Cave and Karst Resources Summary

Abraham Lincoln Birthplace National Historical Park

Kentucky

Compiled by Limaris Soto

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Geologic Features and Systems Branch - Geologic Resources Division
National Park Service - Natural Resources Stewardship and Science

Location and Area

Abraham Lincoln Birthplace National Historical Park (ABLI) is located in LaRue County in central Kentucky (Hutchison et al. 2011). This entire region is often referred to as the "Central Kentucky Karst" which is part of a karstic limestone belt that extends from southern Indiana through Kentucky into Tennessee. Kentucky karst is among the most well-developed karst landscapes in the world (Thornberry-Ehrlich 2010).

ABLI comprises two distinct units: the Birthplace Unit and the Knob Creek Unit (sometimes known as the Boyhood Home Unit) located about 13 km (8 mi) to the northeast from the Birthplace Unit. The Birthplace Unit features a large memorial building and information resources, it is approximately 45.7 ha (113 acres) in size. The Knob Creek Unit is in a more rural setting and is approximately 92.2 ha (228 acres) in size (Hutchison et al. 2011).

At the Birthplace Unit, a natural sinking spring played a significant role in the historical development of the site. Surface water on this karstic landscape is typically rare so in order to take advantage of the rich soil and agricultural opportunities, early settlers were drawn to areas with natural springs and sinkhole ponds. Lincoln's father settled at the site because of the ready access to water and a perennial spring (Thornberry-Ehrlich 2006).

Geology

Two distinct physiographic regions define the geography of ABLI. The Birthplace Unit is located within the Pennyroyal Plateau, which is characterized by sinkhole plains, caves, and other karst features. The Knob Creek unit is located a short distance past the eastern boundary of the Pennyroyal Plateau in the Outer Bluegrass region, just beyond the Muldraugh Escarpment which divide the two. This area is characterized by steep slopes and gullies and is often referred to as the Knobs region of Kentucky (Hutchison et al. 2011).

The bedrock units of the Pennyroyal Plateau consist of thick, stacked beds of carbonate rocks such as limestone and dolomite, which are interlayered with insoluble sedimentary rocks such as sandstone, siltstone, and shale. The Pennyroyal Plateau is significant in being part of the largest continuous region of cavernous rocks in the United States. Areas such as the Pennyroyal Plateau have lost their resistant cap rocks (a necessary component to extensive cave formation) to erosion (Thornberry-Ehrlich 2010).

The dominant surficial geologic units belong to the Mississippian Period (359 million years ago) and, in stratigraphic (descending) order are known as: the St. Louis Limestone, Salem Limestone, Harrodsburg Limestone, and Borden Formation. In some places Quaternary (2.6 million years ago) alluvium overlies the Mississippian bedrock as unconsolidated deposits of mixed sediments mainly associated with streams and their floodplains. The St. Louis Limestone is the only unit exposed at the Birthplace Unit. However, the Borden Formation, Harrodsburg Limestone, and Salem Limestone are all exposed within the Knob Creek Unit (Hutchison et al. 2011).

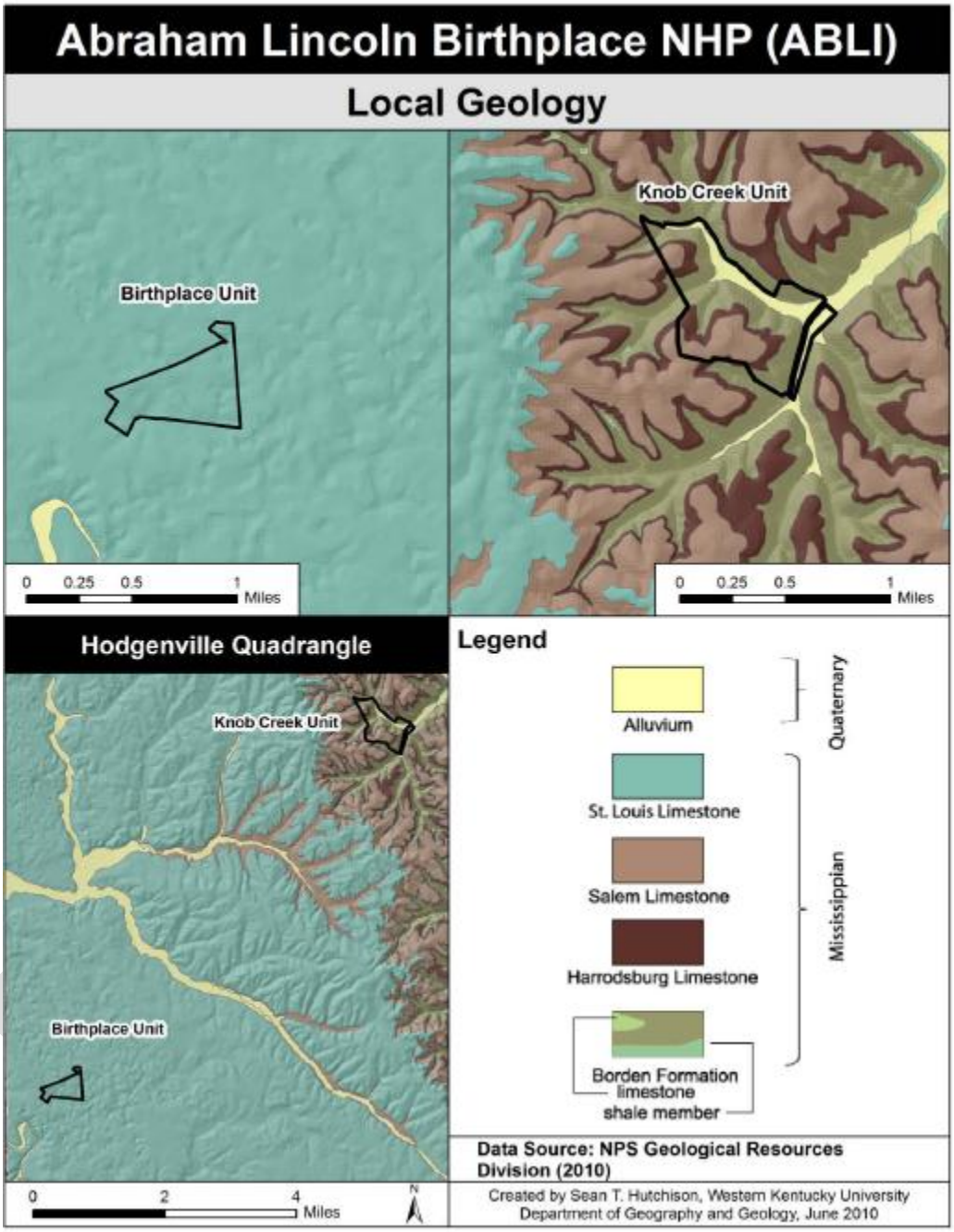
All but some members of the Borden Formation contain thick deposits of limestone and dolomite. The four bedrock units record a longstanding marine basin called the Illinois basin. Around the edges of the basin, these clastic cap rocks have been removed by erosion, exposing underlying limestone at the surface, which forms a broad, low-relief karst plain (the Pennyroyal Plateau) with characteristic sinkholes, small caves, springs, sinkhole ponds, and sinking streams (Palmer 1981).

The St. Louis Limestone is primarily light olive gray limestone, yellowish gray dolomite, and shale with silty, carbonaceous, siliceous, and cherty zones. The lower beds are clayey, laminated, and dolomitic. (Thornberry-Ehrlich 2010). The St. Louis Limestone was quarried due to its relatively pure limestone layers. The St. Louis forms the rolling landscape at the Birthplace Unit and it is prone to karst development supporting a vast network of sinkholes, underground streams and caves in the area (Hutchison et al. 2011).

The Salem Limestone is highly variable with olive gray limestone bedded with yellowish brown shale. There is a fining upward sequence and the bedding layers vary from thin to medium. The lower layers are rich in shale, siltstone, and some calcareous fossil zones and siliceous cements. This unit is prone to karst development, and springs are common at the base (Thornberry-Ehrlich 2010).

The Harrodsburg Limestone contains light olive gray, coarse to very coarse grained limestone with bedding ranging from thick to thin and local brownish gray, thin-bedded, calcareous, and siliceous silty dolomitic limestone interbeds. The unit is prone to karst development and forms springs along its base near the contact with the Borden Formation (Thornberry-Ehrlich 2010; Hutchison et al. 2011).

The Borden Formation contains seven distinct members. The Formation is dominated by shale, siltstone, and thick to thin bedded limestone. Some members contain shale, clay, and silt rich layers. The uppermost member of the Borden Formation, the Muldraugh Member is exposed in the lower hills of the Knob Creek Unit (Hunt-Foster et al. 2009). The Muldraugh Member contains siltstone, dolomite, and limestone grading into fine-grained sandstone interlayered with dolomitic, calcareous, micaceous, and locally glauconitic layers. The Crinoidal Limestone contains thin to thick bedded, cross-bedded, fossiliferous limestone layered with siltstone (Thornberry-Ehrlich 2010). The crinoids are exposed in a cutbank of the north fork of Knob Creek across from a visitor use area at the Knob Creek Unit.



Geologic Map of ABLI (Hutchinson et al. 2011)

Caves and Karst

Karst processes and features dominate the scene and create numerous geologic issues at the park. At ABLI, the landscape shows evidence of the active karst processes of limestone, which includes: dissolution, underground cavity development, spring activity, sinkhole collapse, and erosion (Thornberry-Ehrlich 2010).

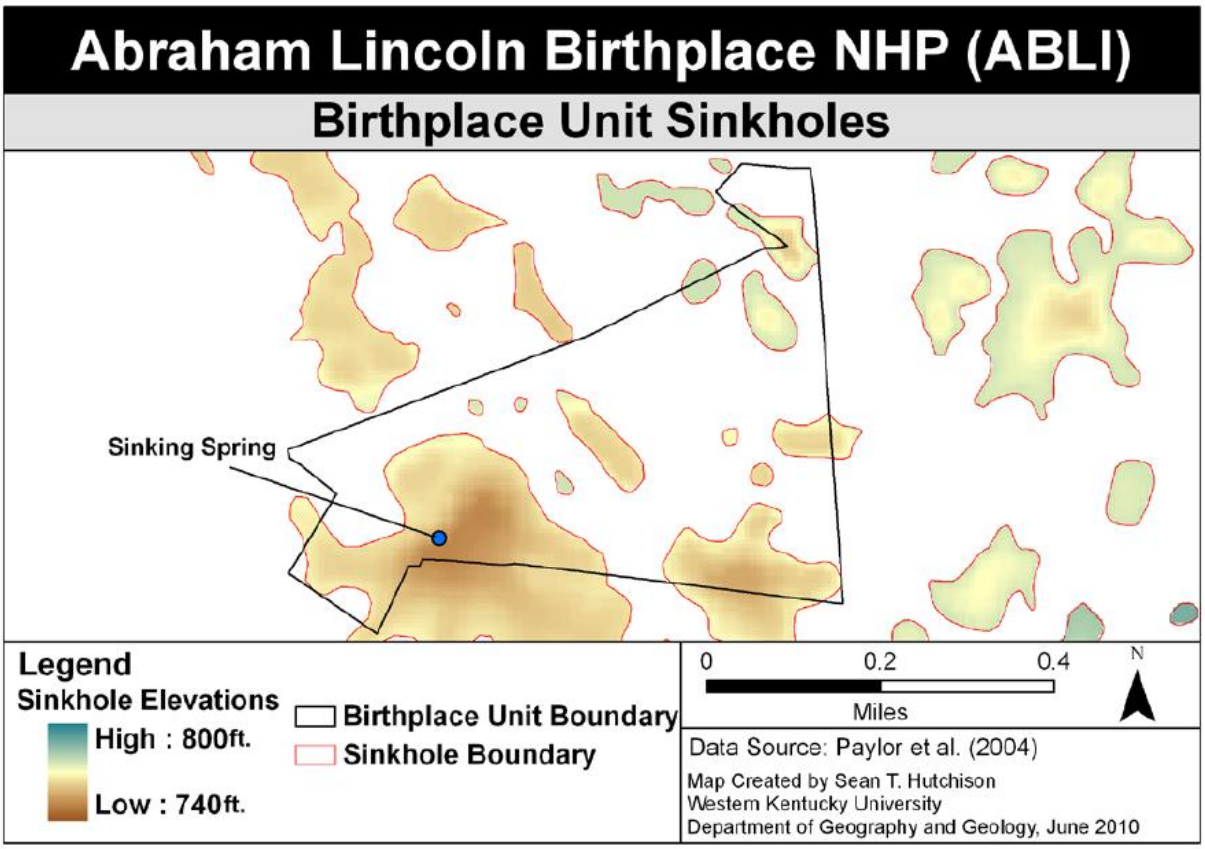
Most of the western part of the Birthplace Unit is one large sink. According to Ek (2001), there is only one cave in the Park. The cave that Sinking Spring flows into reportedly extends about 80 feet before it becomes too small to negotiate. The waters of Sinking Spring have been traced and found to empty into the South Fork of the Nolin River about 1 mile southwest of the spring (NPS 1997; NPS 2006). The cave associated with the spring may support a variety of sensitive cave-adapted biota though no official survey has been conducted (J. Meiman written communication with Thornberry-Ehrlich 2010). Other caves or karst features in the area may contain biological, paleontological or cultural resources (NPS 2006). Caves in the ABLI area are likely formed by both vadose (above water table) and phreatic (at or below the water table) solution. In the Pennyroyal Plateau karst system, emerging passages conduct water through the vadose zone to the phreatic zone and solutional enlargement of conduit occurs in both zones simultaneously (Palmer 1984; Thornberry-Ehrlich 2010).

Sinking spring is likely a high-level spring type. The shallow flow paths inherent in this type of spring are highly connected with surface runoff and therefore have rapid responses to changes in precipitation and contamination. Potential issues with the spring include adjacent agriculture runoff, highway runoff, septic systems, litter and coins from visitors, and increased development that could deplete water resources and lead to a lower groundwater table (Hutchison et al. 2011; Thornberry-Ehrlich 2010).

Sinking Spring on the Abraham Lincoln Birthplace Unit. (NPS Photo)

There are various sinkholes or collapse features at the park. The potential for sinkhole collapse exists at both units of the park and careful determination of the nature of the underlying karst features may help resource management to determine areas particularly at risk (Thornberry-Ehrlich 2010).

According to Hutchinson (2011), there are at least twelve major sinkholes within the Birthplace Unit (See below).



Birthplace Unit Sinkhole Map (Hutchinson et al. 2011)

Archeological/Cultural Resources

No Archeological/Cultural Resources studies as they relate to Caves/Karst studies were obtained during the research of the park.

Biological

A study by Gumbert and others (2006), used mist netting on the surface to survey the presence of bats at ABLI. A total of 47 bats were captured representing seven species. Those include; the Big brown bat (*Eptesicus fuscus*), Silver-haired bat (*Lasionycteris noctivagans*), Eastern red bat (*Lasiurus borealis*), Hoary bat (*Lasiurus cinereus*), Little brown bat (*Myotis lucifugus*), Northern bat (*Myotis septentrionalis*), and Eastern Pipistrelle (*Pipistrellus subflavusi*) (Gumbert et al. 2006).

The Gray bat (*Myotis grisescens*), Indiana bat (*Myotis sodalist*), Evening bat (Nycticeius *humeralis*), and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) potentially occur at ABLI (NPSpecies website;

NPS 2013). It should be noted that the Gray bat and the Indiana bat are on the federally endangered species list. In addition, the Rafinesque's big-eared bat and evening bat have special threat designations on the Kentucky State Nature Preserves Commission list and can be found during the summer as close as Mammoth Cave which is located approximately 55 km (34 mi) southwest of the park (Gumbert et al. 2006; Hutchison et al. 2011).

Adams and others (2009) conducted a subsequent mist nesting survey. The study captured five species of bats within ABLI. Those include: the *Eptesicus fuscus, Lasiurus borealis, Myotis grisescens, Myotis septentrionalis,* and *Perimyotis subflavus*. In addition, results show that the habitat at ABLI consisted of younger forest stands which typically have less roost availability.

Hydrological

The karst landscape of ABLI is considered a moderate threat and recurring disturbance owing to the fact that water quality and quantity can change rapidly in that environment. Karst-related flooding is a significant issue at the Birthplace Unit where it can disrupt park visitation and overbank flow is a concern at Knob Creek Unit (Hutchison et al. 2011). Agriculture, septic systems, and roadways are the primary sources for groundwater contamination in the park area (Thornberry-Ehrlich 2010).

A Baseline Water Quality Data and Inventory Analysis was conducted at ABLI in 1999. Results show that water quality appears to be generally good with some impacts from human activities. Dissolved copper and dissolved thallium were found to be higher than normal levels at the Sinking Spring site. The report identified potential anthropogenic sources of contaminants that include municipal wastewater discharges, agricultural activities, stormwater runoff, recreational use, and atmospheric deposition (NPS 1999).

Groves and others (1999) investigated the surface and groundwater flows that contribute to Sinking Spring. The study estimated that Sinking Spring has an approximate recharge area of 0.5 km^2 (247 ac). They also concluded that the water quality at Sinking Spring is subject to minor threats owing to land use issues. The most likely sources of contaminants are probably from runoff from adjacent agricultural lands, US 31-E highway, and paved areas within the park (Hutchison et al. 2011).

The Cumberland Piedmont Network Inventory and Mapping Program began long-term water quality monitoring at ABLI in fiscal year 2004. Water quality is measured six times per year (bi-monthly) on alternate years at three sites within ABLI; Sinking Spring, Knob Creek and North Branch of Knob Creek. The following parameters are monitored: water temperature, specific conductance, pH, dissolved oxygen. In addition, the samples are also analyzed for *Escherichia coli*, and nitrate (Meiman 2005; 2010).

A Water quality study conducted by Meiman (2005) concluded that the overall quality at the two Knob Creek Unit sites is good. However, Sinking Spring contained high numbers of fecal coliform bacteria and is fairly high in nitrates which are of special concern. Fecal coliform is at its highest levels during high flow conditions and nitrates are generally high throughout all flow ranges. Water quality results for the fiscal year 2006 reveal that the water quality of the three sites were meeting designated use standards. However, results for Sinking Spring show that the nitrate levels are consistently higher than those found in the Boyhood Home Unit streams

but still below levels considered safe for drinking water (Meiman 2007). Results for the water quality study for fiscal year 2010 show that the water quality remained good. However, the dissolved oxygen values for North Branch of Knob Creek were below the state standard due to drought conditions. In addition, nitrate concentrations were found to be elevated at Sinking Spring in January 2008. It appears that nitrate levels increase during low flow and are not always associated with elevated *E. coli* suggesting that the nitrate sources are stored in the epikarst (Meiman 2010). Results for fiscal year 2012 found four violations of state water quality standards. After a rainfall event in January, all three sites exceeded the state recreational limits of *E. coli*. In September 2012, dissolved oxygen at North Branch of Knob Creek was once more recorded below the state standard due to drought conditions.

Epikarst: a relatively thick layer of bedrock that extends downward from the base of the soil zone, is characterized by extreme fracturing, and enhanced solution. Epikarst can store and transport significant amounts of water.

A Natural Resources Condition Assessment (NRCA) report was conducted for ABLI and results show that the water quality overall condition for the park is acceptable. For the assessment, the study analyzed the same six indicators that the Cumberland Piedmont Network Inventory and Mapping Program sampled: dissolved oxygen, pH, specific conductance, nitrate, temperature, and *E. coli*. All parameters (excluding *E. coli*) have met the established reference conditions, since the water quality, monitoring began in 2004. During the sampling period, Knob Creek and Sinking Spring, both exceeded the recreational limits of *E. coli*, therefore the NRCA report determines that the water quality conditions are acceptable (Hutchison et al. 2011).

Paleontological

Fossils have been observed in the park, within the Borden Formation, however, the other geologic units within the park could potentially preserve fossils within ABLI (Hunt-Foster et al. 2009). The Muldraugh Member of the Borden Formation is characterized by the presence of brachiopods, bryozoans, and corals although they have not been formally documented. These fossils are exposed in a cut bank across from a visitor use area at the Boyhood home unit. The crinoids may be intact and show some color banding preservation. The Borden Formation crops out in broad areas throughout the region and generally does not contain rare fossils (Thornberry-Ehrlich 2010).

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