those with siliceous (radiolarians, sponges), or phosphatic (brachiopods, conodonts, bony fish and sharks) skeletons. This indicates an abundance of mobile organisms in the depositional environment, mostly nekton with some plankton and pseudoplankton.

In addition to the production of diverse hydrocarbons, living organisms were responsible for the biogenic phosphate, some biogenic silica, and such heavy metals as zinc (<4,000 ppm) and uranium (<10 ppm).

Many lines of evidence, including stratigraphic distribution, paleoecology, and taphonomy, point convincingly to an origin in coastal marine environments analogous to modern salt marshes but with mostly floating vegetation.

MEYERS, WILLIAM J., and KYGER C. LOHMANN, State Univ. of New York, Stony Brook, NY

Geochemistry of Regionally Extensive Calcite Cement Zones in Mississippian Skeletal Limestones, New Mexico

Petrography and cement stratigraphy of four regionally extensive cement zones in Mississippian crinoidal limestones indicate that these cements precipitated in meteoric phreatic environments. Each major zone has a distinct isotopic and trace element composition.

Marine cements and lime muds in bioherms associated with the crinoidal sands have marine $\delta^{13}C_{PDB}$ (+4.0 ppm). Phreatic cements become lighter in $\delta^{13}C$ in progressively younger zones 1, 2, and 3, representing a trend toward more contribution of organically derived carbon to precipitating waters. Since zones 1, 2, and 3 were all precipitated at shallow burial depths, their trend toward lighter $\delta^{18}O$ with decreasing age suggests increasingly light waters isotopically. At 25°C, the waters responsible for zone 1 and 3 cements are estimated as $\delta^{18}O_{SMOW}$ = +1.5 and −0.9 ppm, respectively. The $\delta^{13}C$ of zone 5 cement is interpreted as a combination of rock-derived and organic-derived carbon, some of which probably came from overlying Pennsylvanian strata. The distinctively light $\delta^{18}O$ of zone 5 is attributed to precipitation at somewhat elevated temperatures, averaging about 45°C, a value in agreement with estimated burial depths.

Zone 1 cements appear to have formed in seaward parts of a freshwater phreatic system at shallow burial depths (relatively heavy $\delta^{18}O$). Zone 1 magnesium and carbon were derived from dissolution of skeletal high-Mg calcites (high Mg and heavy $\delta^{13}C$). The driving force for zone 1 cementation was thus the solubility difference between high-Mg crinoidal calcite and low-Mg zone 1 calcite. Zone 2 also precipitated at shallow depths but in a more widespread groundwater system that contained some organic carbon (light $\delta^{13}C$) and had a more landward recharge area (lighter $\delta^{18}O$). Likewise, zone 3 is formed in a shallow-phreatic lens but with the most landward (freshest) recharge (lightest $\delta^{18}O$). The inferred importance of organic-derived carbon in zone 3 (light $\delta^{13}C$) suggests degassing of CO_2 as a driving force for precipitation. The light $\delta^{18}O$ of zone 5 reflects precipitation at elevated temperatures of deeper burial (750); its element composition (table) suggests a variety of intraformational and extraformational sources.

	$\delta^{13}C_{PDB}$ o/oo	$\delta^{18}O_{PDB}$ o/oo	Wt. % MgO	Wt. % MnO	Wt. % FeO
ZONE 1 (oldest)	+3.7	−1.4	0.28	0.012	0.015
ZONE 2	+2.4	−2.8	0.15	0.056	0.068
ZONE 3	−0.5	−3.6	0.10	0.015	0.016
ZONE 5 (youngest)	+2.2	−7.0	0.16	0.052	0.185

MIDDLETON, LARRY, and JAMES R. STEIDTMANN, Univ. Wyoming, Laramie, WY

Sedimentology and Paleogeography of Cambrian Transgression in Wyoming

Middle and Upper Cambrian deposits in Wyoming represent a classic transgression or onlapping sequence of clastic and non-clastic rocks. However, sedimentologic and paleontologic criteria indicate deposition in a variety of shallow-marine, nearshore environments rather than in a simple progressively deepening marine setting.

The basal, coarse-clastic Flathead Sandstone was deposited in fluvial and nearshore marine environments as evidenced by sedimentary and biogenic structures. Braided stream deposits are characterized by alternating sets of planar cross-stratified and horizontally-bedded conglomerate and sandstone. Intertidal deposits consist of ripple cross-stratified sandstone and silty mudstone. Herringbone cross-stratification and desiccation features are common. Subtidal deposits consist of tabular and lenticular sandstone with both large-scale compound cross-stratification and small-scale trough cross-bedding. Younger, fine clastic and carbonate sequences (Gros Ventre and Gallatin Formations) represent more offshore environments where ooids and stromatolites formed on carbonate shoals.

The shoreline was oriented north-south throughout the Cambrian and was characterized by numerous embayments and islands of Precambrian basement. A number of local, as well as regional, regressions are recorded within this easterly transgressive sequence.

MILLER, F. X., R. W. PIERCE, and F. R. SULLIVAN, Amoco Production Co., Tulsa, OK

New Precision in Biostratigraphy Through Graphic Correlations

Historically, many paleontologic techniques have been proposed which establish biostratigraphic correlations. None of these methods have entirely attained the biostratigraphic resolution now required by exploration geologists for their refined and often subtle stratigraphic plays.

The graphic correlation technique developed by A. B. Shaw offers new precision in biostratigraphy by simultaneously utilizing the "total stratigraphic range" of several fossil groups preserved in the geologic record. Precise correlations of time-equivalent intervals of rock can be made on a local, regional, or worldwide scale.

Time-stratigraphic correlations developed by the graphic technique can be used by the exploration geolo-