Geoscience Information Society

Proceedings Volume 27 1996

PROCEEDINGS OF THE THIRTY-FIRST MEETING OF THE GEOSCIENCE INFORMATION SOCIETY

OCTOBER 28-31,1996
DENVER, COLORADO

EXPANDING BOUNDARIES: GEOSCIENCE INFORMATION FOR EARTH SYSTEM SCIENCE

Edited by
Barbara J. DeFelice

PROCEEDINGS

VOLUME 27

GEOSCIENCE INFORMATION SOCIETY

1997

ISBN : 0-934485-28-3

For information about copies of this proceedings volume, or earlier issues, contact:

Publications Manager
Geoscience Information Society
c/o American Geological Institute
4220 King Street
Alexandria, VA 22032
USA

TABLE OF CONTENTS

PART 1

Symposium

Expanding Boundaries: Geoscience Information for Earth System Science

PART II

Technical Session

Geoscience Information: Current Trends, Future Plans

PART III

Poster Session

Geoscience Information

PREFACE

The Geoscience Information Society (GIS) is an independent, nonprofit, professional society established in 1965. Members include librarians, information specialists, and scientists concerned with all aspects of geoscience information. GIS has members from academia, business, and government, who currently represent seventeen countries. GIS is a member society of the American Geological Institute, and an associated society of the Geological Society of America (GSA). The annual meeting of GIS is held concurrently with that of GSA, and the papers and posters on geoscience information are part of the GSA annual meeting program.

Oral presentations of the papers in this proceedings were given at the 1996 GSA Annual Meeting in Denver, Colorado, October 28-31. This proceedings volume is divided into three parts:

I. Invited papers, given at the GIS Symposium "Expanding Boundaries: Geoscience Information for Earth System Science", held on October 29, 1996;

II. Contributed papers, presented at the GIS Technical Session "Geoscience Information: Current Trends, Future Plans", held on October 30, 1996.

III. Contributed papers for display at the GIS Poster Session "Geoscience Information", on October 29, 1996.

Papers are arranged within each section in the order of the oral presentations. The papers have been edited slightly for consistency. The authors are solely responsible for the opinions and ideas expressed here.

I thank each of the authors for the effort and time they put into writing their papers for this Proceedings volume. They not only prepared and gave excellent and stimulating talks, they were willing to write down their findings and ideas for reference in the future. I want to thank the co-conveners of the paper sessions, Barbara Haner for the Symposium, and Joni Lerud for the Technical Session. I also thank Linda Dorr for her work on the page layout, and Lois Heiser, GIS Publications Manager, for her work in handling the printing and distribution of these Proceedings.

Barbara DeFelice
1996 Program Chair
President, GIS
Hanover, NH
June 1997

PART I

SYMPOSIUM

EXPANDING BOUNDARIES: GEOSCIENCE INFORMATION FOR EARTH SYSTEM SCIENCE

INTRODUCTION

The 1996 Geoscience Information Society Symposium topic "Expanding Boundaries: Geoscience Information for Earth System Science" connected issues of geoscience information dissemination and access with the GSA annual meeting theme of "Earth System Summit" and its focus on the complex interrelated processes that make up the whole earth system. This theme provided a motivation and opportunity to bring together speakers who explored the issues of collecting, organizing, and disseminating information that results from and supports research on the earth system. In the opening paper, Linda Musser offers both a description of Earth System Science and ideas about the implications of this interdisciplinary field for library collections. Sally Scott's study on geologists' use of materials outside the traditional geological subject areas provides insight into the information gathering habits of scientists working in different areas of earth science.

The varied audience for earth system information, ranging from scientists and researchers to teachers, environmentalists and concerned lay persons, was an important aspect of the overall theme. Librarians and other geoscience information specialists have found it necessary to provide geological literature, climate data and water resources information not only to those trained in the traditional disciplines of geology, but also to regional planners, ecologists, and the general public concerned about earth science and environmental issues. This information can be provided in many formats, from printed books to numerical data to images on Web sites, and some of it can be integrated in a geographic information system upon demand by the librarian or user. In their paper, David Mogk and Lee Zia propose the establishment of a national electronic library for undergraduate science education. Daniel Karnes and Robert Brakenridge discuss a web-based project which provides information on extreme flood events to a broad audience. Along with several of the other authors of these papers, Karnes and Brakenridge raise the question of responsibility for long-term storage of electronic information and provision of access to digital data over time.

The National Science Foundation has been supporting research and development of digital libraries. Barbara Buttenfield and Suzanne Larsen give an overview and update on the Alexandria Digital Library project, funded by the NSF to explore the issues of establishing an electronic library of georeferenced materials, primarily maps and images. Mary Larsgaard follows with details on the development of metadata and metadata standards, which is part of the Alexandria Digital Library project.

Changes in government support for research and publication distribution affect our ability to serve the needs of the changing and growing audience for geoscience information. James Smith addresses the print and electronic future of the very important publications of the United States Geological Survey.

Linda Newman and Lois Pausch, in their summary of the classic works of geology, remind us of our roots in this literature and our responsibility to provide readable, accessible, and informative materials to anyone curious about the amazing earth system in which we live.

Barbara DeFelice
1996 Program Chair
President, GIS
Hanover, NH
June 1997

EARTH SYSTEM SCIENCE: THE REAL ENVIRONMENTAL SCIENCE

Linda R. Musser

Earth and Mineral Sciences Library
The Pennsylvania State University
105 Deike Building
University Park, Pennsylvania 16802

Abstract —There is a great deal of confusion as to what constitutes earth system science. This confusion is due in part to the misuse of the phrase "environmental science" for what is really ecology. Ecology deals with the biological aspects of the environment whereas true environmental science deals with all aspects of the planet, physical and biological. Such is earth system science. Earth system science is the study of the interrelationships between and joint functioning of the biosphere, atmosphere, hydrosphere and lithosphere. It encompasses the established fields of earth science, meteorology, oceanography, hydrology, geography and ecology. Just as earth system science researchers range from meteorologists to ecologists, the resources required to support earth system science research must encompass a range of subjects and techniques. This article defines and describes earth system science and explores its implications for library collections.

INTRODUCTION

As with any new area of study there is a certain period of confusion while people become familiar with its focus and extent. This normal "getting-to-know-you" process has been exacerbated in the case of earth system science due to confusion between it and environmental science. Environmental science is commonly equated almost wholly with the study of the biosphere and biospheric interactions with the planet. What is forgotten is that "environment" encompasses much more than just the living realm. What many call environmental science is really ecology. Real environmental science encompasses not only the biological but also the physical aspects of the planet, such as its climate and geology. Earth system science is truly environmental science. It is the study of the interrelationships between and joint functioning of not only the biosphere but the atmosphere, hydrosphere and lithosphere. Some examples of topics of interest to earth system science include climate change induced by volcanic eruptions or biomass burning, the role of ocean circulation in temperature regulation, sequestration of nutrients by vegetation, desertification, and atmospheric ozone variations. Topics of interest occur within widely varying temporal cycles, from minutes to millennia such as individual volcanic events to the decadal cycle of El Niño to the movement of continents. Earth system scientists strive to measure, predict and understand how these cycles affect the functioning of our planet.

It should be noted that, for the most part, these are not new areas of study. Ocean circulation patterns have long been an area of study for oceanographers. Similarly, volcanic eruptions and their climatic effects have been studied and hotly debated by earth scientists and meteorologists alike. Traditional fields of study such as earth science, meteorology, oceanography, hydrology, geography, and ecology are all encompassed by earth system science. The focus however is on the interrelationships between the fields of study. A good example of this is the study of how water, nitrogen and carbon move between and affect the various spheres. An additional aspect of earth system science research is the equipment and techniques used to perform much of the science itself. These fall into three areas: data gathering techniques such as remote sensing and Earth observation systems; data storage systems and techniques required to manage the terrabytes of information generated by data gathering systems; and data analysis techniques such as visualization and computer modeling.

EARTH SYSTEM SCIENCE ORGANIZATIONS

A wide variety of organizations are involved in earth system science research. One of the most important is the International Geosphere-Biosphere Progamme (IGBP). Founded in 1986 by the International Council of Scientific Unions, its goal is to describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions. The IGBP has established a core group of initiatives, eight discipline-based and three related to techniques and support, to investigate various aspects of earth system science (see Figure 1). These are indicative of the scope of earth system science.

Discipline Projects

International Global Atmospheric Chemistry Project (IGAC)
Global Change and Terrestrial Ecosystems (GCTE)
Biospheric Aspects of the Hydrological Cycle (BAHC)
Joint Global Ocean Flux Study (JGOFS)
Past Global Changes (PAGES)
Land-Use and Land-Cover Change (LUCC)
Land-Ocean Interactions in the Coastal Zone (LOICZ)
Global Ocean Ecosystem Dynamics (GLOBEC)

Framework Activities

IGBP Data and Information System (IGBP-DIS)
Global Change System for Analysis, Research and Training (START)
Global Analysis, Interpretation and Modelling (GAIM)

Figure 1. International Geosphere-Biosphere Progamme (IGBP) projects.

The Intergovernmental Panel on Climate Change (IPCC) is also international in scope but is more focused on the climatic aspects of earth system science. It was formed in 1988 by the World Meteorological Organization and the United Nations Environmental Programme in response to concerns about global warming. The IPCC formed several working groups to increase scientific understanding of climate change, its impacts and possible response strategies. The IPCC has published several significant reports summarizing the results of their work to date (Intergovernmental Panel on Climate Change, 1990, 1990a, 1991, 1992, 1995). It is probably worth stating that, while climate is just one aspect of the earth system, it nonetheless constitutes a major focus of earth system science research.

Other organizations involved in earth system science research include university research centers such as the Earth System Science Center at the Pennsylvania State University, government agencies such as NASA's Global Change Research Program, and non-governmental organizations such as Resources for the Future and the Worldwatch Institute.

IMPACTS ON LIBRARY COLLECTIONS

The incorporation of traditional fields of study into the study of earth system science makes the work of the librarian somewhat easier in that many of the needed resources may already exist in their library. Much will depend, however, on the scope of the collection to date. For geoscience libraries, there will be a need to expand the collection in the areas of ecology and, if not previously collected, meteorology, hydrology and oceanography. In addition, it may be necessary to expand the collection into areas of the social sciences as well, since many earth system science studies focus on human impacts on the earth system. Behavioral and economic aspects of attempts to reduce greenhouse gases or slow desertification are good examples of the importance of the social sciences to earth system science.

While expanding the collection is these areas may appear daunting, the overwhelming preference of researchers is to publish in an established publication outlet of their field. It should be reassuring to know that some of the most useful and highly cited works on earth system science have been published in mainstream science journals such as: *Science*, *Nature*, *Journal of Geophysical Research* (various sections), *Geophysical Research Letters*, *Palaeogeography Palaeoclimatology Palaeoecology* (*Palaeo*^{3}), and *Climatic Change*. Interdisciplinary journals do exist, however, and the number appears to be growing, albeit fairly slowly. These titles include: *Global and Planetary Change* (a daughter journal of *Palaeo*^{3}), *Global Environmental Change*, *Modelling of Geosphere Processes*, *Global Change Biology*, *Mitigation and Adaptation Strategies for Global Change*, and *Global Biogeochemical Cycles*.

On the monographic front, the growth in published materials on earth system science has occurred much faster. If one looks at those works that fall outside the normal collecting areas of the geosciences, the annual output would be on the order of 120 titles per year. This figure is based on materials published primarily through normal publishing channels. It does not include the many technical reports published annually on this topic. These "normal publishing channels" include not only commercial and scholarly publishers but governmental outlets as well. Governmental agencies are prolific and important publishers in earth system science. Approximately one-third of the approximately 120 titles published per year could be considered governmental in origin. The benefit of this is that these governmental publications tend to be free or fairly inexpensive. The average price for the non-governmental material is approximately $80, not excessively high for science materials.

CONCLUSIONS

Ultimately, the amount of material each library will collect will depend on the local scope of earth system science research. Earth system science is a huge interdisciplinary field and it will be the rare organization or library that attempts to address all its aspects at a research level. Most libraries will be well served by judiciously adding titles to their collections which address the various subsystems and their interactions while providing access to collections with strengths in the bio-sciences, meteorology, oceanography, energy and geography. Now is the time to form partnerships with libraries with strengths in those areas.

REFERENCES

Intergovernmental Panel on Climate Change, 1990, Climate change: the IPCC impacts assessment: Canberra, Australian Government Publication Service, 1 v.

Intergovernmental Panel on Climate Change, 1990a, Climate change: the IPCC scientific assessment: New York, Cambridge University Press, 364 p.

Intergovernmental Panel on Climate Change, 1991, Climate change: the IPCC response strategies: Washington, DC, Island Press, 272 p.

Intergovernmental Panel on Climate Change, 1992, Climate change: the supplementary report to the IPCC scientific assessment: New York, Cambridge University Press, 200 p.

Intergovernmental Panel on Climate Change, 1995, Climate change, 1994: radiative forcing of climate change and an evaluation of the IPCC IS92 emission scenarios: New York, Cambridge University Press, 339 p.

INTERDISCIPLINARY USE OF SCIENCE INFORMATION BY GEOLOGY FACULTY AND GRADUATE STUDENTS: IMPLICATIONS FOR LIBRARY SERVICES

Sally J. Scott

Science Library
University of Wyoming
Laramie, Wyoming 82070

Abstract — Recognition of the interrelationships between scientific disciplines has led to in increase in interdisciplinary subjects. The geosciences have always been interdisciplinary, depending heavily on an understanding of the basic and associated sciences. The geology faculty and graduate students at the University of Wyoming were surveyed to determine their use of the information resources in the Science Library to ascertain their use of interdisciplinary science materials. Their responses indicated that they did not use extensively the major reference resources or indexing/abstracting resources in the major science disciplines other than geology. They did use the broadly based general science journals, particularly *Science* and *Nature*, and displayed great variation and individual interests in the non-geology subject-focused journals they used. The geochemists visited the Science Library and used the resources more frequently than did geologists in any of the other geology disciplines. The more traditionally geology-focused disciplines such as structural geology and petrology used the other science resources the least. Convenient access to materials was considered very important. The Science Library could increase increase its services to the Geology Dept. by providing lists of materials acquired, educating faculty and students about the available relevant resources, and increasing convenience of use through remote access to databases.

INTRODUCTION

The boundaries between scientific disciplines have become increasingly less distinct. This trend is evidenced by the proliferation of interdisciplinary books and journals. For example, the journal *BioMimetics* is described by the publisher Plenum Press as "*the* journal at the critical interface between engineering and biology." Other emerging interdisciplinary fields are represented by the journal *Chemistry & Biology* and the book series *Progress in Biometeorology*. Examples relevant to geology include the journals *Biogeochemisty, Geomicrobiology*, and *Global and Planetary Change*.

Geology is and nearly always has been a very interdisciplinary subject. It began as a descriptive science focusing on the observable characteristics and composition of rock strata and the fossils contained within them. The emphasis ultimately shifted to the chemical and physical properties of the rocks and the anatomy, behavior and environments of the animals represented by the fossils. Believing that "the present is the key to the past," it was realized that to understand the events of geologic history it was necessary to understand the biological, chemical, and physical processes operating today. This led to interdisciplinary subdisciplines such as geochemistry, geophysics, and paleoecology within the broad field of earth science.

The increasing overlap and interrelationships between the various branches of science are reflected in the changing curricula of university departments and the creation of cross-disciplinary departments and degrees. It was reported in the October 6, 1995 special issue of *Science* on the future of the Ph.D. that interdisciplinary programs are increasing (Moffat, 1996). Cited as an example was the University of Wisconsin, Madison, multidisciplinary program in geological engineering involving geology, physics, and several engineering departments. Two years ago the University of Wyoming began a new School of Environment and Natural Resources, which draws on numerous established academic departments from zoology and geology to economics and philosophy for its curriculum.

Many advances in geology have been heavily indebted to advances in other fields. One highly publicized example is the research involving dinosaur DNA, which would not have been

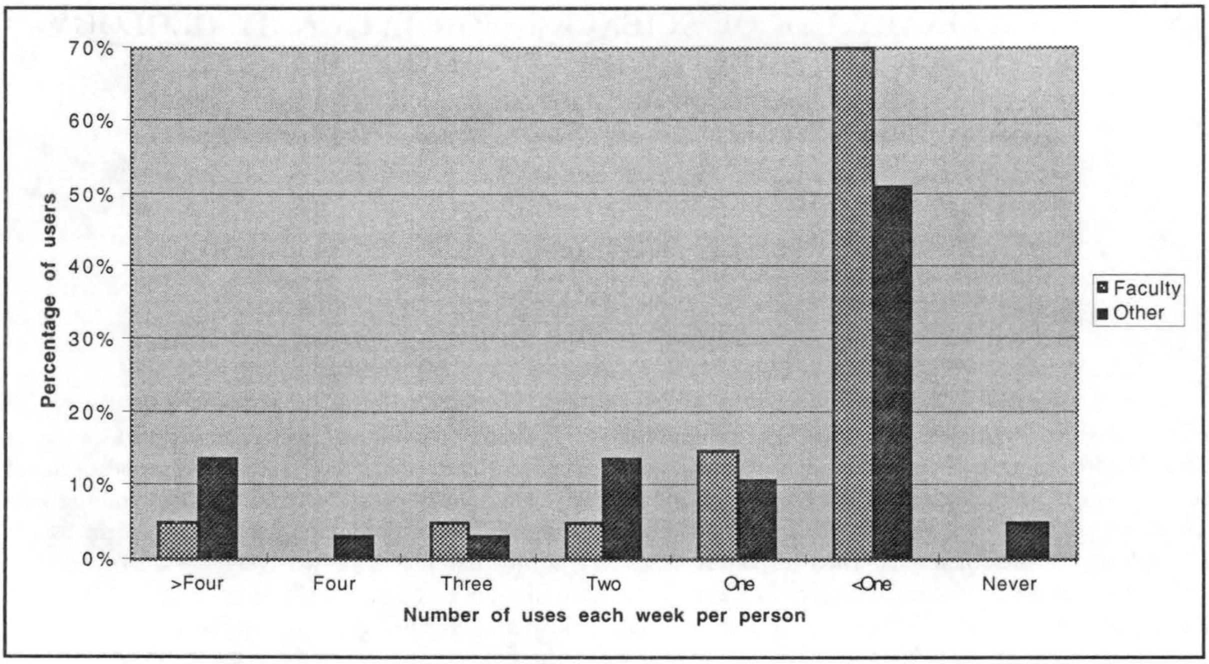

Figure 1: Use of the Science Library by the Geology Department.

possible without the knowledge and technologies developed in molecular biology. Global change is another hot topic drawing upon research in chemistry, physics, atmospheric science, and oceanography as well as earth science.

PURPOSE AND METHODOLOGY

How important is the literature of these sciences to the geologist? How much use do they make of the books and journals in science disciplines other than geology? To address these questions I surveyed the faculty and graduate students in the Geology Department at the University of Wyoming. The primary purpose of the study was to investigate the use of the non-geology science literature by geologists. A secondary purpose was to determine how much they used the Science Library, which would enable us to enhance our service to them if warranted by their use patterns and needs.

Organization of Wyoming Science Materials

At the University of Wyoming the Science and Geology libraries are separate branch libraries. The Science Library serves all the science disciplines except geology. Location of materials is call number driven. All materials classed in the Library of Congress system under QE (geology) and GB (physical geography), for example, are shelved in the Geology Library. Selected limited subject areas are also routed to the Geology Library, notable QC 811-QC849 (geomagnetism) and TA 700-TA 709 (engineering geology and rock mechanics.) The remaining Q (science) categories and all S (agriculture) and T (technology) classifications are in the Science Library. Consequently, most of the books and journals related to climatology (QC), petroleum and mining engineering (TN), remote sensing (TN, et al.), and soils (S), e.g., are in the Science Library.

Classification of any item depends on the subjective evaluation of the cataloger based on the title and apparent emphasis of the work. For example, a database search in CARL on the term "paleobotany" retrieves primarily items classified in QE. A search on "botany - evolution," however, retrieves items classed in QH (natural history) and QK (botany). Obviously, all of these works would be relevant to a paleobotanist. Are these distinctions apparent to the library users, and are they aware of and using these materials? Because of the distribution of materials in the University of Wyoming libraries, surveying use of the Science Library as well as use of the materials was a logical check on how much use geologists were making of the other science information.

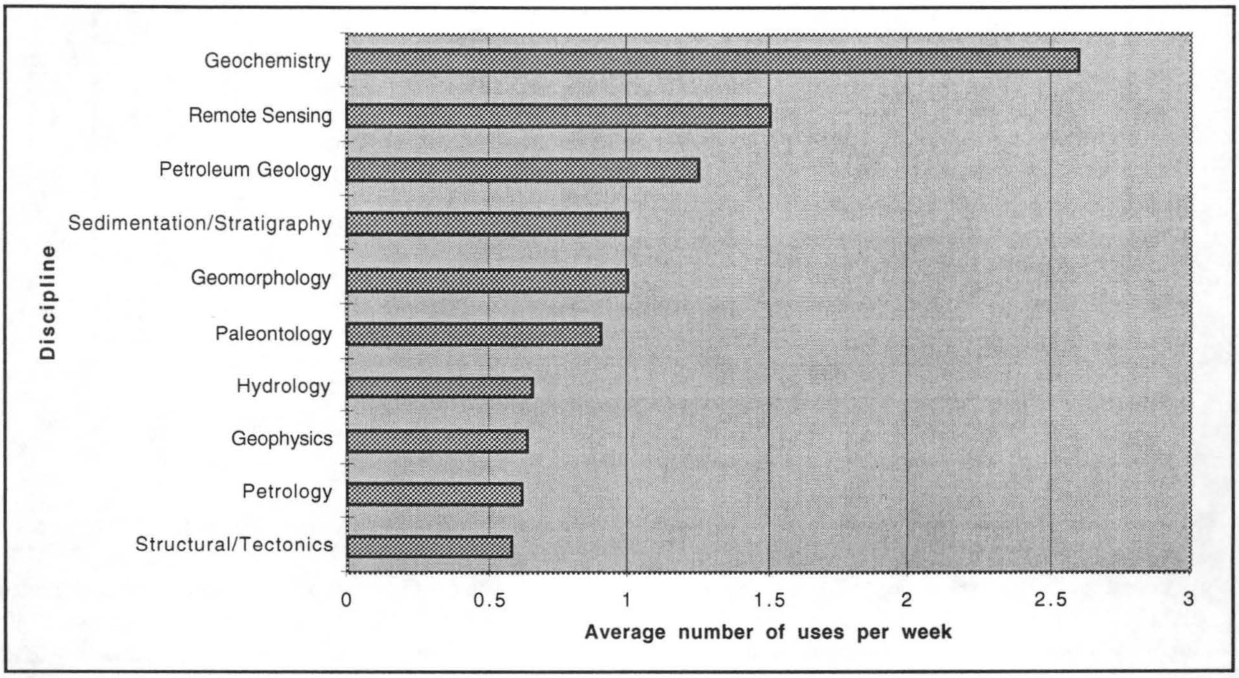

Figure 2: Use of the Science Library by geology discipline.

The Survey

At the time the survey was conducted during the 1996 Spring Semester, there were 28 faculty, 64 graduate students and 12 postdoctoral research scientists in the Geology Department at the University of Wyoming. Fifty-five percent (57) of them responded to the survey, including 71% (20) of the faculty, 45% (29) of the graduate students, and 67% (8) of the postdoctoral scientists. They were asked to indicate on the survey form their status (e.g., faculty), their primary disciplinary focus (e.g., geochemistry), how often they used the Science Library, why they used the Science Library, whether they read or borrowed books from the Science Library, what electronic and printed reference resources they used, what indexing/abstracting resources they used, what general science journals they used, and what subject-specific science journals they used. The survey was designed to be completed quickly. It consisted of multiple choice questions with a few open-ended questions.

RESULTS OF THE SURVEY

The survey participants were asked to indicate how frequently they used the Science Library, from "never" to "greater than four" times per week. Fifty-eight percent of the respondents (70% of the faculty, 51% of the combined graduate students and postdocs) used the library less than one time per week (Figure 1).

When asked to identify their primary research area, 3 faculty, 5 graduate students, and 6 postdocs named geochemisty; 2 faculty and 3 graduate students named geomorphology; 3 faculty, 3 graduate students, and 1 postdoc named geophysics; 1 faculty and 2 graduate students named hydrogeology; 2 faculty and 3 graduate students named paleontology; 2 faculty, 2 graduate students, and 1 postdoc named petroleum geology; 1 faculty and 1 graduate student named petrology; 1 faculty and 4 graduate students named remote sensing; 5 faculty, 6 graduate students, and 1 postdoc named sedimentation and/or stratigraphy; and 3 faculty, and 4 graduate students named structural geology or tectonics. These numbers total more than 57 because several people indicated more than one specialty. A comparison of the use of the Science Library by subject or discipline shows that the geochemists were the greatest users at an average of 2.67 times per week (Figure 2).

	Faculty	Graduate/Postdoc	Total
Science Citation Index	60%	22%	35%
Chemical Abstracts	15%	19%	18%
Petroleum Abstracts	5%	14%	11%
Biological Abstracts	5%	3%	4%
Physics Abstracts	5%	3%	4%
Mathematical Reviews	0%	3%	2%
Zoological Record	5%	0%	2%
Pollution Abstracts	0%	3%	2%
Astronomy & Astrophysics Abstracts	5%	0%	2%

Table 1: Use of the indexing/abstracting resources

When asked how frequently they read or borrowed books from the Science Library, 16% reported often, 74% occasionally, and 9% never.

At the time of the survey, the Science Library offered electronic access to various databases on CARL, which is the UW OPAC, all of the FirstSearch databases, and CompendexPlus, AGRICOLA, CAB, Wildlife Review & Fisheries Review, and the Chemical Kinetics Database on CD-ROM. GeoRef was available at the Geology Library. Only one person indicated use of CompendexPlus. Two people said they used Medline on FirstSearch and three used Dissertation Abstracts on FirstSearch. Bichteler and Ward (1989) pointed out that geologists do not do as much database searching as other scientists. It was not determined in this survey how much they might be using GeoRef.

The remainder of the indexing/abstracting resources were in print. The most frequently used print resource was Science Citation Index, with a total of 35% (60% of the faculty, 22% of the graduate students and postdocs) indicating use (Table 1). It is important to note that use of subject-specific indexing resources reflects the individual areas of specialization. Even though only 18% (10) of the total respondents used Chemical Abstracts, 64% (9) of the geochemists indicated they used it. One questions why the rest of the geochemists were not using it. Even when one compares the use of each indexing source with an associated geology discipline, it is clear that they are not being heavily used by those geologists. Rinaldo and DeFelice (1995, p. 22) concluded in their study on interdisciplinary research needs of researchers working in global change that "faculty generally do not know of the indexes to the formal literature which are outside of their area of doctoral level training."

The CRC Handbook of Chemistry and Physics was used by 32% of the total number of users (40% faculty, 27% graduate students/postdocs). It was the most frequently used reference resource. None of the other basic reference resources received very much use (Table 2).

Journal usage was divided into general science journals with broad coverage of many science disciplines and journals with a more specific subject focus. Table 3 lists the 10 most frequently used general science journals. Clearly *Science* is the most heavily used journal with 58% overall (80% faculty, 46% graduate students/postdocs) indicating use. Several respondents indicated that access to *Science* was the primary reason they visited the Science Library. These results agree with the Bichteler and Ward (1989) study, which reported that about half of the geologists interviewed read *Science* or *Nature.* There were several requests for posting of the *Science* table of contents in the Geology Library. (On a separate occasion we were also asked if we would post the tables of contents of the geology journals in the Geology Library!) This corresponds to the comment by Rinaldo and DeFelice (1995, p. 21) that "researchers frequently prefer to scan tables of contents of journals rather than to rely on subject indexes." Bichteler and Ward (1989, p. 173) noted that about 20% of their respondents found "reproduced tables of contents to be useful." There are duplicate subscriptions to both *Nature* and *Science News* in the Geology Library. Use of both of these publications is probably higher than indicated here. Use of all the general science journals was higher for the faculty than for the graduate students and postdocs.

	Faculty	Graduate/Postdoc	Total
CRC Handbook of Chemistry and Physics	40%	27%	32%
Books in Print	25%	16%	19%
ASTM Standards	5%	11%	9%
Climate/Weather Sources	5%	8%	7%
McGraw-Hill Encyclopedia of Science and Technology	10%	5%	7%
Other general encyclopedias	5%	8%	7%
Subject encylopedia/dictionary	15%	3%	7%
Lange's Handbook of Chemistry	0%	8%	5%
Gale Periodicals Abbreviations Dictionary	5%	5%	5%
American Men and Women of Science	15%	0%	5%
Other biographical resources	10%	0%	4%
Sadtler Standard Spectra	0%	5%	4%

Table 2: Use of the basic reference resources

To determine the use of subject-focused journals, I looked at the specific titles reported by geologists in each discipline. Because there was considerable difference in the numbers of people working in each discipline, I averaged the numbered of journals being used to produce the figures represented in Figure 3. Clearly, the geochemists made the greatest use of science journals outside the field of geology. Among them they listed over 35 journal titles. A comparison with Figure 1 shows that the journal use does not parallel exactly the use of the Science Library, which implies that you cannot necessarily infer the one from the other. Note that because of the distribution of materials by call number, the remote sensing and petroleum geology faculty and students need to use the Science Library to access many of the materials in their disciplines. The paleontologists and geophysicists indicated a much greater use of the science literature than they did of the Science Library in general. Although there was considerable use of the non-geology journal literature, there was great individual variation in the titles chosen (see Appendix 1.)

	Faculty	Graduate/Postdoc	Total
Science	80%	46%	58%
Nature	45%	38%	39%
Scientific American	55%	19%	32%
American Scientist	50%	19%	30%
Science News	30%	14%	19%
Discover	25%	5%	12%
National Academy of Sciences Proceedings	15%	5%	9%
New Scientist	20%	0%	7%
Natural History	15%	3%	7%
Annals of the New York Academy of Sciences	15%	0%	5%

Table 3: Use of the general science journals

Comments by individuals indicated that they liked the convenience of having the Geology Library located in the geology building. There were requests to move paleoclimatology and remote sensing materials over there. One faculty member expressed unhappiness with the steadily diminishing availability of journals due to shrinking budgets and cancellations, a sentiment probably shared by many.

CONCLUSIONS

The results of the survey reveal that overall there isn't a lot of use of the general reference or indexing/abstracting science resources by the faculty and students of the Geology Department. There is good use of the general science journals, particularly by the faculty. Some disciplines within geology, notably geochemistry, paleontology, and geophysics, rely more on the literature of non-geology sciences than others. The more traditional geology subjects such as structural geology and petrology, for example, find what they need in the geology literature. There was great individual variation in the titles of journals listed. Very few were universally used by people within the same area of specialization. Perhaps these journals are not meeting the interdisciplinary needs of these users. Bichteler and Ward (1989, p. 174) suggest that "perhaps journal specialization does not always correspond adequately to the subdisciplinary and interdisciplinary breakdowns within geoscience."

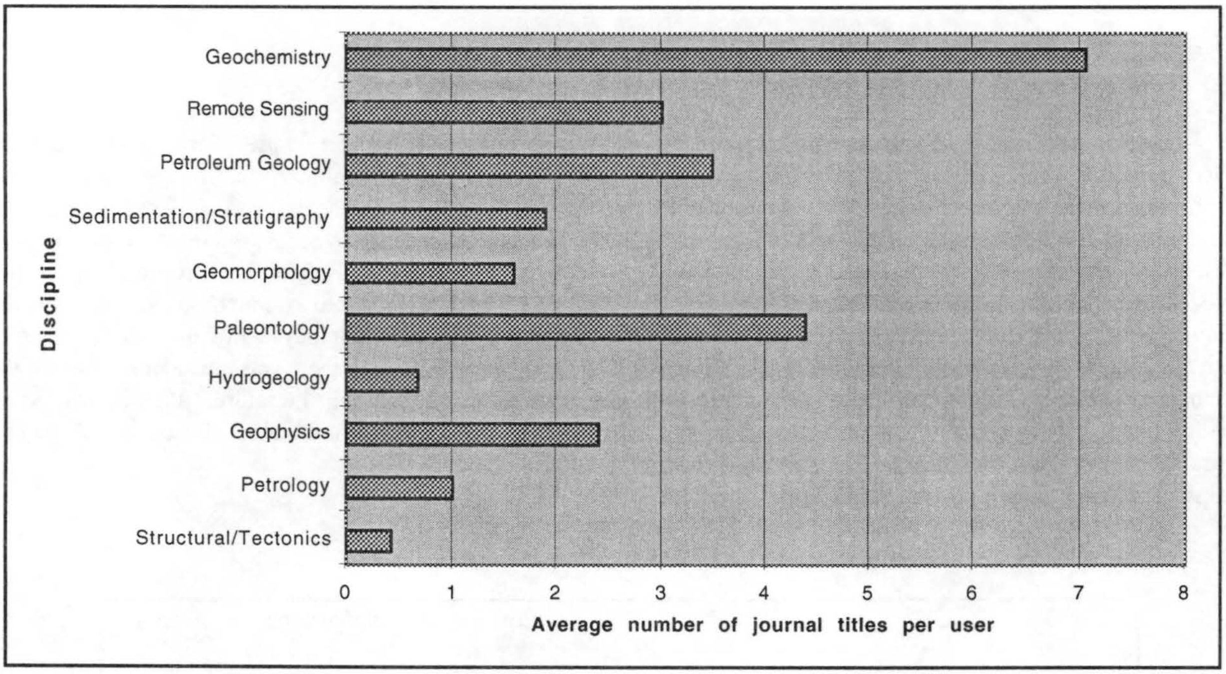

Figure 3: Use of science journals by discipline

Convenience is very important. Most researchers would prefer access to information to be as close as possible, perhaps even in their offices. Even though the average field geologist will trek over all types of terrain in all kinds of weather to locate the perfect outcrop or the missing link, a two-minute walk to the Science Library is apparently too much trouble. It is, perhaps, a different mindset when one is engaged in teaching and academia than when one is doing field work.

IMPLICATIONS FOR LIBRARY SERVICES

The primary mission of the library is to connect users with information. If time is at a premium and library users need resources to be as convenient as possible, the library needs to reach out to provide more personal service. We should keep them informed as to what resources received in the library might be relevant to them. Delivery of documents from the libraries directly to them is a valuable service. Networking of databases enables them to access information directly from their office computers and may increase their use of these resources. One-on-one information service provided by librarians to faculty would enhance delivery of information and provide good public relations for the library. However, librarians have perhaps as many time commitments as the teaching faculty so this is perhaps a goal not easily reached.

Faculty and students need to be educated regarding the resources available in their fields, including viable Internet resources, databases, and interdisciplinary materials.

The Internet is not the answer to everything, however. It is neither structurally well-organized nor reliably consistent. Participants in The University Licensing Program (TULIP), a 5-year examination of the viability of electronic publication sponsored by Elsevier with the cooperation of nine academic institutions, concluded that it will take longer to change to a digital library than expected and not everything will be available electronically, particularly older information (TULIP final report, 1996). This has implications for geology, a subject heavily dependent on historical literature.

Libraries need to provide more access to full-text databases as subscriptions to journals decrease. They should also endeavor to provide faculty and students remote access to library databases from their offices or home computers. Diminishing resources have profound effects on faculty attitudes toward libraries and their relationships with them. Increasing services will balance the negative effects of changing library resources.

The situation at the University of Wyoming is not unique. An examination of the *Directory of Geoscience Departments* and the *Directory of Geoscience Libraries* shows that approximately 19% of all academic institutions with graduate degrees in geology have separate geology branch libraries. The results of this study are specific to the University of Wyoming but may be applicable to situations in other geology branch libraries. It would be interesting to know if interdisciplinary use patterns are any different in libraries where the geology collections are integrated with the other science collections.

SERVICE ENHANCEMENTS AT THE UNIVERSITY OF WYOMING

The Science Library provides a monthly list of all newly acquired books for all the science departments. This enables interdisciplinary researchers in any department to see what has been purchased by other departments which may be of use to them. For example, soils materials are acquired for the geology, civil engineering, and soils departments. The librarians working as liaisons to these departments may or may not keep each other informed of purchases. The faculty may know what their own department has ordered but probably will not know what another department has ordered.

The Library has recently subscribed to ten databases including GeoRef through the Silverplatter Extended Reference Library, which will provide remote access for campus Library users. They are also able to access UnCover Reveal through their e-mail system to see the contents of journals of their choice. We are now providing online access to Compendex and MathSciNet through the Internet.

We are endeavoring to make ourselves more available for reference services to the faculty and students.

REFERENCES

Bichteler, J., and Ward, D., 1989, Information-seeking behavior of geoscientists, Special Libraries, v. 80, no. 3, p. 169-178.

Claudy, Nicholas H., ed., 1995, Directory of geoscience departments, 34th ed., Alexandria, Virginia, American Geological Institute.

Manson, Connie, ed., Directory of geoscience libraries, 5th ed., Geoscience Information Society (in press.)

Moffat, A.S., 1995, Grad schools preview the shape of Ph.D.s to come, in Careers '95: the future of the Ph.D., Science, v. 270, p. 128-133.

Rinaldo, C.A., and DeFelice, B., 1995, Biological information needs and resources for interdisciplinary research areas, in Managing information in the biological sciences: proceedings of the Contributed Papers Session, Biological Sciences Division, Special Libraries Association, 86th Annual Conference, Montreal, June 14, 1995, p. 16-24.

TULIP final report: chapters I-VI, [web page], 1996, http://www.elsevier.com/homepage/about/resproj/trbody.htm, [accessed 21 Oct. 1996].

APPENDIX 1: SCIENCE JOURNALS USED BY UNIVERSITY OF WYOMING GEOLOGY FACULTY AND STUDENTS

No. of Survey Respondents: Faculty - 20; Graduate Students - 29; Other (Postdoctoral Research Scientists) - 8

	Number of Users	
	Faculty	**Grads/Other**
GEOCHEMISTRY	**3**	**5 6**
Ecology		1
Acta Crystallographica, A: Foundations of Crystallography	1	
Acta Crystallographica, B: Structural Crystallography and Crystal Chemistry	1	2
Acta Crystallographica, C: Crystal Structure Communications	1	
Analytical Chemistry	2	4
Applied Spectroscopy		1
Canadian Journal of Chemistry		2
Chemical Physics	1	1
Chemical Reviews		1
Inorganic Chemistry	1	1
Journal of Chemical Physics	2	1
Journal of Physical Chemistry	1	1
Journal of the American Chemical Society	1	3
Journal of the Chemical Society (London): Chemical Communications		1
Journal of the Chemical Society (London): Dalton Transactions		1
Journal of the Chemical Society (London): Faraday Transactions	1	1
Journal of the Chemical Society (London): Perkin Transactions		1
Applied Physics A: Materials Science and Processing	1	
Astrophysical Journal	1	
Physical Review B: Condensed Matter	1	
Physics Today	1	1
MacWorld		1
Materials Science & Engineering	1	1
Annual Review of Materials Science		1
JGR. Oceans	2	1
JGR. Atmospheres	1	1
JGR. Planets	1	3
Applied and Environmental Microbiology		1
Water Research		1
Environmental Science and Technology	2	2
Ambio		1
Journal of Environmental Quality	1	1
Plant and Soil		1
Canadian Journal of Forest Science		1
Water, Air, and Soil Pollution	1	1
Soil Science		1
Soil Science Society of America Journal		2
Plant, Cell and Environment		1
Biogeochemistry		1
Global Biogeochemical Cycles		1

Forest Science			1	
Journal of Colloid and Interstitial Science	1		2	
Surface Science	1		1	
Soils journals			1	
Palaeogeography, Palaeoclimatology, Palaeoecology			1	
Journal of Electroanalytical Chemistry	1		1	
Langmuir	1		1	
Oil and Gas Journal			1	
Journal of Petroleum Technology			1	
SPE journals			1	
Geoderma			1	
Applied Surface Science	1			
Review of Scientific Instruments		1		
Journal of the Electrochemical Society	1			
Geomicrobiology Journal	1		1	
GEOMORPHOLOGY	**2**	**3**		
Papers in Meteorology and Geophysics	1			
Limnology and Oceanography			1	
Hydrobiologia			1	
Water Science and Technology			1	
Arctic and Alpine Research			1	
Proceedings of the Royal Society of London			1	
Cold Regions Research			1	
JGR. Oceans			1	
GEOPHYSICS	**3**	**3**		**1**
JGR. Oceans	1			
JGR. Atmospheres	1			
JGR. Planets	1		2	
Physics Today	1			
IEEE Transactions on Geoscience and Remote Sensing			1	
Hawaii Institute of Geophysics. Yearbook	1			
MacWorld			1	
Acta Metallurgia et Materialia	1			
Experimental Thermal and Fluid Science	1			
Journal of Fluid Dynamics	2			
Oil and Gas Journal			1	
Computers in Physics	1			
Inverse Theory	1			
Physical Review Letters	1			
Applied Mathematics and Computation	1			
Journal of Computational and Applied Mathematics	1			
IEEE Computer Graphics and Computer Simulation	1			
SIAM Journal on Scientific Computing	1			
Byte	1			
Physical Review B: Condensed Matter	1			
HYDROGEOLOGY	**1**	**2**		
Chemical Physics			1	
Journal of Soil Science			1	

PALEONTOLOGY	2	3		
JGR. Planets			1	
American Naturalist	1		1	
Ecology	1		1	
Evolution	2		2	
Journal of Ecology	1		1	
Journal of Evolutionary Biology	1		1	
Journal of Theoretical Biology	1			
Byte	1			
Macworld	1			
Proceedings of the Royal Society, London	1			
American Museum of Natural History. Bulletin	1			
American Museum of Natural History. Novitates		1		
Malacological Society of London. Proceedings	1			
Philosophical Transactions of the Royal Society, London	1		1	
PETROLEUM GEOLOGY	2	2		1
JGR. Space Physics			2	
JGR. Oceans			1	
JGR. Atmospheres			1	
Acta Crystallographic, A: Foundations of Crystallography			1	
Acta Crystallographica, B: Structural Crystallography and Crystal Chemistry			1	
IEEE Transactions on Geoscience and Remote Sensing	1		1	
MacWorld			1	
Journal of Petroleum Technology	1		2	
Oil and Gas Journal			1	
SPE journals	1		1	
PETROLOGY	1	1		
JGR. Planets	1		1	
REMOTE SENSING	1	4		
JGR. Space Physics			1	
JGR. Atmospheres			2	
JGR. Planets			2	
Applied Optics	1			
Astronomy and Astrophysics			1	
IEEE Transactions on Geoscience and Remote Sensing	1		2	
International Journal on Remote Sensing			1	
Photogrammetric Engineering and Remote Sensing	1		2	
Groundwater Research			1	
Applied Spectroscopy			1	

SEDIMENTATION/STRATIGRAPHY	5	6	1
JGR. Space Physics	1	1	
JGR. Oceans	1	2	
JGR. Atmospheres	1	2	
JGR. Planets	1	1	
American Naturalist	1		
Ecology	1		
Evolution	1		
Journal of Ecology	1		
Journal of Evolutionary Biology	1		
Journal of Theoretical Biology	1		
Journal of Chemical Physics		1	
IEEE Transactions on Geoscience and Remote Sensing	1		
Byte	1		
Macworld	1	1	
Journal of Fluid Dynamics	1		
Journal of the Elisha Mitchell Science Society		1	
American Society of Civil Engineers. Proceedings and Transactions		1	

STRUCTURE/TECTONICS	3	4
IEEE Transactions on Geoscience and Remote Sensing	1	
Acta Metallurgia et Materialia	1	
Journal of Fluid Dynamics	1	
Philosophical Transactions of the Royal Society, London	1	
JGR. Planets		1

ADDRESSING OPPORTUNITIES AND CHALLENGES IN EVALUATION AND DISSEMINATION THROUGH CREATION OF A NATIONAL LIBRARY FOR UNDERGRADUATE SCIENCE EDUCATION

David W. Mogk

Dept. of Earth Sciences
Montana State University
Bozeman, Montana 59717

Lee L. Zia*

Division of Undergraduate Education
National Science Foundation
4201 Wilson Blvd.
Arlington, Virginia 22230

Abstract — To facilitate the dissemination of educational materials that have proven effective in science, mathematics, engineering, and technology education, the National Science Foundation is exploring the establishment of a national library for undergraduate science education. The purpose of the library would be to function as an archive of tested materials and methods, as well as a dynamic resource for the active exchange of information. Attributes of the library would include editorial and review functions to provide the highest level of confidence in the quality of the materials; indexing, abstracting and linking services to ensure ease of access by users; mechanisms to actively encourage the development of new materials for broad dissemination; and electronic delivery systems to distribute these materials to the widest audience. Development of the library will require a sound management plan to implement these functions, and ultimately, the library must operate on a self-sustaining basis.

*On leave from the Department of Mathematics, University of New Hampshire, Durham, NH 03824

INTRODUCTION

The past three decades of innovation in undergraduate science, mathematics, engineering and technology (SMET) education have seen the development of a broad variety of resources for faculty and students. Many of these are the result of funding from the Division of Undergraduate Education (DUE) of the National Science Foundation (NSF). For example, since 1990, DUE has provided $11.2 million in support of geoscience projects sponsored by the Course and Curriculum Development, Undergraduate Faculty Enhancement, and Instrumentation and Laboratory Improvement programs (Program Announcement and Guidelines, NSF 96-10). Additional support has been provided for multidisciplinary projects, and to cognate disciplines (e.g. physical geography, civil engineering, etc.), which have a strong geoscience component. Other sponsoring organizations, both public and private, have also made significant investments in the development of educational resources in the geosciences. Many more resources have simply been developed through the efforts of dedicated individual faculty members working on their own time.

In many cases, these educational materials have taken the traditional form of textbooks, papers or journal articles. In addition, ideas and information resulting from faculty efforts have been presented and discussed through talks and other forums at conferences and workshops, though often not captured in permanent form. More recently, emerging educational technologies provide remarkable opportunities for new forms of materials and methodologies through the use of a variety of computer-mediated learning approaches (WWW, CD-ROMs, JAVA applets), which can enable increased emphasis on hands-on learning (e.g. use of educational "kits", remote access to instrumentation, etc.). Indeed the past two years have witnessed an explosion of educational methods and materials that facilitate learning through inquiry by means of hands-on, discovery- oriented approaches that transcend traditional (lecture/textbook/exam) instructional delivery mechanisms.

With specific regard to the geosciences many exciting areas offer opportunity for new educational materials to be developed. The concept of "deep time", the need to visualize three-dimensional structures, and handling scales of observation that range from microns to mountains all present formidable barriers to learning for many students. In another vein, the field experience has been central to geoscience education, yet field experiences are not accessible to many students due to limitations imposed by geography, climate, and personal life circumstances. However, it is now possible to "visit" the deepest ocean basins and the farthest reaches of the solar system through virtual field trips. Real-time data acquisition is also possible for use in class exercises through satellite imagery and meteorologic and seismologic data networks. Computer-assisted learning activities that involve visualization, modeling, and simulation, in addition to enhanced communication, quantification, and information skills are fundamentally changing the instructional methods and materials used in geoscience classes.

However, the dominant mechanisms for dissemination of these materials and methods and reviewed information about these new approaches remain the printed page (textbooks or journal articles) or verbal presentations (workshops or talks at national meetings). While still appropriate and valuable, these traditional media often do not adequately enable the demonstration of the dynamic capabilities of new educational resources. In contrast, the Internet and other electronic media offer an opportunity to move beyond the static image of the printed page, and the phenomenal increase in utilization of these avenues indicates its potential. But this proliferation of electronically delivered educational material remains unorganized at best, and of increasingly variable quality.

In light of the volume and variety of available undergraduate science educational resources, particularly those which presently go "unrecorded," it has long been recognized by the undergraduate community that a system serving: 1) as a "centralized repository" of existing material; 2) as a forum for the submission of project material and/or project information for formal review; 3) as a venue for the systematic generation and/or preservation of informed discussion and review of educational material; and 4) (perhaps most importantly) as a "quality control" agent for the compilation of these resources, would be of great value. Now, in the face of continuing advances in computational and information technology, the form and functionality of resources for undergraduate SMET education has become far richer than that afforded by traditional print media, and their modes of distribution faster, more varied, and potentially more widespread. Thus the need for and challenge of creating and maintaining a "registry and clearinghouse of resources" has become even greater. To facilitate the evaluation and dissemination of education materials that have proven effective in SMET education, the National Science Foundation is exploring mechanisms to design, develop, and implement a national library for undergraduate SMET educational resources.

We use the term "library" in the broadest sense, which encompasses organizational systems of materials; archival, indexing, abstracting, and linking functions; and delivery mechanisms (which would be dominantly in electronic form). We also envision this library to be a dynamic enterprise which would actively promote the development of new materials, engage a rigorous editorial function, and provide an on-going electronic forum for comment and reply on materials within the library and on topics of general interest. The materials in the library would not be restricted to printed materials. For example, the library might include electronic datasets (real-time, as in meteorology or seismology, or otherwise established such as chemical analyses of suites of rocks), field trip guides (either virtual or real), or access to instrumentation or other learning devices (e.g. remote access to facilities, directions for construction of materials, or source references for the acquisition of materials).

RATIONALE

Just as the expanding collection of resources for undergraduate SMET education is changing in its content and form, so too is the audience for these resources. The research and education roles of faculty are in flux, as are their types and backgrounds (e.g. increased employment of adjunct faculty and increased reliance on graduate student teaching assistants). Learning and teaching are taking place in new settings, and the ways in which faculty interact with students are shifting. Finally, the students themselves are changing. "Traditional" lecture/test modes of instruction are being replaced by a new generation of student-centered, constructivist, discovery-oriented methods (e.g. Project 2061, Science for All Americans, AAAS, 1989). In light of these changes, tested mechanisms for delivery of information (e.g. textbooks, prescriptive laboratory workbooks, journal articles) *and* the practice of subjecting material to a process of review, should be combined with advanced communication technologies so as to create a unified resource for undergraduate science education, reflecting contemporary educational practices, and maximizing overall impact on the undergraduate SMET educational enterprise.

If faculty are to continue to create innovative teaching and learning environments, to maintain currency with new ideas and pedagogical approaches, to establish examples of "best practice", to sample from these exemplars, to determine suitability to a local situation, and to communicate their findings to a broader audience, they will need information about mature projects, information about works in progress, the ability to identify developing movements or trends, and the capability to take part in current thinking and debate. Incentives for faculty to use the national library for undergraduate science education include better access to tested materials for immediate use in classes, development of user-networks, and cross-fertilization of materials and methods across disciplines, institution types, geographic settings, and demographics of the user groups. Faculty will also gain national recognition through their contributions to the library, which will require thorough peer-review prior to acceptance. Students too will need access to these resources and capabilities, as they take on a greater role in collaborative learning environments.

The existence of a system that provides information about undergraduate educational developments would also have great utility to the K-12 community and industry/business concerns as they strive with the undergraduate sector: 1) to address school-to-work transition issues, 2) to improve articulation between the K-12 and post-secondary communities, 3) to improve pre-service teacher training, which will impact student preparation for entry to higher education, as well as to influence instructional methods on campuses, and in general, 4) to communicate the value of undergraduate education to society at large, and to help the public determine, on an individual level, where to pursue that value.

In addressing the need for a national library of undergraduate SMET education resources, the NSF is responding to individual and community requests and recommendations for leadership in this area. Program Directors in the NSF Division of Undergraduate Education have long reported a major faculty concern for more effective and widespread access to resources known to have been developed both through sponsored program activities and non-sponsored work. There are many practical barriers to establishment of collaborations among faculty with common educational interests; in the adoption, adaptation, and evaluation of materials that have already been developed; and, especially in the development of inter- and multidisciplinary connections in educational practice. More recently, an advisory panel of specialists in information technology met at NSF on April 18th, 1996 to address questions of the need, form, and function of a new type of information service to serve the undergraduate education community. This panel noted that while other collections of educational material exist (some electronic), these do not adequately serve the undergraduate educational community. Many of the recommendations of this panel are presented in more detail below. On a much larger scale, the Directorate for Education and Human Resources (EHR) at NSF recently completed a year-long review of undergraduate SMET education, which gathered input from faculty, academic institutional leaders, professional scientific organizations, representatives from the industrial and business sector, and parents in written form, from invited testimony, and through public forums (Shaping the Future New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology; NSF 96-139). A major recommendation of this undergraduate review is to develop an effective means of validating, codifying, and disseminating good practices in undergraduate SMET education.

The goals of the national library will be to improve SMET education through:

- more effective use of quantification, communication, and information technologies;
- integration of research technologies and the learning environment;
- development of hands-on educational materials, with emphasis on the evaluation and dissemination of these materials;
- incentives for faculty to develop their own "home-grown" materials for national dissemination, with recognition earned for their peer-reviewed contributions; and

- establishment of an information service in which faculty will have a high level of confidence of finding accessible and effective materials.

FUNCTIONS OF THE NATIONAL LIBRARY

The variety of undergraduate SMET educational resources, their breadth of content, form, and modes of delivery, and the many ways in which such resources might be used, suggest the metaphor of a "living library system" that blends several operational modes. The following are the key functions that have been identified as being critical for the successful development of this national library.

Adjudicatory functions are the most critical aspect of the national library. Educators must have a high level of confidence in the quality of the materials contained in the library. To meet this goal, the library must:

- establish guidelines for both a reviewed and unreviewed portion of the "system"; the unreviewed portion of the system will be devoted to an open presentation of materials under development which will benefit from communal comment and reply, while the reviewed portion will contain materials that have passed a rigorous peer review on par with research review boards. Testing of these materials must be done by faculty and students in authentic learning environments.
- develop protocols for the selection, verification, and validation of educational materials;
- maintain a well-reasoned process for submission of new materials into these portions, and provide encouragement for refinement of material in the unreviewed portion for subsequent movement into the reviewed portion of the system;
- be flexible enough in the review process to accommodate diverse materials (e.g., written, digital, hands-on, etc.); and
- respect intellectual property issues.

Archival functions are also critical to the success of the national library. The library must serve as a primary source of high-quality, useful, and easily accessible materials. Faculty and students who would use this library must be satisfied that it is worth their time and effort to access this service. Toward this end, it is critical that indexing, abstracting, and hyperlinking systems are effective within and across the SMET disciplines. The holdings in the library must be more than a repository (i.e. dumping ground) of large volumes of poor-quality, poorly organized materials.

The national library must also be *dynamic* in its operation. Mechanisms must be established for the active gathering, solicitation, and subsequent organization of resources. An independent authority should be empowered to provide (at a minimum) a "stamp of approval" for the resources provided by the "system" and the manner in which they are gathered, made accessible, and where appropriate, reviewed. The library could host moderated, interactive public forums on educational issues, and recruit scholars to prepare reviews of contemporary educational issues. Commentary on the application, adoption, and adaption of library materials in new educational settings could be appended to materials in the library, thus providing a continuous review process beyond the initial acceptance.

The national library must also provide *service* to meet the present and anticipated needs of science educators. Ease of access to a wide range of materials through a robust system of indexing and searching routines to support a wide spectrum of possible modes of usage is essential. In addition, automatic delivery systems using pre-defined user profiles of either information about resources or the resources themselves in a variety formats would greatly enhance the impact of the national library. The operational policies of the national library should be flexible enough to best accommodate new needs, technologies and materials, while preserving high standards and reaching the broadest possible audience.

FORM OF THE NATIONAL LIBRARY

The realization of this "living library system" could be a "place" consisting of a hybrid of 1) physically available and immediately accessible materials, 2) stored materials both in print and long term electronic format, e.g. CD-ROMs, laserdiscs, and 3) virtually accessible materials via hyperlinks to electronic sites, both on-site and off-site. As more powerful information technological tools become available, more possibilities would develop. The national library must have a well-formulated management plan that includes both personnel and infrastructure necessary to design and implement the library functions. Staffing requirements include specialists in organizational management, marketing, information technologies, and an editorial board with credibility in the SMET disciplines. Development of the national library could be undertaken by professional societies, universities, the private sector or consortia of these groups. Linkages and collaborations with existing educational resource services, other governmental agencies, and private foundations would certainly be an asset. One critical aspect of the national library is the potential to generate revenue by offering services such as bibliographical searches, abstracting capabilities, maintenance and provision of threaded discussion groups, etc.; it is essential that the national library become self-sustaining at some point in its development. NSF can serve as a catalyst for the design, development, and initial implementation of the national library for undergraduate science education. Ultimately, such a service must be operated and maintained by an independent entity (or consortium) in the public or private sector.

DISCUSSION

There are numerous studies that call for thorough reform of what and how we teach in the SMET disciplines (e.g. AAAS, 1989) at the K-12 (National Research Council, 1996) and undergraduate levels (NSF, 1996; NRC, 1996). New education and information technologies present new opportunities to improve SMET education. These present new challenges to demonstrate that the new educational materials and methods are indeed effective, and to disseminate these new materials to the broadest possible audience. The creation of a national library for undergraduate science education will address these two critical needs. A national-level editorial review procedure is essential to test and verify the effectiveness of educational materials, and to confer validation and recognition to faculty who have contributed to the development of these materials. In light of the variety and breadth of new materials, there is also a need to organize, index, abstract and link materials within and across disciplines. Most importantly, there is a compelling need to improve delivery services to faculty and students so that they can readily and effectively access these materials. A national library for undergraduate science education will serve as one of the fundamental agents of change in the overall reform of SMET education.

The opinions expressed are those of the authors, and do not reflect the policy of the National Science Foundation.

REFERENCES

American Association for the Advancement of Science, 1989, Project 2061 Science 4 for all Americans, Washington DC, 217 pp.

National Science Foundation, 1996, Shaping the Future New Expectations for Undergraduate Education in Science, Mathematics, Engineering, and Technology, NSF 96-139, 75 pp.

National Science Foundation, 1996, Program Announcement and Guidelines

Undergraduate Education, NSF 96-10, 45 pp.

National Research Council, 1996, From Analysis to Action Undergraduate Education in Science, Mathematics, Engineering, and Technology Report of a Convocation, National Academy Press, Washington DC, 38 pp.

National Research Council, 1996, National Science Education Standards, National Academy Press, Washington DC

BUILDING A DIGITAL LIBRARY FOR EARTH SYSTEM SCIENCE: THE ALEXANDRIA PROJECT

Barbara P. Buttenfield

Department of Geography, Campus Box 260,
University of Colorado, Boulder, Colorado 80309
email: babs@colorado.edu

Suzanne T. Larsen

Earth Sciences Library, Campus Box 184
University of Colorado, Boulder, Colorado 80309
email: suzanne.larsen@colorado.edu

Abstract — A digital library should be more than a physical library in electronic form. In a digital library, traditional distinctions between books, digital spatial coordinates, maps and satellite imagery should become transparent to library patrons. It should be possible to retrieve maps and images and overlay them with digital attributes from another data source. The digital library catalog should include digital files that are archived in depositories distributed across the nation. It should be possible to browse spatial metadata prior to downloading files. Patrons should be able to visit the library without ever leaving their own offices. This paper is an overview of the Alexandria Digital Library project (ADL), providing comprehensive library services of a map and imagery library over the Internet. This paper describes the origins of ADL, and of merging maps and images into the library information mainstream. We will describe the development of the ADL prototypes, and focus on the features of the current implementation that distinguish ADL from other efforts. We present research issues raised by ADL and their likely impact on the accessibility of spatial data to earth system scientists.

ORIGINS OF THE LIBRARY

Federal agencies that produce and distribute datasets are converting physical distribution mechanisms to electronic form. Scientists who previously ordered data on magnetic tape or CD-ROM from agencies or companies can now access data products directly via the Internet. Those wishing to access electronic data sources must search an increasing volume of Internet information. This requires a new set of skills for the scientist. New tools for generalized and specialized data delivery are required. A major challenge for the coming decade is to enhance the accessibility to all types of digital geospatial data, including but not limited to geographically referenced environmental data.

Organization of and access to digital data via the Internet was identified as a "National Challenge" by the U.S. High Performance Computing and Communications Program (HPCC). National Challenges are fundamental applications that impact the Nation's competitiveness. (NSF, 1996a; Tosta, 1994) A National Research Initiative on Digital Libraries was issued in 1993 with joint sponsorship from the National Science Foundation (NSF), the National Atmospheric and Space Administration (NASA), and the Advanced Research Projects Agency (ARPA). "One goal of this [Digital Libraries] Initiative is to establish better linkages between fundamental science and technology development upon which key aspects of the National Information Infrastructure depends. ... The projects' focus is to dramatically advance the means to collect, store, and organize information in digital forms, and make it available for searching, retrieval, and processing via communication networks — all in user-friendly ways." (NSF 1996b).

Six universities were given four-year awards from a pool of seventy-two submissions. Home pages for all these projects may be found at NSF (1996a).

Each of the six awards has focused on a unique library issue, ranging from digital video made available to public schools (Carnegie-Mellon), to digital versions of science and engineering journals made available to a university campus (Illinois). One project (Stanford) has undertaken to deliver high performance digital linkages between the other five. Three of the six awards focus on environmental data. This paper provides an overview of the Alexandria Project, at the University of California and the University of Colorado.

The Alexandria Project will deliver comprehensive library services for distributed data archives of geographically referenced digital data, maps and satellite images. "Distributed data" means the library's components may archived at sites distributed across the nation and available through the Internet. "Geographically referenced" means that items are associated with one or more regions ("footprints") on the surface of the Earth. Geographically referenced information has been traditionally treated as a special collections problem by librarians, due to complexities of spatial indexing, and physical volume of paper map archives. Our intention is to eliminate the traditional distinctions for special collections such as maps and photos. The project includes assessment of user needs, response to technical impediments, software development, and a rigorous program of user evaluation. Information requirements have been established for three target groups, including environmental scientists, librarians, and K-12 students and teachers.

PUTTING A DIGITAL LIBRARY ON THE INTERNET

To deliver its promised objective, the Alexandria Project is building a software testbed called the Alexandria Digital Library (ADL). The current version is available at the Website http://alexandria.sdc.ucsb.edu. ADL currently provides access to a set of holdings for southern California, with other geographic datasets coming online on a continuing basis. The ADL provides tutorials, general reference information about spatial data and digital spatial data sources, and functions for browsing and retrieving maps, images and data.

Users can search ADL holdings by spatial or temporal location or by data theme. Spatial searches by placename or by spatial footprint can be refined according to specific time periods, data resolution, data category (satellite image, topographic map, geologic map, etc.) Efforts are underway to implement browsing tools based on metadata. Examples of this include collections maintenance criteria (map sheets having multiple editions) or criteria about information content (air photos containing a hydroelectric dam).

The first phase (Spring, 1995) of the ADL testbed produced a rapid prototype running on a UNIX platform. This version was based on a multi-window environment that is common to anyone who has worked with GIS software packages. The rapid prototype served as an early platform for user interface evaluation. A subset of the rapid prototype was ported to a Windows-based CD-ROM. Twenty-five hundred copies of the CD-ROM were distributed along with a questionnaire to solicit community feedback. The CD-ROM version served to make the Alexandria Project visible in many working environments where UNIX is not available, as in many schools and libraries.

The current phase of system design includes a storage component, a catalog component, an ingest component, and an interface component. In terms of storage, ADL is designed to accommodate very large collections of very large digital objects. Environmental data is stored as high resolution, multispectral raster data, or as overlaid themes of vector data. Storage requirements are large. For example, an analog air photograph scanned at 600 dots-per-inch commonly requires 30 MB (90 MB for color) per archived image (Andresen et al, 1996). A single collection of historical photography containing hundreds or thousands of images could require storage on the order of single terabytes at the point of archiving. Distributed storage provides the only feasible architecture for large datasets, and an experimental mirror ADL site has recently been set up at the San Diego Supercomputing Center.

The catalog systematizes all types of information by which the Library holdings may be organized. The catalog forms the basis for user browsing. An archive may be searched only for items which are organized in its catalog. For maps and images, catalog entries include placename, data theme, spatial footprint, and date of compilation. Placenames are provided by the Geographic Names Information System (GNIS) gazetteer, which includes 1.8M names of US features/15 classes, and by the Board of Geographic Names (BGN) gazetteer , including 4.5M names of land/undersea features. The primary catalog is stored in a central relational database (Sybase) housed in Santa Barbara, California.

The ingest component currently provides for input of data, metadata, and catalog information. Data ingest can be accomplished in a number of ways: by scanning analog material, by transfer of created metadata records from Microsoft Access, or transfer from other sources (e.g.., frame-level records from air photo databases, sheet-level records for indexed map series , and USMARC catalogued records for single maps). Following data ingest, new data items are 'added' to Alexandria by entering new metadata records into the catalog. Entries include pointers (presently in the form of URLs) to the actual files. When the metadata records are placed online, the data files become available in the testbed. The ADL team has recently begun to test an ingest mechanism whereby distributed users can ingest their own data, effectively decentralizing the ingest process. These tests should be completed this spring, and put online for general use.

The interface component is most visible to users. To most users, the interface IS the Library. Interface functions include tools for zooming into a browse map, tools to formulate catalog queries by location, theme and time. Utilities for texture matching, and wavelet image decompression will speed data delivery and facilitate exploration of distributed archives.

RESEARCH ISSUES

The Web testbed presents major challenges for system designers. Issues related to the nature of geographically referenced data complicate the situation. Transmission speed continues to impede transfer of large volume data. There is much that is unknown about how people search and retrieve information using the Internet.

Existing data catalog schemes such as the U.S. MARC (Machine-Readable Cataloging) record system do not include geographic referencing. Protocols for exchanging data have been established in the Spatial Data Transfer Standard (NIST, 1992), and in its successor, the Metadata Content Standard (FGDC, 1995) but these are cumbersome in practice (Goodchild, 1995). Incorporating content-based searching will require significant extensions to current cataloging models.

The storage component of ADL contains the collection of digital objects. For the purposes of an operable digital library, a digital object must include the binary representation of the information of interest (the "data"), procedures for interpreting the data (a selected format), and a universal object identifier. Items need identifiers to be found in an archive. For distributed archives to interoperate, the object identifiers must be recognizable to all search engines. There is currently no accepted standard identifier. A number of alternative suggestions relate to URx's of various forms (where the "x" is an identifier, locator, or name) (Andresen et al, 1996).

Another problem is data volume. For satellite images, a item size of 150 MB is not uncommon. Library collections of analog air photos (for example) often number in the millions of images. When scanned at 600 dpi, each image could require up to 100 MB of storage space, resulting in a collection whose disk requirements would number in terabytes. It's easy to see why collections of such items must inevitably be distributed. Eventually, as the library contents increase, the catalog itself should be distributed as well. Considerations for distributing a catalog include the difficulties faced by users in finding an appropriate item; the cost of examining or downloading large items over bandwidth-limited channels; and the provision of access to distributed sets of storage locations (Smith et al, 1996).

The Web environment lacks protocols for map browsing. HTTP protocols lack mechanisms for presenting vector data. This is a serious issue, since a significant and important portion of spatially-indexed information collections involve items represented in vector format (Andresen et al 1996). Second, HTTP is a stateless protocol, designed for small, short transactions. By default, after a user completes an HTTP request, neither the client nor the server maintains any "memory" of the transaction. Web browsers commonly available cannot provide drag-and-click "lasso-ing" functions, because they immediately send an HTTP request after a single mouse click. This prevents setting user-defined environment parameters, or retaining a query history to refine a search.

Lastly, we lack a model of a digital library user. Models of traditional (physical) library users do not translate directly to a digital library environment, which is progressively more than a physical library in electronic form. Many aspects of digital library use have never occurred to potential users, plus it is difficult to articulate information needs and requirements. Metadata needs and requirements are similarly difficult to identify (Bretherton and Singley, 1994). One can build up a profile of ADL users over time, through transaction logging, videotaping, focus groups, and semi-structured interviewing, and these types of data are being collected and are described elsewhere (Buttenfield, 1995; Buttenfield and Kumler, 1996). The challenge is that as ADL changes in appearance and in functionality, user evaluation becomes a process of aiming at a moving target. This is not to say that assessment of user needs is impossible, only that the customary paradigms are inadequate.

SUMMARY

This paper reports on a project to design, develop and test a distributed, high-performance digital library, available on the Internet, in which collections of spatially-indexed information in digital form are dispersed geographically. The program of research and development represents a major step towards the evolution of a distributed digital library supporting both textual and geographically referenced sources of information. We intend to create library services that are scalable to the national level. While various technical issues relating to the storage and content-based access and retrieval of spatial data remain, our long-term goal is to remove the mainstream library distinction between text and special materials such as maps and images.

ACKNOWLEDGMENT

This paper forms a portion of the Alexandria Digital Library Project, jointly sponsored by NSF, NASA, and ARPA. Funding by the National Science Foundation (NSF IRI-94-11330) is greatly appreciated. Matching funds from the University of Colorado are also acknowledged.

REFERENCES

Andresen, D., Carver, L., Dolin, R., Fischer, C., Frew, J., Goodchild, M., Ibarra, O., Kothuri, R., Larsgaard, M., Manjunath, B., Nebert, D., Simpson, J. Smith, T., Yang, T., .Zheng, Q., 1995, The WWW Prototype of the Alexandria Digital Library, Proceedings of the International Symposium on Digital Libraries, Tsukuba, Japan, 1995. Available: http://alexandria.sdc.ucsb.edu/public-documents/papers/japan-paper/.

Bretherton, F., and Singley, 1994, Metadata: A User's View. Proceedings, 7th Symposium on Spatial Data and Metadata, Charlottesville, Virginia, p. 166-174.

Buttenfield, B.P., 1995, User Evaluation for the Alexandria Digital Library Project. Proceedings, Workshop "How We Do User-Centered Design and Evaluation of Digital Libraries: A Methodological Forum." Allerton, Illinois: National Science Foundation and the Graduate School of Library and Information Science, University of Illinois at Urbana-Champaign. Available: http://edfu.lis.uiuc.edu/allerton/95/s2/buttenfield.html.

Buttenfield, B.P. and Kumler, M.K., 1996, Tools for Browsing Environmental Data: The Alexandria Digital Library Interface. Proceedings Third International Conference on Integrating Geographic Information Systems and Environmental Modeling. Santa Fe, New Mexico, January 21-25, 1996 (no page numbers).

NIST, 1992, Federal Geographic Data Committee. Spatial Data Transfer Standard. Washington, D.C.: National Institute of Standards. Federal Information Processing Standard, p. 173.

FGDC, 1995, Federal Geographic Data Committee. Content Standards for Digital Geospatial Metadata. Washington, D.C.: U.S. Department of the Interior.

Goodchild, M. F., 1995, Sharing imperfect data. In H. J. Onsrud and G. Rushton (Eds), Sharing Geographic Information. New Brunswick, N.J.: Rutgers University Press, p. 413-425.

NSF, 1996a, National Science Foundation NSF Digital Libraries Awards Announcement. Available: http://www.cise.nsf.gov/iris/DLAnnounce.html..

NSF, 1996b, National Science Foundation NSF/ARPA/NASA Digital Libraries Initiative Home Page. Available: http://www.cise.nsf.gov/iris/DLHome.html.

Smith, T.R., Geffner, S. and Gottsegen, J., 1996, A General Framework for the Meta-Information and Catalogs in Digital Libraries. Available: http://alexandria.sdc.ucsb.edu/public-documents/ieee/.

Tosta, N., 1994, Continuing Evolution of the National Spatial Data Infrastructure. Proceedings, GIS/LIS, Phoenix Arizona: 769-777. Available: http://wwwsgi.ursus.maine.edu/gisweb/spatdb/gis-lis/gi94096.html.

PROVIDING ACCESS TO EARTH-SCIENCES SPATIAL DATA: METADATA AND THE ALEXANDRIA DIGITAL LIBRARY

Mary Lynette Larsgaard

Assistant Head, Map and Imagery Laboratory, Davidson Library
Investigator, Alexandria Digital Library
University of California
Santa Barbara, California 93106
mary@sdc.ucsb.edu

Abstract —This paper will give an overview of the work done in the Alexandria Digital Library (ADL) on metadata for spatial data. This project of the University of California at Santa Barbara is one of the six Digital Library Initiatives funded by NSF, ARPA, and NASA. The object of the Alexandria Project is to develop a distributed digital library for geographically referenced information. Distributed means the library's components may be spread across the Internet, as well as coexisting on a single desktop. "Geographically reference" means that all the objects in the library will be associated with one or more regions ("footprints") on the surface of the Earth. The centerpiece of the Alexandria Project is the Alexandria Digital Library, an online information system inspired by the Map and Imagery Laboratory (MIL) in the Davidson Library at the University of California, Santa Barbara. The ADL currently provides access over the World Wide Web to a subset of MIL's holdings, as well as to other geographic datasets. Metadata is data about data, which includes but is intended eventually to extend beyond what is provided in online library catalogs. It is essential to the retrieval of information. There will be some discussion of the recent history of standards efforts in this area, who is using these standards, and what impact this work is having or will have on users and producers of geographic information systems.

INTRODUCTION

Working with metadata in the ADL has been a very educational experience — including times when I found out things I didn't really want to know, such as that fields in large tables had to appear, for database-software purposes, on a metadata-entry form in a certain order, which had nothing to do with the order in which a cataloger (or if you prefer, metaloger) needed them.

But first, some background on the ADL. The Alexandria Digital Library is one of six Digital Library Initiative (DLI) projects funded jointly by the National Science Foundation (NSF), the Advanced Research Projects Agency (ARPA), and the National Aeronautics and Space Administration (NASA). The six funded institutions are Carnegie-Mellon, Stanford, the University of California at Berkeley, the University of California at Santa Barbara, the University of Illinois at Urbana-Champaign, and the University of Michigan at Ann Arbor. Each of the six projects — which began in October of 1994 and run through September of 1998 — has a different focus; the focus of ADL is to provide online access to georeferenced information, with an emphasis on spatial data. Since it is estimated that about 90 percent of all spatial data is available only in hard-copy form, metadata is of the greatest importance, given that very often that is all the user will be able to find in digital form. ADL has a beta-test site up on the Web site, which we encourage you to visit, try out, and let us know how to improve it. For more information on ADL, or on any of the other five DLI projects, go to the Web site: http://alexandria.sdc.ucsb.edu.

WHAT IS METADATA REALLY, AND WHAT IS HAPPENING WITH METADATA FOR SPATIAL DATA IN DIGITAL FORM?

There are probably as many definitions of metadata as there are persons who talk about it. By far the most popular definition — one suspects at least in part because of its brevity! — is "data about data";

"information about data" is a bit more accurate. Yet another is "auxiliary information needed to properly utilize the actual data in a database and to avoid any possible misinterpretation of those data," Dr. Terence Smith's definition. Terry is executive director of ADL, who has spent considerable time thinking about metadata and the theory behind it.

And what is to come next? Even more standards; if you don't like the ones you first see, not to worry — there are probably many more. For example, within the library world, we are accustomed to using the *Anglo-American Cataloguing Rules* (2d ed. rev., 1988), referred to as AACR2R, heftily reinforced with *Cartographic Materials: a Manual of Interpretation for AACR2* (1982). Looking at Chapter 9 in AACR2R, one may perceive that the chapter was written to deal with what are in spatial-data terms relatively small and relatively uncomplicated social-sciences statistical datasets. A revision of Cartographic materials is being worked on by the Anglo-American Cataloguing Committee for Cartographic Materials (AACCCM), which is to incorporate the changes from the U.S. Federal Geographic Data Committee's (FGDC) content standard, and we hope will be out by perhaps late 1998. In the meanwhile, we can use the revisions to USMARC and the document from which those revisions came, the *Content Standards for Digital Geospatial Metadata* (1994). A little background on that is important here.

The problem was that a U.S. Presidential Executive Order (U.S. President, 1994) directed that all federal agencies were to use the FGDC content standard (not even completed at the time of the EO) by January of 1995 to document their spatial data in digital form. Because map collections in the U.S. are very heavy users of U.S. government-produced spatial data, and because the Library of Congress is itself a federal agency, the Library of Congress' Geography and Map Division, in the person of Elizabeth Mangan, at the time acting head of Cataloging and head of data preparation — that is, head of USMARCMap — worked extensively with FGDC staff on the document. Ms. Mangan generated a crosswalk between the FGDC fields and USMARC fields. This is available over the Web at: http://alexandria.sdc.ucsb.edu.
(Select public documents, and within that metadata.)

The FGDC content standard was issued in its "final" form in June of 1994. A copy of the standard is available at: http://www.fdgc.gov.

The time period was therefore very tight; the requests for new fields to MARBI (Machine-Readable Bibliographic Information Committee, the overseeing body of USMARC) had to be made in the summer of 1994, since MARBI meets only twice a year, in the summer and in January of each year — and January of 1995 would be too late. Ms. Mangan prepared several documents for MARBI to consider at the MARBI summer meeting, which was at the American Library Association annual conference. MARBI members did a considerable amount of work themselves — I would not be surprised to discover that after the meeting there was some discussion of having t-shirts made, emblazoned with the slogan "I survived the new FGDC fields, MARBI, summer 1994." The requests were passed provisionally; in a few cases MARBI did state that another field number needed to be used, but these were minor changes. Since MARBI is not tied to any one set of cataloging rules, since just proposing revisions to AACR2R is a lengthy procedure, and since the time frame was so short, the plan of action was to take the changes first to MARBI, for inclusion in USMARC, and then later — specifically, the summer of 1997 — to CC:DA (American Library Association's Committee on Cataloging: Description and Access), the body that sends requests for AACR2R revision to the international Joint Steering Committee.

The big changes to USMARC are as follows:

(1) add to 034 (Coded Cartographic Mathematical Data) the G-ring latitude and G-ring longitude values;
(2) add to 037 (Source of Acquisition) $g, Additional format characteristics;
(3) add to 255 (Cartographic Mathematical Data) g-ring coordinate pairs;
(4) 270 (Address) as new field, for address information for a distributor of an item;
(5) 342 (Geospatial Reference Data) as a new field: this field contains detailed information on projection and grid. It should have gone next to 255, but there was no room in the inn, so it was stowed in a 3xx field. What about 255$b, and fixed field Base Map Elements? They're still there — maybe for use only with hardcopy maps?
(6) 343 (Planar Coordinate Data) as new field for coordinate systems developed on a planar surface;
(7) 352 (Digital Graphic Representation) as new field for raster/vector information;
(8) 355 (Security Classification Control) as new field;
(9) 514 (Data Quality Note) as new field for accuracy/resolution; and
(10) 551 (Entity and Attribute Information Note) as new field: vector-data information, e.g., entity and attribute information.

For more detailed information on these fields, see the following Web sites:
http://www.fgdc.gov;
http://www.loc.gov;
http://www.oclc.org.

In the category of works to come:

- The FGDC standard is wending what one suspects is a slow, tortuous way through the International Standards Organization's (ISO) Technical Committee (TC) 211, for "Geographic Information/ Geomatics."
- The FGDC standard is already an ANSI standard.
- Several Federal agencies have developed or are developing metadata standards, some based on FGDC.
- Also on the international scene in Europe is the Comite European de Normalisation; it has a Technical Committee Working Group 2, working on CEN/TC287, Information geographique = Geographic information–Geoinformation; there is a working draft of September 21, 1995.
- Some states in the U.S. have issued metadata standards — for example, Minnesota and Idaho; 3/8/96 Minnesota geospatial metadata guidelines: guidelines for documenting geographic data sets. Version 0.4.3 is the one this author has seen. 12/7/95 is version 4.0 of the Idaho metadata profile.
- Canada has done considerable work on metadata, starting with a publication by the Canadian National Standards Board, Geomatic datasets.
- There is considerable activity in what a cataloger would call brief cataloging or minimal-level cataloging, but that has been translated into the term "core metadata" in this case. Activity in the U.S. and England has been through the various Dublin Core (DC) workshops, organized and co-sponsored by OCLC, Inc. The first was in spring of 1995 at OCLC in Dublin OH; it came up with a list of thirteen elements for description of online datasets. The second was in spring of 1996, at the University of Warwick, England, with the emphasis on how to get the DC operationalized. The third was again at OCLC, in the fall of 1996, and had as its emphasis DC metadata for graphics. For more information on this, see the Web site: http://www.oclc.org:5046/~emiller/.
- SGML (Standardized General Markup Language): has been touted as a replacement for USMARC; in its own way it carries more information than does MARC but it doesn't change the elements, it just tags them differently —with word phrases instead of numbers.

It will be a relief to all of us who have ever cataloged — or rather, who ever expect to catalog — this sort of data to know that the vast majority of new fields that came out of the FGDC content standard, and so far as I have seen out of the other standards, are composed of information intended to be supplied by the producer, and preferably to be extracted by computer software — the latter clause makes metadata sound like a recalcitrant molar.

Metadata is intended to be more than descriptive and subject cataloging, although in current standards it seldom seems to do so; and indeed, every field in the FGDC standard (with the exception of time) is now a valid field in USMARC. Although the field 551, considered as data-dictionary information, does go far beyond what standard cataloging has ever been intended to do, the field gives the option for the cataloger merely (and very sensibly) to put in a URL where the data dictionary is located. Metadata should include all the information required to make a dataset useful. Some urgently needed metadata fields are such as the following:

(a) complete transcription of the header file;
(b) legend (e.g., for scanned geologic map, one needs to be able to call up full legend at any time and figure out what a given formation is);
(c) north arrow; and
(d) scale (in form of bar scale, so that no matter how much the map or image is blown up or shrunk down, the scale will be correct)

I am sure that persons who work every day with spatial data in digital form can easily come up with more.

Multilevel description is an area not much dealt with in FGDC, except for Lineage, and the series field in Section 8, Citation. It is another entire topic on itself; I have written a document on it, available on my homepage at:
http://www.library.ucsb.edu/
(Select people, then larsgaard).

CONCLUSION: OLD WINE, NEW BOTTLES

The basic idea is still the same: provide easy, speedy access to information, and specifically to spatial data. All that's changed is the format of presentation and the methods that users need to use to deal with the data.

REFERENCES

Anglo-American cataloguing code, 2d ed. rev., 1988, Chicago, American Library Association.

Cartographic materials: a manual of interpretation for AACR2, 1988, Chicago, American Library Association.

United States Federal Geographic Data Committee, 1994, Content standards for digital geospatial data, Reston, Va, The Committee.

United States President (Clinton, William, 1992-), April 13, 1994, Executive order 12906, Coordinating geographic data acquisition and access: the national Spatial Data Infrastructure, Federal register 59:17671-74.

THE DARTMOUTH FLOOD OBSERVATORY: AN ELECTRONIC RESEARCH TOOL AND ARCHIVE FOR INVESTIGATIONS OF EXTREME FLOOD EVENTS

Daniel Karnes
G. Robert Brakenridge

Surficial Processes Laboratory
Department of Geography
Dartmouth College
Hanover, New Hampshire 03755

Abstract — Extreme floods occur only rarely in any particular location, but when the Earth as a whole is considered, such events are frequent: almost two per week. From the beginning of 1996 up to September of that year, over eighty extreme floods had occurred. Cloud cover previously made satellite observation of floods difficult or impossible, but, following launch in 1991 of ERS-1 by the European Space Agency, good quality data are available from a new generation of high resolution synthetic aperture radar satellites. These satellites can map peak and near-peak flood conditions along river valleys and through the heavy cloud cover typically produced by tropical storms or hurricanes. The NASA-supported Dartmouth Flood Observatory (http://www.dartmouth.edu/artsci/geog/floods/) includes a frequently updated listing of reported floods, a global map showing flood-affected regions, and an accumulating array of satellite-based image maps showing inundation limits along flooded river valleys from diverse geographical contexts. It was designed as a research tool for focused efforts to understand the origins, geographical distributions, and frequencies of extreme floods, but it also is temporarily serving as an archive of flood inundation maps used by the general public.

INTRODUCTION

Extreme floods are not evenly distributed spatially or temporally. They are low frequency, high magnitude events whose prediction, or even observation, is fraught with difficulties. Recent papers discussing the history of geomorphology emphasize how under-studied such events have been, compared to the more "respectable" and frequent phenomena which are more accessible to Earth Scientists (Baker, 1992). At the same time, the new era of global satellite remote sensing has removed observational constraints for many kinds of extreme natural events, including floods. Having the world as a stage forces the realization that extremely rare events occur, somewhere, nearly every week. Thus, nearly every week, the "flood of the century" occurs somewhere (for instance, at this writing, in January 1997, along many river valleys in northern California). We have found that wire services and WWW-based news services report an average of two extreme flood events per week. In the period from January to September of 1996, we logged eighty flood events. Through satellite remote sensing, we can now detect and study these events as they happen.

Although geomorphologists are interested in extreme events from a research perspective, non-scientists — e.g., local and national disaster officials, humanitarian organizations, the general public — are directly involved in extreme flood events. The eighty events noted above incurred a cumulative loss of approximately 3000 human lives, U.S. $2.18 billion in damage, almost 3 million Ha. of agricultural land inundated, and 3.8 million people displaced. There is thus a practical need for current reporting or observation of flooding. The WWW flood remote sensing site was designed for research purposes, but we have noted a heavy demand for existing flood inundation maps and other data products in the wake of particularly large flood events — especially from those locally affected. We thus continue to pursue our research within academia while also striving to make the results of such work available in a timely fashion to non-specialists via map and image product publication on the WWW site.

This paper describes the satellite and electronic news service technology that helps us to create our basic information, as well as the structure and content of the site. We consider that sites such as ours, which present new maps that are not otherwise published, pose interesting questions for information specialists: how best can such documents be published and archived, and should the long term preservation of such information depend on the sustained operation of our local group and WWW site?

DATA SOURCES

The Dartmouth Flood Observatory (DFO) was initiated with NASA Mission to Planet Earth (NASA-MTPE) funding support and has been developed as a research tool to aid efforts to understand the origins, geographical distributions, frequencies, and magnitudes of extreme floods. Its research products are two-fold: (1) a running tally of flood events, with geographic locations and associated observational statistics recorded in a MapInfo® geographic information system (GIS), and (2) high resolution synthetic aperture radar (SAR) satellite images of particular flooded river valleys, rectified to various map projections and presented as 8 bit color GIF files. The DFO supports a World Wide Web (WWW, or simply, "Web") site available to any user with Internet access and a browser such as Netscape Navigator, Internet Explorer, or NCSA Mosaic. The Web site presents global records of extreme flood events (in text file and MapInfo Exchange, MIF, format) as well as maps (approximate scale 1:50,000) showing the spatial extent of particular large floods. There is much other related information presented on this WWW site, but the above, we believe, constitute the unique contributions of the site.

The original data for the global tally are electronic news service clippings received via various commercial and free (WWW-based) sources. The news information is analyzed in-house, compared for accuracy, and the basic statistics thus obtained are recorded both as a summary text description and as a data table within the global GIS.

The original data for the flood image maps are ERS (European Remote Sensing satellite) SAR images. In the near future, we will also be processing Radarsat SAR images. Both are C-band (5.6 cm wavelength) synthetic aperture radar images obtained from Earth orbit by a transmitter/receiver of an electronically "synthesized" large effective aperture. The images have a ground resolution of approximately 20 meters: objects of about this size or larger can commonly be discriminated. The radar signature of relatively smooth-surfaced flood water is dark (low radar return), whereas even moist land surfaces are radar-bright; thus, floodwater/land interfaces are easily distinguishable. Each orbital image covers 100 km x 100 km; we commonly crop the images to cover only the areas of interest. The data are shipped to us as 16 bit image files, but we have found that transformation into much smaller 8 bit gray-scale images preserves the needed information. Image radar backscatter calibration is not critical, although comparison of before, during, and after SAR images of the same terrain can benefit by calibration to real values of radar return intensity.

The 8 bit images are first "geocoded" by matching image features to their known geographic coordinates (in either latitude and longitude or in Universal Transverse Mercator, or UTM, systems). In this step, digital image processing techniques are used to warp the image to achieve the best possible match of image geometry to a map projection. In hilly terrain and for radar images, such geocoding is best performed after an initial rectification using topographic information, since SAR image geometry is exceptionally sensitive to topographic distortion even from orbital heights. However, for mapping floods along low relief floodplains, topographic rectification is not necessary.

In summary, the combined global and valley-reach specific data are derived from: a) commercial news services, b) free Internet-based news services; c) government-issued flood information; d) European and Canadian/American SAR satellites. The European data source is available due to a unique research outreach sponsored by the European Space Agency: a selected group of scientists are provided free ERS data in return for their assistance in demonstrating new applications for this technology. The Canadian/American Radarsat data are to be provided to us as approved NASA principal investigators and through agreements between the Canadian and American space agencies. Both kinds of satellite SAR data include restrictions on further distribution of the raw data, in order to avoid competition with commercial marketing efforts. However, due to the research nature of our work and the academic institution sponsorship, the image maps we produce are in the public domain and available freely for copying or reuse with only the standard requirement of proper citation and attribution. Both satellite data sources also require that image products made using their raw data cite the raw data source and its copyright.

A TOUR OF THE SITE

The site (http://www.dartmouth.edu/artsci/geog/floods/) is organized into six areas:

- flood databases;
- sample images;
- current flood information;
- links to related sites;
- links to staff home pages and email addresses.

The top page of the flood database area links to a presentation of extreme flood events in the current year, and to an FTP download area for GIS databases for previous years, dating back to 1994.

The "current year flood events image map" page (Figure 1) presents a world map showing locations of extreme flood events for the current year, as point symbols ranging from red (most recent), through pink, to off-white (oldest). These symbols are "hot spots" on the map; they are linked to anchors in a list of information about the flood events, so that clicking with a mouse button on a particular symbol brings up, in a separate window on the page, the record for that event.

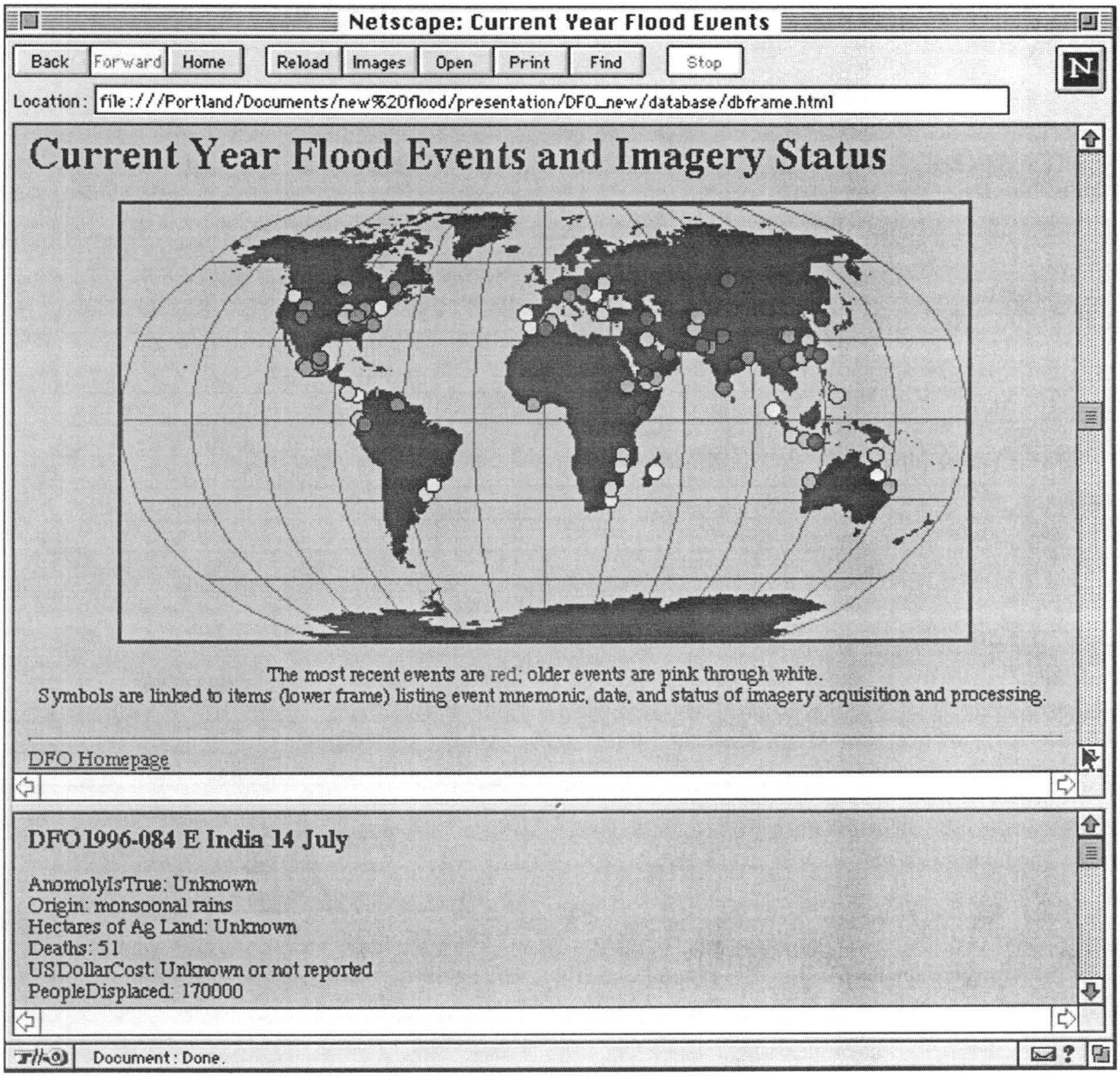

Figure 1: A screen shot of the current year flood events image map.

The FTP area contains information for 1994 through the current year. The current year database is used to construct the text file used in the current year flood events image map, and is updated periodically. For years 1996 and following, the database is available as a set of MapInfo tables in MIF (MapInfo Exchange) format, as well as DXF (Drawing Exchange Format). For 1994 and 1995, the data are in tab-delimited files. Most PC or Macintosh computer graphics programs can input linked object and attribute files in DXF format; and many GIS programs can import MIF files.

The database records information gathered from news reports, and links them to geographic objects. For flood events of known and reasonably large geographic extent (> 500 km^2), these objects are polygons approximating the area involved; for events of small or unknown extent, these objects are points. A related MapInfo® table maps all events to point objects, for use in creating the current events image map and for small-scale browsing.

Table 1 shows the attribute data items recorded for the MapInfo® table "floods96." The information for fields such as "DateStart," "DateEnd," and "Origin" is gathered from news services on the Web, and coded as indicated in the "Notes" column of the Table. For instance, "Origin" (which is coded using a small integer number) is arrived at by summing up the codes for individual causal factors listed in the news reports for a particular flood event. Since the individual causes have codes that increment by powers of 2 (see Table 2), all possible combinations of causes will sum to unique numbers, which can be decomposed into individual codes.

Table 1: Data Items and Definitions in Flood Events Database

Attribute Name	Data Type	Notes
Year	SmallInteger	4-digit year number
EventNumber	SmallInteger	Assigned by DFO
Name	Char(30)	Assigned by DFO
DateStart	Date	
DateEnd	Date	
AnomolyIsTrue	Char(1)	Possible values: Y,N,U (for yes, no, unknown)
Origin	SmallInteger	Coded in powers of 2
HaAgLand	Integer	Hectares of agricultural land involved
Deaths	Integer	
USDollarCost	Integer	
PeopleDisplaced	Integer	
Notes	Char(250)	

The "Rivers" data table records the names of the river drainages associated with a particular flood event. The DFO inventory number can be used as a foreign key to access this table.

There are several cross-reference tables to event identifiers used by agencies such as FEMA (the US Federal Emergency Management Agency) and DHA (Department of Humanitarian Affairs, a UN agency).

SAR imagery, processed to enhance visibility of inundated areas and combined with digital elevation models and other vector information such as transportation routes, is available through another page on the site: "Flood Images". Emily Bryant, one of the DFO staff, provides this description of the process (personal written communication):

Table 2: Codes for "Origin" data item

Code	Origin
0	unknown or not recorded
1	rains
2	snowmelt
4	tropical cyclone
8	frozen ground
16	monsoonal rains
32	flash floods
64	frontal storms, thunderstorms

"After being scaled from 16-bit to 8-bit, the [SAR] image is registered to UTM coordinates, using US Geological Survey (USGS) 1:100,000 scale Digital Line Graph (DLG) files downloaded from the Eros Data Center web site. USGS 1:250,000 scale Digital Elevation Model (DEM) data for the same flooded area are also downloaded and registered to UTM coordinates, using the same DLG data. An inverse Intensity-Hue-Saturation (IHS) transformation is then used to merge the registered SAR and DEM data. The SAR layer is designated as intensity, the DEM layer as hue, and a third layer (often just a uniform middle-gray image) as saturation. When this is transformed to three RGB layers, color (hue) corresponds to elevation (typically navy blue for the lower elevations, green and yellow for mid-elevations, pink for higher elevations), and overall brightness (intensity) corresponds to the SAR return. Smooth surfaces such as open water have a low SAR return and hence look black. The DLG vector data are overlaid on the registered RGB image, with hydrology features represented in bright blue, roads in red, railroads in yellow, and 'miscellaneous transportation' (e.g. pipelines, power lines, airports) in white."

At the top level of the flood images area of the site, reduced-resolution thumbnail and browse images are displayed on the Web pages. This enables users with relatively low-speed connections to view sample data in reasonably short times. If users then wish to download the full-resolution imagery, they can do so by using the FTP area linked to the browse image pages.

"Current information" consists of links to Web sites that provide flood related data and information. For instance, the National Flood Summary WWW page, with flood information for the United States, is updated daily by the US National Weather Service headquarters. The Water Resources Information homepage, which is a product of the US Geological Survey, often has information about current flooding as well as real-time hydrologic data and links to other sites. A page maintained by the US Army Corps of Engineers page also links to real-time hydrograph data for a number of river basins in the Midwest. The current flood information page links to a number of non-US sites, US sites that focus on international weather and disaster information, and sites set up by international organizations

"Related Sites" links are to sites maintained by organizations having some connection with the DFO. These sites include the NASA/JPL Imaging Radar Home Page, the European Space Agency's Earth Remote Sensing User Services, the RADARSAT Home Page, the Alaska SAR Home Page, the Canada Centre for Remote Sensing Home Page, and the home pages for the Earth Sciences Department and the Geography Department at Dartmouth College.

FUTURE PLANS

The real-time hydrograph data mentioned above presents an opportunity for us to develop a graphic display showing river stage as map symbols on a base map of streams. This would entail development of certain scripts or possibly Java-based applications, and would provide real time flood mapping as opposed to the present numerical data stream generated by the gauging stations.

Refining the current flood events map display is a pressing issue. We plan to do this by increasing its temporal resolution, so that accumulating a year's worth of flood events does not cover the oldest entries.

Planned improvements to the database — both the on-line current events version and the downloadable one — involve adding imagery acquisition information for each event. We would also like to make available a larger number of transfer formats — perhaps Arc/Info Exchange format as well as the current MapInfo and DXF.

As our goals and experience with the Web site continue to evolve, we are considering the implications of using a Web-compliant map server to present the spatial database of flood events. This approach would allow users to pan, to zoom in to examine an area in detail, as well as to perform more flexible attribute-based database searches. But this solution may not be the one most appropriate to our own needs. At present, we are in an academic computing environment based on the Apple Macintosh for client applications, with a shared Web server in another unit of the College. Present map-server solutions are based on UNIX, Win95, or NT environments, and would entail the DFO unit's taking responsibility for its own site in a physical as well as virtual sense.

CONCLUSIONS

As with any Web site, ours is a work in progress. We have experienced one major redesign and continue to modify the existing site. In the process, we continue to learn, and re-learn, important lessons in the creation, maintenance, and renewal of tools to provide information.

One such lesson has to do with the difficulty of maintaining continuity of effort in an academic environment. Without a staff dedicated to Web site maintenance, we rely on student workers and our own labor for the monitoring of news reports, collation of data, updating of the MapInfo database, transferring of information to the Web site, and so forth. Main-tenance of a Web site of this nature is technically demanding and time-consuming, and can absorb as many resources as one cares to devote to it.

As a consequence of this realization, our response needs to be an examination of our goals for the site and the resources available to fulfill those goals. There is a large, and ever-expanding, array of possibilities for information delivery; the challenge is to choose the ones that are appropriate to the task and to commit the effort to develop those possibilities.

Questions such as those raised in the Introduction to this paper are clarified if not answered as our experience increases. When considering how best the database and imagery products produced by the DFO should be published and distributed, or in what way these products are best associated with the Web site, we face a paradox resulting from the popularity of the Web and rapid growth in Internet usage. That is: the availability of more volume and types of geographical and earth science data has made it harder to track down the subset that is relevant to a particular problem. As a response to this, initiatives such as the Alexandria Project (http://alexandria.sdc.ucsb.edu/) and the National Spatial Data Infrastructure (http://fgdc.er.usgs.gov/fgdc.html) are underway and in development to provide links, catalogs, and metadata sources for geographical data. Because of the existing institutional linkage between DFO and NASA, NASA's Earth Observation System Data and Information System (EOSDIS) Distributed Active Archive Centers (DAAC) (information at (http://ecsinfo.hitc.com/) form a straightforward avenue for distribution of DFO datasets. At this point the most intriguing possibility is for the DFO to archive database and imagery information, perhaps on a yearly basis, on CD-ROMs. This would allow the Web site to focus on current information and rapid response imagery, while, with the right choice of file format and data organization, users of the CD-ROMs would be able to perform useful analyses of imagery data as well as the global flood event GIS data.

ACKNOWLEDGEMENT

G. R. Brakenridge acknowledges the support of NASA MTPE grant NAGW-3227 and both authors thank the Department of Geography, Dartmouth College, and Dartmouth College Computer Services, especially the Webmaster Group.

FUTURE PUBLICATION PLANS OF THE U.S. GEOLOGICAL SURVEY: PAPER PLANS, ELECTRONIC DREAMS

James G. Smith

U.S. Geological Survey
Volcano Hazards Program
345 Middlefield Road
Menlo Park, California 94025
jimsigp@mojave.wr.usgs.gov

Abstract — The U.S. Geological Survey (USGS) is a large publisher of books and maps. Unusual factors influence its publication policies: USGS publications are not copyrighted; anyone may reproduce USGS data. Money from book sales goes to the U.S. Treasury, reducing incentives for large press runs and reprinting "best sellers," and encouraging less expensive ways of releasing information. The Administration and Congress encourage Federal Agencies to distribute data and publications online.

National Mapping, Water Resources, and Geologic Divisions are presently developing plans for product redesign and for streamlining information and publication processing. However, issues such as archiving and version control of electronic documents remain largely unaddressed. The National Biological Service joined the USGS as the Biological Resources Division in October 1996, bringing its own publication issues.

Trends are clear, while details remain uncertain, but the future USGS will move toward the following: 1) Consolidate existing formal publication series. 2) Disseminate electronic versions of paper products (for example, a Professional Paper available in Adobe Portable Document Format (PDF) or recast in Hypertext Markup Language (HTML) for World Wide Web (Web) distribution). 3) Distribute many books and maps using print-on-demand technologies to fill customer orders and make files available on the Web for on-site printing. 4) Publish purely electronic documents to save printing costs, speed delivery, and facilitate updates. For now, management is still requiring initial paper publication before electronic replicas or mimics. 5) Distribute information electronically that cannot be printed or that is unwanted in paper form (for example, video fly-through animation of Mount Rainier, Wash. eruption scenarios or a spatial data base used to generate a complex geologic map). 6) Distribute more information via the Web without series title, version number, etc. (for example, near real-time stream-flow data; periodically updated statements of status and recent activity for Long Valley Caldera, California; computer-generated, near real-time, earthquake-epicenter maps). 7) Allow mass customization of products (for example, users access Water Resource Division's stream-flow data on the Web, select a particular stream gage, time interval, and tabular or graphic output to create a customized data set before downloading).

INTRODUCTION

The U.S. Geological Survey (USGS) publishes large numbers of maps, books, and digital data. In fiscal year 1996 the USGS sold 4.9 million topographic maps, 1.2 million book publications, and 4,700 digital items. Digital items are especially interesting in this time of rapid technological evolution. Sales of digital items are increasing despite the free availability of much USGS digital data via the Internet. Digital items are also interesting for the sheer amount of data distributed and the number of individual digital products bundled together into a single item offered for sale. For example, a single Digital Raster Graphic (DRG) CD-ROM for sale contains images of 64 individual 7.5-minute (1:24,000-scale) quadrangles, two 1:100,000-scale quadrangles and one 1:250,000-scale quadrangle, as well as viewing software.

In addition to the products it sells, the USGS distributes many publications of general interest to the public free of charge. In fiscal year 1996, the USGS distributed to the general public nearly 1.5 million Map Indexes, General Interest Publications, Circulars, and Fact Sheets, mostly one at a time in response to specific requests or through displays at its publications sales offices.

Factors influencing USGS publications policy, the ways in which USGS publications are evolving, and examples of new and redesigned products are described in the rest of this article.

HISTORIC INFLUENCES ON USGS PUBLICATION POLICIES

Several unusual historical factors influence USGS publication policies and practices. These factors are quite different from those affecting other organizations that publish and sell earth science information.

USGS data and publications, like those of nearly all other federal government agencies, are not subject to copyright (but federal government agencies may have copyright assigned to them; for a good short explanation of copyright issues and governments in the United States, see http://palimpsest.stanford.edu/mirrors/faq/copyright/faq/part3, especially section 3.6). Anyone may reproduce USGS data and publications without the federal government's permission and without paying fees or obtaining a license. Republishers of USGS data are not even required to indicate that the USGS was the original source of "their" data. The philosophical basis for the federal government's not retaining copyright is that the public, through their taxes and the Congressional appropriation process, have already paid once to collect data and generate a publication's content. To require taxpayers to pay again in an attempt to fully recover the cost of generating the original data would be unfair and, in effect, would mean that taxpayers would pay twice for the same information—once to generate it and again to obtain it. This philosophy on copyright is in marked contrast to that of most other national and state governments. (However, many federal government agencies are beginning to produce data that is entering the private sector, using agreements with private publishers who claim copyright. For examples of this trend and a critique, see the testimony of Wayne P. Kelley, Superintendent of Documents, before the Senate Committee on Rules and Administration on 18 June 1996.)

The availability of large amounts of copyright-free data generates a large secondary market for many USGS products. Businesses acquire basic USGS data, add value or repackage the data, and sell the information into other markets without the added business expense of paying royalties or licensing fees to the U.S. Government. The following are a few examples:

- A private company starts with USGS topographic maps of national parks and wilderness areas, accentuates trails, adds tourist information in the margins of the map, reprints the maps on tough waterproof paper, and markets them to hikers and campers through sporting goods stores.
- Because of the danger, USGS employees, as part of their work monitoring restless volcanoes, are commonly the only people allowed close to erupting volcanoes and are thus able to capture dramatic photographs of volcanoes in action. These photographs are available for use royalty-free as illustrations in textbooks and popular publications. More recently, photographs of volcanic activity taken by USGS employees have appeared in commercial CD-ROM collections of stock photos designed for use by desktop publishers.
- USGS digital elevation data for the United States are repackaged as gray scale, shaded relief, and color elevation TIFF files of individual states. In addition to the images of terrain, USGS digital line graph (DLG) and other vector data are used to create highly structured, customizable, geopolitical maps that include individual editable features such as international, state, and county borders; rivers; coastlines; lakes; different classes of roads; and names of features. The data are packaged and sold on a set of CD-ROMs, containing files easily readable by common graphics applications operating on Macintosh and PC computers. The target market is graphic designers and desktop publishers.

In order to completely cover the United States, the USGS must maintain in stock a large number of individual titles for each of its geospatial data products. However, demand is low for most individual titles. For example, the most popular map product published by the USGS is the 7.5-minute (1:24,000-scale) topographic quadrangle map. To completely cover the United States exclusive of Alaska, 53,689 different titles must be kept in stock. About 75 percent, or some 44,000, of the titles sell fewer than 100 copies per year. The USGS does not have the option, open to commercial publishers, of supplying only high-volume titles.

Most copies of USGS book publications are not sold, but given away. The Congressionally mandated Government Documents Library Program administered through the Government Printing Office was set up to assure that citizens across the country had access to U.S. government documents. Some 1,400 participating libraries across the country, at least one in each Congressional district, are eligible to receive free copies of U.S. government publications. In exchange they provide space for the collections and make staff available to assist users in accessing government documents (44 U.S.C. Chapt 19). The

USGS also maintains its own gifts and exchange program with other surveys and educational institutions world-wide. About 750 copies of each USGS publication are earmarked for this program (44 U.S.C. Chapt 17, sec. 1721). Finally, 200 to 500 copies of each press run are allocated for sale to the general public.

Buyers of USGS publications pay only printing and distribution costs. The USGS, along with other federal government agencies, is required by Congress to recover costs of printing and distribution. The prices the public pays for USGS products represent only these costs as determined by the Government Printing Office. (See, for example, Office of Management and Budget (OMB) Circular A130, February 6, 1996, "Agencies shall...Set user charges for information dissemination products at a level sufficient to recover the cost of dissemination but no higher. They shall exclude from calculation of the charges, costs associated with original collection and processing of the information.")

Moneys collected from sales of most USGS products go directly to the U.S. Treasury. While production, printing, storage, and distribution costs for most publications are paid for out of yearly Congressional appropriations to the USGS, money collected from sales of publications is not retained by the USGS to offset these costs, but goes directly to the U.S. Treasury (44 U.S.C., Chapt 17, sec. 1702). An exception is money collected from the sale of topographic maps. Several years ago, the National Mapping Division (NMD) petitioned Congress for permission to retain proceeds from the sale of topographic maps to help offset the cost of printing future topographic maps and to assure that maps were reprinted in a timely manner as they went out of stock. Congress allowed NMD to retain the proceeds of map sales, but reduced NMD's appropriation by the estimated amount of yearly sales of topographic maps. More recently, approval to retain proceeds of map sales was extended to geologic and other thematic maps.

These unusual historical influences on USGS publication policies and practices lead to the following:

1) Little incentive for large press runs or reprinting of "best sellers." Because publication expenses must be paid from yearly Congressional appropriations, while money from sales of these same publications is not retained by the USGS, there is little monetary incentive for large press runs and reprinting "best sellers." When publication costs must compete with field work or data-generation activities for fixed project dollars, publishing generally loses. Lack of post-publication control of content through copyright precludes generating revenue streams from sales of data into secondary markets.

2) Publication of USGS science in peer-reviewed journals rather than in USGS publications. Scientists seek to maximize distribution of the results of their studies at the lowest cost by publishing in scholarly journals that they perceive to be more widely circulated (and perhaps more prestigious) than USGS publications. The cost of preparing a page of material for publication is approximately the same whether done for an earth science journal or for a USGS publication. However, the circulation of leading earth science journals is closer to a typical press run for a USGS publication than many scientists think. For example, compare the typical press run of a USGS publication of around 2,000 to 3,000 with the average monthly circulation of a few earth science journals for 1995 shown in Table 1.

Table 1. Average Monthly Circulation Of Selected Earth Science Journals for 1995.*

Journal Name	Circulation
Geological Society of America Bulletin	7,500
JGR Solid Earth ("JGR Red")	5,100
Water Resources Journal	4,000

*Data for Journal of Geophysical Research Solid Earth, personal communication from Judy Holoviak, Director of Publications, American Geophysical Union (e-mail 23 November 1996). Other figures from Ulrich's International Periodicals Directory, 1996.

3) Fewer formal paper publications and exploration of less expensive products and methods of information dissemination. Publishing exclusively in journals is not a complete solution for USGS authors. Most journals publish only relatively short papers; only a few publish oversize colored maps, but almost none will publish uninterpreted data. Reviews, long interpretative papers, colored maps, and raw data produced by USGS projects must, by default, be published by the USGS. Authors (and perhaps more importantly, their managers) trying to control costs are searching for lower-cost forms of information dissemination. Cost considerations lead to more USGS information being published as cheaper informal publications, such as Open-File Reports and Water Resources Investigations Reports rather than as more expensive Bulletins, Professional Papers, and colored maps. USGS authors are also exploring new means of distributing information, such as fact sheets, CD-ROMs, and videos. The rapid growth of the Web has provided authors with another low-cost method of distributing data and digital mimics of paper publications.

RECENT INFLUENCES ON USGS PUBLICATIONS POLICY AND PLANS

The executive branch and Congress are encouraging federal government agencies to make as much of their information as possible available on-line. Recent executive branch documents are quite specific. For example, "Agencies shall use electronic media and formats, including public networks ... in order to make government information more easily accessible and useful to the public." and "Agencies shall ... provide electronic information dissemination products to the Government Printing Office for distribution to depository libraries." (Office of Management and Budget, 1996) The recently completed USGS Strategic Plan (Policy Council and the Strategic Planning Team, 1996) is equally specific: "[The USGS will] ... assemble and maintain a comprehensive digital library of earth science documents, maps, and data to be used for reproduction, distribution, printing on demand, or revision."

USGS employees are joining the rush to make information available on the Web, buoyed by their belief in the Web's ability to distribute data instantaneously worldwide. Statistics indicate that USGS information on the Web reaches a wide and rapidly growing audience. For example, during the six-month period ending in September 1996, for Water Resources Division (WRD) alone, the number of pages served to non-USGS users doubled to about 40,000 pages per day. Most of the users' computer domain names ended in ".com" or ".edu," which represent the commercial and education sectors of the Internet, not the USGS or other government agencies. Commercial users grew faster than any other sector, increasing by 38 percent in this six-month period (Lanfear, 1996). Most people reaching WRD's Web pages from the ".com" domain came from commercial on-line service providers or commercial online services, such as America On Line or CompuServ, indicating that USGS information is reaching a much broader audience than in the past.

In the last few years, the USGS has changed from an inwardly focused agency to an outwardly focused one. The USGS used to believe that just quietly publishing the results of its scientific studies was enough to ensure survival during successive rounds of budget cutting and governmental examination of relevance to national themes in the post–Cold War era. Its appearance in the Contract with America as an agency marked for abolishment and criticism from Congress about its reticence to effectively communicate and build a rapport with its natural constituents served as clarion wake-up calls (Craig, 1996). The agency realized that it had to broaden its audience and to develop new formats for information dissemination.

TRENDS FOR THE FUTURE IN USGS PUBLICATIONS

Future trends in USGS publications are clear, although exact details remain uncertain. The USGS will have a constrained budget into the foreseeable future as the administration and Congress continue to confront the problem of balancing the budget. Level or reduced funding coupled with inflation will mean looking for ways to do more with fewer publication dollars.

The cost of producing publications keeps rising, and the USGS will continue to look for ways to become a more efficient publisher. The present USGS is working hard to accelerate the change from traditional products, to develop new techniques and products that meet customer demands, and to shrink the interval from project initiation to published results. National Mapping, Water Resources, and Geologic Divisions are presently redesigning products and streamlining information and publication processing. Each division has different audiences for its products and, therefore, different products, but each division is currently evaluating how it has historically paid for production, printing, and distribution of publications. Each division also is experimenting with new methods and products to try to reduce costs and speed delivery of information to the public.

In the past, Geologic and Water Resources Divisions paid for production and printing of their books and maps through assessments at the division level — a so-called tax-based system. Many managers and scientists felt that this system resulted in serious inequalities in who paid for what. Programs that produced mostly low-cost publications — for example, articles submitted to scientific journals — believed they were subsidizing high-cost publications, say a four-color, large format, state geologic map. Because publication, production, and printing were "free," so far as projects were concerned, authors and their managers were commonly not concerned about how much a proposed publication might cost to produce and print. Nor were they always concerned about how well prepared a manuscript was when it was submitted to a publication group, knowing that editors would clean up shoddy manuscripts or spin wordy dross into scientific gold. For example, a multi-chapter USGS Bulletin with 19 authors submitted a few years ago included charts and illustrations prepared using 15 different charting and illustration programs, in addition to traditional hard copy form. Getting this Bulletin ready for the printer was an unnecessarily time-consuming and expensive process.

Both Geologic and Water Resources Divisions are moving toward funding production and publication costs directly at the lowest organizational level, generally a state WRD district or GD project. Publication costs are included in project cycles starting with the initial proposal. Both divisions are also experimenting with "fee-for-service" plans to finance production and publication costs, charging programs or projects directly for time and materials needed to design and edit published products. It is hoped that bringing responsibility for costs to the project level will encourage appropriate forms of publication as well as better crafted manuscripts.

The future USGS will consolidate existing formal publication series. The USGS Professional Paper and Bulletin were recently combined into a single series. Originally, there was a clear distinction between the two series. The larger format Professional Paper contained summations of major studies or important new interpretations, while projects of lesser scope or data release were covered in the smaller format, shorter Bulletin. However, over the years the distinction has blurred. Professional Papers and Bulletins are now the same 8.5 x 11-inch size; there are short Professional Papers that contain mostly data with little synthesis and Bulletins that report extensively on a single major study.

The different map series in the Geologic Division (GD) are also being consolidated. Formerly, the GD published nine different map series for a variety of historical needs. Similar titles such as Oil and Gas Investigations Chart and Oil and Gas Map are confusing to users, especially non-specialists for whom more and more USGS maps are being produced. Slightly different formats confused authors and increased production costs. In the future, all GD maps will be published in a single series.

EXAMPLES OF NEW DIRECTIONS IN USGS PUBLICATIONS POLICY

Fact Sheets

While most United States citizens know that the USGS publishes topographic maps, too few are aware of its other missions. Even long-time members of Congress may not be not aware of the wide range of USGS activities (Craig, 1996; Regula, 1996). The purpose of Fact Sheets is to communicate quickly, in simple, accessible language, to a wide variety of audiences the rationale for important USGS scientific programs, descriptions of their products, and summaries of scientists' findings. Fact Sheets are limited to four pages and effective graphic design and concise non-technical language are encouraged. Fact Sheets are widely distributed and are free of charge. Approximately 250 were produced in both 1995 and 1996. Many Fact Sheets are available via the Web as well as in paper format (see for example, Apodaca and others, 1996; USGS Web addresses in References Cited).

Delivery of Real-Time Data over the Web

The amount of real-time and near real-time data distributed by the USGS via the Web is growing rapidly and reaching groups of people who never before used USGS data.

USGS Hazards Programs were the first to go on-line with real-time data. On-line maps showing recent earthquake epicenters not just in California but across the United States are extremely popular with the general public, emergency crews, and the media (see USGS Web addresses). An earthquake felt in southern California generates hundreds of thousands of requests for epicenter maps per hour for several hours after the quake. Provisional epicenter locations are posted to the Web within one minute following an earthquake. Users linking to real-time earthquake Web pages see a map showing the area in which they are interested, the location and exact time of the most recent quake, and coded symbols showing all earthquakes that occurred in the previous three days and their approximate magnitudes. These pages also link to information on earthquake preparedness and education about earthquakes.

Access to real-time stream-flow information via the Web is another popular recently introduced service. Users can check stream flow and stage of streams all across the United States. The information is easy to access via the graphical interface of the Web. Users first select a state from a map of the United States. Then they select the specific gaging station for which they want data from a statewide list. Real-time graphs of flow and stage for the past week are generated instantaneously and displayed on-screen. Numeric data can also be downloaded by users (see USGS Web addresses). This information is extremely useful to local emergency management officials and citizens to help them decide on actions such as road closure, rescue, and evacuation during times of threatened flooding. Resource managers use the information to manage dams and reservoirs. The National Weather Service relies on USGS real-time stream-flow data in order to forecast the timing and size of flood peaks and to alert emergency managers of possible hazards. The information has also proved popular with fishermen and white-water boaters. In September 1996 over 48,000 hydrographs were generated for some 11,000 non-governmental users.

Experimentation with New Ways of Making Data Available via the Web

Traditionally, most USGS products were designed for visual communication of information to a human user. The chief medium of communication was paper. Rapidly evolving computer technology is shifting the preferred medium from paper toward digital products and the preferred method of delivery to the Web. The USGS is responding by putting databases online and making user customization of downloaded data possible. This trend will certainly continue and quite likely accelerate.

Historical stream-flow data gathered from hundreds of gaging stations across the United States is an example of a large database that recently became available in digital form on-line. Users can access this data base via the Web and customize data they download to fit their needs. In its older paper form, this database was cumbersome, fragmented, and difficult to keep up to date. Stream-flow data was collected by local WRD districts and published in annual volumes. Preparation and publication delays meant that data were unavailable until several months after the close of a water year. A user wanting to compare stream flows from different watersheds or assemble a time series for a single stream gage had to consult several different volumes. Before users could analyze data on their own computers, they had to manually extract data and then re-key it. In short, this is a slow, inefficient process.

Using the Web to make historic stream-flow data available speeds delivery, saves money, and facilitates updates. A map-based interface similar to the one for downloading provisional present stream-flow data is used to enable users to select a state and then an individual stream gage. In addition, they select the historic time interval for which they want data and the form in which they want the data — a graphic representation, or a data table. The customized data is then downloaded to their own computer (see USGS Web addresses).

Distribution of Publications in Multiple Formats

Most users of USGS interpretative products such as Professional Papers or oversize topographic and geologic maps presently want traditional paper publications, but increasing numbers of users are requesting electronic files for downloading and print-on-demand reproduction. How fast the transition from paper to electronic distribution will take place is not clear. Nor is it clear if users will ever completely abandon their need for traditionally printed and distributed paper publications. For the foreseeable future, the USGS will furnish both paper and electronic versions of most interpretative publications.

The best format to use to make publications available on the Web is still evolving. Many USGS paper publications are recast for the Web as Hypertext Markup Language (HTML) documents, but this requires significant extra work to write the necessary computer code or process through HTML editors or converters. Additionally, significant redesign is necessary to ensure that an HTML publication communicates as effectively as its paper parent. The other popular method of creating documents for distribution on the Web is to create Adobe Acrobat® portable document format (PDF) documents. This method uses inexpensive commercial desktop-publishing software and requires minimal redesign for the Web, thus saving both time and money. PDF allows documents to retain original formatting and graphic elements and still be viewed, downloaded, and printed by different computer platforms, in effect creating exact digital mimics of paper products. The same file that gets sent to a commercial printer who prints the paper version is also used to make the PDF electronic version for Web distribution.

HTML and PDF documents are both hypertext documents that offer users another advantage over paper documents. Unlike paper publications, electronic documents with hyperlinks can connect users with supporting databases, Web sites, or even updated versions of previously published documents. USGS Open-File Report 96263 on the Northridge, Calif., earthquake is an example of a document available in paper, HTML, and PDF versions (Scientific Communications Group, 1996; see USGS Web addresses)

Development and Marketing of Experimental Products in Partnership with non–Federal Government Entities

Changes in United States law over the past decade make it possible for federal government agencies to seek partnerships with local and state governments, nonprofit organizations, and businesses to share technical expertise, resources, and information and to market products in ways impossible (not to mention illegal) in the past (see, for example, Federal Technology Transfer Act of 1986 (Public Law 99502) and National Competitiveness Technology Transfer Act of 1989 (Public Law 101189)).

Cooperative research and development agreements (CRADAs) are one way the USGS and private industry can share information and resources to jointly develop new products (63 U.S.C. Title 15, sections 3701-3715. See also USGS Web addresses for more information on CRADAS). The USGS National Mapping Division (NMD) and the 3M Corporation signed a CRADA in July 1996 to jointly develop over a 16-month period print-on-demand alternatives to traditional lithographically printed USGS topographic maps. NMD and 3M hope to develop high-volume map printing systems that the USGS could use in its production facilities. 3M hopes to bring to market low-cost, point-of-sale map printing systems using USGS data for installation in retail outlets such as sporting goods stores and national park information kiosks. Another possible location would be Government Documents Depository Library Program sites where storage of digital map files on CD-ROMs would save large amounts of storage space.

A high-quality, high-volume, print-on-demand system would also help USGS keep inventory costs low for its more than 53,000 individual topographic map titles, yet still make it possible for USGS to support the missions of other federal government agencies when they require quick delivery of USGS maps. For example, the Federal Emergency Management Agency needs thousands of copies of maps when responding to a national disaster such as hurricane Andrew or the Northridge earthquake. One goal of this CRADA is to be able to print and deliver hundreds of needed maps within 24 hours (Holmes, 1996).

Initial test prints of typical USGS topographic quadrangle maps have been favorably received. USGS and 3M plan further testing of public acceptance and plan to have a prototype kiosk set up in the spring of 1997. Further development will take into account customer acceptance of quality and cost of print-on-demand map products. For now the USGS views print-on-demand maps as a supplement to traditional paper maps, not as a replacement.

The USGS is experimenting with new ways to communicate more effectively with those needing its information. A recently released video on the hazards of Mount Rainier, Washington, is a good example of one new approach.

Snow- and ice-clad Mount Rainier, at nearly 14,500 feet elevation, towers over the rapidly urbanizing Puget Sound lowland. Because of its bulk and ice cover, this dormant volcano poses a significant hazard to those living around it, even those as far away as the shores of Puget Sound. Mount Rainier's history indicates that during the past 10,000 years more than 60 mud and debris flows have moved down valleys surrounding the volcano. The most voluminous mudflow, the 5,600-year-old Osceola Mudflow, reached the shores of Puget Sound at the port of Tacoma and covered an area just over 200 square miles across a wide swath in the Puget Sound lowland (Hoblitt and others, 1995).

Local officials and citizens need to consider the possibility of mudflow inundation from Mount Rainier as they make decisions about land use and siting critical facilities in lowland areas. They also need information to build plans into their lives for immediate action if they receive warnings that a mudflow is likely or on the way. The question for the USGS Volcano Hazards Program was how to convey the potential dangers to as wide an audience as possible in an easily understood way. Experience in communicating the hazards of other volcanoes convinced the program's scientists that traditional forms of communication such as Professional Papers, maps, or journal articles would not reach a significant segment of the intended audience.

Instead of traditional paper products, the program decided to produce a commercial quality video on potential dangers of Mount Rainier that would be targeted at residents of the Puget Sound area. The superintendent of Mount Rainier National Park was willing to have a high-quality video on the volcano shown as part of the visitor orientation program at the park's visitor center. Showing the video to park visitors was especially appealing because surveys showed that about 70 percent of visitors to the park live in the Puget Sound lowland.

The Volcano Hazards Program also wanted to make it easy for visitors to take a copy of the video home. This meant finding a way to sell the video. Because the USGS has no experience marketing commercial videos, the USGS decided not to sell the video through its own distribution system. Instead, the Volcano Hazards Program is marketing the video through a cooperative agreement with the Northwest Interpretative Association (NWIA). The NWIA is a private nonprofit organization authorized by Congress to work with the National Park Service to sell educational and interpretative materials, products, and services. If there are profits, a portion will be used by the National Park Service and the USGS to help update exhibits and produce other educational materials. It is hoped that this agreement will become a model for production of other new geoscience products at other National Park areas.

REFERENCES

Apodaca, L.E., Stephens, V.C., and Driver, N.E., 1996, What affects water quality in the upper Colorado River Basin?, U.S. Geological Survey Fact Sheet 10996, 4 p. (Web address of Portable Document Format (PDF) version is http://webserver.cr.usgs.gov/nawqa/ucol/factsheets /esrfsn2.pdf).

Craig, L.E., 1996, Government support for geologic research faces an uncertain future, Geotimes, v. 41, no. 3, p. 2932.

Hoblitt, R.P., Walder, J.S., Driedger, C.L., Scott, K.M., Pringle, P.T., and Vallance, J.W., 1995, Volcano hazards from Mount Rainier, Washington, U.S. Geological Survey Open-File Report 95273, 10 p., plus 1 sheet, scale 1:400,000.

Holmes, Allan, 1996, 3M, USGS study ways to deliver maps electronically, Federal Computer Week, 2 September, 1996, p. 97.

Lanfear, Kenneth J., November, 1996, An Analysis of World Wide Web usage for U.S. Geological Survey sites serving water information during September, 1996, U.S. Geological Survey, Reston, Virginia, Internal USGS Web communication.

Office of Management and Budget, 1996, Management of federal information resources, Washington D.C., Office of Management and Budget Circular A130. (Revised version of 8 February 1996 available at http://www.whitehouse.gov/WH/EOP/OMB/html/circulars/a130/a130.html).

Policy Council and the Strategic Planning Team of the U.S. Geological Survey, 1996, Strategic plan for the U.S. Geological Survey 1996 to 2005, Washington D.C., U.S. Geological Survey, 53 p.

Regula, Ralph, 1996, Surveying the survey: A view from Capitol Hill, Geotimes, v. 41, no. 3, p. 2728.

Scientific Communications Group, Central Region Geologic Hazards Team, 1996, USGS, Response to an urban earthquake: Northridge '94, U.S. Geological Survey Open-File Report 96263, 78 p.

Ulrich's International Periodicals Directory, 1996, New Providence, New Jersey, R. R. Bowker, 34th ed., vols. 2 and 3.

U.S. Geological Survey Web addresses:

- Cooperative Research and Development Agreements (CRADA): See USGS Technology Transfer home page at http://www.usgs.gov/techtransfer/index.html
- Earthquake information on-line: The two main locations for realtime earthquake information on the Web are 1) http://quake.wr.usgs.gov/ and 2) http://www.scecdc.scec.org/
- Fact Sheets: Many Fact Sheets reworked for the Web are available at http://h2o.usgs.gov/public/wid/indexlist.html
- Historic stream-flow data: The home page for historic stream-flow data is http://h2o.usgs.gov/swr/
- Scientific Communications Group: USGS response to an urban earthquake, Northridge '94 — the home page for this Open-File Report is http://geohazards.cr.usgs.gov/northridge/
- Real-time stream-flow data (provisional): The home page for real-time stream-flow data is http://h2o.usgs.gov/public/realtime.html

WRITTEN IN THE STONES:
EXPANDING THE BOUNDARIES OF GEOSCIENCE LITERATURE

Linda P. Newman

Mines Library/MS322
University of Nevada, Reno
Reno, Nevada 89557

Lois Pausch

Geology Library
223 Natural History Building
University of Illinois at Urbana-Champaign
1301 West Green
Urbana, Illinois 61801

Abstract — This presentation reflects the authors' overview of geology as they have found it in the literature including citations to the principal works over the centuries. This review and bibliography of geologic literature is intended, ultimately, for the non-professional. It is presented here for the geoscience information professional, including but not limited to those responsible for collection development, who want to extend their field to anyone seeking to know more about the natural forces and terrain of the earth.

GEOLOGY — IN AWE OF NATURE

In this era of continual education and self-education, we, as earth science specialists, are often asked to share our knowledge when faced with requests for titles on earth science in general or specific areas of geology, such as:

- I'd like to know something about dinosaurs, or
- What's all this about continents moving??, or
- Do we live in the Ring of Fire?, or, especially today:
- How did the planets evolve and, is there life on Mars?

How might we help these eager seekers who do not want to take Geology 101, but do want to learn, on their own, some basics of geology?

We have sought to take our theme, "Expanding Boundaries: Geoscience Information" from the perspective of the novice to our field. Lois and I do not seek to preach to the choir before us, but rather to provide what we hope will be a useful and enjoyable summary of historic, current, general, and specific references to the literature of our field. These references may prove handy for you to share.

We do not present a definitive bibliography: I believe GeoRef has that market covered quite well. It is rather, a quick reference tool to share with the *non-scientist* who seeks knowledge in our field. Today, such people are likely to be web browsers, and we have included several neat addresses. Our goal is not to drown you or the non-geoscientist, but rather to present a taste of the literature to be found and leave it to them to pursue further — probably with *your* guidance.

The ground shakes as T-Rex approaches menacingly. This scene seems almost a current phenomenon, although it occurred millions of years prior to the arrival of Homo sapiens. The earth and its inhabitants evolved and the non-specialist's fascination with that evolution grows with each new book and Hollywood production. Whether the mesmerized spectator of dinosaurs on the Big Screen, or the casual traveler wondering about a roadside cut, or the home owner concerned with radon in the basement, many people have an interest in the physical nature of the earth, but few are trained to understand. An explanation of the forces that resulted in the terrain that is observed while riding, biking, or hiking is often sought by the interested observer.

The explanation for the history of the earth is evolving as the earth itself evolves. For as long as man has been aware of his physical home, he has sought an explanation. Ancient cultures tried to provide reasons for the forces of nature and ways in which to live and work with them. For example, in areas where nature has been especially violent, it had to be appeased — with monuments and often with material, animal, or human sacrifice.

Today, there are books on geology for the traveler, whether going down to the mall or taking that long-awaited vacation. From ancient times to our jet-set present, people have wondered about this physical world and have been entranced by the colorful stories of its formation.

THE WRITTEN RECORD

From the time of early man we have sought an understanding of the stones, minerals, and ores of our world. Development of the science of geology can be traced 5000 years to ancient peoples who mined and cast metal. Four-thousand-year-old cuneiform tablets found in Mesopotamia mention mining and geological concerns. Though the earliest efforts are obscure, we can trace the development of geology in Western Europe, its major contributors, and their significant works.

The earliest known documentation of substance in the field of geology dates from the early Greeks. Their study of the earth — its primary properties, shape and dimensions — is a marvel which extends from the 6th century before the common era (B.C.E.). Herodotus, in the 5th century B.C.E., commented on earthquakes and the nature of floods and was aware that it must have taken a great deal of time to create certain features.

Aristotle probably exerted the greatest intellectual influence on the Western world, and it extends to modern times. Although only translations and copies have survived, and while geological forces were then of minor concern, his thoughts on geology pervaded Western knowledge until recent centuries.

Roman authors, whose works have survived only a little more than the Greeks, utilized the earlier Greek information. Pliny the Elder and his nephew, Pliny the Younger, provided the most significant surviving geologic observation. Pliny the Elder actually died in the eruption of Vesuvius in 79 C.E. He was the author of *Natural History*, a major source of ancient scientific knowledge and observations, including the mineral industry of Rome in the first century. Geology, as it was known, thus spread with the Roman Empire.

Knowledge in the Western world survived the fall of Rome (barely) in two locales: the monastery and the Islamic research center. The results were mixed as the works they translated were often corrupted, perhaps by accident or ignorance, perhaps by prejudice. Arab scientists built on many early Greek and Roman writings, adding more detailed observations and measurements of natural forces.

GEOLOGICAL THEORIES OF THE RENAISSANCE

Western commentators and early scientists were often considered heretical for challenging then-accepted interpretations of the Bible. The discovery of the New World created even more problems for theologians and scientists since some creatures found alive or preserved were not previously known in European existence.

The debate continued well into the 18th century: were fossils the remains of once living creatures? Intellectual attempts to reconcile theology and geologic theory were plentiful. Were the layers of the earth containing fossils a matter of slow accretion or a result of The Flood?

Of importance were the writings of Bernard Palissy, in the 16th century in France, which include discussions on the flow of water through rocks, and the effect of water on the eventual destruction of mountains. Palissy espoused the long held theory that whole mountains might have been formed by warping of the crust.

While several authors used the term "geology" in the 18th century, it might well be attributed to Diderot for popularizing it with his introduction in the *Encyclopedie* of 1751.

George-Louis Leclerc, Comte de Buffon, 18th century France, in his great work *Histoire Naturelle*, blended ancient and current theories in accounting for the deposition of the earth's layers. He separated theological explanations from his concepts of earth's evolution and recognized a *continuous* process of earth building, destruction, and regeneration.

One of the popular theories of the 17th and 18th centuries held that all land was created from earth's molten core. An Italian priest, Moro, was the first to use the terms "primary" for unstratified rocks formed by molten lava, and "secondary" for layered rocks. The term "tertiary" for more "decayed" sediments was applied by Giovanni Arduino, another Italian, in the 18th century.

Understanding the age of rocks along with their deposition helped naturalists to grasp geologic events and relationships. Very gradually, the relationship of a particular layer could be related to others of similar history. Viewing a geologically complex road cut or the Grand Canyon will cause all to wonder on their incredible formation.

Mining in central Europe, especially by the Germans, played a significant role in developing theories of geology. Advances in mining, metallurgy, and geology focused on contemporary study and practice in the 15th century. The works of Georgius Agricola marked the turning away from ancient myths and theory to modern research resulting from direct observation and measurement — as much as instruments of the time would allow. As a doctor in a mining community and a classical scholar, Agricola read the ancient texts (those available in Europe) and studied the mining business in detail. His *De re Metallica* (1556) is a classic revered for centuries and now prized for its historical description and drawings.

THE AGE OF ENLIGHTENMENT

This era marked a transition to inquiries less impeded by political or religious restrictions.

The oldest known "geologic" map is 3500 years old, and depicts areas of gold mines in Egypt. The first "modern" geologic map was produced by Jean-Etienne Guettard, a French naturalist, in 1746. Governments recognized the need for geological knowledge of their nation's resources and began to sponsor surveys. The French Minister of Mining sponsored the first national geologic map series in the second half of the 18th century.

Gradually, very gradually, the ancient ideas of the formation of the earth were reviewed empirically, and new ones were proposed and accepted and/or assaulted.

Most scientific works had limited distribution and were read by only a handful of "naturalists" or scientists. This material was written in Latin and was not for public consumption. Surviving on a daily basis was still paramount for most people of Europe and America, and these debates had little effect on their lives.

THE INDUSTRIAL REVOLUTION

The events of the Industrial Revolution necessitated steady growth in the acquisition of natural resources. Capitalism required more precious metals for wealth accumulation and for coinage for the masses. Urban development demanded more stone and building materials. Factories and modern steam engines needed coal.

While the use of coal had been known in Europe since ancient times, including Roman use in Great Britain, massive demand is relatively recent, brought on by the Industrial Revolution. Coal, or coke from coal, was needed in large quantities by the iron industry. The new steam engines, including railroads, consumed and transported coal. The location and availability of raw materials promoted the quest for greater knowledge of stratigraphy which, in turn, promoted field research and geological mapping. Relationships of mineral deposition thus promoted the study of the age and sequence of rock layers.

James Hutton of 18th-century Edinburgh, regarded by many as the founder of modern geology, had, among his theories, the cyclic approach to rejuvenation or rebuilding of the crust. The crust, as it wore down, deposited beds followed by rebuilding and uplifting of continents. Cataclysmic theories of the earth's origin and formation were replaced with one in which he reported "no vestige of a beginning and no prospect of an end" and which came to be known as Uniformitarianism. Edinburgh University led other universities in Great Britain in the field of geologic studies in the 18th century. The first textbooks on geology came out early in the 19th century.

The greatest of the early professional geologists who began, as most did, as a gentleman-geologist, was Sir Charles Lyell of 19th century Britain. His *Principles of Geology* and the later *Elements of Geology* are classics to be found in any serious geological collection today. He presented his findings clearly, and with great insight, including the significance of the layers of earth, their deposition, and the scale of time involved.

General science organizations had existed since the mid-17th century, but the Geological Society of Great Britain, founded in 1807, was the first in the field of geology. The Geological Survey of the United Kingdom, a government entity, was organized in 1835 as governments began to realize that geological reports of their entire country were required.

Serious fossil collecting by naturalists had been done even in ancient times, but amateur collecting became the rage in Great Britain by 1800. Educated people of means had leisure time. Some had some specific education and often showed great aptitude. The English countryside was geologically accessible at many mine pits and natural sites. Popular fossil books were eagerly added to the libraries of these aristocratic hobbyists.

On the Continent, the power, majesty, and history of glaciers and ice sheets was presented by Louis Agassiz of Switzerland in 1841. His radical theory that there were periods of worldwide glaciation eventually became accepted explanations for many geologic phenomena.

Geological work in North America was very limited and quite provincial. Early explorers, naturalists, and travelers presented little more than passing notions and commentary. It took the Frenchman Comte de Volney's travels after the Revolutions — American and French — to produce the first geological maps with some detail and color in 1803. William Maclure, regarded as the actual originator of U.S. geologic mapping, published his map of the United States as it was perceived in 1809.

American colleges were slow to develop courses in geology. In the early 19th century, Yale became the leading center for geologic studies, but numerous other universities soon developed similar courses. These institutions provided leadership for geological study in the United States, which differed from Europe where centers were not at universities but in scientific societies. James Dwight Dana's great work *System of Mineralogy* was produced in 1837 at Yale.

As the industrial roots of the U.S. deepened, the need for coal increased. The discovery and greater use of coal prompted transportation development — canals, waterways, and eventually the railroad — and opportunities for geologic expansion. When the first oil well was drilled in Pennsylvania in 1859, the impact was not immediate, but eventually this procedure altered mankind and greatly affected geology.

Early in the 19th century, geological societies in the United States, both state and national, began to promote the study and publication of geologic research. Much of the work of state geological surveys was being published for public consumption, often to aid coal exploration, commercial development and settlement. The formation of the Geological Survey of Canada (1867) preceded the U.S. Geological Survey and provided for a more centralized effort to survey that country. The *Geology of Canada* first appeared in 1863.

AMERICAN EXPLORATIONS AND SURVEYS

Pre-Civil War explorations and surveys were partially for military reasons, but also included gathering information on natural resources and possible road and railroad routes. Lewis and Clark, Zebulon Pike, and John Fremont were among the most famous for their efforts. The report on John Fremont's western expeditions in the 1840's were popular publications of the day and are still interesting reading. His maps included geologic information and the drawings are classics. While reports like Fremont's stimulated political and economic expansion, gold spurred the real geological interest in the West.

The discovery of gold in California was the greatest impetus this country had yet experienced for expansion, settlement, and exploration. Migration following the Civil War prompted four famous territorial surveys known by their leaders: King, Hayden, Powell, and Wheeler. Explorations and surveying for the railroad also had geological ramifications. However, the major works of the second half of the 19th century were the western surveys of the U.S. territories. The surveys were sponsored primarily by the War Department. These surveys are all classics to this day, not only for their text, but also for the maps and drawings that they included.

Clarence King led the first exploration directed in part "... to examine and describe the geological structure ... ." His exploration along the 40th parallel took six years and resulted in his nine volume publication including atlases. His work was composed of mineral resource assessment, reporting on mining technology, and descriptions of the flora.

In 1867 Ferdinand Hayden led the U.S. Geological and Geographical Survey of the Territories: Nebraska, Colorado, New Mexico, Wyoming, Idaho, and Montana. The 12-volume report is revered by paleontologists today.

The grandeur of the Colorado River became known to the country with the third survey led by John Wesley Powell. This survey, originally intended to be of the Colorado River, was expanded to the "Rocky Mountain region." It, too, was geographical with surveying and reports on natural resources of the area. The superb drawings of the Colorado canyons remain breathtaking to the reader today. For the geologist, the power of the river to shape the land was a major conclusion of the work.

George M. Wheeler led the fourth great geographical survey in 1872. His survey was west of the 100th Meridian and was undertaken for military and geographical reasons affecting settlement, but his emphasis was on natural resources.

The U.S. Geological Survey as an agency was founded in 1879; its second director was John Wesley Powell, whose organizational talent made it the greatest geological organization and publisher of the U.S.

POPULAR WORKS

Many books in the 19th and 20th centuries have been written with an eye toward making the study of the earth and its makeup more comprehensible and interesting to people who wish to know more yet are not professional geologists. Among these are the reports of early expeditions noted above and William

Maclure's *Observations on the Geology of the United States*, written in 1817 and reprinted in 1966. Other titles in current use are the popular *Roadside Geology* series for states and regions, and the *Centennial Field Guide* series.

The *Centennial Field Guide* series, published by the Geological Society of America, contain a number of papers on the geology of a region of North America written by members of the various sections of the GSA. Although some of the articles may be too technical for the non-geologist, others are easy to read and understand.

The geology of the United States' national parks and monuments is the topic of a growing number of volumes. Among these are *Pages of Stone*, which presents, in rather condensed form, the geology of western national parks and monuments, and *Geology of National Parks*, now in its 4th edition. Individual parks are also represented in the literature; for example, there are *Canyonlands Country*, *Geology of Canyonlands and Arches National Parks*, and *A Roadside Guide to the Geology of the Great Smoky Mountains*.

In addition, there are many books covering individual states or regions of the United States. *Glaciers & Granite: a Guide to Maine's Landscape and Geology* and *From Rift to Drift: Iowa's Story in Stone* are examples. Other titles on individual states and regions of the U.S. and on national parks and monuments are included in the bibliography, but the reader should be warned that there are many, many more to be found than could be listed in any bibliography.

THE 20TH CENTURY AND BEYOND

Of the most intriguing geological issues of the 20th century are the issues of "continental drift" and the related issue of plate tectonics. Alfred Wegener of early 20th century Germany was one of the earliest and strongest proponents of the idea that continents were joined in the past and then were separated and "drifted" across the ocean floor. Paleontological and structural geological data have provided supporting and refining evidence. The primary gap in his theory remained to be explained: what was the force that caused continents to drift? The answer, most simplistically, as we now know, is heat. Or, more precisely, convecting heat which carries the plates, which may include continents as we identify them from the surface.

The state of California suffers violent geologic traumas when several plates rub against each other as they "drift." Mountains are being built as plates push up against plates, or pass beneath one another. Mountains are being built even as they are worn down by other natural forces. The more violent or commercial aspects of geology tend to draw much attention: the damage of earthquakes, volcanoes — from Vesuvius to Mt. St. Helen — have mesmerized humanity. Hot pools and geysers have always drawn a huge following. These locations have been the sites of settlement from Roman towns to California spa resorts. And the search for gold is not limited to huge companies, but is also indulged in by many weekend panners.

In some contexts, geology seems to have come full circle: The explanation for the formation of the earth by ancient Greeks centered on "cosmology," or a study of the cosmos. While ancient belief held that the "elements" of our physical domain were earth, air, fire, and water, it is now known that the "fire" in the earth, water (frozen and liquid), and the force of air, are indeed the major natural forces *shaping* the earth's surface. Modern geology has now reached a dynamic extension of the ancient interpretation of earth's forces with the geophysical considerations of the earth's ongoing evolution. And what of other celestial bodies? What was the nature of their formation? Our attempts to grasp their evolution grows daily and extends ever outward.

The forces of nature which have sculpted the earth's surface continue to do so. Geochemical analysis has continued to advance the knowledge of the life of earth from a few thousand years to millions and, eventually, billions of years ago. Today, the origin of the universe itself, certainly the ultimate geological question, is debated not only by geologists, but also by physicists and a host of other scientists and non-scientists.

EXPANDING OUR BOUNDARIES

Given this brief history of geologic literature, how might we geoscience specialists expand its boundaries? While possibilities are endless, our goal has been to present a paper and bibliography on the evolution of the earth, with modern and extraterrestrial considerations. Obviously this is a very select bibliography of a very great field. The titles mentioned and many more in our bibliography were chosen to give the novice reader — not a professional or a geology student — an idea of the richness of the literature available for the person interested in learning more about the physical earth. We offer it as our effort to expand our boundaries.

BIBLIOGRAPHY

The following is a very selective bibliography of information in the many fields of geology. Titles were chosen to provide insight into the rich literature available in libraries and bookstores for the patron who is not a geologist but who is interested in learning more about the earth and its history.

I. GENERAL TEXTS

Brown, G. C., C. J. Hawkesworth, and R. C. L. Wilson, editors, 1992, *Understanding the earth, a new synthesis*. New York: Cambridge University Press.

Conte, Donald J., Donald J. Thompson, and Lawrence L. Moses, 1994, *Earth science: a holistic approach*. Dubuque, IA: William C. Brown.

Dickey, John S., 1996, *On the rocks: earth science for everyone*. New York: John Wiley.

Dott, Robert H., Jr. and Roger Lyman Batten, 1988, *Evolution of the earth*. 2nd edition. New York: McGraw Hill.

Fowler, C. M. R., 1990, *The solid earth: an introduction to global geophysics*. New York: Cambridge University Press.

Gould, Stephen Jay, 1987, *Time's arrow, time's cycle: myth and metaphor in the discovery of geological time*. Cambridge, MA: Harvard University Press.

Hallam, Anthony, 1989, *Great geological controversies*. New York: Oxford University Press.

Hamblin, W. Kenneth, 1992, *Earth's dynamic systems*. 6th edition. New York: Macmillan.

James, Peter, 1993, *Earth in chaos*. Brisbane, Australia: Boolarong Publications.

Keller, Edward A., 1992, *Environmental geology*. New York: Macmillan Publishing Company.

Lutgens, Frederick and Edward Tarbuck, 1992, *Essentials of geology*. New York: Macmillan Publish-ing Company.

Lyell, Charles, 1990, *Principles of geology*. Chicago: University of Chicago.

Montgomery, Carla W., 1993, *Fundamentals of geology*. 2nd edition. Dubuque, IA: William C. Brown.

Muller, D. W., J. A. McKenzie, and H. Weissert, 1991, *Controversies in modern geology*. New York: Academic Press.

Pipkin, Bernard W., 1992, *Geology and the environment*. Minneapolis: West Publishing.

Seyfert, Brian J. and Stephen C. Porter, 1992, *The dynamic earth: an introduction to physical geology*. 2nd edition. New York: J. Wiley.

Tarbuck, Edward J. and Frederick K. Lutgens, 1992, *The earth: an introduction to physical geology*. New York: Macmillan.

II. REFERENCE BOOKS

Bates, Robert Latimer and Julia A. Jackson, editors, 1987, *Glossary of geology*. Alexandria, Va.: American Geological Institute.

Encyclopedia of earth systems science, Vol. 1-4, 1992, New York: Academic Press.

Magill's survey of science: earth science series, Vol. 1-5, 1990, Pasadena, CA: Salem Press.

McGraw-Hill encyclopedia of the geological sciences. 2nd edition, 1988, New York: McGraw-Hill.

McNeil, Mary, 1991, *Earth science reference*. Lake San Marcos, CA: Flamingo Press.

Mitchell, Richard Scott, 1985, *Dictionary of rocks*. New York: Van Nostrand Reinhold, 1985.

Wood, David N., Joan E. Hardy, and Anthony P. Harvey, 1989, *Information sources in the earth sciences*. New York: Bowker-Saur.

III. GEOLOGY JOURNALS USEFUL TO THE NONPROFESSIONAL

Earth: the science of our planet. Waukesha, WI: Kalmbach Publishing. Quarterly.

Earth in space. Washington, D.C.: American Geophysical Union. 9 issues/year.

Earth sciences history. Tacoma, WA: History of Earth Sciences Society. 2 issues/year.

Geology today. Oxford, England: Blackwell Scientific, 6 issues/year.

Geoscientist. Bath, England: Geological Society Publishing House. 6 issues/year

Geotimes: news and trends in the geosciences. Alexandria, VA: American Geological Institute. Monthly.

Journal of geological education. Bellingham, WA: National Association of Geology Teachers. Monthly.

IV. HISTORY OF GEOLOGY — CLASSIC WORKS

Those interested in the early works in the history of geology will find that many of them, including those written by Herodotus, Plato, and Pliny the Elder, can be found in English translation at many larger public libraries and universities.

Herodotus. *Herodotus*, with an English translation by A. D. Godley, 1921-24, New York: G. D. Putnam.

Plato. *The collected dialogues of Plato, including the letters*, edited by Edith Hamilton and Huntington Cairns, 1961, New York: Pantheon Books.

Pliny the Elder. *Natural history*, with an English translation by H. Rackham. 2nd edition, 1980, Cambridge, MA: Harvard University Press.

V. HISTORY OF GEOLOGY — MODERN WORKS

Adams, Frank Dawson, 1954, *The birth and development of the geological sciences*. New York: Dover Publications.

Albritton, Claude C., Jr., 1975, *Philosophy of geohistory: 1785-1970*. Stroudsburg, PA: Dowden, Hutchinson & Ross, Inc.

Bonney, T. G., 1895, *Charles Lyell and modern geology*. London: Cassell.

Cloud, Preston, 1970, *Adventures in earth history: being a volume of significant writings from original sources, on cosmology, geology, climatology, oceanography, organic evolution, and related topics of interest to students of earth history, from the time of Nicolas Steno to the present*. San Francisco: W. H. Freeman.

Faul, Henry and Carol Faul, 1983, *It began with a stone*. New York: John Wiley & Sons.

Fenton, Carroll Land and Mildred Adams Fenton, 1952, *Giants of geology*. Garden City, NY: Doubleday.

Gohau, Gabriel, 1990, *A history of geology*. New Brunswick, NJ: Rutgers University Press.

Merrill, George P., 1924, *The first one hundred years of American geology*. New Haven: Yale University Press.

Sarjeant, William Antony S., 1980, *Geologists and the history of geology: an international bibliography from the origins to 1978*. 5 volumes. New York: Arno Press.

—. Supplement, 1979-1984, 1987, 2 volumes. Malabar, Fla.: R. E. Krieger Pub. Co.

—. Supplement 2, 1985-1993, 1994, 3 volumes. Malabar, Fla.: R. E. Krieger Pub. Co.

Schneer, Cecil J., editor, 1979, *Two hundred years of geology in America*. Hanover, New Hampshire: University Press of New England.

Thompson, Susan J., 1988, *A chronology of geological thinking from antiquity to 1899*. Metuchen, NJ: Scarecrow Press.

White George W., 1978, *Essays on history of geology*. New York: Arno Press.

Wood, Robert Muir, 1985, *The dark side of the earth*. London: George Allen & Unwin.

VI. MINERALOGY AND GEMOLOGY

Fisher, P. J., 1966, *The science of gems*. New York: Charles Scribner.

Frye, Keith, editor, 1981, *The encyclopedia of mineralogy*. Stroudsburg, PA: Hutchinson Ross Pub. Co.

Hochleitner, Rupert, 1994, *Minerals: identifying, learning about, and collecting the most beautiful minerals and crystals*. Hauppauge, NY: Barron's.

Holden, Martin, 1991, *The encyclopedia of gemstones and minerals*. New York: Facts on File.

Hurlbut, Cornelius S., Jr. and Robert C. Kamerling, 1991, *Gemology*. New York: Wiley.

Liddicoat, Richard T., Jr., 1981, *Handbook of gem identification*. Santa Monica, CA: Gemological Institute of America.

Mitchell, Richard Scott, 1979, *Mineral names: what do they mean?* New York: Van Nostrand Reinhold.

Moore, N. F., 1978, *Ancient mineralogy*. New York: Arno Press.

Roberts, Willard Lincoln, Thomas J. Campbell, and George Robert Rapp, Jr., 1990, *Encyclopedia of minerals*. New York: Van Nostrand Reinhold Company.

Sinkankas, John, 1988, *Field collecting gemstones and minerals* (gemstones and minerals, how and where to find them). Prescott, AZ: Geoscience Press.

VII. FIELD MANUALS FOR THE WEEKEND GEOLOGIST

Black, Jack, 1987, *Gold prospectors handbook*. Baldwin Park, CA: Gem Guides Book Company.

Chesterman, Charles W., 1978, *Audubon Society field guide to North American rocks and minerals*. New York: Knopf.

Cvancara, Alan M., 1995, *Field manual for the amateur geologist: tools and activities for exploring our planet*. New York: Wiley.

Ettinger, L. J., 1992, *The rockhound and prospector's bible, a reference and study guide to rocks, minerals, gemstones, and prospecting*. Reno, NV: Ettinger.

Fay, Gordon S., 1973, *The rockhound's manual*. New York: Barnes and Noble.

Fritzen, D. K., 1959, *The rock-hunter's field manual: a guide to identification of rocks and minerals*. New York, Harper.

Hamilton, W. R., A. R. Wooley, A. C. Bishop, 1989, *The Henry Holt guide to minerals, rocks, and fossils*. New York: H. Holt.

McDonald, James Reid, 1983, *The fossil collector's handbook: a paleontology field guide*. Englewood Cliffs, NJ: Prentice-Hall.

Prinz, Martin, George Harlow, and Joseph Peters, editors, 1978, *Simon and Schuster's guide to rocks and minerals*. New York: Simon and Schuster.

Ransom, Jay Ellis, 1974, *Gems and minerals of America: a guide to rock collecting*. New York: Harper & Row.

—, 1975, *The gold hunter's field book, How and where to prospect for colors, nuggets, and mineable ores of gold*. New York: Harper & Row.

Sanborn, William B., 1987, *Handbook of crystal and mineral collecting*. Baldwin Park, CA: Gem Guide Book Company.

VIII. PALEONTOLOGY

Bakker, Robert T., 1986, *The dinosaur heresies: new theories unlocking the mystery of the dinosaurs and their extinction*. New York: Morrow.

Bishop, Walter W., editor, 1978, *Geological background to fossil man: recent research in the Gregory Rift Valley, East Africa*. Edinburgh: Academic Press.

Day, Michael H., 1986, *Guide to fossil man*. Chicago, University of Chicago Press.

Fenton, Carroll Lane and Mildred Adams Fenton, 1989, *The fossil book: a record of prehistoric life*. Garden City, NY: Doubleday.

Gould, Stephen Jay., 1989, *Wonderful life: the Burgess Shale and the nature of history*. New York: Norton.

Lane, N. Gary, 1992, *Life of the past*. 3rd edition. New York: Macmillan.

Lockley, Martin, 1995, *Dinosaur footprints and other fossil tracks of the western United States*. New York: Columbia University Press.

Psihoyos, Louie, 1994, *Hunting dinosaurs*. New York: Random House.

Ricciuti, Edward R., 1980, *Older than the dinosaurs: the origin and rise of the mammals*. New York: Crowell.

Rudwick, M. J. S., 1976, *The meaning of fossils: episodes in the history of palaeontology*. New York: Science History Publications.

Tidwell, William D., 1975, *Common fossil plants of western North America*. Provo, Utah: Brigham Young University Press.

Weishampel, David B., Peter Dodson, and Halszka Osmolska, editors, 1990, *The dinosauria*. Berkeley: University of California Press.

IX. EARTHQUAKES, VOLCANOES, AND OTHER GEOLOGIC EVENTS

Bolt, Bruce. and others, 1977, *Geological hazards: earthquakes, tsunamis, volcanoes, avalanches, landslides, floods*. Rev. 2nd. edition. New York: Springer-Verlag.

The citizens guide to geologic hazards, 1993, Arvada, CO: American Institute of Professional Geologists.

Decker, Robert and Barbara Decker, editors, 1982, *Volcanoes and the earth's interior: readings from Scientific American*. San Francisco, W. H. Freeman.

Francis, Peter, 1993, *Volcanoes: a planetary perspective*. New York: Oxford University Press.

Golden, Frederic, 1983, *Trembling earth: probing and predicting quakes*. New York: Scribner.

Lipman, Peter W. and Donal R. Mullneaux, editors, 1982, *The 1980 eruptions of Mount St. Helens, Washington*. Washington, DC: U.S. Government Printing Office.

Practical lessons from the Loma Prieta earthquake, 1994, Washington, DC: National Academy Press.

Steinbrugge, Karl V., 1982, *Earthquakes, volcanoes, and tsunamis: an anatomy of hazards*. New York: Skandia American Group.

X. GEOLOGY FOR THE TRAVELER

Almost all areas of the U.S. have "popular" geology publications; these are but a sample.

Baars, Donald L., 1993, *Canyonlands country: geology of Canyonlands and Arches National Parks*. Salt Lake City, UT: University of Utah Press.

Buchanan, Rex and James R. McCawley, 1987, *Roadside Kansas: a traveler's guide to its geology and landmarks*. Lawrence, KA: University of Kansas.

Chronic, Halka, 1984, *Pages of stone: geology of western national parks and monuments*. Vol. 1-4, Seattle: Mountaineers.

Delgado, James P., 1992, *America's national parks: a photographic survey*. New York: Crescent Books.

Ekman, Leonard C., 1962, *Scenic geology of the Pacific Northwest*. Portland, OR: Binfords and Mort.

Feldman, Rodney M. and Richard A. Heimlich, 1980, *The Black Hills: field guide*. Dubuque, IA: Kendall/Hunt Publishing.

Fleisher, P. Jay, 1975, *Geology of selected national parks and monuments*. Dubuque, IA: Kendall/Hunt Publishing.

Geological Society of America, 1986, *Centennial field guides, Vol. 1-6*. Boulder, CO: Geological Society of America.

Harris, Ann G., Esther Tuttle, and Sherwood D. Tuttle, 1990, *Geology of national parks*. 4th edition. Dubuque, IA: Kendall/Hunt Publishing.

Kendall, David L., 1987, *Glaciers and granite: a guide to Maine's landscape and geology*. Camden, ME: Down East Books.

Luther,Edward T., 1977, *Our restless earth: the geologic regions of Tennessee*. Knoxville, TN: University of Tennessee Press.

Maclure, William, 1966, *Observations on the geology of the United States*. Munich: Werner Fritsch.

Mathews, William H., III., 1968, *A guide to the national parks: their landscape and geology*. Garden City, NY: Natural History Press.

Moore, Harry L., 1988, *A roadside guide to the geology of the Great Smoky Mountains National Park*. Knoxville, TN: University of Tennessee Press.

Raymo, Chet and Maureen E. Raymo, 1989, *Written in stone: a geological and natural history of the northeastern United States*. Chester, CN: Globe Pequot Press.

Roadside geology of... Missoula: Mountain Press Publication Company. Various titles for many states and areas of the U.S.

Sansome, Constance J., 1983, *Minnesota underfoot: a field guide to the state's outstanding geologic features*. Stillwater, MN: Voyageur Press.

Troeger, Jack Clayton, 1983, *From rift to drift: Iowa's story in stone*. Ames, IA: Iowa State University Press.

XI. SPELEOLOGY

Ford, T. D., and C. H. D. Cullingford, 1976, *The science of speleology*. New York: Academic Press.

Jacobson, Donald and Lee Philip Strahl, 1986, *Caving: an introductory guide to spelunking*. Boyne City, MI: Harbor House Publishers.

Larson, Lane and Peggy Larson, 1982, *Caving: the Sierra Club guide to spelunking*. San Francisco: Sierra Club Books.

Lyon, Ben, 1983, *Venturing underground: the new speleo's guide*. East Ardsley, England: EP Publishers.

McClurg, David R., 1980, *Exploring caves: a guide to the underground wilderness*. Harrisburg, PA: Stackpole Books.

Moore, George W. and G. Nicholas Sullivan, 1978, *Speleology: the study of caves*. 2nd edition. Teaneck, NJ: Zephyrus Press.

XII. EXPEDITION REPORTS

Darwin, Charles, 1959, *Journal of researches into the geology and natural history of the various countries visited by H.M.S. Beagle*. Abridged and edited by Millicent E. Selsam. New York: Harper.

King, Clarence, 1870-80, *Report of the geological exploration of the fortieth parallel ...* Washington, DC: U.S. Government Printing Office.

Powell, John Wesley, 1961, *The exploration of the Colorado River and its canyons*. New York: Dover Publications.

U.S. Geological and Geographical Survey of the Territories, 1867-83, 12 v. Washington, DC: U.S. Government Printing Office. ["Hayden survey"]

Wheeler, George M., 1875-89, *Report upon United States Geographical surveys west of the one hundredth meridian ...* Washington, DC: Government Printing Office.

XIII. GEOLOGICAL MAPS

American Association of Petroleum Geologists, 1966- *United States geological highway map series, No. 1-12*. Tulsa, OK: AAPG.

Bolton, T., 1989, *Geological maps: their solution and interpretation*. Cambridge, England: Cambridge University Press.

Butler, B. C. M. and J. D. Bell, 1988, *Interpretation of geological maps*. New York: Wiley.

Edmonds E. A., 1983, *The geological map: an anatomy of the landscape*. London: HMSO.

Lisle, Richard J., 1988, *Geological structures and maps: a practical guide*. New York: Pergamon Press.

Maltman, Alex, 1990, *Geological maps: an introduction*. New York: Van Nostrand Reinhold.

Powell, Derek, 1992, *Interpretation of geological structures through maps: an introductory practical manual*. Harlow, Essex, England: Longman Scientific & Technical.

XIV. ELECTRONIC RESOURCES

A major factor in the dissemination of geological information is the great number of electronic resources available on the Internet. These can be accessed by anyone who has a computer linked to the Internet, although there may be fees, as in connecting to GeoRef, the primary bibliographic database for geology.

Homepages are proliferating at a rate not even documentable on a given day. Seek them via a search engine such as AltaVista. Among the interesting sites *currently* for the amateur are:

U.S. Geological Survey: http://www.usgs.gov
On-line Resources for Earth Scientists (ORES):
 http://ftp.csn.org/cogs/ores.tx
The Geological Survey of Canada:
 http://emr1.emr.ca/gs
Cascades Volcano Observatory:
 http://vulcan.wr.usgs.gov/homepage.html
Fossil News, Journal of Amateur Paleontology:
 http://www.halcyon.com/bonebug/
Dino-Trekking: http:www.bridge.net/~gryphon/dino/
The Johnson-Roehr Rock Page:
 http:/darkwing.uoregon.edu/~sroehr.rocks.html

Most state geological/mining surveys and societies have established web cites which include a wealth of information. For example:

Nevada Bureau of Mines & Geology:
 http://www.nbmg.unr.edu
Geological Society of Nevada:
 http://www.infor-mine.com/asso-inst/neva
Illinois State Geological Survey:
 http://denr1.igis.uicu.e...t/isgshome/isgshome.html

PART II

TECHNICAL SESSION

GEOSCIENCE INFORMATION: CURRENT TRENDS, FUTURE PLANS

INTEGRATION OF TEXT AND IMAGE IN THE DIGITAL BOOK FORMAT

Susan Klimley

Science and Engineering Libraries
Columbia University, New York, New York 10027
klimley@columbia.edu

Lisa Fish

Library
Lamont-Doherty Earth Observatory of Columbia University
Palisades, New York 10964
fish@columbia.edu

Robert Cartolano

Consulting Services
Columbia Academic Information Systems
Columbia University, New York, New York 10027
rtc@columbia.edu

Janet Gertz

Preservation Division
Columbia University, New York, New York 10027
gertz@columbia.edu

URL: http://www.columbia.edu/dlc/nysmb/

Abstract — In the geology literature, the relationship between text and image is one of the most varied and complex to be found in books. Many years and much work have gone into developing a digital format to adequately preserve the oversized color maps characteristic of the literature. Efforts are now focused on linking oversized and other images into a digital surrogate for the original book. New problems have been encountered. On pages that contain text and a line drawing, digitizing techniques maximizing the appearance of the text make for poor representation of the illustration. Navigation tools for movement between text and image are untested and the options most advantageous to the reader are not always obvious. There is a great need for automation of the digitizing process so that digital preservation is a cost effective as well as intellectually acceptable option.

INTRODUCTION

The relationship between text and images in printed materials has been recognized and studied for only a short time. A group of art historians met in 1988 to discuss the deterioration of research materials printed on acidic paper. One of the areas they addressed was the importance of text in relationship to images in some fields of study and the inadequacy of high contrast black and white microfilm as a preservation medium for these materials (Scholarly Resources in Art History, 1989). This was one of the first national meetings to identify the problem of text and image preservation using standard microfilming methods. Subsequently a Joint Task Force on the Preservation of Text and Image was convened. With that task force, experimentation with alternative preservation forms for text and image began.

The Joint Task Force noted in its 1992 report that there was little hard data on the extent of images in association with text in various disciplines (Commission on Preservation and Access, 1992). The report stressed the importance of retaining the original format of the text and images in preservation efforts so that future researchers would be able "to reconstruct what the writer saw and used in developing the text, and what the audience read" (Commission on Preservation and Access,1992, p. 2).

Geology librarians have been concerned about text and image since the 1980's. Among geology librarians, as with art historians, the driving issue was the inadequacy of preservation methods. In some respects the preservation problems in geology were even more difficult than in the arts. Geology book and journal images are frequently much larger than page-sized maps and diagrams. The use of color as a data coding device is also common throughout the literature.

In the last year or two, people working on electronic book and journal projects have begun to realize the importance of and the special problems presented by the need to associate text and image in electronic form. Users have only just begun to mention that the text/image relationship is one that must be retained in the electronic literature.

This paper will review the development of digital preservation techniques for preservation of earth science literature. The mechanics of combining two different file types and development of an interface for the *New York State Museum Bulletin* digital preservation project will be discussed. Some preliminary user comments will suggest areas of success and concerns that still exist. Finally, the experiences of working on this text and image preservation project will be put in the context of text and image issues being faced in the development of electronic books and journals.

BACKGROUND

Efforts to use digital technology as a preservation technique for illustrated books did not progress in a linear fashion. Early research by geology librarians focused on examination of available microfilming techniques that had been used for blueprints and other large documents, hoping the techniques might also work for large color geology printed materials (Klimley, 1984). Some librarians experimented with color photocopy surrogates for fragile originals (Newman, 1989).

In 1991, the Joint Task Force on Text and Image funded a project to experiment with the image problems presented by preservation of the *New York State Museum Bulletin*. The *New York State Museum Bulletin* is a multi-disciplinary, heavily illustrated publication containing many areas of geology as well as zoology, botany, and archaeology published since 1887. The wide range of illustration techniques and sizes of plates makes it close to a "worst case scenario," although typical of 19th and 20th century geology books and serials. Archival quality, full frame fiche were made of oversized maps but readers and printers for the fiche were not widely available. An attempt was made to digitize the fiche and microfilm images of the text. The limitations of digital technology and display devices could not meet the standards necessary for either the text or image (Klimley, 1993).

In 1994, a decision was made to work on the specific problem of oversized color images and see if a digital solution could be found. Several different imaging firms produced results using a variety of different imaging techniques with varying degrees of success. The largest, most complex images were maps and they caused the greatest problems. Maps could only be viewed on monitors, a small section at a time. Monitor colors varied greatly from the original image and among the monitors. When the digital files were printed, however, results were quite successful, assuring researchers that even the smallest graphic details were being captured and, with adjustments, colors could be brought close to the originals. Given the trends in digital technologies and the progress that had been made since the 1992 project, it was felt that many of the limitations of existing technology would be overcome in the future. The research returned to the original issue, that of uniting text and image, in a single preservation package.

TEXT PREPARATION

The integration of digital text and image into a digital preservation surrogate required solving problems in a number of different areas. On pages that contained text and a line drawing, digitizing techniques maximizing the appearance of the text poorly represented the illustrations. Navigation tools for movement between text and image were untested and the options most advantageous to the reader were not always obvious. There was a great need for standardization of the digitizing process so that digital preservation would be a cost effective as well as intellectually acceptable option.

The project built upon the earlier work that had been done, continuing to use four numbers of the *New York State Museum Bulletin* that had been used in the previous project (Gertz, 1995). As with that project, it was assumed that the final product should be able to be viewed on a wide variety of computer platforms, without expensive computer hardware or software. Access was provided on a web server using web browsers such as Netscape Navigator, employing low-cost personal computers with standard 14-inch computer displays.

Microfilm copies of the *Bulletins* were scanned by Preservation Resources at 600 dpi resolution. Each digital page image was stored as a black and white TIFF graphics file. The file was compressed using CCITT Fax 4 compression, a very efficient compression method. For each page of the *Bulletin*, one TIFF image was created. Although it was possible to print the TIFF files on a laser printer, TIFF is not supported by today's Internet web browsers, and CCITT Fax 4 compression is not supported by many graphics viewers.

Preservation Resources created corresponding information, known as metadata, for each page, which included bulletin number, chapter, page number, and additional relevant information. This information came as text data in a spread sheet. It was converted to a plain ASCII file.

It was necessary to change the TIFF files into a format that could be easily viewed on the web. The lowest common denominator for displays today is 640 pixels across, and 480 pixels down, and 256 colors. To fit the screen so that the entire page could be seen in the horizontal direction, the image needed to be reduced in size from a 600 dpi resolution to approximately 120 dpi. Best results were obtained by converting from a 600 dpi, 1-bit image, to a 120 dpi, gray-scale image, using 4 bits per pixel. This had an anti-aliasing effect on the typeface, smoothing out jaggies and resulting in a page that was readable using today's web browsers. The resulting image was approximately 600 pixels across by 900 pixels down. The image was stored in another graphic file format, known as GIF. The 72 dpi, 4-bits per pixel, GIF format is widely used by all major web browsers to display images. The file size was also under 100 kilobytes, which made it acceptable for lower speed connections to the Internet.

Lastly, the original TIFF file was also converted to a 300 dpi Postscript file. The Postscript file was converted to PDF or portable document format for printing.

IMAGE PREPARATION

The four *Bulletin* numbers contained 89 plates and figures that required either gray-scale or color scanning. These illustrations were first photographed using 35mm slides, then converted to a Kodak Photo CD format. Past experience with Kodak Photo CD vendors had shown that the vendors' quality control greatly affected the results. A vendor who provided successful results in the past was chosen for the project; yet a number of the Photo CD images were distinctly pink. The vendor agreed to process the slides again, and the resulting images showed no signs of pink.

Preservation Resources cropped the corrected images, and saved them at four resolutions. Two resolutions were selected for display on the web. A thumbnail image, that is a very small version of the images that would display immediately on the web, was also made. All the images except the thumbnails were converted to the JPEG graphic file format, for easier viewing by web browsers, and to reduce the file size for downloading.

INTEGRATION OF THE DIGITAL TEXT AND IMAGE

At this point, there were three file formats for each page of text and two file formats, one in two resolutions, for each plate. To integrate text pages, plates and figures, several hundred HTML pages were created. This work was done automatically using the programming language, Perl, and the available metadata. Most of the metadata provided was accurate and provided enough information to recreate the entire book. The Perl programs produced a table of contents page, serving as the starting point for each volume, a page index, a plate index containing a thumbnail view of every plate and figure, and, most importantly, an HTML page for every text page in the book.

The program that created the HTML pages made a GIF image of each page, linked any corresponding plates to the page, added navigational buttons, provided links to the PDF and TIFF versions of the same page, and added a link to a help page. At the end, the user has access to the high resolution TIFF file, which represents an archive, a lower resolution PDF file for printing and a GIF file for viewing on the web as well as two resolutions for each plate.

Automatic generation of the *Bulletins* from the metadata was key to the viability of the project. The programs identified errors in the metadata so typographical mistakes and omissions could be corrected. Once these errors were corrected, it became relatively easy to modify the "look" of the entire book. By changing the program in one place, for example, additional navigational aids were added to over 800 pages. The programs processed the book in a few minutes, making it possible to experiment with new ideas. Automatically processing the books permitted scaling up to a larger number of books without a correspondingly high increase in processing time.

NAVIGATIONAL AIDS

The original organization of the books was emulated while keeping the interface as simple and easy to use as possible. The use of the web interface provided an easy way to link one page to another. Small graphical arrows were used to indicate the next page and previous page at the top and bottom of each page image. The volume number, chapter, and page number clearly label the top of each page. To facilitate page "turning," a set of links to next and previous page numbers was available on the top of each page. The top of the page included a link to the table of contents, plates, and page index. At the bottom of each page, the location or URL of each page is indicated, as well as a link to an important viewing instructions help page. Links to the original TIFF and PDF documents were also at the bottom of each page.

USE OF THE DIGITAL SURROGATE

The belief that there is a strong relationship between the text and images of literature had a profound effect on the design of the *Bulletin* interface. In the printed *Bulletins*, some images had no page numbers. In the electronic version, care was taken to link the plates to the same pages they were adjacent to in the text. The plate index was not, as it would be in the printed book, simply a list of the titles of the plates, but rather a list of thumbnail sized pictures of the plates. One of the researchers who evaluated the electronic version of the *Bulletin* commented:

> I like the plates page. It corresponds to the way that I often look at geological books and papers, by glancing through the figures, and then checking out the text that goes along with any interesting figures. This serves the purpose, not only of the printed book index but also a way for users to browse through the images of a Bulletin much in the way they would rifle through the pages of the printed Bulletin (Kastens, 1996).

Even with care taken to retain the form of the original books, it was difficult to achieve the functionality of the book. The same researcher quoted above remarked:

> It is not obvious that the plates appear with a page to which they are logically and intellectually attached. Certainly, there are no (plate 3) or (figure 4) parenthetical comments in the text, and in a few of the cases where I actually read the text, the plate and the text varied in their degree of connectedness. I know in a lot of those old books, the plates had to be bound in specific places, not necessarily adjacent to the text they referred to (Kastens, 1996).

The plates were, in fact, very carefully linked to the page to which they were adjacent. So, as the researcher observed, the plates were not always bound in relationship to the text they illustrated in the printed volume. The researcher then reflected:

> I guess in an archiving project, you want to retain the original order of pages in the original book. To a modern user, it might be more useful to put the pictures next to the text they refer to. That would be more work, because a geologically knowledgeable person would have to read the text and make decisions, and there would certainly be room for disagreement about some of the decisions (Kastens, 1996).

These comments suggest text/image aspects of the printed book work because of the physical nature of the bound volume. Perhaps one of the reasons passages of text do not specify the plates related to it is because the bound volume not only permits but requires the user to turn page by page, passing plates "naturally" in the process of reading the book.

Another reviewer of the electronic *Bulletin* remarked that there were two plates associated with a 3-page passage on a paleontological observation. The reader of the electronic version noted and pulled up the first plate and found it unnoteworthy and skipped over the second plate, acknowledging impatience at having to pull up a separate image. Later, when reviewing the plates list with the thumbnails, the reader realized that the second plate had been far more interesting and yet missed when reading the text (Klimley, 1996).

The importance of text/image interaction is only recently being understood in the light of contemporary electronic publishing. Stewart's (1996) recent study of current chemistry journals contains data on the importance of images to users of current science literature. Second in importance only to printing, 72.7% of the users listed "browsing graphics to determine the value of an article" as "very important" and an additional 15% indicated it was "important" (Stewart, 1996, p.341). The same research questioned users on what was referred to as preferences for exact page images versus extracted graphs. 43.2% of the respondents indicated extracted images were adequate, 27% indicated an original page image was needed, and 16.2% said the text and graphics should be together but not necessarily an exact image (Stewart, 1996, p. 345). The variation in responses may indicate lack of experience to determine what is the best placement of text and image.

CONCLUSION

The relationship of text and illustrations in books and journals is only beginning to be understood. Initially, research was driven by the need to make sure preservation techniques adequately captured both the knowledge conveyed by the words and the pictures in books printed on deteriorating acidic paper. Duplication of the original format of the text in relationship to the images was considered very important for understanding what the original writers had intended and what readers had seen in the book.

Of late, the functionality of the text and image on interleaved pages of a book is becoming clearer. The printed book allowed an interplay between the illustrations and the text simply as a result of the pages of the book being turned. It is this functionality that is only now being understood. In the beginning, saving the images and their placement next to text was the concern of art historians and geology librarians. It is now emerging that the functionality of text and image in the book must also be retained not only for preservation but also as electronic publications are developed. Those disciplines dependent on illustrated text are fortunate to have the synergistic experimentation going on in both preservation and new format development. The careful consideration of this problem in the art and geology library communities may result in a solution that not only preserves the traditional functionality of paper text and image but enhances it.

REFERENCES

Commission on Preservation and Access (1992), Preserving the Illustrated Text. Washington, D.C.: Commission on Preservation and Access, 30 p.

Gertz, Janet (1995), Oversized Color Images Project, 1994-1995.Washington, D.C.: Commission on Preservation and Access, 22 p. Also URL: http://www.columbia.edu/imaging/html/largemaps/oversized.html.

Kastens, Kim (1996), Personal e-mail communication, Sept. 5, 1996.

Klimley, Susan (1984), Preservation Options for Geological Serials Containing Maps, in Geoscience Information Society Proceedings, v. 15, p. 51-58.

Klimley, Susan (1993), Notes from the Cutting Edge. Microform Review, v. 22, p. 105-107.

Klimley, Susan (1996), Personal e-mail communication, Sept. 6, 1996.

Newman, Linda (1989), Color Photocopying to Reproduce/Preserve Geologic Maps in Literature, in Wick, C., ed., Geoscience Information Society Proceedings, v. 19, p. 205-208.

Scholarly Resources in Art History: Issues in Preservation (1989), Report of the Seminar, Spring Hill, Wayzata, Minnesota, September 29–October 1, 1988. Washington, DC: Commission on Preservation and Access, 29 p.

Stewart, Linda (1996), User Acceptance of Electronic Journals: Interviews with Chemists at Cornell University. College and Research Libraries, v. 57, p. 339-349.

WHERE IN THE WORLD? FINDING METEOROLOGICAL AND CLIMATOLOGICAL DATA

Lisa A. Recupero

105 Deike Building
Earth and Mineral Sciences Library
The Pennsylvania State University
University Park, Pennsylvania 16802
L2R@psulias.psu.edu

Abstract — This paper looks at how meteorological and climatological data is being located by information professionals. A survey of research institutions which specialize in collecting and storing meteorological and climatological data was conducted. The survey identified trends in how the information professionals locate data by region, date and format; what information is being collected and whom the producers of the data are; and the impact of the World Wide Web on data accessibility. The formation of a new professional association, Atmospheric Science Librarians International (ASLI), is also discussed. The survey generated a useful bibliography of reference resources and Web sites related to meteorological and climatological data, which is included in Appendix B.

INTRODUCTION

Locating meteorological and climatological data can be an arduous task, especially in today's world of electronic data repositories. This paper attempts to identify institutions who are collecting climatic data, examine the holdings and reference resources used by the information professionals at these institutions, and look at the impact of the World Wide Web in accessing the data. In other words, figuring out where in the world to find meteorological and climatological information!

Monitoring the atmosphere, its systems and impacts upon the earth is an ancient practice, whose records can be found throughout history. In the U.S. the earliest records date from the 1600's. Records for the 1600's and early 1700's, recorded in farm journals and diaries, are typically located in university and national archives, including the Library of Congress, the National Archives, and the National Agricultural Library. Newspapers, almanacs and occasionally other periodical literature also provide access to meteorological and climatological data for the late 1700's and early 1800's. Records from civilian and military weather observation networks exist in the historical collections of the NOAA Library in Silver Spring and the publications of various government agencies, including the Smithsonian, the U.S. Geological Survey and also in the Congressional Serial Set (Hagarty, 1962; Baron, 1989; Fusonie, 1989).

In the 1870's the military and civilian weather observation networks were consolidated under the auspices of the U.S. Army Signal Service, which began publishing weather observation compilations in the *Monthly Weather Review*. In 1891 the U.S. Weather Bureau was established as an agency within the Department of Agriculture and became the keeper of all federal weather records. In 1940 the Bureau became part of the Department of Commerce and in 1970 it became the National Weather Service. Data archives for the period 1870-1940 are available in various periodical government publications, the National Center for Environmental Prediction (formerly the National Meteorological Center), the NOAA Library, and increasingly on the World Wide Web (Stanfield, 1984; Baron 1989; NWS, 1996).

Similar histories exist for meteorological observatories in other nations, including the National Climate Data Archive of Environment Canada whose records data back to the mid 1700's (Environment Canada, 1996); The National Meteorological Library and Archive of Great Britain, which has one of the most extensive collections in the world including meteorological data from estate logs from the 1300 and 1400's (Crewe, 1990; Barrott, 1995); and the Royal Netherlands Meteorological Institute (KNMI, 1996), among countless others.

In 1873 the first attempt to coordinate the exchange of international meteorological data was begun, with the establishment of the IMO or International Meteorological Organization. The IMO standardized the instruments, observations, observation techniques and data collected for member countries. After World War II the IMO changed its name to the WMO or World Meteorological Organization. Climate information, for WMO nations, is collected at national observation stations and sent to national data collection centers — the U.S. center is the National Climatic Data Center (or NCDC), in Asheville, North Carolina. The responsibilites of the WMO, in addition to the timely exchange of data between member nations, include the coordination of large-scale international meteorological experiments such as the World Climate Programme (WCP), Global Atmospheric Research Programme (GARP) and Global Energy and Water Cycle Experiment (GEWEX), among others. WMO data is archived in its many published reports and at the designated national data centers (Ratcliffe, 1989; WMO, 1994; WMO, 1996).

THE SURVEY

Access to historical climate data is a tricky affair of sorting through periodical publications and diary entries. It is not until the late 1870's that relatively consistent records for climate information begins to appear. And it is not until after World War II that widespread access to climate data becomes available. In the 1990's this data has become prevalent on the World Wide Web. The number of Web sites containing weather and climate information boggles the mind. It has become so voluminous that no one person can monitor what is available. In an attempt to figure out who is using what resources on the Web, who is collecting what data, and to examine the possibility of developing a resource network for information professionals, a survey was sent to libraries with large meteorological and climatological data holdings.

American Meteorological Society, Library	NOAA Miami Regional Library, Atlantic Oceanographic and Meteorological Laboratory
Atmospheric Sciences Laboratory, Library	NOAA Mountain Administrative Support Center, Information Resources Division Library
Australian Bureau of Meteorology, Library	NOAA National Hurricane Center Library/Tropical Prediction Center
Carbon Dioxide Information Analysis Center	North Carolina State University, Natural Resources Library
Dartmouth College, Kresge Physical Sciences Library	Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center
Desert Research Institute, Library	Penn State University, Earth and Mineral Sciences Library
Environment Canada, Atmospheric Environment Service, Atlantic Regional Library	Purdue University, Earth and Atmospheric Sciences Library
Environmental Protection Agency, Division of Meteorology, Information Service Center	Scripps Institution of Oceanography Library
McGill University, Hitschfeld Environmental Sciences Library	Texas Natural Resources Information System Library
National Climatic Data Center, Library	University of Miami, Rosentiel School of Marine and Atmospheric Sciences, Library
NOAA Library and Information Services Division, Library (Seattle)	USGS Water Resources Division, NY District Library

Figure 1: List of survey respondents.

Libraries were identified using several sources, including the *Directory of Special Libraries and Information Centers*; university libraries that support large meteorology programs, the attendees of the inaugural meeting of the Atmospheric Sciences

Librarians International and the institutions discussed in the article, "Atmospheric sciences information resources in the United States" (Layman, 1993). Surveys were not sent to commercial data producers, such as Accu-Weather, unless they had a sizable library that serves a research audience.

The survey, reproduced in Appendix A, is four pages long, and consists of various question types such as open-ended, check-off and tabular. It is arranged in four sections:

The first section, *Description of Collections*, inquires about the size of the collection; the date, format and geographic coverage of data holdings; and also asks about the size and type of the user population served.

The second section, entitled *Reference Resources*, asks what are the most common general reference resources, print resources, index tools and ready reference resources used by information professionals. It also compares resources used to locate historical data versus resources used to locate current data by both format and geographic area.

Collection Development, the third section, identifies by geographic region and format what data is currently being collected and who the producers of the data are. This section also asks where patrons are referred to when the surveyed institution can not provide needed data; it also inquires whether or not the institution participates in any cooperative collection development agreements and lastly discusses the ASLI organization.

The fourth and final survey section regarding *The World Wide Web* identifies useful web sites for climate data; asks how the Web has affected the ability to provide and access climate data; asks for a comparison of print to online resources, and also tries to determine what information is NOT being found on the Web.

Surveys were mailed to 102 institutions — 81 in the U.S. and 21 international. To date, 23 surveys have been received completed, and 7 surveys were undeliverable as addressed (Figure 1).

RESULTS OF THE SURVEYS

Survey response to date has been small at 24%, but those surveys returned have been very positive and informative.

Collections

Collections profiled in the survey varied greatly in both size and mission. Most of the surveys returned to date were from government agency libraries, a few academic institutions and one professional society. Data holdings ranged from under 10 volumes to over 100,000 (Figure 2). The size of user populations was also quite disparate, from under 25 to over 500. Data holdings were very sparse prior to 1800, increased moderately between 1800 and 1950, and were widespread after 1950. The most prevalent data format found in the surveyed collections was print, followed by CD-ROM, and tied for third were maps and data disks. As suspected, geographic coverage was skewed towards the country or region served by the responding institution.

Reference Resources

The ways in which the information professionals are locating climate data are as varied as their collections. When asked what reference tool they turned to first for locating climate data most started with local databases and holdings while others started by checking remote resources such as the online holdings of the National Climatic Data Center or by calling regional climate centers.

When asked how historical climate data is located, print resources were the most referred to when locating data for geographic areas other than North America, but when locating historical data for North America CD-ROM resources were the most likely starting point. For locating current climate data the use of print resources and CD-ROM resources were nearly tied for all geographic areas (Figure 3). Online resources, specifically the NCDC holdings, were also heavily referred to for locating current climate data.

A bibliography of print resources identified in the surveys is included in Appendix B. These resources fell into the categories of monographs, government publications and journals. The NOAA-produced *Climatological Data* series were the most commonly mentioned print resources. Other NOAA publications mentioned were *Storm Data*, the *Local Climate Data* series and *Monthly Climatic Data for the World*. Monographic resources included stalwarts such as the 16-volume *World Survey of Climatology* and the *Gale Weather Almanac*. Specialized and non-U.S.–specific monographs included: *Trends*, which covers global climate change data, and *Climatic Averages Australia*. Journals referred to included the *Monthly Weather Review* and the Canadian journal *Climatic Perspectives*. Scholarly journals which provide in-depth articles in the field of meteorology included: *The Quarterly Journal of the Royal Meteorological Society* and the American Meteorological Society titles *Journal of Climate* and the *Journal of The Atmospheric Sciences*.

The most popular index tool was *Meteorological and Geoastrophysical Abstracts* on CD-ROM, without a doubt the most comprehensive index for meteorologic and atmospheric sciences literature. The CD-ROM version covers the dates from 1974 to present, while print coverage is available back to 1950. Other databases consulted included: NTIS for access to technical reports, *Chemical Abstracts*, noted as especially useful for atmospheric chemistry and global change issues, *Inspec*, and regionally specific databases. The *Yahoo* Internet search engine was also mentioned as a useful index tool for locating climate data on the Web.

Favorite ready reference tools ran the gamut from the *OCLC Union Catalog* to the *Mariners Weather Log*. Most commonly mentioned were almanacs and guides such as *World Weather Records*, *Weather for U.S. Cities*, and *World Climates*. Online ready reference tools included, the NCDC's online holdings, the *USA Today* weather homepage, UnCover and the NOAA homepage. A personal favorite is the *International Station Meteorological Climate Summary* on CD-ROM. It is produced by the NCDC and provides an incredible collection of time-series data for airfield weather stations worldwide.

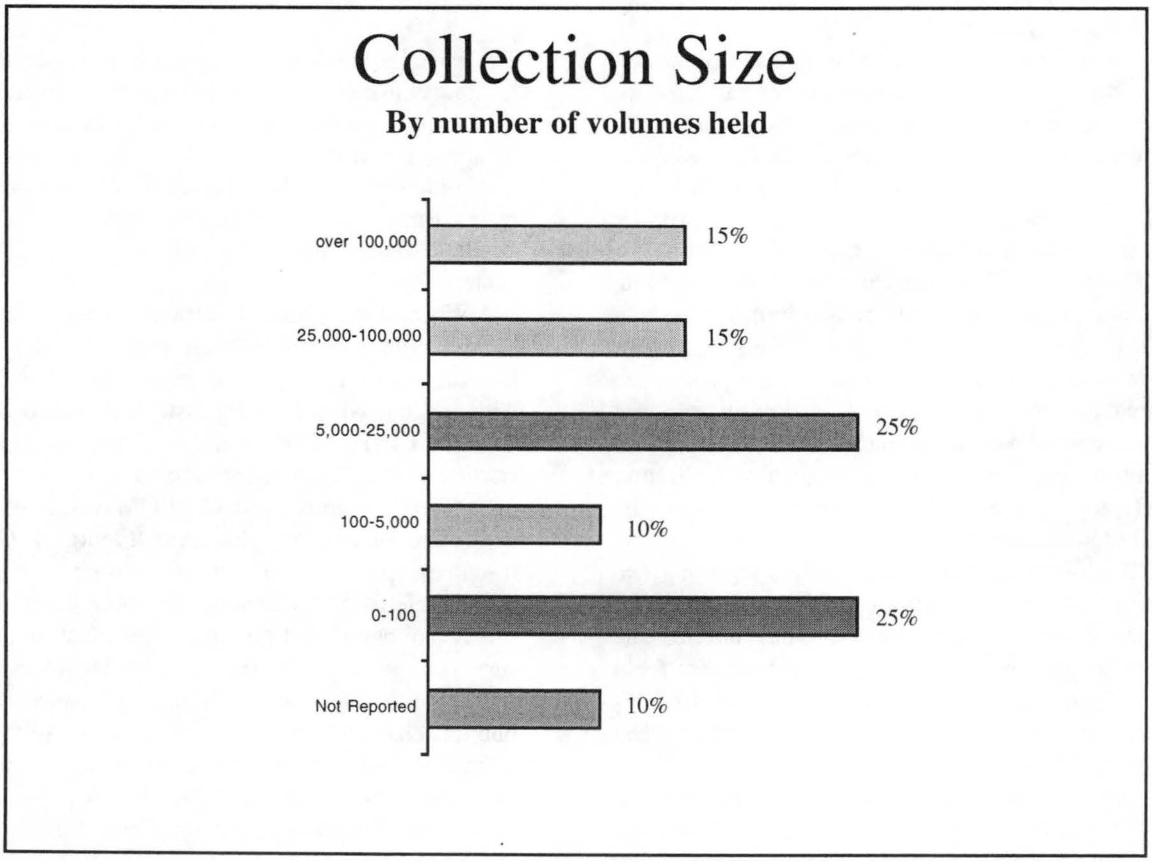

Figure 2: Size of the surveyed collections based on number of volumes held.

Collection Development

When asked about the format of data being collected there was an even split between print and CD-ROM resources. The primary producers of the data being collected are: NOAA, the NCDC, the American Meteorological Society, the National Weather Service, the Canadian Atmospheric Environment Service, the World Meteorological Organization, and other national climate institutes and observatories (Figure 4).

The most common institutions to which patrons are referred when a library is not able to supply needed data were national government agencies such as

NOAA and the NCDC. Other institutions referred to are regional climate centers and agencies such as the Western Regional Climate Center or the Queensland Department of Primary Industry; universities like the University of Nevada Reno, or the University of Texas at Austin; and international organizations like the World Meteorological Organization and UCAR, the University Corporation of Atmospheric Research. Inter-Library Loan was mentioned on several surveys, not only as a source of referral, but also as a form of "cooperative collection development."

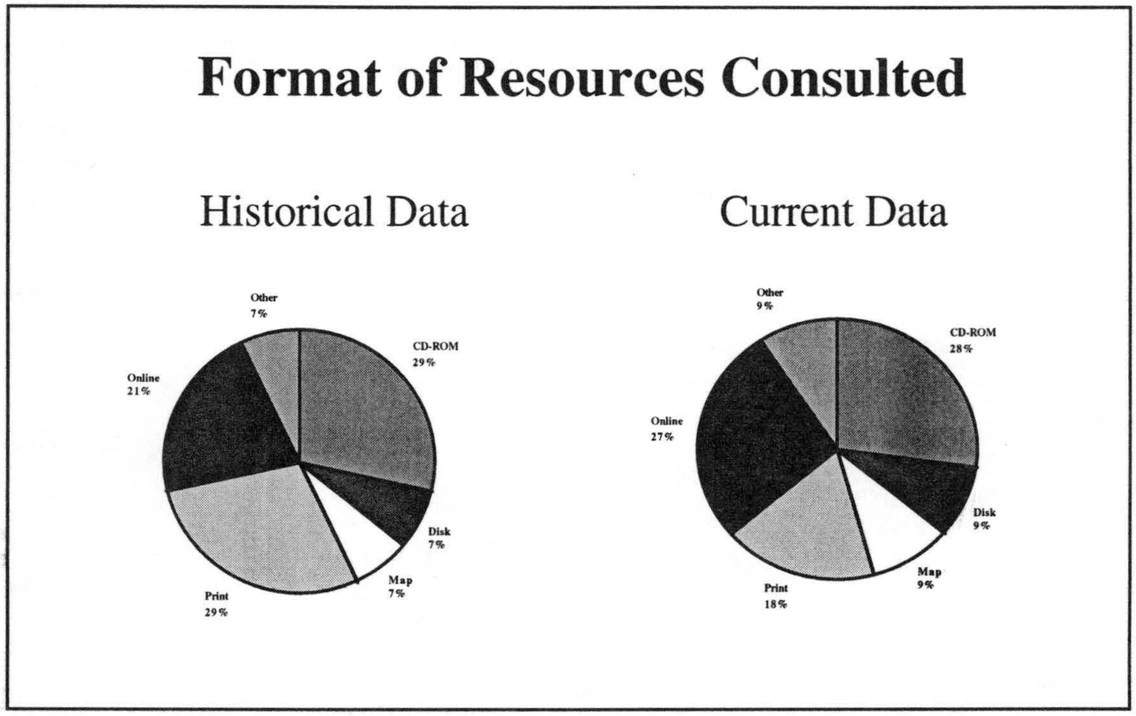

Figure 3: Comparison of the format of resources consulted when locating historical data vs. current data.

Typical cooperative collection development agreements were intra-agency agreements such as those between branches of NOAA or the EPA and university consortia like the CIC. In addition, a few collaborative projects were also mentioned, specifically the production of the *Global Historical Climatology Network* database by the Carbon Dioxide Information Analysis Center and the National Climatic Data Center.

World Wide Web

One of the most exciting results of the survey was the identification of Web resources. A listing of the online resources generated from the survey are included in Appendix B. Internet resources generally fell into four categories:

The first category is *state and regional* sites which provide regional or local data, such as the Pennsylvania State Climatologist's homepage. The second category of Web resources is *national* sites that contain data for particular countries. Most of these sites are produced by national government agencies, such as the National Climatic Data Center or the Australian Bureau of Meteorology. The *global* category covers sites with data for the entire world, such as the World Meteorological Organization homepage. And lastly, *topical* Web sites are related to specific phenomenon or applications, like El Niño or global climate change.

Interestingly, Internet search engines such as *Lycos* and *Yahoo* were also indicated as reliable in locating climate data on the Web.

Most respondents saw the Web as an opportunity to access in an economical and quick way a wide range of data sources, which had previously not been available to their institutions. Data-producing institutions indicated that the Web has "revolutionized" how they fill requests for data. Several respondents also commented that patrons were accessing data on their own and that the Web has made it easier to refer patrons directly to data. When asked about what data is NOT being found on the Web, the lack of continuous time-series data and comprehensive indexing tools were found to be the most troublesome issues.

ASLI

The Atmospheric Sciences Librarians International, or ASLI, organization has been mentioned several times throughout this paper. ASLI is an international organization that supports the exchange of information related to the atmospheric sciences. It was founded by Carol Watts from the NOAA central library and its charter meeting was held in June of 1996 at the Special Libraries Association Annual meeting. In attendance were over 15 librarians from institutions who work with meteorological and climatological data collections. There is currently an ASLI homepage and listserv supported by NOAA. Support has been pledged from the AMS and various other professional organizations. Meetings are being discussed in conjunction with AMS and SLA. A descriptive directory of members is in the works and membership is slowly growing. It is currently free and open to anyone who works with the atmospheric sciences.

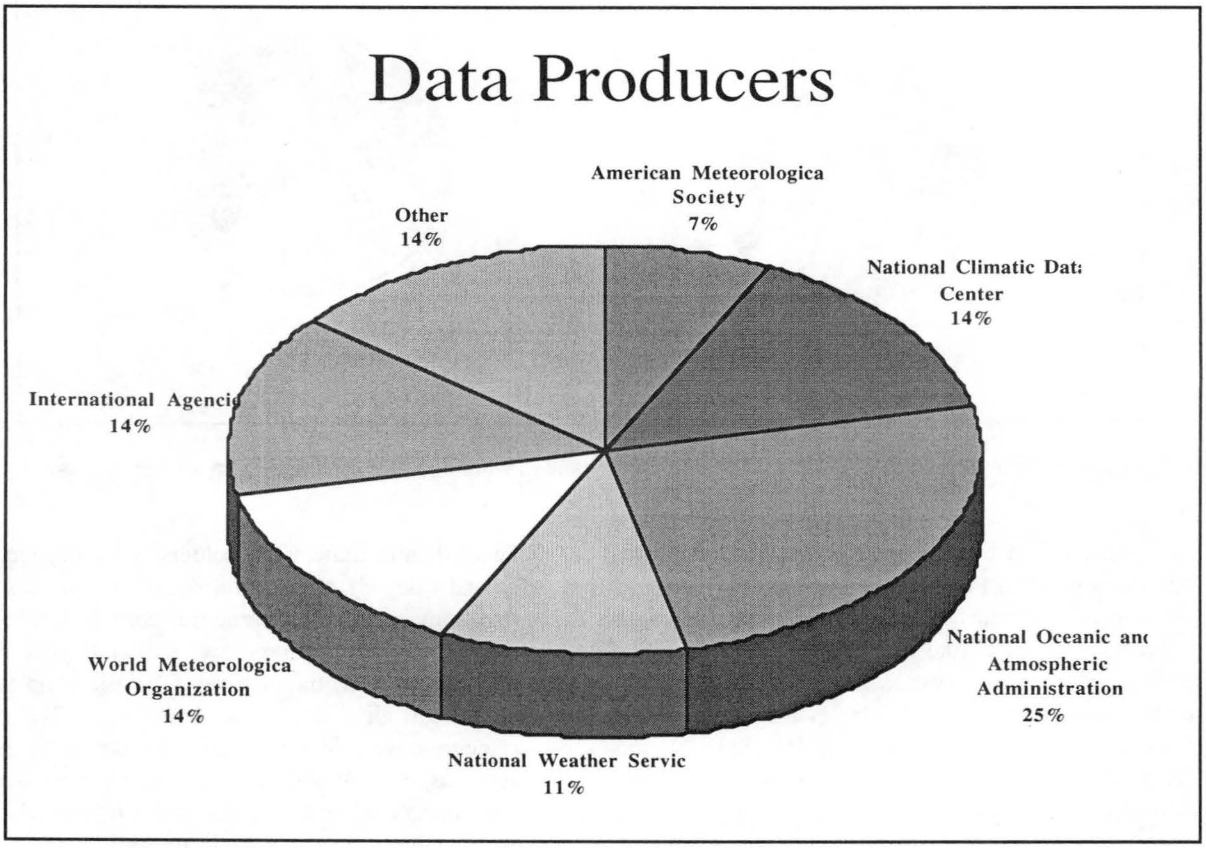

Figure 4: Producers of climatological data based on survey responses.

CONCLUSION

Although these survey results are preliminary, they have pointed out several trends in how information professionals in libraries are accessing meteorological and climatological data. There is a strong trend toward the use of digital resources; a reliance upon the government as producers of data; and a growing desire for a network of data professionals to consult regarding availability of data.

Research points to a continued growth in Internet resources. For instance, Chris Kocot at Environment Canada states that "the Canadian National Digital Climate Archive is contained in a ... database comprising 8 billion individual observations using 550 gigabytes of hard disk storage ... with about 200,000 new observations ingested into the archive on an average day" (Kocot, 1996).This trend is being witnessed throughout the world at climate data centers. This boon to climate data is proving useful, if not daunting, judging from the wide variety of sources consulted by the surveyed data professionals.

Of the surveys returned, only one mentioned relying on sources produced from non-government agencies. Climate data centers, such as the National Climatic Data Center, Australian Bureau of Meteorology, World Meteorological Organization and Environment Canada were the primary producers of data. Most of these agencies are making data available on the Web. However, in some instances, these agencies are packaging large climate data sets and selling them for exorbitant prices. Resources from vendors like Gale and EarthInfo which repackage data into more easily accessible formats are still viable for ready reference. But as more and more comprehensive online resources appear these traditional reference tools may be replaced.

Several respondents indicated that there is a need for professional contact or support in working with climate data. Perhaps the ASLI organization will provide the framework for this support. There is currently an ASLI listserv which to date has had very low to no traffic, but as awareness of the organization grows, so too may its potential activity and utility.

The survey responses have opened many paths into the world of climatic information. They have shown that as the Web and automated observation systems grow, information professionals will need to continue to evolve in their roles as navigators, explorers and mediators between patrons and the vast world of meteorological and climatological data.

REFERENCES

Baron, W.R. 1989. Retrieving American climate history: A bibliographic essay, Agricultural History v. 3 (2), p. 7-35.

Barrott, J.D. 1995. The National Meteorological Library and Archive, The Meteorological Office http://www.meto.govt.uk/sec1/sec1pg7.html (3 Oct. 1996).

Blanchard, C., prod. ed. 1985. Climates of the States Volume 2, p. 1560-1562.

Brinegar, D. n..d. National Climatic Data Center--Mission, National Climatic Data Center http://www.ncdc.noaa.gov/mission.html (3 Oct. 1996).

Bureau of Meteorology. 1996. The charter of the Bureau of Meteorology, Bureau of Meteorology, Australia http://www.bom.gov.au/inside/charter.shtml (16 Sept. 1996).

Crewe, M. 1990. The National Meteorological Library and Archives, State Librarian v. 38, p. 37-39.

Curtis, S. 1985. Reference guides for the weatherwise, Reference Services Review v. 13, p. 89-94.

Environment Canada. 1996. An historical view of the Canadian Climate Archive, Environment Canada, Climate & Water Information Branch http://www.on.doe.ca/climate/historical_view.htm (16 Sept. 1996).

Fleming, J.R. 1989. Guide to historical resources in the atmospheric sciences, NCAR Technical Note 327, 167 p.

Fusonie, A. and Hauser, W. 1989. Climate history at the National Agricultural Library, Agricultural History v. 3(2), p. 36-50.

Hagarty, J.H. 1962. Dr. James Tilton: 1745-1822, Weatherwise v. 15, p. 124-125.

Kocot, C. 1996. National Climate Data Archive, Environment Canada, Climate & Water Information Branch http://www.on.doe.ca/climate/climate_archive.htm (16 Sept. 1996).

Layman, M., and Smith, S. 1993. Atmospheric sciences information resources in the United States--and overview for librarians, Special Libraries (winter), p. 30-44.

National Weather Service. 1996. Evolution of the National Weather Service, National Weather Service http://tgsv5.nws.noaa.gov/pa/timeline.htm (3 Oct. 1996).

Ojala, M. 1995. Weather databases online, Database v. February/March, p. 72-76.

Ratcliffe, R.A. 1989. Meteorology and climatology in Wood, D., Hardy, J & Harvey, P., eds., Information Sources in the Earth Sciences, p. 420-442.

Royal Netherlands Meteorological Institute (KNMI). 1996. KNMI Library, KNMI http://www.knmi.nl/home/BIBLIOTHEEK/library .html#geschiedenis (2 Oct. 1996).

Stanfield, K. 1984. U.S Federal Depository Microfiche: The National Climatic Center Publications, Microform Review 13 (Spring), p. 110-114.

World Meteorological Organization. 1994. Keeping the planet blue: The role of the World Meteorological Organization, Information Development v. 10 (2), p. 72-78.

World Meteorological Organization. 1996. Basic facts about the World Meteorological Organization, World Meteorological Organization http://www.wmo.ch/web-en/wmofact.html (2 Oct. 1996).

APPENDIX A: THE SURVEY

Meteorological and Climatological Library Survey

Description of Collections

Your name, email/phone number & name and address of institution:

Size of meteorological/climatological collection (Indicate number of volumes & titles, include all formats):

Data holding specialties:

Area	Dates of Coverage				Format				
	prior to	1800 to	1900 to	1950 to	CD-ROM	Disk	Maps	Print	Other
Africa									
Arctic & Antarctica									
Asia									
Europe									
North America									
Oceania									
South America									

Please describe any other data holding specialties:

Audience your institution serves:

____academic researchers ____private researchers ____government researchers

____other, please describe

Size of population served:

____1-25 researchers ____25-50 researchers ____50-100 researchers

____100-250 researchers ____250-500 researchers ____ over 500 researchers

Please describe unique characteristics of your user population:

Reference Resources

When answering the next 6 questions, assume your are working with a high-level researcher who needs detailed time-series data.

What are the first general reference resources you try when locating climatological data?

When a patron needs comprehensive historical data (prior to 1950) for the following locations, what reference sources do you use?

Area	Format				
	CD-ROM	Disk	Map	Print	Other
Africa					
Arctic & Antarctica					
Asia					
Europe					
North America					
Oceania					
South America					

When a patron needs comprehensive current data (1950 to present) for the following locations, what reference sources do you use?

Area	Format				
	CD-ROM	Disk	Map	Print	Other
Africa					
Arctic & Antarctica					
Asia					
Europe					

North America					
Oceania					
South America					

What are the five most reliable Internet sites you use in doing climatological research?

What five print resources do you use the most in doing climatological research?

What index tools do you use in locating literature in the fields of climatology and meteorology?

What are your five favorite "ready reference" sources that you use for "quick" access to climatological data? (e.g. average relative humidity in Rome, Italy in March?)

If you could create the perfect meteorological and climatological reference tool what data would it provide that currently available reference tools do not?

Collection Development

What type of climatological data are you currently collecting?

Area	Format				
	CD-ROM	Disk	Map	Print	Other
Africa					
Arctic & Antarctica					
Asia					
Europe					
North America					
Oceania					
South America					

Who is the primary producer of the data you are collecting:

What other institution(s) do you refer to when your institution does not have the data your researchers need?

Do you participate in any cooperative collection agreements with other institutions? If so, please describe the type of data shared, and the access agreements.

Are you aware of the Atmospheric Sciences Librarians International (ASLI) organization? If so, when did you become a member? (If no, see the attached information, or see the ASLI webpage at http://www.noaa.gov/asli/asli.html).

The World-Wide Web

Briefly describe how the WWW has affected your ability to provide climatological data to your patrons.

How would you compare locating data on the WWW to locating data in print resources?

What kind of data are you not finding on the WWW that you would find useful in assisting your patrons?

Please share any additional comments or concerns regarding working with meteorological and climatological data.

Thank you for your participation. Please return completed surveys in the enclosed envelopes of FAX them to (814) 865-3665. I will share the results via the ASLI listserv, as well as the Geoscience Information Society 1996 Annual Proceedings.

APPENDIX B: BIBLIOGRAPHY OF SURVEY IDENTIFIED RESOURCES

Weather Sites on the WWW generated from Survey

State and Regional

Northeast Regional Climate Center: *http://met-www.cit.cornell.edu/nrcc_home.html*
Western Regional Climate Center: *http://wrcc.sage.dri.edu*
USGS Texas Weather Page: *http://txwww.cr.usgs.gov/weather*
Texas A&M Weather Pages: *http://www.met.tamu.edu*
University of Michigan Texas Weather Page: *http://cirrus.sprl.umich.edu/wxnet/states/texas.html*
NOAA Interactive Weather Net: *http://iwin.nws.noaa.gov/iwin/tx/tx.html*
University of Washington: *http://www.atmos.washington.edu/cgi-bin/data.perl*
European Centre for Medium Range Weather Forecasting: *http://www.ecmwf.int*
Penn State University Meteorology Dept.: *http://www.met.psu.edu/welcome.htm*
Pennsylvania State Climatologist: *http://www.ems.psu.edu/PA_Climatologist/PA_Climatologist.html*

National

National Oceanic and Atmospheric Administration: *http://www.noaa.gov*
National Climatic Data Center: *http://www.ncdc.noaa.gov*
National Weather Service: *http://www.nws.noaa.gov*
National Center for Atmospheric Research: *http://www.ncar.ucar.edu*
National Center for Environmental Prediction: *http://nic.fb4.noaa.gov*
Australian Bureau of Meteorology: *http://www.bom.gov.au*
Canadian, Atmospheric Environment Service: *http://www.doe.ca/weather_e.html*
Meteo France: *http://www.meteo.fr/e_index.html*
Direccion Meteorologica de Chile: *http://www.meteochile.cl/*
The Meteorological Office - UK: *http://www.meto.govt.uk/*

Global

Atmospheric Science Librarians International: *http://www.lib.noaa.gov/asli/asli.html*
Global Change Master Directory: *http://gcmd.gsfc.nasa.gov*
Lamont-Doherty Climate Group: *http://rainbow.ldeo.columbia.edu*
Meteorology FAQ: *http://www.scd.ucar.edu/dss/faq/*
NCDC Best of the Rest Weather/Climate Links: *http://www.ncdc.noaa.gov/weathers.html*
UCAR: *http://www.ucar.edu*
Unidata: *http://www.unidata.ucar.edu*
Weather Info Superhighway: *http://thunder.met.fsu.edu/nws/public_html/wxhwy.html*
The Weather Processor: *http://wxp.atms.purdue.edu/*
World Meteorological Organization: *http://www.wmo.ch*
World Data Center System: *http://www.ngdc.noaa.gov/wdc/wdcmain.html*
Yahoo: *http://www.yahoo.com*
Lycos: *http://www.lycos.com*

Topical:

Global Change Research Progamme: *http://www.usgcrp.gov*
El Nino (NOAA): *http://www.pmel.noaa.gov/toga-tao/el-nino/home.html*
Purdue Hurricane and Tropical Data: *http://wxp.atms.purdue.edu/hurricane.html*
Carbon Dioxide Information Analysis Center: *http://cdiac.esd.ornl.gov*
Interactive Marine Observations: *http://www.met.fsu.edu/~nws/buoy/*
American Meteorological Society: *http://www.ametsoc.org/AMS*
Oceanographic & Earth Science Data Services Directory: *http://scilib.ucsd.edu/sio/dataserv/#TABLE*
Tropical Prediction Center: *http://www.nhc.noaa.gov/*

Selected Weather Reference Sources generated from Survey

Monographs

World Survey of Climatology. H.E. Landsberg, editor in chief. NY: Elsevier. 16 Volumes. 1-3 General Climatology, 4 Free Atmosphere; 5. Northern & Western Europe; 6. Central and Southern Europe; 7. Soviet Union; 8. Northern & Eastern Asia; 9. Southern & Western Asia; 10. Africa; 11. North America; 12. Central & South America; 13. Australia & New Zealand; 14. Polar Regions; 15. Oceans; 16. Future Climates of the World.
USA Today Weather Almanac. NY: Vintage Books.
Weather Almanac. Detroit, MI: Gale Research Company. Various Editions.
Climatic Atlas of North and Central America. World Meteorological Organization. 1979.
World Weather Records. Smithsonian Institution. 1921-present.
Trends. Carbon Dioxide Information Analysis Center. Oak Ridge, TN: Oak Ridge National Laboratory. Annual.
Climatic Average, Australia. Bureau of Meteorology. Various Editions.
Climates of the States. Detroit, MI: Gale Research Company. Various Editions.
World Climates. W. Rudloff. Stuttgart: Wissenhchaftliche Rundschau. 1981.
World Weather Guide. E.A. Pearce & C.G. Smith. London: Hutchison. 1993.
Weather of US Cities. Detroit, MI: Gale Research. Various Editions.
World Climatic Data. F.L. Wernstedt. Lemont, PA: World Climatic Press. 1972.
Selective Guide to Climatic Data Sources. W.L. Hatch. NOAA. Various Editions.
Smithsonian Meteorological Tables. Smithsonian Institution. Various Editions.
World Weather Records. Smithsonian Institution. (Decennial)
Tables of Temperature, Relative Humidity, Precipitation and Sunshine for the World. London, Meteorological Office. Various Editions.

Government Publications

Climatography for the US (Series) Decennial Census of the US weather (1931-1983)
Climatological Data (state). Monthly & annual summaries for all 50 states. Asheville, NC: National Climatic Data Center
Storm Data. Asheville, NC: National Climatic Data Center.
Monthly Climatic Data for the World. Asheville, NC: National Climatic Data Center & World Meteorological Organization.
Local Climate Data. Asheville, NC: National Climatic Data Center.

Journals

Monthly Weather Review. US Army Signal Service (1872-1974), American Meteorological Society (1974-present)
Climatic Perspectives. Canadian Meteorological Centre. Continued by *Canadian Climate Summary*, (1996)
Ozone Data for the World. Canadian Meteorological Services & World Meteorological Organization. (1960-)
Quarterly Journal of the Royal Meteorological Society. London, Royal Meteorological Society. (1871-)
Journal of Climate. American Meteorological Society (1988-) (Formerly *Journal of Climate and Applied Meteorology* and *Journal of Applied Meteorology*)
Journal of Atmospheric Sciences. American Meteorological Society (1944-)

Indexes

Meteorological and Geoastrophysical Abstracts American Meteorological Society (Print 1950-, CD 1974-)
Geobase. Elseveir/Geo Abstracts (Print 1966-, CD 1980-)
Inspec. UMI. (CD 1989-)
Chemical Abstracts. American Chemical Society (Print 1903-)
National Technical Information Service.
OCLC National Union Catalog
Web Locators: Lycos, Yahoo, etc.

CD-ROMs

World WeatherDisc. Seattle, WA: WeatherDisc Assoc. Various Editions. (2 CD's).
International Station Meteorological Climate Summary. Asheville, NC: National Climatic Data Center. 1995. (1 CD).
EarthInfo: USGS Daily Values-Streamflow. Annual. (4 regional CD's)
EarthInfo: NCDC Summary of the Day. Annual. (4 regional CD's)

For Information on Atmospheric Science Librarians International, contact:

ASLI
NOAA Central Library
1315 East-West Highway, SSMC3, 2nd Fl, E/OC4
Silver Spring, MD 20910
Fax: 301/713-4598, Phone: 301/713-2600
Email: asli-request@www.lib.noaa.gov
URL: http://www.lib.noaa.gov/asli/asli.html

THE NEW USGS GEOLOGIC NAMES COMMITTEE: LOOKING TOWARD THE FUTURE

Charles D. Blome

U.S. Geological Survey
MS 913, Box 25046,
Federal Center
Denver, CO 80225

Bruce R. Wardlaw

U.S. Geological Survey
MS 926A, 12201 Sunrise Valley Drive
National Center
Reston, VA 20192

Abstract — The Geologic Names Committee (GNC, also referred to as the Committee on Geologic Names), established in 1899, has undergone a number of changes since its inception. In the late 1800s, the committee's task was to evaluate geologic formation (and higher unit) names to determine whether they complied with rules and nomenclature adopted for Survey publications.

In 1961, three regional review-staff offices, called Geologic Names Units (GNU's), were established; they operated until the Survey's Reduction In Force and reorganization on October 15, 1995. In this reorganization, the Survey's former branches became a series of formal teams, one being the National Cooperative Geologic Mapping (NCGM) Team.

In late 1995, the Geologic Division's Chief Paleontologist became chairperson of the Survey's new GNC. Each region (Reston, Denver, and Menlo Park) now has a Geologic Names Subcommittee (GNS) composed of a chairperson selected from the NCGM Team and a member from each of the other teams. The chairperson of each regional GNS and the Chief Paleontologist form the national GNC which provides advice on broad nomenclature issues and serves as a mediator between the regional GNS and author when necessary. The responsibilities of each GNS are to review the geologic nomenclature of all manuscripts for Survey publication; review of non-Survey publications are the responsibility of the author.

Anyone can access the USGS's stratigraphic nomenclature by using the USGS Digital Data Series Compact Disk DDS-6 (Release 3, 1996) which contains the stratigraphic nomenclature databases GNULEX and GEONAMES, or by accessing the internet using the address: 'http://ncgmp.usgs.gov' and selecting 'Lexicon of Geologic Names'. Both databases are being revamped into a single dataset that can be searched by stratigraphic unit name, as well as by age, area, author, and other keywords. This new system will be easier to update and will incorporate for the first time the entire USGS geologic names reference files.

A 1996 SURVEY OF GEOSCIENCE INFORMATION RESOURCES IN SOUTHERN AFRICA: BOTSWANA, ZAMBIA, AND ZIMBABWE

Dena Fracolli Hanson

3732 Lenox Drive
Fort Worth, Texas 76107-1712

Abstract — A year-long stay in Southern Africa provided the opportunity to visit geoscience libraries in Botswana, Zambia, and Zimbabwe. Observations show that, as a result of economic and bureaucratic factors in these Southern African countries, the universities and geological surveys have difficulty accessing current geoscience information. Expense and lack of necessary infrastructure preclude access to online databases and commercial document delivery services, and funds for interlibrary loan are scarce. GeoRef on CD-ROM is available only at the Botswana Geological Survey and at the University of Zimbabwe Department of Geology. Only the University of Botswana still subscribes to the printed Bibliography and Index of Geology. Organizations are generally unable to afford current journal subscriptions, new books, and reports. None of the geological surveys in these three countries has access to electronic mail, and access to the Internet via basic tools like telnet and ftp, let alone web browsers, is provided only at the University of Zambia.

Improvements to Southern African geoscience information are being made possible by a variety of aid projects targeted both at providing access to international literature, and at disseminating the Southern African geoscience literature. However, in these three countries, where the mineral industry contributes a high proportion of the revenue, the present status of access to current geoscience information still is disproportionately poor. A coordinated program, involving African geologists as well as the information community, to donate and ship requested journal issues and publications from the west would be a valuable contribution, as would an opportunity to demonstrate marketing and service aspects of western librarianship to librarians from developing countries.

INTRODUCTION

A year-long stay in Southern Africa from mid-1995 to mid-1996, accompanying my geologist husband on his sabbatical, provided the opportunity to visit government and academic geoscience libraries in Botswana, Zambia, and Zimbabwe, and to discuss the status of geoscience information access with government and academic geologists, students, and librarians. This paper contains my observations on the state of geoscience information in this range of developing Southern African countries. A description of each country and its current economic situation will set the stage for a characterization of each of the geoscience libraries that I visited in these three countries, a review of the aid projects that I observed in place, and finally, suggestions for valuable contributions yet to be made.

COUNTRY BACKGROUND

These three Southern African countries illustrate a range of economic status and development; Botswana is by far the richest of the three, and Zambia the poorest. They are similar in that each has only one main university campus, and each depends heavily on mineral resources for its foreign exchange income — that income which allows the purchase of goods and services from outside the country.

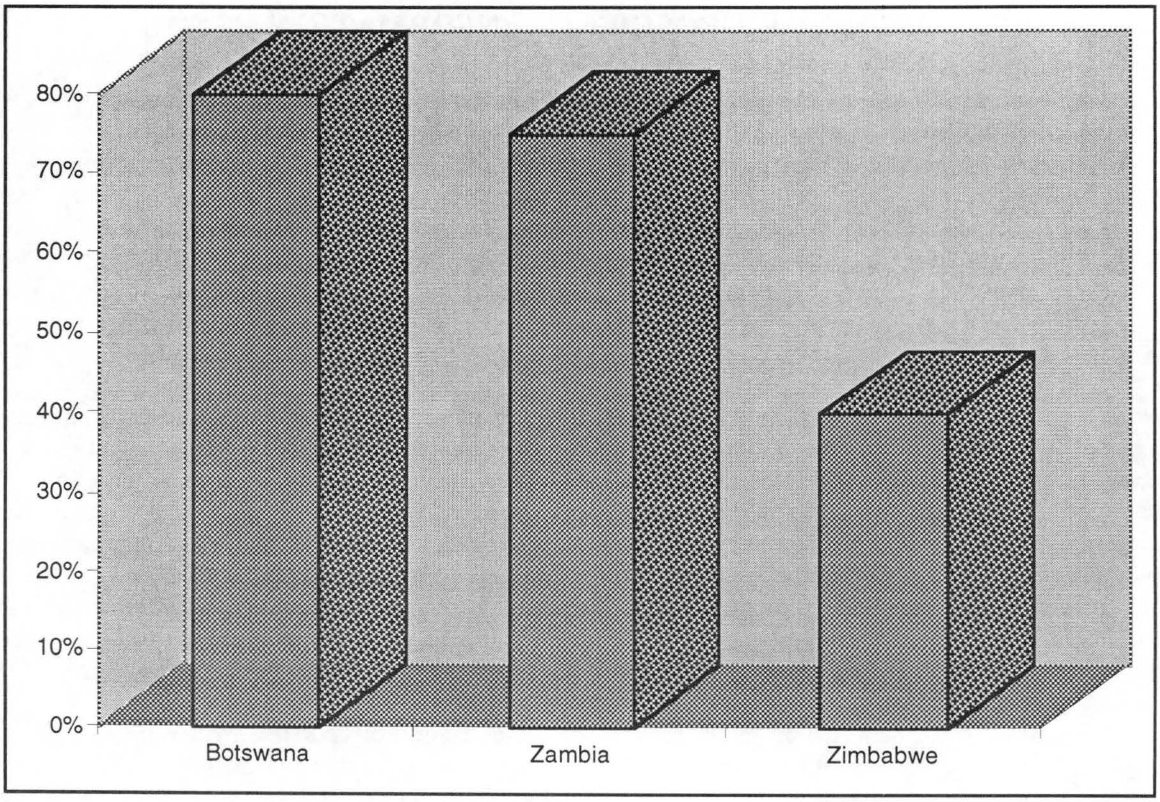

Figure 1: Minerals industry contributions to foreign exchange earnings (Central Intelligence Agency, 1995a,d; Antonides, 1996; Antonides and Mobbs, 1996; Blenkinsop, 1996).

Botswana

Botswana (formerly the British protectorate of Bechuanaland) achieved independence in 1966 and is now governed as a parliamentary republic. English is the official language, though most residents speak Setswana. Most of Botswana is sparsely populated wilderness. With a population of about 1,392,414 (Central Intelligence Agency, 1995a), Botswana lies just above central South Africa and covers 600,372 square kilometers, about the same size as Texas. It is primarily subtropical desert (Kalahari Desert) and savanna (U.S. Department of State, 1993). The economy has historically been based on cattle raising and crops, but the growing mining industry contributes about 44% of the gross domestic product, and about 80% or more of the foreign exchange earnings (Central Intelligence Agency, 1995a; Antonides and Mobbs, 1996). Diamonds are by far the most important mineral resource (comprising about 77% of foreign exchange earnings alone), but nickel, copper, cobalt, coal, and soda ash are also profitable, and petroleum exploration is in progress (personal communication, Dr. Roger Key, 1996; U.S. Department of State, 1993; Antonides & Mobbs, 1996).

Zimbabwe

Zimbabwe, formerly Southern Rhodesia, was a British colony until 1965, when Ian Smith took over the presidency and made a unilateral declaration of independence (UDI). After years of civil war, the Republic of Zimbabwe gained independence in 1980 and is governed as a parliamentary democracy. Zimbabwe covers 390,310 square kilometers, slightly larger than Montana, and has a population of about 11,139,900 (Central Intelligence Agency, 1995d; Crowther and others, 1995). There are three official languages: English, Shona (spoken by about 70 percent of the population), and Ndebele (spoken by about 15 percent of those in the southwest) (McCrea and Pinchuck, 1993).

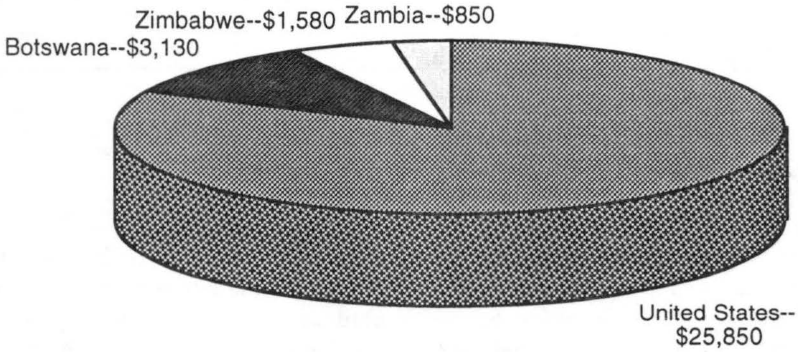

Figure 2. National Product Per Capita, in U.S. Dollars

The Great Dyke, which runs through the center of the country, is host to one of the world's largest platinum and chrome deposits. Minerals and metals account for about 40% to 45% of the foreign exchange earnings (Central Intelligence Agency, 1995d; Blenkinsop, 1996). More than 400 mines produce more than 50 mineral commodities, including gold, nickel, copper, chromite, granite, platinum, diamonds, limestone, phosphate, and coal (Mobbs, 1996).

Zambia

The Republic of Zambia, formerly known as Northern Rhodesia while under British control, obtained independence in 1964. English is the official language, but there are more than 70 local languages and dialects (Crowther and others, 1995). Zambia, with a population of about 9.5 million (Central Intelligence Agency, 1995c), covers 752,614 square kilometers (slightly larger than Texas) (U.S. Department of State, 1992; Crowther and others, 1995), and is primarily plateau and savanna. The minerals industry contributes about 90% of Zambia's foreign exchange earnings (Antonides, 1996). The economy depends heavily on the copper industry, which alone contributes about 75% of the foreign exchange earnings; cobalt, gold, emeralds, zinc, nickel, and lead are also mined (Central Intelligence Agency, 1995c; Antonides, 1996).

Economic Status

The economic status of these three Southern Africa countries is best illustrated by the figures included here.

Figure 1 demonstrates the importance of the minerals industry to each country. As mentioned above, between 40% and 80% of the entire foreign exchange earnings for each country results from the minerals industry.

Figure 2 compares the national product per capita for each of these three countries with that of the United States. There is quite a large discrepancy; however, local currency goes much further in purchasing basic necessities within each country than when it is used to purchase items from outside.

Table 1 helps to explain the purchasing power of local currencies in these developing countries. In order to make the concept relevant to our everyday lives, I have used a bottle of beer as an example. The table shows the typical cost of a

	1 bottle of beer in local currency	Expense in U.S. $	% of a bottle this would purchase in the U.S.
Zambia	700 kwacha	$0.55	.1375
Zimbabwe	7.50 zim dollars	$0.75	.1875
Botswana	4.00 pula	$1.43	.3575
United States	4.00 U.S. dollars	$4.00	1

Table 1: Purchasing power of local currency.

bottle of beer (local currency) purchased in a nice hotel in the capital city of each country. Also shown is the same amount of money converted into U.S. dollars. Note that this amount of currency will only purchase from a tenth to a third of a bottle of beer in a similar setting here in the U.S. Translate this into library purchases: journals and monographs that are expensive for us to purchase are proportionally more expensive in these countries. Here is another way to look at it: $Z400 will send a child to school for a year in the capital city of Harare, Zimbabwe; exchanged into U.S. dollars, this amount will purchase a one-year subscription to a $40 journal, not including overseas postage.

THE LIBRARIES

There are two main geoscience library collections in each country: one on the university campus and one at the national geological survey. Zimbabwe and Zambia each have a reading room in the university geology department, and Zimbabwe has another large collection at the Institute for Mining Research on the university campus. Expense, lack of necessary infrastructure, and the absence of full Internet service preclude access to online databases and commercial document delivery services. The following anecdote illustrates how the infrastructure in these countries makes it difficult to support electronic communication and information access. In Zimbabwe it can take more than six months to have a telephone installed. A doctor living across the street from us needed a phone so that he could be reached when he was on call at the hospital; his professional status earned him expedited service. After six months of visits to the telephone company, and after obtaining special forms, stamps, and professional membership verifications, he was allowed to deposit Z$2000 for the service, though no telephone had yet been installed. It may also be helpful to understand a bit about how the bureaucracy works in these countries: until very recently, photographing public buildings has been considered a breach of security in these countries, and even in 1996 I had to ask special permission to photograph the library buildings outside and inside. At the University of Zimbabwe I visited staff at the reference desk and the public service office, the Head Librarian, and the Director for Communications in a separate building across campus (a matter of about three hours), before being granted permission to photograph the collection and the buildings. At the University of Zambia I was denied permission to photograph anything, and photographs were later provided to me by my husband's colleague in the geology department.

Botswana

The University of Botswana is in the capital city of Gaborone, Botswana. According to the library's brochure, the three-story University Library contains about 200,000 volumes, and subscribes to 1,475 journal titles and 24 CD-ROM databases — but not GeoRef. There are about six ranges of geoscience monographs, which include the Botswana Geological Survey reports, all arranged by Dewey Decimal Classification. A strong collection of current journal issues is on display shelves (e.g., *Remote Sensing of the Environment*, *CIM Bulletin*, *Mining Journal and Mining Magazine*, *Economic Geology*, *Earth and Planetary Science Letters*, *Journal of Structural Geology*, all of the *JGR* titles, *Journal of African Earth Sciences*, *Journal of Geology*, *Geological Magazine*, *Precambrian Research*, and *Mining Magazine*). The University of Botswana has the only library in these three countries currently subscribing to the printed *Bibliography and Index of Geology*, and it also subscribes to *Geologie Africaine/Bibliography* *of African Geology*. There is a solid collection of bound journals extending at least back to the 1970s and early 1980s, and often earlier. The library recently installed an online public access catalog, which I personally found awkward to use as an infrequent patron. Staff are currently engaged in retrospective entry, and are preparing for automated circulation. Anyone can enter the library and use the collection, but only University staff and students have borrowing privileges. There is no security system in place, but security officers examine your bags as you exit. The subject access in the physical card catalog is quite different from that in the United States: one looks up the class number and finds a list of topics by class number, not a list of actual titles available for each topic.

The Geological Survey of Botswana is located in Lobatse, Botswana, a smaller town about 70 kilometers south of Gaborone. The library mainly serves the Survey employees, but there is a good relationship with the University, and the collection is open to on-site use by the community at large. Clement Siyumbwa, Technical Records Officer, has charge of the library in addition to his other responsibilities (e.g., editing the Survey's annual report, and overseeing the entry of the field geologists' notebooks into Lotus 123 for indexing and archiving). In June, 1996, the current issue journal display shelves contained late 1995 to early 1996 issues of *Water Resources Research*, *Mining Magazine*, *Journal of African Earth Sciences*, *Ore Geology Reviews*, *Geological Magazine*, *GSA Bulletin* (sample issues), *Applied Geochemistry*, *Journal of Petrology*, *AAPG Bulletin*, *Oklahoma Geology Notes*, *Hydrology*, *EOS*, and *Hydrogeology Journal*. There is also a subscription to the printed *Geologie Africaine/ Bibliography of African Geology*. The Survey is planning a new information center, but for now the collection is housed in several separate rooms. The four ranges of monographs, another 20 ranges of exchange publications, the new journals issues, and about eight ranges of recent journals and directories are housed with the service desk and card catalog in the main library space. Older journal issues (all unbound) are housed in a locked room reached by an outdoor corridor, where issues are kept in boxes, or in stacks on the floor. A wonderful collection of company and private reports is housed in yet another room, with the most recent (still confidential) reports in storage upstairs. These reports, generated by exploration and mining companies as a part of their agreement with the Botswana government, contain a wealth of information about the country's geology and mineral resources. They are carefully arranged on shelves by company and report number, and are being indexed in an online database using the UNESCO software ISIS. The monograph collection, a lower priority, will be entered into a database at a later date. There is no security system.

Zimbabwe

The University of Zimbabwe is located in the capital city of Harare. The University Library, a six-story building, includes a collection of geoscience monographs and bound journal titles of great breadth and depth, all arranged by Library of Congress Classification. Unfortunately, funds have decreased in the last decade, and now funding for document delivery, books, subscriptions and other publications is scarce to nonexistent. Most of the journal titles run only through the late 1980s, and in 1995 and 1996 there were no paid subscriptions in the library. Interlibrary loan funding appeared to be exhausted before March, with four to five months left in the budget year. Library staff are planning for an online catalog, but the physical card catalog is still the only access point. Again, subject access is different from that in the United States; one looks up a topic, and finds a list of class numbers for that topic — not a list of individual monograph titles. There is no automated circulation system, but there is a security system in place.

The Zimbabwe Geological Survey Library is housed in the Survey's adobe-like buildings in downtown Harare. The library is open to the public, but the collection does not circulate except to Survey staff; photocopies are available for Z$0.50 a page. The library participates in gift and exchange programs and does interlibrary loans. There are over 2,900 confidential reports, indexed by area, district, mine name, and other access points,which are open only to the mine owners and those with letters of permission. Exclusive Prospecting Order (EPO) reports, compiled annually by exploration companies, contain a wealth of geological and mineral information as well as three to ten maps each; these are usually confidential for up to two years, and some may never be open to the public. There is a solid collection of Survey publications, exchange publications, and theses on Zimbabwe geology, and a good collection of older bound journals through the 1980s. There are a dwindling number of current journal subscriptions (only about nine or ten titles), including *Geologie Africaine/African Geology Bibliography*, *South African Journal of Geology*, *Mining Magazine*, *Mining Journal*, and the IMM *Transactions* and *Abstracts*; there is no printed *Bibliography & Index of*

Geology. Titles like *Earth and Planetary Science Letters* and *Economic Geology* stop in the late 1980s. By May, 1996, most subscriptions had lapsed, but we were told they were in the process of being renewed. There is no security system; there are plans for an online catalog using the ISIS software.

The Institute of Mining Research (IMR) Library on the University of Zimbabwe campus houses a collection focused on the mining and mineral processing industry. Affiliated with the University Library, the IMR Library also has no funds for current subscriptions or interlibrary loans, but librarian Pam Barry works with industry, faculty, and others to find donations and outside funding. The IMR recently provided funds for a large book order and some badly needed shelving. The collection includes monographs (arranged by Library of Congress Classification), theses, reprints (with an extensive index), and over 115 serial titles, including government reports and journals. The collection is searchable in the IMR library as an online database using the ISIS software, and a copy of the database can also be searched in the University of Zimbabwe Geology Department.

The University of Zimbabwe Geology Department has a library of theses, monographs, reprints, and some journals. Although there are few current subscriptions (*Canadian Geosciences*, *Geologie Africaine/Bibliography of African Geology*, and the *South African Journal of Geology*), the library contains a lot of valuable information. Journals are organized alphabetically by title, and books are arranged by topic using a modified Dewey Decimal classification. Items circulate to staff and students on the honor system. The department also maintains a well-indexed collection of maps and aerial photos.

Zambia

The multi-storied University of Zambia Library, located in the capital city of Lusaka, was opened in 1969. There is a security system and a newly installed UNIX-based online catalog, and there will soon be an automated circulation system as well. Monographs and serials are organized by Library of Congress Classification. The collection contains about seven ranges of geoscience monographs, but this includes a large number of multiple copies; purchase of new books stopped about 10 to 12 years ago. There is an extensive collection of bound journals, but most titles run only through the mid-1980s; *Geotimes* ends in 1993, *Episodes* in 1991, and *Economic Geology* in 1990. The *Journal of South African Geology* is donated by the Geoscience Council of South Africa. There are no funds for current subscriptions, and the new issue shelves for most disciplines, including geology and other sciences, are glaringly empty.

The Geology Department in the University of Zambia School of Mines has a reading room containing some journals (no current subscriptions), the senior students' independent mapping project reports (a valuable resource), and some reports from other countries. Most of the collection has been donated. The conference room contains runs of older bound journals such as *Mining Magazine*, *Nature*, *Science*, *Metals Progress*, *E&MJ*, and the U.S. Bureau of Mines Minerals Yearbooks.

The Geological Survey of Zambia Library, also in Lusaka, has no funds for new purchases. Most journals run only through the mid-1970s, and the current issue journal shelves display a few issues dating from the late 1980s. There are no funds for subscriptions or new books; anything new is the result of exchange or donation. There is an extensive collection of exchange materials (the USGS publications are well-ordered and accessible); however, the library really cannot even participate in exchange programs anymore because for the past 12 years there have been no funds to publish survey reports and therefore no publications to offer for exchange. The survey halls are empty and dingy; there are no funds for field work, and most of the geologists have gone on extended leaves of absence to work for mining and exploration companies.

CD-ROM Resources

CD-ROM resources are the medium of choice for electronic information in this part of Southern Africa. Even so, there is no access to GeoRef on CD-ROM at the University of Zambia, University of Botswana, the Geological Survey of Zambia, and the Geological Survey of Zimbabwe. The Botswana Geological Survey began subscribing to GeoRef on CD-ROM in June 1995, but few of the staff use this resource. The GeoRef disks are kept in a drawer in the Technical Records office (down an outside corridor from the library), and the Technical Records Officer will search the database for anyone who asks; one geologist (on contract from the British Geological Survey) periodically searched the GeoRef disks himself. There is no Windows operating system, and no jukebox or tower, so it is necessary to use one disk at a time. The University of Zimbabwe Geology Department began a subscription to GeoRef on CD-ROM in July 1996, thanks to Dutch support for the MS program in exploration geology. In addition, Pam Barry in the Institute for Mining Research Library had ordered the

IMMAGE CD-ROM database produced by the Institution of Mining and Metallurgy, and was anxiously awaiting its arrival.

Photocopy Services

Photocopying can be difficult to accomplish in most libraries in these countries. Rarely is one allowed to do one's own photocopying, so making a copy often involves waiting in a long queue or leaving materials to be copied and returning at a later time. The University of Botswana was the only library providing copy-card photocopier access for self-copying. The University of Zambia had a drastic shortage of paper for photocopying; it helped to bring your own.

Electronic Mail and the Internet

During our visit in 1995 and 1996, Zambia was the only Southern African country other than South Africa to have its own Internet node. Internet services like telnet and ftp (let alone web browsers) were not provided by government or academic institutions. When I sent an electronic mail message to the American Geological Institute (AGI) asking about prices and ordering information for the new GeoRef Thesaurus, the response was a referral to the AGI Web page, which didn't do me any good at all.

Botswana expected to have its own Internet node very shortly, and Zimbabwe was exploring options with help from the minerals industry. Meanwhile, Botswana and Zimbabwe libraries and geology departments purchase electronic mail service from a South African university, making long-distance phone calls to reach the node and transfer messages back and forth. University of Botswana faculty were provided this electronic mail service free, but most had to walk across campus to the computer center and use one of the 12 networked computers shared among the faculty. The University of Zimbabwe Geology Department has its own networked computer lab (funded by Dutch aid for its MS program), but a fee for the electronic mail service was charged back to each individual according to message size (both sent and received). We once shut down the entire University of Zimbabwe electronic mail system when a colleague from San Diego tried to send us a binary-data file. The Zimbabwe IMR has also purchased electronic mail access, though librarian Pam Barry had not yet made use of this communication tool. None of the three Geological Surveys had access to Internet electronic mail at the time of my visit.

The University of Zambia Library and Geology Department both have access to electronic mail, and soon after our return to the United States, our colleague in the Geology Department was "surfing the Internet" and gaining access to services like UNCOVER tables of contents.

AID PROJECTS FOR SOUTHERN AFRICAN GEOSCIENCE INFORMATION

During my visits to libraries and geological surveys I was told about several aid projects that were currently enhancing geoscience information access in Botswana, Zimbabwe, and Zambia. The French-coordinated PANGIS program (Pan African Network for a Geological Information System) provides training, hardware, and UNESCO ISIS software (see Appendix I) to each of 28 participating countries, for use in compiling national bibliographies of their own geological and mining information. PANGIS also supports sharing of this information between countries. Botswana, Zimbabwe, and Zambia all participate, and the PANGIS SADC-MCU (Southern African Developing Countries Mining Sector Coordinating Unit) is located in Lusaka, Zambia. These are retrospective databases, and in Zimbabwe I was told they expect a printed product to be available in 1997. The PANGIS database, though a likely bibliographic resource, is not used as such in any of the countries as far as I could tell, especially compared to the usage of such bibliographies in a typical American geoscience library. This may partly be because of the perceived awkwardness of the ISIS software. At the Zimbabwe Geological Survey, Librarian Sheila Nyamfukudza let me play with the database a bit, but we were unable to retrieve any references on the topic of our research, the Zambezi belt — a major Proterozoic orogenic belt in the northern part of the country, and the subject of many publications. At the Botswana Geological Survey, the Technical Records officer will run a search on PANGIS for staff when asked, but this doesn't seem to happen very often; the computer with PANGIS is, like GeoRef, in the Technical Records office down the hall from the library itself. At the Zambian Geological Survey, PANGIS is not associated with the library at all. It is managed by Mr. Michelo, Technical Records Officer, who is not connected with the library.

In Zambia, European Community funds are just now supporting the printing of Geological Survey research and mapping that has accumulated for about 12 years during which there were no funds for printing. At the time of my visit, the printing projects were out for bid; publications were expected be printed and ready for sale during the coming year.

In Zimbabwe, Dutch aid for the MS program at the University of Zimbabwe Geology Department includes funds for a networked computer lab for electronic mail access, computer drafting, and use of other geoscience software packages. It has also purchased several much needed journal titles, and in June 1996, purchased a subscription to GeoRef on CD-ROM.

Pam Barry, Librarian at the Institute of Mining Research (IMR) on the University of Zimbabwe campus, has persuaded mining companies like Anglo American to contribute funds for computer hardware and the IMMAGE CD-ROM database from the Institution of Mining and Metallurgy. In addition, departing faculty leave large donations of journals and books.

At the Geological Survey Department in Zimbabwe, Dr. Andre Vallieres is Project Director for the Canadian International Development Geoscientific Data Management Project (CIDA project no. 766/18022). This project provides sophisticated software and hardware for the compiling and marketing of a Zimbabwean geoscience database. In an effort to help local mineral exploration and encourage foreign mining investment, the project will make geoscience information on Zimbabwe more accessible. The database will contain the text of the Ministry of Mines & Minerals Act, Zimbabwe Geological Survey reports (including the valuable Exclusive Prospecting Order publications), maps and mine plans, IMR reports, theses, Gold Fields company reports, annual reports of other companies, the Zimbabwe Chamber of Mines Journal, geophysics data, and other geoscience information. The collection is to include 125 color maps, 10,000 documents, 18,000 black-and-white maps, and 16,000 technical mine reports by Zimbabwe Geological Survey geologists. Documents are to be updated, scanned, and indexed. The maps and graphics will be vectorized, allowing for editing, and coordinated with a precise locating of each mining property by multiple GPS readings. The database will be Dbase-compatible, will include a thesaurus, and will be searchable via a variety of text fields, as well as via the geographic information systems interface ArcView. Both print and CD-ROM products will be made available for purchase, as well as for viewing at the Survey and at all regional Ministry of Mines offices. Nearly half of the colored maps are out-of-print Geological Survey maps, which will now be available again. The project provides for training of Zimbabwe staff to input data and maintain the database. Software and hardware maintenance contracts are provided for three years (through 1997). The entire system is to be well documented so that Zimbabwe can maintain and operate the project once the Canadians are gone. It is hoped that this information will be used to expand the minerals industry of Zimbabwe, and if things proceed well, Canada may expand this project into other Southern African countries.

CONCERNS

These are all positive efforts being made to improve access to geoscience information in these Southern African countries, but there are concerns to address as well. The degree to which the PANGIS databases are used as a reference tool depends upon how comfortable people are using the ISIS software. A geophysicist in Zimbabwe says it is quite incompatible with other bibliographic management software, and the Zambia Geological Survey Technical Records Officer finds it quite awkward and time-consuming to use. In Zambia, just when it appeared that Zambian Geological Survey research would once again be disseminated, the Minister priced new geologic maps extremely high in order to recover the total cost of their production — field work and equipment included. At the time of our visit, the Zambian Geological Society had petitioned for lower prices, so that individuals and small exploration and mining companies could afford to purchase the publications. At the University of Zimbabwe, a hiring freeze meant that there were barely enough Geology Department faculty to teach required undergraduate courses, let alone those supporting the MS program, and a continuation of this situation could jeopardize future Dutch funding. Even the CIDA project faces a number of challenges at the Geological Survey in Zimbabwe. There are concerns about copyright, future updates and maintenance for hardware and software, and the difficulty of retaining the well-trained staff. Although the products of the database are to be affordable for small companies, the concept is to plough the revenue from the project back into the care and continued feeding of the database and its products. Although in May, 1996, Dr. Vallieres said the Ministry of Finance gave tentative approval to do so, there is a chance that product revenue may not be allowed to come back to the Ministry of Mines; it may go instead into general government funds. This would likely put an end to the continuation of the project.

Finally, most of the aid projects are not addressing the plight of the shrinking geoscience library collections in these countries.

CONCLUSIONS

Things change very quickly these days, and journals are an important way to keep up with new developments. Journals, more than monographs, probably measure the ability of a collection to support the geoscience teaching, research, and industry efforts of a country. Botswana is in the best situation with respect to journal titles; there are many current geoscience titles in the University Library, and the Geological Survey also continues current subscriptions to some geoscience and mining titles. The Zimbabwe Geological Survey receives about nine or ten current titles. In contrast, the current issue journal display shelves at the Zambian Geological Survey, the University of Zimbabwe, and the University of Zambia show a different situation — they are completely empty. The Zambian Geological Survey has had no current subscriptions for almost 12 years, and very little comes in on exchange. At the universities in Zambia and Zimbabwe, those institutions responsible for training future geologists and mining engineers, the situation is getting worse. The University of Zimbabwe did not renew its 1995 subscriptions, and still hadn't renewed for 1996 when we left in August. The University of Zambia hasn't had money for subscriptions for many years.

In summary, although in the past these geoscience collections were quite good, expense and lack of necessary infrastructure preclude access to current journal subscriptions, online databases, and commercial document delivery services. Funds for interlibrary loan are scarce. Internet access is not yet a reasonable alternative in most cases. In these three developing countries, where the mineral industry contributes a high proportion of the revenue, the present status of access to current geoscience information still is disproportionately poor. A coordinated program, involving African geologists as well as the information community, to donate and ship requested journal issues and publications from the west would be a valuable contribution, as would a first-hand opportunity to demonstrate concepts of marketing library services and other aspects of western librarianship to librarians from developing countries. To this end, I have put the Geoscience Information Society International Issues Committee in touch with librarians and geologists in each country to facilitate the donation of needed journal issues. The Committee is also examining ways to bring librarians from developing countries to our western libraries to learn first-hand what services we offer and how we market them to the communities we serve.

ACKNOWLEDGEMENTS

I am grateful to Dr. Andre Vallieres for contributing his time and personal materials to explain the Canadian International Development Geoscientific Data Management Project (CIDA project no. 766/18022). Mrs. Pam Barry, Librarian for the Institute for Mining Research, was a tremendous resource, providing insights and information as well as inspiration. Keith Fisk of the Zimbabwe Geological Survey, Professor Tom Blenkinsop of the University of Zimbabwe Geology Department, Dr. Benjamin Mapani of the University of Zambia Geology Department, and Dr. Roger Key of the Botswana Geological Survey, all contributed valuable insights and information for this paper. In addition, Dr. Benjamin Mapani provided slides of the University of Zambia Library for presentation at the 1996 GIS annual meeting. And I am indebted to members of the staff of each of the libraries that I visited (see Appendix II) for their willingness to talk about their collections and for allowing me to roam the stacks and card catalogs and to even take photographs.

REFERENCES

Antonides, Lloyd E., 1996, The mineral industry of Zambia, in U.S. Bureau of Mines Minerals Yearbook 1994, v. III, International Review, p. 949 - 955.

Antonides, Lloyd E., and Mobbs, Philip M., 1996, The mineral industry of Botswana in U.S. Bureau of Mines Minerals Yearbook 1994, v. III, International Review, p. 113 - 115.

Blenkinsop, TG, 1996, UZ's geology department under-funded, Zimbabwe Chamber of Mines Journal, May, p. 37, 39-40.

Central Intelligence Agency, 1995a, Botswana [CD-ROM]. Available: National Trade Databank — The Export Connection (R); Program: World Factbook; Title: Botswana (Item ID CI WOFACT 033).

Central Intelligence Agency, 1995b, United States [CD-ROM]. Available: National Trade Databank — The Export Connection (R); Program: World Factbook; Title: United States (Item ID CI WOFACT 249).

Central Intelligence Agency, 1995c, Zambia [CD-ROM]. Available: National Trade Databank — The Export Connection (R); Program: World Fact-book; Title: Zambia (Item ID CI WOFACT 264).

Central Intelligence Agency, 1995d, Zimbabwe [CD-ROM]. Available: National Trade Databank — The Export Connection (R); Program: World Factbook; Title: Zimbabwe (Item ID CI WOFACT 265).

Crowther, Geoff, and others, 1995, Africa on a shoestring, 7th ed.: Victoria, Australia : Lonely Planet Publications, 1100 p.

McCrea, Barbara, and Pinchuck, Tony, 1993, Zimbabwe and Botswana, the rough guide, 2nd ed.: London, England: Rough Guide Ltd, 423 p.

Mobbs, Philip M., 1996, The mineral industry of Zimbabwe, in U.S. Bureau of Mines Minerals Yearbook 1994, v. III, International Review, p. 959 - 963.

United States. Department of State. Bureau of Public Affairs. Office of Public Communication, February 1993, Background Notes: Botswana, 4 p.

United States. Department of State. Bureau of Public Affairs. Office of Public Communication, September 1992, Background Notes: Zambia, 6 p.

APPENDIX I. ISIS SOFTWARE

The CDS/ISIS (Computerized Documentation System/Integrated Set of Information Systems) software is a menu-driven information storage and retrieval system designed and developed by UNESCO to manage textual information. The software is available at no cost to developing countries. Field lengths are variable, and fields can be defined as required or optional, can be repeatable, and can have subfields. Messages and menus have multilingual options. Indexing protocols and access points, data-entry worksheets, and display formats all must be defined. The software is inexpensive and powerful, but based on comments from Zimbabwe geologists and students, a Canadian geophysicist, and a Zambian Technical Records Manager, and on the way I saw it employed at several of the surveys, as well as my own experience in searching and retrieving information, users and staff often find it awkward, cumbersome, and frustrating. My sense is that it is rarely used to its fullest capacity. Pam Barry at Zimbabwe's Institute for Mining Research Library appears to have done the best job of exploiting the good features of this software, designing databases containing not only the IMR library's collection, but also bibliographies of theses and articles on Zimbabwe geology and mineral resources.

APPENDIX II. GEOSCIENCE INFORMATION CONTACTS

Mr. Clement Siyumbwa, Technical Records Officer
Botswana Geological Survey
Private Bag 14
Lobatse, Botswana
267-330-327
Fax 267-332-013

Mr. Eddie Lumande
Science Librarian
University of Botswana
Private Bag 0022
University of Botswana
Gaborone, Botswana
lumandee@noka.ub.bw

Ms. Pam Barry
Librarian
Institute of Mining Research
University of Zimbabwe
P.O. Box MP167
Mount Pleasant, Harare
Zimbabwe
pbarry@imr.uz.zw

Ms. Judith Mavodza
Periodicals Librarian
Main Library
University of Zimbabwe
P.O. Box MP167
Mount Pleasant, Harare
Zimbabwe
jma@uzlib.uz.zw

Ms. Elizabeth Mature
Science Faculty
Main Library
University of Zimbabwe
P.O. Box MP167
Mount Pleasant, Harare
Zimbabwe
emature@uzlib.uz.zw

Ms. Shailett N. Nyamfukdza, Librarian
and Mr. Fundayi Andikutse, Assistant Librarian
Library
Geological Survey Department
Ministry of Mines
P.O. Box CY 210
Causeway, Harare
Zimbabwe
263-4-726342
Fax 263-4-739601

Mr. Jameson C. Michelo
Technical Records Officer
Geological Survey Department
P.O. Box 50135
Lusaka, Zambia
260-1-251655
Fax: 260-1-252973

Dr. Benjamin Mapani
Department of Geology
School of Mines
University of Zambia
Lusaka, Zambia
bmapani @mines.unza.zm

Ms. Ann Hamusunse
Periodicals Librarian
University of Zambia
Lusaka, Zambia

THE IMPACT OF THE INTERNET ON THE PUBLIC SECTOR: PROVIDING NATURAL RESOURCE INFORMATION AND TECHNOLOGY TO KANSAS

Timothy R. Carr
Dana Adkins-Heljeson
Rex C. Buchanan
Janice Sorensen
Thomas D. Mettille

Kansas Geological Survey
University of Kansas
Lawrence, Kansas 66047-3726

Abstract — The Kansas Geological Survey uses the Internet as an important communication channel. The Internet provides rapid, cost-effective access to natural resource data, informational sources, publications, and technology. Usage of the Survey's web server has grown dramatically. Today, the Survey is weaving the Internet into all of its ongoing and future research and public service operations.

Technology and information transfer processes are moving away from individual consultations, paper publications, and dusty files, and toward high-speed large-volume conduits for digital data and technology that better fit the wide audience of academic organizations, private and public sector entities, and individual citizens. The Internet provides flexible just-in-time accessibility to fundamental geologic and geographic data, to data compilations, and to the latest research and technical studies. Products are available on-line as they are completed, at a fraction of the time and cost of paper publication. Publications with relational links and search engines allow users to modify the scale and focus to their particular requirements, and permit access to data in a compatible format for validation and risk analysis. The Survey is designing research and technical products that go beyond traditional publications and take advantage of the Internet capabilities (examples include the Digital Petroleum Atlas and the Kansas GIS Core Database).

The Survey's virtual resource center provides a flexible and efficient method to disseminate data and technology, and provide geologic research to a geographically dispersed population. The Internet better enables the Survey's information and research results to serve as the framework upon which individual and public policy decisions are built.

INTRODUCTION

The traditional role of scientific and technical publications is to formalize and record scientific and technical results in time, and to transfer technology to potential users (Kerkoff, 1994). Over the past century and possibly even in the previous decade, the paper report, journal, monograph or book was the fastest and most efficient method to disseminate, validate, and archive research and technical results. Today, traditional channels of scientific and technical communication are being challenged by the sheer volume of publication, the increased unit costs, the relatively decreased resources of academic and industrial library systems, and the rapidity of technical change (Okerson, 1992). In addition, the growth of networks, storage servers, printers, and software that make up the Internet is rapidly changing the world from one in which research organizations, publishers, and libraries control the printing, distribution, and archiving to a world in which organizations and individuals can rapidly and cheaply "publish," provide access and modify scientific results on-line (Taubes, 1996). These changes offer significant challenges and opportunities to the various participants and traditions of scientific and technical publication (Denning and Rous, 1995).

Another drawback of traditional published scientific and technical results is the limitation of paper (cost and space) causing incomplete documentation of the research process. As a result, it is often difficult to replicate or modify traditional paper-published research (Claerbout, 1994). The purpose of reproducing research is to transfer research products to the

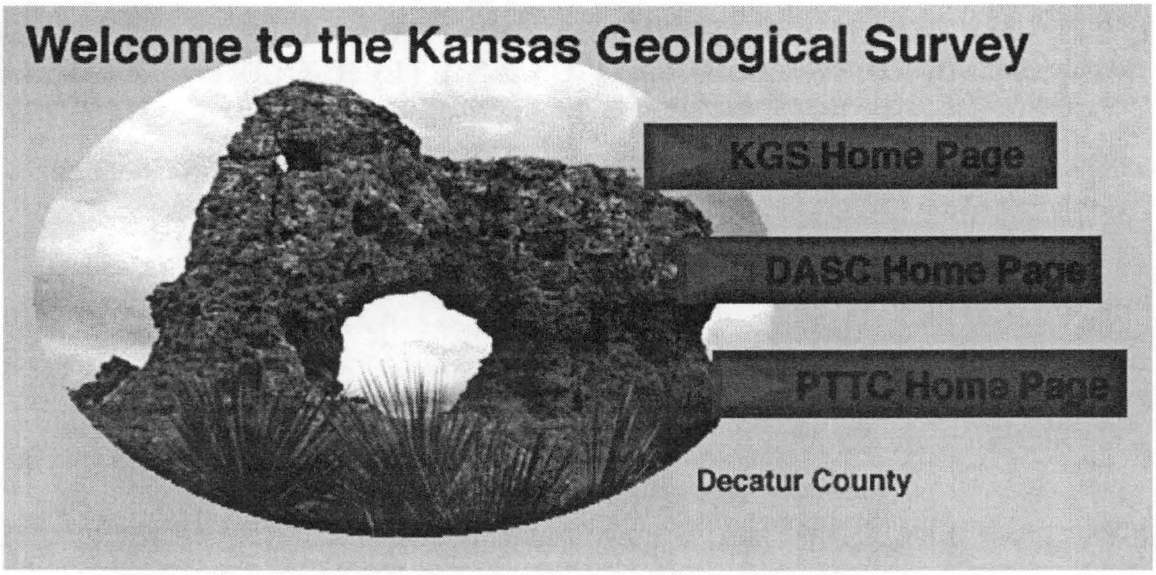

Figure 1. Kansas Geological Survey Homepage provides access to the different areas of the survey (http://www.kgs.ukans.edu). A different Kansas image is displayed each time the user accesses the homepage. Clicking on the image provides a background explanation of the scene.

user, to validate research results, and to facilitate extending the research to better fit user needs. Reproduction of research is a fundamental problem in technology transfer in the earth sciences. This problem has been attributed to loss of steps along the research pathway (Claerbout, 1994). Lack of access to theory, methods, data, or results may form a missing step in the earth sciences. For example, it was common practice to publish measured sections, well logs, and analyses that formed the basis of county geologic studies or maps. With increased publication costs these data are at best archived. The result is an original work that is difficult to replicate, validate, or modify to new needs or opportunities. The resource investment required to reproduce published research may take many months and forms a barrier to technology transfer of fundamental, regional or site specific earth science research. This barrier is a significant impediment to merging results from disparate scientific fields into research solutions for societal and industrial problems and for providing timely scientific information for policy decisions. The shortening life cycles of technology and the increased needs for cross-disciplinary research require a change in the unit of research from the published paper to an easily adapted technologic solution.

The Kansas Geological Survey views electronic publication as an important communication channel that can help better meet its mission of providing the earth science community and the interested public rapid, cost-effective access to natural resource data, information sources, publications, and technology. The Kansas Geological Survey is providing a variety of on-line electronic products and publications and has ongoing experiments with different methods of on-line publication. Efforts are underway in the areas of data archiving and access, access to information resources, education and public outreach, map generation, and formal research publication.

KANSAS GEOLOGICAL SURVEY ON-LINE

The Kansas Geological Survey (KGS) world-wide-web site initiated on-line service on 1 January 1995 (Figure 1; http://www.kgs.ukans.edu). The Survey site has grown to a distributed system of five independent servers with many thousands of web pages and numerous databases. The distributed nature of the site is dictated by the Survey's multiple areas of interest (e.g., hydrology, petroleum, and surface mapping) and diverse clients (e.g., interested citizens, industry, agriculture, research organizations, and governmental units). In the second year of operation, usage of the KGS web site continues to grow at over 250% per year and has reached over 20,000 access "hits" per week (Figure 2). In measuring access hits on the KGS site, all access to images is removed. This eliminates the multiple counting of access hits that result from multiple figures (buttons, bars, arrows, etc.) on a single web page. In addition, all

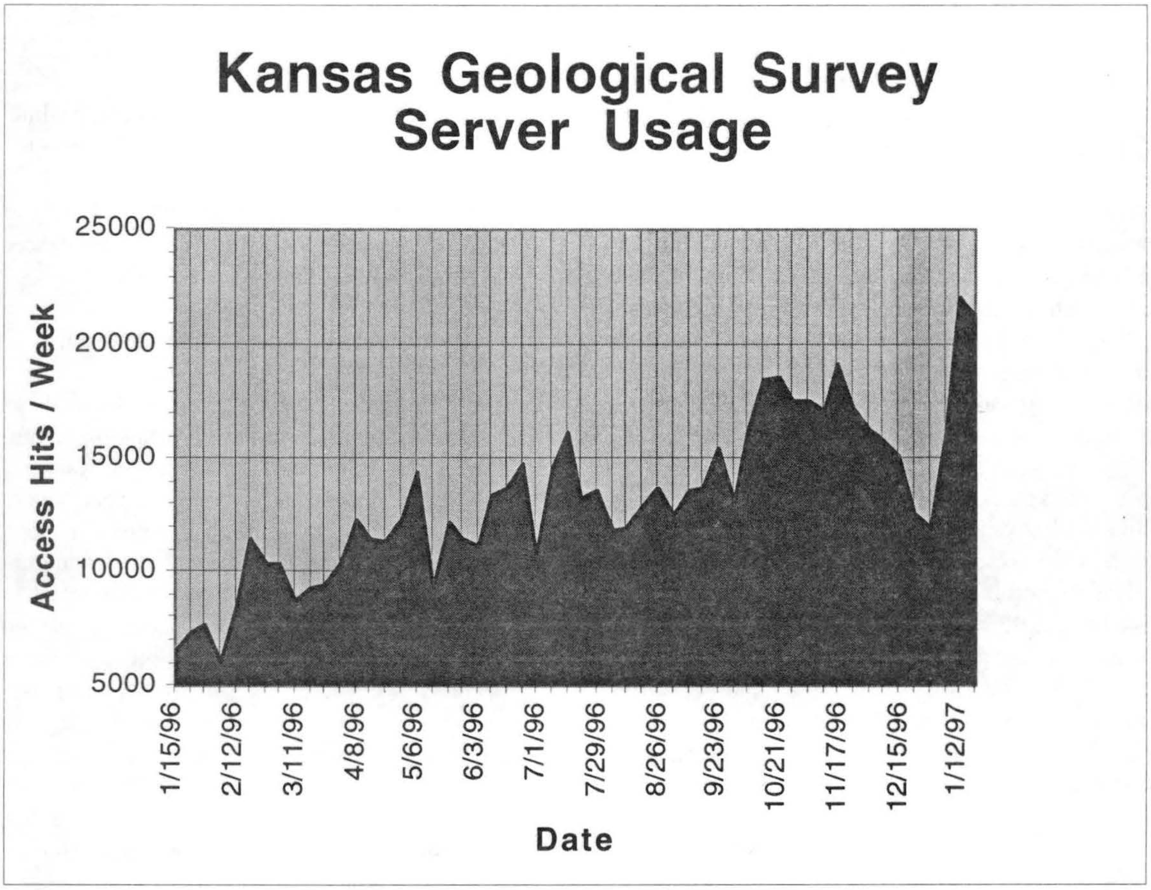

Figure 2. Usage during 1996, measured in access hits per week for the servers that comprise the Kansas Geological Survey web site (http://crude2.kgs.ukans.edu/usage/past_stats.html *and* http://gisdasc.kgs.ukans.edu/usage/index.html).

access from the Kansas Geological Survey subdomain (kgs.ukans.edu) is removed. This measurement protocol produces a consistent and conservative measure of external usage. Current usage statistics are collected daily and weekly and are available on the Kansas Geological Survey web site (http://www.kgs.ukans.edu/usage/past_stats.html).

The Kansas Geological Survey provides an increasing variety of on-line electronic products and publications. The KGS web site covers areas of data archiving and access, access to information resources, education and public outreach, published maps, and formal research publication.

Data Access and Archival Material

Electronic technologies can be applied to problems of assembling and ordering the primary information itself. In the earth sciences we can improve the quality and accessibility to what in the world of print might be called "non-traditional" research products. These include such items as digital geographic and geologic components of maps and other unpublished archival material. The basic digital map data that forms the foundation of geologic research products (e.g., political boundaries and digital elevation models) is provided through the Kansas Data Access and Support Center (DASC; http://gisdasc.kgs.ukans.edu/dasc.html). The state-funded DASC unit provides on-line access to digital geographic data to state agencies and other users. DASC is an on-line source of computer-retrievable mapping data, including data about aquifers, digital elevation models, the environment, geology, hydrology, geographic names, global positioning systems, land cover, rural water districts, legislative districts, soil surveys, utilities, watershed districts, and other information.

The KGS web site provides access to natural resource data using a number of interactive maps and search panels. As an example, annual and cumulative oil and gas production data from any of the more than 6,000 fields in Kansas can be accessed through a series of interactive maps and input panels that search the production database (http://www.kgs.ukans.edu/PRS/petroIndex.html). The interactive maps provide intuitive front-ends while the input panels permit focused searches using various combinations of parameters (e.g. discovery date, cumulative production, and geographic location). Similar input panels and interactive maps can be used to search databases of plugged wells (http://www.kgs.ukans.edu/DPA/Forms/location.html), library of core samples (http://www.kgs.ukans.edu/PRS/Cores/index.html), and digital well information (e.g., electric logs, production data and scout ticket information at http://www.kgs.ukans.edu/DPA/Forms/TW-R.html). Similar on-line database access is being developed for Kansas water resource data (http://www.kgs.ukans.edu/Hydro/hydroIndex.html).

User control of search and retrieval improves efficiency of data retrieval over the original published paper compilation. In addition, electronic access and publication decreases the effort and cost of associated with providing public access to current natural resource data.

Access to Information Resources

On-line versions of printed products can significantly improve access to information compilations. An example is on-line access to updated versions of the published *Bibliography of Kansas Geology* (Sorensen and others, 1989; Sorensen, 1994). To date, nearly 14,000 references from all areas of the geological sciences are included in the bibliographic data files, and updates to the files are incorporated quarterly. Included in the database are references on areal geology, petroleum, water, paleontology, mineral resources, geochemistry, soil science, and environmental geology. In addition to references appearing in published sources, the titles of many unpublished manuscripts, such as open-file reports, theses, and dissertations, are included. The on-line version of the *Bibliography of Kansas Geology* (http://www.kgs.ukans.edu/General/Bibliography/bibstart.html) is updated quarterly and incorporates specific field and complex Boolean searches (e.g., author, county, subject).

Other examples of on-line information compilations include: the *Catalog of Publications* (http://www.kgs.ukans.edu/Datasale/catalog/catalog Start.html); inventory of digital geologic maps of Kansas (http://www.kgs.ukans.edu/General/Geology/index.html); the rules and regulations covering petroleum operations; and listings of active Kansas oil and gas operators (http://www.kgs.ukans.edu/KCC/index.html).

As with on-line access to raw data, on-line search and retrieval improves the user's access to informational resources such as bibliographies. In addition electronic publication significantly reduces the effort and cost associated with providing public access and updating these resources.

Education and Public Outreach

The Kansas Geological Survey works to disseminate research results and other information about earth-science and environmental issues in Kansas. In the past decade, increasing priority has been given to the communication of research results, in appropriate forms, to a variety of audiences. An example of this new emphasis in improved public outreach, *Public Information Circulars* cover a variety of topics of current interest. The public information circulars are intended to reach and appeal to practitioners, policy makers and the interested public that may be interested in the results of research but do not have the time or background to understand the specialized language of the particular earth science subdiscipline. Formatted hypertext and graphics that closely replicate traditional paper publications are used to provide on line access to the public information circulars (http://www.kgs.ukans.edu/Publications/pubIndex.html).

A number of interactive publications, such as the *Physiographic Map of Kansas* and the KanView Project are designed specifically for electronic dissemination. These electronic publications differ from the more traditional published products (digital or paper) by providing dynamic educational links to investigate the state's geology, geography, and people (http://www.kgs.ukans.edu/General/educatIndex.html). The interactive physiographic map of Kansas provides discussions of physiography and displays typical landscapes that characterize the selected region by clicking on that region (Figure 3, http://www.kgs.ukans.edu/Physio/physio.html). The KanView page is a broader attempt to provide on-line access to maps and information that helps visualize Kansas' people, culture, and environment (http://gisdasc.kgs.ukans.edu/kanview/kanview.html). KanView provides map views that are clickable, so users can drill down in to the map to gather more detailed information. Simply click on a theme and region of Kansas that interest you and begin exploring.

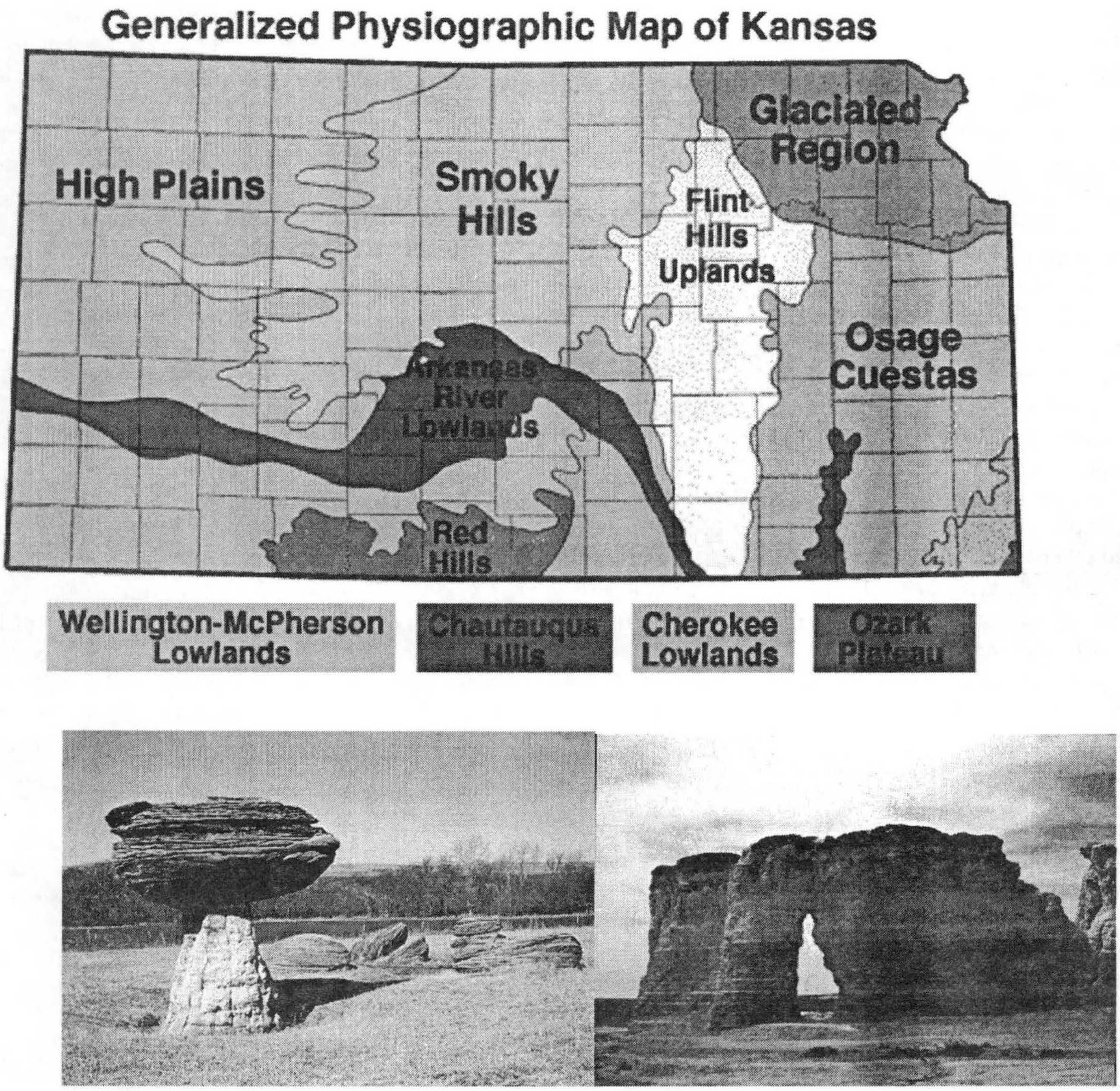

Figure 3. Clicking on a region of the interactive Physiographic Map of Kansas provides a discussion of the selected region and displays typical landscapes (http://www.kgs.ukans.edu/Physio/physio.html).

Research and Technical Publication

Electronic publication of research results provides flexible just-in-time accessibility to the latest research and technical studies. Research and technical products are available on-line as they are completed, at a fraction of the time and cost of paper publication. Dynamic publications with relational links and search engines allow users to modify the scale and focus to their particular requirements, and permit access to data in a compatible format for research validation and risk analysis. The Kansas Geological Survey is working on a number of experiments in electronic scientific publication. Examples of on-line publication of research and technical products include the *Bulletin of Current Research*, geologic and other maps, open-file reports, and non-traditional research products such as the *Digital Petroleum Atlas*.

The *KGS Bulletin Current Research in Earth Sciences* has changed to an electronic, on-line format (http://www.kgs.ukans.edu/Current/index.html). The *Current Research Bulletin* focuses on the mid-continent and Kansas geoscience. Articles in the new on-line version undergo complete peer review, revision, acceptance, and editing, as with any formal publication. However, the unit of publication is a single article as opposed to a bound collection in a journal (Förster and Merriam, 1997, was the first article of *Current Research Bulletin* published in the electronic on-line format; http://www.kgs.ukans.edu/Current/Forster/forster1.html). A number of prospective authors have expressed concerns about the permanence of electronic publication, the impact on tenure and review, and the widespread dissemination of results. The answers to these concerns remain to be completely addressed in the world of electronic scientific publication.

The KGS has long been among the leaders in developing computerized techniques for producing maps and in the actual production of computer-generated maps for research and for sale. As an experiment, selected surface geologic maps and other earth science maps that were generated with digital data and published as paper copies are now archived and are accessible in electronic form at a fraction of the cost. These include maps of Kansas oil and gas fields (http://www.kgs.ukans.edu/PRS/petroMaps/mapsAvail.html) and county surface geology maps (http://www.kgs.ukans.edu/General/Geology/index.html). In addition to improving distribution, making these electronic maps available electronically provides a product that can be loaded by the user into mapping or drawing software and modified to fit specific needs.

Selected *Kansas Geological Survey Open-File Reports* are available on-line (http://www.kgs.ukans.edu/PRS/Info/webPubs.html). The open-file report has no formal circulation beyond the KGS, but may contain useful data and ideas. The difficulty of being aware of the existence of potentially relevant open-file material and retrieving traditional paper open-file reports can be a barrier that severely limits their application in ongoing research. On-line publication of open-file reports provides widespread access within and beyond the KGS. In addition color figures, data and intermediate products (e.g., computer code) that would be expensive or less efficient to print can be included.

The *Digital Petroleum Atlas* (http://www.kgs.ukans.edu/DPA/dpaHome.html) attempts to radically change traditional approaches to generating and disseminating petroleum field, play, and basin studies as a published atlas. The *Digital Petroleum Atlas* (DPA) is an on-line product designed to be dynamic, evolving with new structure, research results, and data. Through complete and flexible user access to technology, interpretative products, and the underlying geologic and petroleum data, the DPA alters the relationship between interpretative result and data, between technology generation and application. Active links, graphical user interfaces, and search mechanisms of the DPA provide a dynamic product with which the reader can interact. The DPA also contains forms of publication that can only be displayed in an electronic environment. These include hypertext search and manipulation functions to customize maps and charts, and access to animated products (e.g., exploration histories through time).

Electronic research and technical products have an advantage over print: they are far easier to transmit for purposes of resource sharing. Electronic products can be easily modified and created on demand to fit user needs. On-line publication removes the limitations and costs of print on paper, and provides a research product that is dynamic, mutable, and interactive.

SUMMARY

The heart of science is the efficient exchange of ideas and the formal dialogue between producers and consumers of a research. For over half a millennium this dialogue has been mediated by the printed page. The advent of electronic publication can improve this dialogue and improve the efficiency of research and transfer of scientific results. The opportunities of on-line publication may be considerably more far-reaching, affecting every aspect of our research institutions and the communications on which they thrive.

The earth sciences are not immune from these pressures and the role of the traditional publication as the primary means of communication is rapidly changing (Carr and others, in press). Electronic publications and network technology are radically altering the relationship between interpretative result and the underlying data. Research institutions such as the Kansas Geological Survey can concentrate on assuring broad access to research and data with questions of the physical location of the primary research materials and final research products becoming secondary. Electronic publication can improve the quality and accessibility to what might be called "non-traditional" research products, everything from digital geographic information, to individual geochemical analyses, to images of thin sections, to unpublished archival material. Electronic publication provides dynamic forms of communication, that can only be displayed in an electronic environment. Forms of communication that use "hypertext" and relational database functions provide text and graphics with which the reader can interact. Electronic publication permits reproducibility of the research and continued manipulation and enhancement of the research product to better address transfer of scientific results in a form usable to society or as unforeseen applications of technology.

The Kansas Geological Survey believes the Internet is an important communication channel for transferring technology and natural resource information. Through the Internet the KGS is working to provide a variety of on-line electronic products and publications and has ongoing experiments with different methods of on-line publication. The KGS web site can be reached at http://kgs.ukans.edu.

ACKNOWLEDGEMENTS

We are grateful to the State of Kansas and the University of Kansas for support of our efforts at the Kansas Geological Survey and the Kansas Data Access and Support Center. We acknowledge the financial support for this work from the US Department of Energy (Cooperative Agreement DE-FG22-95BC14817).

REFERENCES

Carr, Timothy R., Rex C. Buchanan, Dana Adkins-Heljeson, Thomas D. Mettille, and Janice Sorensen, in press, The Future of Scientific Communication in the Earth Sciences: The Impact of the Internet: Computers and Geosciences, June 1997 issue, Available: http://www.kgs.ukans.edu/PRS/publication/OFR96_37/abstract.html.

Claerbout, Jon, 1994, Seventeen years of super computing and other problems in seismology, text of talk at National Research Council meeting on High Performance Computing in Seismology, 2 October Available: http://sepwww.stanford.edu/sep/jon/ nrc.html.

Denning, Peter J. and Bernard Rous, 1995, The ACM electronic publishing plan: ACM, Inc. Available: http://www.acm.org/pubs/epub_plan.html.

Kerkhof, B. M., 1994, Journal publishing and the (electronic) future: Expectation challenges and reality, in, C. Wick (ed.), Finding and Communicating Geoscience Information: Proceedings of the Twenty-Eighth Meeting of the Geoscience Information Society, p. 11-19.

Förster, Andrea and Daniel F. Merriam, 1997, Heat flow in the Cretaceous of northwestern Kansas and implications for regional hydrology: Kansas Geological Survey, Current Research in Earth Sciences, Bulletin 240, part 1 Available: http://www.kgs.ukans.edu/Current/Forster/forster1.html.

Okerson, Ann, 1992, Synopsis, in, A. M. Cummings and others (eds.), University Libraries and Scholarly Communication: A Study for the Andrew W. Mellon Foundation by the Association of Research Libraries, p. xv-xxiv Available: gopher://gopher.lib.virginia.edu:70/00/alpha/mellon/synopsis.txt.

Sorensen, J. H., S. J. Johnsgard, and C. Wozencraft, 1989, Bibliography of Kansas Geology, 1823-1984: Kansas Geological Survey Bulletin B 221, 444 p. Available: http://www.kgs.ukans.edu/General/Bibliography/bibstart.html.

Sorensen, J. H., 1994, Bibliography of Kansas Geology, 1985-1989: Kansas Geological Survey Bulletin B 234, 164 p. Available: http://www.kgs.ukans.edu/General/Bibliography/bibstart.html.

Taubes, G., 1996, Science Journals Go Wired: Science, v. 271, 9 February 1996, p. 764 Available: http://science-mag.aaas.org/science/scripts/display/full/271/5250/764.html.

THESIS AND DISSERTATION CITATIONS AS INDICATORS OF FACULTY RESEARCH USE OF UNIVERSITY LIBRARY JOURNAL COLLECTIONS

Louise S. Zipp

Collection Development Department
204 Parks Library
Iowa State University
Ames, Iowa 50011

Abstract— In recent years citation analysis has been repeatedly used to develop lists of core or protected journal titles. Citation analysis of faculty publications shows only part of the whole picture of collection use. Academic scientists depend primarily on library collections or colleagues for retrieval of journal literature they subsequently cite (Hallmark, 1994). Graduate students probably have not developed effective networks and are likely to be even more dependent on library collections. Their research, theses and dissertations, is deposited centrally and is accessible to researchers. Most citation analysis studies measure faculty demand on collections. Discovering faculty publications and obtaining reference lists can be problematic unless there is a central listing. Despite the benefits of using local data, some citation analysis studies use secondary sources, such as ISI, to compile faculty publication information, even if such sources are not comprehensive or timely. Faculty citation data from a 1993 project (Zipp, 1995) were increased to cover all faculty specialty areas except earth science education. A total of 2127 faculty citations to journals and 1208 journal citations from theses and dissertations from 1991 to 1993 were analyzed. To account for the relative value of each title to each group, Kendall's coefficient of rank correlation was applied to measure association between variables as the proportion of concordant pairs minus the proportion of discordant pairs. Although good for use with tied data, the test requires some care in organization and calculation. Because the test has not been used in recent studies, it was also applied to three other sets of published citation data. McCain and Bobick (1981) studied use in a biological collection at Temple; Noga, Derksen, and Haner (1994) studied use in two geological collections: UCLA and Stanford. The methodology follows Sokal and Rohlf (1995). In three studies a positive association was inferred; from the UCLA data, it was not possible to reject the null hypothesis. Both California studies had markedly smaller test statistic values, perhaps because those studies also incorporated monographic series. Although interesting, the results were not directly comparable with other statistical studies, and the test is not appropriate for use as a predictive tool. Basic descriptive measures were then applied to look for results that might persuade a selector whose collection is at risk. The ten most heavily cited thesis and dissertation titles did not effectively predict that same segment of faculty titles; however, a very high proportion of the top 12-15 faculty titles appeared in the 40 titles most heavily cited by graduate students. Overall, the thesis and dissertation samples predicted the faculty sample by a consistent 70% (n=40 titles). In the Iowa sample, the following titles would not have been identified if only thesis and dissertation citations were analyzed:

- American Journal of Science
- Canadian Mineralogist
- Chemical Geology
- Ecology
- Geological Magazine
- Geophysical Research Letters
- Journal of Environmental Quality
- Journal of Metamorphic Geology
- Journal of Petrology
- Journal of Structural Geology
- Mineralogical Magazine
- Precambrian Research

This set contains interdisciplinary and specialized titles, as well as older titles with reputations for selectivity. Despite the loss of information, thesis and dissertation citations can be substituted for faculty citations when the following criteria are met: (1) other complementary and appropriate measures of use are included in the study — Noga, Derksen, and Haner (1994) recommended circulation and in-house use; (2) reasonable sample sizes are used; and (3) some loss of information can be accommodated. Both parts of this study should be replicated to investigate whether the association remains as strong in the geoscience literature and across other disciplines. For the full report of this research, see Library Resources and Technical Services, vol. 40, no. 4, October 1996.

DEVELOPING A VIRTUAL LIBRARY FOR A GEOSCIENCE CLIENTELE

Patricia B. Yocum

Shapiro Science Library
University of Michigan
Ann Arbor, Michigan 48109

Abstract — Developments in information technology furnish many opportunities to re-think how users and information can be connected in the academic setting. At the same time conventional library ways suggest there are underlying principles which are key to the successful support of research and teaching. An optimal approach for practical application would be to combine the best of the new possibilities with the successes of existing systems. These are the formative ideas which shape the development of the Virtual Geoscience Library (VGL), an experimental service at the University of Michigan which seeks to model and populate an electronic library customized to meet the scholarly needs of faculty in the U of M Department of Geological Sciences. Results to date have been encouraging. The concept has been endorsed by a number of clients, and old and new library services have been blended smoothly in a single composition as have sources networked locally and those found on the Internet. The design and basic organization of the VGL have proven viable and content has increased in both quantity and quality. The effort required to develop and maintain the VGL, however, has been greater than initially expected and use lower than anticipated, highlighting areas where further work is needed.

INTRODUCTION

Experimentation and discovery are hallmarks of the scientific world. In the emerging electronic era they also may characterize how scientific information is handled. Large-scale efforts, such as the NSF Digital Library Project, are conspicuous but smaller efforts are also underway and have the potential to fill smaller niches. The Virtual Geoscience Library (VGL) at the University of Michigan, a networked service under development and available on the World Wide Web, is an example of a small-scale effort.

CONTEXT

Many factors coalesced to prompt the idea of the VGL. There was, first of all, the proliferation of electronic networks and digitized sources. In 1994 the World Wide Web captured attention by demonstrating how a global system could work, while Mosaic, released in the spring and distributed free of charge, showed that electronic navigation could be easy and inexpensive. Ready access to powerful desktop computers, growing skill in their use, and simple but effective programming language such as html also played roles. There was also the power of example. The plethora of digitized sites produced by organizations as well as by individuals sparked a heady, creative atmosphere which encouraged experimentation of all kinds and at all levels.

Local factors were also instrumental in promoting the notion of the VGL. Several years earlier the University of Michigan had decided to consolidate its science libraries and locate them in a large complex on the south side of the central campus. Most of the science departments, however, would remain on the north side. Although the physical distance was not great, the practical and psychological distances had the potential to discourage use by researchers in the affected departments. Technology could further accelerate this direction. Working on the leading edge, the University of Michigan was making huge strides in deploying technology. If early predictions were correct, electronic access to scientific information would be available from the desktop of every faculty member and could shortly make the physical location of libraries — if not libraries themselves — irrelevant.

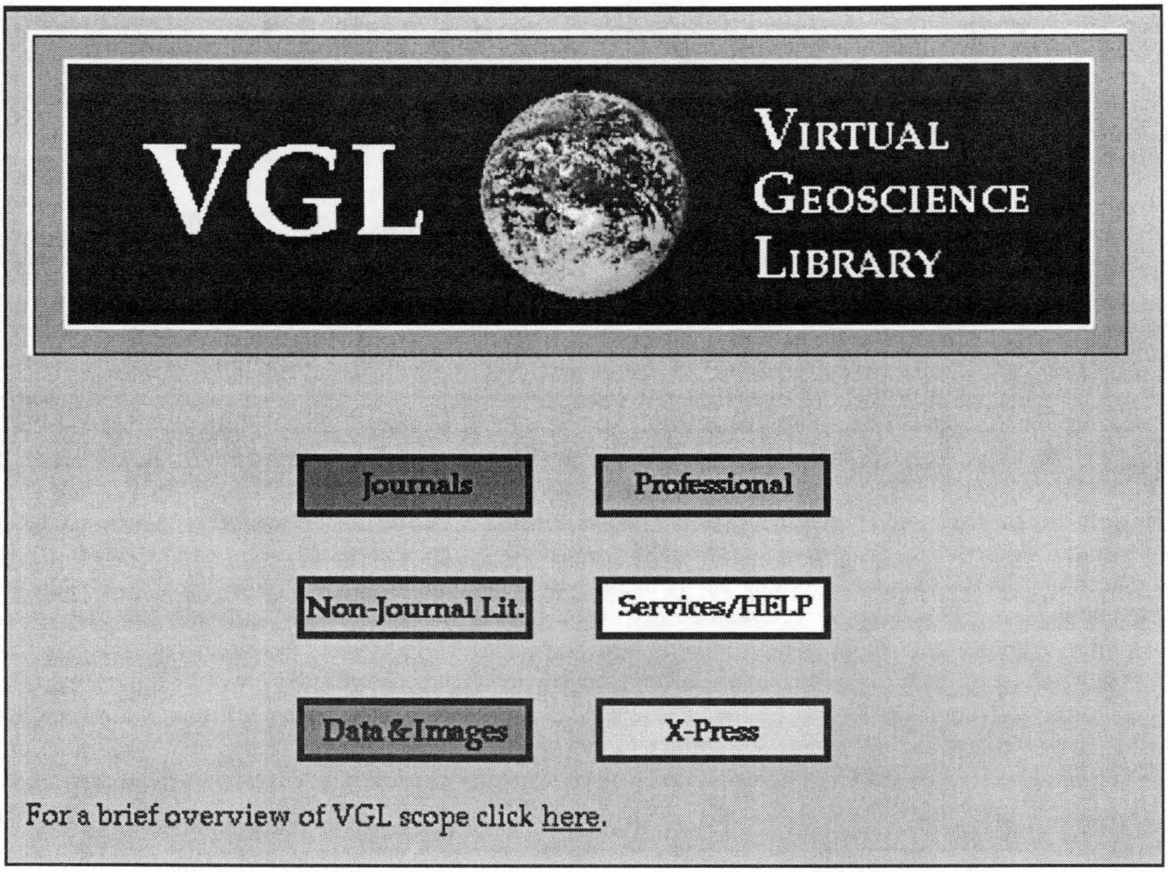

Figure 1: Front page of the VGL.

Information per se, of course, does not constitute a library. But what does? What did the departmental library do for the faculty that made it valuable? What could the new, consolidated library do in the future? Would the faculty need it or would they get all their information from multiple, megalithic information providers? Some answers were evident. In the past the library added value by selecting literature appropriate to local scholarly interests. It organized these sources in coherent collections, put them in convenient sites, and made them retrievable directly by the user. Of equal importance, the library maintained the collections, especially by keeping them current, and offered users knowledgeable assistance.

If these activities held value in the past, would they not have value in the future? Might they be needed even more in the electronic era where confusion seemed commonplace? There were no intuitively obvious reasons to the contrary. Thus, four strengths prototypical to librarianship became core to the VGL effort. These four were selection, organization, maintenance, and user assistance. The challenge was to see if they could work as foundation principles to transform information into a desktop electronic library.

CONCEPT

Simplicity was a formative notion for the VGL. Rather than trying to construct a supra-geoscience library, the VGL was focused to support the research of the tenure track faculty members in the Department of Geological Sciences at the University of Michigan. From the outset the library would have a specific, identifiable clientele of manageable size whose scholarly needs were largely known and with whom contact could be readily made. Using networking technology the library would provide links to sources found on the Internet as well as to those located on campus networks. Insofar as possible the VGL would blend the best features of conventional libraries and the most attractive features of the electronic sphere.

CONTENT

With a specific clientele in mind, selection of resources could be tightly focused. Because of their preeminence in the chain of scientific communication, journals were an obvious first choice for inclusion. Specifically targeted were journals pertinent to local interests. Data and images are also important in science. But whereas these genres are difficult for libraries to collect and

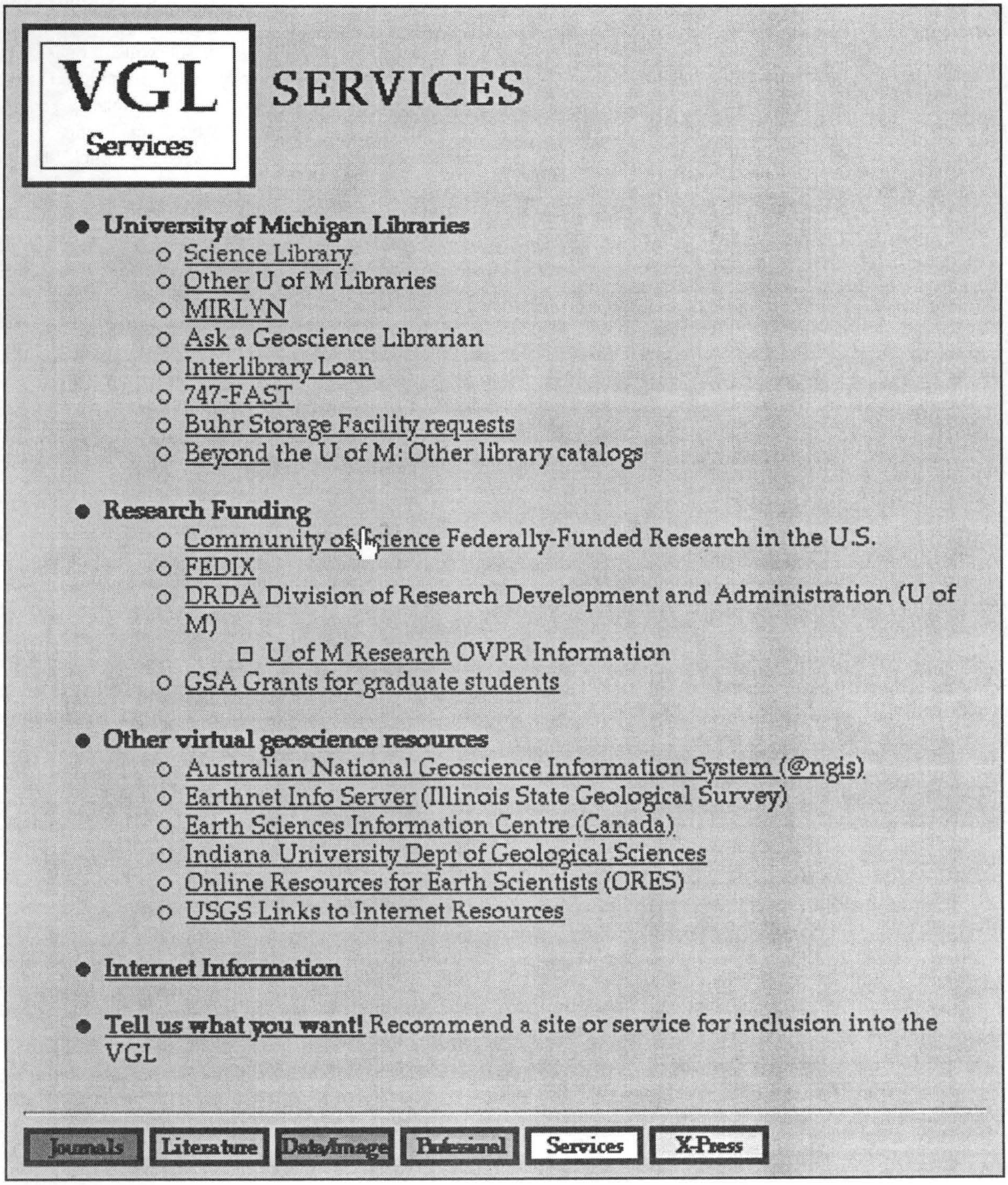

Figure 2: Start of the Services section of the VGL.

maintain in the print environment, electronic capabilities make the task easier. Thus, provision was made to include both in the VGL. Scientists also need other types of information, such as that typically found in indexes, dictionaries, directories, and catalogs. It would make sense, then, to include these in the VGL if networked sources could be located.

The clientele also shaped the selection of services. Existing library services which U of M geologists most commonly used included journal routing, the union list of serials, the library catalog, circulation, storage recall, interlibrary loan, photocopying, and reference assistance. As a result of experimentation in other library units some of these services could be readily incorporated into an electronic library. Thus, before long the VGL could link a user to the centralized ILL office so that a request could be filed electronically from a faculty office. The same capability was added for FAST, a campus-wide document delivery service. Some services could be offered in a reduced form. This included the serials list, which now covers only current subscriptions at the Science Library. Other services could not be offered at all. These included self-service photocopying and journal routing. Loss of the latter, the result of a policy decision to make journals non-circulating in the new library, was particularly difficult for the geologists. Interest in providing the benefits which the routing system furnished thus became a driving force in the development of the VGL.

In the conventional library, faculty use of reference services can be problematic to define, let alone quantify. This is particularly evident in the departmental library where faculty-librarian contact, aided by proximity, is often informal though nonetheless substantive. Large, centralized facilities offer different dynamics, some of which discourage contact. In such instances alternate routes must be cultivated. Fortunately, when the science libraries at the University of Michigan were centralized in 1995 electronic mail was well established on campus. Among the attractive features of e-mail is its power to encourage communication. Electronic messages can be short, informal and convenient. They also provide a non-threatening medium by which to ask for, deliver and receive assistance. Clearly, in the VGL it would be advisable to provide e-mail links to the geology librarian not only in a "Services" section but throughout the library.

DESIGN

The notion of simplicity also governed the design of the VGL. Segregating components by broad categories easily recognized by users seemed appropriate. To aid understanding and use it was important that these categories, as the basic organizational structures of the library, be visible at the first view as well as in subsequent ones. The results are a VGL front page with limited text and a "box" for each category linked to related sources (Figure 1). Each category "box" also appears on subsequent pages (Figure 2); a single "click" brings the user to the start of that section. Though Web browsers and computing equipment display sites variously, experience suggested that most could show a VGL front page as desired if that page were formatted with only six boxes, reinforcing preferences to limit the number of basic categories. At present these categories are "Journals," "Non-Journal Literature," "Data and Images," "Professional," "Services," and "X-press".

Within each section, layout and format differ, reflecting variations in the type and number of links available, their relationship and potential to form a cohesive section, and the likely sequence a user would follow in search of resources. For example in "Services" (Figure 2) the arrangement of links moves from the local to the worldwide while in the "Professional" section (Figure 3) the page starts with sources likely to involve quick "looks" and moves down through those likely to involve lengthier consultations. In some instances the number of links is sufficiently large to require an intermediate grouping. The "Journals" section is a prime example (Figure 4). One of the earliest ideas in VGL development was the inclusion of links to journal tables of contents of interest to U of M geoscientists. Though initially small, the list grew rapidly and now numbers 75 sites arranged alphabetically by journal title and grouped separately (Figure 5). A distinctive grouping for links to full text journals was also anticipated, as was a separate one for the networked catalogs of STM publishers. Similarly, because access to journal indexes is allied to journal use, a grouping was made for these as it was for document delivery options.

DEVELOPMENT AND POPULATION

Development of the VGL was preceded by exploratory work. This included development of an

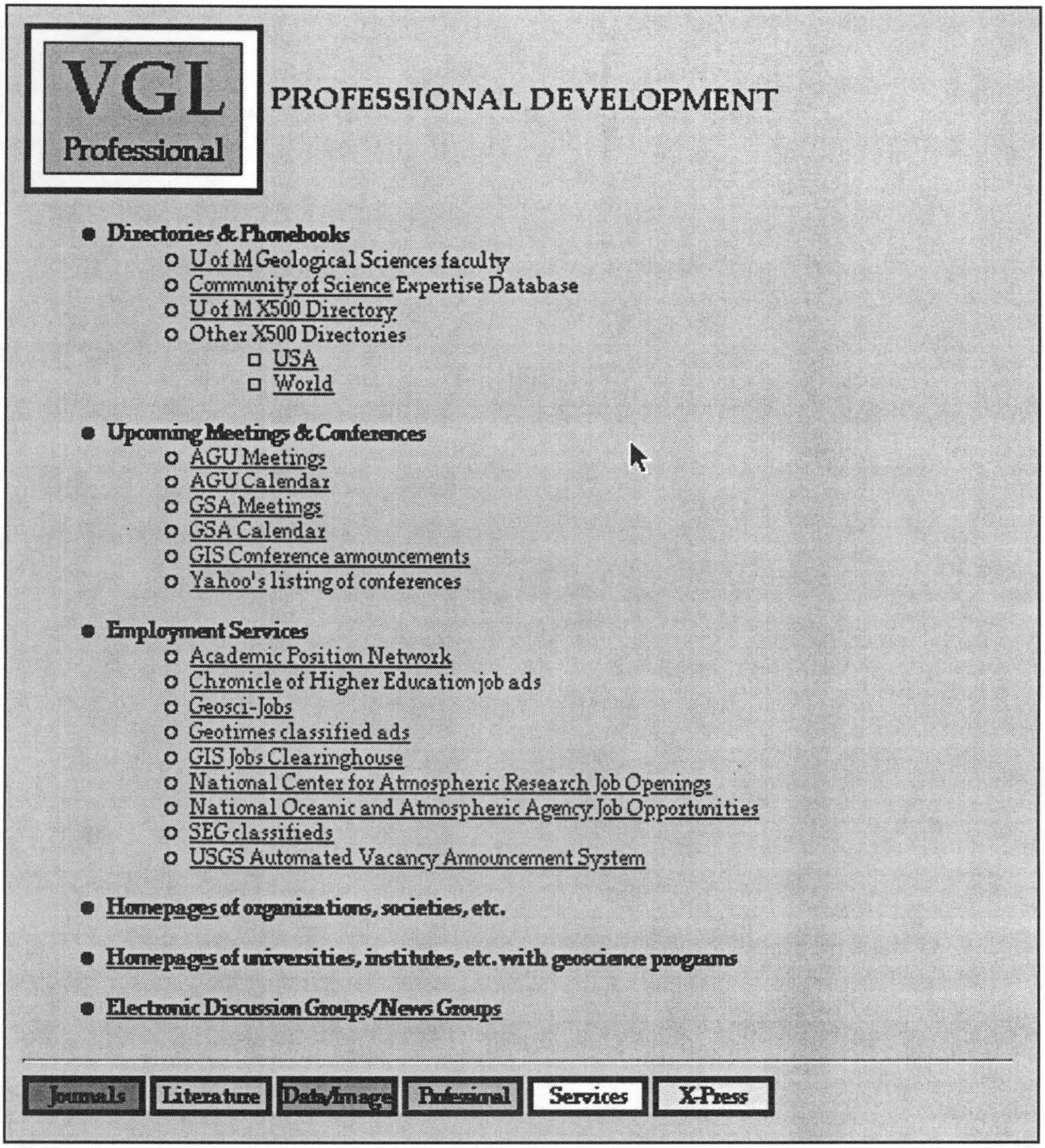

Figure 3: Start of the Professional Development section of the VGL.

electronic reference collection for global change undertaken in collaboration with two students from the U of M School of Information and Library Studies (SILS) and a subsequent project with 14 SILS students who created personalized libraries for five U of M geoscientists. Both projects offered opportunities to test ideas, apply new technologies, and refine concepts. The latter project was particularly fruitful because it identified a very talented student, adept at collaboration and interested in developing the VGL. With her contributing 10 hours per week, work started in earnest on the library in May 1995.

Initial work focused on organization, design and format. Content was added as a result of repeated Web searches and knowledge of sources

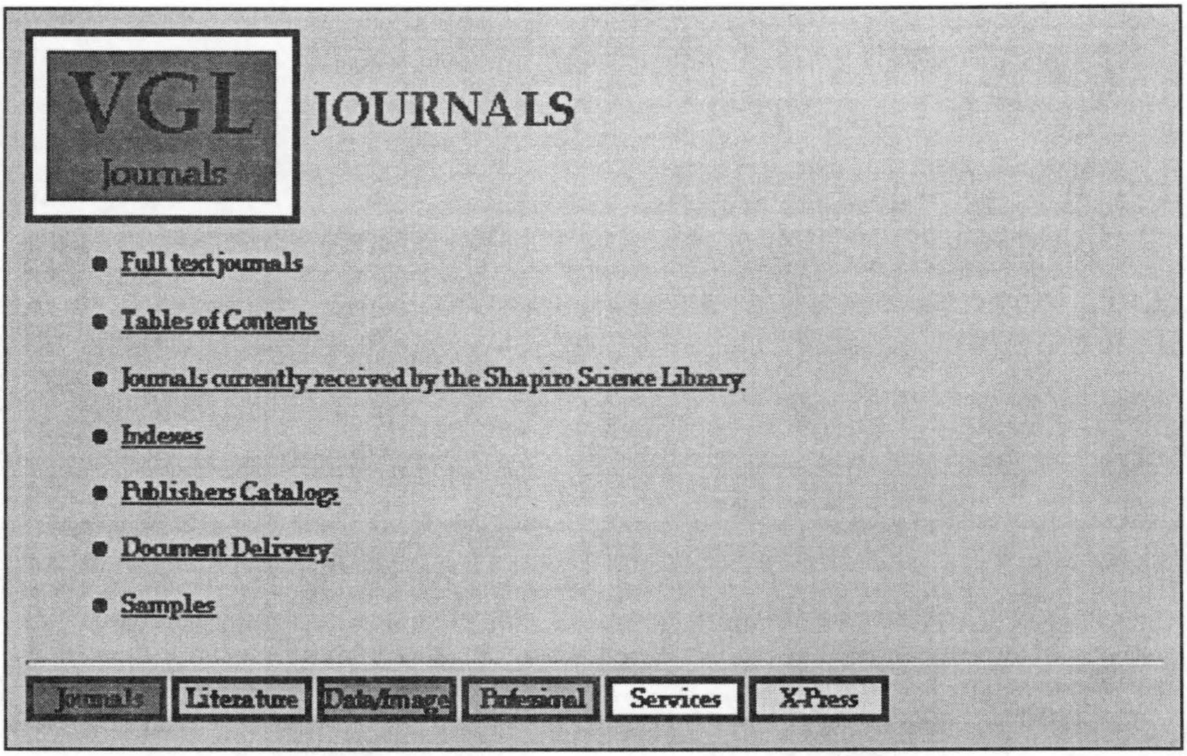

Figure 4: Intermediate grouping in Journals section of VGL.

available locally. In some instances, e.g. full text journals, links were made to illustrate capabilities rather than for relevance to serious geoscience research. Likewise, anticipating future connectivity, some sources such as GEOREF were listed as place holders. Once the index was mounted on the library network the link was activated. By late summer the VGL's organization and design were largely settled and its content was respectable. Informal demonstrations for several librarians and faculty members provided positive feedback and encouragement to proceed.

In September, when a new SILS student succeeded the previous one, work on the VGL was budgeted at three to five hours per week and focused on enriching the library's content. Pursuit also became more directed. For example, rather than searching generally for geoscience journals, the Web was searched for each geology title on the Science Library subscription list. To promote standardization, electronic forms developed by other library units replaced those crafted for the VGL. Sites noted on monitored listservs were explored and, if judged suitable, were listed in appropriate sections. As the number of links grew, maintaining their currency became a challenge. In consequence, the work was systematized, assigned to a night-time student worker, and done monthly. Dead links were rechecked and either replaced with current URLs or removed completely.

DEPLOYMENT

In keeping with its low-budget character, deployment of the VGL was low-key. At the start of fall term 1995 a brief survey was mailed to the 27 tenure-track faculty members in the Department of Geological Sciences. The survey asked what kinds of computer and software each had on the desktop, whether or not they used network browsers, and, if they did, what kinds of sources they accessed and how often they did so. The survey also asked what they would like to see in an electronic desktop library.

Twenty surveys were returned, yielding valuable information. As might be expected at this early stage of networking, desktop technology ranged from modest to exceptional while skills ranged from neophyte to expert. Under these circumstances the use and usefulness of the VGL could be expected to vary considerably. So, with little fanfare in late November 1995, each survey respondent was sent an e-mail message describing the

VGL, giving its URL and encouraging comment. The announcement was followed in January by a presentation of the VGL to a dozen graduate students and faculty member in the geology department. Reviews were favorable.

There were additional reasons for adopting a low-key approach to VGL deployment. One was the underlying notion that if the library genuinely filled a need, use would flourish of its own accord.

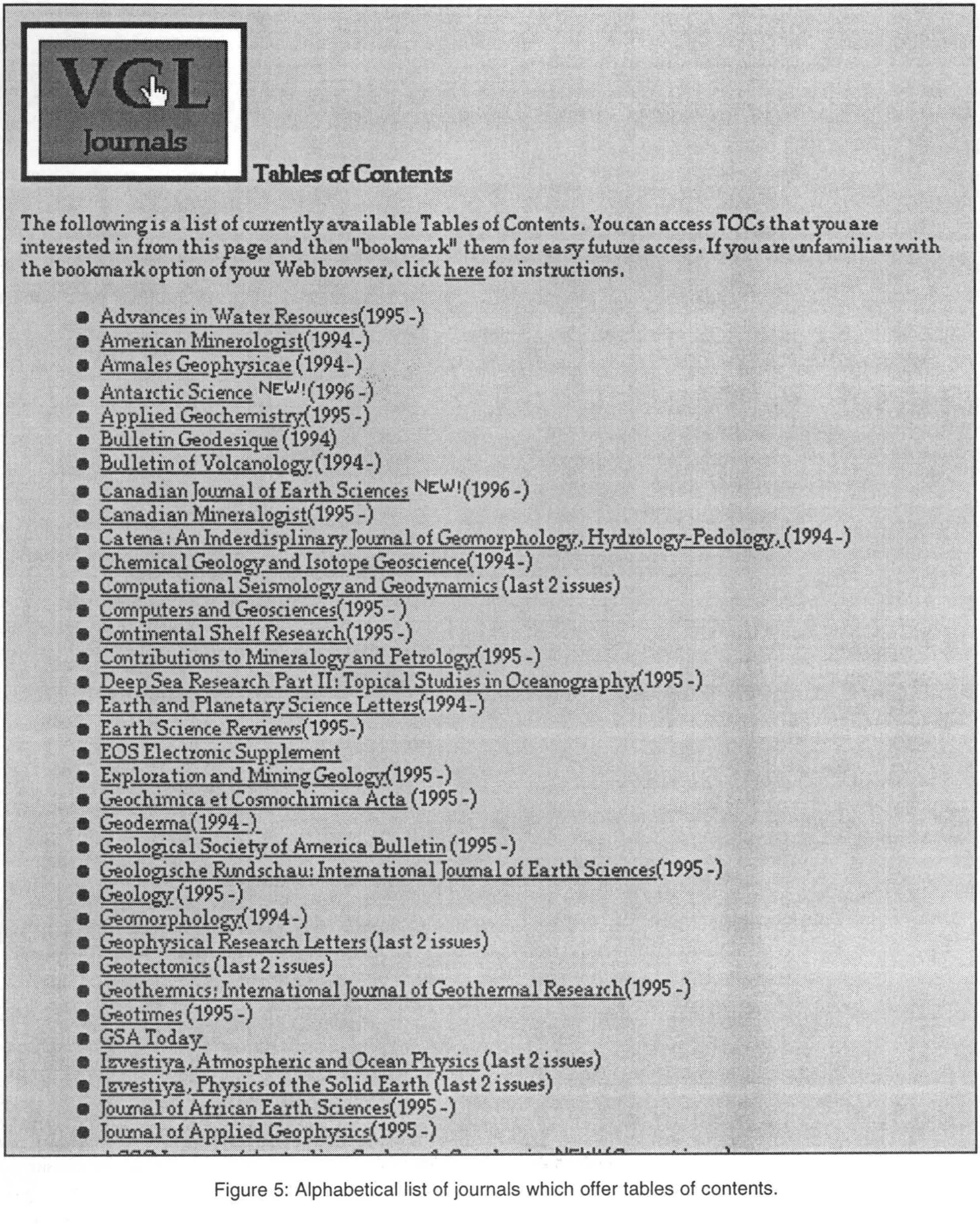

Figure 5: Alphabetical list of journals which offer tables of contents.

Secondly, although the content of the library had increased in six months, more needed to be added to achieve "critical mass." Finally, the approaching absence of the geology librarian for four months would remove the project leader and single continuing staff member from the effort. During her leave the SILS student would oversee maintenance and make changes deemed appropriate.

RESULTS

To date, results of the VGL effort have been encouraging though not spectacular. The most prized result has been the enthusiastic endorsement of the library's concept by faculty members who have seen it demonstrated. The most disappointing result has been the modest use the library has had; from winter to October 1996 less than 800 visits were made to it. Between these poles lie various results as observed from the librarian's perspective.

At the positive end of the spectrum, the experiment has shown that old and new library services can be blended smoothly in a single composition. The same appears true for sources networked locally and those found on the Internet. Though some changes have been made, the design and basic organization of the VGL have proven viable. Content has increased in both quantity and quality. The VGL now holds nearly 250 links to sources selected for their potential to support the research, teaching and professional interests of U of M geoscientists. Among the sections and even within them content varies. The "Journals" section, for example, has been developed to a much greater extent than has "Data and Images," reflecting local priorities and expertise. Within "Journals" the "Tables of Contents" subsection has links to 75 journals representing over 20 percent of the titles on the U of M geology subscription list. "Full Text," however, holds links to only 14 journals. When full text titles appear en masse, of course, the VGL has a place ready to site the pertinent ones.

Development of the VGL has encountered several challenges affecting results. Even though the scope of the library was restricted, the commitment to develop and maintain it proved larger than expected. Student help has brought needed skills and freshness but has also built turnover into the effort, creating need for repeated orientation and training. Although the design phase was exciting, maintenance can be tedious. This has affected not only the currency of existing links but also the search for additional sources. For the librarian who initiated the project and remains its leader, work on the VGL is additional to other responsibilities. Finally, her absence for an extended period suspended oversight critical to the project. The summary effects of these factors has been to compromise the steadiness of development, the currency of some of the links, and thus the usefulness of the library.

There have also been less direct results of the VGL effort. Chief among these have been renewed and enriched contact between the librarian and the geology faculty. This began with the willingness of several faculty members to participate in the SILS project which crafted personal libraries for them. Subsequently, a high percentage (74%) of the department responded to the brief survey regarding computer and network use. Under appropriate conditions the VGL has served as a "talking point" and referral site. Perhaps one of the subtlest effects of the project has been to boost substantive e-mail traffic between the faculty and the librarian. There are probably many causes for this increase, but one of them surely is the heightened awareness of technology's capacity to deliver service.

Subtle results have also been felt in the Science Library. With its stated objective to support faculty scholarship, the VGL has focused attention on academic specializations and increased the knowledge of what is needed if the library is to fulfill its mission. The project has given fresh attention to fundamental questions and placed a priority on service not only for the electronic library but for the physical library as well. For the librarian the VGL has been an organizing medium, providing both opportunity and incentive to learn new technologies and skills which can be broadly applied.

NEXT STEPS

The VGL will remain an experimental effort for the foreseeable future. Development will continue with near-term emphasis placed in several areas. Foremost will be the effort to regularize and improve maintenance and the search for new sources. Software which checks the currency of links needs to be incorporated. Tutorials, explaining how to use selected links, need to be written. The "Non-Journal Literature" section should be reviewed and redefined and the government documents sub-section expanded. Similar work needs to be done in "Data & Images." A concerted promotional and instructional effort within the geology department is due. Mechanisms to measure usefulness need to be developed and greater user input encouraged. As the content grows, the optimal size of the VGL will have to be considered. An early test concerning size may come when campus-wide access to full text subscription journals appears.

CONCLUSION

As scientists well know, experimentation often takes longer than expected. Without it, though, we are less likely to make discoveries which can affect our future. For these same reasons, experimentation such as that involved in the VGL has become crucial to better prepare us in libraries to operate in the new era.

ACCESS

Except where licensing or service restrictions apply, the VGL is open to the public and can be reached at http:// www.umich.edu/~vgl/.

PART III

POSTER SESSION

GEOSCIENCE INFORMATION

GEOLOGICAL HERITAGE CONSERVATION

Terry S. Maley

Bureau of Land Management
3380 Americana Terrace
Boise, Idaho 83706

Abstract — Geological heritage conservation means the planned and careful management of geologically significant features and landscapes to protect their natural, scientific, historic and esthetic values for the benefit of future generations. Geological heritage sites may have scientific, historic, and aesthetic significance. Scientifically significant sites consist of geological features, rock or mineral types, paleontological resources, and landscapes that represent the best example of their kind or are so uncommon that they have great significance for science education and scientific research. Historically significant sites are places where cultural activities or events occurred because of some geological feature or landscape. Categories of historically significant sites include: (1) geological sites significant to the history of geology; (2) sacred geography of Native Americans; (3) old mining districts; and (4) geological features associated with western exploration and settlement. Aesthetically significant sites include landscapes that are visually appealing because of a particular geological setting. Many geological heritage sites have been lost or degraded by human action. Common causes for the degradation of geological sites include extraction under the mining law, flooding, vandalism, tourism, criminal theft, air pollution, and commercialization.

INTRODUCTION

Earth Heritage Programs

Public land management agencies in the United States need a systematic and well-defined geological heritage conservation program to recognize and manage geological heritage sites for their scientific, historic and aesthetic values (Maley and Randolph, 1993 and 1994). In the past, recognition of heritage sites has been haphazard, incomplete, and biased towards resources that have spectacular scenic or other attractive qualities. The term "heritage" as applied to geologically significant features and landscapes means we received these features as part of our birthright and have the opportunity to benefit from them during our lifetime; but we also have the responsibility to pass them to future generations undiminished in quality and quantity. The term "conservation" refers to the planned and careful management of these natural features and landscapes to protect their natural and scientific values. For the most part, small-scale (less than 1 km2), geologically significant features and landscapes, which do not have special scenic qualities, have been ignored.

Natural Areas

Many scenic landscapes derive their form, color and uniqueness or rare qualities almost entirely from geology. World-class examples include Glacier National Park, Yellowstone National Park, Yosemite National Park, Bryce National Park, Zion National Park, Grand Canyon National Park, and Craters of the Moon National Monument, as well as many others. In the United States it is generally more important for a scenic landscape to be a natural area than for scientifically significant geological features and fossil localities to be natural. However, in Great Britain, for example, a large percent of the geological heritage features are road cuts, quarry faces, or denuded landscapes because they better display a feature for scientific study.

In most natural area programs in North America, biological criteria predominate over geological criteria in the process of designating natural area reserves (Juday, 1987). However, in a few cases geological and geographical criteria are included in the formal process of defining natural areas such as regulations under the National Forest Management Act in 36 CFR 219.25 and the policy Manual of the U.S. Fish and Wildlife Service Refuge (8 RM 10.7B.(1)). Juday (1987) gave a compelling case for the use of geological or landform features in conjunction with biological criteria to identify natural areas. He pointed out how biological and geological features are intimately related in most ecosystems, how geological features can be used as a "shorthand" method to describe natural diversity and how, in many ecosystems, geology is a controlling influence.

Physical and biological resources can be valued, used, or conserved in the cultural sense. Natural landscapes are shrinking rapidly and are under tremendous developmental pressure. Once altered by humans, they can never be restored to a natural condition. Because of steadily increasing population, demands for lands and resources are placing the few remaining natural areas in jeopardy. Although it may be impractical to conserve all natural areas, it is crucial that we conserve geologically significant sites and landscapes that have values as the best example of their kind or values for history, scientific research and education. As outstanding examples of undisturbed geological features and landscapes become less common, they become more and more valuable both to science and our heritage (Juday, 1987). We are the trustees and guardians of our earth heritage and are responsible for conserving this heritage so that it can be passed on to future generations undiminished in quantity and quality.

Cultural (Heritage) And Economic Resources

"Resources" is a word used in many contexts and with many different meanings. It is typically applied to a source of economic wealth, such as mineral resources (energy, construction, industrial and water resources). The term "resources" can also include human resources, business resources, or anything that implies usefulness or value. Geological (physical) and biological resources can be classified as economic, cultural, or both. Geological resources in the economic sense might include water used for manufacturing, domestic, and agricultural uses, or minerals used for energy, construction, and manufacturing. Biological resources used in the economic sense might include plants and animals used for food and timber used for construction. Geological and biological resources can also be valued or used in the cultural sense. Examples include: (1) the study of natural history to increase our knowledge; (2) preservation of endangered species where their existence is threatened; (3) preservation of geological features that represent the best example of their kind; (4) preservation of aesthetically pleasing natural landscapes; and (5) preservation of geological sites that played an important role in the history of science.

In many cases, geological and biological resources have both economic and cultural or heritage values. For example, a geologically significant feature or landscape can be of great value to culture for recreational and science values and also have economic values as a tourist resource (Spiteri, 1994). As a tourist resource it can bring a large economic benefit to businesses involved in the tourist industry, such as restaurants, motels, and service stations, without significantly diminishing its cultural values. However, in most cases, the more tourists who visit a site, the more environmental degradation that occurs. Tourism, through user fees, may provide the funding to manage and protect the sites (Spiteri, 1994). Every year millions of visitors from all over the world visit these parks and monuments and spend a large amount of money to enjoy these geological values, so there are both cultural and economic benefits to maintaining the parks. During 1994, approximately 269 million people visited the national parks, including a large percentage of foreigners who traveled to the United States for the primary purpose of visiting our national parks and monuments. Therefore, our national parks serve as both economic and cultural resources.

Scale

The issue of scale is an important consideration in the recognition, assessment and conservation of geological features and landscapes. This concern has been discussed by Spicer (1987) as it relates to National Natural Landmarks and Cowie and Wimbledon (1994) as it relates to World Heritage Sites. Spicer (1987) observed that, as a matter of policy, small-scale and very large-scale features are not designated as National Natural Landmarks unless there is a good reason for doing so. Cowie and Wimbledon (1994) noted that most of the World Heritage Sites tend to be large-scale (greater than 1 km2) features such as the Grand Canyon. However, as a general rule it is politically more difficult to get protection for a large area than a small one, particularly if such protection depends upon termination of other uses.

CLASSIFICATION OF EARTH HERITAGE SITES

Geologic features and landscapes may be significant for their scientific, historic, and aesthetic values. In some cases a single geological site such as Yellowstone National Park may be significant for all three types of values.

Scientifically Significant Sites

Scientifically significant sites consist of geological features, rock or mineral types, paleontological resource,s and landscapes that: (1) represent the best example of their kind; (2) are textbook examples; and (3) are unique or rare. Such sites generally have great significance for science education and scientific research.

Rossbacher (1995) reminds us of the value of experiencing as many important geological sites as possible and restates the old adage that "the best geologist is the one who has seen the most geology." She suggests that those features described in the Centennial Field Guides, developed for the Decade of North American Geology (DNAG) by the Geological Society of America "might be used as a geologist's life list," But, because the DNAG volumes only include North American examples, she also recommends a global list of generic and specific locations that every geologist should visit, which she acknowledges is constrained by space and is open to additions by other geologists. Included among her very appropriate selections are the Grand Canyon, Siccar Point (Scotland), the Alps, Mount St. Helens, Meteor Crater (Arizona), the Banded Iron Formation (Michigan), the Great Barrier Reef (Australia), Ayers Rock (Australia), the Bay of Fundy, the Li River (China), the Dalmation coast of Croatia, Devil's Tower (Wyoming), Giant's Causeway (Ireland), The Waterpocket Fold (Utah), the Goosenecks of the San Juan River (Utah), and Ship Rock (New Mexico). Rossbacher (1995) also quotes a relevant statement by Leveson (1972) on the special value of visiting geological sites to acquire intuitive knowledge of geology:

"As the geologist geologizes, the manifestations of rock — whether textural details that his eye can see and his thumb can feel ... or large-scale labyrinths through which he hikes and climbs — all gradually become part of him, intuitive knowledge that lets him know where he is and what he may expect."

Historically Significant Sites

Cultural activities, events or places occur because of some geological resource. As Savoy (1992, pg. 218) observed, "geologic and geographic setting of regions the physical landscape has influenced or controlled patterns of human exploitation and settlement as well as the life ways of peoples and their cultural landscape." Categories of historically significant sites include: (1) geological sites significant to the history of geology; (2) sacred geography of Native Americans, including cultural landscapes, migration and trade routes, meeting places, hunting areas, hunting camps, and winter camps; (3) old mining districts; (4) geological features associated with western exploration and settlement; and (5) major historic battlefields where geology played a significant role in the outcome.

Scotland has some of the best examples of geological sites significant to the history of geology. Through the remarkable contributions of James Hutton (1726-1797), physician, farmer, scientist, philosopher, and leading member of the Scottish Enlightment, Edinburgh is recognized as the "cradle of modern geology." In 1788 Hutton published Theory of the Earth, which had a profound effect on geological thought and receives some credit as the foundation of modern geology. However, see Gould (1987) for fascinating insights on Hutton's concept of geology. Perhaps the two most historically significant localities that Hutton used to demonstrate and support his ideas are Salisbury Crags, within the city of Edinburgh, and Siccar Point, a locality on the North Sea coast near Edinburgh (Baird, 1988).

Hutton recognized that the crystalline rocks of Salisbury Crags were formed by the intrusion of a basalt sill along the bedding planes of the Old Red Sandstone. He observed the highly significant crosscutting relationships as well as sandstone bedding that is conformable both above and below the sill. Hutton's field-based observations were in direct conflict with Werner's Neptunists views at the time, where the occurrence of a basalt sill would be formed by cold precipitation in sea water. Hutton's Rock, also at Salisbury Crags, may represent the earliest example of geological conservation. Hutton is reported to have requested quarrymen to save a good example of an iron ore vein so that others would have an opportunity to examine it.

In 1840 the Swiss geologist Agassiz noticed striations on an outcrop of basalt on Blackford Hill in Edinburgh (McAdams, 1994). This key exposure caused Agassiz to propose that Scotland was once under an ice sheet. As one of the earliest conserved sites, the striations are now surrounded by a protective fence and sign.

The "great unconformity" at Siccar Point on the Scottish coast is another classic Hutton locality. Hutton correctly interpreted the significance of this spectacular angular unconformity and the relationship of the steeply dipping Silurian graywackes and slates overlain by the less deformed subhorizontal Old Red Sandstone. This site undoubtedly inspired his statement in 1778 that "we find no vestige of a beginning and no prospect of an end." His concept of a very old earth, based on field evidence, represents the beginning of modern geology and a clear break from the young-earth advocates of the time who held that all rocks were formed during the Noachian Flood.

During June of 1995, I made a geological pilgrimage to Edinburgh and Siccar Point, and because it may be relevant to the conservation of geological heritage values, I will describe my efforts to locate Siccar Point. Although thousands of visitors must have made the trip to see the "great unconformity" at Siccar Point since Hutton brought notoriety to the site some 200 years ago, I was somewhat surprised by the difficulty I encountered in finding and accessing the site. Following the coastal highway in a rental car from Edinburgh, I reached the vicinity of Siccar Point as indicated by my road map. At the place where the unconformity should be closest to the highway, the map indicated that I was about 1 km from Siccar Point. Because the hilly landscape was occupied by sheep in pastures that were crossed by many fences, the land appeared to be privately owned. Upon noticing an active rock quarry, I drove up and asked a man standing near the road if he could direct me to Siccar Point. He then inquired if I were a geologist, for in his experience he knew of no other purpose to visit the site. He graciously invited me to park my car at the quarry parking lot and explained to me the best way to reach the site on foot. I was to proceed through the quarry and continue along an old dirt road until it reached a fence that crossed the road. Then I was to cross the fence and turn left and walk over a ridge. After about a 20-minute walk, I reached the famous locality and recognized it at once from the many pictures I had seen in various books over the years. My timing was excellent, since the North Sea was at low tide and the sun was at an ideal position to photograph the unconformity. It was a clear sunny day and I could see a great distance along the spectacular coast line. The Old Red Sandstone, which forms a colorful sea cliff along the coast, also offers textbook examples of 5,000 and 8,000-year-old wave-cut terraces along the coast dicating a rising landmass in response to removal of the heavy ice sheet that covered the area during the last glacial period (McAdams, 1994).

As far as I could determine the site had not experienced any adverse effects from visitors during the 200 years since Hutton made his investigations. It seems obvious that this site was conserved because it is difficult to find, difficult to access, and is only visited by motivated individuals who understand and appreciate its significance. Perhaps the best way to conserve a site is to avoid notifying the general public of its existence.

The Silent City of Rocks in south-central Idaho, located approximately 7 km north of the Idaho-Utah border, is an excellent example of a scientifically significant site that also has significant historical values. The geological features of the City of Rocks cover the 28 million-year-old Almo Pluton in contact with a neissic dome complex that is more than 2.5 billion years old (Maley, 1987). The spectacular rock forms are developed through a combination of jointing and weathering in the granitic rock. Joints control the basic shape of the landforms and facilitate the weathering processes. Solutions migrate along the fractures and disintegrate the surface layers of granite. Although jointing controls the general form of outcrops in the City of Rocks, spheroidal weathering with granular disintegration is the agent responsible for creating the bizarre and remarkable shapes that characterize the area. Case hardening of the outer surface of the granitic forms is also an important mechanism in creating unusual forms such as caves, niches, arches, bathtubs and sinks, hollow boulders, and toadstools.

The Silent City of Rocks is recognized as both a natural and historic landmark and has been included in the federal park system because of its historical and geological significance. The junction of the California and Salt Lake-California connection trails is located near the City of Rocks, and the California Trail, which passed through the City of Rocks, was established in 1843. Joseph Walker led a wagon train off the Oregon Trail at Raft River 80 km to the northeast, through Almo, then through the City of Rocks and on to California. Immigrants were fascinated by the City of Rocks and those who maintained diaries recorded their impressions. Typical is the following description given by a Mr. Lord on August 17, 1849:

"... numerous artificial hydrants forming irregular pointed cones. Nearby they display all manner of fantastic shapes. Some of them are several hundred feet high and split from pinnacle to base by numerous perpendicular cracks or fissures. Some are domelike and the cracks run at different angles breaking up the large masses into huge blocks many of which hang tottering on their lofty, pointed beds ... I have not time to write the hundredth part of the marvels of the valley or rocks ..."

Although a layman, Mr. Lord clearly recognized the unusual nature of these rock forms and recorded their characteristics with impressive accuracy. Surprisingly, it was not until 1988 that the Silent City of Rocks finally received Congressional protection through designation as the City of Rocks National Reserve (Public Law 100-696).

Aesthetically Significant Sites

Many landscapes are visually appealing because of a particular geological setting and have been withdrawn by Congressional action as wilderness areas, National Recreation Areas, National Parks, National Monuments, and Wild and Scenic Rivers. Outstanding examples of aesthetically significant geological sites are Glacier National Park, Yosemite National Park and the Grand Canyon National Park. Generally, this type of site has been recognized and protected.

Categories Of Geological Features And Landscapes

Geological heritage sites include a variety of features and landscapes with a great diversity of size, shape and geological history. The following examples of geological features and landscapes are given to illustrate some, but by no means all, of the possible categories.

1. The place where a geological feature, rock type, or type specimen of a fossil was first recognized and described.

Examples: Snake River Flood Gold (Wyoming and Idaho), the 1200-km-long Snake River, from the headquarters near Yellowstone National Park to Lewiston, Idaho, is the type locality for flood gold occurrences in the United States; Mount Monadnock (New Hampshire) the type locality of a monadnock, or isolated mountain remnant; Como Bluff (Wyoming) the first and best discoveries of certain Jurassic mammals, including 80 new vertebrate species; Morrison Fossil Area (Colorado) the first site of discovery of giant dinosaur fossil bones in North America.

2. Historically significant sites where original contributions to the understanding of geological processes or principles were inspired.

Example: Hutton's Geological Sites in Scotland. Geological sites such as Siccar Point and Salisbury Crags had a major effect on the evolution of geological thought. Though these sites are outstanding examples of their kind, they are primarily significant for their historical role as the specific site where a scientific breakthrough was accomplished.

3. Textbook examples of geological features and processes.

Examples: Ship Rock (New Mexico), an outstanding example of an exposed volcanic neck with spectacular radiating dikes; Spanish Peaks (Colorado), one of the best exposed examples of igneous dikes; Valley of Fire (Nevada), an outstanding example of overthrusting with associated fold.

4. Paleontological sites and other sites that contain scientifically significant stages of biological evolution in the fossil record.

Examples: Dinosaur Trackway (Colorado), one of the largest known exposures of dinosaur tracks on a single bedding plane, with some 1,000 tracks; Hagerman Fossil Beds (Idaho), the world's greatest variety and numbers of animals from Upper Pliocene; Indian Springs Trace Fossil Site (Colorado), the best trace fossil locality in North America that shows the markings of Ordovician animal life; Mammoth Site (Hot Springs, South Dakota), one of the largest concentrations of mammoth remains in the United States; Rancho La Brea (California),, natural asphalt tar pits in which Pleistocene animals became entrapped.

5. Features created by wind (dunes, hoodoos, arches), water (canyons, bedrock forms), ice (cirques, aretes, moraine, etc.), weathering (hoodoos, arches, colored rocks) and mass wasting (landslides, rockfalls, talus, etc.).

Examples: Nebraska Sand Hills (Nebraska), the largest sand dunes complex in the western hemisphere; Bruneau Sand Dunes (Idaho), where the western-most dune is reported to be the largest single sand dune in North America, standing about 160 m above the level of a nearby lake; Malaspina Glacier (Alaska), the largest piedmont glacier in North America; Mount Katahdin (Maine), an outstanding example of glacial features such as eskers, drumlins, kames, kettleholes, and moraines; Moss Island (New York), the best exposure of glacial age potholes eroded by meltwater floods in the eastern United States.

6. Caves and karst topography.

Examples: Craighead Caverns (Tennessee), a cavern system with the largest known underground lake in the United States; Cumberland Cavern (Tennessee), one of the largest cave systems in the country; Wyandotte Cave (Illinois), one of the outstanding cave system within the karst region of the east-central United States; Grassy Cover Karst Area (Tennessee), one of the best examples of karst development and underground drainage in the United States.

7. Hot springs, artesian springs, and aquifers.

Examples: Ichetucknee Springs (Florida), an example of a large artesian spring group and the Floridian aquifer from which Florida's great springs emerge; Thousand Springs and the Snake River Plain

Aquifer (Idaho) — the Snake River Plain aquifer is a remarkable aquifer of great resource and economic significance. For about 160 km downstream from Twin Falls an estimated volume of 5.8 km^3 of water per year enter the Snake River from gigantic springs on the north side of the canyon, making it one of the world's most productive groundwater systems (Whitehead and Covington, 1987; Malde, 1991). According to Meinzer (1927) and Malde (1991), this 160-km reach of the canyon has 11 of the 65 springs in the United States, with an average discharge exceeding 2.8 m^3/s.

8. Geologic features that offer classic research or educational opportunities.

Example: The Great Rift and Associated Volcanic Features (Idaho). The Great Rift system (Russell, 1902; Stearns, 1928; Murtaugh, 1961; Prinz, 1970; Kuntz and others, 1982, 1983, 1986, 1988, 1992) consists of a series of north-northwest-trending fractures, which extend 85 km from the northern margin of the eastern Snake River Plain to the Snake River. Three lava fields, shield volcanoes, cinder cones, lava flows, and fissures are prominently exposed over a 2- to 15-km-wide belt along the Great Rift. Craters of the Moon lava field covers an area of 1600 km^2 and is the largest Holocene lava field in the United States. The flows were extruded during eight eruptive periods beginning about 15,000 years ago and ending about 2100 years ago. Craters of the Moon National Monument is an outdoor museum of volcanic features. Features such as crater wall fragments, cinder cones, mini-shield volcanoes, lava bombs, spatter cones, lava tubes, tree molds, and rifts are among the best examples you can observe anywhere in North America.

9. Outstanding examples of significant stages in the earth's evolutionary history (paleosols, stratigraphic sections, varves, etc.).

Examples: Red Mountain Expressway Cut (Alabama) exposes a remarkable combination of structural and stratigraphic features that document the Paleozoic development of the southern Appalachian fold belt, the Burgess Shale Fauna. The world-famous Burgess Shale locality in the Canadian Rockies contains remarkably well-preserved soft-bodied animals and represents one of the most important paleontological discoveries ever made. Charles D. Walcott, an American specialist in the Cambrian, discovered the fossils in 1909 when his pack horses tripped over a block of shale with an exposed fossilized bedding surface. Although it was once believed that the Burgess Shale contained a restricted local fauna, new discoveries of Burgess Shale-type fossils in the Cambrian of North American, north Greenland and South China established that soft-bodied animals were widely distributed in Cambrian seas (Cowen, 1995).

10. A variety of related and significant geological features within a small geographic area; even though any one feature may not be worthy of special recognition, the combination of related features in proximity may be unique and geologically significant.

Example: Catastrophic Bonneville Flood Features. The Bonneville Flood is one of the largest floods known from the geological record. Gilbert (1878, 1890) recognized the evidence for a catastrophic flood during field study of Pleistocene Lake Bonneville between 1876 and 1879). The size of the Bonneville Flood is secondonly to the Missoula or Bretz Flood which flooded the northwest numerous times (Malde, 1968). Pluvial Lake Bonneville once covered a vast area in northwest Utah to levels almost 335 m above the present level of the Great Salt Lake. Approximately 14,400 years ago (Cerling, 1990), 4700 km^3 of water (O'Connor, 1993) flowed over Red Rock Pass in southeast Idaho and then flowed westward, following the path of the present Snake River. The surface features of this flood are very similar in form and scale to those of the Missoula Flood. Some of the most impressive erosional features occur around Twin Falls and include marginal channels, scablands, coulees, dry falls, and potholes (Maley and Oberlindacher, 1994a and 1995). Depositional features left by the flood include huge deposits of gravels and large trains of imbricate boulders more than 3 m in diameter. These gravel bars are up to 2.5 km long, 1.6 k wide and 100 m thick (Malde, 1968).

11. Archeological and historical sites that have geological significance, such as mining districts, sacred geography, battlefields, obsidian flows used for tool making, and rock shelters.

Examples: Devil's Tower (Wyoming), sacred geography for 20 tribes; Wallowa Lake (Oregon), sacred geography for Nez Perce tribe; Gettysburg National Military Park (Pennsylvania), geologically significant battlefield; Chinese Placer Mines (Idaho) — about the turn of the century and until at least 1912, Chinese miners followed paystreaks into placer gravels deposited by the Salmon River.

12. Geological curiosities such as erratics, meteorites, nonvolcanic craters, hoodoos, etc.

Examples: Odessa Meteor Crater (Texas), one of only two known meteor sites in the United States; Barringer Meteor Crator (Arizona), the largest impact crater discovered in the United States; Madison Boulder (New Hampshire), the largest known glacial erratic in North America; Natural Bridge (Virginia), a karst bridge that also serves as a highway bridge.

13. Unique or uncommon rock or mineral sites.

Example: Palisades of the Hudson (New York), one of the best examples of a diabase sill known in the United States; Square Butte (Montana), one of the best examples of banded magmatic rock in the United States; Orbicular Rocks near Shoup (Idaho), outcrop of orbicular rock with exceptionally well formed orbicules (Maley, 1975).

14. Geological features, formations, and landscapes that have exceptional natural beauty.

Examples: Most of the national parks and monuments, particularly in the western United States, fall in this category. Some of the outstanding examples include Grand Canyon National Park, Glacier National Park, Yosemite National Park, Yellowstone National Park, Death Valley National Park, and Crater Lake National Park.

THREATS TO EARTH HERITAGE SITES

Many geologically significant landscapes have been lost or degraded by human action. Many old photographs are the only record of the way these landscapes appeared before such loss or degradation. Many river valleys have been obliterated by gold dredging or dams. Common causes for the degradation of geological sites include: (1) extraction under the mining law; (2) flooding; (3) vandalism; (4) tourism and vandalism; (5) criminal theft; (6) air pollution; and (7) commercialization.

Extraction Under the 1872 Mining Law

The Mining Law of 1872 was amended by the Act of July 23, 1955, which authorizes that "sand, stone, gravel, pumice, pumicite, or cinders ... which are valuable because the deposit has some property giving it distinct and special value" (30 U.S.C. 611) may be located, providing the elements of discovery such as marketability are met. United States v. Coleman, 390 U.S. 599 (1968). In McClarty v. Secretary of the Interior, 408, F2d 907, 908 (9th Cir. 1969), the Court established the standards to distinguish between common and uncommon varieties of material:

"These guidelines, as we discern them, are (1) there must be a comparison of the mineral deposit in question with other deposits of such minerals generally; (2) the mineral deposit in question must have a unique property; (3) the unique property must give the deposit a distinct and special value; (4) if the special value is for uses to which ordinary varieties of the mineral are put, the deposit must have some distinct and special value for such use; and (5) the distinct and special value must be reflected by the higher price which the material commands in the market place."

Unfortunately, the provision that a deposit "must have a unique property" that gives it "a distinct and special value" also describes many rare or unique deposits of rocks and minerals, which, as the best or only example of their kind, should be preserved for their heritage values in science education and research. In effect, such sites represent an outdoor museum of unique and irreplaceable scientific features in their natural setting. Removal of unique rocks or mineral deposits from their natural setting might be analogous to the theft of a unique mineral specimen from a natural history museum.

Since 1866 the mining laws of the United States have authorized removal of valuable deposits of minerals from public lands. For example, no one will ever be able to study the bonanza native silver lodes that once cropped out on the mountain ranges of Nevada. It is also well established in case law that mineral specimens, gem stones, and gem minerals may be appropriated and extracted from the public lands under the Mining Law. Rogers v. United States, 726 F.2d 1376 (9th Cir. 1984); Utah Onyx Development Co., 38 LD 504 (1910); Pacific Coast Marble Co. v. Northern Pacific R.R. Co., 25 LD 233 (1897); United States v. Bolinder, 28 IBLA 192 (1976).

Flooding

Celilo Falls, a magnificent falls on the Columbia River east of The Dalles, Oregon, served as the ancestral fishing grounds for native Americans. The Dalles hydroelectric dam flooded the area and inundated the falls during the 1950s. The sacred fishing site was used for numerous intertribal ceremonies of the northwest, including those related to fertility, thanksgiving and salmon (Walker, 1988).

Vandalism and Tourism

A combination of tourism and vandalism can cause degradation to a site. In addition to improvements such as access roads and support facilities, removal of "specimens" from a small source of unique rock or mineral can seriously degrade or ruin a site. Even if the scientific values remain, the cumulative effect of many samples taken by visitors may cause serious attrition to a site.

The Belleview erratic is an excellent example of the threat "tourist attrition" poses to geological attractions of a limited size. The Belleview erratic is the largest of more than 300 known ice-rafted boulders carried from glacial Lake Missoula in Montana to the Willamette Valley in western Oregon by one of the catastrophic Spokane Floods about 14,000 years ago (Allison, 1935). This argillite boulder from the northern Rocky Mountains weighed about 160 tons when it was first measured in 1950. However, by 1980 "tourist attrition" had carried off approximately 70 tons or about 2.3 tons per year. Although the boulder is protected by a small state park established to recognize it, as Allen and others (1986, p. 182) observed, "If well-meaning but uninformed tourists continue to take 'souvenirs' at this rate, this unique geological phenomenon will have disappeared by the year 2019."

Criminal Theft

In the Columbia National Wildlife Refuge, located about 10 miles northwest of Othello, Washington, a unique outcrop of columnar basalt was exposed by the Spokane Flood. The general area has also been designated the Drumheller Channels National Natural Landmark interpretive site because of a remarkable landscape left by the catastrophic Spokane Floods that swept across southeast Washington numerous times between 12,000 and 17,000 years ago. These gigantic floods, each containing more than 500 cubic miles of water, scoured the channeled scablands across Washington as they moved southwestward following the drainage of the Columbia River. In the vicinity of the Drumheller Channels, outstanding scabland features, such as anastomosing coulees and empty-rock basins, were carved and are now occupied by numerous lakes and form a unique landscape and ecosystem. The uppermost flow of Columbia River Basalt was partly peeled away by the violent flood waters; however, several remnants of the flow remain as mesas. This basalt flow is characterized by remarkably well-developed columnar jointing, with individual columns about 0.5 meter in diameter and 7 to 10 m tall. On the downstream side of one of the mesas, the basalt columns were separated and pulled away from the rock wall by the force of current and stand as isolated rock towers separated by up to several meters from the mesa rim. There may be no other example in the world of large five- and six-sided columns of basalt completely separated from the outcrop.

In 1994 an individual illegally entered the Refuge with large equipment and removed four of the columns and damaged several others in the extraction process. Needless to say, he removed the best examples and the damage is irreparable because the columns cannot be restored to their original position. The refuge manager published a notice in the local newspaper in an effort to learn the identity of the culprit. Several people came forward with the needed information and the four stolen columns were located. Two of the columns had been installed in a home and the other two were on a flatbed trailer awaiting their planned use as an entry structure to the property.

Air Pollution

Enjoyment of viewing scenic landscapes can be impaired by air pollution. For example, views at Craters of the Moon National Monument are jeopardized by proposed nuclear waste storage and cleanup plans at the Idaho National Engineering Laboratory (1995). The INEL laboratory is only 24 km away from the monument. Several decades ago, visitors could see the Grand Tetons, about 240 km from the site. DOE plans to build three or four more processing plants to incinerate low-level wastes.

Commercialization

Shoshone Falls and Thousand Springs are two geological features along the Snake River in south-central Idaho that were significantly degraded by commercial development. The 65-m-high Shoshone Falls are spectacular when the river is flowing. However, since 1905 almost the entire flow of the Snake River has been diverted for irrigation by Milner dam a few miles upstream (Malde, 1987). The Thousand Springs area along the Snake River in Idaho has 11 of 65 of the largest springs in the United States (Whitehead and Covington, 1987). Many of the most spectacular springs are on private lands and are conveyed through flumes and pipelines rather than gushing out of the aquifer and down the canyon wall. Until the early part of this century when the water was developed for power and irrigation, the springs were a spectacular scenic feature. Springs poured from outlets along the canyon forming an almost continuous wall of water over the north side of the canyon extending for hundreds of meters (Russell, 1902).

INTERNATIONAL PROGRAMS

Earth Heritage Conservation in Great Britain

Great Britain was one of the first countries to play a major role in development of the science of geology as well as start geological conservation practices. Because many of the intervals of geological time were recognized, defined, and named in Great Britain, it has been referred to as "the cradle of the science of geology" (Doyle and others, 1994, pg. 9 and 10). Some of the fundamental concepts in geological mapping, stratigraphy and faunal secession were also developed in Great Britain in the late 1700s and early 1800s.

Although organized wildlife conservation efforts started in the mid-1700s, conservation of geological features and landscapes did not start for another 100 years with one of the first organized effort in Great Britain. Blackford Hill, where Agassiz first recognized evidence that Scotland was once covered by ice, was the first geological site to be preserved in Great Britain (Knill, 1994). In 1887 the City's Parks Department of Glasgow excavated Carboniferous-age Lepidodendron stumps and protected them with a building (Knill, 1994).

A systematic program to conserve Earth heritage sites began in 1945 when the Society for the Protection of Nature Reserves, now the Royal Society for Nature Conservation (RSNC), developed a list of about 400 earth-heritage sites worthy of protection for scientific purposes. The Nature Conservancy, later renamed the Nature Conservancy Council (NNC), was established in 1949 in Great Britain. The NCC was authorized to give advice on conservation in the earth sciences as well as flora and fauna and to designate Sites of Special Scientific Interest (SSSIs). This program offered protection for many of Britain's significant Earth heritage sites. The SSSIs are so important they have statutory protection. In 1977 the Geological Conservation Review (GCR) was started by the NCC for a systematic review of the SSSIs. They include a range of sites, not just the best, to show geological and geomorphological history of Britain. For those sites that do not meet the standards required for SSSIs, but are deserving of protection, the National Scheme for Geological Site Documentation (NSGSD) was established in 1977. The GCR was accomplished by dividing the country into 97 manageable blocks and inviting a team of 200 scientists to be GCR contributors. About 3000 GCR sites were recognized, of which 2200 ultimately became SSSIs (Knill, 1994). The GCR information is published in a 51-volume set. Country agencies may legally prohibit development that could degrade scientific values.

In 1990 the NCC initiated a national networks of locally conserved sites called Regionally Important Geological/Geomorphological Sites (RIGS). The RIGS groups are primarily local and voluntary. RIGS are selected for educational, research, historical and aesthetic significance but designations are less formal than SSSIs and are significant at the local level (Knill, 1994). They are conserved or protected on a voluntary basis.

The Digne Ammonite Slab

The sequence of events that led to the protection of the Isnard ammonite slab in Digne, France, is a remarkable story about "a prophet ... not recognized in his own country" (Martini, 1994). The slab is a 200-m$_2$ outcrop of 195-million-year-old sedimentary rock that contains more than 500 ammonite and nautilus fossils. These fossils range in size from 10 cm to 1 m in diameter and the most characteristic fossil is Cornoceras multicostatum. In 1960 the scientific significance of the site was recognized by the Basses-Alpes Scientific and Literacy Society, and the area, exposed by road construction, was fenced and an interpretative sign was erected. The site is now the most significant of 18 sites in the Haute-Provence Geological Reserve under the management of the Minister of Environment.

After the Digne site became internationally famous, a Japanese national television company filmed it as part of a documentary on Earth History. In 1989 Iwate Prefecture on the Island of Honshu was developing a tourism program and needed a huge exhibit to showcase its theme of the sea. The Japanese designers decided the Digne ammonite slab was the perfect exhibit for their project. In 1990 the Japanese proposed to purchase the site from the French for removal and installation at the exhibit. After many discussions and negotiations, the French authorities approved a contract that would allow the Japanese to reproduce the entire site as a cast.

In 1991 a team of molding specialists produced an elastomer mold of the entire 200-m$_2$ site. The mold consisted of 30 sections that were cast in polyester resin filled with self-colored chalk powder. These casts, which weighed 24 tons, were shipped to Japan in 1992 and erected in the town of Kamaishi. A team of eight French technicians traveled to Japan to create an accurate representation of the Digne site. According to all reports, the cast is even more lifelike and more beautiful than the original (Martini, 1994). The resin copy of the Digne slab was viewed by 2 million visitors at the Japan Expo in Iwate in 1992. Furthermore, the great interest shown by the Japanese in the Digne slab encouraged the French institutions responsible for the site to establish a long-term protection program.

International Conferences

Two successful international conferences on geological heritage conservation were held recently: (1) the First International Symposium on the Conservation of Our Geological Heritage was held June 1991 in Digne-les Bains, France; and (2) the Malvern International Conference on Geological and Landscape Conservation (18-24 July 1993) was convened by the Joint Nature Conservation Committee of the United Kingdom on behalf of English Nature, Scottish Natural Heritage and the Countryside Council for Wales, in association with the Geological Society of London and the Geologists' Association. Representatives of more than 26 countries presented papers at the Malvern conference describing organized earth heritage conservation programs in their respective countries.

World Heritage Sites

World Heritage Site designations originated in 1972 when the Convention for the Protection of the World Cultural and Natural Heritage was adopted by the United Nations Educational, Scientific and Cultural Organization (UNESCO) general conference. For a natural site to be eligible for the World Heritage list, it must qualify under one of the following categories: (1) be an outstanding example representing the major stages of the earth's evolutionary history; (2) be an outstanding example representing significant ongoing geological processes, biological evolution, and man's interaction with his natural environment; (3) contain superlative natural phenomena, formations or features or areas of exceptional natural beauty; and (4) contain the foremost natural habitats where threatened species of animals or plants of outstanding universal value can survive. The designation of a World Heritage site does not specifically affect management or provide any protection to a site, but rather, indicates an international recognition.

Since 1972, about 100 National World Heritage sites, including 30 geological sites, have been recognized by the Convention. Cowie and Wimbledon (1994) estimate that there will be 200 designated Natural Sites by the year 2000. Joyce (1994) speculates that about 1000 sites of international significance might be necessary to adequately cover the world-class geological sites.

Global List of Geological Sites

Geological sites are nominated by countries, organizations and individuals to the Global Indicative List of Geologic Sites (GILGES). This list is the basis for adding new geological sites to the 30 existing sites designated by UNESCO for the World Heritage Site List. GILGES was started in 1990 under the guidance of UNESCO representatives, the International Geological Conservation Programme (IGCP), the International Union of Geological Sciences (IUGS) and the International Union for Conservation of Nature. The 300 sites now on GILGES were selected by a task force in Paris who applied the UNESCO criteria to refine the list of nominations (Cowie and Wimbledom, 1994).

Although 120 countries are signatories of UNESCO, including the United States, it is not necessary to be a member to nominate sites to the GILGES. An imbalance of representative sites on the list is developing because certain countries, particularly those with established conservation programs, are more active in nominating sites. Unfortunately, many countries have made no nominations. As of 1994, GILGES has about 300 geological sites covering diverse geological features from many countries. Sites nominated to GILGES should satisfy the following (Cowie and Wimbledom, 1994):

"... outstanding examples representing major stages of the Earth's history, significant ongoing geological processes in the development of landforms, such as volcanic eruption, erosion, sedimentation etc., or significant geomorphic or physiographic features, for example, volcanoes, fault scarps and inselbergs ..."

IUGS Geosites

To support the GILGES, the IUGS established a new computerized global database of geological sites called "IUGS GEOSITES" at Trondheim, Norway (Cowie and Wimbledon, 1994). The IUGS GEOSITES may eventually include thousands of outstanding geological sites.

Generally, geological sites nominated for World Heritage Site designation tend to be large-scale and exceptional scenic landscapes such as the Grand Canyon and Yosemite National Park in North America. Small-scale sites, especially scientifically significant fossil localities and geological features, without outstanding scenic values, may not receive designation in the World Heritage Site list or even GILGES, but such sites may still qualify for recording in the IUGS GEOSITES computer database.

Many countries are now inventorying geologically significant features and landscapes and are following a variety of approaches and standards. Most countries have a large number of inventoried sites, but a much smaller list of sites designated for a conservation program. Joyce (1994) proposes that a useable definition of international significance is necessary to get a valid list of sites for each country for the World Heritage list. Then each list should be submitted to an internationally based review process to compare the lists and documentation and prepare a rationale for nominations to the World Heritage list.

GEOLOGICAL HERITAGE PROGRAMS IN THE UNITED STATES

Yellowstone National Park

Although Abraham Lincoln signed legislation protecting Yosemite Valley in 1864, Yellowstone National Park, established by an act of Congress on March 1, 1872, represents the first major effort in the United States and possibly the world to conserve and protect an outstanding geological area. Much of the credit goes to Ferdinand Vandiveer Hayden, a geologist who is well known for the Hayden Survey. Hayden was born in Westfield, Mass., on September 7, 1829, and studied geology at Oberlin College. After graduating in 1850, he went to Medical College at Albany, New York, where he graduated in 1853. Though he served as a physician in the Civil War, most of his career was spent on geological field expeditions.

When Hayden surveyed the Yellowstone area in 1871, it was the only remaining area in the coterminous United States left to explore. With a special appropriation of $40,000 from Congress to support the expedition, Hayden set off in June of 1871 with 34 men, including a mineralogist, a topographer, two artists and a photographer. Based on 38 days of field work in the Yellowstone wilderness, Hayden prepared a 500-page report, accompanied by Jackson's photos and Moran's sketches and paintings, to show Interior officials, Congressmen, Senators, and other interested and influential parties. His efforts finally culminated in the simultaneous introduction of a bill in the House and the Senate on December 18, 1871. It is remarkable that, using the transportation and resources available at the time, Hayden could have completed the field expedition of a remote area in the west, prepared a 500-page report as well as many other publications, convinced his superiors in Interior and the Congress, had a bill introduced and had it enacted into law, all in less than nine months. Hayden's report was the basis for the language in the report of the House Committee on Public Lands, which had a strong influence on obtaining approval. A section of the report reads:

"This whole region was, in comparatively modern geological times, the scene of the most wonderful volcanic activity of any portion of our country. The hot springs and the geysers represent the last stages the vents of escape pipes of these remarkable volcanic manifestations of the internal forces. All these springs are adorned with decorations more beautiful than human art ever conceived, and which have required thousands of years for the cunning hand of nature to form ..."

The report of the House Committee also contained the following admonitions if Congress fails to act:

"Persons are now waiting for the spring to open to enter in and take possession of these remarkable curiosities, to make merchandise of these beautiful specimens, to fence in these rare wonders so as to charge visitors a fee, as is now done at Niagara Falls, for the sight of that which ought to be as free as the air or water ...

"If this bill fails to become a law this session, the vandals who are now waiting to enter into this wonderland will, in a single season, despoil, beyond recovery, these remarkable curiosities, which have required all the cunning skill of nature thousands of years to prepare ..."

President Grant signed the bill into law on March 1, 1872, creating the first national park over a region of spectacular geological features and landscapes. This was the nations first effort to preserve an area of outstanding beauty for the enjoyment of future generations and was accomplished only a few months before enactment of the 1872 Mining Law (Act of May 10, 1872; 17 Stat. 91).

The National Wilderness Preservation System

The National Wilderness Preservation System was established by Congress on September 3, 1964, (Pub. L. 88-577; 78 Stat. 890; 16 U.S.C. 1131) to "secure for the American people of present and future generations the benefits of an enduring resource of wilderness." These areas "shall be administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, and so as to provide for the protection of these areas, the preservation of their wilderness character..." Since the original system was set in place, Congress has designated many additional wilderness areas. More than 90 million acres of land have received statutory designation as wilderness. "Wilderness" is defined in the Act (16 U.S.C. 1131(c) as follows:

"A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this chapter an area of underdeveloped federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic or historical value."

Wilderness areas "shall be devoted to the public purposes of recreational, scenic, scientific, educational, conservation, and historical use" (16 U.S.C. 1133). A great many scientifically significant geological features and landscapes exist in lands protected by wilderness status; and in most cases this is adequate protection to conserve their values.

Wild and Scenic Rivers System

The Wild and Scenic Rivers Act (16 U.S.C. 1271 et seq.) was passed by the 90th Congress on October 2, 1968. The purpose of the Act was to preserve in a free-flowing condition selected rivers, which, "with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values." Eight rivers were designated as components of the system, and 27 more rivers were designated for potential addition to the Wild and Scenic Rivers System. The statute also authorizes the Secretary of Agriculture and the Secretary of the Interior to submit proposals to Congress for additional rivers to the system. Congress also said that the "primary emphasis shall be given to protecting its esthetic, scenic, historic, archaeologic, and scientific features" (16 U.S.C. 1281). Lands constituting the bed or bank or within one-quarter mile of the bank of any designated or potential additional river are specifically withdrawn from appropriation under the mining laws (16 U.S.C. 1280).

National Parks And Monuments

Each national park has been withdrawn through a specific act of Congress. National monuments are established by Congressional action and Executive authorization. Many national monuments have been established by presidential proclamation under the Antiquities Act of June 8, 1906 (34 Stat. 225; 16 U.S.C. 431). The purpose of the national parks and monuments "is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 U.S.C. 1).

More than 25 national parks and monuments contain scientifically significant fossil deposits and at least eight of these parks were established for the purpose of protecting outstanding fossil sites (Chure and Fremd, 1987). The Hagerman National Monument near Hagerman, Idaho, was established in 1988 to preserve the 3.5-million-year-old fauna including the fossil horse, Equus simplicadens (McDonald, 1993). Other parks and monuments include the John Day Fossil Bed National Monument in Oregon, the Fluorescent Fossil Beds National Monument in Colorado, Badlands National Park in South Dakota, Fossil Butte National Monument in Wyoming, Agate Fossil Beds National Monument in Nebraska, Petrified Forest National Park in Arizona, and Dinosaur National Monument in Utah.

Scientifically significant fossils and assemblages of fossils are difficult to inventory because they may be obscured by cover or have not been recognized by qualified paleontologists. Furthermore, the scientific significance of a fossil may depend on its geographic and geological distribution. For example, a fossil that is common in one locality may be scientifically significant at another locality (Chure and Fremd, 1987). Once fossils are exposed to the agents of erosion, they will be quickly obliterated by surface processes or taken by collectors. Whether a fossil is destroyed by erosion or removed out of the context of its environment of deposition by unauthorized collectors, all scientific value is permanently lost.

National Natural Landmarks Program

The National Natural Landmarks program is managed by the National Park Service; it is based on the legal authority of the Secretary of the Interior under the Historic Sites Act of 1935 (Public Law 74-292; 49 Stat. 666; 16 U.S.C. 461 et seq.) and two other statutes that refer to national natural landmarks (16

U.S.C. a-1 through a-7; 16 U.S.C. 1908). Implementing regulations for the National Natural Landmarks program, adopted in 1982, are contained in Part 62 of Title 36 of the Code of federal Regulations. On February 6, 1965, the Secretary of the Interior changed the name of the program from National Registry of Natural History Landmarks to National Registry of Natural Landmarks. The program was transferred to the Heritage Conservation and Recreation Service (HCRS) in 1978 and continued there until HCRS was abolished in 1981. Since June 1982 the program has been administered by the National Park Service.

The purpose of the Natural Landmarks program is "to identify and encourage the preservation of nationally significant examples of the full range of ecological and geological features that constitute the nation's natural heritage." 36 CFR 62.1. Sites on the registry are selected for both their geological and ecological values so they cannot be considered strictly geological or ecological sites (Spicer, 1987). Although thousands of potential sites have been identified, about 587 sites in 48 states, three territories and the commonwealth of Puerto Rico have been designated as National Natural Landmarks.

A "National Natural Landmark" is designated by the Secretary of the Interior and includes "outstanding representative example(s) of the nation's natural heritage" such as landforms, geological features, or fossil evidence of the development of life on earth. A geological feature can be nationally significant if it is one of the best examples of that feature known. Such features include, among other things, "geological structures, exposures, and landform that record active geological processes or portions of earth history; and fossil evidence for biological evolution." 36 CFR 62.5 (a).

Potential natural landmarks are identified through one of four sources: (1) natural region studies by the National Park Service or its contractors; (2) federal agency inventory programs; (3) state natural area programs; and (4) any other source, public or private (36 CFR 62.4). If the proposed landmark qualifies for designation, the director of the National Park Service nominates it to the Secretary of the Interior. Areas designated by the Secretary as natural landmarks are included on the National Registry of Natural Landmarks. The regulations (36 CFR 62.9(a)) authorize the National Park Service to enter into agreements with other federal agencies to identify, evaluate, monitor and protect natural landmarks. The national natural landmark program applies to all land in the United States regardless of ownership; this is important because many landmarks involve mixed ownerships of federal, state and private land. As a general rule the National Park Service prefers to obtain the consent or approval of all the owners before a designation is made. The designation of a landmark does not withdraw the land from other uses and the National Park Service has no regulatory authority to manage or preserve the sites, other than getting commitments from the various owners to do so. In the case of state, Bureau of Land Management, and Forest Service administered lands, the land management agencies have various authorities to manage and protect the sites.

The National Registry of natural Landmarks has designated landmarks both inside and outside the park system. Sites outside the system are logical candidates for future additions to the Park Service. About 16 of the 587 sites designated as National Natural Landmarks were later included in 13 units of the National Park System. This, of course, requires congressional action. The recognition given through the designation process in conjunction with the cooperative agreements is probably the best possible way to conserve nationally significant sites on private land.

Section 8 of the National Park System General Authorities Act of 1970 (16 U.S.C. a-1 through a-7), as amended in 1976 (PL. 94-458), requires the Secretary of the Interior to monitor the condition of all designated landmarks and submit an annual report to the Congress identifying those sites that are threatened or damaged. Section 9 of the Mining in the National Parks Act of 1976 (16 U.S.C. 1908) requires that when surface mining poses a threat such as irreparable loss to a landmark, the Secretary is to report to the Advisory Council on Historic Preservation. The land management agencies should refer to the existence of a potential or designated landmark in environmental assessments or environmental impact statements and consider the effect of the proposed action on the site (42 U.S.C. 4321). These agencies should also identify potential and designation landmarks in their land management plans and incorporate provisions to conserve and protect the sites.

Based on the advice of an ad-hoc committee of natural scientists, a "thematic" classification system was adopted in April 1966. The United States, Puerto Rico, the Virgin Islands, and the Pacific Trust Territories were divided into 33 natural regions or physiographic provinces. In June 1968, the National Park Service started contracting with university scientists for nationwide inventories for each theme (Spicer, 1987). Geological inventories after 1978 followed a process-oriented geological classification system s proposed by ten professional geologists who worked under the sponsorship of HCRS.

The National Park Service contracts with scientists to complete on-site evaluations of those sites which are highly ranked in the theme studies. The evaluation reports are reviewed by other scientists and finally by the N.P.S. staff. Following its recommendations, a notice of the National Park Service determination that the site qualifies for National Natural Landmark designation is placed in the federal Register with a specified public comment period. After the comment period, N.S. reviews all information to determine if the site still qualifies for designation. Finally, the N.P.S. Director nominates sites that qualify to the Secretary of the Interior for designation. Once a site is designated as a National Natural Landmark, it is listed on the National Registry of Natural Landmarks.

As a matter of policy, small-scale and large-scale geological features are typically not included in the program (Spicer, 1987). Very small-scale geological structures such as ripple marks or a type of jointing would not be included unless they were of an unusually large scale, rare, or the only evidence of regionally important events. Conversely, large-scale features such as mountain ranges would not be included unless there were some particular advantage to doing so. Also, type sections for the various stratigraphic formations have not been included (Spicer, 1987).

American Indian Religious Freedom Act and Sacred Geography

Many unique or scientifically significant geological attractions and features represent sacred geography to American Indian religious beliefs. Sacred geography may be represented by an imposing mountain such as a volcano, waterfall, cave, colorful rock formation, hot spring, or an unusual landform (Walker, 1988). Sacred geography is a universal and integral part of American Indian religions. The natural landform or feature represents a sacred altar or church where people may communicate with spirits and acquire spiritual powers (Walker, 1988). Degradation or loss of access to such sites may restrict or preclude the opportunity or right to practice a crucial part of religion.

Sacred geological features require religious activities at specific times such as calendrical rituals at the spring and fall equinoxes or the winter and summer solstices. So we have many sacred sites that are particularly sacred at a specific time (Walker, 1988). Excellent examples of these geological sites include Celilo Falls (discussed above), Wallowa Lake, a beautiful glacial lake in northeastern Oregon and Devil's Tower, a spectacular volcanic neck in northeastern Wyoming. Wallowa Lake, a Nez Perce vision quest and ceremonial ground was the home of Chief Joseph. His descendants meet at the lake to memorialize his life, death and their tribal history (Walker, 1988). Unfortunately, the aesthetic aspects of this site are degraded by the construction of many lake-front homes. Devil's Tower is a 382-m-high erosional remnant of a volcanic neck that shows spectacular columnar jointing (Karner and Halverson, 1987). Devil's Tower, which lies within Devil's Tower National Monument, designated America's first national monument by President Teddy Roosevelt in 1906, is an important landmark of the northern Great Plains. It is also a sacred feature for more than 20 tribes who claim cultural relationship to the feature. They use the site for religious ceremonies, particularly during the summer solstice. In June many tribes celebrate on the land surrounding Devil's Tower with Sun Dances, prayer offerings, sweat-lodge ceremonies, and vision quests. Recently, conflicts have occurred between rock climbers and the tribes, so the National Park Service started a voluntary climbing ban which is apparently successful. On August 11, 1978, the American Religious Freedom Act (Public Law 95-341; 92 Stat. 469; 42 U.S.C. 1996) was passed into law. It reads:

"[I]t shall be the policy of the United States to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions of the American Indian, Eskimo, Aleut, and Native Hawaiians, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites."

National Environmental Policy Act

The National Environmental Policy Act of 1969, as amended (Pub. L. 91-190; 42 U.S.C. 4321-4347; January 1, 1970, as amended by Pub. L. 94-52; July 3, 1975; Pub. L. 94-83; August 9, 1975; and Pub. L. 97-258; Sept. 13, 1982) was enacted by the Congress to establish, among other things, a national policy for the environment. One important statement of this policy is to "preserve important historic, cultural and natural aspects of our national heritage ..." (42 U.S.C. 4331).

Federal Land Policy and Management Act

The Bureau of Land Management has legal authority for a geological heritage program, including intensive management of the resources and protective withdrawals under section 204 of the federal Land Policy and Management Act of 1976 (FLPMA). For example, in section 102 of FLPMA, Congress declared that it is the policy of the United States that:

"(2) the national interest will be best realized if the public lands and their resources are periodically and systematically inventoried and their present and future use is projected through a land use planning process coordinated with other federal and State planning efforts;

"(8) the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural conditions ..."

According to this Congressional policy, the land management agencies would be remiss if they did not inventory scientifically significant resources to protect and preserve them through land use planning. Because many of these geological features and landscapes straddle agency boundary lines, the procedures for inventory and evaluation should be similar and provide for coordination among the appropriate state and federal agencies as well as with the scientific community.

Areas of Critical Environmental Concern

Where scientifically significant geological features and landscapes occur on BLM-administered lands, they are initially considered for designation as "areas of critical environmental concern" (ACECs). Section 202c(c)(3) of the Federal Land Policy and Management Act (FLPMA) mandates the agency to "give priority to the designation and protection of areas of critical environmental concern" during the development and revision of land use plans. The regulations (43 CFR 1610.0-5(a) define ACECs as follows:

"Areas of Critical Environmental Concern or ACEC means areas within the public lands where special management attention is required (when such areas are developed or used or where no development is required) to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life and safety from natural hazards. The identification of a potential ACEC shall not of itself, change or prevent change of the management or use of the public lands."

The regulations (43 CFR 1610.7-2 (a)) further require that a potential ACEC satisfy the following criteria:

"(1) Relevance. There shall be present a significant historic, cultural, or scenic value; a fish or wildlife resource or other natural system or process; or natural hazard.

"(2) Importance. The above described value, resource, system, process, or hazard shall have substantial significance and values. This generally requires qualities of more than local significance and special worth, consequence, meaning, distinctiveness, or cause for concern." According to BLM Manual 1613.11A., an area meets the "relevance" criterion if it contains, among other things, "a significant ... scenic value" or "rare geological features."

Upon approval of a draft resource management plan, plan revision, or plan amendment including a proposed ACEC, the BLM State Director shall publish a notice in the Federal Register listing each proposed ACEC and specifying the resource limitations (43 CFR 1610.7-2(b)). After a 60-day period for public comment on the proposed ACEC, approval of the land use plan automatically designates the ACEC. The special management provisions designed to protect the ACEC are incorporated in the plan (43 CFR 1610.7-2(b)).

Forest Service Regulations

Forest Service regulations (36 CFR 219.25) issued under the authority of the Forest and Rangeland Renewable Resources Planning Act of 1974 (16 U.S.C. 1604; 5 U.S.C. 301) may be used to establish "research natural areas" for "geological types that have special or unique characteristics of scientific interest and importance." These research natural areas are recognized through the land-use planning process. The regulations (36 CFR 219.25) state:

"Forest planning shall provide for the establishment of Research Natural Areas (RNAs). Planning shall make provision for the identification of examples of important forest, shrub land, grassland, alpine, aquatic, and geological types that have special or unique characteristics of scientific interest and importance and that are needed to complete the national network of RNAs. Biotic, aquatic, and geological types needed for the network shall be identified using a list provided by the Chief of the Forest Service."

Federal Cave Resources Protection Act

The Federal Cave Resources Protection Act of 1988 (102 Stat. 4546; 16 U.S.C. 4301) requires the Department of the Interior agencies to identify, protect, and maintain caves with scientific, educational and recreational values. Regulations to implement the federal Cave Resources Protection Act of 1988 were published on October 1, 1993 (58 F.R. 51550-55) and made effective on November 1, 1993.

Resource Protection Laws and Regulations

Resource protection regulations (43 CFR 8365.1-5) provide that "[o]n all public lands, unless otherwise authorized, no person shall (1) [w]illfully deface, disturb, remove or destroy ... any scientific, cultural, archaeological or historic resource, natural object or area; [or] (2) [w]illfully deface, remove or destroy plants or their parts, soil, rocks or minerals, or cave resources ..." These regulations apply to public lands administered by the Bureau of Land Management.

Some scientifically significant fossils and rare rock and mineral types are vulnerable to unauthorized removal by collectors. Because fossils and minerals represent a type of government property, penalties for unauthorized collection range from $1,000 in fines and one year imprisonment to $10,000 in fines and 10 years imprisonment (18 U.S.C. 641). The regulations in 43 CFR 9239, as authorized by 43 U.S.C. 1201, state:

"The extraction, severance, injury, or removal of timber or other vegetative resources or mineral materials from public lands under the jurisdiction of the Department of the Interior, except when authorized by law and regulations of the Department, is an act of trespass. Trespassers will be liable in damages to the United States, and will be subject to prosecution for such unlawful acts."

Mineral material trespasses are prohibited by 43 CFR 3601.1, which states:

"Except when authorized by sale or permit under law and the regulations of the Department of the Interior, the extraction, severance or removal of mineral materials from public lands under the jurisdiction of the Department of the Interior is unauthorized use. Unauthorized users shall be liable for damages to the United States, and shall be subject to prosecution for such unlawful acts."

Petrified Wood

Fossil or petrified forests may be scientifically significant. The Act of September 28, 1962 (76 Stat. 652) removed petrified wood from the locatable mineral category and made it available to the public on a free-use basis in limited quantities. The Act defined petrified wood as "agatized, opalized, petrified or silicified wood, or any material formed by the replacement of wood by silica or other matter." This free use program applies to all public land administered by the Bureau of Land Management. No permit for free use is required for specimens over 250 pounds in weight. Specimens over 250 pounds may be used only for museum purposes. Collection of petrified wood on a free-use basis is subject to the rules in 43 CFR 3622.

The Forest Service also administers a free-use permit program to amateur collectors and scientists. The permittee is allowed to collect limited quantities of petrified wood for personal use and may not trade or sell it. 36 CFR 228.62(e).

Fossil Prehistoric Animals Are Not Locatable

On April 5, 1913, Earl Douglas located the Carnegie Museum placer claim near Vernal, Utah, for mining the fossil remains of dinosaurs and other prehistoric animals. According to the record, the fossil remains were excavated for scientific purposes. The Secretary affirmed the decision of the Commissioner, holding that the deposit is not a mineral within the meaning of the mining laws. Earl Douglas, 44 L.D. 325 (1915). The precedential effect of this case should apply to all fossil remains of animals. Therefore, both vertebrate and invertebrate fossils are not locatable under the mining law.

Invalidity Based on South Dakota Mining Co. v. McDonald

Perhaps the first case involving a "great natural wonder" is the case of South Dakota Mining Co. v. McDonald, 30 L.D. 357 (1900), which was cited with approval in United States v. Bolinder, 28 IBLA 187 (1976). The case of South Dakota Mining Co. involved an extensive and beautiful cave that both a mining claimant and a homestead claimant were attempting to control. The cave apparently had many spectacular features such as chambers of different sizes, side chambers, chambers occupying several different levels as well as ascending and descending passages from one level to another. Furthermore, the Secretary of the Interior, in noting that "the cavern is described as a great natural wonder," directed the Department to make an examination of the cavern "with the view to a permanent reservation of the lands covering the same for the benefit of the public." In

Bolinder, the Interior Board of Land Appeals observed that such a "case should be considered in light of the peculiar circumstances presented there and the interest in preserving for the public the unique values of the cave." The Secretary concluded that a cave located for features such as stalactites, stalagmites, geodes, box-works and frost-works for use as natural curiosities is not mineral land.

The Big Wood River Case

A 6-km stretch of the Big Wood River in south-central Idaho contains one of the best examples of bedrock erosional features found anywhere on earth, both in terms of variety and quality of features (Maley and Oberlindacher, 1993 and 1994b). Several months before the Bureau of Land Management (BLM) could establish a protective withdrawal, the area was located by a mining company for the purpose of extracting the beautifully sculpted boulders to supply local, regional and international markets. The water-sculptured boulders, which are sold under the trade name of "Holystone," are used for a variety of decorative and artistic purposes including waterfalls, fountains and as natural stone sculptures. Small boulders are readily sold for more than $2,000 each. The potential market is enormous and the supply is small.

When the company filed a notice to remove the boulders, the BLM issued a contest complaint and denied the company access to the stone. On April 4 and 5, 1994, Administrative Law Judge Ramon M. Child presided over an administrative hearing held in Boise, Idaho. The government's case involved a balancing test based on the authority of the 1892 Building Stone Placer Act (27 Stat. 348; 30 U.S.C. 161). The Building Stone Placer Act limits building stone claims to lands "that are chiefly valuable for building stone." Under this test, BLM asserted that the land embraced by the claims are more valuable as a unique and a scientifically significant geological feature than for the market value of the water-sculpted boulders to the claimants.

The case was based on evidence that the claims embrace one of the best examples in existence of bedrock erosional forms and associated features. This stretch of the Big Wood River channel offers a complete outdoor museum of outstanding examples of every type of pothole, relict potholes, coalesced potholes, exotic pebble types, desert varnish, deep inner channels, dry falls, collapsed cave segments, overprinting of asymmetry and sculpted boulders (Maley and Oberlindacher, 1993 and 1994). The water-sculpted rocks in the Big Wood River represent an outstanding example of the type of natural features that should be recognized and protected from entry under the mining law.

On November 1, 1994, Judge Child issued his decision on the Big Wood River stone, ruling in favor of the government. He noted that the "dispute in this case centers around the question of whether the value of the claimed land for mining purposes is greater than its value for aesthetic, scientific, and recreational purposes and whether this comparison of values is relevant to the determination of whether the mining claims are valid." His order states that the "subject mining claims are hereby declared null and void because the claimed land is more valuable for aesthetic and geological purposes than for building stone or any mining purpose." United Mining Corporation has appealed the Big Wood River case to the Interior Board of Land Appeals.

CONCLUSIONS

A review of the world literature, including the reports of the 1994 International Conference on Geological Conservation in Malvern, England, clearly show that many countries of the world have geological heritage programs in various degrees of development. Britain began a major effort more than 50 years ago that has evolved into the most comprehensive and practical program of its kind despite the fact that it has major land ownership and access problems.

Starting with the establishment of Yellowstone National Park in 1872, the United States has successfully conserved large-scale geological landscapes through a statutory-based national park system. Not only does the western United States have a remarkable number of world-class geological heritage sites, but it has managed to preserved them from development. Millions of foreigners travel to the United States every year for the primary purpose of visiting the national parks.

Through the National Natural Landmark program, thousands of geological sites have been recognized and several hundred have been designated. However, this program tends to favor large-scale sites and sites that have both biological and geological values. Also, the designation of a national landmark does not offer any protection or requirement for special use. As a general rule, small-scale sites and particularly those that are scientifically or historically significant have not been recognized or adequately protected under any of the existing programs. Consequently, these small-scale sites as well as some large-scale sites that have not been recognized or protected under existing programs should be the focus of a new initiative to conserve as many sites as reasonably possible.

Perhaps the best opportunities to conserve those sites that have dropped through the cracks can be found on the federal lands. The total area of the 50 states is 2.3 billion acres. Of this area, approximately 662 million acres, or 30 percent of the total area, is still in federal ownership. Most of this federal land is administered by the U.S. Forest Service and the Interior agencies such as the Bureau of Land Management, the National Park Service, the Fish and Wildlife Service and the Bureau of Reclamation. The Federal Land Policy and Management Act of 1976 and its implementing regulations give sufficient legal authority to develop and administer a comprehensive and systematic geological heritage conservation program on the public lands. The Forest Service and the Bureau of Land Management should work together to develop a Memorandum of Understanding and a unified policy for geological heritage conservation that could be applied consistently to the lands administered by both agencies. Because geological landscapes and features commonly straddle administrative boundary lines, it is critical that both agencies have consistent standards and procedures. The policy should be designed to inventory, describe and evaluate all geological landscapes and features in the federal lands for their scientific, historic and aesthetic values. Each geological heritage site should be evaluated in terms of the appropriate uses of the site and the management options for development and protection. The management plan for each site, which should be integrated the agency land use plan for the area, would identify threatened sites and developmental potential for purposes such as earth science education and research and recreation programs with interpretative centers and trails. Also, a national listing could be established and maintained on a computer database with information abstracted from each geological site report. This would be a convenient method for external users such as educators and scientists to access geological resources information on federal lands.

ACKNOWLEDGMENTS

This paper benefited from my many field investigations and discussions with Bob Randolph and Peter Oberlindacher. I am especially grateful for the editorial review by Don Smurthwaite.

REFERENCES

Allen, J.E., Burns, M., and Sargent, S.C., 1986, Cataclysms on the Columbia: Timber Press, Portland, Oregon, 211 p.

Allison, I.S., 1932, Spokane flood south of Portland, Oregon: Geological Society of America Bulletin 43, p. 133-134.

Baird, W.J., 1988, The scenery of Scotland: the structure beneath: National Museums of Scotland, Edinburgh, Scotland, 36 p.

Cerling, T.E., 1990, Dating geomorphologic surfaces using cosmogenic 3He: Quaternary Research, v. 33, p. 148-156.

Chure, D.J. and Fremd, T, 1987, Protecting fossil resources in the National Park System: Natural Areas Journal, v. 7(4), p. 194-195.

Cowen, R., 1995, The History of Life: Blackwell Scientific Publications, 462 p.

Cowie, J.W. and Wimbledon, W.A.P., 1994, The World Heritage List and its relevance to geology, in O'Halloran, D., Green, C., Harley, M.,Stanley, M., and Knill, J., editors, Geological and Landscape Conservation, Geological Society, London, p. 71-74.

Doyle, P., Easterbrook, G., Elspeth, R., Skipsey, E., and Wilson, C., 1994, Earth Heritage Conservation, Geological Society, London, 272 p.

Geological Survey. 1980. Ferdinand Vandiveer Hayden and the Founding of Yellowstone National Park, U.S. Department of the Interior, Washington, D.C., 44 p.

Gilbert, G.K., 1878, The ancient outlet of Great Salt Lake: American Journal of Science (3rd ser.), v. 15, p. 256-259.

Gilbert, G.K., 1890, Lake Bonneville: U.S. Geological Survey Monograph 1, 438 p.

Gould, S.J., 1987, Time's Arrow Time's Cycle: Harvard University Press, Cambridge, 222 p.

Hutton, J., 1788, The theory of the earth; or an investigation of the laws observable in the composition, dissolution and restoration of Land upon the globe: Transactions of the Royal Society, Edinburgh, v. 1, p. 209-304.

Joyce, E.B., 1994, Identifying geological features of international significance: the Pacific Way, in O'Halloran, D., Green, C., Harley, M.,Stanley, M., and Knill, J., eds., Geological and Landscape Conservation, Geological Society, London, p. 507-513.

Juday, G.P., 1987, Selecting natural areas for geological features: a rationale and examples from Alaska: Natural Areas Journal, v. 7(4), p. 137-156.

Karner, F.R. and Halvorson, D.L., 1987, The Devil's Tower, Bear Lodge Mountains, Cenozoic igneous complex, northeastern Wyoming in Buess, S.S. ed., Rocky Mountain Section of the Geological Society of America: Boulder, Colorado, Geological Society of America, Centennial Field Guide 2, p. 161-164.

Knill, J., 1994, Introductory address, in O'Halloran, D., Green, C., Harley, M.,Stanley, M., and Knill, J., eds., Geological and Landscape Conservation, Geological Society, London, p. xi-xiv.

Kuntz, M.A., Champion, D.E., Spiker, E.C., Lefebvre, R.H., and McBroome, L.A., 1982, The Great Rift and the evolution of the Craters of the Moon lava field, Idaho in Bonnichsen, B. And Breckenridge, R.M., eds., Cenozoic geology of Idaho: Idaho Bureau of Mines and Geology Bulletin 26, p. 423-437.

Kuntz, M.A., Lefebvre, R.H., Champion, D.E., King, J.S., and Covington, H.R., 1983, Holocene basaltic volcanism along the Great Rift, central and eastern Snake River Plain, Idaho: Utah Geological and Mineral Survey Special Studies 61, Guidebook, pt. 3, p. 1-34.

Kuntz, M.A., Champion, D.E., Spiker, E.C., and Lefebvre, R.H., 1986, Contrasting magma types and steady-state, volume-predictable basaltic volcanism along the Great Rift, Idaho: Geological Society of America Bulletin, v. 97, p. 579-594.

Kuntz, M.A., Champion, D.E., Lefebvre, R.H. and Covington, H.R., 1988, Geologic map of the Craters of the Moon, Kings Bowl, and Wapi lava fields and the Great Rift volcanic zone, south-central Idaho: U.S. Geological Survey iscellaneous Investigations Series Map I-1632, Scale 1:100,000.

Kuntz, M.A., Covington, H.R., and Schorr, L.J., 1992, An overview of basaltic volcanism of the eastern Snake River Plain, Idaho, in Link, P.K., Kuntz, M.A., and Platt, L.B., eds., Regional geology of eastern Idaho and western Wyoming Geological Society of America Memoir 179, P. 227-267.

Leveson, D., 1972, A sense of the Earth: Anchor Natural History Books, New York, 176 p.

Malde, H.E., 1968, The catastrophic late Pleistocene Bonneville Flood in the Snake River Plain, Idaho: U.S. Geological Survey Professional Paper 596, 52 p.

Malde, H.E., 1987, Shoshone Falls, Idaho; a Pleistocene relic of the catastrophic Bonneville Flood in Buess, S.S. ed., Rocky Mountain Section of the Geological Society of America: Boulder, Colorado, Geological Society of America, Centennial Field Guide 2, p. 135-137.

Malde, H.E., 1991, Quaternary geology and structural history of the Snake River Plain, Idaho and Oregon, in Morrison, R.B., ed., Quaternary nonglacial geology: conterminous United States: Boulder, Colorado, Geological Society of America, the Geology of North America, v. K-2, p. 251-281.

Maley, T.S., 1975, An occurrence of orbicular rocks near Shoup, Idaho: Geological Society of America Abstracts With Programs, v. 7, no. 5, p. 626.

Maley, T.S., 1987, Exploring Idaho Geology: Mineral Land Publications, Boise, Idaho, 232 p.

Maley, T.S. and Oberlindacher, P, 1993, Bedrock erosion in the lower Big Wood River channel, south central Idaho: Geological Society of America Abstracts with Programs, v. 25, no. 5, p. 113.

Maley, T.S. and Randolph, R., 1993, New program to identify and manage unique and geologically significant resources on federal lands: Geological Society of America Abstracts with Programs, v. 25, no. 6, p. A313-14.

Maley, T.S., and Oberlindacher, P., 1994a, Scientifically significant geological features of the upper Snake ecosystem: Geological Society of America Abstracts with Programs, v. 26, no. 7, p. A-350.

Maley, T.S. and Oberlindacher, P., 1994b, Rocks and potholes of the Big Wood River, south-central Idaho: Idaho Geological Survey nformation Circular 54, 41 p.

Maley, T.S. and Randolph, R., 1994, Unique and geologically significant resources on federal lands in Wick, C., ed., Proceedings of the Geoscience Information Society, v. 24, p. 197-204.

Maley, T.S. and Oberlindacher, P., 1995, Scientifically significant features of the Upper Snake Ecosystem in Haner, B.E. and O'Donnell, J., eds., Proceedings of the Geoscience Information Society, v. 25.

Martini, G., 1994, The protection of geological heritage and economic development: the saga of the Digne ammonite slab in Japan, in O'Halloran, D., Green, C., Harley, M.,Stanley, M., and Knill, J., eds., Geological and Landscape Conservation, Geological Society, Londo, p. 383-386.

McAdam, D., 1994, Edinburgh, a landscape fashioned by geology: British Geological Survey, Edinburgh, Scotland, 27 p.

McDonald, G., 1993, Hagerman fossil beds, Hagerman, Idaho: Rocks and Minerals, v. 68, p. 322-326.

Meinzer, O.E., 1927, Large springs of the United States: U.S. Geological Survey Water-Supply Paper 557, 94 p.

Murtaugh, J.G., 1961, Geology of Craters of the Moon National Monument, Idaho [M.S. Thesis]: Moscow, University of Idaho, 99 p.

National Park Service. 1994. National Registry of Natural Landmarks, U.S. Department of the Interior, Washington, D.C., 136 p.

O'Connor, J.E., 1993, Hydrology, hydraulics, and geomorphology of the Bonneville Flood: Boulder, Colorado, Geological Society of America Special Paper 274, 83 p.

Prinz, M., 1970, Idaho rift system, Snake River Plain, Idaho: Geological Society of America Bulletin, v. 81, p. 941-947.

Rossbacher, L.A., 1995, The geological column: Geotimes, v. 40, no. 12, p. 44.

Russell, I.C., 1902, Geology and water resources of the Snake River Plain of Idaho: U.S. Geological Survey Bulletin 199, 192 p.

Savoy, L.E., 1992, Encounters with the land: GSA Today, v. 2, no.10, p. 215-218.

Spicer, R.C., 1987, Selecting geological sites for national natural landmark condsideration: Natural Areas Journal, v. 7 (4), p. 1157-1178.

Spiteri, A., 1994, Malta: a model for the conservation of limestone regions, in O'Halloran, D., Green, C., Harley, M., Stanley, M., and Knill, J., eds., Geological and Landscape Conservation, Geological Society, London, p. 205-208.

Stearns, H.T., 1928, Craters of the Moon National Monument, Idaho: Idaho Bureau of Mines and Geology Bulletin 13, 57 p.

Walker, Jr., D.E., 1988, Protecting American Indian sacred geography: Northwest Anthropological Research Notes, v. 22, no. 2, p. 253-266.

Whitehead, R.L. and Covington, H.R., 1987, Thousand Springs area near Hagerman, Idaho in Buess, S.S., ed., Rocky Mountain Section of the Geological Society of America: Boulder, Colorado, Geological Society of America, Centennial Field Guide, v. 2, p. 131-134.

GEOPHYSICAL INSTITUTE'S KEITH B. MATHER LIBRARY: DESIGN AND PLANNING FOR THIS NEW FACILITY--OPENING 1998

Julia H. Triplehorn

Geophysical Institute
P.O. Box 757320
903 Koyukuk Dr.
Fairbanks, AK 99775-7320

ffjht@acad3.alaska.edu

Abstract — The Keith B. Mather Library at the Geophysical Institute, University of Alaska Fairbanks will open December 1998. The library will serve the Institute research staff, and two government agencies: Fairbanks Forecast Office of the National Weather Service and the College International Observatory of the U.S. Geological Survey. An agreement has been signed for an International Arctic Research Center. Scientists from around the world will be participating in the new arctic global research center and will also be using the library facilities to support their research. This poster session will describe the design for this library with emphasis on some of the new features: self service checkout, motion sensor lighting, tables wired for lights and computers and earthquake safety considerations.

Editor's Note: Although Julia Triplehorn was not able to present this poster at the 1996 GIS Poster Session, this abstract is included because it was accepted as part of that poster session.

ISBN: 0-934485-28-3
ISSN: 0072-1409