USGS
science for a changing world

Where in the U.S. is the naturally-occurring Frac Sand?

Anna B. Wilson and Mary Ellen Benson

Presented at Frac Sand Insider Conference
Pittsburgh, Pennsylvania
November 17, 2014

U.S. Department of the Interior
U.S. Geological Survey

Outline

- Digital mapping and GIS
- Approach to mapping frac sand geological source units
- Results – Maps generated
  - Geological sources of frac sand in the US
  - Principal producing frac sand source units
  - Potential new sources of frac sand*
  - Sand produced for resin-coated proppants
- Future of the USGS frac sand project

USGS

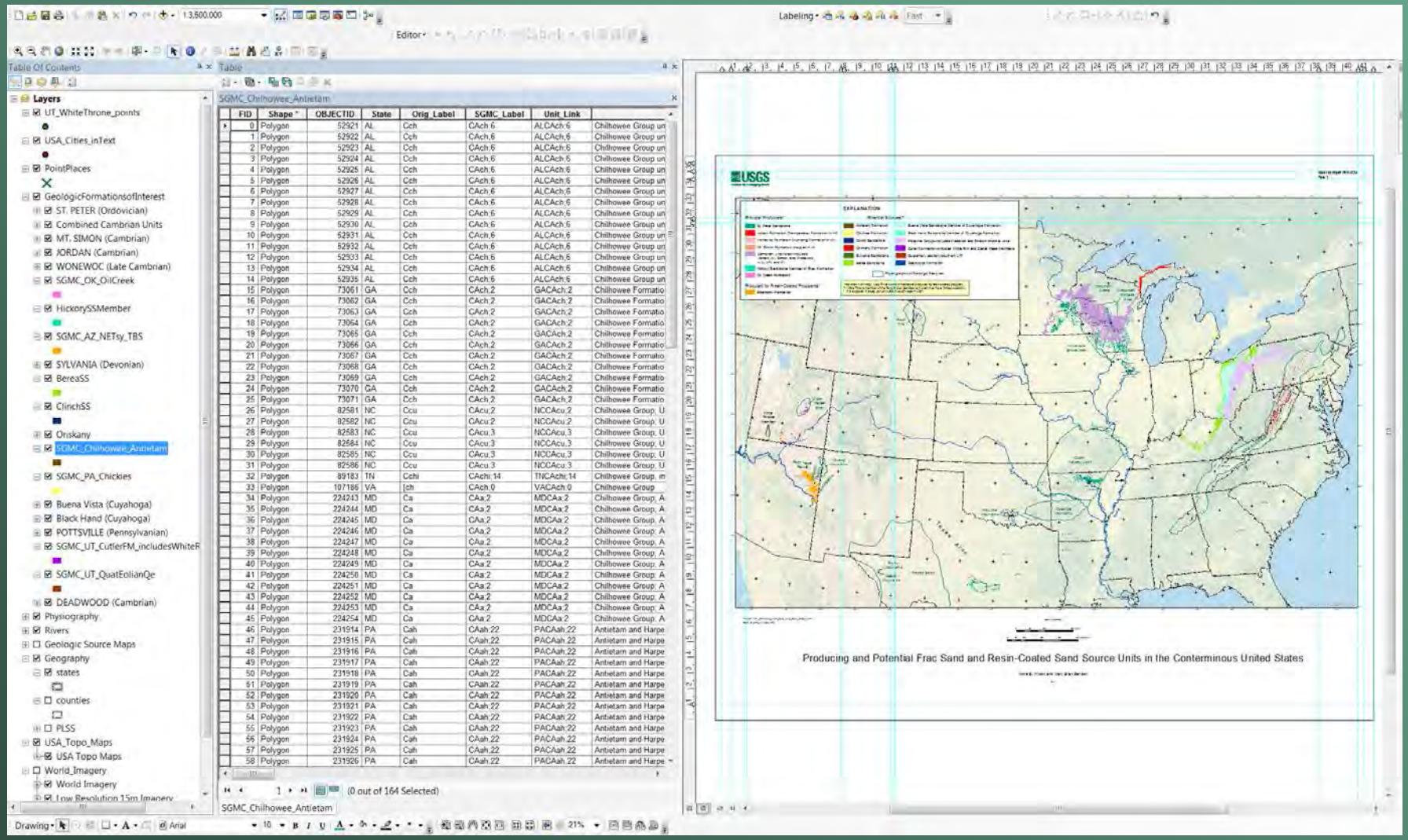
*Note that these source units are presented as reported in published literature or websites as potential frac sand whether or not they meet any or all of the API specifications for frac sand. These units have not been independently assessed, analyzed, or evaluated by the U.S. Geological Survey, and neither the U.S. Geological Survey nor the presenters make any claim as to the suitability of these units as frac sand.

The digital mapping world and GIS

- GIS = Geographic Information Systems
- Software—commonly ArcGIS (ESRI), MapInfo, or another similar package
- GIS maps aren't just images, they have associated spatial data.
- The data are represented by points (i.e. towns), lines (i.e. faults), and polygons (i.e. rock units, water bodies, etc.).
- Each "thing" on the map is coded in a database so it can be searched for or selected or mapped.
- Data can be combined in any number of ways with data from other maps and databases.
- Some GIS data can be served online and used without special software (ie. Directions in Google Maps).

USGS

Mapping in GIS – an example



USGS

(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)

How to find Frac Sand host units ?

- In an ideal world
  - Geology detailed enough to show individual units all by themselves
  - Seamless coverage of the U.S. in GIS
  - Units coded by rock lithology (ie. sandstone)
  - Locations of current and former silica and glass sand mines are accurate and in a mappable database.
  - Locations of active and permitted frac sand mines are accurate and in a mappable database.

USGS

ALAS…

- This is the real world
  - Geology is not consistently mapped in detail.
  - Coverage of U.S. is not seamless.
  - Geology is mapped at various scales.
  - Lithologic coding is inconsistent and variable.
  - Locations of active and former glass sand mines are incomplete and inaccurate.
  - Locations of active and future frac sand mines are incomplete.

USGS

So what did we use ?

- USGS partnered with States to produce digital versions of individual State-scale geologic maps (commonly 1:500,000 or 1:1,000,000).
- USGS coded the units for rock type, age, etc.
- USGS is in the process of stitching the maps into a unified dataset (SGMC).
- We used an early version that has not yet been published, although all the individual pieces are available at http://mrdata.usgs.gov/geology/state/.

USGS

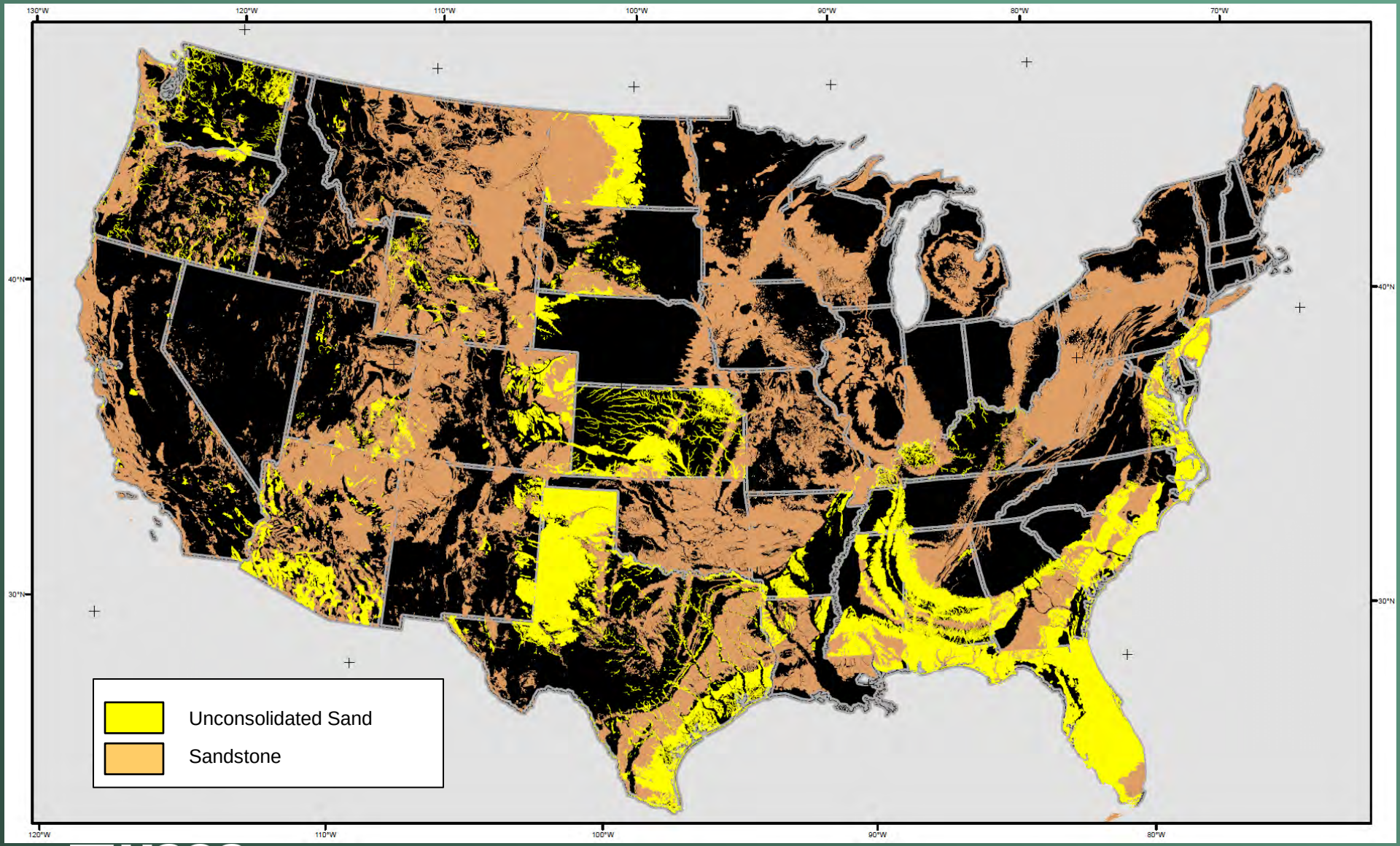
Geologic map of the U.S.

- Geology derived from state geologic maps
  - Geology at 1:500,000 (or 1:1,000,000)
  - Rock formations of interest are not always mapped.
  - Formations of interest are commonly combined with other rock units and may be over-represented.
- Topo background from ESRI[1]

USGS

1. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

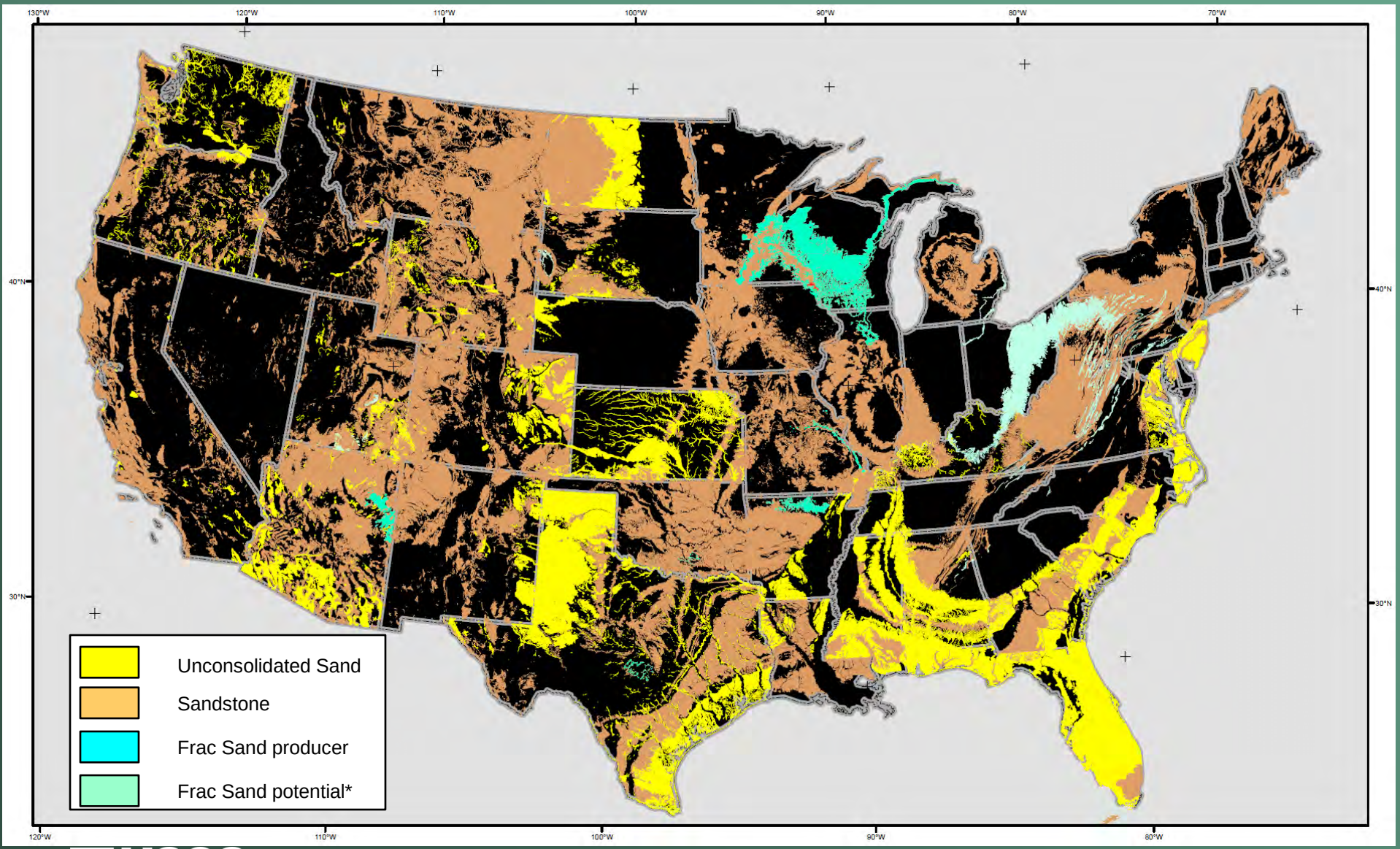
All sand and sandstone units in conterminous U.S.



USGS

(Wilson and Benson, unpublished data;
modified from U.S. Geological Survey, 2014)

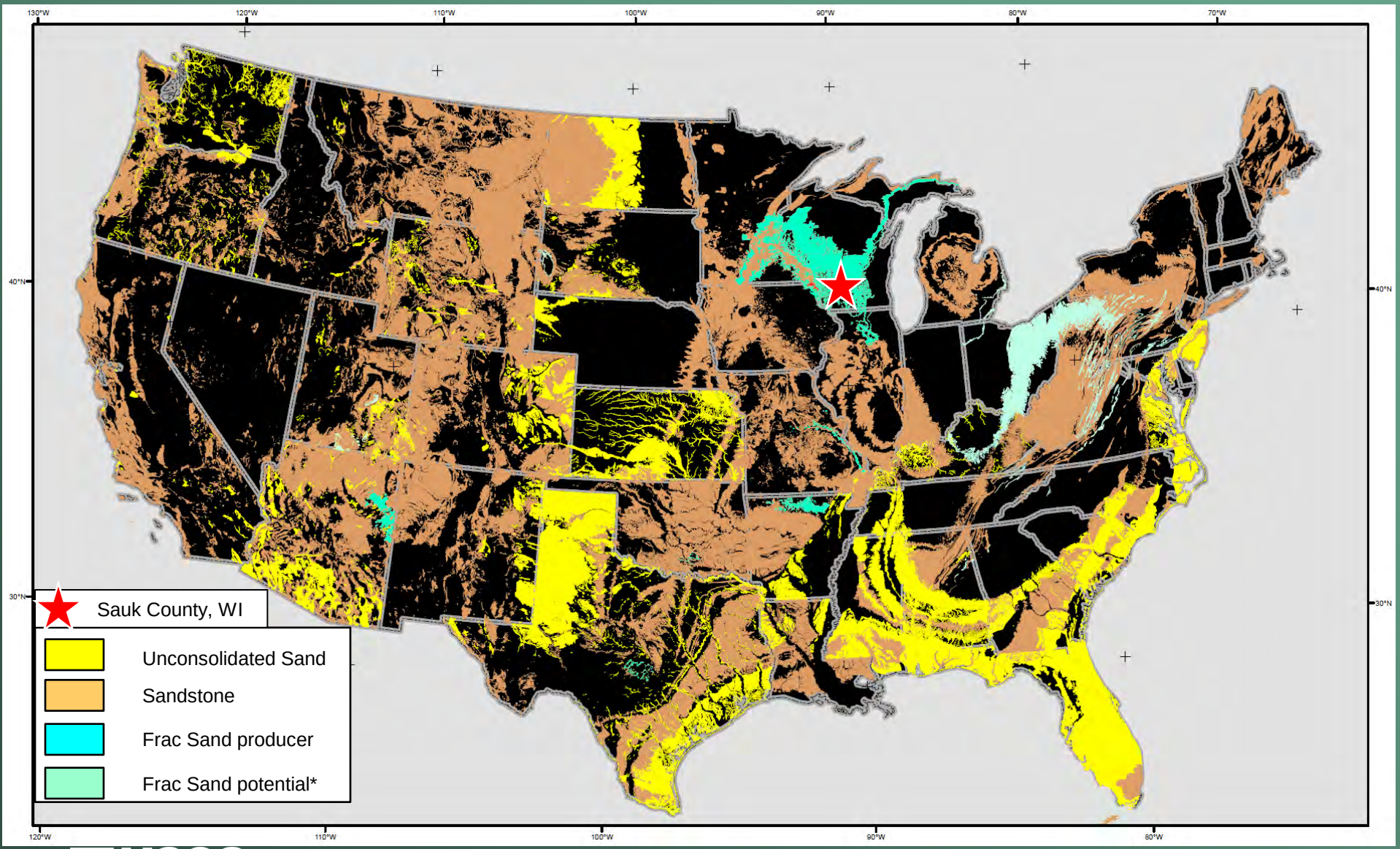
Frac sand versus all sand and sandstone



USGS

(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)

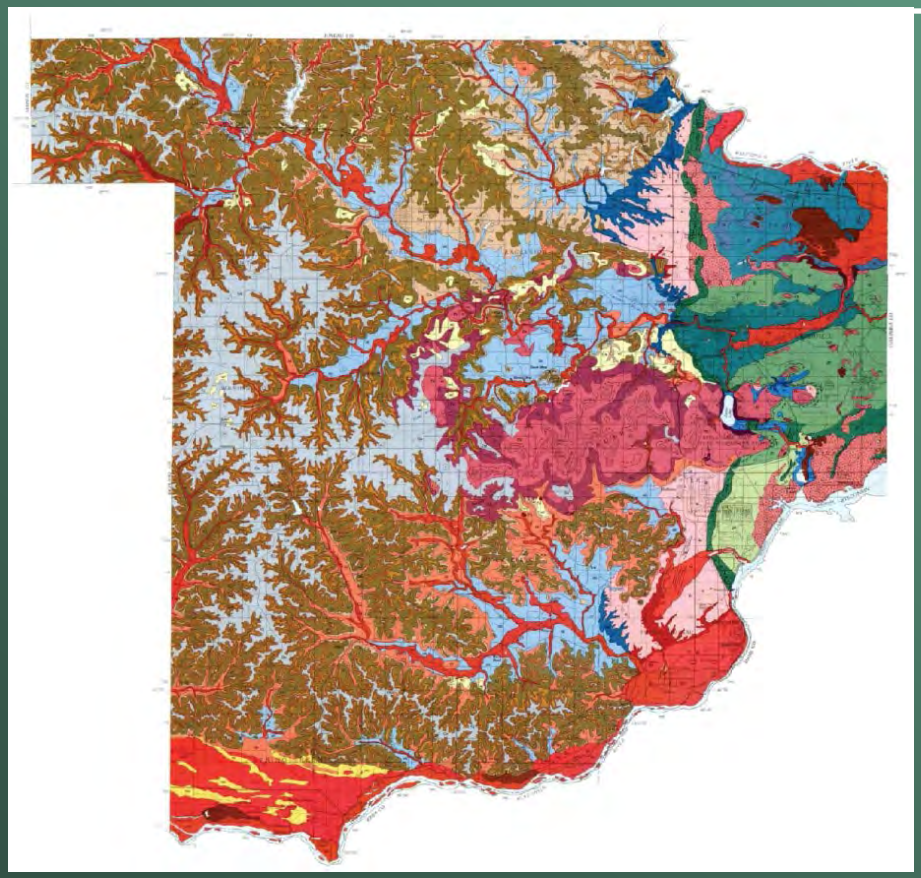
Frac sand versus all sand and sandstone

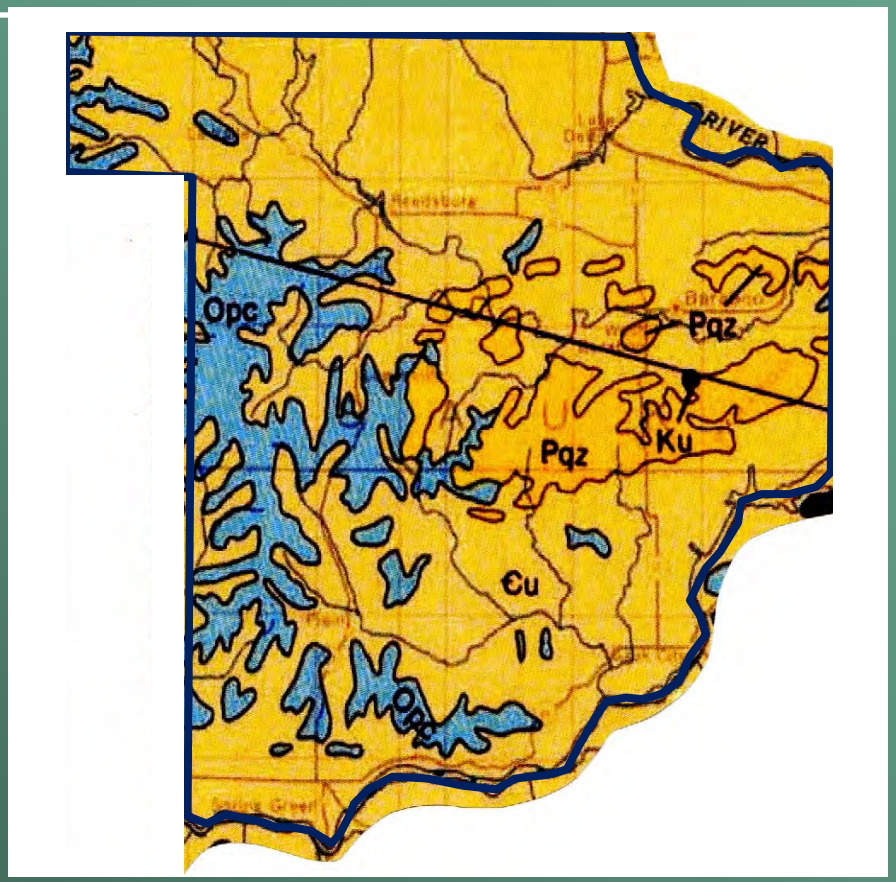


USGS

(Wilson and Benson, unpublished data;
modified from U.S. Geological Survey, 2014)

Comparison of geologic mapping scales for Sauk County, WI



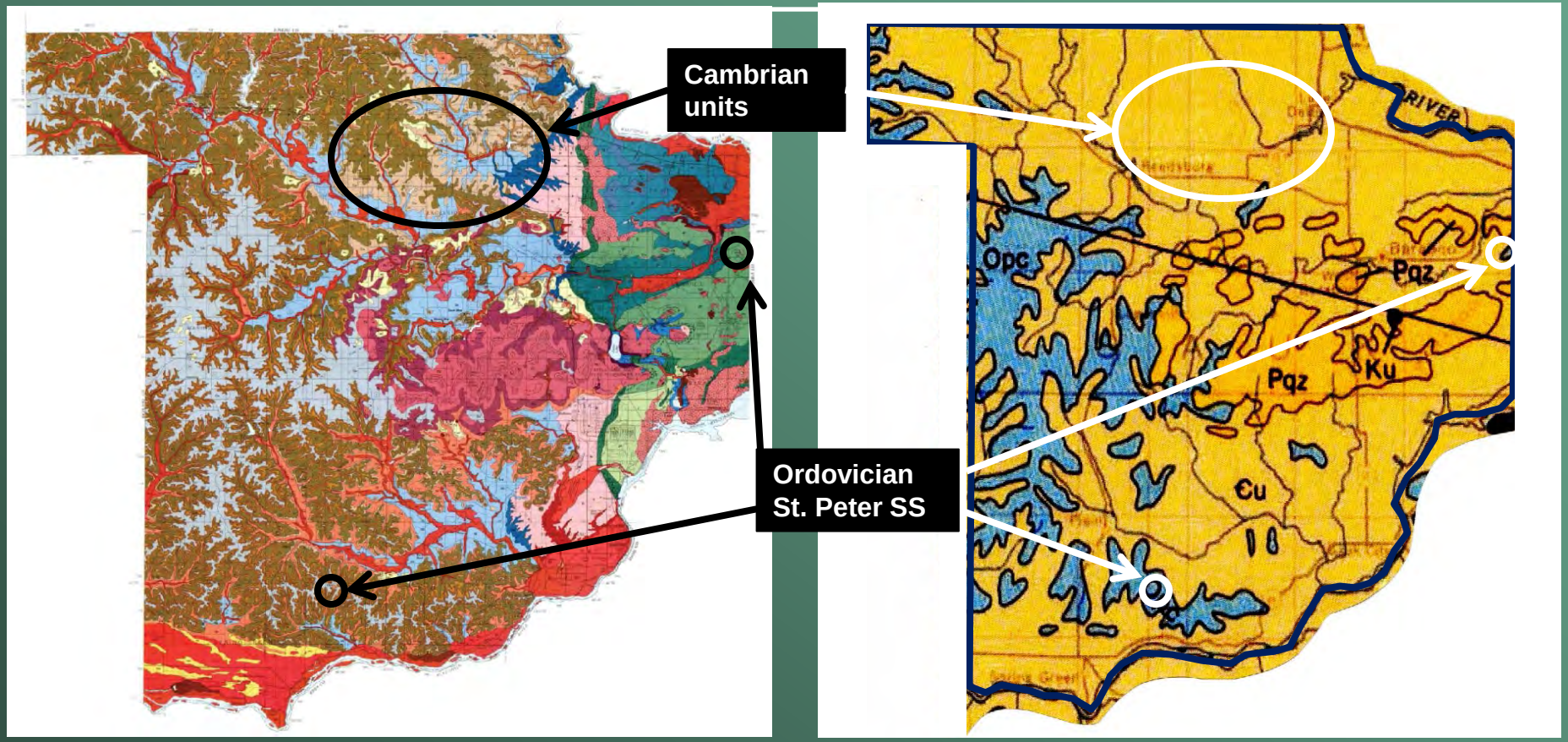


Mapped at 1:100,000 (larger scale) and compiled at 1:1,000,000 (smaller scale)

USGS

Clayton and Attig, 1990 (left)
Mudrey and others, 1982 (right)

Comparison of geologic mapping scales for Sauk County, WI

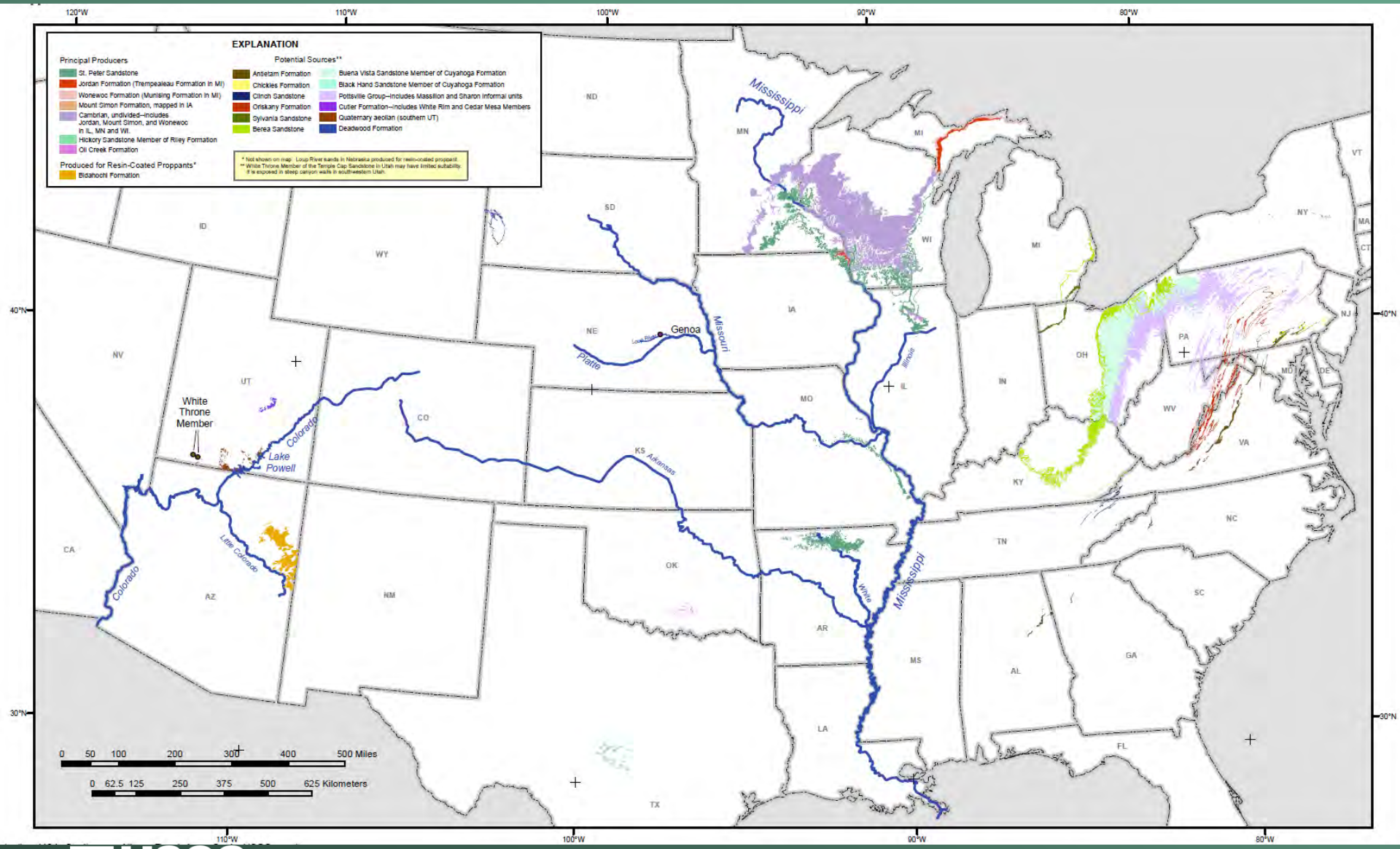


Mapped at 1:100,000 (larger scale) and compiled at 1:1,000,000 (smaller scale)

USGS

Clayton and Attig, 1990 (left)
Mudrey and others, 1982 (right)

Frac sand in the U.S.



USGS

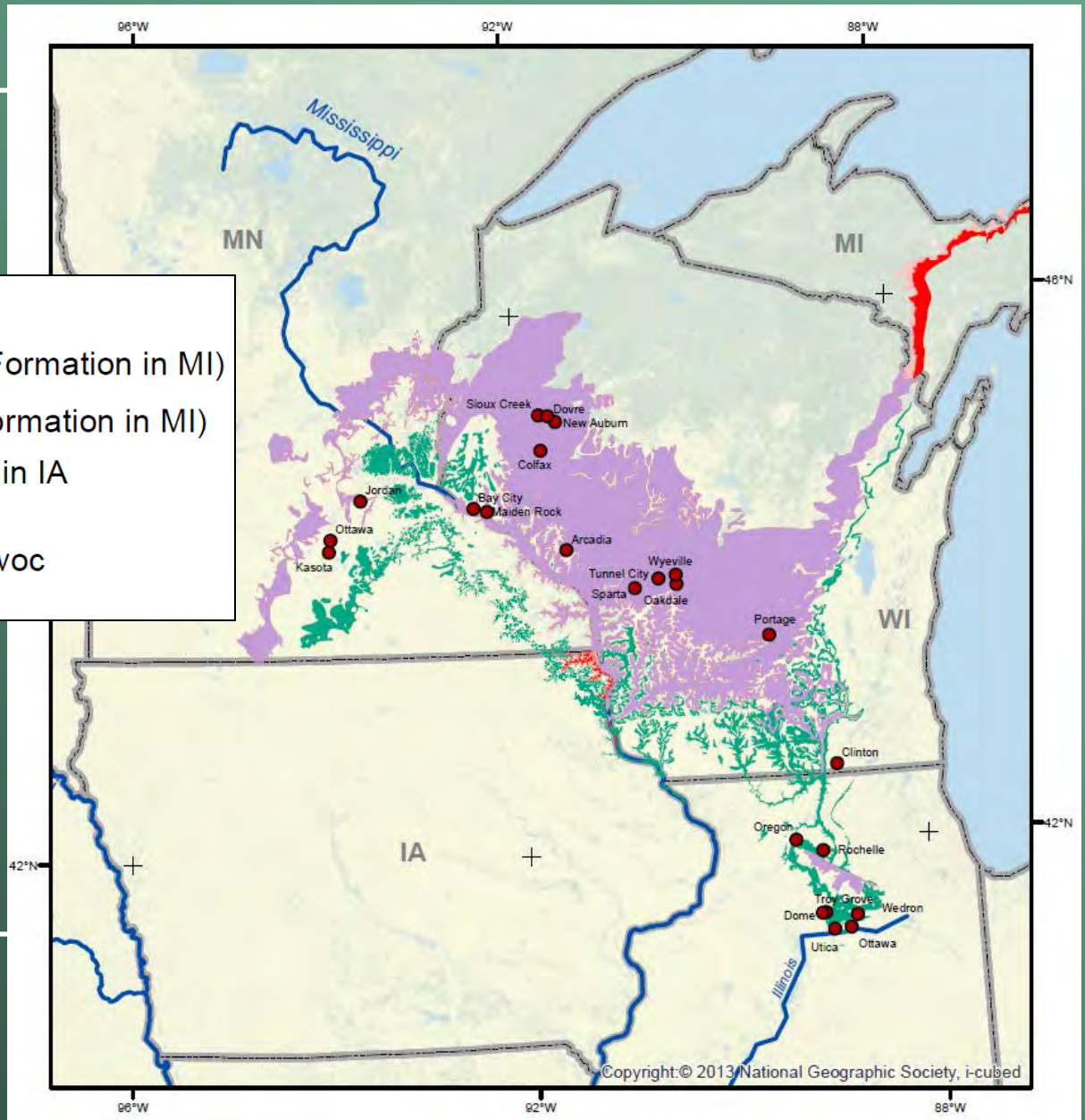
(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)

Geological sources of frac sand in U.S.

("bedrock geology")

USGS

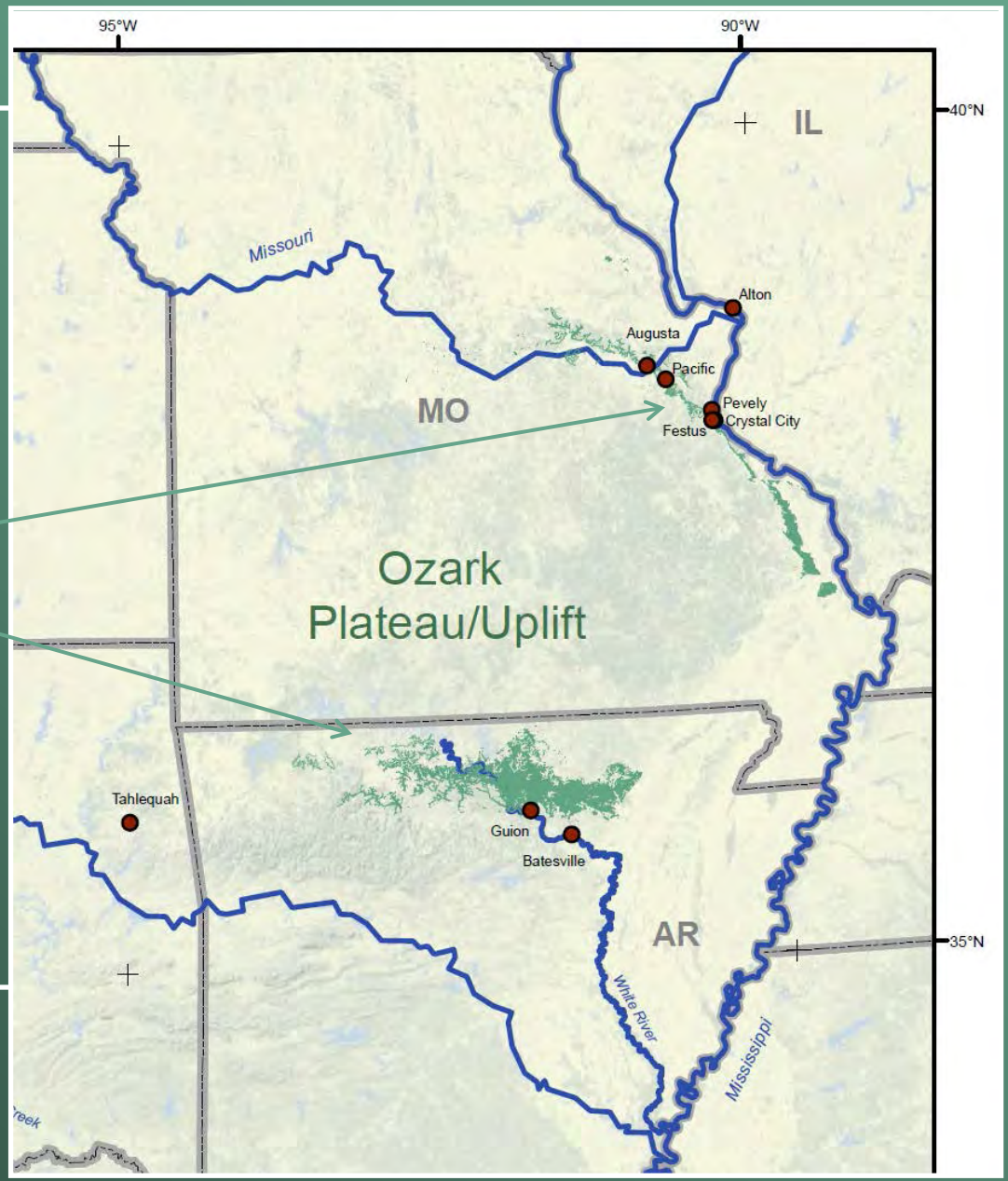
Upper Midwest – “Northern White” or “Ottawa” frac sand near surface



(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)

USGS

Central Midwest –
"Northern White" or "Ottawa" frac sand near surface



(Wilson and Benson, unpublished data;
modified from U.S. Geological Survey, 2014)

USGS

Oklahoma and West Texas – Oil Creek Formation of Simpson Group, a partial equivalent of St. Peter Sandstone

(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)

USGS

Central Texas –
Hickory Sandstone Member of Riley Formation

(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)

USGS

Potential additional sources of frac sand*

- Appalachian region – (Paleozoic)
- Black Hills area of South Dakota (Upper Cambrian and Lower Ordovician)
- Southern and central Utah (Permian, Jurassic, and Quaternary)

*Note that these source units are presented as reported in published literature or websites as potential frac sand whether or not they meet any or all of the API specifications for frac sand. These units have not been independently assessed, analyzed, or evaluated by the U.S. Geological Survey, and neither the U.S. Geological Survey nor the presenters make any claim as to the suitability of these units as frac sand.

USGS

Appalachian region – Paleozoic units*

Pottsville Group (Pennsylvanian):
- Sharon and Massillon sandstones (Wolfe, 2013)

Cuyahoga Formation (Lower Mississippian):
- Buena Vista Sandstone Member (Wolfe, 2013)
- Black Hand Sandstone Member (Wolfe, 2013)

Berea Sandstone (Upper Devonian) (Wolfe, 2013)

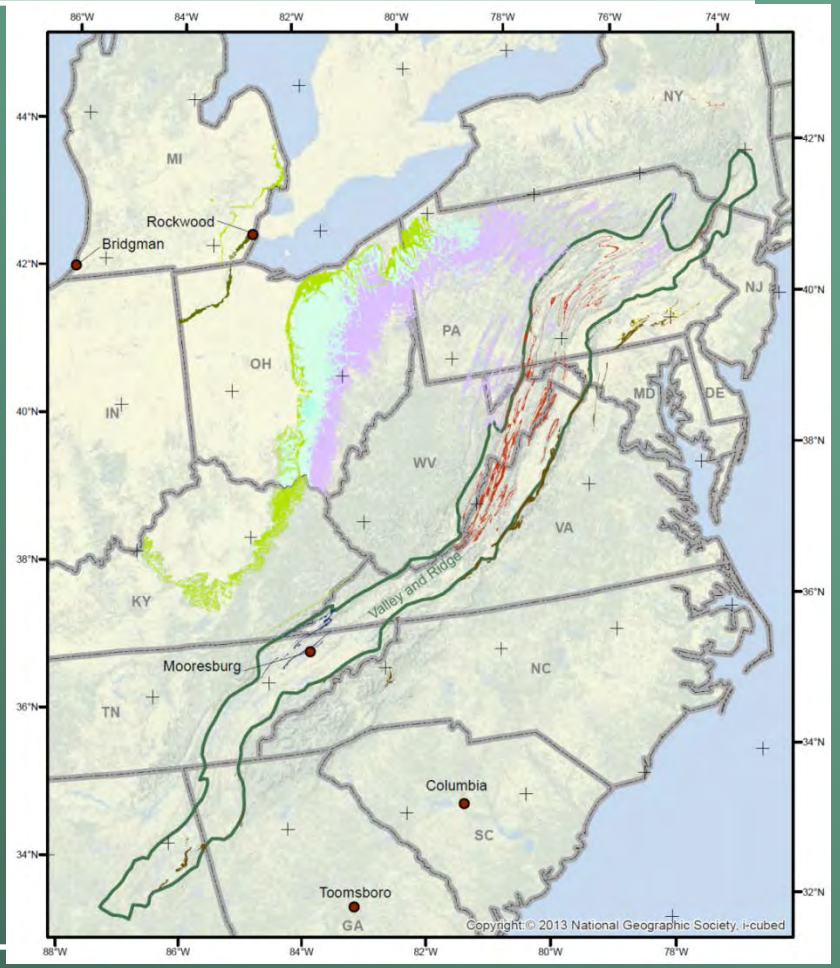
Sylvania Sandstone (Middle Devonian) (Heinrich, 2001, Wolfe, 2013)

Oriskany Group (Lower Devonian):
- Ridgeley Sandstone (Sweet, 1986)

Clinch Sandstone (Lower Silurian) (Zdunczyk, 1992, 2007; Short Mountain Silica, 2014)

Chickies Formation (Lower Cambrian) (Zdunczyk, 2007)

Chilhowee Group (Lower Cambrian):
- Antietam Formation (Zdunczyk, 2007)



(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)

USGS

*Note that these source units are presented as reported in published literature or websites as potential frac sand whether or not they meet any or all of the API specifications for frac sand. These units have not been independently assessed, analyzed, or evaluated by the U.S. Geological Survey, and neither the U.S. Geological Survey nor the presenters make any claim as to the suitability of these units as frac sand.

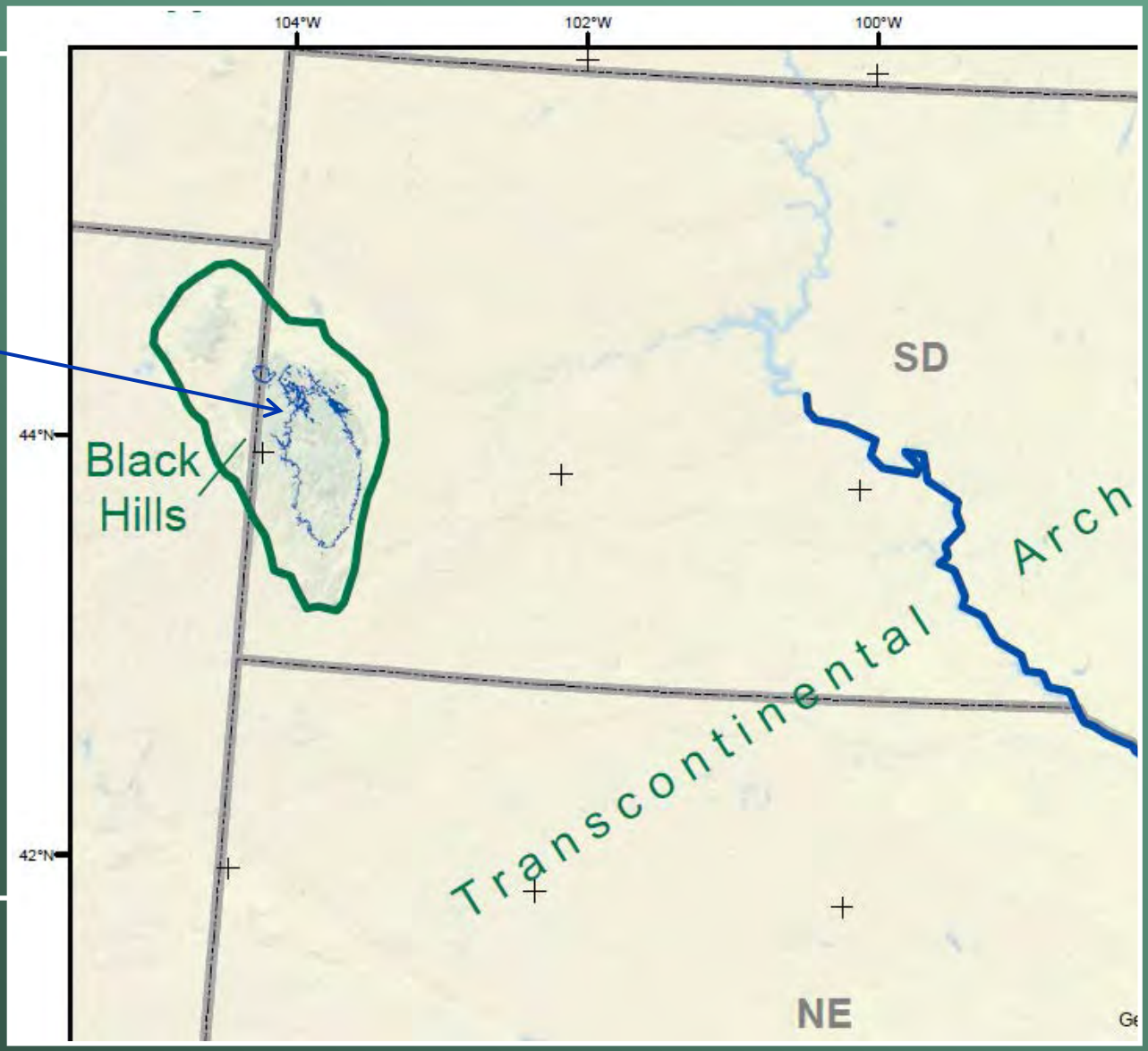
Black Hills area of South Dakota – Deadwood Formation*

Upper Cambrian and Lower Ordovician

Deadwood Formation

(Ching, 1973; Huq, 1983, Hirji, 2014)

(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)



Southern and central Utah*

Permian

Cutler Formation--includes White Rim and Cedar Mesa Members

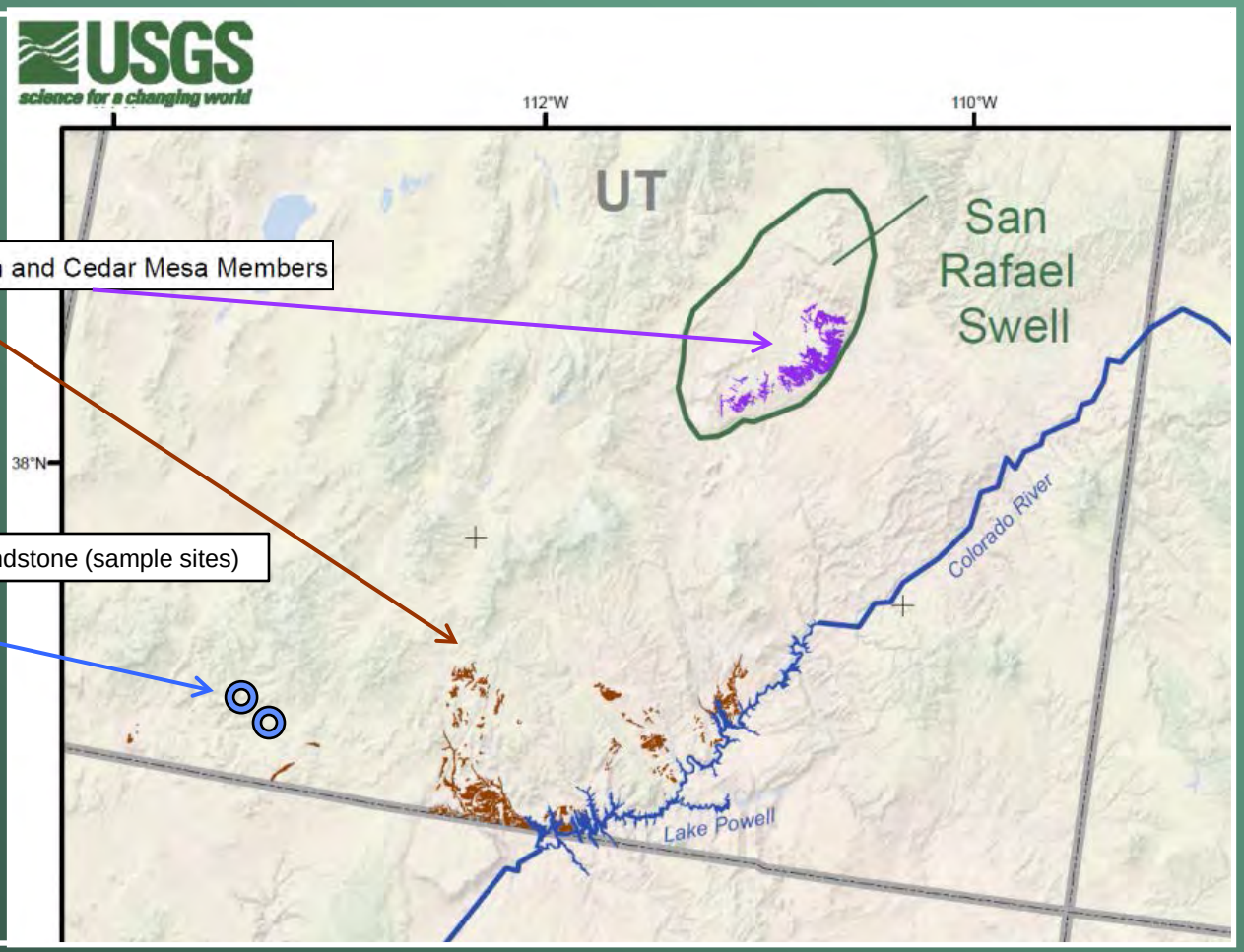
Quaternary aeolian (southern UT)

Jurassic

White Throne Member of the Temple Cap Sandstone (sample sites)

(Rupke, 2014)

(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)



USGS

Sand produced for resin-coated proppants

- Sources of substrate for resin-coated sand
  - Bidahochi sands in Arizona (Pliocene)
  - Loup River sands in Nebraska (Quaternary)

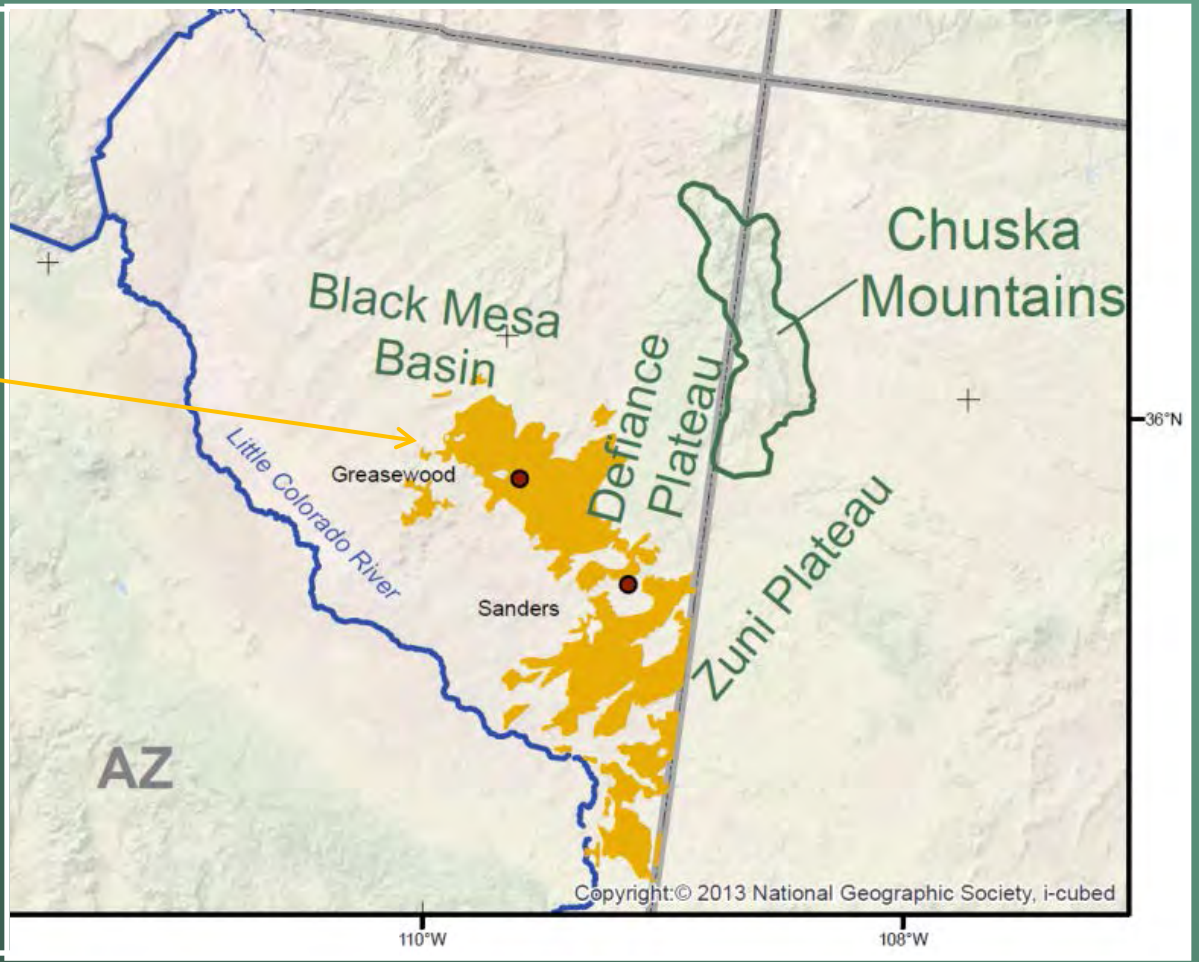
USGS

Lacustrine sands of the Bidahochi Formation – Arizona

Pliocene

Bidahochi Formation

(Zdunczyk, 2007)



(Wilson and Benson, unpublished data; modified from U.S. Geological Survey, 2014)

USGS

Modern fluvial sands of the Loup River, Genoa, Nebraska

Quaternary river sands

(Shale Reporter, 2013)

USGS

What's next? A wish list.

- Map of all silica sand mines and prospects
- Map of all frac sand sources
- Catalog physical specifications of each source unit
- Understand variability within mapped units
- Detailed geologic maps of sand units (1:24,000 best, 1:100,000 might be OK)
- Better understanding of geologic materials for manufactured proppants

USGS

What's coming from USGS?

Benson, M.E., and Wilson, A.B., in press, Frac sand in the United States--A geological and industry overview: U.S. Geological Survey Open-File Report. (online only, includes GIS data)

Benson, M.E., and Wilson, A.B., in press, Frac Sand Sources in the United States: Rock Products supplement issue. (expected 1st quarter 2015)

Benson, M.E., and Wilson, A.B., pending, A geological overview of frac sand in the United States [abstr.]: Society of Mining, Metallurgy, and Exploration Conference, Denver, CO (Feb. 2015)

Wilson, A.B., and Benson, M.E., pending, Where in the U.S. is the naturally-occurring frac sand? [abstr.]: Society of Mining, Metallurgy, and Exploration Conference, Denver, CO (Feb. 2015)

Bleiwas, D.I., in press, Estimates of frac-sand production, consumption, and reserves in the United States: Rock Products supplement issue. (expected 1st quarter 2015)

USGS

General References

Clayton and Attig, 1990, Geology of Sauk Couty, Wisconsin: Wisconsin Geological and Natural History Survey, Information Circular 67, Scale 1:100,000.

Mudrey, M.G., Jr., Brown, B.A., Greenberg, J.K., 1982, Bedrock Geology Map of Wisconsin: Wisconsin Geological and Natural History Survey, Scale 1:1,000,000.

Shale Reporter, 2013, Unwanted Nebraska sand put to use in oil fields, http://www.shalereporter.com/industry/article_54d2a13c-92b7-11e1-8fe8-001a4bcf6878.html (accessed 11-14-13).

U.S. Geological Survey, 2014, Geologic maps of U.S. States: available at http://mrdata.usgs.gov/geology/state/

U.S. Geological Survey Geologic Name Committee, 2007, Divisions of Geologic Time—Major Chronostratigraphic and Geochronologic Units; U.S. Geological Survey Fact Sheet 2007-3015, available at http://pubs.usgs.gov/fs/2007/3015/.

Zdunczyk, Mark, 2007, The facts of frac: Industrial Minerals Journal, no. 1, p. 58–61.

USGS

References for Potential Sources

Ching, P.D., 1973, An investigation of the Cambrian Deadwood Sandstone in the central and southern Black Hills, South Dakota, as potential industrial silica sands: Rapid City, South Dakota School of Mines and Technology, Master's degree thesis, 181 p.

Heinrich, E.W., 2001, Economic geology of the sand and sandstone resources of Michigan: Michigan Geological Survey Division Report of Investigation 21, 31 p.

Hirji, Zahra, 2014, Frac sand boom—South Dakota is latest state to try to cash in, http://insideclimatenews.org/news/20140626/frac-sand-boom-south-dakota-latest-state-try-cash (accessed 06-26-14).

Huq, S.Y., 1983, Potential sand-frac deposits in the basal Deadwood Formation, eastern Black Hills, South Dakota: Rapid City, South Dakota School of Mines and Technology, Master's degree thesis, 117 p.

Rupke, Andrew, 2014, Frack sand in Utah?: Utah Geological Survey Notes, v. 46, no. 1, p. 6–7.

Short Mountain Silica, 2014, About us, http://www.shortmtnsilica.com/about-us.html (accessed 06-03-14).

Sweet, P.C., 1986, Virginia's industrial silica resources: Virginia Minerals, v. 32, no. 1, p. 1–9.

Wolfe, M.E., 2013, Fracture sand in Ohio: Ohio Department of Natural Resources, Division of Geological Survey GeoFacts 27, 2 p.

Zdunczyk, Mark, 2007, The facts of frac: Industrial Minerals Journal, no. 1, p. 58–61.

Zdunczyk, M.J., 1992, Short Mountain Silica—A new producer in Tennessee: Mining Engineering, v. 7.0, p. 3.

USGS

Disclaimer

1. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

2. Note that the source units identified in this presentation are provided as reported in published literature or websites as major or potential sources of frac sand, whether or not they meet any or all of the API specifications for frac sand. None of these units has been independently assessed, analyzed, or evaluated by the U.S. Geological Survey, and neither the U.S. Geological Survey nor the presenters make any claim as to the suitability of these units as frac sand.

USGS