# Fossils, fractures, and foreshore cliffs:

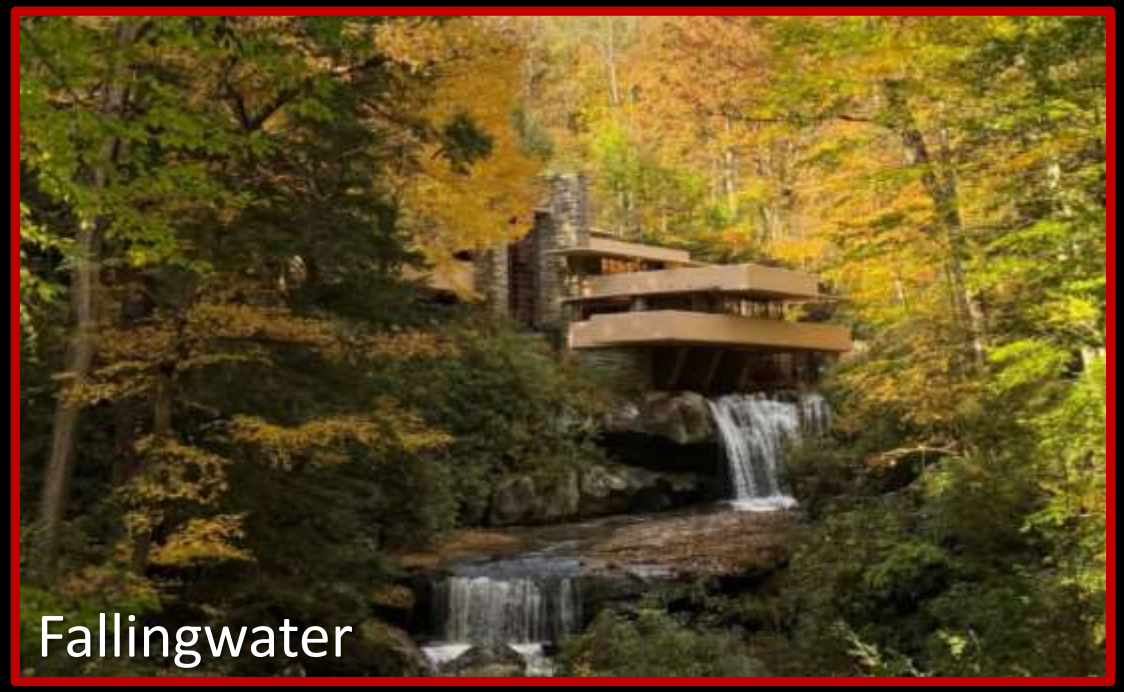
## The influence of geologic features on Frank Lloyd Wright's transition from Prairie School to Organic Architecture at Graycliff on Lake Erie, western New York State, USA

By Fred Zelt, Roger Steck, Philip Stokes, and Carl Brett

Photo by Matthew Digati, courtesy of the Graycliff Conservancy


Taliesin


Graycliff


Fallingwater

# Frank Lloyd Wright's Taliesin, Graycliff and Fallingwater

Photos courtesy of Frank Lloyd Wright Foundation, Graycliff Conservancy, Western Pennsylvania Conservancy

# Acknowledgments

**Taliesin**

- The Frank Lloyd Wright Foundation and Taliesin Preservation, Inc.

**Graycliff**

- Anne Kaplan, Ryan Gravell, Jess Cross and docents of the Graycliff Conservancy
- Paul Moretti and the staff of Penn Dixie Fossil Park and Nature Reserve
- Bob Jacobi, Randy Blood, Kyle Fredrick and the Pittsburgh Geological Society

**Fallingwater**

- Jim Shaulis and Grant Wach
- The Western Pennsylvania Conservancy

**Illustrations**

- Brenda Birrell and CalTopo

# UNESCO World Heritage

Unity Temple, 1905-1908

Robie House, 1908-1910

Taliesin, 1911-1959

Hollyhock, 1919-1921

Fallingwater, 1936-1939

Jacobs I, 1937

Taliesin West, 1937-1959

Guggemheim, 1956-1959

Images: https://whc.unesco.org/



# UNESCO World Heritage

*Stone

Unity Temple, 1905-1908

Robie House, 1908-1910

Taliesin, 1911-1959*

Hollyhock, 1919-1921

Fallingwater, 1936-1939*

Jacobs I, 1937

Taliesin West, 1937-1959*

Guggenheim, 1956-1959

Images: https://whc.unesco.org/

# Selected stone Frank Lloyd Wright buildings

Hillside


Taliesin


Fallingwater


Frank L. Smith Bank Building


Yamamura House


Imperial Hotel


Taliesin West


Como Orchard


Banff Park Pavilion


Graycliff


Kentuck Knob


**X** From Steiner, 2009 **+** Image from wikipedia At least 33 stone houses designed by Wright were built in 1926-1959

# Evolution of windows in Wright-designed houses

**Robie House, 1908-1910**

**Graycliff, 1926-1931**

**Fallingwater, 1936-1939**

**Kentuck Knob, 1953-1956**

## Prairie School — Organic Architecture

Robie House Image: Historic American Buildings Survey, https://www.loc.gov/resource/hhh.pa1691.photos/?sp=36

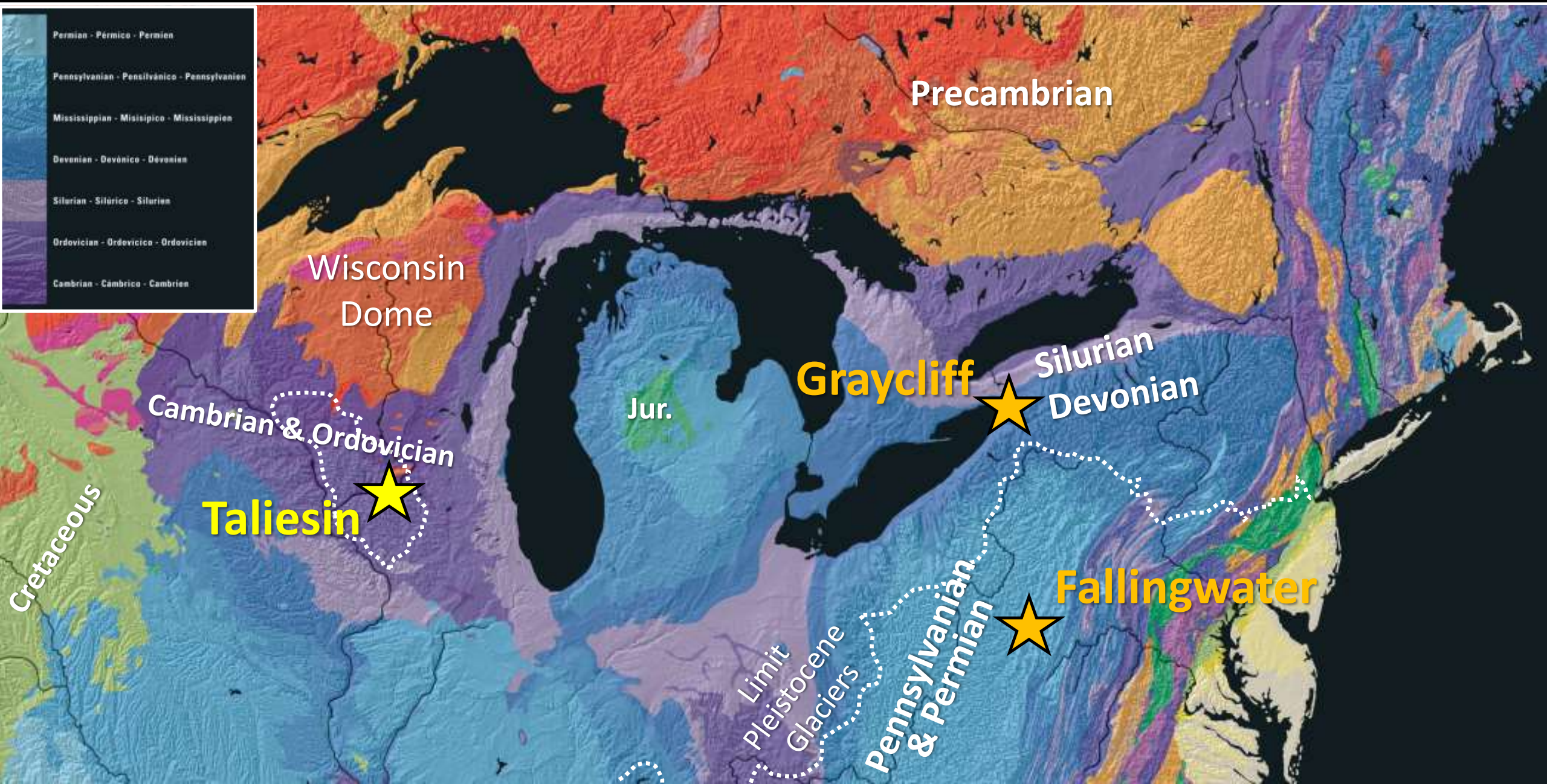
Graycliff Image courtesy of Graycliff Conservancy

Fallingwater Image courtesy of Western Pennsylvania Conservancy

Kentuck Knob Image: Historic American Buildings Survey, https://www.loc.gov/resource/hhh.pa1691.photos/?sp=36

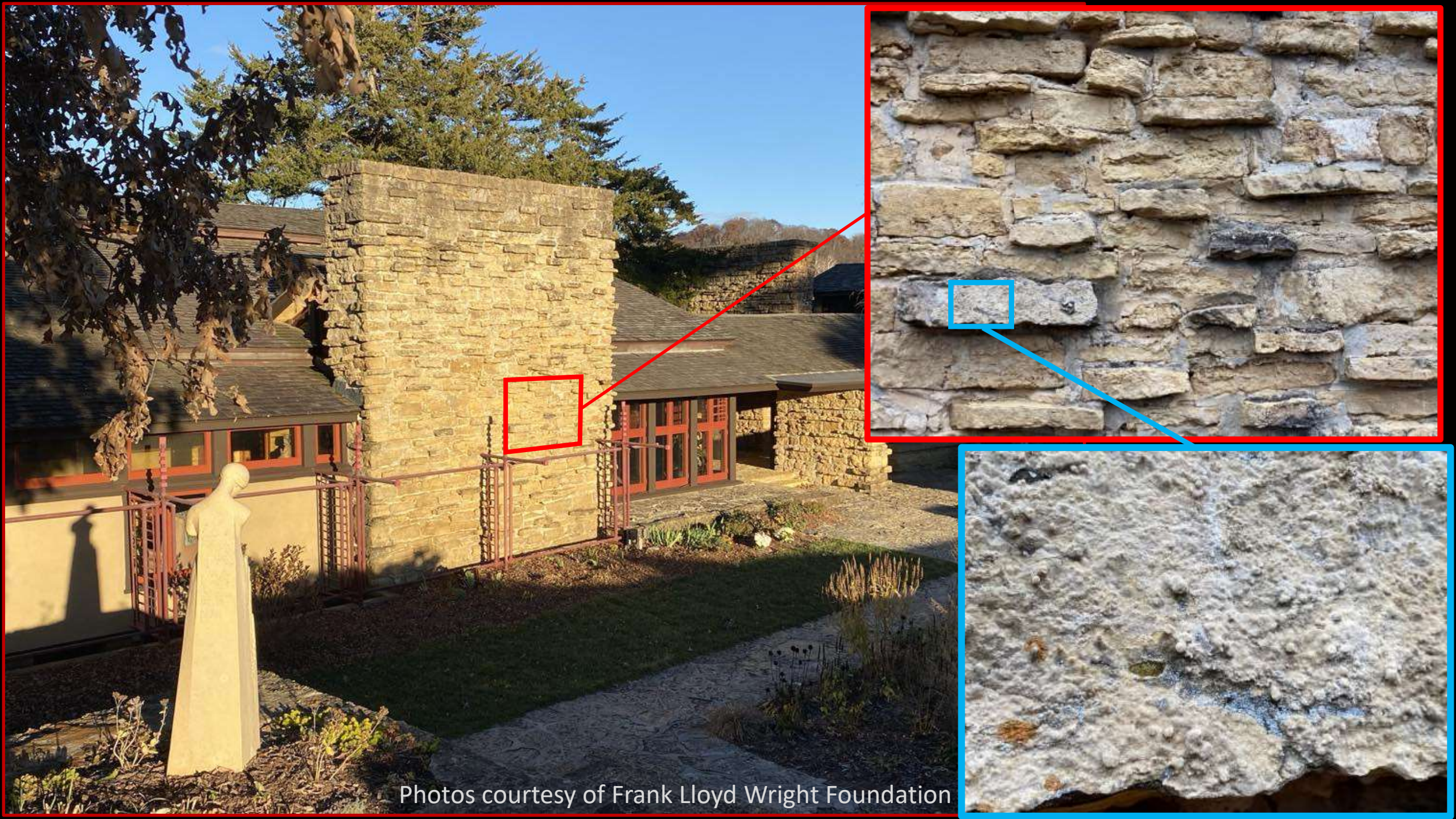
# Geologic Map of North America

Geologic Map: USGS Geologic Investigations Series I-2781
Glacier Limit: Carson et al., 2023 (Driftless); Brittanica.com (other)



# Taliesin

Image courtesy of the
Frank Lloyd Wright Foundation


Photos courtesy of Frank Lloyd Wright Foundation

# Taliesin Living Room

Bedding plane display of sandy dolomite/dolomitic sandstone

Photo courtesy of the Frank Lloyd Wright Foundation

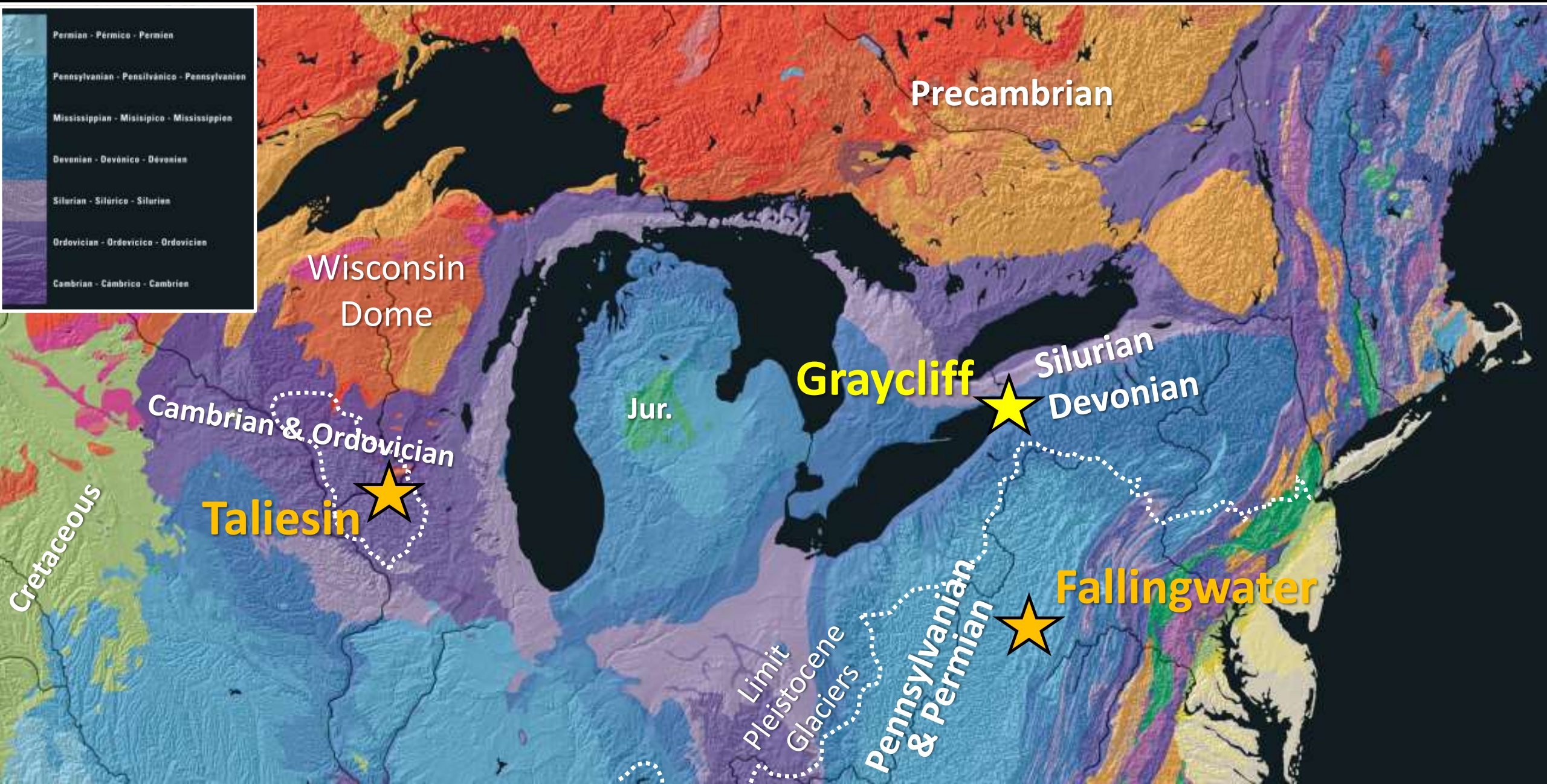
# Taliesin Living Room

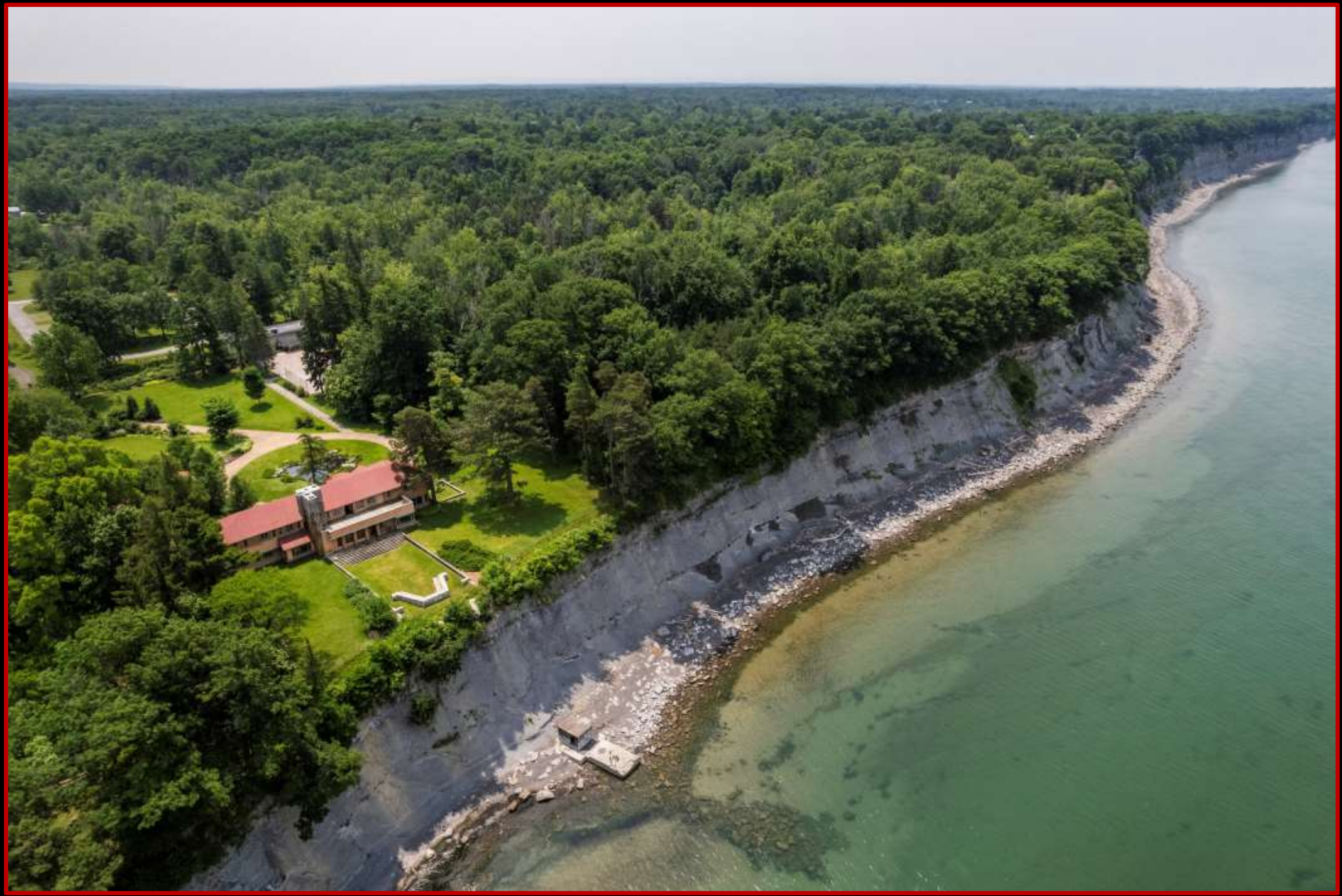
Close up of bedding plane texture of sandy dolomite/dolomitic sandstone

Photo courtesy of Frank Lloyd Wright Foundation

# Geologic Map of North America

Geologic Map: USGS Geologic Investigations Series I-2781
Glacier Limit: Carson et al., 2023 (Driftless); Brittanica.com (other)





# Graycliff perspective view

Photo by Matthew Digati, courtesy of the Graycliff Conservancy


**Graycliff buildings have Wright's preferred orientation**

# Graycliff
## on Lake Erie

Viewpoint on approach to the house provides view of Lake Erie through the living room

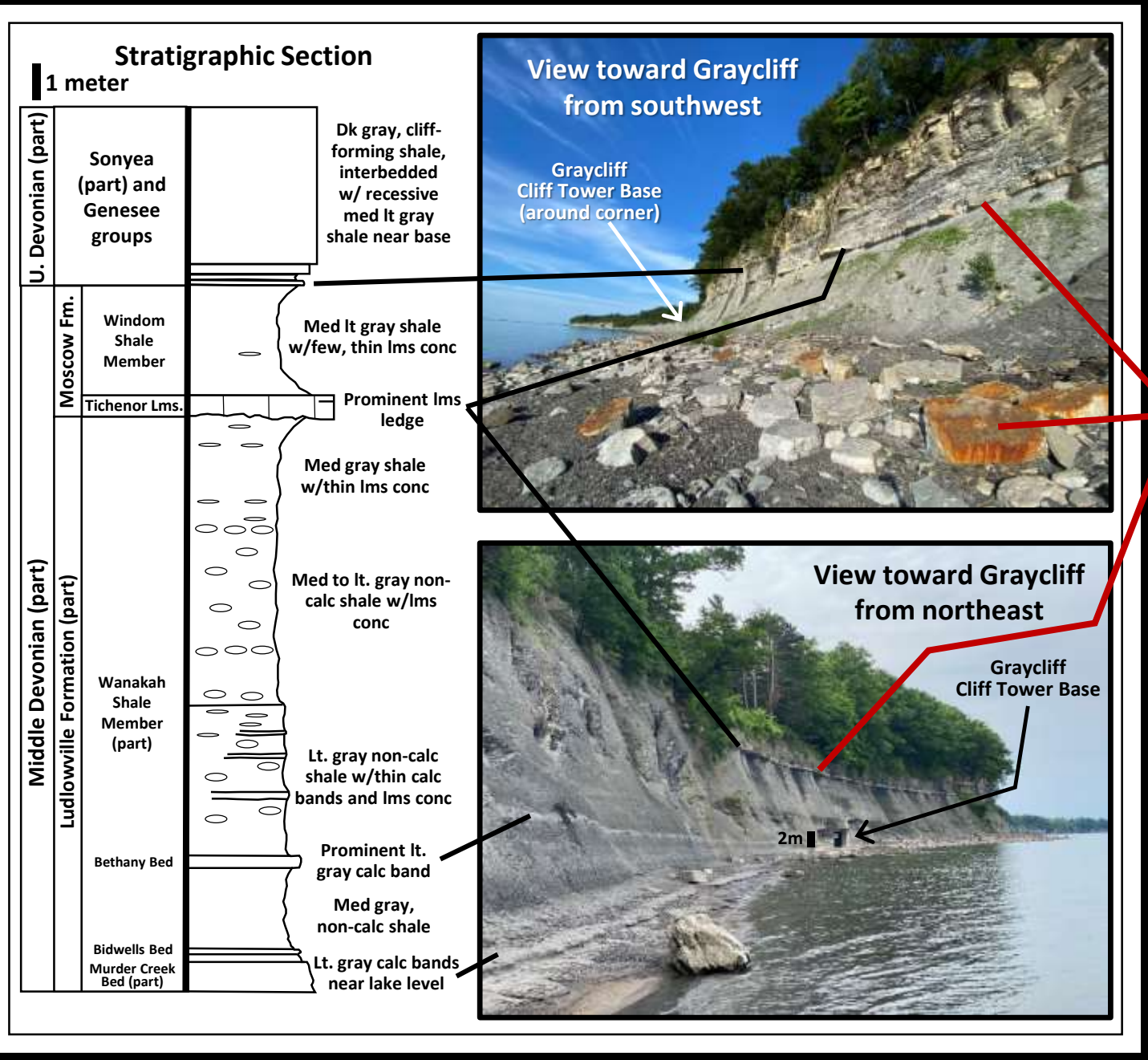
Photo courtesy of Graycliff Conservancy

**View of Lake Erie through the living room**

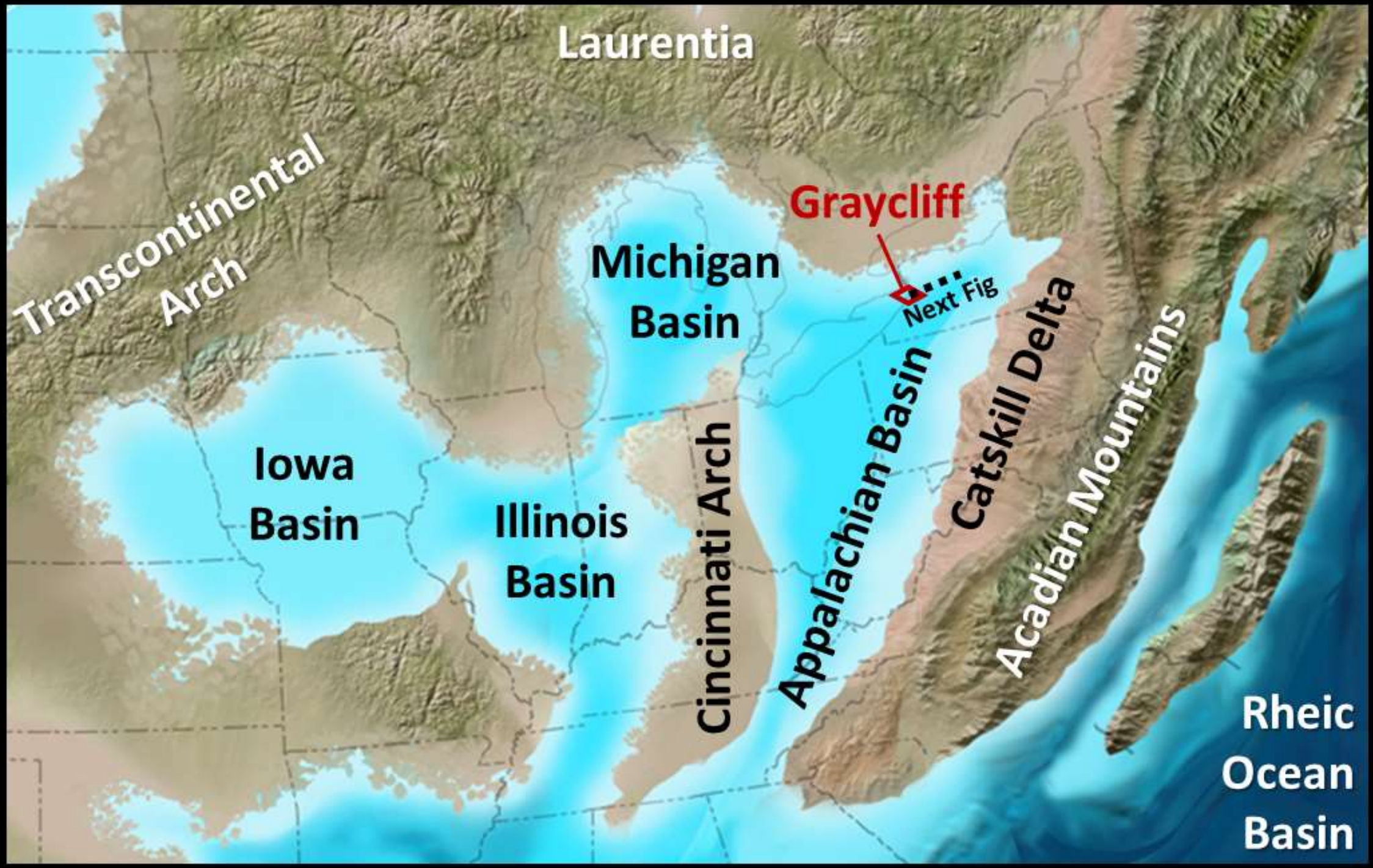
Photo courtesy of Graycliff Conservancy

**Picture windows in dining room**

Photo courtesy of Graycliff Conservancy

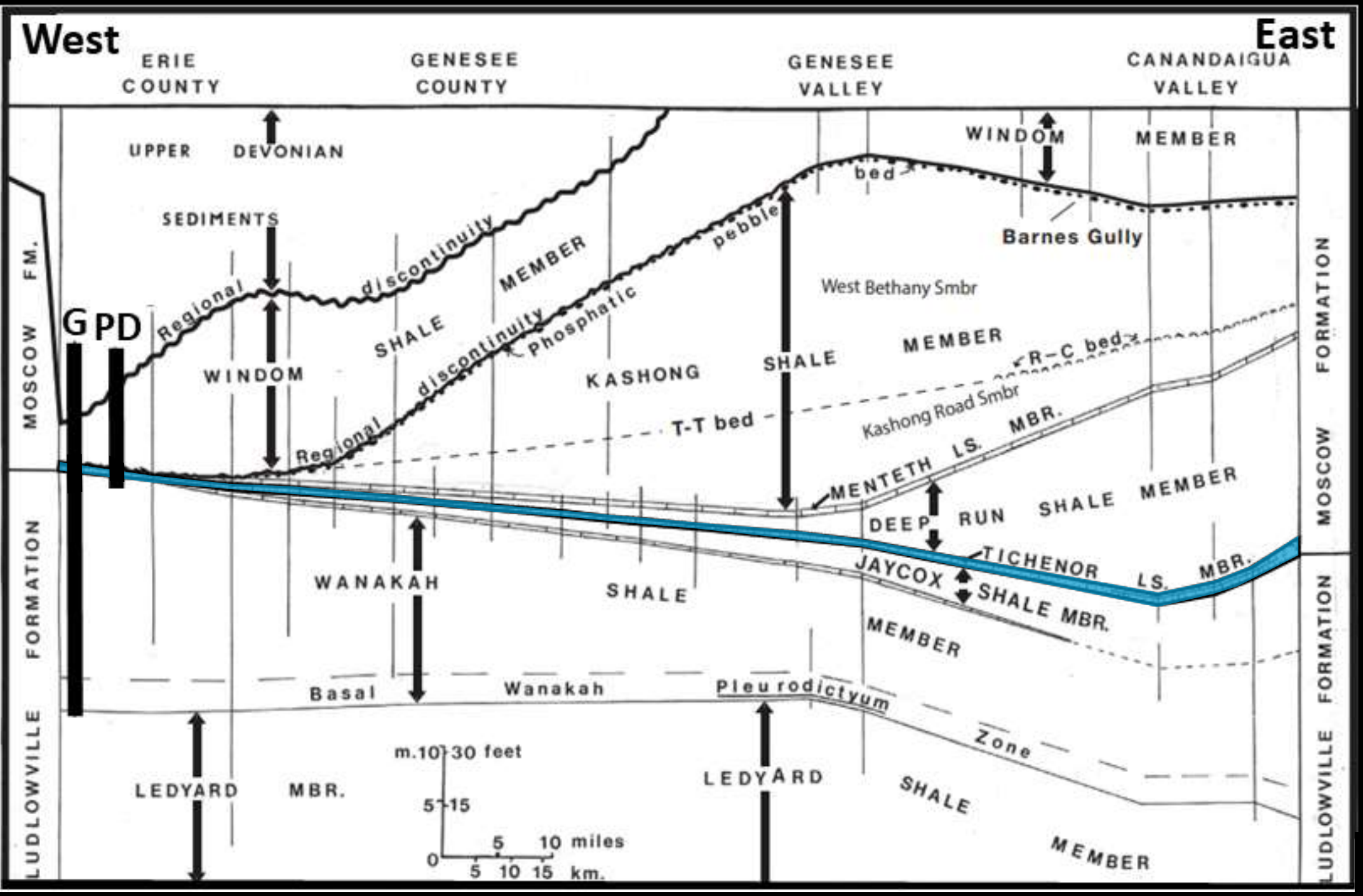



Tichenor Limestone ledge in cliff and boulders on beach at Graycliff




# Middle Devonian (Givetian)

From North America in Deep Time Paleographic Map Series, Ron Blakey




# Stratigraphic cross section

## Tichenor Limestone Member

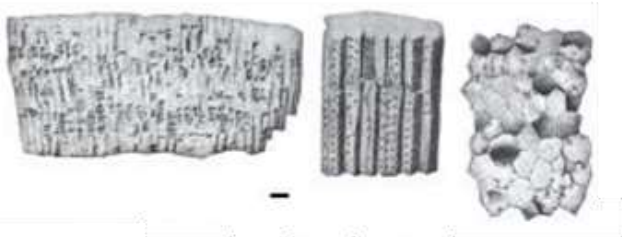
**G** – Graycliff
**PD** – Penn Dixie Fossil Park

Location of cross section shown on paleogeographic map

From Brett et al. (2023) and references therein

# Typical Fossils of the Tichenor Limestone at Graycliff and Penn Dixie Fossil Park

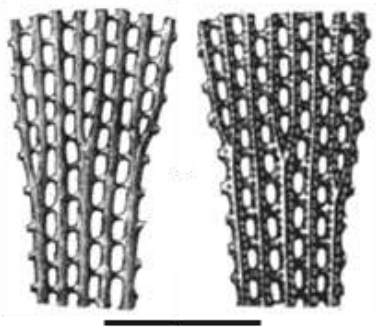
## Tabulate corals



*Favosites hamiltoniae*
Hall, 1876
E, PD

*Pleurodictyum americanum*
Roemer, 1876
PD

## Bryozoans

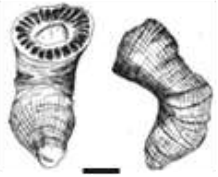


*Fenestella emaciata*
Hall, 1884
From Grabau 1899, fig. 47.
PD

## Echinoderms

*Deltacrinus clarus*
(Hall, 1862)
From Goldring, 1923, pl. 41, fig. 5.
PD

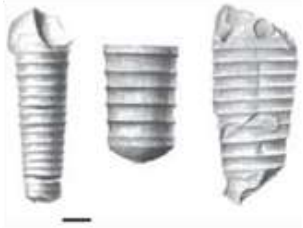
## Horn corals



*Amplexiphyllum hamiltoniae*
(Hall, 1876)
From Grabau, 1899, fig. 5.
E, PD

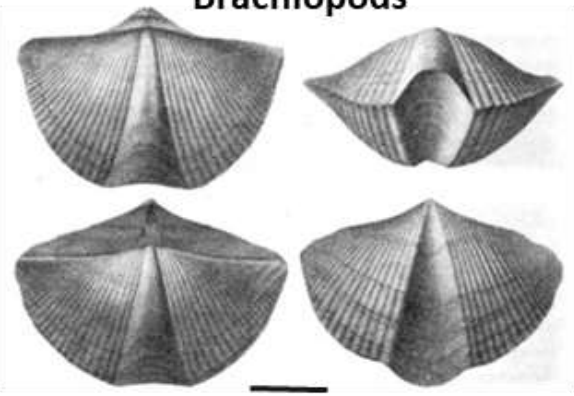
*Stereolasma rectum*
(Hall, 1876)
PD

## Cephalopods



*Spyroceras nuntium*
(Hall, 1861)
G, PD

## Brachiopods



*Mediospirifer audaculus*
(Conrad, 1842)
From Grabau, 1899, fig. 119.
E, PD

## Trilobites

*Pseudodechenella rowi*
(Green, 1838)
PD

*Dipleura dekayi*
(Green, 1832)
E, PD

## Bivalves

*Modiomorpha concentrica*
(Conrad, 1838)
From Hall, 1885, fig. 36-8.
E

# Some of the >60 taxa of Middle Devonian marine macrofossils reported in the Tichenor Limestone

**Scale Bar is 1 cm**

**E**—Eighteen Mile Creek (near Graycliff)
**PD**—Penn Dixie Fossil Park

From references cited in Wilson (2014) via Stokes and Schreiber (2017) unless otherwise noted


Graycliff

# Natural fractures in Tichenor Limestone create rhomboidal diamond shapes

Graycliff Area

# The Diamond Window

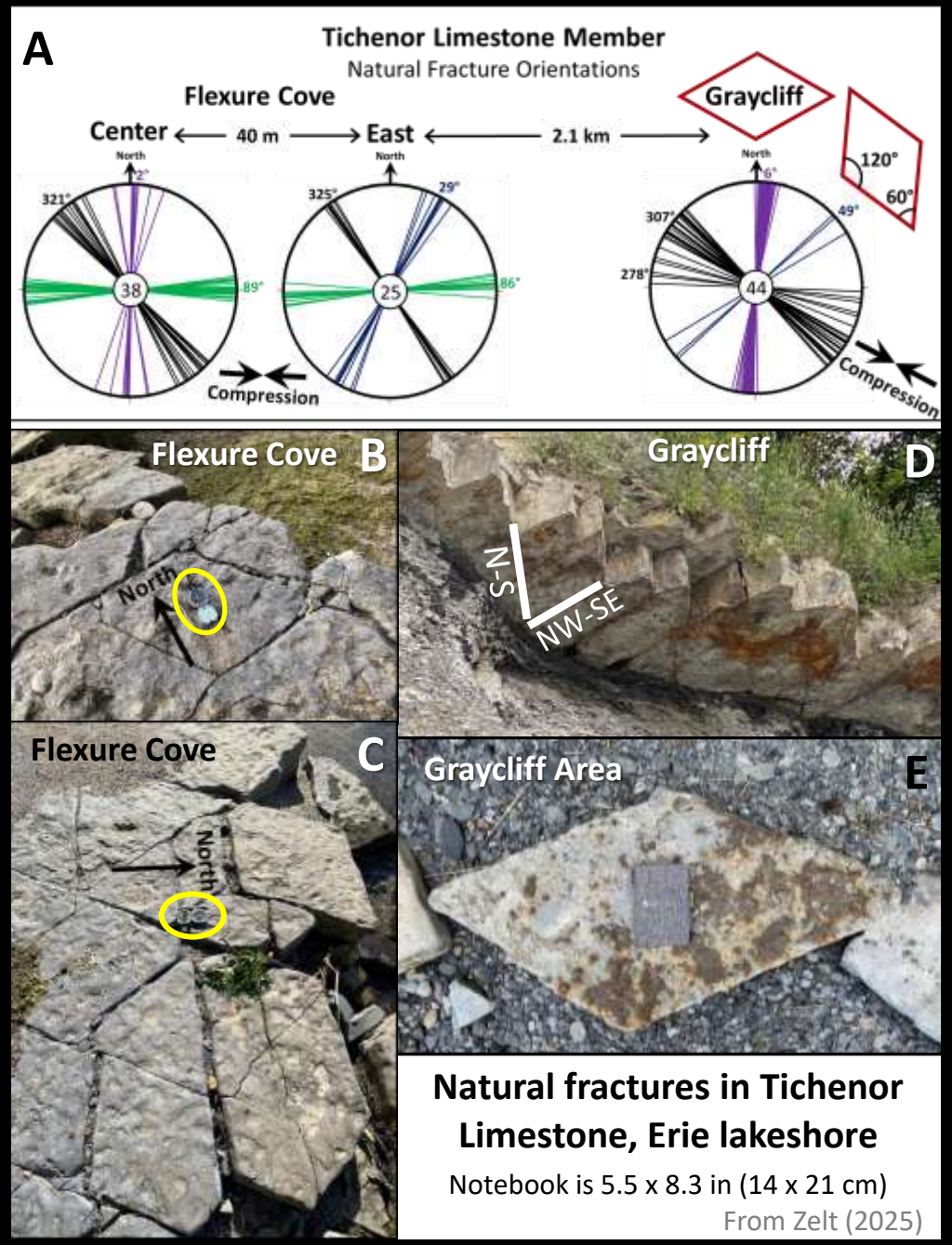
Photo courtesy of Graycliff Conservancy

# Organic basis of Diamond Window

Photos courtesy of the Graycliff Conservancy

# Diamonds in top of Tichenor Limestone on beach at Flexure Cove and recycled Medina sandstone of Graycliff Patio

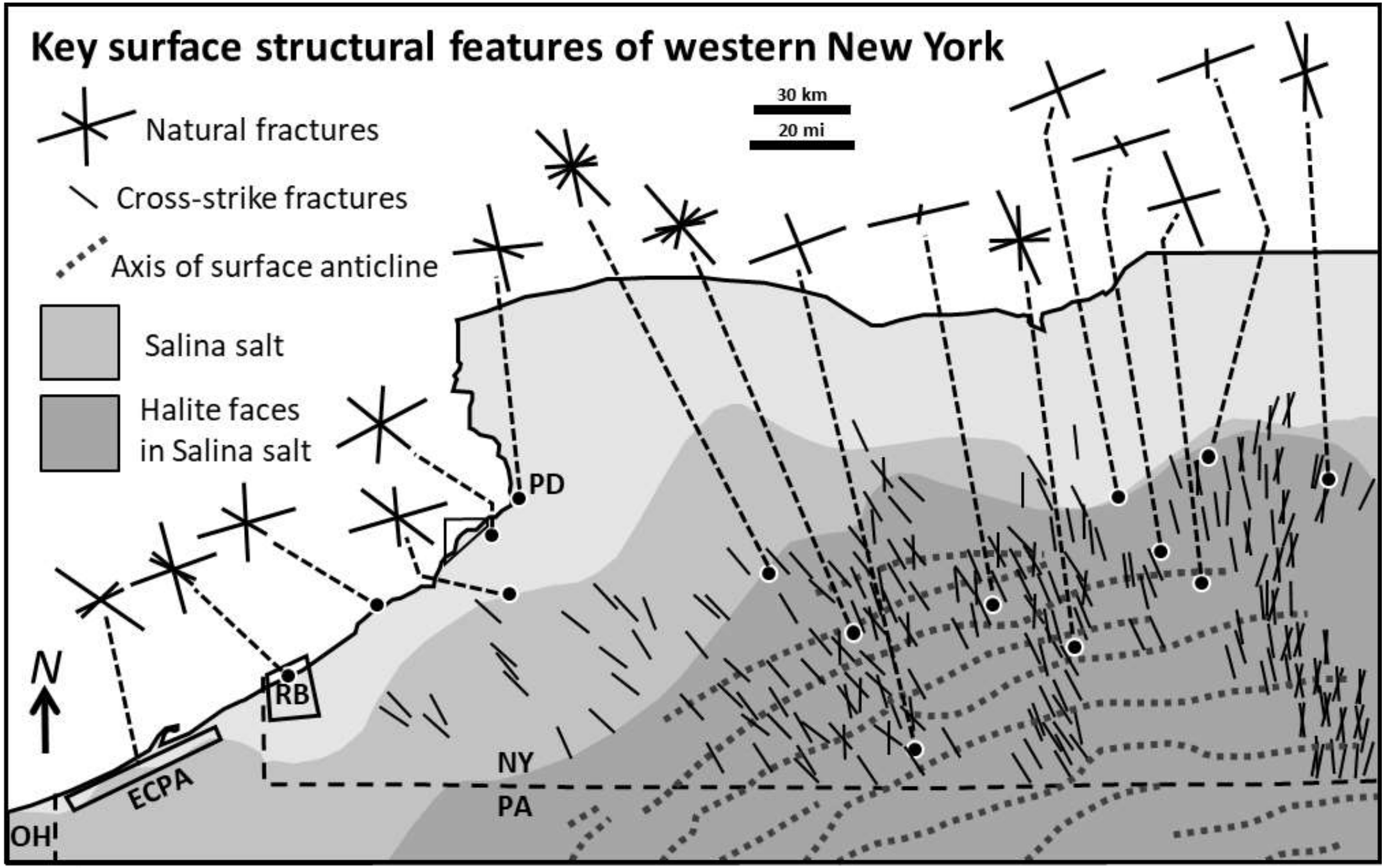
Photos courtesy of the Graycliff Conservancy




**Natural fractures in Tichenor Limestone, Erie lakeshore**

Notebook is 5.5 x 8.3 in (14 x 21 cm)

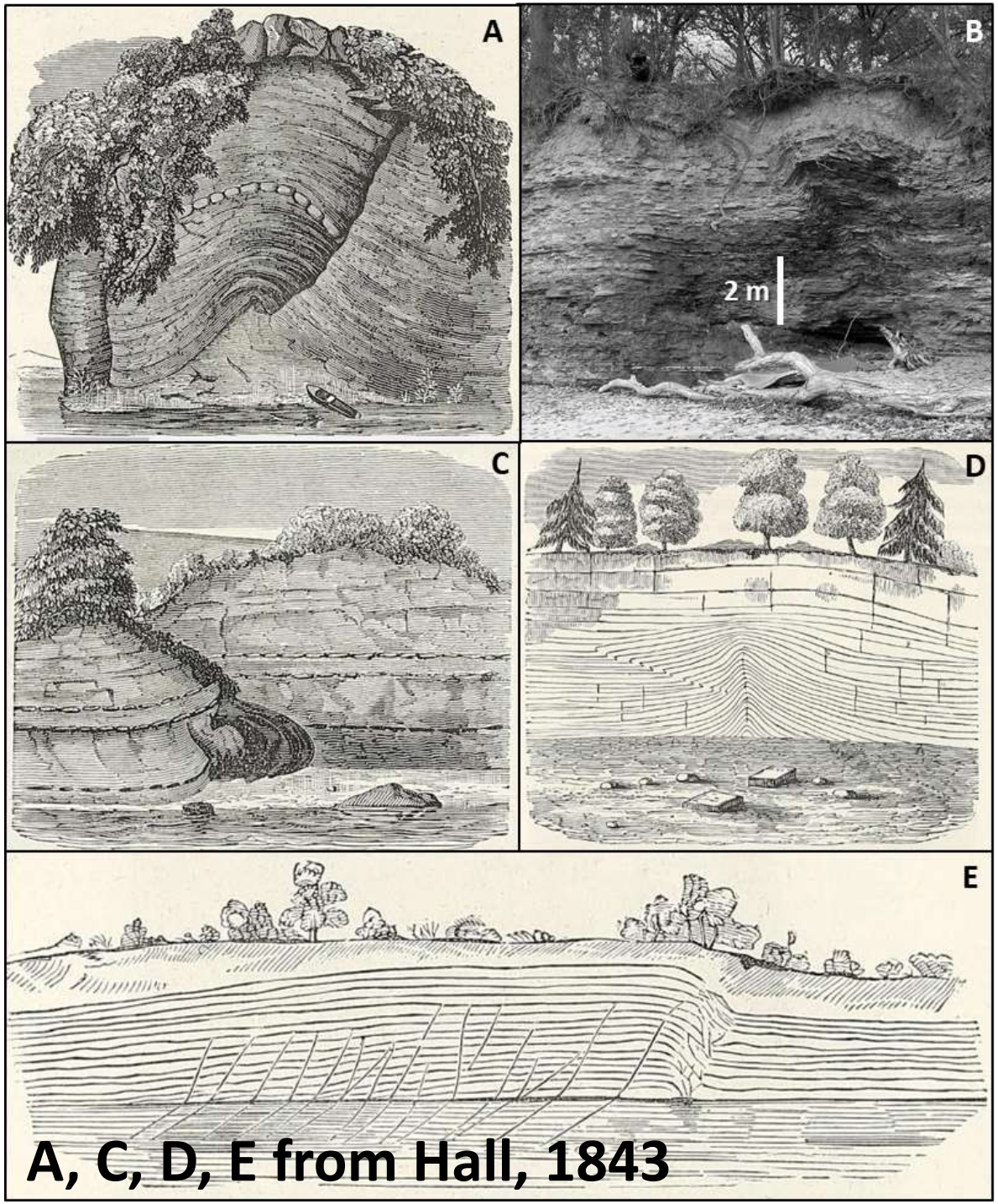
From Zelt (2025)




Principal natural fracture orientations generalized from Lash et al. (2004), Lash and Engelder (2007), Engelder et al. (2009), Lang et al. (2023) and Zelt (2015). Cross-strike fracture orientations generalized from Engelder and Geiser (1980). Axes of surface anticlines from Wedel (1932), Berg et al. (1980), Engelder and Geiser (1980), and Mount (2014). Extent of Salina salt from Clifford (1973). Extent of halite facies of Salina salt from Rickard (1969) and Mount (2014).

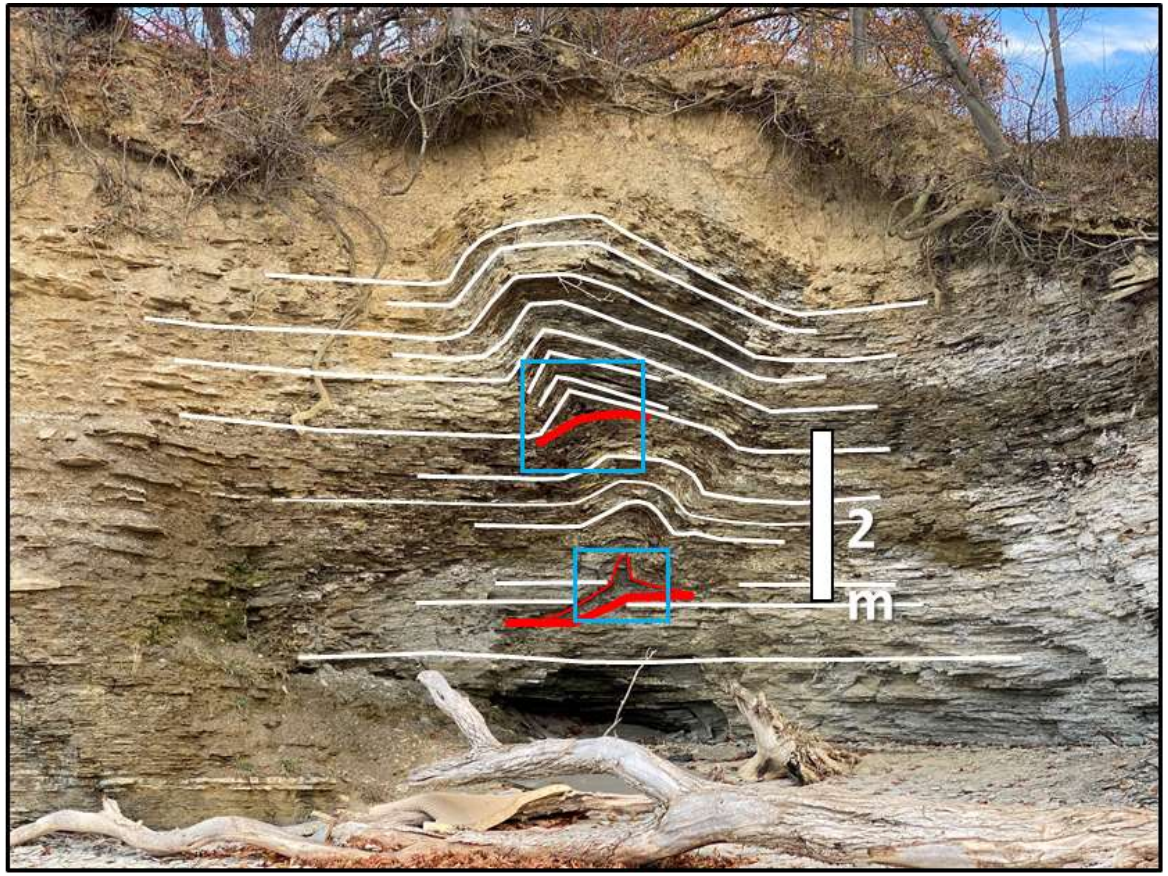
**OH—Ohio; ECPA—Erie County Pennsylvania; RB—Ripley Beach; PD—Penn Dixie Fossil Park; PA—Pennsylvania; NY—New York.**

From Zelt (2025)



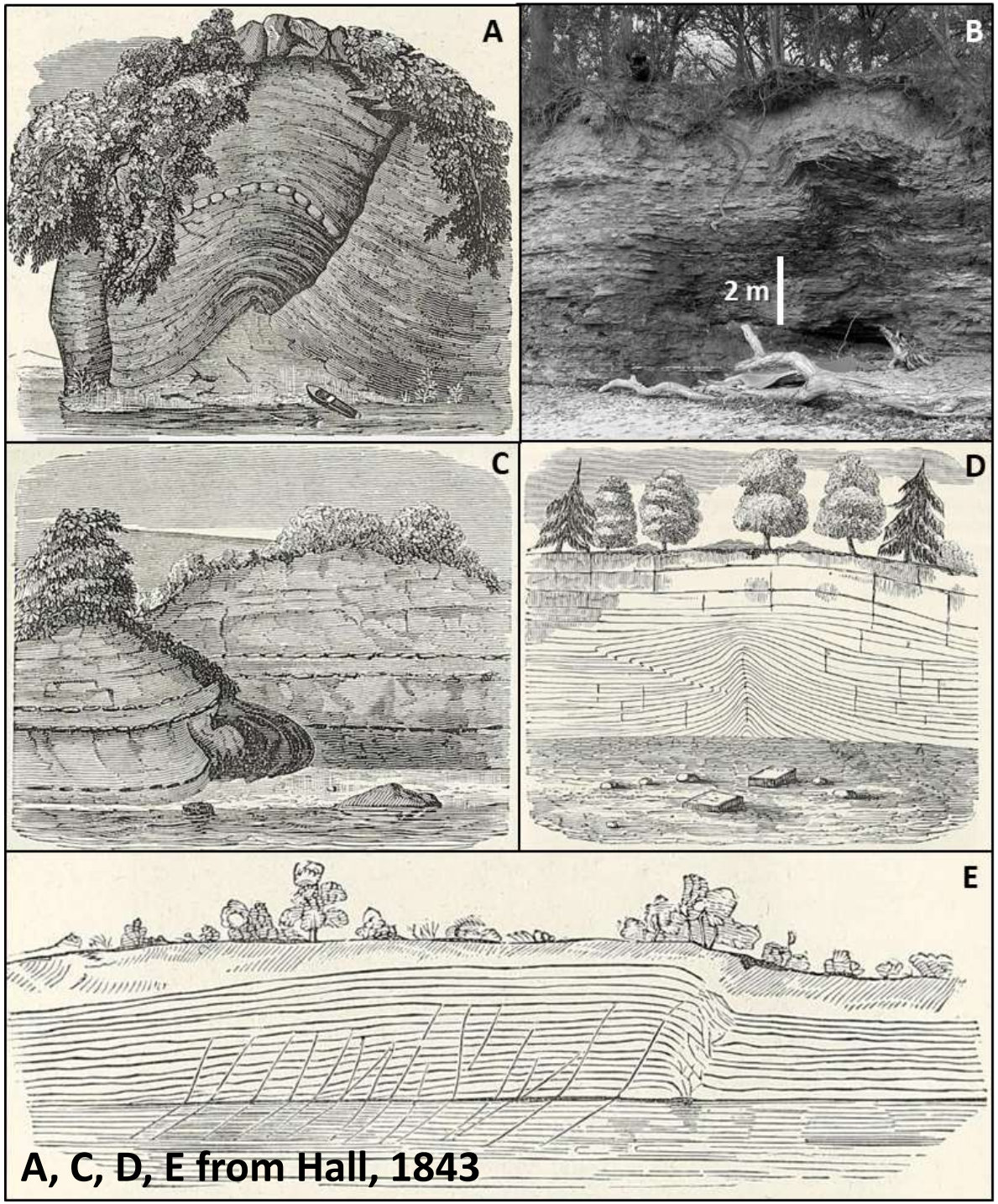

A, C, D, E from Hall, 1843

## B. Ripley Beach




From Zelt (2025)

# Geologic structures in Devonian shale outcrops, western New York from Grabau, 1898



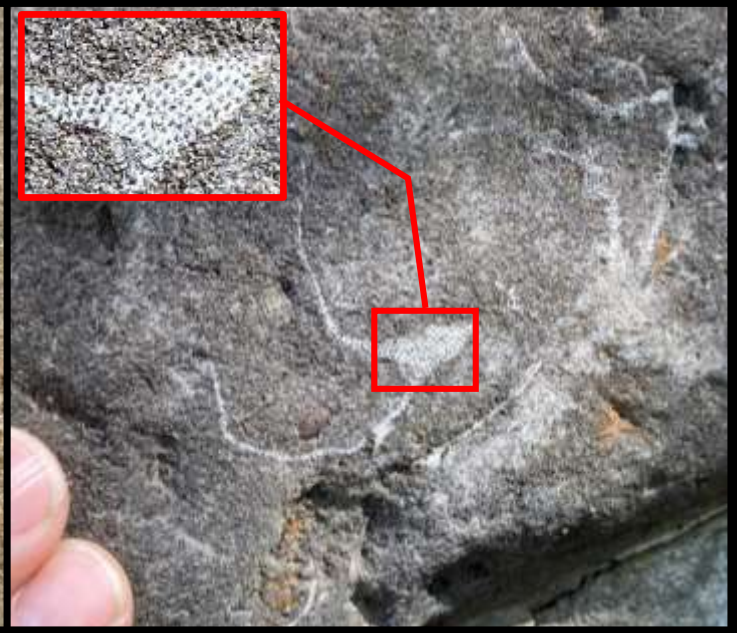

A, C, D, E from Hall, 1843

## C. Flexure Cove

From Zelt (2025)

# Natural Stone Features near Graycliff entrance

Photos courtesy of Graycliff Conservancy



# Examples of the hundreds of fossils in Graycliff wall stones

Photos courtesy of
Graycliff Conservancy

# Brachiopod fossil and split boulders of crystalline rocks near living room fireplace

Photos courtesy of the Graycliff Conservancy

Photo courtesy of University at Buffalo Libraries

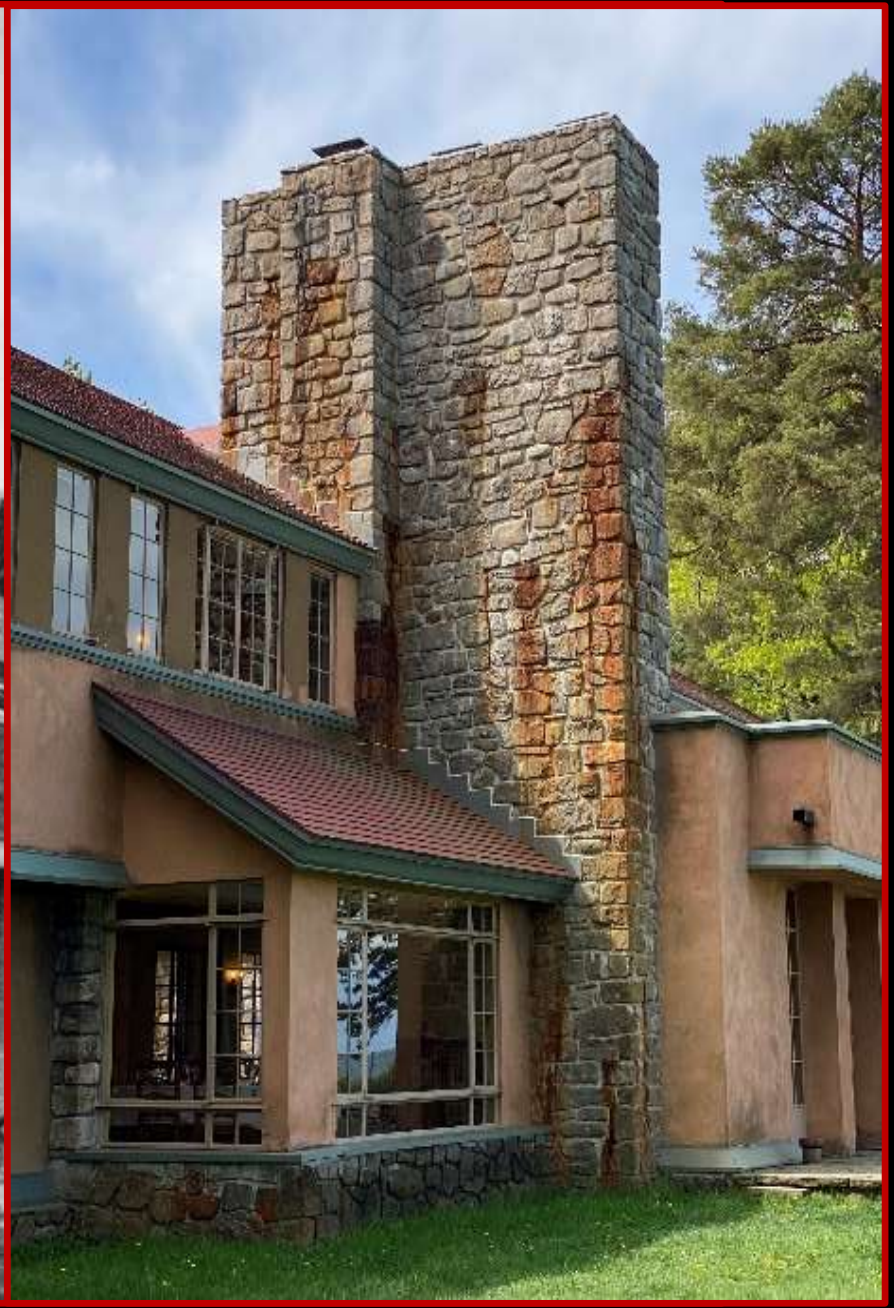


Photo courtesy of Graycliff Conservancy

# Natural weathering of Tichenor Limestone

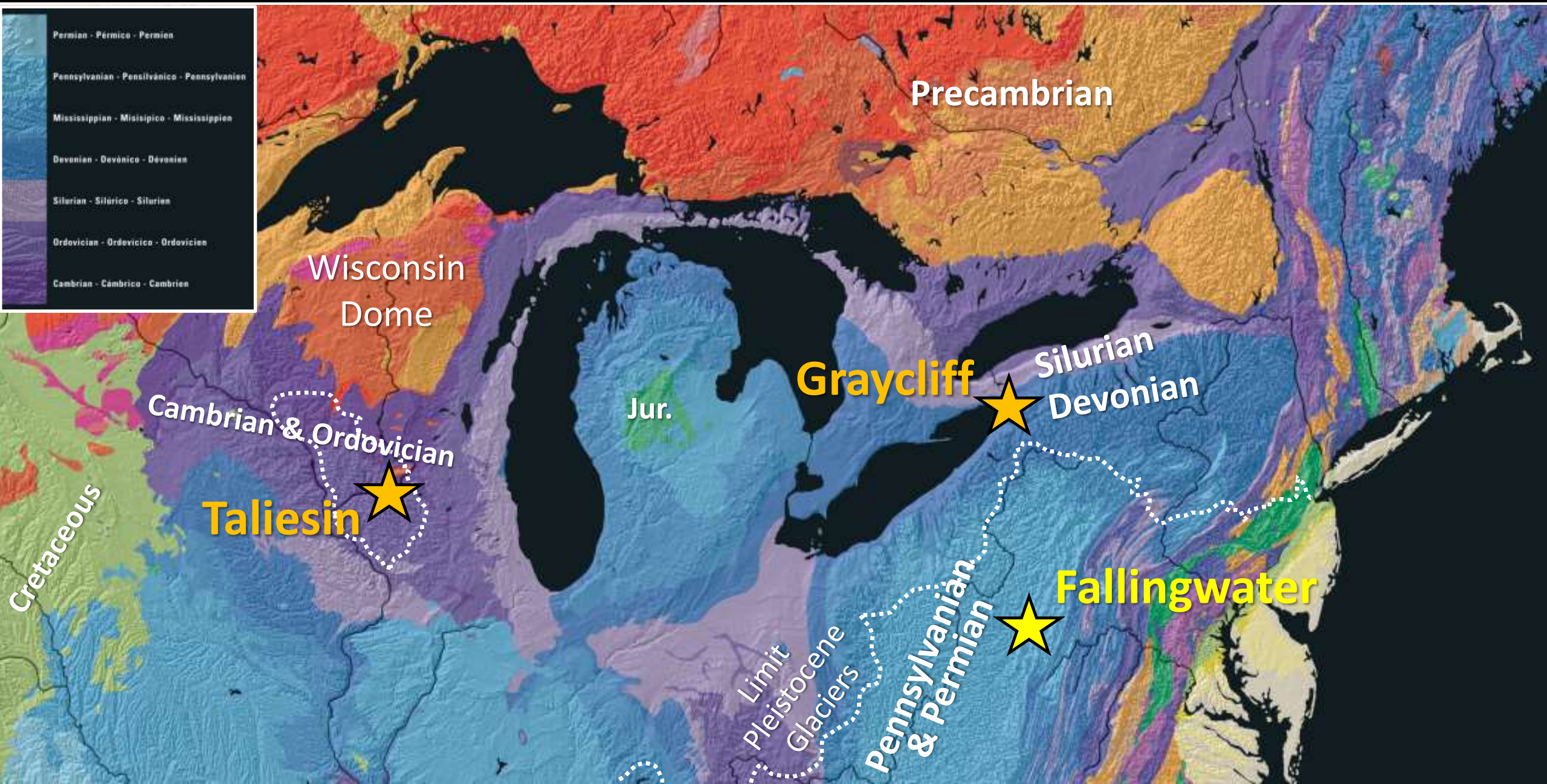
Graycliff with chimney completed historic photo courtesy of the University at Buffalo Archives (MS_22.3_1.14), *Digital Collections - University at Buffalo Libraries*, accessed July 23

# Organic design at Graycliff

Photo courtesy of the Graycliff Conservancy

# Geologic Map of North America

Geologic Map: USGS Geologic Investigations Series I-2781
Glacier Limit: Carson et al., 2023 (Driftless); Brittanica.com (other)



# **Fallingwater** *Organic Design Elements*



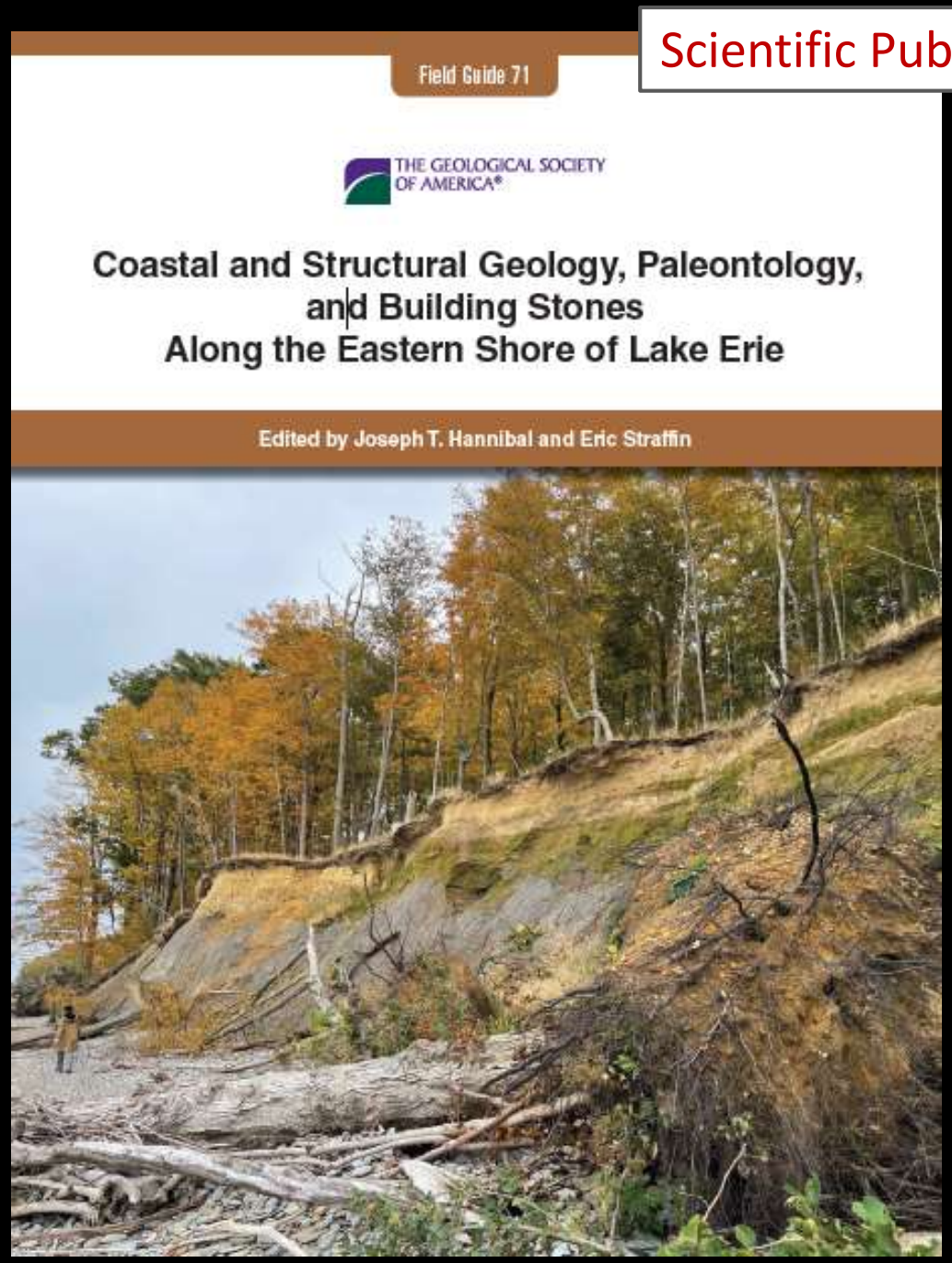
# Fossils, fractures, and foreshore cliffs:

## The influence of geologic features on Frank Lloyd Wright's transition from Prairie School to Organic Architecture at Graycliff on Lake Erie, western New York State, USA

By Fred Zelt, Roger Steck, Philip Stokes, and Carl Brett

Photo by Matthew Digati, courtesy of the Graycliff Conservancy

Scientific Publication




# Opportunity for further exploration

**Geological Society of America Field Guide 71**

**Contents Include**

**Frank Lloyd Wright's Graycliff on Lake Erie in western New York State, USA: Geology, organic design, and associated structures**

by Fred Zelt, 2025