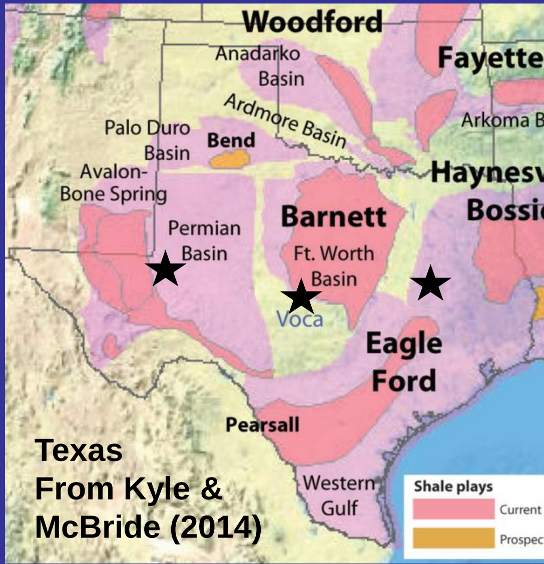
Northern White Sand versus Texas Brown Sand—Why Wisconsin Sand Is Still Important

Dr. Kent M. Syverson, P.G.

Dept. of Geology

UW-Eau Claire

http://www.uwec.edu/geology/index.htm



My background

- Co-supervisor of research project on sandstone cement.
- Consultant in the frac sand industry (for sand companies and private individuals) for >8 yrs.
  - Sand prospecting in Wisconsin
  - Site permitting
  - Third-party reviews for financial organizations
  - Collector of frac sand intelligence for a major research group.
  - Attender of frac sand conferences in Texas to learn about Texas sands and last-mile logistics.

Goals of talk

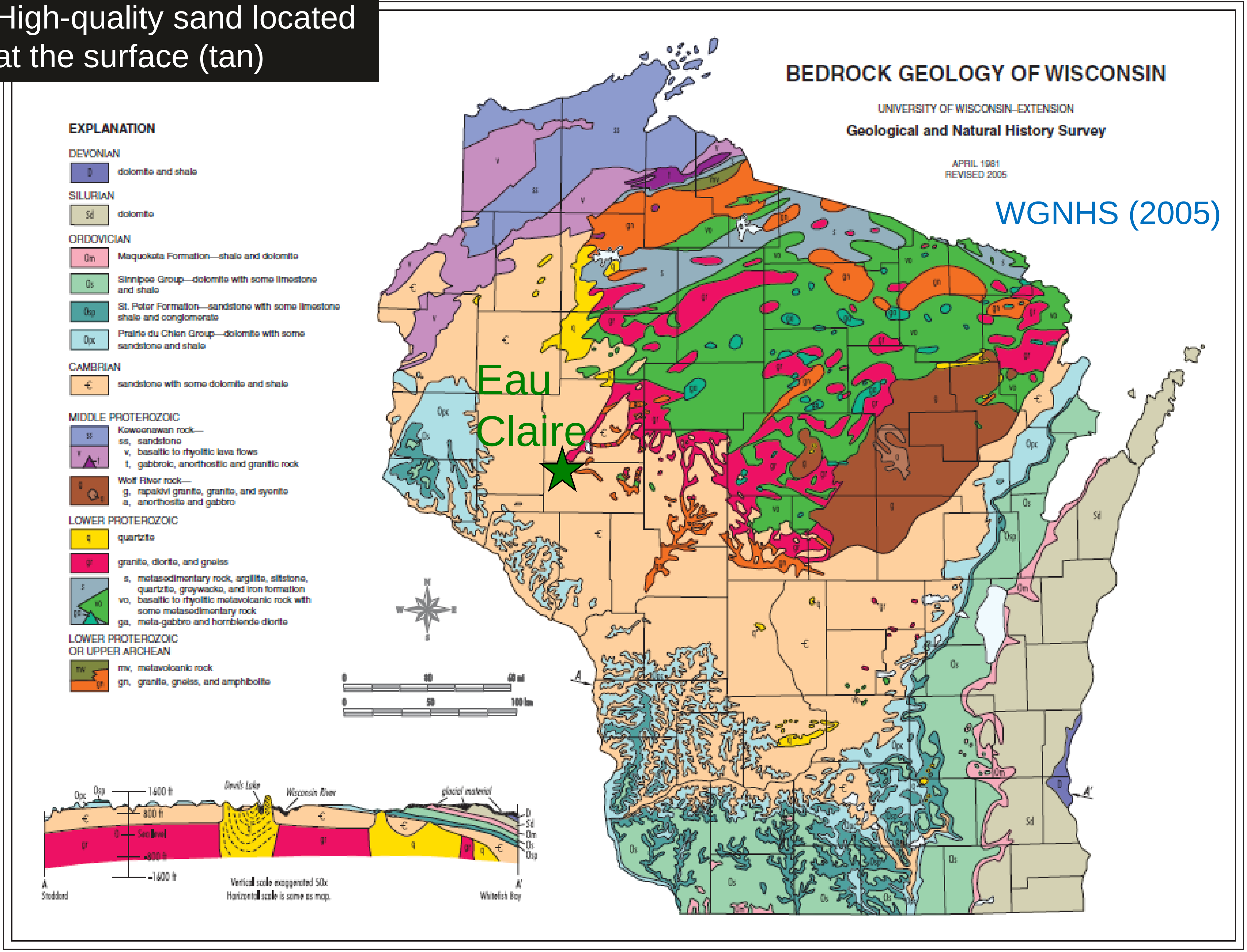
- Describe factors influencing the growth of the sand industry in Wisconsin and Texas.
- Explain the attributes of “top-tier” Northern White frac sands from WI, MN, and IL
- Summarize some attributes of Texas brown sands (Hickory sand)
- Discuss the trends helping/hindering the prospects for Wisconsin sand in today’s market.

- Oil prices crashed below $35/bbl in 2015, and frac sand demand plummeted.
- Now prices ~$50/bbl, and sand demand is rising.

Sand capacity % vs. fracking areas △ △

From InfillThinking.com (2017, used with permission).

High-quality sand located at the surface (tan)



Variables impacting frac sand economics

- Mineralogy (100% quartz best, mono-crystalline silica)
- Perfectly rounded and spherical grains best (standard -- Krumbein shape factors >0.6)

Good WI sand (right)

Rounding = 0.72

Sphericity = 0.75

ISO 103503-2 standard for frac sand (Benson & Wilson (2015, USGS).

Typical properties	ISO 103503-2
Turbidity (NTU)	≤250
Krumbein shape factors	
Roundness	≥0.6
Sphericity	≥0.6
Clusters (%)	≤1.0
Bulk density (g/cm^3)	
Bulk density (lb/ft^3)	
Specific gravity	
Mean particle diameter, mm	
Median particle diameter (MPD), mm	
Solubility in 12/3 HCl/HF for 0.5 hr @ 150°F (weight loss %)	≤3.0

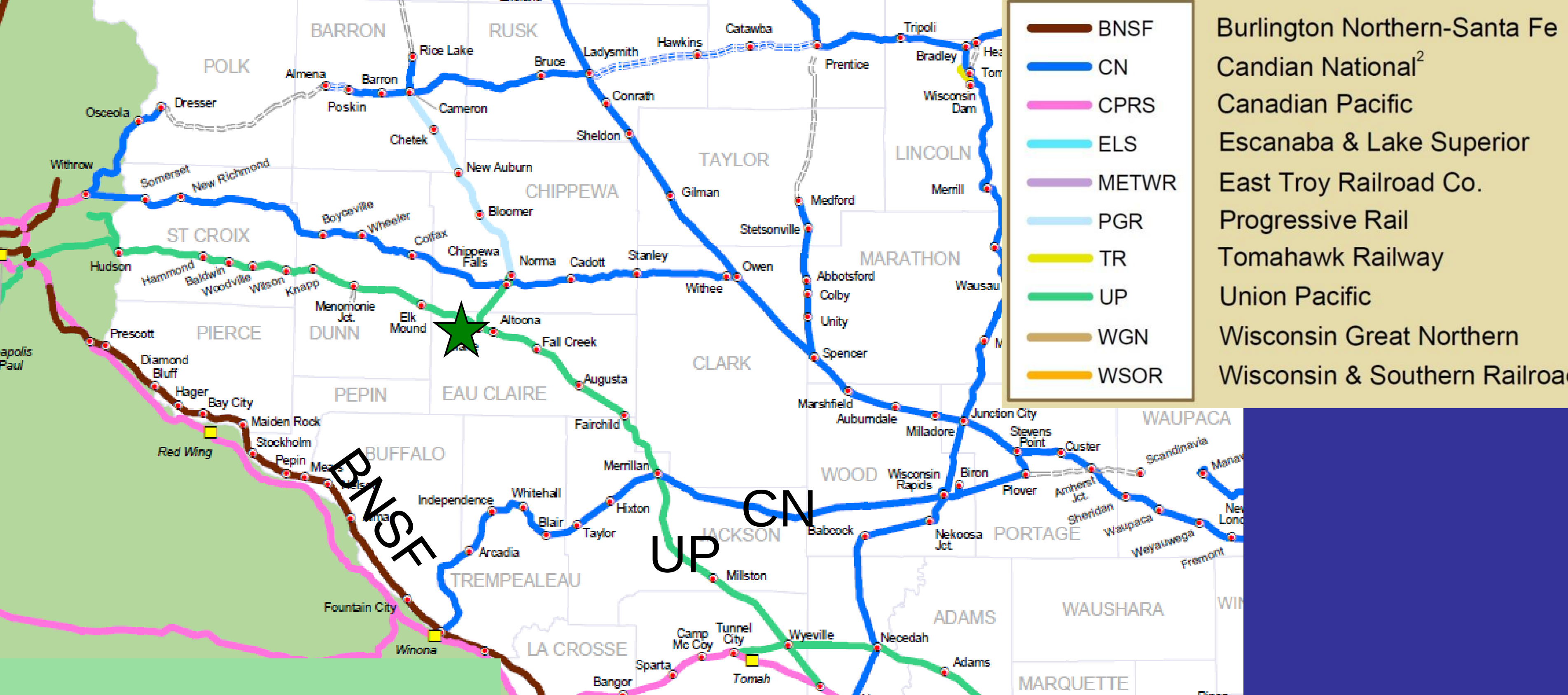
From Benson & Wilson (2015, USGS).

Variables impacting frac sand economics

- Grain size – mesh sizes
- Mesh sizes refer to number of openings per inch on a sieve screen.
  - 20/40 mesh (0.84-0.42 mm)
  - 40/70 mesh (0.42-0.21 mm)
  - 70/140 mesh (0.21-0.1 mm)
  - Fine- to medium-gr. sand best
- Little silt and clay
- Easily disaggregated

Variables

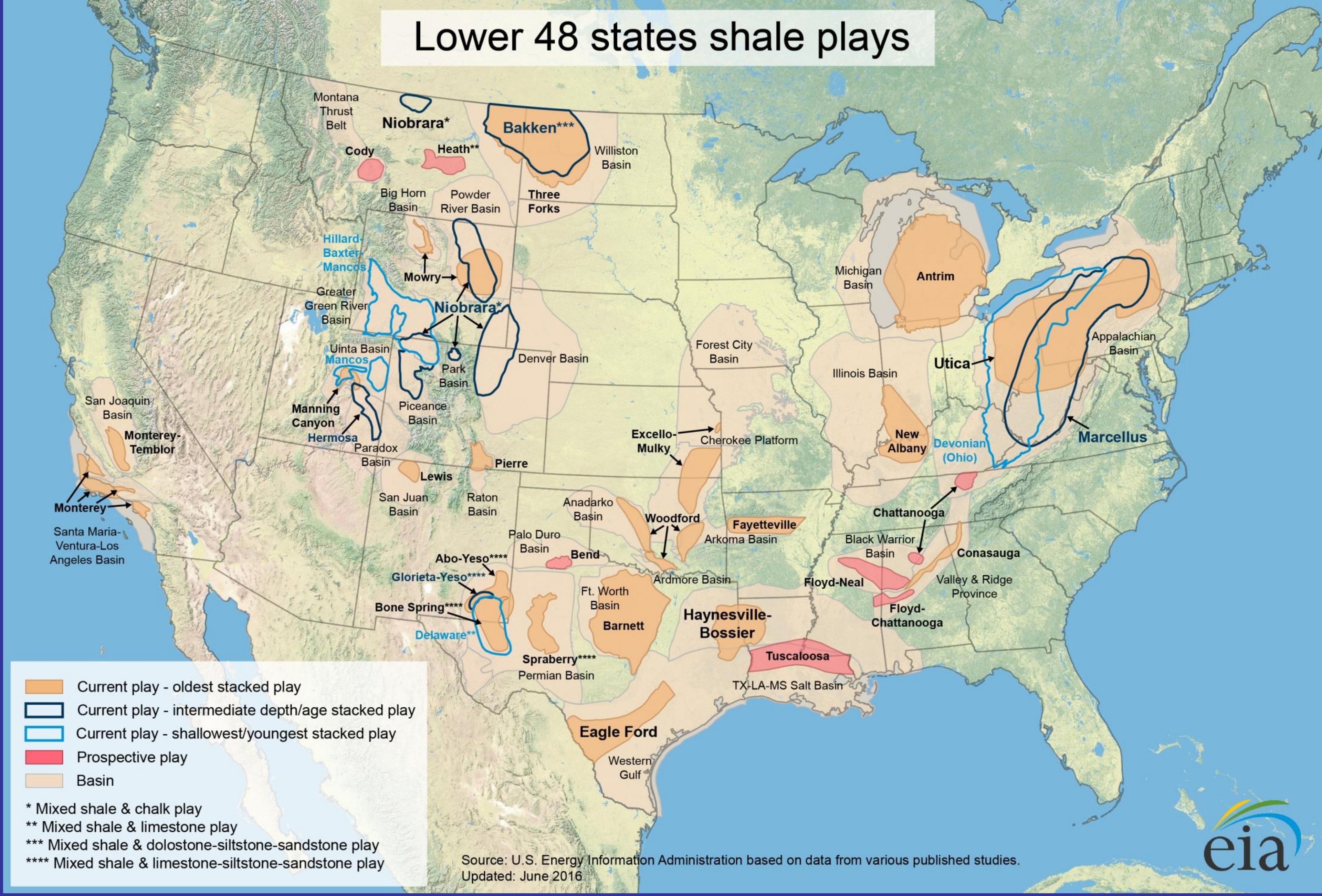
- High crush strength (pressure achieved before 10% fines generated by crushing)
  - 8K to 11K (8000 to 11,000 psi) is quite good for 40/70 sand from Wisconsin
- Little overburden
- Direct access to good transportation
  - Excellent roads (county or state highways)
  - Load to rail or barge
  - Wisconsin has good access to Tier 1 Rail—BNSF, CN, CP, and UP.



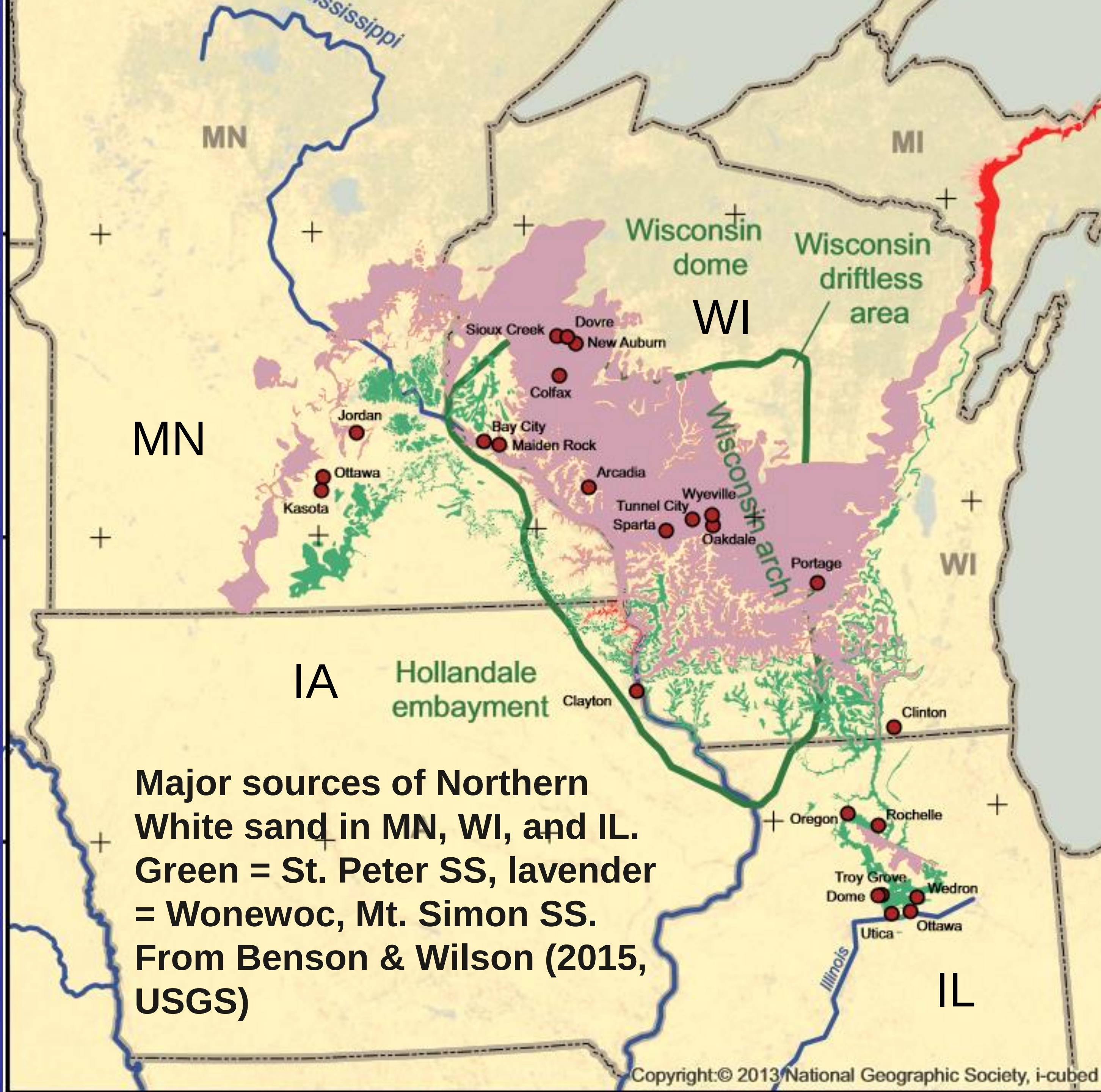
Rail infrastructure.

From Wisconsin DOT (2014)

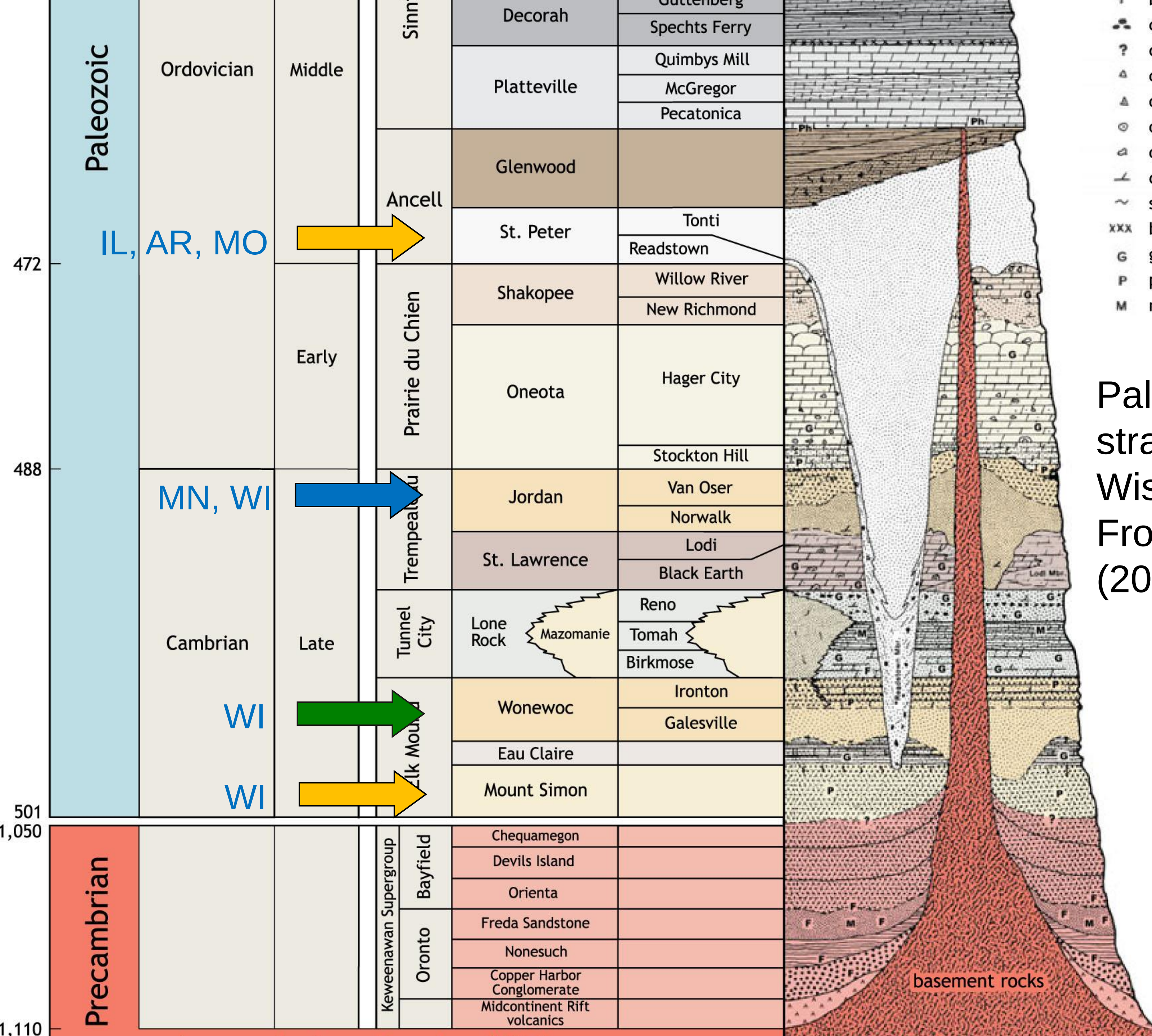
Access to good roads and rail

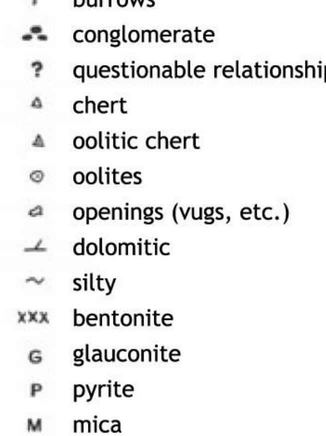


U.S. Energy Administration (public domain, June 2016)



Major sources of Northern White sand in MN, WI, and IL. Green = St. Peter SS, lavender = Wonewoc, Mt. Simon SS. From Benson & Wilson (2015, USGS)

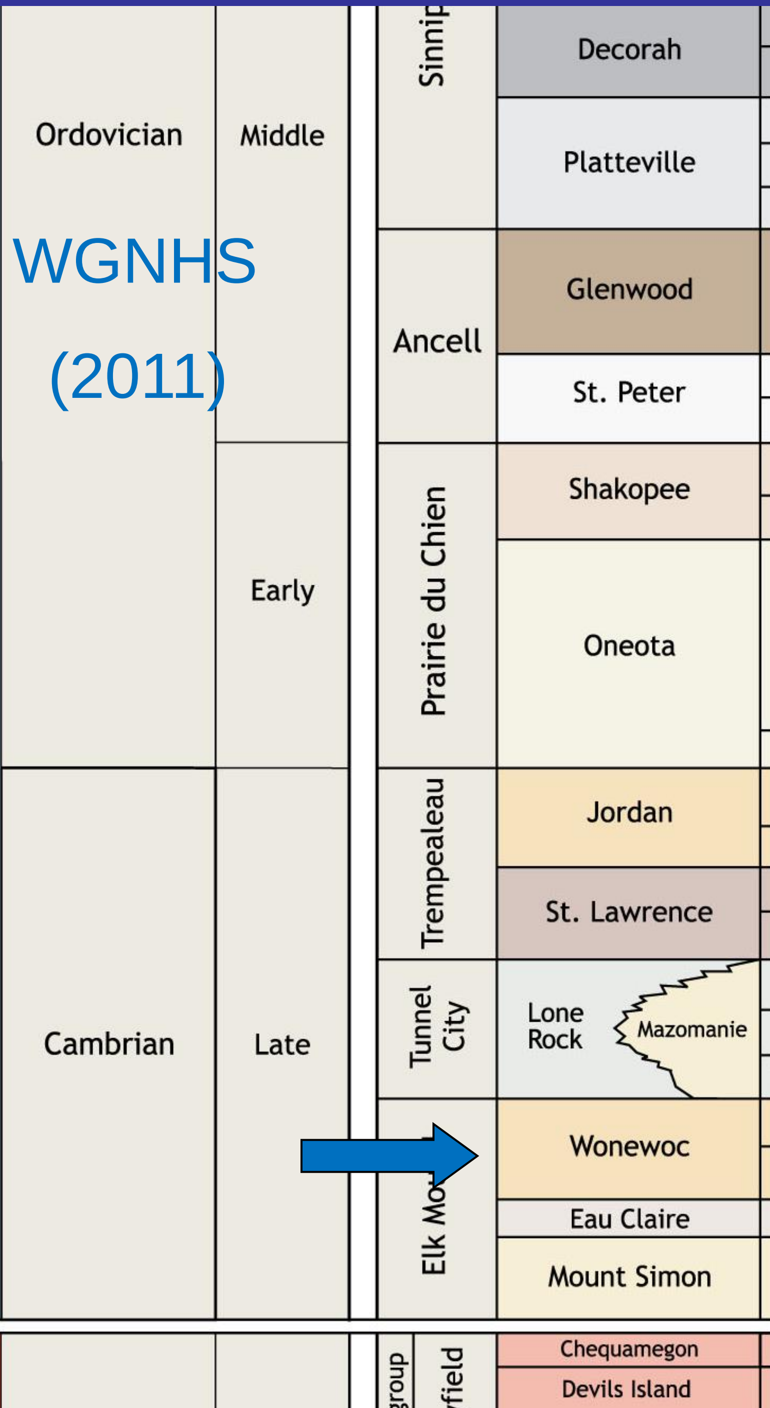


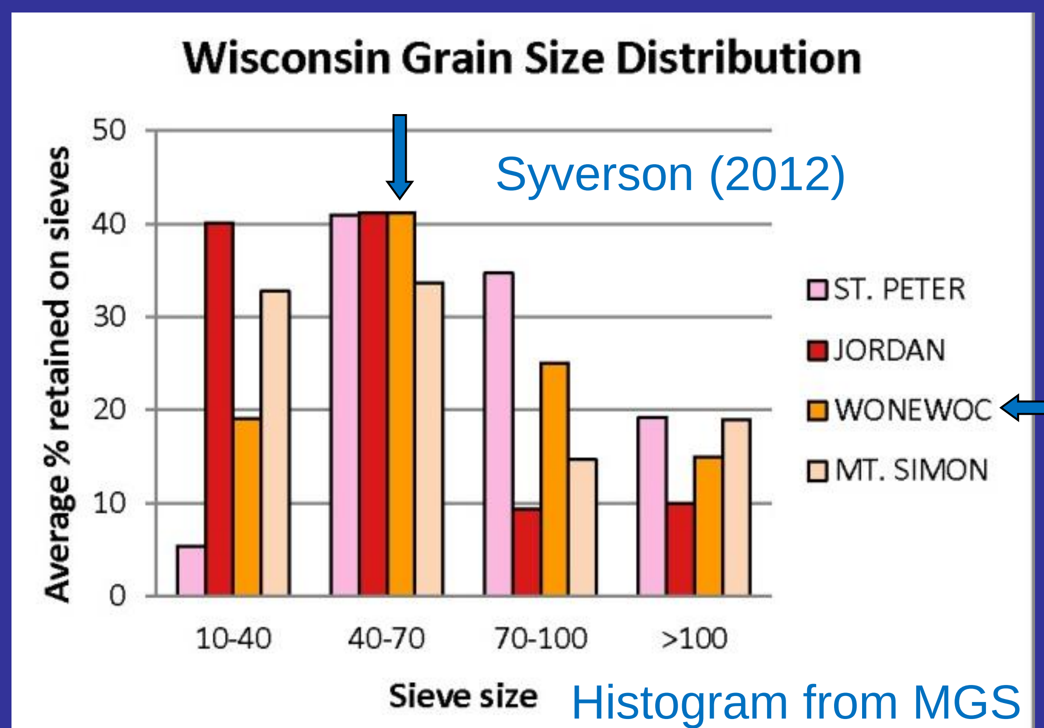


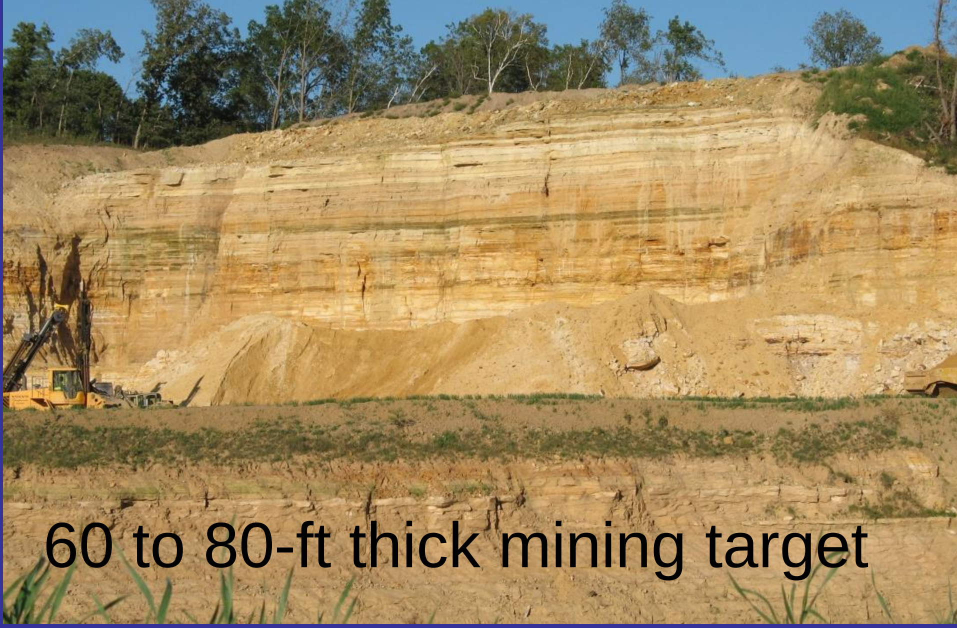
Paleozoic stratigraphy in Wisconsin. From WGNHS (2011).

Wonewoc Fm.

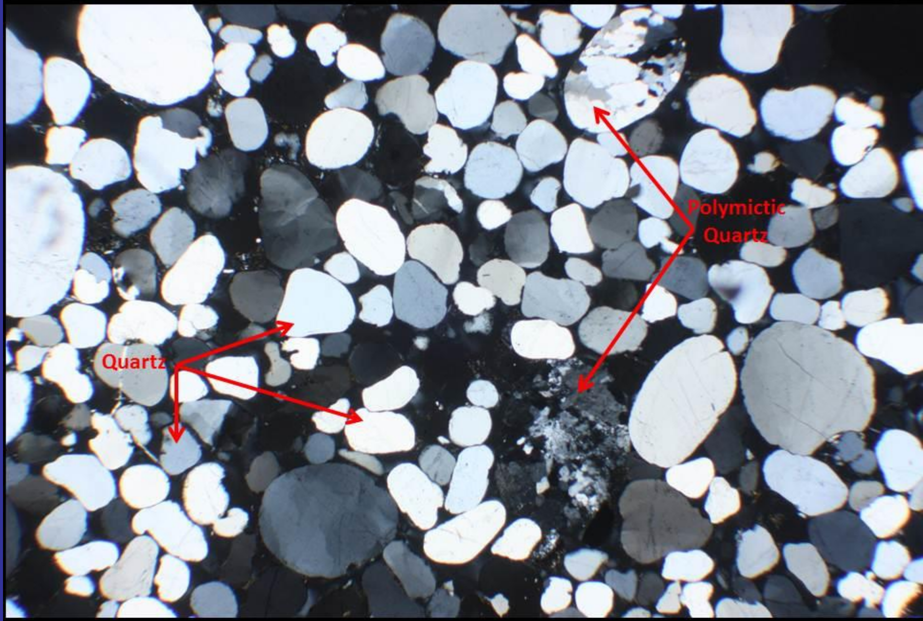
- Good producer 30/50 & 40/70 mesh
- 11K crush strength reported on 40/70 (Preferred Sands, Blair)



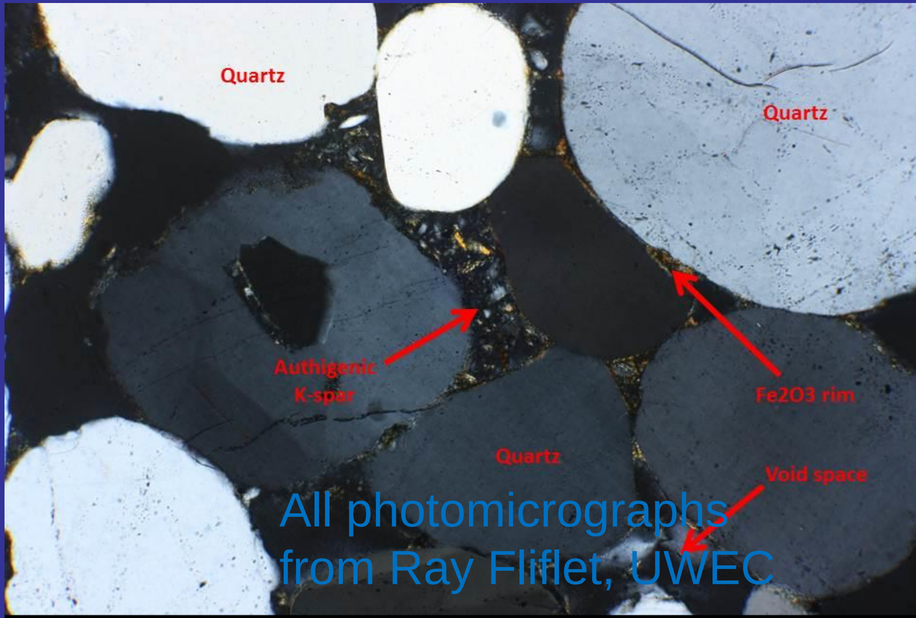




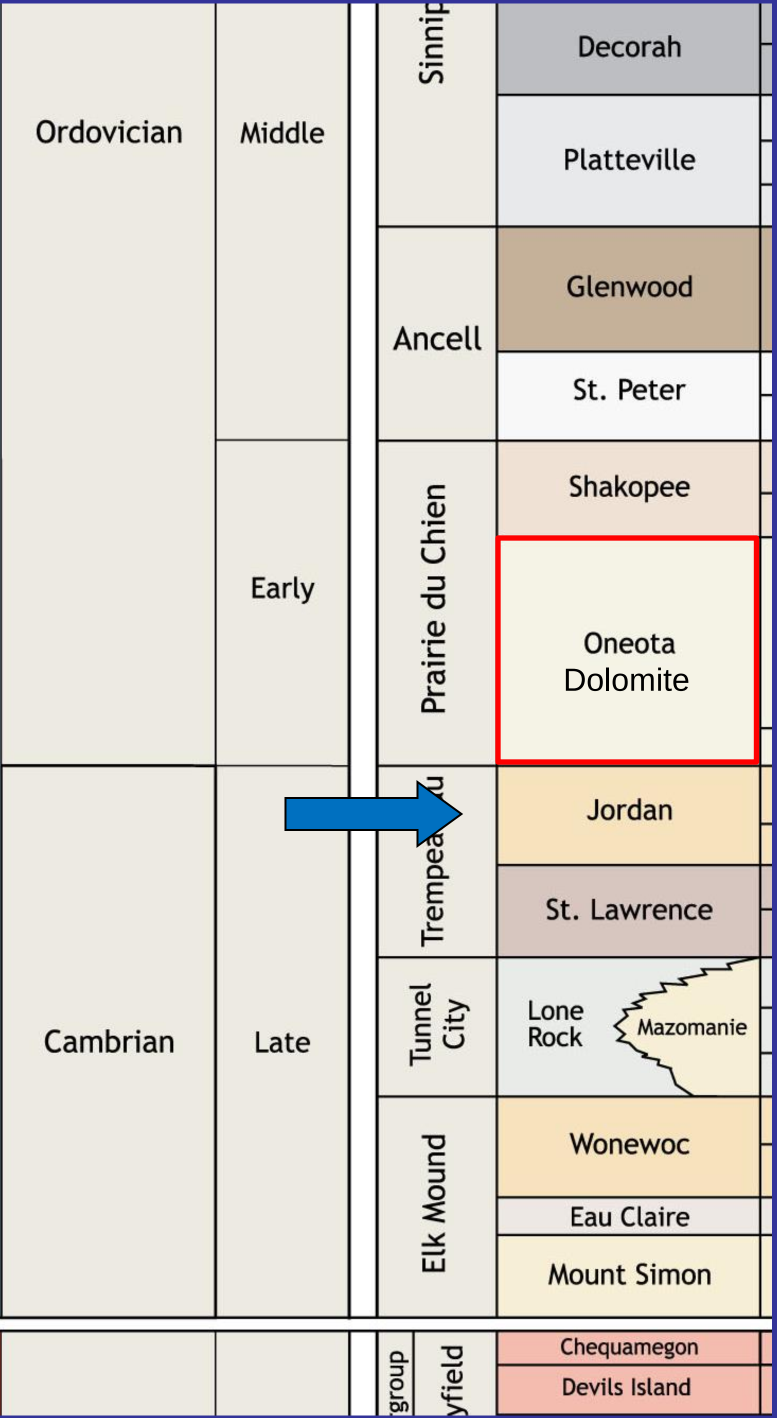
Preferred Sands mine, Blair



Wonewoc Formation, Colfax (F.O.V.=11 mm)

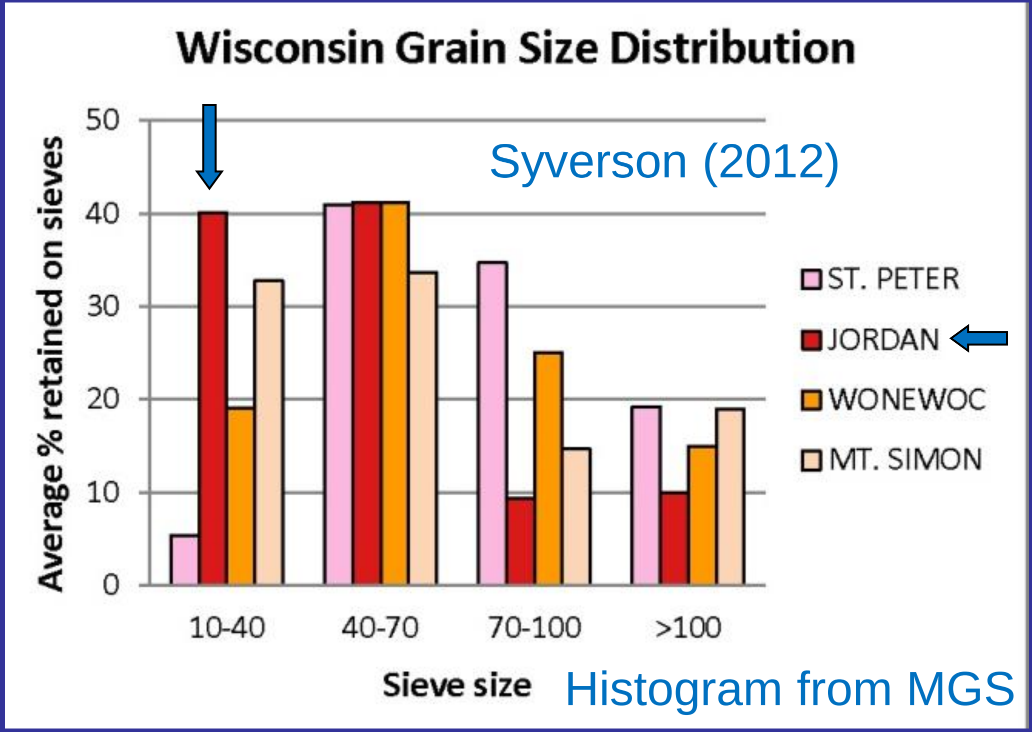


Wonewoc Formation, Colfax (F.O.V.=3 mm)



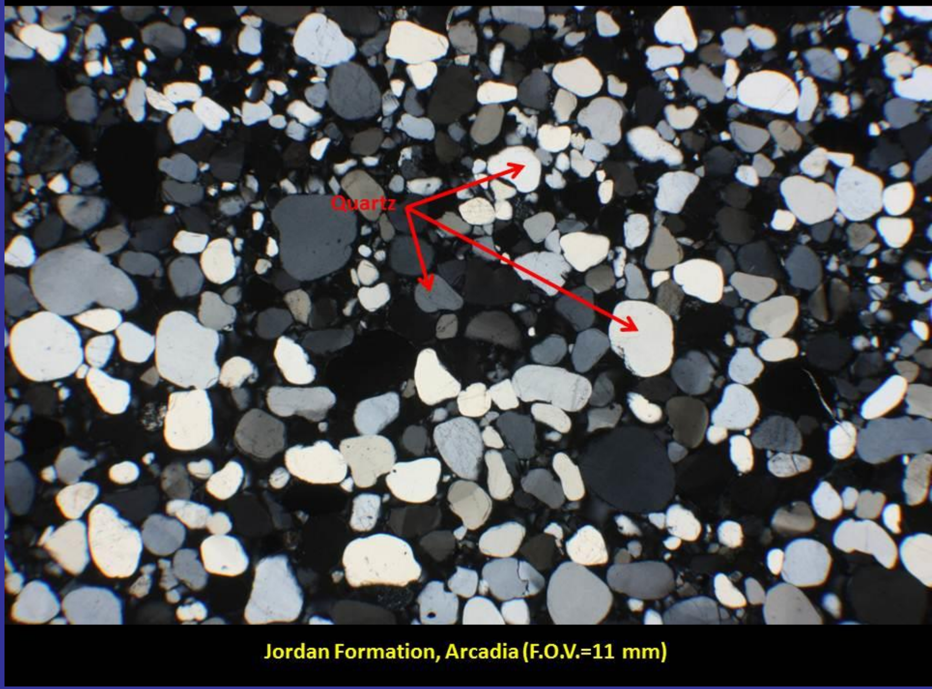
Jordan Fm.

- Upper Jordan Fm. (Van Oser Mbr.) – now too much 20/40
- Overlain by dolomite

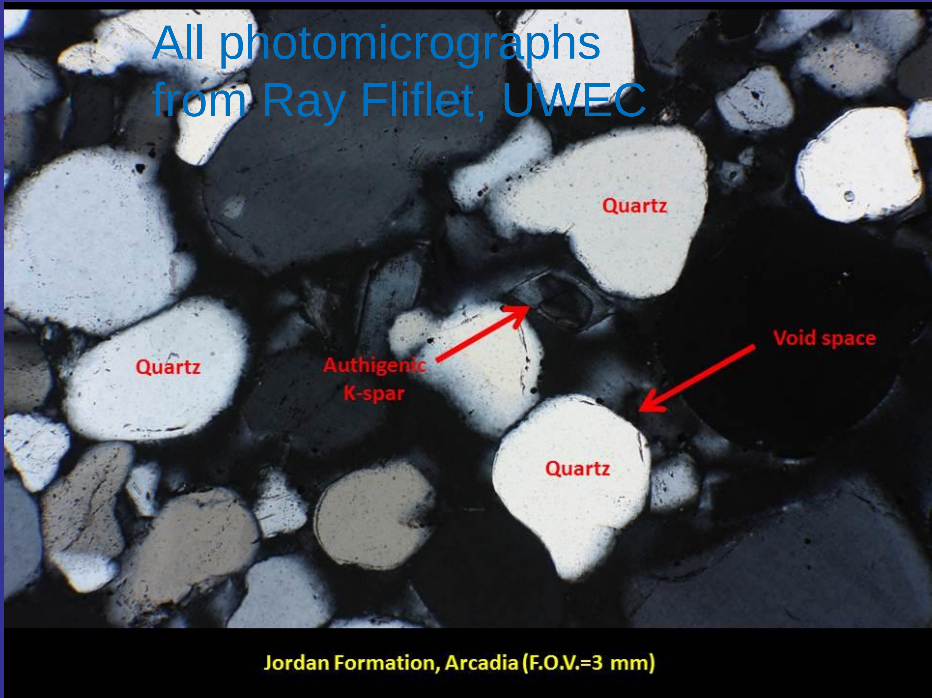


Jordan Formation

- Typically poorly cemented
- Buffalo Cty outcrop (above)--coarse grained (so fallen out of favor)



All photomicrographs from Ray Fliflet, UWEC

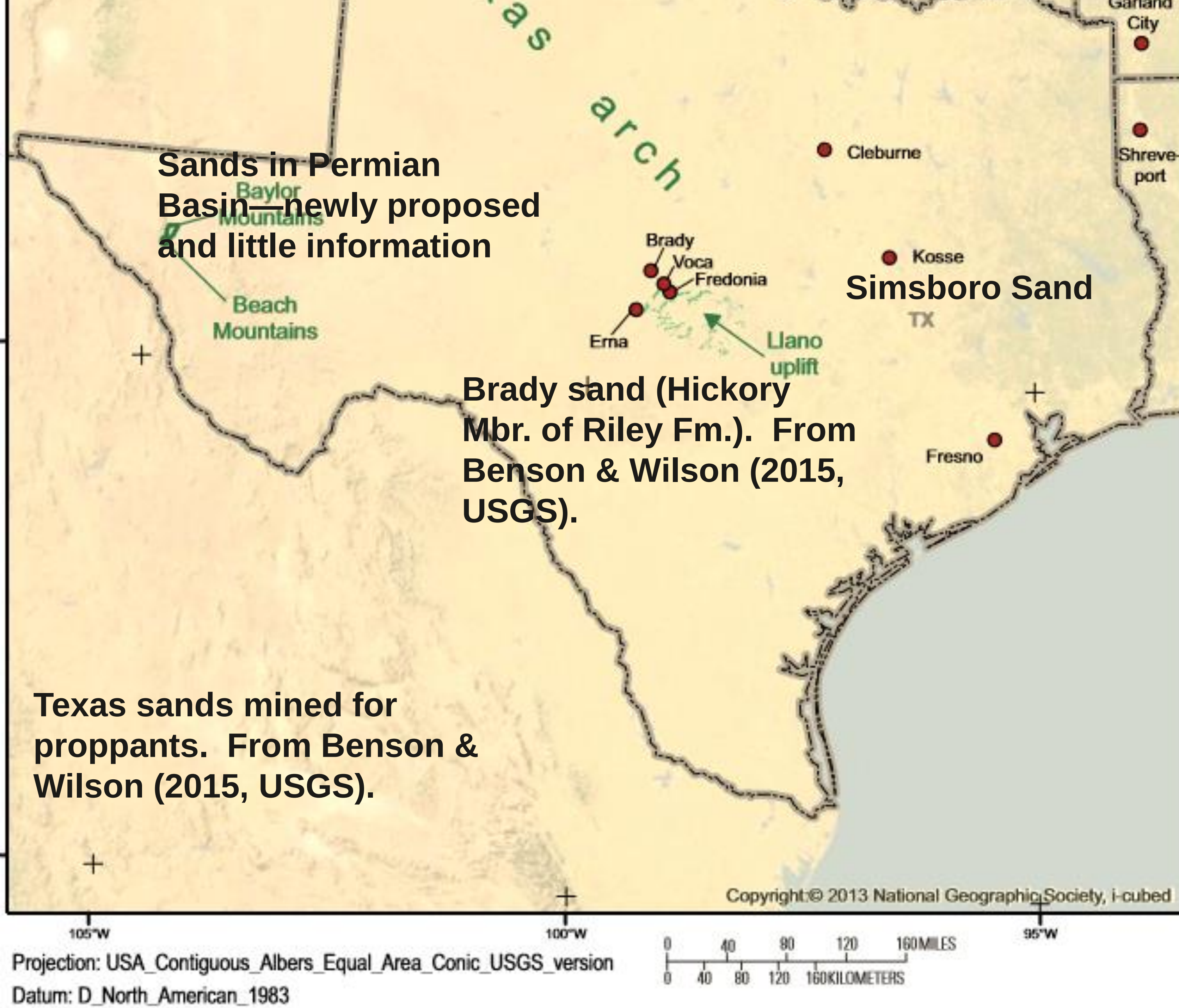


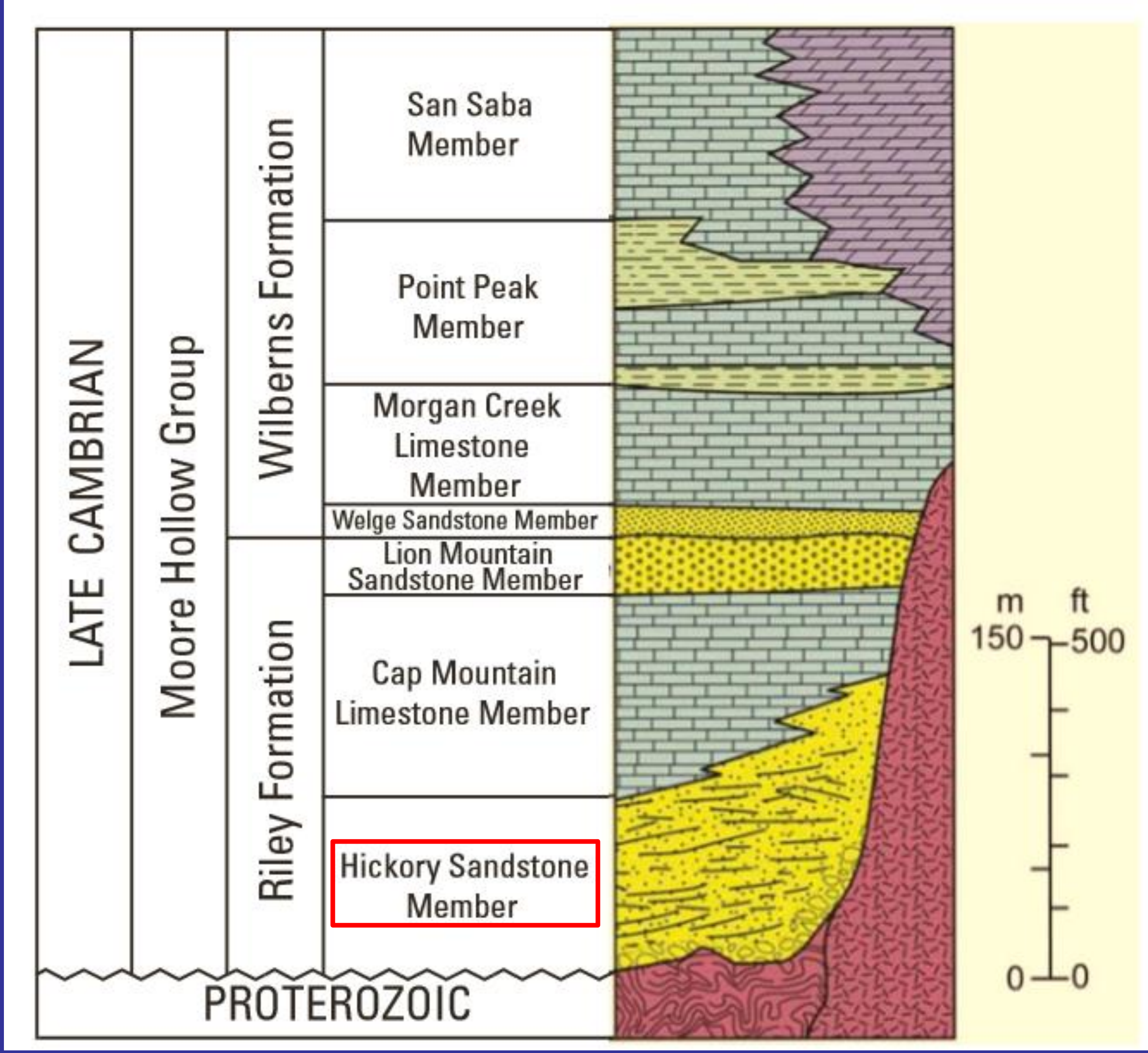
Sands in Permian Basin—newly proposed and little information

Simsboro Sand

Brady sand (Hickory Mbr. of Riley Fm.). From Benson & Wilson (2015, USGS).

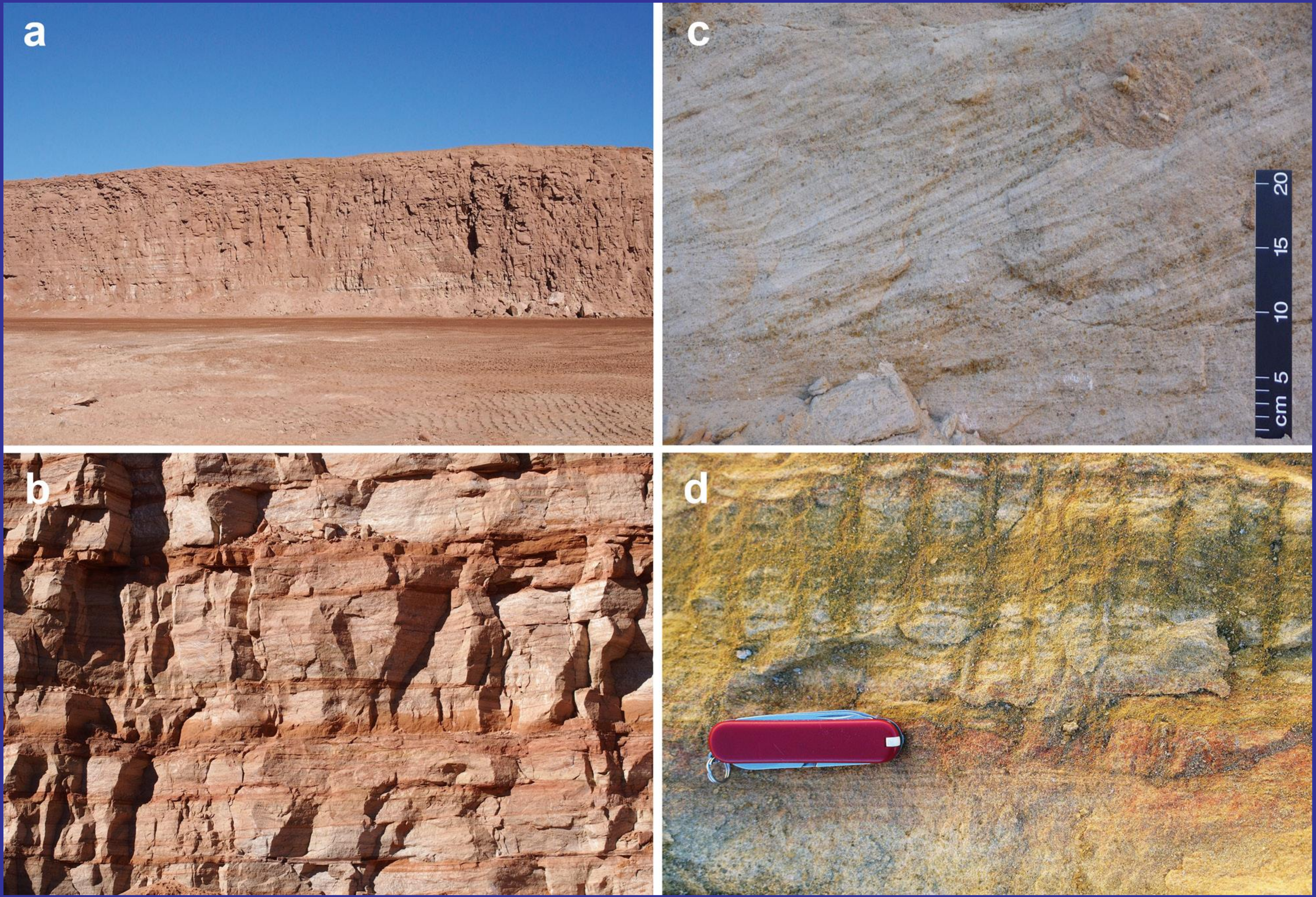
Texas sands mined for proppants. From Benson & Wilson (2015, USGS).

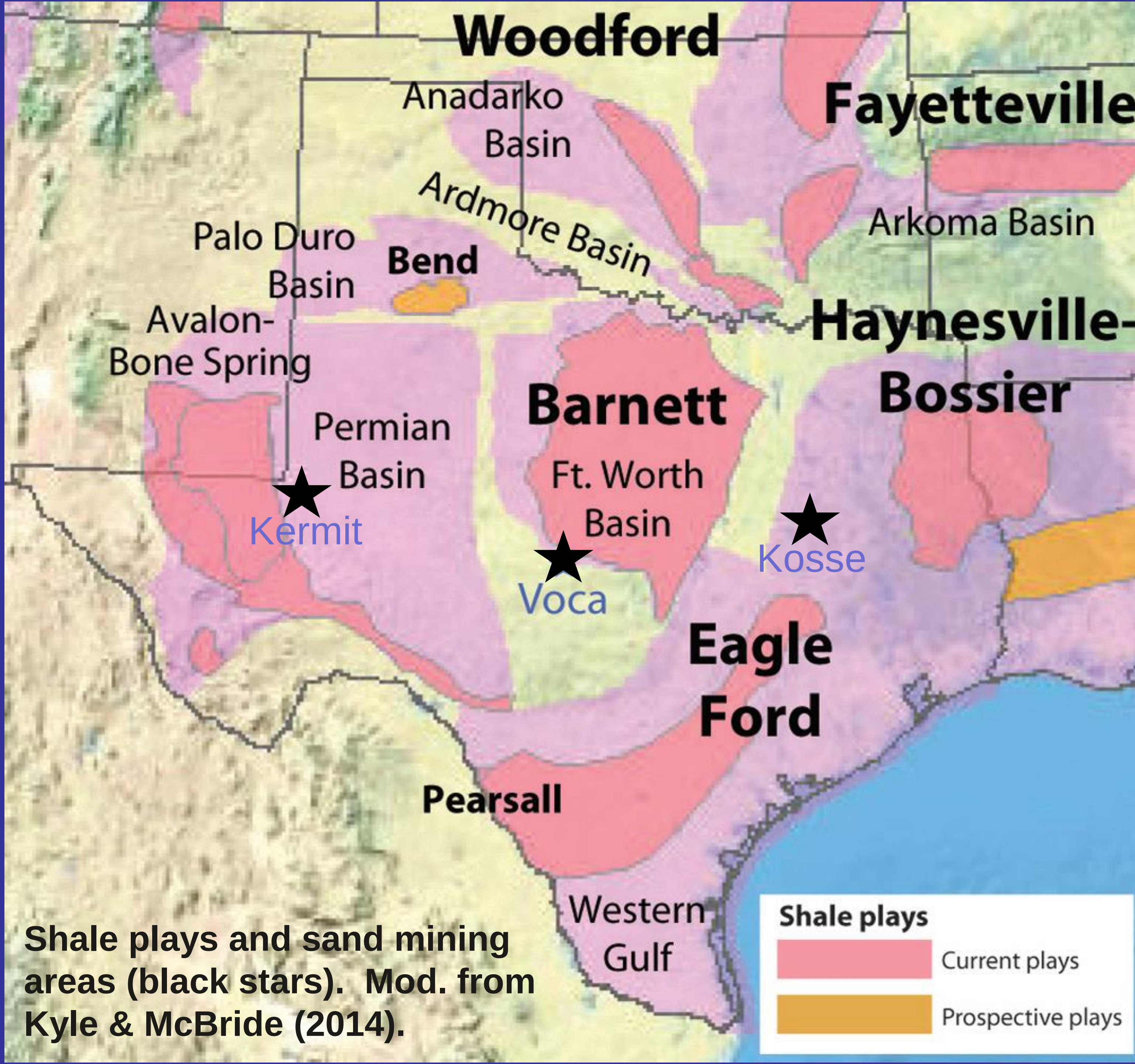




Hickory Sandstone—mined near Voca and Brady, Texas--“Brady brown sand.” From Kyle & McBride (2014)

Hickory Sandstone, Voca, TX.
From Kyle & McBride (2014)





Shale plays and sand mining areas (black stars). Mod. from Kyle & McBride (2014).

Can Northern White sand from WI/MN compete with Texas sand?

- Companies will use sand that generates the most profit.
- Texas sands do not require rail transport, so they are less expensive than WI sand.
- Is Northern White sand from the Midwest still relevant in today’s market and in the future?

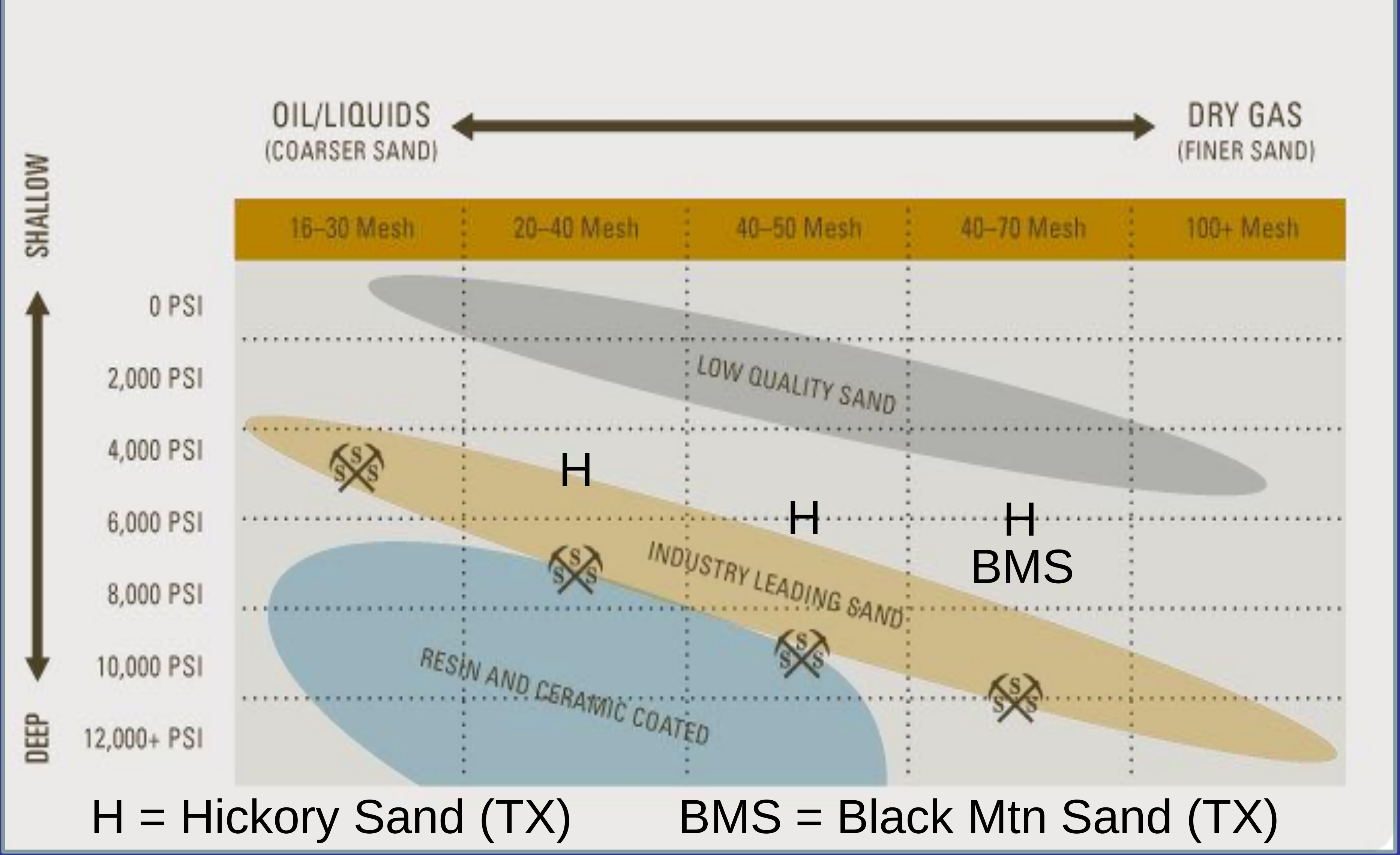
Crush test comparisons

	20/40 mesh	30/50 mesh	40/70 mesh
Northern White sand	7K (FMSA) 7K (Pref.[1], WonFm) 7K (HCLP, WonFm) 7K (HCLP, Wyev.) 7K (NIS[2], WonFm) 6K (BMC[3], WonFm) 7K (EMES,WonJnFm)	8K (FMSA) 8K (Pref. [1], WonFm) 8K (HCLP, WonFm) 10K (HCLP, Wyev.) 8K (NIS[2], WonFm) 8K (BMC, WonFm)	8/9K (FMSA) 11K (Pref. [1], WonFm) 9/10K (HCLP, WonFm) 11K (HCLP, Wyev.) 10K (NIS[2], WonFm) 9K (BMC, WonFm) 11K (EMES, WonJnFm)
Texas sand	5K (FMSA, Hickory)	6K (FMSA, Hickory) 6K (SLCA, Hickory)	6K (FMSA, Hickory) 6K (SLCA, Hickory) 7K (Black Mtn Sand[4])

[1]Preferred Sands
[2]Northern Industrial Sands
[3]Badger Mining Corp.
[4]Located in the Permian Basin

Please note: All values obtained from values ***self reported*** by companies in online technical datasheets.

- Closure stress for hydraulic fractures- typical range = 0.63 to 0.88 psi/foot of depth (Crane’s Petrophysical Handbook)
- *Roughly* 1K per 1000 ft/depth
- Northern White 40/70 sand with 10K crush can be used to ~10,000 ft and Texas 40/70 with 6K crush to depth of ~6000 ft.
  - Pioneer Natural Resources produces oil in Permian Basin at depths ranging from 6,700 to 11,300 ft (Pioneer, n.d.).
  - Significance—Deeper plays in Permian Basin require strong sand. Favors Northern White sand.



Modified from Superior Silica Sands (website, downloaded 4/11/17, used with permission)

Trucking issues

- Comments from logistics person at San Antonio frac sand meeting
  - Reported *one-way* trucking times for Texas sand of 5 hrs—plus waiting time for unloading
  - He preferred Northern White sand because of higher quality AND brought by train to transload near the center of the basin--trucking ~1 hr one way.
- Last-mile logistics with Texas sands can be complicated. Innovations—Sandbox (SLCA) and PropStream (HCLP)

"Last Mile" Delivery Solutions

Trans-Load Storage

- Requires minimally developed land for a transloading facility
- Dramatically reduces last mile distances by utilizing available rail track
- Low capital investment and operating expense
- Proppant protected from elements
- Quickly scalable and highly flexible

Delivery

- Quick loading and unloading
- Enhanced proppant pre-delivery and staging
- Eliminates truck detention
- Enables continuous frac operations
- Minimizes storage footprint
- Allows frac crew to improve efficiency by up to 50%

Wellhead

- Proppant delivered directly into the blender hopper
- Addresses silica dust issue
- Precise control and measurement of proppant
- Increased rate of fracking
- Safer wellsite due to lower truck traffic

Trucking issues are spurring innovation to reduce waiting times at fracking pads. One example—**Sandbox** owned by US Silica.

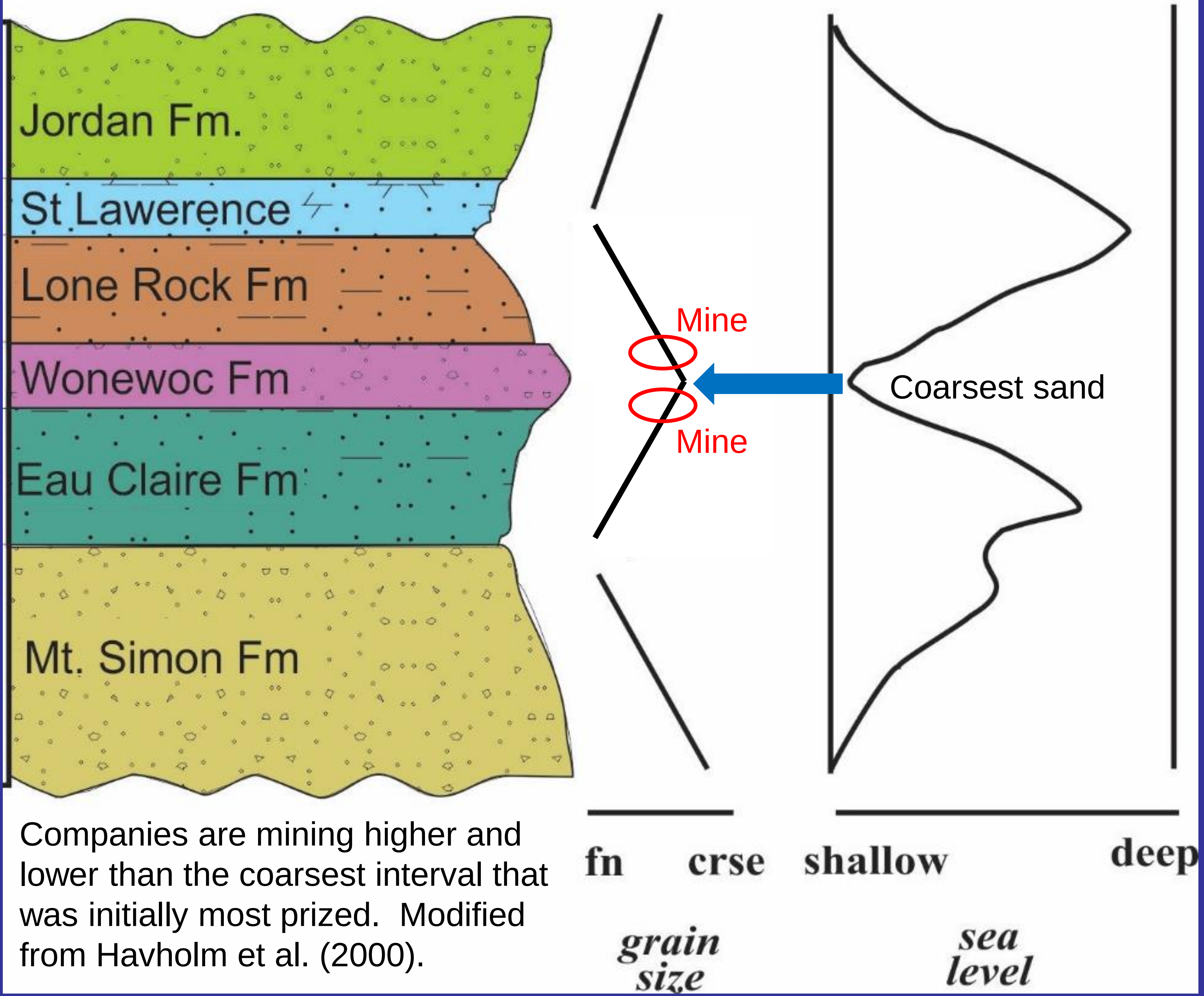
Used with permission from U.S. Silica, https://www.slideshare.net/tswittrig/sandbox-acquisition-investor-us-silica

Sand sources being proposed in Texas

- **EMES**—Osburn Materials, located near Eagle Ford. Capacity—3.1Mt/yr.
- **Preferred Sands**—Near Eagle Ford.
- **Hi-Crush**—Kermit facility in Permian Basin. Capacity—3.0Mt/yr. Under construction.
- **Black Mountain Sand** in Permian Basin. Capacity—4.0Mt/yr.
- ***Big question***—will Texas sand quality be "good enough" to meet much of Texas' proppant demand?

Changes in desired grain sizes

- Wisconsin sand industry expanded when coarse sand (20/40) was highly prized.
- Now fine sands (40/70 and 100 mesh) are in greatest demand
- New trends in Wisconsin
  - Some companies are mining fine-grained “waste sand” from previous years
  - Companies are mining above and below the coarsest parts of sandstone formations



Companies are mining higher and lower than the coarsest interval that was initially most prized. Modified from Havholm et al. (2000).

Union Pacific rail network

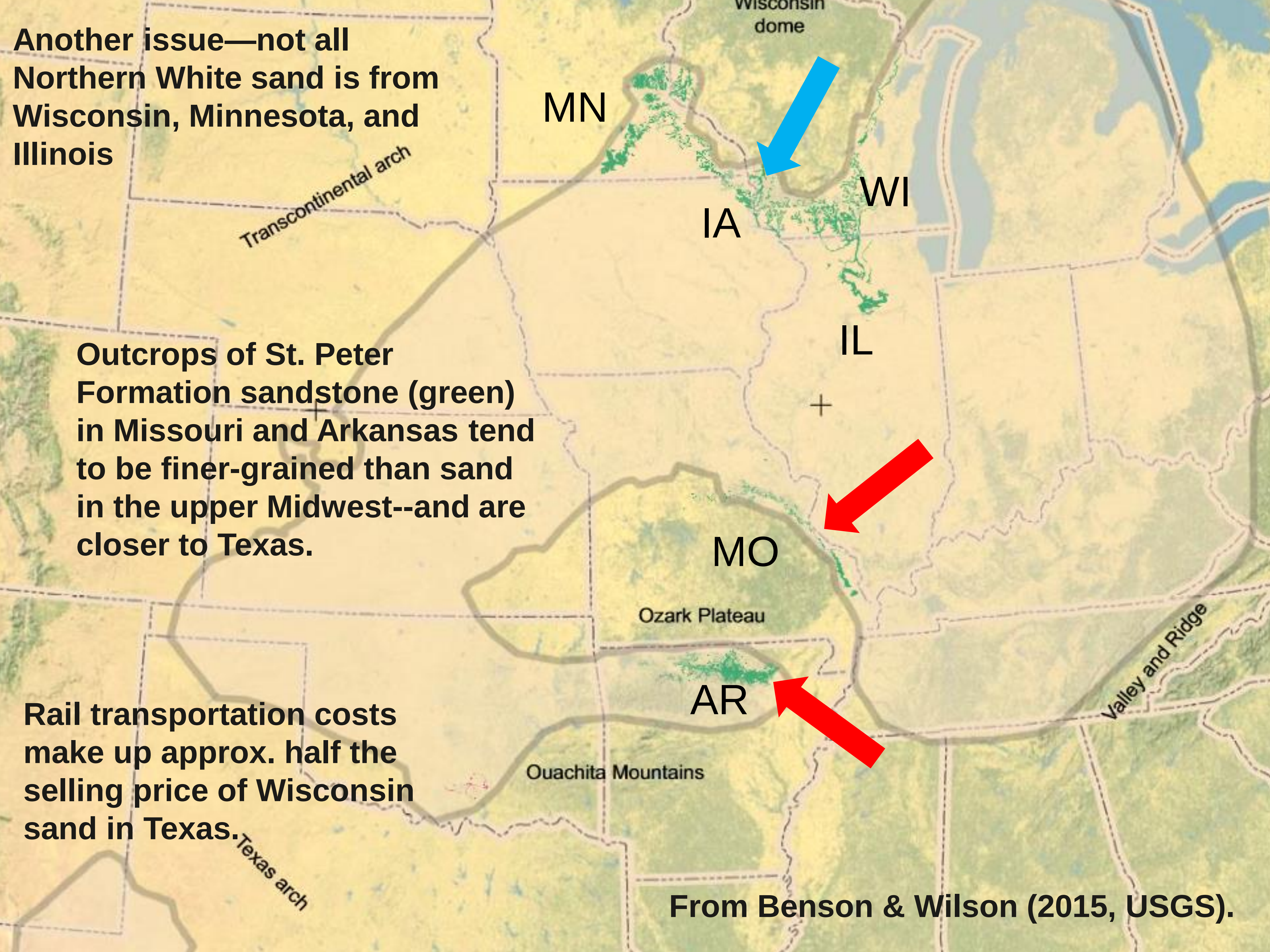
Sand mines

TX shale plays

Wisconsin sand companies are:
1) building additional rail loadouts to gain access to other markets (such as the Permian), and

2) using more unit trains.

http://www.up.com/aboutup/usguide/


Another issue—not all Northern White sand is from Wisconsin, Minnesota, and Illinois
Outcrops of St. Peter Formation sandstone (green) in Missouri and Arkansas tend to be finer-grained than sand in the upper Midwest--and are closer to Texas.
Rail transportation costs make up approx. half the selling price of Wisconsin sand in Texas.
From Benson & Wilson (2015, USGS).
Wisconsin dome
MN
WI
IA
IL
MO
AR
Transcontinental arch
Ozark Plateau
Ouachita Mountains
Texas arch
Valley and Ridge

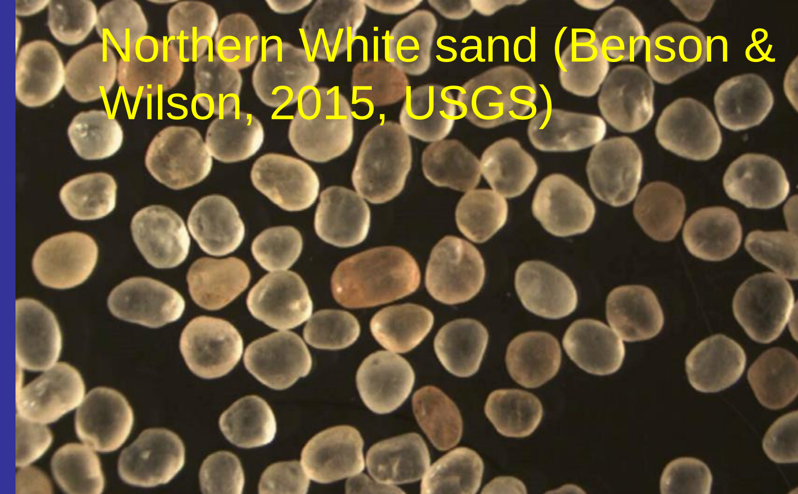
Conclusions

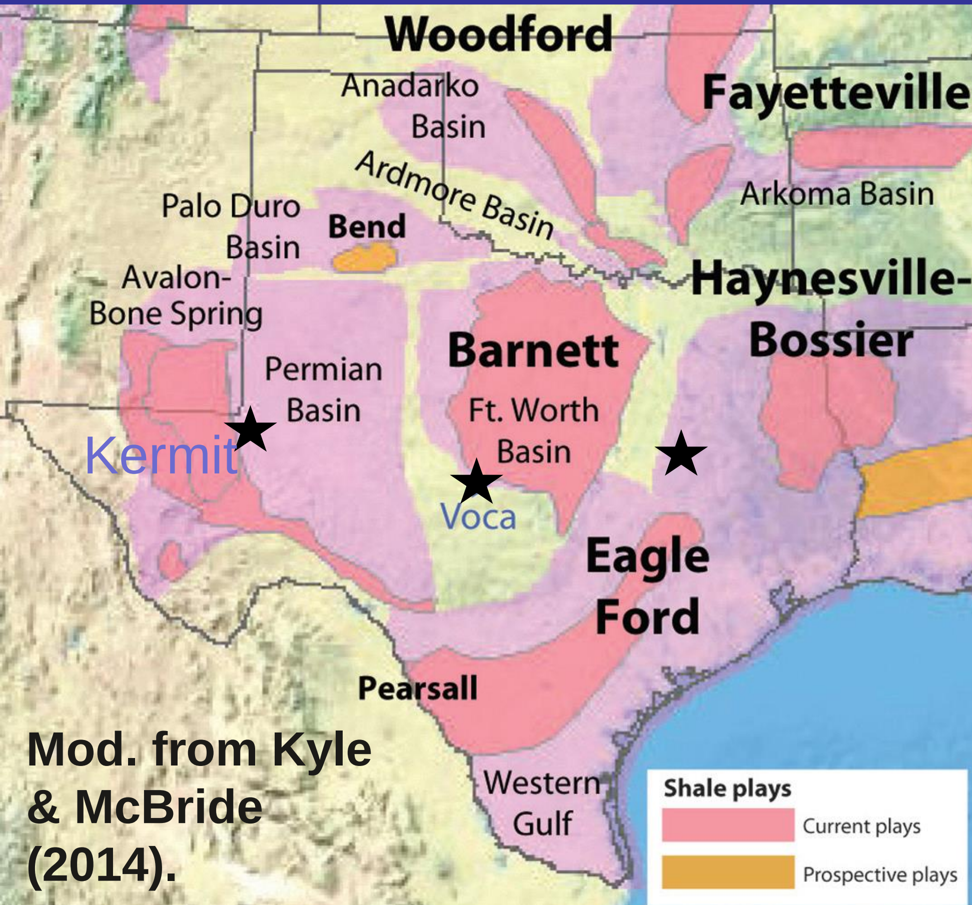
- ***Northern White sand is very strong, so can be pumped at greater depths than Texas brown sand.***
- Wisconsin facilities are mining finer-grained parts of formations (as well as years of waste sand) to provide more 40/70 and 100 mesh sand.
- Wisconsin facilities adding rail loadouts on different rail lines to diversify markets.
- Unit trains--transportation more efficient.

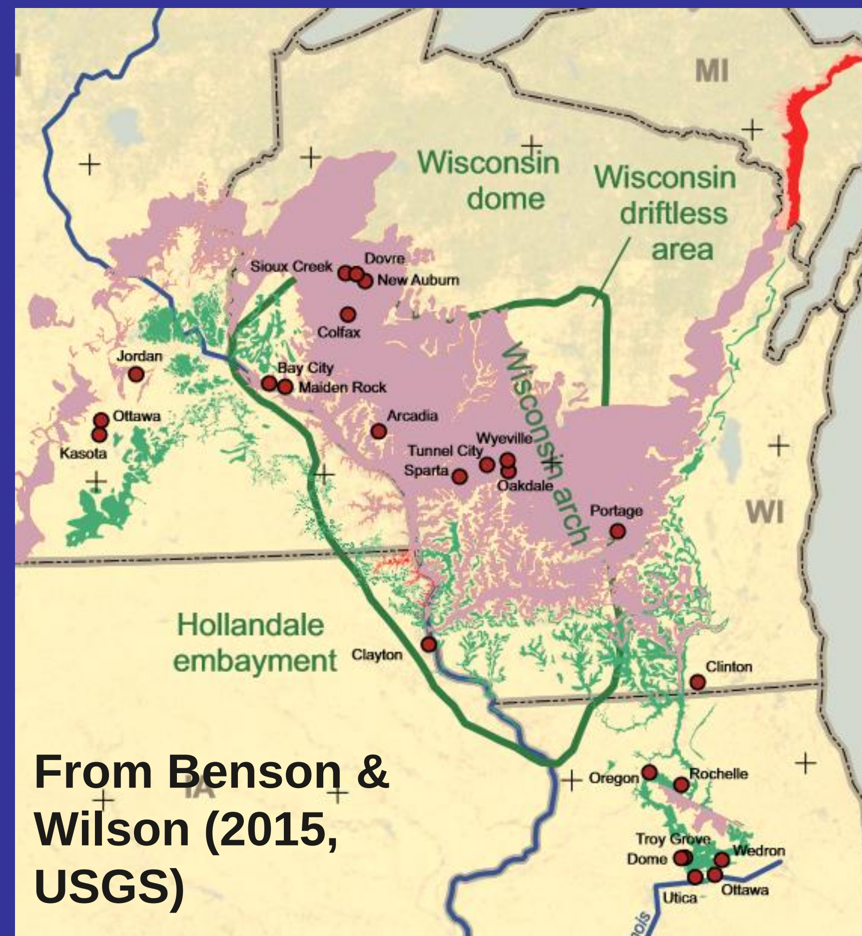
Conclusions (cont.)

- Last-mile trucking logistics in Texas can make use of Texas brown sand difficult.
  - Will use of containers such as Sandbox and PropStream alleviate this problem?
  - Will proposed sand mines in Permian Basin *supply sand of sufficiently high quality* to replace some/much Northern White sand?
- More Northern White sand mines coming online in Missouri and Arkansas. These mines will have lower rail transportation costs than WI/MN mines.

Questions?


Northern White sand (Benson & Wilson, 2015, USGS)


Woodford
Anadarko Basin
Fayetteville
Ardmore Basin
Arkoma Basin
Palo Duro Basin
Bend
Avalon-Bone Spring
Haynesville-Bossier
Barnett
Permian Basin
Ft. Worth Basin
Kermit
Voca
Eagle Ford
Pearsall
Western Gulf
Shale plays
Current plays
Prospective plays
Mod. from Kyle & McBride (2014).


MI
Wisconsin dome
Wisconsin driftless area
Sioux Creek
Dovre
New Auburn
Colfax
Jordan
Bay City
Maiden Rock
Ottawa
Kasota
Arcadia
Wyeville
Tunnel City
Sparta
Oakdale
Wisconsin arch
Portage
WI
Hollandale embayment
Clayton
Clinton
Oregon
Rochelle
Troy Grove Dome
Wedron
Utica
Ottawa
From Benson & Wilson (2015, USGS)

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