PMAG 2002 Workshop

PMAG WORKSHOP

La Jolla
March 24-26, 2002

http://earthref.org/PMAG/

IGPP

SCRIPPS INSTITUTION OF OCEANOGRAPHY UCSD

UCSD

PMAG 2002 Workshop

La Jolla, California
March 24-26, 2002

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Welcome to the PMAG2002 Workshop

The goal of this workshop is to promote a community dialog on directions to be followed in the development of modern paleo, rock and geomagnetic databases. Topics for discussion will include:

- Scope of data types to be archived
- What constitutes essential scholarly reporting of data?
- How and where should data be archived?
- Coordination with other earth science database and digital library efforts
- Public interfaces and tools for data management

We intend to develop a community plan to address the need to update and integrate a number of existing database initiatives so that this area of Earth sciences can take advantage of the technological advances provided by modern web-based data handling capabilities. Such developments cannot take place without broad-based discussion among the community of researchers on what is essential and desirable in terms of archiving data for future scholarly work in paleo-, geo and rock magnetism. We intend for this to take place here. To facilitate this discussion we will also hear about existing database efforts, and about scientific applications for the data we hope to archive for future use.

Enclosed find the conference program and abstract volume, together with your personal schedule for the break-out sessions that we hope you will attend. This program (in PDF form) will also be posted on our website. In addition we have included here for reference, information on two other database initiatives in the earth sciences, GERM together with its umbrella site Earthref.org and Chronos.

Thank you for joining us here and we look forward to a fruitful meeting.

Cathy Constable

Thank You

This conference is split-funded through the NSF Ocean (Marine Geology and Geophysics) and Earth Sciences (Geophysics, Geology and Paleontology, Tectonics, and Instrumentation and Facilities) programs. We acknowledge additional funds from the Institute for Geophysics and Planetary Physics (IGPP) and the Geosciences Research Division of Scripps Institution of Oceanography. Two other local people deserve special acknowledgments. Jason Steindorf put together this conference volume and Arlene Jacobs is the main person responsible for the logistics.

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Program Summary PMAG Workshop

March 24 in 2002
1:00 – 2:00 IGPP Munk Lab Conference Room
Registration
2:00 – 2:30 IGPP Munk Lab Conference Room
Welcome: Logistics and goals of meeting
2:20 – 3:00 IGPP Munk Lab Conference Room
Information Technology, Databases, and Electronic Publishing John Helly - San Diego Computer Center
3:00 – 3:30 IGPP Munk Lab Conference Room
The Paleomagnetic Databases Mike McElhinny - Gondwana Consultants
Coffee Break: 3:30 – 4:00
4:00 – 6:00 IGPP Munk Lab Conference Room
Poster Session: databases, datasets, and requirements for their various applications
Reception/ dinner on IGPP patio/ at the Martin Johnson House T-29 starting at 5:30

March 25 in 2002
Breakfast: Coffee, bagels and fruit 8:00 – 8:30
8:30 – 9:00 IGPP Munk Lab Conference Room
Historical geomagnetic datasets and their applications Andy Jackson - Leeds University
9:00 – 9:25 IGPP Munk Lab Conference Room
GERM, REM, and PMAG on Earthref.org Anthony Koppers, Hubert Staudigel - SIO
9:25– 9:50 IGPP Munk Lab Conference Room
Chronos – Chronostratigraphy database plans Jim Ogg – Purdue University
9:50 – 10:10 IGPP Munk Lab Conference Room
A Relational Database for Rock, Mineral and Environmental Magnetism Peter Solheid, Mike Jackson, Subir Banerjee – University of Minnesota
Coffee Break: 10:10 – 10:30
10:30 – 12:00
Data producers subgroups meet separately -discuss kinds of data produced and what should be archived for various applications Stratigraphy – Board Room Tectonics – Sun City Geomagnetism – Munk Lab Conference Room Rock Magnetism – Reading Room
Lunch Break: 12:00 – 1:00 at the Martin Johnson House
1:00 – 2:00 IGPP Munk Lab Conference Room

Plenary Producer's Reports and Synthesis -

March 25 in 2002 continued

2:00 – 2:30
IGPP Munk Lab Conference Room

Global Paleomagnetic Visual Database
Sergei Pisarevsky – University of Western Australia

Coffee Break: 2:30 – 3:00

3:00 – 4:30
IGPP Munk Lab Conference Room

Subgroups meets separately to
-discuss data recovery, database queries, models, graphical interfaces, software, cross-talk among databases, and stable derived products
Products – Munk Lab
Interfaces/tools – Reading Room
Cross-talk among databases – Sun City

4:30 – 5:30
IGPP Munk Lab Conference Room

Plenary reporting and synthesis

Conference dinner at Stauxigel (Tauxe/ Staudigel) residence at 6:00
Head of Tecolote Canyon
Transportation provided from IGPP/ Andrea Villa Inn

March 26 in 2002
Breakfast: Coffee, bagels and fruit 8:00 – 8:30
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Revisit Posters: www interactions with existing databases
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10:30 – 12:00 IGPP Munk Lab Conference Room
Subgroups meet separately -discuss wholesale data compilation strategies Calibration and standardized procedures Editorial structures Data ownership, enforcement, old data vs. new data
Lunch Break: 12:00 – 1:00 at the Martin Johnson House
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Plenary – wholesale compilation reports
2:00 – 2:30 IGPP Munk Lab Conference Room
Geoinformatics/ IT opportunities at NSF **Robin Reichlin – National Science Foundation**
Break: 2:30 – 2:50
2:50 – 5:00 IGPP Munk Lab Conference Room
Synthesis and recommendations

Subgroup Discussion Topics

During the course of the workshop participants will be divided into a number of subgroups which will meet separately, and then report to the larger group. The goal of the subgroup discussions is to promote a dialog on how to proceed with database development. Each group will have a coordinator and recorder, who will be responsible for reporting the discussion and consensus of the group at the subsequent plenary session. Some issues to consider follow, but groups should add to these as they see fit. It is expected that the subgroup report will flesh out these and other issues.

Data Producer Subgroups: (1) Stratigraphy, (2) Geomagnetism, (3) Tectonics,
(4) Rock and Environmental Magnetism

Participants join a subgroup to discuss one of the above applications of magnetic measurements. What metadata would be required and desirable in databases used for the above applications?

> What kinds of data are being collected and how much of it should be directed to databases? How many databases are needed – one all-encompassing or many subsets of data types?
> What are the current and possible future applications of these data?
> What would be the minimum criteria that make data useful for doing any kind of future science?
> How can a database be structured to allow for changes in the way data are collected and interpreted?

Retail Subgroups: (1) Interfaces/Tools, (2) Database Interoperability, (3) Database Products
How should one be able to interact with the databases? What would be desirable products?

(1) Interfaces/Tools

> Getting data back out: searches according to specific (to be defined) metadata
> Visualization
> Format conversions
> Analysis tools

(2) Database Interoperability

> How should metadata be defined so that it is possible to get at other information relevant to the scientific problem?
> e.g. age in a consistent up to date form, rock magnetic information to go with directional/ intensity measurements, finding historical data that correspond to paleo/archeomagnetic information
> petrological, petrophysical, geochemical data on same rock unit.
> How can data duplication be avoided?

(3) Database Products

> What kind of hierarchical structure should the database have?
> Raw data, processed data of some kind, models derived from the data that represent some kind of standard for the community?

Wholesale Subgroups: (1) Calibration, Standardization, Peer Review, (2) Editorial Structures, (3) Data Ownership, Copyright, Enforcement

How can data compilation be organized in some standardized form?

(1) Calibration/Standardization/Peer Review

Interlab and instrument calibration

How can multiple data producers provide a consistent kind of record?

What constitutes peer review of data? Should it exist?

(2) Editorial Structures

Submission and review process for data

Consider existing models provided by DLESE, GERM, IRIS

(3) Data Ownership, Copyright, Enforcement

Who submits the data?

Old data versus new

Can data be modified?

Referencing process

How can data submission be facilitated/enforced?

Data Producer Subgroups: Kinds of Data, Essential and Desirable Metadata

Stratigraphy	Geomagnetism	Tectonics	Rock/Env Mag
Cande	Champion	Besse ®	Banerjee
Mcmillan	Eighmy	Bowers	Dekkers ®
Ogg	- Jackson	Enkin	Fuller
Opdyke ©	Johnson	Gee	M. Jackson ©
Stoner	Korte	Koppers	Nazarova
Tauxe	Laj	Pisarevsky	Newell
Verosub ®	Lund ®	Schwehr	Peters
	McElhinny ©	Staudigel	Selkin
	Perrin	Van der Voo ©	Solheid
	Shibuya		
	Tanaka		
	Valet		

Retail Subgroups: How do you want to interact with databases? What are the products?

Interfaces/Tools	Database Interoperability	Database Products
Bowers	Constable	Banerjee
Enkin ©	Dekkers	Besse
Gee	Eighmy ®	Cande
M. Jackson	A. Jackson	Champion ®
Johnson	Korte	Fuller ©
Koppers	Laj	McElhinny
Mcmillan	Lund	Opdyke
Newell	Nazarova	Peters
Ogg	Perrin ©	Pisarevsky
Stoner	Selkin	Schwehr
Valet ®	Solheid	Tanaka
Verosub	Shibuya	Tauxe
	Staudigel	Van der Voo

Wholesale Subgroups: How to organize data compilation in some standardized form

Calibration/Standardization /Peer Review	Editorial Structures	Data Ownership/Copyright/ Enforcement/ Old versus New
Bowers	Banerjee ©	Besse
Enkin	Constable	Cande
Gee ©	Dekkers	Champion
M. Jackson	Eighmy	Fuller
Korte	A. Jackson ®	Johnson ©
Laj®	Lund	Koppers
Newell	McElhinny	Nazarova
Ogg	Mcmillan	Opdyke
Pisarevsky	Perrin	Peters
Selkin	Staudigel	Schwehr
Stoner	Tanaka	Shibuya
Tauxe	Valet	Solheid ®
Verosub		Steindorf
		Van der Voo

Poster Abstracts

Listing in alphabetical order by first author

Treating a large number of paleomagnetic data…

Besse, J

The GPMDB database is an efficient tool that allows fast research of the huge number of(disparate) published paleomagnetic data accumulated over more than 30 years. Maintenance has been remarkably well done since the onset of the project, under an inexpensive database program which can be run on personal computers. Using usual database languages or programs such as SQL or Access allows a fast and convenient way of sorting and selecting data (albeit the interfaces are not always user friendly).

On one hand important improvements of the database structure can be made such as :
- (Easy to do) Adding a modified rock and magnetization age determination computed by the database itself for sedimentary rocks by using various published time scales (which should therefore be all included in the database). This is specially useful for age comparison between stratigraphic and radiometrically dated series.
-(Harder): inclusion of data tables at the site level (allows for example easier by age comparison, easier regional fold test, psv analysis, etc).
-(Much Harder) On-line original publications of data on pdf files.
- Easy coupling with GIS.

On the other hand, a very large amount of data is sometimes difficult to interpret, and requires the use of efficient data treatment programs. Paleomagnetic treatments are illustrated using as an example the construction of a global APWP for the last 200Ma with the Paleomac program (JP. Cogné, available at http://www.ipgp.jussieu.fr/~cogne). Such program, which performs all standard principal statistical analysis and processing on a sphere, provides high interactivity between the user and data displayed on screen, and a fast and easy way to handle, add and remove data, allowing easy computations on subsets of points.

Spectral Analysis of unevenly spaced climatic time series using CLEAN: signal recovery and derivation of significance levels using a Monte Carlo simulation

Dekkers, M J; Heslop, D

Many paleosecular variation and paleoclimate records are unevenly distributed in the depth cq. time domains. The CLEAN algorithm (Roberts et al., 1987) is designed to process such data records. We present a Monte Carlo based method for the determination of errors associated with frequency spectra produced by the CLEAN transformation. The Monte Carlo procedure utilises three different types of simulation involving a data stripping operation and the addition of white and red noise to the analysed time series. The simulations are tested on both synthetic and real data sets demonstrating the ability of the procedures to extract coherent information from time series characterised by the low signal-to-noise-ratio that is typical of many paleoclimatic and paleosecular variation records. Significance levels derived for the Monte Carlo spectra of four time series from the Vostok ice core are utilised in the study of eccentricity components contained within the paleoclimatic archive since ~420 ka. Inversion of the Vostok frequency spectra into the time domain reveals the differing influence of orbital parameters in the paleoclimatic proxy records as well as the relative magnitudes of the eccentricity components contained in the time series of greenhouse gas concentration, ice volume and local temperature.

References

Roberts, D. H., Lehar, J, and Dreher, J. W., 1987. Time Series Analysis with CLEAN. I. Derivation of a Spectrum. Astron. J., 93(4): 968-989.

Independently Dated Virtual Geomagnetic Poles in Archeomagnetic Studies

Eighmy, J L

Archaeomagnetic dating depends on establishing models of prehistoric change in the geomagnetic field. In the absence of written or observatory records, these models have been created from large sets of independently dated virtual geomagnetic pole positions. Worldwide, approximately 1550 independently dated archaeomagnetic pole positions dating back to about 5000 B.C. are available in the NGDC database. Included in this database are approximately 250 pole positions from North America archaeological sites dating back to about A.D. 600. Since these data will be extremely important in the study of the history and nature of the Earth's magnetic field, a widespread understanding of terminology in archaeomagnetic sampling, the nature of "independent dating" in archaeology, and the dating precisions typically achieved in archaeology will insure comparability across archaeomagnetic and paleomagnetic databases

The evolution of the lists of "Palaeomagnetic directions and pole positions", 1960 – 1980

Randolph J. Enkin and Edward Irving

A Reversal Database

Fuller, M

With the renewed interest in reversal transition fields following the suggestion of longitudinally confined VGP paths (Clement 1989 and Laj et al., 1991), a reversal dbase was compiled (Athanassopoulos et al.,1995). An overall listing of the records in the dbase was provided with the key references. For each reversal an excel file gave the site latitude and longitude, the succession of field directions (intensity, if available) and the VGPs. No attempt at quality control was made because it was not clear which criteria should be used. This meant that indubitably some poor data were included. However, it also meant that good data were not excluded by inappropriate rejection criteria. This dbase affords an example of an early attempt at such compilations for reversals. The VGPs in the compilation were used in an analysis of the Brunhes Matuyama transition field that demonstrated longitudinal asymmetry of the field with the VGPs predominantly in the hemisphere of the prime meridian and not in the Pacific hemisphere (Shao and Fuller 1999). This result was robust in the sense that it was also obtained when the more restricted database of Love and Mazaud (1997) was analyzed.

References

Athanassopoulos, J., Fuller, M., Dunn, R., and Williams, I., Atlas of Reversal Records, EOS, *76*, 31, p. 306, 1995.

Clement, B., Longitudinal distribution of Brunhes-Matuyama transitiona VGPs, EOS Trans. AGU., 70, 1073, 1989.

Laj, C.A., Mazaud, A., Weeks, R.. Fuller, M., and Herrero-Bervera, E., Geomagnetic Reversal Paths, Nature, 351, 447, 1991.

Love, J.J., and Mazaud, A., A database for the Matuyama Brunhes Magnetic Reversal, Phys. Earth. Pla. Sci., 103, 207-245, 1997.

Shao, J-C, and Fuller, M., Hemispherical Asymmetry in reversal Transition Fields, IUGG XXII, Abstracts, A292, 1999

Historical geomagnetic datasets and their applications

Jackson, A

We have recently finished our compilation of historical direct observations of the magnetic field from published and manuscript sources. In this talk I will describe the science that can be accomplished based on this compilation of geomagnetic data stretching back to 1510.

The most widely-used products of this work are the continuous space-time models of the magnetic field. These are the models gufm1 (Jackson et al, 2000) and its predecessors ufm1/ufm2 (Bloxham and Jackson, 1992). These models are designed to describe the magnetic field at the core surface, but can equally describe the surface field and can be used for comparison with palaeomagnetic directional data within the last 400 years, and studies of the evolution of maritime navigation, amongst others.

I will attempt to describe the limitations of the data, and its application to determining the magnetic field and flow at the core surface. The determination of flow at the core surface leads to a link between geomagnetism and geodesy because the speed of flow in the core gives an indication of the core angular momentum. A demonstrable link exists between the geomagnetic predictions of the rotation speed of the mantle and the historical measurements of the same, in the form of perturbations in the length of the day.

References:

Bloxham, J. and Jackson, A., 1992. Time-dependent mapping of the magnetic field at the core-mantle boundary, J. Geophys. Res., 97, 19537-19563.

Jackson, A., Jonkers, A. and Walker, M., 2000. Four Centuries of Geomagnetic Secular Variation from Historical Records, Phil. Trans. R. Soc. Lond., 358, 957-990.

The Role of New Lava Flow Data Sets in Investigations of Paleomagnetic Field Behavior

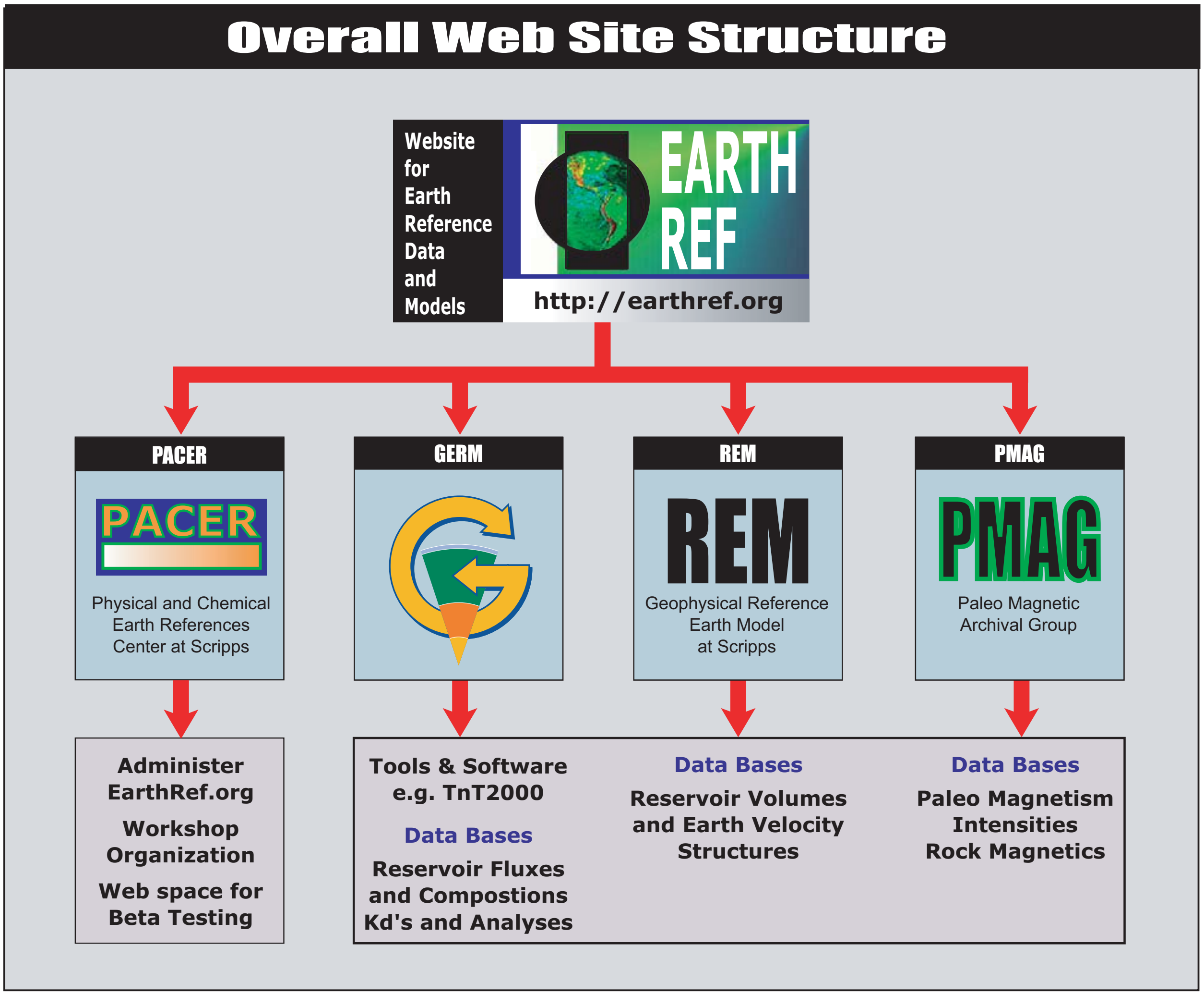
Johnson, C L; Constable, C G; Tauxe, L

Over the past three years a multi-institutional (Scripps Institution of Oceanography, University of Florida, University of California Santa Cruz, University of Alaska, University of Wisconsin) project has resulted in a significant new data set of paleomagnetic direction and absolute paleointensity measurements relevant to studies of 0 – 5 Ma geomagnetic field behavior. The goal of the project was to enhance or replace existing data sets in order to better elucidate global and regional paleomagnetic field behavior. New paleomagnetic data sets have been collected from 10 locations forming a transect through the western Americas from Alaska, through British Columbia, the Western U.S., Costa Rica, Chile and Patagonia. Additional data have been collected in south-eastern Australia and Spitzbergen and from new measurements of previously collected cores from Antarctica, Nunivak, and Easter Island. These new data sets drastically improve spatial and temporal sampling of 0-5 Ma field behavior, and enable critical evaluation of previously collected data sets from nearby locations. Calibration between paleomagnetic laboratories involved in this project ensures reproducible, consistent results. An overview of this project and synthesis of the results obtained to date is presented. Cases that enable comparisons with previously collected data sets are highlighted. Such comparisons emphasize the need to pay careful attention to quality control in selecting data for secular variation and time-averaged field studies. The results from this project, combined with other published lava flow paleomagnetic data and current field programs provide new insights in paleomagnetic field behavior.

GERM, REM and PMAG on EarthRef.org

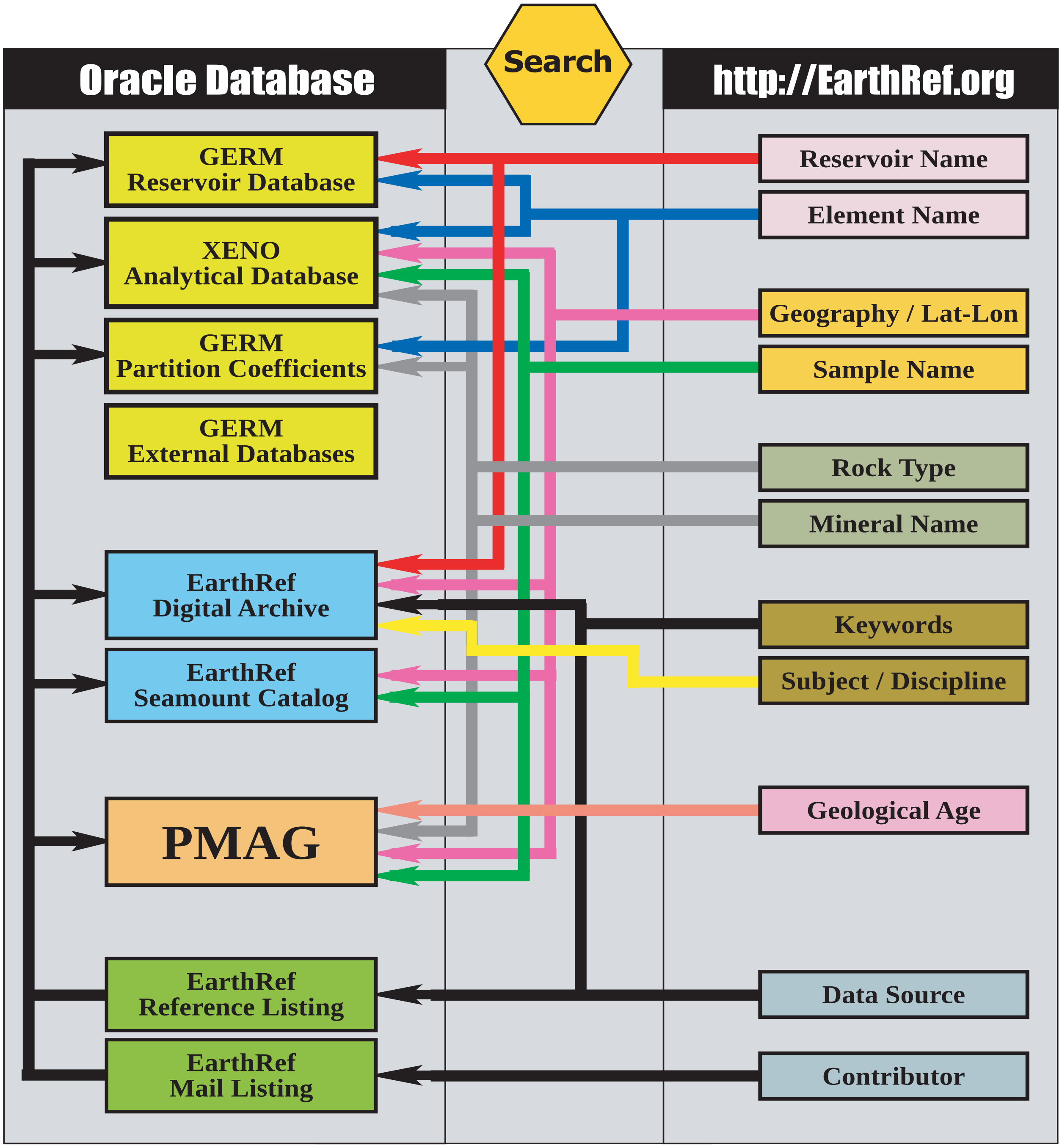
Koppers, A; and Staudigel, H

An exponentially increasing number of geochemical, geophysical and paleomagnetic data has led to major advances in our understanding of the Earth. As a side-effect, it also has exponentially increased the need for meaningful data archiving and digital access of these data. The latter process, however, has been extremely slow — hampering development of global reference models, such as GERM and REM. In fact, to date there is none global model that attempts to optimize constraints from all types of geochemical, geophysical and paleomagnetic data. For these reasons, it is crucial to begin to establish databases that are comprehensive and available to the whole Earth science community through online connections.



The research center for Physical and Chemical Earth References (PACER) at the Scripps Institution of Oceanography was established to help create such global reference models by electronically making available a wide range of Earth science data. As part of these efforts PACER supports GERM, REM and PMAG while maintaining multiple online databases under the **http://earthref.org/** umbrella web site. This overall structure is depicted in Figure 1.

EarthRef.org has been build on top of a relational database that allows for archiving and electronic access to a great variety of data types and formats. These online databases are designed in Oracle 8.1.5 and they are maintained at the San Diego Supercomputer Center (SDSC). By involving a highly-specialized and established facility for data archival, such as the SDSC, we are assured of an increased robustness and longevity of the EarthRef.org electronic data archives. It also guarantees direct access to advisors with regard to state-of-art solutions in Information Technology (IT). These databases are directly available via**http://earthref.org/databases/**.



The philosophy behind the EarthRef.org databases is to have a flexible architecture that allows for the archiving, searching and downloading of any type of Earth science digital data. Ultimately, these data sources can be linked with on-line modeling tools that allow for a variety of calculations, relating various Earth science data. Our development of the TnT2000 global geochemistry modeling tool at **http://earthref.org/tools/tnt2000/** is a first attempt at this.

Data archived in Earthref.org may include individual data points (chemical analyses, age determinations, magnetic measurements) or any arbitrary digital objects (ADO). These ADO's can serve as original data resources (an image of a data table or illustration, as background information for the ASCII data tables) or, more so, as any resource useful in research or teaching (such as maps, correlation diagrams and modeling codes). ADO's can be searched for on basis of metadata and subsequently be downloaded as data files.

The GERM Relational Databases

The GERM Reservoir Database is the original GERM database that contains summary data on the geochemistry of each reservoir in the Earth. These geochemical data can be searched for based on reservoir name, element, reference and availability of data. This relational database only includes peer-reviewed literature data. As a result, numerous interesting but unpublished data sources were omitted that originally were available on the GERM website. In the long run, and in case these data do ***not*** get published in the peer-reviewed literature, they may still be made available through the EarthRef Digital Archive (see below). We also maintain links to external databases, such as the GEOROC and PETDB analytical databases.

The KD's Database contains partition coefficient data for all types of rocks and minerals and for every element. All KD values can be searched for using combinations of rock name and mineral, element and reference. Up to this moment all data has been compiled by Roger Nielsen (Oregon State University) and includes experimental and empirical data.

Digital Archives

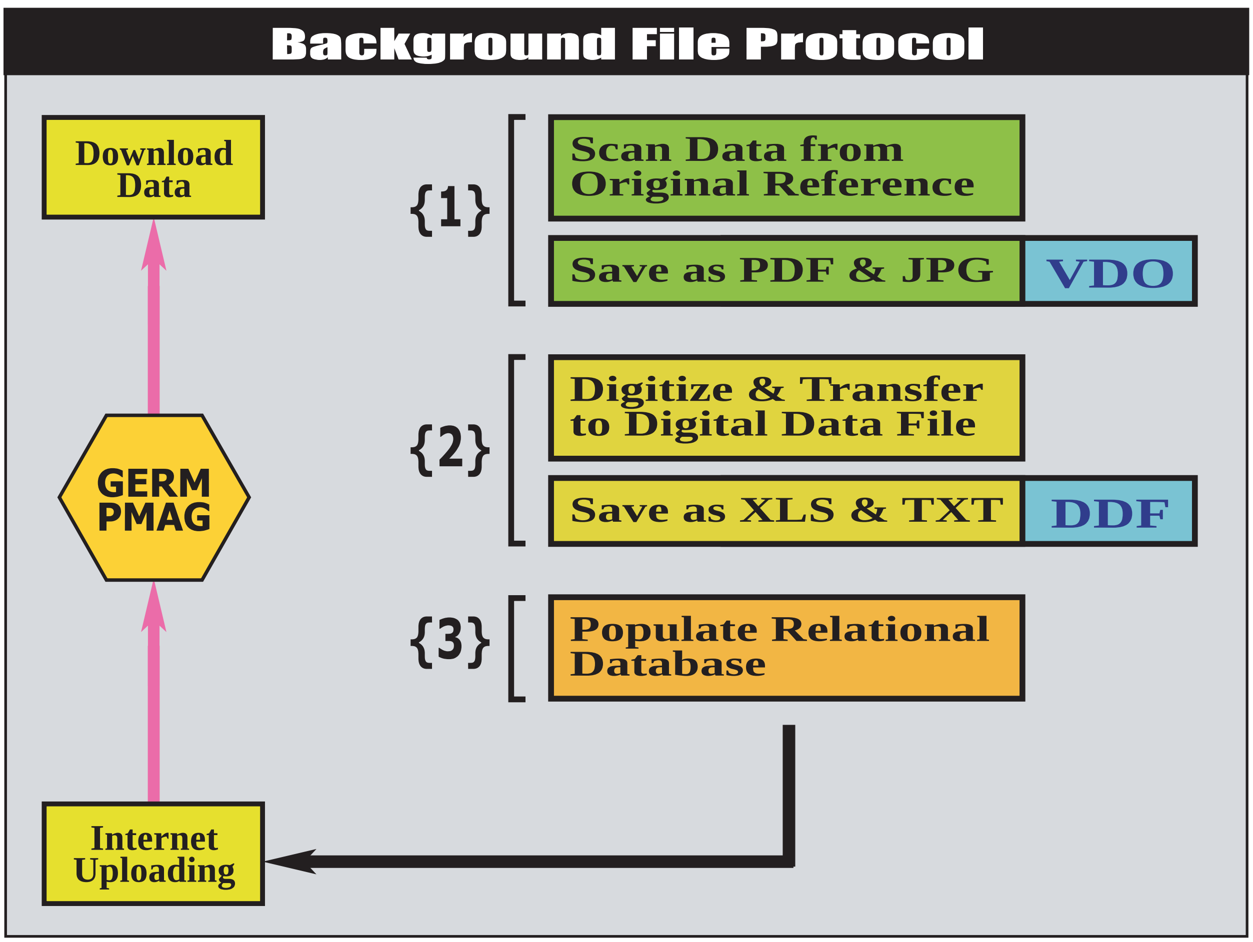
We have developed the EarthRef Digital Archive (ERDA) that contains any "arbitrary digital objects" (ADO) ranging from data tables to diagrams to reports to geological maps to videos. In the same category we are also developing an electronic Seamount Catalog containing bathymetry maps, dredge locations and data on seamount morphology. The major goal of these archives is to supply the Earth scientist with simple means to have access to the widest possible variety in electronic files or ADO's with direct relevance to research and teaching. These ADO's may be archived as peer-reviewed contents or as an open exchange of useful resources shared between scientists (without peer-review).

ERDA data objects are extensively described in terms of metadata. These metadata are used when Earth scientists search through this online database in order to download their needed files. These metadata ***minimally*** include keywords (e.g. sediment, REE, argon), descriptions and the data file specifics. However, there are many optional types of metadata, which (when made available with each data contribution) would significantly increase the success of finding these data files in the online data queries. For example, the ERDA contributions can also be characterized for their latitude-longitude, geography (e.g. Alps, Massif Central), age range in Ma or geological age (e.g. Cretaceous, Archean), science discipline and subject (e.g. mineralogy and petrology, igneous petrology), project name, measured parameters (e.g. density, SiO2, magnetic susceptibility), materials (e.g. basalt, water, magnetite) and analytical techniques (e.g. ICP-MS, XRF).

The Seamount Catalog contains bathymetric maps from seamounts surveyed with various multibeam systems. It also contains a database on dredge locations and the morphology of these seamounts. In order to generate complete maps of the seamounts (when the surveys were incomplete) we have merged the multibeam data with the bathymetry database of Sandwell & Smith (1996, 1997). All maps are available for downloading in high and low JPG formats, next with their gridded bathymetry data and the original multibeam data files.

Reference Database

Key to each Earthref database is the Reference Database. By searching for references one can find its way into each database (Figure 2). More importantly, for each reference every abstract, data table, technical note and/or appendix is available in a digital form that can be downloaded as TIFF/PDF/JPEG images and Microsoft Excel/Word data files.



EarthRef.org archives these files as arbitrary digital objects (ADO) and digital data files (DDF) before digesting them into the relational databases using easy-to-use data forms (Figure 3). During this process the layout of the original reference is retained as closely as (humanly) possible. As a consequence, each data point that has been entered into the EarthRef.org relational databases can be traced back to its original reference and, even more significant, to the "actual" data table it has been derived from. This ensures direct ***traceability*** of each data point available in the EarthRef.org databases to its source. These ADOs and DDFs may also serve as "original" records to check for potential digitization errors. However, most importantly, the digitized data tables and text fragments may serve as a new ***online*** source for performing research and teaching.

Mailing List

A general Earth science mailing list is maintained. Scientists who wish to add themselves to this list or who need to make an address change can do so via data forms on the EarthRef.org web site (which will be operational shortly after the PMAG workshop). This mailing list will also be used to identify data contributors to the EarthRef databases.

New PMAG Initiatives

The PaleoMagnetic Archival Group (PMAG) helps in the design of modern paleo, rock and geomagnetic databases. A start has been made to implement an integrated database for paleomagnetism within the existing EarthRef.org framework. As will be shown in our poster presentation, this design focuses around the general ***workflow*** that results in the determination of typical paleo- and rock-magnetic analyses. This ensures that individual data points as measured on *specimens* can be traced between the actual analyses and the *samples*, *sites*, *sections* and *expeditions* they belong to. These relations will guarantee ***traceability*** of the data by distinguishing between original and derived data. They may also serve to recalculate site means when new data becomes available. Please visit the PMAG web site at **http://earthref.org/PMAG/** for more information.

Global Continuous Geomagnetic Field Model for the Past 3000 Years - an Application for Data from Paleo- and Archeomagnetic Databases

Korte, M; Constable, C

Geomagnetic field models provide important information towards the understanding of the magnetic secular variation and the dynamics of the Earth's core. Historical measurements of the magnetic field are sparse before AD 1600. Paleo- and archeomagnetic data are used to model earlier epochs of the field. PSVMOD1.0 [Lund and Constable, in preparation] is a compilation of globally distributed paleodirectional data from archeomagnetic artifacts, lava flows and lake sediments at 24 sites. It is spanning the time interval from 1000 BC to AD 1800 and has been modeled by Constable et al. [2000] at averaged 100 year intervals. We are now working on a time continuous model of the data and aim to improve the model by adding data from additional sites and in particular intensity information. Data bases with appropriate search functions are the preferred source of data for this work. We present some of our existing models and the data used for them and describe our demands on data for the improvement of the models.

The Paleomagnetic Databases

McElhinny, M

Catalogues of global paleomagnetic data were first published by Ted Irving in the *Geophysical Journal* between 1960 and 1965 (Nos. 1-7) and subsequently by myself between 1967 and 1980 (Nos. 8-16). Alexei Khramov published catalogues of data from the former Soviet Union. At the Vancouver IUGG meeting in 1988, Rob Van der Voo proposed that the paleomagnetic community move to an electronic version of these catalogues for use on a desktop PC system.

Funding for the setting up of this database was obtained from 9 countries mainly through their various scientific research foundations. The major contribution was from NSF, which provided about 30% of the total budget. This enabled my wife (Jo Lock) and I to set this up over a period of two years. We chose ORACLE as the first platform being the only PC system on the market that used SQL, the international standard for relational database management systems. ORACLE worked under MS-DOS, but when Microsoft moved into the Windows environment in 1995 we moved over to the their ACCESS database. This has been a more user friendly platform and is still being used today for the PC version of the Global Database.

As a result of the success of implementing the Global Paleomagnetic Database, IAGA proposed that further databases be developed in all aspects of paleomagnetism and rock magnetism. The complete list of databases currently available are:

1. Global paleomagnetic database (GPMDB).
2. Polarity transitions database (TRANS).
3. Secular variation determined from lake sediments (SECVR).
4. Paleointensities (pre-archeomagnetic) (PINT).
5. Paleosecular variation from lavas 0-5 Ma (PSVRL).
6. Magnetostratigraphy (MAGST).
7. Archeomagnetic directions (ARCHEO).

Although funding for the initial Global Database was obtained from 9 supporting countries, support for updating and maintenance has been much more difficult. NSF is the only funding agency that has so far been prepared to provide funds for this purpose. If these databases are to be maintained in the future, the funding problem needs to be solved.

Simulating Stacked Relative Paleointensity Records: Compiling Data and Filling the Gaps

McMillan, D G; Constable, C G; Parker, R L

For the analysis of relative paleointensity records from marine sediments, it is common to average, or stack, several records from the same locality to enhance the signal of regional secular variation. The stacking technique has also been extended to globally distributed relative paleointensity records in order to infer global variations of the paleofield. When calibrated to virtual axial dipole moment (VADM), such a record is a proxy for the geomagnetic dipole moment whose variations are thought to reflect long term changes in the geodynamo. However, the many uncertainties associated with each record make it difficult to assess the quality of the records individually and of the resulting stack. We describe a method, making use of geodynamo simulations, that provides a quantitative assesment of the quality of stacked relative paleointensity records and isolates the effects of different types of errors. For meaningful results, we design a stacking process that closely mimics that which has been used for paleomagnetic data. As such, we seek as much information as possible about original tie point depths, the ages and age uncertainties that are assigned to them and the methods by which those ages are determined. We report a data compilation that corresponds to the relative paleointensity records of Guyodo and Valet's set number 1 [Nature, 399, 249-252, 1999] spanning the last 300 kyr. The often tedious task of forming this compilation and the conspicuous dearth of relevant information in the literature underscores the importance of establishing a clearinghouse in which all useful data may be deposited. We discuss the techniques we have used to assign tie point data and fill gaps due to unreported or inaccessible results and arcane methods. Lastly, for a stacked record that has been calibrated to VADM, we show examples of the spectral degradation of the paleomagnetic signal that arise from uncertainties in tie point selection, tie point ages, sedimentation ratesand measurement error.

A Magnetic Petrology Database for Satellite Magnetic Anomaly Interpretations

Nazarova, K

A Magnetic Petrology Database (MPDB) is now being compiled at NASA/Goddard Space Flight Center in cooperation with Russian and Ukrainian Institutions. The purpose of this database is to provide the geomagnetic community with a comprehensive and user-friendly method of accessing magnetic petrology data via Internet for more realistic interpretation of satellite magnetic anomalies. Magnetic Petrology Data had been accumulated in NASA/Goddard Space Flight Center, United Institute of Physics of the Earth (Russia) and Institute of Geophysics (Ukraine) over several decades and now consists of many thousands of records of data in our archives. The MPDB was, and continues to be in big demand especially since recent launching in near Earth orbit of the mini-constellation of three satellites - Oersted(in 1999), Champ(in 2000), and SAC-C(in 2000) which will provide lithospheric magnetic maps with better spatial and amplitude resolution (about 1 nT). The MPDB is focused on lower crustal and upper mantle rocks and will include data on mantle xenoliths, serpentinized ultramafic rocks, granulites, iron quartzites and rocks from Archean-Proterozoic metamorphic sequences from all around the world. A substantial amount of data is coming from the area of unique Kursk Magnetic

Anomaly and Kola Deep Borehole (which recovered 12 km of continental crust). A prototype MPDB can be found on the Geodynamics Branch web server of Goddard Space Flight Center at http://core2.gsfc.nasa.gov/terr_mag/magnpetr.html 200 records are included in this prototype database. The MPDB employs a searchable relational design and consists of 7 interrelated tables. The schema of database is shown at http://core2.gsfc.nasa.gov/terr_mag/doc.html. A MySql database server was utilized to implement MPDB. The SQL (Structured Query Language) is used to query the database. To present the results of queries on WEB and for WEB programming we utilized PHP scripting language and CGI scripts. The prototype MPDB is designed to search database by geographical location, tectonic structure, major satellite magnetic anomalies, magnetic properties, chemistry and reference, see http://core2.gsfc.nasa.gov/cgi-bin/katianh/third.pl . The output of database are HTML structured table, text file, and downloadable file. This database will be very useful for studies of lithospheric satellite magnetic anomalies on the Earth and other terrestrial planets.

Fundamental Rock Magnetic Database

Andrew J. Newell

Synthetic magnetite samples are the basis for much of what we know (or believe we know) about magnetic minerals in rocks. Measurements of their magnetic properties are often scattered across several publications. A database would make it easier to compare rock magnetic methods that use multiple hysteresis parameters. Theories could also be more effectively tested against multiple measurements for the same sample. I have put a variety of information on synthetic samples, including information on their synthesis and characterization, in electronic form. Some criteria, such as crystallinity and possible oxidation state, could be the basis for quality criteria. I have included detailed information on size distributions, where it is available. These can be used to better constrain errors in models. Some inconsistencies in the data are discussed, as well as possible sources of error. Future publications of measurements on synthetic samples should include the raw measurements and should attempt to estimate the uncertainties in the measurements.

Calibration of the Pass-Through Superconducting Magnetometer

Parker, R L; Gee, J S

It has been understood since their introduction that pass-through magnetometers must inevitably provide a reduced-resolution image of the true magnetization within a core. Deconvolution can improve this performance. Previous work on the question relied on the assumption that the core passes along an axis of symmetry of the magnetometer, in which case orthogonal components of magnetization are recorded independently on the three orthogonal pickup coils. If, however, the axis of the specimen does not coincide with the symmetry axis, cross talk between the coils arises which introduces unexpected distortions in the magnetometer output, including amplitude bias and significant errors in the declination and inclination estimates. Departures from the symmetrical arrangement arise with the geometry of U- channel measurements, and surprisingly, because magnetometers themselves can be misaligned, so that the geometrical axis of the sensing volume is significantly displaced from the magnetic axis.

To correct for these effects the sensitivity of the instrument within the measurement region must be measured, not just along one axis, but throughout the volume. We have conducted such calibrations on three superconducting magnetometers and discovered misaligned in each one. We describe how the measurements are made and we show how a mathematical model may be constructed for interpolating and extroplating the sensitivity function. We illustrate the spatial response functions of several magnetometers. Appropriate methods for correction of the distortions are under development, but will not be presented here.

Paleointensity database

Perrin, M

The paleointensity database was initially constructed by Masaru Kono and Hidefumi Tanaka. Since 1995, Mireille Perrin took in charge the keeping of the database with the help of Elisabeth Schnepp for the update of the 0-5 Ma interval. The initial contribution of Valeri Shcherbakov (Institute of Borok) was valuable for the update of older Russian data.

Only absolute paleointensity determinations from igneous rocks and baked contacts are registered in the database and each entry corresponds to a mean result for a given cooling unit. Archaeological artifacts are not included. All methods of paleointensity determinations are taken into account as well as all field configurations (normal, reverse or transitional polarity). More than 2000 data are now available from almost 200 references.

Although the number of entries in the paleointensity database almost doubled in the past 5 years which indicates a renewed interest in this type of studies, the quality of the data as well as their temporal and geographic distributions remains extremely uneven and a proper time-averaging of the paleomagnetic field cannot yet be expected, except maybe for the first Ma. However long term features of the dipole field as the existence of a period of low field during most of the Mesozoic are now firmly established even though the transition mode between this Mesozoic low and the Quaternary high field remains unclear.

Towards environmental magnetic protocols

Peters, C; Dekkers, M J; Langereis, C G

Many publications document magnetic parameters of synthetic or natural well-characterized mono-mineralogical samples. Typically each publication focuses on a specific magnetic mineral. Here a mineral magnetic data set comprising of room temperature data of individual magnetic parameters for several magnetic minerals has been compiled from the available literature. The magnetic parameters include low-field susceptibilities, an hysteretic and isothermal remnant magnetizations and (remnant) coercivities. The minerals include magnetite, haematite, goethite, pyrrhotite and greigite. The data set is being used to compare the grain size variation between the different mineralogies for each of the parameters, with the aim of identifying the most appropriate parameters for assessing magnetic concentration and domain state. The data set is also being used to identify combinations of magnetic parameters which are characteristic of each individual magnetic mineral. Ultimately the published data, in combination with new data, is being used to propose measuring and interpretational protocols within environmental magnetism.

Global Palaeomagnetic Visual Database

Pisarevsky, S

The Global Palaeomagnetic Database (GPMDB) created and developed by McElhinny and Lock (1991, 1996) is used by researchers all over the world. The user-friendly interface makes it unnecessary for users to learn about details of the Microsoft Access software.

The next step in the development of these databases lies in the visualization of data and in the integration of the palaeomagnetic data with Geographical Information Systems (GIS). One of the most popular GIS software among Earth scientists is ArcView. Due to the relative simplicity of the structure of the GPMDB it quite easy to integrate palaeomagnetic data into GIS. It is just necessary to prepare a database file in DBASE format (using the export option of the Microsoft Access, for example) and then to create a subsequent graphic theme (layer, coverage) in ArcView.

The wide variety of ArcView options enable the use of graduated colours, labels, and different symbols to emphasize ages, palaeomagnetic directions, or other data features. Palaeomagnetic data may be combined with the geological, tectonic and other maps using a variety of spherical projections. In addition to all “traditional” services known for the GPMDB users, such as queries, ArcView and supplementary Avenue scripts provide many new possibilities. For example, it is very easy now to choose data from a particular polygon (e.g. craton, terrain, orogenic belt etc.). Users of the new visual database also can “instantly” create a stereoplot for any selected data subset and to calculate mean directions and palaeopoles. It is also possible to display palaeopoles for the selected group of data and to reconstruct a palaeoposition of the continental block using these poles, or Euler pole of rotation. Some examples will be demonstrated.

There are obvious advantages of using the visual database. For example, if there are some errors in the geographical position of some data, in many cases it is easy to find them. It is much easier now to test some plate tectonic hypotheses. For instance, it is possible to compare data from two adjacent terrains to decide the time of their collision. Some examples of such tests will be demonstrated.

True trends or artifacts? Paleointensity databases and data processing

Selkin, P

Compilations of paleointensity measurements have made it possible to examine the statistics of geomagnetic intensity variations over geologic time (Selkin and Tauxe, 2000; Tanaka et al. 1995 Perrin and Scherbakov 1997). To insure that artifacts of data processing do not contaminate statistics, it would be ideal to be able to process all paleointensity data subject to a consistent set of criteria. For example, one might want to analyze only data from Thellier experiments that passed pTRM checks within a certain tolerance. Users of such a database should be free to choose their own set of criteria, depending on the question being addresses. For this reason, a new paleointensity database should collect all the data from paleointensity experiments – not only the paleointensity estimate. Such a database should also contain all information necessary not only to evaluate reliability but also to transform each paleointensity estimate into a VADM or VDM, according to the user's choice. This requires information on the paleolocation of the samples from both magnetic and plate reconstructions. All available age information and detailed data on rock type (when available) and present location should be included as well, allowing the user to sort the data according to a variety of useful parameters.

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Cathedral Model and Bazaar Model for the PMAG database

Shibuya, H

Database construction and maintenance are very time consuming task, which will provide the basis of the analysis, but does not produce any direct scientific output by itself. Moreover, database tends to go more detailed discussing what data to be archived. It is worth archived, if the data were used. However, if it is more detailed, the chance of usage will decrease, while the labor will increase explosively. The most difficult thing is that we cannot foresee which data is needed, because the data selection or data archive from different view point is highly creative scientific art. Therefore, it is very exhausting task to construct and maintain the database by a small designated group. Here we call this way as the Cathedral Model of database.

Then, what is the rational expectation to the database? Several datasets have been circulated for years in the paleomagnetism community. It is partly for the economy and accurateness digitizing data, and partly for the comparison of the analyses on the same basis of data. Those two reasons tell us the principles of our database. 1) The data once digitized should be reused and circulated as much as possible. 2) The data selection or selection criteria itself is the important data in the database. What we have to provide in our database are those functions. Those two principles require the database which accept any data that the contributors want to put, and which includes the selection by a contributor as a part of the database. Here we call it the Bazaar Model. The database manager needs only to provide the agora for the Bazaar to encourage the circulation and of data.

Growing the number of data by new sophisticated instruments, it grows harder to archive data and to set criteria. The Bazaar Model is, therefore, only way for the durable databases. We should begin to try before the number of data expand to be unmanageable.

A Relational Database for Rock, Mineral and Environmental Magnetism

Solheid, P; Jackson, M; Banerjee, S K

A rock-magnetic database will serve a variety of purposes. We anticipate the most common uses will be: 1) As a standard for comparison in interpreting data for natural materials, in terms of their magnetic mineralogy and size distribution. For this purpose it is most useful to include detailed "full-waveform" experimental results (e.g., complete hysteresis loops, low-temperature remanence unblocking curves, etc) for discrete size fractions of the most important minerals. 2) To provide experimental data for comparison with theoretical predictions or numerical models. 3) To quantify the environmental signal that is recorded in sediment magnetic data. For this reason there is a strong need for access to both mineral magnetic data for various mixtures of minerals and grain sizes, and summary magnetic data used in environmental studies.

The structure of a database should be optimized to accommodate the levels of complexity in the data and the sorts of manipulations required. On the one hand, mineral magnetic data are remarkably simple. With few exceptions (such as Mössbauer spectroscopy and magnetic microscopy), there is just one dependent variable of interest: magnetic moment (normalized by mass or volume, and sometimes by applied field). On the other hand, there is a very large number of independent variables, which include both material characteristics (composition, particle size, defect concentration, internal stress state, stoichiometry, concentration/interaction, anisotropy…) and experimental conditions (applied DC field, temperature, heating/cooling rate, applied AC field frequency and amplitude, applied stress, time, orientation…). Significant complexity arises from the fact that M usually depends not only on the instantaneous values of this entire set of independent variables, *but also on their history*. For example, cooling in the presence or absence of an applied field can result in significantly different unblocking temperature spectra, hysteresis characteristics, and even low-field susceptibility. The development of a true rock-magnetic database must first start with the determination of how much of this complexity should be built into its structure, and how to do so.

A first step at constructing a rock magnetic database has been initiated in 2001 with the Rock Magnetic Bestiary (RMB). The RMB is a growing collection of full-waveform magnetic data for various samples of uniform magnetic mineralogy and grain size. It is not a database in the strict sense of the word, but rather a browsable collection of full-waveform data that can be viewed on line (http://www.geo.umn.edu/orgs/irm/bestiary/index.html) and downloaded for use as type curves or for comparison with modeling results. Initially the RMB contains data for some commercially available oxides and laboratory-synthesized titanomagnetites. We are beginning to include other synthetic and well-characterized natural samples, but it is clear that this format is limiting and cannot be developed as comprehensively as a database. The RMB will eventually evolve into or be superseded by a fully functional rock magnetic database (RMD).

We also envision a separate relational database for environmental magnetism. The requirements differ greatly for a rock magnetic and an environmental magnetic database. As mentioned above, the RMD will be structurally complex, including full-waveform data and extensive detail on sample characteristics and measurement conditions. In contrast, environmental magnetic data consist mainly of depth or age dependent magnetic parameters for various geographical locations, a format that is partly, if not wholly similar to the existing paleomagnetic databases. Detailed rock magnetic data that is produced in conjunction with environmental magnetic studies, can easily be linked through the two databases.

GERM and EarthRef.org: Developments, Lessons, and Expansion into PMAG

Hubert Staudigel, Anthony Koppers, J. Helly

The Geochemcial Earth Reference Model (GERM) initiative is a grass roots initiative that uses the vision of a reference model to provide an intellectual and information technology (IT) infrastructure to geochemistry. GERM organizes workshops approximately every two years to offer a synthesis of the Earth as a geochemical system in a few well-selected keynote presentations with extensive discussions. This scientific context serves as a basis for discussions and working group efforts on optimizing databases and the overall IT infrastructure in geochemistry. One of the major goals is to make accessible disciplinary databases to other sub-disciplines in geochemistry and to the Earth sciences in general. In this context, GERM helps preserve and make digitally available legacy data sets, aids in the development of databases, and actively participates in the discussion of how data should be published.

EarthRef.org serves as a host to GERM, with a specific site and a broad underlying relational (Oracle) database supported by the San Diego Supercomputing Center (SDSC). SDSC serves EarthRef.org as an IT, server hardware and software support for EarthRef.org. Recently, PMAG (i.e. PaleoMagnetic Archival Group) has been established within EarthRef.org, serving as a nucleus for development of a metadata structure in paleomagnetism and for the establishment of some specific paleomagnetic databases.

GERM and EarthRef.org have supported and/or developed several important initiatives in geochemistry and Earth Sciences:

Beginning with its 1998 meeting six GERM Steering Committee members developed G-cubed, a new electronic journal in earth sciences. G-cubed is designed as a traditional, high quality earth science journal that has many special features that serve important needs and eliminate problems perceived in scientific publishing. Special features include publication types that allow for the publication of data or technical advances, low cost, rapid publication, publication of electronic products (such as websites, animations etc.) and a copyright policy that offers maximum access to published materials. With respect to the GERM reference model materials, relevant G-cubed papers are freely available when accessed from the EarthRef.org website.

GERM has been active in the development of metadata concepts and formats for geochemistry and Earth sciences in general. This work has resulted in a series of publications or manuscripts that are available for discussion at this workshop and through EarthRef.org at **http://earthref.org/metadata/GERM/**. Main points of these concepts include a logical structure and modular nature of metadata, as well as information that helps access to these data from a range of search types, by location, rock type, tectonic setting, modeling relevance or relevance to a particular expert level (K-12, college, research). Metadata also include more standard concepts like analytical procedures, or archiving related metadata.

GERM and EarthRef.org has established a relational data base that archives contributed and legacy data. Legacy data are archived including images of the relevant aspects of the original papers, as well as the data themselves in ASCII text format. This archival format has been chosen to allow for easy upload and download of all materials that support scholarly publications.

EarthRef.org has developed a series of other databases and web computational tools. For example, EarthRef.org hosts a Seamount Catalogue that archives geographic information on seamounts and related morphological information in a relational database.

Ongoing efforts include the development of concepts to archive legacy geochemical samples, and the beginning of a PMAG website that offers support for metadata development, establishing an IT infrastructure for paleomagnetism and the setup of an integrated database for archeomagnetic data and paleointensity.

EarthRef.org is currently strengthening its ties with the American Geophysical Union (AGU) through direct links with G-cubed, accreditation as a data repository site that are directly citable from the AGU journals, and an agreement of free mutual electronic access between AGU journals and EarthRef.org.

On the Necessity of Step-Level Data for the Paleointensity Database

Tanaka, H; Kono, M

Recent accumulation of paleointensity experiments from volcanic rocks revealed that past criteria for acceptance of the results were not stringent enough. Before the onset of worldwide debate on the reliability of paleointensity experiment (Merrill, 1987), success of experimental results were judged by only the linearity test on the Arai plot which often lacked the pTRM test. Recent paleointensity studies usually include quite many reliability tests along with rock magnetic measurements such as hysteresis parameters. Nevertheless final decision of acceptance of the results heavily depends on each researcher. Considering the fact that definite consensus for the acceptance criteria is not yet attained in the community, we think that it is the best way to leave all the raw data for reassessment in the future.

On the other hand, with knowledge of reliability problems in the paleointensity experiments it may happen that we reject many data which otherwise should have survived. We think that recent trend of excluding all the Thellier data without pTRM tests might lead us to lose many useful results. Here we present reassessment of two paleointensity results for 4000 yr B.P. by the Thellier method which were reported as successful in Tanaka (1982). One is 113 micro T of FJ6 from two samples and another is 77 micro T of SB5 from four samples. Although the former included two pTRM tests, inspection on the orthogonal plot of zero-field steps lead us to conclude that those results should have been rejected because they were actually contaminated by TCRM. In the latter case, it turned out that the raw data actually included a pTRM test, though for only one step, which Tanaka (1982) did not show for unknown reason. Reexamination of these data indicates that they were surely successful fulfilling most of the criteria for successful Thellier paleointensity experiment.

Based on our case study we advocate inclusion of step-level data to the next generation of the paleointensity database. We will also discuss about the subsidiary data such as hysteresis parameters or magnetic susceptibility versus step records.

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Paleomagnetism of the Southwestern U.S.A. recorded by 0-5 Ma Igneous Rocks

Tauxe, L; Constable, C; Johnson, C; Miller, W; Staudigel, H

The issue of permanent non-dipole and even non-zonal contributions to the time averaged field lies at the very heart of paleomagnetism and the study of the ancient geomagnetic field. In this paper we focus on results from the southwestern U.S. for the last 5 million years. (This time interval was chosen so that the influence of plate motion is negligible). The data on which models for the time averaged geomagnetic field are based must be of the highest quality in order to detect any persistent non-dipole features. Several decades of work in the southwestern U.S. has resulted in the publication of paleomagnetic data from over 800 individual paleomagnetic sites. As part of a new investigation of the San Francisco Volcanics, we collected paleomagnetic samples from 47 lava lows many of which have been previously dated. The new data combined published data have higher VGP dispersion about the geographic axis than their global counterparts in the same latitude band, and their average direction deviates from that expected for a geocentric axial dipole field. Contributions to the scatter can arise from tectonic activity, lightning, sub-Curie temperature syn-emplacement rotation, incomplete removal of overprints, and secular variation of the geomagnetic field. We consider the issue of data selection and find that removal of data sets from tectonically active areas and judicious selection according to Fisher's precision parameter [Fisher, 1953] results in a spherically symmetric data set with antipodal normal and reversed modes. Furthermore, the selected data are not inconsistent with a geocentric axial dipole field, especially when taking into account the bias that results from using unit vectors [see Creer 1983]. However, the scatter in directions is larger than predicted by recent models of paleosecular variation and much larger than that found when the new data presented in this paper are considered alone. There are many differences in field and laboratory methods between the existing published data and the new data. The published data represent three decades of effort by more than a dozen different investigators, collected for various purposes using a range of field methods for which there is little documentation.

Without full documentation of the field methods, it is very difficult to assess the quality of the resulting data. Mechanisms need to be put in place for better (preferably digital) recording of field, laboratory, and analysis methods, so that new paleosecular variation models can draw from fully documented data sets.

How non-dipolar was the ancient geomagnetic field?

Tauxe, L

One of the critical assumptions in paleomagnetism is that the geomagnetic field is on average approximated reasonably well by a geocentric axial dipole (GAD). The GAD model is testable for the recent past and while not a perfect description of the average field, it certainly is true that the largest non-GAD term is generally found to be of the order of 5% of GAD.

As we go back in time, it becomes more difficult to test the GAD hypothesis. Plates move. Rock units deform. Chemical changes happen. Magnetic moments relax. Evans (1976) came up with a clever way to test the dipolar nature of the geomagnetic field in ancient times. Realizing that plates move and that their movements cannot be accounted for without the GAD assumption, he simply assumed that they move randomly on the surface of the Earth and that many paleomagnetic poles derived from many locations and ages could provide a statistical sampling of the ancient geomagnetic field. Evans concluded that the distribution of inclinations from the global paleomagnetic data base spanning the Phanerozoic was consistent with that of a dipolar field.

Since the work of Evans, many more paleomagnetic data have become available allowing a closer examination of the question. Kent and Smethust (1998) concluded that the frequency distribution of Paleozoic and Pre-Cambrian inclination data are severely biased toward shallower directions and are not consistent with a GAD model. They discussed several possible causes of the bias: inclination ``error'' in sediments, non-random plate motion, and non-GAD field behavior.

An additional cause of bias in ancient paleomagnetic data may be the effect of tilt. Tauxe (1999) showed that random tilt will produce the pattern of inclinations observed in the so-called ``crystalline'' rocks extracted from the GPMB97 data base. If only lava flows meeting minimum criteria are used that have structural corrections, the frequency distribution of inclinations becomes more ``GAD-like'', but the data points are too few to provide a robust estimate. One of the principle problems in the current (GPMB00) and previous databases is that the data are presented as study averages, mixing together data from sedimentary, intrusive and extrusive sites. What is required is a database that preserves the data from individual sites, so that only data from particular rock types can be extracted with greater ease.

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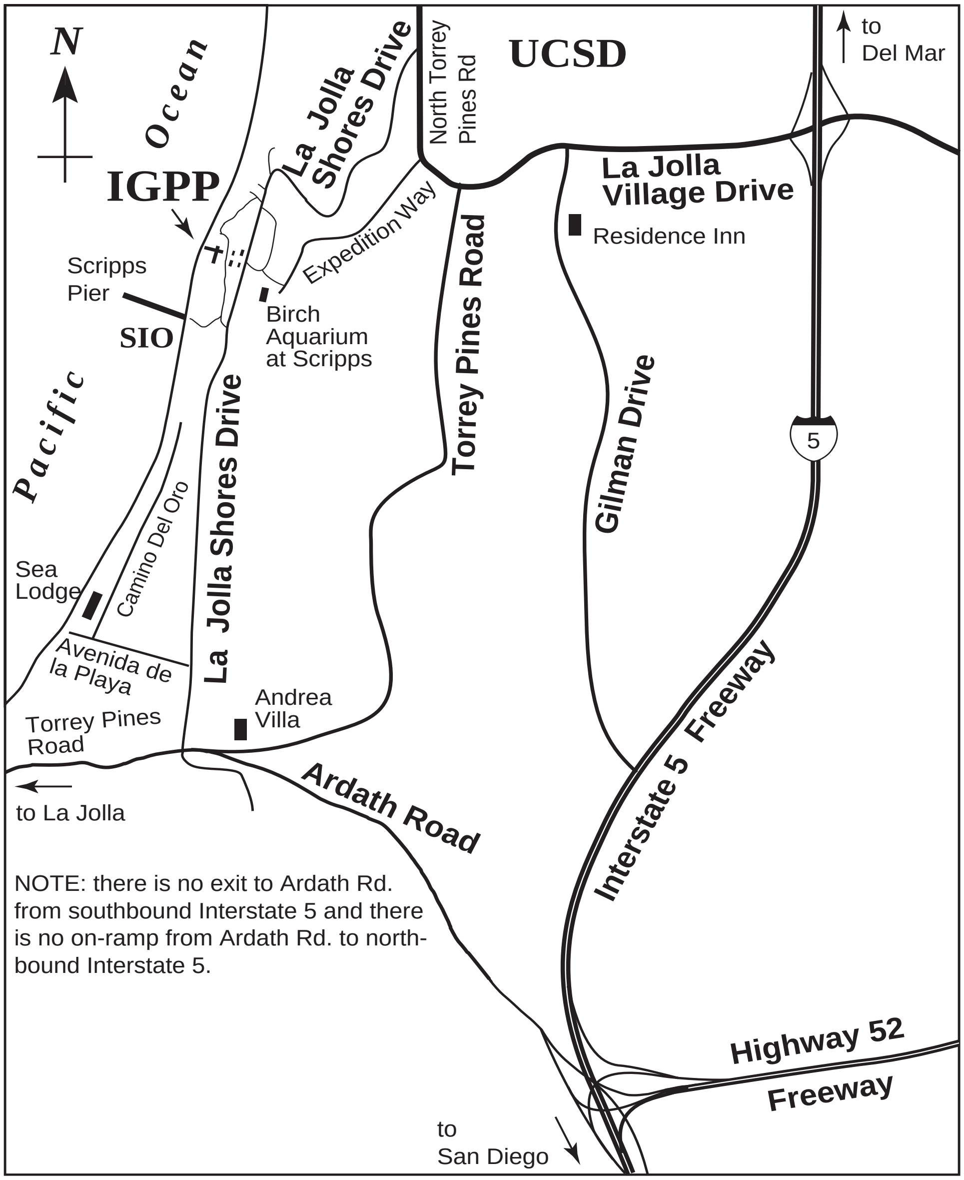

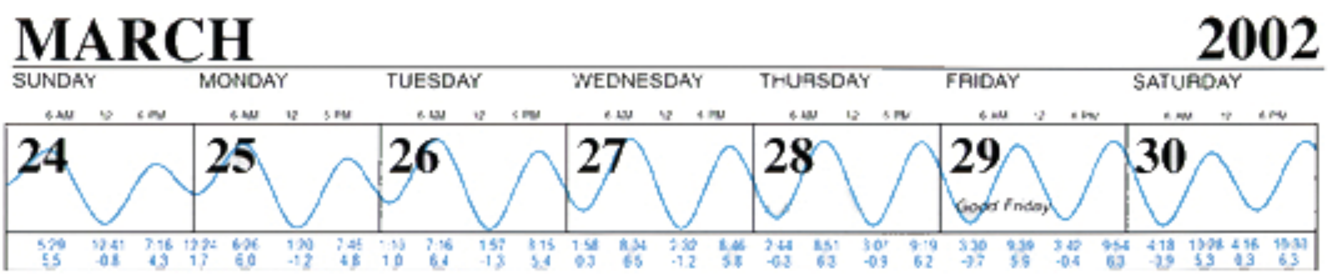

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