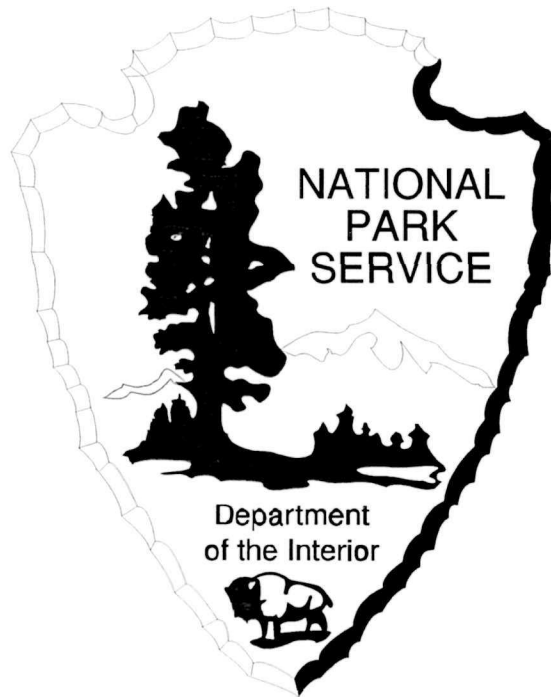


*Geologic Resources Division
Inventory and Monitoring Program*

Geologic Resources Inventory

1998
***U.S. Department of
National Park Service
Natural Resources***



***the Interior
Program Center***

NPS Geologic Resources Inventory Plan

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NPS Geologic Resources Inventory Plan

Bedrock and surficial geologic maps and information provide a critical basis for groundwater, geomorphic, soils, and environmental hazard studies. Geologic maps describe the underlying "physical habitat" for many natural systems and are an integral component of the geophysical inventories stipulated in the National Park Service's (NPS) Natural Resources Inventory and Monitoring Guideline (NPS-75). In the spirit of NPS-75, this proposal outlines a cooperative effort between the NPS Geologic Resources Division (GRD) and Inventory and Monitoring (I&M) Program (Natural Resource Information Division - NRID) to cooperate with the U.S. Geological Survey (USGS) and individual state geological surveys to implement a systematic, comprehensive inventory of the geologic resources for NPS units with significant natural resources (i.e., about 265 parks). The on-going and proposed NPS Geologic Resources Inventory consists of three main phases: 1) a bibliography of park geologic literature and maps, 2) evaluation of existing, needed, and in-progress map coverage and subsequent digital products, and 3) compilation of a geologic report incorporating basic geologic information, hazards and issues, and existing park data and studies. In addition to existing geologic data, new mapping projects may be considered on a case by case basis after careful evaluation of park needs, associated costs, potential cooperators, and funding sources.

Geologic Resources Inventory Status

In addition to existing inventory activities with the Geologic Resources Bibliography (GeoBib) and data management planning, the GRD and I&M sponsored a Baseline Geologic Data Workshop in Denver in the fall of 1997 to gather input from NPS personnel and cooperators on basic geologic data needs that could be provided by the I&M Program. Discussions at the Denver meeting and subsequent work by task groups are included in this proposal. Colorado, Utah, and North Carolina were chosen as pilot project states to maximize the cooperation among NPS, USGS, and state surveys, but in general, the discussions and work have affirmed the existing three-phase approach stated above and illustrated in Figure 1 below. Brief summaries of the Denver workshop and the organization of the state pilot projects are included in Appendix A and Appendix B, respectfully.

Geologic Resources Inventory Process

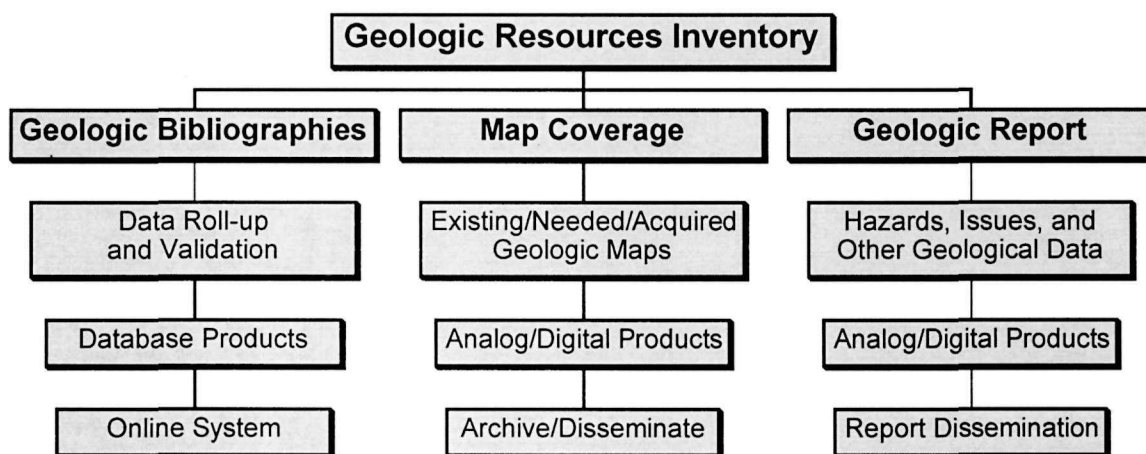


Figure 1. The three themes of the geologic mapping inventory process discussed in text.

The GeoBib project is completing the initial phase of data collection for existing geologic resources (maps and literature) for each park unit and publishing the data on the NRID Intranet. The bibliography is discussed in more detail in a later section. In addition, index maps showing the location of associated

geologic maps are being prepared for the Colorado parks. Once map coverage for each park is determined, map products can be evaluated, and potential mapping projects identified and initiated.

Pilot geologic issues/map scoping meetings (Park Teams) are being organized during 1998 to evaluate the resources for Colorado parks and will be followed by pilot projects in Utah and North Carolina in the next fiscal year. The Park Teams will identify existing maps for digitizing or conversion to NPS standards. A separate task group is developing a geology-GIS standards document (Appendix G) to insure uniform data quantity and quality for digital geologic maps, and a pilot digitizing project for Craters of the Moon National Monument has been proposed by Columbia Cascades Support Office (CCSO) GIS personnel. Park scoping meetings will also identify any needs for new geologic mapping. However, the high cost of geologic field mapping and thematic map digitization indicate the need for additional long-term planning and exploration of cost-effective programs and partnerships to satisfy NPS geologic map needs.

After completion of map inventory activities, a geologic report incorporating USGS and state geological literature, park, and GRD data will complete the project for each park. The geologic report content, format, and database are being developed and are outlined in a later section and Appendix F.

Relationships with existing data standards and programs

The Level I Inventory goal of bedrock and surficial geologic maps for each park at 1:24,000 scale is compatible with similarly specified scales for base cartography, soils maps, and vegetation maps. However, acceptable geologic map scales must be determined on a case-by-case basis in consideration of existing products, individual park needs, and associated mapping costs. The USGS is digitizing maps for on-going mapping projects, but scales vary and digital coverage of all NPS areas will probably never occur without in-house or contracted work by the GRD and I&M Program.

Geologic Resource Bibliographies (GeoBib)

The GeoBib project is rolling-up individual park bibliographies and publishing the data on a secure intranet database system. Bibliographic searches of the Georef and Geotitles databases for each park were conducted by the USGS and converted to Procite data files. On-going work is converting the Procite data for the intranet system, editing the map citations for duplicate entries, and preparing a list document and index map of associated geologic maps. When complete, the GeoBib database will contain about 100,000 references to geologic resource literature in an on-line database.

With GRD and I&M funding, a Colorado State University student was hired to work on the GeoBib database. Bibliographies for 27 parks in the three pilot states have been edited for duplicate map citations and used to compile a list of park-associated geologic maps. Bibliographies for additional 15 western parks have been converted and loaded into the database for editing. Once a park's duplicate map citations have been removed, geologic map citation lists are prepared for each park and used to develop index maps showing the footprint of associated geologic maps in relation to park boundaries. The map lists and index maps are converted to word processing documents for electronic file transfer to cooperators.

Digital Geologic Map Coverages

A few agencies are digitizing geologic maps using conventional methods as well as vectorization or heads-up digitizing of scanned images. The NPS should evaluate these methods to allow versatility in data acquisition. Scanning and vectorizing of geologic map masters will be tested in a pilot digitizing project of four geologic maps of Craters of the Moon National Monument by Columbia Cascades Support Office (CCSO) GIS personnel. In addition, as part of this inventory proposal, the I&M Program and GRD will obtain conventional digitizing technology and digitize some geologic maps in house. On-

going and completed park mapping and digitizing projects will be tracked in the Dataset Catalog system on the NRID Intranet. Digital map products will be archived and distributed on CD-ROM.

Baseline Geologic Inventory Report

The inventory report will summarize the exploration history, geology, unique features, paleontology, disturbed lands issues, available geologic data, geologic hazards, and other geology-related issues as needed to describe the basic geologic resources of each park. Several report sections, such as of stratigraphic columns and geologic cross sections graphics, will be developed with student employee assistance. Other sections will summarize ongoing NPS programs such as disturbed lands and paleontology. A database system is being developed on the NRID Intranet to provide on-line access for report development and dissemination. Many report tasks are outlined in Appendix E and an expanded report outline may be reviewed in Appendix F.

Geologic Inventory Implementation Schedule and Budget

Immediate Needs (FY98)

I. Facilities

- | | |
|---|-----|
| A. 1 modular cubicle for student assistant at NRID office, Fort Collins | N/C |
|---|-----|

II. Computer/Communications Resources

- | | |
|---|------------|
| A. Intranet Server Infrastructure (already funded and complete) | N/C |
| B. Data development and archiving hardware for Geologic Inventory | |
| 1. GIS workstation (I&M) and 2'x3' digitizer tablet (WRD) | N/C |
| 2. Arc/Info NT, ArcView 3.0 and Spatial Analyst (in work I&M) | N/C |
| 3. External 4X CD-ROM writer to archive digital data (I&M) | <u>N/C</u> |
| Subtotal | <u>N/C</u> |

III. Training (no training requested)

IV. Fixed Costs

- | | |
|---|---------------|
| A. Estimated costs for inventory database applications (* anticipated cost) | |
| 1. NPS Geologic Bibliography (dev. mostly complete - I&M server) | N/C* |
| 2. Geologic Inventory Reports (in development - I&M server) | N/C* |
| 3. NPS Geologic Strata Lexicon (in development - I&M server) | N/C* |
| B. 1 CSU student to edit GeoBib data and prepare map lists/index maps
(already funded, GRD \$6000, I&M \$4000) | 10,000 |
| C. Geologic map and issues evaluation activities for 10 Colorado parks** | 40,000 |
| D. Pilot geologic map digitizing project for Craters of the Moon at CCSO | <u>10,000</u> |
| Subtotal | 60,000 |

** Unused evaluation funds will supplement digitizing projects and student salaries.

FY98 Budget Total	60,000
--------------------------	---------------

First Year (FY99)

I. Facilities (* anticipated cost)

A. 1 modular cubicle for 2 student assistants at NRID office, Fort Collins	N/C
B. Office space for 2-3 student assistants at GRD office, Denver	<u>N/C*</u>
Subtotal	N/C*

II. Computer/Software Resources

A. Development costs for Geologic Inventory database applications	N/C*
B. ArcView/ArcInfo and related software	<u>8,700</u>
Subtotal	8,700

III. Training - GIS related

Subtotal	9,000
----------	-------

IV. Fixed Costs (annual) (* anticipated cost)

A. Support costs for Geologic Inventory database applications	N/C*
B. Consumables/supplies and hard copies of geologic maps	8,000
C. Off-site archiving of Geologic Inventory products	N/C*
D. 5 student employees (20 hours/week X 9 mos. + 40 hrs/wk X 3 mos.)	75,000
F. Geologic maps and issues scoping meetings for 17 UT and NC parks**	63,700
G. Map related costs including consumables, hard copies, and digitizing	<u>70,000</u>
Subtotal	216,700

** Unused evaluation funds will supplement digitizing projects and student salaries.

FY99 Budget Total

234,400

Remaining Colorado Pilot Project Items

Digitizing

BLCA/CURE/FLFO - 11 maps	25,000
MEVE/YUHO/HOVE - 7 maps	15,500
GRSA - 3 maps	7,500
COLM - USGS	
ROMO - I&M in house (?)	10,000
DINO - I&M (20 maps)	50,000
BEOL - ?	2,500

Other

MEVE - USGS Fassett mapping	1,000
CURE - Bartleson mapping	5,000
COLM - Map publishing in FY 2000	5,000

Reports

BLCA - Hanson - Done	
CURE - GRD/I&M?	
COLM - USGS Pro Paper (Scott) revisit in 2000	
GRSA - Park Lead	2,000
ROMO - GRD/I&M	
DINO - GRD/I&M (Hanson basis)	
MEVE - Griffiths report and USGS Pro Paper (Fassett), includes YUHO and HOVE	
FLFO	
BEOL	

TOTAL

Second Year (FY2000)

I. Facilities

II. Computer/Communications Resources

III. Training - Windows NT, Arc/Info, ArcView (GRD and I&M) 10,000

IV. Fixed Costs (annual) (* anticipated cost)

A. Support costs for Geologic Inventory database applications	N/C*	
B. Consumables/supplies and hard copies of geologic maps	8,000	
C. Off-site archiving of inventory products		N/C*
D. 5 student employees (20 hours/week X 9 mos. + 40 hrs/wk X 3 mos.)	72,000	
1. Complete GeoBib work then digitize geology GIS projects (I&M)		
2. Convert/develop geology GIS products, catalog, and archive (I&M)		
3. Pilot digitize and develop geologic map GIS projects (GRD)		
4. Develop/digitize geologic columns and cross sections for reports (GRD)		
5. Review literature, collect, edit, and assemble final (GRD or I&M)		
E. System administration; hardware and software upgrades		N/C
F. Geologic map and issues scoping meetings for 25 parks	100,000	
G. Digitizing costs (40 maps at \$2500/map)	100,000	
		290,000

** Unused evaluation funds will supplement digitizing projects and student salaries.

FY2000 Budget Total 290,000

Annual Fixed Costs (FY2001-2010)

A. 5 student employees (20 hours/week X 9 mos. + 40 hrs/wk X 3 mos.)	72,000	
B. Operating expenses		
1. System administration; hardware/software upgrades (Divisions maintain/fund)		N/C
2. Consumables/supplies and hard copies of geologic maps	8,000	
3. Off-site archiving of inventory products (I&M funds)		N/C
4. Training for server/application skills update and maintenance (Divisions fund)		N/C
C. Geologic maps, hazards, and issues scoping meetings for 25 parks	100,000	
D. Digitizing costs (40 maps at \$2500/map)	100,000	

** Unused evaluation funds will supplement digitizing projects and student salaries.

Fixed Budget Total 280,000

Appendix A - Summary: Baseline Geologic Data Workshop

Denver, CO, November 19-20, 1997

The purpose of the meeting was to discuss NPS geologic baseline data needs and identify the geologic data that should be provided to parks through the Inventory and Monitoring Program. In keeping with that theme, the status and objectives of the Servicewide geologic inventory were presented and discussed. In addition, participants presented and discussed a wide array of geology-related and management issues that affect NPS units. In general, the consensus of the group was that bedrock/surficial geologic maps in digital format for each NPS unit were appropriate baseline data, but that a geological needs assessment should be included with the baseline inventory. Cooperation among the NPS, USGS, and state survey mapping programs was discussed at length. Approaching the baseline inventory on a state by state basis was proposed, and three pilot states were chosen. In closure, basic steps in the inventory process, several workgroups, and action items were agreed upon.

Basic inventory steps (outlined in I&M Geologic Inventory handout)

1. Geological Bibliography roll-up and search for existing map data
2. Obtain and evaluate existing data for digitizing (plus needs assessment)
3. Digitize existing maps and pursue new mapping as needed
4. Roll up bibliographic, map, and other data into a comprehensive park report

Prioritized Pilot Demonstration Projects

1. Colorado (due to close proximity of GRD, I&M, CGS, and USGS offices)
 - Evaluation of maps and needs assessments by February 1998 target
2. Utah (UGS mapping in Zion and a ready cooperator)
3. North Carolina (representative of eastern and coastal parks)
4. Alaska (proposed but not slated for action)

Working Groups

Colorado Pilot Project – State Team

- | | |
|----------------------------|-----------------------------------|
| • Bob Higgins, NPS GRD | • Vicki Cowart, Colo. Geol. Surv. |
| • Joe Gregson, I&M Program | • Chuck Blome, USGS |
| • Bruce Heise, NPS GRD | |

Digital Geologic Map Standards and Derivative Products

- | | |
|--------------------|----------------|
| • George Dickison | • Joe Gregson |
| • Keith High | • Marsha Davis |
| • Danny Rosenkrans | • Dave Miller |

Evaluation of Outcomes

- Peter Lyttle
- Lindsay McClelland
- Judy Rocchio

Appendix B - Geologic Map Evaluation and Park Needs Assessment

Assessment of geologic hazards and issues relative to park needs and evaluation of existing geologic maps for potential digital products will often require several meetings for each park. State Geological Resource Inventory Steering Groups (State Teams) will be formed for each state and meet as necessary to organize agency cooperators to assist with each park in the state. Once organized, a Park Geology Workshop will be held at each park that requests one. After the park meeting, Geologic Map Workshops will be held at a central office to evaluate the geologic maps, map projects, and potential digital products for each park. Recommendations from the meetings and workshops will be used to develop digital geologic maps and reports for the NPS Geologic Resources Inventory.

Park Geology Workshops (Scoping Meetings)

A meeting will be held at each park to familiarize park staff with the inventory process and to discuss geology-related park hazards and issues. Park meetings will also review the park GMP, geology-associated RMP statements (with GRD assistance as needed), and any geology-related interpretive themes identified by the park. Two or three members of the Park Team (see below), funded by I&M, will attend the park meeting and document park issues for the final inventory report. Each park may invite associated cooperators and scientists (funded by the park) to contribute to the meeting. The park meeting may also be used to determine the park's representative or contact for the geologic inventory.

Geologic Map Workshops (Map Evaluation Meetings)

A second meeting will be held at a central office, often at the USGS, to review geologic issues, evaluate the existing geologic maps for the park, and to recommend maps for digitizing. The I&M Program will fund one park representative to attend the map evaluation meeting. Map evaluation meetings will be brief, typically less than 1/2 day, and several may be scheduled together for efficiency.

State Geological Resource Inventory Steering Groups (State Teams)

To maximize the assistance and coordination of cooperating state geological surveys and USGS mapping programs, the geological inventory will proceed on a state by state basis. For each state, a state working group (State Team) will be formed consisting of representatives of the NPS Geological Resources Division (GRD), the NPS I&M Program, the USGS, and the state survey. The state team will set priorities for the state and appoint workgroups (Park Teams) to evaluate the geologic information for each park.

Park Geological Information Evaluation Workgroups (Park Teams)

Park teams containing knowledgeable geoscientists will complete an issues/needs assessment (Park Geology Workshop) and review geological maps (Geologic Map Workshop) for each park. A Park Team will be appointed for each park by the State Team and consist of representatives from the park (1), the NPS GRD, I&M Program, or other NPS geologist(s) (1-2), the state geological survey (1), the USGS region (1-2), and other members as needed and funding allows. Park teams will typically consist of 4-6 members. 2-3 Park Team members will participate in the Park Geology Workshop (as funding allows). The Park Team will serve as the geologic mapping evaluation workgroup for the park.

Team Member Roles

- GRD/I&M representative(s) will be responsible for coordinating meetings/workshops, setting the agenda and meeting sites, and facilitating the workflow to insure completion of all scoping and evaluation tasks. The I&M Program will provide map citation lists and preliminary map coverage graphics to the team prior to the workshop.

- The NPS park representative will be the main geological inventory contact for the park and will provide park-specific information and knowledge of geology-related park issues. At the Park Geology Workshop, the park will provide copies of the park GMP, a review of geology-associated RMP statements (with GRD assistance as needed), a list of interpretive themes identified by the park, and information about known geological issues and hazards for participant review and discussion.
- The state survey representative should be knowledgeable of the park's geology, associated mapping, and other projects or issues. At the workshop, the state survey will provide copies of identified maps and other documents for review.
- The USGS representative should be knowledgeable of the park's geology, associated mapping, and other projects or issues. At the Geologic Map Workshop, the USGS will provide copies of associated maps and documents for team review.
- Other representatives will be chosen for and provide in-depth expertise on the geology and geological issues associated with the park. Other NPS geologists cooperating with the inventory program may be appointed to represent the GRD or I&M Program as needed.

Task List for Park Teams

1. Review geology, geologic maps, and associated publications for park study area
 - Complete and annotate maps/publications list
2. Review park-specific materials
 - Park General Management Plan (GMP)
 - Geology-associated Resource Management Plan (RMP) statements
 - Park interpretative themes
3. Identify and discuss key geological issues and themes
 - Identify geological themes
 - Interpretations, education, and outreach
 - Resource preservation issues
 - Hazards and problems
 - Identify research needs
 - Other issues
 - Outline summary of discussion
4. Review Digital/GIS Mapping Needs
 - Discuss digital requirements and NPS GIS standards
 - Discuss process for selecting maps to digitize
5. Select optimum maps for digitizing
 - Quality (in the broadest sense), scale, age, surficial vs. bedrock, etc.
 - List annotated citations of maps to digitize
6. Identify New Mapping Needs
 - Baseline geology for park (i.e., new/revised field map projects)
 - Derivative products (e.g., slope stability layer derived from existing data)
7. Workshop report(s) with recommendations and results
 - Geological needs assessment summary for GRD
 - Prioritized digital and field mapping lists for I&M Program

Appendix C

Geologic Maps as Management Tools for the National Park Service

[USGS handout from Baseline Geologic Data Workshop, Denver, CO, November 19-20, 1997]

The National Park Service requires unbiased scientific information to carry out its mission of management, monitoring and interpretation of much of the Nation's public lands. In 1997 there are more than 250 separate cooperative projects between the four Divisions of the USGS and individual national park facilities (map on reverse side of this handout [not included]). The breadth of issues, products, information, and services being exchanged between these two DOI sister agencies is extensive and includes many issues related to geology, water resources, biology, and cartography.

In 1994 the National Cooperative Geologic Mapping Program in the Geologic Division of the USGS and the NPS entered into a Memorandum of Understanding designed to facilitate cooperation and exchange of geologic information. NPS personnel ranked approximately 40 of their project proposals that required for geologic mapping for land use and land management decisions. Fourteen projects were selected that met the needs and programmatic goals of both agencies. Bedrock and surficial geologic maps in GIS format, as well as scientific reports, have and will form the basis for a variety of interpretive publications. These include digital GIS files, resource and hazard potential, trail guides, interpretive brochures and visitor center exhibits. Issues addressed include water availability and quality, scientific, archeological and cultural resource management, trail and visitor center location, ecosystem characterization, inventory of paleontologic, geologic and archaeologic sites. Public educational outreach is a major aspect of this interagency effort, including working with earth science teachers to develop geologic teaching modules that include field trips for students. While USGS geologists will help NPS develop innovative ways to communicate geologic information to the public, NPS will offer USGS the opportunity to reach the vast audience of park visitors.

For further information contact:

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Appendix D

Draft Geologic Resources Inventory Personnel and Cooperators List

NPS Inventory and Monitoring Program

- Rich Gregory - Advisory Group, Natural Resource Information Division Chief
- Gary Williams - Advisory Group, I&M Program Manager
- Joe Gregson - Inventory Development and Coordination
 - I&M Representative on State and Park Teams
 - Inventory Database Development and Implementation
 - Inventory Data Products Distribution and Archiving
- 2-3 Student Employees
 - Edit GeoBib data and prepare map lists/index maps
 - Convert/develop, catalog, and archive geology GIS products
 - Pilot digitize/develop geologic map GIS projects
 - Develop/digitize geologic columns and cross sections for reports
 - Review literature, collect, edit, and assemble final reports

NPS Geologic Resources Division

- Dave Shaver - Advisory Group, Geologic Resource Division Chief
- L. McClelland - Advisory Group, Coordination with USGS
- Bob Higgins - Inventory Development and Coordination
 - GRD Representative on State and Park Teams
- Bruce Heise - Inventory Development and Coordination
 - GRD Representative on State and Park Teams
- Dave Steensen - Disturbed Lands Summaries
- 2-3 Student Employees
 - Develop/digitize geologic columns and cross sections for reports
 - Pilot digitize/develop geologic map GIS projects
 - Review literature, collect, edit, and assemble final reports

Other Active NPS Cooperators

- Craig Dalby - CCSO GIS Lead for Craters of the Moon Digitizing Project
- Marsha Davis - Advisory Group, CCSO Geologist
 - NPS Representative on State and Park Teams
- Emily McLuen - Craters of the Moon Pilot Digitizing Project
- Vince Santucci - Paleontology Summaries, NPS Paleontology Coordinator

U.S. Geological Survey

- Peter Lyttle - Advisory Group, National Coop. Geologic Mapping Program
- Chuck Blome - State Team Representative, Colorado and Central Region States
- Dave Miller - Advisory Group, Geology-GIS Model, CRMO and CIRO Projects
- GIS/Geologists - Park Teams, Issues, Advise about GIS/Digital Map Products

State Geological Surveys

- Vicki Cowart - Colorado State Team, Colorado State Geologist
- State Geologists - Other State Geologists for State Teams
- GIS/Geologists - Park Teams, Issues, Advise about GIS/Digital Map Products

Appendix E

Draft Inventory Tasks: 4/23/98

Geologic Resources Bibliography (I&M/GRD - 1 student)

- Edit map citations for duplicates
- Prepare map citation lists for each park in MS Word 6.0
- Prepare geologic index maps for each park and convert to MS Word 6.0
- Order 3 copies of available geologic maps identified by park teams.

Geologic Map Digitizing (I&M/GRD/Cooperators - 1-2 students or contract)

- Digitize Arc/Info coverage(s) for selected maps per inventory standards
- Provide digital data, hard copies, and source materials to I&M Program
- Develop and provide FGDC spatial metadata to I&M Program

Digital Map Product Development (I&M - 1 student)

- Convert Arc/Info coverage(s) to ArcView shape format
- Develop ArcView project files and "one off" map layouts
- Update metadata and catalog data in I&M Dataset Catalog
- Copy digital data to CD for archive and distribute as needed

Geologic Inventory Report Development (I&M/GRD)

- Write summary of geologic hazards/issues from literature and scoping meeting
- Write general summary of park geology (geologic setting)
- Get cooperators to write disturbed lands and paleontology sections
- Compile and write "other topics" section(s) as needed

Geologic Columns and Cross Sections (GRD - 1 student)

- Standard textual stratigraphic descriptions from geologic maps and literature in MS Word 6.0 and ASCII text for GIS input (or other format if needed)
- Standard graphical stratigraphic column for each park
 - Printable MS Word 6.0 format (or other if needed)
 - Viewable .GIF format for intranet report and WWW applications
 - Drawing exchange file .DXF format for data exchange
- Cross sections as needed to understand structure and stratigraphy
 - Printable, viewable, and exchange files as noted above

Geologic Inventory Report Assembly (I&M/GRD - 1 student)

- Review literature for useful report sections
- Obtain text and permissions for literature use as needed
- Input acquired report sections, text, graphics, and links developed above
- Review report content with I&M/GRD coordinators for completeness
- Prepare completed report in MS Word 6.0 for print and electronic distribution
- Catalog report in I&M Dataset Catalog and archive/distribute as needed

Baseline Geologic Resources Inventory Report Outline

Executive Summary

History of Geologic Exploration (for cultural and interpretive information)

Geologic Setting (general summary of park geology)

Stratigraphy

- Stratigraphic column (Web and printable graphics)
- Rock unit names, abbreviations, and descriptions (digital geologic map attributes)
- General stratigraphic information will help populate separate NPS Geologic Lexicon
- Cross sections/fence diagrams

Structure (general description, map(s), and cross sections(s))

Unique Geologic Features (summary and/or map)

- Landforms
- Type localities

Paleontology (summary and reference to fossil list in NPSpecies DB)

Disturbed Lands (summary and reference to AML/GRD data resources)

Geologic Hazards and Issues (summary from literature and scoping meetings)

Geologic Data

- References
- Links to GeoBib, NPS Geologic Lexicon, NPSpecies, etc.
- Metadata for geology GIS coverage(s)
-

Other Sections and Topics as needed.

NPS Inventory and Monitoring Program
Digital Geologic Map Standards for
the Geologic Resources Inventory

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The NPS Inventory and Monitoring (I&M) Program is developing a procedure to contract services to produce digital versions of published and unpublished (manuscript) geologic maps at a variety of scales. For each map, the contractor is required to adhere to specifications included in attachments A and B.

In each case, the contractor is supplied with the original publication separates or manuscript map. In some cases, the geology is separated from the base map information. In other cases, the geologic lines and base map features are contained on a single sheet; this increases the cost of map digitization.

Provided that scale-stable materials are available for scanning, the contractor is required to precisely register the digital map output to the original map. The contractor delivers Arc/Info export and ArcView useable files with fully attributed coverages and/or shape files (according to Attachments, provided below). The attributes for all polygons, lines, and points are incorporated into the PATs and AATs of the coverages created (add ArcView language). The contractor is requested to make proof plots of the map for I&M to check. In some cases, this is not possible due to the size

of the map and plotting limitations of the contractor. If the contractor cannot plot the map, then I&M will do so (preferably on a stable base) to compare with the scanned materials.

The agreements state that upon delivery of map files and proofs, I&M must within four weeks examine the deliverables and accept or reject them. Proofing involves the following steps:

- verification that the proof plot exactly matches the source
- verification that all lines and points were digitized, and
- verification that all features were properly attributed.

From previous experiences at USGS, the contractor has never failed to meet all of these tests. The contractor is to misattribute no more than 10 percent of the features; but they have never approached this level of error. Typically, no contractor errors in positioning or attributing are found. The more significant problem is attribution of tiny polygons that cannot be identified, even by a geologist familiar with the area.

ATTACHMENT A

STATEMENT OF WORK

1 BACKGROUND

The National Park Service Inventory and Monitoring (I&M) Program has a requirement for digital geologic map data production services. The service needed at this time is to digitize state geologic maps and production of topologically structured ARC/INFO (TSAI) files (**need reference to ArcView products**). TSAI data files include all geologic information on a geologic map including faults and other structural-geologic information and lithologic information at a scale of 1:24,000. The purpose of these data files are to provide the digital data necessary to reproduce any or all of the information contained in the published geologic map using ARC/INFO version 6.0, ArcView 3.0, or newer software. If any of the criteria or formats defined in this statement of work significantly impact the cost, the Contractor can propose a proven, most cost effective alternative that meets the Government's purpose.

2 REQUIREMENT

The contractor shall deliver TSAI data to NPS in accordance with the specifications described here. Completed work includes the digitization of all geologic information on the geologic map and the production of the TSAI data files meeting ARC/INFO data export file specification (version 6.0) or newer) and the NPS specifications detailed in Attachment B (Data structure for digital geologic maps). The project addressed by this contract requires the production of TSAI data representing contacts, faults, fold axis, formation names, and other geologic information found on the specified state geologic map and defined in the legend of that map. All digitized data are to be complete, appropriately attributed, and topologically structured to allow for duplication of the published map using ARC/INFO and ArcView software (version 6.0 or newer) or to allow for creation of a new map using any combination or selection of features and attributes.

3 GOVERNMENT FURNISHED MATERIALS (GFM)

- 3.1 Two (2) stable-base copies of the geologic map. The cleanest material available will be used; however in some case extraneous non-geologic information may be included on this material.
- 3.2 One published colored copy of the geologic map.
- 3.3 Shipment of GFM-Commercial shipment of the GFM by the government and the Contractor shall be by registered mail, return receipt requested. This requirement may be waived in the event other methods of shipment are more advantageous to the Government, e.g., messenger, air freight, etc. If other than registered mail is used, a receipt shall be furnished by the Contractor to the Contracting Officer with a copy to the Contracting Officer's Representative (COR).

4 DELIVERABLE PRODUCTS—The following data and material shall be delivered by the Contractor for the geologic map digitized and processed:

4.1 Topologically Structured ARC/INFO (TSAI) Data (need reference to ArcView products)

4.1.1 The Contractor shall produce two TSAI data files in ARC/INFO export format (version 6.0 or newer) **(need reference to ArcView products)** for the supplied map. The first TSAI data product will be the lithologic polygons (a polygon coverage). The second TSAI data product will be the structural geologic information (an arc coverage). TSAI data produced must meet the format specifications detailed in Attachment B.

4.1.1.1 The polygon and arc coverage will have some duplicate arcs because many of the faults will also be boundaries of lithologic polygons. The Contractor should make every effort to make these duplicate arcs identical in both TSAI data files.

4.1.2 The Contractor shall record the TSAI files **(need reference to ArcView products)** representing the geologic map on computer compatible **CD-ROM media** or some other alternate format, such as Internet ftp, as agreed with the COB at time of delivery. **A version of the digital data on the CD-ROM will be directly useable in ArcView 3.0 without the need for import and/or conversion.** A CD-ROM should have a label indicating the map name, the Contractor's name, and the name of the data files.

4.2 Verification Plots—A minimum of two plots are required. These plots will contain the polygon and arc coverages. If the contractor is not able to plot the map, the NPS may, at their discretion, produce the plots.

4.2.1 Line verification—One plot on stable-base material at the scale of the GFM published map shall be delivered for each TSAI geologic map. The purpose of this plot is to verify the positional accuracy and attributes of all lines. Each plot shall be provided as a positive image on clear or translucent media (film or frosted mylar) 0.004" or thicker. The elements, which shall be shown on the plots, and symbology to be used are indicated below.

4.2.1.1 The selection of line weights and other symbols should be similar to those on the GFM. The numbers given below are only listed as approximate sizes.

4.2.1.2 Nodes, points where 3 or more arcs intersect, might be plotted using a circle with a line weight of 0.005" and diameter of 0.080". The circle shall be centered over the recorded coordinates of the node. For pseudo nodes, points where 2 arcs join, and for hanging nodes, end points of an arc, which does not join another arc, symbols might be diamonds and squares respectively.

4.2.1.3 All lines should be plotted with a distinctive line weight similar to those on the GFM. For example, all geologic contact and fold axis might be plotted with a line weight of 0.005". All faults might be plotted with a line weight of 0.010".

4.2.1.4 All dashed and dotted lines should be reproduced similar to those displayed on the published map.

4.2.1.5 All thrust faults and other decorated lines should be plotted with decorations similar to the published geologic map. These decorations must be on the same side as shown on the published map. Colored lines could also be used to help differentiate line types. See Attachment B for more information of decorated lines.

4.2.1.6 Plotting material shall measure an appropriate size to get the proof print on the minimal number of pages. In the case that the map will not plot on one page, one smaller scale plot should be provided to verify the registration across plotting page boundaries.

4.2.1.7 Tick marks measuring 0.1" in length and positioned and labeled with latitude and longitude on the latitude-longitude points shown on the GFM published geologic map shall appear on all plots with a distinctive fine line weight.

4.2.1.8 The following information shall be printed in the margin of all plots:

4.2.1.8.1 Plot generation date, plot scale, source-data map name, map authors, map scale, and map publication date (e.g. Geologic Map of Nevada, Stewart and Carlson, 1977)

4.2.1.8.2 Contractor name, name of the Contractors' contract, address, and phone number.

4.2.2 Polygon verification plot—one full color plot at the scale of the published map shall be delivered. The purpose of this plot is to verify the attributes of all polygons. Each plot shall be provided as a positive image on paper base or other appropriate media for good color display. The elements which shall be shown on the plots and the symbology to be used is indicated below.

4.2.2.1 All lines as defined above in section 4.3.1.

4.2.2.2 Because of the wide variety of hardware, there are many options how this might be colored. The purpose of the coloring is to provide a product with colors similar to the published map to facilitate verification of the assigned polygon (formation) attributes. Because these maps often combine colors and patterns the Contractor should select a display method that will make comparisons between the published map and the verification plot as easy and rapid as possible.

4.2.2.2.1 The coloring scheme should allow for easy identification of the attributes of small polygons. Solid colors are generally best for this objective.

4.2.2.2.2 The coloring scheme should be similar to the scheme used on the GFM published geologic map, but does not need to duplicate those colors. The objective is that similar colors will aid verification.

4.2.2.3 A colored legend should accompany this colored map which defines the relationship between colors and symbols on the map and the attributes of the lines and polygons.

4.2.3 Although the line weights specified may not be achievable, given the variety of plotting equipment and plotting media available, they should be as close to the original specifications as possible and must be completely legible and be precise enough to permit effective evaluation of the completeness and positional accuracy of the data produced.

4.3 Intermediate products --**A Geologic Raster Graphic (GRG, analogous to a DRG) that is scanned at 150 DPI and geographically registered would make an excellent baseline geology inventory product.** Other products, such as raster scanned images that are made in the course of obtaining the TSAI data file could be of value to the Government. Such products would be considered in evaluation the Contractor.

4.4 Status Reports—Two (2) copies of a monthly status report shall be delivered to the COR by the tenth (10th) calendar day after the end of each month, beginning with the month following the delivery of the

GFM to the Contractor. The content of the report is specified in Paragraph 6.9. A status report is not necessary if the Deliverable Products can be completed in 40 days or less.

4.5 Final Report—Four (4) copies of a final report shall be delivered to the COR at the completion of the project. The content of the report is specified in Paragraph 6.10.

5 QUALITY STANDARDS

The following standards shall be met by the Contractor to ensure the quality and accuracy of the digital cartographic data provided to the Government.

- 5.1 The government intends to use these TSAI with ARC/ INFO software (version 5.0.1 or newer) (**need reference to ArcView products**). Knowledge of the full details of the formats necessary so the TSAI data can be imported and directly used with the ARC/ INFO software with the ARC/INFO import procedure are the responsibility of the Contractor. **A version of the digital data on the CD-ROM will be directly useable in ArcView 3.0 without the need for import and/or conversion.** Information regarding the ARC/INFO software may be obtained from: Environmental Systems Research Institute, Inc., 380 New York Street, Redlands, California.
- 5.2 Category-defined features that appear on the state geologic map of the government furnished materials shall be digitized and assigned attribute codes. Ninety-eight percent (98%) of the coded elements will be as shown on the GFM published geologic map. All formats in attribute tables will be in accordance with the standards contained in Attachment B. When proper attribute codes cannot be determined using Attachment B, the Contractor shall notify the COR for resolution. Resolution of these problems will often require the Contractor to involve a geologist experienced with state geologic maps and access to people with the necessary information to correctly tag the attribute.
- 5.3 The positional accuracy of ninety percent (90%) of all nodes shall be inside the true position of the node defined by the intersecting lines on the GFM scale-stable source. The positional accuracy of ninety percent (90%) of all vertices shall be inside the line as found on the GFM scale-stable source. The remaining ten percent (10%) of all TSAI elements shall be within 0.010" in any direction from the true (correct) position shown on the GFM scale-stable source.
- 5.4 Linear features shall be digitized with a point density sufficient to preserve the graphic quality of the feature as represented on the GFM. Thus, angularity of lines that is not visible on the GFM scale-stable source should not be visible on the digitized product when plotted at the same scale as the GFM scale-stable source

6 TASK DEFINITION

6.1 The Contractor shall perform the following tasks to produce the required deliverable products detailed in section 4.0. The TSAI data produced shall comply with the ARC/INFO export format (version 5.0.1 or newer) and the content and quality standards stated in Section 5.0 and Attachment B. **A version of the digital data on the CD-ROM will be directly useable in ArcView 3.0 without the need for import and/or conversion.**

6.2 The Contractor shall furnish all personnel, labor, facilities, material, and any other items, except as otherwise provided as GFM, required to produce the necessary TSAI files required as deliverable items.

6.3 The Contractor will require the services of a geologist experienced in the use of geologic maps in order to properly attribute all of the elements shown upon the map. The Contractor shall document that such an experienced person is available to assist in solving questions about attributing.

6.3.1 The COR will provide consultation with the Contractor's geologist at least by telephone to help resolve attributing problems.

6.4 Task A—Preparation

Due to the wide variety of computer equipment used by private industry to perform work of the type required, and the varied production techniques used to optimize the operation of these systems, all preparation of digitizing media is the responsibility of the Contractor. The Government will not prepare or furnish any materials other than those identified as GFM.

6.5 Task B—Data Collecting and Attributing

The Contractor shall digitize and attribute all features defined in the legend of the published GFM and any Contractor materials derived from GFM as a result of Task A.

6.6 Task C—Editing

The Contractor shall edit the data collected in Task B as necessary to correct all attributing errors and element misalignments, to delete duplication and extraneous information, to add missing data, and to provide topological structure necessary to digitally reproduce the GFM published geologic map.

6.7 Task D—Processing

The Contractor shall perform all data processing required using the data produced through Task C to generate the TSAI data files in the ARC/INFO export format (version 5.0.1 or newer), and with the content and quality standards detailed in Attachment B and Attachment A, section 5. **A version of the digital data on the CD-ROM will be directly useable in ArcView 3.0 without the need for import and/or conversion.**

6.8 Task E—Verification

For each TSAI data produced, the Contractor shall generate the verification plots detailed in Section 4.0. The Contractor shall inspect each TSAI data file produced under this contract to ensure full compliance with the standards detailed in Section 5.0 and Attachments B prior to delivery to the Government.

6.9 Task F—Status Reports

The Contractor shall prepare monthly status reports outlining significant work accomplished during the reporting month, including a percent-of completion summary for the TSAI geologic map. The report shall also discuss problems encountered during the reporting month, corrective action taken, and impact, if any, on delivery schedules.

6.10 Task G—Final Report

The Contractor shall prepare a final report detailing the equipment used and the procedures and processes followed in the generation of the TSAI data specified in this contract. The report shall include, but not be limited to, a description of the resources required (personnel and equipment hours) for the completion of Tasks A-E. Developmental problems associated with computer hardware and software shall be addressed. All deviations from the formats outlined in these specifications as allowed by these specifications shall be clearly reported.

6.10.1 The Contractor shall assess the potential for improvement of the TSAI production process and recommend changes to Government specifications that would improve the efficiency of the digital cartographic data production.

6.10.2 Summary of specialized comments in the Final Report as referenced in other parts of these specification.

6.10.2.1 New words added to the word list of attributes.

6.10.2.2 Changes in attribute tables lengths.

6.10.2.3 Convention for digitizing decorated lines.

6. 10.2.4 Map projection used and all associated parameters.

7 INSPECTION AND ACCEPTANCE PROCEDURES

Prior to acceptance by the Government, all products will be validated using one or more of the following types of inspection to determine the level of quality for each TSAI characteristics prior to acceptance. Failure of the delivered TSAI data file to pass all test and acceptance procedures described will result in a rejection of the entire product and the procedures detailed in Section 8.0 will apply.

7.1 Inspection Procedures for TSAI Characteristics The inspection procedures for the following TSAI characteristics will be performed by the Government for the verification of the TSAI data. In addition to the verification plots supplied by the Contractor, the Government will generate selected paper and scale-stable film plots from each delivered TSAI data file. ARC/INFO software (version 5.0.-1) **and ArcView 3.0 or greater** will be used as part of the validation process. Inspections are intended to ensure

compliance with stated standards for the following: 1) file format, 2) content completeness, 3) positional accuracy, 4) attribution accuracy and 5) topological fidelity. Specified objectives are indicated below:

- 7.1.1 Format—The ARC/INFO import commands will be used to import the data. Errors contained in the data that prevent the proper loading of the file into the ARC/INFO environment will cause the TSAI to be rejected. **A version of the digital data on the CD-ROM will be directly useable in ArcView 3.0 without the need for import and/or conversion.**
- 7.1.2 Topology—Topology relationships contained in delivered TSAI data will be tested for logical consistency using ARC/INFO routines. Checks will be made for intersections such as extensions of lines through nodes, lines crossing other lines except nodes, and lines crossing themselves. Polygon (area) adjacency will be checked to ensure that area left and are right definitions of lines are consistent. Topological violations will cause the TSAI to be rejected. **What to specify for ArcView products?**
- 7.1.3 Feature Content—Feature content will be performed by comparing both Contractor and Government generated verification plots against scale-stable and published CFM. All geologic map specified features appearing on the color proof must be represented on the plots. Extraneous, duplicate, or missing data will cause the TSAI to be rejected.
- 7.1.4 Positional Accuracy—A visual comparison will be made between Contractor supplied stable-base line-verification plot and GFM stable-base materials. A software comparison will be made between Government digitized test nodes and arcs and Contractor digitized features. Errors in position which exceed the accuracy standards detailed in Section 5.0 will cause the TSAI to be rejected.
- 7.1.5 Attributing—The attributing of elements contained in delivered TSAI data will be checked for conformance to specifications detailed in Attachment B. ARC/ INFO software will be used to check the encoded data against a table of valid attribute codes to ensure that each code or combination of codes is valid for the category and element type. Further verification of the encoded data will be made by manual correlation of file listings, verification plots, and the color composites produced by the Government from GFM. Errors in attributing which exceed the standards in Section 5.0 will cause the TSAI to be rejected.
- 7.1.6 Corrections—The Government may choose to make minor edits, such as deleting extraneous and duplicate data, adding small amounts of missing data, or making minor positional corrections. This provision does not require the Government to make such correction, nor does it relieve the Contractor of responsibility for meeting all specifications of this contract. Edits may be made at the Government discretion when the number of elements to be edited does not exceed five percent (5%) of the total number of lines and nodes contained in the delivered file.

7.2 Acceptance Procedure

Products passing the inspections and test detailed in Section 7.0 will be accepted by the Government. The Contractor will be notified of acceptance, in writing, within thirty (30) calendar days from receipt by the COR of the deliverables.

8 REJECTION PROCEDURES

Upon receipt of any deliverable product by the COR, the following procedures will apply:

- 8.1 The Contractor will be notified in writing that the deliverable was rejected and the cause for rejection.
- 8.2 Written notice will be forwarded to the Contractor within thirty (30) calendar days from receipt of the deliverable. All Contract supplied materials will be returned to the Contractor with the rejection notice.
- 8.3 The Contractor agrees to correct and ship at no additional cost to the Government, the rejected deliverable within twenty (20) calendar days from the receipt of the rejection notice. Corrected deliverables must meet stated TSAI standards.
- 8.4 New verification plots shall be produced upon completion of all corrections to rejected deliverables.
- 8.5 The corrected deliverables and new verification plots shall be delivered to the Government for testing as described in Section 7.0

ATTACHMENT B

ARC/INFO GEOLOGIC-MAP DATA STRUCTURE

The terminology used here is that of ARC/INFO (version 6) and **ArcView 3.0**

Standard names for coverage(s) or shape files? (e.g., Surficial, Bedrock, Structure, etc.)

1 POLYGON ATTRIBUTES

1.1 Add to the polygon attribute table (PAT) as the last item, formation. The field length is 10, field width is 11, and the field type is character.

What about a lookup to sort the lithology into stratigraphic sequence?

What about a field for the complete rock unit name (e.g., Dakota Sandstone)

What about lithologic descriptions from the map?

1.2 The information in this item will be formation symbol as shown on the GFM published map by a symbol or color. All of these names must appear in the legend associated with GFM published map. The symbol convention should reproduce the symbols as used on the map, e.g. Tv for Tertiary volcanics.

1.2.1 Certain characters used on the map will not have standard keyboard characters; so the following conventions should be used for these special symbols.

1.2.1.1 OL - Oligocene, EP - Paleocene, PL - Pliocene, CZ Cenozoic, MZ - Mesozoic, PZ- Paleozoic, K Cretaceous, TR - Triassic, PN - Pennsylvanian, PM Carboniferous or Pennsylvanian-Mississippian, C Cambrian, PC - Precambrian.

1.2.1.2 All superscripts or subscripts should be typed as normal characters, i.e. no superscripts or subscripts can be used. These should be lower case letters. The conventions used here should be noted in the final report.

1.2.1.3 Where the allowed work list does not include the appropriate word the Contractor should make an appropriate selection and document this in the final report on the project. If there seems to be confusion resulting from the selection of words, the selection should be discussed with the COB.

2 ARC ATTRIBUTES

2.1 Add to the arc attribute table (AAT) as the last four items, [type, modifier, accuracy, and name].

2.1.1 Field lengths can be increased if required and this change should be documented in the final report.

2.2 The item ltype is for the type of line. The item length is 30, the item width is 31, and the item type is character.

2.2.1 ltype can have the following values: contact, fault, fold, other.

2.3 The item modifier denotes the type of contact, fault, fold or other. The item length is 20, the item width is 21 and the item type is character.

2.3.1 The following words can be used with faults: (normal, thrust, reverse, strike-slip, strike-dextral, strike-sinistral, none.) **(Better as: normal, thrust, left lateral, right lateral, oblique, and other without using the word "slip" which has the connotation that a measured offset has been obtained.)**

2.3.2 The following words can be used with folds: anticline, syncline, overturned anticline.
(add monocline, overturned syncline)

2.3.3 The following words can be used with other: map boundary, water boundary, or glacier boundary.

2.4 The item accuracy is a modifier denoting the positional accuracy on the location of the geologic feature. This does not refer to any aspect of the digitizing accuracy. This is normally shown on the map by the type of line, such as solid, dashed, or dotted lines. The item length is 15, the item width is 16, and the item type is character.

2.4.1 The following words can be used: certain, approx. located, inferred, inferred ?, concealed, concealed ?, gradational.

2.4.1.1 The query (?) after the word denotes that the line had ? along the line.

2.4.1.2 Solid lines are normally certain. Dashed lines are generally approximately located. Dotted lines are generally concealed. However this should be verified with the explanation that accompanies the GFM published map.

2.5 The item name is used only for those faults or folds that have identified names shown on the map. This item should include both upper and lower case characters as in normal writing with proper names.

2.5.1 The name field length is 20 (**50?**), the field width is 21 (**51?**), and the field type is character.

2.6 Where the allowed word list does not include the appropriate word, the Contractor should make an appropriate selection and document this in the final report on the project. Additions to the allowed word list must be documented in the final report. If there seems to be confusion resulting from the selection of words, the selection should be discussed with the COR.

2.7 Decorated lines, that is those lines with some sort of symbol on one side of the line such as thrust faults, require that the lines be digitized in a fixed direction relative to the decorations so the decoration will plot on the side shown on the GFM published map. The convention to use is that these lines will be digitized

in the direction that puts the decoration on the right side, e.g. if the decoration is on the east side of the line, then digitize from south to north.

2.7.1 The important thing is that all decorated lines are digitized in a standardized manner relative to the side the decoration is drawn. The convention used should be documented in the final report.

3 MAP PROJECTION AND UNITS

3.1 All coordinates of the TSAI data set will be x-y digitizer coordinates.
(This should be decimal degrees of longitude and latitude.)

Appendix H

Draft Proposal to Digitize 4 Geologic Maps for Craters of the Moon N.M.

Proposal is in work by Marsha Davis and CCSO GIS team.

Appendix I - NPS I&M Geologic Mapping Inventory Priorities 7/28/97

1	Zion NP	56	Glen Canyon NRA
2	Big Bend NP	57	Fort Clatsop NM
3	City of Rocks N RES	58	Redwood NP
4	Castillo de San Marcos NM	59	John Muir NHS
5	Big Thicket N PRES	60	Chickasaw NRA
6	Lake Meredith NRA	61	Palo Alto Battlefield NHS
7	Alibates Flint Quarries NM	62	Pipe Spring NM
8	Padre Island NS	63	Petersburg NB
9	Cedar Breaks NM	64	Lincoln Boyhood NM
10	Great Sand Dunes NM	65	Obed Wild and Scenic River
11	Mount Rushmore N MEM	66	Big South Fork National River and Recreational Area
12	Gulf Islands NS	67	Kobuk Valley NP
13	Bent's Old Fort NHS	68	Apostle Islands NL
14	North Cascades NP	69	Rainbow Bridge NM
15	Florissant Fossil Beds NM	70	Agate Fossil Beds NM
16	Chiricahua NM	71	Fossil Butte NM
17	Mammoth Cave NP	72	Pecos NHP
18	Jewel Cave NM	73	Navajo NM
19	Russell Cave NM	74	Oregon Caves NM
20	Grand Teton NP	75	Sunset Crater Volcano NM
21	Guadalupe Mountains NP	76	Channel Islands NP
22	Harpers Ferry NHP	77	Walnut Canyon NM
23	Fort Sumter NM	78	Great Smoky Mountain NP
24	Tonto NM	79	Acadia NP
25	Montezuma Castle NM	80	Bighorn Canyon NRA
26	John Day Fossil Beds NM	81	San Juan Island NHP
27	Hagerman Fossil Beds NM	82	Death Valley NP
28	Wind Cave NP	83	Kaloko-Honokohau NHP
29	Hot Springs NP	84	Shenandoah NP
30	Congaree Swamp NM	85	Petrified Forest NP
31	Chickamauga & Chattanooga NMP	86	Yucca House National Monument
32	Scotts Bluff NM	87	Natchez Trace Parkway
33	Point Reyes NS	88	Haleakala NP
34	Casa Grande Ruins NM	89	Wupatki NM
35	Denali NP & PRES	90	Voyageurs NP
36	Kings Mountain NMP	91	Hovenweep NM
37	Capulin Volcano NM	92	Glacier Bay NP & PRES
38	Wrangell-St Elias NP & PRES	93	Dinosaur NM
39	Vicksburg NMP	94	Devils Tower NM
40	Saint-Gaudens NHS	95	Manzanar NHS
41	Badlands NP	96	Catoctin Mountain Park
42	El Malpais NM	97	Cape Krusenstern NM
43	Coronado NM	98	Fort Davis NHS
44	Timpanogos Cave NM	99	Big Cypress N PRES
45	Muir Woods National Monument	100	Hopewell Furnace NHS
46	Golden Gate NRA	101	Boston Harbor ?
47	Mississippi NRR	102	Jean Lafitte NHP & PRES
48	Hopewell Culture NHP	103	Homestead NM of America
49	Aniakchak NM & PRES	104	Biscayne NP
50	Bryce Canyon NP	105	Pea Ridge NMP
51	Noatak N PRES	106	Tuzigoot NM
52	Golden Spike NHS	107	Grand Portage NM
53	Santa Monica Mountains NRA	108	Kalaupapa NHP
54	Ozark NSR	109	Effigy Mounds NM
55	DEWA Land Resources Project Office	110	Colorado NM

111	Bluestone NSR	171	Saratoga NHP
112	New River Gorge NR	172	Katmai NP & PRES
113	Lake Clark NP & PRES	173	George Washington Birthplace NM
114	Gauley River NRA	174	Cumberland Island NS
115	Joshua Tree NP	175	Crater Lake NP
116	Indiana Dunes NL	176	National Capital Parks-East
117	Yukon-Charley Rivers N PRES	177	Mesa Verde NP
118	Fire Island NS	178	Shiloh NMP
119	Pu'uhoonua o Honaunau NHP	179	Chattahoochee River NRA
120	Puukohola Heiau NHS	180	Allegheny Portage Railroad NHS
121	Minute Man NHP	181	Grant-Kohrs Ranch NHS
122	Yosemite NP	182	Amistad NRA
123	Lava Beds NM	183	Ocmulgee NM
124	Ninety Six NHS	184	Whitman Mission NHS
125	Kenai Fjords NP	185	Lake Mead NRA
126	Pipestone NM	186	Eisenhower NHS
127	Antietam NB	187	Gettysburg NMP
128	Assateague Island NS	188	Fredericksburg & Spotsylvania NMP
129	Home of Franklin D Roosevelt NHS	189	Fort Pulaski NM
130	Virgin Islands NP	190	Buffalo NR
131	Bering Land Bridge N PRES	191	Blue Ridge PKWY
132	Carlsbad Caverns National Park	192	Saguaro NP
133	War in the Pacific NHP	193	Guilford Courthouse NMP
134	Marsh-Billings NHP	194	Fort Caroline NM
135	Sagamore Hill NHS	195	Fort Bowie NHS
136	Sitka NHP	196	Pictured Rocks NL
137	Curecanti NRA	197	Chaco Culture NHP
138	Grand Canyon NP	198	Wilson's Creek NB
139	Canyonlands NP	199	Cumberland Gap NHP
140	Olympic NP	200	Little River Canyon NP
141	Upper Delaware Scenic and Recreational River	201	Lyndon B. Johnson NHP
142	Great Basin NP	202	Isle Royale NP
143	Little Bighorn Battlefield NM	203	Johnstown Flood N MEM
144	Saint Croix/Lower St. Croix NSR	204	Fort Necessity NB
145	Cuyahoga Valley NRA	205	Fort Frederica NM
146	Morristown NHP	206	Valley Forge NHP
147	El Morro NM	207	Horseshoe Bend NMP
148	Gateway NRA	208	Booker T. Washington NM
149	Nez Perce NHP	209	Timucuan Ecological & Hist Preserve
150	Big Hole NB	210	Rocky Mountain NP
151	Weir Farm NHS	211	Thomas Stone NHS
152	Cabrillo NM	212	Bandelier NM
153	Canaveral NS	213	Fort Laramie NHS
154	Gates of the Arctic NP & PRES	214	Organ Pipe Cactus NM
155	George Washington Carver NM	215	Appomattox Court House NHP
156	American Memorial Park	216	San Antonio Missions NHP
157	Moore's Creek NB	217	Black Canyon of the Gunnison NM
158	Cape Lookout NS	218	Hubbell Trading Post NHS
159	Monocacy National Battlefield	219	Fort Matanzas NM
160	Klondike Gold Rush NHP	220	Fort Vancouver NHS
161	Stones River NB	221	Cape Cod NS
162	Fort Union NM	222	Devils Postpile NM
163	Coulee Dam NRA	223	Sequoia & Kings Canyon NP
164	Alagnak Wild River	224	Friendship Hill NHS
165	Aztec Ruins NM	225	Arkansas Post NM
166	Salinas Pueblo Missions NM	226	Yellowstone NP
167	Carl Sandburg Home NHS	227	Gila Cliff Dwellings NM
168	Sleeping Bear Dunes NL	228	Rock Creek Park
169	Kennesaw Mountain NBP	229	Prince William Forest Park
170	Cape Hatteras NS	230	Abraham Lincoln Birthplace NHS

231	Saugus Ironworks NHS	249	Fort Donelson NB
232	Ebey's Landing NHR	250	Lassen Volcanic NP
233	George Washington Memorial PKWY	251	Buck Island Reef NM
234	Mojave N PRES	252	Glacier NP
235	Niobrara/Missouri NR	253	Hawaii Volcanoes NP
236	Dry Tortugas NP	254	Mount Rainier NP
237	Greenbelt Park	255	Natural Bridges NM
238	Fort Scott NHS	256	White Sands NM
239	Canyon de Chelly NM	257	National Park of American Samoa
240	Whiskeytown-Shasta-Trinity NRA	258	Cowpens NB
241	Pinnacles NM	259	Manassas NBP
242	Chesapeake & Ohio Canal NHP	260	Colonial NHP
243	Fort Union Trading Post NHS	261	Capitol Reef NP
244	Everglades NP	262	Arches NP
245	Theodore Roosevelt NP	263	Craters of the Moon NHP
246	Fort Larned NHS	264	Knife River Indian Village NHS
247	Tallgrass Prairie National Preserve	265	Richmond NBP
248	Petroglyph NM		

Priority Ranking Criteria

1. Parks with on-going geology mapping projects.
2. Ranked by the highest park priorities for either surficial or bedrock geology mapping.

Source Natural Resources Information Division, Inventory and Monitoring Program, Joe Gregson, 1998