



Natural Stone Materials 101

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How knowing a little geology can help you!

- To appreciate the unique beauty and value of stone
- Understand how different types of stone will perform in different environments
- Predict durability and chemical sensitivity
- Gain credibility with your client
- Every stone has a history and a story to tell

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Stone is the original building material

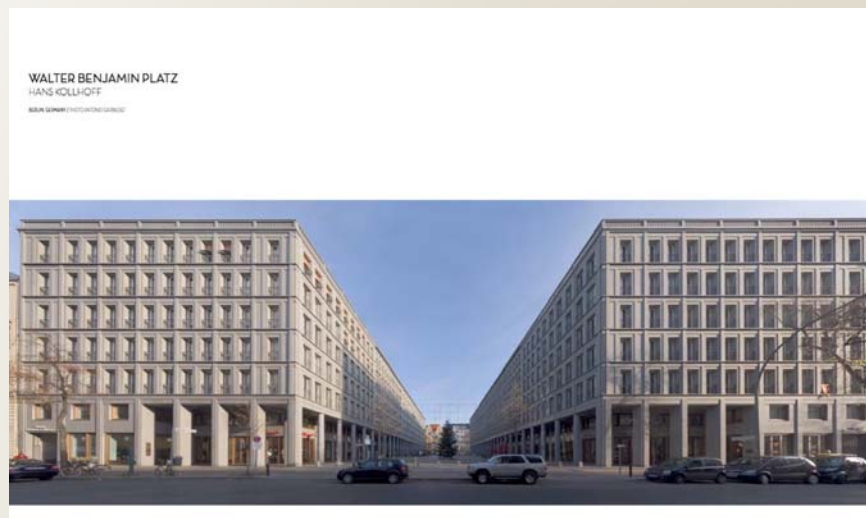
Ancient exterior



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Modern exterior



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Wet environments



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Dry environments

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Rough Finishes

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Highly Polished Finishes



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What is Natural Stone?



- **Stones which have been harvested from their in-situ position in the earth, then cut and machined into final products without alteration to the natural fabric of the material.**
- **Engineered products which have been processed into small particles and reconstituted with cementitious or resin binders do not meet the definition of natural stone**

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What is Natural Stone?

BASIS OF STONE COMPOSITION

- Calcareous Stones
 - Made up of Calcium Carbonate
- Siliceous Stones
 - Made up of Silica or Silicates

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What is Natural Stone?

BASIS OF STONE FORMATION

- Sedimentary
- Metamorphic
- Igneous

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Stone is broken down through erosion

- The agents of erosion are wind, water, ice, sand... & acid rain
- Wear can be minimized through selection and maintenance
- Stone knowledge is the key to successful installations



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The rock cycle determines origin

- Earth's internal and external processes continuously recycle the earth's materials
- This process forms the three types of stone origins: **Igneous, Metamorphic and Sedimentary**
- Granite, an *intrusive igneous* rock, means that it cools and solidifies inside the earth's crust.
- Erosion from wind, water & ice breaks the granite down into smaller and smaller particles

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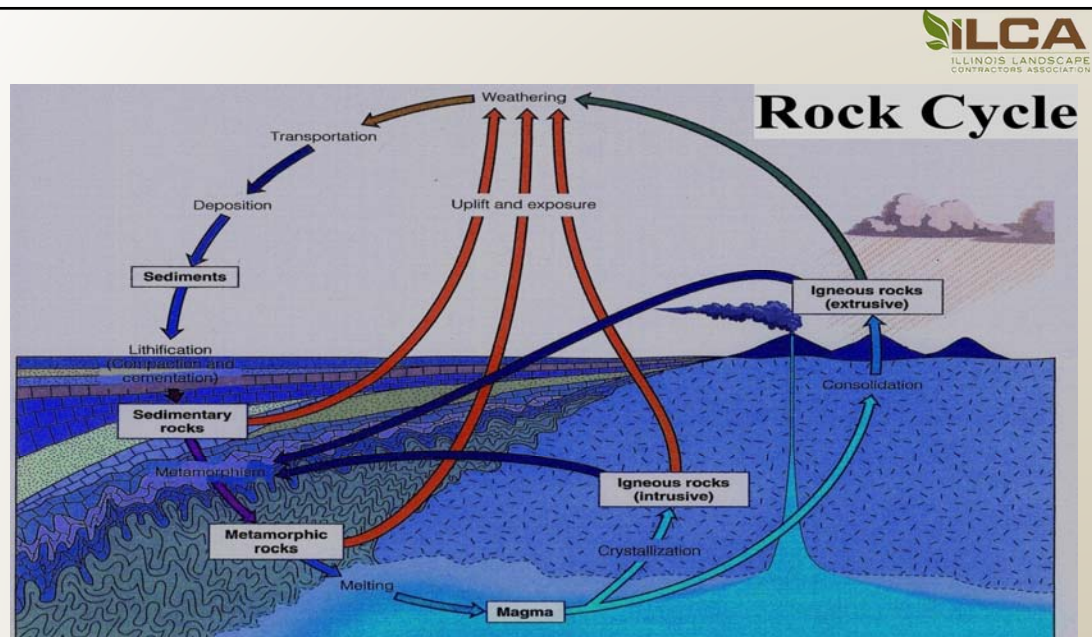
The Rock Cycle-Origins



- The particles are transported by wind, water and gravity and are deposited in layers forming *sedimentary* stone
- As layer upon layer of sediment is deposited it is compressed by the weight of the layers above
- It is also heated by molten magma inside the earth's crust
- This causes changes in the structure of the stone, forming *metamorphic* rock such as quartzite or slate
- If the metamorphic rock sinks deeper into the Earth's mantle, it can re-melt, beginning the cycle over again

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Physical Geology Exploring the Earth 4th Edition, James S. Monroe & Reed Wicander, Figure 1.17, Page 20

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What is Natural Stone?

IGNEOUS FORMATION

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Igneous Stone

- Igneous: (Born of fire) – Granite
- The stone industry and geologists do not always agree on the classification of granites

Stone Industry: Veined Granite
 Geologist: Gneiss

Stone Industry: Homogenous Granite
 Geologist: Granite

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What is Natural Stone?

METAMORPHIC FORMATION

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Metamorphic Stone

- Metamorphic: (Changed in structure)

Gneiss

Quartzite

Slate

Marble

- Gneiss-made from granite or sedimentary stone
- Quartzite-made from quartz sandstone
- Slate-made from shale or siltstone
- Marble-made from limestone

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What is Natural Stone?

SEDIMENTARY FORMATION

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Sedimentary Stone

- Limestone, Sandstone, Travertine, Onyx

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Composition-What stone is made of

- There are two general categories (like steel & wood)

<p>Silicates (glass)</p> <ul style="list-style-type: none"> • Acid resistant • Very hard & durable <p style="text-align: center;"><i>Examples</i></p> <ul style="list-style-type: none"> ◦ Granite ◦ Gneiss ◦ Sandstone ◦ Slate ◦ Quartzite ◦ Schist 	<p>Calcium Carbonates (Sea Shells)</p> <p>Acid sensitive</p> <p>Softer and less durable</p> <p style="text-align: center;"><i>Examples</i></p> <p>Limestone</p> <p>Travertine</p> <p>Marble</p> <p>Onyx</p>
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A Few Minerals Found in Rock

- **There are more than 3,500 different minerals, but only about a dozen make up the bulk of dimension stone:**
- **Quartz, Feldspar, Mica, Calcite, Garnet, Magnesium, Iron, Copper, etc.**









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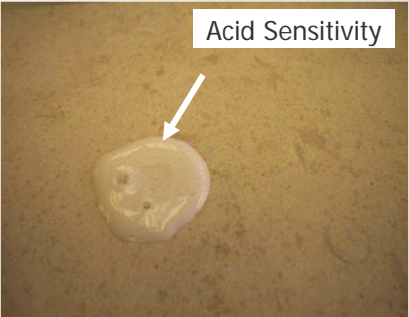
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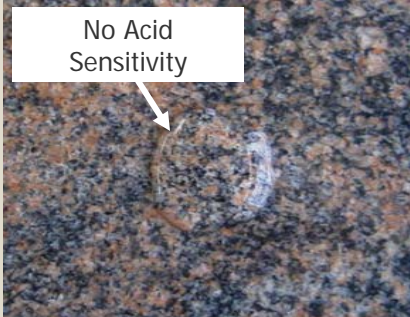
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Determine Composition

- **Acid Sensitivity**
 - **Silicates, generally not acid sensitive**
 - **Calcium Carbonates, are acid sensitive**




Acid Sensitivity



No Acid Sensitivity

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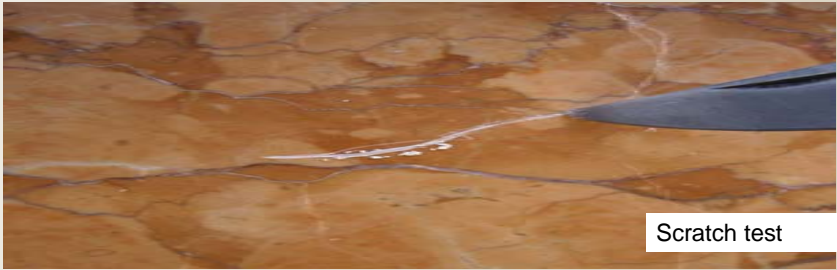


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Determine Composition

Hardness

- **Silicates, generally harder than a pocketknife Blade**
- **Calcium Carbonates, Generally Softer**



Scratch test


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Mineral hardness: scratch test



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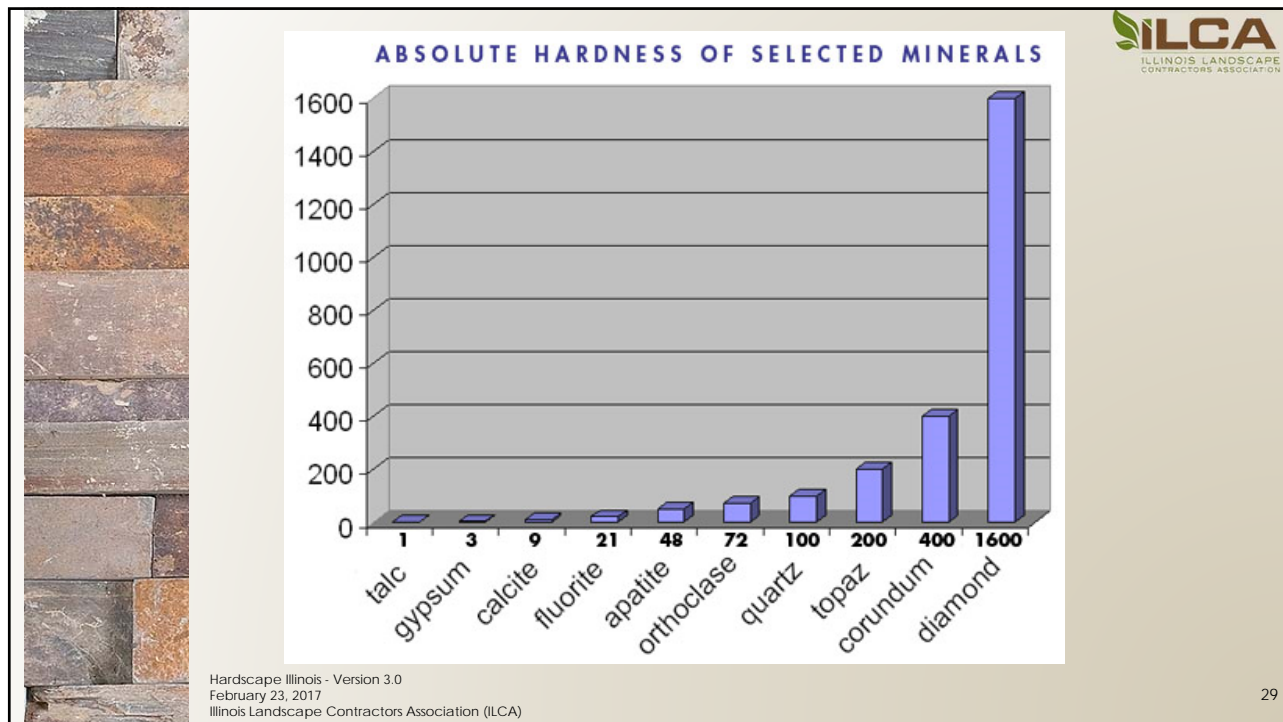
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Mohs scale of relative hardness: 1822

Mohs' Hardness	Mineral used for comparison	Simple Hardness	Cutting Hardness* (A Rosiwal)
10	Diamond	-	140000.00
9	Ruby, Sapphire, Alexandrite, Chrysoberyl	-	1000.00
8	Aquamarine, Emerald, Morganite, Spinel, Topaz	-	175
7	Amethyst, Citrine, Garnet, Iolite, Kunzite, Peridot, Tanzanite, Tourmaline, Zircon	Scratches window glass	120
6	Diopside, Lapis lazuli, Orthoclase, Turquoise	Can be scratched with steel file	37
5	Apatite, Obsidian, Sphene, Glass	Can be scratched with a knife	6.5
4	Coral, Fluorite, Pearl	Can easily be scratched with a knife	5
3	Calcite, Ivory	Can be scratched with a copper coin	4.5
2	Amber, Gypsum	Can be scratched with a fingernail	1.25
1	Talc	Can be scratched with a Fingernail	0.03

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Silicate family: Granite


- This is not where granite comes from

Hot Lava, Arenal Volcano, 1991, Costa Rica

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Granite

- Granite is an “intrusive” igneous stone
- Formed from the cooling and crystallization of magma (molten rock) deep *inside* the earth's crust
- The slower the magma cools, the larger the mineral crystals become
- Granite can be exposed to weathering and erosion by wind, water, ice, etc...
- This constantly breaks down the granite into smaller and smaller particles (sediment)

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Bethel White Granite Quarry in Vermont



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The "Gneiss" Story


- Gneiss is metamorphic
- Usually formed from the partial melting and re-crystallization of granite or sedimentary rocks
- "Like" minerals band together creating segregated banding of light and dark minerals
- Exhibits similar characteristics to granite




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Quartzite




- Quartzite is a metamorphic stone
- It does not show light and dark banding or crystal structure
- Derived from Quartz sandstone





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Sandstone



- Sandstone is a sedimentary rock that can be made up of any mineral particle between 1/16 & 2 mm in size
- Quartz sandstone is the most common type of sandstone and made up of "beach" sand
- Sandstone is a product of decomposed granite
- When exposed to metamorphism (heating and pressure) Sandstone may become quartzite. If it's porous, it's still sandstone!

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Sandstone quarry

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Slate

- Slate is a very fine-grained metamorphic rock that commonly exhibits layering and usually splits easily along bedding planes
- Slate is created from silt deposited in lakes and lagoons
- The rough broken surface layer is called “clefting” or “cleavage”
- Slate is the result of low-grade metamorphism of shale, or more rarely, volcanic ash

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The Calcium Carbonate Family: Limestone

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- Limestone forms in the ocean
- Organisms such as plankton, corals, shell fish extract calcium carbonate from the sea water
- As these organisms die their "Structures" pile up on the ocean floor sometimes exhibiting fossilized shells
- These layers can be compressed and heated under hundreds or even thousands of feet of rock
- Oceans sometimes recede and expose limestone


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Limestone varieties

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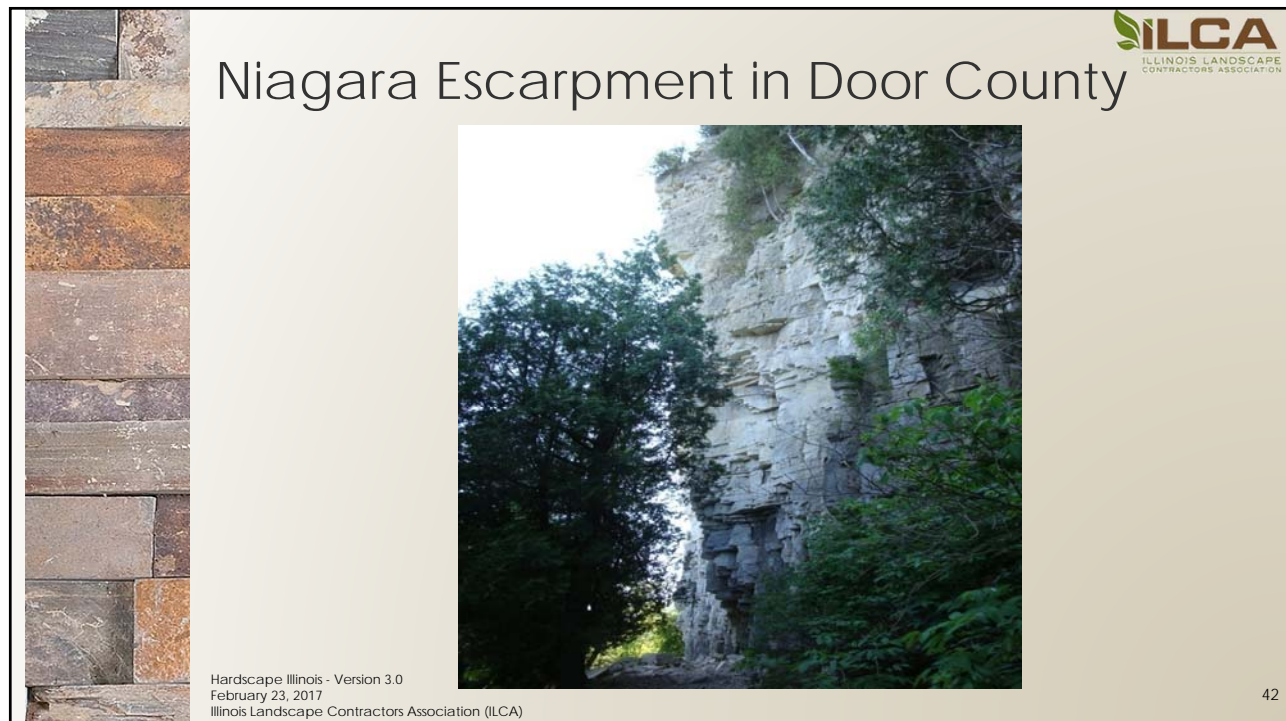
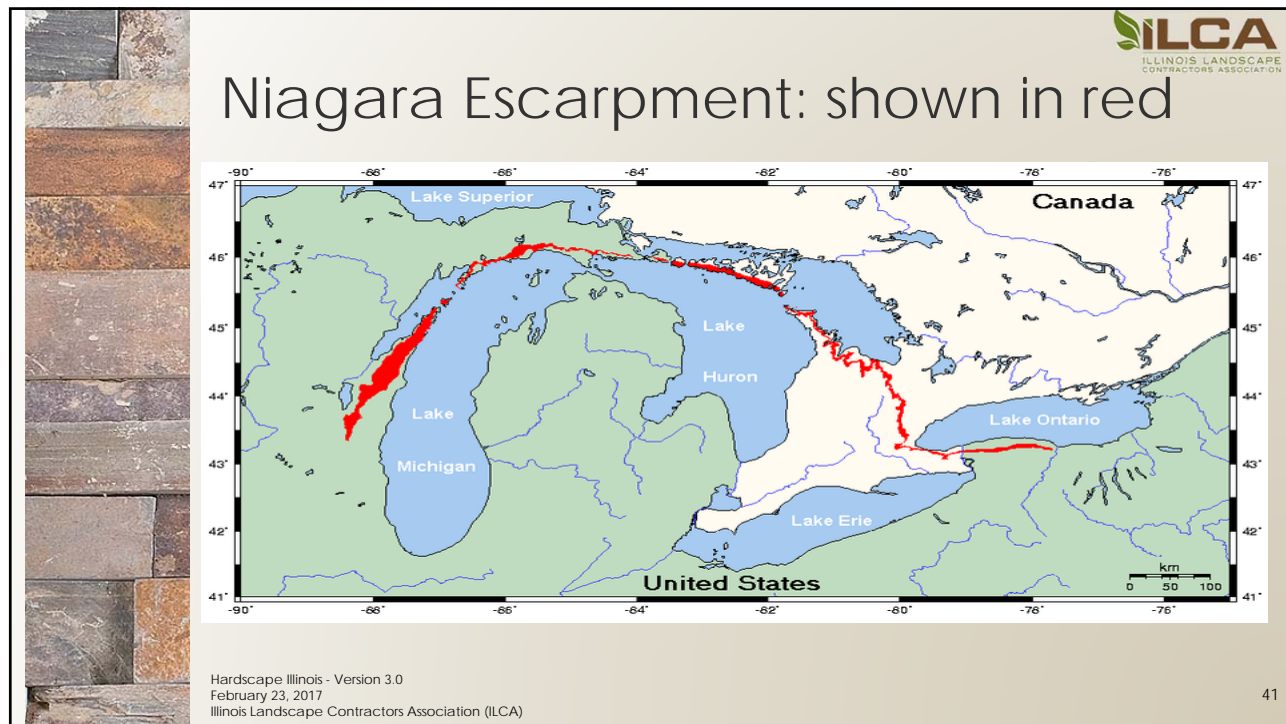


Buff
Traditional buff color ranging from cream to light brown with some veining and grain movement visible in the face and fine to medium grained stone.

- Jerusalem Limestone
- Indiana Limestone

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Limestone Quarry: Chilton


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Limestone Quarry: Kansas

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The Creation of Travertine

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- Acidic groundwater dissolves Limestone, transports it underground where it may be returned to the surface by way of geothermal (hot) springs
- Voids are caused by the gas bubbles migrating up through the hot springs as the calcium carbonate is being deposited
- This is why Limestone can contain fossils but Travertine does not
- Any shells or fossils would have been dissolved or left behind in the process of dissolving the Limestone

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The Creation of Marble

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- *True* marble is created when limestone is compressed by overlaying rock layers and subjected to heat from inside the earth
- This causes a metamorphic process or a “Change in structure”
- Calcium Carbonate changes to Calcite
- *True* marble is acid sensitive just as limestone, travertine and onyx
- *True* marble will take a high polish and ranges from 3-5 on the Mohs Hardness Scale


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Danby Marble Quarry in Vermont

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Inside the mountain


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Wire sawing block

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240 ton block of marble




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Finished Slab



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Onyx-the "cold" Marble

- Onyx is created when dissolved calcium carbonate is deposited in a very cold environment such as deep caverns
- Stalactites and stalagmites grow slowly from the inside out, forming "growth rings" like icicles
- Onyx is the only translucent stone
- Onyx is acid sensitive
- Onyx has a hardness of 3-5

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Onyx growth rings & translucence




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PUTTING IT ALL INTO PLACE...


	Sedimentary	Metamorphic	Igneous
Calcareous	Limestone Travertine Onyx	Marble	
Siliceous	Sandstone	Slate Quartzite Serpentine	Granite

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Resources and Training

- 
 • MIA+BSI, The Natural Stone Institute
- Dimension Stone Design Manual
 - www.marble-institute.com
- 
 • ASTM International (formerly American Society for Testing and Materials)
 - www.astm.org
- 
 • ICC (International Code Council)
 - www.iccsafe.org

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Additional Resources

- **Stones of North America App**
- (By MIA, with Support by Mapei)
- Discover North America's finest natural stones
- Search stones by type, color, use, & location
- View life-sized images of stones in vivid color
- See commercial & residential examples
- Get technical and usage specifications
- Locate local quarries and Fab centers
-




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Questions



Discussion

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