Geologic Resources Inventory Workshop Summary
Great Smoky Mountain National Park
May 8-9, 2000

National Park Service
Geologic Resources Division
and
Natural Resources Information Division

Version: Draft of July 24, 2000

EXECUTIVE SUMMARY

An inventory workshop was held for Great Smoky Mountain National Park (GRSM) on May 8-9, 2000 to view and discuss the park's geologic resources, to address the status of geologic mapping by the United States Geological Survey (USGS), various academics, the North Carolina Geological Survey (NCGS), and the Tennessee Geological Survey (TNGS) for compiling both paper and digital maps, and to assess resource management issues and needs. Cooperators from the NPS Geologic Resources Division (GRD), Natural Resources Information Division (NRID), NPS Great Smoky Mountain NP, USGS, NCGS, TNGS, University of Tennessee at Knoxville (UTK) and the Tennessee Department of Transportation (TDOT) were present for the two-day workshop. (***See Appendix A, Great Smoky Mountain NP Geological Resources Inventory Workshop Participants, May 8-9, 2000***)

Day one involved a field trip throughout Great Smoky Mountain NP led by USGS Geologist Scott Southworth.

Day two involved a daylong scoping session to present overviews of the NPS Inventory and Monitoring (I&M) program, the Geologic Resources Division, and the on going Geologic Resources Inventory (GRI) for North Carolina.

Round table discussions involving geologic issues for Great Smoky Mountain NP included interpretation, paleontologic resources, the status of cooperative geologic mapping efforts, sources of available data, geologic hazards, and action items generated from this meeting. Brief summaries follow.

OVERVIEW OF GEOLOGIC RESOURCES INVENTORY

After introductions by the participants, Tim Connors and Joe Gregson presented overviews of the Geologic Resources Division, the NPS I&M Program, the status of the natural resource inventories, and the GRI in particular (*see Appendix B, Overview of Geologic Resources Inventory*).

They also presented a demonstration of some of the main features of the **digital geologic map** for the Black Canyon of the Gunnison NP and Curecanti NRA in Colorado. This has become the prototype for the NPS digital geologic map model as it reproduces all aspects of a paper map (i.e. it incorporates the map notes, cross sections, legend etc.) with the added benefit of being geospatially referenced. It is displayed in ESRI ArcView shape files and features a built-in help file system to identify the map units. It can also display scanned JPG or GIF images of the geologic cross sections supplied with the map. Geologic cross section lines (ex. A-A') are subsequently digitized as a line coverage and are hyperlinks to the scanned images.

The developing NPS theme browser was also demonstrated for adding GIS coverage's into projects "on-the-fly". With this functional browser, numerous NPS themes can be added to an ArcView project with relative ease. Such themes might include geology, paleontology, hypsography (topographic contours), vegetation, soils, etc.

The NPS GRI (Geologic Resources Inventory) has the following goals:

1. to assemble a bibliography of associated geological resources for NPS units with significant natural resources; "GRBIB",

2. to compile and evaluate a list of existing geologic maps for each unit,

3. to develop digital geologic map products, and

4. to complete a geological report that synthesizes much of the existing geologic knowledge about each park.

It is stressed that the emphasis of the inventory is ***not*** to routinely initiate new geologic mapping projects, but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System. In cases where map coverage is nearly complete (ex. 4 of 5 quadrangles for Park "X") or maps simply do not exist, then funding may be available for geologic mapping.

GRBIB

During the scoping session, each park is presented with a compiled, park specific geologic bibliography as compiled by GRI staff. The sources for this compiled information are as follows:

- AGI (American Geological Institute) GeoRef
- USGS GeoIndex

- ProCite information taken from specific park libraries

These bibliographic compilations are then validated by NPS staff to eliminate duplicate citations and typographical errors, and check for applicability to the specific park. After validation, they become part of a Microsoft Access database parsed into columns based on park, author, year of publication, title, publisher, publication number, and a miscellaneous column for notes.

From the Access database, they are exported as Microsoft Word Documents for easier readability, and eventually turned into PDF documents. They are then posted to the GRI website at: http://www2.nature.nps.gov/grd/geology/gri/products/geobib/ for general viewing.

Upon review of the compiled bibliography, Bob Hatcher (UTK) noted that many applicable publications were missing from our outputs. He has since supplied a list of relevant publications to GRD to add to the bibliographic database.

EXISTING GEOLOGIC MAPS

After the bibliographies were assembled, a separate search was made for any existing surficial and bedrock geologic maps for Great Smokies. The bounding coordinates for each map were noted and entered into a GIS to assemble an index geologic map. Separate coverage's were developed based on scales (*1:24,000, 1:100,000*, etc.) available for the specific park.

Numerous geologic maps at varying scales and vintages cover the Great Smokies area. In addition, the USGS is currently involved in a comprehensive project to refine the mapping of GRSM, led by Scott Southworth. See Appendices C and D for a list of geologic quadrangle maps and their status.

DEVELOPING GEOLOGIC PRODUCTS

GRSM Perspective

Some of the main geologic issues that GRSM staff are interested in are:

- Geologic hazards (landslides, debris flows, earthquakes);
- Complete geologic map coverage for all of GRSM at 1:24,000 scale;
- Interpretation of geologic features and processes for the visiting public to explain how landscapes have changed and why people have come to this region over the years.
- geology as it relates to the ATBI (all taxa biologic inventory); and
- man's effects on natural processes

Geologic hazards are a common theme at GRSM because of landslides and debris flows that can affect the visiting public (estimated at 10 million per year) and destroy park roads. Earthquakes are also of interest to park staff. Seismic stations in the area are sparse. It was suggested to have one in the park, as this is one of the higher earthquake activity areas east of the New Madrid Fault zone. Unfortunately, earthquakes usually only receive attention after they've occurred. Bob Hatcher

mentioned that UTK has a website on earthquake activity in the region at: http://tanasi.gg.utk.edu/quakes.html

Keith Langdon (GRSM) gave the group some background on why the park thinks geology is important to understanding the other natural resources of GRSM. The ATBI (all taxa biologic inventory) currently underway relies heavily on geology and its influences on soils and general geochemistry of the park. GRSM would like to derive "probability" maps based upon these associations to better predict biologic distributions.

GRSM does not have a staff geologist, so in 1992 they requested assistance from the USGS for help in geologic mapping, mining issues and general understanding of geomorphic/geologic features and processes.

Geology plays a large role in ecosystem management and is thus a major component for understanding species distribution, soils and general geochemistry as it pertains to the ATBI. With sufficient geologic data, it should be possible to derive "probability" maps based upon these associations.

Chuck Parker (USGS-Biologist stationed at GRSM) talked of how man's activities have disrupted biologic processes in the park, specifically where Anakeesta metasediments have been used as road fill. The highly acidic nature of the Anakeesta Formation has indirectly resulted in affecting fish and salamander populations in the Newfound Gap area negatively.

Chuck is also interested in the timing for waterfall development in the park, especially at Black Creek Falls (?). Fish populations above the waterfalls are important to the biologic story and he hopes that geologic data will give him some controls on when these features developed. Bob Hatcher talked of recent uplift and the subsequent effects on drainages being the major control on these features. The evolving science of cosmogenic isotope dating may be able to shed more information on this subject; dates of ~172,000 year exposure were mentioned for the area.

Chuck would like to know if there are geologic controls related to the floral-faunal break between southern and northern brook trout.

USGS Perspective

Scott Southworth updated the group on the existing USGS project to conduct regional geologic mapping and produce digital geologic databases for GRSM to support the ATBI.

Some of the more interesting things about GRSM geology for Scott are:

- Sulfitic rocks;
- Large areas with debris flows underlain by Anakeesta and Chilhowee rock types;
- Karst areas;
- Limestones in Foothills block of Walden Creek Group and Cosby;
- Mapping the geology correctly and producing a usable geologic database.

- Evidence east of Gatlinburg lending support to neotectonics in park(fission track data suggest post Cretaceous uplift along fault system;
- fans in Cosby area where bedrock geology is Greenbriar, Dunn Creek and Great Smoky and all converge at one site in foothills
- abandoned meanders of Little River;
- White Oak Sink;
- Big Spring Cove area has a window based on geomorphology;
- Cades Cove;
- well developed elevated colluvial terraces of Tuckasegee River near Bryson City;
- Foothills Parkway has geomorphic bedrock controlled features (perched, abandoned valley sitting up high)

He distributed "USGS Project: Geology of the Great Smoky Mountains NP", which summarized USGS activities at GRSM. The joint NPS-USGS project was initiated in October 1992 by the NPS Southeast Region and an interagency agreement was developed.

Its initial goals were to:
- produce geologic maps for unmapped *1:24,000* quadrangles;
- upgrade existing *1:62,500* scale mapping to *1:24,000* scale;
- conduct detailed surficial mapping of the entire park; and
- develop digital geologic map coverage for use in a park-wide GIS

As a result, the following quadrangles have been mapped and published:
- Fontana Dam and Tuskeegee (Southworth 1995; OF 95-264)
- Mount LeConte (Schultz 1998; OF 98-32)
- Cades Cove (Southworth et al. 1999; OF 99-175; http://geology.er.usgs.gov/eespteam/smoky/cades_cove/Cades_Cove_WP/introduction.htm)
- Mount Guyot, Luftee Knob and Cove Creek (Schultz 1999; OF 99-536)

Additionally, other miscellaneous products to date include:
- Report on Sulfidic rocks of Lakeshore Drive "Road to Nowhere" (?? correct terminology) for Senator Helms inquiry, Interpretation workshop with Gene Cox, and report on secondary minerals from weathering of Anakeesta Formation at Alum Cave (Flohr et al. 1995; OF 95-477)
- Report on water chemistry related to Fontana Mine and sulfidic rocks (Seal et al. 1998; OF 98-476 and Seal et al. 1999; OF 99-375)
- Report on Paleozoic fossils (Repetski 1999; NPS-GRD Technical Report 98-1
- Various abstracts on fission track analysis for uplift rates (Naesers)
- Folio on Geologic map (which Scott considers as only preliminary at this time) and geologic history of Great Smoky Mountains NP; a visitors guide (Great Smoky Mountains Natural History Association in cooperation with USGS, 2000)

Anticipated products in the near future are:

- Digital Mount LeConte quadrangle (Schultz) and website (Southworth)
- *1:100,000* scale geologic compilation map for GRSM
- geochemistry of black sulfidic shales (Foley)
- lithogeochemistry of bedrock units (Robinson)
- Remote sensing (Rowan)
- Fission track for timing of uplift (Naesers)
- Be10 dating of erosion surfaces and surficial deposits

More details on these projects can be found at:
http://geology.er.usgs.gov/eespteam/smoky/smoky.html

Scott hopes to work closely with NRCS (Natural Resource Conservation Service) personnel who are currently mapping the soils so as to integrate USGS work and make sure that it can all be incorporated into a master geologic database.

Scott displayed a new plot of vegetation classes (*1:125,000 scale*) derived from LANDSAT data from spectral satellites, sometimes called HIMAP technology. This makes for a good mineralogical and vegetation mapping tool as it uses some 260 channels of spectral data at 0.01 micron resolution and 2 meter resolution. This particular map covered only the western edge of the park, and it is hoped that the entire park will be flown in the near future.

As of May 2000, the USGS project is only funded through December 2001 by the USGS. The NPS is very supportive of USGS efforts at GRSM and is willing to lend any support to ensuring the continuance of this project until completion. Scott has requested a letter from the acting GRSM superintendent as a show of support for continuing this project to give to his managers at the USGS. To date, it is unknown if such a letter has been sent by the park. GRI staff will follow up on this matter with GRSM staff.

Scott also mentioned that the existing topographic base map coverage leaves much to be desired and often hinders the geologic mapping process. Currently, base cartographic data are only available as DRGs (digital raster graphics). Joe Gregson thought that DLGs (digital line graphs) would be produced later this year that would be more useful in geologic analysis.

Scott is very interested in having a separate meeting with USGS, GRI and GRSM staff to further discuss the database he is developing and how it can fulfill the desired GRI goals. GRI staff intends to work closely and cooperatively to meet this goal.

USGS Professional Paper 349 is devoted to the geology of GRSM as follows

TNGS Perspective
Pete Lemiszki (TNGS) says that his group is not actively working in GRSM, but would like to have a better working relationship with the USGS, NCGS and NPS as it pertains to the geologic issues regarding GRSM. Specifically, Pete would be interested in

further studying fracture systems and the hydrology for applications in geohydrology, landslides, and geologic hazards.

Pete located the original 1948 geologic mapping park plan by Philip B. King in their archives; these documents may be of historical significance and GRD would like to obtain copies if possible for our "History of Geologic Exploration" section for our report.

Pete mentioned that TNGS has an agreement in place with USGS to digitize all existing quadrangles in Tennessee, and they are awaiting deliverables from the USGS. The format for the deliverables was unknown at the time of the meeting. The map was compiled in 1966 at 250,000 scale.

NCGS Perspective

Carl Merschat (NCGS) told the group that the NCGS was involved in a cooperative mapping project with the Tennessee Valley Authority (TVA), but most of their efforts have been concentrated along the Blue Ridge Parkway.

However, NCGS has published the Noland Creek quadrangle that was mapped as part of a graduate thesis. Also, the western half of the Asheville *1:100,000* sheet is slated for completion by 2006 and the eastern half by 2003. This sheet consists of 32 *1:24,000* quadrangles. Scott Southworth expressed interest in further discussing this mapping project with NCGS staff for stratigraphic correlations and identification of similar map units.

Academic Perspective

Bob Hatcher (UTK) has had numerous students mapping in and around GRSM for many years, including NCGS Geologist Mark Carter. Some of the mapping was done at *1:12,000* and compiled at 1:24,000 scale. The Dellwood and Bunches Bald quadrangles were specifically mentioned.

Bob mentioned a few things of interest to him regarding GRSM geology:

- Is the Cades Sandstone actually the Thunderhead
- The Web Mountain area appears to be a "window"
- Phil King (USGS mapper in 1940s) may have miscorrelated some units
- The NPS bibliography is missing numerous articles of relevance to GRSM that he knows of; he has since supplied those references to add to our bibliography
- He is very interested in seeing a geologic database for GRSM and hopes it will be an excellent resource for the geologic community for many years to come.
- He spoke of research to core in caves to determine the rates of earthquake occurrence in the region and use deformed flood plain sediments to deduce earthquake timing; use "teetering" rocks to know when earthquakes have occurred.

COMPONENTS OF THE DIGITAL DATABASE

Scott wants to make sure that any geologic database produced will be sufficient to answer questions like " Where are the greenstones, where is the colluvium that covers the greenstone, and how close is it to the waterfalls that contain fish X".

Harry Moore is very interested in the GIS containing a hazards layer and would like to see it buffered around the park boundary into populated areas.

GRSM has 28 quadrangles within its proper boundaries; it is desired to have each one of these mapped (if not already) at 1:24,000 scale and available digitally.

NRCS soils data should be able to integrate into the master geologic database

Keep cave locations confidential and exempt from EFOIA requests

Incorporate as much of the information from PP-349 into the database assuming the information is still geologically useful.

Have entire park compiled at 100,000 scale

Have good website on USGS and NPS-GRD outlining the geology

Geochemistry layer to show influence on landscape and soil formation; maybe use pH as factor to produce chemical variability maps. Use soil folks data

Draw correlations between soil-bedrock-vegetation

GEOLOGIC REPORT
It is the desire of the GRI to produce an encompassing geologic report for each park containing the following elements:

- History of Geologic Exploration
- Geologic Setting
- Geologic History
- Structure
- Unique Geologic Features
- Paleontology
- Disturbed Lands
- Geologic Hazards and Issues
- Geologic Data
- References
- Future Research topics
- Other topics and sections as needed

USGS Professional Paper 349 series is useful but does not cover all of the above topics adequately for NPS needs. Scott Southworth is producing additional reports on the geology of GRSM and it is hoped that his reports will cover the GRI bullets.

Other Issues

Interpretation

One goal of GRD is to promote geologic resource interpretation within the National Park Service. GRD has staff and technology to assist in preparation of useful materials including developing site specific bulletins, websites, and resource management proposal (RMP) statements appropriate to promoting geology. Jim Wood (GRD) and Melanie Moreno (USGS-Menlo Park, CA) have worked with several other NPS units in developing web-based geology interpretation themes, and should be considered as a source of assistance should the park desire. GRD has also received much positive recognition for the "Park Geology Tour of National Parks" and subsequent "Geology Field Notes" at http://www2.nature.nps.gov/grd/tour/index.htm. GRD posted these sites based on available park brochures, but they are always in need of fresh material. Park staff may wish to review these and suggest improvements to GRD.

Status of Soils Mapping

Note: Awaiting Pete Biggam (NPS-Soil Scientist) suggestions as of 2000-07-20

Paleontology

GRD provides support on policy and GPRA (government performance and results act) goals related to paleontological resources in parks. At the present time, Paleontology is ***not*** one of the main baseline natural resource inventories, but it has been included within the GRI.

NPS Paleontologists are in favor of a mandate for protecting paleontological resources within federal lands. GRD staff have led refresher-training courses for NPS rangers at multiple parks to raise awareness for the protection of paleontological resources. Often a first step is for parks to determine whether they have paleontological resources, and then to have a baseline inventory completed.

Many parks have become interested in having Paleontological Surveys conducted. Surveys are already completed or in progress for Big Bend, Zion, Yellowstone and Death Valley. Vince Santucci (Vince_Santucci@nps.gov; NPS-GRD Paleontologist) is willing to discuss such matters with park staff, if they are interested.

Often, these surveys have shed valuable new information on previously unrecognized resources. These surveys involve a literature review and subsequent bibliography, as well as recognition of type specimens, species lists, and maps (which are unpublished to protect locality information), and also make park specific recommendations for protecting and preserving the resources.

Samples of existing paleontological surveys are available online at:
http://www2.nature.nps.gov/grd/geology/paleo/surveys/surveys.htm

If a paleontological survey were conducted and yielded significant findings, the following might be derivative steps:

- Develop resource management plans including inventory and monitoring to identify human and natural threats to these resources;
- Incorporate findings or suggestions into park general management plans (GMP);
- train park staff (including interpreters and law enforcement) in resource protection; the fossil trade "black market" has become quite lucrative for sellers and often results in illegal collecting from federal lands;
- Collections taken from the area residing in outside repositories could be tracked down for inventory purposes;
- Fossils offer many interpretive themes and combine a geology/biology link and should be utilized as much as possible in interpretive programs.

OTHER SOURCES OF NATURAL RESOURCES DATA

-

ACTION ITEMS (need to redo)

Many follow-up items were discussed during the course of the scoping session and are reiterated for quick reference.

General:

Interpretation: If desired consult with GRD's Jim Wood (jim_f._wood@nps.gov) or Melanie Moreno at the USGS-Menlo Park, CA (mmoreno@usgs.gov) for additional assistance with various interpretation themes

Natural Resources:
Geologic Mapping:
Natural Resource Data Sources:

APPENDIX A
Great Smoky Mountain NP Geological Resources Inventory Workshop Participants
May 8-9, 2000

NAME	*AFFILIATION*	*PHONE*	*E-MAIL*	Field Trip	Scoping Session
Joe Gregson	NPS, Natural Resources Information Division	(970) 225-3559	Joe_Gregson@nps.gov	x	x
Tim Connors	NPS, Geologic Resources Division	(303) 969-2093	Tim_Connors@nps.gov	x	x
Scott Southworth	USGS, Reston	(703) 648-6385	Ssouthwo@usgs.gov	x	x
Don Byerly	Univ. of Tennessee	(423) 974-6007	Dbyerly@utk.edu	No	No
Bob Hatcher	Univ. of Tennessee	(423) 974-6565	Bobmap@utk.edu	No	X
Carl Merschat	North Carolina Geologic Survey	(828) 251-6208	Carl.Merschat@ncmail.net	X	x
Peter Lemiszki	Tennessee Geologic Survey	(865) 594-5596	plemiszki@mail.state.tn.us	x	X
Keith Langdon	NPS, GRSM	(423) 436-1705	Keith_Langdon@nps.gov	X	x
Mark Carter	North Carolina Geologic Survey	828-251-6208	Mark.Carter@ncmail.net	x	X
Chuck Parker	USGS	865-436-1704	Chuck_Parker@usgs.gov	No	x
Harry Moore	TN DOT	865-594-9436 865-594-9373	Hmoore@mail.state.tn.us	No	X
Richard Schulz	GRSM, GIS	865-430-4745	Richard_Schulz@nps.gov	No	x
Lindsay McClelland	NPS, Geologic Resources Division	202-208-4958	Lindsay_mcclelland@nps.gov	x	X
Michael Kunze	NPS, GRSM	865-436-1703	Michael_Kunze@nps.gov	No	x

APPENDIX B

Overview of Geologic Resources Inventory

The NPS Geologic Inventory is a collaborative effort of the NPS Geologic Resources Division (GRD) and Inventory and Monitoring Program (I&M) with assistance from the U.S. Geological Survey (USGS), American Association of State Geologists (AASG), and numerous individual volunteers and cooperators at NPS units, colleges, and universities.

From the perspective of the servicewide I&M Program, the primary focus (Level 1) of the geological inventory is

1. to assemble a bibliography of associated geological resources for NPS units with significant natural resources,

2. to compile and evaluate a list of existing geologic maps for each unit,

3. to develop digital geologic map products, and

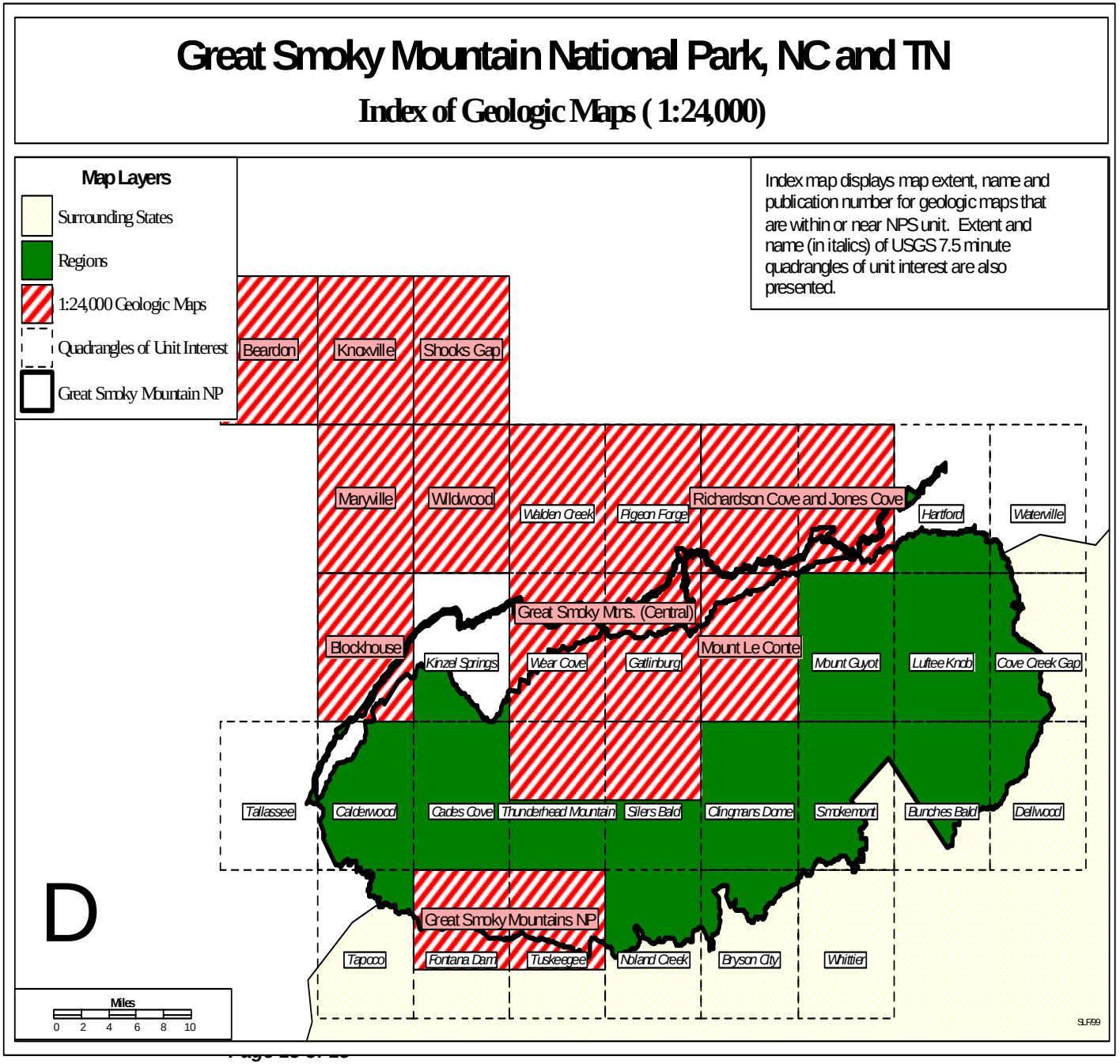
4. to complete a geological report that synthesizes much of the existing geologic knowledge about each park. The emphasis of the inventory is not to routinely initiate new geologic mapping projects, but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System.

The NPS Geologic Resources Division is an active participant in the I&M Program and has provided guidance and funding in the development of inventory goals and activities. GRD administers the Abandoned Mine Lands (AML) and Geologists In Parks (GIP) programs which contribute to the inventory. NPS paleontologists, geologists, and other natural resource professionals also contribute to inventory planning and data. A major goal of the collaborative effort is to provide a broad baseline of geologic data and scientific support to assist park managers with earth resource issues that may arise.

For each NPS unit, a cooperative group of geologists and NPS personnel (the Park Team) will be assembled to advise and assist with the inventory. Park Teams will meet at the each NPS unit to discuss and scope the geologic resources and inventory, which is the subject of this report. If needed, a second meeting will be held at a central office to evaluate available geologic maps for digital production. After the two meetings, digital geologic map products and a geologic report will be produced. The report will summarize the geologic inventory activities and basic geology topics for each park unit. Due to the variety of geologic settings throughout the NPS, each report will vary in subject matter covered, and section topics will be adapted as needed to describe the geologic resources of each unit. Whenever possible the scientific sections of the report will be written by knowledgeable cooperators and peer reviewed for accuracy and validity.

APPENDIX C

List of Geologic Maps for GRSM at *1:24,000* scale



APPENDIX C
List of Geologic Maps for GRSM at *1:24,000* scale

Quadrangle	Scale	Author	Year	Digital	Acceptable for database	Pub #
Blockhouse	1:24,000	R.B. Neuman & R.L. Wilson	1960			GQ 131
Bryson City						
Bunches Bald						
Cades Cove	1:24,000	Scott Southworth	1999			OF 99-0175
Calderwood						
Clingmans Dome						
Cove Creek Gap	1:24,000	Art Schultz	1999			OF 99-0536
Dellwood						
Fontana Dam	1:24,000	Scott Southworth	1995			OF 95-0264
Gatlinburg	1:24,000	P.B. King	1964			PP-349 C
Hartford						
Jones Cove	1:24,000	Warren Hamilton	1961			PP-349 A
Kinzel Springs	1:24,000	R.B. Neuman & W.H. Nelson	1965			PP-349 D[1]
Luftee Knob	1:24,000	Art Schultz	1999			OF 99-0536
Mount Guyot	1:24,000	Art Schultz	1999			OF 99-0536
Mount Le Conte	1:24,000	Art Schultz	1998			OF 98-0032
Noland Creek	1:24,000	David Moh	1975			NCGS
Pigeon Forge	1:24,000	P.B. King	1964			PP-349 C
Richardson Cove	1:24,000	Warren Hamilton	1961			PP-349 A
Silers Bald	1:24,000	P.B. King	1964			PP-349 C
Smokemont						
Tapoco						
Thunderhead Mountain	1:24,000	P.B. King	1964			PP-349 C
Tuskeegee	1:24,000	Scott Southworth	1995			OF 95-0264
Walden Creek	1:24,000	P.B. King	1964			PP-349 C
Waterville						
Wear Cove	1:24,000	P.B. King	1964			PP-349 C[2]
Whittier						

[1] Portions of the Wildwood, Kinzel Springs, Blockhouse, Tallassee, Calderwood, and Cades cove quadrangles are compiled at 1;62,500 in USGS PP 349-D

[2] portions of the Walden Creek, Pigeon Forge, Wear Cove, Gatlinburg, Thunderhead Mountain, and Silers Bald quadrangles are compiled at 1:62,500 scale in USGS PP 349-B

APPENDIX D
Maps associated with USGS Professional Paper 349

Folio and Title	Quadrangles covered	Scale	Author	Year
A Geology of the Richardson Cove and Jones Cove Quadrangles	Richardson Cove Jones Cove	1:24,000	Warren Hamilton	1961
B Geology of the eastern Great Smoky Mountains, North Carolina and Tennessee	??	1:62,500	Hadley, J.B.; Goldsmith, R.,	1963
C Geology of the Central Great Smoky Mountains Tennessee	Walden Creek Pigeon Forge Wear Cove Gatlinburg Thunderhead Mountain Silers Bald	1:24,000	Philip B. King	1964
	All above compiled as “Central” map	1:62,500		
D Geology of the Western Great Smoky Mountains Tennessee	Kinzel Springs	1:24,000	Robert B. Neuman; Willis H. Nelson	1965
	Portions of : Wildwood Kinzel Springs Blockhouse Tallassee Calderwood Cades Cove	1:62,500		