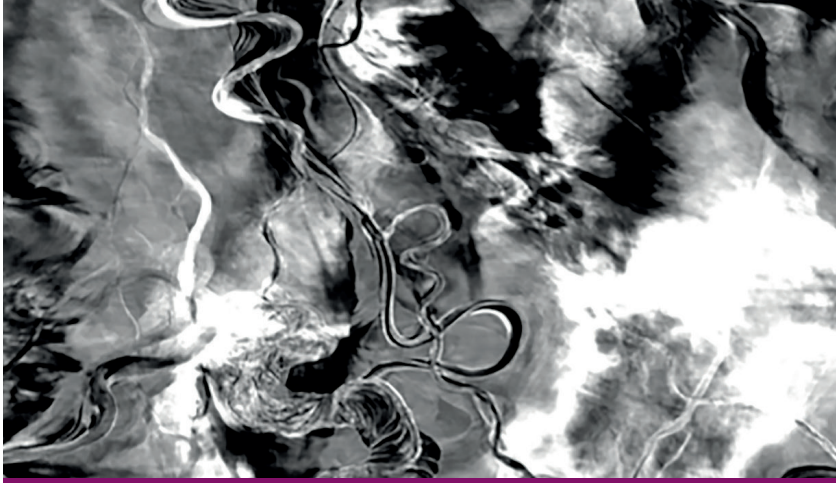
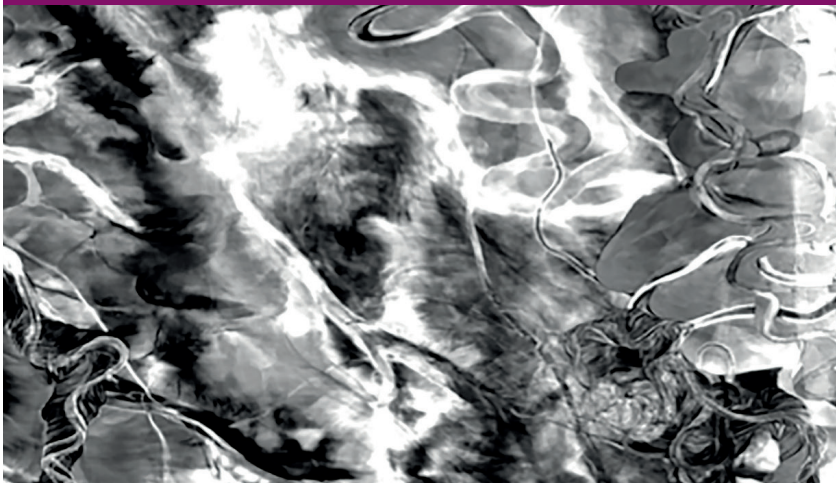
SHEARWATER®

Clearly Better.



Processing & Imaging



Revealing possibilities
shearwatergeo.com

SHEARWATER

Processing & Imaging

Agile, responsive teams of experts, available when, where and for however long you need them. Get high-quality data rapidly, reduce costs and build in flexibility at the heart of your project.

Processing & Imaging

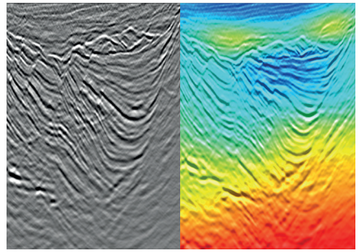
Our Reveal processing software and imaging experts provide a truly integrated service, together with our flexible approach we deliver solutions to meet all your challenges.

In-house R&D

Our in-house R&D department delivers industry leading technology implementing innovative, proprietary algorithms in the Reveal software platform.

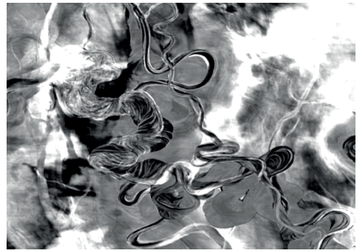
Agile Responsive Teams

Shearwater provide agile teams that can work from existing processing centers or from dedicated 'pop-up' processing centers, so our teams can be close to your project.



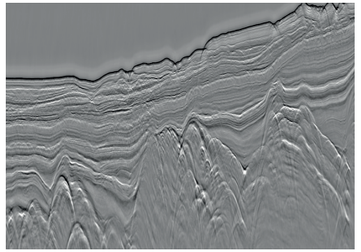
Capability

Our onboard and onshore processing capabilities provide you with the expertise and service to achieve the highest quality seismic imaging.



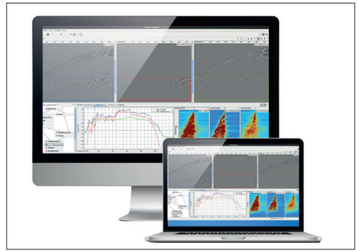
Cost Efficient

Our business model and experienced teams allow us to keep costs low, whilst maintaining delivery of superior quality data.



Superior Quality Processing

Our expert Geophysicists will reprocess your data using Shearwater's advanced technology - producing clearly better results.



Powered by Reveal

Reveal software gives Shearwater a strong differentiator in the P&I market. By having our own software it allows our Geophysicists to apply technology knowledgeably, intuitively and interactively.

Focus on Quality

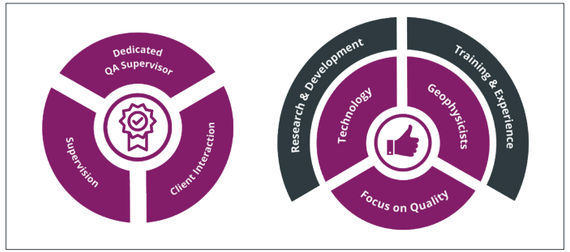
We have an uncompromising attitude towards building in quality at every stage of our practices and processes.

Dedicated QA Supervision
A dedicated Quality Assurance Supervisor ensures best practice guidelines are followed on all projects.

Seasoned QC
We offer a high ratio of experienced Supervisors to Geophysicists on every project, this provides the delivery of high quality seismic products to our clients.

Client Collaboration
We understand that no one knows their data like the client. Shearwater recognizes the importance of working with the client during projects to ensure the very best quality is delivered.

By combining the flexibility of our Geophysicists and implementation of local QC, Shearwater can work directly with you to produce clearly better results.



Building a Culture of Excellence

Our employee engagement program, **focus**, provides the training and understanding of Shearwater's expectations that enable a true culture of excellence. It is unique in our industry and is another demonstration of our commitment to innovation.

focus enables our employees to be:

Safe:
Understands the nature of hazards. Actively reports and removes hazards to safeguard both themselves and others.

Inclusive:
Identifies opportunities for colleagues throughout the organization. Contributes with relevant ideas and information for the greater benefit of the business and clients.

Respectful:
Politeness, honor and care for anyone, regardless of status or position within or outside the organization.

Dynamic:
Energetic approach to the business with a positive outlook.

Ambitious:
A strong desire to succeed through hard work and determination.

Our Processing Teams

Powered by Reveal software, our in-house R&D team delivers industry-leading technology such as **SHarp***sig* deghosting, **Flexi***source* deblending and 3D Full Waveform Inversionz

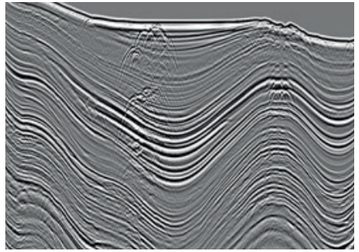
At Shearwater we process your land and marine seismic data by combining the latest processing software with experienced Geophysicists and efficient hardware.

Through the implementation of Shearwater Reveal we have the capability and proven experience to offer:

- Acquisition QC & technical supervision on vessels and client offices
- Local Geophysicist resource with a license of Reveal within client's offices to work directly with asset team
- Set-up of a local center or processing hub for projects that require in-country operations for QC or full processing
- Joint R&D collaboration projects
- Software and training tailored to client's requirements

This flexibility benefits each project. By giving clients rapid access to data, speeding up the QC process, reducing the timing between receipt of data and the delivery of the final data, we maximize the value of the seismic results.

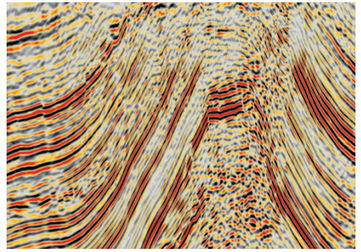
Our Technology



SHarp Broadband

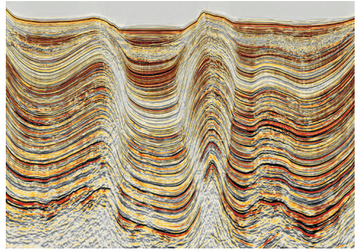
SHarp technology provides increased bandwidth from data recorded with legacy, conventional or broadband acquisition.

SHarp*sig* technology allows improved debubble and AVO using the near field hydrophones to compute a directional source signature.



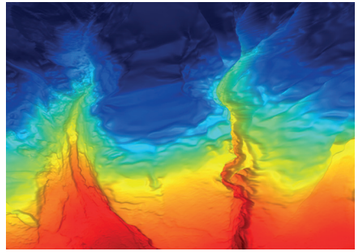
Land Processing

Shearwater's land processing includes the latest techniques to increase your data quality. Tools including; 3D Radon, Offset Vector Tiling, 3D fkxky, Tau-pxpy denoise, 5D regularization, Time and Depth Migration, plus many more.



Time Processing

Our range of imaging techniques can be used to enhance your data; Shot-by-shot designature using NFH, True Azimuth 3D SRME, 3D SWME, IME, Anisotropic PSTM, and more.



Depth Imaging

Depth Imaging capabilities deliver exceptional data results using; TTI Anisotropic, non-parametric tomography, TTI Anisotropic Kirchhoff, Beam, RTM and Shearwater **FWI**.

Discuss your processing requirements with our team:

sales@shearwatergeo.com

PROCESSING TOOLBOX

- SHarpSig DESIGNATURE & DEBUBBLE USING NFH DATA
- DENOISE: DESWELL, FK & TAU-P FILTERS, RANK REDUCTION DENOISE, P-DOMAIN SINA
- SHarp DEGHOSTING
- DEMULTIPLE: WEMA, 2D/3D SRME, 2D/3D SWME, DMA, IME, HIGH-RES RADON
- DEBLENDING OF OVERLAPPING SHOTS
- FOURIER REGULARIZATION (3D / 4D / 5D)
- VELOCITY ANALYSIS: MANUAL, AUTOMATIC SEMBLANCE, AVO BASED, AZIMUTHAL-NMO
- ISOTROPIC AND VTI ANISOTROPIC 2D AND 3D KIRCHHOFF MIGRATION
- MIGRATION FROM TOPOGRAPHY OR OBC/OBN DATUM ELEVATIONS
- FKXKY AND TAU-PXPY FILTERS
- NON-LOCAL-MEAN (NLM) FILTERS
- MULTI-MODEL, 2D &3D FREQUENCY DEPENDENT SUBTRACTION

Our experienced processing teams provide you with the expertise and service to achieve the highest quality seismic imaging in all geological environments.

Shearwater's processing and imaging experts provide a truly integrated service.

You will have access to our own in-house clusters. The use of cloud computing benefits you by delivering your results to you in a time frame that allows you to meet your decision deadlines.

Pre-Processing

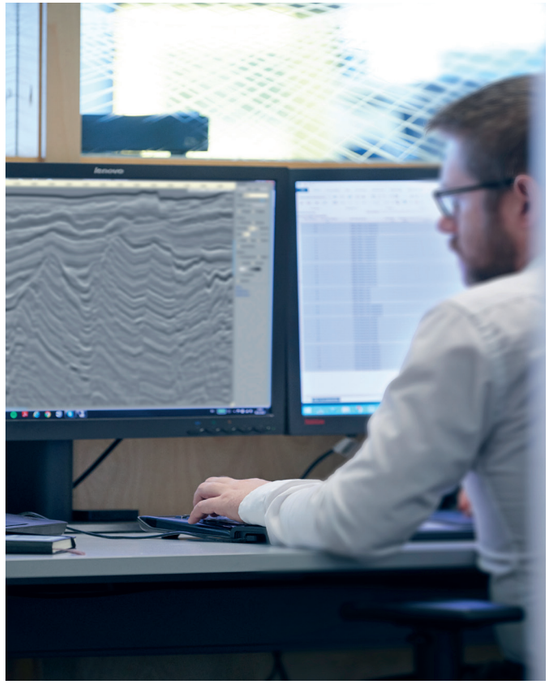
At Shearwater we believe that every step in the processing sequence is important.

High quality processing is all about incremental improvements in the data at every stage. A typical processing sequence has many stages, each one has to be optimized carefully with full involvement and advice from the client.

This begins with Pre-Processing. The R&D team at Shearwater has invested time and research into the best methods at the early processing stages, such as shot-by-shot designature and debubble which in turn lead to more accurate phase alignment during deghosting.

Our dual-model, multi-frequency, 3D least squares adaptive subtraction used for modelled multiple removal stages is another example of attention to detail that is imperative if the approach of incremental improvement at every stage is to be followed.

To ensure the maximum value can be gained and the highest quality imaging is achieved, it has never been more important to have optimal pre-processed seismic data.



SHarp*bb* Technology

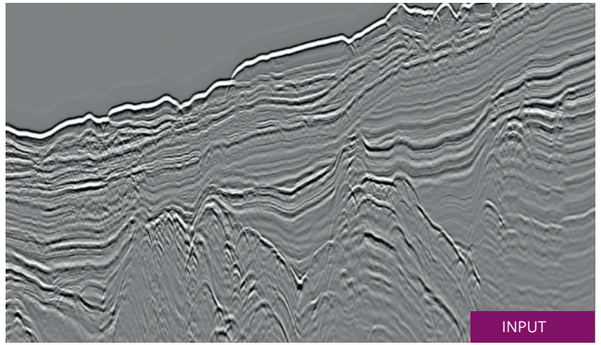
SHarp*bb* processing provides enhanced bandwidth for all streamer configurations

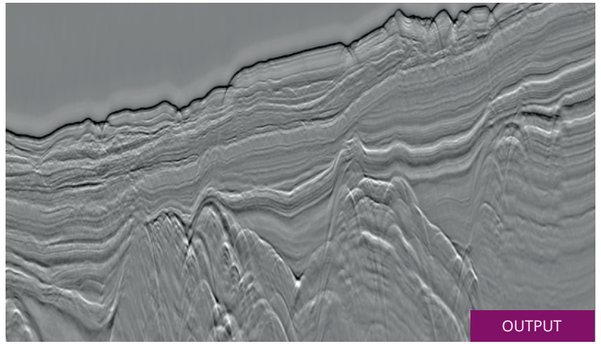
Complete Broadband Toolbox for advanced Source and Receiver Deghosting:

SHarp: Receiver Deghosting using operators that can accurately deghost a flat or slanted cable as well as account for the non-linear offset distribution on the outer cables of a 3D spread. Moreover, a frequency dependent, sea surface reflection coefficient can be selected.

SHarp*vs*: Variable Sea State Receiver Deghosting uses phase-shift extrapolators between non-planar interfaces to account for irregular cable depths as well as a rough sea state.

Further Reading:
Guided phase-shift deghosting (2017); Sergio Grion 79th EAGE Expanded Abstracts





PROCESSING TOOLBOX

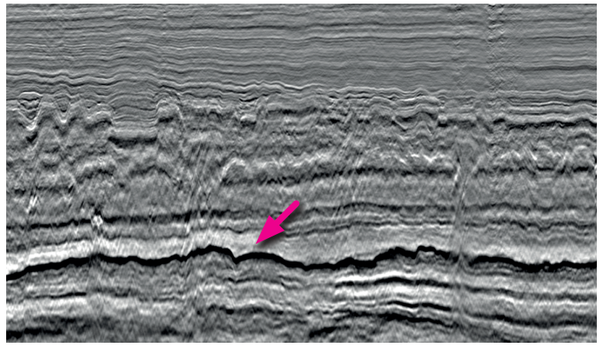
SHarp*sig*

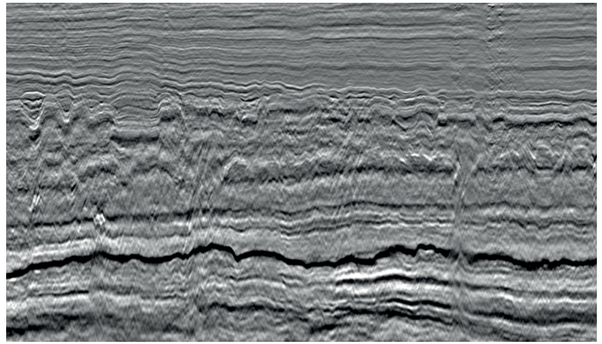
SHarp*sig* technology enhances bandwidth using the near field hydrophone data.

- Improved deghosting and debubble
- Directional, Shot-by-Shot designature
- Accurate low frequency amplitude and phase
- **SHarp***sig* algorithm explicitly accounts for bubble motion leading to more accurate estimation of notional signatures, resulting in more effective debubble and accurate treatment of phase down to the lowest signal low-frequency

Example *(shown right)*
PSTM following designature using modelled 1-D signatures (top) & directional NFH-derived signatures (bottom). **SHarp***sig* result shows a sharper wavelet and absence of a preceding low-frequency halo above the top chalk event.

Further Reading:
Estimation of air-gun array signatures from near-gun measurements least-squares inversion, bubble motion and error analysis (2015); Neil Hargreaves, Sergio Grion and Rob Telling, 85th Annual SEG Meeting Expanded Abstracts 149-153

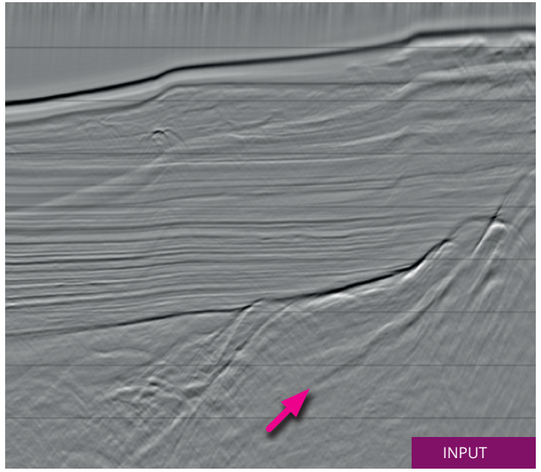


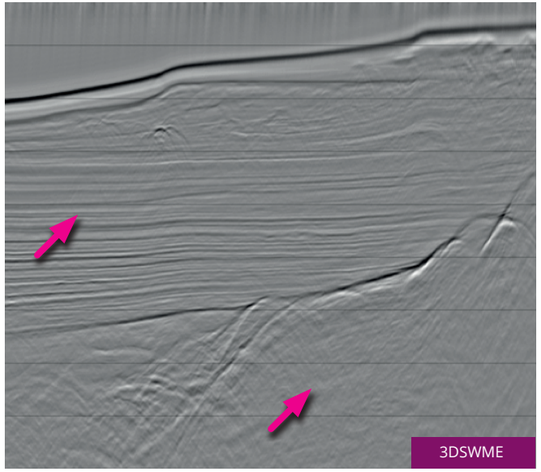


Bathymetric Driven 3DSWME

The Shearwater SWME method is a wavefield-consistent form of multi-channel prediction-error filtering. The multi-channel prediction filters are themselves estimates of the near-offset water-bottom reflection, derived from the primaries and multiples that are present at the available offsets, and predict all orders of surface multiples when convolved with the input data.

The example is a stack taken from an outer streamer, which is prone to poor/incomplete/missing image of the waterbottom given the additional crossline offset; this is shown in the change in the waterbottom character across the section. To circumvent this, the 3DSWME is fed a bathymetric surface to utilise in the 3DSWME modelling phase, to the benefit of the prediction.





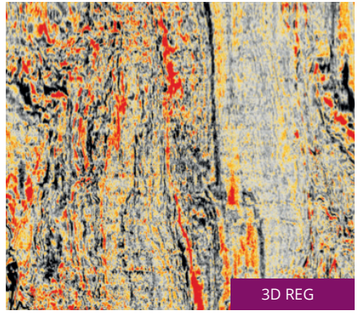
PROCESSING TOOLBOX

Advanced Regularization

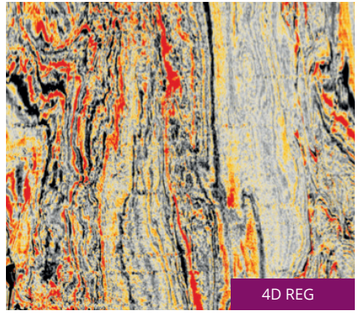
The Shearwater Fourier Domain Regularization interpolates irregularly spaced, land or marine data onto a regular, well populated grid suitable for further processing and imaging.

- Interpolate missing shots and receivers
- Interpolate shots and receivers on to a regular grid
- Interpolate trace mid-points to bin centres
- Uniform, regular coverage
- 3D, 4D or 5D

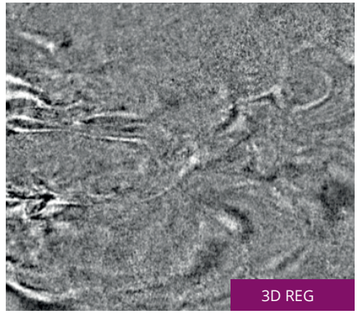
Marine



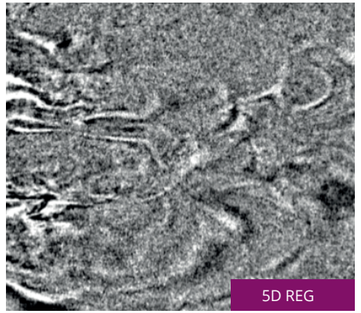
Marine



Land



Land



Dual, Triple and Multi-Source Deblending

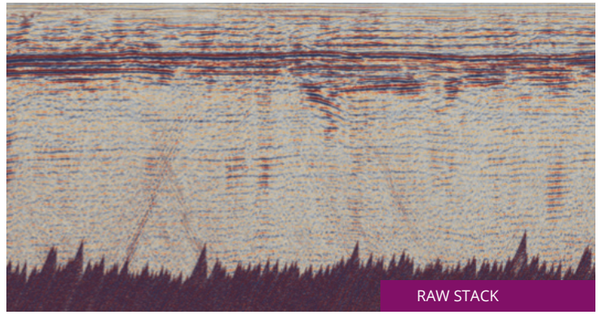
The Shearwater deblending provides accurate shot separation for dual, triple or multi-source surveys.

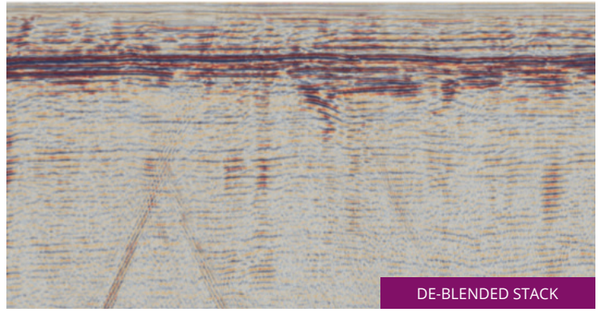
3D rank reduction deblending separates overlapping shots acquired with a random dither caused by the irregular movement of the equipment through the ocean's waves. This allows acquisition with shot overlaps ranging from a few hundred milliseconds to several seconds. Resulting in a number of benefits such as higher fold, higher crossline resolution or faster vessel speed and less equipment towed through the water.

- Cost effective acquisition
- Natural random dither
- Higher fold
- Improved crossline resolution
- Record length extension
- Part of the **Flexi***source* package
- Not Limited to Shearwater Acquisition

Further Reading:

Record-length Extension by Rank-reduction Deblending; M. Maraschini, A. Kielius, J.B. Barnes, & S. Grion, 78th Annual EAGE Conference





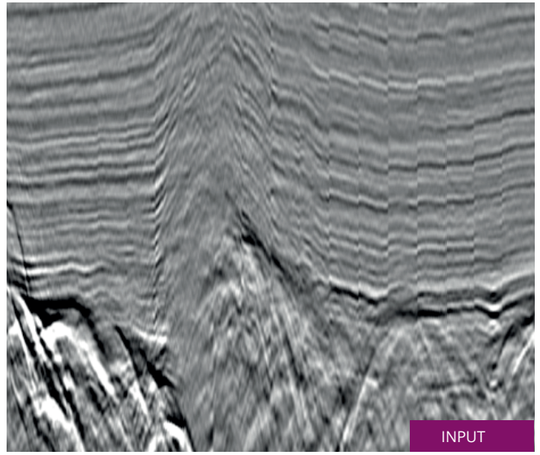
PROCESSING TOOLBOX

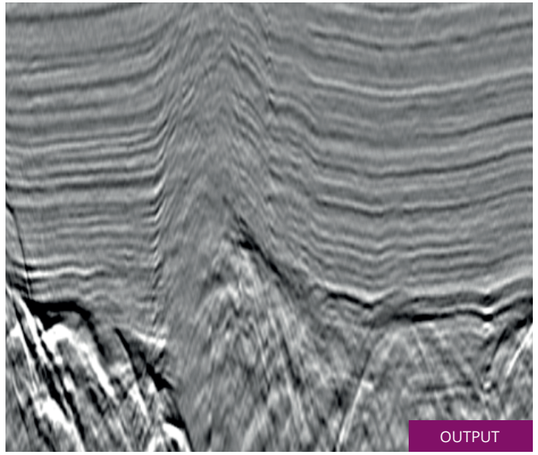
Multi-Azimuth NMO

Variations in NMO (gather flattening) can correspond to azimuth, often related to stress regimes which creates a horizontal component of anisotropy in the subsurface (known as HTI).

Given a typical wide tow geometry, the sensitivity in moveout to azimuth can manifest itself as a repeating pattern in the seismic. This is most pronounced at near offsets which experience the greatest azimuth variation.

The example below shows a crossline with a clear sailline pattern highlighting the azimuthal NMO effect. The azimuthal NMO result incorporates an additional azimuth term within the NMO to account for a defined fast-slow axis.





LAND TOOLBOX

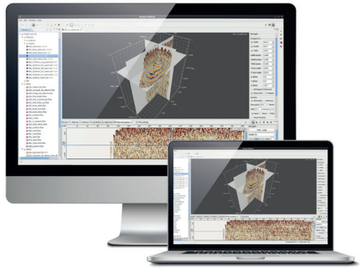
- FIRST BREAK PICKING
- 2D/3D TOMOGRAPHIC REFRACTION STATICS
- 3D FKXKY AND TAU-PXPY NOISE SUPPRESSION
- RESIDUAL STATICS
- 5D REGULARIZATION
- TIME AND DEPTH MIGRATION
- OFFSET VECTOR TILING
- HTI AZIMUTHAL VELOCITY ANALYSIS
- MULTI-COMPONENT

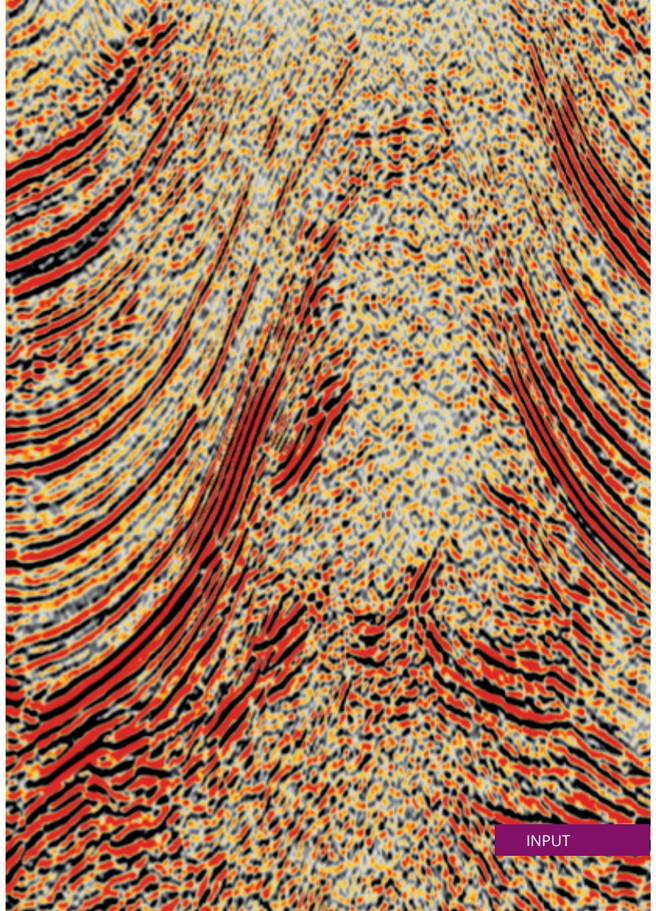
Land Processing

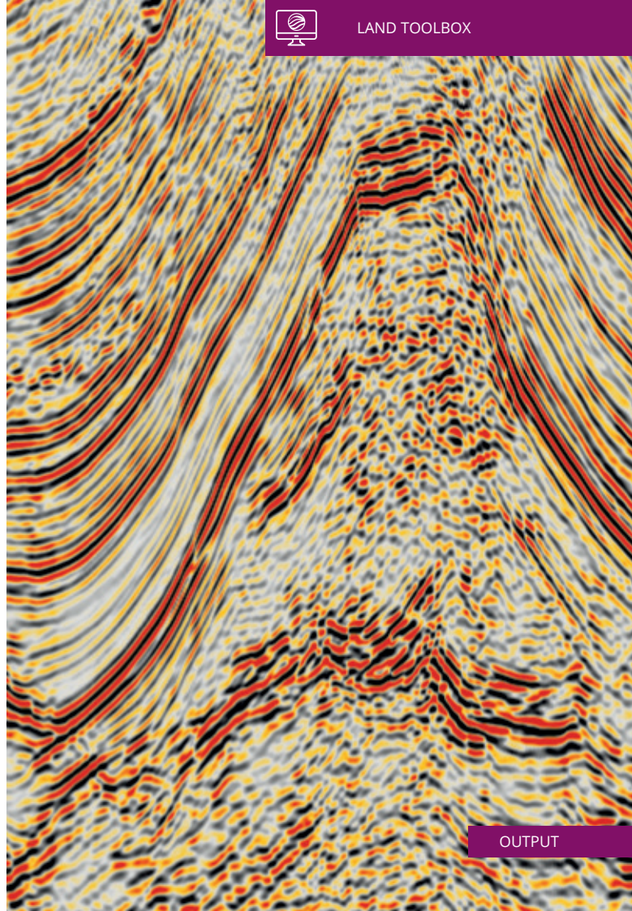
We listen carefully to the needs and requirements of interpreters throughout the processing stages to ensure an excellent land seismic data imaging product.

At Shearwater we understand the complex challenges associated with 2D and 3D land data processing and imaging.

With our experienced land processing geophysicists and flexible Reveal processing software, we can apply careful geometry QC, effective denoise in several domains, accurate refraction & residual statics, along with meticulous velocity analysis, enabling consistent high-quality results to be produced.







DEPTH IMAGING TOOLBOX

- ISOTROPIC, VTI AND TTI KIRCHHOFF
- ISOTROPIC, VTI AND TTI BEAM
- ISOTROPIC, VTI AND TTI RTM
- Q KIRCHHOFF
- MIGRATION FROM TOPOGRAPHY
- FULL WAVEFORM INVERSION

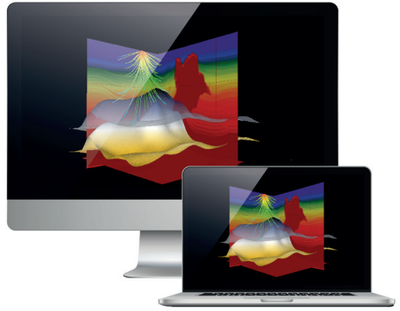
MODEL BUILDING TOOLBOX

- 2D/3D VISUALIZATION OF SEISMIC, HORIZONS, MODELS AND WELL DATA
- STACK-SWEEP MANUAL UPDATING
- ISOTROPIC, VTI AND TTI, NON-PARAMETRIC, GRIDDED TOMOGRAPHY
- Q TOMOGRAPHY

Depth Imaging

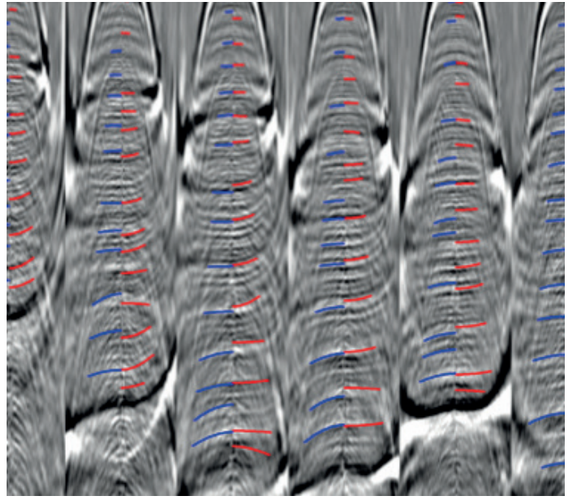
Depth Imaging capabilities deliver exceptional data results.

Shearwater's depth imaging and model building tools incorporate well and cultural information into the same Reveal graphical user interface as all our other processing tools. This enables our geophysicists to combine surface seismic data with well logs and horizons to optimize the model building process.



Multi-Azimuth Imaging

For dual-azimuth data, Shearwater collates the azimuths into butterfly gathers. This quickly highlights azimuthal-variations in moveout.



This example presents butterfly gathers with their corresponding CIG picks prior to running a dual-azimuth tomography update. Picks are colour-coded according to their respective azimuth.

Each survey has its respective Gamma volume, which can then be differenced to create a dGamma QC. This shows the areas of the seismic that suggest that azimuthal variation in moveout is present.

A Delta tomography is the tomographic inversion of the anisotropic property 'Delta' (as per Thomsen's parameters). It can be inverted for in dual-azimuth surveys to account for dGamma variations.

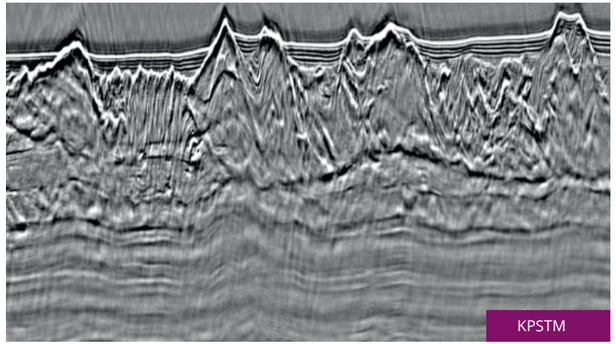
Kirchhoff PreSDM

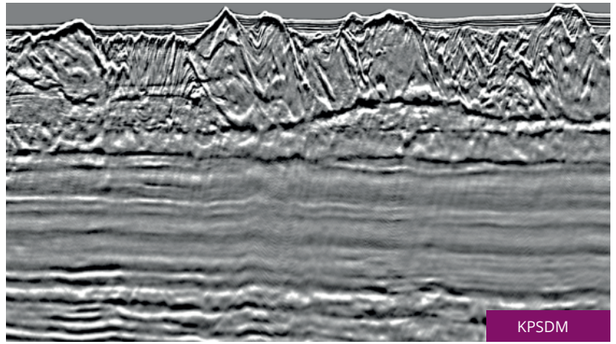
The Shearwater Kirchhoff Depth Migration provides enhanced images in complex geology.

The Shearwater Kirchhoff PSDM is a true amplitude, anisotropic Pre-Stack Depth Migration ideally suited to moderately complex geology with strong lateral velocity changes.

Kirchhoff PSDM is a highly versatile algorithm used throughout model-building and final imaging. The Shearwater Kirchhoff PSDM uses wavefront reconstruction travel times selected by user criteria such as first arrival or minimum velocity contrast.

- Isotropic, VTI and TTI anisotropic
- Steep dips including turning rays
- Target output lines, volumes or honeycombs
- Target output CMPs for velocity model building
- Horizon illumination maps
- Land, marine or seabed





DEPTH IMAGING TOOLBOX

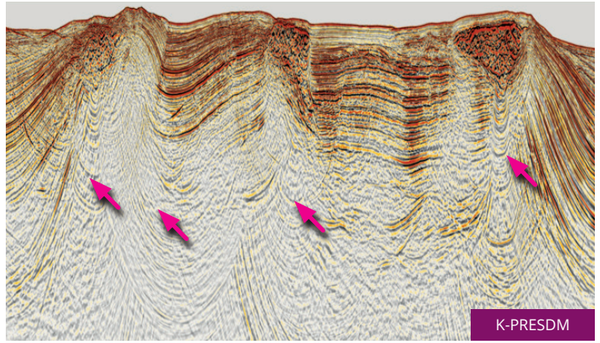
Beam Migration

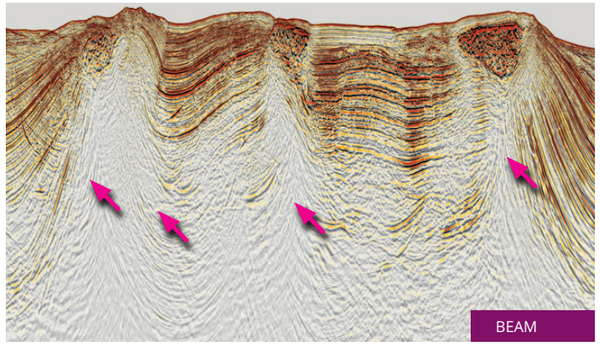
Beam Migration achieves enhanced multi-raypath imaging by retaining aspects of Kirchhoff PSDM.

It is ideally suited for depth imaging in areas of complex geology where there may be many raypaths between a surface location and a subsurface imaging point. Beam Migration can image the energy from the multiple raypaths. Sub-salt imaging is a typical example of a complex overburden imaging problem that can benefit from Beam Migration.

Beam Migration retains many of the convenient aspects of Kirchhoff PSDM (common offset input, target-oriented outputs, steep dip imaging) but overcomes the limitations of KPSDM by accounting for multi-arrivals without the computational expense of WEM/RTM algorithms. Flexibility within the Beam Migration algorithm allows tailoring of the imaging to remove anomalous noise or multiple energy.

- Multi-raypath depth imaging
- Isotropic, VTI and TTI anisotropic
- Steep dips
- Target output lines, volumes or honeycombs
- Target output CMPs for velocity model building
- Noise removal
- SMART BEAM





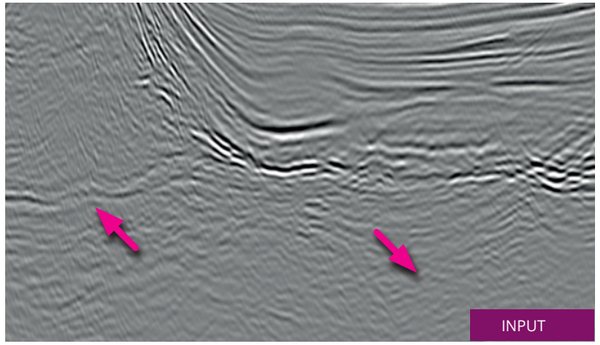
Reverse Time Migration

Shearwater's leading depth imaging technique, Reverse Time Migration (RTM), produces superb imaging in the most complicated geology.

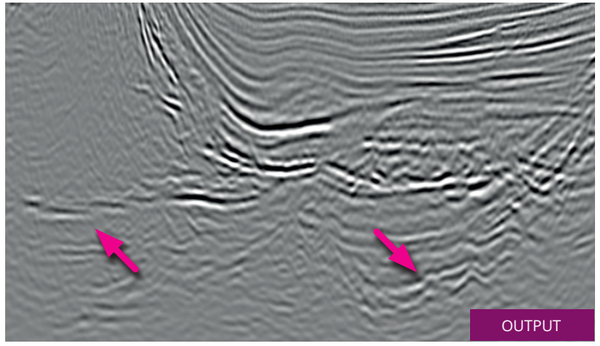
The Shearwater RTM is our most advanced depth imaging algorithm. It is suited to geology with rapid or sudden lateral changes in velocity that cause significant distortion of the wavefield.

Its use of the two-way wave equation allows clear imaging below the most complex overburdens. The input velocity models can also include small scale details.

- Depth imaging below sharp lateral velocity changes
- Isotropic, VTI and TTI anisotropic
- Detailed velocity models
- Two way wave equation



INPUT



OUTPUT

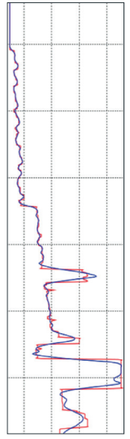
DEPTH IMAGING TOOLBOX

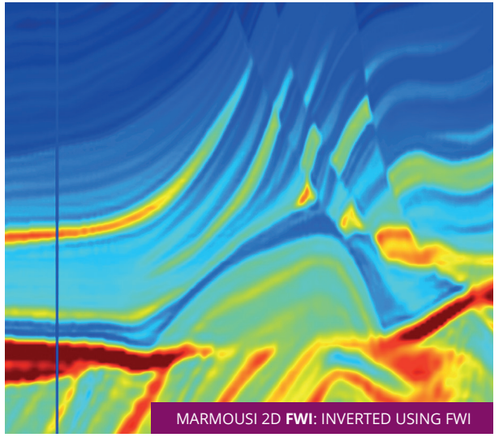
Full Waveform Inversion

Using the latest technology in building high-resolution earth models for seismic imaging and interpretation.

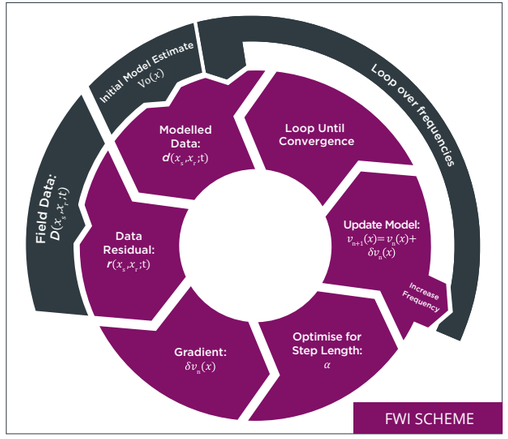
Full Waveform Inversion (**FWI**) is an iterative tomographic technique, driven directly by differences between the true seismic data and synthetic data modelled with the estimated earth model. All modelling is performed using an accurate solution of the two-way wave equation, leading to much greater resolution in the inverted model than can be achieved through conventional ray-based tomographic algorithms.

Shearwater's **FWI** is fully integrated within the Reveal platform, enabling easy incorporation of inversion into larger model-building workflows. For example, intermediate output models may readily be used to test for gather flattening as the inversion proceeds.

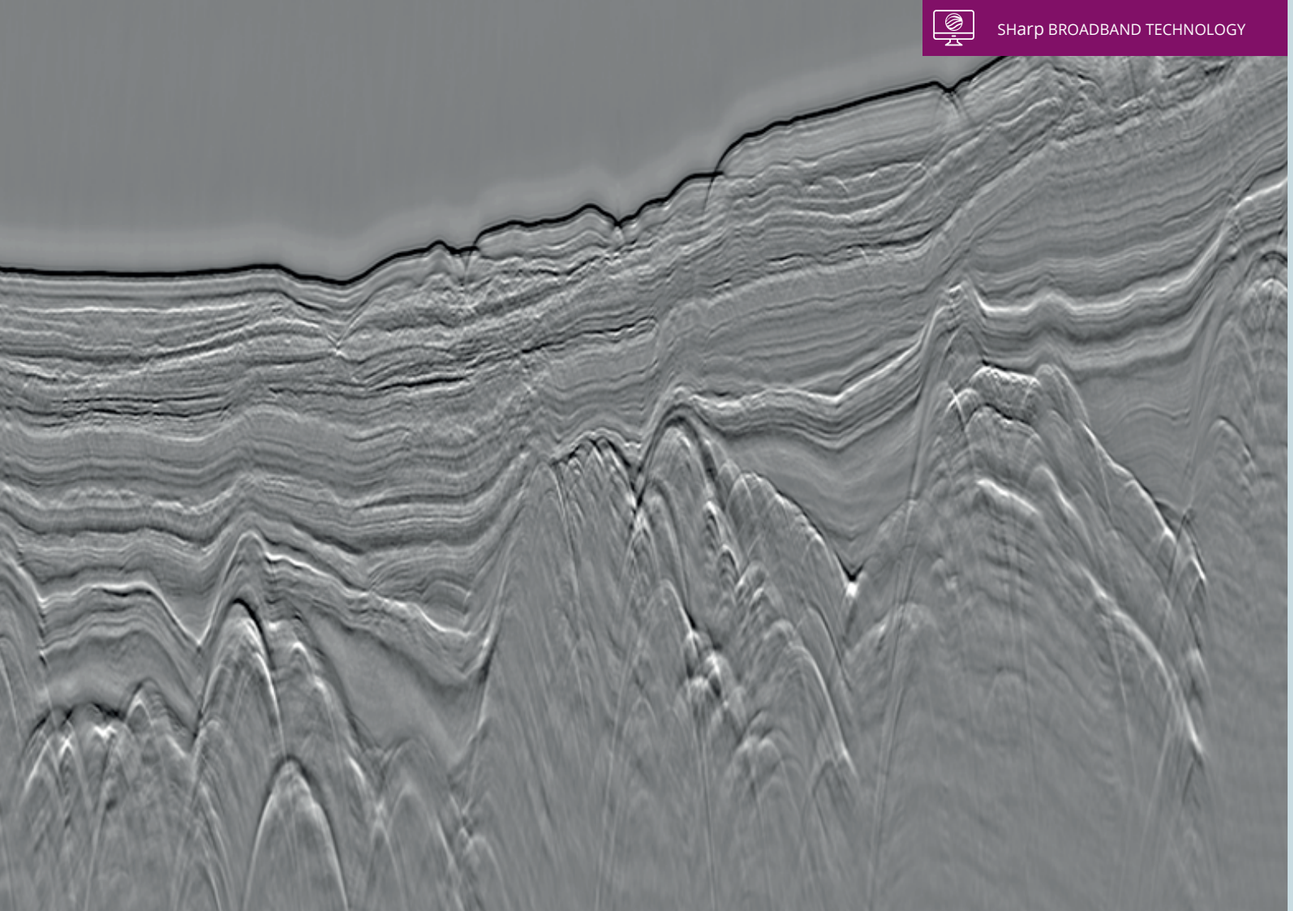




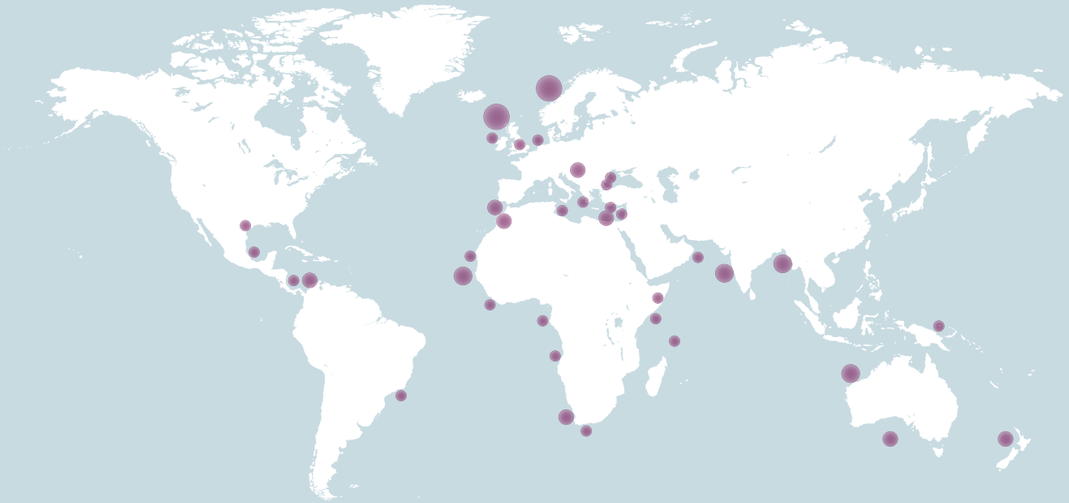
MARMOUSI 2D **FWI**: INVERTED USING FWI



FWI SCHEME



Processing & Imaging Global Experience



Worldwide Marine Projects

- United Kingdom
- Bulgaria
- Myanmar
- Liberia
- Kenya
- Mexico
- Turkey
- Norway
- India
- Australia
- Mauritania
- Angola
- South Africa
- Nicaragua
- Netherlands
- Papua New Guinea
- Oman
- Ireland
- Egypt
- Namibia
- Lebanon
- Senegal
- Tunisia
- Morocco
- New Zealand
- Gabon
- Greece
- Colombia
- Seychelles

Worldwide Land Projects

- Morocco
- Hungary
- Kurdistan
- United States
- United Kingdom
- Somaliland

SHEARWATER

Clearly Better.

Our modern fleet, expert imaging teams and innovative software combine to offer exceptional results. Fast, flexible and cost-effective, Shearwater is the cutting edge geophysical services company.

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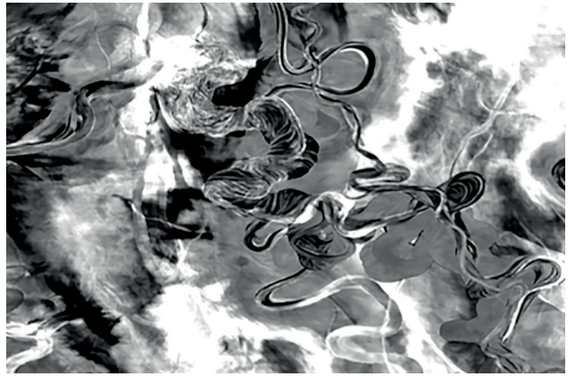

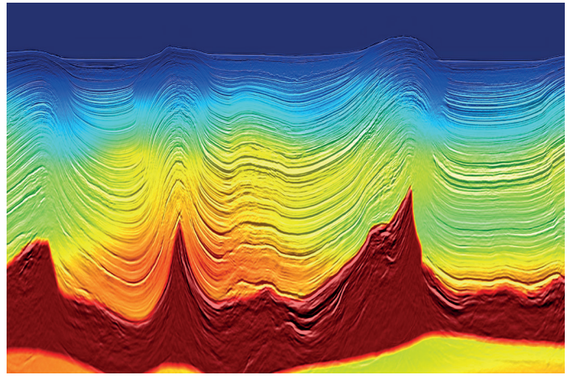

Marine Acquisition

A powerful fleet, complete with modern technology, manned by experienced crews with advanced Fast Track processing capacity. Work safely and efficiently, in all operating conditions - delivering a cost-effective, high-quality service.

Processing & Imaging

Agile, responsive teams of experts, available when, where and for however long you need them. Get high-quality data rapidly, reduce costs and build in flexibility at the heart of your project.

Reveal Software

A modern, powerful and intuitive solution for demanding seismic data analysis, Reveal is a full processing software that can scale to run from a laptop in the field through to the largest data center.

Multi-Client

Our full service Multi-Client business offers refreshing flexibility and clarity. Reduce financial exposure and maximize your exploration returns.

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