of Mesozoic rocks. Feldspathic-quartzose sediments were transported from the east by river systems draining granitic terrains perhaps as far away as the Idaho Batholith. Local volcanism within the drainage system, along the coastal plain, and on volcanic islands to the west, added variable amounts of volcanic rock fragments to the feldspathic-quartzose sediments.

Chronostratigraphic correlations suggest that the arkosic sandstones were deposited along the margins of the depositional system during the early Eocene, prograded westward during the middle Eocene, and then regressed during the latest Eocene and Oligocene simultaneously with the influx of abundant pyroclastic debris. The pyroclastic material was derived from ancestral Cascade Mountain Range volcanism. Onset of Cascade volcanism, and volcanic-lithic grain dilution of the feldspathic-quartzose sandstones, began in the south during the early middle Eocene and extended northward reaching Washington in the early late Eocene.

The Eocene tectonic history of western Oregon and Washington provides a framework for understanding the occurrence of the feldspathic-quartzose rocks in a dominantly "graywacke" fore-arc provinence.

During the early Eocene, a northwest-southeast seamount chain was extruded on the Farallon and Kula plates west of an eastward-dipping subduction zone. Subduction of the oceanic plates moved the seamount chain obliquely toward the subduction zone.

In middle Eocene time—49 to 40 m.y.b.p.—the seamount chain reached the subduction zone creating instability in the subduction system and resulting in the westward jump of the underthrust boundary between the Farallon-Kula and North American plates. The westward jump of the underthrust boundary resulted in both the accretion of the seamount chain as part of a newly formed fore-arc accretionary prism, and a decrease in magnetic arc volcanism. The relative decrease in arc volcanism occurred during the interval after the consumption of the detached eastern subduction plate and the onset of magma generation from the newly formed western subduction zone.

Coincident with and continuing after the subduction zone jump and seamount accretion, eastwardly derived arkosic sediments prograded across Oregon and Washington spilling into the new fore-arc basin and enveloping the seamounts. Basaltic intrusion within the fore-arc basin occurred along tensional fault systems within the accretionary prism.

As the western subduction zone developed, a new, more western magmatic arc formed along the axis of the modern Cascade Mountains. Beginning in the late Eocene, the fore-arc basin subsided and the sea transgressed eastward depositing fine-grained arc-derived tuffaceous sediment over the entire basin.

ARONSON, JAMES, Case Western Reserve Univ., Cleveland, OH, and ROGER L. BURTNER, Chevron Oil Field Research Co., La Habra, CA

K/Ar Dating of Illitic Clays in Jurassic Nugget Sandstone and Timing of Petroleum Migration in Wyoming Overthrust Belt

Authigenic illite is a prominent pore-fill in the Nugget Sandstone, the main reservoir rock of most fields in the southwest Wyoming Overthrust belt. Illite, a good K/Ar clock, was dated from several well samples, all from the Absaroka thrust sheet. This includes a producing well in the Clear Creek field where seven samples traverse the gas, oil, and water zones. The ages of the Clear Creek suite are virtually concordant at 110 ± 2 m.y. Assuming hydrocarbon emplacement would have arrested authigenesis in the oil and gas zones, the similarity of ages from the hydrocarbon zones with the water zone indicates hydrocarbon emplacement was post 110 m.y. ago (middle Cretaceous). Ages obtained from the other Absaroka sheet Nugget samples fall in the narrow range of 102 to 120 m.y.b.p. This indicates illite authigenesis was a relatively short-lived "event" for the Nugget in the Absaroka sheet.

The Wyoming-Idaho-Utah overthrust belt involves several thrust sheets each of which was emplaced over its foreland sequentially from west to east over a time spanning tens of millions of years. We attribute the mid-Cretaceous illite growth in the Absaroka sheet to burial conditions established when that part of the Nugget was thrust upon by the Crawford sheet. The burial was accomplished both tectonically and by synorogenically derived sediment. If true, our illite dates imply a somewhat older age for the Crawford sheet than previously interpreted. We attribute the post-illite hydrocarbon emplacement in the Absaroka Nugget as a result of thrusting of the Absaroka sheet on top of its foreland containing middle Cretaceous petroleum source-bed shales. These beds were thermally matured when buried by the emplacement of the Absaroka sheet and its derived sediment in the Late Cretaceous.

ARP, G. K., ARCO Oil and Gas Co., Dallas, TX

Yellow Cat Revisited: A Review of Helen Cannon's Selenium Indicator Plants

In the late 1940s, Helen Cannon of the USGS conducted her famous studies on the association of plants to selenium. She used this association for detection of sedimentary uranium deposits on the Colorado plateau. Cannon demonstrated that locoweeds (*Astragalus*) from the Yellow Cat area of the Thompson district in eastern Utah did reflect the presence of selenium-rich uranium deposits by their colonization of the soils over the deposits.

During the subsequent 30 years, Cannon's work has repeatedly been cited as a classic example of the use of indicator geobotany in mineral exploration. During the same 30-year period, geobotanical techniques have not found wide utilization as an exploration tool. Further, Cannon's work has not been demonstrated elsewhere to any extent.

In 1980, the author returned to Yellow Cat to see what changes, if any, may have transpired at the site. We also wanted to gather insight into why geobotanical methods have not gained wider acceptance and perhaps determine why subsequent work is so rare.

Results of this study support Cannon's basic work. The results also suggest that the methods are ecologically sound and have applicability to modern mineral exploration programs. Limitations to the method are also discussed, along with some speculation as to why geobotanical methods have not seen wider application.

ASQUITH, G. B., Pioneer Production Corp., Amarillo, TX, and M. D. ALLISON, Derrick Petroleum Co., Gainesville, TX

Depositional Environments of the Mississippian Chappel Bioherms, Hardeman County, Texas

Numerous crinoid-fenestrate bryozoan banks are developed within the Mississippian Chappel Formation, located in the Hardeman basin, Hardeman and Wilbarger Counties, Texas. The banks are oval in shape and range in size from 2 to 12 mi (3 to 19 km) in diameter. Stratigraphic, hydrocarbon entrapment in the banks has resulted in cumulative production exceeding 6 million bbl of oil plus 13 bcf of gas.

The Chappel Formation is a shallow-water limestone, overlain by the oolitic grainstones of the Mississippian St. Louis Formation. Three distinct Chappel facies can be identified: the bank core, flank, and interbank facies. The bank core is composed of crinoid-fenestrate bryozoan mudstones and wackestones; the flank consists of crinoid-bryozoan grainstones and packstones; and the interbank consists of argillaceous sponge spicule mudstones with minor crinoid and bryozoan debris. Chert is a major constituent of the interbank facies but decreases in amount toward the bank core.

Bank growth began in a low-energy environment with the mechanical accumulation of lime mud which was baffled and trapped by crinoids and fenestrate bryozoan. Once the bank core reached wave-base, the crinoid-bryozoan mudstones and wackestones were reworked and redeposited as the crinoid-bryozoan grainstones and packstones of the flank facies. The extensive development of the flank facies, compared with bank core development, indicates that the top of the bank remained at or near wave-base for an extended period of time.

Porosity development in the Chappel banks is secondary and results from dolomitization of the micritic bank core, fracturing and leaching. Although the crinoid-bryozoan grainstones of the flank facies were originally porous, primary intergranular porosity is now absent because of epitaxial cementation.

The Chappel banks can be located in the subsurface by using isopach maps which help identify interval thickening within the Chappel. In addition, thinning, shown by the isopach intervals on horizons immediately overlying the Chappel Formation, can also be used to delineate the presence of these bank deposits.

In subsurface exploration, the bank facies can be differentiated from the interbank facies by petrographic analysis and by noting the more "massive" and also lower gamma ray log response. The lower gamma ray log response is caused by a lack of argillaceous material in the bank facies.

AUBRY, M.-P., C.N.R.S., Univ. Claude Bernard, Lyon, France, and Woods Hole Oceanographic Inst., Woods Hole, MA

Late Eocene to Early Oligocene Calcareous Nannoplankton Biostratigraphy and Biogeography

The extinction of *Discoaster barbadiensis* and *D. saipanesis*, the last representatives of the highly successful low- and mid-latitude group of Paleogene rosette-shaped discoasters, close to the Eocene-Oligocene boundary, has been unfortunately seen by some as evidence of a major extinction "event" in the calcareous nannoplankton. These extinctions (and a few others that occur at about the same time) should be more properly viewed against the larger background of calcareous plankton biostratigraphy and paleobiogeography.

A compilation of DSDP Paleogene calcareous nannoplankton data from low, middle, and high latitudes shows maximum diversity values (ca 120 species) during the middle Eocene (NP14-15) and minimum diversity values (ca 37 species) in the early Oligocene (NP22). The approximately 70% reduction in diversity occurs over an interval of approximately 7 m.y. in a stepwise fashion with the most abrupt reduction (~50%) occurring between the late middle Eocene (NP16) and the early late Eocene (NP18). A further reduction of about 20% occurs across the Eocene-Oligocene boundary (NP18 to NP22), and the values for the remainder of the Oligocene (NP23-25) stabilized at about 50+ species.

A quantitative investigation has been made of late Eocene-early Oligocene calcareous nannoplankton assemblages at 4 DSDP sites in the North (Site 292, 16°N) and South (Site 277, 52°S) Pacific, Indian (Site 219, 9°N) and South Atlantic (Site 363, 20°S) Oceans. An equatorward migration of high latitude floral assemblages occurred during the late Eocene and early Oligocene. This migration was initiated in the late middle Eocene (NP16-17) and the replacement of a tropical flora (dominated by discoasters and *Reticulofenestra reticulata*) by mid-high latitude assemblages (dominated by reticulofenestrids, *R. bisecta, R. hesslandi, R. umbilica, R. hampdenensis*) was not completed until the early Oligocene (NP22; see Figure 1). The extinction of the rosette-shaped discoasters and *R. reticulata* is related to the late Eocene-early Oligocene isotopic cooling event but does not reflect its maximum. These species became extinct when sea surface temperatures reached a threshold value below which they could not survive.

Sites	Age	*Reticulofenestra reticulata*	*Reticulofenestra bisecta; R. hesslandii; R. umbilica* s. l. (%)	*Reticulofenestra* gr. *R. hampdenensis* (%)
219	early Oligocene NP21-22		≈ 25%	0%
(≈9°N)	late Eocene NP18-NP19	up to 30% LAD at the E/O boundary	5%	0%
292	early Oligocene NP21-22		≈ 25%	≈ 5%
(≈16°N)	late Eocene NP18-NP19-20	~ 15% LAD well below the E/O boundary	12%	0%
363	early Oligocene NP21-22		very poor recovery	
(≈20°S)	late Eocene NP18-NP19-20	LAD in the late middle Eocene	≈ 25%	≈ 10%
277	early Oligocene NP21-22		≈ 12%	≈ 45%
(≈52°S)	late Eocene NP18-NP19-20		≈ 30%	≈ 30%

Migrations of species of *Reticulofenestra* from high latitudes toward low latitudes during late Eocene/early Oligocene interval. *R. reticulata* is a warm-water taxa, whereas *R. bisecta*, *R. hesslandii*, *R. umbilica*, and *R. hampdenensis* are cold-water taxa. As percentages show, the proportions of these latter forms increase at lower latitudes through late Eocene/early Oligocene, as intensity of the isotopic cooling increases.

Isotopic records on benthic and planktonic foraminifera from the same sites (Keigwin, work in progress) show a strong parallelism between climatic changes (sharp cooling in the late middle Eocene, at the Eocene-Oligocene boundary, maximum cooling within the earliest Oligocene) and calcareous nannoplankton migrations. The extinctions of the *Reticulofenestra umbilica* group and equilibrium within the floral migration patterns in the calcareous nannoplankton coincide with the maximum isotopic cooling event in the earliest Oligocene. Our data indicate that extinctions among the calcareous nannoplankton occurred in sequential, step-like manner over a several million year interval. They may best be explained as reflecting the gradual but clearly defined trend towards decreasing temperature values during the late Eocene to early Oligocene.

AVES, HELENA S., Helchris Assocs., Inc., and DANIEL M. TAPPMEYER, Sun Exploration and Production Co., Dallas, TX

Use of Synthetic Sonic Logs Derived from Seismic Data in Interpretation of Stratigraphic Variation in Cretaceous Carbonates of North Field Area, Qatar

This study uses geologic and synthetic sonic sections to evaluate the hydrocarbon potential of the Lower and middle Cretaceous Thamama Group carbonates of the Mishrif, Nahr Umr, Shuaiba, and Kharaib Formations in the North field, Qatar. The North field area, a regional high throughout Lower and middle Cretaceous time, is documented by depositional thinning and by