cline) east of the Antler orogenic continental margin. The terrigenous detritus was derived from a rising cordillera composed of Devonian and older oceanic rocks that during the Antler orogeny was first deformed and subsequently obducted eastward onto the outer carbonate shelf as the Roberts Mountains allochthon. Significant amounts of westerly derived detritus in Upper Devonian deposits reflect early Antler orogenic activity along the continental margin. Recurring uplift of the cordillera followed Antler obduction, as shown by chert detritus, derived from the allochthon, in Lower and Upper Mississippian deposits. In Late Mississippian time, clastic sediments filled the foreland basin and spread eastward across the carbonate shelf onto the craton. Volume of detritus diminished in latest Mississippian to Early Pennsylvanian time, as evidenced by widespread carbonate deposition in the Pennsylvanian.

Locally in the early Late Devonian and regionally in the late Late Devonian and Mississippian, western detritus came as a steady influx of mostly clay, silt, and sand debris, and as an irregular influx of conglomeratic debris. Many units exhibit turbidite features—graded bedding, convolute laminae, and sole marks. Some fine-clastic units contain indigenous ichnofossils and displaced fossil invertebrates, fish remains, and terrestrial plant debris; few limestones contain indigenous fossil invertebrates. The sequence and thickness of rocks vary areally, indicating irregular bottom relief which produced a complex system of sediment traps and environments.

PRICE, LEIGH C., Dept. Geol. Sci., Univ. California, Riverside, Riverside, Calif.

SOLUBILITY OF PETROLEUM IN WATER AS FUNCTION OF TEMPERATURE AND SALINITY AND ITS SIGNIFICANCE IN PRIMARY PETROLEUM MIGRATION

The aqueous solubilities of individual hydrocarbons, petroleums, and petroleum fractions increase with increasing temperatures. The rate of solubility increase is uniform from room temperature to about 100°C, after which the rate of increase rises markedly. At temperatures above 150°C, solubilities are high enough to account for the transfer of significant quantities of dissolved hydrocarbons in geologic systems.

Salinities of 350,000 ppm NaCl concentration reduce the aqueous solubilities of individual gasoline-range hydrocarbons to 5-7% of their solubilities in fresh water. A temperature drop from 150 to 25°C reduces the aqueous solubility of a whole petroleum by a factor of 4.5-20.5. Thus, the pronounced decrease in solubility of petroleums at higher salinities and lower temperatures encountered at shallow depths readily serves to release dissolved hydrocarbons during the upward movement of subsurface waters.

Other investigators have shown that 15-20% water, by volume, remains in Gulf Coast argillaceous sediments at depths below 14,000-18,000 ft. This quantity of water is sufficient to account for the primary migration of petroleum from source rocks by molecular solution.

Faults are believed to provide the pathways for vertical movement of water and dissolved hydrocarbons from great depth. Eventually the fluids are focused into sands when the fault becomes impermeable to further fluid movement. Field examples are present in the Gulf Coast and Los Angeles basin. This mechanism is restricted to argillaceous basins containing high concentrations of expandable mixed-layer clays that are buried to a minimal depth of 20,000 ft. It does not apply to carbonates or argillaceous limestones in which primary migration can occur at much shallower depths.

PRYOR, WAYNE A., Dept. Geology, Univ. Cincinnati, Cincinnati, Ohio

PETROLOGY AND SEDIMENTOLOGY OF *OPHIOMORPHA NODOSA* AND MODERN CALLIANASID BURROWS

The trace fossil, *Ophiomorpha nodosa* Lundgren, callianasid burrows, and other similar decapod domichnia exhibit petrographically distinct wall structures that are formed by the mandibular activities of the decapods during construction of their tubular domiciles. These decapod burrows are lined with one or two layers of aggregated sand pellets, 1-10 mm in diameter. The pellets, in turn, are composed of radially oriented, 0.025-0.5-mm subspherical masses of sand grains in a fine-grained, organo-clay matrix.

Callianasid decapods live and construct ophiomorphid burrows in a wide range of marine and brackish-water environments, including estuaries, bays, lagoons, tidal pools and creeks, beaches, shallow-littoral deposits, and in sediments at least 1.5 km offshore at depths of at least 12 m. Ophiomorphid burrows of *Callianasa major* and *C. atlanticus* average only about 5 burrows/sq m in the high-energy, open-marine shore zones and increase to an average of 20 burrows/sq m in 10 m of water, 1 km offshore. The highest concentrations of actively used ophiomorphid burrows, up to 450/sq m, are in the protected, low-energy, tidal pools of the bay and lagoon shores. Contrary to previous reports, callianasid burrows and their ancient equivalents, *Ophiomorpha nodosa* Lundgren, are not indicators of the high-energy, open-marine littoral zone.

Callianasa major and *C. atlanticus* burrows extend down, vertically, to depths of 4.7 m below the sediment surface, where they branch laterally as interconnected, horizontal gallery systems of wide extent. Identical configurations of *Ophiomorpha nodosa* Lundgren are present in the Gulf Coastal Plain Mesozoic and Cenozoic sediments.

RICCI LUCCHI, FRANCO, Univ. Bologna, Bologna, Italy

SEQUENTIAL ANALYSIS OF TURBIDITE BASINS IN NORTH-CENTRAL APENNINES

The Miocene Marnoso-arenacei and Laga Formations form two of the largest outcropping turbidite units of the north-central Apennines, where extensive exposures make facies analysis feasible. Following a more general model proposed by Mutti and Ricci Lucchi (which utilizes bed geometry), sedimentary structures and texture, facies association (slope, submarine fan, basin plain) and sedimentary facies (conglomeratic sandstones, sandstones, sandstones with shale interbeds, shales with sandstone interbeds, chaotic deposits, hemipelagic pelites) were recognized. The value of sequential analysis for comparing stratigraphic subunits within a submarine fan system, and particularly for differentiating between inner fan, mid-fan, outer fan, and basin-plain environments, is emphasized. Recurrent patterns of sedimentation (megasequences or megarhythms, 10-100 m thick) are composed of sets of thick, mostly arenaceous, massive, graded, or crudely laminated layers, with alternate finer grained beds, which are thinly laminated in the lower part. Two main types of "ordered" megasequences are recognized: (A) positive, or thinning upward, interpreted as filling of fan valleys or channels; and (B) negative, or thickening upward, considered to be prograding outer fans along nonchanneled distributaries. Three monotonous, or random, sequences composed of finer grained sediments are also present: (C) slope deposits (thin layers, with a sandstone/shale ratio less than 1); (D) interdistributary fan deposits (thin to medium layers, sand/shale ratio less than 1; and (E) basin-plain deposits (medium to thin layers, with sporadic isolated thick turbidite units, sandstone/shale ratio greater than 1). The vertical association of these subunits, and especially those of the A and B megasequences, show both similarities and differences in the sedimentary history and tectonic control of the Miocene basins. Further application of these criteria to other turbidite basins probably will aid in predicting the location and geometry of sandstone bodies.

RISTVET, BYRON L., FRED T. MACKENZIE, Dept. Geol. Sci., Northwestern Univ., Evanston, Ill., and DONALD C.