



Exploration geology: A growing service sector at Ryder Scott

Applied geoscience is not new to Ryder Scott. For years, we have routinely integrated the results of our geological and geophysical analyses into multidisciplinary studies.



John Hodgkin
Exec. VP - Geoscience

In fact, Ryder Scott has been providing geoscience expertise to the oil and gas industry since 1937 when the then fledgling firm pioneered chip-coring analysis. Until recently our typical focus was on detailed reservoir analysis in existing fields. However, in the last decade, Ryder Scott has been asked by clients to assess the exploration potential of fields and basins, to conduct prospect and play analyses and to evaluate the potential of international concessions.

Our staff of 13 geoscientists has considerable experience in applying conventional methods of exploration geology, ranging from defining structural traps to designing step-out drilling programs. The addition of several highly skilled explorationists combined with our extensive experience integrating the related disciplines of geology, geophysics and petrophysics has positioned us to expand our role in assisting our clients.

The results of recent studies have been utilized in evaluating regional exploration trends, hydrocarbon

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Multi-featured LogWizard newest freeware in suite

Ryder Scott has introduced LogWizard, a multi-featured well-log analysis tool and most recent of the six Microsoft Excel-based freeware programs posted on the firm's web site at www.ryderscott.com. "This program provides the engineer or geologist with an advanced, easy-to-use, fast log analysis tool that will solve most common problems," said developer James Latham.

With LogWizard, a user analyzes density-neutron or sonic logs using either of two templates and calculates the following petrophysical values based on user-selected methods:

- Shale content—applicable to consolidated and unconsolidated formations
- Total porosity—uses arithmetic-average or sum-of-squares method
- Effective porosity—uses arithmetic-average or sum-of-squares method
- Formation water saturation—solves using Archie or modified Simandoux algorithms

For sonic logs, the program template uses interval transit time to calculate uncorrected sonic and effective porosities. For water-saturation and shale-content computations, LogWizard includes visual basic functions that can be exported or linked to other Excel applications.

Based on user-selected criteria, LogWizard calculates gross reservoir sand thickness and net pay thickness as well as average porosities and water

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resource potential, prospect portfolios and upside potential as well as in probabilistic risk analysis.

The industry is being redefined by the move to international petroleum provinces, the growth of 3D seismic and the increase in outsourcing technical services. As these trends continue to grow, we believe that our geoscience staff has the unique ability to combine advanced technology with judgement, experience and the insight necessary to assist our clients in making sound business decisions.

In that vein, please read the article on the next page written by geoscientist Steve Phillips. He discusses the application of risk assessment to exploration and provides three recent examples that illustrate the role of Ryder Scott in this type of work.

Also take a look at the LogWizard program described on Page 1. It is just one of several tools that our geology staff uses to analyze rock and fluid properties.

Publisher's Statement

Reservoir Solutions newsletter is published quarterly by Ryder Scott Company LP Petroleum Consultants. Established in 1937, the reservoir evaluation consulting firm performs more than 1,000 studies a year. Ryder Scott has issued reports on more than 200,000 wells or producing entities in North America. The firm has also evaluated hundreds of international oil and gas properties involving thousands of wells. Ryder Scott multidisciplinary studies incorporate geophysics, petrophysics, geology, petroleum engineering, reservoir simulation and economics. With 117 employees, including 66 engineers and geoscientists, Ryder Scott has the capability to complete the largest, most complex reservoir-evaluation projects in a timely manner.

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saturation for pay sections. The program also incorporates an R_w calculator to assist users in computing formation water resistivity from log data.

The template also contains areas for entering core data or notes. LogWizard's flexibility allows the user to add data-entry lines to sections in progress to accommodate additional information.

Latham has incorporated extensive, sophisticated data-validation safeguards for entered information and conditional-formatting checking for the results. For instance, the system requires that porosity data be entered as decimal values. If a user enters porosities greater than 1, the LogWizard generates an error message and prompts the user to re-enter another value between 0 and 1.

The conditional-formatting feature changes the color of the font of the calculated value, if that value is not valid, thus alerting the user. Those features, already built into Excel, help protect against data-input errors.

The program files for the LogWizard download, as well as for

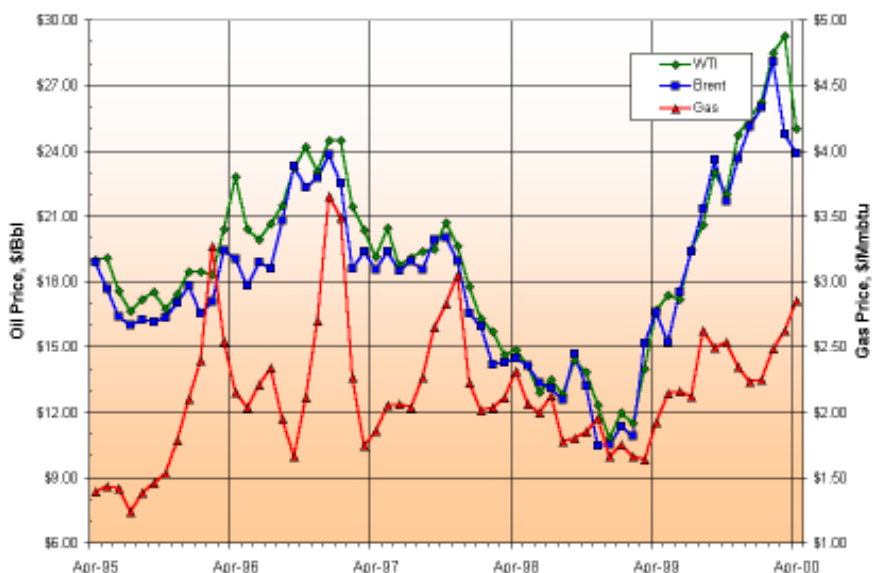
the other five, are self-extracting "zip" files. The installation process is automated to eliminate the need to manually place program files in the appropriate directories. The user simply has to open the autoinstall*.doc file for any Ryder Scott download and click the install button.

As is the case with all downloads, the user-friendly LogWizard produces presentation-quality on-screen views and hard-copy output. Ron Harrell, CEO of Ryder Scott, said, "These programs are not designed to be substitutes for the more sophisticated suite of evaluation tools used by Ryder Scott for complete in-depth analyses. However, the six freeware applications constitute a suite of software tools that will enable a competent evaluator to prepare a reserves estimate for most properties."

All six programs are posted on the web site at www.ryderscott.com with a detailed description of each one. Ryder Scott plans to produce a free CD-ROM with the entire suite of programs for quick installation.

Editor's Note: Ryder Scott does not guarantee or warrant the accuracy or reliability of this software and disclaims its fitness for any particular purpose.

Benchmark oil and U.S. composite gas price history



The West Texas Intermediate Crude (WTI) prices are the posted prices of Exxon Co. USA published in the *Crude Oil Price Bulletin Summary*. Composite spot gas prices are the wellhead prices published in the *Natural Gas Week* newsletter. Brent oil prices are the published, posted prices available to the general public from commodity quotation services over the Internet.

Ryder Scott assesses risk in exploration projects

— Steve Phillips, Ryder Scott geophysicist

The business of classifying reserves as proved, probable and possible is fundamentally an assessment of risk. Oil and gas reservoirs within the 3P band of the risk spectrum get the most attention from Ryder Scott engineers and earth scientists.

Increasingly, however, clients ask Ryder Scott to apply risk-assessment expertise to undrilled prospects and trends. In some of these cases, Ryder Scott performs original geophysical mapping and basin-modeling work.

News-making exploration frontiers can lie under thousands of feet of water, in remote deserts, below complex salt formations or in equally complex political environments. Frontiers with less dramatic characteristics are still diligently sought within easy reach of existing reservoirs. In either case, oil and gas exploration today requires very close alignment of technical and business processes. The balance between cost, potential and risk is a foremost consideration at every step.

Gambler or Investor?

Three growing practices by exploration companies are identified by Peter R. Rose (*AAPG Explorer*, April 1999) that help unite the technical and business aspects of identifying potential oil and gas resources.

- Adopt some method of risk analysis.
- Bring objectivity and consistency to portfolio valuation.
- Apply more discriminating economic criteria to prospect selection.

Rose contends that failure to combine these practices with technological advances results in “gambling” as opposed to “investing” an exploration budget. As an analogy, consider the situation of a casino customer vs. that of a casino operator. A gambler depends on luck to occasionally beat the odds.

Casino operators on the other hand, rely on statistically favorable expected outcomes.

They cannot predict if a single spin of the roulette wheel will be a moneymaker or loser. But, they do know who will be ahead at the end of the night. The question for an exploration manager: Can you place an adequate number of bets, with odds sufficiently well known, for a large enough reward?

Better definition of the odds (risk factors) and size of the reward (reserves distribution) are results Ryder Scott personnel deliver to exploration clients. Most projects begin with some geotechnical determination of the maximum, minimum and most likely ranges of various reservoir properties such as bulk rock volume, net-to-gross ratio, porosity, hydrocarbon saturation and recovery factor.

For undrilled prospects, this information is often produced by integrating seismic interpretation with regional geologic data. Once the magnitude of a prospect is estimated for a range of successful cases, we consider the probability that one or more of the necessary conditions for success is missing. Geologic risk factors include:

■ **Trap Risk**—The probability that adequate vertical and lateral seals exist that could confine hydrocarbons within adjacent reservoir rock.

■ **Reservoir Risk**—The probability that a lithology exists with sufficient porosity, permeability and continuity to contain moveable hydrocarbons.

■ **Source Risk**—The probability that a lithology exists with sufficient quantity and quality of thermally mature organic matter to have expelled oil or gas that feasibly could have migrated to the reservoir.

■ **Timing and Migration Risk**—The probability that a source rock expelled oil or gas after the reservoir and trap were in place and that a flow path existed between source and reservoir. This includes the probability that subsequent geologic events did not cause excessive leakage, remigration or degradation of the trapped hydrocarbons.

■ **Total Geologic Risk** = Trap Risk x Reservoir Risk x Source Risk x Timing and Migration Risk

In addition to the total geologic risk, other risk factors could also apply. For example, a client seeking to bid on a minor working interest might face the risk that a well would never be drilled. In any case, risking a prospect portfolio allows a company to balance the cost of an exploration program against the economic potential of an oil or gas discovery. Here are three short examples where Ryder Scott assisted in exploration risk assessments of undeveloped areas.

Venture capitalists seek opinion on prospect portfolio

Inspired by industry success in the deepwater Gulf of Mexico exploration, in late 1998, an investment group prepared to increase its stake in EEX Corp., a Houston company with significant lease holdings in the trend. Because of previous work for the investors, they chose Ryder Scott to evaluate EEX's prospect portfolio.

On very short notice, Ryder Scott geologists, geophysicists and engineers reviewed exploration concepts, well and seismic data, mapping of reservoir sizes and properties and plans for future wells and facilities. The firm generated a report detailing independent opinions of data quality and completeness, earthscience methodology, geologic and economic risks and feasibility of development plans.

Company relies on evaluation of acquisition target

Recently, a Ryder Scott client began looking for acquisition opportunities near existing properties in South America and became interested in a planned divestiture of interests in a large, adjacent concession



An engineering consultant's view of the upstream industry in China

Part I

— Ron Harrell, CEO at Ryder Scott Petroleum Consultants

An onsite visit to any one of several of the large, mature onshore oil fields in China reveals antiquated surface facilities and operating methods with evidence of little concern for minimizing the footprints of development. Some fields have been in continuous production since the early-to-mid 1900s. Conversely, a visit to a relatively new development, particularly offshore, will disclose a state-of-the-art facility equal to that seen in the Western world.

The general population in China has and continues to be isolated from much of the rest of the world because of political reasons. However, the technical branches of the oil and gas industry have managed to stay abreast of Western technology quite well since the Cultural Revolution ended in 1976.

Much has already been written about China's four large E&P companies, which aspire to attract public capital through initial public offerings (IPOs) of securities through the Hong Kong and U.S. stock exchanges. In addition, some of the companies are experimenting with private placements of capital.

CNOOC—The most Westernized E&P company in China

The first of the major companies to enter the IPO chase was Chinese National Offshore Oil Co. (CNOOC). CNOOC selected financial advisor Salomon Smith Barney in March 1999. The IPO team was completed in May 1999 with the selection of Ryder Scott Co. CNOOC had earlier engaged the law firms of Skadden, Arps, Slate and Flom, LLP; Freshfields, Cravath, Swaine & Moore; and Herbert Smith as well as the accounting firm Arthur Andersen

From the reservoir evaluation viewpoint, the

CNOOC geoscientists and engineers are becoming more involved in the economics of production.

CNOOC estimates of hydrocarbons in place were found to have been carefully prepared by well-trained geoscientists and reservoir engineers using an ample amount of quality data. Indeed, the depth of study of each reservoir, regardless of size or ultimate value, exceeds that typically seen outside China. The luxury of having a large, academically well-trained evaluation staff is a common feature of a state-owned petroleum

company that does not have to face the profitability demands of sophisticated stockholders. This overstaffing existed in the former Soviet Union and is common to certain Middle Eastern countries as well. Regardless of the levels of competency, evaluators with Western publicly and privately owned oil and gas companies usually are more motivated, typically through incentives, to be more productive and progressive in reservoir studies.

CNOOC and its western partners typically use 3D seismic to help locate all drilling sites on identified structures. This exposure to Western partners, typically major oil companies, has served to elevate CNOOC's technical competence and its familiarity with international business practices. Data acquisition and processing along with the computing hardware and evaluation software used by CNOOC are consistent with that used worldwide. International service companies are typically engaged to run a full array of open-hole well logs. Ample sidewall coring is per-

formed to complement the petrophysical data obtained through well logs. Well testing programs are conducted to determine productivity levels and to aid in establishing down-dip reservoir limits. Well tubulars are designed to meet expected flow conditions and production goals.

The CNOOC geoscientists and engineers are becoming more involved in the *economics* of production as they are made aware of production costs and the value of the produced oil and gas. Their primary concerns however seem to be focused on production quotas and maintaining these quotas from year to year. They have made excellent progress in their calculations of the expected recovery efficiency, and thereby initial reserves, through the use of numerical reservoir simulation models prepared in their national research facility just outside Beijing. This agency, China Offshore Production Research Center (COPRC), is staffed with highly educated, technically qualified reservoir engineers and geoscientists who maintain ongoing reservoir simulation studies of the fields in which CNOOC has participating interests.

The CNOOC reserves evaluators are gaining experience in monitoring reservoir performance indicators and using this information to adjust or revise the estimate of both initial and remaining *economic* reserves. They continue, however, to place a great deal of reliance on the product of their volumet-





ric estimate of hydrocarbons in place and a recovery efficiency selected through reservoir simulation or analogy to similar reservoirs. As CNOOC's major fields begin to approach an early stage of maturity, declining pressures and increasing water production data will need to be analyzed and used to adjust some of the volumetric parameters, particularly in the area of petrophysical analyses and net pay counts.

Despite those shortcomings, the summary of the estimated remaining oil and gas reserves as of the beginning of 1999 as prepared by CNOOC was within a reasonable tolerance compared to the independent estimate prepared by Ryder Scott.

CNPC—Competent researchers, limited vintage data

By July 1999, China National Petroleum Corp. (CNPC) had selected its IPO team led by Goldman Sachs & Co. and China Investment Capital Corp. (CICC) as financial advisors and a firm other than Ryder Scott as reservoir consultants. The evaluation of CNPC reserves was a formidable task given that many, if not most, of their fields and wells are mature or approaching maturity. They also were developed under conditions where the initial collection of reservoir data was limited at best and where production records for the approximately 70,000 wells were not well maintained and not easily accessible in a desirable format.

There are significant differences in reservoir geology for the fields across the whole of China that are widespread geographically. The far-flung field locations make efforts to gather and assimilate data even more challenging. The limited collection of reservoir data is not the product of the current CNPC technical staff and operating personnel but rather the result of questionable reservoir and field-management practices many years ago. Even though the present staff has instigated improvements in data gathering and analysis, there remain many situations where the absence of reliable data is of serious concern.

CNPC's national research organization, the Research Institute of Petroleum Exploration & Development (RIPED), located in Beijing is reportedly patterned after the Exxon Corp. research arm, Exxon Production Research and Development (EPRD), in Houston. The RIPED campus is extensive, containing many well-appointed buildings, and is staffed by highly competent researchers. Research and development is focused on refinements in a wide spectrum of

activities from geophysics through refining, sales and marketing. The approximately 1,800 researchers and faculty members are well traveled and seem to be "plugged into" the rest of the world through technical journals and the Internet. The laboratories, offices, classrooms and other facilities appear to be modern and well equipped.

CNPC reportedly has approximately 1.5 million employees mostly in China. The present company was reorganized some two years ago as both CNPC and China Petrochemical Corp. (Sinopec) were established as integrated oil companies with designated areas of upstream activities in China. Before this separation by the State Council in Beijing, CNPC was primarily an upstream company, whereas Sinopec concentrated on downstream activities.

PetroChina, a new company carved out of CNPC, is a creation of the State Council and is designed to enhance the marketability of the IPO that was recently launched with a listing on the New York Stock Exchange. PetroChina has about 500,000 employees in its direct employ and does not own any petroleum assets outside of China. Even downsized to two-thirds of its past size, the slimmed-down staff is roughly equivalent to the total count of 123,000 employees at ExxonMobil, 97,000 at BPAmoco and 388,000 at General Motors Corp.

CNPC's researchers are technically savvy; their facilities are modern and well equipped.



Editor's Note: This article is the first part of a two-part series on upstream China. In Part II, Mr. Harrell discusses Sinopec, China Coalbed Methane Corp. and concludes with remarks on what the future holds. Part II will be published in the September *Reservoir Solutions* newsletter. Also, the entire article was scheduled to appear in the July issue of the *Oil & Gas Executive Report* published by the Society of Petroleum Engineers.

Ryder Scott professionals join internal asset teams

Clients benefit from fresh perspectives

Increasingly, Ryder Scott personnel are working on internal asset review teams in the offices of various major and independent oil and gas companies. The increase in this on-location work represents a departure from the firm's traditional reserves evaluation services, which are usually carried out in Ryder Scott offices. Companies are finding that integrating expert outside perspectives into the more homogenous mix of ideas from employees is paying dividends.

"We stand to benefit from this outside perspective," said a reservoir engineering manager of a "major." "With an external consultant on our team, we are exposed to new ideas and ways of doing things."

In a large company, the asset review team typically meets with the various operating units and examines reserves assets and "threats" to the reserves base, which, if not dealt with, might necessitate de-booking. The team makes recommendations, such as allocating manpower and dollar commitments to mitigate reserves threats.

"Activities of the team might involve devising a plan to accelerate the addition of reserves or finding ways to prove up overlooked reserves," the manager remarked. Typically, the multidisciplinary team is composed of engineers, geologists and geophysicists. The outside professional working in a smaller company might be a member of a smaller team and perform a broader scope of duties. The following on-going client arrangements are examples.



■ **Fred Richoux** (pictured), a Ryder Scott senior vice president, works on an internal audit team at a major company with about \$27 billion in annual revenues. He makes sure that supporting documentation of reserves is in place, so that they are auditable by accountants, government agencies, etc.

If Richoux finds insufficient backup data, then he asks the particular district office to supplement the existing information. The company is currently considering dispatching Richoux to the individual districts for on-site work there. Although it wasn't part

of the original project, the company may ask that Ryder Scott comment on reserves methodology and results in some areas to assure reporting compliance.



Ryder Scott engineer **Tina Obut** (pictured), vice president, augments the company's evaluation staff as a member of an internal acquisition-and-divestiture team. As a non-employee, she has no administrative duties but rather focuses solely on the technical work at hand, which fast tracks projects and enables the company to look at more acquisitions.

She trained on the company's proprietary software at no cost to the client and now conducts Monte Carlo probabilistic reservoir engineering studies on site. Obut also opines on reserves classifications of potential acquisitions.

■ For the last three years, **Joe Magoto**, a senior vice president at Ryder Scott, has served on the internal reserves audit team of a large, multinational independent. The four-member team is composed of a chief petroleum engineer, chief geologist, manager in charge of corporate reserves, who reports to the CEO, and Magoto.

The team travels once a year to operating units in Alaska, the Far East, and Louisiana and Texas to audit reserves. Ryder Scott does not issue an independent reserves report but instead makes recommendations in corporate reports issued to each business unit.

"We received high praise from the management committee and the senior vice presidents again this year. A more defensible reserves ledger has not only boosted our credibility, but also improved a fundamental business practice that is the foundation of many business decisions."

Please see continuation on next page

The outside consultant position has evolved from an advisory one to a position in which Magoto is delegated the responsibility of actually drafting the corporate report letters to several business units. Also, the team issues a "Watch List" of reserves that are at risk as audited. The team recommends that the company write off those reserves over time or prove them up.

The Watch List "forces" the business units to focus on problems that they may otherwise defer. The list also encourages the units not to overbook reserves for concern that the properties might be added to the Watch List, which is reviewed by the CEO.

"The Watch List 'forces' the business units to focus on problems that they may otherwise defer. The list also encourages the units not to overbook reserves..."

The manager of operations analysis at the company, said, "As we close the third year of the new reserves process, it is apparent we have changed for the better and that the change is sustainable. We received high praise from the management committee and the senior vice presidents again this year. A more defensible reserves ledger has not only boosted our credibility, but also improved a fundamental business practice that is the foundation of many business decisions. I appreciate the help from Joe Magoto and support from Ryder Scott. Using an external expert as part of our reserves team and using the available Ryder Scott technical resources have made a material difference."

Ryder Scott professionals to teach UH engineering courses

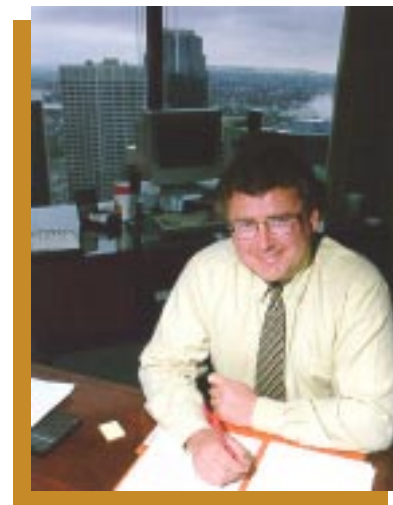


The University of Houston will offer two graduate petroleum engineering courses on reservoir simulation and characterization, respectively, to be taught, in part, by Ryder Scott engineers. An influencing factor in the selection of instructors was the favorable reception to two Society of Petroleum Engineers Gulf Coast section reservoir simulation seminars hosted by

Ryder Scott in April. The seminars were presented by Ryder Scott engineers **Dean Rietz**, **Grant Robertson** and **Miles Palke** as well as **Robert Gochnour**, an engineer at BP Amoco Upstream Technology Group.

UH will offer a course on reservoir characterization taught by **Akhil Datta-Gupta** and Palke this fall. The reservoir simulation course—taught by Robertson, Rietz and Gochnour—will be offered in the

■ **Andy Thompson** (pictured), vice president at Ryder Scott Canada, served as the corporate in-house reservoir evaluation coordinator at a major Canadian company last year. With about \$4 billion in assets, the company is one of the five largest oil and gas companies in Canada. He reported daily to offices of the client and, as part of an internal team, supervised the reservoir evaluation work of the independent engineering firm that estimated the reserves.



During that period, Thompson found significant additional value in one of the fields that was overlooked by the third-party consultant and therefore not booked. He recommended that the company not sell the property as planned and management agreed.

When the company closed its U.S. office, the reserves coordinator at that location relocated to the corporate office and transitioned into Thompson's position. However, management decided to engage Ryder Scott to serve as the independent reserves auditor for the entire company.

Currently Thompson audits the company's reserves using the Merak Portfolio system, which has streamlined the evaluation process.

spring semester 2001.

The SPE seminar on simulation fundamentals was targeted to managers, among others, needing an overview. **Joe Tigner**, coordinator-reserves and compliance at EOG Resources Inc., said that his company uses reservoir modeling for large- and small-scale projects as a normal part of reservoir management. "As a result of taking the fundamentals course, my understanding of how modeling can affect reserves bookings has been enhanced," he remarked. "The course is an excellent overview for those of us who are on the periphery of modeling activities."

The more in-depth, two-day SPE seminar on simulation for practical decision making was aimed at those planning to conduct or review modeling studies. In preparation for reviewing simulation results pertaining to a coalbed-methane project, **Marc Connolly**, reservoir advisor at Conoco Inc., took the two-day seminar. "The course is an excellent review of basics. It has greatly helped me increase my basic understanding of simulation," he said.

For further information on the UH courses, access the UH web site at www.chee.uh.edu or contact **Christine Economides**, director of the UH petroleum engineering program, at cee@slb.com.

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area. With this in mind, the client commissioned Ryder Scott to perform data-room work and issue a report.

The sales package included one producing field and a much larger exploration area with very few wells. Because the value of the producing field was well known, the winning bid was likely to come from the company placing the greatest value on the exploration potential.

Ryder Scott's main task was therefore to take a fresh look at the well control and 2D seismic data beyond the developed field to help determine how much the client should bid above the value of the 3P reserves. The seller provided a prospect inventory tabulating unrisks, maximum-case reserves. The Ryder Scott investigation balanced these proposed volumes against the previously mentioned risk factors. Ultimately, the client adjusted its bid accordingly.

Partners request mapping of deeper objectives

In another South America concession area, partners in a string of oil and gas fields shot 3D seismic for the first time over their developed and undeveloped holdings. The primary value of the survey had been to assess stepout drilling of known reservoirs.

Ryder Scott, which performs annual reserve reports on these fields, began to look at new seismic maps. The client asked the firm to improve definition of the known reservoirs and to examine new prospects defined by the seismic.

Ryder Scott received the digital seismic data on tape and loaded that information on workstations. One bonus of the new 3D data was a first look at undrilled structures below the existing reservoirs. Because time limitations prevented the partners from performing detailed mapping of the deep structures, Ryder Scott performed that work. The firm's seismic interpretation produced volumetric estimates of gas in place, balanced by an estimation of the geologic risk factors. The client intends to test these prospects soon.

The three previous examples are typical of recent exploration projects evaluated by Ryder Scott. The

staff of qualified geophysical, geological and petrophysical personnel strives to meet the specific requirements of each project on an individual basis.

The firm maintains access to a comprehensive suite of both PC- and Unix-based software applications for geophysical interpretation, geological mapping, petrophysical interpretation and 3D reservoir modeling. The diverse software platforms allow us to offer greater flexibility and provide a work product compatible with the client's software. The expansion of exploration services will further enable Ryder Scott to assist clients in meeting their business objectives.



At an April 30 reception to honor his career with Ryder Scott, former CEO Ray Cruce was given a plaque to commemorate the establishment of the Raymond V. Cruce Endowed Presidential Scholarship fund at the University of Texas. The presenters (from left) were UT officials Tricia Berry, director of the engineering scholarship office; Ekwere Peters, chairman of the petroleum engineering department; and John Halton, assistant dean for college relations in the College of Engineering. To fund the scholarship, employees made financial commitments exceeding \$150,000.

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