National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Paleontological Resource Inventory and Monitoring
Appalachian Highlands Network

Natural Resource Technical Report NPS/NRPC/NRTR—2008/080



ON THE COVER
Neuropteris sp. (seed fern) specimen from Big South Fork River and Recreation Area. Photo courtesy Tom Des Jean (BISO).

Paleontological Resource Inventory and Monitoring
Appalachian Highlands Network

Natural Resource Technical Report NPS/NRPC/NRTR—2008/080

Vincent L. Santucci
National Park Service
George Washington Memorial Parkway
Turkey Run Park
McLean, VA 22101

Ryan T.P. McKenna
Department of Geology
Portland State University
Portland, OR 97207

Jason P. Kenworthy
National Park Service
Geologic Resources Division
Oregon State University
104 Wilkinson Hall
Corvallis, OR 97330

Tim Connors
National Park Service
Geologic Resources Division
Denver, CO 80225

NOTE:
This report provides baseline paleontological resource data to National Park Service administration and resource management staff. The report contains information regarding the location of non-renewable paleontological resources within NPS units.
It is *not* intended for distribution to the general public.

February 2008

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

The Natural Resources Technical Reports series is used to disseminate the peer-reviewed results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service's mission. The reports provide contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations. Current examples of such reports include the results of research that addresses natural resource management issues; natural resource inventory and monitoring activities; resource assessment reports; scientific literature reviews; and peer reviewed proceedings of technical workshops, conferences, or symposia.

Views, statements, findings, conclusions, recommendations and data in this report are solely those of the author(s) and do not necessarily reflect views and policies of the U.S. Department of the Interior, NPS. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Printed copies of reports in these series may be produced in a limited quantity and they are only available as long as the supply lasts. This report is also available from the Appalachian Highlands I&M Network intranet (NPS access only) site (http://www1.nrintra.nps.gov/im/units/APHN/index.cfm), or by sending a request to the address on the back cover.

Please cite this publication as:

V. L. Santucci, R. T. P. McKenna, J. P. Kenworthy, and T. Connors. 2008. Paleontological Resource Inventory and Monitoring—Appalachian Highlands Network. Natural Resource Technical Report NPS/NRPC/NRTR—2008/080. National Park Service, Fort Collins, Colorado.

NPS D-90, February 2008

Contents

Page

Figures v

Tables vii

Abstract ix

Acknowledgements xi

Introduction 1

Paleontological Resource Inventory Strategies and Methodology 3

Comprehensive Park-Specific Paleontological Resource Inventories 3

Servicewide Thematic Paleontological Resource Inventories 3

Inventory and Monitoring Network Paleontological Resource Inventories 3

Paleontological Resource Management Legislation and Guidance 5

Additional References and Websites of Interest 6

Big South Fork National River and Recreation Area 9

Baseline Paleontological Resource Inventories 9

Paleontological Resource Management, Preliminary Recommendations 14

Literature Cited 14

Additional References 15

Data Sets 18

Blue Ridge Parkway 19

Baseline Paleontological Resource Inventories 19

Paleontological Resource Management, Preliminary Recommendations 21

Literature Cited 22

Additional References 22

Data Sets 25

Great Smoky Mountains National Park 27
Baseline Paleontological Resource Inventories 27
Paleontological Resource Management, Preliminary Recommendations 31
Literature Cited 31
Additional References 34
Data Sets 35
Obed Wild and Scenic River 37
Baseline Paleontological Resource Inventories 37
Paleontological Resource Management, Preliminary Recommendations 39
Literature Cited 39
Additional References 40
Data Sets 43

Figures

Page

Figure 1. Map of the Appalachian Highlands Network Parks 2

Figure 2. Geologic Time Scale 45

Tables

Page

Table 1. Stratigraphic correlation chart of the Appalachian Plateau Province 10

Table 2. Fossils and outcrop locations for the formations of GRSM's Lower Cambrian Chilhowee Group..... 29

Abstract

Paleontological resources (fossils) are any remains of past life preserved in a geologic context. Paleontological resources are non-renewable resources found in nearly 190 National Park Service units. Despite the abundance and diversity of these resources throughout the NPS, until recently few parks have adequate baseline paleontological resource data.

The NPS National Inventory and Monitoring Program and the NPS Geologic Resources Division have developed various strategies to provide parks with the baseline paleontological resource data necessary for greater understanding and appropriate management of these resources. This report presents a paleontological resource summary for the parks of the Appalachian Highlands Network. The summary was compiled through extensive literature reviews and interviews with park staff and professional geologists and paleontologists. Preliminary paleontological resource management recommendations are also included for each park. Similar summaries have already been prepared for 18 other NPS Inventory and Monitoring Networks. The National Inventory and Monitoring Program provided funding to complete these paleontological resource summaries for each of the remaining networks.

In general, the paleontological resources known from the parks of the Appalachian Highlands Network are limited to Paleozoic fauna and flora. Big South Fork National River and Recreation Area (BISO) and Great Smoky Mountains National Park (GRSM) contain some interesting fossil occurrences within the park boundaries. A rich Late Paleozoic flora and at least two dozen ichnogenera (trace fossils) are preserved at localities in the Kentucky portion of BISO. GRSM preserves additional trace fossils and a diverse group of Paleozoic marine invertebrates. Fossils are extremely rare in the highly metamorphosed rocks at Blue Ridge Parkway (BLRI) and have not yet been identified within the Obed Wild and Scenic River (OBRI).

Acknowledgements

The authors graciously thank all those individuals, both within and outside of the National Park Service who have contributed valuable information, comments, and suggestions for this report. Reports such as this are impossible without extensive input from those people who know the resources the best.

We wish to thank the National Park Service staff who graciously provided information, comments, suggestions, and/or reviewed their park's section: Tom Des Jean, Sue Jennings and Myra Marcum (BISO); Jackie Holt and Bambi Teague (BLRI); Keith Langdon and Nancy Finley (GRSM); Rebecca Schapansky and Joseph Zagorski (OBRI).

A special thanks to the APHN Network Coordinator Robert Emmott whose support was instrumental in making this report a reality. Thanks to Southeast Region staff Larry West (I&M Coordinator) and Kathy Harris (I&M Program Support) for their comments and recommendations.

The continued valuable support and information provided by the National Park Service Geologic Resources Division (GRD), in particular Tim Connors, Sid Covington, Bruce Heise, Bob Higgins, Lindsay McClelland, Lisa Norby, Jim F. Wood, and Jim C. Woods, is greatly appreciated.

A number of individuals from institutions outside of the National Park Service were also instrumental in the creation of this report. We extend our appreciation to: Scott Southworth and John Repetski (US Geological Survey); Carl Merschat (North Carolina Geological Survey); Michael Hoyal, Elaine Foust, and Barry W. Miller (Tennessee Division of Geology); Mark Carter (Virginia Division of Natural Resources); Dan Chaney (Smithsonian Institution); and Mark Maki (Shaw Environmental and Infrastructure Inc.).

Thanks to Wesley Hill, Geological Society of America's GeoCorps program coordinator for support of Ryan McKenna's internship to summarize paleontological resources from GRSM. Alyson Cartwright and Jane Darbyshire, GSA GeoCorps interns, initiated summary work on OBRI and BLRI.

Finally, this report would not have been possible without the funding from the National Inventory and Monitoring Program and the support of the APHN Network and Geologic Resources Division. The enthusiasm and support of Bert Frost (Deputy Associate Director; NPS Natural Resource Science and Stewardship) and Gary Williams (National I&M Program Manager) is acknowledged. We extend a sincere thanks to Bert and Gary for providing the means upon which this work, and similar work, can be accomplished.

Introduction

Paleontological resources, or fossils, are any remains of past life preserved in geologic context. There are two main types of fossils: body fossils and trace fossils. Body fossils are the physical remains of an actual organism (shells, bones, teeth, plant leaves, etc.) while trace fossils (burrows, coprolites, footprints, trackways, etc.) preserve evidence of an organism's activity or behavior. Fossils are non-renewable natural resources that possess great scientific, educational, and interpretive value.

The establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within National Park Service (NPS) areas. Although nearly 190 NPS areas have been identified with paleontological resources, few parks have adequate baseline paleontological resource data.

In conjunction with the NPS Geologic Resources Division and the NPS Inventory and Monitoring (I&M) Program, paleontological resource inventories have been initiated in dozens of parks Servicewide and are further described in the Methodology and Inventory Strategies section of this report. This report presents paleontological resource inventory and monitoring data compiled for the parks of the Appalachian Highlands I&M Network (APHN).

The Appalachian Highlands Network includes four National Park Service areas in North Carolina, Virginia, Tennessee, and Kentucky as shown in Figure 1. Big South Fork National River and Recreation Area (BISO), Blue Ridge Parkway (BLRI), Great Smoky Mountains National Park (GRSM), and Obed Wild and Scenic River (OBRI).

The parks that comprise the Appalachian Highlands Network vary in size from 2,094 to 211,040 ha (5,174-521,490 acres), and include two of the most visited units in the National Park System (GRSM and BLRI). The network parks are divided between two ecologically distinct physiographic regions: the Cumberland Plateau of Kentucky and Tennessee, and the Southern Appalachian Mountains of Virginia, North Carolina, Tennessee and Georgia. Both these regions are characterized by high levels of biological diversity and endemism.

The Appalachian Mountains are among the oldest ranges in the world, having changed relatively little over the past 200 million years. This long stability, combined with great variation in geology, landforms, and climate, has fostered enormous biological diversity, especially in the south where the land was never covered by glaciers or inundated by oceans. Within the Southern Appalachians, the Blue Ridge Mountains (Blue Ridge Province) rise abruptly above the rolling Piedmont to the east and form the backbone of the Appalachians in this region. The Southern Appalachians are one of the most species-rich temperate areas in the world, with 2,250 species of vascular plants, including over 130 species of trees, over 200 species of birds, and thousands of species of invertebrates. The ecoregion is also recognized as a world center for salamander diversity. Network parks protect the largest contiguous stands of old-growth forest in the eastern United States, as well as many of the best remaining examples of globally imperiled species and communities.

West of the Blue Ridge Mountains are the Valley and Ridge Province and the Cumberland Plateau. The Valley and Ridge Province consists of folded and unmetamorphosed Paleozoic sedimentary rocks. These consist primarily of early Paleozoic sandstones, shales, and limestones, with some Pennsylvanian coal beds. These sedimentary units are underlain by large thrust faults generated by intercontinental collisions during the late Paleozoic. The Cumberland Plateau is an extensive tableland of sandstone and shale carved by water into a labyrinth of rocky ridges and deep gorges.

The Cumberland River system historically contained approximately one-third of the United States freshwater mollusk diversity. The Big South Fork and Obed rivers have experienced a substantial reduction from historic species numbers, resulting from water quality degradation associated with siltation and acid mine drainage from coal mining. The Cumberland Plateau parks contain several

globally rare terrestrial vegetation communities (Cumberlandian boulder / cobble bars, sandstone cliffs / outcrops, and rock shelters) which support large numbers of rare and endemic plants.

Collectively, the paleontological resources of the APHN Network contribute to a greater understanding of the history of life on earth. Continued paleontological resource inventories will serve to expand this ever-widening base of paleontological knowledge represented throughout the National Park Service. Although nearly 190 parks have already been identified as containing paleontological resources, much of what is to be known about the history of life on earth remains to be discovered.

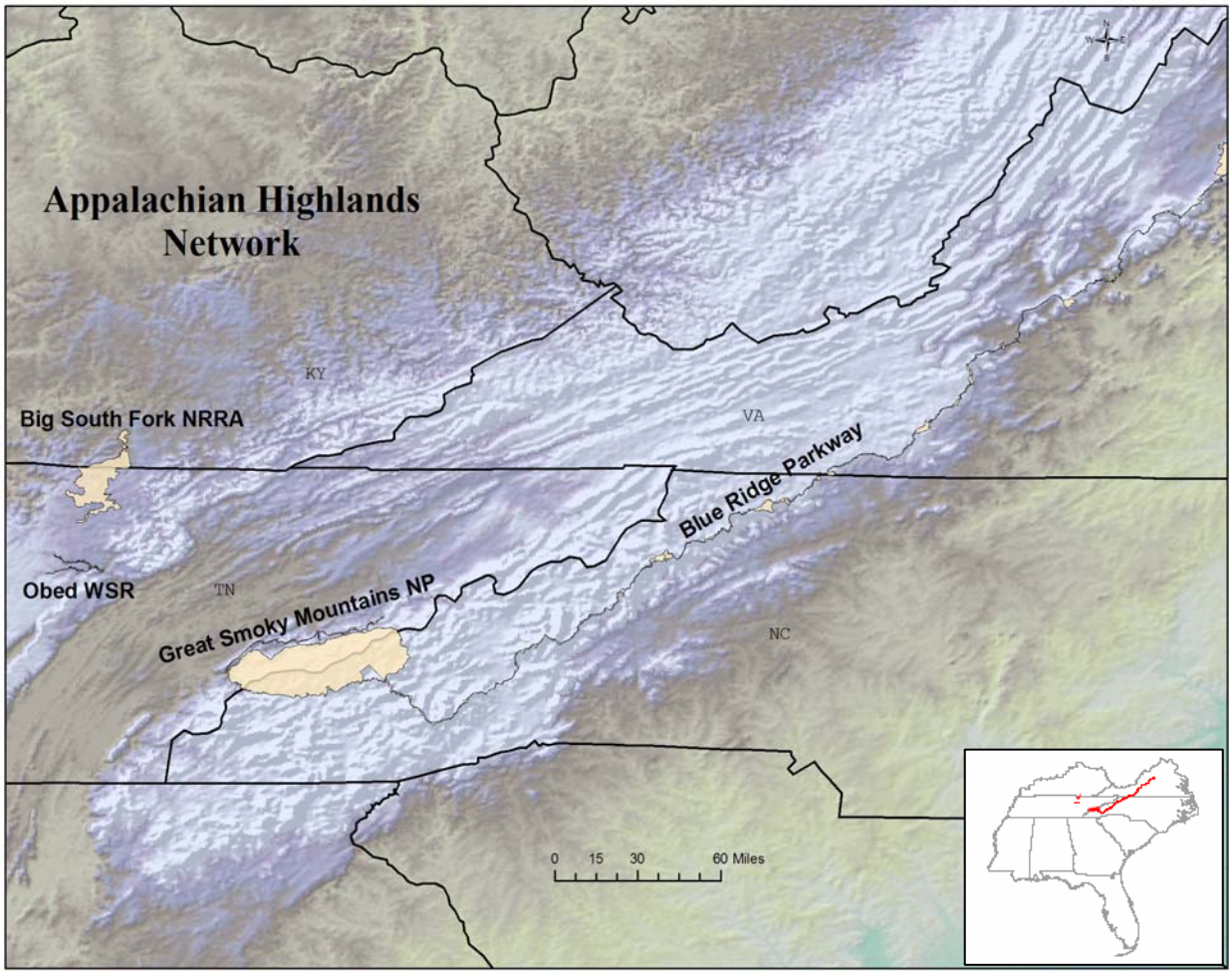


Figure 1. Map of APHN network parks. Map courtesy Patrick Flaherty, APHN Data Manager.

Paleontological Resource Inventory Strategies and Methodology

To better document fossil occurrences and to provide baseline paleontological resource data in National Park Service areas, the NPS Geologic Resources Division (GRD) and the NPS Inventory and Monitoring Program (I&M) have established three paleontological resource inventory strategies, each with its own goals and objectives. These strategies include: comprehensive park-specific paleontological resource inventories, Servicewide thematic paleontological resource inventories, and Inventory & Monitoring Network-based baseline paleontological resource inventories. Santucci and Koch (2003) outline basic paleontological resource monitoring strategies and potential threats to fossil resources.

Comprehensive Park-Specific Paleontological Resource Inventories

Comprehensive park inventories are designed to identify all known paleontological resources within a single park unit. A team of specialists from within the NPS and from educational institutions and cooperators work with the targeted park to identify and address all aspects of its paleontological resources, including resource management, museum curation, law enforcement, and interpretation. Paleontology-specific training for park staff is an important component of many comprehensive paleontological inventories. Park-specific comprehensive paleontological resource inventories have been completed at Yellowstone NP (first park to have inventory completed), Arches NP, Bighorn Canyon NRA, Death Valley NP, Grand Teton NP, Santa Monica NRA, Walnut Canyon NM, and Zion NP.

Servicewide Thematic Paleontological Resource Inventories

Servicewide thematic paleontological resource inventories compile data regarding specific types of paleontological resources that occur in parks throughout the NPS. The first thematic paleontological resource inventory was an inventory of fossil vertebrate tracks from NPS areas (Santucci et al. 1998). This thematic inventory identified 19 NPS units that preserve fossil vertebrate tracks. Subsequent discoveries have increased the number of parks identified with fossil vertebrate tracks to 25 and warranted an updated publication (Santucci et al. 2006). Another thematic paleontological resource inventory identified paleontological resources associated with NPS caves in 35 parks (Santucci et al. 2001). Cave fossils occur in two contexts: First, fossils can be preserved in the marine limestones in which caves develop; second, the remains of Pleistocene/Holocene animals and plants that lived, died or were transported into caves after death are common types of cave fossils. Servicewide thematic inventories have also been initiated for fossil fish (Hunt et al. 2006) and fossils found in cultural resource contexts (Kenworthy and Santucci 2006).

Inventory and Monitoring Network Paleontological Resource Inventories

Network-based paleontological resource inventories compile baseline paleontological resource data for each of the parks within a particular network. Network-based inventories have been completed for 18 of the 32 I&M Networks including: the Appalachian Highlands (this report), Chihuahuan Desert, Eastern Rivers and Mountains, Greater Yellowstone, Gulf Coast, Mediterranean Coast, Mid-Atlantic, Mojave Desert, National Capital Region, Northeast Coastal and Barrier, Northern Colorado Plateau, Pacific Island, Rocky Mountain, San Francisco Bay Area, Sierra Nevada, Southern Plains, Southwestern Alaska, and Upper Columbia Basin networks. Research for summaries of the Arctic, Great Lakes, Northern Great Plains, and South Florida/Caribbean networks are currently underway. NPS I&M Program funding is targeted to complete paleontological resource summaries for the remaining networks by the end of FY2009. Citations for the completed reports are in the Additional References section.

I&M Network Paleontological Resource Inventory Methodology

Network-based paleontological inventories were funded directly by the individual networks from 2002-2006. In FY2006, the National I&M Program provided funds to complete reports for the remaining networks between FY2006-2009. These funds provide stipends or salary for contractors, interns, or paleontological technicians who perform data mining activities. A brief summary outlining the basic techniques used to assemble an I&M Network-based inventory follows below.

The most valuable component of any paleontological resource inventory is an intensive literature search. Various databases contain citations for geology or paleontology themed publications. The American Geological Institute's GeoRef is the primary database for geology references and contains millions of references from the middle 1700s through today. GeoRef, available in both online or CD-ROM versions, is accessible at many major university libraries. The NPS NatureBib (which supersedes PaleoBib) is an internet-based database for scientific citations presented as bibliographic references but does not yet contain a comprehensive paleontology bibliography. The USGS Library in Reston, Virginia is a premier repository for geologic publications, and houses most of the publications obtained for the network-based paleontological resource inventories. Additionally, museum libraries such as at the Smithsonian Institution's National Museum of Natural History, and university libraries provide access to a wide range of geological and paleontological publications. Individual state geological surveys are also excellent sources of information and geologists familiar with local geology and paleontology.

The literature search also includes gray (unpublished) literature searches of individual park files, museum archives, local newspapers, field notes, etc. These are often excellent sources of anecdotal information about park resources. In addition to literature searches, interviews with park staff, university faculty, geologists from the USGS and state surveys, and even local amateur geologists or paleontologists can yield information regarding park paleontological resources. These interviews frequently result in capturing data that might otherwise be undocumented and potentially lost or unrecognized. Bibliographic searches include a search for geologic maps associated with each park. The NPS Geologic Resources Division maintains a database of geological map coverage for many parks (current contact is Tim Connors). In addition, the USGS National Geologic Map Database (NGMDB; see citation below in Additional References section) lists maps for a given geographic area or place name and provides information on where to obtain maps. Geologic maps show the types of rocks and the associated geological formations within a park area. These maps, alone, will often indicate the potential for paleontological resources to occur within a park.

Fossils are most commonly found in sedimentary rocks such as sandstones, shales, and limestones. Fossils, with few exceptions, are not found within igneous rocks (volcanic or intrusive origin) or metamorphic rocks (altered by heat, pressure, and/or chemical change) due to the extreme heat and/or pressure associated with their origin and history. The nomenclature for geologic formations can be confusing, but the NGMDB includes a searchable lexicon of valid geologic formation names that can be very useful in clearing up nomenclatural confusion. This lexicon provides a basic summary for each formation, summarizes current and past usage of the various formation names found in the literature, and provides an annotated bibliography for each formation.

The information from these various sources for each park is then compiled and summarized in a written report and developed into individual datasets. The reports undergo peer review by professional geologists, paleontologists, and staff from each park for accuracy before being submitted to the network. These reports are designed to consolidate baseline paleontological resource data for each park to support management operations and decision-making. Therefore, the reports are written in NPS language and in addition to the scientific information, the reports address issues of resource management, protection, and interpretation.

The paleontological resource inventory reports synthesize information regarding the scope and significance of fossils documented from each park. Fossils are assessed and organized based upon

taxonomy, stratigraphy, and paleoecology. Paleontological resources can be divided into four taxonomic groups: paleobotany (fossil plants), invertebrates (animals without backbones), vertebrates (animals with backbones), and trace fossils (evidence of biological activity such as tracks, traces, burrows, etc.). Fossils typically have a finite stratigraphic range and occurrence in geologic time (a geologic time scale is included in Appendix A). The period between the first and final occurrences of a fossil species is referred to as the stratigraphic range zone. Thus specific groups of fossils may be identified directly with a particular stratigraphic unit or stratigraphic range. Likewise, rock units often represent specific ancient sedimentary depositional environments. Paleoecologically, fossil groups may occur primarily, or in some instances only, in specific environmental conditions (temperature, aquatic, terrestrial, etc.). Thus many fossils may be useful as indicators of past environmental conditions. The reports are organized stratigraphically, presenting the geologic and paleontologic information chronologically from oldest to youngest. Important fossils documented from localities outside a park are often reported in the park inventory, as these data may indicate the potential for fossils in similar stratigraphic units exposed within park boundaries.

Given the tremendous diversity of past life, the existence of life for over a billion years, and the range of environments to which life has adapted, there is a broad spectrum of research interests in paleontology. It is not surprising that most of what is to be learned about the history of life remains to be discovered. Through research, more than 190 NPS areas have been identified as containing paleontological resources. However, the paleontological research for a particular park may vary widely from an incidental fossil discovery to over a century of intensive paleontological investigations. The inventory reports include information on the history of paleontological research, descriptions of current cooperative projects, identification of any museums or universities serving as repositories for park fossils, and a comprehensive list of publications related to paleontological research associated with the park. The reports include all bibliographies that may be associated with a park's paleontological resources. However, bibliographic data are subdivided in the report into those cited in the narrative (References Cited) and other associated bibliographies (Additional References). The cooperative projects section highlights paleontological resources projects, if any, that the park has funded or supported. Formal datasets are established for known associated paleontological collections, research, or activities.

Paleontological Resource Management Legislation and Guidance

I&M Network reports such as this one are meant to provide network parks with sound baseline paleontological resource data that can stimulate future research, interpretation, education, or resource management projects. The proper management of resources identified through these inventories is mandated by many NPS policies. For example, the 2006 National Park Service Management Policies (§1.4.6) stipulates that paleontological resources are considered park resources and values that are subject to the "no impairment" standard set forth by the NPS Organic Act in 1916. Basic guidelines for management of paleontological resources are found in sections 4.8.2 and 4.8.2.1 of the 2006 NPS Management Policies. Another legislative protection for paleontological resources is found in the NPS Omnibus Management Act of 1998. Section 207, with the following statement, "Information concerning the nature and specific location of…paleontological objects within the units of the National Park System…may be withheld from the public source," safeguards paleontological locality information from requests under the Freedom of Information Act.

Paleontological resource management issues were the subject of a Report of the Secretary of the Interior in May 2000, prepared in response to a Congressional request for an assessment of the need for a unified federal policy on the collection, storage and preservation of fossils and for standards that would maximize the availability of fossils for scientific study. That report, an "Assessment of Fossil Management on Federal & Indian Lands" summarized a number of principles relating to paleontological resources and their management. The Paleontological Resources Management section of Natural Resource Management Reference Manual 77 provides guidance and additional information regarding the implementation and continuation of paleontological resource management programs. Links to the above

documents are listed in the Additional References section. The Geologic Resources Division is assembling a geologic resource monitoring manual that includes chapters on various geologic resources, including in situ paleontological resources, and a set of monitoring vital signs that may be applicable to a variety of parks. Monitoring represents the next phase in paleontological resource management, following the initial research inventory (represented by this report) of potential fossils and any subsequent field work to identify fossils within a park. Publication is expected by early 2008. Contact the Geologic Resources Division for more information or to obtain a copy of the report when it is available.

Our knowledge of the fossil record is only as good as our previous field season. The potential for new paleontological discoveries is proportionally related to our understanding as managers and stewards of this non-renewable evidence of life from the past. We believe that the baseline information provided in these reports and the resulting increased understanding of paleontological resources will inevitably result in paving the way for future fossil discoveries in NPS areas.

Additional References and Websites of Interest

Website addresses are current as of 2 February 2008.

Elder, W. P., T. Nyborg, J. P. Kenworthy, and V. L. Santucci. 2008. Paleontological Resource Inventory and Monitoring—San Francisco Bay Area Network. Natural Resource Technical Report NPS/NRPC/NRTR—2008/078. National Park Service, Fort Collins, Colorado.

Hunt, R. K., V. L. Santucci and J. P. Kenworthy. 2006. A preliminary inventory of fossil fish from NPS units. Pages 63-69 *in* Lucas, S. G., J. A. Spielmann, P. M. Hester, J. P. Kenworthy, and V. L. Santucci (editors). America's Antiquities (Proceedings of the 7th Federal Fossil Conference). New Mexico Museum of Natural History & Science, Albuquerque, NM. Bulletin 34.

Hunt, R. K., V. L. Santucci and J. P. Kenworthy. 2007. Paleontological Resource Inventory and Monitoring, Pacific Islands Network. National Park Service TIC# D-24.

Kenworthy, J. P. and V. L. Santucci. 2003. Paleontological Resource Inventory and Monitoring, Southwestern Alaska Network. National Park Service TIC# D-93.

Kenworthy, J. P. and V. L. Santucci. 2003. Paleontological Resource Inventory and Monitoring, Northeast Coastal and Barrier Network. National Park Service TIC# D-340.

Kenworthy, J. P. and V. L. Santucci. 2004. Paleontological Resource Inventory and Monitoring, National Capital Region. National Park Service TIC# D-289.

Kenworthy, J. P. and V. L. Santucci. 2006. A preliminary inventory of NPS paleontological resources found in cultural resource contexts, Part 1: General Overview. Pages 70-76 *in* Lucas, S. G., J. A. Spielmann, P. M. Hester, J. P. Kenworthy, and V. L. Santucci (editors). America's Antiquities (Proceedings of the 7th Federal Fossil Conference). New Mexico Museum of Natural History & Science, Albuquerque, NM. Bulletin 34.

Kenworthy, J. P., V. L. Santucci, M. McNerney, and K. Snell. 2005. Paleontological Resource Inventory and Monitoring, Upper Columbia Basin Network. National Park Service TIC# D-259.

Kenworthy, J. P., V. L. Santucci, and C. C. Visaggi. 2007. Paleontological Resource Inventory and Monitoring, Gulf Coast Network. National Park Service TIC# D-750.

Kenworthy, J. P., C. C. Visaggi, and V. L. Santucci. 2006. Paleontological Resource Inventory and Monitoring, Mid-Atlantic Network. National Park Service TIC# D-800.

Koch, A. L., J. P. Kenworthy, and V. L. Santucci. 2004. Paleontological Resource Inventory and Monitoring, Rocky Mountain Network. National Park Service TIC# D-436.

Koch, A. L. and V. L. Santucci. 2002. Paleontological Resource Inventory and Monitoring, Northern Colorado Plateau Network. National Park Service TIC# D-206.

Koch, A. L. and V. L. Santucci. 2003. Paleontological Resource Inventory and Monitoring, Southern Plains Network. National Park Service TIC# D-107.

Koch, A. L. and V. L. Santucci. 2003. Paleontological Resource Inventory and Monitoring, Greater Yellowstone Network. National Park Service TIC# D-1025.

Koch, A. L. and V. L. Santucci. 2003. Paleontological Resource Inventory and Monitoring, Mediterranean Coast Network. National Park Service TIC# D-177.

Koch, A.L. and V. L. Santucci. 2004. Paleontological Resource Inventory and Monitoring, Eastern Rivers and Mountains Network. National Park Service TIC# D-265.

Santucci, V. L. 1998. The Yellowstone Paleontological Survey. Yellowstone Center for Resources, Yellowstone NP, WY. YCR-NR-98-1.

Santucci, V. L., A. P. Hunt, and M. G. Lockley. 1998. Fossil vertebrate tracks in National Park Service areas. Dakoterra **5**:107-114.

Santucci, V. L., A. P. Hunt, T. Nyborg, and J. P. Kenworthy. 2006. Additional fossil vertebrate tracks in National Park Service areas. Pages 152-158 *in* Lucas, S. G., J. A. Spielmann, P. M. Hester, J. P. Kenworthy, and V. L. Santucci (editors). America's Antiquities: 100 Years of Managing Fossils on Federal Lands. New Mexico Museum of Natural History and Science, Albuquerque, NM. Bulletin 34.

Santucci, V. L. and J. P. Kenworthy. 2007 Paleontological Resource Inventory and Monitoring, Sierra Nevada Network. Natural Resource Technical Report NPS/NRPC/NRTR—2007/053. National Park Service, Fort Collins, Colorado.

Santucci, V. L., J. Kenworthy, and R. Kerbo. 2001. An inventory of paleontological resources associated with National Park Service Caves. NPS Geological Resources Division, Denver. Technical Report NPS/NRGRD/GRDTR-01/02. TIC# D-2231.

Santucci, V. L., J. P. Kenworthy, and C. C. Visaggi. 2007. Paleontological Resource Inventory and Monitoring, Chihuahuan Desert Network. National Park Service TIC# D-500.

Santucci, V. L. and A. L. Koch. 2003. Paleontological resource monitoring strategies for the National Park Service. Park Science **22**(1):22-25.

Santucci, V. L., A. L. Koch, and J. P. Kenworthy. 2004. Paleontological Resource Inventory and Monitoring, Mojave Desert Network. National Park Service TIC# D-305.

General APHN Information

APHN I&M Network: http://www.nature.nps.gov/im/units/aphn/index.cfm

Geological Survey Websites

Kentucky Geological Survey (University of Kentucky): http://www.uky.edu/KGS/
North Carolina Geological Survey (Raleigh): http://www.geology.enr.state.nc.us/
Tennessee Division of Geology (Nashville): http://www.state.tn.us/environment/tdg/
Virginia Department of Mines, Minerals and Energy (Richmond):
http://www.dmme.virginia.gov/divisionmineralresources.shtml/
U.S. Geological Survey: http://www.usgs.gov
Geological Society of America: http://www.geosociety.org
American Geological Institute: http://www.agiweb.org

Library catalogs

U.S. Geological Survey Library Catalog: http://igsrglib03.er.usgs.gov:8080/#focus
Smithsonian Institution Libraries Catalog: http://www.siris.si.edu/

Museums

North Carolina Museum of Natural Sciences: http://www.naturalsciences.org
Tennessee State Museum: http://www.tnmuseum.org
Science Museum of Virginia: http://www.smv.org
Virginia Museum of Natural History: http://www.vmnh.net/index.cfm
Smithsonian National Museum of Natural History Dept. of Paleobiology: http://www.nmnh.si.edu/paleo/

Resource Management/Legislation Documents

NPS 2006 Management Policies (§1.4; Park Management): http://www.nps.gov/policy/mp/chapter1.htm
NPS 2006 Management Policies (§4.8.2.1; Paleontological Resources):
http://www.nps.gov/policy/mp/chapter4.htm
NPS 1998 Omnibus Management Act (paleontological resource summary):
http://www2.nature.nps.gov/geology/paleontology/paleo_5_1/index.htm
NPS Natural Resource Management Reference Manual #77 (paleontology section):
http://www.nature.nps.gov/rm77/paleo.cfm
Assessment of Fossil Management on Federal & Indian Lands: http://www.fs.fed.us/geology/fossil.pdf

National Park Service Paleontology Program sites

NPS Geologic Resources Division: http://www2.nature.nps.gov/geology/
NPS Paleontology Program: http://www2.nature.nps.gov/geology/paleontology/
NPS Park Paleontology Newsletter: http://www2.nature.nps.gov/geology/paleontology/newsletter.cfm
I&M Network paleontological resource summary project website and PDFs of all reports (InsideNPS):
http://inside.nps.gov/waso/custommenu.cfm?lv=4&prg=753&id=4518
NPS Technical Information Center (Denver, repository for technical (TIC) documents):
http://etic.nps.gov/

Other geology/paleontology tools

Bates, R. L. and J. A. Jackson (editors). American Geological Institute dictionary of geological terms (3rd Edition). Bantam Doubleday Dell Publishing Group, New York.
U.S. Geological Survey Geologic Terms Glossary:
http://wrgis.wr.usgs.gov/docs/parks/misc/glossarya.html
Topozone (interactive access to all USGS topographic maps): http://www.topozone.com
U.S. Geological Survey National Geologic Map Database (NGMDB): http://ngmdb.usgs.gov/
U.S. Geological Survey Geologic Names Lexicon (GEOLEX; geologic unit nomenclature and summary):
http://ngmdb.usgs.gov/Geolex/geolex_home.html
U.S. Geological Survey Geographic Names Information System (GNIS; search for place names and geographic features): http://gnis.usgs.gov/
Paleobiology Database (search for fossil taxonomy, localities, or geologic formations):
http://paleodb.org/cgi-bin/bridge.pl
Paleontology Portal (general fossil info based on geographic location or geologic time):
http://www.paleoportal.org/
University of California-Berkeley Museum of Paleontology online paleontology exhibits:
http://www.ucmp.berkeley.edu/
U.S. Geological Survey, description of physiographic provinces: http://tapestry.usgs.gov/Default.html

Big South Fork National River and Recreation Area

Big South Fork National River and Recreation Area (BISO) was established to protect this area of the Cumberland River and its tributaries. Its rugged terrain has pristine rivers, beautiful sandstone arches, vast bluffs, and important natural and historical resources. The National Area was initially established on May 7, 1974 and administered by the U.S. Army Corps of Engineers. An interim management of the national scenic river began in October 1976. The complete transfer of jurisdiction from Secretary of the Army to Secretary of the Interior was finalized on October 1, 1990. The park encompasses 50,711 ha (125,310 acres), of which 91% is federal, and extends from Tennessee into Kentucky. The park now serves as a major recreation area with hiking, horseback riding, camping, and canoeing.

Baseline Paleontological Resource Inventories

The Big South Fork watershed lies within the Cumberland Plateau, which is in the southern portion of the Appalachian Plateaus structural province. A large escarpment divides the eastern coal field region and the plateau. The area is dominated by a sandstone belt of cliffs and steep-sided, narrow crested valleys. The stream topography of the area is characterized by a dendritic drainage pattern and narrow, v-shaped gorges. A focal point of the area is the Big South Fork River gorge with its many sheer bluffs at the gorge rim towering over wooded talus slopes. The river valleys of the area are dotted with huge boulders, which have broken from the cliff faces. The park's rivers and streams are characterized by stretches of fast, rugged whitewater and quiet pools.

The geology of the Big South Fork is characterized by parallel, horizontally-bedded sedimentary rock of Pennsylvanian and Mississippian age rock. The Pennsylvanian rocks are predominantly sandstone and shale, and include siltstone, conglomerate, and coal. The weathering processes on these rocks have produced an impressive array of geologic features, including arches, mesas, chimneys, cracks, and rockshelters. The underlying Mississippian age limestone contains oil and gas deposits, which are found both within and outside of the Big South Fork National River and Recreation Area.

The Mississippian sandstones and siltstones are the result of a great influx of mud, silts, and sands brought in by rivers and streams from uplands many miles to the northeast and deposited as a great delta. The Mississippian limestones of the region were deposited 350 million years ago in the bottom of a warm, shallow sea. At the end of the Mississippian, approximately 320 million years ago, the seas receded, and were overlain by Pennsylvanian aged sediments. The warm climate of the Pennsylvanian allowed extensive forests to grow and great coastal swamps to develop at the edges of water bodies. Marine waters advanced and receded many times, which produced many layers of sandstone, shale, and coal. Vegetation of all sorts fell into the water and was buried under blankets of sediments, which over long geologic time were compressed into coal. The nonvegetative sediments such as sand, clay, and silt were compressed into sandstone and shale. Over the last million years, unconsolidated Quaternary sediments have been deposited along the larger streams and rivers.

The boundary of BISO encompasses areas in both Kentucky and Tennessee. Therefore, stratigraphic nomenclature of formal geologic units is not always uniform across the state boundaries. A mapable geologic unit which extends across state boundaries may result in different names for this unit within each of the states. Additionally, there may be scholarly debate regarding the stratigraphic interpretation. This frequently results in changes in nomenclature over time or even geographically. Therefore, it is not the objective within this inventory to resolve any stratigraphic nomenclature discrepancies in the scientific literature. However these discrepancies will be pointed out in order to provide clarification in this report. Table 1 illustrates the changes in stratigraphic nomenclature across state boundaries for Paleozoic units within the Appalachian Plateau Province (Lloyd and Lyke 1995; Trapp and Horn 1997).

Table 1. Stratigraphic correlation chart of the Appalachian Plateau Province. Adapted from Lloyd and Lyke (1995) and Trapp and Horn (1997). Fm = Formation. See Figure 2 for complete geologic time scale.

<table>
<tr><th>Geologic System</th><th>West Virginia</th><th>Virginia</th><th>Kentucky</th><th>Tennessee</th></tr>
<tr><td>Quaternary</td><td>Recent Valley Alluvium</td><td rowspan="4">Recent Valley Alluvium</td><td rowspan="2">Recent Valley Alluvium</td><td rowspan="3">Recent Valley Alluvium</td></tr>
<tr><td>Permian</td><td>Dunkard Group</td></tr>
<tr><td rowspan="2">Upper Pennsylvanian</td><td>Monongahela Group</td><td>Monongahela Group</td></tr>
<tr><td>Conemaugh Fm</td><td>Conemaugh Fm</td></tr>
<tr><td>Middle Pennsylvanian</td><td rowspan="2">Allegheny Group</td><td rowspan="2">Breathitt Fm</td><td>Cross Mtn. Fm
Vowell Mtn. Fm
Redoak Mtn. Fm
Graves Gap Fm
Indian Bluff Fm</td></tr>
<tr><td>Lower to Middle Pennsylvanian</td><td>Harlan Fm</td><td>Slatestone Fm
Crooked Fork Group</td></tr>
<tr><td rowspan="2">Lower Pennsylvanian</td><td rowspan="2">Pottsville Group
Formerly: Kanawha Fm
New River Fm
Pocahontas Fm</td><td>Wise Fm
Gladeville Sandstone
Norton Fm
Lee Fm</td><td rowspan="2">Lee Fm</td><td>Crab Orchard Mtn. Group</td></tr>
<tr><td></td><td>Gizzard Group</td></tr>
<tr><td>Upper Mississippian</td><td>Mauch Chunk Group</td><td>Pennington Fm</td><td>Pennington Fm</td><td>Pennington Fm</td></tr>
<tr><td>Upper to Middle Mississippian</td><td>Greenbriar Limestone</td><td>Greenbriar Limestone</td><td>Newman Limestone</td><td>Newman Limestone</td></tr>
</table>

Slade / Monteagle Formation (Mississippian)

The Mississippian Slade Formation consists of twelve members, including the St. Genevieve Limestone, in central Kentucky. Because of the tenuous correlation of strata along the Cumberland Escarpment with the Newman Limestone as mapped in the type locality, the name "Newman" as used on the State map has now been restricted from use in central and eastern Kentucky. The part of the Newman Limestone that is largely carbonate has been reassigned to the newly defined Slade Formation.

The Monteagle Formation is the stratigraphic equivalent that is defined in Tennessee. The Monteagle Formation includes both the Kidder Limestone Member and the St. Genevieve Limestone Member. The Kidder Limestone Member is 90 to 230 ft of fine- to medium-grained, skeletal and oolitic limestone, commonly crossbedded, with some lime mudstones and minor siltstone and shale in the upper half. The lower contact is placed at a breccia, locally silicified, at the top of the Ste. Genevieve Limestone Member, which lies above the highest occurrence of *Platycrinites penicillus*. A distinctive limestone with abundant large crinoid columnals occurs in the upper third of the Kidder Limestone Member.

These limestones and shales were deposited on a shallow-marine carbonate platform. The silicified breccia at the top of the St. Genevieve Limestone Member of the Monteagle Formation suggests a period of subaerial exposure. Sandstones interpreted to represent barrier bars and skeletal-sand shoals in these units, and limestones interpreted as tidal-flat deposits, also suggest very shallow water. The St. Genevieve Limestone marks the uppermost occurrence of *Platycrinites penicillus* (Graboswki 1986).

The Kidder Limestone Member of the Monteagle Formation is somewhat more resistant to weathering than are the underlying limestones. The Hartselle Formation is generally poorly exposed, except where it includes a thick sandstone unit, and commonly forms a soil-covered bench above the Kidder Limestone Member.

Hartselle Formation / Bangor Limestone (Mississippian)

These Mississippian rocks units overlie the St. Genevieve Limestone Member of the Monteagle Limestone in south-central Kentucky along the western margin of the Cumberland Plateau. They are

approximately equivalent to the lower part of the rocks of Chester age in western and west-central Kentucky. They thin to the northeast north of Rockcastle County, where they are included in the upper part of the Newman Limestone.

The Hartselle Formation is largely green clay shale which may be equivalent to the Hardinsburg Sandstone of western Kentucky. It ranges from 0 to 15 m (50 ft) in thickness, thinning northward in Rockcastle County. The Hartselle contains a minor amount of fine-grained, quartzose sandstone, especially at the base, where it is in erosional contact with the Kidder Limestone Member, and is mostly sandstone near the Kentucky Tennessee State line.

The Bangor Limestone lies above the Hartselle Formation and consists of dark-gray argillaceous and arenitic skeletal limestone. In the south it is as much as 55 m (180 ft) thick, but generally is 6 to 15 m (20-50 ft) thick; the equivalent unit in Rockcastle, Powell, and Rowan Counties, now called Poppin Rock Member of the Slade Formation, is 5 to 8 m (15 to 25 ft) thick (Ettensohn et al. 1984). The Bangor Limestone is generally well exposed because it lies between shale units.

Pennington Formation / Paragon Formation (Upper Mississippian)

The upper Mississippian rock units along the northwestern edge of the Kentucky coalfields include the Newman Limestone. Some authors differentiate the older Newman Limestone from the younger Pennington Formation. More recently, both units are sometimes included in the Pennington Group along with the Bangor, Kidder, and Monteagle limestones. Another stratigraphic interpretation includes the Newman Limestone within the Paragon Formation (Ettensohn et al. 1984).

The Pennington Formation is composed primarily of greenish-gray and reddish-brown clay shale, with beds of fine to medium grained, crossbedded, fossiliferous limestone. The Pennington Formation was formed in a shallow marine environment.

In eastern Kentucky, the Paragon Formation is exposed along the Cumberland Escarpment and on Pine Mountain. This stratigraphic interval consists of a wide range of depositional facies including channel facies. Some channel sandstones are thick 10 m (33 ft) and extensive. The Stoney Gap Member on Pine Mountain is fine- to coarse-grained, quartzose, exhibits well-developed lags with fossil wood debris, and trough and planar crossbeds oriented unimodally down-dip. These features might suggest fluvial conditions, but shale-draped foresets, reactivation surfaces, and *Arenicolites* burrows upwards within channels indicates tidal and brackish-water influences and a position in the fluvial-estuarine transition (Greb 2006).

There is one notable area on the west bank of the Big South Fork of the Cumberland River at Leatherwood Ford, Tennessee, where the Paragon Formation contains an assemblage of invertebrate fossils. Chaney et al. (2004) report horn corals, bivalves, lingulid brachiopods, and blastoids from this locality (see also Des Jean 2007).

Lee Formation (Lower Pennsylvanian)

The Lower Pennsylvanian Lee Formation is characterized by massive pebbly quartzose sandstone that locally contains lenses of conglomerate with quartz pebbles as much as 6.4 cm (2.5 in) in diameter. In the type area in Lee County, Va., near Middlesboro, Ky., the formation is commonly more then 488 m (1,600 ft) thick and is about 80 percent sandstone. The sandstone is mostly thick bedded, moderately well sorted, and fine to coarse grained. Sandstone units are interpreted to be fluviatile because they are commonly fining-upward, crossbedded, channel-form deposits that contain mineralized or coalified plant remains such as ancient logjams at their bases. The Lee Formation has been described in detail by Rice (1984). Rocks of the Lee Formation are exposed in three major outcrop belts: in steeply dipping beds along Cumberland Mountain and Pine Mountain, and along the western side of the Cumberland Plateau. Also, isolated outcrops of Lee sandstone occur in highly folded and sheared masses along and just northwest of the trace of the Pine Mountain overthrust fault. The sandstone members of the Lee are resistant and

generally form prominent hogbacks at or near the crests of Cumberland and Pine Mountains and, in that area, make up two other prominent ridges. Lee sandstone units also cap the Pottsville Escarpment along the western side of the Cumberland Plateau.

In the type area, which is part of the Cumberland Mountain outcrop belt in Lee County, Va. and adjacent parts of Kentucky, the Lee is divided into eight members. These are, in ascending order, the Pinnacle Overlook, Chadwell, White Rocks Sandstone, Dark Ridge, Middlesboro, Hensley, Bee Rock Sandstone, and Naese Sandstone Members. The Dark Ridge and Hensley Members are mostly shale, siltstone, thin-bedded silty sandstone, and coal; the Hensley also locally contains beds of conglomeratic quartzose sandstone. The other members are dominantly sandstone.

There is varying opinion regarding the stratigraphic nomenclature associated with the Rockcastle Conglomerate. Some authors include the Rockcastle Conglomerate within the Crab Orchard Mountains Group, as outlined in the OBRI portion of this report. Miller et al. (2006) report the Rockcastle Conglomerate just above the Fentress Formation. The Fentress Formation is rich in marine trace fossils including the following ichnogenera: *Asteriacites, Asterosoma, Bergaueria, Caprionichnus, Conostichus, Haplotichnus, Helminthohpsis, Kouphichium, Lennea, Limulicubichnus, Nereites, Palaeobullia, Planolites, Protovirgularia, Psammichnites, Rhizocorallium, Rosselia, Skolithos, Thalassinoides,* and *Zoophycos* (Miller and Knox 1985).

Chestnut et al. (1994) report on the occurrence of an early tetrapod trackway within the Rockcastle Sandstone of the Lee Formation discovered in McCreary County, Kentucky just northeast of BISO. This rare specimen represents the evidence of an early reptile (*Notalacerta missouriensis*). The trackway includes both manus and pes impressions, claw marks, and a trail drag impression. The fossil is now on display at the University of Kentucky in Lexington. Another example of a similar vertebrate amphibian trackway was found just to the east of BISO near the Scott County and Campbell County line (Kohl and Bryan 1993). This specimen is housed at the USGS office in Clinton, Tennessee.

Breathitt Group (Pennsylvanian)

The Breathitt Group is a Pennsylvanian sequence composed of sandstone, siltstone, shale coal and ironstone (Smith 1976a, 1976b). This unit contains the majority of the mineable coals in the region. The two most widely recognizeable members within the Breathitt Group are the Magoffin and Kendrick Shale Members. These units represent marine transgression deposits and consist of coarsening upwards bay-fill sequences which are frequently fossiliferous (Rice 1986). Fusulinids occur within the Stoney Fork and Vanport Limestone members of the Breathitt Group.

A rich paleoflora is associated with the coal beds or tailings of the Breathitt Group. Fossil plants also occur in the friable shales at the top of the coal beds. These shales have a tendency to absorb moisture and swell with humiditiy resulting in rapid deterioration of the fossils which occur in these beds. In general, the fossil plants are much more abundant and accessible in the northern third of the park in Kentucky. Specifically, the localities where the Stearns and Barren Fork coal zones of the lower Breathitt Group (previously Breathitt Formation) are exposed yield the highest quantities of fossil plants. The thick, cliff-forming Pennsylvanian Era sandstone units of the Breathitt Group dominate the landscape. Fossil plants are also found within these sandstones including the rare stigmarian (leaf stem) axes and calamitean stem fragments.

During March 2003 Dan Chaney from the National Museum of Natural History (Smithsonian Institution) led a paleontological survey team at BISO (Chaney et al. 2004). The team visited all sites previously known to have fossil exposures, as well as sites which have a high potential for the presence of fossils. Chaney's team recognized that the more significant fossil localities were located in the northern one-third of BISO. In particular, the localities were primarily fossil plant producing zones in the Barren Fork and Stearns coal beds and the associated tailings from earlier coal mining operations. Chestnut (1992) identifies these fossil plant-rich coal beds within the lower Breathitt Group (previously the Breathitt

Formation). These coal zones are not well exposed or may be locally absent in the Tennessee portion of BISO.

The Yamacraw Bridge area of BISO is one of the most important paleontological localities in BISO. A geologic cross section at Yamacaw Bridge has been produced by Chestnut (2002). The U.S. National Musuem collected paleobotanical specimens from this locality (Chaney et al. 2004).

Below is a list of paleobotanical specimens reported by Chaney et al. (2004) from BISO (based on the collections from Worley (W), Yahoo Falls (YF), Yamacraw-Blue Diamond (YB) and Zenith (Z). A specimen of *Neuropteris* is figured on the cover of this report.

Calamitales

Asterophyllites sp. (W)
Calamites indet. sp. (W)

Sphenophyllales

Sphenophyllum sp. (YB)

Medullosales

Mariopteris sp. (W)
Mariopteris cf. *Mariopteris nervosa* (W)
seed indet (W, YF)
Neuropteris cf, *N. tenuifolia* (YB)
?*Eusphenopteris* (YB)
Alethopteris sp. (YB)
Sphenopteris sp. (YB)
Radicites roots (YB)

Lepidondendrales

Lepidophylloides sp. (W, YB)
Lepidodendron cf. *L. mannabachense* (W)
Lepidodendron aculeatum (W)
Lepidodendron sp. (YB)
Cf. *Lepidocarpon* (YB)
Lepidostrobus sp. (YB)
Stigmaria ficoides (Z)

Pteridosperm rachises (YB)

Park Collections

Based upon the most recently available data, BISO has 44 cataloged paleontological specimens in the park's museum collection. These include a variety of Late Paleozoic fossil plants including lycopsid seed ferns such as *Lepidodendron* and *Sigillaria*. Specifically the park collection includes bark, branches, and leaf fossils of these primitive plants (T. Des Jean, BISO Archeologist, pers. commun., 2000). The park collection also contains specimens of sphenopsids including species of the scouring rush plants such as *Calamites*. Additionally, the park collection includes some unidentified species of Mississippian brachiopods, crinoid stems (cf. *Culmicrinus*), and a blastoid (cf. *Pentremides*). There are also worm trails / traces in the collection from a locality in Fentress County, Tennessee (T. Des Jean, BISO Archeologist, pers. commun., 2000).

Paleontological Resource Management, Preliminary Recommendations

- The National Park Service Geologic Resources Division coordinated geologic scoping for BISO during June 2007. The participants of the BISO Geologic Scoping meeting developed a series of recommendations for future work, including recommendations relative to paleontology.
- The park should consider future field inventories for paleontological resources in order to more fully document *in situ* occurrences of fossils. If any significant paleontological localities are discovered within BISO, the park may consider a formal site documentation and condition assessment. Monitoring of significant sites should be undertaken at least once a year in the future.
- Incorporate a paleontological resource evaluation associated with future reclamation activities associated with the old Worley Mine. There is a good potential for the exposure of significant paleobotanical specimens during reclamation.
- The park would benefit from the recruitment of a geologic intern through the National Park Service Geologist-In-Parks Program. The intern could help develop educational information regarding the geology and paleontology of BISO.

Literature Cited

Chaney, D. S., W. A. DiMichele, and S. F. Greb. 2004. Paleontological Inventory of Big South Fork National River and Recreational Area with Emphasis on Paleobotany. Report to BISO.

Chesnut, D. R., Jr. 1992. Stratigraphic and structural framework of the Carboniferous rocks of the central Appalachian Basin. Kentucky Geological Survey, Lexington. Series 11 Bulletin 3.

Chesnut D. R., Jr., D. Baird, J. H. Smith, and R. Q. Lewis. 1994. Reptile trackway from the Lee Formation (Lower Pennsylvanian) of south-central Kentucky. Journal of Paleontology **68**:154-158.

Des Jean, T. 2007. Fossils of Big South Fork or, alternatively: The Paleontological Resources of the Upper Cumberland Plateau. National Park Service. Miscellaneous Field Studies.

Ettensohn, F. R., C. R. Rice, G. R. Dever, Jr., and D. R. Chesnut. 1984. Slade and Paragon Formations; New stratigraphic nomenclature for Mississippian rocks along the Cumberland Escarpment in Kentucky. U.S. Geological Survey, Reston, VA. Bulletin 1605-B.

Grabowski, G. J. 1986. The geology of Kentucky – A text to accompany the geologic map of Kentucky: Mississippian System. U.S. Geological Survey, Reston, VA. Professional Paper 1151-H.

Greb, S. F. 2006. Fluvial-estuarine channels in the Paragon Formation and Pennington Group, Upper Mississippian, Eastern Kentucky. Geological Society of America, Abstracts with Programs **38**(4):5.

Kohl, M. S. and J. R. Bryan. 1993. A middle Pennsylvanian (ca. 315 million years) amphibian trackway from the Cross Mountain Formation, east Tennessee Cumberlands. McClung Museum, Knoxville, TN. Research Notes 13. Online. (http://mcclungmuseum.utk.edu/research/renotes/rn-13txt.htm). Accessed 26 February 2008.

Lloyd, O. B. and W. L. Lyke. 1995. Ground Water Atlas of the United States: Illinois, Indiana, Kentucky, Ohio, and Tennessee. U.S. Geological Survey, Reston, VA. Hydrological Atlas HA 730-K.

Miller, M. F. and L. W. Knox. 985. Biogenic structures and depositional environments of a Lower Pennsylvanian coal-bearing sequence, northern Cumberland Plateau, Tenneessee. Pages 67-97 *in*

Curran, H. A. (editor). Biogenic Structures: Their use in interpreting depositional environments. Society of Economic Paleontologists and Mineralogists. Special Publication 35.

Miller, M. F., A. K. Rindsberg, and S. R. Jackson. 2006. Lower Pennsylvanian siliciclastics of the northern Cumberland Plateau: Depositional environments and biogenic structures of the Fentress Formation and Rockcastle Conglomerate. Pages 185-194 *in* Southeast Sectional Meeting, Geological Society of America. Field Trip Guide 7.

Rice, C. L. 1986. The geology of Kentucky – A text to accompany the geologic map of Kentucky: Pennsylvanian System. U.S. Geological Survey, Reston, VA. Professional Paper 1151-H.

Rice, C. L. 1984. Sandstone units of the Lee Formation and related strata in eastern Kentucky. Pages G1-G53 *in* U. S. Geological Survey, Reston, VA. Professional Paper 1151-G.

Smith, J. H. 1976a. Geologic map of the Nevelsville Quadrangle, South-Central Kentucky. U.S. Geological Survey, Reston, VA. Geologic Quadrangle Map GQ-1326.

Smith, J. H. 1976b. Geologic map of the Bell Farm Quadrangle and part of the Barthell SW Quadrangle, McCreary and Wayne Counties, Kentucky. U.S. Geological Survey, Reston, VA. Geologic Quadrangle Map GQ-1496.

Trapp, H. and M. A. Horn. 1997. Ground water atlas of the United States: Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, and West Virginia. U.S. Geological Survey, Reston, VA. Hydrologic Atlas HA 730-L.

Additional References

Barger, E. A. 1984. Petrology of Lower Pennsylvanian sandstones, northern Cumberland Plateau, Tennessee. M.S. Thesis. Vanderbilt University, Nashville, TN.

Bergenback, R. E. 1987. Devonian-Mississippian clastic sedimentation in northern Tennessee. Journal of the Tennessee Academy of Science **62**(4):35.

Bergenback, R. E. 1986. Devonian-Mississippian clastic sedimentation in northern Tennessee. Abstracts - SEPM Midyear Meeting **3**:9.

Bergenback, R. E. 1978. Carboniferous depositional environments in the southern Cumberland Plateau. Pages 63-86 *in* Field Trips in the Southern Appalachians. Tennessee, Division of Geology, Nashville. Report of Investigations 37.

Churnet, H. G. 1995. Depositional environments of Lower Pennsylvanian coal-bearing siliciclastics of Southeast Tennessee. Abstracts with Programs - Geological Society of America **27**(2):43.

Churnet, H. G., R. E. Bergenback, and R. A. Gastaldo. 1985. Field trip Lower Pennsylvanian sediments and associated coals in the Walden Ridge South. Pages 34-69 *in* Woodward, N. B. (editor). Field Trips in the Southern Appalachians. University of Tennessee, Knoxville. Studies in Geology Knoxville 9.

Conant, L. C. and V. E. Swanson. 1961. Chattanooga Shale and related rocks of central Tennessee and nearby areas. U.S. Geological Survey, Reston, VA. Professional Paper 357.

Dever, G. R., Jr., H. P. Hoge, N. C. Hester, and P. R. Ettensohn. 1977. Stratigraphic evidence for Late Paleozoic tectonism in northeastern Kentucky. Eastern Section of American Association of Petroleum Geologists and Kentucky Geological Survey, Lexington. Field trip guidebook.

Drahovzal, J. A. 1967. The biostratigraphy of Mississippian rocks in the Tennessee Valley. Pages 53-60 *in* Field trip guide to Mississippian sediments in northern Alabama and south central Tennessee. Alabama Geological Society, Tuscaloosa. Annual Field Trip Guidebook 5.

Englund, K. J. 1964. In the Cumberland Mountains of Southeastern Kentucky: Stratigraphy of the Lee Formation. Pages B30-B38 *in* U.S. Geological Survey, Reston, VA. Professional Paper 501-B.

Englund, K. J., and T. W. Henry. 1984. The Mississippian-Pennsylvanian boundary in the central Appalachians. Ninth International Carboniferous Congress, Compte rendu **9**:330-336.

Ettensohn, F. R. and D. R. Chestnut. 1979. Echinoderm paleoecology and paleoenvironments from the Glen Dean and Lower Pennington (Chesterian), south-central Kentucky. Ninth International Carboniferous Congress Proceedings: 62-63.

Garrett, M. W. 1975. Depositional environments of lower Pennsylvanian strata in the Hanging Limb area, Cumberland Plateau, Tennessee. M.S. Thesis. Vanderbilt University, Nashville.

Greb, S. F. 1998. Geology of the Pond Creek Coal, Pineville Formation, Middle Pennsylvanian, Eastern Kentucky coal field. Abstracts with Programs - Geological Society of America **30**(4):15.

Greb, S. F. and D. Chestnut. 1994. Paleoecology of an estuarine sequence in the Breathitt Formation (Pennsylvanian), Central Appalachian Basin. Palaios **9**(4):388-402.

Hoffelt, J. 1998. Guide to the roadside geology of I-24. Pages 153-155 *in* Schindel, G. M. and J. L. Hickman (editors). Journeys Through TAG. National Speleological Society, Huntsville, AL. Annual Convention Guidebook 1998.

Hunt, A. P., S. G. Lucas, and N. D. Pyenson. 2005. The significance of the Union Chapel Mine Site: A lower Pennsylvanian (Westphalian A) Ichnological Konzentrat-Lagerstätte, Alabama, USA. Pages 3-14 *in* Buta, R. J., A. K. Rindsberg, and D. C. Kopaska-Merkel (editors). Pennsylvanian footprints in the Black Warrior Basin of Alabama. Alabama Paleontological Society, Birmingham. Monograph 1.

Jillson, W. R. 1929. Geologic map of Kentucky. Kentucky Geological Survey, Lexington. Series 6. Scale 1:500,000.

Keith, A. 1897. Wartburg folio, Tennessee. U.S. Geological Survey, Reston, VA. Geologic Atlas of the United States Folio GF-40. Scale 1:125000.

Kohl, M. S. and J. R. Bryan. 1994. A new Middle Pennsylvanian (Westphalian) amphibian trackway from the Cross Mountain Formation, East Tennessee Cumberlands. Journal of Paleontology **68**(3):655-663.

Lawson, C. B. 1988. Paleocurrent and environment of deposition of the Rockcastle Conglomerate in the Northwest Cumberland Plateau area of Tennessee. Journal of the Tennessee Academy of Science **63**:24.

Lin, J.-P. and K. Hunter. 2001. Conodonts from the Bangor Limestone (Chesterian) near Huntsville, Alabama. Abstracts of the 110th Meeting of the Tennessee Academy of Science. Journal of the Tennessee Academy of Science **76**(1):27.

Maples, C. G. 1990. *Harmostocrinus jonesi* n.sp. (Crinoidea): An evolutionary intermediate between *Abrotocrinus* and *Harmostocrinus.* Journal of Paleontology **64**(1):141.

McDowell, R. C. 1981. Correlation chart for units on the Geologic Map of Kentucky. U.S. Geological Survey, Reston, VA. Miscellaneous Field Studies Map MF-1291.

McDowell, R. C. (editor). 1986. The geology of Kentucky – A text to accompany the geologic map of Kentucky. U.S. Geological Survey, Reston, VA. Professional Paper 1151-H.

McDowell, R. C., G. J. Grabowski, Jr., and S. L. Moore. 1981. Geologic Map of Kentucky. U.S. Geological Survey, Reston, VA. Scale 1:250,000.

Miller, A. M. 1919. The geology of Kentucky. Kentucky Department of Geology and Forestry, Series 5. Bulletin 2.

Miller, M. F. 2006. Marine margin and braided stream depositional environments recorded in Lower Pennsylvanian rocks, northern Cumberland Plateau, Tennessee. Abstracts with Programs - Geological Society of America **38**(3):86.

Miller, M. F. 1987. Depositional setting of Lower Pennsylvanian sandstones, northern Cumberland Plateau. Journal of the Tennessee Academy of Science **62**(4):36.

Minkin, S. C. 1977. Pennsylvanian deltaic sediments of the northern Cumberland Plateau, Tennessee. M.S. Thesis. University of Tennessee, Knoxville.

Morse, W. C. 1931. Pennsylvanian invertebrate fauna [of Kentucky]. Kentucky Geological Survey, Ser. 6., **36**:293-348.

Nicholson, S. W., C. L. Dicken, J. D. Horton, K. A. Labay, M. P. Foose, and J. A. L. Mueller. 2005. Preliminary integrated geologic map databases for the United States: Kentucky, Ohio, Tennessee, and West Virginia. U.S. Geological Survey, Reston, VA. Open-File Report OF-2005-1324. Scale 1:250000.

Platt, B. F. and S. T. Hasiotis. 2008. A new system for describing and classifying tetrapod tail traces with implications for interpreting the dinosaur tail trace record. Palaios **23**(1):3-13.

Pomerance, J. B. 1964a. Geology of the Whitley City Quadrangle, Kentucky and the Kentucky part of the Winfield Quadrangle. U.S. Geological Survey, Reston, VA. Geologic Quadrangle Map GQ-260.

Pomerance, J. B. 1964b. Geology of the Barhell and part of the Oneida North Quadrangles, Kentucky. U.S. Geological Survey, Reston, VA. Geologic Quadrangle Map GQ-314.

Read, C. B. and S. H. Mamay. 1964. Upper Paleozoic floral zones and floral provinces of the United States, with a Glossary of stratigraphic terms by G. C. Keroher. Pages K1-K35 *in* U.S. Geological Survey, Reston, VA. Professional Paper 454-K.

Rice, C. L. 1990. Geologic map of part of the Jellico East Quadrangle, Campbell and Claiborne counties, Tennessee. U.S. Geological Survey, Reston, VA. Geologic Quadrangle Map GQ-1674.

Rice, C. L. and J. H. Smith. 1980. Correlation of coal beds, coal zones, and key stratigraphic units in the Pennsylvanian rocks of eastern Kentucky. U.S. Geological Survey, Reston, VA. Miscellaneous Field Studies Map MF-1188.

Rich, M. 1981. Upper Mississippian foraminifera in the Southern Appalachians. Abstracts with Programs - Geological Society of America **13**(7):538.

Robbs, E. E. 1980. The petrology and paleoenvironments of the Pennington Formation (Upper Mississippian), east central Tennessee and Northwest Georgia. M.S. Memphis State University, Memphis, TN.

Roberts, J. B. 1980. The petrology and paleoenvironments of the Mississippian Big Clifty Formation in South-central Tennessee; implications for regional paleogeography. M.S. Thesis. Memphis State University, Memphis, TN.

Sciple, L. 1981. Depositional and diagenetic environments of Fort Payne Mounds (Mississippian), northern Cumberland Plateau, Tennessee. M.S. Thesis. Vanderbilt University, Nashville.

Strimple.H. L. and W. D. Knapp. 1966. Pennsylvanian fauna from eastern Kentucky: Part 2, Crinoids. Journal of Paleontology **40**(2):309-314.

Swingle, G. D., R. A. Miller, E. T. Luther, W. D. Hardeman, D. S. Fullerton, C. R. Sykes, and R. K. Garman. 1966. Geologic Map of Tennessee [East Central Sheet]. Tennessee Division of Geology, Nashville. State Geologic Map SEC. Scale 1:250000.

Thomas, W. A. 1972. Mississippian stratigraphy of Alabama. Alabama Geological Survey, Tuscaloosa. Monograph 12.

Thomas, W. A. and H. R. Cramer. 1979. The Mississippian and Pennsylvanian (Carboniferous) systems in the United States – Georgia. U.S. Geological Survey, Reston, VA. Professional Paper 1110-H.

Wanless, H. R. 1946. Pennsylvanian geology of a part of the southern Appalachian coal field. Geological Society of America, Boulder, CO. Memoir 13.

Waters, J. A. 1980. Paleontology and stratigraphy of the upper Bangor Limestone (Mississippian) around Lookout Mountain, Georgia – Tennessee. Georgia Geological Survey, Atlanta. Open-File Report 80-9.

Waters, J. A. 1978. The paleontology and paleoecology of the Lower Bangor Limestone (Chesterian, Mississippian) in northwestern Alabama. Ph.D. Dissertation. Indiana University, Bloomington, IN.

White, J. F. and G. Briggs. 1974. Pennsylvanian depositional environments in the Cumberland Plateau of northern Tennessee. Abstracts with Programs - Geological Society of America **6**(4):411.

Wilson, R. L. 1981. Carboniferous coal basins of the southeastern United States; a case study on Lookout Mountain, Georgia. Abstracts with Programs - Geological Society of America **13**(7):582.

Data Sets

Big South Fork National River and Recreation Area Paleontological Archives
5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Big South Fork National River and Recreation Area Files and Archives
1974–present. (letters, notes, exhibit text, etc.). Originated by BISO staff; status: Active.

Smithsonian Institution Paleobotanical Collection from Big South Fork River and Recreation Area.
2004 – present. (fossils, field notes, photographs). Originated by Dan Chaney, Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C.; status: Active.

Blue Ridge Parkway

The Blue Ridge Parkway (BLRI) was established in 1935 to provide a scenic drive atop the southern Appalachian Mountains connecting Shenandoah National Park, Virginia, and Great Smoky Mountains National Park, in North Carolina. The Parkway extends 755 km (469 miles) along the crest or backbone of the Appalachian Mountains. The Parkway crosses the North Carolina – Virginia state line at milepost 216.9, with slightly more than half of the park within North Carolina.

The park preserves both a rich natural and cultural history. Park elevations range from 198 to 1,843 m (649-6,047 ft) above sea level providing diverse habits supporting remarkable biodiversity. Hundreds of miles of wildflowers, shrubs and trees, representing a variety of vegetation zones, offer wonderful displays of color from spring through the fall.

Baseline Paleontological Resource Inventories

The Blue Ridge Province and Mountains represent the backbone of the central and southern Appalachians. The Blue Ridge Province extends from Georgia to Pennsylvania and is bound by the Piedmont to the east and south, and the Valley and Ridge Province to the west. It is important to note and distinguish that the Blue Ridge Parkway does not extend the entire Blue Ridge Province, but includes much of the middle and southern portions.

The Appalachian Mountains are an elongate belt of folded and thrust faulted marine sedimentary rocks, volcanic rocks, and slivers of an ancient ocean floor. Deformation occurred through a long series of plate tectonic events known as orogenies. Although the birth of the true Appalachian Mountains began approximately 475 million years ago (mya), the geologic history of the Blue Ridge area extends back more than a billion years.

The geologic history of the Blue Ridge Mountains is significantly influenced by the following mountain building events: Grenville orogeny (1.1 billion years ago), Taconic orogeny (475-405 mya), Acadian orogeny (390-350 mya), and Alleghenian orogeny (300-245 mya). Rocks of the Blue Ridge Mountains underwent tremendous deformation and metamorphism. Therefore, the rarity of fossils at BLRI is directly related to the tectonic history of the area.

Prior to the development of the Appalachian Mountains, the upper Proterozoic / lower Paleozoic stratigraphy of the southern Appalachians preserves the history of the proto-Atlantic Ocean called the Iapetus Ocean (Hatcher 1972, 1978; Rankin 1975, 1976). The transition from a continental rift / incipient ocean systems (Ocoee Supergroup and Grandfather Mountain Formation) to a passive margin setting (Ashe and Alligator Back formations), resulting in the opening of the Iapetus Ocean, is well preserved in the southern Appalachians.

The breakup or rifting of the ancient supercontinent began during the Late Proterozoic (800 to 700 mya). A deep trough developed between the two rifted landmasses. Sediments eroded from the Grenville basement rocks accumulated in the rift basins for more than 200 million years, forming thick sequences (Carter et al. 2001). Intermittent volcanic lava flows occur within the sedimentary deposits. By the early Cambrian (550 mya), nearshore marine sediments hosted some primitive lifeforms. The fossilized remains of trilobites and invertebrate burrows are not common, but can be found in Cambrian metasediments along the Blue Ridge Parkway.

Between 550 – 450 million years ago, the Taconic Orogeny fused the proto-North America and the Blue Ridge fragment. Large faults were formed during the period. The rocks and sediments formed prior to the orogency were subjected to extensive metamorphism during the orogeny. When paleontological resources are subjected to metamorphism they become altered and sometimes are destroyed. During deformation carbonates within the shell material frequently recrystallizes resulting in obliteration of the

original morphology. Geologists can utilize the distortion of paleontological material to determine the amount and direction of stress. Additionally, the sediment in which the fossils are contained will undergo metamorphic changes which may prevent the opportunity to determine the ancient sedimentary depositional environment.

Basement Complex (Middle Proterozoic)

During the Middle Proterozoic, approximately 1.1 billion years ago, the Grenville orogeny influenced some of the oldest rocks exposed at BLRI. Plate collision involving the old supercontinent and the associated mountain-building events resulted in metamorphism of the pre-existing rocks. Some of the Grenville basement rocks are exposed at the Thunder Hill Overlook (Milepost (MP) 290) and the Woodfin Valley Overlook (MP 446) along the Parkway (Carter et al. 2001).

The Basement Complex is represented by Biotite Granite Gneiss and Blowing Rock Gneiss near the North Carolina – Virginia state line. In addition to these two units, a Granodioritic Gneiss and Migmatitic Biotite-Hornblende Gneiss are present at the Grandfather Mountain area in North Carolina and extend south to the terminus of the Parkway at Cherokee.

Metasedimentary Complex (Upper Proterozoic)

During the Upper (Late) Proterozoic, sediments and volcanics filled the valley between proto-North America and the Blue Ridge. These deposits were later subjected to metamorphism, at least twice, forming the Alligator Back Formation, the Ashe Metamorphic Suite, the Great Smoky Group, the Snowbird Group, and the Grandfather Mountain Formation (Cook et al. 1990). This complex forms the resistant backbone of the Appalachian Mountains.

Metasedimentary Complex (Upper Proterozoic): Ashe Metamorphic Suite

The Ashe Metamorphic Suite is a more granular unit which consists of thicker layers. It is exposed for about 161 km (100 miles) within BLRI south from Milepost 345. The Ashe Metamorphic Suite occurs within BLRI near Bald Knob Ridge (MP 352.4), Craggy Dome Overlook (MP 364.1), and Bear Den Overlook (MP 323).

Metasedimentary Complex (Upper Proterozoic): Alligator Back Formation

The Alligator Back Formation is the most widespread rock unit exposed within the Blue Ridge Parkway. The name was derived from a locality at the crest of Bluff Mountain where bodies of gneiss form what appear to be ribs which radiate from the crest. The Alligator Back Formation has a thinly-layered pinstripe appearance due to banding. This unit is located at (MP 217.5), Little Glade Millpond Overlook (MP 230.1), and Alligator Back Overlook (MP 242.4) within BLRI.

Metasedimentary Complex (Upper Proterozoic): Grandfather Mountain Formation

The Grandfather Mountain Formation is a metasedimentary unit which retains the original sedimentary and volcanic layering despite undergoing metamorphism. The unit is largely fine-grained arkose, shale, and meta-volcanic rock. The metamorphism occurred during the Taconic Orogeny. The Grandfather Mountain Formation is visible at the Wilson Creek Valley Overlook (MP 303.6).

Metasedimentary Complex (Upper Proterozoic): Great Smoky Group / Snowbird Group

The Great Smoky Group consists of metagraywacke, schist and slate. There are no metamorphosed basalts in this unit and is a defining character that distinguishes from the Ashe Metamorphic Suite and Alligator Back Formation. This Great Smoky Group sediments were deposited into large rift troughs closer to the edge of the continent. These units are exposed at Yellow Face Overlook (MP 450.2) and Ballhoot Scar Overlook (MP 467.4).

Chilhowee Group (Proterozoic-Lower Cambrian)

The Chilhowee Group consists of complex stratigraphic sequence of quartzites, metasandstones, metasiltstones and metashales / slates which span the uppermost Proterozoic through the Lower Cambrian (Simpson and Sundberg 1987; Walker and Simpson 1991). In the southern Appalachian region the Chilhowee Group is confined primarily to the westernmost Blue Ridge. In this area the Chilhowee Group consists of a 600-1200 m thick sequence with a three-fold stratigraphy including: Cochran / Unicol formations, Nichols / Hampton formations, and, Erwin Formation (Walker and Simpson 1991). The Chilhowee Group is separated from the older biotite granitic gneiss by a fault. This fault and the Chilhowee Group rocks are visible in the Linville Falls Visitor Center area of BLRI (MP 316.5).

The Chilhowee quartzites and sandstones contain trace fossils including *Skolithos* (worm burrows). The trace fossils are very abundant in the vicinity of Big Levels in Virginia, and also occur in the Grandfather Mountain area (MP 300-305) of North Carolina (M. Carter, Virginia DMME Geologist, pers. commun., 2008). An occasional trilobite may occur in the finer-grained rocks, but these are generally very rare and rather insignificant (M. Carter, pers. commun., 2008).

Park Collections

According to the BLRI website, 1,048 paleontology specimens are listed with the park collections. However, the park curator indicated that these are not listed properly and these should actually be referenced as geology specimens (J. Holt, BLRI Museum Curator, pers. commun., 2008). Park staff indicated there is one specimen of limestone with fossils and there are 20 specimens of petrified wood in the collection, but these may have been collected from localities outside of the park. Park curatorial records on these specimens are limited with most of the specimens donated during the 1950s. The fossiliferous limestone specimen is on exhibit at the North Carolina Mineral Museum and records indicate it was donated by the Mayland Community College in Spruce Pine, North Carolina. Six specimens are listed as found in Harnett County, North Carolina, and three specimens from near Germantown, Stokes County, North Carolina. Petrified wood is known from Triassic localities within the Piedmont and may be the source of these fossils. There is one specimen of petrified wood on exhibit at the parks Museum of North Carolina Minerals Visitor Center. The original construction of this museum took place in 1956 and the geology collections came from local sources (J. Holt, BLRI Museum Curator, pers. commun., 2008)

Paleontological Resource Management, Preliminary Recommendations

- The National Park Service Geologic Resources Division coordinated geologic scoping for BLRI between May 10-12, 2000. The participants of the BLRI Geologic Scoping meeting developed a series of recommendations for future work, including recommendations relative to paleontology. Geologic mapping for the North Carolina section of the Parkway is nearing completion.
- Geologic mapping is planned for the Virginia portion of the Blue Ridge Parkway beginning in 2008. These mapping projects will enhance future opportunities to identify fossiliferous or potentially fossiliferous units at BLRI.
- Interviews with the geologists or paleontologists who are knowledgeable about BLRI should be undertaken whenever possible. These interviews should be documented and archived by the park.
- Park staff should continue to be made aware of the potential for discovery of fossil material during other field work or construction activities, particularly along road cuts, stream banks, gullies, and other erosional features within the park.
- Any documentation of paleontological localities at BLRI can be considered as potential sites for future paleontological resource monitoring.

Literature Cited

Carter, M. W., C. E. Merschat and W. F. Wilson. 2001. A geologic adventure along the Blue Ridge Parkway in North Carolina. North Carolina Geological Survey, Raleigh. Bulletin 98.

Cook, F. A., L. D. Grown, and J. E. Oliver. 1990. The Southern Appalachians and the Growth of Continents. Scientific American October 1980. Reproduced as Pages 140-155 *in* Moores, E. M. (editor). Shaping the Earth, Tectonics of Continents and Oceans. W.H. Freeman and Company, New York.

Hatcher, R. D. 1972. Developmental model for the southern Appalachians. Bulletin of the Geological Society of America **83**:2735-2760.

Hatcher, R. D. 1978. Tectonics of the western Piedmont and Blue Ridge, southern Appalachians: Review and Speculation. American Journal of Science **278**:276-304.

Rankin, D. W. 1975. The continental margin of eastern North America in the southern Appalachians: The opening and closing of the proto-Atlantic Ocean. American Journal of Science **275**-A:298-336.

Rankin, D. W. 1976. Appalachian salients and recesses: Late Precambrian continental breakup and the opening of the Iapetus Ocean. Journal of Geophysical Research **81**:5605-5619.

Simpson, E. L. and F. A. Sundberg. 1987. Early Cambrian age for synrift deposits of the Chilhowee Group of southwestern Virginia. Geology **15**:123-126.

Walker, D. and E. L. Simpson. 1991. Stratigraphy of Upper Proterozoic and Lower Cambrian siliciclastic rocks, southwestern Virginia and northeastern Tennessee. Pages 121-159 *in* Schultz, A. and E. Compton-Gooding (editors). Geologic Evolution of the Eastern United States. Virginia Museum of Natural History. Guidebook 2.

Additional References

Berquist, P. J. 2003. The Mars Hill Terrane: extent, age, and origin of the oldest rocks in the Southeastern USA. Abstracts with Programs - Geological Society of America **35**(1):19.

Brame, R. I. 2005. Improving the quality of earth science education using paleontological research in the George Washington Jefferson National Forest. Abstracts with Programs - Geological Society of America **37**(7):176.

Brown, T. 2000. A karst resource inventory of the George Washington and Jefferson National forests. Virginia Journal of Science **51**(2):128.

Cattanach, B. L., C. E. Merschat, G. N. Bozdog, R. S. Latham, and R. M. Wooten. 2007. A new digital geologic map of the Blue Ridge Parkway in North Carolina. Abstracts with Programs - Geological Society of America **39**:99.

Clark, S. H. B. 2001. Birth of the mountains; the geologic story of the Southern Appalachian Mountains. U.S. Geological Survey, Reston, VA. General Interest Publication.

Conley, J. F. 1987. Mafic rocks in the Alligator Back Formation, the upper unit of the Lynchburg Group, in the southwestern Virginia piedmont: An ophiolite sequence. Pages 55-681 *in* Virginia Division of Mineral Resources, Richmond. Publication 74.

Cook, F. A., D. S. Albaugh, L. D. Brown, S. Kaufman, J. E. Oliver, and R. D. Hatcher. 1979. Thin-skinned tectonics in the crystalline southern Appalachians: COCORP seismic-reflection profiling of the Blue Ridge and Piedmont. Geology **7**:563-568.

Croom, H. B. 1833. Organic remains found in the marl pits of Lucas Brenners, Esq., in Craven County, North Carolina. Farmer's Register **1**.

Dhople, A. M. 1993. North Carolina's late Precambrian fossils. Florida Scientist **56**(1):47.

Driese, S. G. and C. I. Mora. 2002. Paleopedology and stable-isotope geochemistry of Late Triassic (Carnian-Norian) paleosols, Durham Sub-basin, North Carolina, USA.: implications for paleoclimate and paleoatmospheric PCO_2. Pages 207-218 *in* Renaut, R. W. and G.M. Ashley (editors), Sedimentation in continental rifts. Society of Sedimentary Geology.

Espenshade, G. H., D. W. Rankin, K. W. Shaw, and R. B. Neuman. 1975. Geologic map of the east half of the Winston-Salem quadrangle, North Carolina and Virginia. U.S. Geological Survey, Reston, VA. Miscellaneous Investigations Series Map I-709-B. Scale 1:250,000.

Hack, J. T. 1960. Interpretation of erosional topography in humid temperate regions. American Journal of Science **258**-A:80-97.

Hack, J. T. 1982. Physiographic divisions and differential uplift in the Piedmont and Blue Ridge. U.S. Geological Survey, Reston, VA. Professional Paper 1265.

Hack, J. T. 1989. Geomorphology of the Appalachian Highlands. Pages 459-470 *in* Hatcher, R. D., W. A. Thomas, and G. W. Viele (editors). The Appalachian-Ouachita Orogen in the United States. Geological Society of America, Boulder, CO. The Geology of North America F-2.

Harris, L. D. and K. C. Bayer. 1979. Sequential development of the Appalachian Orogen above a master decollement – a hypothesis. Geology **7**:568-572.

Hatcher, R. D., W. A. Thomas, P. A. Geiser, A. W. Snoke, S. Mosher, and D. V. Wiltschko. 1989. Alleghanian Orogen. Pages 233-318 *in* Hatcher, R. D., W. A. Thomas, and G. W. Viele (editors). The Appalachian-Ouachita Orogen in the United States. Geological Society of America, Boulder, CO. The Geology of North America F-2.

Hendricks, J. R. 2005. Evolutionary history of Plio-Pleistocene *Conus* from the Southeastern United States. Abstracts with Programs - Geological Society of America **37**(7):307.

Hope, R. C. 1985. North Carolina Fossils. Rocks and Minerals **60**(2):68-71.

Horton, J. W. and V. A. Zullo. 1991. An introduction to the geology of the Carolinas. Pages 1-10 *in* Horton, J. W. and V.A. Zullo (editors). The Geology of the Carolinas. University of Tennessee Press, Knoxville.

King, P. B., R. B. Neuman, and J. B. Hadley. 1968. Geology of the Great Smoky Mountains National Park, Tennessee and North Carolina. U.S. Geological Survey, Reston, VA. Professional Paper 587.

Lillie, R. J. 1999. Parks and plates; How Earth's dynamic forces shape our national parks. Abstracts with Programs - Geological Society of America **31**:230.

Lukert, M. T. 1982. Uranium-lead isotope age of the Old Rag Granite, northern Virginia. American Journal of Science **282**:391-398.

Milici, R. C., C. T. Spiker, and J. M. Wilson. 1963. Geologic map of Virginia: Commonwealth of Virginia. Department of Conservation and Economic Development. Scale 1:500,000.

Moecher, D. P., R. J. Tracy, and M. A. Massey. 2002. Monazite chemical ages reveal more than one "Great Smoky Group" in southern Blue Ridge, Appalachian Orogen. Abstracts with Programs - Geological Society of America **34**(6):69.

North Carolina Geological Survey. 1958. Geologic map of North Carolina. North Carolina Geological Survey, Raleigh. General Geologic Map. Scale 1:500,000.

North Carolina Geological Survey. 1985. Geologic map of North Carolina. North Carolina Department of Natural Resources and Community Development, Raleigh. Scale 1:500,000.

Olson, S. L. and P. C. Rassmussen. 2001. Miocene and Pliocene birds from the Lee Creek Mine, North Carolina. Pages 233-265 *in* Ray, C. E. and D. J. Bohaska (editors). Geology and Paleontology of the Lee Creek Mine, North Carolina, III. Smithson Institution, Washington, D.C.

Osberg, P. H., J. F. Tull, P. Robinson, R.Hon, and J. R. Butler. 1989. The Acadian Orogen. Pages 179-232 *in* Hatcher, R. D., W. A. Thomas, and G. W. Viele (editors). The Appalachian-Ouachita Orogen in the United States. Geological Society of America, Boulder, CO. The Geology of North America F-2.

Peyer, K., J. G. Carter, H. D. Sues, and P. E. Olsen. 2001. An articulated poposaurid rauisuchian archosaur from the Late Triassic Deep River Basin, North Carolina. Abstracts with Programs - Geological Society of America **33**(2):27.

Rankin, D. W. 1970. Stratigraphy and structure of Precambrian rocks in northwestern North Carolina. John Wiley and Sons Publishers. Map Scale 1:714,000.

Rankin, D. W., A. A. Drake, L. Glover, R. Goldsmith, L. M. Hall, D. P. Hall, D. P. Murray, N. M. Ratcliffe, J. F. Read, D. T. Secor, and R. S. Stanley. 1989. Pre-orogenic features. Pages 7-100 *in* Hatcher, R. D., W. A. Thomas, and G. W. Viele (editors). The Appalachian-Ouachita Orogen in the United States. Geological Society of America, Boulder, CO. The Geology of North America F-2.

Raphael Unrug, W. I., J. B. Ausich, R. J. Cuffey, B. L. Mamet, S. L. Palmes, and S. Unrug. 2000. Paleozoic age of the Walden Creek Group, Ocoee Supergroup, in the western Blue Ridge, southern Appalachians: Implications for evolution of the Appalachian margin of Laurentia. Geological Society of America Bulletin **112**:982-996.

Sanders, A. E. 2002. Additions to the Pleistocene mammalian faunas of South Carolina, North Carolina, and Georgia. Transactions of the American Philosophical Society 92.

Scheckler, S. E. 1984. Persistence of the Devonian plant group Barinophytaceae into the basal Carboniferous of Virginia, USA. Compte Rendu – Ninth International Congress on Carboniferous Stratigraphy and Geology 2:223.

Shallow, J. 2004. Geologic map of the Blue Ridge Parkway. Abstracts with Programs - Geological Society of America **36**(5):229.

Steltenpohl, M. G., W. E. Hames, M. J. Kunkle, and J. W. Mies. 2001. Ar^{40} / Ar^{39} data from western Blue Ridge and their implications for timing of metamorphism. Abstracts with Programs - Geological Society of America **33**(2):6.

Stewart. K. G. and M. R. Roberson. 2007. Exploring the Geology of the Carolinas. University of North Carolina Press, Chapel Hill.

Stose, G. W. and A. J. Stose. 1944. The Chilhowee Group and Ocoee Series of the southern Appalachians. American Journal of Science **242**: 367-390, 401-416.

Thomas, R. E. and K J. Englund. 1999. The Lower Pennsylvanian unconformity in the central Appalachian basin. U.S. Geological Survey, Reston, VA. Geologic Investigations Series Map I-2597. Scale 1:250,000.

Villa, M. 2001. A GIS construction of geologic map of the George Washington National Forest. Virginia Journal of Science 52(2):112.

Virginia Division of Mineral Resources. 1993. Geologic map of Virginia. Virginia Division of Mineral Resources, Richmond. Scale 1:500,000.

Virginia Division of Mineral Resources. 2003. Digital representation of the 1993 geologic map of Virginia. Virginia Division of Mineral Resources, Richmond. Publication 174. Scale 1:500,000.

White, R. A. 1997. Depositional processes of the Dean Formation near Murphy, North Carolina. M.S. Thesis. Georgia State University, Atlanta.

Zug, G. R. 2001. Turtles of the Lee Creek Mine (Pliocene: North Carolina). Pages 203-218 *in* Ray, C. E. and D. J. Bohaska (editors). Geology and Paleontology of the Lee Creek Mine, North Carolina, III. Smithson Institution, Washington, D.C.

Data Sets

Blue Ridge Parkway Paleontological Archives
5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Blue Ridge Parkway Files and Archives
1982–present. (letters, notes, exhibit text, etc.). Originated by BLRI staff; status: Active.

Great Smoky Mountains National Park

Great Smoky Mountains National Park (GRSM) spans the Tennessee and North Carolina border in the heart of the southern Appalachians. Generally, the area is known for its scenic beauty and good hiking trails. Moore (1988) wrote a comprehensive roadside guide to the park's geology which should only add to the enjoyment of auto touring professional geologists and laymen alike. The approximately 2,110 sq km (815 sq mile) area of the Great Smoky Mountains was established as a park in 1934, five years before the last lumber company ended operations. Home to many peoples through the millennia, the Smoky Mountains were most notably the home of the Cherokee. The Cherokee lived in permanent settlements there before much of the tribe was relocated to Oklahoma in the "trail of tears" of 1838 and 1839. GRSM offers many views into American history from the historic buildings and structures that still stand to the heirloom varieties of apples in orchards symbolizing the park's agricultural past.

The Park has a complex geology with approximately 1,700 m (5,600 ft) of topographical relief. Over 15,000 species are currently known from the park, including some that are rare and endemic to the Smokies, many of which are associated with particular types of geology. Additionally, the park maintains diverse habitats for wildlife, such as black bears, nearly 120 breeding species of birds, and recently reintroduced elk. Recognized as the "Salamander Capital of the World", GRSM contains a large number of salamander species, including 24 species of lungless salamanders alone.

Baseline Paleontological Resource Inventories

Located in both the Valley and Ridge and Blue Ridge physiographic provinces, GRSM bedrock is dominated in its south and southeastern regions by non-fossiliferous Mesoproterozoic and Neoproterozoic rocks (as can be seen by example in Schultz et al 2000). By contrast, the regions of the park with the majority of fossiliferous rocks reside in the sedimentary Paleozoic deposits in the north and northwest. Beyond park boundaries Quaternary fossils have been found nearby in addition to Paleozoic fossils located in formations that also exist within park boundaries (Robinson 1981; Ruppel and Walker 1977).

Recently, Southworth et al. (2006) mapped ninety-four stratigraphic units to completion for GRSM. Fifty-four of these are Precambrian and non-fossiliferous based on their descriptions. The entirety of the Mesozoic Era, Tertiary Period, and many periods in the Paleozoic are not present in the park. Additionally, surficial Quaternary deposits and debris flows contain organic remains which have been dated (Southworth et al. 2006).

Mesoproterozoic and Neoproterozoic Rocks

Mesozoic igneous (plutonic and/or volcanic) and metamorphic (altered by high temperature and/or pressure) rocks outcrop in the park as ultramafic rock, a suite of gneisses, granite, and granodiorite (Southworth et al. 2006). Because of the intense heat and/or pressure associated with the formation of igneous and metamorphic rocks, they typically do not preserve fossils. Amphibolite layers and lenses can be found within the hornblende biotite, biotite, and migmatite gneisses found in the park. In particular, the largest body of amphibolite found is 274 m (900 ft) wide by 610 m (2,000 ft) long near the town of Dellwood. From a migmatic biotite gneiss outcrop at the southern end of Ela dome on Highway 74, Aleinikoff et al. (2007) report a date of 1.194 ± 0.008 billion years (Ga). It is the oldest absolute age date in the western Blue Ridge province. It falls approximately 4 km (2.5 miles) outside of the GRSM park boundary.

Neoproterozoic rocks are by far the largest component of GRSM's geology. Composed most frequently by sedimentary rocks, the Neoproterozoic units in the park also contain metamorphic assemblages. In addition to sedimentary deposition, these metamorphics illustrate the structural deformity and large-scale tectonic processes that have dominated the lithologic collection. Sedimentary rocks in the park's

Neoproterozoic assemblage are comprised of sandstones, siltstones, shales, conglomerates, quartz pebble conglomerates, boulder conglomerates, greywacke, limestones, dolostones, and argillaceous shales. Metamorphic rocks are comprised of metasandstones, metasiltstones, metagraywackes, metaconglomerates, slates, muscovite schists, phyllites, quartzites, and gneisses. For instance, some metamorphic rocks are represented by the Ashe Metamorphic Suite's muscovite-biotite gneiss, mica schist, amphibolite and metasiltstone, and the Metcalf Phyllite (Southworth et al. 2006). In addition, younger Neoproterozoic rocks contain less metamorphic units.

No fossils have been discovered in the Precambrian rocks of Neoproterozoic age. Still, potential for new Precambrian discoveries remains. Based on the volume of sedimentary rocks and the richness of different sedimentary environments from river deltas to deep and shallow marine settings, Proterozoic fossils (such as cyanobacteria biomarkers, conodonts, and stromatolites) may be encountered in the future. Despite the range in sedimentary environments, the possibility for preservation may be grim. This is in part due to the deposition of sediments in high energy, shallow marine environments and the number of turbidity currents and oxygen-poor environments in many of the deep marine sequences. However, poor preservation will most likely be the case concerning the identification of fossilized remains with respect to the deformed nature of the park's Proterozoic strata. This situation is noted by Repetski et al. (2006) regarding the conodonts studied from the Walden Creek Group (mid-Paleozoic or Late Proterozoic age; still unresolved) approximately 100 km (62 miles) west outside park boundaries near Springtown, Tennessee in Polk County.

Chilhowee Group (Lower Cambrian)

The Chilhowee Group from oldest to youngest is comprised of the Cochran Formation, Nichols Shale, Nebo Quartzite, Murray Shale, Hesse Quartzite, and Helenmode Formation. Good exposures in the park where fossils have been recovered are summarized in Table 2. Southworth et al. (2006) describe the Cochran Formation as gray conglomerate at the base overlain by maroon pebbly arkosic sandstone interbedded with shales and siltstones. These beds are in turn overlain by light gray arkosic sandstone, cross-beds, and quartzite (distinguished from overlying Nebo and Hesse Quartzites by gray hematite concretions). Nichols Shale, Nebo Quartzite, Murray Shale, and Hesse Quartzite are predominately either shales or quartzites, respectively. Moreover, Southworth et al. (2006) note a sharp contact between the white colored Nebo Quatzite 3 and the overlying greenish-gray colored Murray Shale. In addition to these older Chilhowee Group rocks, the Helenmode Formation is the youngest formation of gray shales and siltstones with a quartzite base and a sandstone cap (Southworth et al. 2006).

The oldest fossils found are found just outside of the park (Neuman and Nelson 1965) are interpreted to be ribbon-like impressions in the Nichols Shale near Chilogatee Gap. Exposures of Nichols Shale outcrop in Chilogatee Gap and an old quarry north of Walland on the east side of the Little River. Overlying the Nichols Shale, Southworth et al. (2006), identify *Skolithos linearis* in the Nebo Quartzite. Moreover, King et al. (1968) reported that all the formations of the Chilhowee Group above the Cochran Formation contain fossils. In general, King et al. (1968, p. 10), note that the quartzites and sandstones contain the tubelike burrowing trace fossil *Skolithos linearis* (confirmed by Southworth et al. 2006) and the shales and siltstones contain "tracks and traces on bedding surfaces."

Ostracod genus *Indiana* of the Murray Shale on Chilhowee Mountain had been originally identified in 1889 by the late Charles Doolittle Walcott while working for the U.S. Geological Survey. Walcott was canonized in the book "Wonderful Life" by Stephen J. Gould (1989) for his original work on the faunas of the Burgess Shale. The location at Murray Gap had been lost for 72 years before it was rediscovered by Laurence (1963). The ostracod gives the shale an early Cambrian age.

Southworth et al. (2006) describe fewer and shorter *Skolithos linearis* trace fossils from the Hesse Quartzite on Chilhowee Mountain. In the Helenmode Formation, King et al. (1968) reference Walcott (1890) and Resser (1938) as having published findings on the trilobite genus *Olenellus* and "other fossils" in a report for the U.S. Geological Survey. *Olenellus* was discovered on Chilhowee Mountain.

Table 2. Fossils and outcrop locations for the formations of GRSM's Lower Cambrian Chilhowee Group. From top to bottom, formations in the table are listed youngest to oldest. Note that the Cochran Formation has extensive exposures, yet contains no known fossils.

Formation	Locations of Outcrops	Fossil(s)	Source
Helenmode Formation	Town of Walland-south end of Little River Gap	Trilobite *Olenellus*, "other fossil shells"	King et al. (1968; Resser (1938); Walcott (1890)
Hesse Quartzite	Chilhowee Mtn. along Foothills Parkway	*Skolithos linearis* trace fossils	Southworth et al. (2006)
Murray Shale	Chilogatee and Murray gaps	Ostracod *Indiana*	Southworth et al. (2006); King et al. (1968); Laurence (1963); Laurence and Palmer (1963)
Nebo Quartzite	Mt. Nebo Springs	*Skolithos linearis* trace fossils	Southworth et al. (2006); King et al. (1968)
Nichols Shale	Chilogatee Gap and an old quarry north of Walland on east side of Little River	trace fossil, ribbon-like impressions	Southworth et al. (2006); Neuman and Nelson (1965)
Cochran Formation	South side of Green Mtn., west slope on Chilhowee Mtn. (extensive exposures), east side of Chilhowee Mtn. on north end of Happy Valley	None	Southworth et al. (2006)

Jonesboro Limestone (Lower Ordovician)

Lower Ordovician rocks of the Jonesboro Limestone at Cades Cove contain multiple micro and macrofossils. Repetski (1997) created an open-file report on the marine organisms collected by workers over the Twentieth Century (see Additional References). In this report Repetski (1997) identifies four localities (USGS fossil locality number 10448-CO, USGS fossil locality number 10449-CO, USGS fossil locality number 10450-CO, and a site with no given USGS fossil locality number). There are 287 specimens and unidentifiable fragments of conodont from USGS fossil location number 10448-CO, such as *Colaptoconus quadraplicatus, Drepanoistodus concavus, Eucharodus parallelus,* and *Macerodus dianae* to name four. However, at USGS fossil locality number 10449-CO, much less was collected; only three specimens (one being *Colaptoconus quadraplicatus*) are known. The other two localities (USGS fossil locality number 10450-CO and unnamed USGS fossil locality) contain seven and 24 specimens or unidentifiable fragments, respectively.

Other fossils from the Cades Cove area consist of brachiopods, gastropods, and trilobites. Repetski (1997) processed a brachiopod-rich wackestone block consisting of 103 conodonts and an unspecified number of brachiopods in a hydrochloric acid bath. The conodonts collected belong to the same species and genera as the four localities mentioned above. Neuman (1947) reported one of the few published accounts of macrofossils in GRSM from Cades Cove. The specimens came from three localities near Gregory Road and Gregory's Cave and Quarry. The brachiopods consist of *Diaphelasma pennsylvanicum* (locality 1), *Finkelnburgia virginica* (locality 1), and *Xenalasma syntrophioides* (locality 3). The molluscs consist of the gastropods *Hormotoma* (locality 2), *Lecanospira* (locality 1), and nautiloid cephalopod *Orthoceras* (locality 2). Neuman (1947) only reported one trilobite genus found in locality 1, *Hystricurus*.

Chickamauga Group (Middle Ordovician)

Moore (1977) reported on the Middle Ordovician formations of the Chickamauga Group in the GRSM area. The Chickamauga Group formations and lateral equivalents Moore (1977) studied are the Chota, Sevier, Blockhouse, Tellico, Holston, and Lenoir formations. In particular, he focused on the marine environments and the algae that formed them. Moore (1977) describes the mixed terrigenous (terrestrial derived sediments transported to ocean) and carbonate, and deep water shale basin environments as rarely preserving skeletonized algae. The calcareous algae are mainly found in rocks of low terrigenous abundance. Here, clastic (sedimentary) materials continually inundate the habitat, making the environment unsuitable for living. Moore (1977) describes four subenvironments: an oolite shoal/reef complex, a lagoonal complex, a tidal flat complex, and a shoreline/beach complex. In some areas, the algae are restricted to the lagoonal subenvironment of the Sevier Formation. Micrites, biomicrites, and pelmicrites represent algal traces of *Vermiporella, Contexta, Hedstroemia, Nuia, Solenopora* Type R, and *Girvanella* genera. It is also mentioned that in the Sevier Formation marine macrofossils such as bryozoans, pelmatozoans, brachiopods, and sponges have been found. The deep marine shale basin environments contain no algal fossils. Moore (1977) concludes that the absence of algae is due to the sediment deposition occurring below the photic zone. However, locality data is missing in Moore's report. The mixed terrigenous and carbonate environment and the deep marine shale basin environment described above are correlated to a map of eastern Tennessee illustrating the different marine environments from Middle Ordovician strata.

North of GRSM are strata containing fossil conodonts and graptolites and marine sedimentary environments in rocks of formations found within park boundaries (Benedict 1977; Bergstrom and Carnes 1976; Bergstrom 1977a, 1977b, 1977c; Walker 1977). These formations include the Lenoir, Ottosee, Knox Group, and the Sevier lateral equivalent, Holston Formation. It is possible that these potentially fossiliferous formations contain fossils in the regions of the park nearest to the outcrops of these formations.

Chattanooga Shale (Upper Devonian / Lower Mississippian)

Neuman and Nelson (1965) report on conodonts, linguloid brachiopods, and marine megafossils in black shales of the Chattanooga Shale. These fossils may be regarded as Upper Devonian/Lower Mississippian in age. The fossils place the rocks near the top of the shale in the early Mississippian. None of the other overlying Mississippian age rocks contain fossils.

Quaternary Surficial Deposits

Plant fossils have been discovered in Holocene deposits in the area of the Raven Fork valley (Leigh and Webb 2006). Samples were retrieved from both GRSM park lands and adjacent property belonging to the Eastern Band of Cherokee Indians. Radiocarbon (^{14}C) dates were recovered from the floodplain south of Raven Fork, a terrace, hillslope deposits on the eastside of the valley, and alluvial and colluvial fans. UTM coordinates for dated materials can be found in Table 1 in Leigh and Webb (2006). Dates range from within the past 250 years to approximately 11,000 years before present (b.p.). The oldest date (11,092 calendar years b.p.) comes from a leaf stem 5.5 m (18 ft) into Tight Run fan. Other early Holocene dates at 10,556, 10,195, and 9721 calendar years b.p. come from the charred remains of wood. No significant pattern appears to relate increasing depth of the recovered materials with increasing age estimates throughout the valley. Only two other published reports on dates from Quaternary surficial deposits are from the Southern Blue Ridge province.

Other ^{14}C dates from the GRSM park and surrounding area are reported in Delcourt (1980), Davidson (1983), and Kochel (1990). Delcourt (1980) dated organic remains from nine discontinuous terraces on the Little Tennessee River with ages ranging from 7,000 to 31,000 years b.p. from the lowest to highest terraces, respectively. Davidson (1983a) received a date of 6600 years b.p. from "The Lake in the Woods" (now known as Gum Swamp) at Cade's Cove in his Master's thesis. However, there is some question as to whether Davidson actually used radiocarbon dating techniques to establish the dates he reported. Kochel

(1990) recovered dates from five debris fans at approximately 16,000 to 18,000 years b.p. in the area of Dellwood in North Carolina. However, the full range of Kochel's dates is from 1000 to 25,000 years b.p.

Elsewhere, there has been a discovery made in Finger Quarry in Blount County, Tennessee approximately 72 km (45 miles) from the GRSM park boundary at Gatlinburg (Robinson 1981). The fossils were found in a Pleistocene clay fill in a fissure in marble of the Holston Formation. Robinson (1981) identified ruffed grouse (*Bonasa umbellus*) and fourteen mammals, such as an opossum (*Didelphis marsupialis*), armadillo (*Dasypus bellus*), rabbit (Leporidae), woodchuck (*Marmota monax*), eastern woodrat (*Neotoma floridana),* unknown canid (*Canis* sp.) gray fox (*Urocyon cinereoargenteus*), black bear (*Ursus americanus),* raccoon (*Procyon lotor*), jaguar (*Panthera onca*), horse (*Equus* sp.), long-nosed peccary (*Mylohyus* sp.), unknown cervid (Cervid sp.; elk), white-tail deer (*Odocoileus virginianus*), and tapir (*Tapirus* cf. *veroensis*). Additionally, near Gray, Tennessee, a Tertiary assemblage and ecosystem including mammals, reptiles, amphibians, and fossil pollen has been excavated (Desantis 2005; Schubert 2006; Whitelaw 2006). The site is approximately 161 km (100 miles) to the northeast of GRSM.

Although the Holston Formation is not found in the park, Tennessee has many sinkholes with multiple sinkholes in rocks of the Walden Creek Group (Licklog, Shields, Wilhite, and Sandsuck Formations) in GRSM (Southworth et al. 2006). Sinkholes occur within the Jonesboro Limestone at Cades Cove, Whiteoak Sink and Big Springsm. Similarly, there are sinkholes in the Shady Dolomite near Foothills Parkway at Walland (K. Langdon, GRSM Biologist, pers. commun., 2008).

Park Collections

According to the National Park Service museum catalog records database, there is one paleontological specimen with the GRSM park collections.

Paleontological Resource Management, Preliminary Recommendations

- The National Park Service Geologic Resources Division coordinated geologic scoping for GRSM between May 8-9, 2000. The participants of the GRSM Geologic Scoping meeting developed a series of recommendations for future work, including recommendations relative to paleontology.
- Given the diversity of paleontological resources in GRSM, as well as the potential for unauthorized collection, field-based paleontological resource inventories within the park are recommended. A specific survey to assess modern and fossil remains associated with karst resources should be undertaken.
- The park staff should develop a funding proposal to support a Pre-settlement Paleoenvironmental Assessment of Holocene and Pleistocene floral and faunal assemblages in the area within and around the Great Smoky Mountains.
- Paleontological resource localities within the park should be mapped and GIS data obtained to support long term management, protection, and research.
- Park staff should continue to be made aware of the potential for discovery of fossil material during other field work, particularly along road cuts, streams, creeks, gullies, and erosional features of the park.

Literature Cited

Aleinikoff, J. N., S. C. Southworth, and M. J. Kunk. 2007. SHRIMP U-Pb geochronology of zircon and titanite and $^{40}Ar/^{39}Ar$ of hornblende and muscovite from Mesoproterozoic rocks of the Western Blue

Ridge, Great Smoky Mountains National Park area, TN and NC. Abstracts with Programs – Geological Society of America **39**(2):78.

Benedict, G. L. 1977. Stop 3: Lenoir, Holston, and Ottosee Formations: shallow shelf lagoon, deeper shelf, and shelf marginal environments. Pages 52-59 *in* Ruppel, C. S. and K. R. Walker (editors). The ecostratigraphy of the middle Ordovician of the southern Appalachains (Kentucky, Tennessee, and Virginia), USA: A field excursion. University of Tennessee, Department of Geological Sciences, Knoxville. Studies in Geology 77-1.

Bergstrom, S. M. 1977a. Conodont and graptolite biostratigraphy of the Mosheim section. Pages 130-134 *in* Ruppel, C. S. and K. R. Walker (editors). The ecostratigraphy of the middle Ordovician of the southern Appalachains (Kentucky, Tennessee, and Virginia), USA: A field excursion. University of Tennessee, Department of Geological Sciences, Knoxville. Studies in Geology 77-1.

Bergstrom, S. M. 1977b. Notes on the conodont biostratigraphy of the Alcoa Highway section. Pages 74-76 *in* Ruppel, C. S. and K. R. Walker (editors). The ecostratigraphy of the middle Ordovician of the southern Appalachains (Kentucky, Tennessee, and Virginia), USA: A field excursion. University of Tennessee, Department of Geological Sciences, Knoxville. Studies in Geology 77-1.

Bergstrom, S. M. 1977c. Notes on the conodont biostratigraphy of the Hiwasee River section south-southeast of Charleston. Pages 74-76 *in* Ruppel, C. S. and K. R. Walker (editors). The ecostratigraphy of the middle Ordovician of the southern Appalachains (Kentucky, Tennessee, and Virginia), USA: A field excursion. University of Tennessee, Department of Geological Sciences, Knoxville. Studies in Geology 77-1.

Bergstrom, S. M. and J. B. Carnes. 1976. Conodont biostratigraphy and paleoecology of the Holston Formation (middle Ordovician) and associated strata in eastern Tennessee. Geological Association of Canada Special Paper **15**:27-57.

Davidson, J. L. 1983a. Paleoecological analysis of Holocene vegetation, Lake in the Woods, Cades Cove, Great Smoky Mountains National Park. Thesis. University of Tennessee.

Delcourt, P. A. 1980. Quaternary alluvial terraces of Little Tennessee River valley, east Tennessee. University of Tennessee Department of Anthropology Report of Investigations **29**:110-121 and 175-212.

Desantis, L. R. and S. C. Wallace. 2005. Anomalous paleoecology of a Neogene fossil site, Gray, TN, USA: Using stable isotope analyses to interpret canopy density. Abstracts with Programs – Geological Society of America **37**(7):340.

Gould, S. J. 1989. Wonderful life: the Burgess Shale and the nature of history. W.W. Norton and Company, New York.

King, P. B., R. B. Neuman, and J. B. Hadley. 1968. Geology of the Great Smoky Mountains National Park, Tennessee and North Carolina. U.S. Geological Survey, Reston, VA. Professional Paper 587.

Kochel, R. C. 1990. Humid fans of the Appalachian Mountains. Pages 109-129 *in* Rachocki, A. H. and M. Church (editors). Alluvial fans: A field approach. Wiley & Sons, New York.

Laurence, R. A. 1963. Rediscovery of the Murray Gap locality, Blount County, Tennessee. Geological Society of America Special Papers **76**:248-249.

Laurence, R. A. and A. R. Palmer. 1963. Age of the Murray Shale and Hesse Quartzite on Chilhowee Mountain, Blount County, Tennessee. Pages C53-C54 *in* U.S. Geological Survey, Reston, VA. Professional Paper 475-C.

Leigh, D. S. and P. A. Webb. 2006. Holocene erosion, sedimentation, and stratigraphy at Raven Fork, Southern Blue Ridge Mountains, USA. Geomorphology **78**:161-177.

Moore, H. L. 1988. A roadside guide to the geology of the Great Smoky Mountains National Park. The University of Tennessee Press, Knoxville.

Moore, N. K. 1977. Distribution of the benthic algal flora in middle Ordovician carbonate environmental units of the southern Appalachians. Pages 18-29 *in* The ecostratigraphy of the middle Ordovician of the southern Appalachains (Kentucky, Tennessee, and Virginia), USA: A field excursion. University of Tennessee, Department of Geological Sciences, Knoxville. Studies in Geology 77-1.

Neuman, R. B. and W. H. Nelson. 1965. Geology of the western Great Smoky Mountains, Tennessee. U.S. Geological Survey, Reston, VA. Professional Paper 349-D.

Neuman, R. B. 1947. Notes on the Geology of Cades Cove, Great Smoky Mountains National Park, Tennessee. Journal of the Tennessee Academy of Science **22**(3):167-172.

Repetski, J. E. 1997. Paleozoic fossils in Cades Cove, Great Smoky Mountains National Park, Tennessee and North Carolina. U.S. Geological Survey, Reston, VA. Open-File Report 97-0747.

Repetski, J. E., R. D. Hatcher, Jr., S. C. Southworth, and J. R. Thigpen. 2006. Conodonts from the Walden Creek Group, southeastern Tennessee. Abstracts with Programs – Geological Society of America **38**(3): 66.

Resser, C. E. 1938. Cambrian system (restricted) of the southern Appalachians. Geological Society of America Special Paper **15**:140.

Robison, N. D. 1981. A description of the Pleistocene faunal remains recovered from Finger Quarry, Blount County, Tennessee. Journal of the Tennessee Academy of Science **55**(1):68-71.

Schubert, B. W. 2006. On the identification of fossil salamanders and snake: A case study from the Mio-Pliocene Gray Fossil Site of Tennessee. Abstracts with Programs – Geological Society of America **38**(3):85.

Schultz, A., S. Southworth, C. Fingeret, and T. Weik. 2000. Geology of the Mount Le Conte 7.5-minute quadrangle, Great Smoky Mountains National Park, Tennessee and North Carolina. U.S. Geological Survey, Reston, VA. Open-File Report 00-0261.

Southworth S., A. P. Schultz, D. Denenny, M. J. Kunk, J. N. Aleinikoff, N. D. Naeser, C. W. Naeser, and A. Matmon. 2006. New geologic map and geochronology of the Great Smoky Mountains National Park region, Tennessee and North Carolina. Abstracts with Programs - Geological Society of America **38**(3):78.

Walcott, C. D. 1890. The fauna of the lower Cambrian or *Olenellus* zone. Pages 509-763 *in* U.S. Geological Survey, Reston, VA. 10th Annual Report.

Walker, K. R., 1977. Stop 5: Holston and Chapman Ridge Formations; shelf edge skeletal sand banks, organic buildups, and quartzose-sand-wave environments. Pages 68-73 *in* Ruppel, C. S. and K. R. Walker (editors). The ecostratigraphy of the middle Ordovician of the southern Appalachains

(Kentucky, Tennessee, and Virginia), USA: A field excursion. University of Tennessee, Department of Geological Sciences, Knoxville. Studies in Geology 77-1.

Walker, K. R., S. P. Dunagan, B. Glumac, E. C. Rankey, K. Srinivasan, and A. Stefaniak. 1995. Sequence stratigraphy and evolution of a Cambrian platform carbonate succession, Southern Appalachians. Pages 174-224 *in* Driese, S. D. (editor). Guidebook for field trip excursions, Southeastern Section, GSA. University of Tennessee, Department of Geological Sciences, Knoxville. Studies in Geology 24.

Walker, K. R. and K. F. Ferrigno. 1973. Major middle Ordovician reef tract in east Tennessee. American Journal of Science **273**-A:294-325.

Whitelaw, M. J. 2006. Stratigraphy and palynology of the Mio-Pliocene Gray Fossil Site, Washington County, east Tennessee. Abstracts with Programs – Geological Society of America **38**(3):78.

Additional References

Davidson, J. L. 1982. Paleoecological analysis of Holocene vegetation, Lake in the Woods, Cades Cove, Great Smoky Mountains National Park. Association of Southeastern Biologists Bulletin **29**:57.

Davidson, J. L. 1983b. Holocene vegetational and climatic changes in Cades Cove, Great Smoky Mountains National Park. Ecological Society of America Bulletin **64**:132.

Hack, J. T. 1982. Physiographic divisions and differential uplift in the Piedmont and Blue Ridge. U.S. Geological Survey, Reston, VA. Professional Paper 1265.

Hack, J. T. 1989. Geomorphology of the Appalachian Highlands. Pages 459-470 *in* Hatcher, R. D., W. A. Thomas, and G. W. Viele (editors). The Appalachian-Ouachita Orogen in the United States. Geological Society of America, Boulder, CO. The Geology of North America F-2.

Harris, L. D. and K. C. Bayer. 1979. Sequential development of the Appalachian Orogen above a master decollement – a hypothesis. Geology **7**:568-572.

Hatcher, R. D., W. A. Thomas, P. A. Geiser, A. W. Snoke, S. Mosher, and D. V. Wiltschko. 1989. Alleghanian Orogen. Pages 233-318 *in* Hatcher, R. D., W. A. Thomas, and G. W. Viele (editors). The Appalachian-Ouachita Orogen in the United States. Geological Society of America, Boulder, CO. The Geology of North America F-2.

Neuman, R. B. 1946. Fauna from the Great Smoky Mountains National Park, Tennessee. Geological Society of America Bulletin **57**:1219.

Osberg, P. H., J. F. Tull, P. Robinson, R. Hon, and J. R. Butler. 1989. The Acadian Orogen. Pages 179-232 *in* Hatcher, R. D., W. A. Thomas, and G. W. Viele (editors). The Appalachian-Ouachita Orogen in the United States. Geological Society of America, Boulder, CO. The Geology of North America F-2.

Rankin, D. W., A. A. Drake, L. Glover, R. Goldsmith, L. M. Hall, D. P. Hall, D. P. Murray, N. M. Ratcliffe, J. F. Read, D. T. Secor, and R. S. Stanley. 1989. Pre-orogenic features. Pages 7-100 *in* Hatcher, R. D., W. A. Thomas, and G. W. Viele (editors). The Appalachian-Ouachita Orogen in the United States. Geological Society of America, Boulder, CO. The Geology of North America F-2.

Repetski, J. E. 1998. Inventory of Paleozoic Fossils in Cades Cove, Great Smoky Mountains National Park, Tennessee. Pages 99-102 *in* National Park Service Paleontological Research. Geologic Resources Division, Denver, CO. Technical Report NPS/NRGRD/GRDTR- 98/01.

Rodgers, J. 1953. Geologic map of east Tennessee with explanatory text. Tennessee Division of Geology, Nashville. Bulletin 58.

Ruppel, C. S. and K. R. Walker (editors). 1977. The ecostratigraphy of the middle Ordovician of the southern Appalachains (Kentucky, Tennessee, and Virginia), USA: A field excursion. University of Tennessee, Department of Geological Sciences, Knoxville. Studies in Geology 77-1.

Sitterly, P. 1976. Paleoecological analysis of the Meadow Marble (Middle Ordovician) in Blount County, Tennessee. Thesis. University of Tennessee, Knoxville.

Southworth, S., P. Chirico, and T. Putbrese. 1999. Geologic story and map of parts of the Cades Cove and Calderwood quadrangles, Tennessee and North Carolina, Great Smoky Mountains National Park. U.S. Geological Survey, Reston, VA. Open- File Report 99-0175. Scale 1:24,000.

Stewart. K. G. and M. R. Roberson. 2007. Exploring the Geology of the Carolinas. University of North Carolina Press, Chapel Hill.

Unrug, R. and S. Unrug. 1990. Paleontological evidence of Paleozoic age for the Walden Creek Group, Ocoee Supergroup. Tennessee Geology **18**:1041-1045.

Data Sets

Great Smoky Mountains National Park Paleontological Archives
5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Great Smoky Mountains National Park Files and Archives
1934–present. (letters, notes, exhibit text, etc.). Originated by GRSM staff; status: Active.

Great Smoky Mountains National Park Museum Collection
1934–present. (museum specimen; associated specimen notes; collection records; maps; etc.). Originated by GRSM staff; status: Active.

U.S. Geological Survey Paleontology Collections, Cades Cove, Great Smoky Mountains National Park
1975–present. (fossils, field notes, photographs, etc.). Originated by John Repetski; status: Active.

Obed Wild and Scenic River

Obed Wild and Scenic River (OBRI) encompasses 72 km (45 miles) of free-flowing protected streams in eastern Tennessee. The park was authorized on October 12, 1976, and stretches over more than 2,093 ha (5,173 acres; 67% federal). The Obed River and its two main tributaries, Clear Creek and Daddy's Creek, cut into the Cumberland Plateau providing some of the most rugged scenery in the southeast portion of the United States. The park was established to protect the natural and historical resources of this portion of the Cumberland Plateau. Settled by early Native Americans and pioneers, the scenery of the park looks much the same as it did hundreds of years ago, and helps to preserve the early birthplace of the nation. OBRI offers visitors Class II through IV white-water, camping, hiking and other outdoor recreational activities.

Baseline Paleontological Resource Inventories

Obed Wild and Scenic River is situated within the Cumberland Plateau physiographic province of Tennessee. The site is located in Cumberland and Morgan counties. The terrain consists of rolling uplands and deeply incised river and stream drainages. The Cumberland Plateau is apparent by the long cliffs which separate it from the lower elevations of the Valley and Ridge physiographic province. The same mountain-building forces that resulted in the Southern Appalachian Mountains and deformed the rocks of the Valley and Ridge formed the structures of the Cumberland Plateau. Rocks along the eastern escarpment of the plateau and many miles westward along some zones were extensively faulted and folded.

OBRI covers six 1:24,000 topographic quadrangles, of which the three northern quadrangles (Jones Knob, Twin Bridges, and Pilot Mountain) have completed geologic maps (E. Foust, Tennessee Division of Geology, Geologist, pers. commun., 2008). The northeast portion of the Obed watershed is drained by the Emory River. This area is more mountainous and a dendritic drainage pattern has developed with a system of streams which flow through narrow valleys. The Obed River watershed is immediately underlain by gently dipping Pennsylvanian sandstones, siltstones, shales, some conglomerates, and coals. These rocks have a thickness of about 457 m (1,500 ft).

The geology of east-central Tennessee is predominantly composed of Pennsylvanian sandstones, shales and conglomerates. The thick Pennsylvanian sedimentary sequence one time capped most of the area and protects the underlying Paleozoic rocks. In deeper canyons and river cuts, the older Mississippian limestones are exposed. The Pennington Formation of Mississippian age is a transition from the basal Pennsylvanian sandstone and shale to underlying Mississippian carbonate rocks that are along the Sequatchie Valley escarpment, Grassy Cove, and smaller cove areas south-southeast of the watershed boundary.

The present topography has been formed by continuous lowering of the surface by erosion, a process that involves slope retreat on beds of different resistance. Pennsylvanian sandstones were removed by erosion from the Central Part of the Nashville Dome (structural high along the Cincinnati Arch) during the Mesozoic Era and the underlying Mississippian limestones were exposed. Slope retreat by limestone dissolution then began forming an escarpment and initiated its subsequent retreat in all directions away from the dome (Crawford 1982). Erosion continued both downward and outward and a plainlike surface developed upon the more cherty and erosion resistant lower Mississippian rocks during the late Cretaceous period (Miller 1974).

Along the escarpments of the Cumberland Plateau are rather narrow but important areas of karst. Caves and karst features are abundant in this region, with most of the larger caves occurring in the Monteagle Limestone near the base of the escarpment. The base of the escarpment usually corresponds to an area of cherty St. Louis Limestone and Warsaw Formation. Maps of reported cave locations in Middle Tennessee show highest concentrations of caves along two somewhat parallel lines that trend northeast-southwest.

The easternmost line corresponds with the western escarpment of the Cumberland Plateau while the other corresponds with the escarpment of the Highland Rim. In both locations, one finds a similar relationship between erosion resistant caprock and underlying weak limestones.

Churnet (1996) reports that within the Pennsylvanian siliciclastics of the Cumberland Plateau in Tennessee are discontinuous coal seams. Typically above these coal seams are shale deposits which contain fossilized remains of marine and brackish fauna. Although there is the potential for fossils within the Pennsylvanian sedimentary rocks within OBRI, there are currently no known fossil localities within the park (R. Schapansky, OBRI Resource Management Spec., pers. commun., 2008).

Crab Orchard Mountain Group (Pennsylvanian)

The Crab Orchard Mountain Group is a Pennsylvanian-aged unit which consists of near littoral and marginal marine sedimentary deposits (Milici 1974, 2005). The Crab Orchard Mountain Group includes the basal Sewanee Conglomerate, Whitewall Shale, Bon Air / Newton Sandstone, Vandever Shale and Rock Castle Conglomerate / Sandstone (Stearns 1954). The Crab Orchard Mountain strata is the principle geologic unit along the banks of the Obed River.

Although fossils are not specifically identified from the Crab Orchard Mountain Group from within the boundaries of OBRI, Pepper (1996) speculates the probable occurrence of the palynological species *Florinites mediapudens* in the upper portions of the Crab Orchard Mountain Group.

Crab Orchard Mountain Group (Pennsylvanian): Bon Air / Newton Sandstone / Whitewell Shale

The Newton Sandstone is gray to brown or pink, fine to medium grained sandstone unit. The Newton is locally conglomeratic (Hardeman 1963). The Whitewell Shale is a mostly dark-gray to light-brown shale. There are some minor siltstones and sandstone lenses within the Whitewell. The Richland coal occurs near the base and the Sewanee coal occurs in the upper portion of the Whitewall Shale. Locally the Whitewell Shale may be exposed beneath the Newton Sandstone (M. Hoyal, Tennessee Division of Geology, Geologist, pers. commun., 2008).

An amphibian trackway was discovered within the Whitewell Shale at Lookout Mountain, Georgia (Schneck and Fritz 1985). The tracks exhibit pentadactyly (5 digits) in both the manus (hand) and pes (foot) and represent the first occurrence of Paleozoic amphibian remains from Georgia. The tracks were associated with a tidal flat facies in the Whitewell Shale which immediately underlies a thick massive channel lens of the Newton Sandstone (Schneck and Fritz 1985).

Crab Orchard Mountain Group (Pennsylvanian): Vandever Shale

The Vandever Shale is a Pennsylvanian sandy shale and siltstone unit with thin sandstone and coal beds. The shale is predominantly dark-gray to light brown in color. Two prominent coal beds occur in the Vandever Shale known as Lantana and Morgan Springs coal beds. This unit crops out in steep slopes at OBRI (Butts 1919).

Crab Orchard Mountain Group (Pennsylvanian): Rockcastle Conglomerate / Sandstone

The Rock Castle Sandstone is a Pennsylvanian aged unit consisting of gray to brown, medium to coarse grained sandstone. This thick-bedded sandstone is locally conglomeratic with quartz pebbles and forms an extensive caprock in east-central Tennessee (Butts 1919). A thin coal-bearing shale is locally present near the middle of this unit (Hardeman 1963).

Quaternary Alluvium / Colluvium

Quaternary alluvium and colluvium are extensive along the escarpment of the Cumberland Plateau. These deposits consist of a mixture of boulder-size sandstone blocks to finer grained materials. These alluvial

and colluvial deposits are very limited at OBRI based upon the configuration of the park boundary along the river.

Park Collections

According to the park curator, the OBRI park collections do not contain any paleontological specimens (R. Schapansky, OBRI Resource Management Spec., pers. commun., 2008).

Paleontological Resource Management, Preliminary Recommendations

- The National Park Service Geologic Resources Division coordinated geologic scoping for OBRI during June 2007. The participants of the OBRI Geologic Scoping meeting developed a series of recommendations for future work, including recommendations relative to paleontology.
- Park staff should continue to be made aware of the potential for discovery of fossil material during other field work, particularly along rivers, streams, creeks, gullies, and other erosional features of the park.
- The park may consider working with a local university, college, or the state geological survey to undertake field inventories for fossils.

Literature Cited

Butts, C. 1919. Geology and oil possibilities of the northern part of Overton County, Tennessee, and of adjoining parts of Clay, Pickett, and Fentress counties. Tennessee Geological Survey, Nashville. Bulletin 24.

Churnet, H. G. 1996. Depositional environments of Lower Pennsylvanian coal-bearing siliciclastics of southeastern Tennessee, northwestern Georgia, and northeastern Alabama, USA. International Journal of Coal Geology **31**(1-4):21-54.

Crawford, N. C. 1982. Karst Hydrogeology of Tennessee. *in* Guidebook for Karst Hydrogeology Workshop, Nashville, Tennessee, August 31- September 3, 1982.

Hardeman, W. D. 1966. Geologic Map of Tennessee. Tennessee Division of Geology, Nashville. Scale 1:250,000.

Milici, R. C. 2005. Appalachian coal assessment: Defining the coal systems of the Appalachian basins. Pages 9-30 *in* Warwick, P. D. (editor). Coal Systems. Geological Society of America, Boulder, CO. Special Paper 387.

Milici, R. C. 1974. Stratigraphy and depositional environments of Upper Mississippian and Lower Pennsylvanian rocks in the Southern Cumberland Plateau of Tennessee. Pages 115-133 *in* Briggs, G. (editor). Carboniferous of the Southeastern United States. Geological Society of America, Boulder, CO. Special Paper 148.

Miller, R. A. 1974. The Geologic History of Tennessee. Tennessee Division of Geology, Nashville. Bulletin 74.

Pepper, R. A. 1996. Palynological correlation of major Pennsylvanian chronostratigraphic boundaries in the Illinois Basin and other coal basins. Geological Society of America, Boulder, CO. Memoir 188.

Schmalzer, P.A., C.R. Hinkle, and H.R. DeSelm. 1980. Vegetation patterns in a section of the Obed Wild and Scenic River, Cumberland County, Tennessee. Pages 257-272 *in* Proceedings of the Central

Hardwood Forest Conference 3. Online. (http://www.ncrs.fs.fed.us/pubs/ch/ch03/CHvolume03page257.pdf). Accessed 4 February 2008.

Schneck, W. M. and W. J. Fritz. 1985. Amphibian trackway (*Cincosaurus cobbi*) from the lower Pennsylvanian ("Pottsville") of Lookout Mountain, Georgia: First Occurrence. Journal of Paleontology **59**(5):1243-1250).

Stearns, R. G. 1954. The Cumberland Plateau overthrust and geology of the Crab Orchard Mountains area, Tennessee. Tennessee Division of Geology, Nashville. Bulletin 60.

Additional References

Barrett, H. E., Jr. 1979. Paleoenvironmentally determined maceral, lithotype, and elemental relationships in two coals of the Cumberland Plateau, Tennessee. M.S. Thesis. University of Tennessee at Knoxville, Knoxville.

Bayer, K. C. 1982. Map showing approximate eastern limit of commercial oil and gas fields in relation to structural features and physiographic provinces in the Appalachian region. U.S. Geological Survey, Reston, VA. Oil and Gas Investigations Chart OC-121. Scale 1:2,514,286.

Bergenback, R. E. 1978. Carboniferous depositional environments in the southern Cumberland Plateau. Pages 63-86 *in* Field Trips in the Southern Appalachians. Tennessee Division of Geology, Nashville. Report of Investigations 37.

Berry, E. W.1919. Upper Cretaceous floras of the eastern Gulf region in Tennessee, Mississippi, Alabama, and Georgia. U.S. Geological Survey, Reston, VA. Professional Paper 112.

Berry, W. B. N., A. J. Boucot, J. M. Berdan, G. Klapper, A. Martinsson, C. B. Rexroad, R. P. Sheldon, and A. M. Ziegler. 1970. Correlation of the North American Silurian rocks. Geological Society of America, Boulder, CO. Special Paper 102.

Cecil, C. B. and K. J. Englund. 1989. Origin of coal deposits and associated rocks in the Carboniferous of the Appalachian Basin. Pages 84-104 *in* Cecil, C. B. and C. F. Eble (editors). Coal and Hydrocarbon resources of North America; Volume 2: Carboniferous Geology of the Eastern United States. American Geophysical Union, Washington, DC. 28th International Geologic Congress Field Trip Guidebook T143.

Chestnut, D. R. 1994. Eustatic and tectonic control of deposition of the Lower and Middle Pennsylvanian strata of the central Appalachian basin. Pages 51-64 *in* Dennison, J. M. and F.R. Ettensohn (editors). Tectonic and Eustatic Controls on Sedimentary Cycles. SEPM, Tulsa, OK. Concepts in Sedimentology and Paleontology 4.

Churnet, H. G. and R. E. Bergenback. 1986. Depositional systems of Pennsylvanian rocks in the Cumberland Plateau of southeastern Tennessee. Georgia Geological Society. Fieldtrip Guidebook 6(4).

Cropp, F. W. 1963. Pennsylvanian spore succession in Tennessee. Journal of Paleontology **37**(4):900-916.

Devery, H. B. 1987. Analysis of the microfauna, facies variation, and stratigraphy of selected outcrops of the Bangor Limestone (Chesterian; Mississippian) in Colbert, Franklin, and Lawrence counties, Northwest Alabama. M.S. Thesis. Mississippi State University, Mississippi State, MS.

Devery, H. and C. Dewey. 1986. Chester (Mississippian) ostracodes from Bangor Formation of Black Warrior Basin, northern Alabama. AAPG Bulletin **70**(5):581.

Ettensohn, F. R. 1994. Tectonic control and cyclicity of major Appalachian unconformities and associated stratigraphic sequences. Pages 217-242 *in* J *in* Dennison, J. M. and F.R. Ettensohn (editors). Tectonic and Eustatic Controls on Sedimentary Cycles. SEPM, Tulsa, OK. Concepts in Sedimentology and Paleontology 4.

Ferguson, C. C. 1969. Geologic map of the Sparta Quadrangle, Tennessee. Tennessee Division of Geology, Nashville. Geologic Map 332-NW. Scale 1:24,000.

Garman, R. K. 1969. Geologic map of the Welchland Quadrangle, Tennessee. Tennessee Division of Geology, Nashville. Geologic Map 328-NE. Scale 1:24,000.

Gillespie, W. H. and H. W. Pfefferkorn. 1979. Distribution of commonly occurring plant megafossils in the proposed Pennsylvanian system stratotype. Pages 87-96 *in* Englund, K. J., H. H. Arndt, and T.W. Henry (editors). Proposed Pennsylvanian Systems Stratotype, Virginia and West Virginia. Ninth International Congress on Carboniferous Stratigraphy and Geology Meeting. Fieldtrip Guidebook 1.

Hass, W. H. 1956. Age and correlation of the Chattanooga Shale and the Maury Formation. U.S. Geological Survey, Reston, VA. Professional Paper 286.

Hassler, S. E. and C. W. Stock. 1993. Conodont biostratigraphy of the Tuscumbia Limestone, Pride Mountain Formation, and Monteagle Limestone. Pages 51-59 *in* Pashin, J. C. (editor). New perspectives on the Mississippian System of Alabama. Alabama Geological Society. Annual Field Trip Guidebook 30.

Kendall, J. M. 2004. A regional online fossil and stratigraphy guide for southeastern K-12 geoscience educators. Abstracts with Programs - Geological Society of America **36**(2):99.

Knox, L. W. 2005. Some unusual ostracodes from a dark shale in the Bangor Limestone (Carboniferous) of Alabama, U.S.A. Page 55 *in* Kohring, R. and B. Sames (editors). 15th international symposium on Ostracoda; program and abstracts. Berliner Palaeobiologische Abhandlungen 6.

Lawson, C. B. 1988. Paleocurrent and environment of deposition of the Rockcastle Conglomerate in the Northwest Cumberland Plateau area of Tennessee. Journal of the Tennessee Academy of Science **63**:24.

Lin, J.-P. and K. Hunter. 2001. Conodonts from the Bangor Limestone (Chesterian) near Huntsville, Alabama. Journal of the Tennessee Academy of Science **76**(1):27.

Lumsden, D. N. 2003. Organodiagenetic dolomite on a deep subtidal shelf, Fort Payne Formation (Mississippian), Tennessee, U.S.A. Pages 323-332 *in* Ahr, W. M., P. M. Harris, W. A. Morgan, and I. D. Somerville (editors). Permo-Carboniferous carbonate platforms and reefs. Society for Sedimentary Geology, Tulsa, OK. Special Publication 78.

Maples, C. G. 1990. *Harmostocrinus jonesi* n. sp. (Crinoidea); an evolutionary intermediate between *Abrotocrinus* and *Harmostocrinus*. Journal of Paleontology **64**(1):141.

Milici, R. C. 1969. Geologic map (and two coal maps) of the Spencer quadrangle, Tennessee. Tennessee Division of Geology, Nashville. Geologic Map 103-NW. Scale 1:24,000.

Miller, M. F. 1984. Distribution of biogenic structures in Paleozoic nonmarine and marine-margin sequences: An actualistic model. Journal of Paleontology **58**(2):550-570.

Miller, M. F., S. Jackson, A. K. Rindsberg. 2006. Marine margin and braided stream depositional environments recorded in lower Pennsylvanian rocks, northern Cumberland Plateau, Tennessee. Abstract with Programs - Geological Society of America **38**(3):86.

Rice, C. L. and J. F. Schwietering. 1988. Fluvial deposition model in central Appalachians during the early Pennsylvanian: Evolution of sedimentary basins – Appalachian Basin. Pages 1-10 *in* U.S. Geological Survey, Reston, VA. Bulletin 1839-B.

Rich, M. 1980. Carboniferous calcareous foraminifera from northeastern Alabama, south-central Tennessee, and northwestern Georgia. Cushman Foundation for Foraminiferal Research. Special Publication 18.

Rich, M. 1974. Upper Mississippian (Carboniferous) calcareous algae from northeastern Alabama, south-central Tennessee, and northwestern Georgia. Journal of Paleontology **48**(2):361-374.

Sanders, L. E. and L. W. Knox. 2003. Paleoecology of bryozoans from a Chesterian dark shale interval within the Bangor Limestone, Scottsboro Alabama. Abstracts with Programs - Geological Society of America **35**(1):66-67.

Schlee, J. 1963. Early Pennsylvanian currents in the Southern Appalachian Mountains. Geological Society of America Bulletin **74**:1439-1451.

Schoefernacker, S. R. and M. F. Miller. 2001. Recently Discovered Ancient (Pennsylvanian) Arthropod Trackways, Northern Cumberland Plateau. 2001 Meeting of the Middle Tennessee Division of the Tennessee Academy of Science. Unpublished Program.

Shaver, S. A., C. F. Eble, J. C. Hower, and F. L. Saussy. 2006. Petrography, palynology, and paleoecology of the Lower Pennsylvanian Bon Air coal, Franklin County, Cumberland Plateau, southeast Tennessee. International Journal of Coal Geology **67**(1-2):17-46.

Stapor, F. W., Jr. and D. L. North. 1999. Facies and conodont content of a condensed interval; Mississippian (Chesterian) Bangor Limestone, central Tennessee and North Alabama. AAPG Bulletin **83**(8):1373.

Stephenson, L. W. 1914. Cretaceous deposits of the eastern Gulf region and species of *Exogyra* from the eastern Gulf region and the Carolinas. U.S. Geological Survey, Reston, VA. Professional Paper 81.

Swingle, G. O. 1961. Structural Geology Along the Eastern Cumberland Escarptment, Tennessee. Tennessee Division of Geology, Nashville. Report of Investigations 13.

Wanless, H. R. 1946. Pennsylvanian geology of a part of the southern Appalachian coal fields. Geological Society of America, Boulder, CO. Memoir **13**.

Waters, J. A. 1986. Mississippian paleogeography and paleobiogeography of the Southern Appalachians and Ouachitas. Abstracts with Programs - Geological Society of America **18**(3):271.

Waters, J. A. 1980. Paleontology and biostratigraphy of the upper Bangor Limestone (Mississippian) around Lookout Mountain, Georgia – Tennessee. Georgia Geologic Survey, Atlanta. Open-File Report 80-9.

Waters, J. A. 1978. The paleontology and paleoecology of the lower Bangor Limestone (Chesterian, Mississippian) in northwestern Alabama. Dissertation. Indiana University, Bloomington.

White, J. F. 1975. Depositional environments of Pennsylvanian Redoak Mountain Formation, northern Cumberland Plateau, Tennessee. M.S. Thesis. University of Tennessee, Knoxville.

White, J. F. and G. Briggs. 1974. Pennsylvanian depositional environments in the Cumberland Plateau of northern Tennessee. Abstracts with Programs - Geological Society of America **6**(4):411.

Wilson, C. W., J. W. Jewell, and E. T. Luther. 1956. Pennsylvanian geology of the Cumberland Plateau. Tennessee Division of Geology, Nashville.

Data Sets

Obed Wild and Scenic River Paleontological Archives
5/1985–present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

Obed Wild and Scenic River Files and Archives
1976–present. (letters, notes, exhibit text, etc.). Originated by OBRI staff; status: Active.

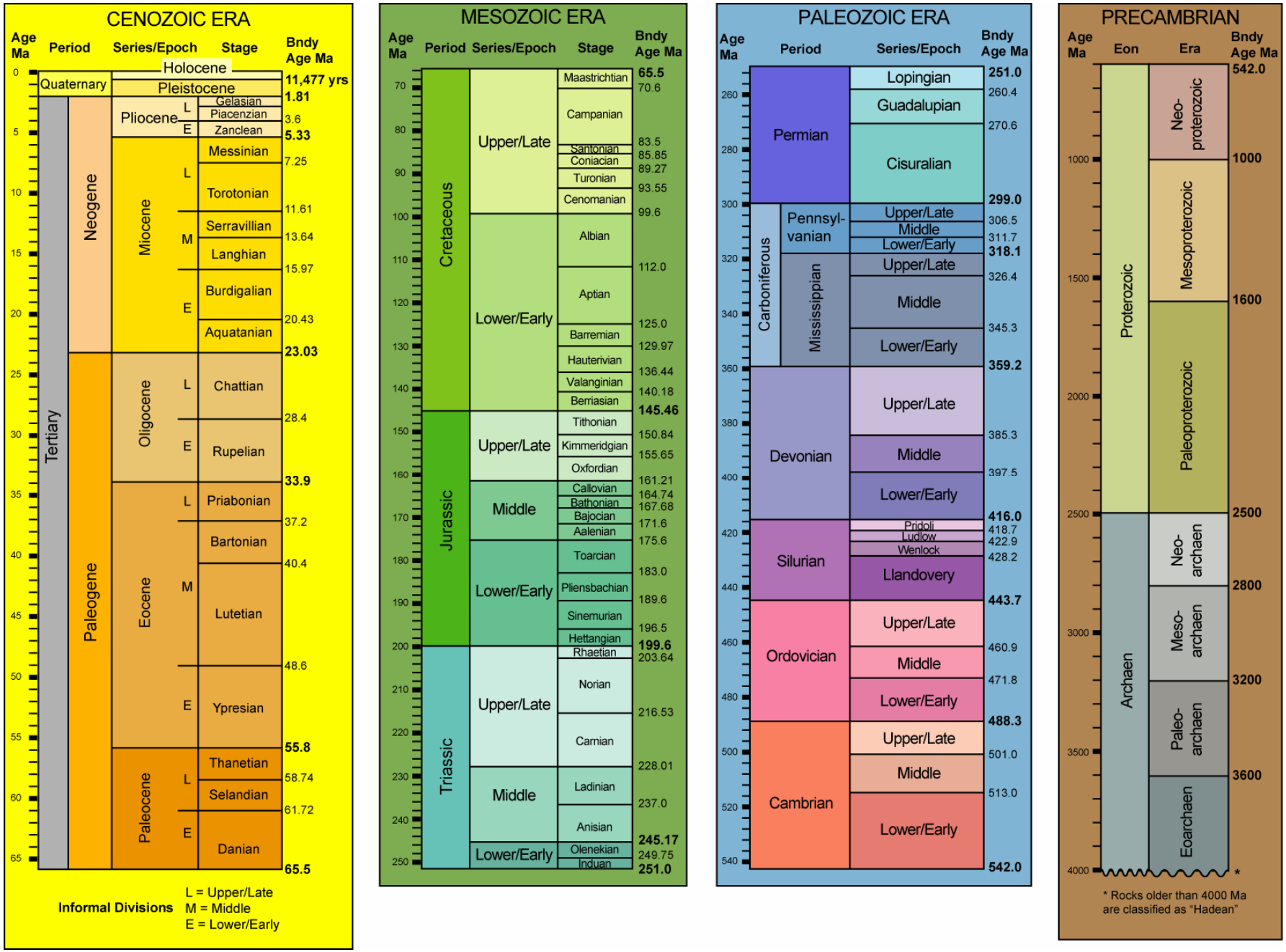


Figure 2. Geologic Time Scale. *Ma = Millions of year old. Bndy Age = Boundary Age*. Colors are USGS standard colors found on geologic maps. Modified from 1999 Geological Society of America Time scale (www.geosociety.org/science/timescale/timescl.pdf). Boundary dates and additional information from 2004 International Commission on Stratigraphy (www.stratigraphy.org/gssp.htm) and U.S. Geological Survey Fact Sheet 2007-3015 (http://pubs.usgs.gov/fs/2007/3015/).

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS D-90, February 2008

National Park Service
U.S. Department of the Interior

Natural Resource Program Center



Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov