Jurassic eolian sandstones, but predominantly in Cretaceous sandstones and fractured shales. The San Juan basin is gas-prone, although significant oil fields are common. The Cretaceous Blanco basin gas field is one of the largest in the United States. The key to exploration in this mature area lies in understanding the complex stratigraphy that controls most of the traps.

The San Juan basin area was a part of larger depositional basins prior to the Laramide orogeny. Major sedimentation in the area began during the Pennsylvanian with deposition of shelf-carbonates and flanking arkosic clastics from Ancestral Rocky Mountain uplifts. Regression during the Permian resulted largely in nonmarine clastic deposition. Triassic fluvial red beds were deposited across the area after an erosional interval. After another erosional interval, Jurassic nonmarine clastics and restricted limestones and evaporites were deposited. During the Cretaceous, the sea returned and repeatedly transgressed and regressed across the basin, producing well-developed depositional cycles. Laramide uplift around the San Juan basin during latest Cretaceous and earliest Cenozoic time produced the structural basin which became partly filled with Paleocene and Eocene nonmarine clastics.

PAGE, MARY M., and CLARENCE KUHNEL, Robertson Research (U.S.) Inc., Houston, TX

Rock-Eval Pyrolysis as Source Rock Screening Technique

Rock-Eval pyrolysis (by the IFP-FINA Method) provides a rapid (20 min) screening evaluation of the source potential, type, and maturity or organic matter (OM) in rocks. Whole rock samples are used, thereby eliminating time-consuming sample preparation.

The pyrolysis instrument is a dual-detector gas chromatograph to which a pyrolysis heating chamber and gas-handling circuits have been added. A small sample (0.1 g) is heated from 250 to 550°C at a uniformly increasing temperature in a furnace flushed with helium. The volatilized gases are swept either directly into the flame ionization detector or into a CO_2 trap and then into the thermal conductivity detector. The signal is fed through an integrator to a strip-chart recorder, resulting in three peaks: Peak 1, the amount of OM (mg hydrocarbons/g rock) present in the rock as oil-like components and broadly analogous to the solvent-extractable (bitumen) part of the OM; Peak 2, the amount of OM (mg hydrocarbons released/g rock) cracked from the insoluble (kerogen) part of the OM pyrolysis. The temperature of maximum evolution of Peak 2 provides an estimate of maturity; Peak 3, the amount of CO_2 (mg CO_2/g rock) derived from the oxygen in the kerogen.

Comparison of pyrolysis data with conventional geochemical data suggests the following interpretation. Peak 2—hydrocarbon potential: poor, 0 to 2.5; fair, 2.5 to 5.0; good, 5.0 to 10.0 mg hydrocarbons/g rock. Peak 2/Peak 3—expected hydrocarbon type: gas, 0 to 2.5; gas + oil, 2.5 to 5.0; oil, 5.0 to 10.0 mg hydrocarbons/g rock. Peak 1/(Peak 1 + Peak 2)—migrated hydrocarbons: present, greater than 0.2. Temperature of maximum evolution: immature, 435°C; oil-generating, 435 to 450°C; gas generating, 450 to 470°C; cooked out, 470°C or greater.

Because of problems, such as the presence of solid bitumen and mixed kerogen type, Rock-Eval does not replace conventional geochemical evaluation. Instead, pyrolysis data outline general trends facilitating the selection of samples for further analysis.

PALMER, JAMES E., Illinois State Geol. Survey, Urbana, IL

Future Trends in Coal Resource and Reserve Evaluations in United States

Most currently available estimates of coal resources and reserves in the United States were prepared to determine only general areas of coal occurrence and thicknesses of beds. Such estimates were usually accompanied by coal analyses to indicate the coal rank and to a much lesser degree, other quality parameters of the coal deposits. Estimation of coal tonnage was accomplished by simple but time-consuming arithmetic and/or geometrical procedures, which usually involved the use of hand-drawn maps and the polar planimeter. For many regions of the United States, data and/or manpower available were so limited that only broad estimates of coal resources could be made. As a result, our national coal resource data base is quite limited in both scope and detail.

In the future, computers will be used extensively to process such data as depth, thickness, quality, environmental factors, and other parameters associated with coal resources. Computers can be programmed to generate many kinds of maps and numerical tabulations. By the use of point data (e.g., drill holes, outcrops) resources can be classified according to any desirable classification system, such as thickness categories.

Most procedures currently used to evaluate coal resource and reserve data rely upon point-of-observation spacing only for geologic assurance of coal occurrence. Several major studies are underway to develop geostatistical methods such as kriging and the use of variograms, which facilitate evaluation of other uncertainties inherent in both quantity and quality data on coal resources. Thus, by use of computer processing and geostatistical methods, a more comprehensive understanding of the amount of characteristics of United States coal resources will be developed during the coming decade.

PARKER, JOHN M., Consulting Geologist, Denver, CO, and PAUL D. HESS, Brownlie, Wallace, Armstrong & Bander, Denver, CO

MonDak Mississippian Oil Field, Williston Basin

The MonDak Mississippian limestone oil field contains 13.7 million to 68.6 million MT (100 million to 500 million bbl) of recoverable oil. It produces from irregular intervals, both vertically and horizontally, in a 168 m section of fractured Mississippian limestone. Dip in the field is eastward into the Williston basin at 3 to 11 m/km, with some structural flattenings and irregularities. The trap is not structural. The reservoir is limestone with a depositional texture range from mudstone to grainstone, but most of the reservoir rock is wackestone. Normal matrix porosity is 2 to 4% and matrix permeability is less than 0.01 md. Some lentils of fossil fragment grainstone have porosities in the 6 to 15% range and permeabilities of 0.01 to 1.0 md. Production is primarily from vertical microfractures and macrofractures. The reservoir is slightly ovepressured. Oil gravity is 32 to 39°API, gas-oil ratios range from 250 to 650 cu ft/bbl, and produced water range from 10 to 90%. The field is located in the west-central part of the Williston basin in the states of Montana and North Dakota. The discovery well was completed in 1958 as a workover of a test plugged and abandoned in 1954. A diagonal offset to the discovery was completed in 1960. No other completions were made in the Mississippian until 1976. As of June 1, 1980, there will be 182 completed Mississippian wells on a 65-ha. spacing pattern and 10 drilling rigs operating.

PARRISH, JUDITH TOTMAN, and A. M. ZIEGLER, Univ. Chicago, Chicago, IL

Climate Asymmetry and Biogeographic Distributions

With the acceptance of the hypothesis of continental drift, paleontologists have been able to employ two concepts that have had important implications for paleobiogeographic distributions of organisms. One concept is that continents previously combined into one have separated, and vice versa, and the other is that a single continent may have been at different latitudinal positions during its history. Paleontologists have used this latter concept to explain, for example, present-day polar positions of ancient tropical forests or to reconstruct pole-to-equator diversity gradients in benthic marine communities. The model underlying these reconstructions and explanations is that climatic belts are wholly temperature-controlled and parallel with latitude. An important feature of climatic zonation that has been largely ignored is that along ocean margins, climatic zonation is asymmetric east to west. This is because the major ocean currents, which affect the climate, are asymmetric, with colder currents dominating the regime on the eastern sides of the oceans and warmer currents dominating the western sides.

Atmospheric circulation maps have been constructed for several Paleozoic periods, from which ocean-current maps have been derived. In these reconstructions, the asymmetry of climate along the ocean margins, caused by the asymmetry of the currents, is reflected in the distribution of ancient terrestrial and marine communities.

PETERS, K. E., Chevron Oil Field Research Co., La Habra, CA, B. G. ROHRBACK, Cities Service Corp., Tulsa, OK, and I. R. KAPLAN, Inst. Geophysics, Univ. California, Los Angeles, CA

Geochemistry of Artificially Heated Humic and Sapropelic Sediments: Protokerogen

Artificial heating experiments have provided information on the early diagenetic relation of classes of organic constituents in recent sapropelic and humic sediments. Lipids, humic acids, and kerogens isolated from heated Laguna Mormona algal mat and Staten Island peat have been studied by varied techniques including elemental analysis, gas chromatography, programmed temperature pyrolysis, and stable isotope ratios. A temperature and time dependent set of constructive and destructive reactions plays a role in the quantity and quality of kerogen isolated from each heated sample. For humic kerogen the dominant constructive process is conversion of humic acid to new kerogen. The dominant constructive process for sapropelic kerogen is the grafting of lipids onto existing kerogen.

Short-term, high-temperature laboratory simulations of burial maturation result in a dominance of destructive over constructive reactions. Part of the volatiles lost from sapropelic sediment during these experiments is isotopically light, hydrogen-rich lipids which might otherwise be grafted onto the kerogen during slow burial maturation. These results explain the common lack of agreement in evolution paths followed by laboratory-heated protokerogens and natural kerogens at progressively greater depths in cores.

PETERSON, FRED, R. H. TSCHUDY, and S. D. VAN LOENEN, U.S. Geol. Survey, Denver, CO

Mudstones as Exploration Guides to Tabular Sandstone-Type Uranium Deposits in Salt Wash Member, Morrison Formation (Upper Jurassic), Henry Basin, Utah

Sedimentologic and palynologic studies in the Henry basin indicate that a particular type of mudstone can be used as an exploration guide to uranium deposits in nearby sandstone beds. Most Salt Wash mudstones bear no relation to the ore deposits and consist of non-organic red or green mudstones deposited in overbank environments on a flood plain. Other unfavorable but organic-rich gray mudstones contain carbonized wood fragments up to about 1-cm long, palynomorphs including the alga *Botryococcus*, powdery carbonaceous material, and structureless blebs of organic matter. These mudstones lack swelling clays, are moderately to highly calcareous, and are associated with thin limestones. Most of these mudstones were deposited in shallow and relatively large lakes at least several kilometers wide and several tens of kilometers long.

Favorable organic-rich gray mudstones that lie near uraniferous sandstones contain minute carbonized wood particles less than about 0.5 mm long, a palynomorph suite lacking *Botryococcus*, cutinous and epidermal tissue, pyrite, and swelling clays. These mudstones are non-calcareous to slightly calcareous, and rarely contain limestone. Favorable mudstones occur just above or below uranium-bearing sandstones, or interfinger with sandstones that contain uranium anomalies within several hundred meters of the mudstone. These mudstones are associated with distal braided stream sandstones and were deposited in small shallow lakes or ponds up to several square kilometers in areal extent lying between stream courses or in abandoned stream channels. The mudstones lie in structural lows that were active during deposition, and they tend to occur in the part of the low where fluvial sedimentation was least active. Prospecting strategies based on these observations should search for favorable mudstones in tectonic lows in strata deposited by distal braided streams.