interbedded with basal sandstones. This facies was deposited in part on the remnants of a Middle to Late Jurassic volcanic arc. It is laterally equivalent to the Nooksack Group and underlying Wells Creek volcanic rocks, and correlative with strata in the Methow trough. Overall, the stratigraphic sequence and basement rocks are remarkably similar to the basal Great Valley sequence and underlying rocks in the California Coast Ranges. The western facies consists of thinly bedded to massive volcaniclastic sandstones complexly interbedded with ocean-floor (MORB) basalts, basaltic tuffs, ribbon chert, and polymict pebbly mudstone. Clastic rocks contain rare fragments of amphibolite, blueschist, and upper Paleozoic limestone in addition to voluminous volcaniclastic debris. This clastic eugeosynclinal association is a deposition unit rather than a melange formed by offscraping or accretion. In contrast to the eastern facies, basaltic rocks and pelagic cherts are distributed throughout the section and are interspersed with terrigenous clastic rocks. Coeval, lithologically comparable sequences are the Kelp Bay group (southeastern Alaska), the Pacific Rim complex (western Vancouver Island), and probably the Yolla Bolly terrane in the easternmost Franciscan. The western and eastern facies in northwestern Washington are presently separated by middle Cretaceous thrust faults.

CRADDOCK, CAMPBELL, Univ. Wisconsin, Madison, WI

Tertiary Deformation in Western Spitsbergen

During Cretaceous time, before the opening of the northernmost Atlantic Ocean, western Spitsbergen lay oppostie northeastern Greenland. With the opening of the Norwegian Greenland Sea during early Tertiary time, Spitsbergen slid past northeastern Greenland along a transform fault zone. This strike-slip displacement was accompanied by a strong transpression of the adjacent rocks, causing uplift of crustal blocks in a narrow belt along the western coast of Spitsbergen. Eastward from this coast, three structural zones can be recognized; (1) a 30-km-wide coastal zone of Hecla Hoek strata (upper Precambrian-lower Paleozoic) which was strongly deformed during the Caledonian orogeny and uplifted during early Tertiary time; (2) a 10-km-wide disturbed zone of Devonian-Cretaceous strata with some sills; tilted, folded, and faulted during early Tertiary time; and (3) an interior zone of flat-lying Tertiary sedimentary beds. Most Hecla Hoek structures are probably pre-Devonian, but a prominent westward-dipping foliation may be Tertiary in age. The beds of the disturbed zone display an impressive variety of folds and faults related to uplift, tilting, and slippage between beds; one cliff shows a sequence with large recumbent folds resting in fault contact upon an unfolded sequence. Other structures, however, are related to eastward thrusting of the massive Hecla Hoek rocks onto the younger beds. A graben in the coastal zone, with nearly horizontal Tertiary beds, probably reflects a new tectonic regime (transtension) that formed after Spitsbergen had moved clear of Greenland.

CRAWFORD, G. ALLAN, Union Oil Co. of California, Brea, CA

Allochthonous Carbonate Rocks in Toe-of-Slope Deposits (Permian, Guadalupian), Guadalupe Mountains, West Texas

Channelized allochthonous carbonate toe-of-slope deposits, equivalent to the Goat Seep Dolomite, and possibly the Getaway Bank, are well exposed along the west face of the Guadalupe Mountains. There are five rock types present: (1) fine rudite conglomerate, (2) carbonate megabreccia, (3) oolitic packstone/grainstone, (4) wavy-laminate wackestone, and (5) thin-bedded sandstone/siltstone. The rudites ($\sim < 1.0$ m thick) appear to have been deposited by laminar debris flows, as evidenced by clasts aligned parallel to bedding, a non-erosive base, and the presence of a rigid plug. In contrast, the megabreccias (> 2 m thick) may have been deposited by turbulent debris flows, based on their erosional bases and lack of aligned clasts. The other rock types are interpreted to have been deposited by fluid density flows and turbidity flows.

The carbonate rocks in the toe-of-slope strata occur in lens-shaped deposits (0.5 km wide × 30 to 50 m deep) that are surrounded by sandstone and siltstone. The lenses are interpreted as basinward-trending channels that have been filled with shelf- and shelf-edge derived sediments deposited at the base of a carbonate buildup. The channels are typically filled with megabreccia at the base, consisting largely of shelf-edge debris, which is overlain by finer rudites and/or oolitic packstone/grainstone, consisting largely of shelf-derived debris. It is interpreted that the megabreccias were derived from large slumps or slides near the shelf-edge and that the shelf-derived sediments were later carried across the shelf-edge and were deposited in the toe-of-slope as separate, finer units.

CRESS, LELAND D., Colorado School Mines, Golden, CO (Present address: Pennzoil, Denver, CO)

Climatic and Structural Controls of Stacked Algal Lime Mud Mound Development in Oquirrh Group (Pennsylvanian and Permian), Deep Creek Mountains, Southeastern Idaho

Oquirrh Group rocks comprise the uppermost of a series of allochthons exposed in southern Idaho. The basal unit of the Oquirrh Group, the West Canyon Limestone (Atokan), is composed largely of lime mudstone and fossiliferous lime wackestone with the exception of a coarse quartzarenite and lime mudstone clast debris flow that originated from syndepositional faulting. Overlying this unit are unnamed cyclic back-mound siltstones, sandstones, cherts, and fossiliferous wackestones and packstones that thicken southward from 270 to an estimated 1,000 m of noncyclic strata of similar lithologies. Cyclic, thinly stacked algal lime mud mounds are inferred to have developed in Desmoinesian time. In Virgilian time, syndepositional faulting controlled the development of thickly stacked (700 m) algal, lime-mud mounds. To the north and west, cyclic back-mound lithofacies consist of siltstone, sandstone, chert, lime mudstone, and fossiliferous wackestone and packstone. Similar but noncyclic fore-mound lithofacies are greatly thickened southward suggesting that syndepositional faulting controlled sedimentation.

In Wolfcampian time, cyclic, stacked bryozoan algal lime mud mounds (300 m thick) developed. Thin tabular lime mud mounds developed in cyclic back-mound lithofacies. Similar fore-mound lithofacies thickened in a southerly direction. As many as 50 cycles developed in Middle Pennsylvanian to Lower Permian rocks. Eustatic sea level changes caused by late Paleozoic glaciation controlled cyclic sedimentation.

Syndepositional faulting in Atokan, Desmoinesian, and Virgilian times also had the effect of keeping the northern and eastern parts of the study area in the marine photic zone. This area may have constituted a paleohorst within the Oquirrh basin in Pennsylvanian and Permian times.

CREVELLO, P. D., J. W. PATTON, G. K. GUENNEL, Marathon Oil Co., Littleton, CO, et al

Source Rock Potential of Basinal Carbonate Muds, Bahamas

Some carbonate muds deposited in intraplatform basins of the Bahamas contain sufficient organic matter to be considered potential source rocks. The sediments are Holocene to late Pliocene and immature.

Total organic carbon (TOC) values range between 0.1 and 2.58% for the basinal sediments of Tongue of the Ocean and Exuma Sound, though averaging 1.0% in the Tongue versus 0.33% for Exuma Sound. The difference appears to be related to the sedimentation rates of the basins, estimated to be 10 to 200 mm/10^3 years for Tongue of the Ocean and 4 to 50 mm/10^3 years for Exuma Sound.

In Tongue of the Ocean we have correlated cyclic variations in TOC with fluctuations of sea level. High sea levels are recorded by aragonite-rich basinal muds (peri-platform ooze) with an average TOC of 0.7% and an abundance of organic-rich turbidite muds with TOC averaging 1.21%. Peri-platform ooze deposited during low sea levels is calcitic, contains few turbidites, and generally is organic lean—0.1 to 0.3% TOC. Of the organic matter, δC^{13} suggests different sources for the organics deposited in the turbidite muds (−13.9 to −16.4‰ PDB) and the peri-platform ooze (−17.4 to −26.13‰ PDB). Cyclic variation in organic content in the Tongue is portrayed in the color of the muds: green muds have high TOC, while brown and white muds are leaner. Cyclic variation in sediment color also occurs in Exuma Sound and Columbus Basin. Basin depth does not seem to influence the TOC: Columbus Basin, the deepest, appears to be as rich in organics as the Tongue (shallowest). No clearcut correlation with kerogen types is seen at present.

Gas chromatographic analysis of organic matter evolved from samples heated only to 350°C demonstrated that the material evolved was not simply vaporized, but represented the thermal cracking of relatively heat-sensitive material. Mass spectral pyrolysis experiments on some samples suggests the presence of amino acids or proteins.

CROUCH, JIM, Sohio Petroleum Co., San Francisco, CA

Continental Borderland off Northern Baja California, Mexico: Rifted Segment of Pacific Margin

The California continental borderland consists of two geomorphic provinces: the northern borderland which forms the Pacific margin off southern California and the southern borderland which forms the margin off the northern Baja California peninsula. Although these two provinces are longitudinally continuous, bathymetric, geophysical, and bottom sample data suggest that their structure, lithology, and tectonic evolution differ markedly. Relative to the northern borderland, the southern borderland is on the average much deeper (0.5 to 1 km), ubiquitously volcanic (basaltic), and from heat flow and isostatic considerations, underlain by much thinner crust. Seimsic reflection profiles across the southern borderland show a thin veneer (generally <300 m) of relatively undeformed strata overlying an irregular nonstratified acoustic basement. Dredge hauls from exposed basement highs along these profiles have yielded chiefly basaltic rocks.

Major northwest-southeast-trending synclinoria bound the northwestern and southeastern limits of the southern borderland (Valero Basin and Vizcaino Bay, respectively), and the synclinal axes of these basins strike directly into the southern borderland. Seismic refraction data across these synclinoria indicate that they contain more than 3 km of sedimentary strata (above 6.6 km/sec basement) or at least 10 times the thickness of sedimentary strata recognized on seismic reflection profiles that cross the southern borderland.

The available data suggest that the southern borderland is a rifted segment of the Pacific margin. The extent of rifting is estimated to be about 260 km on the basis of basalt outcrops and seismic reflection profiles. Rifting had probably begun by 17 m.y. ago, and is inferred to be related to the southward migration of the Rivera triple junction.

CULVER, STEPHEN J., and MARTIN A. BUZAS, Smithsonian Inst., Washington, D.C.

Distribution of Recent Benthic Foraminifera from Newfoundland to Yucatan

Benthic foraminifera are important environmental and paleoenvironmental indicators. In 1978, we commenced a project to produce a syntheses of the depth and geographic distributions of all species of recent benthic foraminifera recorded on the continental margins of North America using all published data (800 papers published over the past 150 years). To date, this project has resulted in computerized compilations for the Atlantic continental margin, the Gulf of Mexico, and the Caribbean region. Data manipulation has produced maps dealing with individual species distributions, genus distributions, and foraminiferal zoogeographic provinces. Geographic and depth distributions for over 300 commonly recorded species are tabulated for the eastern continental margin and the Gulf of Mexico. Four depth-related groups of species are noted for the east coast and 14 for the Gulf of Mexico. Species distributions can be used as paleoenvironmental (including paleobathymetric) indicators back at least to the Miocene and genus distributions back to the late Cretaceous.

CUMELLA, STEPHEN P., Univ. Texas at Austin, Austin, TX

Mixing-Zone Origin of "Primary" Dolomite Grains from Cretaceous Marine Sandstones of Western Interior Basin

In a series of papers in the early 1960s, the occurrence of "primary" dolomite grains in Cretaceous sandstones of the Western Interior basin was documented. These grains are usually single crystals, with a rhombic outline that has been modified to varying degrees of roundness by abrasion. The grain size of the dolomite mimics that of other grains in the sandstone. Because these dolomite grains are confined to marine facies, it is unlikely that they are extrabasinal. Also, there is no evidence that the dolomite formed by replacement of other grains. The remaining possibility is that dolomite formed within the basin before significant burial.

Petrographic and stratigraphic evidence from the San Juan basin suggests that primary dolomite was formed in a mixing zone of meteoric water that discharged into shoreface environments. Thick coastal-plain coal sequences and paleoclimatic reconstructions support the existence of a large meteoric flow system in the western part of the Western Interior basin during the Cretaceous. As meteoric water discharged into shoreface sediment, dolomite rhombs were precipitated in the interstices of uncompacted sands. Some of the dolomite thus formed was close enough to the ocean bottom to be later eroded, abraded, and redeposited during storms or transgressions. Dolomite rhombs that were not eroded are similar in appearance to resedimented grains, but show no evidence of abrasion.

CURIALE, JOSEPH A., Univ. Oklahoma, Norman, OK

Origin and Geochemical Correlation of Near-Surface Oil and