cm/year and 1.75×10^{-7} mmol/sq cm/year. The diffusion coefficient in this zone is in the range of 2.8×10^{-7} to 4.2×10^{-7} sq cm/sec. Below 4 m the diffusion coefficient was less than 5.4×10^{-8} sq cm/sec.

DOTT, R. H., JR., and M. CHAN, Univ. Wisconsin, Madison, WI

Eocene Eustatic Versus Tectonic Changes on Pacific Margin—Comparison Between San Diego, California, and Coos Bay, Oregon

Distinction of eustatic from tectonic causes of sea level change in environments like the Pacific margin is difficult, but the worldwide Vail sea level curve provides a useful standard for comparison. It has been applied with apparent success to the Paleogene of southern California. At San Diego, early Eocene regression was followed by middle Eocene transgression and partial filling of a submarine canyon. At the end of middle Eocene time, regression allowed a gravelly fan-delta to debouch into the canyon. Transgression followed in late Eocene time, and then latest Eocene regression resulted in deposition of nonmarine sediments. These three sea level changes fit the Vail curve so well that eustatic changes seem indicated.

Around Coos Bay, Oregon, middle Eocene turbidites (Flournoy-Tyee) with bathyal foraminifera are overlain by siltstones with evidence for deposition in shallowing-upward neritic depths (Elkton). This prograding shelf sequence is punctuated by channels filled with siltstone or massive sandstone. Shelf deposits are overlain unconformably by a coarse, sandy, coal-bearing facies (Coaledo), which represents progradation by a delta complex across the former narrow shelf. Both here and at San Diego, deltas remained active during late Eocene transgression. Regression at the end of middle Eocene time here and in Washington correlates so closely with San Diego and the Vail curve as to suggest a eustatic fall as its cause. In latest Eocene time at Coos Bay, however, abrupt transgression with deposition of muds (Bastendorf) at lower bathyal depths occurred while widespread regression characterized southern California. Seemingly in Oregon, local tectonic subsidence masked the latest Eocene eustatic fall.

Preliminary comparisons between widely scattered synchronous localities suggest that the Vail curve offers promise for ultimately distinguishing the elusive causes of transgression and regression even in tectonically mobile regions.

DOUGLAS, HUGH, Hugh Douglas & Co., Ltd., San Francisco, CA

Survival Strategies for United States Uranium Producers in 1980s

The dramatic fall in the spot price of uranium oxide during 1980 from $42 per pound to around $25 has been accompanied by a sharp cutback in uranium production, planned new mines, and exploration, which is of particular concern to geologists. Against this background in the United States, new mines in Australia, Canada, South Africa, and other foreign countries continue to come on stream. Despite lower prices for yellow cake, these mines remain economic for only one reason—they are mining ore that is 3 to 4 times the average grade of ore mined in the U.S.

In addition to this classic ore grade/price relation, the structure of the uranium industry is undergoing change to increasing captive production. For the independent miner and seller of uranium, the shrinking merchant market and shift in the economics of the world uranium industry calls for a reexamination of his role in the industry both in the U.S. and in the world.

DOUGLAS, ROBERT, Univ. Southern California, Los Angeles, CA, and SAMUEL SAVIN, Case Western Reserve Univ., Cleveland, OH

Deep-Sea Oxygen Isotope Record and Sea Level Fluctuations

The oxygen isotopic composition of deep-sea microfossils reveals two trends for the past 100 m.y.: a long term (10^8 years) increase in the ^{18}O content of deep-sea benthic foraminiferal carbonate which suggests a progressive cooling of polar regions related to changes in ocean basin-continent geometry, and the poleward shift of land area since the Cretaceous; and 10^6-year steplike fluctuations in the ^{18}O content of planktonic and benthic microfossils related to changes in the area of shelf seas, relative and eustatic sea level, and polar glaciation.

Benthic isotopic results, after correction for probable ice volume effects in the Oligocene and post-middle Miocene, correspond closely to sea level fluctuation. This correlation appers to be the result of climatic (largely temperature) effects caused by changes in global albedo patterns. During the sea level highstands in the Cretaeous and early Tertiary, shallow seas covered more than 50×10^6 sq km which maximized heat storage in the ocean. The planetary thermal gradient was low, with polar regions producing warm bottom waters (10 to 15°C). In this regime, sea level fluctuations controlled climate. The cause of the sea level fluctuations is unclear. After the middle Eocene, falling eustatic sea level, the reduction of shelf seas to less than about 30×10^6 sq km and the initiation of glaciation in Antarctica produced a rapid cooling of ocean bottom waters and a change in the global heat flux. In this regime, which became fully established with the closure of Tethys and the expansion of southern hemisphere glaciation in the Miocene (ca 15 m.y.), there has been a progressive cooling of deep waters in the ocean and an increase in the vertical thermal gradient. Eustatic and relative sea level fluctuations have been controlled by climatic events in polar regions.

DOUGLASS, RAYMOND C., U.S. Geol. Survey, Washington, D.C.

Carboniferous-Permian Boundary in Southwestern United States

Carboniferous and Permian rocks are exposed in several long sections in southeastern Nevada, the most accessible and best exposed section being in North Arrow Canyon, Clark County. Carboniferous and Permian strata, in steeply dipping beds along the nearly level canyon, are rich in many fossils which have been studied by specialists and students for several years. The section is considered excellent as a reference stratotype for the Carboniferous-Permian boundary in the western cordilleran region.

The sections to the north in east-central Nevada lack most of the late Carboniferous while those to the east in western Arizona contain only a few marine zones. The section to the south near Lee Canyon is more complete but not as well exposed, and access is difficult.

Fusulinids are among the fossils well represented in the succession; they include a progressive series of species and genera from early *Millerella* to advanced *Triticites* in the Carboniferous and to *Schwagerina* and related forms in the Early Permian.

DOWNEY, J. E., U.S. Dept. Energy, Morgantown, WV, T. S. DYMAN*, U.S. Geol. Survey, Denver, CO, and L. A. WILCOX, Petroleum Information Corp., Denver, CO

Eastern Gas Shales Project (EGSP) Data System: Useful Exploration and Research Tool

The U.S. Department of Energy in Morgantown, West Virginia, and the U.S. Geological Survey and Petroleum Information Corp. in Denver, Colorado, have created two large data files for the Eastern Gas Shales Project (EGSP). All computer-compatible well, outcrop, and sample data generated by EGSP contractors from Devonian shales throughout the Appalachian basin are being edited, converted to a data base, and accessed by Department of Energy contractors to produce digital printouts, charts, and maps.

The EGSP Well Data File was developed as an extension of the Petroleum Information Well History Control System (WHCS) and contains geologic, engineering, and production test data for more than 6,000 wells. The EGSP Sample Data File contains geochemical, lithologic, and physical characterization data on more than 50,000 samples from 17 EGSP cored wells, and 140 additional wells and outcrops.

Well and sample data can be retrieved to produce (1) production test summaries by formation and location; (2) contoured isopach, structure, and trend surface maps of Devonian shale units; (3) sample summary reports by location, well, contractor, and sample number; (4) cross sections displaying digitized log traces and geochemical and lithologic data by depth for wells; and (5) frequency distributions and bivariate plots.

EGSP Data System products are being used by EGSP contractors to help solve Devonian shale exploration and research problems in the Appalachian basin. Although part of the EGSP Well Date File is proprietary, and distribution of complete well histories is prohibited by contract, maps and aggregated well data listings can be made available to the public through published reports.

DOWNEY, MARLAN W., Shell Oil Co., Houston, TX

Overview of Seals for Hydrocarbons

Seals for hydrocarbons need to be analyzed and described at two differing scales. A micro view of the rock matrix, pore structure, and fluid content of the seal surface provides quantitative information about the capacity of the seal to impede hydrocarbon movement at a specific measured point. Such micro information often can be accurately measured, but can rarely be extrapolated to describe the overall (mega) sealing capacity of a large hydrocarbon trap.

Efforts have been made over the years to describe the lateral variability of seals for hydrocarbon accumulations. One of the best features of the simple anticlinal structure is that it generally provides sequential sealing surfaces. Top-seal surfaces may be expected to have relatively little lateral variability (at least on the scale of an individual anticline). Faulted structures, in contrast, require not only a top seal, stable in lithology over the trap area, but require juxtaposition of the hydrocarbon-bearing interval against a sealing lithology at the fault plane surface. Large hydrocarbon columns become almost impossible to seal if the trapping configuration requires multiple faults with throws that vary along the individual faults.

Stratigraphic traps for hydrocarbons typically require a top seal, bottom seal, and an updip lateral seal. In addition, the transition from reservoir to seal must be very rapid or the hydrocarbon accumulation will largely occupy a "waste-zone"—not quite a reservoir, hardly a seal.

Regionally, it can be shown that hydrocarbons are preferentially distributed under major roofing seals. These major sealing units are characterized by broad extent, by laterally stable character, and commonly by ductile lithologies. Where these regional seals are above significant source rocks and reservoirs, they largely control the emplacement of hydrocarbon accumulations.

DOYLE, LARRY J., Univ. South Florida, St. Petersburg, FL

Morphology of Continental Shelf-Slope Break

The continental shelf-slope break has been defined as the point of first change in gradient at the outermost edge of the continental shelf, fundamental boundary of the earth's crust. Through the projection of its strike must pass all materials carried from the continents to the ocean basins. Although morphology of the shelf-slope break commonly depends on the crustal change between continents and ocean basins, it is a reflection of tectonics and structure, lithology, age of the margin, sea level, deposition, erosion, reworking, and diagenesis. Many details of specific physical factors and processes influencing morphology of the break remain to be discovered. Therefore, analysis of the resultant of all these factors, the morphology of the break itself, will be useful in understanding the components which formed it. As many of the factors which affect the transition from shelf to slope are dynamic, continental shelf-slope break morphology is not static but changes through time. Changes in morphology must commonly interact in a feedback loop to alter the processes contributing to that morphology. If the elements of formation were to remain constant, the shelf-slope break would go through a regular morphologic evolution as it ages. Variation in the processes involved, such as sea-level state, most commonly interrupt the cycle.

Because the shelf-slope break represents the upper boundary of the continental slope, it is convenient to discuss the interplay of the various factors involved as extensions of the 6 types of continental slopes. The resulting framework for shelf-slope breaks is: folded or faulted, stepped breaks; progradational transitions; pull-apart transitions; sharp, steep shelf-slope breaks resulting from crustal convergence; breaks associated with reefal dams; and breaks associated with diapir dams. A shelf-break classification emphasizing shelf-to-slope morphology, based on comparison of different world margins, is proposed.

DRAGOSET, BILL, and KEN LARNER, Western Geophysical, Houston, TX

Data Enhancement from 500-Channel Streamer

Seismic reflection data obtained with a 500-channel, digital streamer cable can be processed by array-forming techniques that include optimal weighting and time-shifting of individual channels. Such processing can improve the vertical resolution of horizons at early and intermediate times as well as enhance the continuity and clarity of later reflections. In addition to the recording of individual channels, a separate recording can be made aboard ship with the individual channels array formed to simulate data obtainable with any of a wide variety of conven-