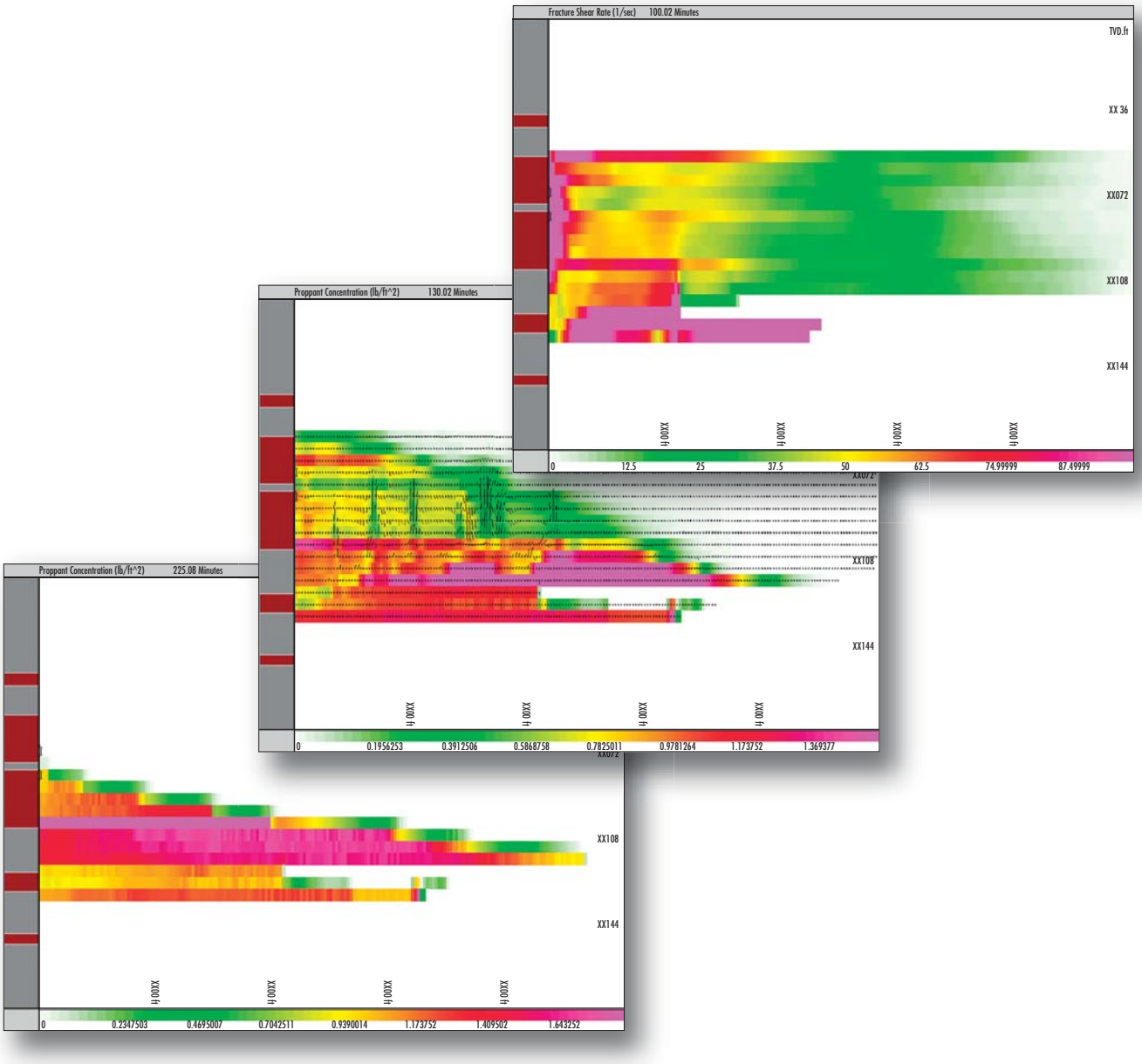
PRODUCTION ENHANCEMENT

THE GOHFER FRACTURE SIMULATOR

Core Lab
RESERVOIR OPTIMIZATION

The GOHFER® simulator is easy to use for realistic 3-D fracturing design; and it is the ultimate tool for designing treatments in complex, heterogeneous reservoirs for vertical, deviated, and horizontal wells.



A major innovation in fracture stimulation optimization

For the past 15 years, the GOHFER system has been expanded and continually refined using established formulations that have been verified in Stim-Lab's laboratory and in the field. This is not a black-box model, but a flexible tool that provides users with "quick-look" job design capability and the power of unlimited data integration.

GOHFER advantages

Some of the advantages of using the GOHFER simulator include:

- Direct integration of digital log data
- The unique ability to properly predict proppant transport
- The power to handle horizontal and asymmetric fracture modeling, including complex reservoir geometry – not just horizontal "layer cake" formations
- Being able to model multiple perforated intervals, with diversion between perforations, for limited entry design
- Allowance for vertical and lateral variation of leakoff and rheology across the fracture
- Accurate modeling of frac pack designs using pressure distribution screen-out criteria
- Accounting for hindered settling and convection
- Modeling fracturing acidizing
- Inclusion of poroelastic effects in stress computations

Putting the pieces together

ProTechnics has combined openhole data, unparalleled GOHFER 3-D simulation, and award-winning completion imaging services to enable a level of fracture-stimulation diagnostic evaluation never before achieved.

Multi-zone tight gas completion: A case study

Figure 1 is a composite of history-matched data from a two-stage frac job in a tight gas sand formation. Fracture height growth and zonal containment were among the major concerns when designing these frac jobs. In the first-stage frac (pumped at 55 bpm), the pad fluid (as seen in the SpectraScan Image track) was traced with Sc-46 LZW (yellow), the first 60,000 lb. of white sand with Sb-124 ZW (blue), and the final 55,000 lb. of sand with Ir-192 ZW (red). Proppant coverage is relatively uniform and contained, with upward growth extending about 44 feet above the top perforation.

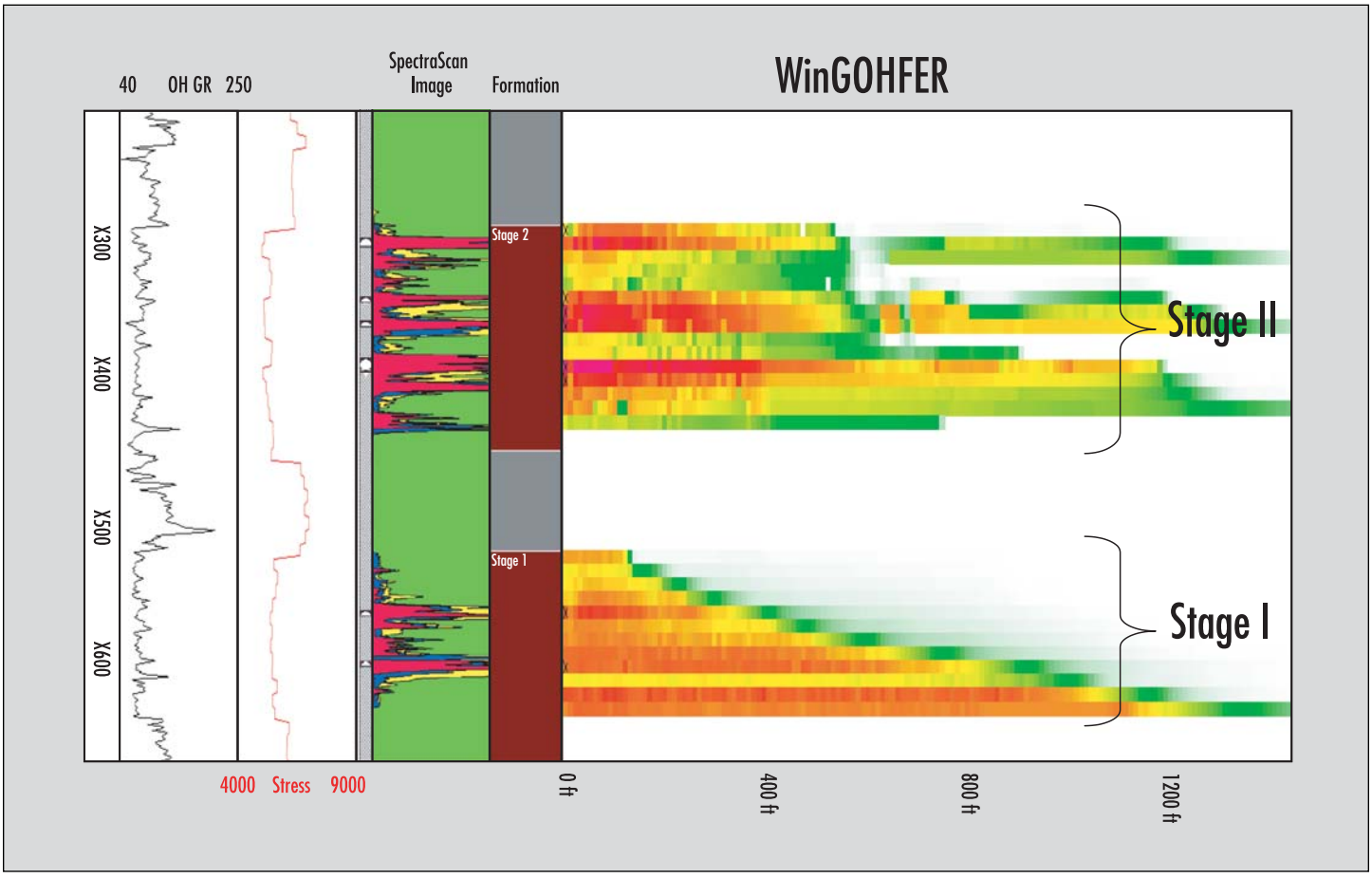


Figure 1. History-matched data from a two-stage frac job in a tight gas sand

The second-stage frac (pumped at 80 bpm) was traced with Sc-46 LZW (yellow) in the pad fluid. The first 75,000 lb. of sand-laden fluid was traced with Sb-124 ZW (blue) and the final 80,000 lb. with Ir-192 ZW (red). Coverage predicted by the GOHFER simulator is almost an exact match to that shown by Zero Wash® tracers, with the extent of downward growth terminating at the shale break at X430.

This containment has very little to do with conventional containment mechanisms related to variations in Poisson's ratio. It should be noted that most of the containment is generated by changes in rock density and strength and by porosity/permeability relations that are expressed in Biot's constant in the GOHFER computation of stress. From the combined data on this multi-zone completion, we can conclude that:

- Log data, even without sonic travel time, can be used to model and predict fracture geometry in tight gas sands.
- GOHFER simulations match observed treating-pressure trends and proppant placement shown by SpectraScan® images.
- Fracture height containment is far better than would be predicted from conventional approaches to modeling multi-zone completions.
- Barriers to height growth can be successfully predicted using the GOHFER simulator.

Reservoir characterization and fracturing modeling with wireline data

Digital log data from openhole LAS files are imported directly into the GOHFER simulator. All data necessary for reservoir characterization and fracture modeling are derived from log data on a foot-by-foot basis using multiple calculation and correlation procedures, then discretized over a user-defined spatial grid for input to the simulator.

The plots in Figure 2 show the discretized log input data as automatically read into the GOHFER simulator and interactively processed by the engineer. The effect of varying pore pressure, including local depletion and varying overpressure with depth, is included in the stress calculations. A separate minimum in situ stress and a critical stress for fissure opening are accounted for when pressure-dependent fissure leakoff is encountered.

Unlike many models, a static stress profile is not hard-entered into the GOHFER simulator. Instead, the computation of the stress profile is an interactive part of the history-matching process based on computed elastic properties, field-measured pore pressures, closure stresses,

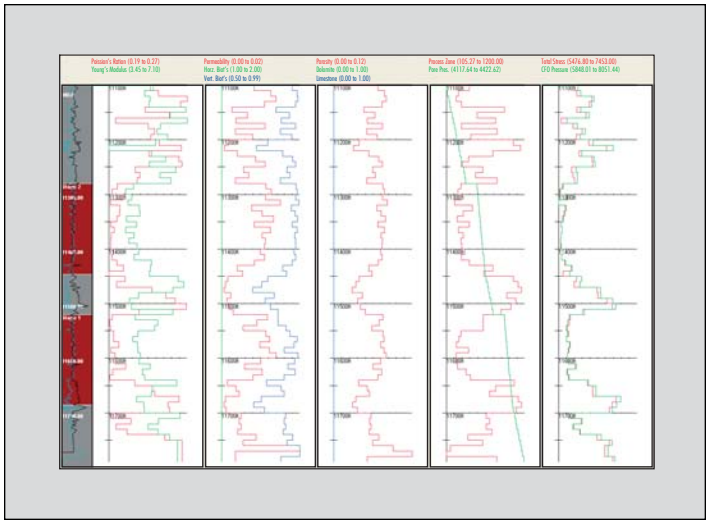


Figure 2. Discretized log input data as automatically read into the GOHFER simulator and interactively processed by the engineer

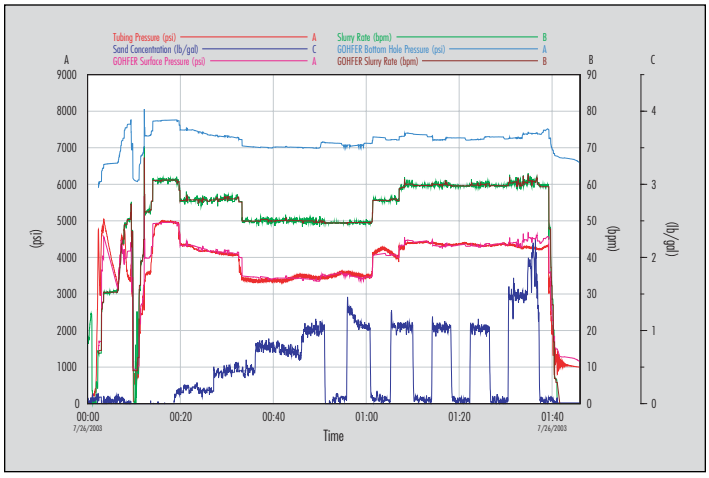


Figure 3. Match of the first-stage frac

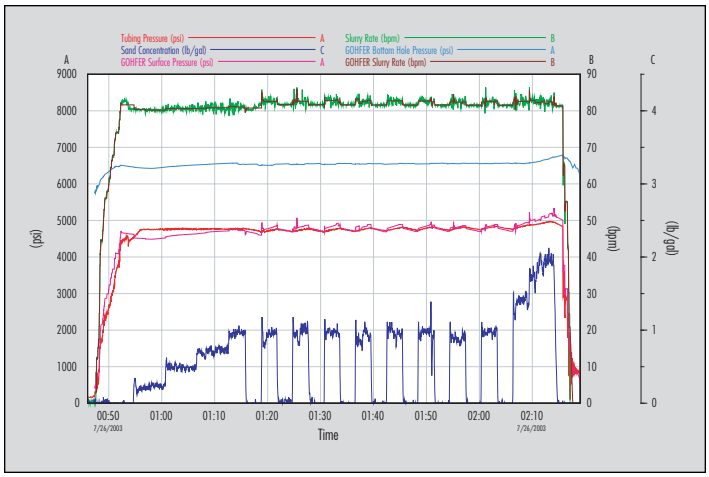


Figure 4. Match of the second-stage frac

and the effects of dynamic deformation during fracture propagation. These poroelastic effects are handled through the spatially variable Biot's constant. The inclusion of local variations in permeability and porosity allow modeling of spatially variable leakoff, which strongly affects fracture geometry and proppant placement.

In the match of the first-stage frac (Figure 3), the wellbore is initially filled with completion brine, which is displaced by low-friction slick-water. The GOHFER simulator allows injection of up to ten fluids with different wellbore frictions, densities, and time-dependent rheological properties during a single run. The effects of solids loading and N_2 and CO_2 quality on fluid friction and density are automatically accounted for. The accuracy of the wellbore friction model is clearly shown by the match between surface pressures and large rate changes during the job.

While there are no drastic rate changes in the second stage (Figure 4), the impact of changing slurry friction during the sand stages and the sweeps seen in the surface treating pressure are accurately matched by the simulator. The field-recorded rates, volumes, and concentrations are automatically converted to a pumping schedule for greater ease of use in the history-match run.

Optimize your fracture simulations and stimulations

The GOHFER simulator is easy to use for realistic 3-D fracturing design; and it is the ultimate tool for designing treatments in complex, heterogeneous reservoirs for vertical, deviated, and horizontal wells.

To arrange a demonstration, contact your Core Lab representative, or call 713-328-2320.