Pea Ridge National Military Park

Geologic Resources Division
National Park Service
US Department of the Interior

The Geologic Resource Evaluation (GRE) Program provides each of 270 identified natural area National Park Service units with a geologic scoping meeting, a digital geologic map, and a geologic resource evaluation report. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity for discussion of park-specific geologic management issues and, if possible, include a site visit with local experts. The purpose of these meetings is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and potential monitoring and research needs. Outcomes of this scoping process are a scoping summary (this report), a digital geologic map, and a geologic resource evaluation report.

The National Park Service held a GRE scoping meeting for Pea Ridge National Military Park on April 25, 2007 at Buffalo National River park headquarters in Harrison, Arkansas. Tim Connors (NPS-GRD) facilitated the discussion of map coverage and Bruce Heise (NPS-GRD) led the discussion regarding geologic processes and features at the park. Participants at the meeting included NPS staff from the park, Geologic Resources Division, Cave Research Foundation, Missouri State University, Arkansas Geological Survey, and the U.S. Geological Survey as well as cooperators from Colorado State University (see table 1). This scoping summary highlights the GRE scoping meeting for Arkansas Post National Memorial including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Pea Ridge National Military Park, authorized on July 20, 1956, commemorates a pivotal 1862 Union victory over Confederate troops (including ~1,000 Cherokee and Choctaw-Chickasaw Indians) to maintain control of Missouri during the American Civil War. This battle was crucial to the Mississippi campaign. The military park covers 4,300.35 acres (Federal: 4,278.75 acres) of rolling hills in northwestern Arkansas. Located in Benton County, the park is 7 km (4.5 miles) northeast of Rogers and Bentonville, Arkansas. The military park also includes a small, 56-acre outlying unit that is unnamed. The park's 2006 GMP aims to expand the park area to the west and south connecting the two units. The park sits on the boundary between the Pea Ridge and Garfield 7.5-minute quadrangles between the Big Sugar Creek and Little Sugar Creek drainages. The dominant physiographic landforms in the park are Elkhorn Mountain (elevation > 490 m, 1,600 ft) and Round Mountain (elevation >460 m, 1,520 ft). These are erosional remnants of a large-scale plateau. The stratigraphy of the area includes nearly flat-lying, relatively undeformed sedimentary strata. The primary geologic unit in the park vicinity is the Mississippian-age Boone Formation. This unit is susceptible to karstification including cave and sinkhole development. Locally, this limestone-rich unit is capped by resistant sandstones, possibly of the Batesville Sandstone unit. This resistant unit caps the highest hills in the region. Dissected plateaus, ridges separated by valleys and ravines, and gently rolling open areas characterize the landscape at the military park. These landforms had strong connections to the historical context of the area.

Geologic Mapping for Pea Ridge National Military Park

During the scoping meeting Tim Connors (NPS-GRD) showed some of the main features of the GRE Programs digital geologic maps, which reproduce all aspects of paper maps, including notes, the legend, and cross sections, with the added benefit of GIS compatibility. The NPS GRE Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation set for the GRE Program. Staff members digitize maps or convert digital data to the GRE digital geologic map model using ESRI ArcMap software. Final digital geologic map products include data in geodatabase, shapefile, and coverage format, layer files, FGDC-compliant metadata, and a Windows HelpFile that captures ancillary map data. Completed digital maps are available from the NPS Data Store at http://science.nature.nps.gov/nrdata/.

When possible, the GRE program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, usually composed of the 7.5-minute quadrangles that contain park lands (figure 1). Maps of this scale (and larger) are useful to resource management because they capture most geologic features of interest and are positionally accurate within 40 feet. The process of selecting maps for management use begins with the identification of existing geologic maps and mapping needs in vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data to be derived by GRE staff as well as determine areas in need of further mapping or refinement. Table 2 (at the end of this document) lists the source maps chosen for Pea Ridge National Military Park as well as any further action required to make these maps appropriate for inclusion.

PERI is situated mainly on the Pea Ridge 7.5' quadrangle and has a sliver on the Garfield 7.5' quadrangle (to the east). Both quadrangles have been mapped at the reconnaissance level by the Arkansas Geological Survey (AGS), but never published or put into a digital format at large-scale. Also, there is some stratigraphic nomenclature differences between the unpublished quadrangles with regards to the Boone formation and its potential for karst. Because of these issues, the AGS has proposed to revisit the PERI area of interest and to attempt to remap and revise these reconnaissance level maps and then supply the NPS with a more concise digital version of the PERI area of interest that will supercede the existing Pea Ridge and Garfield 7.5' quadrangles.

Table 2 lists the source maps chosen for Pea Ridge National Military Park, in addition to a unique "GMAP ID" number assigned to each map by GRE staff for data management purposes, map scale, and action items.

Also of interest, there is a U.S. Geological Survey Folio from 1905 that covers the area and contains excellent descriptions of geologic units, features, and processes relevant to the area. It would provide an important source of information for the GRE digital geologic mapping team and report author. The folio is available at the following address: http://txspace.tamu.edu/handle/1969.1/2952

The reference is as follows: Adams, G.I. and Ulrich, E.O., 1905, Fayetteville folio, Arkansas-Missouri, USGS, Geologic Atlas of the United States Folio GF-119, 1:125,000 scale

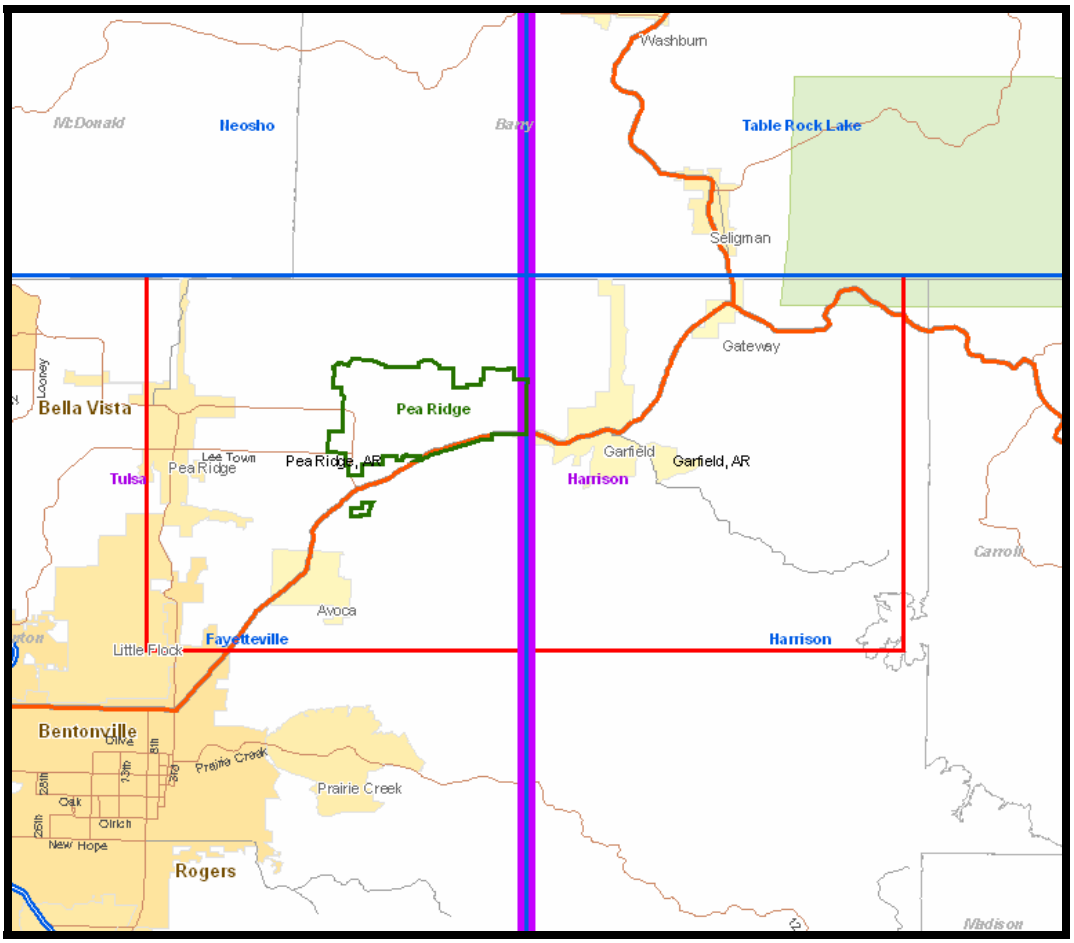

Figure 1. Maps of interest for Pea Ridge National Military Park. The figure shows USGS 7.5' quadrangles (red outline), 30' × 60' sheet (blue outline, blue font labels), and 1° × 2° sheets (purple outline, purple font labels). The green outlines represent park boundaries.

Additional items of interest pertaining to geologic mapping from the scoping

The military park has some interest in groundwater flow maps, karst feature (cave) maps, and identifying and locating springs. Geologic maps used in conjunction with historic sources may help the military park determine the original vegetation patterns, early landforms (prairie, savannah, forests, etc.), and historic roads. These are targets for restoration at Pea Ridge National Military Park.

Geologic Resource Management Issues

The scoping session for Pea Ridge National Military Park provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRE report. During the meeting, participants prioritized the most significant issues as follows:
(1) Karst issues
(2) Mass wasting
(3) Fluvial issues
(4) Disturbed lands
(5) Paleontological resources
The area surrounding Pea Ridge National Military Park, including Bentonville, Arkansas, is experiencing rapid population growth. According to Kevin Eads (NPS-PERI) approximately 1,200 people move into the city each month. By the year 2025, the county's population is expected to double. Residential growth is developing along the western, northwestern, and northern boundaries of the park. A planned expansion of Hwy. 62 along the southern edge of the park will increase development interest there. Increasing population in the surrounding areas and subsequent visitation at the military park will impact all geologic resource management issues at Pea Ridge National Military Park.

Karst Issues

Karst processes are active on the landscape at Pea Ridge National Military Park. Karstification involves the processes of chemical erosion and weathering of limestone or dolomite (carbonate rocks) (Palmer, 1981). Dissolution occurs when acidic water reacts with carbonate rock surfaces along cracks and fractures. Karst features present at the park include one small cave (there are several other rumored caves), many sinkholes, springs, sinkhole ponds, sinking streams, and dissolution holes. The one known cave is only ~10 m (30 ft) long. Sinkholes in the area contain debris from the Batesville Sandstone. The primary karst-susceptible unit in the military park area is the Boone Formation. An upper level chert layer in this formation acts as an aquitard and subsequently, springs are concentrated along this bedding plane.

Sinking streams typically appear as dry creek beds in the park. These only flow immediately following a precipitation event. Sinking streams and sinkholes attest to pervasive dissolution of the underlying limestones in the area. As surrounding development of the area continues, the potential for pollution and contamination of park resources increases. Houses in these developments have individual septic systems which can introduce household waste into the groundwater. Karst-influenced aquifer systems are especially vulnerable to contamination because any input is quickly transferred through the system with little if any natural filtering or sorption (Ryan and Meiman, 1996). Also, as population growth demands more groundwater resources, the potential for karst collapse is increased as the water table is lowered (Dougherty, 1989).

An additional geologic hazard related to karst dissolution are shrink-and-swell clay horizons in deeply weathered limestone deposits. These clays expand in volume when water-saturated and shrink upon desiccation. These changes in volume create hazardous road and trail bases, and may threaten foundations of buildings and park infrastructure if present in sufficient quantities.

Mass Wasting

There is some potential for slope creep and mass wasting at the military park. The slopes associated with Elkhorn and Round Mountain may experience rockfall and landslides. The Fayetteville Shale unit is typically unstable in outcrop and is a regional landslide horizon. West of Elkhorn Tavern, near the east overlook, massive boulders (~5 m, 15 ft in diameter) of resistant sandstone (Wedington or Caneville?) have spalled off, creating strategic cover used by Confederates during the Civil War battle. This sandstone unit poses a problem when exposed along slopes and/or undercut. This area of relatively high landslide and rockfall potential contains a tour road. Development of buildings, roads, and visitor use facilities must be carefully situated near outcrops of the Fayetteville Shale, undercut chert layers in the Boone Formation, historic landslides, and exposures of resistant sandstone atop steep slopes.

Fluvial Issues

Erosion by local streams and rivers carved the Pea Ridge landscape into its characteristic ridges, plateaus, valleys, and ravines. The impervious surfaces (parking lots, houses, driveways, etc.) associated with surrounding developments will increase surface runoff in the park area, impacting local drainages, erosion rates, peak flows, and channel morphology. Increased surficial runoff will enhance stream channel incision. Erosion and incision already threatens horse and foot trails in the park and has potential to threaten the historic context of the military park. In the detached unit, earthworks, including rifle pits and trenches, are being muted by surface runoff and erosion.

The Little Sugar Creek bounds the southern edge of the detached unit, south of the main unit. This creek is prone to flooding following major storm events. So far, these flood events have not damaged the park road.

Disturbed Lands

Disturbed land features at Pea Ridge National Military Park include some park roads (not historic) and an old quarry dug for road aggregate in the detached unit. This quarry supplied material during the 1950's-1960's construction of Hwy. 72. The park would like these features filled and restored to battle-era condition. There are some quarries adjacent to the detached area as well, but these are currently of minor concern.

Paleontological Resources

The Mississippian-age Boone Formation at Pea Ridge National Military Park is fossiliferous. Fossils include trace fossils, crinoids, brachiopods, and assorted invertebrates. Some of the resistant sandstone in the area, including the Hale Formation, may contain petrified wood stumps and plant casts. Middens are also found locally. These may contain information about early flora and fauna as well as paleoclimate. Fossils are not considered rare in the area, but the threat of theft is possible.

Features and Processes

Prairie mounds occur throughout the military park area. These geomorphic mounds of dirt are enigmatic in origin. Geologists hypothesize that these may be wind blown or fluvial deposits. Potential loess deposits in the military park may support an aeolian origin for the mounds.

Humans have been exploiting the resources of the Pea Ridge area since prehistoric time. Ancient flint quarries attest to indigenous people using the chert nodules (Boone Formation) for flint knapping to make tools and trade implements. Early trade routes were later used by European

settlers. This area provided a flat surface and fewer water crossings for roads, trade routes, and eventually funneled Civil War troops here for the 1862 battle. The Overland-Butterfield Stagecoach route went through the area. Old roads and cultural features adding to the historic context of the area are disturbed land features the park is interested in focusing on. The approaching 150-year anniversary of the battle at Pea Ridge (2012) is inspiring widespread restoration projects in the park including historic roads, buildings, and battlefield landforms.

Round Meadow in the western end of the park may be the remains of a Pleistocene lake. More research in this area is needed to substantiate this idea. If the feature is a paleolake, lacustrine deposits may contain useful indicators of paleoclimate and depositional conditions including fossils, pollen, and sedimentary varves.

Small-scale round ponds and depressions may be remnant buffalo wallows. Bison frequented this area prior to European settlement and would have wallowed in local dust deposits.

Erosion and karst processes are largely responsible for the landscape at Pea Ridge National Military Park. Erosion has largely removed the resistant, insoluble rocks such as sandstones, siltstones, and shales from the top of the limestone-rich soluble layers of the Boone Formation. Insoluble rocks cap nearby topographically high areas such as Elkhorn and Round Mountains. Sinkholes, sinkhole ponds, small caves and springs characterize the karst features present in the region. The landscape at the military park is a testament to active erosion and karst processes of limestone dissolution, underground cavity development, and spring activity.

Recommendations

(1) Perform groundwater dye trace studies to understand the flow of groundwater in the military park and its immediate surrounding area, with particular focus on areas with housing developments nearby.
(2) Find appropriate party to map in detail all cave and karst features in the park.
(3) Perform a comprehensive paleontological inventory of the military park. Establish a plan to deal with potential illegal sampling and collecting.
(4) After establishing baseline conditions (water quality, location, flow changes, etc.), monitor changes to the local springs to indicate any outside influences affecting the hydrogeologic system.
(5) Determine if sufficient quantities of shrink-and-swell clays are present in the units to necessitate changes in plans for infrastructure development.
(7) Incorporate historical land use evolution and delineation studies and the effects of geology on the park's history into interpretive programs.

Action Items

(1) GRD will contact the appropriate person in the AML program to discuss remediation projects at the military park. Targets include old quarries and non-historic roads.
(2) GRE will produce digital geologic map for the site (see above geologic mapping section).
(3) Site may want to consult AGS future publication regarding heavy metal sampling in the military park area. Sampling was done by Mike Howard and Andrew Grose as a baseline inventory for the state of Arkansas.
(4) GRE report author needs to obtain the 1905 Fayetteville U.S. Geological Survey folio generated for this area.

(5) GRD will contact Vince Santucci (NPS-GWMP) regarding a possible paleontological inventory for the site.

References

www.nps.gov/peri (accessed May 1, 2007)

www.topozone.com (accessed May 1, 2007)

Dougherty, Percy H. 1989. Geomorphic transect of the Cumberland Plateau, Pottsville Escarpment and Pennyroyal Plateau of east central Kentucky. In *1989 Speleofest guidebook*, eds. Stecko, D., Jay Kessel, Guidebook to the Kentucky Speleofest 18: 31-38.

Palmer, A.N. 1981. *A geological guide to Mammoth Cave National Park*. Teaneck, NJ: Zephyrus Press.

Ryan, M., Joe Meiman. 1996. An examination of a short-term variations in water quality at a karst spring in Kentucky. *Ground Water* 34 (1): 23-30.

Table 1. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
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Table 2. GRE Mapping Plan for Pea Ridge National Military Park

Covered Quadrangles	GMAP [1] ID	Reference	GRE appraisal	GRE Action	GRE file location or URL	Scale
Pea Ridge	74680	unknown author, 2007, Reconnaissance Geologic Map of the Pea Ridge 7.5' Quadrangle,, Arkansas, 132, unpublished 7.5' field sheet, 1:24000 scale	2007-0724: AGS staff think this map needs revisited / refined to better match east neigboring Garfield (GMAP 74679). AGS proposing to re-evaluate this map in the field and verify Boone Formation occurrence and distirbution because of ties to karst as well as other nomenclature issues. AGS would then supply to NPS for conversion. GRE received scan from AGC.	1. Obtain updated data from from AGS, 2. conversion to NPS model	E:\gis-nps_by_gmap_id\74680_pea_ridge_AR_7.5'	24000
Garfield	74679	Glick, Ernest E., 1970, Reconnaissance Geologic Map of the Garfield 7.5' Quadrangle,, Arkansas, 132, unpublished, 1:24000 scale	2007-0724: AGS staff think this is good quality map and recommend it; GRE received scan from AGS. Doesn't edge-match to west neighboring Pea Ridge 7.5' (GMAP 74680). PERI says they only need up to park boundary, but GRE would likely use full quadrangle	1. Obtain updated data from from AGS, 2. conversion to NPS model	E:\gis-nps_by_gmap_id\74679_garfield_AR_7.5'	24000

[1]GMAP numbers are unique identification codes used in the GRE database.