deposits: Asphalt Ridge, Hill Creek, PR Springs, and Sunnyside. In central-southeast Utah, 21 deposits contain between 10 and 15 billion bbl, a less precise estimate because of the lack of definitive subsurface data. About 90 % of this is contained in 3 giant deposits. Elsewhere in Utah 4 less important deposits are found.

A wide variety of crude oils in varying stages of preservation and alteration has been analyzed. Gravities (API) range from minus values to near 15°; range in deposits considered of commercial interest is 8 to 15°. Uinta basin deposits of Tertiary age contain oil with an average sulfur content around 0.4 %. Permian and Triassic deposits in central-southeast Utah yield oils with between 3.0 and 4.3 sulfur.

Two types of deposits are recognized: *in situ* (oil fields in their original position breached by erosion) and migrated (oil displaced from a ruptured trap to another position). Most southern Uinta basin and central-southeast Utah deposits are *in situ;* northern Uinta basin deposits appear to be migrated; actually they are seeps disseminated on the outcrop.

The deposits exist in a wide variety of physical situations, and reservoirs tend to be heterogeneous. Mining appears to be the most likely method of large-scale exploitation. Serious legal, political, environmental, and technologic problems exist. Growing scarcity of energy and petrochemical sources is creating an economic climate in which development is feasible.

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CHARACTER DISPLACEMENT IN CAMBRIAN AGNOSTID TRILOBITES

The phenomenon known as *character displacement* develops when the ranges of 2 or more closely related species overlap geographically. Differences between the species are accentuated in the zone of sympatry, but remain less pronounced in the parts of their ranges outside that zone. Characters displaced may be morphologic, ecologic, behavioral, or physiologic. Biologists have shown that size is one of the most common morphologic characters displaced. A moderate difference in size—on the order of 1.3—appears to be sufficient to cause obligated feeding on different kinds of food, and thus permits sympatric species to avoid competitive elimination.

Although character displacement in modern faunas has been well documented, to my knowledge no examples have been described from the fossil record. Analysis of several extensive collections of Cambrian fossils suggests that size displacement was common among agnostid trilobites. Where 2 or more agnostid trilobites are found together, the interspecific ratio of maximum size usually is close to 1.3. Also, maximum size generally is more uniform where given species are separated than where they are found together. The similarity of these patterns to those displayed by certain modern faunas indicates that sympatric agnostids were structurally specialized to feed on resources of different sizes. This conclusion helps to explain how superficially similar species of Cambrian agnostids may have coexisted without competitive elimination. The examples further indicate that character displacement was operating early in the history of metazoans.

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LATE CRETACEOUS AND EARLY TERTIARY STRATIGRAPHY AND PALYNOLOGY, HOBACK RIVER BASIN, WESTERN WYOMING

Pollen samples collected in the Hoback River basin yield Eocene, Paleocene, and Late Cretaceous dates. These dates, especially the Late Cretaceous ones, have helped redefine the stratigraphy in this area. Previously mapped Paleocene parts of the Hoback Formation can now be assigned to Upper Cretaceous Harebell Formation, Mesaverde Formation, and lenticular sandstone and shale sequence.

The pollen data also confirm structural reinterpretations. Previous maps show an anticlinal fold in the Hoback Formation, which parallels the Cliff Creek thrust. The Game Hill fault has been mapped, and places Cretaceous rocks against a middle Paleocene slice of the Hoback Formation. This slice lies between the Cliff Creek thrust and Game Hill fault. Evidence suggests the Game Hill fault predates the Cliff Creek thrust.

In addition to aiding structural and stratigraphic refinements in this area, the pollen samples allow comparison between early Tertiary invertebrate, vertebrate, and palynologic dates derived from identical sites.

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FOSSILIFEROUS CONCRETIONS—POSSIBLE EVIDENCE OF PURPOSEFUL FOOD GATHERING

Concretions containing many, closely packed fossils are sufficiently numerous to warrant special attention and probably a distinctive designation. A few examples emphasize the problem of origin: (a) one concretion from shale above the no. 5 coal bed of Illinois (Pennsylvanian) yielded at least 1,000 uncrushed *Composita argentea;* the sparse fauna of the matrix is extensively crushed; (b) 3 concretions from the Deseret Limestone (Mississippian) of north-central Utah yielded several hundred specimens of the ammonoid *Dzhaprakoceras* known previously only from Asia; (c) one concretion from the Colorado shale (Early Cretaceous) near Harlowton, Montana, yielded 1,400 uncrushed specimens of the ammonite *Gastroplites,* a relatively rare genus in North America, (d) numerous concretions from the Ferron Sandstone (early Late Cretaceous), Emery County, Utah, under investigation by the writers, have a well-preserved molluscan fauna, whereas the matrix is practically unfossiliferous; and (e) very abundant concretions in the Fox Hills Formation (late Late Cretaceous) of South Dakota commonly show dense accumulations of several molluscan species; fossils are otherwise sparse.

It is proposed that such fossiliferous concretions have resulted from selective, purposeful, food-gathering or hoarding activities of large vertebrate or invertebrate marine animals. No other agency seems capable of bringing together large numbers of sessile, somewhat heavy, and probably still-living animals into small compact masses. Whether these represent food not yet ingested, undigestable residues (coprolites?), or contents of some part of the alimentary canal in process of digestion is not known. The term "gastric concretion" is proposed as sufficiently broad and descriptive to cover this type of accumulation.

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GEOLOGICAL MALPRACTICE, AN APPROACHING THREAT

Geologists' studies of environment of deposition are increasingly subject to scrutiny by those who are not professionally knowledgeable in the subject. The study becomes one related to the phrase "to depose" and the environment becomes the legal context of malpractice litigation, the scrutiny by lawyers. Until very recent years, professional earth scientists were well insulated in the practice of their "black arts" from the lay public. Most contacts were with corporate clients or sophisticated investors. The dramatic increase in use of geologic maps and written opinion occasioned by the drilling fund, environmental impact statements, and the expansion of business in general, coupled with the developing sense of professionalism among earth scientists and a litigation-conscious public combine into "malpractice exposure." The geologist who understands this trend can minimize this exposure and afford himself, his employer, and his family a measure of protection as the times change.

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EFFECT OF PETROGRAPHIC COMPOSITION ON HEATING VALUE OF LIGNITE

Heating value of borehole samples of lignite ranges from 500 to 1,000 Btu/lb within short distances. Much of this variation is caused by (1) weathering at shallow depth, resulting in a decrease in heat value, and (2) loss of moisture because of improper handling of the sample, resulting in an increase in heating value. Aside from these factors, the petrographic composition of lignite is the most important parameter that ultimately controls its heating values (assuming geologic history is the same after the peat stage). Chemical analyses of hand-picked pure maceral material exhibit considerable variation in elemental composition and heating values. On an as-received basis, the heating values of resinite and huminite (vitrinite) are 16,000 Btu/lb and 7,500 Btu/lb, respectively. The hydrogen and carbon contents are 10 % and 80 %, respectively, for resinite and 5 % and 70 % for huminite, calculated on a dry, ash-free basis.

Lignite mined near Larson, Burke County, North Dakota, contains resinite particles with a diameter up to 0.5 in. Published data (212 samples) indicate that the average heating value of this lignite is 460 Btu/lb more than the average value for all lignite in North Dakota (7,280 versus 6,820 Btu/lb). A presence of 5 % resinite could account for this difference in heating values.

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FLUVIAL CYCLES AND THEIR INTERPRETATION, DAKOTA FORMATION (CRETACEOUS), UINTA MOUNTAINS, NORTHEAST UTAH

The Dakota Formation provides excellent exposures of cyclically deposited fluvial channel sandstones. Each successive channel sequence represents a cycle that commonly decreases in thickness upward. A general fining-upward sequence is typical within each cycle. Rarely, however, are cycles topped with material smaller than very fine-grained sandstone. Outcrops of the cyclic deposits range in thickness from 65 to 115 ft.

The base of each cycle is the basal erosional surface of each channel. The basal sandstones contain the coarsest sediment, which ranges in size from medium grain sand to pebbles. Boulder size fragments of bank material are commonly incorporated in the basal sandstone. Sorting is very poor to moderate. Almost all basal sandstones are nonresistant to erosion and moderate to dark reddish-brown in color. Sandstones above the basal unit are well to very well sorted and range in color from light brown to white.

The cementing agent of the sandstone is mainly clay, which apparently is kaolinite altered from potassium feldspar. Only minor amounts of calcite and silica cement are present. Virtually all samples contain various amounts of subangular to subrounded, frosted quartz grains.

Sedimentary structures are primarily trough and planar cross-stratification and parallel stratification. Thicker cycles commonly have medium- and small-scale trough and planar cross-stratification overlain by parallel stratification. Thinner cycles may contain exclusively trough and/or planar cross-stratification. Ripple marks are uncommon, but where present are situated at or near the top of cycles.

Most cycles probably were deposited in sinuous streams. Thicker sections of the Dakota apparently were deposited in streams of higher sinuosity than thinner sections.

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DEPOSITIONAL ENVIRONMENTS OF WHEELER FORMATION, DRUM MOUNTAINS, MILLARD COUNTY, UTAH

The Wheeler Formation in the Drum Mountains represents the transition between shoal and deeper open-shelf environments. Lithologic evidence suggests continuous deposition and frequent oscillation of lithotopes. The following facies can be recognized: (1) intra-shoal basin with mottled and thin-bedded intrasparites; (2) shoal with trilobite biosparites; (3) deeper open-shelf rhythmite consisting of thin-bedded pelsparite interbedded with fissile calcareous shale or argillaceous partings; and (4) deeper open-shelf shale.

Faunal assemblages and types of fossil preservation further support the interpretation of a transition between shoal and open-shelf environments. Shallower facies are dominated by assemblages of diverse, probably benthic, nonagnostid trilobites, whereas the deeper facies are dominated by pelagic agnostid trilobites. In the shoal facies, trilobites are commonly disarticulated and are found in a sparry matrix, whereas rhythmites of the open-shelf facies commonly contain articulated specimens.

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GEOLOGIC CYCLES OF EARTH, MOON, AND MARS

The geologic cycle of a planet depicts the interaction of impact, surface, and internal tectonic processes on the planetary surface. The earth has a "closed-loop" geologic cycle in which source rocks are eroded but are continuously recycled. In contrast, the moon apparently has an "open-loop" geologic cycle in which the primitive crust is irreversibly destroyed. On the earth, impact plays a minor role and surface and tectonic processes are approximately equally active; that is, if averaged over the globe throughout geologic history, the rate of uplift equals the rate of erosion. On the moon, impact processes are dominant and there are only minor surface and tectonic effects. Preliminary interpretations of the rock cycle and the "ice cycle" of Mars are presented as sources of questions for future analysis. Apparently, the geologic cycle of Mars involves surface and tectonic phenomena as well as impact phenomena.

Surface processes active on Mars include eolian erosion and deposition. The "channels" in the equatorial regions are evidence of intermittent stream erosion. The tectonic processes of Mars have been investigated by mapping regional stress patterns from analysis of observed lineament (fracture) systems.