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PRECAMBRIAN CYCLIC CARBONATE FACIES, WESTERN MONTANA

At least 5 main carbonate facies are recognizable in the Helena Formation (of the Precambrian Belt Supergroup) and its equivalents of western Montana: (1) stromatolite-"ribbon limestone" beds dominate the shallow-water shelf carbonate facies; (2) dark-gray to black argillaceous "pod carbonate" facies, of slightly deeper water origin; (3) green-gray and green argillite-dolomite and tan dolomite facies; (4) dark shale and platy dolomite facies of the central basin; and (5) a more highly clastic facies derived from a probable western source.

The Helena carbonate facies are markedly cyclic, with individual cycles expressed in several ways depending on horizontal and vertical stratigraphic position in the overall depositional complex of the basin. A characteristic cycle in the shelf carbonate belt includes, from base upward, (1) a stromatolitic dark limestone overlying an eroded, scour surface at the top of a dark, brown-weathering massive silty dolomite; (2) a massive "ribbon limestone" bed; (3) a dark argillite or argillaceous "pod carbonate" thinly bedded unit that may be green gray or green in some cycles; and (4) a black or dark-gray, brown-weathering massive dolomite unit, in places containing scattered "ribbon" organic structures. The brown-weathering dolomite in almost all places shows a prominent scour surface of varied relief at the top and overlain by a prominent stromatolitic structure.

Reasonable interpretations for each of these rocks and facies can be made to fit the environmental provinces of a normal epicontinental basin. However, a complete analysis of cycle and basin facies genesis must face the question of marine versus nonmarine origin of Belt sediments. Most, if not all, of the "marine" sedimentary features of the Helena carbonate beds can fit the broad sedimentary patterns of an extensive lacustrine basin. This possibility needs further study, and conceivably could help to explain problems related to Early Cambrian stratigraphy and faunas.

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DIFFERENTIATION OF LACUSTRINE AND FLUVIAL SANDSTONE BY ANALYSIS OF PALEOCURRENT PATTERNS

Oil-impregnated intervals, up to 75 ft thick within a stratigraphic interval of about 250 ft in the Garden Gulch and Parachute Creek Members of the Green River Formation (Eocene), are exposed in beds that dip gently northward in the P. R. Spring area of the southeast Uinta basin, Utah. Reserve estimates indicate that there may be about 3.7 billion bbl of oil in place.

It is necessary to distinguish lacustrine from fluvial sandstone in these intertonguing beds because most of the oil is in lacustrine sandstone. Paleocurrent study indicates that paleocurrent patterns can be used for these distinctions. A total of 308 paleocurrent measurements was made at 13 localities in the P. R. Spring area; 123 from sandstone beds of fluvial origin and 185 from lacustrine sandstone bodies.

Of 9 fluvial paleocurrent patterns, 7 indicate that streams flowed northward into Lake Uinta in the P. R. Spring area. The considerable scatter in the paleocurrent measurements suggests that the streams had low gradients and were meandering. Many of the fluvial sandstone bodies are oriented approximately north-south and contain northward-inclined foreset laminae.

Of 10 lacustrine paleocurrent patterns, 9 have significant intervals in the south half of the compass. These directions are interpreted to be dominantly the result of onshore lake currents. The shorelines of Lake Uinta probably trended northeast through much of the P. R. Spring area, but on the northeast, shorelines were oriented northwest-southeast.

The paleocurrent patterns of fluvial and lacustrine sandstone are both unimodal. The environments can be differentiated, however, on the basis of paleocurrent orientations; the fluvial currents flowed northward; the lacustrine currents were southerly.

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GEOLOGY OF FELDER URANIUM DEPOSIT, LIVE OAK COUNTY, TEXAS

(No abstract submitted)

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NEWCASTLE FORMATION IN WILLISTON BASIN

(No abstract submitted)

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ENVIRONMENTAL RESTRICTIONS ON MINERAL RESOURCE DEVELOPMENT IN ROCKIES

Exploration geologists, though by nature unbounded optimists, might profit by a realistic investigation of the factors which may constrict future mineral resource development in the Rockies. The two major factors which adversely affect present and future development of each mineral in a different manner are land availability and the additional cost factors for environmental protection.

The amount of land available for mineral exploration and development will be curtailed substantially by present and future land withdrawals, highways, and growing urbanization. In Montana, Idaho, Wyoming, Utah, Colorado, New Mexico, and Arizona, specific land withdrawals prohibit or seriously curtail mineral development. The present wilderness area encompasses 9,996,000 acres with more being proposed at each hearing. National Park and Monument lands contain 6,446,000 acres with significant additions proposed at several places. The Department of Defense controls 10,066,000 acres. Additional scenic and other mineral withdrawals are being proposed with increasing frequency. Highway right-of-ways have little effect on oil exploration, but prohibit all open pit mineral extraction and can seriously affect underground mining. In Colorado, for example, 787,000 acres are covered by public roads. Each mile of interstate highway system utilizes approximately 40 acres of land surface. Growing urbanization, though not a problem everywhere, definitely curtails mineral development in some areas. It specifically affects sand and gravel, stone aggregate, and industrial minerals.

The mounting concern for the mineral industries' real and fancied degradation of our environment is creating a proliferation of new laws and regulations. Each of 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.

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REEVALUATION OF UNCONFORMITY CRITERIA IN CARBONATE SUCCESSIONS

(No abstract submitted)

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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.

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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.

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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