these adds an incremental cost to mineral exploration and development. Water pollution control forces deeper surface casing, pit linings, liquid effluent treatment, and surface-water diversion around many mineral operations. Land restoration includes land leveling, erosion protection, and revegetation. Refuse or tailings disposal, likewise, may require expensive treatment facilities, extensive materials handling, stabilization techniques, and permanent revegetation. Air pollution control may require dust control, stack devices, and prevent the burning of waste. Operators not only face physical problems, but must also consider aesthetics from the viewpoint of ardent environmentalists. The Environmental Quality Act of 1969 can be invoked for any "significant" operation that affects federal lands or agencies. As an example of state control, Wyoming has prepared a 99-page booklet listing its environmental control laws. Determining which state or federal law or regulation applies can be difficult in itself. The mineral industry faces not only the expenses of meeting minimum statutory requirements, but most enlightened operators face even greater costs in their voluntary efforts to be good citizens. Public hearings and citizen-sponsored lawsuits challenging any operation with significant, real or imagined, environmental impact will increase.

Without extensive effort to understand and plan for future problems of land availability and the costs of environmental protection, those problems will limit seriously Rocky Mountain mineral potential.

ROSE, P. R., Shell Oil Co., Denver, Colo.

REEVALUATION OF UNCONFORMITY CRITERIA IN CARBONATE SUCCESSIONS

(No abstract submitted)

SANFORD, E. R., Great Canadian Oil Sands, Ltd., Fort McMurray, Alta.

GEOLOGY AND MINING OPERATIONS OF OIL SANDS AT FORT McMURRAY

Lease 86, the 4,000-acre tract of land presently being mined by Great Canadian Oil Sands Ltd. is in northeastern Alberta and has estimated recoverable reserves of 490 million bbl of oil.

The heavy viscous oil is found in the Lower Cretaceous McMurray Formation, which is unconformably on the Devonian strata. Several hypotheses have been expounded on the source and origin of the hydrocarbons; however, the lack of positive proof has not led to the acceptance of any hypothesis.

Modern strip-mining operations, high-powered scrapers, and bucketwheel excavators are used by GCOS to deliver the oil sand to the plant site, where a hot-water separation process extracts the bitumen from the mixture of sand, shale, and clay. The bitumen is upgraded to a high-quality synthetic crude in the refinery and delivered by means of a 16-in. pipeline to the Interprovincial Pipeline system at Edmonton for shipment to eastern refineries.

SHOMAKER, JOHN W., New Mexico Bur. Mines and Mineral Resources, Albuquerque, N. Mex.

RECENT COAL DEVELOPMENTS IN SAN JUAN BASIN, COLORADO AND NEW MEXICO

The principal San Juan basin coals are in the Upper Cretaceous Fruitland Formation; smaller reserves of somewhat better quality are found in several formations of the Mesaverde Group. Nearly all are subbituminous A or B, or high-volatile bituminous C, with sulfur content averaging about 0.7%.

Since 1953, when coal exploration began in earnest in the basin, 5 major lease blocks totaling on the order of 2¾ billion tons of potentially strippable coal have been established. Additional areas underlain by perhaps another 2 billion tons are in preliminary stages of exploration. In 1971 the Navajo mine at Fruitland probably will be the largest in the United States.

Of this reserve, about 485 million tons (10%) is committed to electric power generation. Much of the rest, particularly a large lease held jointly by El Paso Natural Gas Co. and Conoco's Consolidation Coal subsidiary, is likely to leave the basin in the form of synthetic liquid hydrocarbons or gas. Gasification and liquefaction technology is moving rapidly, and that, plus availability of major reserves of suitable coal, rising demand for fuels, and increasing availability of pipeline and marketing capacity as gas production declines, seems to indicate the future for the basin. The ultimate reserve would appear to be equivalent to about 14½ billion bbl of oil.

SIMPSON, FRANK, Saskatchewan Dept. Mineral Resources, Regina, Sask.

SEQUENCE ELEMENTS IN STRATIGRAPHIC ANALYSIS OF LOWER COLORADO (CRETACEOUS) STRATA, WEST-CENTRAL SASKATCHEWAN

Sedimentary rocks referable to the Lower Colorado subgroup are fairly well defined in the subsurface as that predominantly argillaceous sequence delimited by the base of the Speckled Shale Formation (Turonian) and the top of the Mannville-Blairmore succession (middle Albian). The sequence exhibits pronounced lateral variation and locally discernible diachronism of sandstone bodies; both the lowermost Joli Fou Formation and the uppermost Big River Formation display a northerly increase in sand content, whereas the lenticular sandstone bodies of the Viking Formation, which separates them over most of the study area, become progressively finer grained on the north, so that the formation may no longer be differentiated.

The Lower Colorado succession may be described in terms of repetition of 5 principal sequence elements, each characterized by the predominance of particular gross lithologies and associated internal sedimentary structures: (1) a mudstone element, including structureless mudstones and mudstones containing lenses and intermittent layers of siltstone; (2) a siltstone element, in which lenticular and wavy-layered siltstones and fine-grained sandstones alternate with structureless mudstones; (3) a silty sandstone element, consisting of sandstones with varying proportions of silt-grade material and thin, discontinuous mudstone interlayers, displaying disruption of flaser layering, due to burrowing activities of organisms, as well as loading and injection phenomena; (4) a sandstone element, which may exhibit dune-scale, inclined laminae, horizontal laminae, ripple cross-laminae, and trough cross-laminae; and (5) a conglomeratic element, with pebbly sandstones, conglomerates, and pebbly mudstones. Subordinate lithologies, such as coquinoidal limestones, sideritic oolites, concentrations of iron sulfides, and accumulations of phosphatic bodies, also are present.

The use of sequence elements in stratigraphic analysis provides a systematic approach to description of