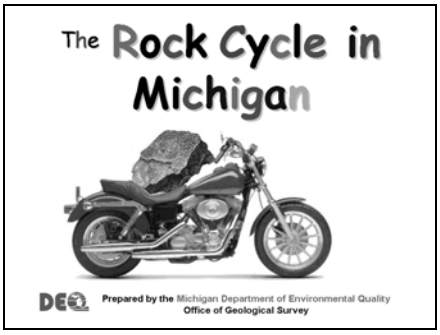
Slide 01



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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, P O Box 30256, Lansing 48909, email wilsons15@michigan.gov.

Resources about Geology in Michigan are on-line at http://www.michigan.gov/deggeologyinmichigan (deq geology in michigan - all lowercase - no spaces)

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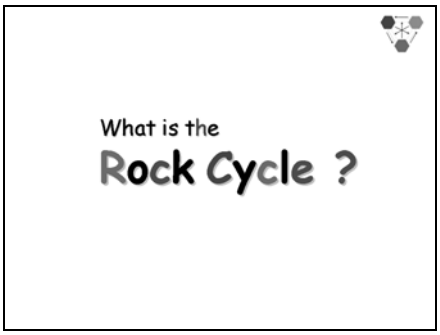
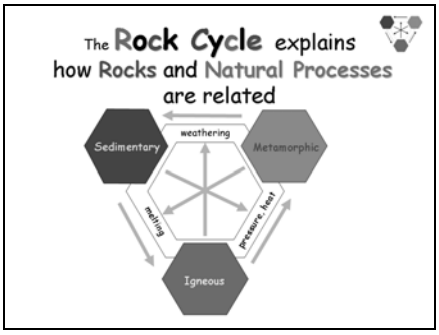
Slide 02



Segue Slide. Next few slides will answer the question - or at least start the answer…

Slide 03



Is the rock cycle really this simple, neat and colorful? (NO) – but it helps show the relationships of the 'pieces'.

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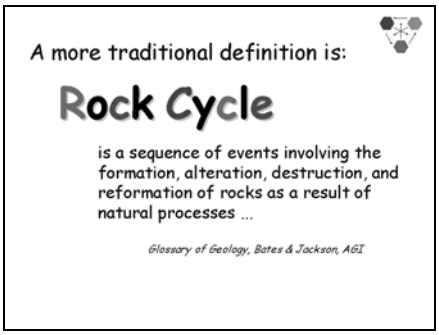
Slide 04



The 'full definition reads "The rock cycle is a sequence of events involving the formation, alteration, destruction, and reformation of rocks as a result of natural processes such as magmatism (melting of rock into magma), erosion, transportation, deposition, lithification, and metamorphism."

A possible sequence for the rock cycle involves the crystallization of magma to form igneous rocks that are then broken down to sediments (clasts) as a result of weathering, the sediments later being lithified to form sedimentary rocks which are in turn altered by heat, pressure and or fluids to become metamorphic rocks.

Student activity:

Imaging yourself as a mineral - explain what would happen as you 'move' around the rock cycle.

Do the rock cycle and plate tectonics support or contradict each other? Explain.

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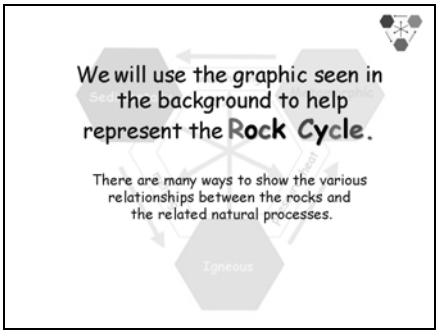
Slide 05

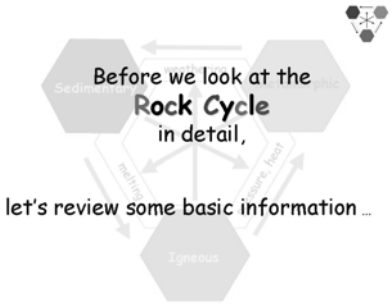


Segue Slide

This is a diagram that represents what the rock cycle is and how the components relate to each other. There are many

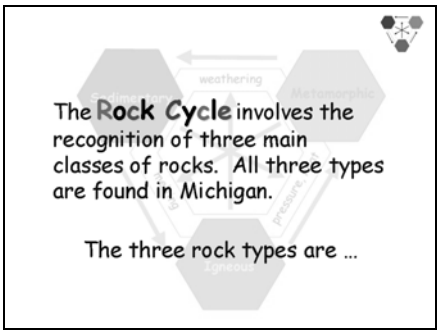
other possible diagrams for the Rock Cycle. Look for some on the web. How do they compare to the graphic model used here? How would you draw the rock cycle?
Created September 2001

Slide 06



Segue Slide

Slide 07



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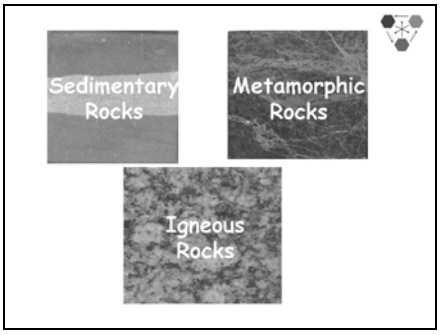
Slide 08



The wrong names are used on purpose to:
See who is listening.
See how students react to an error.
See who is willing to question science / authority, especially if there is a good reason.
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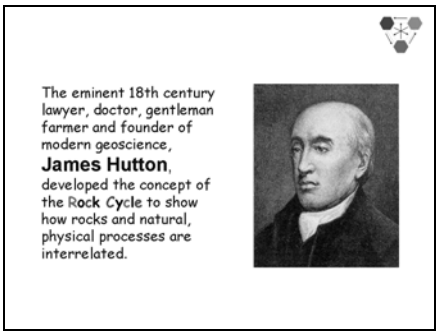
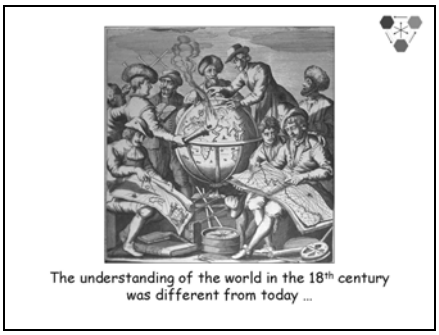
Slide 09



IT'S AN OLD, OLD , OLD, OLD WORLD
http://www.nytimes.com/books/97/11/09/home/gould-arrow.html
TIME'S ARROW, TIME'S CYCLE Myth and Metaphor in the Discovery of Geological Time. By Stephen Jay Gould. Illustrated. 222 pp. Cambridge, Mass.: Harvard University Press. $17.50. 1987. In part the review reads: STEPHEN JAY GOULD begins this lively, scholarly book by adding to Sigmund Freud's list of "great outrages upon its naive self-love" that humanity "has... had to endure from the hand of science." Freud listed a Galilean outrage (the earth's peripheral cosmic position), a Darwinian one (the human species' simian evolutionary origin) and a Freudian one (the mind's subconscious irrationality). Mr. Gould adds what might be called a Lyellian outrage (although the Victorian barrister and natural philosopher Charles Lyell would doubtless have been distressed at the term): the discovery of "the great temporal limitation imposed by geology upon human importance... the notion of an almost incomprehensible immensity, with human habitation restricted to a millimicrosecond at the very end!" ... Mr. Gould shows that the actualities of Hutton's and Lyell's work were, if anything, the opposite of the textbook legend. Hutton's theory of the earth as a geological clockwork of eroding continents balanced against uplifting ocean basins was not based on field observations but on his wishful, speculative confusion of geological process with Newtonian physics. An admirer of Newtonian precision and regularity, Hutton never thought of reading the planet's history from rock strata as we do today. He considered rock strata equivalent to planetary revolutions - unchanging manifestations of physical laws, without any untidy historical significance.
Created October 2, 2000, revised September 2001

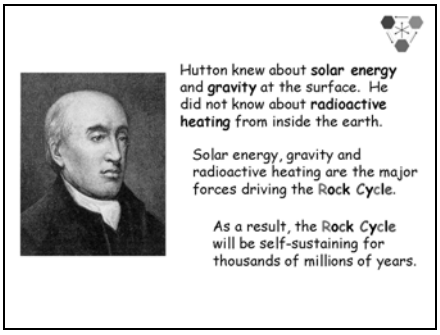
Slide 10



Hutton and many of the other early geologist had a vastly different perspective on what the 'science' of the day was telling us. Do these early or 'old' ideas hold up? Well the ideas relating to the rock cycle do.
General question what time frame does the 18th century cover?
Graphic came from http://www.henry-

davis.com/MAPS/Ren/Ren1/Reno.html
Created October 2, 2000

Slide 11



The following come from
http://geoweb.princeton.edu/courses/Geo210/summaries.html
1. Internal heat provides the energy for earthquakes, landslides, volcanic eruptions - 2. Solar radiation provides the energy for hurricanes, floods, tornadoes - 3. Potential energy is available when rocks can Slide downward. The potential energy equals the work done to lift the rock against the force of gravity. Work = force x distance. - 4. Units: Force is measured in Newton. Energy in Newton-meter (Nm) or Joule (J). The force of gravity on a rock of mass m equals F=mg, with g=10 (m/sec)/sec. g is the gravitational acceleration, it implies that the velocity of a falling rock increases every second by 10 m/sec (on earth). - 5. When a rock slides or falls, potential energy is converted to kinetic energy or heat (1 cal=4.2 J). Kinetic energy is proportional to the square of the velocity of the falling rock. When the rock hits the ground, kinetic energy is used to deform, break, and (mostly) heat the rock. - 6. The early Earth was warmed up by asteroid impacts, radioactive decay, formation of the iron core - 7. Radioactive heating diminished exponentially since formation of Earth 4.57 billion years ago
Question for students to ponder - If the earth is being heated by radioactive elements how is it similar or different from a nuclear reactor? Will the Earth explode? Why? / explain. Is the Earth loosing or gaining heat ? How soon before the Earth melts or freezes?
Please send a copy of your students' work to Steve Wilson, MI DEQ GSD, P O Box 30256, Lansing 48909; via email to wilsons15@michigan.gov. Their work will be compiled and posted to the GSD web site. Please include teacher's name, grade, school name, city and student's name.
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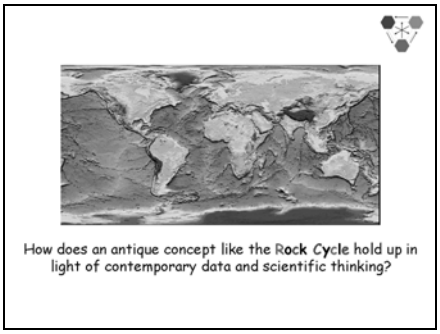
Slide 12



A version of the topographic and bathymetric map of the world. Map like these are the results of satellite imagery, remote sensing and computer base geographic information systems (GIS).
Graphic came from http://www.ngdc.noaa.gov/mgg/
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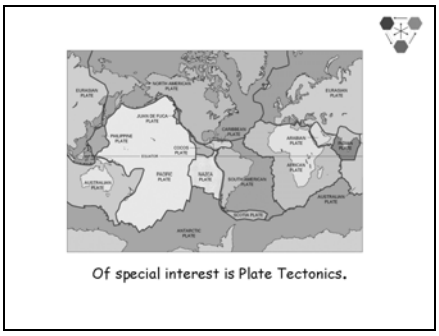
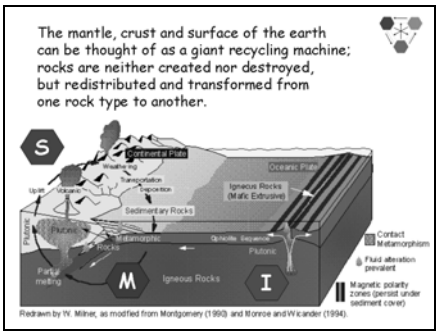
Slide 13



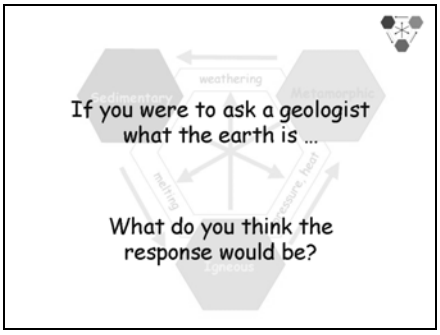
Map showing plate boundaries came from
www.er.usgs.gov/eastern/plates/html
There are so many great pate tectonics exercises out there if you don't believe me use your favorite search engine and take a look.
Created October 2, 2000

Slide 14



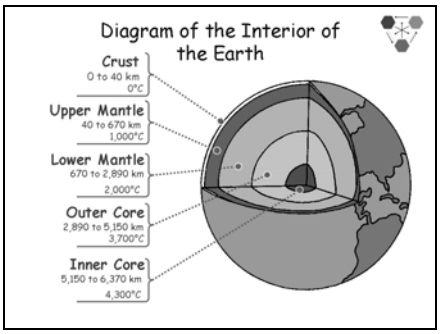
The ocean floor moves like a giant conveyer belt from mid ocean ridges toward subduction zones.
The North American and European plates are moving away from each other. They are moving at a rate about that equal to the growth of hair or fingernails. These two plate will move apart about your height in your lifetime (results may vary, void where prohibited, batteries not included).
The graphic on this page came from:
http://www.science.ubc.ca/~geol202/rock_cycle/rockcycle.html, as of August 2000. Terms not found in the Rock Cycle in Michigan Glossary are defined at the web site.
Student activity:
Plate tectonics and the hard boiled egg (egg is cooled to room temperature).
Crack the egg and mark the outline of the larger pieces with a permanent marker. Have students compare results. Have students move one or more of the larger pieces around on the egg. Note what happens. Pieces shell (crust) collide and one rides over the other and 'oceans' open up.
Created October 2, 2000

Slide 15



Segue Slide

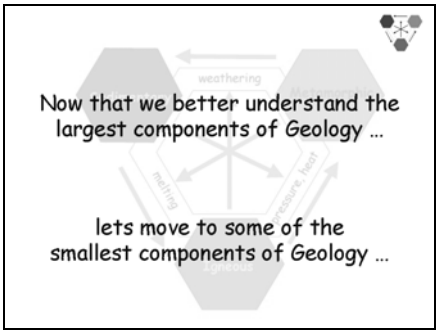
Slide 16



Crust – The 'outer' layer consisting of the part of the earth we live on.
0 to 40 km (0 to 25 miles) - 0°C (32°F) - - The upper 100-200 kilometer (km) of the Earth, consisting of the crust and uppermost mantle is characterized by a geothermal temperature gradient of 20-30 °C per kilometer (40-50 °F per mile).
The part of the mantle near the crust, about 50-100 km down, is especially soft and plastic, and is called the asthenosphere. The mantle and crust above are cool enough to be tough and elastic, and are known as the lithosphere.
Mantle - A rock layer that reaches about half the distance to the center of the earth. Parts of this layer become hot enough to liquefy and become slow moving molten rock or magma.
Upper Mantle - - 40 to 670 km (25 to 415 miles) - 1,000°C (1,800°F)
Lower Mantle - - 670 to 2,890 km (415 to 1,800 miles) - 2,000°C (3,600°F)
Outer Core - - A mass of molten iron that surrounds the solid inner core. Electrical currents generated from this area produce the earth's magnetic field.
2,890 to 5,150 km(1,800 to 3,200 miles) - 3,700°C (6,700°F)
Inner Core - - A mass of solid iron. Although ambient temperatures would normally melt iron, the immense pressure on it keeps it in a solid form. This concentration of mass is partially responsible of determining how fast the Earth rotates. (spinning a fresh egg vs.. a boiled egg or the spinning skater – conservation of angular momentum)
5,150 to 6,370 km (3,200 to 3,960 miles) - 4,300°C (7,500°F)
Have students use work sheets to reinforce information about layers of the earth.

Measurements can and do vary from one source to another due difference in definitions, when the work was done, quality and quantity of supporting information and procedures used to extrapolate the data.
http://wwwneic.cr.usgs.gov/neis/plate_tectonics/plate_tectonics.html
Created October 2, 2000

Slide 17



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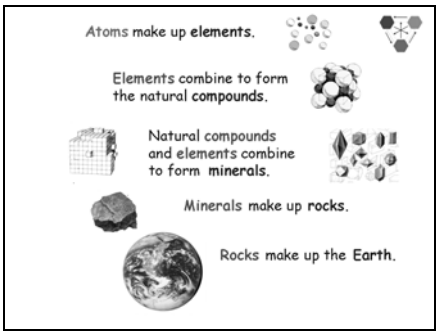
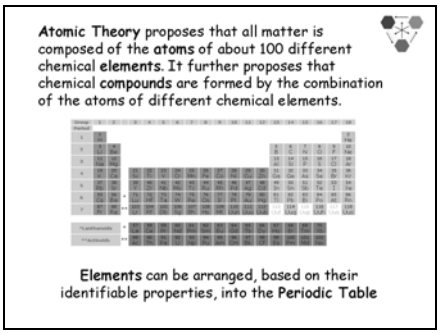
Slide 18



Here the intent is to show how the various pieces; atoms, elements, compounds, and minerals, rocks and even the Earth, are related to each other in a hierarchy.
Classroom exercise- Take some road salt (larger pieces of rock salt used to melt ice and snow) and have the students look at them and describe what they see. A magnifying glass is very handy here. Students should note blocky nature made up of various sizes of blocks or cubes. As appropriate, note the differences between 2 dimensional references like square or circle and 3 dimensional references like block, cube and sphere.
This will require three samples of rock salt that will be broken to show the physical characteristics of a mineral. With goggles on to protect the eyes, have a student gently tap sample 1 with a metal spoon (or some other relatively heavy blunt object) and observe what happens (salt/halite cleaves or breaks into many smaller blocks or cubes). On a sample 2 use a butter knife placed diagonally on one of the faces of a salt block and gently tap edge of the knife blade. What happens? (results is similar to the spoon maybe fewer small pieces) On sample 3 use a butter knife placed parallel to the sides about in the middle of a piece of salt and gently tap edge of the knife blade. What happens? (Fewer, cleaner breaks / fewer pieces because energy was direct more specifically along the cleavage planes in the rock salt. - much like a diamond cutter does when the start working on a new diamond).
How many crystal faces are there on a cube - how many

directions of cleavage are there What is the angular relationships. Examine regular table salt with a hand lens and describe what you see. Grow crystals from salt water or sugar water - have students dissolve the sugar or salt in water - how can they tell when they have added 'enough?' When the salt or sugar does not dissolve any more but goes right to the bottom of the glass - what happens with mixture is heat? (supersaturated solution). Try a mixture of salt and sugar to see what happens. What other household materials could be used to grow crystals (alum, Epson salts …). Students should observer the crystal growing experiment daily and record their observations. Have students explain how the terms dissolve, mixture, precipitate and crystal relate to the crystal growing exercise. Another variation is to have students place their crystal growing containers in different locations – sunny window sill, on heat register, in a storage closet and have them discuss what effect the location had on the outcome of their experiment.
For even more go to GEOMAN's page @ http://jersey.uoregon.edu/~mstrick/index.html
Created October 2, 2000, revised September 2001

Slide 19



Here is a good point to help students see the links between chemistry and geology. How many elements are there? Well are we talking just naturally occurring, or naturally occurring and those made readily in the lab, do we include those that are very unstable and do not exist in nature (at least for any length of time) and what about the elements that exist 'on paper only' and just who/what is the source that decides into which category an element might be classified?
Whatever the count there is an order to the arrangement and each element has its own set of uniquely identifiable properties or characteristics.
Reinforce the relationship between atoms, elements and compounds.
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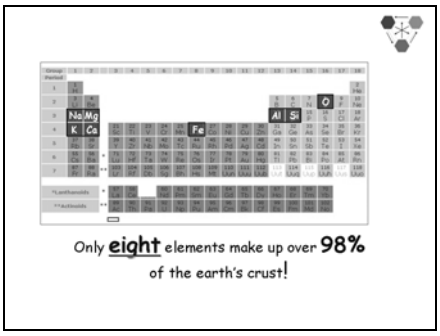
Slide 20



The impact of the 'eight great' elements is seen in the Rock Cycle in Michigan.
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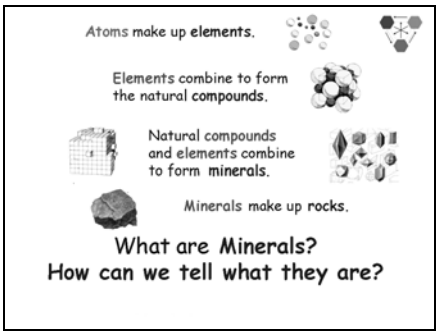
Slide 21



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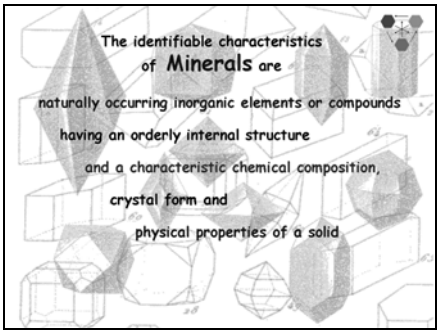
For even more go to GEOMAN's page @ http://jersey.uoregon.edu/~mstrick/index.html
Created October 2, 2000, revised September 2001

Slide 22



Student activity:
Here is a great time to play what is (or is not) a mineral. You can start the process by asking if ice a mineral. A student will answer - if the student says yes AND can explain why, they get to ask another class member about some other possible mineral (or 'non mineral'). Be sure to include sugar (Organic & manmade), amber (organic), water (not solid), steam (not a solid), mercury (not a solid)... The students can continue to ask each other questions but once someone has answered correctly they take over the person that asked the question is 'out'.
A variation is to have every one stand - when they answer (correctly) they can sit down. With this twist everyone is involved.
Created October 2, 2000

Slide 23

What is the difference between a rock forming mineral and one that is not? (Rock forming minerals are those minerals than make up igneous, metamorphic and sedimentary rocks, and determine their classification. The more important rock forming minerals include quartz, feldspars, micas, amphiboles, pyroxenes, olivine, clays, calcite and dolomite.
What are the characteristics of minerals that help you identify them. (Color, streak, luster, hardness, specific gravity and crystal form)
Do all of the minerals found in the crust of the earth exist in Michigan? (No there are thousands of different minerals found worldwide.)
Student activity:
Have the students find what minerals are in their area. See the lists of Minerals found in Michigan. One list is alphabetically sorted by mineral name and lists the counties where it is found. The other list is sorted by County name and lists the minerals found there. After they have determined what is found in their area ask them if they know of any outcrops, quarries, or mines in the area. Please send a copy of your students' work to Steve Wilson, MI DEQ OGS, P O Box 30256, Lansing 48909; via email to wilsons15@michigan.gov. Their work will be compiled and posted to the OGS web site. Please include teacher's name, grade, school name, city and student's name.
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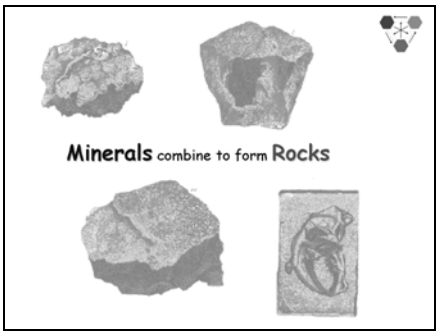
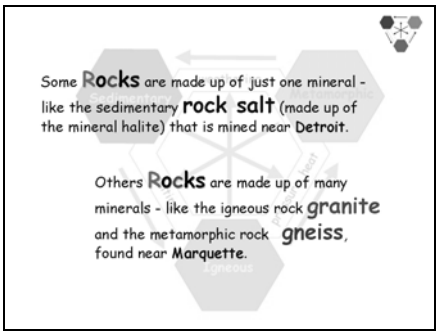
Slide 24



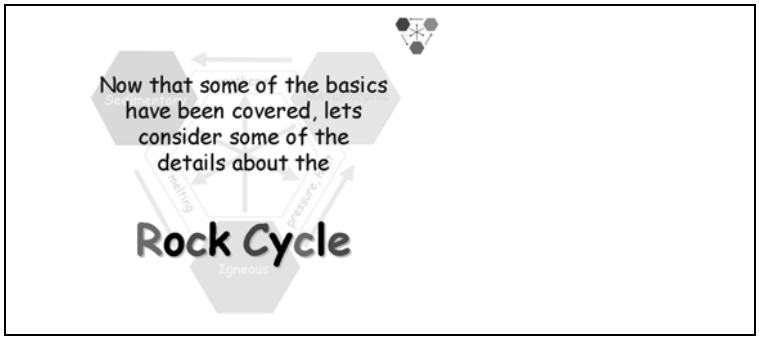
Rocks are not "pure" entities like minerals, compounds or elements. A rock can (and usually does) contain a variable amounts of "other constituents". For example, a limestone could have up to 10 percent clay in it and still be classified a limestone.
Remember the full hierarchy = atoms >> elements >> compounds >> MINERALS >> ROCKS >> Earth.
Created October 2, 2000

Slide 25



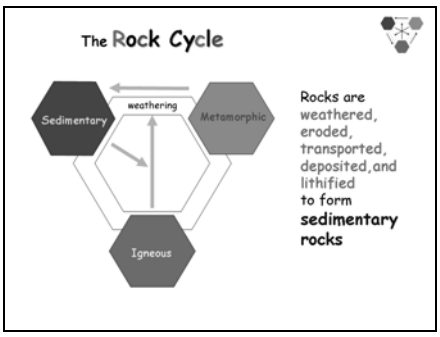
Student activity:
What rocks have students found in their neighborhood? Have your students write a story or essay (with photographs or drawings) about what rocks are used in buildings and as ornaments in their neighborhood / town / area. Are they local materials or were they imported. Can the students identify the rocks?
For more information and background about salt go to http://www.detroitsalt.com/
Created October 2, 2000 ; rev 10, 2004

Slide 26



Segue Slide

Slide 27



Terms are defined in the Glossary for Rock Cycle in Michigan.
Student activity.
Journal on the rocks: Have students keep a journal and/or write an essay of their observations of sedimentary process in action around them. Have them make notes about what they see that relates to the various sedimentary processes currently at work around home, in their neighborhood and where they travel. Things like gullies forming on hill sides, streams carrying sediments especially after a heavy rain (why do streams carry sediments all the time?), rounded boulders are physical weathering, a road cut showing layers of sediments. This exercise with help them become more aware and observant of their environment. The assignment could be for an extended period of time with regular reports as to the status of their observations - what they saw when and where. You can set a format for the report or let the students 'find out as they go' and learn for what each other does. This further reinforces the idea that science is observation and interpretations of what they see. They can also include what kinds of rocks are used in fences, buildings and cemeteries in their and if the materials are they local or imported?.
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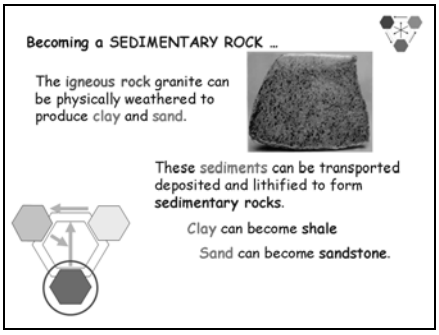
Slide 28



See the rock classification information included in The Rock Cycle in Michigan GAME.
Sedimentary Rocks are classified as:
clastic – those that come from clasts (grains or particles) of some other material, usually as a result of physical weathering or
precipitate – those that come from the precipitation of chemical in solution as a result of chemical weathering.
Fossils are most common in sedimentary rocks.
Feldspar is the most common mineral in the Earth's crust.
Clay is the most common weathering product. Shale is the most common sedimentary rock.
Picture is from the Dimension Stone Feasibility Study (DSFS) found on the CD as a report and numerous graphics.
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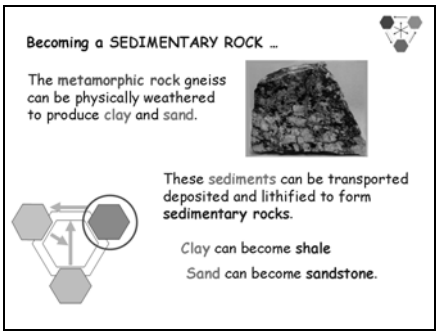
Slide 29



See the rock classification information on-line at
http://www.michigan.gov/deqgeologyinmichigan
(deq geology in michigan - all lowercase - no spaces)
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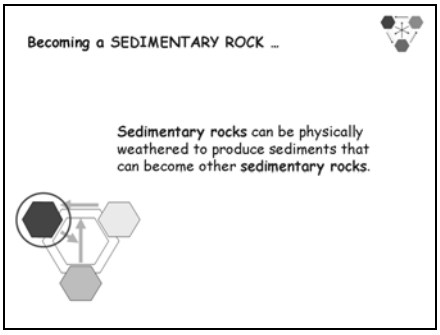
Slide 30



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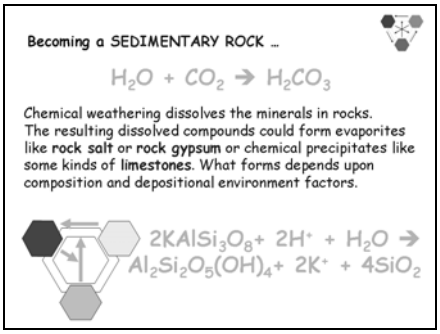
Slide 31



Background shows one of the MANY possible combinations of elements in chemical weathering.
The formation of carbonic acid (one possible form of acid rain / runnoff)
H2O + CO2 --> H2CO3
Acid then dissociates and the following happens:
2KAlSi3O8 (feldspar)+ 2H+ + H2O --> Al2Si2O5(OH)4 (clay)+ 2K+ + 4SiO2
Feldspar is the most common mineral in the Earth's crust.
Clay is the most common weathering product. Shale is the most common sedimentary rock.
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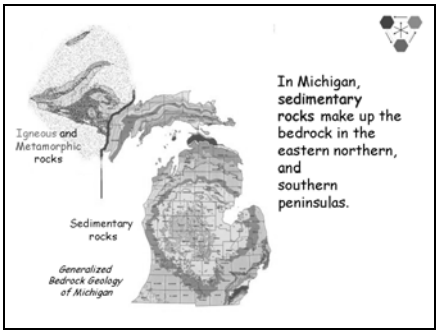

Student activity:
Are you in sedimentary, igneous or metamorphic country?
Create a poster, display or newsletter that - locates your neighborhood and describes if it is in sedimentary, igneous or metamorphic country.
What kinds of rocks are used in fences, buildings and cemeteries in your area? Are these local materials or have they been imported?
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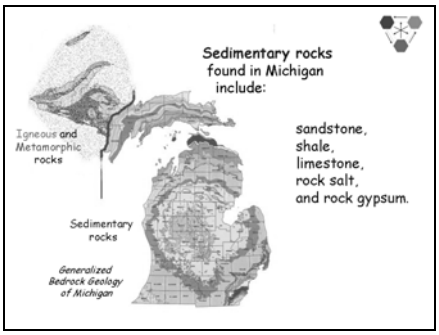
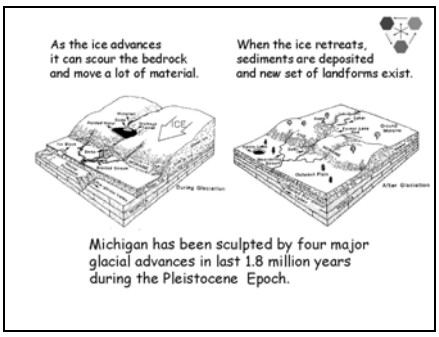


sandstone (comes from sand),
shale (comes from clay),
limestone (comes from the hard shells of fossils and/or precipitation from sea water),
rock salt (comes from salt water), and
rock gypsum (comes from salt water).
Created October 2, 2000

Slide 34



Illustrations are from Bulletin 4 Glacial Lakes around Michigan. The book and related items on-line at
http://www.michigan.gov/deqgeologyinmichigan
(deq geology in michigan - all lowercase - no spaces)
Student activity:
There is a flipbook included as part of the Bulletin 4 Glacial Lakes around Michigan material. after the file is printed students can make a flipbook that will let them animate

the ice movement over Michigan. There are several other illustrations that can be printed for student reference and or coloring.
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Student activity:
In teams discuss - What can happen to sediments - do they just become sedimentary rocks? Summarize your findings and make a presentation to the class.
(no – they could be subducted and converted to magma and become igneous rocks or they could be metamorphosed. The most likely prospect is that they will be eroded to another location and become a sedimentary rock – that could be metamorphosed or melted then weathered …).
What are some of the economic materials that are found in glacial deposits? (sand, gravel, clay, water, peat, marl)
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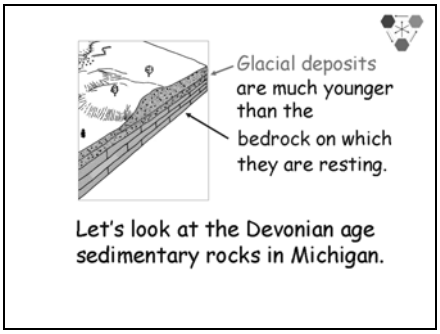

The concept of geologic time, and principle of superposition (younger rocks are on older rocks)
Student activity
What is the age of the bedrock in your area? What is the age of the glacial deposits? What is the difference in the ages?
"How Big? How Much?" – just how thick is a mile of ice – how many gallons of water/ice is there in a mile of ice – how much does it weigh? Have some fun crunching numbers and figuring out how to get from a to b.
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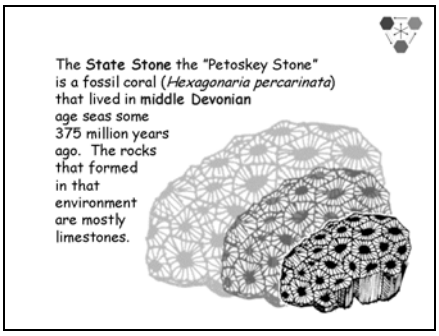

Have you ever found a Petoskey stone or any other fossils? - Where?
What can be implied from finding Petoskey stones in MI? - It was once covered by WARM, CLEAR, SHALLOW seas (corals don't grow just anywhere) – MI was covered by a shallow sea during middle Devonian time. Life forms were different than they are today.
Are all the rocks you find fossils in middle Devonian? – No Michigan has rocks from the Precambrian to the Jurassic with fossils in them.
Are all the rocks in the glacial sediments middle Devonian in age. The glaciers scraped and bull dozed all kinds of rocks form Precambrian to the Jurassic and spread them around the area.
More Petoskey stone info on line at
http://www.michigan.gov/deqgeologyinmichigan
(deq geology in michigan - all lowercase - no spaces)
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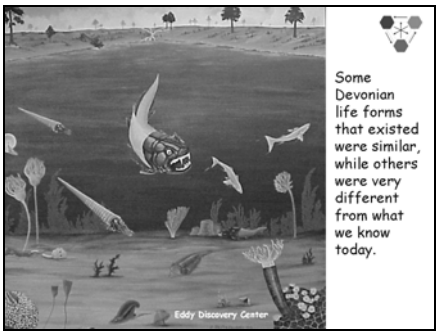
Slide 38



One of the paintings on display at the Eddy Discovery Center. These dioramas are original works done by Pat Rutkowski, an accomplished paleontologist and artist from the Detroit area.
Created September 2001

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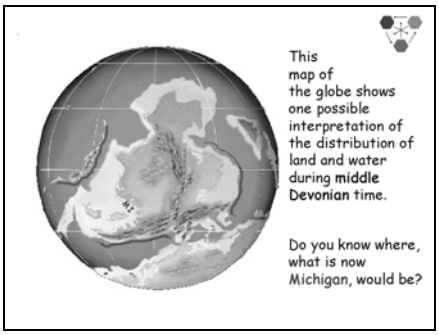
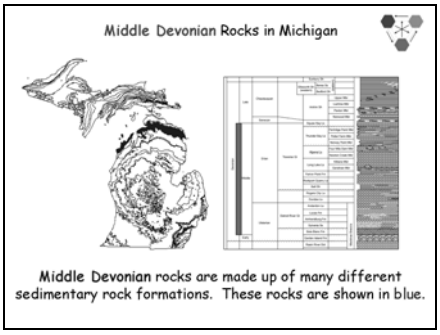


The map represents what Earth might have looked like some 375 million years ago.
Notice the relative position of what is now Michigan SOUTH of the equator in shallow seas.
How did they make this map (or others like them)? Cartographers (people who make maps) use whatever information they can find in whatever form to make their map. They look at what rock types are where and what age they are and what environment that kind of rock could have formed. Sandstones form in shallow water whereas shales form in deeper water. They also get other information from fossils like, corals form in shallow, warm, clean marine environments whereas plants grow on land. Further information comes from studying the paleomagnetism in the rocks. As minerals form, some record information about which way north was and where on the globe they were when they formed. By carefully discovering and analyzing these 'compasses' it can be determined where on the earth the rocks formed. Understandably, the more information, one has, for the area of interest (middle Devonian fossils) and/or related areas (all of the Paleozoic fossils and rocks), the better the understanding and resulting interpretation will be.
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
Created October 2, 2000

Slide 40



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.
Student activity:
Using the Bedrock Map, determine how far away your school is from bedrock that might contain Petoskey stones and other middle Devonian fossils.
Chart is based on the recently published "Stratigraphic Nomenclature for Michigan" chart. Resources about Geology in Michigan are available at http://www.michigan.gov/deqgeologyinmichigan (deq geology in michigan - all lowercase - no spaces)
Created October 2, 2000, revised September 2001

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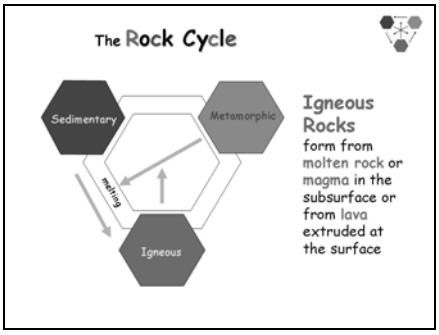

There are pillow basalts found near Marquette. Where are pillow basalts found today. How are they formed? From the contact of molten lava with water. Today this is happening occasionally in Hawaii and along mid ocean ridges. Other igneous rocks are found in the western northern peninsula.
Student Activity:
Have the students write a short story about how it would feel to be a magma becoming an igneous rock. Some should be intrusive others should be extrusive.
Boiled eggs one more time: Take a fresh egg. Carefully make a small crack in the egg. Then with a pin make a small hole into the egg. Carefully place the egg into boiling water and watch what happens. As the egg white (albumen) heats up it expands and extrudes out of the egg - like an extrusive igneous rock. After the egg is cooked carefully remove it from the water and let it cool (running it under cold water will speed up the process. Have the students carefully remove the extruded egg and then crack and peal the egg. Compare the 'extrusive' egg white with the 'intrusive' egg white left inside the shell - have students document / write about what the observe.
The way to tell a fresh egg from a boiled egg is to lay them on a flat surface and spin them. The fresh egg does not spin very well the boiled egg does - the yoke (the core) cannot move in the boiled egg hence it spins better or longer. This is the conservation of angular momentum - the same part of physics that controls how fast a skater can spin base on extended arms = dispersed mass = slow spin = raw egg - - verses - - arms tucked in = compact mass = faster spin = boiled egg.
Created October 2, 2000 ; rev 10, 2004

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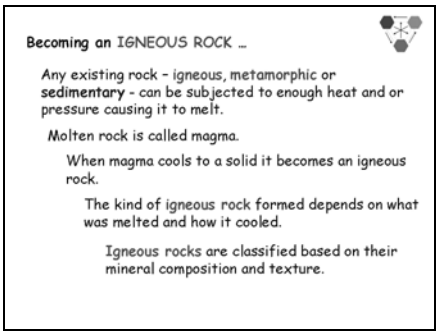

See the rock classification
Igneous rocks are classified based on their mineral

composition and texture.
Texture is an expression of crystal size common terms are:
Glassy – looks like glass, individual minerals are not visible - obsidian
Frothy – looks like foam, individual minerals are not visible - pumice / scoria
Fine grained / aphanitic – dense individual minerals are usually not visible – basalt / andesite
Coarse grained / phaneritic – individual crystal are visible – granite / gabbro
Porphyritic – mixed fine a readily visible crystals – porphyritic basalt / basalt porphyry
Igneous rocks that form at or near the surface are referred to as extrusive or volcanic igneous rocks.
Igneous rocks that form deep below the surface are referred to as intrusive or plutonic igneous rocks.
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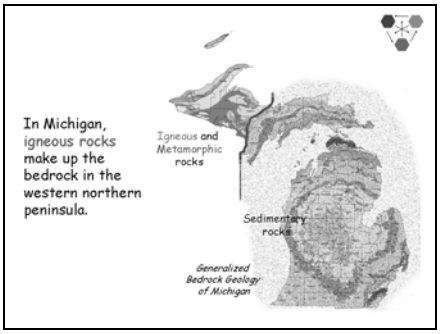

Student Activity:
Prepare a paragraph describing - Where is the closest igneous rock that you know about? In the glacial till? In the aggregate in the cement used to make the school? A rock you have in your hand? A building stone? Draw a picture or take a photograph and describe what you have found.
Using the Bedrock Map, determine how far away your school is from bedrock that is igneous rock.
Created October 2, 2000; rev 10, 2004

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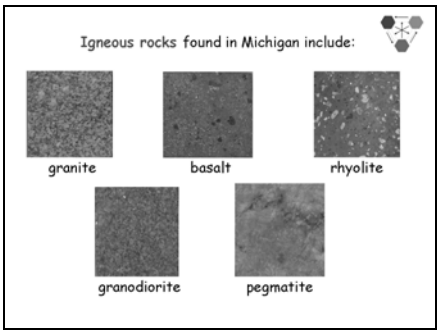
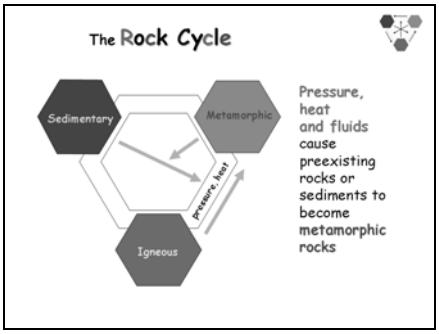


How are these rock similar? How are they different? Where are they found?
Illustrations are from the "Dimension Stone Feasibility Study: Development Potential in Michigan's Upper Peninsula" done by H. James Bourque & Associates. The graphic for these and many others are available from the GSD web site.
Student activity:
How would you use or convert one or more of these graphics in to wallpaper or a screen saver for a PC?
Picture is from the Dimension Stone Feasibility Study (DSFS).
Created October 2, 2000

Slide 45



Surf the web to find out how you can conduct an experiment that would help explain metamorphism.
Student Activity - The 'tink' test.
You need a piece of unfired pottery and a piece of fired or glazed potter, and a metal rod, screwdriver or similar material to tap with.
Take a piece of pottery that has not been fired in a kiln and tap it lightly with metal object. What sound is made?
Now repeat the process with a piece of pottery that has been fired in a pottery kiln. What sound is made?
The fired pottery has a more metallic 'tink' whereas the unfired potter has a duller sound to it(a 'thunk').
What is pottery made from slip. Do you know what slip is?
What is the process of firing pottery in a kiln analogous to?
Slip is = clay, a sediment
unfired pottery = shale, a sedimentary rock (made of clay with the water removed)
glazed pottery = slate, a metamorphic rock derived from the sedimentary rock shale.
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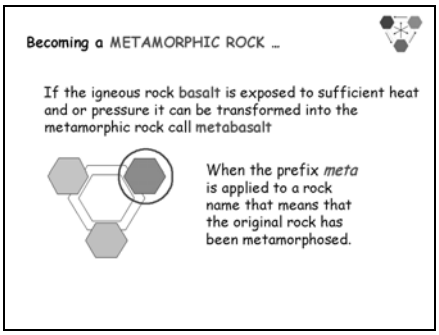

See the rock classification information on-line.
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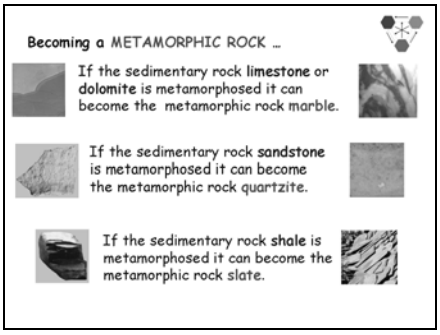

See the rock classification information on-line
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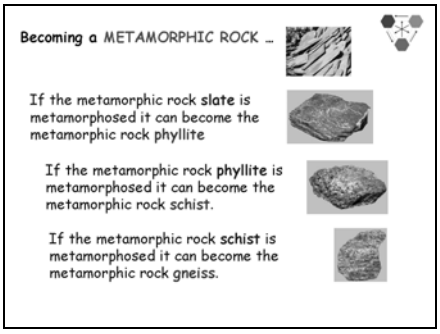

See the rock classification information on-line
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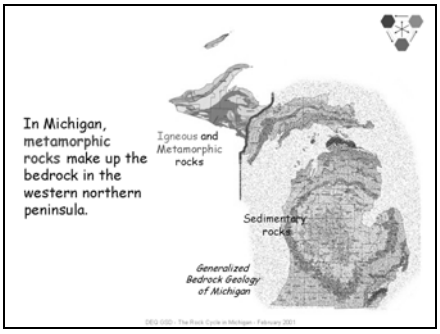

The western northern peninsula (da UP heah?) has the oldest, most complex bedrock geology found in Michigan.
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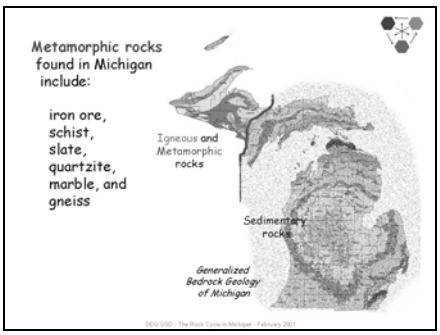

iron ore (derived from banded iron formations),
schist (derived from slate),
slate (derived from shale),
quartzite (derived from sandstone),
marble (derived from limestone and dolomite), and
gneiss (derived from granite, shale and sandstone layered together).
Created October 2, 2000

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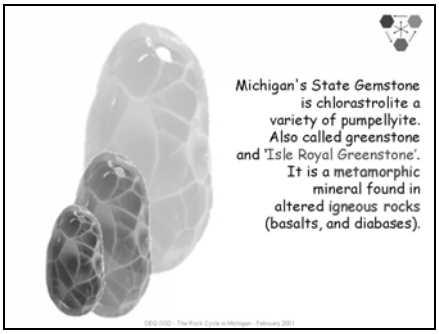

From the Rock Cycle in Michigan Glossary
pumpellyite - - Closely related to the epidote family. It is widespread low-grade metamorphic mineral in altered basalts, and diabases. Pumpellyite was in honor of Raphael Pumpelly, a noted 19th century U.S. Geological Survey geologist who made many contributions to the knowledge and understanding the copper deposits of the Keweenaw Peninsula. Chlorastrolite is now known to be a variety of pumpellyite. Chlorastrolite was named the "official state gem" of Michigan by the Seventy-sixth Legislature (Act 56, PA 1972, effective March 30, 1973). Also called greenstone and Isle Royal greenstone. In general, pumpellyite is abundant in all the amygdaloidal lodes. Found in: Houghton, and Keweenaw counties. Chemical formula = Complex silicate of Ca, Fe, Mg & Al.
chlorastorite - - (See pumpellyite) A mineral found in Michigan. Chlorastorite is a variety of pumpellyite.
greenstone - - (See pumpellyite) an informal mineralogical term.
greenstone - - A nonfoliated metamorphic rock that contains fine grained green mafic minerals, including chlorite and some amphiboles. In Michigan greenstones are found in the western northern peninsula. Petrography (rock) term.
Isle Royale greenstone - - (See pumpellyite) an informal term.
amygdaloidal - - A rounded tear drop shaped nodule or mass of mineral formed in cavities left by gas bubbles in extrusive igneous (volcanic) rocks. In Michigan many minerals are found in amygdaloidal basalts including pumpellyite variety chlorastrolite which is the State stone the 'greenstone' or Isle Royale greenstone'. Amygdule and amygdaloid comes from the Greek word for almond.
vesicular / vesicle - - The presence of numerous holes or cavities that form by bubbles of gas trying to escape usually an extrusive igneous rock. Vesicles are common in some northern peninsula igneous rocks especially in the 'copper country'. The vesicles fill with a range of minerals to form amygdules. Minerals found include feldspar, epidote, thompsonite, and pumpellyite variety chlorastrolite - the Michigan state gem "Isle Royal greenstone."
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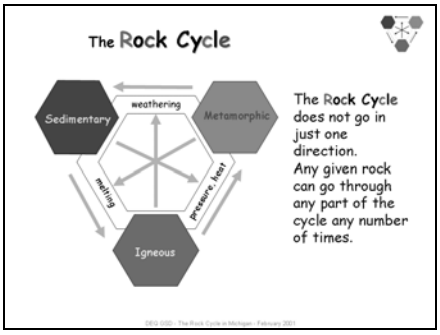

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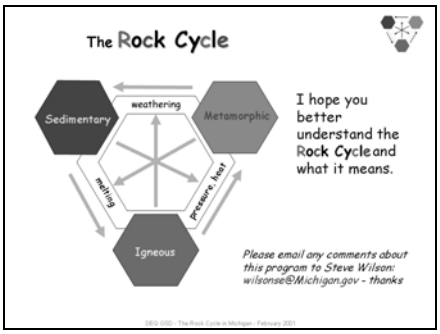

Please forward any ideas, feedback, comments, suggestions, tips, tricks, traps, alterations, permutations, variations, changes, deletions, and / or additions to Steven E. Wilson, MI DEQ OGS, P O Box 30256, Lansing 48909, email wilsons15@michigan.gov. Material available on-line at http://www.michigan.gov/deqgeologyinmichigan (deq geology in michigan - all lowercase - no spaces)

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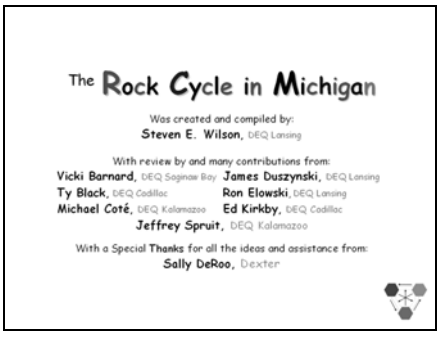

These are the people who made the Rock Cycle in Michigan possible. Their help and contributions are appreciated.
Created October 2, 2000; rev 10, 2004