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PAMPHLET

LITHOLOGIC CROSS SECTIONS OF PHANEROZOIC ROCKS IN THE NORTHERN MIDCONTINENT, U.S.A.

Compiled by

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FOLIO NOTE

This publication is part of a folio of maps and cross sections of the northern Midcontinent area (bounded by lat 36°-46° N. and long 88°-100° W.) prepared under the Midcontinent Strategic and Critical Minerals Project. This project is a cooperative activity between the U.S. Geological Survey and the geological surveys of the included States. Other maps in this folio published to date include U.S. Geological Survey Miscellaneous Field Studies Maps MF-1835-A through F (Mugel, 1986; Jorgensen and others, 1986; Marvin, 1988; Pratt, 1987; Anderson, 1988; Hills and others, 1991) and U.S. Geological Survey Miscellaneous Investigations Series Maps I-1853-A (Sims, 1990) and I-2214 (Sims and others, 1991). Additional maps in the folio showing various geologic aspects of the same area may be published in this same map series with different letter suffixes (MF-1835-H, I, and so on).

INTRODUCTION

This set of lithologic cross sections along even-numbered lines of latitude and longitude is intended to complement a map of Phanerozoic structures (Anderson, 1988) and several lithofacies maps in this series on the Phanerozoic sequences of the northern Midcontinent area. The series was originally conceived for use with other data as a potential guide to regional prospecting for sediment-hosted mineral deposits (Pratt, 1985), but these cross sections and the structural map may prove useful for other purposes as well.

The cross sections were compiled from cross sections of each State at 1:500,000 horizontal scale and 1:6,000 vertical scale, prepared by the following individuals: J.D. McFarland III (Arkansas), J.W. Baxter, P.L. Fox, and H.R. Schwalb, (Illinois), C.H. Ault, J.B. Droste, and J.B. Patton (Indiana), W. Bunker, O. Plocher, and R.R. Anderson (Iowa), R.A. Evenson and W.L. Watney (Kansas), W.H. Anderson (Kentucky), J.H. Mossler (Minnesota), J.W. Whitfield and J.A. Martin (Missouri), M.P. Carlson (Nebraska), S.B. Anderson (North Dakota), K.S. Johnson (Oklahoma), R.A. Schoon (South Dakota), E.T. Luther (Tennessee), and B.A. Brown and R.M. Peters (Wisconsin). All sections were photographically reduced 50 percent, both horizontally and vertically, for the present compilation. The principal sources of data were drill-hole lithologic logs in the libraries of the State geological surveys. Locations of drill holes are shown by tick marks above each cross section ("control-well locations"); numbers alongside the tick marks indicate the total depth of the well in feet above or below mean sea level, where this information is available. Additional data regarding many of the drill holes are summarized in another map in this folio (Mugel, 1986). We thank Gary Krizanich for signal service in the final redrafting of the sections; and Frank J. Adler, formerly of Phillips Petroleum Company, for an especially constructive critical review.

Preparation of the cross sections involved arbitrary decisions at several stages. First, construction of sections for reduction to a vertical scale of 1 in.=1,000 ft required numerous generalizations from the drill logs, many of which are at much larger scales; suffice to say that some logs are more detailed than others, and the same is true of the cross sections. Second, it is in the nature of cross sections that subsurface control is not complete, and that where adjacent well logs show different lithologies in the same stratigraphic interval, the contributors had to make arbitrary calls as to where to draw lateral contacts. In some places, lateral transitions are shown without any apparent break or contact. This generally reflects a wide spacing between the control wells, such that placing even an arbitrary contact would have implied a higher level of data than actually exists. Third, in addition to the arbitrary decisions by each

contributor within his own State, compilation of the complete cross sections required matching of units at 37 places where sections cross State lines, as well as the full length of the Nebraska-Kansas join along lat 40° N. Rarely did the cross sections match initially; adjustments were made by the senior author in consultation with the contributors, in some cases requiring several iterations, in an attempt to avoid abrupt transitions or "State-line faults".

The only exception to this adjustment practice is at the junction of lat 38° N. and long 88° W., which falls in Indiana a mere 1.5 mi east of the Illinois line. Initially, no cross sections had been solicited from Indiana and the Indiana portion of the section along lat 38° N. was extrapolated to long 88° W. by the Illinois State Geological Survey in their section along lat 38° N. After all the sections had been received and compiled and the differences adjusted, we realized that the section along long 88° W. contained a gap of some 18 mi in Indiana, which could not reasonably be interpolated between the adjoining sections from Illinois and Kentucky. The Indiana Geological Survey graciously provided a cross section for this gap, but to avoid any further delay in releasing this publication, we have not attempted to reconcile discrepancies at the 38°-88° junction.

DISCUSSION

In keeping with the initial intent, these cross sections emphasize the distribution of major lithologies. The vertical scale of the sections precludes showing formational boundaries, so the lithologic units are grouped into the subsequences and sequences of Sloss (1963, 1982)—"*** chronologic increments defined by interregional unconformities [which are] almost everywhere present in the cratonic interior where the appropriate chronostratigraphy is preserved and which are capable of extrapolation to surfaces of apparent conformity at the former positions of continental slopes and in the interior of certain basins." (Sloss, 1982, p. 27). These subdivisions are shown in Sloss's table 1 and are reproduced here in slightly modified form; a generalized version of this table is also printed on each sheet. (The cross sections were prepared before the publication of Sloss's 1988 revision of these subdivisions, which differs in several details from the 1982 version.) We have added conventional lithologic patterns at selected intervals along each section to give an idea of gross lithologic packages at a glance. In addition, on the long 88° W. section, the lowermost Sauk III dolomite and the sandstone that caps it have been patterned between about lat 36°40' N. and lat 38° N. to clarify the structural complexities. Elsewhere the sections are left unpatterned to avoid appearing too "busy", and on the supposition that users may want to use colored pencils or pens to highlight units of particular individual interest. A few general remarks on the principal or most conspicuous units may serve as an orientation; from the youngest down, these are:

Tejas III: the principal overburden—Quaternary and upper Tertiary glacial deposits, loess, and residuum.

Tejas II and I: lower Tertiary deposits in the Mississippi embayment.

Zuni IV and III: Cretaceous clastic rocks of the eastern Great Plains (South Dakota, Nebraska, and Kansas), and Upper Cretaceous and lowermost Tertiary sedimentary rocks in the Mississippi embayment.

Zuni II and I and Absaroka III: represent the lowermost Cretaceous and the Jurassic and Triassic, and are largely absent.

Absaroka II: Permian evaporite and interbedded shale in Oklahoma and Kansas.

Absaroka I: Lowermost Permian and Pennsylvanian interbedded sandstone, shale, and limestone; includes interbedded coal in the Illinois basin and around the flanks of the Ozark uplift.

Kaskaskia II: Mississippian limestone.

Kaskaskia I: most notably, the organic Chattanooga Shale (Upper Devonian part) in Oklahoma and southern Kansas; also Middle Devonian carbonate rocks in northern Kansas, Nebraska, Iowa, northern Missouri, and Illinois.

Tippecanoe II: Lower Devonian and Silurian limestone in Oklahoma, Arkansas, and Tennessee.

Tippecanoe I: Upper and Middle Ordovician carbonate rocks—Simpson Group, Platteville and Decorah Formations, Galena Dolomite, Viola and Kimmswick Limestones, and correlatives.

Sauk III: the regional Ordovician-Cambrian carbonate package—Cotter and Oneota Dolomites down through Bonneterre and Eau Claire Formations; Arbuckle Group; and correlatives.

Sauk II: the widespread basal sandstone beds of earliest Late Cambrian and Middle Cambrian ages—Lamotte and Mt. Simon Sandstones and correlatives.

More detailed stratigraphic terminology can be obtained by referring to the appropriate COSUNA chart (Adler, 1987; Bergstrom and

Morey, 1985; Mankin, 1987; Shaver, 1985). Sloss (1982) provides an excellent discussion of the sedimentational history. Users desiring additional details on the stratigraphy or control wells should contact the contributors at the respective State geological surveys, where in most cases the original, larger-scale cross sections are available for inspection or copying.

For maximum utility with reference to regional structures, we recommend using these cross sections in tandem with the structural and Precambrian maps of Anderson (1988) and Sims (1990).

ADDITIONAL COMMENTS ON SPECIFIC FEATURES

Section along lat 36° N.

Fault at long 97°40' W.: The abrupt decrease in the thickness of Kaskaskia II from west to east is due to deeper erosion of Kaskaskia II on the upthrown block (east side). There is an unconformity at the top of Kaskaskia II on both sides of the fault, but it cuts deeper on the east side.

Fault at long 96°32' W.: Absence of Kaskaskia I and II west of the fault is correct; absence is based on subsurface mapping of pre-Pennsylvanian rocks (Jordan and others, 1962).

Section along lat 38° N.

Just east of long 97° W., in the Nemaha uplift fault block bounded by the Elbing and Humboldt faults, the lithologies of the units between the base of Absaroka I and the top of Sauk III dolomite could not be labeled owing to lack of space; from the top down they are: Kaskaskia II chert, Kaskaskia II cherty dolomite, Kaskaskia I shale, Kaskaskia I dolomite, Tippecanoe I limestone, and Tippecanoe I sandstone.

Section along lat 42° N.

Eastward from long 93°30' W.: The great thickness of sedimentary rocks eastward from the Thurman-Redfield structural zone is interpreted to be Sauk II, and not Keweenawan, on the basis of fossil fragments at depth. Deep burial of the Precambrian surface is substantiated by Sims (1990).

At long 90°25' W.: The deep "holes" in Tertiary and Ordovician rocks are coincidental. Local incision of upper Tippecanoe II by Tertiary streams is typical of the region. Sauk III is incised by lowermost Tippecanoe I (St. Peter Sandstone). The erosional characteristics are not necessarily superimposed one-for-one but cross at an angle to each other.

Section along lat 44° N.

Between long 100° W. and long 99° W., the Zuni III sequence may include some rocks of Tippecanoe I age (Red River and Winnipeg Formations) (F.J. Adler, written commun., 1988).

Section along lat 46° N.

In the Williston Basin, Lochman-Bal' (1972) and Foster (1972) showed rocks of Late Cambrian and Early Ordovician age (Sauk III) present west of about long 99° W., reaching about 200 ft in thickness at long 100° W. Further comparison with this same general source (the atlas of the Rocky Mountain Association of Geologists) shows that Mississippian rocks (Kaskaskia II) do not extend eastward of long 99° W. (Craig, 1972), and that Pennsylvanian rocks (Absaroka I) do not extend eastward of long 100° W. (Mallory, 1972). It is also possible that 0-100 ft of rocks of Zuni I age (Piper and Nesson Formations) and 0-200 ft of rocks of Zuni II age (Morrison, Swift, and Rierdon Formations) are present between about long 99° W. and long 100° W. (F.J. Adler, written commun., 1988).

Section along long 88° W.

In Kentucky, the depth to basement is based on seismic data. Specifically, the extreme thickness of Sauk II (Cambrian shale) midway between lat 37° and 38° N. is based on (1) confidential seismic data, which indicate basement surface at about -28,000 ft, and (2) a westward thickening of the Eau Claire Formation (Sauk III) in western Kentucky toward a deeper basin in Webster and Union Counties. This extreme thickness is believed to be related to growth faulting and extensional tectonics on the south side of the northernmost hinge of the Rough Creek fault system.

At the Kentucky-Indiana border is a true "State-line" fault; it is the northwesternmost fault bounding a fault block that is unnamed in Kentucky but is called the Mt. Vernon graben in Indiana.

Section along long 92° W.

Between lat 37°40' N. and lat 38°10' N.: The sandstone lens in Sauk III represents the Roubidoux Formation of Early Ordovician age.

Section along long 94° W.

At lat 41°40' N.: See the comment on excessive thickness of Sauk II under "Section along lat 42° N."

Section along long 96° W.

Between about lat 42°30' N. and lat 43°30' N.: Zuni IV includes a minor thickness of Zuni III in the lowermost part of the Dakota Formation.

Section along long 100° W.

At lat 46° N.: See comments under "Section along lat 46° N."

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Table 1. Chronostratigraphy of stratigraphic sequences (Modified from Sloss, 1982)

Erathem or System	Subsystem	Series	Stage	Ma	Sequence
Quaternary		Holocene and Pleistocene			
Tertiary	Neogene	Pliocene			Tejas III
		Miocene			
		Oligocene		29	
	Paleogene	Eocene		49	Tejas II
		Paleocene		60	Tejas I
Cretaceous		Upper	Maastrichtian		
			Campanian		
			Santonian		Zuni IV
			Coniacian		
			Turonian		
			Cenomanian	91	
			Albian		
		Lower	Aptian		Zuni III
			Barremian		
			Hauterivian		
			Valanginian		
			Berriasian	129	
Jurassic		Upper	Portlandian		
			Kimmeridgian		Zuni II
			Oxfordian		
			Callovian		
		Middle	Bathonian	150	
			Bajocian		Zuni I
			Aalenian		
		Lower	Toarcian		
			Pliensbachian		
			Sinemurian	185	
			Hettangian		
Triassic		Upper	Rhaetian		
			Norian		
			Carnian		Absaroka III
		Middle	Ladinian		
			Anisian		
		Lower	Scythian	232	

Permian	Ochoan Guadalupian Leonardian Wolfcampian	Tatarian Kazanian Kungurian Artinskian Sakmarian	286	Absaroka II
Pennsylvanian	Virgilian Missourian Desmoinesian Atokan Morrowan	Stephanian D C Westphalian B A C Namurian B		Absaroka I
Mississippian	Chesterian Valmeyeran Kinderhookian	Viséan A	335	Kaskaskia II
Devonian	Upper Middle Lower	Famennian Frasnian Givetian Eifelian Emsian Siegenian Gedinnian	372 401	Kaskaskia I
Silurian	Upper Middle Lower	Pridolian Ludlovian Wenlockian Llandoverian	431	Tippecanoe II
Ordovician	Upper Middle Lower	Ashgillian Caradocian Llandeilian Llanvirnian Arenigian Tremadocian	458	Tippecanoe I Sauk III
Cambrian	Upper Middle Lower	Trempealeaun Franconian Dresbachian	515 548	Sauk II Sauk I
Late Proterozoic			600	

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