Western Interior Mississippian Lithosomes: A Progress Report

By

William J. Sando

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WESTERN INTERIOR MISSISSIPPIAN LITHOSOMES: A PROGRESS REPORT

By William J. Sando

Abstract

A lithosome is "a vertically and horizontally segregated body of sedimentary rock, characterized by its lithic content and inferred genetic significance, which mutually intertongues with one or more bodies of differing lithic constitution" (Sando, 1990). Lithosomes are useful for describing regionally significant variations in depositional environments derived mainly from detailed studies of stratigraphic sections. Although mentioned in the North American Stratigraphic Code, lithosomes are not part of the formal nomenclatural hierarchy, which is based on geologic mapping. They offer a convenient way to overcome difficulties posed by using mapping units to describe regional depositional history, without compromising the integrity and stability of geologic mapping.

This paper is a progress report on a comprehensive revision of Mississippian stratigraphy in the Western Interior region of the United States using the lithosome concept. It describes the operational procedure being used, and presents both a preliminary chronometric lithofacies profile and paleogeographic maps for the northern part of the Western Interior basin. Some examples of clarifications of stratigraphic relations by lithosome analysis are discussed.

INTRODUCTION

My current project work is concerned with analyzing the depositional history of Mississippian rocks in the Western Interior states of Arizona, California, Colorado, Idaho, Montana, Nevada, Nebraska, New Mexico, North Dakota, South Dakota, Utah, and Wyoming. This analysis will contribute important information on changes in Mississippian sea level and climate within the Western Interior basin, and these environmental changes can then be placed in a global event framework. In the following discussion, some new terms are used for paleotectonic features in order to distinguish crustal structure elements from superimposed depositional elements.

During Mississippian time, the Western Interior region of the USA was part of an extensive epicontinental marine basin located at the western margin of the North American protocontinent, which marked the junction of two colliding crustal plates (Fig. 1). The eastward-moving oceanic plate west of the continental margin was characterized by clastic and volcaniclastic sedimentation. The western edge of the protocontinent was marked by the Antler upwarp (new term=Antler uplift of previous authors), where Late Devonian plate collision produced a mountainous island chain that became a source of terrigenous detritus during Mississippian time. Plate collision also produced the Antler downwarp (new term=Antler foreland basin of previous authors) east of the Antler upwarp; this area was the site of terrigenous and carbonate sedimentation during the Mississippian. A broad cratonic platform (Western Interior platform, new term) east of the Antler downwarp also was a locus for Mississippian sedimentation. The platform was characterized by shelf carbonate deposition during most of Mississippian time, but also received terrigenous sediments that accumulated in cratonic depressions (Big Snowy-Williston depression, Wyoming depression, Uinta depression) formed...
in the Late Mississippian. The Western Interior platform was bounded on
the east by the Transcontinental arch, which was a highland area that
contributed terrigenous detritus to the Western Interior basin throughout
the Mississippian.

Current stratigraphic and paleogeographic syntheses of the Western
Interior Mississippian (Gutschick and others, 1980; Sandberg and others,
1982; Poole and Sandberg, 1991) are based on biostratigraphic and
lithostratigraphic correlations of local, formal stratigraphic units
defined mainly by geologic mapping. The latest such synthesis (Poole and
Sandberg, 1991), an admirable step forward built mainly on conodont
correlations, did not present detailed stratigraphic profiles across the
entire Western Interior basin, and derived paleogeographic maps for only a
few selected time slices.

Goals of my current study are to present a unified stratigraphic
classification that reflects regionally significant bodies of sedimentary
rock and to construct detailed chronometric lithofacies profiles across and
along the depositional strike of the entire basin. Biostratigraphic
correlations of the rock units are made by means of a composite biozonation
based on foraminifers, corals, and conodonts. After a stratigraphic
framework is compiled for the entire basin, this framework will be used to
derive a series of detailed paleogeographic maps at close-spaced time
slices through the entire Mississippian interval. Interpretation of the
geologic history revealed by the time-slice sequence will provide a basis
for classifying depositional models and for identifying local events that
may have global significance. Such an approach should permit
differentiation of effects of global eustatic events, local and regional
sea floor subsidence, and local and regional uplift.

Data currently being evaluated consist of approximately 1,000
biostratigraphically- and lithostratigraphically-calibrated control points
gleaned from nearly 40 years of original stratigraphic research and a large
volume of published research by other investigators. This report describes
the operational procedure of the study and presents some preliminary
results.

APPLICATION OF LITHOSOME CONCEPT TO WESTERN INTERIOR MISSISSIPPIAN
STRATIGRAPHY

The basic unit used for lithostratigraphic analysis in this study is
the lithosome, which is defined as "a vertically and horizontally
segregated body of sedimentary rock, characterized by its lithic content
and inferred genetic significance, which mutually intertongues with one or
more bodies of differing lithic constitution" (Sando, 1990, p. E3). A
lithosome name is derived by contracting the geographic name of the formal
stratigraphic unit that is most typical of the lithosome and printing the
name in capital letters (Sando, 1990). The reference section for a
lithosome may be the type section of a formal stratigraphic unit, or it may
be a more representative locality discovered during later regional
studies. New lithosomes may be created for units not previously recognized
in the formal stratigraphic hierarchy. The history of the lithosome
concept and reasons for using the concept for regional
stratigraphic analysis are discussed by Sando (1990), which presents an
eexample of its use in the Mississippian of Utah.

Lithosomes emphasize lithologic similarities and differences that are
thought to represent regionally significant variations in depositional
environments and are derived mainly from detailed studies of stratigraphic
sections. Lithosomes are not intended to supplant formal stratigraphic
units that emphasize local and regional lithic variations useful for
geologic mapping and that are defined mainly by mapping studies.

OPERATIONAL PROCEDURE

Definition and recognition of lithosomes depends on four-dimensional
regional stratigraphic analysis. Lithic units are established by field and
laboratory study of each stratigraphic section. Chronometric units are
established by means of a 26-zone composite biozonation for the Western
Interior Mississippian (Fig. 2) from fossils collected during study of
stratigraphic sections. Field data on variation in lithology, thickness,
and stratigraphic position are combined with laboratory data on succession
of faunal zones in a data sheet for each stratigraphic section control
point (Fig. 3). Lithosome boundaries are identified, and environmental
parameters are inferred from both lithic and biotic data.

Control points are plotted on state base maps (1:1,000,000) for primary
locations. After selection of control points for chronometric lithofacies
profiles, selected control points are transferred to a base map for the
entire study area (Fig. 4). The example presented shows some preliminary
profile locations for the northern part of the Western Interior basin.

Chronometric lithofacies profiles are compiled from data sheets for
each control point (Fig. 5). The example presented shows one of the
profiles located on Figure 4. The vertical dimension of the profile is
time, measured both biometrically and radiometrically, and the horizontal
dimension is distance along the profile transect. Some preliminary
time-slice positions are indicated at the right side of the profile.
Preliminary lithosomes are defined and labelled, and their gross
lithologies are indicated by means of patterns in the example.

Paleogeographic maps (Fig. 6) are produced by compiling geographic
positions of lithosome boundaries for each selected time slice on a base
map containing all the profiles. Locations of boundaries in areas outside
of the profiles are determined from other control points. The example
shows the distribution of preliminary lithosomes and regionally significant
environments for five time slices in Idaho, Montana, and Wyoming, based on
chronometric lithofacies profile D-C (Fig. 5) and numerous other control
points (not shown). Note that each lithosome (see Table 2 for preliminary
data) is defined so as to represent a regionally significant depositional
environment or environmental complex. Some of the lithosomes are confined
to the area of the example, but others extend into adjacent areas; their
precise geographic limits will not be known until the entire Western
Interior basin is examined by the methods described above.

LITHOSOMES VS. FORMAL STRATIGRAPHIC UNITS

This brief report would be incomplete without giving some examples of
how lithosomes facilitate regional stratigraphic analysis. The following
examples are taken from the chronostratigraphic lithofacies profile illustrated herein (Fig. 5).

**COCANUS**

The COCANUS lithosome (Fig. 5) is an exact equivalent of the shale and siltstone facies of the upper tongue of the Cottonwood Canyon Member of the Madison Limestone in Wyoming and the Lodgepole Limestone in Montana and Wyoming. This rock unit, which ranges from a few centimeters to approximately 8 m thick, was regarded as a part of the underlying Three Forks Formation (Upper Devonian) on geologic maps published prior to its formal recognition by Sandberg and Klapper (1967). In fact, the entire Cottonwood Canyon Member (maximum thickness about 25 m), which includes subordinate stratigraphic units of both Early Mississippian and Late Devonian age, was included in the Three Forks before Sandberg (1963) described the complex relationships of its component lithic units by detailed studies of the lithology and conodont zonation of this stratigraphic interval, which was much too thin to map at conventional mapping scales. The recognition of these thin units permitted detailed description of the history of the earliest Mississippian transgression in the Western Interior basin (Sandberg and Klapper 1967).

The unmappability of the Cottonwood Canyon and its components delayed their acceptance as formal stratigraphic units and cast a shadow on their geological significance. Tradition was a barrier to separating them from the Three Forks Formation and classifying them as a part of the succeeding Madison Limestone. A cumbersome hierarchy of formation, member, tongues, and facies had to be devised in order to fit these important lithic units into the formal stratigraphic classification. Geologic mapping derived little or no benefit from the revision because the boundary originally used to differentiate mapping units remained the best choice for future mapping studies.

Recognition of COCANUS as a distinct lithosome places emphasis on its importance for analyzing regional depositional history and frees it from the cumbersome formal hierarchy that tends to belittle its importance. Geologic mapping is unaffected by this approach because lithosomes are not part of the formal stratigraphic nomenclature and do not have to be recognized on geologic maps.

**SCOTT, RAULCAN, AND SURCAN**

Four formations (in ascending order) make up most of the thick Upper Mississippian sequence mapped extensively in the Lost River and Lemhi Ranges of south-central Idaho (in ascending order): Scott Peak Formation (carbonates about 700 m thick), South Creek Formation (shale and carbonate about 125 m thick), Surrett Canyon Formation (carbonate about 300 m thick), and Arco Hills Formation (shale and carbonate about 125 m thick) (Skipp and others, 1979a). Another formation, the Railroad Canyon Formation (shale and carbonate about 260 m thick), has been mapped above the Scott Peak in the Beaverhead Mountains near the Idaho-Montana boundary (Ruppel and Lopez, Jr., written commun., 1987). W. J. Perry, Jr. mapped Scott Peak, South Creek, and Surrett Canyon Formations in his Medicine Lodge thrust sheet.

Wardlaw and Pecora (1985) proposed a new nomenclature for Upper Mississippian rocks previously called Big Snowy Group in southwestern...
Montana, and this new classification included the Lombard Limestone, a formation that was correlated with the Railroad Canyon Formation. W. J. Perry, Jr. (written commun., 1987, and in Perry and others, 1989) mapped the Lombard Limestone in his McKenzie thrust system and Four Eyes Canyon thrust sheet in the Tendoy Range and in his Snowcrest-Greenhorn thrust system northeast of the Tendoy Range. Wardlaw (1985, fig. 3) showed the temporal relationships of Upper Mississippian formations in southwestern Montana and south-central Idaho based on conodont distributions.

Skipp and others (1979a, p. AA21-22) correctly interpreted the main depositional geometry of the Scott Peak, Surrett Canyon, and South Creek Formations in Idaho as representing "carbonate-bank and forebank deposits", and Wardlaw (1985, fig. 3) refined these paleogeographic concepts. However, the constructions of these authors suffered somewhat from obfuscation of the unity of the South Creek and Arco Hills with the Railroad Canyon, the lower part of the Lombard with the Scott Peak, and the upper part of the Lombard with the Surrett Canyon, because they had to deal with formational units implying different environmental facies in different areas and did not consider the entire area in which the same lithic facies were developed.

A lithosome approach to the depositional geometry (Fig. 5, sections 36-44) clarifies the depositional relationships. In this construction, SCOTT=Scott Peak+lower part of Lombard, RAILCAN=Railroad Canyon+South Creek+Arco Hills, and SURCAN=Surrett Canyon+upper part of Lombard. A time-slice paleogeographic map based on the lithosome equations (Fig. 6, Time slice 16) shows SCOTT as an extensive shelf-carbonate production area and SURCAN and RAILCAN as allochthonous deposits in a deep basin adjacent to the shelf. Preliminary paleogeographic studies indicate that the SCOTT shelf extended southward from British Columbia (upper part of Mt. Head Formation) across Idaho to the Idaho-Utah line.

CONCLUSIONS

The foregoing examples deal with only a few of the many lithosome equations anticipated as results of complete regional analysis. Although some lithosomes not previously recognized in the existing formal stratigraphic classification will be discovered in the process, the net result will be a reduction in the number of lithic units. This procedure will provide a better basis for understanding the history of Mississippian sedimentation in the Western Interior basin.

REFERENCES CITED


Wardlaw, B. R., 1985, Late Mississippian-Early Pennsylvanian (Namurian) conodont biostratigraphy of the northern Rocky Mountains: 10th International Congress of Carboniferous Stratigraphy and Geology, Compte Rendu, v. 4, p. 391-401.

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<td>Cabin Creek, T. 6 N., R. 22 E., Custer Co., Idaho</td>
<td>Skipp (1961a, b), Skipp &amp; Mamet (1970), Skipp &amp; others (1979a)</td>
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<td>Hawley Mountain, T. 9 N., R 26 E., Butte Co., Idaho</td>
<td>Mamet &amp; others (1971), Skipp &amp; others (1979a)</td>
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<td>Copper Mountain, T. 10 N., R. 30 E., Clark Co., Idaho</td>
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<td>Sacajawea Peak, T. 2 N., R. 6 E., Gallatin Co., Montana</td>
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<td>49</td>
<td>Ralph Lowe Sandquist #1 well, T. 16 N., R. 36 E., Garfield Co., Montana</td>
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TABLE 1. Geographic locations and references for control points on chronometric lithofacies profile D-C (Fig. 5).
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<td>Bull Ridge Member of Madison Limestone, Sun River Dolomite, and equivalent beds in Mission Canyon Limestone and Charles Formation</td>
<td>Bull Lake Creek, Fremont Co., WY (Sando, 1968)</td>
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<td>COCANUS</td>
<td>Shale and siltstone facies of upper tongue of Cottonwood Member of Madison Limestone and Lodgepole Limestone</td>
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Figure 1. Map of western United States showing Mississippian paleotectonic units and location of study area (hachured polygon). Modified from Sando and Bamber (1985, fig. 2).
Figure 2. Western Interior Mississippian time scale, showing biozonations based on foraminifers, conodonts, and corals and composite biozonation used in chronometric correlation of lithosomes (modified from Sando, 1985, fig. 3).
Faunal control
* forams
* conodonts
* corals
* brachiopods
Δ other

DATA SHEET - STRATIGRAPHIC SECTION

NAME: Baldy Mountain (Arasta Creek)  NUMBER: MT-15

LOCATION: Sec. 26, 27, 34, 35 - T. 7 S., R. 3 W., Madison County, Montana

SOURCE: Sando & Durro (1980), Wardlaw & Pecora (1985), Pecora & Wardlaw (unpub. MS.), Sando (file)

KIND OF DATA:
Lith log ✓ Descrip. ✓ Thickness ✓ Fossils ✓ Detailed ✓
Generalized ✓ Composite

REMARKS:

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Three Forks Fm.

Figure 3. Sample data sheet used to compile data for control points on chronometric lithofacies profiles (Section 44 on Fig. 5).
Figure 4. Geologic map of northern part of Western Interior basin showing Mississippian isopachs and locations of some preliminary chronometric profiles (modified from Sando (1976, fig.2).
Figure 5. Chronometric lithofacies profile D-C (Fig. 4) across depositional strike of northern part of Western Interior basin, showing preliminary Mississippian lithosomes. See Table 1 for geographic locations of control points. Closed arrows indicate transgression; open arrows indicate regression.
Figure 6. Preliminary paleogeographic maps of northern part of Western Interior basin showing distribution of preliminary lithosomes (in parentheses) in five selected time slices (Fig. 5).