# KARST IN THE LILLEY FORMATION, PEEBLES 7.5-MINUTE QUADRANGLE, OHIO

Douglas Aden
Douglas.Aden@dnr.ohio.gov

Ohio Department of Natural Resources
Division of Geological Survey
2045 Morse Rd., Bldg. C, Columbus, Ohio 43229

## Introduction

During the 2017–2018 field season, karst was mapped in the northern half of the Peebles 7.5-minute Quadrangle (Aden and Parrick 2018). This is a continuation of eight years of detailed karst mapping in Ohio to update the statewide karst database. Sinkholes are located by extracting enclosed depressions from a Digital Elevation Model (DEM) generated from Ohio's statewide Light Distance and Ranging (LiDAR) data. Depressions are then reviewed digitally and subsequently checked in the field. By the end of 2019, statewide karst data will be available online as an interactive map. This will allow the public and consultants to directly access this regularly updated data and download it for use in a Geographical Information System (GIS).

In southern Ohio, the primary karst-forming bedrock is mapped as a single, undivided, Silurian-age unit. However, more detailed bedrock mapping was completed for the Peebles Quadrangle (Figure 1), which differentiates these units (Swinford, 1991). This mapping, in combination with field observations, suggests that the Lilley Formation is the most karst-prone in the quadrangle (Swinford, 1985).

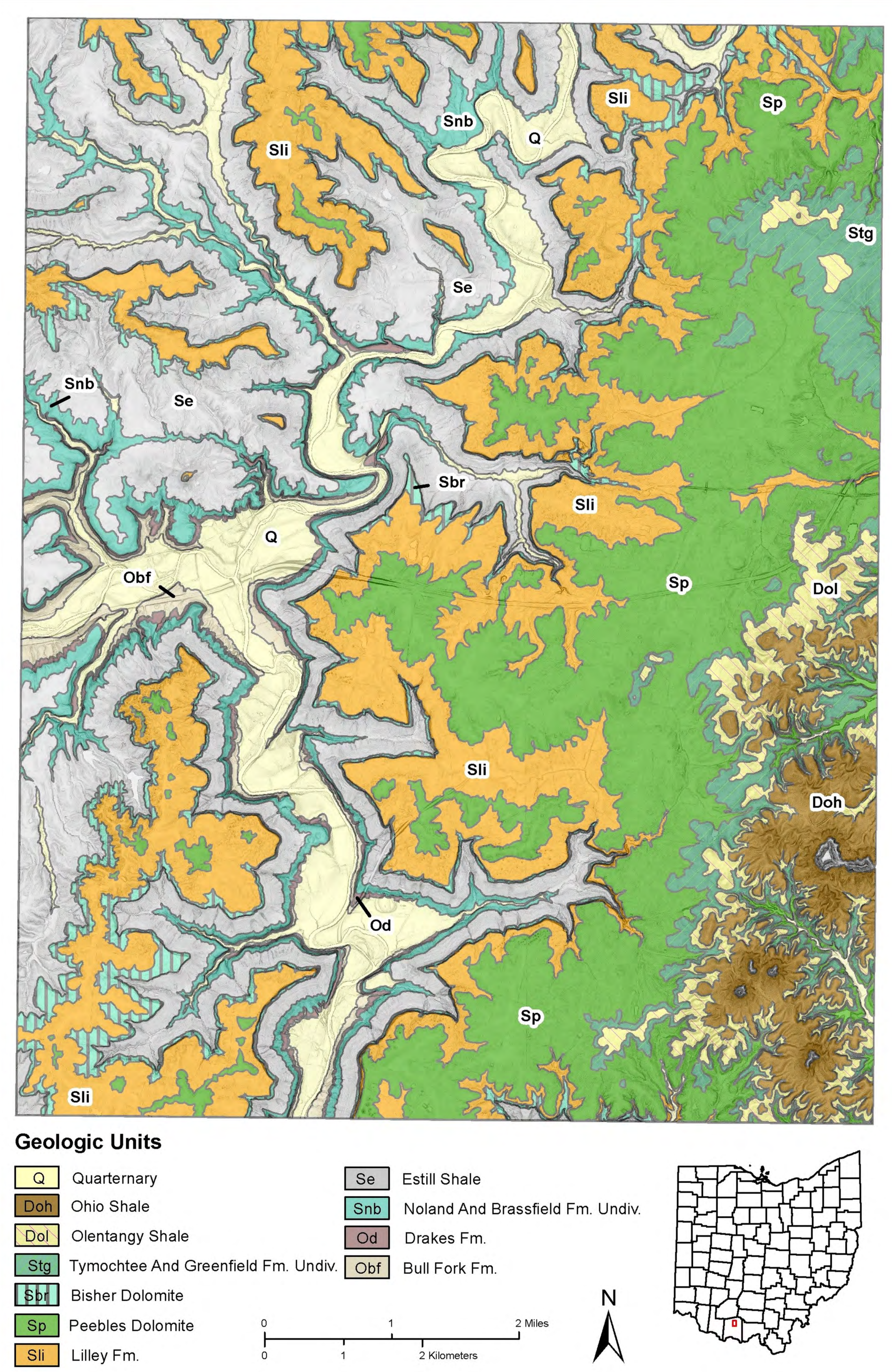


**Figure 1.** Bedrock units, such as the Lilley Formation, are divided out in the Peebles Quadrangle unlike the surrounding quadrangles where they are grouped with other carbonates. In this quadrangle units range from upper Ordovician to Devonian in age.

## Methods

To determine what percentage of sinkholes occur in the Lilley Formation, mapped karst was intersected with the detailed bedrock mapping for the Peebles quadrangle (Figure 2). This composite of the detailed bedrock and karst maps illustrates that 82% (1,336 out of 1,637) of sinkholes occur in the Lilley Formation (Figure 2, 3, 4, 5), 7% in the Nolan and Brassfield Formations Undivided (Figure 6), 5% in the Estill Shale (Figure 7), 4% in the Peebles Dolomite, and 2% in other formations (Figure 8). Measured sections in the area indicate that the two formations containing the most sinkholes vary locally from dolomite to limestone. Acid tests on the Lilley Formation show this variability as well, indicating limestone with variable percentages of dolomite. The Lilley Formation also contains vugs in many areas, which facilitate dissolution.

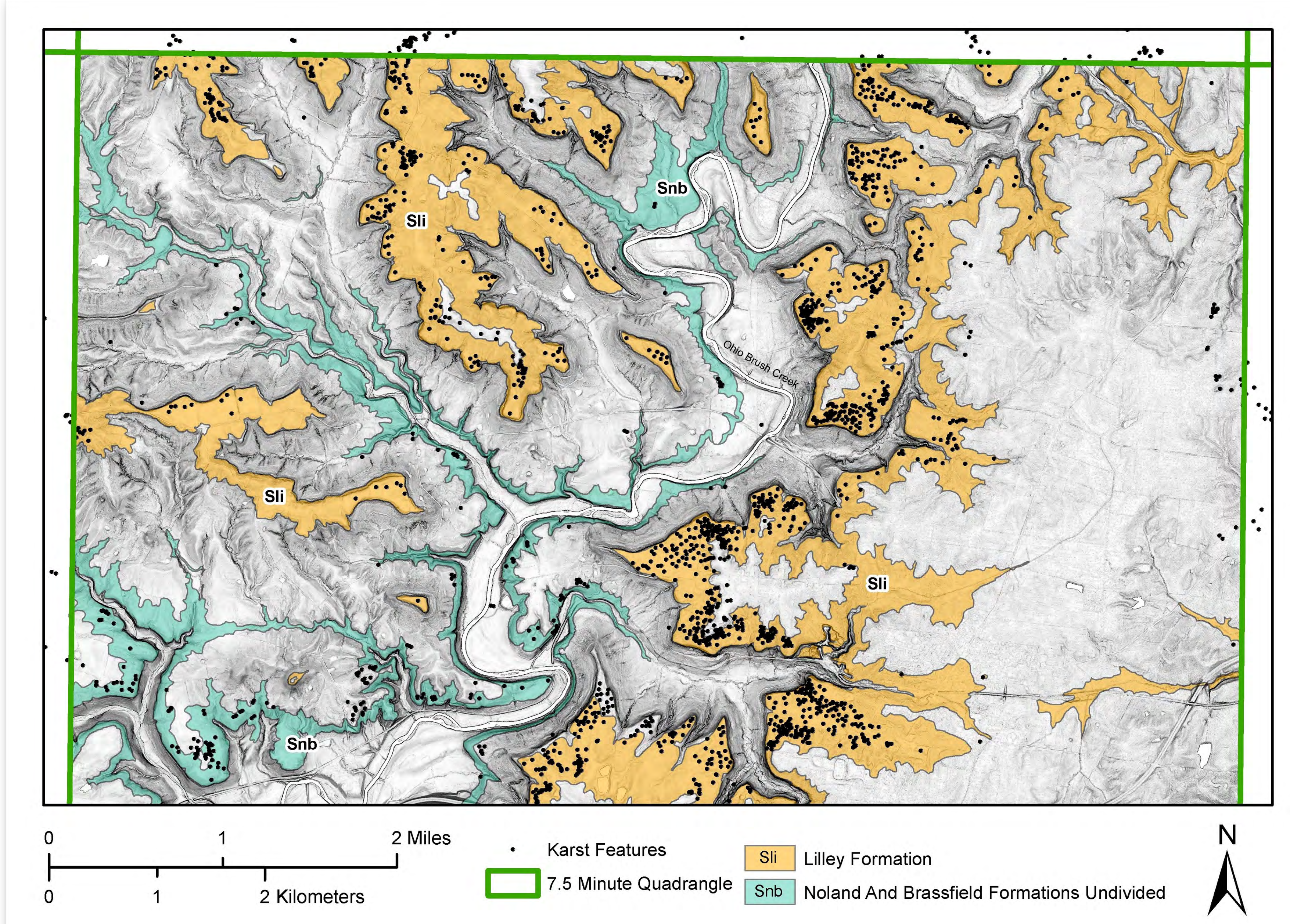


**Figure 2.** The northern half of the Peebles Quadrangle showing the intersection between the karst points and the Lilley Formation and the Noland And Brassfield Formations Undivided. These are the two limestone bearing units in the quadrangle and where the majority of sinkholes are found.

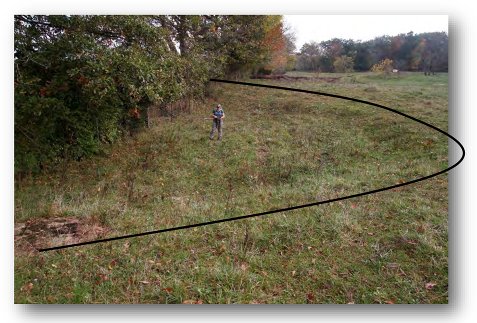

**Figure 3.** Lilley Formation forming a bedrock rim around this sinkhole. Open fracture in the trees was 30 feet (ft) deep.

**Figure 4.** An 8-ft-deep sinkhole forming in the Lilley Formation.

**Figure 5.** Exposed Lilley Formation on the flank of an unusually large sinkhole ( >1km long) in the town of Peebles Ohio.

**Figure 6.** Sinkhole and exposed bedrock in the Noland and Brassfield Formations Undivided.

**Figure 7.** Sinkhole with some trash, likely forming through thin or missing Estill Shale into the underlying Noland and Brassfield Formations Undivided.

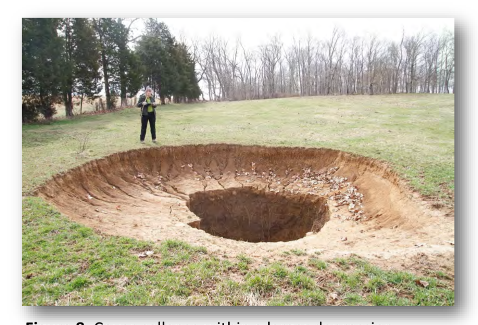

**Figure 8.** Cover collapse within a larger depression, forming in the Tymochtee and Greenfield Formations Undivided. Based on lack of vegetation, this sinkhole formed recently.

## Results

A review of measured sections in the area shows that the Lilley Formation varies locally from limestone to dolomite. Limestone is more susceptible to dissolution than dolomite (Liu et al. 2005), which may explain the concentration of sinkholes in the Lilley Formation relative to the surrounding dolomites (Figure 9, 10). The Nolan and Brassfield Formations Undivided also contain limestones and have the next largest percent of sinkholes. The presence of sinkholes in the Estill Shale is counterintuitive, owing to its insoluble nature. Sinkholes in the Estill Shale are generally found adjacent to mapped areas of the Nolan and Brassfield Formations Undivided (Figure 11, 12). These sinkholes may have formed by the collapse of the Estill Shale into the underlying dissolved carbonate. Alternatively, the appearance of sinkholes in the Estill Shale could be an error in the location of the mapped contact. This could be confirmed with additional field work, although no shale outcrop was observed in any of these sinkholes.


**Figure 9.** The majority of sinkholes form within the Lilley Formation (Sli, yellow). Note the large depression in the south east. Some sinkholes are forming stratagraphically above in the Peebles Formation (Sp, green), and some below in the Bisher Formation (Sbr, blue). See Figure 10.

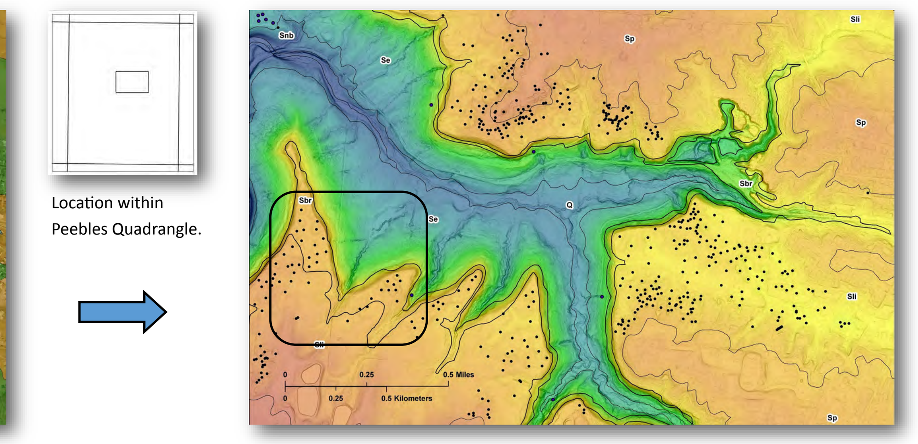


**Figure 10.** Digital Elevation Model showing that sinkholes correspond to specific elevations. This DEM shows that a portion of the Bisher Formation is likely mapped incorrectly in the square. These sinkholes match the elevation of features found in the Lilley. Compare to figure 9.

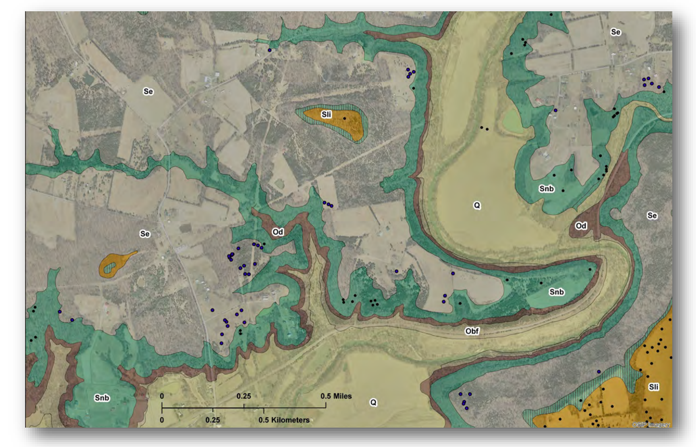


**Figure 11.** The next most common sinkhole forming unit after the Lilley Formation is the Nolan and Brassfield Formations Undivided (Snb, teal). Note some sinkholes found in the Estill Shale (Se, grey).

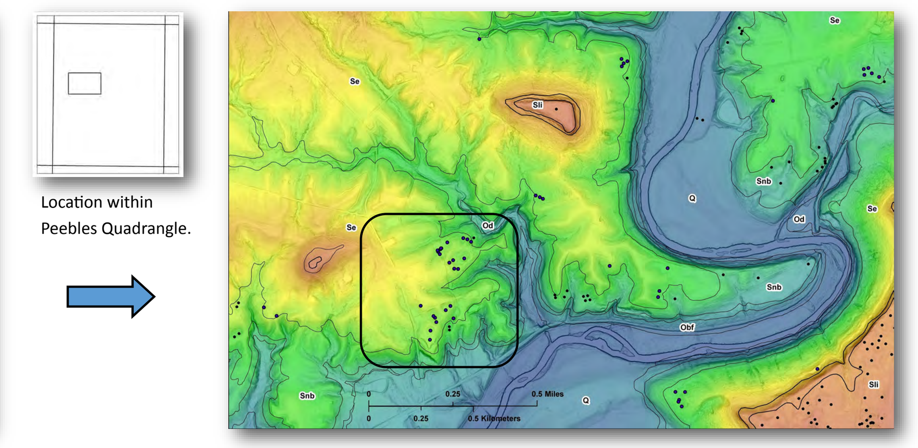


**Figure 12.** Digital Elevation Model showing that many of the sinkholes mapped in the Estill Shale (square) are very close in elevation to—and may have formed in—the Nolan and Brassfield Formations Undivided.

## Future Work

Studying which units are the most susceptible to sinkhole formation allows for hazard mitigation by potentially avoiding the most at-risk units. Although field checking is incomplete for the southern half of the Peebles Quadrangle, this relationship appears to be maintained here as well (Figure 13). Future detailed bedrock mapping could use sinkhole locations from detailed karst maps to extrapolate the location of the Lilley Formation in nearby quadrangles and map it separately from adjacent Silurian-age carbonates (Figure 14).

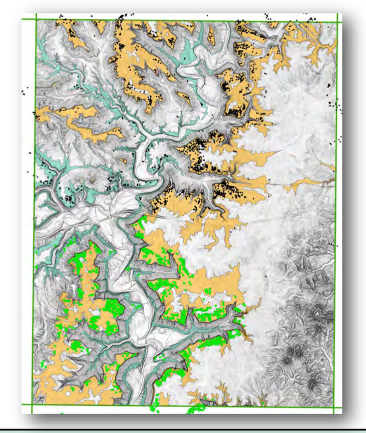

**Figure 13.** Green and white potential sinkhole points in the southern half of the Peebles Quadrangles have not yet been field checked, but are still primarily occurring in the Lilley Formation.

**Figure 14.** On the northern edge of the Peebles Quadrangle, this 42-ft sinkhole is the deepest known sinkhole in the state. Bedrock (Lilley Formation) outcrops at the surface, but intersects the Bisher Dolomite approximately halfway down this solution enlarged fracture.

## Acknowledgements and References

The author thanks Brittany Parrick for her invaluable help with field mapping and data processing.

Aden, D.J., and B.D. Parrick. 2018. Kast of northern portions of the Peebles and Jaybird 7.5-minute quadrangles, Ohio: Columbus, Ohio Department of Natural Resources, Division of Geological Survey Open-Fine Report 2018-3, 40 p., 37 maps.

Liu Z., Yuan D, Dreybrodt W. 2005. Comparative study of dissolution rate-determining mechanisms of limestone and dolomite. Environmental Geology v49, n2, 274–279.

Swinford, E.M. 1991. Geologic map of the Peebles quadrangle. Ohio: Columbus, Ohio Department of Natural Resources, Division of Geological Survey Digital Map Series BG-2 Peebles.

Swinford, E.M. 1985. Geology of the Peebles Quadrangle, Adams County, Ohio. The Ohio Journal of Science. v85, n5, 218-230.