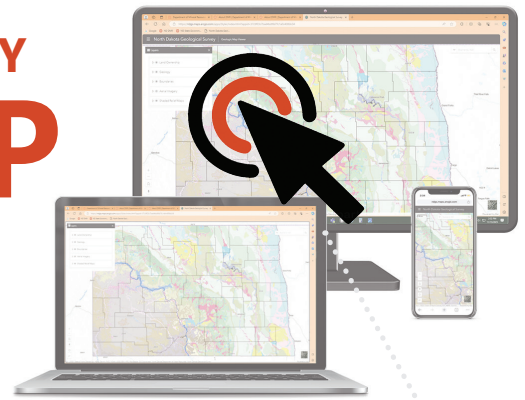


NORTH DAKOTA GEOLOGICAL SURVEY GEOLOGIC MAP VIEWER:



Touring the State's New Online Resource

<https://www.dmr.nd.gov/dmr/ndgs/geologic-map-viewer>

BY BENJAMIN YORK

We are excited to announce the unveiling of the North Dakota Geological Survey's (NDGS) *Geologic Map Viewer*! This new *Geologic Map Viewer* (fig. 1), referred to as the *Viewer*, provides a wealth of information about the geology of the state, making it an essential resource for anyone seeking to view North Dakota geology and topography in an easy-to-use application. The *Viewer* is a compilation of datasets published by the NDGS and other agencies which, when layered over each other, present a comprehensive and insightful display of data. It includes detailed information about the state's geology, boundaries, yearly aerial imagery, and monumental datasets such as 1-meter LiDAR (Light Detection and Ranging) derived hill shade of the entire state.

One of the key features of the *Viewer* is its accessibility. Anyone with an internet connection can access it on a variety of devices, such as phones and computers, making it an invaluable resource for researchers, students, and anyone else who wants to learn more about North Dakota's geology.

The *Viewer* is also designed to be user-friendly, with a simple, intuitive interface that makes it easy to find the information you need. Without online applications such as the *Viewer*, someone would have to bring all the separate layers into Geographic Information Systems (GIS) software and adjust the colors and transparency to make the data usable.

The *Viewer* is always evolving and being updated with the latest datasets that the NDGS feels are beneficial and compatible with the viewer. Some datasets are exclusively hosted by the NDGS, while the remaining reference datasets are found on the ND GIS Hub (<https://www.gis.nd.gov>). Currently, the sub-layers in the "Layers" section (fig. 2) include, in order, Land Ownership, Geology, Boundaries, Aerial Imagery, and Shaded Relief Map. To view the attribute table filled with information about each polygon, click the item and a pop-up will display (fig. 3).

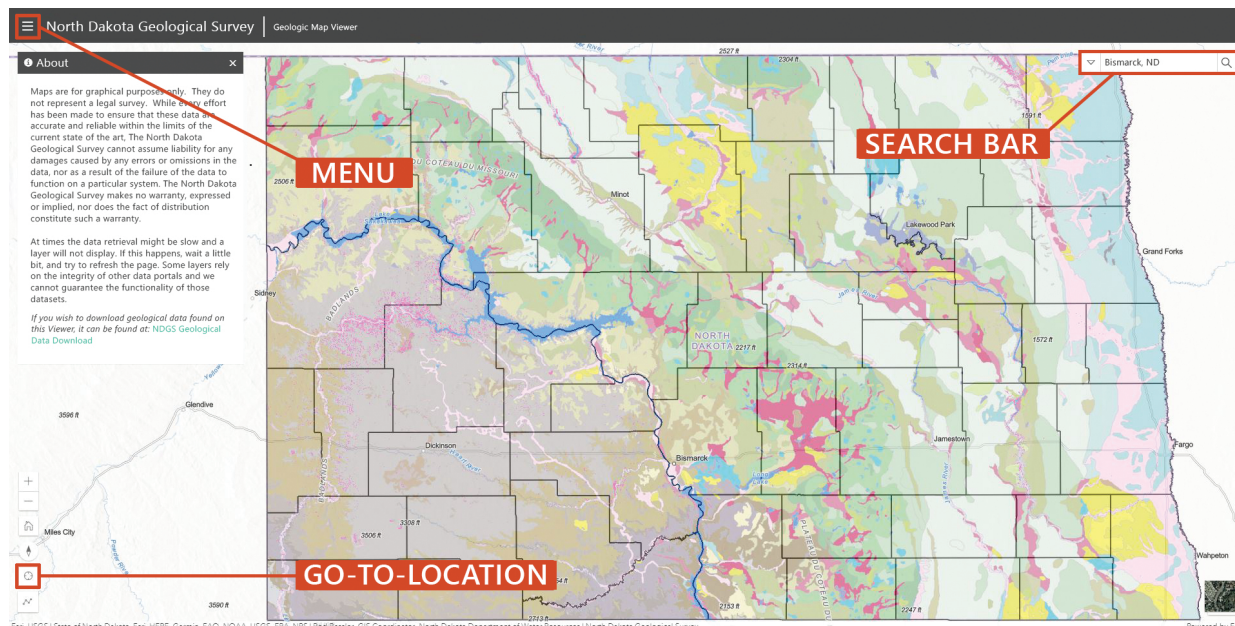


FIGURE 1. Here is the *Geologic Map Viewer* after the website is launched. The 1980 surface geology map by Clayton is the first thing you'll see along with the "About" section in the upper left. Some useful tools are the "Search bar" in the top right, and the "Show location" in the bottom left. You can access other basemaps and layers by clicking the three horizontal bars in the top left, which is the "Menu".

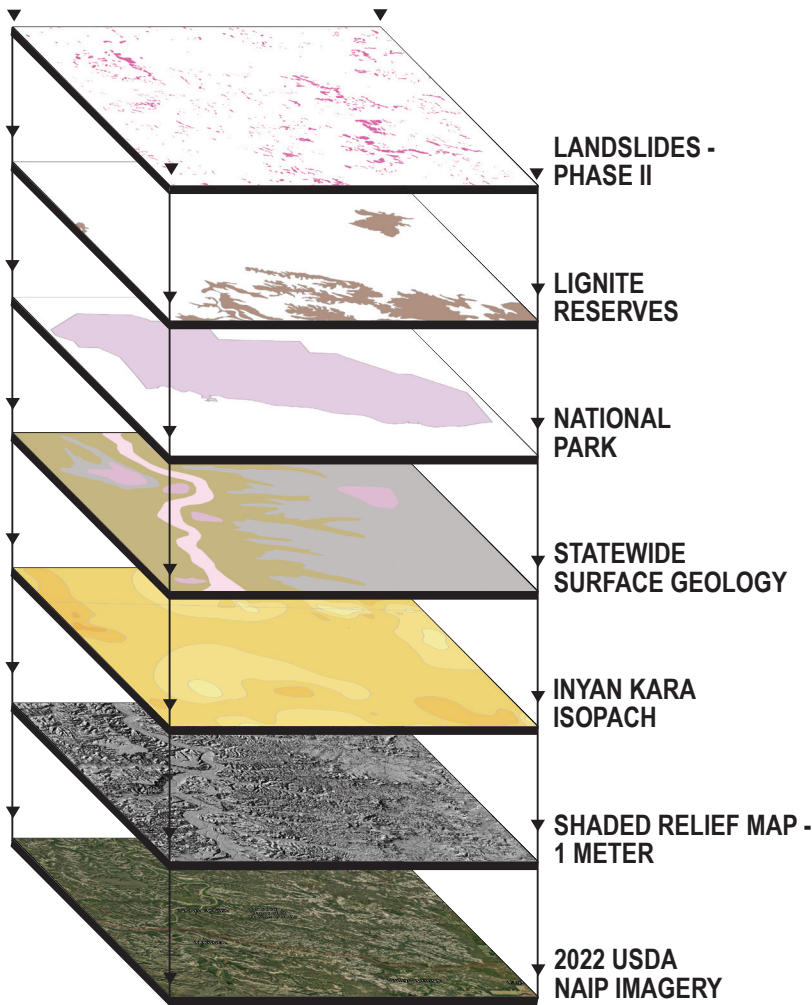


FIGURE 2.

This figure demonstrates the effectiveness of stacking layers within the Viewer. Any of these layers can be toggled on or off to create a unique composition for understanding that area of the map. This area depicted is in and around the South Unit of the Theodore Roosevelt National Park.

LAND OWNERSHIP

The first sub-layer that you will have the option to toggle on and off includes Federal and State Government owned lands. For Federal, this includes layers such as Bureau of Land Management, Bureau of Reclamation, and national parks and grasslands. For State, some useful layers to switch on and off would be trust lands, and state parks and forests.

GEOLOGY

Many of the geology datasets have been digitized from paper maps. All layers exclusively hosted by the NDGS rather than the ND GIS Hub can be found here in the Geology sub-layer. At present, with the intention to add more, the geology sub-layer contains the following datasets:

1) Statewide Landslides

"Landslide areas in North Dakota are depicted on this map as mapped from historical aerial photographs,

recent digital aerial imagery, and LiDAR digital elevation models, over seven years from 2016 to early 2023. These landslide areas were mapped at variable scales generally at 1:12,000 or less and presented at 1:24,000 scale in 1,476 individual quadrangles that cover the state. A total of 66,000 landslide areas were identified based dominantly on their surficial geomorphological expression and represent landslide areas identified up to the last date of LiDAR data collection available." – Excerpt from NDGS Areas of Landslides in North Dakota, Geologic Investigations No. 269 (Anderson et al., 2023).

2) Statewide Surface Geology and Landforms

This map shows the distribution of surface geologic units in the state of North Dakota. The coverage contains only area features. Linear features, such as beach ridges, eskers, and ice margins, are contained in the Landforms layer. The original data is derived from the 1:500,000 Geologic Map of North Dakota (Clayton et al., 1980).

3) Statewide Bedrock Geology

Digitized geologic bedrock map of North Dakota from NDGS Miscellaneous Map No. 25 (Bluemle, 1983). The primary source of information used to compile the original map was the test-hole data obtained during drilling by the North Dakota Department of Water Resources for their groundwater studies. The NDGS and U.S. Geological Survey were also involved in these groundwater studies. The map is only as accurate as the density and reliability of the control points. The bedrock geology map is precise in the southwestern part of the state where there are bedrock surface exposures, but less precise in areas of thick glacial overburden where only a few test holes reached bedrock.

4) Coal Reserves

This layer of strippable lignite deposits in North Dakota is from NDGS Miscellaneous Map No. 34 (Murphy, 2001). The reserves were calculated using geophysical logs from over 18,000 holes, including test holes on file with the NDGS and USGS. Western and central North Dakota are underlain by approximately 32,000 square miles of lignite deposits, with some deposits near the surface and others extending as deep as 1,800 feet or more. Using the calculations described in MM 34, it is determined that North Dakota contains 25.1 billion tons of strippable lignite reserves.

5) Earthquake Locations

This layer is a point file of all earthquakes that have an epicenter in North Dakota. Each point has location, magnitude, intensity, and estimated depth information associated with it. The information was collected from multiple sources and published in the NDGS Geologic Investigations No. 187 (Anderson, 2015).

6) Inyan Kara Formation

This layer is an isopach map, displaying thickness contours, of interpreted injectable sandstone bodies

of the Inyan Kara Formation of the Dakota Group. The Inyan Kara Formation consists of marginal marine and non-marine sandstone and shale. The purpose of this layer is to identify favorable areas where the potential for encountering sandstone bodies for injecting produced water is greater. This layer was prepared using wireline logs (gamma ray and resistivity) from thousands of wells and is a compilation of fifteen 100K maps.

BOUNDARIES

Like the land ownership sub-layer, the boundaries datasets are useful for geographic references and visualizing how geology aligns with political and civil borders. Datasets such as county boundaries, reservations, 1:24,000 quadrangles, and PLSS townships and sections have relevance to geology datasets provided on the *Viewer*.

AERIAL IMAGERY

In addition to the default Imagery base map, the *Viewer* also has various aerial imagery that can be used for reference. The primary dataset is the U.S. Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP). Currently, the *Viewer* displays NAIP imagery from 2003-2022. NAIP imagery is collected during the active agriculture season with the primary recipient being the USDA Farm Service Agency. The imagery is useful for repeat analysis since it is captured roughly the same time every year.

The remaining imagery is various historical datasets from several agencies. The oldest statewide imagery is the USDA

1957-1962 aerial dataset. This can be especially useful to see the terrain before all of the anthropogenic changes such as urban development or road installation had taken place. It can also be useful for visualizing how long certain landslides have been active. Using the USDA 1957-1962, USGS 1995-1998, and the most recent USDA 2022 imagery you can see how a location has changed in roughly 30-year increments.

SHADED RELIEF MAPS

The *Viewer* displays 1-meter and 10-meter resolution statewide hill shade models, or shaded relief map, which simulates the sun's effects and creates shadows and shading to create a clearer picture of what the topography looks like. To learn more about shaded relief/hill shade maps, check out this Esri blog (Nagi, 2014).

The 1-meter shaded relief map is derived from LiDAR. LiDAR is typically collected from aircraft and is usually delivered as a point cloud dataset, and then is converted into a digital elevation model (DEM) which is easier for scientists to work with. For more information on how the NDGS uses LiDAR and its derivatives, please check out these newsletter articles about LiDAR (Maiké, 2016, 2021). The *Viewer* connects to an elevation data portal hosted by the North Dakota Department of Water Resources (NDDWR). Through the NDDWR LiDAR portal (<https://lidar.dwr.nd.gov>), a user could download individual collection tiles, but the *Viewer* instead connects to an already rendered statewide shaded relief map. This allows users of the *Viewer* to overlay other useful datasets right over the modeled terrain.

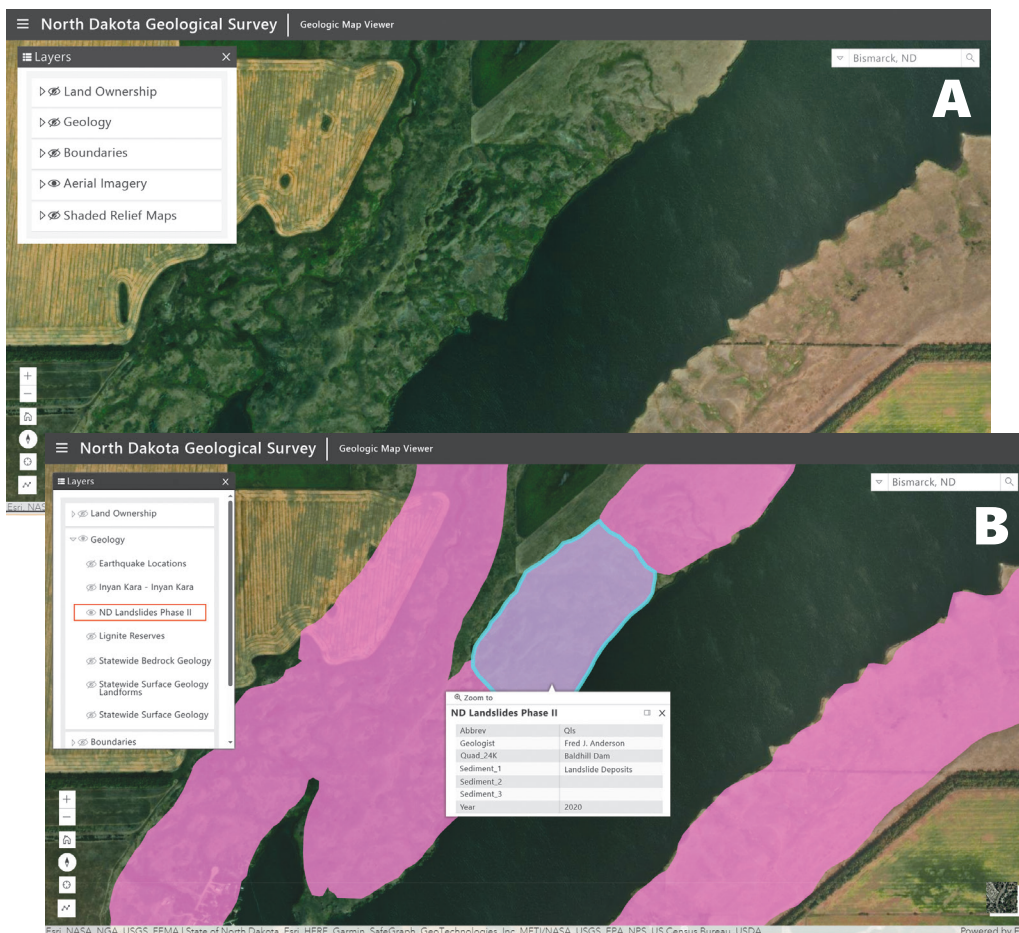


FIGURE 3.

The "Layers" located in the menu (three horizontal bars in the top left), contains **(a)** all the information that the *Viewer* has to offer. Many of these layers, such as the Land Ownership and Boundaries, are from others state of federal agencies, but all of the layers in the Geology section are produced by the NDGS. Within the *Viewer* the user can click on any feature to show the attribute table. The feature highlighted in the figure **(b)**, a landslide north of Valley City, displays the attribute table containing information such as the year the feature was mapped, and who mapped it.

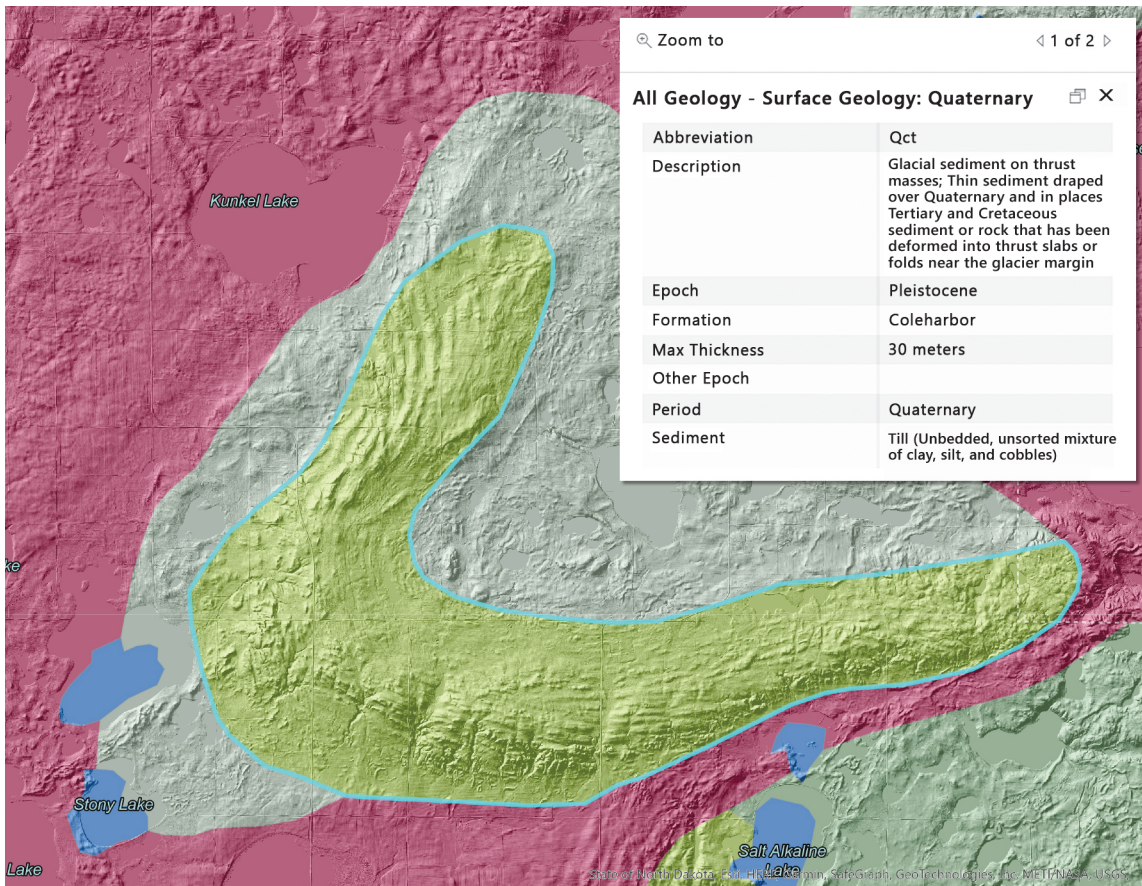


FIGURE 4.

The *Viewer* can also display multiple layers at the same time to create an even more useful dataset. One example of this layer combination would be displaying the Statewide Surface Geology over the 1-meter shaded relief map. The feature highlighted is a glacial thrust mass near Horsehead Lake in Kidder County. Some layers have detailed descriptions, such as this feature within the Surface Geology, seen in the attribute table.

The other shaded relief map on the *Viewer* is a 10-meter shaded relief map derived from the National Elevation Dataset (NED) originating from the USGS. The NED dataset is a compilation of LiDAR collects, contour maps, elevation collections, Shuttle Radar Topography Mission data, and other sources. The NED dataset covers the entire United States, but for the *Viewer*, just North Dakota is used for the statewide 10-meter shaded relief map.

CONCLUSION

In addition to all the layers that the *Viewer* has to offer, there are some additional features and tools the user has available to them. In the top right (fig. 1), there is a search bar where you can select different datasets to search locations. Under “Esri World Geocoder,” you could search for town names or latitude/longitude, and you could even search for Township/Range/Section by selecting “PLSS Sections” in the drop-down. There is also a button in the bottom left, that looks like a target and crosshair, that will show your location within the *Viewer*; this is especially useful when using our application on a mobile device. These are just a few of the tools and features that the *Viewer* has to offer.

Having all of these layers present in one location, with all the colors and transparency already adjusted for ideal display, the *Viewer* alleviates the need for complex and expensive GIS software for those who just want to use maps for reference. Many NDGS datasets are published online as PDF or downloadable shapefile links, but having a one-stop-shop for geology and geography datasets saves time by removing the need to download data and manipulate the layers to make it useful.

A lot of work has gone into making the datasets that are displayed in the *Viewer*. The NDGS hopes that this new tool can serve the public well and will constantly evolve to meet the needs of both the public and industry. You can contact Benjamin York at bcyork@nd.gov with any comments or suggestions.

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