Studies show that up to 25% of the volume of coal is lost as fine coal particles in the coal mining and handling process. These fines, considered to be nontransportable and useless may be concentrated as thick "deposits' in tailings ponds.

Actually, if the fines can be transported (as in the case of local slurry pipelines directly to the user), they are preferred, for most coal-burning electrical power plants inject the coal into their boilers as dust (−200 mesh). This allows for greater burning efficiency. Unfortunately, since fines are rarely available, utility companies must grind all coal received. Such grinding is very expensive, frequently costing as much as the coal itself.

At present, the concept of agglomeration of coal fines into coherent pellets strong and stable enough to allow transportation is being considered, and several pilot-scale operations have been undertaken. These have shown that while pelletization can be done with relative ease, the economics of the process is at best marginal. The binders considered to date include bentonite, various oils and asphalts, and organic waste. Obviously a binder which burns is preferable to one which contributes to the ash. Unfortunately, in each case, the coal pellets must be reground to dust to be injected into the furnace.

If, however, a binder is employed which is both combustible and contains a small amount of water, the expensive grinding stage can be eliminated. When a pellet held together by a water-soluble polymer or other water-based binder is introduced into a hot environment (a pre-heating chamber or the boiler itself), the vapor contained in the binder vaporizes and undergoes a rapid volume increase, causing a dramatic pressure increase inside the pellet. Meanwhile, the tensile strength of the pellet is being lowered by the degradation of the binder. Once the internal pressure exceeds the ability of the pellet to contain it, the pellet bursts. This "explosion" reduces the pellet once again to dust, since any pellet fragments would likewise burst. No grinding is necessary, and the economic picture of the process improves dramatically.

Application of this process finds breadth when one considers the potential sources of coal fines. As environmental regulations tighten, coal-cleaning standards rise. To effectively remove organic sulfur from coal, the coal must first be crushed, and conceivably large supplies of coal dust would be available. Pelletizing might also find application between the end of a slurry pipeline and the ultimate user. Another potential source is in-situ comminution of thin, deep coal seams, which reduces the coal to small fragments before pumping it to the surface.

To be sure, coal agglomeration will find widespread use in the near future, and the use of a water-based binder will make the process economically feasible. Indeed, the self-bursting concept may revolutionize the burning industry.

MORRISON, JOAN, and UWE BRAND, Brock Univ., St. Catharines, Ontario, Canada

Chemical Diagenesis of Pennsylvanian Brush Creek (Pennsylvania) Carbonate Components: Trace Elements

The various (low-Mg calcite, intermediate-Mg calcite, high-Mg calcite, and aragonite) carbonate components from the Pennsylvanian Brush Creek Formation of Pennsylvania are preserved in different stages of diagenetic alteration. In general, these components follow the predicted diagenetic changes in structure, mineralogy, and chemistry deduced from theoretical considerations for progressively altered carbonates.

The low-Mg calcite brachiopods show no signs of either structural or chemical alteration. The shell material is preserved as low-Mg calcite fibers with no apparent dissolution and/or infilling by diagenetic calcite. Also, the average Sr^{2+} content of the brachiopods is 820 ppm, which is in agreement with the chemical content of their Holocene counterparts. In contrast, the intermediate-Mg calcite rugose corals show signs of structural aggrading neomorphism. The trabecular fibers are in part recrystallized to small mosaic calcite grains. This structural alteration is concomitant with chemical changes in the Brush Creek rugose corals. The least-altered components contain about 1,770 ppm Sr^{2+}, whereas the most altered components contain only about 1,030 ppm Sr^{2+}. For the high-Mg calcite crinoids, diagenetic alteration is mostly a cementation process with minor mineralogical alteration. The open meshwork structure typical of the Echinodermata is infilled in the Brush Creek crinoids by diagenetic cement. This infilling cement has decreased the average Sr^{2+} content of 2,140 ppm of unaltered crinoids to that of 1,090 ppm Sr^{2+} for the most-altered Brush Creek crinoids. Scanning electron microscope analysis of the originally aragonitic mollusks (gastropods, pelecypods, and cephalopods) shows a complete structural diagenetic transition series. The original and least-altered mollusk material is preserved as nacre, which is always aragonite. The second phase of the transition series in the mollusks is represented by the aggrading neomorphism of the nacreous tablets into small, coarse mosaic calcite crystals. The structural transition is completed by the replacement of the mosaic calcite by coarse calcite spar. Mineralogically, the mollusk material changes from aragonite to aragonite-calcite to calcite, relative to the least- and to the most-altered specimens, respectively. The structural and mineralogical changes of the originally aragonitic mollusks are also confirmed by changes in their overall chemical composition. Average Sr^{2+} values measured for the least-altered Brush Creek mollusk material is 4,470 ppm. Mollusk material of the second phase of the diagenetic transition series contains on average about 2,170 ppm Sr^{2+}. The most-altered mollusks, which are calcite, contain on average about 1,110 ppm Sr^{2+}. Similarily, the Na^{+} values follow the diagenetic trend of strontium. The least-altered material contains 750 ppm Na^{+}, the intermediate-altered material contains 420 ppm Na^{+}, and the most-altered material contains 250 ppm Na^{+}.

Thus the diagenetic alteration process and rate proceed in accordance with mineralogical stability. This sequence is aragonite, high-Mg calcite, intermediate-Mg calcite, and low-Mg calcite relative to fastest to slowest reaction, respectively. The diagenetic alteration and preservation process of the Brush Creek carbonate components is probably a two-stage event. The first stage occurs in the marine phreatic zone, and the second stage occurs in the meteoric phreatic zone.

MORTON, JOHN P., Univ. Texas, Austin, TX

Age of Clay Diagenesis in Oligocene Frio Formation

The Rb-Sr isotopic dating method can be applied to sedimentary rocks to determine the time of formation of diagenetic illite. In the Pleasant Bayou 1 geothermal test well in Brazoria County on the Texas Gulf Coast, the interval from 9,300 to 16,500 ft (2,800 to 5,000 m) consists mainly of overpressured shale and sand of the upper Oligocene Frio Formation. Rb-Sr isotopic analyses of the less than 0.06 μ fraction indicate that clays within the zone of "hard" geopressure, which extends downward from 11,000 ft (3,400 m), formed in equilibrium with pore water and record an age of diagenesis at 23.6 ± 0.8 m.y. This sharply defined age is in contrast to the result that would be expected if burial diagenesis had been a gradual, continuing process, in which clays at different depths would have accumulated various amount of Rb at different times in the past. If this were true, the ages of diagenesis would have varied continuously from older in the deeply buried part of the stratigraphic section to younger in the upper part of the section.

Instead, the data favor a "punctuated diagenesis" in which clay transformation occurred in a relatively brief episode early in the history of the sediment. Once formed, the clay particles persisted as closed isotopic systems. Rapid clay diagenesis in a thick package of sediment could release an enormous amount of interlayer water, and this release would have been a potential mechanism for transporting cement constituents as well as petroleum from the deeper shale beds.

Oxygen isotope data from these clays can be interpreted as supporting a smectite-to-illite conversion at a much lower temperature than those prevailing at depth today. Low-temperature early diagenesis could reduce permeability through precipitation of released silica. Further burial would then have created an optimal situation for the formation of geopressure by aquathermal pressuring.

MUKHOPADHYAY, B., and R. G. BECK, ARCO Oil and Gas Co., Dallas, TX, and J. C. RENAULT, New Mexico Bur. Mines and Mineral Resources, Socorro, NM

Thermoluminescence Evidence of Uranium Migration: Jackpile Mine Area, New Mexico

Uranium (U), equivalent U (eU), and natural thermoluminescence (NTL, corrected for sensitivity variation) were analyzed on a large number of core samples from the Jackpile uranium deposits, New Mexico. These parameters were also analyzed on outcrop samples collected from the Jackpile sandstone which hosts these deposits. NTL, U, and eU show a positive correlation reflecting the secular equilibrium among U and its daughter products in these deposits. The U anomaly for the outcrop and core samples and the eU anomaly (from gamma log) are both areally restricted to within these deposits. However, NTL of the outcrop samples produced an anomaly several times larger in area than the U and eU anomalies. Further, the trend of this NTL anomaly parallels the sediment transport direction of the Jackpile sandstone.

The Jackpile uranium deposit is probably about 100 m.y. old. The NTL anomaly appears to be detectable long after (60 m.y.?) uranium was leached out from the present barren outcrop areas. Though this work was done on a sandstone uranium deposit, findings of this investigation are applicable to exploration of other types of uranium deposits.

MULLINS, HENRY T., Syracuse Univ., Syracuse, NY

Base-of-Slope Carbonate Aprons: An Alternative to Submarine Fan Model

Along the deep margins of carbonate platforms, classic submarine fan deposition typically does not occur. Rather, coarse turbidites and debris flows are deposited as a wedge-shaped apron of debris that parallels the adjacent shelf edge. The carbonate slope north of Little Bahama Bank is a good example of a wedge-shaped base-of-slope debris apron. This slope consists of a relatively steep ($\sim 4°$) upper slope (200 to 900 m, 660 to 3,000 ft) that is heavily dissected by small (50 to 150 m, 160 to 500 ft, in relief) submarine canyons; and a broad, smooth, gentle (1 to 2°) lower slope (900 to 1,300 m, 300 to 4,300 ft), devoid of any well defined canyons or "fan valleys." The upper slope developed during the Tertiary as a prograding slope-front-fill facies of fine-grained, peri-platform oozes, whereas the lower slope has developed as a chaotic-fill facies of large slide blocks, coarse debris flows, and turbidites. Sediments along the upper slope are derived from both the overlying water column and the adjacent shallow-water banks. Sediments along the lower slope are "internally" derived via submarine cementation and subsequent submarine sliding of upper slope sediments. Debris flows are generated by these submarine slides and evolve from mud to grain-support, and commonly develop turbidity currents along their tops as they travel across the lower slope. As such, this base-of-slope apron can be divided into: (1) a proximal apron facies, characterized by thick (up to 5.5 m, 18 ft) mud-supported debris flow deposits and thick (up to 2.6 m, 8.5 ft), coarse-grained turbidites interbedded with subordinate amounts of peri-platform oozes; and (2) a distal apron facies, consisting of thinner, grain-supported debris flow deposits, and thinner, finer grained turbidites interbedded with subordinate amounts of peri-platform oozes. Seaward of the distal apron facies is a basinal facies of thin (< 20 cm, 8 in.), fine-grained turbidites interbedded with peri-platform oozes that comprise 60+% of the near surface sediments.

Such a model for base-of-slope, peri-platform carbonate sedimentation offers an alternative to the submarine fan model for those geologists and explorationists working with ancient carbonate mass-flow deposits. A good understanding of modern carbonate slope processes and products should aid in unravelling the complex stratigraphy of ancient carbonate slopes.

MULLINS, HENRY T., Syracuse Univ., Syracuse, NY and DAVID K. NAGEL, Moss Landing Marine Laboratories, Moss Landing, CA

Detection of Shallow Hydrocarbons with High-Frequency Seismic Reflection Data

High-frequency (200 to 15,000 Hz), high-resolution seismic reflection profiles can be a valuable tool in the exploration for offshore hydrocarbon accumulations. The occurrence of hydrocarbons (particularly natural gas) either in the water column or shallow subbottom can result in strong acoustic impedance (density $\times$ velocity) contrasts which may produce a number of anomalous seismic responses including: (1) water-column anomalies, which are strong reflections that rise from the ocean bottom into the overlying water column as a result of natural gas seepage; (2) subbottom amplitude anomalies ("bright spots") that, when found along geologic structures, may indicate shallow hydrocarbon accumulations; (3) seismic smears, which are "turbid," chaotic, high-amplitude events that may indicate shallow, gas-charged sediments; and (4) seismic wipeouts, transparent zones commonly found below seismic smears or water-column anomalies indicating total reflection and/or absorption of seismic energy in an overlying zone of gas.

A high-frequency, high-resolution seismic reflection profile survey of the continental margin off northern Santa Cruz County, California, using both a 300-joule "uniboom" and a 1-kilojoule sparker has resulted in the detection of all four of these seismic anomalies. The shelf here is cut diagonally by the San Gregorio fault zone which marks the southeast boundary of the Outer Santa Cruz basin. Northeast of the San Gregorio fault, the shelf is dissected by the Monterey Bay fault zone. More than 100 water-column anomalies (gas seeps) have been detected, some of which rise over 50 m (160 ft) into the overlying water column. Most water-column anomalies correlate with subbottom geologic structures such as anticlines, faults, and truncated, tilted strata. Several subbottom amplitude anomalies, seismic smears, and seismic wipeouts have also been detected and correlated with structures. All these anomalies have been found in association with the middle Miocene Monterey Formation, the late Miocene Santa Cruz Mudstone, and the Pliocene Purisima Formation. Samples of natural gas have also been collected from a shallow