

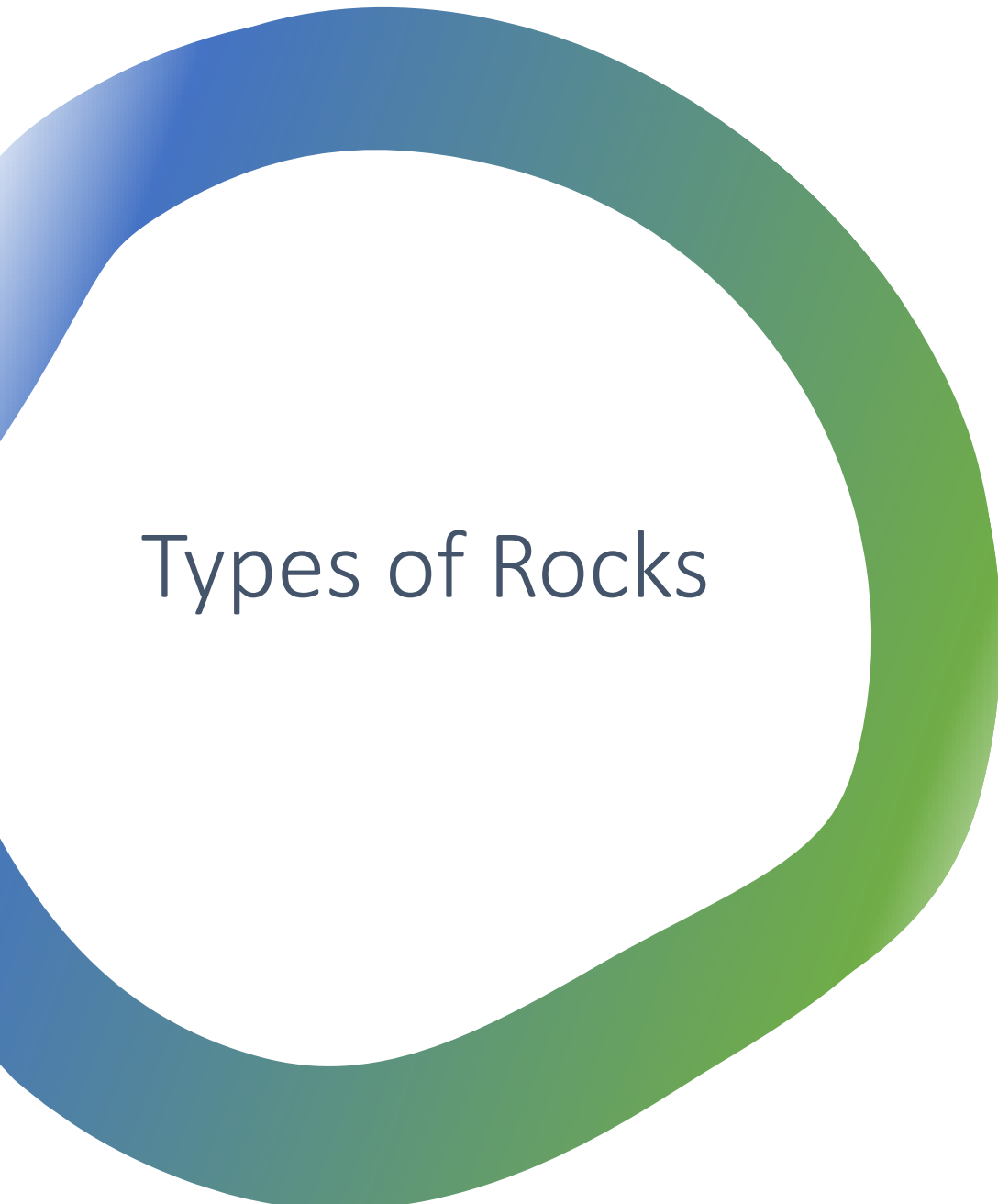


Geology of West Virginia Aggregates

Trevor Armes

Overview

- Discuss
depositional
history of West
Virginia
- How the quality of
aggregate is tested
- How this relates to
the quality and
resources in West
Virginia

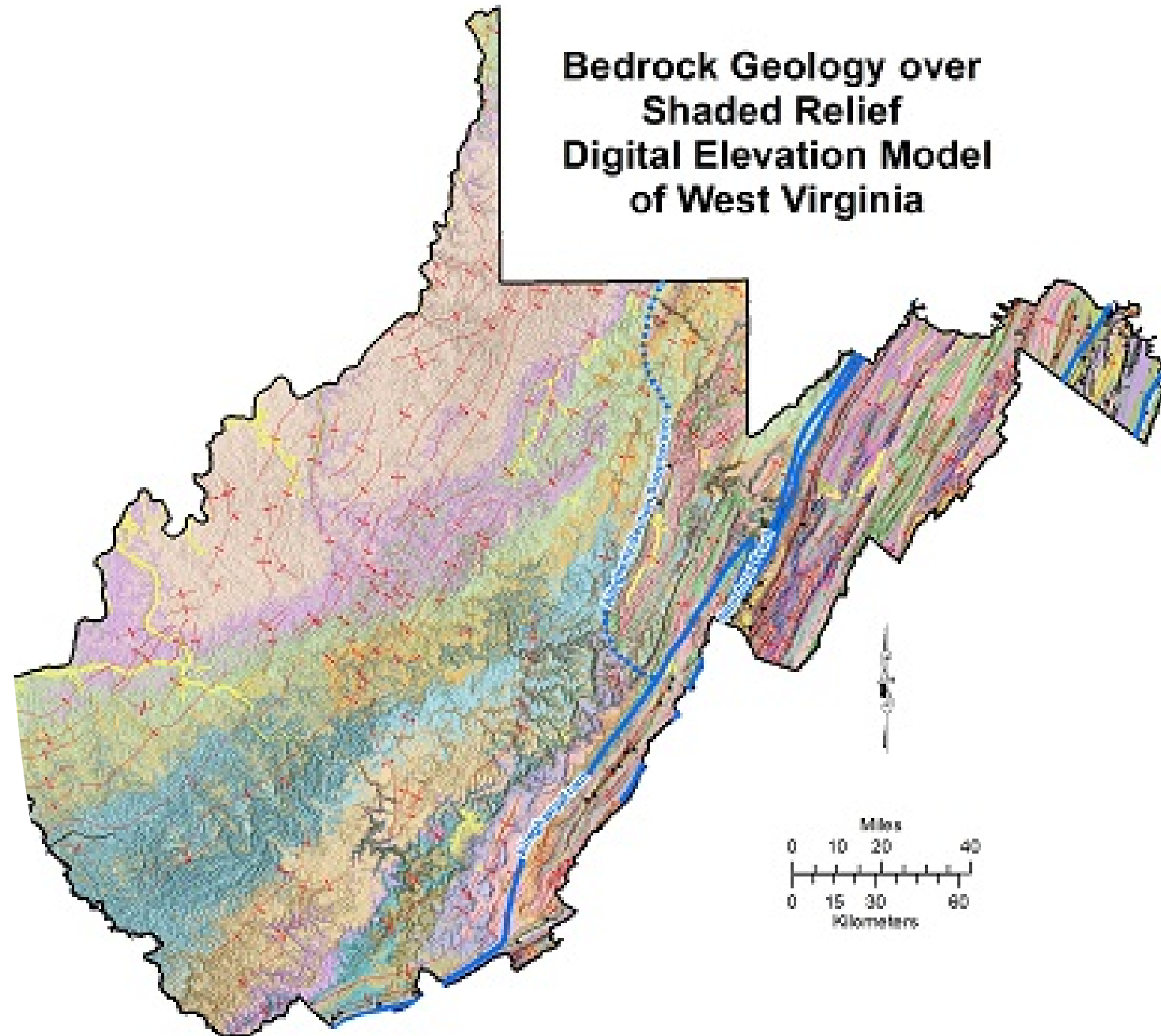


Types of Rocks

- Igneous – Forms when lava or magma cools (extrusive and intrusive)
- Metamorphic – Forms from the application of intense heat and/or pressure to a pre-existing rock (parent rock)
- Sedimentary – Formed from the accumulation and cementation of sediments from various sources

Introduction

- Due to the geologic history of West Virginia the state is predominantly overlain with sedimentary rocks
- There are few igneous and metamorphic exposures in the state
- This is due to three orogenies throughout our history:
 - Taconic, Acadian, and Appalachian Orogenies
- Most of these sediments were deposited during the Paleozoic Era
 - 542 +/- to 251.0 +/- 0.4Ma years



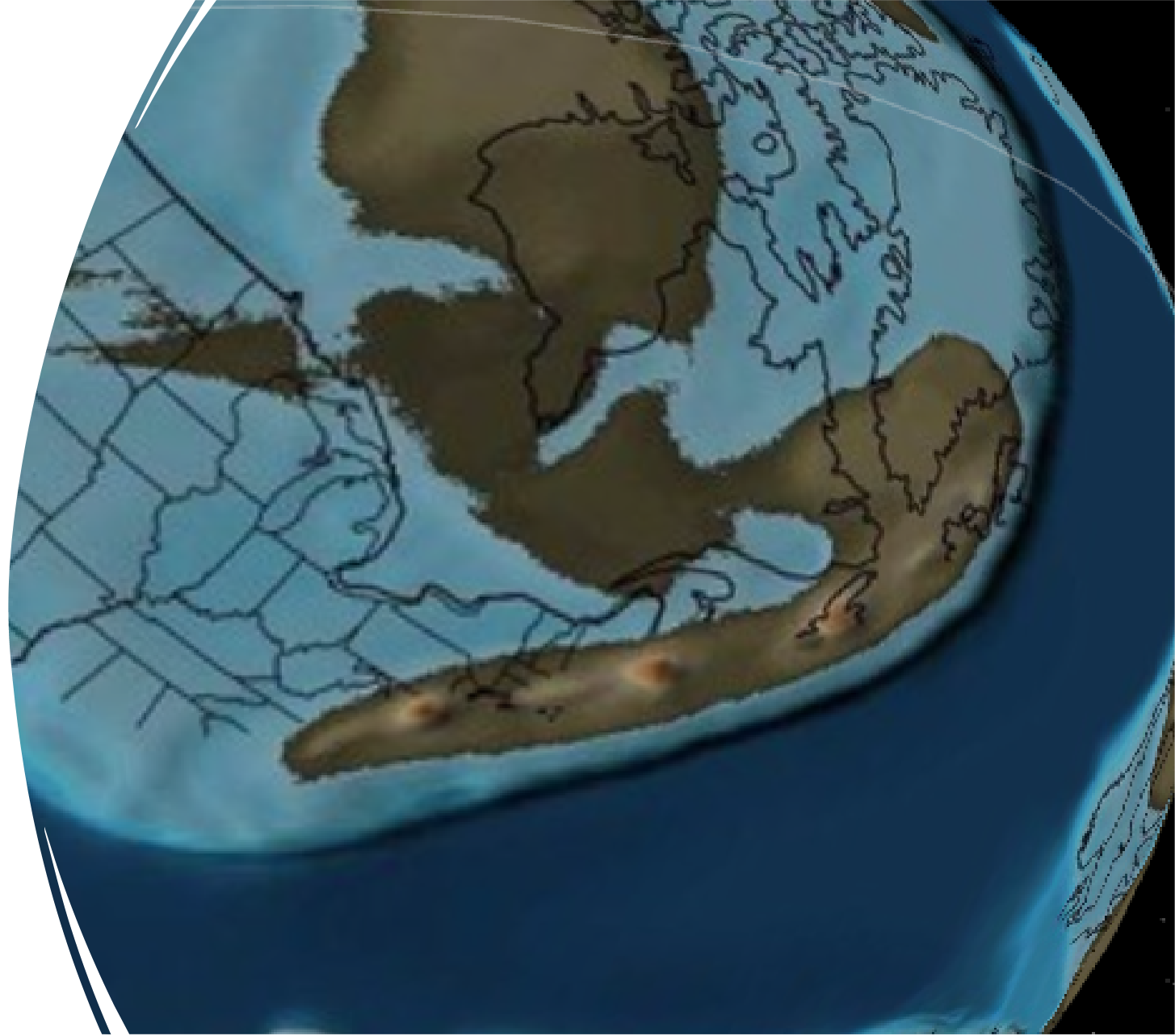
Periods of the Paleozoic Era

Paleozoic

	251.90 Ma
Permian	299.0 Ma
Pennsylvanian	323.2 Ma
Mississippian	358.9 Ma
Devonian	419.2 Ma
Silurian	443.8 Ma
Ordovician	485.4 Ma
Cambrian	541.0 Ma

Taconic Orogeny

- West Virginia was a shallow ocean during the Cambrian (Pre-Taconic)
- Taconic Orogeny began in the late Ordovician
- Subduction caused North America to collide with an island arc
- Mountain range formed east of West Virginia



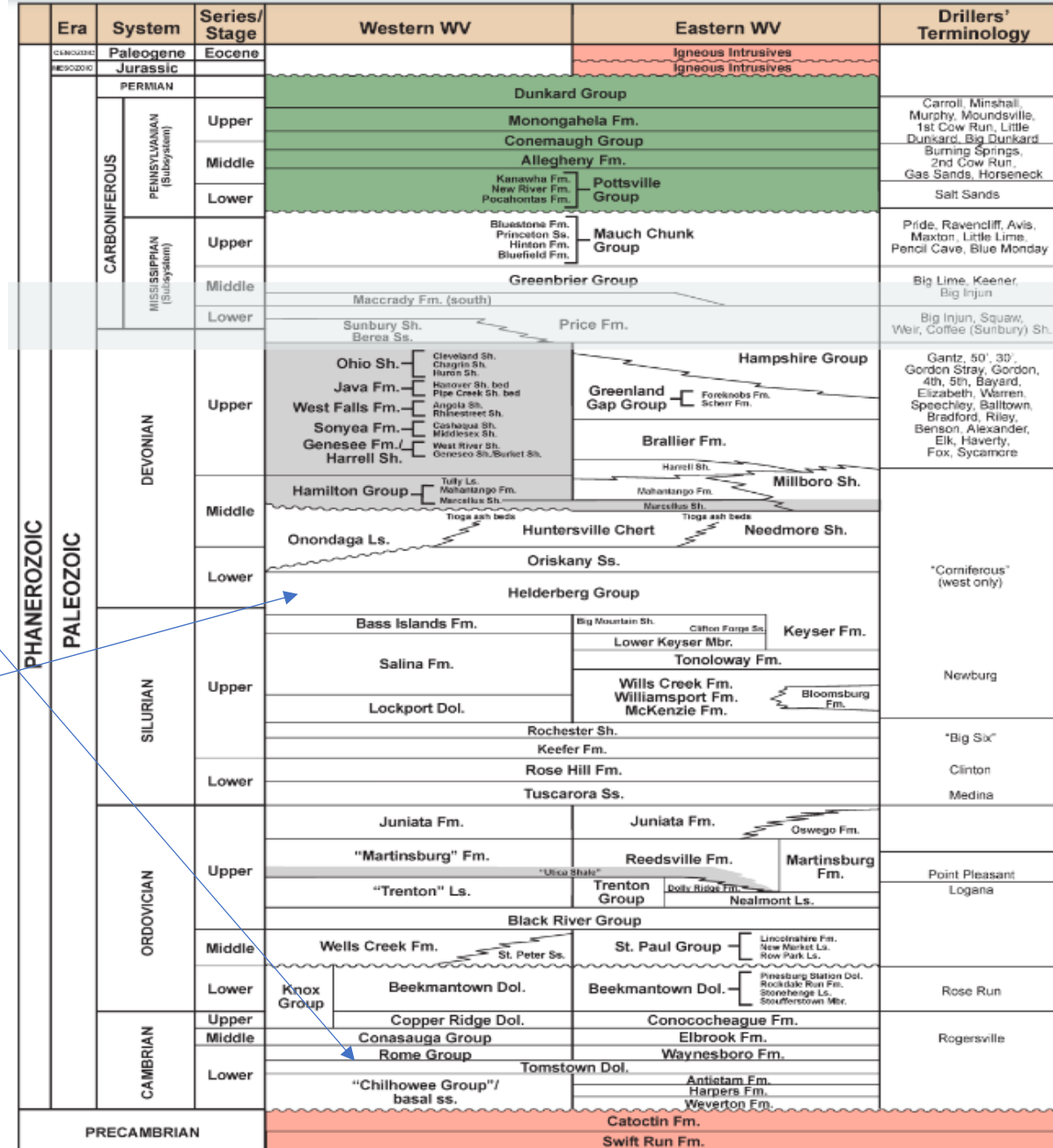


Taconic Orogeny

- Marine and nonmarine deposition through Silurian and Devonian Periods
- The newly formed mountain range provided a source for weathering and erosion
- Clastics and carbonates were deposited over West Virginia through the Silurian into the Early Devonian
- Shale, sandstone, limestones, and dolostones

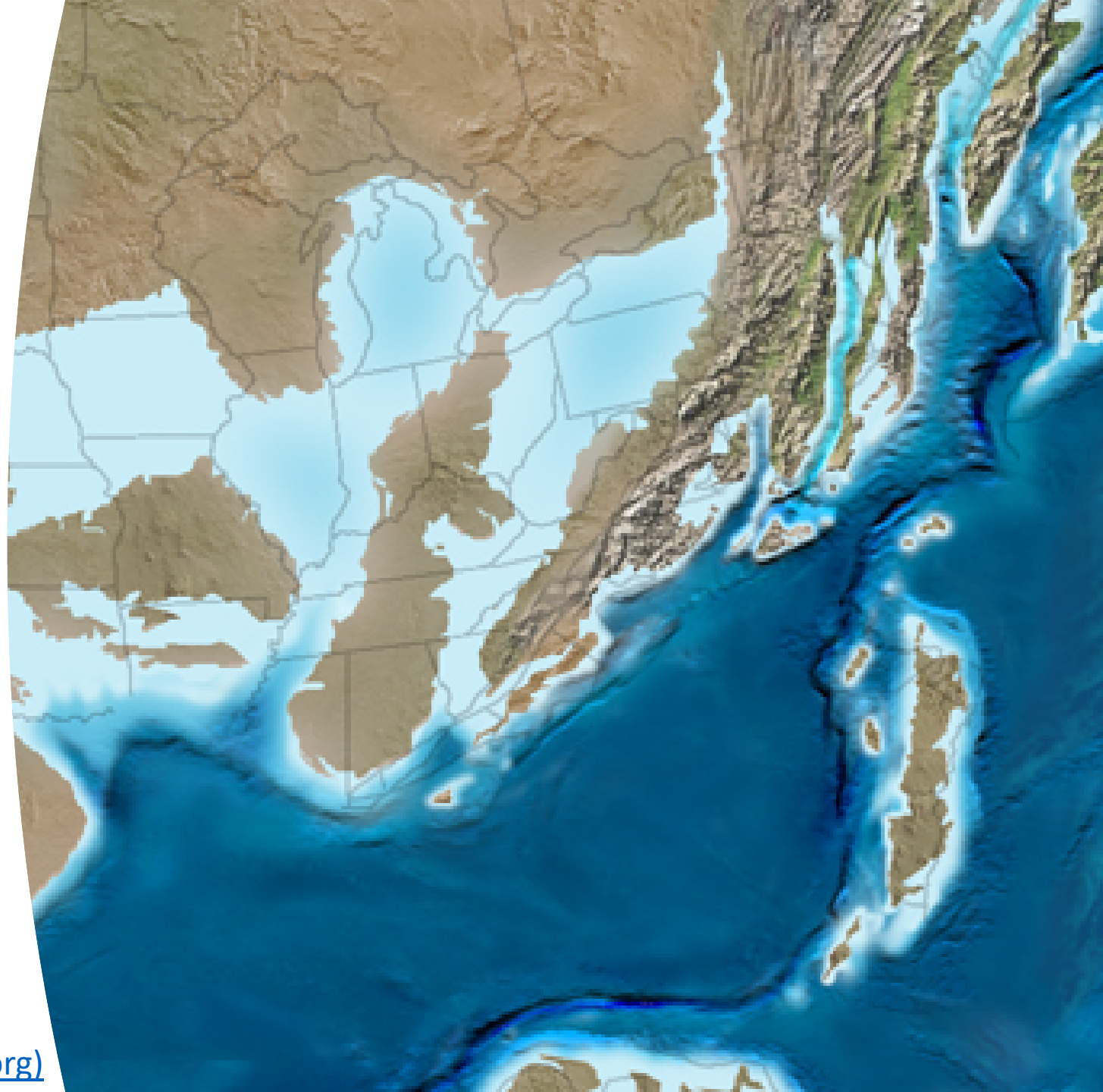
Tomstown
Dolomite – low
silica dolomite
from Lower
Cambrian

Helderberg
Group –
Limestone
alternating
with shale and
sandstone,
Lower
Devonian



Acadian Orogeny

- This event took place from the middle to late Devonian
- $\sim 397.5 \pm 2.7$ to 359.2 ± 2.5 Ma years
- Mountains uplifted northeast of modern WV
- Majority of WV was the Appalachian Basin
- Sea began regressing westward towards late Devonian





Acadian Orogeny

- Clastic marine sediments were deposited during this time
- Sea regressed westward away from WV
- Hampshire formation deposited – red shales and sandstones over most of WV

<https://blogs.agu.org/mountainbeltway/2018/03/14/new-media-hampshire-fm-corridor-h-wv/>



<http://palaeos.com/paleozoic/carboniferous/carboniferous.html>

- Sea pushed its way back into WV during the Mississippian
- Greenbrier Group was deposited, consisting mainly of limestones
- Moving into Pennsylvanian the land lowered, and Appalachia became a swamp
- This is where most of our coal came from, along with sandstone and shale deposits

Appalachian Orogeny

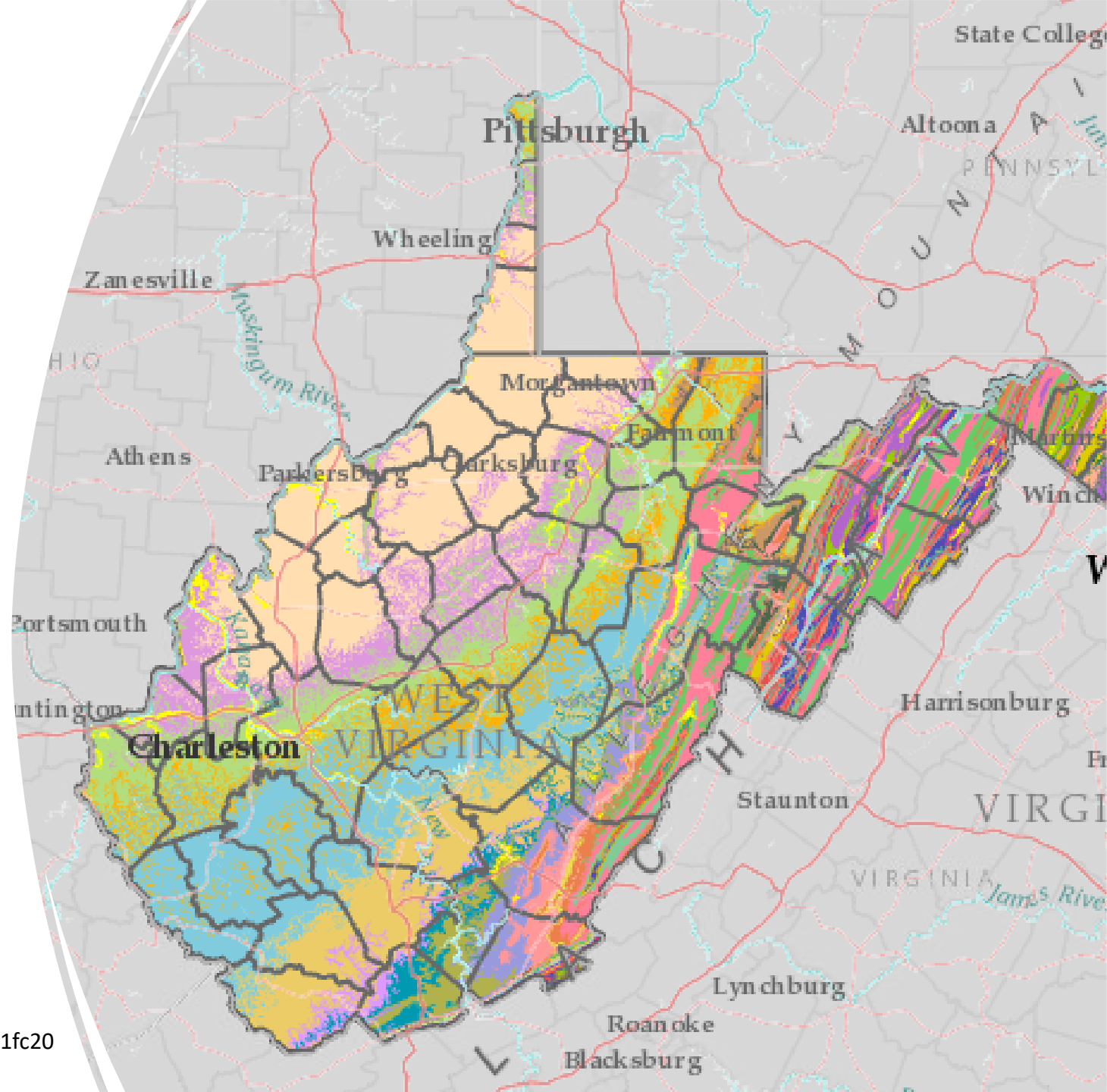
- Collision of Africa and North America raised the Appalachian Mountains
- This event took place in the Pennsylvanian and Permian periods, peaking around 290 Ma years ago
- This was the formation of the “modern” Appalachian Mountains
- **Left:** Map of the beginning of the Appalachian Orogeny, 300 million years ago

<http://palaeos.com/paleozoic/carboniferous/pennsylvanian.html>

[WVGES::WV Historical Geology \(wvnet.edu\)](http://wvnet.edu/WVGES/WV_Historical_Geology)

Appalachian Orogeny

- After this uplift sediments were not deposited over WV anymore
- WV was no longer under the sea and erosion of the mountains began
- Folding and thrust faults occurred, predominantly in the eastern part of the state



“Recent” Time

- Mesozoic Era 251 +/- 0.4 – 65.5 +/- 0.3 Ma years ago
- No sedimentary rocks from this time in WV, which is why we do not have dinosaur fossils
- Igneous activity in surrounding areas made some igneous dikes exposed in Pendleton County
- These dikes are from the Jurassic Period



“Recent” Time

- Cenozoic Era 65.5 +/- 0.3 Ma – 11,700 +/-99 years
- More igneous intrusions were created during this time, which are also found in Pendleton County
- Glaciation created a lake that extended throughout WV in the Quaternary
- Lake deposits, predominantly clay, were deposited through out the region during this time





Aggregate Quality

- Aggregate used for construction must meet certain quality standards
 - Durability
 - Resistance
 - Deleterious
 - These are a few of the important quality characteristics
- 

Los Angeles Abrasion (Abrasion Resistance)

- Aggregates used in construction must be resistant to abrasion
- Los Angeles Abrasion test obtains a percent wear result
- Aggregate is put into cylinder with steel balls
- Sample is rotated 500 times
- Material passing No. 12 sieve is percent wear



Sodium Sulfate Soundness (Durability)

- Indication of freeze thaw resistance of aggregate
- Aggregate submerged in sodium sulfate and dried
- Five cycles are completed
- This allows crystals to grow, which fractures the aggregate
- Sieving determines the percent loss



Deleterious Material

Deleterious materials are particles that can impact the strength, durability, or workability of a final product. This can include shale/shale like particles, friables/clay lumps, coal and lightweights, organic impurities, and silica content. We test for these materials to ensure there are not too many of them present.





Shale

MP 703.00.27

- Walter Huang PhD (Petrology, 1962) defines shale, “Shale is a laminated and thinly bedded fine grained clastic rock containing mainly silt and clay and including many particles less than 1 or 2 microns”
- Slakes and disintegrates
- Absorbs water (PI)
- Softens when in contact with water
- Shale like material (exhibits some properties of shale)



Shale Like material



Shale example showing lamination

Friables and Clay Lumps MP

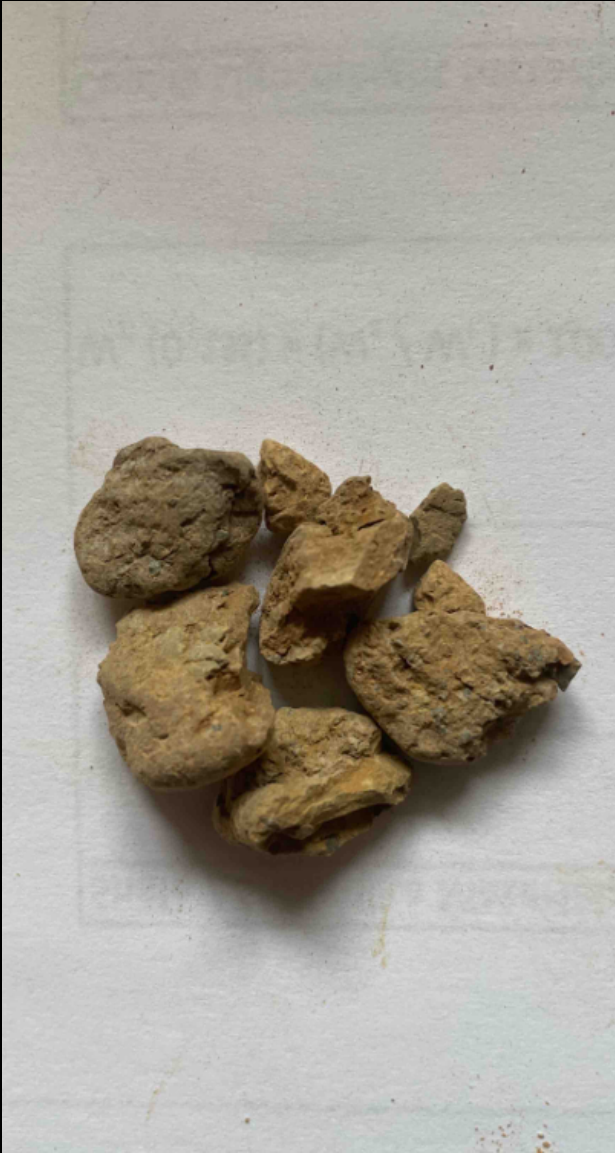
703.01.20

Pieces of dirt or clay that easily break down

Occur from over burden or contamination

Impacts workability of mixtures

Harder pieces impact final product



- Left: hardened clay lumps that would survive the mixing process
- Right: Softer friable particles that would cause workability issues



Coal and Lightweights MP 702.01.20

Coal and lightweight material is determined with heavy liquid

Causes segregation

Creates pop outs

Carbon in coal impacts moisture content



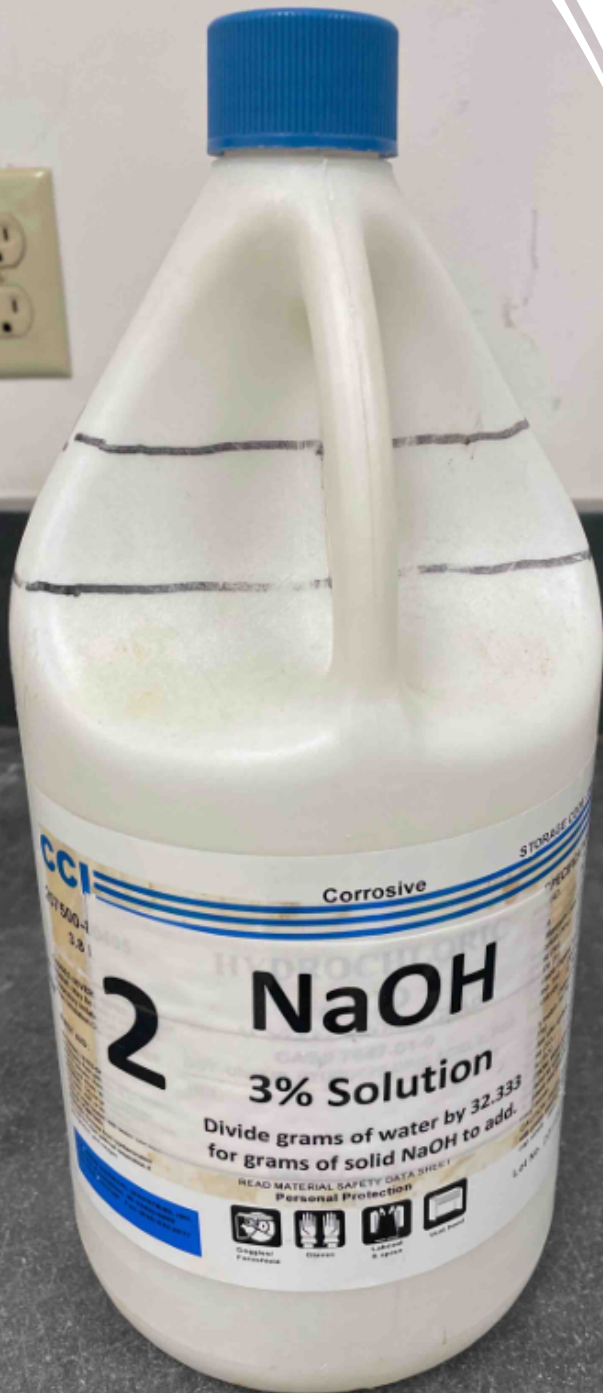
Lightweight material
used for hydration
curing – stalite

- Lightweight aggregate in river gravel
- Coal pieces found in gravel

Organic Impurities

AASHTO Designation: T 21-05

- Tests fine aggregate used for concrete
- Organic particles decay, weakening stability
- rapidly breakdown
- Samples with too much organic matter are mortar strength tested
- Determined with 3 % Sodium Hydroxide solution



Test Results

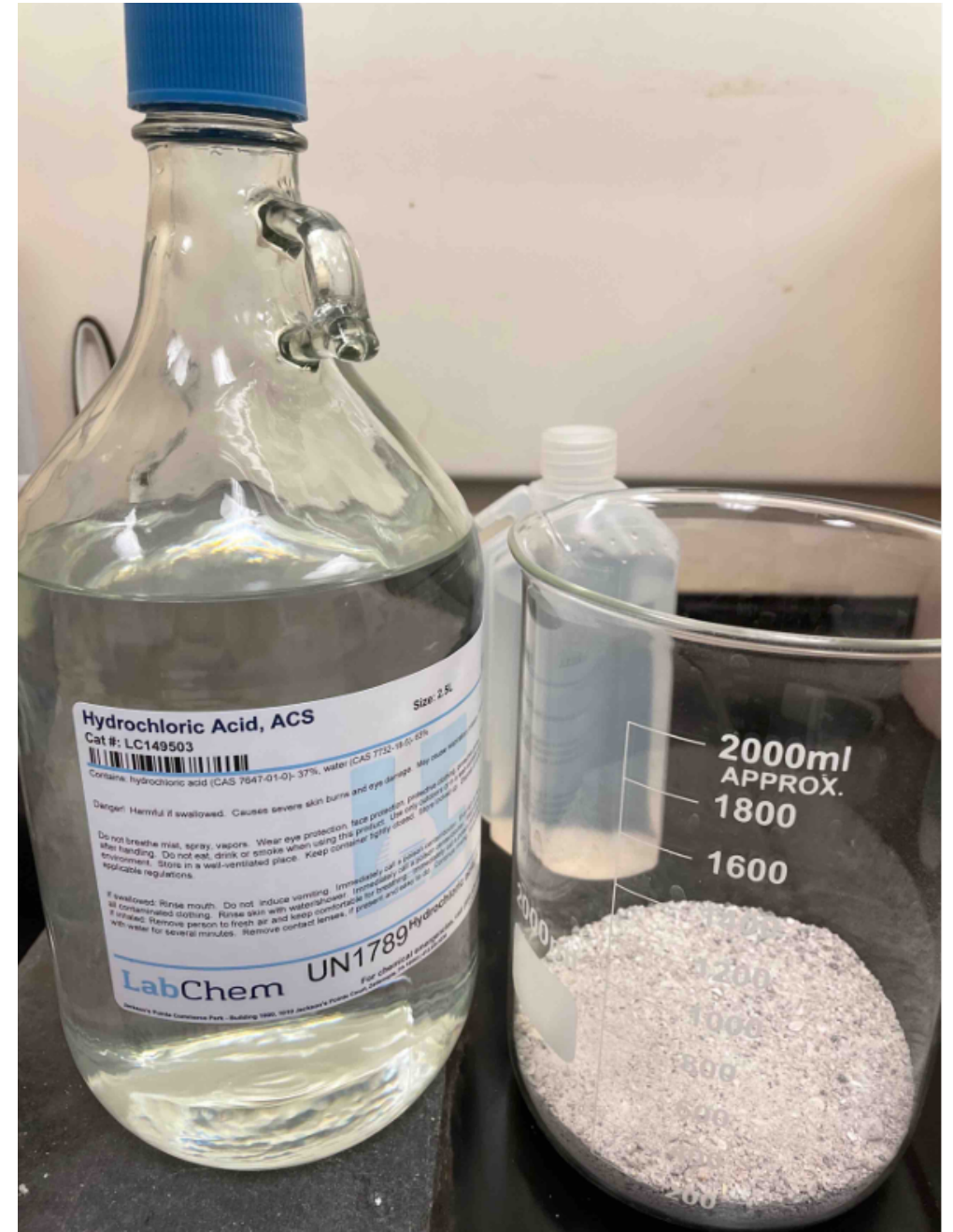
- Jar used for solution and material
- Glass color standard
- Results of 1, 2, 3 are in the acceptable range
- Results of 4 and 5 are sent to concrete lab



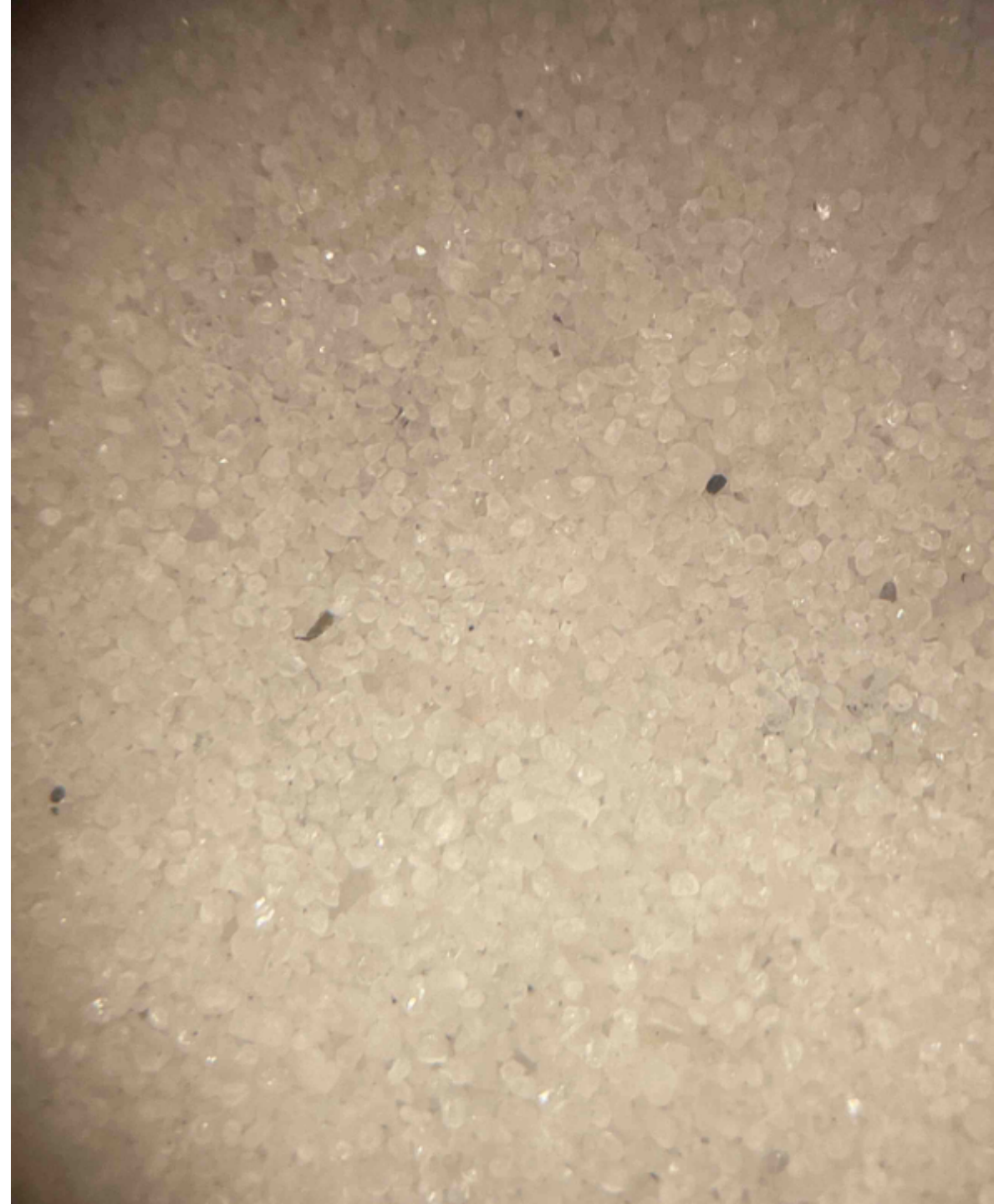
Insoluble Residue

MP 703.00.29

- skid resistant properties for HMA
- Limestone (CaCO_3) is not skid resistant
- Silica is what creates skid resistance in limestone
- Minimum 10 % (+200) silica content to be skid resistant
- Dolostone $\text{CaMg}(\text{CO}_3)_2$ Tested separately for elemental magnesium



- Insoluble particles are checked under microscope to make estimation of silica content
- (Almost) pure silica on right



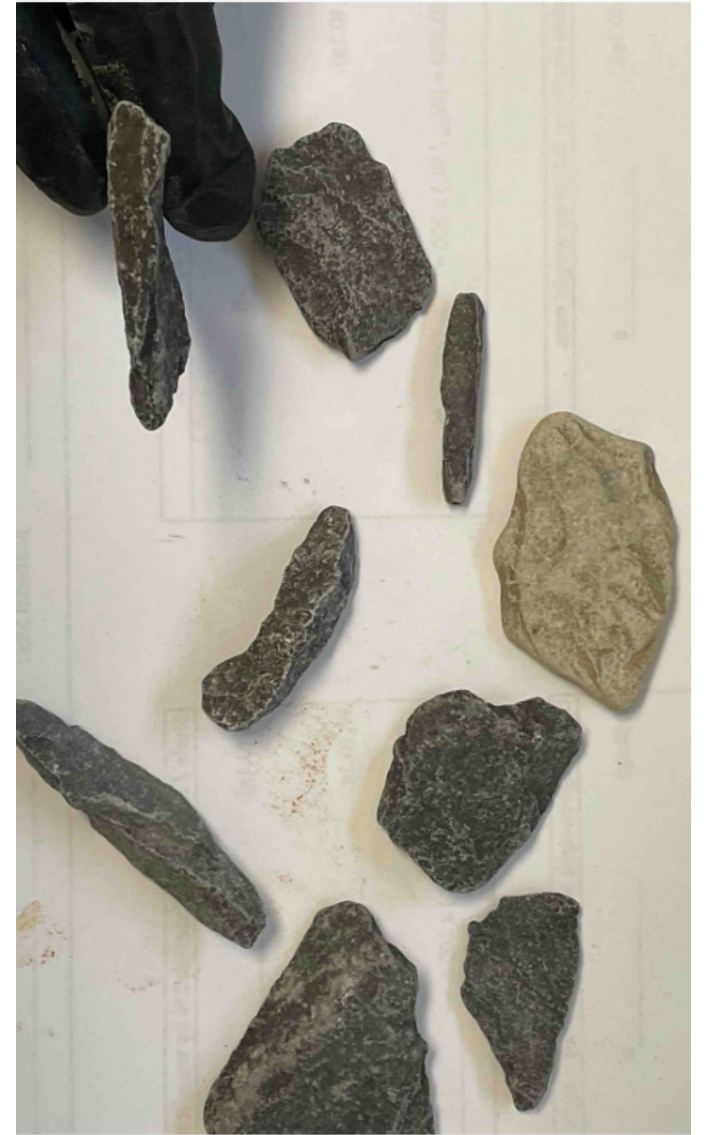
Thin and Elongated

MP 703.00.25

- Thin aggregate has a width 4 times greater than its thickness
- Elongated aggregate has length 4 times greater than its width
- Too many of these cause decrease of strength, skid resistance, and workability
- Internal and External damage
- Base Course, Portland cement concrete, and bituminous concrete



- French fries and Potato chips
- Thin and elongated pieces found in a limestone sample
- This test applies to natural and crushed aggregate
- Pieces like this easily fracture



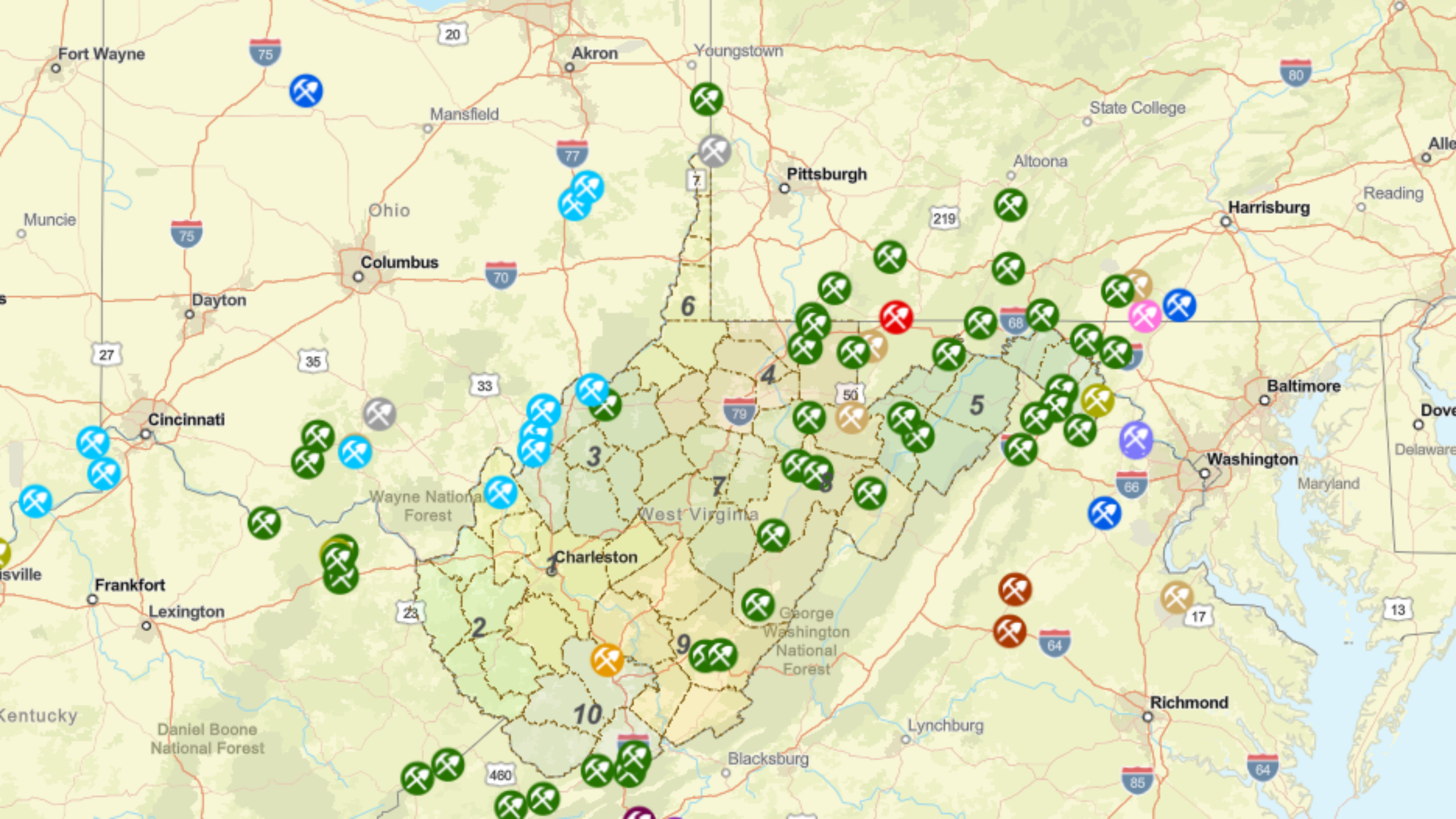


Where does our stone
come from?



Approved Sources for West Virginia

- WV has a list of approved and potential aggregate sources
- These sources must pass quality testing to be approved
- (Commercial & Potential Skid Resistant Sources) – under APL
- This list contains a variety of different aggregate types

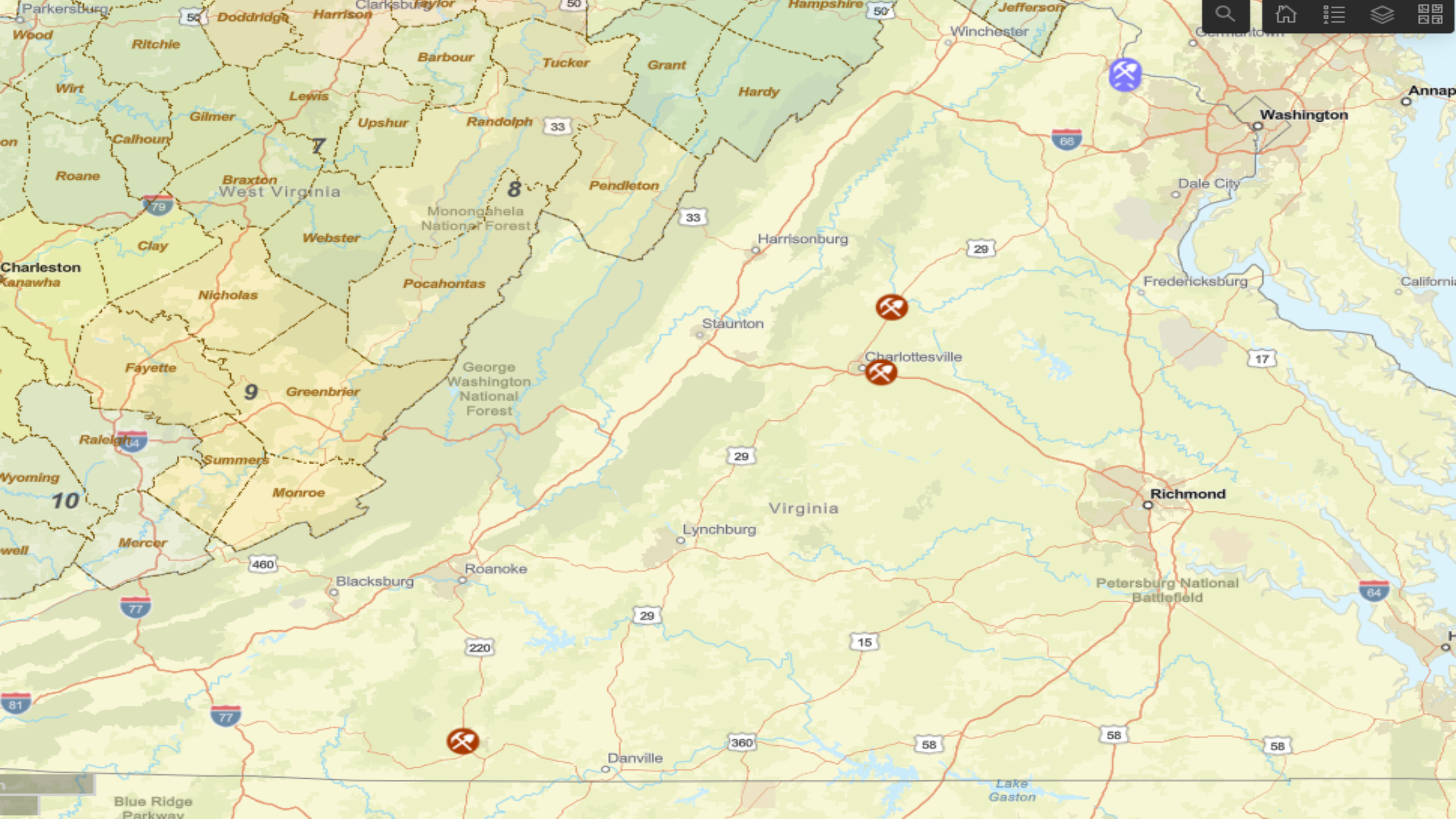


Igneous rock types

Five sources of igneous rock
on approved source list

3 sources of granite 2 of
diabase

All three sources are
located in Virginia

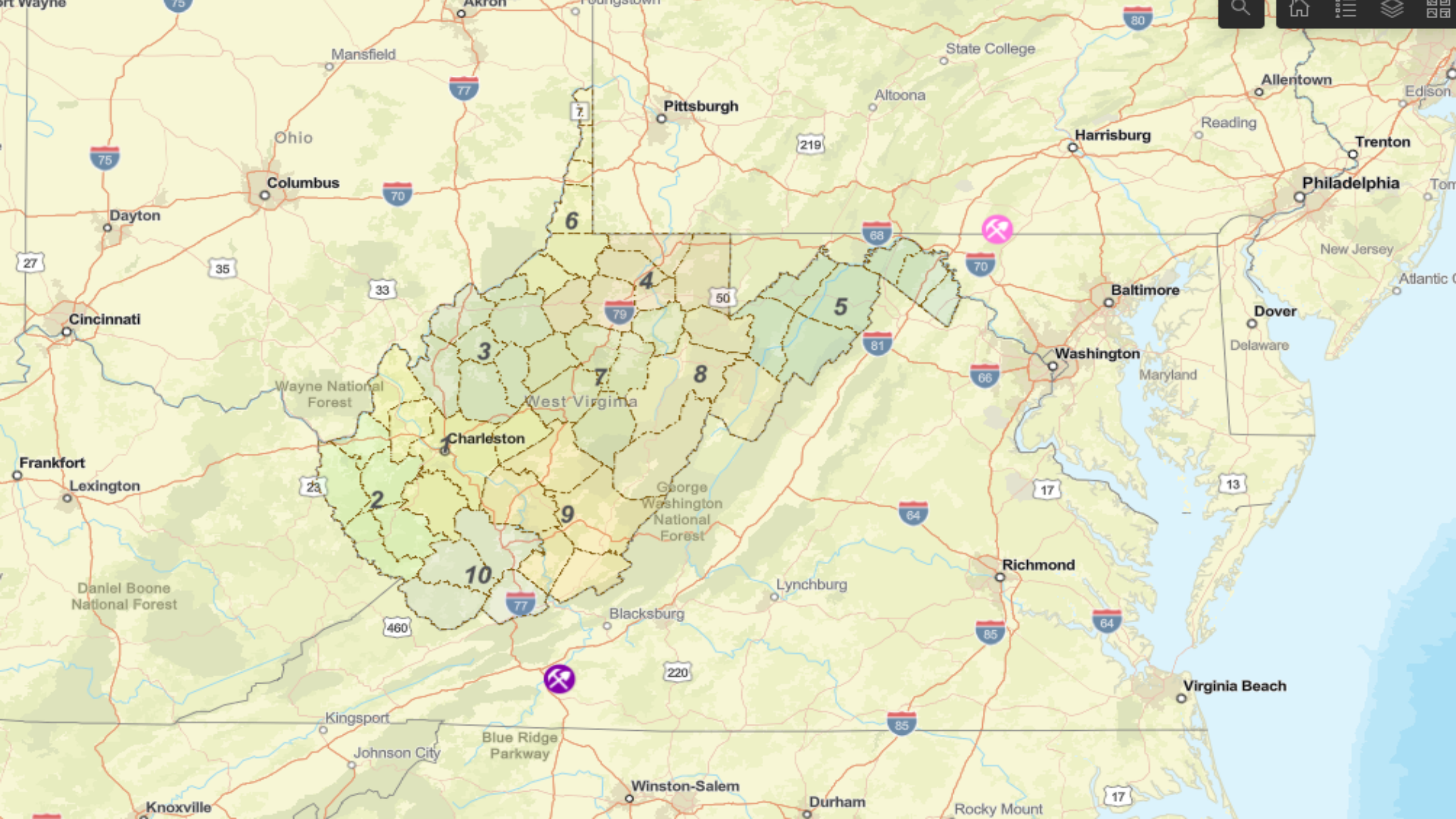


Metamorphic rocks

Two
metamorphic
sources

One phyllite
and one
quartzite

Located in
Pennsylvania
and Virginia



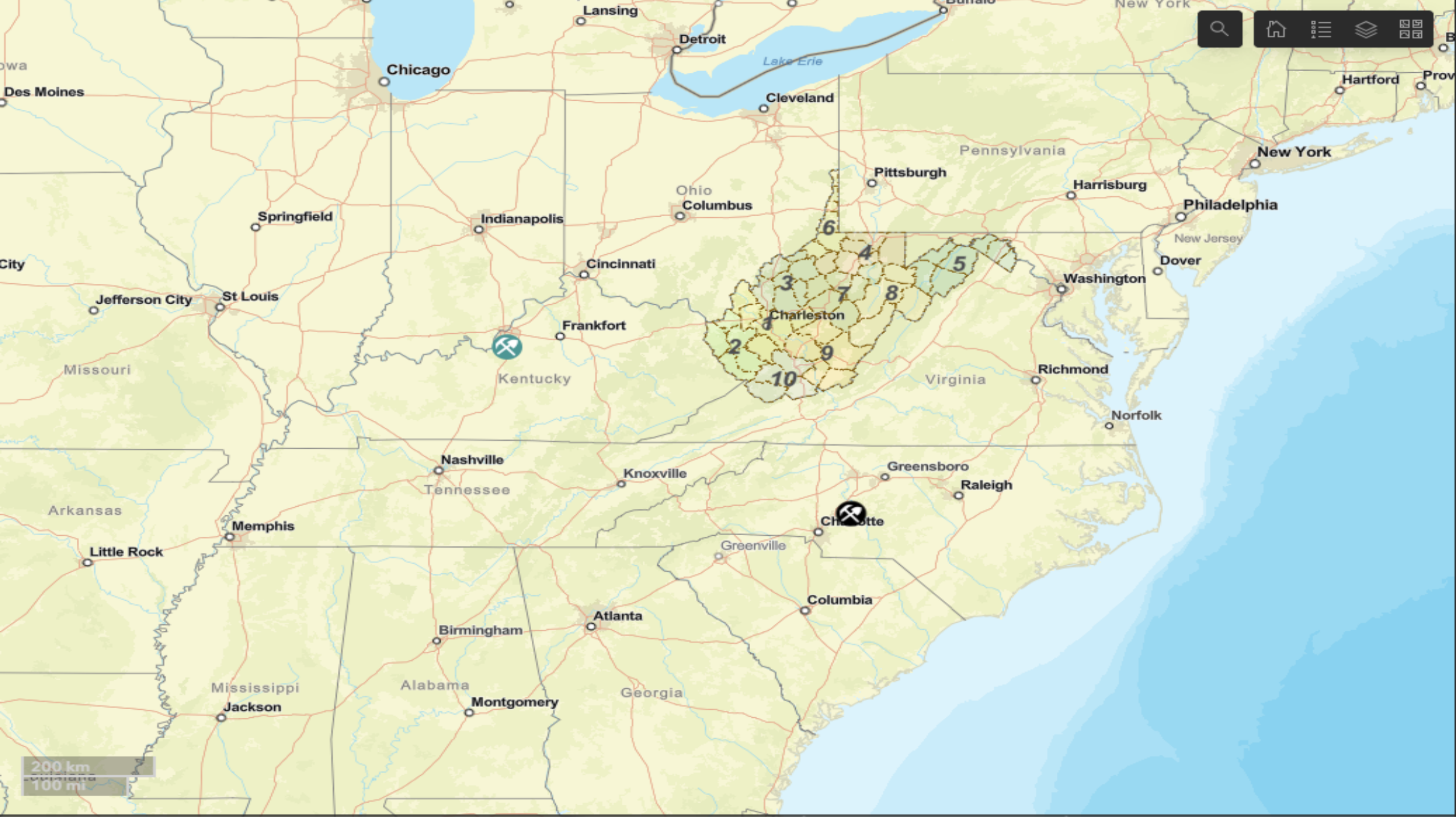
Lightweight aggregate

These are manufactured products

Expanded shale or slate

Two sources

Kentucky and Pennsylvania



Sedimentary Aggregates

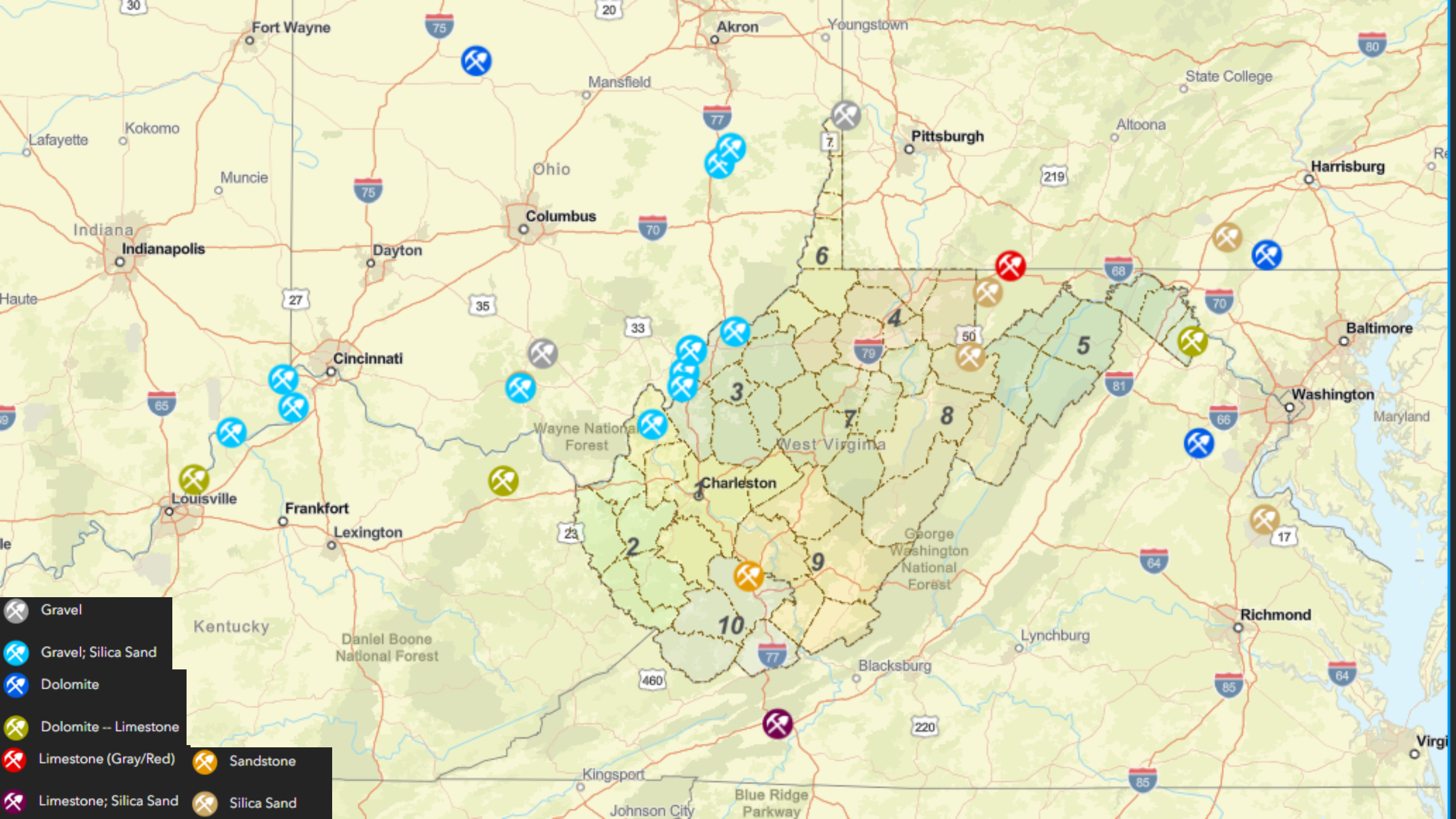
Dolomite

Sandstone and silica sand

Gray/Red limestone

Gravel

Limestone





References

- Bentley, C. (2018, March 14). New Media to Show Off Exemplary Features of the Devonian Aged Hampshire Formation Along Corridor H, West Virginia . *AGU Advancing Earth and Space Sciences*. September 12, 2023, <https://blogs.agu.org/mountainbeltway/2018/03/14/new-media-hampshire-fm-corridor-h-wv/>
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