AUGUST 2025 | ISSUE #2

THE BEST JUST GOT BETTER.

In 2022 DUG launched its revolutionary multi-parameter full waveform inversion (MP-FWI) imaging solution. We have since **completed over 70 successful projects** from all over the world. We are now at the dawn of a new, even more exciting era — **an era where elastic least-squares imaging is a reality.**

DUG Elastic MP-FWI Imaging is not only a complete replacement for the traditional processing and imaging workflows, it also replaces the subsequent inversion workflow for elastic rock properties.

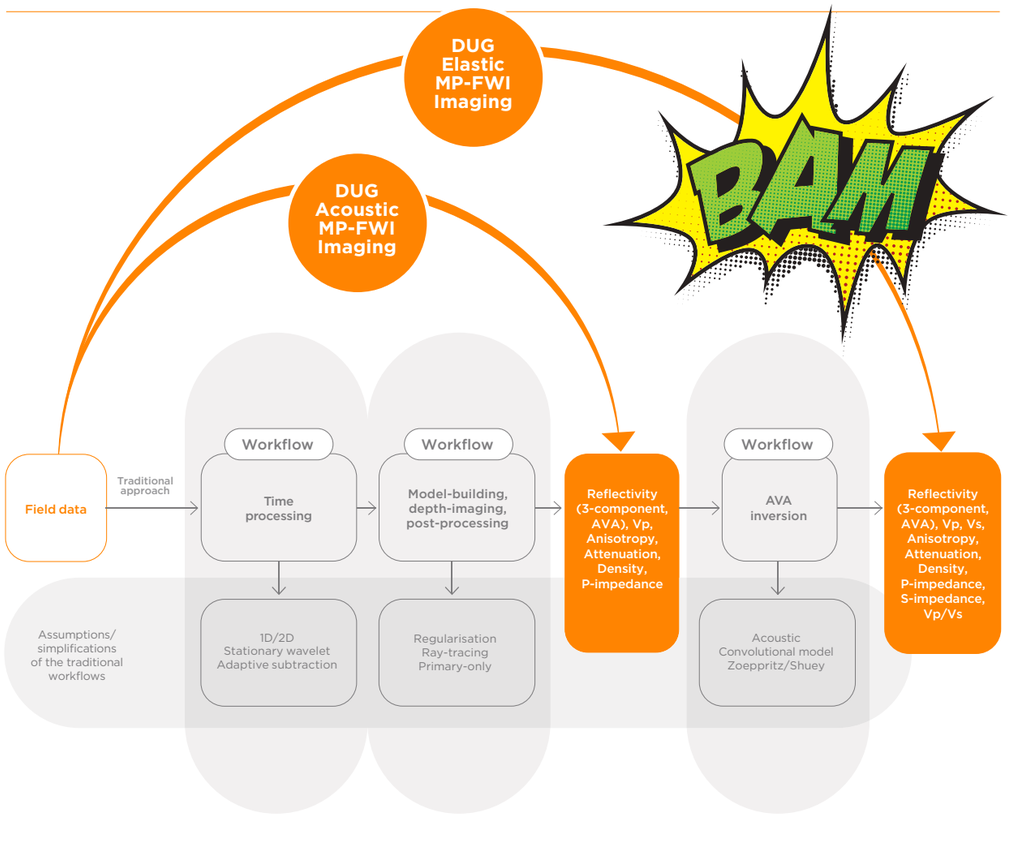
Elastic MP-FWI Imaging accounts for **both compressional and shear waves,** handling variations in seismic wave dynamics as a function of incidence angle, including in the presence of high impedance contrasts and onshore near-surface geological complexity. **Multiples and converted waves are now treated as valuable additional signal**, increasing sampling, resolution and constraining the inverted parameters.

DUG has invested over a decade of R&D to realise this opportunity. Our new Elastic MP-FWI Imaging technology is the product of a multi-year, significant and ongoing R&D effort, which has seen the continuous integration of complete-physics FWI imaging including viscoelasticity, anisotropy and multi-parameter updates. When using the full wavefield for simultaneous velocity model building, rock property inversion and true-amplitude imaging, **a multi-parameter solution is a necessity.**

As well as three-component reflectivity and velocity, DUG Elastic MP-FWI Imaging determines fundamental rock properties like P-impedance, density and Vp/Vs from field data, without the need for a secondary amplitude variation with angle (AVA) inversion step. DUG Elastic MP-FWI Imaging simultaneously resolves not only subsurface structural features but also quantitative rock property information while avoiding the need for extensive data pre-processing and (post-imaging!) AVA-inversion workflows.

These are very exciting times and our growing band of caped crusaders is excited to share our latest results around the world. On that note we are super excited to introduce **Dr Fabio Mancini** who's joined our team as **Chief Geophysicist for APAC and the Americas!**

OUR CAPED CRUSADERS:
Tom Rayment | CHIEF GEOPHYSICIST, **Fabio Mancini** | REGIONAL CHIEF GEOPHYSICIST APAC, AMERICAS



LEAP WHOLE WORKFLOWS IN A SINGLE BOUND.

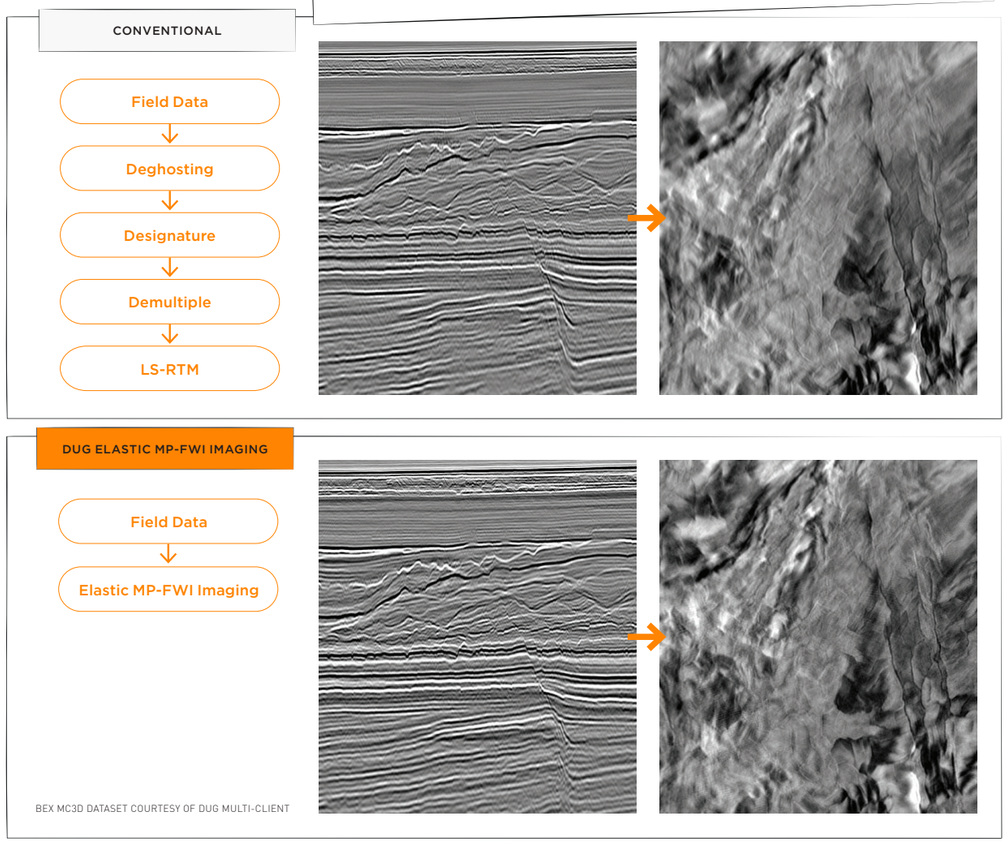
Traditional processing workflow involves the testing and application of dozens of steps such as deghosting, designature, demultiple and regularisation, which are all designed to overcome the limitations of conventional imaging.
These workflows are complex, subjective, and very time-consuming due to their serial nature and they rely on many assumptions and simplifications.
All of these issues impact the output data quality. The resulting, primary-only data then undergoes a similarly complex model-building workflow to derive an estimate of the subsurface velocity, which is used for depth imaging.
After post-migration processing the pre-stack reflectivity undergoes another workflow to derive rock properties for interpretation. This workflow also relies on simplifications of the actual physics.
These workflows mean that projects can take many months to years to complete.

DUG Elastic MP-FWI Imaging is a unique approach to seismic processing and imaging which turns the traditional paradigm on its head.

It solves the elastic wave equation to derive both relectivity and all three (Vp, Vs, density) of the fundamental rock properties from field-data input — removing the approximations and limitations of the conventional workflows.

SUPERCHARGE YOUR LEGACY DATA.

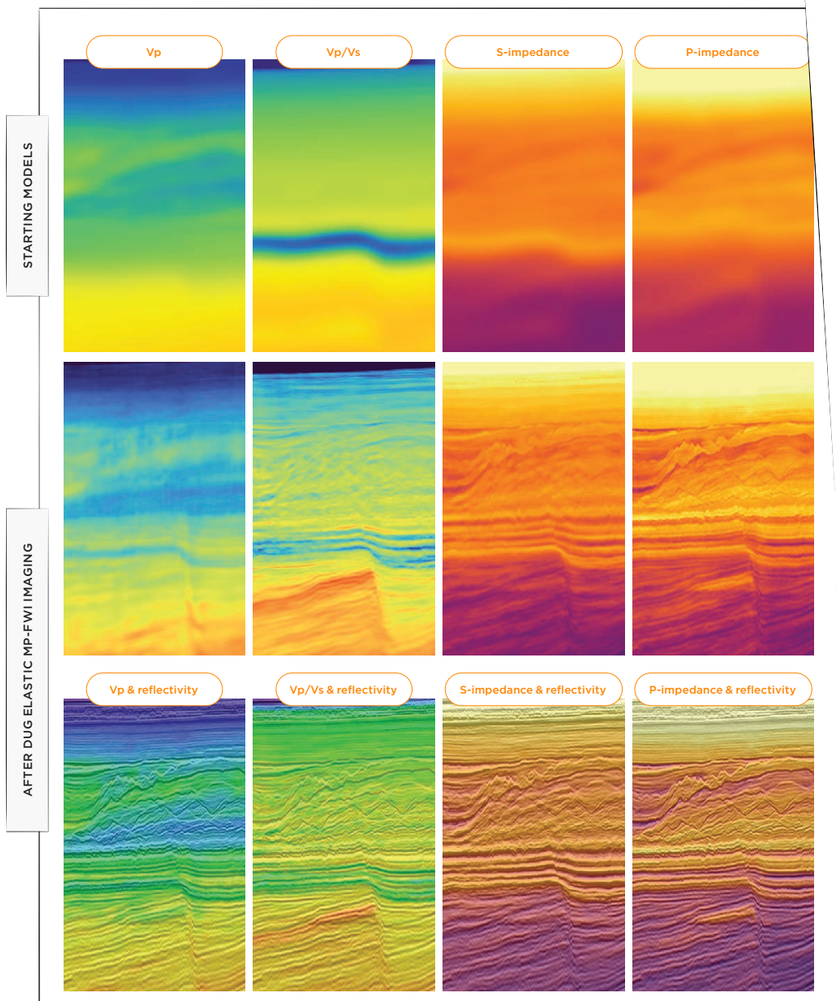
Supercharge your legacy data with DUG Elastic MP-FWI Imaging and use the entire wavefield, including all free-surface multiples and converted waves, as high-octane signal. Multiples are normally considered as problematic noise, however they illuminate the subsurface in complementary ways to primary reflections. When imaging with primaries and multiples the subsurface is sampled far more completely, and with a wider range of angles — constraining the inverted reflectivity, rock properties and attenuation.



Comparison of the reflectivity derived with DUG Elastic MP-FWI Imaging using raw field data, versus a conventional LS-RTM workflow using extensively pre-processed input. This legacy dataset was acquired in 2006 on the Australian North West Shelf. This region contains rapidly changing shallow velocity variations due to localised channel features and carbonates.

The MP-FWI imaging results demonstrate an increase in spatial resolution - the channel features, reservoir flat spot, and complex faulting are sharper and more clearly delineated.

FANTASTIC ELASTIC!



DUG Elastic MP-FWI Imaging enables simultaneous inversion of reflectivity (3-component, directional, horizontal), P-wave velocity, S-wave velocity, density, P-impedance and S-impedance, providing quantitative interpretation-ready outputs of the highest resolution and amplitude fidelity — using field data input. Simply fantastic!

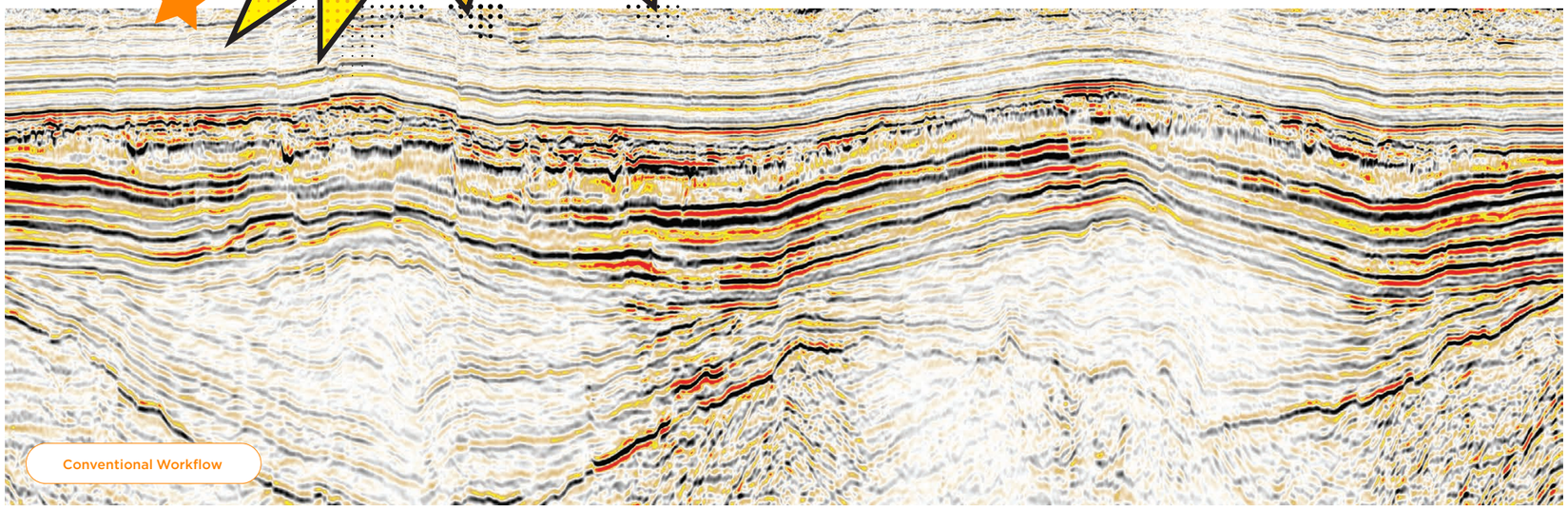
The updated rock property models show a significant increase in resolution. We can readily identify the reservoir location — a beautiful example of a flat spot!

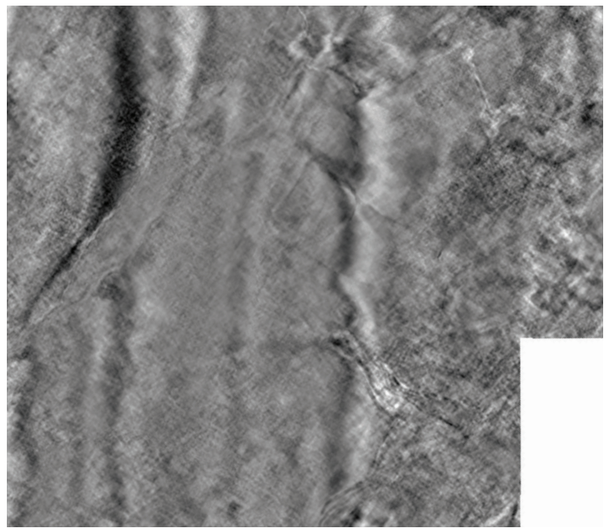
BEX MC3D DATASET COURTESY OF DUG MULTI-CLIENT

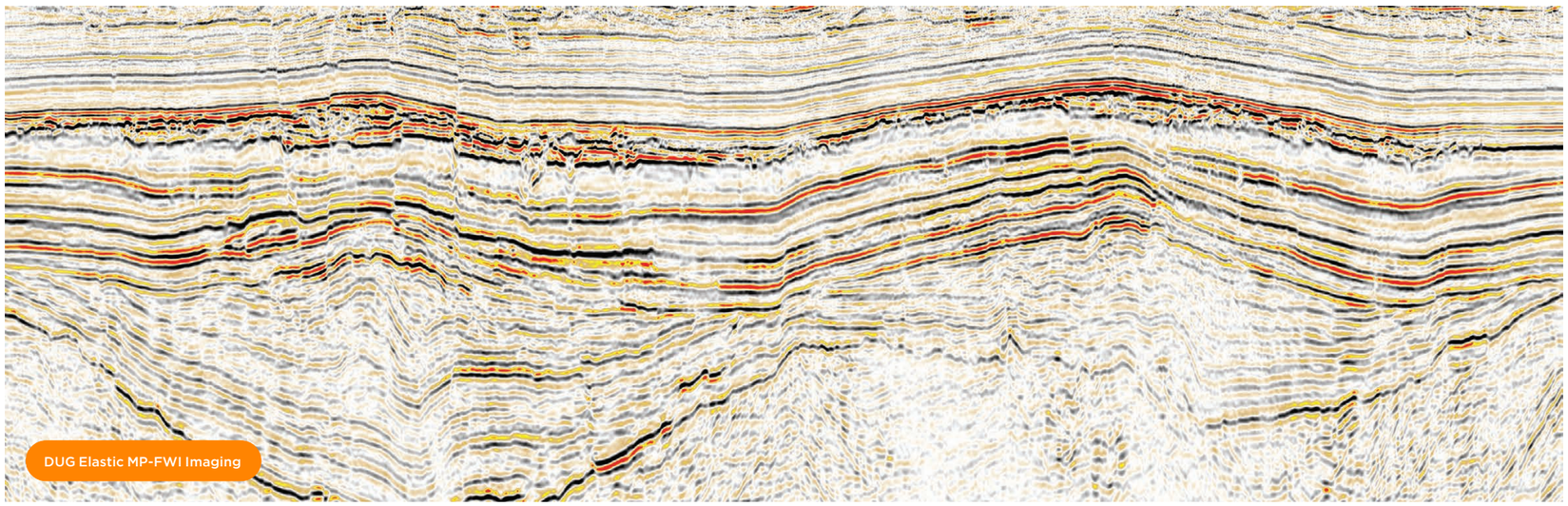
LAND POWER ACTIVATED!

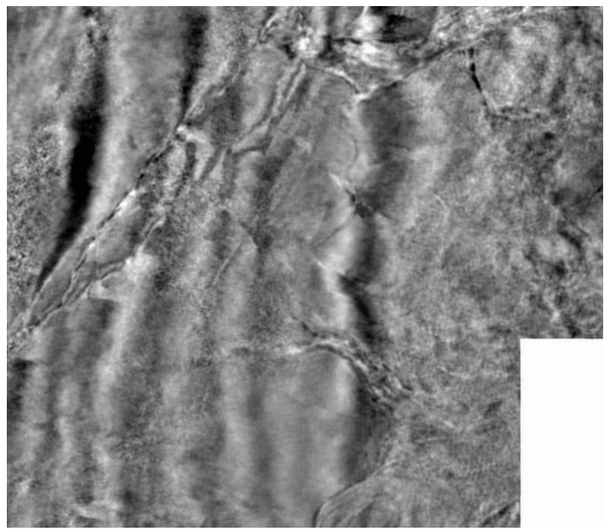
DUG ELASTIC MP-FWI IMAGING HAS PRODUCED FAR SUPERIOR RESULTS.

Land seismic data, such as this example, can often exhibit strong elastic effects that violate the assumptions of acoustic imaging. This desert setting has geological complexity both in the near-surface and at the target depth, including high-impedance carbonates. Conventional pre-processing workflows are non-trivial, especially on land data, where stages such as demultiple often require complex modelling and adaptive subtraction workflows. Significantly better illumination and event continuity is obvious when comparing the sections in the figure below. They are the result of **DUG Elastic MP-FWI Imaging** using the full wavefield, including interbed multiples. Incredible near-surface detail has been resolved, as can be seen on the shallow depth-slices to the right. Subtle structural and stratigraphic features that were simply not imaged with a conventional processing and imaging workflow have now been resolved.



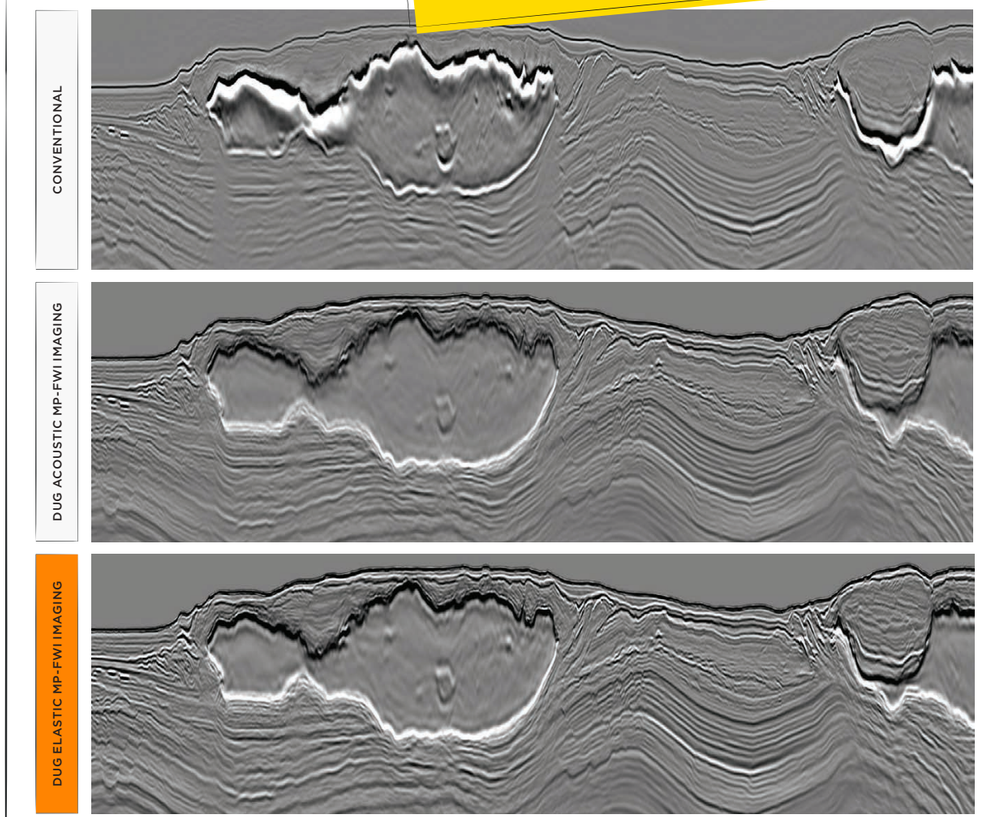






IT'S A BIRD. IT'S A PLANE. IT'S HIGH IMPEDANCE!

HIGH IMPEDANCE CONTRASTS A PROBLEM? **NEVER FEAR.** DUG ELASTIC MP-FWI IMAGING IS HERE!



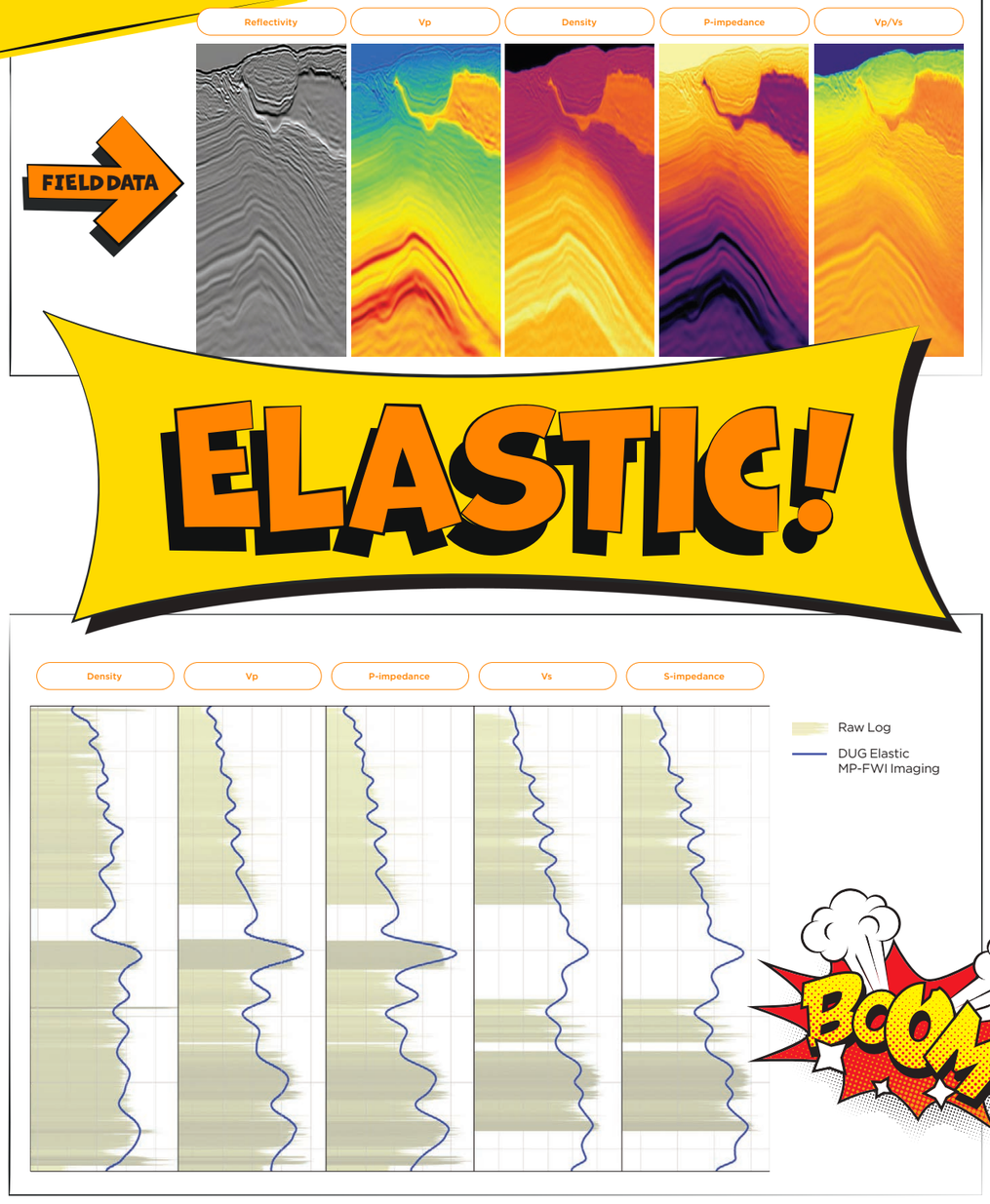
DATA COURTESY OF SHELL

Here we consider an OBN dataset from the Gulf of America where water depths are approximately 2 km. In the figure above we see a comparison of the downgoing mirror RTM using pre-processed data (top), DUG Acoustic MP-FWI Imaging reflectivity using field-data input (middle), and DUG Elastic MP-FWI Imaging reflectivity using field-data input (bottom). We can immediately see the improvements that the MP-FWI imaging approaches bring over the conventional RTM with respect to resolution and illumination. The elastic MP-FWI imaging result has obviously produced the superior image around the high-impedance contrast caused by the salt, and the structures beneath it.

LOOKS LIKE A JOB FOR... ELASTIC!

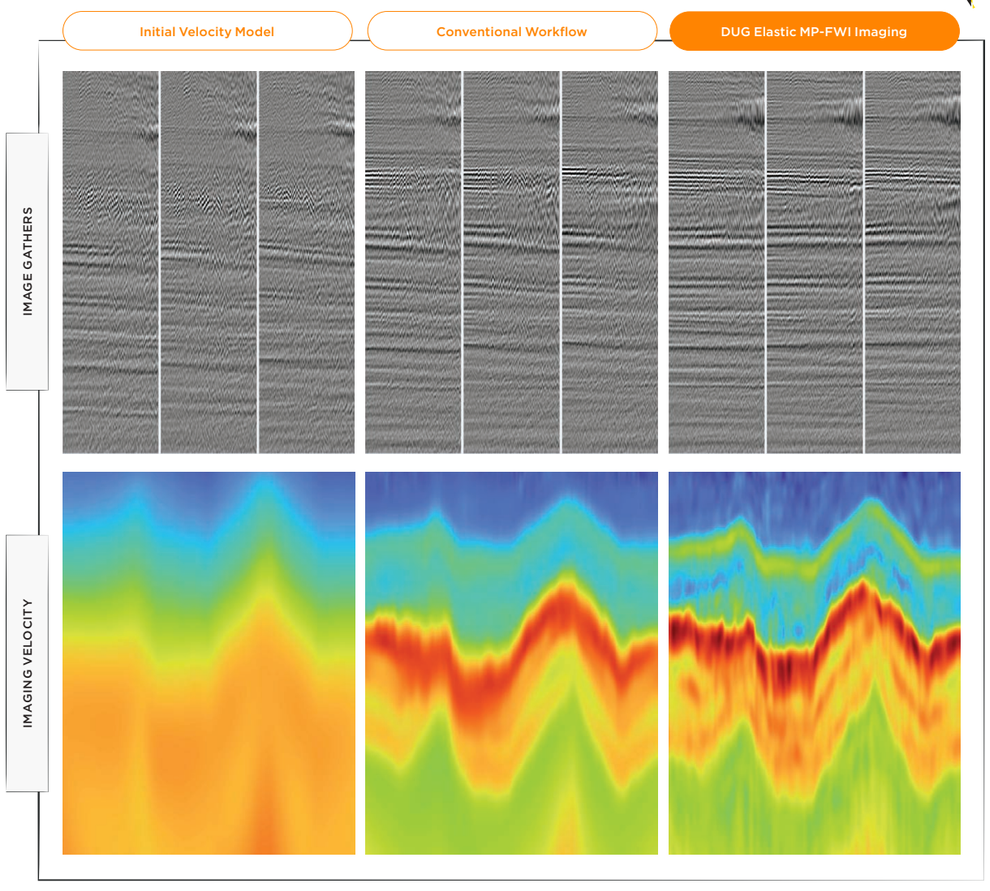
Here we see the successful application of **DUG Elastic MP-FWI Imaging** to generate accurate models of P-impedance, Vp/Vs ratio, and Vp directly from the raw field data. These quantities were derived without the need to generate angle stacks for an AVA inversion workflow.

The Elastic MP-FWI Imaging derived quantities are geologically conformable and show a good match to the available well information. DUG Elastic MP-FWI Imaging removes the subjectivity of traditional workflows with respect to the generation of vital quantitative interpretation attributes.



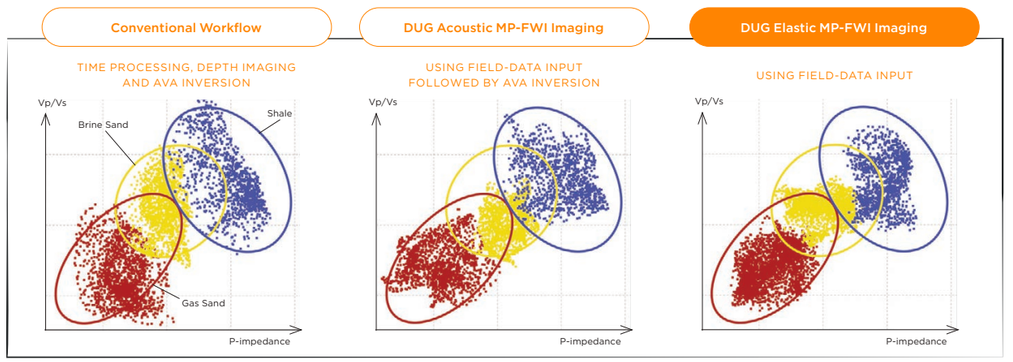
DATA COURTESY OF SHELL

TRUTH. JUSTICE. AND BETTER PHYSICS.



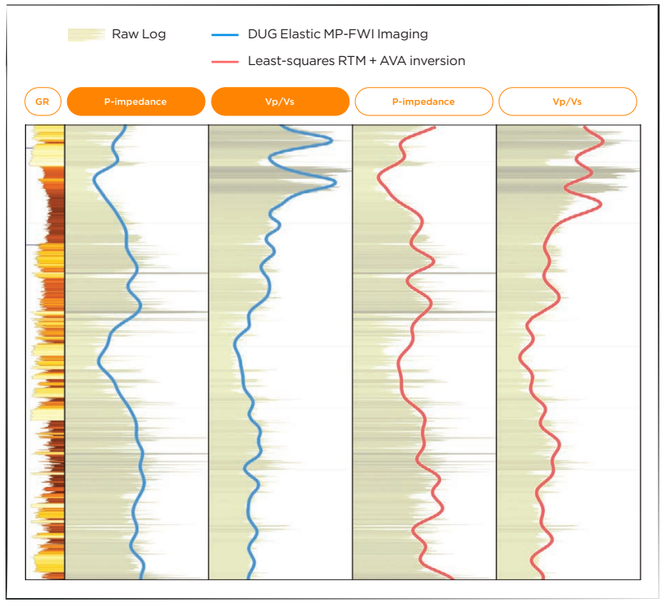
The Earth is inherently elastic. As data processing has advanced to better honour physics, we have continually refined our ability to understand the subsurface. Here, velocity model updates generated using a conventional workflow and **DUG Elastic MP-FWI Imaging** were evaluated using a Kirchhoff pre-stack depth migration (KpreSDM), using the fully pre-processed data as input. The figure above compares common-offset-vector KpreSDM snail gathers using the initial velocity model (left), the conventionally derived velocity model (middle), and the DUG Elastic MP-FWI Imaging derived velocity model (right). The MP-FWI imaging velocity model demonstrates a clear and significant kinematic improvement (gather flatness) and a reduction of jitter due to the azimuthal variations, particularly around the high-impedance contrasts given by the carbonates in this onshore, desert setting. The structural imaging improvements from the DUG Elastic MP-FWI Imaging reflectivity are showcased on pages 6 and 7.

SHEAR BRILLIANCE.



In the figure above, three equivalent crossplots of elastic rock properties are compared. The ellipses indicate the expected distribution of the labelled lithology and fluid combinations from statistical rock physics analyses of well log data.

Quantitative interpretation requires true amplitudes and high signal-to-noise ratio. Less scatter translates to less uncertainty. **DUG Elastic MP-FWI Imaging** delivers high-resolution elastic rock property outputs — directly from field data. It eliminates the need for conventional time processing, depth imaging and AVA inversion workflows, along with their assumptions that ultimately affect AVA compliance. With DUG Elastic MP-FWI Imaging more certain predictions can be realised.



> THE FACT THAT DUG MP-FWI IMAGING IS DELIVERING MATERIAL IMAGING UPLIFTS USING FIELD-DATA INPUT IS VERY POWERFUL. BUT TO COUPLE THIS WITH HIGH-RESOLUTION ELASTIC ROCK PROPERTY OUTPUTS FOR QUANTITATIVE INTERPRETATION IS EVEN MORE EXCITING, PROVIDING IMMEDIATE OPPORTUNITIES FOR NEW SURVEYS AND MAXIMISING THE VALUE OF LEGACY DATASETS.
>
> MARTIN STUPEL, GEOPHYSICAL MANAGER GEOPHYSICAL PURSUIT INC.

Here we compare the elastic rock property well ties from DUG Elastic MP-FWI Imaging (the blue curves on the left) to a conventional processing, imaging and AVA inversion workflow (the red curves on the right). It is obvious that the DUG Elastic MP-FWI Imaging results are a better match to the well.

BEX MC3D DATASET COURTESY OF DUG MULTI-CLIENT

WITH GREAT POWER, COMES GREAT RESULTS.

Accurate Physics → More Signal → Better Illumination → Higher Resolution → Superior Outputs

IN A FLASH

It's not just about high performance computing (HPC) power. Elastic MP-FWI imaging requires significant, coupled software engineering, geophysical expertise and HPC resources.

Our global network of HPC facilities is backed by our proprietary software solutions, energy-efficient immersion cooling systems and tailored geoscience services. We continue to undertake R&D on all aspects of MP-FWI imaging, both from a geophysical and computer science perspective. Integrated in DUG Insight, **DUG Elastic MP-FWI Imaging** delivers unsurpassed imaging and high-resolution rock properties in greatly reduced turnaround time.

VISIT **DUG.COM/FWI** FOR MORE INFORMATION