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GEOPHYSICAL SOCIETY HOUSTON

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GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 1 • Number 3

TECHNICAL ARTICLES:

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TECHNICAL ARTICLES

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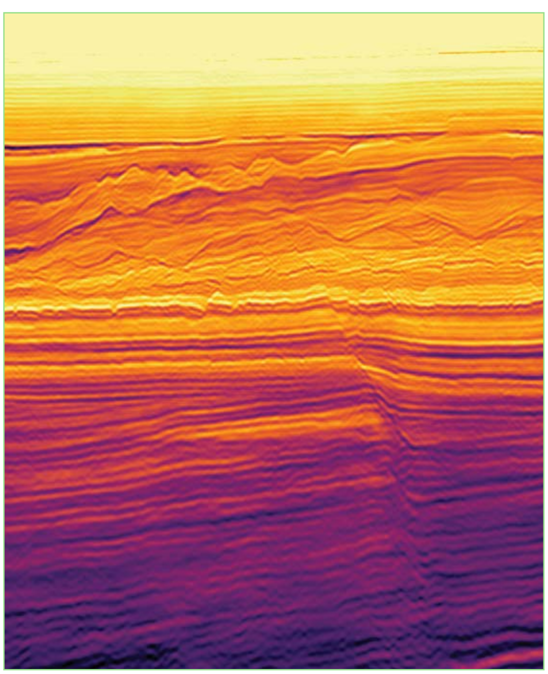
On The Cover...

In this depth image of high-frequency P-impedance we can readily identify the reservoir location — a beautiful flat spot! Made with DUG's elastic multi-parameter full waveform inveersion (eMP-FWI) imaging, using field-data input. This technology is a complete replacement for traditional seismic processing and imaging workflows, and the subsequent inversion workflow for elastic rock properties — simultaneously solving for reflectivity, Vp, Vs, P-impedance, S-impedance and density.



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Word from the Board

By: Kurang Mehta, 1st Vice President **November 2025**

The Geophysical Society of Houston (GSH) is a vital technical society that offers a convenient stage for geophysical collaboration across Houston. It is growing to become popular not only within the US, but also overseas. A key reason for the continued success of the Society is the collective effort of all the Board members and the broader geophysical community. As First Vice President, I am honored to be a part of this important society. Embarking on this journey a few months ago, it was my privilege to lead the effort in pulling together a successful Fall Forum on Oct 16, 2025, titled "From Waveforms to Insights – Latest Developments in Processing, Inversion and Artificial Intelligence".


Kurang Mehta

With the momentum created at the Fall Forum, my goal is to continue bringing high-quality geophysical discussions at the monthly Technical Lunches and SIG presentations. For a sustained line-up of speakers, GSH always welcomes professionals who would like to give a technical presentation in any of the above technical series. Regular follow-up discussion and high-quality potential collaboration has been a key outcome of these technical events.

April 2026, our next Spring Symposium is going to honor Tom Smith. Several volunteers have already signed-up to help with the Spring Symposium – thank you very much! With our seminars, events, and workshops, GSH is facilitating and accelerating the spread of cutting-edge geophysical technology and enabling learnings from each other's geophysical experiences.

In addition to organizing good-quality technical events, GSH is constantly striving to spread the word on energy sustainability and technical outreach, especially for our younger generation geophysicists. It is important that we bring emerging professionals into the mix and actively transfer our technical knowledge and leadership skills to them. This also includes working collaboratively with other societies such as HGS (Houston Geological Society) and SEG (Society of Exploration Geophysicists).

Skills that will be needed in the near future will be very different from what is required at this time. It is important to bring in younger geophysicists and offer them opportunities to volunteer or take on GSH roles to keep them engaged and up-to-date on the latest technological developments; making it easier for them to build/acquire the necessary skill sets of the future.

It is my honor to take on the role as First Vice President of GSH during the year 2025-26. In this capacity, my focus will always be to uplift the technical knowledge-level and let GSH be a safe space for both experienced and younger professionals to have meaningful geophysical discussion. With the Fall Forum behind us, and the Spring Symposium coming up in April 2026, I am in the middle of my term. This has allowed me not only to learn the current state of the GSH but also focus my effort on the mission and make progress implementing the vision of this important technical society.

I would like to conclude by requesting all geophysicists within Houston (and outside) to become a member of GSH and actively participate in the technical events organized throughout the year. By working together and learning from each other, we can keep up with the fast-changing world of technology and find a place for geophysics in the future. GSH will continue to be an enabler for innovation, collaboration and knowledge-transfer. I appreciate everyone who has helped me and GSH in this very exciting growth journey.

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Lessons from Missed Opportunities and Surprise Successes

Thursday, January 15, 2026
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Morning Session 1 "Practical Paths to Informed Decisions"

- **Systematic Exploration, Geologic Insight, Professional Networks, and Business Actions Leading to the Discovery of Unconventional Resources in The Permian Basin Wolfcamp Formation** Bill Fairhurst, Riverford Exploration
- **Risking Exploration Prospects – Lessons from the Dark Side in Leadership and Practice** Mark Shann, Westlawn Americas Offshore
- **Pendleton Field: A Case Study of the Horizontal Development of the Fractured Saratoga Chalk, Sabine Parish LA** Julie Garvin, Garvin Resources

Session 2 "Look Back Studies and New Ideas In Mature Areas"

- **The Sedimentology, Depositional History, and Reservoir Modelling of Zama Field, Offshore Mexico** Steve Cossey, Cossey and Associates; James Pasley; Howard White
- **Lessons from Understanding Structural Styles of the Central Graben in the UK and Norway** Rich Sears, Leading Energy Now

"The Deep-Dive Entrepreneur: Fusing Technical Mastery with Strategic Value Creation"
Special Luncheon Presentation by Scot Fraser, Aurivos

Afternoon Session 3 "Development and Testing of the Working Models"

- **The Opening Up of Mauritania Offshore: the Promise, a Discovery, the Disappointment, a Second Wave, and What Was Never Tested** Brian Frost, Retired, Anadarko
- **The Importance of "Co-Opetition" Among Players: The Case of the Vaca Muerta Unconventional Play** Daniel Minisini, ExxonMobil; Fernando Sanchez Ferrer, GeoPark
- **New Value from Old Wells – A Case for Revisiting Dry Holes**
  Matt Flannery, Stratum Reservoir

Session 4 "Integration of Geophysics & Geology in Play-Based Portfolios"

- **Reflecting on the Experience of an Exploration Project in Suriname – Lessons Learned from Seeing Both Sides of the Table** Scotty Salamoff, Bluware
- **Understanding Strawn Deposition and Production in Southern Oklahoma Using Machine Learning** Deborah Sacrey, Auburn Energy
- **Forensic Science in Geophysics: Unlocking the Value of Vintage Subsurface Data**
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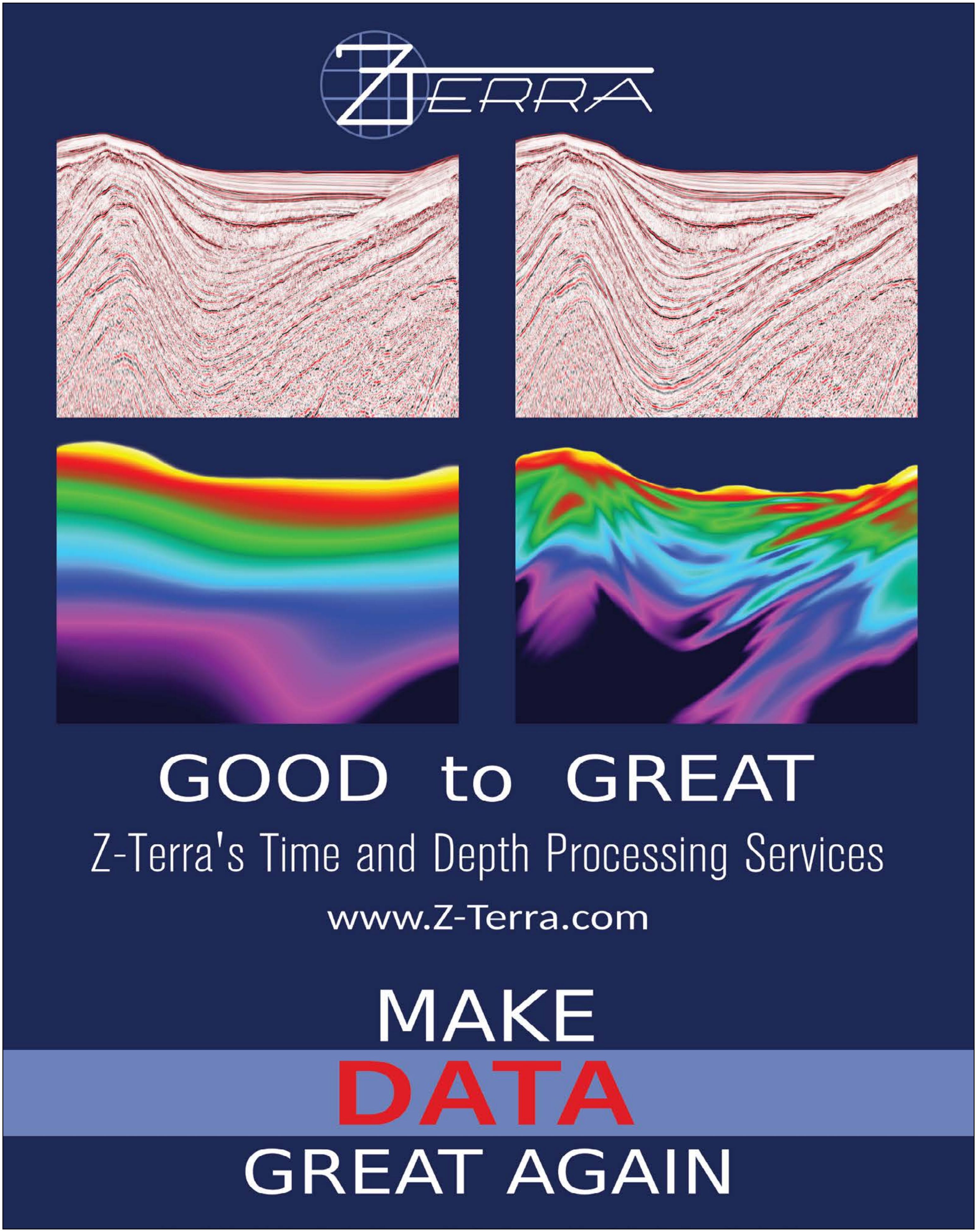
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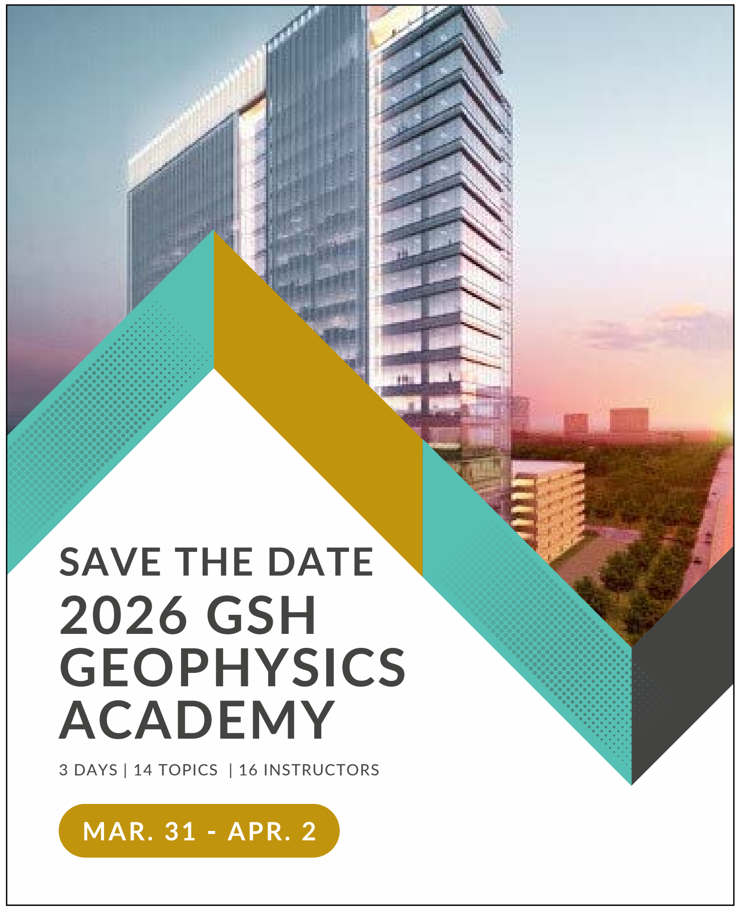

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GSH Museum News

GSH Museum Gravity Instrument Collection 1920 to 2022

ANNOUNCING A FOUR PART VIDEO SERIES EXPLORING THE 100 YEAR DEVELOPMENT OF THE INSTRUMENT TO MEASURE THE EARTH'S GRAVITY

Over the years, the GSH museum has been collecting vintage geophysical instruments including gravity meters. When each instrument arrives, staff members catalog it by recording its type, vintage, and donor. The goal is "preserve and educate."

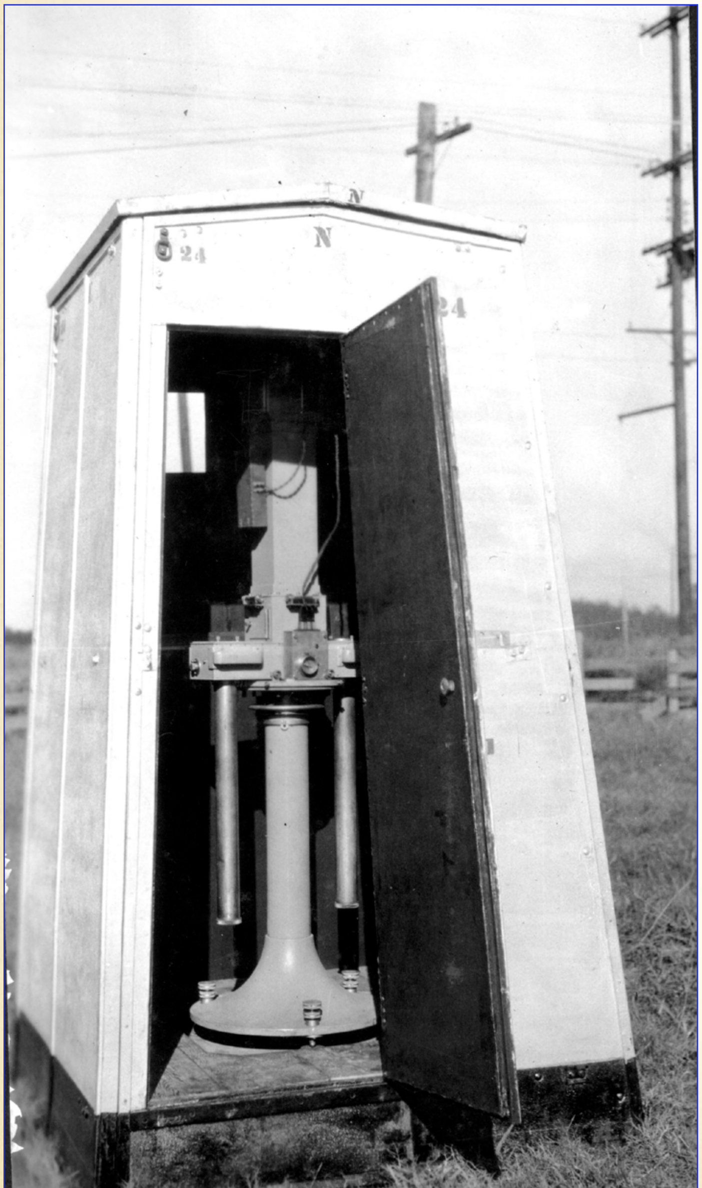

Figure 1. Tortion Balance & Cabin

A few years ago, Bill Gafford, GSH Museum Director, observed that the collection had grown to span 100 years: from a 1920 Askania Torsion Balance to a 2022 Syntrex gravity meter. In 2022, he decided it was time to have an archive made of the principal instruments in the collection and set out a plan that included asking Scott Hammond at Bell Geospace, Houston, for funding and me to be a geophysical advisor.

Building on Bill's work, we organized the list of instruments into a Timeline starting with the 1920 instruments. I reached out to industry colleagues for their insights on development of the gravity meter. I asked them to rattle their 'memory beads' to relate stories on the pioneers who initially designed and built the gravity meters, and the modifications made to the meter in order to go airborne and seaworthy. The gravity meter went under water in a diving bell before it started measuring the gravity field from a marine ship.

My colleagues were terrific. They came from Canada, California, New York, and Texas to have their commentary filmed and recorded. The result is a four part video series. The average length is 22 minutes per video except for the Video 2 Archival which is over 60 minutes. The four-part video series can be found on the GSH website.

The first video sets the stage with Bill Gafford describing the GSH Museum's beginning and addition of the potential fields instruments. He introduces the Robert Iverson Collection, originally acquired by the SEG, that added 20 opened (cut-out) instruments and allow us to view their inter-workings.

The second video is the principal video. It is the archival of the key instruments of the GSH Museum Collection. Five industry experts comment on the design and development of the meters. We start with Chris Nind, one time President of Syntrex, Canada, who defines the difference between relative and absolute gravity

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Figure 2. Gulf Meter

before discussing the Worden, Syntrex, and LaCoste-Romberg meters. Alan Herring, Vice-President EDCON, comments on GPS and the importance of navigation and position to measuring gravity field. Kevin MacNabb, founder of MWH Geo-Surveys, describes the reliability and versatility of the land gravity meters; including a delightful story about a 50-year-old L&R meter.

Figure 3. First FTG instrument 1998
Photo credit Bell Geospace

The third video features commentary emphasizing the business of measuring the earth's gravity field. After the Industrial Revolution created a monumental need for oil & gas, gravity meters played an important part in exploration. In the early 1900's, everyone was searching for salt domes. Bob Neese, President Gravity May Service, tells us about his father, Urban Neese, who in 1950 started an exploration company using the gravity meter to find salt domes. Luise Sanders, President Sanders Geophysics, describes her father, George Sanders who designed modifications to land gravity meters in order to acquire data via fixed-wing aircraft. Other experts offer stories and insights about how gravity is being used today.

Figure 4. Outback

The fourth video is on the future of gravity measurements: current advancements to the gravity meter instrument and where gravity data will be essential in the future. Dan DiFrancesco, Owner Niagara Gravity, describes what he sees developing in new technologies. Marshall Mac Nabb, President MWH Geo-Surveys who took over a 45-year-old business in 2023, comments on the instrument supplements such as digital terrain models that are advancing data resolution.

It took two years to complete this project. My deep gratitude goes to the colleagues who volunteered their time to share their expertise. This project was successful thanks to the financial support provided by Scott Hammond and Marshall MacNabb. Additionally, the unwavering commitment of Bill Gafford was instrumental throughout the entire process.

Corine Prieto
President
Geophysics-Minerals

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Rapid Lithofacies Interpretation Using Wireline Logs and Deep Learning

Margarita Kongawoin[1], Kyle Rosa[1] and Jie Guisset[1]

Interpreting lithofacies from wireline logs remains a fundamental task in subsurface evaluation, yet workflows are still dominated by manual interpretation, subjective judgement, and variability between interpreters. These limitations are amplified in regional studies and early-stage screening exercises, where large numbers of wells must be assessed rapidly and consistently. Decisions such as reservoir presence, interval ranking, or identification of zones requiring petrophysical review are often delayed by the time required for detailed lithological interpretation.

This paper demonstrates how a deep-learning workflow trained on rock-physics-calibrated training labels can generate fast, reproducible lithofacies predictions directly from standard wireline logs. Rather than replacing geological interpretation, the workflow provides a consistent first-pass screening tool that highlights stratigraphic variability, identifies log-quality issues, and guides focused quality control. The approach is particularly valuable when working with incomplete, noisy, or legacy datasets.

A rock-physics foundation for AI-based lithofacies prediction

The performance of any supervised machine-learning workflow depends critically on the quality and consistency of its training labels. In this study, training labels are derived from end-member rock-physics interpretations developed from DUG's multi-client rock physics library across the North West Shelf, incorporating more than 300 wells from the Browse, Bonaparte, Canning, Perth, and Carnarvon basins.

End members represent the cleanest and most diagnostic examples of each lithology, selected only

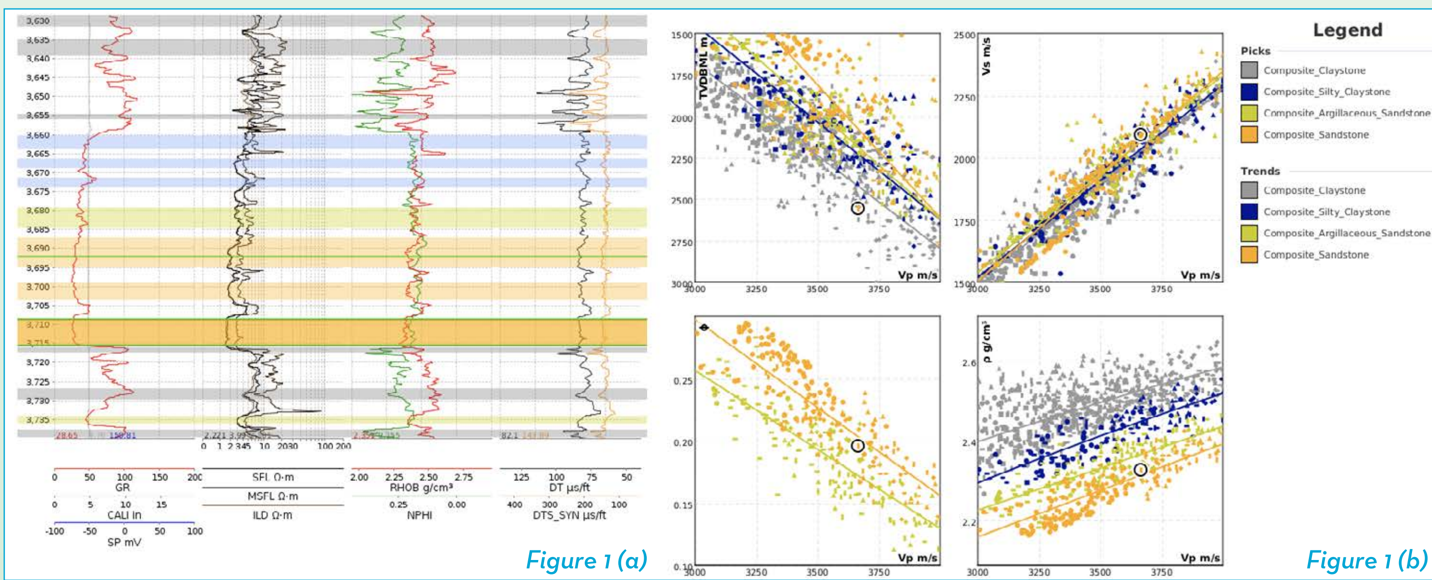

Figure 1. (a) End-member lithology picks (a subset of the group) used to train the AI/ML model, (b) after Backus upscaling, each interval maps to a single point in elastic-property space. Solid lines show depth-dependent rock-physics trends. These clean, physically consistent end members form the core training dataset.

[1] DUG Technology

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where wireline responses are internally consistent. Clean sandstone end members, for example, are identified where gamma ray, density, neutron porosity, and elastic responses collectively indicate minimal clay content and quartz-rich mineralogy. Shales, siltstones, argillaceous sands, and carbonates are treated in the same manner (Duncan et al., 2004 and Lamont et al., 2008). Intervals affected by poor borehole conditions or noisy logs are naturally excluded, resulting in a high-quality, internally consistent training dataset (Figure 1).

Model architecture and workflow

The lithofacies model architecture follows the framework described by Rosa, Kongawoin and Guisset (2025), combining a transformer-based sequence model with a one-dimensional convolutional neural network. The architecture is designed to capture both long-range depth-dependent trends and local log-response variability while handling missing data through attention masking.

The contribution of the present work lies not in modifying the model architecture, but in demonstrating its application within a broader interpretation workflow. This includes the use of rock-physics-calibrated training labels, derived from end-member intervals where density, neutron porosity, sonic, and gamma-ray responses are internally consistent, as well as the conditional use of model-estimated logs and multi-well quality control.

The model accepts commonly available wireline curves—including caliper, gamma ray, spontaneous potential, resistivity, compressional sonic (DT), density, neutron porosity, photoelectric factor and shear sonic—using whichever subset is present for an individual well. This enables prediction even in older datasets where logging suites may be incomplete.

From an interpreter's perspective, the workflow provides a rapid, objective screening tool that highlights stratigraphic changes, flags log inconsistencies, and directs attention to intervals requiring further review.

Case study: rapid insight from offset wells

Four anonymised wells (A–D) from within and adjacent to a gas field in the Northern Carnarvon Basin were selected for evaluation. Legacy wireline datasets were loaded, and AI/ML lithofacies predictions were generated consistently across all wells. The initial multi-well correlation (Figure 2) reveals two notable discrepancies: sandier interbeds in Well B relative to offset wells, and reduced sandstone confidence in the M50 interval of Well C. These discrepancies provide

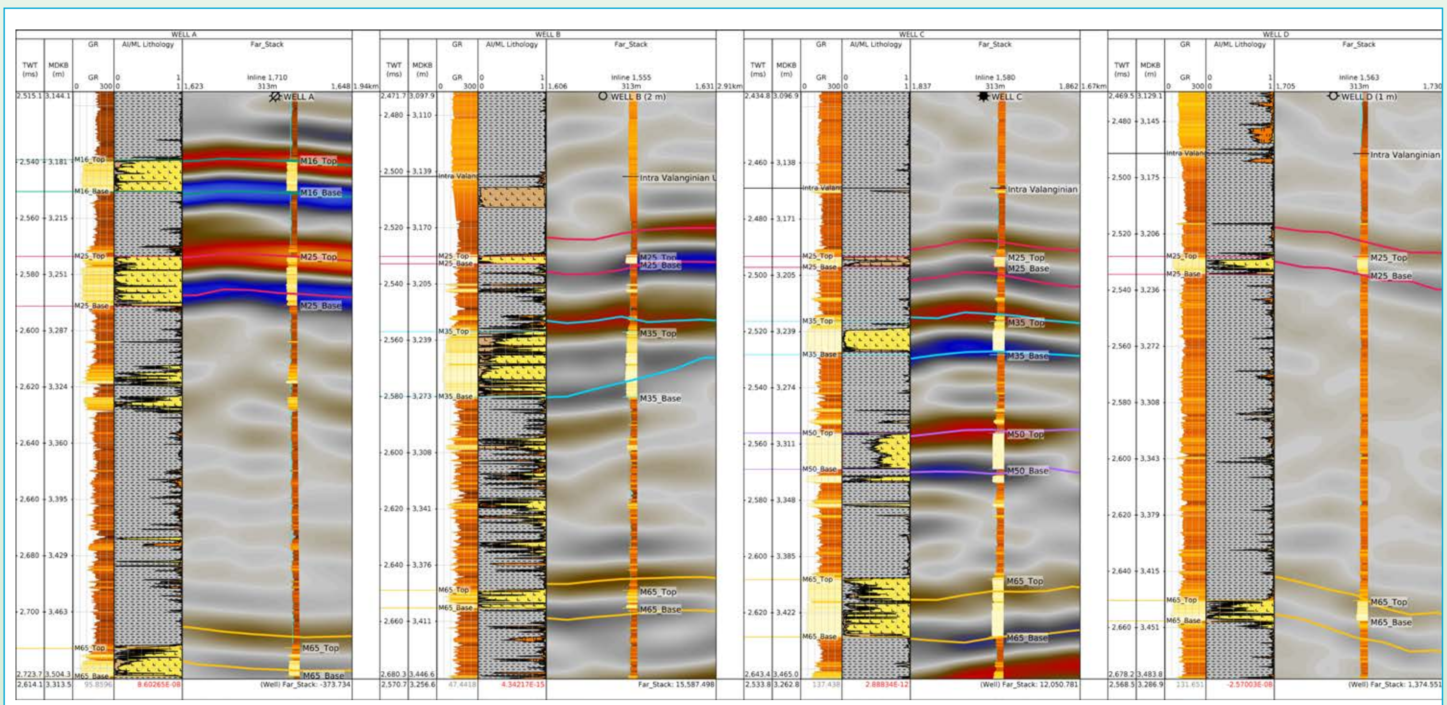

Figure 2. Initial multi-well correlation for Wells A–D, flattened on the Base M25 Sand. Shown are regional markers, gamma ray, AI/ML lithology prediction, and far-stack seismic amplitude. The correlation highlights two anomalies: sandier interbeds in Well B (between the M35 and M36 sands) and reduced sandstone confidence in the M50 interval of Well C.

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the basis for the two case studies that follow.

Density-log spiking and targeted density substitution

Figure 3 shows the curves used as inputs for the AI/ML lithofacies prediction for Well B (first five tracks), together with the resulting lithology prediction (sixth track). Between the M35 and M36 sands, the model predicts multiple siltstone intervals. Inspection of the density log reveals numerous high-amplitude, short-duration spikes that are not mirrored consistently in the other porosity or elastic logs.

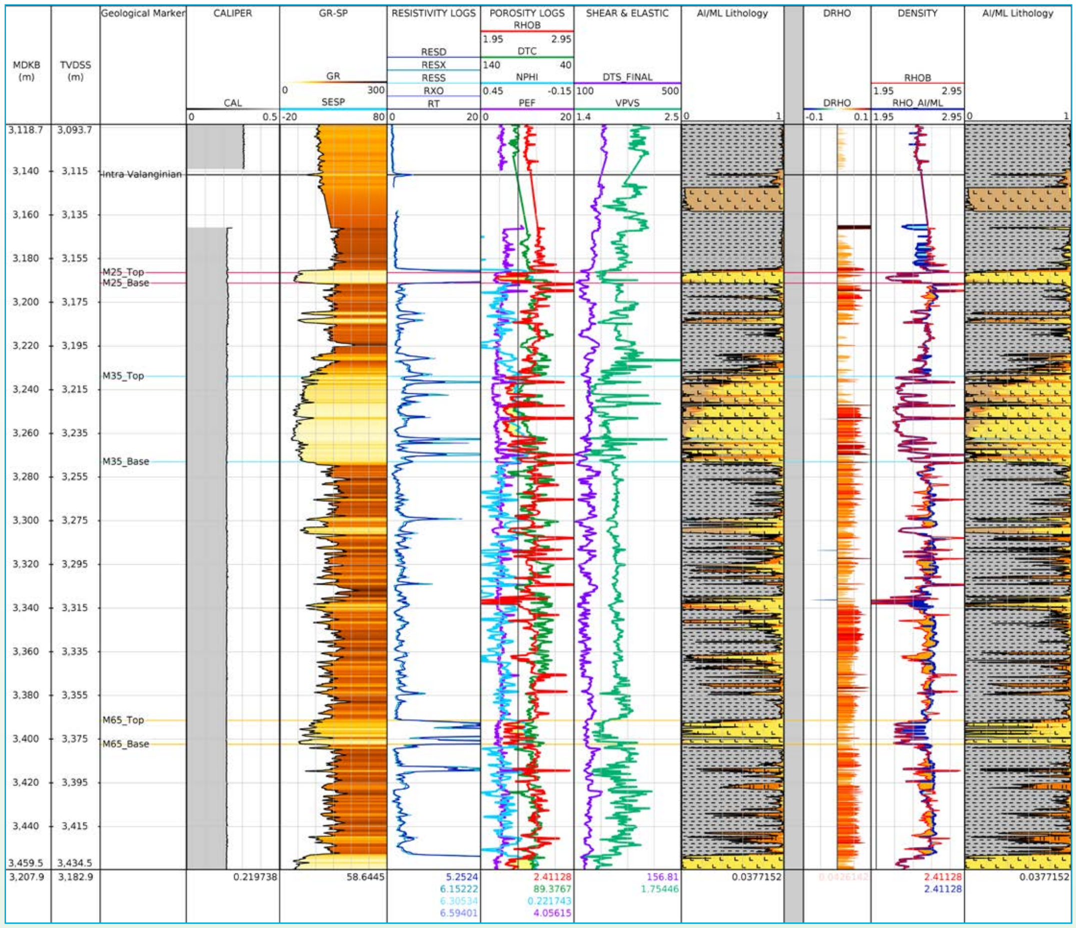
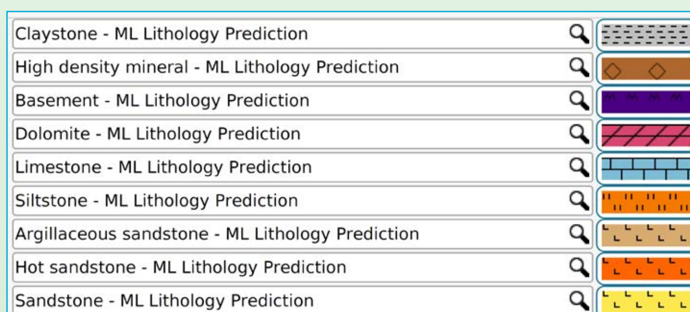


Figure 3. Well B log display illustrating density-log behaviour and targeted density substitution. Shown are the wireline curves used as inputs to the AI/ML lithofacies prediction (left), together with the resulting lithology classification (sixth track). The density correction log (DRHO; third track from the right) highlights intervals of elevated correction magnitude, predominantly positive, indicating increased sensitivity of the density measurement to environmental effects. Measured density (second track from the right) is shown in red, with the edited density shown in blue. AI/ML density substitution was applied only in shale-prone intervals (GR > 90 API) where |DRHO| > 0.03 g/cc; measured density was retained elsewhere. Pink fill indicates intervals where the model-estimated density is higher than the measured density, while blue fill indicates lower values. The edited density reduces spurious high-frequency excursions and results in a more geologically consistent lithofacies prediction between the M35 and M36 sands.

The third track from the right in Figure 3 displays the density correction log (DRHO). Predominantly positive DRHO values indicate that an upward correction was applied to the raw density measurement to compensate for environmental effects. Elevated absolute DRHO values therefore highlight intervals where the measured density is more sensitive to borehole conditions and where confidence in the corrected RHOB is reduced.



Legend – figure 3

To assess the influence of these intervals on lithofacies prediction, we tested the use of the AI/ML model's density estimate in a targeted manner. Rather than regenerating a full synthetic density log, a conditional substitution was applied in Well B. Measured density values were replaced with the model-estimated density only where two criteria were met: (1) gamma ray exceeded 90 API, identifying shale-dominated intervals, and (2) the absolute density correction exceeded 0.03 g/cc, indicating reduced measurement reliability. Outside these intervals, the measured density was retained. This dual-gate approach confines modification to shale-prone sections exhibiting elevated density correction and avoids unintended alteration of clean reservoir sands.

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In Figure 3, the measured density is shown in red and the edited density in blue. Where the AI/ML estimate is higher than the measured density, the fill is shown in pink; where it is lower, the fill is blue. The edited density exhibits a smooth, geologically reasonable trend, lacking the sharp excursions present in the measured curve. When this revised density is used as input to the lithofacies prediction, shale intervals become less silt-rich and the resulting facies distribution is more consistent with the offset wells.

Although any use of model-estimated curves requires validation through petrophysical judgement, this workflow effectively isolates intervals where density behaviour is likely to bias interpretation, allowing focused QC while improving efficiency and interpretive confidence.

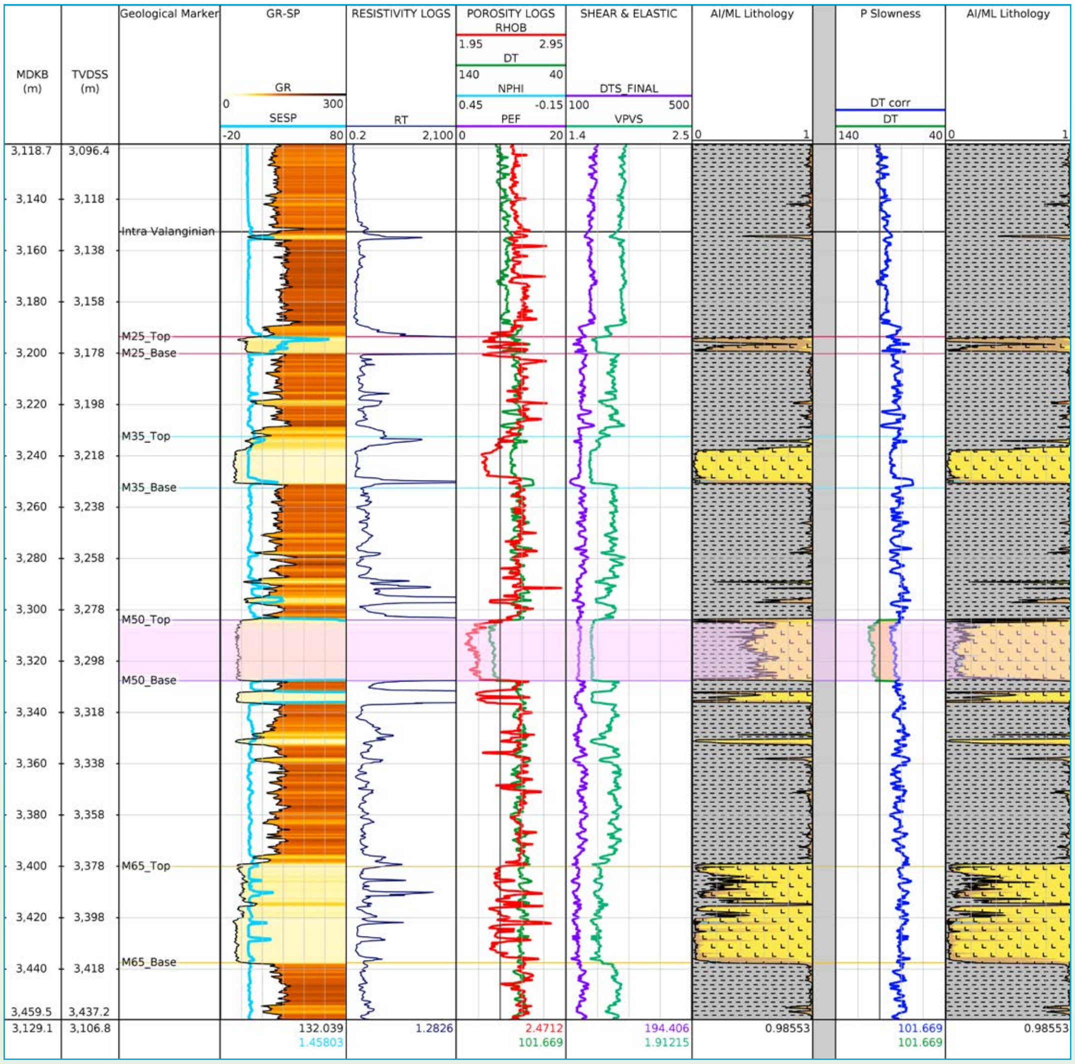
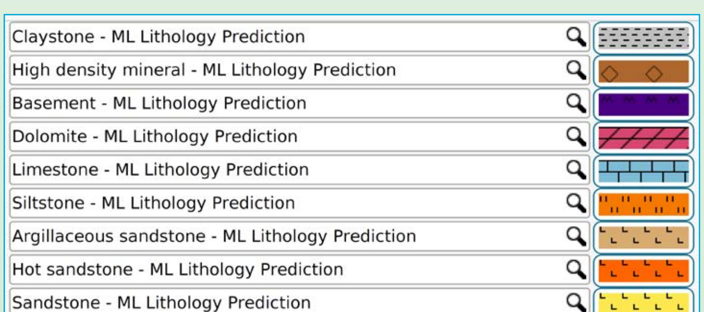


Figure 4. Well C wireline logs and AI/ML lithofacies predictions illustrating the impact of addressing compressional sonic cycle skipping in the M50 interval. Shown are the wireline inputs to the AI/ML workflow (left), together with the resulting lithology prediction using the measured sonic log (centre) and the corrected (model-estimated) sonic log (right). Despite low gamma ray and high resistivity, the lithology prediction using the measured sonic assigns reduced sandstone probability within the M50 interval. After substitution of the AI/ML estimated DT in the affected interval only, the lithology prediction shows increased sandstone confidence, consistent with offset wells. The correction is localised to the cycle-skipped interval, with the measured sonic retained elsewhere.



Legend – figure 4

Sonic cycle skipping and AI/ML correction

The M50 interval in Well C initially appears to contain clean sandstone based on low gamma ray, high resistivity, and consistent neutron-density porosity behaviour (Figure 4). Despite this, the AI/ML workflow assigns a lower sandstone probability in this interval than in equivalent stratigraphic intervals in Wells A, B and D (Figure 2).

To investigate this discrepancy, a sonic-density cross-plot (DT versus RHOB; Figure 5(a)) was examined. A distinct cluster of points with unrealistically fast compressional slowness (DT) is evident. When these points are projected back into the well view (Figure 4), they coincide precisely

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with the M50 interval in Well C. Such behaviour is characteristic of cycle skipping in the compressional sonic log. The affected DT values are inconsistent with the corresponding density and neutron porosity responses and fall outside physically plausible elastic relationships. Within this interval, the sonic log cannot be considered a reliable measure of formation velocity.

To assess the impact of this issue, the lithofacies prediction was recalculated using an AI/ML-generated DT curve within the affected interval. This adjustment does not introduce new geological information; rather, it restores elastic consistency with the independently measured density and neutron porosity logs. The resulting lithology prediction shows increased sandstone confidence in the M50 interval, bringing Well C into closer agreement with the offset wells.

To further assess whether the sonic correction preserves physically meaningful behaviour, DT–RHOB cross-plots were examined before and after correction (Figure 5a–b). Prior to correction, M50 points in Well C depart strongly from the collective well data due to unrealistically fast DT values. After correction, the same points collapse back toward the main data cluster without altering the broader elastic distribution, indicating that the adjustment restores internal consistency rather than imposing a new trend.

This example illustrates how AI/ML lithofacies prediction can act as a diagnostic tool, highlighting intervals where elastic logs violate rock physics expectations and guide focused quality control rather than wholesale data modification.

Updated multi-well correlation

After applying the targeted density substitution in Well B and addressing sonic cycle skipping in Well C, lithofacies predictions were regenerated for all wells. The updated correlation (Figure 6) shows improved continuity of key reservoir units and greater consistency across the well set. AI not only identifies where log issues are affecting interpretation, but also provides synthetic curves that allow interpreters to produce a corrected, plausible multi-well comparison.

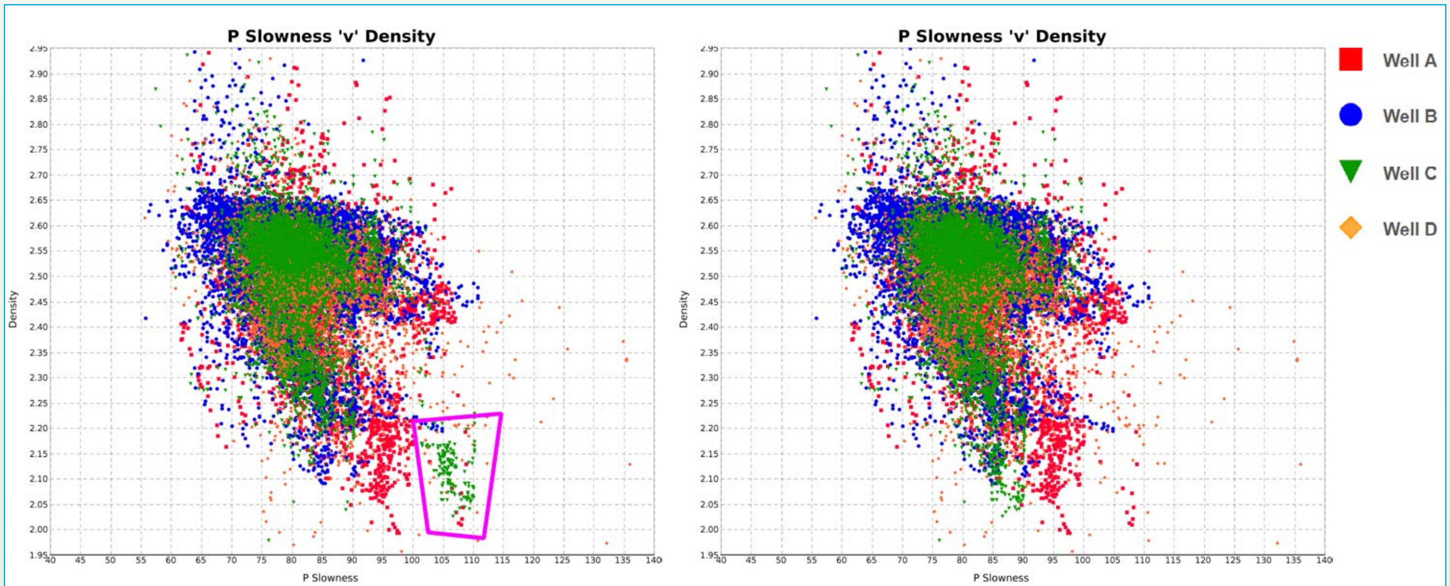

Figure 5. (a) Cross-plot of compressional slowness (DT) versus bulk density (RHOB) for all wells in the study. The highlighted polygon encloses a cluster of points with anomalously fast DT values relative to density. When projected back into the depth domain (Figure 4), these points correspond to the M50 interval in Well C and are interpreted as indicative of sonic cycle skipping. (b) DT–RHOB cross-plot after substitution of the AI/ML estimated DT in the affected interval of Well C. The previously anomalous points collapse back toward the main elastic trend defined by the remaining data, while the broader DT–RHOB distribution remains unchanged. This indicates that the correction restores elastic consistency without altering the overall character of the dataset.

Conclusions

Deep-learning workflows grounded in rock physics provide a powerful means of accelerating lithofacies interpretation across multiple wells. By training on curated end-member lithologies, the presented

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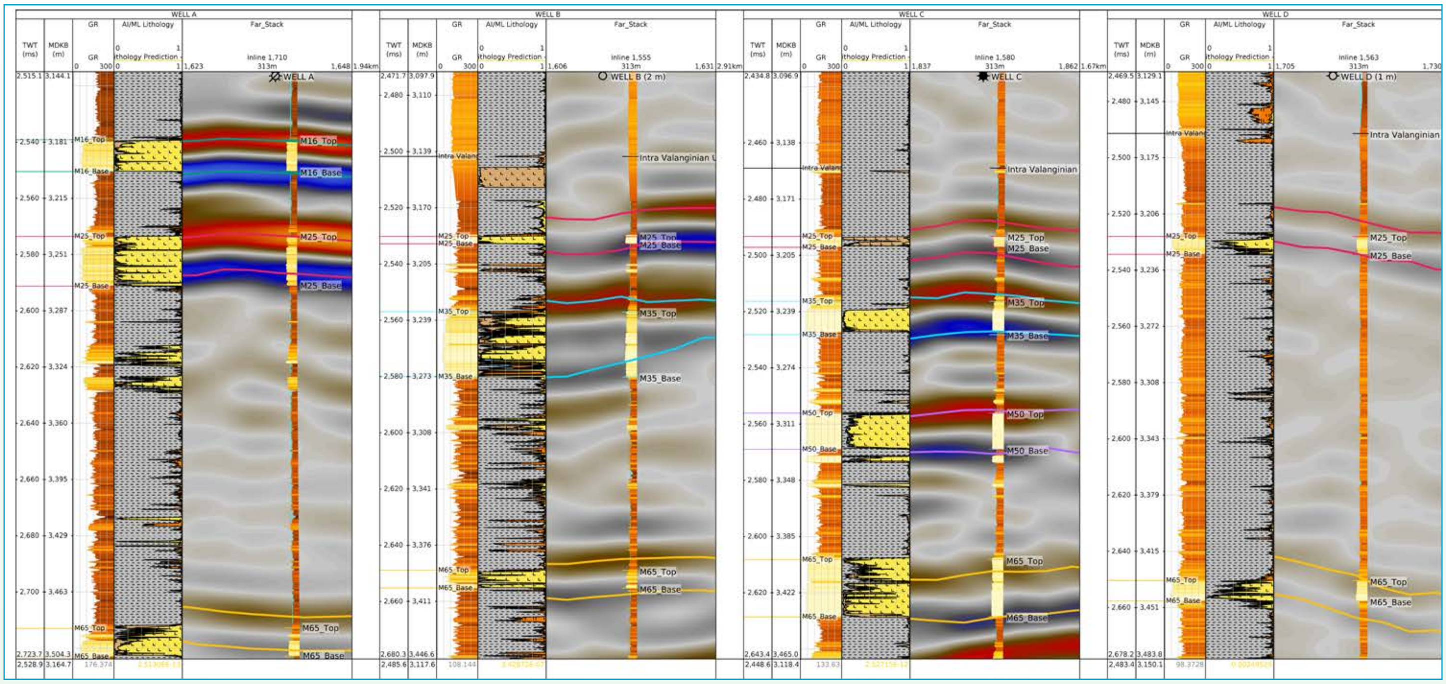

Figure 6. Updated multi-well correlation for Wells A–D after correcting density in Well B and addressing sonic cycle skipping in Well C. The revised AI/ML lithology prediction shows improved continuity of key reservoir units (M25, M35, M36, M50), more geologically consistent vertical facies profiles, and enhanced well-to-well alignment. Correlation is shown in TWT and flattened on the Top M25 Sand.

workflow delivers reproducible, geologically coherent predictions while also helping to diagnose log-quality issues that may otherwise distort interpretation.

The anonymised case study demonstrates how AI/ML lithology prediction provides rapid insight into geological variability, supports QC by highlighting anomalous intervals, and guides more efficient interpreter review.

While AI does not replace petrophysics, it significantly accelerates early-stage analysis and improves consistency across large datasets.

As regional studies continue to expand and logging suites vary across vintages, workflows such as this will play an increasingly important role in enabling scalable, objective subsurface interpretation.

References

i. Duncan, G., Jamieson, M., Morrison, A. and Glinsky, M.E., 2004. Lithology and fluid prediction in lightly explored basins. ASEG 17th Geophysical Conference and Exhibition, Sydney.

ii. Lamont, M.G., Thompson, T.A. and Bevilacqua, C., 2008. Drilling success as a result of probabilistic lithology and fluid prediction: a case study in the Carnarvon Basin, WA. The APPEA Journal, 48(1), 31–42.

iii. Rosa, K., Kongawoin, M. and Guisset, F., 2025. Classifying lithofacies in wireline logs with deep learning. EAGE Workshop on Enhancing Subsurface Practices Using AI/ML, Perth.

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Geophysical Society of Houston

Using Radioactive Tracer and Microseismicity to Measure Time-Dependent Stress Shadow Effects

Jonathan P. McKenna, **MicroSeismic, Inc.**

Multi-stage, multi-well completions cause pore-pressures to increase around each stage treated, compound from earlier offset treatment stages, then dissipate as the injected fluid leaks off into the rock formation. Rock stresses change in a dynamic fashion from virgin reservoir stress to an altered stress influencing subsequently treated stages which can restrict slurry propagation from these injections into regions experiencing excess stress. Stress shadows are time-dependent and dissipate over time and return to the virgin stress state. Microseismic focal mechanisms detected from a high-fold wide azimuth surface array can be used to observe and calculate stress changes in the reservoir and constrain the time it takes for stresses to return to the virgin reservoir state. Operators can take advantage of stress changes and contain fractures close to the stages by building stress wedges around subsequently treated stages. After stress dissipates fluid propagates into previously opened fractures leading to poor fracture containment.

In this paper, we review the effects of time-dependent stress shadows on multi-well completions in the Wolfcamp Formation in Southeast New Mexico. Then radioactive tracer data from the Niobrara Formation in the Denver-Julsburg basin is analyzed to provide further verification of the time-dependent process.

Increased stresses from previous treatments remain elevated for ~7 days which push fluid injected on neighboring wells away from the stress shadow. Production of well-specific tracer corroborates the hypothesis that local stress-shadows are elevated for ~7 days which can push fluid from subsequent neighboring wells. After stresses dissipate through the fractures created during the initial stimulation, new tracer on offset wells was produced as much as 3,000 ft away on a neighboring well.

Introduction

Microseismic monitoring is a proven technology for observing and mapping reservoir response to hydraulic fracture stimulations. The event radiation pattern of the P-wave first arrival reveals advanced characteristics of the fracture describing deformation at the source location when detected using a high-fold wide azimuth surface array. The full-moment tensor can be generally decomposed into the relative percentages of isotropic, double couple and compensated linear vector dipole components (e.g. Aki and Richards, 1980) which fully describes the failure process in terms of volume change, amount of shearing, and other complexities related to deformation. The local stress field can be calculated using a set of focal mechanisms by minimizing the misfit angle between the modeled stress field and the observed focal mechanism slip vectors (Angelier, 1989) where the local stress field extent is defined by the spatial extent of the observed focal mechanisms. The local stress field orientation and relative magnitude can be resolved for a group of microseismic focal mechanisms by minimizing the misfit angle between the modeled stress field and the observed focal mechanism slip vectors for the subsets using a method described by Vavrycuk, 2014.

Injected fluid from hydraulic fracturing causes pore-pressures to increase around each stage treated, compound from nearby treatment stages, then dissipate as the injected fluid leaks off into the rock formation. Rock stresses respond by transforming from the background virgin stress state to a highly altered stress state then slowly return to the original virgin stress state. This phenomenon occurs due to stress shadows that linger around the treated rock where due to poroelastic and mechanical effects (Zoback, 2007; Roussel et al., 2009) and remains elevated until pore-pressure dissipates, and stress returns to the original virgin stress state.

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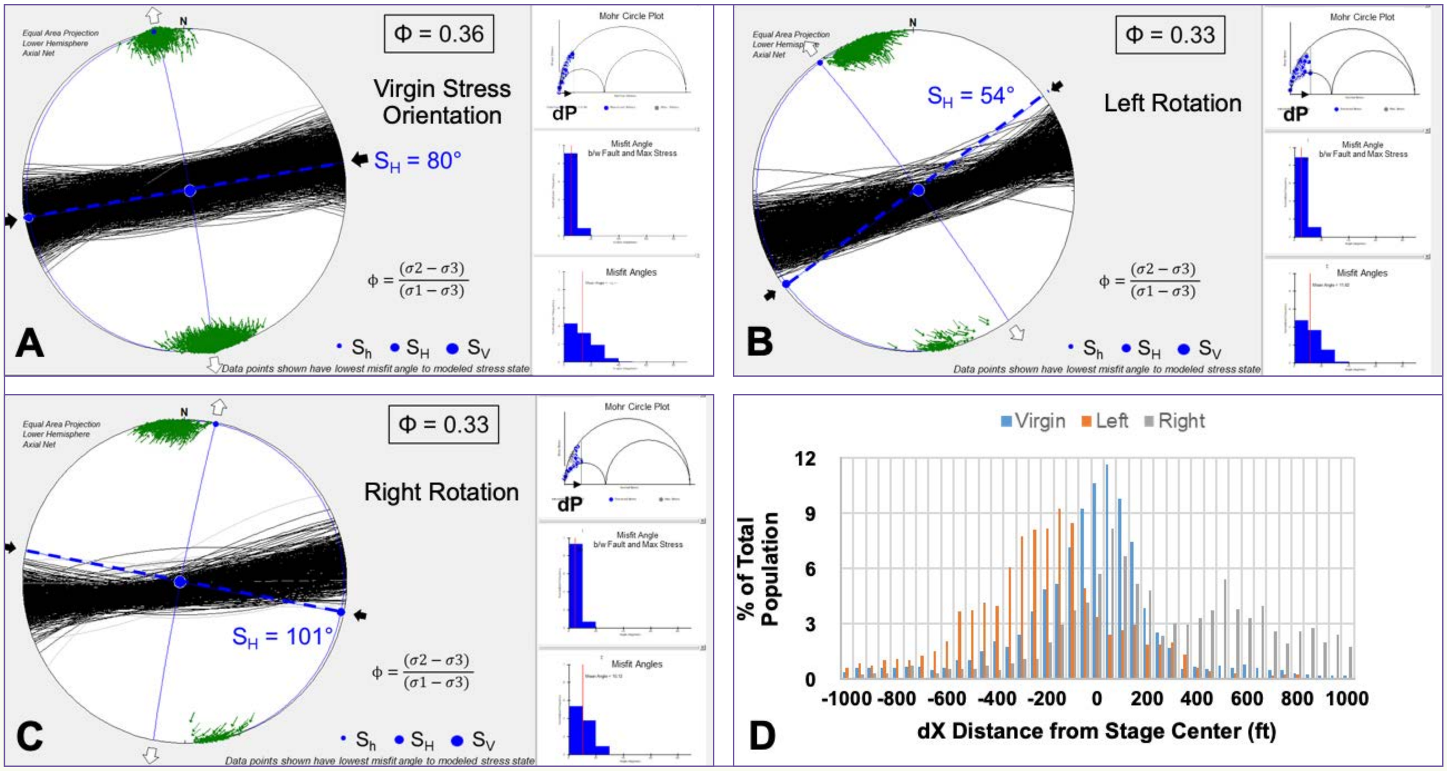

*Figure 1: (A) Virgin stress, (B) altered left-lateral rotation, (C) altered right-lateral rotation, (D) Stress-state distribution horizontally from wellbore. Top 3 images—green slip linear vectors: located at poles to fracture planes (black), oriented by rake (normal dip slip point outward, strike slip point parallel to great circle), point to **Shmin**. **Shmin** oriented by blue dashed linie, **Sv** vertical representing normal stress regime. Right side plots from top to bottom—Mohr circle, misfit angle between fault and maximum stress, misfit angles. This figure is modified from McKenna et al. 2022.*

For an example of the use of microseismic focal mechanisms to measure stress rotations from a multi-stage, multi-well hydraulic stimulation see McKenna et al., 2022. In the Wolfcamp Formation in Southeast New Mexico, McKenna showed that stress shadow impact on neighboring wells is dependent on stage-lag time (time between start pumping time of current stage and end pumping time of neighboring stage from a partner well). Findings are summarized in this section.

Results from McKenna et al, 2022 show that in the Wolfcamp Formation study area, *SHmax*=N80°E and stress anisotropy, ϕ=0.36 in the virgin stress state $\left(\phi = \frac{(\sigma_2 - \sigma_3)}{(\sigma_1 - \sigma_3)}\right)$. During hydraulic stimulation horizontal stress anisotropy is reduced (ϕ=0.33) due to stress shadowing and *SHmax* rotates ~+/- 24°. Increased pore-pressures from previous treatments remain elevated for ~7 days confining fluid distribution to near the well on ensuing stages. Sufficient pressure dissipates after leakoff providing opportunity for the fluid to propagate into previously opened fractures.

Stress inversion results are shown in Figure 1. The green slip linear vectors shown on the stereo net all point to minimum horizontal stress, *SHmin*. These slip linear vectors are located at the pole azimuth to the fracture planes (fracture strike +90°) with highest dips plotting on the outer perimeter of the great circle and shallowest dips plotting towards the origin of the great circle. Slip linear vectors are oriented by the fracture rake.

In figure 1A, slip linear vectors (green) matching the virgin reservoir stress point outward indicating that they are primarily composed of normal dip-slip focal mechanisms. As shown on figure 1D, the virgin stress events are distributed proximal to the treatment well.

In figures 1B-C, slip linear vectors (green) matching both the left-lateral and right-lateral altered stress states are oriented more parallel to the great circle indicating that they are primarily composed of strike-slip focal mechanisms. Left-lateral stress rotation events are concentrated on the left side of the wellbore and right-lateral stress rotation events are located on the right side of the wellbore (figure 1D) matching theoretical

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models that show principal stress trajectories wrapping around a cylindrical opening based on the Kirsch equations (Kirsch 1898, Jaeger and Cook 1979).

Stress inversion results (*SHmax* azimuth and stress anisotripy, ϕ) are calculated for each initial input value of *SHmax* azimuth and stress regime (e.g. normal, strike-slip, reverse stress regimes). It has been shown that virgin reservoir SHMax orientation interpreted from the stress inversion method is calibrated as the output *SHmax* orientation consistent with the greatest number of events and has the highest stress anisotropy value, ϕ (McKenna et al., 2022). This *SHmax* orientation also matches the average strike of the observed normal dip-slip mechanisms and is consistent with published values (e.g. Lund Snee and Zoback, 2020) for the area of study.

Figure 2 shows the impact of stage-lag time on the development of stress shadows. Fracture and proppant modeling is performed using a method described by

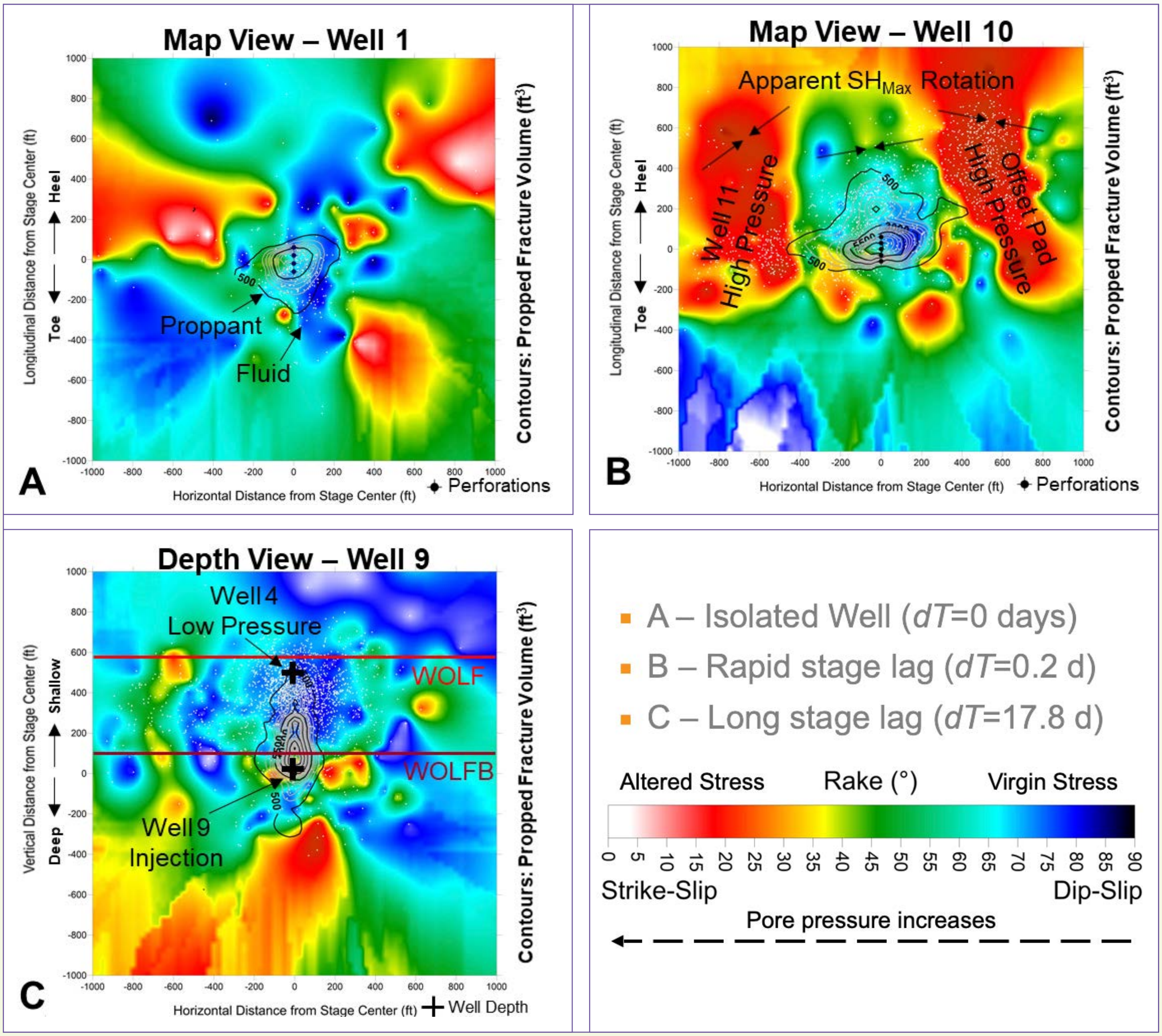

*Figure 2. Contours show modeled proppant which mimics normal rake distributions (cool colors). All stages stacked, referenced to treatment stage center. Image colored by rake, events white. (A) Well 1 treated in isolation (dT =0), (B) Well 10 zippered with well 11 (**dT** =0.2 d), (C) Well 9 treated below well 4 after pore pressure dissipates (**dT** =17.8 d). This figure is modified from McKenna et al. 2022.*

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McKenna et al., 2015. Initial calibration of the fracture model is performed by assuming that the total fracture volume informed by the microseismicity is equal to the injected slurry volume minus leakoff into the formation (after McGarr, 1976). Leakoff is measured using Diagnostic Fracture Injection Test (DFIT) or similar tests. Figure 3 shows the different ways to visualize the data: microseismic events, Discrete Fracture Network (DFN), Stimulated Rock Volume (SRV) and Productive Stimulated Rock Volume (PSRV®). The SRV and PSRV® are geocellular representations of the DFN and Propped Discrete Fracture Network (PSRV®) respectively.

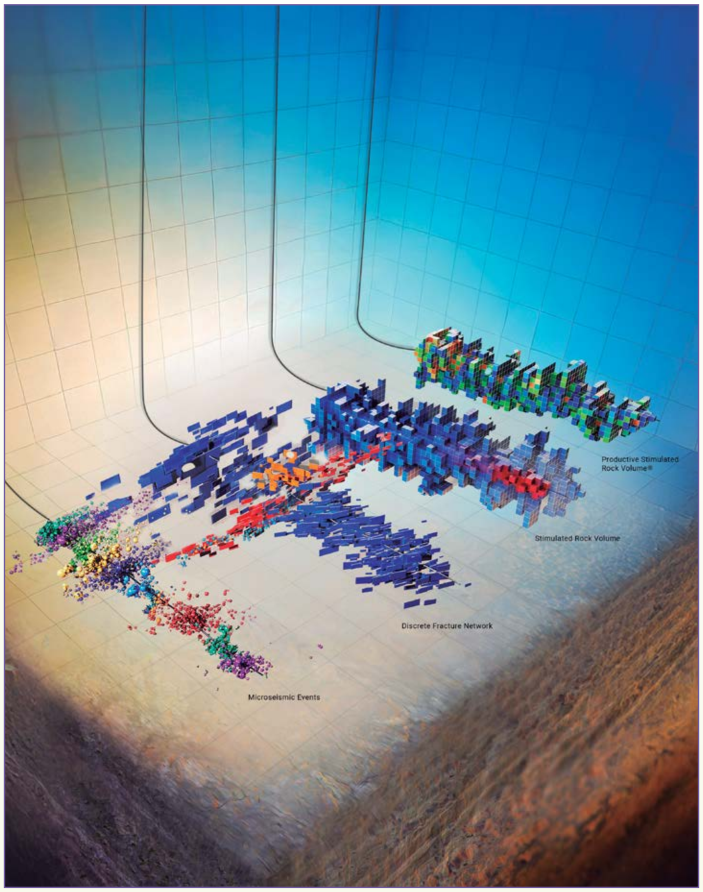

Figure 3. Example microseismic data displayed as microseismic events, Discrete Fracture Network (DFN), Stimulated Rock Volume (SRV) and Productive Stimulated Rock Volume (PSRV®)

Three examples are shown on Figure 2 in order of increasing stage lag time from A-C: (A) an isolated well, (B) rapid stage-lag time with zippered well treatments spaced 900 ft to the left and right of the treatment well, and (C) long stage-lag time with the deep well treated 17.8 days after the shallow treatment well. Each plot shows fracture rake values ranging from cool colors (dip-slip) to warm colors (strike-slip). In this example, cool dip-slip events represent fractures occurring where the rock stress matches the virgin stress state and warm strike-slip colors represent areas where the rock is experiencing an altered stress state due to stress shadow effects from previously treated stages. Stress shadow effects during stimulation of the isolated well (figure 2A) are confined to the outer fracture tips and modeled proppant remains close to well being treated.

In the case of zippered wells (figure 2B), stress shadow effects are pronounced around the previously treated wells on either side of the treatment well and proppant is contained between the high stress regions and pushed towards the heel of the well away from stress shadow effects on the toe. Since well spacing is 900 ft and the majority of proppant is contained within 200 ft horizontally from the wellbore, stress shadows are primarily located 300-650 ft from the wellbore which is between the wellbores in the fractured but unpropped region of the newly developed fractured network. An apparent rotation in SHmax was observed where *SHmax*=N80°E for events proximal to the wellbore (virgin reservoir stress state, figure 1A), *SHmax*=N54°E for events on the left side of the wellbore (altered stress state, figure 1B), and *SHmax*=N101°E for events on the right side of the wellbore (altered stress state, figure 1C). These results suggest that the rotation direction is dependent upon the azimuth that the stress shadow in encountered by the injection.

For the final case (long stage-lag time, figure 2C) stress shadow effects have dissipated after 17.8 days passed since stimulation of the shallow Well 4. This is evidenced by the fact that fracture rakes have returned to cool colors which are normal dip-slip rakes that are characteristic of the virgin reservoir stresses. In this case, proppant from Well 9 is transported back to Well 4 via the newly created fractures created during the initial stimulation of the shallow Well 4 which reduces the effectiveness of the stimulation around the treatment Well 9.

Figure 4 shows the results of the stage-lag analysis performed by McKenna et al., 2022 using events that match the virgin reservoir stress state for wells treated in the Wolfcamp Formation. Figure 4A summarizes the average values for each well and shows the treatment order for each well. Results show that for wells treated in isolation from offset wells or treated with stage lag, dT<7 days, events associated with the virgin stress state

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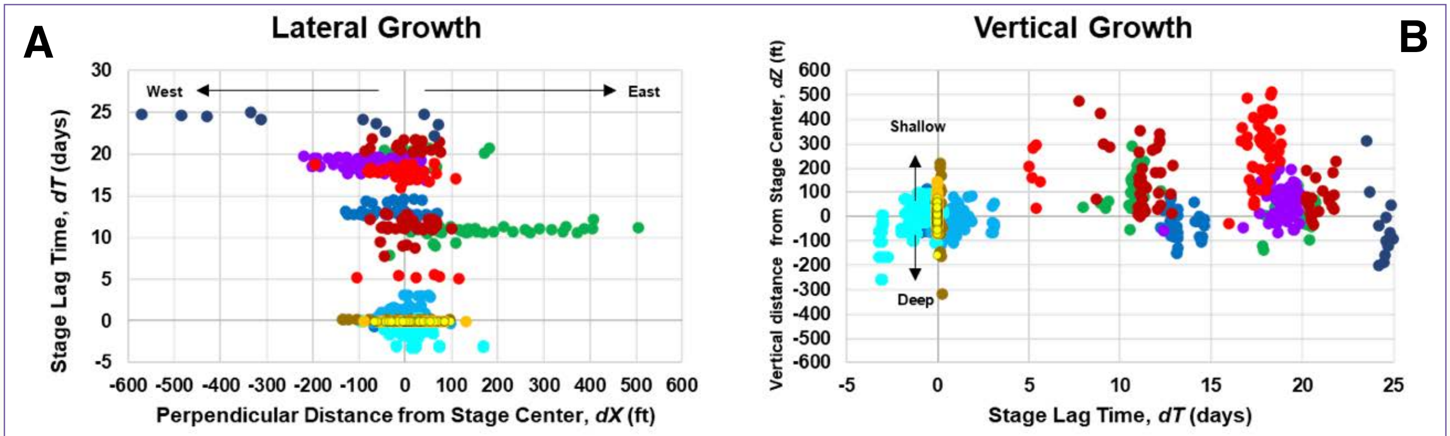

Treatment Order
6→4→1→2→3→9→7→5→8→11→10

- Low stage lag: events remain close to wellbore
- High stage lag: events propagate to neighboring wells unhindered along previously created fractures

C

Well	Partner Well	dT Avg	dX Avg	dZ Avg
1	2	0.0	30	22
2	1	0.0	10	6
3	6	12.8	-20	-17
4	6	1.1	6	-20
5	3	11.0	98	97
6	3	-1.0	12	18
7	4	19.3	-69	66
8	3	12.1	4	97
9	4	17.8	-1	294
10	11	0.2	-32	-1
11	12	24	-356	91

Figure 4. (A) ***dX*** *centroids for each well-stage increases with* ***dT****. (B)* ***dZ*** *centroids for each well-stage increases with* ***dT****. (C) Stage lag (dT) and average centroid locations for each well (****dX*** *and* ***dZ****). This figure is modified from McKenna et al. 2022.*

are centrally distributed horizontally and vertically from the wellbore. After 7 days, stress has dissipated and injected fluid fills previously created fractures from the neighboring well.

Theory and/or Methods

Microseismicity detected during hydraulic stimulation of multiple wells in the Denver-Julesburg basin were analyzed to (1) invert observed focal mechanisms to determine stress orientations and relative magnitude of the principal stresses, and (2) establish a correlation among stage-lag time and event-population centroid with respect to each stage treated. This method was reported by McKenna, 2023 and is summarized here.

Fracture growth and associated increased pore-pressure from the injection predominantly grows in the direction of SHmax which increases pore-pressure and stress around subsequent stages in the treatment. Therefore, SHmax orientation measured from the stress inversion was used to determine the nearest offset stage along SHmax azimuth that is influenced by each stage in the treatment. Stage center locations were rotated counter-clockwise by SHmax - 90° so that the dominant fracture growth direction is oriented to East-West. Then the newly rotated stage center coordinates were plotted versus treatment date of each stage treated.

The stage-lag time analysis was performed to test the results found by McKenna et al., 2022 that stress shadows develop around previously treated stages that restrict slurry propagation from subsequent injections but dissipate over time. The correlation is used to constrain stage-lag time for local stress shadows to dissipate, allowing fluid to propagate toward previously treated stages along newly created fractured network.

Stage-lag times are compared to injected well-specific tracer chemicals during production over a 25-day period to understand the influence stage-lag time has on fracture growth and tracer movement. The tracer is blended with proppant during the treatment in a

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solid form that mimics the characteristics of proppant but once it encounters oil, the tracer reverts to a liquid so that it can flow back to the closest well and be produced and quantified at the surface over time. After ~6 months, most tracer concentrations fell below detection limits. It should be noted that the parent wells were not on production during flowback of the tracers.

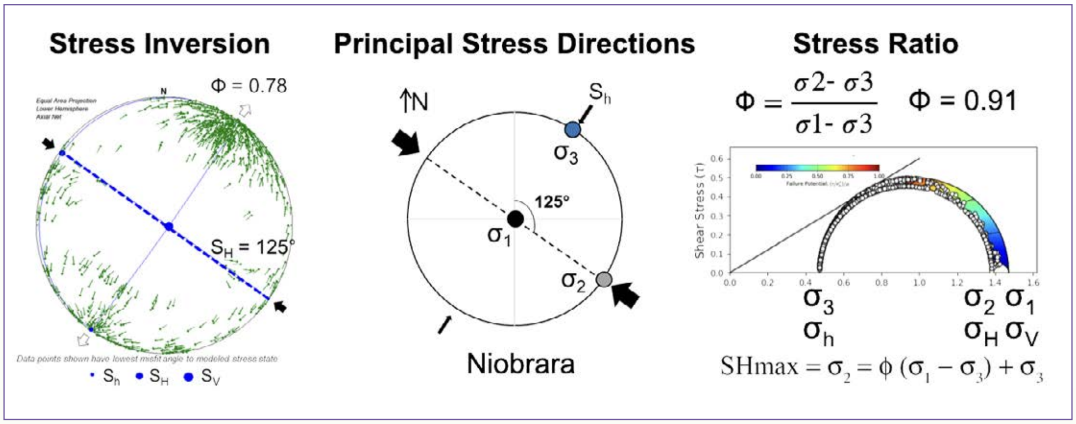

Figure 5: Left figure shows a plot of treatment date of each well's stage as a function of the rotated northing coordinate of each stage center. Right figure shows the discrete fracture network model.

Results

Stress inversion results (Figure 4) show that in the Niobrara Formation *SHmax*=N125°E and stress anisotropy, ϕ=0.91 in the virgin stress state. This information was used to determine the dominant fracture growth direction which is shown on figure 6 as a green dashed line.

Figure 6A shows the treatment order plot using the rotated stage center coordinate outlined in the methods section. Using the rotated stage coordinates and combining that with the fact that stages were treated from North to South (heels located in the South, figure 6B), the leading well stages are located earlier in time and with lower rotated Northing coordinates. The actual treatment order for each well shown in Figure 6A differs from the apparent treatment order when not considering the dominant fracture growth orientation is parallel to *SHmax*.

The conclusion from McKenna et al., 2022 is that stress shadows should exist in the direction of the partner well if the treatment well was treated < 7 days after the partner well and the treatment fluid should be pushed away from the stress shadow that persists around the partner well. Figure 7B shows the stage-lag average times for the treatment wells and the final column summarizes whether or not a stress shadow will persist in the direction of the partner well or if dT<7. If a stress shadow should still exist around the partner well then the tracer should be pushed away from the partner well. We use the stage-lag time <7 days to predict whether the tracer should be pushed away from the partner well or not and compare the actual tracer distribution to this prediction and results are tabulated in the last column of figure 6B.

Results of the produced tracer are summarized in figure 7. Well numbers correspond to the order that the wells were treated. The first well treated, Well 1, is located to the West of a parent producing well shown as a dashed line between well 1 and well 2. All parent

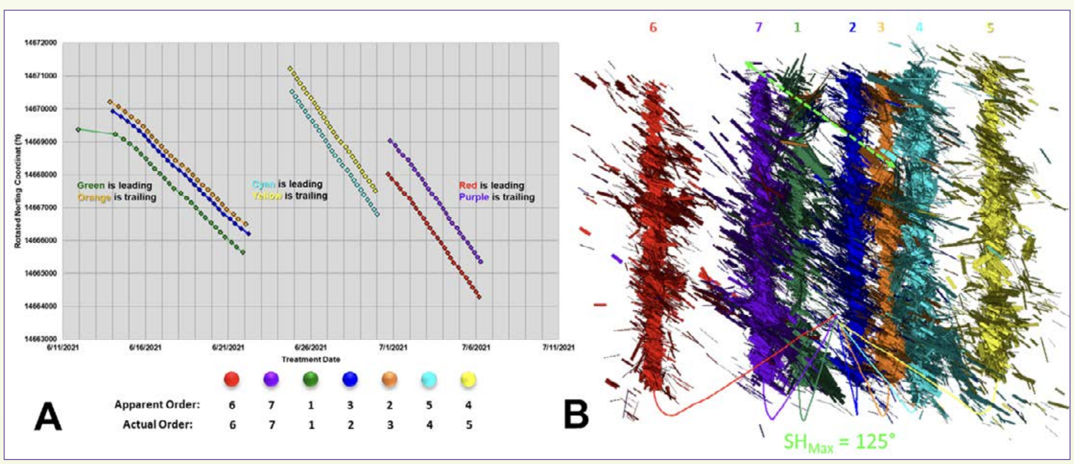

Figure 6: (A) Plot of treatment date of each well's stage as a function of the rotated northing coordinate of each stage center, (B) discrete fracture network model created from the observed micrroseismicity.

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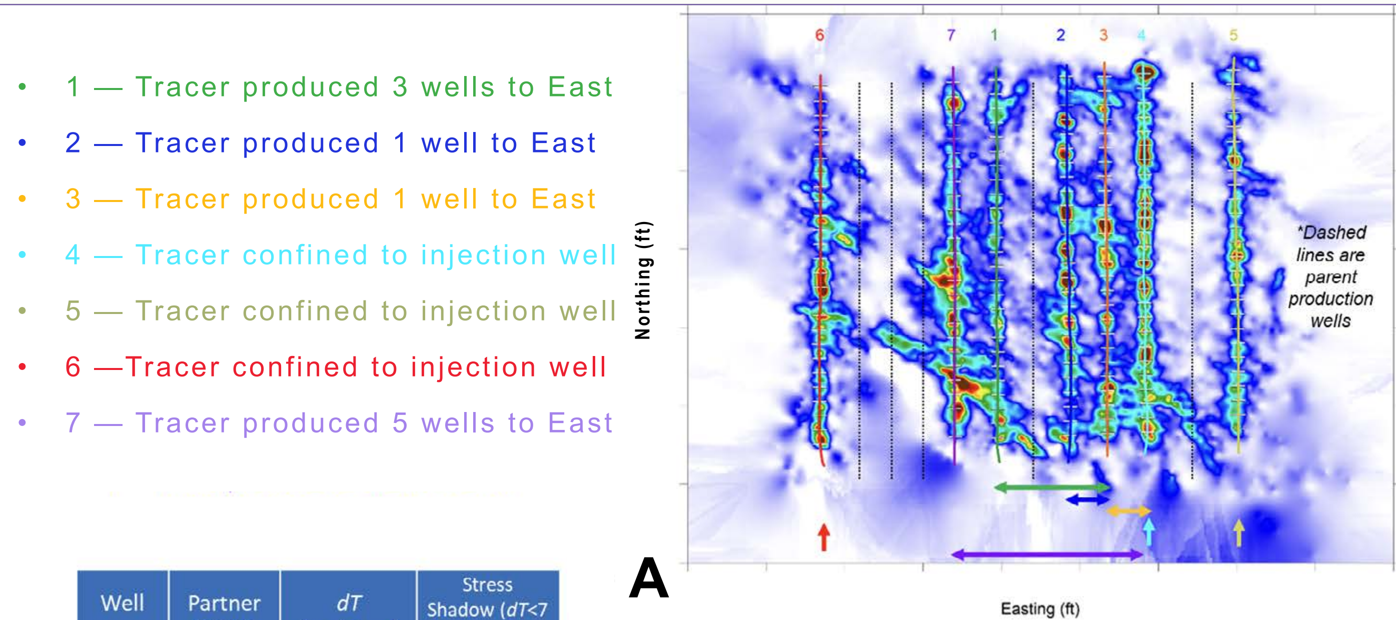
wells were drilled and produced > 1 year or 365 days prior to the treatment of the wells in this study and dT >> 7 days so tracer should go towards the producing well which it does. In fact, the tracer is found all the way over on Well 3. Production from the parent producing wells creates a local sink in pore-pressure and much of the microseismicity from Well 1 went East. According to figure 7C, 85.54% of tracer injected into Well 1 was produced by well 1, 10.62% produced by Well 2 and 3.14% produced by Well 3. The fact that most of Well 1 injected tracer went to the East sets up a chain reaction where the stress shadow around Well 1 pushes tracer injected into Well 2 to the East and the stress shadow around Well 2 pushes tracer injected into Well 3 also to the East. This is predicted to occur because stage-lag time for Well 2 and 3 are both < 7 days. The majority of tracer injected into Well's 4 and 5 were produced by themselves because there is an old parent well to the East of Well 4 and no other well to the East of Well 5 where tracer could be produced and measured.

Tracer from Well 4 is correctly predicted to not go back towards its Partner Well 3. Very few fractures from Well 4 make it all the way to Well 5 (Figure 5).

Well 6, located on the far West portion of the pad has three parent producing wells to the East between Well 6 and Well 7. Even though much of the micoseismicity from this well went East (Figure 6), the majority of the tracer was produced by itself and negligible amounts of tracer made it to Well 7. Finally, by the time Well 7 was treated, 14 days had elapsed since Well 1 was treated (Well 7 dT=14.0 days, figure 7B). By this time, the stress shadow initially developed around Well 1 had dissipated. This allowed injected tracer to be produced on Wells 1-3 and produced as much as 2500 ft to the East. In addition, this influx of fluid may have been responsible for pushing tracer from Wells 1-3 even further East than during the initial treatment of that well.



B

Well	Partner Well*	dT Avg (days)	Stress Shadow (dT<7 days)?
6	Parent	>365	No
7	1	14.0	No
1	Parent	>365	No
2	1	1.3	Yes
3	2	0.5	Yes
4	3	9.1	No
5	4	0.6	Yes

C

Injection Well (columns) / Production Well (rows)

WELL	6	7	1	2	3	4	5
6	99.20	0.55	0.24	0.32	0.30	0.38	0.25
7	0.19	58.93	0.11	0.00	0.00	0.01	0.00
1	0.27	23.67	85.54	0.14	0.78	0.29	0.17
2	0.13	13.03	10.62	81.20	0.86	0.82	0.02
3	0.17	2.56	3.14	17.73	92.84	0.47	0.04
4	0.02	1.26	0.29	0.59	5.21	97.95	0.11
5	0.01	0.00	0.04	0.02	0.01	0.08	99.40

Figure 7: (A) Heat map created from DFN shown in Figure 5B with colo-coded arrows by Well showing approximate distribution of tracer production. Dashed lines show location of parent production wells. (B) Average stage-lag times, dT for each well calculated as a function of it's partner well, and wheter or not a stress shadow effect is predicted to be present towards the partner well if dT >7.5 days. (C) Tracer production matrix showing percent of each injection well-specific tracer that was measured for each producing well.

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Conclusions and Discussion

Increased stresses from previous treatments remain elevated for ~7 days which push fluid injected into neighboring wells away from the stress shadow. Production of well-specific tracer corroborates the hypothesis that local stress-shadows are elevated for ~7 days. After stress dissipates through the fractures created during the initial stimulation, new tracer on offset wells was produced as much as 3,000 ft away on a neighboring well.

Stress shadows develop around previously treated stages then dissipate over time and return to the virgin stress state. Stress shadow time dependency can be quantified as the time it takes for rock to return to the virgin reservoir stress state from an altered rotated stress state due to the initial fracturing process. Wells should be treated in a timely fashion where stage-lag time on either side of the treatment well is less than stress dissipation time. Similarly, if fractures are expected to grow upward, deep wells should be treated <7 days after shallower wells above the treatment wells to take advantage of stress shadows before dissipating.

Virgin and altered stress states can be identified by performing a stress inversion of the microseismic focal mechanisms. Regions identified as experiencing virgin stress represent initial fluid propagation into unpressured rock. Regions experiencing altered stress are also regions experiencing high stress which would restrict slurry propagation from subsequent injections. Treatment of neighboring wells on both sides of the treatment well with stage lag time < time for stress dissipation time can result in better containment of injected fluids around treatment stages. After stress dissipates through the newly fractured network, new injected high-pressure fluid on offset wells can either overcome the dissipated pressure from previously treated wells or migrate around it and cause new fractures.

References

i. McKenna, J.P., O. Quezada, N.M. Toohey, and M.H. Grealy, 2015. A data-driven proppant-filled fracture model: Comparing sliding sleeve and plug and perforation completion styles. SEG national conference, New Orleans LA. https://doi.org/10.1190/segam2015-5933284.1

ii. Kirsch, G., 1898. Die thoeorie der elastizitat und die bedurfnisse der Festigkeitslehre, Zeischrift des Verlines Deutscher Ingenieure, 42, p707.

iii. Jaeger J.C., and Cook N.G.W., 1979. Fundamentals of rock mechanics, 2nd edn. New York, Chapman and Hall.

iv. Lund Snee, J.E., and M.D. Zoback, 2020. Multiscale variations of the crustal stress field throughout North America. Nature Communications (11) 1951: 1-9.

v. McGarr, A., 1976. Seismic moments and volume changes. Journal of Geophysical Research, vol 81, no 8, pp 1487-1494.

vi. McKenna, J.P., C. Remington, and M.S. Blaz, 2022. Stress rotations and compounding pore-pressures from multiple well injections. IMAGE International meeting for applied geoscience and energy, Houston TX. https://doi.org/10.1190/image2022-3749361.1

vii. McKenna, J.P. Treatment order is the cheapest and easiest change to make better wells. Latin America URTeC: 3971592. https://doi.org/10.15530/urtec-2023-3971592

viii. Vavrycuk, V., 2014 Iterative joint inversion for stress and fault orientations from focal mechanisms. Geophysics J. Int. 199, 69-77.

ix. Zoback, M., 2007. Reservoir Geomechanics, 449 pp., Cambridge University Press, Cambridge.


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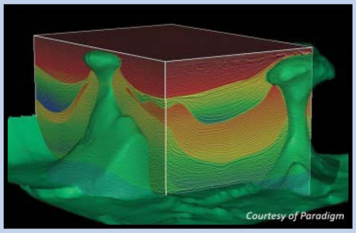

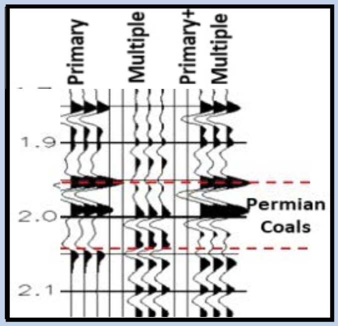

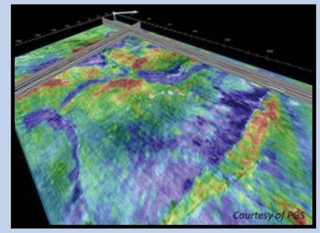

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Doodlebugger Diary

Abu Dhabi's Desert Presents a Challenge

Story and Photos by Paul Hellier • Originally published in the 1978 Spring *Western Profile* • Recounted by Scott Singleton

The Doodlebugger Diary recounts the experiences of geophysicists during their working lives. I've published extensively on my own experiences and encourage those of you with experiences of your own to also contribute. Your fellow industry professionals would love to hear your stories.

Previously I reprinted a series of early 1980's articles from the GSI Shotpoints and GSI Grapevine that can be found at http://gsinet.us/. However, in the past few years I have been reprinting various interesting and engaging Western Geophysical Profile articles from the 1970's, which is interesting to me because this is when I first became a doodlebugger and Western Geo is the company that first hired me to work offshore. The full set of scanned Profile issues can be found at https://library.seg.org/page/western-profile.

Prolog by Scott Singleton

Most oil and gas professionals have at one time or another either worked on or are at least familiar with the significant weathering zone challenges presented by the humongous sand dunes of the Arabian Peninsula. In the world of 3D, raypaths matter, and sand dunes are notorious for altering those ray paths or muting them entirely. These problems are so pervasive that the SEG SEAM Arid Model was developed from 2011 to 2016 to allow subsurface professionals an opportunity to test processing, imaging, and reservoir characterization algorithms on these environments.

Figure 1: "Continuous white sand dunes" is the way that the client explained the desert prospect in Abu Dhabi to Party 35. It appears that he was right.

With this in mind, I was quite thrilled to find an article about data acquisition in this kind of environment from the late 1970's, which predated much of the imaging revolution of the 1980's that involved the advent of large-scale 3D acquisition. I was hoping that the author would somehow weave into his story a recognition of the challenging acquisition environment this crew was facing. Unfortunately, I found none of that. Perhaps I was expecting too much. Instead the author appeared to be a party manager with not much knowledge of what the recording crew was trying to accomplish. He does refer to two 'weathering experts' that

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came over from Algeria, and of the 'seismologist' who was in their main operations group in Abu Dhabi, but we really don't find out anything about what those people did or found during their time on the project. What I did find is a lot of revealing pictures of the crew, equipment, and environment, which I present here in this recounting.

For those of you who would like to dive a bit further into the techniques these crews were using during this period and how that then developed into what we use today, I provide an epilog where I discuss some of that.

The Story of Party 35

Your Party 35 story starts long before Abu Dhabi, when Party V-35, upon completing operations in Pakistan, transferred all of its equipment to Dubai for stacking. Here it sweltered under the Arabian Peninsula sun for several months until word was received from Houston to get everything but the vibrators operational, by yesterday. (Isn't it always!). So we dropped the "V" and became Party 35.

Figure 2: One of Party 35's pickups demonstrates the difficulty of navigating those "continuous white sand dunes" in the Abu Dhabi desert.

The crew started assembling. Some came from Libya, some from Saudi Arabia, some from Pakistan. Those from Libya and Saudi Arabia, where the "Golden Goodness" (beer) was hard to find, really enjoyed the change to the free atmosphere of Dubai. Most evenings saw the personnel drift from the "Little A" (Airlines Hotel) to the "Big A" (Ambassador Hotel), where a nightly band catered to the tastes of all of the crew.

Figure 3: The Field Supervisor and Mechanical Supervisor checking (or rather posing next to) one of Party 35's air drills.

Soon the equipment tarted to appear. A trailer camp came from Pakistan and four extra buggies and cables arrived from Tanzania. With the presence of our new air drills, or "Coker's Puffers" as they became known, our days in Dubai were numbered. We had spent a month assembling and organizing all of the equipment so it was with some regrets that we headed in convoy for the Emirate of Abu Dhabi and the prospect area.

Abu Dhabi lies to the southwest of Dubai and is the capital of the United Arab Emirates (UAE). This newly-formed (1971) country is composed of seven emirates and covers 30,000 square miles. Shaped like a Bedouin's

Figure 4: The Catskinner (left) and Party Manager discuss the tracks on one of Party 35's vehicles in Abu Dhabi.

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Figure5: Party 35 Mechanic dresses to withstand the heat of Abu Dhabi's desert.

dagger, it lies along the south edge of the Arabian Gulf. The population at present stands at 600,000, of which only 20% are citizens and the balance is made up of Indians, Iranians, and Arabs of other nationalities *(Ed Note: the authors appear to be quoting the population of UAE as a whole, which was about 600K in the late 1970's. That population (UAE) now stands at 11.3 million, with 1.6 million living in Abu Dhabi).* With such a small indigenous population, the UAE has the distinction of having the highest per-capita income in the world. Within a handful of years the desert has been pushed back by armies of construction workers who have invaded the once-brown townships. The work proceeds at a frantic rate and vast building sites spread for miles with forests of cranes and scaffolding littering the horizon. Abu Dhabi Emirate consists of 80% of the land area of the UAE and provides 90% of the federal budget, being the richest in oil.

Figure 6: Party 35's efforts on Abu Dhabi's subquadt flats (see note) are highly visible.*

Party 35 did not have the pleasure of any first impressions, however, as we bypassed the city and headed toward the southwest of the emirate to the area of continuous white sand dunes — at least this is how the client described them. Not only does our all-buggy crew have to traverse these dunes, but also we have to negotiate our way over and around the huge dunes that rise 200 to 300 feet from the numerous subquadt flats* (see note) that prevail in the southern region. Add to this the high winds and blowing sands that change the topography and bury cables and flags, and temperatures that soar to 130° F: This, then, is the prospect area. In fact it is the start of the "Empty Quarter" of Arabia.

Figure 7: To reassure doubters that Party 35 really is out there in Abu Dhabi – somewhere – someone posted a sign.

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* Ed Note: I am not familiar with the term 'subquadt'. I tried looking it up and came up empty handed. Based on the context, it seems apparent it refers to the low elevation flats between sand dunes. If any of our readers know what this term means, please reach out to us.

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Figure 8: This mosque in Abu Dhabi was one of the attractions for Party 35.

So rough is the terrain that it was immediately decided to order Western's first 6 x 6 buggy. From its first day in the field this magnificent machine has "eaten" any terrain that it has had to cross. This must be the first of many more.

The Algeria crew sent maintenance experts who now keep our D7 caterpillar, "Miss Pussy," purring through the dunes cutting access roads to the lines for our "Puffers" and recording crew. They also sent surveyors and weathering zone experts to aid our technical crew. In the end this was a major operation with a team of mechanics to maintain 37 vehicles and numerous drillers

Figure 9: A clock tower In Abu Dhabi tells the time for Party 35.

to keep the shot holes coming for the "observers" on the recording crew. This is in addition to the Abu Dhabi-based team consisting of our seismologist, party manager, and operations processing manager.

Epilog

When reading this recounting of a 1978 survey in Abu Dhabi, I assumed it was a 2D survey, even though they did not specify this, mainly because 3D acquisition did not become commonplace until the mid to late 1980's (1, 2). And even at that time, the data most geophysicists used was the more commonly available 2D (personal recollection). It wasn't until the 1990's that 3D acquisition really took off in most places, including the current context of the Arabian Peninsula (3).

I also noted, somewhat humorously, that at the beginning of this recounting the Houston main office told them to skip bringing the vibs out of storage and to just get the crew up and running on location as soon as possible. This means they were shooting dynamite, which of course was the way everyone acquired seismic data before vibrators became commonplace, but is hardly an efficient way of shooting a large amount of data in a short period of time.

I will add from a personal perspective that the rush to get the crew on location was a common thing seismic acquisition companies were doing at this time. The price of oil was climbing, having gone from $14.85 during much of 1978 to $39.50 in June of 1980, which in hindsight was an ominous omen given the collapse of oil prices in the first half of 1986 ($30.38 in October 1985 to $10.25 in March 1986). Nonetheless, in the late 1970's everyone

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was rushing out as quick as possible to find and produce as much as humanly possible. This rush to market actually began with the Arab Oil Embargo of 1973 which forced oil to jump from the mid-$3 range where it had been for over 2 decades to $10.11 by early 1974 (4). This meant that anyone getting into the oil industry at this time was experiencing what everyone termed a heyday, and certainly it was the wild west as far as making money and seeing exotic locals. I had some of the best times of my life then and saw much of the world.

Figure 10: Our Mechanical Supervisor, who is a long way from his home base of Galveston, Texas, admires some of the camels in Abu Dhabi's desert.

But back to the subject at hand — seismic imaging underneath monstrous sand dunes on the Arabian Peninsula. It was precisely because of these imaging problems that 3D techniques began to be used extensively (3). However, in the beginning of this phase it was still noted that huge amounts of noise contaminated these early 3D volumes (2, 3). This led to a complete revision of the original orthogonal line setup to include 'bricks' and 'patches', and then imagers realized that it was actually uniform bin populations they needed to emphasize, thus the concept of CMP domain hits, and finally azimuthal distributions of said hits (3).

In the 2000's computing capabilities had advanced significantly, as had acquisition and imaging algorithms, and operators naturally looked back at all the legacy data they had acquired, wondering if those data could be made better. Reprocessing legacy data is an idea as old as oil exploration itself, but with new algorithms and compute capability these ideas started bearing some fruit, particularly in the 'difficult data environments' of the Mideast and North Africa (5). In particular, I call your attention to some key processing algorithms that helped make this possible, namely Surface Wave Analysis (SWAMI) (for complex weathering zone problems), and regularization algorithms such as Matching Pursuit Fourier Interpolation (MPFI) and 5D Interpolation (6), all of which are common in today's processing flows, particularly in the Mideast.

References

i. 3-D Seismic Data: The Data Cube, AAPG Wiki (3-D seismic data: the data cube - AAPG Wiki, accessed 12-17-25)

ii. 3D Seismic Surveys – Past, Present and Future, CSEG Recorder, Vol 26 #06, June 2001 (3D Seismic Surveys – Past, Present and Future | CSEG RECORDER)

iii. 3-D Land Seismic Acquisition in Saudi Arabia, GeoArabia, vol 1 #4, 1996, by GeoScienceWorld, https://doi.org/10.2113/geoarabia0104511

iv. Crude Oil Prices (1946-2025), Macrotrends (Crude Oil Prices (1946-2025))

v. Realizing the Potential of Legacy Seismic – Getting More Value from Vintage Data, ADIPEC Conference 2017, SPE-188678_MS (https://doi.org/10.2118/188678-MS)

vi. Innovative Processing Approaches to Overcome Sampling Sparseness and Irregularity in 3D Seismic Data Offshore Abu Dhabi, ASEG-PESA 2015 (https://doi.org/10.1071/ASEG2015ab075)

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The great outdoors as a geoscience gateway – Students and surveys in the Little Hatchet Mountains of New Mexico

Robert R. Stewart, Nawaz Bugti, Upal Shahriar, Dave Hume, and Peter Copeland

Introduction

The calling of a geoscientist may have been heard in the whistle of a mountain wind, waves lapping on the shore, or perhaps in a country song on a County road. While

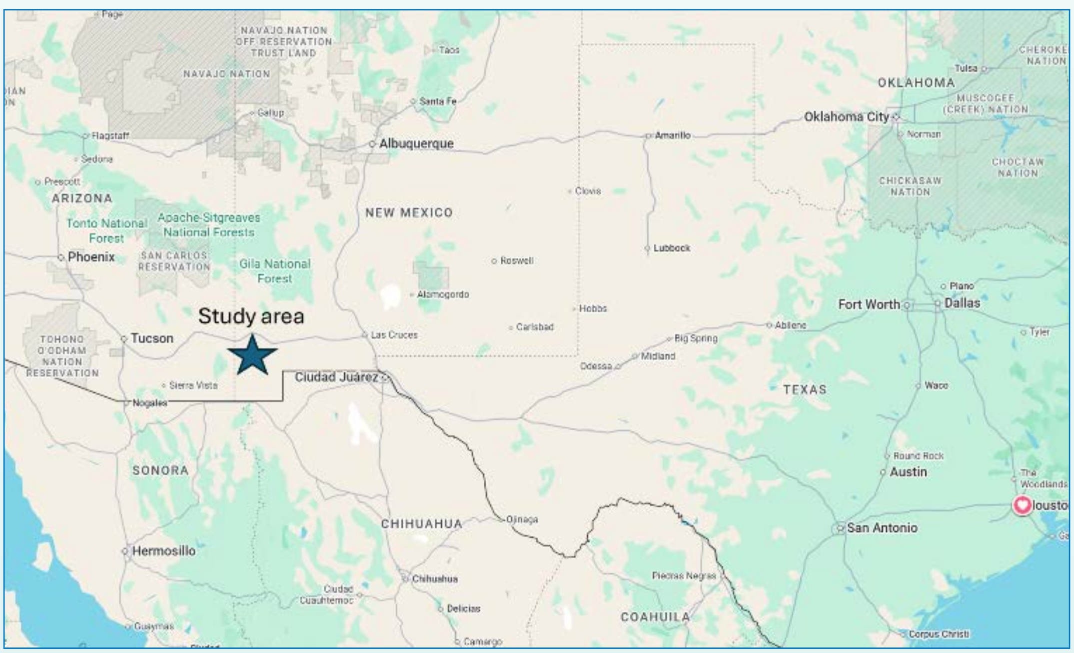
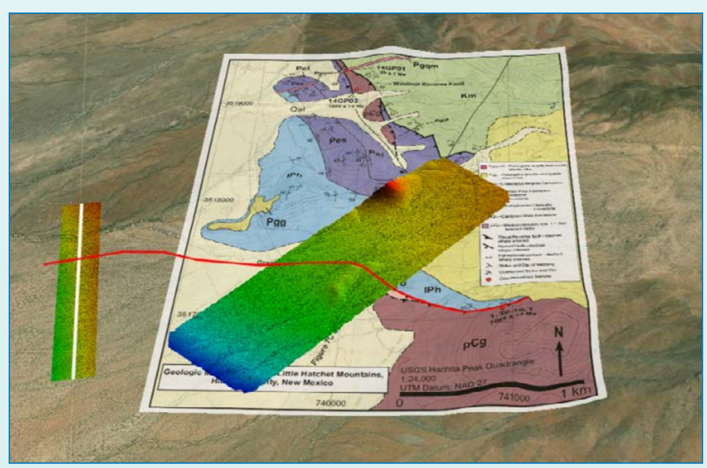


Figure 1. Location of the main study area and a geologic map of the Little Hatchet Mountains overlain on a Google image of the area with two drone-derived elevation maps added. An outline (red) of the proposed Granite Pass Fault is also annotated.

there are other encouraging summons (city sounds and computer clicks) to our field, it's critical to provide young people the chance to experience compelling natural settings and their processes — and perhaps, they'll join us in practice and camaraderie as geoscientists. With this in mind, we convened a "FIELDGeo (Field Investigations and Education Leading to Degrees in Geoscience) trip", supported by a $1 million, 5-year award from the National Science Foundation (NSF) and led by Dr. Pete Copeland and a group of us from University of Houston (UH). The primary goal of the grant is to introduce some 50 students per year to sites of geologic and geophysical interest in West Texas and southern New Mexico. One of our viewing and study areas in 2025 was the Little Hatchet Mountains of New Mexico (Figure 1). In particular, we were interested in demonstrating geophysical equipment to the students and mapping the Granite Pass Fault zone with as many geophysical techniques as possible.

Most of the students, who signed up for the adventure, had not previously participated in a geologic field trip. Our primary



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intent again was to get them to some fascinating scenic areas and develop their interest and understanding of geologic structures and geophysical surveying — it's hard not to love the Guadalupe and Hatchet Mountains, Carlsbad Caverns, and White Sands (and geophysical instruments)! There were a series of overview sessions and communications at UH prior to departure in early January. We added a dedicated team of geophysical graduate students and staff to demonstrate the various geophysical methods as well as undertake surveys and research in the Granite Pass area of the Mountains. In particular, we located the geophysical surveys to cross a suspected, but hitherto un-imaged part of the Granite Pass Fault. Imaging this Fault was our main geophysical research goal.

Figure 2. Students on the field trip receive briefings on the geology of the areas as well as the geophysical techniques used to further explore the subsurface.

Once in the field, some participants camped and others were lodged at the New Mexico Tech Playas Training and Research Center. Mornings would begin with geologic (Figure 2) and safety briefings … and lots of coffee.

It turned out to be a little more chilly than desirable (snowing several days), and of course, there were key learning experiences, such as flat tires and persnickety equipment. Nonetheless, the participants approached the challenges with admirable and hardy enthusiasm (Figure 3).

After reconnoitering and selecting our geophysical surveying site, we flew an airborne drone across the area (as shown in Figure 1). We next ran our ground-

Figure 3. Classic challenges of field work — inclement weather and flat tires. The geophysics team and other participants handled them with aplomb.

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Figure 4. *We conducted 2D ground-penetrating radar (GPR) surveys using the Sensors & Software NOGGIN 250 MHz system (left). On the same line, we undertook gravity and magnetics (middle) measurements. In addition, we used the Geometrics 64-channel Stratavisor system (which has been our educational workhorse for 20 years) as well as the Earthscope continuously recording 3C nodes and Dawson's vertical geophone nodes.*

penetrating radar (GPR) along our main north-south line. This was followed by both gravity and magnetic surveys. While these geophysical measurements were being made, we simultaneously were acquiring seismic data (Figure 4). We had three types of seismic receivers deployed (48 channels from the Stratavisor; 200 vertical geophone nodes generously supplied and deployed by Dawson Geophysical Co.; and 24 3C seismic nodes from Earthscope). We used

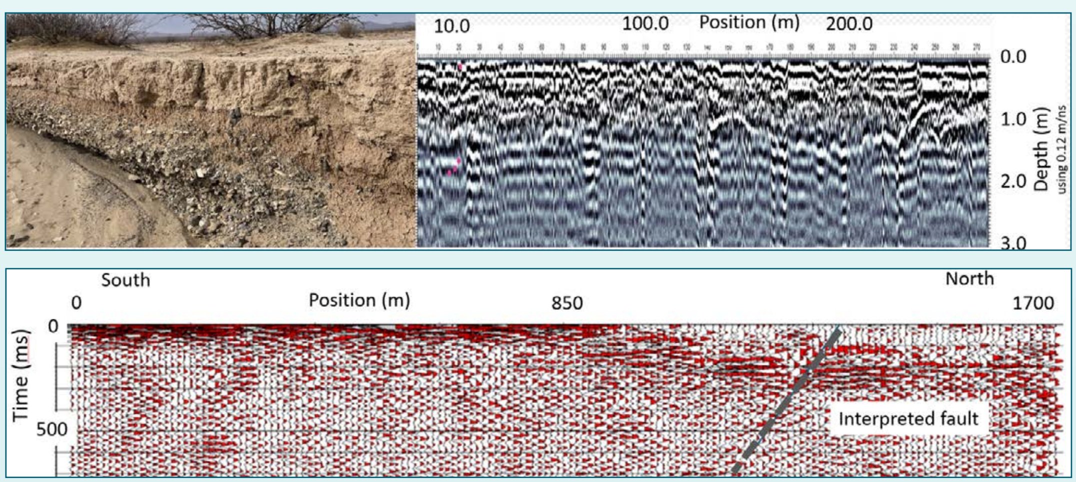

Figure 5. ***Above:*** *Photograph of an erosional cut in our study area and proximal GPR line with depths to about 3.0 m (10 ft) with a possible paleo-stream feature at 200 m.* ***Below:*** *A seismic section to a time of 700 ms (approximately 700 m). We note the dipping event (an interpreted fault) as well as a difference in the northern near surface – perhaps suggestive of a reverse-movement sense.*

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both a 5 kg hammer and 40 kg accelerated weight drop as seismic sources.

The GPR results, showed an alluvium layer with some structure to about a 1.5 m (5 ft) depth. This was confirmed by an excavation pit and nearby erosional features. The deeper geology is complex in the area, with Precambrian igneous rock, intruded Tertiary granites, and possibly Pennsylvanian limestones (Clinkscales and Lawton, 2017).

We returned to UH after a solid week of surveying and a fine drive back through West Texas. All hands arrived safely with disks fully loaded with data which we have subsequently been processing. On the processed seismic data, as perhaps expected in this intrusive environment, we don't see layered stratigraphy, but there is an exciting hint of a south-dipping, high-angle (about 80°) fault in the section (Figure 5).

Summary

In this field trip, we were able to show students many interesting geologic outcrops and exposures as well as demonstrate the techniques of geophysics used to see beneath the surface. We gathered some intriguing data and have provided a possible extension to the proposed high-angle, southward-dipping Granite Pass Fault. Our results were shown at the recent Geological Society of America (GSA) Meeting in San Antonio (Sauer et al., 2025) and will be worked up for publication. The students had a fascinating and we hope formative time. The staff and instructors also had an edifying and enjoyable time – especially after warming up and loading down the data!

Acknowledgments

This field trip was supported by an NSF Award (FIELDGeo – Field Investigations and Education Leading to Degrees in Geoscience). There will be two more annual winter field trips supported by the Award. We greatly appreciate the efforts of field assistants Johanna Villagomez, Andres Galindo, Victoria Smith, and Mike Castele of UH. Mike Alison of Raptor Aerial Services donated his time and expertly flew the drone surveys. Dawson Geophysical was exceptionally generous in supplying a crew and 200 seismic stations for the surveys. We thank Li Li Shen for her processing of the seismic data and Yomi Ojelabi for his efforts with the GPR data. We are grateful to the staff at New Mexico Tech's Playas facility for their logistics and lodging hospitality.

References

i. Clinkscales, C.A., and Lawton, T.F., 2017, Mesozoic–Paleogene structural evolution of the southern U.S. Cordillera as revealed in the Little and Big Hatchet Mountains, southwest New Mexico, USA: Geosphere, 14, 1, 1–25, doi:10.1130/GES01539.1.

ii. Sauer, M., P. Copeland, R. R. Stewart, A. Möller, R. Goldstien, V. B. Sission, S. Lineberry, T. Lawton, A. Lane, M. Allison, L.L. Shen, U. Shariar, O. Ojelabi, K. Vermillion, and D. Mongovin, 2025, Integrated investigation of the Granite Pass reverse fault, southwest NM: Presented at Geol. Soc. Am. Ann. Mtg., San Antonio.

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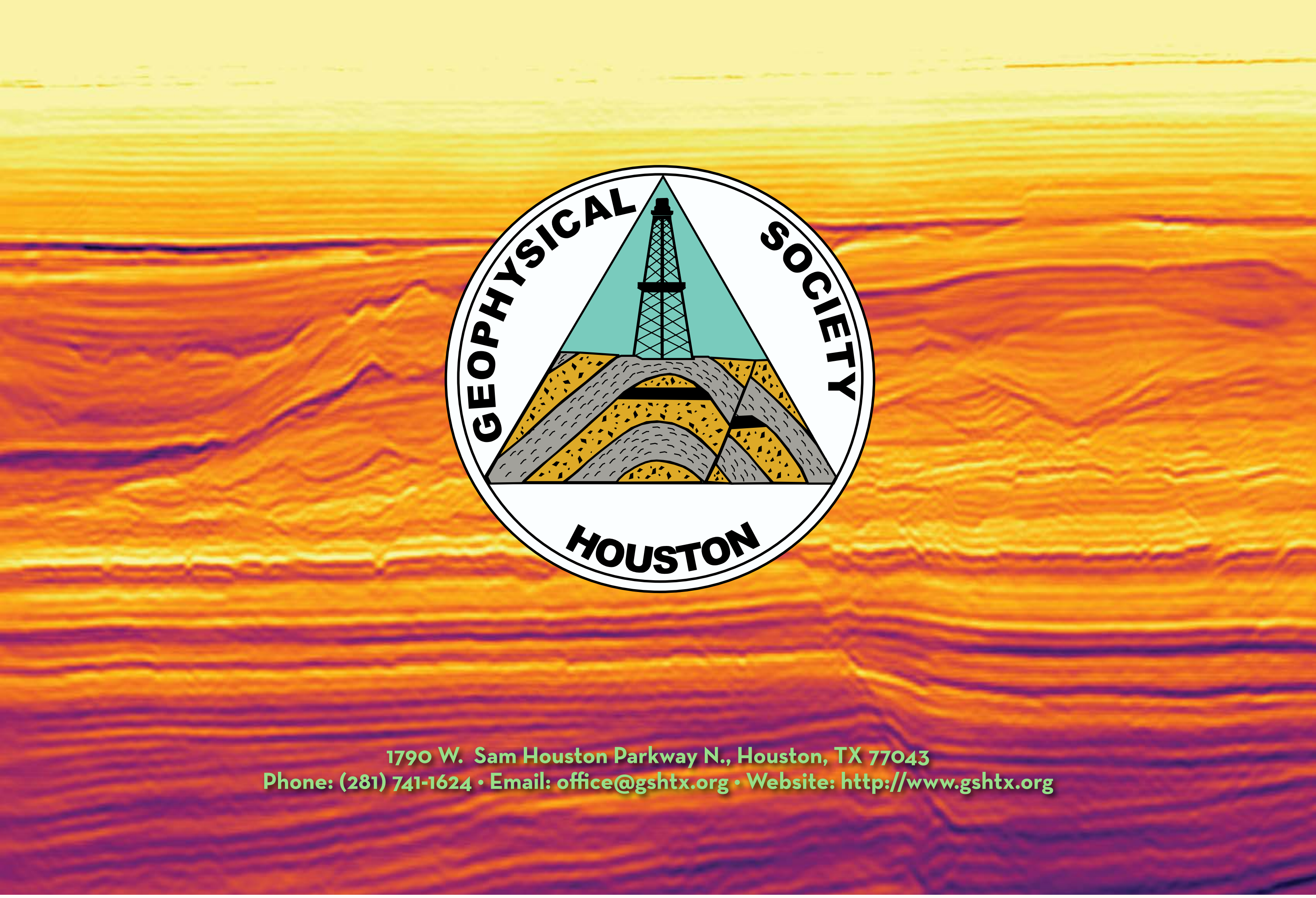

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