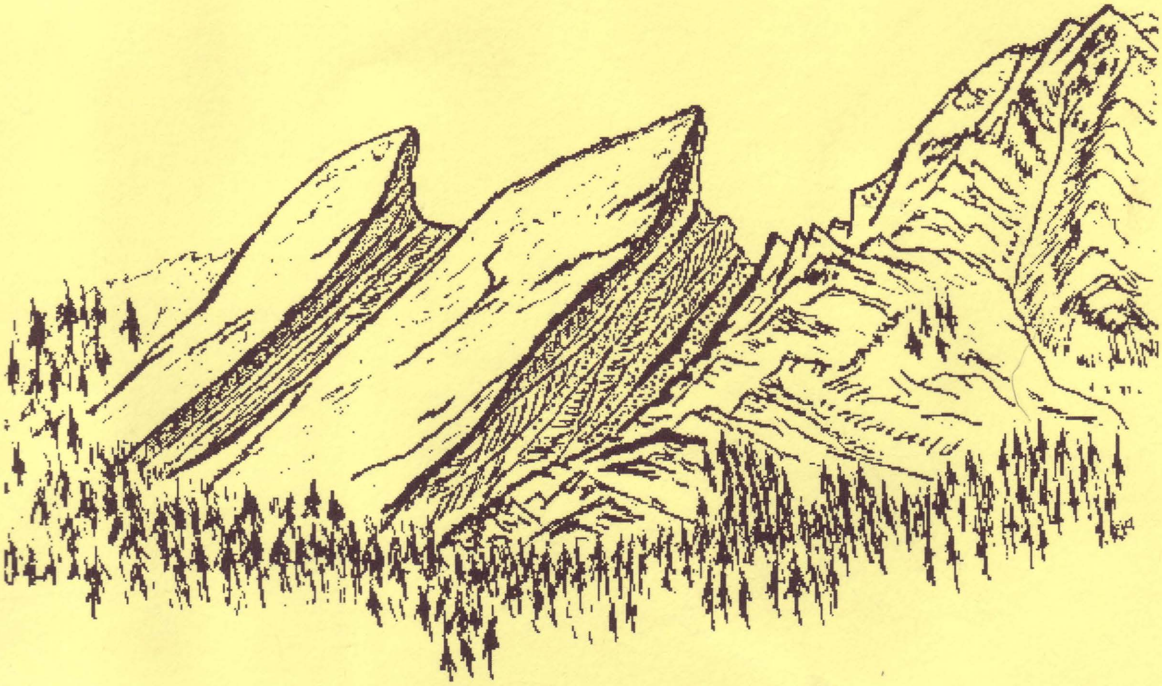
GEOSCIENCE INFORMATION SOCIETY



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Cover Illustration: Colorado Front Range of the Rocky Mountains drawn by Dick Gibson

TABLE OF CONTENTS

Geological Time and CHRONOS: Databases, Tools, Outreach, Education, and the Geoinformatics Revolution (continued)

Geological Time and CHRONOS: Databases, Tools, Outreach, Education, and the Geoinformatics Revolution (continued)

Geological Time and CHRONOS: Databases, Tools, Outreach, Education, and the Geoinformatics Revolution (continued)

FIELD TRIP

PREFACE

This volume represents the proceedings of the sessions sponsored by the Geoscience Information Society at its thirty-ninth annual meeting held in conjunction with the Geological Society of America (GSA) annual meeting in Denver, Colorado in November 2004. The posters and papers presented at the geoscience information sessions are followed by the abstracts of papers from the special sessions on geoinformatics. Because the GSA's new journal *Geosphere* will feature the full versions of many of the papers presented at the geoinformatics sessions, only the abstracts are included herein.

In addition to the poster and paper sessions, the Geoscience Information Society held discussion sessions on electronic resources, preservation, collection development, and professional issues – some parts of which are reported in the *GSIS Newsletter*. A field trip to the Boulder, Colorado area was also held. The trip included stops at the Celestial Seasonings tea factory, the Leanin' Tree Museum of Western Art, and the National Center for Atmospheric Research where the group toured their library and hiked the weather trail.

This volume would not have been possible without the contributions of many. I thank Dick Gibson for granting permission to include his description and illustration of the geology of the Fountain Formation near Boulder in this volume and all the authors for their contributions. The Geological Society of America granted permission to reprint many abstracts. Finally, I want to thank Doris Herr for her able and amiable assistance in the preparation of this volume.

Linda R. Musser, editor.

ACCESSING GEOSCIENCE INFORMATION IN THE DIGITAL AGE

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Abstract -- Modern geoscience information comes in many forms: a CD-ROM or DVD with digital data or documents on one or more topics, a publication, map or data on a Web site, or a print publication. As government agencies move to economize, electronic publications are becoming more common than print publications. As a result, locating this information is becoming increasingly more difficult. Depending on format, some geoscience information is still not available in online catalogs. When records are available, they may not provide an adequate description of an item to allow users to determine whether an item contains the information they need. Finally, Web search engines may not be able to locate information because of the way that information is presented on agency Web sites.

This study examined access to geoscience information from federal and state agencies, including both print and digital products. Among the questions asked were: whether online catalogs and cataloging records provide enough information to allow users to find needed information, whether standard Internet search engines can locate data, publications and maps on agency Web sites, whether bibliographic information on agency Web sites can be searched with Internet search engines, whether the digital information can be located using publication databases, such as GeoRef and the National Geologic Map Index. All of these factors must be considered when providing reference service, instructing library users and developing library collections. Finally, suggestions on how government agencies and libraries might remedy these problems are provided.

INTRODUCTION

In 1987, the U.S. Geological Survey published 1636 items. Of those, 262 were maps, 196 were books, 1078 were fiche, 7 were serials, 3 were computer files, 2 were visual items (probably posters) and 1 is now on the Internet. GeoRef has 5 URLs listed for items published that year. In 2003, the U.S. Geological Survey published 1063 items. Of those, 66 were maps, 255 were books, 12 were fiche, 0 were serials, 5 were computer files, 0 were visual items and 954 can be viewed on the Internet. GeoRef has 1142 URLs listed for items published that year. From these statistics, it is clear that both the information available to our libraries and our users have changed. Information about the entire world is accessible on our computers. A recent poll of 1400 scientists by the Science Advisory Board indicated that their greatest frustration is limited access to online full-text documents (Science Advisory Board, 2004). Many of our users would prefer to use an item online rather than come to the library and look at a print volume. But a GeoRef search may not provide all of the information needed to access electronic geoscience information.

Many government earth science agencies are publishing their information in multiple formats which are accessible through various means. As a result, the usual online catalog search may not provide access to all resources. One possible solution to these problems could be federated searching, which allows users to search many resources at once, including their local library's online catalog, a bibliographic database such as GeoRef, and even the Internet. Given the wide variety of materials available on the Internet from federal and state agencies, the possibility that a given user will locate relevant information using a federated search should increase. However, in reality, there are a lot of reasons why digital resources can and cannot be located. Among the questions to ask about locating digital geoscience information are:

- Do records in online catalogs provide enough information to find materials?
- Can online catalogs and databases be used to locate data, publications & maps on agency Web sites?
- Can information on agency Web sites be located with Internet search engines?
- Can digital information be located using databases such as WorldCat, GeoRef and the National Geologic Map Index?

ACCESS TO GEOSCIENCE INFORMATION IN ONLINE CATALOGS

The *Landview 6* DVD and the *Global GIS Database: Digital Atlas of North America* are two examples of modern digital geoscience information. The *Landview 6* DVD contains Census Data, the Geographic Names Information System, which used to come on a separate CD-ROM, and Envirofacts data from the U.S. Environmental Protection Agency. The *Global GIS Database: Digital Atlas of North America* contains geospatial data for boundaries, relief, hydrology, geology, seismicity, places, transportation, utilities, population, ecological regions, volcanoes and ore deposits. So, what kind of subject access do these resources have in our online catalogs?

The subject headings used for *Landview 6* are:

United States - Census 22nd – Maps
United States – Maps

The *Global GIS Database: Digital Atlas of North America* subject headings are:

North America – Maps

It is obvious that people looking for specific digital spatial information about their area are not going to find it with these types of subject headings. Hopefully, they will know a librarian who has memorized the contents of these digital products and will ask for assistance. These examples indicate that digital materials, especially DVD products that may contain more than one set of data, need to be cataloged so that their entire contents can be located.

ACCESS TO GEOSCIENCE INFORMATION IN DATABASES

According to Google, there are "about 550,000 links" to Web sites that contain "usgs.gov" in their URL. How well are we doing at identifying, cataloging and indexing this content? Someone using the online catalog at Indiana University would find 1803 online publications from the U.S. Geological Survey; people using other libraries that have loaded the Marcive catalog records would find a similar number. As of November 2004, the GeoRef database contained records for 6093 online publications from the U.S. Geological Survey, while WorldCat contained records for 3172 online publications.

Usually, specific digital content can only be located with a precise search. I have worked with several people looking for articles from the *Middle Rio Grande Basin Study Workshop Proceedings*, which were held between 1996 and 2000. The Study's unofficial Web site, which is no longer being maintained, has links to the 1996, 1998 and 1999 workshops (USGS Rocky Mountain Mapping Center, 2001). The official Web site doesn't provide links to any of the proceedings (U.S. Geological Survey, 2004). So, how accessible are the digital proceedings in a Federated Search? Libraries that have loaded Marcive records will find information on the 1996, 1998 and 1999 proceedings, which have been sent to libraries as microfiche. WorldCat provides records for these same proceedings in microform or print, but not the online versions. GeoRef does not provide any links to the online workshop proceedings. Finally, the USGS Library catalog has records for the 1996, 1998, 1999 and 2000 proceedings, but provides a link only to the online proceedings from 2000. Given that most people do not want to sit down and read the microfiche, one solution would be to provide links to the online workshops in our local OPACs and WorldCat. Since this is not yet an option, users will have to resort to an Internet or federated search to find the digital items. Unfortunately, they will only be found by doing extremely precise searches in Google or the USGS Web site (Middle Rio Grande Basin Proceedings). A search of the USGS Web site provides 2278 hits on "Middle Rio Grande Basin Proceedings," while Google yields "about" 14,200 items. It is clear from this example that materials that are available in multiple formats have to be cataloged and indexed so that their digital counterparts can be located.

LOCATING DATA, PUBLICATIONS AND MAPS ON STATE GEOSCIENCE AGENCY WEB SITES

State geoscience agencies are important sources of data, publications and maps about their areas. To economize, many of these agencies are now publishing their reports in digital format, either on CD-ROM or online (Figure 1). These agencies provide access to these publications through various means, either a publication list in the form of a PDF or HTML document or through a database (Figure 2). Alabama provides their publication list in the form of an Excel spreadsheet, while Massachusetts does not provide any information on their publications. However, just because a publication list is available on a Web site, doesn't mean that the publications will be found using a federated search system or Internet search engine (Figure 3). Generally, publication lists in HTML format are searchable but there are some exceptions, as in the case of Arizona. Some PDF documents can also be searched with an Internet search engine. However, databases can only be searched by federated search systems and Internet search engines if an Internet interface to the database has been developed.

For the most part, Internet search engines and Federated searches will not solve the problem of providing access to digital state geological survey publications. The Montana Bureau of Mines and

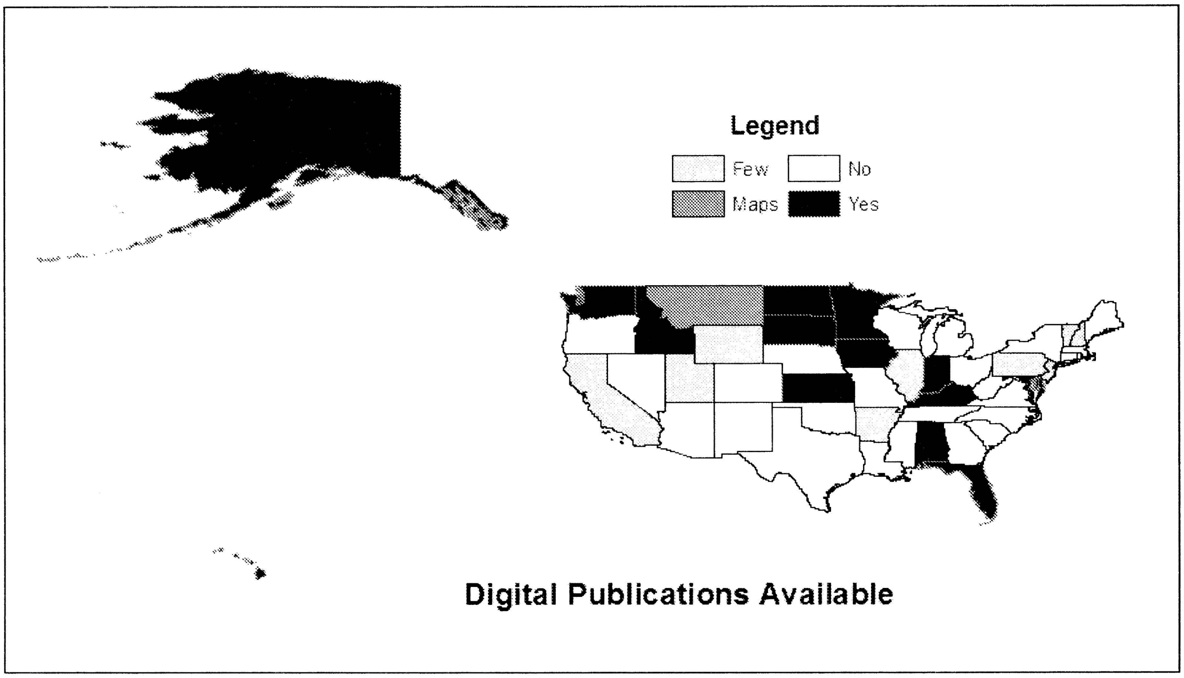

Figure 1. Map showing states with online publications on their state geological survey Web sites.

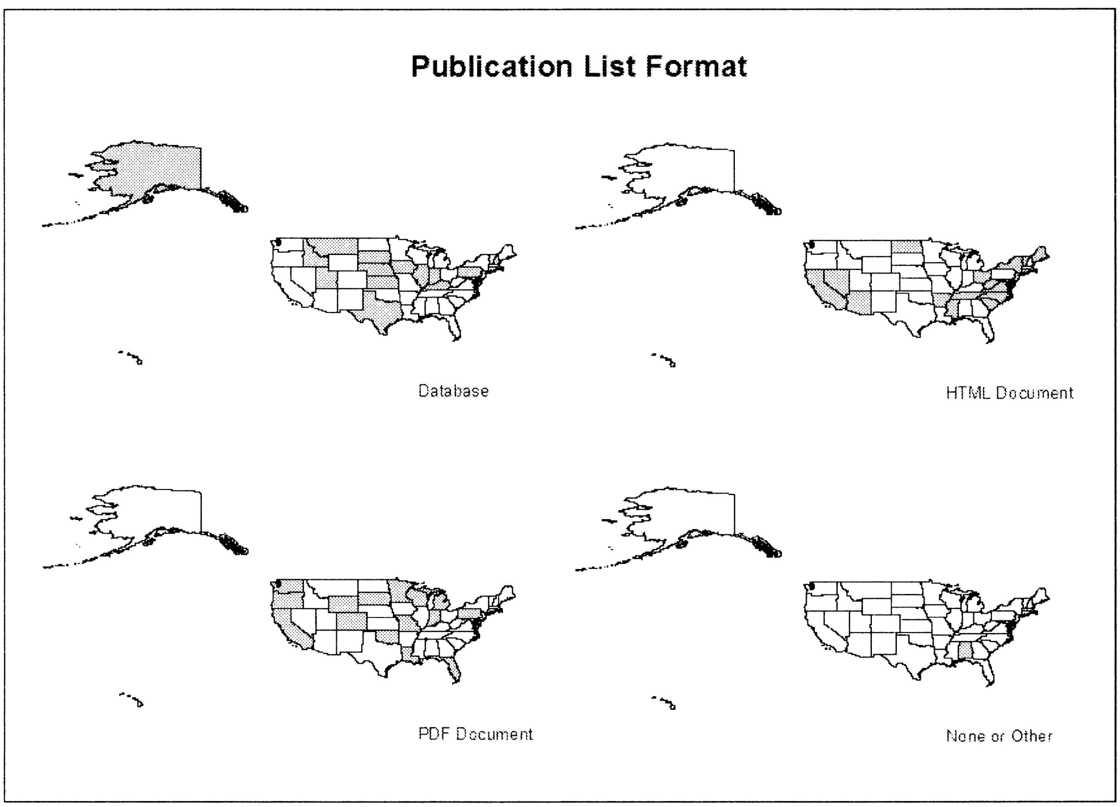

Figure 2. Map showing format of publication lists on state geological survey Web sites.

Geology, which has a large number of digital maps available, is a good example of why information is not readily accessible. The MBMG provides an index map (Figure 4) from which users can perform a search for a map of a particular area (Montana Bureau of Mines and Geology, 2004). Thus, a user who wants to link to the map for the Bozeman area can click on the map to search for the Bozeman map in the MBMG publication database. The search yields an intermediate Web site that provides basic bibliographic information and a link to another Webpage with information on the citation and links to the entire map, the map in sections, or the report (Figure 5). However, a user who searches for the exact title of that map, or the words "Bozeman Geologic Map" with an Internet search engine will not find it. The top level metadata for the Web site shown in Figure 5, viewed by clicking View-Source in an Internet browser, provides minimal information at best:

```
<HTML>
<HEAD>
<TITLE>MBMG Publication Search</TITLE>
</HEAD>
```

Another solution to the metadata problem could be provided from the index map site. But the metadata for that site isn't much better:

```
<HTML>
<HEAD>
<TITLE>State Map Program</TITLE>
</HEAD>
```

In order for information to be found using an Internet search engine, Web page metadata must be specific. The ideal solution would be to add a more descriptive title and keywords for all of the quadrangles that appear on the index map to the Web site with the index map. That metadata would be similar to the metadata shown below:

```
<HTML>
<HEAD>
<TITLE>Montana State Geologic Map
Program</TITLE>
<META content="Montana; Geology; Geologic
Map; Geological Map; Bozeman; Bridger;
Hebgen Lake; [add other quadrangle names here];
Quadrangle" name=keywords>
</HEAD>
```

However, even when a state survey offers access with an HTML document, the publications on that document may not be found. The Arizona Geological Survey's publication list is one very long document that lists all of the publications available from the Survey. Internet search engines usually will not index extremely long HTML publications.

Links to digital state geological survey publications should be available in databases, such as GeoRef or the National Geologic Map Database. But neither of these databases has records for the digital Montana maps. Digital content from state geological surveys will only be included in these databases if the organization reports information about their publications to database producers. Even if the Montana maps were included in the National Geologic Map Database, they probably would not be found with an Internet or federated search, because these search engines do not automatically search Web databases. An interface to free databases, such as the National Geologic Map Database, has to be programmed before it can be searched. CSA, Dialog or OVID databases are fine, but when it comes to some of the federal and state agency databases, users will have to wait for the programmers to work their magic.

CONCLUSIONS

Geoscience information comes in a variety of forms, including digital, which geoscience information librarians and users will have to learn to deal with. In order to provide access to this information, some changes will have to be made. Digital materials on CD-ROM and DVD must be cataloged so that their entire contents can be located. This is especially true of CD-ROMs and DVDs with multiple data sets. Items available in multiple formats have to be cataloged and indexed so that their digital counterparts can be located.

Federated search systems and Internet search engines will not solve the problem of locating digital information about specific areas for a number of reasons. Long HTML documents may not be indexed by Internet search engines; agencies that provide publication lists in HTML form should divide their lists so that search engines will be able to index them. In order for information to be located using a federated search system or an Internet search engine, Web page metadata must be specific. At present, most metadata on agency Web pages is often too general. Finally, agencies that provide access to publications using a database must develop interfaces so that their databases can be searched by Internet search engines.

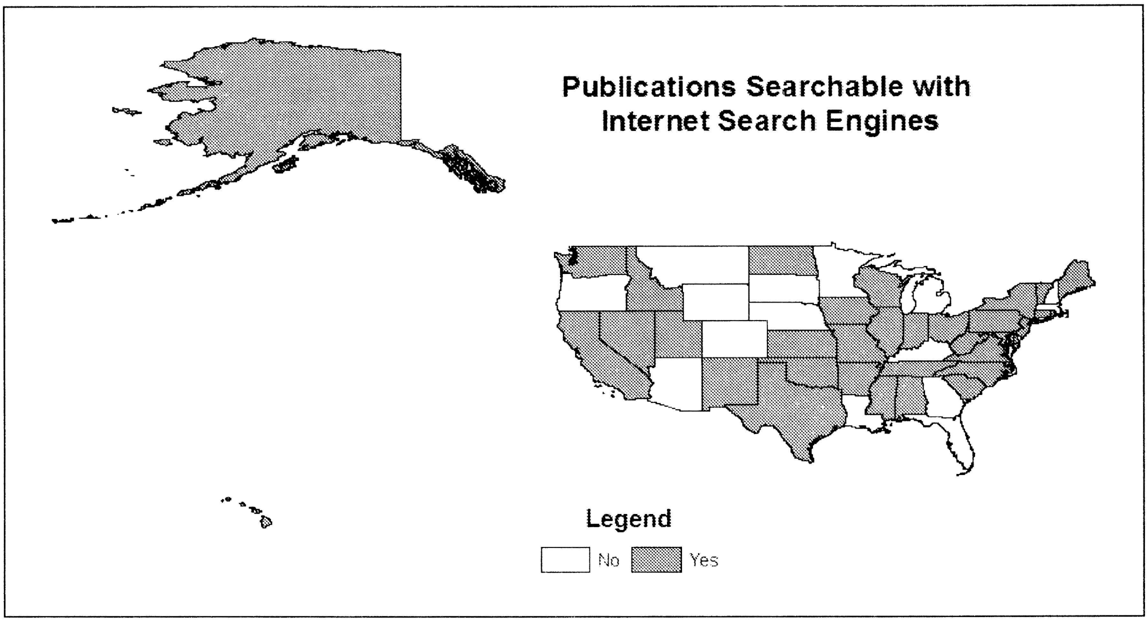

Figure 3. Map showing states with publication lists that can be searched using Internet search engines.

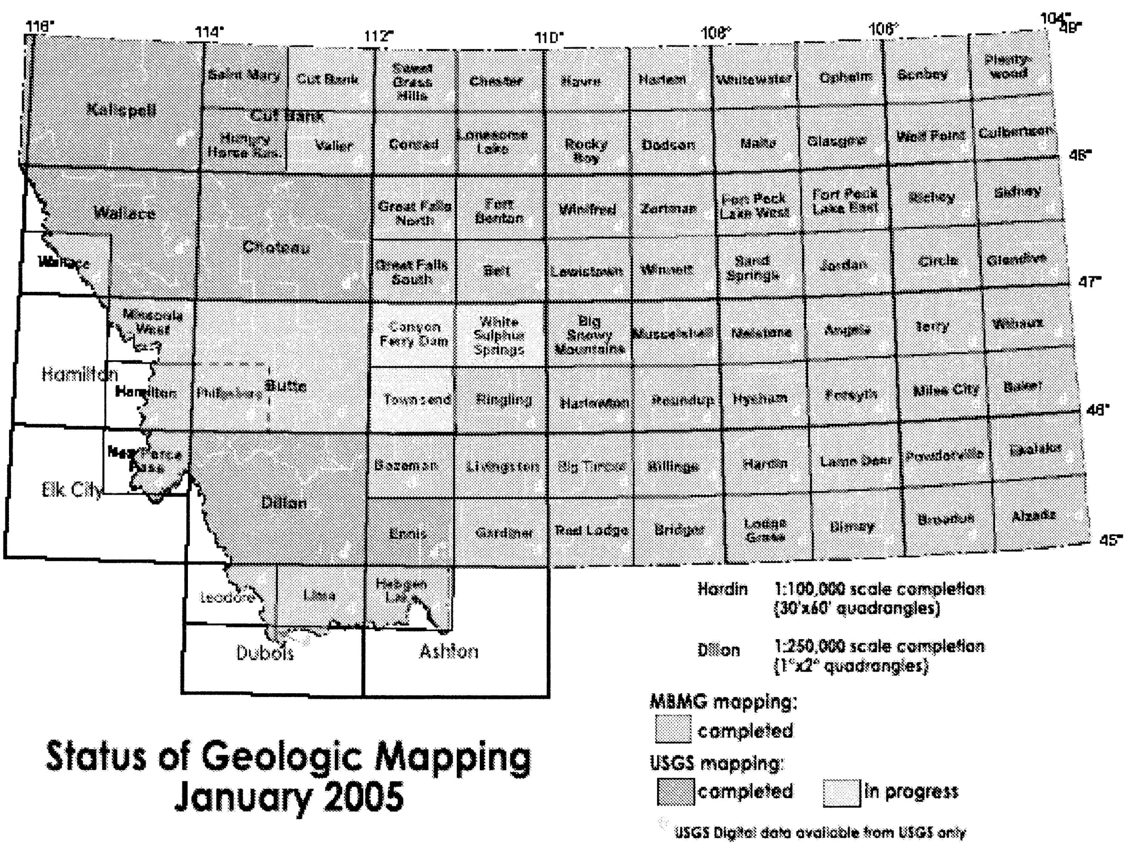

Figure 4. Index map to digital geologic maps available from the Montana Bureau of Mines and Geology (Montana Bureau of Mines and Geology, 2004).

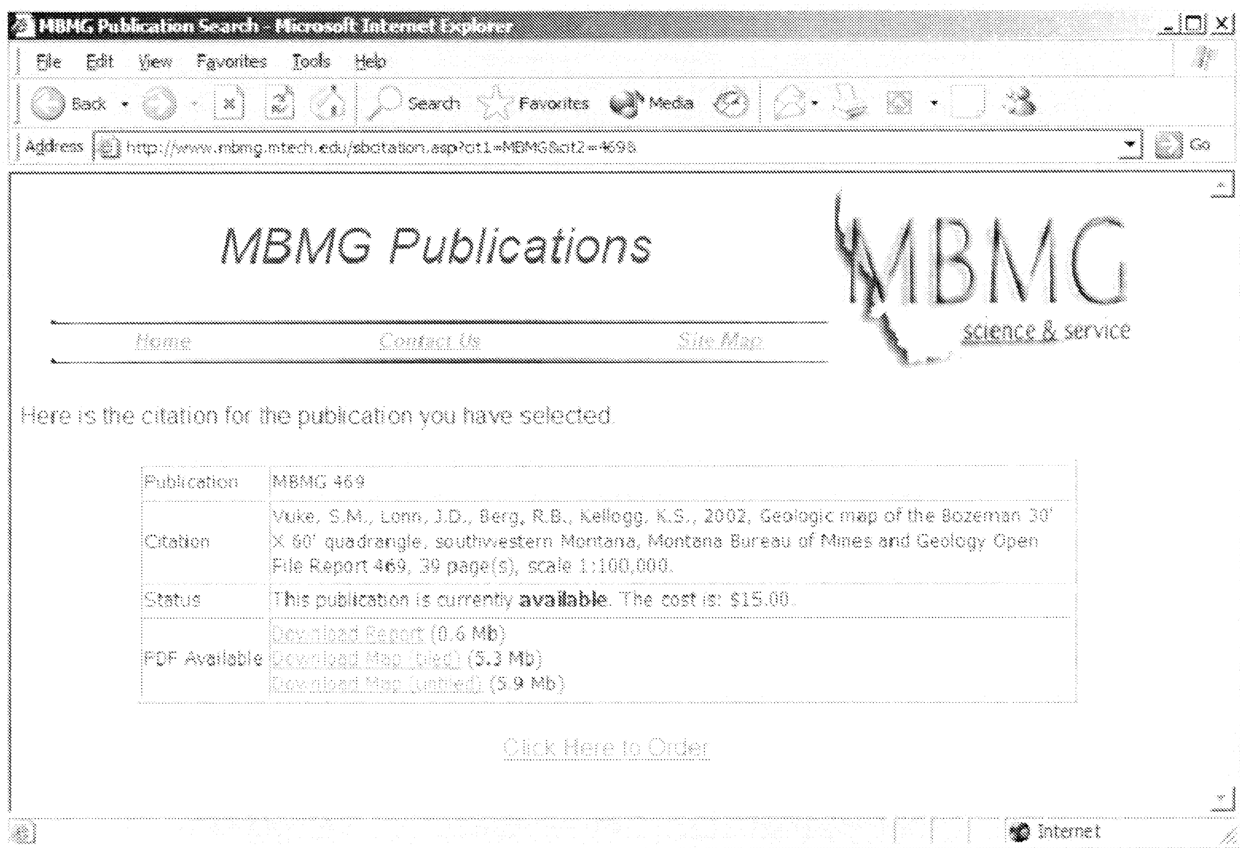

Figure 5. Image showing search results obtained from Montana Bureau of Mines and Geology map interface (Vuke, et al., 2002).

REFERENCES

Montana Bureau of Mines and Geology, 2004. *State Geologic Mapping Program*. Accessed January 24, 2005. http://www.mbmg.mtech.edu/stmap.htm.

Science Advisory Board, 2004. Scientists Frustrated with Limited Access to Full-Text Documents. *SAB News* October 10, 2004. Accessed January 24, 2005. http://www.scienceboard.net/community/news/news.214.html.

U.S. Geological Survey, 2004. *Middle Rio Grande Basin Study*. Accessed January 24, 2005. http://nm.water.usgs.gov/mrg/index.htm.

USGS Rocky Mountain Mapping Center, 2001. *Middle Rio Grande Basin Study*. Accessed January 24, 2005. http://rockyweb.cr.usgs.gov/html/mrgb/.

Vuke, S.M., Lonn, J.D., Berg, R.B., Kellogg, K.S., 2002. *Geologic map of the Bozeman 30' X 60' quadrangle, southwestern Montana*. Montana Bureau of Mines and Geology Open File Report 469, 39 page(s), scale 1:100,000. Accessed January 24, 2005. http://www.mbmg.mtech.edu/sbcitation.asp?cit1=MBMG&cit2=469&.

SEARCHING FOR CURRENT INTERNATIONAL GEOSCIENCE LITERATURE

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Abstract -- Keeping up with the literature, efficiently finding the most relevant literature, and conducting comprehensive geoscience literature searches in today's changing world of publication and accessibility is challenging. How well do the geoscience information tools meet this challenge? A comparison study of two geoscience databases, one science database and one Internet search engine looked at the geographic coverage, subject content, source material indexed, formats included, and currency of each in an attempt to be better able to recommend information tools to researchers. The databases included in the study were: GeoRef, produced by the American Geological Institute and GEOBASE, produced by Elsevier; Science Citation Index Expanded, produced by the Institute for Scientific Information; and Scirus a comprehensive science-specific Internet search engine.

INTRODUCTION

A year ago I presented a paper looking at bibliographic access to the international geological literature published before 1900 (Scott, 2003). This year I am looking at the other end of time, the international geological literature published after 2000, a century later. As opposed to limited electronic access to the older literature, we have several means of electronic access to current literature and information. The question to be answered is: "Where to start to look for geoscience information about some place outside North America?" I examined the two geoscience databases, GeoRef and GEOBASE, as well as looking at the ISI Science Citation Index Expanded and one Internet search engine, Scirus, that is described as designed for science. I used two tests in comparing the databases: international serial coverage and international subject coverage.

DATABASES

First some information about the two geoscience databases, GeoRef and GEOBASE. The GeoRef database is produced by the American Geological Institute. It "provides access to the geoscience literature of the world. GeoRef is the most comprehensive database in the geosciences and continues to grow by more than 80,000 references a year. The database contains over 2.4 million references" (GeoRef Information Services, 2004). GeoRef staff scans over 3000 journals to locate geoscience articles. A selected list of 99 journals is given priority for indexing.

The GEOBASE database is produced by Elsevier. From the description on their web page: "GEOBASE is a unique multidisciplinary database supplying bibliographic information and abstracts for development studies, the Earth sciences, ecology, geomechanics, human geography, and oceanography. The database provides current coverage of over 1,800 journals and archive coverage of several thousand additional titles. GEOBASE is unequalled in its coverage of the international literature. GEOBASE contains over 1 million records from 1980, with 76,000 records added annually" (GEOBASE, 2004).

A comparison of the serial lists for these two databases indicates 923 titles are indexed by both. Of GeoRef's 99 priority titles, 85 are also indexed in GEOBASE. The titles of the serials included in GEOBASE but not in GeoRef were examined to determine their subject orientation. Most of the titles were not geology but economics, social science, agriculture, biology or other. GEOBASE's description indicates it includes more than the geosciences.

There is another database that many researchers use, the ISI Science Citation Index Expanded. This database indexes 5,300 major journals across 164 scientific disciplines. It is therefore more inter-disciplinary than either GeoRef or GEOBASE.

The Internet search engine/database I have included in this paper is Scirus. As described on the Scirus web page: "Scirus is the most comprehensive science-specific search engine on the Internet. Driven by the latest search engine technology, Scirus searches over 167 million science-specific web pages. In addition to web pages, Scirus indexes several special sources:

- 14.6 million MEDLINE citations
- 5.5 million ScienceDirect full-text articles
- 1.2 million patents from the USPTO
- 261,000 e-prints on ArXiv.org
- 5,352 BioMed Central full-text articles
- 10,600 NASA technical reports
- 14,878 full text articles from Project Euclid

(Scirus, 2004)

This is owned by Elsevier and is available free on the Internet. There is an advanced search screen and you can limit your searches to either journals or web sites or both.

I included Scirus in this study because we often hear that the web is replacing the need for library research. Usually Google is mentioned but I chose Scirus because of the ability to also search some journals and its focus on science. A different paper another year might compare search engines for geoscience research.

INTERNATIONAL SERIAL COVERAGE

The first test was to see how well the database indexed serials published outside North America. I selected 81 international serials representing about 32 countries and currently received by the Orton Memorial Library of Geology at The Ohio State University. The list of titles is included as an appendix. The ISSN was used to search both GeoRef and GEOBASE to determine current coverage. Of the 81 titles, all 81 are covered by GeoRef with 51 being unique to GeoRef. GEOBASE included 29 of the serial titles and ISI included 13 of the titles. Scirus did not include any of the 81 titles.

Of the 81 titles, GeoRef (including the GeoRef Preview database) was over a year behind for only 7 titles. The conclusion to this part of the study is that GeoRef has more international serial coverage and with the GeoRef Preview database is fairly up-to-date.

INTERNATIONAL SUBJECT SEARCHES

My other test for comparing the international coverage is actual searches. These are simple searches not taking into account the differences in the various search engines. The results of three searches are analyzed here.

First search: keyword phrase "tropical glaciers" from 1999 to date

GEOBASE – 13 hits, 3 unique
GeoRef – 11 hits, 5 unique
ISI Science Citation Index Expanded – 27 hits, 15 unique
Scirus – 21 hits for journals, 14 unique and 392 web sites

Some observations about the results: Scirus is searching the full text of the article including the references. One of the hits was in the title of a reference, in some other cases the term appeared only once in the text. For GeoRef, three of the five unique hits were abstracts of GSA meeting papers, the other two were in international journals not covered by GEOBASE. For GEOBASE, the three unique hits are in GeoRef but the search term "tropical glaciers" did not pick them up – a difference in search engines and indexing. Of the 15 unique hits in the ISI Science Citation Index Expanded, five hits are recent (2003-2004) citations to AGU journals that have not been indexed in GeoRef. Also ISI for recent years is searching the full text therefore picking up the term that might not be in the title, abstract or index terms in GeoRef or GEOBASE. ISI database also includes other science journals, for example, *Atmospheric Chemistry and Physics*.

Second search: geological maps of Spain published after 2001.

GEOBASE – 13 hits, 5 unique
GeoRef – 1 hit
ISI Science Citation Index Expanded – 4 hits, 1 unique
Scirus – 44 hits, 43 unique

Observations about the results: Scirus is picking up the term "geological map" from figure captions providing access to maps that might not be assigned a subject heading of geological maps during database indexing. Also the most recent Elsevier journals are searchable as soon as they are published online. Seven of the hits in GEOBASE are also in GeoRef but were not picked up by the simple search strategy used. Of the five unique hits in GEOBASE, three are in international journals covered by GeoRef but references are not in GeoRef or GeoRef Previews even through references from later issues of the same journal are there.

Third search: McMurdo Dry Valleys and limited to publication year 2004.

GEOBASE – 16 hits, none unique, all were also in ISI, only 4 are duplicates of GeoRef hits.
GeoRef (and GeoRef Preview) – 12 hits, 5 unique
ISI Science Citation Index Expanded – 38 hits, 20 unique
Scirus – 13 hits, 6 unique

Observations about these search results – again the fact that ISI is a multidiscipline science database is evident, many of the ISI hits are in journals such as *Cellular and Molecular Biology*, *Polar Biology*, *Aquatic Geochemistry,* and *JGR-Atmospheres*. GEOBASE and ISI are finding articles on climate, soils, water chemistry, and bacteria, not topics usually included in GeoRef.

CONCLUSIONS AND POSSIBLE RESEARCH DIRECTIONS

1. GeoRef includes more foreign geoscience journals than GEOBASE. Does GeoRef include all geoscience journals published in the world? I do not know but this limited study indicates to me that GeoRef probably includes the major serials from most countries. GeoRef includes many scientific reports such as publications of state and national agencies. GEOBASE includes only a few of these.
2. GEOBASE is more interdisciplinary with the social sciences and business. It is worldwide in coverage but not comprehensive.
3. ISI Science Citation Index Expanded is interdisciplinary with all sciences but limited in the number of geoscience journals included.
4. Scirus is very current for selected journals and provides references to some web sites.
5. For comprehensive research, multiple databases will have to be consulted.
6. There is still a need for the reference interview and bibliographic instruction. Information is there; we just need to guide people to the proper place to start looking, teach them good search techniques and how to evaluate the results.
7. There are some new players coming that we need to watch and evaluate, such as Scopus, Google Scholar, and the development of the semantic web.

REFERENCES

GEOBASE, 2004, http://www.elsevier.com/wps/find/bibliographicdatabasedescription.cws_home/422597/description#description, Elsevier (Accessed October 25, 2004).

GeoRef Information Services, 2004, http://www.agiweb.org/georef/index.html, American Geological Institute (Accessed October 25, 2004).

Scirus, 2004, "About us", http://www.scirus.com/srsapp/aboutus/, Elsevier (Accessed October 25, 2004).

Geoscience Information Society Proceedings, 2004, v. 34, p. 105-108.

APPENDIX – SERIAL LIST

Acta geodaetica et geophysica Hungarica
Acta geologica polonica
Acta palaeontologica Polonica
Alcheringa
Anuarul Institutului de Geologie si Geofizica
Australian journal of earth sciences
Australian journal of mineralogy
Berichte der Deutschen mineralogischen gesellschaft
Beringeria
Boletim (Instituto Geologico (Sao Paulo, Brazil))
Boletim de geociencias da Petrobras
Boletin (Univ. Nac. Autonoma de Mexico. Inst de Geologia)
Boletin de la Real Soc Espanola de Hist Nat. Sec geologica
Bulletin - Geological Survey of Canada
Bulletin - Geological Survey of Western Australia
Bulletin (Council for Geoscience (South Africa))
Bulletin (Norges geologiske undersokelse)
Bulletin de la Societe geologique de France
Bulletin of the Geological Society of Denmark
Chemie der Erde : Beitrage zur chemischen Mineralogie,...
Chishitsu chosa kenkyu hokoku/ Bull. Geol Survey of Japan
Chishitsu Chosajo hokoku/ Report Geol. Survey of Japan
Coloquios de paleontologia
Cuadernos de geologia iberica
Daiyonki kenkyu = The quaternary research
Di qiu xue bao = Acta geoscientia sinica
Di zhi xue bao = Acta geologica Sinica
Earthwise / British Geological Survey
Eclogae geologicae Helvetiae
Eiszeitalter und Gegenwart
Estudios geologicos
Folia Quaternaria / Polska Akademia Nauk
Freiberger Forschungshefte. [Reihe] C
GeoArabia
Geologica Bavarica
Geologica Belgica
Geological quarterly
Geologisches Jahrbuch. Reihe A:
Geologisches Jahrbuch. Reihe B: Regionale Geologie Ausland
Geologisches Jahrbuch. Reihe D: Mineralogie, Petr...
GFF
Grasteinen/NGU, Norges geologiske undersoke
Gu sheng wu xue bao = Acta palaeontologica Sinica
Huo shan di zhi yu kuang chan = Volcanology & mineral resources
Israel journal of earth sciences
Izvestiya. Physics of the solid earth
Journal of African earth sciences
Journal of the Geological Society of India
Kuang chuang di zhi = Mineral deposits
Meddelelser om Gronland. Geoscience
Memoir (Council for Geoscience (South Africa))
Memoir (Geological Survey (Namibia))
Memoirs of the Fukui Prefectural Dinosaur Museum
Memoirs of the Geological Survey of Belgium
Memorie descrittive della carta geologica d'Italia
MESA journal / issued by the Geological Survey of South Australia
Munchner geowissenschaftliche Abhandlunger. Reihe A,
Neues Jahrbuch fur Mineralogie. Abhandlunge
Neues Jahrbuch fur Mineralogie. Monatshefte
Newsletters on stratigraphy
Periodico di mineralogia
Professional paper / Geological Survey of Belgium
Quarterly notes/Geological Survey of New South Wales
Revista del Museo Argentino de Ciencias Naturales
Revista do Instituto Geologico
Sbornik vedeckych praci. Rada hornicko-geologicka. Doklady...
Scientific technical report (GeoForschungsZentrum Potsdam)
Scottish journal of geology
SGU series C. Research papers = Forskningsrapporter
South African journal of geology
Special paper (Geologian tutkimuskeskus (Finland))
Studia geologica Polonica
Terra Antartica
The Mercian geologist
The Palaeobotanist
Tutkimusraportti / Geologian tutkimuskeskus = Rep of Invest.
Zeitschrift fur geologische Wissenschaften
Zeitschrift fur Geomorphologie. Annals of geomorphology
Zeitschrift fur Geomorphologie. Supplementband
Zeitschrift fur Gletscherkunde und Glazialgeologie
Zentralblatt fur Geologie und Palaontologie. Teil I:

A CENTURY OF GEOLOGY LIBRARY USE: GATHERING EVIDENCE FROM THE STACKS

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Columbia University Libraries
New York, NY

Abstract -- Libraries are created in response to need. When the need no longer exists the library does not thrive. The benefits the library provides no longer merit the energy and resources required to build the collection and to keep entropy at bay. The Geology Library of Columbia University is such a library. It is the librarian's responsibility to plan and oversee the deconstruction of a collection that was built and created by librarians and faculty during the last one hundred years. In order to accomplish this task it is necessary to consider the history of the library and its collections, and to analyze its use to the extent usage can be reconstructed.

HISTORY OF THE GEOLOGY LIBRARY

The history of a branch library at Columbia University is difficult to reconstruct. Over the years detailed records and branch annual reports were often discarded. Fortunately the history of the Geology Library in the first half of the 20th century was recorded by one of its earliest librarians, Amy Hepburn (Hepburn, n.d.).

Columbia University moved to its present location in 1897. Science materials within the library's collections were placed in readings rooms and offices within the science departments (Linderman, 1959). The Geology Department, located in Schermerhorn Hall, served as repository for earth science materials until it was overwhelmed by the task of housing the collection and making it accessible to readers. The Geology faculty petitioned the University Librarian for a librarian to take charge of geology publications and in 1912 Mary Florence Wilson was selected to be the first librarian for a new Geology Library located on the main floor of Schermerhorn Hall. Miss Wilson was successful in organizing and developing the collection but she resigned in 1916 to direct the library of the American Geographical Society. She later became the librarian for the League of Nations. Miss D. Hepburn succeeded Miss Wilson in 1917 but she was soon promoted to a position in Low Library; the position of geology librarian was filled by Miss Hepburn's sister Amy in 1918. Amy Hepburn served as librarian of the Geology Library for the next 35 years.

During Amy Hepburn's tenure collections and patronage grew substantially. At the core of the early collection was the personal library of Professor John Newberry; to this core were added University Library purchases and other professors' collections, notably the personal library of Professor James Kemp in 1920. The Geological Society of America had offices in Schermerhorn Hall beginning in 1931. The Society's proximity ensured that the Geology Library could quickly and easily acquire their publications in duplicate.

The Geology Library underwent major renovation and expansion in 1946. The reading room moved up one floor, the old reading room became the map room, an internal staircase was installed to link the two floors and 8500 linear feet of shelving was added in 2-level stacks adjacent to the new reading room. Three years later the Lamont Geological Observatory (now Lamont-Doherty Earth Observatory) was established in Palisades, New York, 17 miles north on the west side of the Hudson river. Immediately Geology Library staff developed a branch library to serve the basic information needs of the Lamont community. This branch became the present Geoscience Library.

Between 1949 and 1979 the Geology Department faculty migrated to Lamont. In 1979 the Geology Department's administrative staff relocated to Lamont as well (Simpson, 2004). By the 1960's the Geology Library's map collection had become a multidisciplinary, research level resource serving all of the University. It was renamed the University Map Room and was relocated to the Lehman Library in the School of International and Public Affairs building. However, by the mid-1980's the University Map Room's usage had dwindled and the geology librarian and government documents librarian were charged with deconstructing the map collection. That project was a portent of the task now being planned for the Geology Library collection.

PURPOSE AND METHODOLOGY

Recently administrators from the University Libraries, Lamont-Doherty Earth Observatory and the Dept. of Earth and Environmental Science have discussed the need for a new library for the Lamont campus and a central science library for the Morningside (main) campus of Columbia University. The Geology/Geoscience librarian was asked to determine what parts of the Geology Library collection would go into each of these proposed new facilities and what materials should be consigned to Columbia University Libraries' offsite storage facility.

Identifying what Geology Library materials had been used and what materials were likely to receive use in the future was critical in devising a good plan for collection deconstruction. Since a substantial part of the Geology collection had only recently been represented in the online catalog, use data could not be obtained easily. The Geology/Geoscience librarian in consultation with the Lamont Library Advisory Committee developed criteria for selecting monographs for a new library facility on the Lamont campus. Serial use also was examined where data is available but the methodology described here can be applied only to monographs. It was agreed that only materials used three or more times since 1960 were appropriate for removal to Lamont. The year 1960 was selected because materials used from that date forward would reflect information needs affected by the development of plate tectonic theory. Monograph use was identified by date-due stamping or other check-out marks left in the back of books. Approximately 25 students inventoried the Geology Library monograph collection. Students recorded zero use, 1, 2 or 3 or more uses, the last date due stamped in the books, and specifically noted if there were 3 or more uses since 1960.

RESULTS

Approximately 55% of the monograph collection's 25,000 plus titles showed no evidence of use (figure 1). More than 37% of the monographs showed signs of some use while little more than 7% (approximately 1900 titles) met the criteria for inclusion in a new library at Lamont. The Geology Library contains a great deal of material outside the parameters of traditional geology publications. Analysis of materials falling into QE and 550 classes showed that 60% of the monographs showed no evidence of use (figure 2). 33% of geology monographs received some use and, as with the collection as a whole, 7% met the criteria for selection. At a finer level of analysis specific geology subject areas revealed only a small divergence from the overall trend. Petrology materials, for example, have seen somewhat greater use (figure 3). 50% of petrology monographs showed no indication of use, while 40% had some use and 10% met the criteria for selection.

Although the levels of use for monographs in this collection followed a similar trend, one interesting usage pattern became evident. Among the materials showing 3 or more uses since 1960, materials in the Dewey classes outstripped use of LC class materials by an average of 15%. The difference is more pronounced when considering traditional geology subject materials; Dewey geology monographs received 35% more use than LC geology monographs. This is particularly notable because monographs have been classed in LC only since 1963. This data argues for the long term value of geology publications.

MORE EVIDENCE FROM THE STACKS

Among the most remarkable finds in the inventory of the Geology Library were the monthly statistical reports for the library from 1939 to 1963. These have never been cataloged and the set is probably unique within the University Libraries. This data, although incomplete, provides some sense of the changes in use of the Geology Library since 1912. Figure 4 paints a dramatic picture of the life of the library; the rapid drop in usage corresponds to the migration of its chief clientele to the Lamont campus.

CONCLUSIONS

The Geology Library at Columbia University grew to serve a remarkable Geology Department during the first half of the 20th century. That user community changed during the second half of the 20th century, both in its proximity to the Geology Library and its areas of research interest. This usage study demonstrates that only about 7% of the Geology Library monographs merit relocation to Lamont-Doherty Earth Observatory. A library cannot thrive when it has such little use as demonstrated in the usage study; deconstruction of the Geology Library collection will soon begin. The space it occupies will eventually have other uses but its collections, although they will be dispersed, will not be discarded.

REFERENCES

Hepburn, Amy L. *History of the Geology Library, 1912-1952*. Typewritten manuscript.

Linderman, Winifred B. *History of the Columbia University Library, 1876-1926*. Ph.D. dissertation, Columbia University, 1959, pp. 223-231.

Simpson, Robina. Personal communication, November 2004.

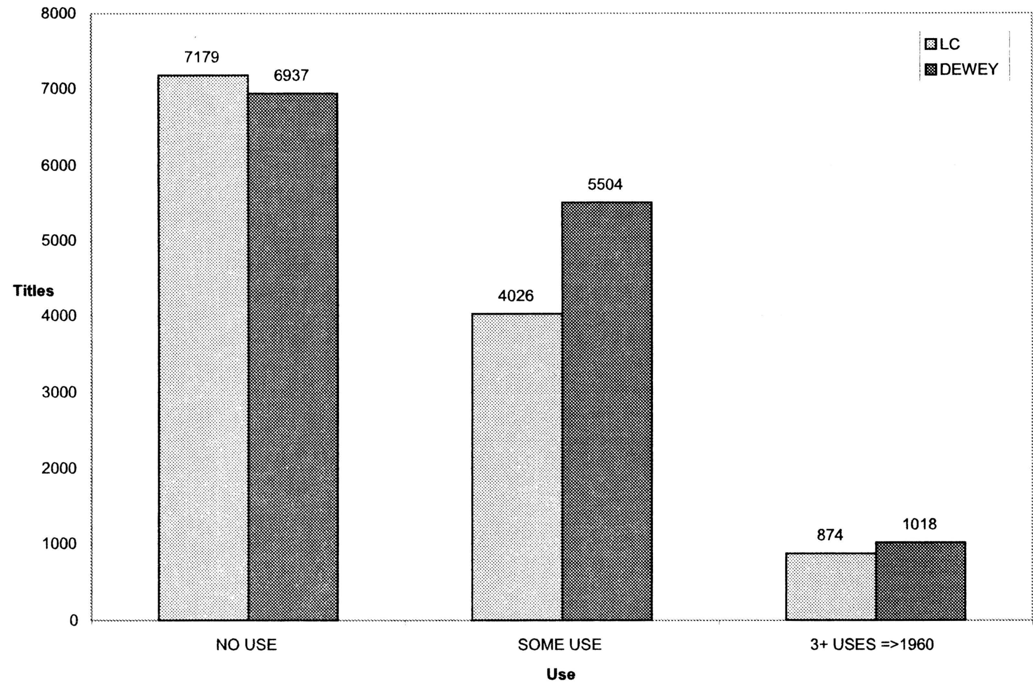

Figure 1 – Geology Library Total Monograph Use – 25540 Titles

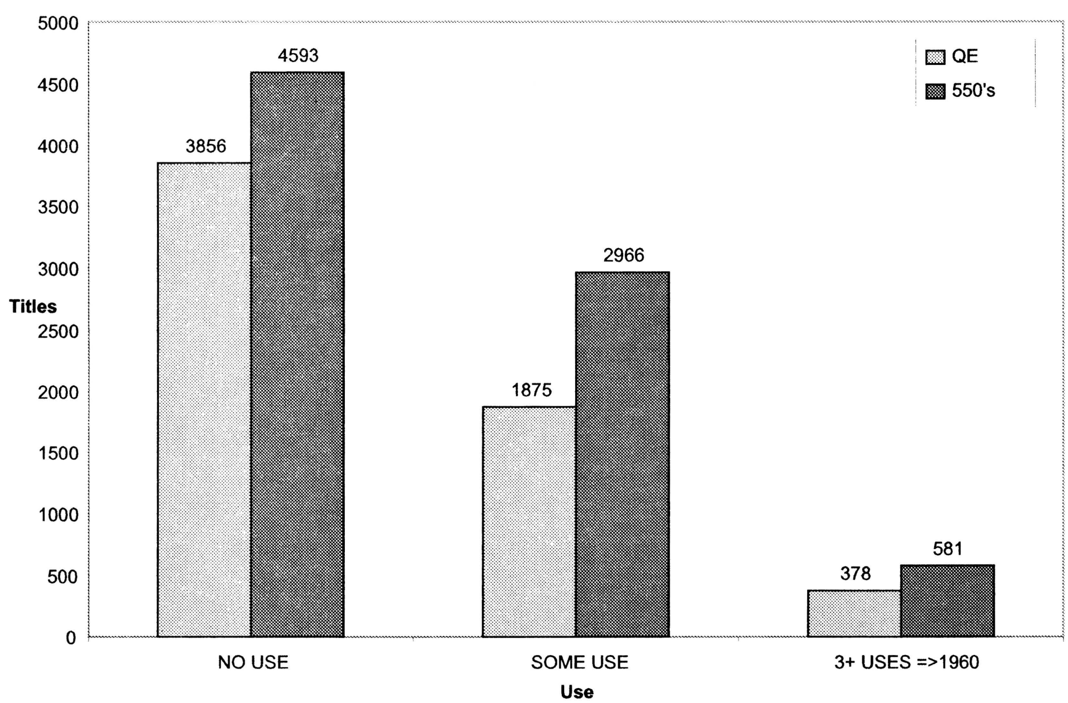

Figure 2 – Geology Library Geo Monograph Use – 14, 329 Titles

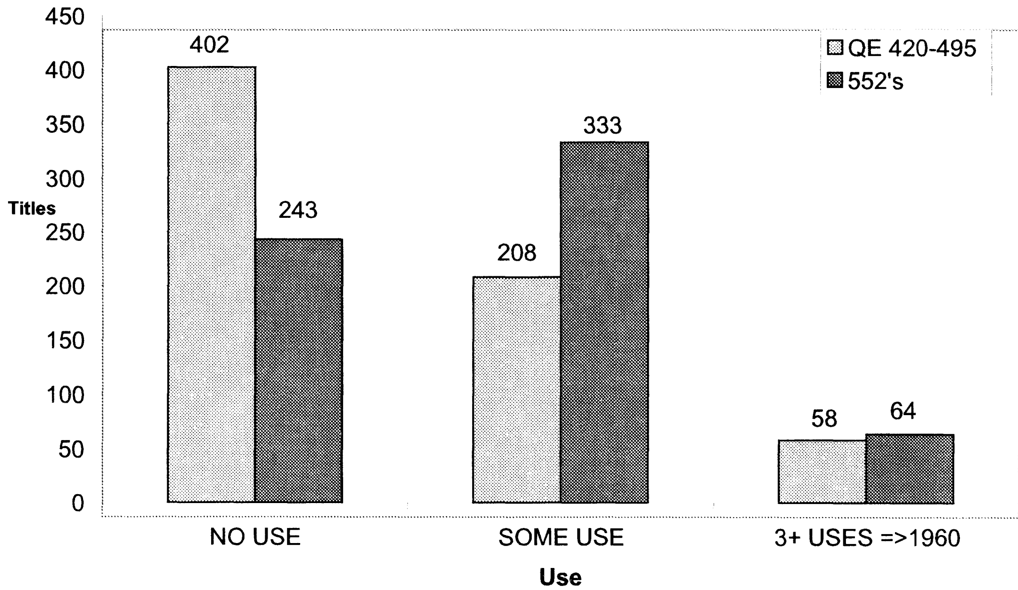

Figure 3 – Geology Library Petrology Monograph Use – 1, 308 Titles

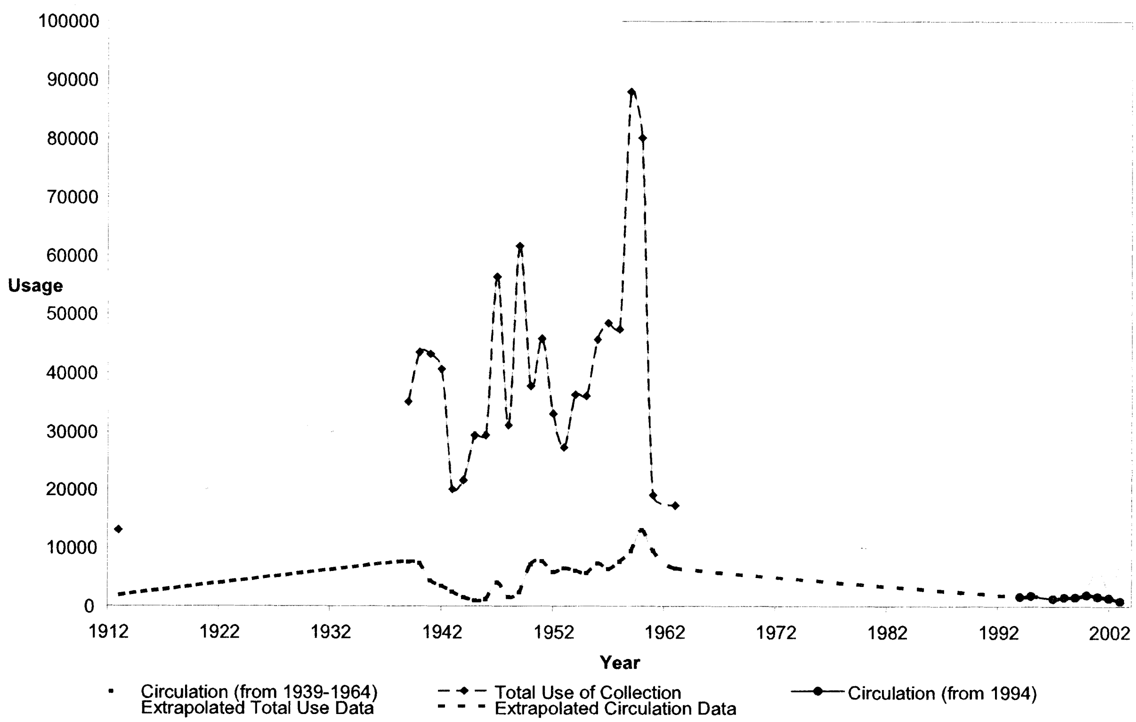

Figure 4 – Almost 100 Years of Use of the Geology Library, Columbia University

PREPARING GEOLOGY UNDERGRADUATES FOR THE PRESENT AND THE FUTURE: BIBLIOGRAPHIC INSTRUCTION AND INFORMATION LITERACY AS CORE ELEMENTS IN A TECHNICAL WRITING CLASS

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Abstract -- In the mid 1990's, the University of Colorado, Department of Geological Sciences realized that the required upper division writing class was not meeting the needs of its students. It was determined that a technical writing class focusing on the geosciences was needed. Dr. Mary Kraus was the leading proponent of this and enlisted the Head of the Earth Sciences Library to help design and co-teach the class with her. The class, Writing in the Geosciences, is required for an undergraduate geology degree. While the class has changed through the years with several different Geological Sciences faculty co-teaching, the information literacy component, focusing on research strategies, critical thinking regarding the validity of information retrieved, and knowledge of bibliographic databases, has remained a mainstay. The current faculty member teaching the class, Dr. Henrietta Laustsen, has done so for several years and works closely with the librarian organizing the syllabus and designing assignments, taking into account comments from previous class members on course evaluations. Building a resume, as a writing assignment, is also a part of the class and is taught by the librarian. This paper focuses on the role of the librarian in a team-taught scientific writing class.

BACKGROUND

In the mid 1990s faculty members in the Department of Geological Sciences at the University of Colorado recognized that the technical writing skills of the undergraduate students were very poor. The University-required upper division writing class did not address these problems. In general, throughout an undergraduate science student's college career, few papers were assigned and those assigned were graded mostly on content, rather than writing skill and format. As the undergraduate curriculum in geology was being reorganized, a writing class required for completion of a degree in geology was put into place. Ideally this class would satisfy the upper division writing core requirement, a three credit class. However, at that time all such classes had to be evaluated by the University Writing Program and certified. Few classes outside of the Writing Program were granted this status. For that reason and the fact that the number of credits for the major was close to the maximum allowed, the class was set at only one credit hour.

COURSE DESIGN

The class was originally designed by a faculty member of the Department of Geological Sciences, Dr. Mary Kraus, and the Head of the Earth Sciences Library. The basis of the class would be a library research paper on a topic of the student's choice within the broad subject of earth sciences. The class was designed to be small, a maximum of twenty students, so individual attention could be given to each student's work. The class was originally conceived as a sort of capstone class to be taken in the senior year. The rational was to send graduates of the department out into the world with good technical writing skills.

The overzealous first draft of class content required a paper, an oral presentation and other assignments. Since the class met only once a week for an hour, this proved too time consuming and all but the paper was eliminated. The first few years the class was taught, the paper was required to be at least fifteen pages long. It was built through a series of assignments that were turned in separately; an abstract, an outline, cited references, a section of the paper, illustrations and charts, the "final" paper (not a draft) and the final "final" paper (incorporating corrections of the "final" paper). Along the way the skills needed to write a good scientific paper were presented with each assignment. This involved a good dose of grammar, correct style for bibliographic citations and in-text citing, how to properly cite illustrations or charts, as well as the "voice" or style of a scientific paper. The potential for plagiarism was discussed as well. The concept of a "final" paper and a "final" final paper was developed to discourage the idea that an unfinished draft is an end product. The Faculty Course Questionnaire (student evaluations of classes and instructors required in every class by the University), uniformly showed that while some students saw merit in the class, most felt it was far too much work for one credit.

In addition to the paper, the students are required to submit a resume and cover letter, following the librarian's presentation on this topic. Since this is a form of written communication, it was thought to be appropriate for this class. Most of the students are seniors or juniors who will be looking for jobs, internships or graduate schools. The resumes are not graded, however students must meet individually with the librarian to discuss the resume and cover letter. Traditionally this has been a very popular assignment with the students.

Several different faculty members have taught the class throughout the years, always with the librarian contributing at least three sessions and attending all class sessions. For the last five years, Dr. Henrietta Laustsen has taught the class.

HOW THE CLASS HAS CHANGED THROUGH THE YEARS

As noted, the original concept was a fifteen page paper. Most of the students felt this was more work than warranted for a one credit class. The last four or five years a five page paper has been required. This is five pages of text; not counting cited references, the abstract, or illustrations, tables or graphs. There has been much less grumbling but when all of the material not counted in the five pages of text is totaled, the paper is in actuality at least ten pages long. It is all in the packaging! Peer review was also added to the class. All assignments, with the exception of the resume and cover letter, are edited by both the instructor and a peer. The instructor assigns a numeric grade and the peer reviewer does not grade the paper. The peer reviews are evaluated by the instructor as well. Recently Dr. Laustsen has begun a process of "self-editing". The paper is returned directly to the student after the lecture and the student marks corrections on his/her own work and makes the corrections on a new draft then turn both in the next week. The self editing has proven very effective. The students keep a folder of all the assignments, which is turned in with the final paper.

The biggest change and challenge in the class over the years has been the perception and use of information from the Web. When we first began in the mid 1990's, the Web was not really an issue. However, in the last few years we have had to address the use of Web resources seriously. This has tied in very well with discussions regarding evaluating scholarly material and critical thinking.

THE LIBRARY/INFORMATION LITERACY COMPONENT

It is rare when a librarian is given more than a single class period to teach research methods and library resources. This class is a true team taught class in that the instructor and the librarian are in every class together. The librarian teaches three sessions, two on research strategies and library resources and one on building a resume and writing a cover letter. Being in every class allows the librarian to comment on material presented by the instructor as well as respond to questions regarding library research issues as they come up.

The first library presentation is usually about three to four weeks into the class. This follows lectures and assignments on grammar and the concept of scientific writing. Students should have an idea of their topic by this time. This presentation focuses on research skills and evaluating types of information. Many of the students have difficulty determining if their topic is too broad or too narrow. In many cases the students pick topics with which they are not completely familiar. Using examples, we discuss creating a hierarchy of concepts to provide a better understanding of their topic. The importance of understanding and building a vocabulary in the area of their research is stressed. The students are required to run their preliminary topics by the instructor and librarian so it can determined early on if there will be any problems finding information in the scholarly record.

Types of information are discussed, such as the scholarly record vs. popular press. Various formats for information are identified: books, chapters in books or edited volumes, journal articles (both in print and online), conference proceedings, maps, and government publications.

Many of the students, even at this level, have made very little use of the bibliographic databases available through the library catalog. A variety of databases are introduced with a focus on how they work, what they cover, how they are different, and, once the student has found a reference in the database, how to find out if the library owns it or not. Explaining how to decipher citations for various types of resources is a part of this discussion as well.

This sounds quite simplistic to those have been doing research for some time. This is partially because most researchers began by using paper indexes and going to the paper journal on the shelf. The academic bibliographic databases have traditionally been set up with this structure in mind. While there have been some changes, such as links from the bibliographic database citation to the full text article or at least to the record in the catalog for the journal, this is a long way from Google. And for this reason this process is quite foreign to most undergraduates. Being computer literate is not the same thing as being library literate.

IMPACT OF THE WEB

Explaining online research has gotten much more complicated with the pervasive use of the Web for information gathering. Students tend to see library bibliographic databases as an extension of Google and try to use the same search strategy. Several years ago students could be told categorically not to use the Web for this sort of assignment. But this is no longer the case. United States government publications, like those of the USGS, are published on the Web. IEEE publications are searchable by Google. Most societies and organizations have reputable Web pages with information appropriate to the class. One can no longer make blanket statements regarding the non-scholarly nature of the Web. The Web does have scholarly content but the focus must be on evaluating resources found on the Web for their value, scholarly content, creator, and point of view.

In reality, students must think critically about all the resources they use, both traditional and Web-based. Publication in a scholarly journal does not always guarantee quality or scientific accuracy, as much as one would like to believe it does. Since many of the students choose controversial topics, the concept of evaluating resources for bias is especially important. In general, most of the student papers for this class are citing some Web sites but the focus remains on the traditional scholarly record.

Citing Web resources is another issue. Most style manuals now have information on this. However, it has been difficult to find scholarly articles in the geosciences that cite Web sites to use as examples.

The importance of Web resources was made clear several years ago when a student did a paper on the Arctic National Wildlife Refuge. His primary resource was a Web site. But the Web site had bibliographies on it that led him to scholarly papers and government publications, some quite obscure, that would have been very difficult to find without this resource.

WHAT IS THE FUTURE OF THE CLASS?

The University of Colorado, Department of Geological Sciences recently completed a self study as part of the Program Review that takes place every 6 years. The Committee on Undergraduate Education, formed for the self study, recommended that steps be taken for this class to be certified to satisfy the core requirement for upper division writing. The Department accepted this recommendation. The process for this has changed since the class was first designed so it is much more likely that this could happen.

The class would need to be increased to three credits. It is likely that it would draw students from other sciences as well as geology. This is the case for the upper division writing classes in physics and biology that already exist. Because the upper division writing classes are at the 3000 level instead of the 4000 level, where the class is currently, it would mean that students would be likely to take it in their sophomore or junior year instead of as seniors. This would be very positive since the skills they learn could then be transferred to papers they write as undergraduates.

How to add content to the class so that it warrants the additional credits is under discussion. The oral presentation, part of the original concept of the class, would be added. Other types of writing assignments, such as funding proposals and project proposals or reports are being considered. Creating posters to be presented to the class and team projects are also ideas that have been under consideration.

Good writing skills are the key to success in both the academic and non academic world. In the large university setting not enough attention is paid to the fundamentals of writing in scientific disciplines. Papers that are assigned are generally read for content only; style, format and mechanics are rarely taken into consideration. Rarely is a research paper for a science course returned to the student to be revised and resubmitted. While this is really the only way to learn to write well, it is unrealistic for most classes. The only goal for this class is technical writing and communication. With continual feedback on assignments throughout the semester from the instructor, the progress seen in the writing skills of students from the first assignment to the "final" final paper is sometimes extraordinary. It provides clear evidence that such a class is needed and should be expanded.

THE COLD REGIONS BIBLIOGRAPHY PROJECT: GEOSCIENCE TO TOURISM AND EVERYTHING IN BETWEEN

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Abstract -- In 2000, the American Geological Institute (AGI) began to migrate the Cold Regions Bibliography Project from its previous home at the Library of Congress to the American Geological Institute. The Project produces two bibliographies, the *Antarctic Bibliography* and the *Bibliography on Cold Regions Science and Technology*. These two bibliographies have covered the literature of the cold regions of the world since 1951 and include a wider range of materials for inclusion than the coverage of GeoRef, which is also produced by AGI and is the premier geoscience abstracting and indexing database.

By the end of 2004, AGI will be concluding 4 ½ years of the compilation and has undertaken to keep the bibliographies up-to-date and as complete as possible. Government and Russian publications have traditionally comprised a significant portion of the coverage of the bibliographies. In 2000, the staff at AGI was covering approximately 40% of the journals and government publications needed for the project. The evolution of the selection process to include biology, chemistry, oceanography, meteorology and even tourism has included wider contacts with international organizations and an increase in the number of libraries and collaborators that AGI works with to obtain information. In addition to attempting to provide comprehensive coverage for the bibliographies, AGI has continued to add enhancements to the databases to make them as useful and as accessible as possible to diverse research communities.

INTRODUCTION

In July 2000 the American Geological Institute (AGI) assumed the compilation and dissemination of the *Antarctic Bibliography* and the *Bibliography on Cold Regions Science and Technology* from the Library of Congress. These bibliographies, with combined references approximating 224,000, were recognized as the primary bibliographic source for researchers in the cold regions of the world. Maintaining the comprehensiveness and an equal level of excellent coverage of the bibliographies when they resided at the Library of Congress was the goal of AGI, working as part of a cooperative agreement with the U. S. National Science Foundation (NSF) (Tahirkheli, 2002). The *Antarctic Bibliography* and the *Bibliography on Cold Regions Science and Technology*, collectively known as the Cold Regions Bibliography Project (CRBP), are jointly funded by NSF and the U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory (CRREL).

The *Antarctic Bibliography*'s scope includes the entire continent of Antarctica and the surrounding Southern Ocean. Selected subantarctic land masses are also included, especially when pertinent to logistical support for research. The *Bibliography on Cold Regions Science and Technology*'s scope includes worldwide cold regions and focuses on scientific and engineering research. Both bibliographies are updated weekly and are currently openly available at http://www.coldregions.org. The bibliographies may be searched separately or combined. Alerts are posted for both bibliographies on the Cold Regions Web site for new citations, published after June 2000, that have been added during the previous month. In addition, AGI produces for the *Bibliography on Cold Regions Science and Technology* a shelf list for the CRREL Library and sends out individual monthly alerts to researchers. Any materials covered for both bibliographies must be available to the staff of AGI in case future users need to obtain copies. To this end AGI digitizes uncopyrighted materials to provide continued access for the future.

COVERAGE REVIEW

The following scientific disciplines are included in the *Antarctic Bibliography*: biological sciences, cartography, expeditions, geological sciences, ice and snow, logistics, medical sciences, meteorology, oceanography, atmospheric physics, terrestrial physics, political geography and general (including tourism). The *Bibliography on Cold Regions Science and Technology* covers research that includes the nature of snow, ice and frozen ground, materials in cold temperatures, the impact of cold temperatures on human activities and facilities, and cold-related environmental problems. For both bibliographies, publications in any language and from any country are accepted with an emphasis on formal and government publications. For the *Antarctic*

Bibliography, maps, news stories, K-12 education materials, and meeting abstracts are generally excluded from the bibliography. For the *Bibliography on Cold Regions Science and Technology*, news stories are generally excluded from the bibliography except where CRREL is the focus of the news. Educational materials for K-12 that cover ice, snow, and frozen ground are accepted and meeting abstracts are occasionally included especially where the abstracts are extended and well documented with references.

The challenge for AGI in compiling these bibliographies was to expand coverage from GeoRef's geoscience-based perspective to include the broader range of the CRBP. For the *Antarctic Bibliography*, a gap existed in coverage beginning with July 1998 (3500 items) and the first requirement for AGI was to fill this gap over a two-year period. In addition, AGI needed to locate and compile at least 2000 new Antarctic citations each year. For the *Bibliography on Cold Regions Science and Technology,* AGI needed to locate and compile 5000 items per year. The scientific disciplines that presented the greatest challenge included biology, the medical sciences, meteorology, atmospheric physics and general studies. In addition, research in the polar regions is focused in a limited number of countries and organizations, many with which AGI had not previously had direct exchange relationships. For example, while AGI had frequently covered the National Institute of Polar Research's (Japan) *Polar Geoscience*, other series had seldom been scanned or received.

Quantity

To assess progress in expanding coverage by AGI staff, the totals compiled over the past four years were compared to the expected totals.

Bibliography	Items Expected	Items Completed
Antarctic Bibliography	12,500	17,400
Bibliography on Cold Regions Science and Technology	20,000	24,700

Table 1: Expected and completed totals for bibliographies to October 15, 2004.

As seen in Table 1, totals for both bibliographies exceed project requirements substantially. One note, however, on the *Antarctic Bibliography* – the totals include a special file of approximately 4500 references obtained from the Scott Polar Research Institute. This file extended the coverage of the *Antarctic Bibliography* back to 1951.

Country of Publication

Another measure of coverage for the polar bibliographies is a comparison of the percentage of publications by country of publication.

The distribution of publications for 2003 is shown in Figure 1. From this graph, it is easy to see that the distribution of publications on the cold regions of the world is distributed differently from the standard GeoRef coverage indicating a need for AGI to widen its efforts to obtain information from regions like Scandinavia and Russia. The Antarctic coverage is especially unique in that countries that are parties to the Antarctic Treaty produce almost all of the publications. An interesting anomaly can be seen in the relative lack of publications on Antarctica in the U. S. in comparison to the level of publication from much smaller countries. The proportions of publications on Antarctica in countries like Germany, Italy and the United Kingdom are worthy of note. This higher proportion is the result of very active research and publication efforts by those countries on the Southern continent.

The Russian literature, traditionally very strong in engineering for cold regions, is clearly a big component of the coverage of the *Bibliography on Cold Regions Science and Technology* when compared with coverage by GeoRef and the *Antarctic Bibliography*.

Types of Publications

The types of publications that predominate in each bibliography vary. The *Antarctic Bibliography* prefers formal peer-reviewed publications, meeting papers and government documents. No K-12 education materials, meetings abstracts, maps or news sources are appropriate for this bibliography. The *Bibliography on Cold Regions Science and Technology* accepts a wider array of types of publications including K-12 education materials when appropriate, patents, Web sites, and data sets. Meeting abstracts and news sources are occasionally included, but are generally considered out-of-scope.

The types of publications included in the bibliographies were reviewed and compared to the GeoRef coverage for the period of 2003 (see figures 2, 3, and 4). For the *Antarctic Bibliography* the time period included 2000-2003. For the *Bibliography on Cold Regions Science and Technology* the time period covered 2003.

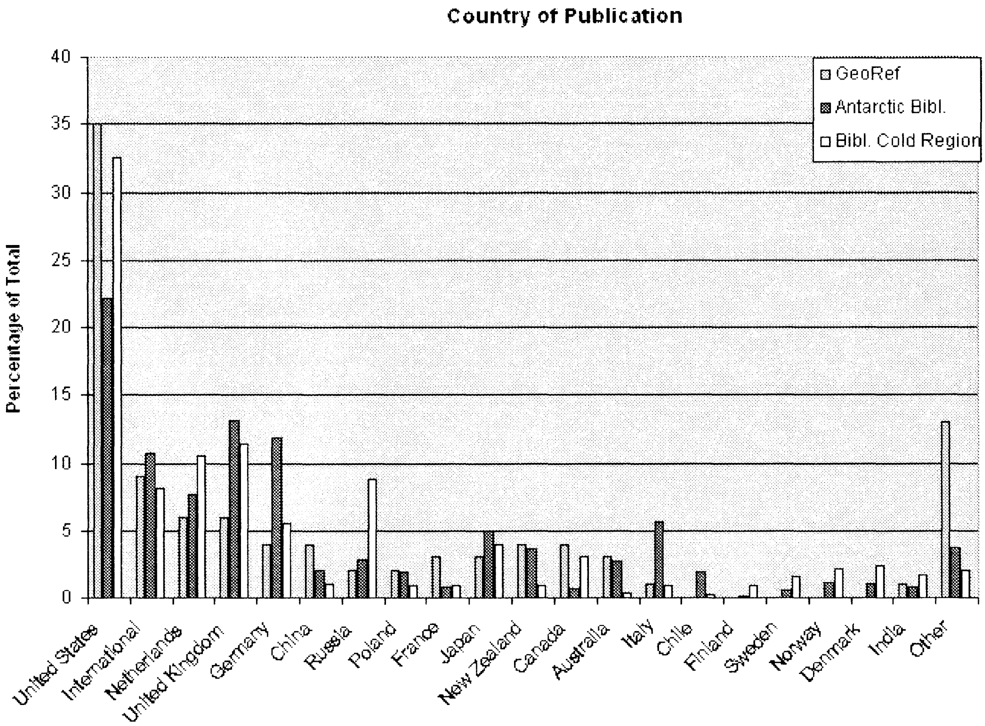

Figure 1

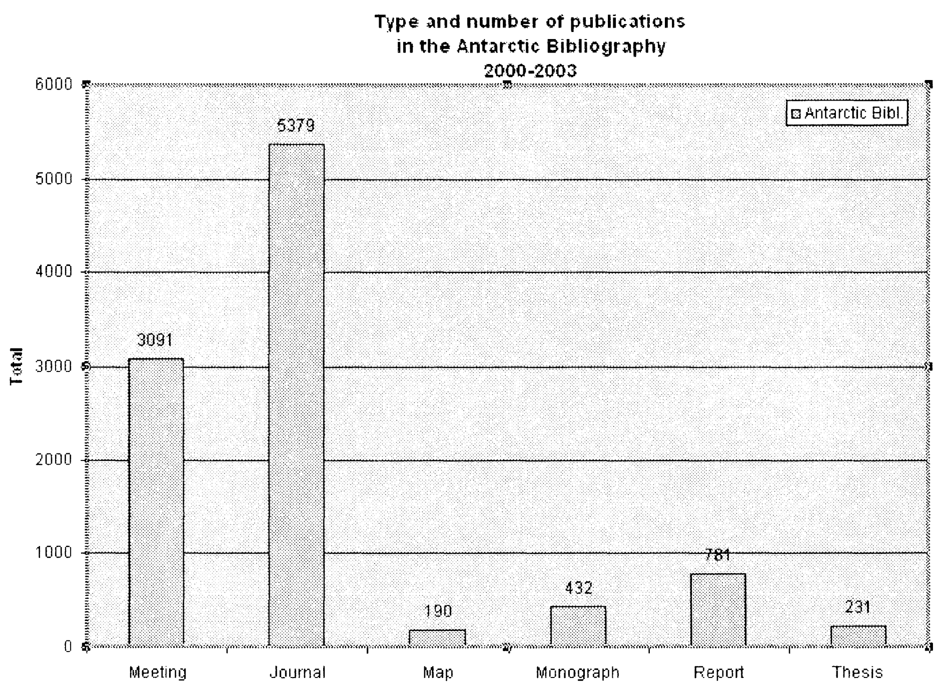

Figure 2

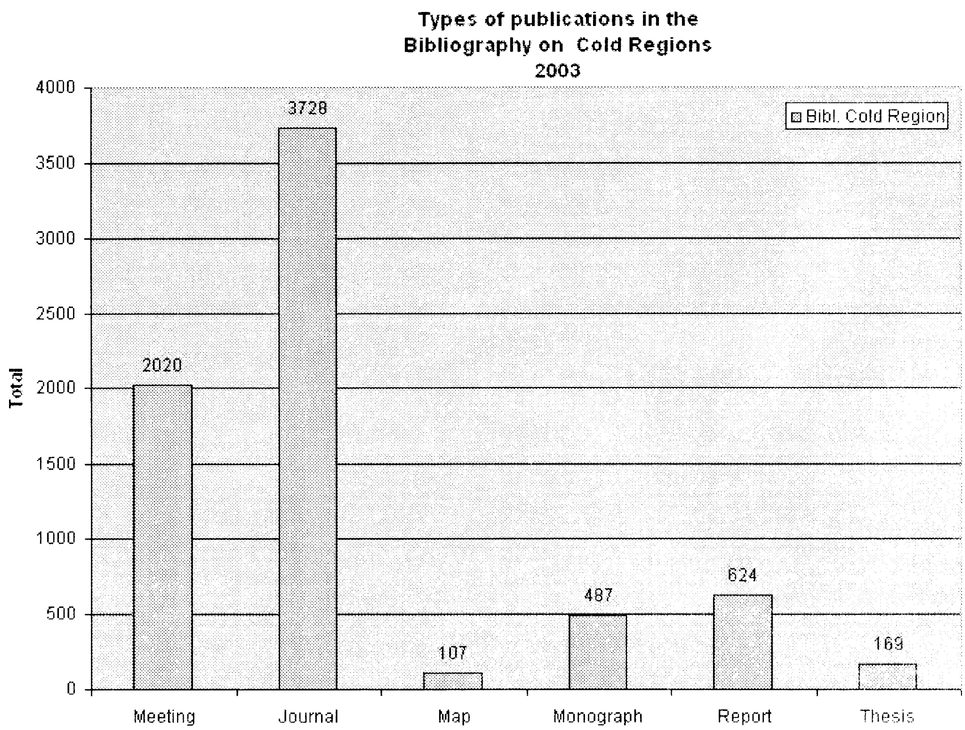

Figure 3

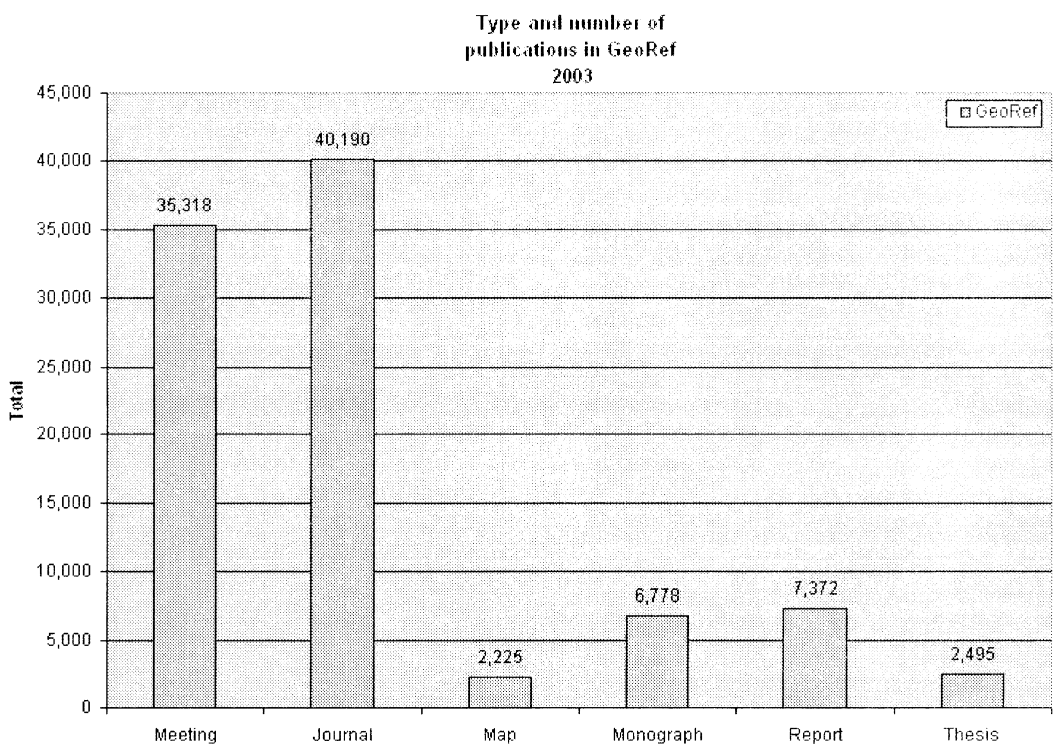

Figure 4

Type of Publication	Antarctic Bibliography	Bibliography on CRST	GeoRef
Meeting	31	28	37
Journal	53	52	43
Map	2	2	2
Monograph	4	7	7
Report	8	9	8
Thesis	**2**	**2**	**3**

Table 2: Percentages of total publications by type for the period of 2003.

Table 2 demonstrates the focus of the two bibliographies on the journal literature and the restriction of coverage of meeting abstracts. By contrast, 25% of GeoRef coverage each year is meeting abstracts. In spite of the original restriction on maps for the *Antarctic Bibliography*, coverage of maps was initiated shortly after the bibliographies began to be compiled at AGI. The significance of maps and their inclusion in the bibliographies is now seen as appropriate.

Subject Coverage

A preliminary study of subject coverage of the *Antarctic Bibliography* was reported previously (Tahirkheli, 2004) and indicated a need for further examination. The coverage of the scientific disciplines in the *Antarctic Bibliography* by AGI was compared to an equivalent number of items chosen from the early 1990s and compiled by the Library of Congress (see Table 3).

Subject Categories	*AGI Antarctic 2003*	*LOC Antarctic 1992/1993*
Atmospheric Physics	146	86
Biological Sciences	638	723
Cartography	38	23
Expeditions	94	11
General	257	197
Geological Sciences	842	494
Ice & Snow	170	341
Logistics	71	58
Medical Sciences	18	35
Meteorology	53	343
Oceanography	221	171
Political Geography	3	45
Terrestrial Physics	32	56
Totals	2583	2583

Table 3: Coverage of Antarctic Bibliography by Subject

It is clear that Geological Sciences has increased substantially while Meteorology and Ice & Snow show declines in numbers. At first glance this difference may appear to indicate a loss in coverage in some subject areas, however; variations exist in the assignment of subject categories to the publications. From the geological perspective, ice and glaciers are geological and often may be assigned by AGI staff to Geological Sciences rather than Ice & Snow as in previous years. Studies of climate change which have focused on long-term climate variations are assigned to Geological Sciences rather than Meteorology. Nonetheless, the data indicate a need to more actively monitor the meteorological literature and the consistent assignment of subject category to better differentiate between true paleoclimate and recent climate change.

Minor increases are noted in Expeditions and in General. Increasing levels of tourism and interest by the general public in the Antarctic region are reflected by this number.

PARTNERS

In expanding the AGI coverage for the Cold Regions Bibliography Project, several partnerships have been key. The National Science Foundation, through its Office of Polar Programs, collects publications from other Antarctic Treaty nations. These publications are supplied to AGI to supplement *Antarctic Bibliography* coverage. The U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, NH maintains an extensive collection of materials dedicated to cold regions engineering and technology. These materials are supplied to the AGI staff for use in compiling the bibliographies. Approximately 40% of the references in the current bibliographies are derived from the CRREL library.

A major activity of the Project is the development of international cooperative agreements with groups engaged in bibliographic activities that overlap with the Cold Regions Bibliographies. To date, three groups have been actively pursuing collaborative initiatives with AGI. The Scott Polar Research Institute began supplying information for the *Antarctic Bibliography* in 2000 and currently provides 33% of the references for the *Antarctic Bibliography*. Antarctica New Zealand provides checklists of publications and hopes to eventually provide full bibliographic information. Italian Programma Nazionale di Ricerche in Antartide (PNRA) and AGI have had several discussions on the establishment of exchange and have traded electronic data for testing. Further exploration is needed.

Two of the challenges involved in developing such collaborative agreements are: the organization providing information for the bibliographies must provide abstracts for the *Antarctic Bibliography* and they must make source documents available for document delivery. With the ever-increasing availability of electronic publications, the source document question has declined in significance, but not disappeared.

WHAT'S NEXT

AGI is continuing to compile the bibliographies and expand coverage based on the preceding subject analysis. The funding cycle for the bibliographies ends in late 2005 and AGI hopes to secure further funding to enhance the bibliographic search interface and provide additional features. Possibilities include: geographic coordinate search capability, controlled vocabulary searching, and linkages to appropriate sites (e.g. the Antarctic Master Directory, DLESE, etc.).

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REFERENCES

Tahirkheli, Sharon N. 2002. "The evolution of the Cold Regions Bibliography Project through migration and cooperation." In *Proceedings of the 19th Polar Libraries Colloquy*, June 17-21, 2002, edited by Caning, K. and Jakobsen, V. S., p. 62-67. Copenhagen: Danish Polar Center.

Tahirkheli, Sharon N. 2004. "Distribution of Source Materials for the Antarctic Bibliography and the Bibliography on Cold Regions Science and Technology." In *Proceedings of the 20th Polar Libraries Colloquy,* June 2004. *(In press).*

THE STATUS OF REGIONAL GEOSCIENCE LITERATURE PUBLISHED OUTSIDE NORTH AMERICA

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Abstract -- Geoscience has a rich literature published by long-established societies of various sizes, geological surveys and institutes, universities, and commercial publishers. Twenty years ago, libraries collected this literature through subscriptions, government depositories, and gift and exchange programs. Indexes, browsing in libraries, and the invisible college were gates to this literature. This situation has changed considerably. Now much of the literature is available in digital formats and through the Web. Journal exchange programs are greatly reduced. Indexes have moved online. Geoscience information seekers can get many full-text articles from electronic journals or directly from authors by e-mail and personal Web pages.

Many geoscience libraries are still cancelling journals. A 1998 study examined whether North American libraries were reducing the availability of foreign regional geoscience journals because they had to maintain current collections of the major international journals. The results showed a steady cancellation in the number of foreign geoscience serials in North American libraries.

This study re-examines the availability of non-North American regional geoscience literature. There has been a reduction of literature from countries undergoing political or financial instability. The regional geoscience literature is still being indexed, though the bibliographic databases are missing recent issues of some serials. Cancellation of foreign regional geoscience literature has stabilized somewhat, except for journals that are more expensive or are very slow. The Web has opened up distribution for some small geological surveys, while the larger ones have taken advantage of GIS to provide detailed information for their areas. Finally, the foreign regional geoscience literature is being cited, but the highest cited papers of authors are usually in non-regional journals. The results indicate that the regional literature produced outside North America is still a valuable component of geoscience information.

INTRODUCTION

Geoscience has a rich literature. Professional societies, commercial publishers, geological surveys, academies, and universities publish paper and electronic journals, maps, databases, books, GIS data, newsletters, field trip guidebooks, reports, and many Web resources. Twenty years ago, libraries collected this literature through subscriptions, government depositories, and gift and exchange programs. The key to the literature was the index and abstracts services such as the *Bibliography and Index of Geology*. With the growth of the Web, a large amount of literature and information has become readily available, although some major parts are constrained by licenses.

The literature from geological surveys and small geological societies has long been an important part of the geoscience literature. However, its availability to researchers and students has been affected by changes in distribution and constraints on library funding. This paper focuses on this "regional literature," specifically the literature that is published outside the United States and Canada.

Regional geoscience literature can be distributed widely if the journals are included in major online journal products such as Elsevier's *Science Direct* or *Springer Link*. Some of the regional titles are core to the field, but a large number have appeared on potential serial cancellation lists, especially those from undergraduate institutions.

A 1998 study (Noga, 1999) examined whether North American libraries were reducing their holdings of foreign regional geoscience journals to maintain their subscriptions to major international journals. The results showed a steady cancellation pattern of foreign regional geoscience journals. Since 1998, libraries have encountered a new constraint as they have signed up for large electronic journal packages. These "Big Deal" packages tend to restrict cancellations, so that a library facing a funding shortfall would have to look for savings from the rest of the serials collection. A library that needs to balance its serial budget may have to cut its regional journal collection, even though the average cost of a regional journal is usually lower than the cost of a commercial journal.

This paper re-examines the availability of the non-North American regional geoscience literature. North America is defined as the United States and Canada for this study. Five questions will be considered.

1. Has the output of foreign regional geoscience literature decreased?

2. Are bibliographic databases covering the foreign regional geoscience literature?

3. Are North American libraries still collecting the foreign regional geoscience literature?

4. Is foreign regional geoscience literature available on the Web?

5. Is foreign regional geoscience literature cited?

The appendices show the data that address these questions.

HAS THE OUTPUT OF FOREIGN REGIONAL GEOSCIENCE LITERATURE DECREASED?

North American libraries received maps, reports, and other serials from foreign regional geological surveys as gifts or exchanges into the early 1990s. Many gift and exchange programs were curtailed as libraries decided to just order the materials that they specifically needed. Geological surveys in several countries were reorganized and merged with other agencies, which affected publication programs. Regional societies also examined their journal programs. Some moved their titles to commercial publishers. Others combined their journals with journals from similar societies in other countries to form larger titles to compete with the large commercial journals. For example, three European geophysical societies merged their journals to form *Geophysical Journal International* in the late 1980s. Finally, the advent of the Web offered a whole new way of distributing literature.

To assess changes in the output of regional geoscience literature, approximately 200 geosciences journals were searched in the *WorldCat* database. The journals and other serials in the study were chosen to cover the different regions of the world. China is well represented because of increasing interest in its geology. Some translation journals are included in the data set.

Appendix 1 lists titles that have ceased, according to *WorldCat* records or through searches of the individual catalogs of libraries that held the journals. A journal that had not been received by any library for several years was assumed to have ceased, unless the publisher's Web site indicated otherwise. Some continuing were marked "ceased" in *WorldCat*, even though one or more libraries were found to have issues from 2003 or 2004.

The short list in Appendix 1 gives a glimpse of what type of foreign regional literature might be decreasing. Not many libraries held the Chinese journals on the list, so a lack of current issues in just a few libraries will lead to a view that the journals have ceased. Some English versions of Chinese titles have ceased. Perhaps the rest of the Chinese journals are indeed available in China, but no evidence was found. Even if the journals are still published, for all practical purposes, they are unavailable to North American libraries.

The effects of political instability are apparent in the list of ceased serials. For example, holdings of the *Iran Oil Journal* in North America stopped in 1978, a year before the Iranian Revolution. The Geological Survey of Iran does supply abstracts of one of its publications at its Web site (Geological Survey of Iran).

The Journal of the Geological Society of Iraq stopped coming to North American libraries after the 1994 issues, a couple of years after the first Gulf War. The *Boletim Geologico* from Mozambique seemed to cease in 1990, but a new volume was published in 2004, after a long period of political instability.

The dissolution of the Soviet Union affected the availability of literature from the Commonwealth of Independent States. The publisher Nauk/Interperiodica began the simultaneous translation of several Russian-language science journals in 1991 (IAPC "Nauka/Interperiodica"). As a result, distribution of several Russian Academy of Sciences journals was maintained as long as libraries had the funds to subscribe. Other former Soviet journals did not fare so well. For example, distribution problems probably contributed to a loss of a third of North American library holdings of *Geologiya va Mineral Resurslar* from Uzbekistan within three years of its split from the USSR. This study does not provide an in-depth look of the output of Russian literature.

Seven Romanian journals from the Insitutul de Geologic al Romaniei are listed as ceased titles in Appendix 1. They are all supposed to be published annually (World of Learning), but none are being sent to North American libraries, according to searches of catalogs for libraries that have *WorldCat* holdings. However, another Romanian institution, the Academia Romana, started a journal that includes some geoscience articles. The journal is available at four libraries in the United States.

Research published in Africa is scarce. The Sierra Leone Geological Survey has not published anything since the 1960s. The Mines and Geological Department of Kenya stopped publishing most publications, including maps, by 1990. The Senegal Direction des Mines et de la Geologie has not published since the 1980s. There is at least one current geoscience journal from Nigeria, and publication of the *Egyptian Journal of Geology* appears to be delayed. The most prolific area of geoscience publishing in Africa appears to be South Africa, Namibia, Botswana, and even Mozambique.

ARE BIBLIOGRAPHIC DATABASES COVERING THE FOREIGN REGIONAL GEOSCIENCE LITERATURE?

Appendix 2 shows indexing coverage of the serials in the basic data set. Three bibliographic databases were chosen to investigate indexing coverage. *GeoRef* is the largest database that covers geoscience. *Chemical Abstracts* is a large database that covers a wide range of the scientific literature. The *Web of Science* was chosen because it is popular among scientists.

The serial titles were searched first in the journal index of *GeoRef*. If they were not found, the titles were searched as keywords. Some of the serials were indexed, but articles from recent volumes were not found. Indexing of these titles was considered stopped or lapsed, and the indexing is marked with an "S" in Appendix 2. An example is *Meyniana*, which *GeoRef* has indexed through volume 45, though volume 56 has been published.

The *Chemical Abstracts Source Index* (CASSI) was consulted to identify which serials were indexed in *Chemical Abstracts*. This database selectively indexes a lot of titles, in contrast to the *Web of Science*, which includes all articles when it indexes a publication.

Table 1 summarizes the state of indexing coverage for the regional serials in the three large databases. Only about 10% of the serials in Appendix 2 were not found in *GeoRef*. Some missing titles are general journals such as the *Bulletin de la Societe Luxembourgeois*, which includes geoscience articles for that country. Others were new titles such as the *Austrian Journal of Earth Sciences*, whose predecessor was indexed. A third group were serials on the fringe of *GeoRef*'s coverage, such as the *Publications of the Institute of Geophysics, Polish Academy of Sciences E*.

Chemical Abstracts picks up some articles from a wide range of geological survey and society journals. It includes few paleontology journals. In contrast, the *Web of Science* misses most of the regional gesocience literature, but it does index some of the paleontology journals, such as *Alcheringa* and *Rivista Italiana di Paleontologia e Stratigrafia*.

	Indexed (Y)	Not Indexed (N)	Indexing Stopped or Lapsed (S)
GeoRef	174	17	9
Chemical Abstracts	110	88	2
Web of Science	24	173	3
	308	**278**	**14**

Table 1. Summary of Indexing of Foreign Regional Geoscience Serials

ARE NORTH AMERICAN LIBRARIES STILL COLLECTING THE FOREIGN REGIONAL GEOSCIENCE LITERATURE?

Two hundred journals and other serials from countries around the world were selected to check their availability in North American Libraries. Appendix 3 lists these titles, the country of publication, and the number of current, lapsed, online-only, and cancelled subscriptions. The percentage of subscriptions that have been cancelled represents the overall decrease in library holdings. The appendix is sorted by the last column which gives the number of cancelled subscriptions since the 1998 study (Noga, 1999). These figures represent the current decrease in library holdings of these serials.

Each serial title was searched in the *WorldCat* database to identify the North American libraries that have some holdings. Then the titles were searched in the individual library catalogs to determine the status of each library's subscription. Holdings that included the latest issues or volumes were considered "current" subscriptions, unless the catalog record noted that the serial was recently cancelled.

Some libraries did not have current issues of a serial, but their holdings were only a volume or year behind. These subscriptions were considered "lapsed" rather than cancelled. Some libraries did not list unbound issues in their catalogs. The frequency of publication was used to assign these subscriptions to either the "lapsed" or "current" subscription categories.

Some library catalogs indicate that the library has a current subscription, though several recent volumes have not been received. For the purposes of this study, they were considered cancelled subscriptions. In fact, few library catalogs clearly state that a subscription has ceased.
About one third of the titles in Appendix 3 are not

journals. Libraries could decide to cancel standing orders to these monographic series, and then buy selected volumes from their monograph budgets. In effect, they would still be collecting some of the series. If most libraries that cancelled the standing orders did this, then the holdings of these series are higher than reported in Appendix 3. Further searching of individual volumes of these series in *WorldCat* and library catalogs would show if this is the case.

Many of these publications are irregular; so some libraries closed their holdings after claims were not filled. For example, fourteen libraries closed their holdings for the *Revista de la Asociacion Geologica Argentina* in 1990, but the holdings of eight libraries show that the journal continues. Another explanation would be that the society changed its distribution policy or increased the price of the journal.

An extreme case of a lack of current holdings is the Venezuelan journal *Geominas: G.* No libraries have acquired issues since 1987. However, it is available electronically, and the latest issue is from 2002 (*Geominas: G*). Another example is the *Journal of the Geological Society of Sri Lanka*, which no North American library is currently receiving even though it has published up to volume 11 in 2003.

Widespread library holdings can decrease substantially if a publication goes online. Recent volumes of the *Record* from the Geological Survey of Western Australia are available online at no charge, but only one library catalog noted that current volumes are available at the Web site. Eighteen libraries stopped receiving paper copies in 2001 and the remaining five stopped afterwards. If these libraries add the Web site link to their catalog records, then effectively they will maintain access for their users.

Some libraries have taken advantage of their online journal packages to restore access to previously cancelled print subscriptions. For example, *Studia Geophysica et Geodaetica* was cancelled by several libraries by the early 1990s, when the price increased substantially after the Velvet Revolution in Czechoslovakia. However, the *Kluwer Online* journal package provided online access to this journal and to several Russian translation journals that many libraries had cancelled in the 1980s and 1990s. At least twenty-five libraries were able to restore access to recent issues of *Studia Geophysica et Geodaetica* when they provided access to *Kluwer Online*.

Overall, North American libraries appear to have completed most of their cancellation of foreign regional geoscience journals by 1999. Three of the serials in Appendix 3 with high amounts of recent cancellations are palaeontology journals. Perhaps this reflects changes in academic geoscience programs in North America. Another trend is the movement to online-only subscriptions, which is seen in the holdings of the *South African Journal of Geology*, *Paleontological Research*, and the *Norwegian Journal of Geology*.

IS FOREIGN REGIONAL GEOSCIENCE LITERATURE AVAILABLE ON THE WEB?

Online Journals and Other Serials

Many geoscience journals are available electronically, especially if they are published by a commercial publisher or a large geoscience society. Several serials in Appendix 3 have some online content, even if there are only tables of contents. EBSCOhost is an example of an aggregator that includes access to regional geoscience journals. It includes the *South African Journal of Geology* and the *New Zealand Journal of Geology and Geophysics*. *Springer Link* (formerly *Kluwer Online*) provides access to several Russian translation journals such as *Lithology and Mineral Resources*.

Some open-access serials were found in this study, and they are listed in Appendix 4. Most of the Polish journals in Appendix 3 have current full-text articles on the Web at no charge. The Geological Society in Tapei provides free online access to *Western Pacific Earth Sciences*. Two publications from Spain, the *Journal of Iberian Geology* and *Geologica Acta*, are trying to increase their distribution and importance by publishing free online as well as in print.

Some regional geoscience publications, such as *Geologie de la France*, have ceased in print and moved completely online. An example of a data journal that has moved online is the *Boletin de Sismos Proximos*, which provides seismic information for Spain (www.mfom.es/ign).

Geological Surveys

Foreign geological surveys have taken advantage of the Web to provide access to publication lists, newsletters, information for the general public, full-text reports, databases, and maps. Appendix 5 lists several surveys that provide literature on the Web.

Most geological survey Web sites try to educate the public, list and sell their publications, and describe their research and other activities. Small-scale geological maps, colorful brochures on projects, and basic explanations of geological phenomena are found on several sites.

Many geological surveys put their newsletters up on the Web. Some provide full-text access to a few technical papers. However, there is a tendency to ask users to order most bulletins, papers, and reports rather than provide them openly online.

Databases are often available on the survey Web sites. For example, the British Geological Survey provides several databases such as a photographic archive, lexicon of rock units, chronostratigraphic database, taxonomy database, water database, and a digital data catalogue. Some geological surveys will provide a lot of geoscience information but subscriptions are needed. The Netherlands Institute of Applied Geosciences TNO has a substantial database called *DINO*, which has various subscription levels (Netherlands Institute of Applied Geosciences TNO). Spain (Instituto Technologico GeoMinero de Espana) also provides a lot of data free online to individuals who register.

Large geological surveys are putting map viewers on their sites so that users can pinpoint areas of interest and find relevant geoscience data. This is the most common example of full-text regional geoscience information that is available online. The British Geological Survey has an interactive map called the "Geology of Britain," which provides topographic, remote sensing, and geological mapping of user-specified areas.

The country that perhaps has made the greatest move to providing geoscience information electronically is Australia. The national geological survey, Geoscience Australia, has an extensive Web site (Geoscience Australia) with over 50 databases. A palaeogeographic atlas and several map viewers show geology, geophysics, mineral resources, and topography of Australia at different scales. There are also tools to find place names, compute geodetic parameters, determine geomagnetic field values, and even measure distances. This survey still sells a lot of maps and products, but the wealth of open-access information is impressive.

The Northern Territory Geological Survey provides geophysical data, mapping, textual reports, and data set exports on its Web site. The Survey "prides itself on providing the latest information and publications to the public as soon as they are available" (Northern Territory Geological Survey).

The Geological Survey of Western Australia provides an interactive GIS-based mapping system called *GeoVIEW.WA* that allows users to view and make their own maps from statewide geoscience data sets that are also available on the Web site (Geological Survey of Western Australia). The Web site provides access to a mineral exploration database, petroleum exploration database, mines and mineral deposits database, and a GIS-based register of airborne geophysical surveys. The Survey's recent *Bulletins*, *Excursion Guides*, *Explanatory Notes*, *Fieldnotes*, *Annual Reviews*, maps, *Mineral Resources Bulletins*, *Records*, *Reports*, and miscellaneous books are all available online. Each publication listing has thorough summaries of the series and ordering information for paper copies. It is truly a masterful resource.

Increased Distribution of Literature

One opportunity presented by the Web is the distribution of maps, reports, and data from small countries that had a minimal paper distribution system. For example, the Geoservices Division of the Guyana Geology and Mines Commission distributes research project information, a geological map, a mineral exploration map, a draft geochemical atlas, and license statuses on its Web site (Guyana Geoservices Division). This site is a good example of how a small geological survey can distribute its research results widely at a reasonable cost.

Brazilian geoscience information was hard to obtain before the Internet. Some publications were sent to major libraries in North America, but publication lists with firm ordering and fulfillment procedures were not common. The Servico Geologico Brazil's Web site provides access to a wealth of data on the country through a geoscience GIS system and several project pages on geology, mineral resources, geochemistry, and hydrology. This is a good example of the Web really increasing the availability of regional geoscience information (CPRM – Servico Geologico do Brasil).

IS FOREIGN REGIONAL GEOSCIENCE LITERATURE CITED?

Appendix 3 shows that North American libraries have reduced holdings of several regional geoscience journals and other serials. The cost savings from the cancellation of a single title is often not great, but each library considered an individual title less important to its users than the large society and commercial journals or perhaps even other regional journals. There is an expectation that the articles in the cancelled journals are less useful, especially when the articles are published in a foreign language.

One measure of the value of regional literature is a comparison of citation rates for articles in regional journals with citation rates for articles in non-regional journals. A pool of authors who publish in both types of journals was needed to compare the citation patterns. 125 authors were chosen from 8 journals (Table 2).

Journal	Authors
Acta Palaeontologica Polonica	13
Alcheringa	9
Geobios	12
Israel Journal of Earth Sciences	12
New Zealand Journal of Geology and Geophysics	17
Norwegian Journal of Geology	29
Revista Italiana di Paleontologia e Stratigrafia	15
South African Journal of Geology	18

Table 2. Source of Authors for Citation Study

Each journal's cited half-life year was determined from the 2003 Science Edition of the *ISI Journal Citation Reports*. The year 1990 was used if the cited half-life year could not be determined for a journal. All the first authors of articles from the cited half-life year of the sampled journals were searched in the cited reference section of the *Web of Science*. Authors that had papers that were published within five years of the sample year were included in the study. Each author also had to have published cited papers in both regional and non-regional journals.

The citation rate for each cited paper was calculated by dividing the number of citations by the citation period. For each author, the highest-cited articles in their regional and non-regional journals were compared. Figure 1 shows the citation rate for the highest-cited articles in regional and non-regional journals for each author. The graph is arranged in order by the authors who had the highest-cited regional journal articles.

For most authors, the highest-cited non-regional journal paper was cited more than the highest-cited regional journal paper. This is not a surprising result, because authors send papers to the journals that they think will have the most impact. However, some of the authors in the middle of the figure had similar citation rates for the highest-cited papers in both types of journals. Their citation rates differed by one citation per year. This result shows that the regional journals are being cited, in comparison with their international competitors.

Several of the highest-cited articles by authors who publish in the *New Zealand Journal of Geology and Geophysics* were published in regional journals, not in the non-regional journals. This shows the quality of the *New Zealand Journal of Geology and Geophysics*. Unfortunately, it was cancelled by half of the North American libraries that once held it; about 5 per cent cancelled access since 1998.

Table 1 showed how few regional journals were indexed by the Web of Science. The low coverage of these journals could depress the citation rates of articles in the regional journals, because the primary audience of many articles may be authors in other regional journals.

The results are based on authors that published in only a few journals, and the citation rates for many of the highest-cited articles are below 5 per year. Larger and broader samples would be needed to make a definitive citation analysis of regional versus non-regional journals.

CONCLUSION

Foreign regional geoscience serials were the target of cancellation projects at many libraries in the 1980s and 1990s. However, the cancellation pace slowed down by 1999. The availability of foreign geoscience literature in North American libraries is probably more affected by the irregularity of publication of some titles and how well libraries keep up with the move of this information and data to the Web. Some serial titles have ceased, but a large drop in publication was not found in this study. The Web has become an excellent source for a lot of data from foreign geological surveys, especially if the data can be spatially located. Geological survey bulletins and report series were an important part of the regional literature in the paper era, but little are available on the Web. Digital distribution offers foreign geoscience societies and geological surveys exciting opportunities for wide distribution of their research, not just to libraries and scientists, but to the general public in a period of growing interest in the Earth.

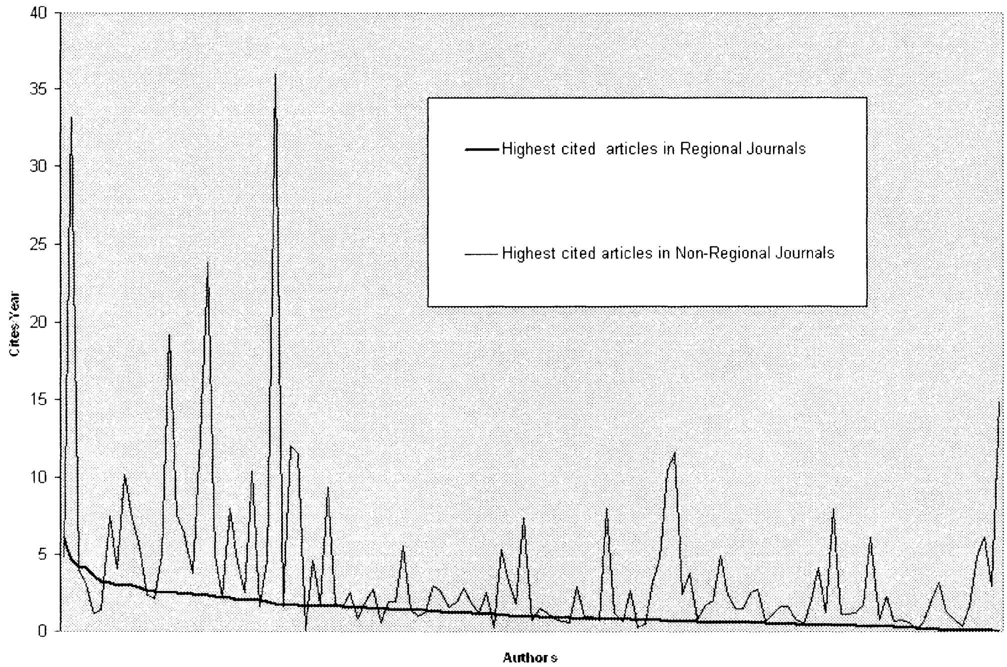

Figure 1: Highest Cited Articles by Author

REFERENCES

British Geological Survey, (http://www.bgs.ac.uk/), accessed 2/20/2005.

CPRM – Servico Geologico do Brasil, (http://cprm.gov.br), accessed 2/24/2005.

Geologica Acta, (http://www.geologica-acta.com:8080/geoacta/HomeAC.do), accessed 2/20/2005.

Geologische Bundesanstalt, (http://www.geolba.ac.at/GBADB1/index.html), accessed 2/23/2005.

Geological Survey of Iran, (http://www.gsi.ir), accessed 2/23/2005.

Geological Survey of Ireland, (http://www.gsi.ie), accessed 2/24/2005.

Geological Survey of Queensland, (http://www.nrm.qld.gov.au/science/geoscience/tenure_maps.html), accessed 2/23/2005.

Geological Survey of Western Australia, (http://www.doir.wa.gov.au/GSWA/), accessed 2/21/2005.

Geominas: G, (http://150.185.136.100/scielo.php?script=sci_serial&pid=0016-7975&lng=es&nrm=iso), accessed 2/21/2005.

Geoscience Australia, (http://www.agso.gov.au), accessed 2/25/2005.

Guyana Geoservices Division (http://www.sdnp.org.gy/ggmc/geoservi.hmtl), accessed 2/22/2005.

IAPC "Nauka/Interperiodica," (http://www.maik.rssi.ru/eng/comp.htm), accessed 3/04/2005.

INGEMMET, (http://www.ingemmet.gob.pe/publicaciones/index.htm), accessed 2/23/2005.

Instituto Technologico GeoMinero de Espana, (http://www.igme.es), accessed 2/24/2005.

Meyniana, (http://www.gpi.uni-kiel.de/veroeff/Meyniana_eng.html), accessed 3/01/2005.

Netherlands Institute of Applied Geosciences TNO, (http://dinoloket.nitg.tno.nl/dinolks/SilverStream/Pages/LksEnWatIsDino.html), accessed 2/23/2005

Noga, Michael Mark, 1999, "Non-North American Geoscience Literature in North America Libraries: Have We Said Goodbye to the Yorkshire Geological Society," *Geoscience Information Society Proceedings*, v. 29, pp. 23-40.

Northern Territory Geological Survey, (http://www.minerals.nt.gov.au), Information Centre; Publications and Products: Downloadable Resources, accessed 2/23/2005.

SciELO, (www.scielo.org), accessed 2/22/2005.

World of Learning, (www.worldoflearning.com), accessed 2/20/2005.

Appendix 1. Ceased Foreign Regional Geoscience Serials

Country	Journal Title	Year	Library Holdings
Azerbaijan	Izvestiia Akademii Nauk Azerbadizhan...Seriia Nauk o Zemle	1992	
Bulgaria	Neftena I Vuglishtna Geologiia	1992	
China	562 Zong He Da Dui Ji Kan (Bulletin of the 562 Comprehensive Geological Brigade)	2001	
China	Advances in Geophysical Research	1991	
China	Contributions from the Various Organizations of Ministry of Geology and Mineral Res.	1997	
China	Geological Memoirs Series 1 Regional Geology	1992	< 5 libs in NA
China	Geological Memoirs Series 4	1991	< 5 libs in NA
China	Geological Memoirs Series 6 Hydrogeology & Engineering	1992	< 5 libs in NA
China	Geological Memoirs Series 7	1993	< 5 libs in NA
China	Geology of Fujian	1999	< 5 libs in NA
China	Guangdong Geology	1994	< 5 libs in NA
China	Journal of Earthquake Prediction	2000	< 5 libs in NA
China	Bulletin of the Institute of Mineral Deposits Chinese Academy of Sciences	1997	
China	Geological Research of South China Sea	2000	< 5 libs in NA
China	Qian Han Wu Ji Di Zhi = Precambrian Geology	1995	
China	Zhongguo Di Li Ke Xue Wen Zhai = Zhongguo Dili Kexue Wenzhai	1999	< 5 libs in NA
China	Di Zhi Yan Jiu Suo Fen Kan; Bulletin of the Chinese Acad Geol Sci Ser II	1981	
China	Zhongguo Hai Shang You Qi = China Offshore Oil and Gas (Geology)	1996	< 5 libs in NA
China	Bulletin of the Shenyang Inst of Geology and Min Resource, Chinese Acad of Geo Sci	2001	< 5 libs in NA
China	Hebei Di Zhi Heueh Yan Xue Bao = Journal of Hebei College of Geology	1997	
India	Current Trends in Geology	1991	
India	Journal of Himalayan Geology	1995	
Indonesia	Berita Geologi = Geosurvey Newsletter	1995	< 5 libs in NA
Indonesia	Bulletin Geotamben: Geologi Pertambangan Dan Energi	1999	< 5 libs in NA
Iran	Iran Oil Journal	1978	
Iraq	Journal of the Geological Society of Iraq	1994	
Ireland	Bulletin - Geological Survey of Ireland	1991	
Israel	Current Research (Makhon ha-Geologi)	2002	
Jamaica	Journal of the Geological Society of Jamaica	1998	
Japan	Special Report - Geological Survey of Japan	1979	
Japan	Miscellaneous Publication (Gondwana Research Group)	2000	< 5 libs in NA
Japan	Journal of the Faculty of Science Hokkaido Univ Ser 4 Geology and Mineralogy	1994	
Luxembourg	Bulletin - Luxembourg. Service Geologique	1995	
Mexico	Paleontologia Mexicana	1993	
Mexico	Revista de la Sociedad Mexicana de Paleontologia	1998	
Morocco	Notes et Memoires du Service Geologique	1986	
Namibia	Bulletin (Geological Survey (Namibia))	1997	
Philippines	Philippine Journal of Volcanology	1986	
Poland	Geologia (Akademia Gorniczo-Hutnicza w Krakowie)	1992	
Poland	Geology of Poland	1990	

Appendix 1. Ceased Foreign Regional Geoscience Serials (continued)

Country	Journal Title	Year	Library Holdings
Poland	Quaternary Studies in Poland	1999	
Poland	Studio Societatis Scientiarum Torunensis Sectio C Geographia et Geologia	1999	
Portugal	Memorias do Instituto Geologico e Mineiro	1997	
Romania	Analele Universitatii Bucuresti. Geologie	1999	
Romania	Romanian Journal of Petrology	1996	
Romania	Romanian Journal of Stratigraphy	1998	
Romania	Romanian Journal of Mineralogy	1999	
Romania	Romanian Journal of Mineral Deposits	1998	
Romania	Romanian Journal of Tectonics and Regional Geology	1998	
Romania	Romanian Journal of Geophysics	2000	
Romania	Romanian Journal of Paleontology	1997	
Russia	Experiment in Geosciences	1999	< 5 libs in NA
South Africa	Bulletin (Marine Geoscience Group (South Africa))	1988	< 5 libs in NA
South Africa	Bulletin (University of Cape Town)	1993	
South Africa	Handbook (Council for Geoscience (South Africa))	1998	
Swaziland	Annual Report of the Geological Survey and Mines Department for the Year...	1989	< 5 libs in NA
Sweden	Striae (Societas Upsaliensis pro Geologia Quaternaria)	1998	
Switzerland	Publications du Departement de Geologie et de Paleontologie de l'Univ de Geneve	1999	
Turkmenistan	Izvestiia AN Turkmenistana. Turkmenistana Ylymlar Akad Kharbar Fiz-Mat...Geologik	1998	
Ukraine	Tektonika I Stratigrafiia	1993	
Ukraine	Geophysical Journal (translation of Geofizcheskii Zhurnal)	2001	
Ukraine	Geokhimiia I Rudoobrazovanie	1995	
United Kingdom	Tertiary Research	2004	

Note: "< 5 libs in NA" indicates that less than 5 libraries in North America were found to have any holdings.

Appendix 2. Indexing of Foreign Regional Geoscience Serials in Major Databases

JOURNAL	COUNTRY	GeoRef	CAS	Web of Sci
Ameghiniana	Argentina	Y	N	Y
Revista de la Asociacion Geologica Argentina	Argentina	Y	Y	N
Alcheringa	Australia	Y	N	Y
Quarterly Notes (Geological Survey of New South Wales)	Australia	Y	N	N
Report (Geological Survey of Western Australia)	Australia	Y	Y	N
Austrian Journal of Earth Sciences	Austria	N	N	N
GeoArabia	Bahrain	Y	N	N
Geologica Belgica	Belgium	Y	Y	N
Revista Brasileira de Geociencias	Brazil	Y	Y	N
Revista Brasileira de Paleontologia	Brazil	Y	N	N
Acta Geologica Gansu	China	Y	N	N
Acta Micropalaeontologica Sinica	China	Y	N	N
Acta Petrologica et Mineralogica	China	Y	Y	N
Bull Inst Geophys Geochem Explor Min Geol & Min Res	China	Y	N	N
Bulletin of the Tianjin Inst Geol Min Res Chinese Acad Geo Sci	China	Y	N	N
Di Qiu Ke Xue: Wuhan di Zhi Xue Yuan Xue Bao = Earth Science	China	Y	Y	N
Di zhen di zhi = Seismology and Geology	China	Y	N	N
Di zhi ke xue = Scientia Geologica Sinica	China	Y	Y	N
Geology of Shaanxi	China	N	N	N
Hai Yang Di Zhi Yu Di Si Ji Di Zhi = Marine & Quaternary Geol	China	Y	Y	N
Journal of Chang'an University Earth Science Ed.	China	N	Y	N
Journal of Jilin University. Earth Science Edition	China	Y	N	N
Kuang Chuang Di Zhi = Mineral Deposits	China	Y	Y	N
Palaeoworld	China	N	N	N
Petroleum Science	China	N	N	N
Sedimentary Geology and Tethyan Geology	China	Y	N	N
Shi You Shi Yan Di Zhi = Experimental Petroleum Geology	China	Y	N	N
Tetisi Di Zhi = Tethyan Geology	China	Y	N	N
Xiandai Dizhi = Geoscience	China	Y	N	N
Xibei Dizhi = Northwest Geoscience	China	Y	N	N
Zhongguo Di Zhi = Zhongguo Dizhi	China	Y	Y	N
Zhongguo Quyu Dizhi = Regional Geology of China	China	Y	N	N
Zhongguo Yan Rong = Carsologica Sinica	China	Y	N	N
Geologia Colombiana	Colombia	Y	Y	N
Geologia Croatica	Croatia	Y	Y	N
Journal of the Czech Geological Society	Czech Republic	Y	Y	N
Studia Geophysica et Geodaetica	Czech Republic	Y	Y	Y
Geol Surv of Denmark and Greenland Bulletin	Denmark	Y	N	N
Egyptian Journal of Geology	Egypt	S	Y	N
Proceedings of the Estonian Academy of Sciences Geology	Estonia	Y	Y	N
Documents du BRGM	France	Y	Y	N
Geodiversitas	France	Y	Y	Y

Appendix 2. Indexing of Foreign Regional Geoscience Serials in Major Databases (continued)

JOURNAL	COUNTRY	GeoRef	CAS	Web of Sci
Beringeria	Germany	Y	N	N
Eiszeitalter und Gegenwart	Germany	Y	Y	N
Geologica Bavarica	Germany	Y	Y	N
Kolner Forum fur Geologie und Palaontologie	Germany	N	N	N
Meyniana	Germany	S	Y	N
Palaeontographica Abt A Palaozoologie Stratigraphie	Germany	Y	N	Y
Palaeontographica Abt B Palaophytologie	Germany	Y	N	Y
Palaontologische Zeitschrift	Germany	Y	N	N
Scriptum	Germany	Y	N	N
Bulletin of the Geological Society of Greece	Greece	Y	Y	N
Magyar Geofizika	Hungary	Y	Y	N
Academy Proceedings in Earth & Planetary Sci	India	Y	Y	N
Bulletin of Pure & Applied Sciences Sec F Geology	India	S	N	N
Bulletin Series B (Geological Survey of India)	India	Y	Y	N
Clay Research	India	Y	Y	N
Geological Bulletin of the Punjab University	India	Y	S	N
Indian Journal of Earth Sciences	India	Y	Y	N
Indian Journal of Petroleum Geology	India	Y	N	N
Indian Mineralogist	India	Y	Y	N
Journal of Geophysics (Association of Exploration Geophysicists)	India	N	N	N
Records of the Geological Survey of India	India	Y	Y	N
Special Publication Series (Geological Survey of India)	India	Y	N	N
Indian Journal of Geology	India	Y	N	N
Jurnal Geologi dan Sumberdaya Mineral = J Geol Min Res	Indonesia	Y	N	N
Journal of the Earth and Space Physics	Iran	Y	N	N
Geological Curator	Ireland	Y	Y	N
Acta Vulcanologica Journal of the National Volcanic Group	Italy	Y	N	N
Annali di Geofisica	Italy	Y	Y	Y
Bollettino di Geofisica Teorica ed Applicata	Italy	Y	Y	N
GeoActa	Italy	Y	Y	N
Geografia Fisica e Dinamica Quaternaria	Italy	Y	Y	N
Geologica Romana	Italy	Y	Y	N
Memorie di Scienze Geologiche	Italy	Y	Y	N
Periodico di Mineralogia	Italy	Y	Y	N
Rivista Italiana di Paleontologia e Stratigrafia	Italy	Y	N	Y
Studi Trentini di Scienze Naturali. Acta Geologica	Italy	Y	Y	N
Bull of National Sci Museum Ser C Geology & Paleontology	Japan	Y	Y	N
Chishitsugaku Zasshi = Journal of the Geol Soc of Japan	Japan	Y	Y	N
Geoscience Reports of Shizuoka University	Japan	Y	Y	N
Gondwana Research	Japan	Y	N	Y
Jishin = Zisin	Japan	Y	Y	N
Jishin Kazan Geppo = Seism and Volc Bull of Japan	Japan	N	N	N

Appendix 2. Indexing of Foreign Regional Geoscience Serials in Major Databases (continued)

JOURNAL	COUNTRY	GeoRef	CAS	Web of Sci
Journal of Earth and Planetary Sci, Nagoya Univ	Japan	Y	Y	N
Journal of Faculty of Science Hokkaido Univ Ser VII Geophysics	Japan	Y	N	N
Journal of Geosciences Osaka City University	Japan	Y	Y	N
Kaseki	Japan	N	N	N
Kenshin Jiho = Quarterly Journal of Seismology	Japan	Y	N	N
Memoirs of the Geol Soc of Japan (Chishitsugaku Ronshu)	Japan	Y	Y	N
Nankyoku Shiryo = Antarctic Record	Japan	Y	Y	N
Okayama University Earth Science Reports	Japan	Y	N	N
Palaeontological Society of Japan Special Papers	Japan	Y	N	N
Paleontological Research	Japan	Y	N	N
Report of National Res Inst for Earth Sci & Disaster Prevention	Japan	Y	Y	N
Transactions Japanese Geomorphological Union = Chikei	Japan	Y	N	N
Qazaqstan Geologiiasy = Geology of Kazakstan	Kazakhstan	Y	Y	N
Geologija – Geology – Geologiia	Lithuania	Y	N	N
Bulletin de la Soc Naturalistes Luxembourgeois	Luxembourg	N	N	N
Bulletin of the Geological Society of Malaysia	Malaysia	Y	Y	N
Warta Geologi	Malaysia	Y	N	N
Boletin (Universidad Nacional de Mexico)	Mexico	Y	Y	N
Geofisica Internacional	Mexico	Y	Y	N
Revista Geofisica	Mexico	S	N	N
Revista Mexicana de Ciencias Geologicas	Mexico	Y	N	N
Boletim Geologico (Direccao Nacional de Geologia Mocambique)	Mozambique	S	N	N
Memoir. Geological Survey of Namibia	Namibia	Y	N	N
Journal of the Nepal Geological Society	Nepal	Y	N	N
Cainozoic Research	Netherlands	Y	N	N
Geologica Ultraiectina: med van het Mineral-Geol Inst...Utrecht	Netherlands	Y	Y	N
Grondboor en Hamer	Netherlands	Y	N	N
Scripta Geologica	Netherlands	Y	Y	N
Geological Society of New Zealand Miscellaneous Publication	New Zealand	Y	N	N
Guidebook (Geological Society of New Zealand)	New Zealand	Y	N	N
Institute of Geological & Nuclear Sciences Monograph	New Zealand	Y	N	N
New Zealand Journal of Geology and Geophysics	New Zealand	Y	Y	Y
Newsletter Geological Survey of New Zealand	New Zealand	Y	N	N
Journal of Mining and Geology	Nigeria	Y	Y	N
Bulletin Norges Geologiske Undersokelse	Norway	Y	Y	N
Norwegian Journal of Geology	Norway	Y	Y	Y
Special Publication (Norges Geologiske Undersokelse)	Norway	Y	N	N
Boletin de la Sociedad Geologica del Peru	Peru	Y	Y	N
Publicacion Especial (Sociedad Geologica del Peru)	Peru	Y	N	N
Acta Geologica Polonica	Poland	Y	Y	N

Appendix 2. Indexing of Foreign Regional Geoscience Serials in Major Databases (continued)

JOURNAL	COUNTRY	GeoRef	CAS	Web of Sci
Acta Geophysica Polonica	Poland	Y	Y	S
Acta Palaeobotanica	Poland	Y	N	N
Archiwum Mineralogiczne	Poland	Y	Y	N
Folia Quaternaria	Poland	Y	Y	N
Geologia (Akad Gorniczo-Hutnicza im S. Staszica w Krakowie)	Poland	Y	Y	N
Geologia Sudetica	Poland	Y	Y	N
Geological Quarterly (Instytut Geologiczny (Poland))	Poland	Y	Y	Y
Mineralogia Polonica	Poland	Y	Y	N
Polish Polar Research	Poland	Y	N	N
Prace Panstwowego Instytutu Geologicznego	Poland	Y	N	N
Przeglad Geofizyczny	Poland	Y	N	N
Przeglad Geologiczny	Poland	Y	Y	N
Publications of the Inst Geophys Polish Acad of Sciences D	Poland	Y	Y	N
Publications of the Inst Geophys Polish Acad of Sciences E	Poland	N	N	N
Rocznik Polskiego Towarzystwa Geologicznego	Poland	S	Y	N
Studia Geologica Polonica	Poland	Y	Y	N
Studia Geomorphologica Carpartho-Balcanica	Poland	Y	N	N
Studia Quaternaria (Polska Akademiia Nauk)	Poland	Y	N	N
Comunicacoes do IGM (Instituto do Geologico e Mineiro)	Portugal	Y	N	N
Comunicacoes Ser de Ciencias da Terra (Inst Invest Cient Tropi)	Portugal	Y	N	N
Estudos Notas e Trabalhos do Instituto Geologico e Mineiro	Portugal	Y	Y	N
Garcia de Orta Serie de Geologia	Portugal	Y	Y	N
Proc Romanian Acad Ser B Chem, Life Sci and Geosciences	Romania	N	N	N
Revue Roumaine de Geologie	Romania	Y	Y	N
Revue Roumaine de Geophysique	Romania	Y	Y	N
Studia Universitatis Babes-Bolyai Geologie	Romania	Y	Y	N
Biulleten Moskovskogo Obshchestva Ispytatelei Prirody	Russia	Y	Y	N
Fizika Zemli	Russia	Y	Y	Y
Geokhimiia	Russia	Y	Y	S
Geologiia I Geofizika	Russia	Y	Y	Y
Geomaganetizm I Aeronomiia	Russia	Y	Y	S
Geomorfologiia	Russia	Y	Y	N
Geotektonika	Russia	Y	Y	N
International Journal of Geomagnetism and Aeronomy	Russia	N	N	N
Izvestiia Vysshikh Uchebnykh Zavedenii Geologiia I Razvedka	Russia	Y	Y	N
Izvestiya. Physics of the Solid Earth	Russia	Y	N	Y
Lithology and Mineral Resources	Russia	Y	Y	Y
Litologiia I Poleznye Iskopaemye	Russia	Y	Y	N
Moscow University Geology Bulletin	Russia	Y	Y	N
Otechestvennaia Geologiia	Russia	Y	Y	N

Appendix 2. Indexing of Foreign Regional Geoscience Serials in Major Databases (continued)

JOURNAL	COUNTRY	GeoRef	CAS	Web of Sci
Vestnik Sankt-Peterburgskogo Universiteta Ser 7 Geol Geograf	Russia	Y	Y	N
Trans of the Royal Soc Edinburgh Earth Sci	Scotland	Y	Y	Y
Acta Geologica Universitatis Comenianae	Slovakia	Y	Y	N
Contributions to Geophysics & Geodesy	Slovakia	N	N	N
Geologica Carpathica	Slovakia	Y	Y	Y
Slovak Geological Magazine	Slovakia	Y	Y	Y
Geologija : Razprave in Porocilia	Slovenia	N	Y	N
Bulletin (Council for Geoscience (South Africa))	South Africa	Y	N	N
Geobulletin (Geological Society of South Africa)	South Africa	Y	N	N
Memoir (Council for Geoscience (South Africa))	South Africa	Y	N	N
Palaeontologia Africana: Ann of Bernard Price Inst for Palaeo	South Africa	Y	N	N
South African Journal of Geology	South Africa	Y	Y	Y
Boletin Geologico y Minero (Instituto Geologico y Minero Esp)	Spain	Y	Y	N
Estudios Geologicos (Insitituto de Geologia (Spain))	Spain	Y	Y	N
Geogaceta (Sociedad Geologica de Espana)	Spain	Y	N	N
Geologica Acta	Spain	Y	Y	N
Journal of Iberian Geology	Spain	S	S	N
Revista de la Sociedad Geologica de Espana	Spain	Y	N	N
Revista Espanola de Micropaleontologia	Spain	Y	N	N
Journal of the Geological Society of Sri Lanka	Sri Lanka	Y	N	N
GFF	Sweden	Y	Y	Y
Memoires de Geologie Lausanne	Switzerland	Y	N	N
Petroleum Geology of Taiwan	Taiwan	S	Y	N
Western Pacific Earth Sciences	Taiwan	Y	Y	N
Turkish Journal of Earth Sciences	Turkey	Y	Y	Y
Turkiye Jeoloji Bulteni = Geological Bulletin of Turkey	Turkey	Y	N	N
Geofizicheskii Zhurnal. The Journal of Geophysics	Ukraine	Y	Y	N
Geologicheskii Zhurnal	Ukraine	Y	Y	N
Heolohiia I Heokhimiia Horiuchykh Kopalyn	Ukraine	Y	Y	N
Mineralogicheskii Zhurnal	Ukraine	Y	Y	N
Geoscientist	United Kingdom	Y	N	N
Mercian Geologist	United Kingdom	S	Y	N
Proceedings of the Yorkshire Geol Society	United Kingdom	Y	Y	Y
Comunicaciones Paleo del Museo de Hist Nat de Montevideo	Uruguay	Y	N	N
Geologiya va Mineral Resurslar	Uzbekistan	N	Y	N
Geominas G (Universidad da Oriente (Curmana, Venezuela)	Venezuela	N	Y	Y

Note: "Y" indicates that the serial is indexed.

Note: "N" indicates that the serial is not indexed.

Note: "S" indicates that indexing appears to have stopped.

Appendix 3. North American Library Holdings of Foreign Regional Geoscience Serials

JOURNAL	COUNTRY	Current subs	Lapsed subs	Online only	Cancelled subs number	Cancelled subs (%)	Cancelled 1999-2004 numbers
Comunicacoes do IGM (Instituto do Geologico e Mineiro)	Portugal	0	2	0	31	94	26
Report (Geological Survey of Western Australia)	Australia	0	5	0	32	87	18
Palaontologische Zeitschrift	Germany	52	5	0	47	45	14
Scripta Geologica	Netherlands	9	17	0	26	50	13
New Zealand Journal of Geology and Geophysics	New Zealand	85	0	4	106	54	11
Ameghiniana	Argentina	8	11	0	55	74	9
Alcheringa	Australia	45	6	0	56	52	9
Memoires de Geologie Lausanne	Switzerland	7	1	0	3	27	9
Petroleum Science	China	2	0	0	7	78	7
Revista de la Sociedad Geologica de Espana	Spain	3	0	0	7	70	7
GFF	Sweden	42	5	0	19	29	7
South African Journal of Geology	South Africa	56	2	21	30	27	7
Indian Journal of Earth Sciences	India	3	5	0	42	84	6
Chishitsugaku Zasshi = Journal of the Geol Soc of Japan	Japan	23	0	0	55	71	6
Geologiia I Geofizika	Russia	8	2	0	24	71	6
Geokhimiia	Russia	12	0	0	24	67	6
Proceedings of the Yorkshire Geol Society	United Kingdom	19	3	0	43	66	6
Palaeontographica Abt B Palaophytologie	Germany	42	0	0	68	62	6
Geologica Carpathica	Slovakia	10	1	0	18	62	6
Rivista Italiana di Paleontologia e Stratigrafia	Italy	27	0	0	35	56	6
Geol Surv of Denmark and Greenland Bulletin	Denmark	8	0	0	6	43	6
Izvestiya. Physics of the Solid Earth	Russia	14	1	0	6	29	6
Bull of National Sci Museum Ser C Geology & Paleontology	Japan	22	5	0	10	27	6
Geologica Belgica	Belgium	28	0	0	6	18	6
Warta Geologi	Malaysia	1	0	0	16	94	5
Boletin de la Sociedad Geologica del Peru	Peru	6	1	0	40	85	5
Qazaqstan Geologiiasy = Geology of Kazakstan	Kazakhstan	3	1	0	8	67	5
Acta Palaeobotanica	Poland	12	6	0	37	67	5
Rocznik Polskiego Towarzystwa Geologicznego	Poland	18	1	0	32	63	5
Indian Journal of Geology	India	6	5	0	18	62	5
Palaeontographica Abt A Palaozoologie Stratigraphie	Germany	34	6	0	61	59	5
Journal of the Czech Geological Society	Czech Republic	12	0	0	9	43	5

Appendix 3. North American Library Holdings of Foreign Regional Geoscience Serials (continued)

JOURNAL	COUNTRY	Current subs	Lapsed subs	Online only	Cancelled subs number	Cancelled subs (%)	Cancelled 1999-2004 numbers
Bulletin (Council for Geoscience (South Africa))	South Africa	11	2	0	5	28	5
Geodiversitas	France	36	2	1	11	22	5
Paleontological Research	Japan	25	4	11	11	22	5
Przeglad Geofizyczny	Poland	1	0	0	18	95	4
Revista de la Asociacion Geologica Argentina	Argentina	4	1	0	48	90	4
Archiwum Mineralogiczne	Poland	4	0	0	37	90	4
Bulletin of the Geological Society of Malaysia	Malaysia	7	0	0	31	82	4
Special Publication (Norges Geologiske Undersokelse)	Norway	5	0	0	12	71	4
Revista Geofisica	Mexico	8	2	1	21	66	4
Geotektonika	Russia	9	0	0	12	57	4
Palaeontologia Africana: Ann of Bernard Price Inst for Palaeo	South Africa	18	6	0	31	56	4
Kuang Chuang Di Zhi = Mineral Deposits	China	9	2	0	10	48	4
Austrian Journal of Earth Sciences = Mitteilungen der Osterr Geol	Austria	18	4	0	15	41	4
Boletin Geologico y Minero (Instituto Geologico y Minero Esp)	Spain	13	2	0	10	40	4
Trans of the Royal Soc Edinburgh Earth Sci	Scotland	75	7	3	40	32	4
Proceedings of the Estonian Academy of Sciences Geology	Estonia	6	2	4	5	29	4
Memoir (Council for Geoscience (South Africa))	South Africa	12	0	0	4	25	4
Nankyoku Shiryo = Antarctic Record	Japan	30	1	0	7	18	4
Academy Proceedings in Earth & Planetary Sci	India	19	1	9	5	15	4
Revista Brasileira de Geociencias	Brazil	2	3	0	33	87	3
Bollettino di Geofisica Teorica ed Applicata	Italy	9	4	0	51	80	3
Vestnik Sankt-Peterburgskogo Universiteta Ser 7 Geol Geograf	Russia	2	3	0	18	78	3
Special Publication Series (Geological Survey of India)	India	2	1	0	10	77	3
Geologija : Razprave in Porocila	Slovenia	7	0	0	18	72	3
Journal of Iberian Geology	Spain	8	5	0	15	54	3
Quarterly Notes (Geological Survey of New South Wales)	Australia	9	0	0	10	53	3
Jishin = Zisin	Japan	8	1	0	10	53	3
Estudios Geologicos (Insitituto de Geologia (Spain))	Spain	10	12	0	20	48	3
Geologica Bavarica	Germany	14	5	0	17	47	3
Geofisica Internacional	Mexico	34	4	1	35	47	3

Appendix 3. North American Library Holdings of Foreign Regional Geoscience Serials (continued)

JOURNAL	COUNTRY	Current subs	Lapsed subs	Online only	Cancelled subs number	Cancelled subs (%)	Cancelled 1999-2004 numbers
Geoscience Reports of Shizuoka University	Japan	6	0	0	5	45	3
Clay Research	India	1	4	0	4	44	3
Norwegian Journal of Geology	Norway	56	4	26	53	38	3
Journal of Faculty of Science Hokkaido Univ Ser VII Geophysics	Japan	7	0	0	4	36	3
GeoArabia	Bahrain	6	0	0	3	33	3
Memoir. Geological Survey of Namibia	Namibia	16	2	0	8	31	3
Geologia Colombiana	Colombia	14	6	0	8	29	3
Turkiye Jeoloji Bulteni = Geological Bulletin of Turkey	Turkey	17	1	0	6	25	3
Journal of Geosciences Osaka City University	Japan	25	3	0	9	24	3
Geoscientist	United Kingdom	11	5	0	5	24	3
Journal of Mining and Geology	Nigeria	2	0	0	14	88	2
Acta Petrologica Mineralogica	China	1	0	0	6	86	2
Mineralogia Polonica	Poland	2	0	0	8	80	2
Geomorfologiia	Russia	3	0	0	10	77	2
Mercian Geologist	United Kingdom	5	2	0	23	77	2
Records of the Geological Survey of India	India	11	4	0	45	75	2
Di zhi ke xue = Scientia Geologica Sinica	China	9	1	0	27	73	2
Biulleten Moskovskogo Obshchestva Ispytatelei Prirody	Russia	4	9	0	36	73	2
Eiszeitalter und Gegenwart	Germany	14	6	0	45	70	2
Geobulletin (Geological Society of South Africa)	South Africa	4	2	0	14	70	2
Polish Polar Research	Poland	5	0	0	11	69	2
Petroleum Geology of Taiwan	Taiwan	6	2	1	19	68	2
Lithology and Mineral Resources	Russia	6	0	29	72	67	2
Otechestvennaia Geologiia	Russia	8	0	0	15	65	2
Geologica Ultraiectina: med van het Mineral-Geol Inst...Utrecht	Netherlands	10	0	0	18	64	2
Memorie di Scienze Geologiche	Italy	6	2	0	11	58	2
Di zhen di zhi = Seismology and Geology	China	6	1	0	9	56	2
Indian Mineralogist	India	15	3	0	23	56	2
Revista Espanola de Micropaleontologia	Spain	28	7	0	44	56	2
Revista Brasileira de Paleontologia	Brazil	1	1	0	2	50	2
Journal of Geophysics (Association of Exploration Geophysicsts)	India	1	1	0	2	50	2

Appendix 3. North American Library Holdings of Foreign Regional Geoscience Serials (continued)

JOURNAL	COUNTRY	Current subs	Lapsed subs	Online only	Cancelled subs number	Cancelled subs (%)	Cancelled 1999-2004 numbers
Fizika Zemli	Russia	8	0	0	8	50	2
Meyniana	Germany	11	3	0	12	46	2
Revue Roumaine de Geologie	Romania	1	14	0	13	46	2
Kaseki	Japan	6	0	0	5	45	2
Revista Mexicana de Ciencias Geologicas	Mexico	22	1	0	19	45	2
Jishin Kazan Geppo = Seism and Volc Bull of Japan	Japan	4	0	0	3	43	2
Studia Universitatis Babes-Bolyai Geologie	Romania	12	0	0	7	37	2
Acta Micropalaeontologica Sinica	China	13	3	0	9	36	2
Geologia Croatica	Croatia	11	0	0	6	35	2
Scriptum	Germany	4	2	0	2	25	2
Mineralogicheskii Zhurnal	Ukraine	8	4	0	4	25	2
Gondwana Research	Japan	4	3	0	2	22	2
International Journal of Geomagnetism and Aeronomy	Russia	10	0	2	3	20	2
Journal of Earth and Planetary Sci, Nagoya Univ	Japan	38	3	0	3	7	2
Egyptian Journal of Geology	Egypt	4	0	0	49	92	1
Journal of the Earth and Space Physics	Iran	1	0	0	12	92	1
Acta Geologica Polonica	Poland	8	0	0	71	90	1
Geologia Sudetica	Poland	4	0	0	36	90	1
Geological Bulletin of the Punjab University	India	2	3	0	20	80	1
Studia Geologica Polonica	Poland	5	6	0	35	77	1
Periodico di Mineralogia	Italy	4	1	0	16	76	1
Estudos Notas e Trabalhos do Instituto Geologico e Mineiro	Portugal	6	0	0	19	76	1
Memoirs of the Geol Soc of Japan (Chishitsugaku Ronshu)	Japan	1	1	0	5	71	1
Geologicheskii Zhurnal	Ukraine	7	0	0	15	68	1
Zhongguo Yan Rong = Carsologica Sinica	China	2	0	0	4	67	1
Acta Geophysica Polonica	Poland	21	1	0	39	64	1
Palaeontological Society of Japan Special Papers	Japan	12	1	0	22	63	1
Studia Geomorphologica Carpartho-Balcanica	Poland	2	5	0	11	61	1
Magyar Geofizika	Hungary	3	1	0	6	60	1
Journal of the Nepal Geological Society	Nepal	1	5	0	8	57	1
Zhongguo Di Zhi = Zhongguo Dizhi	China	1	0	0	1	50	1
Documents du BRGM	France	1	3	0	3	43	1
Annali di Geofisica	Italy	4	0	0	3	43	1
Bulletin Norges Geologiske Undersokelse	Norway	28	4	0	23	42	1

Appendix 3. North American Library Holdings of Foreign Regional Geoscience Serials (continued)

JOURNAL	COUNTRY	Current subs	Lapsed subs	Online only	Cancelled subs number	Cancelled subs (%)	Cancelled 1999-2004 numbers
Bulletin of Pure & Applied Sciences Sec F Geology	India	1	2	0	2	40	1
Revue Roumaine de Geophysique	Romania	3	13	0	9	36	1
Geofizicheskii Zhurnal. The Journal of Geophysics	Ukraine	9	0	0	5	36	1
Sedimentary Geology and Tethyan Geology	China	4	0	0	2	33	1
Acta Vulcanologica Journal of the National Volcanic Group	Italy	5	1	0	3	33	1
Tetisi Di Zhi = Tethyan Geology	China	1	2	0	1	25	1
Acta Geologica Universitatis Comenianae	Slovakia	2	1	0	1	25	1
Geogaceta (Sociedad Geologica de Espana)	Spain	3	0	0	1	25	1
Report of National Res Inst for Earth Sci & Disaster Prevention	Japan	7	1	0	2	20	1
Proc Romanian Acad Ser B Chem, Life Sci and Geosciences	Romania	4	0	0	1	20	1
Hai Yang Di Zhi Yu Di Si Ji Di Zhi = Marine & Quaternary Geol	China	9	0	0	2	18	1
Beringeria	Germany	7	2	0	2	18	1
Okayama University Earth Science Reports	Japan	8	0	0	1	11	1
Journal of the Geological Society of Sri Lanka	Sri Lanka	0	0	0	6	100	0
Geominas G (Universidad da Oriente (Curmana, Venezuela)	Venezuela	0	0	0	25	100	0
Geologiya va Mineral Resurslar	Uzbekistan	3	0	0	22	88	0
Bulletin of the Geological Society of Greece	Greece	1	0	0	6	86	0
Moscow University Geology Bulletin	Russia	8	0	0	50	86	0
Boletin (Universidad Nacional de Mexico)	Mexico	7	2	0	41	82	0
Garcia de Orta Serie de Geologia	Portugal	4	0	0	18	82	0
Grondboor en Hamer	Netherlands	3	0	0	13	81	0
Geology of Shaanxi	China	1	1	0	8	80	0
Jurnal Geologi dan Sumberdaya Mineral = J Geol Min Res	Indonesia	1	0	0	3	75	0
Transactions Japanese Geomorphological Union = Chikei	Japan	1	0	0	3	75	0
Boletim Geologico (Direccao Nacional de Geologia Mocambique)	Mozambique	0	3	0	9	75	0
Przeglad Geologiczny	Poland	7	0	0	20	74	0

Appendix 3. North American Library Holdings of Foreign Regional Geoscience Serials (continued)

JOURNAL	COUNTRY	Current subs	Lapsed subs	Online only	Cancelled subs number	Cancelled subs (%)	Cancelled 1999-2004 numbers
Zhongguo Qu Yu Di Zhi = Regional Geology of China	China	2	0	0	5	71	0
Bull Inst Geophys Geochem Explor Min Geol & Min Res	China	1	0	0	2	67	0
Shi You Shi Yan Di Zhi = Experimental Petroleum Geology	China	1	0	0	2	67	0
Publications of the Inst Geophys Polish Acad of Sciences D	Poland	3	1	0	7	64	0
Izvestiia Vysshikh Uchebnykh Zavedenii Geologiia I Razvedka	Russia	7	1	0	16	64	0
Litologiia I Poleznye Iskopaemye	Russia	5	1	0	10	63	0
Geologica Romana	Italy	23	1	0	35	59	0
Folia Quaternaria	Poland	15	3	0	24	57	0
Xiandai Dizhi = Geoscience	China	4	1	0	6	55	0
Geomaganetizm I Aeronomiia	Russia	6	0	0	7	54	0
Studia Geophysica et Geodaetica	Czech Republic	13	2	25	40	50	0
Geological Society of New Zealand Miscellaneous Publication	New Zealand	1	0	0	1	50	0
Prace Panstwowego Instytutu Geologicznego	Poland	8	0	0	8	50	0
Comunicaciones Paleo del Museo de Hist Nat de Montevideo	Uruguay	0	18	0	16	47	0
Di Qiu Ke Xue: Wuhan Di Zhi Xue Yuan Xue Bao = Earth Science	China	15	1	0	12	43	0
Newsletter Geological Survey of New Zealand	New Zealand	3	0	0	2	40	0
Geological Curator	Ireland	5	0	0	3	38	0
Institute of Geological & Nuclear Sciences Monograph	New Zealand	7	0	0	4	36	0
Bulletin de la Soc Naturalistes Luxembourgeois	Luxembourg	10	1	0	6	35	0
Kenshin Jiho = Quarterly Journal of Seismology	Japan	2	0	0	1	33	0
Publications of the Inst Geophys Polish Acad of Sciences E	Poland	2	0	0	1	33	0
Heolohiia I Heokhimiia Horiuchykh Kopalyn	Ukraine	7	0	0	3	30	0
Geologia (Akad Gorniczo-Hutnicza im S. Staszica w Krakowie)	Poland	7	1	0	3	27	0
Bulletin Series B (Geological Survey of India)	India	5	2	0	1	13	0
Geografia Fisica e Dinamica Quaternaria	Italy	8	1	0	1	10	0
Slovak Geological Magazine	Slovakia	11	3	0	1	7	0

Appendix 3. North American Library Holdings of Foreign Regional Geoscience Serials (continued)

JOURNAL	COUNTRY	Current subs	Lapsed subs	Online only	Cancelled subs number	Cancelled subs (%)	Cancelled 1999-2004 numbers
Acta Geologica Gansu	China	1	0	0	0	0	0
Bulletin of the Tianjin Inst Geol Min Res Chinese Acad Geo Sci	China	1	0	0	0	0	0
Journal of Chang'an University Earth Science Ed.	China	1	0	0	0	0	0
Journal of Jilin University. Earth Science Edition	China	1	1	0	0	0	0
Palaeoworld	China	1	0	0	0	0	0
Xibei Dizhi = Northwest Geoscience	China	6	0	0	0	0	0
Kolner Forum fur Geologie und Palaontologie	Germany	1	3	0	0	0	0
Indian Journal of Petroleum Geology	India	0	2	0	0	0	0
GeoActa	Italy	10	6	0	0	0	0
Studi Trentini di Scienze Naturali. Acta Geologica	Italy	1	7	0	0	0	0
Geologija - Geology - Geologiia	Lithuania	4	0	0	0	0	0
Cainozoic Research	Netherlands	11	0	0	0	0	0
Guidebook (Geological Society of New Zealand)	New Zealand	1	2	0	0	0	0
Publicacion Especial (Sociedad Geologica del Peru)	Peru	1	0	0	0	0	0
Geological Quarterly (Instytut Geologiczny (Poland))	Poland	17	4	0	0	0	0
Studia Quaternaria (Polska Akademiia Nauk)	Poland	3	0	0	0	0	0
Comunicacoes Ser de Ciencias da Terra (Inst Invest Cient Tropi)	Portugal	1	4	0	0	0	0
Contributions to Geophysics & Geodesy	Slovakia	6	0	0	0	0	0
Geologica Acta	Spain	11	0	2	0	0	0
Western Pacific Earth Sciences	Taiwan	24	4	3	0	0	0
Turkish Journal of Earth Sciences	Turkey	7	0	3	0	0	0

Note: "Lapsed subs" refers to holdings that lack the issues from the current publication year.
Note: "Online subs" refers to current holdings that are online only.

Appendix 4. Some Open-Access Foreign Regional Geoscience Serials

Journal	**Country**	**Web Address**
Acta Geophysica Polonica	Poland	http://agp.igf.edu.pl
AIG Journal	Australia	http://www.aig.asn.au/aigjournal
Bulletin of the Mineral Research and Exploration Inst of Turkey	Turkey	http://www.mta.gov.tr/english
Carnets de Geologie - Notebooks on Geology	France	http://paleopolis.rediris.es/cg
Geologia Croatica	Croatia	http://www.geologia-croatica.hr
Geologie de la France	France	http://geolfrance.brgm.fr/main.asp
Glacial Geology & Geomorphology	United Kingdom	http://ggg.qub.ac.uk
Revista Geologica de Chile	Chile	http://www.scielo.cl
Revista Mexicana de Ciencias Geologicas	Mexico	http://satori.geociencias.unam.mx/TOC.htm

Note: All Web sites accessed 3/5/2005

Appendix 5. Content Available on Foreign Geological Survey Web Sites

Country	**Agency**	**Contents**
Australia	Geoscience Australia	Over 50 databases and map viewers online; several online fact sheets; several tools
Austria	Geologische Bundesanstalt	Sophisticated digital access to mapping, full-text articles, and data
Belgium	Service Geologique de Belgique	Info on digital mapping and publications, but none online
Botswana	Geological Survey of Botswana	Publications list
Brazil	CPRM – Servico Geologico do Brasil	Extensive geoscience GIS system and project and program sites with many maps online
Bulgaria	Geological Institute (Bulgarian Acad Sci)	Tables of contents of some journals
Bulgaria	Geophysical Institute (Bulgarian Acad Sci)	Tables of contents of journal (in preparation)
Chile	Servicio Nacional de Geologia y Mineria	Describes mapping, but no maps online. Links to Revista Geologica de Chile
China	China Geological Survey	Some maps online (small-scale); index maps for mapping projects but no availability
Czech Republic	Czech Geological Survey	Map Server; full-text Bulletin online; Czech/English geodictionary; description of databases
Denmark	Danmarks og Gronlands Geologiske Under	Three newsletters and some mapping viewers (particularly Greenland maps)
Egypt	Egyptian Geol Survey & Mining Authority	English site describes organization, lists publications, and lists information contacts
El Salvador	Servicio Nacional de Estudios Territoriales	Several map viewers, online reports, photographs; extensive geographic info on hazards
Emilia-Romagna (Italy)	Servizio Geologico Sismico e dei Suoli	Geognostic and archaeological databases; some maps online
Finland	Geological Survey of Finland – GTK	Several databases that identify literature, cores, and other databases on Finnish geology
France	BRGM	InfoTerre provides an interactive map to find geoscientific info on France; other online maps
Germany	Bundesanstalt fur Geowissen und Roshstoffe	Databases on literature and mapping; description of large mapping projects of Europe
Greece	Institute of Geology and Mineral Exploration	Index map for geological map series, sample maps from extensive Project GEOCHARTA
Guyana	Geoservices Division	Maps of the country and short project reports
Hungary	Hungarian Geological Survey	Foldtani Kutatas (Geophysical Prospecting) full-text online quarterly; info on databases
India	Geological Survey of India	Index maps for map series
Iran	Geological Survey of Iran	Index to scientific reports

Appendix 5. Content Available on Foreign Geological Survey Web Sites (continued)

Country	**Agency**	**Contents**
Iran	National Geoscience Database of Iran	Map viewer; minerals and seismic databases; Publication "Geosciences" has some full-text
Ireland	Geological Survey of Ireland	Extensive mapping, groundwater, seabed, landslide, and exploration data available online
Israel	Geological Survey of Israel	Just two links to the Web sites of individual scientists
Italy	Servizio Sismico Nazionale	Seismic map viewer; some online reports and publications list
Japan	Geological Survey of Japan, AIST	1:200,000 seamless digital geol map of Japan; Online Bull Geol Survey Japan; map indexes
Korea	Korea Institute of Geoscience & Min Resource	Extensive geoscience GIS system; oil and gas, coal mine database; theses list
Latvia	Geological Survey of Latvia	Map viewer; full-text annual reports
Mexico	Consejo de Recursos Minerales	Map viewers showing geology and mineral resources; some full-text reports
Mongolia	Mineral Resources Authority of Mongolia	Describes information available and mapping projects
Namibia	Geological Survey of Namibia	Geological map of country, map index, and some reports available online
Netherlands	Netherlands Inst of Applied Geosci TNO	DINO – a database on the Dutch subsurface with different levels of access
New Zealand	Institute of Geological & Nuclear Sciences	Map viewers showing geology, earthquakes, fossil records, petroleum data, and petrology
Northern Territory (Australia)	Northern Territorial Geological Survey	Full-text publications, maps, and data; extensive databases including cores and wells
Norway	Norges Geologiske Undersokelse	Several map viewers, geoscience databases, full-text Reports series and info sheets
Pakistan	Geological Survey of Pakistan	Some maps online (small-scale)
Peru	Insituto Geologico Minero e Metalurgico	Boletin Informativo available electronically; map indexes and publication indexes
Poland	Panstwowy Instytut Geologiczny	Full-text of some journals; databases on mineral resources and water; news
Portugal	Instituto Geologico e Miniero	Mineral resources, photographic, bibliographic, and water databases; directories
Queensland (Australia)	Geological Survey of Queensland	Interactive Resource and Tenure Maps (IRTM) viewer
Russia	Inst of Geology Karelian Research Centre RAS	Brief descriptions of research, conferences, and administration
Saudi Arabia	Saudi Geological Survey	Descriptions of projects; index maps; popular texts
Slovak Republic	Geological Survey of Slovak Republic	GeoFond database – index to literature
Slovenia	Geological Survey of Slovenia	Some information on geological mapping and databases

Appendix 5. Content Available on Foreign Geological Survey Web Sites (continued)

Country	**Agency**	**Contents**
South Africa	Council for Geoscience (Geological Survey)	A few full-text reports; information on databases; some downloadable software
Spain	Instituto Geologico e Miniero de Espana	Geocience information available through map viewers
Sri Lanka	Geological Survey & Mines Bureau	Publication lists
Sweden	Sveriges Geologiska Undersokning	Map Services on the Web: Mineral and bedrock, wells, Quaternary dep, groundwater, etc.
Switzerland	Bundesamt fur Wasser und Geologie	Report series online; hydrological database; public information brochures online
Tanzania	Geological Survey of Tanzania	Geological map of country, index map of geological mapping, info on databases
Turkey	Maden Tetkik ve Arama Genel Mudurlugu	Maps online (no GIS system); some earthquake reports; full-text Bulletin online
United Kingdom	British Geological Survey	Extensive databases on photos, mapping, geodata, taxonomy, stratigraphy; some full-text
Uruguay	Direccion Nacional de Mineria y Geologia	Geological map of Uruguay online; some mineral stats; directories; little research content
Western Australia	Geological Survey of Western Australia	Mineral resources and petroleum databases; extensive GIS-based map viewer

THE ALLIANCE FOR EARTH SCIENCES, ENGINEERING AND DEVELOPMENT IN AFRICA LIBRARY PROGRAM

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Abstract --- The Alliance for Earth Sciences, Engineering and Development in Africa (AESEDA) is an international initiative of The Pennsylvania State University College of Earth and Mineral Sciences. The mission of the Alliance is to develop human resources, promote economic vitality, enable stewardship of georesources, and build sustainable livelihoods in Africa via the integration of physical science, engineering, and social sciences cooperatively with the Pennsylvania State University, African universities, and Historically Black Colleges and Universities. As part of its mission, the Alliance developed a library/information resources component to promote collaboration among partner institutions in providing access to library and information resources related to geo-resources management and sustainable livelihoods in Africa. This paper describes ASESEDA, the Library Program and its goals for the future.

WHAT IS AESEDA?

In 2002, the College of Earth and Mineral Sciences at Penn State hired a new dean, Dr. Eric Barron. During his first months as dean, Dr. Barron spent much time learning about the programs in the college and about the diverse research interests of individual faculty members. He noticed that throughout the college, in all departments, were faculty who had active connections to Africa. Recognizing the potential synergism, he created a task force to explore ways of developing a college-wide focus on Africa and to evaluate the research and educational benefits of such an endeavor. The task force submitted its report to Dr. Barron in December and in the spring of 2003, the Alliance for Earth Sciences, Engineering, and Development in Africa (AESEDA) was born.

The mission of the Alliance is to develop and foster inter-institutional, interdisciplinary research, education, and outreach initiatives aimed at harnessing georesources for sustainable livelihoods in Africa. This mission is grounded in the strengths of the College of Earth and Mineral Sciences with its historic commitment to and integration of science, engineering, and social sciences. As stated on its website, the College of Earth and Mineral Sciences "is a place where scientists, engineers, and social scientists work together to study the Earth and the environment, natural resource engineering and management, and the materials that sustain and stimulate progress" (PSU, 2002).

In pursuing its mission, AESEDA has three over-arching goals:

1. to promote a diverse international milieu that encourages excellence in intellectual inquiry related to promoting sustainable development of geo resources in Africa;
2. to create effective, international, collaborative learning environments that support excellence in education and research;
3. to support and build opportunities for disadvantaged populations, while helping to ensure intellectual and cultural diversity in all areas of Alliance activities (AESEDA, 2003).

The Alliance focuses its attention on georesources and sustainable livelihoods, areas of expertise in the College, and utilizes a multidisciplinary approach to help design better solutions to the challenges facing Africans. Collaboration with colleagues across the Atlantic, in the Historic Black Colleges and Universities (HBCUs), and with other departments at Penn State combine to produce a diverse intellectual and cultural climate that, hopefully, will lead to innovative solutions and partnerships, and attract more diversity to these fields of study.

AESEDA PARTNERS

The rich diversity of the Alliance is achieved via collaboration and partnership on many levels and in many regions. In Africa, several nations are members of the Alliance. In Nigeria, partner institutions include the University of Lagos and University of Ibadan. Two South African universities are also involved in the Alliance – the University of Cape Town and University of the Witwatersrand. Agostinho Neto University in Angola, Kwame Nkrumah University of Science and Technology

(Ghana), and Addis Ababa University in Ethiopia also participate.

In the United States, partner institutions include Howard University, Alcorn State University, Mississippi Valley State University, Jackson State University, Tougaloo College, and the Mississippi Consortium for International Development. It is worth noting that none of the Historically Black Colleges and Universities offers a bachelor's degree in the geosciences so partnership with the Alliance may open some new avenues for students at these institutions.

There has been great interest in the Alliance, which has posed some challenges to such a young organization. In addition to the existing partner institutions listed above, the Alliance has been approached by other African institutions interested in joining the partnership including Rivers State University of Science and Technology (Nigeria), Western University College (Ghana), Medical University of South Africa, and the University of the North (South Africa). In the United States, discussions have been held with Lincoln University, Cheney University, North Carolina A & T University, and Tuskegee University.

AESEDA PROGRAMS

In support of its mission, the Alliance's programs address research, education, and outreach (i.e., service), which mirror the three legs of scholarship upon which land grant universities such as Penn State are based. One program example is AfricaArray, which couples education in seismology with the development of an array of seismic recoding stations across Africa. Another program is the development and delivery of a course on environmental justice, co-taught by instructors at Penn State and the University of the Witwatersrand. A third program involves curricular reviews at partner institutions; the Library Program constitutes yet another.

AESEDA LIBRARY PROGRAM

The goals of the Library Program are to assist partner institutions in developing information resource capacity on-site to support AESEDA programs, and to improve access to African publications and resources. While research resources in the United States are heavily slanted towards the electronic, various contention and supply issues (lack of reliable power, Internet access, access to computers, etc.) make electronic resources difficult to access for some partner institutions. Information resources in the form of paper journals and books are highly desired for their accessibility for multiple users and long-term ownership issues.

The AESEDA Library Program focuses on information sources related to georesources and is thematic by institution. Each partner institution has a specific subject responsibility and will be the prime repository in Africa for the Alliance on that subject. For example, the University of Cape Town focuses on climate issues; the University of the Witwatersrand focuses on mining; and so on. Since the Alliance supports partnerships among institutions of higher education, only collegiate level materials are collected.

Ideas for future activities are many and include coordinating donations to partner institutions. A fair number of book donation programs to Africa already exist and the Alliance may be able to assist partners by coordinating some of these activities. Developing a textbook program whereby multiple copies of textbooks used in georesources programs are gathered and shared with partners is another option. Obtaining additional funding to support the Library Program is always desirable since many of the activities are limited simply by the funding available. Utilizing partnership connections to meet and engage African library colleagues in the broader geoscience librarianship community would be a useful endeavor. And, finally, working with Alliance members to improve access to African dissertations and other publications would be beneficial to all.

The boundaries of the Library Program are limited only by the time of those involved and the funding available to pay for the program (mostly shipping costs). While this service program is not the primary focus of the Alliance, it furthers its mission and contributes to the vitality of the partner institutions. It is hoped that access to information will be improved for partners on both sides of the Atlantic.

REFERENCES

Alliance for Earth Science, Engineering, and Development in Africa, 2003. "What is AESEDA?" http://www.aeseda.psu.edu/index.html. Accessed 11 April 2005.

Pennsylvania State University, College of Earth and Mineral Sciences, 2002. "What We Study" http://www.ems.psu.edu/Explore.html. Accessed 11 April 2005.

LIBRARY AND ARCHIVES MATERIALS AVAILABLE ON THE KANSAS GEOLOGICAL SURVEY'S WEBSITE: WHERE WE ARE AND WHERE WE ARE HEADED

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Abstract -- Making geologic studies and select archive collections available on the Internet has been a goal at the Kansas Geological Survey for over ten years. Two projects, scanning out-of-print geologic studies from the library collection and measured stratigraphic sections from the archives, are underway. At present, 26 geologic reports to match text covering 32 counties are available on the KGS website. Four reports covering 6 counties are in preparation. Nine reports covering 12 counties still need to be scanned. Over-sized sheets included with the reports (i.e. geologic maps) initially not included are now being attached as PDF files. Some photographs from the original publications may be re-photographed. However, this will depend on the location of the original photograph. The second project involves the KGS collection of measured stratigraphic sections. The measured sections are original documents. They are mostly hand written and the sections are hand drawn. They are arranged by county and date mostly from 1930's through the 1950's. They represent the field work of the Survey's most prominent geologists. Converting the sections into electronic files requires typing the text and redrawing the section using PhotoShop. PDF and TIF files that show the original are attached to the record for any questions regarding interpretation of the information. Presently, measured sections for 19 counties are available. Future projects include scanning the KGS collection of aerial photographs and underground mine maps.

BULLETINS AND MEASURED SECTIONS

In many cases, out-of-print county bulletins are the best (and possibly only) sources of detailed geologic information. Choice of county for the library's scanning project is based on: critical need for information, water-resource questions, strong growth, high populations, environmental concerns, and continued loan demand. Twenty-six publications have been placed online; others that have been scanned are in progress. The next round of work may move beyond works that are out of print to those books with: need for quick access, strong demand for information, or need to "repurpose information."

The OCR (optical character recognition) takes 4-6 days per book. Microsoft Word is used to assist in spell checking the OCR'd text. Information is not updated, but KGS editorial staff go over text to catch mistakes and to standardize publications. Figures are limited to 360-400 pixels in width if placed in main web pages. Enlarged figures are placed on separate web pages if the figures are too complex for 360 pixels. Small tables are placed in main web pages. Tables that are too wide are placed on separate pages. Plates are scanned using a large flat-bed scanner at the University of Kansas Map Library. The plates are saved at 150 DPI images and presented as full size and half size Acrobat PDF files.

Measured sections are on file at the KGS for most counties in the state. The original sections are written in long hand and sections themselves hand drawn in pencil or ink. Looking through the files reads like a "Who's Who at the Kansas Geological Survey" with the original works by Drs. Raymond C. Moore, Maxim K. Elias, and Norman D. Newell, only to mention a few. The measured sections are filed by county and arranged by legal description (section, township, and range). Some, but not all, have been published in KGS publications. They are used by geologists involved with the KGS geologic mapping program. At present, 19 counties have been scanned and are available on the KGS website.

TECHNOLOGY

Most of the older books are 6" x 9", though publications issued as "Volume", not "Bulletin" are 8 ½" x 12". After scanning, the text must be carefully proofed. The older books often use small fonts with very thin strokes. Depending on the scanning software and the condition of the original, words like "north-south" can become "nortli-sotitli," "Permian" can become "Periiian," and "by" can become "bv." Better scanners and better software can help, but finding a good-quality original to scan from helps the most. Tables of data are typed into Excel directly because the Excel-web page link can save time in creating HTML.

For the measured sections project, a student assistant types the text and redraws the section. This is done using a program in Oracle. A PDF and TIF file is attached to the record for needed clarification of the online version of the record.

Computer hardware requirements for both projects is minimal: Dell OptiPlex GX110 (Pentium III), Acer Scan Prisa 620P, TextBridge OCR software, Photoshop 6, and Microsoft Office 2000.

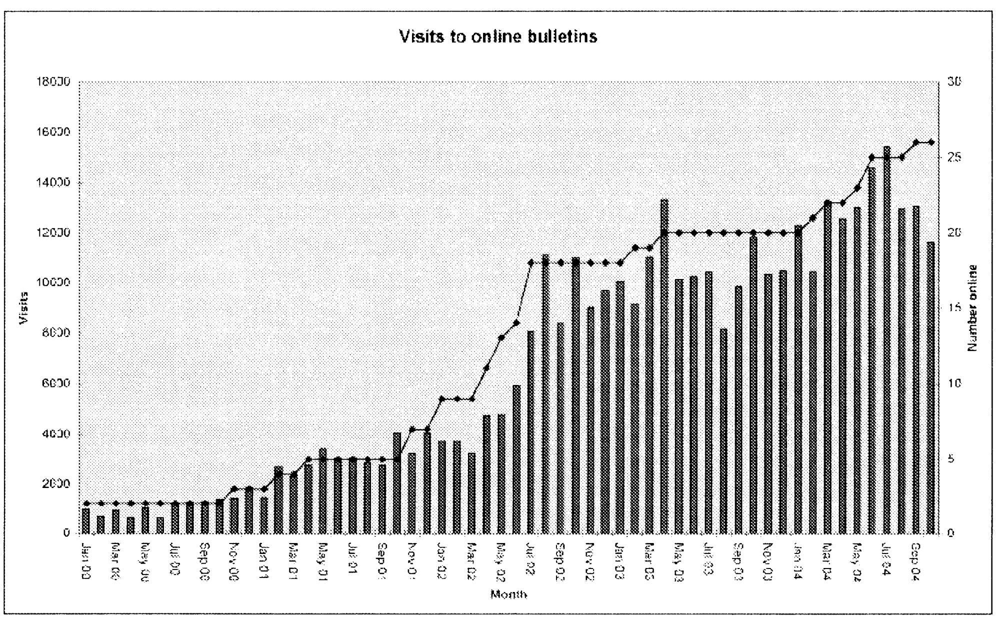
FUTURE PROJECTS

The KGS has an extensive collection of aerial photographs. The photos are used primarily by the geologists involved with the KGS geologic mapping program. The photographs will be scanned at a high resolution, geo-referenced, and be available on the Internet. The first project would be to scan the collection of historic photos of the Kansas River valley on file at the KGS. The Kansas River valley is located in the northeastern part of the state and covers 10 counties. These photos date from the 1930's to the 1950's and number approximately 2,270. A second project would be to scan and geo-reference photographs on file for one particular county. The Map Library at the University of Kansas holds large collections of aerial photographs and possibly will partner with this project.

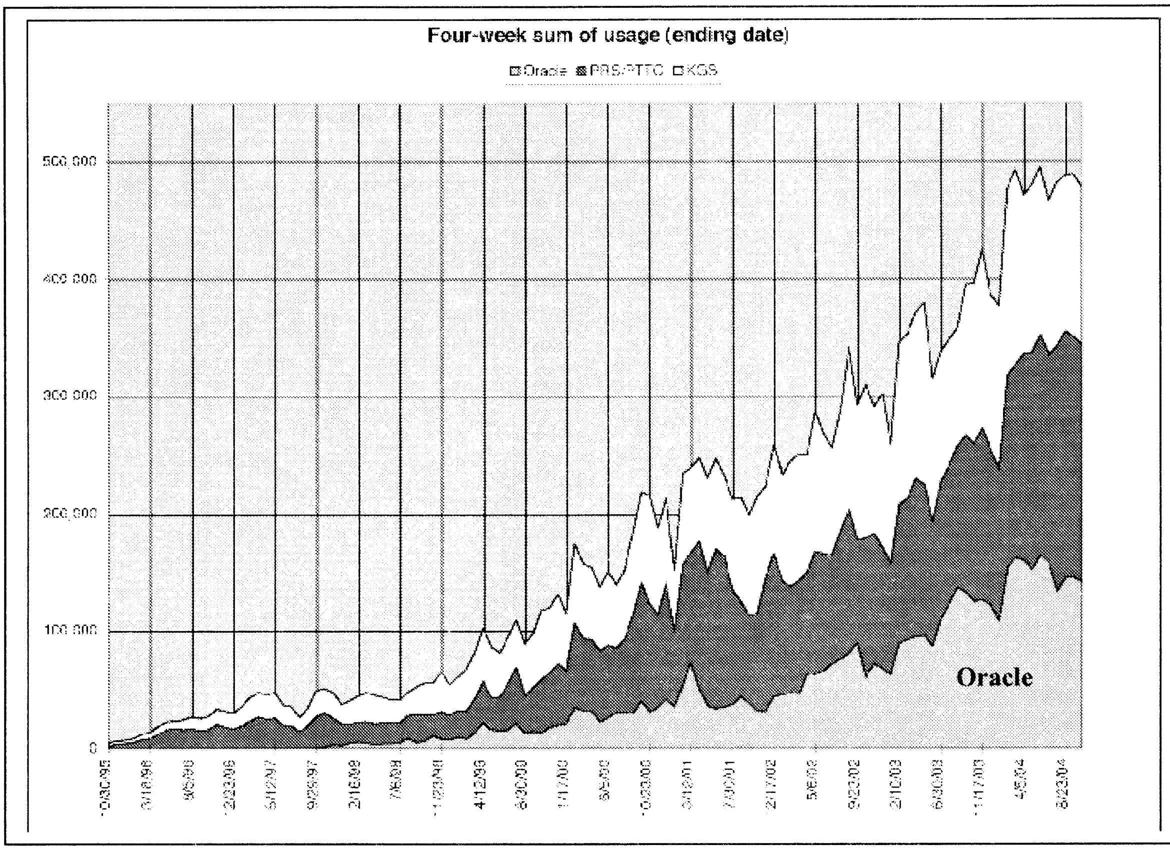
Underground mining operations have been active in Kansas for many years. Mining in southeast Kansas for lead, zinc, and coal led the way followed by salt, gypsum and limestone in other parts of the state. The State Geologist of Kansas, mandated by state statute, has the responsibility for collecting and archiving maps of active underground mines in the state. This responsibility was transferred to the State Geologist in July 2000 from the Secretary of Human Resources. All maps prior to 2000 were transferred to the KGS and include active and inactive mines. The oldest maps in the collection date from the late 1960's. Scans of new maps are planned and eventually the entire collection will be done.

CONCLUSION

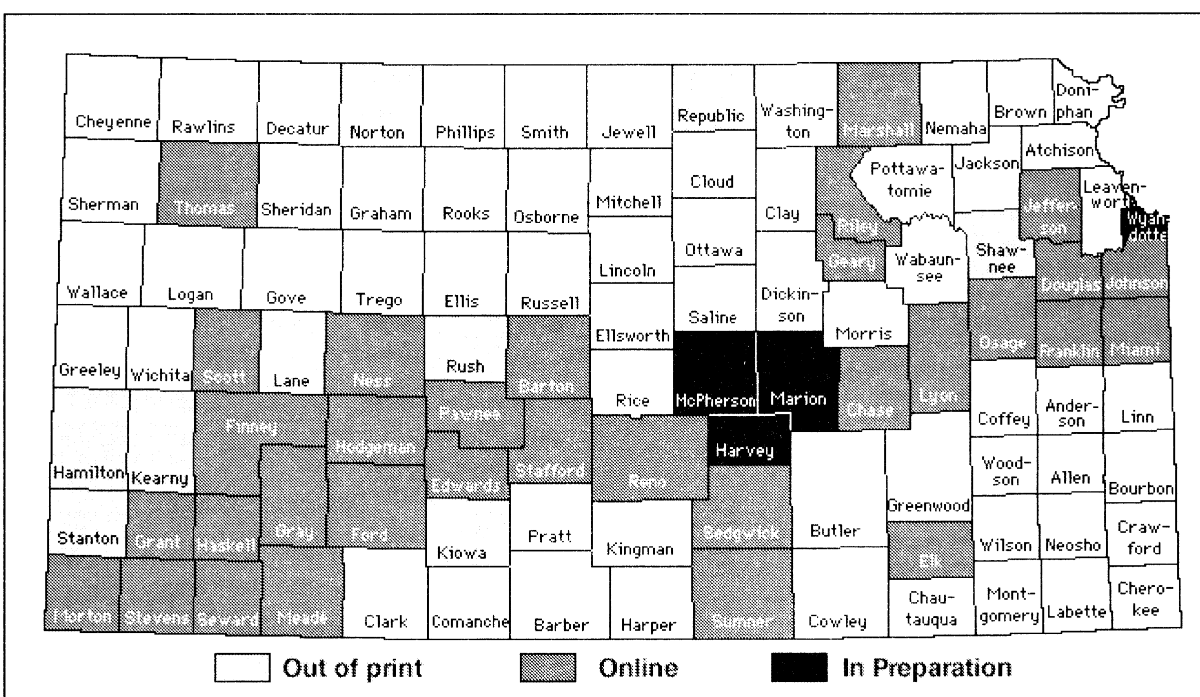
Placing out-of-print geologic studies on our website is nearly completed. The original plates included with the study are being added as PDFs. The measured sections project is, however, far from being completed. The aerial photograph projects are still in the planning. There is a possibility that the KGS will purchase an over-sized scanner and work will be done in house. A select group of underground mine maps have scans. Maps from 2000 to present will be scanned in the coming year.



This chart of web statistics counts visitors to web pages only. Images are filtered out. We also try to filter out web crawlers, though crawlers that hit only a few pages a day are harder to notice and remove. As we have added more pages (more bulletins), the number of visits has increased. Most visits are single hits from a computer. People jump to a page based on a search engine result, look at that page, and jump out.



The above chart shows the steady growth of visits to the KGS web site. The Oracle section, showing database use, has shown the most growth lately.



THE WILDERNESS SOCIETY, SIERRA CLUB, AND THE BLM: POLITICAL ADVOCACY LITERATURE AND THE NATIONAL LANDSCAPE CONSERVATION SYSTEM

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Abstract -- The literature of environmental organizations and other political advocacy groups often contains significant geoscience content. As this literature includes a political motive seeking to influence public opinion, legislation, or administrative policies, it sometimes mirrors and augments literature emanating from government agencies. Even if these connections are not strong or deep, it is helpful that geoscience researchers and librarians have awareness of the potential relevancy political advocacy literature has for their professions.

Literature pertaining to the National Landscape Conservation System (NLCS) illustrates this connection. Bureau of Land Management (BLM) literature regarding the NLCS was compared to similar literature from the Wilderness Society, Sierra Club, and a coalition of environmental organizations supporting the NLCS as well as the published secondary literature from all sources. To some extent, these sources are repetitions of each other. Even so, each has a unique angle, interpretation, and style of presentation. It is suggested that the library and other informational fields pay more attention to factually oriented political advocacy literature.

This poster presentation was a condensation of "The Relevance of Political Advocacy Literature to the Library Field: A Case Study of the National Landscape Conservation System" *Dttp: Documents to the People* Vol. 32 (4) (Winter 2004), pp. 25-29.

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REACHING OUT TO ACADEMICS AND GRADUATE STUDENTS: COLD CALLS AND INCENTIVES AT THE SCRIPPS INSTITUTION OF OCEANOGRAPHY

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Over the past few years the Scripps Institution of Oceanography (SIO) Library has experienced a drop in the library gate count, in-person visits, reference queries, and attendance at library classes. Since the librarians were convinced that there was still a need, a program was put in place to reach out to faculty and researchers (academics) by making phone calls to their offices, "cold calling". To add to the graduate students' attendance at library orientation classes, incentives in the form of $10 gift certificates to the coffee & snack bar adjacent to the library were offered. The new instruction & outreach librarian believed in the benefits of one-on-one instruction, so individualized consultations were offered to the graduate students with the "bribe" of a $20 gift certificate to the coffee bar for attending.

The goal of the "cold calling" program was to contact each academic, department by department, to ascertain if their informational needs were being met and if they were informed about the latest databases and electronic resources the library offered in their subject disciplines and for their specific areas of research. Several phone conversations with the faculty and researchers resulted in immediate questions and resolution of their access or searching problems on the spot. Also, individual consultations with the academics were scheduled and held in their offices to assist them with database searching, loading of specialized software, online requesting of documents, access to electronic journals, and bibliographic software program use (e.g. EndNote).

Reports on librarian time spent researching the academics before cold calling, preparation for the consultations and classes, and the amount of positive feedback from the academics and students branded this new program as a success. Revision of the program goals and plan a year after implementation, to streamline the workflow, turned this new venture into a routine service of the SIO Library.

Outreach Plan - Students

- Graduate Students
  - At the general graduate orientation the students are invited to attend library orientation classes and consultations.
  - Due to benefits of one-on-one consultations, $20 gift certificates are offered for attending 1-hour sessions, while $10 certificates are offered for attending the 30-minute drop-in library classes.

Cold Calling Academics

Before Calling:
- A Department is targeted, e.g.
  - List of current academics is compiled
  - Each academic's website, or general site entry, is checked
  - Searches of appropriate databases are conducted

Outreach Plan - Faculty

- Faculty & Researchers
  - Systematic contacting of all permanent academics to promote resources, services and offer consultations
  - Cold calling of approximately 30 academics each quarter, around 2-3 per week.
  - After 3 attempts to reach by phone, an email message is sent detailing services, consultation offer, and contact information

Testimonials & Comments by Academics

- "Everything I do with the library is just great"
- "I did not catch the wave and use none (databases) successfully"
- "..love the electronic journals – no time for consults"
- "I've become good at OVID searching"
- "..not familiar with INSPEC, only search journal on CD"
- "…do not do much research in present incarnation (administration) but appreciate you going out to the troops"
- "…very happy with electronic databases, use them all the time"
- "Get very good help from the library"
- "..new interface is very difficult, will call back with specific questions"
- "…thanks for the call, have no needs now, but keep on doing it"
- "…maybe have a group session with the grad students"
- "..love Avanti (electronic document delivery)"

Gift Certificates

Statistics

Time spent researching and contacting academics well worth the total number of people reached (20% of total academics in the first year of the program)

Significant number of graduate students attending classes and consultations (50% of first year class)

MODELING DISCIPLINE-SPECIFIC GEOLOGICAL CONCEPTS WITH THE W3C XML SCHEMA

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Abstract --Interchange and storage of geological data require translating geological concepts and non-standard data structures into structured, domain-specific markup languages. Domain (discipline) concepts, such as plate, fault, or earthquake, modeled and designed with UML, can be mapped into the elements of the XML Schema to compose discipline-specific markup languages which could be shared across the field. These languages require geologists to assign precise definition, meaning, syntax, data structure, and type to concepts within each discipline. The languages minimize the loss of information in transit from one source to another, and allow efficient sharing, storage, and management of geological information. The XML Schema can be mapped into a relational database schema, allowing a one-to-one correspondence between the data storage and the markup language.

Developing efficient, discipline-specific, modular, and reusable components, based on the XML Schema's namespace and the principles of object-oriented design, reduces redundancy, increases efficiency, scalability, and extensibility, and simplifies the maintenance and future extension of the XML code and database schema. Applying the best practices of XML Schema composition and reuse, we present a UML conceptual model and markup language for the main concepts of plate tectonics knowledge base (TectML) and related concepts of orogeny, fault, deformation, rock, and earthquake.

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THE MEDICINAL USES OF MINERALS, ROCKS, AND FOSSILS

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Abstract --The uses of fossils, minerals, and rocks for healing date back thousands of years. Peoples all over the world have applied these geologic materials in various forms to soothe and cure. While modern day America uses a few common minerals such as clay and calcite for medical purposes, other countries manufacture tons of pharmaceuticals with a multitude of minerals and fossils.

Various traditional and non-traditional medical disciplines take advantage of these earth materials. Research as to what their healing effects might be is rather scarce. Over eighty minerals and mineraloids were documented for medicinal purposes past and present. The clay minerals lead the list, followed by quartz, amber, hematite, pearl, and malachite.

Over eighty illnesses and maladies have been treated with these earth materials. Minerals were, and still are being used for a wide range of ailments such as malachite and clay for infections, clays and pearls for gastrointestinal problems, and amber (succinite) for alcoholism and to strengthen the immune system.

Some minerals are clearly therapeutic while the healing reported from others may be due to the placebo effect. Color, such as red minerals being used to treat body ailments, the value and beauty of a gem, and the shape have all plaid a big role in placebo related results. The purported anti-microbial properties of malachite were documented in a preliminary study with Staphylococcus aureus and Pseudomonas aeruginosa.

Most commonly, the minerals were directly applied to the body, consumed as tea produced by soaking them in water, or taken internally in the form of powder. Many other forms of application exist.

The geographic distribution of uses of medicinal fossils and minerals is world wide, with the exception of polar regions.

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GEOINFORMATICS AND GEOLOGICAL SCIENCES: THE NEXT STEP

Topical Session 94

This session focused on geoinformatics projects in the geoscience community, in particular from those associated with distributed data and computational resource integration efforts.

THE DIGITAL MISSISSIPPI: 3-D VISUALIZATION OF CENTURY-SCALE CHANNEL EVOLUTION AND FLOOD RESPONSE USING THE GEOWALL SYSTEM

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Abstract --A prototype database of river channel and floodplain change through the past 100 years on the Mississippi river system is visualized using the GeoWall and GeoWall 2, a three-dimensional visualization and ultra-high-resolution display system. The database consists of systematic surveys, maps, hydrologic data, and major engineering modifications of the Mississippi and Missouri river system over time, at present focusing on the Middle Mississippi. Input sources were digitized, registered, rectified, standardized to a uniform vertical datum, and stored in a GIS. The full database is envisioned as a system-wide tool for statistical hydrology, hydraulic modeling, environmental assessment, and public outreach.

Visualizations were produced using software that can display over 100 million elevation datapoints interactively. The GeoWall is a three-dimensional visualization system, and the GeoWall 2 is a 8-100 million pixel ultra-high resolution display. All software is either open-sourced or from low-cost commercial vendors; further information is available at www.geowall.org.

One application of this system is to illustrate the impacts of channel regulation and levee construction on flood levels, frequencies, and floodplain zonation. As previously reported, channel and floodplain modifications along the Middle Mississippi River have resulted in increased flood hazard. Three-dimensional, interactive visualization using GeoWall illustrates evolving flood response of the Mississippi for four time-slices: 1880, 1908, 1940, and 1998. This pairing of geo-/hydro-informatic database and advanced visualization capability creates a powerful tool for fluvio-geomorphic research, educational applications, and conveying changes in river and flood dynamics to both expert and non-scientific audiences.

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GIS-BASED AUTOMATED TIME-SERIES REMOTE SENSING DATA CONVERSION AND INFORMATION RETRIEVAL

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Abstract --The earth system (land, ocean, and atmosphere) is a complex and dynamic system. Geoinformatics for the Earth should not only deal with the geologic record of long-term processes that have shaped the earth, but should also deal with the current dynamic changes of the Earth system such as precipitation, vegetation, temperature, soil moisture, land use and land cover, etc. Remote sensing has been revolutionized in recent decades by the explosion of new data with spatial resolution from sub-meter to tens of kilometers and temporal resolution from minutes to tens of days. However, many obstacles, such as different data formats, different coordinate systems, interoperability, and large hourly or daily datasets have hindered scientists and educators in the access and full use of these tremendous and constantly growing volumes of datasets available. The algorithms and approaches needed to deal with these voluminous and diverse data are not fully developed. In this paper, we will present a GIS based approach to automatically convert different types of remote sensing data such as from NEXRAD and MODIS into a GIS grid format, project or reproject them to a common user-defined coordinate system, and clip and retrieve time series of information (such as precipitation, snow cover, reflectivity, NDVI, temperature) for any region or pixel of interest. The final results then can be easily employed in various applications to encourage integrated analyses in research, education, planning and other applications.

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ONTOLOGY DRIVEN DATA MINING FOR GEOSCIENCES

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Abstract --The application of data mining algorithms is a critical part of the knowledge discovery process. Application of traditional data mining techniques (clustering, classification) has resulted in extracting novel information from large scientific data bases (e.g. atmospheric sciences, genetics), and helped to manage costs and design of effective sampling/experimental strategies. As scientific data becomes more complex, as in solid earth science, it is important to relate data to the concepts within disciplines. Domain knowledge is represented in the form of an ontology, which describes the concepts or terms in a domain and the hierarchical relationships that exist between them. The data sets of the domain can then be structured by associating them to the concepts of the ontology. The user can easily retrieve the relevant data sets to be compared by navigating the ontology. Thus, data mining algorithms can be applied at different levels of the abstraction and help the user discover more meaningful patterns. We applied this ontology driven data mining approach to the GeoRoc (http://georoc.mpch-mainz.gwdg.de/) data base. The data set corresponding to the class of convergent margins was ontologically structured into different subclasses. Convergent margin settings include geometrical relationships between upper plate and the subducted (lower) plate. In addition, the composition of both plates (continental, oceanic) leads to well recognized geochemical affinities. Similarities and differences between these environments are further constrained by rate of subduction, angle of subduction as well as the age of the plates involved in convergent margin settings. An ontology was developed taking these properties of convergent margins into consideration, and the data set was structured accordingly. Correlation analysis of this dataset showed a high negative correlation between Si and Fe in continental convergent margins (correlation coefficient >0.9 for Cascades and Andean arc) which is in sharp contrast to the moderate negative correlation in oceanic continental margins (<0.6 for Tonga and Mariana). This example demonstrates the role ontologies can play in data mining algorithms to explore the underlying processes responsible for similarities and differences between various geologic environments.

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INFORMATION TECHNOLOGY DEVELOPMENTS FOR GEODYNAMICS RESEARCH IN THE ROCKY MOUNTAINS

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Abstract --Some recent research at UNAVCO and the University of Colorado has been focused on Rocky Mountain tectonics, and Information Technology in the areas of data visualization and distributed data serving. At UNAVCO, we are participating in the geodynamics work in the Rocky Mountain Testbed of the GEON NSF Information Technology Research project. As part of this work, a variety of seismic tomography models, GPS velocity vector data, strain rate models and other data have been incorporated into the Integrated Data Viewer (IDV). The IDV is an open-source visualization and analysis tool developed by UCAR that has several exciting capabilities such as online collaboration, and a variety of 1-d, 2-d and 3-d viewing options. The collected data sets are being served on a platform-independent distributed data service called OPeNDAP. Through this system, self-describing data is easily accessible to a wide audience and fosters sharing in the earth sciences. Testing such systems now allows us to be more prepared for the volumes of data anticipated from various Earthscope projects.

As part of the scientific research for GEON, we have also begun investigations into quantifying Colorado seismicity. The Rocky Mountain Front IRIS/PASSCAL seismic experiment recorded many local events that previously had not been examined. We have begun to locate these events and are working to create focal mechanisms, a seismic hazard map, and calculations of stress drop for this region. New IT capabilities will help augment the quality of this work through sharing the data with a larger audience and providing a means to view and analyze integrated data.

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A SCALED RELATIONAL DATABASE DESIGN FOR ORGANIZING AND ANALYZING INFORMATION: APPLICATION TO GEOLOGY AND ORE DEPOSITS OF THE GREAT BASIN

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Abstract --Geoscientists with the U.S. Geological Survey's Metallogeny of the Great Basin Project are developing a comprehensive relational database to manage large volumes of existing and newly compiled data to facilitate understanding of relationships between world-class ore deposits and associated geologic features in the Great Basin. Scientists routinely synthesize attributes of geologic features to solve earth science problems. A growing and challenging technical concern is how to develop user-friendly, computer-aided schemes to store, organize, update, and analyze data pertinent to these problems. Project geologists are exploring the utility of a scaled, relational database to manage increasing volumes of diverse data. Geologic information ranging from mineral isotopic data to regional mapping is acquired from regions containing gold and base-metal deposits, industrial mineral deposits, geothermal resources, petroleum reserves, and non-mineralized terrain and then recorded as feature attributes. For example, mineral resource information is organized in the telescoping hierarchy scheme: sample, ore deposit, hydrothermal system, mineral belt, and metallogenic province. This "scale of observation" organization links sample-sized attributes, which populate a database, to a family of increasingly larger-scale feature attributes at higher levels in the database. Relational database keys (join-items) merge data across this hierarchy scheme to permit further relevant queries. Relational join-items cross-link to analogous sedimentary rocks, igneous rocks and deformational features datasets each of which are linked to isotopic and fossil age data to facilitate understanding of the temporal, spatial, and genetic relationship of ore deposits to other geologic features. This scheme enables users to retrieve pertinent information from multiple datasets for input into external software for various GIS, statistical, petrologic, or other analyses. The results of these analyses are used to populate additional database fields. This relational database is both a conventional data storage, organization and retrieval system and a research tool that allows scientists to efficiently work with information in creative ways to solve geologic problems.

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LIDAR DATA DISTRIBUTION, INTERPOLATION AND ANALYSIS ON THE GEON GRID - A CONCEPTUAL FRAMEWORK

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Abstract --Acquisition and analysis of large LiDAR (Light Distance And Ranging) datasets pushes the computational limits of typical data distribution and processing systems. The high point-density of LiDAR datasets makes grid interpolation difficult for most geoscience users who lack the computing and software resources to handle these massive datasets. We present a conceptual framework that utilizes the GEON cyberinfrastructure to offer online data distribution, interpolation to grid, and analysis of large LiDAR datasets. Utilizing GEON's powerful grid computing infrastructure, we propose a workflow that begins with users querying and selecting a segment of the larger dataset via an ArcIMS based interface. Once a selection has been made, the user can choose to perform a variety of grid interpolations and analyses via Web services running on the GEON grid. Each interpolation and analysis task will be developed and implemented as a Web service module; these modules will then be strung together to build the workflow. Our proposed framework employs GEON's distributed computing capability to offer Triangular Interpolation Network (TIN), Inverse Distance Weighted (IDW), Kriging and Splined interpolation of LiDAR point data. Each gridding algorithm represents the measured land surface differently, thus, users can compare the quality of the resulting DEMS for the morphometric or process analyses they are performing. We propose development of Web service-based gridding capability through the utilization of existing software (ESRI Spatial Analyst and GRASS – an open source GIS) or, at a greater investment of time, borrowed from published computational algorithms that can be adapted as modular Web services for GEON. Web service-based grid analysis capability allows the user to perform basic grid manipulations such as generating hillshades, and performing raster and DEM calculations. Most of the desirable tools for these types of manipulations exist within the ESRI and/or GRASS suites of GIS software and could be implemented as modular Web services on GEON. Download capability would be offered at any point in the proposed workflow with the user choosing from a variety of common file formats including, binary GRID, ASCII GRID and text file. The workflow would be wrapped in an authentification protocol already developed by GEON.

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THE ROLE OF CONCEPTUAL MODELS IN GEOINFORMATICS

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Abstract --Computer information systems that will archive, query, retrieve, and display geologic information tailored to specific requirements are the foundation for a leap in scientific development similar to that fostered by the invention of the geologic map. In order to achieve this potential, some standardization of a conceptual model for basic elements of geoscience is required to provide a consistent framework for developing interoperable systems using a semantic markup language as an interchange format. These models must be developed in the framework of larger community modeling efforts for interdisciplinary knowledge domains, such as time, location, material science, and physics.

Models are presented for concepts that are central to geologic science: Earth material, geologic units, geologic structure, and geologic time scales. The described models build on the NADM C1 model [North American Geologic-Map Data Model Steering Committee, 2004], and are being implemented for the USGS National Geologic Map Database Project. An Earth material is a substance defined by chemical constituents, in concert with crystal structure, physical properties, or properties related to the nature and arrangement of constituent particles. Earth material is a mass noun, not countable. A geologic unit is a part of the Earth located and distinguished from other parts of the Earth based on geologic properties. Geologic units are countable. A geologic structure is a configuration of Earth material within the Earth, and may or may not be countable. The existence of a geologic structure requires the existence of some Earth material substrate. Geologic time scales are modeled as hierarchical collection of named intervals within a temporal topologic complex (ISO 19108) constrained such that only one path between nodes in the complex may be subdivided. A top-level vocabulary defines subclasses of these concepts, and description schemas specify relationships and attributes used to characterize defined classes and instances that extend the top-level subclasses. A geologic map is modeled as a particular instance of a more general geoscience knowledge representation framework. Models are presented as UML static class diagrams.

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THE PLATE BOUNDARY OBSERVATORY: DATA MANAGEMENT PLANS AND STATUS

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Abstract --The Plate Boundary Observatory (PBO), part of the larger NSF-funded EarthScope project, is designed to study the three-dimensional strain field resulting from deformation across the active boundary zone between the Pacific and North American plates in the western United States. The science goals of PBO require that plate boundary deformation be adequately characterized over the wide range of spatial and temporal scales common to active continental tectonic processes.

PBO will meet these needs using 875 continuous GPS sites, 175 borehole strainmeter stations, and five laser strainmeters, all installed over the next five years. In addition, 226 existing continuous GPS sites will be incorporated into PBO, and there will be a pool of 100 portable GPS receivers available for survey-mode observations. These stations will provide raw observations from which PBO Analysis Centers will create a wide range of derived data products, including time series of strain and GPS station position, GPS velocity vectors, and regional strain maps. All PBO data and data products will be made available to the community as rapidly and freely as possible through the EarthScope Data Portal.

PBO began operations in September 2003 and the first five new PBO continuous GPS stations were installed in January 2004, with the first PBO borehole strainmeter installations anticipated by January 2005. Data from the first six months of PBO facility operations are now available through the PBO archives at the UNAVCO Facility in Boulder and the Scripps Orbit and Permanent Array Center in San Diego. We will present an update on the current status of, and future plans for, PBO data collection, analysis, and distribution.

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PBO FACILITY CONSTRUCTION: YEAR 1 ACCOMPLISHMENTS

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Abstract --The Plate Boundary Observatory (PBO), part of the larger NSF-funded EarthScope project, will study the three-dimensional strain field resulting from active plate boundary deformation across the Western United States. PBO is a large construction project involving the reconnaissance, permitting, installation, documentation, and maintenance of 875 permanent GPS stations and 175 strainmeter stations in five years. PBO has a demanding 5-year project installation schedule, for both GPS and strainmeter installations. During the first year of the project, PBO not only met the first year GPS production goals, but also completed various project startup activities, including developing and implementing policies and procedures to streamline the remote office operations. Operations are ongoing in the five PBO remote offices that were located, staffed, and setup in the first year of the project. The GPS station design was completed and procedures were developed to ensure consistent construction practices throughout the six PBO regions. The GPS driller selection and evaluation plan was developed to ensure a competitive subcontractor selection process. A PBO construction safety plan was developed and implemented to ensure safe PBO worksites. Finally, Year 1 saw the beginning of the development of a robust database and other Web-based tools to facilitate the data entry, documentation, and reporting of all the reconnaissance, permitting, and installation activities. The completion of these tasks was necessary in order to meet the even more demanding schedule for year two.

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GEOLOGIC TIME AND CHRONOS: DATABASES, TOOLS, OUTREACH, EDUCATION, AND THE GEOINFORMATICS REVOLUTION I AND II

Topical Session 112

Cinzia Cervato and Walter S. Snyder, Presiding

Geologic time is a unifying theme for the geosciences. The CHRONOS project (www.chronos.org) is creating an interactive and dynamic framework to collect and share Earth system history data. The purpose of this session was to present the first results of projects involving Earth system history data funded by the NSF-sponsored Geoinformatics Initiative and to encourage the involvement of other groups. Presentations and posters described activities of the geoinformatics community involved in database and data networking projects, creation of analytical and visualization tools, and outreach and educational activities related to the Earth's history.

Editor's note -- Many of the papers presented in this session will be featured in the new GSA-journal *Geosphere*, therefore only abstracts are reprinted here.

GEOINFORMATICS - COMMUNITY CYBERINFRASTRUCTURE FOR THE EARTH SCIENCES

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Abstract --CHRONOS is a successful parts of the larger "geoinformatics" system (GI) (cyberinfrastructure applied to the Earth sciences). Based on CHRONOS, other operating GI projects, and numerous workshops, the salient features of the system can be summarized. The most fundamental point is that GI must be a bottom-up, community-driven effort. The funding and construction of the system must be driven by the needs and perspectives of the domain science, but in collaboration with computer scientists. During the initial building and maturing of GI, the implementation and enhancement of current technologies is more important that pursuing "new" or "cutting-edge" CS or IT approaches. GI must be a system - a system that encompasses multiple database sites, real-time observatories, computational modeling centers, and that provides seamless access to the necessary computational resources. It must be easy to use in terms of getting data into and out of the system, and provide the tools necessary for researchers to analyze these data. The community is very adamant that the system will be "distributed", that there will be multiple centers, hubs, nodes, etc. versus just a few designated mega-sites.

GI will require long-term support, also a very strong point made by the community. It is not simply a task of designing a few unsophisticated databases, quickly loading them up with data, and - bingo - you are done. It will be version 10 before the system is stable. Whereas we tend to think of "infrastructure" in terms of brick-and-mortar facilities, ships, and equipment - GI is also infrastructure - it is a platform for doing science. It will become (is becoming) the basic platform for conducting all future Earth science research. It really is that simple.

It is important to reemphasize that GI is not only about databases; rather it is about a systems approach to cyberinfrastructure. It must become one large, interoperable machine that needs all its parts working together to function properly. Anything short of that risks failure. Several projects, such as CHRONOS, are underway that allows GI to begin to function as a system – one that now is incomplete, but that become a complete system as budgets permit. Most importantly, the success or failure of the system will be the responsibility of both the community and relevant funding agencies.

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CHRONOS - A TIME-CALIBRATED NETWORK OF FEDERATED DATABASES AND TOOLS FOR SEDIMENTARY GEOLOGY AND PALEONTOLOGY

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Abstract --Earth system history research depends increasingly upon the analysis of voluminous, multidisciplinary, time-calibrated data. CHRONOS is a community resource dedicated to making available these data, together with a toolkit to analyze and visualize them, to the broad geoscience community, the public, K-16 students and educators, policy-makers, and the media. This international interactive network of paleobiology, biostratigraphy, radioisotope geochronology, and sedimentary geochemistry data is made accessible through a common portal (www.chronos.org), is a node on the Geoscience Network's GRID (www.geongrid.org), and has been funded by the National Science Foundation since August 2003.

CHRONOS and its partners are working to provide a comprehensive information network related to the evolution and diversity of life, climate change, geochemical cycles, paleoceanography, geodynamical processes, and other aspects of the Earth system. The bulk of the data is currently contained in three main networked databases: PaleoStrat (www.paleostrat.org) is the sample-based database engine for terrestrial stratigraphic data; Neptune is CHRONOS's database for age-calibrated marine plankton occurrences from DSDP and ODP cores; PaleoBiology (www.paleodb.org) is a federated database containing global, collection-based occurrence and taxonomic data for fossil animals and plants. Currently under development is a sedimentary geochemistry information system in collaboration with the emerging SedDB project, IODP, and GeoSystems. CHRONOS is also pursuing active collaborations with paleontologists and paleontological societies to upgrade, develop, and network digital databases for taxonomic information for all fossil groups at the species level.

CHRONOS is partnering with Tapestry of Time, the Smithsonian Institution, AGI, NAGT, NESTA, USGS, EARTHTIME, and geoscience educators to develop educational resources that 're-humanize' scientific discoveries that have led to our current understanding of Earth history, and virtual reality applications aimed at conveying the concept of deep time and visualizing the processes involved in some of the most significant milestones in the history of Earth.

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THE PROMISE OF CHRONOS

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Abstract --A major challenge for geoscience cyberinfrastructure is to develop an effective approach to working across traditional discipline and organizational boundaries. It is relatively easy to speak of such cooperation, such "interoperability", but perhaps another thing to actually implement a viable approach. CHRONOS is one of these efforts, and it targets broad community participation that focuses on uniting terrestrial-based and marine-based data sets and tools dealing with time series analysis (time scale), paleontology and stratigraphy. But it cannot do it alone, does not want to do so, nor should it. There are other efforts that will participate in this collaboration, for example: PetDB, the MARGINS databases, JANUS, GEON, NAVDAT, etc., as well as upcoming efforts such as SedDB and others. Furthermore, because our science is global in nature, our cyberinfrastructure efforts must be international in scope. That means working with international researchers and organizations to build a global network of interoperable systems.

We have all had the experience of trying to merge our newly generated dataset with legacy data accessible only in the literature or someone's filing cabinet. And we have generally faced long searches in the library as we tried to track down a specific paper or the work of a specific scientist. Conflicting formats, lack of metadata, etc. could easily frustrate or complicate our efforts. CHRONOS envisions a future in which extensive datasets are available to all of us instantly and in which we have visualization tools that would make such comparisons much simpler and, potentially, more powerful.

As geoscientists have developed substantially more extensive and more accessible observational datasets, we have seen a flowering of ideas about processes and events unknown a few years ago. The future interoperability of such datasets brings the promise that geoscientists routinely place their research in an Earth system context and that we will dramatically expand our understanding of the extensive interconnections between Earth subsystems. This is a future in which we all should participate.

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PALEOZOIC-PRECAMBRIAN TIME SCALE 2004

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Abstract --The Geologic Time Scale 2004 program under the guidance of Felix Gradstein, Chair of the International Commission on Stratigraphy, reviews international definitions of divisions of geologic time at their "Global boundary Stratotype Section and Point" or GSSPs; integrates stratigraphy (bio-, chemo-, magneto- and sequence-stratigraphy scales); and gives numerical ages for boundaries and major events within each stage. Except for the Carboniferous and Cambrian, which have only a single intra-system GSSP, most Paleozoic stages are defined by GSSPs. The new Ediacaran period of the uppermost Proterozoic was assigned a basal GSSP in Australia in 2004. The boundaries of all other international Precambrian eras and periods are fixed at assigned numerical ages. Most of the Paleozoic time scale is derived by combining selected radiometric ages (mainly U-Pb) with different mathematical interpolation methods (constrained optimization or CONOP, graphical correlation, and/or spline-fitting of integrated biozonations for each period). Utilization of astronomical (Milankovitch) cycles for scaling is still in its infancy within the Paleozoic.

Computed ages (rounded to nearest 1 myr) for the BASES of geologic periods are:

251 Ma=Triassic (base of Mesozoic Era) 444 Ma=Silurian 299 Ma=Permian 488 Ma=Ordovician 359 Ma=Carboniferous 542 Ma=Cambrian (base of Paleozoic Era) 416 Ma=Devonian 630 Ma=Ediacaran (youngest period of Precambrian)

The compilation of GTS2004 is summarized in A Geologic Time Scale 2004 (~600 pages with summary poster, Cambridge University Press, www.cambridge.org). Summary diagrams and tables of GSSPs are on the ICS Web site (www.stratigraphy.org), and the source data will be accessible through the CHRONOS database system. Coordinators for the Paleozoic-Precambrian time scale include Felix Gradstein, Frits Agterberg Bruce Wardlaw, Vladimir Davydov, Michael House, Mike Melchin, Roger Cooper, Pete Sadler, John Shergold, Andrew Knoll, Wouter Bleeker and Laurence Robb.

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CENOZOIC-MESOZOIC TIME SCALE 2004

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Abstract --The geologic time scale is the framework for deciphering the history of the Earth. The Geologic Time Scale 2004 (GTS2004) program under the International Commission on Stratigraphy of IUGS had three components: (1) Status of international definitions ("Global boundary Stratotype Section and Point" or GSSP) of divisions of geologic time, (2) High-resolution integrated stratigraphy, and (3) Numerical age scale for both boundaries and all major events within each stage. The Paleozoic-Precambrian portion of GTS2004 is summarized in a companion GSA presentation by Alan Smith.

Half of the 20 Cenozoic stages are fixed by GSSPs, but only 8 of the 30 Mesozoic stages are officially defined. Therefore, the summary scale has selected the most probable boundary definitions being considered by the subcommissions of ICS.

The Neogene Period (Holocene through Miocene) time scale has an ultra-high-resolution scaling from astronomical (Milankovitch) cycles. Astronomical cycles tied to radiometric ages also scale portions of the early Paleogene, middle Cretaceous, and early Jurassic-late Triassic. Depending on the time interval, other portions merge selected high-resolution radiometric ages, seafloor spreading models, strontium-isotope segments, and geomathematical interpolation methods.

Computed ages (rounded) for the BASES of geologic epochs are:

Holocene -- 11.5 ka, Pleistocene -- 1.8 Ma, Pliocene -- 5.3 Ma, Miocene -- 23 Ma (base of Neogene Period)
Oligocene -- 34 Ma, Eocene -- 56 Ma, Paleocene -- 65.5 Ma (base of Cenozoic Era)
late Cretaceous -- 100 ±1 Ma, early Cretaceous -- 145 ±4 Ma
late Jurassic -- 161 ±4 Ma, middle Jurassic -- 176 ±2 Ma, early Jurassic -- 200 ±1 Ma
late Triassic -- 237 ±2 Ma, middle Triassic -- 245 ±2 Ma, early Triassic -- 251 Ma (base of Mesozoic Era)

The compilation of GTS2004 involved a large number of specialists, and is summarized in A Geologic Time Scale 2004 (~600 pages with summary poster, Cambridge University Press, www.cambridge.org). Summary diagrams and tables of GSSPs can be downloaded from the ICS Web site (www.stratigraphy.org). The source data will eventually be accessed through the CHRONOS system. Coordinators for the Cenozoic-Mesozoic time scales include Felix Gradstein (GTS2004 chair), FritsAgterberg Phil Gibbard, Luc Lourens, Hanspeter Luterbacher, and John McArthur.

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APPLYING THE CHRONOS MODEL TO DEEP-SEA SEISMIC REFLECTION PROFILES AND DRILLING

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Abstract --We have applied the CHRONOS model in a pilot study for our GeoMapApp database browser. For implementation we have digitized the bulk of Lamont-Doherty's single channel seismic reflection profiles for the Southern Ocean around Antarctica and for the North Atlantic Ocean. These data were acquired between 1960 and 1980. To this dense set of tracks that commonly image the sediment cover down to the volcanic bedrock of the oceanic crust, we have added relational tables containing biostratigraphic and lithostratigraphic summary information from the early Deep-Sea Drilling Project (Legs 1 to 49). For each drill hole a 'chronos' table assigns age and age uncertainty in millions of years to every subsurface depth. From subsurface depth additional links are made to tables that describe the core sections, biozones, the dominant and minor lithologies, key and secondary constituents, carbonate and silica estimates, and sedimentation rate. The initial 'chronos' table that assigns age to depth requires decisions of members of our team. Since calibrations might vary from investigator to investigator, users of the database have the ability to enter their own 'chronos' tables instead. The eventual goal is to have a participatory user community interactively create and edit the 'chronos' tables and rank them with a measure of community-acceptance in order to aid the non-expert. The GeoMapApp WEB browser displays the tracklines on a bathymetry basemap to which basement isochrons can be added. A click on any track brings up the selected reflection profile in a sub-window. Movement of the cursor along the profile displays latitude, longitude, depth, sediment thickness, and basement age. Tools exist to digitize the bedrock reflector or any other reflector of choice and save these values for others. A click on a drill site displays a drill site summary diagram. Selecting a geological time interval (such as 67 ± 2 my) in a search menu lights up every drill site location on the basemap with colored-symbols representing the dominantly lithology. When the cursor is placed at the drill site, a popup window displays additional information relevant to that time interval. Our pilot study is to learn the degree to which such interactive tools aid future syntheses of the Ocean Drilling Project and lead to new discoveries.

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LARGE DATA BASES IN PALEONTOLOGY

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Abstract --Large data bases are used by paleontologists to answer questions about the diversification of life, mass extinctions, recoveries from extinction events, radiations, replacements, ecological guilds, paleobiogeography, and the tree of life. Until 1990, much of the work was individual, and each analyst compiled his/ her own databases. Databases were first distributed in printed form, or on computer disks. Since 1990, many paleontological databases, both comprehensive and particular, have been made available through dedicated Web sites or as Web-based material linked to published papers.

Most databases are static, but others are revised periodically, or continuously, some by a single person, others by mutual team effort. Team-built databases have many advantages: (1) bigger and better than anything created by a single person; (2) cost-effective; (3) widely used. There can also be problems: (1) strict design/ editorial control is required or they may be unreliable; (2) they may be so ambitious that they never achieve their objectives. Careful planning of inputs and outputs is essential.

The best-known is the Paleobiology Database at < http://paleodb.org/ >. This is a community effort, launched by John Alroy in 1999, and is an organic project, growing by the addition of fossil lists, collections from all times and all places. Its aim is to allow searching to species level and to fine stratigraphic resolution, and especially to allow a variety of sampling standardization protocols.

Another is The Fossil Record 2, perhaps the last major paleontological database to be published as a book. This database is a comprehensive listing of all families of plants, animals and microbes, with contributions from 100 authors worldwide. Evidence is presented of the first and last fossil within each family, the confidence of assignment, and the broad environment occupied by the family. Attempts were made to standardise the stratigraphic terminology and to encourage authors to use cladistically-determined families where possible. The data were also made available in various formats on the Web in 1993, and the Web site <http://palaeo.gly.bris.ac.uk/frwhole/FR2.html > allows a variety of downloads, searches, and graph-plotting. In the context of CHRONOS, I will present a proposal for further development.

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PHILOSOPHICAL BASIS OF RADIOMETRIC DATING

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Abstract --Radiometric dates are a key part of the CHRONOS data set, however, the interpretation of these dates is not always straightforward. Radiometric dating is based upon the assumption that the half-life of radioactive decay is a constant, but long-duration experiments at Brookhaven have shown significant deviations from constancy. Also no explanation is given why decay rates vary so greatly. Especially noteworthy is the fact that free neutrons decay on average in 11 or 12 minutes, whereas the neutrons in stable isotopes never decay.

The common philosophical axiom that all forces are transmitted by interactions leads to an alternative explanation of spontaneous radioactivity by relating decay to particle interactions. Gamma decays are similar to X-rays, caused by shift of electron-orbit. Beta decays could be a neutron-neutrino interaction to form a proton, an electron and two neutrinos.

The varying decay rates could thus be related to the degree of shielding from neutrinos and/or density of cosmic neutrino flux. Objections to this include an argument that the capture cross-section is too small for neutron to interact with neutrinos. The reasoning is circular, because the small capture cross-section has been estimated on the basis of the negligible decay rate of essentially stable isotopes.

With a half-life of ~ 6000 yrs, theoretical DPM (disintegration/min) of C-14 should be <10 counts annually. In fact, the measured DPM decreased by some 1400 counts or 1.5% (99,800 in Nov. 1998 to 98,400 in May 2000) with several significant oscillations. This experimental DPM temporal trend parallels measured variation of cosmic-ray intensity. The correlation of our DPM counts to cosmic ray intensity suggests that the beta-decay rate may have varied in response to changing neutrino flux. This interpretation provides a philosophical basis for radiometric dating: time is measurable because the number of neutron-neutrino interactions in any given sample is a function of the total neutrino flux during the passage of time. Calibration of C-14 ages against historical dates has discrepancies as large as 10%, which our experiments suggest that it may have resulted from the assumption of constant half-life. Young ages from colder years during the Holocene may be an indication of more effective shielding from cosmic rays during those time intervals.

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EARTHTIME: A COMMUNITY-BASED EFFORT TOWARDS HIGH-PRECISION CALIBRATION OF EARTH HISTORY

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Abstract --Many fundamental problems in the geosciences rely on precise and accurate knowledge of geological time. For example, in paleontology information on the rates of origination vs. extinction of fossil taxa is essential to understanding what drives biological evolution and the precise timings of major extinctions is crucial for pinpointing probable causes. Interactions and/or interdependence among Earth's major biogeochemical cycles can only be examined through space-time correlations of multiple extended, uninterrupted, and high-resolution geochemical time series. Similarly, Earth's paleoclimatic conditions can be effectively evaluated only with a common geological timescale to quantify synchrony, lags and leads among climate proxy records. In each case geological time is customarily treated as the "independent variable"; deductions and conclusions are made assuming that the geological timescale as given is basically precise and accurate. The time has come to reframe these research areas with a new geological timescale with significantly improved accuracy and precision standards commensurate with new and emerging geochronologic and chronostratigraphic methodologies. Current geological timescales are based on data of highly variable quality. Most, if not all of these compilations are tied to paleontologically defined boundaries. Furthermore, many timescales have averaged dates obtained by different techniques, with differing (though largely ignored) absolute uncertainties. Inconsistent calibrations between different geochronometers are increasingly evident and must be reconciled before a seamless timescale can be contemplated. The result, which is propagated into subsequent publications, is a timescale that is often poorly calibrated in absolute terms. Consequently, the greatest uncertainty in most analyses of geologic and evolutionary rates is the timescale itself. To address these problems EARTHTIME is proposed as a new community-based effort to focus attention on the calibration of at least the last 800 million years of earth history using a unified, multi-chronometer approach. This in turn will allow earth scientists to address a whole new series of questions that rely on knowledge of precise rates of biological, geological, and climatic change.

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A COMMUNITY APPROACH TO DATA INTEGRATION: BUILDING MEANINGFUL LINKS ACROSS DIVERSE DATASETS

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Abstract --Heterogeneity is common to databases generated in the social sciences, humanities and some environmental sciences. The data, authors, research methods, uses, and audiences of many datasets are all highly diverse. Such heterogeneity requires database integration to be a theoretically informed interpretive process. The University of Chicago's XSTAR project is leading development of new methods of collaborative, community-based data integration for the field of archaeology. With XSTAR, data integration takes place in two steps:

(1) Syntactic integration: Legacy datasets are migrated for representation in the data structures described by the Archaeological Markup Language (ArchaeoML). (2) Semantic integration: Thesaurus relationships are established between related terms and "classes" in each source database. Different archaeological databases may use diverse human languages and different terminological and typological systems. A human expert must match terms between such datasets. The nuances of meaning in a given context are often very subtle.

XSTAR technologies enable multiple thesaurus "mappings" between diverse project datasets to coexist. Thus, the same information architecture can allow multiple and evolving data integration schemes to develop and keep pace with changing research agendas. No one integration scheme should be considered "definitive" because it is the result of potentially contestable theoretical judgments and interpretations.

These tools will help to integrate diverse datasets now often viewed in relative isolation. The tools to link datasets will create a forum for discussion and debate within the field of archaeology. Experts will be encouraged to explicitly define how the results of diverse excavation projects and surveys relate to each other. In our view, this will make an important contribution to the discipline, since the reasoning implicit behind diachronic and regional syntheses will be made much more transparent and open for evaluation. Similar such methods can be applied to several disciplines, including the environmental sciences and geology. Bringing together diverse datasets will likely catalyze innovative new research of greater scope and analytic rigor.

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A FORMAL MODEL FOR THE GEOLOGICAL TIMESCALE AND GSSP

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Abstract --The ICS proposes formal chronostratigraphic units based on boundaries defined by a specific point in a sequence of rock strata in a unique and specific location (Global Standard Stratotype Section and Point, GSSP). Each stratotype shows evidence of a geological event deemed to correspond with the particular boundary. The age of the boundary may then be estimated through observations made on specimens retrieved from the section. However, correlation with other locations usually involves consideration of geological events not illustrated in the GSSP. This practice requires a clear understanding of relationships between events, stratigraphic sections, ages, and the elements of the standard geological timescale. We describe an information model for the geological timescale that formalizes these relationships, incorporating the principles underlying the GSSP.

The geological timescale is a temporal ordinal reference system (TORS), in which the standard named intervals (Phanerozoic, Paleocene, etc) correspond to component "ordinal-eras" of varying rank. An era may be composed of an ordered sequence of member eras of the next lower rank, but within a reference system only one such decomposition is permitted for each era. Such a system corresponds to a "constrained temporal-topology-complex". The boundary between eras is a "time-node". The age of the node is the position of an associated time-instant. In the geological timescale this association is indirect, via observations made on specimens retrieved from the stratotype showing evidence of a specific stratigraphic event. Different stratigraphic events may be observed in other locations, having various relationships with the events associated with the GSSP.

A model for this system, expressed using the object-modeling notation UML, is based on a generic model for TORS given in ISO 19108, extended with classes for the stratigraphic elements described above. Use of UML provides precise definitions of the components in the model and relationships between them. Furthermore, it also supports direct implementation in software such as Java, C#, and RDBMS schemas, using standard CASE tools. An XML encoding is also provided, defined using a W3C XML Schema conformant with Geography Markup Language, and thus compatible with many modern geospatial software systems.

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CHRONOS-GEOCHEMICAL CYCLES: PAINTING EARTH SYSTEM HISTORY WITH NUMBERS

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Abstract --Earth history is archived in the chemical composition of sediments and their contained fossils. This archive provides evidence for meteorite impacts, mass extinctions, gas hydrate expulsions, climate cycles, and the beginnings of life. The paleochemical record in sediments also provides a means of global correlation through variations in the isotopic records of C, Sr, S, and other elements. With the explosion of data on geochemical proxies obtainable with modern automation, the time is ripe to develop a paleochemical database and IT system for visualizing, manipulating, and modeling those data. We describe progress made towards creating such a system - the Geochemical Cycles Domain of CHRONOS (CHRONOS-GC). To launch this effort, 27 geoscientists met last June to discuss: (1) appropriate data and metadata, (2) visualization and computational tools, (3) outreach and education opportunities, and (4) community support and participation. Participants agree that all geochemical data related to Earth history would be welcome. These include stable isotopes, radioisotopes, trace metals and anions, biomarkers, organic elemental ratios, and sediment composition. Metadata will be an important measure of data quality and will include information on investigators, sample material and quality, sample locality and stratigraphic position, and analytical methods. The system must be able to plot and correlate isotopic, chemical, and paleobiologic records from different localities using different user-defined age models and correlation schemes. Improved age models and correlation schemes will permit rigorous testing of the timing and synchronicity of isotopic and paleobiologic events and more accurate evaluation of the rates of global change. Educational efforts will include problem-oriented tasks that can be linked to textbooks and lab manuals, focusing on exciting scientific issues. Workshop participants have formed working groups defined by measurement (e.g., O and C isotopes, X/Ca ratios) and materials (e.g., marine carbonates, barite, phosphates). These working groups are open to all and will (1) help design and review database schema, metadata needs, and visualization and computational tools; (2) answer queries from IT specialists; and (3) enlist community support for populating and using CHRONOS-GC.

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SESAR: AN ONLINE SOLID EARTH SAMPLE REGISTRY FOR UNIQUE SAMPLE IDENTIFICATION

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Abstract --The study of solid earth samples is fundamental to our understanding of Earth's dynamical systems and evolution. Many different data types of geological samples contribute to our knowledge of the Earth's history: age determinations, chemical compositions and isotope ratios of rocks and their mineral components, descriptions of lithology, texture, mineral or fossil content, and physical property measurements. The usefulness of these data is critically dependent on their integration and increases exponentially when the various data types can be analyzed as a coherent data set.

As the Geoscience community is now taking advantage of the rapid progress in information technology to build a digital data and knowledge system that will allow the sharing and integration of data across disciplines, it becomes essential, even unavoidable to use unique identifiers to reference specimens unambiguously. Currently, different samples are often given identical names, and different names are given to the sample splits, as they are passed from investigator to investigator to undergo new analyses.

We will present the Solid Earth Sample Registry (SESAR), which addresses the urgent need for unique sample identifiers that are crucial for the development of a Geoscience Cyberinfrastructure. The project will build a Web-based digital registry for solid earth samples that will provide for the first time a way to uniquely name and identify samples on a global scale, along with the generation of barcodes for sample labeling. We will show the prototype of the registry, demonstrating its structure, user-friendly Web interface, and functionality, and outline future plans for further enhancement of the system, pertaining to interoperability within the Geoscience Cyber-infrastructure.

The unique identifiers will dramatically advance interoperability among existing and emerging data and information systems for sample-based data such as CHRONOS, EarthChem, SedDB, PaleoStrat - to name a few, which are currently seriously hampered in their potential to link disparate data on samples by the inability to uniquely identify them. SESAR will allow wide ranges of sample-based data types to be linked and integrated, opening an extensive range of new opportunities for discovery and for interdisciplinary approaches in research.

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COMPUTER-ASSISTED SEQUENCING OF LARGE NUMBERS OF EVENTS FROM THE GEOLOGIC RECORD – ESCAPING THE CONSTRAINTS ON RESOLVING POWER IMPOSED BY TRADITIONAL BIOZONES

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Abstract --The CHRONOS database hub is designed to retrieve information concerning the relative age of large numbers of geologic events, including ash falls, geomagnetic pole reversals, excursions in ocean composition, and the origination and extinction of species. The information may take many forms, including numerical age estimates (e.g. from EARTHTIME), superpositional relationships in measured stratigraphic sections (e.g. PALEOSTRAT, NEPTUNE), and taxon coexistences (e.g. PALEOBIOLOGY DATABASE). Several software tools (e.g. BIOGRAPH, CONJUNCT, CONOP, GRAPHCOR, PAST, PC-SLOT, RASC) already use such information to estimate the sequence of events according to geologic optimization criteria. Together, the databases and tools can build an electronic stratigraphic record, with a grand composite time line of geologic events, complete with confidence intervals.

The coupling of community databases with software tools enables a third generation approach to geologic time correlation. In the first generation, individuals built sets of biozones manually from a few stratigraphic sections, using a tiny fraction of available origination and extinction events. The approximately 80 million year interval of the Ordovician and Silurian, for example, has been divided into 50-60 zones and sub-zones for graptolites and 30-40 for conodonts. In the second generation, individuals compiled all available events for one or two clades from all published stratigraphic sections and sequenced them with computer assistance. For Ordovician through Silurian time, we used CONOP9 to sequence the first and last occurrences of 1429 graptolite taxa from 262 sections and 1027 conodont taxa from 208 sections (more than 21,000 locally observed range-end and other events). After allowing for overlapping confidence intervals on the placement of events, more than an order of magnitude improvement remains relative to the resolving power of traditional zones and subzones. The third generation is now at hand, in which the process can involve the whole community, via shared databases, making feasible the compilation and quality control of much larger datasets and the sequencing of multi-clade geologic histories. The second generation broke the constraints of manual computation; the third generation breaks the constraint of individual expertise.

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CHRONOS: A SERVICES BASED FRAMEWORK FOR CHRONOSTRATIGRAPHIC INFORMATION RETRIEVAL

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Abstract --CHRONOS is developing a set of network-available services that define and provide chronostratigraphic data in an open and standards-based method.

The CHRONOS system is a data "conduit" as well as hosting environment, providing a means to ingest and display information from both hosted and federated data sources. Display systems include Web interfaces (Chiron) and GIS interfaces along with various services oriented interfaces. Time-based "temporal information systems" are also being developed for this system as well as ontology and metadata systems for better relation and discovery of resources.

By developing services that are available both to the Internet via standard Web services practices and the Grid environment via GEONGrid, CHRONOS is able to provide data building blocks in a services oriented manner for use by the community in a wide range of applications from Web sites to desktop applications.

Using the Neptune and Timescale databases as examples, various interfaces into the CHRONOS systems can retrieve and display data using publicly available descriptions and interface methods. Utilizing both SOAP (Simple Object Access Protocol) and WSDL (Web Services Description Language), it is easy to construct clients into the database in a wide range of languages and platforms. Data is retrieved in various formats using their initial XML (eXtensible Markup Language) representation that can be transformed via XSLT (XML Style Language Transform) to appropriate formats for the user. An initial set of reference clients and transformations will be available in an open source manner to help users and developers get a head start on the creation of tools that utilize these services in addition to the Web based interfaces available from www.chronos.org. Other means of data retrieval, including representative state transfer (ReST) style interfaces, are also being tested.

An example of the use of CHRONOS as a community resource that can be incorporated into the normal IT structure of existing and future projects is the ability to incorporate data from the geologic timescale database directly and seamlessly from the CHRONOS system into a remote Web site using Web services.

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AN ONTOLOGY FOR INTEGRATING STRATIGRAPHIC DATABASES

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Abstract --One way to establish connections between different database schemata is through an ontology. Related data items from different source schemata can be co-located by registering them with an ontology, describing typed relationships between the stored data objects. For relational databases, a method of semantic registration is to associate with a database attribute (represented as a column) additional semantic information such as a natural language description or a scientific article defining the specific attribute. We employ W3C standards, in particular the Resource Description Framework (RDF) and the Ontology Web Language (OWL) for representing ontologies.

This work is done as part of the Chronos project whose main objective is to develop a network of databases, tools and analytical methodologies that broadly deal with chronostratigraphy. Part of this work involves federating several distinct, independently developed databases.

The representation consists of two parts, both of which are written using RDF/OWL. The first part is a high-level description that records "knowledge" about the database types. This knowledge is recorded in classes and their typed relations to other classes. The second part, which is automatically generated, contains information about the databases that is cross-referenced to the defined types. The tables and columns represent "instances" of the classes defined in the first part.

The RDF Schema specification contains constructs such as "rdfs:isDefinedBy", "rdfs:seeAlso", "rdfs:label" and "rdfs:comment" that can be used as a standard mechanism for binding database columns to references or English language definitions. These constructs thus act as a bridge between the machine readable data contained in a database and the human readable knowledge contained in the scientific literature.

If the database metadata has been precisely specified by the ontology references, then the necessary conversions and other operations are defined implicitly. Thus a program that can read and parse the both parts of the ontology can automatically perform the necessary manipulations of the data.

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AUTOMATING DATA EXTRACTION FROM TEXT USING XML TAGGING

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Abstract --Despite the advent of the age of Information Technology, much valuable Earth Science information is not available digitally. The main bottleneck in acquiring such digital information is the enormous and often unrewarding effort needed to manually enter data into computer databases. However recent advances in computing technology open up the possibility of automating or semi-automating the digitisation of significant sections of this extensive and valuable information. The process exploits stylistic and organisational conventions in text documents, allowing the preparation of dedicated software that automatically scans and generates xml-tags around discrete subsections of the information being presented. Such tags allow complex queries to be run across the information, because computers can use them to find records that fulfil multiple search criteria. The ability to execute complex queries is the main justification for the existence of databases; this new approach to data extraction, storage, and retrieval represents an intermediate stage in what should be seen as a spectrum of data processing techniques. The main advantages are speed (no manual data entry), fidelity (no recoding of information), completeness (none of the original information is lost) and flexibility (information of any nature can be tagged irrespective of whether or not it is fully consistent with a standardised format). Automatic tagging of text makes digitisation practicable for a wide range of information that is currently not available in this format. It can be applied to formal taxonomic descriptions of species (a rich source of important biodiversity information) or to any description (rocks, minerals, etc.) that follows a standardised format. The talk will demonstrate automatically tagged taxonomic descriptions from paleontological monographs, showing how complex queries involving morphology, stratigraphy, biogeogeography can be run across the tagged text. The tagged information can be readily displayed using www browsers, and can be made available via the www to greatly increase the range of users.

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A WEB-CENTRIC APPROACH FOR SHARING PALEONTOLOGY COLLECTIONS DATA

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Abstract --Museum collections are the foundation of paleontology, but because many natural history museums have small budgets and huge collections, museum scientists are challenged to make these critical data current and available to the public. Advances in information technology have revolutionized how museums collect and share information, making distributed collaboration using multi-tier Web applications a possible solution to this challenge. In the Department of Invertebrate Paleontology at the Natural History Museum of Los Angeles County (LACMIP) we have developed such a database system using established Web application protocols (http://ip.nhm.org/ipdatabase). This system presently contains information for over 30,000 fossil localities, 180,000 specimens (including over 10,000 type and figured specimens) as well as locality maps and specimen images when available. Users can view the database via a simple interface designed for any standards-compliant Web browser. Registered users can also add information and update records as stratigraphic and taxonomic concepts change. The goal is to establish two-way communication between our database and a broad community of users wherein the museum shares its collections and information, and in return users contribute new data acquired in using the collections. The LACMIP system is designed so that information can be added but is never deleted, and contributors are credited by name. For example, specimen lots can be associated with multiple taxonomic determinations allowing for differences in taxonomic practice and opinion. As an initial step to building links with other systems, we have developed a simple interface whereby each locality, specimen lot, type specimen, and image in our system can be found at an easy-to-read Web address. This alternate interface for browsing our database can be cited in online publications. Because our database can be structured as a collection of links, it can be searched using standard Web search engines. As data exchange standards become accepted, such links can be used to create meta-databases that could become global networks of collections, taxonomic, stratigraphic, and publications databases.

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THE PALEONTOLOGY PORTAL

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Abstract --The Paleontology Portal, http://www.paleoportal.org, built by the UC Museum of Paleontology, is a joint project of the Society of Vertebrate Paleontology, the Paleontological Society, and the U.S. Geological Survey, with funding from the National Science Foundation. This Web site provides a central, interactive entry point to high-quality North American paleontology resources on the Internet for multiple audiences: the research community, K-12 educators, government and industry, the general public, and the media. Using Web-based technology and relational databases, users can explore an interactive map and associated stratigraphic column to access information about particular geographic regions, geologic time periods, depositional environments, and representative taxa. Other features include highlights of famous fossil sites and assemblages and a Fossil Gallery. Throughout the site, users will find images and links to information specific to each time period or geographic region, including current research projects and publications, Web sites, on-line exhibits and educational materials, and information on collecting fossils.

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STRATISTICS: SPATIAL DATA ANALYSIS AND DATA-MODEL COMPARISONS IN THE EARTH SCIENCES

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Abstract --The data used as the basis for the reconstruction of earth history are either implicitly or explicitly spatial; i.e., their coordinates in 1-, 2- or 3-dimensional spatial frameworks are relevant to their analysis and interpretation. For example, the field description of the occurrence of a particular fossil taxon includes not only the associated lithology, but its geographic coordinates and its location in the overall section. Similarly, the interpretation of the occurrence of a paleoclimatic indicator, such as an evaporite deposit, requires detailed knowledge of both its spatial and temporal location. Paleoenvironmental and paleogeographic reconstructions require accurate description and interpretation of the spatial distribution of the underlying data. Similarly, the output of many earth science models, such as basin evolution and paleoclimate models, is also spatial. These models are generally assessed by the perceived agreement between spatial patterns predicted by the model and corresponding values from the data. Reconstructing regional or global events and patterns and testing geoscience models thus requires the ability to integrate a wide variety of spatial information. STRATISTICS is a toolkit for the spatial characterization of data relevant to Earth history and for the quantitative comparison of these datasets with the models used to simulate them. The software makes available a broad suite of quantitative and visualization techniques for the characterization of the spatial properties of geologic data and for the comparison of data and model output derived from multiple sources. These techniques are based on methods developed in the field of spatial statistics and landscape ecology, which can be directly applied to the study of spatial heterogeneity in earth science. The new toolkit complements other proposed CHRONOS toolkits, which will focus on areas such as quantitative biostratigraphy and time-series analysis.

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APPLICATION OF THE VIRTUAL CHRONOS NETWORK TO MESOZOIC / CENOZOIC PALEOCEANOGRAPHY AND PALEOCLIMATOLOGY

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Abstract --CHRONOS is an NSF Geoinformatics initiative to develop a network of databases and visualization methodologies that enhance chronostratigraphy and understanding of Earth System History through time (see www.chronos.org). The CHRONOS platform will be of particular importance in Mesozoic / Cenozoic paleoceanography and paleoclimatology, with its numerous large and disparate data sets (e.g., time scale construction, paleoenvironments, paleoclimatology, paleoceanography, paleotectonics, and evolution). In addition, partnerships developed between CHRONOS and other programs (including the Integrated Ocean Drilling Program) will further facilitate research and public outreach relevant to late Mesozoic / Cenozoic time.

To realize the potential of the CHRONOS platform, a wide range of data are needed. Integrated databases on stratigraphy, paleogeography, land albedo, ice sheets, sea-surface temperatures, continental temperatures, greenhouse gas levels, thermohaline circulation, and biotic evolution will support a new generation of comprehensive studies of Earth System History. To this end, a CHRONOS workshop on Mesozoic / Cenozoic paleoceanography and paleoclimatology was held on October 27-28 at the University of South Florida in St. Petersburg (see http://www.chronos.org/meetings/workshops.html) . Along with database and tool development, a series of time-slice studies will serve as test-beds for the CHRONOS platform. One of the intervals targeted is the mid-Miocene climate transition ca. 17-13 million years ago. This was a particularly dynamic interval of time that included the Neogene climate optimum closely followed by a major increase in Antarctic glaciation. A central unanswered question is: What caused the transition from the warmest interval of the past ca. 35 million years to the late Neogene glacial world in less than 2 million years? The time-slice approach adopted for the last glacial maximum (CLIMAP Project Members, 1976, The surface of the ice-age earth, Science, 191:1131-1137) will serve as an initial investigative model. The CHRONOS system will provide the scientific community with state-of-the art databases, analytical and visualization tools, and key partnerships, thereby fully capitalizing on the Geoinformatics revolution.

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BUILDING BRIDGES BETWEEN GEOSCIENCE RESEARCH, TEACHING AND LEARNING WITH THEMATIC DIGITAL RESOURCE COLLECTIONS: AN EXAMPLE USING THE CRETACEOUS PERIOD

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Abstract --Digital resources have revolutionized the way undergraduate geoscience educators design and teach courses by providing dynamic learning media directly linking research and learning. Although these resources are now invaluable classroom tools, the new challenge of organizing select resources into coherent, practical teaching collections remains. To address the problem of resource organization and usability we created a thematic collection based on an interval of geologic time, the Cretaceous Period. The goals of this collection are to discover and organize superlative digital resources relevant to the Cretaceous Period, thereby providing a useful teaching tool and exemplar for future theme-based collections using an Earth system approach. The collection was created by first determining a set of key Cretaceous topics and concepts of potential utility. By systematically searching the Web for these specific topics, instead of a more general "Cretaceous" search, we located more technical sites and obtained a more diverse information base. Accurate, relevant sites were imported from DLESE or cataloged directly into the Carleton College Science Education Resource Center (SERC) database. Once resources were compiled into this database, they were further organized and arranged into the Cretaceous collection, a new element in SERC. To accommodate multiple teaching styles and pedagogies Cretaceous resources were arranged by: (1) subject, (2) earth system components (e.g., biosphere, atmosphere etc.), and (3) inquiry-based topics that address compelling contemporary research questions. This collection forms an important step in advancing the quality and usability of digital geoscience resources while providing a useful teaching tool for undergraduate geoscience educators.

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IT'S TOO BIG AND TOO DIVERSE: CURRENT ISSUES IN GEOSCIENCE DATA EXPLORATION

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Abstract --Current cutting-edge visualization tools have illuminated a number of unexpected data storage, transport and display issues. The deployment of scientific observatories has created integration issues by one discipline's data sources available to experts in other fields. Geochemical, sedimentary, paleomagnetic and GIS databases are all online but do not come together into interoperable interfaces other than Microsoft Excel. Seismic model visualizations are now so large that they can only be run on the Earth Simulator computer in Japan.

We will discuss the issues involved when stereo display is common, screen real estate is limited only by wall size, storage is large and networking is really fast.

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EMERGING COMPUTING TECHNOLOGIES FOR DATA-INTENSIVE GEOSCIENCE RESEARCH AND EDUCATION

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Abstract --New requirements imposed by data-intensive geoscience research and education are demanding capabilities well beyond what the current generation of computing tools are able to provide. The presentation will outline a new model for data-intensive multi-layered, multi-resolution, temporal geoscience exploration that leverages emerging infrastructure and techniques in visualization, data mining, data storage and networking.

This new model is currently being explored in the context of a variety of geoscience applications that include: Visual core description and correlation; seismic modeling; and ground water modeling.

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COREWALL: A VISUALIZATION ENVIRONMENT FOR THE ANALYSIS OF LAKE AND OCEAN CORES

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Abstract --A primary need for studies of sediment and rock cores is an integrated environment for visual core description. Digital line-scan images of split-core surfaces should be the fundamental template for all sediment descriptive work, including annotations about structures, lithologic variation, macroscopic grain size variation, bioturbation intensity, chemical composition, and micropaleontology, among other features. Hard-rock visual core descriptions have corresponding requirements. The integration of core-section images with discrete data streams and nested images provide a robust approach to the description of sediment and rock cores. This project provides for the real-time and/or simultaneous display of multiple integrated databases, with all the data rectified (co-registered) to the fundamental template of the core image. Virtual initial core description (ICD) sheets are created on-the-fly as data are acquired. This visualization tool enables rapid multidisciplinary interpretation during the ICD process. Such interpretation is commonly limited to the final step before publication of study results.

A database exists to contain information on submitted data, including multi-sensor core-logger data, high resolution scanned images of split core sections, text annotations and photomicrographs of smear slides of lithologic constituents and microfossils. A prototype environment for working with the high resolution data is the Personal GeoWall-2, a single computer used to drive 6 tiled LCD screens and a pair of projectors. The combination allows one to juxtapose high resolution core images and sensor data next to fully stereoscopic visualizations.

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G-GRID: PROPOSED DEPLOYMENT OF MULTIDIMENSIONAL INFORMATION INFRASTRUCTURE FOR GROUNDWATER MAPPING IN THE UPPER U.S. MIDWEST

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Abstract --In Minnesota, 70% of the population obtains drinking water from groundwater, but the capacity of this resource and its vulnerability to climate change, contamination, and overuse are not well known. Water resource managers are, however, increasingly committed to ensuring that groundwater usage is sustainable. New approaches to make better use of existing databases therefore are being developed for construction of the groundwater maps that are required for water resource management in this and similar regions. Vast amounts of information are available, largely in the form of databases of water well records. Unfortunately, however, the information tends not to be used at the regional scale because the infrastructure to do so has not been adequately developed.

A recently completed model for the Winnipeg region of Canada, however, demonstrated methods for creating a regional 3D geologic map through interpretation of large databases. This approach is now being coordinated with paleoclimatic research, regional characterization of subsurface material property heterogeneity using tools such as borehole geophysics, and geostatistical methods for quantitatively modeling heterogeneity of subsurface strata on a regional basis - in part through transfer of methods from the hydrocarbon industry. Large portions of these databases based on or containing hundreds of thousands of well records can already be viewed and interpreted visually with emerging visualization systems such as the GeoWall. But when appropriate interpolation and extrapolation methods are applied at the regional scale to the prediction of subsurface properties on a regular grid - a basic requirement for analysis - a multi-dimensional digital model beyond the capability of conventional computing resources can readily be generated. Our current efforts therefore are emphasizing methods for making both large groundwater databases and resultant models more available to users in a networked environment.

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SOURCE TO SINK ON ONE ACRE: USING RESEARCH DATA AND TOOLS TO CREATE AN OUTDOOR MUSEUM EXPERIENCE

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Abstract --The National Center for Earth-surface Dynamics (NCED), an NSF Science and Technology Center, has created a 1.2 acre exhibit to teach earth surface dynamics at the Science Museum of Minnesota. This outdoor exhibit space, called the Big Back Yard uses miniature golf, interactive exhibits and elements of landscape design to introduce casual visitors and school groups to surface process science, sustainable land management and how the earth's surface changes over time. Together with the Museum's Mississippi River Gallery and the National Park Service's Mississippi River National Center, housed in the Museum lobby, visitors can now explore one of the greatest concentrations of river- and earth science-related educational opportunities available anywhere in the nation.

Organized around a theme of "source-to-sink", each golf hole and interactive exhibit in the Big Back Yard is designed around research experiences of NCED PIs. Extensive use is made of existing geoscience databases including NASA and USGS remote sensing imagery and maps, and topographic data from multiple sources. Many of the interactive exhibits are based on experimental facilities at NCED's St. Anthony Falls Laboratory. The park is also the focal point for several related programs for K-12 students and teachers. This presentation will visually introduce the Park and describe the collaborative process used by NCED museum and research staff to design and build an intensely research and data-based outdoor learning environment.

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USE OF ANAGLYPH MAPS TO ASSESS STUDENT UNDERSTANDING OF EARTH SCIENCE CONCEPTS

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Abstract --We will present results from a preliminary study exploring comparative use of topographic and anaglyph maps in middle and high school classrooms. The purpose of the study was to assess the effectiveness of 3-dimensional maps in increasing student understanding of earth science concepts and maps. In the middle and high school setting, it may not be possible to use GeoWalls because of cost and/or technological issues. However, many of the same concepts and skills that GeoWalls would be used to teach, can be understood with the use of anaglyph maps, a paper version of a GeoWall. Middle and high school teachers and students from five schools in Minnesota, faculty from a K-12 teacher preparation institution and a research institution were involved with this study.

Teachers prepared pre and post-tests for the topographic and anaglyph maps used in the study. Students and teachers were surveyed for their attitudes toward using the different types of maps. Preliminary results show that some gains were made in content for the anaglyph maps in comparison to the topographic maps. However, the largest gains were made in students' attitudes towards the different types of maps. Clearly, more students preferred using the 3-dimensional maps to the topographic maps. While the 'novelty' effect of the anaglyph maps and using the colored transparency glasses may have some influence on this, comment analysis showed that students clearly understood the anaglyph maps and their landscape features. Higher-order thinking was also visible in observations of students in the classrooms. Follow-up teacher workshops have led to the development of background material and exercises related to the maps.

The session discussion topics will include use of existing data sets in map generation, use of the maps in standards based teaching, and use of the maps in field and classroom based activities. Example maps will be presented.

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GIS TO GEOWALL: HARNESSING 3D VISUALIZATIONS

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Abstract --The Geowall (www.geowall.org) provides a simple, low-cost platform for 3D graphics visualizations. The Geowall uses two projectors for virtual reality. Existing software consists primarily of viewers, designed to display and manipulate 3D models created by other software. We have integrated two Geowall viewers (Immersaview and Walkabout) with a powerful, easy to use, and free GIS (MICRODEM). MICRODEM allows easy, graphical selection of map areas and display of digital elevation models (DEMs), satellite imagery, orthophotos, scanned maps, and vector shape files and TIGER line data. For export to the Geowall, MICRODEM produces a VRML file with the terrain mesh and one or more image textures to drape on the terrain mesh. MICRODEM then opens either Immersaview or Walkabout for immediate 3D interaction with the terrain. The two programs display different and complementary views of the terrain. Immersaview displays 3D surface diagrams with the capability to rotate and zoom. Walkabout supports the exploration of scenes containing dynamic objects, 'walking' topographic surfaces draped with maps and remote sensing images. Immersaview and Walkbout run on the Windows, Linux, and Mac operating systems, but MICRODEM only works on Windows. However, the VRML and texture files created by MICRODEM can be displayed on other operating systems. In addition to stereo viewing on the Geowall, Immersaview and Walkabout both allow single-monitor 3D scene manipulation. All three programs are available for free download at www.evl.uic.edu/cavern/agave/immersaview/, www.evl.uic.edu/aej/macagave/walkabout.html, and www.usna.edu/Users/oceano/pguth/website/microdem.htm. Much of the power of these 3D visualizations lies in having multiple textures, such as scanned topographic maps, geologic maps, satellite imagery, or overlays created from the DEM such as slope or topographic shading. Rapid switching between textures shows the multiple relationships among parameters.

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BUILDING THE CHRONOS SYSTEM DATABASES: A PARTNERSHIP PROCESS

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Abstract --CHRONOS is working with the community and other groups to develop a comprehensive suite of chronostratigraphic databases. CHRONOS is not working alone, rather striving to develop interoperable systems with Neptune, PaleoStrat, JANUS, SedDB, and others national and international projects. CHRONOS is a collaborative node on the GEON GRID, which is working to provide even broader and faster access to the system.

A key to successful database construction is working with the discipline researchers to ensure that their needs are addressed. Conversely, we have quickly discovered that this also requires researchers who are willing to broaden their understanding of databases and cyberinfrastructure in general. CHRONOS is also working closely with science-based initiatives, such as EARTHTIME and GeoSystems, to provide them with the databases and tools to meet their needs. With its partners, CHRONOS is designing and helping to populate databases for the various constituents of chronostratigraphy, including: biostratigraphy, magnetostratigraphy, geochronology, chemostratigraphy, and cyclostratigraphy, as well as those necessary for time scale documentation and age model construction. Also included are the necessary metadata for each to help the researcher understand the "who, what, when, where, and how" of the data compilations that help define chronostratigraphy.

One example of database development is provided by Neptune, a relational database of close to 400,000 age-calibrated and taxonomically documented Cenozoic marine plankton occurrences from DSDP and ODP cores currently being populated with Mesozoic data and post-1997 ODP sites. Another is the development of a geochronology database that rides on the underlying structure of the PaleoStrat system. One of the challenges here has been to utilize the PaleoStrat engine to provide the necessary information on the stratigraphy, lithology, paleontology, chronostratigraphic ages, petrology, etc. and at the sample level build a geochronology database module to meet the needs of the geochronology community that is trying to calibrate the time scale (i.e., EARTHTIME). These modules must also be compatible with those that exist or are being constructed such as EarthRef, the Canadian Geological Survey Knowledgebase, and Geoscience Australia's Ozchron.

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CHIRON: A FRAMEWORK FOR BUILDING WEB INTERFACES

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Abstract --The enormous success of the Internet as a means to share information, files, and data has made the Web browser a universal platform for data access. CHRONOS's goal is to provide data and services to the chronostratigraphic community. To accomplish this goal, and to reach the broadest possible audience, CHRONOS is also utilizing Web interfaces to provide an intuitive portal to the data it hosts.

Web interfaces into different data sources or services often contain many lines of duplicated code. To minimize the amount of duplication, we have developed a framework, named Chiron after one of CHRONOS's offspring in Greek mythology, for building Web interfaces. This open-source, cross-platform framework takes care of common Web interface tasks like navigation, parsing user input, and handling downloads so the developer can focus on writing the interface-specific code.

The main design goal for Chiron was modularity. The developer should only have to write the code to connect a database once. For all future Web interfaces requiring database connectivity, he/she can simply reuse the database module written before. This highly modular design allows the developer to pick and choose from existing or newly developed modules to build the exact interface required.

Besides maximizing code reuse, the other benefit of Chiron's modular design is nearly infinite flexibility and extensibility. The framework is not tied to any specific application. Interfaces built on Chiron are currently being used by CHRONOS to provide database search capabilities, geologic timescale rendering capabilities, and dynamic Web service invocation and experimentation capabilities. In addition to these scientific tasks, Chiron has also been used as a file sharing and 'blogging' platform.

Chiron achieves its modularity by partitioning the interface code into the natural dichotomy of Resources and Services. Resource modules define the mechanism for retrieving data from some particular source. Service modules define the actions that should be performed on the data retrieved from Resources.

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PALEOSTRAT – AN "EVOLUTIONARY DEVELOPMENT APPROACH"

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Abstract --PaleoStrat (www.paleostrat.org) was conceived in 1997 and has become part of the CHRONOS federation of databases. PaleoStrat started as a prototype and is based on the idea of developing an initial implementation to solicit user comment and then to refine the concept through a series of versions until an adequate system has been developed. Rather than having separate specification, development, and validation phases, we concurrently carried out these activities, utilizing rapid user feedback. Thus, PaleoStrat has evolved through a prototype stage to initial implementation. The prototype effort was also dictated by the inherent complexity of the data we are trying to accommodate.

The overall system design for the Paleostrat system consists of three key components: 1) a database, 2) a Web interface for data input and access, and 3) visualization and mapping tools. We have taken an "Evolutionary Development Approach" in designing the Paleostrat system and several processes have been put in place that allows us to streamline the data entry, and develop component based visualization and mapping tools. Through this programmatic approach we used such technologies as: persistent stored modules/stored procedures, Microsoft Active Server (an open standard based software architecture) in conjunction with scripting using Active Server Pages (ASPs), Active Data Objects, and developing within the .NET framework. We have implemented very efficient means for the data entry. Furthermore by utilizing software such as Adobe's® Scalable Vector Graphics (SVG) and ESRI® ArcIMS® we have developed an interactive, database-driven tool for constructing stratigraphic sections (or well/drill hole descriptions). The overall goal is to make all of these data interactively available on the Web, with mirrored sites at CHRONOS, the USGS, and elsewhere to ensure perpetual availability of the data.
PaleoStrat has been supported by National Science Foundation grants EAR 0106796, EAR-ITR 0218799 and EAR 0312392.

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PALEOSTRAT - A PARTNER AND DATABASE ENGINE FOR THE CHRONOS SYSTEM

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Abstract --PaleoStrat (http://paleostrat.org; or http://paleostrat.net; or www.paleostrat.com) was conceived in 1997 as a prototype information system for sedimentary, paleontologic, biostratigraphic, stratigraphic, geochemical, and paleomagnetic data. Since then, other efforts have emerged or are emerging, such as *CHRONOS*, *GEON*, and *SedDB*, among others, including international sites. Because *PaleoStrat*'s purpose is to be a platform that is openly and easily available to the community, *PaleoStrat*, as an independent system, strives to work with these other efforts to help build a more broadly-based and effective system. For example, the data input through *PaleoStrat* and tools developed by both *CHRONOS* and *PaleoStrat* will be available through either the *CHRONOS* portal or the *PaleoStrat* Web site.

PaleoStrat is being designed to help a broad range of research, including phylogenetic, paleobiologic, sequence stratigraphic, basin analysis, paleogeographic, and other studies that address a variety of questions about the evolution of tectonostratigraphic systems. The system targets research-grade data that are based on samples and the precise locations of these data in space and time. Spatial data focus on latitude and longitude and meters above the base of the section (or below the surface for wells). Temporal data is generally provided by biostratigraphic and/or geochronologic data.

Our purpose is to make all data available to the users via visualization tools (stratigraphic column, maps, etc; see abstract of Taylor at al., in this volume). Specifically, we are trying to build a suite of Web-based tools that will: 1) Allow all interested researchers located anywhere in the world access to a high-resolution, multitaxa biostratigraphic data sets. 2) Provide an interactive, Web-based tool for correlation among stratigraphic sections, wells and drill holes based on research-grade data. 3) Incorporate high-precision geochronology to provide optimum age-control on period and stage boundaries. 4) Make all of these data interactively available on the Web, with mirrored sites at CHRONOS, the USGS, and elsewhere to ensure perpetual availability of the data. To reach these goals, PaleoStrat will continue to build partnerships with other national and international databases.

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THE PERMIAN-TRIASSIC TIME SLICE PROJECT OF CHRONOS: A REFINED CHRONOSTRATIGRAPHIC FRAMEWORK TO ANALYZE EXTINCTION AND RECOVERY

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Abstract --Development of a high-resolution, integrated global chronostratigraphic framework will resolve the sequence of events, thereby constraining the causes of the catastrophic late-Permian extinctions and early-Triassic recovery. The Permian-Triassic Time Slice Project spans a 20-million-year interval from the base of the *Jinogonodolella postserrata* conodont zone (Capitanian, Middle Permian, ~265 Ma), to the base of the *Neospathodus waageni* conodont zone (early Smithian, Early Triassic, ~245 Ma). The Project is a *CHRONOS* Beta-test of how to code, access and integrate different types of stratigraphic data to address a major earth history event. The main emphases of the Project are to encourage active international sharing of data and expertise, experiment with the most effective methods of coding information in different disciplines, from different stratigraphic methods, and develop methods to apply visualization and analysis tools to the composite datasets. Each stratigraphic method, especially conodont biostratigraphy, require standardization to achieve consistent correlations. To this end, a taxonomic dictionary was developed (available at http://www.PaleoStrat.com) with reference citation, original taxonomy, digital image library and open synonymy that include all the published figured specimens and original descriptions. In addition, digital images of over 1,000 unpublished specimens from Iran, Pakistan and China were incorporated. In the first round of the open synonymy, the Changxing Limestone at Meishan, China, previously divided into 2-3 conodont zones, now can be divided into 6 well-defined zones based on the redefined *Clarkina* species. Correlation to other sections and other fossil groups (such as radiolaria) is also strengthened.

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PAST (PALEONTOLOGICAL STATISTICS) - COMPREHENSIVE TEACHING AND RESEARCH PACKAGE FOR PALEONTOLOGICAL DATA ANALYSIS

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Abstract --Computer-based data analysis is now a standard part of the paleontologist's toolbox. This wide field covers subjects such as cladistics, ecological data analysis, morphometrics, quantitative biostratigraphy, time series analysis and spatial statistics. The free software PAST (Paleontological Statistics) for Windows has been developed as part of a package intended both to introduce these subjects to students and professionals, and as a fully operational research tool. After continuous development through five years, the program now includes almost one hundred well-tested modules, in an easy-to-use spreadsheet environment with graphical and numerical output throughout. The modern user interface and full integration with the desktop makes the learning process easy, leaving more time for understanding and experimentation. The package also includes a number of worked case studies and exercises with real data sets, a manual and an email user group with about 400 members, all available on the Web at http://folk.uio.no/ohammer/past. A companion book called "Introduction to palaeontological data analysis" is in press. PAST has been downloaded by several thousand researchers and students in different fields, and is used in numerous courses worldwide.

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CHRONOS AGE-DEPTH PLOT: A JAVA APPLICATION FOR STRATIGRAPHIC DATA ANALYSIS

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Abstract --One of the most important steps in analysis and correlation of stratigraphic data is establishing an age model or line of correlation for an individual core hole or stratigraphic section. CHRONOS Age-Depth Plot (ADP) is a Java re-implementation of an earlier Macintosh program for plotting the ages of stratigraphic events versus depth and interactively fitting a line of correlation to those data. ADP is delivered from the CHRONOS Web site via Java WebStart and runs locally on the user's machine, allowing access to local data files as well as data from the Neptune database via a GIS interface. ADP allows the user to develop a line of correlation (LOC) using a palette of tools for adding, moving, and deleting LOC control points. In addition, the user is able to zoom in to a more detailed view of different plot regions, toggle the display of different plot groups, and edit plot and axis titles and labeling. Output options include saving of the LOC control point data , event data projected to the LOC, and of the plot itself in PNG, JPEG, or SVG (Scalable Vector Graphics) format. SVG is an XML specification for describing vector graphics and the output SVG file is designed for convenient editing of various plot characteristics, with font and line characteristics for various plot elements and the palette of plotting symbols defined at the top of the file. In addition to being a useful application in its own right, ADP serves as a prototype for other clients interfacing with the Web services provided by the CHRONOS portal.

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USING THE NEPTUNE DATABASE TO EXPLORE MESOZOIC-CENOZOIC CHRONOSTRATIGRAPHY AND THE DEEP SEA MICROFOSSIL RECORD

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Abstract --For 35 years, the Deep Sea Drilling Project (DSDP) and the Ocean Drilling Program (ODP) have retrieved sediment cores from throughout the world's oceans, but access to age and species distribution data from those cores have been largely dependent on searches through hard copy publications. The relational chronostratigraphic database, Neptune, provides a major advance to accessing these data for select sites with high-quality micropaleontologic data. Originally developed in the early 1990's at the ETH Zurich, Neptune has become CHRONOS's time-calibrated data engine for marine plankton data. It is accessible on-line (http://services.chronos.org/databases/neptune/index.html) and can be used for studies of evolution, paleobiogeography, and paleoceanography.

Sites included in Neptune are selected on the basis of the availability of well-documented microfossil range data (calcareous nannoplankton, foraminifera, diatoms, and radiolarians) generated by post-cruise research. The database is searchable and data can be exported to produce age range charts, geographic distribution maps, and occurrence charts. At present, Neptune contains the occurrences of about 8800 plankton species names in Cenozoic samples of 165 DSDP and ODP drill holes from all ocean basins up to ODP Leg 135. The database is currently being updated at the University of Massachusetts with additional ODP sites up to Leg 210, the last expedition of the ODP (2003), and inclusion of Mesozoic data from both DSDP and ODP. Neptune is also integrated with a cross-platform graphic correlation tool for age vs. depth plotting (ADP - http://services.chronos.org/webservices/adp/index.html).

Most of the data in Neptune are contained in four basic data tables: 1. Planktonic microfossil data (individual microfossil records in individual samples, based on range-charts in DSDP Initial Reports and ODP Scientific Results); 2. Taxonomy (species names with synonymies); 3. Age models (age assignment for each sample); 4. Biogeography (all species names reported). We seek additional published microfossil distributional data from DSDP and ODP sites to include in the Neptune database; please contact Mark Leckie (mleckie@geo.umass.edu) if you are interested in submitting your data.

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A DYNAMIC, INTERNET BASED DIGITAL TAXONOMIC ATLAS OF MESOZOIC PLANKTONIC FORAMINIFERA

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Abstract --The first relational taxonomic database to be hosted at the CHRONOS Web site (www.chronos.org) is an Atlas of Mesozoic Planktonic Foraminifera. This was developed initially at the Smithsonian Institution using standard PC-based database software, and it consists of over 300 senior synonym species records that include original and emended species descriptions, morphologic descriptor fields, biostratigraphic range information, images of the species holotypes and paratypes (with many new SEM images), and SEM images that illustrate the morphologic variability of the species concept. In order to broaden the taxonomic expertise overseeing development of the database and to speed up progress toward database completion, a Mesozoic Planktic Foraminifer Working Group (MPFWG) has been formed. Comprised of 15 foraminifer paleontologists from nine different countries, the MPFWG has met to systematically review and revise all the morphologic descriptor categories, debate the senior synonym list, discuss various phylogenetic hypotheses for the major planktonic foraminifer lineages, and divide responsibility for preparing the Atlas for publication on the CHRONOS Web site. After migrating the database to the Internet, it is now accessible for all MPFWG participants for editorial revision and for addition of SEM and thin section images. Once thin-section images are added and all the text entries have been completed and reviewed, the database will be published and become available to the research community (~Summer 2005). A "public comment" field has been added to the species records initially to provide a forum for discussion and debate among the WG members and then as a means of recording comments from the Internet user community when the database is publicly accessible. These comments will be considered by the MPFWG, who will continue to oversee the database by providing yearly revisions and updates. We anticipate that this dynamic taxonomic database will prove to be invaluable as a continually updated lookup guide for the planktonic foraminifer and paleoceanographic research communities, and it will provide a major step toward stabilizing taxonomic concepts of Mesozoic planktonic foraminifer species.

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ENSURING THE FUTURE OF CHRONOS THROUGH DEVELOPMENT OF THE NEXT GENERATION OF MICROPALEONTOLOGISTS

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Abstract --CHRONOS provides an opportunity for chronostratigraphers to collaborate in building improved time scales that are accessible to the geologic community. Yet the future of this dynamic program may be threatened if we do not actively recruit and train the next generation of stratigraphers, including biostratigraphers. We address this situation by development of hands-on, experiential laboratory activities in micropaleontology using sediments recovered by the Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP). These samples offer choice examples of key paleontological and paleobiological concepts such as punctuated equilibrium, adaptive radiation, iterative evolution and biostratigraphy, and opportunities for education on topics such as changes in sea level and ocean circulation, and paleoclimatology, and possible linkages between evolution and climate change.

The extensive collection of DSDP and ODP cores provides a unique opportunity for students to explore micropaleontology and become familiar with broad applications of microfossil groups. We are selecting choice materials to develop hands-on laboratory exercises using routine research techniques. For example, students are required to count specimens from different groups, identify key taxa, apply biostratigraphic zonation, and make important determinations of paleoclimate, paleodepth, sea level, and ecology based on microfossil assemblages.

We plan to publish a laboratory manual with materials (slides, washed residues) and instructions on how to acquire deep-sea samples for educational purposes. Because of their ease of use, these packaged labs will be attractive to a range of educators and scientists, including some who may not be experts in micropaleontology. The materials will help to teach basic skills in micropaleontology, provide exposure to the far-ranging utility and implications of micropaleontological data, and ensure that a new generation of micropaleontologists will become involved in ocean drilling and CHRONOS.

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CHRONOS-CLIMATE CYCLES: A THEMATIC DOMAIN OF THE CHRONOS INTEGRATED CHRONOSTRATIGRAPHIC DATABASES PROJECT FOR EARTH SYSTEM HISTORY RESEARCH

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Abstract --CHRONOS-Climate Cycles is one of six thematic domains that are currently under development for the virtual *CHRONOS* network. The purpose of this domain is to populate *CHRONOS* with the key paleoclimate data that have been used to calibrate geologic time, e.g., orbitally forced stratigraphy, and to provide sophisticated means for the geoscience community to investigate new data and methodology. The domain's database will be configured according to frequency scale (orbital, millennial, annual, diurnal) and linked to other *CHRONOS* databases through at least one independent time control, e.g., geopolarity reversals, radioisotope dates, chemostratigraphy, or biozonation. The domain will host an online laboratory with platform-independent tools for modeling, interpolation, correlation, filtering, tuning, demodulation, and spectral analysis. An educational module with interactive tutorials will explore climate forcing mechanisms (e.g., insolation) and climate system responses. A proof-of-concept demonstration that applies modern chronostratigraphic data and analytical procedures to the legacy SPECMAP dataset is used to illustrate basic geoinformatics elements in *CHRONOS-Climate Cycles*.

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LOCATING GEOSCIENCE DATA AND TOOLS THROUGH NASA'S GLOBAL CHANGE MASTER DIRECTORY

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Abstract --NASA's Global Change Master Directory (GCMD) enables researchers, educators and students to discover and access information on nearly 15,000 Earth science data sets and services. The GCMD covers a broad range of Earth science disciplines, with nearly 18% of the database holdings directly relevant to geoscience disciplines such as geochemistry, geomagnetism, seismology, tectonics, and volcanoes. Other geoscience disciplines include marine geophysics, land surface processes, hydrology and space weather. Geologic time periods can be specified as dates BP (or ybp or kya) and/or as chronostratigraphic units (Quaternary, Permian, Cambrian, etc.).

The GCMD also offers over 900 descriptions of Earth science tools, resources, and services. Users can search for tools by selecting keywords from the following categories: data management/data handling, hazards management, metadata handling,information services, data analysis and visualization tools, models, Earth science educational resources, and environmental advisory services. The last four topics contain the majority of the geoscience tools and services. Some examples of geological time period tools are "Global Paleogeographic Views of Earth History – Late Precambrian to Recent" and "Regional Paleogeographic Views of Earth History". Both of these are educational resources and data analysis and visualization tools. The GCMD provides direct links to tools and services from the data set descriptions, and, where possible, links to data sets that can be used with the tools. The GCMD homepage is http://gcmd.nasa.gov.

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CHRONOS AS AN EDUCATIONAL TOOL IN MUSEUMS AND SCIENCE CENTERS

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Abstract --Even when museum exhibits on the history of the Earth and its life are otherwise compelling, most visitors leave with only a vague conception of how geoscientists determine the ordering or numerical ages of geological events. Most exhibits rely on static visual images of relative dating or abstract descriptions of radiometric dating. Since public understanding of how scientists derive scientific information is a key component of scientific literacy, and since ordering of geological events is the foundation of our understanding of evolution of the Earth system, it is clearly desirable to create more effective approaches to exhibits on stratigraphy. CHRONOS, which will enable users to "play" with the data of geologic time, offers outstanding opportunities for innovative solutions for improving public understanding of and access to temporally-ordered geologic data.

Museums may offer the first point of contact with CHRONOS for many in the general public. In these settings, ideally surrounded by real objects, museum docents, and appropriate signage, visitors may be willing to try activities and user-friendly technology that they might not seek elsewhere. After their museum experience, visitors may be encouraged to try CHRONOS at home or in classrooms. Museums nationwide that use CHRONOS-based interactives could also be used as vehicles to promote its use in other contexts, through leaflets, Earth Science Week activities, or other dissemination techniques.

The potential exists to build a user-interface that could serve the needs of many museums nationwide. Successful application of CHRONOS to museum environments could serve as a general model for application of geoinformatics to informal learning environments. The Museum of the Earth is a new exhibits facility at the Paleontological Research Institution in Ithaca, NY., in which most of the exhibits and educational programs are oriented around events and processes in geologic time. This setting will be used to test museum implementation of CHRONOS, for example in "Discovery Labs" with on-line computer stations, Museum classroom education programs, and teachers workshops.

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DATASETS, RESEARCHERS, MUSEUMS AND EDUCATORS: USING HIGH END TECHNOLOGY TO BRING AFFORDABLE VISUALIZATION TO THE CLASSROOM

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Abstract --The National Center for Earth-surface Dynamics (NCED), an NSF Science and Technology Center, in conjunction with the GeoWall community and partners at the University of Minnesota, has developed a cost-effective, paper-based method to bring high-end technology into classrooms, informal and field-based educational settings. We use existing geoscience data sets, such as NASA satellite data and USGS elevation data, to produce visualizations for formal and informal education settings.

Pre- and in-service K-12 educators at NCED work with practicing K-12 and research staff at NCED and partner institutions to develop materials that promote greater understanding of "source to sink" processes of erosion, transport and deposition. Preliminary research indicates that students respond enthusiastically and gain a greater understanding of surface process science when using these visualizations. In addition to visualizations, activities include lesson plans and background material designed to aid educators working with students at varying educational levels. A Web site and educator workshops provide ongoing support to educators.

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PREDICTING PLANT PRESENCE/ABSENCE ACROSS LANDSCAPES: A MORPHOMETRICALLY BASED MODEL USING PUBLICLY AVAILABLE DATA AND THE GEOWALL

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Abstract --Photosynthetically-active radiation (PAR) is the most important energy source for all green plants in aquatic and terrestrial ecosystems. The amount of photosynthesis and a corresponding plant biomass increase is proportional to PAR. Spatial distribution and the amount of plant biomass are important because that determines the microbiological and geochemical heterogeneity across ecosystems.

We have developed an algorithm that predicts the spatial distribution of PAR and corresponding plant biomass across landscapes using only the time of the year and the local topography. This algorithm will be superimposed over an entire watershed drainage area to predict plant presence or absence across landscapes. Prediction results can be instrumental in guiding studies in landscape sustainability.

This algorithm was developed within the GIS software MicroDEM and uses freely available digital elevation data from the USGS or higher resolution airborne LIDAR data. At each point in the DEM, the algorithm first computes the horizon for each azimuth. Then for each day of the year, the algorithm computes the sun position as a function of time and determines when the sun first appears over the horizon and when it disappears below the horizon. The resulting duration of direct solar illumination can be compared to the duration of daylight from standard predictions of sunrise and sunset, which do not consider terrain blocking, and displayed as maps showing the degree of terrain blocking. We create a map for each day of the year and an annual average, stored as standard GIS grids. The predictions are visualized using the programs Walkabout and Fledermaus and displayed on the GeoWall. We can also display graphs for each location showing the duration of direct illumination throughout the year, which may have complex relationships as terrain blockage changes with seasonal changes in solar position.

With bare earth USGS DEMs the results do not consider shading from vegetation, but LIDAR data with both bare earth and first return canopy top can consider this additional complexity.

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THE SPATIAL-TEMPORAL INFORMATION MATRIX (STIM CUBE): AN EFFICIENT WAY TO STORE GEOLOGICAL INFORMATION

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Abstract --Geologists have traditionally used maps and stratigraphic sections to describe the spatial and temporal location of geological information. The "Spatial-Temporal Information Matrix", or STIM is the digital equivalent of these tools. A hyperdimensional cube, the STIM model permits the storage and quick retrieval of all kinds of geological information. The three principal axes of the STIM model can be visualized as a cube whose Z-axis is time, and whose X & Y axes are present-day geographic coordinates (latitude and longitude). The STIM cube can be subdivided into billions of "box-cells", or boxels. Each boxel can hold any type of geological information. It can be a "value" (e.g. paleo-elevation, rock property, or geochemical measurement) or an "index" that points to values or attributes in a more complex table or database. Some of the advantages of STIM are: 1) it is compatible with existing geographic information systems (GIS), 2) it permits data from many different data sources to be combined in a common data structure, 3) it allows new associations to be made between disparate data types, 4) and it provides a new way to visualize spatial-temporal data. Inexpensive mass-storage makes the STIM model physically possible. It is estimated that a STIM model describing the geophysics, geochemistry, and stratigraphy of the Earth back to the late Precambrian would require approximately 50 terabytes. Further efficiencies and increases in resolution could be made by implementing a method of dynamic scaling that modifies the size of each boxel depending on the data density and resolution. To test the STIM approach the authors are constructing a STIM cube that describes the paleo-position of any present-day geographic feature back through time. In this data model, the uppermost level of the cube is an x-y grid of present-day latitude and longitude. Each boxel (specified by latitude, longitude and time) contains the paleo-latitude and paleo-longitude of that geographic location back through time. This Paleo-Reconstruction Information Matrix (PRIM) would allow users to produce paleo-reconstructions illustrating the past locations of any kind of geological data set. A PRIM cube with a boxel size of one degree by one degree, and a temporal resolution of 1 million years would require only 80 megabytes of storage.

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GIS DATABASE FOR TESTING OF THE IDEAS: (1) THAT ALKALINE IGNEOUS ROCKS AND CARBONATITES (ARCS) ERUPT IN RIFTS, (2) THAT THEIR DEFORMATION TO FORM DARCS IS CONCENTRATED IN SUTURE ZONES AND (3) THAT ARCS IN RIFTS MAY RESULT FROM DECOMPRESSION MELTING OF DARCS ON SUTURES IN THE UNDERLYING MANTLE LITHOSPHERE

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Abstract --Rifts in continents are characterized by sodium and carbonate rich igneous rocks. We are beginning work on a global database, elaborating on a published catalog of these alkaline rocks and carbonatites (ARCS) using a map of the ca. 700 intra-continental rifts of the world to estimate the generality of the association of ARCS with rifts throughout geologic time. Deformed alkaline rocks and carbonatites (DARCS) form a subset compositionally identical to ARCS but with gneissic structure. Gneissic deformation is associated with continental collision and sites of continental collision form sutures within continents. ARCS formed in continental rifts are preserved at continental margins when oceans open. When those oceans close the ARCS become deformed, developing gneissic structure and becoming DARCS. We are preparing a new map of the global distribution of suture zones and plan to test the idea that DARCS are concentrated in suture zones. ARCS associated with rifts have been recognized to have been erupted in discrete episodes over hundreds of millions of years. We can test the idea that this is because those rifts formed over older sutures within which DARCS had been carried by subduction to depths within the lithospheric mantle. Rifting episodes over DARCS at mantle depths generate new ARCS by decompression melting.

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GEOLOGY OF BOULDER FLATIRONS: THE FOUNTAIN FORMATION

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The Fountain Formation is a sandstone of Pennsylvanian age that crops out along the Front Range in Colorado. It forms the Flatirons west of Boulder as well as the Red Rocks near Morrison and the Garden of the Gods near Colorado Springs. Most of the Fountain Formation can be called an arkose, a coarse, feldspar-rich sandstone that is typically pink in color because of the abundant pink feldspar grains within it. It was deposited by alluvial fans and braided steams draining off a nearby mountain uplift, part of the Ancestral Rockies. Much of Central Colorado was uplifted during this mountain-building event, which occurred about 230 million years before the modern Rockies were raised. The Fountain Formation was deposited about 290-296 million years ago.

In some parts of the Fountain Formation you can easily see the channels and cross-beds (small dune-like forms) that indicate deposition by streams. Although most of the grains (both pink feldspar and buff to white quartz) are coarse sand size (around 2 mm and sometimes larger), you should be able to find extremely coarse individual clasts. Feldspar crystals an inch or more long may show perfectly flat cleavage (breakage) faces.

Most of the pink color comes from feldspar, but in some zones a dark purplish color is probably imparted by hematite (iron oxide) cement. The Fountain Formation is pretty crumbly, which indicates that it is not very well cemented. Together with its coarse grain size, this is evidence for a deposit that was laid down very near the source area. Further evidence for this is the presence of feldspar, which is unstable relative to quartz. In mature sandstones that have been transported great distances, most of the feldspar has weathered to clay and is gone, leaving only clean quartz in environments like beaches.

Even more evidence for the proximity of the source of the Fountain sediments is the fact that in most areas of the Front Range, these rocks lie directly upon 1.7-billion-year-old Precambrian rocks. The surface between the Precambrian rocks and the Fountain Formation is called an unconformity, and it represents a time break of nearly one and one-half billion years for which there is no rock record. If any rocks were deposited during this interval, they were eroded during the uplift of the Ancestral Rockies.

Sand and gravel from the Fountain Formation is the primary constituent of the ice-abatement material that Colorado Departments of Transportation put on snowy roads in the Front Range area. When one of these rocks chips your windshield, at least now you know a bit about its history!

For more technical information on the Fountain Formation, a good starting point is the Rocky Mountain Association of Geologists' *Geologic Atlas of the Rocky Mountain Region*, the big red book published in 1972. See especially papers by Mallory on the Pennsylvanian strata (p. 131).

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