SEPTEMBER 2000

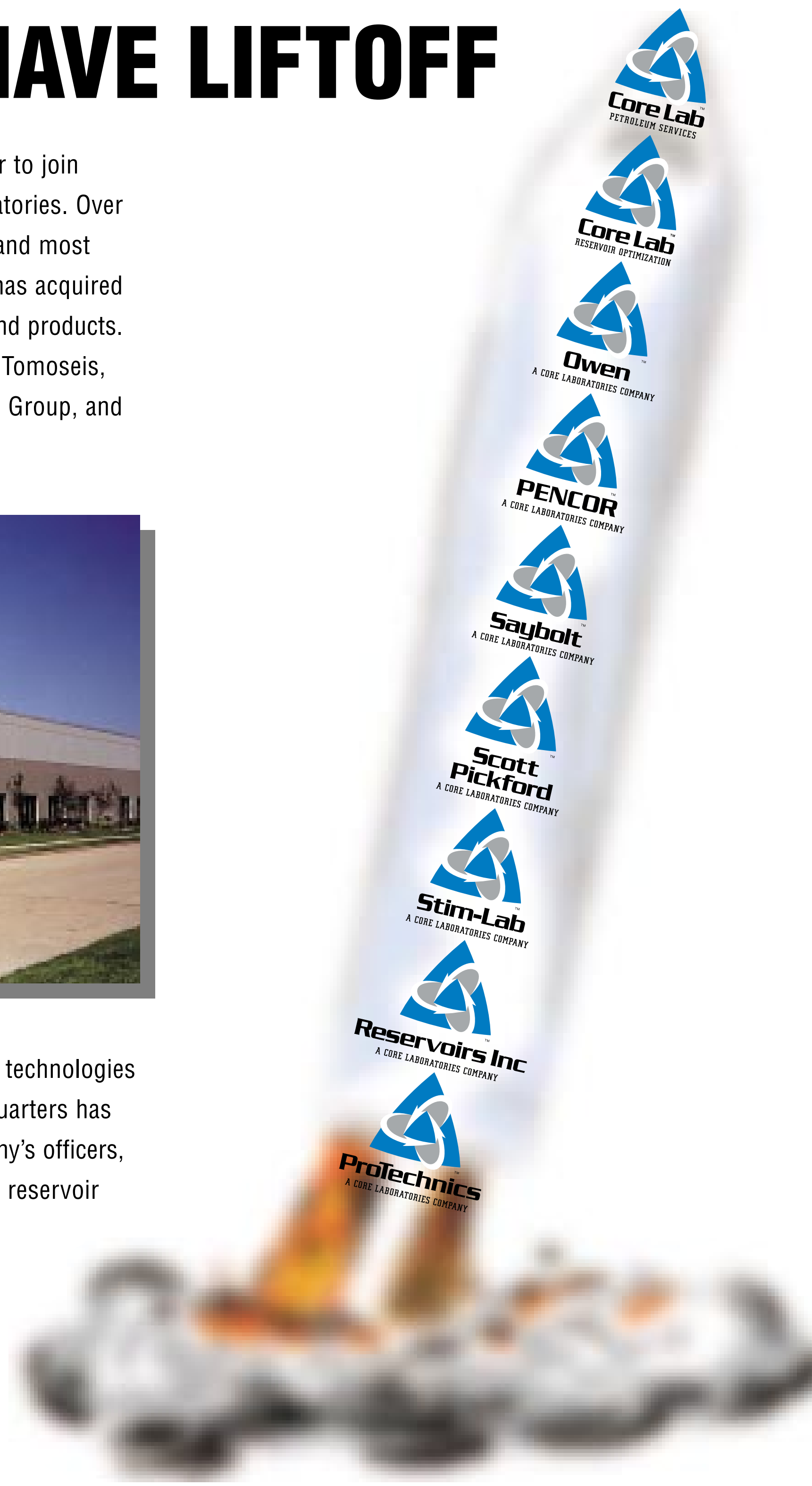
# PROTECHNOLOGY

ProTechnics
A CORE LABORATORIES COMPANY

A REGULAR TECHNICAL REVIEW FOR CLIENTS OF PROTECHNICS, A DIVISION OF CORE LABORATORIES

# HOUSTON, WE HAVE LIFTOFF

**ProTechnics** has moved our Houston headquarters in order to join forces with the other fast-growing divisions of Core Laboratories. Over the past 3-1/2 years, Core Lab, the world's largest, oldest and most respected name in petrophysical rock and fluids analysis, has acquired a number of companies who offer "best in class" services and products. Among them are Stim-Lab, Owen, Scott Pickford, Saybolt, Tomoseis, Coherence Technology Company, Integra, Pencor, Andrews Group, and Reservoirs Inc.




To fully realize the combined value of this diverse group of technologies and expertise, a new 140,000 square foot corporate headquarters has been constructed in northwest Houston unitizing the company's officers, management, sales and technologists to deliver the best in reservoir optimization services to our clients.

Pictured here is our new facility at 6316 Windfern. If you would like to arrange a tour of these facilities for your first chance to take a second look at the new Core Lab, please call or email us at **(713) 328-2320** or **protechnics@corelab.com**.

# FRACTURE INITIATION FRO

Stimulation procedures in intentionally deviated wellbores are commonplace today. In actuality, it is difficult and often impractical to drill an absolutely vertical wellbore. Acidizing, propped acid fracs, frac packs and conventional fracturing procedures are routinely performed in deviated open holes, in uncemented slotted or perforated liners, and in conventionally cemented and perforated casings. Tracer diagnostics are used to determine the percent of the interval stimulated, to locate fracture initiation points, to evaluate diverter effectiveness and to provide information about fracture orientation relative to the wellbore.

## Fracture Mechanics

When a material fails (fractures), fractures propagate perpendicular to the direction of the least principal stress or in the direction of maximum stress. Since the overburden (vertical) stress in all but the shallowest wells is the highest of the three principle stresses, fractures are generally considered to be near-vertical (0° dip). The horizontal direction (strike) to which the fracture orients is then perpendicular to the direction of the smallest of the two horizontal stresses.

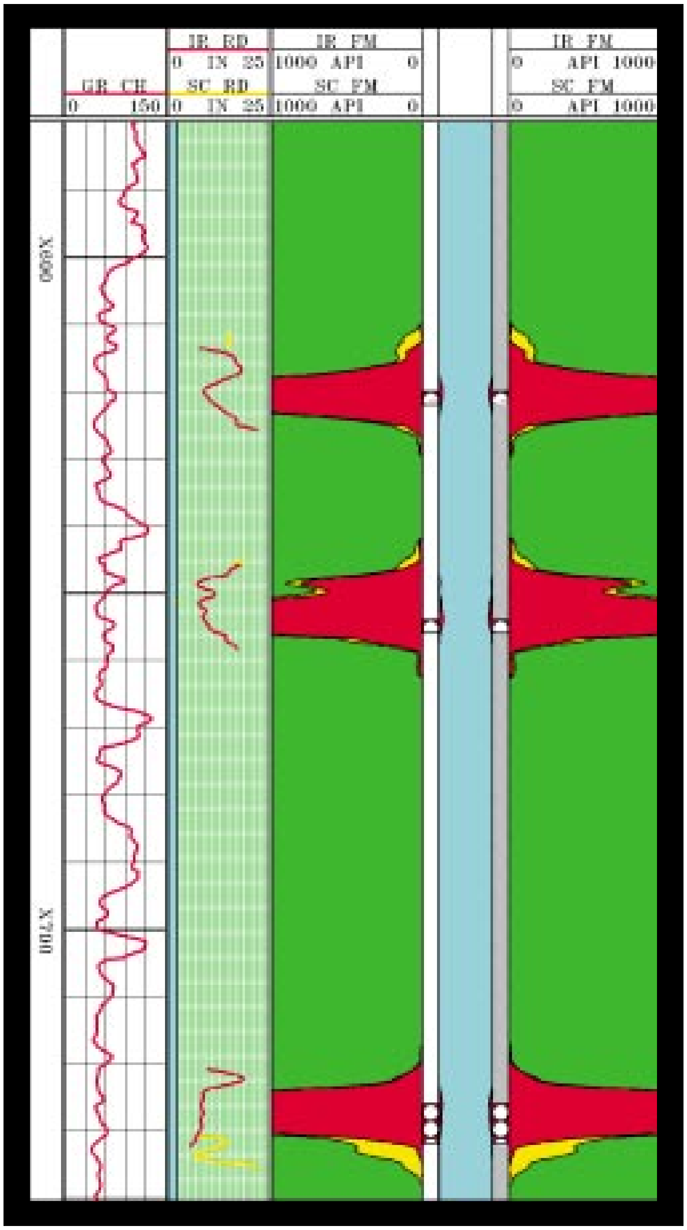
The height of a hydraulically induced fracture is largely determined by the difference in confining stress between bounding layers and the zone of fracture initiation, and the net fracturing pressure. Factors such as injection rate, slurry density, viscosity, number of perforations and formation pore pressure all influence the net pressure obtained during a treatment.

The degree of height confinement, friction along the fracture face(s), anisotropy, and the volume of fluid being pumped determine the length of a fracture. Fracture width is largely a function of the viscosity of the fracturing fluid and the magnitude of tangential stress.

## Deviated wellbores

Tracers do not always define the total fracture height, but should be considered as the minimum fracture height at the wellbore. Due to the depth of investigation of tracer technology (<2 feet), if a fracture deviates away from the plane of a wellbore, the tracer count rates are attenuated fairly rapidly (1/distance$^2$). Studies have shown that the fracture tends to remain in or close to the plane of the wellbore when the well is moderately (<30 degrees) deviated (SPE 20656). When fracturing a well, the supercharged area of leakoff near the fracture face is a stress-altered zone where the actual stresses are higher than the in-situ

**FIGURE 1**




On this SpectraScan Image from Latimer County, OK, notice that the tracer count rates do not extend to the top and bottom of the sands as indicated by the pre-frac gamma ray in Track 1. The tracer count rates decline uniformly and rapidly above and below the centerpoint of each of the three perforated intervals. Our unique and proprietary relative distance calculation (SPE 17962) in Track 2 shows the effective distance to the cloud of traced particles to be low (around 8″ ) near the center of each fracture's contact with the wellbore. This increases up to a maximum of about 20″ (the Ir-192 tracer's maximum depth of investigation) above and below the center of the fracture. This is a classic example of separate fractures exiting the plane of the wellbore. Using simple geometry, the fracture appears to be dipping at about a 14° angle relative to the wellbore. (Fracture moves out 12″ in 4 feet or arc tan of 12″/48″)

# OM DEVIATED WELLBORES

stress. The act of drilling a wellbore reduces the stress field near the wellbore causing induced fractures to preferentially dip toward the wellbore axis so that the measured tracer height is generally close to or equal to the actual fracture height. It should be pointed out that the angle of incidence of fracture to wellbore trajectory could also be high when a well is near vertical but shallow depths or regional tectonic stresses cause the fracture dip to be sub-vertical. In either of these cases the results and analysis of tracer diagnostics procedures are similar.

In highly deviated wellbores (>30 degrees), the fracture can leave the plane of the wellbore so that a vertical fracture in a highly deviated well will be visible for only a few feet above and below the interval where it connects with the wellbore. Certain characteristics of the tracer image are evident when this occurs: a uniform rate of decrease in tracer counts above and below the perforated interval with the lowest energy tracers disappearing most quickly (due to more rapid attenuation), and an increase in the relative distance measurement above and below the fracture's coincident interval as the fracture begins to deviate away from the wellbore. ***(Figure 1)***

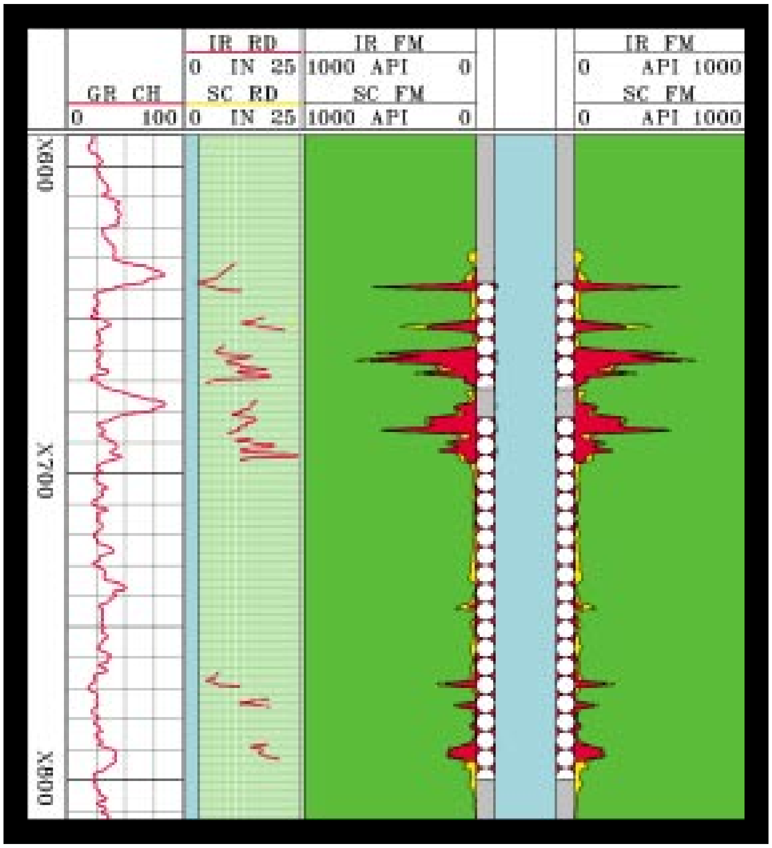
The information to be gained from tracing highly deviated wellbores includes the percentage of perforations connecting the reservoir to the wellbore (i.e., propped interval vs. total perforations). Additionally, tracers easily identify the occurrence of multiple "en echelon" fractures. ***(Figure 2)*** These fractures are more likely to occur in a deviated wellbore where a separate fracture could be initiated at each open perforation. Where these multiple parallel fractures exist, fracture models that assume a single fracture could easily over-predict the length and/or height of the fracture system. Tiltmeter and microseismic imaging have confirmed a more height-contained fracture geometry in the presence of multiple parallel fractures than is predicted by 3-D models, even when using treatment pressure history matching. Utilizing the distinctive tracer signature (a series of gamma "spikes" at regularly spaced intervals), the experienced fracture modeler can select a multiple fracture option and thus be able to obtain a more accurate and unique solution through the pressure history matching process. Knowing the location and number of fracture initiation points can further refine the fracture modeling process.

In conclusion, when completing high angle wellbores or formations with highly dipping beds, tracer diagnostics are useful in determining the percentage of interval covered, the time-based distribution of the stimulation slurry, qualitative orientation of induced fractures, minimum fracture height, and total contact area between the wellbore and formation.

## Come Visit Us at SPE

**ProTechnics and the rest of the Core Lab family look forward to visiting with you at the SPE ATCE in Dallas, October 2-4. Stop by and see us at exhibit #1145.**

**FIGURE 2**




The SpectraScan Image seen here is of a long continuously perforated interval in a large unbroken sand body with highly deviated bedding planes (>70°). Notice the 7 very regularly spaced "en echelon" fractures near the top and bottom of the perforated interval. No fractures were initiated within the middle portion of this reservoir. The relative distance signature here confirms the presence of fractures crossing the wellbore at a high incident angle.