HANDLING GEOSCIENCE DATA AND INFORMATION

Proceedings of the
Geoscience Information Society

volume 1

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The Proceedings of the Geoscience Information Society are published from time to time by the Society. Volume 1 of the Proceedings contains papers presented at the Symposia of the Society, held in connection with the Society's first Annual Meeting, San Francisco, November 1966, and second Annual Meeting, New Orleans, November 1967. Copies of these Proceedings may be obtained from the Society, c/o American Geological Institute, 2201 M Street, N. W., Washington, D. C. 20037. for $2.00. They are free to members. Checks should be made out to the Geoscience Information Society.

The GEOSCIENCE INFORMATION SOCIETY was organized as an independent non-profit professional society on November 5, 1965 to deal with the problems raised by the information explosion in the earth sciences. The Society's basic objective is to improve the exchange of information in the geosciences through the mutual cooperation of its members—geoscientists, librarians, documentalists, editors, and other information specialists. The Society issues Newsletters and a Membership Directory, steers suitably-trained people into the profession, and provides advice to individuals and organizations. It has recently published a union list of Geologic Field Trip Guidebooks of North America, a Buying List of 100 Good Geology Books for the High School Library, and a Directory of Geoscience Libraries: U. S. and Canada. A Checklist of Geoscience Serials is in preparation.

The Society holds an Annual Meeting every November in conjunction with the Annual Meeting of the Geological Society of America. Symposia on the problems confronting those who handle geoscience information are featured at these meetings.

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Proceedings of the Geoscience Information Society

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THE NATIONAL SYSTEM FOR STORAGE AND RETRIEVAL OF GEOLOGICAL DATA IN CANADA

by

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ABSTRACT

A computer-based system for storage and retrieval of geological information is being developed in Canada; it is designed for independent use by any organization and for maximum interface between all files. Uniformity is sought in methods of recording references and geographic location, methods of coding, and methods of indexing. Pilot tests have been made. The system will be monitored by a Secretariat consisting of a National Coordinator and a clerical staff.

During the early 1960s, the use of computers for storage and retrieval of geological data in Canada had increased to the point where the National Advisory Committee on Research in the Geological Sciences requested that its standing committees, each of which represents a major discipline in geology, report on data processing activities in their respective fields. A review of these reports indicated that many organizations were preparing to establish computer files and were seeking advice. Those which had established files were using a variety of standards, making it difficult or impossible to integrate, compare or exchange files. Out of this review the N.A.C.R.G.S. proposed the concept of the National System for storage and retrieval of geological data that could be used voluntarily by any organization. If feasible, such a system would make a substantial contribution toward establishing the massive common data base that the science of geology should have.

This paper summarizes the activities and recommendations of a committee formed by the N.A.C.R.G.S. to investigate this concept. Credit for the work belongs to the 42 scientists who served on the committee and its 8 sub-committees. I would like especially to acknowledge the contribution of Dr. S.C. Robinson of the Geological Survey of Canada who was chairman of the committee and provided the dynamic leadership necessary to bring this project to its present status.

Terms of reference and objectives

Upon consideration of the directive given by the N.A.C.R.G.S., the committee interpreted its terms of reference as follows:

1. The committee was to take the necessary steps to develop the National System for recording, storage and retrieval of geological data in computer-processable form.

2. The system is to provide for the disciplines that together compose the earth sciences.

3. The system is to be designed for independent use by any organization in Canada that wishes to use it. It is specifically not the purpose of the study to initiate a central national file of geological data.

Within those terms of reverence, the objective of the study may be stated as follows:

1. To study current and potential uses, requirements and problems in recording, storage and retrieval of geological data using computer methods.

2. To recommend the basic principles to be followed in developing the National System.

3. To develop a method of indexing which will serve as a key to the existence and location of geological data in Canada.

4. To undertake pilot studies that test the principles on which the National System would be based, and that also develop standards for recording data in specific fields.

5. To propose an organization to continue development of the National System.

Subcommittee work

Figure 1 illustrates the organization of the committee. Its members include representatives of the mining and petroleum industry, universities, and federal and provincial agencies. In addition, we have sought assistance and advice from outside the committee ranks. We hope that the results of our work will not bear the image of an imposed "government" scheme, but will instead be regarded as something desirable created by those who will use it.

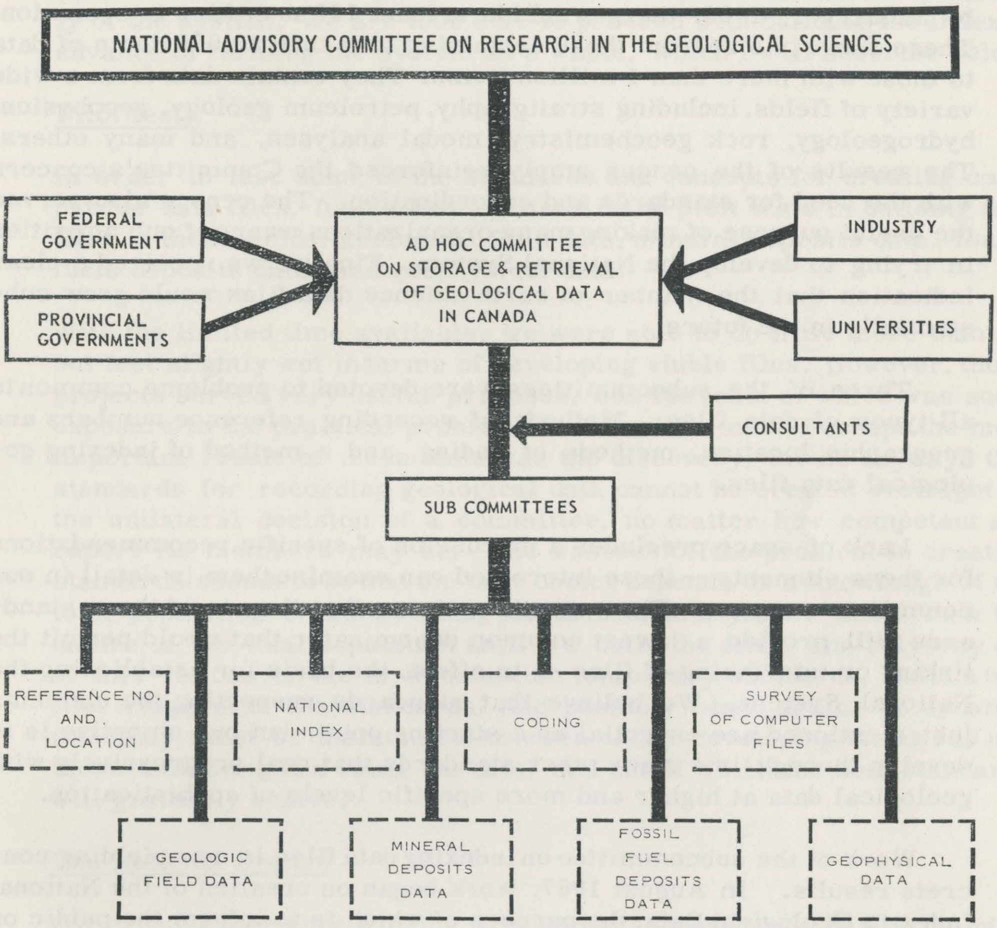

Figure 1. Relationship of Committee to its subcommittees and National Advisory Committee (after Committee, 1967, fig. 2).

One of the 8 subcommittees made a census of existing computer-processable geological data files in Canada. The census indicated that by January 1, 1968, there would be at least 135 such files in operation. These range in size from those containing less than 10,000 items of data to those with more than 1 million items. They contain data from a wide variety of fields, including stratigraphy, petroleum geology, geophysics, hydrogeology, rock geochemistry, modal analyses, and many others. The results of the census amply reinforced the Committee's concern with the need for standards and co-ordination. The census also served the useful purpose of making many organizations aware of our activities in trying to develop the National System. Finally, we received a clear indication that the number of earth science data files would grow substantially in the future.

Three of the subcommittees were devoted to problems common to all types of data files: Methods of recording reference numbers and geographic location, methods of coding, and a method of indexing geological data files.

Lack of space precludes a discussion of specific recommendations for these elements -- those interested can examine them in detail in our committee's report. The essential point is that the use of these standards will provide a lowest common denominator that would permit the linking or interfacing of files -- in effect, the basis for establishing the National System. We believe that standards respecting the elements just mentioned are essential as a starting point, but our objective is to develop through time many other standards that deal progressively with geological data at higher and more specific levels of sophistication.

Work of the subcommittee on indexing data files is now yielding concrete results. In August 1967, work began on creation of the National Index to Geological Data, the purpose of which is to inform the public on the existence and physical location of non-confidential geological data in Canada. The data may be contained in all kinds of documents, including publications, conventional files and computer files. The index is prepared by selecting from the document appropriate concepts that will lead the searcher to the data he is seeking. Processing, searching and retrieval from the National Index will be performed by an IBM 360/Model 65 in Ottawa. The supporting software, contributed by Imperial Oil Ltd., has been thoroughly tested and used elsewhere for several years. It works.

The National Index to Geological Data will focus attention on the data content of documents, not on the information content. It is not conceived as competing with any existing bibliographic indexes, such as the U.S.

Geological Survey's Bibliography of North American Geology. Although the National System requires the Index, the Index can exist independently of the system. We are thus able to proceed with building the Index in advance of forming the system as a whole, which I will describe below.

Pilot tests

In order to test some of the standards and concepts for creating compatible data files, four subcommittees made pilot tests in building data files in these fields: geological field data, mineral deposits data, fossil, fuels deposits data, and geophysical data.

With the limited time available, we were able to do little more than get out feet slightly wet in terms of developing viable files. However, these projects served very useful purposes, not the least of which was some exposure to the practical problems in the real world. Perhaps the most important result of these tests was the discovery, for us anyway, that standards for recording geological data cannot be created overnight by the unilateral decision of a committee, no matter how competent and expert its members may be. The essence of the problem in creating standards seems to be that the best choice depends on a knowledge of the total population of things being described, and yet we don't know the nature of the total population until we build the file. The only way out of this vicious circle is to establish temporary standards, build a test file, reappraise the standards, and possibly begin again. A dynamic interplay must be maintained between those developing standards and those collecting and using the data, and out of which the best standards will gradually evolve.

The National System

Out of our experience with the subcommittees, particularly with the pilot tests, our concept of the National System emerged as one of a flexable, dynamic organization of people, rather than as a fixed set of rules and regulations, which I suspect some members of the N. A. C. R. G. S. and our own committee originally expected. Figure 2 shows the National System.

The heart of the National System will be the Secretariat, consisting initially of one man, the National Coordinator, Geological Data Systems, and appropriate clerical assistance. It will be responsible to the Standing Committee on Storage and Retrieval of Geological Data, and ultimately to the National Advisory Committee. The main functions of the Sec-

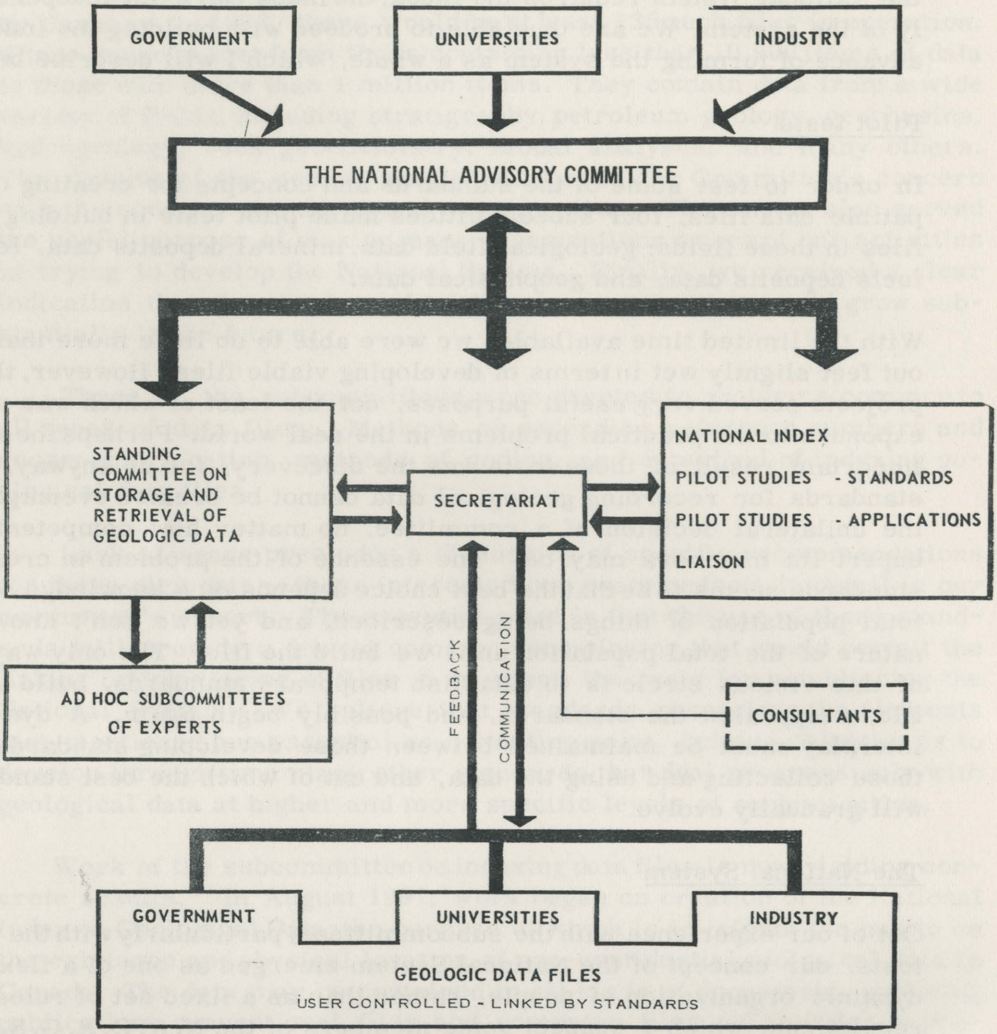

Figure 2. Organization of National System (after Committee, 1967, fig. 4).

retariat will be to implement policies set by the Standing Committee, to maintain the National Index, to direct and co-ordinate pilot projects and to provide liaison between all those using computer technology for data storage and retrieval in the earth sciences. It will have access to consultants in systems and data processing.

The data files themselves will be held and controlled, as they always have been, by various users in government, universities and industry. Their participation in the National System will be voluntary and their decision to participate will be governed by whatever they may consider to be their own best interests. By "participation", we mean simply that they will adopt some or all the recommended standards for recording and storing geological data; that they will voluntarily contribute to the National Index, and that they will exchange ideas with the Secretariat. Note that the owners of the data files are at the same time represented on the N.A.C.R.G.S., where policy for the system is set.

Conclusions

The original motivation for investigating the concept of the National System came from a concern for the potential loss of time, money and achievement if costly masses of data continued to grow in unrelated and uncoordinated ways. At the same time, the implications are staggering for both the scientific advancement of geology and the development of Canada's mineral resources, if the vast data resources of the present and the future can be harnessed on a national scale and focused on particular problems, such as the testing of a new hypothesis or the search for a new economic mineral resource. This very large "if" depends on two things: computer technology to handle large volumes of data-- (this is here today), and, on the establishment and acceptance of basic minimum standards for recording data. The purpose in creating the National System is to satisfy this second condition.

Being a geologist myself, I have no illusions about the difficulty of the task. But we must try. Until geology arrives at the point where it has a large common resource of objective observations and measurements -- data -- its potential as a science will remain in its present fledgling and unfulfilled state.

Reference

Committee on Storage and Retrieval of Geological Data in Canada, 1967, A national system for storage and retrieval of geological data in Canada: National Advisory Committee on Research in the Geological Sciences, 175 p.

AUTOMATIC DATA PROCESSING OF GEOLOGICAL LITERATURE BY THE UNITED STATES GEOLOGICAL SURVEY _/

by

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ABSTRACT

Since its beginning in 1884 the information system of the United States Geological Survey has developed continuously to meet the ever changing nature of geologic research. Geophysical Abstracts and Abstracts of North American Geology are now published monthly, and the preparation of these journals beyond the "rough-draft" stage is completely automated. Magnetic tapes prepared during this process are used to compile yearly indexes, and these yearly tapes then become archival tapes for automatic retrieval of bibliographic data. The search program for the bibliographic data should be coordinated where possible with other information storage and retrieval systems in geology.

<u>History of information systems for geological literature</u>

Every system for handling information develops uniquely for its particular discipline; it depends on the needs of that discipline, the personalities of the people who put it together, and also on how it is refined over the years. The United States Geological Survey has a long history of handling information, and its system has developed in just such a manner.

The first publication of an informational nature by the Geological Survey was its Bulletin 7, <u>Mapoteca Geologica Americana</u>, which appeared in 1884. It is a catalog of geologic maps of North and South America. The first <u>Bibliography of North American Geology</u> was published in 1886-- U. S. Geological Survey Bulletin 44, compiled by N. H. Darton. This bibliography has continued without interruption. After Darton came F. B. Weeks, who devised the first indexing system in the bibliography, a

_/ Publication authorized by the Director, U. S. Geological Survey system in which certain key words or descriptors are broken down hierarchically. This system evolved further under J. M. Nickles in the late 1920's to the basic structure that we use today.

Publication of Geophysical Abstracts began in 1929, by the U. S. Bureau of Mines. From 1936 to 1942 this publication was issued by the Geological Survey, then from 1942 to 1947 by the Bureau of Mines, and from 1947 to date by the Geological Survey. About 10 years ago, when we suddenly became aware that the scientists of the U.S.S.R. were making such remarkable progress, we started monitoring their literature on a large scale. No steps needed to be taken in geophysics, however, because this subject had been covered in depth since 1929.

An experiment in the use of computer processing for handling abstracts of the geological literature began in the Geological Survey in 1963. The success of this experiment was marked by publication of Abstracts of North American Geology, beginning in January 1966. About 30 years ago, the Geological Society of America began publishing the Bibliography and Index of Geology Exclusive of North America. This publication was expanded into a monthly abstract journal in January 1967 as a joint project of the Geological Society of America and the American Geological Institute. A computer program similar to that used by the Geological Survey was prepared to produce this journal.

Technical bibliographies, U. S. Geological Survey

The staff of the Technical Bibliographies of the U. S. Geological Survey comprises seven full-time abstracters and three full-time typists. Editing, proofing, and general office work are distributed among the abstracters and typists according to the abilities and inclinations of the individuals and the exigencies of the moment, attendant on publishing deadline journals. All material in the Bibliography of North American Geology processed by the project and having a publication date of 1961 forward has been placed on magnetic tape. Those items for 1963 forward have abstracts. Geophysical Abstracts since 1966 has been placed on magnetic tape. About 80,000 geological and geophysical articles have now been recorded. The magnetic tape for the Bibliography of North American Geology for 1964 has been released to several companies and universities for development of experimental retrieval programs.

Stages in the preparation of a Monthly Journal

1. Acquisition is entirely a function of the U. S. Geological Survey Library. Any geological literature that reaches our office is sent immediately to the library. We may from time to time suggest the acquisition of items.

2. The publications that appear weekly on the new book shelf of the Survey Library and those that are kept in the reading room bins constitute the material covered by our unit. The new book shelf is covered weekly. Twenty of the bin publications are the responsibility of a group of Survey geologists. The other bin publications are covered by geologists within the unit. An article selected for inclusion is then abstracted and indexed by this same person. Directions for preparation of this material to meet computer requirements, as well as general standards, are given on page 8 of the Guide to Indexing Bibliographies and Abstract Journals of the U. S. Geological Survey.

3. Each rough-draft abstract is checked against a card file in which all previous abstracts are recorded, according to journal—or publisher if the publication is not a serial. Duplication is rarely found. The rough draft is then listed on the appropriate journal card according to author, volume, number, year, and the issue in which the abstract will appear.

4. Next, the rough draft is edited for scientific accuracy, style, and consistency of indexing. No changes in wording or punctuation are generally made from this point on.

5. The rough draft is recorded on a Flexowriter, which produces a hard copy on a card and a punched paper tape. Geophysical Abstracts is assembled in sections before it is recorded on the Flexowriter, and the abstracts are not subsequently alphabetized by author. Abstracts of North American Geology is recorded on the Flexowriter at random.

6. The card produced by the Flexowriter is checked against the rough draft. Any record (abstract) that contains an error is physically cut from the tape.

7. The Flexowriter tapes are read onto a magnetic tape. The computer then assigns a unique number to each record and splits the abstracts onto one tape and the indexing onto another. Each tape is sorted that is, all material is alphabetized, except the abstracts of Geophysical Abstracts.

8. The sorted tape is "dumped," that is, printed out on a high-speed printer. The abstract (front) part of this print-out is checked against the cards produced on the Flexowriter in step 5. The index (back) part is read for consistency. Errors are corrected by dropping entire records. No records can be eliminated from Geophysical Abstracts at this point.

9. After the records with errors are dropped, the sorted tape is run through a "type-setting" program in which the pages are composed. The tape is then used to produce a punched paper tape for the Photon.

10. The Photon composes positive camera-ready copy. The copy is checked at this stage. When an issue passes this stage, it seems to fade away. We ship it off, and then sometime later we see a finished copy. The imperfections that worried us seem to have disappeared. Their place is filled by the usual errors that jump up from a newly printed page.

Indexing

The usefulness of scientific information tends to diminish with time. This transitory quality can be expressed as the "halflife" of the infor-tion. Aerospace technology has a very short half-life, whereas treatments of celestial mechanics may be useful for a much longer time. Cato the Elder's technology for fermentation of *Vitis vinifera* is as good today as it was when written 2,000 years ago. Geological information has a very long half-life. Geologic maps that are currently being produced on 7.5-minute base maps should be useful for hundreds of years. The description of the mineralization in a mine may never be subject to further updating because the object of the study may be mined out completely.

The long duration of the scientific value of geological information necessitates an efficient method of finding this information. Toward this end, a system of indexing has been developed during the last 82 years. This system has evolved along with geology itself. As the system reflects the process by which the human brain seeks to locate a particular item within a general field, it is entirely suitable for automatic manipulation by the mechanical brain of the computer. Retrieval programs have already been written based on the indexing system, and they operate very successfully. The system of indexing used for *Abstracts of North American Geology, Geophysical Abstracts,* and Bibliography and Index of Geology Exclusive of North America has been compiled in the booklet Guide to Indexing Bibliographies and Abstract Journals of the U. S. Geological Survey. This is available on request from the Geological Survey

Coordinated retrieval system for geological information

Computer retrieval programs in geology must search such diverse fields as paleontology, igneous petrology, and geomorphology; yet, all these divisions of geology have many areas in common. Names of rocks, stratigraphic units, commodities, chemical elements, and landforms should be the same in each search program. Where possible, each program should have identical data fields for information that is common to all geology. Further, those items of information that are unique to the purposes of a particular program should be handled in fields of the computer program that are similar in structure.

An ideal program for retrieval in geology can handle bibliographic, paleontological, geochemical, commodity, and professional personnel data. Each of these areas would be provided with computer subroutines unique to the subsystem. With such a coordinated program, the searcher could, for example, search any or all systems for information pertaining to Colorado. The same search program could be used to ask for occurrences of barite in Arkansas, Gryphaea in Texas, Cretaceous in the eastern United States, or all references to charnockite. The system should be available to anyone with a compatible hardware configuration.

A comprehensive approach to retrieval of geological information will enable the geologist now and in the future to retrieve information with full access to his entire science. Anything less than this would be hard to justify. The human brain is not restricted by nature to a particular field; the computer brain for geology must also be without artificial confinements.

AN INFORMATION SYSTEM IN MICROPALEONTOLOGY

by

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ABSTRACT

An information storage and retrieval system for micropaleontology is being developed according to a multi-phase plan. The information forms a natural hierarchy; however, the documents have a great range in depth of data. Specialized indexing must be based on a controlled vocabulary. Existing information systems have been examined, and their common direction is reflected in similarities of data elements i mplementation of the system could bring in 1968. —Editor's abstract

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This is a progress report on a joint project by the American Museum of Natural History and the American Geological Institute that was initiated in February 1967. The purpose of this investigation is to analyze the possibility of developing an information storage and retrieval system for micropaleontologic data.

Becker and Hayes (1963) in their text Information Storage and Retrieval emphasize two aspects of effective information-system development.

1) Optimum systems development is interdisciplinary in character; it involves teamwork by the user, systems designer and equipment supplier. No single individual can hope to have all the specialized knowledge required for optimal information-systems development.

2) Users' needs must be well defined and some measure of their relative importance must be provided. This is the most important and at the same time the most difficult aspect of defining an information system.

Most of the effort involved in this project to date has been concerned with detailed analysis of the users' needs in cooperation with other members of the micropaleontologic community and with documentation specialists.

TD

This is the first time that a broad teamwork approach has been applied to this problem. This report is primarily concerned with the progress made in defining user requirements.

Phase I

Phase I of this investigation was concerned with analysis of a specific literature sample, in cooperation with documentation specialists, in order to estimate feasibility of documentation systems. This information sample was used to design a preliminary input form, and to indicate the type of question that the system would be required to answer.

About 100 articles were studied for information on two foraminifera, the Albian-Cenomanian planktonic species Globigerina washitensis (Carsey), and the Recent benthonic species Miliammina fusca (Brady).

My conclusions concerning the structure of micropaleontologic information are as follows:

1) This information forms a natural scale hierarchy from that associated with the taxon through that associated with the assemblage, sample, station and locality.

2) Great variability exists within documents regarding the depth of information associated with each of these entities, and the degree of specific linkage existing between them. A given paper may supply very specific information on the systematics or taxon level, but very general information (or none at all) on assemblage context or source data.

3) Methods must be devised for evaluating depth of information content as well as the degree of linkage existing between its various elements. Several preliminary schemes have been developed that depend either upon weighting techniques, or upon assigning categories that can be alphanumerically coded.

4) Information content is too specialized for in-depth information retrieval using available indexing schemes. Specialized indexing capability must be based on newly developed controlled vocabularies that adequately represent information content.

Principal conclusions of the documentalists are that:

1) Design and implementation of a machine-based information system

having the required information-handling capabilities is technically feasible.

2) System development and maintenance expense would be primarily due to two factors.

a) Personnel required for preparation of machine input would have to have special training in micropaleontology.

b) Machine handling of the detailed data on source, which would include geographic, stratigraphic, lithologic, ecologic and assemblage data, would be the most expensive part of the system implementation, and should be closely scrutinized by potential users for the degree of detail considered necessary.

Results of Phase I were issued as a report, "A Proposed AGI/Micropaleontology Information System", and formed the basis of a preliminary meeting on July 19, 1967. Among those present were Alan B. Shaw (representing Society of Economic Paleontologists and Mineralogists), Angelina Messina and I (American Museum of Natural History), Harry C. Kent (Colorado School of Mines), William R. Riedel (Scripps Institution of Oceanography) and James F. Mello (U. S. Geological Survey). Informal discussions regarding a coordinated documentation system for micropaleontology have widened the interested group to include Donald F. Squires (Smithsonian Institution), Alfred Traverse and William Spackman (Pennsylvania State University), Helen P. Foreman (Oberlin College) and James D. McLean, Jr. (McLean Paleontological Laboratory).

Phase II

Phase II of the investigation is now nearing completion and is concerned with a comparative study of existing and projected information systems for the micropaleontological community, with the objective of developing specifications for a "universal" information system in micropaleontology.

Descriptions of the projected systems of the American Museum of Natural History, U. S. Geological Survey, and Scripps Institution of Oceanography, and the already developing system of the Colorado School of Mines were analyzed for system direction and data elements. General conclusions after this phase of the investigation are that these systems are potentially compatible:

1) A common direction is evidenced by the similarities of data element classifications and proposed system output requirements. There appears to be general agreement on the level of detail required for description of "source" oriented information.

2) A coding structure for most of the data elements included in this report appears feasible, thus making the internal manipulation and storage requirements of the system more efficient.

3) Output requirements of the group include specialized bibliographic data, data on systematics supplied by catalog formats, and specimen=associated information.

Phase II results were issued as a second report entitled "A Comparative Study of Information Systems for the Micropaleontological Community". Its purpose is to facilitate consensus within a group of micropaleontologists who are active in documentation work.

It seems probable at this time that joint efforts of the committee can result in system specifications that (a) are acceptable to each committee member, (b) will assist proposed systems designers in their work, and (c) will lead to information systems beneficial to the entire geological community.

The unification of the committee's design and implementation efforts, and the possible creation of a central data bank for system processing would enable all geologists to benefit from the "products" of a computer-based micropaleontology information-processing system. System data banks could contain information from contributors such as AGI, Colorado School of Mines, Scripps, Pennsylvania State University, and the Amer-Museum, and others. For this reason alone, system processing could develop outputs of greater value that we can forecast now.

After documentation of the committee's decisions (as a supplement to the Phase II report), systems development may go through three more phases.

Phase III

* Output study (user survey)
* Documentation of input coding structures
* Finalization of input form
* Defining indexing standards

* Beginning vocabulary building
* Investigation of existing generalized systems, which could be adopted for systems processing

Phase IV

* Fulfilling hardware requirements, including input mechanisms
* File design
* System=processing specification designs
* System=processing cost estimates
* Data=center requirements
* Documentation of input techniques
* Expansion of vocabulary
* Initialization of abstracting
* Initialization of input operations

Phase V

* System implementation including computer programming
* Testing
* File building—both internal (tape or disc files) and external (microfilm and hard-copy files)
* Vocabulary control
* Final documentation
* Initial processing
* Data center creation and operation

This project can be a vast undertaking, long term in nature, of great significance to geology, and is as yet undefined in ultimate scope. If initial design and implementation phases are well planned, and if the scope of Phase IV and Phase V work is realistically set forth, system analysis and design phases could be completed during 1968, and systems implementation begun in the same year.

Becker, J., and Hayes, R. M. Information Storage and Retrieval: Tools, Elements, Theories, John Wiley and Sons, New York, 448 p., 1963.

Documentation Incorporated. A proposed AGI/Micropaleontology Information System, unpublished report to the American Geological Institute, July 1963.

Documentation Incorporated. A comparative study of Information Systems for the Micropaleontological Community, unpublished report to AGI, November 1963.

THE UNIVERSITY OF TULSA INFORMATION RETRIEVAL SYSTEM

by

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ABSTRACT

Petroleum Abstracts reviews all phases of petroleum exploration and production on a weekly basis. Each abstract is indexed according to key words that are listed in a thesaurus. The bibliographic citations and key index terms are entered on magnetic tape as an information storage file. This file is used to produce the Alphabetic Subject Index each month, the Dual Dictionary Coordinate Index every four months, and the cumulative Master Record Tape each year.

The University of Tulsa's weekly bulletin Petroleum Abstracts commenced publication in January 1961. Since that time, over 75,000 abstracts have been issued, reviewing significant developments in all phases of petroleum exploration and production. Sources for these abstracts include more than 650 different scientific and trade journals, reports issued by various government agencies (both state and federal), and technical papers from major professional society meetings, plus a thorough review of all patents issued by 20 different countries.

Original documents (journals, reports, patents, etc.) are reviewed immediately as received, and selections made of the particular items considered to be significant and pertinent to the areas of interest. These items are then summarized by skilled abstracters who are knowledgeable in the technical field represented (geology, petroleum engineering, chemistry, etc.). After suitable grammatical editing of the abstracts, the final bulletin copy is typed on special prespaced forms, for direct offset reproduction (see figure 1, right-hand side). Every effort is made to keep time lag to a minimum and, as most abstracting is done in-house, the published abstracts usually appear within a month of receipt of the original publications. In format, the abstracts are arranged four to a page, with guidelines provided to facilitate clipping and filing items of special interest. Abstracts are grouped in sections according to subject. In addition, individual abstracts are available on card stock (5 1/2 x 4 inches), printed from the same plates as the bulletin (figure 2).

Fig. 1 - Flow Diagram of Information System

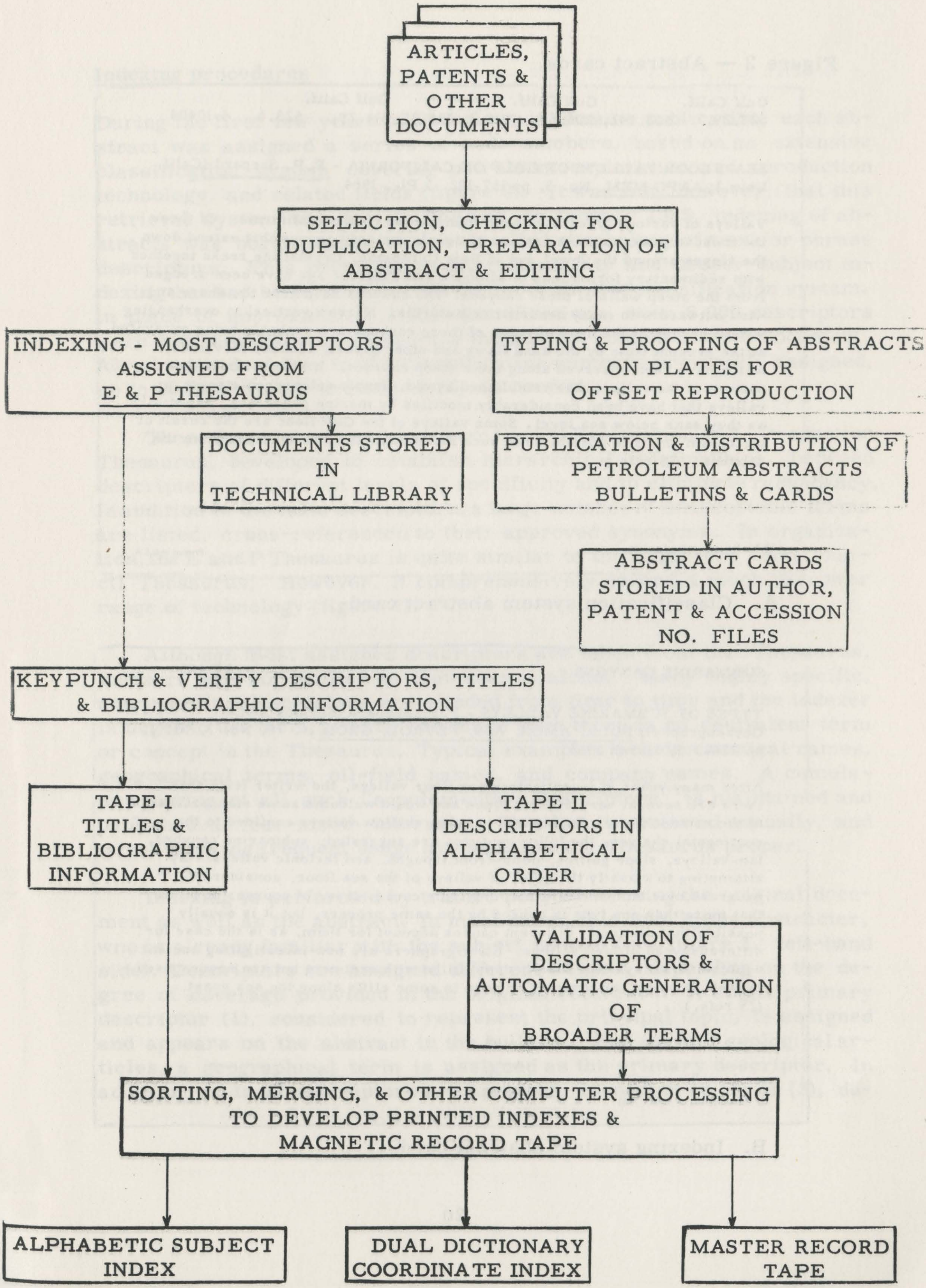


Figure 2 — Abstract cards.

Gulf Calif. Gulf Calif. Gulf Calif.
523.29, 506.142, 506.69, 510.2, 510.31, 514.29, 523.6 4-10404

SEA-FLOOR VALLEYS OF GULF OF CALIFORNIA - F.P. Shepard (Calif. Univ.); AAPG MEM. No. 3, pp 157-192, 1 Pl., 1964

Valleys of various types have been found in the Gulf of California. Of these the most impressive is the series of deeply incised canyons that extend down the slopes around the lower end of Baja California. Crystalline rocks together with sedimentary formations of Miocene and Pliocene age have been dredged from the steep walls of these canyons. The canyons head near the shore and wind outward with many dendritic tributaries. Narrow vertical to overhanging walled gorges at the head of some of these canyons are probably being excavated at the present time by the sand flows and other gravity-induced movements which have been observed along their steep courses. It seems likely that the pattern of the valleys was established by old, deeply submerged stream valleys that have been considerably modified by marine processes, especially as they sank below sea level. Some valleys of the Gulf floor are the result of tectonism and it is possible that such movements may have helped form the canyons. (19 refs.)

A. Classification system abstract card

SUBMARINE CANYONS 53,485

TYPES OF SUBMARINE VALLEYS - F. P. Shepard (Scripps Inst. Oceanography); BULL. AMER. ASS. PETROL. GEOL. v. 49, No. 3, Pt. 1, pp 304-310, March 1965

After many years of investigating sea floor valleys, the writer feels that there are several very distinct types and would welcome some standardization of the nomenclature. In addition to some shallow valleys confined to the continental shelves, the following types are suggested: submarine canyons, fan-valleys, slope gullies, delta-front troughs, and tectonic valleys. By attempting to classify the types of valleys of the sea floor, considerable progress may be made in explaining their cause. It is, of course, possible that more than one type is caused by the same process, but it is equally possible that distinctly different causes account for them, as is the case for different types of land valleys. Stratigraphers are now investigating ancient submarine valleys that have become filled with sediment but are now exposed by well data, or can actually be seen in some cliffs along the sea coast. (15 refs.)

B. Indexing system abstract card

Indexing procedures

During the first few years of Petroleum Abstracts publication, each abstract was assigned a series of code numbers, based on an extensive classification system covering petroleum exploration and production technology, and related fields (figure 3). It was felt, however, that this retrieval system was too limited and, in January 1965, indexing of abstracts was begun, based on a controlled vocabulary of work or phrase descriptors. This permitted greater flexibility and deeper subject indexing than had been possible with the more limited classification system. In place of approximately 1,200 classifications, over 6,000 descriptors were now available to categorize the subject content of each document. Also, instead of two to six classification numbers previously assigned, up to 90 descriptors are now used, as needed.

These descriptors are taken from the TU Exploration and Production Thesaurus, developed to establish hierarchical relationships between descriptors of different levels of specificity and to eliminate redundancy. In addition to the valid descriptors, a large number of unacceptable terms are listed, cross-referenced to their approved synonyms. In organization, the E and P Thesaurus is quite similar to the Engineers Joint Council Thesaurus; However, it comprehensively covers a much narrower range of technology (figure 4).

Although most assigned descriptors are taken from the Thesaurus, indexers are not limited to that source alone. Many highly specific, nonrecurring descriptors are needed from time to time and the indexer is urged to use them, after he has made sure there is no equivalent term or concept in the Thesaurus. Typical examples include chemical names, geographical terms, oil-field names, and company names. A cumulative listing of all such "supplementary descriptors" is maintained and published at four-month intervals. This list is reviewed annually, and terms showing frequent usage are added to the Thesaurus proper.

Indexing is performed by trained personnel, using the original document as well as the abstract. In most cases, it is done by the abstracter, who is already familiar with the subject content (see figure 1, left-hand side). Descriptors are assigned different weights, depending on the degree of coverage provided in the original reference. A single primary descriptor (1), considered to represent the principal topic, is assigned and appears on the abstract in the bulletin. For certain geological articles, a geographical term is assigned as the primary descriptor. In addition, up to 12 descriptors are assigned, identified as (2) or (3), de-

Figure 3. Example of TU classification system

514 Stratigraphy and Historical Geology

- .1 Principles of Stratigraphy
- .2 Stratigraphy of Specific Areas (subdivide by country or state)
  - .21 Europe (excluding USSR)
  - .22 Asia (including USSR and Russian Arctic)
  - .23 South America and Caribbean
  - .24 North and Central America
  - .26 Australasia and Antarctica
  - .27 Africa
  - .28 Pacific Island Arc
  - .29 Oceans and Seas (international waters)
- .3 Type Wells and Sections (arranged alphabetically by stratigraphic unit)
- .4 Facies Change, Permeability Pinchouts, Porosity Lenses
- .5 Correlations
- .6 Biostratigraphy

Figure 4. Exploration and Production Thesaurus format

Stratigraphic cross section
- * Stratigraphic cross section
- BT Geologic cross section
  - Cross section
    - Chart
- SA Stratigraphic correlation
- SA Stratigraphy

Stratigraphic map
- NT Cementation map
- NT Facies map
- NT Grain size map
- NT Isochore map
- NT Isopach map
- NT Moment map
- NT Trend map
- BT Map
- SA Paleogeologic map
- SA Reef
- SA Stratigraphic map classif
- SA Stratigraphy

Stratigraphic test
- Use exploratory well

Stratigraphic thickness
- Use formation thickness

Stratigraphic trap
- UF Facies Trap
- UF Lithologic trap
- UF Stratigraphic oil
- NT Hydrodynamic trap
- NT Unconformity trap
- BT Trap (geology)
  - Geologic structure
- SA Combination trap
- SA Permeability barrier
- SA Pinchout
- SA Reef
- SA Stratigraphic barrier
- SA Stratigraphy
- SA Structural trap

pending on their relative importance. Any less pertinent descriptors assigned are given a (4) ranking. In a later state of computer processing, all broader terms listed in the Thesaurus under the assigned descriptors are automatically posted, with a (5) designation.

Indexers assign the most specific descriptors available, consistent with the content of the document. Searching can later be accomplished at any desired level and specificity and, if a broader base search is desired, the broader automatically generated terms will assure retrieval of the pertinent document.

After indexing has been completed, all retrieval data (titles, authors, patent numbers, bibliographic data and descriptors) are keypunched, processed on a UNIVAC 1108 computer, and stored on magnetic tape for later use (see figure 1, lower half).

Information retrieval tools

Three separate search tools are prepared from this information storage file. Two are published indices, for manual searching, and the third is a Master Record Tape, for computer searching.

The first of the printed indices, the Alphabetic Subject Index, is a multiple listing of document titles under all class (1) and (2) descriptors assigned thereto, arranged alphabetically by descriptor. Two types of entries appear in this Index. Under the primary descriptor (1), a listing of all class (2) and (3) descriptors accompanies the title. In effect, such a listing acts as a "thumbnail abstract", allowing the searcher to evaluate the pertinency of a reference, without referring to the published abstract.

Secondary descriptors (2) are merged into the alphabetized index, but carry only a listing of the title, preceded by its primary descriptor. All entries carry the sequentially assigned abstract number, for retrieval purposes (figure 5).

Supplemental appendixes to the Alphabetic Subject Index contain this information: (a) Pertinent bibliographic data for each abstract, arranged sequentially by abstract number; (b) an alphabetic author listing, with corresponding abstract numbers; and (c) a listing of patent abstracts, by country and sequential patent number.

The Alphabetic Subject Index is issued monthly, covering the weekly Petroleum Abstracts bulletins issued during the corresponding period.

Figure 5 — Alphabetic subject index format.

STRATIGRAPHIC CORRELATION
CONCEPTS IN LATE PALEOZOIC CORRELATIONS 81,864

*CYCLIC DEPOSITION	*LITHOLOGY
*PALEONTOLOGY	*PALEOZOIC
.FACIES	.GEOLOGIC HISTORY
.MEGAFOSSIL	.MICROFOSSIL
.WELL LOG	

BRITISH COLUMBIA*PERMIAN STRATIGRAPHY, PEACE RIVER AREA, NORTHEAST BRITISH COLUMBIA 82,721

GERMANY*THE GIVETIAN OF THE GEROLSTEIN TROUGH (EIFEL) 81,804

MONTANA*STRATIGRAPHY AND CORRELATION OF THE PRECAMBRIAN BELT SUPERGROUP OF THE SOUTHERN LEWIS AND CLARK RANGE, MONTANA 81,826

ORDOVICIAN*COMMENTS ON CORRELATION OF THE NORTH AMERICAN AND BRITISH LOWER ORDOVICIAN 81,843

UNITED KINGDOM*A STUDY OF THE NEILSON SHELL BED, A SCOTTISH LOWER CARBONIFEROUS MARINE SHALE 82,443

USSR*STRATIGRAPHY OF LOWER AND MIDDLE JURASSIC OF GUZERIPL SUBZONE, NORTHERN SLOPE OF THE WESTERN CAUCASUS 82,766

Figure 6 — Dual dictionary format

STRATIGRAPHIC CONVERGENCE							79,746	
STRATIGRAPHIC CORRELATION	76,530	76,551	76,552	76,553	76,534	76,785	76,536	76,
	77,030	76,571	77,012	76,783	76,554	77,005	76,586	76
	77,300	76,581	78,002	76,993	78,164	77,025	76,776	76,
	77,700	76,761	78,052	77,233	78,304	77,275	76,986	77,2
	78,020	76,971	78,302	77,263	78,554	78,025	77,006	77,2
	78,050	77,021	78,562	78,053	78,594	78,265	77,016	77,73
	78,300	77,031	78,582	78,253	78,984	78,285	77,026	78,0
	78,310	77,241	78,982	78,283	79,014	78,565	77,266	78,
	78,990	77,271	79,002	78,553	79,254	78,605	77,716	78
	79,280	77,711	79,252	78,613	79,574	78,985	77,736	76
	79,840	77,721	79,542	78,983	79,834	79,245	78,046	78,
	80,200	77,731	79,842	78,993	79,864	79,255	78,166	78,
	80,460	78,051	79,872	79,003	80,224	79,275	78,266	78,9
	80,470	78,401	80,202	79,233	80,784	79,495	78,286	79,2
	81,070	78,551	80,222	79,543	81,154	79,525	78,316	79,
	81,080	79,001	80,732	79,953	81,304	79,795	78,576	79
	81,100	79,261	80,772	80,223	81,774	79,815	78,606	79
	81,300	79,281	81,092	80,453	81,794	79,835	79,516	79.
	81,370	79,551	81,282	80,483	81,804	80,235	79,546	79,
	81,780	79,861	81,362	80,493	81,864	80,775	79,576	79,8
	81,810	79,871	81,762	80,513	81,874	81,795	79,826	80,2
	81,830	80,201	81,842	80,743	82,404	81,805	79,866	80,2
	81,840	80,221	81,882	80,753	82,414	81,875	79,886	80,
	82,400	80,231	82,082	80,773	82,434	82,435	80,206	80,
	82,720	80,461	82,422	81,113	82,444	82,495	80,236	80
	82,770	81,021	82,442	81,763	82,724	83,075	80,506	81,
	83,070	81,331	82,452	81,803	82,774	83,595	80,516	81,
	83,580	81,341	82,742	81,843	83,064	83,865	80,746	81,0
	83,600	81,361	83,062	81,883	83,334	84,265	80,776	81,0

The June and December issues are cumulative, covering all abstracts published from the beginning of the year. The December issue is hardbound, thus serving as a permanent annual index to Petroleum Abstracts.

The second manual searching tool is the Dual Dictionary Coordinate Index. This index contains an alphabetic listing of all assigned descriptors (classes 1 through 5) with a tabulation of the numbers of the abstracts to which they are assigned, following each descriptor (figure 6). In addition, the cumulative list of "supplemental descriptors" is included in each issue, as an appendix. The Dual Dictionary is issued in pairs, at four-month intervals, for use with established coordinated search techniques. The August and December issues are cumulative for the year, and the December issue is hardbound for permanent library reference.

It will be recognized that the Alphabetic Subject Index, containing only the most pertinent descriptors, is a quick and shallow searching tool, whereas the Dual Dictionary, tabulating all assigned descriptors, becomes a deep-searching tool, for more comprehensive subject coverage.

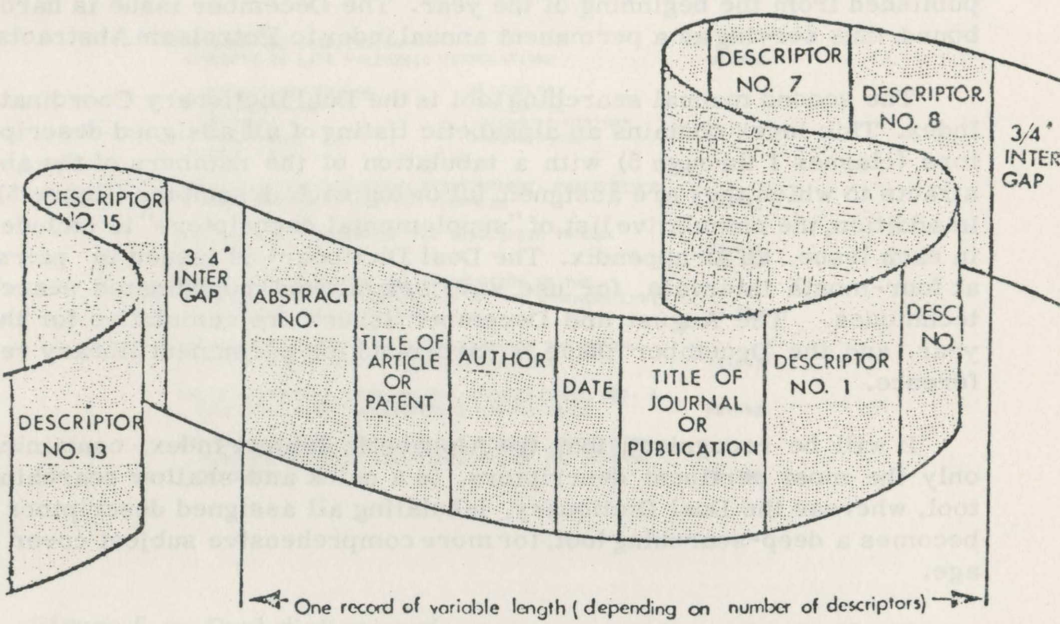
The Master Record Tape contains all retrieval data except the original abstract, and is designed for computer searching. It is cumulative for each year, being updated at four-month intervals. This also may be considered as a deep-searching tool, as it contains all of the assigned descriptors. A generalized format for the Master Record Tape is shown in figure 7.

The economic feasibility of using a computer to perform a simple search may be questionable. On the other hand, by accumulating search questions and processing them on the computer in groups of 10, 20, or even 50, the computer cost is not much higher and, when prorated over all the requests, may amount to no more than a few dollars per question.

System searchability

The principal advantages of the T. U. information storage and retrieval system are its basic simplicity and flexibility. It can be searched at different levels of specificity, depending on the needs of the questioner. For a shallow search of a single specific descriptor or concept, the Alphabetic Subject Index provides a quick, convenient method. For more comprehensive coverage, or for complex questions requiring coordination of two or more descriptors in various logical relationships,

Figure 7 — Generalized format of master record taps



Reel of Magnetic Tape is 1/2-inch Wide and 2,400 to 2,700 Feet Long.

the Dual Dictionary or Master Record Tape may be employed. Searching efficiency, as measured by the relevance and recall ratios of the resulting answers, is in a large measure dependent on the care with which the search question is formulated.

Conclusion

The primary consideration, in both the development and operation of the University of Tulsa information-retrieval system, has been to provide maximum flexibility in searching, with regard to both specificity of subject matter and comprehensiveness of retrieval. Rather than establishing an optimum level of relevance and recall for all questions, these factors can be controlled by proper wording of the search questions, to yield answers that will most satisfactorily match the questioner's needs.

RECENT DEVELOPMENTS IN GEOLOGICAL DOCUMENTATION AND BIBLIOGRAPHY

by

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In recent years there has been an increasing interest in the documentation and bibliography of the earth sciences, evidenced by increased production of all types of bibliographic guides and dictionaries, formation of new societies, and an increase in newsletter publications. This paper is an attempt to review the significant developments of the last four years. It does not attempt to be complete, for no fewer than three hundred bibliographies in the earth sciences have been recorded in the last three years. This arrangement of the material is on a purely personal basis and falls into three divisions: arrangement by type of publication, bibliographies and documentation in individual facets of the earth sciences, and an annotated list of all the material mentioned in the body of the text.

Section 1:

General studies, guides to the literature and bibliographies of bibliographies of bibliographies.

In 1966, H. E. Hawkes produced his Study of scientific publications in the Geological Sciences (3), which surveys the amount of non-oriental geological literature of the world for 1961, the principal languages involved, the principal sources and the completeness and promptness of documentation services. Dederick C. Ward's Geologic reference sources (10) is a most welcome publication. The material ranges from elementary to technical and includes general sources of information, monographs, bibliographies, dictionaries, and lexicons.

With regard to bibliographies of geological bibliographies, E. de Margerie's (7) great work is well known as is its simplified continuation by E. B. Mathews (8). There is now a pressing need for an extension of these compilations although new bibliographies are recorded in the Geological Newsletter of the International Union of Geological Sciences (28). Two other works should be mentioned--Bibliography of bibliographies on the geology of the states of the United States by H. K. Long (6), and B. Kummel's Compilation of bibliographies of use to paleontologists and stratigraphers (5).

The Commission for the Geological Map of the World in Paris has produced three numbers of its Selected geologic bibliography--regional descriptions and maps (1). The areas covered are Africa, the Middle East and South America. It records general bibliographies and maps and also includes main regional descriptions.

Crystallography has had two guides to its literature, one is a journal article -- J. S. Kasper's The literature of crystallography (4) describing the International Union of Crystallography's publications, journals, crystal-structure data, and about 20 books. The other is a book -- Crystallographic book list edited by H. D. Megaw (9), concerned with books, collections of papers, conferences, and serial publications. The original was issued in 1965 with a supplement in 1966.

Geodoc (2) is a new venture of the Coridon Press and is compiled by E. L. Martin of the Institute of Geological Sciences in London. The publication, which comprises five series, is issued in index-sheet form and records commemorative and special volumes, British stratigraphic terms, index to small-scale geologic maps, a selective reference index and a catalog of geological periodicals and series.

International and National, current and retrospective, bibliographies, abstracting and indexing services.

The computerization of the two American-based bibliographies, Bibliography and index of geology exclusive of North America(15) and Bibliography of North American geology (16) has been well advertised and it appears that the earth sciences are now in the very fortunate position of having two monthly compilations that cover their literature in a very competent way. The cooperation of Great Britain and possibly other countries is to be welcomed.

British cooperation was discussed in 1966 at a meeting held in London at the Office for Scientific and Technical Information and in 1967 at the Institute of Geological Sciences (22).

Two most useful pamphlets were issued in 1967 in conjunction with the North American Bibliography, namely Guide to indexing bibliographies and abstract journals of the U. S. Geological Survey (25) and Serial publications commonly cited in technical bibliographies of the United States Geological Survey (26).

Although the Bibliography Exclusive of North America provides excellent service, there is still a need for a two-tier system of abstracting and indexing--the international and national. An example of the latter is provided by British geological literature (17), which commenced publication in 1964 and in the first instance attempted to cover all the geologic literature produced in the British Isles together with any material published abroad on this area. With the advent of the new American service it was decided, from 1967, to cover only publications directly concerned with the geology of the British Isles. From volume 4 (1967), a complete change in the style of the bibliography has taken place. It is now printed on only one side of the sheet and thus serves both the subscriber who wishes to retain a copy intact for the library and also the one who wishes to cut it into standard 75x125mm cards. The entry itself has also been altered and now includes author, title, reference, B. G. L. reference number, abstract, subject headings, location reference to 1 inch geologic map and the National (or Irish) Grid 10 km reference if the area is not too extensive. From British geological literature have stemmed the County bibliographies (17) the first two of which are in preparation.

Other national indexes to geological literature have been issued in recent years. D. A. Bassett is the compiler to two excellent bibliographies--Bibliography and index of geology and allied sciences for Wales and the Welsh Borders (12) covering the years 1536-1958 in two volumes and a Sourcebook of geological, geomorphological and soil maps for Wales and the Welsh Borders (1800-1966) (13). The bibliography has been continued in the Geological journal and the Welsh geological quarterly (12). Dr. Bassett is also the main force behind this quarterly, which contains many items of documentation interest.

Italy is well served by the Bibliografia geologica d'Italia (14), which has now issued ten parts with a further eight parts at least planned. Several further volumes in the series Geologicheskaya literatura SSSR (21) has been published in the last year. G. J. Snowball is the compiler of Annotated bibliography and index of the geology of Zambia (24), which indexes pertinent literature for the years 1931-1963 in three parts with further parts planned.

A preliminary bibliography and index of the geology of Pakistan (23), compiled by T. W. Offield of the U. S. Agency for International Development, is arranged alphabetically by author with a subject index.

The guide to South American geological literature mentioned above (1) does not include two valuable bibliographies, one being for the continent as a whole--Selected bibliography of South America geology by H. R. Cramer (18) -- the other for just one state, Bibliography of the geology and mining of British Guiana by C. G. Dixon and H. K. George (19).

Covering at least part of the same area as the other publication by the Commission for the geological map of the world (1) is M. A. Avnimelech's Bibliography of Levant geology (11) which includes Cyprus, Hatay, Israel, Jordania, Lebanon, Sinai and Syria.

Geomorphology is well served by Geographical abstracts A (formerly Geomorphological abstracts) (20). A complete index is available for 1960-1965 and in the future an annual index will be issued for all the sections of Geographical abstracts with an index for each section every four years.

Newsletters and news journals

The importance of news media with respect to documentation cannot be overestimated and there has in the last two years been a significant increase in the number published.

The Geological newsletter of the International Union of Geological Sciences (28) commenced publication in 1967 and is potentially one of the most important recent developments. The Contact and information bulletin of the IUGS Commission on Geological Documentation appeared in the Circular letter (38) of the IUGS and has been absorbed into the Newsletter. An idea of the scope of this series can be obtained from the contents of the first issue of 1967; coming events to the end of 1968 are listed, news and reports from IUGS commissions, reports from international scientific associations affliated to the IUGS and from other international scientific organizations, news and reports from regional and national geological institutions and geological documentation. This last section includes a list of new books for 1966, reprints, new editions and translations, reports of international conferences and symposiums, reviews prepared or in preparation for the Documentation Committee (the Committee is actively sponsoring preparation and publication of reviews), news on bibliographies and other forms of documentation, inventory of available geological maps, news from existing documentation services (in this issue Le Departément Information du Bureau de Recherches Géologiques et Minières).

It is obviously important for all those interested in geological documentation to cooperate with the IUGS in every possible way so that the Newsletter will become internationally comprehensive.

Atlas (27), a news supplement to the journal Earth-Science Reviews (36), from 1967 and previously to all Elsevier journals in the geological sciences, has been greatly expanded. Coming events are listed as well as general news items and reviews. Various special surveys are projected, the first is to be on the earth sciences in Scandinavia.

Geonews (29) is sent free of charge to all subscribers to Geodoc (2) and British Geological Literature (17); the first number was issued in 1967. It is the intention of the compiler that the newsletter should have a definite bias to reporting documentation news and the first issue does in fact contain a full account of the Geodoc program.

The Geoscience Information Society surveys the work it is doing in its Newsletter (30); a section entitled "Recent publications by G.I.S. members" commenced with issue number 4. The five issues that have so far been sent to members provide an excellent current guide to activities in the fields that interest the Society.

Two more specialized newsletters are the Ostracodologist (32) and the Newsletter, International Committee on the History of Geological Sciences (31). The former, of which number 10 was issued in April 1967, includes information on recent developments, addresses and research being undertaken by individuals as well as a yearly ostracod bibliography. The latter has just been distributed through each country's corresponding member, G. E. Murray and C. J. Schneer for the U.S.A. and Mrs. J. M. Eyles for Great Britain. Objectives of the Committee, outlined in this first issue, "to coordinate studies on the history of geological sciences which are carried out in various countries" and "to prepare by way of international cooperation the 'General history of the geological sciences'".

Review journals and papers

In the rapidly expanding sections of the earth sciences the review article is of considerable importance; mention has already been made of the IUGS contributions (38). [H.E. Hawkes is the author of an NSF Scientific documentation project paper entitled Recent review articles in geology (33).] The Elsevier Publishing Company is responsible for such periodicals as Earth-science reviews (36). Important papers published in this journal include ones on Precambrian palaeontology, paleovolcanology, clay mineralogy, and concepts in palaeoecology. Although some other journals issued by this company are not solely devoted to review papers they do often contain a single review paper in an issue (36).

At present there are no annual publications such as Progress in.. or Annual review of ... for the earth sciences as a whole although one is planned (33). However, papers on topics of interest to earth scientists have appeared in other review journals, for example Fossil plant taxonomy by K. I. M. Chesters in Vistas in botany (35) and H. B. Fell's Cretaceous and Tertiary surface currents of the oceans in Annual review of oceanography and marine biology (37). For those interested in periglacial research an excellent review for several countries was published in Biuletyn peryglacjalny (39).

Terminology: dictionaries and including also stratigraphic terminology and classification

Stratigraphic terms are well documented in the continuing Lexique stratigraphique international. American terms from 1936-1960 are listed in the Lexicon of geologic names of the United States for 1936-1960 (46). This work supplements the former one by M. Grace Wilmarth and is itself being continued by annual supplements that appear as Bulletins of the United States Geological Survey (46). A very recent local dictionary is that by W. W. Bishop, Annotated lexicon of Quaternary stratigraphical nomenclature in East Africa (41), which forms a paper in Background to evolution in Africa.

In recent years there has been a significant increase in the number of papers on stratigraphic classification and terminology and in the production of national codes of practice. The former is the subject of two review articles -- Concepts of stratigraphical classification and terminology by L. Størmer (49) and Stratigraphic classification: a review by W. J. Verwoerd (53). The concept of an international code was reported on by P. C. Sylvester-Bradley in Towards an international code of stratigraphic nomenclature (50). One of the recent additions to the list of national codes is C. L. V. Monty's paper on a Belgian code (48). Although Great Britain has yet to publish a code, the Geological Society of London has initiated a Stratigraphical Code Subcommittee, which has produced a report (44).

The third edition of J. Challinor's A dictionary of geology (42) has just been published. This dictionary gives definitions and examples of the usage of geological terms, as well as relevant references.

The Russian publishing house Nauka issued in 1965 a palaeontological dictionary (40). The main text is an explanation of terms, which gives the Latin equivalent, group, Russian synonyms and their meaning in at least two other languages including English.

Two dictionaries of Russian terms, for palaeontology and geology, have been produced by Telberg Book Corp. (51, 52). The information is limited to the original Russian with a direct translation. A part of a whole series of language dictionaries the *International tectonic dictionary -- English terminology* (43) was published in 1967, and an *International dictionary of geophysics* (45) have been published by Pergamon Press.

Directories

There is pressing need for an up-to-date directory of geologists to replace those produced for the International Geological Congress (54). At least one step in this direction is the announcement of the preparation of the second edition of the *International directory of paleontologists* (56). A *Directory of ostracode workers* was published as a paper in *Micropaleontology* (62).

The mineralogists are fortunate in that at least two directories of persons exist -- *World directory of mineralogists* (57) and *World directory of crystallographers and of other scientists employing crystallographic methods* (58), Computers are playing a more and more important part in geology (see also below) therefore the compilation by T. V. Loudon and Mrs. E. P. Adams entitled *G.O.S.S.I.P. annotated list of some geologists who use a computer* is very welcome (61). The list includes mainly workers in the U.S.A. and Great Britain.

S. R. Kaplan's *A guide to information sources in mining, minerals and geosciences* (59) is divided into two sections, the first being a directory of institutes, surveys, and the second a list of periodicals and series. Although there are gaps in the information given this is a valuable venture.

The Geoscience Information Society has issued the preliminary edition of its *Directory of Geoscience libraries in the United States and Canada* (55). Plans have been made to extend coverage to Great Britain and possibly Europe. *Geological survey libraries of Africa* (60) includes a list of the surveys with addresses; information given includes date of establishment, stock, annual intake, catalogue, and classification scheme.

Periodicals and series

There is a considerable need for studies on the serial literature of the earth sciences, for example on characteristics and frequency. The only item in this catagory that has come to my notice is Qualitative-quantitative evaluation of geophysical serials (63).

Two societies in Great Britain have issued lists of their serial holdings -- Periodicals in the Geologists' Association and university college libraries (68) and List of periodicals taken in the library [of the Geological Society of London] (69). The Geological Society intends to publish a complete list of its holdings in due course. The British Museum (Natural History) is preparing a list of its periodical and serial holdings, which constitute an extensive catalog of earth science publications. The Museum has already issued a List of serial publications in the Department of Mineralogy. . . (65).

The various series publications of the early state surveys of the U.S.A. were, until recently, a collective source of much confusion to all librarians. However, this dilemma has now been rectified by an Index of state geological survey publications issued in series by J. B. Corbin (66).

A list of series used in conjunction with the North American bibliography was mentioned earlier (26) and a useful guide to the abbreviations of Russian journals will be found in Geologicheskaya literatura SSSR (21).

For convenience, guidebooks are included in this section. The Geoscience Information Society has a committee devoted to their bibliographical control, which hopes to issue a preliminary checklist in the near future (67). Guidebooks for one state have already been listed in Field-trip guidebooks of Oklahoma geology (64).

Catalogs

Some recent catalogs concern meteorite collections, for example the Institute of Meteoritics, University of New Mexico (76), Mineralogical Museum, University of Copenhagen (70), British Museum (Natural History) (73) and the Canadian National meteorite collection (72).

The Catalogue of the active volcanoes of the world including solfatara fields (74) has published four parts since 1964, covering Turkey and the Caucasus, Iran, Italy, Colombia, Ecuador and Peru and the West Indies.

In palaeontology, mention must be made of the Catalogue of described and figured specimens in the Begg Collection in the Hunterian Museum (71) and the continuing Catalogue of type specimens in the Walker Museum of Paleontology and Chicago Natural History Museum (77). The International Council of Museums, Committee number 2 for museums of natural history, is attempting to prepare a catalog of publications issued by natural-history museums listing their type specimens in zoology and paleontology. They are also attempting to form a collection of such works (75).

The only library catalog in recent years of direct application to geology is one of the most comprehensive earth-science libraries in the world, namely that of the United States Geological Survey (78).

Translations

International geology review (79) is well known as a source of translations but perhaps not quite so well used in one particular part of the journal which contains a Catalogue of translations of Russian papers in geology, solid-earth geophysics and related sciences through 1961 (81).

There has been considerable activity by several concerns to commence cover-to-cover translations of Russian journals, for example Geotectonics (83), Paleontology journal (87), Oceanology (86), Meteoritica (85), Lithology and mineral resources (84). Two excellent lists of such translations are issued by the National Lending Library for Science and Technology (80) and as part of certain issues of Technical translations (82).

Theses

North American theses up to 1964 have been listed in two publications by J. and H. Chronic (88), and one by D. C. Ward (88). Continuations of these lists are being sponsored by the Geoscience Information Society and the American Geological Institute (88). Various other, more local, listings of theses have been noted, for example those in the Proceedings of the Ussher Society (89) and a Cumulative list of theses of African geology submitted to the University of Leeds (90).

Maps

Maps have always been listed and indexed in the two American-based bibliographies (15, 16) and general works such as that by D. C. Ward

(10) list various sources; however there have been two recent developments of considerable interest.

In the first issue of the Geological Newsletter of the IUGS for 1967 (92) there are details of maps under the heading "Inventory of available geological maps" for Cyprus, Italy, Portugal, and Australia (excluding Western Australia) and a previous issue covered Nigeria, Tanzania, Zambia and Western Australia.

The Commission for the Geological Map of the World has issued a preliminary list of Maps of the international series (91) covering geological and (where published) tectonic, metallogenic, coal and ore maps for Africa, North and Central America, South America, Australia, South East Asia, the Far East, and Middle East. The details given for each map include, scale, number of sheets, data, existence of explanatory pamphlet, and address of vendor.

A local list of maps for Kenya and northern Tanzania is included in the Report on the geology and geophysics of the East African rift system (93).

Section 2:

Computers and geology

Mention has already been made of the increasing use of computers. The need for a short bibliography has been met by T. V. Loudon's compilation, which appeared as Report 1 of Computation in sedimentology (96). The Kansas Geological Survey is responsible for a series of works on computer applications in the earth sciences. In February 1967 it issued a List of computer publications (95), which includes not only the series devoted solely to computers but also any other publications that have been issued separately or in other series by the Survey. A survey of the use of computers in the earth sciences in one country is recorded in the report of the Committee on storage and retrieval of geological data in Canada (97). A recent textbook is Geological data processing using Fortran IV by F. G. Smith (98).

The International Union of Crystallography produced, in 1962, a World list of crystallographic computer programs (94).

Education in the earth sciences

In 1963, the American Geological Institute published for the National Association of Geology Teachers an Annotated bibliography of geological education (99), which contains 76 citations. The Geoscience Information Society plans to bring this publication up to data. In 1965 a conference was held at the Georgia Institute of Technology entitled Changing identity of graduate earth science education and when the proceedings were published an excellent annotated bibliography on the theme of the conference was included (100).

For teachers there is the Reference series of the Earth Science Curriculum Project (101), which has issued nine booklets. Two papers in the Journal of geological education are also of interest -- J. R. Schubel's A reading course in marine geology (104) and Paperback books for earth science teachers by C. V. Proctor (103). Mark W. Pangborn has compiled A buying list of 100 good geology books for the high school library (102).

Geomorphology

The international abstracting service for geomorphology has been described (20). The publishers of this, GeoAbstracts, can also supply Current research in geomorphology (107) (a register of U.K. work in progress) and K. M. Clayton's Bibliography of British geomorphology (106), both of which are publications of the British Geomorphological Research Group, as well as An annotated bibliography of memoirs and papers on the soils of the British Isles Part 1 by B. T. Bunting (105).

Other bibliographies relevant to this section are an annotated bibliography of Quarternary shorelines 1954-64 (108) by H. G. Richards and R. W. Fairbridge and the bibliographic references in Thermal springs of the United States and other countries of the world (109).

History and philosophy of geology

In The Fabric of geology, C. C. Albritton, Jr., published the Philosophy of geology: a selected bibliography and index (110), which has since been kept up to date with further compilations published in the Journal of the Graduate Research Center (110). G. W. White is the author of Reference books for the history of geology (115) and an Annotated bibliography for the history of geology (116). A further guide to this facet is Contributions to the history of geology by A. LaRocque (113).

An excellent history of maps is provided in D. A. Bassett's work, mentioned earlier (13). The catalog produced as a result of an exhibition held at Reading University entitled The history and development of geological cartography (111) lists maps that can be considered landmarks in geological mapping.

The problems, possibilities and sources of research in the history of geology are very well documented in two papers in the History of Science, namely R. Rappaport's Problems and sources in the history of geology 1749-1810 (114), and the follow up by V. A. Eyles, The history of geology: suggestions for further research (114).

Frequently the study of the development of geology, or one particular facet of the science, in a particular region will, when published, contain an excellent bibliography. An example is A. A. Day's The development of geophysics in Australia (112), which has a bibliography of 321 references.

The International Committee on the history of geological sciences has already been mentioned (31).

Paleontology

As well as the paper mentioned in the section on review journals (36), a Select bibliography of Pre-Cambrian fossils was appended to G. E. Murray's paper on Indigenous Precambrian petroleum (119). Vertebrate paleontology has continued to be well served by publications in the Memoirs of the Geological Society of America (117, 123) and an excellent selected bibliography is to be found in the new edition of A. S. Romer's Vertebrate paleontology (122). Since 1963 four further parts of the Treatise on invertebrate paleontology (124) and five further parts of the Osnovy paleontologii (120) have been published.

In 1966, volume 6 of the World report on palaeobotany (121) was issued and listed the literature for 1964-65. The Handbook of paleontological techniques, edited by B. Kummel and D. Raup, contains a Bibliography on paleontological techniques by Kummel (118).

To conclude this survey it should be mentioned that no attempt has been made to cover the general reference and bibliographid aids that have been published in the last four years although many of these will be of considerable use to the earth scientist.

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CONSIDERATIONS IN DEVELOPING STORAGE-RETRIEVAL SYSTEMS FOR MARINE GEOSCIENCE DATA

by

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ABSTRACT

A basic geologic sampling-index form is used to code oceanographic data by the National Oceanographic Data Center. New as well as old data are entered according to these forms even though the older data are commonly less complete. Important advances have been made recently in position and depth determination; the occurrence of such data must always be monitored. The information system must be able to handle information obtained by new techniques, and nomenclature for reporting data should be standard. As this information system develops, it is expected that the originators of data will provide material that is increasingly compatible with the system.

But for the intervening liquid curtain separating the observer from the sea floor, the problems of marine geoscience would be those of terrestrial geoscience. This is also true for geoscience information systems. Although the ocean provides the marine geoscientist with a convenient - if not always comfortable--means of transporting men and equipment, it hides the bottom and it is notoriously unstable and restless. It is difficult to know very precisely where on the sea floor a sample has been taken. This uncertainty of geographical positioning is increased when the observor is at a point a mile or more removed from the sampling spot at the other end of a thin cable. Thus, we must preceed cautiously with geological investigations of the seas because of the absence of the essential element in conventional mapping: good topographic control, with accurate positioning implicit in the concept.

Despite these limitations, geological and geophysical investigations are being made at a gradually accelerating rate.

The National Oceanographic Data Center (NODC) is establishing a marine data bank for oceanography, including geoscience subjects.

While developing these geoscience systems we have wrestled with problems that result in part from the nature of the marine environment, and in part from the newness of these scientific observations. These problems include:

1. Design of a format suitable for data collected recently or a decade or more ago, and also suitable for data to be collected in the future.

2. Difference in requirements of deep-ocean stations as compared with nearshore operations.

3. Continual development of new instruments, collection techniques, and analytical methods.

4. Degree of error tolerated in measurements.

5. Lack of standardization for some basic secimentary units.

The attemnts to resolve the problems we met in coding the basic geologic sampling-index form have had varying degrees of success. This sampling-index form was prepared because it was the general opinion of marine geologists that the first most useful service NODC could perform in the area of marine geology was to make available information as to what sampling had been made on the sea bottom and what general bottom type had been encountered or collected. This was the basic requirement with provision for other details such as equipment characteristics and preservation procedures used. It was desired to incorporate these other details, if available from the source, and to encourage reporting of such data in future surveys. More detailed analyses such as comprehensive chemical, size-fraction, and mineralogical data for these samples would be highly valued, but because of their paucity, systematic and adequate treatment would wait until a geological sampling inventory was under way. This decision was made because of the poor state of standardization of units and measurement techniques and especially because it is imperative that we avoid unintentional duplication of sampling programs involving expensive ship time and effort. It need not be stressed that knowledge of what already has been taken from the sea floor is most useful in planning future programs. Workers in government, academic institutions, and industry can, of course, be provided with fertile leads for inquiry.

To discuss some of the problems listed above:

1. For historical data of greater or lesser antiquity most of the entry spaces on the form dealing with details of instrumentation, sample preservation techniques, and information other than position and sediment type would often remain unfilled, but as already stated the mere presence of these spaces is expected to suggest the reporting of such data when available. Take such seemingly extraneous data as free-fall distance of a corer associated with weight and penetration distance, although heretofore it has been rarely available, if included in sampling reports it could provide a valuable addition to the scarce reports of the mass engineering character of the sea floor. On the other hand, an attempt to include every possible scientific observation could seriously hamper the goal of providing a quick inventory of what has been done.

The main difference in the nature of historical data and that recently obtained results from improvement in position-determination or navigational accuracy. Inaccuracies in positioning in old sources are highly probable, but the user of such data must make his appraisal on the basis of dates, ships, institutions or whatever insights he may have. The NODC can reject data that are suspect because of internal inconsistencies or implausible locations, depths, time lapse between stations and the like, but otherwise it presents the position as given.

For recent data, navigational accuracy is requested in terms of limits of nautical miles. The best known is "less than 0.2 nautical miles"; the least known is "greater than or equal to 20 nautical miles." It is doubtful that samples taken from positions known only within 20 nautical miles can have any real geologic significance. But most navigators are reluctant to confess to any substantial uncertainty, and they report position to fractions of a minute even though that may not be justified. The actual navigation system used is considered less significant than the accuracy obtained because of such difficult to evaluate skill of operator, weather, position relative to signal strength, and condition of equipment. Furthermore, the equipment itself is frequently modified or supplanted, rendering obsolescent any code prepared to identify it.

At the time the forms were prepared, ocean readings of a tenth of a minute (commonly converted from seconds) were all that could be reasonably expected. With the increasing use of satellite navigation readings to hundredths of a minute (50 feet of latitude at the equator, and less else here) are becoming more common and the widespread use of this facility may be the answer to the navigation problem for new data.

The other positional aspect, that of depth, also poses problems. Depth data from older sources are generally suspect because of the use of hemp rope, which was subject to stretching, or wire soundings. Both were affected by the vagaries of current movements and, where depths were great, uncertainty as to when the bottom was reached. The depths must be given as reported and the user must evaluate the method of the depth reading and the time when it was made. Recent echo determinations may be more accurate; NODC indicates whether standard corrections were applied. However, anomalous density variations affecting sound values may not always be known for the column of water at the sampling site.

2. Requirements of nearshore stations have made it desirable to retain position determinations to hundredths of a minute; this is true even though many such data are reported in relation to fixed shore references and not to geographic coordinates. Possibly some intensive nearshore work would result in stations requiring positioning identification finer than hundredths of a minute--say, a station every five feet or so. However, retention of so much detail when considering ocean sampling as a whole yields diminishing returns. If the volume of such dense data ever becomes great, a much finer positional indication will have to be provided for.

3. The appearance of new collecting gear possibly associated with new techniques in general may be handled by existing entries. If a basic new technique emerges either for collection or analysis, the designation of "other" with succinct description on punch cards for the station must be resorted to until the nature of the change can be described and circulated as a supplement.

4. The degree of error is of major importance in many analyses. For some purposes it may be relatively large and still useful, but for others small errors will render the data useless. In several systems under consideration the problem in error variation is treated by permitting the analyzer to provide this value. On the form, four columns showing plausible error in percentage are provided for each applicable field. This can be reported as standard deviation from the mean. NODC is dependent upon the originator for error information and subjective appraisals can be made by users of such data on such considerations as laboratory designation, date of analysis, and equipment used.

5. A serious factor in recording sediment by gross characteristics is the difference in size definitions employed by various laboratories. For

example, silt has been reported as comprising material within the size limits of 0.0313 mm and 0.00195 mm. According to more general use of the term the silt size extends only between 0.0313 mm and 0.0039 mm with the fraction between 0.0313 and 0.00195 (9 Phi) included as clay. These standardization problems make it difficult to present meaningful data except as absolute measurement values. NODC has been coding the more generally used system based on Shepard's 1954 paper, "Nomenclature Based on Sand-Silt-Clay Ratios" (Journal of Sedimentary Petrology, v. 24, no. 3).

I hope that self interest may lead to reporting of such basic information in the most commonly accepted standard format. There is no legal instrument to force this procedure, but an extensive data bank using a common standard can do much to encourage uniformity.

Other problems arise from the combination of effects produced by source material prepared for publication, or in manuscript, or ship-log form, or as lithologic-position designations on charts and maps with no concern for conversion to a data processing format.

It is expected that as NODC becomes better adjusted to these difficulties, and emerges with uniform, usable data from the heterogeneous sources, the originators of the data also will become aware of the desired format, and provide data that are more compatible with it.

This is but a short list of the difficulties and considerations involved in developing storage-retrieval capabilities for marine geoscience data. It may be that the effort to make dissimilar sources of data fit into a common format is too great a burden for the system as presently concieved. However, the effort will have been worthwhile if the data currently being generated, and those to be produced later, are influenced by the awareness of a common form with the final result being a more uniform product.

NODC's desire is to make available to oceanography the value and interest as quickly, easily, and economically as possible. If modifications are in order--if improvements can be made--I would be grateful if you would send your comments and suggestions to the National Oceanographic Data Center, Washington, D. C. 20390.