolute lamination, groove and flute casts. The sandstone beds are lithic arenite with more than 40% volcanic-derived framework grains. Over 500 measurements of sole marking in the Shumagin and Sanak Islands show maxima