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CHANNEL SANDSTONES AND RELATED ERODED AND COMPACTED INTERVALS IN LUDLOW FORMATION OF SOUTHWESTERN NORTH DAKOTA

The Ludlow Formation (lower Paleocene) of southwestern North Dakota contains elongate lenticular light- to medium-gray sandstone bodies several kilometers long, hundreds of meters wide, and more than 30 meters thick. Internal sedimentary structures, relation to surrounding beds, and fossil content indicate a fluvial-channel origin for these sandstone bodies. Marginal and bottom relations between these channel-sandstone bodies and the enclosing rocks are typically crosscutting, with the sandstone being inset in trough-shaped channels.

One sandstone body, otherwise typical of the above sandstone bodies, is not inset but is a thick lens between marker lignite beds. Lignite beds are separated by less than 1.5 m of sediment at the margins of this body. A kilometer distant, the lignite beds are separated graphically by more than 30 m of channel sandstone. The underlying marker lignite beds are not eroded or crosscut but remain intact and are split or wedged from the overlying marker lignites by the sandstone body. This relation indicates that the channel-fill sandstone occupies a preexisting, largely non-stream-eroded depression, and lies with minimal erosional unconformity on the underlying sediments. The occupied depression was probably formed as a result of localized compaction of sediments. Other possibilities for the development of the depression include intermittent deformation associated with the nearby Cedar Creek anticline, or the possible solution of underlying salt beds of Paleozoic and Mesozoic ages. Whatever the origin of the depression, it was occupied and back filled by channel deposits of a stream. Other channel-sandstone bodies in this area combine the inset and wedging relationship in the interval between marker lignite beds.

This rapid, large-scale wedging part of marker lignite beds creates problems in detailed correlation within the Ludlow Formation.

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BIOSTRATIGRAPHY OF *GLOSSOPLEURA* ZONE OF WEST-CENTRAL UTAH

In 2 measured sections in the House Range and Drum Mountains, the Chisholm and Dome Formations have a combined thickness of approximately 600 ft. The Chisholm Formation consists of shale and thin-bedded limestone. In the House Range the Dome Limestone forms massive cliffs, but in the Drum Mountains it is thin-bedded and forms slopes.

Trilobite faunas of the lower half of the Chisholm Formation in the House Range and the entire Chisholm of the Drum Mountains are typical of the *Glossopleura* assemblage zone. These include 12 genera and 19 species. Faunas from the Dome Limestone and the upper half of the Chisholm Formation in the House Range are not diagnostic of either the *Glossopleura* or *Bathyuriscus-Elrathina* Zones. In the Drum Mountains the Dome Limestone in unfossiliferous.

Poliella is the only trilobite found in the upper half of the Chisholm Formation in the House Range. It has been reported previously below and, in one place, in association with *Glossopleura*. The reversed stratigraphic occurrence of *Glossopleura* and *Poliella* in the House Range indicates that the use of *Poliella* as an index to a lower Middle Cambrian zone should be evaluated.

The *Glossopleura* fauna of western Utah shows strong affinities with faunas of the upper Arrojos Formation of Sonora, Mexico; upper Bright Angel Shale of the Grand Canyon, Arizona; lower Stephen Formation of British Columbia; upper Pioche Shale of the northern Egan Range, Nevada; and the Chisholm Shale of the Pioche District, Nevada. Trilobites of the Dome Limestone do not correlate well with any described faunas of similar facies or stratigraphic position.

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DEPOSITIONAL ENVIRONMENTS OF ENTRADA FORMATION (JURASSIC), NORTHEASTERN UTAH

In northeastern Utah the Entrada Formation contains 2 lithologic units; a lower pale yellowish-orange, fine- to medium-grained sandstone; and an upper moderate reddish-orange, very fine-grained silty sandstone. The upper unit is present only locally and where present interfingers with the lower unit. The rocks of the lower unit were deposited in 2 environments, beach and dune. The upper unit is a shallow-water marine deposit.

The beach sequence is usually the thickest part of the lower unit. These deposits are characterized by horizontal stratification, disturbed bedding, and small- to medium-scale wedge- and tabular-planar cross-stratification mostly of low angle. In the backshore zone channels containing medium-scale trough cross-stratification parallel the shoreline. Ripple marks and burrowed structures are uncommon in the lower unit.

The dune sequence is characterized by medium- to large-scale wedge-planar cross-stratification of high angle. The cross-strata are tangential to the lower bounding surface. Trough cross-stratification is present, but not common. Most cross-stratification is faint and indistinct on weathered surfaces, suggesting that water probably reworked the sand after deposition.

The upper silty sandstone unit is "structureless," except for sparse horizontal stratification.

Dominant paleocurrent directions, based on 275 measurements, are west and southwest. Nine of 11 locations show a unimodal distribution, and 79% of these measurements are between 151 and 300°. The other 2 locations show bimodal distributions; southeast-northwest and southeast-northeast.

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GEOTHERMAL RESOURCES OF COLORADO

The United States is facing serious energy crisis. It is estimated that the electrical requirements of the United States will reach 5.8×10^{12} Kwh by 1990. Most of the future electrical power will be produced by conventional generating plants; however a large share will have to be produced by other sources, such as nuclear and geothermal generating plants.

Geothermal resources—the natural heat of the earth's interior—have been used increasingly since the start of the century to generate electricity. The present worldwide geothermal generating capacity has reached nearly 900,000 kw and will probably increase tenfold in the near future.

On a worldwide basis, geothermal exploration efforts today are directed primarily to areas of surface heat leakage in regions which have experienced volcanism in the recent geologic past. Exploration for a commercial geothermal reservoir is similar to that for metalliferous mineral and hydrocarbon deposits, and involves common geologic, geophysical, and geochemical techniques. All conventional geologic exploration methods are used, such as surface and subsurface mapping, and photogeologic and remote sensing techniques to delineate the more favorable parts of the area. In conjunction with geologic mapping, geophysical methods are used. These include surface and shallow-subsurface temperature and heat-flow measurements, heat discharge from springs, rock thermal conductivity measurements, and electrical resistivity measurements. The geochemical character of the thermal springs in the region affords a rapid, preliminary evaluation of the reservoir temperature. Among some of the more useful geochemical thermometers used are the chloride and silica contents of the waters and sodium/potassium ratio.

The geothermal resources of Colorado are indicated by 113 thermal springs and wells having a temperature higher than 21° C. Most of these springs and wells are in the southern Rocky Mountains of southwestern Colorado.

The temperature of the thermal waters in Colorado ranges from a low of 21°C at Eldorado Springs to a high of 84°C at