A Proposal to the ICSU Grant Programme for 2003 – Category II
Rescue of Old Analogue Magnetograms by Converting to Digital Images

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Motivation and Objectives

Routine observations of the Earth's magnetic field variations began in early 1800s in London and Paris. At that time, an observer visually detected deviations of a compass needle and recorded this manually in a notebook; an automatic recording system was invented only in 1840s. Therefore, by now more than 160 years of geomagnetic field observations recorded in various locations mainly by analogue scientific instruments are in possession of the World Data Centers and various government agencies or scientific institutions. These time series are extremely important for studying secular and long-term variations of the main geomagnetic field, as well as for determining the character of short-term field variations over almost two centuries. The latter is important for better understanding of long trends in the solar activity and its forcing to the Earth's atmosphere and climatic changes.

A most long-time series of geomagnetic *aa* index exists since 1868; this index has been utilized in many analyses of geomagnetic activity over thirteen 11-year-long solar activity cycles. *Lockwood et al.* [1999] have used the *aa* index to show that geomagnetic activity gradually increases since 1900s. However even having the long-time index series, scientists need daily magnetograms recorded at certain magnetic observatories to check some historical geomagnetic events or simply to compare the geomagnetic activity levels nowadays and in the past. For example, geomagnetic storms are important because of great vulnerability of the worldwide technological systems (e.g., a fleet of low-orbit and geostationary satellites, space and ground communication links, power grids and pipelines, etc.) to "space weather". *Mayaud* [1973] listed occurrences of geomagnetic storms since 1868, but actual knowledge about the past storm conditions can be obtained only upon checking the analogue magnetograms.

Most of the geomagnetic data time series, recorded after International Geophysical Year (IGY, 1957-1958), are collected and stored in then established World Data Centers [*Guide to WDC System*, 1996; http://www.wdc.rl.ac.uk/wdcmain/]. For example, the "Combined International Catalog of Geomagnetic Data" [*Abston et al*., 1985] presents a status of the worldwide geomagnetic data collection updated to 1984 (note that an on-line version of this Catalog was updated by April 1998 and available from ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/CATALOG/catalog.txt). Although in this Catalog some of pre-IGY geomagnetic data are shown as stored at WDCs, that inventory is insufficient for locating many archives where the old analogue magnetograms recorded around the World can be found. For example, we do not know how many analogue magnetograms left after the First (1890-1892) and Second (1930-1932) Polar Years and where all these magnetograms are actually located.

Therefore, we realize that even with the explosion of modern information technology and Interned, we are now losing important scientific information on the analogue media collected by our predecessors. Another example, once the ICSU Panel on WDCs was informed that the old (as after 1870) magnetograms of Shanghai magnetic observatory were about to be destroyed due to limitations and difficulties in their proper storage. The WDC Panel and U.S. NOAA put some funding together to make microfilm copies of the original magnetograms, which are now saved at WDCs. We are afraid that a still greater threat faces magnetic observatories in many countries where the historically valuable data might literally be destroyed.

Recently the IAGA Division V "Geomagnetic Observatories, Surveys and Analyses" (http://www.sprl.umich.edu/mist/iaga/div_v.html) has embarked on a new initiative "Old Analogue Magnetograms Inventory", where it has proposed to the worldwide geomagnetic community to begin converting old analogue magnetograms to the digital, computer-readable images. To expedite this effort, a portion of the above-mentioned catalog has been extracted to create a "Pre-IGY Catalog of Analogue Geomagnetic Data (1841–1960)" held in the World Data Centers for Geomagnetism (http://www.sprl.umich.edu/mist/iaga/pre-igy-analog.html). This Pre-IGY Catalog allows the worldwide geomagnetic community to re-check existing inventories and to plan rescue efforts in saving important historical records. The Pre-IGY Catalog's time coverage is extended up to 1960 to show a continuity of observations at the most currently operated magnetic observatories. The color-coding shows a proposed sequence in converting old analogue magnetograms of certain observatories to digital images, prioritizing firstly to rescue the most rare (e.g., existing only in a single copy) magnetograms and hourly mean tables. The pilot project has already been started at the WDC for Geomagnetism in Kyoto, Japan (http://swdcdb.kugi.kyoto-u.ac.jp/film/). We think that the prepared Pre-IFY Catalog is a good start for the proposed project on the "Rescue of Old Analogue Magnetograms by Converting to Digital images".

Proposed Actions

Thus, being aware of the existing problems with the proper storage of analogue magnetograms and concerning on the future fate of these historical records, we identified the following problems and propose a rescue project:

1. The "Combined International Catalog of Geomagnetic Data" needs a complete revision and this should be the one of the most important priorities for the World Data Centers for Geomagnetism. The revised version should contain a search engine and posted on the World Wide Web. All Centers for Geomagnetism should update this on-line catalog timely.
2. We have to inventory (completely as possible) all old analogue magnetograms and hourly mean tables that are listed or not listed in the Combined Catalog. It is important to know actual accessibility of these records in their storage locations. A responsible organization or person should do this in each country with the help from the closest WDC for Geomagnetism. Information on the data status in each country should be reported to WDCs and then added to the Catalog. Appropriate measures should be taken for keeping the original magnetograms at least until their conversion to digital images.
3. If some country cannot take a necessary responsibility on the old magnetograms storage, we must develop a procedure that will allow rescuing these old magnetograms. With the use of modern technologies, it becomes not necessary to make a microfilm copy of the old magnetograms; instead, we can convert the analogue magnetograms into high-quality digital images by a digital camera or a scanner, and then store these images on the computer hard and/or optical disks. The appropriate techniques are now under consideration and development; a satisfactory level of quality of these digital images is now achieved. The WDCs and responsible countries should undertake necessary steps in utilizing the proposed techniques.

In order to resolve the above-mentioned problems, we propose here a project for rescue of old magnetograms by converting to digital images; this will save valuable information about the geomagnetic field and will help in wide dissemination of this information for unforeseen scientific studies and other possible applications.

Project Milestones

Five World Data Centers for Geomagnetism and Solar-Terrestrial Physics will be engaged in this project. These Centers are located in Kyoto (Japan), Copenhagen (Denmark), Mumbai (former Bombay, India), Moscow (Russia), and Boulder (Colorado, U.S.A). With a modest funding support from the ICSU Grant Programme, the following actions will be accomplished:

1. All World Data Centers will update their main geomagnetic catalogs merging them into an International Master Geomagnetic Data Catalog through establishing a "single-point" access via the Centers' Web sites.
2. A subset of this Master Catalog showing old analogue materials will be created and updated through the local (in each country) sources. All five Data Centers will prioritize a sequence for converting most rare or unique analogue data to digital images at each center, dividing necessary workload but sharing common responsibilities.
3. Two sets of necessary equipment (e.g., digital cameras, flatbed/film scanners, and notebook computers with the optical recording drives) will be purchased and delivered to two Data Centers (e.g., Mumbai and Moscow).
4. Supported through the project, these Centers will start massive conversion of available analogue materials to digital images following the pilot technique developed in Kyoto Center.
5. With modest travel support through the project, two workers of these centers may visit local institutions either for retrieving analog materials not available in the data centers, or for accomplishing technical work by converting local analogue materials to digital images at the sites.

During the proposed two years, all current rare and unique analogue magnetograms will be converted to digital images. We expect that this may constitute more than 50% of all analogue materials currently needed to be converted to digital images; more detailed examination of all available archives will also be undertaken during a course of the project.

The proposed project fits to the current ICSU Priority Theme "Dissemination of Information on Science and Technology", where it addresses the problems concerning data access and the impact of recent developments in information technology. In addition, the proposed project builds a new capacity by expanding a network of available data for development of new scientific initiatives.

The main beneficiaries from the proposed activity will be the international scientific communities of the IUGG and IAGA. The collected information about past changes in the Earth's magnetic field can be utilized in the studies of solar forcing on climate changes, shielding effects of the geomagnetic field from cosmic radiation affecting life on Earth, and development of modern technologies capable to withstand strong electromagnetic storms in geospace environment. The proposed activity may also be beneficial for the ICSU-lead joint initiative on the Global Terrestrial Observing System focused on deeper understanding of global changes in the Earth System. The rescued data can be used to construct a useful climatology of the geomagnetic field variability, to be the backdrop for current global change studies.

A leading body for this project will be the IAGA Division V "Geomagnetic Observatories, Surveys and Analyses". We are sure that the worldwide geomagnetic community will enthusiastically cooperate in the proposed effort in preserving old analogue magnetograms for future studies that are currently unforeseen, as well as by keeping this historical treasure in now digital libraries.

Thus, the proposed project's goals are aimed to maximally possible preservation of old analogue geomagnetic data from their irreversible lost and to maximally possible dissemination of this invaluable scientific information collected since the beginning of XIX century through digital libraries and archives. As new knowledge about nature may lead humankind to new frontiers, there is no more than important to timely undertake appropriate measures in preserving already accumulated knowledge.

References

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