

**PS Curious Case of Lack of Strata Assignable to the *Pterospathodus celloni* Superzone (Telychian, Llandovery, Silurian) in the Eastern Portion of the Midwestern Basins and Arches Region (New York, Ohio, Kentucky, and Indiana)\***

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**Abstract**

Telychian strata are present throughout the eastern portion of the Midwestern Basins and Arches region (MBA) in New York, Ohio, Kentucky, and Indiana. Most conodont biostratigraphies developed for Telychian strata prior to 2000 assigned those strata to the *Pterospathodus celloni* and/or succeeding *Pt. amorphognathoides* Zone, the two zones previously recognized as comprising most/all of the Telychian. Significant revision of Silurian conodont taxonomy beginning in the late 1990s resulted in recognition of seven conodont zones belonging to three conodont superzones and one conodont zonal group comprising the same portion of the Telychian. Restudy of conodonts from research on Telychian strata conducted by the authors and others prior to 2000 and sampling and processing for conodonts from Telychian strata located in New York, Ohio, Kentucky, and Indiana conducted mostly in the last decade, as well as information published by others during the last decade, make it possible to recognize that strata assignable to the *Pterospathodus celloni* Superzone are mostly absent throughout the eastern part of MBA in New York, Ohio, Kentucky, and Indiana.

Strata assigned to the *Pterospathodus amorphognathoides amorphognathoides* Zonal group typically overlie strata assigned to the *Pt. eopennatus* Superzone, or even older, Aeronian strata. Examples of strata assigned to the *Pt. am. amorphognathoides* Zonal group overlying strata assigned to the *Pt. eopennatus* Superzone include Willowvale Shale or Westmoreland Hematite overlying Sauquoit Shale and Rockway Dolomite overlying Merrittton Limestone in New York, Estill Shale overlying Waco Formation in Ohio and Kentucky, and Osgood Formation overlying Lee Creek Formation in Indiana. One exception is a section near Rochester, New York, where both the *Pt. am. amorphognathoides* Zonal group and *Pt. celloni* Superzone (*Pt. am. angulatus* Zone) are recognized in the Williamson Shale.

Silurian sea-level curves typically indicate high sea levels during much of the time represented by *Pterospathodus celloni* Superzone, and time represented by some/most of the *Pt. am. amorphognathoides* Zonal group, and typically indicate lower sea levels during the time represented by the *Pt. eopennatus* Superzone, including a significant drop in sea level near the end of the time that superzone represents. The sea-level

record would seem to favor deposition of, and less erosion of, strata assignable to the *Pt. celloni* Superzone than strata assignable to the *Pt. eopennatus* Superzone. Tectonic activity along the Appalachian Orogenic Belt must have played an even more important role than eustasy in the stratigraphic record of the eastern portion of the MBA in New York, Ohio, Kentucky, and Indiana during the 1.5 to 3.0 million years of time represented by the *Pt. celloni* Superzone.

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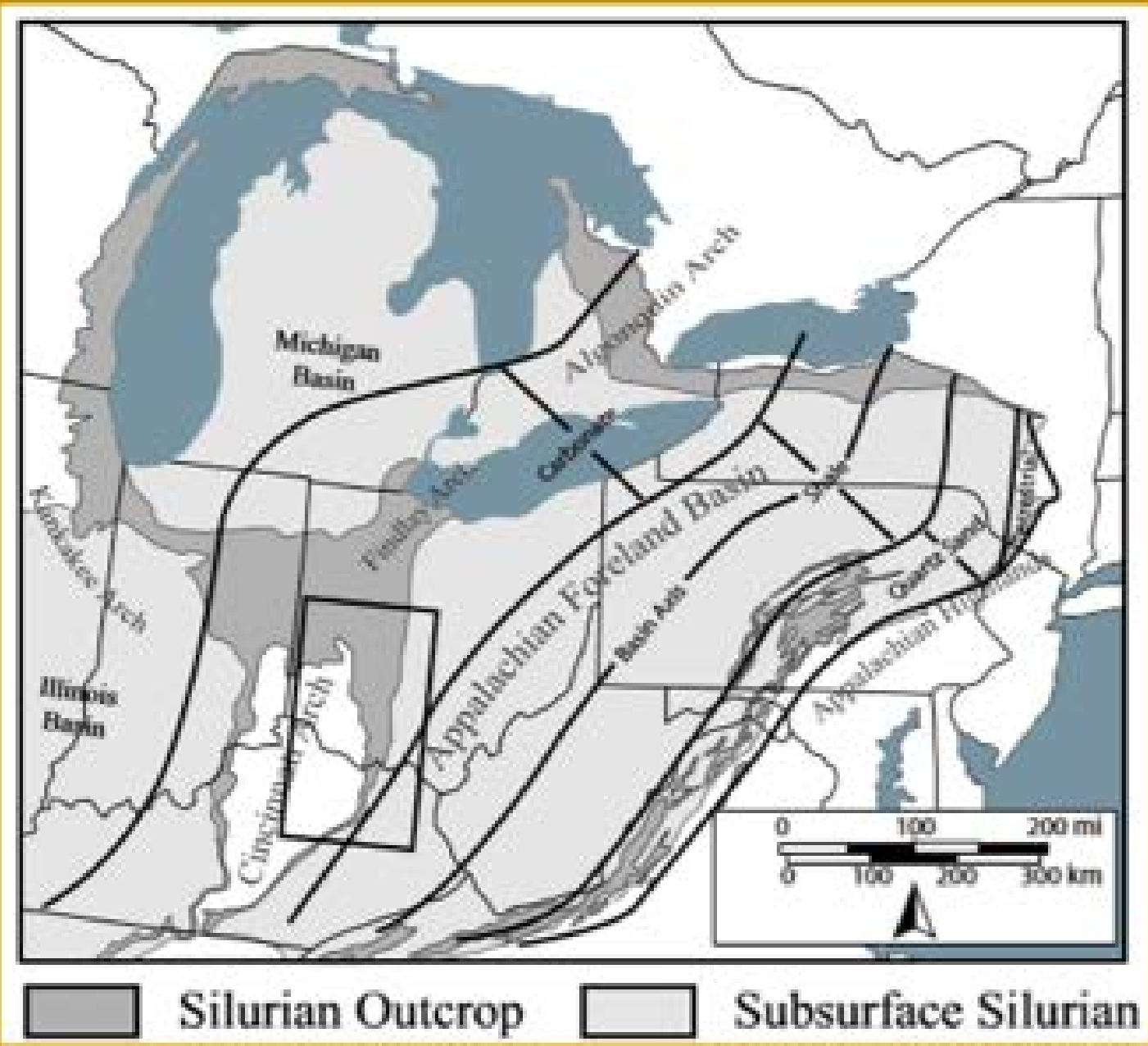
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Curious Case of Lack of Strata Assignable to the *Pterospathodus celloni* Superzone (Telychian, Llandovery, Silurian) in the Eastern Portion of the Midwestern Basins and Arches Region (New York, Ohio, Kentucky, and Indiana)

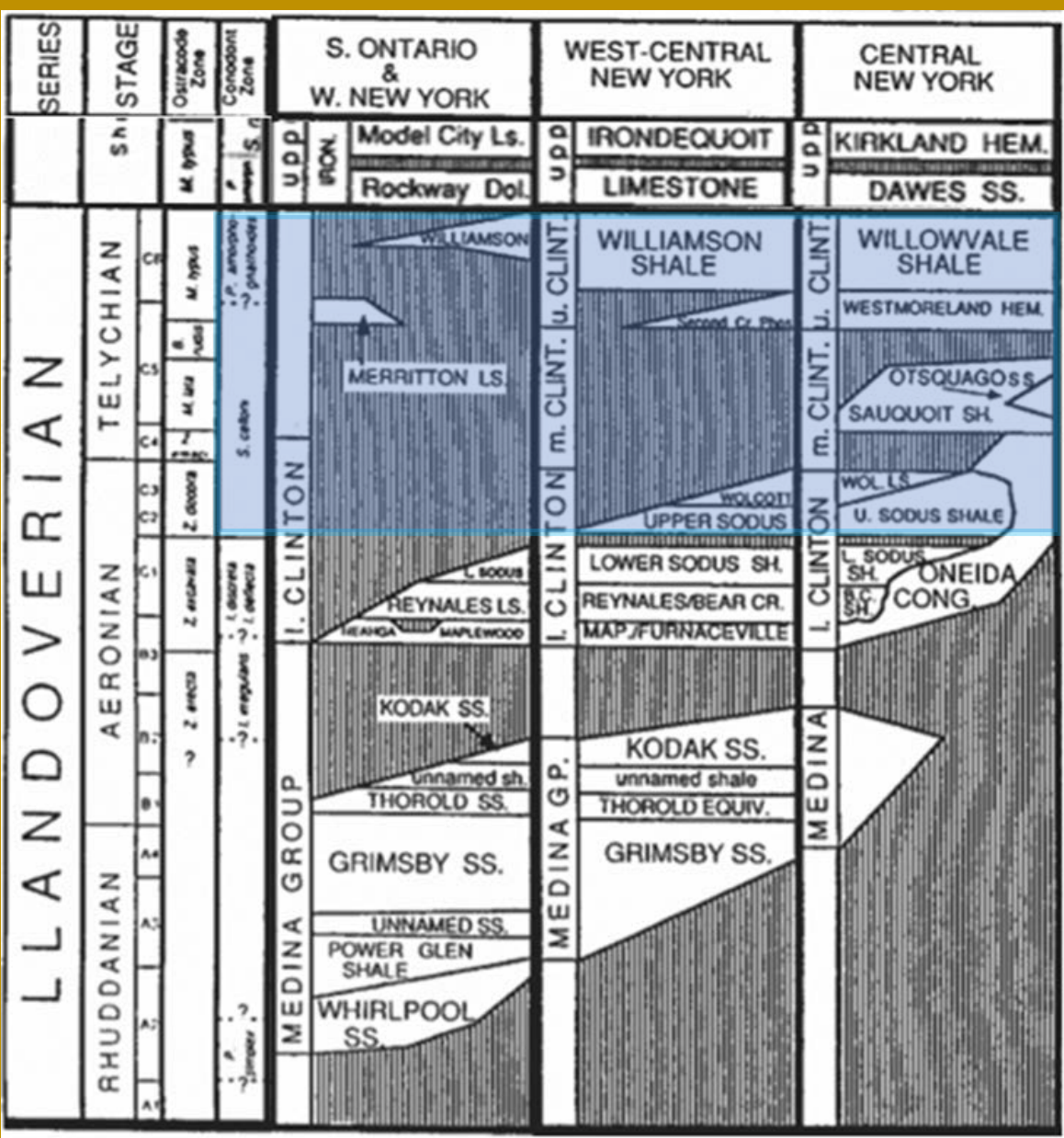
Kleffner, Mark A., School of Earth Sciences, The Ohio State University Lima, 4240 Campus Drive, Lima, OH 45804, Bergström, Stig M., School of Earth Sciences, The Ohio State University, Columbus, OH 43210-1308



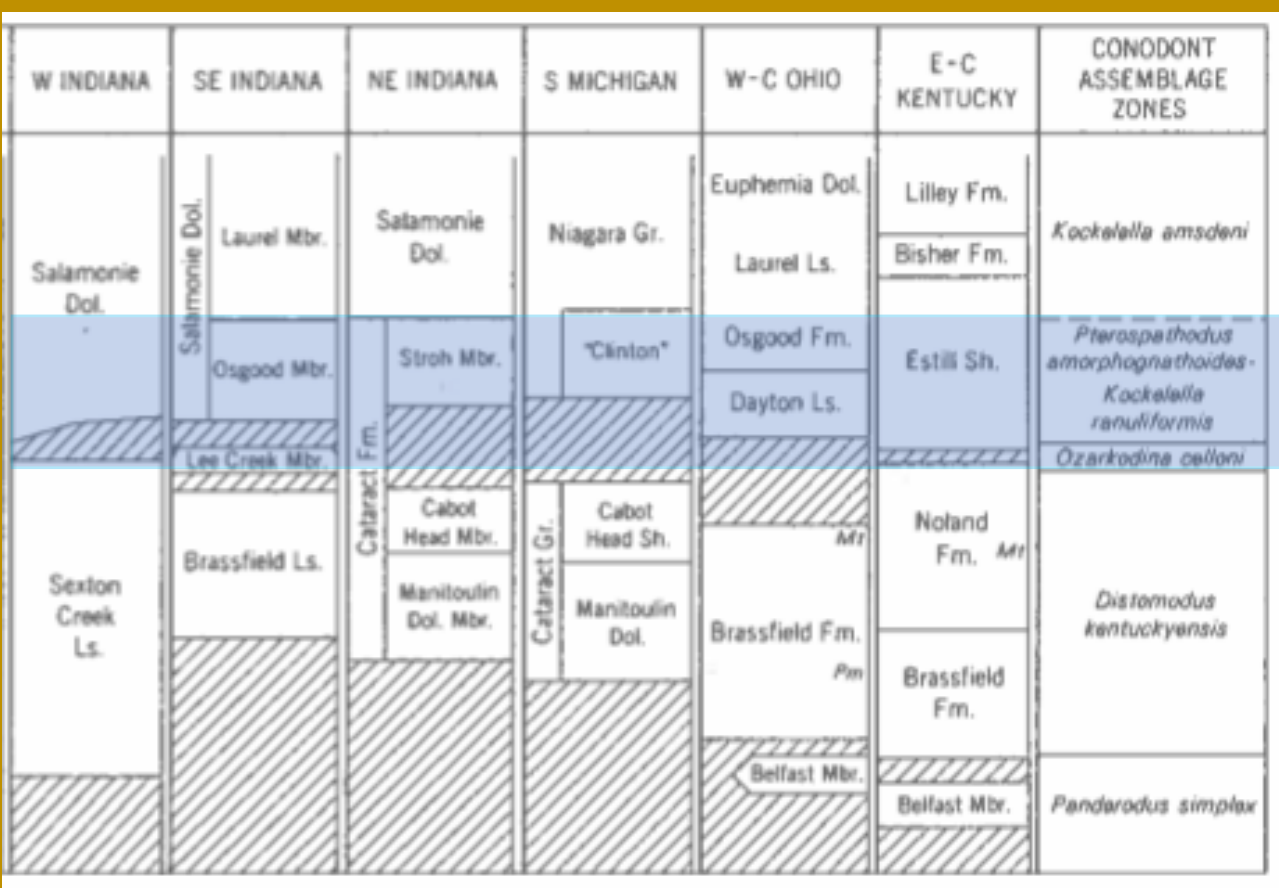
Laurentia in Middle Silurian from Paleomaps Project (C.R. Scotese); Eastern portion of Midwestern Basins and Arches region outlined with red diamond



Eastern Portion of Midwestern Basins and Arches region (from Sullivan et al. 2016)



New York Llandovery Stratigraphy (Brett et al. 1996)



Ohio, Kentucky, and Indiana Llandovery and Wenlock Stratigraphy (Rexroad 1980)

Revision of Conodont Zonation of Telychian Stage (Männik 2007)

Walliser 1964	Aldridge 1972	Bischoff 1986	Brazaukas 1987	SUPER-ZONE	ZONE	SUBZONE	GRAPTOLITE ZONE
<i>P. amorphognathoides</i>	<i>P. amorphognathoides</i> Assemblage Zone	<i>P. amorphognathoides</i> - <i>P. latus</i>	<i>P. procerus</i> <i>P. amorphognathoides</i>	<i>Ps. bicornis</i>	Upper <i>Ps. bicornis</i> Lower <i>Ps. bicornis</i>		<i>C. murchisoni</i>
Not studied (tabula)			<i>P. celloni</i> <i>P. angulatus</i>	<i>P. celloni</i>	Upper <i>P. a. amorphognathoides</i> Lower <i>P. a. amorphognathoides</i>		<i>C. centrifugus</i> <i>C. insectus</i> <i>C. lapworthi</i>
<i>P. celloni</i>	<i>Iridodella inconstans</i> Assemblage Zone	<i>P. celloni</i>	<i>Llandoverygnathus pennatus</i>	<i>P. celloni</i>	<i>P. a. lithuanicus</i> <i>P. a. lennarti</i> <i>P. a. angulatus</i>	Upper <i>P. a. angulatus</i> Lower <i>P. a. angulatus</i>	<i>O. spiralis</i>
Not studied (tabula) or gap in the section		<i>A. irregularis</i> <i>P. pennatus</i>	<i>Aulacognathus latus</i>	<i>P. eo-pennatus</i>	<i>P. eo-pennatus</i> ssp. n. 2 <i>P. eo-pennatus</i> ssp. n. 1	Upper <i>P. eo-pennatus</i> ssp. n. 2 Lower <i>P. eo-pennatus</i> ssp. n. 2	<i>M. griesstonensis</i> <i>St. sartorius</i> <i>St. crispus</i> <i>Sp. turriculatus</i>

Telychian strata are present throughout the eastern portion of the Midwestern Basins and Arches region in New York, Ohio, Kentucky, and Indiana.

Most conodont biostratigraphies developed for Telychian strata prior to 2000 assigned those strata to the *Pterospathodus celloni* and/or succeeding *Pt. amorphognathoides* Zone, the two zones previously recognized as comprising most/all of the Telychian (blue-highlighted regions on two figures on the left). Significant revision of Silurian conodont taxonomy beginning in the late 1990s resulted in recognition of eight conodont zones belonging to three conodont superzones and one conodont zonal group comprising the same portion of the Telychian (blue-highlighted region on figure on the right ).

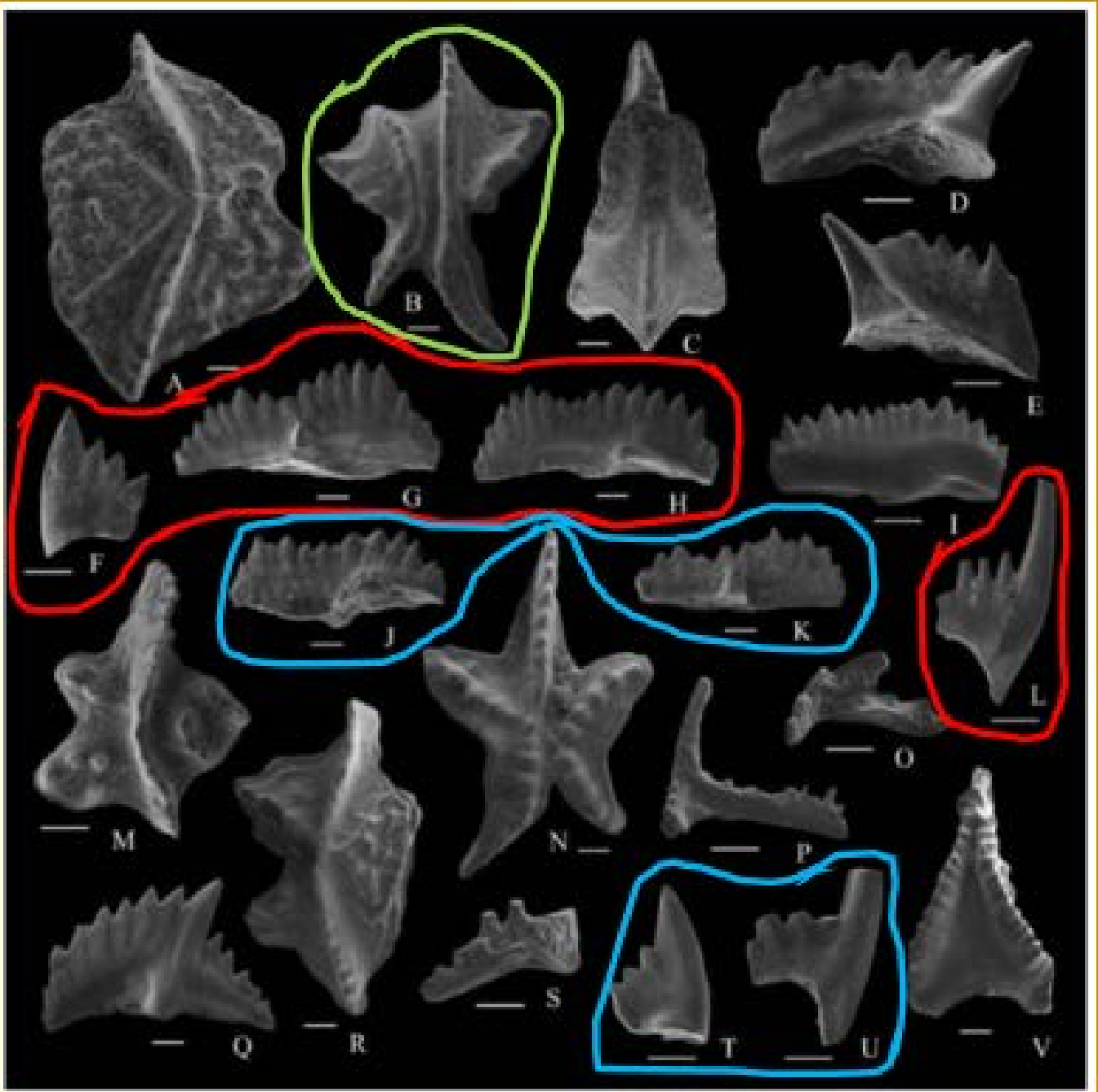
*Aulacognathus kuehni* Mostler

*Pterospathodus eo-pennatus* ssp. n. 2 Männik

*Pterospathodus eo-pennatus* ssp. n. 1 Männik

SUPERZONE	ZONE	SUBZONE
<i>P. eo-pennatus</i>	<i>P. eo-pennatus</i> ssp. n. 2	Upper <i>P. eo-pennatus</i> ssp. n. 2
<i>P. eo-pennatus</i>	<i>P. eo-pennatus</i> ssp. n. 1	Lower <i>P. eo-pennatus</i> ssp. n. 1

*Pterospathodus eo-pennatus* Superzone conodonts (Männik 2007)



*Pterospathodus celloni* (Walliser)

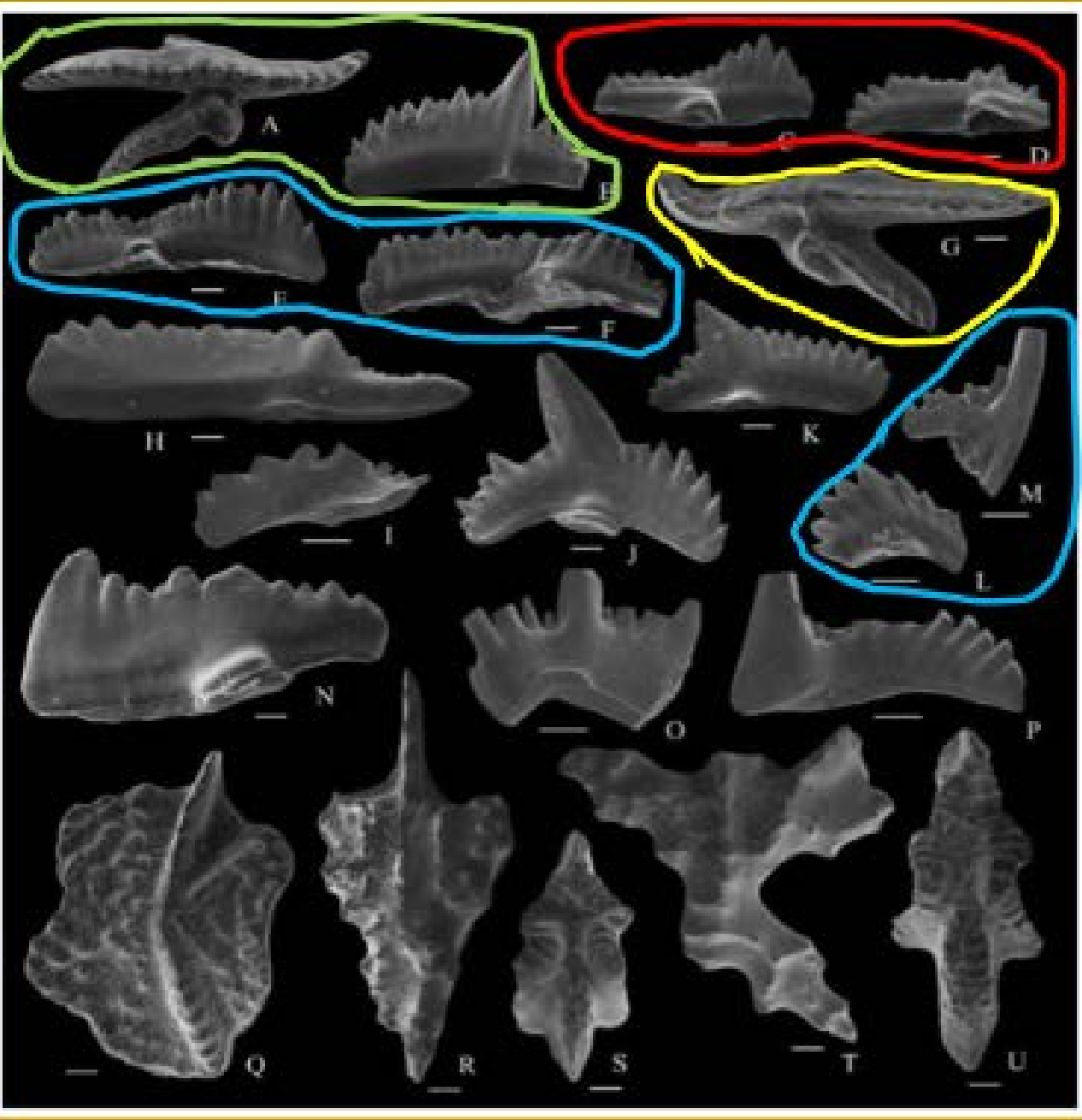
*Pterospathodus amorphognathoides lithuanicus* Männik

*Pterospathodus amorphognathoides lennarti* Männik

*Pterospathodus amorphognathoides angulatus* Walliser

SUPERZONE	ZONE	SUBZONE
<i>P. celloni</i>	<i>P. a. lithuanicus</i> <i>P. a. lennarti</i> <i>P. a. angulatus</i>	Upper <i>P. a. angulatus</i> Lower <i>P. a. angulatus</i>

*Pterospathodus celloni* Superzone conodonts (Männik 2007)



*Pterospathodus a. amorphognathoides* Walliser

*Apsidognathus walmsleyi* Aldridge

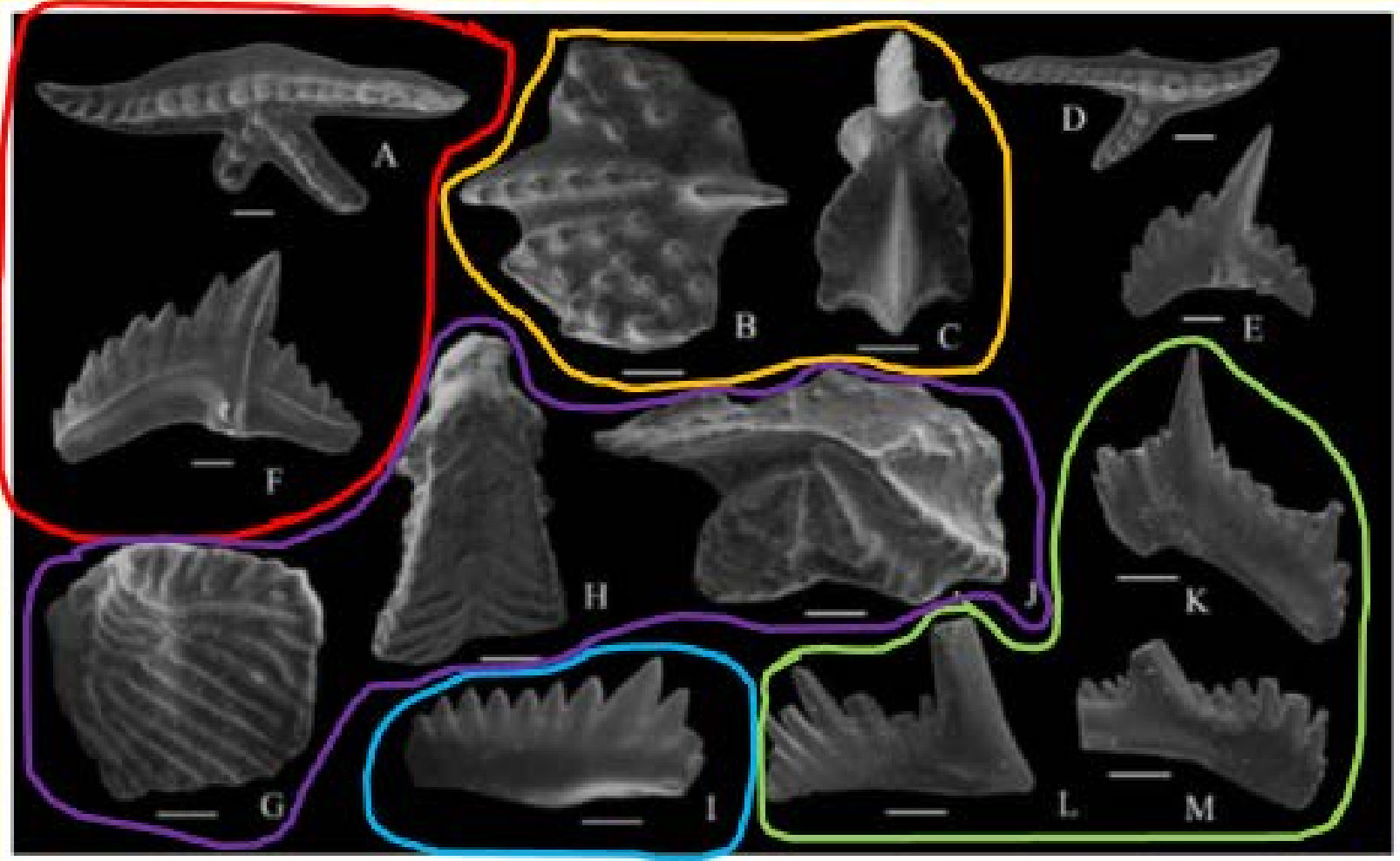
*Apsidognathus ruginosus* Mabillard & Aldridge

*Pseudolochodina fluegeli* ssp. n. (Männik)

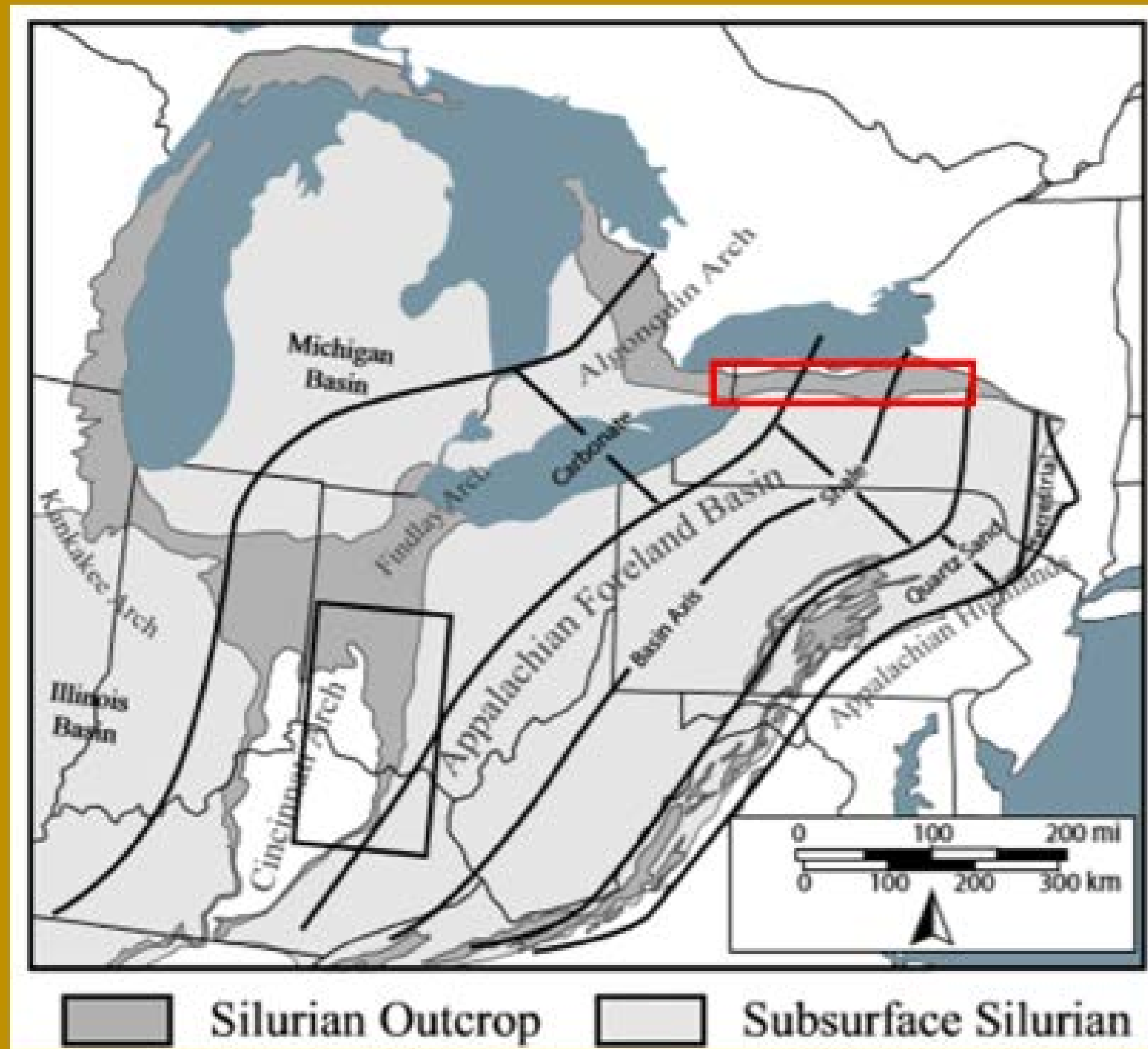
*Wormiella pectis, pectislinata* (Woolf & Rexroad)

SUPERZONE	ZONE	SUBZONE
<i>P. a. amorphognathoides</i>	<i>P. a. amorphognathoides</i>	Upper <i>P. a. amorphognathoides</i> Lower <i>P. a. amorphognathoides</i>

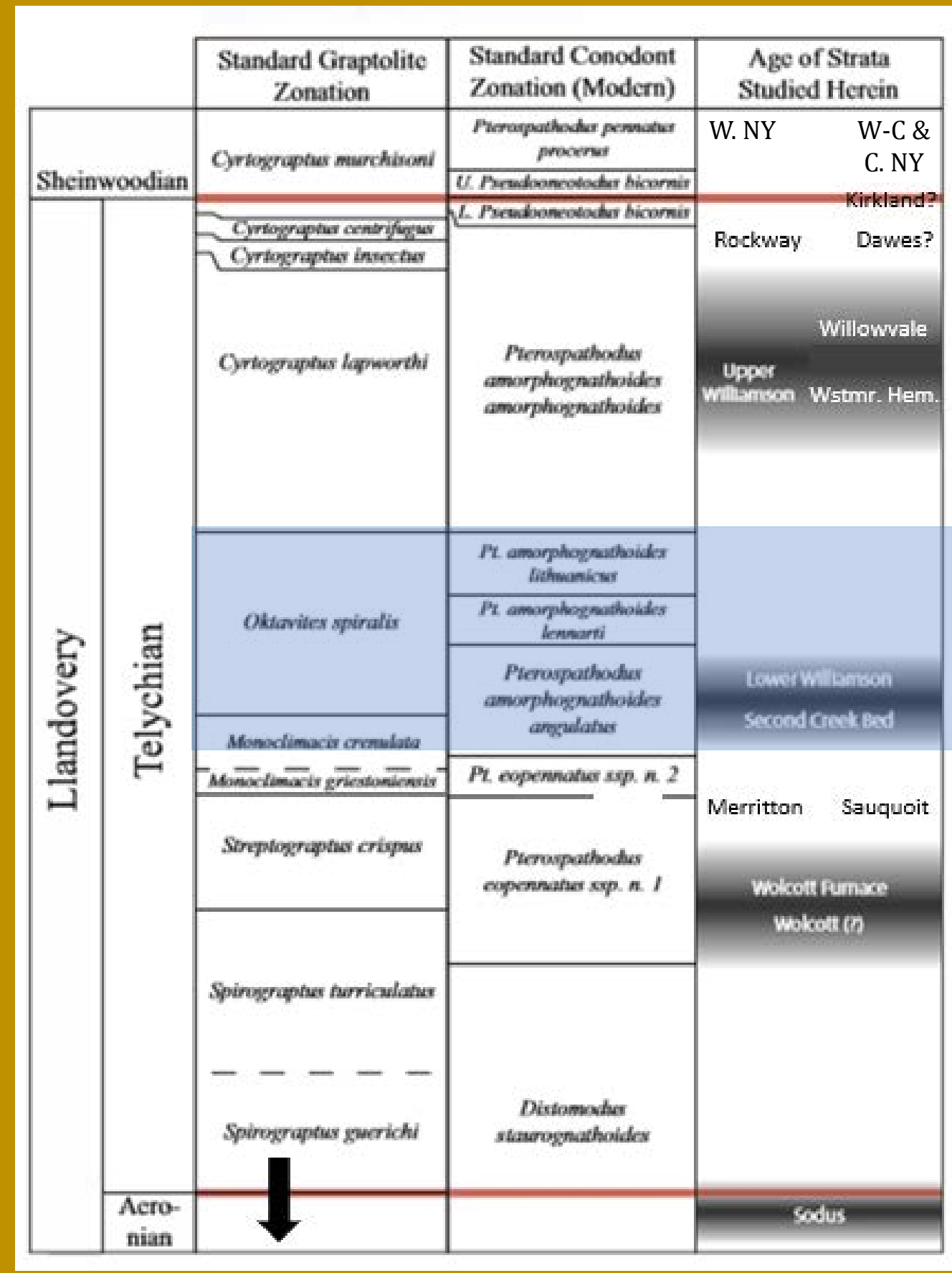
*Pterospathodus amorphognathoides amorphognathoides* Zonal group (Männik 2007)



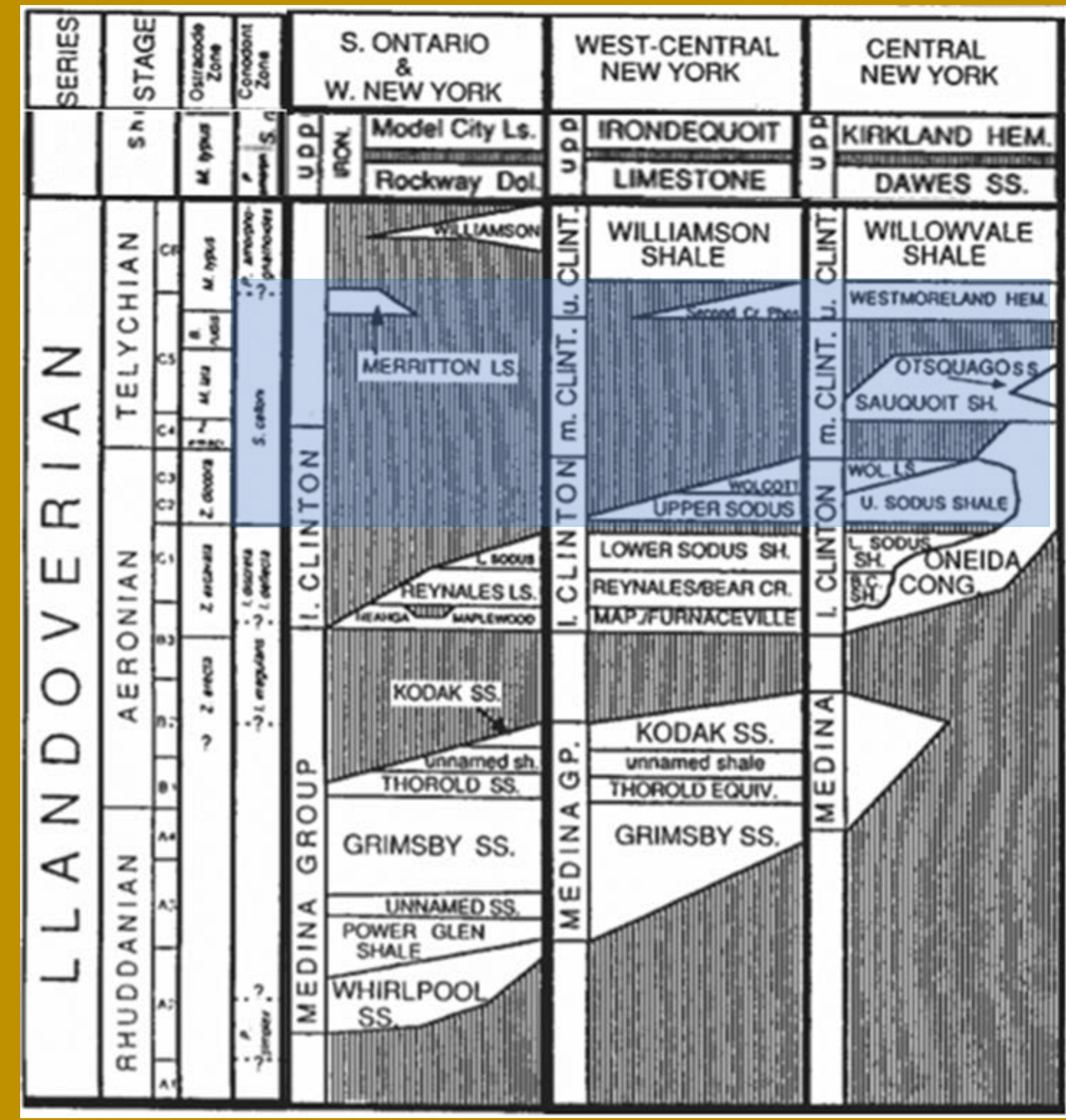
Conodont species and subspecies that serve as zonal indices for the eight conodont zones, three conodont superzones, and one zonal group currently recognized for the Telychian. Elements identified as representative of subspecies of *Pterospathodus eo-pennatus* were recognized as representing *Pt. celloni* prior to Männik's (1998) taxonomic revision of *Pterospathodus*. Restudy of conodonts from research on Telychian strata conducted by the authors and others prior to 2000 and sampling and processing for conodonts from Telychian strata located in New York, Ohio, Kentucky, and Indiana conducted mostly during the last decade make it possible to recognize that strata assignable to the *Pterospathodus celloni* Superzone are mostly absent throughout the eastern part of the Midwestern Basins and Arches region in those states.



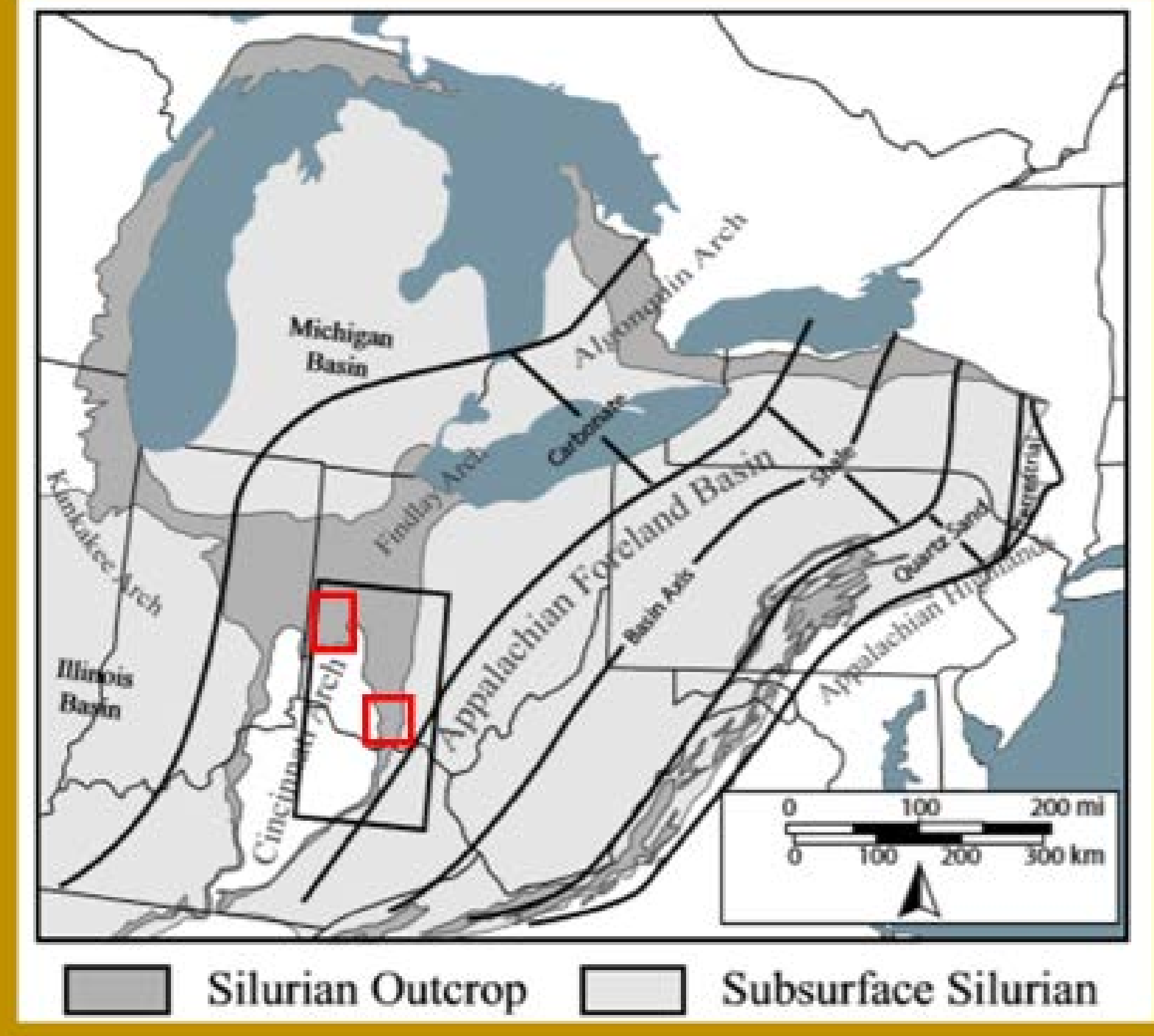
Eastern portion of Midwestern Basins and Arches region with area of study in New York outlined in red (Figure is from Sullivan et al. 2016)



Telychian biostratigraphy modified from Sullivan, Kleffner, and Brett (2014)



New York Llandovery stratigraphy (Brett et al. 1996)

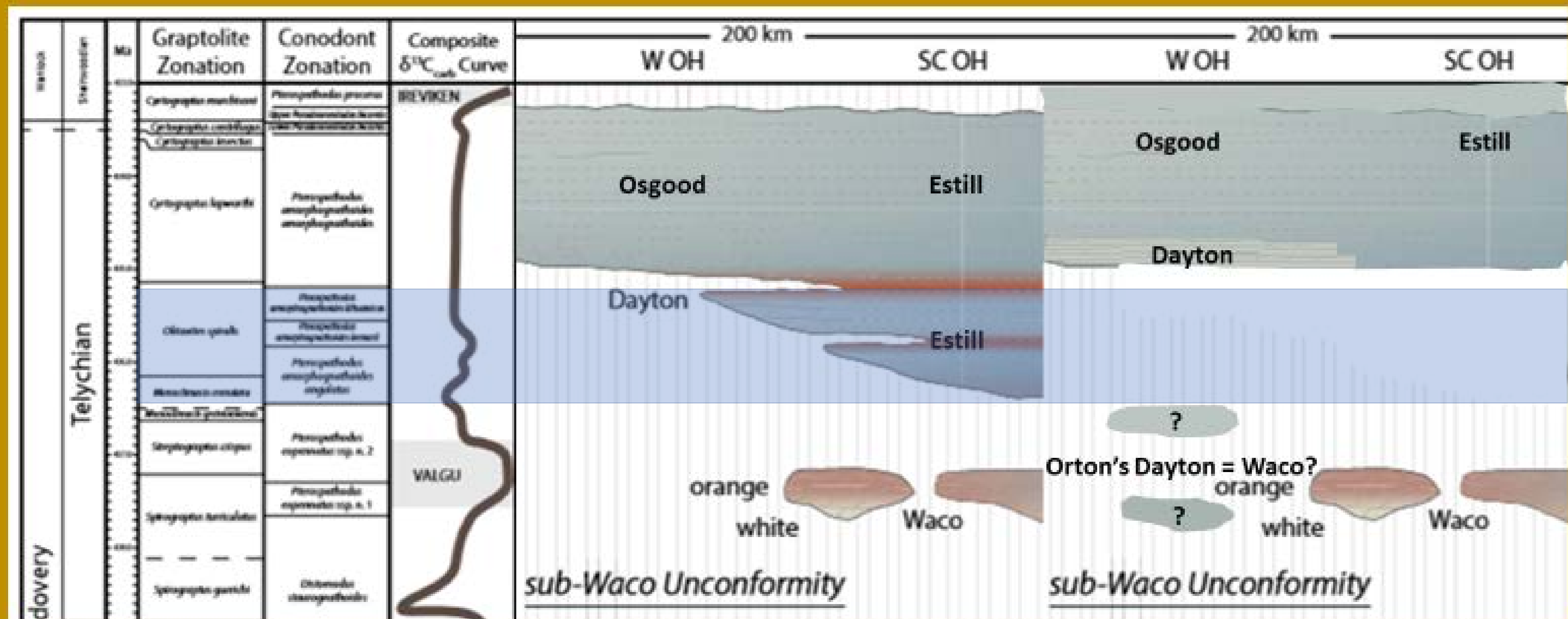


Eastern portion of Midwestern Basins and Arches region with areas of study in Ohio outlined in red (Figure is from Sullivan et al. 2016)

Telychian conodont biostratigraphy for strata in western, west-central, and central New York developed during restudy of conodonts from research on Telychian strata conducted by the authors and others prior to 2000 and new study of Telychian strata shown in figure on the left shows only the lower part of the Williamson and Second Creek bed within the *Pt. celloni* Superzone, compared to the Merrittan, Upper Sodus, Wolcott, Second Creek, Sauquoit, Westmoreland Hematite, Otsquago Sandstone, and upper part of the Oneida Conglomerate previously (compare blue-highlighted regions).

W OHIO	SC OHIO	CONODONT ASSEMBLY ZONES
Eupheria Dol.	Lilley Fm.	<i>Kockella amsdeni</i>
Laurel Ls.	Bisher Fm.	
Osgood Fm.	Estill Sh.	<i>Pterospirifer</i> <i>amorphognathoides</i> <i>Kockella</i> <i>ranuliformis</i>
Dayton Ls.		<i>Ozarkodina celloni</i>
	Waco mbr	
	Noland Fm.	<i>Distomodus kentuckyensis</i>
Brassfield Fm.	Brassfield Fm.	
Belfast Mbr.	Belfast Mbr.	<i>Panderodus simplex</i>

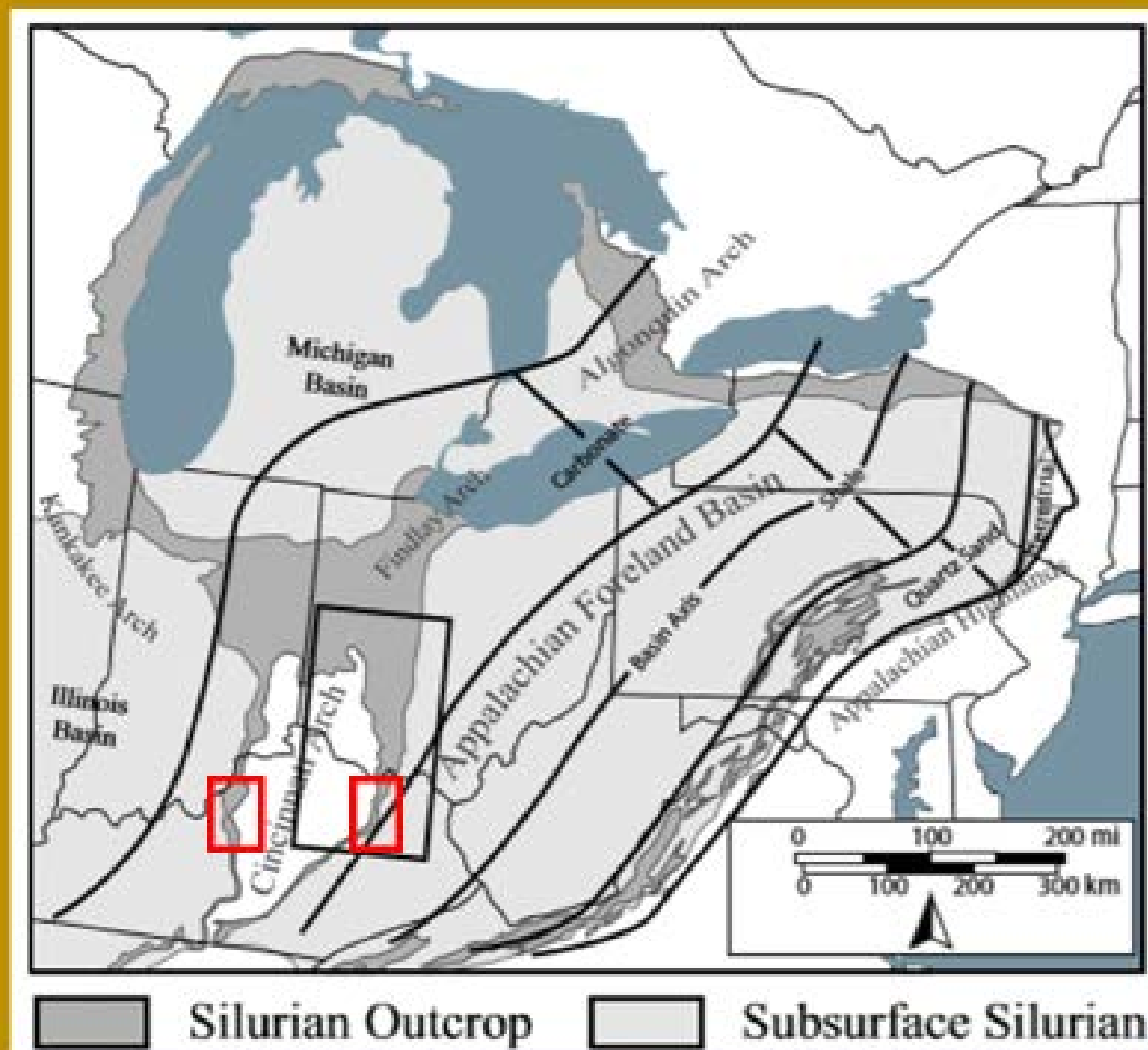
Modified from Rexroad (1980)



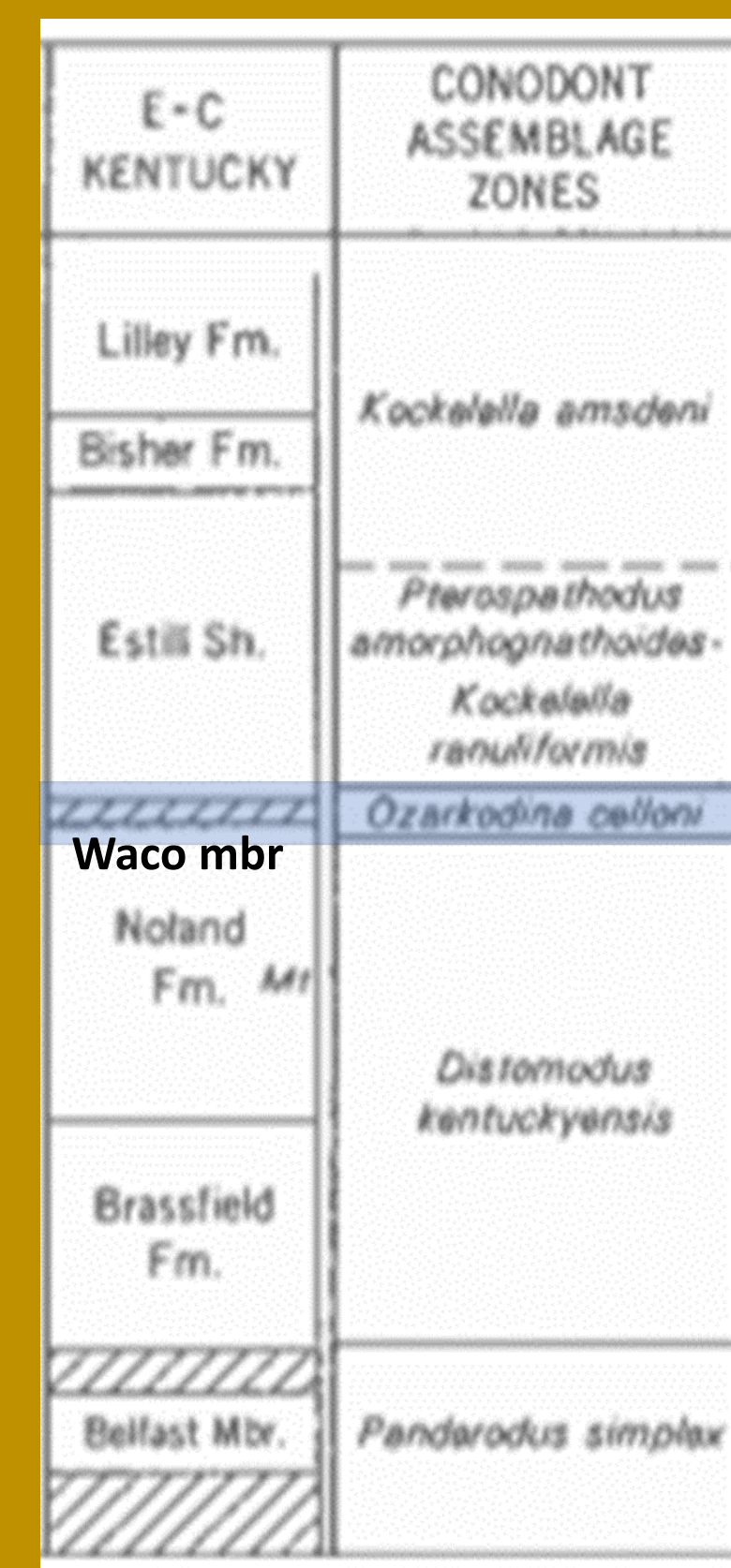
Ohio Telychian conodont biostratigraphy (Sullivan et al. 2016)

Revised Telychian conodont biostratigraphy

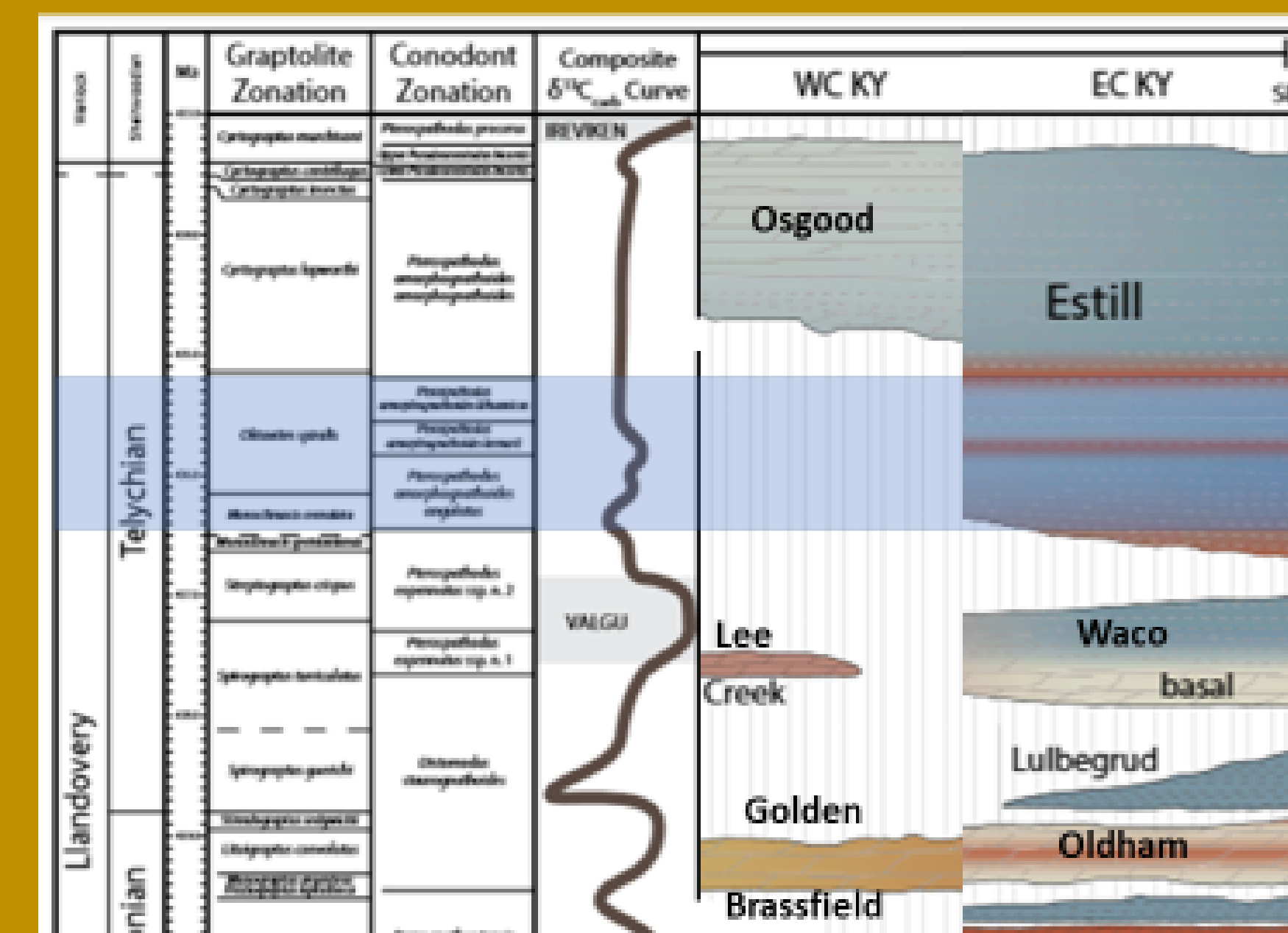
Most recently revised Telychian conodont biostratigraphy for strata in western and south-central Ohio on right-hand side of figure to the right developed during restudy of conodonts from research on Telychian strata conducted by the authors and others prior to 2000 and new study of Telychian strata shows an absence of any strata within the *Pt. celloni* Superzone, compared to the Estill and Dayton in a fairly recent revision shown in center of figure to the right. Telychian conodont biostratigraphy prior to 2000, like the one developed in the figure on the left, shows an absence of any strata in the *Pt. celloni* Superzone in western Ohio and shows the upper part of the Waco and lower part of the Estill within that superzone (compare blue-highlighted regions on both figures).



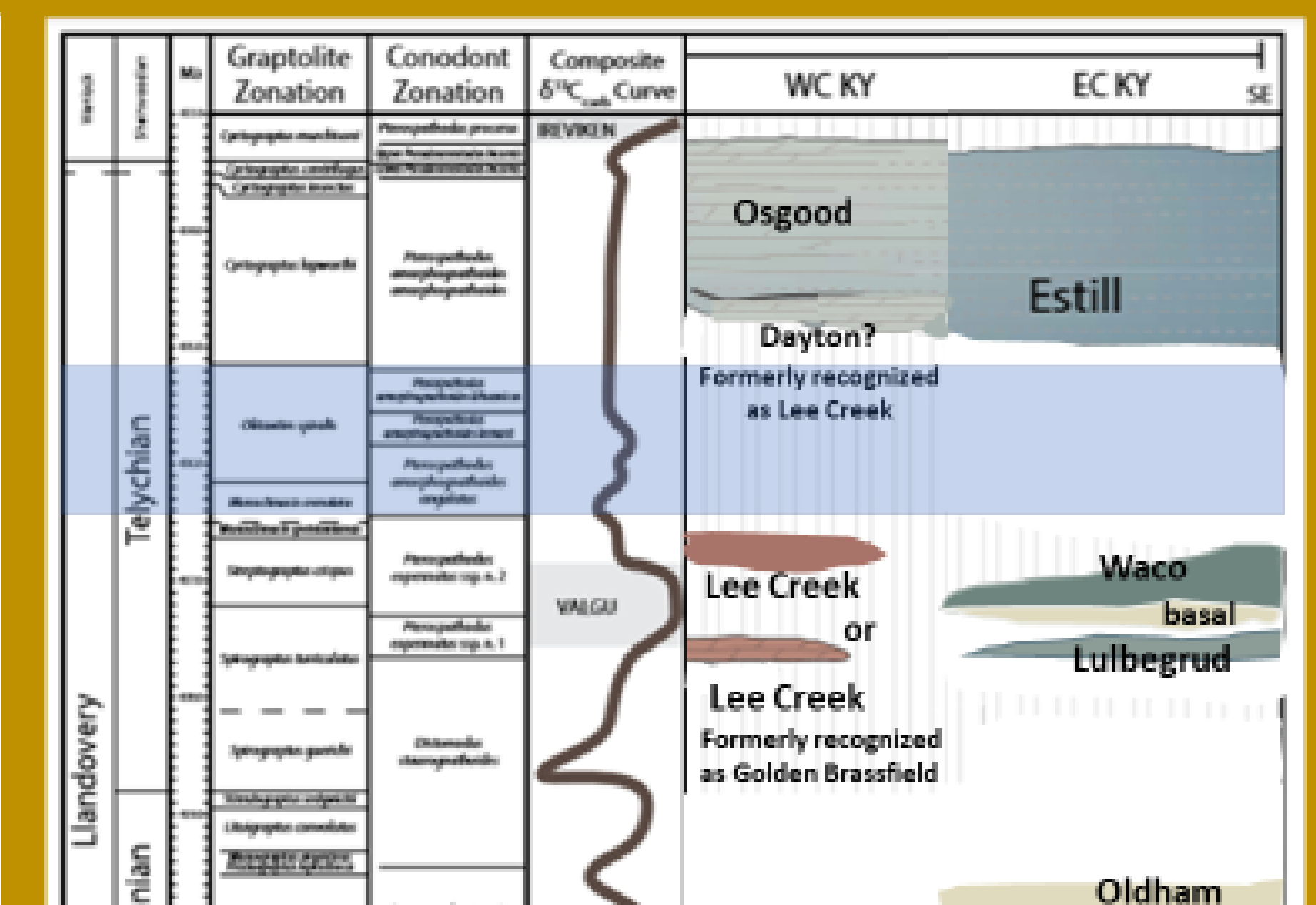
Eastern portion of Midwestern Basins and Arches region with areas of study in Kentucky outlined in red (Figure is from Sullivan et al. 2016)



Modified from Rexroad (1980)

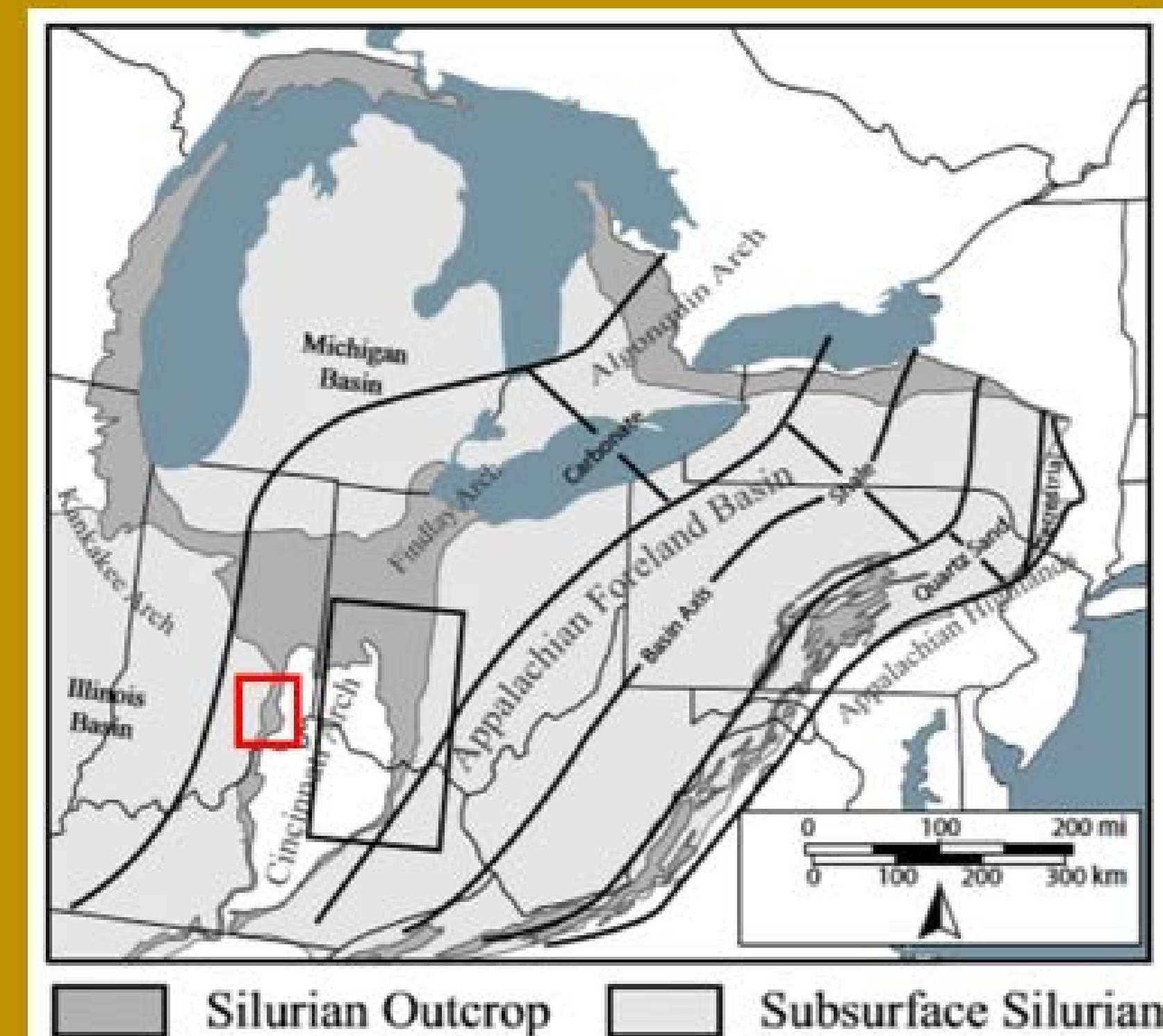


Telychian and Aeronian (part) conodont biostratigraphy of Kentucky (Sullivan et al. 2016)



Revised Telychian and Aeronian (part) conodont biostratigraphy of Kentucky

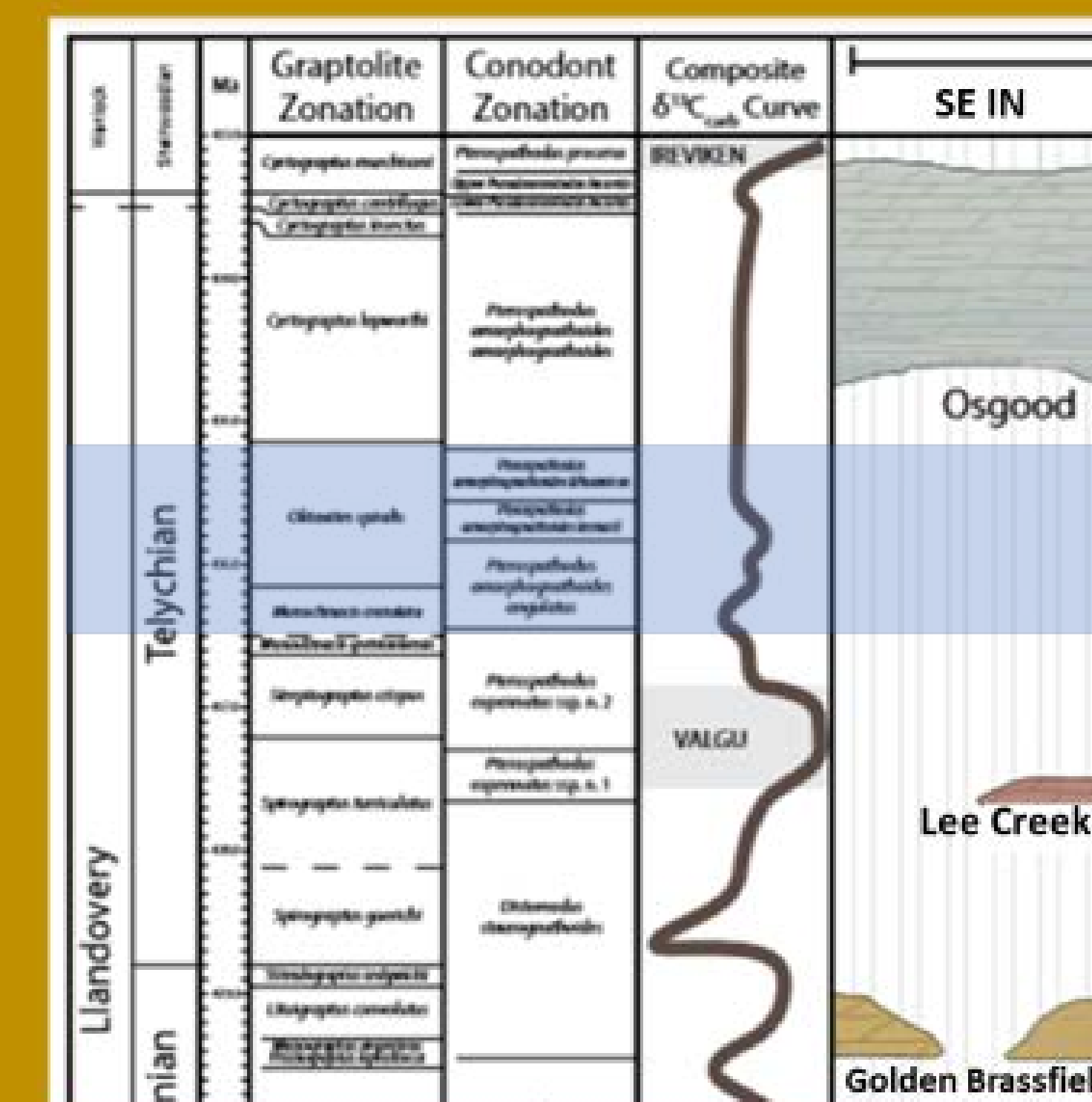
Most recently revised Telychian conodont biostratigraphy for strata in east-central Kentucky on figure to the right developed during restudy of conodonts from research on Telychian strata conducted by the authors and others prior to 2000 and new study of Telychian strata shows an absence of any strata within the *Pt. celloni* Superzone., compared to the Estill in a fairly recent revision shown on figure in the center. Telychian conodont biostratigraphy prior to 2000, like the one developed in the figure on the left, shows the upper part of the Waco and lower part of the Estill within that superzone (compare blue-highlighted regions on the three figures).



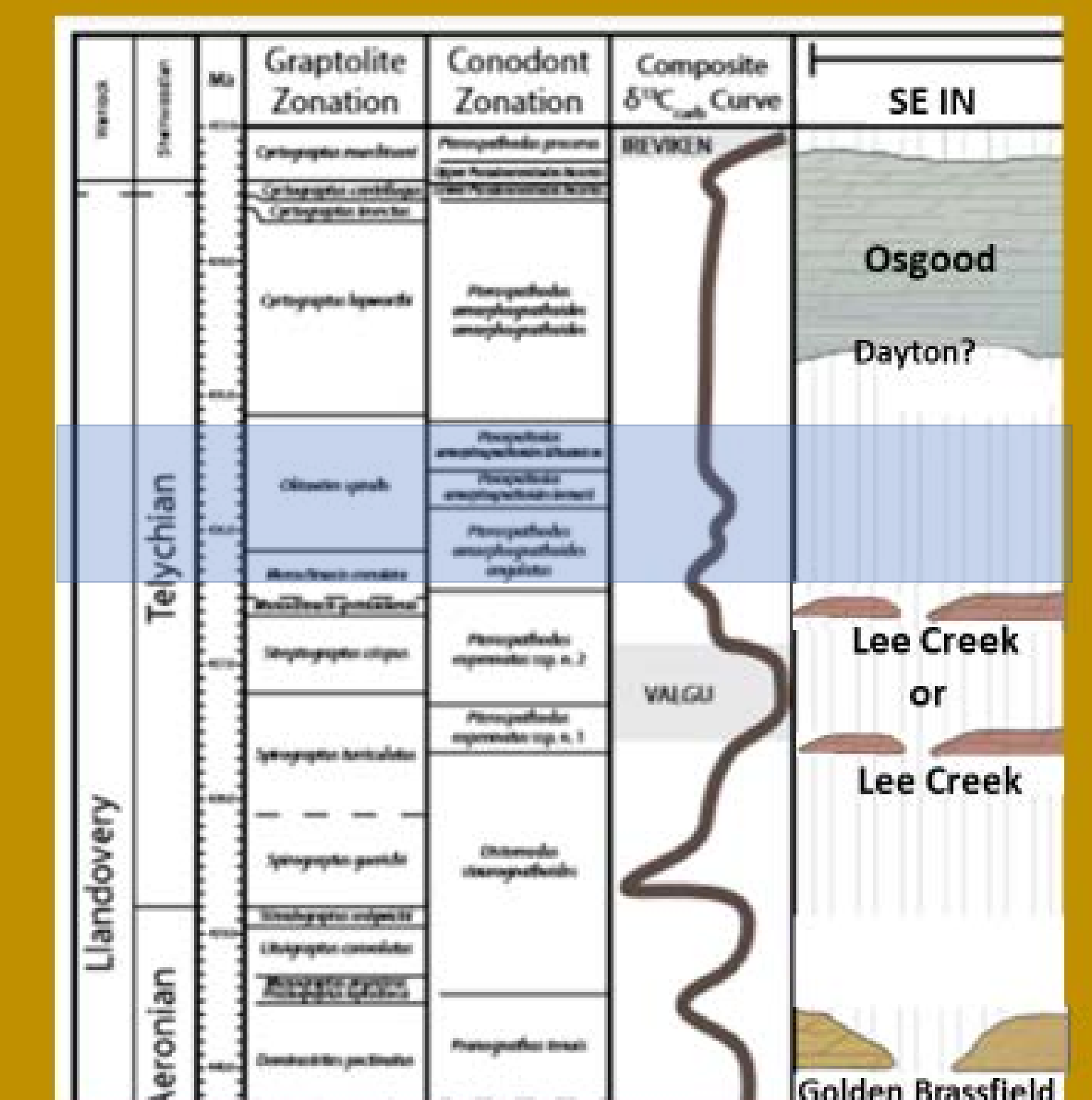
Eastern portion of Midwestern Basins and Arches region with area of study in Indiana outlined in red (Figure is from Sullivan et al. 2016)



Modified from Rexroad (1980)

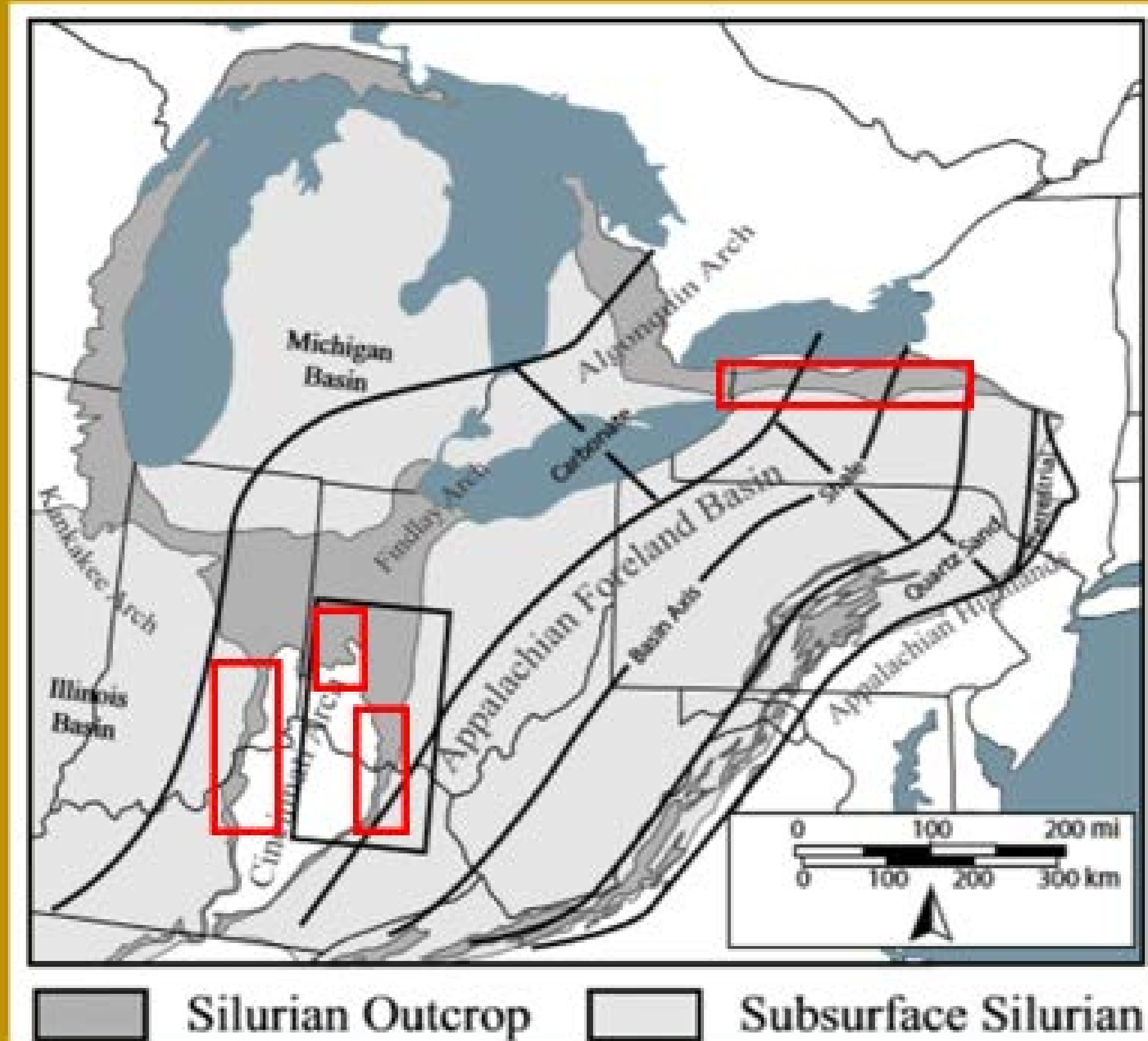


Telychian and Aeronian (part) conodont biostratigraphy of southeastern Indiana (Sullivan et al. 2016)

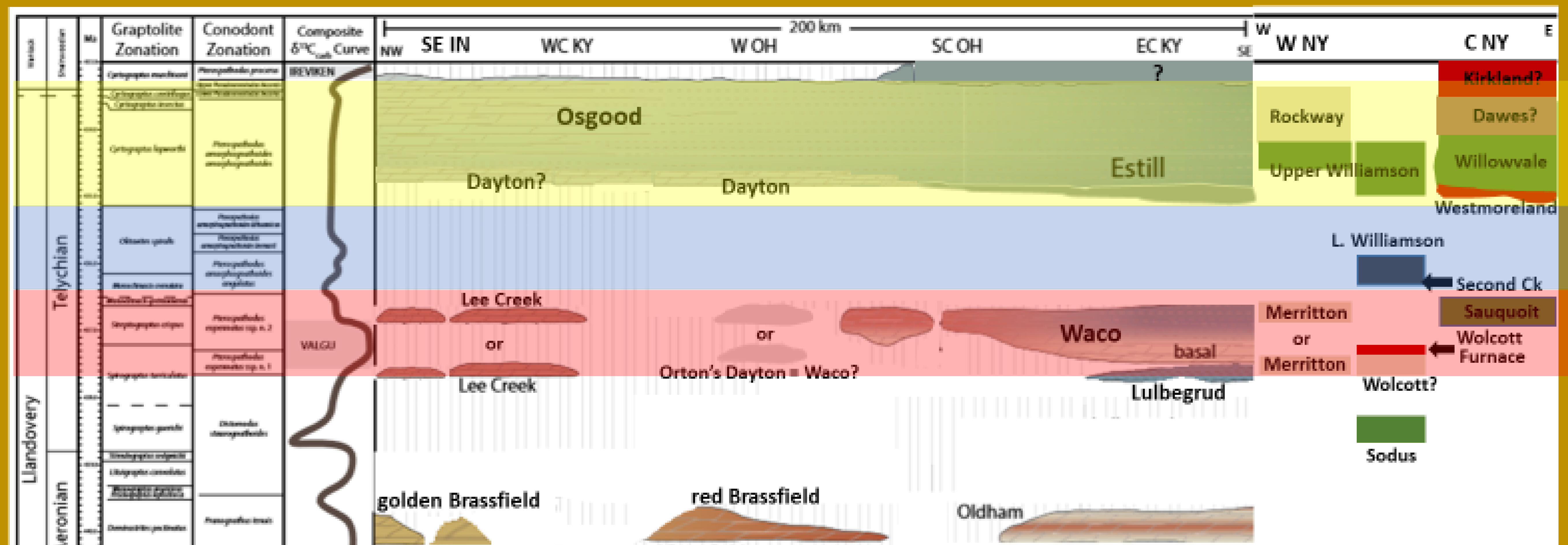


Revised Telychian and Aeronian (part) conodont biostratigraphy of southeastern Indiana

Most recently revised Telychian conodont biostratigraphy for strata in southeastern Indiana on figure to the right developed during restudy of conodonts from research on Telychian strata conducted by the authors and others prior to 2000 and new study of Telychian strata shows an absence of any strata within the *Pt. celloni* Superzone; the same is also true in a fairly recent revision shown on center figure. Telychian conodont biostratigraphy prior to 2000, like the one developed in the figure on the left, shows the Lee Creek in the *Pt. celloni* Superzone in southeastern Indiana (compare blue-highlighted regions on the three figures).

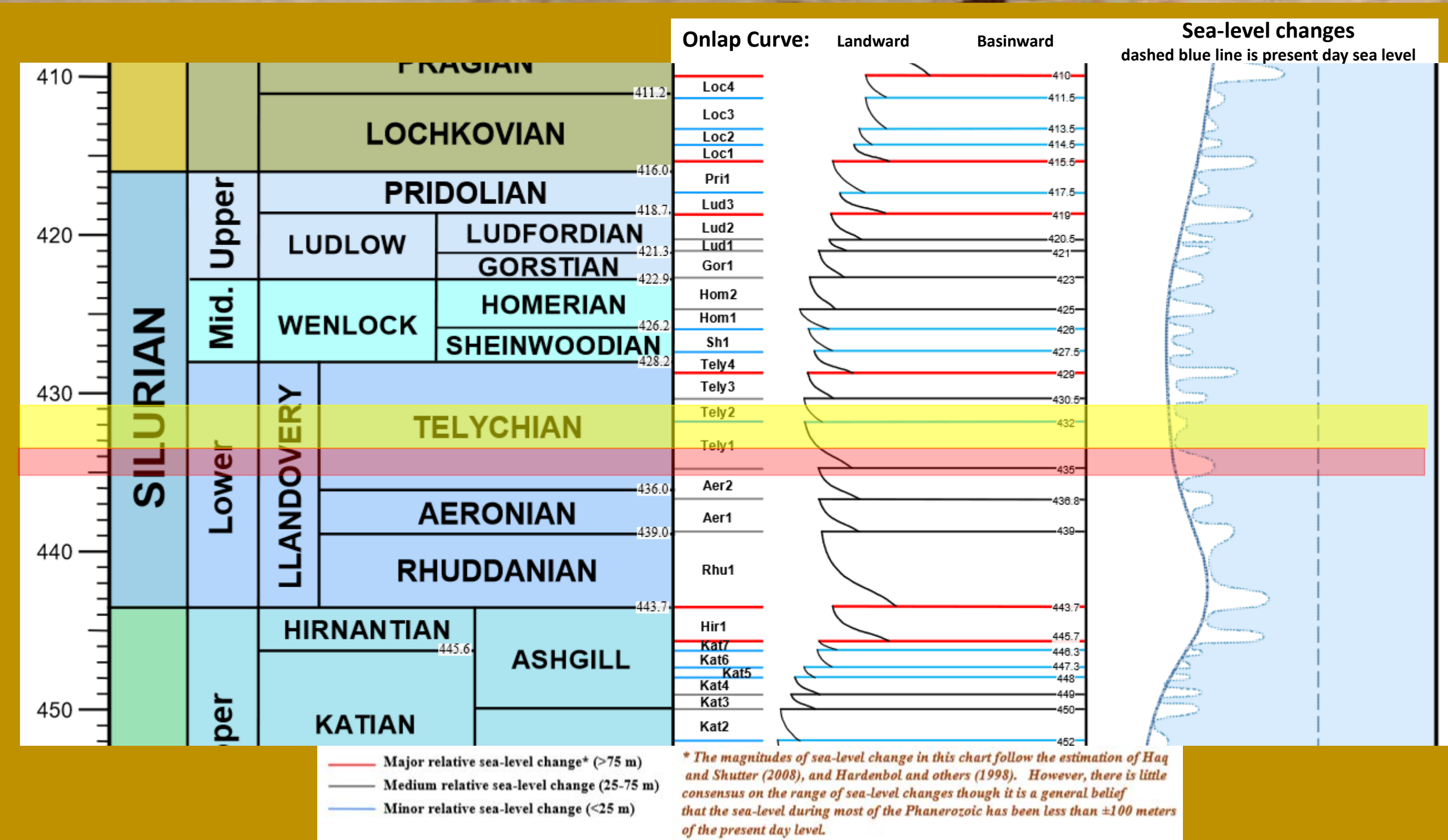


Eastern portion of Midwestern Basins and Arches region with all areas of study of Telychian strata outlined in red (Figure is from Sullivan et al. 2016)



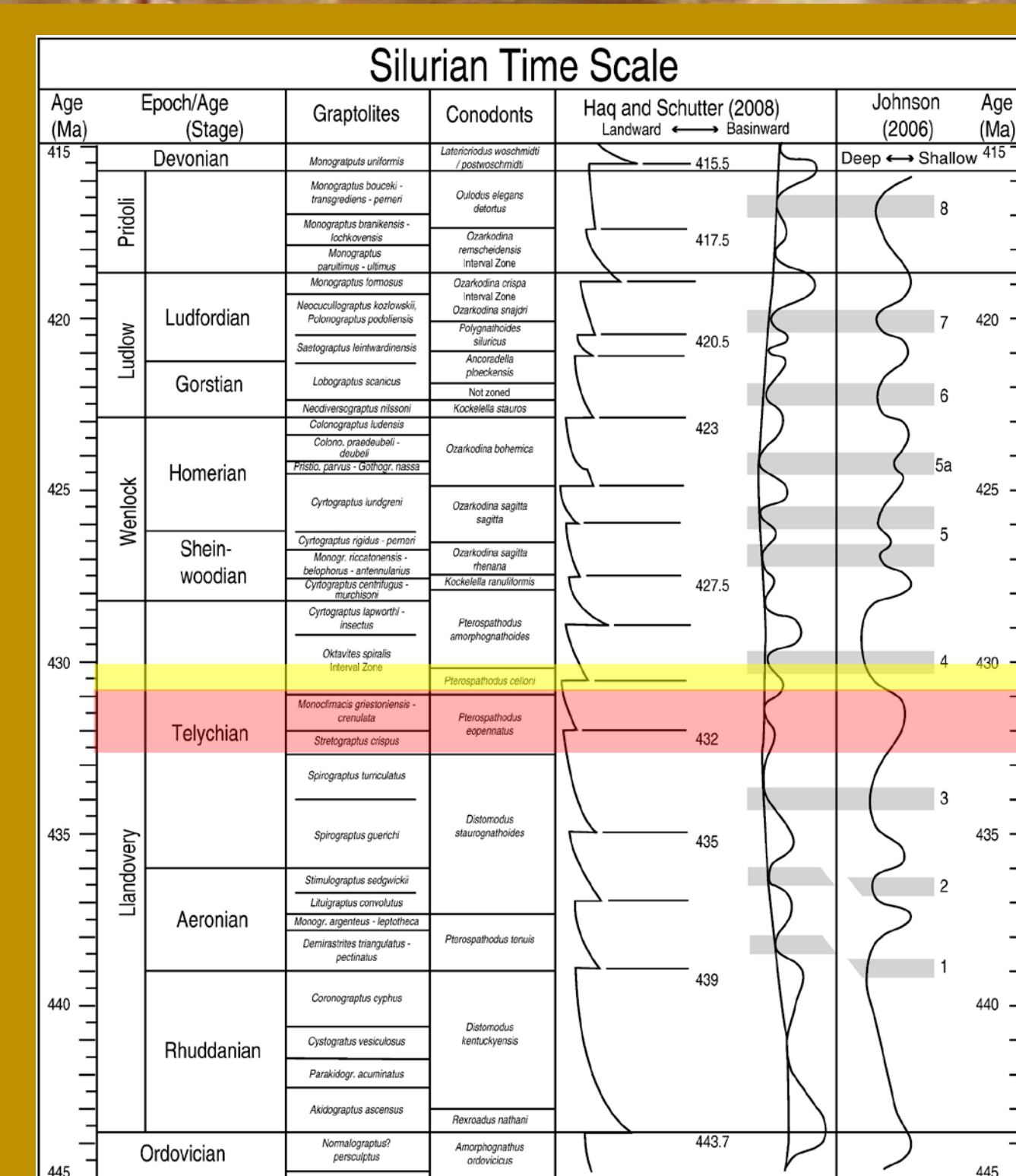
A revised conodont biostratigraphy for the Telychian of the eastern portion of the Midwestern Basins and Arches region (New York, Ohio, Kentucky, and Indiana)

*Pterospirifer celloni* Superzone (blue-highlighted region on figure above). are mostly absent throughout the eastern part of MBA in New York, Ohio, Kentucky, and Indiana. Strata assigned to the *Pterospirifer amorphognathoides* Zonal group (yellow-highlighted region on figure above) typically overlie strata assigned to the *Pt. eopennatus* Superzone (red-shaded area in figure above), or even older, Aeronian strata. Examples of strata assigned to the *Pt. am. amorphognathoides* Zonal group overlying strata assigned to the *Pt. eopennatus* Superzone include Willowvale Shale or Westmoreland Hematite overlying Sauquoit Shale and Rockway Dolomite overlying Merrittton Limestone in New York, Estill Shale overlying Waco Formation in Ohio and Kentucky, and Osgood Formation overlying Lee Creek Formation in Indiana. One exception is a section near Rochester, New York, where both the *Pt. am. amorphognathoides* Zonal group and *Pt. celloni* Superzone (*Pt. am. angulatus* Zone) are recognized in the Williamson Shale.



A Compilation of Phanerozoic Sea-Level Change, Coastal Onlaps and Recommended Sequence Designations (Snedden and Liu, 2010)

Silurian sea-level curves typically indicate higher sea levels during much of the time represented by *Pterospirifer celloni* Superzone (yellow-highlighted regions in two figures above), and typically indicate lower sea levels during the time represented by the *Pt. eopennatus* Superzone (red-highlighted regions in two figures above).



Silurian eustasy (Johnson 2010)

## CONCLUSIONS

- \* Strata assignable to the *Pterospirifer celloni* Superzone are mostly absent throughout the eastern part of the Midwestern Basins and Arches region in New York, Ohio, Kentucky, and Indiana. In fact, the only location at which Telychian strata studied in that region were within the *Pt. celloni* Superzone (Williamson Shale and Second Creek bed), is near Rochester, New York. The Rochester region and immediate vicinity have previously been recognized as the location of the depocenter of the Appalachian Basin during the time the Williamson was deposited.
- \* Strata assignable to the *Pt. eopennatus* Superzone are present throughout most of the eastern part of the MBA in New York, Ohio, Kentucky, and Indiana.
- \* Since Silurian sea-level curves typically indicate higher sea levels during much of the time represented by *Pterospirifer celloni* Superzone and typically indicate lower sea levels during the time represented by the *Pt. eopennatus* Superzone, the sea-level record would seem to favor deposition of, and less erosion of, strata assignable to the *Pt. celloni* Superzone than strata assignable to the *Pt. eopennatus* Superzone. Distribution of strata assignable to those two superzones is exactly opposite of what would be predicted based on the sea-level record.
- \* Tectonic activity along the Appalachian Orogenic Belt must have played an even more important role than eustasy in the stratigraphic record of the eastern portion of the MBA in New York, Ohio, Kentucky, and Indiana during the 1.5 to 3.0 million years of time represented by the *Pt. celloni* Superzone.

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