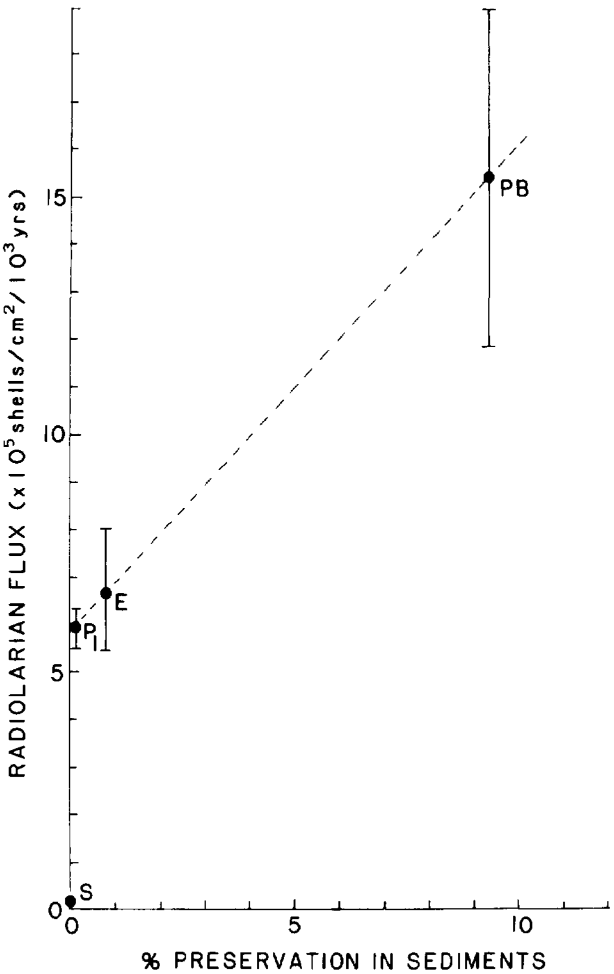
extent of fluxes to the sea floor (see figure). Differential preservation of the species is evidently taking place. For example, Spumellaria, a solution resistant end member, represents 29.2% preservation, whereas Nassellaria and Phaeodaria represent 2.8% and 0%, respectively, in the core tops from the Panama basin. Clearly, thanatocoenosis in the Holocene sediments is drastically different from the living counterparts in the overlain water column. Major dissolution depth of spumellarian and nassellarian shells is at the sea floor. Phaeodarian shells dissolve in the water column as well as at the sea floor.



THOMPSON, K. F. M., ARCO Oil and Gas Co., Dallas, TX

Origin of Natural Gas, San Juan Basin, New Mexico

The Lower Cretaceous Dakota Formation produces gas, gas-condensate, and at the basin margins, gas-rich oil. The coal-bearing Upper Cretaceous produces gas with little or no condensate. Delta ^{13}C(PDB) values for methane, measured in dry and condensate-bearing gases, average −43.3 ±3.4‰, indicating derivation from sapropel and petroleum, not coal. Locally, isotopically identical methanes occur in all productive formations over a stratigraphic interval of 1,500 m (4,900 ft). Gas chromatography revealed close similarities in ratios involving the subsidiary alkanes of gases in the Dakota, Mesaverde, and Pictured Cliffs Formations. Both lines of evidence demonstrate extensive vertical migration. In the Dakota Formation there is an approximate gradient from the center of the basin to the margin in the $\delta^{13}C$ values of methanes: from −37.7‰ (Ro = 1.9%) to −51.9‰ (Ro = 0.7%).

The mean $\delta^{13}C$(PDB) value of three basin-margin oils is −27.7 ± 0.2, whereas the condensates of the central portion of the basin average −27.2 ± 0.6. These facts are interpreted in terms of a derivation of gas condensate from oil. Condensates and oils were compared on the basis of the detailed composition of their gasoline fractions, particularly in terms of paraffinicity (heptane and isoheptane values). Allowing for natural fractionation, the paraffinicity values were very similar, indicating that the condensate liquids and oils had almost identical thermal histories, rather than the oils being of normal thermal aspect and the condensates mature or supermature. This suggests that most of the condensates sampled were formed by merely physical processes. Abundant gas, generated in the central supermature basin region is postulated to have caused entrainment of oil liquids (condensate) in solution, and to have migrated to cooler reservoirs, both vertically and updip. Apparent gas migration pathways are traceable in fluid property (GOR) data in the Chacon Dakota field.

Deuterium/hydrogen ratios were determined in methanes from Dakota and Mesaverde reservoirs in the high-rank, basin-center region. Although both formations contain Type III kerogen or coal, delta D (SMOW) values of −164‰ and −167‰, respectively, are compatible with those of other dry, mature petroleum gases. When considered in conjuction with the carbon isotope ratios, the values did not indicate derivation of the methanes from coal, though some admixture could have occurred.

THOMPSON, P. R., ARCO Oil and Gas Co., Dallas, TX

Foraminiferal Evidence for Sources and Timing of Mass-Flow Deposits South of Baltimore Canyon

Shallow seismic reflection surveying of the continental rise between Accomac and Baltimore Canyons shows stratified layers overlying an unstratified interval believed to be mass-flow deposits. Planktonic and benthonic foraminifera from 43 piston cores and grab samples, collected between 150 and 2,360 m (492 and 7,743 ft) depth, have been used to interpret the source and age of unstratified sediments along canyon axes.

Five mappable seabed faunal distributions characterize the outer shelf, slope, and upper rise. Multiple regression was used to relate Rose bengal stained assemblages as well as total sediment assemblages to water depth , median grain size, bottom temperature, and oxygen content in order to index the subsurface samples to these modern physical parameters.

Major lithologic and micropaleontologic contrasts characterize the sediment columns from the canyon axes: soupy, olive clays with foram assemblages similar to living populations overlie firm, gray to rusty-brown clays with Pleistocene planktonic foraminifera and benthics today found in upper slope areas. This, combined with the presence of sand layers bearing shelf forams, suggests that the mass-flow deposits are related to slope failures in response to glacially lowered sea levels.

THORNBURG, TODD M., and L. D. KULM, Oregon State Univ., Corvallis, OR

Depositional Environments and Sedimentary Processes in Chile Trench

The Chile Trench is a long, linear basin that concentrates clastic terrigenous material at the foot of the Andean continental margin. In southern Chile, high rainfall and river runoff, combined with intense Pleistocene glacial activity, transport large volumes of detrital sediment to the offshore regions. Sediment bypassing the continental margin has produced a wedge-shaped deposit which swells to >30 km (>18.6 mi) in width and 2 km (6,560 ft) or more in thickness. Convergence of the Nazca plate with South America at the rate of 10 cm/yr indicates that these trench wedge deposits are no older than 300,000 years. Good piston core control over the wedge shows that very fine to medium-grained sand may locally constitute >50% of the stratigraphic section.

Two distinct depositional environments exist in the south Chile trench. South of 41°S lat., it appears that unconfined turbidity sheet flows spread radially from the mouths of submarine canyons to deposit laterally extensive, rhythmic sequences across the entire trench wedge. Seismic reflectors in this region are flat and continuous. In seven piston cores, graded sand beds can be correlated across 30 km (18.6 mi) by stratigraphic position, mineralogical content, ash content, radiometric dates, and characteristic grain-size distributions (i.e., mean size, sorting, skewness); individual sheet flows can be identified and studied spatially. Skewness is consistently positive; the mode is perhaps the most descriptive grain-size parameter since it most closely reflects the carrying competency of the turbidity current at the time of deposition.

At 41°S lat., an axial channel (up to a few 100 m in depth) develops in the trench wedge, trending northward along the gravitational gradient. Sediments may be transported parallel to the margin, via the axial channel, hundreds of kilometers from their canyon mouth source. In this region, submarine fans develop at the mouths of submarine canyons, prograding across the trench wedge and displacing the axial channel seaward; the fan distributaries become confluent with the main axial channel. Tensional faulting in the subducting oceanic basement commonly displaces the overlying trench strata; these normal faults can influence the position of the axial and fan channels. Alternating periods of deposition (characterized by flat-floored channels, levees about 50 m [165 ft] high, and graded silt and sand facies) and periods of erosion and/or winnowing (characterized by V-shaped furrows; reflection hyperbolics; seismic reflectors truncated against erosional scarps; and massive, nongraded, laminated sand facies) combine to produce complex fan morphologies (such as inactive or remnant lobes, hanging valleys, and possibly braided channels) and sedimentary facies that change rapidly over space and through time.

Late Pleistocene to Holocene sedimentation rates in the Chile trench range from several centimeters to >1 m/1,000 yr (>3 ft/1,000 yr). Erosional hiatuses and a variety of depositional environments contribute to the wide range of sedimentation rates.

THUNELL, ROBERT C., Univ. South Carolina, Columbia, SC and BRUCE H. CORLISS, Woods Hole Oceanographic Inst., Woods Hole, MA

Late Eocene and Early Oligocene Carbonate Sedimentation in the Deep Sea

The transition from carbonate-poor late Eocene sediments to carbonate-rich early Oligocene sediments undoubtedly reflects a major reorganization of the way in which carbonate was fractionated between shelf regions and deep basins. During Eocene time carbonate was being deposited on the shelves marginal to the extensive Tethys Sea, whereas in Oligocene time carbonate sedimentation on the continental shelves decreased, but increased in the deep sea. In the deep sea, this facies change represents a lowering of the carbonate compensation depth (CCD) with the magnitude of the drop varying in a systematic fashion from one ocean basin to another. The CCD drop was most dramatic in the equatorial Pacific, sinking nearly 1,500 m (4,900 ft) in less than 2 m.y. Both the magnitude and abruptness of this drop in the CCD decrease steadily away from the equatorial Pacific. In the South Pacific and South Atlantic, the CCD drop across the Eocene/Oligocene boundary was on the order of 1,000 m (3,280 ft) and 750 m (2,460 ft) respectively. Similarly, in the North Atlantic, not only was the magnitude of this drop reduced to only several hundred meters, but it appears to have occurred over a prolonged period of time.

By early Oligocene time a distinct latitudinal trend in the depth of the CCD existed in the Atlantic Ocean. The maximum depth was centered around 10°N paleolatitude and most probably marked a zone of high productivity. Above 40° north and south lat., there was a definite shoaling of the CCD. This is a feature that also occurs in the present-day Atlantic and may be due to the production of cold bottom waters at high latitudes.

Time series carbonate records from sites located above the CCD show varying responses across the Eocene/Oligocene boundary. DSDP Site 219 (Indian Ocean) and Site 292 (western equatorial Pacific) show no change in carbonate content across this boundary indicating that they were consistently above not only the CCD but the lysocline as well. In contrast, Site 77B (eastern equatorial Pacific), Site 277 (southwest Pacific), Site 363 (southeast Atlantic), and E128 (Gulf of Mexico) all show decreases of 10 to 25% across the boundary in conjunction with a distinct dissolution event. All of these sites may be recording a shoaling of the lysocline that accompanied the drop in the CCD across the Eocene/Oligocene boundary.

TONNSEN, JOHN J., General Hydrocarbons, Inc., Billings, MT

Influence of Tectonic Terranes Adjacent to Precambrian Wyoming Province on Petroleum Source and Reservoir Rock Stratigraphy in Northern Rocky Mountain Region

The perimeter of the Archean Precambrian Wyoming province can be generally defined. A Proterozoic suture belt separates the province from the Archean Superior province to the east. The western margin lies under the Western Overthrust belt and extends at least as far west as southwest Montana and southeast Idaho. The province is bounded on the north and south by more regionally extensive Proterozoic mobile belts. In the northern belt, Archean rocks have been incorporated into the Proterozoic rocks, but the southern belt does not appear to contain rocks as old as Archean. The tectonic response of these Precambrian terranes to cratonic and continental margin vertical and horizontal forces has exerted a profound influence on Phanerozoic sedimentation and stratigraphic facies distributions. Petroleum source rock and reservoir rock stratigraphy of the northern Rocky Mountain region can be correlated with this structural history. In particular, the Devonian, Permian, and Jurassic sedimentation patterns can be shown to have been influenced by articulation among the different terranes comprising the ancient substructure. Depositional patterns in the Chester-Morrow carbonate and clastic sequence in the Central Montana trough are also related to this substructure. Further, a correlation between these tectonic terranes and the localization of regional hydrocarbon accumulations has been observed and has been useful in basin analyses for exploration planning.