Slide 01

If you use this program, please provide feed back about how it was used. The information you provide will help the OGS plan future revisions of this program as well as new products and services.

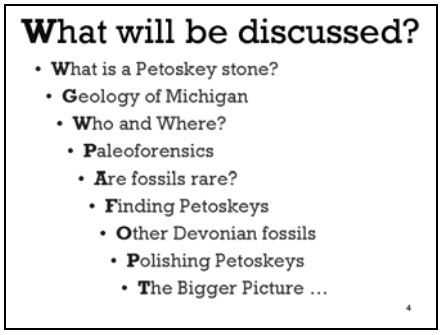
Please forward any ideas, feedback, comments, suggestions, tips, tricks, traps, alterations, permutations, variations, changes, deletions, and / or additions to Steven E. Wilson, MI DEQ OGS, PO Box 30256, Lansing 48909, email wilsons15@michigan.gov. Material available on the web at www.michigan.gov/deggeologyinmichigan .

Graphic from Microsoft clipart

Title slides

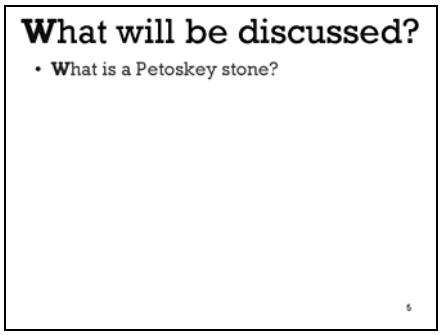
Slide 02

Slide 03



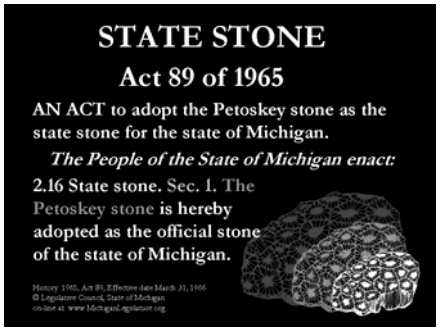
Slide 04

Used to help keep presentation on track – all points



Slide 05

Used to help keep presentation on track - specific point

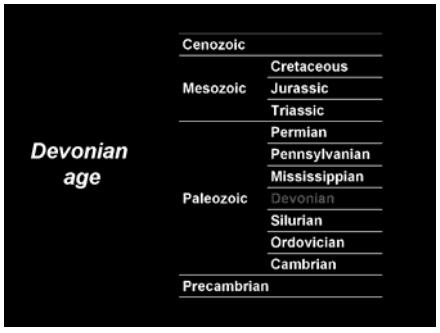


Slide 06

The legislation that designates the "Petoskey stone" the state stone is not very helpful with respect to identifying exactly what a Petoskey stone might be.

See the Michigan Fossil Poster Pack and the Petoskey Stone handout available online at http://www.michigan.gov/deggeologyinmichigan (deq geology in michigan - all lowercase - no spaces)

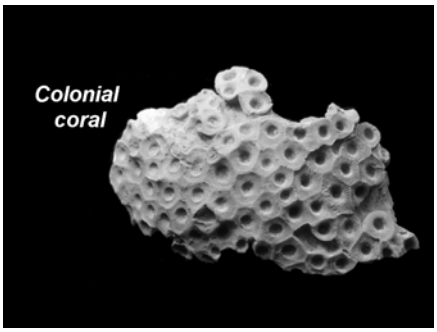
drawing by Steven E. Wilson, from PA 06, COLLECTING ROCKS, MINERALS AND FOSSILS IN MICHIGAN: 1976; Wilson, S. E. - - Text of legislation modified from Legislative Council, State of Michigan on-line at www.MichiganLegislature.org qpq



Slide 07

Where the Devonian fits in the geologic time scale.

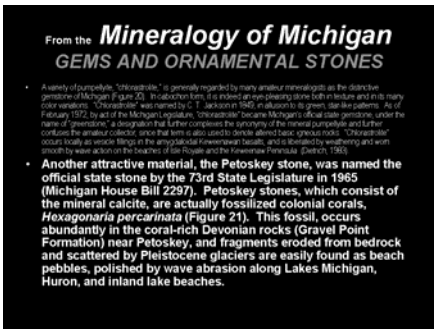
Source: Digital image made by Steven E. Wilson, DEQ OGS.



Slide 08

Natural surface or "rough" Petoskey from the Charlevoix Medusa Portland Cement Company (now owned by Cemex). Some Petoskeys should not be polished, especially if they provide clues about the fossil that would be lost by cutting, grinding, sanding and or polishing. Cleaning fossils is an art and science in its own right. Lapidary may improve the appearance but it can have its "costs" as well.

Digital image made by Steven E. Wilson, DEQ OGS.



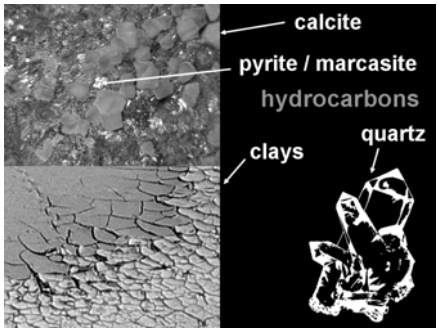
Slide 09

MORE from the revised Mineralogy of Michigan about calcite ...

"A very common and widespread rock-forming mineral. Calcite is the chief constituent of limestone and marbles and is also widespread as a hydrothermal (gangue) mineral in veins, lodes, and replacement deposits of a great variety of metallic mineralizations. In Michigan, outstanding calcite occurrences are of the following main types: 1. As exceptionally fine and complex crystals in cavities and veins in the Keweenaw native copper lodes. It is the most widespread mineral of the ore-forming period. This is a deservedly famous occurrence for this mineral, and its specimens grace mineral collections all over the world. 2. As crystals in cavities and veins in iron ores. 3. As vein-filling, concretion, and vug crystals in various limestone and shale formations. 4. In marls of glacial lakes. Northern and Southern Peninsulas.

Calcite is also the major mineral constituent of Petoskey stones, masses of fossil colony coral (Hexagonaria percarinata) that occur abundantly in the Devonian reef limestones of the Gravel Point Formation (Traverse Group) in Charlevoix, Emmet, Cheboygan, Presque Isle, and Alpena Counties. Coral groups weathered out of the limestone were widely scattered by Pleistocene glacial action, and are readily found on beaches as pebbles and cobbles rounded by wave abrasion. Dietrich (1983) provides a concise description of the fossil and its occurrence."

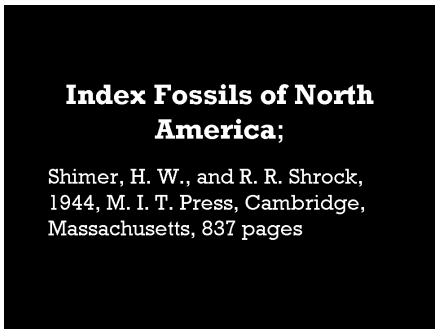
Source: MINERALOGY OF MICHIGAN; Heinrich, E. W.; revised by George Robinson Gives the geological characteristics and locations for the mineral occurrences in Michigan, information available on line at www.michigan.gov/deqgeologyinmichigan .



Slide 10

Petoskeys are not made up of just one mineral (or rock). But getting even a mention in the "Mineralogy of Michigan" is significant. If you look closely you might see, in addition to calcite, minor amounts of pyrite or marcacite, varying amounts of clays, some quartz replacement and even hydrocarbons.

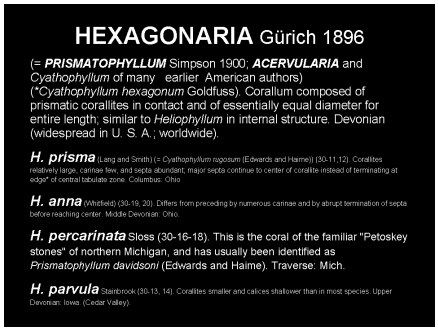
Source: Digital image made by Steven E. Wilson, DEQ OGS - calcite and marcacite from Bayport Limestone, Cheney quarry, Bellevue, Michigan - mud-cracks (in clays), Wallace Stone company Bad Ax, Michigan; - Illustration of quartz crystals from Eddy Discovery Center (MI DNR Parks) handout



Slide 11

One of the standard references is "Index Fossils of North America". The material is dated but it is a starting point for more information about Petoskeys

Source: Shimer, H. W., and R. R. Shrock, 1944, INDEX FOSSILS OF NORTH AMERICA", M. I. T. Press, Cambridge, 837 p.



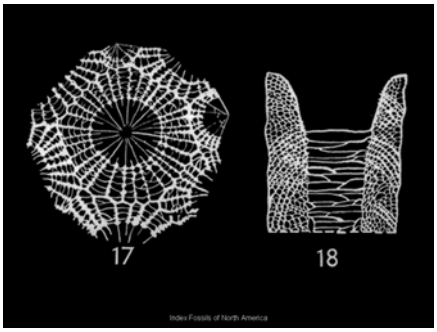
Slide 12

"INDEX FOSSILS OF NORTH AMERICA". Text found associated with the genus Hexagonaria

Notice the typical shorthand used to reference an immediately previously reference genus name in this case H. for Hexagonaria .

Note other species, variation in geologic age from Middle to Upper Devonian. Note different locations - Ohio and Iowa - not just Michigan

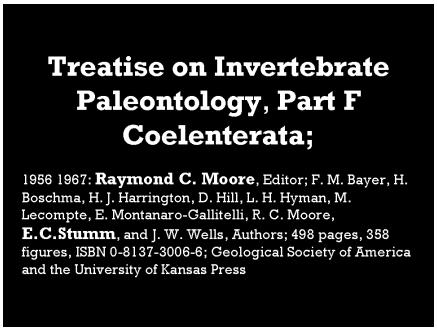
Source: Shimer, H. W., and R. R. Shrock, 1944, INDEX FOSSILS OF NORTH AMERICA, M. I. T. Press, Cambridge, 837 p.



Slide 13

Some of the most common used illustrations of Hexagonaria percarinata come from "Index Fossils of North America". Plate 30 figures 17 and 18 (16 is also Hexagonaria percarinata but is not included here).

Source: Shimer, H. W., and R. R. Shrock, 1944, INDEX FOSSILS OF NORTH AMERICA, M. I. T. Press, Cambridge, 837 p.

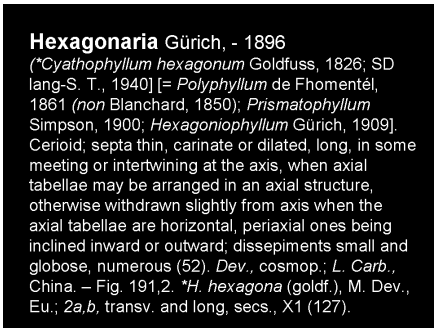


Slide 14

A more contemporary reference "the Treatise" (for short, see full reference below) is as close to a standard for invertebrate paleontology as exists.

Notice that Dr. E. C. Stumm, then with the Museum of Paleontology at the University of Michigan, is listed as one of the distinguished authors.

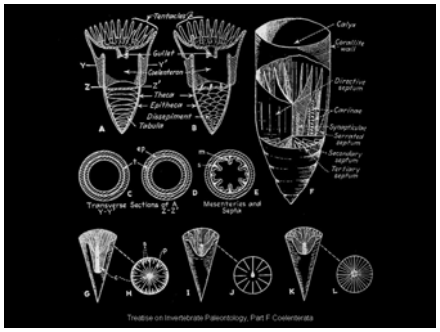
Source: TREATISE ON INVERTEBRATE PALEONTOLOGY, PART F COELENTERATA; 1956 1967: Raymond C. Moore, Editor; F. M. Bayer, H. Boschma, H. J. Harrington, D. Hill, L. H.Hyman, M. Lecompte, E. Montanaro-Gallitelli, R. C. Moore, E. C. Stumm, and J. W. Wells, Authors; 498 pages, 358 figures, ISBN 0-8137-3006-6; Geological Society of America and the University of Kansas Press



Slide 15

THEXT USED TO DESCRIBE FOSSILS – LIKE Hexagonaria – can seem confusing to the uninitiated.

Source: TREATISE ON INVERTEBRATE PALEONTOLOGY, PART F COELENTERATA; ... Geological Society of America and the University of Kansas Press qpq

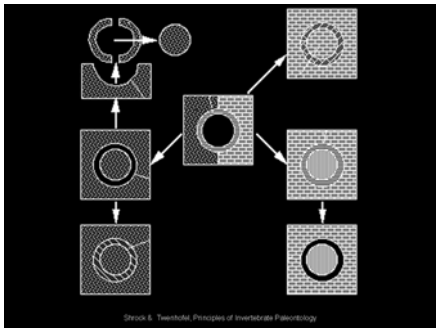


Slide 16

"The Treatise" goes into great detail about corals, their life cycle, associations, morphology (or hard parts), taxonomy (naming) and many more details not discussed at this time.

The illustrations seen here are of coral morphology or structure - what you would/should/could/might expect to see in a fossil coral. These are meant to show some of the level of detail and advanced information available in these books.

Source: TREATISE ON INVERTEBRATE PALEONTOLOGY, PART F COELENTERATA; 1956 1967: Raymond C. Moore, Editor; F. M. Bayer, H. Boschma, H. J. Harrington, D. Hill, L. H.Hyman, M. Lecompte, E. Montanaro-Gallitelli, R. C. Moore, E. C. Stumm, and J. W. Wells, Authors; 498 pages, 358 figures, ISBN 0-8137-3006-6; Geological Society of America and the University of Kansas Press

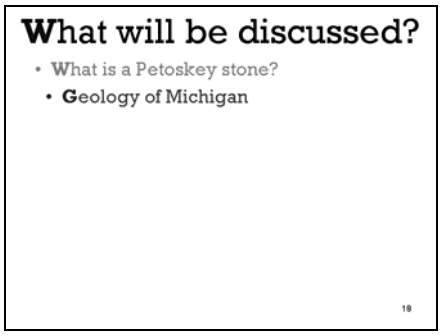


Slide 17

The process of becoming a fossil is involved and the resulting "products" can be confusing, especially when you look at many different groups of fossils from different locations.

But, we are not going to discuss becoming a fossil or have a pop quiz on the different kinds of fossilization.

Source: Shrock, R. R. and Twenhofel, W. H., PRINCIPLES OF INVERTEBRATE PALEONTOLOGY, New York,



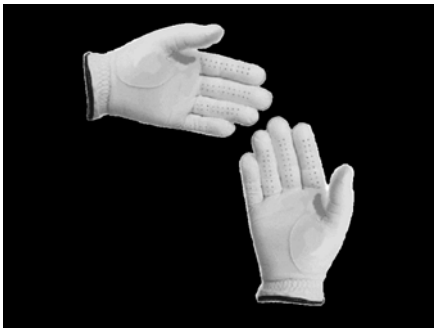
Slide 18

Used to help keep presentation on track

Slide 19

We should take a little bit of time discussing some general concepts of the Geology in Michigan.

One place to start is with geologic maps.

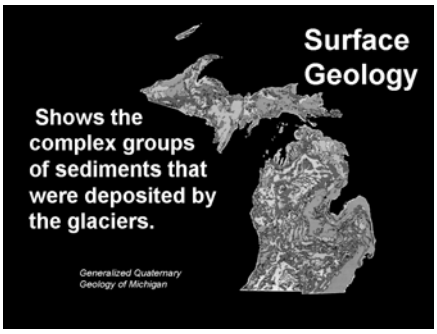

Slide 20

It is easy to spot a Michigander - especially when asked, "Where do you live?"

Lets look at a different kind of map …

For more information about the Geology of Michigan check out - http://www.michigan.gov/deqgeologyinmichigan
(deq geology in michigan - all lowercase - no spaces)

Source: Digital image made by Steven E. Wilson, DEQ OGS from Microsoft clipart.



Slide 21

Glacial or Quaternary Geology is what we see across most of the state. What we see are glacial landforms mad of sands, gravels and clays left by the retreating glaciers

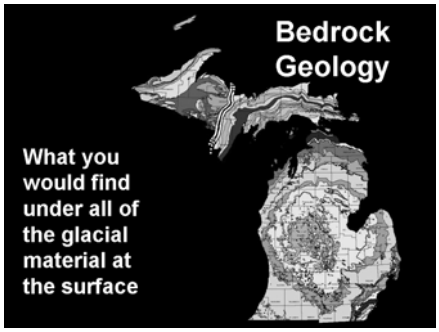
Source: "QG 01 QUATERNARY GEOLOGY OF MICHIGAN"; 1982; Farrand, W. R.; Colored "surface geology" of the State. Includes both peninsulas, 1:500,000, 2 sheets. Digital image made by Steven E. Wilson, DEQ OGS.

For more information about the Geology of Michigan check out - http://www.michigan.gov/deqgeologyinmichigan
(deq geology in michigan - all lowercase - no spaces)


Slide 22

If we remove all of the glacial sands, gravels and clays we don't have a blank …

Digital image made by Steven E. Wilson, DEQ OGS.

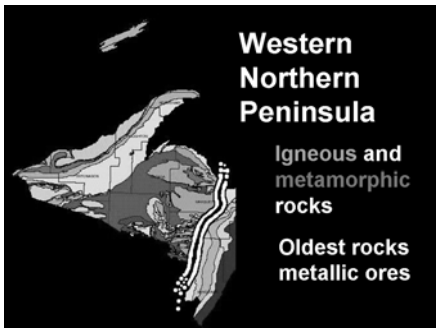


Slide 23

What we have is the bedrock geology - what you would see if you removed all of the glacial sands, gravels and clays. The colors would be different but the pattern would be very close to what you see here.

Source: "BG 01 BEDROCK GEOLOGY OF MICHIGAN", 1987; Wilson, S. E.; Colored map of the aerial extent of geologic formations. Includes both peninsulas; 1:500,000, 2 sheets. Digital image made by Steven E. Wilson, DEQ OGS .

For more information about the Geology of Michigan check out - The Rock Cycle and more at
http://www.michigan.gov/deqgeologyinmichigan
(deq geology in michigan - all lowercase - no spaces)



Slide 24

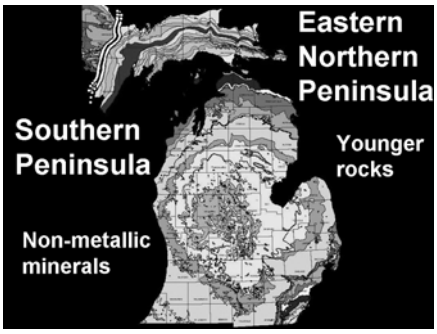
This shows the western northern ("upper") peninsula in more detail. This is where we find igneous and metamorphic rocks as major components of the bedrock. There are also ancient sedimentary rocks as well. These are the geologically oldest rocks in the state, many measured in BILLIONS of years, not just millions.

Some of the most complex geology in the state is in this area.

This is where the Metallic mines are located. The copper mines are found in the Keweenaw Peninsula while the banded iron formations are found in several areas. Other ore deposits exist in the area as well.

The Value of the iron and copper deposits have meant more to the State and National economies than the infamous "gold rush" in California.

Source: “BG 01 BEDROCK GEOLOGY OF MICHIGAN”, 1987; Wilson, S. E.; Colored map of the aerial extent of geologic formations. Includes both peninsulas; 1:500,000, 2 sheets. Digital image made by Steven E. Wilson, DEQ OGS .



Slide 25

The eastern northern peninsula and all of the southern peninsula are made up of sedimentary rocks. These rocks formed in what is called the Michigan Basin. These sedimentary rocks hold the vast and varied non-metallic resources of our state. These include: limestone and dolomite, shale, sandstone, gypsum and rock salt. One commonly overlooked resource is oil and gas - more about that later.

Source: “BG 01 BEDROCK GEOLOGY OF MICHIGAN”, 1987; Wilson, S. E.; Colored map of the aerial extent of geologic formations. Includes both peninsulas; 1:500,000, 2 sheets. Digital image made by Steven E. Wilson, DEQ OGS .


Slide 26

To better understand what the Michigan basin is, lets look at just the southern peninsula of the state.

Lets tilt it (gently),

Lets uses the super saw to cut it into four pieces,

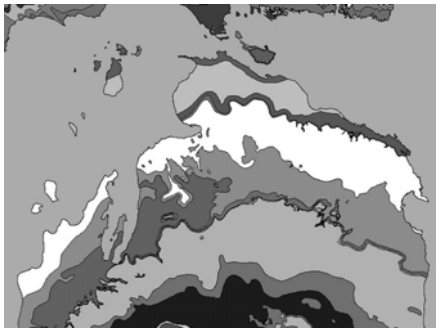
Lets separate the pieces,

Lets add in the pattern that is revealed (primarily from oil & gas) geologic records,

and with a dash of color we can see why there is a circular pattern to the rocks.

The youngest rocks in the state (Jurassic) are found in the center of the southern peninsula. As one moves away in any radial direction from the "center" the bedrock one might encounter is progressively older and older (eventually to Cambrian age rocks in the northern peninsula (and elsewhere out state)). The rocks are all tilted or dipping toward the center like a collection of nested bowls or measuring cups. Geologically, such structures are called basins.

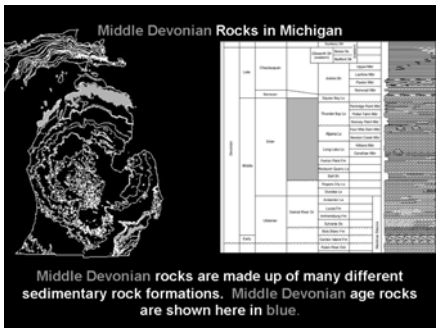
Source: “BG 01 BEDROCK GEOLOGY OF MICHIGAN”, 1987; Wilson, S. E.; Colored map of the aerial extent of geologic formations. Includes both peninsulas; 1:500,000, 2 sheets. And illustration by D. Bell in Door and Eschman, “Geology of Michigan”. Digital images made by Steven E. Wilson, DEQ OGS .


Slide 27

This is a detailed (larger scale or closer up) map of the northern part of the southern peninsula. The white area is the area that has the middle Devonian Traverse Group rocks making up the bedrock. This is where Petoskeys are found "in situ" (in place). Where would the cities - Charlevoix, Petoskey and Alpena - be on this map? Why are they missing? (This map is not of the surface features like cities and roads or rivers.)

The scale of a map is the ratio between distances on the map and corresponding distances in the ground. If a map has a scale of 1:500,000, then 1cm on the map equals 500,000cm or 5 km (3.1 miles) on the earth's surface. A large scale map shows great detail - representative fraction is large like 1/25,000 (typical topographic map). A small scale map shows only large features - representative fraction is small, e.g. 1/500,000 (statewide maps)

Source: “BG 01 BEDROCK GEOLOGY OF MICHIGAN”, 1987; Wilson, S. E. Digital image made by Steven E. Wilson, DEQ OGS .



Slide 28

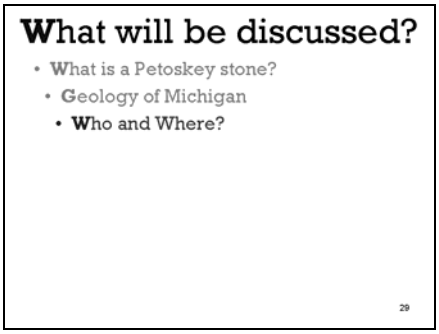
The area in blue is where middle Devonian bedrock is found. Bedrock is the "solid" rock that is found under the sands gravels and clays left by the glaciers. Because the glaciers moved from north to south the rocks and fossils found in these rocks can be found over a much wider area across the southern peninsula.

The illustrations are from the Bedrock Geology Map and the Stratigraphic Succession Chart.

Source: Chart is based on "STRATIGRAPHIC NOMENCLATURE FOR MICHIGAN" chart. And “BG 01 BEDROCK GEOLOGY OF MICHIGAN”, 1987; Wilson, S. E.; Colored map of the aerial extent of geologic formations. Includes both peninsulas; 1:500,000, 2 sheets. For more information about the Geology of Michigan check out - The Rock Cycle and more at http://www.michigan.gov/deqgeologyinmichigan

(deq geology in michigan - all lowercase - no spaces)

Digital image made by Steven E. Wilson, DEQ OGS. qpq



Slide 29

Used to help keep presentation on track

Slide 30

This is a list of species of Hexagonaria found in Michigan that have been reported in the literature. Other species might exist.

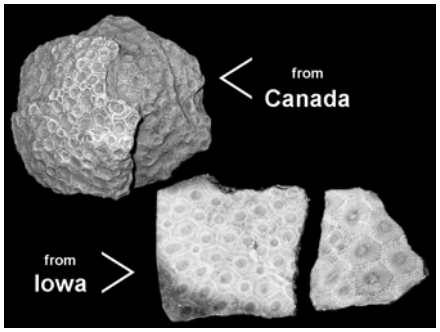
To distinguish one species from another takes a LOT of work and very specialized technical skills. It is very likely that species other than Hexagonaria percarinata are called Petoskey stones but they are a species of Hexagonaria.

Slide 31

This is a list of the species of Hexagonaria that have been documented worldwide. How could there be so many different variations or species of this animal?

Slide 32

This is a list of the localities that have reported occurrences of Hexagonaria.



Slide 33

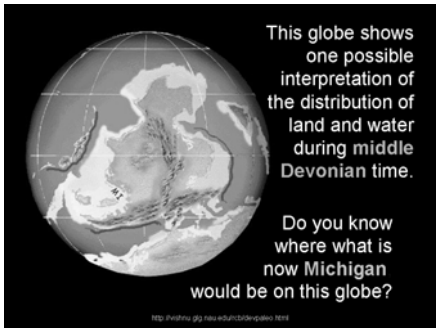
Sample from Canada (rough, unpolished – upper left)

Sample from Iowa (cut and polished – lower right) - probably 2 different species

Let's try some "paleo forensics"

The distribution and proliferation of any coral (or other plant or animal) is a function of being able to survive/adapt to a given environment or rang of environments. Stability of these environments over (geologic) time is a factor as well. The land surface was open for a long time before organisms adapted to living on land. The epicontental sea that covered what is now Michigan covered a wider area as well. Hence, Devonian corals and other marine organisms can be found in many different locations today. Plate tectonics has scrambled the arrangement but the pieces of the puzzle can be reconstructed by people studying paleogeography and paleoenvironment as well as other aspects of geology like geophysics and geochemistry.

Digital image made by Steven E. Wilson, DEQ OGS.



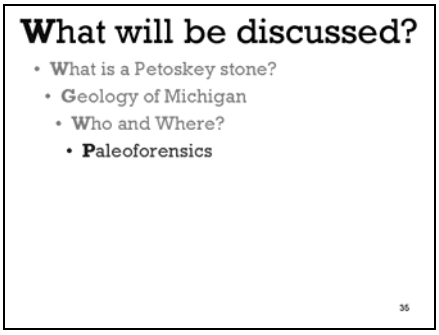
Slide 34

The map represents what Earth might have looked like some 375 million years ago.

Notice the relative position of what is now Michigan SOUTH of the equator in shallow seas.

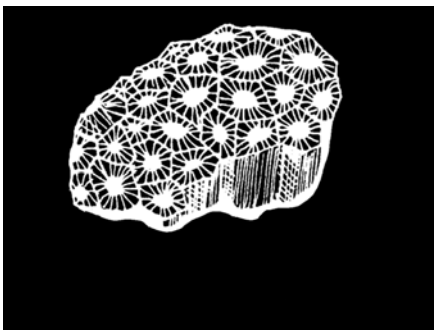
How did they make this map (or others like them)?

Source: graphic is base on map found at http://vishnu.glg.nau.edu/rcb/devpaleo.html - other sites for additional information include - - http://geology.er.usgs.gov/eastern/tectonic.html - - http://wwwneic.cr.usgs.gov/neis/plate_tectonics/plate_tectonics.html - - http://bvsd.k12.co.us/schools/cent/earth_science/Schmoker%20Activities/GeoTime/PlateTectonics.html



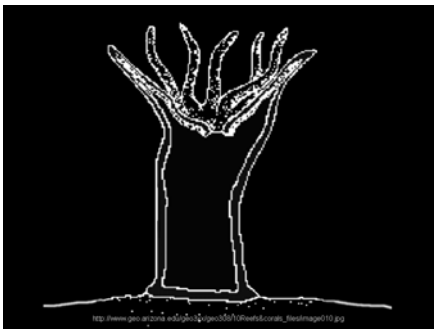
Slide 35

Used to help keep presentation on track

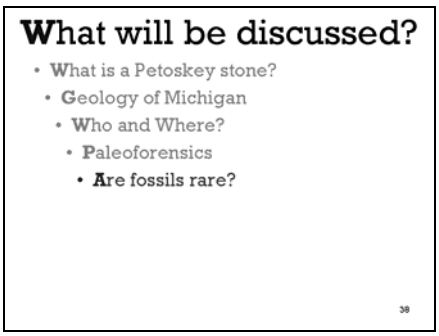

Slide 36

Source drawing by Steven E. Wilson, from PA 06, COLLECTING ROCKS, MINERALS AND FOSSILS IN MICHIGAN: 1976; Wilson, S. E.

Digital image and frame animation made by Steven E. Wilson, DEQ OGS.

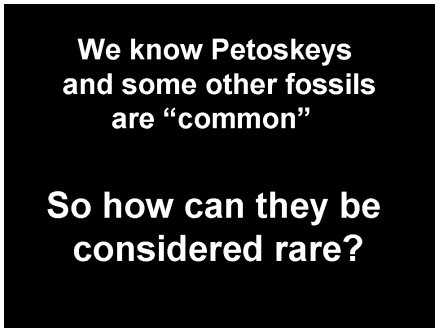

Slide 37

Source
http://www.geo.arizona.edu/geo3xx/geo308/10Reefs&corals_files/image010.jpg



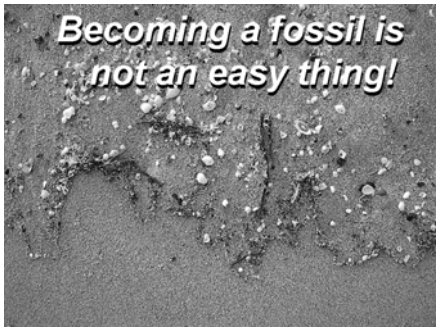
Slide 38

Used to help keep presentation on track



Slide 39

Segue slide. This is really a rhetorical question – please see next slide



Slide 40

Only a small fraction of what is or was alive is likely to be buried - a first step in fossilization.

Source: Photograph by Steven E. Wilson, DEQ OGS. qpq

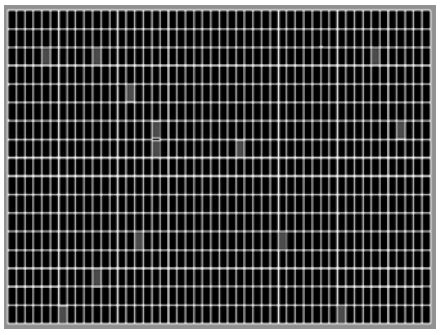
Slide 41

Information is presented on the slide

The fossil record represents only a tiny fraction of the organic history of life on Earth.

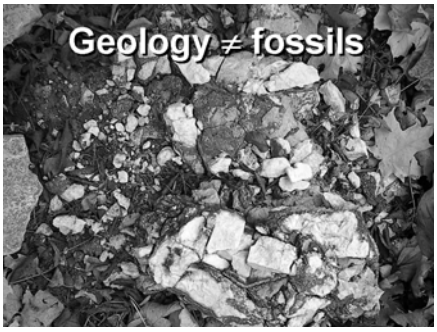
For those who want to 'do the math': (a) Recognized living species: 1.5 x 106 (there are likely many more) (b) Estimated number of species since 600 million years ago: / Cambrian time = 982 x 106 (c) Total number of fossil species known: 130,000 (d) % of total possible recovered: 0.013%

Source: Raup, David M., and Stanley, Steven M., 1978, "PRINCIPLES OF PALEONTOLOGY" San Francisco


Slide 42

Graphic representation of 0.013% red rectangles represent 0.013% of the total area of the larger rectangle.

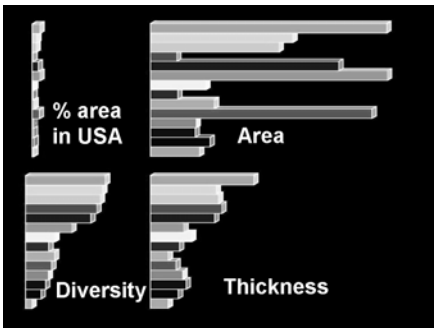
Source: Digital image made by Steven E. Wilson, DEQ OGS.



Slide 43

Geologic forces of weathering and erosion make becoming a fossil unlikely.

Source: Digital image made by Steven E. Wilson, DEQ OGS.



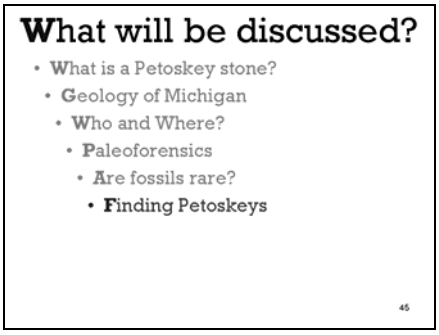
Slide 44

Why are fossils rare?

The further back in geologic time one goes, the less common fossils become due to the destructive nature of geologic processes - like erosion and/or metamorphism. These processes alter or destroy fossils as well as rocks and the geologic information they have recorded.

Illustrations based in part on information from: Raup, David M., and Stanley, Steven M., 1978, "PRINCIPLES OF PALEONTOLOGY" San Francisco

Source: Digital image made by Steven E. Wilson, DEQ OGS.



Slide 45

Used to help keep presentation on track


Slide 46

At some spots along the Lake Michigan shore there are bluffs of middle Devonian rock that run out to the waters edge (at least at 'normal' water levels).

Source: Photograph by Steven E. Wilson, DEQ OGS.


Slide 47

This is one of the quarry buildings that stood on the Penn Dixie Cement Quarry property, just south of Petoskey. The quarry has been closed and the land converted to residential development.

Source: Photograph by Steven E. Wilson, DEQ OGS.


Slide 48

Houses now sit on the man made bluff and all along the acreage that was once the property of the quarry.

Source: Photograph by Steven E. Wilson, DEQ OGS.


Slide 49

The old quarry is now flooded and is a marina with access to Lake Michigan. Eighty (80) feet or so of water now covers prime fossil

collecting grounds.

Digital image made by Steven E. Wilson, DEQ OGS.


Slide 50

Beaches are a great place to find Petoskeys. The later in the summer season, the fewer and smaller the specimens. But each spring a new supply is rafted in by the ice that forms along the shore. Be sure the beach is public access. Beaches are private property. Getting permission may be difficult but it is required and can save you a lot of trouble.

Source: Photograph by Steven E. Wilson, DEQ OGS.


Slide 51

You never know whom you might meet on the beach. After being contacted by the Detroit Free Press, I arrange a trip to the Charlevoix - Petoskey area so the YAK could find its own Petoskey stones as it learned about Michigan state symbols. To bad we did not have time to go after greenstones.

Source: Photograph by Steven E. Wilson, DEQ OGS.


Slide 52

Road cut through a drumlin in an undisclosed location in Emmet County. Can you spot the Petoskey?

Source: Photograph by Steven E. Wilson, DEQ OGS.


Slide 53

What if we move in closer ...

Source: Photograph by Steven E. Wilson, DEQ OGS.


Slide 54

Even closer ...

Source: Photograph by Steven E. Wilson, DEQ OGS.


Slide 55

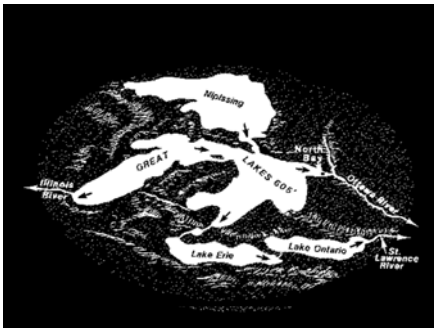
Petoskeys can be found in many places. This is some parking lot / landscaping stone in downtown Charlevoix. Pebbles in green circles are Petoskeys, blue circles are other fossils, red circles are likely igneous or metamorphic glacial hitch-hikers from more northern bedrock.

Spray bottles or looking after a light rain increase your odds of spotting the "Petoskey pattern."

Source: Photograph by Steven E. Wilson, DEQ OGS.

But if the bedrock source for Petoskeys is from Petoskey to Alpena how can they be found elsewhere in Michigan? (go to next slide). The glaciers did it. They plucked, scoured and transported Petoskeys to wide area south of the bedrock where they are found in place.

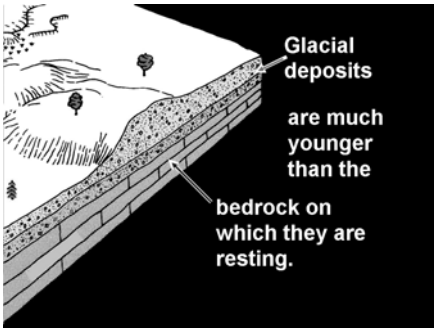
Source: Adapted from, BU 04-R "THE GLACIAL LAKES AROUND MICHIGAN" 1988; Farrand, W. R.; Explains the formation of the Great Lakes; 8.5 X 11



Slide 56

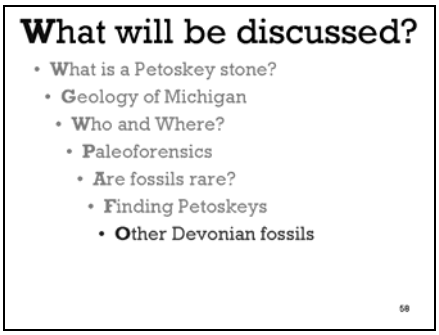
Animation of the deglaciation of Michigan

Source BU 04-R "THE GLACIAL LAKES AROUND MICHIGAN" animated by Steven E. Wilson



Slide 57

Source BU 04-R "THE GLACIAL LAKES AROUND MICHIGAN" modified by Steven E. Wilson

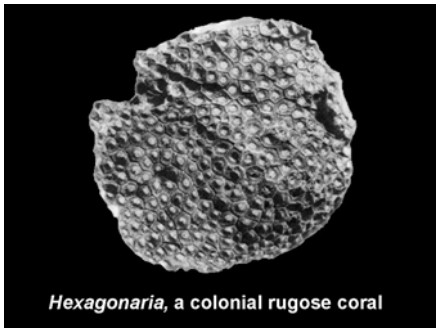


Slide 58

Used to help keep presentation on track

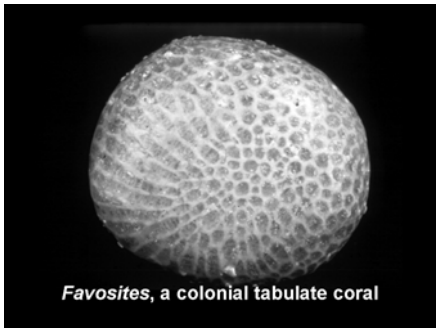
Slide 59

"Some Devonian life forms that existed were similar, while others were very different from what we know today." This is one of the paintings done by Pat Rutkowski, an accomplished paleontologist and artist from the Detroit area.



Slide 60

Picture of a Petoskey stone from the Michigan Fossil Poster Pack see http://www.michigan.gov/deqgeologyinmichigan (deq geology in michigan - all lowercase - no spaces)

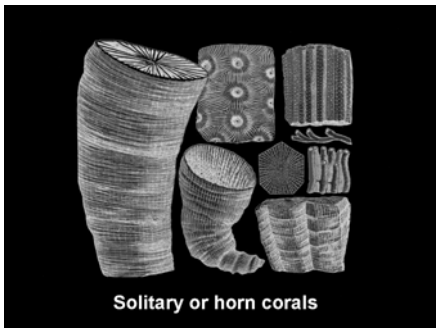


Slide 61

Picture of another colonial coral commonly found in Michigan known as Favosites.

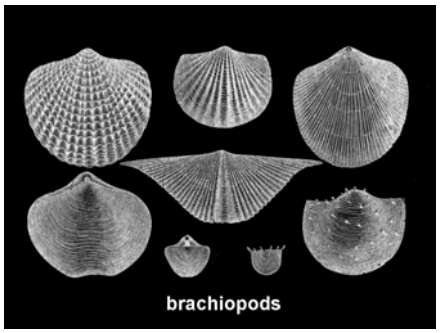
Note the small whitish knob at bottom center of the specimen. This specimen was treated with acid. Because quartz does not dissolve in acids that does dissolve carbonates, the quartz remains and sticks out from the specimen.

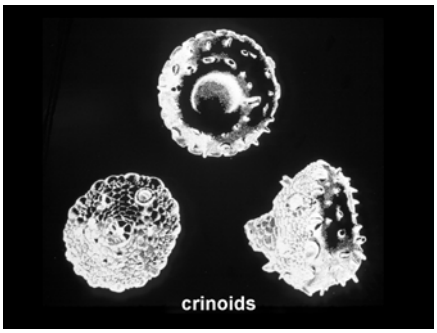
Source: Photograph by Steven E. Wilson, DEQ OGS

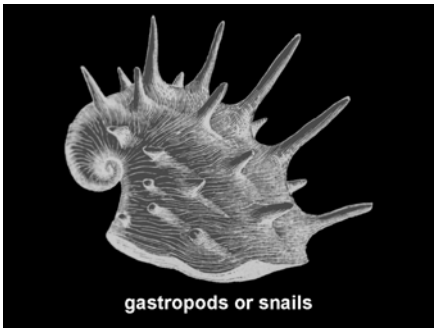


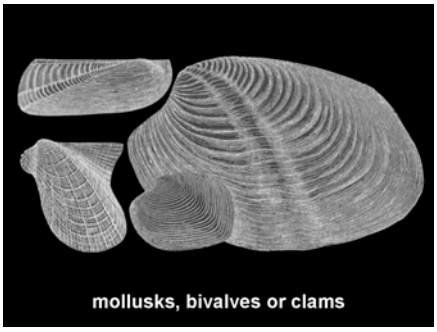
Slide 62, 63, 64, 65, 66

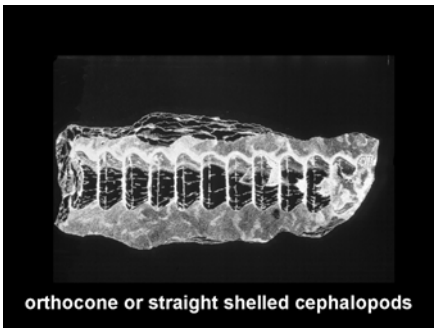
Source: Dana, James, "MANUAL OF GEOLOGY" New York: Iveson, Blakeman, Taylor, 1895





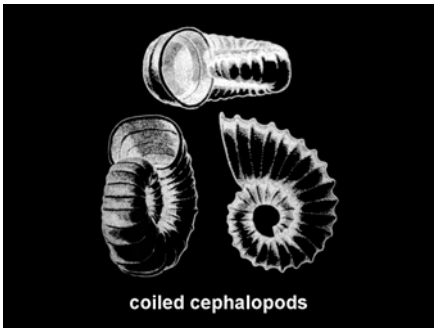


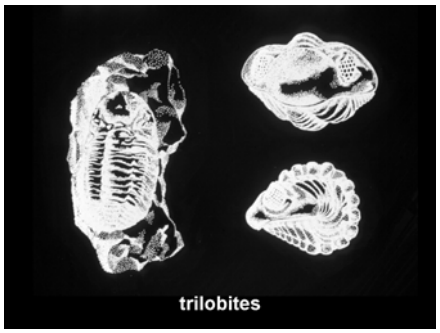


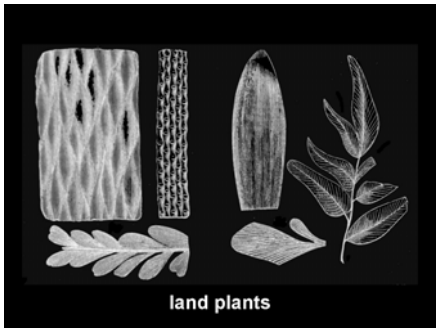


Slide 67, 68, 69

Source: pen and ink drawing by Jim Campbell, Geological Survey, Department of Conservation not dated

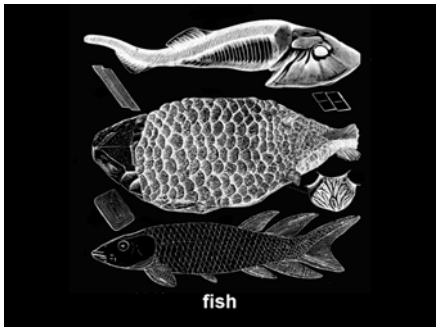


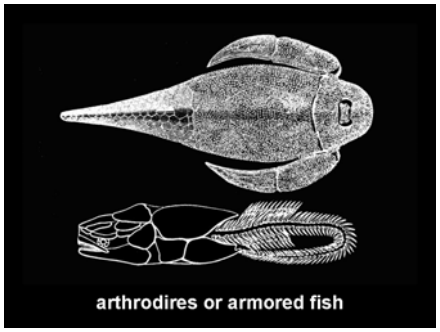


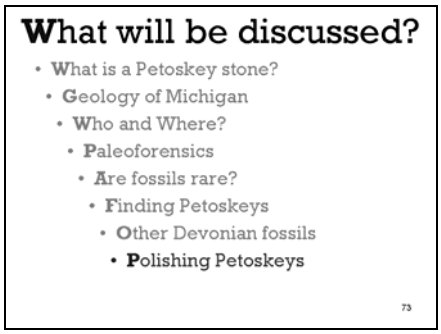


Slide 70, 71, 72

Source: Dana, James, "MANUAL OF GEOLOGY" New York: Iveson, Blakeman, Taylor, 1895







Slide 73

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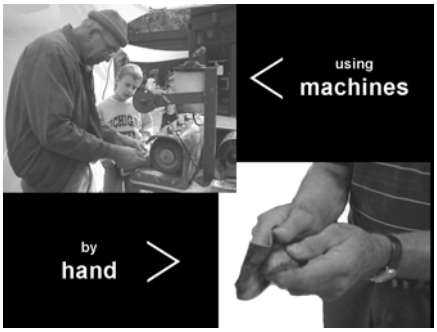
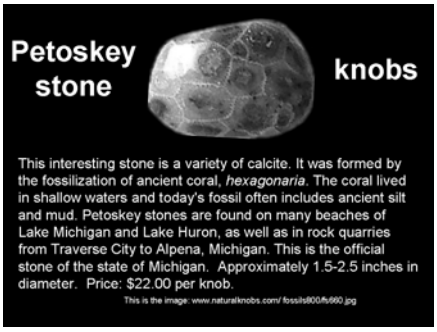


Slide 74

Because Petoskeys are primarily calcite they are a relatively good lapidary material. They can be shaped and polished many different way. Equipment and supplies can be very simple to elaborated and sophisticated.

For more information - on the web see, go to www.michigan.gov/deqgeologyinmichigan the select Michigan Fossil Poster Plus One of the files listed (and downloadable) is Petoskey Stone 4 page handout. Find out more about about the lore, history and geologic information about the official state stone Hexagonaria percarinata hand polishing instructions are included.

Source: Photographs by Steven E. Wilson

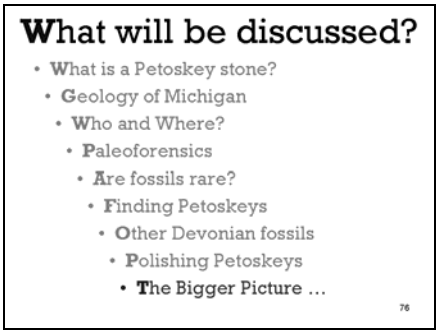


Slide 75

Too interesting to pass up - from the web

Source: www.naturalknobs.com/ fossils800/fs660.jpg

Digital image made by Steven E. Wilson, DEQ OGS.



Slide 76

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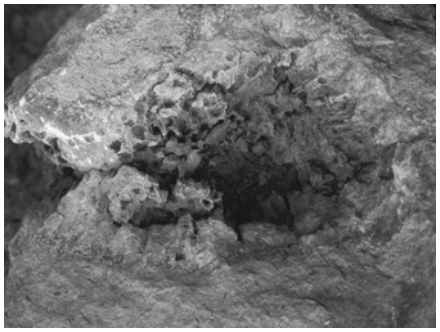
Slide 77

Not are corals are in any condition to be collected - at least by mere mortals with normal strength. This Petoskey has been eroded or was not even fossilized. However this can be a good thing . . .

Source:Digital image made by Steven E. Wilson, DEQ OGS.


Slide 78

Where there is enough pore space (porosity) with connections (permeabilty) over geologic time the marine organism are converted into oil. If there is a large enough network of pores and permeability it might become a an oil and gas reservoir.

Digital image made by Steven E. Wilson, DEQ OGS.

Slide 79

Michigan Oil & Gas map, John Esch, DEQ OGS

Slide 80

I hope you now have a better idea of some of the stories that are told by the Petoskey stone

SOMETHING RARE - - - YET COMMON.

Source: Digital image made by Steven E. Wilson, DEQ OGS.

Slide 81

Please forward any ideas, feedback, comments, suggestions, tips, tricks, traps, alterations, permutations, variations, changes, deletions, and / or additions to:

Steven E. Wilson, MI DEQ OGS, PO Box 30256, Lansing 48909
email wilsons15@michigan.gov

Your comments are appreciated!

This presentation and other educators and student resources about Michigan geology are available on-line at
www.michigan.gov/deqgeologyinmichigan
(deq geology in michigan - all lowercase - no spaces)