GEOSCIENCE
INFORMATION
SOCIETY

PROCEEDINGS
VOLUME 3

Proceedings • Volume 3 • 1972

Proceedings of the Seventh Annual Meeting of the Geoscience Information Society, November 13, 1972
Minneapolis, Minnesota

Proceedings Volume 3

July 1973

The papers in this volume of the Society's Proceedings were presented orally at the Seventh Annual Meeting in Minneapolis, Minnesota on November 13, 1972, with the exception of the scheduled paper by Dr. Bruce B. Hanshaw on the Resource and Land Information (RALI) Program. Dr. Hanshaw was delayed in Denver by the blizzard and Dr. James W. Clarke agreed to update this rapidly changing area.

Papers are arranged in alphabetical order according to authors' surnames. Each paper is reproduced in the style submitted by the author. Retyping and plate preparation has been limited to publication requirements.

I wish to thank the members of Chevron Oil Field Research Company's Office Services for their help in preparing these papers for publication.

H.K.P.

For sale by the Publications Chairman of the Society, c/o American Geological Institute, 2201 M. Street, N. W. Washington, D. C. 20037 - $5.00.

CONTENTS

RESOURCE AND LAND INFORMATION (RALI) PROGRAM

A Prospectus for Program Development

Frank Clarke

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

The Resource and Land Information (RALI) Program is designed to provide comprehensive data on the land and natural resources, interpreted to focus on user problems, and translated and communicated to users in forms they can understand and utilize. There are abundant indications that those who deal with problems of increasing resource demands, planning land use and protecting the environment find existing information systems inadequate for their purposes. Available data are scattered through the files and libraries of a wide spectrum of State and Federal agencies. They are difficult to locate and assemble and often are not available in forms understandable to the potential user. There is obvious lack of ability to interpret data in terms of environmental quality indices and environmental trends.

The program is a recognition of the problem and a commitment to seek a solution. Stated in terms of objectives, it is an effort to insure the availability of (1) an adequate data base on all aspects of the land and its resources, including the configuration of the land surface; the structure, composition and physical properties of the soils and the rocks beneath the surface; the distribution and magnitude of water, mineral and energy resources; vegetation, wildlife, and present land use; (2) information products translated into forms that are easily understood by users such as land planners, resource managers, environmental analysts, policy and decisionmakers, the courts and the public-at-large, and that are relevant to their problems; and (3) an analytical capability to contribute to solution of multidiscipline problems related to resource development, land use and environmental protection.

A Program Design Effort

RALI today is in the early stages of a design effort which is depicted in Figure 1. Although the broad objectives have been defined, specific agency roles and missions, organizational assignments, and the ultimate configuration of the RALI system are by no means crystalized. However, the steps required to better define deficiencies in existing information systems and to devise means for mitigating them can be spelled out with more confidence. Logical steps in analysis and design should:

- Identify the range of needs which an acceptable resource and land information system should serve.
- Determine the system components by which basic data would be acquired, assembled, interpreted and disseminated, including arrangements for storage, updating and manipulation for problem solving.
- Define expected roles and missions of the various institutions expected to contribute to the overall information program, including consideration of the mechanisms for achieving coordination and compatibility among them.
- Seek out deficiencies in existing information systems which might logically be addressed by RALI.

An effort of this kind is necessarily an iterative process involving a series of approximations which eventually will surface the needs and point the way to corrective actions.

Basic Assumptions

The RALI approach starts with the basic assumptions that:

Innovative acquisition technology can help to fill gaps in existing data, particularly in critical areas.

Existing information can be made more visible and more easily accessible.

- Machine storage techniques can be upgraded to improve access manipulation and intersystem exchange.
- Information can be made more useful by providing analyses and interpretations in terms of user needs.
- The total resource and land information effort can be improved by better coordination among data collectors and users and by striving for compatibility among the individual systems.

RALI Approach

Assessment of user needs is a priority consideration in the RALI program. Examining needs in terms of problems to be solved and decisions to be made in resource management, land use planning and environmental analysis will identify deficiencies which might be addressed by RALI. A methodology for the needs survey is depicted in Figure 2. Attention is being concentrated on the needs of Interior bureaus as a model for more comprehensive surveys, but concurrent studies are being made in cooperation with individual States, with the Council of State Government and with consultants who specialize in a wide range of land use planning activities.

Inventories of data banks and data systems in both the State and Federal agencies are proceeding along with the needs survey. Again, priority attention is being given to availability of data in Interior and its adequacy in terms of Department needs. Special attention is directed toward identification of information products which serve a variety of needs and thus are candidates for computer storage and systematic cataloging.

Significant effort is being directed to a study of the practibility and desirability of cataloging principal and land resource information sources and products at least for the Department of the Interior, and possibly for the whole Federal-State establishment.

Research is underway on new techniques for data collection, improved computer processing and an innovative way of converting basic data to derivative information products which speak directly to the need of the user in language and graphics he can understand. Workshops, symposia and guidebooks are parts of this effort to improve the usefulness of information flowing from the wide range of mission-oriented agencies and to bridge the gaps between data collectors and users.

RALI Demonstrations

Although RALI cannot be accurately defined until planning studies now underway are completed, it is possible to demonstrate possibilities in matching data to data needs and several field projects are underway for this purpose. One project in southeastern Florida is interpreting existing information in terms of impacts of land use alternatives on surface water and ground water supplies and is exploring possibilities of mitigating these impacts.

A project in the Tucson-Phoenix corridor is developing information products to lay a base for analyzing the effects of gradual transition from an agricultural-recreational economy to a more industrialized one.

Another in the Nothern Great Plains is providing information to potential land use conflicts in a proposed target area for increased development of coal resources.

Finally, a project in the environs of Puget Sound is providing the basis for analyzing and interpreting consequences of increasing urbanization in estuarine environments.

The RALI Organization

The RALI program established by Secretarial Order in September 1972 provides for interbureau participation in conducting the program planning studies, research, and practical demonstrations discussed above. The U.S.Geological Survey serves as lead bureau and provides a Program Manager to direct the work. Policy guidance is provided by a committee of Assistant Secretaries under the chairmanship of the Assistant Secretary for Program Policy. Bureau coordinators work directly with the Program Manager in developing and implementing the plan and through their respective superiors bring to the attention of the Policy Committee issues in need of resolution.

The work is accomplished by permanent or ad hoc task forces as appropriate. The organization is depicted diagrammatically in Figure 3.

External Relations

The objective of RALI cannot be achieved by a single agency or even the Federal government, but eventually will require close cooperation and coordination of Federal efforts and those of State agencies such as state geological surveys, planning offices, etc. Toward this end, a concerted effort is being made to develop meaningful information exchange with the Council of State Governments and through this avenue with the individual States and their appropriate agencies. A formal mechanism of coordination is being established with several Federal agencies concerned with land use and resource information and similar arrangements will be sought with others.

It seems unlikely that a single all-purpose national system for resource and land information ever will be practicable, particularly if it embodies the concept of a single massive computer storage and retrieval system. A more practical objective is a composite system built on the capabilities of individual data banks--one which incorporates the optimum in compatibility and flexibility for information exchange. Hopefully, the RALI planning effort will identify the opportunities that lie ahead for developing an effective system that will fully utilize and help to develop national, state, and local capabilities.

Figure 1

PROGRAM DESIGN CONSIDERATIONS

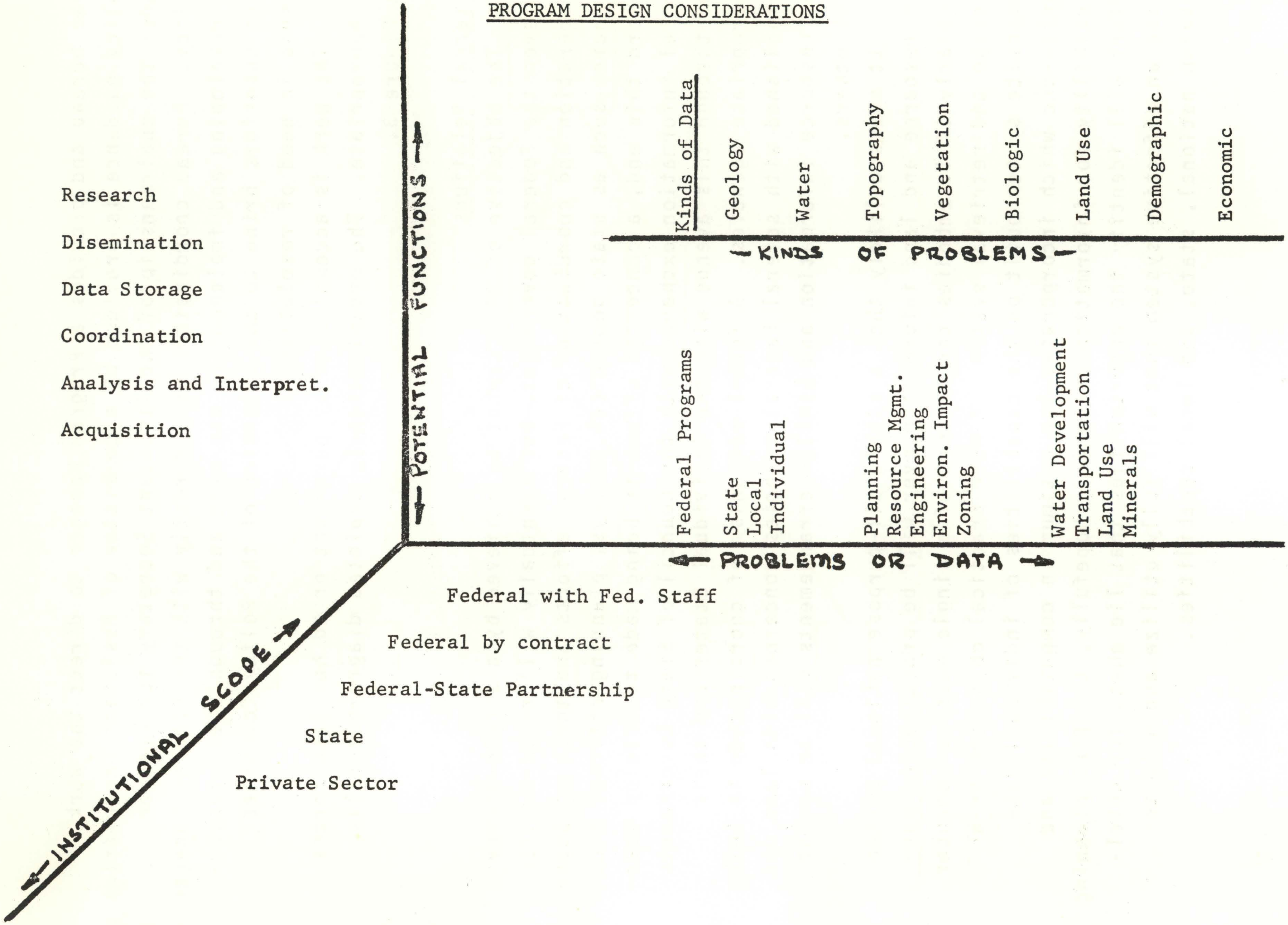


Figure 2

The Determination of Data Needs

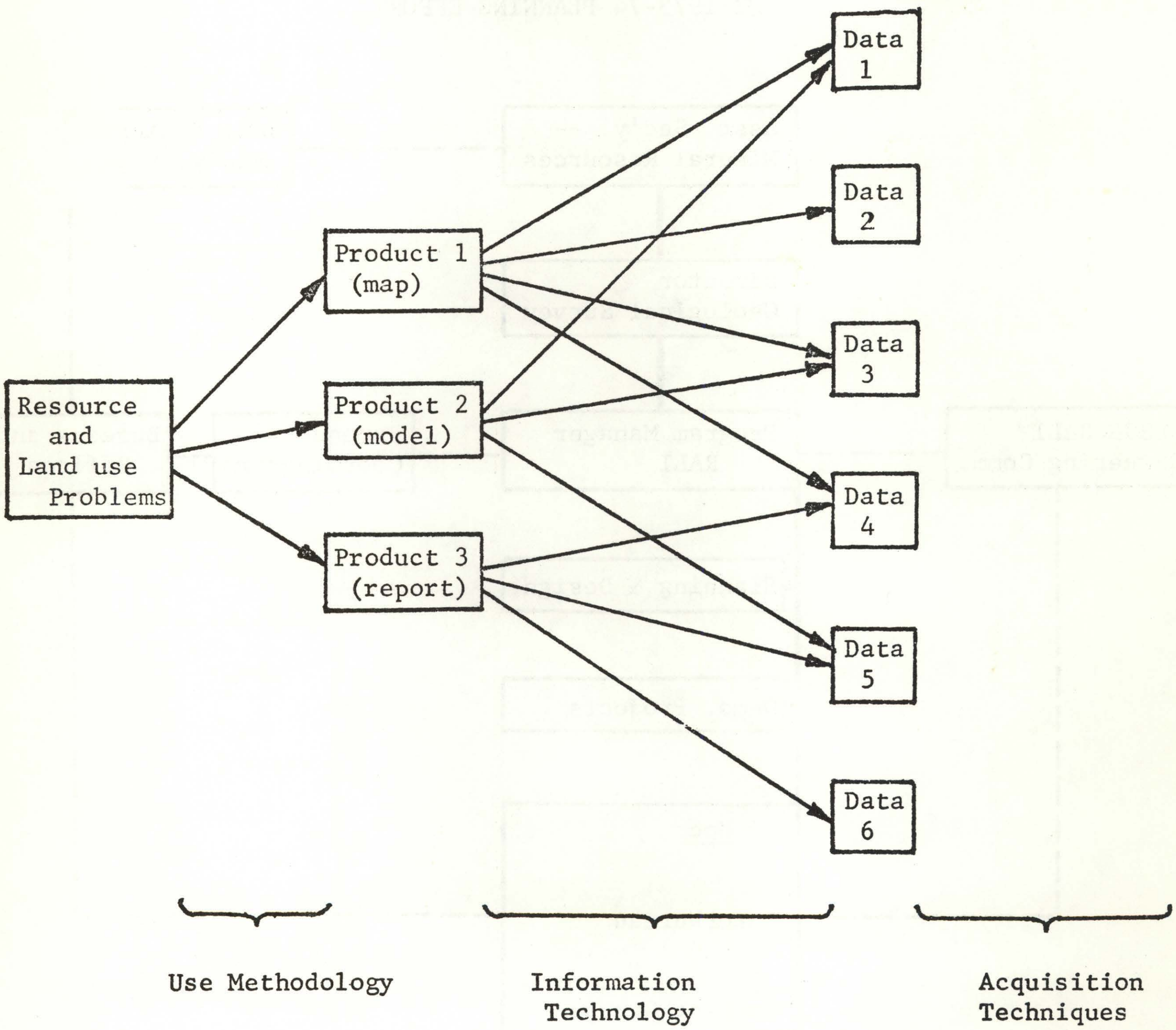
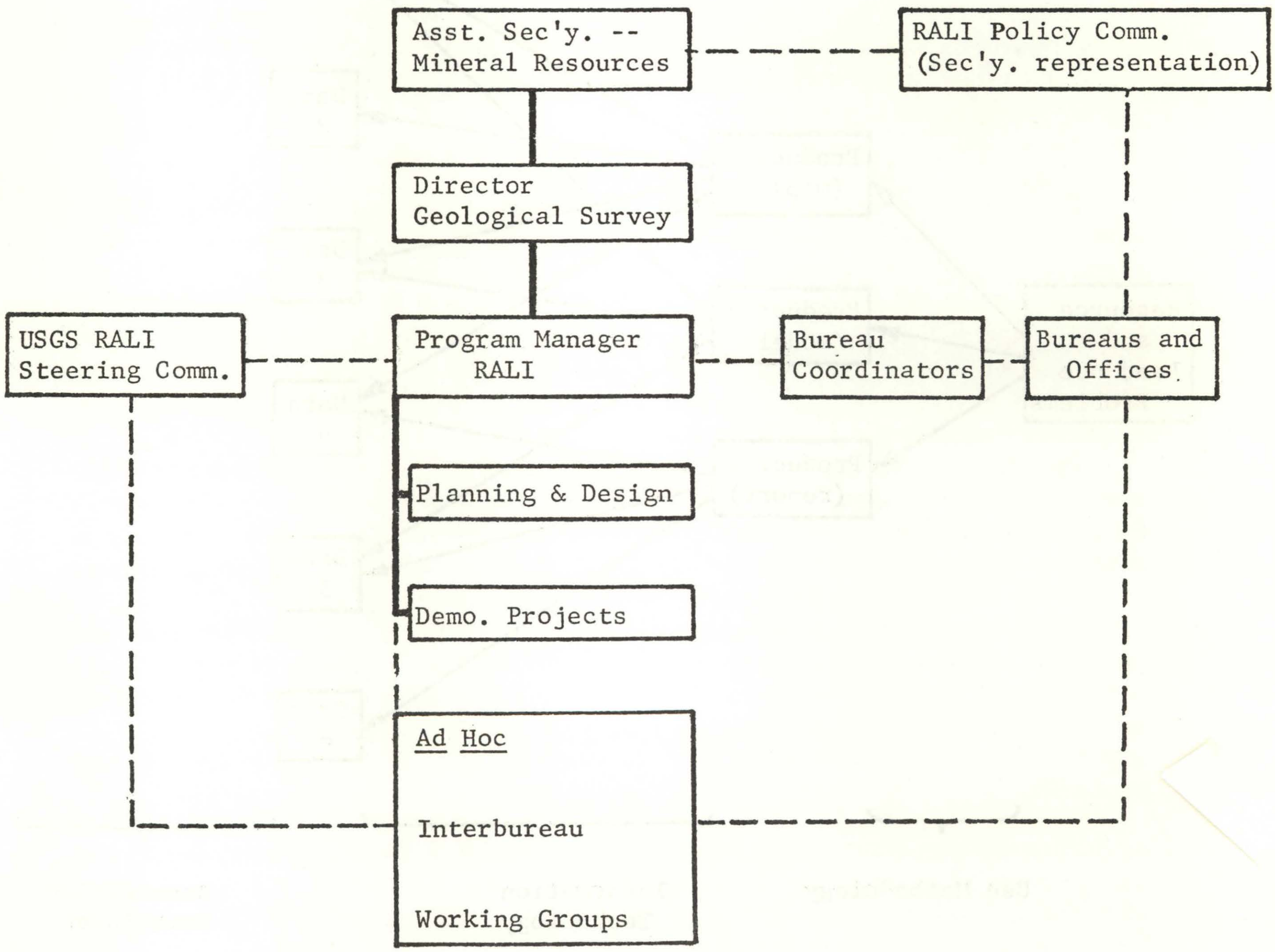


Figure 3

INTERIM RALI ORGANIZATION
for the
FY 1973-74 PLANNING EFFORT



ANOTHER PRODUCT OF GEO-REF: THE BIBLIOGRAPHY AND INDEX OF MICROPALEONTOLOGY

Harold L. Cousminer, Department of Geology, Rutgers University, Newark, New Jersey 07102; and Julia Golden, Micropaleontology Press, The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024

ABSTRACT

The Bibliography and Index of Micropaleontology is being produced from the GEO-REF data base by a cooperative program developed between The American Museum of Natural History and the American Geological Institute. Procedures are described that are applicable to the production of specialized bibliographies in other areas of geoscience.

INTRODUCTION

The main objective of this project is the production of a specialized bibliography and index of the current world-wide literature in micropaleontology. The idea of a specialized micropaleontology bibliography was originated by the senior author and supported by the editorial staff of Micropaleontology Press of The American Museum of Natural History (AMNH). The initial plans for a micropaleontology information system were much more ambitious (Cousminer, 1969). However, it was concluded, after several years of research, that only a bibliography was feasible at this time and would be funded only if it did not represent a duplication of work being done by other organizations.

Therefore, a joint program was begun with the American Geological Institute (AGI) whose computer system, GEO-REF, produces the Geological Society of America's Bibliography and Index of Geology. The format and computer program were already in existence. It was found that with only slight modifications, GEO-REF could be used successfully to produce the Bibliography and Index of Micropaleontology.

The joint program benefits micropaleontologists by making available economical and up-to-date bibliographic information listed by microfossil category and supplemented with a comprehensive annual subject index. AGI and GEO-REF also benefit from the cooperation with AMNH. The GEO-REF system is being used by a larger segment of the geological community; and additional citations and index sets are being contributed to the data base by AMNH.

Because the procedures used in producing our publication are directly applicable to the production of specialized bibliographies in other of the geosciences now being included in the GEO-REF file, they are described in some detail. It is hoped that other subject specialists will take advantage of this potential of GEO-REF to produce similar specialized bibliographies dealing with their own fields of interest.

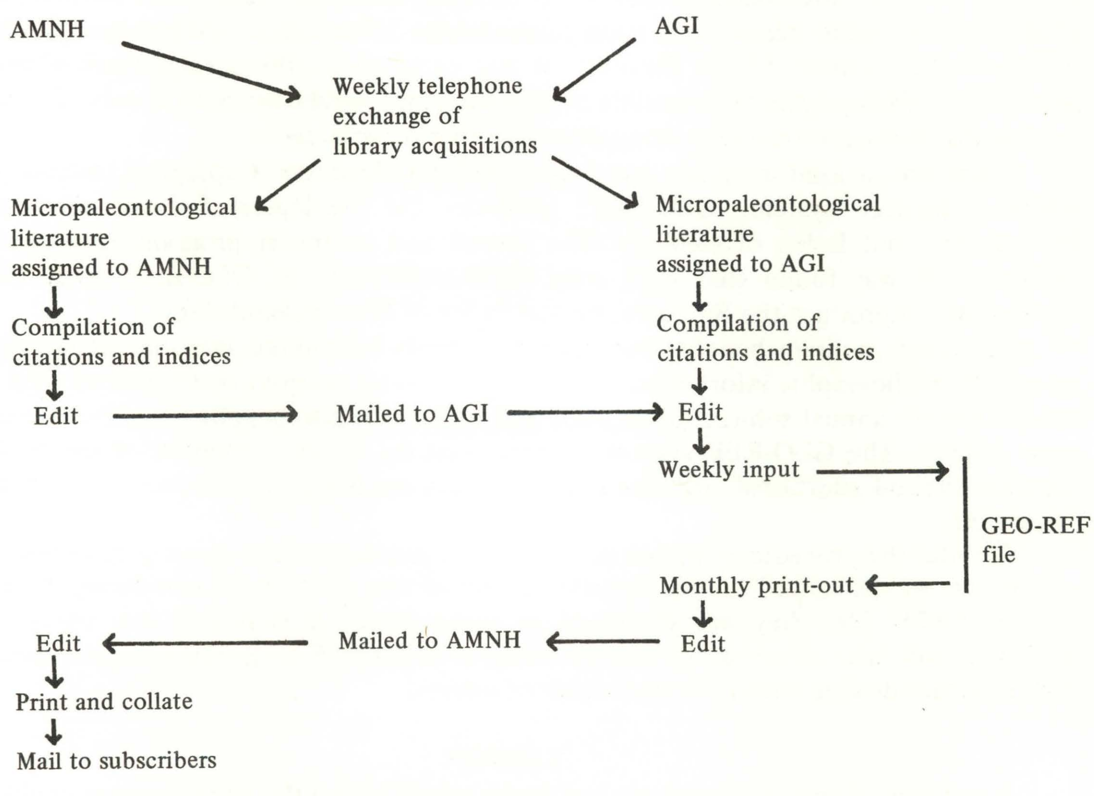
LIAISON

A number of specific problems had to be solved before the joint program could begin. Several of these problems concerned the coverage of current literature. Both institutions receive many of the same journals, however, each group also receives journals the other does not. In addition, each institution receives periodicals at a different time. Another problem in coverage stems from the fact that single micropaleontological articles are often published in journals which emphasize other subjects.

These problems were largely solved by pre-agreement that certain periodicals and symposia would be handled by AMNH, while others would be covered by AGI. Weekly telephone conferences between the two groups were also instituted to ensure coverage of new acquisitions without omissions or duplications.

At present, the program is organized in the following manner. Each week AMNH calls AGI and transmits the list of new journals which were received by the library and which contain micropaleontological articles. After checking their records AGI returns the call and tells AMNH which articles have not been covered. AMNH then compiles the citations and index sets for those articles. The citation sheets (see sample on following page) are edited and sent to AGI where they are edited again. The information is recorded on magnetic tape and becomes part of the GEO-REF file. By December 31,1972, we will have contributed about 2,000 citations with index sets to GEO-REF.

Once monthly AGI sends AMNH the computer print-out of approximately two hundred citations. AMNH is charged $17.00 per page for the camera-ready copy. The copy is edited by AMNH, printed and then mailed to subscribers. This program is summarized in the flow chart below (text fig. 1).



Text figure 1. Flow chart of AMNH-AGI liaison

Category 20 E72-73

Steineck, P. Lewis.; Gibson, James M.; and Morin, Ronald W.

Foraminifera from the Middle Eocene Rose Canyon and Poway Formations, San Diego, California

J. Foraminiferal Res., Vol. 2, No. 3, p. 137-142, illus.(incl. sketch map), 1972
Appendix p. 142-144

Keywords: Planktonic foraminifera indicate Middle Eocene age, benthonic foraminifera indicate water temperature, Rose Canyon Fm. deposited in outer shelf-upper bathyal environment, Poway Fm. deposited in inner shelf

---

21. Foraminifera
22. Miscellanea
23. Eocene, California, San Diego, benthonic, planktonic, paleoecology, biostratigraphy

---

21. Eocene
22. United States
23. California, San Diego, Foraminifera, paleoecology, middle Eocene

---

21. California
22. Stratigraphy
23. Eocene, biostratigraphy, paleoecology, San Diego

---

21. Paleoecology
22. Foraminifera
23. Eocene, marine, California

DESCRIPTION OF BIBLIOGRAPHY AND INDEX FORMATS

The Bibliography and Index of Micropaleontology (BIM) is published in two parts: a monthly citation list and an annual subject index. It is published unbound and printed on both sides of 8½ by 11 inch paper in the same format and graphic quality as the monthly bulletin Bibliography and Index of Geology.

The monthly bibliography (to date, November 13, 1972, nine issues have been published) consists of about 200 citations arranged by microfossil category. Each title is identified by an accession number and augmented by keywords. The monthly issues contain about 10 to 15 sheets. The pages are numbered consecutively and identified by the volume and issue numbers. Each issue also contains an alphabetical author index keyed to the accession numbers.

An annual index, to which subscription is optional, will be published at the end of the year. It will contain the subject indices and cross-references (about five listings for each citation) for the 2,400 to 3,000 citations included in the bibliography. Each index set will be keyed to its citation and also include the author's name, month of publication and accession number. The index can be used only in conjunction with the bibliography. The index will also contain complete lists of authors and serials cited.

FOSSIL CATEGORIES

A main feature of BIM is the capability of the system to search, sort and print-out citations in microfossil categories. This capability was added to GEO-REF by a special program contracted for by AMNH (Micropaleontology Press) with Auto-Graphics Inc. of Bethesda, Maryland.

All papers on micropaleontological subjects are assigned unique numbers that identify the subject category (see text fig. 2). Note that the first three digits identify the year of citation, the next two identify the subject category and the remaining three digits are the citation number.

Example of document number (accession number):

E72-73501 = foraminifera paper 501, cited in 1972

List of categories of microfossil groups

- 70 Algae (includes nannofossils and other lime-secreting algae)
- 83 Annelida (scolecodonts)
- 71 Conodonts
- 72 Diatoms
- 73, 74, 75 Foraminifera
- 76, 77 Ostracoda
- 78, 79 Palynomorphs (includes spores, pollen, acritarchs, dinoflagellates and chitinozoans)
- 84 Problematic fossils (microfossils not assignable to established categories)
- 82 Protista (includes silicoflagellates, ebridians, archaeomonads, tintinnids, nannoconus and thecamoebans)
- 81 Radiolaria
- 85 Miscellaneous (papers not dealing with specified microfossil groups and also includes fish otoliths and scales)

Text figure 2.

No attempt was made to create categories that correspond to biologically valid taxa. For instance, category 70 includes all lime-secreting algae, which is a very heterogeneous group. Category 78, 79, is used for papers dealing with palynomorphs. This includes a biologically diverse group of microfossils some of which are of plant origin (spores, pollen, dinoflagellates), while others are biologically unknown or may even be of animal origin (acritarchs, chitinozoans). All of these elements are studied by palynologists since they may be found together in the same acid residues, have a closely similar size range and are all morphologically distinguishable under the compound microscope. By utilizing a system of major categories based on working groups, subjective problems of taxonomic assignment that usually plague compilers of paleontological data are avoided.

KEYWORDS

Keywords are added to clarify the information given in the title and to briefly abstract the article. The titles of most paleontological articles give insufficient information on the fossil group studied and the geographic area and stratigraphic source of the samples. Many titles give this information using local stratigraphic and geographic names which may be unfamiliar to the reader.

Providing abstracts for each article cited is time-consuming and expensive. Abstracters, who are subject specialists, are difficult to find and must be paid for their services. Abstracts greatly reduce the number of citations that can be placed on a page and thus increase the total number of pages required for the same number of citations without abstracts. Adding abstracts to citations increases page costs by a factor of two to three. These costs must be applied to both computer print-out and printing charges.

An economical solution to the problems of "cryptic" titles and long abstracts is the use of keywords. A few well-chosen words or phrases, despite their brevity, can inform the user about the content and scope of a given article. Guidelines developed by AMNH include the use of keywords to inform the user about the geographic source, stratigraphic level, taxonomic group and main interpretative data given by the author. Such information given in the title is not repeated in the keywords (see examples below).

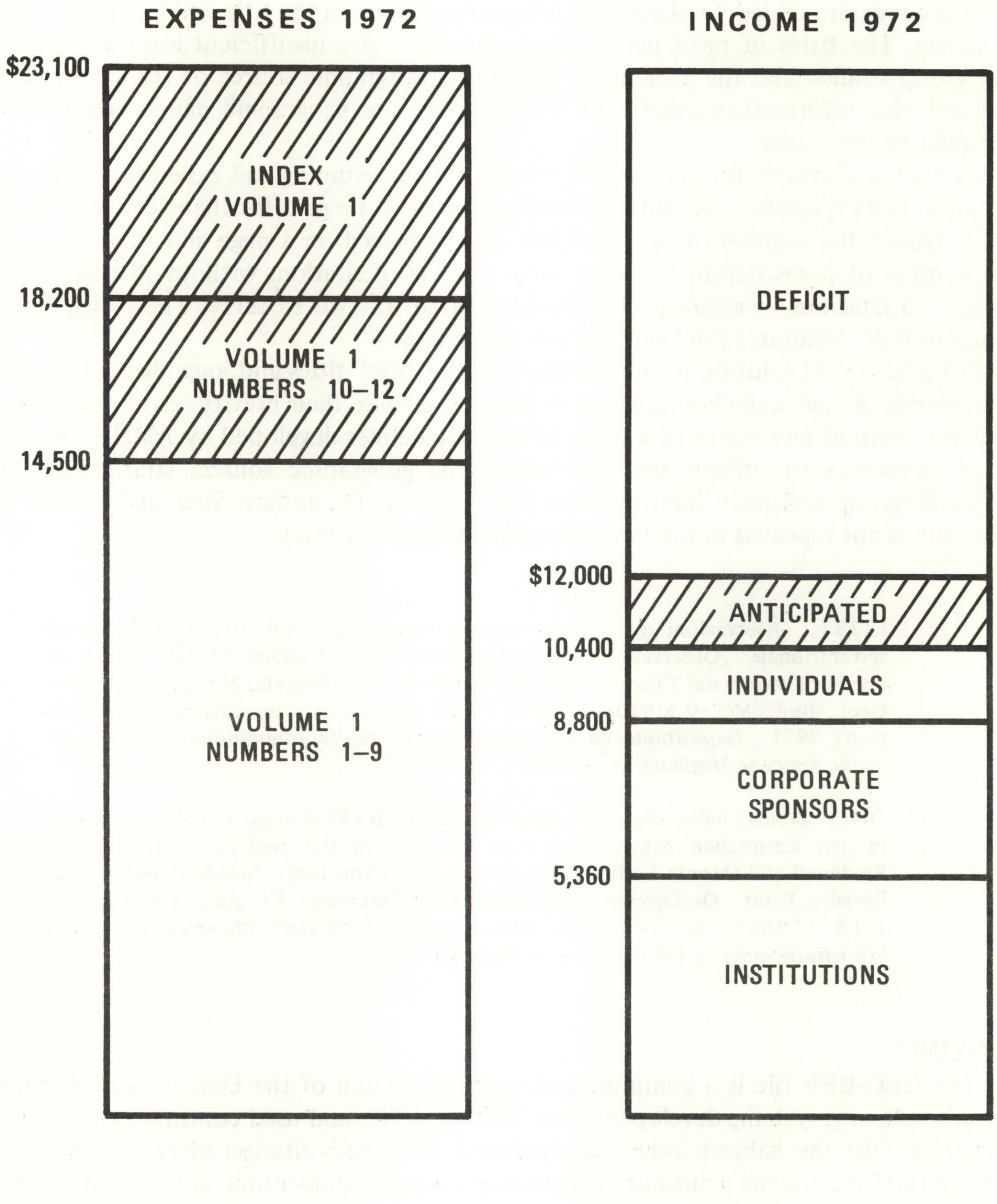
E72-73331. Osservazioni e considerazioni stratigrafische sul flysch del Cilento settentrionale [Observations and stratigraphic considerations of the flysch of northern Monti del Cilento]: Cestari, Generoso; and Ruscelli, Maria. Italy, Serv. Geol., Boll., Vol. 9 (1970), p. 81-111 (incl. Engl. sum.), illus. (incl. geol. sketch map), 1971. *Depositional environment, biostratigraphy, foraminiferal studies, part of the Miocene Magliano Series, Italy*

E72-71046. Bericht ueber die geologische Aufnahme des Findenigkofels (Monte Lodin) in den Karnischen Alpen (Kaernten) [Report on the geologic survey of the Findenigkofel (Monte Lodin) in the Carnic Alps, Carinthia]: Jaeger, Hermann; and Poelsler, Peter. Oesterreich. Akad. Wiss., Math.-Naturwiss. Kl., Anz., Vol. 105, No. 1-15 (1968), p. 149-155, illus., 1969. *Conodont biostratigraphy and lithostratigraphy of the Paleozoic in Austria*

INDEXING

The GEO-REF file is a computerized updated version of the United States Geological Survey's indexing system, developed from 1892 to 1932, and used continuously since then. In machine file, the subject index sets included with each citation serve a dual function. They are the basis for the print-out of the comprehensive subject indices to the Bibliography and Index of Geology and the Bibliography and Index of Micropaleontology. In addition, they serve as retrieval tags in the GEO-REF system for specialized retrospective search requests received by AGI.

During the development of BIM, we endeavored to use the GEO-REF indexing procedures and citation formats so that records generated by AMNH could be input directly to GEO-REF without conversion. This required special training and the junior author spent two weeks at AGI to learn the system. Subsequently only minor supervision of our indexing procedures has been necessary. A procedural manual, assembled by Mr. Dirgham Salahi (Editor-in-chief of GEO-REF), has served as a useful guide for our indexing procedures and of course, the editorial staff of AGI is always available for consultation.



Text figure 3.

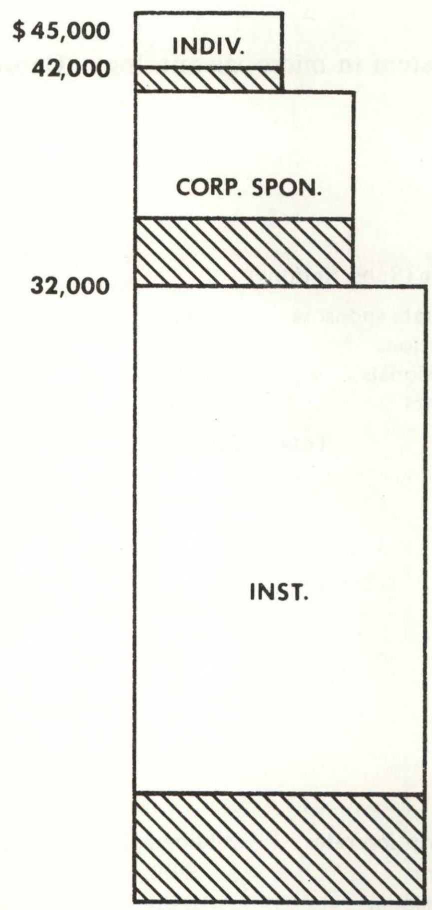
OPERATIONAL RECORD

Input citation sheets were accumulated during the last quarter of 1971 and the decision was made to begin production of BIM with the January 1972 issue. For economic reasons the management of GEO-REF decided to switch computer contractors at the end of 1971. This unfortunately resulted in considerable delay. Time required for inputting data into the new file and solving minor computer problems delayed the publication of the January 1972 issue until April. There is little doubt that this delay adversely affected the initial subscription rate.

Text figure 3 shows by bar graph expenses and earnings during the first ten months of operation. Funds expended for development of the system during 1971 are not included. An additional large-scale cost to be incurred at the end of the current year involves production of the annual index. Computer print-out and publishing costs for the index are anticipated to be about the same as the total costs of the twelve issues of the bibliography, because the number of pages in the index will be approximately the same as in the bibliography.

FUTURE EXPECTATIONS

Based on current subscriptions to the journal Micropaleontology (1,200) also published by Micropaleontology Press, we feel that a reasonable subscription potential for BIM is about six hundred (400 institutions, 50 oil companies, 150 professionals and 75 students). This would amount to an annual income of over $45,000 (see subscription rates below and text fig. 4). Within the first ten months of operations, we have subscriptions representing one-half of the individuals, more than one-third of the corporate sponsors and one-fifth of the institutions.



Text figure 4. Anticipated Maximum Annual Earnings
(shaded areas indicate current subscribers)

We expect an increased rate of subscriptions once the entire volume for 1972 (both the bibliography and index) is available and can be evaluated by potential users. Chances are good that we will move from deficit financing in 1972 to a self-sustaining basis by the end of 1973.

ACKNOWLEDGEMENT

We wish to express our gratitude to the staffs of GEO-REF and the AMNH library. This bibliography could not be produced without their help. We also gratefully acknowledge the National Science Foundation for initial development funds and the Standard Oil Company (New Jersey), Shell Oil Company and Mobil Oil Company for contributions that helped initiate this bibliographic service.

REFERENCES CITED

Bibliography and Index of Geology, Volumes 31-37 (1967-1972). The Geological Society of American Publication Sales, Colorado Building, P. O. Box 1719, Boulder, Colorado 80302

Bibliography and Index of Micropaleontology, Volume 1, 1972. Micropaleontology Press, The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024

Cousminer, H. L., 1969. An information system in micropaleontology. Geosci. Inf. Soc., Proc., Vol. 1, pp. 13-17.

APPENDIX

Current Budget for 1972

Expenses (Vol. 1, Nos. 1-9)

Salary	$ 7,000
Computer	2,850
Computer program	1,000
Printing	2,100
Advertising	975
Travel & telephone	300
Postage	275
	$14,500

Expenses (Vol. 1, Nos. 10-12, estimated)

Salary	$ 2,000
Computer	800
Printing	700
Postage & telephone	200
	$ 3,700

Expenses (Index, Vol. 1, estimated)

Computer	$ 3,000
Printing	1,800
Postage	100
	$ 4,900
Total	$23,100

Income (Subscriptions)

Corporate sponsors	$ 3,600
Institutions	5,360
Professionals	1,330
Students	144
Total	$10,484

Subscription rates:	Bibliography	Index
Student	$ 8.00	$ 5.00
Professional	10.00	10.00
Institutions	40.00	40.00
Corporate sponsors	100.00	100.00

ASPECTS OF UNBIASED AND BIASED CONTOURING OF GEOLOGICAL DATA BY HUMAN AND MACHINE OPERATORS

by

E. C. Dahlberg

Amoco Canada Petroleum Company Ltd.
444 - 7th Avenue S.W.,
Calgary, Alberta

ABSTRACT

Representative contouring of geologic map data seeks to estimate the most likely configuration of an incompletely known surface from a sample of spatially distributed data points. Each contour line is, in effect, a statistic since it represents an estimate of a "true" value at an explicitly located geographic point.

By contrast, interpretive contouring presents a visualization of a conceptually meaningful geologic form such as a barrier bar, stream channel, dune or beach which the data could conceivably reflect. Each contour line is now a biased estimate based on speculation and additional information such as regional fabric and lithology, constrained only by the control points.

Thirty versions of a twelve point model map contoured by experienced professional geologists demonstrate the astonishing degree of variation attributable to just human differences.

Quantitative analyses of these maps suggest that (1) Areas of major ambiguity are mathematically predictable as a function of control point configuration. (2) Machine contoured maps closely approximate the unbiased "consensus" map. (3) The degree of interpretive license displayed by maps of the same data contoured according to delta front, salt dome, reef and channel, stream erosion and other models can be compared to and isolated from random operator variation.

Statistical methods for exposing subjective and objective aspects of contour maps serve geologists who are asked to accept hypotheses based on map evidence (in the scientific sense) and managers who bet cash on them (in the economic sense).

INTRODUCTION

A very large portion of the information communicated between not only geoscientists but members of other professions as well is done so in a graphic mode, i.e. as some kind of map. Many of these maps are based on numerical data which for the sake of clarity is contoured. A quantitatively contoured map is thus basically a picture of a surface which attempts to illustrate how some parameter of interest (generally a measurement or a count) varies over a planar area.

In the earth sciences a map is most simply a graph of a function $Z = f(X,Y)$ where Z represents the magnitude of the mapped variable which varies over a portion of the Earth's surface as a function of X, Y which are latitude and longitude locators.

Specifically, then, a geochemical map pictures variation (inferred) of some chemical elemental content of the soil, rocks, etc. in an area. A structural contour map depicts spatial variation in the vertical position of the top of a formation of interest. Paleontological maps show percentage or abundance variation in fossil species, facies maps illustrate areal variability in mixtures of rock types and even phase diagrams are "maps" showing variability in the compositions of chemical compounds as a function of eH or pH, temperature and pressure etc. Examples appear in Figures 1, 2 and 3.

THE NATURE OF QUANTITATIVE MAPS

These and all other "maps" have one basic point in common to whit that it is generally impossible and always impractical to obtain a measured value for the mapped quantity Z for every possible comtination of X and Y. Thus it is necessary to estimate the behaviour of the mapped parameter over the major portion of the map area, so that some degree of uncertainty is incorporated in the final product.

The actual map itself is a planar picture of a generally non-parametric*, extremely complex surface such as the "carbonate isolity surface," the copper in parts per million surface," or the "surface of the sea floor," whose geometry is represented by patterns of contour lines. The problems therefore relate to aspects of accurately estimating and picturing such a surface from a finite collection of data points.

The major concern for the map user, be he a fellow scientist, manager, military man etc., is the evaluation of how faithfully a contoured map depicts the actual surface (be it hypothetical or real) from which the sample of points has been obtained. This paper examines such aspects as bias, subjectivity, accuracy, precision and objectivity and their roles in the process of quantitative contouring as well as evaluation of the resulting maps.

CONCEPTS

The following concepts have served as guidelines in our approach to the subject. Though proposed prior to the study, results of the experimental work have tended to reinforce our acceptance of their axiomatic utility.

1. Two mutually exclusive modes of quantitative data contouring are proposed, representative and interpretive.

*Polynomial approximations are sometimes utilized for representing the surface parametrically.

2. Representative contouring involves an attempt to depict the most likely configuration of an incompletely known surface (Z) from a sample of spatially distributed data points.

3. Contouring in the representative mode is effectively unbiased, the contours are geometrically "best" estimates of the surface parameter values.

4. The errors are largely random thus the quality of the maps can be assessed by statistical criteria.

5. The other mode of contour mapping is interpretive; the purpose is to fit a conceptualized version of the surface into the data control.

6. Contouring in this mode is biased since estimates of surface values are largely governed by prior experience related to the phenomena concerned or additional data independent information.

In order to investigate critical aspects of human and machine contouring procedures a twelve point model map was contoured by thirty experienced professional geologists ... all people who make their livings with maps. The following points are evident.

1. An astonishing degree of variation is attributable to just human differences with no conceptual bias. Paired examples show perpendicular trends, areal "highs" on some are "lows" on others etc.

2. Variation in point estimates among the maps reflects ambiguity i.e., uncertainty and is a direct function of control point density, distance and magnitude. Uncertainty is thus theoretically mappable for purposes of quality control.

3. The "average" map represents the consensus of thirty estimates of the configuration of the "true" surface, so it constitutes the statistically best criteria for evaluating individual map patterns.

4. The machine contoured version of the same map is a close approximation to the consensus map suggesting that such (often controversial) maps may serve as effective criteria for documenting "interpretive license" in maps contoured by human operators.

5. The separation of subjective from objective aspects of contour maps is apparently possible by use of simple statistically appropriate methods. The details of these will be elaborated upon by this author in future communications.

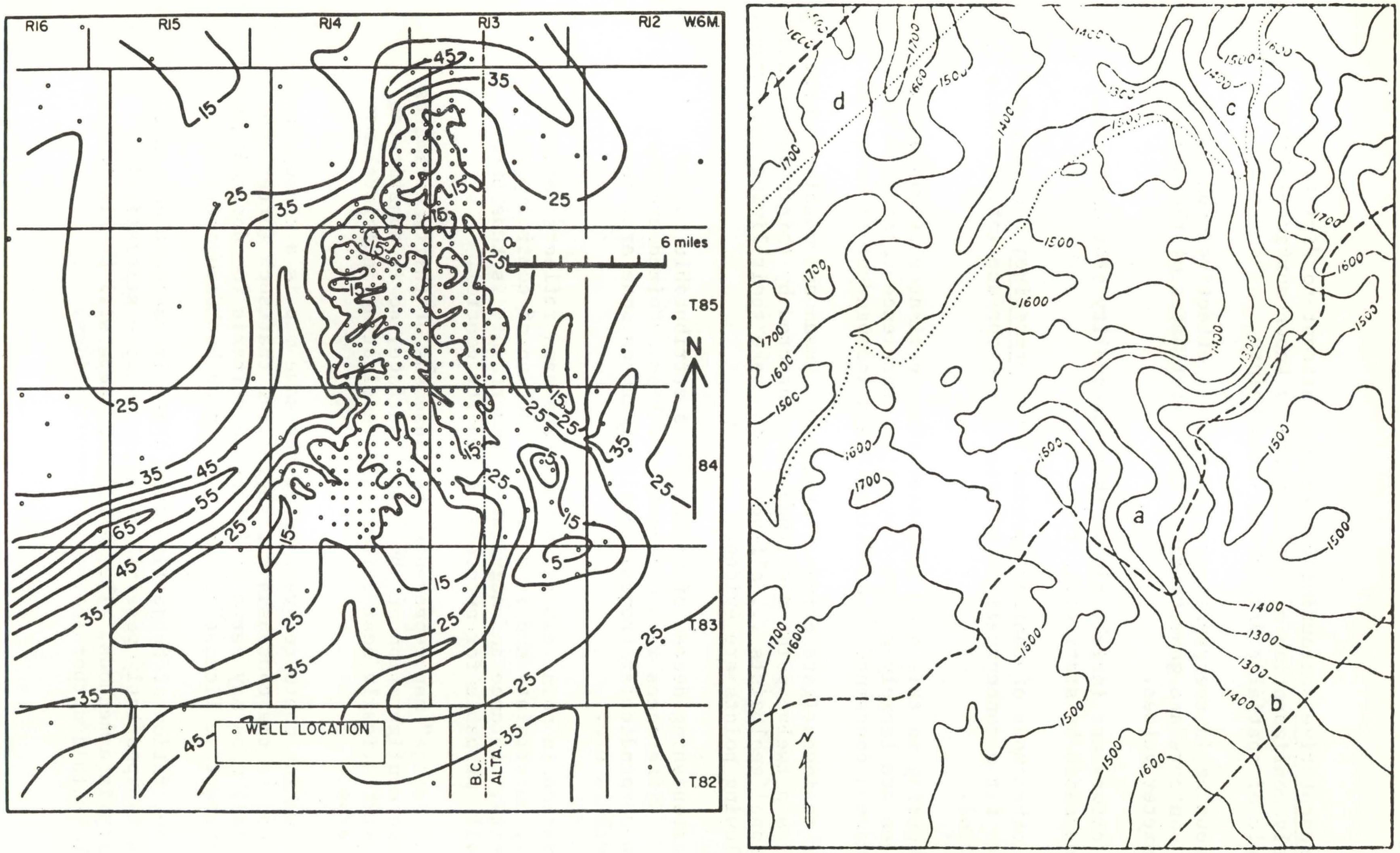


FIGURE 1 - Two types of contour maps. Left is an Isopach map showing how thickness of a sandstone varies regionally. Note extreme degree of crenulation in contours where data control (circles is dense. This demonstrates relationship between degree of resolution of features and control point density. Right is a topographic map representing a portion of the earth's surface.

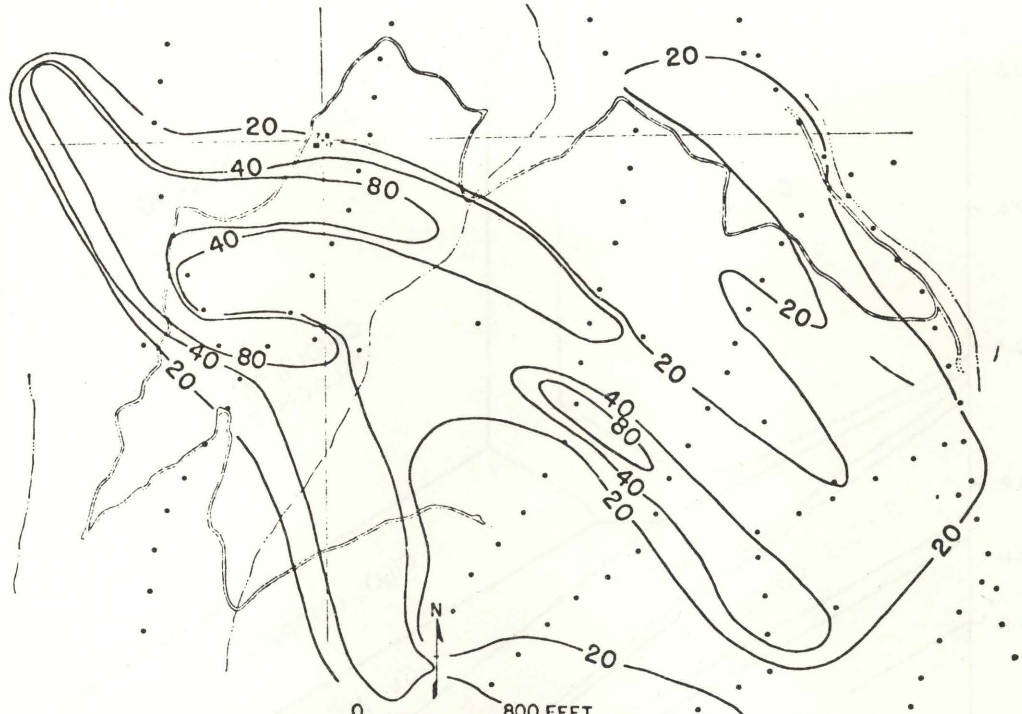


FIGURE 3 — Molybdenum Anomaly, Cumo Prospect, Boise County, Idaho.

MOLYBDENUM ANOMALY

• Soil Sample Site
~40~ ppm Mo

FIGURE 2 - Geochemical Map showing how Molybdenum content of the soil varies in the area of the Cumo Prospect. The form of the surface represented by the contour lines is inferred from chemical measurements made at each sample site (dot) on the map.

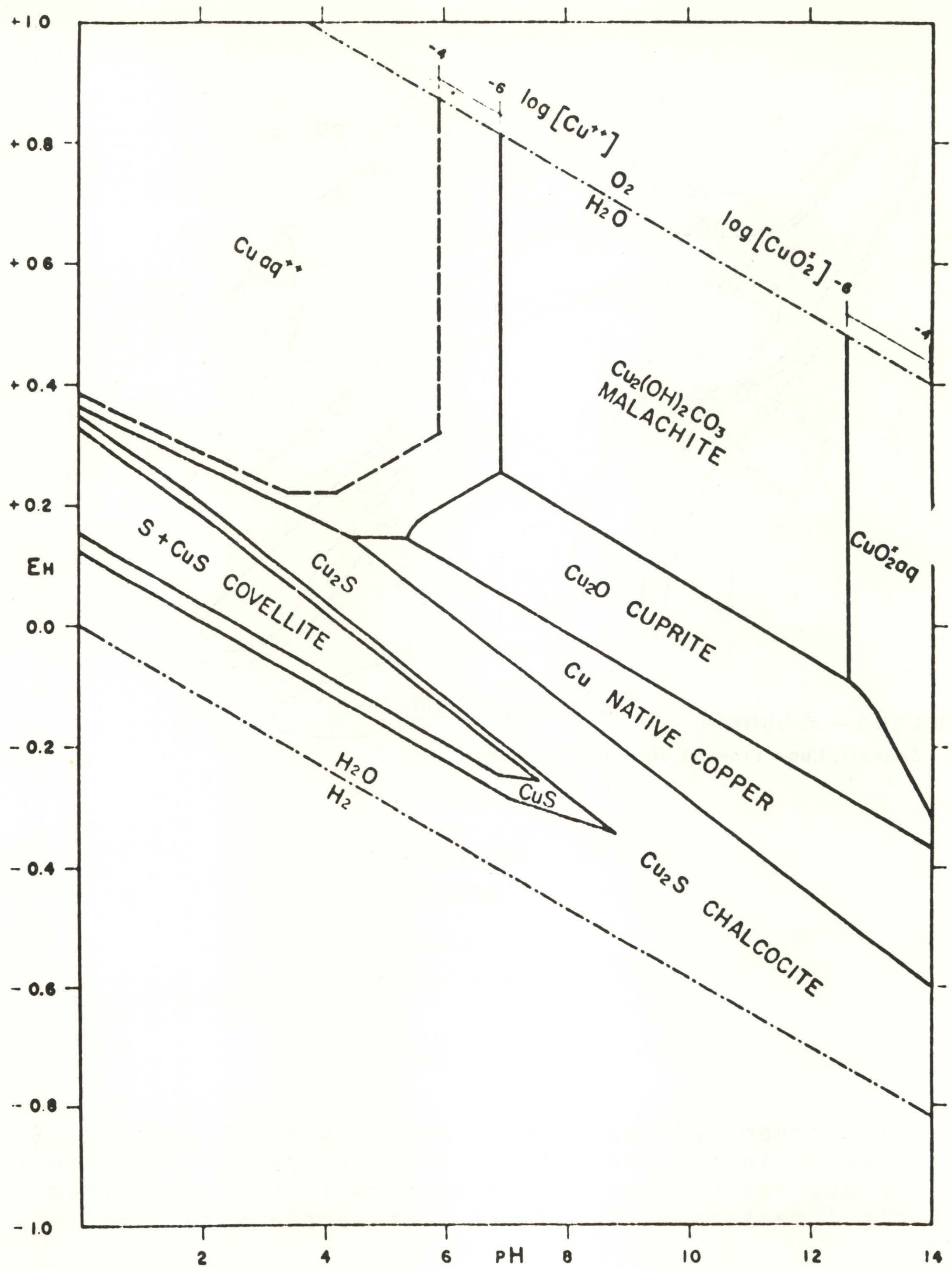


FIGURE 3 - This chemical phase diagram is essentially a map, too. It shows which copper compounds exist under varying conditions of electronegativity (Eh) and acidity (pH). On this "map" Eh levels are "latutudes" and pH levels are "longitudes." Since experiments could not be run for all possible combinations of Eh and pH, the locations of the field boundaries are somewhat inferential.

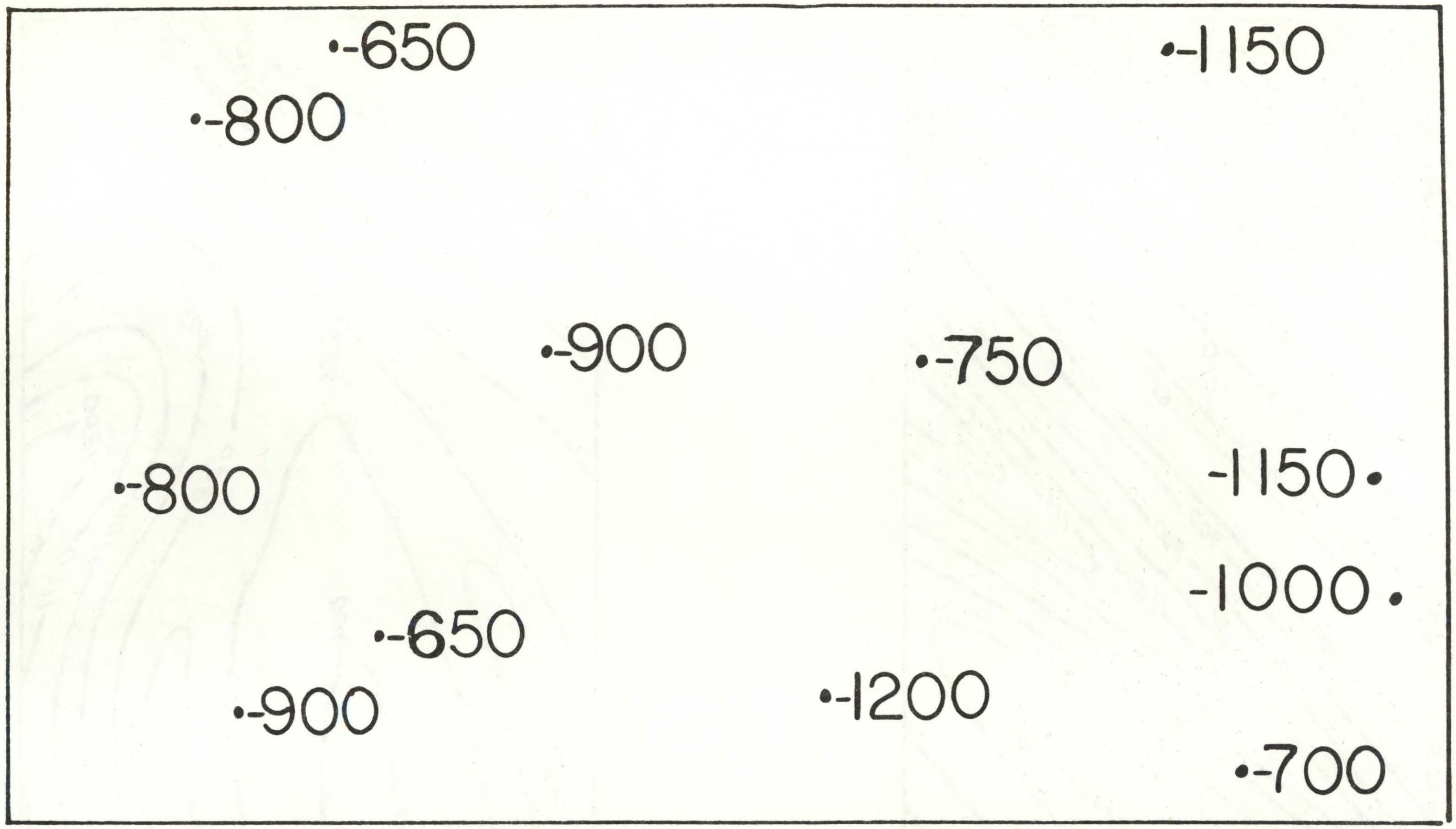


FIGURE 4 - This model map was used to evaluate comparative degrees of variation in human and machine contouring both from map to map and between various portions of the same map. The data are estimates of the elevation (below sea level) of the top of some geologic unit. The objective of representative contouring is to depict what the most likely form of the surface is, from the collection of data points provided. Some typical versions follow.

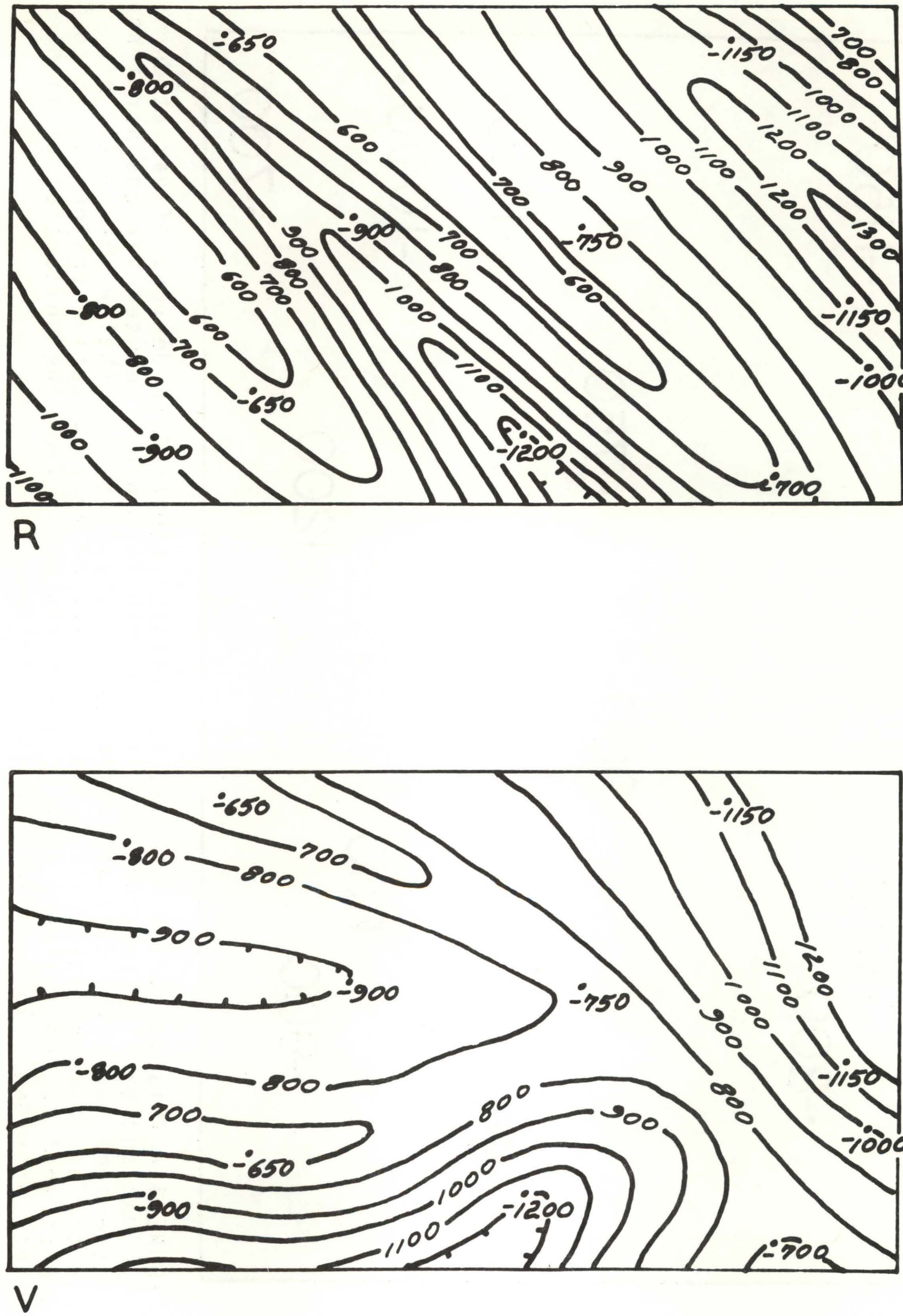
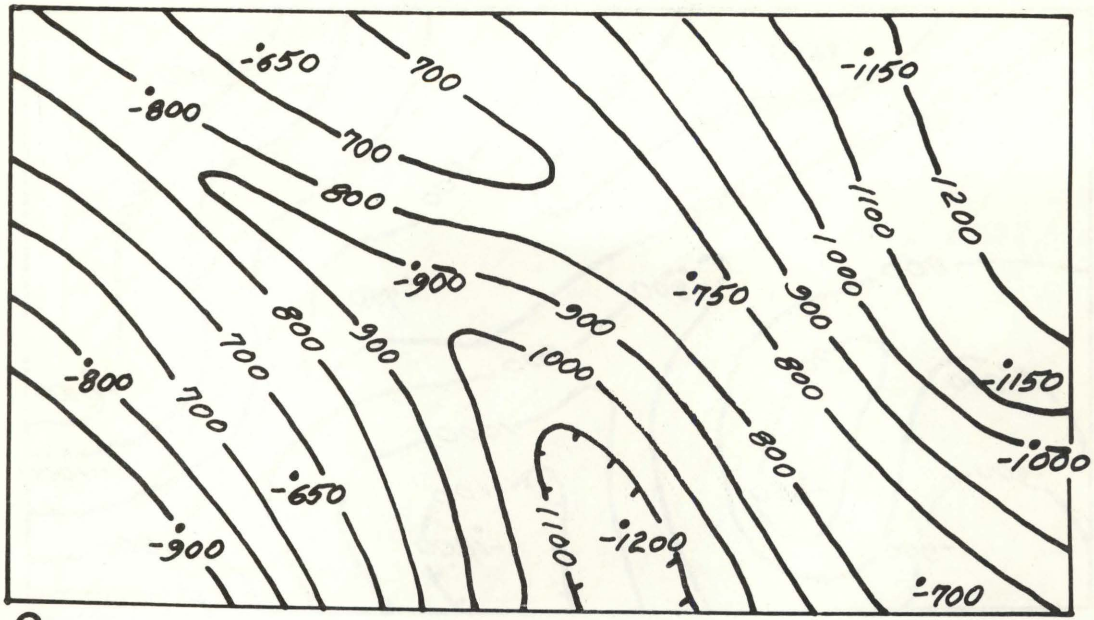
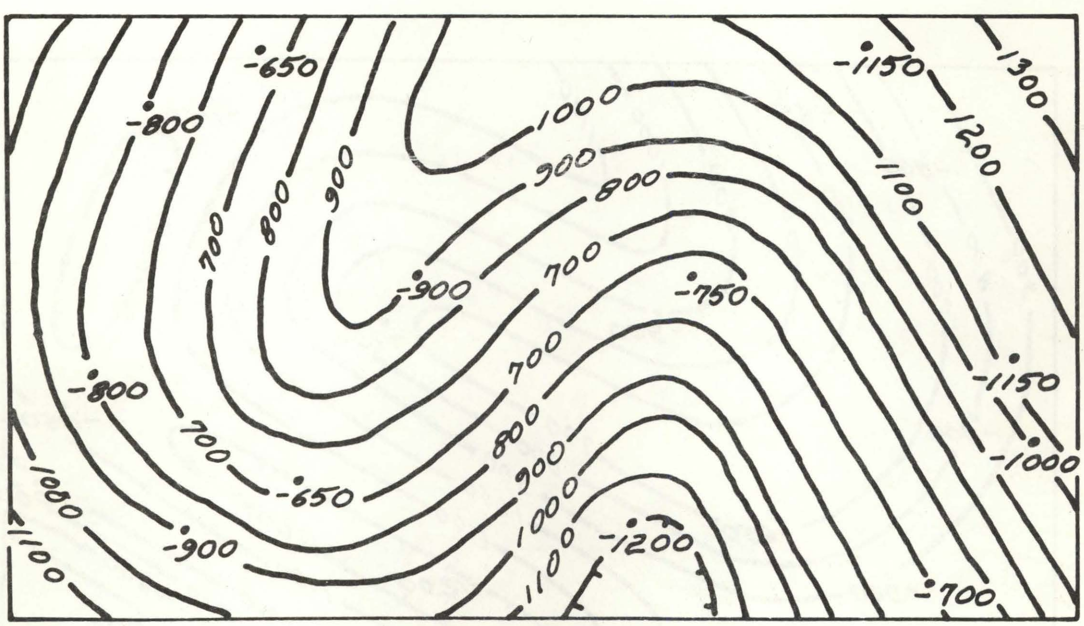


FIGURE 5 - Two contrasting though equally legitimate (with respect to the data control) estimates of the "actual" unknown but sampled surface. High degree of parallelism in R with two elongate NW-SE trending "highs." V shows a low on the west edge where R is high. Different regional trends.

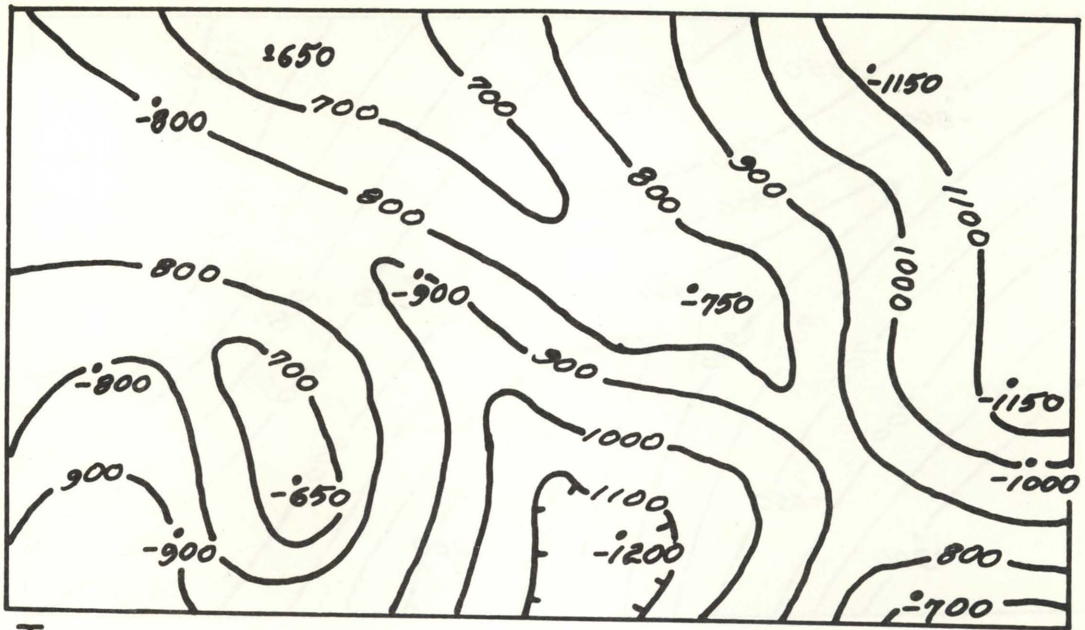


C

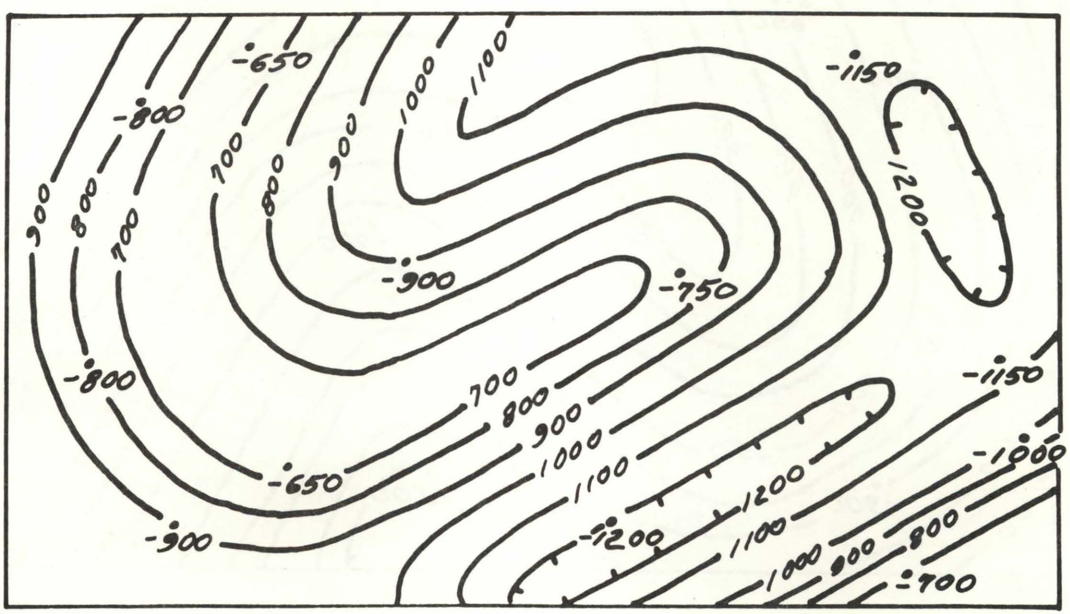


D

FIGURE 6 - Representative contouring of the model map. C visualizes a constant NW-SE regional fabric while D presents an S-shaped ridge winding through the central portion of the map.



T



X

FIGURE 7 - Two very different maps. T is rather isotropic and trendless while X shows a unique sickle-shaped high with two isolated deep basins to the east.

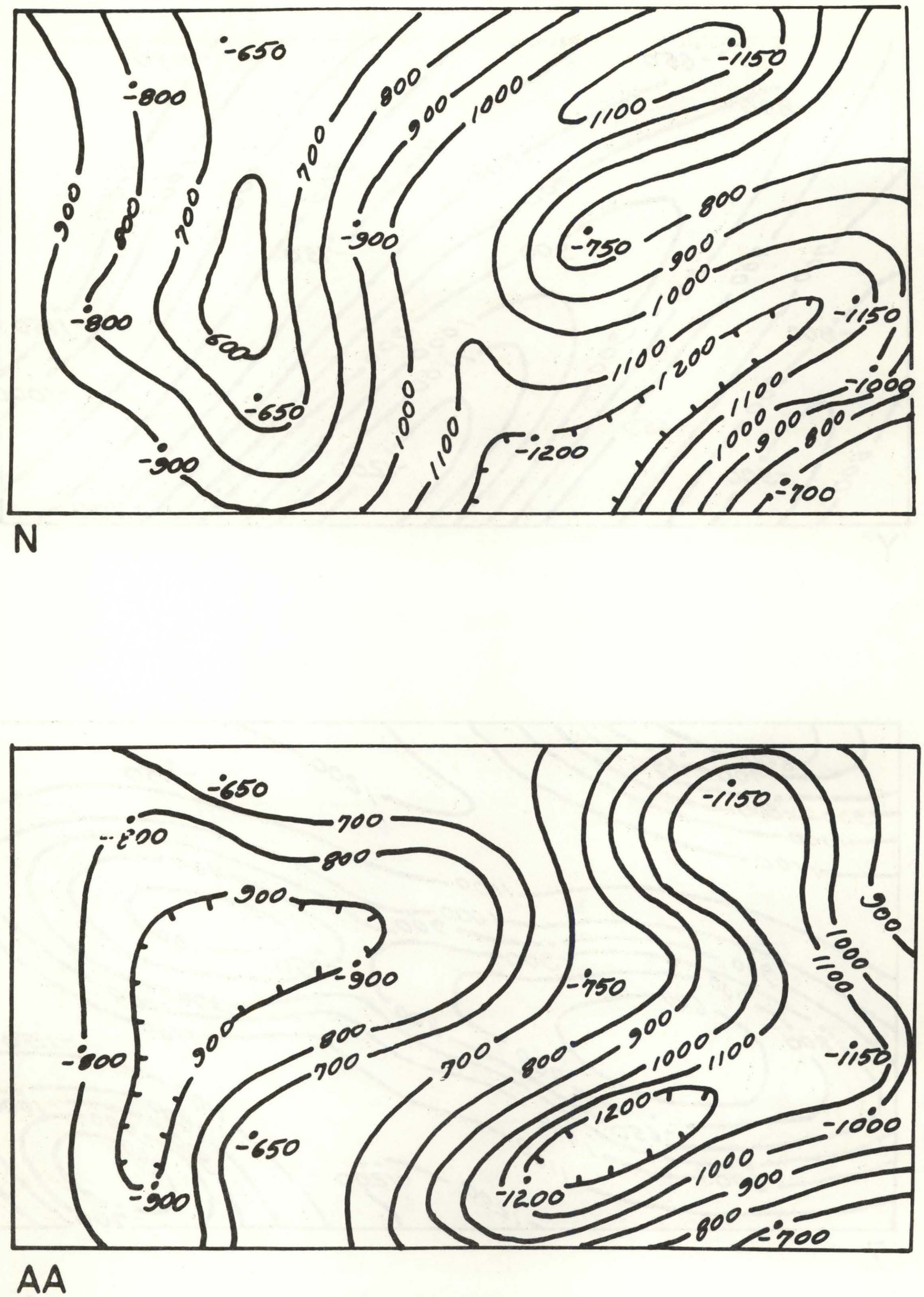
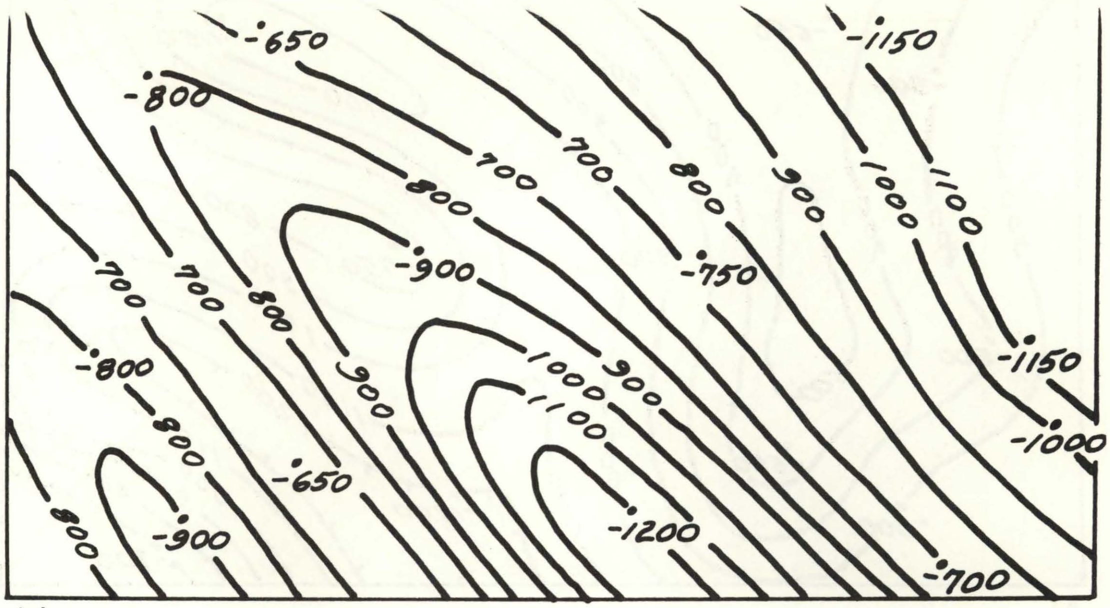
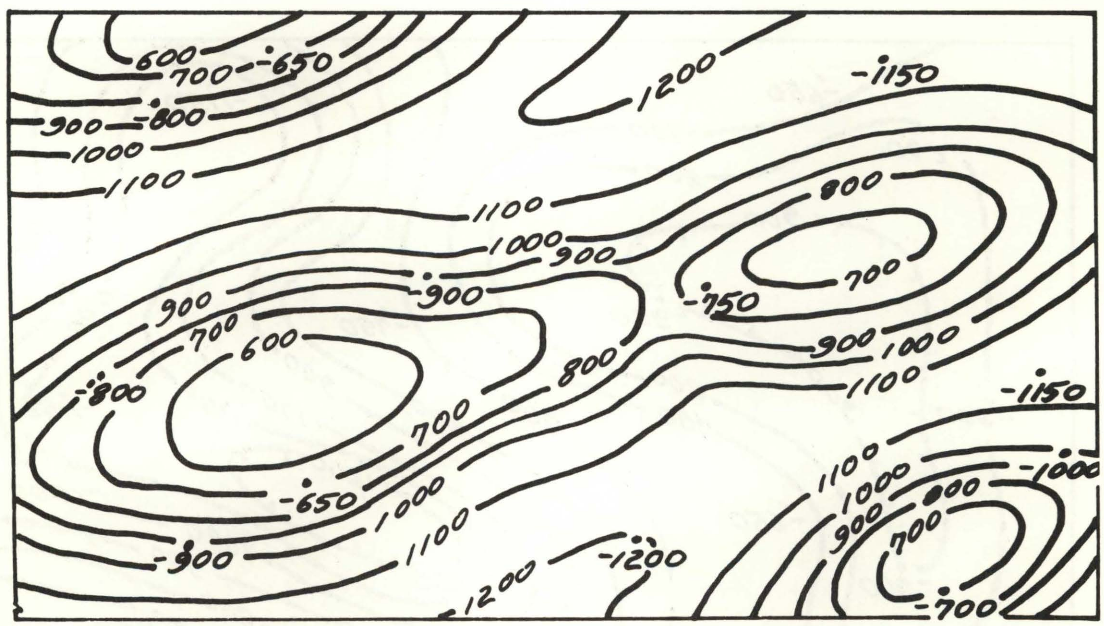


FIGURE 8 - Two extremely contrasting versions particularly with respect to the locations of highs and lows. Note a 600 foot "high" to the left of center in N is a >900 foot depression in AA. Good demonstration of the relative magnitude of variation in estimates which can occur without violating the control.

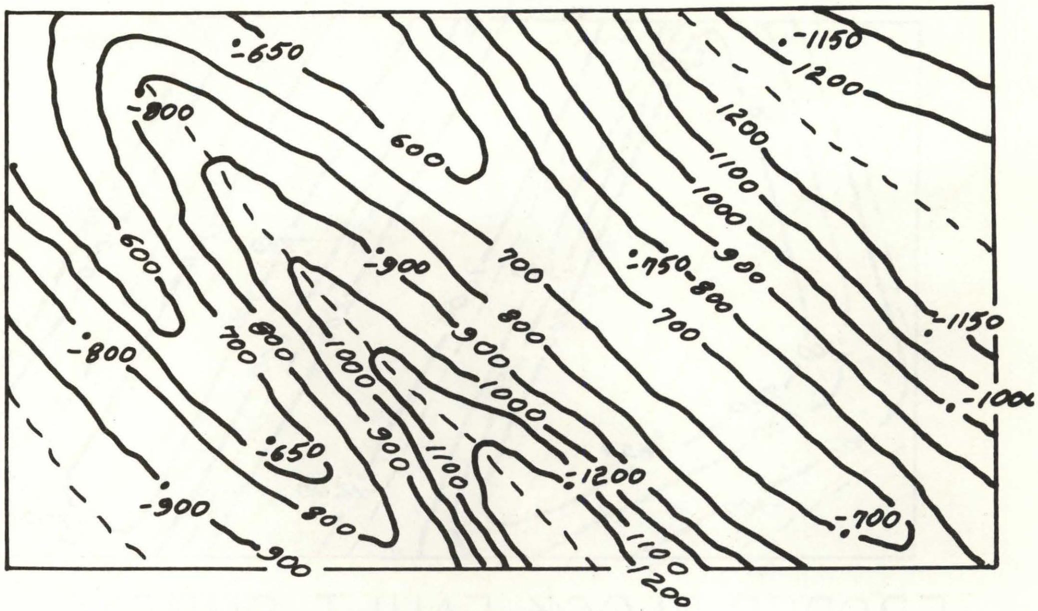


Y

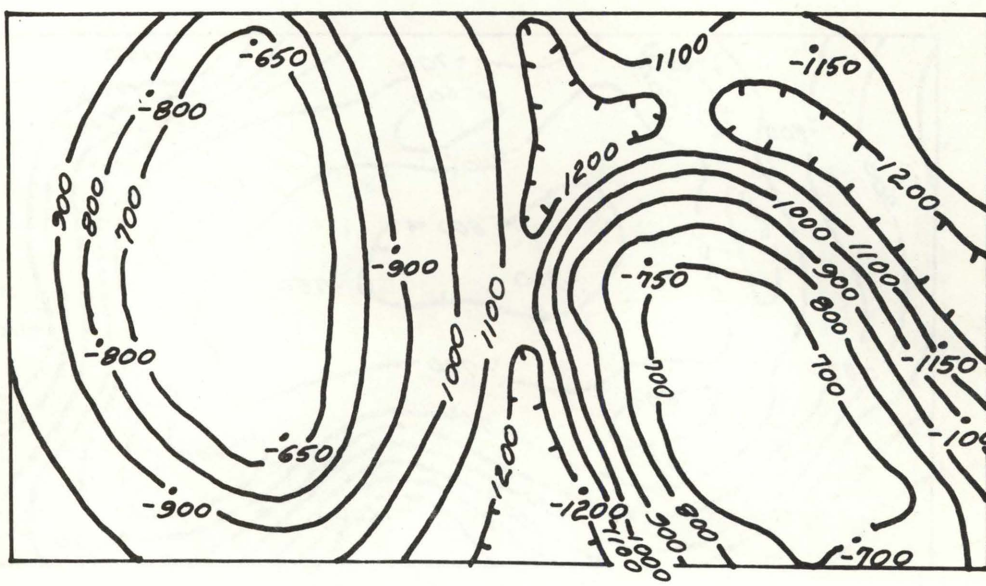


Z

FIGURE 9 - Z is suppodedly a more valid version of what the actual surface really was. Its configuration was verified by more detailed drilling than has been presented on the model maps. Degree of map accuracy would be assessed by comparison with this map while degree of map precision would be assessed by comparison with the average or consensus map.

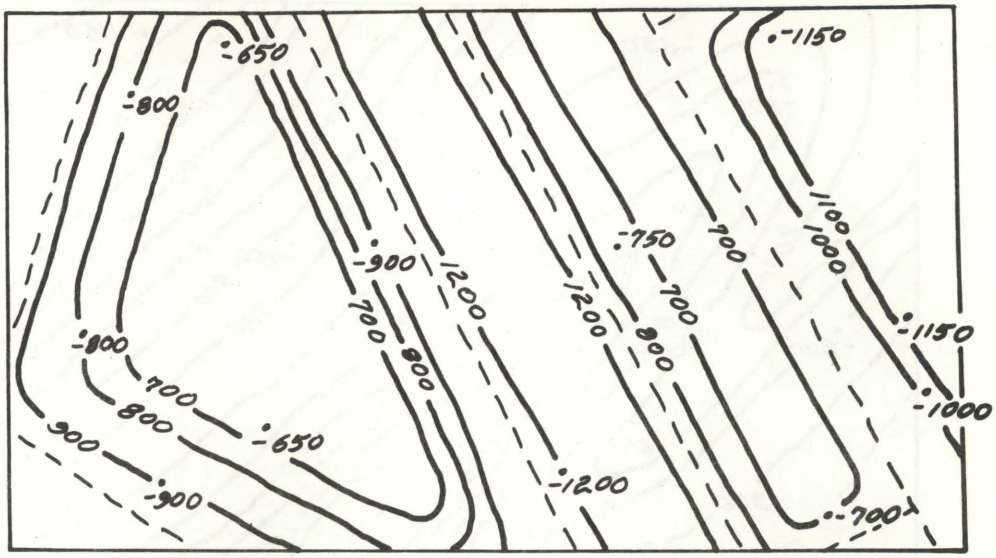


STREAM EROSION
INTERPRETATION

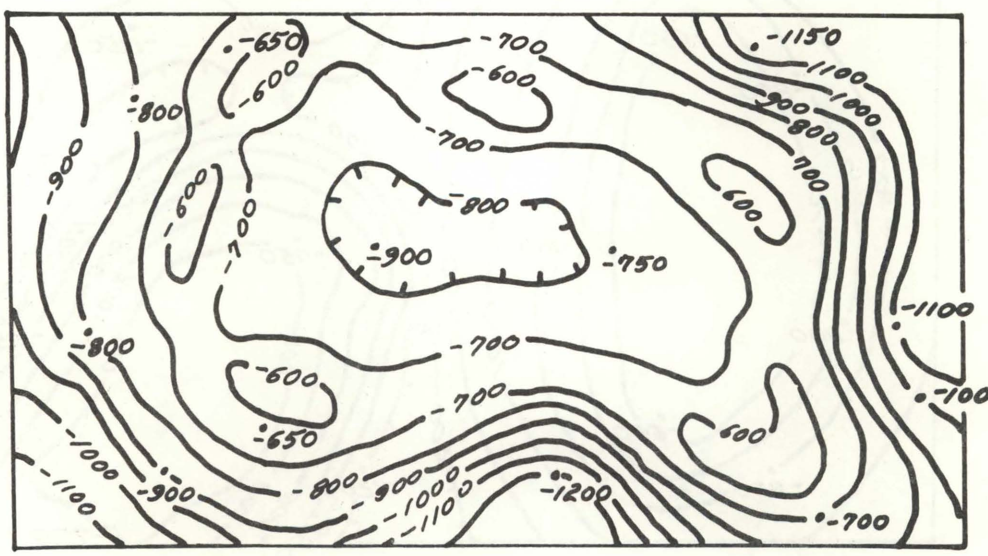


SALT DOME
INTERPRETATION

FIGURE 10 - Interpretive maps by Mr. Doug Lavoie of AMOCO Canada. Contouring is purposely biased by a geologic concept which "fits" within the framework of the data. Much of the map is highly speculative.

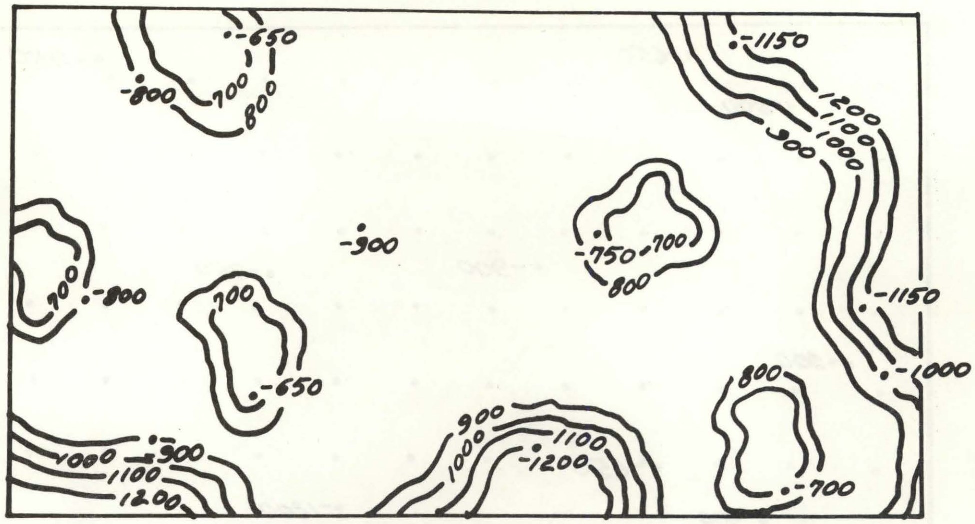


ERODED BLOCK FAULT SURFACE INTERPRETATION

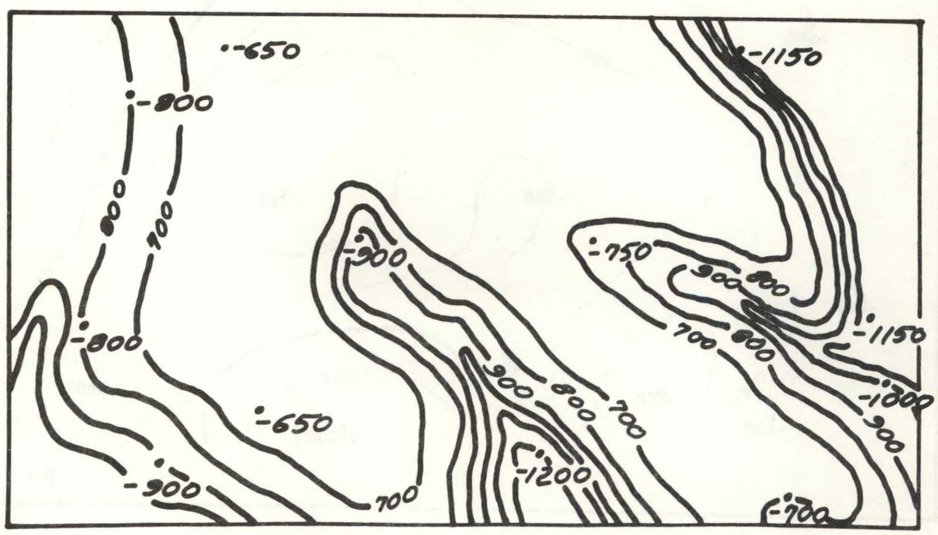


ATOLL INTERPRETATION

FIGURE 11 - Interpretive versions of the model map.

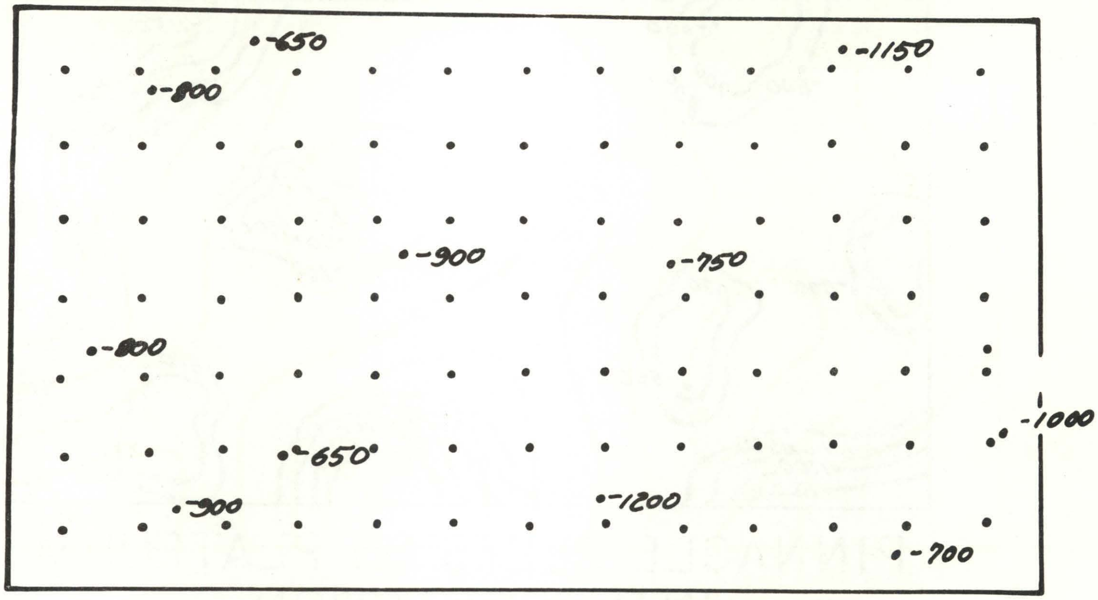


PINNACLE REEFS ON PLATFORM
INTERPRETATION

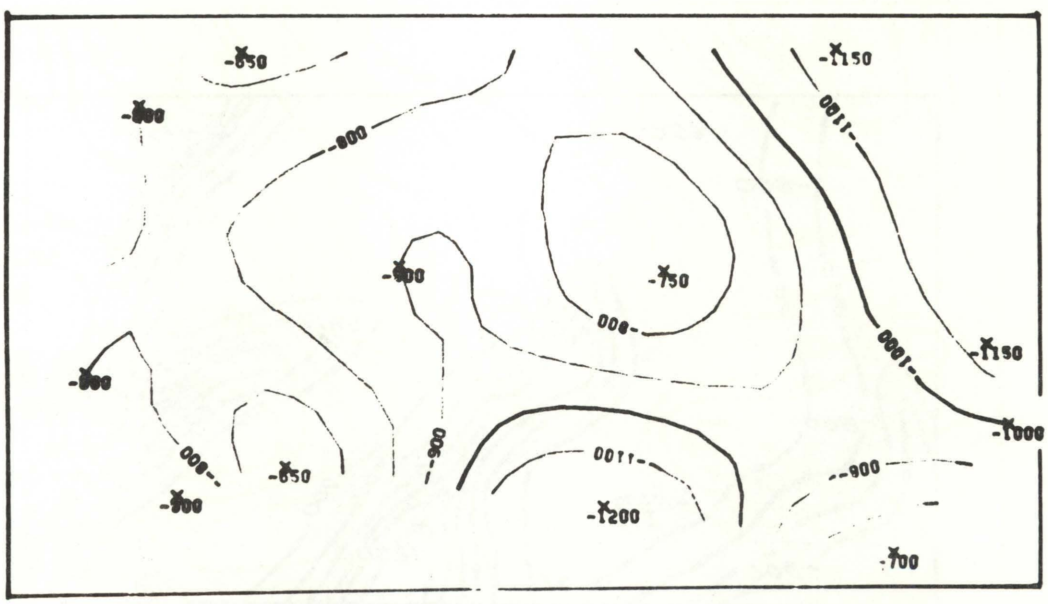


DELTA FRONT
INTERPRETATION

FIGURE 12 - Additional geological interpretations of the map data. In reality the interpretation would be tempered by independent considerations of regional geologic environment, lithology of units involved, etc.

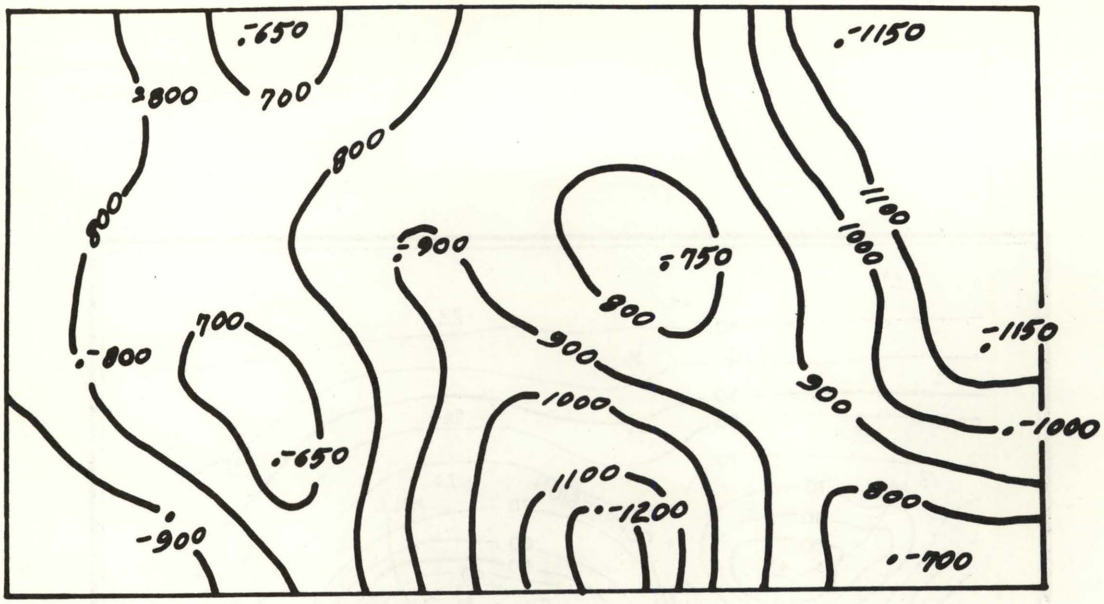


MAP SAMPLING GRID

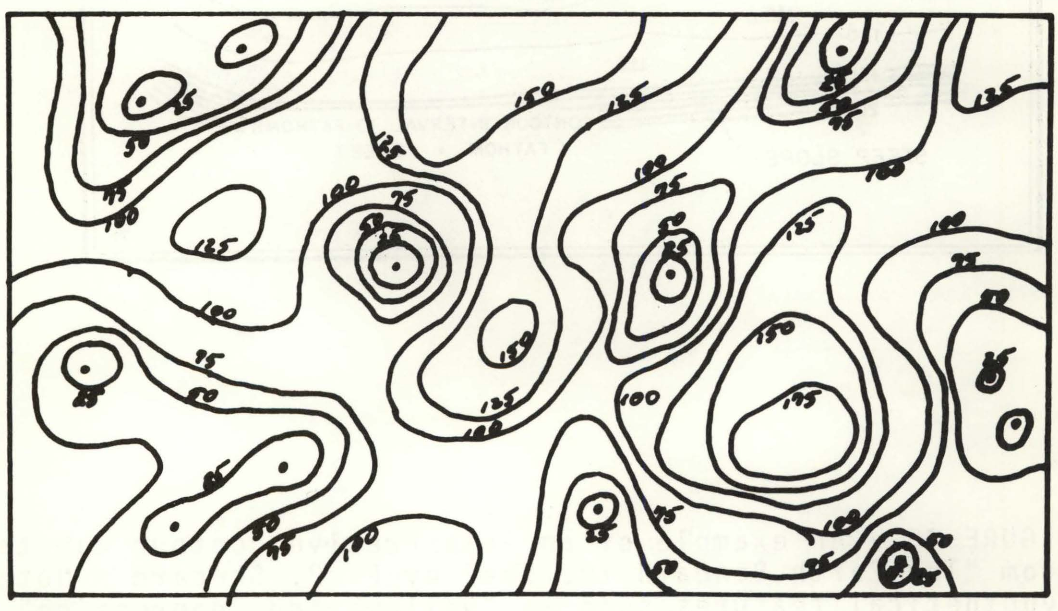


COMPUTER GENERATED MAP

FIGURE 13 - The computer generated map was contoured by a machine in an unbiased manner according to pre-specified, basically geometric rules. The sampling grid shows the points at which all maps were analyzed in order to arrive at the average and ambiguity maps.



CONSENSUS MAP



MAP OF REGIONAL AMBIGUITY
(STANDARD DEVIATION AT EACH SAMPLE PT.)

FIGURE 14 - The consensus map is the average of all thirty versions of the model map. It is thus the best statistical estimate of what the "actual" surface really looks like. The ambiguity map shows areas of the map where variation in estimates of the actual surface was the greatest. A relationship to the density and proximity of control points is apparent.

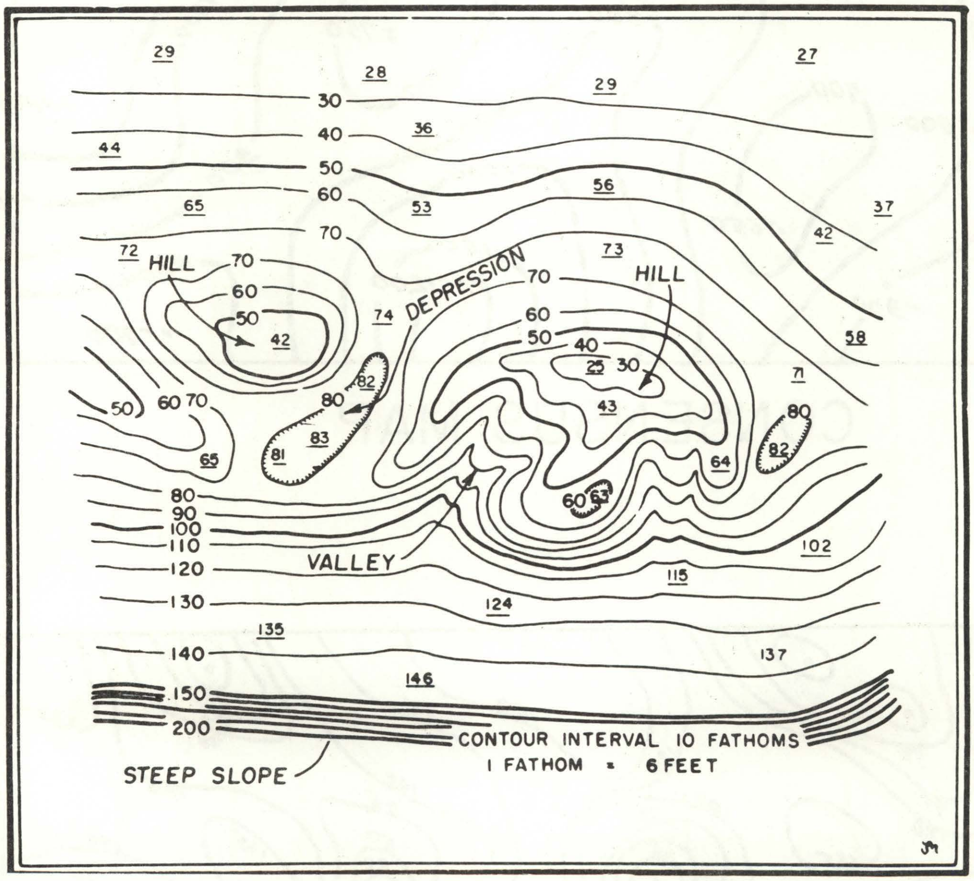


FIGURE 15 - An example of an interpretive contour map taken from "The Earth Beneath the Sea" by F. P. Shepard. Note hypothetical features such as "valley" and "depression" are labelled. Degree of control suggests that their existence is highly speculative, unless based on additional information.

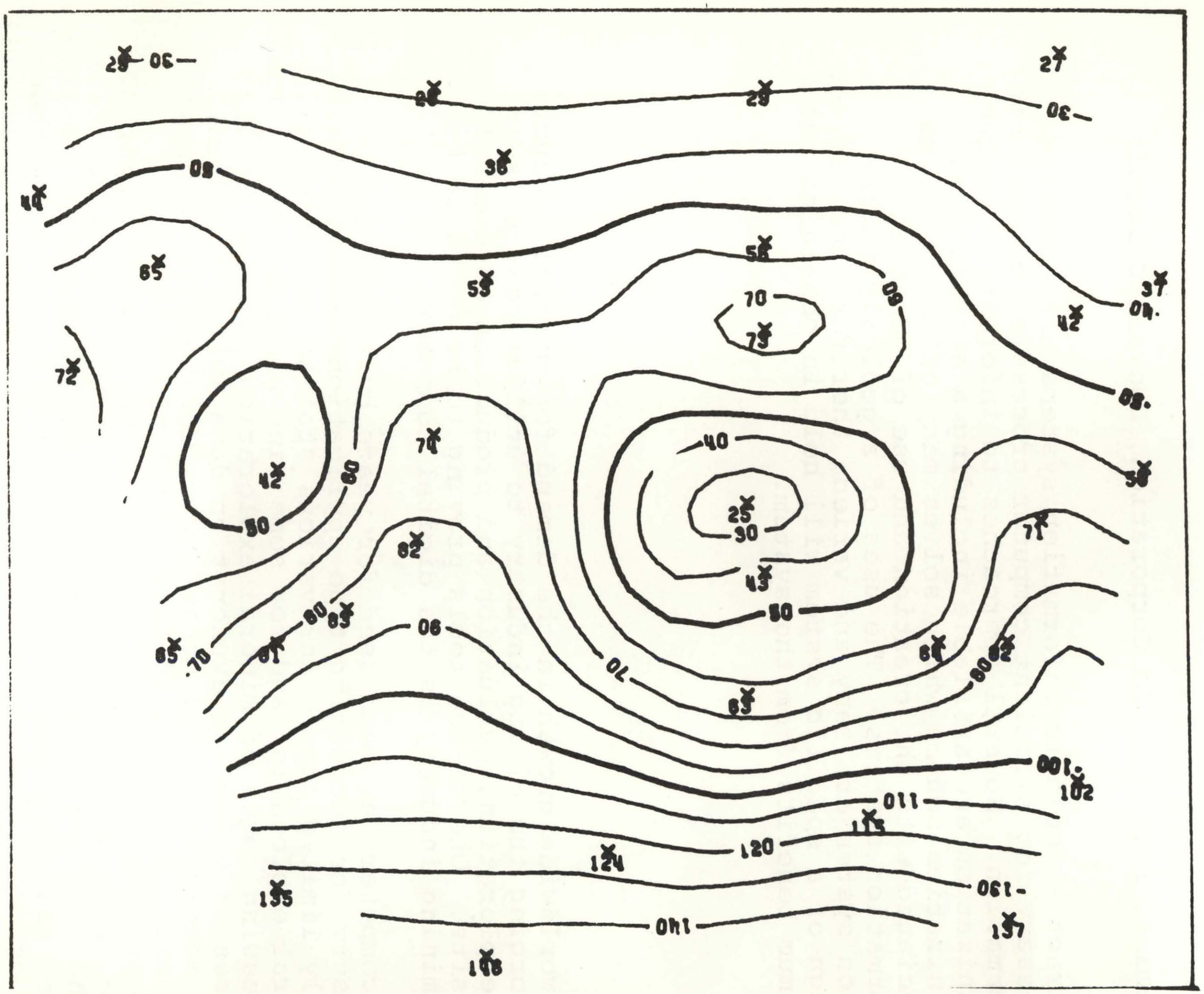


FIGURE 16 - The mechanically contoured version of the map in Figure 15. Note that there remains little substantiating evidence of the features described on the interpretive map.

COMPUTER BASED GEOLOGIC INFORMATION SYSTEMS FOR MINING

Junemann, Paul M., IBM Corporation, Denver, Colorado

Abstract - Geologic information systems are becoming necessary for efficient computer processing of geologic information. Several approaches to information system organization are available including a hierarchical organization scheme which solves many of the problems associated with the creation and use of geologic information systems. The uses of a geologic information system are many and varied; therefore the correct design of a specific system will help in obtaining the maximum benefits from the system.

The worldwide growth in the demand for mineral products is forcing the mining industry to utilize new tools in the exploration, evaluation and production of mineral deposits. One of the tools proving to be of value to the mining industry is the digital computer.

The computer has been used for years by the mining industry for accounting type applications and to a relatively limited degree for various statistical studies in mineral exploration and for some mine planning work. The increasing costs of mineral exploration and the rapidly increasing volume of exploration data (with the advent of remote sensing and other new exploratory techniques) now requires the use of more efficient methods of processing exploration (geologic) data. As Mr. J. B. M. Place, President of the Anaconda Company said in his talk at the 1972 American Mining Congress, "The task of finding a rich mineral deposit is more difficult and costly than ever before. Exploration costs have more than doubled and perhaps tripled for the entire domestic industry in the last dacade and a half. And the odds against finding a viable mineral deposit are estimated at about 10,000 to one". A geologic information system is therefore becoming a necessity to efficiently and effectively process large amounts of data.

A geologic information system consists of a file of computer readable data containing most of the geologic data available for an area of interest. An area of interest may be as large as the world or as small as a single prospect. The geologic data may include information from outcrop samples, mine samples, drill holes and drill hole logs, laboratory analyses of various samples (for both chemical and physical properties), geophysical surveys (electrical, magnetic, gravity, and seismic), remote sensing, and also information from published sources (U.S.G.S., U.S. Bureau of Mines, and academic publications). This geologic data (with the exception of remote sensing) has been the basic data used by geologists for many years. Geologists have developed many manual techniques and a few computerized techniques to process the data in their search for deposits of minerals. Most of the computerized techniques that have been developed emulate manual methods that require a considerable computational effort. Such techniques are used for electrical, magnetic, and gravity surveys, trend and residual studies, and so forth. The cost of computation in the past slowed the development of geologic computer applications, but the recent reductions in computer costs, along with technological advances such as "virtual memory" computers is now making many large, complex applications economically practical. Exploration costs (the money spent on obtaining and gathering geologic data) are rapidly increasing. We must insure that the maximum use be made of the data. The computer is a tool that will greatly aid the geologist in fully utilizing the data.

A geologic information system can be as simple in scope as a simple indexing type of system which points the user to the location of the desired data in either digitized or non-digitized files. This type of system is similar to the literature abstract systems and their retrieval schemes. Systems of broader scope are those where the geologic data has been made machine readable ("digitized") and can be utilized directly by a computer. These types of systems can be "off-line", where the storage medium (cards, magnetic tape, magnetic disk) must be mounted in order to utilize the data. In "on-line" systems, the data is always available to the computer. Combinations of both systems are also possible.

There are two basic ways to organize the geologic information systems - integrated or fragmented. Most systems of the past and present are of the fragmented type, where each basic type of geologic data is stored as a separate file. The drill hole analyses are separate from the electrical surveys which are separate from the mine samples, etc. The integrated type of information system combines all of the different types of geologic information into one file. Until recent developments in data file organization, processing techniques and computer storage devices were made, the integrated type of information system was usually implemented only by the very sophisiticated computer users with large computers available. The new data file organization schemes and storage devices now make the integrated file approach practical for the small computer user.

The integrated information system approach requires considerable planning to obtain the best organization of the data. A file organization scheme known as a hierarchical system allows the merging of a wide variety of differing types of information into one file. An example of this type of organization is the IBM Information Management System (IMS). The hierarchical technique provides for one common element from all the various types of data to furnish the link between them. In a geologic information system this common element could be the geographical location of the data as represented by the latitude-longitude, Lambert coordinates, section-township-range, or some other such system. The degree of refinement of the geographical location will vary with the scope of the total information system. A large system might use a township as a basic unit while a smaller system limited to one mine or prospect might use a square foot.

Within each geographic element will be a hierarchy of elements containing the various types of geologic information stored in the file. Figure 1 illustrates a hierarchical organization for a part of a geologic information system. This is a small and simple example to show the logical relationship of the various types of data that could be contained in the system. A search of the system for data on a specific syenite rock would start through the GEOGRAPHIC LOCATION, through GEOLOGIC DATA to rock type, to IGNEOUS, and on further to SYENITE where specifics on composition, texture, etc. would be found. Some items will have an additional specification of depth or elevation to provide for three dimensional information. Provisions are made for various logical combinations of sub-elements of information and also for multiple entries in any of the data elements that might have multiple values, such as the assay results from a drill hole.

The hierarchical structure of a geologic information system allows the users of such a system to easily determine what information is available in a given geographic area. Further - the users are free to combine any of the available information without concern about multiple data files and their attendant problems.

The ability to combine any available information opens the way to many new exploration and evaluation techniques. It becomes feasible to combine trends of geological, geophysical, and geochemical data and produce a map contoured on a "figure of merit" that combines the information contained in each separate type of data. Correlation studies may be easily made on widely varying types of data.

Economic evaluation studies can combine all minerals of economic value to produce more accurate results. Mine planning studies can have ore grade information, ore/rock type codes, hardness/grindability information, and possibly current open pit bench configuration. Geologic information systems also allow for more complete and comprehensive simulation studies to be made to study the optimum development, operation and economics of a property before it is actually mined.

The creation of a geologic information system is not a simple task. The multitude of information stored in various media, formats, locations, codes and of varying reliability and accuracy must all be reduced to machine readable data. Experience has indicated that the resultant file will contain approximately five percent errors, due to both errors in the original data and to transcription errors. For this reason a considerable editing effort will be required.

The maintenance of a geologic information system consists of both adding new information to the system and correcting errors as they are found. The problem of maintenance is much less with an integrated information system than with a fragmented system where one addition or alteration may require altering multiple files. Some of the hierarchical file organization techniques allow for the addition of entirely new types of data without causing the users of the file to modify their current operations.

When a geologic information system is in the planning and design stages, one of the most important considerations is who will be using the system. If the system is not easily usable by all of the intended users, it will risk failure. A good geologic information system should be of use to the geologist, the economist (for evaluation and perhaps taxation), the engineer (for mine and production planning) and the corporate executive (for long range planning). The design should also consider if all the users will be using the system in a passive manner, submitting a request for information to a data processing group and waiting for the results to be forwarded to him, or if some users will operate in an interactive mode. The interactive user has available a device such as a cathode ray tube terminal that allows him to submit a request and see the results in a matter of seconds or minutes. This type of user demands an integrated, well organized information system to adequately respond to his requests. Programs of both the passive and interactive type to process geologic data are currently available to and used by the mining industry.

The costs involved in the design, creation, maintenance and use of a geologic information system vary widely with the magnitude of the system desired. The wide range of costs precludes stating what an "average" cost might be. Only a study of a specific geologic information system will furnish the required data on which to base a cost figure. The use of a file organization technique that allows for easy, non-disruptive expansion and growth will allow costs and effort to be spread out over as much time as desired, yet allowing a useable (if limited) system to be available in a reasonable time.

In conclusion, the two factors of increasing demand for mineral products and the steadily increasing costs of mineral exploration are causing geologists to utilize the computer as a tool in the exploration and development of mineral properties. To make effective use of the computer as a tool, the geologic data must be available in a well organized, easy to use geologic information system. The necessary data organization techniques, computer hardware, and application programs are available today. The combination of a good geologic information system and a computer gives the geologist the most powerful tool he has ever had to assist him in his search for minerals. Finally, to again quote Mr. Place, "We must look to technology for opportunities to reduce the cost of exploration, or to increase its cost-effectiveness".

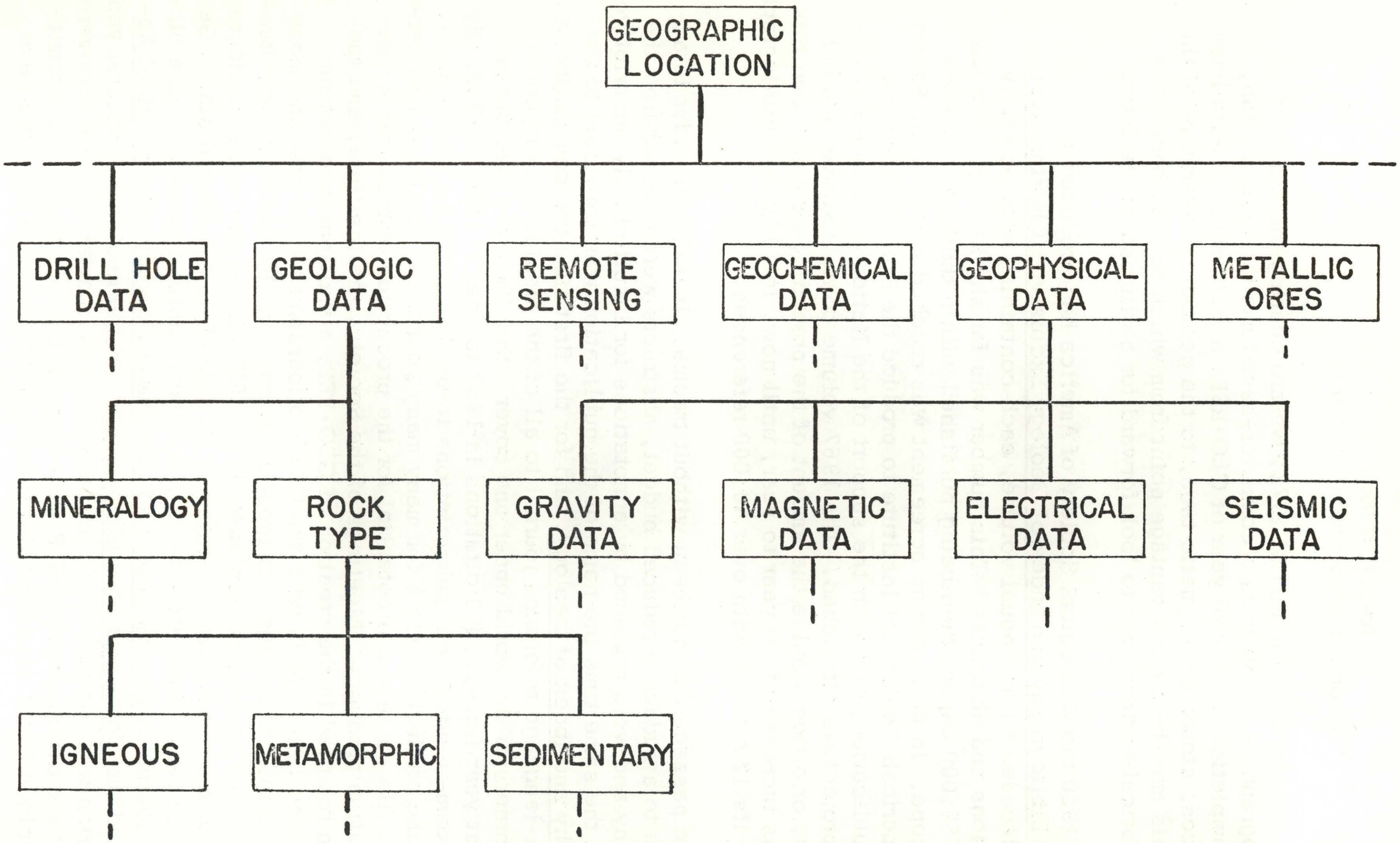

GEOGRAPHIC LOCATION
DRILL HOLE DATA
GEOLOGIC DATA
REMOTE SENSING
GEOCHEMICAL DATA
GEOPHYSICAL DATA
METALLIC ORES
MINERALOGY
ROCK TYPE
GRAVITY DATA
MAGNETIC DATA
ELECTRICAL DATA
SEISMIC DATA
IGNEOUS
METAMORPHIC
SEDIMENTARY

FIGURE I

GEO•REF, A Report and Forecast

Joel J. Lloyd
American Geological Institute

As we approach the end of 1972, we are nearing the close of the GSA Bibliography's 6th year as a computer-based monthly publication, and the completion of the 3rd year of GEO•REF, a multipurpose data base of references, stored on magnetic tape, to the geological literature of the world. This may be a good vantage point from which to look back for a quick historical review, and to look forward for a glimpse of the future.

In 1966 the Geological Society of America had produced and published the Bibliography and Index of Geology Exclusive of North America for three decades as an annual volume, each containing approximately 6000 citations and abstracts. This number was far short of the estimated 40,000 to 50,000 papers then being published within the Bibliography's subject scope. In that year an agreement was reached between the Society and the American Geological Institute to produce the Bibliography as a monthly publication, and with the support of the National Science Foundation, the project was launched. The 1967 volume contained over 11,400 references, or almost double the amount of the preceding annuals, and this number was increased from year to year, until now, in 1972, the Bibliography will close its 12th issue with over 40,000 references.

The passage has not been without trauma. In 1969, in order to accommodate to a suddenly reduced budget, abstracts were dropped from the Bibliography and were replaced by annotations for insufficiently descriptive titles. At the same time the name of the publication was truncated to the Bibliography and Index of Geology, and for the first time the community had an English-language reference journal to all of the disciplines of geology from all corners of the world under one cover. Significantly the contents jumped that year from 17,000 citations in 1968 to over 27,500 in 1969. By 1970 it became evident that subscriptions to the Bibliography alone would not cover the production costs for many many years, but that the computer-based data file contained a potential for the production of many other useful information products. Meetings of the Society, the Institute, and the Foundation resulted in the creation of GEO•REF, a multipurpose system under the direction of AGI, with the GSA Bibliography as its first and most important client. Subsequent to those meetings, the House of Society Representatives, by resolution designated GEO•REF as the center for bibliographic control of the geoscience literature. During 1971, the United States Geological Survey announced its intention to cease publication of its three bibliographic journals, Abstracts of North American Geology, Geophysical Abstracts, and the North American Bibliography, at the end of that volume year. This decision was met with consternation in some quarters, and with fevered activity at the offices of GEO•REF when the Institute accepted the commitment to include in its data base the information that would normally have been covered by the Survey bibliographers.

The economic premise of GEO·REF was (and is) that each reference stored on magnetic tape has multiple uses, and that the initial intellectual and computer storage costs should be shared by its users. Thus the reference to a paper on the Miocene stratigraphy of X-county, California, originally published by the Journal of Sedimentary Petrology, would appear in the GSA Bibliography, its indexes would be selected out for inclusion in the annual index of that volume of the Journal, it might also appear in the American Museum of Natural History's Bibliography and Index of Micropaleontology, it could conceivably be drawn from the GEO·REF file for inclusion in a Bibliography of California produced by the Division of Mines and Geology, it would be included on magnetic tapes leased to several information centers in a search and retrieval format, and it might appear in the pages of a special bibliography of foraminfera. It is evident that the cost of using GEO·REF will decrease in direct proportion to the extent of its use.

GEO·REF is not standing still, however, and waiting for an influx of users to bring its costs down. Through the introduction of operating efficiencies and through a consistent search for more economical procedures, the system will store between 50,000 and 60,000 references in 1972 with approximately the same number of employees and budget with which it input 11,400 references in 1967. The result is that the cost of processing a single document has been reduced from around $35 in 1967 to $9 in 1972. Nor has the search for further cost-savings stopped. A change just made, to transfer the keyboarding of information to the computer from a contracted service to an "in-house" operation is expected to drop the per reference processing cost another dollar in 1973.

The greatest part of the input costs remains the intellectual processing of material - the reading, indexing, classifying, and citing of the current papers. This work is performed by a staff of eight to ten editors, all geologists, and the majority holding Masters or Doctors degrees. This cost can be substantially reduced if we obtain the cooperation of the entire community. GEO·REF is now producing the Bibliography and Index of Micropaleontology which is published by the American Museum of Natural History and distributed to subscribers in monthly issues. The original work of accessing, reading, indexing, and preparing the micropaleontological literature is being shared by GEO·REF and the Museum. An editor/indexer, hired and housed by the Museum in New York City, spent a training period in Washington with GEO·REF. She now prepares about one half of the micropaleontological papers and periodically sends them to Washington where they are input to the system. Her contribution, about two thousand papers a year, releases a GEO·REF editor to process an equal number that would not otherwise have been added to the data-base. The increased volume brings down the per reference cost, moves GEO·REF closer to self sufficiency, and will allow the saving to be passed along to the user.

Similar cooperative arrangements are now being considered in vertebrate paleontology and with the California Division of Mines and Geology for the tape storage of ten years of their literature. GEO•REF is preparing a Manual to their operating procedures which will cut down the training time and supplement the instructions for cooperating groups. Further cooperation is being sought both nationally and internationally through the Societies, research institutions, and libraries. It is almost needless to point out that when each subdiscipline is providing its special interest literature, prepared and indexed by experts in its field, rather than by the "generalists" that GEO•REF must obviously use, the final product will not only be less expensive but will be beyond qualitative reproach.

The magnetic tape storage of references to the historical literature of geology, dating back to the 19th century has concerned us for several years. It is not necessary to demonstrate to this group the importance of the older writings to the research geologist - it must be very well known. We are still planning to add this store to the GEO•REF data base and it is the subject of present conversations with the National Science Foundation that will lead to the submittal of a formal proposal. The accession will not only provide another important service to the community, but it will greatly enhance the value of retrospective searches of GEO•REF tapes.

We have divided the historical literature into two groups - that which was indexed and cited in bibliographies prior to the introduction of electronic data processing, and the great corpus of literature, particularly the non-North American, which has never been included in a secondary reference. Our initial approach will be to the first group, that now in print. We estimate that the combined bibliographies of the GSA prior to 1967, and the USGS before 1963, contain about half a million indexed references. Modern computer methods exist for copying and storing the information from those pages without requiring further keyboarding. A corrective edit is required, however, to bring the diverse indexing systems that were used through the years to a compatible keyword set. The cost of this project will be in the area of a million dollars and will certainly have to spread over several years. When the first task is accomplished, we will turn to the second, the unrecorded literature.

In the meantime GEO•REF goes on with its generation of monthly bibliographies, primary journal indexes both annual and comulative, computer listings to special interest groups for distribution at symposia and conferences, tape leasing to information centers and to industry, and retrospective searches. In all of these areas further use of the data base is being sought. The AGI's own Committee on Geoscience Information, with a member representing the Geoscience Information Society, is taking an active interest in the problems and the workings of GEO•REF. We urge all of the members of G. I. S. to take further interest in the bibliographic system. You stand between it and the ultimate users in the role of interpreter. We welcome your interest and your contribution directed to building a more effective system.

COMPUTERIZED LITERATURE SEARCHING IN GEOLOGY

by

John H. Schuenemeyer
Computer Center

and

George S. Koch, Jr.
Department of Geology

University of Georgia
Athens, Georgia 30601

ABSTRACT

Computerized literature searching provides an efficient method of staying abreast of current literature and reviewing existing documents. This paper describes how the geologist and others use a computerized literature search system. Search results from several branches of geology are presented.

INTRODUCTION

We are living in what has frequently been called the Age of Technology, and it is true that we have seen a rapid increase in the pace of scientific and technological development within the past 50 years or so. One result of this effort has been what is usually referred to as an "information explosion." Across all subject disciplines, publishers of scientific journals, technical reports, abstract and index compilations, and even the U.S. Patent Office have found themselves floundering in an attempt to handle the increasingly large volume of material, both physically in terms of the amount of printed material and economically in terms of rising publication costs. The users of the literature -- the scientists, engineers and managers -- are also faced with the same two problems: increasing volumes and increasing costs. It has become exceedingly difficult for the individual researcher to keep up with literature in even a narrow subject field. Compounding this difficulty is the fact that more and more of our technological problem areas are multidisciplinary. Waste disposal, for example, may draw from geology, chemistry, civil engineering, and sociology. Publication costs are constantly going up, which affects both the individual scientist and the libraries.

So, over the past 8 to 10 years, both the users and the publishers have turned to computer technology as a means of coping with both the volume and the costs. Aside from the newspaper industry, the leaders in the area of applying computer technology to their publishing problems have been the abstracting and indexing services which attempt to prepare summaries of all documents pertinent to their particular subject areas. They also generate indexes of various types in order to retrieve these documents. These organizations include not only the large, professional-society based services in fields such as geology, chemistry, biology, and engineering, but also federal government agencies and the commercial sector.

Largely as a byproduct of the publishing business, the bibliographic and indexing language of the traditional library reference resources are also available in machine-readable form, suitable for subsequent computer processing to serve the scientist. That is, questions can be matched against the magnetic tape files, and bibliographies of pertinent references to published papers, reports, or patents can be provided directly to the researcher. Long hours formerly spent in the library to find references can now be used instead to study the relevant literature which has already been located. The organizations which have evolved for the handling of computer-based retrieval services on these bibliographic data bases (as the machine-readable versions are named) are generally known as Information Dissemination Centers, some of which are associated with libraries while others have grown up within computer centers. There are presently some 30 to 40 established Information Dissemination Centers as defined for membership in either ASIDIC (Association of Scientific Information Dissemination Centers) or in EUSIDIC, its European counterpart. These include, in this country, universities such as Georgia, Pittsburgh, Lehigh, and UCLA; companies such as Dow Chemical, Eastman Kodak, Dupont, General Telephone and Electronics, the Institute for Scientific Information, and the 3i Co.; and non-profit organizations such as the Illinois Institute of Technology Research Institute and BioSciences Information Service. There are also centers in Canada and Japan, and in Sweden, England, Denmark, The Netherlands, Germany, France, Finland, and other European countries. Although the centers have taken somewhat different approaches during the development period, the pattern which has emerged is fairly consistent. They all were established to provide bibliographic retrieval services to supplement the traditional reference resources of the library. They all have information specialists to work with the users of the service in formulating the search questions. They all have programmers to develop the computer programs. And they all have access to relatively large computer installations. In the remainder of this presentation, the use of the University of Georgia literature search system will be described with special emphasis on searching geological data bases.

The Georgia Information Dissemination Center (GIDC) provides computer-based literature searches for the faculty, research staff, and graduate students of the 28 state-supported colleges and universities within the University System of Georgia and also provides services* to other universities, government agencies, and industrial organizations on a cost-recovery basis. Since the center was established at the University of Georgia in July, 1968, it has grown from 10 search questions or profiles on one data base in the field of biochemistry to more than 5000 standing profiles for current awareness or SDI searches on 14 data bases. Retrospective, or demand, searches are provided on the accumulated files of

* For additional information, write Georgia Information Dissemination Center, Computer Center, University of Georgia, Athens, Georgia, 30601.

more than 4 million documents for 20 data bases, and average 400 to 500 per month. The current subject areas and bibliographic data bases are shown in Figure 1.

AGRICULTURE
- Cain

BIOLOGY
- Biological Abstracts
- BioResearch Index
- Toxitapes

CHEMISTRY
- CA-Condensates
- Chem.-Biological Activities
- Chemical Titles

NUCLEAR SCIENCE
- Nuclear Science Abstracts

SOCIAL SCIENCE
- Sociological Abstracts

BEHAVIORAL SCIENCE
- Psychological Abstracts

EDUCATION
- Current Index to Journals in Ed.
- Research in Education

ENGINEERING
- Cite
- Compendex

GEOLOGY
- Biblio. of N. Am. Geology
- Geo.Ref
- Geophysical Abstracts

PHYSICS
- SPIN

RESEARCH REPORTS
- GRA

TOXICOLOGY
- Toxitapes

Figure 1. Bibliographic data bases used for current awareness and/or retrospective searches.

The GEO.REF data base, supplied by AGI, is a monthly issue and corresponds to the printed Bibliography and Index of Geology. The computerized retrospective collection for this data base starts with Volume 31 (1967). The other two geological data bases are from the U. S. Geological Survey and are retrospective collections only. Many other data bases, such as Chemical Abstracts, Compendex (Engineering Index), and GRA (Government Report Announcements) contain citations which are of interest to the geologist. For example, Compendex contains citations in geological and mining engineering, metallurgy, and land reclamation. Most data bases, but not all (e.g., SPIN), have corresponding printed versions. The frequency of the publication of the computer-readable issues varies from weekly to quarterly, just as do the corresponding printed versions, but in general the magnetic tapes precede the printed issue by at least two weeks.

The principal types of documents covered in the GIDC data bases are shown in Figure 2.

Journal Articles

Government Reports

Maps

Books

Conference Proceedings

Figure 2. Type of documents referenced

Most document citations are from journals; however, theses and patents are included in some data bases. The degree of journal coverage varies; some abstracting services, such as SPIN, abstract all articles from the journals they cover, while others, such as Compendex, abstract only those articles of an engineering nature. Most abstracting and indexing services supply lists of the journals covered, together with the type of coverage -- occasional, partial, or complete.

The type and amount of information contained in a document citation varies widely; however, all of the GIDC citations contain the information shown in Figure 3.

Primary Document Citation
(Journal Reference)

Secondary Document Citation
(Abstracting Service)

Document Title

Authors' Names

Figure 3. Information contained in all citations

In addition, many citations contain some or all of the entries shown in Figure 4.

Controlled Vocabulary Terms

Free Index Terms

Abstracts

Location of Work

Alpha or Numeric Classification Codes

Figure 4. Other entries in citations

Abstracting services which use controlled vocabulary or key word terms supply a printed thesaurus. The thesaurus may also contain related terms, broader and narrower terms, and sometimes the frequency of occurrence within a document collection. Free index terms are key words in the abstract or title but not part of a controlled vocabulary. Alpha or numeric classification codes are used to specify subject areas, names of journals, and document language. For example, all document citations in the SPIN data base on seismology carry the code TLDLAU. In the GEO.REF data base, all citations on marine geology carry the classification code 10; classification codes in GEO.REF correspond to fields of interest listed in the table of contents of the Bibliography and Index of Geology.

SEARCH QUESTION CODING TECHNIQUES

At the Georgia Information Dissemination Center, information specialists provide the interface between the user of computerized literature search services and the computer systems. The specialists are people who have degrees in the subject areas for which they code profiles -- biology, chemistry, geology, education, etc. Additionally, the reference librarians at several institutions within the University System of Georgia prepare profiles for users on their campuses, consulting the University's subject specialists as necessary. All of these people serve as specialized reference librarians. They talk with the users about their literature needs and then formulate a search question. They can also provide advice on the most appropriate data bases to be searched. An early attempt to have users code their own profiles was a complete failure. When the user visits the information scientist he should have the information shown in Figure 5.

Well-Defined Statement or Question

Synonyms, Key Words, Alternate Spellings, and Foreign Language Spellings.

Scope of Output - Broad or Narrow

Bibliographic Citation

Figure 5. User supplied information

The number and percent of relevant answers is directly related to a well defined search question. Synonyms and related terms should be supplied, especially for data bases such as GEO.REF which do not have a controlled vocabulary. For example, an abstract containing the term LUNAR but not the term MOON would not be retrieved by a search question containing only the term MOON. The scope of output is frequently influenced by the amount of literature in a given field and the degree of risk of missing a relevant answer that the user is willing to take. Figure 6 shows a tradeoff which the user must frequently make.

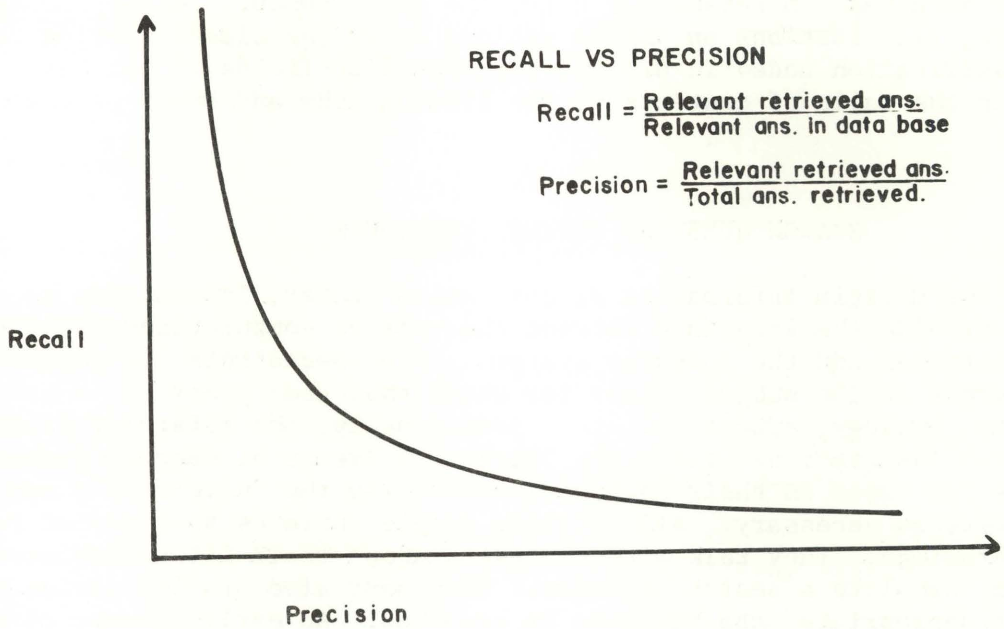


Figure 6. Recall vs. precision

If a user, e.g., someone working on his doctorate, does not want to miss anything written in a field of interest, the search question often must contain many broad and related terms which increase the chance of retrieving many irrelevant document citations. On the other hand, a user who wants a sampling of the articles in a given field and is willing to accept a high risk of missing relevant answers can achieve high precision; i.e., most of his answers will be relevant. Terms or search questions in a field where a small volume of literature exists normally are restricted less than those concepts about which much has been written. For example, it would not be unreasonable to retrieve all document citations about anorthosite, but the user who wished to retrieve all document citations on titanium might be buried in computer printout. An important point emphasized by the information specialist and successful user of computerized literature searching is that good search questions or profiles are rarely prepared the first time. Search output is reviewed by the information specialist but should also be carefully reviewed by the user. If the user believes that the profile is yielding insufficient answers, additional related or broader terms may be added or restrictions may be removed. If the user is receiving too high a percentage of irrelevant answers, the document citations should be classified as relevant, possibly relevant, or not relevant. Then he, working with the information scientist, often can formulate restrictions to eliminate many of the unwanted citations. The user must assume the responsibility of calling any suspected deficiences to the attention of the information specialist.

GEOLOGICAL EXAMPLES

Let us now consider a few specific examples. Figure 7 illustrates two sample search questions.

1. Geochemistry of titanium.

2. Anorthosite and ophiolite
   excluding lunar occurrences.

Figure 7. Search questions

The formulation of the search question and output will be illustrated for each. Search questions are formulated using standard Boolean logic with the AND, OR, and AND NOT operators. Figure 8 shows the search terms and Boolean logic for the titanium question.

GROUP	TERM NO.	TYPE	WEIGHT	TERM
G001	1	TXT	00000	TITANIUM
G001	2	EIT	00000	TITANIUM
G001	3	TXT	00000	TI
G002	4	TXT	00000	GEOCHEM*
G002	5	EIT	00000	GEOCHEM*
G002	6	TXT	00000	PETROLOG*
G002	7	EIT	00000	PETROLOG*
G002	8	TXT	00000	ORE DEPOSIT*
G002	9	EIT	00000	ORE DEPOSIT*
G002	10	CAS	00000	053*
G002	11	TXT	00000	MINERAL*
G002	12	EIT	00000	MINERAL*

G001*G002

NUMBER OF ANSWERS 53

Figure 8. Terms for the titanium search question

In order to get a hit or retrieve a document citation for the titanium question, a term from group 1 (G001) and a term from group 2 (G002) must be found in the document citation. The asterisk in the Boolean expression indicates the AND operation. A TXT or text mnemonic causes titles, free index terms and abstracts to be searched. The EIT term is a Compendex controlled vocabulary mnemonic and the CAS mnemonic is a Chemical Abstract classification code. Frequently, a single search question can be run against several data bases. The asterisks indicate truncation. Thus, the term GEOCHEM* would retrieve words such as geochemistry and geochemical. Both left and right truncation are permitted. In this profile the terms of group 2 are 'anded' with the terms of group 1 to restrict the answers that would be obtained if we searched only on titanium and, of course, to reduce the number of irrelevant answers. Figure 9 shows a document retrieved from GEO.REF by the titanium search question.

```
****************************************
PROFILE = 005660-003          OCT. 12, 1972
                           QUESTION WT.      +0
BEUS, ALEXEI A ,
    TITANIUM DISTRIBUTION IN THE LITHOSPHERE
CHEM  GEOL  VOL  8, NO  4, P  247-275, 1971

KEYWDS.  TITANIUM, DISTRIBUTION, CRUST, CRUST, COMPOSITION, TITANIUM,
  DISTRIBUTION, BIBLIOGRAPHY, GEOCHEMISTRY, TITANIUM
BIBLIOGRAPHY AND INDEX OF GEOLOGY(GEO.REF) E72-13029
****************************************
```

Figure 9. Titanium document citation

The profile number is a unique user-question number assigned by the computer. The author (or authors) is the first item printed, followed by the document title and the journal citation. This citation is one which a U.S. geologist would be likely to miss without the aid of computer searching. Following the primary citation are keywords or free index terms. The last line contains the secondary citation or name of the abstracting and indexing service followed by the accession number. Abstracts can be printed for a slight additional cost. The printout of document citations from other data bases is similar. Controlled vocabulary terms are usually printed and classification codes are frequently printed.

The second search question concerns anorthosite and ophiolite; the search terms and Boolean expression are shown in Figure 10.

GROUP	TERM NO.	TYPE	WEIGHT	TERM
G001	1	TXT	00001	ANORTHOSITE*
G001	2	EIT	00001	ANORTHOSITE*
G001	3	TXT	00000	OPHIOLITE*
G001	4	EIT	00000	OPHIOLITE*
G002	5	TXT	00000	LUNAR
G002	6	TXT	00000	MOON
G002	7	EIT	00000	LUNAR*
G002	8	EIT	00000	MOON*

G001*-G002

NUMBER OF ANSWERS 18

Figure 10. Terms for the anorthosite and ophiolite search question

The terms in group 2 (G002) are 'and noted' with the terms in group 1 (G001), which means that a document citation which includes the words anorthosite or ophiolite but also contains the term lunar or moon will not be retrieved. The asterisk minus is a symbol for AND NOT. The AND NOT logic is frequently employed to exclude journals which are normally reviewed by the user. This profile also illustrates the use of weighting. Answers may be sorted by an assigned weight. In this case all anorthosite answers will appear together and before the ophiolite answers. An anorthosite answer is shown in Figure 11.

```
****************************************
PROFILE = 005660-004            MAR. 03, 1972
                          QUESTION WT.      +1
SMITH, BRUCE D.,HODGE, DENNIS S.,
    GEOLOGY AND GEOPHYSICS OF SYENITES ASSOCIATED WITH LARAMIE ANORTH
    OSITE, WYOMING
CONTRIB. GEOL. (WYO., UNIV.) VOL. 9, NO. 1, P. 27-38, ILLUS. (INCL. G
 EOL. MAP), 1970

KEYWDS.  IGNEOUS ROCKS, INTRUSIVE, PETROLOGY, TEXTURES, WYOMING, SOUT
 HEAST, WYOMING, PETROLOGY, SOUTHEAST, INTRUSIVE, INTRUSIONS, STRUCTU
 RE, WYOMING, SOUTHEAST, PRECAMBRIAN, WYOMING, SOUTHEAST, GRAVITY SUR
 VEYS, WYOMING, SOUTHEAST
BIBLIOGRAPHY AND INDEX OF GEOLOGY(GEO.REF) 1971, 35(1), E71-01486(09)
****************************************
```

Figure 11. Anorthosite document citation

This is another citation which probably would not have been found without computer searching. Note that the question weight is printed on each citation. An ophiolite citation is shown in Figure 12.

```
****************************************
PROFILE = 005660-004          MAR. 03, 1972
                         QUESTION WT.        +0
PERRIN, M.,
    THE OPHIOLITIC NAPPE OF EASTERN ELBA
SOC. TOSCANA SCI. NATUR., ATTI, MEM., SER. A VOL. 76, P. 45-87 (INCL.
  ITAL. SUM.), ILLUS. (INCL. GEOL. MAP 1.25,000), 1969

KEYWDS.  ITALY, AREAL GEOLOGY, ELBA, EAST, MAP, ITALY, MAPS, GEOLOGIC
 , ELBA, EAST, FOLDS, OVERTHRUST, ITALY, ELBA, TECTONICS, ITALY, ELBA
 , EAST, FOLDS, EVOLUTION, SEDIMENTARY ROCKS, LIMESTONE, GENERAL, ITA
 LY, ELBA, SEDIMENTARY ROCKS, JASPER, GENERAL, ITALY, ELBA, JURASSIC,
  MALM, JURASSIC, ITALY, ELBA, EAST, MALM, CRETACEOUS, ITALY, ELBA, E
 AST, MALM, PROTOZOA, CALPIONELLA, JURASSIC, CRETACEOUS, ITALY, MALM,
  ELBA, IGNEOUS ROCKS, OPHIOLITE, PETROLOGY, ITALY, ELBA
BIBLIOGRAPHY AND INDEX OF GEOLOGY(GEO.REF) 1971, 35(1), E71-00758(01)
****************************************
```

Figure 12. Ophiolite document citation

In addition to controlled vocabulary and free text (TXT) terms, classification codes, when available, can be a powerful tool to obtain both high recall and high precision. Figure 13 illustrates the use of the GEO.REF classification codes and document language codes.

Search Statement: Economic geology in GEO.REF; English and Russian citations of special interest.

Boolean Expression: (G001 & G002) + G001

Group	Weight	Dem	Term
G001		GCN	02
G002	1000	PDL	EN
G002	500	PDL	RU
G002	400	PDL	GG

Figure 13. Numeric classification and document citation

The mnemonic GCN is the GEO.REF code for economic geology and will cause all citations on economic geology to be retrieved. The primary document language codes (PDL's) are EN (English), RU (Russian), and GG (Georgian). The Boolean expression reads group 1 and group 2 or (indicated by +) group 1. The purpose of this expression together with the weighting is to cause all English citations on economic geology to print first followed by articles in Russian. If the +G001 were left off, only articles in economic geology in English or Russian would be printed. Since much has been written in the field of economic geology, this question should be restricted, say to economic geology as related to the valuation of ore deposits or whatever is the user's interest. Searching on authors is shown in Figure 14.

Group	Weight	Dem	Term
G001	30	ATI	VISTELIUS, A*
G001	20	ATI	KRUMBEIN, W*
G001	10	ATI	WATSON, GEOFFREY*
G001		ATI	WATSON, G*

Figure 14. Author search

Weighting is used to group articles within authors. Note, that the term WATSON, GEOFFREY* would not pick up articles by Dr. Watson if only his first initial appeared in the citation, therefore, the term WATSON, G* is included. The term WATSON, G* would pick up articles by anyone with a last name of Watson and a first name beginning with G.

The need for synonyms and related terms has been shown in several of the previous examples; however, because of its importance, a final example will be shown in Figure 15. All of the terms in Figure 15 refer to land reclamation; however, some are rather broad such as LAND USE, while others such as REFORESTATION are narrower in scope. The probability of retrieving a relevant citation is normally related to the number of different ways that a concept can be expressed.

LAND USE*

LAND UTIL*

LAND RECLAMATION

DISTRUBED MINE LAND*

REFORESTATION

LAND FILL*

RECULTIVATION

Figure 15. Synonyms and related terms

CONCLUSION

Search questions are entered into the system via on-line terminals. There are three at the University in Athens, one in Atlanta serving Georgia Tech and Georgia State, and another at the Environmental Protection Agency in Cincinnati. Searching of the profiles against the data bases is performed in the batch mode. The complete retrospective collection of the GIDC is searched every two weeks. Output for those requesting retrospective searches is mailed during this period or sent via leased lines to remote users. The search questions for users who wish to be kept up-to-date are stored in the computer system and automatically run against new issues of the data base tape.

The impact of computerized literature searching on present information habits of the university community was explored in a recent survey of the users within the 28 University System institutions. Over 97% of the respondees indicated that the computer-based services had contributed either some or substantially to their professional activities, with the major contributions being the amount of time saved in searching the literature (though not necessarily a savings in time spent using the library materials) and the significant broadening of subject areas which can be routinely monitored. The GIDC staff is highly encouraged that the computer-based services have proved a helpful supplement to the traditional institutional library resources, and is constantly seeking improvements in computerized literature searching.

DEVELOPMENT AND INITIAL USE OF COMPUTER-BASED GEOSCIENCE INFORMATION FILES AT MARATHON OIL COMPANY

Clarence A. Sturdivant
Betty J. Miyahara
Stephen O. Boyle

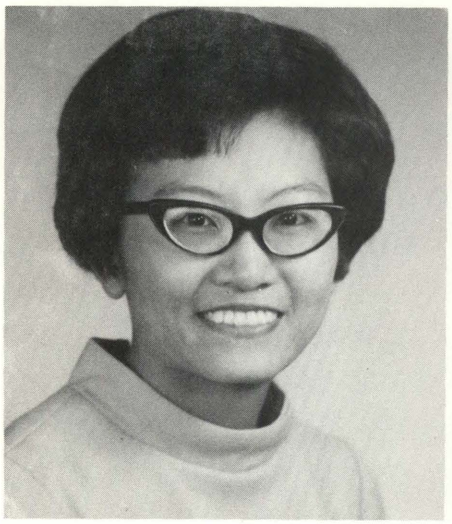
Marathon Oil Company
Denver Research Center
Littleton, Colorado 80120

Presented before the Geoscience Information Society
November 13, 1972, Minneapolis, Minnesota

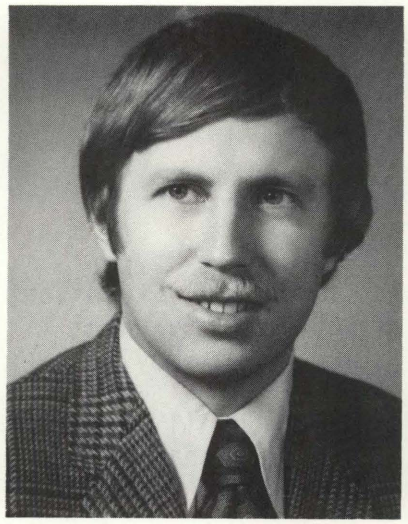
FOREWORD

This paper describes, in a general way, very specific work accomplished during the year 1972-73 at Marathon Oil Company's Research Center, Technical Information Section, Littleton, Colorado. More detailed information may be obtained by contacting us directly by mail or telephone. We welcome your comments, suggestions, and criticisms.

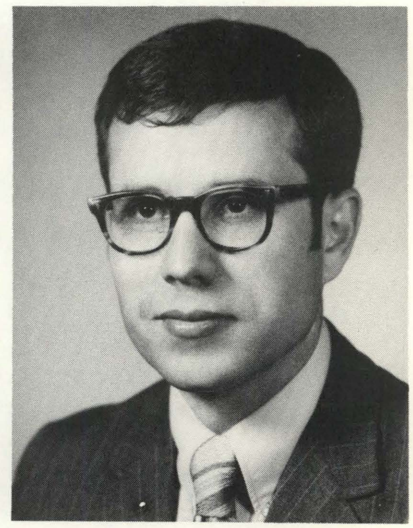
About the people who did the work described in the paper . . . .



Betty J. Miyahara, Associate Information Specialist, joined Marathon Oil Company in 1970 and has been responsible for the entire systems design and programming effort which went into this work. She holds a B.S. in Mathematics from Colorado State University and an M.A. in Mathematical Statistics from the University of Washington (Seattle).



Stephen O. Boyle, Associate Information Specialist, has been employed at Marathon since 1971 and is responsible for all literature searching activities surrounding the data bases described in the paper. He holds the B.S. in Chemistry from Loras College (Iowa) and the M.A. in Physical Chemistry from the University of Colorado.



Clarence A. Sturdivant, Supervisor of Technical Information at Marathon's Research Center joined the company in 1963 and directed the work described in the paper. He holds the B.A. in Geology from the University of Colorado and an M.A. in Librarianship from the University of Denver.

DEVELOPMENT AND INITIAL USE OF COMPUTER-BASED GEOSCIENCE INFORMATION FILES AT MARATHON OIL COMPANY

Clarence A. Sturdivant
Betty J. Miyahara
Stephen O. Boyle
Marathon Oil Company
Denver Research Center
Littleton, Colorado 80120

Computer-based literature searching, after a rather slow start, is just now being taken as a commonplace thing in the oil business. This activity today centers primarily around the research laboratories of the various companies, and for the most part the primary users of machine searches are still the research scientists and engineers employed in these complexes. To date, petroleum companies, both in the U.S. and elsewhere have concentrated on using the various computer-based information products that they themselves have been responsible for creating and developing (solely with their own financial resources, I might add) through the American Petroleum Institute (API) and the University of Tulsa. For several years now, at least one of us has been less than content with the totality of coverage of geoscience literature provided to us by these subsidized contractors. I guess to some extent the API, at this point in time, can be held less guilty of any inadequacy of geoscience literature coverage in their products in that they got themselves out of this particular area of work in 1960 after a miserably poor start in the mid 50's. Tulsa University continues to produce what to some is the world's definitive source of petroleum exploration information, but what to us is still a small subset of the literature needed and demanded by todays petroleum explorationists. As a direct result of the needs of these individuals within my company we, who operate the only technical information facility within the organization, set about earlier this year to span what we felt were gaps in our information program by preparing for machine searching as many pertinent geoscience information files as we could find and reasonably afford and make them available for both retrospective searching and current awareness (SDI). Having already had subscriptions to both Tulsa's PETROLEUM ABSTRACTS and the API's ABSTRACTS OF REFINING LITERATURE tape services, we were interested in converting what ever new files we decided to purchase (or lease) to the same standard format (for purposes of discussion lets call it the "API STANDARD FORMAT" since it was first used by the API in 1964) for 1.) ease in assimilating the data into existing systems and for 2.) uniformity in readily and quickly applying our existing searching software.

GOVERNMENT REPORTS ANNOUNCEMENTS/INDEX (NTIS)

We couldn't have started with a worse first pick than the GRA/I data file to begin our program. It by far has proved to be the most difficult file we've processed for searching primarily because of the atypical construction and coding of the records on the tape ("Clearinghouse coding"). Then too, after our stated objective of making any new files look "just like" the old ones, we found it necessary to completely remove from the tapes all abstracts and various delimeters for computer-controlled typesetting and photocomposition -- these tapes as well as most of the others I will describe today are full of this material which for purposes of any searching system are definable by one rather descriptive word - - - trash! We can, however, appreciate this data being on the tapes and we do understand that the primary purpose of these tapes is to drive photocomposers -- it's just a shame they can't be cleaned up before being peddled as search tapes. Possibly this is the reason they're so cheap!

All of this does not detract from the value of the GRA/I file. We have found that Sections 8, 12, and 13 (Earth Sciences and Oceanography, Mathematical Sciences, and Civil and Marine Engineering) to be of special significance to our earth scientists' interests and probably they themselves alone are well worth the cost of the file. We are using the GRA/I for primarily SDI purposes now, but have stored all of the 1972 information we've received and have made plans for possibly utilizing it for retrospective searching in the future. Page one of the handout

I distributed is a sample of the type of retrospective searching output we already have available. The file isn't very large, however, when compared to the 260,000 items gone before it. The $50.00 NTI Search currently being promoted and utilizing Lockheed's DIALOG system can't be beat, in our opinion.[1]

BIBLIOGRAPHY OF NORTH AMERICAN GEOLOGY and GEOPHYSICAL ABSTRACTS (USGS)

It seemed since we first got ourselves into computer-based literature searching back in late 1963, we never really had an effective way to quickly search (in-house) the geological and geophysical literature back for, say, the last 10 years. Indeed the only file around our place that went significantly back in time was a UNITERM® patent index our chemists used.

Learning of the availability of the USGS's NAB and GA files and of the success others had experienced using them[2], we purchased both during the spring of this year, reformatted them (again into the API Format) and began using them only for retrospective searching. For the first time with any geoscience file we could go back further than 10 years thus eliminating a weakness in our machine searching capability by providing a new dimension of time depth to searches.

Our main complaint with both of these files is the almost completely uncontrolled nature of the indexing with 130,530 unique terms for NAB ('61-'70) and 30,198 unique descriptions for GA ('66-'71). We realize that problems of uncontrolled vocabularies, shallow indexing (and a lot of other reflections of the weakness of man) in data files can at least be partially offset by utilizing sophisticated searching software available today, but at this point in time our emphasis in expenditures is favoring new files rather than new searching software.

Our immediate plan for at least partially solving the vocabulary problems with NAB and GA (and possibly others) is to construct a permuted word list - Page two of the handout - bottom figure - which is a poor substitute for a good thesaurus - top figure.

GEO·REF (AGI)

The "star horse" of our geoscience data file "stable", is without question GEO·REF. It was the easiest of all files to convert to API Format and it fit most readily into our program because of the extremely marketable nature of the information it contains. We did not lease and probably don't intend to lease the retrospective GEO·REF files issued earlier than 1972. This is primarily because of two reasons: 1.) the total cost and 2.) the unclear (at least unclear to us) nature of the overlap relationship between it and the NAB/GA files discussed earlier. If some individual in the audience can give us guidance on the latter point, we would appreciate it very much. Even so, we would like to see the AGI offer for lease subsets by subject of the retrospective file. Perhaps this might generate only a slight amount of business since the AGI is still offering a real bargain on its demand retrospective searches.

The real payoff of GEO·REF for us has been with SDI work. The variety of over 40,000 documents a year and the ability to pick and choose from these using the machine to zero in on our interests is what is most pleasing to us. The loss of abstracts is disturbing to some but this is more than made up for by the high recall and relevancy of the information provided to them. The format of the 4X6 notices is also, for some strange reason, very appealing to earth scientists.

MARKETING

A. E. Cawkwell[3] has said most scientists do not want information, although they need it. Selling new information services can be difficult, but for us, because of the reasonably enlightened environment in which we are working, this chore has been rather easy. In fact, we now have such a problem keeping up with the demands placed on our small staff, we have toned down our literature searching marketing campaign to some extent. When running full blast the selling program consisted of nothing more than a few internal seminars and brochures, but a good thing can't be kept a secret. It is truly amazing how quickly, especially in the operating divisions of the company, the word will spread that services of this nature are available.

I guess good information like good liquor will sell itself. Apparently the newer breed of geologist, like the old, still has a thirst for both!

REFERENCES AND RESOURCE DOCUMENTS

1. American Society For Information Science, 1972 Annual Meeting, October 23-26, Shoreham Hotel, Washington, D.C. CONTRIBUTED PAPERS (Author Forums) Paper 17: NTISearch: A National Technical Information Service Bibliographic Search System, by Samuel A. Tancredi and William R. Ryerson.

2. Journal of the American Society for Information Science, Volume 23, No. 1, Jan.-Feb. 1972: Development of the U.S. Geological Survey Bibliographic System Using GIPSY, by Dwight Moody and Olaf Kays.

3. Royal Aeronautical Society. One-Day Symposium on Problems of Using External Information Services. June 16, 1971, Attitudes in Promoting and Using External SDI Services, by A. E. Cawkwell.

4. AVOCON: Automated Vocabulary Control, by William Hammond, Infodata Systems, Inc. Arlington, Virginia, 1972.

Printed in U. S. A.