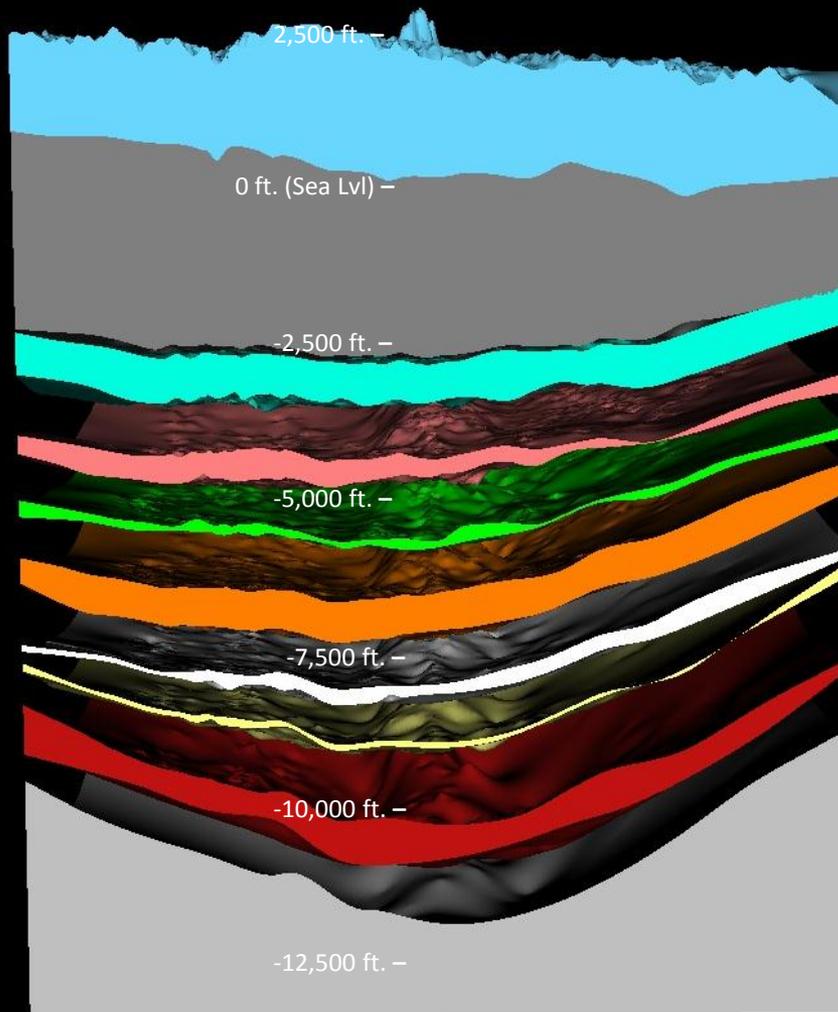


Three-Dimensional Geologic Model of Northwestern North Dakota

Timothy O. Nesheim and Stephan H. Nordeng

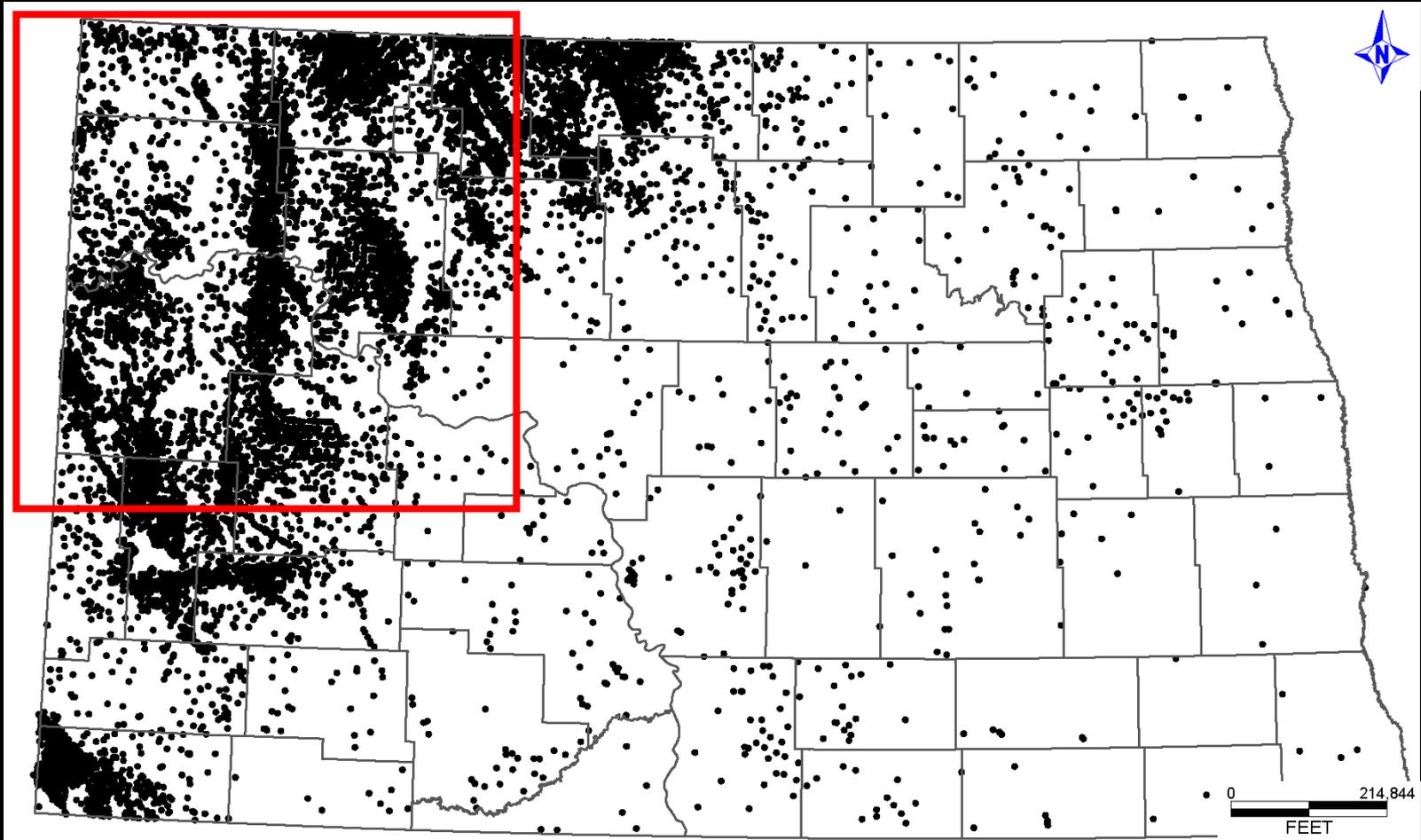


Three-Dimensional Geologic Model of Northwestern North Dakota

- The primary purpose of this document is to illustrate the three-dimensional shape of several significant geologic units within the Williston Basin of North Dakota.
- The geologic intervals depicted in this document were modeled using geophysical log tops (from oil & gas wells) within the computer program Petra.
- Some of the geologic surfaces were generated from several thousand data points (e.g. Spearfish Formation) while other were generated by only a few hundred data points or less (e.g. Red River Formation). Questionable data points (geophysical log tops) were removed.
- Vertical exaggeration is used throughout most of this document to help viewers see subtle features within the Williston Basin of North Dakota.
- The surface topography of North Dakota, as well as the extent of water bodies such as Lake Sakakawea and the Missouri River, are only schematic.
- While production statistics only show oil production through 2009, significant natural gas has also been produced and sold from North Dakota.



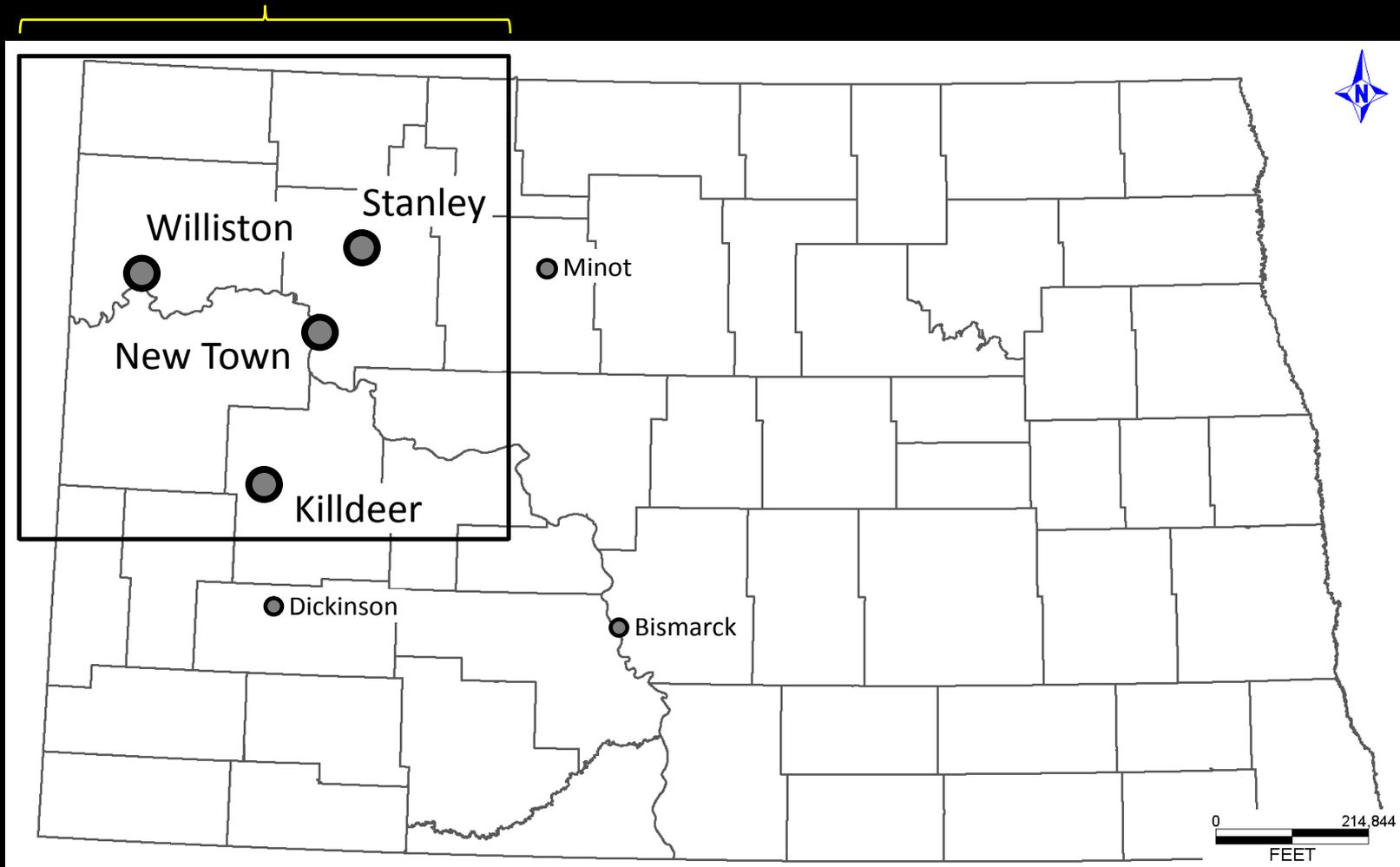
>19,000 Oil & Gas wells have been drilled in North Dakota



-Black dots show the location of oil and gas wells drilled in North Dakota



Area of 3-D Model



North



~135 miles



West ←

~135 miles

→ East



South



North



West ←

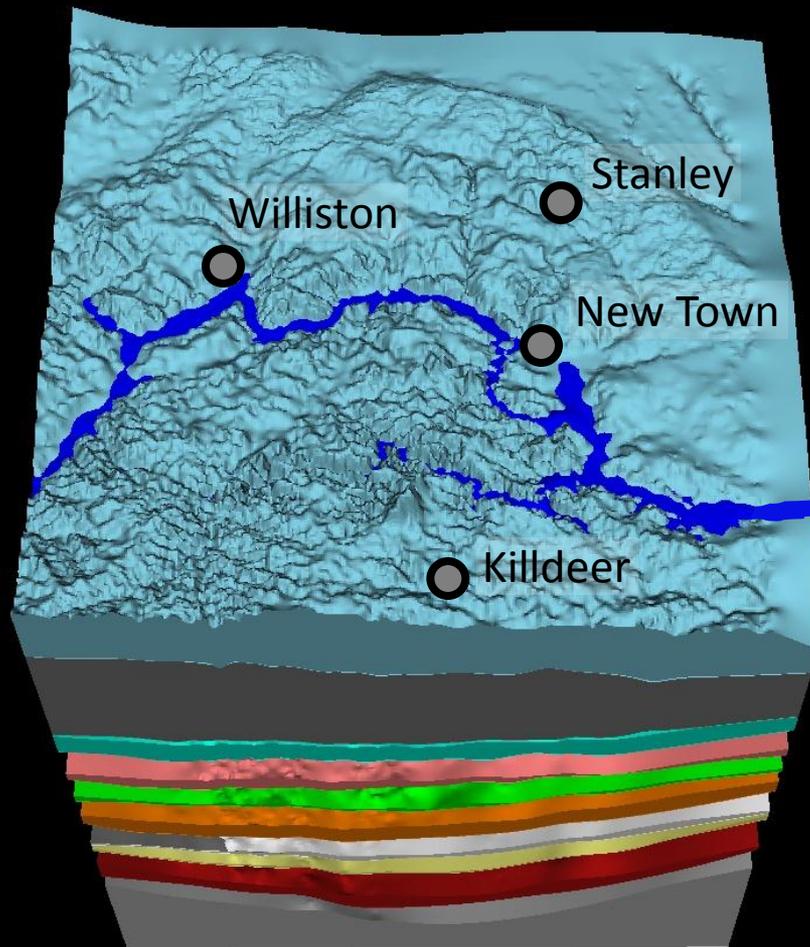


→ East

South

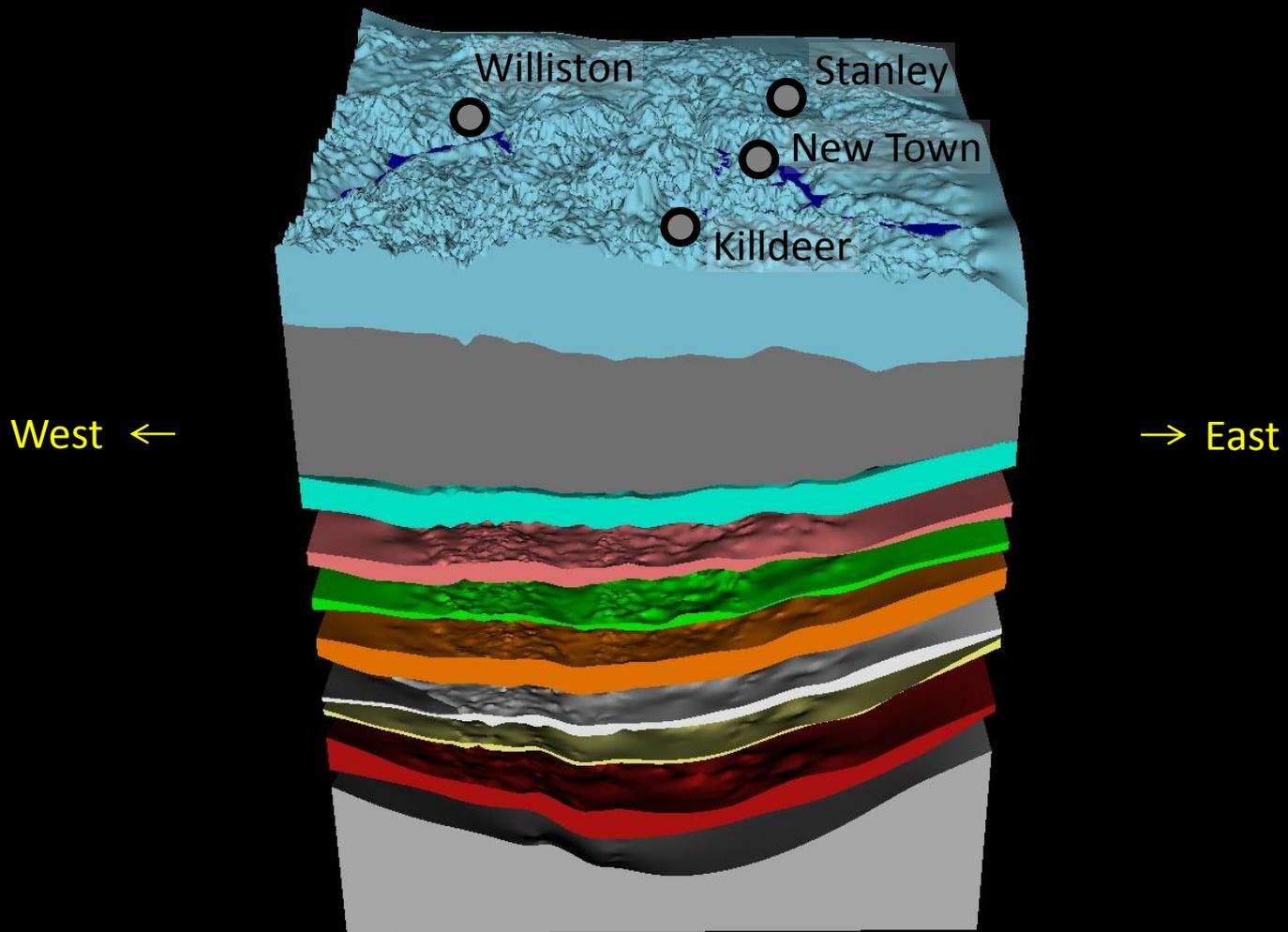


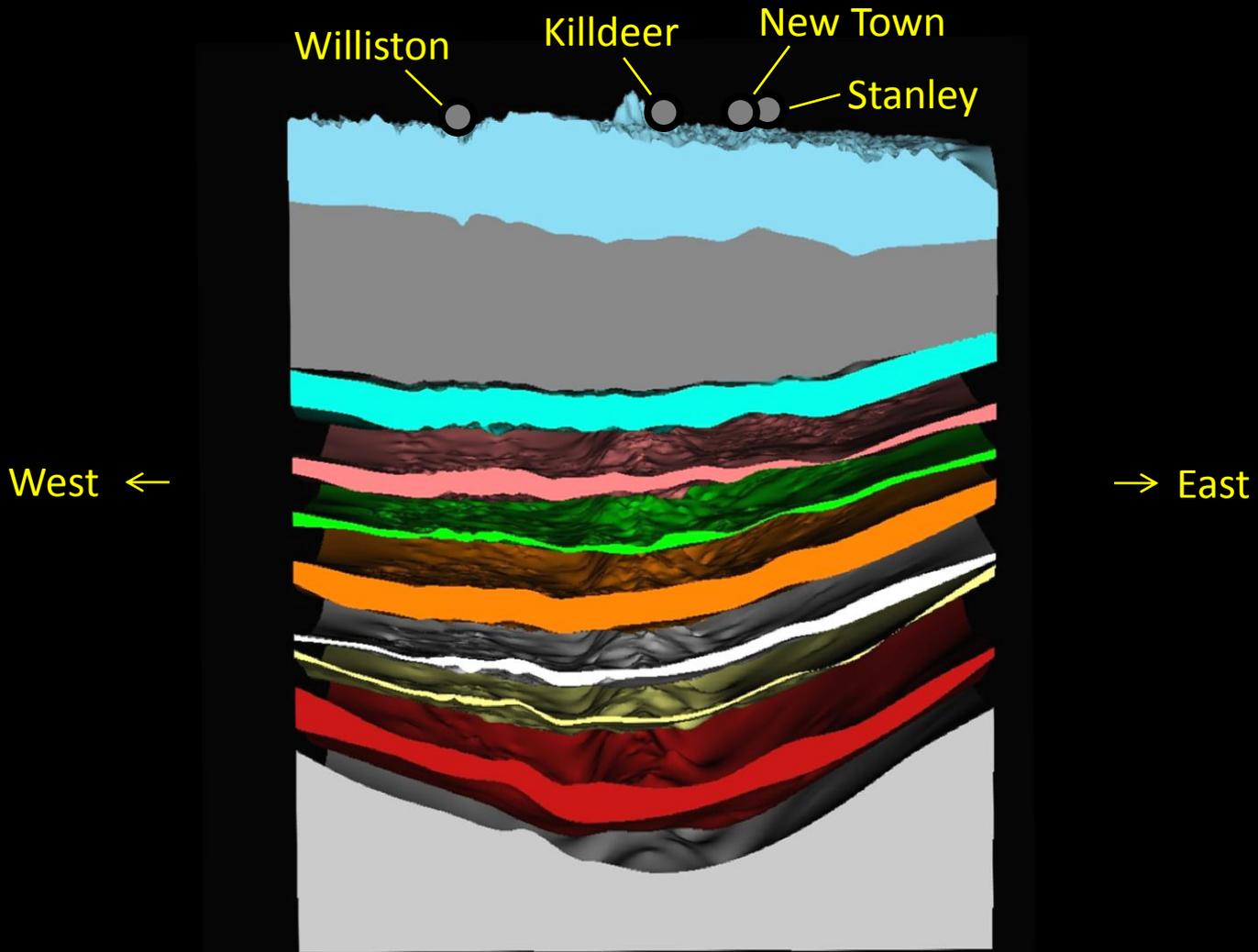
West ←



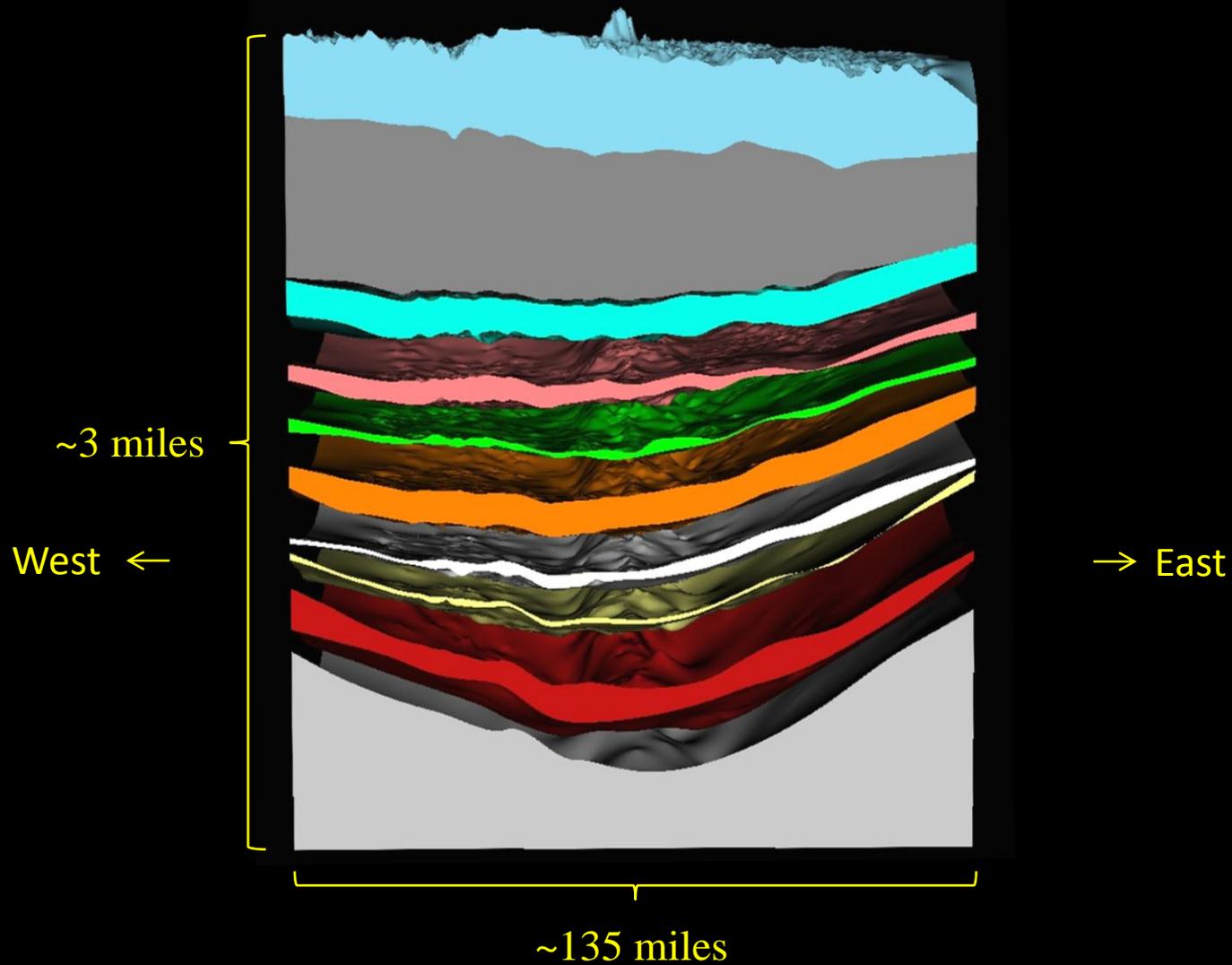
→ East



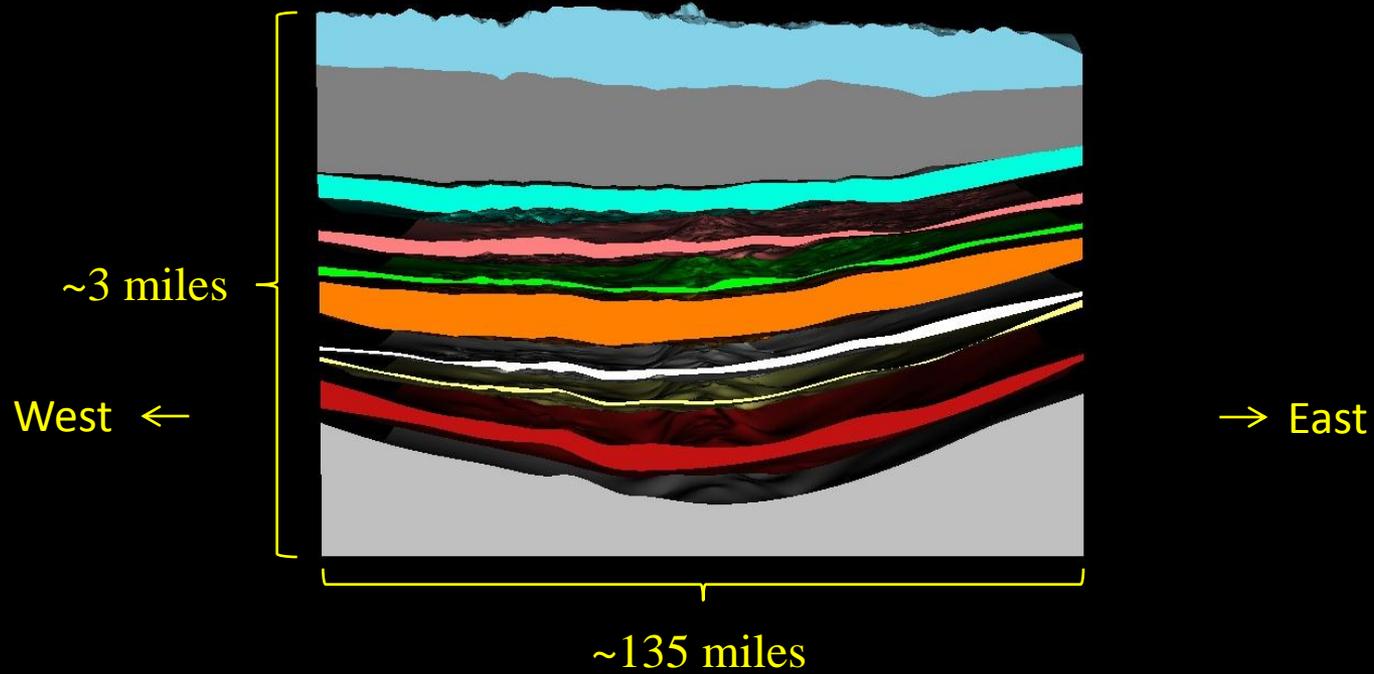




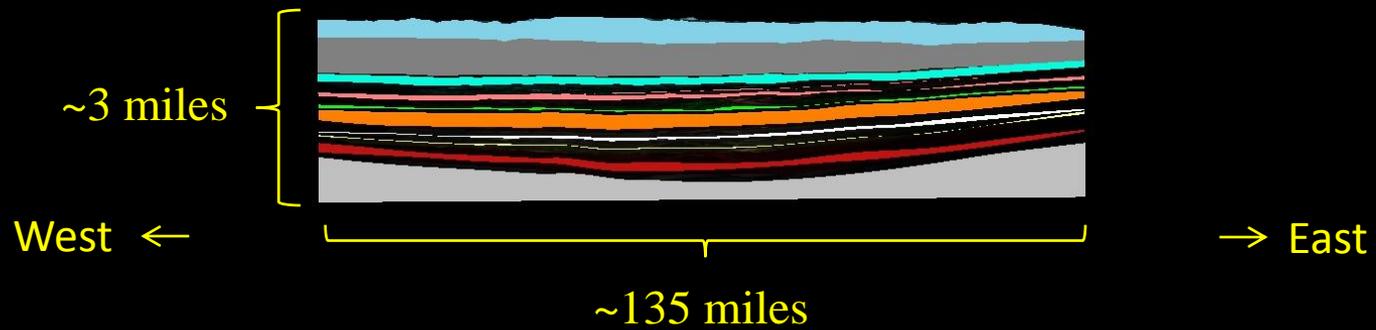
50:1 Vertical Exaggeration



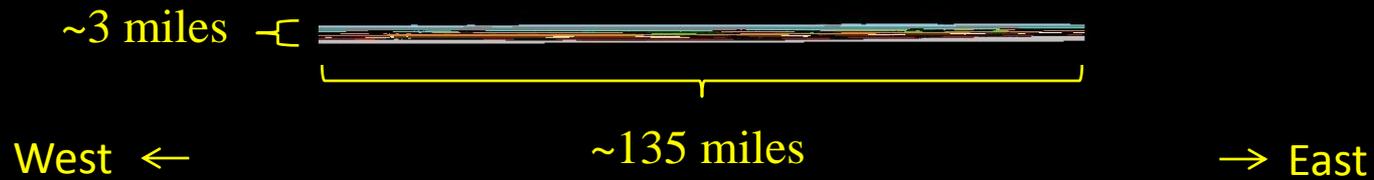
30:1 Vertical Exaggeration



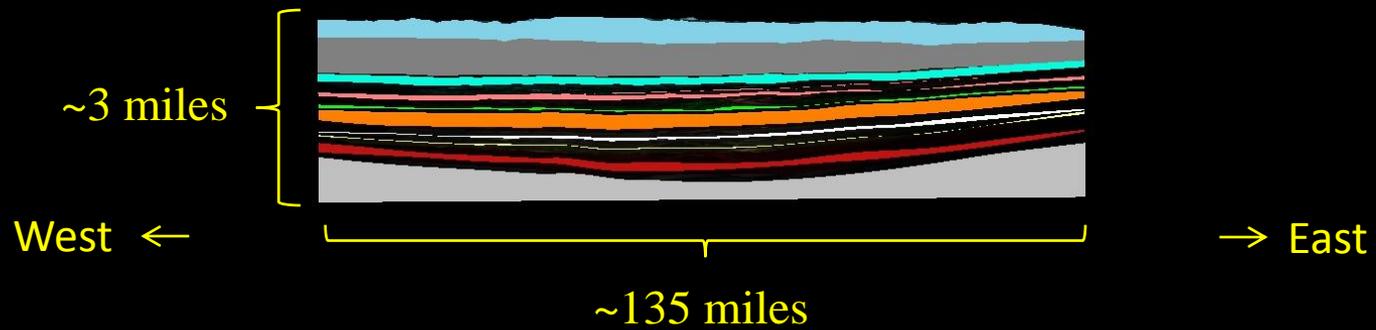
10:1 Vertical Exaggeration



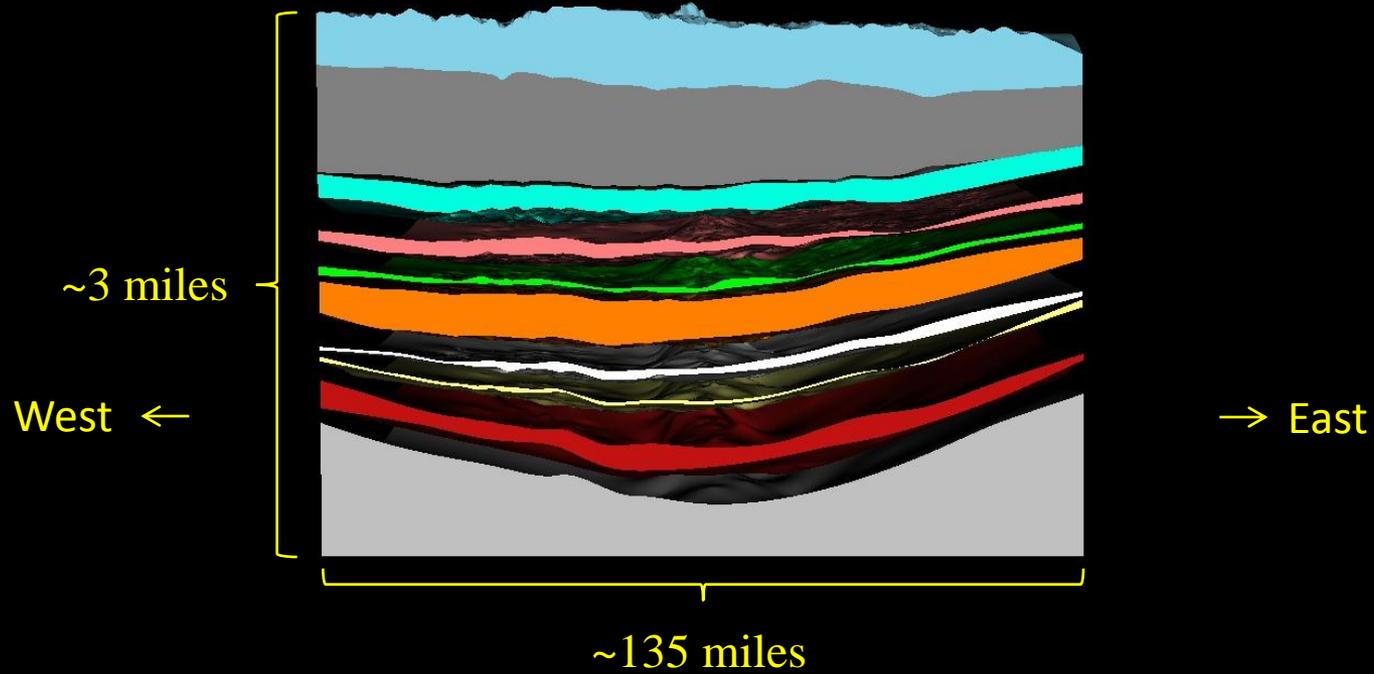
1:1, No Vertical Exaggeration



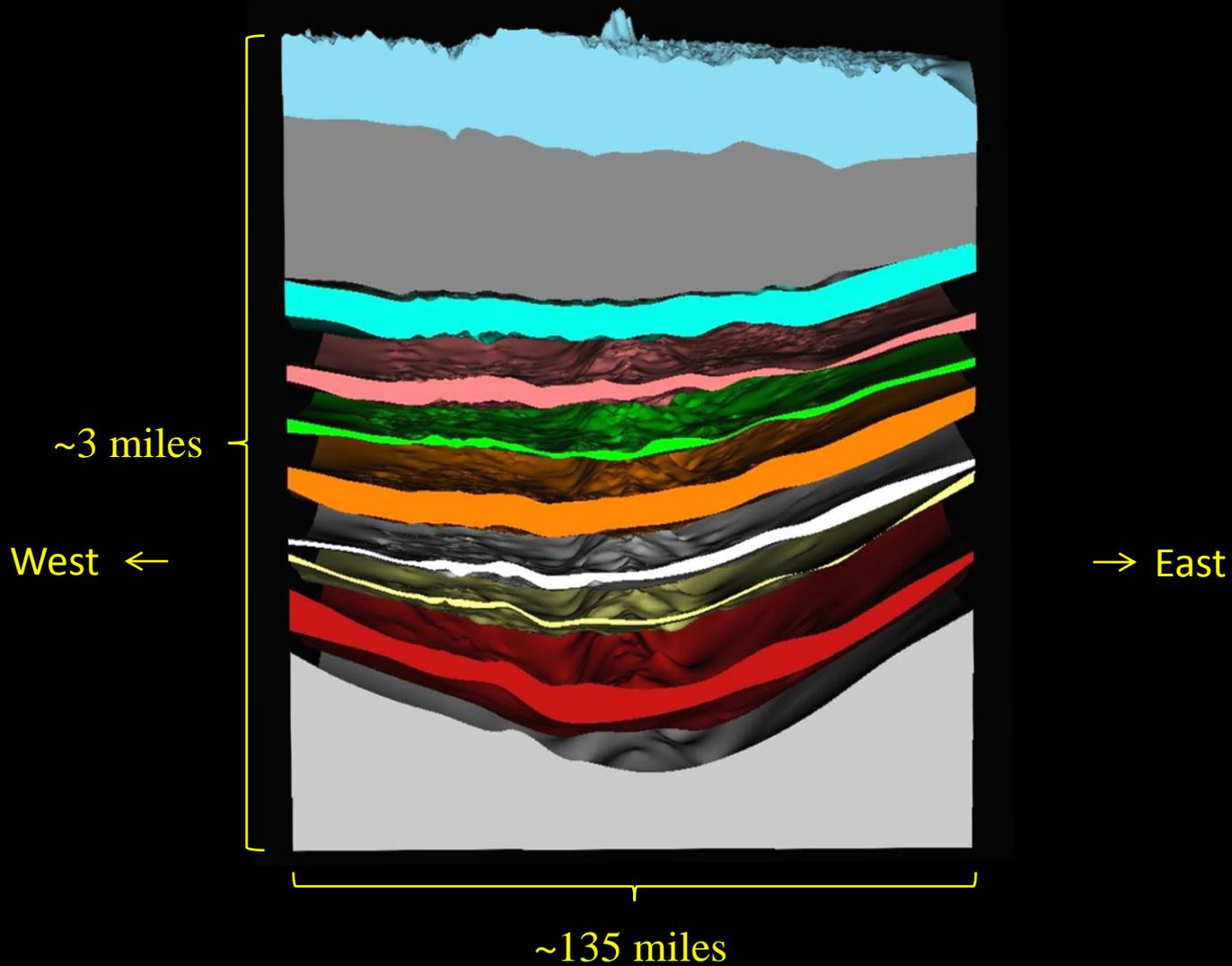
10:1 Vertical Exaggeration



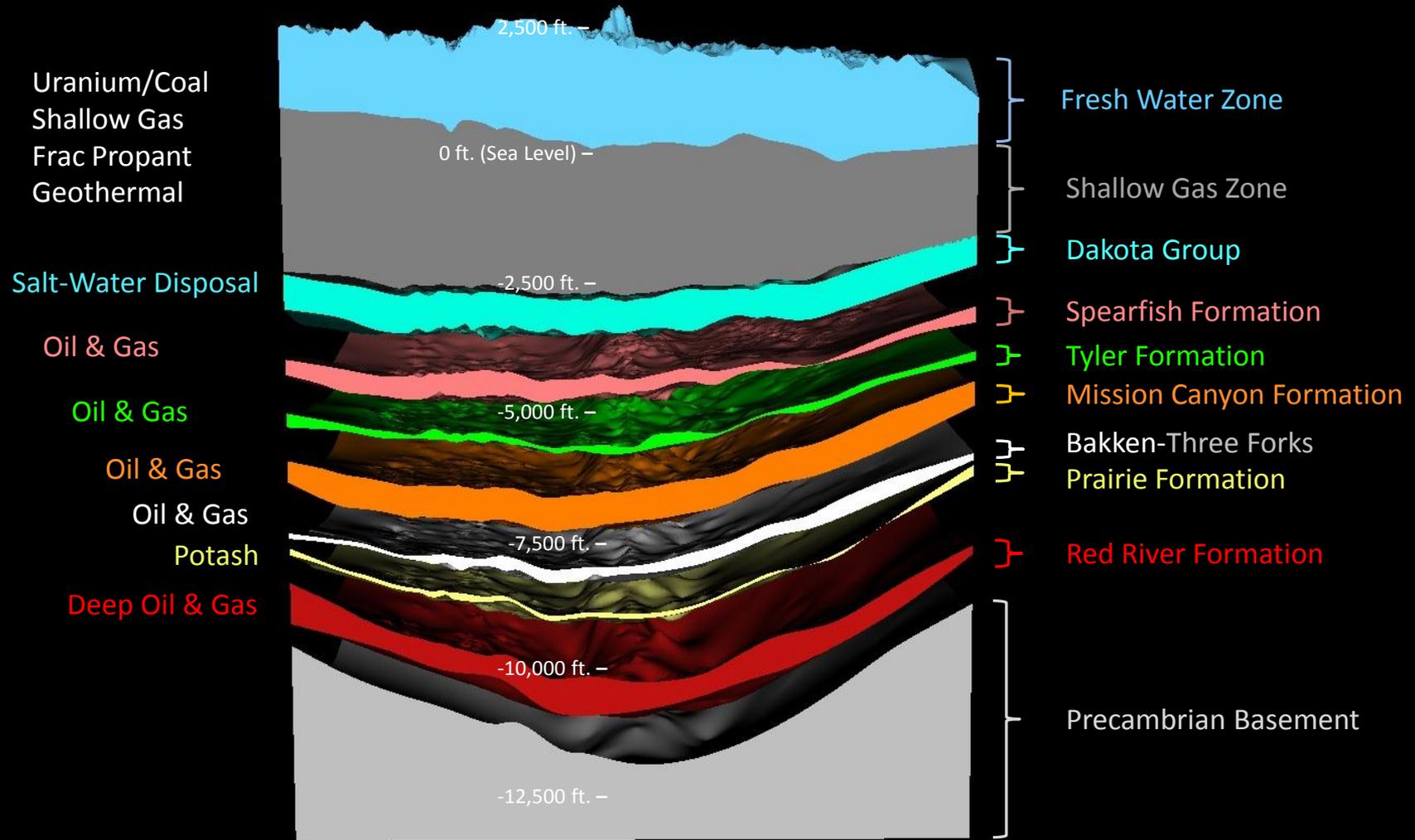
30:1 Vertical Exaggeration



50:1 Vertical Exaggeration

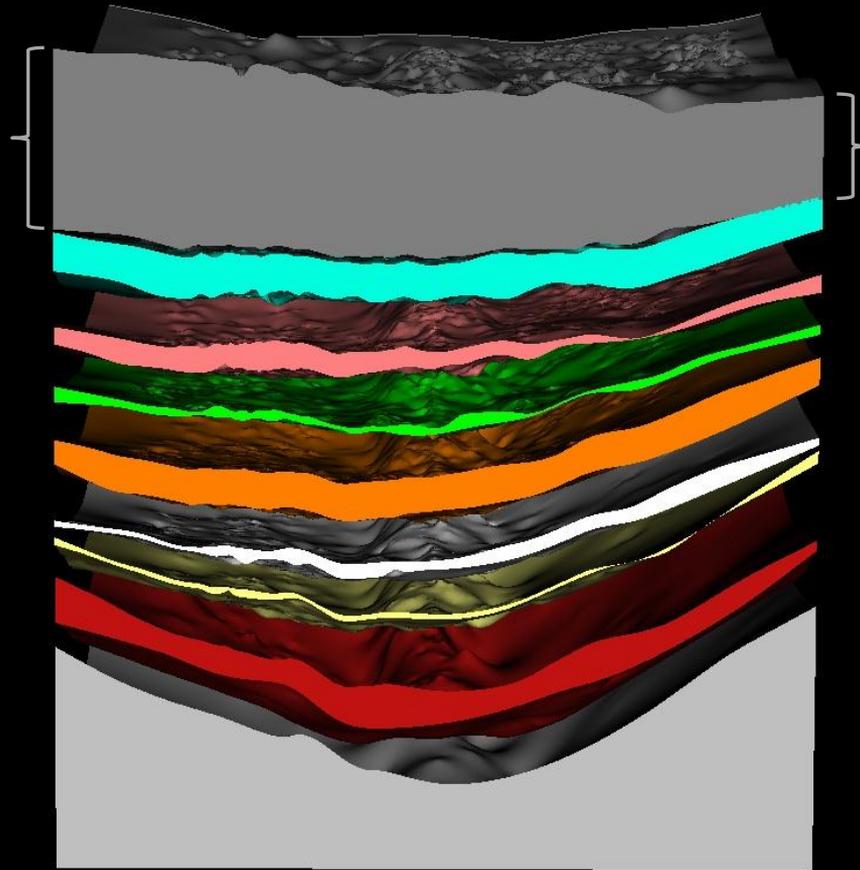


Three-Dimensional Geologic Model of Northwestern North Dakota



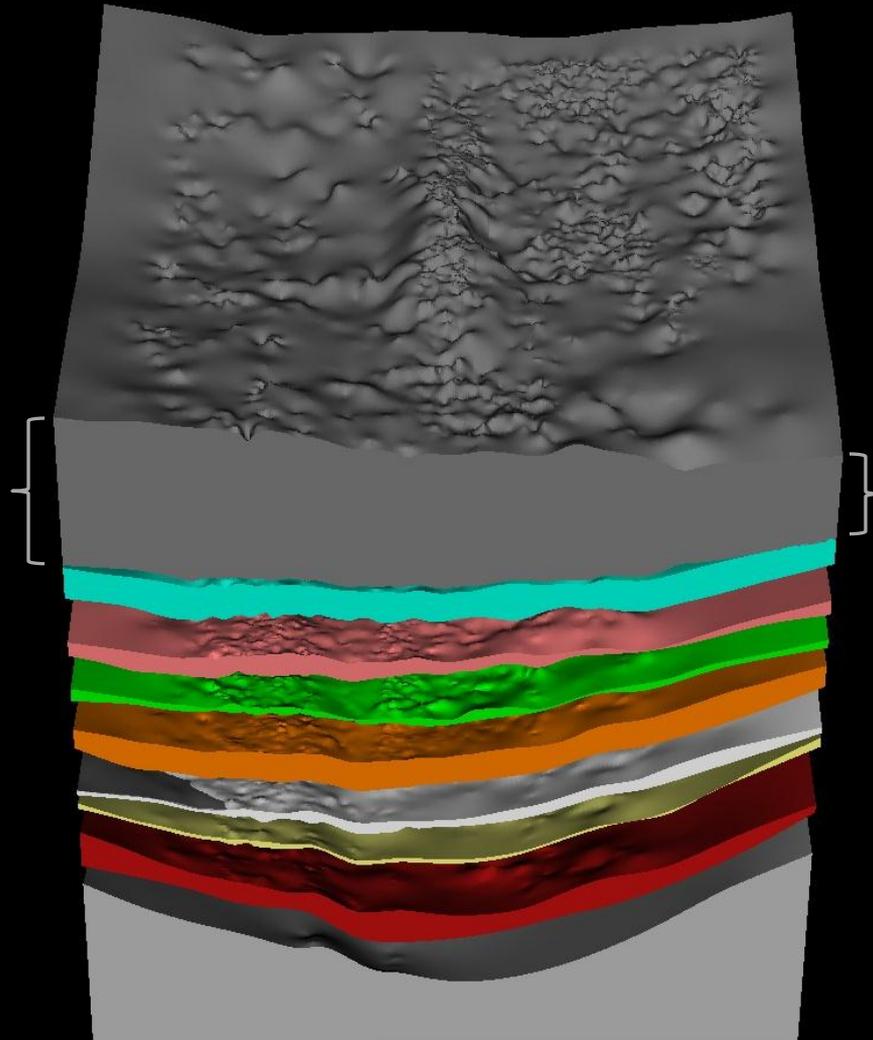
Shallow Gas Prospects

- Pierre Fm.
- Niobrara Fm.
- Carlile Fm.
- Greenhorn Fm.



Shallow Gas Prospects

- Pierre Fm.
- Niobrara Fm.
- Carlile Fm.
- Greenhorn Fm.



Shallow Gas Prospects

- Pierre Fm.
- Niobrara Fm.
- Carlile Fm.
- Greenhorn Fm.

Pierre Fm.
Grey silty shale



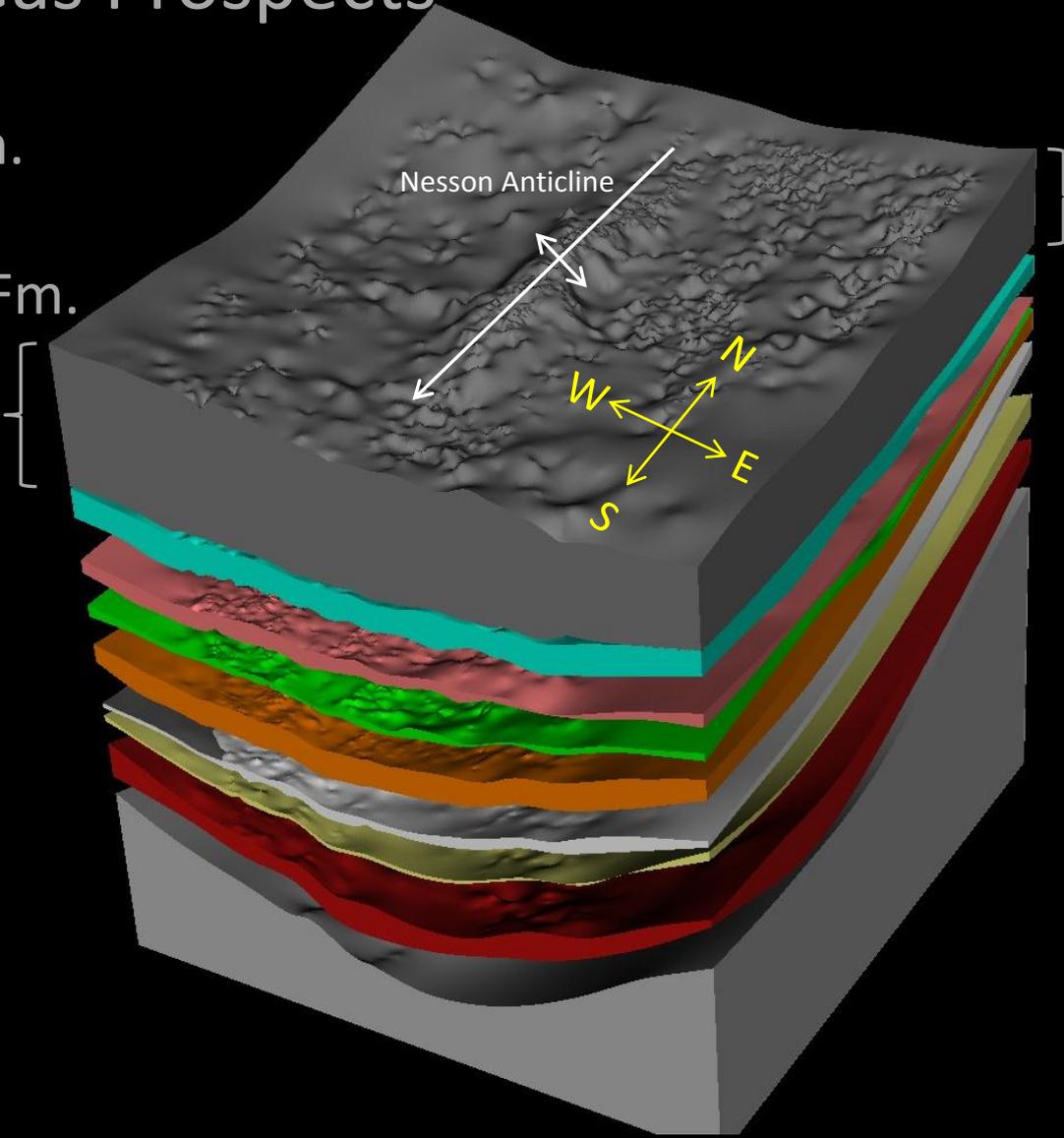
Niobrara Fm.
Greyish-brown
chalky shale



Carlile Fm.
Grey shale

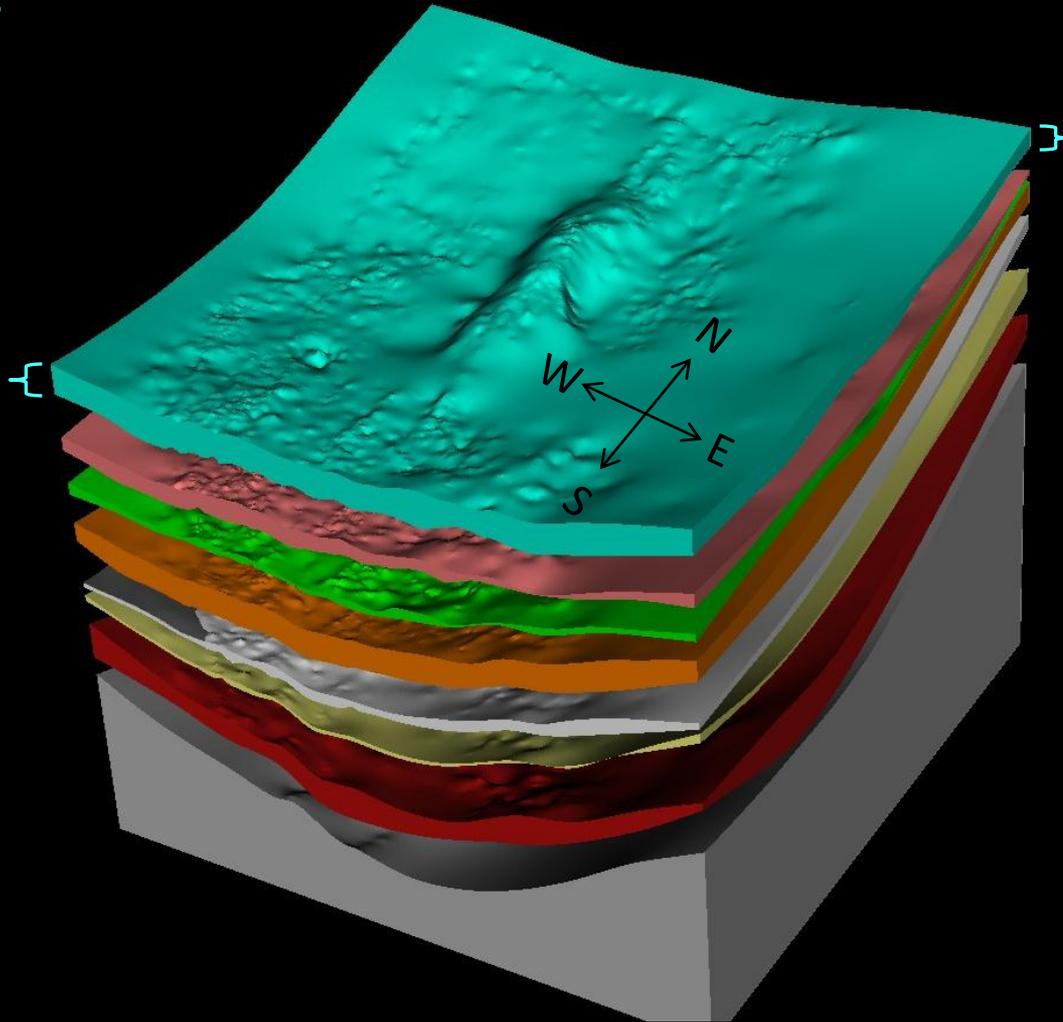


Greenhorn Fm.



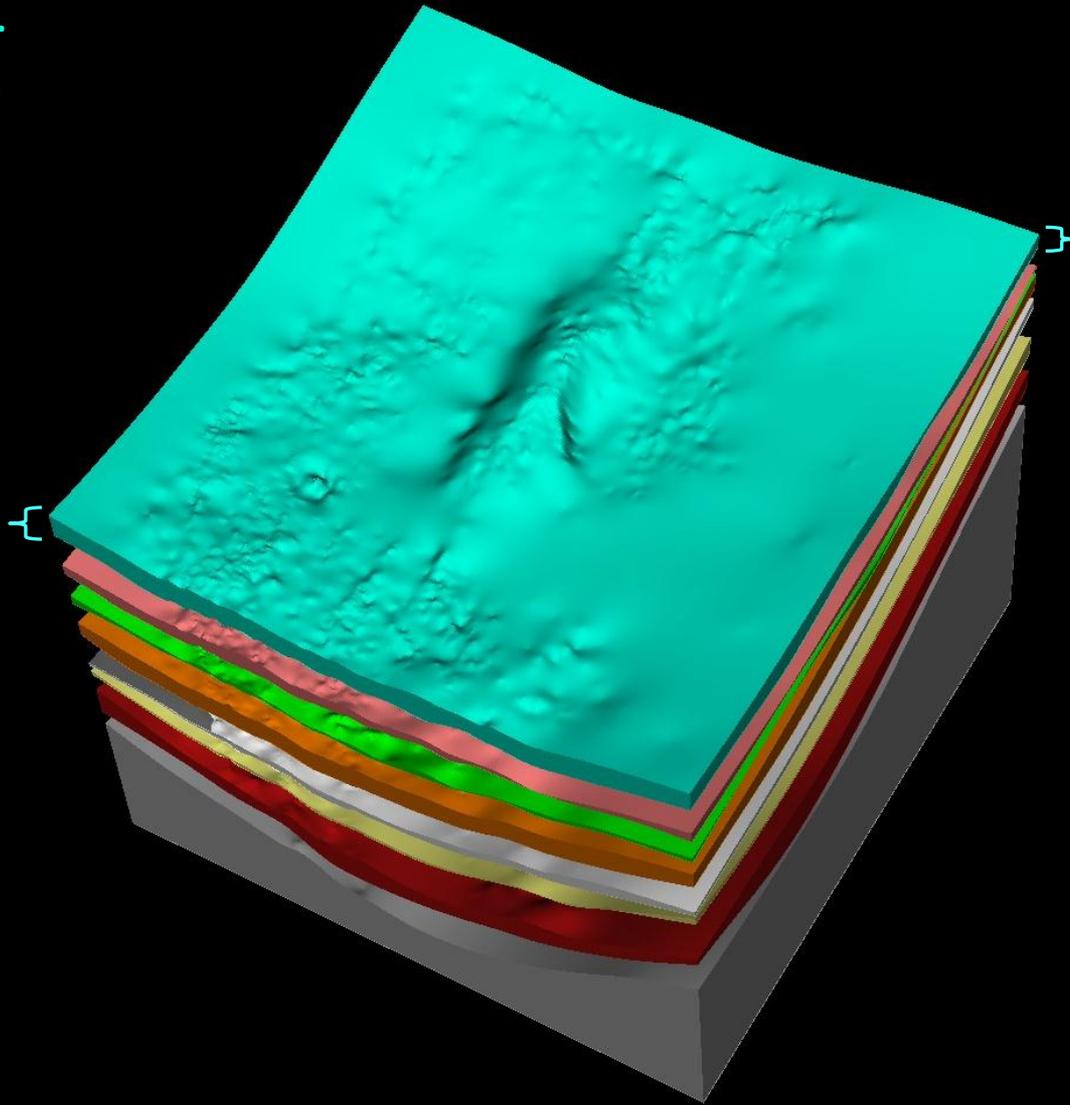
Dakota Group

- New Castle Fm.
- Skull Creek Fm.
- Inyan Kara Fm.



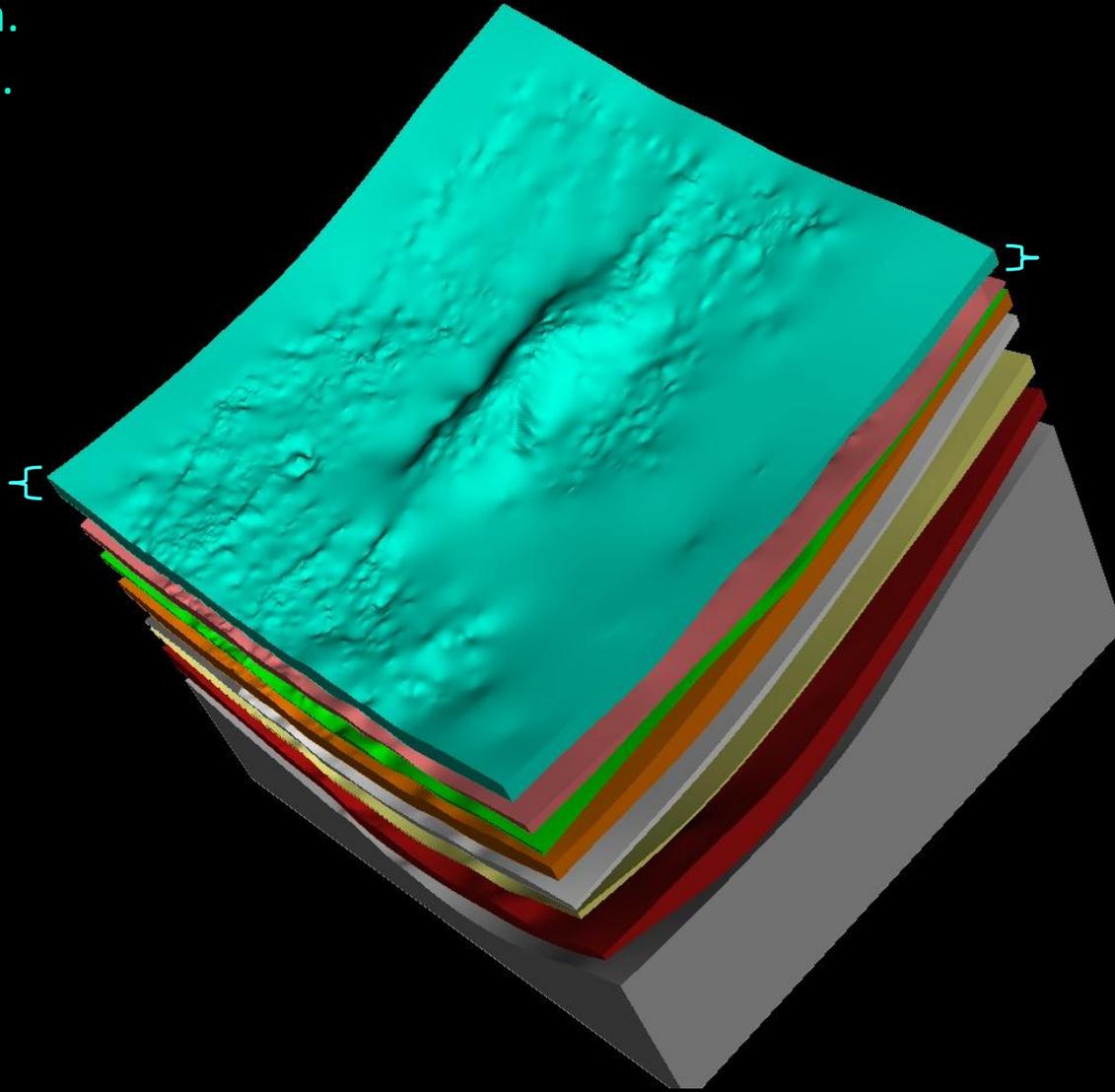
Dakota Group

- New Castle Fm.
- Skull Creek Fm.
- Inyan Kara Fm.



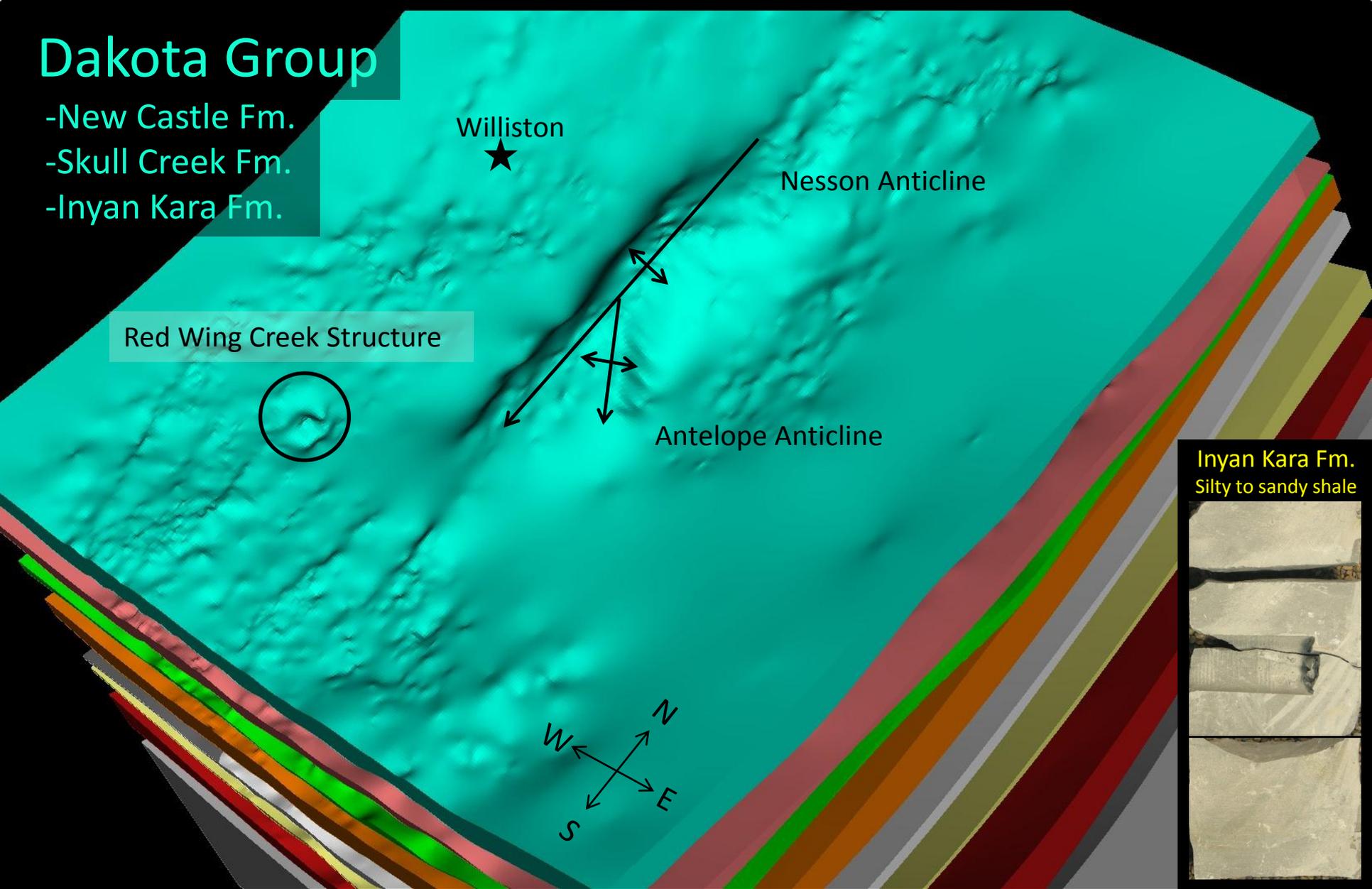
Dakota Group

- New Castle Fm.
- Skull Creek Fm.
- Inyan Kara Fm.



Dakota Group

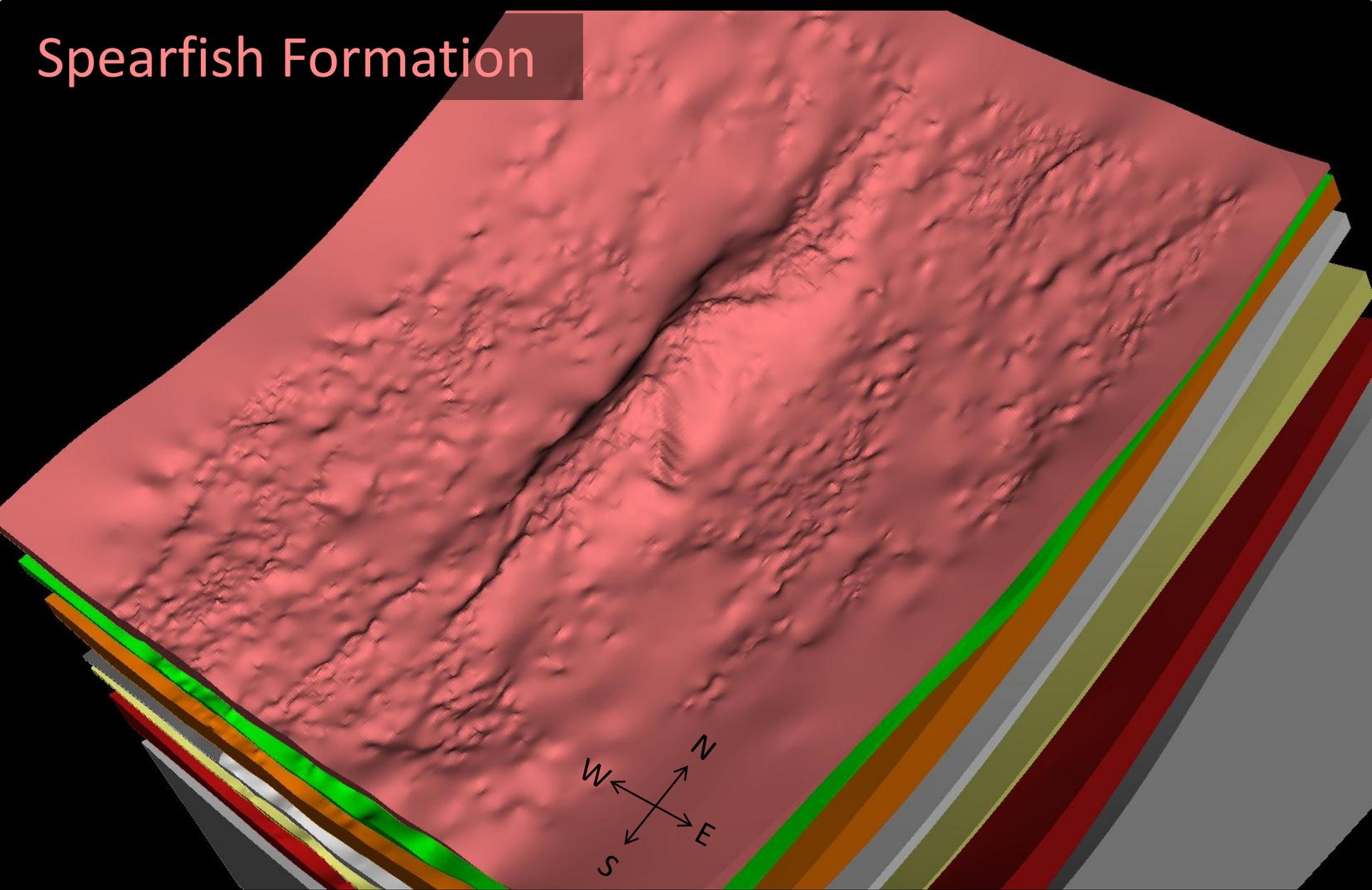
- New Castle Fm.
- Skull Creek Fm.
- Inyan Kara Fm.



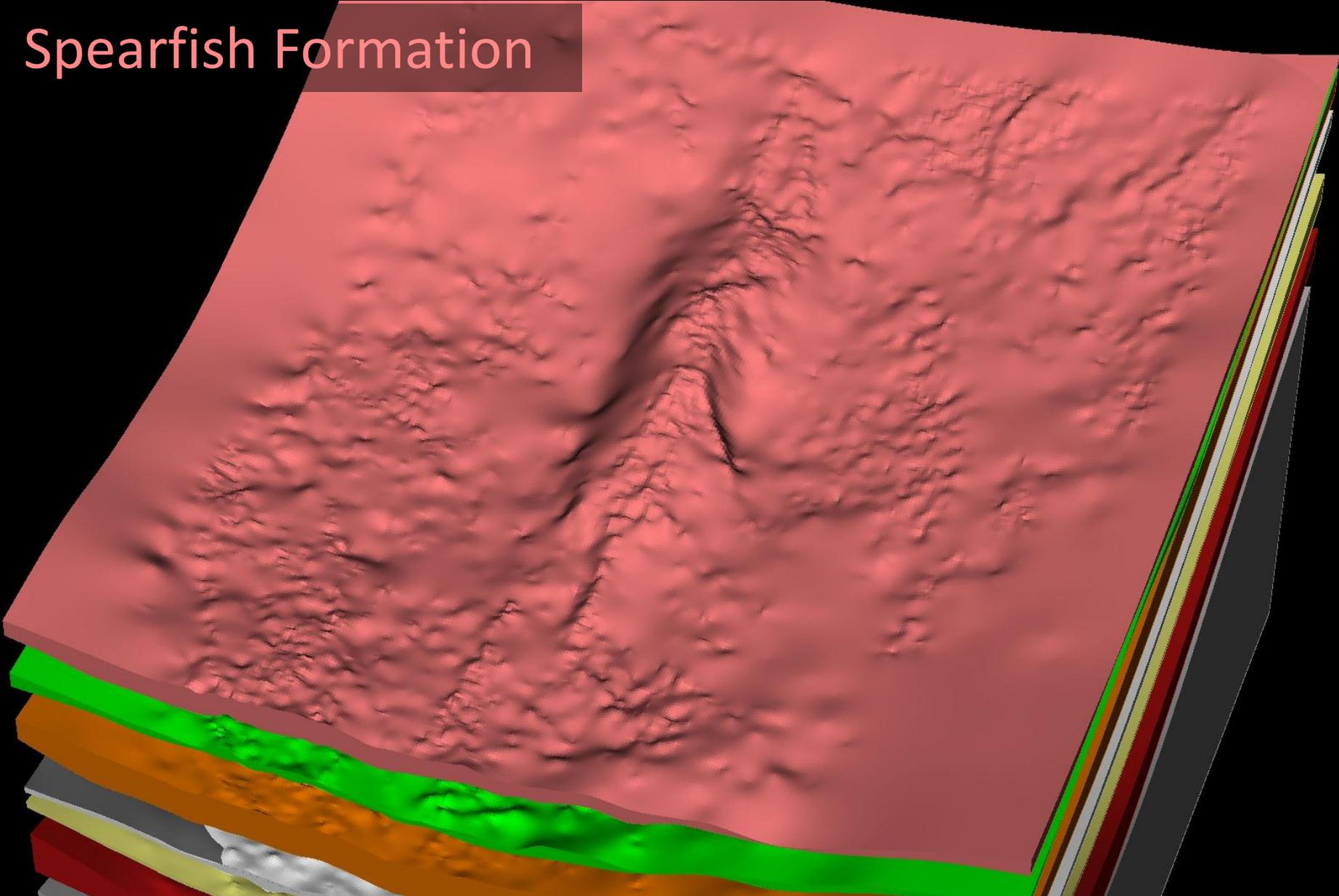
Inyan Kara Fm.
Silty to sandy shale



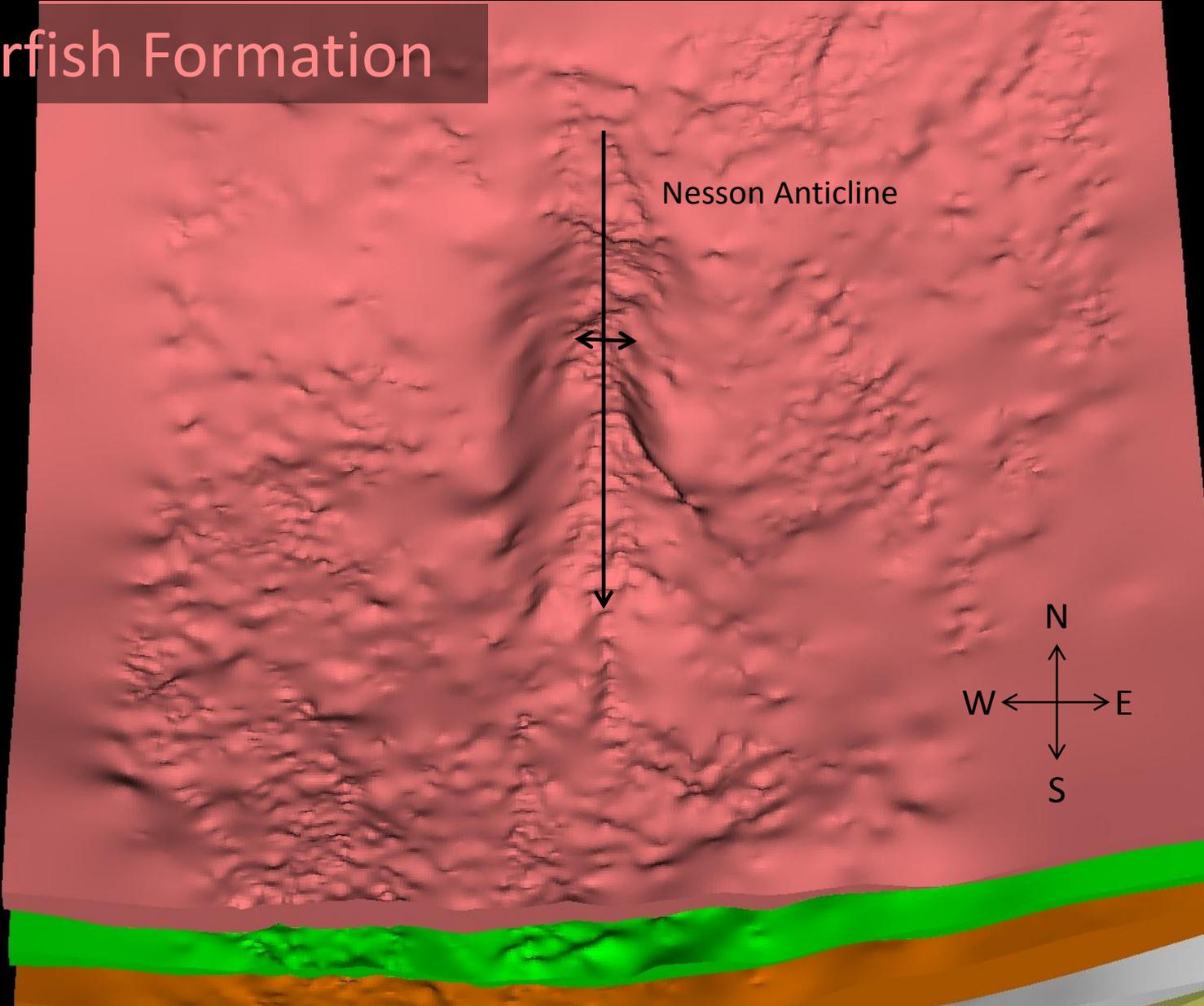
Spearfish Formation



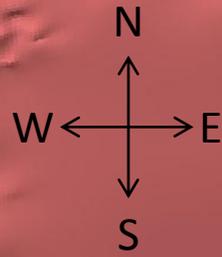
Spearfish Formation



Spearfish Formation



Nesson Anticline



Spearfish Rock Types

Red-brown dolomitic siltstone



Red-brown anhydritic sandstone

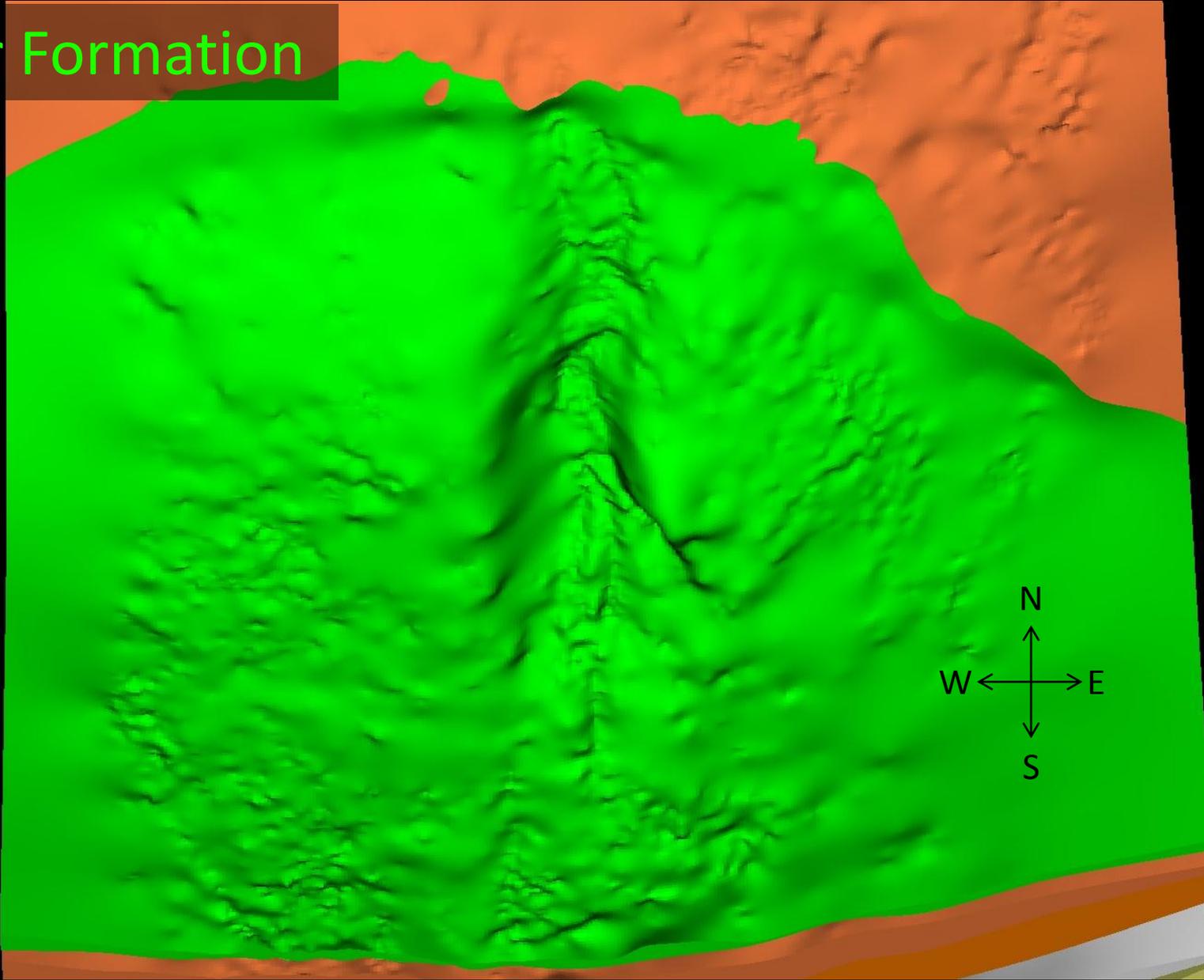


North Dakota Geological Survey

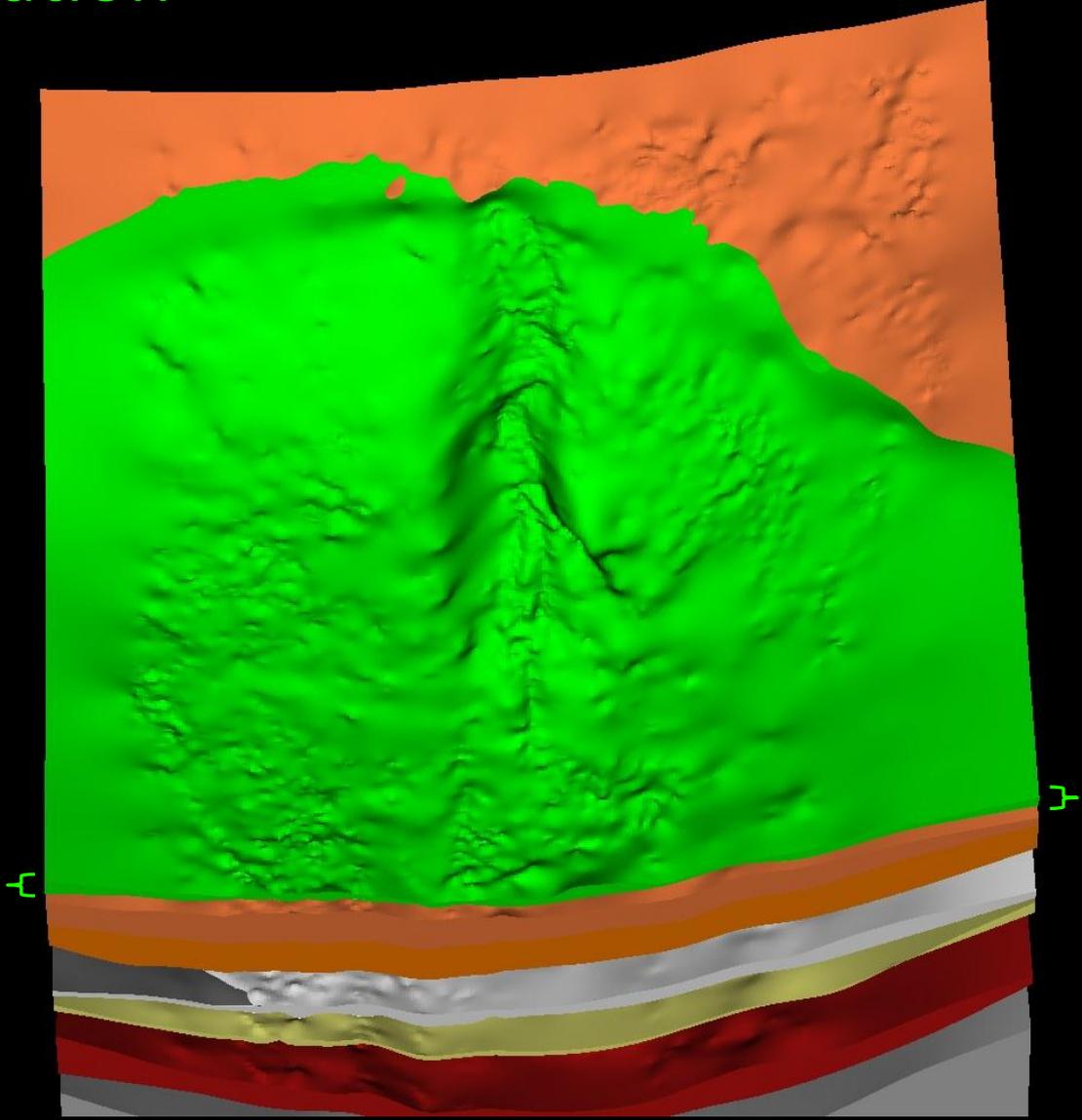
Cum. Oil Production: >50,000,000 BBLS
2009 Production: 389,192 BBLS

GI-137

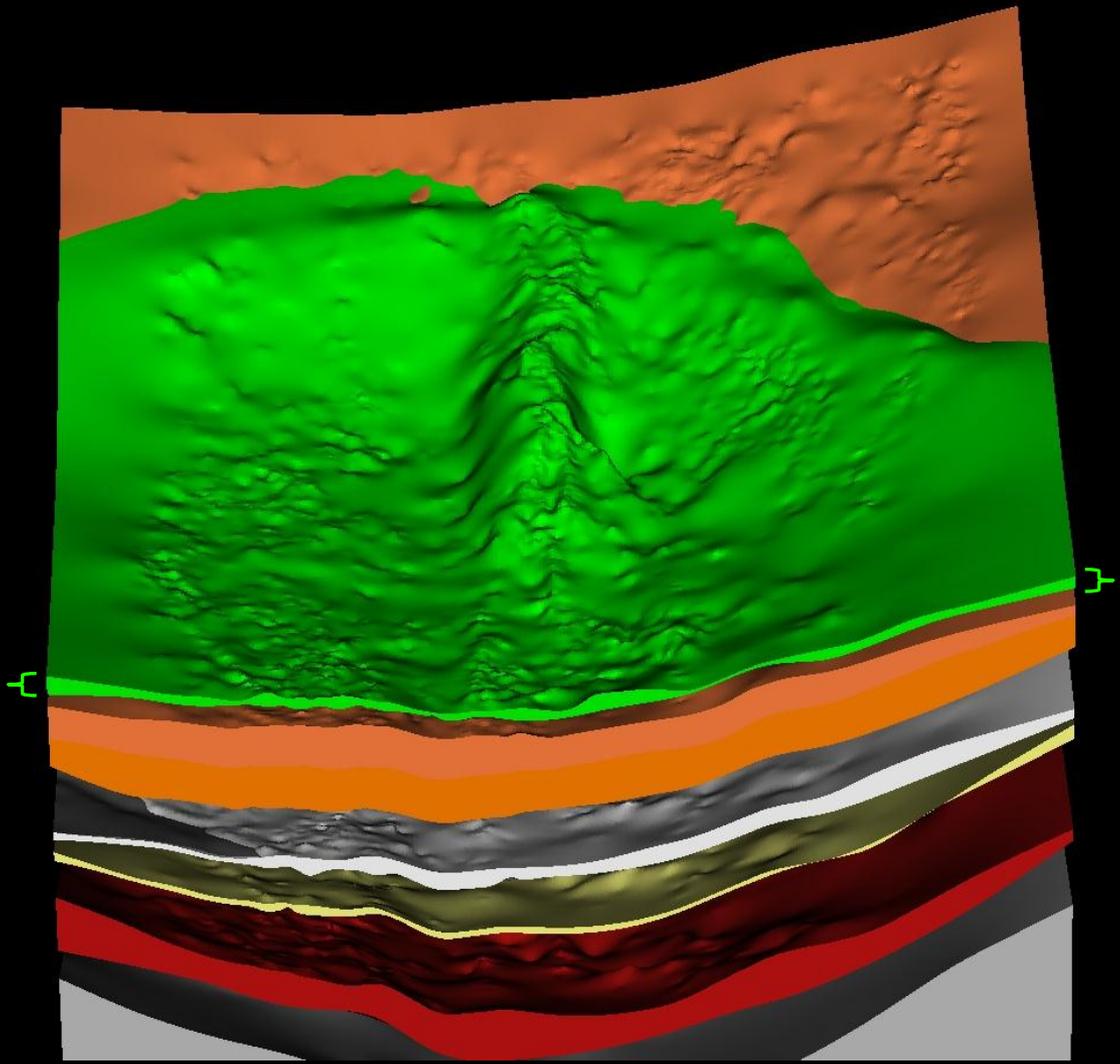
Tyler Formation



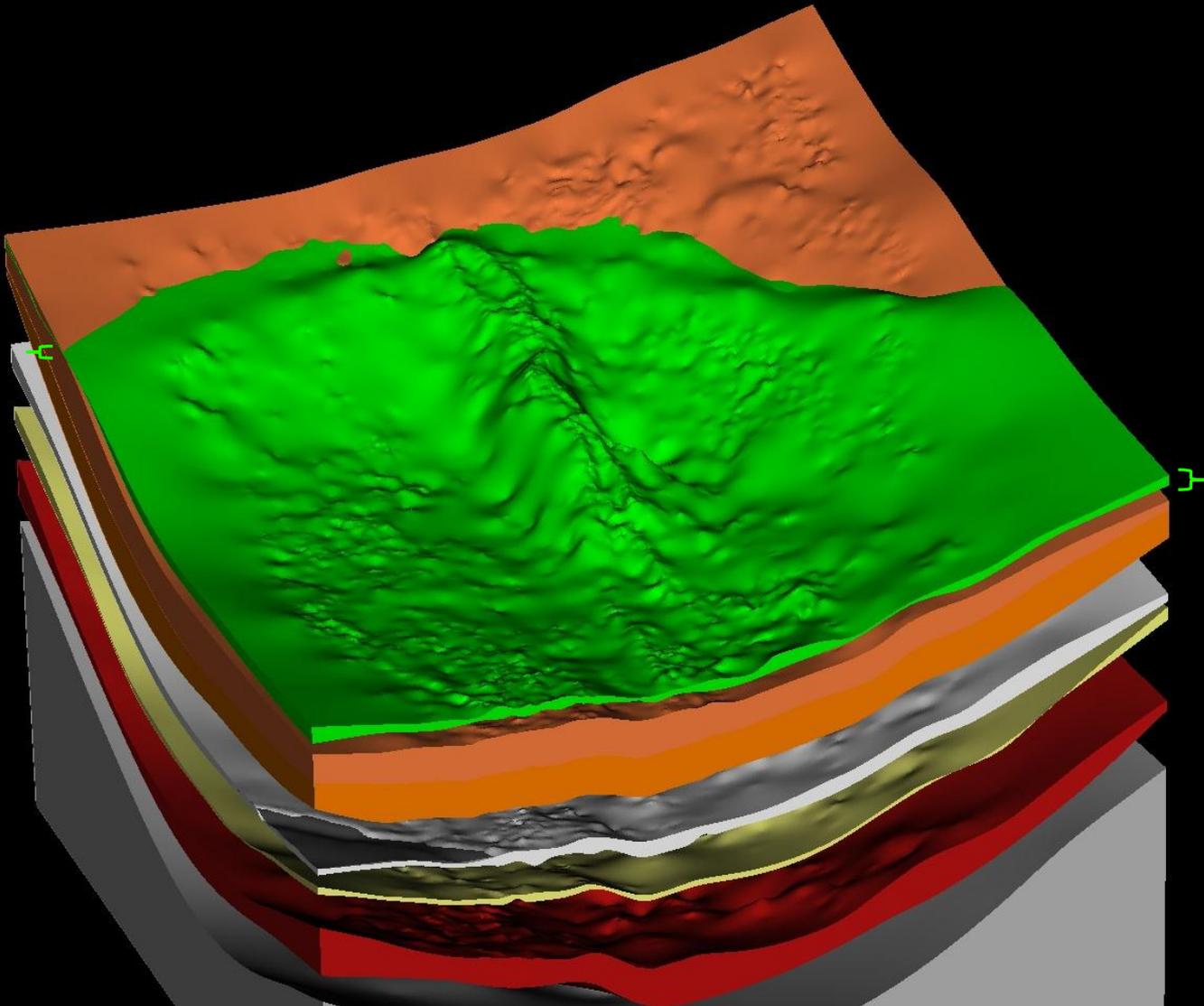
Tyler Formation



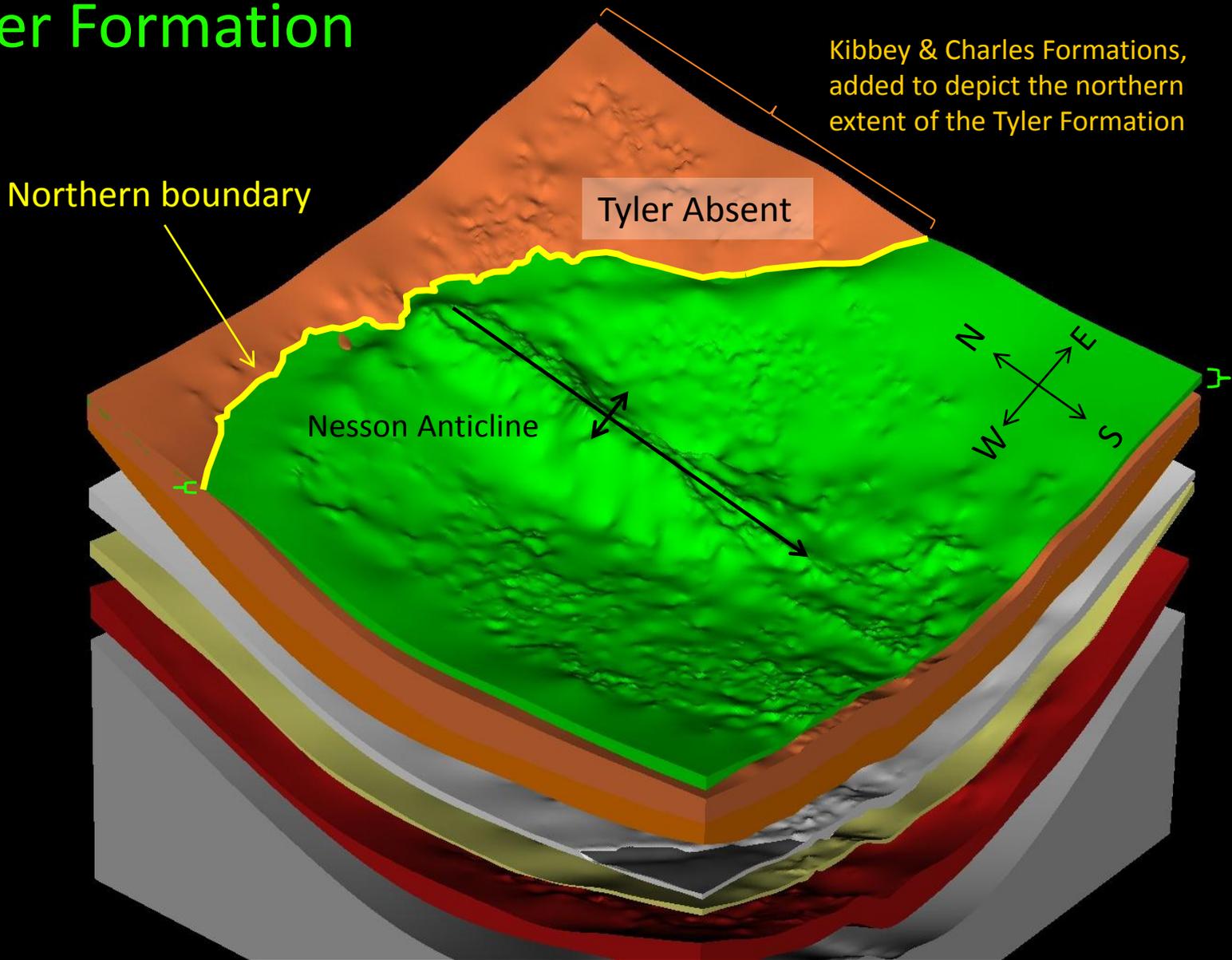
Tyler Formation



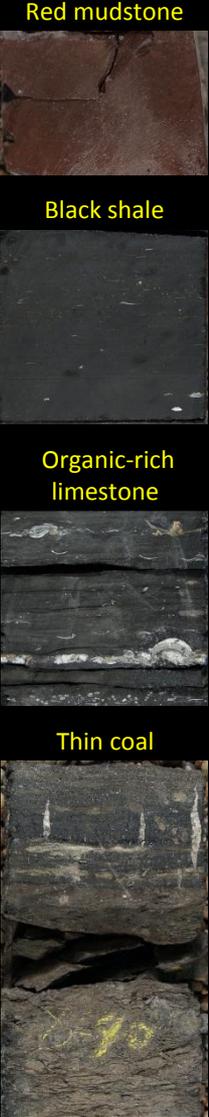
Tyler Formation



Tyler Formation



Partial Tyler Core Sequence

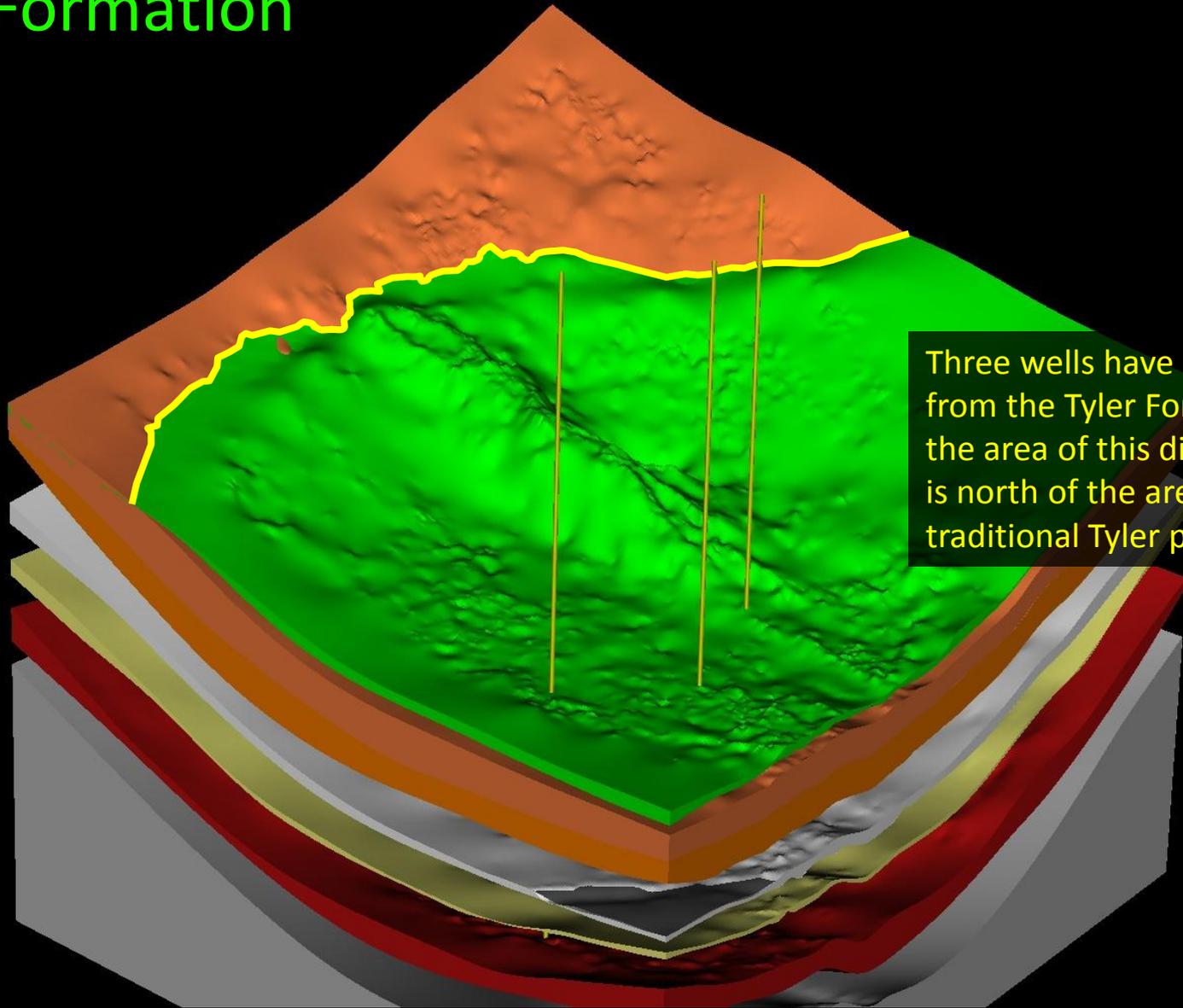


North Dakota
Geological Survey

Cum. Oil Production: >83,000,000 BBLS
2009 Production: 572,879 BBLS

GI-137

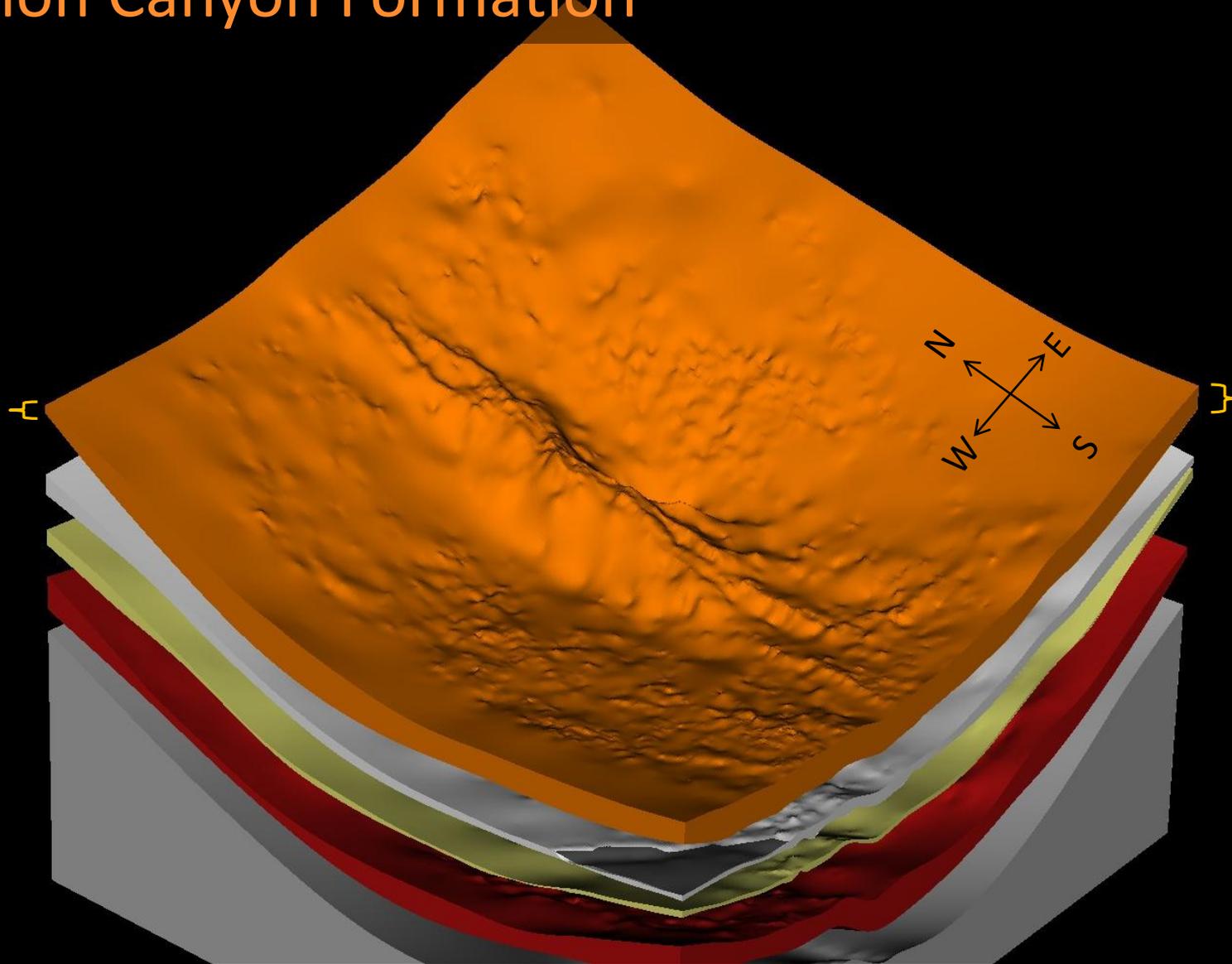
Tyler Formation



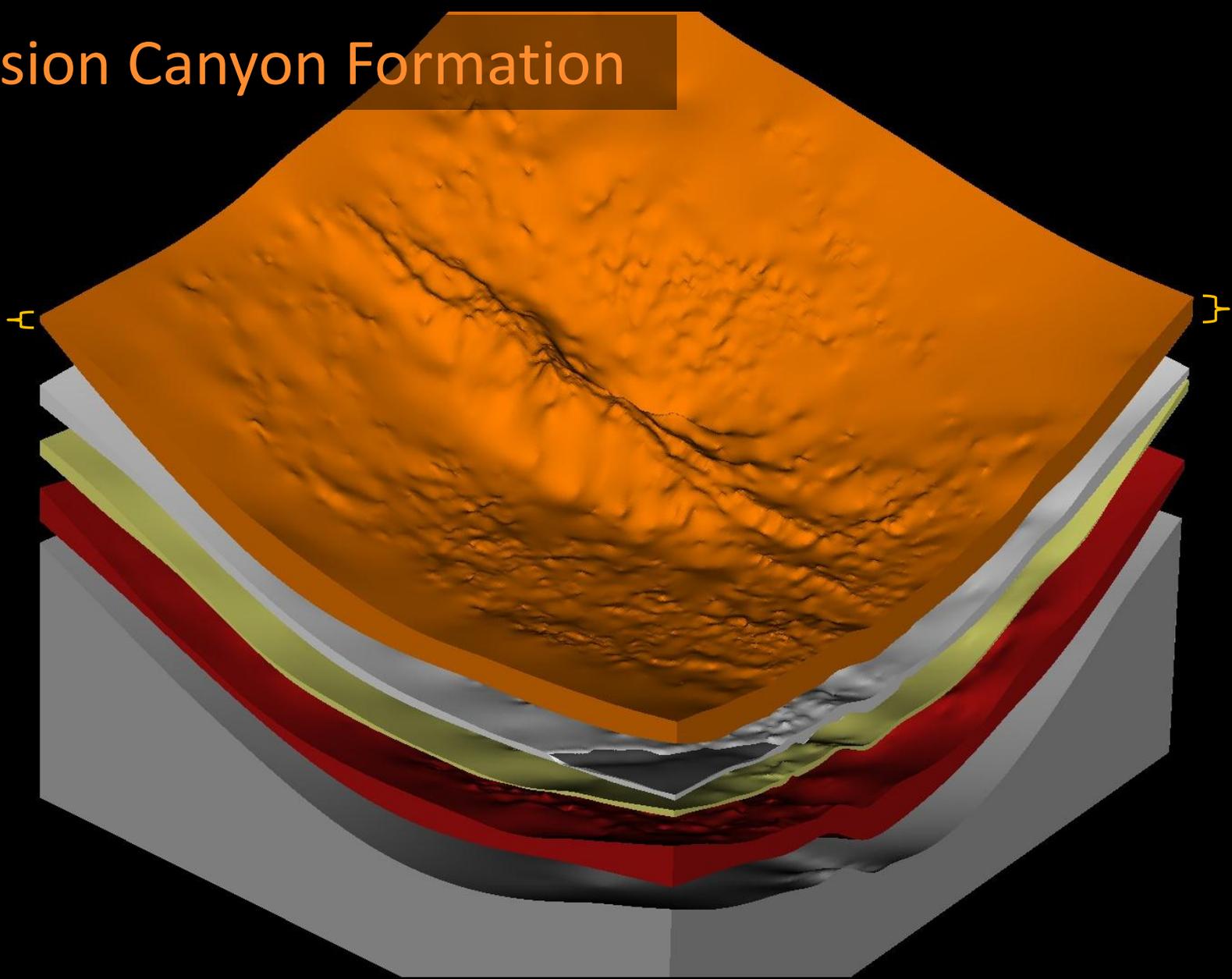
Three wells have produced oil from the Tyler Formation within the area of this diagram, which is north of the area of current/traditional Tyler production



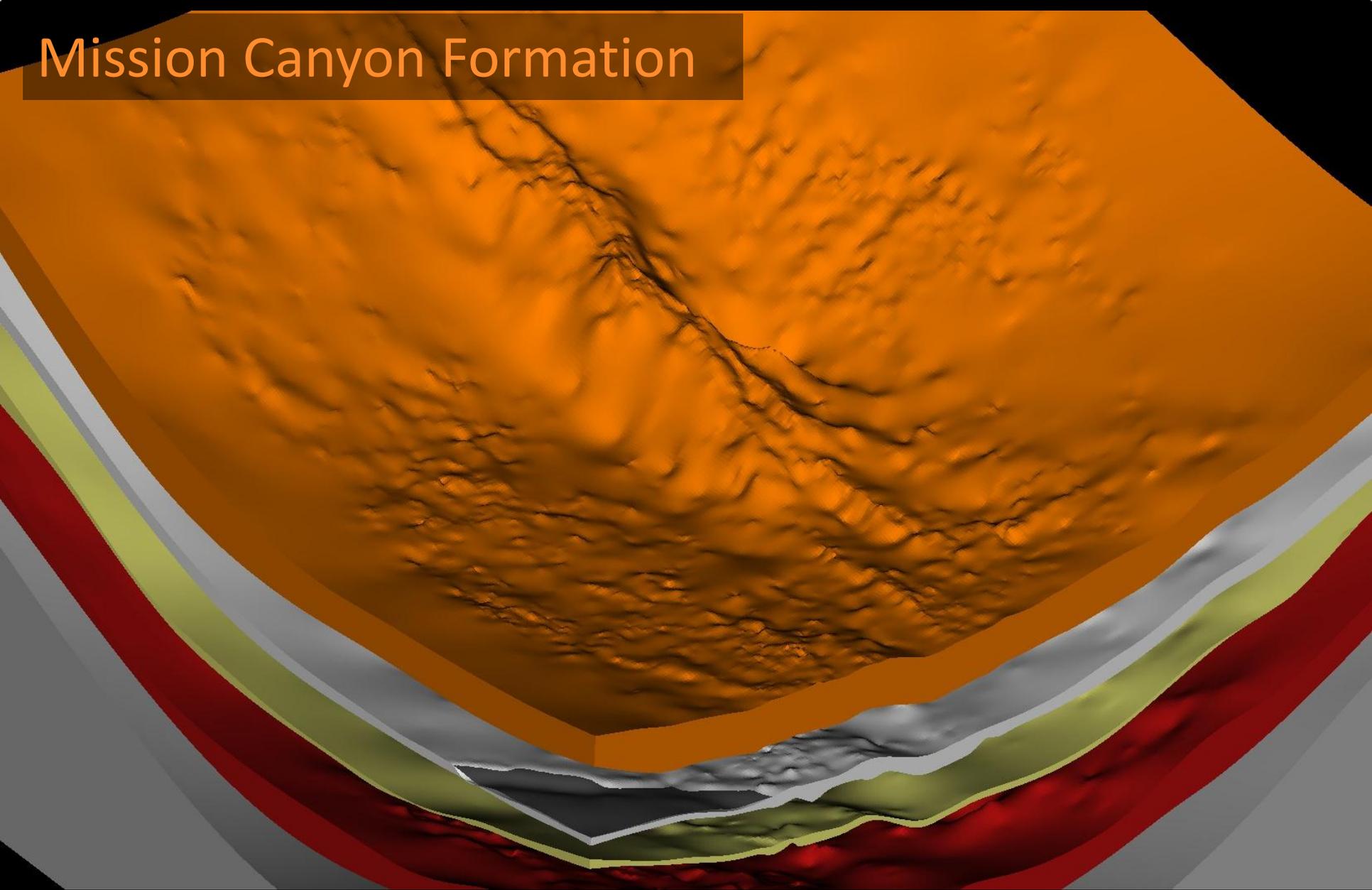
Mission Canyon Formation



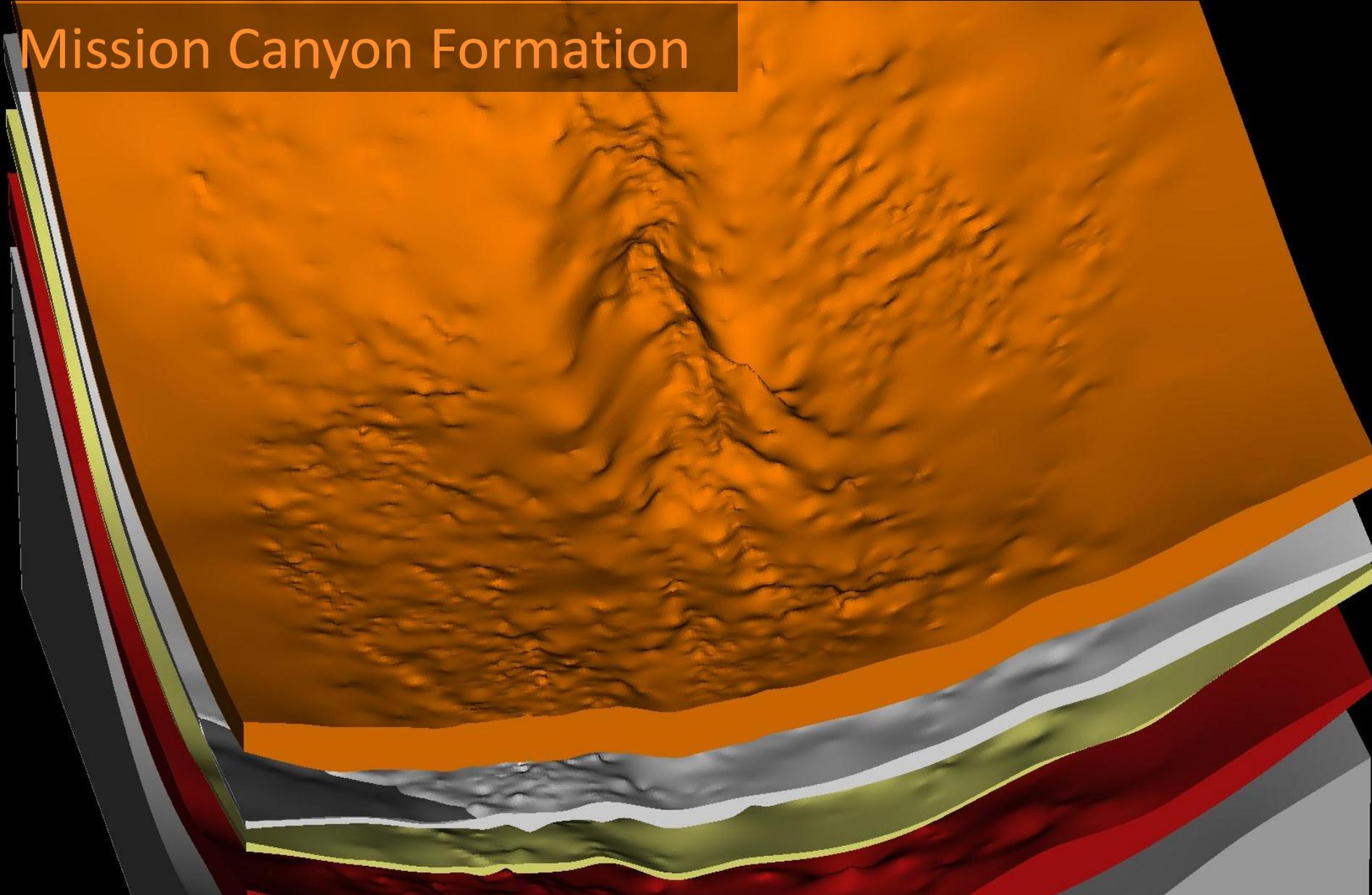
Mission Canyon Formation



Mission Canyon Formation

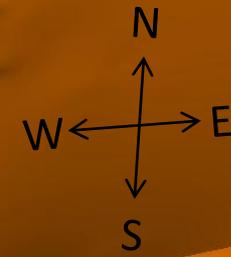


Mission Canyon Formation



Mission Canyon Formation

Nesson Anticline



Mission Canyon Core Examples

Dolomite



Limestone



Slightly anhydritic limestone



Cum. Oil Prod.: >900,000,000 BBLS (Madison Group)
2009 Production: >9,700,000 BBLS

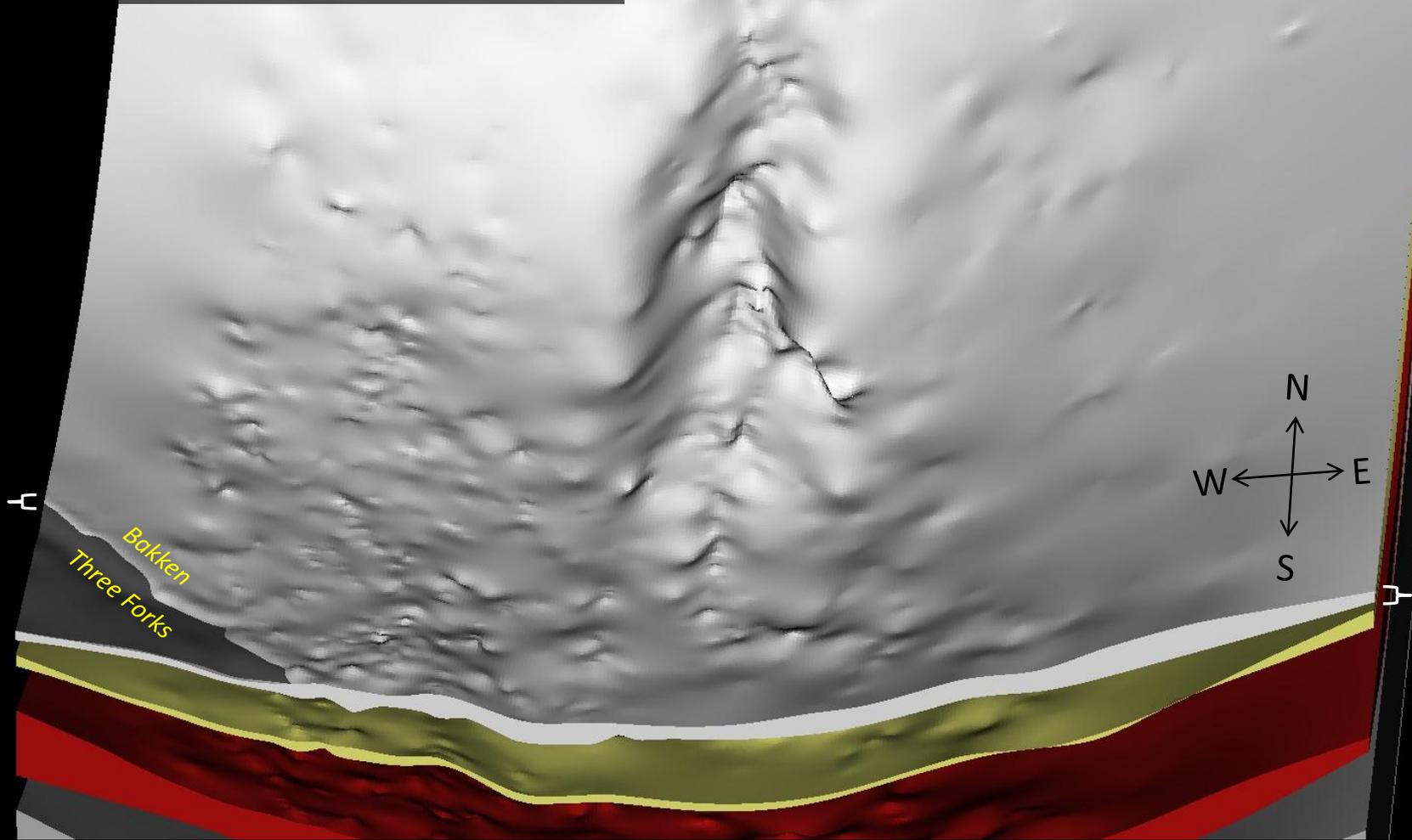
GI-137



North Dakota
Geological Survey

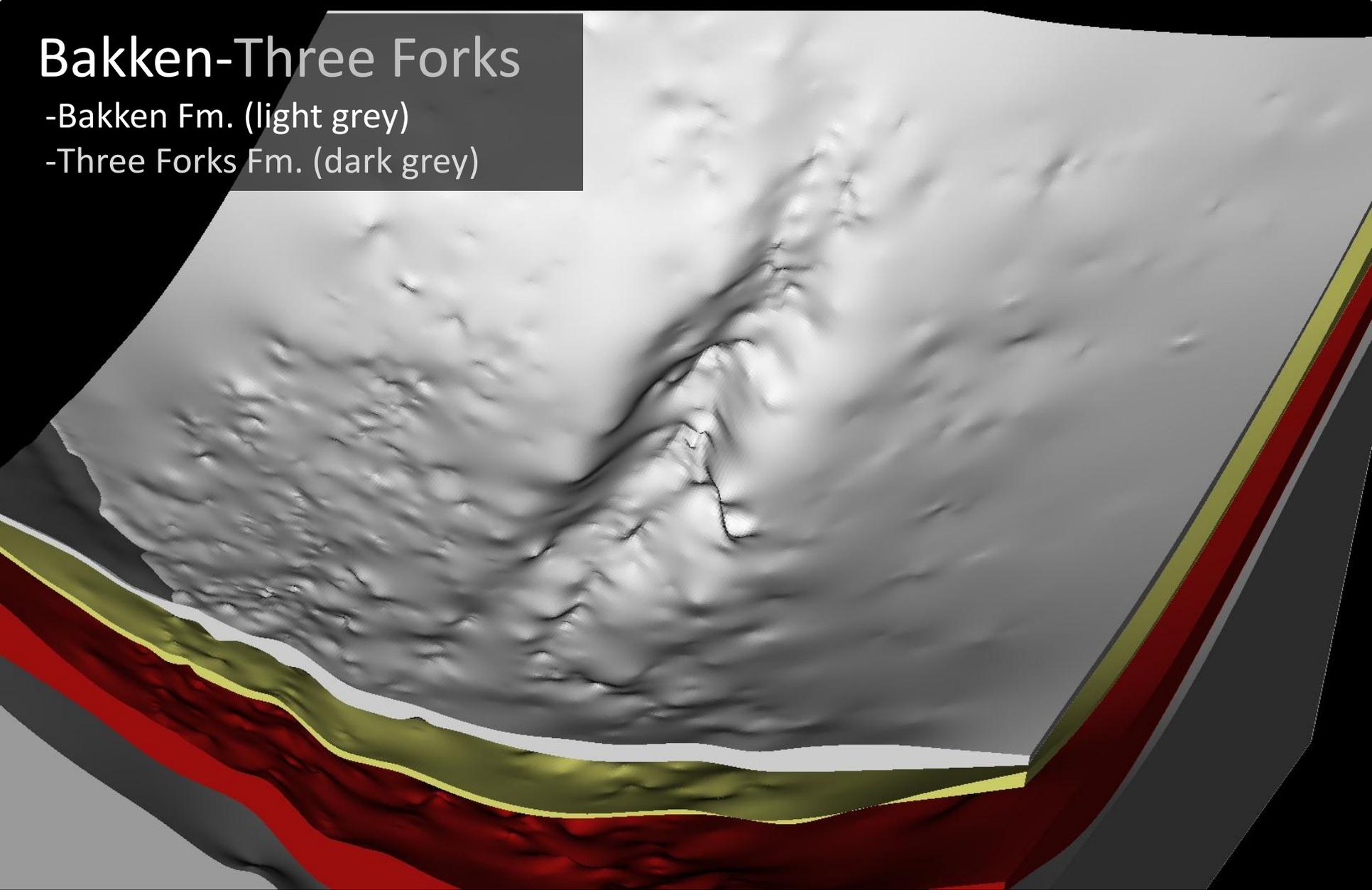
Bakken-Three Forks

- Bakken Fm. (light grey)
- Three Forks Fm. (dark grey)



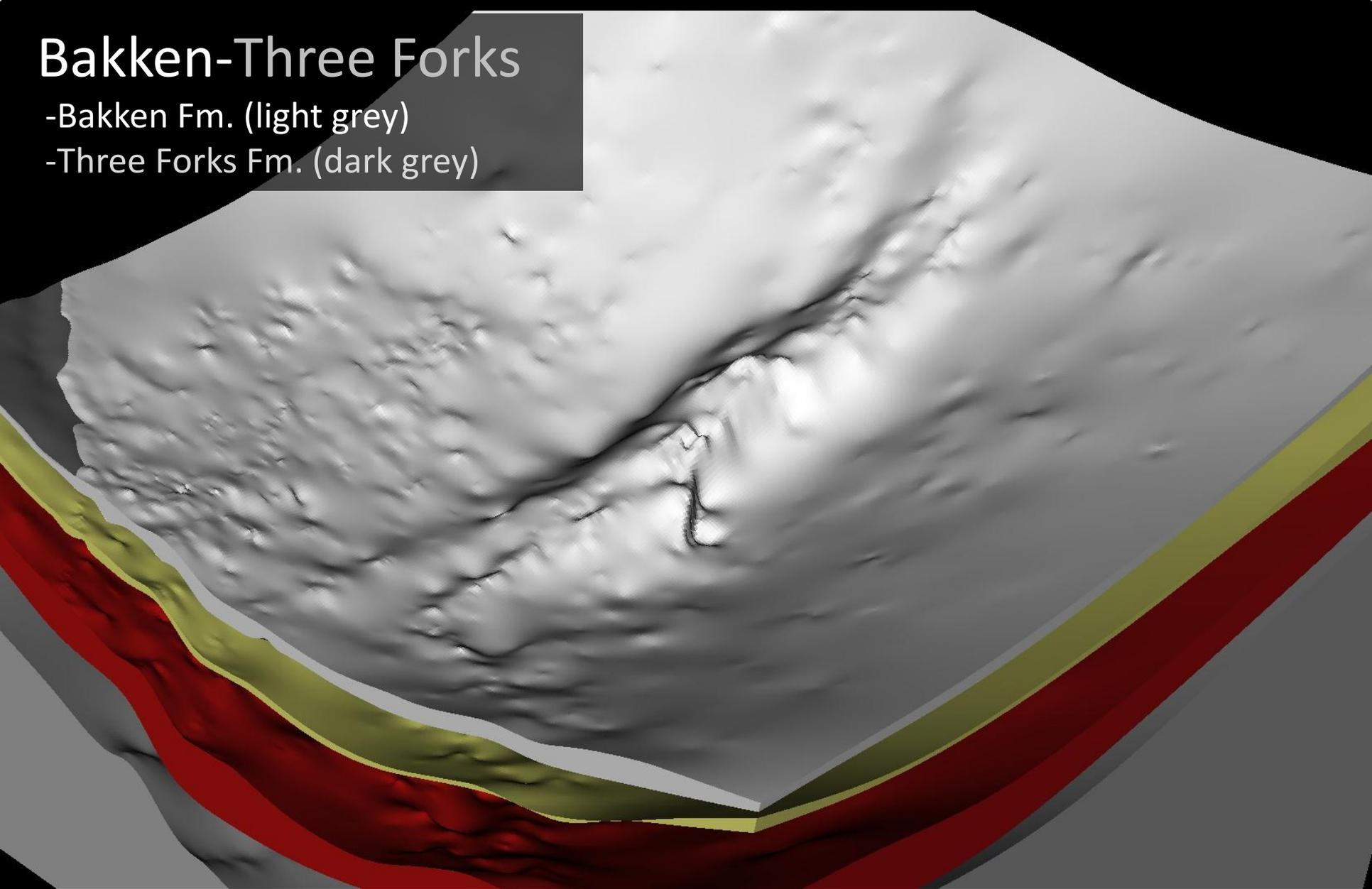
Bakken-Three Forks

- Bakken Fm. (light grey)
- Three Forks Fm. (dark grey)



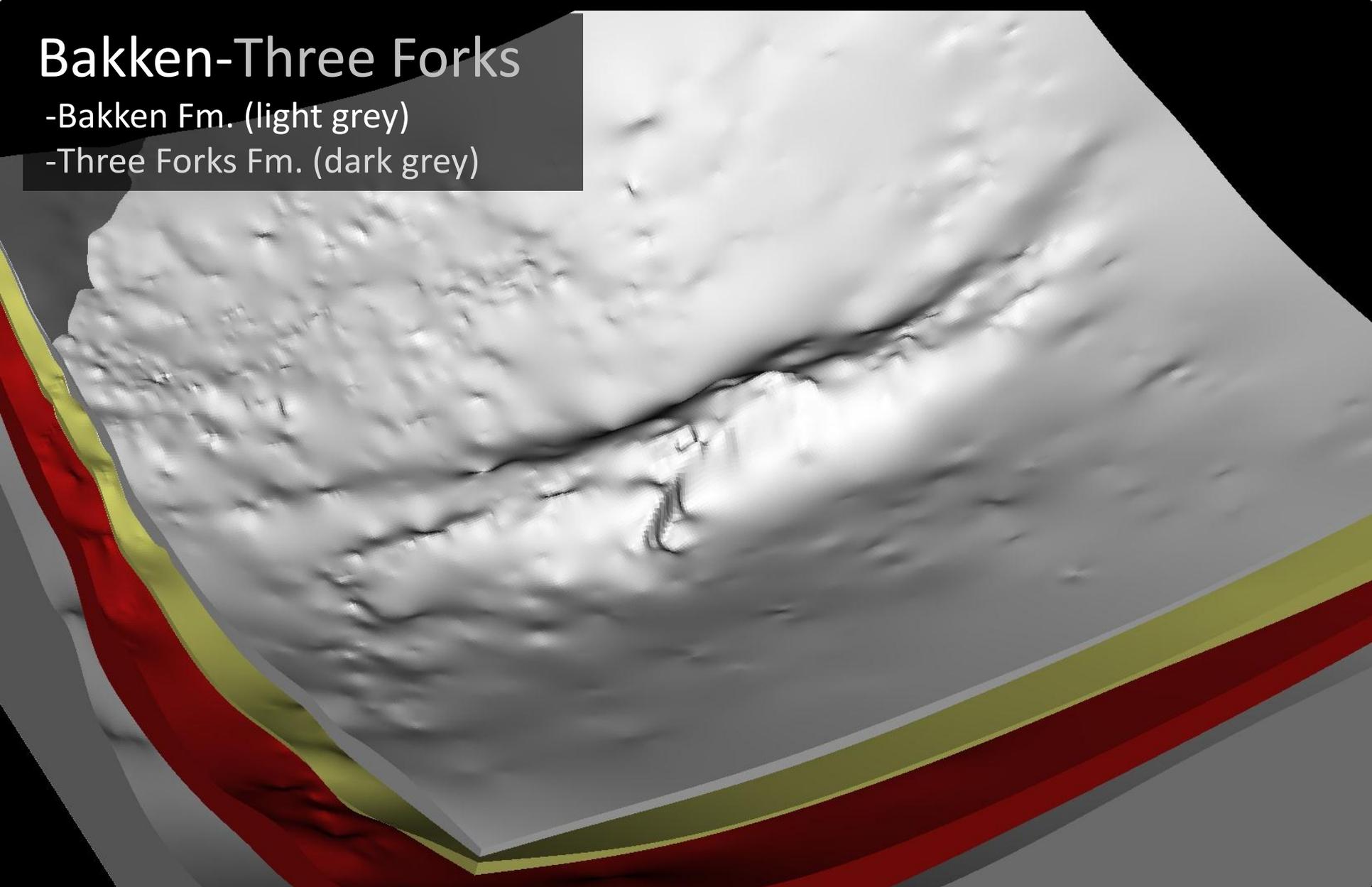
Bakken-Three Forks

- Bakken Fm. (light grey)
- Three Forks Fm. (dark grey)



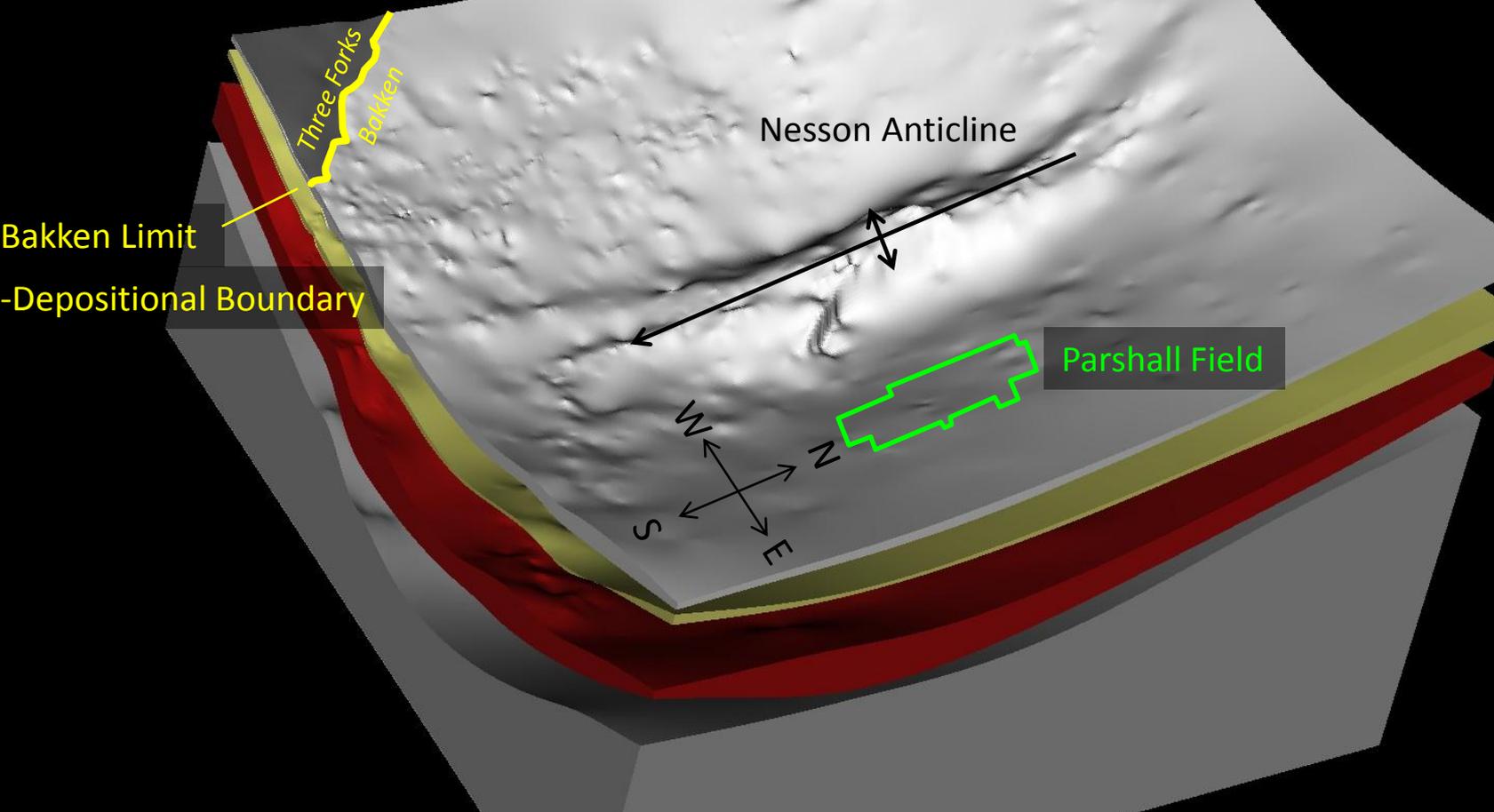
Bakken-Three Forks

- Bakken Fm. (light grey)
- Three Forks Fm. (dark grey)



Bakken-Three Forks

- Bakken Fm. (light grey)
- Three Forks Fm. (dark grey)



Upper Bakken
Black shale



Middle Bakken
Sandy carbonate



Lower Bakken
Black shale



Three Forks
Dolomite

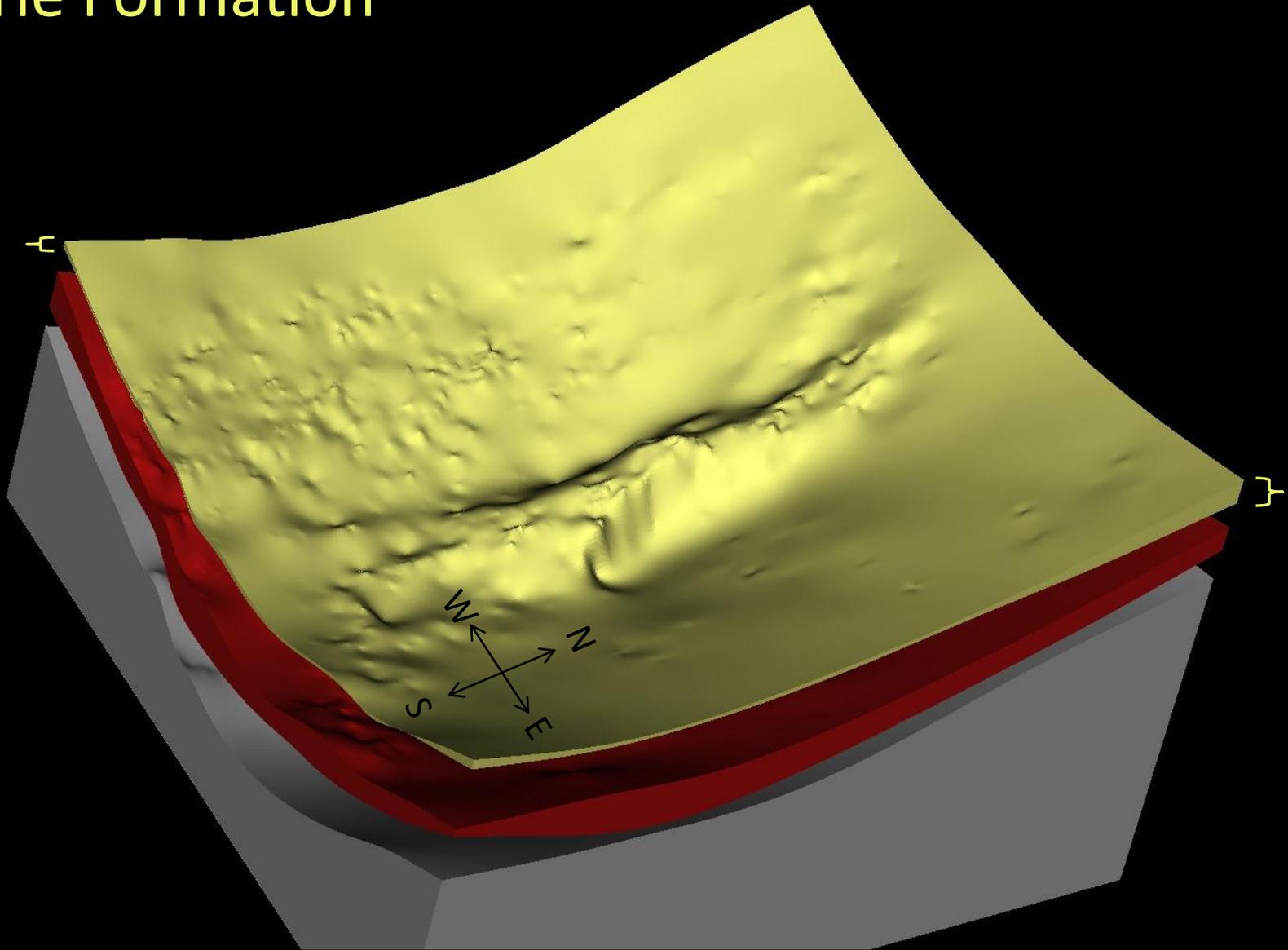


North Dakota
Geological Survey

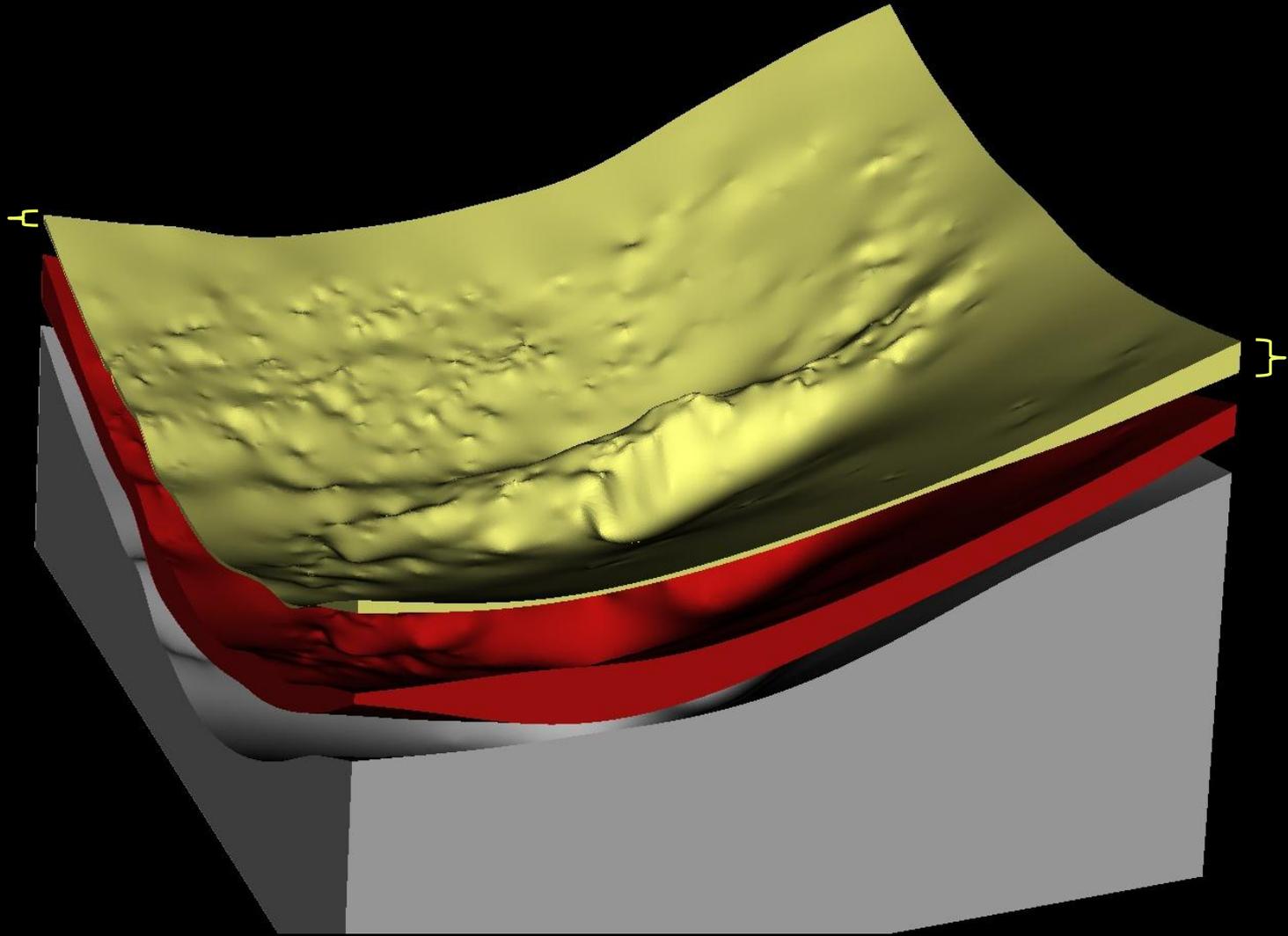
Cum. Oil Production: >120,000,000 BBLs
2009 Oil Production: 49,481,620 BBLs

GI-137

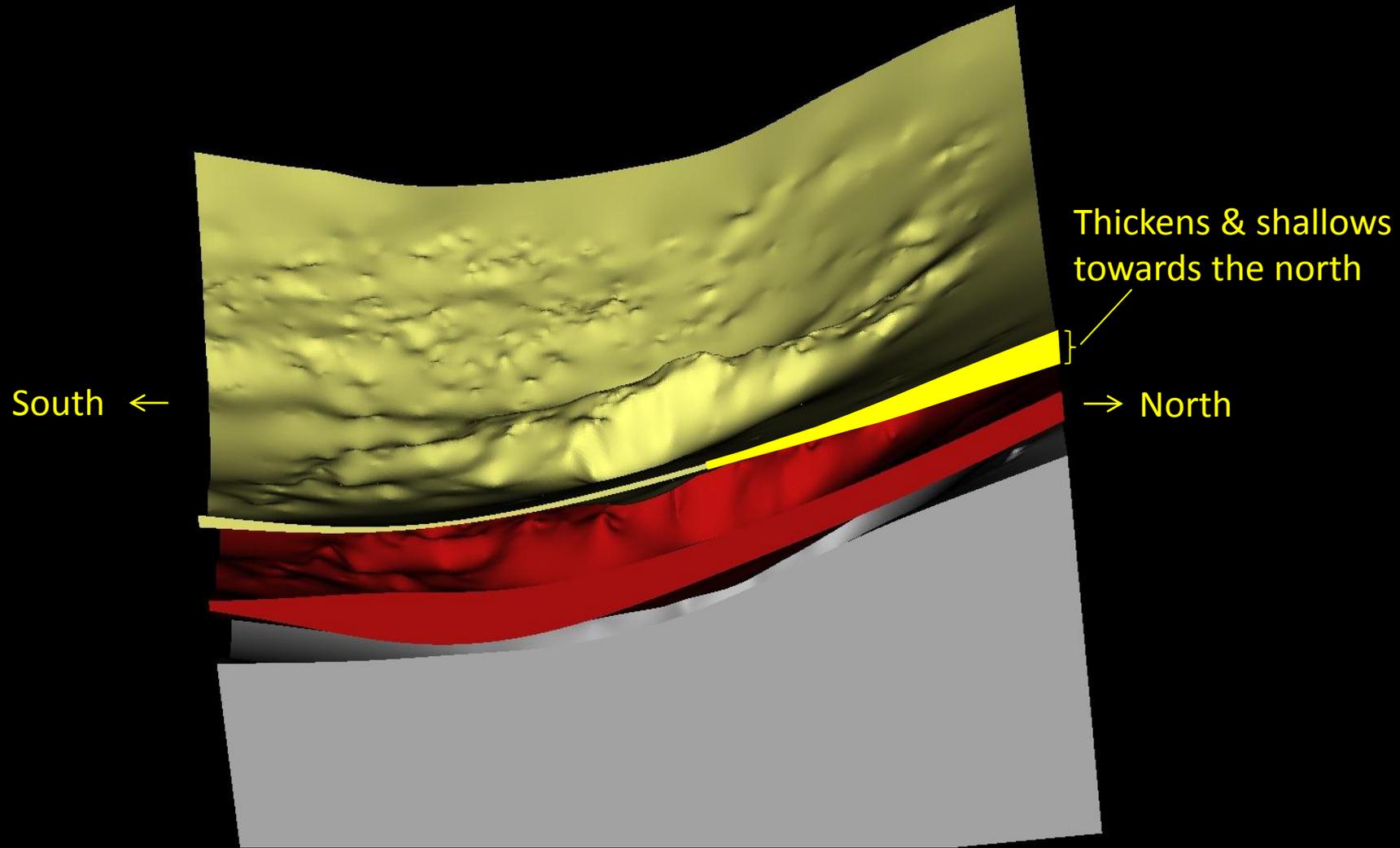
Prairie Formation



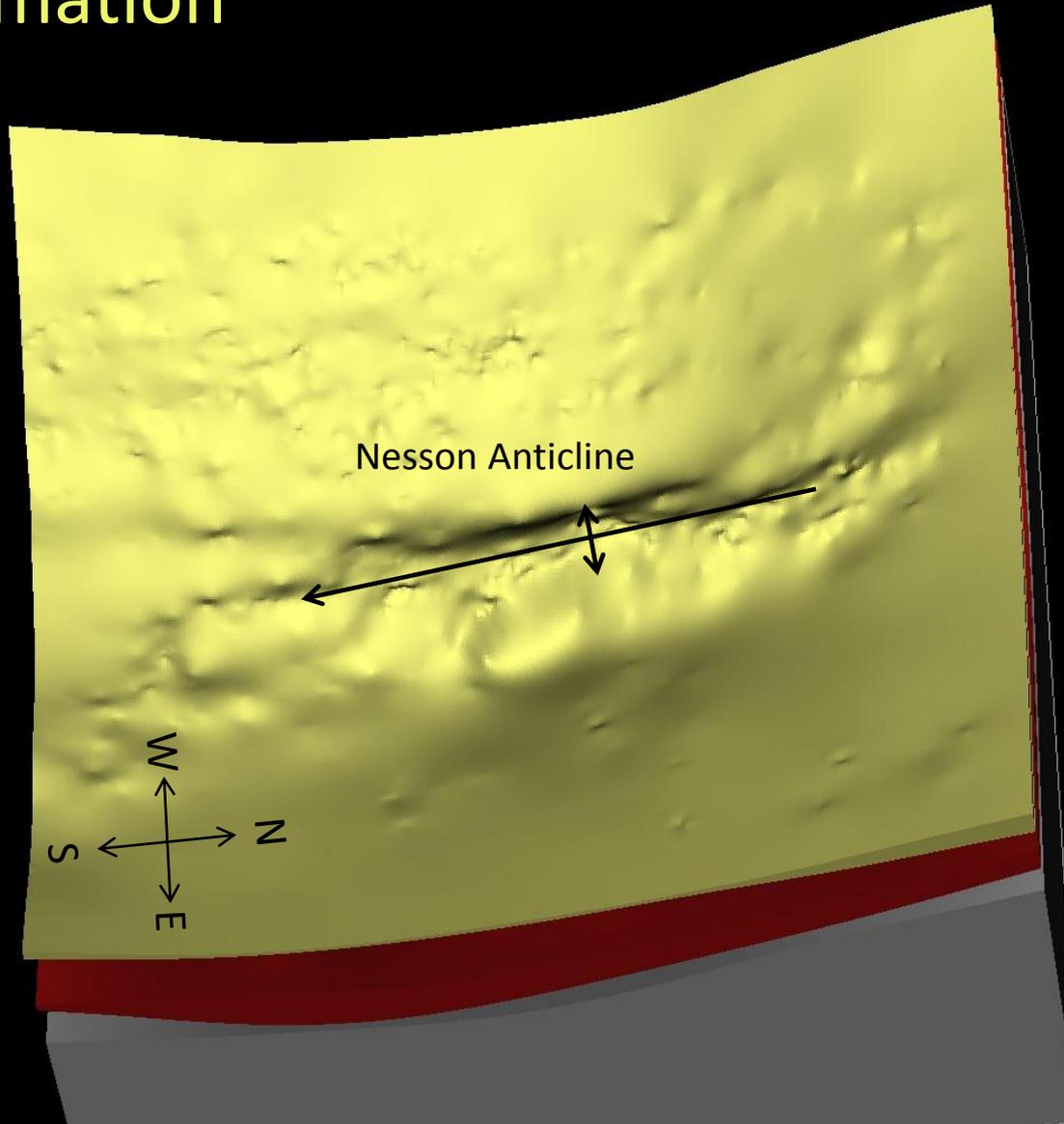
Prairie Formation



Prairie Formation



Prairie Formation



Prairie Evaporite
Potash



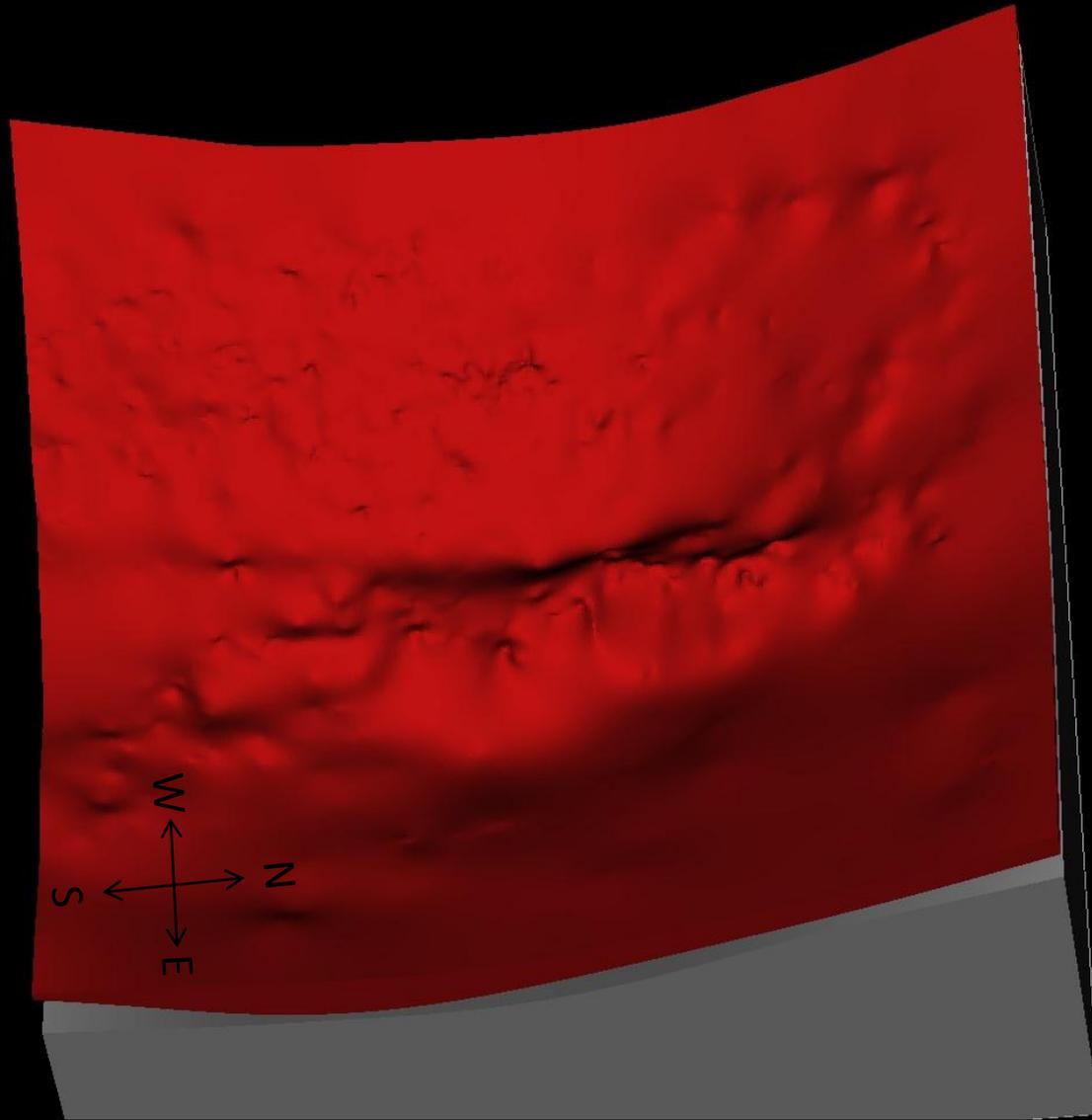
**~50 Billion Tons of Potash in
northwestern North Dakota**

GI-137

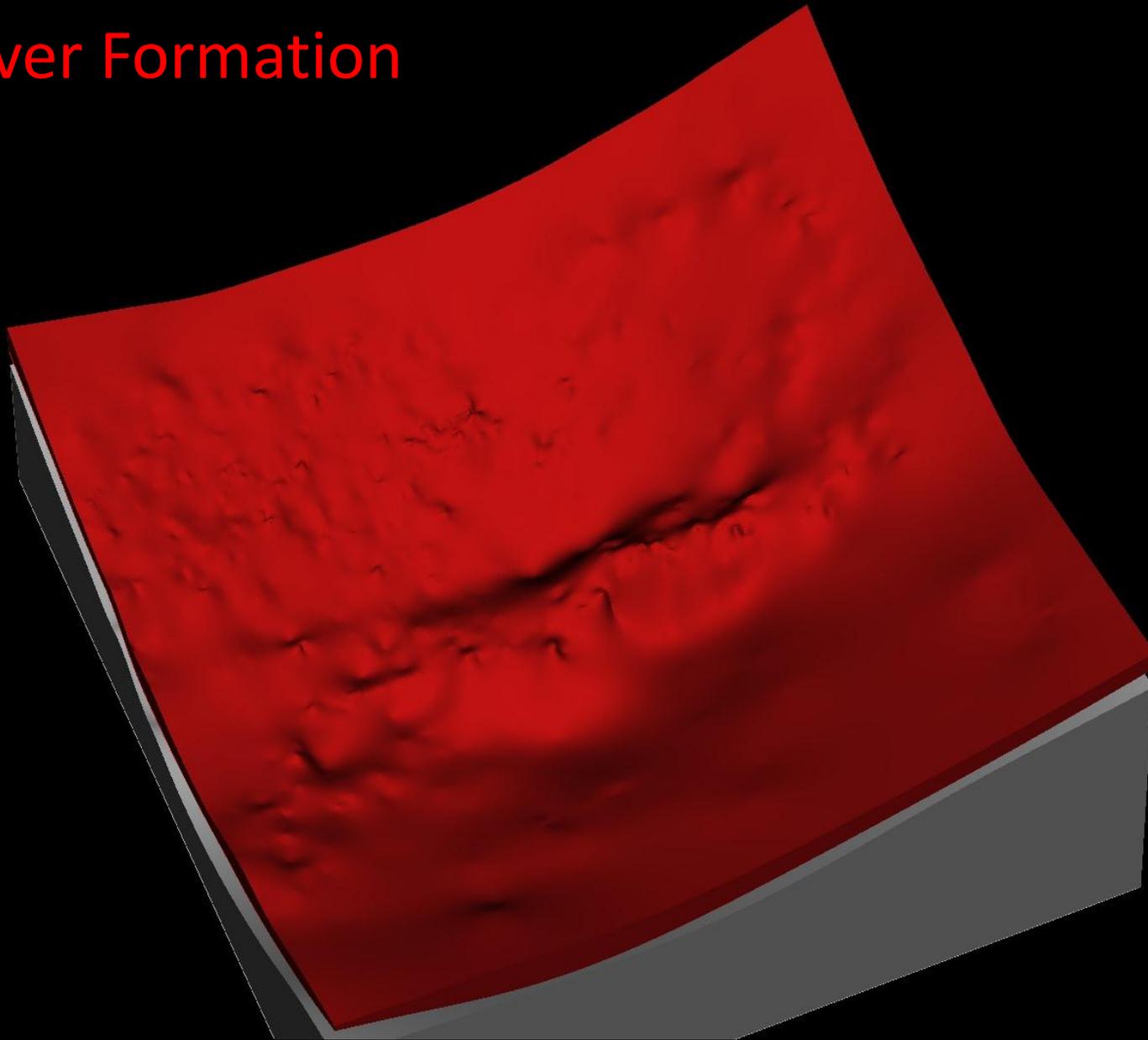


North Dakota
Geological Survey

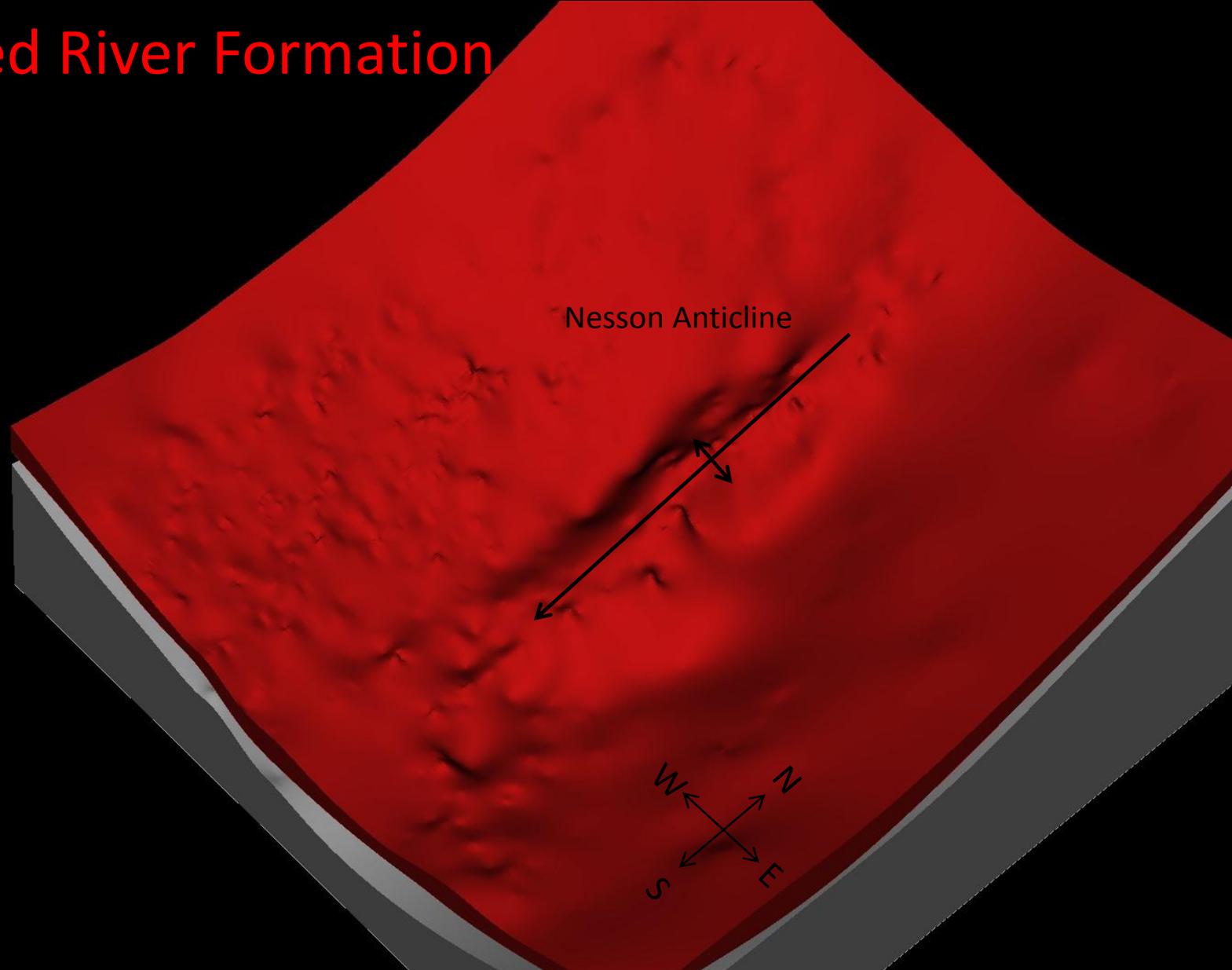
Red River Formation



Red River Formation



Red River Formation



Red River Rock-Type Examples

Brownish-grey dolomite



Grayish-brown dolomite



Slightly fossiliferous limestone

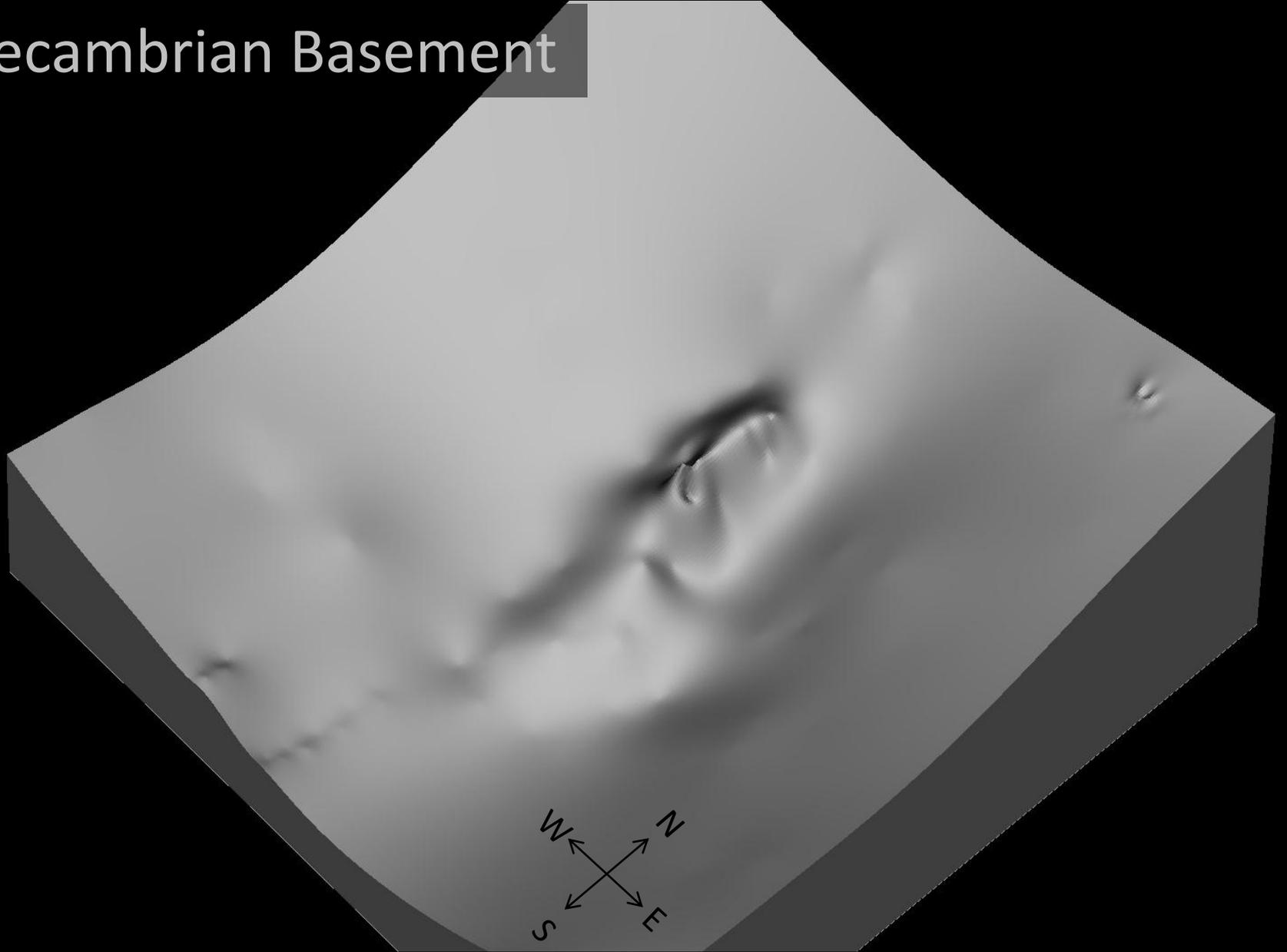


North Dakota
Geological Survey

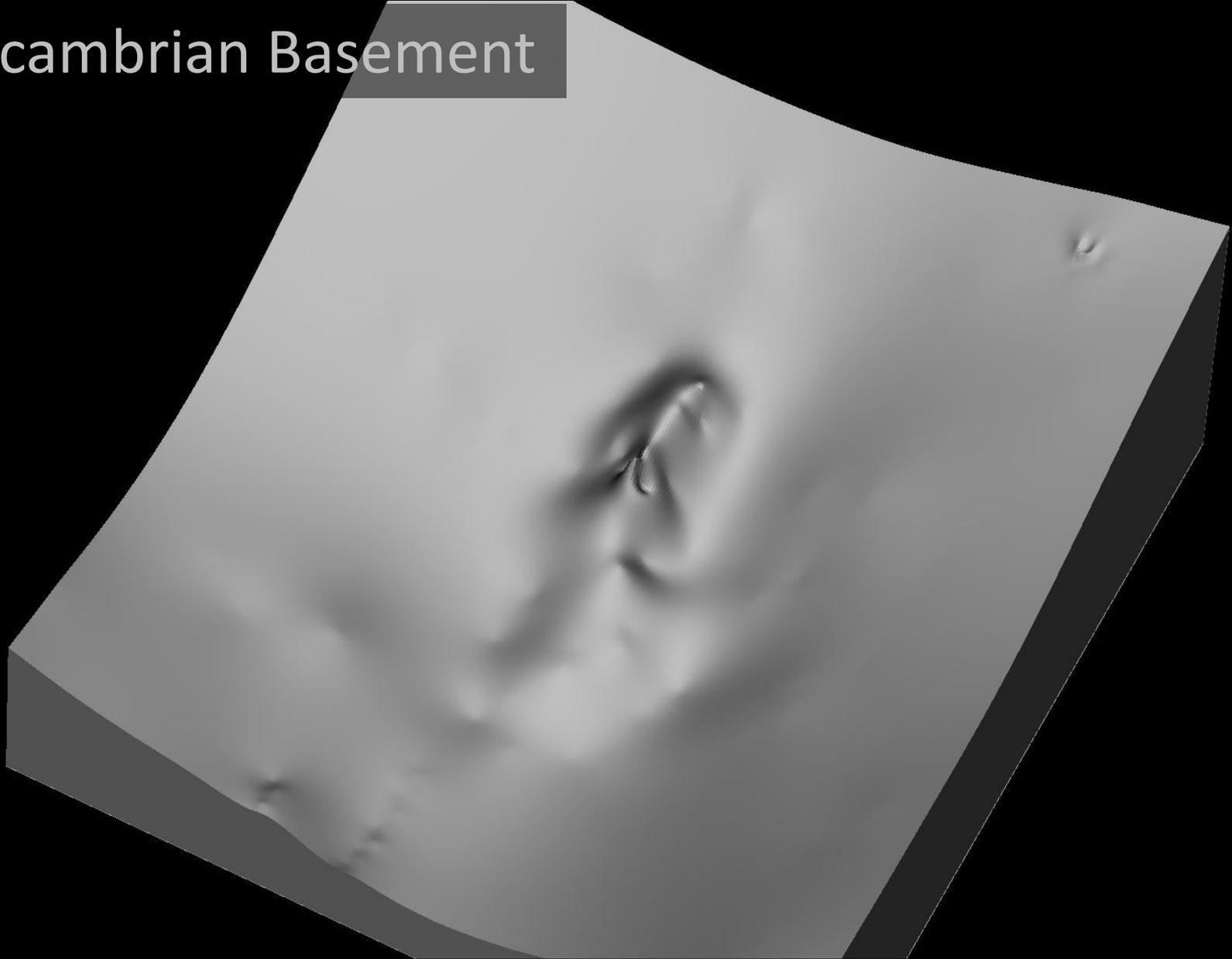
Cum. Oil Production: >215,000,000 BBLS
2009 Oil Production: 14,054,604 BBLS

GI-137

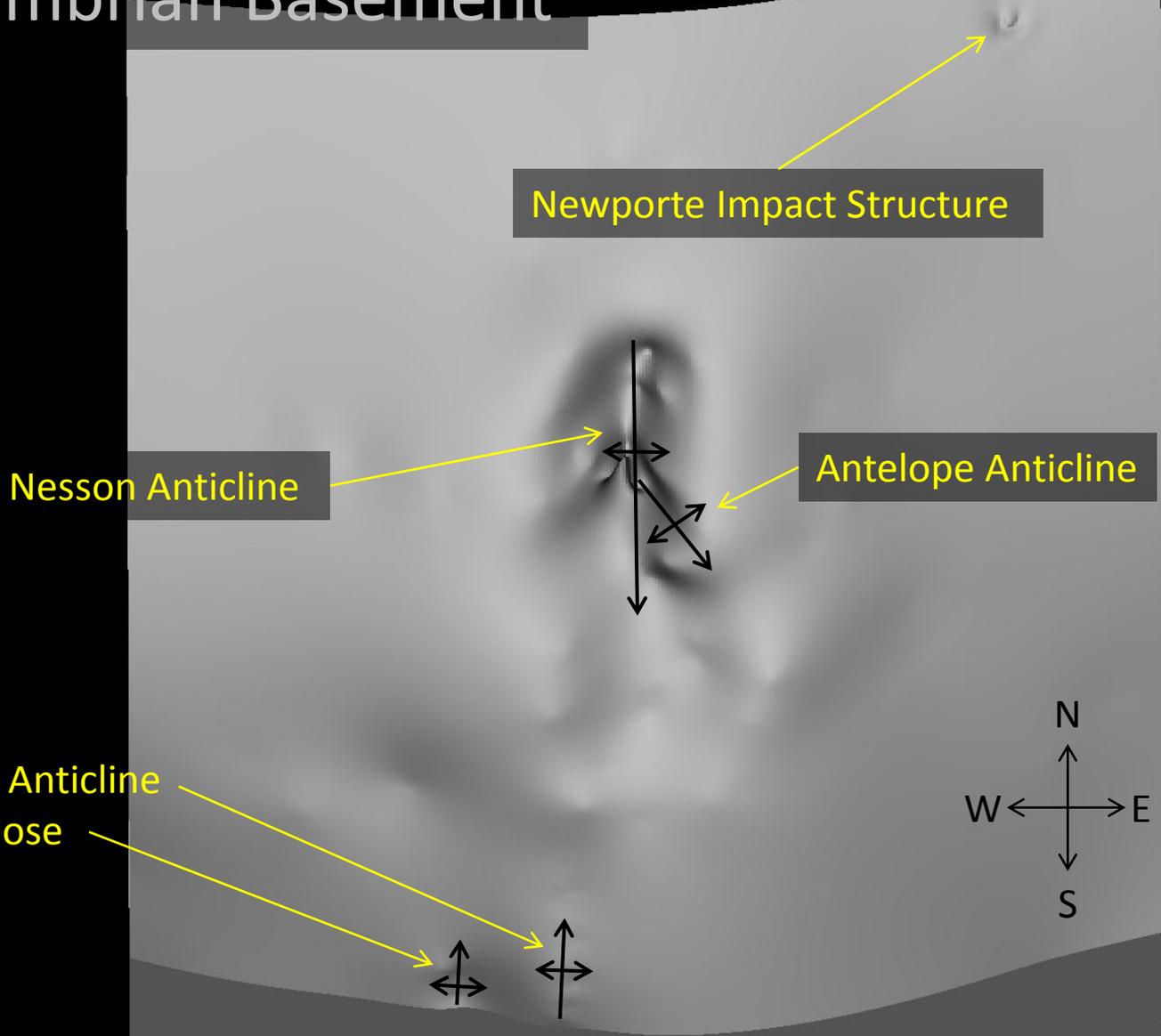
Precambrian Basement



Precambrian Basement



Precambrian Basement



Precambrian Rock-Types

Chlorite schist/gneiss



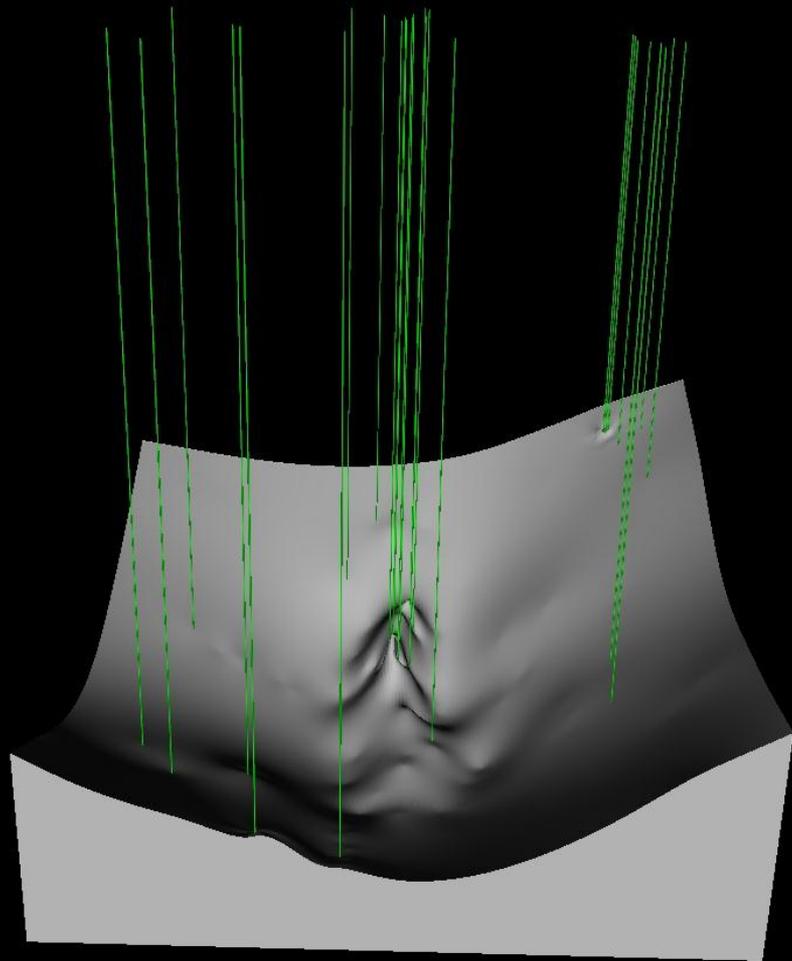
Mafic granulite



Andesitic gneiss

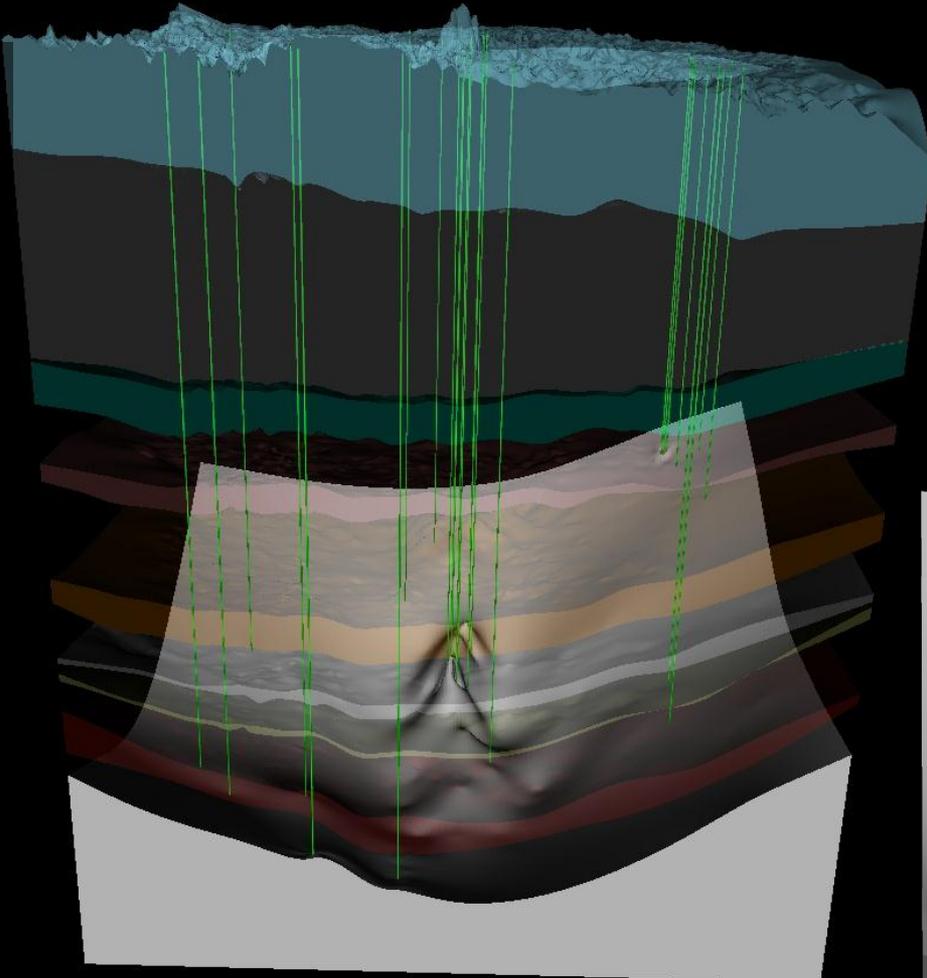


North Dakota Geological Survey

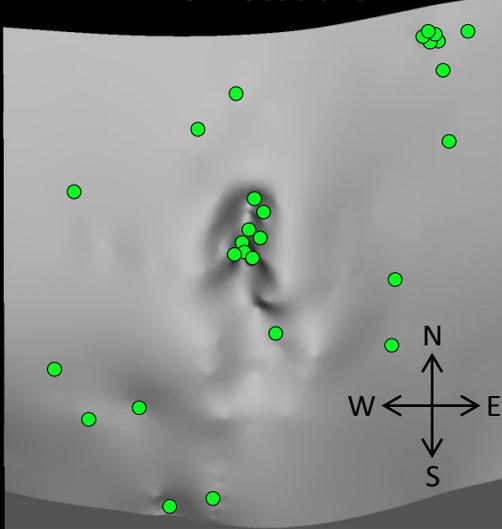


More than 8,000 Oil & Gas wells have been drilled in northwestern North Dakota, but only 27 wells have penetrated the Precambrian basement, making it the least understood geologic group of in the Williston Basin.

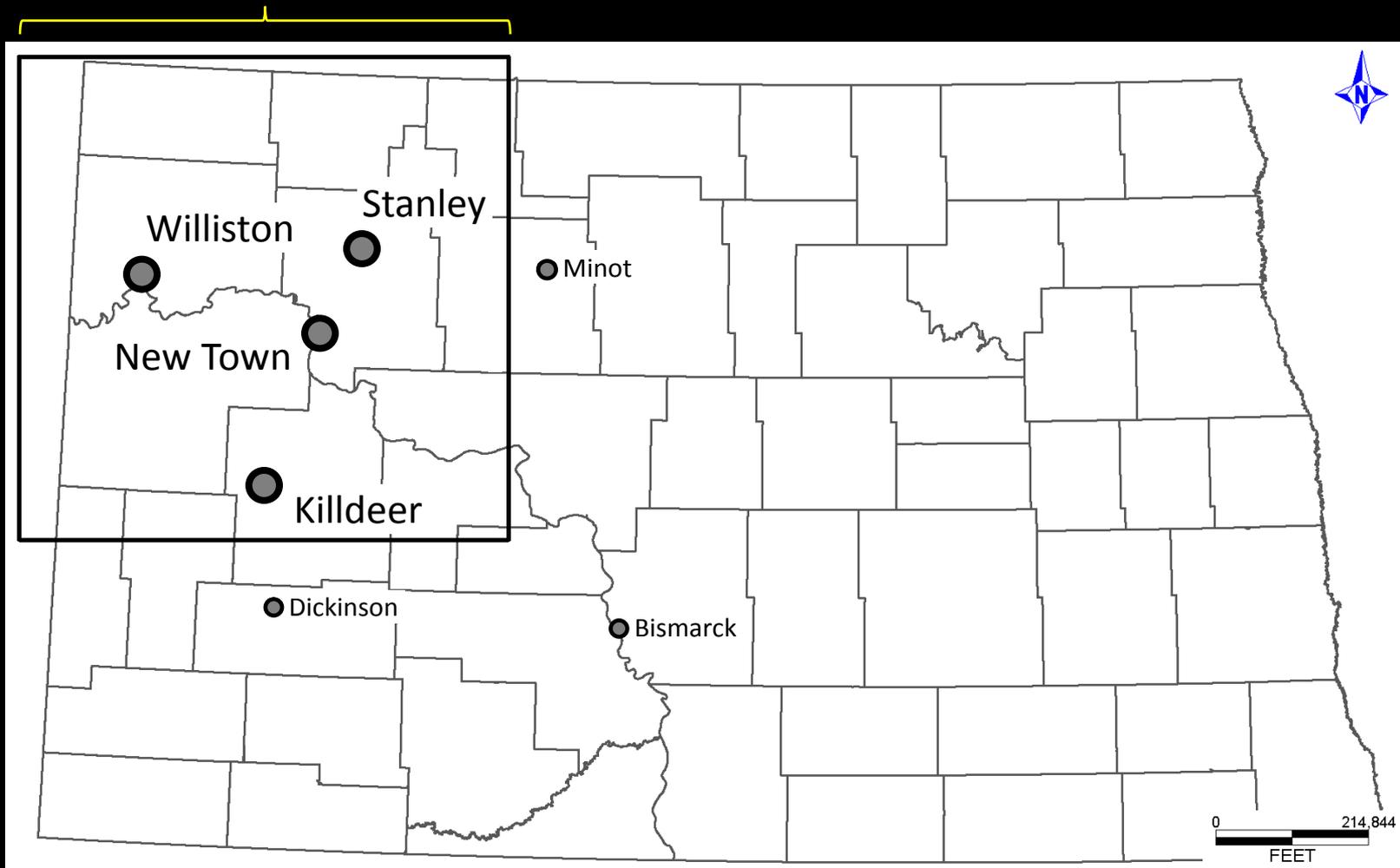
The Precambrian surface in this diagram was generated by combining the 27 Precambrian well penetrations with the structure contour surface of the Red River Formation.



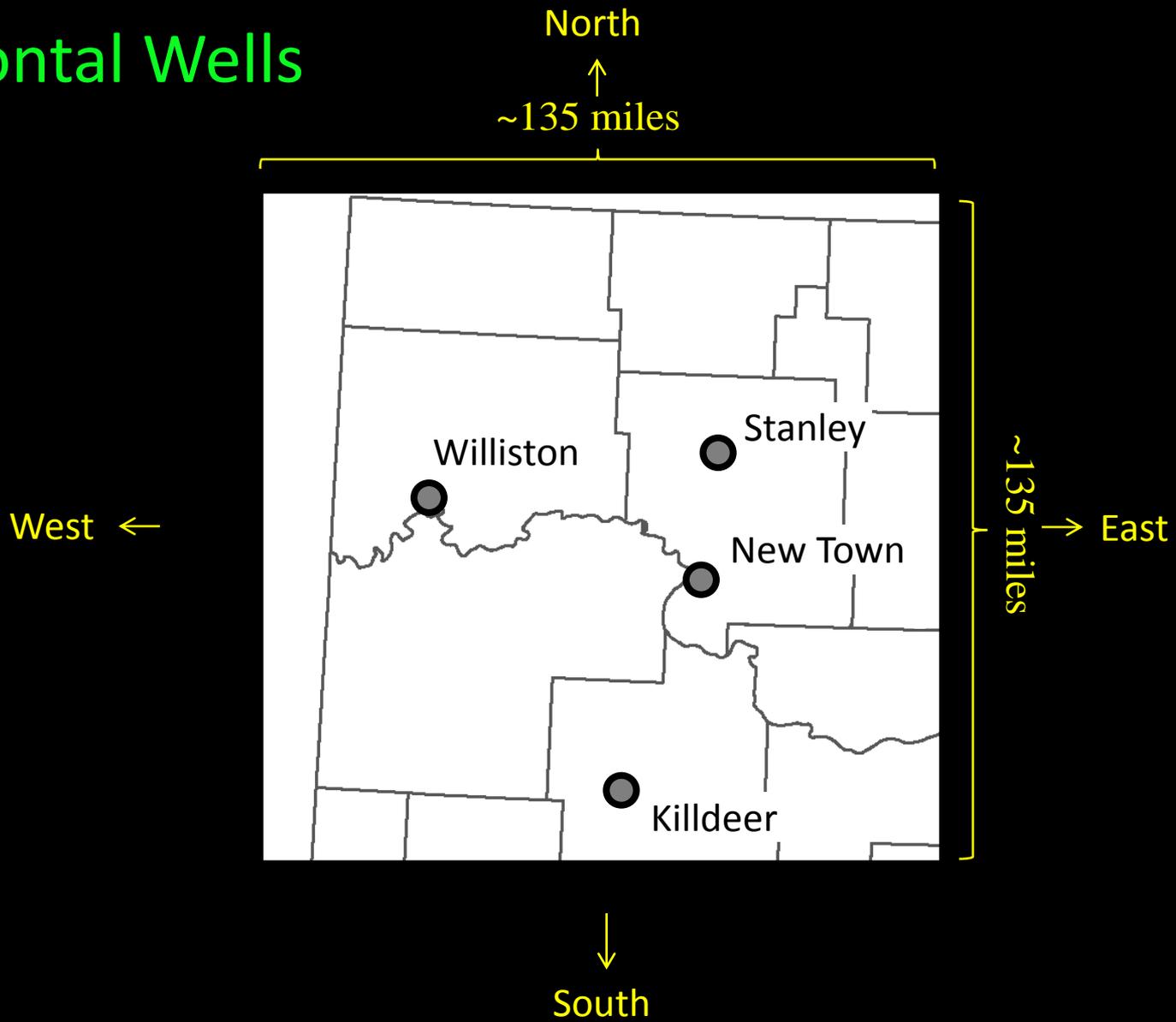
Map view of Precambrian Well Locations



Horizontal Wells



Horizontal Wells



Horizontal Wells

North



West ←

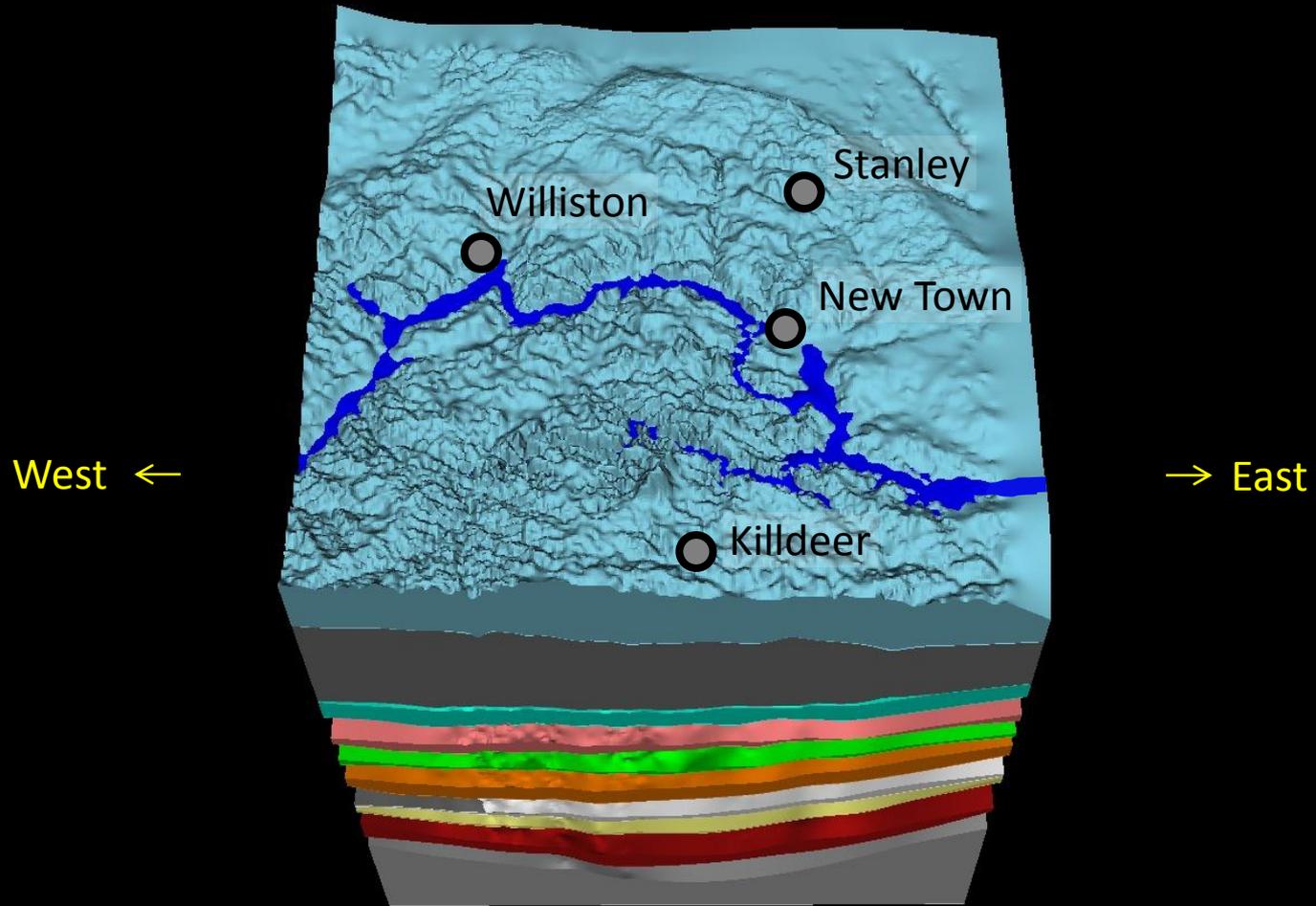


→ East

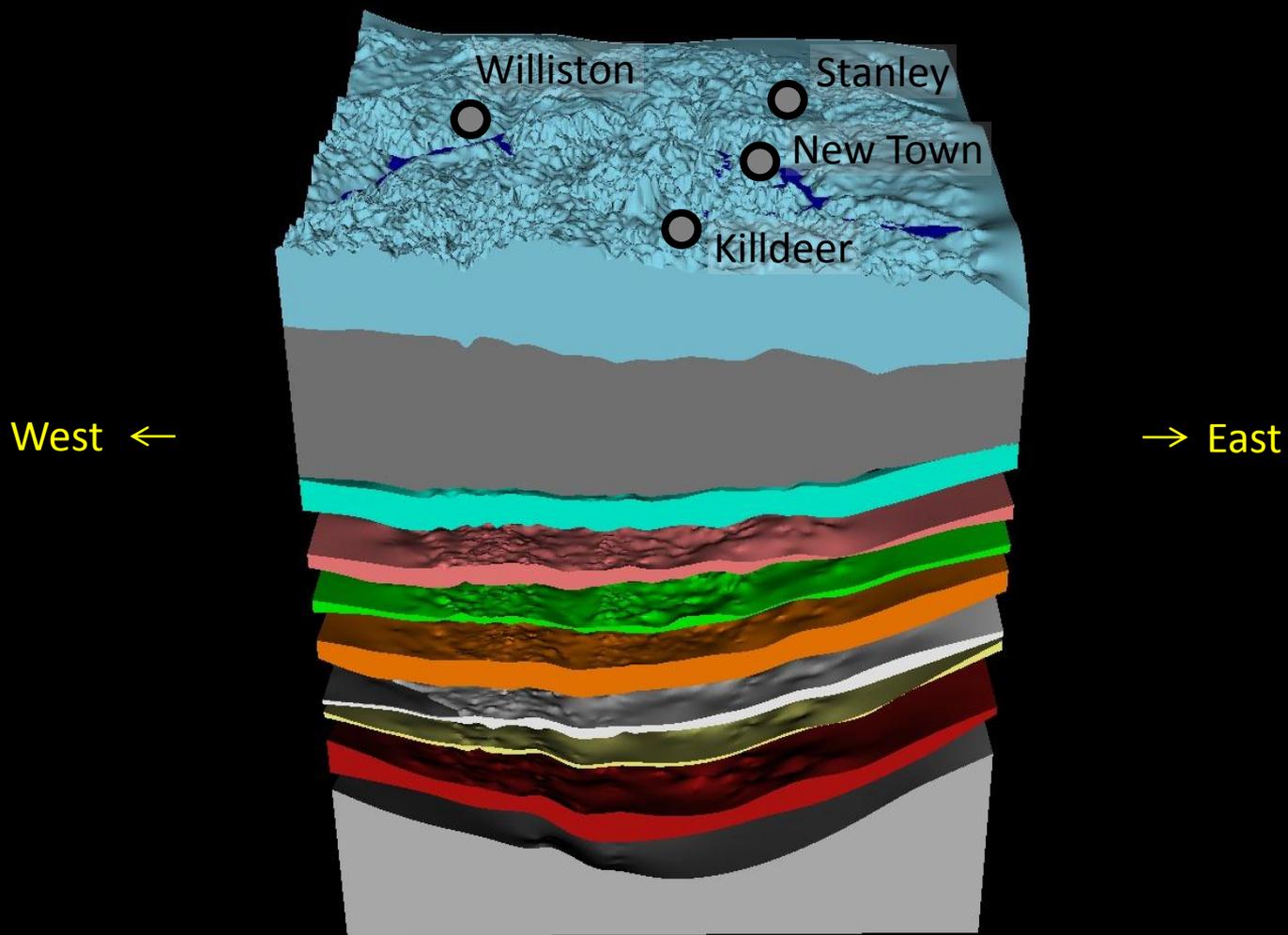
South



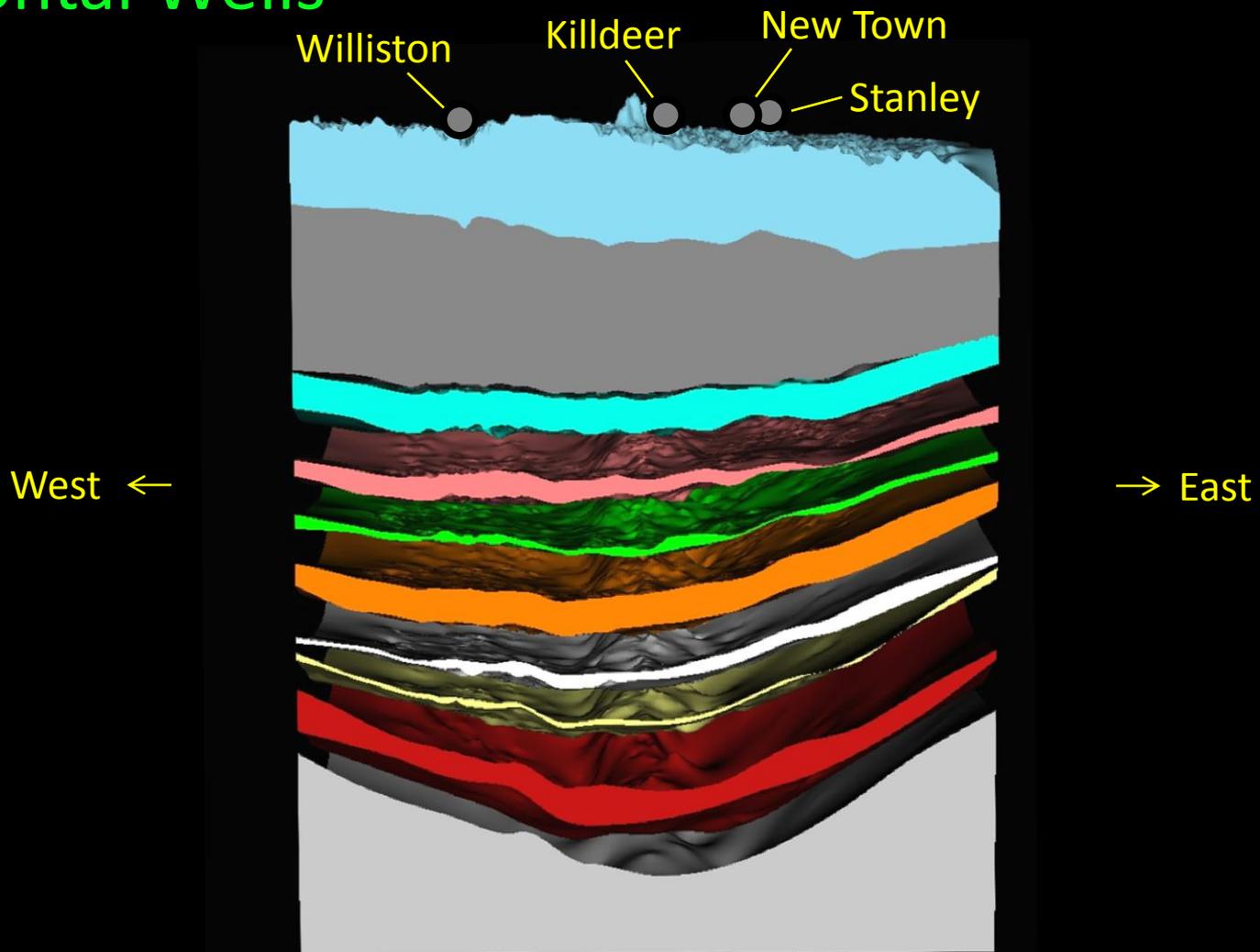
Horizontal Wells



Horizontal Wells



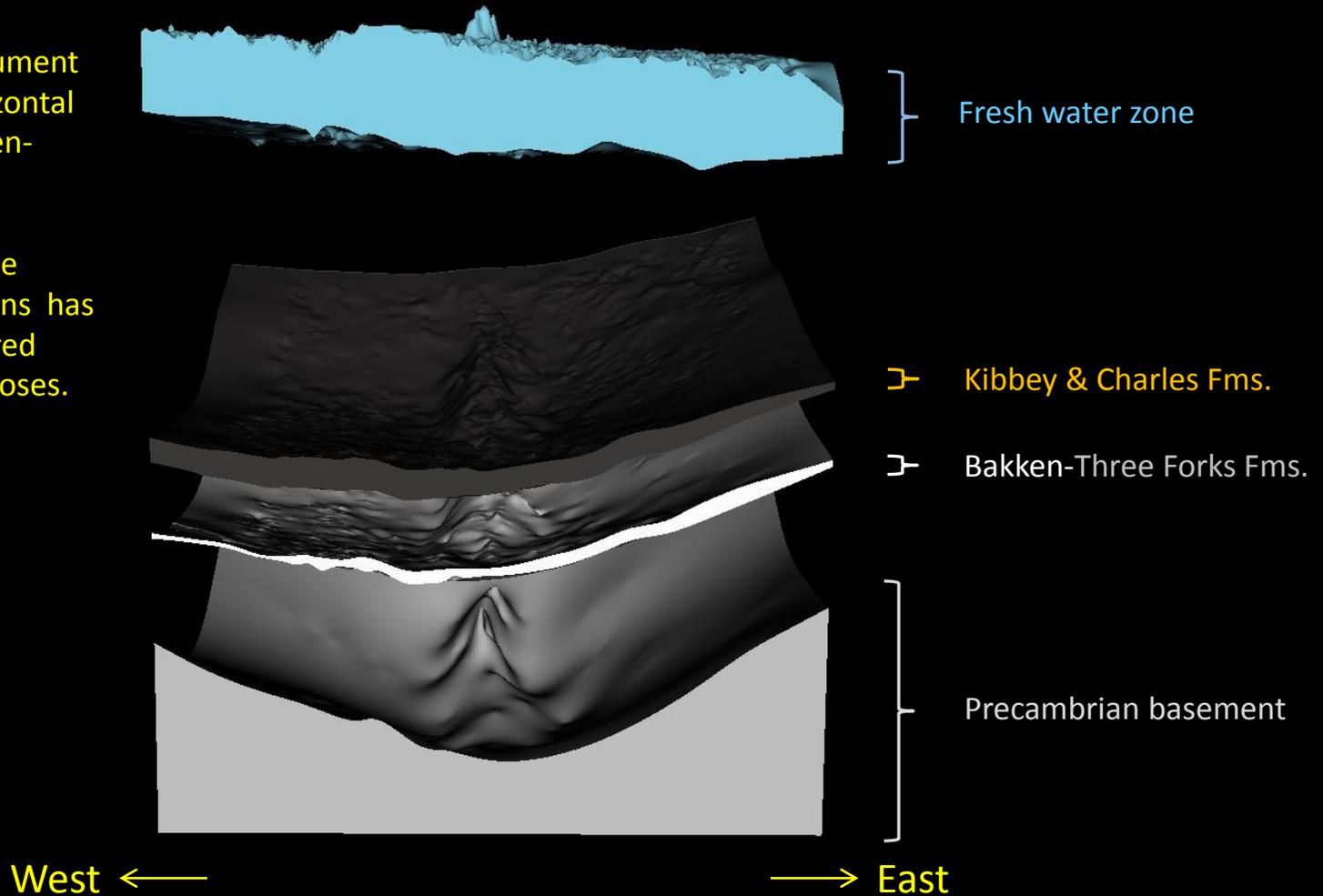
Horizontal Wells



Horizontal Wells

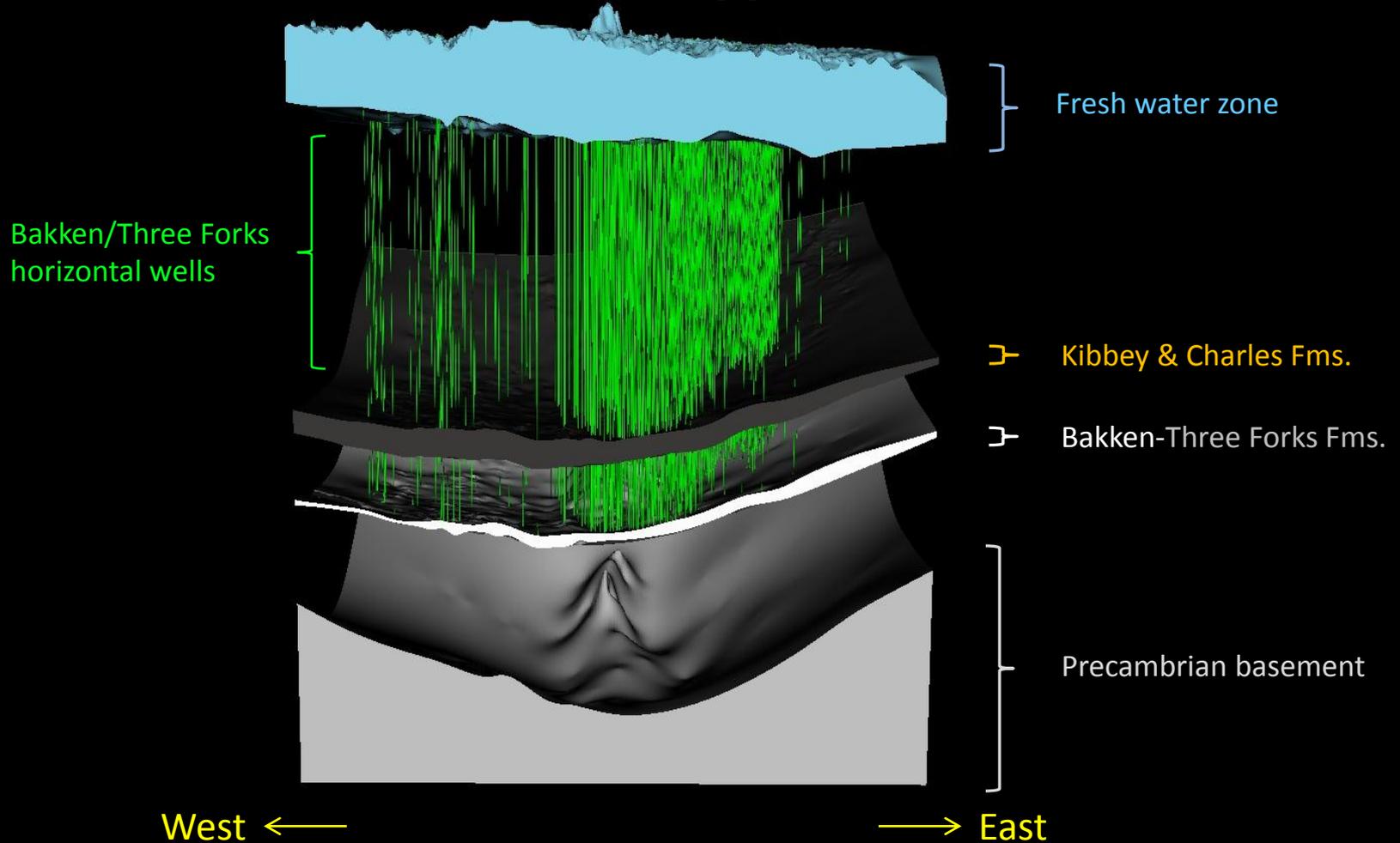
The remainder of this document will focus on showing horizontal wells drilled into the Bakken-Three Forks system.

An interval consisting of the Kibbey & Charles Formations has been added, which is colored dark grey for imaging purposes.



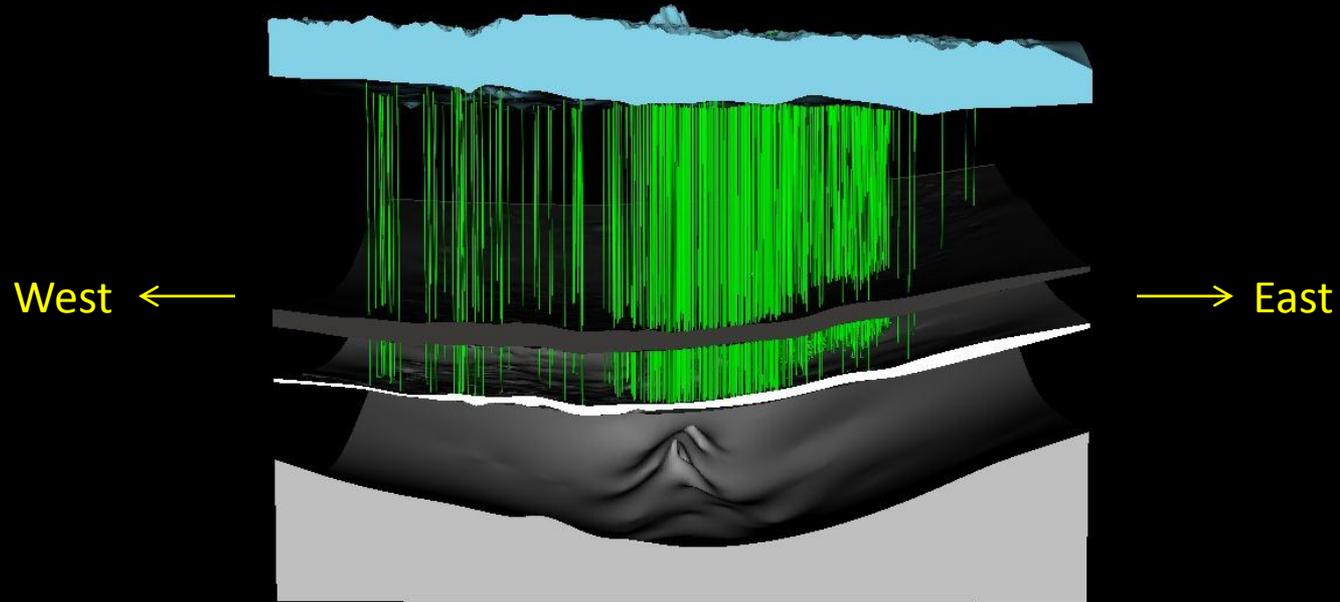
Horizontal Wells

50:1 Vertical Exaggeration



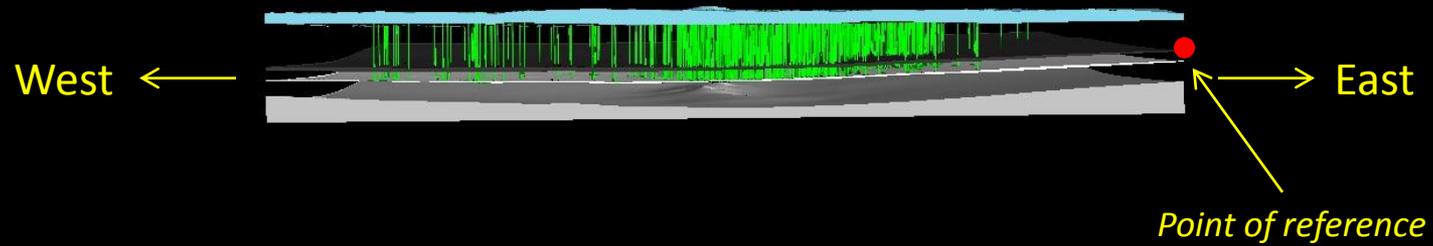
Horizontal Wells

30:1 Vertical Exaggeration

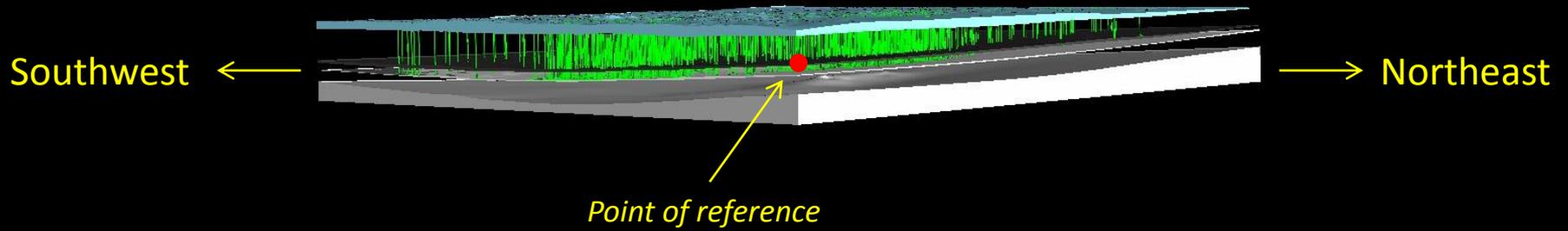


Horizontal Wells

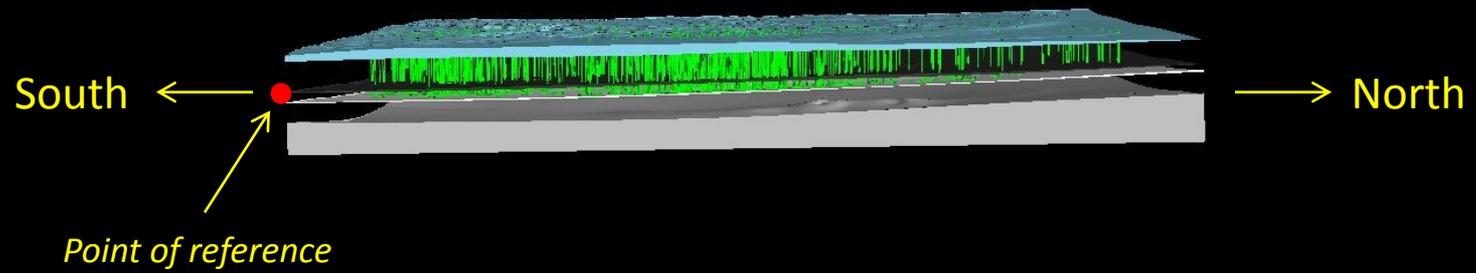
5:1 Vertical Exaggeration



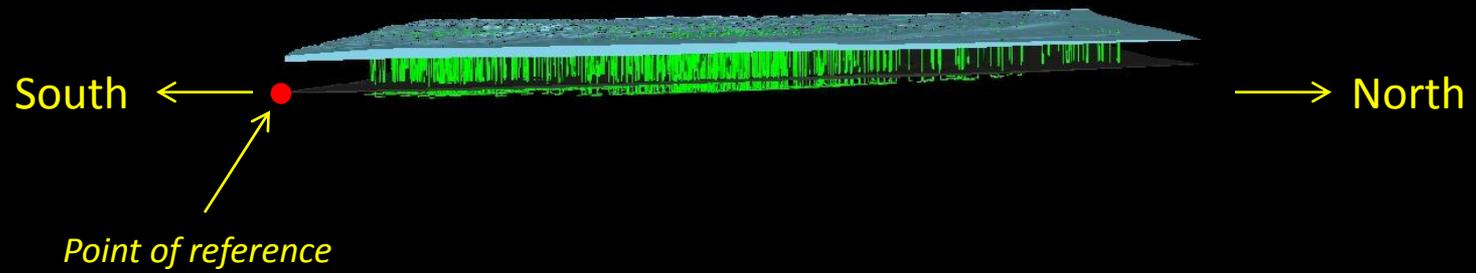
Horizontal Wells



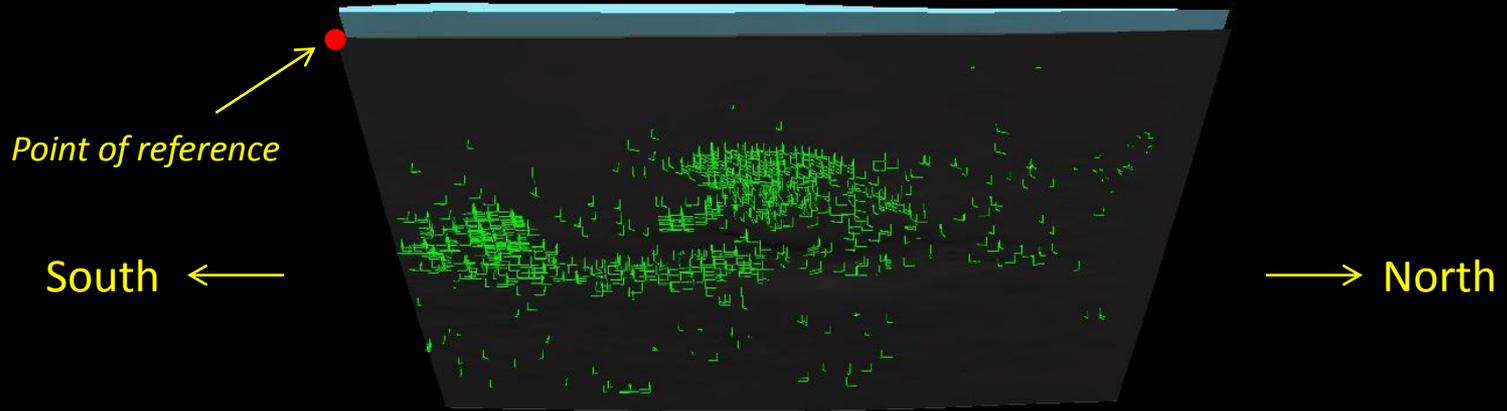
Horizontal Wells



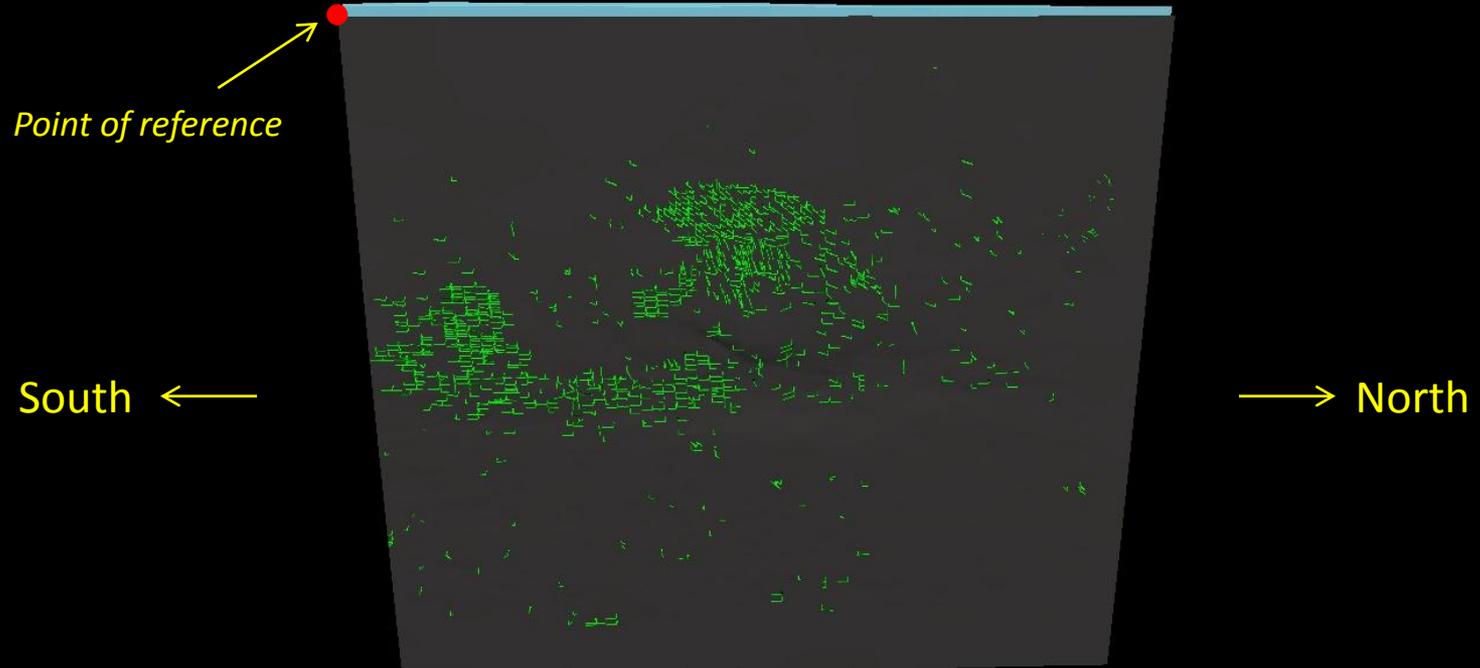
Horizontal Wells



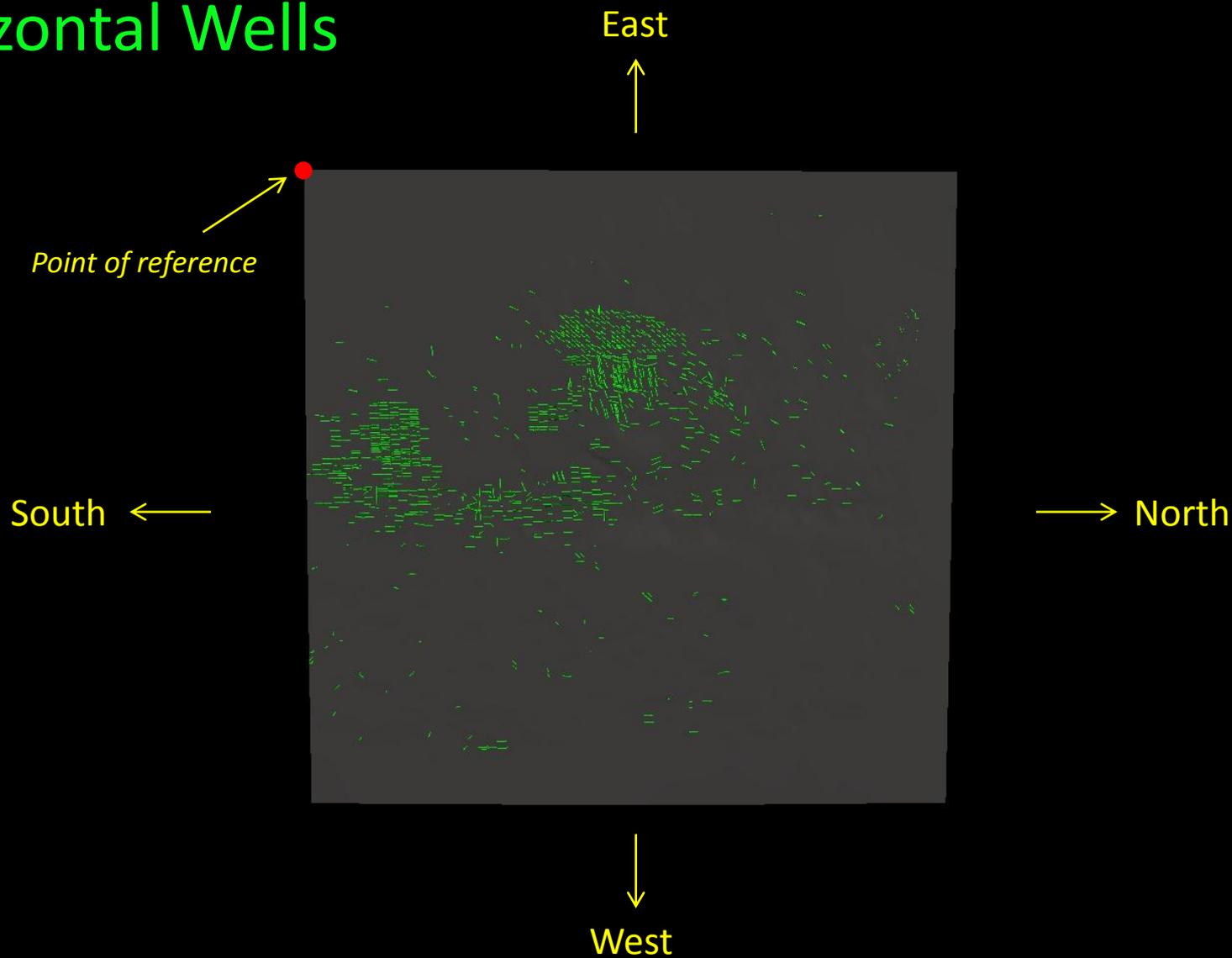
Horizontal Wells



Horizontal Wells

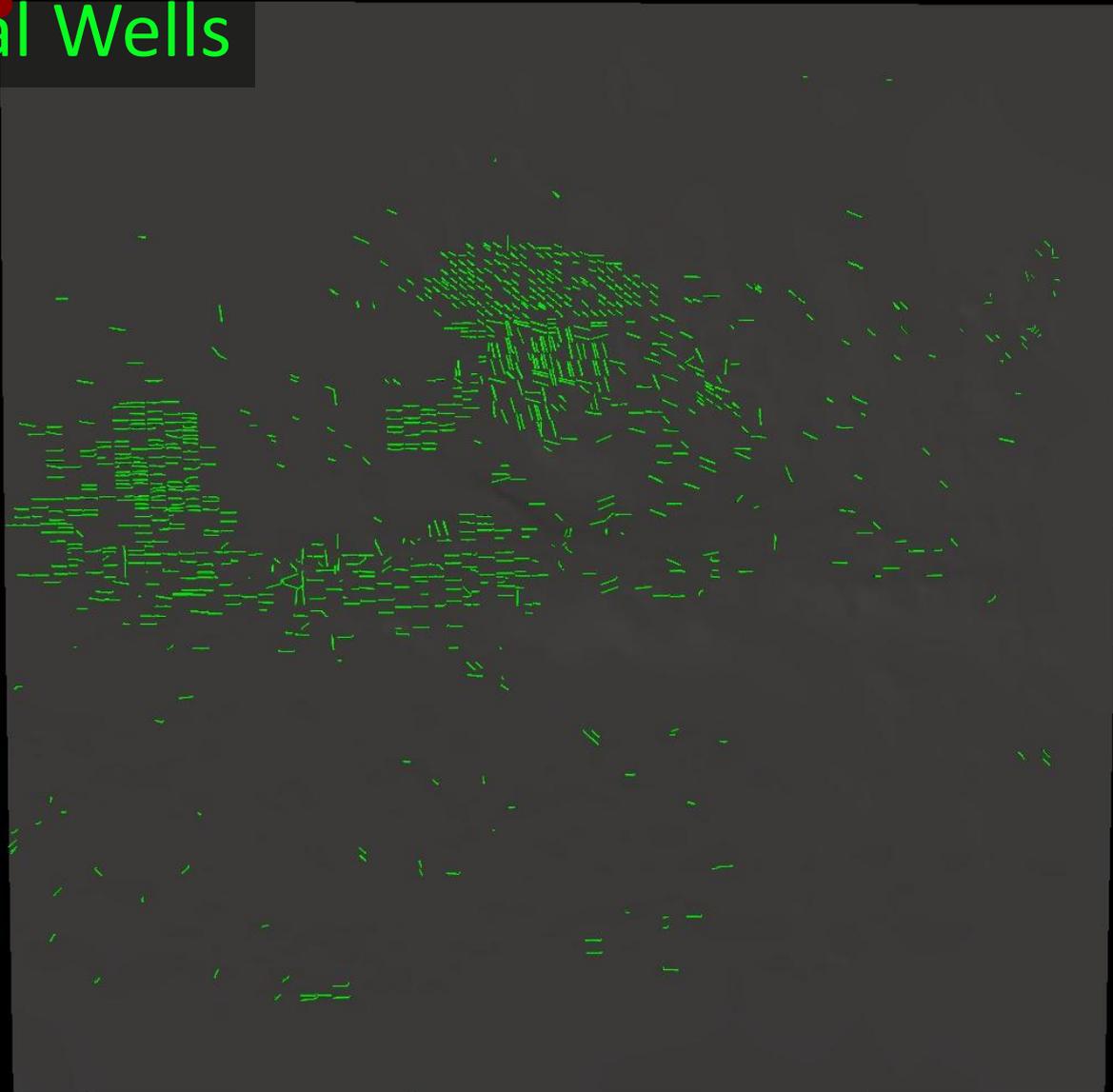


Horizontal Wells



Horizontal Wells

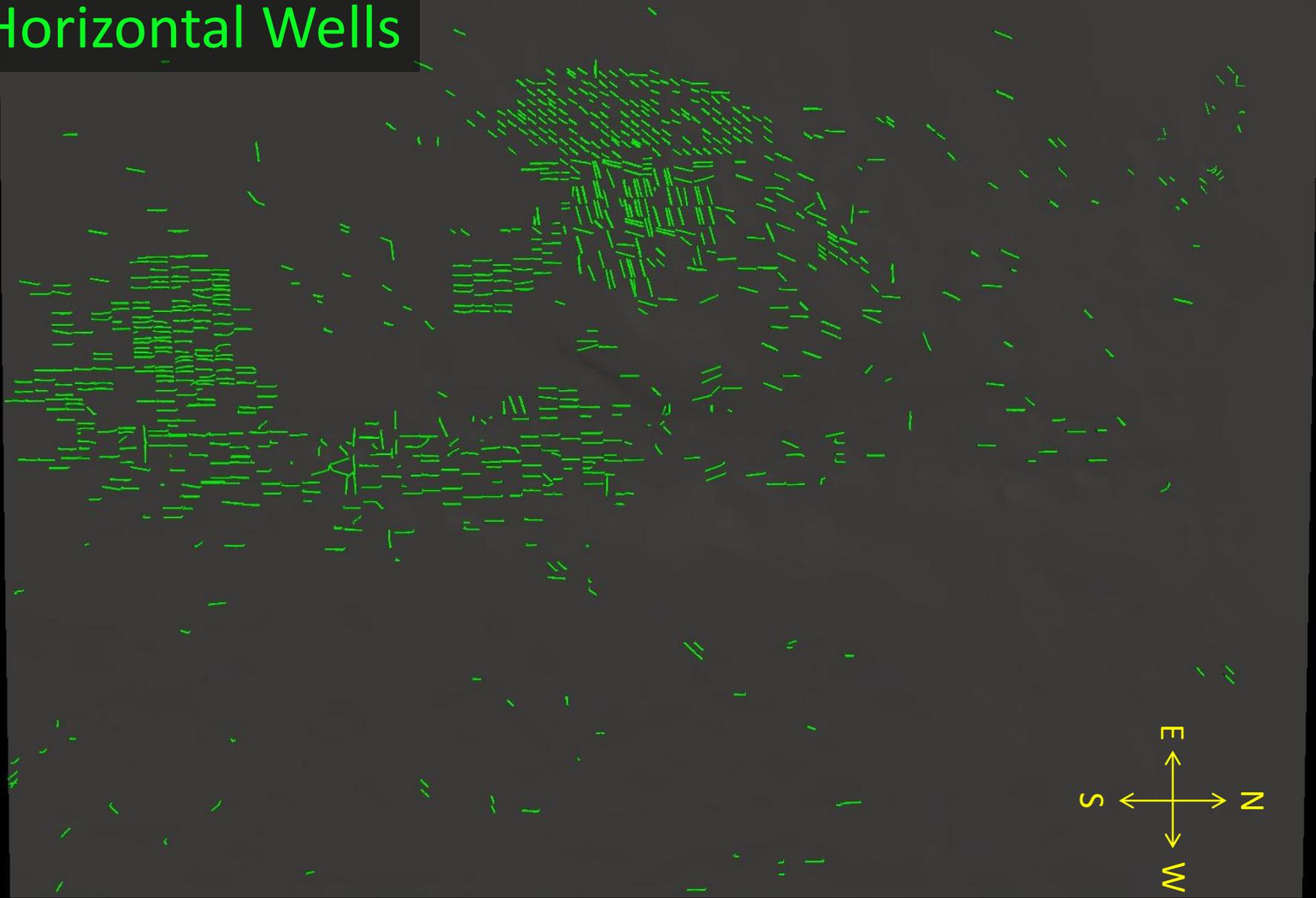
South ←



→ North

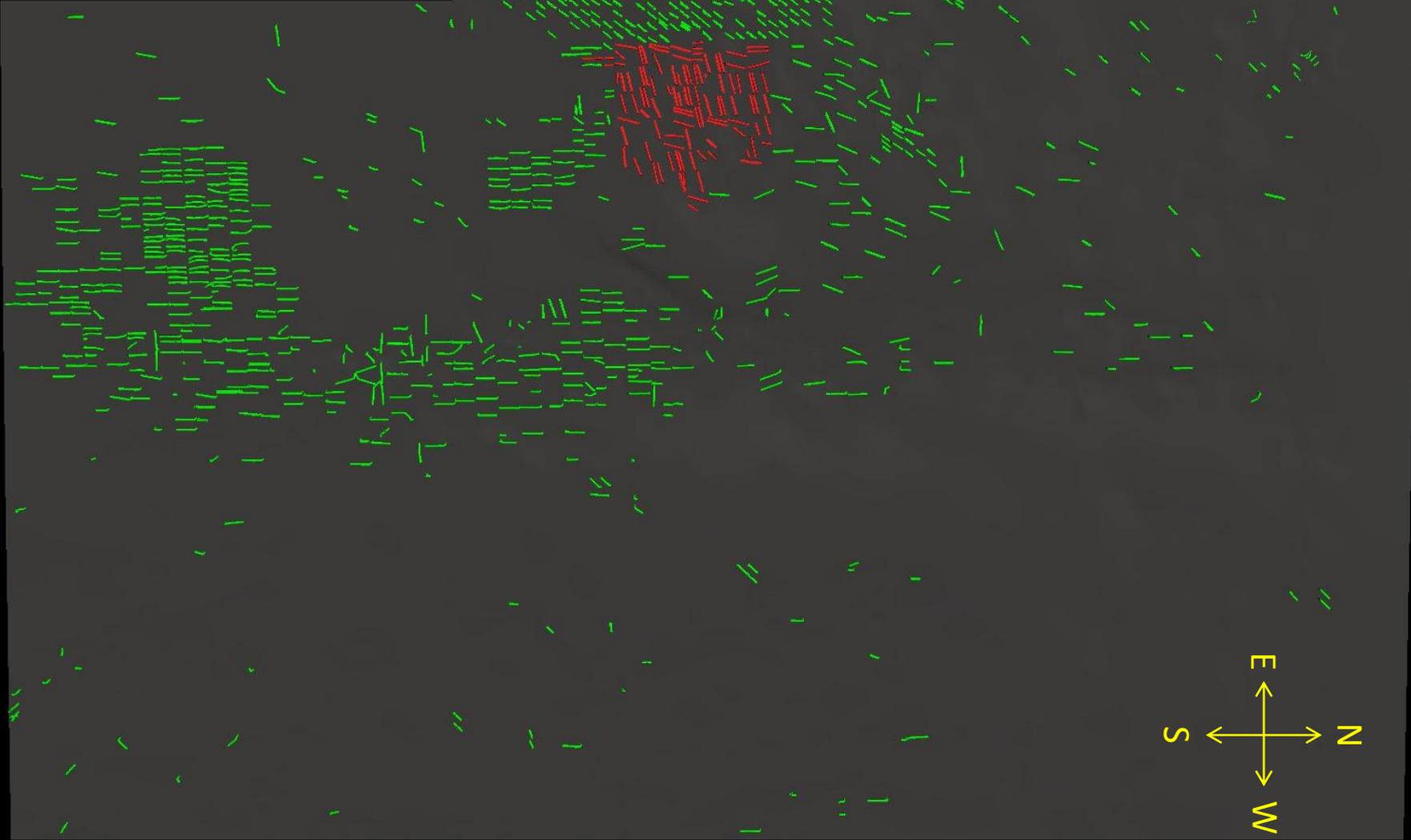


Horizontal Wells



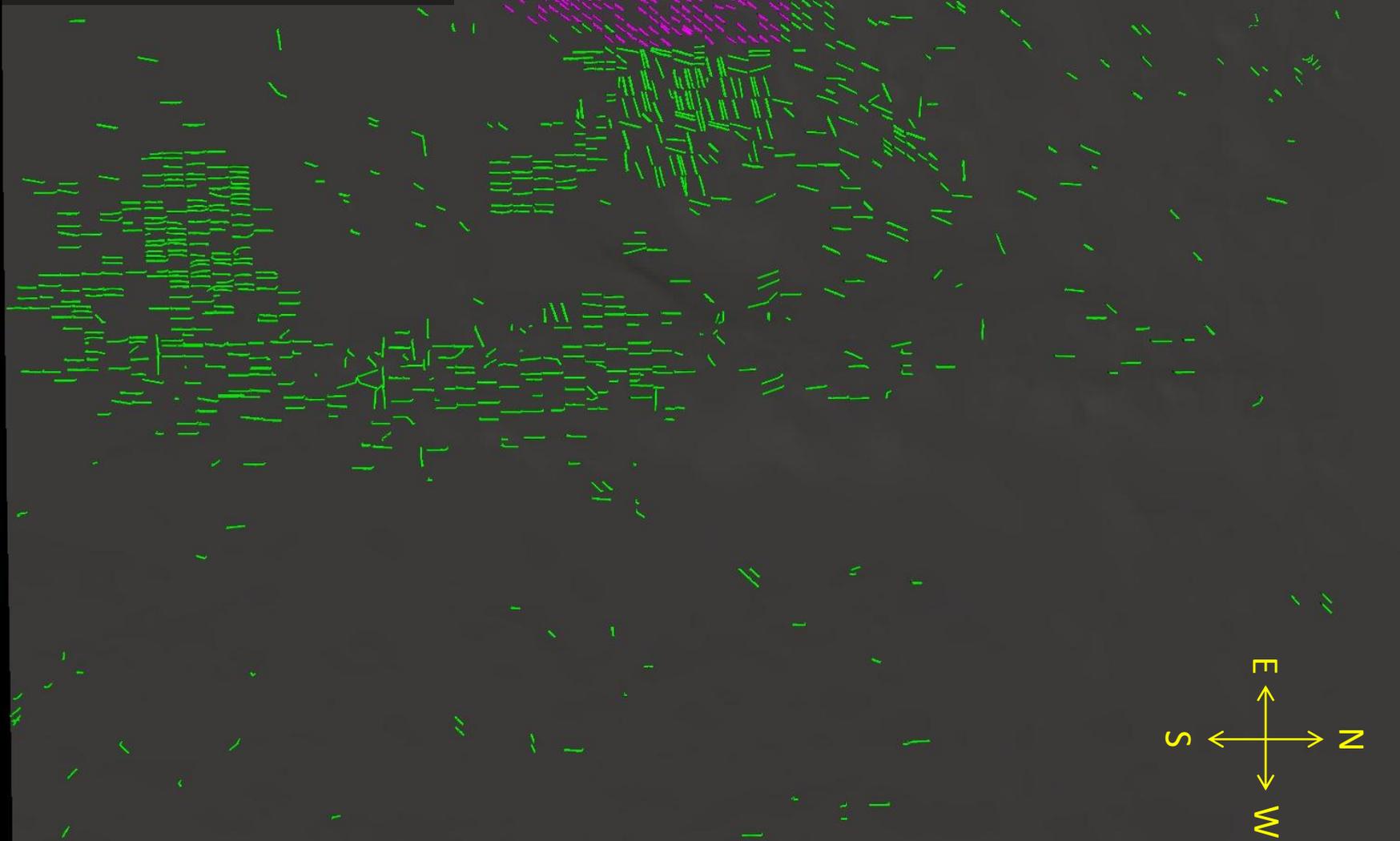
Horizontal Wells

-Sanish Field

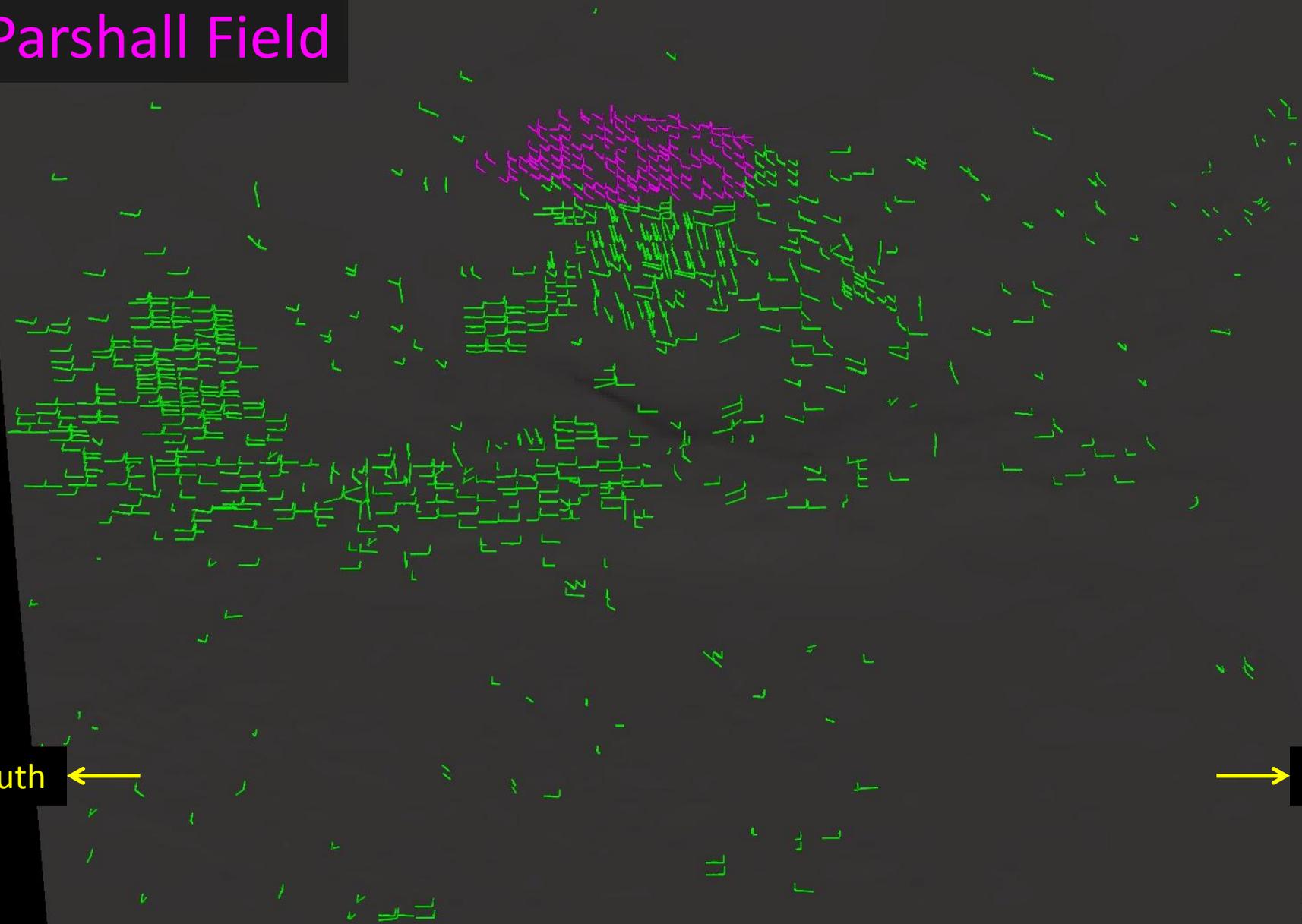


Horizontal Wells

-Parshall Field



Parshall Field

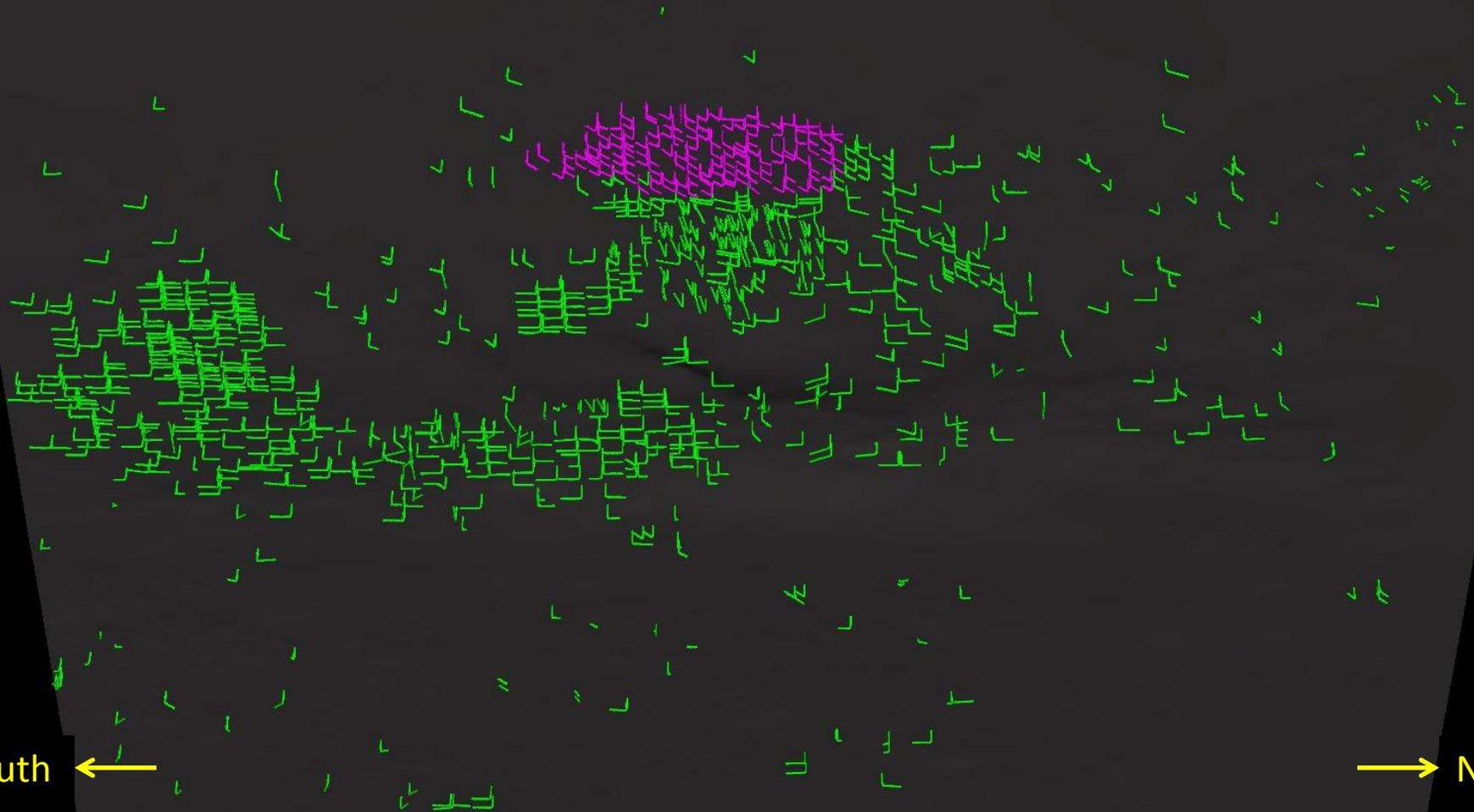


South ←

→ North



Parshall Field



South ←

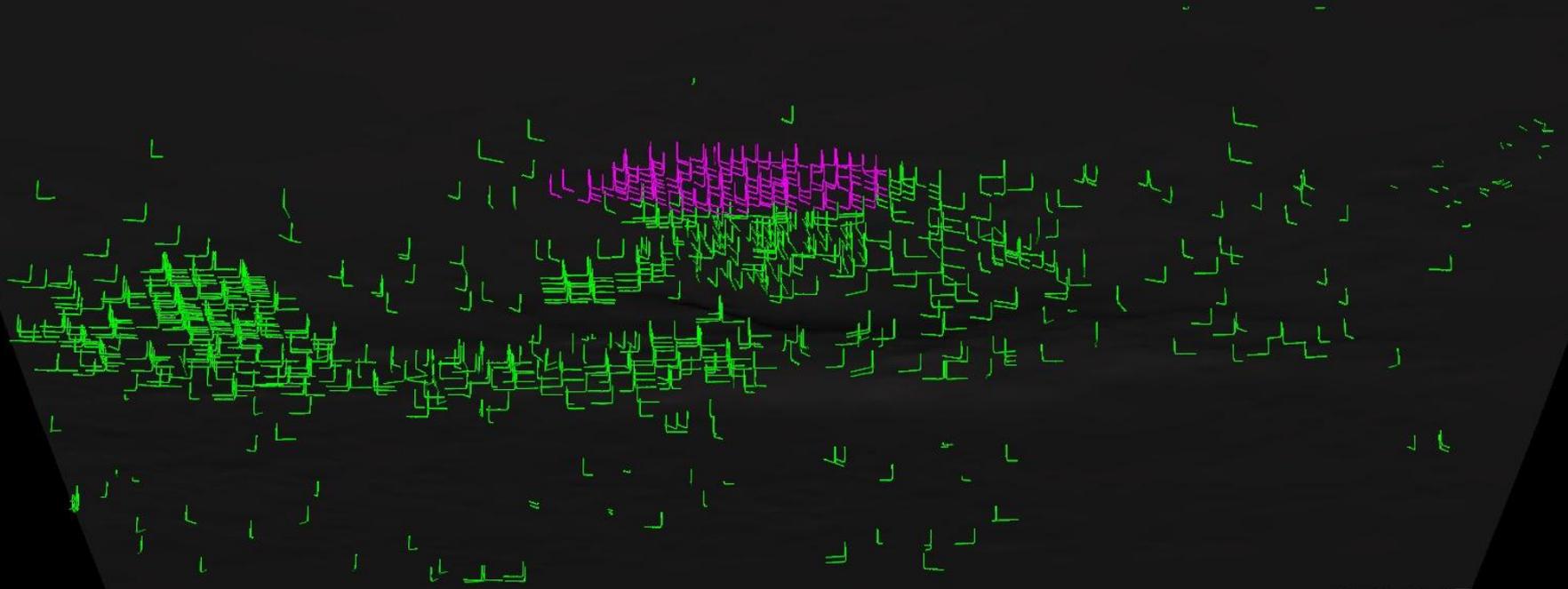
→ North



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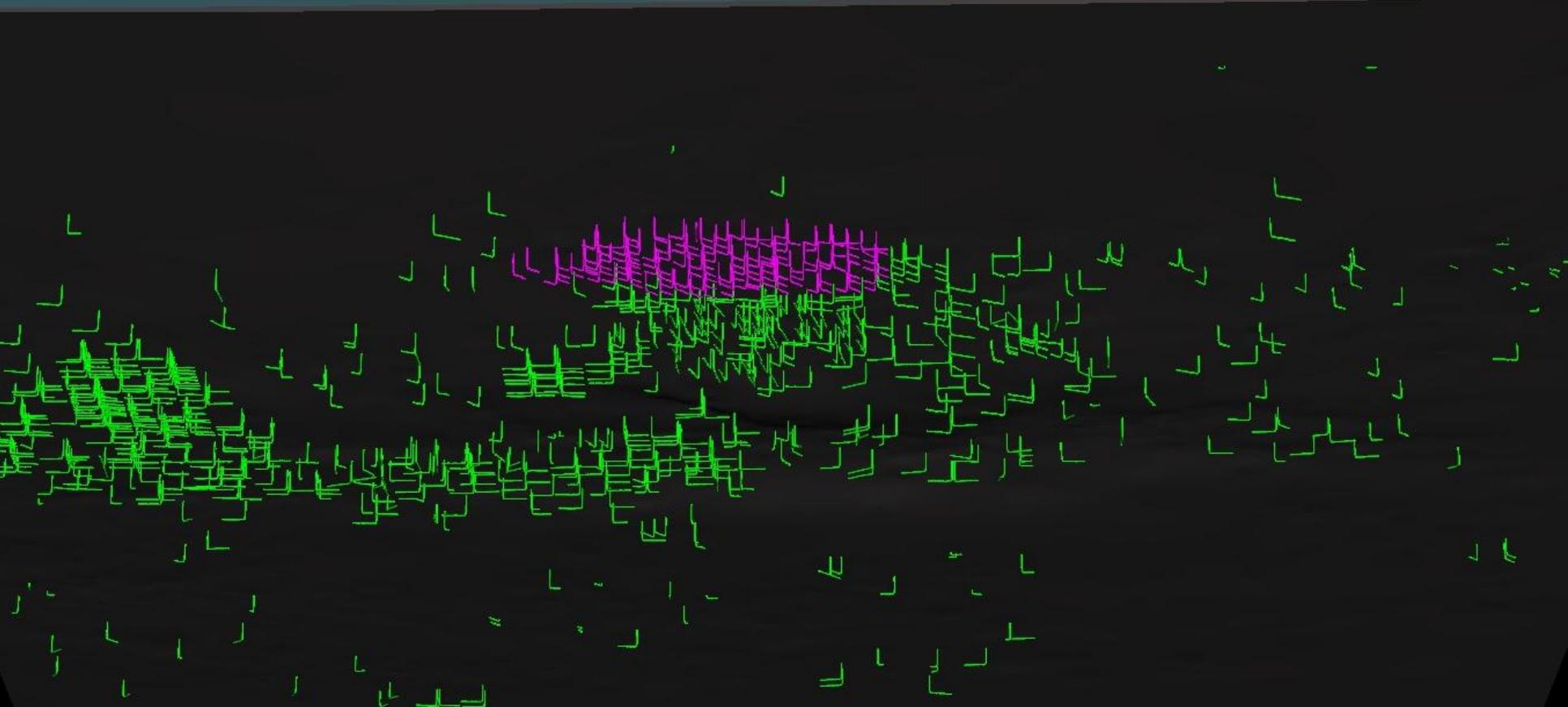
Parshall Field



South ← Traditionally, oil & gas wells in the Williston Basin were only drilled vertically. Currently, Bakken-Three Forks wells are drilled downwards ~2 miles (vertically) and then up to 2 miles horizontally. → North



Parshall Field



South ←

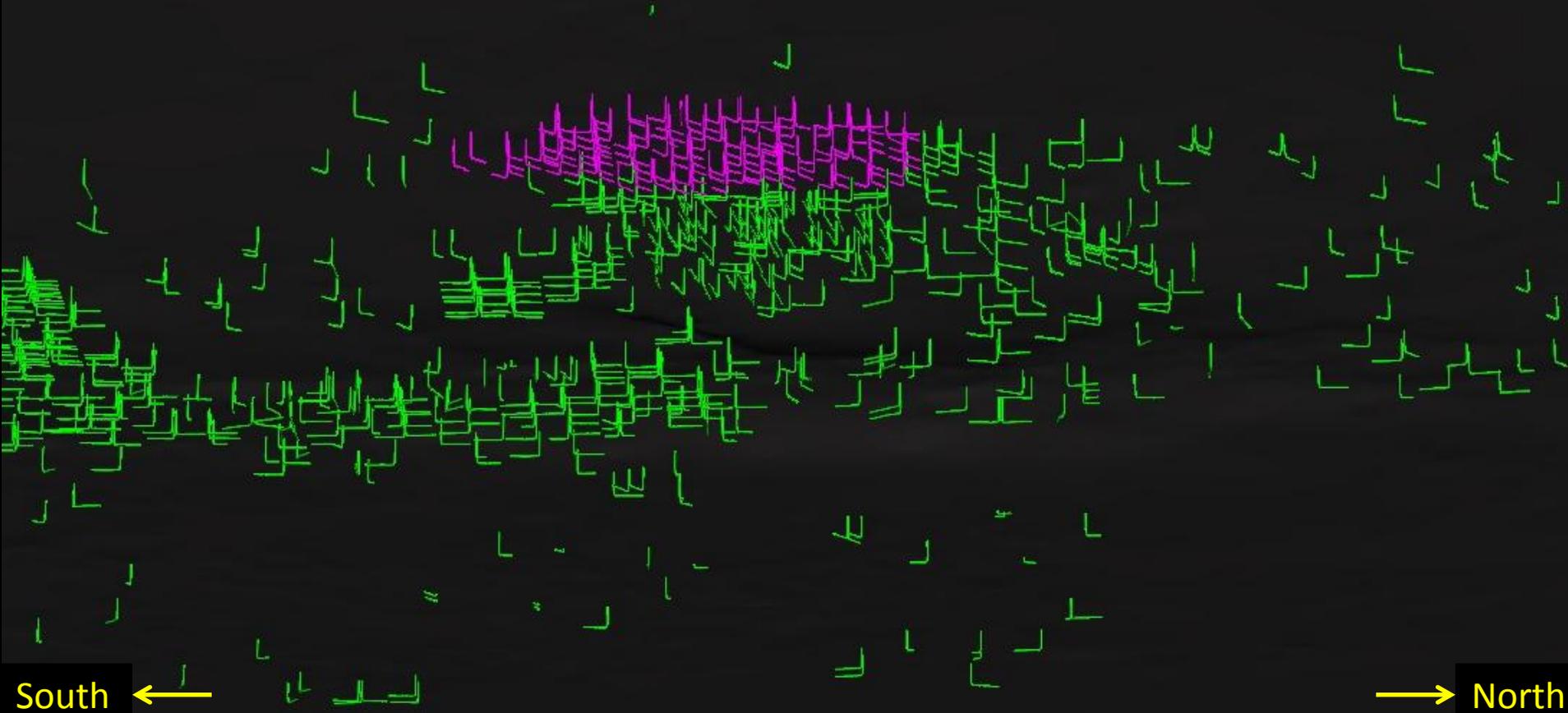
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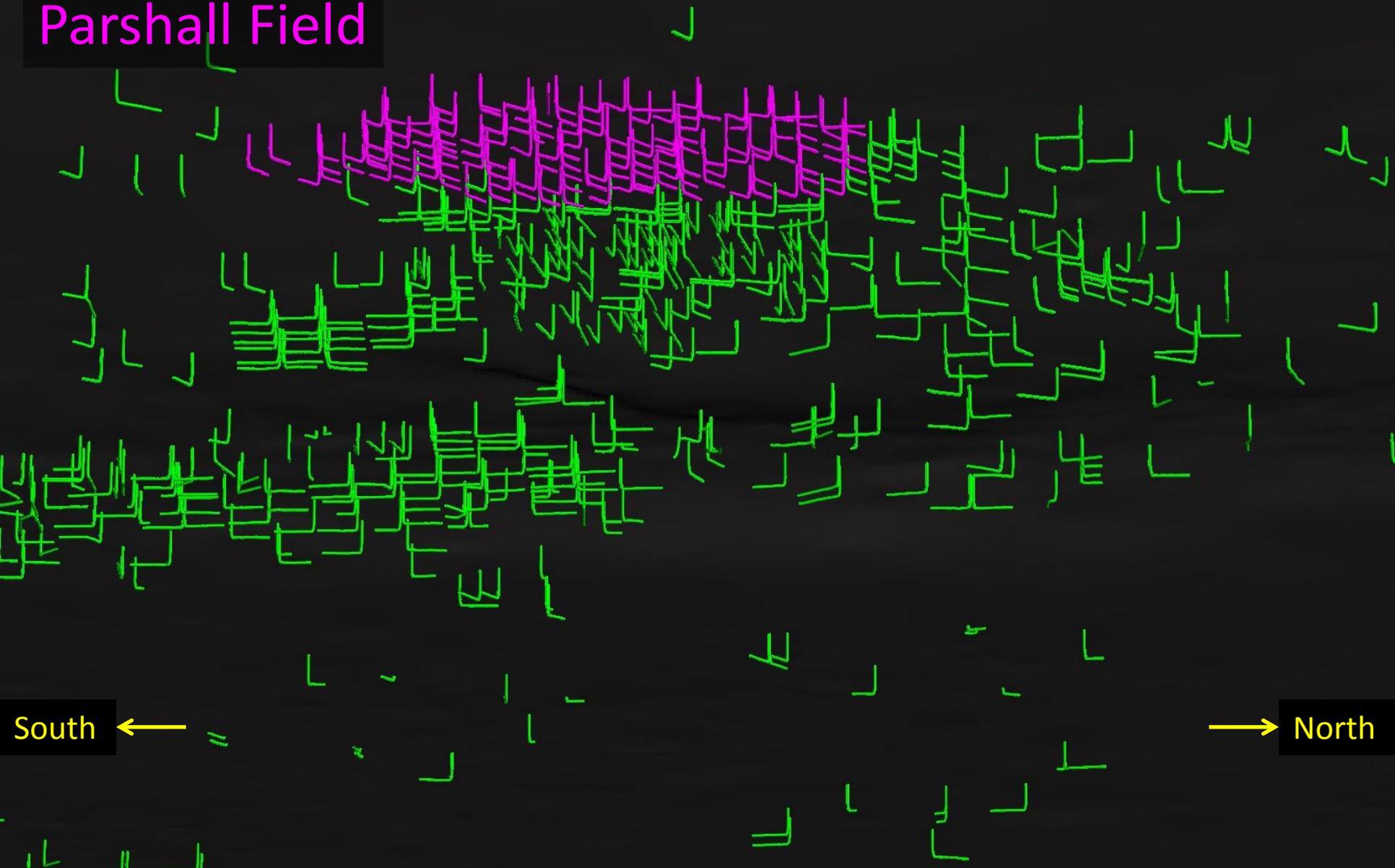
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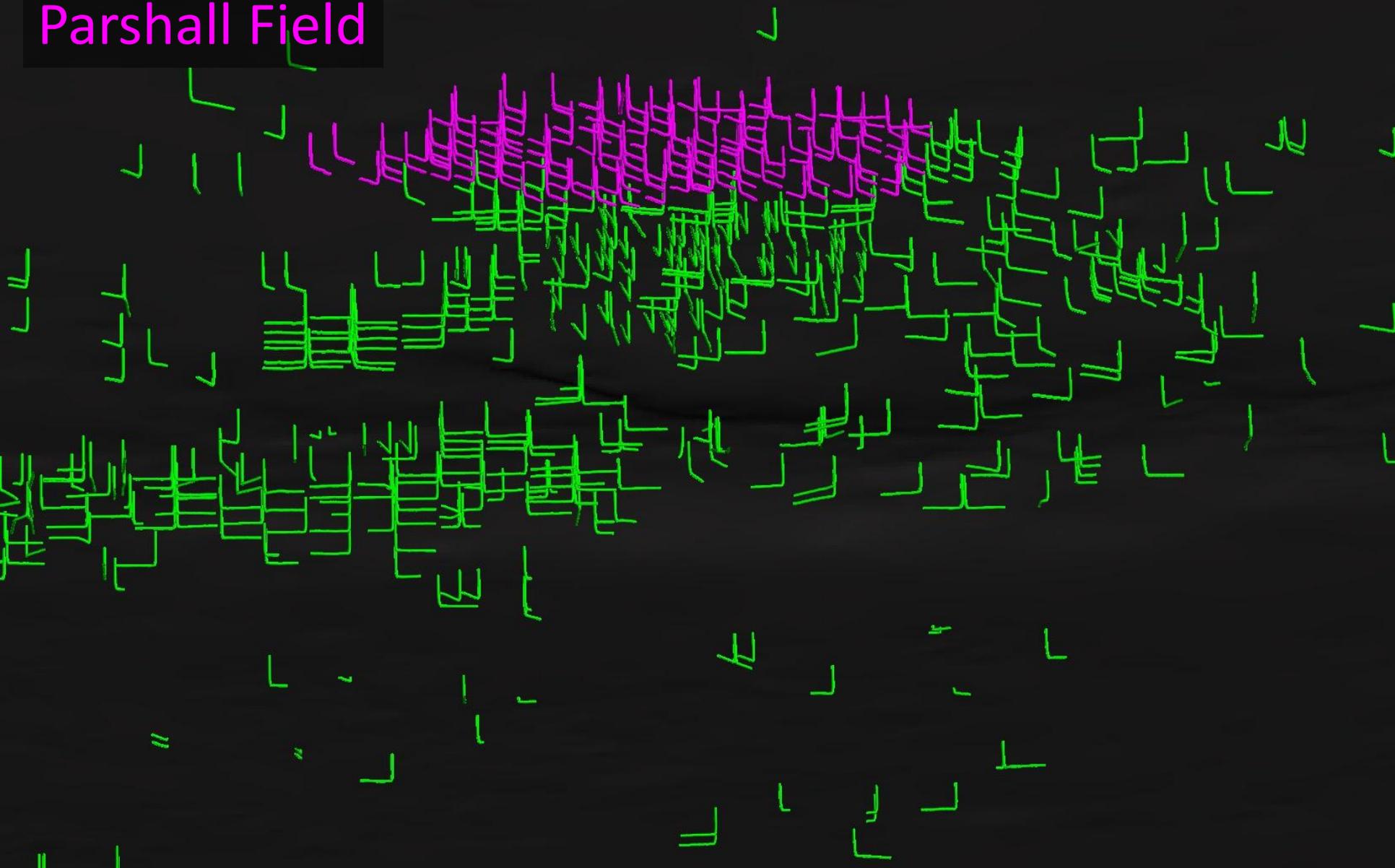


South ←

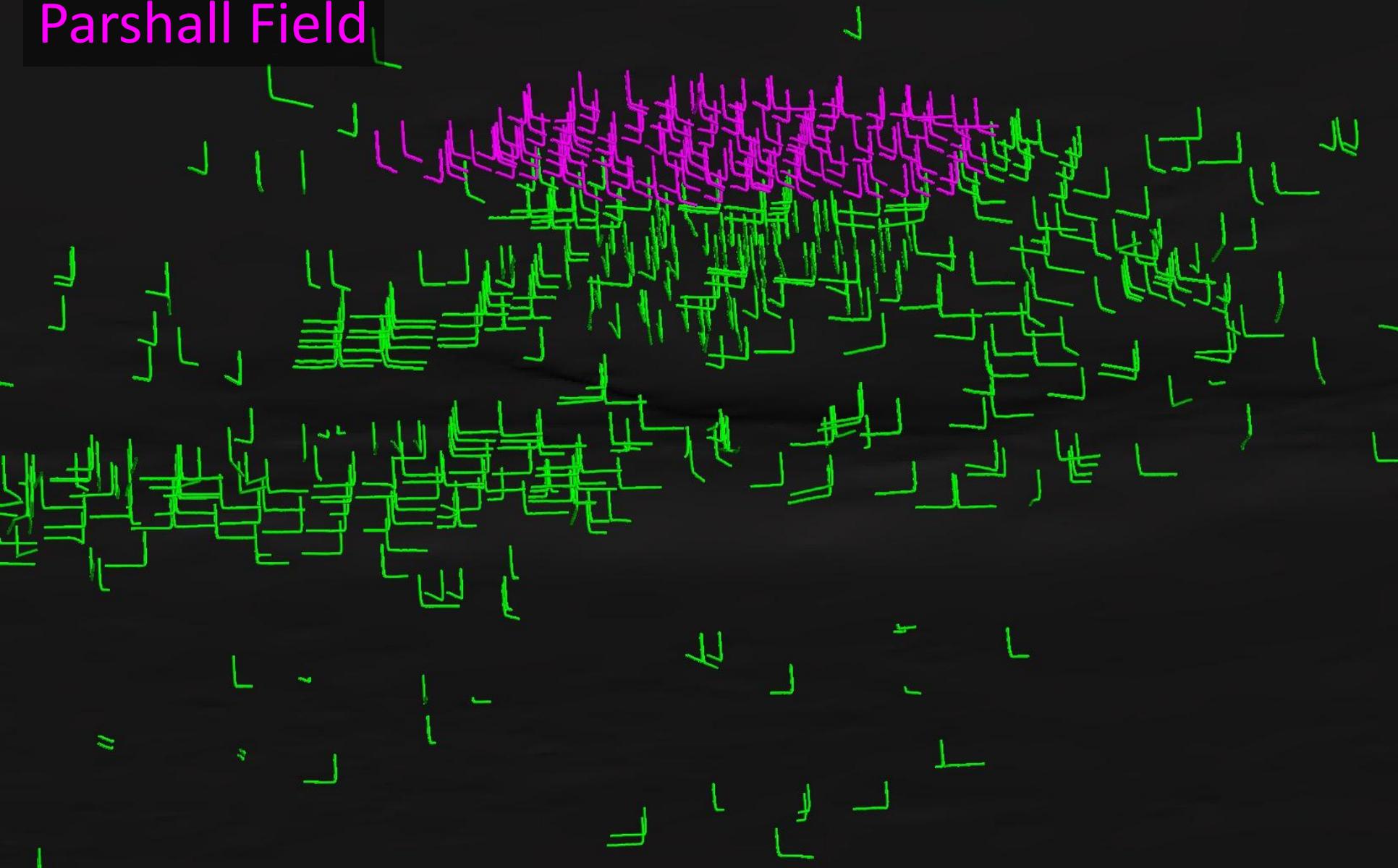
→ North



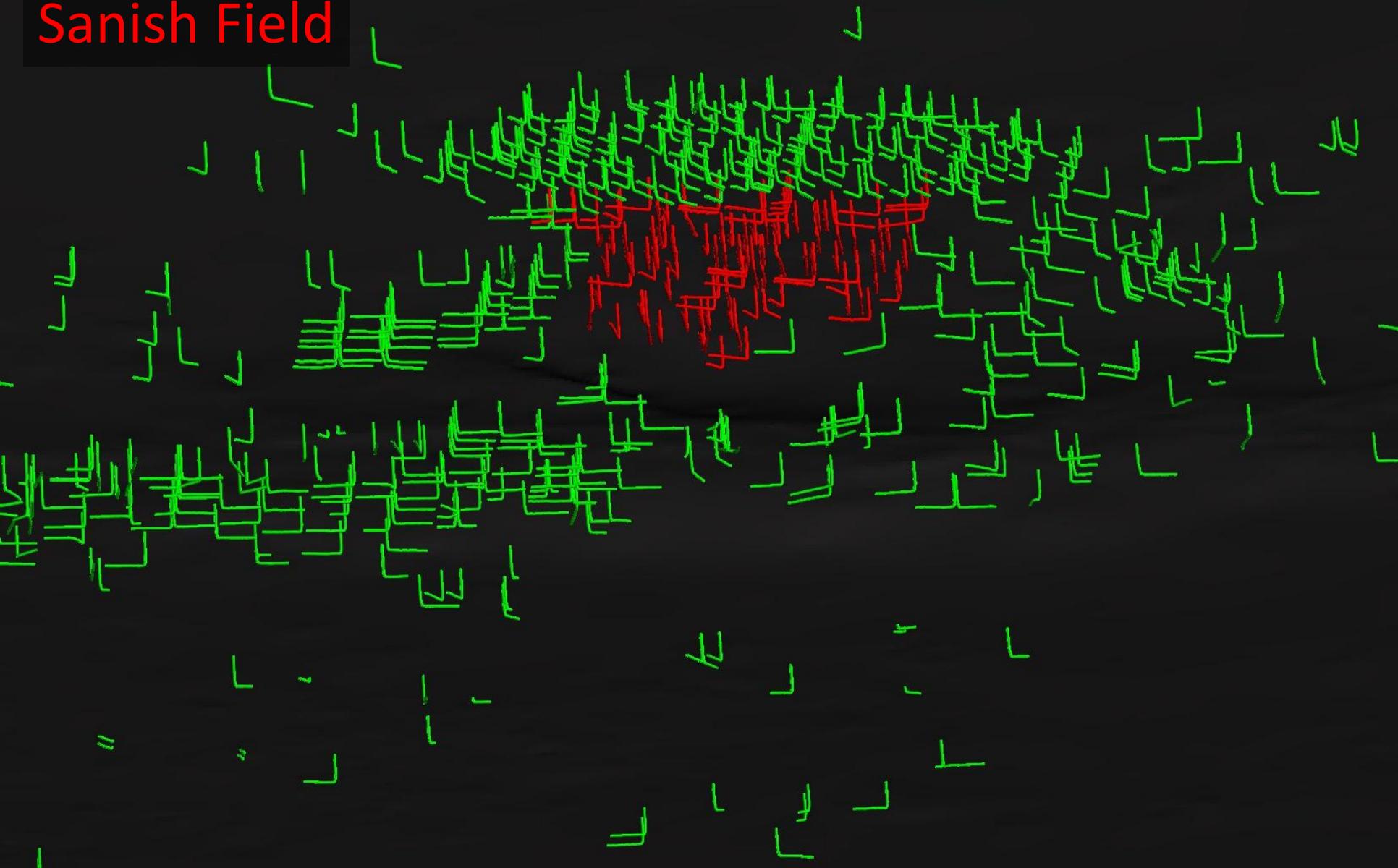
Parshall Field



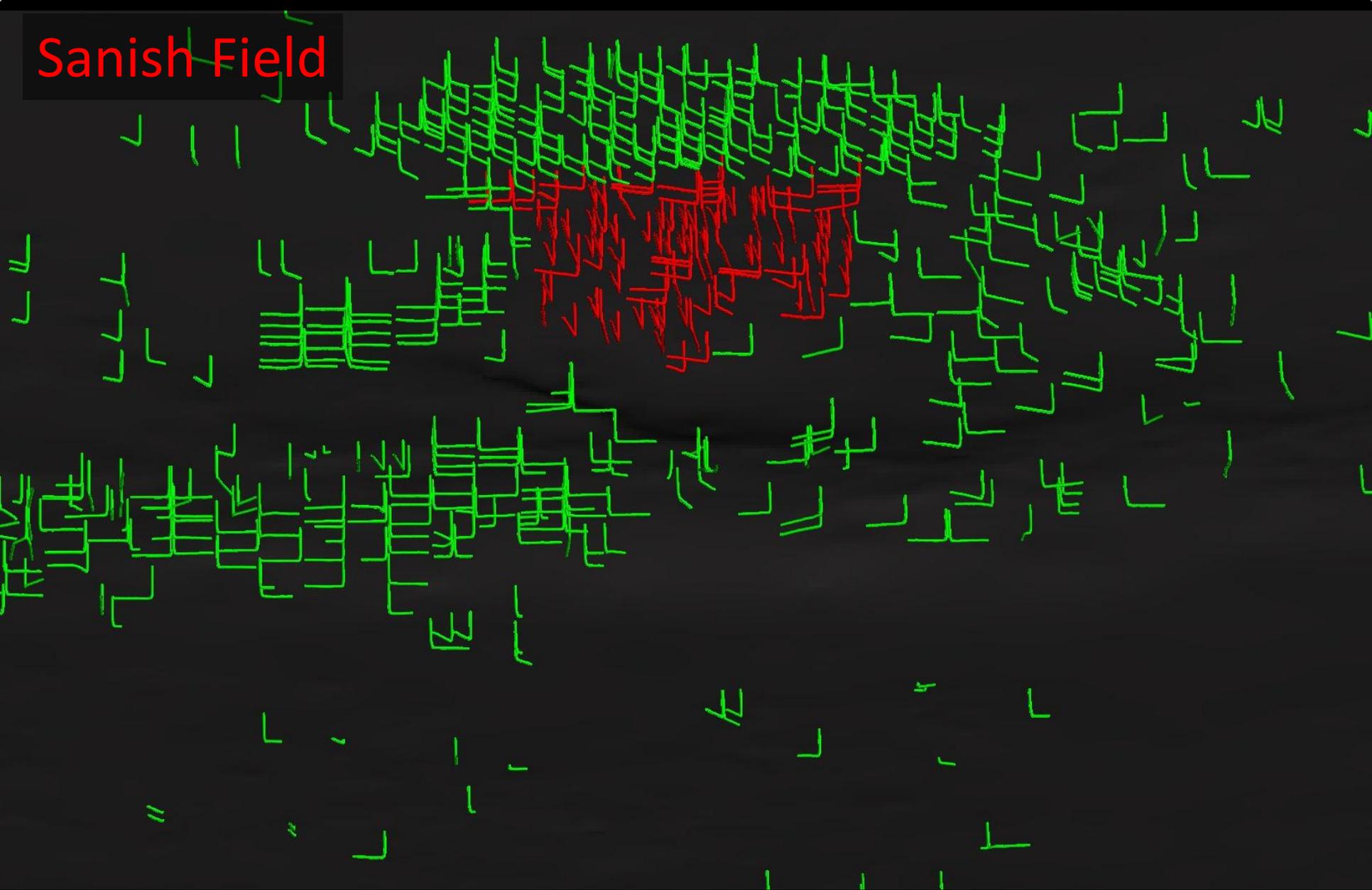
Parshall Field



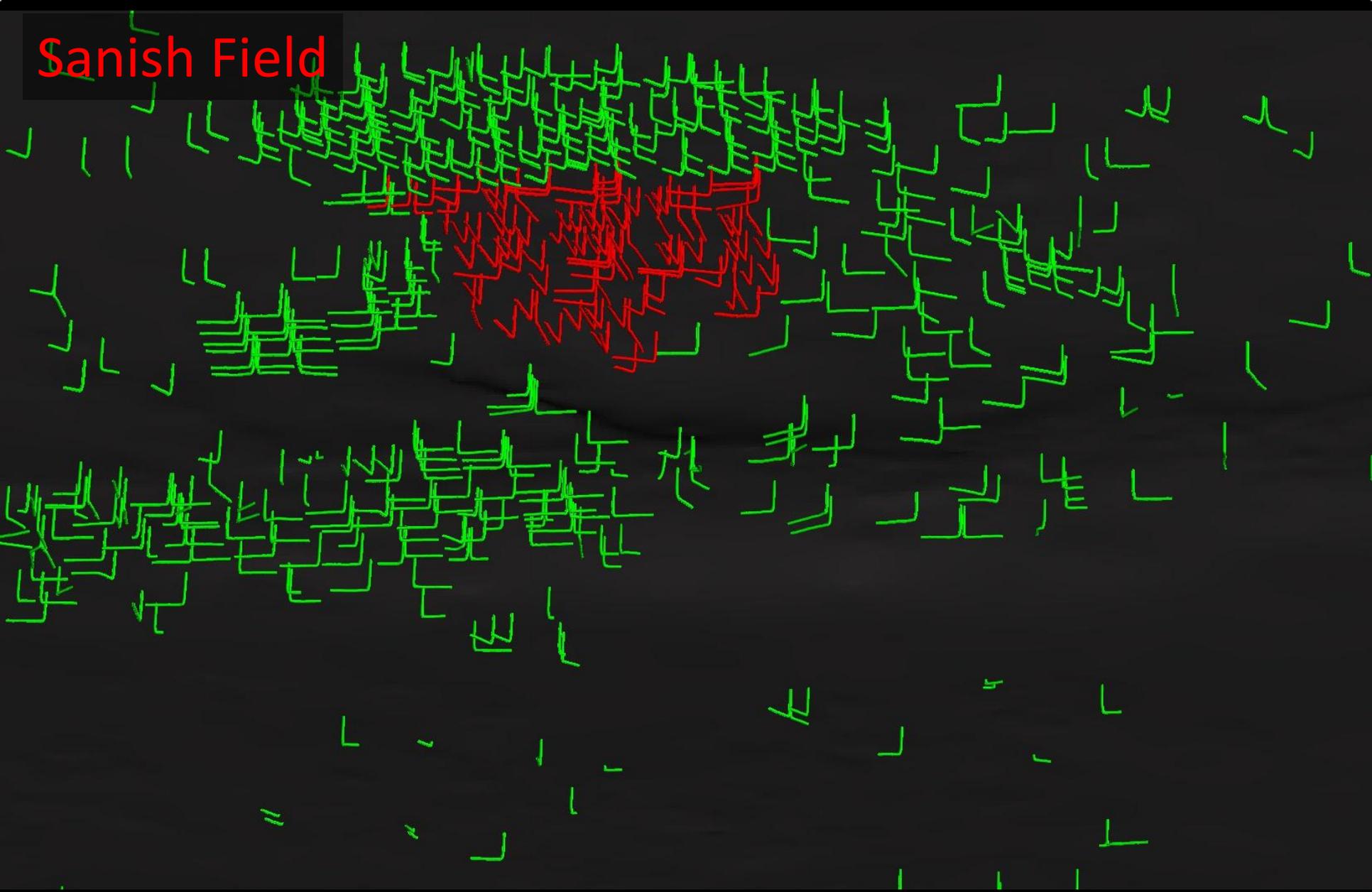
Sanish Field



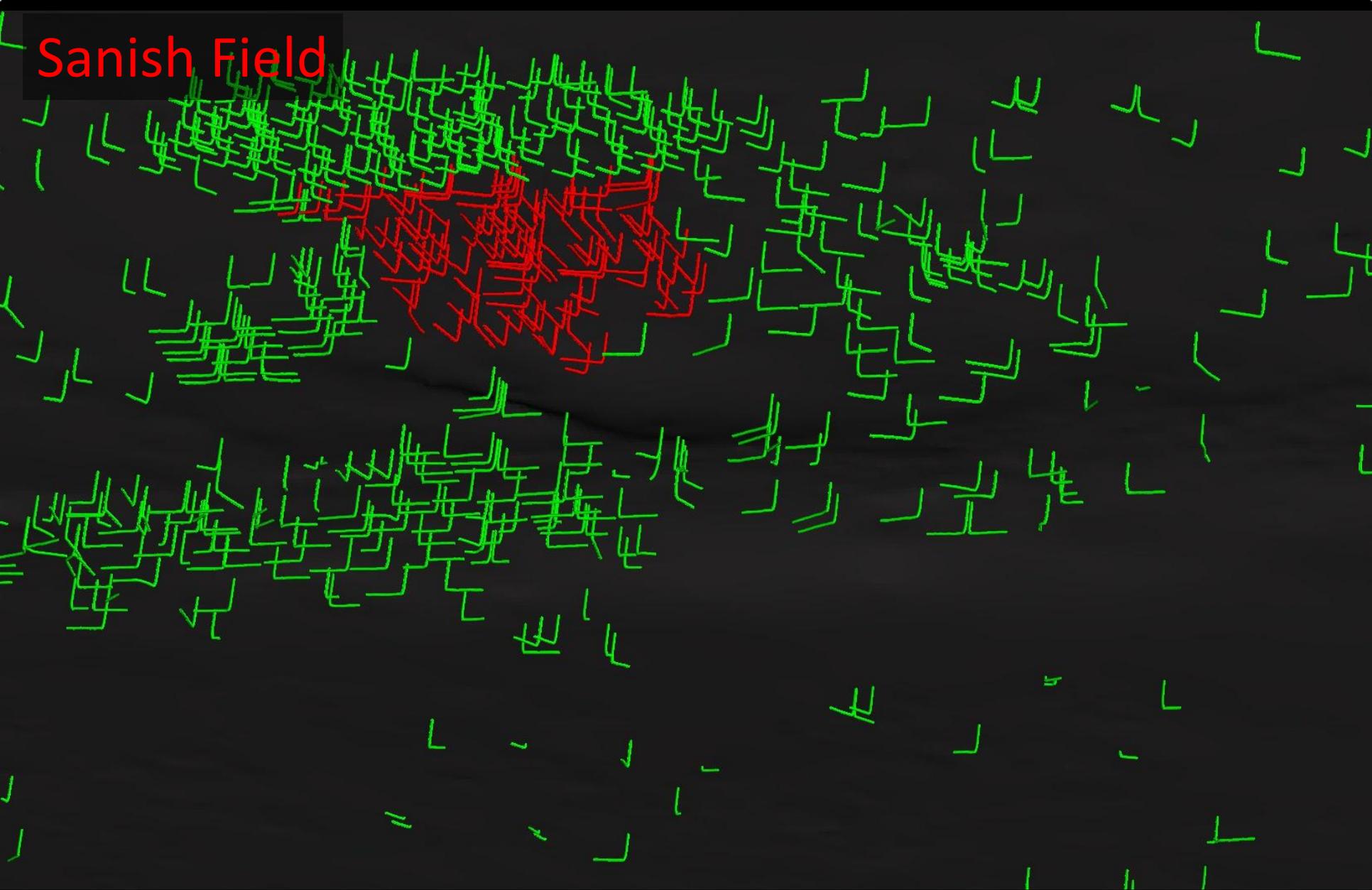
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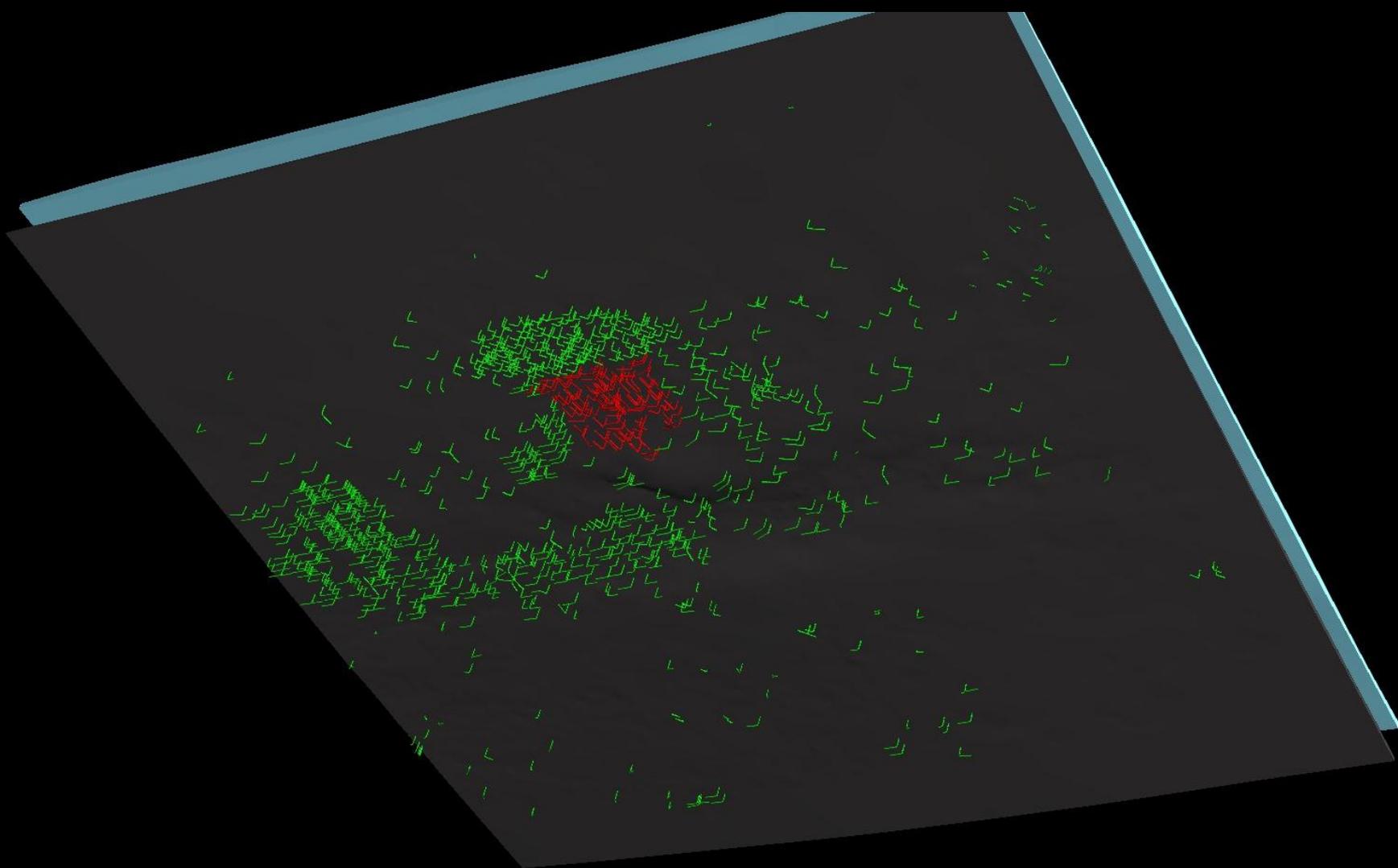


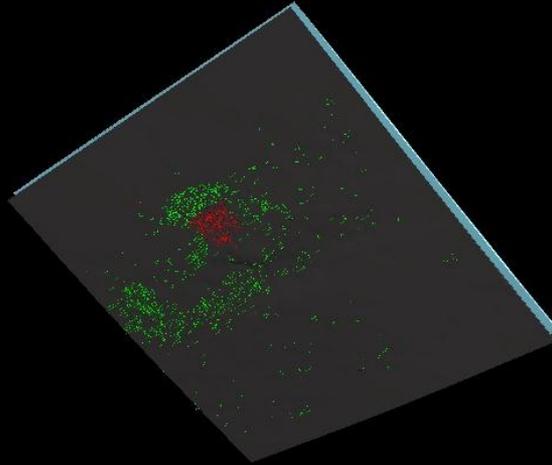
Sanish Field



Sanish Field











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