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THE DO'S AND DON'T'S OF GEOLOGICAL DATA MANAGEMENT

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Abstract -- The paper briefly describes the background to the establishment of databases in the geological sciences and concentrates discussion on some of the problems likely to be encountered in the management of non-bibliographic (i.e., source), as opposed to bibliographic, data. A difference is recognised between these types of data in terms of their utility rather than their inherent characteristics.

The problems highlighted fall into two groups: the user, problem definition, commitment, data as a resource, policy, technology vis à vis theory, uses of data, the role of computers and user training; and the more practical aspects of databases, namely data acquisition, structure, management, flow, access, presentation and integration, hardware and software and the use of microform. Each area is discussed and some attempt is made to suggest possible solutions. The paper concludes by recognising the difficulty in dealing with the more fundamental problems but accepting that they can have a potentially more long-lasting effect on the success of any database system implementation. Thus, the definition of the problem, the recognition of the use to which data may be put and the commitment to data as a resource are emphasised as being particularly crucial factors in this context.

Introduction

Despite the traditionally non-numerate nature of the geological sciences in general, with the possible exceptions of geophysics and geochemistry, recent years have seen a greater utilisation of computer techniques in all sections of the geologist's work environment.

The collection and analysis of the large volumes of data required in geological problem-solving (Clark & Cook, 1979) has necessitated the availability of storage and retrieval capabilities. This has

resulted in the utilisation of computers for these operations, as well as for data collection and analysis, and from these developments we have seen the increasing use of databases in the geological sciences.

The establishment of databases in the geological sciences has involved not only the solving of practical problems, for example, the design of data structures, data input formats, transfer of non-machine readable data into the computer, etc. (Martin, 1976), but also the necessity for clear definition of the objectives of particular systems in relation to users' needs and available resources. While these practical problems are often easily resolvable given adequate resources and profitable interaction between the users and the designers of systems, the more fundamental problems have proved, in the case of some databases, insurmountable in the short term and have impeded greatly future developments.

During the 1960's and 1970's many organisations committed themselves to store some or all of their geological data in a computer in some form of database. Recent history is littered with examples of early mistakes and disasters (see Bie & Gabert, 1980), often caused by ill-conceived or over-ambitious plans outrunning the knowledge, expertise and support of the personnel involved. Despite these failures, many databases survive and their existence and the need for them within the geological sciences is no longer in doubt (Baxter & Horder, 1981; Horder, 1981). One of the intentions of this paper is therefore to examine some aspects of employing computer databases in the geological sciences from the geoscience information standpoint and to draw attention to some of the problems that are involved, in order that we can now benefit from the early geological database pioneers.

The paper attempts to identify and draw attention particularly to problems that the author has encountered during his involvement in the handling of geoscience data of various types. For many readers of this paper, much of what follows will not be new; it should, however, be instructive to encounter the points raised in the geoscience information context and to study them in one review.

Despite the invocation of Professor G. T. McBride (President of the Colorado School of Mines) for information geoscientists to aim to define during the course of this Conference the questions they need to address in their work, the identification of further problems may not be totally unhelpful at this stage. Some attempt is made to offer solutions to the problems identified, and what follows can therefore be viewed as some points for consideration by those who work with or plan to work with geological databases.

Emphasis

The emphasis throughout this paper is on 'source' as opposed to 'bibliographic' geoscience data (from here on referred to simply as 'data'). Unlike some speakers at this Conference, the author believes there is a fundamental difference between bibliographic and non-bibliographic (i.e., source) geoscience data and the respective databases. This difference has nothing whatever to do with the data contained within bibliographic and source databases - numeric data are often held within bibliographic databases, for example, MINSYS (Lea, 1981), while bibliographic data are contained in source databases, for example, the UK National Geochemical Data Bank (Horder, 1981). The difference relates simply to the uses to which the data contained in these systems are put and the different data handling requirements this places on the data management systems. In very simple terms, source data are processed (i.e., analysed, plotted, displayed, etc.) following retrieval from the database in order to aid data interpretation. Bibliographic data, on the other hand, are only retrieved and listed. The uses to which the data are put are therefore different and complementary. It is highly desirable from the user's point of view to successfully integrate these two types of data into a single workable system. Furthermore, this is also feasible since in reality source and bibliographic data represent the two end members of a data continuum. To date, however, nobody has achieved this objective satisfactorily. The emphasis is also upon source data because in the author's view this is the area of real expansion in the geoscience information field. It is the numbers, the digital data, that geoscientists are interested in, while not necessarily being concerned with somebody else's interpretation or ideas about those numbers. Access to such numbers is required in order to improve data interpretation, and there are now no real technical problems involved in the computer-handling of large volumes of source data through geological databases. The bibliographic database can only provide a mechanism which may reduce the 'field of search' for the required data; it is the availability of the actual data which the geoscientist ultimately requires.

The Problems

Perhaps, not surprisingly, the problems one will encounter in dealing with geoscience databases fall into two main groups. The first group is more concerned with more general, fundamental matters, while the second group contains problems relating to the more practical or physical nature of the systems. Not surprisingly, the second type of problem is more easy to define and more easy to solve than the first type. Unfortunately, however, the first type of problems, are the ones

which are crucial to the success of a database system and the ones that are most often glossed over or ignored by users and designers alike. The more general fundamental problems which can be identified relate to the user, the definition of the problem being addressed, the level of commitment involved, an understanding of data as a resource, the need for data handling policies, the existence of modern techniques supporting antique theories in database applications, the uses to which data are put, the role of computers and the need for user training. These areas will be considered initially.

The User. It is a strange paradox that the user is the largest problem area that we as geoscience database specialists will face and the most important problem for us to solve. By this I mean that the user almost certainly will not be able to clearly define his/her needs, will almost certainly not know what it is possible to achieve and what it is impracticable to attempt and what the difference is in practical terms between users' needs and users' wants. It is essential that we as geoscience database specialists do understand these problems, are in a position to advise users and plan accordingly. It is also probable that the user will change his/her ideas at some point in the project. It is therefore necessary to constantly review requirements as projects progress and to maintain a high degree of flexibility in order to compensate for unforeseen changes in emphasis when they occur. The inexperienced user will also generally find the market place of current day database technology bewildering and possibly technologically confusing. It is paramount, therefore, that the user is insulated from it as far as is necessary and sees his/her role as being that of defining requirements. It is our job then to refine these requirements with the user and then to plan accordingly to meet them.

The Problem. A further difficult aspect of all database applications is the definition of the problem(s) being addressed. It is one of the areas that is nearly always neglected, ignored or given minimal consideration and it is the one which is most vital to the success of a database application, the one which must be performed most rigorously and thoroughly and the one to which a considerable proportion of the available resources must be contributed if overall success is to be achieved. This aspect cannot be emphasised too strongly, because if proper, thorough project (problem) analysis is not performed, at worst the application will not work or at best it will do something for which it was not designed and for which the user has no need. Within my present organisation, rigorous procedures exist, and are followed, in order that project (problem) analysis is performed and performed correctly (Computing and Information Processing Department, 1979). The general need for this is also well recognised in computing projects in general (Loudon, 1979). It is quite common within my organisation for over fifty per cent of the available project time and resources to

be devoted to adequate and thorough project analysis. Handsome dividends are reaped from this procedure in subsequent stages of a project; the consequences of not doing so are severe and expensive. As noted earlier, there are regrettably many examples where this approach has not been adopted (Bie & Gabert, 1980).

Commitment. Data are collected with one objective in mind and one only, viz., to aid in solving a geological problem by understanding better the available data. The amassing of huge volumes of digital data serves no purpose in itself. Data may be utilised for many problems that may have been unforeseen at the time of their original collection and analyis. It is therefore essential to preserve the integrity of the data in order to preserve their future usefulness. In order to do this it is necessary to make an adequate commitment at the outset so that the data can be properly managed and accessed. Geologists have an obligation to do this and are in a unique position to maintain the integrity of the data they collect. They are, in fact, the best people to perform this task, rather than pass the responsibility to others who are unfamiliar with, and have no interest in, the data content and structure. It is a regrettable fact, however, that in all branches of geoscience information, the emphasis is usually, because of limited resources, upon the support necessary to fulfil the immediate aims of the project. It is clearly a costly but necessary task to ensure that data can be made available in a useful form to future scientists (Botbol, 1981; Horder, 1981).

Data as a Resource. The increase in the volumes of data now collected by many organisations and the increase in the varieties of data recorded (Horder, 1981; Lea, 1979) illustrate that large amounts of time and money are being devoted to both automated and manual data collection activities as a preliminary to complex data analysis. Hand in hand with the recognition that an adequate, non-trivial commitment, principally financial, must be made if the integrity of these large volumes is to be maintained, must be that data, like equipment and manpower, is a valuable, non-expendable resource and an expensive one at that. All resources, particularly valuable ones, must be properly administered (Horton, 1979) and controlled if they are to be of use and fulfil their defined role within the organisation.

Data Policy. It is a sad reflection on geoscience information generally, despite current awareness in some sectors (Bearman, 1982; Clark, 1982), that few, if any, internationally or even nationally, acceptable policies exist for the transfer and management of geoscience data. This is particularly true in the dealings of the developed countries with those of the Third World (Clark, 1982). It appears to be left very much to individuals or possibly unrepresentative organisations to make the running. Regrettably, national organisations, such

as geological surveys, have not taken a lead despite the existence in their ranks of enlightened, concerned individuals. The problem is acute and it is not diminishing. Grass roots practitioners of geoscience information and database applications need to feel that their work can be set in the wider context of first nationally and then internationally accepted standards and policies for geoscience data management and transfer. The necessary awareness and appreciation by the geological community that data is a resource to be utilised and conserved, requires action in this wider context than just that of the organisation which derives the data. The responsibility is a wider one and must be seen as such in order that appropriate action can be taken and soon.

Modern Technology - Antique Theory. At the present time there are few, if any technological problems associated with the handling of large volumes of digital data either from the hardware or software points of view. Despite this, however, our approach to database applications in particular and, to a lesser extent, computer applications in general, is archaic and does not match the advanced technology available. When a geologist has collected a thousand magnetic tapes of airborne geophysical data, this is not the appropriate time to go to the database expert and ask him or her how this vast volume of data should best be stored and analysed in order to achieve the geologist's objectives. The time to enter into these discussions is during the project design phase. We need to design from the bottom up, and not expect to be able to utilise computer and database techniques when the project is half-way to completion. We need to design our data acquisition activities in full awareness of our planned or perceived data storage and analysis requirements and of the project's overall objectives, rather than thinking these factors can be ignored and meaningful and appropriate results still produced. The data stored in geological databases are generally from two main sources. First, those data which have been collected with the express intention of entering them into a database; what can be termed 'current' data; data which have not existed previously. Second, those data which already exist and are being transferred from, for example, manual data records, or another computer file or database, into the current database; what can be termed 'backlog' data. Much of this second type of data may be historical, retrospective data, having been recorded many years previously. The geological sciences often rely in many fields, for example, petrology, upon the reinterpretation of much retrospective, as well as current, data. Several projects exist to-day which involve the encoding of large volumes of such retrospective data prior to their computer (re)interpretation (e.g., Chayes, 1982; Le Maitre & Ferguson, 1978). Such projects often work systematically through data covering certain time periods or encoding data from particular journals, whereas others may operate on a project specific basis. Both activities are equally valid since they are complementary and fulfil quite different

objectives. The drawback from which all such projects suffer, is that the standards of recording and even the data themselves will be different from and perhaps fall below those of the current data, while there will almost certainly be a high degree of heterogeneity between different sorts of retrospective data. Unfortunately, there is no solution to this problem since the retrospective data are precisely that and cannot now be altered to meet changed objectives without considerable additional effort and expenditure of limited resources, which in themselves may not be justifiable. What can, however, be attempted is to prevent a repetition of such inconsistencies and heterogeneities by careful data documentation, high standards of data recording and standardisation in formats, etc., where possible. Unfortunately, as we all know, standardisation is a moving target. Careful thought, planning and flexibility are required, therefore, in order to ensure that our theoretical approach matches our technological capability.

Uses of Data. Although it may seem hard to believe, very little thought is generally given to how data are going to be processed and analysed, by both geologists and database managers, prior to data collection. It is, however, vital that the uses to which data are to be put are carefully thought out and planned in advance. The only reason for collecting source data and storing them in a computer is in order that they can be used for further analysis and interpretation. The data will be passed - for example - to a plotting program to produce a contour map or to a statistical analysis package in order to calculate principal components or to a modelling program so as an optimised ore deposit model can be produced. The type of computer processing to be performed on the data will influence directly, not only what data are recorded, but how they are recorded. Thus the data output requirements directly influence the data input requirements. Both, however, are independent of the database structure, etc., in which the data are stored. The geologist therefore should not be concerned with the intermediate or middle phase. As long as the data output required is produced from the data input provided, he can remain ignorant of the database procedures. These procedures are rightly the province of the database expert who will be aware of the geologists' requirements.

Role of Computers. It is an unfortunate consequence of the present highly advanced state of new computer technology for handling large volumes of highly varied digital data that it has engendered in many people an almost blind faith in a false god. For many geoscientists, the first stage of a computer (or database) project is to acquire the computer hardware in the belief that this solves the problem or at least contributes to solving it. The reverse is almost nearer the truth. There is an old, anonymous adage which states that:

"To err is human, to really louse things up requires a computer."

For many applications a computer is just not necessary, either for reasons of the small volumes of data involved, limited costs, the

objectives, etc., or a combination of all of these factors. Geological databases are not necessarily computer-readable. Many most certainly are, but many equally are not. The UK Institute of Geological Sciences has, for example, three times as much geological data held manually than it has in computer-readable form (Horder, 1981). It is essential that a greater degree of discrimination is exercised in the utilisation of computers in all technical fields, not least geology, and that we resist the temptation to employ computer technology just because it is there.

User Training. The largest and most expensive resource available to any organisation is not its equipment or its data, but its staff. The acquisition of data and computer technology (hardware and software) will not in themselves solve the complex geological problems with which we are faced. Only the people utilising these tools will achieve this. Furthermore, they will only achieve satisfactory results if they are adequately trained in the use of such technology as is available. In this sense the computer is no different from the hand lens to the geologist. It is a tool to be used. The training must be at two levels: namely, in the use of computers themselves, i.e., what buttons do I press, etc., and, more importantly, in understanding how and why certain techniques available on computers, e.g., multivariate statistical analysis, are applied in certain specific cases and what the results mean. Expertise and even proficiency at the second level is much harder to achieve than it is at the first, but it is the most important aspect of user training. Much discussion has taken place recently in the computing and geoscience information communities about the merits of external computing facilities as opposed to developing in-house expertise. It is undoubtedly true that in-house expertise takes longer to build up, and in instances where a quick answer is required, external bureaux provide the only feasible solution. It is equally true to say, however, that in the longer term it is only the development of in-house, computer/database/data interpretation expertise which will profit the organisation and reward the investment in time and resources. Education of the user community, at all levels, in the advantages and disadvantages of using computer databases is essential in order to realise their full potential.

The more practical problems which can be identified relate to data acquisition, data structures, data management, data flow, data access, data presentation and data integration as well as aspects of hardware and software and the use of microform. Unfortunately, lack of space precludes the discussion of these substantial subjects in themselves, in anything other than fairly cursory terms which may emphasise the most important points. These problems are, however, referred to elsewhere, either in publications on data management in general (Date, 1977; Dean, 1977; Martin, 1976) or in those on the application of computers to geology (e.g., Loudon, 1979; Henley, 1981; Howarth, 1982; Horder & Howarth, 1982). Some limited comments only on these practical problems follow here.

Data Acquisition. Currently geoscientists collect more data of more varied types and in a greater number of different forms than has ever been available previously (Baxter & Horder, 1981; Lea, 1979). For example, in 1980 the UK Institute of Geological Science's machine-readable data holding totalled over 124 million items (Horder, 1981). The volumes of data routinely handled are vast. For example, the US Geological Survey generates between five hundred and seven hundred magnetic tapes annually just from marine seismic surveys (Botbol, 1981). Direct acquisition of nearly all types of data in computer-readable form is now possible, even to the extent of directly recording qualitative geological data, electronically, in the field using hand-held data loggers and other microprocessor based equipment. The problem with these systems is the lack of compatability between various forms of output media, together with the need for the inclusion of adequate qualifying data and for a high standard of data editing. The acquisition of vast volumes of data faster does not necessarily ensure an improved standard of data interpretation and analysis. To quote an unknown sage, garbage (rubbish) in, still means garbage (rubbish) out.

Data Structures. The way in which data are structured in order to facilitate computer storage will determine the means of access to those data. The advent of 'relational' (i.e., tabular) database structures (Codd, 1970) and the resultant database management systems (Loudon, 1979) during the last five to ten years, provide greater flexibility in the storing of data and the ways of accessing them than is possible with hierarchical or network database structures. It is obviously important to make use of the implicit natural data structures which exist; for example, geophysical data are naturally hierarchical while geochemical data are naturally tabular. It must also be noted, however, that the relational structure of data (Codd, 1970; 1982) offers great flexibility and its utilisation is becoming a common feature of both geosciences and other database applications (Jeffery & Gill, 1975; NERC, 1977).

Data Management. Management of data is an expensive, onerous and essential aspect of data handling if the data are to have any long-term usefulness. A question which must be addressed, however, is to what level of sophistication do we need to go in order to manage effectively the data we collect so as to provide the level of access required. A database, a collection of relatable and related data, is amended, updated, accessed, etc., by computer programs which are known as a database management system (DBMS). Many and varied DBMS's are available on the market which are generally expensive software items which often impose additional overheads on the computer system. A DBMS may be an overkill in order to achieve one's data management requirements. The installation of a DBMS does not necessarily confer any degree of success on an application (Bie & Gabert, 1980) nor will

its utilisation affect data comprehensiveness which is a function of data collection. A DBMS will, however, greatly ease the data management burden, where it was already an onerous task. The use or not of a DBMS must be, therefore, both task size and task application dependent.

Data Flow. The flow and transfer of information at both the international and trivial level can often present unnecessary problems. For example, we are all too well aware of how unnecessarily difficult it can be to transfer data on magnetic tape between two different computer installations. There is a need for standardisation not so much on common data formats but on agreed formats for data exchange (e.g., Sutterlin, et al, 1977) in order that these problems can be minimised. The increasing role of telecommunications, employing packet-switching techniques and satellite-based communications networks are significantly increasing both the capability to exchange data over long distances and the rates at which this can take place. Unfortunately, such capability does not necessarily confer any greater degree of success.

Access to Data. Stored data in any form are only of use if they can be accessed effectively, quickly and efficiently. In computer/database terms this requires the appropriate retrieval and indexing systems. For both computer-readable and non-computer readable data collections, the use of specialist intermediaries, 'gate-keepers', (Pruett, 1982) familiar with a particular subject area may be a valid means of data access. Access points to the data must also be correctly sited in order to best serve the user community. This aspect is very application-specific and may utilise distributed processing techniques, time-sharing computer services, etc., in order to provide the means of access to the data where the users are.

Data Presentation. Once data are accessible, they must be presented in a form which is easily understandable to the user and maximises the information content. In terms of source data for geologists, the pictorial representation of data, the map, scatter plot, profile, etc., is the most acceptable since the geologist does, and has continued over the years to, 'think in pictures'. The use of computer graphics, both interactive and off-line, as a means of displaying data retrieved from geoscience databases has been increasing over the last five to ten years. Furthermore, the use of colour graphics, still too expensive for certain applications but becoming increasingly more available, will increase since for certain geoscience applications it offers the advantage of providing the additional dimension of colour which monochrome (i.e., black and white) graphics do not.

Data Integration. It is becoming increasingly apparent that in order to provide better and more comprehensive solutions to geological problems, it is necessary to process, integrate and analyse often quite large volumes of different types of geoscience data, in digital form, interactively (Horder, 1981). For example, in the use of geochemical, airborne geophysical and LANDSAT-derived geological data in the search for mineral deposits, image processing techniques provide the necessary facilities to make such analysis possible. Studies have been carried out, notably in the USA and Canada, which utilise these techniques, which originate principally from the processing techniques related to satellite-based imagery data collecting systems (e.g., Batten et al, 1982). The principal drawback to the application of image processing techniques for data integration and analysis, is that the techniques are young and in general untried. If one looks from the mineral exploration point of view, nobody to the author's knowledge, has yet collected and analysed geoscience data using such techniques, identified a target, drilled it on the ground and found an ore deposit from which an economic mine has been developed. Until such time as these techniques are proved, for many geoscientists, especially those in the industrial sector, image processing techniques can only be viewed as a research and development tool, with great untried potential.

Aspects of Hardware and Software. The current advances in hardware technology have been rapid with the result that much apparently comparable equipment is available on the market. This can produce a most confusing picture to the novice information geoscientist and geologist. Expert advice is required, but not from the manufacturers of either hardware or software, who have a vested interest in selling the user their product. Expert, and as far as possible, impartial advice should be sought wherever possible. The rapidly advancing technologies have resulted in computers becoming cheaper and cheaper with value for money increasing. What is not getting cheaper is the software to mount on the computer, which is now one of the most expensive elements in a computing project. Consequently, the system should be software and not hardware driven (Johnson & Parker, 1982). Beware of falling into the trap of buying the black box, the computer, and then wondering what to do with it because no suitable computer programs are available. The name on the cabinet is immaterial, what counts is the availability of the right software. When considering software aim for machine independence, data independence, modularity of design, the use of a common language (e.g., FORTRAN) and user friendliness (ease of use). These features, if achieved, will provide software which will be transferable across several generations of hardware and will then prove highly cost-effective (Johnson & Parker, 1982). Finally, always buy as much software as possible; do not try and write it from scratch. Only write what you absolutely have to and cannot obtain commercially, or beg, or acquire. Basically, geologists are not software engineers, they are amateurs in this field and will consequently not produce the best products (Johnson & Parker, 1982).

Use of Microform. There is a great temptation in many organisations (Markham, 1982), generally for reasons of saving space, to embark on a programme of microfilming all their original data on paper, files, maps, etc., rather than computerising selective parts of it or creating a computerised index to the total data holdings. Microform does offer savings in space terms as opposed to the original paper records and computer-produced microform output is cheap and easy to produce and disseminate. It is not possible, however, to take a microfiche reader easily into the field whilst doing field work or onto an airplane whilst travelling. The hardcopy produced from microform readers is generally expensive and of a generally poor quality. Finally, and most importantly, converting the data holdings of an organisation into microform provides no more flexibility whatsoever, in terms of accessing and retrieving the data, than having the data held manually. Here more consideration should perhaps be given to the utilisation of computerised indexes to manual data holdings than to ingenious but totally inflexible microform-based systems.

Conclusion

During the course of this discussion of the management of geological data, I have attempted to draw attention to both philosophical-fundamental aspects as well as to the practical aspects of the design and implementation of these database systems. I have assumed throughout that the intention to implement a database for some or all of an organisation's geoscience data is cost justifiable. A lot of the points discussed draw attention to factors for consideration when technical justification is required. In this context it is worth reiterating that the most significant points to be stressed are:

- the vital need to adequately define the problem(s);
- the necessity to determine the use to which the data one is recording are to be put, well in advance; and
- the recognition of data as a resource and an acceptance of the degree of commitment which this recognition involves.

Unfortunately no books exist which specifically describe in more detail than is possible in this volume, the many and varied aspects of the management of specifically geological as opposed to scientific and technical data, in general. What perhaps comes nearest to it, is the set of papers published by the Geological Society of London in 1981 as the proceedings of a conference entitled "Databanks and Databases in Geology" (e.g., Horder, 1981; Duncan, 1981). This set of papers, including particularly their bibliographies, provides a useful reference point to this subject.

In conclusion, I can end no more appropriately than to requote some words which can be used to describe the application of database technology in the geological sciences to-day although they were written 170 years ago. The words were coined when Napoleon's armies were marching victoriously across Europe and at about the same time that the British were being ejected from Yorktown. They were written by a German more renowned for his literature than his geological achievements, Goethe. He said this:-

> "The modern age has a false sense of superiority because of the great mass of data at its disposal. But the valid criterion for distinction is rather the extent to which man knows how to form and master the material at his command."
>
> Goethe, 1810.

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APPLICATION OF THE COMPUTER-BASED GEOLOG SYSTEM TO EXPLORATION AND DEVELOPMENT DATA

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Abstract--GEOLOG System is a computer-based management scheme for collection and analysis of all types of exploration-development data such as: 1) geological data from drill holes, trenches, mine workings and detailed surface traverses, 2) survey data related to the above, and 3) analytical data from drill holes. We emphasize the necessity of having a systematic, consistent and accurate way of entering the above types of data so that predictive models can be developed rapidly to guide exploration-development decisions.

Our systems start with detailed readable entry of geological data on GEOFORM. Entry of this data in the field or office using our MICROGEOLOG editor with a microcomputer ensures error free data recorded on diskettes. Data from these diskettes are read into THE MINING COMPUTER where sophisticated interactive programs for analysis and display of the data are available. Some straightforward output includes printed logs called GEOLIST and coloured graphical plots called: GRAFLOG Plan, Strip, and X-Section. Graphical output can be obtained so rapidly that manual methods are largely obsolete. GEOLOG System is being used world-wide on many types of mineral deposits. Several applications to Canadian deposits are described in this paper.

INTRODUCTION

GEOLOG System (GLS) improves the data acquisition and analysis aspects of mineral exploration, development and mining. The System, illustrated in

figure 1, was designed by geologists and engineers, and has evolved over 15 years of successful application in a wide variety of geological environments. Early versions of GLS are in Blanchet and Godwin (1972, 1978) and Godwin et al (1977, 1982). It is now the most advanced and comprehensive data gathering and processing system for drill hole data that is commercially available.

We emphasize that GEOLOG System is, first, a data gathering system. Its uniqueness is due to its effectiveness in bringing a significantly improved measure of objectivity, consistency, measureability and readability to handwritten logs. Computer processing comes later in the process, and, for some projects, this could be much later or not at all. Consequently, GLS should be used at the start of exploration and development work on the basis of improved drill data logging, with the knowledge that, if the project proves interesting, computer-based services are readily available to take the logged data to any desired level of processing.

The system facilitates: 1) geological modelling, 2) geotechnical analysis, and 3) geostatistical studies. These form the foundation for feasibility studies that can be aided by application of other packages designed by IGC (Blanchet et al, 1980) namely (figure 1: top of diagram) Reserve Calculation Systems (RCS), Mine Design Systems (MDS), Mine Scheduling Systems (MSS), and Financial Modelling Systems (FMS).

Exploration and mining companies in Canada, the United States and Australia are currently using the GEOLOG System; major implementations are in the final planning stages in South America and the Philippines. Their application is mainly to the management and analysis of the large volumes of data associated with core-drilling.

This paper outlines the GEOLOG System. Specifically, we illustrate how data is: 1) collected on GEOFORM, 2) entered and edited with the aid of a microcomputer and a program called MICROGEOLOG, 3) printed as a log called GEOLIST, and 4) displayed as coloured plots by a series of programs collectively called GRAFLOG (figure 1).

GEOLOG, GEOFORM, GEOCODER, and GEOSYSTEMS are registered Trademarks of International Geosystems Corporation (IGC).

GEOFORM

GEOFORM of figure 2 is the data-capture format that has been refined to its current, advanced level through several years of field testing in different geological environments that include: vein uranium, porphyry

Figure 1: This flowchart shows the organization of the GEOLOG System and its relationship to IGC'S complete mine evaluation system.

copper-molybdenum, disseminated gold (Champigny and Sinclair, 1980, p.158), greisen tin, shale-hosted, volcanogenic, disseminated copper (Wilton et al, 1980) and coal deposits. Figure 3 shows two geologists logging in the field with GLS. Such users have found that the System, while permitting them virtually complete freedom of expression by allowing unlimited comments, facilitates rapid yet comprehensive logging; it also provides a very effective means of recording assay data by integrating it with the geodata. Logging rates are comparable or faster than those obtained by conventional methods.

Our System has been used on projects involving from one to nineteen drill rigs where more than 20 km of drill core were produced per month. One to twelve geologists have logged on a given property at one time or over several field seasons. Consistency, normally extremely difficult in such extended or large programs, is enhanced by using GEOFORM (figure 2) and simple, easily remembered codes available in a comprehensive handbook that we call GEOCODER (an example extracted from GEOCODER is given in figure 4).

Figure 2 shows entry of commonly encountered exploration data on a GEOFORM designed for logging drill holes in a volcanogenic deposit. Headings used are generally applicable to descriptions of most deposits. However, headings can be changed, as required, for each project, thus preserving the universality and general readability of GEOFORM. Note that GEOFORM allows field entry of all types of exploration and development data, such as:

(1) identification of company, property name, drill hole or trench name, etc.,
(2) all survey data pertaining to location of, for example, the collar of a hole and deviations down-the-hole,
(3) details of lithology, structure, alteration and mineralization,
(4) unlimited writing of remarks and summaries in normal note form, and
(5) detailed listing of analytical data.

GEOFORM improves data acquisition aspects of mineral exploration and development. In essence, recording data is relatively very simple. Only a few codes are required to enter data effectively; it is entered in a form that is readable with short familiarity, not only to geologists but to managementg joint venture partners, consultants, government personnel. Basic guidelines for the design of GEOFORM included:

(1) simplicity and speed of data entry,
(2) readability of entered data,
(3) consistency in data entry either by a geologist or by a team of geologists,
(4) logical organization of data entries, and

Figure 2: This GEOFORM describes a section of drill core from a volcanogenic deposit. It is the multi-purpose logging sheet (35 cm by 21.5 cm) for recording all types of project data including: survey, geological (lithology, structure, alteration and mineralization) and assay information.

Figure 3: Geologists are recording on GEOFORM data from an uranium deposit in the Northwest Territories.

ROCKS

The first 4 letters of a rock type name is its preferred Code (granite = GRAN = GR and diorite = DIOR = DR) where GR & DR are the Short Forms, used for forming compound rock names (granodiorite = GRDR, quartz diorite = QZDR), **but if 4th letter is a vowel** (as in aplite), **that vowel is replaced by the next consonant** (aplite = APLT, argillite = ARGL, and andesite = ANDS), **and if a double letter occurs within the first 4** (as in agglomerate) **one is dropped** (to become AGLM)

CODE	SHORT FORM	ROCK TYPE NAME									
ACID		acidic rock,gen	DACT	DC	dacite	LIMS	LS	limestone	QZIT		quartzite
ADAM	AD	adamellite =	DIAB	DB	diabase	LS/B		" bed	QZDR	QD	quartz diorite
(QZMZ)	QM	quartz monzonite	DB/D		" dyke	LSRF		" reef	QZGB	QG	quartz gabbro
AGLM	AG	agglomerate	DB$L		" sill	LSSQ		" sequence	QZMZ	QM	quartz monzonite

MINERALS

AC	actinolite		CZ	clinozoisite		H:	hematite : magnetite min.comb'n,undif*	NF	nepheline		TA talc
AD	adularia		CF	coffinite				NI	niccolite	44Ni	TL tellurides,gen Te
AB	albite		CU	copper,native	Cu	HE	hematite alone				TN tennantite50CU56Sb+As
AM	almandite		CO	cordierite		H>	HE>MG				TE tenorite 80Cu
Al	alunite		CV	covellite	66Cu	H=	HE=MG	OL	olivine(chrysolite)		TT tetrahedrite Cu+Sb
AX	amphiboles,gen		CI	cuprite	89Cu	H<	HE<MG	OP	opal		TX TT,TN undif
AA	andalusite					MG	magnetite alone	OQ	opaques,gen		TZ topaz
AG	anglesite	68Pb						OX	oxides,gen		TO tourmaline
AH	anhydrite					HB	hornblende (see B*)	OR	orthopyroxene,gen		TR tremolite
AN	anorthite		DC	dickite		HU	huebnerite 61W				
AP	apatite		DG	digenite		HM	hydromica (IL)	PH	phlogopite		
AR	aragonite		DI	diopside		HY	hypersthene	PF	plagioclase(see K:)		
AS	arsenopyrite	45As	DO	dolomite				PT	platinum	Pt	UR uraninite(pitchblende

TYPIFYING & QUALIFYING MINERALS

Rock-Forming Minerals	2-Code for Typifying Minerals	3-Code Qualifying, Materials, Minerals & Descriptors					
actinolite	AC	AC%	actinolitic	limonite	LI%	limonitic	COAL MATERIALS SUMMARY
albite	AB	AB%	albitized		LIM	limey	
		AMG	amygdaloidal		LP%	lapilli %	PET peat, peaty
		AM%	" , % amyg's		LT%	lithic % (RX%)	LIG lignite,-ic
andalusite	AA	AA%	andalusic		LCn	leached, n=1-9	SBT sub-bituminous

NOTE : The third character, %, present in many of the 3-character codes, is to be either replaced with a G - Scale percentage estimate of the amount of the mineral or material present, . . . or left blank

TEXTURES

AM	algal matted	LM	laminated
A*	amygdaloidal	LB	lensoid-banded (streaky)
AB	animal bored,burrowed	LN	lenticular
AP	aplitic	LE	lineated
AG	augen structured	LS	listric-surfaced
		LL	lit-par-lit
BN	banded	LT	lithic
BD	bedded		
BC	bioclastic	>>	macroveined
BI	bioturbaceous=dia-turbed by animals	MX	massive
		<<	microveined
BK	blocky	MC	mud-cracked
BT	botryoidal	MY	mylonitic
BR	brecciated		
		ND	nodular
(C	casted		
(X	crystal-casted	OS	open-structured -disrupted, matrix-supported
(F	flute-casted		
(L	load-casted		
CA	cataclastic	PW	partings & whisps of coal
CM	chilled margin		
CT	clastic		
CS	closed-structured		

F-SCALE

Scale Value	Description
X	shattered
9	extremely well fractured
8	very well fractured
7	well fractured
6	fairly well fractured
5	moderately fractured
4	fairly lightly fractured
3	lightly fractured
2	very lightly fractured
1	slightly fractured
0	unfractured

T-SCALE

MODE THICKNESS					
Range	Assgn Value	Scale Value	Bedding Description	Splitting or Textural Term	
< 2mm	1 mm	0	varved	fissile	FS
2 to < 5mm	3 mm	1	laminated		
.5 to < 2cm	1 cm	2	very thin	flaggy	FY
2 to < 5cm	3 cm	3	thin	slabby	SB
5 to <20cm	10 cm	4	med. thin		
20 to <50cm	30 cm	5	medium	blocky	BK
.5 to < 2 m	1 m	6	med. thick		
2 to < 5 m	3 m	7	thick		
5 to <20 m	10 m	8	very thick	massive	MX
>20 m	30 m	9	extrmly thk		

Figure 4a: An assemblage of portions of pages from the GEOCODER illustrates codes for: Rocks, Minerals, Typifying and Qualifying Minerals, Textures, Fracture Intensity (F-Scale), Bedding Mode Thickness (T-Scale)

GRAIN SIZE & CHARACTERISTICS

IGNEOUS, METAMORPHIC & CHEMICAL	PARTICLE DIAMETER RANGE	THE S-SCALE FOR GRAIN OR PARTICLE SIZE: ASSGN VALUE	SYMBOL	<<FOR GENERAL WORK>> <FOR DETAIL WORK>	SYMBOL	ASSGN VALUE	VOLCANI-CLASTICS
Glassy	mm	.003 mm	0	CLAY SIZE	A	.003 mm	
	2^{-8} = .004						
Extremely fine grained (aphanitic)	2^{-7}	.008	1	V.FINE SILT	B	.006	fine ash
				FINE SILT	C	.011	
	2^{-6} = .016						
	2^{-5}	.03	2	MEDIUM SILT	D	.022	
				COARSE SILT	E	.044	
	2^{-4} = .06						
Fine grained	2^{-3}	.12	3	V.FINE SAND	F	.088	coarse ash
				FINE SAND	G	.177	
	2^{-2} = .25						
	2^{-1}	.5	4	MEDIUM SAND	H	.354	
				COARSE SAND	I	.707	
	2^{0} = 1						
Medium grained (granular)	2^{1}	2	5	GRIT	J	1.41	
				GRANULE	K	2.83	
	2^{2} = 4						
Coarse grained	2^{3}	8	6	V.SMALL PEBBLE	L	5.66	small lapilli
				SMALL PEBBLE	M	11.3	
	2^{4} = 16						
Very coarse grained	2^{5}	3.2 cm	7	MEDIUM PEBBLE	N	22.6	large lapilli
				LARGE PEBBLE	Ø	45.3	
	2^{6} = 64						
Pegmatitic	2^{7}	13 cm	8	SMALL COBBLE	P	90.5	cobble-size bombs & blocks
				LARGE COBBLE	Q	181	
	2^{8} = 250						
Megapegma-titic	2^{9}	½m	9	SMALL BOULDER	R	362	boulder-size bombs & blocks
				MEDIUM BOULDER	S	724	
	2^{10} = 1m						
Extra-coarse megapegma-titic	2^{11}	2m	X	LARGE BOULDER	T	1450	extra large bombs & blocks
				V.LARGE BOULDER	U	2900	

LC-COLOUR

The GEOSYSTEM LC-Colour Code is an abbreviated, 2-character version of the more detailed GEOSYSTEM Colour Code (LBHU). LC is for Lightness-Colour.

Lightness L-Scale C28 Lower Tier		Colour Range C-Scale C29 Lower Tier		EXAMPLES	
W	white* (also in C29)	R	Red	9R	palest red=pale pink
9	palest	U	brown (Umber)	8R	pale red = pink
8	pale	O	Orange	7R	light red
7	light	T	Tan (khaki)	6R	lighter red
6	lighter (m.light)	Y	Yellow	5R	medium red
5	medium (50% ")	L	Lime (Y-G)	4R	darker red
4	darker (m.dark)	G	Green	3R	dark red
3	dark	Q	aQua (B-P)	2R	very dark red
2	very dark	B	Blue	1R	darkest red
1	darkest	V	Violet (B-P)	W	white (dead white)
N	black (Noir, Nil=0% lightness) (*White=100% ")	P	Purple	W	white (dead white)
		M	Mauve (P-R)	9	off-white
		W	White (also in C28)	N	black (jet black)
		A	grAy	N	black (jet black)
		N	black (Noir)	1A	charcoal black

G-SCALE

SCALE VALUE	ASSIGNED VALUE	RANGE	DECODED 2-DIGIT FORM
X	100%	Essentially 100%	H%
9	90	85 to 99	90
8	80	75 to <85	80
7	70	65 to <75	70
6	60	55 to <65	60
5	50	45 to <55	50
4	40	35 to <45	40
3	30	25 to <35	30
2	20	15 to <25	20
1	10	7 to <15	10
=	5	3 to < 7	5%
+	2.5	2 to < 3	2+
)	1	.5 to < 2	1%
*	.3	.2 to <.5	.3
(	.1	.05 to <.2	.1
-	.03	.o2 to <.05	03
.	.01	Trace = <.02	01
0	0	Nil, Absent	00
/	.07	Present; Estimate impossible	07
?	0	Possibly Present	??

Figure 4b: An assemblage of portions of pages from the GEOCODER illustrates codes for: Grain Size, Colour, and Grade (G-Scale)

Figure 5: Field entry of data from GEOFORM onto floppy diskettes was done in the field with the aid of this microcomputer. The printer provides field usable logs. An edit program, called MICROGEOLOG can be used to prevent entry errors. Both camp power and battery power were used to operate the microcomputer.

(5) field use of GEOFORM without dependence on computers.

MICROGEOLOG

We have recently implemented field entry of data on GEOFORM with the aid of a battery and/or camp power driven microcomputer (an Intertec Data Systems Corporation "Superbrain") which puts the data on compact, readily mailable or shippable floppy diskettes (figure 1). The major advantage of this procedure is that data entry can be controlled by an edit program called MICROGEOLOG, so that errors can be corrected in the field at the source. The diskettes, therefore, provide almost error-free data that can be entered on THE MINING COMPUTER (a Honeywell "Level 6/DPS 6" minicomputer) where they are checked by an additional edit program (figure 1).

This method of data entry is so effective that MICROGEOLOG is used to acquire data in our main office before entry on THE MINING COMPUTER. Rapid attainment of clean data is essential if fast, economical turnaround of output is to be achieved.

GEOLIST

GEOLIST, illustrated in figure 6, is printed by a high speed printer after all entries from GEOFORM have been thoroughly edited and the file has been corrected (figure 1). This output, printed with readable headings, reproduces all the details on GEOFORM. This document, therefore, is the basic record that describes a drill hole. It commonly is used to produce company and assessment reports. Note that in GEOLIST:

(1) general identification data occurs at the top of the first page,
(2) assay data are listed after geological data in self explanatory tables (assay data also can be merged with geological data), and
(3) remarks are highly readable (specific remarks can be made above and below the geological data as header and summary remarks, respectively).

Thus, GEOLIST is a comprehensive, readable listing of all data collected on GEOFORM and forms the basic documentation of data collected on a property. Consequently it also displays data from the file record that is the information base for: GRAFLOG, statistical analysis, gridding and contouring, grade and tonnage estimation, and open pit design.

```
I G C                                                                                    PAGE : 1  DATE :1981/ 9/ 8

                                  G E O L O G   E D I T   L I S T I N G                    SYSTEMS ENGINEERING BY
                                                                                         INTERNATIONAL GEOSYSTEMS CORP.

                                              FORMAT VERSION : 6802

DRILLHOLE/TRAVERSE :WHCH021          COLLAR ELEVATION:      204.00        AZIMUTH( DEG ) :  330.00      GEOLOGGED BY : DFR +
TOTAL DEPTH/LENGTH :    22.86        NORTHING(- IF S):     2500.00        VERTICAL ANGLE :  -45.00      DATE (YY/MM/DD)1 810702
CORE/HOLE DIAMETER :      BQ         EASTING (- IF W):     7025.00        CO-ORD SYSTEM  :   GRD        PROJECT NUMBER : LGT

   F   - I N T E R V A L -    CORE  T- %      TYPI- QAL  TEX-  GRAIN TOTAL PGI   STRUCTUR-1 ALTERATION MINS  ORE-TYPE MINS
X  L (UNITS =    .  DEC.PLACE)RECOV-  M M ROCK FYING MIN TURES CHARACS FRAC                 H  H  H  H  H ANY H  H  H ANY  Q Q - M
E  A  (MT=METRIC FT=FOOTRIC)  ERY    O I      TM TM MAT TX TX F C X M DEN  /RI T ID STK DIP  A  A  A  A  A MIN A  A  A MIN - - - -
Y  G  F R O M - T O -  I N T (  .  ) D X TYPE  1  2 QM1 1  2 F F C A   MI   1   AZM  RT QZ AK CY CB MG XX PY CP GL YY    L T H
- --- ----.-- ----.-- ---.-- ---.-- -- - ---- -- -- --- -- -- - - - - ---- --- - -- --- --- -- -- -- -- -- -- -- -- -- -- -- - - - -
X  F                         ROCK   FM     RT    TM QM2 TX TX S R S O S        T ID STK DIP QG MU CL EP HE HA PR MO PR HA    S C I N
E  L                         QUAL   AGE EN- Q LC- 3       3  4 O N H / M        2    AZM  RT H  H  H  H  H  H  H  H  H  H     X 10
Y  G                         DESIG      VIR   COL            R D P C   L          STRUCTUR-2  A  A  A  A  A  A  A  A  A  A

/ OVB   0.00     3.66    3.66            OVER                                  P

/       3.66     5.00    1.34            GAHR            MX    2 3   3         P                          <0        <.
L                                                 4G                                                                    B.
R       3.66     5.00        UNIT FO FROM 3.66 TO 4.00M.   CORE BLOCKY

/       5.00     8.33    3.33            BASL                  2 2   2         P   CN      B3A
L                                                 4G                                                  <( <(     Q(

/       8.33     9.48    1.15            D/LM        FX        2 3   5         P                          <A
L                                 CIF         5R    RI                                                      <(
R       8.33     9.48        UPPER AND LOWER CONTACT BRECCIATED-FELDSPAR PHENOS REPLACED BY
R       8.33     9.48        CARBONATE.

/       9.48    22.86   13.38            BASL                  2 2   2         P                          V0
L                                                 5G                                                  <(     <(
R       9.48    22.86        UNIT HIGHLY VEINED ABOVE FIRST QGV

/ QGV  10.00    10.43    0.43          X VEIN HE        BR                     R   CN      U6A            <0
L                                                 4R                                                            B2
R      10.00    10.43        ALL CARBONATE NO QUARTZ

/ QGV  19.51    19.66    0.15          X VEIN HE                               R   CN      U40                        B(
L                                                                                                   <(     P1

/ VEN  20.21    20.30    0.09          X VEIN HE        BR    2 4   7         R                          P+
L                                                 5R                                                  <(     B+

/ VEN  22.00    22.01    0.01          X VEIN HE                               R                          P+
L                                                 5R                                                  <.
R      22.00    22.01        MICRO VEIN
```

Figure 6: Computer-generated drill hole log, called GEOLIST, has headings that are readable with short familiarity. All entries are sequenced by From-To-Metrage.

GRAFLOG

GRAFLOG is generated from the same "geodatabase" that was used to generate GEOLIST (figure 1). Any quantitative, semi-quantitative or qualitative data recorded on GEOFORM such as aspects of lithology, structure, alteration, mineralization for assays can be displayed as requested by project personnel. All programs are interactive and persons not familiar with computers can quickly learn to produce the GRAFLOG Plans, Legends and X-Sections that are described below. The MINING COMPUTER drives a Hewlett Packard 7580A, 8-pen plotter that rapidly produces coloured plots up to 61 by 113 cm (24 by 44 1/2 in). Drafting is normally on tracing paper or film from which Ozalid prints can be produced. One particularly exciting feature of this new, state-of-the-art plotter is that existing diagrams can be overprinted. If these diagrams happen to be slightly off scale the material to be overprinted can be automatically justified.

GRAFLOG Plans, such as figure 7, can be produced from GEOFORM survey data entered in the direct access files (figure 1). Collars of holes, marked by "x", are labelled with appropriate hole names. Total footage or metrage is notated at the end of the hole. Holes in this example have marked deviations. Variations in strike down the hole, of course, show in the plan view; variations in dip can be seen by the variable spacing between fiducial marks (in this case the marks are every 50 m down-the-hole). Note that if grids and holes are plotted in different colours the overall effect is more legible.

A shale-hosted zinc-lead-silver-barite deposit located in the Yukon Territory has been explored with deep diamond drill holes most of which are wedged (figure 7). At least three steeply dipping massive sulphide horizons have been recognized. Highly fractured ground and certain characterisitics of the host rocks caused large deviations during the course of the drilling. Consequently, down-the-hole dip and azimuth changes had to be measured at regular intervals. This data was entered on the "Superbrain" microcomputer and The Mining Computer (Honeywell Level 6). Three dimensional coordinates were calculated every 5 m down-the-hole and used to predict the piercement point of the hole with one or several massive sulphide horizons. The predicted location of the piercement point was obtained only a few hours after the hole was surveyed.

A legend showing project-specific graphic symbols and data abbreviation can be developed in about one day for any project. This legend, which can be plotted by computer, specifies what is to be plotted, where this feature is to be plotted, where this feature is on GEOFORM (figure 2), and the type of symbol and its plot location on GRAFLOG (figure 8). Writing these intructions is rapid and straightforward. In addition, to these instructions, pen colours can be specified for specific rock types. For example, ore zone units or important breccia units might be coloured red to aid in visual correlations and projections beween drill holes.

Figure 7: This computer-generated plan map of drill holes, called GRAFLOG Plan, is from wedged holes in a shale-hosted deposit in the Yukon Territory; this map was plotted in about one minute. Fiducial marks are ploted every 50 m down-the-hole.

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I G C GRAF*LOG PROJECT ID : U308 DATE : 82MAY12

Figure 8: These computer-generated strip plots are from an unconformity-type uranium deposit in the Northwest Territories and were plotted in about four minutes. The two strip plots are plotted at 1:500 and 1:100 respectively.

Borders and vertical lines that provide the frame for the GRAFLOG output are generally drafted in brown to minimize distraction from other features on the strip plot.

GRAFLOG strip plots can be produced rapidly, hole by hole, allowing much detail to be graphically presented . Strip plots have the projected graphical geology plotted along the drill hole. In figure 8 strip plots of a drill hole from an unconformity-type uranium deposit in the Northwest Territories are reproduced. The two strip plots are plotted at a 1:500 and 1:100 scale respectively. The larger scale plot shows the dominant lithologies (figure 8, column 2) and the general distribution of selected alteration and ore minerals. The smaller scale strip plot shows an enlarged portion for the interval 36.4 to 53 m where the mineralized unconformity was intersected. Details of the ore zone are characterized by 90 percent chlorite, 10 percent pyrite and a high gamma ray count (figure 8, columns 6,8 and 9).

Figure 9 is a GRAFLOG cross-section from a stratiform barite-zinc-silver deposit in northeastern British Columbia. Any desired vertical cross-section can be produced from the "geodatabase" (figure 1). In this example of output a concise plan view above the section is drawn so that strike variation and collar location are apparent without reference to the drill hole plan. Note that clarity is enhanced by different colours in the original plots. Sections are defined by a starting point and an end point, and a width on each side of the section (these do not have to be equal) within which all available or selected drill hole data will be projected onto the section. Only principal rock types are plotted on figure 9 but other geological data can be added as required, as a number of strips on the sides of each drill hole. Dollar signs as ore symbols are used to facilitate the correlation between drill holes. This is readily visible on the section in figure 9. A plot of the projection of the hole only can be produced if no geological information is required.

An application of the GEOLOG System at a later stage is the generation of slice maps where composited bore hole data is plotted at the intersection point of the bore hole with the appropriate plane. The slice map in figure 10 represents a 30 m bench composite of three selected minerals taken from the GEOLOG data base of a porphyry copper-molybdenum deposit in northern British Columbia.

Figure 9: This computer-generated vertical cross-section of drill holes, called GRAFLOG X-section, is from a stratiform barite-zinc-lead-silver deposit in northeastern British Columbia; this section was plotted in about eight minutes. Note that a plan view for the cross-section is at the top of the plot. Colour plotting enhances the original.

Figure 10: Computer generated slice map showing a 30 m bench from a porphyry copper-molybdenum deposit in northern British Columbia. Drill hole piercing point at mid-elevation of the bench is annotated with: drill hole name (eg WCDH038), estimated % pyrite [eg 5) 9.000], and measured quartz vein density [eg 6) 2.723 veins/m].

CONCLUSIONS

Mining companies are constantly involved in high risk ventures where the probability of finding a profitable mine can be low. In attempting to minimize the risk, mining and exploration companies have developed strategies in planning and analysis to assist management decision making. These strategies vary in complexity within each company but many realize the value of the computer in the analysis phase. GEOLOG System can play a critical role in decision making because it:

1. ensures a more efficient and effective total approach to the exploration, discovery, development and exploitation of deposits;
2. provides a way of making the descriptive language of geology amenable to computer processing; that is, to statistical analysis and graphical presentations; and
3. can create a complete multi-dimensional assemblage of all significant aspects of a commercial body in order that the profitability of the total process of extracting, concentrating and marketing the body can be optimized.

Our System includes a growing number of efficient editing, processing and analysis programs that prepare, merge and assemble selected parts of the "geodatabase" for various types of graphic presentations, printouts or plotter compilations.

Perhaps the most exciting aspect of our System is the speed with which detailed exploration data can be presented graphically. We estimate that about two hours of plotting of, for example, detailed GRAFLOG X-Sections could take a geologist-draftsman team a full month! More time to define exploration parameters will significantly advance the mineral industry.

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AVAILABILITY OF NATIONAL URANIUM RESOURCE EVALUATION DATA

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Abstract--The National Uranium Resource Evaluation (NURE) program of the Department of Energy (DOE) was initiated in 1974 with the goal of a comprehensive assessment of the uranium resources in the United States. During the seven years of the NURE program, an unprecedented quantity of geoscience information was gathered throughout the conterminous United States and Alaska. The resulting data bases are substantial and can be applied to the search for many mineral resources other than uranium.

Data is generally indexed by the National Topographical Map Series (NTMS) 1:250,000-scale quadrangles. Types of data include geologic maps, radiometric and magnetic data from aerial surveys, geochemical data from waters and sediments, radiometric data from borehole logging, mineralogic data from rock sample analyses, and data on uranium resource evaluations. Reports of NURE investigations are open filed at 20 repository libraries throughout the United States. All data are available for purchase on microfiche from the Technical Library in Grand Junction. Computer-readable magnetic tapes of the aerial and hydrogeochemical data may also be purchased from the Library. Service companies in Grand Junction can provide printed copies of reports and maps. Radiometric borehole logs are available from commercial log libraries.

An Earth Science Information System index is currently being developed at Grand Junction. When completed, the system will permit an inquirer to quickly identify all available NURE data by quadrangle or data type.

Introduction

The National Uranium Resource Evaluation (NURE) Program was launched in 1974 by the U.S. Atomic Energy Commission. It was continued by succeeding agencies, the Energy Research and Development Administration (ERDA) and the Department of Energy (DOE). The program was designed to accomplish a comprehensive assessment of the Nation's uranium resources and, in so doing, to identify those geographic and geologic environments in which potential resources may occur. In addition, as part of NURE, concerted efforts were made to improve and develop equipment, techniques, and procedures to aid in uranium exploration and evaluation. It should be emphasized that NURE was not designed as a uranium exploration program; the actual search for minable deposits of uranium in the United States remains the responsibility of uranium exploration companies. It was intended, however, that many of the results of the NURE studies and investigations be made available to assist the uranium companies in their exploration activities, while fulfilling the Congressional mandate for information on which to base decisions for the Nation's long-range nuclear energy program.

Under the NURE Program, extensive geologic studies to identify and evaluate geologic environments favorable for uranium were carried out by

geologists of DOE's Grand Junction Area Office (GJAO); its prime contractor, the Bendix Field Engineering Corporation (Bendix); the U.S. Geological Survey (USGS); geological consulting firms; state geological survey organizations; and universities. These studies were supported by a NURE data acquisition program which included aerial radiometric and magnetic surveys, hydrogeochemical and stream sediment surveys, geologic drilling in selected areas, and geophysical logging of selected boreholes.

Data acquisition was completed in 1981. During the seven years of the NURE Program, an unprecedented quantity of geoscience information was gathered throughout the conterminous United States and Alaska. The resulting data bases in geology, geophysics, and geochemistry are substantial and can be applied to the search for many mineral resource commodities other than uranium. This paper describes briefly what data are available, where the data are located, and how they can be obtained by the public.

In early 1977, the decision was made to organize and report the results of the NURE surveys and resource estimates in terms of the $1^{o} \times 2^{o}$ quadrangles of the National Topographic Map Series (NTMS). As a result, most data can be accessed by the quadrangle name. Figures 1 and 2 show the distribution of these quadrangles throughout the conterminous 48 states and Alaska, respectively.

Information Availability

To accomplish prompt release of data, reports and maps generated by NURE are made available to the public through an open-file system wherein reports are made available for public inspection at the Grand Junction Office and at selected repositories throughtout the United States. All reports are available for perusal at the following locations:

Government Publications Section
Zimmerman Library, Univ. of New Mexico
Albuquerque, New Mexico

U.S. Geological Survey Library
345 Middlefield Road
Menlo Park, California

Documents Division, Marriott Library
University of Utah
Salt Lake City, Utah

U.S. Geological Survey Library
1526 Cole Blvd.
Golden, Colorado

U.S. Geological Survey Library
Gifts & Exchange Unit, Natl. Center
Reston, Virginia

U.S. Geological Survey Library
U.S. Court House, Rm. 678
Spokane, Washington

There are about 30 other locations throughout the conterminous United States and Alaska where NURE reports are placed on open file on a case-by-case or regional basis. Figure 3 shows the location of these open-file repositories.

When a report is open-filed, the Grand Junction Area Office issues a news release to notify all interested persons and companies of its availability. At the present time, there are 1,345 entries on Grand Junction's mailing list. This includes listings in all 50 states and 18 foreign countries.

FIGURE 1. NTMS Quadrangles in the Conterminous United States (scale: 1:250,000)

FIGURE 2. NTMS Quadrangles in Alaska (scale: 1:250,000)

FIGURE 3. Open-File Locations for NURE Reports

The Technical Library at the Grand Junction Area Office is operated by Bendix. Paper copies of all open file materials are available at the library for public inspection. With the exception of the geologic folios, the library does not sell paper copies of reports. Microfiche of all open file material may be purchased from the library. The Technical Library compiles and makes available to the public bibliographies of open-filed reports, including price quotations for microfilmed copies. Also, several commercial printing companies in Grand Junction can provide printed copies of reports.

NURE reports are entered into the data bank of DOE's Technical Library Information Center at Oak Ridge, Tennessee, and abstracts are published in a monthly issue of Energy Research Abstracts. Abstracts prepared at Oak Ridge are published in the International Atomic Energy Agency's monthly journal Atomindex.

Any questions regarding the availability of NURE data and prices of microfiche, magnetic tapes, etc. should be directed to: Technical Library, Bendix Field Engineering Corporaton, P.O. Box 1569, Grand Junction, Colorado 81502, phone (303) 242-8621, Ext. 278.

Types of Information

Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Surveys

Five national laboratories participated in the NURE HSSR program. Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge Gaseous Diffusion Plant, and Savannah River Laboratory conducted the field sampling program, analyzed the samples, and reported the results; Ames Laboratory conducted a multilaboratory quality assurance study of the analytical results from the other four laboratories. Some 717,175 samples were collected in 414 NTMS quadrangles. More than 14 million individual elemental determinations were performed, with over 500 data reports issued to date. Figure 4 shows the status of the surveys in the conterminous 48 states, and Figure 5 shows the survey coverage in Alaska.

Geochemical data acquisition was organized and conducted by NTMS 1:250,000-scale quadrangle. Samples of sediments and waters from streams and lakes, and from available springs and wells, were collected in 310 of the 468 quadrangles in the conterminous United States, and in 104 of the 153 quadrangles in Alaska. Sampling density ranged from 5 to 10 square miles per sample site. Field data collected at each sample site included air and water temperature; surface radioactivity levels, determined by portable scintillation counter; stream width and flow rate; well depth, casing, and aquifer formation when known; presence of hydrogen sulfide; property ownership and address when appropriate; vegetation type and density; topographic relief; potential sources of contamination; pH, specific conductance, and alkalinity; time of collection; and surface geologic information.

The principal method of chemical analysis for uranium in stream-sediment samples at all four national laboratories was delayed neutron counting (DNC) following neutron irradiation in a nuclear reactor. Multielement analyses were performed when needed for interpreting the geochemical significance of total uranium concentrations as determined by the delayed neutron method of analysis.

FIGURE 4. Status of U.S. HSSR Surveying as of April 30, 1982

FIGURE 5. Status of Alaska HSSR Surveying as of April 30, 1982

The analytical data were interpreted by such methods as factor analysis, discriminant analysis, cluster analysis, multiple linear regression, stepwise regression, and contour plotting. Maps, histograms, and other graphic presentations were used to display concentrations, concentration ratios, factor scores, residuals, and other variables or statistical quantities. Residuals of more than 7,000 sediment and water samples are archived at the Oak Ridge Gaseous Diffusion Plant. Consideration will be given to making suites of these samples available to government and non-government organizations for further analyses where a significant benefit to the public interest will be served.

These data also have dramatic potential application in precious-metal, base-metal, and strategic-mineral resource programs, and in the definition of possibly toxic concentrations of elements in sediments and natural waters. In addition, they have application to geologic site characterization studies, such as those proposed for nuclear waste depositories.

Microfiche copies of all the HSSR quadrangle reports, as well as computer-readable magnetic tapes containing the digitally recorded geochemical data are available from the Technical Library.

Airborne Radiometric and Magnetic Surveys

Airborne radiometric and magnetic survey data have been acquired for 562 NTMS quadrangles in the conterminous United States and Alaska. These data were collected by seven subcontractors, using rotary- and fixed-wing aircraft systems.

Reconnaissance surveys flown in the western United States were usually on a flight-line spacing of 3 miles; flight-line spacing in the eastern United States and in Alaska was generally 6 miles. Survey lines were flown either east-west or north-south; tie lines spaced 12 to 18 miles apart were flown at right angles to the survey lines. Nominal ground clearance was 400 feet, and the spectrometer sampling interval was one second.

Magnetometer data acquired during the radiometric surveys were based on instrumentation with 1/4-gamma sensitivity, and estimated accuracies of ±5 gammas in flat gradient areas and ±10 gammas in steep gradient areas. Figure 6 shows the current status of the survey in the conterminous 48 states; Figure 7 shows the survey coverage of Alaska. Over 300 reports have been issued to date. These reports were generated by the survey subcontractors and may be purchased directly from those subcontractors, whose names and addresses are available from the Technical Library. Microfiche are available from the Library. Computer-readable magnetic tapes containing the radiometric and magnetic data are available for purchase from the Technical Library.

Computer-generated quadrangle contour maps, reflecting the total magnetic intensity with the International Geomagnetic Reference Field (IGRF) removed, are now being produced by Bendix. Fifty-five quadrangles have thus far been completed. Copies of these maps may be obtained at the requestor's expense through any one of a number of copy companies in Grand Junction.

FIGURE 6. Status of U.S. Aerial Surveying as of April 30, 1982

FIGURE 7. Status of Alaska Aerial Surveying as of April 30, 1982

Geologic Quadrangle Maps

Of the 621 NTMS quadrangles in the conterminous United States and Alaska, geologic maps for 187 quadrangles are available at a scale of 1:250,000 from the U.S. Geological Survey (USGS) or individual state geological surveys. The NURE Program produced 288 geologic maps, also on 1:250,000-scale quadrangle bases. Figure 8 shows the location of the NURE generated maps in the conterminous U.S., and Figure 9 shows their location in Alaska.

These maps are compiled by subcontractors from published sources, university theses and/or photogeologic interpretation. No original field mapping or systematic field checking was undertaken.

Copies of the geologic quadrangle maps, scale 1:250,000, produced for the NURE Program are available to the public, and may be obtained at the requestor's expense through any one of a number of copy companies in Grand Junction.

Drilling and Logging Projects

The NURE drilling program was designed to provide subsurface data for uranium resource assessment in favorable areas where little or no such information was available. The drilling was done in 23 locations to support the Quadrangle Assessment, Intermediate-Grade, and World-Class programs, as well as certain research studies. Drilling in support of the Quadrangle Assessment program was terminated in 1980.

The NURE drilling program had a wide variety of objectives, but all were related to the common goal of improved resource assessment through development of information on the geochemistry, stratigraphy, lithology, and structure of subsurface rocks. Drilling for the R&D studies, which were designed to provide information for evaluating the orebody "halo" concept for possible remote detection of an orebody, was done under closely controlled conditions, with the target sections being completely cored. One project at Lemhi Pass, Montana, was for thorium resource assessment.

A total of 455,683 feet in 325 holes were drilled in the program, from which 74,020 feet of core were recovered. Information on the individual drilling projects is summarized in Table 1.

Logging data from the NURE drilling projects are incorporated in each project's Engineering Report, available on microfiche from the Technical Library. Some 39 reports relating to NURE drilling have been open-filed to date.

To supplement the subsurface information acquired from the NURE Project drilling and logging, gamma-ray and other logging were also accomplished in selected areas of industry drilling. These logs were obtained through the services of Century Geophysical Corporation and Bendix Field Engineering Corporation. The following log types are available: natural gross-gamma ray, neutron-neutron, spontaneous potential, single-point resistance, gamma-gamma density, temperature, caliper, and KUT. Not all log types were run in every hole. Over 1,700,000 feet of logging were accomplished of industry-drilled holes in the quadrangles listed in Table 2. The logging of industry drilling was performed by three Bendix subcontractors: Fugro, Inc.

FIGURE 8. U.S. Open-Filed NURE Geologic Quadrangle Maps

FIGURE 9. Alaska Open-Filed NURE Geologic Quadrangle Maps

TABLE 1. NURE Drilling Projects: Subsurface Geologic Investigations

Drilling Projects[a]	Fiscal Year(s)	No. of Holes	Drilling Footage	Evaluation Results
Quadrangle Assessment				
1. Pedro Mtns., Wyo.	1976	1	2,197	Leaching pervasive to substantial depths. Enough leached to account for Wyoming Basin deposits.
2. Carson Sink, Nev.	1977	1	8,512	Deltaic sediments unfavorable as uranium hosts.
3. Red River Valley, N. Dak./Minn.	1977–78	32	18,349	Potential of onlapping Mesozoic and Paleozoic sediments at Precambrian basement unconfirmed.
4. Upper Michigan, Mich.	1978	6	9,896	Michigamme slate and lower Precambrian rocks unfavorable.
5. E. Chaco Canyon, N. Mex.	1978–79	15	70,421	$50/lb probable potential increased by 70,000 tons U_3O_8.
6. Missoula-Bitterroot Valley, Mont.	1978–79	7	14,458	Favorable deposit environment but no anomalous U_3O_8 values encountered.
7. Spor Mtn., Utah	1978–79	30	33,163	Decreased possible potential by 156,000 tons U_3O_8.
8. Sonora Pass, Calif.	1979	19	6,573	Potential host has larger aerial distribution than previously postulated.
9. SW Prescott, Ariz.	1979–80	18	62,724	Subsurface environment favorable in Date Creek, Big Sandy, and Walnut Creek basins.
10. Sand Wash, Colo.	1979–80	25	25,081	Possible potential reduced by approximately 42,000 tons U_3O_8.
11. San Rafael Swell, Utah	1979–80	22	34,823	Favorable Chinle Formation area expanded.
12. Owens Valley, Calif.	1979–80	8	18,593	Limited favorable areas for Coso Formation. Favorable area defined in Rose Valley.
13. SE Texas, Oakville/Goliad, Tex.	1979–80	11	28,024	Favorable Oakville/Goliad Formations area reduced.
Totals		195	332,814	
Intermediate-Grade				
14. Brushy Basin, Utah	1979	14	6,868	Mineralization erratic; no large tonnages.
15. Red Desert, Wyo.	1979–81	19	24,753	Shallow uraniferous mudstones continuity confirmed. Presence of deeper favorable strata.
16. Sand Wash, Colo.	1980	19	11,709	Discontinuous deposits; unfavorable for large tonnages.
17. McDermitt, Nev./Ore.	1981	11	7,419	Evaluation incomplete.
Totals		63	50,749	
World-Class				
18. SE Wyo. Pebble Conglomerate, Wyo.	1979–80	25	19,209	Concentrations low; wrong stratigraphic regime; too metamorphosed.
19. Nemo, S. Dak.	1979	5	2,211	Wrong environment for placer uranium concentrations; continuity unlikely.
Totals		30	21,420	
R&D				
20. Copper Mtn., Wyo.	1979	7	6,351	Evaluation incomplete.
21. Red Desert, Wyo.	1979	12	8,261	Evaluation incomplete.
22. San Juan Basin, N. Mex.	1979–80	14	33,714	Evaluation incomplete.
Totals		33	48,326	
Thorium				
23. Lemhi Pass, Mont.	1978–79	4	2,374	Thorium-bearing veins persist below 2000 ft.
Totals		4	2,374	

[a]The numbers identifying drilling projects are keyed to their locations shown in Figure 2.

TABLE 2. Logging of Industry-Drilling Areas

Quadrangle	No. of Holes	Total Drilled Footage Logged	No. of Logs Open-Filed as of 10/1/81
Alliance, Nebr.	3	5,839	2
Arminto, Wyo.	37	113,073	32
Austin, Tex.	37	151,222	30
Bakersfield, Calif.	55	114,750	48
Beaumont, Tex.	12	45,797	5
Beeville, Tex.	42	161,130	33
Brownsville, Tex.	2	10,295	2
Caliente, Nev.	3	2,523	3
Casper, Wyo.	19	61,115	17
Cheyenne, Wyo.	12	19,908	10
Chico, Calif.	5	3,031	3
Corpus Christi, Tex.	12	60,715	9
Crystal City, Tex.	51	189,359	43
Denver, Colo.	43	48,184	42
Eagle Pass, Tex.	13	39,317	12
Ekalaka, Mont.	29	49,441	10
Elko, Nev.	1	492	1
Ely, Nev.	25	14,530	25
Forsyth, Mont.	1	951	1
Fresno, Calif.	17	29,444	16
Gillette, Wyo.	2	10,129	0
Glendive, N. Dak./Mont.	2	2,290	2
Goldfield, Nev.	4	1,876	4
Greeley, Colo.	33	58,606	31
Hardin, Mont.	4	6,461	0
Lander, Wyo.	15	46,907	12
Laredo, Tex.	32	118,638	27
Lemmon, N. Dak./S. Dak.	7	15,563	17
Limon, Colo.	2	7,604	2
Lund, Nev.	13	12,461	12
Mariposa, Calif.	1	460	1
McAllen, Tex.	12	30,950	9
McDermitt, Nev.	2	1,190	2
Miles City, Mont.	2	1,769	2
Monterey, Calif.	24	57,491	22
Newcastle, Wyo.	8	34,383	2
Palestine, Tex.	5	25,000	0
Preston, Wyo.	1	759	1
Rawlins, Wyo.	17	73,093	13
Rock Springs, Wyo.	13	56,612	4
Sacramento, Calif.	8	8,338	6
San Antonio, Tex.	36	63,223	25
San Jose, Calif.	19	25,401	8
San Luis Obispo, Calif.	6	16,108	6
Santa Rosa, Calif.	1	756	1
Scottsbluff, Nebr.	23	86,997	21
Seguin, Tex.	43	158,739	33
Sterling, Colo.	17	49,018	16
Texarkana, Tex.	2	8,546	0
Thermopolis, Wyo.	28	97,016	24
Tonopah, Nev.	1	633	1
Torrington, Wyo.	5	12,875	3
Tyler, Tex.	23	108,556	0
Ukiah, Calif.	1	393	1
Watford City, N. Dak.	5	14,282	5
Winnemucca, Nev.	2	1,308	0
Totals (as of 10/1/81)	848	2,335,547	657

(now ERTEC), High Life Helicopters, Inc., and Kleinfelder and Associates.

Nonproprietary logs of industry drilling are open-filed for purchase by the public through Petroleum Information (PI). Each log is assigned a PI reference number and should be ordered from Petroleum Information by this number. If the reference number is not known, the requestor can obtain the log by giving the operator name, hole number, township/range/section or survey number, and county. The requestor will receive a 5-inch-wide paper copy with a vertical scale of 1 inch = 40 feet.

Open-filed logs obtained from the various geographic regions (South Texas, or California/Nevada, for example) can be viewed and paper copies purchased from the appropriate PI regional library; e.g., Texas logs may be viewed and copies purchased from the Houston Well Log Library. Any of these logs available from Petroleum Information can be viewed and purchased at the Denver PI Log Library, P.O. Box 2612, Denver, Colorado 80201. The Technical Library in Grand Junction has a paper copy of each log available from Petroleum Information. The public may view the log at this location but must purchase copies through Petroleum Information.

The Technical Library in Grand Junction has a paper copy of each log available from Petroleum Information. The public may view the log at this location but must purchase copies through Petroleum Information.

Quadrangle Evaluation

Quadrangle evaluation consisted of the collection and analysis of geologic, geochemical, and radiometric data for the purpose of classifying geologic environments as favorable or unfavorable for the occurrence of uranium deposits.

Of the 621 quadrangles covering the conterminous 48 states and Alaska, 163 were evaluated under the NURE Program. Priorities were based on their relative favorability for the presence of uranium resources. Evaluation of 77 quadrangles were done by Bendix geologists, 24 by the USGS, 20 by state surveys and universities, and 42 by private firms.

The results of the evaluations were compiled into folios. Each folio contains a geologic map, geologic cross sections, maps showing the location of uranium occurrences and rock samples collected. Also included is information on the geologic setting, a description of methods and procedures used for performing the evaluation, sections that separately describe and discuss favorable, unfavorable, and unevaluated areas or environments, and appropriate illustrations and data tabulations.

Folios have been open-filed in two forms, preliminary and formal; they differ only with respect to the degree of editorial review and graphic refinement they have undergone. Formal folios have been issued on 26 quadrangles. One hundred thirty-six quadrangles were open-filed in a preliminary format. Of these preliminary folios, 22 have been reissued in a final format. As of May 1, 1982, one folio, Salton Sea, has not yet been open filed. Figures 10 and 11 show the status of quadrangle evaluations in the conterminous United States and Alaska, respectively.

A limited number of paper copies of the formal and final folios are available for purchase from the Technical Library. Microfiche are available on all folios.

FIGURE 10. Status of U.S. Quadrangle Evaluation as of April 30, 1982

FIGURE 11. Status of Alaska Quadrangle Evaluation as of April 30, 1982

Geologic Studies and Technology Applications

Numerous topical studies on the geology of uranium deposits have been made as part of the NURE Program. Topics addressed include recognition criteria for a variety of geologic environments with uranium deposits, definitive models of the major uranium deposits of the world, and uranium provinces. World-Class geologic investigations dealt with nonsandstone types of deposits that are important uranium producers in other countries of the world, but not, as yet, in the United States. Intermediate-grade studies were concerned with potentially large tonnages in deposits ranging in grade from 0.01 percent to 0.05 percent U_3O_8. Geologic studies also included numerous investigations on the origin of uranium deposits, compilation of the uranium occurrences in the states of Colorado, Utah, Arizona, and New Mexico, and uranium favorability studies of selected areas. These research-oriented efforts have contributed greatly to the general knowledge of uranium geology in the United States and in the world.

To date, some 156 reports have been open-filed regarding geologic studies conducted under the NURE Program. Microfiche copies of these reports are available from the Technical Library.

The NURE Program produced a heritage of radiometric technology and facilities unparalleled anywhere in the world today. The past seven years have seen great technological strides. The development of an intense national assessment effort under strict time constraints mandated vast improvements in our ability to provide reliable assessments quickly. Successful technology development was necessary to support detailed aerial, surface, and subsurface investigations, both for the NURE Program and for use by industry. The major areas in which this technology development took place under NURE auspices were: aerial surveying techniques, surface exploration techniques, subsurface exploration techniques, and calibration facilities.

A total of 122 reports have been open-filed to date on technology applications. Microfiche copies are available from the Technical Library.

Earth Science Information System

An Earth Science Information System (ESIS) index is currently being developed in Grand Junction by Bendix for the on-site CDC 6600 computer. The ESIS will consist of eight files and will be effected by the Query Update software package.

All six NURE geoscience data types described in this paper are being incorporated into the index. When complete, ESIS will permit an inquirer to quickly identify all that is available of NURE data by quadrangle name, geographic coordinates, or other key identifiers.

DATABASE AND INVENTORY SYSTEM DESIGN

FOR TRACKLINE DATA

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Abstract--A database management system associated with trackline data (data collected at fixed intervals along survey tracks) should include:

a) clear definitions of all data elements and formats,

b) user friendly access to a software package that integrates the database with an interactive data inventory and documentation file, and

c) graphic peripherals--such as cathode-ray tube (CRT) terminals, plotters, and computer-output-microfilm (COM).

A unique database management system known as GEODAS (GEOphysical DAta System) has been developed by NOAA's geophysical data center. GEODAS incorporates computer software routines that:

a) process trackline data into a common format database,

b) provide both graphical and textual inventory information, and

c) retrieve data and information using a user friendly menu with multi-parameter select criteria.

The GEODAS inventory has been used as a remote access system by research institutions throughout the United States.

In its role as a national and international data repository, the National Geophysical Data Center (NGDC) plans to expand the GEODAS inventory, designed primarily for underway marine geophysical data, to include other trackline databases (e.g., aeromagnetics and seismic reflection). We also hope to provide remote access to the data files and to expand our computerized inventories to act as a data-referral system for data held by other organizations.

Introduction

Trackline data, as discussed in this paper, tend to follow linear patterns. Typically, data surveyed along tracks are collected onboard a moving platform (i.e., ship, plane, truck, satellite, or even an iceberg). Examples of such data include underway marine geophysics, aeromagnetics, or seismic reflection.

By their very nature, these data tend to have geographical significance; most indexing schemes focus on location as a prime key. This paper reviews data-management strategies associated with trackline data, and recommends approaches that optimize user interaction.

Data and Information

How do data differ from information, or are they the same? The number "9821436" certainly can represent a data element, but its information content can only be apparent if we know its format, context, and ownership. Its format could translate to 982,143.6; its context could be interpreted as an observed gravity value in mgal units; and its owner could be a geographic position described in another portion of the data file. In addition, for data to be truly informative it also should be current, accessible in a timely manner, and should observe validation rules. One could better appreciate these attributes by reviewing the data processing requirements of an aircraft's altimeter.

As we approach the "information age," we are challenged to design our database systems to provide information, not just numbers. Our systems should be "user friendly" and should answer the questions: What data are available? Where are they located? How do I access the files? What? Where? and How? These are the types of questions that our information systems must support.

Why do we manage data? We do it to ensure that data are processed in a timely manner--in both the assimilation and access phases--and to maintain data integrity with respect to documentation and security.

The Environmental Data and Information Service (EDIS) has fostered standards in its data-management practices to ensure that information is the end-product of all its data services. To respond to what data are available, EDIS has published catalogs and developed a computerized data dictionary (which is part of a larger service called DAMUS--Data Archive Management and User Service); to identify where these data are, EDIS has developed inventory systems (some of which are remotely accessible on graphics terminals); and, to simplify the "How do I get it?", EDIS has implemented many "user friendly" procedure files and referral services, such as the National Environmental Data Referral and Service (NEDRES).

System Design

To make systems "user friendly," one must always evaluate trade-offs associated with different system-access methodologies. What information is really needed by the user? To respond to these needs, we need to know: Does the user require on-line access to the main collection of data, or only a subset? Does the user require an instant response, or is a delayed response adequate, or is a combination of responses reasonable? These questions are critical for designing a system that supports transaction processing--where the user has an interactive dialog with the machine. Furthermore, care should be taken to design a strategy that is flexible enough to accommodate changing technologies.

Most geophysical data files are historic in nature, and are not dynamically updated with new information. These files, which are typically voluminous, have no requirements to be on-line for immediate access. When scientists require information from the file, they select a subset, perform their analysis, and on occasion update the main file. There is a need, however, for immediate access to inventory information: What data? Where? and How do I get it? Therefore, an inventory file can be created from the main collection (see figure 1).

To generate this inventory file for trackline data, we must abstract sufficient inventory information from the data file to re-create the track for each parameter surveyed. In other words, recorded survey positions are keyed to alert search routines that specific data were collected between specific geographic locations. But, how are these points identified?

a) To determine starting and ending points, we must compute a sampling rate. Where the data-collection intervals exceed the sampling rate by a certain amount, collection termination points are identified.

b) Turning points are found using vector analysis, in which azimuth variations exceeding a fixed tolerance represent the determining factor.

c) Because a straight line is not "straight" on every map projection, a minimal number of track positions are required; hence, points are picked at fixed spatial distances (e.g., for global marine files, at least every 90 miles).

Format Design

In designing data formats, many have found it useful to create headers that describe the content and format of the data records. There are many benefits to this practice:

1) Summary information can be coded, facilitating search strategies,

2) Formats can be briefly defined, and

3) Instrumentation and processing methods can be specified.

Figure 1. Data and information system for trackline data.

Headers are frequently indispensable, especially in data-exchange formats, for users are generally unaware of data-processing procedures at other institutions. The "Marine Geophysical Data Exchange Format--MGD77" is an example of such a format (Hittelman et al., 1977). It is sanctioned by the Intergovernmental Oceanographic Commission (IOC) as an accepted standard for international data exchange, and it has been translated into French, Japanese, and Russian. The header portion of this format is utilized in both an inventory file and the data-exchange formatted tape. In an on-line inventory file, it provides the user with documentation and summary information; in the off-line data-exchange tape format, it gives the recipient what he needs to translate data into information.

System Access

An example of system-access methodology for trackline data developed at NGDC is GEODAS--GEOphysical DAta System (Hittelman and Metzger, 1982). GEODAS, designed primarily for underway marine geophysical data (i.e., bathymetry, magnetics, and gravity), contains data for 1,555 port-to-port operations (as of January 1982). Two files are managed by GEODAS (see figure 1):

1) an inventory file, known as HEADIN (for header/inventory) and

2) the master data file.

Attribute summaries of these files are given in Table 1. The inventory file documents the port-to-port operation and maintains records of where the data file is located (i.e., tape and file location). In addition to the MGD77 header information, other summaries are maintained--such as the number of specific data records in each port-to-port operation. The most valuable information, however, is the synthesized navigation file, which supports the generation of graphical summaries. It is a record-addressable file in a header/data format. The header contains imbedded links to direct the search to the location of the next header. Thus, in a query, if one can determine from the header that the information in this particular port-to-port operation will not satisfy the search criteria, one can immediately jump to the next header without reading any of the intermediate trackline data.

A "user friendly" interactive program has been designed to permit remote access to this inventory. An example of the search menu is given in figure 2; a sample response to this menu is shown in figure 3. The interaction is in simple language, and explanations and examples are presented.

Once a customized search has been completed, a tabular summary is generated (see figure 4) and an interim "result" disk file is created.

SEARCH CRITERIA CODE MENU:

01 - INSTITUTION
02 - PLATFORM
03 - MGG NUMBER
04 - CRUISE ID
05 - PROJECT
06 - FUNDING
07 - AREA SEARCH BY LAT/LONG LIMITS
08 - AREA SEARCH BY 10 DEGREE AREA IDS
09 - SEARCH ONLY FOR CERTAIN GEOPHYSICAL PARAMETERS SURVEYED
10 - SEARCH BY YEAR OF CRUISE
11 - SEARCH BY DATE CRUISE ADDED TO SYSTEM

INDIVIDUAL CRUISES ARE SELECTED IN THE SEARCH BASED ON:
- UNION (OR) WITHIN A CRITERIA CODE
- INTERSECTION (AND) BETWEEN CRITERIA CODES

EXCLUSION IS PERMITTED IN CRITERIA CODES 01-06 , BY ENTERING A NEGATIVE CRITERIA CODE.

EXAMPLE : "-01" COULD BE USED TO EXCLUDE CERTAIN INSTITUTIONS.

ENTER NEXT SEARCH CRITERIA CODE.
99 - TO FINISH
00 - TO REPRINT SEARCH MENU

Figure 2. Menu generated by SEARCH program.

```
→ 07
  ENTER LAT/LONG BOUNDRIES
  ENTRIES ARE FREE FORMATTED DECIMAL DEGREES
  LONGITUDES MUST BE BETWEEN -180 AND +180
  NORTH +  SOUTH -  EAST +  WEST -
  ENTER TOP LATITUDE...99 IF NO MORE AREAS
→ -45
  ENTER BOTTOM LATITUDE
→ -55
  ENTER LEFT LONGITUDE
→ -70
  ENTER RIGHT LONGITUDE
→ -55
  ENTER TOP LATITUDE...99 IF NO MORE AREAS
→ 99
```

Figure 3. Sample response to Search Menu, which summarizes area search procedure [Arrow (→) designates user response.].

Table 1. Attributes of Files within GEODAS, (January 1982)

	Data File	Inventory File
Number of characters.....	1.5 billion	12 million
Access method.....	index-sequential*	record-addressable; imbedded links

*The file is indexed by a directory that identifies a tape number and its location within that tape; it is sequential because the data records with in each port-to-port survey are in chronological order.

Inventory Graphics and Data Retrieval

The summary temporary disk file contains information on search criteria, cruise ID's, and pointers to access specific file locations in both the inventory and the database (for all port-to-port operations successfully identified). If the plot option was initiated, the file also contains all positional information (i.e., the trackline points) within the area specified. This file is accessed through the user-defined job ID.

The system user has many options at this point through user friendly software, which could within seconds plot the entire inventory file that meets the search criteria (see figure 5), plot each data-contributing institution separately, plot only tracks containing one survey parameter, and even zoom-in on complex portions of the plot. Any or all of these plots could be generated either on the graphics (CRT) terminal or COM (computer-output-microfilm). In addition, at this point a request can be generated to create a data tape and the mechanism to do this (i.e., the preparation of a "submit" run stream) is transparent to the user.

FALKLAND ISLANDS

JOB ID - 99KO

DATE - 4/29/82
****

SEARCHING FOR DIGITAL DATA ONLY
****

1 AREA SELECTED

-45.000

-70.000 -55.000

-55.000
****

33 FILES 252,235 RECORDS. 43,919 IN AREA
****

GEOPHYSICAL DATA SUMMARY IN NAUTICAL MILES

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

MGG NUM	CRUISE/LEG	NAVIGATION	BATHMETRY	MAGNETICS	GRAVITY	SEISMICS	SSCAN/REFRAC	DIG REC COUNT
01010067	C1212	747.5	743.3	747.5	747.5	747.5	747.5	1340
01010099	C1503	343.5	310.1	343.5	343.5	343.5	343.5	808
01010100	C1504	563.3	562.7	556.1	561.5	563.3	563.3	1471
01010101	C1505	563.1	555.9	563.1	563.1	563.1	563.1	1297
01010102	C1506	1896.3	1877.4	1896.3	1896.3	1896.3	1896.3	6082
01010111	C1605	2712.7	2587.9	2712.7	2712.7	2712.7	2712.7	7712
01010112	C1606	325.0	318.9	325.0	325.0	325.0	325.0	938
01010134	C1801	736.2	736.2	623.2	736.2	736.2	.0	1760
01010181	C2106	1078.0	952.9	728.2	.0	.0	.0	2034
01020006	ELT06	2218.9	2176.7	1157.2	.0	.0	.0	5529
01020007	ELT07	873.7	873.7	520.8	.0	.0	.0	1517
01020011	ELT11	812.9	812.9	.0	.0	.0	.0	1653
01020022	ELT22	655.2	641.0	.0	.0	655.2	.0	1179
01030007	V1707	88.9	88.9	.0	.0	.0	.0	126
01030008	V1708	247.7	234.1	.0	185.0	.0	.0	546
01030009	V1709	41.7	41.7	.0	.0	.0	.0	61
01030010	V1710	477.0	456.9	464.8	297.7	477.0	.0	699
01030011	V1711	234.2	234.2	234.2	234.2	234.2	.0	266
01030022	V1805	1066.3	1055.3	897.9	1038.0	1066.3	.0	780
01030023	V1806	76.1	74.2	76.1	76.1	76.1	.0	92
01030024	V1807	601.1	506.5	578.5	586.1	601.1	.0	609
01030175	V3102	1894.6	1894.6	939.5	1785.8	1894.6	.0	3355
01030176	V3103	860.0	859.7	809.9	848.7	860.0	.0	1680
01090015	ZAP1	806.5	.0	.0	.0	806.5	.0	32
01090016	ZAP2	170.7	.0	.0	.0	170.7	.0	5
01090017	ZAP3	1193.7	.0	.0	.0	1193.7	.0	35
TOTALS		21284.7	18595.6	14174.4	12937.4	15922.9	7151.4	41607

OREGON STATE UNIVERSITY

MGG NUM	CRUISE/LEG	NAVIGATION	BATHMETRY	MAGNETICS	GRAVITY	SEISMICS	SSCAN/REFRAC	DIG REC COUNT
07100001	DRAKE03	42.0	.0	.0	.0	.0	.0	75
TOTALS		42.0	.0	.0	.0	.0	.0	75

SCRIPPS INSTITUTION OF OCEANOGRAPHY

MGG NUM	CRUISE/LEG	NAVIGATION	BATHMETRY	MAGNETICS	GRAVITY	SEISMICS	SSCAN/REFRAC	DIG REC COUNT
15020020	CAT005MV	580.1	580.1	545.4	.0	.0	.0	1084
15020029	FDRK01MV	29.8	.0	.0	.0	.0	.0	35
15020030	FDRK02MV	49.2	43.7	.0	.0	.0	.0	121
15040022	PIQR03WT	89.4	89.4	.0	.0	.0	.0	82
15050034	DSDP36GC	362.0	362.0	290.3	.0	362.0	.0	547
TOTALS		1110.5	1075.2	835.7	.0	362.0	.0	1869

JAPAN

MGG NUM	CRUISE/LEG	NAVIGATION	BATHMETRY	MAGNETICS	GRAVITY	SEISMICS	SSCAN/REFRAC	DIG REC COUNT
56040009	UM66-B	626.7	624.7	624.7	.0	.0	.0	368
TOTALS		626.7	624.7	624.7	.0	.0	.0	368
GRAND TOTALS		23063.9	20295.5	15634.8	12937.4	16284.9	7151.4	43919

Figure 4. Search summary table.

Figure 5. Graphical summary display.

Summary

In conclusion, I would like to highlight data-management practices that generally are useful to many systems, but in particular are useful to trackline data files:

1) Documentation for data files is a critical element in any database system, for it lessens organizational dependencies on individuals. Developing "exchange formats" often insures that documentation becomes an integral part of the data file.

2) Transaction processing can usually be improved if subsets of the database, rather than the main collection, are accessed. For example, to locate data in a geographical area of interest, one could access an inventory file (which is perhaps 1% as large) instead of the main database.

3) Distributed processing is useful in system design, because it allows for changing technologies. Portions of one's system could be online, to accommodate instantaneous response requirements, although other portions could be off-line.

4) User friendly interfaces, which are designed with simple menus (including instructions, examples, and prompters), promote broader system usage and lessen training requirements of the staff.

5) Inventory and referral systems can be designed in a layered manner, where the generalized information always points the user in a direction of the more detailed description (if required.) The highest level of trackline inventory is a graphical plot, which is linked to the actual data file.

Future expansion possibilities for trackline data at NGDC include: broadening of GEODAS to multiple trackline databases, providing access to the inventory system by national commercial information networks, providing graphical referral service (e.g., to other international sources), and allowing direct user access to the databases.

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Hittelman, A. M., and Metzger, D. R., 1982, Marine geophysics: data base management and supportive graphics: in press (scheduled to be published in Computer and Geosciences, v. 8, no. 4).

No paper available--

NATIONAL GEOSCIENCE INFORMATION SYSTEM IN INDIA

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India is among the foremost countries to launch a national information system for science and technology (NISSAT). Development of the information system on minerals and related geosciences has been identified as the priority sector under the NISSAT Programme. The Geological Survey of India (GSI), as the lead agency in geoscience and with a sound information infrastructure, is to act as the national information centre for Geosciences. The primary activities of the proposed system will be based on:

- Central Information file of index to the literature on Indian geoscience for storage and retrieval of information.
- Documentation services, comprising current awareness bulletins, bibliographies, data compilations and annual abstracts of Indian geological literature.
- Document supply services, based on comprehensive library resources, translation and reprographic facilities.
- Referral services, built up on the inventory of national geoscience information resources and union catalogue of geoscience serials.
- National and International cooperation, involving exchange of documents and resource sharing.
- Manpower development: specialised and in-service orientation training programmes.

Apart from bibliographic data storage system, the GSI is actively engaged in the development of data-base system. A computer based Geodata Centre has already been set up for storage, retrieval and dissemination of geoscience data.

The plans for future development envisage primarily the development of systems design for switching over the manual information file to the machine readable data base to provide rapid access to information.

THE ROLE OF THE INFORMATION SPECIALIST IN U.S. STATE GEOLOGICAL SURVEYS[1]

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Abstract--In fulfillment of their statutory objectives, state geological surveys in the United States have active public information programs. Information programs and services vary, depending on the staff, facilities, and funding of the particular state survey, but most surveys provide (1) assistance to the public, through response to letters, telephone calls, and visitors, and (2) publications, both technical and general-interest, about the geology of the state. Thus, information specialists in state geological surveys perform the duties of librarian, bibliographer, information officer, editor, computer expert, and/or technical writer. Information specialists in state surveys assist (1) the general public, including landowners, students and teachers, individuals, and groups; (2) industry and private consultants; and (3) federal, state, and local government agencies.

As the geological survey for the State of Texas, the Bureau of Economic Geology employs a variety of information specialists classified as either "research" or "support" staff. Research staff interact directly with the public and contribute to the publications program; the support staff, which includes editors, computer experts, cartographers, and administrative staff, coordinate and disseminate the results of research programs. Information facilities at the Bureau include a reading room, a well sample and core library, and editorial and cartographic facilities. The Bureau provides both services (bibliographic services, rock and mineral identification and sampling, public lectures, and testimony) and publications (including geologic research and a bibliography and index of Texas geology). Recent economic developments will probably affect the nature and scope of information services provided by the Bureau and by other state geological surveys.

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[1]Publication authorized by the Director, Bureau of Economic Geology, The University of Texas at Austin.

Introduction

State geological surveys in the United States offer a variety of services and published information to thousands of people each year. In 1980, state geological surveys collectively employed over 3,000 researchers and support staff, and their combined budgets exceeded $65 million (Conrad, 1981, p. 1). Although they differ in organization, funding, staff, and facilities, the fifty state surveys (fig. 1) have the same purpose, which is to provide geologic information to the citizens of their respective states. In the discussion to follow, I will describe the many roles of information specialists in state geological surveys by delineating the characteristics of surveys as a sector of the geologic information community and by discussing in detail the state geological survey with which I am most familiar, the Texas survey.

Characteristics of State Surveys

State geological surveys were established, and their early operations largely determined, by enabling statutes passed by the state legislatures. State surveys were mandated to conduct research on the geology of their states, to make the results of their findings available to the public, and to report periodically to the state legislature on their activities. State legislatures still affect the programs and funding of the surveys, especially when federal and state legislation involves environmental or energy issues; in such cases, the state legislature contracts with the state survey for conducting the required research. The survey then presents its findings, usually in the form of publications, to the legislators and to the public.

Figure 1. Location map of U.S. state geological surveys. From Association of American State Geologists, 1976, p. 74-75.

In addition to their affiliation with the political sector, many surveys also have close logistical and financial ties to the academic community. Many surveys occupy offices located on a university campus, use university libraries and other campus facilities, and employ staff from the university. Surveys also receive funding from the university's overall operating budget or from grants from the geology department or other university units. The proximity of an on-campus survey to classrooms and departmental offices creates a built-in academic orientation and clientele, just as its status as a quasi-state agency ensures a governmental user group. These two constituencies, the university and the state, along with the business sector and the general public, determine the functions of the state geological surveys.

Research and Service at State Surveys

The common denominator of all state geological surveys is their research activity (fig. 2). In addition to basic statewide geology, surveys investigate environmental, engineering, and economic geology, particularly as applied to the resources of their state (table 1). Results of this research are published in a variety of formats (fig. 3), including books, maps, and kits. Survey staff also publish articles in professional journals and give lectures to classes and professional associations. Some of the state surveys have published information about their history and current operations; although not widely available (Masterson, 1982, p. 1), these in-house documents are highly informative and useful to other surveys (Davidson, in press). Coordinating these research activities and serving as liaisons with the federal government are survey staff members, sometimes known as Regulations Information Specialists or Quality Assurance Officers, whose domain is the complex world of federal contracts and grants.

Figure 2. Types of research conducted at U.S. state geological surveys.

Figure 3. Publications of state geological surveys.

Table 1. State geological surveys in the United States. From Hayes (1911), Leighton (1932), Association of American State Geologists (1981), and sources cited in Masterson (1982).

Survey	Date Founded	Funding Sources	Organization or Research Areas	Staff	No. of Publications	Facilities and Services
ALABAMA (205)349-2852 Ernest A. Mancini Geol. Survey of Alabama P. O. Drawer O University, AL 35486	1873	USGS; NASA	Administrative Division Environmental Division Water Resources Division Geologic Division Mineral & Energy Resources Div. Geochemistry & Water Quality Div.		27 (1980)	Coal Information Center USGS, CRIB State Water Use Data System
ALASKA (907)274-9681 Ross G. Schaff Div. of Geology and Geophysical Surveys 3001 Porcupine Drive Anchorage, AK 99501	1959	USGS; USBM	water resources minerals oil and gas geothermal geologic hazards	Doubled in 1980		Mines & Geology Bulletin Well sample & core facility 3,000 visitors (1975)
ARIZONA (602)626-2733 Larry D. Fellows Bureau of Geology and Mineral Technology Geological Survey Branch 845 N. Park Ave. Tucson, AZ 85719	1915 (Ariz. Bur. Mines) 1977 as BGMT	USGS; DOE; NRC; U.S. Water & Power Resources Services	geologic mapping mineral and energy resources geologic hazards	13 (1976)	7 (1979)	New building (1975) Well sample & core facility library Fieldnotes USGS, CRIB 2,400 visitors (1980)
ARKANSAS (501)371-1488 Norman K. Williams Arkansas Geol. Commission Vardelle Parham Geol. Center 3815 W. Roosevelt Road Little Rock, AR 72204	1907	USGS' Ozarks Regional Commission; NRC; USBM	general geology environmental geology economic geology petroleum geology geophysics geochemistry water resources		4 (1980)	NCIC
CALIFORNIA (916)445-1923 James F. Davis Div. of Mines & Geology Calif. Dept. Conservation 1416 9th St., Room 1341 Sacramento, CA 95814	1880	USGS; DOE	data acquisition advisory services information dissemination			California Geology CDMG Notes Clearinghouse, museum
COLORADO (303)866-2611 John W. Rold Colorado Geological Survey 1313 Sherman St., Room 715 Denver, CO 80203	1907; 1929; 1969	USGS; DOE; EPA; USBM; USBLM	engineering & environmental geology ground water Mineral resources Mineral fuels			Library
CONNECTICUT (203)566-3540 Hugo F. Thomas Conn. Geol. & Natural History Survey State Office Bldg., Room 553 165 Capitol Avenue Hartford, CT 06115	1903	USGS; U.S. Fish & Wildlife	aerial photography topographic mapping soils hydrology biology	8 (1980)		Director of Natural Resources Information
DELAWARE (302)738-2833 Robert R. Jordan Delaware Geological Survey University of Delaware Newark, DE 19711	1951	USBM; OMB (CZM); USGS	geologic investigations hydrologic investigations basic data collection service & consultation	13 PTE 13 p.t. (1976)	8 (1976)	175 visitors (1975)

Table 1 (cont.)

Survey	Date Founded	Funding Sources	Organization or Research Areas	Staff	No. of Publications	Facilities and Services
FLORIDA (904)488-4191 Charles W. Hendry, Jr. Bureau of Geology 903 W. Tennessee St. Tallahassee, FL 32304	1907	USBM	geologic investigations mines & reclamation oil & gas technical support	40 (1980)	12 (1980)	well sample and core facility
GEORGIA (404)656-3214 William McLemore Geol. & Water Resources Div. Dept. of Natural Resources 19 M. L. King Dr., S.W. Atlanta, GA 30334	1889	USGS	geology hydrology			COSUNA
HAWAII (808)548-7533 Robert T. Chuck Div. of Water & Land Develop. Dept. of Land & Natural Res. P.O. Box 373 Honolulu, HI 96809						
IDAHO (208)885-6785 Maynard M. Miller Idaho Bur. of Mines & Geol. Moscow, ID 83843	1919	USGS; USBM; USBLM; Forest Service	geology mineral resources analytical services hydrogeology & hydrology environmental & economic geology	12 (1980)		Microprobe Lab. Atomic Absorption Lab. Remote Sensing MILS CRIB
ILLINOIS (217)333-5111 Robert E. Bergstrom Illinois State Geol. Survey 615 E. Peabody Dr. Champaign, IL 61820	1851; 1905	Ill. Dept. Trans- port.; USGS; Indiana Survey; Kentucky Survey	mineral resources environmental geology statewide & basic geology	182 (1980)		Library Applied Lab. 50,000 inquiries/yr.
INDIANA (812)335-2862 John B. Patton Dept. of Natural Resources Indiana Geological Survey 611 North Walnut Grove Bloomington, IN 47401	1881; 1919	DOE	geology coal petroleum	44 (1980)		
IOWA (319)338-1173 Donald L. Koch Iowa Geological Survey 123 N. Capitol Iowa City, IA 52242	1892	Iowa Conserv. Comm.	geological studies water resources stratigraphy technical services	37 FTE 12 p.t (1976)		Well sample and core facility
KANSAS (913)864-3965 William H. Hambleton State Geol. Survey of Kansas Raymond C. Moore Hall 1930 Ave. A, Campus West Lawrence, KS 66044	1864; 1895	DOI; USGS;	geologic research geochemistry environmental geology subsurface geology water resources			Library Well sample and core facility Foley Geohydrology Center
KENTUCKY (606)258-5863 Donald C. Haney Kentucky Geological Survey University of Kentucky 311 Breckinridge Hall Lexington, KY 40506	1854	USGS; NRC; DOE; Ky. Dept. Nat. Res.	water resources industrial & metallic minerals oil and gas coal special projects publications			

Table 1 (cont.)

Survey	Date Founded	Funding Sources	Organization or Research Areas	Staff	No. of Publications	Facilities and Services
LOUISIANA (504)342-6754 Charles G. Groat Louisiana Geological Survey Box G, Univ. Station Baton Rouge, LA 70893	1934	DOE; EPA; LSU; La. Dept. Nat. Res.	deep-basin research geothermal research geologic mapping industrial minerals			
MAINE (207)289-2801 Walter Anderson Maine Geological Survey State Office Bldg., Room 211 Augusta, ME 04330	1929	USGS; EPA; DOE; NR	hydrogeology bedrock mapping peat resource evaluation			CUSMAP
MARYLAND (301)338-7066 Kenneth N. Weaver Maryland Geological Survey Merryman Hall Johns Hopkins University Baltimore, MD 21218	1896	USGS; EPA; NASA	geology water resources archeology			
MASSACHUSETTS (617)292-5690 Joseph A. Sinnott Dept. of Environmental Quality Engineering Div. of Waterways 1-11 Winter St., 7th floor Boston, MA 02114	State Geologist appointed in 1971	NSF/RANN			7 (1980)	
MICHIGAN (517)373-1256 R. Thomas Segall Michigan Dept. of Natural Res. Geological Survey Division P.O. Box 30028 Lansing, MI 48909	1837; 1869; 1921	USGS; NSF; Office of Surface Mining	groundwater geology reclamation and mining control oil and gas economic and environmental		8 (1975)	
MINNESOTA (612)373-3372 Matt Walton Minnesota Geological Survey 1633 Eustis Street St. Paul, MN 55108	1872	USGS; ERA; NRC; NASA; Battelle	geology hydrogeology geochemistry geophysics economic geology			
MISSISSIPPI (601)354-6228 Alvin R. Bicker, Jr. Bureau of Geology P.O. Box 5348 Jackson, MS 39216	1906	DOE; Ms. Board of Health	environmental geology ground water surface geology subsurface geology mining & reclamation	10 (1973)		Library Mississippi Geology
MISSOURI (314)364-1752 Wallace B. Howe Div. of Geol. & Land Survey P.O. Box 250 Rolla, MO 65401	1853; 1870; 188	USGS; DOE; EPA; NRC	mineral resources engineering geology water resources			Well sample and core facility NCIC CUSMAP
MONTANA (406)496-4101 Sid Groff Mont. Bur. of Mines & Geol. Montana College of Mineral Science and Technology Butte, MT 59701	1919	USBM; USGS; USBLM; Dept. Fish & Game	Administrative Div. Information Service Div. Geology Div. Energy Div. Hydrology Div. Analytical Div.	46 (1980)		

Table 1 (cont.)

Survey	Date Founded	Funding Sources	Organization or Research Areas	Staff	No. of Publications	Facilities and Services
NEBRASKA (401)472-3471 Vincent H. Dreeszen Conservation & Survey Div. University of Nebraska Lincoln, NE 68588	1919	USGS; DOE; NURE; USBLM; Civil Defense	ground water soil surveys mapping			Well sample and core facility Remote sensing center
NEVADA (702)784-6691 John Schilling Nevada Bur. of Mines & Geology University of Nevada Reno, NV 89557	1929	USGS; DOE; NURE; USBLM; Civil Defense	mapping minerals geologic hazards geothermal research	26 FTE 11 p.t. 5 contract (1980)	20 (1980)	NCIC 220 inquiries/day Isochron/West
NEW HAMPSHIRE (603)862-1216 Robert I. Davis Office of State Geologist James Hall Univ. of New Hampshire Durham, NH 03824	(State Geologist became full time in 1980)	USGS; Univ. New Hampshire	mining and reclamation construction materials bedrock geology			CUSMAP
NEW JERSEY (609)292-2576 Frank J. Markewicz Acting State Geologist N.J. Geological Survey CN029 Trenton, NJ 08625	1864					12,000 inquiries (1975)
NEW MEXICO (505)835-5420 Frank E. Kottlowski New Mexico Bur. of Mines & Mineral Resources New Mexico Tech Socorro, NM 87801	1927	USBLM; NURE	minerals and coal oil and gas geothermal metallurgy and chemistry environmental geology mapping		21 (1976)	MILS Isochron/West
NEW YORK (518)474-5816 Robert H. Fakundiny New York State Geol. Survey CEC 3136, Empire State Plaza Albany, NY 12230	1836; 1904	USGS; NRC; DOE; N.Y. State	environmental geology engineering geology regional geology		19 (1980)	Empire State Geogram
NORTH CAROLINA (919)733-3833 Stephen G. Conrad North Carolina Dept. of Nat. Res. & Community Develop. P.O. Box 27687 Raleigh, NC 27611	1823; 1905	USGS; TVA	basic geology geophysics & geochemistry economic geology petroleum water resources			
NORTH DAKOTA (701)777-2231 Don L. Halvorson North Dakota Geol. Survey University Station Grand Forks, ND 58202	1895	USGS; ERDA/DOE; Old West Regional	ground water hydrothermal research oil and gas			7,500 inquiries (1972)
OHIO (614)265-6605 Horace R. Collins Ohio Div. of Geol. Survey Fountain Square, Bldg. B Columbus, OH 43224	1900	ERDA/DOE; State of Ohio	coal oil and gas sand and gravel mapping		12 (1976)	Well sample and core library (1980)

Table 1 (cont.)

Survey	Date Founded	Funding Sources	Organization or Research Areas	Staff	No. of Publications	Facilities and Services
OKLAHOMA (405)325-3031 Charles J. Mankin Oklahoma Geological Survey 830 Van Vleet Oval, Rm. 163 Norman, OK 73019	1908	DOE; NURE; USGS; NRC; Am. Chem. Soc.	energy minerals environmental/engineering water resources public information			
OREGON (503)229-5580 Donald A. Hull State Dept. of Geology & Mineral Industries 1069 State Office Bldg. 1400 SW Fifth Avenue Portland, OR 97201	1929?	USGS; DOE; USBM	mined land reclamation mapping geologic hazards geothermal oil and gas	33 (1976)	10 (1976)	Oregon Geology
PENNSYLVANIA (717)787-2169 Arthur A. Socolow Bur. of Topo. & Geol. Survey Dept. of Envir. Resources P.O. Box 2357 Harrisburg, PA 17120	1919; 1914	USGS; NSF; 1899; 1919	mineral resources environmental geology water resources topographic mapping	64 (1981)	16 (1973)	Well sample and core library NCIC Pennsylvania Geology 2,800 inquiries (1980)
RHODE ISLAND Robert L. McMaster Assoc. State Geologist for Marine Affairs Grad. School of Oceanography Kingston, RI 02881	1909					
SOUTH CAROLINA (803)758-6431 Norman K. Olson South Carolina Geol. Survey Harbison Forest Road Columbia, SC 29210	1824; 1901	USGS	minerals peat geologic mapping	10 FTE 14 temp (1980)	8 (1980)	South Carolina Geologic Notes
SOUTH DAKOTA (605)624-4471 Merlin Tipton South Dakota Geol. Survey Science Center Univ. of South Dakota Vermillion, SD 57069	1893	USGS	Administration Countywide Studies Urban and Rural Studies Basic and Analytical Studies	21 (1974)		library
TENNESSEE (615)741-2726 Robert E. Hershey Dept. of Conservation Division of Geology G-5 State Office Bldg. Nashville, TN 37219	1831	USGS; DOE; TVA; Dept. Health	geologic mapping environmental geology magnetic mapping waste disposal oil and gas			Well sample and core facility NCIC CRIB
TEXAS (512)471-1534 W. L. Fisher Bureau of Economic Geology University Station, Box X Austin, TX 78712-7508	1909	DOE; EPA; NURE; EPRI	Administrative Cartographic Research Editorial	297 (1982)	44 (1980)	Reading Room Well sample and core facility Mineral studies lab.
UTAH (801)581-6831 Genevieve Atwood Utah Geol. & Mineral Survey 606 Black Hawk Way Salt Lake City, UT 84108	1941	USGS; USBM	Administrative Geological Investigations Information and Education Illustrations and Editorial Sales			Library Utah Geology Well sample and core facility

Table 1 (cont.)

Survey	Date Founded	Funding Sources	Organization or Research Areas	Staff	No. of Publications	Facilities and Services
VERMONT (802)828-3357 Charles A. Ratte Agency of Environmental Conservation Heritage II Office Bldg. Montpelier, VT 05602	1844; 1898	USBM; USGS; DOE	mining topographic mapping			
VIRGINIA (804)293-5121 Robert C. Milici Virginia Div. of Mineral Res. P.O. Box 3667 Charlottesville, VA 22903	1908	USGS; USBM	basic geology geophysics, geochemistry economic geology	35 (1978)	12 (1980)	Well sample and core facility Virginia Minerals NCIC; COSUNA
WASHINGTON (206)459-6372 Dept. of Natural Resources Geol. & Earth Resources Div. Olympia, WA 98504	1901	DOE; NSF; USGS; NOAA; EPA	geothermal mineral land use regulatory		6 (1975)	Well sample and core facility
WEST VIRGINIA (304)292-6331 Robert B. Erwin W. Va. Geol. & Econ. Survey P.O. Box 879 Morgantown, WV 26505	1897	DOE; USGS; EPA; W.V. Dept. Nat. Res.	Analytical Div. Oil and Gas Div. Archeology Div. Coal Div. Economic Geology Div.			Well sample and core facility Library Mountain State Geology
WISCONSIN (608)262-1705 Meredith E. Ostrom Wisc. Geol. & Natural History Survey 1815 University Ave. Madison, WI 53706	1897	USGS	mineral resources environmental geology geophysics, geochemistry water resources soils mapping	21.5 FTE 56 other		Subsurface Sample Repository 4,400 inquiries
WYOMING (307)742-2054 Gary B. Glass Wyoming Geological Survey Box 3008, Univ. Station Laramie, WY 82701	1933	USGS; USBM	stratigraphy oil and gas minerals coal environmental	14 (1980)	10 (1980)	10,000 inquiries (1980)

State geological surveys also provide public information (fig. 4). Survey staff receive thousands of letters, calls, and visits from people in search of information. Some of the visitors use the survey's library or laboratories; others need a question answered, a publication, or a list of all the survey's publications. This is the passive role of the state geological survey, wherein the public comes to the survey. Survey staff assume a more active role by going to the public with information: leading field trips, giving lectures or courses, and supplying expert testimony. In addition, state geological surveys participate in international exchanges of publications, wherein survey publications are exchanged not only with other U.S. state surveys but also with libraries and research centers worldwide. Whether the survey provides these services actively or passively is determined by its own resources and by the needs of its users.

Figure 4. Services provided by state geological surveys.

Users of Survey Information and Services

State geological survey clientele can be categorized in various ways, one of which is by occupation or avocation. Four sectors of the community make use of the survey (fig. 5): government, industry, education, and special interest groups. Government users include not only federal and state officials and legislators but also

Figure 5. Users of state geological survey information.

employees of other agencies, such as the state department of transportation or the local water board. Users from industry include researchers, attorneys, and librarians. Students and faculty from primary through university level visit the survey and invite survey staff to give lectures at their schools. Special interest users are a cross section of society, including rock collectors, professional and civic groups, museum and library personnel, and staff from other state geological surveys. These four user groups (fig. 5) are usually composed of people who are not geologists but who have an interest in a particular aspect of their state's geology. State geological surveys have a special obligation to these non-geologist groups of users (Weaver, 1974, p. 1), and it is a part of the information specialist's role to ensure that non-geologists receive adequate answers to their queries and comprehensible publications on topics of interest to them.

Having discussed state geological surveys in general, I will now discuss a particular survey, the geological survey in Texas. I chose Texas' survey in part because I am most familiar with it and in part because there is considerable published information by and about this survey.

The State Geological Survey of Texas: The Bureau of Economic Geology

Texas' survey, known as the Bureau of Economic Geology, was founded by action of the University of Texas Board of Regents in 1909 (Ferguson, 1981, p. 9). Located in Austin, the Bureau currently has four office sites, one of which (Bureau North) is on the fifth floor of the Geology Building on The University of Texas campus. Research and support staffs have offices there and in two buildings that are within walking distance of campus (Bureau South and Bureau West), whereas the Mineral Studies Laboratory and the Well Sample and Core Library are located approximately 10 miles north of campus at the Balcones Research Center. The main Bureau offices are within walking distance of the State Capitol, other state office buildings, and the campus; these geographic details have a significant effect on our organization, our users, and our plans for future facilities and services.

Organization of the Bureau

The Bureau's Director, Dr. William L. Fisher, and four associate directors supervise nearly 200 full- and part-time employees who are classified as either Research Staff or Support Staff (fig. 6). Research staff, who are assigned to specific research projects headed by senior staff members, include geologists, geochemists, and biologists. Their primary responsibility is to collect, analyze, and publish data as part of ongoing studies of Texas geology and to assist and answer questions from the public. "Support staff" is the collective name for the editorial, cartographic, mineral studies, well sample and core, administrative/secretarial, word processing/typesetting, and computer service departments; in other words, people whose areas of expertise are geology-related but not geologic. Their purpose is to assist the research staff in publishing scientific information and to assist the directoral staff in administrative matters. The Bureau's Public Information staff, which at present consists of one part-time and three full-time employees, assists callers and visitors and oversees the Reading Room at Bureau North. They also handle a large volume of correspondence and maintain an open file of more than 500

Figure 6. Organization of the state geological survey of Texas, the Bureau of Economic Geology.

documents. The administrative/secretarial staff is responsible for direct-mail sales of publications and for the upkeep of the Bureau's mailing list, which now consists of names of over 3,500 recipients of Bureau publications, including over 150 people in other countries. Another unit of the Bureau, the Quality Assurance Office, maintains procedures and records in compliance with the Bureau's federal contract and grant requirements. Bureau allocations (fig. 7) are divided among staff salaries, research, and services.

Figure 7. Allocations of the Bureau of Economic Geology.

Research, Publications, and Services

Bureau research encompasses diverse topics and areas of Texas, including statewide basic research, energy resources, mineral resources, coastal and environmental studies, land resources, and geologic mapping (fig. 8). Bureau research, like that conducted at other state surveys, is at the same time more wide-ranging and yet more specific than are other types of geologic information such as theses and dissertations, publications of geologic societies, or trade publications on geology. Results of Bureau research are published as contract reports or as its own reports of investigations, circulars, guidebooks, handbooks, maps and atlases, and cross sections (fig. 9). These are sold at cost, over the counter and through direct mail and

Figure 8. Types of research conducted at the Bureau of Economic Geology.

Figure 9. Publications of the Bureau of Economic Geology.

standing order sales, or distributed as part of cooperative agreements for exchange of publications. During its 72-year history, the Bureau has published over 700 publications and distributed a total of over 1 million publications worldwide (Bureau of Economic Geology, 1982, p. 1). The Bureau also distributes free of charge three of its in-house documents: annual reports, lists of publications, and announcements of new publications. Other administrative documents, which are not distributed to the public but which have great importance to us (and may be of interest to other surveys), are the staff newsletter, the employee handbook, and the quality assurance documents.

Apart from its publications, the Bureau's service to the public (fig. 10) includes reference services, analytical services, and educational services, all of which are supplied at the Bureau's offices. Extramural activities engaged in by Bureau staff members include publishing articles in scholarly and professional journals, leading field trips, organizing conferences, and giving lectures and expert testimony. To show what these activities entail and whom they serve, I will next discuss the kinds of users we serve.

Figure 10. Services provided by the Bureau of Economic Geology.

Users of Bureau Information and Services

People who visit, call, or write to us have been classified as geologic academic, geologic business, and non-geologic users (Fishman, 1979, p. 3; fig. 11). Geologic academic users include not only our University of Texas faculty and staff but also students and faculty from primary school through high school, both in

Figure 11. Users of Bureau of Economic Geology information. Terminology of Fishman (1979, p. 3).

Austin and from out of town. Geologic academic users come to our offices individually or on group tours, and Bureau staff go onsite to give lectures, short courses, or semester-long courses. We are planning to start a new service for our academic users at the university level, namely a compilation of geologic research topics and researchers in Texas geology; we hope to have the first of these directory volumes available in late 1983 (J. Price, personal communication, 1982).

Geologic business users are those with business-related interests in Texas geology. Whether from industry, government, or the private sector, their particular concern is the economic implications of Bureau research. Although geologic business users are long-standing users, our public information staff tries to avoid becoming their unofficial consultants (M. McBride, personal communication, 1982).

Non-geologic users are those who have a specific, if nontechnical, interest in Texas' resources. They include rock and mineral collectors, civic and political groups, and landowners. Many of these users visit the Bureau in person, particularly if they need extensive assistance. Also, Bureau staff members are often invited to speak to civic or other groups on topics of general interest, such as water quality in area creeks, the impact of urban development on the Austin environment, and so forth. The primary role of the information specialist here is not necessarily to supply information, but to determine whether the non-geologist user can best be helped by direct interaction with the staff geologists.

Future Plans

The Bureau of Economic Geology plans to expand its research programs, increase its publications and services, and enlarge and consolidate its facilities in the coming years. Research areas that will be pursued include energy research, mineral resource studies, environmental geology research, map preparation and revision, and bibliographic and information services (fig. 12). We anticipate an increasing demand for publications and services, particularly if federal agencies no longer provide them. To meet this increased demand, we will have a larger staff housed in a centralized office complex (fig. 13).

The University of Texas Board of Regents has approved the construction of two new buildings for the Bureau. One building will house most of the research and support staff; a second complex will house the Well Sample and Core Library and the Mineral Studies Laboratory. The third Bureau facility is the core repository. The move to new quarters, planned for 1985, means that since we will be further from campus and its facilities, we will have to expand and improve our present capabilities, such as the Library and the Well Sample and Core Library. Intense planning is being devoted to all of the Bureau's new offices (E. G. Wermund, personal communication, 1982). In particular, the Well Sample and Core Library is anticipated to be among the best of its kind in the world because of its size, organization, and equipment (Davidson, in press).

Energy resources
Mineral resources
Environmental geology
Mapping revisions
Bibliographic services

Figure 12. Future research at the Bureau of Economic Geology.

Figure 13. Future facilities of the Bureau of Economic Geology.

Our optimism, which is not shared by many other state geological surveys, is tempered by economic realism. Inflation and the New Federalism mean that surveys have had to redefine their activities and cut back their services. The threatened dismantling of the U.S. Department of Energy and cutbacks in other federal agencies are clear indicators that states, and therefore state geological surveys, will have to assume more financial responsibility for what were federal programs. The role of the information specialist in the future must be to improve the quality of service to users and to address some of the fundamental problems plaguing geologic information, such as bibliographic control (Bichteler, 1979, p. 263). Because of their role as intermediary between the scientist and the users, the information specialists have the opportunity, if not also the duty, to make the scientific community aware of the needs of their constituents and thereby improve the quality of information emanating from state geological surveys.

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THE INFORMATION SERVICES AND SYSTEMS OF THE AUSTRALIAN BUREAU OF MINERAL RESOURCES

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Abstract--BMR's information resources can be divided into two broad categories. Firstly, there are the 'public' services which include publications; an open-file system for unpublished reports; a procedure for early release of map-type data, particularly geophysical; and standard library services.

Secondly, there are 'in-house' computer-based storage and retrieval systems. These include both general and specialist reference databases; and geophysical, geological, and geochemical source data files. These files are primarily used to generate maps, but the data are also available to the public in digital form. The most important of these are the Australian National Gravity Repository (data on 500 000 stations), the Airborne Geophysical Database (digital and analogue data from 3 500 000 km of survey flying), the Marine Geophysical Database (data from 185 000 km of traverses), and the Earthquake Data File (29 000 events). Recent years have seen the development of systems to record geological data including field observations.

None of the databases is publicly available on-line. However, ways of making BMR's large resources of data more readily available are being explored as part of the organisation's new role of being the primary national source of geoscience data.

Introduction

The Bureau of Mineral Resources, Geology and Geophysics (BMR) was formed in 1946 as a federal organisation to provide, in cooperation with State government departments, scientific and technological research in support of mineral development. To appreciate the development of BMR's information services and systems, it is necessary to examine briefly BMR's past and present role and activities.

For about 30 years, BMR functioned essentially as a national geological survey, its primary program being the systematic geological and geophysical mapping of Australia and Papua New Guinea at a basic scale of 1:250 000. Much of this work was carried out in cooperation with the Geological

Surveys of the six Australian States, the Northern Territory and Papua New Guinea. Among BMR's other activities were national responsibility in the fields of seismology, geomagnetism, and gravimetry; projects in the disciplines of petrology, geochronology, palaeontology, and petroleum technology; and mineral and petroleum commodity studies. BMR's present information services and systems have developed largely from these activities.

In 1978, BMR's role and programs were reviewed by the Australian Science and Technology Council. As a result of that review, and in recognition of the fact that future mineral discoveries will increasingly rely on sophisticated research, BMR's new role is to participate in that research by (a) developing a comprehensive understanding of Australian geology, (b) being the primary national source of geoscience data, and (c) undertaking mineral resource assessments.

As far as geoscience information is concerned, the new role has given us the opportunity to look afresh at the large resources of geoscience data that BMR has accumulated over the past 36 years with the objectives of making it more accessible to those who need it, and of identifying gaps and deficiencies in our data systems and services that we might usefully fill.

Information services

Publications

In common with most national geoscience organisations, BMR has a very active publishing program. The publications are primarily of a specialist nature and are designed (i) to record the results of geoscientific field, laboratory, and observatory research, and related activities, and (ii) to provide a continuous review of the Australian mineral industry.

Monographic series. Bulletins and Reports fall into this category. The former are published as books and are commonly accompanied by maps. The latter are published as microfiche and, as such, represent an important innovation in BMR's publication practices. The change from book to microfiche format took place in 1977 with two aims: to reduce the cost of publication, and to reduce the delay in publication. To minimise user resistance to microfiche, considerable thought was given to the method of presentation and marketing. A contents list is printed on the front of the microfiche envelope and an accompanying card gives full bibliographic information together with an abstract.

The use of microfiche has generally been well received in BMR and in the Australian geoscience community generally, and is now widely used by BMR in other publications and in unpublished reports.

Serials. The BMR Journal of Australian Geology & Geophysics is a quarterly publication which commenced in 1976. It provides a means of rapid publication of results of BMR research and other activites.

Information and data on the Australian mineral industry are published in the Australian Mineral Industry Annual Review and the Australian Mineral Industry Quarterly.

Other serial publications include monthly Observatory Reports (geomagnetic data) and Seismological Bulletins, a quarterly Petroleum Newsletter (drilling and exploration statistics), a six-monthly map showing petroleum exploration and development titles, and a Yearbook. The latter has been written for the non-specialist and contains a review of current programs, fifteen or so short articles on particular aspects of the program, and a full list of publications and other data issued during the year.

Maps. BMR has published a large number of 1:250 000-scale geological maps covering quadrangles in Australia and Papua New Guinea. Each of these is accompanied by Explanatory Notes. Research projects in key areas have resulted in the publication of some 60 maps at 1:100 000-scale, mostly in northern and central Australia. Other research projects have resulted in the compilation of regional maps at 1:500 000 and 1: 1 000 000. Most geological maps are also made available at a preliminary stage of production in 2- or 3-line colour format.

Up until 1973-74, most magnetic, radiometric and gravity maps were published as printed maps. Since that time, geophysical maps have been provided as dyeline and transparent copies through the Australian Government Printer's Copy Service. This method of publication has several advantages: the data can be released much quicker than is the case with printed maps, storage costs associated with printed maps are eliminated, and the 'master' transparency can be replaced as often as necessary as new or revised data become available. This ensures that the customer always receives the most recent information. As these maps are produced from data in computer files, they will be discussed in more detail later.

A series of stream-sediment geochemistry maps is also produced from computerised data and will also be discussed later.

The BMR Earth Science Atlas of Australia commenced publication in 1979. It is in loose-leaf format, and is designed to provide a first reference to the gology and geophysics of Australia. Most maps are at a scale of 1:10 000 000, and each map is accompanied by a commentary.

Open file service

An open file service exists to make unpublished BMR information readily accessible to the public. This information is contained in documents called Records which are produced in limited numbers. Reference and loan copies of Records are available at the BMR Library in Canberra and at the capital city library of each of the State Geological Surveys. The borrower is permitted to make photocopies of Records, or alternatively photocopies may be purchased from selected firms.

Library

The BMR Library is at present the most comprehensive geoscience library in Australia. Holdings include 20 000 monographs, 3000 serial titles (most of which are received on an exchange basis with other Australian and overseas geoscience organisations), 20 000 reprints, and a large number of pamphlets and reports. While primarily established to serve BMR's scientific staff, the library's inter-library loan and reference services are much in demand by other libraries and the mining and exploration industries generally.

The library has on-line access to the Australian Earth Sciences Information System through the AUSINET network, and also to databases on DIALOG and ORBIT. Library holdings are controlled by a computer-based system which also provides a useful bibliographic reference tool. This will be mentioned later.

Technical information service

Enquiries from industry, government departments, and the public are handled by a small group of information officers. A range of lists, catalogues, brochures, and other 'hand-out' material has been produced to facilitate this activity.

Petroleum exploration reports

During the period 1959 to 1974, the Australian government subsidised some 1600 drilling and geophysical operations in Australia to stimulate the search for petroleum. These operations resulted in a substantial volume of reports and data which are in regular demand both for inspection at BMR's Canberra office, and for purchase from selected photocopying firms.

Core and cuttings laboratory

BMR's core library houses material from (i) BMR's own stratigraphic drilling projects; (ii) the subsidised drilling operations mentioned in the preceding section; and (iii) all offshore drilling operations. There is also some material donated by exploration companies. The laboratory holds over 1 250 000 catalogued samples from more than 3300 wells. Facilities are provided at the laboratory for inspection and non-destructive testing.

Information systems

Only computerised databases are described. It is recognized that the organisation has numerous card-file and other types of manual systems but space limitations preclude their description.

Most of BMR's database activity takes place on two computer systems. The large geophysical data files are processed on a Control Data CYBER 76 computer belonging to the Commonwealth Scientific and Industrial Research Organisation in Canberra. All the reference databases and many of the smaller source databases use BMR's own HP-1000 computer system with HP's IMAGE database management system. Over 200 million characters of disc is currently used on the HP-1000 system for information storage and retrieval purposes.

Reference databases

With the exception of the library loans database, all the reference databases have a common basic content of author(s), title, publication, and subject and location descriptors. Other information is included depending on the specific purpose of the database.

Publications and Records Index. This database is designed to provide a comprehensive index to BMR's own publications and unpublished reports. As it was commenced in 1979, it contains only 400 complete records; author/title information for a further 5000 older documents has also been included. These documents will be indexed as time permits.

Stratigraphic Index. This database records all published references to Australian stratigraphic names. It is also used to record names reserved by field geologists for future use. The index has been maintained since 1949, initially as a card system and since late 1978 in machine-readable form. The computer database currently contains 4000 references covering some 15 000 stratigraphic names, and an active program is in hand to transfer further references from the card files to the computer system.

Library loans system. While primarily a computerised system for controlling library holdings and borrowings, monographic-type items are given keywords to facilitate the work of the reference librarian. Over 6000 items have been indexed to date. The database can also be used to produce accession lists.

Specialised indexes. Various indexes and bibliographies have been developed in conjuction with specific BMR projects. They are:

Digital image processing of remotely-sensed data (700 references)
Geology of the Australian Capital Territory (160)
Murray Basin (1000)
Oil shale (200)
Volcanology of Papua New Guinea (600)

Source databases

BMR's source databases can generally be divided into three categories:

(a) Databases that are essentially numeric data files set up to store data from digital acquisition systems, or digital or coded data from surveys or laboratory investigations; these data files are commonly very large and are frequently used to produce maps (e.g. airborne and marine geophysical data files, Australian National Gravity Repository).

(b) Databases containing alphanumeric data set up to store the results of field, laboratory, and/or office investigations to facilitate data manipulation and interpretation (e.g. Period Study database, Georgina Basin Project database).

(c) Databases set up as management tools to summarise information for use in project planning. These databases commonly advise the user of the existence and location of other related data (e.g. Seismic shot-point index, Petroleum exploration well data).

Geophysical data

Airborne survey data. BMR has been acquiring airborne magnetic and radiometric data in Australia since 1951. Data from surveys up until about 1968 (1 900 000 km of traversing) are in analogue form as strip charts. Most data acquired since 1968 (1 600 000 km) are in digital form and stored on magnetic tape on a survey block basis. The data are used to produce a range of machine-drawn magnetic and radiometric profile and contour maps.

Australian National Gravity Repository. This database contains the principal facts of over 500 000 gravity stations throughout Australia (onshore and offshore) and Antarctica. It includes data from BMR's Australia-wide reconnaissance surveys (11 km x 11 km grid) and 10-minute values from BMR's continental margins marine geophysical surveys. These data are supplemented by data from detailed surveys by BMR and other organisations. The data are currently being re-compiled and two new series of Bouguer anomaly maps at scales of 1:1 000 000 and 1:250 000 are being machine-drawn on BMR's flat-bed plotter.

Earthquake data file. BMR, in its capacity as the national earthquake authority, maintains a database containing the location, magnitude, and other information of some 29 000 earthquakes recorded since 1900 in the region 0°-90°S, 75°-165°E. The file can be searched on a range of criteria, and the results printed or plotted.

Earthquake phase data file. This file contains the earthquake arrival times from all stations in the BMR seismological network and selected stations in other Australian networks, Papua New Guinea, and Solomon Islands. The monthly Seismological Bulletin is automatically produced from this file.

Marine geophysical data. A regional geophysical survey of most of the Australian continental margin and Papua New Guinea waters was made from 1970 to 1973. Seismic, gravity, magnetic, and water-depth recordings were made along 185 000 km of traverses. These data are supplemented by those from earlier, more detailed surveys on the northwestern part of the continental shelf. The data are available as machine-drawn maps, sections, microfiche, and magnetic tape.

Geomagnetic database. This database, which is still under development, contains, geomagnetic observations at the 86 Australian first-order stations since 1900, together with data from Papua New Guinea and Pacific Islands networks and Antarctic observatories. There are currently 2000 observations in the database.

Seismic data. Processed seismic sections from all BMR reflection and refraction surveys are stored on analogue magnetic tapes (surveys up to 1975) and digital magnetic tapes (from 1976). A seismic shot-point index has been developed to record details of shot-point and seismic survey traverse locations from onshore surveys. Information from this database can be output in tabular form and as plots at any desired scale and projection.

Geochemical data

Stream-sediment geochemical data. BMR has made reconnaissance stream-sediment geochemical surveys of seven 1:100 000 map sheet areas - six in northern Australia and one in southeast Australia. Sampling and 25-element analytical data have been converted to machine-readable form and are processed on the CYBER 76 computer using the INFOL database management system. All data are available as COM, and selected data have been published in map form. The sample locations and analytical data on these maps were drawn on the computer-controlled flat-bed plotter.

Whole-rock geochemistry data. These data are stored and processed on a HP-9825 desk-top computer. Peripheral equipment includes a printer, four-colour plotter, floppy disc unit, VDU, and digitiser. Data stored for each sample include sample number, location information, rock type, stratigraphic unit, and 14 major and 30 trace element values. The system currently stores information on 3500 samples from various parts of Australia and Antarctica. Software has been developed to print selected analyses, and calculate and plot chemical variations and relationships.

Petroleum geochemistry database. This database contains petroleum source rock data and geochemical analyses from over 6400 samples from petroleum exploration wells in many parts of Australia. Data recorded comprise location of well, depth and type of sample, and over 30 items of analytical data such as TOC, vitrinite reflectance, saturated hydrocarbons, and kerogen.

Geological data

Georgina Basin Project database. The Georgina Basin is located in western Queensland and the Northern Territory and occupies 325 000 km^2. BMR has been carrying out a research project on the early Palaeozoic rocks of the basin since 1974, and a computer file has been developed to record all field and laboratory data from the project. The file currently contains over 3500 sets of field observations, and over 1000 geochemical analyses, faunal determinations, carbonate petrographic reports, and biostratigraphic analyses. The file is maintained on the CYBER 76 computer and uses the INFOL database management system for processing and interrogation.

Great Artesian Basin hydrogeological database. This database was set up in the early 1970s to support a major study of the hydrogeology of the Great Artesian Basin which covers an area of 1 700 000 km^2 of northeast and central-east Australia. The database contains detailed information on the stratigraphy, lithology, physical and chemical properties, and hydrodynamics of all aquifers in the basin. This information was obtained from the records of 4500 flowing artesian wells from 1880 to 1972, together with some data from the 20 000 pumped wells in the basin.

Lachlan Fold Belt database. Since 1979, BMR has been making a geophysical study of the Lachlan Fold Belt, a large region of Lower to Middle Palaeozoic sedimentary and igneous rocks in southeastern Australia. A small database has been developed for this project to record field sample data including location, geology, physical and chemical properties, and petrography.

Mineral specimen index. This database provides a detailed index for 9000 mineral specimens held in the BMR and national collections. Twenty-four items are indexed for each specimen.

Palaeontological Data Retrieval System. This database contains detailed descriptive and other information on over 7000 palaeontological specimens held in various reference collections. The information is used to produce catalogues of the various collections.

Period Study database. This database is being developed to support research projects on specific geological Periods. The first such project is on the Oligocene Epoch, and detailed data on 150 occurrences of Oligocene rocks is currently in the database.

Permian Coals Project database. The database contains detailed geological information on coal occurrences from over 300 boreholes in the Permian basins of eastern Australia.

Some other databases

Petroleum exploration well data. This data file comprises basic information on over 1000 wells drilled for petroleum in Australia. The data comprise name and location, owner, drilling date(s), total depth, and an indication of what further data are available. Tabular and plotted outputs are available.

Mineral statistics. A database and application software are currently being developed to store and process statistics on Austrlian mineral production, imports, and exports.

Mineral deposits index. An index to Australian mineral deposits is also being developed. The pilot database is modelled on the Geological Survey of Canada's CANMINDEX.

Acknowledgments

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No paper available--

RECENT DEVELOPMENTS IN GEOLOGICAL INFORMATION IN INDIA

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Besides the Geological Survey of India (GSI), many other agencies in India are engaged in investigation and acquisition of geological data that would be useful in planning proper exploitation and utilisation of natural resources for the development of the country. These agencies include the Indian Bureau of Mines (IBM), Oil and Natural Gas Commission, Atomic Energy Department, State Directorates of Geology and Mining, Public Sector Undertakings like the Mineral Exploration, National Mineral Development Corporation, etc. The data collected by these several agencies have now assumed large proportions that the storage and retrieval of information have been unmanageable without resort to sophisticated equipment like the computers.

A Computer Group was constituted in 1971 for the Airborne Geophysical Surveys and the Computer Cell of the AMSE Wing of the GSI started the development of Computer Programmes in 1973. The Government has accepted the setting up of a "Geodata Centre" for mineral and earth sciences at Calcutta and at the other regional centres of the GSI, so as to organise on modern lines the data collection, storage and retrieval.

The Indian Bureau of Mines has recently set up a mini-computer for in-house storage and retrieval. The other data banks are the GSI for metallic and non-metallic minerals, Coal Mines Planning and Design Institute for Coal and Lignite, and Oil and Natural Gas Commission for Oil and Natural Gas.

The GSI and IBM have added a few more divisions to diversify their activities and have also started publication of new series to disseminate the information. More Geological/Earth Science Societies have come into existence and their publications help in the dissemination of geological information.

No paper available--

HUMANIZING SCIENCE COMMUNICATION - INNOVATION AT SEG

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Today the problem in science communication is three-fold. It exists not only between specialized fields of knowledge and the general public, but among the various specialties themselves, and within given specialties. SEG has concluded after considerable research, that the basis of the problem is as much human as it is technical, i.e., to the extent that the typical social tendency of an individual scientist today, on meeting a stranger, is to ask not who he is, but what. Technology, essentially a positive value, thus ironically compresses the invaluable social aspect as it becomes broader, thereby diminishing understanding of science in virtual proportion to its growth.

The solution at SEG was to create a new communications tool that will contain human interest material about the hopes, dreams, aspirations, successes, and frustrations of seismologists. We will treat field action, long neglected in this science, with as much attention as the esoterica of the laboratory. Approximately one-half the new magazine will include the bones and sinews of a culture, i.e., essays, art, wit, and related material published as much for their aesthetic excellence as their relationship to science.

The magazine will be circulated to SEG members, to Congress, pertinent government agencies, editorial page editors of the major dailies, and the electronic media, here and abroad. It is imperative that these information outlets receive correct, readable stories about our business, the distinction of our scientists, and the importance of geophysics generally, and in a fashion that is candid and not self-serving. We believe we can achieve this by humanizing our science to the extent that it becomes better understood at worst, and appreciated at best--both by other scientists and the lay public as well.

THE AUSTRALIAN EXPERIENCE WITH INFORMATION TRANSFER IN THE GEOSCIENCES

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Abstract--In Australia, there is a good tradition of documentation in the geosciences back to the early days of colonial settlement. Further, exploration booms compounded by mandatory reporting of exploration results generate a sizeable information resource of 'unpublished' open file reports. Collections however are dispersed and access has been of variable quality. In addition, the interdisciplinary nature of new literature and rapid advances have all created the need for better transfer of information.

From January 1972, by co-operative concensus the Australian Mineral Foundation (AMF) assumed the major role in Australia for continuing education and provision of national information services in the mineral and petroleum disciplines. In co-operation with the Bureau of Mineral Resources, Geology and Geophysics and State Geological Surveys, the Commonwealth Scientific and Industrial Research Organization (CSIRO), the National Library and with industry AMF has established the Australian Earth Sciences Information System (AESIS) as the national reference data base for the geosciences in Australia.

AESIS commenced in 1976 and covers geology and associated areas through to mining, mineral processing, coal preparation, petroleum exploration technology, and aspects of analytical chemistry, energy, environmental protection, remote sensing, computer and mathematical applications, and policy and legislation all germane to the geosciences, restricted to Australian material. In December 1981 AESIS had about 17,000 records on file, about 40% of which cover unpublished reports. A retrospective project funded by the mineral and petroleum industries to cover some 20,000 unpublished reports, back to 1965, is under implementation.

Co-operative working between a range of government and industry bodies is the essence of the entire system. It is being fostered down to the level of individual authors through participation in indexing and increased cognisance of the information transfer process and use of machine-based systems, thereby assisting better technical communication in the mineral and petroleum industries in Australia.

Introduction

Though geologically old and inhabited for millenia, Australia in the documented record is a relatively young country. Geoscience information can therefore be traced to the first generation of new settlers and in fact forms a significant part of the developmental history of the Australian nation.

But for the discovery of gold and other mineralization the economic health of the Australian colonies would have remained precarious. However, like other nations before, Australia received great impetus from the romance of the gold rushes and all the activity associated with mining mineral commodities. Latter day affluence too cannot be divorced from the post-World War II mineral boom.

Reliance on metals and minerals for success with the new settlements caused early administrators to foster mining and exploration by appointing 'mining surveyors' and 'government geologists'. Due to the dedication of the incumbents of these positions in each State and their almost single-handed prodigious industry, often under extremely difficult circumstances, we have an excellent tradition of documentation in the earth sciences in Australia. A tradition which we believe has gone a long way in laying the ground for the geoscience information available in the country today. This resource did, however, remain dispersed and fragmented, and access has always been of variable quality.

Australian Geoscience Literature

Early documentation. The main early formal records of a geological and mining nature are in the publications of the learned societies and the State Geological Surveys and their respective precursors. However, once the Surveys got underway they were and have been the principal sources and repositories of geological and mining information in Australia. As Johns (1976) states "... enshrined in the pages of Survey bulletins, memoirs and reports (to say nothing of their maps) can be found many if not most of the significant advances in geology in Australia".

Whilst the discovery of industrial materials is reported as early as 1788 in Sydney Cove (in the first year of settlement) and coal in 1791 at the mouth of the Hunter River; gold in 1839 in New South Wales; silver-lead at Glen Osmond in South Australia in 1841 (about a kilometre from the present AMF building); gold in Clunes, Victoria in 1851 and so on, the beginnings of more formal and systematic geological records only became possible after the appointments of goverment geologists or some equivalent officials around the middle of the century. How each State progressed with such first appointments is shown below.

State	Person	Position	Date
1. New South Wales	Samuel Stutchbury	Geological Surveyor	1849
2. Northern Territory	H.I. Jensen	Chief Geologist	1911*
3. Queensland	Richard Daintree	Government Geologist for Northern Qld	1868
	C.D.H. Alpin	Government Geologist for Southern Qld	
4. South Australia	Johann Menge	Mine and Quarry Agent and Geologist	1836
5. Tasmania	Charles Gould	Geological Surveyor	1859
6. Victoria	A.R.C. Selwyn	Government Geologist	1852
7. Western Australia	Ferdinand von Sommer	"Government Geologist"	1847

* Prior to this date the Northern Territory was under the jurisdiction of South Australia.

The mid-nineteenth century therefore saw the first surge of published documentation with the latter half of the century showing the results of the untiring zeal of these first officials and their immediate successors. The History and role of Government Geological Surveys in Australia edited by Johns (1976) outlines their story very well and Appendix A to this paper lists some of the first major contributions to the geoscience literature at that time. These publications highlight the extensive record of mining activity and mineral wealth of the States in those days. It is almost unbelievable that one could document every single mine in South Australia as H.Y.L. Brown did in 1887 (322 in 1887 and 1,277 on L.C.E. Gee's update in 1908), or that the total production of gold at the turn of the century in Western Australia was in the region of 4,200,000 ounces, valued at about Pounds Sterling 16,500,000 at that time. At today's value that would be the cash equivalent of Pounds Sterling 0.9 billion.

Table 1 shows the commencement years of some official early serial publications and serials of the better known learned societies associated with the geosciences in Australia. Figure 1 shows the rate of growth in the number of serial titles which are still current and known to carry papers of interest to the geosciences, as presently recorded in the Australian Earth Sciences Information System (AESIS).

The initial surge and post-war quantum jump in volume is easily discernible.

Coincidently the Mineral Economics Section of the Australian Bureau of Mineral Resources, Geology and Geophysics (1982) identifies four development stages for Australia's mineral industry: early settlement and exploration, 1788 to 1851; establishment of the industry, 1851 to 1910; the lean years, 1910 to 1950; the large and varied developments of the last three decades.

Table 1.--Commencement Date of Early Australian Serials of Relevance to the Geosciences

	Title	Commencement Date
1.	Australasian Institute of Mining and Metallurgy. Proceedings. (Formerly Australasian Institute of Mining Engineers. Proceedings)	1897
2.	Australian Mining (Formerly Mining and Chemical Engineering Review)	1908
3.	Australia Museum. Record	1890
4.	Commonwealth of Australia. Yearbook (Incorporates mining statistics from 1851)	1901
5.	Linnean Society of New South Wales. Proceedings	1876
6.	Medical Journal of Australia	1914
7.	Mineral Resources Review (South Australia) (Formerly Mining Review)	1903
8.	National Museum of Victoria. Memoirs	1906
9.	New South Wales. Geological Survey. Memoirs (Geological series and subsequently Palaeontology)	1887
10.	New South Wales. Geological Survey. Records	1889
11.	New South Wales Yearbook	1887
12.	Queensland. Geological Survey. Publication	1897
13.	Queensland Museum. Memoirs (Formerly Annals)	1891
14.	Queensland Government Mining Journal	1900
15.	Royal Society of New South Wales. Journal and Proceedings	1867
16.	Royal Society of Queensland. Proceedings	1884
17.	Royal Society of South Australia. Transactions	1877
18.	Royal Society of Tasmania. Papers and Proceedings	1848
19.	Royal Society of Victoria. Proceedings	1888
20.	Royal Society of Western Australia. Journal	1914
21.	South Australia. Geological Survey. Bulletin	1912
22.	South Australia. Museum Board. Record	1918
23.	South Australian Naturalist	1919
24.	Tasmania. Geological Survey. Bulletin	1907
25.	The Bulletin	1880
26.	Victoria. Geological Survey. Memoir	1903
27.	Victoria. Geological Survey. Report	1874
28.	Victorian Naturalist	1884
29.	Victorian Yearbook	1873
30.	Western Australia. Geological Survey. Annual Report (Includes technical papers)	1897
31.	Western Australia. Geological Survey. Bulletin	1898
32.	Western Australia. Geological Survey. Memoir	1919
33.	Western Australian Yearbook	1886

Figure 1. Growth in number of the more durable Australian serials having relevance to the geosciences from 1848 onwards. Based on titles recorded in AESIS.

Post-World War II developments. This sudden increase in the published literature whilst not unique to Australia at the time was nevertheless due in part to the release of funds to universities and other tertiary educational institutions by the Federal Government, and the fostering of research and development through the Commonwealth Scientific and Industrial Research Organization (CSIRO), which previously had concentrated mostly on the rural sector with great success.

A significant post-war development was the creation of the Bureau of Mineral Resources, Geology and Geophysics (BMR) as an organization in its own right. The BMR has today the largest collection of geoscience information in Australia and probably generates the most geoscience information as well, over any other single organization. The BMR is the subject of a separate paper at this Conference (E.P. Shelley).

A unique development in 1959 was the creation of the Australian Mineral Industries Research Association (AMIRA) which initiates and co-ordinates, through a small permanent secretariat, jointly sponsored research and development contracts on behalf of its member companies which are drawn from the Australian mineral industry. AMIRA was established, initially, to co-ordinate the mineral industry's interests in the operation of The Australian Mineral Development Laboratories (AMDEL). AMDEL was created in 1960 by incorporating the resources of the Research and Development Branch of the South Australian Department of Mines to function as an independent contract research organization with some guaranteed work from Commonwealth and State authorities and the mineral industry; a unique arrangement. Some larger companies also increased their own in-house Research and Development activities as did tertiary institutions at about this time.

Change in nature of geoscience information. The publication output which resulted as a consequence of these new levels of activity naturally escalated. The nature of these publications also underwent progressive changes with interdisciplinary intrusions and diversification impeding the ability of people to cope with these new situations in conventional ways.

This interdisciplinary encroachment gave rise to a basic problem which impinged on fundamental areas of information transfer. It was not enough now to attempt to keep up with information, there were new techniques and subjects to learn before one could perhaps assimilate the new literature.

Larsen referring to general trends in geoscience information in his Introduction to the 1981 edition of Ward et al. (1981) more than confirms this multidisciplinary nature of the new literature and says "Geology today encompasses a subject spectrum broader than ever before".

As a result the continuing education of practising geologists and engineers became a problem of some proportions.

Open-file reports. The whole scene was further compounded (in the best sense of the word) by Australia's mineral boom of the 1960s, both from the need to have better access to information in general and from the very volume of documentation generated by exploration and departmental activity during the boom years.

It is significant to emphasise that the States of Australia have unique legislation in regard to requirements which accompany the granting of exploration licences. This legislation is made possible by historical antecedent which vests all mineral rights with the State. It is mandatory for the holders of such licences to report on work carried out on a licenced area on a periodic basis and on relinquishment of the licence. On relinquishment such reports come into the public domain giving rise to a wealth of regional and economic geological information and data.

By the very nature of this population of information, awareness of these reports and access to them were never satisfactory. Dixon and Tellis (1972) estimated that the number of such reports at that time was in the region of 30,000.

Better transfer of information. As Rudd (1979) states "In hindsight the Australian mineral industry appears to have had a steady growth but in fact its growth has been a combination of cyclic 'booms' and 'busts' resulting from fluctuating metal prices and changing economic conditions and a series of major steps brought about by the discovery of new resources or the development of conditions which made new markets available". In boom periods the Government Surveys generally lose staff to industry and this phenomenon has always made it difficult for them to cope satisfactorily with processing and organization of exploration documentation. Some manage better than others, but in the 1960s industry felt that the systems then prevailing were far from satisfactory. The Australian tradition of documentation had and was creating an immense record. The problem of better access was still proving elusive.

With the two problems of better access to information and more active continuing education in mind some Adelaide-based academic and industry leaders, in association with the State Government, took the initiative to create an agency to address itself to these problems. The agency is the Australian Mineral Foundation.

The State Surveys and the BMR have made appreciable progress since the 1960s in organizing and controlling their information and as it transpires all developments at the State, Federal and national level have been mutually beneficial.

Australian Mineral Foundation (AMF)

The role envisaged for AMF was unique inasmuch as no such combination of functions appears to exist elsewhere. The background to such a concept therefore perhaps bears some elaboration.

As emphasised by Crowe (1980) one of the greatest problems facing applied scientists today is how to keep abreast of the rapid advances and changes in technology. The problem is accentuated by the need to maintain a wider knowledge of matters outside a professional's primary discipline. This is particularly true in the sphere of exploration where high-risk and high-level expenditure are involved.

Interpretative techniques in the mineral industry encompass a variety of fields - geology (including mineralogy, petrology, structural geology), geochemistry, geophysics, mining engineering (along with associated specializations such as drilling, blasting, ventilation, rock mechanics), mineral processing, extractive metallurgy, coal preparation, environmental sciences, mineral economics, law, marketing, accounting and management. It has been argued that a new graduate entering this industry is confronted, more than in any other, with rapid obsolescence of his knowledge and enormous gaps in his tertiary training.

The difficulties facing new graduates and even experienced professionals has been aggravated in the post-World War II era by a proliferation in docu-

mentation. The Australian experience mentioned earlier has been similar to developments in the international arena.

Assimilation of this vast array of information has become of critical importance, particularly to the applied technologist. While the information transfer process is improved by the creation and development of information services and data bases there is always the inevitable publishing delay between the creation of knowledge and the availability of that knowledge through the various professional publications. As stated by Crowe (1980) a continuing education programme geared towards well-designed, short-term, practical, interdisciplinary courses aimed at teaching new operational skills and presenting the latest theories can render vital assistance to industry by shortening this time delay. The geographic location of Australia away from the main stream of major developments made such education programmes nigh imperative.

The AMF concept was the brainchild of Emeritus Professor E.A. Rudd, former Professor of Economic Geology at the University of Adelaide in South Australia and erstwhile Chief Geologist of The Broken Hill Proprietary Company Limited. Through his efforts and the combined initiative of the South Australian Government and several Australian mining and petroleum companies AMF was formally constituted in May 1970 and commenced operations in January 1972.

The two principal objectives of the Foundation are:

- to provide advanced training for persons in technological and management fields related to mineral and petroleum exploration development, production, organization and management,

- to provide a range of information services pertinent to the geosciences including both responsive and current awareness services,

and a broad range of constitutional powers has been provided in order that these objectives could be met.

As a national body it is important that its operations and policies are determined in line with the national interest and so the administrative Council has wide representation from a range of government and industry bodies. Details of the representation are given in Appendix B.

At the time of initiation of the AMF concept it was considered that Adelaide would provide a more suitable location (Figure 2). Two generous donations towards the capital fund from Adelaide-based donors, allocation of crown land by the South Australian Government and substantial financial support from 27 mineral and petroleum companies to meet operating costs in the first three years served to seal the proposition.

AMF's education programme. Details of the continuing education philosophy and range of education programmes at AMF are given elsewhere in Crowe (1978) and Crowe (1980). From the commencement of operations in January 1972 to 30th April 1982, one hundred and eighty two courses and seminars have been presented in Australia with another eight being offered in South East Asia, Indonesia, the Philippines, Papua New Guinea and Singapore.

Figure 2. AMF location.

A total of 5,419 students have benefited from these programmes; the bulk of the students have come from industry and in most cases all expenses have been met by their supporting company or organization. One of the major concerns at this stage is the lack of participation of staff from tertiary institutions due invariably to the reduced funds available to these organizations in these times of economic stringencies. In an endeavour to increase such participation in AMF programmes, a subsidy system has commenced in 1982 whereby a limited number of spaces at AMF programmes will be available to selected tertiary institute staff at substantially reduced registration fees, thereby fostering interchange between academia and industry.

Information services development. In parallel with the development of the education programme at AMF an evolving programme of information services based on a substantial geoscience library has continued.

In referring to geosciences, AMF has used the term in its broadest sense because the services provided by AMF cover the mineral industry as a whole and the petroleum industry from exploration through to oil and gas distribution to the refinery or gas plant.

Close liaison with industry and government and tertiary institutions relating to the geosciences is maintained because AMF has a strong co-ordinat-

ing role. In many instances it has acted as the catalyst to initiate development. In the early years of AMF's operation a survey was undertaken of industry and government information needs pertaining to mining and petroleum and subsequent developments have evolved from the recommendations of the survey report (Dixon and Tellis, 1972). Specifically the information services provided by AMF are:

- All conventional library services.
- Current awareness services through a monthly bulletin: Earth Sciences and Related Information - Selected Annotated Titles (ESRISAT) with full document back-up, covering national and international geoscience literature on a selective basis.
- Retrospective reference and on-line search services with access to Australian data bases and overseas data bases through Lockheed Dialog and SDC in the USA, QL/Systems in Canada and ESA in Europe. Access to other systems will be arranged as required.
- Creation, co-ordination and control of the Australian Earth Sciences Information System (AESIS), amplified later in this paper.
- Library education programmes and consulting services.

A communication centre. While reference has been made in this paper to the role of AMF as an institute of information transfer, its broader role is that of a communication centre to promote whenever possible exercises which improve the communication process within the two industries of minerals and petroleum and from the two industries to the wider public.

The problem of interdisciplinary communication within the industries has already been highlighted. Aside from the communication between disciplines other factors impinge upon the information process.

For example, governments in Australia are now more sensitive to public demands in many areas. This has allowed many individual groups to stress areas of concern for such things as pollution of the environment, the rights of minority indigenous peoples (the Australian Aborigines) and there has been greater intrusion of governments into not only control of, but competition with mineral and petroleum companies. Further, the effect of international politics and marketing influences on local decision making in the mineral and petroleum industries is of paramount significance.

In the light of all this it is no longer satisfactory, for example, for a graduate geologist to be a specialist in only a chosen geological discipline. To these technological skills must be added skills in environmental matters, dealing with indigenous peoples, communicating with government departments (in some cases fifteen to twenty different departments), mineral economics, mineral and petroleum law, communicating with the public at large, international mineral marketing and industrial relations.

One of the privileges of purveying information to the geoscience commun-

ity is that it comprises an exciting group of people including entrepreneurs, highly-skilled technologists, some with brilliant minds, some as 'prima donnas' and very much individualists. Most have that pioneering spirit and sense of adventure which is so essential to the resource industries because mines and petroleum wells are only where you find them whether in the oceans, the arid zones or the deepest jungle and not in city outskirts. With this range of people to serve, the challenge is there to create and develop services which meet their needs and if possible to anticipate their needs. These are people who are seekers of information to:

1. Update their existing skills.
2. Learn new skills.
3. Learn to communicate with other disciplines and a wide range of people.

The first pre-requisite then of any successful provider of information is to develop information transfer processes and systems which meet the needs of the practitioners in their industries. The design of systems to meet the needs of the information specialist is doomed to short term failure and eventual extinction if those needs do not match those of the practitioner. The emphasis, therefore, in all things must be on USER ORIENTATION.

It is in the light of this user orientation approach that the importance of developing communication skills in professionals within the mineral and petroleum industries has been highlighted.

At AMF technological courses have had this development emphasised and recently instituted management programmes place great emphasis on communication in the faculty programme.

In addition training programmes are organized to assist the technologist to benefit from information systems. In this regard the importance of the information scientist is highlighted as a helpful intermediary between the needs of the technologist and the information source. In some circles the future technologist is seen as a computer specialist with a terminal at the elbow carrying out interactive interrogations at will.

However, AMF has seen fit to emphasise the fact that not all valuable information is necessarily available only through computer-based information systems. Valuable as these systems are they are only part of an information resource comprising, in addition, people and a great range of special collections of very useful information.

This then has been a major development within the AMF services - to provide a total service to the enquirer through the specialist librarian, information analyst and subject specialist with access to extensive national and international resources through co-operative arrangements and the use of the new information network systems.

AMF's success will continue to depend on its ability to assess the needs of the industries it serves and it has several procedures for this. One such method is the use of the seminar to bring together practitioners and purveyors of information to examine the state-of-the-art and to evaluate patterns for future development. It was at one such seminar in 1975 that AMF was commis-

sioned to co-ordinate the development of a national data base for the geosciences and so the Australian Earth Sciences Information System (AESIS) was born.

Australian Earth Sciences Information System (AESIS)

AESIS is the Australian national earth sciences reference data base. Brief details of its scope and general content are given in Appendix C, in the form which accompanies every issue of *AESIS Quarterly* one of the principal products from the data base.

It is to be stressed that AESIS is not just a geological data base but endeavours to cover the full range of topics that takes in "a broad spectrum which has the common thread of involvement with the earth, its resources, and its environment" (Parkin and Tellis, 1977) in the Australian context. See Appendix C for the Broad Subject Categories covered.

At the end of December 1981 there were about 17,000 citations on file, 40% of which cover unpublished material mostly held by the State Geological Surveys and the BMR. The annual rate of input for current material averages between 3,000-3,500 records.

Though this is not a large file relative to other international geoscience data bases, our studies have shown that, excluding ephemera, it is a very major advancement on the Australian content of any other geoscience reference source.

AESIS development and philosophy. The development of AESIS, its indexing vocabulary - the Australian Thesaurus of Earth Sciences and Related Terms - and associated products and services, including costings and some cost benefit figures, have been discussed by Parkin and Tellis (1977) and Tellis (1981) in earlier papers.

However, some of the philosophy associated with the system and experience gained in development of AESIS could be of interest to this forum.

Some developmental factors. In essence our developmental philosophy has been guided by two over-riding criteria: pragmatism and co-operation.

Nevertheless the viability of AESIS has rested on sound initial analyses incorporating subjective and intuitive weightages, and an implementation pattern that has endeavoured to respond to the needs of both the users and the generators of geoscience information in Australia.

It is obvious that there should be much coincidence between the people that make up these two populations; what may not be as obvious is that their characteristics in each role are not necessarily the same. Proprietorship does not normally engender a philanthropic disposition whilst deprivation usually fosters an acquisitive instinct. Such is not in the best scientific tradition but as we move outwards from the scientific core to the inevitable areas of economic and political constraints the milieu changes and so therefore do the considerations upon which decisions are made.

Within these generalizations the main elements considered necessary for a viable working reference data base is shown in the simplified models at Figures 3a and 3b, presented at another forum, Tellis (1979). The elements represent the following considerations:

i. A sizeable and growing area of information which is useful but not readily accessible	TARGET INFORMATION
ii. A relatively large population of users who would use this information if it were accessible	CLIENTELE
iii. A system through which the two could meet; a storage and switching mechanism	DATA BASE
iv. Resources to sustain the operation	FUNDS, REVENUE, CO-OPERATIVE FUNCTIONING
v. Management	CONTROL and CO-ORDINATION

The implemented version of this configuration for AESIS is shown in Figure 4.

The most important feature of AESIS, which with the Canadian system is unique, is its coverage of unpublished documented information, referred to in the second group of 'Target information' in Figure 4. The usefulness and viability of AESIS rests very much on its ability to function successfully as a national referral system for this body of documented information.

A pragmatic system for transmission of information on these documents which did not affect their proprietary nature was evolved and implemented on a co-operative basis. The resources of governments and the flexibility of industry was combined to achieve this. The system is sensitive to the requirements of the custodians of these documents and the needs of users, and importantly is complementary to the State and BMR systems. The better the individual organization's own system the better has been their participation in the national system.

AESIS also bridges the gap in coverage of Australian mining and extractive metallurgy documentation which has no comparable access through any other system.

AESIS working system. AESIS is mounted on CSIRONET, the Australia-wide computing network hosted by the Commonwealth Scientific and Industrial Research Organization (CSIRO), Figure 5. The software and all special programs and routines, about forty-five to date, have been developed by the Systems Development Group of CSIRO's Central Information Library and Editing Section (CILES). The computing system briefly described by Parkin and Tellis (1977) has since been considerably augmented.

Public on-line access is available through AUSINET, the Australian bibliographic computing network (Figure 5) hosted by ACI Computer Services utilizing conversion programs developed by that organization. Again the resources and expertise of governmental agencies and the entrepreneurial initiatives and

Figure 3a. Simplified main elements in information transfer.

Figure 3b. Simplified main elements in overall functioning system.

Figure 4. AESIS overall functional format

Figure 5. AMF hookup with national networks.

flexibility of industry have been combined to advantage. Access through AMF for retrospective searches is also provided and represents about 50% of the usage of AESIS for this purpose, mostly through telephone search requests received from around Australia. Repackaged products in the nature of *AESIS Special Lists* on a range of topics have proved very popular. Where possible these reference lists are organized under AESIS broad subject categories and are produced with some or all of the seven indexes which accompany *AESIS Quarterly* as one composite document. The whole production is machine-based involving negligible intellectual involvement, through to camera-ready computer type-set copy.

From Volume 8 (1983) the map sheet indexes will be accompanied by a graphic indication of 1:250 000 sheet areas in which new reports have been released on open-file.

Retrospective input programme. One of the factors that made the commencement of AESIS possible in 1976 was the decision to cover only current material from the year of commencement. Retrospective material was to be included as and when received. As a consequence retrospectivity in AESIS has been running at about 15%.

An attempt at some retrospective input was made in 1980-81 and the major published Australian geoscience serials literature for 1975 was included. Notwithstanding the continuous pressure to include additional retrospective material it was clear no significant progress could be made without the availability of substantial resources.

Some major industry groups had been pressing for more retrospective depth in the data base and a survey conducted by the Australian Geoscience Information Association in 1980 to assess AESIS showed the only criticism received concerned the lack of retrospectivity in the data base.

In response to these demands AMF, with AESIS Advisory Committee endorsement, initiated a proposal for the input of retrospective material which would include only unpublished literature, as the main published material would have been captured by international data bases such as GeoRef, access to which was now readily available in Australia. A ten-year period back to 1965 was recommended for coverage as it represented a period of high activity in the mineral and petroleum industries in Australia when considerable information and data were generated.

As AMF is a not-for-profit organization, the availability of funds for developmental programmes is limited; this proposal was therefore put to industry through AMIRA in mid-1981. Sufficient funds were obtained from a number of sponsoring companies and organizations and implementation of the programme commenced on 1 March 1982.

For greater flexiblity, economic and long term advantage a PDP 11/44 mini-computer hooked into CSIRONET is being used for all data entry (Figure 5). The mini-computer can function as a host work station on CSIRONET and will be accessible to all terminals on the network if and when required. In due course additional usage is envisaged such as the creation and maintenance of small special reference and factual data files, maintenance and up-dating of the thesaurus and some local shared usage, and eventually distributed data

entry on-line. CSIRONET facilities for retrospective searching and the production of computer type-set copy, output on microform, graphics and tapes will continue.

The retrospective programme is scheduled to cover some 20,000 open-file and departmental unpublished reports, and higher degree theses. The project is expected to take two years to complete.

There will be a twelve-month lag before these retrospective references are available for public use. They will however be available for access to the companies and organizations supporting the project. Periodic hard copy listings in the same format as *AESIS QUARTERLY* or the repackaged *AESIS Special List* series will also be available to these organizations as will be microfiche cumulations in due course.

Better Information Transfer Through Better Retrieval

In the progression from documenting available information to inclusion of this recorded information in some store (data base), to retrieval of references when required, there are quite obviously many factors involved which influence the efficiency or reliability with which information is eventually obtained.

Indexing through intellectual involvement has a time honoured place in this process, whether it be by use of controlled vocabularies or free language, and machine searching of text is gaining increasing popularity as computing systems grow in sophistication and economic availability. The indications are that these methods are equally acceptable. With the growing availability of documentation and the printed word in machine readable form right from the creation of, at least, the published record, the free language process is being seen as faster and certainly more economical.

Nevertheless neither the machine nor the indexer - within the normal economic constraints imposed on the indexing process - can detect concepts which are not explicity mentioned in the record. The record to all intents and purposes today, and probably for some time to come, is the title and abstract of a document and whilst the expert indexer has the advantage here, as far as the machine is concerned the title and abstract is the record.

Editors have always asked for meaningful titles and good abstracts. With the trends we have just discussed, the connotation of 'meaningful' and 'good' have changed somewhat, and the persons affected by this shift in emphasis are the authors and generators of documents.

Author involvement. Authors must now bear in mind that titles and abstracts are not just for human consumption any more. The language and terms used in these areas of their documents must not only say what the work is about, but also cover the concepts involved through vocabulary which takes into consideration the searchers point of view for retrieval by machine systems.

To aid this process in the geosciences in Australia, the Foundation has suggested to all major geoscience publishing societies and organizations that

they adopt the practice of instructing authors to include key-word strings with their papers/documents. No institution has negated the proposal as such and some of the major institutions have or are implementing the process.

There has been some apprehension expressed in some forums with regard to allocation of terms by authors, mostly from a misunderstanding of or wrong use of the practice. It is not contended that the author is necessarily the best person to allocate indexing terms. What is being said is that authors should be the best persons to identify the concepts in their contributions, and even more importantly should be given the opportunity to nominate the concepts they consider to be important for retrieval purposes. The vocabulary used for actually indexing concepts with some consistency can probably be left to the monitoring/controlling agency.

Diodato (1981, p 361-369) says that "discussions of source indexing have taken place at least since the early 1960s". He identifies many journals world-wide where source indexing is used. From his study of the American Mathematical Society author indexing programme he suggests that authors' contributions enhance the indexing effort.

We believe, however, that the process does much more than that. Adoption of such a practice must progressively alert authors to the requirements of the information transfer process as they alternately are generators of information and increasingly users of computer-based information retrieval systems. This in-built educational process would help to tighten the feed-back loop and contribute significantly to better information transfer through better retrieval and in some measure better technical communication in the geosciences.

Conclusion

Co-operative working between a range of government and industry bodies with a suitable and acceptable co-ordinating agency to foster continuing education and national information services has proved a successful formula for assisting better information transfer in the geosciences in Australia. This has especially been so for unpublished material.

The provision of two-way forums for leaders in industry, academia and government to interact with the geoscience community on a programmed basis on the one hand, through to encouragement of authors to participate in indexing to increase their cognisance of the information transfer process in today's machine-based information systems on the other must contribute significantly to better technical communication in the mineral and petroleum industries in Australia.

Acknowledgement

Information supplied by officers of all the Geological Surveys with respect to early publications and open-file reports held by their respective Surveys is gratefully acknowledged. Thanks are also due to Miss Claire Conroy and Mrs Ann Ninham of the AMF library for checking details presented in Figure 1 and Table 1 and to Mrs Helen Ingham for typing the manuscript.

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Appendix A

First Formal Publications and Some Early Major Contributions to the Geoscience Literature of Australia, Principally by Officers of the State Geological Surveys*

1. New South Wales

1876	First Annual Report of the Department of Mines for the year 1875.
1880	First State geological map (based on earlier work by Rev. W.B. Clark and S. Stutchbury).
1882	Etheridge, R. Jr and R. Logan Jack. A bibliography of papers on Australian geology.
1901	Pittman, E.F. The mineral resources of New South Wales. Sydney, New South Wales Geological Survey.

2. Northern Territory

1882	Tate, Professor R. produced first specific geological report dealing with NT.
1889	Brown, H.Y.L. produced 14 reports covering the geological structure and almost every mineral bearing area.
1889	Brown, H.Y.L. First geological map of NT.

3. Queensland

1872	Daintree, R. Notes on the geology of the colony of Queensland. Geological Society of London. Quarterly Journal 28: 271-317.
1879	Gregory, A.C. Report included in Parliamentary Papers.
1883	Jack, R. Logan. First sketch of a geological map of the Hodgkinson Goldfield. Geological Survey of Queensland. Publication no. 14.
1886	Jack, R. Logan. Handbook of Queensland Geology. Geological Survey of Queensland. Publication no. 31. (Also issued with Essays prepared for the Colonial and Indian Exhibition, London, 1886).
1892	Jack, R. Logan and Etheridge, R. Jr. The geology and palaeontology of Queensland and New Guinea. Geological Survey of Queensland. Publication no. 92.
1914	Dunstan, Benjamin. Queensland Mineral index. Geological Survey of Queensland. Publication no. 241.

4. South Australia

1846	Burr, Thomas. Remarks on the geology and mineralogy of South Australia. (in Deputy Surveyor General's report).
1848	Mines and mining companies in South Australia in the Royal South Australian Almanack for 1848 (Extracts reproduced by H.Y.L. Brown in Record of the mines of South Australia, 4th edition, 1908).

1883	Brown, H.Y.L. First geological map of South Australia (at 16 miles to an inch).
1887	Brown, H.Y.L. A record of the mines of South Australia. (Substantially revised and augmented in the 4th edition compiled by L.C.E. Gee, 1908).

5. Tasmania

1882	'Mining Department' reported on in Parliamentary reports. G. Thureau appointed Inspector of Mines in that year.
1888	Johnston, R.M. A systematic account of the geology of Tasmania. Hobart, Government Printer.

6. Victoria

1853	First geological reports included in Parliamentary Papers.
1856	Quarter sheet (6 miles x 9 miles) mapping programme commenced (a total of 86 were published).
1859	Mining Surveyor's Report. Board of Science - no. 1.
1869	Brough Smyth, R. Goldfields and mineral districts of Victoria. Melbourne, Government Printer.
1874	Geological Survey of Victoria. Report no. 1.

7. Western Australia

1847	Gregory, J.W. and Gregory, F.T. presented a geological map and sections of part of Western Australia to the Geol. Soc. London.
1861	Gregory, F.T. The geology of a part of Western Australia (paper presented to Geol. Soc. London).
1871	Brown, H.Y.L. General report on a geological exploration to the North East of Champion Bay. Perth, By Authority.
1886	Nicolay, Rev. C.G. Some notes on the geology of Western Australia (for the Colonial and Indian Exhibition in London, 1886).
1889	Government Geologist first Annual General Report.
1894	Woodward, H.P. Mining handbook to the Colony of Western Australia. Perth, Government Printer.
1898	Maitland, A. Gibb. Bibliography of the geology of Western Australia. Geological Survey of Western Australia. Bulletin no. 1.
1900	Maitland, A. Gibb. The mineral wealth of Western Australia. Geological Survey of Western Australia. Bulletin no. 4. (Maitland published 91 Bulletins 1896-1922).

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* Based on information in Johns (1976) and details supplied to the authors by officers of the respective Surveys.

Note: E.W. Skeats (1933) states 'The published works of most of the early pioneers and explorers of Australia show clearly the pluck and skill displayed in pursuit of their investigations'. Some of the more important contributions that he mentions in addition to the above are those by Major T.L. Mitchell (1839), Dr Ludwig Leichhardt, a Prussion scientist (1843-45),

Count P.E. Strzelecki, a Polish geologist (1845), Charles Darwin (1844), James D. Dana, the great American contemporary of Darwin (1890), J.B. Jukes (1846), subsequently Director of the Irish Geological Survey; E.T. Hardman (1883), Rev. J.E. Tenison-Woods (1862); E.M. Hargraves (1854).

(from Skeats, Professor E.A., 1933, Some founders of Australian geology. Australian National Research Council. David Lecture, 1933, no. 1. Sydney, the Council.)

Appendix B

Representative Council of Australian Mineral Foundation

Seven nominees of Council including the Chairman and Deputy Chairman:

Representatives from:

Colleges of Advanced Education
The Australasian Institute of Mining and Metallurgy
Australian Coal Association
The Australian Mineral Development Laboratories (AMDEL)
Australian Mining Industry Council
Australian Mineral Industries Research Association (AMIRA)
Australian Petroleum Exploration Association (APEA)
Commonwealth Scientific and Industrial Research Organization
Commonwealth Department of National Development and Energy
Petroleum Exploration Society of Australia (PESA)
State Departments of Mines and Geological Surveys
Universities (Schools of Geology)
Universities (Schools of Mining Engineering)

Appendix C

AUSTRALIAN EARTH SCIENCES INFORMATION SYSTEM (AESIS)

AESIS is the Australian national earth sciences data base developed by the Australian Mineral Foundation in cooperation with the Bureau of Mineral Resources - Geology and Geophysics, Commonwealth Scientific and Industrial Research Organisation, State Departments of Mines and Geological Surveys, the National Library of Australia, the Australian Geoscience Information Association, and many companies. AESIS is coordinated by the Australian Mineral Foundation.

AESIS covers Australian-generated published and unpublished documented material over the full range of the earth sciences, as indicated by the Broad Subject Categories listed on the inside back cover. From 1979 AESIS also covers material published on continental Australia by non-Australian sources.

AESIS Quarterly is the hard-copy current awareness service produced from this data base.

☆ *AESIS Quarterly* contains citations in-put to the system during the preceding quarter. Entries are arranged under broad subject categories. *AESIS Quarterly* is published in March, June, September and December. Each issue includes 7 indexes: Subject, Locality, Author, Map Sheet (1:250 000/ 1:100 000), Mine/Deposit/Well name, Stratigraphic name and Serials index. Cumulative indexes for the year are included in the December issue.

☆ An explanation of the elements comprising a citation is given on the inside back cover.

☆ A *progressive* cumulation called *AESIS Cumulation*, re-sorted in main author sequence, with all 7 indexes, is produced separately on microfiche and included with the December issue of the *Quarterly* each year. The *Cumulation* is produced in 5-year segments.

☆ The annual subscription to *AESIS Quarterly* for 1982 is $Aust. 125.00 This subscription includes *AESIS Cumulation* on microfiche. For AMF member companies a subscription to *AESIS Quarterly* is automatically included in their membership fee.

☆ AESIS is available for retrospective computer searches through AMF and on AUSINET. Charge per search through AMF is $Aust. 30.00, plus 15¢ per off-line printed citation, on a 24-hour turn-around basis. Priority searches incur additional charges. Charges are subject to review. AUSINET has an independent charging schedule.

☆ AESIS commenced in 1976, but coverage of Australian-generated published material now goes back to 1975. Other retrospective material is in-put to the system as and when received and comprises about 15% of the data base content so far.

☆ Earth science workers and organisations in Australia are encouraged to register material in AESIS to ensure that their contribution to the national information resource is both recognised and generally available to the earth science community. For unpublished material, this may be done by the use of Data Transmission Sheets, a copy of which is enclosed with each issue of the *Quarterly*. Material can include papers, reports, theses, maps, explanatory notes etc. For published material, please check that AMF is receiving copies.

☆ The Australian Thesaurus of Earth Sciences and Related Terms, 2nd edition (1979) is used for indexing in the system.

For further information on the system or for retrospective searches or help in obtaining copies of cited material not readily available from conventional sources, please contact:

Manager, Information Services
Australian Mineral Foundation
P.O. Box 97, Glenside,
South Australia 5065

Telephone: Adelaide (08) 79 7821
Telex: AA 82520

AESIS BROAD SUBJECT CATEGORIES

1000	Aerial surveys	1230	Geophysics	1390	Mining
1010	Analytical chemistry	1235	Geosphere	1400	Miscellaneous
1020	Blasting	1237	Historical geology	1410	Oceanography
1030	Cartography	1240	Hydrogeology	1420	Operations research
1040	Chemical engineering	1250	Industrial materials	1430	Palaeontology
1045	Climatology	1260	Management	1440	Petroleum
1050	Coal	1270	Marine geology	1450	Petrology
1060	Comminution	1280	Marine mining	1460	Policy and legislation
1070	Computer applications	1290	Materials handling	1470	Pollution
1075	Control systems	1300	Materials technology	1490	Radiation
1080	Dredging	1305	Mathematical applications	1500	Regional geology
1090	Drilling	1310	Metamorphism	1510	Rehabilitation
1100	Earth sciences information	1330	Mineral economics	1520	Remote sensing
1110	Economic geology	1340	Mineral exploration	1530	Research and development
1120	Education	1341	Mineral exploration - NSW	1540	Safety
1130	Energy	1342	Mineral exploration - NT	1550	Sedimentary geology
1140	Engineering geology	1343	Mineral exploration - PNG	1560	Seismology
1150	Environmental protection	1344	Mineral exploration - QLD	1580	Steel making
1160	Extractive metallurgy	1345	Mineral exploration - SA	1590	Stratigraphy
1170	Extraterrestrial geology	1346	Mineral exploration - TAS	1600	Structural geology
1180	Gemstones	1347	Mineral exploration - VIC	1610	Surficial geology
1185	General geology	1348	Mineral exploration - WA	1620	Surveying
1190	Geochemistry	1350	Mineral industry	1625	Synthetic fuels
1200	Geochronology	1360	Mineral processing	1630	Volcanism
1210	Geodesy	1370	Mineral resources	1640	Wastes
1220	Geography	1380	Mineralogy	1650	Water resources

SAMPLE ENTRY

1550 SEDIMENTARY GEOLOGY

ENTRY NO. — TITLE

Q79-10 The Proterozoic Barney Creek Formation and some associated carbonate units of the McArthur Group, Northern Territory.

AUTHORS — Brown, M C Claxton, C W Plumb, K A

SOURCE — *Bureau of Mineral Resources, Geology and Geophysics. Record* 1969/145, 59 pages; 12 fig, 15 plates, 40 ref, 5 tables (1969)

*NOTE/AVAILABILITY — [Available at all open file centres]

ANNOTATION — *The stratigraphic setting and depositional environment of a massive sulphide deposit - the HYC.*

SUBJECT DESCRIPTORS — Syngenetic deposits/ Sedimentary environments/ Stratigraphy - NT/ Proterozoic/ HYC deposit/ McArthur Group/ Barney Creek Formation/ Northern Territory: McArthur River/ SE5303 — STRATIGRAPHIC NAME

MINE/DEPOSIT/WELL NAME — LOCALITY — MAP SHEET

* Notes and availability are shown in brackets, where appropriate. For example:

- **[Restricted]** - indicates that the document will only be available for sighting/copying by permission or negotiation with the source organisation.
- **[Open File - Qld. Available from the Department]** — means the document is available on 'open-file' with the Geological Survey of Queensland; similarly **[Open File - W.A. Microfilm roll available from the Department]** — means on 'open-file' with the Geological Survey of Western Australia; etc. and **enquiries are best addressed to the Department concerned.**
- Where there is no such indication the document is available either from the source shown in the citation, or through conventional library sources or AMF.

COCKINGTON PRINT

GEOSCIENCE INFORMATION IN THE GEOLOGICAL SURVEY OF SOUTH AFRICA

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Abstract-- Geoscience information has been the most important area of responsibility of the Geological Survey of South Africa since its inception in 1912. In meeting this responsibility the Survey has gathered, processed and communicated geological data and information by various means as is reflected in the large number of official publications, maps and reports that have been issued. At the same time the Geological Survey has also developed into a repository for geological information generated by the technologically advanced mining industry in the country.

The advent of computer technology has created new possibilities in utilising the wealth of geoscience information, and since 1976 the Survey has actively pursued means and methods of using the computer. This has resulted in a number of applications in two areas which can be broadly defined as data management and information management. Examples are a computer-based geoscience bibliographic data base called SAGEOLIT and a specialised data base for coal.

SAGEOLIT is a computer-based inhouse information referral system which has concentrated until recently on unpublished geoscience information on South Africa. Activities are at present directed towards extending the system to include published literature. The system uses and is based on the STAIRS system and references include the standard bibliographic data as well as keywords, abstracts, locality names and geographic references.

The coal data base which is being developed is based on borehole data submitted by mining companies and includes the localities of boreholes, lithological descriptions of the stratigraphic sequences, and data relating to the description, sampling and analysis of coal seams. The data base utilises a locally developed system called CORES (Coal Ore Reserve Evaluation System) and is used to calculate and evaluate coal reserves and resources on a regional basis.

Introduction

A growing awareness of the potential impact that computer technology could have on data and information management in the earth sciences led to several in-depth studies into this field in the developed countries during the late sixties and early seventies (Ward, 1979, Brisbin and Ediger, 1967, Parkin and Tellis, 1977).

A similar study was conducted in South Africa between 1969 and 1971 (Pretorius, 1971). This feasibility study into the possibility of establishing in South Africa an information storage and retrieval facility for the geological sciences was carried out under the auspices of the Council for Scientific and Industrial Research by the Economic Geology Research Unit of the University of the Witwatersrand. Funds were supplied by the South African Chamber of Mines.

The principle conclusions reached at the end of the study were:

- There is a need to establish an information storage and retrieval system in the geological sciences in South Africa, this need being largely motivated by a desire to know what information is contained in owner-controlled proprietary files and unpublished reports.
- It would be preferable to have this system take the form of an information analysis centre, producing bibliographies, indexes and condensed and reprocessed information.
- The best location for the centre would be at the Geological Survey.

In 1973 the Geological Survey indicated its willingness to accept this responsibility. After bringing about certain organisational changes during 1974 and 1975 the Geological Survey started working on this task, soon realising that:

- Before the establishment of a national geoscience information centre can be attempted, the expertise and experience should be developed through building inhouse information systems.
- Two distinguishable fields of interest, namely information management and data management would have to be addressed in doing so.

Since then a variety of geoscience information requirements have received attention and some solutions have been implemented. Two of these are described briefly in the remainder of the text.

SAGEOLIT-South African Geoscience Information Referral System

Between 1976 and 1979 while acquiring hardware and software systems the Geological Survey set out to define and design an inhouse information referral system, the philosophy being that an inhouse system largely reflects the needs of a national system and developing such a system would identify and help to solve most of the problems that could be expected when embarking on a national system.

Objectives and systems overview

An information referral or bibliographic system should be able to generate secondary

information such as bibliographies and indexes, provide SDI-services, and also provide hands-on access to allow for retrospective information searches.

In addition to these requirements the design of such a system for the geological sciences in South Africa also had to recognise that:

- Both published and unpublished information must be referenced, and unpublished geoscience information may be of a somewhat unusual nature i.e. files, maps, borehole logs, etc.
- Some of the material to be referenced, especially unpublished information, would remain with the originating organisation.
- Geoscience information is largely concerned with particular localities or geographic areas and is thus often of local interest only but, on the other hand, fundamental research findings are applicable worldwide.

A system configuration (Figure 1) which attempts to accommodate all these requirements was conceived. The system uses a data capture sheet (Figure 2) and utilises two commercially available software packages i.e. STAIRS (Storage And Information Retrieval System) and ATMS (Advanced Text Management System) for data capture and information retrieval respectively. A third software system TLIS (Thesaurus and Linguistic Integrated System), which is compatable with STAIRS, is also available and can be used to aid in the development of a geoscience thesaurus for South Africa.

Selection, indexing and abstracting

When actual work on the system started in 1979 all efforts were aimed at unpublished reports held by the Geological Survey. As a result a policy for selecting items to be referenced was almost unnecessary. More recently however, when it was decided to extend the system to include published literature, a guideline for selection was set so as to try to select for inclusion all published literature acquired by the Survey's library and which deals with geoscience in Southern Africa – Southern Africa being broadly defined as Africa south of 17° South – or deals with geological subjects which are considered to be of fundamental interest. Selection is done on a weekly basis by a panel of selectors who are geoscientists, each being responsible for a particular sub-discipline or number of related sub-disciplines. Selection further includes the responsibility of classifying an item as belonging to one of 25 broad subject categories.

In addition to the normal bibliographic information, indexing of unpublished information entails the assignment of three types of descriptors namely:

- Subject descriptors (includes stratigraphic terminology).
- Locality names.
- Geographic references (a code which uniquely describes an area in terms of latitude and longitude i.e. $1° \times 1°$, $\frac{1}{2}° \times \frac{1}{2}°$ or $\frac{1}{4}° \times \frac{1}{4}°$).

As most unpublished reports do not have an abstract a short descriptive abstract is prepared at the same time.

FIGURE 1. SYSTEM CONFIGURATION FOR A SOUTH AFRICAN GEOSCIENCE INFORMATION REFERRAL SYSTEM.

AUTHOR/COMPILER. _____

TITLE. _____

CORP. AUTHOR.

REFERENCE. _____

YR. _____ MO. _____ VOL. _____ NO. _____ PP. _____ LAN. _____ ABSLAN. _____

PUBLISHER. _____

PLACE. _____ ISBN / ISSN _____

HOLDING LIBRARY. _____ TYPE. _____

DOC ID. _____ CLASS. _____

FILE. _____ VOL. _____ NO. _____

SUBJECT DESCRIPTORS. _____

GEOGRAPHIC REFERENCE. _____

LOCALITY NAMES. _____

ABSTRACT/DESCRIPTION. _____

FIGURE 2. DATA CAPTURE SHEET USED FOR THE SOUTH AFRICAN GEOSCIENCE INFORMATION REFERRAL SYSTEM.

Most published literature nowadays appears in print with fairly detailed abstracts. As a result it was decided to limit indexing and abstracting of such material to adapting and shortening primary author-prepared abstracts, assigning geographic references where applicable to articles dealing with Southern Africa, and preparing abstracts for unabstracted Southern African literature.

Information retrieval and output

Information services are designed to retrieve information and to help individuals keep abreast of developments. The former is performed through retrospective search functions and the latter through current awareness services. The retrieval functions offered by the STAIRS software package allows an almost unlimited number of search, select and processing options. In essence it is possible to search the complete data base or selected parts of the data base for any significant word or combination of words which occur anywhere in the complete document profile or to limit a search to one of the "paragraphs" e.g. "author" in the document profile.

Until recently retrieval facilities have been used exclusively for retrospective searches. When at the end of 1981 it was decided to extend the system to include published literature it was also decided to introduce a current awareness service by producing a monthly acquisition list and an annual bibliography for South Africa. At present test runs for these services are being conducted.

Present status and the future

At present the system contains 2 800 references to unpublished information and 1 300 references to published literature, the growth rate being approximately 250 references per month. A considerable backlog still exists with regard to unpublished documents and it is conceivable that an attempt will also be made to input Southern African published literature retrospectively. The biggest single problem area at this stage concerns consistency in indexing and vocabulary control, improvement of which is largely constrained by limited human resources.

Use of the system has been limited to employees of the Geological Survey and as such it can still be regarded as being experimental. It has, however, been designed in such a way that it can be developed into a fully national system. A decision to do so will require a concentrated effort on the part of the Geological Survey in convincing mining companies, universities and other geoscience institutions not only to support the system as users but also to commit themselves to some extent into providing input for the system. The degree of support for such a scheme will no doubt depend on the quality of the services it can offer.

A Geological Data Base for Coal

The 1973 energy crisis has transformed coal from being just another mineral commodity into a strategic commodity. As a result coal mining and coal utilisation technology are

developing very rapidly and decisions concerning its exploitation from a national point of view require resource/reserve evaluations on a almost yearly basis. In 1978 it was decided to try to meet this requirement by developing a computer-based system that would be capable of rapidly re-evaluating reserves and resources as technological and economic variables change and is based on unbiased fundamental data, that can be updated with a minimum of effort as new data become available.

After evaluating available computer systems it was decided to use a locally developed system for this purpose. This system called CORES (Coal Reserves Evaluation System) was developed jointly by the Industrial Development Corporation of South Africa and Computer Sciences (Pty). It is an integrated combination of programs and routines for the capture, storage, retrieval and processing of geological and analytical data. It operates under the Computer Sciences Corporation's CSTS Operating System which is available on the INFONET Time-sharing network. The programs have been written for the latest FORTRAN release and use is also made of a general purpose data base management system.

During 1979 a test run was conducted and towards the end of 1980 the Geological Survey initiated the first phase of a programme which aims at eventually computerising all the available geological data for coal in South Africa. This first phase entailed the establishment of a geological data base for one of the major coalfields in South Africa namely the Highveld–Witbank coalfield and the calculation of total reserves for this field.

System and project overview

In concept the CORES system can be viewed as consisting of four sections (Figure 3) each providing a number of different functions:

- Data capture, validation, data base creation and basic geological reporting.
- Selection, subject to varying mining and quality constraints, including vertical selection of best mineable thickness.
- Geological interpretation, modelling, gridding and contouring.
- Reserve calculation and assessment.

Data accumulation and data base creation. In accumulating data and setting up a data base CORES uses a Project Control File. This file defines the structure of the input data as well as all valid parameters, codes, symbols and formulae. In addition the data base management system allows for the definition of a data base structure and contents through a data-definition language.

Basically CORES provides for the following categories of input data:

- Header data, i.e. data which uniquely identify and localise a borehole.
- Lithological data, i.e. descriptive lithological data which characterise and distinguish rock and coal units.

FIGURE 3. SIMPLIFIED FLOWCHART OF CORES.

– Analytical data, i.e. the results of chemical and physical analyses performed on coal samples.

Possibly the biggest problem that had to be dealt with during the Highveld–Witbank project was the fact that borehole and analytical data are not standardised – data had been submitted over a period of about 20 years by some 30 different mining companies. As a result a complete scheme was set up to correlate coal seams, code data onto standardised coding sheets (Figure 4) and capture data via interactive front-end capture and validation programs which were specifically developed for this purpose. It was also decided to use two types of input namely:

– A condensed record, that is, a description of coal seams, dolerites and overburden, the depth of such units and sampling and analytical data for coal.
– A detailed record which apart from the same data as the condensed record also includes a comprehensive lithological description of the complete stratigraphic sequence.

The reporting facilities – mostly posting and cross-sections – were mainly used during input as an aid in checking coal correlations and borehole localities.

Selection of data. It is common knowledge that coal seams vary both vertically and horizontally in composition and therefore in quality. It is also known that constraints that define mineable coal both from a technical and economic point of view also change from time to time. The Selection subsystem of CORES provides the facility of selecting a 'best horizon' within any particular coal intersection subject to quality contraints defined by the user. The subsystem provides for eight different modes of selection all using user-specified constraints and one of the following basic criteria:

– The thickest horizon.
– The thickest horizon within a range of thicknesses.
– The 'best' quality at a given thickness.
– The 'best' quality within a range of thicknesses.
– The weighted average of the entire seam or a specified portion.

The results of selection are stored in data files which are later used during the interpretation phase.

Apart from other objectives the Highveld–Witbank project was aimed at evaluating coal reserves on a regional basis and more specifically at calculating, for the major coal seams, total raw in-situ coal reserves and total raw mineable coal reserves.

The selection for in-situ reserves was done by using selection Mode 4, i.e. selection based on the weighted average analysis of the total coal seam, excluding only roof and floor protection, if specified. For total mineable coal reserves Mode 7, that is selection which finds the thickest possible band of coal within a maximum and minimum range of thicknesses which conform to specified quality constraints, was used.

Geological interpretation and modelling. The evaluation of exploration data can not be made by merely using numerical/mathematical procedures. Application of such techniques

FIGURE 4. STANDARDISED CODING SHEETS USED FOR CAPTURE OF COAL DATA

should only take place within the framework and under the influence of an acceptable geological model. Functions and facilities aimed at achieving this are provided in the Interpretation and Modelling subsystem of CORES.

This subsystem is founded on a set of procedures which create a 'grid' of values or a digital model for each of a set of variables and which also allow the user to change the grid in accordance with the applied geological interpretation. This can be done through one of three different approaches namely:

- Values for the variable being considered are interpreted and gridded according to the mathematical/numerical formulae of the gridding routines used in CORES.
- Data are interpreted and gridded by the gridding subroutines, the grid being influenced geologically by introducing additional digitised data such as dummy boreholes or user grids.
- A plot of values for the variable is produced, the geologist manually interprets and contours the data and introduces the manual interpretation back into the system by digitising.

Another facility provided in the Interpretation and Modelling subsystem is that of demarcating and defining areas for reserve calculation in terms of geological, mining or legal boundaries. At the same time areas of interpretation can also be specified to avoid extrapolation into areas where the density of data precludes meaningful interpretation.

The first objectives of the Highveld--Witbank project did not include any detailed geological evaluations of the coalfield or any part of it. For this reason use of the facilities afforded by the Interpretation and Modelling subsystem have in essence been limited to demarcating and defining reserve blocks in terms of mining, geographical and geological boundaries. A total of 58 reserve blocks was finally delineated for the project.

Reserve assessment. The Reserve Assessment subsystem of CORES firstly provides a facility to extract from the geological data base all the data pertaining to the cells of the digital model for those areas which are defined as reserve blocks. Secondly these are integrated with the data created during interpretation and gridding into a single model. This model is finally used for the calculation on a cell by cell basis of the total reserves for a particular block. In the eventual reserve report the system summarises the total reserves by means of a histogram which shows the distribution of reserves according to various mining and quality parameters. A summary of all the definitions, options and contraints defined by the user is also produced along with a printer map which indicates the distribution of unit cells used during reserve calculation.

Reserve reports for total in-situ coal reserves and total mineable coal for the 58 reserve blocks defined for the three major seams in the Highveld–Witbank coalfield were produced at the beginning of May 1982.

Present status

The Highveld–Witbank coalfield comprises an area totalling approximately 40 000 km^2. Between December 1980 and December 1981 geological and analytical data for just over 5 000 boreholes within this field were accumulated into a data base. As stated previously

this project represents the first phase of a programme for which the end objective is a national geological data base for coal. The second phase, namely computerising data for the Eastern-Transvaal coalfield, commenced in December 1981.

There is little doubt that the immediate results – reserve assessment on a regional basis – obtained from the Highveld–Witbank project are of great importance. However the most important benefit is that a facility has been created which will not only allow rapid reassessment of reserves but which also provide the means of doing a great variety of other investigations for the Highveld–Witbank coalfield. At least three such projects have already been motivated.

Conclusion

The management, processing and communication of geoscience data and information have always been considered to be of great importance by the Geological Survey of South Africa. The advent of computer technology has had a major impact on the methods and processes employed in these areas. The two examples outlined in the preceding text attempt to illustrate developments in the Geological Survey of South Africa resulting directly from employing these methods.

The geoscientist like most other scientists is basically result-orientated and therefore has little concern for his data once he has obtained a result. Perhaps the biggest contribution that computer technology could make in the geological sciences is to bring a realisation of the importance of a standardised approach in observing and recording geological facts. If this can be achieved advances in geoscience information management, processing and communication will be advanced significantly.

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THE CONTINENTAL SCIENTIFIC DRILLING PROGRAM DATA BASE - 1982

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Abstract--The Continental Scientific Drilling Program (CSDP) data base maintained at Lawrence Livermore National Laboratory is funded by the Office of Basic Energy Sciences of the Department of Energy. It is a central repository of information concerning approximately 1800 government funded and scientifically interesting drill holes in the United States. This data base can help reduce drilling costs and maximize scientific value of drilling efforts of government agencies and industry. The services of the CSDP data base are free of charge and available to all.

Introduction

The scientific community uses information obtained from drill holes to gain knowledge of the earth's history. A large amount of public and private funds is invested each year in drilling programs for geologic exploration. Most deep drilling programs have been in the oceans. The Deep Sea Drilling Program (1968) and the International Phase of Ocean Drilling (1975) are only two of these ocean drilling programs. But the concept of plate tectonics has shifted attention from the oceans to the continents. It became clear to the geoscience community in the 1970's that there was a need to maximize the scientific value of current and planned continental drilling efforts of government agencies and industry, and to supplement these efforts with holes drilled solely for scientific purposes (National Academy of Sciences, 1979, p. 8). The Continental Scientific Drilling Program was formed to provide this central focus for continental drilling and to direct communication and cooperation of various constituencies, thus maximizing the results of investments. As part of this program, Lawrence Livermore National Laboratory (LLNL) was funded by the Office of Basic Sciences of the Department of Energy (OBES/DOE) to establish a data management program (Howard, 1979). A data base was established and acts as a central repository which catalogues information on United States drill holes. Through the unrestricted use of this data base, it is possible to reduce drilling costs and maximize the scientific value of current and planned efforts of government agencies and industry by 1) offering the opportunity to add on

experiments, and 2) supplementing information from existing drill holes included in the data base (Energy and Technology Review, 1981, p. 25).

Initially, CSDP data base was to catalog federally funded drill holes. Most of these holes were drilled by DOE, and can be found in the list of DOE-funded drill holes (Howard, et al., 1980). This was quickly expanded to include scientifically interesting holes that are not federally funded. "Scientifically interesting" holes are those which are drilled in an area that has little or no previous information, holes reaching geologic basement, record setting holes, and other selected holes. The data base currently catalogs approximately 1860 drill holes. Most of these holes are government funded (at federal and/or state levels). Some are commercially funded.

The sources of information for the data base are varied. A nucleus for the data base of DOE-funded drill holes was provided by the A.D. Little Corporation (Little, 1979). United States Geological Survey (USGS) has provided their drilling inventories for fiscal years 1979, 1980, and 1981. Scientifically interesting drill holes from the Lawrence Berkeley Laboratory (LBL) Geothermal Resources Information Database (GRID) and USGS Geotherm Data Base are included. A number of holes are brought to our attention by state geologists and members of academia. Any person with information about a drill hole that meets CSDP data base requirements is encouraged to contact us in order that the hole may be included in the data base.

Data Base Structure

CSDP data base is maintained on the Livermore Computer Center (LCC) CDC 7600's through the Master Control Program. There are 24 textual and numerical parameters (arrays) for each drill hole.

Information about drill holes to be entered into the data base is generally submitted to us on drill hole data sheets (Appendix), which we have designed to collate the necessary information about each hole. The information is then taken from these sheets and formatted to the parameters in which the data are stored. An attempt is made to maintain the exact form in which the data are submitted, but some changes may be made to meet the parameter restrictions - integer format, length of text, word order, etc. English measurement units are currently used, since the drilling industry has yet to convert to the metric system.

Data Base Parameters (arrays)

IDN: A number assigned to the hole by us for record keeping purposes.
Hole Designation: The name of the hole.

Holes in Group: If there are many similar nearby holes in a project, they may be entered as a group of drill holes (entered once as a group rather than each hole entered individually) with the number of holes for the project noted.

Purpose: The reason(s) for which the hole was drilled. The categories are:

CG	Coal gasification
C	Coal
EG	Engineering geology
EQ	Earthquake studies
G	Gas
GE	Geologic exploration
GP	Geopressure
GT	Geothermal
HF	Heat flow
HDR	Hot dry rock
HW	Hot water
MER	Methane removal
MR	Mineral resources
NPR	Naval petroleum reserves
NT	Nuclear testing
NWR	Nuclear waste repository
OG	Oil and gas
OR	Oil recovery
OS	Oil shale
PS	Petroleum storage
RM	Radionuclide migration
U	Uranium
WR	Water resources

Site Location: County and state.

Site Coordinates: Latitude-longitude location is preferable for plotting procedures. If it is not possible to locate the drill hole by this method, Township-Range location may be used. Township-Range location must be identified by a baseline or meridian.

Surface Elevation: Mean feet above sea level of the drill hole.

Depth: Depth of the hole. If the hole is proposed, the planned depth should be entered.

Start Date: Start date of drilling. If the hole hasn't been started yet, this should be the proposed start date.

Completion Date: Completion of date of drilling.

Status: The current condition of the hole - proposed, injection, observation, plugged, etc.

Geologic Setting: The lithologic description of the formations penetrated by the drill hole.

Drilling Stages: Diameters and corresponding depths of the hole.

Casing Stages: Diameters and corresponding depths of casing in the hole.

Samples: Samples taken from the drill hole (note core, sidewall, or cuttings) and corresponding depths.

Geophysical Logs: A list of geophysical logs which have been run in the hole.

Well Testing: Any tests that have been performed in the hole.

Funding Agency: The government and/or private agency that paid for the drill hole. If there is more than one funding agency, list all.

Additional Information: Any necessary or pertinent information for the hole not included in other parameters; examples - project name, publication reference number, KGRA location, specific or multi purpose of hole.

Total Cost: The total cost of the hole. If the entry is for a group of holes, this value indicates total cost of all holes in the group.

Principal Investigator: The person responsible for the hole. This is the person who may be contacted for further information.

Information Submitted by: The person who submitted, and generally the one who has checked, the information listed for each hole. This person is not necessarily the principal investigator.

Date: The date the information for a hole was first entered into the CSDP data base.

Update: As new information becomes available for a hole, it is entered and the update is shown in addition to the original entry date.

The data base is constantly updated. Individual entries are updated as information on them is received. New drill holes are added as we learn about them.

Data Output

Any of the above parameters can be sorted on and ordered. For example, all holes sorted by depth; holes in oil shale; holes with temperature logs, sorted by depth; holes in California, drilled between 1970 and 1980, sorted by county; a large number of combinations are possible. The data can then be printed in two different formats - full page printouts or tabular listings. Full page printouts show all information included in the data base about one drill hole (Fig. 1). Tabular listings show selected parameters for any number of holes. Figure 2 is a page from a listing of all holes in California, sorted by county. It shows, from left to right, county, state, hole designation, purpose, depth, and record number. Most parameters can be printed on listings.

Data Base Access

The services of CSDP data base are available to all, and are free of charge. For printouts or information about the data base, please call or write:

COLORADO

HOLE DESIGNATION CER RB MHF-3

SITE LOCATION RIO BLANCO CO., COLORADO

SURFACE ELEVATION 6517 FEET

DEPTH 8170 FEET

SITE COORDINATES

T03S,R98W,S11NW
6TH PRINCIPAL MERIDIAN

PURPOSE: GAS

START DATE (YR-MO-DA) 74-05-10
COMPLETION DATE 74-09-17

GEOLOGIC SETTING (DEPTHS IN FEET) -

GREEN RIVER 445-2980; WASATCH 2980-5590;
FORT UNION 5590-6452; MESAVERDE 6452-TD

LOGGING (DEPTHS IN FEET)

INDUCTION, LATEROLOG, SONIC, MICROSEISMOGRAM,
GAMMA, NEUTRON POROSITY, TEMPERATURE

DRILLING STAGES (DIAMETERS (IN.) AND DEPTHS (FT.))

26. 0-290; 15. 290-5603; 9.88 5603-TD

CASING STAGES (DIAMETERS (IN.) AND DEPTHS (FT.))

16. 0-290; 10.75 0-5600; 7. 0-8165

SAMPLES (DEPTHS IN FEET)

CONVENTIONAL CORE 5925-7085

WELL TESTING

DRILL STEM, PRE AND POST FRACTURE TESTS,
SPINNER, AUDIO

PRINCIPAL INVESTIGATOR

R. L. MANN
CER CORPORATION
2225 E. FLAMINGO RD
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INFORMATION SUBMITTED BY:

CHARLES ATKINSON
PROJECT MANAGER
DOE / NEVADA OPERATIONS OFFICE
2225 E. FLAMINGO RD.
LAS VEGAS, NV 89109
(702) 735-7136

ADDITIONAL INFORMATION

WESTERN GAS SANDS PROJECT. TEST ADVANCED
HYDRAULIC FRACTURING TECHNOLOGY AND COMPARE
TO NUCLEAR STIMULATION

FUNDING AGENCY(S): DOE; CONSORTIUM

DATE 80-07-16
UPDATE 81-10-09

RECORD 1652

Figure 1. Full page printout showing all information included in the CSDP data base about one drill hole.

CSDP - CONTINENTAL SCIENTIFIC DRILLING PROGRAM DATABASE - LLNL

COUNTY	STZ	HOLE DESIGNATION	PUR-POSE	DEPTH	RECORD
ALAMEDA	CA	LLNL-SH-1	GE	155	2209
ALAMEDA	CA	LLNL-SH-2	GE	155	2210
BUTTE	CA	T12N/R1E-34RD1 (TEST HOLE 2)	WR	1400	413
COLUSA	CA	1 WILBUR HOT SPRINGS	GT	3757	1225
COLUSA	CA	SUNDECO-BAILEY MINERALS 1	GT	9104	1904
FRESNO	CA	COALINGS POLYMER INJECTION WELLS	OR	2271	1345
FRESNO	CA	VEE 3	U	2943	1842
FRESNO	CA	17S/15E-19A01M	U	1611	1844
FRESNO	CA	TEXAS PACIFIC LUCAS 1	U	1141	1845
FRESNO	CA	42-30 J	U	5010	2018
FRESNO	CA	WILSON S71-7	U	5000	2019
FRESNO	CA	HELM UNIT 23-35	U	4765	2020
FRESNO	CA	NORD-MONTARA A-5	U	5100	2021
FRESNO	CA	34-3P	U	5010	2022
FRESNO	CA	NOBLE 15	U	5000	2023
FRESNO	CA	CALIFORNIA LANDS 87-15	U	5000	2024
FRESNO	CA	YOUNG 4-15	U	5000	2025
FRESNO	CA	COELHO	U	5000	2026
FRESNO	CA	BOSTON RANCH 2	U	5000	2027
GLENN	CA	BUTTE CITY	WR	1450	1959
HUMBOLDT	CA	GBL	HF	540	294
IMPERIAL	CA	KERSHAW 1-3	GT	12000	295
IMPERIAL	CA	S.H. ELMORE 1	GT	12000	296
IMPERIAL	CA	HOLLY SUGAR-DOE 44P	GT	10000	298
IMPERIAL	CA	BORCHARD A-3	GT	12888	299
IMPERIAL	CA	FEDERAL-DOE-SPERRY 87-6	GT	6290	1
IMPERIAL	CA	LACEY 1-28	GT	6600	790
IMPERIAL	CA	MERCER 1-28	GT	13383	904
IMPERIAL	CA	MERCER 2-28	GT	13381	905
IMPERIAL	CA	SLATER 1	GT	13097	906
IMPERIAL	CA	VEYSEY 7	GT	5689	907
IMPERIAL	CA	VEYSEY 8	GT	8905	908
IMPERIAL	CA	VEYSEY 9	GT	6802	909
IMPERIAL	CA	VEYSEY 10	GT	6828	910
IMPERIAL	CA	EMANUELLI 1	GT	12831	60
IMPERIAL	CA	EAST BRAWLEY STRAT TEST 1	GT	850	923
IMPERIAL	CA	EAST BRAWLEY STRAT TEST 1A	GT	2002	924
IMPERIAL	CA	ORITA C-131	GT	2002	925
IMPERIAL	CA	CA-964 48A-7	GT	6916	926
IMPERIAL	CA	CA-964 46B-7	GT	3524	927
IMPERIAL	CA	CA-964 48-7	GT	7523	928
IMPERIAL	CA	SHARP 1	GT	6070	929
IMPERIAL	CA	SHARP 2	GT	6487	930
IMPERIAL	CA	MESA 5-1	GT	6017	931
IMPERIAL	CA	MESA 6-1	GT	8032	932
IMPERIAL	CA	MESA 6-2	GT	6004	933
IMPERIAL	CA	MESA 8-1	GT	6204	934
IMPERIAL	CA	CA-1903 18-28	GT	8002	936
IMPERIAL	CA	CA-1903 16-29	GT	8022	937
IMPERIAL	CA	CA-1903 46-7	GT	3094	938
IMPERIAL	CA	FEDERAL 16-30	GT	7999	939

Figure 2. One page of a tabular listing of all drill holes in California included in the CSDP data base, showing county, state, hole designation, purpose, depth, and record number.

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Changes and Development

The data base is being changed from Master Control Program (MCP) to FRAMIS: MCP manages data as a flat file, while FRAMIS has a relational arrangement. Both data base management systems were developed at LLNL. We are evaluating computer programs to generate U.S. and state maps showing drill hole locations. References to other drill hole data bases are now being added, and these will be included with each data printout.

Plea for Help

The main purposes of this data base are to catalog specific drill holes and to maximize the scientific value of current and planned drilling efforts. To do this, we need current material. Existing data base entries must be updated with accurate data. Outdated and incomplete information quickly limits the usefulness of the data base. Holes that meet the data base requirements - government funded and/or scientifically interesting - are important to include. If you know of drill holes that meet these requirements, please write or call to inform us of them.

Especially important is publicity of drill holes that offer the opportunity for add-on scientific investigations. The Continental Scientific Drilling Committee of The National Research Council publishes a "Drilling Early Warning Newsletter" (DEW) when such a drilling project is brought to their attention. Pertinent information about such projects should be directed to Robert Andrews, Staff Officer of Continental Scientific Drilling Committee, 202-389-6319.

CSDP Data Management Workers

A number of people of the Earth Sciences Department of LLNL have worked on the compilation of data, the formation of the data base, and its maintenance. They are:

Project Leader: Nancy Howard
Advisor: Don Emerson
Programmer: Glenn Hage

Technicians: Mary Lou Higuera, William Richardson, Carmela Bell
Geologists: Gayle Pawloski, Bern Qualheim, Neil Crow

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APPENDIX

CONTINENTAL SCIENTIFIC DRILLING PROGRAM
DATA BASE

DRILL HOLE DATA SHEET

1. Hole designation:_____

2. Project name (if applicable):_____

3. Number of similar holes in group:_____

4. Purpose of hole:_____

_____

5. Site location: State_____

County_____

Coordinates Lat. (deg)_____(min)_____(sec)_____

Long. (deg)_____(min)_____(sec)_____

Latitude-Longitude location is preferable for plotting procedures. If this information isn't available, use Township-Range location.

_____1/4 ____1/4 ____1/4 Sec____ T____ R____

_____Baseline/Meridian

6. Surface elevation: _____ft

7. Depth: _____ft

8. Start date of drilling (state proposed date if drilling hasn't started):_____

9. Completion date of drilling:_____

10. Hole status (circle):

production	injection	abandoned	plugged	currently drilling
temperature	proposed	disposal	capped	observation
water level	open	other _____		

11. Geologic setting (age, formation, rock type, depth from top to bottom of formation):

_____

_____

_____

_____

12. Drilling stages (diameter and depth):

_____

_____

_____

_____

13. Casing stages (diameter and depth):

_____

_____

_____

_____

_____

14. Samples (type, interval):

Core_____

_____

Cuttings_____

Others_____

15. Logs taken (circle):

electric	acoustic televiewer	nuclear	density
induction	sonic	gamma	temperature
laterolog	sonic attenuation	gamma-gamma	magnetic
microlog	3D	neutron porosity	gravity
microlaterolog			dip
SP	other_____		

16. Well testing (circle):

drill stem fluid flow formation other_____

17. Funding agency:

federal_____

state_____

private_____

other_____

18. Additional information or comments:

_____

_____

_____

_____

19. Total cost of drilling:_____

20. Principal investigator:

Name_____

Address_____

_____

Phone Commercial ( )_____

FTS_____

21. Submitter of information:

Name_____

Address_____

_____

Phone Commercial ( )_____

FTS_____

22. Date: _____

Information should be sent to

Gayle Pawloski, L-222
Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, CA 94550
Phone (415) 423-0437
FTS 543-0437

GEOLOGICAL ACTIVITIES OF THE WORLD DATA CENTER-A: GLACIOLOGY [SNOW AND ICE]

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Abstract--The World Data Center-A: Glaciology [Snow and Ice] (WDC-A) is one of three international centers for snow and ice data established by the International Commission of Scientific Unions in 1957. The major functions of each center are to facilitate the exchange of snow and ice related information, to assure preservation of important cryospheric data, and to act as an information clearing house.

The WDC approaches its information service responsibilities by managing a journal/reprint collection, producing subject specific bibliographies, inventorying data sets within selected sub-disciplines, and by holding user-orientated workshops. Data sets have been acquired for archiving within the Center's limited resources only when they are of high scientific merit, or in danger of irretrievable loss.

Cataloging of the journal/reprint collection is performed by a computer based index system, currently adapted to the System 2000 Data Base Management System on a Univac computer. This has facilitated the retrieval of cataloged material and the production of quarterly New Accessions Lists. Current problems center around the structure of System 2000 software and typical difficulties encountered during software conversions. A computer index to aerial and terrestrial glacier photographs taken by the U.S. Geological Survey and others is also under development using System 2000.

Recent inventories have included worldwide ice cores, snow cover, and sea ice data sets. All of these are related to national programs to understand climate variability and to provide background material for climate monitoring and impact assessments. Future inventories, catalogs, and bibiliographies are planned to include permafrost, Antarctic sea ice, and Western U. S. snow cover.

Introduction

The World Data Center-A for Glaciology [Snow and Ice] collects and manages data on all forms of snow and ice. Major subdisciplines include: avalanche research, fresh water ice, glacier fluctuations, glacier mass balance, ground ice (permafrost), paleoglaciology, polar ice sheets, sea ice, and seasonal snow cover. The World Data Center-A: Glaciology (herein called Data Center or WDC) approaches its information service responsibilities primarily by managing a

journal/reprint collection, by producing subject specific bibliographies and by inventorying data sets within selected sub-disciplines. It also holds periodic special workshops of data producers and users. Data sets have been acquired for archival only when they are of high scientific merit, or in danger of irretrievable loss, and do not tax the Center's limited resources.

This paper will first provide a brief historical sketch of the World Data Center-A for Glaciology, a current program overview and then describe three projects undertaken during the past six years. Two of these projects are ongoing programs and the third has been completed. The purpose, methods, results, problems, and future directions of each project will be explained.

History

The World Data Center (WDC) system was established in 1957 to archive, manage, and exchange geophysical data collected during the International Geophysical Year. The initial success of the IGY Data Centers lead to the formalization of a continuing system under the aegis of the International Committee of Scientific Unions (ICSU). World Data Centers exist for each of seven disciplines: glaciology, meteorology, oceanography, rockets and satellites, rotation of the earth, solar-terrestrial physics, and solid-earth geophysics. Generally, three Data Centers service one discipline. WDC-A's are in the United States, WDC-B's are in the Union of Soviet Socialist Republics, and WDC-C's are in European countries. In theory each of the Centers A, B, and C contain the same data, but in practice this varies by discipline and country. In March of 1982 NOAA established the National Snow and Ice Data Center (NSIDC) which co-exists with the WDC-A: Glaciology.

Current Program Overview

The WDC mandate is to collect, manage, and redistribute geophysical and solar data on a world-wide basis (ICSU, 1979, p. 1-4). The Data Center has attempted to break this broad mandate into five more specific functions for snow and ice. These are described below.

Collect Cyrospheric Data. Data produced by snow and ice research is bibliographic, numeric, photographic, and digital in nature. The Data Center has concentrated on selecting data sets which might not be available elsewhere. The Defense Meteorological Satellite Program (DMSP) satellite imagery collection is an example of one such case. The DMSP imagery is in a format particularly suitable for snow and ice research because of its polar stereographic, gridded format and it is a set otherwise not available. In other cases the Data Center performs "data rescue" when an organization or individual is unable to manage their data. In 1979 the Great Lakes Environmental Research Laboratory could no longer maintain the Great Lakes ice data archive. The Data Center, after a review of the collection's merit, assumed possession of these data and makes them available to the user community. Table 1 lists the major holdings of the Data Center.

Maintain International Exchange Agreements. The WDC provides an official channel for international data exchanges with WDC-B (Moscow), and WDC-C (Cambridge), and other foreign research groups. Recently Glaciology has exchanged information with Poland, Sweden, Japan, Denmark, Switzerland, as well as Centers B and C.

Provide Broad User Access to Snow and Ice Information. The Data Center services about 200 formal information and data requests per year and at least the same number of informal enquiries. In addition, specialized data reports and bibliographies provide users with information sources for specific needs. Bibliographies of Arctic sea ice, glaciological studies in China, Great Lakes ice, avalanches, and a special report on glaciology field stations have been published in the Data Center's Glaciological Data report series. A Committee on Data for Science and Technology (CODATA) index to agencies and groups involved in snow and ice reserch is being prepared and will be distributed in 1983. Users may also consult the snow and ice library maintained by the World Data Center.

Survey New Data Sources and Data Requirements. Since 1976 two specialized data inventories have been completed and published. WDC staff, with funding from NOAA-EDIS have inventoried ice core data, snow cover and sea ice data. Each attempts to list all known data sets and provide key descriptive information, including referral to sources. Both inventories were aided by workshops where the survey results and other necessary actions to assure data availability were discussed. The ice core data inventory is presented in more detail below.

Provide a Data and Information Referral/Clearing House Service. Part of the WDC's role is to act as an information clearing house. This is accomplished by using information resources from within the Center, principally the snow and ice library, through referral to other national agencies involved in snow and ice research, and if necessary through international exchanges with Centers B and C. The clearing house function is particularly needed in the snow and ice related disciplines since most of the data are at present collected operationally by a wide spectrum of agencies, institutions, and individuals. No one organization has provided a data management focal point. The WDC and the newly designated NSIDC could provide national and international coordination for matters relating to snow and ice data.

Specific Projects

Citation Data Base. In order to improve access to the Snow and Ice Library, a computer based indexing system was initiated in 1977. Reasons for the data base are three-fold. First, the data base is the in-house card catalog to the collection. Second, it permits automated production of the New Accessions Lists, the Data Center's quarterly list of accessions. Third, it offers key-word searches, aiding information/literature retrieval, in batch and on-line modes. The system also permits digital transfer and entry of previously catalogued information from the Cold Regions Bibliography Project of the Library of Congress.

To date, the Data Center has entered over 10,000 citations into a System 2000 Data Base operated on a Univac 1100 Series computer. Twelve New Accessions Lists have been produced using the old OUTFOL based system. The first issue using System 2000 will be published in July 1982. Microfiche indexes to the collection for 1978-79 are routinely used to access material in the Snow and Ice Library. Table 2 lists accessions and cataloged items by calendar year and Table 3 gives numbers of citations for several sub-disciplines.

Development of the system has required considerable effort. Over the past five years the system has undergone one complete computer conversion - from a CDC Cyber to a Univac 1100 (a Data General M-600 Eclipse was also considered but not used). Four different information management packages were studied and two were implemented, requiring considerable systems analysis and programming support.

The data file was first implemented on a CDC 6600, and later a Cyber 750 using a locally supported record management and report writer package called OUTFOL (Merril, 1978). In this system entries were keyed in via a timeshare link, edited, then loaded into the data file. OUTFOL is particularly well suited for report generation. The Cold Regions entries were converted from the Marc II format (Avram, 1968), using specially developed software, modified, and then loaded into the data file.

In 1981 NOAA-EDIS implemented the Data Archive Management and User's Services (DAMUS) System and all WDC operations were transferred to a Univac 1100, the host computer of DAMUS. Since all prior software only supported OUTFOL on the local CDC installation, the entire Citation Data Base was unloaded and redesigned. After several months of development, the Citation Data Base is now operational using the System 2000 data base management system. However, the Cold Regions MARC II format decoding software is not yet operational under DAMUS.

Time estimates for the various tasks involved in the development of the system are presented in figure A. Over the past five years approximately 7.9 staff-years have been devoted to the project. The largest time consumer is consistently data entry (42%) and software development is second largest (28%). The current level of staff commitment of 1.2 full time equivalent (FTE) positions, is slightly less than the five year average of 1.6 FTE, but data entry still constitutes the greatest percentage. The average cost of each citation entry over the lifetime of the project is approximately $20; however, 1982 estimates suggest a current rate of $15 per citation.

Future additions to the system include production of a new integrated microfiche index. The microfiche and supporting documentation will be sold as a research tool to interested scientists. Update services will be offered. Probable costs are $40-60 for the index and $10/year for updates. In conjunction with the distribution of the index, the Data Center will probably offer document delivery on listed items, and remote on-line access to the data base.

Glacier Photograph Index. In 1964 the Project Office for Glaciology Water Resources Division, United States Geological Survey (USGS) began administration of the annual aerial photosurvey of snowline and glacier fluctuations of North Pacific Coast and interior Alaskan glaciers. The results, a photographic collection, consisting of approximately 110,000 negatives of glaciers, snowlines, and other glacial features photographed since 1960, primarily by Austin Post supported by Bob Krimmel and Larry Mayo. (Called the Post Collection in this report.)

A second set of historical glacier photographs has been assembled by W.O. Field and the American Geographical Society and is gradually being transferred to the WDC for archival. The Field collection contains approximately 40,000 terrestrial and aerial photographic prints of glaciers, many dating back to the early 1900's and before. Both photographic collections offer a unique opportunity to trace in detail glacier fluctuations and other related glacial features in North America over the past 80-100 years.

In order to facilitate user access to these collections, and to update an existing but limited photo index for the Post collection at the Project Office for Glaciology, the WDC started a glacier photo indexing program in conjunction with the USGS. In early 1978, the WDC designed a set of descriptive identifiers and an indexing form for all types of glacier photographs, with the collaboration of Austin Post and other glaciologists. Information contained on the index form for each glacier includes at least the following: glacier name, location, glacier features, photo/camera type date, and photographer.

The Glacier Photograph Index has a history similar to the Citation Data Base. In 1978 the index information was entered into an OUTFOL data file on the Cyber. Data Entry was suspended in late 1979 due to lack of funds and the slow progress of data entry operators. In 1980 additional funds were sought and acquired from the USGS and the data entry process streamlined. However, additional work was not begun until early 1982 because the OUTFOL data base required conversion to System 2000. Now that the design of the System 2000 data base is complete, data entry has restarted. Currently about 2500 entries are keyed in per week. More operators will be added this summer, to meet the completion deadline of December, 1982.

When finished, the data base will contain about 110,000 entries. A microfiche index sorted by several keys; minimally including glacier name, location, and date will be produced. The original index sheets along with the original photographs will be microfilmed. All these items will be available at the WDC and the Project Office for Glaciology.

Ice Core Inventory. In April 1978, WDC-A for Glaciology began a survey and data inventory of ice core studies conducted by research insititutions world-wide. Ice core research is a major source of paleoclimatic information for long term studies of climatic change and trace chemical variations (United States Climate Program Plan, 1979). This project was part of the United States effort to identify and consolidate "proxy" climate data.

In total, over 20 km of ice have been drilled by international research teams; however, only a portion of these cores have been retrieved from the

field and analyzed and even less remains in storage. About 50 institutions world-wide are involved in these efforts.

Three methods have been employed to collect the necessary data: 1) a written user survey (Weaver, 1978, p. 10-18); 2) searches of published literature; and 3) interviews with active scientists through on-site visits, and through the Workshop on the Future of Ice Core Data, September 24-26, 1979, (Barry and MacKinnon, 1980, p 1-14). The user survey was designed to provide enough information about each core to characterize the types of studies completed, in progress, or possible; to provide the source for published information; and to provide a contact point for more information. The literature search was conducted to locate published and in-house research reports which describe ice core collection, core analysis, or other ancillary studies. Sources included computerized bibliographic data bases, abstracting journals, and recommendations from individual scientists. The literature review was published in Glaciological Data-8 Ice Cores. On-site visits were made to the major North American and European laboratories currently active in ice core research.

The ice core inventory assembled data on 414 individual cores, collected on five continents and spanning 1949 to 1979. 329 cores were collected in polar regions (north polar 147, south polar 182) with the balance acquired in temperate alpine (69) and tropical alpine (16). Eighty percent of the ice cores are less than 100 m in length, (MacKinnon, 1980, p. 15-23).

A workshop was held in September 1979 at the WDC for Glaciology to determine data mangement needs of ice core researchers, and the climate modelling community. Several recommendations from the Workshop are applicable to other WDC data management activities. For example: The cost of formating data for archiving purposes appears to be inadequately recognized by funding agencies; individual scientists are concerned with the question of receiving credit and recognition when their archival data are used by others. The WDC was specificallly asked to track known and proposed ice core sites and drilling institutions. Additionally the Data Center was asked to establish a data bank containing: an inventory of basic data on existing cores, including location, depth, drilling procedure, atmospheric and surface data at the drilling site, and measurements and observations performed during the recovery of the core. Such recommendations - costs of data management, protection of principal investigator's rights, and broad-based research information tracking may be applied to other areas of glaciology. The Data Center attempts to accomplish these goals, but level of effort depends greatly on resources available.

Summary

Observed Trends in WDC-A for Glaciology Operations. From this brief description of the Data Center's current programs several generalizations are evident which may determine future directions (see figure B). 1) The WDC's acquisitions have more than doubled over the past six years and an increasing percentage of the holdings are digital. In 1976 digital data files were virtually zero, current 1982 estimates total 436 x 10^6 bytes of data. 2) Revenues from charges for redistribution of data have risen from zero to a projected $7K total in 1982, suggesting that an important secondary demand for

glaciological data exists. 3) Parallel to the increased data accession and sales, general user contacts have grown from about 300 in 1976, (mainly in the form of subscriptions to Glaciological Notes), to approximately 1450 in 1981. The 1981 total includes direct and indirect contacts, such as subscriptions to Glaciological Data and New Accessions Lists. 4) On the other hand, the size of Glaciology's staff has decreased from a high in 1979 of 6.7 FTE to the present 5.2 FTE. (Staff size in 1976 was 1.75 FTE.)

In order to manage increased user contact and collection size with fewer staff, the Data Center must devise work aids to improve staff efficiencies. The most promising area is the development of an information management system (see figure C) which would permit rapid retrieval of information on data sets or on catalogued items in the Snow and Ice Library. Such a system would place answers to the most often asked questions at the fingertips of staff members greatly reducing the time necessary to answer information requests. Users could access the system through the Data Center staff or possibly directly via a remote access computer terminal.

The data sets which will be acquired by the Data Center in the coming years will generally be digital and will increase in complexity. More integrated, multi-disciplinary data sets will be acquired or assembled and may span media types. For example, the Data Center will acquire a set of digitized sea ice charts from Canada, the USA and Sweden in the near future. Although these data use a common exchange format, they still require integration into a uniform data base. As mass storage technology becomes less expensive, current photographically based information, such as the DMSP satellite imagery collection, might be rearchived using laser video (or digital) disks.

Future Projects. The Data Center will maintain its statutory obligations, current data holdings including updating and user services, and where possible additional user needs assessments and acquisition of new data sets. Specific projects in planning include the CODATA Inventory of snow and ice data sources, bibliographies of permafrost, Antarctic sea ice, and Western U. S. snow cover and an evaluation of NASA multi-frequency microwave data.

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United States Climate Program Plan, 1977: Federal Coordinating Council for Science, Engineering, and Technology, Interdepartmental Committee for Atmospheric Sciences, Washington, D. C., 82 p.

Table 1. Abbreviated List of WDC-A: Glaciology Data Holdings

Description	Source
Snow and Ice Data Sets	
British Met. Office, Monthly Ice Charts	British Met. Office
FLEWEAFAC Sea Ice Charts	Fleet Weather Facility
Environment Canada Ice Summary Charts	AES - Ice Forecast Group
Environment Canada Ice Atlases*	AES - Ice Forecast Group
Northern Hemisphere Ice Limits, 1901-56*	M. Kelley, U. E. Anglia, U. K.
Arctic Drifting Buoy Data*	Polar Science Center, U. Wa.
Polar Continental Shelf Ice Atlases 1969-74	Polar Cont. Shelf Prog., Canada
Dankse Met. Inst. Ice Charts	Dankse Met. Institut
Arctic/Antarctic Ice Concentrations*	G. Kukla, et al.
Sea Ice Concentration Grids, N. Hemisphere*†	J. Walsh
Snow and Ice Data, N. Hemisphere	M. Bilello, CRREL
NESS N. Hemisphere Snow-Ice Boundaries*	NESS
USDA Weather-Crop Bulletin, Snow Cover	USDA
USDA SCS - Snow Surveys, Water Supply Outlooks for Western States including Alaska	USDA - Soil Conservation Service
Snow Cover Data: Canada	AES - Canada
Water Conditions in California	California Dept. Water Resources
Ice Coring/Glacial Geophysics	
Ice Core Chemistry	Virginia Polytechnic Institute
Ice Core Data - Danish	Denmark
Ice Core Data* - NSF	SUNY - Buffalo/NSF
Radio Glaciology*† Greenland, Antarctica	NSF
Snow and Ice Library	
Data Center Holdings	Multiple sources
Bibliographic Data File*	WDC staff input
Map Reference Collection†	Multiple sources
Photos, Glaciers	
U.S. Army Theodolite	U.S. Army
Reid Glass Plate Collection	A.G.S.
Matthes Collection	A.G.S.
Johnson Collection	A.G.S.
A.G.S./W.O Field Collection	A.G.S.
U.S.G.S./A. Post	Glaciology Project Office
Glacier Photograph Computer Index*	WDC Staff Input
Great Lakes Environmental Research Laboratories†	
Aerial Photography of Great Lakes Ice	GLERL
SLAR Imagery of Great Lakes Ice	GLERL
Weekly Ice Thickness	GLERL
Surface Ice Reports	GLERL
Air Temperature Climatology	GLERL
Water Level Gage Ice Reports*	GLERL
Satellite Imagery	
Defense Meteorological Satellite Program†	Air Force Global Weather Central
Historical Archives	
National Park Service Records†	NPS

*Digital formats.
†Adjunct collections of national snow and ice data.

Table 2. Citation Data Base Statistics.

DATE	NUMBER OF ACCESSIONS BY YEAR	NUMBER OF CATALOGED ITEMS BY YEAR
PRE-1976	3361	0
1977 (9/76-12/77)	666	0
1978	823	1582
1979	2088	3311
1980	1933	3362
1981	1810	2508
TOTAL	10681	10763

Table 3. Citation Data Base Statistics.

DATA BASE KEY WORD ENTRIES BY SOME MAJOR SUB-DISCIPLINES

DISCIPLINE	NUMBER
AVALANCHE RESEARCH	255
FRESHWATER ICE	528
GLACIER FLUCTUATIONS	290
GLACIER MASS BALANCE	266
GROUND ICE (PERMAFROST)	376
PALEOGLACIOLOGY	145
POLAR ICE SHEETS	675
SEA ICE	1378
SEASONAL SNOW COVER	375

THE SYSTEM HAS 2420 DISTINCT KEY WORD ENTRIES FOR AN AVERAGE OF 18 KEY WORDS PER CITATION.

LEFT BAR IS TOTAL EFFORT FROM 1977-1982 OR 7.9 STAFF-YEARS
RIGHT BAR IS CURRENT LEVEL OF EFFORT IN 1982 OR 1.2 STAFF-YEARS

Figure A. Level of Effort

LEFT LINE IS 1976
MIDDLE LINE IS 1979
RIGHT LINE IS 1982 PROJECTIONS

Figure B. Observed trends WDC-A: Glaciology operations.

Figure C. Proposed data management scheme.

DATA AND ITS RETRIEVAL FROM THE REGIONAL PLANETARY IMAGE FACILITIES

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Abstract--The Regional Planetary Image Facility at Jet Propulsion Laboratory is one of ten centers funded jointly by NASA's Planetary Geology Program and by the institutions where each facility is located. The centers were established in an effort to provide a reference library of all planetary and satellite images returned by spacecraft missions, as well as relevant scientific reports, engineering data files, mosaics and maps produced as a result of these missions. The centers are intended for use by the scientific community to support planetary research programs and are open to the general public to promote a better understanding of the solar system and the U.S. Planetary Exploration Program.

As a result of the need for rapid retrieval and the large quantity of images (approximately 200,000), the Planetary Image Facility at Jet Propulsion Laboratory recently compiled a laser videodisc to store black-and-white images gathered over the last decade from planetary missions. Videodisc technology provides very high density storage (108,000 images per disc) with the added capability of allowing for a computer interface. The videodisc player allows single-frame viewing or playback in forward or reverse directions at selectable speeds from 1 to 30 images per second. Images can also be accessed randomly in less than 5 seconds. Currently, the JPL Image Facility is using an Apple II Plus microcomputer with a Sony videodisc player and a Sony color monitor.

Facility Background

Since 1965, when the Mariner 4 mission to Mars returned the first images of another planet, the problems of gathering, storing, and retrieving planetary imaging data have become increasingly complex. By 1976, after nearly a decade of United States planetary missions and the return of more than 225,000 images (Figure 1), finding a solution to the problems had become imperative.

The Planetary Geology Program Office, under the Office of Space Science and Applications at NASA Headquarters, decided in 1976 to establish several data centers for storage and retrieval of planetary imaging data. The primary purposes, for the establishment of these centers, were to make these data available to more

UNITED STATES DEEP SPACE MISSIONS

Missions	Launch	Target	Approximate Number of Images	Remarks
Mariner 2	August 27, 1962	Venus	non-imaging	First succesful probe
Ranger 7	July 28, 1964	Moon	4,000	Impacted lunar surface
Mariner 4	November 28, 1964	Mars	20	First martian flyby
Ranger 8	February 17, 1965	Moon	7,000	Surface impact
Ranger 9	March 21, 1965	Moon	6,000	Surface impact
Surveyor 1	May 30, 1966	Moon	11,000	First soft landing
Lunar Orbiter 1	August 10, 1966	Moon	200	First orbital/impact
Lunar Orbiter 2	November 6, 1966	Moon	400	Orbital/impact
Lunar Orbiter 3	February 4, 1967	Moon	300	Orbital/impact
Surveyor 3	April 17, 1967	Moon	6,500	Soft landing
Lunar Orbiter 4	May 4, 1967	Moon	300	Orbital/impact
Mariner 5	July 14, 1967	Venus	-	Flyby
Explorer 35	July 19, 1967	Moon	non-imaging	Magnetic measurements
Lunar Orbiter 5	August 1, 1967	Moon	200	Orbital/impact
Surveyor 5	September 8, 1967	Moon	18,000	Soft landing
Surveyor 6	November 7, 1967	Moon	30,000	Soft landing
Surveyor 7	January 7, 1968	Moon	22,000	Soft landing
Apollo 6	April 4, 1968	Earth	800	First Apollo spacecraft
Apollo 7	October 11, 1968	Earth	500	First manned spacecraft
Apollo 8	December 21, 1968	Moon	1,000	First manned lunar flight
Mariner 6	February 25, 1969	Mars	100	Flyby
Mariner 7	March 27, 1969	Mars	200	Flyby
Apollo 10	May 18, 1969	Moon	1,300	Orbital
Apollo 11	July 16, 1969	Moon	1,300	First manned soft landing
Apollo 12	November 14, 1969	Moon	1,600	Second manned soft landing
Apollo 13	April 11, 1970	Moon	1,600	Aborted after 56 hours
Apollo 14	January 31, 1971	Moon	1,300	Third manned soft landing
Mariner 9	May 8, 1971	Mars	7,500	First Mars orbiter
Apollo 15	July 26, 1971	Moon	9,000	Fourth manned soft landing
Pioneer 10	March 3, 1972	Jupiter	200	First Jupiter images
Apollo 16	April 16, 1972	Moon	7,000	Fifth manned soft landing
Apollo 17	December 7, 1972	Moon	11,000	Last manned soft landing
Pioneer 11	April 6, 1973	Jupiter/Saturn	-	First Saturn images
Explorer	June 10, 1973	Moon	non-imaging	Radio astronomy
Mariner 10	November 3, 1973	Venus/Mercury	8,000	First Mercury flyby
Viking 1	August 20, 1975	Mars	30,000	First martian soft landing
Viking 2	September 9, 1975	Mars	20,000	Second martian soft landing
Voyager 1	September 5, 1977	Jupiter/Saturn	35,000	Flyby
Voyager 2	August 20, 1977	Jupiter/Saturn/Uranus	35,000	Flyby
Pioneer Venus 1	May 20, 1978	Venus	-	Radar orbiter
Pioneer Venus 2	August 8, 1978	Venus	-	Probe

Figure 1. U.S. Planetary mission to-date.

planetary researchers and to establish an organized plan for retrieval. Until then, data sets were being used mainly by members of the various photography teams for their own research. And as time passed, there was an increased likelihood that the data might become inaccessible, damaged, or lost. The Regional Planetary Image Facilities now provide reference centers for researchers and serve as archives for imaging data. They also play an important role in educating the general public about the solar system and about the U.S. Planetary Exploration Program.

The NASA Planetary Geology Office established seven original facilities with a Planetary Geology Program Principal Investigator (PI) at each home institution serving as Director of the Facility. Most PI's already had collections of mission data in use, thereby limiting the initial expenditures for set-up. Data sets were also duplicated and shared between facilities. Since 1977, fourteen facilities, with affiliated branch libraries, have opened across the U.S. (Figure 2) and in Europe (Figure 3).

Data and Retrieval

Planetary image data are usually in digital form, converted to an analog signal for transmission to Earth, then digitized again at the Deep Space Network (DSN) receivers. The conversion to photographs is a lengthy task (Figure 4) and the documentation and support data plays a major role in the usefulness of the data set. Each regional center houses not only photographs but also the negative and positive film products, and other image formats, such as maps, mosaics, and special color products. Certain data sets are available on microfiche and videodisc. In addition, the Regional Planetary Image Facility at the Jet Propulsion Laboratory (JPL) of the California Institute of Technology in Pasadena, stores magnetic tapes which contain raw imaging data.

Documentation and support data are provided both on printed hardcopy and in a computer data base. Presently, the picture and engineering data files for approximately 150,000 images are stored in an interactive computer program called the Better Image Retrieval Program (BIRP), which was written by the Space Science Group at Washington University (Arvidson, et al., 1979; Bolef and Guinness, 1979). The BIRP program was designed to run on a small computer system (DEC PDP 11/34) and to be compatible with other minicomputers. It is written in DEC Fortran IV+ (85%) and in DEC assembly language MACRO-11 (15%). It consists of a main calling program and approximately forty subroutines. A separate file is stored for every searchable parameter. Figure 5 illustrates picture and engineering data parameters that are likely to be stored in the BIRP data base for each image. A user searches the data base for images that satisfy his criteria, one parameter at a time. With each selected parameter, the file becomes smaller and ultimately provides only the images which satisfy the specific parameter requirements.

Figure 2. U.S. Regional Planetary Image Facility locations.

Figure 3. European Regional Planetary Image Facility locations.

Figure 4. Conversion process from digital data to photographic data.

SAMPLE VALUES*:

EMANG = 34°	SCLAT = 32°	SCALT = 3400 km
INANG = 40°	SCLON = 305°	SLANTR = 3900 km
PHANG = 66°	SUNLAT = 3°	TOD = (SUNLON - CLON)/15 + 12 = 13.6
	SUNLON = 336°	

SAMPLE VALUES*:

ULLAT = 24°	URLAT = 23°	SCAZ = 299°
ULLON = 325°	URLON = 315°	SUNAZ = 136°
CLAT = 19.5°	LRLAT = 15°	NORAZ = 268°
CLON = 320.5°	LRLON = 316°	PICHT = 550 km
LLLAT = 16°		PICWD = 600 km
LLLON = 326°		

*SAMPLE VALUES INCLUDED FOR ILLUSTRATIVE PURPOSES ONLY

Figure 5. Illustration of picture/engineering parameters.

At the JPL Image Facility, the BIRP retrieval system runs on a PDP 11/34 computer. The Image Facility can access the data base by using either a Lear-Siegler model #ADM-3A terminal directly with dial-up capability or an Apple II Plus microcomputer, also with dial-up capability. The user can receive a printed listing from the printer attached to the Apple or see the list displayed on the Apple's 12" black-and-white monitor. The Lear-Siegler provides screen display only.

A user has two choices--photographs or videodisc--for immediate viewing of an image listed by the BIRP program. The photographs are kept in binders and are stored in the Facility for constant access. The videodisc, recently produced by the JPL Image Facility, provides immediate display on the monitor located next to the Apple computer. Software to allow the BIRP program to control the videodisc player has recently been produced by Washington University and will soon be available at all the facilities.

The laser videodisc, one of the newest technologies in data storage and retrieval (Goldstein, 1982), has a maximum capacity of 108,000 images per disc. Our disc, the first in a series of three, contains approximately 100,000 black-and-white images from the Mariner 9 and 10, Viking Orbiters and Landers, and Voyager (Jupiter only) missions. The disc was produced by photographing the images on 35mm film and transferring the film to 1" videotape. The tape, in turn, was sent to the Sony Corporation in Japan for mastering and copy production.

In order to use the videodisc, the Image Facility purchased a Sony videodisc player (model LDP-1000), which can interface with the Apple microcomputer. The player can provide single-frame viewing or playback in forward or reverse at speeds ranging from 1 to 30 frames per second. Random access of any image is made within 5 seconds. The Apple computer can provide viewing at any comfortable speed with the aid of a T & G Products joystick. The high-density storage provided by the videodisc (Figure 6) allows the user to view many images in a relatively short time to determine the relevance of an image to his or her. research without having to sort through a large number of binders.

With the advent of videodisc technology and with the assistance of the computer data base, a user will eventually be able to request to see all existing images of a given feature on any planetary surface and receive a catalog within 15 minutes.

The work described in this paper was carried out by JPL under contract with NASA.

Figure 6. Illustration of videodisc storage capacity.

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A METHOD FOR CORE SELECTION OF GEOSCIENCE JOURNALS FOR LIBRARIES WITH LIMITED RESOURCES

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Abstract--At a time when scientific journal literature is proliferating, the Library at Wichita State University (a medium sized, urban university) is facing increasing inflation and diminishing resources. In order to cope, the Science Librarian must establish logical criteria for adding new journals and maintaining current subscriptions on the basis of those titles most needed by science faculty for research and informational needs.

In response to economic stringency, the Science Librarian created a classification index which would be used as an indicator in the formulation of journal subscription policies. To test this method, the Science Librarian selected the area of geological journal literature.

A series of criteria which best describe the nature of a journal were selected (i.e. length of paper, number of citations of the paper, number of authors per paper, number of cited authors per paper, year of citations, etc.). Various methods of analysis were applied to the data and results computed. Through the use of this index, the Library will have a logical basis to evaluate individual titles thus compiling a core list of journal titles for its unique situation.

Typical of today's institutions of higher education, Wichita State University is facing diminishing financial resources. The Library budget--like all budgets at universities--is shrinking. Budget deficiencies have an obvious impact on the acquisition of periodical literature. Compounded by the 13.3 per cent annual increase in journal subscriptions (Brown and Phillips, 1981, p. 1387), the lack of funds forces a critical examination of all journal expenditures. In addition to this problem of economic stringency is the proliferation of scientific periodical literature.

In an effort to cope with this situation, the W.S.U. Library must establish guidelines for the addition of new scientific journals and the maintenance of current subscriptions. It is imperative that these guidelines reflect the W.S.U. science faculty and students' research, current awareness, and basic informational needs.

In response to these needs, the W.S.U. Science Librarian devised a journal classification index. Such an index will be employed when formulating journal subscription policies. The Science Librarian selected the area of geological and earth science literature to test the classification index.

Classifying objects, whether they are a collection of journals or a collection or rocks, involves the placing of these objects within homogeneous groups revealing the relationships between the members of the group. (Davis, 1973, p. 456) A journal classification index or system would provide a basis for classifying or grouping journals. As a result, logical and similar groups would reveal the intrinsic value of a particular journal in relation to other journals. The Science Librarian, the science faculty, and Head of Collection Development could use this information to develop journal subscription policy. Those planning journal policy would, of course, need to employ other criteria besides the index.

The classification index would provide an analysis of quantifiable variables used to describe a journal's characteristic behavior. Through the comparison of these variables, the journals which display similar characteristics could be grouped. For example, journals which typically publish lengthy articles with numerous references of an historic nature would group together. By precisely defining periodical needs with respect to basic characteristics, one could utilize the groupings to indicate which journals would best meet an institutions unique informational needs. Thus, an individualized listing of "core" journals for a given institution could be compiled.

The journal classification index is not intended to replace traditional methods of journal selection. However, the means of supplementing a traditional subjective method with a quantifiable measure of descriptive variables, is advantageous to the selection process. A classification index is extremely useful in assessing an area of journal literature with which one is unfamiliar.

Twenty-three criteria shape the key elements of the classification index. These criteria were chosen because they described basic characteristics of a journal (i.e. length of the articles, number and age of the references, etc.) and because they could be measured through quantifiable, tangible variables. While some of the criteria do not have marked significance by themselves, the combination of factors provides a synergistic effect in characterizing journal quality.

The first of the descriptive variables is the average length of an article. This was calculated by counting the number of words on a page, selected at random, then multiplying that value times the number of pages within the given article. This procedure results in average value for the length of an article for a journal title. An article's length is indicative of the type of article that it is--survey, summary, brief research note, etc.

The second variable is simply the number of references per article, counted from the reference listing of articles selected at random.

The third variable is the number of references divided by the number of pages in the article. This provides a number of references per page. Thus, there is a gauge of references in relation to article length.

The fourth variable is the number of languages in which the article was written. Language differences can provide a determination of the audience for the journal. An article had the value of one (language) if it and the abstract were in English and had been orginally published in English. A value of two (languages) was assigned if the article were in English and the abstract in a different language. For example, an article which was published in the Canadian Journal of Earth Sciences, in English with a French abstract received a value of two in the language category. If an article or the complete journal were translated from a language other than English, it also received the value of two. The articles from Geotectonics, for example, a Russian journal translated into English, were assigned a two. This method allowed a measure of the degree of dissimilarity on the basis of language. While it is evident that the majority of journals selected for this study are in English and originally published in English, a measure of the differences between the multi-language titles needed to be made.

The ratio of the number of different journal titles which were referenced and the number of different reference sources divided by the total number of references, comprised the fifth variable. The references were individually assessed to determine this number. Thus, if an article had twenty-five references and sixteen of the references were to the same journals, the number of different titles would be ten divided by the twenty-five total references. A value of 0.40 would result. Some of the references were, of course, from sources other than journal literature (i.e. books, U.S. Geological Survey Professional Papers, maps, etc.). This diversity of the references made analysis of individual references very important. This value is an important indicator of the extent of the literature which was consulted.

The sixth variable was computed by the number of authors of the particular article. The seventh variable accounted for the number of different languages in which cited studies were written. This determined a value of 1.00 if all of the references were to English articles, 2.00 if one article was in French and the remainder in English, etc.

The eighth through thirteenth variables were determined by the number of authors of each reference. For example, the eighth variable equaled the number of single-authored references; the ninth variable, the number of references with two authors, etc. The thirteenth variable included the number of references with six or more authors. The analysis of the authors of the references provides an indication of citation patterns.

The remaining ten variables, fourteen through twenty-three, were based on the age of the references. The number of references which were zero to five years old in terms of the date of publication of the selected article became the fourteenth variable. This process continued, ranging in five year increments, and ending with the twenty-third variable, which showed the number of references which were to studies greater than forty-five years old. This analysis of the year of publication of the cited studies is indicative of the current versus historical nature of the citations. In

this situation, the historical references would be those which are in the latter categories. The age of a reference can be significant in assessing the body of knowledge available on a given topic and its gain of prominence and acceptance in the field.

Methodology

Twenty-five earth science/geology journals were selected to test the classification index. The journals surveyed were current titles which had been published at least ten years. Within this parameter, only the past ten years of a journal were utilized, regardless of its publication history. The journal selection was limited to those titles currently maintained at W.S.U. due to the exhaustive nature of the study. The titles selected for inclusion are diverse, but the majority are considered core journals for geology collections. Other titles considered peripheral, were also selected. A few of the titles represent field-oriented or specialized journals. Thus, the titles selected form a viable collection which ranges in diversity from basic to specialized journals. The twenty-five journal titles are listed in Table 1.

Table 1.--Geological Journals Selected for This Study

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS. BULLETIN
AMERICAN JOURNAL OF SCIENCE
AMERICAN MINERALOGIST
CANADIAN JOURNAL OF EARTH SCIENCES
CONTRIBUTIONS TO MINERALOGY & PETROLOGY
EARTH SCIENCE
ECONOMIC GEOLOGY
EOS. TRANSACTIONS OF THE AMERICAN GEOPHYSICAL UNION
GEOLOGICAL SOCIETY OF AMERICA. BULLETIN
GEOLOGICAL JOURNAL
GEOLOGICAL MAGAZINE
GEOLOGICAL SOCIETY OF LONDON. JOURNAL
GEOPHYSICS
GEOTECTONICS
INTERNATIONAL GEOLOGY REVIEW
JOURNAL OF GEOLOGY
JOURNAL OF PALEONTOLOGY
JOURNAL OF PETROLOGY
JOURNAL OF SEDIMENTARY PETROLOGY
LITHOS
PALAEOGEOGRAPHY PALAEOCLIMATOLOGY PALAEOECOLOGY
QUATERNARY RESEARCH
SEDIMENTARY GEOLOGY
SEDIMENTOLOGY
SEISMOLOGICAL SOCIETY OF AMERICA. BULLETIN

Twenty-five articles were selected randomly from the last ten years of each designated title. The twenty-three variables for the classification index were tallied and the results were double-checked. The tally sheet (Figure 1) demonstrates how the data were collected.

Title _____ Author(s) _____

Vol. ( ):pp._____ _____

1) _____ # words x _____ # pp.

2) _____ # references

3) _____ # refs/ _____ # pp.

4) _____ # languages of article

5) _____ # of different sources of refs./ _____ # refs.

6) _____ # authors of article

7) _____ # languages referenced in articles

Number of authors per reference:

8) 1 =	10) 3 =	12) 5 =
9) 2 =	11) 4 =	13) 6≥

Age of references:

_____	1960	1970	1980	14) 0 - 5 =
_____	1961	1971	1981	15) 6 -10 =
_____	1962	1972	1982	16) 11-15 =
_____	1963	1973	_____	17) 16-20 =
_____	1964	1974	_____	18) 21-25 =
_____	1965	1975	_____	19) 26-30 =
_____	1966	1976	_____	20) 31-35 =
_____	1967	1977	_____	21) 36-40 =
_____	1968	1978	_____	22) 41-45 =
_____	1969	1979	_____	23) 46-50≥

Figure 1. Tally Sheet for Data Collection

Each of the randomly selected articles from the twenty-five titles required a completed data sheet. The resulting 14,375 pieces of data (575 pieces per title) were entered, after double checking for accuracy, into computer files for each title. Typographical errors were at that point corrected to ensure data accuracy. These values were standardized by the Z-score method, in order to allow their comparison. The Z-score method is based on the equation $Z = \frac{X - \bar{X}}{S}$; where X = value, $\bar{X}$ = mean and S = standard deviation.

The standardized values were input to the CLUSTR program (Davis, 1973), and the weighted pair group averaging (WPGA) method for clustering was used. Cluster analysis is a technique that shows the interrelationships of objects within a similarity coefficient matrix by grouping or clustering the variables (or objects) so that their interrelationships become apparent.

The resulting similarity matrices were constructed for each of the twenty-five titles. In this situation, an R-mode analysis, which compares variable to variable, was used. The symbolic two-dimensional representation of cluster analysis, a dendrogram, was produced for each journal title In a dendrogram, the different variables group or cluster so that their interrelationship, as shown by the similarity matrix, become apparent (Harbough & Merriam, 1968, p. 174).

The means ($\bar{X}$) of each variable, determined from each of the journal's articles, also were analyzed. This analysis facilitated the comparison of journal titles. Similarity matrices for both the comparison of the titles and the variables (from the mean data), were constructed. The comparison of the variables (R-mode) was illustrated by a dendrogram. In addition, the comparison of journal titles, (Q-mode analysis), was represented by a dendrogram. The dendrograms provided a visual evaluation of the data for the classification of the journal titles.

Results

The results from the comparison of the means of the variables compared to variables (R-mode analysis) were significant. (Dendrogram, Figure 2) Grouped or clustered together, were the variables that will be described herein. Essentially, this comparison revealed three main groups: (1) single-authored references, the chronologically older references, article length and the total number of references; (2) multi-authored references, the chronologically most recent references, and the number of references per page; and (3) language of the article. In addition, a subgroup within the first group (single-authored, historical references) included the number of languages referenced and the number of different sources divided by the total number of references.

Thus, when comparing the variables which compose the classification index, one can conclude the following. During the last ten years, the journal articles sampled from the twenty-five test journals reveal that the most recent articles cited are written by two or more persons. Single-authored references are those of historical nature as indicated by the grouping of these variables. A tendency exists for the variables designating total number of references and article length to be grouped with the single-authored, historical reference variables. The subgroup with the value for ratio of the number of different reference sources divided by the number of total references and the number of languages referenced, indicate the diversity of references. This diversity is indicative of articles in which the author consulted numerous sources. Therefore, evidence exists indicating an extensive survey of the literature rather than merely citing the same journal numerous times.

The comparison of the actual journal titles (Q-mode analysis) is based on the mean data for each title. This comparison is represented by the dendrogram found in Figure 3. Ultimately, the comparison on the basis of the discussed variables, forms the classification index. The journals first

Figure 2. Dendrogram for R-mode Analysis of $\bar{X}$

Figure 3. Dendrogram for Q-mode Analysis of $\overline{X}$

grouped or clustered within two main groups. In the first major group, nineteen journals clustered: Association of Petroleum Geologist. Bulletin, American Journal of Science, Geological Journal, Journal of Geology, Journal of Petrology, Earth Science, American Mineralogist, Palaeogeography Palaeoclimatology Palaeoecology, Contributions to Mineralogy & Petrology, EOS Transactions of the American Geophysical Union, Geological Society of America. Bulletin, Journal of Sedimentary Petrology, Lithos, Geological Magazine, Geological Society of London. Journal, Geotectonics, International Geology Review, Journal of Paleontology, and Sedimentology. In the second major group, the remaining six journals clustered: Canadian Journal of Earth Science, Geophysics, Economic Geology, Seismological Society of America. Bulletin, Quaternary Research and Sedimentary Geology. The rationale for the two main groups is not readily apparent. However, the number of references, the ratio of the number of different references to total number, and the length of the articles seem to be the most important.

By moving the cut-off higher on the dendrogram representing the Q-mode analysis of the mean variables, six groups are recognized. The vertical dotted line on Figure 3 delimits the boundary of these groups. With a few exceptions, these six groups of journals show remarkably similar characteristics.

The first group (Group A) contains American Association for Petroleum Geologist. Bulletin, American Journal of Science, Geological Journal, Journal of Geology, Journal of Petrology, and Earth Science. Within this group are the more generalized journals which cover a wide range of geological topics. Whereas, the A.A.P.G. Bulletin normally contains articles on economic and petroleum related topics, within the restrictions of the given variables, the journal resembles those journals which are usually thought of as general and cover broad topics. Another journal within this group, Earth Science, is much less specialized as indicated by the fact that it clustered low within the group. Figure 4 is the dendrogram which represents this group. The variables 2, 8, 9 (number of references, single-author and two authored references) consistantly cluster together in Group A.

The second group (Group B) contains American Mineralogist, Palaeogeography Palaeoclimatology Palaeoecology, and Contributions to Mineralogy and Petrology. The two mineralogy and petrology journals, American Mineralogist and Contribution to Mineralogy and Petrology, logically group together. The random articles from Palaeogeography Palaeoclimatology Palaeoecology demonstrate the same characteristics as those from the petrology journals.

A dendrogram for Contributions to Mineralogy and Petrology, representative of Group B, is found in Figure 5. Consistant within this group, is the clustering of the number of references per page and single authored references. An addition, the number of references and the chronologically current (0 to 5 years old) references cluster in all of the journals from this group.

The third group (Group C) contains those journals which are considered "soft-rock" titles, containing articles of that nature. EOS Transactions of the American Geophysical Union, Geological Society of America. Bulletin,

Figure 4. Dendrogram Representing Journal Group A

Figure 5. Dendrogram Representing Journal Group B

Journal of Sedimentary Petrology and Lithos. Two of the journals from this group are society publications. The other two in the group could have fallen within Group B because they are mineralogy and petrology journals but display characteristics more in keeping with the members of Group C. From Group C, a representative dendrogram, (Figure 6) for the Geological Society of America. Bulletin is shown. The articles from this group display more classic and fewer references with multiple authors. For this group, variables fourteen and fifteen (references zero to ten years old) and variables two and nine (number of references and multi-authored references) always cluster together.

Geological Magazine, Geological Society of London. Journal, Geotectonics, International Geology Review, Journal of Paleontology, and Sedimentology cluster together forming Group D. Within this group, the first four journals form a subgroup. These titles represent journals of an international and regional geology orientation. The later two journals have articles which are of interest to specialists. Figure 7 displays a dendrogram which is characteristic of this group. Note the grouping of variables seven, seventeen, twenty-one and eighteen; these variables deal with the languages referenced in the articles and the chronologically older references. Also, indicative of this group is the cluster of variables which include the number of references, one-to two-authored references, and the number of references per page.

Group E includes the Canadian Journal of Earth Sciences, Geophysics, Economic Geology, and the Seismological Society of America. Bulletin. These titles represent journals which typically contain geological articles of an economic orientation. Titles of this nature ordinarily are multi-authored with chronologically current reference type. Figure 8 depicts the typical dendrogram of this group.

The final group, Group F, is formed by two journals, Quaternary Research and Sedimentary Geology. These two journals are known to cover applied geology with an emphasis on the environment. Characteristic of this group were citations to articles six to ten years old with a single author. Group F is illustrated by the dendrogram in Figure 9 with the grouping of variables eight and fifteen.

Conclusions

Through a classification index, a librarian can be more objective in determining the journals most necessary for a particular library. By selecting variables that may be quantified, a librarian can apply statistical techniques to the data. In this classification index, all of the variables involved an analysis of the authors, article length, language, and the references. The analysis of these factors enables a librarian to determine journal characteristics and utility by quantifiable means.

Figure 6. Dendrogram Representing Journal Group C

Figure 7. Dendrogram Representing Journal Group D

Figure 8. Dendrogram Representing Journal Group E

Figure 9. Dendrogram Representing Journal Group F

One of the journal clusters yielded a group that could constitute a core collection. The journals from Group A could be designated most important to the majority of geology collections because of their general coverage of the field.

Beyond this core group, the remaining clusters must be analyzed within the context of the institution, its library and the informational needs of its users. For example, in an undergraduate institution serving a predominately monolingual community, the journals containing foreign language articles and numerous references to foreign language articles would be superfluous. In a special library, supporting a research company, current articles with an economic orientation might be critical. Thus, titles displaying these features (Group E) should be included in the collection. In a university with a graduate program, the advanced researcher, concerned with gaining historical perspective through a comprehensive survey of the literature, would need journals that consistently publish articles with extensive reference lists (Groups C & D).

The journal classification index provides librarians with a means of quantifying variables. The resulting journal clusters, previously described, are indicative of the kind of articles a journal publishes. This quantifying helps a librarian to be more objective when making journal selection decisions. Because these decisions are based upon quantifiable measures, a librarian has an objective basis for justifying selection decisions.

With the exception of two previous studies, not much research has been done in helping librarians achieve a measurable classification of geological journal literature. Pilkey and Wilcox (1981) did an analysis of sedimentology journals, which measured the number of times a journal was cited. Kohut (1974) did an analysis of obsolescence patterns of geological literature. Both of these studies provide an objective means for assessing a journal's value.

Librarians are not, by and large, subject specialists, although they have the responsibility of making selection decisions in particular disciplines. Traditionally, they have made decisions in a subjective manner. The journal classification index and the previously described studies help librarians utilize precise, quantifiable journal selection tools. As library budgets continue to shrink, these tools will enable librarians to identify a core collection for their institution. Through the journal classification index, the justification for selection decisions will be supported with numerical measures. If selection decisions made by librarians, are based upon an analysis of the additional objective information gained from the journal classification index, the resulting choices will be superior.

Acknowledgments

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THE GEOLOGICAL CONTENT OF THE GEO ABSTRACTS BIBLIOGRAPHIC DATA BASE.

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Abstract--In its aim to cover geography comprehensively, Geo Abstracts has always included a proportion of geological material. Within the last 10 years major additions have been made by initiating secondary journals covering sedimentology, geophysics and tectonics, while we now produce the machine-readable version of Mineralogical Abstracts. Future developments will add many more abstracts of geological items for on-line retrieval, but may not be matched by a corresponding extension of printed abstract journals.

When I started Geomorphological Abstracts in 1960 to provide an English-language abstracting service in my own research area, mainframe computers were being programmed to produce KWIC and KWOC indexes; indeed our first cumulative author and subject index for 1960-65 used a development of a KWOC index and was run on my College's computer. However, until 1980 hardware costs precluded us developing our use of computers any further, although we have recognised that sooner or later we would be producing Geo Abstracts and its related journals in machine-readable form. That has become possible through the availability of microcomputers, and the development of our relatively low cost system has already been described (Clayton 1981).

From the beginning of 1980, Geo Abstracts (Parts A-G) have been produced in machine-readable form, and from Fall 1982 we expect to have tapes available on DIALOG. The initial coverage will be 60 000 abstracts, covering Geo Abstracts from the beginning of 1980, and Mineralogical Abstracts, Geophysics and Tectonics Abstracts and International Development Abstracts from the beginning of 1982. We shall complete coverage of our publications by producing Ecological Abstracts in machine-readable form from 1983. In addition we hold computer tapes of titles, authors and keywords from 1960 which have been used to produce the printed subject and author indexes. These contain about 200 000 items, and we shall complete the citations to give full coverage of the 1960-1979 items, although without abstracts. We aim to complete this task by the end of 1983. From 1983 we shall also be adding over 50 000 abstracts a year to our machine-readable file.

Geo Abstracts spans a core area of the environmental sciences and provides the only English-language service with abstracts covering geography and quite a large part of geology. It has never been subsidised, but by keeping our production costs among the lowest (per abstract) in the world, we have been able to market a steadily increasing list of secondary journals. The number of abstracts printed (and indexed) each year is given in Table 1. Our primary aim was to cover geography comprehensively, but given our initial interest in geomorphology (including the Quaternary) we have covered geomorphology, Quaternary studies, soils and sedimentology since 1972. This

Table 1.--Number of abstracts printed (and indexed) from 1960 to the present date

Year	No. of abstracts	Year	No. of abstracts
1960	223	1971	8660
1961	424	1972	13884
1962	447	1973	15596
1963	549	1974	22671
1964	957	1975	21101
1965	1004	1976	21996
1966	4854	1977	28032
1967	6216	1978	31258
1968	6723	1979	32403
1969	6798	1980	32350
1970	7679	1981	33254

gave an average annual geological output in 1972/73 of 3989 items of geological interest in Parts A and E, with 383 additional items in the geological sections of Part G (remote sensing) from 1974. Subsequent additions have included geophysics from 1977, geotectonics from 1982 and (under contract) Mineralogical Abstracts also from 1982. We estimate our current geological coverage, all in machine-readable form, at 12 700 items in 1982. The growth in coverage of geological journals is set out in Table 2.

As will be seen from this description of the growth of our coverage, so far we have expanded by the traditional approach of expanding existing journals (eg the addition of tectonics to geophysics in 1972) or by creating new ones (eg. Geo Abstracts, Part E, Sedimentology in 1972). For some time we have been considering whether to take this expansion further. We have no wish to duplicate other services where they include abstracts, so it was very pleasing that we were given a contract to produce Mineralogical Abstracts on machine-readable form from 1982. However, the broad area of regional geology, stratigraphy, economic geology and palaeontology remains uncovered except in the two geological services which choose not to carry abstracts, GeoRef and GeoSystems.

Had we not converted to machine-readable form, I believe we would have launched a regional and stratigraphic geology abstracts in 1984. Indeed, we may still do so, but suddenly it is far less of a priority since no longer is it the only way ahead that will (at least after a few years) pay for itself.

Table 2.--Estimated coverage of journals by Geo Abstracts, 1966-1982

Year	Total no. journals for which abstracts are provided at least in part	No. of geological journals covered at least in part	No. of geological journals covered comprehensively
1966	800	228	114
1970	900	240	140
1978	1000	376	285
1982	1500	700	620

Instead, from 1981, and with a large expansion planned for 1983, we plan to extend our coverage of books and journals to provide increasingly comprehensive coverage of geology on our tapes and complete with abstracts. We can only guess how far our in-house editorial and keyboarding costs for this additional material will be offset by royalty revenues from the increased amount of material on our tapes, but given our low costs we are optimistic that costs will be covered. If so, this will leave us free to produce a printed journal if demand exists, and to be able to price it to recover print, paper and distribution costs alone. In today's difficult library market that seems a big step forward, and it will also facilitate the move towards revenue from tapes and away from printed journals which must be our future strategy.

A computer tape record allows further flexibility which we are anxious to exploit. Printed secondary journals are expensive places to read and abstract short notes, discussions and replies, obituaries and much other rather ephemeral material. Yet if these can be placed on tape at a low enough cost, then they are there to be retrieved by those who might need them, and to be passed by by those who are not interested. Already we are placing discussions and reply items on tape as citation-only entries, and excluding these from our printed journals. For an increasing number of core journals, all material is being entered in machine-readable form, however brief or ephemeral. The possible clutter on the tapes is small (perhaps 2% of the entries at most) and we feel that many users will find a completely comprehensive coverage of well over a thousand journals of value.

Because of our selective coverage of geology hitherto, the main effect of widening the journals and conference proceedings we already receive, is improved coverage of geology. We are in fact working towards a situation where we offer comprehensive cover of all the geological, geographical and core environmental journals. The scope of the Geo Abstracts tape will then be defined broadly in subject terms and precisely in terms of sources; these, too, will be listed in machine-readable form.

Time will tell how far our approach will commend itself to geologists, and how they will spread their use among the competing English-language services. The GeoRef/GeoSystems choice has already received some comment in the literature, and preference is turning out to be a complex matter, with

Table 3.--Amount and proportion of past (and projected) material of geological interest included in Geo Abstracts

Year	No. of abstracts of geological interest	Proportion of total material covered (%)
1960	211	95
1961	263	62
1962	393	88
1963	383	90
1964	863	94
1965	939	29
1966	1421	24
1967	1478	30
1968	2042	26
1969	1791	28
1970	2177	30
1971	2222	30
1972	4162	25
1973	3966	25
1974	4846	21
1975	4281	20
1976	4352	20
1977	7411	26
1978	6793	22
1979	7409	23
1980	7188	22
1981	6701	20
1982	12700*	32*

* estimated figures

variations in coverage, indexing and ease of searching. We shall be providing very different tapes from these two services. At first our coverage of geology senso stricto will be narrower, but at times the inclusion of related material (soils, gound-water, climate, soil mechanics) will offset that for some enquirers. In time we expect our coverage to be as full in geology as these existing services, but with the added attraction that abstracts will be provided for 98% of the items. Indexing will not be sophisticated, for that would push up our costs to unacceptable levels, although we are giving geographical indexing (of all our material) high priority.

The amount and proportion of past (and projected) material that is geological is given in Table 3. As the pool of geological material available only in machine-readable form grows we shall be considering how best to assemble it for publication. Will our past plans for a Regional and Stratigraphical Geology Abstracts still make sense, or are we passing into a decade when printed sources will become less and less used? We have also considered printing an index to the material on tape. It would allow the precise (and thus cheap) retrieval of single items by users with access to terminals, yet allow us to provide printout to order from those in the Third World who do not yet have easy access to the new technology. SDI and similar services are obviously also possible. It is not that we believe that the era of printed journals, primary or secondary is at an end, but we are increasingly reluctant to add to them further.

Clayton, K.M., 1981, A low-cost system for producing machine-readable abstracts, Proc. 3rd International On-line Conference, 1981, pp 151-155.

USING THE SUBJECT-INTEREST-PROFILE FOR COLLECTION DEVELOPMENT IN THE EARTH SCIENCES

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Abstract--In these days of tight collection development budgets and buildings that can hold no more materials, it has become necessary to practice collection selection rather than collection development. Use of a subject interest profile (SIP) is one tool that can be used by bibliographers selecting materials either for addition to the collection or for deacquisition.

A profile of research and/or teaching interests of each major client or client group can be drawn up. Each of these subjects of interest can be further described by geographical parameters and the intensity of interest determined. Library of Congress classification numbers can also be added where appropriate.

All of this information is stored in a data base. The information in the file can be manipulated to create a subject listing, a list of geographical areas of interest bound to pertinent subjects, or a list of relevant LC classification ranges. Using the results, a map showing the areas and subjects of interest to the clients and thus to the bibliographer selecting materials can be compiled.

Selection Rather than Collection Development

It is not news to you to say that the cost of Earth Sciences materials is high and that the cost is increasing. Nor is it news that monies for acquisition of materials is not nearly as plentiful as it once was; for many of you perhaps, the monies are already very scarce. In addition, funds are scarce for building new buildings and buying new shelving to house our growing collections. Perhaps the most expensive part of the acquisitions process is the staff that is required to order, catalog, and process the materials.

For all of these reasons, we have been forced to take a hard look at the titles we are selecting for purchase. In order to make the best possible use of our funds, our space, and our staff time, we need to acquire the titles that will be most useful to our clientele and only those titles.

In order to determine which titles will be most useful for our patrons, several different techniques have been suggested. Johnson and Trueswell (1978, p. 289) used a method of journal collection evaluation using various criteria such as measurement of use by patrons, titles containing patrons' publications, and titles containing works citing patrons' publications. Crissinger (1981, p. 113) is one among many others who have used a journal citation study to aid in selection. Another avenue of approach for determining the needs of our users is to examine the curriculum and the research interests of the faculty and graduate students. Nancy Pruett (1979, p. 149) examined annual reports and conducted structured interviews with her researchers. The science librarians at Stanford University have followed a

somewhat similar procedure to become familiar with user needs and then stored the data in an on-line file.

Stanford University, a private institution founded in 1885, is comprised of six schools which are served by at least 22 libraries, seven of which are grouped together (politically, not physically) to form the Science Department of Stanford University Libraries. Several of these science librarians realised, as many of you no doubt have done, that merely drafting a collection development policy was not enough. The subjects collected or not collected must be based on more than our intuitive preceptions, we needed hard data to help us decide what to collect and also what to deselect. We therefore examined the curricula of the various schools and departments which we serve, but more importantly at a research institution, supporting primarily faculty, research associates, and graduate students, we made concerted efforts to become acquainted with the needs of our primary researchers. We examined the annual reports, the prospecti sent out to new graduate students, and the publications of our clients. In addition, the Stanford Sponsored Projects Office sends out to each bibliographer a list of all grants currently held by members of our schools. We also conducted a search of the Smithsonian Science Information Exchange database searching for information about research going on at Stanford. Finally, questionnaires were sent out to each faculty member asking for lists of topics they were interested in, and keywords that might describe their research interests, as well as topics that they were not interested in. After all of the data for each researcher was assembled, interviews were held with the faculty members to discuss their research and the research being done by their graduate students and other research associates.

We were now able to compile for each faculty member a profile of his or her research interests, and we also felt that we were fairly familiar with the research needs of the graduate students. This information we then entered into an on-line file, which we titled the Subject Interest Profile file or SIP file.

Our SIP file is mounted on the Stanford database system, which is called SPIRES, for Stanford Public Information Retrieval System. The system is implemented on an IBM 3081.

Each record in the SIP file is composed of two types of elements: the non-subject parameters and the subject descriptors. I will describe the contents and function of each.

Non-Subject Parameters

Several non-subject parameters are included in each record (fig. 1). Each record has a unique computer-assigned number called "REC01". Obvious items include the name of the individual and the department or departments or other research groups to which he or she belongs, denoted by the field name "AFF". The date that the file was last updated is also one of the elements of the computer record.

We include a short abstract (often drafted by the individual researcher or taken from department-published materials) summarizing the faculty member's research. Including an abstract allows for freeform expression of

REC01 = 2976

NAME = Coleman, Robert G.;

AFFILIATION = Dept. of Geology;

[Subject Descriptors]

DATE = May, 1982;

ABSTRACT = He is interested in petrology and geochemistry. He has focused on the origin of oceanic crust, on tectonic structure zones, and recently on basalt volcanism. Present areas of interest are the Klamath Mts, Arabian Peninsula, and California Coast Ranges.;

PUBLICATIONS = Ophiolites: ancient oceanic lithosphere?: New York, Springer-Verlag, 1977, 229 p.;

GRAD-STUDENTS = 5;

POSTDOCS = 2;

RESEARCH-ASSOC = 3;

Figure 1. Non-subject parameters

the research interests not bound by the deficiencies of the chosen thesaurus. A field is also designated for publications of note. However, since one of the purposes of the file is to aid in the selection and location of materials, publications listed in the database are not necessarily the individual's most notable publications, but rather those most indicative of present research interests. For some researchers, such key publications are difficult to select and so the publications field is an optional one.

The last fields in each record are grouped together under the term "LABSIZE" and are set aside for recording the number of graduate students, post-doctoral fellows, and research assistants who are working with an individual faculty member or primary investigator. We have included this information in the file because these individuals will also be using the library and presumably their information needs will parallel those of their advisor; at least this is the theory. In fact, for some geologists, at least at Stanford, the subject interests of advisees may match their mentors, but their geographic interests may not be the same. Therefore, when conducting one's interview with a professor, it is important to inquire as to what geographic areas are of additional interest for their graduate students. This data, on the number of researchers working with each principal investigator, may be of further guidance in extreme budget crises. For example, if all other considerations are equal and one has funds to purchase only one title, the title required by the researcher with ten student advisees would be purchased, rather than that requested by a faculty member with only two students.

Subject Terminology

Dvorzak (1980, p. 5) has suggested that the fields of interest terms used in the Bibliography and Index of Geology and/or the GeoRef thesaurus would be the most pertinent terminology for describing Earth Science patrons' interests. This would certainly be the most applicable set of terms to describe collection development needs in the Earth Sciences. However, we decided against using Subject specific thesauri such as GeoRef for the Earth Sciences or Chemical Abstracts for the Chemists, because one purpose of the common file was to coordinate selection of materials with bibliographers of the other fields.

In order for the meaning of the subject terms in the file to be as consistent from one bibliographer to another within Stanford and even, possibly, from one institution to another, we chose one thesaurus of subject index terms, to which all of the bibliographers strictly adherred. We first constructed the file using the Smithsonian Science Information Exchange (SSIE) thesaurus. Since the SSIE database is composed of information about research in progress, and since the topics covered by the database included the hard sciences and the social sciences, as well as the medical disciplines, it was assumed that the terms in the thesaurus would be both current and applicable for our purpose. In addition, since we were using information from the SSIE database as one of our sources of data, those index terms could be used directly, without translation on our part.

After a year's trial, however, it was decided to scratch the file and reconstruct it using the Library of Congress List of Subject Headings. There

were several reasons that helped to make this large task palatable. First, in the Fall of last year the future of the SSIE database appeared very uncertain and it was preferrable to use a thesaurus that would continue to be updated. Secondly, comparison of Stanford's collection development policy with that of other Research Libraries Group libraries would be much more meaningful if all bibliographers used a common thesaurus. The other bibliographers preferred using the Library of Congress List of Subject Headings. Thirdly, it was easier to assign Library of Congress classification ranges to the LC subject headings than to the SSIE terms. Since the collection development conspectus of the Research Libraries Group is drawn up using LC class numbers, these class ranges were a useful data element. Finally, we came to realize as we were coding the subject terms, using the new thesaurus, that the new terms seemed no less current and descriptive than the SSIE terms had been. After struggling with the Library of Congress List of Subject Headings and the SSIE thesaurus terms, neither of which truly describes many geological concepts, I would agree that the GeoRef thesaurus would be much preferrable, if one is trying to construct a geology-only subject profile.

Subject Information

Each subject in the profile is described in a section of the record termed "SUBJECTS-WEIGHTS" (fig. 2). The individual elements of each SUBJECTS-WEIGHTS are: "MAIN-HEADING", "SUBDIVISION", "INTEREST-WEIGHT", "PRIMARY-LOCATION" and "DESCRIPTORS". The main-heading is a subject heading taken from the Library of Congress subject heading thesaurus. This element is searchable as a bound phrase, with right-hand truncation possible. Each main-heading is permitted (but need not have) one or more LC subdivisions; this is the element where the geographic areas of interest to the faculty member and/or her advisees and associates are recorded. The subdivision field is indexed in a separate phrase index, so that each geographic subdivision can be searched independently. For example, searching the file for Somalia would retrieve this record. The subdivision field is tied to the main-heading and cannot occur by itself. This means that each geographic indicator cannot occur alone, but is bound to a subject. In reality, this makes sense; rare is the geologist who is interested in all possible aspects of the geology, geohydrology, geophysics, pedology (to name a few) of any area. Or, if that rare person does exist, he is unlikely to be interested in all fields to the same depth.

The value assigned to the field "SUBJECT-WEIGHT" delineates the depth of interest that the researcher has in that particular topic. The values set for this field can be correlated with selection intensity as set forth in the Stanford Collection Development Policy (1980, p. 8). The subject-weight cannot be translated directly into selection intensities because we do not have unlimited funds. Some of the variables that might be used for determining selection level include: The number of faculty who are interested in a particular subject, the level of their interest, the number of graduate students and other research associates working with these faculty, and the possibility of patrons from other libraries on campus also having need of these subjects (Walker and Sullivan, 1981, p. 5). At present, funds are still available to purchase most of the things that seem to be necessary for a researcher's use. Therefore, at present, a subject-weight of "1" could be matched with selection intensity level "B. Advanced research", a subject-weight of "2" indicates the need to collect

```
NAME = Coleman, Robert G;
SUBJECTS-WEIGHTS;
  MAIN-HEADING = INTRUSIONS (GEOLOGY);
    SUBDIVISION = SAUDIA ARABIA;
  INTEREST-WEIGHT = 1;
  PRIMARY-LOCATION = EAR;
  DESCRIPTORS = QE452;
SUBJECTS-WEIGHTS;
  MAIN-HEADING = INTRUSIONS (GEOLOGY);
    SUBDIVISION = JORDAN;
    SUBDIVISION = EGYPT;
    SUBDIVISION = ISREAL;
    SUBDIVISION = ETHIOPIA;
    SUBDIVISION = SUDAN;
    SUBDIVISION = SOMALIA;
    SUBDIVISION = OMAN;
  INTEREST-WEIGHT = 2;
  PRIMARY-LOCATION = EAR;
  DESCRIPTORS = QE453;
SUBJECTS-WEIGHTS;
  MAIN-HEADING = INTRUSIONS (GEOLGOY);
    SUBDIVISION = MONTANA;
  INTEREST-WEIGHT = 1;
  PRIMARY-LOCATION = EAR;
  DESCRIPTORS = STILLWATER-COMPLEX;
SUBJECTS-WEIGHTS;
  MAIN-HEADING = JADE;
  INTEREST-WEIGHT =1;
  PRIMARY-LOCATION = ART;
  PRIMARY-LOCATION = STK;
  PRIMARY-LOCATION = EAR;
  DESCRIPTORS = NK5750;
  DESCRIPTORS = QE391.J2;
SUBJECTS-WEIGHTS;
  MAIN-HEADING = EARTH;
    SUBDIVISION = MANTLE;
  INTEREST-WEIGHT = 1;
  PRIMARY-LOCATION = EAR;
  DESCRIPTORS = PETROLOGY;
SUBJECTS-WEIGHTS;
  MAIN-HEADING = OPHIOLITES;
    SUBDIVISION = NORTH AMERICA;
    SUBDIVISION = SOUTH AMERICA;
    SUBDIVISION = EUROPE;
    SUBDIVISION = AFRICA;
    SUBDIVISION = ASIA;
    SUBDIVISION = AUSTRALIA;
    SUBDIVISION = ANTARCTICA;
    SUBDIVISION = ARCTIC OCEAN;
    SUBDIVISION = PACIFIC OCEAN;
    SUBDIVISION = ATLANTIC OCEAN;
    SUBDIVISION = INDIAN OCEAN;
  INTEREST-WEIGHT = 1;
  PRIMARY-LOCATION = EAR;
  DESCRIPTORS = QE462.06;
```

Figure 2. Subject Descriptors

on level "C. Research level" and a level of "T" (teaching assignment only) might be interpreted as "D Level. Study level".

Note that the file is set up so that an individual researcher's geographical interests vis a vis a particular subject field can also be weighted. For example, one of Robert Coleman's main research areas is Intrusions occurring in Saudi Arabia. He is interested also but to a lesser degree, in intrusions found in the other lands bordering on the Red Sea. Another major area of interest is the Stillwater complex in Montana.

The "PRIMARY-LOCATION" field is used to record in which libraries on campus the collection concerning this topic is held. Note that materials on Jade, for example, may be held in the Art Library and the main stacks, as well as in the Earth Sciences Library. This is a searchable field, so that we can make a list of all topics held at any location.

The "DESCRIPTORS" field is where free-text terms (terms not used by Library of Congress but necessary to correctly describe the subject of interest) is in-put. For example, Dr. Coleman is interested only in the petrology of the earth's mantle, not the subject as a whole. However, Library of Congress does not make provision for this specific topic. In this field we have attempted to make provision for new topics or narrow topics not delineated in the chosen thesaurus. It is also the field where the LC classification ranges are recorded. Since this field is searchable, a list of all LC ranges that should be collected by a library can be printed out, together with the subject-weight value.

Selection and Geographic Descriptors

A collection development policy is a necessary tool, aiding the bibliographer in choosing the most useful items for the collection. However, except for making a decision on such broadly based titles as "Coal Geology", the standard collection development profile, with attendant classification ranges is not helpful. For the traditional descriptive literature: the geological survey bulletins, the geological society memoires, the hydrologic maps, and so on, which comprise the bulk of the individual pieces published in the field, it is helpful to have a geographical descriptor attached to the subject field.

The School of Earth Sciences has always had international research interests. The first faculty member hired by the then fledgling Stanford University, J. C. Branner, was a geologist whose field of research was in South America. Presently over 40 percent of our students come from overseas, and their research interests are generally inclined toward non-American topics; in addition, the majority of the faculty interests are not confined to North America. This means that the collection must include materials from all over, in all languages. The collection development policy states that the topic foraminifera is an important one, of selecting intensity level "B". However, when faced with a title on foraminifera published in India, for example, the question arises as to whether this particular title should be added to the collection. Because the SIP file is set up with geographic indicators tied to subject fields, the decision can be made that yes, this particular item should be useful to the researchers who are my clients.

Some topics need geographic parameters in order to be useful. Others, for example, the petrology of the mantle, do not. For many subjects it depends on what type of research the faculty are actually carrying out, as to whether geographic parameters apply. Therefore, discussion with the faculty member as to the nature of the research is vital. For others, they are interested in a particular topic, wherever it occurs. Robert Coleman (see fig. 2) is interested in any Ophiolites found anywhere, therefore, the geographic parameter is the world. In practical terms, this means that I have listed in the file, all continents and all oceans. When deciding which titles based in or published in Africa to select, for example, I can check my SIP file under "Africa" and find what topics need to be acquired.

In order to make this information as practical as possible, I have pulled out the topics related to each continent, or part thereof, and recorded them on an outline map of the continent (see fig. 3). When faced with the decision as to whether to pursue a particular standing order, or to cancel a subscription, reference to the SIP map in question provides the information as to client interest. I find that the geographic descriptors are most helpful when making selection decisions regarding publications from state or national agencies, or from societies. The subject headings alone seem to provide sufficient guidance for selecting titles from commercial publishers.

This file is also extremely useful when defending one's holdings and selection decisions to administrators. When the question is posed: "Why do you need to collect from this country or that?", it is valuable to be able to outline who is working in a particular area, and what kinds of materials are needed.

Obviously, selection of areas needing map coverage, and what kind of coverage, i.e. hydrological, gravity, geological, metallogenic, and so forth, is made much easier by referring to the file. Comparison of the SIP map and the map holdings is an easy way to determine collection weaknesses and the priority order for attacking the collection holes.

Why did we go to all the trouble to enter all of this information onto an online database? Why not just write a list of subject headings in a collection policy or complete a profile of each researcher's interest? One obvious reason was the ability to massage the data easily. Thus we can rearrange our data alphabetically by subject heading or geographical areas of interest or arrange a print out alpha/numerically by call number. More importantly, however, with the plethora of libraries at Stanford and the decrease in acquisition funds, it was necessary to cut out as much duplication as possible. However, as Emmanuel (1979, p. 117) has noted, sciences are becoming more and more interdisciplinary, and at the same time, new branches of science are forming at the junctions of the disciplines. The implication of this trend for institutional libraries with many branches is that clients using different units will need the same material. When an institution's libraries are so fragmented, it becomes necessary to have a vehicle for deciding where such interdisciplinary collections as environmental studies or hydrology would be housed. In addition, such a file alerts bibliographers to the need to purchase pertinent items needed by other disciplines. For example, the Earth Sciences bibliographer needs to collect information on historical earthquakes for one researcher in the Civil Engineering Department.

Figure 3. SIP map of Africa

Finally, the SIP file is a very adaptable method of helping earth sciences information managers cope with a unique selection problem: geographical descriptors can be a necessary part of each subject heading.

Acknowledgements--I want to express my appreciation to Charlene Fermer for typing this paper. Thanks also to Michael Sullivan for programming the SIP file as well as critiquing the paper and to Roy Derksen, Peggy Green, and Harry Llull for their suggestions regarding the paper.

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INFORMATION BROKERAGE

FOR THE WORKING GEOLOGIST

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Abstract--The geologist evaluates a mineralized area with a variety of tools, ranging from highly sensitive geophysical equipment to a pick and sample bag. One of the less obvious "tools" is complete knowledge of written material on the geographical area being considered. Before undertaking an investigation of a particular prospect, a comprehensive search of retrospective and current literature must be undertaken, to assure the geologist that all pertinent studies have been evaluated before new work commences.

The information broker is capable of providing this necessary tool through use of on-line literature searching and perusal of indices to older U.S. Bureau of Mines and U.S. Geological Survey reports. Staff specialists can assist the geologist with document delivery services to supply journal articles, book loans, maps and patents. With the service provided by information brokers specializing in geoscience literature, the working geologist can effectively determine pertinent characteristics of the exploration site in a time-saving and most cost-effective way.

TechSearch, an information brokerage company, specializes in technical literature research for the mining and energy industries.

The extent of our scope is illustrated by the following examples. TechSearch recently located the last U.S. cobalt deposit by using our technical expertise in working with old USGS documents; we've also ascertained the most beneficial climate area in a multi-state western region for growing hybrid trees to be processed for alcohol fuels. Some interesting non-technical projects have also come our way...a metallurgist from a large local mining company is also an art buff, and has instructed us to undertake many art authenticity studies. We got to know one eleventh-century Chinese emperor, who was also a prolific painter and calligrapher, quite well! Besides research, some of our projects have included literature requests via computer terminal. One client has a program especially written to request maps and documents through transmittal over the phone wires instead of typing the request and incurring the time delay of using the mail. The same client has an ongoing project with us which involves cataloging several thousand documents. This task is completed at our office where the important data for each document is entered on our computer

terminal and sent directly into the client's computer, enabling this large research company to have an "on-line" card catalog.

The goal of this paper is to present an overview of our company, supplying background information and a description of our service. Explanation will then be given as to how our service might be utilized by the working geologist, intent on examining the mineralization of a particular geographical area. First a little background about our company and ourselves...TechSearch was created in 1978 by two dissatisfied corporate librarians, Susan Gallanter and Betsy Porter. Ms. Porter has the technical expertise in our company, with a degree in chemistry and biology from Park College in Kansas City, Missouri; a master's degree in librarianship from the University of Denver; and a master's degree in science history from Harvard University. Her work experience includes virus research at KU Medical Center, teaching secondary school science, and several years as a technical literature specialist for a large metallurgical laboratory in Golden. Susan entered the technical information field through the back door with an undergraduate degree in English literature from the State University of New York. She also obtained a master's degree in librarianship from the University of Denver. Susan's previous work experience was her greatest preparation for the venture with TechSearch. She was the technical librarian for Amax Exploration, Inc. and acquired expertise in engineering and geology through this association. The background experience that both partners had was the cornerstone for TechSearch, which is a response to current technology information needs.

TechSearch has been in business for over four years, averaging approximately thirty regular clients with more new prospects every day in our energy-rich locale. We have employed up to sixteen people on various projects, and we're currently operating with seven on our staff. The majority of individuals that work for us have a master's degree in library science, with additional degrees and/or experience in a technical field. Numbering in our ranks are an environmental specialist, a technical editor, and a chemist.

TechSearch has five main areas of service that we provide to information requestors:

Computerized and manual literature searches

Example: A mineral exploration firm has an interest in gold, and would like a complete survey of active and inactive gold mines, as well as areas with suspected potential.

Document retrieval

Example: "Please obtain an article on solvent extraction techniques that I think appeared in Chemical Engineering Progress Symposium Series sometime last year," or "USGS Professional Paper #905 is out of print. Can you obtain an original copy for us and have it duplicated for our in-house library?"

Reference work

Example: In the 1980 legislative session a bill passed mandating a certain state agency to "compile and maintain current

information necessary to answer any inquiry concerning the proper action to take to counteract, eliminate or minimize the public health hazards of a hazardous material incident." The project leader required a comprehensive, annotated bibliography of references, chemical directories and handbooks, local, state and national directories of personnel, agency and publications. This project required on-line computer searching of six data bases to obtain cites to the most recent literature, manual searching of EPA publications and Colorado State Library documents, and contacting key individuals involved in hazardous wastes problems. As you can see from this example, we use many channels to obtain information...from on-line searching, manual perusing of guides to the literature, and phone contact.

Library organization

Example: A New York-based mining company has an exploration office in Denver with approximately 4,000 items in its collection, many books, maps, and reports have been sent from various defunct field offices and have also been contributed by geologists and mining engineers as a result of many business trips and conference attendance. Their request is to have the library catalogued so that the company has a complete inventory of holdings, can easily gain access to needed materials through author, title, and subject, and so that money is not needlessly spent on multiple copies of books and journal subscriptions.

Map and patent procurement

Example: Corporate headquarters for the EXXON company in Houston needs five USGS topo maps in the office within 24 hours. We can purchase copies at the Federal Center and send them out Federal Express. Patent delivery is not quite so quick. If the patent is older than 1959, we can obtain it within 2-3 weeks from a patent delivery company, and newer patents can be obtained with one-day service for local sources.

Translations

Example: A biochemical journal has published an article on microbial enhanced oil recovery that one of our clients needs... the twist is that the article is in Russian and is very technical. TechSearch has access to a translations expert who has a Ph.D. in chemical engineering and specializes in technical literature in at least five languages.

During the past year or two, a television commercial was shown where a medical person in Paris had a problem with a difficult diagnosis. Using a terminal and satellite communications, he contacted the National Library of Medicine in Washington, D.C., and within minutes, had the answer and initiated proper medical treatment. Not visible in the advertisement were the endless hours of creating a master medical data base and the highly sophisticated software to permit effective searching of the data base to elicit the needed information.

TechSearch offers this same technology to our clients through use of three services in the United States which offer terminal access to

hundreds of different data bases. The System Development Corporation, Lockheed Retrieval Service, and Bibliographic Retrieval Service are vendors for well over one hundred data bases on various subjects. Some are very large...Chemical Abstracts has over 4,000,000 items. Others are small and very specialized, such as World Aluminum Abstracts with 70,000 items, and Surface Coatings Abstracts, at 25,000 items. The problem used to be to find the needle in the haystack. Today the problem is further complicated by finding the right haystack to search.

It seemed very fitting to use an example from our files which would illustrate the capacity of computerized literature searching while tying in the location of our meeting place today...Golden, Colorado, home of Coors beer! (See Figure 1.) In all, twenty-six relevant citations were obtained on this subject, spanning the time period of 1967 to within the last month this search was executed. The search itself took one-half hour to perform. One would expect this would be very expensive; however, the very opposite is true with respect to the time/cost factor. A typical search of one data base costs anywhere from $25.00 to $100.00, depending on the number of citations and the complexity of the search retrieved. The following citation from Georef (see Figure 2) contains valuable information in addition to the cite, such as descriptors which aid in identifying other subject areas revelant to the topic.

The number of technical journals and reports increases yearly. Even in very limited areas of technology, there is more information being published than a professional can read, or even scan on a continuing basis. One answer to this problem is known as SDI or selective dissemination of information. TechSearch specialists work with our clients to develop a standardized profile of their information interests. We then run that profile against mutually agreed upon data bases on a monthly basis and provide the client with the results of each month's search. Also, we will insure that the profile is periodically updated to reflect any changes which may have taken place in the client's information needs. This can be done on an individual basis or for a small group of professionals whose interests and information needs are compatible. The advantages of SDI are many:

AVOIDS DUPLICATION OF RESEARCH
PREVENTS UNNECESSARY JOURNAL SUBSCRIPTIONS
KEEPS THE PROFESSIONAL CURRENT IN A PARTICULAR AREA
MONITORS SPECIFIC ITEMS
OBTAINS INFORMATION ON CERTAIN COMMODITIES
MONITORS PUBLICATIONS BY SPECIFIED AUTHORS

In many cases, the references produced by an online or manual search may be available in the client's library. When this is not the case, TechSearch will obtain the full-scale document if requested.

Some resources for our document delivery service include The British Lending Library, Colorado School of Mines, Library of Congress, U.S. Air Force Academy, U.S. Bureau of Mines, U.S. Geological Survey, University of Colorado, and the University of Denver. We take special pride in our proximity to the map sales and public inquiry offices of the U.S.

MARKETING & ADVERTISING RESEARCH METHODS OF THE MAJOR BREWERS

AGRICULTURE FOOD SCIENCE

FOODS ADLIBRA

39,000 ITEMS/MO. UPDATE

BUSINESS ECONOMICS

PTS PROMPT

305,000 ITEMS/MO. UPDATE

PTS PREDALERT

8,000 ITEMS/WKLY UPDATE
CURRENT MO.

ABI INFORM

107,000 ITEMS/MO. UPDATE

SOCIAL SCIENCE

SOCIAL SCISEARCH

765,000 ITEMS/MO. UPDATE

PSYCHOLOGICAL ABSTRACTS

305,500 ITEMS/MO. UPDATE

MANAGEMENT CONTENTS

63,000 ITEMS/MO. UPDATE

NEW YORK TIMES DATABASE

OVER 1.55 MILLION ITEMS/WKLY UPDATE

(FIGURE 2)

GEOREF DATABASE

MANGANESE AND COPPER GEOCHEMISTRY OF INTERSTITIAL FLUIDS FROM MANGANESE NODULE RICH PELAGIC SEDIMENTS OF THE NORTHEASTERN EQUATORIAL PACIFIC OCEAN.

CALLENDER, E.; BOWSER, C.J.

U.S. GEOLOGICAL SURVEY, RESTON, VA. USA UNIV. WIS. USA

AM. J. SCI. 280:10, 1063-1096P.,1980.

LANGUAGES: ENGLISH

LATITUDE: N000000; N200000 LONGITUDE: W1800000; E1400000

DESCRIPTORS: PACIFIC OCEAN; NODULES; MANGANESE; DISGENESIS; METALS; SEDIMENTS; COPPER OCEANOGRAPHY; GEOCHEMISTRY; PORE WATER GENESIS; SECONDARY STRUCTURES; SEDIMENTARY STRUCTURES; EDUATORIAL PACIFIC; NORTHEAST PACIFIC; REMOBILIZATION; SOLUBILITY; DESORPTION; PRECIPITATION

Geological Survey and one of four USGS libraries in the U.S. Our staff can provide next-day service on USGS maps and documents, when going through mail-in procedures can take weeks. The time involved in providing hard copy of documents varies, depending on whether the item is available locally, but the TechSearch staff does everything possible to obtain needed materials quickly.

In addition to the above-listed services, TechSearch can organize a client's technical reports or existing library using available indexing systems or developing one to meet the unique needs of the company. Many companies are organized into several separate divisions. In many cases each division maintains its own file of technical reports and in some cases very little cross-fertilization among divisions takes place. In fact, duplicate effort may be expended because of this lack of communication. A central corporate file system of all technical reports properly indexed and abstracted provides an invaluable tool to corporate technical personnel. The same is true for the library which is comprised of books, journals and conference literature. We can index, abstract and store this vital catalog information on an inhouse computer system or on available timeshared facilities. We can also train the librarian to effectively utilize the data base created. If a library already exists under manual operation, we can replace the 3x5, hole-in-the-bottom card file with today's information technology. The savings by elimination of only one duplicated research project will probably more than pay for the cost involved.

Because we specialize in providing research information to the energy and mining fields, we have almost daily conversations with geologists from many companies in the Rocky Mountain area. Certain patterns emerge from our talks on the procedure the geologist uses to obtain data on particular mineralized areas.

The geologist usually consults inhouse information before going to outside sources. This can take the form of searching company-owned data bases, geographical files, or conversations with colleagues. The geologist then consults the card catalog of the local information source, whether it be a university or federal library. The Bibliography and Index of North American Geology is checked, along with annual periodical indices and geological map indices. When pertinent citations are compiled, the geologist then usually finds the books, articles or maps in the library, or assigns this task to a secretary or company librarian. However, if this professional is acquainted with TechSearch services, both of these time-consuming steps can be avoided, with our staff assuming all responsibility for isolating the needed information and providing hard copy. One important note...In a constant effort to stay ahead of the competition, the geologist values the use of negative information, and if a search for published information on a particular geographical area is fruitless, it can indicate that preliminary investigations have not been undertaken by other companies.

The following occurrences are usually when a geologist seeks our services:

NEW PROJECTS
ONGOING RESEARCH AND DEVELOPMENT
TRACKING NEW DEVELOPMENTS IN A PARTICULAR FIELD
PREPARING BIBLIOGRAPHIES
GATHERING INFORMATION
AVOIDING DUPLICATION
AT PROJECT CONCLUSION

It seems as though we are most frequently called upon to provide on-line literature searching and document delivery. Computerized searching involves all of the above points, and document delivery follows when pertinent cites are selected. Many of the geologists we deal with have called from the field with requests for documents, and others are in a similar position, being located at remote headquarters all year long. TechSearch serves as "legs" for the geologists, in order to obtain information from published collections which are very far out of reach. On occasion, we have also organized personal collections to provide the geologist with subject access to his or her own book and report collection.

The diverse services of TechSearch are available to geologists and other technically oriented energy professionals to aid in research activities. Information technology has never been stronger, and our capabilities can provide quick access and cost-effective ways to obtain needed background information for mineral exploration ventures. TechSearch has provided a much needed service for the past four years, and our growing client list indicates that the demand will be even greater in the future.

CLASSIFYING AND SCREENING THE GEOSCIENCES JOURNAL LITERATURE WITH CITATION DATA

Ann Marie Cunningham

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Abstract--The Institute for Scientific Information® uses a number of citation-based tools to index and classify scientific journal papers. These tools are used to filter information, focus data bases, classify papers, and retrieve information.

ISI® uses reference citation data to filter the more than 30,000 scientific journals to ensure that the coverage of ISI's products represents the most significant of the world's scientific publications.

ISI also employs a sophisticated reference citation-based method for selecting, classifying and retrieving articles on the basis of research-front specialties. Many of these new techniques are now available online via the ISI® Search Network, particularly in the new ISI/GeoSciTech™ data base released in June 1982.

Introduction

It is estimated that over 30,000 scientific and technical journals from around the world are published annually. With the amount of information generated by these publications, a systematic approach for selecting the relevant literature is essential to help researchers keep up with important information in their fields.

Over twenty-five years ago, the Institute for Scientific Information®, ISI®, a privately-owned, Philadelphia-based company, was founded with the purpose of establishing an effective and efficient approach to managing the literature. Today, ISI produces over thirty products and services which organize the literature into a manageable form. Through the use of citation-based methods, they select journals, classify papers, and focus data bases for more relevant information retrieval.

Citation Indexing

Presently, ISI has one of the world's most comprehensive data bases to the significant journal literature in the sciences, social sciences, and the arts and humanities. Over 6,200 journals are indexed annually from cover to cover providing users with access to millions of articles, editorials, discussions, technical notes, review papers, etc.

The most unique indexing technique we employ is citation indexing. Citation indexing is based on the proven concept that a subject relationship exists between a current paper and the earlier references which appear in the bibliography of that paper. Citations provide subject links from one paper to another. (Illustration 1)

A Subject Relationship Exists Between a Current Paper and the References in its Bibliography

The Role of Water in Quartz Deformation

Mervyn S. Paterson
and
K. R. S. S. Kekulawala (*)

Research School of Earth Sciences, Australian National University, Canberra 2600, Australia.

Abstract. — This review of the experimental studies in quartz deformation since the discovery of hydrolytic weakening concentrates on defining the ro ter more closely. The experiments show so ly inconsistent features that are clarified i new results from a joint mechanical, infrar tron microscopical study of a number quartzes, natural and synthetic, and of OH- heat-treated in various ways. The results the diffusivity of the effective OH species concentration dependent and low enoug MPa to explain the failure to weaken stro heating with water at these pressures. The hydrolytic weakening at 1,500 MPa may the higher degree of ionization of the w concentration dependence of the diffusivi librium solubility of OH is also discussed a cations for further experimental work exam

Key words : quartz, plastic deformation weakening, water, diffusivity, solubility.

Le rôle de l'eau sur la déformation du quar

Résumé : Cette revue des études expérime déformation du quartz depuis la découve d'adoucissement hydrolytique met en évidence plus définitivement le rôle de l'eau.

Reference

Baëta, R. D. and Ashbee, K. H. G. (1969 *a*). — Slip systems in quartz : I, Experiments. *Amer. Mineralogist*, *54*, 1551-1573.

Baëta, R. D. and Ashbee, K. H. G. (1969 *b*). — Slip systems in quartz : II, Interpretation. *Amer. Mineralogist*, *54*, 1574-1582.

Balderman, M. A. (1974). — The effect of strain rate and temperature on the yield point of hydrolytically weakened synthetic quartz. *J. geophys. Res., U.S.A.*, *79*, 1647-1652.

Blacic, J. D. (1975). — Plastic deformation mechanisms in quartz : the effect of water. *Tectonophysics*, *27*, 271-294.

Carter, N. L., Christie, J. M. and Griggs, D. T. (1964). — Experimental deformation and recrystallization of quartz. *J. Geol., U.S.A.*, *72*, 687-733.

Christie, J. M., Carter, N. L. and Griggs, D. T. (1964). Experimental evidence of basal slip in quartz. *J. Geol., U.S.A.*, *72*, 734-756.

Illustration 1.

Since 1961, we have most notably used the citation indexing technique in the Science Citation Index®--a multidisciplinary index to the core journal literature of the sciences and technology. This same principle has been applied in a number of ISI indexes including our newest--the GeoSciTech Citation Index™ which covers

- geology
- environmental science/ toxicology/health
- metallurgy/mining
- oceanography/marine sciences
- photogrammetry
- petroleum science/fuel technology
- geosciences/geotechnology
- limnology/water resources
- mineralogy
- meterology/atmospheric science
- paleontology
- soil science

Research-Front Specialties

Research-front specialties employ a sophisticated citation-based method of classifying articles. Research-front specialties are individual areas of intense research activity which interact and sometimes overlap. The focus of these specialties and the pattern of interaction between them comprise a map of the cutting edge of research in this field.

Using citation analysis, ISI has developed a method of indexing the relevant literature. This method is called co-citation clustering. A cluster is a group of highly-cited, closely related papers which form the core literature in a given specialty. These papers are the most significant work in a research area.

In creating a research-front specialty, we look first for highly cited papers. For example, in Illustration 3, we find that Baeta's 1959 paper has been cited 16 times. Blacic's 1975 paper has been cited 15 times. Both papers are highly cited. Next, we look at the more recent papers to see what citations they have in common. Bossiere, Frondel, Kirby, Lister, Morrison-Smith, Paterson, Trepied and Twiss have cited both Baeta and Blacic. There are a total of 9 co-citations between these papers.

GEOSCITECH CITATION INDEX 1976-80
SAMPLE CITATION INDEX ENTRIES

BAETA RD .....
69 AMER MINERALOGIST 54 1551

AYENSU A	PHILOS MAG	36	713	77
BALL A	PHYS CHEM M	3	163	78
BOSSIERE G	TECTONOPHYS	51	57	78
FRONDEL C	AM MINERAL	63	17	78
KIRBY SH	B MINERAL	102	124	79
KIRBY SH	GEOPHY RL	4	97	77
LISTER GS	J STRUC GEO	1	99	79
LISTER GS	J STRUC GEO	2	355	80
LISTER GS	TECTONOPHYS	45	107	78
MITCHELL TE	J AM CERAM	62	254	79
MORRISON.DJ	TECTONOPHYS	33	43	76
PATERSON MS	B MINERAL	102	92	79
TREPIED L	J MATER SCI	13	492	78
TREPIED L	J PHYS LETT	39	433	78
TREPIED L	PHYS ST S-A	49	713	78
TWISS RJ	J GEOLOGY	84	701	76

16 CITATIONS

BLACIC JD .....
75 TECTONOPHYSICS 27 271

AYENSU A	METALLOGRAPH	11	369	78
BOSSIERE G	TECTONOPHYS	51	57	78
DOUKHAN JC	B MINERAL	102	138	79
FRONDEL C	AM MINERAL	63	17	78
GODBEER WC	AM MINERAL	62	831	77
KERRICH R	GEOSCI CAN	5	109	78
KIRBY SH	B MINERAL	102	124	79
LISTER GS	TECTONOPHYS	45	107	78
MORRISON.DJ	TECTONOPHYS	33	43	76
PATERSON MS	B MINERAL	102	92	79
TREPIED L	J MATER SCI	13	492	78
TREPIED L	PHYS CHEM M	5	201	80
TREPIED L	PHYS ST S-A	49	713	78
TULLIS JA	B MINERAL	102	110	79
TWISS RJ	J GEOLOGY	84	701	76

15 CITATIONS

9 CO-CITATIONS

Illustration 3.

By continuing on through the alphabet looking for highly cited and highly co-cited papers, we identify 9 papers (Illustration 4) which form the core of a research-front which we number 81-0286 and name Deformation of Quartz and Quartzite. The number is an accession number used in online searching. The research-front is named by ISI Subject Specialists based on the commonly occurring natural language phrases appearing in the titles of the current papers.

ISI/GEOSCITECH 1982

* 81-0286

DEFORMATION OF QUARTZ AND QUARTZITE

ARDELL AJ; CHRISTIE JM; MCCORMICK JW. DISLOCATION IMAGES IN QUARTZ AND THE DETERMINATION OF BURGERS VECTORS. PHILOSOPHICAL MAGAZINE 29: 1399-1411, 1974

AYENSU A; ASHBEE KHG. CREEP OF QUARTZ SINGLE CRYSTALS, WITH SPECIAL REFERENCE TO MECHANISM BY WHICH WATER ACCOMMODATES DISLOCATION GLIDE. PHILOSOPHICAL MAGAZINE 36: 713-723, 1977

BAETA RD; ASHBEE KHG. SLIP SYSTEMS IN QUARTZ: I, EXPERIMENTS. AMERICAN MINERALOGIST 54: 1551-1573, 1969

BAETA RD: ASHBEE KHG. SLIP SYSTEMS IN QUARTZ: II, INTERPRETATION. AMERICAN MINERALOGIST 54: 1574-1582, 1969

BAETA RD; ASHBEE, KHG. MECHANICAL DEFORMATION OF QUARTZ: I, CONSTANT STRAIN-RATE COMPRESSION EXPERIMENTS. PHILOSOPHICAL MAGAZINE 22: 601-623, 1970

BLACIC, JD. PLASTIC DEFORMATION MECHANISMS IN QUARTZ: THE EFFECT OF WATER. TECTONOPHYSICS 27: 271-294, 1975

GRIGGS, DT. MODEL OF HYDROLYTIC WEAKENING IN QUARTZ. JOURNAL OF GEOPHYSICAL RESEARCH 79: 1653-1661, 1974

MC LAREN, AC; RETCHFORD, JA. TRANSMISSION MICROSCOPE STUDY OF THE DISLOCATIONS IN PLASTICALLY DEFORMED SYNTHETIC QUARTZ. PHYSICA STATUS SOLIDI A-APPLIED RESEARCH 33: 657-668, 1969

MORRISON-SMITH, DJ; PATERSON, MS; HOBBS, BE. ELECTRON MICROSCOPE STUDY OF PLASTIC DEFORMATION IN SINGLE CRYSTALS OF SYNTHETIC QUARTZ. TECTONOPHYSICS 33: 43-79, 1976

Illustration 4.

Nearly 3,600 research-front specialties have been identified in ISI/GeoSciTech. The names and corresponding numbers of the research-fronts are listed in the Index to Research-Fronts in ISI/GeoSciTech. In Illustration 5, we have a sample entry. The user merely enters the Index to look for the area of interest. Next, the user locates the corresponding research-front number.

CONFIGURATION
CONFIGURATION of the MAGNETOTAIL and PLASMA SHEET 81-0110

CONVERSION
CONVERSION of CELLULOSE to METHANE by ANAEROBES 81-0029

CRYSTAL
CRYSTAL STRUCTURE and CRYSTAL CHEMISTRY of MICAS 81-0252

CRYSTAL STRUCTURE of SPINELS 81-0081

DEFORMATION
➡ DEFORMATION of QUARTZ and QUARTZITE 81-0286

DYNAMICS
DYNAMICS of and PRODUCTS from COAL HYDROPYROLYSIS 81-0259

Research Fronts in

ISI/GeoSciTech™

Illustration 5.

The user then keys in the research-front number online to retrieve a relevant, focused bibliography on the topic of interest. The system responds with the name of the research-front and the number of postings. There are 53 recent papers which have cited at least 1 of the 9 papers identified earlier as the core documents for this research area. (Illustration 6).

```
DATA BASE?
@GEOSCI

* SP=81-0286
    DEFORMATION OF QUARTZ AND QUARTZITE
SET 1: 53 HITS

* EXPAND SPWT=81-0286#
TYPE: SPWT
  1 <18> 81-0286-01
  2 <12> 81-0286-02
  3 <9>  81-0286-03
  4 <2>  81-0286-04
  5 <5>  81-0286-05
  6 <5>  81-0286-06
  7 <1>  81-0286-07
  8 <1>  81-0286-08
NO MORE HITS
ACTION?/LEAVE/SEPARATE 8
SET 2: 1 HIT
ACTION?/LEAVE/
```

Illustration 6.

Each issue of the GeoSciTech Citation Index provides users with four main access points: author (Source Index), author's affiliation (Corporate Index), article title-word pairs (Permuterm® Subject Index), and cited references from the current author's bibliography (Citation Index). In the citation index, all current authors who have cited the same earlier work are listed together under that work. For example, (Illustration 2) a paper by Baeta and Ashbee on "Slip Systems in Quartz" published in 1969 in the American Mineralogist, Vol. 54, beginning on page 1551, has been cited by Ayensu, Ball, etc. in these authors' more recent papers. Therefore, it is easy to build a current bibliography in a particular field by looking up an older paper related to that field in the Citation Index. Standard bibliographic policy requires that an author give full bibliographic reference to works that illustrate, elaborate or serve as precedent for the current work.

SAMPLE CITATION INDEX ENTRY

BAETA RD .....
69 AMER MINERALOGIST 54 1551

AYENSU A	PHILOS MAG	36	713	77
BALL A	PHYS CHEM M	3	163	78
BOSSIERE G	TECTONOPHYS	51	57	78
FRONDEL C	AM MINERAL	63	17	78
KIRBY SH	B MINERAL	102	124	79
KIRBY SH	GEOPHY RL	4	97	77
LISTER GS	J STRUC GEO	1	99	79
LISTER GS	J STRUC GEO	2	355	80
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MORRISON.DJ	TECTONOPHYS	33	43	76
PATERSON MS	B MINERAL	102	92	79
TREPIED L	J MATER SCI	13	492	78
TREPIED L	J PHYS LETT	39	433	78
TREPIED L	PHYS ST S-A	49	713	78
TWISS RJ	J GEOLOGY	84	701	76

Illustration 2.

Selection of Coverage

In addition, citation data is used to filter the information from the estimated 30,000 scientific and technical journals to guarantee that we cover only the most significant publications in our products.

Through a variety of studies we and other researchers have discovered that a small core of the world's thousands of journals account for most of the

important material published. This finding--known as Bradford's Law of scattering--enables us to limit our coverage to only the most significant journals in a given field. In the GeoSciTech Index we cover the core journal literature of the geosciences by indexing 350 journal titles.

How do we identify these core journals? We take recommendations from our editorial advisory board. We consult with experts in the field, and with information scientists who know which journals are being used by publishing geoscientists.

We also use statistical methods to determine the important journal literature. We look at a journal's impact factor, which is the measure of the frequency with which the average journal article has been cited in a year. We also consider the immediacy index, or how quickly the average article in a particular journal is cited. We determine the total number of citations received by a journal title. These statistics enable us to determine what publishing geoscientists consider to be indispensable journals in their field.

This citation data is useful in selecting not only the 350 core journals in the GeoSciTech Citation Index, but also individual articles related to the geosciences published in any of the 6,200 journals in our total ISI data base. We select those articles which frequently cite the 350 core journals as well as those articles which contain relevant terms in the article titles. We identify approximately 17,000 items for the GeoSciTech Citation Index in this manner each year. Added to the 38,000 articles in the 350 core journals, the total number of source items that are covered in this index annually is 55,000. Our careful selection procedures ensure that we are providing you with access to more than 94% of the most important geosciences information.

Discipline Oriented Online Data Bases

In 1981, ISI began using journal citation data to define discipline oriented online data bases. We began with ISI/BIOMED™ and ISI/CompuMath™ which became available in November 1981. In June 1982 we released ISI/GeoSciTech®. Additional disciplinary data bases are planned for the future in such fields as polymer science, biochemistry, applied physics, etc. All of these online files are only available through the ISI® Search Network.

To arrive at the journals covered by each data base, we identify all of the journals in the Science Citation Index that pertain to the discipline. The list is then refined by citation analysis. We sometimes identify additional journal titles which must be added to the discipline oriented file in order to ensure comprehensive coverage of the significant literature of that field. We have specifically added 20 titles in ISI/GeoSciTech™ which are not in the SCI®. The core journals and selective article coverage found in the printed GeoSciTech Citation Index are also available in the online file.

Access points to ISI/GeoSciTech include author and author affiliation, title word, language, document type and cited reference. In addition, the user has the capability of searching on a research-front specialty.

Another unique capability of the system is the ability to weight the papers according to their relatedness to the subject of the research. This is not a ranking by importance of the papers, but rather by how many of the core documents have been cited in a current paper. The higher the weight, the more likely it is that those current papers are related to the specialty. Lower weights could reflect new people working in this research area or, perhaps, a new direction for the research field. In our example, of the 53 current papers, we have a range from 18 papers which cited one core document to 1 paper which cited 8 of the 9 core documents.

In Illustration 7, we have printed out the paper which we identified as having the highest weight. In the bibliography of this paper we have highlighted the 8 core documents cited by Paterson and Kekulawala.

```
* FORMAT 2

* PRINT 2 1

AN GS0014521
TI ROLE OF WATER IN QUARTZ DEFORMATION
LA ENGLISH
DT ARTICLE
AU PATERSON MS; KEKULAWALA KRSS
CS AUSTRALIAN NATL UNIV, RES SCH EARTH SCI, CANBERRA 2600, AUSTRALIA
SO BULLETIN DE MINERALOGIE 102(2-3): 92-98
YR 79
RF 35
ON GW380
CR ANDERSON OL: 1977 V15 P77 REV GEOPHYS SPACE PH
   AYENSU A: 1977 V36 P713 PHILOS MAG
   BAETA RD: 1969 V54 P1551 AMER MINERALOGIST
   BAETA RD: 1969 V54 P1574 AMER MINERALOGIST
   BAETA RD: 1970 V22 P601 PHILOS MAG
   BAETA RD: 1970 V22 P624 PHILOS MAG
   BAETA RD: 1973 V18 P155 PHYS STATUS SOLIDI A
   BALDERMAN MA: 1974 V79 P1647 J GEOPHYS RES
   BLACIC JD: 1975 V27 P271 TECTONOPHYSICS
   CARTER NL: 1964 V72 P687 J GEOL
   CHRISTIE JM: 1964 V72 P734 J GEOL
   GRIGGS DT: 1967 V14 P19 GEOPHYS J R ASTR SOC
   GRIGGS DT: 1974 V79 P1653 J GEOPHYS RES
   GRIGGS DT: 1964 V45 P102 TRANS AMER GEOPHYS
   GRIGGS DT: 1965 V147 P292 SCIENCE
   GRIGGS DT: 1966 V152 P4 SCIENCE
   HEARD HC: 1968 V266 P1 AMER J SCI
   HOBBS BE: 1972 P 29 AMER GEOPHYS UNION MO
   HOLZAPFEL WB: 1969 V50 P4424 J CHEM PHYS
   JONES ME: 1975 V131 P429 J GEOL SOC LONDON
   JONES ME: 1978 V37 P703 PHILOS MAG
   KATS A: 1962 V17 P133 PHILIPS RES REP
   KEKULAWALA KRSS: 1970 V46 PTI TECTONOPHYSICS
   KIRBY SH: 1975 V56 P1062 EOS TRANS AMER GEO
   KIRBY SH: 1977 V4 P97 GEOPHYS RES LETT
   KIRBY SH: 1977 V58 P1239 EOS TRANS AMER GEO
   LANGER K: 1974 V52 P17 FORSTCHR D MINERAL
   LAZARUS D: 1963 P43 SOLIDS UNDER PRESSUR
   MCLAREN AC: 1970 V29 P104 CONTRIB MINERAL PETR
   MCLAREN AC: 1966 V19 P19 AUSTRAL J PHYS
   MCLAREN AC: 1969 V33 P657 PHYS STATUS SOLIDI A
   MORRISONSMITH DJ: 1976 V33 P43 TECTONOPHYSICS
   ROBERTS G: 1966 V2 P82 PHYS CHEM GLASSES
   TREPIED L: 1978 V13 P492 J MATER SCI
   TWISS RJ: 1976 V84 P701 J GEOL
SP 81-0286
```

Illustration 7.

There are two characteristics of the method used by ISI to define a research-front which make these specialties a useful way to search the literature. The specialties are derived from the citation patterns of the publishing scientists. The scientists themselves indicate what the focal point of their research activity is by the papers they refer to in their bibliographies. Even the names of the research-front specialties are derived from

the words and phrases used by the scientists in the titles of their papers, thereby reflecting the terminology in current use among them. Second, the process for identifying research-fronts allows the specialties to be redefined often enough to pick up shifts in focus. The process is dynamic because research is dynamic.

Conclusion

By classifying and screening the geosciences journal literature by means of citation data, ISI has attempted to assist you in managing the flood of scientific information. By further refinement of the literature through citation indexing and research-front specialties we are providing you with more effective information retrieval. As ISI further refines its indexing methods, we are confident that we will be able to continue to provide efficient access to the journal literature in the future.

Paper unavailable--

NCIC - A SERVICE TO THE GEOLOGIC COMMUNITY

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The amount and types of cartographic data available to the geologic community are increasing at a tremendous rate, especially when one considers that not all of the data are strictly geologically orientated.

The Landsat multispectral scanner data, new graphic map products, and digital terrain data are but a few of the non-geologic data types which can be of immense value to the contemporary geologist.

The National Cartographic Information Center of the U.S. Geological Survey, as the principal focal point for the collection, organization and distribution of information pertaining to the nation's cartographic data, is able to provide members of the geologic community with answers to the questions - what's available?; who has it?; and how much does it cost?

WORLD GEOSCIENCE LITERATURE AND TRANSLATION

(Extended Abstract)

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The present survey is focused on three main issues: (1) the distribution of world geoscience literature according to language; (2) the availability of translated literature; and (3) the extent to which Soviet and Eastern European literature is communicated to Western, and particularly United States, scientists.

We determined the language breakdown of world earth-science literature by counting citations in the two most comprehensive English-language references and the comprehensive Soviet Union reference, Referativnyi Zhurnal. The two English-language references are GeoRef (U.S.), which is the source of Bibliography and Index of Geology, issued by the American Geological Institute, and GeoArchive (U.K.), which is associated with Geotitles Weekly, issued by Geosystems (London). The French Bulletin Signaletique, from Bureau de Recherches Geologiques et Minieres (BRGM), will be incorporated in GeoRef beginning in 1982 and has not been considered separately because its organization is quite different from that of the three services used. Total citations broken down by language were available from GeoRef and GeoArchive, whereas citations from every 25th page were counted in Referativnyi Zhurnal (RZh), and final figures were multiplied by 25. Three of RZh's many subdivisions, Geologiia, Geofizika, and part of Gornoe delo (an estimated 17% of Gornoe delo citations), were found to correspond to the scope of coverage of each of the English-language indices.

Citations within individual services for 1977 and 1981 (Figs. 1 and 2) demonstrate that neither GeoRef nor GeoArchive record more than a small proportion of Russian citations listed in RZh. RZh also covers more Eastern European literature (e.g., Polish, Bulgarian, Czech, Ukrainian) than the English-language indices. In 1977, RZh covered twice as many citations in Japanese as the English-language counterparts, but by 1981 GeoRef and GeoArchive had substantially increased coverage of Japanese, Italian, Spanish, and Portuguese literature. In contrast, RZh coverage of English language literature had decreased from levels nearly equalling those in English language services in 1969 (Manheim, 1972, p. 39) to substantially lower percentages by 1977.

Total earth-science citations have steadily increased at a rate of about 7% per year, from slightly less than 20,000 in 1955 (estimated by Zakharov, cited in Manheim, 1972, p. 16) to the more than 89,000 that we estimate for 1977 (Table 1). The 1977 total for each language is taken from the source having the highest number of citations. This technique minimizes national bias in coverage. No total data are given for 1981 because the breakdowns are

regarded as incomplete for GeoRef and RZh. Surveys of world earth-science literature conducted in the 1960's and early 1970's showed that total Russian-language citations exceeded total English-language citations. Our current results agree with the report of Wood (1979, p. 226) that English-language publications had taken the lead by 1977, but we find a much larger role for Russian literature in that year than Wood (1979) found. Of the total 1977 earth-science citations surveyed, Wood found Russian citations to account for 23.5%, whereas we find 41.2% to be in Russian (Table 1). The source of this discrepancy cannot be ascertained because Wood's survey methods were not specified.

Figure 1. Number of articles published in predominant languages (top) and in nonpredominant languages (bottom), as listed in 1977 indices.

To assess the role of translations in making foreign literature available to English-speaking scientists, we used two of the most comprehensive translation lists: The World List of Scientific Translations and List of Translations Notified to the International Translations Centre (ITC) in Delft, Holland, and the Translations Register-Index issued by the National Translations Center (NTC) in Chicago. We also recorded the languages of journals listed in the British Library Lending Division's Journals in Translation. A survey of the earth-sciences and oceanography sections in both lists and of geoscience journals in Journals in Translation reveals that Russian is the language of articles most often translated (Table 2). The total number of translated articles listed in the Translations Register has decreased sharply from 294 in 1977 to 91 in 1981. According to NTC staff members, the decline in acquisitions, as well as NTC's inability to incorporate its planned-for on-line data-retrieval system, is mostly due to lack of support from the industrial and scientific communities.

Figure 2. Number of articles published in predominant languages (top) and in nonpredominant languages (bottom), as listed in 1981 indices.

Table 1. -- Language Breakdown of all Earth-Science Literature Surveyed

Language	1977 #	%
ENGLISH	42,986*	48.0
RUSSIAN	36,912**	41.2
FRENCH	2,659***	3.0
GERMAN	2,558**	3.0
POLISH	1,353**	1.5
JAPANESE	942**	1.1
SPANISH	806***	0.9
OTHER	1,367	1.5
TOTAL	89,583	100.2

*GeoArchive
**Ref.Zhur. (estimated as described in text)
***GeoRef

Table 2. -- Number of Translated Earth-Science Publications Listed in the 1977 List of Translations Notified to the International Translations Centre

Translated to -- from	ENGLISH	GERMAN	FRENCH	OTHER	TOTAL
RUSSIAN	1226	815	167	3	2211
POLISH	45	170	10	1	226
CZECH	11	151	10	0	172
HUNGARIAN	9	22	0	0	31
JAPANESE	29	0	0	0	29
OTHER	35	54	3	1	93
TOTAL	1355	1212	190	5	2762

Even existing translations available are not fully utilized. For example, Wood (1967, p. 123) reported that nearly half of British scientists polled wanted to use a foreign source but could not because of the language barrier. Only an average of 15% of the scientists were aware of the major translations centers available to them, and only about a third of those 15% made any use of the centers.

Lack of linguistic skills affects efficient use of translations. According to Manheim (1972, p. 38), the earth science community needs a "critical mass" of at least 10% of the scientists in the community who know a particular language and can evaluate foreign literature before it can use translation services and other tools effectively. Many U.S. and British scientists cannot read languages other than English. Wood (1979, p. 227) found 63%, 11%, 5%, and 2% of British scientists able to understand French, German, Spanish, and Russian literature, respectively. In 1972, the U. S. Scientific Manpower Commission (cited in Manheim, 1972, p. 33) found that about 35% of the U.S. geoscientists could cope with any one of French, German, or Spanish, and less than 2% could cope with Russian. Although such data are no longer being collected, informal polls suggest that the percentages are even lower at present.

A review of the articles listed in the ITC and in the List of Translations in the Library of the Geological Survey of Canada (both 1977) showed that about 49% of Russian citations were from periodical literature. In contrast, some 79% of documents cited in GeoRef were from periodical literature. These figures confirm earlier findings that whereas most Western scientific literature consists of periodical articles, much of the Soviet and some Eastern European literature is published in nonperiodical form. This literature cannot be readily received by subscription or exchange but must normally be individually ordered and tends to be overlooked by Western scientists and library staff.

We conclude the following: (1) the top four languages in frequency of earth-science citations are English (48%), Russian (41%), and French and German (each 3%); (2) translations are underutilized by American earth scientists, and their retrieval in translation centers has declined; (3) retrieval of English-language citations by the leading Russian indexing service has also declined in recent years; and (4) the ability of English-speaking earth scientists to assimilate foreign, and especially Russian, literature has not only not kept pace with improvement in literature coverage by English language indexing services, but has actually declined. The only bright spot is the maintenance of translation journals by organizations such as the American Geophysical Union and the American Geological Institute.

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THE FUTURE OF SCIENTIFIC PUBLICATION

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Abstract--Publications are at once the end-product of scientific research and the raw material for future research. The amount of material that must be published is roughly proportional to the size of the scientific community engaged in research. For the earth sciences this community seems to be growing. Resource and environmental concerns make it unlikely this growth will be stemmed in the foreseeable future. The question is how we will publish all we must and who will pay for it.

There are a number of pressures acting that could change publishing significantly, but none is compelling to the readers or authors of scientific papers. Information technology is advancing rapidly, and the mere fact of this advance is taken by some as a sure harbinger of dramatic change, but there is little evidence to support them. Others point to the economic squeeze on libraries as a probable cause for change. The analysis of the cost-effectiveness of possible changes must extend over all sectors of the communication process. Ignorance of the copyright law and a fickle legislature pose the great threats to scientific publication. Respect for copyright is essential to the continued dissemination of science regardless of the medium.

Publishing covers a multitude of sins, and we in the geosciences span the lot of them as the program for this meeting amply testifies. I am going to limit myself to scientific publication, which I define as the making public of the results of scientific research so that they are available for testing by others, and available to be used as a foundation for future research and for development. Publishing entities include government agencies, commercial and not-for-profit organizations, individual entrepreneurs and some less entrepreneurial types who pursue it as a labor of love and duty. Magnetic tapes, film and paper are the most common media used for scientific publication today, but we are certainly not limited to these. In spite of the variety of media available to us and the penchant of many scientists for the esoteric, the printed book and the printed journal are far and away the most important vehicles of scientific publication.

Contrary to what you may have read in Science (Black 1981, p. 715 and Abelson 1981, p. 393) scientific journal publishing can be a very profitable enterprise. In fact, this business is so good that rarely does a journal fail because it is a bad journal. The sick journals I have seen are usually that way because of poor management, and even

many poorly managed ones are healthy.

Books are a far second. The appetite for journals has consumed library resources for the purchase of books, and high risks exacerbated by high interest rates have pushed book prices upward and sharply curtailed circulation. While book publishing stays barely afloat, journal publishing is charging ahead fulfilling a large fraction of the communication needs of researchers. For 300 years scientific journals have been published with astonishingly little change. In the face of this long history of stability, it may be a little presumptuous to think that there will be significant changes in the next few years. Nevertheless, there are constant pressures to peer through the looking glass into our future. I personally believe that we could see what needs to be done more clearly if we stood back and looked at our own reflection.

Technologic Reality

Technology is the source of one massive pressure to look ahead. There is no denying that we are living in a time in which our technological capability to handle information is advancing, perhaps more rapidly than any technology ever has before it. Growth has been exponential in the last 35 years, but don't extrapolate this trend into the indefinite future. Exponentials have a way of bending over.

We are in the age of electronics. We can store virtually anything, find it again, and transmit it anywhere. And all this without interference from middlemen like postmen, librarians, and publishers. There are electronic journals and bibliographic data bases. Various sophisticated retrieval systems are the bread and butter for many entrepreneurs. There are electronic experiments in all phases of publication and there seems to be widespread enthusiasm for digitizing scholarly publications. I believe that underlying this enthusiasm is a faith in technological promise that is untempered by economic and social realities. In this enthusiasm there may be great danger to the scientific enterprise as a whole.

The journal system works today partly because, by and large, it is very well regulated. It is regulated by editors who represent both authors and readers; it is regulated by scientific societies who do the same on an institutional basis; and it is regulated most importantly by the marketplace.

Some of the lure of electronic publication seems to focus on evading this regulation. For example, virtually unlimited storage and inexpensive access lead some to argue that editorial decisions can be left to the reader. This, at least, is the argument in the extreme. On the other hand, what is published with ink on paper is limited by what people will buy, and editors are bound by page budgets. Ultimately, as the marketplace in the electronics world settles down, so too will there be economic limitations, but in the interim there is a significant risk of turning the literature into an ASCII-coded garbage heap through which scholars will have to sift at great time

and expense.

The difficulty and cost of retrieval rises exponentially with the amount of material from which a given piece must be retrieved, whether you are extracting it from a computer or from a library stack.

The imprint of a scientific publisher serves as an important presorting criterion for scientists. It allows him to focus on the best and most important work during his preliminary research. This use of the imprint is not likely to change regardless of the medium used for the output. The imprint testifies to the quality of what is presented. Scientists will continue to demand that the review and editorial process go on as it has for hundreds of years, and that it be done before material is formally disseminated. The publisher's reputation for quality will be recognized in electronic systems just as it is on the shelf.

Electronic networks are touted as offering the opportunity for rapid informal exchanges. We have rapid informal exchange between authors who know each other right now. They all use the telephone. But these people know each other; they know how to discount each other's claims and oral communications, and how to read between the lines for more information. These informal networks could be significantly expanded, perhaps through existing electronic mail systems; however for publication of research results such systems will be unsatisfactory. I think that expansion beyond the circle who know each other, and who are already successfully communicating informally, is unlikely to be sustained because such broadcasting of unreviewed, unedited material will quickly take too much of the scientist's time and he will not use the new system. Additionally, the archive will be in danger.

Better editing is one key to improved scientific communication. There is a great deal of duplicate publication that can and should be eliminated. Many authors are guilty of publishing essentially the same work in more than one journal, and reviewers frequently fail to weed out repeat reporting by different researchers of the same line of thought. I recently encountered a case in which essentially the same paper was published by different authors just one year apart in the same journal. It had been handled by two different associate editors and by different sets of reviewers who apparently hadn't been doing a very good job of keeping up with the literature themselves, or at least didn't recognize the congruity of the papers and were willing to permit similarity.

Additionally, the literature is bloated with repetitious background material and individual reports on vanishingly small advances in knowledge. Also adding to the burden of everyone involved with the system are reports released for rapid dissemination, perhaps even in microfiche or electronics form, and later polished for formal journal publication.

More stringent review standards and mechanisms for eliminating the repetitious background material must be developed.

On the distribution end, the electronic publishing option appeals strongly to some users who see the application of powerful search and retrieval techniques as upgrading their access to the literature. But, in fact, electronic distribution as a substitute for printed journals stumbles across tradition, reader acceptance, and even access itself.

The biologist will tell you that, if he wants credit for a new species, he must describe that species in a publication that is traditionally produced with ink on paper. Those are the international rules. There have been numerous attempts to get microfilm accepted. What do you think the chances are of accepting an electronic medium in the near future? There are also habits in the practice of scholarship that will be at least a generation in the breaking. Handling the original work is essential for some scholars. For others it provides pleasure and inspiration to their research. Even though I may recognize that the information is the same, I do not get the same kick out of reading the Philosophical Transactions of the Royal Society from a photocopy as I do from sitting down in the stacks with a dusty volume and leafing through the pages. These non-tangible facets of information retrieval are a significant aspect of scholarship.

Perhaps one of the most important reasons for eschewing exclusively electronic dissemination is that it restricts access to information. Electronic dissemination discriminates against those who do not have the special tools required to access the system. It discriminates in the worst possible way. Not on the basis of ability to contribute or learn, but on the basis of sheer material wealth. Ideas are generated by people; ideas are not respectors of national boundaries nor of economic or political status.

Many publishers are receiving manuscripts in electronic form and saving keystrokes. A large fraction of publications are converted to electronic form at some point in the production. I expect that we are not far from shipping manuscripts around to reviewers electronically, but again, I caution you that in doing so we will limit the set of people who are involved in the process and may be foregoing ideas.

I have no doubt that scientific journals will be disseminated electronically, but that will be only one of the media we use. I suspect that ink, or its equivalent, on paper, or its equivalent, will still be with us in the 1990s, and I venture to guess that it will still be the medium of choice around the world. Where the printing is done may be another question. It is quite conceivable, that as technology advances, there may be far more local printing than even now is supported by the photocopying industry.

Economic Perceptions

Another pressure to look for change ahead comes from a perception of economic necessity. Everyone is complaining about the cost of publication--librarians, individual readers, and authors who are

assessed page charges. The libraries cry the loudest. They can't take what they need and they are turning to alternatives such as local networks, photocopying and other nefarious schemes to avoid paying the legitimate charges for information. I might add that in some cases they are avoiding unconscionable prices that really should be avoided--but by refusing to use the material at all, not by breaking the law.

These economic perceptions could change the scientific publishing enterprise if they were to come into focus over a short period of time. But they have been sharpening at a steady rate over a period of 20 years, and as a result they are only effecting minor changes in the publisher's format, and perhaps somewhat larger changes in the library as is shown by the shift of acquisition budgets from books to journals. Remember that journal publishing is a lucrative business for some. There is a great deal of fat that can be cut out. Libraries still have an opportunity to emphasize quality and trim their budgets, or shift more money back to books. Many journals are obviously overpriced for their return to the scientific community, as measured, for example, by citations per subscription dollar. Any journal failures that result from a new emphasis on upgrading the quality of library holdings would strengthen science.

Electronic media will not be an economic panacea for libraries. In the long run electronic transfers are likely to be better controlled than the mailing of photocopies, and electronic publication is not cheap. At the same time journal publishers have other disincentives to greater use of certain electronic media possibilities. Journal publishing is currently a money-up-front game; the subscription fee is paid before costs are incurred by the publisher. In some scenarios electronic dissemination means payment only when the material is used. In such a case the risk is substantially increased and the investment costs raised. Higher risk means higher prices, and the prospect of higher prices will almost inevitably inhibit change.

Marketplace Considerations

Forces that undermine the marketplace constitute the third pressure to look into the future. One of these forces that could radically change or perhaps destroy scholarly publishing is the seemingly ingrained attitude that library services must be free. Of course it is important to the functioning of a democracy that news and considerable amounts of basic information be freely available to every citizen. What cannot be free is specialized technical information. The obligation that seems to be felt by libraries to provide free access to scientific publications could drag the whole system under. Scientists must be prepared to enter the marketplace and to pay for their information requirements directly. Only in this way can a library properly tune its services to its publics, and can the costs to society of the information required for research be kept under control and properly allocated.

When the marketplace is not working, waste is inevitable. I believe that overfunding of libraries in the U. S. has resulted in the purchase of non-essential material. The voracious appetite of the library community for journals has fueled the explosion of titles and encouraged the publication of marginal materials. Long years of buying this material has made it seem a necessity, but there is no hard evidence to support any such claims, and citation statistics point in the other direction.

Publishers offer their users a multitude of opportunities to pay fees for their services, such as page charges, reprints, and subscriptions. These are the avenues through which we should gain our total support. It is through payment for these services that users assure that the publishing enterprise does what they want it to do. In an operating marketplace the level of these fees reflects value placed by the user on the service provided. Libraries must begin to do the same if they are to be cost effective and continue as partners with publishers to serve an important role in the research process.

Governmental Interventions

Government has the power to upset the marketplace with money and regulation. The U. S. Government, given its unwieldy frame and volatile temperament, is a very likely candidate to wreak havoc on the entire scientific enterprise. The support of large projects is a favorite government trick for keeping us off balance. Government funds are effectively unlimited. Given this asset and the capriciousness with which the power it confers can be exercised, it is advantageous not to permit large, government-supported projects to dominate our intellectual endeavors. Government funding is controlled by politicians; that means that funds are going to be turned on or cut off for political reasons, which in turn means de facto political censorship of any government-sponsored activity. Our library systems are not immune from this control. I for one don't think we can afford censorship or political restriction of any kind; therefore, those who have a stake in scholarly information should assume a substantial share of the responsibility for funding it.

Another thing large government projects do is preclude other options. They do this by drying up funding through the trick of overcommitting to one particular area. The space shuttle is an example of this problem, although one largely outside the information area. The commitment to the shuttle has cut off or deferred many other programs. I believe that the single-minded overcommitment to free library services has similarly stunted experimentation with alternative information delivery services.

Government also makes sweeping changes in the structure of the economy through legislation of special benefits. The copyright law is a good example. If a balance of rights cannot be maintained in spite of the fact that there are more voting users than voting owners of intellectual property, there can be no information industry or information economy. The copyright law must command the respect

deserved by a regulation implementing a fundamental constitutional right. The U. S. Congress has thus far failed to provide adequate legislation to assure the constitutionally guaranteed protection.

Similar respect for copyright around the world is essential. There have always been certain countries that have elected to copy scientific journals rather than purchase them from the publishing entity. This practice puts the burden of covering costs for publication on those who are not large enough to make such piracy economically viable, or on those who respect the rights to intellectual property and recognize the need to share the costs of information dissemination. Developing countries are particularly hurt by the higher prices forced by the withdrawal of a major country from the market. Scientific relations can also be hurt by this practice, since individual scientists in the U. S. own and/or control the bulk of scientific publishing through their societies.

One's own government may also compete in the information marketplace. When it does, the resources of the government don't just dislocate the marketplace; they destroy it. The result can be disastrous for the small private sector publisher. There are numerous books and journals issued by the U. S. Government that preempt the market for more cost-effective private publication.

National interests may also interfere with scientific publication. For example, there is concern in the U. S. defense establishment that the open publication of basic research results in a loss of military advantage. Government intervention between the researcher and publisher is threatened. This kind of intervention could have severe consequences for the quality of publication and the quality of science overall.

Those who believe that part of a country's strength is founded on the excellence of its scholarship, and that scholarship and publication are integral to one another, must be eternally vigilant to assure that the system is not violated by a lumbering government.

My Prediction

In spite of the fact that the capacity of government to wreak havoc is almost unlimited, that the economics of scientific publishing are poorly understood, and that the economic outlook for the world is at best uncertain, and in spite of the fact that over the next ten years there will be significant advances in the technology that can be applied to handling knowledge, I believe that scientific publishing will not be revolutionized. Revolutions come about because people demand them. There is no demand for this one. It is true that some publications will not survive, and the fat may all be cut out of the system. Those who do survive should be the publishers who upgrade their input standards, who assure that all new work and ideas that are based on sound research are published and are accessible no matter how divergent the results are from current thought, and those who build a financially sound program based on users paying all the costs of the

system. These publishers will continue to provide strength and vitality to the research process.

Journals, in particular, play a critical role in this process. Journals at once lend credence to claims that knowledge has been advanced, disseminate new knowledge to those who are doing research, provide for the archiving of knowledge so that future researchers can use it, and give recognition to contributors to the body of knowledge. Printed journals will not be replaced until they begin to fail their users, and even then devising a better mechanism or set of mechanisms will be a major challenge.

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Second International Conference on Geological Information - A Summary of Issues and Prospects

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Introduction

During the three days of the Conference, only the second to be held on this subject, many ideas and views on almost every aspect of geological information were discussed. These ranged from general, global matters, such as the need for the establishment of national and international policies governing the flow of information throughout the geological community, to the more specific and everyday problems that practitioners of geoscience information face; for example, the criteria to be used in the building of library collections during a time of financial constraints and changing user demands.

Professor G. T. McBride (President of the Colorado School of Mines) in his opening remarks to the Conference suggested that one of the objectives to be achieved during the course of this Conference was to define the questions which need to be answered by information geoscientists. It should perhaps be considered a bonus if any answers to general, rather than specific, questions are arrived at.

This paper (prepared during the course of the Conference), attempts to present some issues and prospects and pose some questions which have become apparent to the authors during the course of the Conference and previously, and which are vitally significant to the future conduct of geological information. It is hoped they will be given further consideration and thought by the participants and all those interested in geoscience information and its communication, especially within the context of their parent organisations.

Issues and Prospects

The Commodity. As geoscience information specialists, we are in the business of understanding and transferring geoscience information in all its forms, be it digital data; interpretations and ideas in books, periodicals, etc.; or the graphical representation of data and ideas in maps. It is a paradox, often disregarded or not recognised, that the commodities we deal with - text (words) and data - are open to considerable misinterpretation and misunderstanding as to what they are and what they represent. This problem may in part be overcome and hence misinterpretation reduced to a minimum by adequate documentation, indexing, etc., and the presentation of data about data, in order that data integrity can be preserved over long periods of time and during the transfer of information between users/sites.

The User. Several speakers (e.g. Crowe, 1982; Harvey, 1982; Pruett, 1982; Spilhaus, 1982; etc.) have emphasised in different contexts the pre-eminent role of the user in geoscience information and the importance of an awareness of user needs. A question we should perhaps ask ourselves is whether we, the suppliers/conveyors of geoscience information, really do know what the users want and what the users need? It should be recognised that there is a vast difference between user wants and user needs - but can we, as practitioners of geoscience information, recognise this difference and plan accordingly? It is essential that adequate evaluation of users' needs is made at an initial stage and then throughout the running of a project (Horder, 1982), in order that the management and manipulation of the geoscience information are appropriate and relevant. Examples apply particularly with regard to access to data, methods of indexing, mechanisms of retrieval and in the establishment of channels of communication.

Flexibility. Following on from an accurate assessment of user needs and the implementation of appropriately designed systems, it is essential to maintain a high degree of flexibility in both system design and system implementation. An indexing system designed for the geological literature of one country may not necessarily be appropriate for indexing the geological maps from that same country. Equally, a computer data retrieval system designed for handling the holdings of the geological libraries of an international mining company at a limited number of self-contained sites may not be the best designed system to implement in order to provide data retrieval facilities (distributed computer processing) for exploration geologists working with source data at many, varied and dispersed field sites. The maintenance of flexibility during the disparate procedures of system design is therefore essential.

Source and Bibliographic Data. Widely divergent views were expressed during this Conference on the nature and relationship of source and bibliographic data and their handling by the computer. This is an area where there can be no compromise. Horder (1981, 1982) has stated that there is a fundamental difference between source and bibliographic data, and this is concerned with the uses to which the data are put and not any inherent differences in the content of either type of data. An appreciation of a difference between source and bibliographic data, based on such criteria, is essential to system design and implementation.

The Library. The library/information centre is, in many organisations, the central or co-ordinating body for the flow and handling of geoscience information. For many geoscientists, a library is the primary access point not only to published material, but also to bibliographic (and source) data in computer databases. Currently, libraries are under attack from a variety of directions as well as having both adverse and favourable critics. Two problems need to be, and are now having to be, addressed which may, in the longer term, have lasting and possibly detrimental effects on users should the wrong decisions be made. Firstly, in the present climate of financial constraint how do libraries develop suitable policies and systems to build adequate collections and still service user requirements? In formulating such policies do libraries and information geoscientists adequately understand what is expected of them by their parent organisation or indeed individual users? Equally, do those who hold the financial reins fully appreciate that access to information is an increasingly costly activity? Secondly, libraries need to reassess their position with regard to co-operation and co-ordination of services, especially in such areas as acquisitions, cataloguing, and in implementing newer systems required by users, such as document delivery. This is not a time to be parochial in outlook. Furthermore, libraries face problems because much geological research relies on the older literature, both in terms of housing and conserving relevant material and in providing access to it.

The Third World.* There was some emphasis during the Conference on the current status of geoscience information in the Third World and much discussion on their future needs and the role of the developed nations. As information geoscientists, unfamiliar in detail with this area, the authors can make only general comments. However, one point does stand out from the discussions, and that is that the techniques available to the developed nations for the management and manipulation of geoscience data seem singularly inappropriate to the needs of the Third World, as they have been discussed at the Conference. For example, large expensive interactive computer systems employing colour graphics, etc. are inappropriate in countries where even obtaining filing/index cards for manual systems presents a serious problem (Hepworth, 1982). Perhaps, then, if this is a recognisable failing of the developed nations, it is their role to rectify this situation and, initially, be in a position to recognise, and then respond to, more appropriately, the needs of the Third World countries in their handling of geoscience information.

*/ As a direct result of the Symposium on Geoscience Information for Developing Countries held during the Conference, three working groups were established:

International Geoscience Library Co-operation Group (with the immediate project of getting geoscience libraries from both the North and South to sign up for library "twinning", i.e., matching libraries to facilitate gift programmes, information exchange, etc.).

Working Group on Editing, Publishing and Translating (with the immediate projects being:- getting a list of editors who would be willing to help authors and editors from Third World countries in getting their materials into "publishable" form).

Working Group on Databases and Inventories (with the immediate projects being:- (i) form group of advisors to assist decision-makers from the Third World in adequately assessing the need and cost for developing databases; (ii) perform survey of Third World countries on what exists, and what potential needs there might be; and (iii) develop an easy-to-use data entry form that would be the first, yet crucial, step in office management of records and reports before one can even think of computerising).

Anyone interested in the aims of one or more of these groups should contact Julian Green, Head Librarian, Geological Sciences Library, Harvard University, 74 Oxford Street, Cambridge MA 02138, U.S.A.

Operations. The design and implementation of systems is only part of the handling of geoscience information. The system must be used and usable. Here not only design but also user competence and expertise play an important part. Nancy Pruett (1982) introduced to the Conference the not unfamiliar concept of the "gatekeeper": the specialist intermediary who acts as an interface between the user and the sources of information. A point worthy of consideration, therefore, is what should be the split between the "hands-on" operations by the user, and the utilisation of these specialist intermediaries, the "gatekeepers", in the process of selection and access to the relevant geoscience information. The use of both these methods is not, in the author's opinion, mutually exclusive for most applications. However, the balance between them must to some degree be determined by the application under consideration.

Communication. In order to be of value to the geoscience community, information must be communicated. Since the early nineteenth century, the main channel of communication has been the printed word either as the book or the periodical. It would now appear that the scene is set to change because of the relative inefficiency of the present system and the increasing cost of its component parts. The costs of using electronic computer-based systems, however, are in fact falling. On-demand publishing and rapid document delivery are two possibilities which stem directly from such electronic, computer-based systems. The geoscience community will have to decide which parts of the new communications system are appropriate for information in the different facets of geology. Geoscience information quality must not deteriorate and the integrity of the archival copy must be safeguarded. The geoscience community will need to be very sure of its communication requirements and be willing to press the information purveyors to achieve the desired objective (Harvey, 1982; Spilhaus, 1982).

Finance. Inevitably, the economic aspects of the handling of geoscience information must be considered. The current economic situation is going to have an effect on the handling of geoscience information. Not least are the increasing costs which are being experienced by libraries and users of data in, for example, the cost of publications - books, periodicals, maps, etc.; the cost of computer programs; and, perhaps most significantly, the cost of people. We need to assess the effect of increasing costs in all sectors of our operations. For example, will one of the results of rising costs be a widening of the gap in obtaining information and in speed of access to information? If the answer is: Yes, can a slower rate of operation be accepted in these areas? When available funds are limited and the costs of certain activities rise, a question which might be legitimately asked is what is the value of geoscience information activities to the geological community as a whole?

Putting a "value" or dollar figure on scientific work of this, or any, type, some people would argue, is an extremely difficult, if not impossible, thing to attempt. Be that as it may, the handling of geoscience information is a service, and services cost money to operate. The geological community might, therefore, legitimately expect to put a "value", in whatever terms it chooses, on the types of work with which the people at this Conference are engaged. It is, then, the role of geoscience information specialists to ensure value for money.

International Policy. Several speakers at this Conference (Bearman, 1982; Clark, 1982; Harvey, 1982; Horder, 1982), and indeed at the first conference on geological information held in London in 1978, have drawn attention to the need for the groups involved worldwide in geoscience information to work towards developing common policies for the handling of geoscience information as a resource and on the need for these fairly disparate and geographically separated geoscience information tribes to develop a common voice. The individuals within these groups need to be able to see their activities in an overall context in order for them to be effective both individually and corporately. The first stage is the development of effective policies for the handling and transmission of geoscience information (Burk, 1979; Clark & Cook, 1979). However, once such policies are defined and agreed, should we be speaking with a unified international voice to national agencies, when matters of national and international information policy are considered and may affect the flow of geoscience information? Unlike the more traditional areas of the geological sciences, like mineralogy, structural geology, etc., geoscience information lacks subject unity and identity; our subject is more of a technique to be applied throughout the various branches of geology than a branch in its own right. Under these circumstances, an international identity and voice are more critical if, as a group, we wish to be effective in international cooperation and management of geoscience information resources. At this, and also the first (London 1978), International Conference on Geological Information (Harvey & Diment, 1979), there was little support expressed by the participants for the formation of a worldwide federation of national geoscience information groups. If the worldwide geoscience information community has rejected this avenue as a means to creating its international voice, it must find an alternative and soon. This problem is more acute now than it was in London in 1978 and, given the increasing awareness and appreciation of the value of geoscience information by other members of the geological community in general, it will be more pressing still when the Third International Conference on Geoscience Information meets in Adelaide in 1986. The authors believe we are overdue in "getting our international act together". The time is both right and appropriate for action now.

The Future. It is important that the programmes of future meetings of the International Conference on Geological Information maintain a state of balance between the disparate elements of geoscience information and communication. The user of geological information does not necessarily wish to sit through, for example, lengthy theoretical papers on information transfer policies, the intricacies of relational *vis à vis* network and hierarchically structured databases or the comparative merits of various information retrieval packages, none of which are, or are likely to be, employed by the user's parent organisation. The user wants to be informed and helped with the problems encountered daily. However, those participants whose responsibilities are for persuading government agencies of the need for geological information transfer or for defining internal geoscience information handling policies for large multinational, commercial, and government organisations, are not necessarily interested in hearing papers about, for example, data formats of particular computer files, the merits of various computer hardware or the value of full text retrieval of geological data to exploration geologists in the Yukon. It is a fact that international meetings of this type attract a highly heterogenous audience in the sense described above. Both types of presentations, therefore, are relevant, valuable and significant to some, if not all, of the participants. The balance between theories and practice needs to be achieved and may, perhaps, be handled best by varying the form of presentation dependent upon its theoretical or practical bias, in order that as far as possible all interests participate and all participants remain interested.

Conclusion

In attempting to summarise the salient issues and prospects from the Second International Conference on Geological Information, it is fully appreciated that the points discussed above by no means represent a totally comprehensive review of the ideas exchanged. The authors have attempted to concentrate on those issues which are the most important and merit further consideration by participants and readers of this volume alike. Not least amongst the issues discussed, in the authors' view, is that the international geoscience information community needs a corporate voice and needs it soon. It is to be hoped that by the time the Third International Conference takes place in Adelaide, Australia, in 1986, the geoscience information community will have come to recognise, as it has been reluctant to do at this and the previous Conference, the vital need for such a corporate voice worldwide and that the foundations will have been laid for this and the implementation

of geoscience information policies, because, to paraphrase what the German philosopher Hans Sachs said, "We, the geological community, neglect our information at our peril". The responsibility is therefore with us, the world-wide geoscience information community, to ensure that we are equal to the tasks required of us in the future.

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