Formation, Cabin Creek field, Montana. The field is located on the Cedar Creek anticline in southeast Montana. The Red River Formation is a sequence of alternating limestones and dolostones. Lateral and vertical variations of dolomitization are mostly responsible for reservoir heterogeneity. Production is from the U2, U4, and U6 dolostones, whereas the interstratified U1, U3, and U5 limestone units are nonproductive. Cumulative Ordovician and Silurian production was 61,574,000 bbl of oil as of September 1979, with reserves of 13,426,000 bbl. Waterflood began in 1964, and the field is a good candidate for tertiary recovery by the carbon dixoide miscible process.

Studies of thin sections, mercury capillary pressure curves, and resin pore casts have shown that several different types of pore systems occur, each associated with a particular depositional environment and diagenetic regime. Pore-system geometry is a function of the size and shape of the dolomite crystals composing the reservoir rock matrix. The size, sorting, and shape of pore throats determine the reservoir characteristics of each pore system. In addition to dolomitization, post-depositional leaching of calcite and evaporitc sulfate minerals was important in reservoir porosity development.

Mean pore-throat size, a statistical measure of pore geometry, was found to increase as porosity increased. Using this relation and electric log porosity values, it is possible to predict pore geometry and, as a consequence, recovery efficiency, if lithofacies distribution, porosity type, and diagenetic history are known. Since residual oil saturation is strongly dependent on the pore-system characteristics of the reservoir rock, it is possible to identify parts of the reservoir which have potentially high residual oil saturation, thus establishing targets for enhanced recovery.

RYBERG, PAUL T., Univ. Arizona, Tucson, AZ

Lithofacies and Depositional Environments of Coaledo Formation, Coos County, Oregon

The middle to upper Eocene (Narizian) Coaledo Formation, well exposed along the southwestern Oregon coast, includes seven basic lithofacies types which constitute a complex marine-deltaic sedimentary sequence. The lithofacies are defined by lithology, fossils, bedding characteristics and sedimentary structures.

Petrographic examination of Coaledo sandstones indicates a dominantly andesitic volcanic source with subordinate plutonic, metamorphic, and sedimentary sources. Paleocurrent indicators suggest that these source areas were located to the southeast, from the initial calc-alkaline vents in the southern ancestral Cascades and from the northern Klamath Mountains. Regional paleocurrent analysis also suggests open-ocean conditions to the west, offshore from a wide, swampy coastal plain.

The pre-Coaledo units exposed in the Cape Arago area are interpreted to be delta foreset deposits. Coarsening-upward sequences recognized within the lower Coaledo member are interpreted as delta topset deposits, including subaqueous distributary channel, interdistributary tidal flat, lagoonal, and barrier-bar facies. The lower part of the middle member is characterized by deeper marine facies. The upper part of the middle Coaledo member represents prodelta deposition during a second progradational phase. Coarsening-upward sequences are recognized in the upper Coaledo member, again representing delta topset deposits. Uppermost Coaledo sands and overlying units show a gradual return to deeper marine conditions.

Coaledo sediments unconformably ovelrie gently folded fore-arc sediments of the Tyee basin. Deposition of coal-bearing deltaic sediments far to the west of the axis of the basin suggests regional tectonic uplift along the flank of the basin, or progradational filling of the continental flank of the basin.

RYER, THOMAS A., U.S. Geol. Survey, Denver, CO

Eustatic Control of Distribution of Lower Upper Cretaceous Coal Beds in Utah: Application in Coal Exploration

Upper Cretaceous rocks in the Western Interior of North America record a series of transgressions and regressions that reflect shifts in the balance between rates of tectonic subsidence and sediment input and rates of eustatic sea level fluctuation. One of the transgressive-regressive cycles spans latest Albian through middle Turonian time and appears to have been primarily controlled by the rise and fall of worldwide sea level. The distribution of coal-bearing strata in this part of the Upper Cretaceous section in Utah reflects, and is probably a direct function of, this eustatic cycle. Rocks deposited during the transgressive phase of the cycle generally contain only thin beds of high-ash and high-sulfur coal that are of little or no economic value. Likewise, rocks of the regressive phase contain little coal. The accumulation of thick deposits of peat was restricted to the transgressive and regressive maxima of the eustatic cycle. These peats formed the coals of the Alton, Harmony and Kolob, and the Emery and Vernal coalfields, respectively. The delicate balance between subsidence, sediment input, and eustatic sea level change that existed at times of maximum transgression and maximum regression allowed for the stacking of deltaic sequences, which then resulted in the accumulation of thick bodies of peat. This situation invites the development of a predictive model relating the distribution of economic deposits of coal to the various phases of the eustatic cycle. This model is applied to predict the areas most likely to contain thick beds of coal in the deep subsurface between the northern limit of the Emery coalfield and the southern edge of the Uinta basin in central Utah.

SAELAND, G. T., Statoil, Stavanger, Norway, and G. S. SIMPSON, Esso Exploration and Production Norway, Inc., Stavanger, Norway

Seismic Interpretation of Statvik Field, Norway—3-Dimensional Study of Subunconformity Trap

The Statvik field is located in Norwegian North Sea block 34/10. Initial exploration was based on the interpretation of a one-kilometer 2-D migrated seismic grid. In 1979, at a relatively early stage in the exploration phase, it was decided that better quality data were needed to adequately map the structurally complex, highly faulted area, and to guide further delineation drilling. A 3-D seismic survey was therefore shot, covering the whole structure.

It is obvious from a comparison of individual lines that the 3-D data is of significantly higher quality than the 2-D data. Furthermore, the extremely dense grid of lines makes it possible to develop a more accurate and complete structural and stratigraphic interpretation.

Specifically, the 3-D data made it possible to map more accurately the dip and the subcrop of the subunconformity strata. The early geologic model had the Jurassic reservoir sands dipping steeply westward over the whole of the structure. This implied extensive erosion of the main reservoir sands toward the east. With the 3-D seismic data, however, we were

able to recognize and map much gentler dips in the eastern part of the structure. The result of this is to move the mapped subcrop of the reservoir sands much farther eastward, thus extending the eastern limit of the field considerably.

Based on this 3-D interpretation, three successful oil wells have been drilled. These are located in parts of the field that could not be accurately mapped on the basis of the 2-D seismic data, because of its poor quality. This has increased the estimate of the field's reserves such that Statoil were able to declare the field commercial in late 1980.

SANCETTA, CONSTANCE, Lamont-Doherty Geol. Observatory, Palisades, NY

Diatoms in Sediments as Shelf-Slope Indicators

Diatoms, a group of unicellular algae, are limited to the upper 50 to 100 m of the water column, owing to their light requirement. Benthic diatoms, consequently, are restricted to the continental shelf, and primarily the inner shelf, coasts, and estuaries. Planktonic diatoms occur on the shelf (neritic) and in deeper waters (pelagic); certain genera are restricted to one region while others occur in both. Salinity appears to exercise an important control on these distributions, so that a salinity front frequently produces a sharp boundary between populations. The shelf-slope break is usually associated with a sharp salinity gradient, where low-salinity shelf waters encounter a high-salinity oceanic current. The result is that benthic and low-salinity planktonic diatoms characterize shelf sediments, while higher-salinity planktonic diatoms and an absence of benthic diatoms characterize the slope and ocean basin sediments.

A transect across the southeastern Bering shelf and slope, with stations at 25-km intervals, shows a dramatic change in species composition of the sediment assemblages at the 200-m isobath. Shallower samples are dominated by benthic marine species and a group associated with the presence of winter sea ice, while below 200 m the assemblages are dominated by a species common in the North Pacific and the Bering basin. The ratio of this pelagic species to the benthic species shows a high correlation with depth ($r = .85$). Other work in the literature, while not directly addressed to this question, suggests that similar transitions can be found off Peru, west Africa, and in Miocene deposits of the U.S. East Coast.

SANCHEZ, JOSEPH D., and TERRENCE L. BROWN, U.S. Geol. Survey, Denver, CO, and WILLIAM J. MULDOON*, Conoco Inc., Lake Charles, LA

Stratigraphy and Intertonguing Between Coal-Bearing Upper Cretaceous Blackhawk Formation and Star Point Sandstone, Central and Southern Parts of Wasatch Plateau Coalfield, Central Utah

Intertonguing of the lowermost part of the coal-bearing Blackhawk Formation and the uppermost part of the marginal marine Star point Sandstone has caused a progressive steplike offset of the Blackhawk coal beds in the central and southern parts of the Wasatch Plateau. The tongues of the Star Point Sandstone are marginal shore deposits representing episodic transgressions of the Upper Cretaceous epeiric seaway. The development of these sandstone tongues affected the geometry, lateral continuity, and thickness of the associated Blackhawk coal beds.

Mapping and exploration of sandstone tongues in the lowermost part of the Blackhawk Formation will help identify the thicker coal beds. Knowledge of their distribution can assist the exploration geologist in mapping the coal-bed geometry. Economic coal beds associated with the marginal marine sandstone tongues trend parallel to the paleoshoreline and may be thicker landward of the sandstone tongues. These coal beds are the primary targets of current drilling programs directed toward exploration and development of Blackhawk coals in the study area.

SANDBERG, P. A., and BRIAN N. POPP, Univ. Illinois, Urbana, IL

Pennsylvanian Aragonite from Southeastern Kansas—Environmental and Diagenetic Implications

Unaltered acicular aragonite cements have been found in Pennsylvanian limestones from southeastern Kansas as spherulitic arrays encased in pore-filling spar in intragranular voids. Identical cements are documented in Pleistocene carbonate rocks. Associated early cements in intergranular pores include aragonite botryoids now altered to irregular noemorphic calcite, and bladed calcites inferred to have been precipitated as magnesian calcite. In addition, phylloid algal blades of *Archaeolithophyllum,* now altered to irregular neomorphic calcite mosaics, contain varying concentrations of oriented inclusions of original aragonite. The unaltered aragonite cement was apparently protected from diagenetic alteration by the enclosing calcite spar and organic matter on the skeletal substrate. Individual aragonite relics in the algae probably survived because of enclosure in organic envelopes, a phenomenon observed in Pleistocene examples.

We see two explanations for the precipitation of these metastable carbonate cements in Pennsylvanian seas, both of which raise perplexing questions regarding ancient carbonate deposition. (1) Several authors have suggested a domination of calcite in Paleozoic non-skeletal carbonate deposition; our cements could represent some local departure from that general pattern, or (2) these carbonates document part of a long-term temporal trend in non-skeletal carbonate mineralogy from a domination of calcite in Paleozoic seas to aragonite and magnesian calcite domination in Quaternary seas. However, later calcite domination as evidencd by calcite cements and ooids in the Jurassic and Cretaceous, suggests that if the latter explanation is accepted the postulated trend was neither simple nor unidirectional.

SARG, J. F., Exxon Production Research Co., Houston, TX, and L. J. SKJOLD, Esso Exploration and Production Norway, Stavanger, Norway