A Geophysical Outlook—Part 9

Improve exploration efficiency with managed data bases

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20-second summary

Computers and digital data storage techniques potentially provide geophysical and geological interpreters access to vast quantities of exploration information. This data access and handling is commonly referred to as data base management. Most data base handling procedures implemented to date have been less than successful in exploration organizations. This article, the ninth in a series on new exploration technologies, discusses recent developments in data base management and satellite communication as they relate to exploration geophysics.

AS THE VOLUMES OF DATA available to explorationists increase, it is imperative that an efficient system for storing and accessing such data be developed. While on the surface this seems a very simplistic statement requiring a rather simplistic solution, at closer examination the task is a tremendous one. There is no ideal data base that will perfectly suit all of the varying disciplines within exploration.

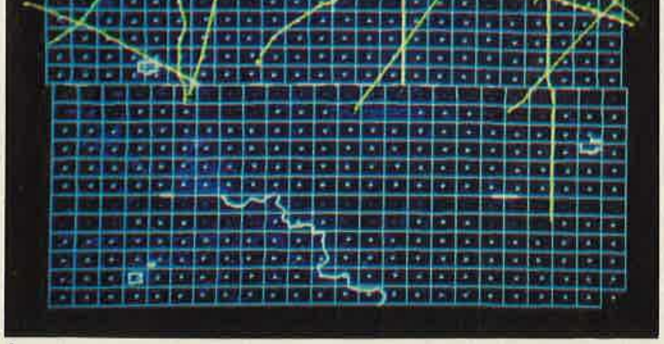
The science that has been developed to address this task is called data base management (DBM). This article addresses some of the computerized approaches to data storage and retrieval currently being utilized or experimented with and then discusses a long-range application for such sophisticated data handling within the exploration industry, including optical disc storage and the use of satellite communications for data transmission.

WHY DBM?

It seems some people in the industry—specifically managers—are having a hard time being sold on the necessity for computerized data base management. However, if one has ever been a seismic interpreter, the problems associated with handling exploration data are readily evident. These are best illustrated by specific examples.

As a seismic interpreter, the author found that on a majority of interpretation assignments organizing and getting access to the right data sets in the proper format consumed up to half of the total project time. This generalization held fairly consistent for projects done for U.S. divisions, international affiliates, or on in-house generated projects over a five-year period.

A particularly frustrating example was an assignment given the au-



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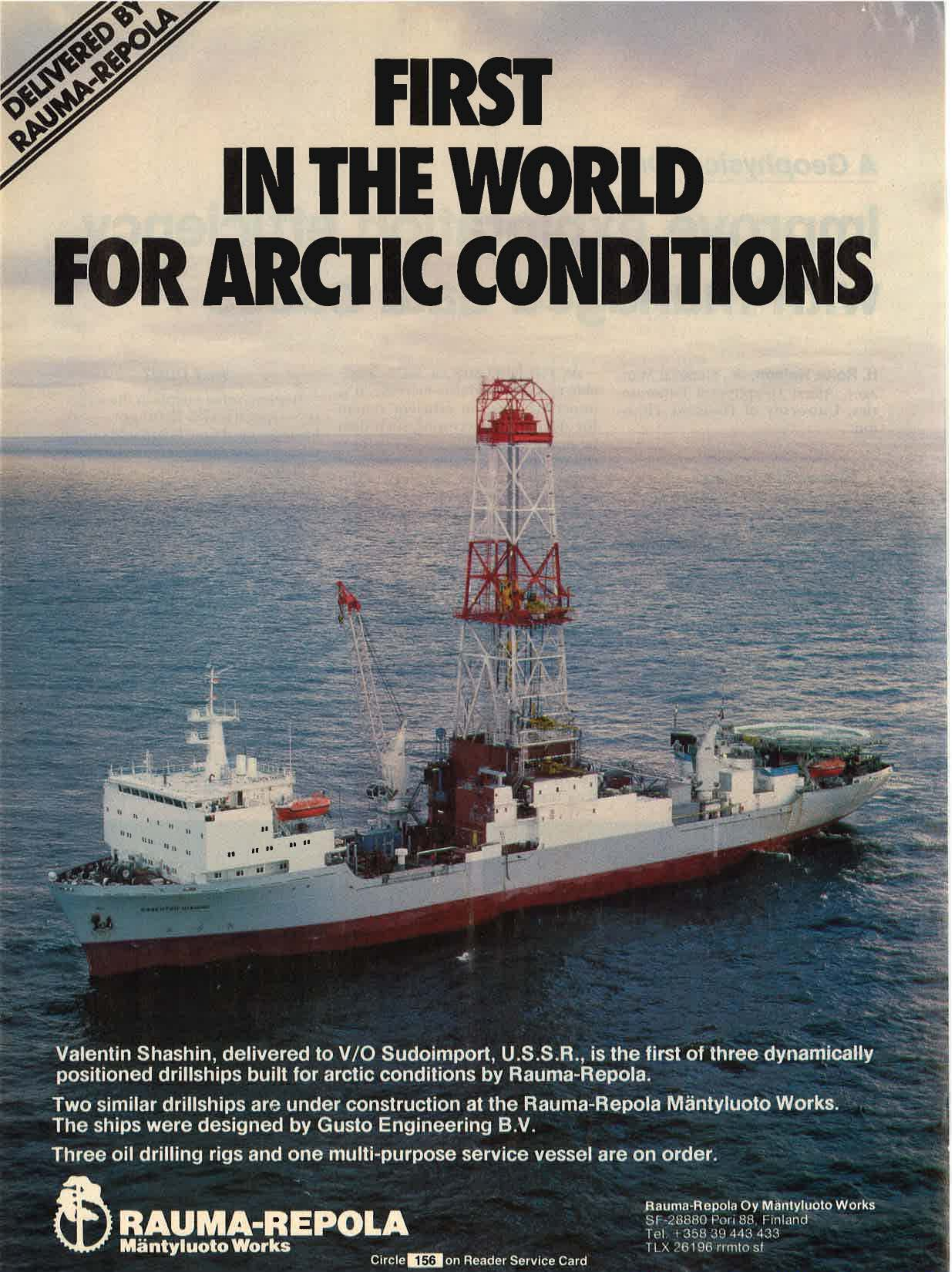
Courtesy Intergraph Corp.

Fig. 1—Using two display screens, one can effectively "zoom" in on a specific set of graphic data. An aggregate of lease blocks is shown in 1A and a select few of these were zoomed in on in 1B.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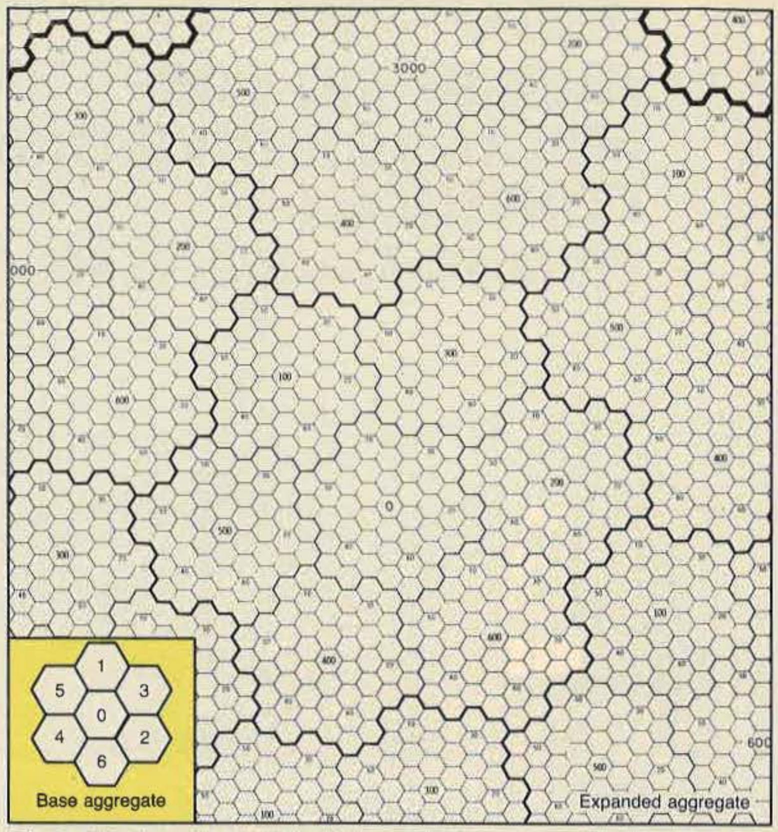
thor in 1975 to do a regional interpretation offshore Argentina. An earlier trade had provided 5,000 km of seismic that had never been evaluated. However, the data could not be found anywhere. No one was sure where it was stored, and a thorough search of several warehouses did not turn it up. Therefore, a request was made for another copy of the data. The week the copied data set finally arrived, a draftsman remembered something about the original data set. It turned up in two map tubes, on the top shelf of several bookcases in one of the warehouses. The excuse for having missed it on the original search was that it was arbitrarily mixed with data from the Far East and every tube had not been emptied in the search. The point is that retrieval based on an individual's memory will not compare to retrieval based on computer memory, especially with present personnel turnover rates. Similar problems occurred on several projects the author was involved with simply because the filing systems were inscrutable.

Such examples point to the fact that the use of digitally stored data bases is important to the entire spectrum of corporate organizational philosophies within exploration. This ranges from the huge multinationals centralized around a large mainframe computer, to smaller companies with computer processing distributed among a network of mini-computers, to independent consultants that use commercial data bases, like the Petroleum Information (P.I.) well log files.



Courtesy Interactive Systems Corp.

Fig. 2—This illustrates the GBT structure of the Lucasian graphic data base. Each individual hexagon represents 1 millisecond of arc. Note there is only a single address needed for locating each main hexagon, compared to a dual *x* and *y* address needed to locate a point on a conventional Cartesian data storage structure.

WHY CURRENT PROBLEMS?

There are many reasons why current data base management systems used within the exploration industry are poorly designed and hence cause serious problems. A major factor is that data organization has often been left to the most competent available geophysical technician, who normally has no training or experience in library management or data storage. Another factor is that the increase in exploration activity has created a shortage of qualified interpreters, and economic pressures give precedence to short-term objectives. With the rapid expansion of exploration over the last decade, most organizations have not put time into planning and implementing a workable DBM system. Therefore, the decision makers have not been convinced, based on recent systems, that data base management will save time and money in the long run. Ironically, however, managerial initiative and long-term planning are the first steps to solving the problem.

Illustrating the problem of management commitment to DBM, Townsend described,[1] not completely in jest, seven steps that have been followed in the development of corporate data bases. These are:

1. Uncritical acceptance
2. Wild enthusiasm
3. Dejected disillusionment
4. Total confusion
5. Search for the guilty
6. Punishment of the innocent
7. Promotion of the nonparticipants.

To this could be added:

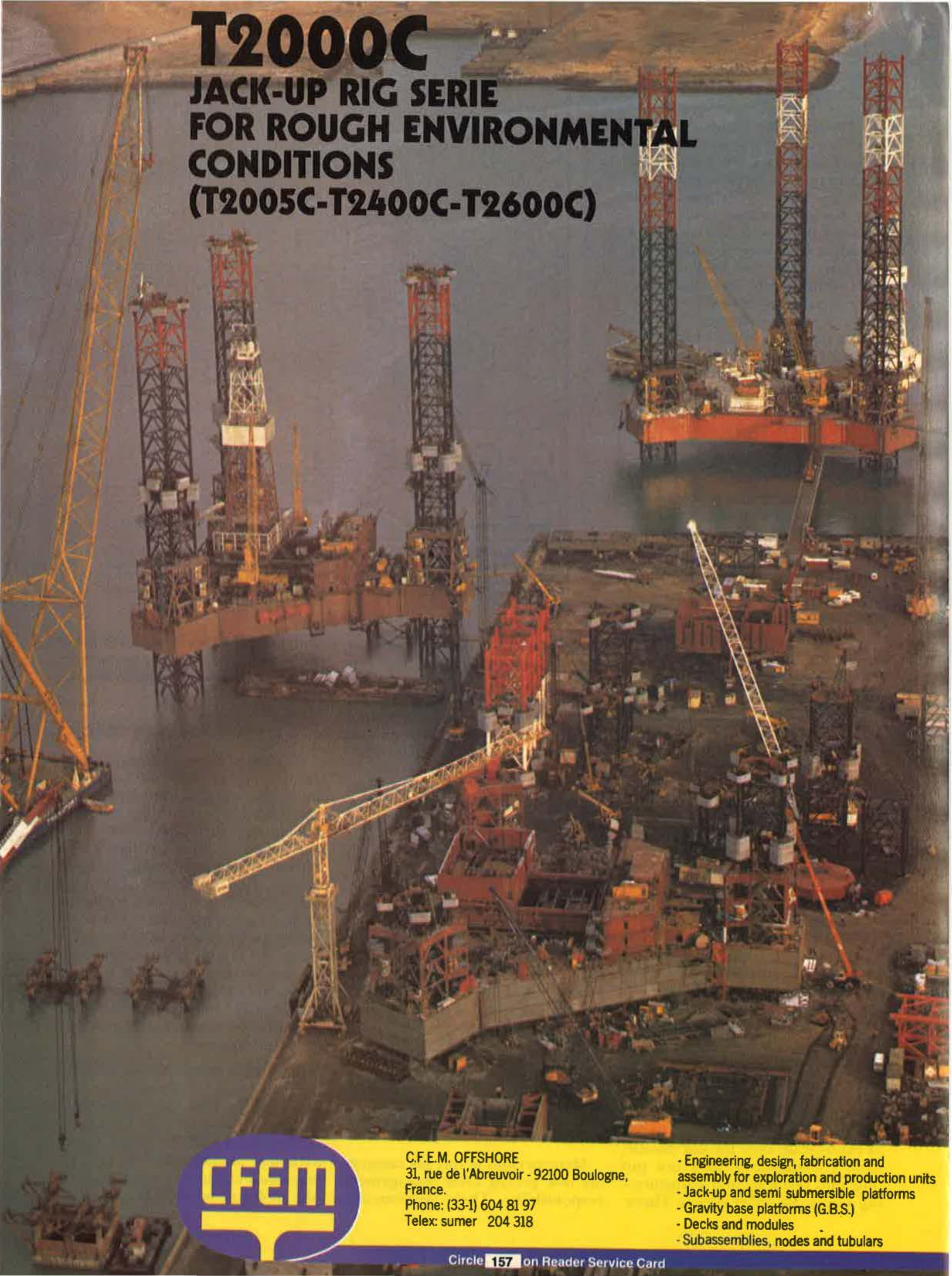
8. Cautious pursuit of an organized data base system by new hirees trained in computer capabilities and unaware of corporate politics.

Many persons in this last category are now getting some management responsibility. Their implementation of workable DBM systems promises to have a major impact on future exploration procedures and results.

THE FOUNDATION OF DBM

Efficient data base management for the exploration industry requires the selection of appropriate computer hardware, software and display equipment. However, the foundation for such a system is the scheme or format chosen for data storage. It is imperative that portions of the data base be retrievable from a variety of avenues. That is, the computer must be able to rapidly access and output any type or classification of data requested from a given data base. Both the size of the data base and the access issues must be addressed when choosing an appropriate format.

Size of data base. When one reviews the many different data sets that need to be accessed by explorationists, the size of the computer's reference task comes to focus. These data sets include, among others: maps showing data location, geography, political boundaries, culture,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lease information; maps from previous evaluations (seismic time maps, depth maps, isochron or isopach maps); location and navigation information; well log data; seismic velocity data; gravity and magnetic surveys; landsat imagery; aerial photography; side scanning radar plots; geochemical information; geological outcrop information; reports and textual material; or the seismic data at each processing step. Obviously, accessing all these data using any technique can be a problem.

Access. Even if there is only one type of data on file, data access can be a problem. For example, the Seismic Acoustics Laboratory at the University of Houston has six catalogs of seismic data and the related collection of location maps[2] defining over 1.5 million seismic traces or over 41 gigabytes (10^9) of data. There is presently not a well-defined way to easily access a specific subset of these data. An organized system for managing the data base is just starting to be developed. The plan is that new data will be systematically added to the system and the old data easily retrievable. This is a small problem compared to the data oil companies must keep track of.

Ready access to the required data sets is, in general, not being provided to interpreters attempting to solve interpretation problems. Few, if any, interpreters can sit down at an interpretation work station, call up needed data sets and then use the computer interactively to aid in building an interpretation. In fact, few divisions within the same company are able to effectively transfer data sets for joint projects. This does not have to be the case; the technology is available.

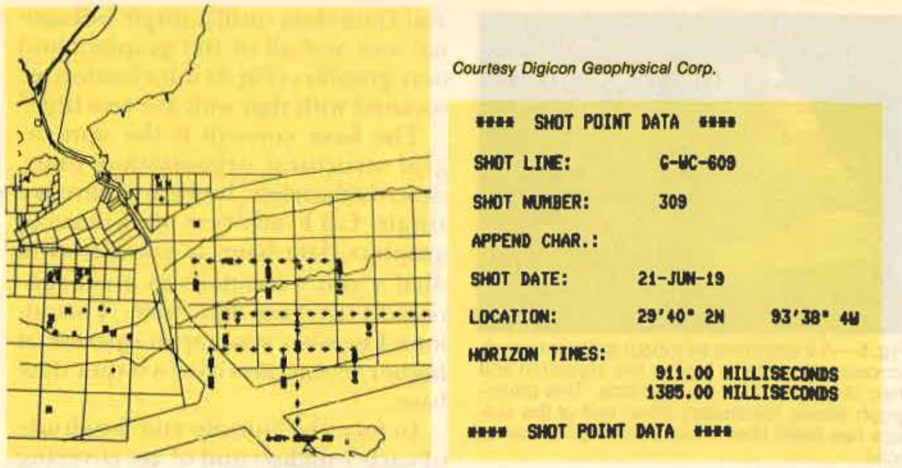

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Fig. 3—Displays from two CRT screens used to integrate an exploration data base. This shows that both textual and graphic data can be utilized in these computerized data systems. Fig. 3A graphically illustrates seismic line locations and lease boundaries. Fig. 3B shows the back up text, which describes a specific shot point from the map.

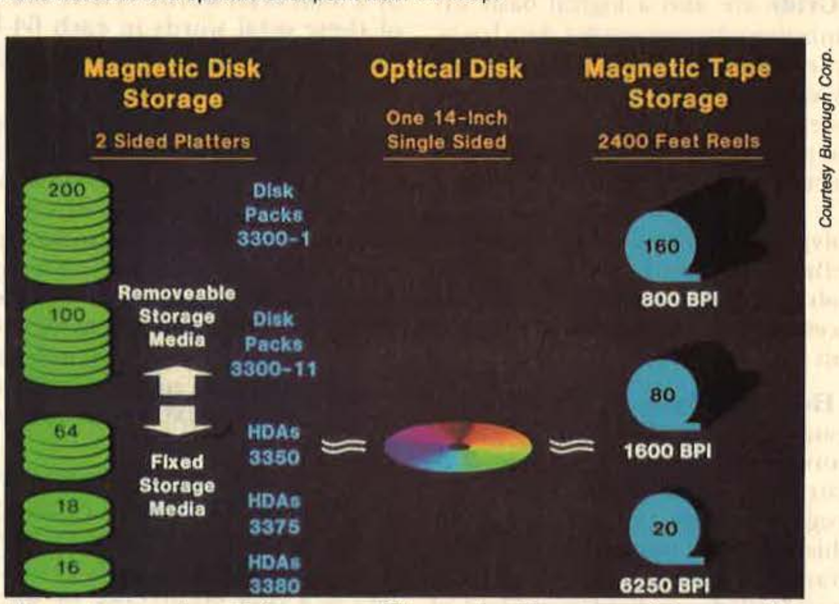


Fig. 4—A comparison of storage capabilities on disc drives, magnetic tapes and the optical disc.

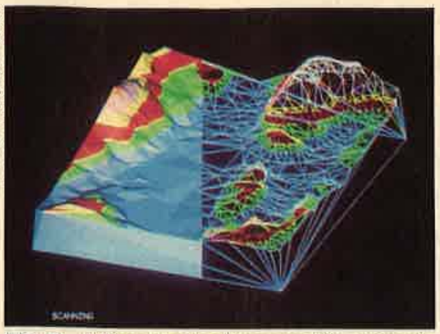
STRUCTURING STORAGE

Successful implementation of a data base management system requires well-defined procedures for inputting data into a data base and efficient methods for retrieving, analyzing and interpreting these digital files. The system needs to be evolutionary along user-defined routes rather than being instantly created in a rigid format.[1,3] Because data bases are never static for long, such flexibility is critical. And yet, there must be some sort of structure that ties the data base together.

This structure can be critical to data retrieval when a data base becomes large, as they have a habit of doing. Even hands-on evaluation of a system gives the user virtually no information on how well the data base manager will perform when the system reaches maturity. As is generally the case in the "real world," there is not a "best" data base structure that works efficiently for all types of data bases and user requests.

Retrieval speed is a function of the system response time or the quantity of data searched for during each new data base inquiry. Retrieval from an unstructured data set is a function of the size of the data set. Structuring a data set can reduce search time by a factor of 40,000.[4] Hierarchical or tree structures are widely used in data base management. For example, when geographic locations are kept at the first level of a hierarchical organization, an explorationist can rapidly "zoom" in on a particular area (subset) of interest.

Tree structured searches are like following the line of responsibility on a corporate organization chart. For example, suppose a data base were established for the world, and an interpreter wanted to look up the data in a specific lease block offshore Texas. The computer would search down the North America "branch," then the Texas "branch," then the offshore "branch" and end up with the lease block numbers requested. Each time a new "branch" in the "tree" is passed, all data in the data base not in that subset are ignored for the remainder of the search. Fig. 1 illustrates the last two steps of this type of search. The hierarchy can also be set up to have branches for non-graphic data, contours, shot-



Courtesy Intergraph Corp.

Fig. 5—A triangularized topographic surface is processed through a hidden line algorithm and then displayed as a solid surface. This photograph shows the display when half of the surface has been filled in as a three-dimensional solid.

point data, elevation/depth data, well logs, etc.

Grids are also a logical basic organizational structure for data bases. Synercom calls each grid a facet, which is another name for a map sheet. Given an x and y location they can rapidly specify a facet, or given a facet can quickly retrieve the range of x and y values within that facet.[5] Polygonal retrieval allows users to define an area of interest within a global polygon, and then all of the facets defining data within that polygon are pulled out.

Hexagons form a basic organizational structure that is topologically more efficient than grids. Fig. 2 illustrates the base and expanded aggregate of this type of structure. This has been named the Lucasian Graphic Data Base after the developer Dean Lucas.[6] This method of representing an N-dimensional surface so that a computer can easily work with the data distributed on the surface is called GBT. GBT stands for Generalized Balanced Ternary (ternary refers to being based on the number three). GBT is an extension of the one-dimensional system known as a balanced ternary.[7]

GBT is not only a method for representing space (geographic locations on earth's surface), but also a sophisticated addressing scheme that allows rapid access to the representation. In addition there is an algebraic system that operates on the addressing scheme to allow rapid searching for a specific hexagonal unit. Simply stated, this structure allows a computer to examine the general content of a data set without looking at the detail. An algorithm can then determine at a high level if finer information is needed. GBT permits layered accessing of finer and finer data until a single hexagonal unit and all of the graphics and non-graphics (Fig.3) information associated with that unit are reached.[7]

The basic concept is the same as grid structural organization units, described earlier; however, there is a single GBT address in Lucasian graphics data base, as compared to dual x and y locations in a conventional Cartesian data base. This allows Lucasian systems to operate at higher access rates over a larger data base.

In fact, the latitude and longitude of each 1 millisecond of arc covering the entire surface of the earth can be stored in one 64-bit GBT address word. Each GBT hexagon is defined by a 3-bit octal word.* There are 20 of these octal words in each 64-bit word, or 7^{20} unique locations defined in a single computer word.

Relational data base management is a phrase that is often used to describe how different attributes, like spatial and textual material, can be related to a structural organizational unit. The concept is based on having the actual content of data within records arranged into simple tables. Relational DBM is virtually an indexing system, and, as in most scientific areas, relational DBM has its own language.

The key definition to understanding DBM is that a *relation* is simply a table. The relation name is known as a map. A column in the relation (table) is a *field* occurrence or an *attribute*. A row in the table is a *record* occurrence or a *tuple*. *Selection* is to separate a subset of records (rows) within a relation. *Projection* is taking a subset of fields (columns) within a record. *Joining* creates new relations (tables) from two or more existing relations, based on common field content.[6]

The software package INGRES was developed at the University of California at Berkeley as a relational data base management system. It places all data in a series of tables or relations. There is a fully integrated data dictionary and the data manipulation language is much like English. This is the type of system that can be used to relate data sets directly to a basic structural organizational unit. The system also maintains a system catalog, which can be updated to allow flexibility in inputing new data types and used to set controls to ensure data integrity. The tables can also be used to create an open-ended number and hierarchy of menus for data base manipulation. As this type of software system improves, it can be moved into hardware to further improve the efficiency when the data base gets very large.

*Octal refers to the 8-digit numbering system that is easier for computers to use than our standard decimal numbering system because it is a power of 2 (on or off).

Storage becomes one of the key considerations in structuring large data sets. When one realizes that it takes 1.5 billion bits (750 Megabytes) to store maps of the City of Houston,[5] the problems of attempting to build a worldwide exploration data base appear insurmountable.

Further, the *type* of data that is included in the data file makes a tremendous difference in the amount of storage space required. One solution is to store only key parameters (map interpretations and other data reductions) in the data base, the idea being that these are the data of common interest to other departments. This saves storing voluminous, unreduced exploration data like seismic sections. Another solution extends this by keeping large-volume data on magnetic tape for easy batch retrieval.

Electronic storage technology is improving rapidly enough that the amount of data that can be economically stored for electronic access is regularly improving. Data base systems are available with real-time retrieval of data from up to four fixed or removable discs (160 MBytes to 675 MBytes each).[8] With a little planning, this much direct access memory will allow the solution of most exploration data base problems. If necessary, larger storage systems could download (transfer) subsets of the data base (projects defined by map boundaries) to a user terminal for local evaluation.

Storage technology may also get a boost from a new technology called optical disc storage. This technology uses a laser to burn through an opaque absorber in order to write (turn a bit on). The system only allows one write, but one 14-in. disc will store 2,000 Megabytes of data, or the equivalent of almost seven 300-Megabyte discs.[9] Fig. 4 compares this amount of storage with standard disc and tape storage. A jukebox configuration of this storage medium provides almost unlimited storage capability.

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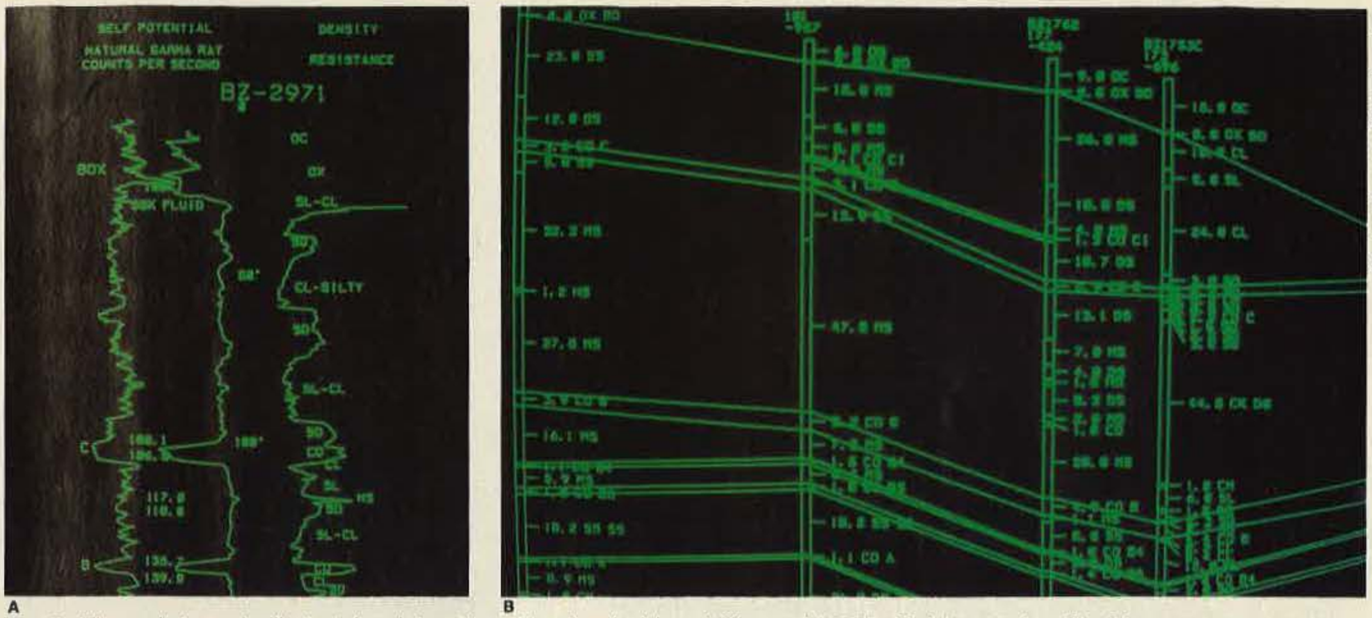

Courtesy Synercom Technology, Inc.

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Fig. 6—These photographs illustrate how interactive retrieval and mixing of different data sets aids interpretation. Fig. 6A compares a gamma ray and resistivity well log. Fig. 6B shows a small portion of a well log correlation for an overview evaluation.

Courtesy University of Houston, Image Processing Lab

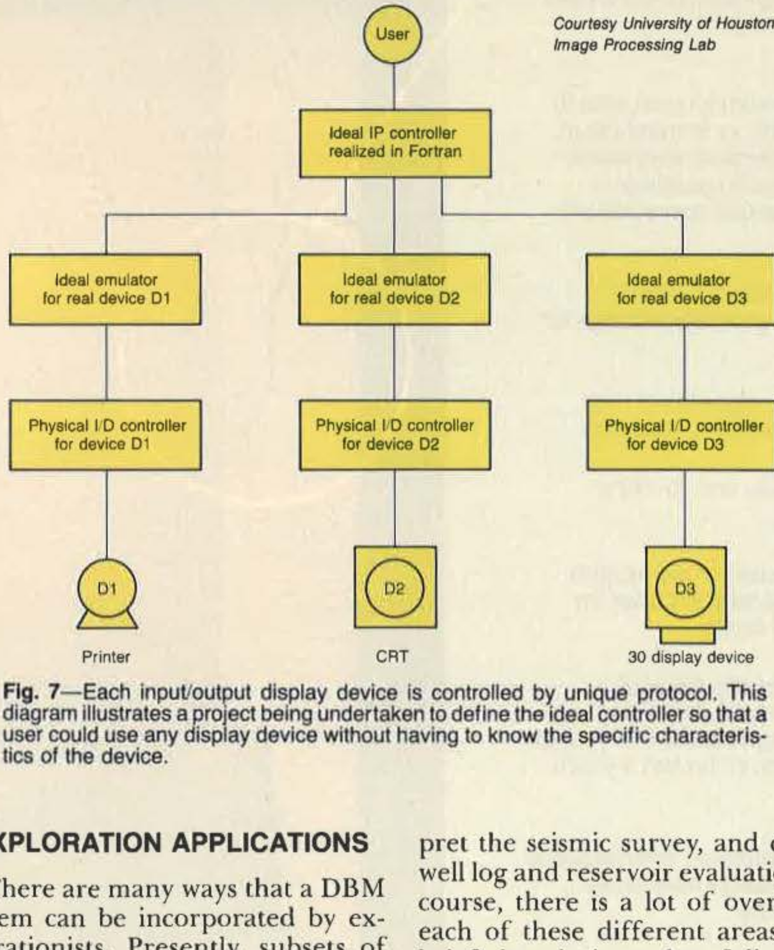

Fig. 7—Each input/output display device is controlled by unique protocol. This diagram illustrates a project being undertaken to define the ideal controller so that a user could use any display device without having to know the specific characteristics of the device.

EXPLORATION APPLICATIONS

There are many ways that a DBM system can be incorporated by explorationists. Presently, subsets of the systems described are being used independently for geographic, geophysical and geological projects. Eventually, integrated systems will be developed to allow an exploration team to evaluate new areas for an exploration play, check for previous surveys, evaluate the lease situation, plan a new seismic acquisition survey, interactively process and interpret the seismic survey, and do the well log and reservoir evaluation. Of course, there is a lot of overlap in each of these different areas. The brief descriptions that follow describe a few of the ways these systems are presently being used in three exploration areas. There probably is not a currently marketed system that can perform all of these options at once; however, everything described is being demonstrated presently by one DBM system or another.

Geographic. A relational geographic data base can be built that consists of culture (rivers, coastline, etc.), river depth and width, political and civil boundaries, lease blocks and ownership, shipping lanes, etc. The location of leases can be input in conventional or legal terms. Standard cartographic and line symbols are available. When maps are scaled, the cartographic line symbols remain at the same scale. Fig. 5 shows how a topographic contour map can be triangularized and viewed as a three-dimensional object, the hidden lines removed and the remaining surface displayed as a solid. In fact, user-responsive displays can be rapidly generated in a wide variety of views and orientations. The standard projections (Equator Mercator, Transverse Mercator, Lambert Conical, etc.) are available, and coordinate transformations can occur between different projections. In fact, independent coordinate systems, like that used in Nigeria, can be defined and integrated into world data base storage systems.

Geophysical. Figs. 1 and 2 show how data base systems are being used to evaluate textual and graphic data like shotpoint and well locations. Some systems are sufficiently sophisticated that seismic sections can be evaluated, tied and interpreted on the screen. One geophysical area where the techniques described are being fairly widely used is computer contouring. Automatic contouring is considerably less expensive than hand drawn maps and the turnaround time is reduced dra-

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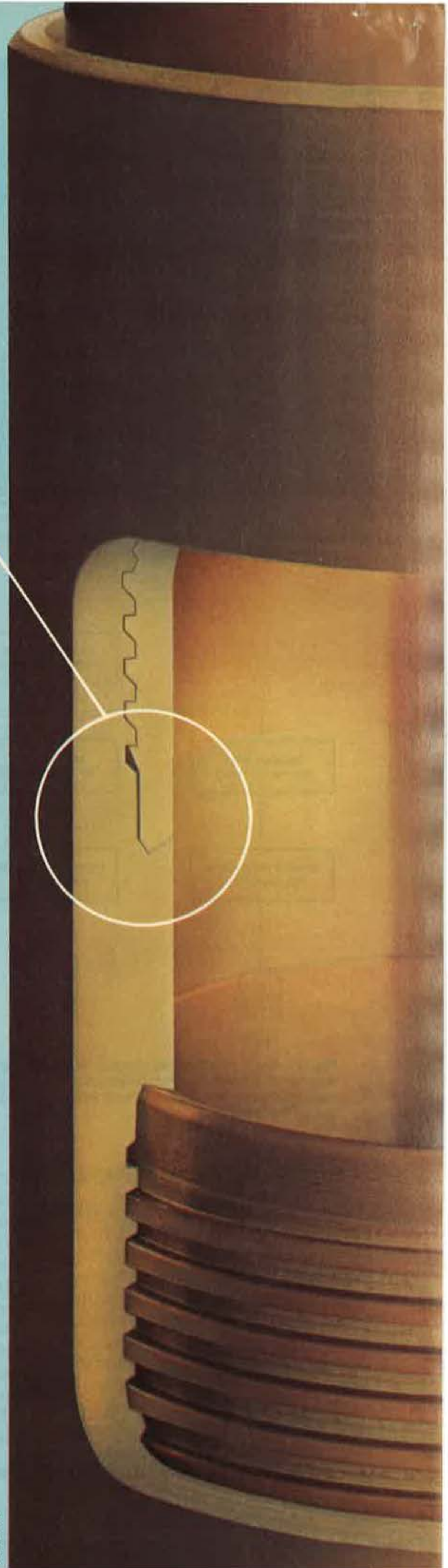

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Fig. 8—The ground communication coverage of the INMARSAT satellites. Note the large gap in coverage that excludes Oklahoma City, Denver and Calgary from receiving signals directly from INMARSAT. To transmit data to the areas within the gap, information must be re-sent through another satellite. This is just one of the problems that have kept satellite data transmission out of the oil patch.

matically. Line numbers, borders, title and title blocks can be plotted automatically. Although these maps need to be tied with other information, like regional structure and known geology, by an interpreter, they still can be of great benefit. This is especially true if there are a large number of maps that need to be generated, such as isochron and depth conversion maps.

Using the computer to do interactive wavelet processing on a seismic section opens a new world for interpreters. For example, a particular wavelet shape can be designated, graphically extracted and moved across the section to identify reflections with similar characteristics. This capability is especially useful in correlation of seismic and synthetic well log data. Many of the systems the author is aware of are set up so that transportable industry-accepted application software can be used with them.

Geological. Standard API symbols for mapping well descriptions are available. Fig. 6 gives an example of how well log data can be edited by direct graphical manipulation. There are pre-defined algorithms that are on line to compute porosity, water saturation and lithology parameters. Even distorted paper logs can be digitized and then evaluated on a corrected CRT display. Once a well relational data base is set up, the data base can be queried to get a display of all wells in an area with production between 8,000 and 12,000 feet.

Input/output. A hardcopy print or photograph of the results of a search are normally available in one form or another. However, the key to an interactive graphics tool is the softcopy display device.[10] One of the problems with explorationists using any of these input/output devices is that they are all different. This means that each device has a slightly different protocol, which frustrates non-computer scientists. Fig. 7 illustrates some research under progress


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at the University of Houston's Image Processing Laboratory to help solve this problem. The plan is to define an ideal display device controller that the explorationist will always talk to, no matter which terminal happens to be used.

Simplified procedures of using input/output devices will literally bring them into the analyst's office. There are presently systems that can be 6,000 ft away from the computer system and data storage center. Considerable intelligence can be placed locally in the terminal so that continuous pan, zoom and local dynamics are possible. As communication procedures continue to improve, the power of a major computer center can be placed in the field, or in a small remote division office.

SATELLITE DATA TRANSMISSION

Data bases and satellite transmission will not be tied directly together for several years. However, planning for the efficient use of DBM systems requires that a company evaluate the upcoming use of satellite data transmission over the next decade. Initially the use of satellites will be to batch download information overnight, because of the present long response times.[11] The biggest reason for the long response time is transmission rates, yet, these problems are already technically solved.[12] Therefore, the use of satellite transmission for distributed remote DBM is really a matter of politics and economics. Initial applications will include the capability to transmit data directly from the field to a processing center, to transmit data between processing centers, or to provide direct communication to field crews anywhere in the world.

Digicon and M/A-Com Linkabit Inc. of San Diego have reported a joint development and marketing arrangement to provide high speed, secure data transmission systems for the seismic exploration industry. Sea trials of a four-node system that transmits marine seismic tapes to a data processing center onshore is planned for the fourth quarter of this year. This system will use the Inmarsat satellite system and Marisat ship terminals currently tariffed at 56,000 bytes per second. The Digicon system contains 6,250 bpi tape drives, an encryption (encoding) description and a high-speed line error component.[13]

There are political and technical reasons why these communication systems have not been used to transmit geophysical data before. One of the biggest problems is illustrated in Fig. 8. There is a big gap in Inmarsat's ground communication coverage that excludes Oklahoma City, Denver and Calgary, among others, from its transmission range. In order to transmit from the Gulf of Mexico to one of these oil centers, it is necessary to send the information back up to another satellite system. Also, industry wants to be able to transmit at 6 million bytes per second, which can happen now, but is expensive. Stabilization of the 7.5- to 12-m sending or receiving dish at sea is another critical technical problem;[12] however, there are stabilized platforms available.

The political problems include legal regulations associated with transmitting from international waters. Also, although the system is inherently designed for transmitting 1.5 million bytes per second with "error free," high throughput performance, it is only tariffed for transmitting at a rate of 56,000 bytes per second.[13] There is also the intangible fear that someone might destroy the satellite or that it will break down at a critical time.

SECURITY

The integrity of a computer data base or the satellite transmission of a portion of that data is of vital importance to those companies that are beginning to use these new technologies. Computer crime must be taken into account.

Data bases can be secured only by approving system users for a specific project. This can be complicated when a relational data base system is used, because user access can be even further limited within a project. But too much security can defeat the benefits of an interactive system. If someone wants to steal information, they will find a way and a self-justification to do so, regardless of the security. However, regularly changing passwords, requiring special authorization to edit master tapes and building in controls to allow monitoring of all access to the data base are the best security steps available.

For satellite transmission, there are cryption devices approved by the Bureau of National Standards that can be used to secure transmitted data. The ability to transmit 46 MB of data totally cryptic, with one of 2,400 codes that can be changed daily, is available today.[12]

SUMMARY

One of the newest and thus least wide spread technologies in oil and gas exploration is the efficient use of computer data bases and satellite data transmission. There are all kinds of reasons why these procedures are good or not good. However, when it comes to the bottom line, they will have widespread use by explorationists when they are recognized as being cost effective technologies that aid in the management of the ever increasing volumes of scientific data available to industry. In fact, implementation of these systems promises to provide the same production increases that followed switching from batch to interactive processing procedures.

It seems that the decrease in time required to make critical exploration decisions will provide enough pay back alone to justify the initial investment of planning, hardware and software. Cecil C. Miller, senior geophysicist and operations manager of Tetra Techs Energy Management Decision, talks about his company's use of Cybernet to manage separate geological and geophysical data bases. "All people have a tendency to resist change. But in our circumstance change was forced, due to the magnitude of the task. You either use data processing or you don't get the job done."[14]

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