

OIL & GAS JOURNAL

CAEX at Work



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INFORMATION The Competitive Weapon

Information—its completeness, accuracy and interpretation—always has been crucial to oil companies. It is vital, for instance, in acquiring or renewing valuable lease positions, evaluating prospects and exploiting reserves. And in the midst of today's changing market conditions, the potential of increasing operating efficiencies and market share by making better use of information represents clear opportunities to those oil companies that respond rapidly.

Information has become a weapon. A competitive weapon. Whether attempting to improve a company's success ratio, its field development procedures or production results, it is clear that the skillful use of information is often the differentiator between success and failure, the key to outrunning a competitor.

The Information Revolution

Strategic information certainly is not a new concept. However, the rapid advancements of computing technology made during the last decade have ushered in an "information revolution," the effects of which are profound. Indeed, this information revolution should prove every bit as dramatic as the industrial one.

Advances in computer technology have put powerful information tools (competitive weapons) into the hands of decision makers. These tools are used to improve the access, integration and assimilation of information, such that better and faster decisions can be made.

While putting better information tools into the hands of exploration and production professionals has been part of the strategic planning of oil companies for years, it is only now coming to fruition. Interactive workstations already have brought capabilities to geophysicists and geologists that were impossible just a few years ago. Recent advancements in computing technology are providing new analysis techniques: horizon flattening/geologic reconstruction, multi-attribute analysis and comparing seismic with well data are just a few examples.

Interactive, graphics-based microcomputers are becoming the "information window" through which exploration and production professionals access the vast data pool available to them, both internally and in the open market. Each decision is quickly supported by a more detailed analysis, which is made possible by an extensive and accurate base of information.

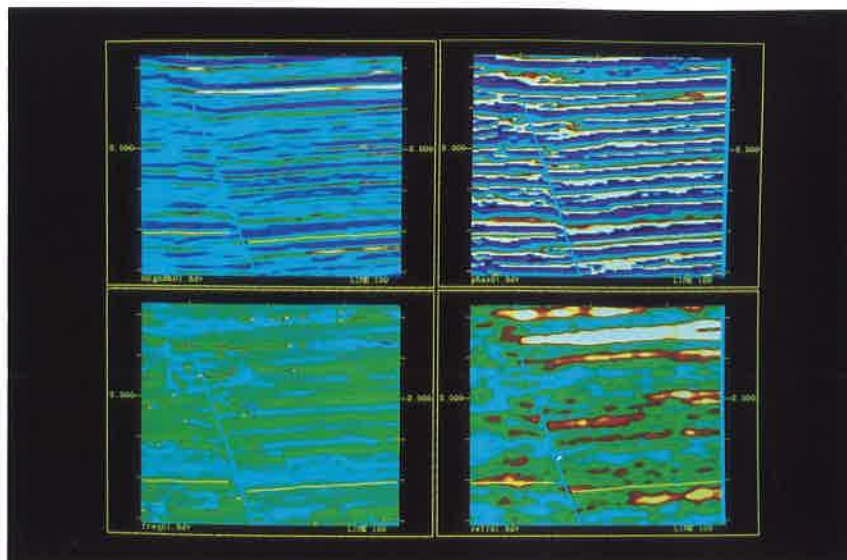
This is the information revolution...

Rise of the Information Weapon

Higher quality information and its most effective use are competitive weapons that oil companies will fine tune and customize. Oil company information weapons can be characterized as computing tools:

- that are geared to the ways geophysicists, geologists and reservoir engineers think and develop subsurface models.
- that enable interactive data processing, synthesis and analysis through graphic representations that are meaningful to the decision makers.
- through which all exploration and production disciplines can share their unique analyses and interpretations, thus continually building on each other's expertise to create an ever more comprehensive vision of the subsurface.
- that allow exploration professionals to create more in-depth interpretations due to increased data access and speed of data manipulation (new models can be tested and retested from a variety of perspectives).
- that can provide interactive access to the vast reservoirs of information contained in corporate and divisional databases.

The transformation of data existing within oil company computing systems into strategic, competitive information weapons already has begun to occur.



Windowing capabilities combined with multi-attribute displays are examples of the new analysis techniques possible with CAEX.



Landmark's optical disk technology enables instant access to large data volumes.

Britoil's Clyde Field:

A Landmark in the Use of Computer-Aided Exploration

In March 1987, the Clyde oil field 240 km East of Dundee in the North Sea came on stream after an investment of £550 million by Britoil and its partners, Shell and Esso. The event was significant for Britoil, the project leader, because it represented the first exploration-to-development project to be completed by the company since its formation in 1982. The Clyde field also represents one of the first oil fields in the world to be developed using CAEX (computer-aided exploration) technology.

During the surveying and evaluation phase of the project, Britoil's Glasgow-based exploration team used the Landmark III 3D interpretation workstation to help them visualize the structure of the Clyde field, to determine its size and eventually to site four discovery wells. Subsequently, CAEX was used to help pinpoint the first production wells that will be used to extract an estimated 154 million barrels of oil over the next 13 years.

"At first we had expected to achieve some labour savings, but as we gained experience with the Landmark interpretation system, we soon discovered that its real benefit was in allowing us to evaluate all of our seismic data rather than just samples. This gave us increasing confidence that our model of the geological structure was correct," says Colin MacLean, who heads up Britoil's Exploration, Geology and Geophysics group.

CAEX, he believes, has greatly improved his company's exploration decision-making process and has given the company an early lead in a highly competitive business. For Britoil, the competitive edge this imparts could be the key to the company's future profitability. Unlike its larger competitors, Britoil has no refinery and distribution operations and must rely on a continuing flow of new commercially exploitable oil field discoveries if it is to stay in business.

The Clyde field was first evaluated using traditional seismic surveying techniques. During this evaluation, Britoil commissioned a detailed 3D seismic survey. Initially, MacLean's team began the analysis task using manual methods. This was taking too long. The Landmark III was brought in to speed the task.

The Clyde field survey revealed an oil field beneath a dome of impervious Upper Jurassic rock approximately 4,000 meters beneath the sea bed. Trapped beneath this rock cap, in an oil-laden layer of Fulmer Sand, is an estimated 409 million barrels of oil, more than one quarter of which is recoverable. On the basis of this information, Britoil and its two partners invested over £913 million with the expectation of recovering 154 million barrels of oil over the next 13 years. The first oil now has begun to flow, six months ahead of schedule and £363 million under the original development budget.



Colin MacLean, Britoil's Manager of Exploration, Geology and Geophysics group, at the Landmark system.

CAEX Information Tools for Enhanced Drilling Decisions

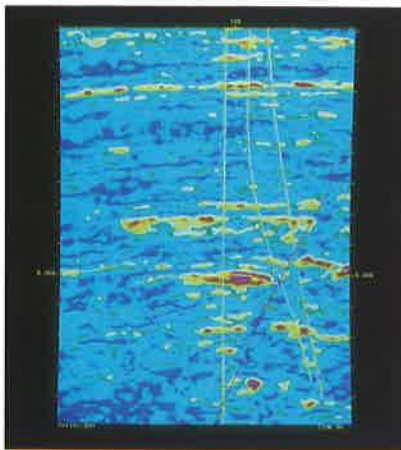
Computer-aided exploration and production (CAEX) is the application of interactive microcomputer technology to the information analysis needs of the exploration and production professional—geophysicist, geologist or reservoir engineer. The goal of CAEX is to provide these professionals with easily-accessible tools so that they can optimally utilize information with which to make more accurate decisions.

Building a CAEX environment involves bridging the perspective and work of one discipline with another. For instance, a specialist in rock mechanics will develop a rock-mechanics model and use this model to refine a geologic model. The geologic model, in turn, is integrated into a geophysical model and more refinements are made to this new model via computer. The geophysical model is then fine tuned through comparisons with

actual geophysical sections. During the entire dynamic process, communications are taking place at each level. The ultimate, detailed Earth model that emerges from this process represents a synthesis of all the disciplines and consequently, a more accurate interpretation.

CAEX ENVIRONMENTS Deploying the Information Weapon

The declining price of oil experienced during the mid-'80s, coupled with the more geologically complex locations of remaining reserves, has encouraged many oil companies to adopt leading-edge technologies as a competitive strategy. For example, three-dimensional seismic prospecting, a technique that has existed for about ten years, was being used only infrequently for interpreting extremely complex geologic structures. More recently, however, oil companies have realized that the increased detail available from 3D surveys can give them an edge in their efforts to more accurately depict the Earth's subsurface before committing costly drilling resources. But, 3D surveys do not lend themselves to traditional interpretation and mapping techniques. Oil companies have discovered that a



Displays combining reflection strength, deviated wells and fault picks allow explorationists to more effectively utilize available information.

whole new set of computing tools are needed to extract the value that this more detailed surveying technique can provide.

Oil companies first pursued the development of these tools internally. It soon became more cost-effective to look to system developers to provide these computer solutions. Landmark Graphics Corporation, whose founders came from the oil industry, saw the opportunity to provide the first turnkey solution in the form of an interactive, 3D seismic interpretation workstation. CAEX thus emerged.

During the same period of time, industry economics have shifted wildcatting efforts toward reservoir development projects. Oil companies have adopted new ways of integrating information to build the most accurate reservoir model prior to initiating field development. Accordingly,

CAEX Solutions for 3D Interpretation

Computer-aided exploration and production began with the advent of interactive microcomputer technology. Landmark, a pioneer in the development of CAEX, was able to foresee the impact that interactive technology would have on the geophysical interpreter. Today, the Landmark III interpretation system has become the industry-standard interpretation tool for geophysical interpreters.

Landmark applied its knowledge of the interpretation process to the design of its Landmark III system. In order for geophysicists to adapt this new technology into their projects, Landmark understood that an easy-to-use, explorationist-oriented user interface would be required to minimize the need for training. And, to enable a variety of subsurface models, Landmark understood that the system must have the highest performance imaging capabilities.

Adaptation and expansion of new computer technologies requires a long-term investment by users and decision makers. Landmark designed the Landmark III with an open, industry-standard architecture that could be upgraded to higher performance levels and capabilities as new technologies became available. At the same time, the Landmark III was designed to remain compatible with the tremendous investment made in software and training by the user. Finally, this new computer workstation would have to enhance the skills and expertise of geophysicists, giving them tools to be more productive, accurate and strategically valuable to the organization.

Today, Landmark offers a comprehensive set of 3D interpretation application programs, including interactive fault interpretation, horizon mapping and post-stack

processing. Landmark continues to enhance and expand its 3D interpretation programs through user requests for additional capabilities.

Landmark is committed to ensuring that its customers are not penalized by "buying in early" as it continually upgrades the performance capabilities of the Landmark III as new technologies become available. This maintains a migration path for its users, protecting their investment against obsolescence. The Landmark workstations have migrated continuously from the original Intel 8088-based system to its 80286 microprocessor engine, and most recently to the 80386. Each upgrade is offered to users at about 10% of the original investment. Also, Landmark is the only CAEX vendor successfully delivering optical storage technology with its systems.

The Landmark III is a departmental-class system designed to offer interpreters the most sophisticated interactive computing capabilities. In addition to complex 3D analysis, image processing applications previously available only on large mainframes or supercomputers, will be available on this family of departmental products. Also, as applications sharing becomes more widespread, the departmental workstation class will become the CAEX "information base" or "hub" (the repository of all the interpreted data pertaining to any given oil field). The enormous data storage capabilities of the departmental workstation will bring data from widespread areas throughout oil companies into the hands of individuals who need it for daily decision making.

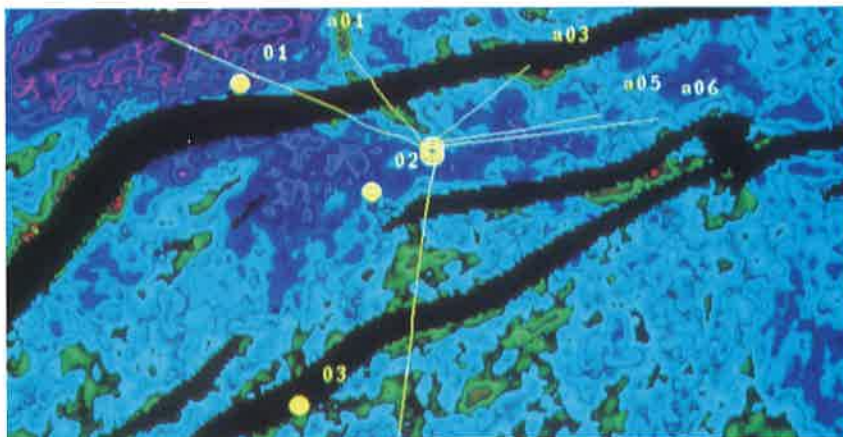


Today, the Landmark III is the industry-standard interpretation tool for geophysicists

multi-disciplinary exploitation teams have emerged, contributing their perspectives in the form of an integrated "Earth model." The interactive interpretation workstation is evolving as the focal point for these interdisciplinary teams.

Bridging Disciplines & Data with Technology

Providing interactive interpretation tools to geophysicists is just the beginning. The next step is to make these tools available on the desktops of every exploration professional. With the widespread expansion of interactive interpretation technology into the workflow of the decision maker, the next challenge is to integrate the work of one discipline with the interpretations and analyses of the others. Only by



Bridges will be built by Landmark and its partners to provide a pathway through which E&P disciplines can share their unique analyses and interpretations. Here, deviated wells are overlayed on amplitude extraction map.

Interactive Interpretation for Every Explorationist

As microprocessor-based hardware becomes less expensive and more powerful, interactive workstations now are emerging in the offices of individual exploration professionals. Placed on the desk, these interactive systems can be dedicated to assisting in the daily tasks every explorationist must complete—data collection, mapping, preparation of displays, and presentation of results for recommendations to management. Landmark's goal is to bring interactive interpretation to the desktops of the geophysicist, geologist and reservoir engineer, to allow them to interpret more quickly and in much more detail, and to provide them a window from their individual offices to information formulated elsewhere in the CAEX environment.

Landmark's InterpreterPlus product family includes the first high-performance, interactive workstation specifically designed for interpretation in the E&P office. These desktop systems allow the explorationist to interpret, map and produce presentation hardcopy displays significantly faster and more accurately than with manual, paper techniques. InterpreterPlus applications are tailored to each discipline's needs and work style, leaving time for the "magic"—integrated modeling, fault mapping, attribute analysis, velocity interpretation, autopicking and interactive processing, among others—those things that can only be done interactively on a workstation. Each product in the InterpreterPlus series is priced such that it is viable as a dedicated resource for the individual explorationist.

Landmark's InterpreterPlus family solves many of the problems that have hampered

the viability of individualized CAEX tools for the office.

• Multi-faceted Data Capture

to ensure easy data in/data out. This includes a range of solutions such as networked SEG-Y disk transfers from host to workstations, alliances with leading processing vendors for direct output of processed data in Landmark format for direct loading onto optical disks; data access via database query using SQL-compatible format, a telecommunications link via a high-speed modem allowing vendors to download data directly to desktop systems.

• Integrating Paper

to enable users to combine existing paper sections with interactive interpretation.

• Industry-standard hardcopy

to enable the explorationist to present results to management. InterpreterPlus helps the user to produce annotated images, scaled contour maps that include shot points, horizon values, land/lease boundaries, coordinates and culture. Additionally, interpreted scaled seismic displays can be plotted in wiggle, color variable density and combined formats. Applications running on the InterpreterPlus line range from seismic interpretation to a full complement of geologic functions such as log correlation, stratigraphic and structural mapping, cross section and editing, palimpsestic restoration, mapping and modeling.



Landmark's InterpreterPlus provides the functionality and price/performance necessary to make interactive "office" interpretation feasible.

con't.

providing tools for the mutual sharing of the perspectives of each of the disciplines, will the building of an integrated Earth model be realized.

To achieve integration of the disciplines, applications are necessary to convert or "bridge" information generated by one exploration professional into information that will be understood and useful to another professional with a different scientific perspective. For example, a velocity "bridge" application will allow the conversion of seismic data (measured in two-way travel time) to a form (depth) which will allow the geologist to interpret the significance of the geophysicist's interpretation. Landmark will facilitate the development of bridge applications necessary for true data integration through alliances.

Alliances Create Bridges: Energy Analysts Inc. and CogniSeis Development, Inc.

Landmark is committed to building a team of applications specialists with proven expertise in solving complex application problems. Its acquisition of Energy Analysts,

Inc. (EAI) brought a group of industry leading experts into the company who understand and, for years, have been solving problems in geologically complex areas. Landmark, with the team from EAI, will be developing new interactive applications in the areas of velocity, well log, and petrophysical analysis for Landmark's CAEX workstations. Energy Analysts's expertise, combined with the interactive environment, will help resolve a traditional gap between geophysics and geology: an accurate velocity interpretation.

Landmark's recent alliance with CogniSeis is another step taken to resolve the data exchange issues of building interdisciplinary exploitation teams. Both companies are jointly developing products which solve these data exchange issues. The two companies will focus on projects that enable a close coupling of seismic trace processing and data interpretation. For the first time, the processing geophysicist will have access to interactive tools to provide higher quality data to the interpreter, and the interpreting geo-

physicist will be able to reprocess the data when unsure of anomalies within the data set. Also, as part of the exclusive agreement, Landmark and CogniSeis will develop an optical disk file exchange format that will allow for transportable media between processing and interpretation systems.

Formation and management of databases is the most difficult issue facing the creation of a multidiscipline approach. Major oil companies have large investments in widely dispersed databases that reside in a variety of machines or on magnetic tape, film and even paper. Smaller oil companies, on the other hand, may just be beginning to create a database; thus, integration is of less significance to them. Nevertheless, each type of company must expand access to its database through a simple process using straightforward (English-like) query languages. In this way, a workstation may be used as a window to the corporate database and as a tool for cross-discipline data exchange. ■

PLACID OIL: CAEX Used for Exploitation in Green Canyon

The initial lease purchase of Green Canyon Block 29, Gulf of Mexico, by Placid Oil Company in 1983, was based on 2D seismic data obtained in the 1970s and early 1980s. A successful discovery well and subsequent data analysis for offset appraisal drilling indicated unusually complex structure and stratigraphy. This, combined with the high cost of appraisal drilling in water depths of up to 2,500 ft., prompted Placid to begin accumulating large volumes of 3D data from Block 29 and surrounding acreage. This included both Placid proprietary data and open market spec data.

Subsequent encouraging exploratory results led Placid to purchase additional multiple-lease 3D surveys. The exceptionally large 3D volumes from these areas (at one point as many as 116 blocks) prompted Placid explorationists to investigate CAEX technology.

The criteria used by Placid for evaluating and selecting CAEX technology required a workstation with total standalone capabilities, significant data storage with flexibility in accessing and organizing information, and minimal training requirements. "The Landmark workstation was uniquely appropriate for this type of project," said John C. Farris, manager of exploration. "Of great significance to Placid was



CAEX is playing a key role in Placid's Green Canyon field.

Landmark's optical storage technology. This allowed us to easily work with data from multiple areas and to distribute the workload among our geophysicists with few constraints. The speed of accessing large data volumes on optical media resulted

in avoiding bottlenecks in data loading typically encountered with many workstations and eliminated the need for extra and expensive hard disk drives—switching between data sets became almost as easy as switching tracks on a cassette tape.

LANDMARK Providing CAEX Information Solutions



With over 150 system installations in 18 countries Landmark partnerships are global.

The true strength of the system undoubtedly resides in its interpretation software and its enormous functionality and versatility which Landmark continues to update and improve. This versatility made the Landmark system our system of choice."

Interactive interpretation techniques have had an impact on the daily work of the geophysicists involved in the Block 29 project. New methods of viewing fault patterns and salt structuring from multiple directions, and the reconstruction of depositional histories by selectively flattening horizons, are examples of techniques that would be extremely time consuming and virtually impossible without CAEX technology. Of key importance is the manner in which a project can be accelerated—explorations are able to look at significantly more information in more detail within a given time period with less personnel, while providing a significantly greater level of confidence in a given prospect. This technical flexibility and speed have been critical to Placid's exploratory success and instrumental in the Green Canyon 29 development program. They will become even more critical as development drilling necessitates map revisions limiting the decision period between wells.

The 29 facility will be the world's deepest subsea well/floating production system. It will produce from a 24-well template in

Green Canyon Block 29 and Ewing Bank Block 999, and from satellite wells in 2,250 ft. of water in nearby Green Canyon Block 31. The facility, scheduled to begin production in late 1987 or early 1988, will be capable of handling up to 30,000 bopd and 120,000 MMcf/d. The liquids capacity of the system can be increased an additional 10,000 bopd to 40,000 bopd as the field is developed, or as additional fields are delivered through the system. Currently, Green Canyon 29 Field is estimated to contain reserves totalling over 70 MMBOE.

Green Canyon 29 field also includes Ewing Bank 999 and Green Canyon 31, which were both leased in 1984, subsequent to the 29 discovery, for a combined bid over \$17 million. Placid continues to employ CAEX technology and the skill of its exploration staff in drilling additional discovery wells on these three deepwater locations.

The future of CAEX for companies like Placid, says Farris, "depends on the ability to obtain the performance of large workstations on a smaller system at a lower cost so that CAEX systems can be put in each explorationist's office, giving everyone in the interpretation process access to these tools. The next step is to extend the benefits of CAEX beyond the geophysicist to geologic applications."

Landmark Graphics Corporation, since the installation of its first interpretation workstation three years ago, has been working to apply interactive technology to the full exploration and production "team." Having proven the benefits that can result from the application of interactive technology to 3D seismic interpretation, Landmark has begun to deploy computer-based "information" tools for other E&P professionals.

Landmark is working toward a completely integrated computer-aided exploration and production (CAEX) environment where:

- The different disciplines will have access to "personal" computing tools tailored to their specific needs.
- Information from existing corporate data pools will be accessed and integrated.
- Oil company MIS managers will be free from reliance on any one computer vendor.
- The knowledge of an expert in one field can be shared with experts from a variety of other disciplines.

Partnerships to Solve Problems.

Landmark's challenge is not only to have a thorough understanding of how oil companies will need to uniquely implement their CAEX environments, but also to remain tightly coupled with technology providers who supply the basis for Landmark's CAEX solutions.

It involves partnerships...

- **foremost with the E&P professional,** understanding how problems have been solved in the past and improving on those, understanding new problems as they arise, and now, with new CAEX tools, understanding the things that have been impossible before.

The user is a true partner in Landmark applications development. Landmark's Technical Assistance Request program offers users a vehicle for direct one-on-one input into the product development design team. Eighteen major releases of software have come as a result of customer input. Through the feedback from 60% of its customer base, Landmark implemented 50 requested enhancements to its current software products in the past four months.

Both domestic and European user groups interact and discuss exploration problems and unique solutions using CAEX tools.

- **with technology suppliers,** to capture the latest technology for creating the most cost-effective and performance-efficient platforms on which to run applications. Landmark's unique relationships with IBM, Intel, Interactive

con't.

Systems Corp. and Optimem have enabled Landmark's unparalleled response in bringing new products and new capabilities to meet its customers' needs.

- **with the MIS managers**, who are chartered with integrating new CAEX tools with existing computer equipment and who are responsible for the building of a complete environment between the different exploration disciplines. Through its Application Support group, Landmark works with MIS managers to meet each company's specific needs.
- **with universities**, to teach future explorationists leading-edge CAEX techniques. Landmark's University Partnership Pro-

gram, a \$1-million-a-year international program, is designed to provide the E&P departments of educational institutions access to CAEX systems, technology and training.

Technology Transfer: Creating "Expert" CAEX Interpreters

Landmark's Technology Transfer Group is chartered with the mission of imparting the "magic" of interactive CAEX technology to the spectrum of exploration and production professionals who would benefit from its application in their decision process. The Technology Transfer staff is comprised of geophysicists and geologists whose day-to-day tasks are identical to

those of Landmark's customers— solving complex interpretation problems using CAEX tools. This group of individuals, working with real data sets, are continually looking for new ways to apply CAEX tools to the interpretation process.

The Technology Transfer Group is responsible for creating "Expert Landmark Interpreters" around the world. User classes are created and taught on a worldwide basis. Working with oil industry experts on state-of-the-art interpretation research concepts, this group is able to bring new ideas to Landmark's product development team, always pushing the limits of CAEX technology in Landmark's future products.

How Technology Transfer Works

Landmark's Technology Transfer Group has been challenged with a recent project to bring CAEX technology to the People's Republic of China. The PRC's Ministry of Petroleum is interested in developing a computer-aided exploration capability. The Chinese are working diligently to quickly incorporate interactive computers into their exploration activities, and Landmark is playing a strong role in helping them to do this.

Landmark has recently completed a joint interpretation project working with representatives of Zhi Da University, the Bureau of Geophysical Prospecting and Ren Qui Oil Field personnel to utilize the latest 2D interactive interpretation techniques to solve a significant exploration problem. The explorationists working on the Ren Qui Oil Field, 60 kilometers from Beijing, are trying to understand why certain wells previously drilled were producers and others were dry within the same formation. Interpreters were unable to predict the type of rock to be encountered, and traditional methods based on structural mapping had not proven accurate.

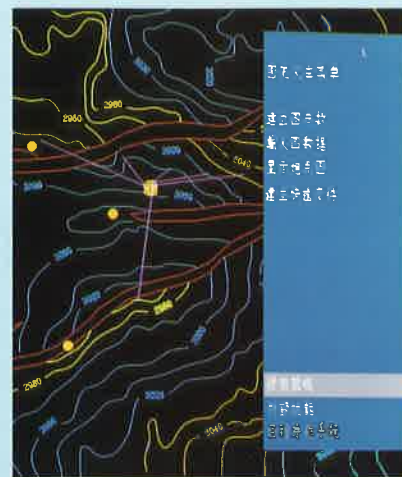
It was believed the key to improving the success rate in the area was to distinguish conglomerate beds with production potential from other similar rocks. The objective of the joint interpretation project was to better define the subsurface to understand this phenomenon and recommend specific drilling locations while 17 rigs were waiting to be placed. The ability to rapidly pull together well data, 2D seismic stratigraphy and other non-seismic methods to make accurate maps was crucial.

Landmark team members included seven of our geophysicists with solid interpretation background with major oil companies. These Landmark members assisted the Chinese team members in learning to leverage the "magic" of CAEX

technology. For example, the interactive system was used to do a detailed stratal interpretation of several conglomerate fans picking all continuous peaks and troughs within a specific sequence. A definition of the seismic facies that were more sand prone quickly followed. In addition, individual shot records were used to do an amplitude vs. offset study. (It is not possible to map changing amplitude vs. offset relationships using traditional paper seismic sections.) The interpretation team used this technique to show a clear delineation of important geologic relationships on one seismic line. The project concluded with the identification of five drilling locations. This was the first seismic stratigraphic interpretation done in China on an interactive workstation using Chinese data only.

The scope of the China project has been an immense undertaking for the Landmark team whose goal is to accelerate the use of CAEX technology in oil exploration and production endeavors throughout

the world. It demonstrates Landmark's commitment to supporting and teaching its users and potential users the benefits of working with CAEX tools, and Landmark's ability to tailor unique solutions to the interpretation problem at hand.



Members of the Landmark—Peoples Republic of China interpretation project team.