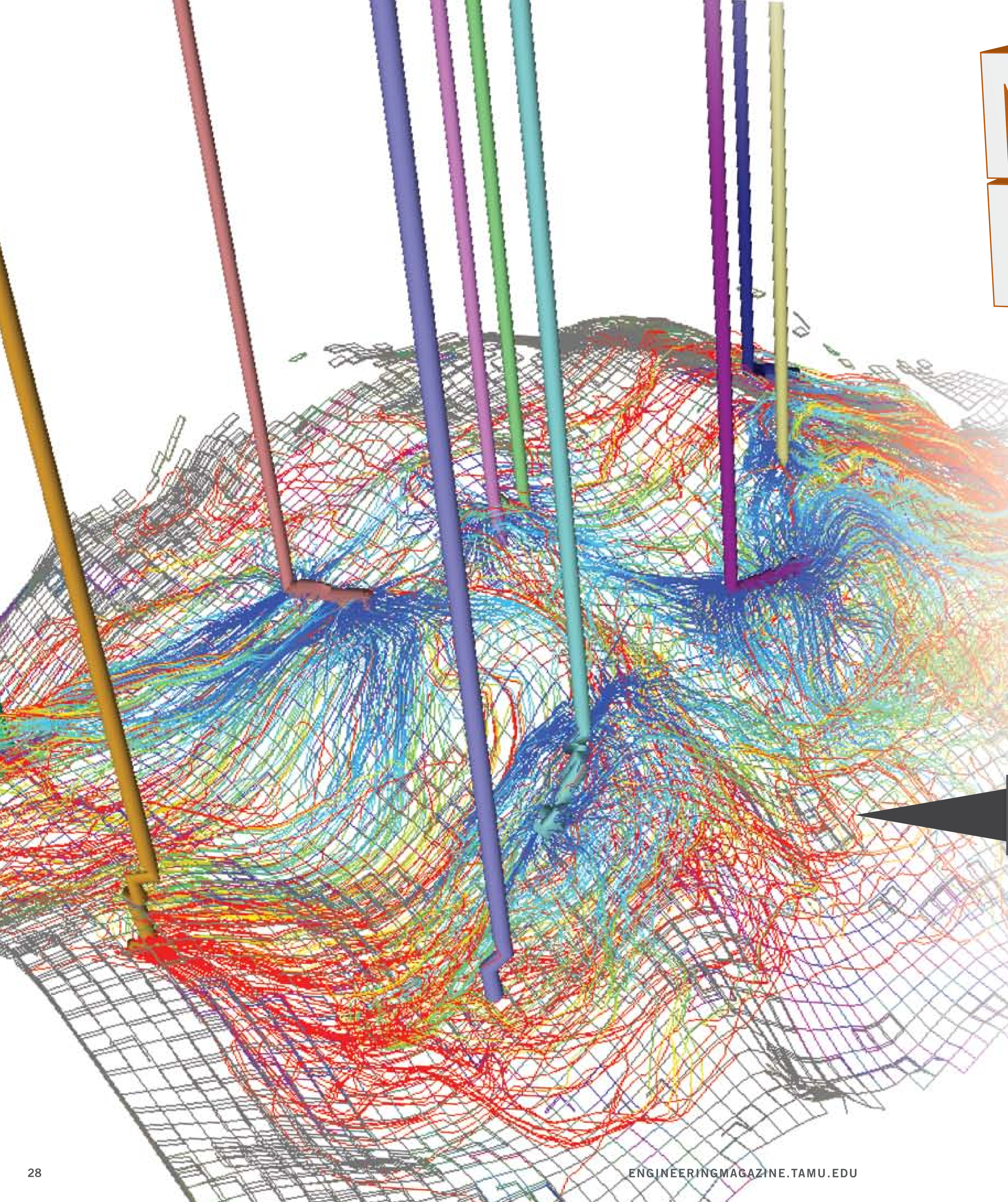


Streamlines represent the flow of oil, water and gas between wells in a reservoir. Regions with many lines are well swept, whereas regions with few lines indicate locations for potential infill drilling targets.

MODEL ENGINEERS

Striving to minimize the guesswork involved in oil production

by Kara Bounds Socol

In 1956, James Dean offered movie audiences one of the most memorable scenes in cinematic history. Dean portrayed ranch hand Jett Rink in *Giant*, whose triumph was palpable as his only oil well hit its target. With outstretched arms and his face to the sky, Rink freely let oil cover him from head to toe. Instantly, he became a rich man.

In virtually all movies celebrating the fortune-changing role of the oil industry, luck tends to be the primary component of success. And although luck still has its place in this make-or-break business, Texas A&M petroleum engineering researchers are making significant strides toward replacing this gamble with data availability and scientific accuracy.

Minimizing the guesswork

From the exorbitant costs of wells to the high price of treating water involved in extraction, oil recovery is expensive. Many in the oil industry therefore rely on reservoir simulation models to help diminish financial risks by turning shots in the dark into educated speculations.

Texas A&M is at the forefront of reservoir model development, boasting some of the field's most prominent names as members of its faculty. Among these researchers are Michael King, the John and Debbie Bethancourt Endowed Professor in Petroleum Engineering, and Akhil Datta-Gupta, the LeSuer Chair in Reservoir Management.

The men met years ago at British Petroleum (now BP), where Datta-Gupta was an engineering specialist working with King, the team leader of the fluid-flow group. Datta-Gupta transitioned into the academic world, coming to Texas A&M in 1994. King, however, remained at BP for 27 years, leaving his senior adviser position for a Texas A&M faculty appointment only two years ago.

Despite their different career paths, the bonds that Datta-Gupta and King forged led to multiple research collaborations. One such effort in the late 1980s yielded streamline techniques for reservoir modeling.

The art of performance prediction

A reservoir simulation model starts as a computerized, three-dimensional picture of an oil reservoir. In developing these models, researchers use mathematical equations to

From the exorbitant costs of wells to the high price of treating water involved in extraction, oil recovery is expensive. Texas A&M petroleum engineering researchers are at the forefront of reservoir model development, which can help industry exectives decide where to drill.

The models help executives decide whether the amount of oil they will potentially recover makes a project financially viable.

model the physical processes taking place in the reservoir. Seismic, well and other subsurface information is gathered from many sources. This data is compiled into computer models that convey such information as the length and continuity of the reservoir, its geological makeup, pore sizes, permeability and architectural characteristics.

Streamline simulation takes the conceptualization a step further by looking at predicted fluid flow through these models.

From this information, oil industry executives can determine the number of wells to employ and the optimal well placement and oil-recovery method. Models give them an idea of where injection wells are needed to keep subsurface fluid pressure from dropping. These models show which reservoir regions aren't being depleted by current wells. And, most important, the models help executives decide whether the amount of oil they will potentially recover makes a project financially viable.

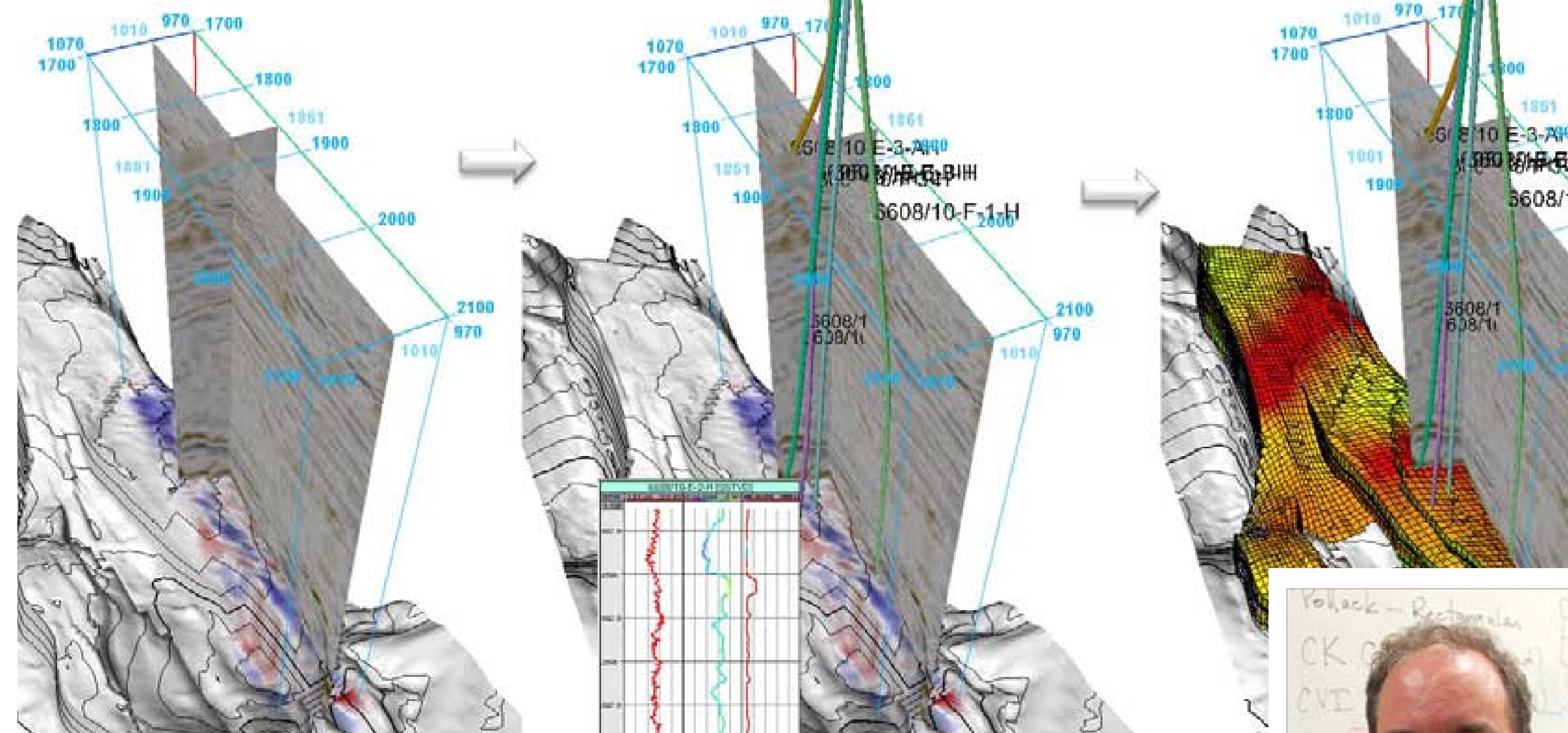
Ultimately, oil executives want to minimize the number of wells, minimize cost and minimize the developmental footprint, Datta-Gupta says.

Like weather reports, reservoir simulations are merely predictions. But whereas a weather forecast might give a prediction days ahead of time, reservoir simulations are often making these judgments months or even years out.

"Part of what we need to get good at is uncertainty quantification," King says. "A reservoir model may have lots of detail and information, but little might be hard information. We're working at getting performance prediction to look like what's actually going on in the field."

Too much information

Collecting as much data as possible may seem like a good thing. Gathering data for a reservoir model, however, results in tens to hundreds of millions of computational elements — more information than a computer can handle. Converting this high-resolution



To develop a subsurface model, researchers must integrate geologic, petrophysical, geophysical, well and production data into a coherent three-dimensional representation of the reservoir, here shown as a complex computational grid that can then be used to model flow and predict reservoir performance.

model into a lower-resolution one that a computer can run, yet maintaining the details critical to understanding the reservoir, can present a formidable challenge.

"We either keep the cell physics and lose resolution, or we maintain resolution and simplify some of the physics," King says.

The former option is called "upscaling" and is King's forte. The latter, known as "streamline simulation," is Datta-Gupta's specialty. In 2007, the Society of Petroleum Engineers published an industry-standard textbook on streamline simulation that Datta-Gupta and King wrote.

Fine-scale features of high-resolution models can have a critical impact on reservoir performance. With upscaling, King can determine whether a model needs to remain in high resolution or whether it can go to a lower resolution and maintain its quality of detailed information. This decision entails sorting through endless computational elements, determining which are vital to the model. To be effective, the upscaled model must replicate such fine-scale flow behavior as reservoir pressure, injection or production rate, and the performance of injected fluids.

With streamline simulation, Datta-Gupta separates three-dimensional problems into a series of one-dimensional elements and then uses equations to track the fluid fronts along these elements. This process drastically reduces computation time compared with conventional methods.

Aggie efforts

King says the streamline-based inversion techniques Datta-Gupta has developed are beyond anything that has ever been done.

But Datta-Gupta and King aren't the only Texas A&M researchers working to improve reservoir simulation models. Among others are petroleum engineering assistant professors Behnam Jafarpour, W.F. and Marilyn Albers Family Faculty Fellow, and Eduardo Gildin, C.J. Craft Jr. Faculty Fellow, who are developing numerical techniques related to reservoir management and optimization. Another is Duane McVay, associate professor of petroleum engineering and the Mike and Heidi Gatens Development Professor in Unconventional Resources. McVay is among the leading authorities on unconventional reservoirs — those that require massive stimulation treatments or special recovery processes and technologies to produce an economically feasible volume of oil. Heavy oil and tar sands are examples of unconventional reservoirs.

The international oil industry now routinely uses the model innovations that Texas A&M researchers have developed. These improvements have also led to the creation of several software programs.

The two scenarios

Streamline simulation involves "closed-loop" reservoir management and optimization, King says. This process entails making short-term predictions — about a year out — to develop an initial model and then updating

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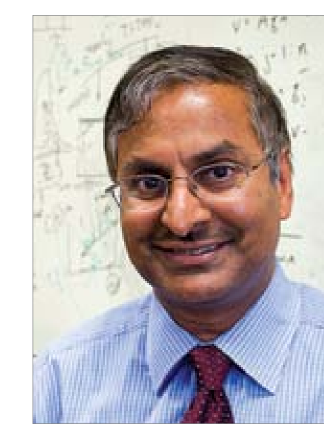

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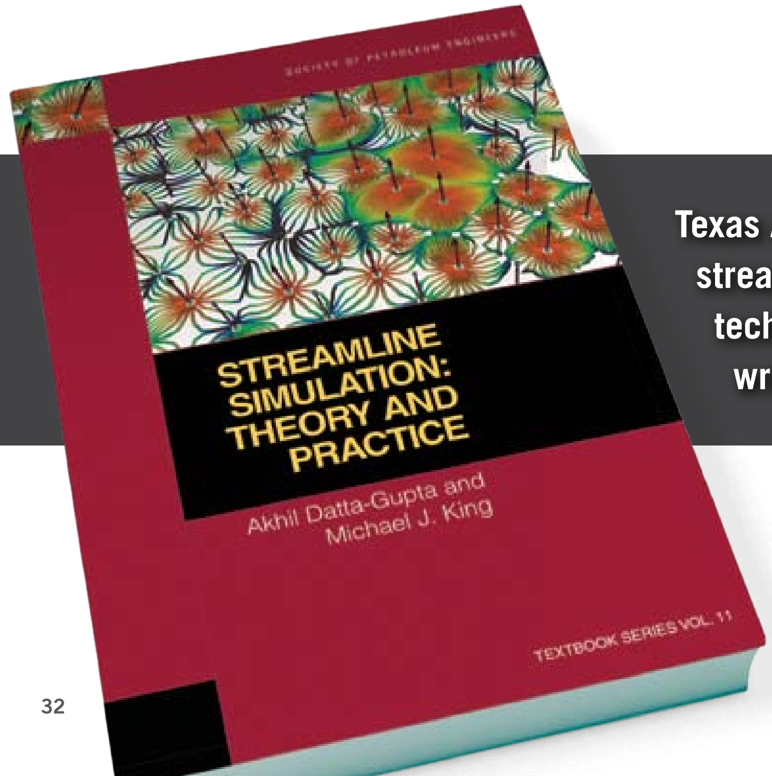
With their students, King and Datta-Gupta are developing better techniques to represent the impact of fine-scale features of the reservoir on petroleum recovery; better ways to integrate production data into reservoir models; and better approaches to reservoir management.

> "Part of what we need to get good at is uncertainty quantification. A reservoir model may have lots of detail and information, but little might be hard information. We're working at getting performance prediction to look like what's actually going on in the field."

the model with new feedback from the reservoir. Doing so lets researchers fine-tune the simulation process as they compare their predictions with reality.

Although all the many details that reservoir models yield are important, King says, oil producers are ultimately interested in two questions: What is the best-case scenario and what is the worst-case?

As world leaders in developing streamline-based flow simulation, Texas A&M researchers are getting closer to answering these crucial questions. ☆



Texas A&M Engineering is at the forefront of streamline-based multiphase flow simulation technology, and Datta-Gupta and King have written the first textbook in this area.

Harold Vance Department of
PETROLEUM ENGINEERING
TEXAS A&M UNIVERSITY

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Quick Facts

968 Students (Fall 2010)
630 Undergraduate
338 Graduate

***U.S. News & World Report* Rankings**
(among public institutions)
1 Undergraduate
2 Graduate

21 Faculty
12 Professors
6 Associate professors
3 Assistant professors

2 National Academy of Engineering Members

18 Endowed Positions
6 Chairs
3 Professorships
4 Development professors
5 Faculty fellows

$16 Million Overall Budget
48 percent — research

Research Areas

- Advanced drilling technology
- Advanced production technology
- Analysis of reservoir performance
- Energy
- Enhanced recovery
- Environmental and water issues
- Heavy oil recovery
- Hydraulic fracturing
- Improved oil recovery
- Naturally fractured reservoirs
- Oilfield chemistry
- Reservoir characterization
- Reservoir simulation
- Resource assessment and uncertainty analysis
- Shale gas
- Tight gas
- Unconventional resource assessment
- Upscaling
- Well completions
- Well control
- Well stimulation