Distribution and Stratigraphic Significance of Foraminifera and Algae in Well Cores from Madison Group (Mississippian), Williston Basin, Montana

GEOLOGICAL SURVEY BULLETIN 1529-F

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By WILLIAM J. SANDO *and* BERNARD L. MAMET

CONTRIBUTIONS TO STRATIGRAPHY

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Determination of age and correlation of the Madison Group in the subsurface of the Williston Basin on the basis of foraminifers and algae

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ILLUSTRATIONS

CONVERSION FACTORS

Metric unit		Inch-Pound equivalent	
Length			
millimeter (mm)	=	0.03937	inch (in)
meter (m)	=	3.28	feet (ft)
kilometer (km)	=	.62	mile (mi)
Area			
square meter (m^2)	=	10.76	square feet (ft^2)
square kilometer (km^2)	=	.386	square mile (mi^2)
hectare (ha)	=	2.47	acres
Volume			
cubic centimeter (cm^3)	=	0.061	cubic inch (in^3)
liter (L)	=	61.03	cubic inches
cubic meter (m^3)	=	35.31	cubic feet (ft^3)
cubic meter	=	.00081	acre-foot (acre-ft)
cubic hectometer (hm^3)	=	810.7	acre-feet
liter	=	2.113	pints (pt)
liter	=	1.06	quarts (qt)
liter	=	.26	gallon (gal)
cubic meter	=	.00026	million gallons (Mgal or 10^6 gal)
cubic meter	=	6.290	barrels (bbl) (1 bbl=42 gal)
Weight			
gram (g)	=	0.035	ounce, avoirdupois (oz avdp)
gram	=	.0022	pound, avoirdupois (lb avdp)
metric tons (t)	=	1.102	tons, short (2,000 lb)
metric tons	=	0.9842	ton, long (2,240 lb)
Specific combinations			
kilogram per square centimeter (kg/cm^2)	=	0.96	atmosphere (atm)
kilogram per square centimeter	=	.98	bar (0.9869 atm)
cubic meter per second (m^3/s)	=	35.3	cubic feet per second (ft^3/s)
Specific combinations—Continued			
liter per second (L/s)	=	.0353	cubic foot per second
cubic meter per second per square kilometer [(m^3/s)/km^2]	=	91.47	cubic feet per second per square mile [(ft^3/s)/mi^2]
meter per day (m/d)	=	3.28	feet per day (hydraulic conductivity) (ft/d)
meter per kilometer (m/km)	=	5.28	feet per mile (ft/mi)
kilometer per hour (km/h)	=	.9113	foot per second (ft/s)
meter per second (m/s)	=	3.28	feet per second
meter squared per day (m^2/d)	=	10.764	feet squared per day (ft^2/d) (transmissivity)
cubic meter per second (m^3/s)	=	22.826	million gallons per day (Mgal/d)
cubic meter per minute (m^3/min)	=	264.2	gallons per minute (gal/min)
liter per second (L/s)	=	15.85	gallons per minute
liter per second per meter [(L/s)/m]	=	4.83	gallons per minute per foot [(gal/min)/ft]
kilometer per hour (km/h)	=	.62	mile per hour (mi/h)
meter per second (m/s)	=	2.237	miles per hour
gram per cubic centimeter (g/cm^3)	=	62.43	pounds per cubic foot (lb/ft^3)
gram per square centimeter (g/cm^2)	=	2.048	pounds per square foot (lb/ft^2)
gram per square centimeter	=	.0142	pound per square inch (lb/in^2)
Temperature			
degree Celsius (°C)	=	1.8	degrees Fahrenheit (°F)
degrees Celsius (temperature)	=	[(1.8×°C)+32]	degrees Fahrenheit

CONTRIBUTIONS TO STRATIGRAPHY

DISTRIBUTION AND STRATIGRAPHIC SIGNIFICANCE OF FORAMINIFERA AND ALGAE IN WELL CORES FROM MADISON GROUP (MISSISSIPPIAN), WILLISTON BASIN, MONTANA

By WILLIAM J. SANDO and BERNARD L. MAMET[1]

ABSTRACT

Core samples of the Madison Group (Mississippian) from four wells in the Williston Basin, Montana, have yielded microfauna and microflora that are less abundant and diversified than those from outcrops of the Madison to the west because of less favorable environmental conditions in the Williston Basin area during Madison time. Mamet Zones 7, 8, 9, 10, and 11 (or possibly 12) are represented. Microfossil distribution supports the interpretation that the upper part of the Madison in the Williston Basin is no younger than early Meramecian (early Visêan) and that the Madison is bounded above by the same regional disconformity that has been widely observed in surface sections.

INTRODUCTION

In a recent review of paleontologic evidence bearing on the age and geologic history of the Madison Group in the Williston Basin, Sando (1978) presented arguments, based on the distribution of corals, that the Madison Group in the subsurface is the same age as it is in outcrops west of the Williston Basin and that it is bounded above by the same regional disconformity observed in surface sections. These arguments run counter to most previously published interpretations of the age and nature of the upper boundary of the Madison in the Williston Basin (Perry and Sloss, 1943, p. 1301-1302; Hadley, 1950, p. 44; Sloss, 1952, p. 65, 67; Nordquist, 1953, figs. 4 and 5; Gardner, 1959, p. 331-332; Sandberg, 1962, p. 64; Roberts, 1966, fig. 2; Maughan and Roberts, 1967, p. B5, fig. 1, pl. 2).

In order to test these conclusions, thin sections were made from core samples from the seven wells reported on by Sando (1978); Mamet searched the thin sections for foraminifers and algae and studied rewarding samples. The purpose of this report is to present data on the distribution and significance of these samples. No previous study of these microfossils from the Williston Basin has been published.

[1]Département de Géologie, Université de Montréal, Montreal H3C 3J7, Canada.

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We are grateful to J. T. Dutro, Jr., and J. M. Berdan, U.S. Geological Survey, for their very helpful suggestions and their critical review of the manuscript. The excellent quality of the thin sections results from the work of K. R. Moore, U.S. Geological Survey.

DISTRIBUTION OF MICROFOSSILS

Although samples from all seven wells were examined, only the Pine, Richey, Eggebrecht, and East Poplar wells along the west flank of the Williston Basin in Montana provided adequate fauna and flora for zonal determinations (wells 1-4, fig. 1). Foraminifers and algae are rare in all cores; of 176 samples studied, only 28 samples contained zonally identifiable microfossil assemblages. Identifiable samples were zoned according to the North American scheme of Mamet and Skipp (1970a, b).

Figure 2 shows the distribution of zonally identifiable microfossils. Data on corals in these wells can be found in Sando (1978), and detailed lithic descriptions of the units in the wells can be obtained from American Stratigraphic Company logs. Coral zones recognized in the wells are those of Sando and others (1969). The correlation datum is the Coral Zone C_2/D boundary.

BIOSTRATIGRAPHY

LODGEPOLE LIMESTONE

The Lodgepole Limestone, lowermost formation in the Madison Group, contains a few samples in the upper part that represent Zone 7, which ranges from uppermost Kinderhookian into lower Osagean (middle Tournaisian of Europe). The Zone 7 assemblage is widespread in the Woodhurst Member of the Lodgepole, where it coincides with Coral Zone C_1. In the Williston Basin cores, the assemblage is very sparse and poorly diversified and consists mostly of Earlandiidae and accessory Endothyridae and Tournayellidae:

Bisphaera sp.
Brunsiina sp.
Calcisphaera laevis (Williamson)
Earlandia clavatula (Howchin)
E. elegans (Rauzer-Chernoussova)
E. minima (Birina)
Latiendothyra sp.
L. of the group *L. parakosvensis* (Lipina)
Palaeospiroplectammina tchernyshinensis (Lipina)
Rectoseptaglomospiranella sp.
Septabrunsiina sp.
Septaglomospiranella primaeva (Chernysheva)

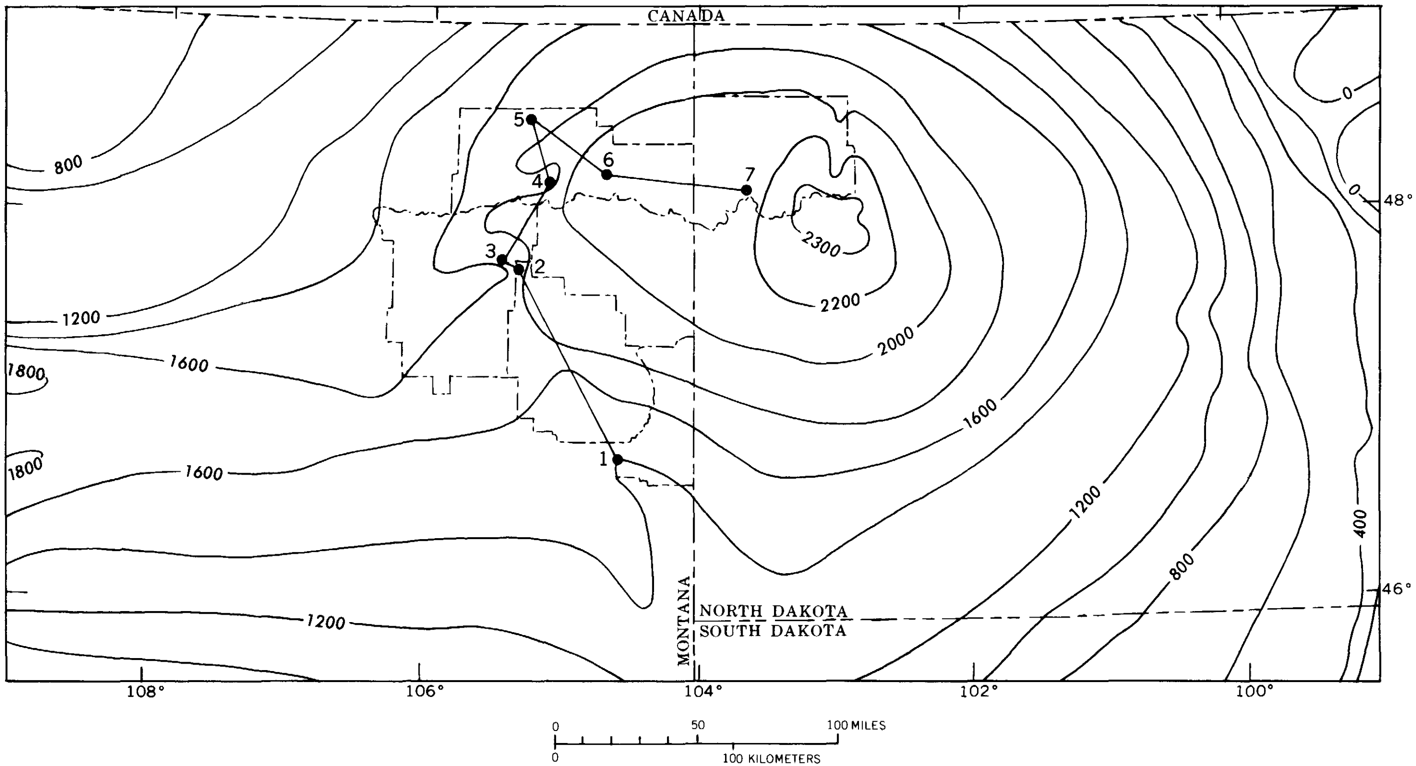

FIGURE 1.—Isopach map of Madison Group in the Williston Basin, showing locations of subsurface sections shown on figure 2 and discussed in text. (1) Shell Oil Co., Pine Unit No. 1, SW¼SW¼NE¼ sec. 30, T. 12 N., R. 57 E., Wibaux County, Mont. (2) Shell Oil Co., Richey area, Northern Pacific Railroad No. 1, SW¼NW¼NW¼ sec. 19, T. 23 N., R. 50 E., Dawson County, Mont. (3) Hodge, Smith, and Hodge Co., No. 1 Eggebrecht, CSW¼SE¼ sec. 3, T. 23 N., R. 49 E., McCone County, Mont. (4) C. H. Murphy Co., East Poplar Unit No. 1, CSW¼NE¼ sec. 2, T. 28 N., R. 51 E., Roosevelt County, Mont. (5) California Co., Grimm No. 1, CNE¼SE¼ sec. 13, T. 32 N., R. 49 E., Roosevelt County, Mont. (6) Socony Vacuum Oil Co., Damm No. F-33-23p, NW¼SE¼ sec. 23, T. 29 N., R. 54 E., Roosevelt County, Mont. (7) Texas Co., Donahue No. 1, CSW¼NE¼ sec. 23, T. 154 N., R. 100 W., Williams County, N. Dak. Isopach interval 200 ft except for 100-ft interval at center of basin. (Modified from Sandberg, 1962, fig. 15.)

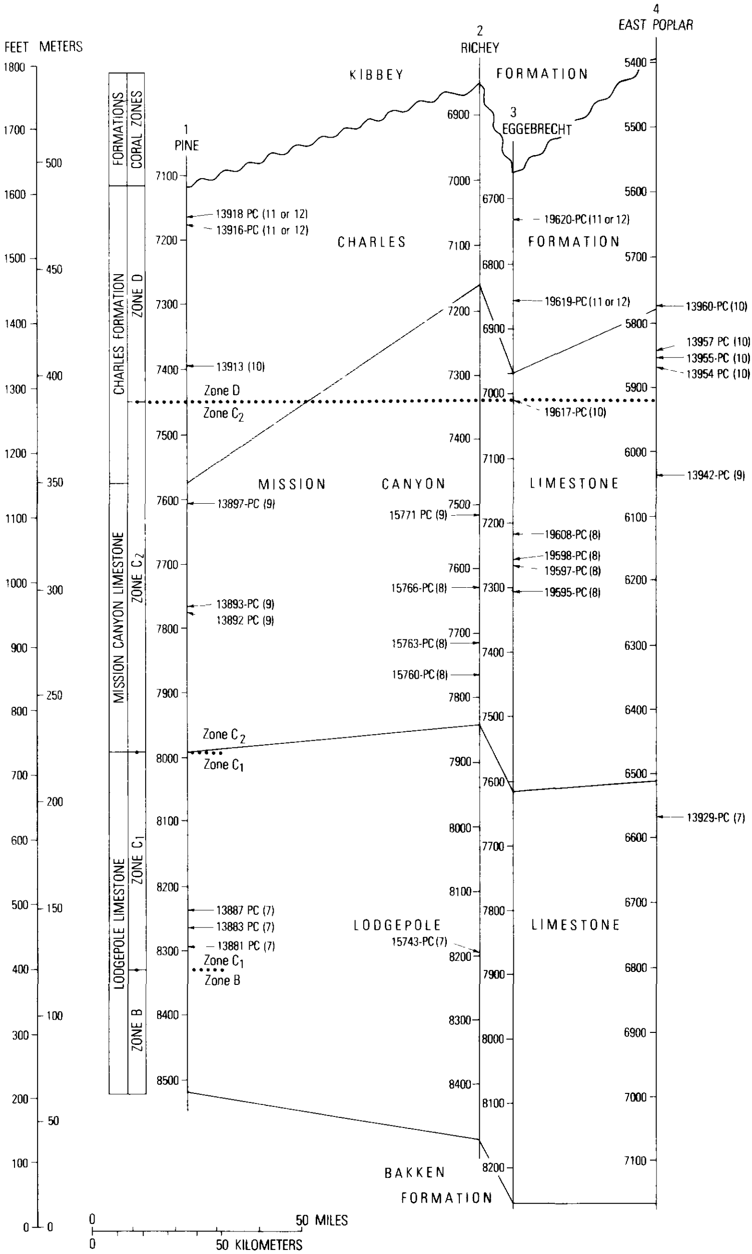

FIGURE 2.—Distribution of zonally identifiable microfossils in the Pine, Richey, Eggebrecht, and East Poplar cores. Formation boundaries (solid lines), coral zones (dotted lines), and correlation from Sando, 1978, pl. 1. Positions of microfossil samples indicated by arrows followed by USGS locality numbers and by Mamet Zone numbers (in parentheses).

MISSION CANYON LIMESTONE

The overlying Mission Canyon Limestone contains good representatives of Zones 8, 9, and 10. Zones 8 and 9 are characteristic of the lower part of the Mission Canyon elsewhere, and Zone 10 is widespread in the upper part of the formation. Zones 8 and 9 are of middle and late Osagean age (late Tournaisian of Europe) and coincide mostly with Coral Zone C_2. Zone 10 is of latest Osagean and early Meramecian age (early Viséan of Europe) and coincides with the lower part of Coral Zone D.

In the Williston Basin cores, Zone 8 is represented by an abundant and diversified microfauna and microflora. Some levels contain algal bafflestones and algal mats. *Columbiapora johnsoni* is sporadic, sometimes very abundant and sometimes absent, and encrusting *Asphaltinella* shows the same erratic pattern. Foraminifers are mostly Tournayellidae, and endothyrids are poorly represented:

Asphaltinella sp. (sometimes very abundant)
Bevocastria sp. (common in algal nodules)
Bisphaera sp.
Calcisphaera sp.
C. laevis Williamson
Columbiapora johnsoni Mamet
Diplosphaerina sp.
Earlandia clavatula (Howchin)
E. moderata (Malakhova)
Issinella sp.
I. grandis Reitlinger
Kamaena sp.
Latiendothyra sp.
Nostocites sp.
Palaeospiroplectammina tchernyshinensis (Lipina)
Parathurammina sp.
Phaeophycophyta
Rectoseptaglomospiranella? sp.
Septabrunsiina parakrainica Skipp, Holcomb, and Gutschick
Septaglomospiranella sp.
Septatournayella sp.
cf. *Spinoendothyra?* sp. (very scarce)
Tuberendothyra sp.

Zone 9 is represented in the cores by an abundant and diversified microfauna and microflora. The microflora consists of *Issinella* bafflestones and *Bevocastria* nodular wackestones. Foraminifers are still dominated by Tournayellidae, along with minor Endothyridae (the *Spinoendothyra* fauna is quite sparse):

Bevocastria sp. (very abundant in lagoonal facies)
Calcisphaera laevis Williamson
Earlandia clavatula (Howchin)
E. elegans (Rauzer-Chernoussova)
Endothyra sp.
Eoforschia sp.
Inflatoendothyra sp.
Issinella grandis Reitlinger (very abundant in bafflestones)
Kamaena sp.
K. pirleti Mamet and Roux
Latiendothyra sp.
Palaeoberesella sp.
P. lahuseni (von Möller)
Proninella sp.
Pseudoissinella sp.
Septabrunsiina sp.
S. parakrainica Skipp, Holcomb, and Gutschick
Septaglomospiranella sp.
Septatournayella pseudocamerata (Lipina *in* Lebedeva)
Spinoendothyra sp.
S. spinosa (Chernysheva)

Zone 10 is represented by an abundant and diversified microfauna and microflora. Tournayellidae are slowly eliminated and replaced by Endothyridae, Globoendothyridae, and Endothyranopsidae:

Calcisphaera laevis (Williamson)
C. pachysphaerica (Pronina)
Dainella sp.
Diplosphaerina sp.
Earlandia clavatula (Howchin)
E. vulgaris (Rauzer-Chernoussova and Reitlinger)
cf. *Eblanaia?* sp.
Endothyra sp.
Eoparastaffella sp.
Eotuberitina sp.
cf. *Globoendothyra?* sp. (or *Eogloboendothyra?* sp.)
Globoendothyra of the group *G. baileyi* (Hall)
Inflatoendothyra sp.
Issinella sp.
Parathurammina sp.
Priscella sp.
Quasipolyderma sp.
Radiosphaerina sp.
Septatournayella(?) henbesti Skipp, Holcomb, and Gutschick

CHARLES FORMATION

The Charles Formation, uppermost formation in the Madison Group, is characterized by microfossil assemblages of Zones 10 and 11 (possibly ranging into Zone 12). In the outcrop area of the Mississippian west of the Williston Basin, these zones are found in the upper part of the Mission Canyon Limestone (Sando and others, 1969). Zones 10 and 11 are of early Meramecian age (early Viséan of Europe) and are ordinarily the youngest zones found in the Madison Group beneath a regional disconformity overlain by the Big Snowy Group in Montana and the Amsden Formation in Wyoming (Sando and others, 1969). The only exception to this rule is in the Bighorn Mountains of Wyoming and Montana, where rare occurrences of Zone 12 are known (Sando and Mamet, 1974). The rest of Meramecian time (Zones 13 through 15) is represented by an hiatus wherever the Madison is directly overlain by the Chesterian (Big Snowy Group and lower part of the Amsden Formation) (Sando and others, 1975, fig. 13). The occurrence of Zone 11 (possibly ranging into 12) microfossils near the top of the Charles Formation in the Pine and Eggebrecht wells corroborates the interpretation based on corals (Sando, 1978, p. 236)—that the top of the Charles Formation in the subsurface is bounded by the same disconformity that is so well documented in outcrops of the Madison to the west.

Zone 11 (possibly ranging into 12) microflora is abundant and diversified in a lagoonal facies. Among the foraminifers, the endothyrids, globoendothyrids, and endothyranopsids dominate; the *Eoendothyranopsis* fauna is poorly represented:

Asphaltinella sp. (abundant in algal mats)
Brunsia sp.
Calcisphaera laevis (Williamson)
C. pachysphaerica (Pronina)
Dainella sp.
Erlandia of the group *E. clavatula* (Howchin)
E. vulgaris (Rauzer-Chernoussova and Reitlinger)
Eblanaia sp.
Endothyra sp.
cf. *Eoendothyranopsis?* sp.
Eoendothyranopsis of the group *E. spiroides* (Zeller)
E. spiroides (Zeller)
Eoforschia sp.
E. moelleri (Malakhova *in* Dain)
Eoparastaffella sp.
Globoendothyra bridgensis Skipp
cf. *Inflatoendothyra?* sp.
Issinella sp.

Kamaena sp.
Nostocites sp.
Orthriosiphonoides sp.
Palaeoberesella sp.
Paracalligelloides sp.
Parathurammina sp.
Planoendothyra? sp.
Priscella sp.
Pseudoissinella sp.
Radiosphaerina sp.
cf. *Septabrunsiina?* sp.
Septatournayella(?) henbesti Skipp, Holcomb, and Gutschick
Skippella sp.
Stacheiinae

ENVIRONMENTAL INTERPRETATION

The Williston Basin foraminifers belong to the North America Realm (Mamet, 1977; Mamet and Skipp, 1979) but are far less abundant and diversified than in the Lodgepole and Mission Canyon Limestones of the outcrop area to the west (see microfossil lists in Sando and others, 1969). In the Williston Basin, most of the foraminiferal microfauna is observed in limestones that show signs of restricted circulation (sulfates are present in the Lodgepole and are widespread in the Mission Canyon and Charles). Pseudomorphs of sulfates are common in algal-rich lagoonal phases; this environment is basically unfavorable to foraminifers, which prefer open-marine conditions. On the other hand, the algal microflora is more abundant and diversified, including palaeoberesellids, issinellids, and bevocastriids. Dasyclads are usually restricted to *Columbiapora. Asphaltinella* is quite common and is accompanied by stacheiins in the upper part of the Charles Formation.

REGIONAL CORRELATION

Figure 3 shows correlation of the Madison Group in the Pine Well core with type sections of the Madison and its component stratigraphic units in the outcrop area to the west in Montana. Figure 4 shows locations of the sections.

The correlation diagram (fig. 3) was originally based on coral zones recognized by Sando (1978). Occurrences of zonally determined microfossil collections have been added to the diagram, and microfossil zone boundaries have been drawn. Three of the four microfossil-zone boundaries coincide with coral-zone boundaries. Thus, the microfossil correlations confirm the correlations made on coral zones and support the

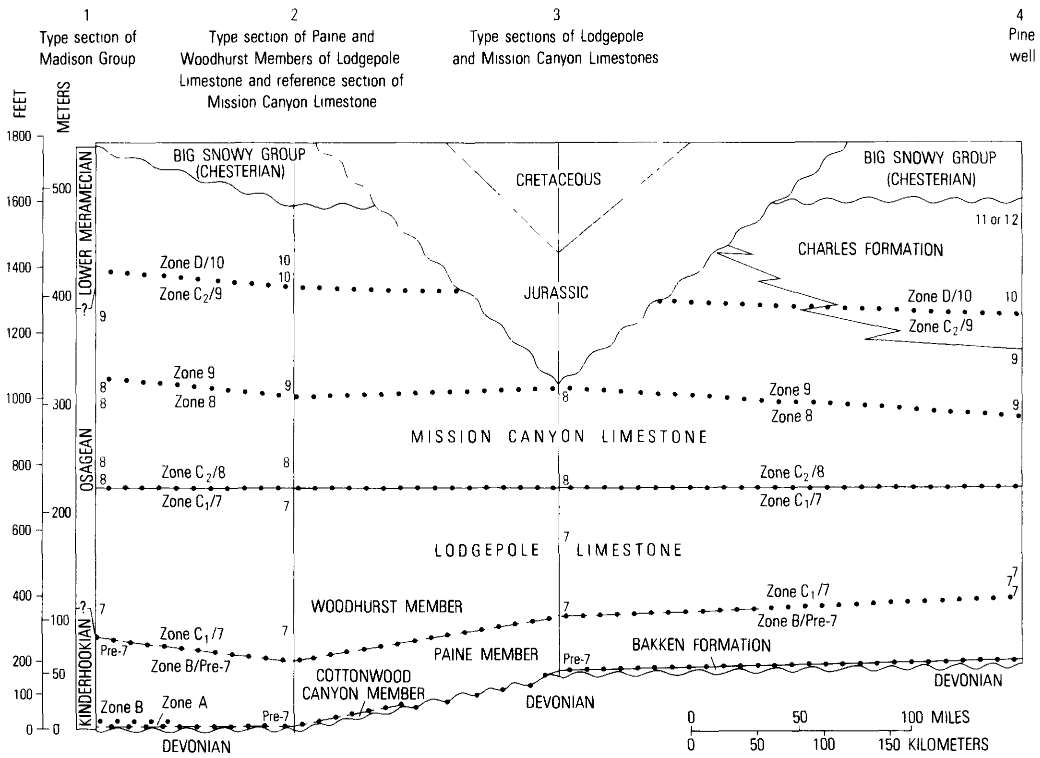

FIGURE 3.—Correlation of Madison Group in Shell Pine Unit No. 1 well (4) with (1) Logan section, (2) composite of Monarch-US 89 and Dry Fork sections, and (3) composite of Little Chief Canyon and Mission Canyon sections. Figure 4 shows locations of sections. Formation boundaries indicated by solid lines (wavy where disconformable), member boundaries indicated by dashed lines, fossil-zone boundaries indicated by dots. Positions of microfossil collections indicated by zone numbers adjacent to sections. (See Sando and Dutro (1974) for descriptions of the type sections and Sando (1960) for log of Shell Pine well.)

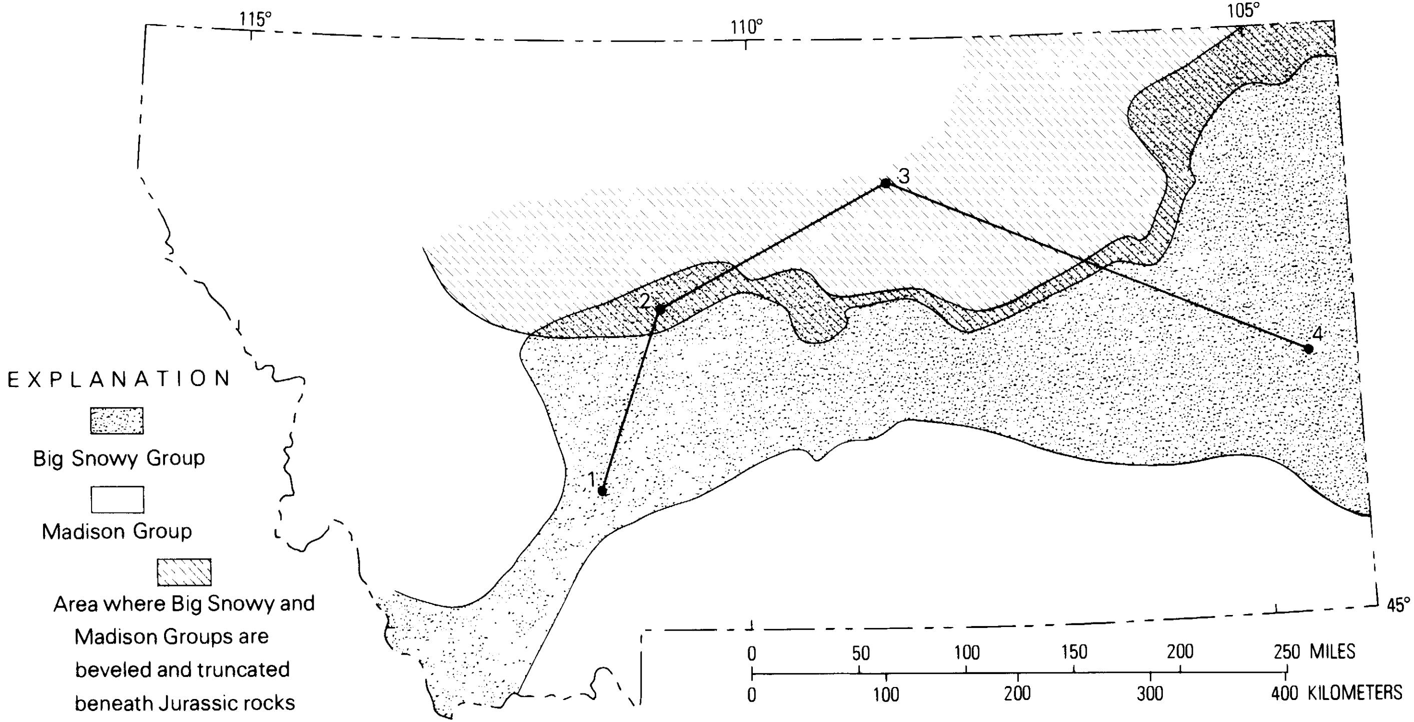

FIGURE 4.—Paleogeologic map of Montana showing distribution of Big Snowy and Madison Groups and locations of stratigraphic sections shown on figure 3. (1) Logan section (SE¼SW¼ sec. 25, T. 2 N., R. 2 E., Gallatin County).(2) Composite of Monarch-U.S. 89 and Dry Fork sections (SE¼NE¼ sec. 27, T. 16 N., R. 7 E. and SE corner sec. 35, T. 16 N., R. 7 E., Cascade County). (3) Composite of Little Chief Canyon and Mission Canyon sections (NE¼NW¼ sec. 30, T. 26 N., R. 25 E., and SE¼NW¼ sec. 32, T. 26 N., R. 24 E., Blaine County). (4) Shell Oil Co., Pine Unit No. 1 well (SW¼SW¼NE¼ sec. 30, T. 12 N., R. 57 E., Wibaux County). (Modified from Maughan and Roberts, 1967, pl. 3.)

interpretation that the Madison Group in the subsurface of the Williston Basin is the same age as the Madison Group of outcrop.

CONCLUSIONS

Foraminifers and algae in the Madison Group of the Williston Basin are not as abundant or diversified as they are in other areas where the Madison microfossils have been studied, because of less favorable environmental conditions during Mississippian time in the Williston Basin. Despite these limitations, the presence of Zones 10 and 11 (possibly ranging into 12) assemblages near the top of the Charles Formation and the absence of assemblages from younger Meramecian zones indicates that the Charles is no younger than early Meramecian and that it is bounded above by the same regional disconformity that characterizes the top of the Madison Group in outcrop areas outside the Williston Basin.

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